

GEOLOGICAL SURVEY OF JAPAN.

REPORTS

OF

PROGRESS

FOR

1878 AND 1879;

BY

BENJAMIN SMITH LYMAN.

TOOKEI:

PUBLISHED BY THE PUBLIC WORKS DEPARTMENT.

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ERRATA.

Page 10, line 10 from bottom, *for even read : ever.*

„ 24, „ 4 *for Takinoya read : Takinoyu.*

„ 84, „ 11 from bottom, *for crude read coarse.*

„ 190, „ 13 from bottom, *for Frechville read : Frechville.*

Pages 21, 22, 54, 80, 81, 82, 90, 91, 93, 94, 101, 187, *for blister copper, read: coarse copper.*

Page 205, line 11 from bottom, *for Takashima, read : Tokushima.*

On the MAP OF PORONAI.

1st left hand columnar section, lines 2, 4, 5 from bottom, *for 587 read : 589.*

„ „ „ „ „ line 7 from bottom, *for 586 read : 587.*

3rd „ „ „ „ „ line 6 from bottom, *for 600 read 606.*

4th „ „ „ „ „ line 5 from bottom, *for 5.35 —5.35, read : 3.35—3.35.*

In the REPORT OF PROGRESS OF YESSO GEOLOGICAL SURVEYS FOR 1875 AND SEVEN COAL SURVEY REPORTS.

Page 156, line 5, *for 586 read : 587.*

„ 156, lines 18, 23, 31, *for 587 read : 589.*

„ 157, line 1, and line 4 from bottom, *for 587 read : 589.*

„ 158, line 1, *for 586 read : 587.*

In the GENERAL REPORT ON THE GEOLOGY OF YESSO.

Page 39, line 7 from bottom, *for 586 read : 587.*

„ 40, lines 7, 12, 20, 24, *for 587 read : 589.*

In the REPORT ON THE SECOND YEAR'S PROGRESS OF THE SURVEY OF THE OIL LANDS OF JAPAN.

Page III, line 22, *for Hanagawa read : Hunagawa.*

„ 27, „ 13 from bottom, *for westerly read : westerly and.*

„ 31, „ 6, *for boiling it read : boiling.*

„ 34, last line, *for 12 read : 1.2.*

„ 38, line 15, *for 66 $\frac{2}{3}$ read : 66 $\frac{3}{4}$.*

„ 61, „ 16, *for mountain, read : mountain region.*

GEOLOGICAL SURVEY OF JAPAN.

REPORT OF PROGRESS FOR THE YEAR 1878, BY BEN-
JAMIN SMITH LYMAN, CHIEF GEOLOGIST AND
MINING ENGINEER.

To His Excellency

K. INOUE,

Public Works Minister.

SIR :

I beg to make the following report of the progress of the Geological Survey of Japan during the year 1878, its first annual report. My aim is to give here a short statement of the work that has been done and of the way the time has been spent by the assistants and myself; but to reserve the details and results of our work mainly for future special reports.

As already mentioned at the end of my report on the second year's progress of the Geological Survey of the Oil Lands of Japan, it was decided that from the beginning of February, 1878, our survey should be made to apply to the geology of all Japan. Of course there was no expectation whatever in any quarter that the geology of the whole country could be thoroughly elucidated within a year or two; but I hoped that at least a useful, though modest,

beginning might be made and that the new name and organization would serve well to reunite the varied geological labours of my assistants for many and many a year after my own retirement ; since the work to be done is infinite in amount and necessarily can never be fully completed as long as mineral substances shall be mined or quarried in Japan. Neither the financial nor other circumstances of the empire made it probable that a very great annual outlay could for some time to come be applied to purposes that seem indeed rapidly to be more and more appreciated here, but that in spite of their great and manifold importance are even in western countries still thought worthy of absorbing only an extremely small portion of the whole national revenue. From like considerations it was also clear that we must give attention more particularly to matters of directly practical advantage than to those that were only indirectly useful though of very great weight in an educational or purely scientific point of view. It is certain, too, that affairs that have a pretty direct utilitarian bearing give very ample scope for the exercise of the highest human faculties ; and it may at least be questioned whether even so called “ pure science ” or “ divine philosophy ” would be anything better than the gratification of an idle curiosity or an opportunity for mental gymnastics were it not for the practical applications and benefits more or less indirectly brought about, yet more or less clearly aimed at or kept in view. Especially in a subject so novel to Japan as geology was it probably advisable to begin first with its more immediately useful branches trusting that their study and practice would soon lead to a higher estimate of the value of the more remotely advantageous ones. Our attention, therefore, has for the the last half dozen years been given more especially to such geological surveying as would be a guide in regard to the working of mineral deposits, as for example,

the coal of Yesso, and the rock oil of Echigo and Toootomi. There are however many other minerals in Japan that have been and are well worth mining and for which such surveys would be extremely desirable as very greatly lessening at comparatively trifling expense the risks that are at best to a sufficiently high degree unavoidable. All those surveys can best be made by a single body of geological surveyors harmoniously working and conferring together and collecting as the sole receptacle for the whole country the numerous detached notes, facts and specimens that may from time to time be offered by occasional observers, official or unofficial, throughout the land, who are generally very glad to find a repository where such gleanings may be garnered up, and where they may be of great value as a part of the whole, though sometimes unimportant by themselves.

The aim, then, during the past year has been not only to carry on and, if possible, finish the special survey of the oil lands of Japan, but to complete the hasty reconnaissance of the whole country that had already been begun, with a view to learning something of its general geological structure and particularly to ascertaining what places most needed detailed surveys, either for immediate mining purposes or for a thorough understanding of the position, extent and composition of the different formations, especially as regards useful minerals. Without first taking a general view of the whole country it would be far more likely to happen that the relative importance of different regions should be greatly misunderstood and future work very disadvantageously planned and carried out. It was also possible that here and there some facts of immediate use might be noticed, and advice might sometimes be given on the spot in respect to mines or minerals. Indeed the eagerness to receive such advice was almost everywhere very striking,

and it was much to be regretted that without detailed surveys and greater leisure, desires of that kind could not be more fully met. It is yet quite possible, however, that in making separate reports on each of the principal places and regions visited, a careful consideration of the facts observed and noted by myself or recorded by others may lead to further conclusions and opinions of some value. Moreover, there is some reason to hope that from the notes of our survey and from various papers already published, and from a number of yet unpublished reports, notes and facts that have been collected in our office or in other branches of the government, a general account of the geology, mines, metallurgy and mineralogy of all Japan may be prepared that will at least be much more complete and detailed than any yet made public, and that may prove to be of importance not only to the Japanese Government and people but to the world at large, and may serve perhaps as a satisfactory base for future more thorough investigations.

The assistants of the Geological Survey of Japan have been the same that worked on the Geological Survey of the Oil Lands ; namely :

Mr. T. Yamauchi, Chief Assistant Geologist.

„ T. Inagaki, Assistant Geologist.

„ T. Kuwada, „ „

„ J. Sugiura, „ „

„ T. Kada, „ „

„ I. Ban „ „

„ J. Shimada, „ „

„ E. Yamagiwa, „ „

„ S. Maeda, „ „

„ S. Nishiyama, „ „

„ M. Maeda, Accountant.

„ Y. Akiyama, „

„ J. Adachi, Clerk.

The two accountants have aided in the surveying and mapping in addition to their special duties. Mr. Adachi has, during my journeys, accompanied me, and has aided to some extent in the account keeping. The division of the assistants into parties continued the same as in the two previous years.

They have mainly confined their attention to the continuation of their work on the oil surveys ; but in their journeys to and from Echigo, have made such observations as they could without delay ; and Messrs. Kuwada and Nishiyama spent a day or two in surveying at the Akadani coal mines in northern Echigo. My own attention too, while in the office, was chiefly taken up by matters connected with the oil surveys ; likewise a part of the time while travelling, but the rest of the time by the more general reconnaissance.

I set out with Mr. Adachi for a visit to the Tootoomi oil survey on the 17th of April, and returned on the ninth of May. On the 21st of June, we started on a long journey ($1,126\frac{1}{2}$ leagues, or about 2,800 miles), first northward through Aidzu to the northern and middle Echigo oil surveys and thence southward through Ishikawa Ken, the Sanindoo, around Kiushiu, through and across Shikoku, through Kii, the Kinai, and back by the Tookaidoo. At the end of the year we had only reached Koochi in Shikoku, and did not arrive home until the third of February, 1879. In Echigo we visited the assistants at their surveys in Kambaragoori and afterwards assembled them all at Dooyama near Idzumozaki, where I worked with them for three weeks on the geology of their maps.

The assistants (except Messrs. Sugiura, Ban and Adachi) worked in the office until 28th May, and then set out for Echigo, where they worked until late in the autumn at the surveys and mapping begun by the different parties there in 1876. Messrs. Sugiura and Ban made a

trip to the Tootoomi oil field from the 16th of April to the eleventh of June, to extend and correct their survey begun the year before; and, after a fortnight more spent in mapping their work in the office here, set out for their Echigo survey on the 26th of June. Messrs. Kada and Shimada returned from Echigo on the 17th of October, and the others in November; Messrs. Yamauchi, Yamagiwa and M. Maeda as well as Messrs. Sugiura and Ban, on the tenth; Messrs. Kuwada and Nishiyama on the 21st; Mr. Inagaki on the 24th and Mr. S. Maeda on the 25th.

FIELD WORK.—*Surveying*.—In 1876 the assistants had with almost uninterrupted fair weather done so much field work to the comparative neglect of office work that they had been unable in the short following winter season to finish the mapping so far as to have the geology studied out; and in the summer of 1877 they had been mostly occupied in adding to the extent of some of the surveys or in undertaking the field work of new surveys in other regions, such as Tootoomi and Akita. In the spring of 1878, however, we had undertaken to mark on the maps the probable geological structure and the outcrop of the oil bearing beds with the help of both the observed rock exposures and the very numerous well sections that had been collected together by diligent inquiry. But (in 1878) on reaching Echigo again (and it was the same in Tootoomi) the assistants found that many of the statements in regard to the depth at which oil or certain rocks had been met with in digging the wells were very inexact. The length of the fathom had been counted differently by different men, and by the same men at the upper and lower parts of the same well; and many statements had been given with too great precision that were merely inexact remembrances of pretty old wells. It was therefore impossible to make so confident a use of the well sections as had been hoped, and rock

exposures were sought out with renewed zeal and thoroughness, requiring much additional surveying. The early surveying (of 1876) was also found to be in need of important correction in some places and a number of new lines had to be run with the transit. Moreover, a great many new wells dug in the two years (1876-78) had to be surveyed, plotted on the maps, and recorded as fully and accurately as possible. In a number of cases the depth of wells was tested and corrected by the assistants' own measurements.

Trial wells.—Our intention also at starting was, after a little addition field work and mapping, to test our geological mapping by some experimental digging, if necessary, and to give advice to the country people where they would best dig for oil; but owing to so many unexpected alterations in the facts on which our geological mapping was based we were not able to give such advice quite so soon nor over so wide a space as we had hoped. Nevertheless in the Idzumozaiki region of Echigo and in Kambaragoori the probable outcrop of the oil bearing beds has through a considerable space been marked out on the ground and a few wells have already been begun in accordance with our advice, and those that have been dug deep enough to form an opinion have been so successful as to inspire the operators with far more faith in our survey than they had in some cases at first. From Tootoomi too word has come during the writing of this report, that in the past year many new wells have been undertaken, partly according to our advice, and that the result has much increased the confidence of the larger and more intelligent operators in the value of our work.

As the country people were almost everywhere eager to dig deep wells on their own account wherever we should encourage them to do so, it was unnecessary for us to undertake any such expensive works merely for the

purpose of testing the geological structure, and accordingly the assistants did not at first go beyond a little superficial digging to try supposed outcrops or uncover imperfectly exposed dip surfaces. After I had left Echigo, however, probably owing to an imperfect understanding of the circumstances, orders were given me by the government to instruct the assistants to begin some deep wells ; and the orders were insisted upon, in spite of my renewed attempts to explain the circumstances more clearly. Accordingly three deep wells were begun near Idzumozaki, and placed especially in charge of Mr. Akiyama, who on their account still remains in Echigo; and two of the wells have been remarkably successful. At my suggestion, however, the wells were at the end of January, 1879, quite removed from the Geological Survey and from my charge. It is my opinion that, although the digging of oil wells is profitable to the country people, it can be (as shown in my report for 1877) but little so, if at all, to a mercantile company (even at higher prices for oil than those that have prevailed the past year), and on the average could only result in loss to the government. We found last summer in Echigo that the cost of well digging by a mercantile company as stated in my report for 1877, was one-half greater than what it cost the villagers or farmers ; and it is almost absolutely unavoidable that government work should be at least twice as costly as that of a company. The government must pay higher prices for labor and materials, besides the salary and travelling allowances of an official for oversight and probably must besides sell the oil produced at a disadvantage. The country people on the other hand oversee their own work, can get labor and materials from their own families or land or can bargain for them at their own convenience and have to pay no excessive prices. The produce of the oil wells is on the average so small

that, when the cost is trebled there must clearly be in general nothing but loss. There was, perhaps not unnaturally, some impatience to arrive at definite results from our survey ; but there are already good direct results if our maps and advice can serve as a guide to the country people in digging their wells, and if we can prevent the waste of money by a government oil speculation that would probably be disastrous. Indirectly, lessened risk or increased certainty in oil well digging will be a good result to the nation in diminishing the losses and augmenting the profits and wealth of the inhabitants of the oil regions. It seems to me therefore highly unwise for our survey (in spite of the hopes entertained at the outset) to undertake deep well digging except where it may prove absolutely necessary to test some geological opinion that seems probably to be correct, but too uncertain to be a guide for private operators.

Improvement of Methods.—We carried an iron lift pump to the Tootoomi oil field for trial in the oil wells, if need be; and during my visit there the making of a wooden plunger pump was begun. The average product of the oil wells, as shown in my report for 1877, is so little that a very small outlay for apparatus would take away the profit altogether; so that it is absolutely necessary to make use only of the most inexpensive methods and work with the utmost economy. Even an iron pump with an iron pipe and pump rod would probably be too dear a luxury in most cases ; and, if the pump were to be worked by hand, there would be little or no saving in the cost of power as compared with the present system of raising the water in a bucket. As the wells, however, are very narrow (about three feet and a half square), only one man can work in them at a time ; and if his time is taken up in baling water he cannot of course make so good progress in digging in the few hours when the daylight is

sufficiently strong. A pump may therefore be at times an important convenience ; and especially so if horse power or water power should be applied to that and other purposes connected with the well digging. It seemed possible that an iron bound wooden plunger pump with a light bamboo pump rod and a stout bamboo pipe tightly wound with cheap country made cords might be strong enough to serve for raising the surface water from some little depth (and it often penetrates only to a depth of ten fathoms); and it would have the advantage not merely of cheapness of first cost but of such simplicity of construction that it could be made and repaired by the country carpenters and blacksmiths. For a greater depth two or more separate lifts might be made use of. At any rate the inexpensive trial of such a pump for moderate depths would readily satisfy the operators whether it would be worth their while to go to the expense of an iron pump and pipe. The wooden pump made at Tootoomi cost us only two yen and three-quarters all complete (without pipe and rod); and with good bamboos not wound with cords the water was carried safely to a height of about five fathoms. The Tootoomi operators were however so indifferent in the matter (as they are little troubled with water there), that we could not get the pump made by their busy carpenters until after I came away ; and I do not know that it was even tried in an oil well at all. About the end of the year it was sent to Echigo to be tried there by Mr. Akiyama, if convenient, and to serve perhaps as a model for others ; but with what result we have not yet heard. Before its arrival, however, he used the iron pump in at least one well.

While in Echigo I showed the assistants for the benefit of the well diggers how the surface water or the water of a lower portion of a well might probably be stopped out successfully by means of strong wooden tubbing thorough-

ly closed on its out side at the bottom (and likewise at the top if it should not reach to the surface of the ground) by clay rammed in between it and the walls of the well above a broad support set in the rock at some distance below the water bearing veins ; but I am not aware that the advice has yet been followed in any case. Tubbing is already made there very neatly for common water wells ; and we were told at Dooyama that it would cost, for a diameter of three feet and a half feet and a thickness of two tenths of a foot, only twenty-five cents a running foot, It is pretty clear therefore that the expense of suitable work of the kind would be much less than the cost of pumping out the water during the whole time that the well is getting dug and yielding oil. It is found that below a depth of thirty fathoms there is seldom any water to speak of, and commonly none below twenty fathoms, and often none below ten fathoms, variously in different regions. The removal of the water either by stopping it out or by constant pumping is especially desirable, because its presence hinders the flow of the oil.

We had hopes of experimenting in the field for the improvement of the lighting of oil wells which is now, by daylight merely, so dim that digging is carried on only between nine and three o'clock. We took a small portable electric mine lamp to Echigo, and tried it in the method prescribed by the Yokohama merchant of whom it was bought. It contained for a galvanic battery a small brass jar holding a porous cell in which a large piece of coke hung from the hard rubber cover of the jar ; along side there was a Ruhmkorff coil ; and the whole was contained in a small strong wooden box to be strapped on the miner's back. A couple of copper wires from the Ruhmkorff coil were protected by india rubber tubes and reached to a strong glass tube carried on the miner's breast and containing a Geissler tube with rarefied air and platinum

wire points. We had already tried charging the battery with a solution of blue vitriol but had not succeeded in making a good light, and now by the seller's advice, after the delicate platinum wire connections had once broken and been repaired, charged it with dilute sulphuric acid in the brass jar and nitric acid in the porous cell. The galvanic action was very strong, and a little flickering light was produced, which however disappeared within a few minutes, before it could be tried in the dark drainage drift of an oil well near by. The electric action was so strong too that on touching the connecting metallic wires or screws with the finger or a piece of metal there was a small visible spark. It was clear therefore that it would not be safe in an oil well ; for even so small a spark could set fire to the explosive gas there. It seems extremely doubtful whether a lamp requiring so much care and apparently getting out of order so easily can ever be safely used by the country people so entirely ignorant are they of electric matters ; though it is possible that some other electric light might be more successful.

It seemed, then, the more worth while to try the plan of increasing the daylight in a well by a large reflector made of common window glass in a sash so hung that it could be turned both vertically and horizontally so as to send the sun's rays at any hour of the day down a well or along a drainage drift. For the wells and for many drifts such glass without any silvering would "totally reflect" the rays, and the cost would therefore be little. The experiment was to have been tried by the assistants after I left Echigo ; but owing to busy preoccupation with the surveying and mapping it was neglected. The village well diggers were not very eager to have such an improvement in the light, except perhaps for drainage drifts ; though the time that digging in a well could be carried on every day might be doubled, and consequently (for

example) the water to be raised while digging a well lessened by one half. They seem to feel pretty well satisfied with the present plan of lighting the well by a large sheet of yellow oil paper hung over it at an angle of forty-five degrees, covering a hole in the roof of the grass hut built over the well; and certainly the apparatus is inexpensive.

The present method of sending air into the wells was also considered while in the field, but, would seem to be hardly capable of much improvement so long as merely human labor is employed; for the application of such power by treading upon the oscillating top of the large wooden bellows is probably the most economical and effective mode of using human strength. If, however, horse power or water power should come into use, probably the Hartz ventilator, or the trompe blast, or a revolving fan, or blowing cylinders would be a more convenient blast apparatus.

It seems pretty certain that, in many cases at least, there would be decided economy in making use of horse power (with a gin) or water power in digging the oil wells; since so large a portion of the power required is applied in so purely mechanical a way. Nevertheless the cost of the capital needed and the expense of repairs to machinery make it advisable to begin experiments in that direction rather cautiously. I am more than ever of the opinion that the setting up of steam engines and boring machines would be unprofitable; for the experiment has had now for a year or more a long trial in Kubikigoori in Echigo, where the machinery that was formerly used a little near Idzumozaiki by the old Oil Company has been tried again. Although the well proved to be in an exceptionally favorable place, the progress of the work was slow and expensive on the whole, and pieces of the apparatus had to be sent for repairs to this city, some two hundred miles. But a

horse gin could easily be made by the country carpenters, would not be costly and would enable decidedly cheaper power to be used than the present human labor. It is true that in the case of shallow wells it would take nearly or quite as many men to attend to the horse and to the careful guiding of the water bucket or the rope net in which stones and earth are raised from the bottom of the well as it now does to do the raising altogether ; but at deep wells more lifting power is needed, up to six men or more, and there would be a saving. Besides, the same horse gin could work the blowing machine, which now in deep wells requires the labor of even as many as eight men. In Echigo, horse hire (including the horse boy) costs about double the wages of a laborer. A gin would have the advantage that after the digging of one well was finished, and perhaps one or two other very near ones, the machine could be removed at no very great expense to any other site for a new digging.

Water wheels would be more permanent, and consequently of less universal application ; but by rods or ropes or wires the power could be carried to a considerable distance in any direction from its source. Particularly the blast might be carried in pipes very far and very conveniently, with small loss from friction ; and in the same way with compressed air used in a machine just like a steam engine a distant water wheel could give all the power needed for raising the stones, earth and water, and for blowing such power would doubtless be in many cases far cheaper than horse power ; but in other places suitable streams would be too remote, and sometimes water is in so great demand for irrigation that the farmers already in possession might require an excessive price for its use in the summer season.

Although small water power machines of various kinds are extremely numerous in Japan, the total neglect of so

great a source of power and wealth as the larger streams might furnish is very striking. The reason is no doubt that the people have not yet become familiar with the methods of building large dams, nor become accustomed to accumulate and risk capital in such enterprises. Of course there is always the condition that the power can in general be carried to no very great distance from the stream, so that the material on which the work is to be done has to be brought to the mill and therefore the roads or other means of communication must be in such a condition as to make the carriage not too costly. For that reason the improvement of the waggon roads would become additionally important. The very damming of the rivers would be a means of improving their navigation; and water carriage, in spite of its slowness, excels so very greatly in cheapness that it is especially desirable for Japan.

The rain fall is enough and the descent of the rivers from the central mountains to the sea ample to give in the aggregate an immense amount of power. The simplest of the water machines, the little spoon shaped water lever so often seen in the country in use for pounding and cleaning rice, saves the work of a full grown man, and consequently must earn for its owner the equivalent of a man's wages, and therefore adds to the owner's wealth and to that of the state as much as is necessary for the maintenance of at least one inhabitant, perhaps far more, if you consider that it never sleeps and is rarely indisposed or in need of a holiday. Every man that could so be replaced by a water machine would be free to undertake other work that might be more in need of intelligence, or would have leisure for study or amusement. Increased wealth often leads merely to increased luxury, but that is not the necessary nor final result; and if it be at all desirable that the higher human faculties should be cultivated, it is

certainly a decided gain that, so far as possible, the labor required by the human race should be accomplished by the forces of external nature, forces that are mostly derived more or less directly from the rays of the sun. Already great differences in both the wealth and enlightenment of different nations can be seen to depend very much upon the extent to which natural forces are utilised; to which a man's lifetime is not necessarily taken up in the very grossest mechanical labors, in cultivating his fields or in grinding grain or spinning and weaving by hand merely, in pounding rice with a treadmill, in carrying burdens along roads impassable to horses, or in leading single pack horses over roads too bad for waggons, in carrying by land where improved river or sea navigation would make water carriage possible; on the degree to which the streams do not flow down idly to the sea, the wind does not blow uselessly, the tide does not rise and fall without good effect, the underground stores of coal are not left unburnt, and even the direct warmth of the sun is turned to account.

Office Work.—Our time in the office during the spring was chiefly taken up in mapping, especially in working out the geology with the help of numerous cross sections, as already described for the preceding winter months in my report for 1877. The accounts were also completed, as mentioned there, with a single-entry ledger. Between my Tootoomi journey and the long journey my time was taken up in great part by the writing of that report and getting it printed, particularly after the assistants had started for Echigo.

MY OWN JOURNEYS.—*The Tootoomi Journey.*—The journey to Tootoomi and back was described in my report for 1877. While there I spent a couple of days in visiting several newly discovered or newly tried oil places (at least so called), namely: Ooiso, Ogami, Hirugaya, Kurobe,

Nakanishi, Hirai, Umakatatani, Shatsubonya, Hashigara, Nakamura, Nita, Katahama ; but found none of them to be very promising, though all but two or three had traces of oil or of oil gas. Another day with Messrs. Sugiura and Ban I verified their very careful and numerous observations of the dip of rocks near Sugegaya. The rest of the time was mostly spent in working with them or alone in the office on the geology of the maps, trying to make out satisfactorily the details of the geological structure with the help of the well sections and of such additional field work as they were able to do hastily and map at once. It proved, however, to be desirable to extend the search for more rock exposures, and they both therefore staid a while after my return. Even otherwise there was no opportunity to begin or advise new wells at once, as the oil leases already granted were pretty full of wells, and the issue of new leases was at the moment delayed by litigation.

The Long Journey.—Starting on the 21st of June, by the same road as the year before (the Ooshiukaideo), we went northward as far as Nogi (17 leagues) and then turning to the left of the main road, still northerly, within half a dozen leagues reached Tochigi near the northern edge of the great Tonegawa plain. A few of the minerals of the Ken were shown to us by the Kenchoo at Tochigi : but the Ken is not very rich in productive mines and those of Ashio are reckoned by far the most important. From Tochigi we went still northwards to Imaichi on the main road of the preceding year from Utsunomiya to Nikkoo and two leagues southeasterly from Nikkoo. The road for the first half of the way as far as Kanuma was nearly flat, with hills on the left growing higher and higher as we went forward. They would appear to be of the metamorphic and crystalline rocks of the Kamoikotan Group or Series, as shown by the

pebbles at the crossing of the Ogura river near Kanasaki, two-thirds of the way to Kanuma, including some coarse syenite, some fine, grained granite, some blackish and some light gray quartzite. Near Idzuru among the hills some three or four leagues west of Kanasaki there are said to be some very interesting large limestone caverns, also no doubt in the metamorphic Kamoikotan rocks ; but we did not delay to turn aside, and, see if possibly the caverns contained prehistoric human remains, as happens so often in western countries. As far as Kanasaki, we had since leaving home seen no rock exposures except one or two of what seemed to be old alluvium. Perhaps half a league north of Kanasaki and nearly as far south of Ni-regi, we passed an exposure of light gray granular perlite. From Kanuma the road had a much more decided, but still gentle ascent growing gradually steeper the rest of the way to Nikkoo, Hachiishi village (about 2,000 feet above the sea), with numerous road side exposures of buff, yellow or brown decomposing pumice, sometimes underlying level bedded gray volcanic ashes.

From Nikkoo we went six leagues and a half southwestward on the Koodzuke road to the Ashio copper mines ; at first rising rapidly and crossing midway a pass about 4,000 feet above the sea, and then descending to the village of Ashio, still in the midst of mountains, about 2,000 feet above the sea again. The first league and a half or so was the road of the previous year to Chiuzenji with exposures at Hachiishi of quartz porphyry. Another half league further on, near Hosoo village there were still exposures of the decomposing pumice but they were soon succeeded by somewhat similar looking ones of decomposing gray granitic sand ; together with which was exposed in place here and there all the way to within half a league of Ashio village gray quartz porphyry with orthoclase (occasionally coarse) and, at least in some cases,

oligoclase and quartz, without mica, in a dark or light gray, sometimes dark green, matrix which is often so scanty as to give the rock at first sight a granitic or syenitic look. The preceding year I had found river pebbles of a similar rock containing besides the two feldspars and quartz in a scanty gray matrix hornblende also, what might be called a syenite porphyry and it was said to occur in place about a league down stream from Kagonnotaki. On the Ashio road a very few minute grains of yellow iron pyrites were seen in the porphyry. I suppose all these porphyries to be ancient and to belong properly with the crystalline rocks hitherto classed together under the Kamoikotan series. On the Chiuzenji road I had also seen pebbles and exposures of hard, blackish gray old volcanic rock, andesite, containing much glassy triclinic feldspar (probably oligoclase) in small crystals, dark green pyroxene and magnetite in a grayish black matrix that was sometimes vesicular. On the way to Ashio village from half a league short of it and close up to the principal mines a league north the exposures were of black clay slate (sometimes with imperfect cleavage), like the slate near Kamaishi and elsewhere among Kamoikotan rocks. At the mines themselves however the rock is again the gray quartz porphyry, abounding with quartz in grains of pea size in a white feldspar matrix. The rock contains also many pea and bean size, more or less rounded, bits of black slate; a circumstance that was noticed too in like rock near Hosoo. Like facts observed elsewhere in the journey (see for example pp. 25, 31, 39, 40, 41) and compared with closely similar ones recorded nearly forty years ago as occurring in syenite in my native region (see Hitchcock's *Geology of Massachusetts*, 1841, pp. 669 and 677-9), where syenite has more recently been found to contain fossil trilobites, strengthen my suspicion that

many if not all of the plutonic looking rocks of the Kamoikotan Group are in reality metamorphic.

The presence of the bits of black slate of course show that in any case the porphyry at the mines is newer than the slate that furnished the fragments ; yet the slate that is exposed between the main village and the mines would rather appear to lie in the form of a sharp, narrow basin running northeast and southwest with the porphyry of the mines underlying it conformably on the northwest. But the dips are nearly vertical and perhaps sometimes reversed ; so that the structure is a little doubtful.

The Ashio coppermines have been worked ever since 1610. They are in two groups, of which the main one at Idezawa and Akakura covers a space of half a league in diameter, and is a little over 2,500 feet above the sea, on the headwaters of three or four small valleys that descend from the Bizendate mountain as a central point, and is about a league north of Ashio village. The other group at Sunokobashi is much smaller and lies about half a league southerly from Bizendate in a small valley that empties into the Watarase River at Ashio village. The veins are perhaps fifty or more in number, and run generally northeast and southwest, though many are in other directions ; and the dip of the veins is said to be generally about vertical. The ore is almost wholly copper ore, mainly copper pyrites (with a very little black oxide of copper); but one mine is said to yield a little galena. The greatest width of ore is in the Oogiri mine, where I measured it at one point seven-tenths of a foot in width, and where for a length of about two fathoms it maintains a width of four-tenths of a foot, but then quickly becomes about one tenth of a foot or less, which is said to be the greatest width throughout the rest of the mine. The other mines are all inferior and only three of them are worked by the owner, though a score of miners work on

their own account some other veins that are said to be about half a tenth of a foot wide. The whole number of mines would seem to be about as large as the number of veins. They are all adits, very narrow, crooked and uneven ; some of them are up to 200 fathoms or more in length ; and in no case is there mining below natural drainage level.

Both blister copper (aradoo) is made with roasting in kilns and smelting in small hearths in the old Japanese style ; and blue vitriol is manufactured with roasting, leaching, boiling down and crystallizing. It was stated to me that in the eleven months ending with May, 1878, the ore smelted amounted to 313,000 lbs. (3,756 kamme); and that the ore (including one tenth of slag) from which the blue vitriol was made yielded about five per cent. of vitriol (and contained therefore about $1\frac{1}{4}$ per cent. of copper). Evidently by some error, however, it was stated (very precisely) that the amount of blister copper made in the last half of 1877 was 59,827 lbs. (44,870 catties), which would have been $41\frac{9}{10}$ per cent. of the ore smelted in the same time (143,917 lbs.), whereas pure copper pyrites contains only $34\frac{6}{10}$ per cent of copper ; and that in the first five months of 1878, the amount made was 48,800 lbs. (36,600 catties) which would have been $28\frac{7}{8}$ per cent. of the ore smelted in the same time, a result almost equally improbable. At the copper mines visited by me in 1877, (Osaruzawa, Ani, Yusenji, Kanabira), where the ore is similar to that of Ashio and the same methods of washing are followed, the yield of refined copper to the washed ore smelted does not vary much from twelve per cent. It seems therefore quite probable that the yield of blister copper at Ashio in the first five months of 1878, may have been only the half of what is stated above or at most 25,000 lbs. (3,000 kamme), about fourteen per cent. of the ore that was smelted. There are

also several circumstances that confirm such a low estimate, and show too that the amount of blue vitriol made was only about half what was stated, or about 3,333 lbs. (400 kamme instead of 777 kamme) a month. The blister copper was worth last summer (subtracting the cost of freight to Yokohama, fifty cents a picul) about fifteen dollars and a half a picul; and the blue vitriol about eight dollars and forty cents a picul. The income, then, for the first five months of 1878, after subtracting the outlay for fuel (which as near as could be ascertained was about \$1,150), appears to have been at the rate of about \$541 a month or \$6,500 a year; and that divided among 300 men which must apparently have been about the number of workers employed (in a population of probably 450) would give them an average of only \$1.80 a month.

Again, each miner is paid by the day in money twenty cents and in food the value of $6\frac{1}{5}$ cents; or in all $26\frac{1}{5}$ cents, and his tools are estimated to cost in addition six cents; making the whole day's work cost $32\frac{1}{5}$ cents, not counting powder and light and special rewards for good work. The carriers are paid in like manner the value of $16\frac{1}{5}$ cents a day. By the piece, as stated to me, ten dollars are paid in comparatively soft rock for cutting a length of five feet by four feet high and $2\frac{1}{2}$ to three feet wide, about a month's work: and in hard rock 20 dollars for the same space, about two month's work; and in addition the same food and tools (and probably powder and light) are supplied as in work by the day. The whole cost is therefore respectively at least \$13.66 and \$27.32, not counting the cost of carrying out the stuff mined. Supposing then the cost of dressing, roasting and smelting the ore to blister copper to be about six dollars and a half (about the average in the Chingoku, and apparently not far from the cost at Ashio in former years) leaving nine dollars as the value of a picul of copper in the ore; and even supposing no copper to be

lost in smelting ; it would need an average width of about one quarter of a foot of ore that is one-half pure copper pyrites (or somewhat richer ore than the average of washed ore at other Japanese copper mines) to pay expenses with the comparatively soft rock and cheap mining ; for there would be in the space under consideration (reckoning 250 lbs. of copper pyrites to the foot, and $133\frac{1}{3}$ lbs. to the picul) $5 \times 4 \times 0.25 \times \frac{1}{2} \times 250 \times 34\frac{6}{10} \times \frac{2}{100} \times 9 = 14.51$ dollars in value of copper ; and it would need a width of about half a foot of such ore to pay with the harder rock. There cannot in my opinion be the least pretense that a width of even a quarter of a foot would be maintained as an average of any large portion of the vein containing one-half its bulk of pure ore even in the Oogiri mine, much less in any of the others. It seems therefore quite sure that with present prices such thin veins in such hard rock cannot be worked with profit.

We returned to Nikkoo and set out for Aidzu, passing through Imaichi again, and Oogua and Takatoku (five leagues from Nikkoo) of the preceding year's journey ; and seeing near the ferry just short of Takatoku another outcrop of the quartz porphyry like that of the Ashio Pass. At Oogua we were told about some recent attempts to reopen the long abandoned Senoo copper mine in the neighboring village of Kobiyaku, and it appears that there had been found a width of about one or even up to $2\frac{1}{2}$ tenths of a foot of a mixture of copper pyrites, with some three times its own quantity of gangue that was partly kaolin ; and a specimen of the ore was shown us. It is not in the least probable that such a thin poor vein can be worked with any profit in the very hard rocks of that region. The next day, several leagues further on, a man brought us more specimens of the Senoo ore, and some of magnetic pyrites, of which he said there was a vein nine feet wide about a hundred fathoms from the copper mine.

At Takatoku we entered almost at once the mountains again, and kept on up the valley northward through Oohara and (without crossing the river to see a spring on the opposite shore at Takinoya in Takimura, which we heard of afterwards, as very hot, but without taste or smell and apparently very pure water) through Fujiwara (near which many holes for ore were dug about a hundred years ago), to Takahara, where we saw on the opposite river bank the Kawaji hot springs. The temperature of the main spring is 43°C. and the flow perhaps a cubic foot a second. There is much gas but, it would seem, no sulphur. There is another spring a few yards down stream with a temperature of 41°C. but only half as strong in quantity and with less gas; and one of rather warm water a few yards upstream of perhaps one tenth the yield of the main spring. At a spot called Koshiozawa about half a league from the village of Ikari, on our road half a dozen leagues north of Takahara, there is said to be high up the mountain a vein of copper ore, of which a good looking specimen was shown, perhaps one-half made up of copper pyrites; and another specimen was perhaps one-fifth copper pyrites and the rest bluish gray siliceous gangue. The country rock was described as white and very hard. A hole about three feet deep was dug there in 1872, and then temporarily abandoned. There are said to be two places at Ooshiosawa, a spot about five furlongs still further north, where there were old copper mines, adits about ten fathoms long abandoned a dozen years ago and now fallen in. It was said also that at Arayu in Shiobara, four leagues east-north-east of Ikari, there was a hot sulphur spring of abundant yield; and that there was limestone there.

From Takahara to Ikari there were many exposures of rock still of the Kamoikotan Group, chiefly quartz porphyry, often greenish gray in color weathering light

brown, but sometimes with a dark gray matrix ; sometimes with slightly rounded and somewhat angular fragments of blackish siliceous slate and pinkish quartzite, making it a pudding-stone ; sometimes syenitic or even a true syenite ; sometimes crumbling into gray or light brown sand ; sometimes forming high cliffs near the river or high up on the mountain side. Similar exposures were seen here and there for four leagues northward from Ikari as far as the mountain pass about 3,000 feet above the sea, near Yokogawa, the boundary of Aidzu ; sometimes with rather angular pebbles as large as the fist. Thence northerly down hill by a narrow valley through Itozawa to Kawashima, four leagues, there were similar rocks ; and then four leagues north-easterly with a rather more open country and fewer roadside exposures through Nakaarai and Tajima to Narahara, here and there like rocks were seen, and many of their pebbles found in the shingle of the rivers. From Narahara I crossed the river and went by the more difficult road past the Yunohara and Ashinomaki hot springs to Wakamatsu (ten leagues), the principal town of Aidzu (about 800 feet above the sea) ; while Mr. Adachi with the baggage went by the more commonly travelled road. From what he saw it would appear that only the same ancient crystalline rocks occur along that road. At the river crossing of Narahara there were exposures of light gray soft shaly sandrock, with nearly level dip, apparently of like age with the Toshihets Group of Yesso or the oil bearing rocks of Echigo. It would seem to be of very limited extent, confined to the lowermost part of the valley, near the river level. The other exposures along the road, pretty frequent all the way to within a couple of leagues of Wakamatsu, where the valley opened out into the beautiful, basin like, mountain circled plain of Aidzu, were of the same ancient character as before ; and chiefly greenish

gray, very hard quartz porphyry, though reddish brown and crumbling towards the edge of the plain ; but just above Yamoshima there was interstratified a light gray hard metamorphic shale, and at Oogawa, about midway, there was a black clayslate with imperfect cleavage. I take it that the mountain range between Shimodzuke and Aidzu is of anticlinal structure in the main; and the slate of Oogawa may perhaps correspond to that of Ashio.

The hot springs at Yunohara are at the edge of the river, and are two in number, besides another said to be of like character on the opposite shore. One of the two had a temperature of 45° C., and the other 62° ; and each a yield of perhaps twenty gallons a minute. The water seems to contain no sulphur ; has a very little gas ; and leaves a very slight, white, apparently calcareous deposit. Near Ashinomaki, some half a mile below the village, there are three springs in the river shingle, through which the water escapes ; and the temperatures are 43° , 43° and 41° C. There seems to be no sulphur in the water, and no taste to it ; but it forms a very slight deposit of white salt. On the opposite shore of the river is the Oyanoyu spring, said to be of about the same temperature. From Wakamatsu we visited the Higashiyama or Tenmeiji hot springs, the most celebrated of Aidzu, and distant about a league easterly, just inside the edge of the mountains, still apparently in the same ancient rocks, greenish gray and slightly decomposed. There are twelve springs besides four or five old ones that are now broken in, all within a length of a couple of hundred yards along a small river. The following are the names of the twelve and their temperature in Centigrade degrees, and the roughly estimated yield of some of them in gallons a minute : Oomiya, 60° , 82 gals. ; Arima, 59° , 60 gals. ; Yonekura, 59° , much ; Mukootaki, (temperature at end of pipe across the river) 57° ; Yadoya, 57° , 35 gals. ; Ana, 57° , 10 gals. ;

Sooyu, 57° ; Fujiya, 56° , 15 gals. ; Choojiya, 55° , little ; Kitsune, 54° , little ; Furutaki and Shintaki (two pipes from one spring), 47° ; Mujina, 40° , 12 gals. The water of all seems to be of about the same quality, without sulphur, taste, smell, gas nor deposit, except a slight, white one containing silica and carbonate of lime.

At Wakamatsu rainy weather enabled me to write and send back a report on the Ashio copper mines. Also we were consulted about the Ishigamori gold mines about a league distant to the east ; and some specimens of their ore were brought to us. The vein was carefully described as at one place 0.15 ft. wide for a length of about two fathoms, but in general only 0.01 ft. or 0.02 ft. wide, and not by any means averaging more than 0.05 ft. in width. The ore was red ferruginous cellular quartz ; part of which (a heap described as 0.2 ft. long) they had reduced to a red powder and washed, obtaining a small quantity of magnetic iron sand that formed a heap about 0.02 ft. long or perhaps one thousandth of the ore. In the magnetic sand there were two or three minute specks of gold, perhaps one thousandth of the little heap ; making the gold to be only one millionth of the bulk of the whole ore, or say one thousandth of one per cent. of its weight ; and certainly it can hardly be ten times as much as that or one hundredth of one per cent. There was also some tabular barite with the ore, and some granular gypsum containing a few minute crystals of copper pyrites. The country rock appears to be a greenish white, very hard quartz porphyry. Reckoning the cost of mining to be the same as at Ashio, one cubic foot or at most 125 lbs. (15 kamme), of ore, obtained from a space 5 ft. by 4 by 0.05, would cost for mining from \$13.66 to \$27.32 ; and even if its gold were one hundredth of one per cent., it would be worth only four dollars. It is very clear then that there would be no profit in working the vein. It is not sur-

prising therefore that the mines were abandoned about two hundred years ago ; and though they were reopened by the Ono Company a few years ago were quickly given up again.

We were consulted also in regard to a mine at Onogawa about eight leagues by road northerly from Wakamatsu, where an enthusiastic countryman had for about twenty years been digging an adit now 35 fathoms long, led on by a vein of "yellow shining stuff of the color of gold," perhaps iron pyrites; and at last had for nine feet been in a vein that was said to be ash colored with red spots, and that, as he averred, had yielded when smelted by him with lead a large proportion of silver. We advised his patron, who furnishes his capital, and who consulted us, to obtain if possible an impartial and trustworthy analysis of the ore from the Government Mining Office.

On starting forward from Wakamatsu I made an excursion to Tonokuchi at the mouth of the beautiful Inawashiro Lake (sometimes called Bandaiko), two leagues to the east and some 1,750 feet above the sea ; and near it found blocks, apparently not quite in place, of old volcanic, dark gray andesite, containing glassy triclinic feldspar (probably oligoclase), augite and magnetite in a dark gray matrix; and on the way near Yasubara, at the entrance to the hills, saw an exposure of very soft tufaceous light brown gravel in which there were egg size pebbles of grayish white, long fibred pumice containing glassy triclinic feldspar (probably oligoclase), augite and magnetite. From the road there are also views of Bandaisan, a high mountain some three leagues to the northwest of Wakamatsu, with its top often hid in clouds, evidently from its shape a volcanic mountain, and no doubt, the source of the rocks just described, as well as of the materials of the high plateau crossed near the lake, and most likely the cause of the lake's origin by damming up the former outlet of the portion of the valley now filled with water.

Then we went three leagues northerly through the plain to Shiogawa on the main outlet of Inawashiro Lake ; and thence three leagues and a half to the north-eastward I visited the saltwells of Ooshio, about 1,500 feet above the sea, and a couple of leagues within the edge of the hills again, near the flanks of Bandaisan. In the village of Ooshio the only rocks to be seen were perhaps not in place, though large ; and they were dark gray andesite again, very like that seen near Tonokuchi, and containing likewise glassy oligoclase, augite and magnetite. In the village street there are two warm salt springs about ten yards apart both curbed with wood, and dug deep it was said into the rocks just described. One, fifteen feet deep has a temperature of 39° C. and the other, said to be about twenty feet deep, marks 37° C., and both are yellowish red with a great deal of iron rust, of which there is a copious deposit ; and both are very gaseous with small bubbles. The yield of each is perhaps six gallons a minute. About a hundred yards to the north, in the very edge of the village, there were five small wells, some four to nine feet deep, four of which are still visible ; the deepest one with a temperature of 28° C. and the rest cold, but three of them at least mixed with surface water. The yield of salt water is also less than at the two main springs, and those that are mixed with other water are especially weak in salt and one of them is colorless : but the others are red with iron rust. A hundred yards or so southwest of the main springs there is a well about nine feet deep not very salt and with a small yield of water, a little gas and a little iron rust. No salt has been manufactured at Ooshio for half a dozen years past ; but before that, it was made, according to the villagers' statement, for a thousand years. It is known for a certainty to have been made for about 250 years. The water was allowed to stand a while, and, after the iron rust had deposited

itself, was boiled down ; and white salt of good taste was produced. One shoo of water, they say, yielded 12 momme ($\frac{1}{10}$ lb.), of salt, or about $2\frac{1}{2}$ per cent., somewhat less than sea water ; and for seven shoo (of 400 momme each), or nearly a peck and a half of salt thirty cubic feet (half a tana) of wood were burned, worth now $62\frac{1}{2}$ sen ; making the salt cost for fuel alone about nine cents a shoo, or nearly $2\frac{3}{4}$ cents a pound. Whereas on the sea shore of Akita, where it is made, the salt costs less than one cent a shoo. Of course, then, there can be no profit in making salt at Ooshio. The yearly product used to be about 800 piculs, and was made, in the five last months of the year. They told us that at Atsushio, four leagues southwesterly from Ooshio, and two from Kitakata there were about three springs, too hot to bear the hand in them, likewise red from iron rust, and yielding seven momme of salt to one shoo of water (about $1\frac{1}{2}$ per cent. in weight)

Then we went from Shiogawa through the alluvial plain a couple of leagues westerly to Bange ; and began there the ascent north-westward of the hills that separate the main valley of Aidzu from northern Echigo. On crossing the first low ridge (perhaps a thousand feet above the sea) and descending to Funato (a couple of leagues) we met with exposures of soft greenish-gray sandrock, sometimes weathered brown, apparently of like recent age with very similar rocks of the Echigo oil regions. Along the river at Funato and Katakado opposite, which drains all western Aidzu we found the pebbles apparently exclusively of Kamoikotan rocks, some of black slate and some of gray syenite. On the hill beyond we passed exposures again of the light gray or brown very soft sand rock, sometimes with level dip, sometimes beyond Tabane-matsu dipping as much as fifty degrees easterly or thirty degrees, north-westerly. Just short of the hamlet of

Karusawa (about four leagues from Bange) there were some pebbles in the rock, among others some bean size, rounded ones of obsidian containing small glassy feldspar crystals; and about a hundred yards beyond Karusawa, Mr. Adachi found some imperfect fossil shells in dark brown shales among the soft sand rock beds. For a league or so beyond that, past Shitatani, there were many exposures of a soft, somewhat fine grained, pale, but rather bright, green sandrock, weathering red on cliffs, probably of like age. Thence onward to the Kuruma pass (about seven leagues from Bange) exposures were fewer, and were of greenish gray very soft sand rock like that seen before. At the pass (perhaps 1,000 feet above the sea) there were exposures of crumbling granite with a strike of north 10° east and a dip of 85° easterly; and they continued some hundreds of yards on the further slope with nearly vertical westerly dips. Then light, bright green soft sand rock recurred (near Hoosaka) with a strike of north 35° east and a northwesterly dip of 45° ; and a little further on with level dips; and with numerous exposures as far as to the Echigo boundary line on the Torii pass (also perhaps 1,000 feet above the sea). Thence going over the Fukutori pass (perhaps 1,250 feet above the sea at the end of Sakoozan, the mountain on our right, we went down to Tsugawa on the Aga River the outlet of the Inawashiro Lake, passing in our descent many exposures of red crumbling granite, that contained dark red feldspar, white feldspar, quartz and black mica without hornblende. In it there were, at one place at least, rounded pebbles of fist size of dark green and dark red quartzite. There were by the road side also many blocks of a gray granite with white feldspar, quartz and black mica. Shortly before reaching Tsugawa we found at the ferry of the Tokonomi River, a considerable stream from the southwest, only pebbles of Kamoikotan rocks, gray granite, black slate, and brown sand.

At Tsugawa they told us about some of the mines in the neighborhood. At Kusakura in Kanose village, three leagues to the northeast are the principal mines of all Aidzu (for this part of Echigo was formerly under the Prince of Aidzu); and are said to yield \$30,000 in value of copper yearly. There is perhaps only one vein, though there are 19 mines. The width of the ore in the vein is commonly about a quarter of a foot, but widens in one place to about three feet. A specimen of the ore shown was about two thirds copper pyrites and one third iron pyrites, covered with rust; and no gangue was visible except traces of quartz. They were expecting soon to finish a new, low drainage level, called the Oogiri, and were working on it in two hour shifts. The whole number of workmen employed at the mines, including charcoal burners, is 500. [Fuller information gathered by Messrs. Kuwada and Nishiyama will be given in a report to be appended hereto.]

At Kujiuro Hadate, in Yazawa village, two leagues west from Tsugawa, there is a silver mine, worked since 1875; and said to yield from sixty to eighty momme of silver to three kamme of ore (two or three tenths of one per cent.)

From Tsugawa we went down the river by boat nine leagues (as it was called) to Kasujima, just below Bunda of our journeys of the two preceding years. The river for the upper half of the way ran in a very crooked, rapid course among high, rocky hills and mountains; and the rocks were all of the Kamoikotan Series. They were chiefly gray or red and brown, probably granitic, partly crumbling; but about a league below Tsugawa there were exposures of gray and white limestone. About a mile, however, north of Kiyogawa, a village on the right bank a few hundred yards below Tsugawa, there are two coal places visited later in the season by Messrs. Kuwada and

Nishiyama. The places are a quarter of a mile apart ; and the coal appears to be but one bed ; and is only about a quarter of a foot thick, unworkable of course. About a league distant there is said to be another like exposure of coal, perhaps the same bed. The coal is black and shining , and undoubtedly of like age with that of Akadani only a few leagues distant to the north, and, though occurring in small basins in Kamoikotan rocks, is probably a part of the neighboring oil bearing formation. Just after coming out of the mountains into the great Echigo alluvial plain we passed a small village called Kusoodzu, where Messrs. Kuwada and Nishiyama visited a spot that has a little smell of oil in the gravel ; but it is evidently nothing of importance.

From Kasujima it was but a league or so to Suibara, and thence by the same road as in former years we went northward to the little oil field of Kurokawa ; where Messrs. Kuwada and Nishiyama were surveying, and where we spent a couple of days together in office work on the geology of their map. But as the rainy weather had already delayed us beyond the first of July when we had hoped to complete our accounts for the preceding fiscal year, we hastened southward again, by roads we had already travelled two three times, through Niitsu (where we passed a night with Messrs. Inagaki and S. Maeda near their survey) to Kusoodzu and Dooyama in the Idzumozaiki region. There the assistants all joined us, and after the accounts were completed, I spent about three weeks in working out so far as possible the geology of the maps with their aid ; and gave them instructions in regard to their surveying for the rest of the season. Then in the middle of August Mr. Adachi and I resumed our journey and travelled rapidly southwestward mainly over roads already traversed but partly by sea, through southern Echigo, Etchin, Kaga and Echizen to Imajoo, near the northern line of Wakasa.

From Imajoo we went southwesterly seven leagues to Tsuruga, the well sheltered, large harbour (with a sandy bottom) on the north-west sea shore over against Lake Biwa; and on the way saw exposures of Kamoikotan rocks only; the first third of the way black slate and brown or gray weathered shales; then for some hundreds of yards gray syenite, weathering brown, and crumbling to a brown sand, near a mountain pass about 1,900 feet above the sea. Thence descending to Tsuruga there were very few rock exposures, but two or three of dark gray shales and black slates.

I did not get many good dips; but suppose the slate and shales to overlie the syenite on either side of the ridge. On the way we were given a couple of egg size pieces of very hard, compact, pure looking magnetite, parts of rounded and polished pebbles that had been found by a charcoal burner in digging for a place for a charcoal kiln in the mountain about a league east of Shimboo (a village about midway on our road) and over a league westerly from Itatori, a village on the road of the preceding year between Imajoo and Nakanokawachi; and in the lands of Itatori. On the eastern shore of Tsuruga harbor some hundreds of yards north of the town there are gray exposures of Kamoikotan limestone, that is burnt for lime. On the west of the harbor there were brown earthy exposures, as if from Kamoikotan shales.

From Tsuruga we went seven leagues south westward to Mikata, in Wakasa, through a moderately rough country, mostly pretty low, with some large alluvial flats, and with the sea near by on our right and hills perhaps 800 feet high near our left. There were only few rock exposures, but about midway there were some of dark brown and dark gray shales sometimes with pebbles, and of black slate, and grayish brown quartzite all belonging to the Kamoikotan group. Here

and there elsewhere there were exposures of brown earth apparently likewise on the outcrop of Kamoikotan shales. At Mikata they told us about the mica that was gathered formerly on the hill a quarter of a mile east of village. It was found in the loose earth and was of a silvery or golden color in spangles an eighth or a sixteenth of an inch broad. In the rock there was a vein of mica, but it was black. The mica was separated from the earth by a common grain-fanning machine ; and was used for ornamenting wall paper. The working of the place was begun thirty years or more ago, and was profitable under the daimiate ; but of late years became gradually less so, until it was abandoned a couple of years ago after heavy losses.

From Mikata we went seven leagues first southerly then westerly, to Obama on the sea shore again ; passing through a country much like that of the day before, and seeing but few rock exposures. Those few were chiefly about midway and near Obama ; and were still all of Kamoikotan rocks, dark brown quartzite, brown and reddish brown hard shales and gray quartzite ; and there were some exposures of the brown earth that the shales form in decomposing. At Oniu, a league and a half short of Obama, they are skilled in cutting small ornaments out of carnelian and chalcedony that they import from Tonamigoori in Etchui. They say that limestone is worked near Oniu, at Kooya village and Konotani in Nigoridani.

From Obama about four leagues westerly took us through a like country of low hills and in great part along the sea shore to Hongoo ; and on the way we saw many exposures of the Kamoikotan hard shales, brown, dark brown, greenish gray, gray and bright red, and a few of gray quartzite weathering brown, and many of the brown earth that results from the decomposition of the shales.

At Hongoo they told us of the Nojiri copper mines, about two miles to the south-west. The ore vein or veins was called eight fathoms in width (perhaps length was meant), but the ore was said to be very little. The ore was yellow (copper pyrites), but partly black (probably oxide of copper). The mines, anciently worked for a long time, were abandoned for about a hundred years, until 1831, when they were taken up again and worked for about ten years and abandoned again as not paying. In February, 1878, the farmers began a little once more to try to work them, but had not fairly got under weigh when we passed ; and an Oosaka man has a mining lease adjoining, but is not working it now. It is an instance of the way in which the hopefulness of men lead them again and again to take up unprofitable old mines. Charcoal for smelting costs three or four cents a kamme ($8\frac{1}{2}$ lbs.) ; but common charcoal only about two cents. The mine water was complained of as killing the rice growing in the fields. About a mile southwest of Hongoo some copper furnaces were at work smelting old slag, which was said to yield seven or eight per cent. of copper, and sometimes ten.

From Hongoo to Takahama, on the sea shore it was two leagues westerly, over the same low hilly country ; and there were like exposures again of the Kamoikotan shales and quartzite and of the brown earth far and near on the hill sides. The next six leagues westerly as far as Maedzuru, in Tango, were of the same character too ; and still the same for three leagues beyond that north-westerly, as far as Yura, on the sea shore.

At Maedzuru they showed us close to the Keirenji temple some small copper mines that were begun in the summer of 1875 and abandoned the next year. There were two adits called fifteen fathoms and six fathoms long ; and there were said to be two more, high above on

the hill, all perhaps on the same vein. There is no ore visible now at the drift, but some from the old workings, was shown ; and that from the lower adits proved to be mainly white iron pyrites (marcasite) with little more than traces of copper pyrites, though in one piece of the ore there was a mass of copper pyrites as large as a bean. Such very poor ore is said to have been 0.8 foot wide at the end of the longer drift. The ore shown from the upper holes was an impure looking brown hematite dark and blackish, said to fill the whole width of a wide exposure of rock and to have many spots of what would appear to be iron pyrites. The country rock is the Kamoikotan hard shales, weathered dark brown. The vein seems to have a strike of south 60° west and a dip of about 70° southeasterly. The vein is clearly quite unworkable.

From Yura I went by boat along the sea shore a league and a half eastward to the Kanazaki copper mines at the end of a wild, rocky promontory in Shirasugi village. The country rock is a very hard blackish Kamoikotan quartzite. The vein or rather two veins or layers are only one-fifth of a foot in width each, separated by about a foot of irregular stone, and appear not to be one-tenth made up of copper pyrites, which is merely sprinkled through marcasite. There is also a parallel vein (or probably a layer of the same vein) of marcasite called six feet thick, about five feet southeasterly from the copper pyrites ; and in the quartz of the five feet there is also some marcasite. The vein is vertical, and has a strike of about south 45° west. The ore was first dug a little under the daimiate, about 1865 ; but the actual mining was done wholly in 1877 ; and then there were only about ten miners. There are three adits about 25 fathoms long, all connected under ground. About 50,000 lbs. (6,000 kamme) of ore in all were obtained. In 1878, it was

roasted once, about 1,500 kamme at a time, for seven days, kindling, at the outset with 50 kamme of wood. The roasted ore was leached; the copper precipitated by old iron (hoes and the like), that costs ten cents the kamme; and the liquor was afterwards boiled down in iron pots, (sometimes lined with lime), and green vitriol crystals were formed. For the boiling 50 kamme of wood were burned for one picul of green vitriol, or about three to one in weight; but wood costs only from three to four cents for ten kamme. Charcoal costs ten cents for ten kamme. About 80 piculs of green vitriol were made, worth two dollars a picul at Kiyooto; and costing a quarter of dollar a picul for carriage by sea to Oosaka or thrice that by land. Of the precipitated copper about 30 kamme were made, or one twentieth of one per cent. of the ore; and it was worth a dollar a kamme at Oosaka. It is very plain that such thin veins of such poor copper ore in such hard rock cannot be worked profitably; and that for the green vitriol, even the cost of fuel, cheap as it is, (not counting that of mining) is as much as the value of the vitriol at the works.

We were shown there a specimen of ore from the Nobara lead mines, three leagues distant to the northwest, worked about twenty years ago, and abandoned after three years trial. The ore shown contained a little galena and still far less copper pyrites sprinkled through dark brown zinc blende. Only lead was made there.

The Kanazaki mines are at the outlet of a small bay or a harbor that extends to Maedzuru with a depth, it is said, of twelve or thirteen hiro of five feet each, with a mud bottom or mud and sand. It is said that most of the harbors along here have sandy bottoms; but that the one at Miyadzu has a mud bottom and is still deeper than that of Maedzuru.

From Yura we went by land to Miyadzu (three lea-

gues) over a very hilly road. The rocks were almost wholly a crumbling gray, or light granite, in great part very soft but with many harder layers showing the dip clearly in very large bare exposures over the hillsides. Where the rock was unexposed the brown granitic sand in the road betrayed its presence everywhere. The strike was north 60° east, and the dip was nearly or quite vertical; sometimes eighty degrees one way or the other, as if the ridge just northwest of Yura were of anticlinal structure, with the shales therefore overlying the granite. Somewhat less than half way, there was an example of the hard rich brown shales, about six feet thick and exposed for a length of about 20 feet, imbedded conformably in the light brown granite, pointing very markedly to the sedimentary origin of the granite too. The very clear, regular and rather thin bedding of the granite just as seen the year before very strikingly in Mino also tends to show the same thing. The broken character of the outline of the seashore from Tsuruga to Miyadzu, with many small bays and promontories, so unlike the coast for a long distance on either side, and indeed generally throughout the greater part of Japan, is very noticeable; and I take it to be due to the presence of the Kamoikotan shales and crumbling granite, in general easily worn away but with many harder portions between. The whole space is in the main a shallow indentation or a bay. As the waves of the sea alone would not so eat into the coast, the effect was probably produced sub-aerially at some former time of greater elevation of the land above sea level. The headlands and hills, and the bays and valleys trend in general northeast and southwest, in accordance with the strike of the rocks.

At Miyadzu they showed us (as they had also done at the Kanazaki mines) small fragments of dark gray or brownish hard shale with imperfect fossil leaves like

those of a conifer, somewhat like a yew for example ; and one small piece of light gray hard shale with very imperfect fossil net veined leaves. They are picked up it is said on the sea shore near Miyadzu at a place called Hioki, near the long narrow spit with pine trees celebrated as the main feature of one of the three most famous landscape views of Japan and called the Heavenly Ladder (Ama no Hashidate), because from the neighboring mountain pass the sea is prettily seen between the tree trunks as if between the rounds of a ladder. The stones with fossils have perhaps been brought down by a river from a little distance in the interior or many have come from rocks concealed just beneath the sea ; and are probably of somewhat similar age with the Toshibets Group. They are called tenkiyoo shibaishi ; and are said to be sold sometimes as curiosities at the tea house of the mountain pass.

From Miyadzu however twelve leagues and a half westward to Toyooka, in Tajima, through a country of moderately high hills, we saw no signs of any such recent rocks, but found numerous exposures of crumbling light brown, sometimes reddish gray granite, containing a great deal of black mica and very little, if any, hornblende. There were also many exposures of the light brown sand into which the rock crumbles. About half way, at the pass about 400 feet high between Masudome and Nonaka, there was a case where a layer about a foot thick of the reddish gray crumbling granite was enclosed between two beds of brown shales, in all an exposure of some ten feet in thickness. The strike there had changed to nearly east and west, and the dip was 70° north 5° east. A few hundred yards short of that place the crumbling brown granite appeared partly to pass into a fine pebble rock. About three quarters of the way, just beyond Kumihama there were a few exposures of Kamoikotan hard brown

shales near brown granitic exposures on either side though not visibly in contact with them.

Toyooka is on a pretty large river some three or four leagues above its mouth. We turned southward up the valley, and went fourteen leagues to the Ikuno mines in the very southernmost corner of the province. At first we were in an alluvial plain of moderate width, and saw no rocks ; but on a hillside near Midzumoo beyond Sano and perhaps a league and a half from Toyooka we saw a few exposures of a Kamoikotan brown pudding rock containing pebbles, mostly of egg size or less but some of them up to half a foot or a foot in diameter, of very hard greenish gray quartz porphyry, but none of syenite nor black slate ; in a matrix of brown metamorphic grit. A couple of leagues further on, beyond Ebara, there were exposures of reddish and greenish gray serpentine very impure with calcite that permeates its mass and forms here and there small white grains and crystals ; together with also some very minute yellow grains of pyrites. Half a league further on, near Oda there were a couple of exposures of hard brown and greenish Kamoi-kotan shales ; and similar exposures occurred here and there for a two or three leagues to Yabu. Then there were several exposures of light gray, and light brown, hard quartz porphyry probably, and on the neighboring hillsides numerous large exposures of brown crumbling granitic (or porphyritic) sand. From Nishibirata (two or three leagues further on) there were a number more of exposures of porphyry, that continued here and there with the brown crumbling form of probably the same rock for three or four leagues. Then from Yamaguchi the remaining league and a half to Ikuno town there were several exposures of very hard oligoclase quartz porphyry with minute grains of magnetite. Half a mile short of Ikuno we crossed the dividing ridge between the Japan Sea and the

Pacific Ocean, by a pass some 1,150 feet above the sea and some fifty feet above the town and furnaces. From the town of Ikuno to the furnaces and silver mines it is about half a mile eastward, up the valley ; and on the road just below the mines there is exposed a green oligoclase quartz porphyry, containing chlorite and minute cubes of pyrites but no visible quartz grains ; and it is said to be the same as the country rock of the silver veins. The chlorite appears to have been altered from hornblende, though the form is generally a little indistinct. The oligoclase crystals are of the same color as the matrix. The whole rock has perhaps been somewhat altered by the infiltration of magnesian waters, just as the neighboring serpentines have probably been to a still greater degree. For half a league easterly up the narrow valley to the Kanagase copper mines there are exposures of similar rocks ; and at those mines there is like porphyry but much more visibly quartzose. In the mines there is also much dark gray serpentine that is very calcitic, partly invisibly so but partly in thin white seams ; and there is a reddish and greenish dark gray impure serpentine containing quartz grains and probably invisible quartz, and thin white seams and small grains of calcite, apparently an intermediate stage in the transition from quartz porphyry to serpentine. It is possible that the magnesian waters that effected the change rose from below through the fissures that are now filled by the veins ; and that, as the veins are most numerous at Kanagase, the change there has consequently been more complete than at the silver mines ; but perhaps an original difference in the composition of the rocks was favorable to the change. At Hiroku, a spot a league and a half northeasterly from the furnaces, gray steatite is said to be found in a bed nine or ten feet thick.

At the silver mines, within a mile in length and a third of mile in breadth, from the mountain Kiseizan on

the west through Taseizan and Tenjoozan to Seetokuzan on the east, there are three principal veins : the Tasei (said to be from three feet up to 20 feet in width or even more and to average ten feet) and the Kiusei (some seven feet wide), both running about west northwest and east-southeast, and long ago pretty much worked out above water level ; and a little further east the Kikusei, (about ten feet wide), more nearly northwest and southeast in its course, and hitherto not much worked and chiefly known on the surface. There are, it is said, many other small and poor veins of unknown number. The Tasei vein dips, for example, at the main shaft 60° north 20° west. The ore is black sulphuret of silver (stephanite), sprinkled through white quartz gangue. There is also sometimes copper pyrites and iron pyrites. There is with the silver about double its value in gold ; so that really these are gold mines rather than silver ones ; though the gold is said to have been neglected formerly.

The mines according to tradition are 1,200 years old, but have been worked especially since the time of Taikoo, three hundred years ago, and were still flourishing a hundred years ago. But gradually the ore above water level became exhausted, and the mines were one after another abandoned. About ten years ago, the government took them up, and has since been working them. The principal workings have been in the Tasei vein on a shoot or deposit of ore that appears to be on the whole about circular in shape in the plane of the vein. It had at water level about its greatest horizontal length, 600 feet ; at the next level (131 feet lower) it was 450 feet long ; at the third level (131 feet still lower) its length at the time of our visit was not yet known, but appeared to be much less, and so far only about thirty feet of "good ore" (fourth class ; that is, yielding about $5\frac{1}{2}$ hundredths of one per cent. in silver and $1\frac{1}{8}$ hundredths of one per cent.

in gold) had been found ; and it was feared that on the fourth level (which had not yet reached the shoot) there would be no ore to speak of. The other shoots and veins had not yet been found to be of much importance. The mines are worked in foreign style under the guidance of Europeans ; and the narrow irregular galleries of old times are no longer driven, but wide and high ones with iron rail tracks. The mines are of course pumped, but the amount of water seems to be small.

The ore dressing works and furnaces are close by the silver mines ; and are conveniently arranged in fine large brick buildings. There are 75 wet stamps and 25 dry ones, of 5 cwt, each ; 28 shaking tables (18 fine and 10 coarse) ; 4 roasting furnaces each 75 feet long by 10 feet wide, with twelve doors and two fires ; and there are 32 Freiberg amalgamation revolving barrels. There are several turbine water wheels and a number of steam engines. The works including those of the mines, here and at Kanagase, are said to have cost over a million dollars.

At the Kanagase copper mines there is a steam pumping engine inside the mines but no furnaces or other costly works. But there has been a good deal of exploratory mining done in the last half dozen years with the result that the old miners are now known to have pretty thoroughly worked out the ore down to water level ; and now explorations have been begun 160 feet lower down. The veins are numerous. The ore is chiefly copper pyrites containing a little silver ; and there is a little galena ; but there is not yet any yield of ore to speak of.

The product of the gold and silver works for the year ending 30 June, 1878, was about \$234,000 (subtracting the cost of separating the two metals afterwards at Oosaka, about \$7,000) ; and the running expenses (without interest or amortisation) were about \$180,000. The

ore mined was about six-sevenths of the amount smelted, the other seventh having been left over from the preceding year. All but about a seventieth of the ore is of the fourth class ; and the ore smelted in the first half of 1878, yielded on the average about \$56 to the ton, of which about \$36.50 were gold and \$19.50 silver ; and \$1.60 the cost of separating the two metals. The whole number of men employed (exclusive of the Kanagase mines) is about 965, including about forty officials, 321 men at the furnaces, and 604 at the mines. The miners are paid from \$20 to \$60, averaging \$40, for a length of ten feet along the vein by a width of say ten feet and a height of six feet, including the powder which is nearly one-fourth of the whole expense ; and each miner earns about \$6.50 a month. Fuel costs : wood (matsu), for the roasting furnaces, \$3.50 a cubic fathom ; coal (from Miike) for the steam engines, about \$5.00 a ton, delivered at the furnaces (it was said). The carriage of coal from the shore of the Inland Sea at Shikama to the mines, twelve leagues, used to cost \$17 a ton ; but costs now only two dollars, over the excellent new road that has been built there—a fine illustration of the immense saving that would be effected all over the country by the building of good roads.

From Ikuno we went back by the Toyooka road again ; but at the village of Namba, about nine leagues from Ikuno, we turned westward through Yooka, about a quarter of a league distant up the valley of the Yae River. In less than a league beyond there were exposures of brown and gray shales between the villages of Konigi and Takayanagi, with dips of 25° and 75° , both north 30° west, forming a basin with one dip reversed. Just beyond the town of Yagi (a league and a half from Yooka) there were exposures of dark green and dark brown calcitic serpentine, similar to that of the Toyooka

road. About a league further on near the small village of Makuri there were exposures of a puddingstone weathered dark brown with pebbles up to egg size, and dark green and blackish shales weathering brown. Close beyond began exposures of dark green serpentine weathering light gray ; and it was exposed in many places, to half a league past Sekinomiya (three leagues from Yooka), where began more steeply the ascent north-westward of the now narrow valley to a high mountain pass. The serpentine is well known throughout the region and is used for very handsome tombstones. It is called Onjakuishi because small pieces of it are heated in the fire and carried by old men in the bosom for warmth. Then began exposures of a dark green pebble rock with pebbles up to egg size of black slate, granite, gray quartzite and green feldspar, but none of serpentine ; and like exposures were seen for about a quarter of a league. Then for another quarter of a league there were exposures of a very hard, gray (brown weathering) Kamoikotan grit, at first coarse but further on finer, that contained imperfect fossil shells, the only fossils that I have met with in that rock, but they were unfortunately extremely difficult to cut out. They are probably quite too imperfect for determination. Some of them are portions of a long (up to a third of a foot) slightly tapering slightly curved univalve somewhat of the shape of the toxoceras, but perhaps a cyrtoceras or allied to the orthoceras though I cannot detect the siphuncle ; and there is also at least one very imperfect bivalve, possibly an area. A few score yards further on there was exposed a pebble rock with bean size pebbles of quartzite. Then a few yards beyond, there began exposures of black slate, which continued here and there across the Yao Valley Pass, close by, (about 1,700 feet above the sea) and northward to near Muraoka, (three leagues and a half from Sekinomiya), in many places

weathering brown and gray or associated with dark brown shales. In one place about five feet of them overlay a decomposing quartz porphyry and underlay about five feet of a blackish nodular ferruginous limestone. Then there was an exposure of a pea pebble rock weathered brown, lying with a gentle south-south-easterly dip between blackish slate above and below. The true dips generally from Yooka to Muraoka are probably south-south-easterly and north-north-westerly ; but there are cleavages that mislead.

It is said that at Nakaze near Sekinomiya there is an old abandoned copper mine that the government thinks of re-opening ; and one of the Ikuno foreigners had gone to look at the place a short time before we came along. Also at a league south-east of Takai, a small village we passed half a league south of Muraoka, there are said to be very old abandoned gold mines. Likewise at Ushirodani, in Ootani village, a league and a half south-westerly from Muraoka there is said to be a gold mine that was worked about five months in the spring and summer of 1877 ; and some poor looking specimens of its unwashed and washed ore were shown us, without any visible gold.

On our road northerly from Muraoka the black slates occurred again with gentle south-south-easterly dips ; and within half a mile or so, among them and conformably underlying one exposure of them with a dip about level there was an exposure of some seven feet in thickness of very hard gray fine pebble rock or coarse grit slightly calcareous, which contained fragments of bivalve and other fossils like those seen in the upper part of the Yae valley ; but it was impossible of get any of them out. Then for a couple of hundred yards there were more exposures of black slate with gentle south-south-easterly dips ; followed by one (with like dip) of about six feet of green sand rock with a few bean size pebbles of black slate and of whitish

quartz underlying about twenty feet of egg size pebble rock. Thence north-westward across the Maruni Pass (some 1,100 feet above the sea) and the Haruki Pass, (some 1,700 feet above the sea) to Yumura (four leagues and a half from Muraoka) there were here and there exposures of the same gray (or light brown weathered) Kamoikotan pebble rock with pebbles up to fist size, and even head size, and of greenish brown weathered hard sand rock, and sometimes brown shaly sand rock, and a little of gray shales. At the village of Otaosa, a mile or so short of Yumura, in brown weathered, hard sand rock there were fossils again like those already mentioned.

At Yumura there are two hot springs ; one close by the bath house, covered up, but with a temperature of 91° at the outlet, a couple of feet distant, and a yield of perhaps fifty gallons a minute. According to an analysis said to have been made by some foreigner at Kiyooto, about 1868, the water would appear to contain four fifths of one per cent, of mineral substances, of which nearly half was carbonate of lime, about one third was chloride of sodium, about one thirteenth was chloride of magnesium, and the rest showed traces of silica, alumina and magnesia. The other spring, at a level some ten feet lower, issues from the rock by the river side within a space of some ten feet in diameter and has a temperature of 95° with gas and with a yield of perhaps five cubic feet ($37\frac{1}{2}$ gallons) a second. The hot water is used by the villagers for cooking, for steeping hemp and the like ; and occasionally one of them unfortunately falls in and is scalded to death, as happened about the time of our visit. The rock is a brown weathered hard quartzite, apparently of the Kamoikotan series, broken up into small fragments by cross seams, in some parts looking like a head size pebble rock. The dip was 45° north-west.

There are however volcanic rocks at no great distance,

for we were shown a small nut size bit of obsidian, that was said to come from a mass six feet long at Kaneo village, about a league to the south-west. They showed us also a specimen of a bright pink, or flesh red, soft fuller's earth, and one of greenish gray color, from a place called Inago in Yumura. It is said to be used as soap by the villagers.

From Yumura a couple of miles northerly to Takeda there were still exposures of coarse pebble rock and of yellowish brown hard shaly sand rock; but then the road turned westerly and there were exposures of brown crumbling granite and of reddish gray granite, to the Kamoo Pass, the boundary between Tajima and Inaba (some 1,200 feet high). Just beyond the pass there were bits of black slate again. Thence northerly a couple of leagues to Iwai there were a few exposures of greenish gray (brown weathering) shaly looking rock.

At about half a league from Kamoo village and a league from Iwai to the left of our road it is said there is an old silver mine, that is supposed to have been worked three hundred years ago, but was long abandoned. It was taken up again about 1865, and worked less than a year and abandoned again, "because they did not get to the rich part of the vein;" but the ore yielded some silver. On the road from Kamoo to the silver mine there was a copper mine worked for about three years, about 1865; but it was abandoned, probably because it did not pay. At Nagatani, nearly a league from Iwai towards the sea coast of Tajima, it is said there are fossil leaves resembling grass in a very hard black stone, too fine-grained or free from grain to serve for inkstones and probably quartzite, and some specimens were sent to the Home Department in 1877.

At Iwai (five leagues from Yumura) there are seven hot springs within a space of some fifteen yards in length.

Their names and temperatures are the following : Kabu and Ichi or Goten (two separate baths over one spring) 57° ; Nakai, 47° ; Kojoroo, 47° ; Miyada Yachiroo, 47° ; Maeda Tokue, 46° ; Itoo Esaburoo, 46° ; Yamada Jiuzoo, $45\frac{1}{2}^{\circ}$. The quantity yielded by them is not visible in any case. The Kabu and the Yamada springs have much gas in large bubbles ; the Itoo has none. In other respects the water of them all would seem to be of the same quality, and not to be sulphurous, and to leave little or no deposit.

From Iwai a couple of leagues north-westerly to Hosokawa on the sea shore there were many exposures of brown crumbling granite and granitic sand ; with one of greenish gray and greenish brown pebble rock just short of Hosokawa, and, close by, one of blackish brown shales between light brown shales. From Hosokawa the road ran along the soft sandy sea beach for about a league westward passing a rocky island a short distance off, and with sand covered hills of a hundred feet or more in height just inland ; one of them however with gray cliffs. Then the road turned south-westward away from the sea, and crossing the sand hill, past an exposure of brown crumbling granite, at length in half a league reached firm ground near the village of Hamasaka. Thence another league southerly with low hills and exposures here and there of brown crumbling granite on our left and a small river and a rather wide alluvial plain on our right brought us to the large town of Tottori. The country all the way from Ikuno to Hosokawa had been very mountainous.

At Tottori we were shown some mineral specimens, but none of any value. There was some brown impure looking lignite that came from Dooji, Yamada and Imodani in Shimoaji village, Takakusagoori. There was also some so called copper ore, that was iron pyrites with mere traces of copper pyrites ; and some that had only small cubical

crystals of iron pyrites. A large quartz crystal was shown, nine tenths of a foot in thickness, but full of flaws ; and it came from Hinogoori in Hooki, probably from granite, as is the case with the Kai crystals.

From Tottori we went westerly a couple of leagues through the plain past a pretty large lake and over some sand hills to the sea beach at the village of Uchiumi, opposite a small island a few hundred yards off with vertical rocky sides, no doubt of the same volcanic rock of which exposures began here to occur along the road. It was a New Volcanic tufa pebble rock with pebbles of head size, or sometimes up to three feet in diameter, of an Old Volcanic, andesite, containing glassy triclinic feldspar (probably oligoclase), decomposing augite and magnetite in a grayish, sometimes brownish, green decomposing matrix. Numerous exposures of the same rock with the pebbles sometimes with a gray or reddish gray matrix and sometimes imbedded in abundant level bedded, very soft gray tufa sand rock (sometimes a scarcely coherent volcanic ash), were seen on the road all the way west to near Yonago in Hooki (23 leagues from Tottori) ; and came, of course, from the fine conical extinct volcano Daisen on our left. At first there were here and there also a few exposures of brown, hard, apparently Kamoikotan, shales or of bright brown quartz porphyry, both with south-easterly dips ; and at the village of Hamamura there was one of gray crumbling granitic rock ; and further on again a few of red and brown shales with north-westerly dip ; but after the first half dozen leagues from Tottori such exposures were scarcely to be seen at all. The andesite pebbles, though once, near Suwamura, with a fresh and firm, reddish and greenish matrix (containing there a dark brown mica besides the oligoclase and augite), were generally soft and partially decomposed, and in decomposing produced a slippery

clay that was very noticeable in the hilly road in wet weather. The road passed along the sea coast sometimes over a beach of loose sand, sometimes crossing low hills, sometimes going a little inland or behind the sand hillocks near the shore.

Near Yonago, and from it three leagues westerly over low hills around the south-eastern end of the large bay called Nakaumi to Yasugi in Idzumo there were numerous exposures of somewhat crumbling gray and light brown oligoclase quartz porphyry, containing decomposing gray triclinic feldspar (probably oligoclase) crystals and a little dark brown mica. From Yasugi I made an excursion a couple of leagues southward to the town of Mori and back. The road lay along the bank of a broad shallow river in an alluvial flat, wide at first but growing narrower upstream to Mori, nearly in the edge of the mountains. At one or two points where the road touched the hills, there were exposures of rock similar to those seen near Yonago and Yasugi. Mr. Adachi, who is a native of Mori, says that the rocks further upstream are a crumbling granite and a hard greenish gray rock that would appear to be quartz porphyry. The river bed below Mori shows much of the reddish granitic sand. Mr. Adachi went by a short road from Yonago across the hills to Mori, and passed one of two recent trial holes dug for so called copper ore at Shinuto in Okanoshoo village, about two leagues from Yonago. The ore would seem to occur in the quartz porphyry and to be chiefly iron pyrites, though a little copper pyrites is said to have been found.

From Yasugi we went half a dozen leagues north-westerly by a nearly level road near the shore of the Nakaumi on our right and with hills on our left that become high mountains at a short distance. Within a league of Yasugi we passed, near the village of Arashima,

exposures and quarries of a soft, light gray and brown mottled tufa, sometimes light gray, mottled with white. The rock, especially in the light gray portions, looks somewhat like decomposing pumice, almost clay like, and contains minute octahedral crystals of iron pyrites, and here and there traces of glassy feldspar. The rock is so soft as to be easily cut, even with the fingernail; and is found a durable stone under water, but not able to bear the frost well. Onward for a short distance from Shimoitoo, a couple of leagues from Yasugi there were exposures of soft greenish gray shaly sand rock, weathering brown, probably a portion of the rocks associated with the coal bed found further on and near Matsue, and most likely of about the same age as the Echigo coal and oil bearing rocks. Then, although we went past some low hills a league or two further on, we saw no more rock exposures; and the rest of the way was through an alluvial plain.

I visited the Adakae copper mines inside the edge of the mountains half a league south-westerly from Adakae village, which was on the main road a couple of leagues short of Matsue. The mines are all near together within a space of less than a mile in length; and are owned by the following six companies. Hoomanzan (the principal mines), Ushironotani, Hidokaze (very small), Takegatawa (very small), Iwazaka (idle), Bisshookosai (idle). The mines of the Hoomanzan Company were opened in 1865, and belonged then to the Prince; but have been worked by the company for the past five years. There are said to be fifteen veins and thirty mines; but only one vein is now worked, with a mine 25 fathoms long. The ore is chiefly copper pyrites sprinkled through white quartz, but they say there is also some black ore (probably oxide of copper); and it is at the thickest place four-tenths of a foot wide, and at other points had been half a foot, but in

general is only two-tenths of a foot, or less. The country rock is a greenish gray tufa, mottled with white, so soft that it is very easily dug and is called mere mud. There are forty roasting kilns for 500 kamme of ore each ; and four smelting hearths (of which two are idle). Only blister copper (aradoo) is made. In the year ending 30 June, 1878, from 170,022 kamme ($632\frac{1}{2}$ tons) of washed ore 25,328 kamme ($94\frac{1}{4}$ tons), or $14\frac{5}{8}$ per cent., of crude copper were made. The copper sells for \$15 a picul at the mines or \$17.50 at Oozaka ; the carriage costing about \$2.50. There are 120 workers employed : 51 in the mines ; 20 at the washings ; 26 at the kilns and furnaces ; and 23 others. Mining one fathom (6 feet long by 4 feet high by 3 feet wide) costs \$0.75, beside 1 shoo of rice (\$0.05) a day and 1 shoo of oil (\$0.36) a month for each man ; and about five feet in length a day are dug by four men together. Wood costs \$0.45 for 100 kamme ; and charcoal \$3 to \$3.50 for 100 kamme. About 100,000 kamme of charcoal a year are burned.

The Ushironotani mine is a couple of hundred yards down stream from the Iioomanzan. It was begun in July, 1876. It is said, there is only one mine and one vein with a dip of 70° northerly ; and that the ore is at most about $4\frac{1}{2}$ tenths of a foot wide ; and there would appear to be two “ ore shoots,” of which the western is the larger. The ore and the country rock are like those of the Iioomanzan. The mine extends about 200 feet below water level, and is pumped with Japanese bamboo pumps ; but there is not much water. There are 56 roasting kilns and four smelting hearths ; and only blister copper is made. In the year ending 30 June, 1878, from 133,739 kamme ($498\frac{1}{4}$ tons), of washed ore 12,892 kamme ($44\frac{1}{4}$ tons), or about $9\frac{1}{8}$ per cent., of copper were made. There are 210 workers employed : 135 at the mines ; and 75 at the furnaces and washings.—It is evident that the Iioomanzan

and the Ushironotani mines are worked with a profit on account of the softness of the country rock in spite of the narrowness of the veins ; but there is a great lack of surveying, mapping and labour saving expedients that would be very desirable and probably increase the profits.

At the Hoomanzan they showed me a flat bit of titanite iron (menaccanite) about a tenth of a foot long that came from Mimasaka, but the name of the mountain and koori was not known.

I visited also the Yada coal mines in a very low hill about half a mile south of the main road and a league and a half short of Matsue. They were first worked by the government in 1863, and the coal was burned by a steamer ; but at the end of eight years the steamer stopped running and the mines were abandoned. In the autumn of 1873, however, some Nagato men took up the mines and worked them for about five months ; and since that no digging has been done. The mines were two adits, the larger one thirty fathoms long ; and now both have fallen in so as to be inaccessible. According to the description given on the spot there was a thickness of three feet of coal (at one mine only two feet) under a foot of soft blackish earth, which was covered by some twelve feet of greenish gray and light brown shaly soft sand rock. The coal is black and shining and not fibrous , and is said not to have fallen quickly to powder when exposed to the air in heaps for months. There is now none of it to be seen, except small bits that have been in the weather for years. The roof is evidently too soft, and had to be propped at every three feet. The coal dipped about 5° (in another place 15°) north 15° west, away from the mouth of the mines into the hill, so that water accumulated inside ; and much earth was brought out (probably to make natural drainage possible), and spoiled the adjacent rice field, adding to the expense. If the thickness and quality of

the bed have not been exaggerated, mining might pay ; but a careful survey should first be made so as to find a place to attack the coal where an adit would drain itself.

I saw too the Akasaki coal mines¹ in the edge of Matsue itself, half a league or less north-easterly from the Prefecture. The very little mining that has been done took place in April, 1878. There are three small adits within a distance of about 20 yards, in a single low hill, one of ten and two of six fathoms in length ; all apparently on the same bed, which dips 20° north 5° west. At one of the drifts, the coal is visible, and measures one foot and a quarter in thickness ; underlying some six feet of light gray soft shales, and overlying some six feet of soft greenish gray sand rock weathering light brown. At the other places the coal is said to be of about the same thickness, but is only partially exposed. The coal is black and shining, feeling rather heavy. Some of it that had been exposed to the weather for months was still black and firm.

I visited likewise the Matsue pottery, near by, about half a league north of the Prefecture. It is a small pottery, but a few fine articles are made, in the Fujina style ; and it is said to be 100 years old. There is one kiln (thirteen fathoms long by two fathoms wide) now used ; but there is one more disused. The clay comes from Mijiro village in Ooharagoori, six leagues to the south-west ; the same place that supplies the Fujina potteries.

In passing I visited the Fujina potteries too, a couple of hundred yards north-westerly from the main road at the village of Fujina, about a league westerly from Matsue. They are said to be 200 years old. There is one kiln 28 fathoms long by three fathoms wide, with 11 ovens ; one kiln about 10 fathoms long by two fathoms wide, with six ovens, and another rather smaller kiln ; and there are about 100 potter's wheels. There are three

bakings : the first is for the white biscuit ; the second is for the yellow glaze, the characteristic of the place ; and the third is for the fancy painting. The two first bakings take about two days each, and the third much less. The clay comes from Mijiro. The glaze comes from Kimatsu, in Oomori village, three leagues distant.

From Matsue, at the head of the Nakaumi and at the outlet of the Shinji Lake, a league and a half westerly to Yumachi the only rock exposures were of soft greenish gray and greenish brown shaly sand rock and sandy shales ; such as were to be seen in the hills about the northern edge of Matsue ; but Kamoikotan rocks occur probably only a very short distance south of the road, near Fujina, and carnelian and chalcedony are found in the hills there. Yumachi is in a little alluvial plain on the shore of the lake ; but southward a mile to Tamatsukuri, the road follows the bank of a small river among high hills, of Kamoikotan rocks, as I supposed from what I saw afterwards, though I was belated and passed there after dark. Mr. P. Kempermann, however, mentions in an interesting account of a "Journey through the Central Provinces of Japan," (read before the German East-Asiatic Society, in 1878, and republished in English in the Japan Weekly Mail, 14 Sept., 1878) that "at Yumachi on the south bank of the lake he found on the foot of one of the spurs of the main range large basalt columns, and higher up andesite." Perhaps the exposures were somewhat further west than the road we travelled. He speaks also of the occurrence of graphite (a mineral of the Kamoikotan rocks) near Tamatsukuri ; but none was brought to my notice.

At Tamatsukuri there are some hot springs, but they issue from greenish gray or light brown pretty hard sand rock, in places quite hard and a good whetstone, apparently a metamorphic, Kamoikotan rock. There are three springs within some fifty yards. One, about ten yards

back from the river, has a temperature of 64° C. with a yield of perhaps fifty gallons a minute : another, at the principal hotel (Nishimura) has a temperature of $62\frac{1}{2}^{\circ}$ C. with a like yield ; and the third at the edge of the river, has a temperature of 59° C. and a yield of perhaps 125 gallons a minute. The water seems to have extremely little mineral matter in it, and has no taste nor smell ; and forms little or no deposit, but perhaps traces of a white one, that may be salt.

At Tamatsukuri and at Yumachi chalcedony, carnelian, agate, green jasper and smoky quartz are cut into small ornaments very neatly. The stones here as elsewhere, come no doubt from Kamoikotan rocks and are found in several places near Tamatsukuri, almost wholly on the east side of the river, towards Fujina, and inside of Fujina ; but one large crystal of smoky quartz was found on the westside of the river near Tamatsukuri. Some of the ornaments are small magatama of green jasper cut and polished in imitation of ancient ones that are found in the ground near Tamatsukuri. The hotel landlord knows of five ancient ones that have been picked up in the village, the largest about two-tenths of a foot long. They are of prehistoric origin, are believed to have been made by the gods, and are therefore collected and preserved in Shintoo temples. In the temple close by, there are three ancient magatama ; one is about 0.11 feet long of reddish chalcedony ; another is about 0.07 feet long of similar but rather paler material ; and the third is about 0.09 feet long of dark green jasper. They are polished, but less finely so than the lapidaries there now know how to polish stones. The lapidaries remark that the carnelian and chalcedony are equally hard, but are harder than the vitreous limpid or smoky quartz, which again are of equal hardness.

They showed us some obsidian that had been brought from the island Oki, which is therefore in part at least

volcanic. The stone was found too soft and brittle for ornaments, except for round beads.

From Tamatsukuri we went southward eight leagues and a half among the hills and mountains to Minari, near the central ridge of the Island. The road at first did not go over very high ground, but had small passes of some 400 or 500 feet in height. Near Minari however the passes were higher, up to some 900 or even 1,100 feet above the sea; and the valley at Minari itself was about 700 feet high. Within half a mile of Tamatsukuri we came to exposures of light gray granite weathering light brown containing, besides the white, and sometimes slightly reddish, feldspar and abundant quartz and (sometimes scanty) mica, a little magnetite; and such exposures continued frequent all the rest of the way. The granite was sometimes hard, at least in parts, but generally was very crumbling; and there was much granitic sand. At some points near Minari, there was a larger proportion of magnetite, and here and there a little magnetic sand in the road.

In the region about Minari there are eight iron making places, of which however only three seem to be working, namely, at Amegawa, a league and a quarter easterly from Minari; Une, the same distance south-easterly from Minari; and Makibara. The rest are small or not at work and are at Nodzuchi (two leagues easterly from Amegawa), formerly the most flourishing of all, but now less so; Shikatani; Bokura; Riunokoma; and Yashirodani. I went from Minari to the Amegawa works; and Mr. Adachi to those of Une, which I also visited on the way back. The road was still among the hills with the crumbling Kamoikotan granite everywhere.

The iron ore used at all the works is iron sand; and is obtained: either by cutting down the granite and breaking it up by hand and washing it; or the river sand is

washed ; or the ore is taken from alluvial ground. The ore from such alluvium is reddish and more fusible than the other kinds owing no doubt to its long exposure to weathering influences ; the ore washed from the rock is next in fusibility ; and the ore separated from river sand is the least fusible, probably owing to its being protected by water from the air, or because its weathered surface has been continually worn off. The difficult fusibility is very likely due in part to the presence of titanium. Most of the ore used at Amegawa is brought on horse-back from various places over two leagues distant ; but is washed again at the furnace and reduced to half its weight. Some ore, however, is washed on the hill side close by the Amegawa furnace in the winter half of the year ; but the rock there is reckoned in general of inferior quality, though some parts are pretty good. Six men work together in one place and produce 800 to 1,000 loads, sometimes only 600 loads (of 24 kamme or $1\frac{1}{2}$ piculs each), in one season of about 180 days, or 1,080 days' work ; and that amount of ore is likewise reduced one-half by the final washing at the furnace. In one such season, it is said, the six men cut down and wash the rock throughout a length of about 30 fathoms by a width of about $5\frac{1}{2}$ fathoms and a height of three fathoms ; say 500 cubic fathoms for about 500 loads or $45\frac{2}{3}$ tons of the ore of the final washing, or about one-half of one per cent. of the weight of the rock. The only vein of magnetite known is at Hatakeyama in Oomaki village, three leagues south of Amegawa ; but it is only a quarter of a foot thick and is therefore quite unworkable.

The Amegawa iron works are over 100 years old. The only furnace there, like the others of Idzumo, makes both pig iron and steel in one operation of three days ; but across the mountains in Bingo with similar furnaces they-

make (it is said) only pig iron in an operation four days long. The furnace is essentially like the blast furnace of western countries ; but extremely low and with a very long horizontal section, and of extremely little durability, as it is built merely of a common yellow clay. The shape is closely like that of the Rachtette furnace, a recent invention of western countries ; the size, however, is small. The height is only 3.7 feet, and the width at top 3.2 feet outside or 2.4 feet inside, but the length is $9\frac{1}{2}$ feet outside. The outer sides are battering, and the inner ones still more so near the bottom, so that only half a foot in width along the middle of the bottom is flat. The vertical section crosswise differs then from that of the blast furnace in being widest at the top instead of near the middle. In the course of the operation, however, the inner sides rapidly wear away toward the bottom so that the section becomes much wider there than at first. The extreme lowness of the furnace can be accounted for by the fact that the minuteness of the particles of the ore enable them to be deoxidised in a very short descent. The great length of the furnace is made up for by a row of nineteen tweers on each side, for which there are elliptical holes 0.2 feet high and 0.7 feet above the bottom outside and 0.5 feet inside ; so that the heat is kept up throughout the whole length. The progress of the smelting can also be viewed through the holes, at the side of the nozzles, and any obstructing slag can be poked away with a small rod inserted there ; and at each end of the furnace at the bottom there is a hole 0.4 ft. in diameter for drawing off slag and pig iron, and there likewise the smelting can be watched. At the end of the first twenty four hours that hole is closed and two other similar ones are opened on either side of it near the corners, as the side walls have already become thin. Below the bottom, which is on a level with the ground,

there is a layer 0.8 ft. thick of ashes of the maki, a conifer (*Podocarpus macrophylla*); and below them there are 4.2 ft. in depth by $3\frac{1}{2}$ ft. in width and $9\frac{1}{2}$ ft. in length of hot coals; and the five feet together are called the fukutoko (or hearth). Below it is a depth of seven feet filled with red and black clay; from the bottom of which there is a horizontal drain to a neighboring hillside. The whole depth of twelve feet is walled about with half a foot or more in thickness of stone (granite and other kinds). The fukutoko with the parts below is permanent; and at some places is not allowed to cool down for a hundred years. The furnace proper is built of wet clay in a day, and dried with a wood fire in the following night.

At three o'clock the next morning the same brands from the wood fire are removed and the furnace filled with large charcoal, the tweers are adjusted, the coals kindled and the blast begun. At about five o'clock the charcoal in burning has become about 0.4 of a foot shallower than at first. Then they put on iron sand perhaps about 16 kamme ($133\frac{1}{3}$ lbs or one picul), but not a weighed quantity; then some more charcoal until the top is made level again with the top of the furnace. When the fire has again become about 0.4 ft. lower, another picul of iron sand and some more charcoal are put on; and so on repeatedly. The first day and night, ore and charcoal are charged about 33 times in 12 hours; and the second day at about the same rate but growing quicker, so that on the third day there are 42 charges in 12 hours. Throughout the operation, slag is running out at the end holes of the furnace, and some pig iron too, called dzuku, which, though variable, amounts to perhaps 180 kamme (1,500 lbs.) in all. On the fourth morning at three o'clock (that is at the end of 72 hours), after having charged in all about 3,800 kamme of charcoal and 3,600

kamme (30,000 lbs.) of ore, they stop the blast (which has been continuous) and take away the nozzles. Then they break up the furnace, brush off the coals that remain on the mass of metal that has been produced, and let it cool. The mass is steel, but the outside of it is bad steel called *kera*; below it there is melted pig iron, or *dzuku*, which on the removal of the steel mass cools and becomes solid at once. The steel mass weighs about 540 kamme (4,500 lbs.) of which two-thirds are good steel and the rest *kera*. The two are separated with the hammer. The *dzuku* weighs about 360 kamme (3,000 lbs.), or together with the previous 180 kamme (1,500 lbs.) about 540 kamme (4,500 lbs.) in all; making the whole product then about 1,080 kamme (9,000 lbs. or about four tons) or 30 per cent. of the ore. With a larger furnace sometimes 1,200 kamme are produced. When the metal has been cooling a couple of hours, at about six o'clock in the morning the steel mass is pulled out and then immediately the *dzuku*. The *dzuku* without further cooling is thrown at once into a small pond of water close by, and is afterwards broken up with hammers. The hot steel mass is likewise thrown into water at some places, but not here; and after cooling it is broken up into small bits. The same day that the metal masses are removed the furnace is rebuilt, so that on the fifth day the blowing recommences. In a month, then, there are seven or eight operations, except when occasionally there are interruptions from disordered apparatus. In a year there are about seventy operations with a vacation of two months in the hottest part of summer. The *dzuku* and *kera* both go to forges in other villages; Komuri, two leagues distant; Komaki two leagues; Yakawa, three leagues; Maki, three leagues; Sumoni, two leagues), and are converted into bar iron there, yielding about 62½ per cent. The *dzuku* is sometimes

made in other villages into good cast iron by means of twice remelting.

The blast is given by a pair of wooden bellows on each side of the furnace ; and they are like the bellows of an oil well, except that they are in two halves, end to end, with the hinges of the top boards at the outer ends, so that the man who treads them stands in the middle and steps first on one board and then on the other. The boards are each five feet long by three wide and rise and fall at the inner end about $1\frac{1}{2}$ feet. The work is so severe that the men are relieved about once an hour, and in the twenty-four hours there are three sets of men, or six men in all. The nozzle is chiefly of bamboo about 0.15 ft. in diameter, but at the furnace end is of iron for a length of about two thirds of a foot, and at the very end with an inside diameter of 0.06 ft. The furnace and bellows, charcoal and ore bins, and resting rooms for the workmen are all in a high building about fifty feet square.

Of wood about 2,000 kamme are used in the three days operation ; 1,000 kamme for drying the furnace and 1000 kamme expressly for making ashes. For the ashes maki only is used ; and it has to be burned green, otherwise (it is said) the ashes are inferior. The ashes would seem to serve as a flux ; and at the same time form the bottom of the furnace through which the metal and slag do not penetrate.

The charcoal used is very large, some pieces two or three feet long by half a foot in diameter, but many smaller ; and it is broken up a little before putting on the fire. The coals in the fukutoko do not diminish in several years, and when the work is interrupted are kept warm by a mound shaped charcoal fire on top covered with clay except a hole at one end before which a few sticks of wood burn slowly.

One steel mass (with *kera*), that I saw, was of irregular shape, about nine feet long by about $3\frac{1}{2}$ feet wide and half a foot thick, including some cinders and ashes on top and slag below ; and the *dzuku* is said to be of about the same shape but much thinner. The *kera* surrounds the good steel on all sides. The breaking up into small pieces is done partly with hand hammers by eight men : and, in the case of the more difficult lumps, by letting fall upon each of them a mass of *dzuku* weighing 360 *kamme* from a height of some ten feet. The mass is raised by means of a rude tread wheel worked by four men ; and falls between a guiding framework about $2\frac{1}{2}$ feet square. The twelve men in all do the breaking up in four days, just the time of one complete furnace campaign.

Besides the twelve men who break up the steel (with 48 days' labor) ; and the six men who blow the furnace (with 18 days' labor), there are two men for charging the charcoal, and two for the ore (twelve days' labor), and twelve men for building the furnace (twelve days' labor) ; so that there are in all ninety days' labor for each operation.

The cost of labor is very low, because strongly attached old family retainers are employed. The bellows' men and steel breakers average about nine cents a day, including four cents worth of rice (one *shoo*). It is owing to such low wages that the works still succeed no worse. At washing the ore of the hillside near the furnace about ten cents a day are earned. Ore brought from a distance is bought at about 14 cents for a load of 24 *kamme*. After washing again at the furnace and reduction to one half its weight, it is worth 25 cents a load (so stated, but the two bought loads to make one of the last washing would cost 28 cents) ; and the yield therefore is at least $3\frac{1}{8}$ cents to the cubic yard of such rock as that

near the furnace. Charcoal costs about 12 cents for for 10 kamme. Maki wood is worth from $2\frac{1}{2}$ to 3 cents for 10 kamme according to quality. The steel sells for about \$5 a load of 30 kamme (or \$44.80 a ton), or about \$60 for the product of one operation ; but averages say \$45. A like load of dzuku and of the best kera (yielding 50 or 60 per cent. of iron) brings about \$2 a load (or \$17.92 a ton) both alike ; or say \$48 for the whole product of them in one operation. The making of bar iron from dzuku and kera costs (it is said) about \$2.70 a load ; but with inferior dzuku and kera it costs more. Bar iron sells at Amegawa for \$5 to \$7 for 24 kamme according to quality, averaging perhaps \$6 ; or say \$67 a ton. Dzuku brings \$3 a load (or about \$27 a ton) at Matsue.

The chief expenses of the 70 operations of a whole year would be :

266,000 kamme charcoal	\$3,192
140,000 „ wood, say	385
10,500 loads of ore @ 25 sen	2,625
6,300 days' labour @ 9 sen	567
Clay for furnace building say	70
	<hr/>
	\$6,839

or \$97.70 for each operation ; or \$24.34 for each ton of product. But something should be added for the wear and tear of tools and of the breaking machine, deterioration of the buildings, cost of superintendence, and interest on the capital.

The whole product for the same year of 70 operations would be 281 tons (75,600 kamme) of which one third would be good steel. The value of the whole product would be at say \$93 for each operation \$6510 (or at \$108 it would be \$7560). The information is not quite precise enough to decide with certainty whether there be any profit or not.

The day I visited Amegawa the furnace was not in blast ; and the operation is given as it was described to me on the spot. As such inquiries are unusual there and were unexpected and the answers had not been specially prepared, it is possible there may in some points be a little inexactness, though evidently no more than under the circumstances was unavoidable. It will therefore be well to compare the statements with those obtained at the closely similar establishment of Une, and with the observations of the operation there.

The Une iron works are 103 years old (since 1776); and they say that the fire has in that time never gone out.

The furnace is 9.3 ft. by 3.3 feet, as they told me ; but by Mr. Adachi's measurement of the patterns the outside width at the top was 3.4 ft., the inside 2.7 ft., the outside width at the bottom 3.7 ft. and the inside 0.65 ft. There are twenty tweers on each side. The furnace house, bellows and other apparatus are closely like those at Amegawa ; and my short visit was at about six o'clock in the evening of the second day of the operation. Each bellows was making about 28 strokes a minute with one-half of the bellows, or say 14 strokes for each pair, and the effort was very violent. For the three days eight men are employed to tread the bellows, and on the second day were changing 12 times in the daytime and about ten times in the night. On the first day the treading is slower and the changing less frequent ; on the third day more rapid and more frequent. They change about once for two charges of the furnace ; that is about once an hour. The treading of the two men on the opposite sides of the furnace keeps time, so that the air rushes in from both sides at once ; and the flames (about three feet and a half high) rise slightly higher at that instant.

The iron sand is charged only along the sides near the walls of the furnace ; and the charcoal is charged

slightly nearer the middle. When freshly charged the charcoal rises slightly (about a quarter of a foot) above the top of the furnace. At the time of my visit they were charging three times an hour; and on the third day they charge still oftener.

The ore charged in one operation of three days amounts to 220 or 230 boxes of 14 or 15 kamme (sometimes 17 or 18 kamme); say 3300 kamme (but possibly about 3,600 kamme as at Amegawa). Of charcoal in the same time 4,200 or 4,300 kamme are charged; and of wood 720 or 730 kamme are used for making ashes and 1,200 or 1,300 kamme for drying the furnace: about 2,000 kamme in all. The ashes have to be made for each operation.

The clay for building the furnace has to be brought from a distance of three quarters of a mile (11 choo), from land belonging to the furnace owner, and the carriage costs \$0.0043 for ten kamme and the digging somewhat more; say in all about one dollar for the 800 or 1,000 kamme that are needed for a furnace.

There is always some slag with the dzuku at the end of the operation below the level of the bottom of the furnace, the ashes and coals beneath having become somewhat depressed; but it does not penetrate the ashes.

The whole product of one operation is from 720 to 1,020 kamme (6,000 to 8,500 lbs.), or about 30 per cent. as at Amegawa, sometimes 1,200 kamme (10,000 lbs.); of which the dzuku varies from 90 to 480 kamme (750 to 4,000 lbs). There are about sixty operations in a year; but the number varies in different years. They are idle in July and August, and in 1878 began blowing on the seventh of September. They say that in the hot weather the metal does not melt so well as it does in the cold. Probably the labor of treading the bellows so rapidly is too severe in hot weather; but the draft upward from the fire would be slightly less active, and the air slightly rarer.

In Bingo, where with a four days' operation dzuku alone is made, the furnace is said to be longer and narrower, about 10 ft. by 2.8 ft. If the furnace is narrow there is less charcoal, and so not enough heat for steel, they say ; but for dzuku alone less charcoal is needed. The tweers are about 20 (18 to 21) on each side of the furnace and are a little smaller than for making steel. The dzuku is drawn off in a melted state by the holes at the end of the furnace. In other respects, they say, the Bingo process does not specially differ from the Idzumo.

As the Japanese method of making pig iron from sand ore is the only one successfully practised in any part of the world, and as the amount of such ore in Japan seems to be very large indeed, it is worth while to consider whether the process cannot be so improved as to be more decidedly profitable. The whole cost of the steel and pig iron product appears to made up mainly in the following proportions :—

Charcoal.....46 $\frac{2}{3}$ per cent.

Ore... 38 $\frac{1}{2}$ „ „

Labor :

Breaking.....4 $\frac{1}{2}$

Blowing.....1 $\frac{1}{2}$

Charging.....1

— 7 „ „

Furnace :

Wood for drying.....4

Clay.....1

Labor.....1

— 6 „ „

Wood for ashes..... 2 „ „

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Evidently the cost of fuel and ore are far the most important items. It must be borne in mind however that nearly

all the remaining fifteen per cent. are only about half price owing to the exceptionally low wages paid at the iron works. It seems clear that much economy might be effected as regards: 1° washing the ore; 2° the carrying of the ore, fuel and other materials; 3° the fuel; 4° the flux; 5° the breaking up the metal; 6° the blast; 7° the furnace building.

1°. For washing the ore from the hillside it seems highly probable that the California hydraulic method might be used with profit, although the ore in inferior rock like that of Amegawa be only one half of one per cent. of the granite and in value only $3\frac{1}{8}$ cents to the cubic yard. In California the yield of the gravels and rocks washed in that way averages at different places from five to twenty-five cents to the cubic yard (sometimes more); and the method has been said to cost ten cents to the cubic yard, some say five cents, or more than six times cheaper than the method of sluicing, by which the Idzumo iron sand is now washed. Necessarily the expenses here would be much less than in California; for whatever canals or apparatus might be needed could be made here with labor that costs at worst hardly a fifth of that of California and the interest on capital here would not be extremely in excess of what it is there. In California, too, water is comparatively very scarce and is brought by costly aqueducts from great distances, sometimes scores of miles. Here in Japan, water is so very much more abundant that there would be no need of such long and expensive aqueducts. In collecting the gold in California there is a little expense for quicksilver that would not be needed for the iron sand; but it is possible that magnetized plates or bars might be profitably used to aid in retaining the iron sand in the sluices. The crumbling granite to be washed is much more friable than some of the rocks washed by the hydraulic method in California. One

point to be considered in imagining washings on a large scale is whether the rice fields would probably be seriously injured by the great amount of sand carried down by the rivers. On the other hand the removal of the hills would leave more flat ground for new rice fields.

2°. The cost of carrying the ore must at present be an important part (a third or even a half) of its final cost ; and with good waggon roads or with navigable streams would be much lessened. A like remark would hold good in regard to the carriage of fuel, of the metal on its way to market, of the food and comforts of life for the workmen ; and improved roads would not merely benefit the iron interest directly, but the farmers and other inhabitants would waste far less of their labor in mere carrying, and every industry would obviously receive advantage indirectly as well. Merely if seven-eighths of the cost of carrying the metal to market by land could be saved over good roads (as in the case of the coal carried to Ikuno) or about seven dollars a ton in sending to Matsue, there would even now be a handsome profit in iron making. The ore at present brought from a distance to Amegawa is before using reduced by washing (it is said) to one half its weight; and therefore if the final washing were done before carrying, the cost of carriage would be reduced one half. As the fuel, including the wood, weighs sixty per cent. more than the ore of the last washing it is desirable to carry the finally washed ore to the neighborhood of the places where the fuel grows rather than to carry the fuel to the ore ; and fuel can be floated down stream on brooks that would not carry a boat for the ore. Nevertheless, as ore could be carried very cheaply down in boats on the larger streams (with improved navigation) it would seem advisable to have the iron works at some distance down stream in the larger valleys near good water power rather than far up in the narrow valleys among the moun-

tains, where the supply of fuel would be comparatively small and the water power trifling.

3°. In case the iron manufacture should be very much extended it would be necessary to use coke instead of charcoal; and at places near the seashore it might already be advantageous to do so; for with furnaces built of better materials and perhaps of slightly altered dimensions its use would no doubt be possible. The iron produced would not be so good in quality as that made with charcoal; but the difference would probably be more than made up in cheapness.

4°. The only flux used at present appears to be the wood ashes carefully renewed for every operation in excess of those produced by the charcoal and by the wood burnt for drying the furnace; and probably owing to insufficient flux there is a great loss of iron in the slag; so that only about thirty per cent of iron can be got from carefully washed ore of a kind that when perfectly pure would contain nearly three-fourths its own weight. For in order to separate the particles of quartz in the ore they must be made fusible by combining with the oxide of iron to form a slag; and the clay (silicate of alumina) in the ore or in the walls of the furnace combining with the quartz and the oxide of iron form a fusible double silicate of alumina and protoxide of iron, also at the cost of iron. It seems desirable here to add lime to the ore charged (as is done in the blast furnaces of western countries), in order that a double silicate of alumina and lime may be formed in which the lime will take the place of iron and so in a great degree prevent its loss. The alkaline matter of the wood ashes serves the same purpose, but they are much more costly than lime would be. It would be best to charge quick lime rather than limestone, and by burning the lime at the quarries there would be a saving of about one-third in carriage, a point of great impor-

tance with the present bad roads where waggons cannot be used. Limestone is found abundantly, it is said, about four leagues east from Amegawa, at Tari village in Iinogoori, Hooki. It is also said to be found in quantity 13 leagues south-east of Minari, at Mido village, in Nukagoori, Bingo.

5°. The present mode of breaking up the metal with the clumsy tread wheel is extremely rude and costly; and no doubt the same end could be accomplished far more economically by water power, or possibly with the help of the very strong modern explosives. It is possible too that it would be cheapest with water power trip hammers to forge the large lumps into more suitable shapes without breaking them up into the very small bits now required by the country blacksmiths with their hand hammers.

6°. The blast is now produced in a very expensive way, by the labor of men; whereas so purely a mechanical kind of work could doubtless be effected much more cheaply by water power or even by horse power, and the simple machinery required would not by any means be too difficult for the country carpenters to build. The blast would besides be steadier and consequently better. Moreover with water power it could probably be satisfactory in the hottest months of the year; so that more operations could be made, and the loss of interest on the capital and the deterioration of the buildings would be less for each operation, or for each ton of product. If a hot blast were used instead of the present cold one there would be a very important saving in expense; especially as the very abundant waste heat of the furnace could probably be used without difficulty for warming the blast.

7°. The cost of the furnace itself is about \$1.46 for each ton of product (of which two thirds is for the wood used in drying); and is perhaps not more than the cost would be with a high western blast furnace, if the high rate of

interest in Japan be considered and the great capital that would be needed. But some saving might probably still be effected if the low furnace were built of stone or fire-brick that could stand the heat (if any such could be obtained near at hand), and an apparatus were used for hoisting out the lump of steel, or if only pig iron were made, as in Bingo, and drawn off in the melted state. The quartzite of Tamatsukuri would no doubt answer the purpose well, and could easily be carried to the iron region so near in the small quantity required, were it not for the badness of the roads, which is such an immense hindrance to every kind of industry. With a permanent stone or brick furnace the labor and time of rebuilding for each operation would be saved ; and as the operations could follow one another at once with the furnace already hot there would be a saving of heat and consequently of fuel. In making dzuku alone, as it is drawn off melted, there need be no interruption of the process for many weeks or months. The form of the furnace would not so rapidly change, the lower part would remain narrow throughout the operation, and the hot coals of the fukutoko would therefore probably be unnecessary in order to keep up sufficient heat ; so that the bottom of the furnace could be made likewise of stone or fire brick without ashes.

It seems then very certain that the manufacture of iron from Japanese sand ore can without exceptionably low wages be made decidedly profitable merely by very simple improvements on the process now in use, without aspiring to any radical changes of method. The enormous quantity of suitable ore that appears to exist in Japan seems likewise to justify the expectation that iron making will become a very important business. Iron sand has been washed here and there through a space at least forty leagues (100 miles) long, and it would seem that the iron-bearing granite underlies the whole region. To be sure

no careful tests of its richness or ease of working at different points have yet been recorded ; but if the average should be anything like that of the rock called inferior at Amegawa the quantity of ore would be immense, as a little calculation will readily show. Even a single hill made up of such rock and only one mile (say 15 cheo) long by one-fourth of that in average width and three hundred feet in average height would contain (at one half of one per cent.) more than a million tons of ore of the last washing. In a space 100 miles long by twenty five miles wide there would be room for ten thousand such hills with contents in ore amounting to ten thousand million tons. It would be too great boldness to say now that there is so large a space so richly filled throughout ; but it would seem almost certain that the amount of such ore is very great indeed, and it must be very well worth while to ascertain by geological surveys how large a portion of the region contains it in a workable form. Indeed, the subject of iron is likely to become far the most important mining question of Japan after the coal fields of Yesso.

From Minari we went northward again by the same road for a couple of leagues and then turned north-westward down a steep narrow valley gradually growing wider and more level to Kisuki on the Iino River, $5\frac{1}{2}$ leagues from Minari. All the way there were numerous exposures of the same light brown crumbling granite.

A few hundred yards north of Minari we stopped a few minutes to look at an iron sand washing place, but were not so fortunate as to see the men at work. The ore is said to be brought from a quarter of a mile up stream where the rock is pulled down for the purpose. The washing is done in a sluice about forty fathoms long in eight parts of unequal length, sloping gently with the ground of a small valley, but with a fall of a couple of feet

between the different parts. The width of the sluice is in general about $1\frac{1}{2}$ or two feet ; but in one part is four feet. The bottom is of boards, and the sides partly of boards but mostly of flat stakes. An iron hoe about half a foot square, and a smaller long handled wooden hoe are the tools used. The work seemed to be done by two men.

At Kisuki there is a small finery forge for converting dzuku and kera into wrought iron bars. As we passed through the town in the afternoon and as the forge works only in the forenoon we had no opportunity to see the operation ourselves ; and were afterwards disappointed in our hopes of seeing the whole process conveniently at some other place. Nevertheless I saw the fire places and tools at Kisuki and obtained some imperfect information in regard to the details of the method.

There are two forge fires, each under a hood that tapers upward into a low wide chimney, of which below the hood there is only the back wall and the right side. Behind the back wall there is for each fire a wooden box hand bellows with a piston and horizontal rod, like the bellows of all Japanese forges. One fire is a bloomery for reducing the dzuku apparently to blooms ; and the other fire is a chafery for making bar iron from the blooms and kera by reheating and welding. The bloomery fire place or hearth is a trough-like space three feet long (at right angles with the backwall of the chimney), 0.6 foot deep and 1.5 feet wide at the top and one foot wide at the bottom. The sides are made of iron plates about 0.06 foot thick, and the bottom slopes slightly forward. The tweezer or bellows nozzle enters from the bellows through the chimney back at the back end of the hearth and at the bottom of it and is level, and reaches forward to $1\frac{1}{2}$ feet from the chimney back. That portion of the hearth was at the time of my visit full of forge cinders. The chafery hearth is 3.25 long, nearly at right angles with the back

of the chimney, 0.85 foot wide (both at top and bottom) and one foot deep at the deepest point, which was about the middle of the length. The twee or bellows nozzle just reaches to the hearth at the back and is level; and has a diameter of 0.15, and is made of bamboo covered with clay.

The furnace and forge work lasts from midnight until noon. Charcoal is first charged upon the bloomary hearth, and upon that about seven kamme of dzuku; and then the blowing is begun. In about an hour a lump or ball is formed; which is hammered into a bloom, and put with about the same weight of kera into the chafery fire. Each day eight blooms are so made. The bloom and kera are heated in the chafery fire and hammered repeatedly until bars are formed. During the heating, melted cinder runs out and is drawn off from the front of the hearth. After the first hammering the lump of about five kamme is cut into four parts with chisels by four men striking with heavy hammers, on a small anvil set in the ground. Each part is made into a bar that weighs a kamme and a quarter (about ten pounds), and is 1.8 feet or 1.9 feet long by 0.4 feet wide and 0.03 feet or 0.04 feet thick. One cubical box of charcoal of $2\frac{1}{2}$ feet on an edge, about fifty kamme in weight, it was said (but probably at least one fourth heavier than that), is burnt in a whole day's work, as I understand; and costs about twenty cents (for each ten kamme, probably). There are eight workmen in all: two for the bellows, four for striking, one for holding the chisel and one for attending to the fire. The labour and charcoal required as here given seem rather to confirm the statement at Amegawa that the cost of converting dzuku and kera into bar iron was \$2.70 a load. In one day forty kamme ($333\frac{1}{3}$ lbs.) of bars are produced. If the charcoal burnt weighs only about sixty kamme the economy is about as great as in the closely similar processes of

western countries ; for there one and a half to three times the weight of the bar iron is needed. The loss of iron in fining the dzuku and kera, $37\frac{1}{2}$ per cent., is large but they may be very impure so that the loss would be far from being merely in iron. The Kisuki method is not on the whole a bad one, though in western countries puddling is more economical owing to the possibility of using inferior fuel and workmen of less skill, while needing however better roads than now exist in the Japanese iron regions for more convenient concentration of materials so as to work on a large scale.

From Kisuki our road four leagues north-westerly to Ootsu a league short of Imaichi lay down stream along the banks of the Iino River, a couple of hundred yards wide but shallow, with high hills near on either side for the greater part of the way, and still numerous exposures of the light brown crumbling gneiss. Towards Ootsu however there were exposures of greenish gray and dark brown sand rock and of gray shales weathering brown with rather steep north-westerly dips ; probably a part of the same Kamoikotan rocks that we had seen at Tamatsukuri. Then we came out upon a wide alluvial plain ; and passed through it by Imaichi to Kidzuki about three leagues north-westerly on the sea shore, near the south-west end of a range of high hills and mountains along the coast from beyond Matsue. From Kidzuki we went a league and a half northerly up among the hills to the Udoo copper mines, passing numerous exposures of dark brown, sometimes light brown, sometimes olive, hard Kamoikotan shales, in some places black slate, in other places greenish gray shales and shaly sand rock weathering brown with some nut size pebbles and small cubical iron pyrites. The pyrites is especially abundant near the mines. The rock thereabouts is in parts bright green and very talcose.

There is but one vein in the mines at present worked, though there is said to be another worthless one on the road about two-thirds of a mile to the south. The vein dips at one point 50° south 60° west. The greatest width of the vein in the portion now worked out was called (and appeared to me to be) three fathoms and a half wide, in which however is included a large lump of rock left projecting into it about parallel to the walls of the vein; and within the length of some two fathoms the vein becomes much narrower. In many other places the worked out vein (said to have contained ore) was five or six feet wide; in one place, for example, about five feet wide through a length of some ten feet and a height of twelve feet. The widest of the places now worked that I saw was 3.1 feet wide, and there the vein was said to hold ore throughout though mixed more or less with cubical iron pyrites. Several other places were shown where the copper ore was 0.8 feet or 1.0 feet wide and pretty pure looking. The vein has been explored throughout a length of 160 fathoms, and appears to contain two shoots of copper ore. The north-westerly end of that space for a length of sixty fathoms and a depth of thirteen fathoms contained, it is said, much ore; but below that the country rock changed and there was no ore. The next forty fathoms in length south-easterly had no ore. The next sixty fathoms contains much ore and has been worked to a depth of about eight fathoms towards the north-west, less towards the south-east, without coming to an end of the ore. The ore is copper pyrites; but the greater part of the vein is filled with cubical iron pyrites, which is abundant also throughout those parts of the vein that are bare of copper ore, but is left untouched so far as may be. The ore is said to contain a little silver, amounting to about $6\frac{1}{2}$ hundredths of one per cent. of the blister copper. The vein is easier to work than the country rock, which is therefore dug into as little as possible.

The mines have been worked only since 1866 (except an old abandoned drift some ten fathoms in length on the road about two-thirds of a mile to the south of the present mines). There are three mines now abandoned in the north-westerly worked out end of the vein, and one, the only one now worked, in the south-easterly end. There is no mining below the level of the drainage adit. Not much timbering is needed owing to the firmness of the rock. Small two-wheeled carts are used in the mine, but there are no rails. Mine lamps of the French pattern are used.

The ore is crushed, and washed by hand in the same manner as at most other Japanese copper mines. The ore is roasted only once; for 25 days in about 75 kilns, in general about four feet square and high, holding about five hundred kamme each; but three of the kilns are ten feet long by six wide and four high, and roast 3,000 kamme of ore each in 30 days; and there are eight kilns of intermediate size that roast about 1,000 kamme each. The weight of the wood burnt is about that of the ore. The smelting is done in what is called the Hitsubuki method of the neighborhood of Oosaka. The best and middle class ore is smelted in 13 mabuki hearths directly to blister copper (aradoo); and the low class ore is smelted to matte (kawadoo) in two Oobuki hearths; and the aradoo is not refined. The mabuki hearth is about 1.75 ft. in diameter and 0.8 ft. deep with a flat bottom smaller than the top, and has a cover of clay from the back to within about 0.3 ft. from the front edge, leaving an opening there about 0.8 ft. wide. There are two tweers at the back, about a foot apart where they enter at the upper back edge of the hearth, and they are inclined towards each other and downwards so that each points to about the centre of the space enclosed by the hearth. The tweers are of bamboo 0.25 ft. in diameter,

tapering at the end (which is made of clay) to a diameter of 0.1 ft. For each there is a box (piston) bellows 1.7 ft. high by 0.7 ft. wide with a stroke of 1.5 ft. The operation is said to begin at three o'clock in the morning and to last until eleven; but really ends in many cases much earlier. One hundred kamme of roasted ore are smelted in one operation and 70 kamme of charcoal are burned. The first hour and a half or two hours are spent in melting the ore with the two tweers in use at the back; then one of the two tweers and its bellows are removed from the back and placed at the left side of the hearth and arranged there to blow over the upper edge of the hearth towards the centre; and at the same time the other bellows at the back is stopped. The opening at the front of the hearth is generally kept closed, loosely, with flat stones and pieces of charcoal. The bellows are worked with from 22 to 40 strokes a minute, rapidly later in the operation and with great effort. About three times the blast is interrupted, the front hole opened and slag removed, which is smelted again with the ore of the next day's operation. Fifteen or twenty minutes before the smelting is completed a couple of small billets of wood are thrown in upon the melted metal. At the end, the cover, the twee and the bellows are removed, some water sprinkled or poured on and the blister copper removed in rough, round, thin cakes, from two to four in number, commonly three. Sometimes a couple of thin cakes of matte are first taken off. The hearth is at once repaired and made ready for the next day's operation. The Oobuki hearth is of about the same shape as the mabuki one, but larger, and measures 2.25 ft. across and is said to be 1.5 ft. deep. There are two tweers at the back with a bellows for each. From three o'clock until eleven in the morning there are three operations, with a charge of 100 kamme of roasted ore in each one. The ore is simply

melted in one uniform operation, and the matte taken off in thin cakes. The slag runs off throughout the operation ; but is especially drawn off at the end.

In the year ending 30 June, 1878, it is said there were smelted 376,111 kamme (1,400 tons), of ore and 87,138 kamme (324 tons) or $23\frac{1}{6}$ per cent., of blister copper were made worth about one dollar a kamme ; and six tenths of such a year's supply of ore was added to the stock on hand, leaving at last more than enough for a year and a half of smelting. The expenses of the year are represented to have been about \$40,000 less than the value of the copper made ; or subtracting the cost of mining the unsmelted ore, over \$46,000 less.

The wood (matsu) burnt in a year amounts to 600,000 kamme, costing \$2,400 ; and comes uphill from Saginra two leagues distant. The charcoal used in a year is 350,000 kamme, costing \$9,800 ; and comes from Iwami. There are about 380 workers, namely : 53 miners, 75 miners' aids, 74 kiln and furnace men, 53 ore washers (women), 80 to 100 laborers for carrying, 13 men in the office. Mining is paid by the month and not by the piece. Miners, for example, are paid \$5, \$4.50 and \$4 a month in three classes, besides 3 too of rice worth \$1.30, one shoo of oil worth \$0.35, and have their dwellinghouse free of rent. In addition, the 53 miners receive all together 30 kamme of powder a month, worth \$42 ; and a reward of three cents for every ten kamme of ore ; and have their pay cut down for days lost from work.

It is extremely desirable that a carefull geological and topographical survey should be made of the whole neighborhood of so prosperous and promising a mine ; and that, if such a survey should make it seem probable that the south-easterly ore shoot, the one now worked, continues (unlike the north-westerly one) to a considerable depth,

as seems now most likely, a drainage level should be dug from the sea shore, somewhere near the village of Sagi, or from the bottom of the valley that has its mouth there; and that arrangements should be made to remove the smelting works to some point near the mouth of that level. The amount of ore that could be mined without pumping would thereby become as great as possible; the cost of wood and charcoal would be reduced very much; and the nearness to the little harbor of Sagi would in many ways be extremely convenient. As the vein fortunately dips in that very direction the distance at sea level would be somewhat less than it is in a straight line from the present mines (probably less than half a mile); and any future workings to the deep with pumping would be still closer to the sea shore, and shafts there would find the smelting works already conveniently near. The small river there would perhaps furnish good means of washing the ore, and possibly supply power in addition for the mine pumps and the furnace blast. But without a careful survey and map any attempt to begin a new level or like improvements would most likely lead to costly blunders.

We retraced our steps from Udoo and Sagi to Kidzuki, and recrossed the alluvial plain to Maki on the Kando River half a league westerly from Imaichi; and under mistaken impressions went up the river southward, two leagues and a half to the Ottatsu copper mines, the owners of which were anxious to borrow money from the government for carrying on their work. It turned out that the mines had been abandoned as unprofitable in the spring of 1878, after having been worked since the spring of 1875. The chief rock of the region forms high dark gray cliffs along the river, and is a hard dark gray and dark brown coarse tufa pebble rock with pebbles of partly vitreous blackish, partly fine granular gray vesicular andesite con-

taining very minute crystals or grains of glassy triclinic feldspar (probably oligoclase), augite and magnetite, and in the cavities a very thin, greenish white, rather soft lining with a very few extremely minute crystals of heulandite apparently. There are said to be three mines and two ore veins. The veins are admitted to have been too thin to work with profit ; but the miners were always in hopes of coming upon some wide vein of which the two were supposed to be mere branches. They said that some foreigner, who in passing visited the place, encouraged them in that belief ; but I do not know of any grounds for it, not of any reason whatever to believe that the mines or veins would be any more profitable in the future than they have been in the past. The veins have been tested in the most thorough, though the costliest, way by three or four years of digging on them ; and the probability is that the same number of years more of digging would meet with no better result. Some specimens of ore were shown ; chiefly copper pyrites with cubical iron pyrites, and one with zinc blende, and one with some malachite. The gangue is gray quartz.

In the year ending 31 March, 1878, about $24\frac{1}{2}$ tons (6,626 kamme) of ore were smelted, and produced a little over three tons (848.4 kamme), or 12.8 per cent., of crude copper worth a dollar a kamme, or say \$850 in all. The ore on hand grew less in the same year by over 1,200 kamme. The current expenses in the same time (excluding the yearly tax of about \$4) are represented to have been \$3,697 ; of which about two-thirds, \$2,289 was for mining proper, and about one-third, 1408, was for dressing, roasting and smelting the ore. There appears then to have been a loss of at least \$2,850.

There is said to be a copper mine, or rather a trial digging at Ashidani, a mile and a quarter up the Kando river from the Ottatsu mines ; but the work there was

stopped in August or September, 1878. The prospect is represented to be very promising, and the owners likewise hope that the government will lend money for the work.

We returned down the Kando River past Maki to Koshi in the plain half a league beyond. Between the two, iron sand is washed in the broad shallow bed of the stream ; and we saw about ten men at the work, in pairs. It is said there are sometimes twenty men so washing, sometimes only one ; also that the washing of iron sand in the river there began only in 1878, and that in four months (from the fifth to the eighth, lunar style) about 1,000 loads of 30 kamme each worth nine cents a load were produced. With good luck a man and his aid have washed six such loads in a day ; but that is unusual. The method is simply with a large wooden shovel to make a heap, a couple of feet high above water, of the best of the river sand (chiefly granitic and reddish in color, except where a little blackish with iron ore), and with a large long-handled wooden dipper to throw water on an upstream edge of the heap or a little to one side ; so that the lighter particles are carried away by the current. The washing seems to be very profitable as wages go in that region.

From Koshi we went across the alluvial plain westerly a league and a half to Jundookichi, on the bank of a small lake and near the sea ; and thence through sandy low hills of reddish gray fine sand, that may have come from granitic rocks, half a league further to the sea shore at Aoki. Thence the road took us southerly, near the sea past occasional exposures of level or nearly level bedded greenish gray shales or shaly soft sand rock to Kumura, three leagues from Koshi ; and then south-westerly, still among low hills near the shore and with like rock exposure, to Taki village half a league beyond Kumura. There we saw some fossils in loose blocks of the sand rock, and Mr. Adachi brought some away. They are

all very imperfect, almost all bivalves with the white shells partly preserved, but one univalve cast, and one very small fragment that looks like a belemnite or belemnitella, which would go to show that the rock was at least as old as the cretaceous. The stone contains grains of limpid quartz and small reddish felsitic pebbles, about the size of a pea, and greenish sand; all apparently from Kamoikotan rocks, without any volcanic materials. The rock is probably of about the same age with the coal bearing rocks near Matsue, and perhaps with the ammonite bearing rocks near the coal of Yesso.

Going further westward among the hills near the seashore we found the rock exposures more pebbly and coarse, hard, greenish gray and greenish brown to the boundary of Iwami; and then with the pebble rock much yellowish brown shales; and a little short of Hane (four leagues from Kumura) there was no more of the pebble rock, but a soft very fine grained light gray, greenish gray or greenish brown tufa sand, sometimes with a few pebbles and among them a little fibrous pumice; and so on a couple of leagues south-westward, rather inland, to Oota, with some hard light brown pebble rock again near that town. At a small river half a league beyond Oota the pebbles were in great part of Kamoikotan rocks, but partly of old volcanic andesite containing glassy triclinic feldspar (probably oligoclase), augite, magnetite and brown or blackish muscovite in a pale red or pale greenish gray, fine grained matrix. The source of all these old volcanic rocks is no doubt the rather fresh looking extinct volcano Sambei, which is called about eight leagues by mountain road, probably not half that in a straight line, to the south-east of Oota.

Another half league south-westerly mostly through alluvial flat land brought us to columnar very dark gray fine grained andesite containing a little glassy triclinic

feldspar (probably oligoclase), augite and magnetite. Some of the columns are ten feet long and a foot and a half in diameter ; and the dip at right angles to them is 15° north 75° east. There were but a couple of exposures of the columnar rock, on either side of the village of Kuri ; and between them and beyond there were many of level bedded light greenish gray soft tufa sand rock weathering brownish, along the road up a narrow valley south-westward to near the village of Oomori (three leagues from Oota), and even half a league farther, or nearly up to that part of the same village called Ginzan-machi, some 500 feet above the sea. At Ginzan-machi and a few hundred yards beyond, the rock exposed is a hard, rough-feeling, but slightly decomposing, gray andesite containing much white, granular, mostly decomposing, but partly glassy, triclinic feldspar (probably oligoclase), minute augite and very minute magnetite and decomposing mica (probably muscovite).

Close to the village and the main road there are in the same rock the formerly celebrated silver mines, called the Iwami Ginzan or Oomori Ginzan. There are said to be about thirty veins, all running about east and west ; and towards the east the country rock is harder and the veins narrower, half a foot to one foot at most, while towards the west the rock is softer and the veins wider ; and still westward again the rock changes and the veins run out. There are (it is said) many veins that are half a foot or one foot wide, but three that are much wider. One of them is said to be three fathoms wide, another one fathom ; and the third about three feet. The greatest length that has been worked on any vein is said to be the very moderate one of about 750 feet. The greatest width of ore now worked is said to be about half a foot ; but the best specimens shown me (from the Shinkuchi mine) indicated a width of about 0.2 ft. of copper pyrites ; and in

another case (from the Shoorenji mine) a width of 0.1 ft. of copper pyrites about half filled with ore, of which there was said to be another corresponding layer of like thickness on the other side of the vein. Specimens from the Mikiyama mine showed an average width of about 0.02 of copper pyrites. The specimens were said to show the full width of the best ore places now worked. The ore is chiefly copper pyrites associated with much carbonate of iron and zinc blende, which with quartz gangue fill up the greater part of the vein in the specimens shown. Sometimes there are traces of white kaolin ; and it is said there is sometimes silver ore visible. In one mine (the Saisei) there is galena of which several specimens were shown that indicated a width of 0.6 ft. (said to be the full width of the vein) of galena chiefly, and apparently some black silver sulphuret (stephanite). The galena was rather coarsely crystalline. It is said to yield six-tenths of one per cent. of the ore in silver and 15 per cent. of lead. A very little carbonate of iron was associated with the galena. At the mines there is also found a pulverulent red hematite, associated with sulphate of baryta. The red powder is purified by washing, and sold at a high price as a medicine under the name of mumeoi, especially as a styptic for staunching bleeding wounds. Formerly arsenic was found in the mines ; but for some time none has been produced. In the silver obtained from smelting all the ores there are said to be eight-tenths of one per cent. in weight of gold ; but it is commonly not separated. The vein rock is in general harder than the country rock.

The mines were begun about 600 years ago, and have been worked continuously ever since. They were especially flourishing about 300 years ago ; and are said to have yielded then 3,600 kamme of silver or over half a million dollars, for yearly four or five years, and 3,000 kamme and 2,000 kamme a year for a long time. But the ore

above water level has been gradually exhausted ; and in the great earthquake of 1872, so much money was lost in the region that capital has been lacking to work vigorously the small and even large places above water level that are believed still to contain good paying ore. Consequently there is a strong desire to borrow money for the purpose from the government. The mines at present are worked on a small scale by two individuals or separate firms or companies. One is Mr. Adachi Soemon's, who has worked the mines since 1874, with furnaces a couple of hundred yards off the main road at Ginzan-machi. The other consists of three men who have been mining since August, 1877 ; and at the time of our visit had their furnaces a hundred yards or so still higher up the hill, but were building new ones in the village itself.

It is said that in all there are about 300 mines, about 150 in each ownership ; but each is now working only two. There is a low drainage level that is 5,400 feet long and cuts across the veins and is the longest drift. The longest one lengthwise of the veins is about 750 feet long. The mines extend to a height of 150 fathoms above water level, and 15 or 16 years ago were worked in the Saisei mine to a depth of about forty feet below it, with the help of Japanese bamboo pumps. The drainage level would appear to discharge about $2\frac{1}{2}$ cubic feet a second. There is said to be a good deal of water in the mines, probably owing to unevenness in cutting the drift. The mining galleries are narrow, in the old style ; but powder is now used.

The ore is sorted broken and roasted in the Japanese methods, similar to those of Udoo, Adakae and other mines ; but at present only on a very small scale.

At Mr. Adachi Soemon's place there are five kilns for roasting ore and one for roasting matte. Three of the

ore kilns are for 100 kamme each, and the other two for 300 kamme each; and the kiln for matte holds 20 kamme. The ore is roasted only once, and but three or four days, and about 30 kamme of wood (mixed kinds) are used for 100 kamme. The kawa is roasted seven times; and about ten kamme of like wood are used in each roasting. The ore is smelted to matte in three arabuki hearths, which are of about the shape of a hollow hemisphere with a diameter of $1\frac{1}{2}$ ft. and a depth of 0.8 ft. There are two tweers with a diameter of 0.15 ft. at the upper back edge of the hearth, 0.72 ft. apart, both inclined towards each other and downwards so as to point at the middle of the hearth at a level about 0.15 ft. lower than the edge. The hearth is under the usual broad hood that tapers upward into a low chimney made of bamboo plastered over with clay. The back chimney wall reaches to the ground, and behind it there is a common box bellows, for each tweer. The arabuki operation is carried on nearly every day, but was not on the day of our visit. The charge consists (they say) of the roasted product of 100 kamme of raw ore and about 40 (30 to 50) kamme of charcoal. The operation lasts about six hours and yields about ten (five to 20) kamme of matte in thin cakes. Four men are employed at each hearth, of whom three are for the bellows. The matte is smelted to blister copper (aradoo) in a single mabuki hearth, of a shape similar to that of the arabuki hearth but of smaller size, 0.8 ft. in diameter and 0.5 ft. in depth, with the same two tweers, bellows and chimney. The hearth is covered for about two-thirds of the diameter from the back with a clay cover that can be removed without breaking, and even the small opening so left in front has a cover in three or four pieces with slight cracks between; except the left hand corner of the front, which is a triangle with a base of about half a foot and is closed by coals that are occasionally removed during the opera-

tion, while the opposite corner is kept covered with fine black charcoal. The mabuki operation is not done every day now, the ore is so scanty, and they blow only when 100 kamme of matte have accumulated. In September, 1878, for example they blew 17 times. They charge in each operation about thirty kamme of matte and about three kamme of slag from the preceding operation and burn about twenty kamme of charcoal of this and the following liquation and cupellation all together (the last two requiring comparatively little); and obtain about four or five kamme of blister copper from 100 kamme of the raw ore. Four men do the work, including three for the bellows; but the day of our visit there were only three men in all. That day's operation was made with a hearth of the size of the arabuki hearth; and began they said with 25 kamme of matte and yielded eight kamme blister copper. They had begun blowing at daylight; and about five hours afterward were blowing with only one bellows, which was placed square in front of the hearth. The tweer was pointed downward at an angle of say 70° with the horizon, and passed through the middle piece of the front of the cover about 0.2 ft. from the front edge of the hearth. The diameter of the tweer was about 0.1 ft. The bellows' man was working very hard with 32 strokes a minute, which he afterwards increased to 35. About an hour later, they skimmed off half a dozen masses of slag as large as the fist after having put in a small stick of wood and covered the molten metal with charcoal. Still an hour later they removed a dozen such masses of slag; and in another hour, more again. Then after half an hour more they stopped the blast, took away the bellows and tweer and the whole front of the cover, poured on some water, and took off two or three small irregular masses of matte, about 0.8 ft. long by 0.5 ft. wide and 0.03 thick. Then more water

was poured on and similar irregular, somewhat thicker masses of blister copper were taken off two or three times until the hearth was empty. Finally the back half of the cover was removed without breaking; and the hearth was ready to be repaired for the next operation. The liquation process (nambambuki) is next carried out to separate the silver from the copper. About three kamme of blister copper is charged with $1\frac{1}{2}$ kamme of lead (bought at Oosaka), and melted together. The lead is separated from the copper by liquation and carries with it most of the silver. The remaining copper somewhat diminished in weight from what was charged is called nambandoo, and is sold at Oosaka. The lead obtained is also somewhat less in weight than the original amount; and is cupelled at once in charges of three kamme, with an operation about three hours long. The result in silver is said to be seven-hundredths to one-tenth of one per cent. of the raw ore. The ashes of the cupellation hearth are mixed hard wood ashes; and sometimes two or three too are used for one hearth, according to size. There is still another process called the koobuki, in which they charge as much as 25 kamme; but that is not now practised here.

At the upper furnaces the ore and matte are roasted just as at Mr. Adachi's place; and the arabuki is the same. There are eight roasting kilns, of which four are for matte; and they average 20 kamme each in capacity. There is but one arabuki hearth, and it has a diameter of 1.6 ft. and depth of 1.1 ft. and two tweers, with a diameter of 0.1 ft., at the upper back edge of the hearth, 0.25 ft. apart, pointing to a level 0.3 ft. below the front edge, and so inclined towards each other as to aim cross-wise at points 0.7 ft. apart on the front of the hearth. The treatment of the roasted matte is, however, different from that of the lower furnaces; and it is smelted to blister copper by the ginzambuki, a process followed

generally, they say, where there is much silver. The ginzambuki is done in a hearth in the ground, like the mabuki and arabuki hearths, but of a little different shape and size. The back of the hearth is nearly a flat plane, so that the shape of the hearth at top is about semicircular with a diameter from right to left of 1.5 ft. and from front to back (radius of the semicircle) of 0.8 ft. (as it was called, though at the time of my visit it had worn to 1.0 ft.); and with a depth of 0.35 ft. There are two tweers apparently about level at the upper edge of the hearth 0.35 ft. apart, each with a common box bellows behind the chimney back, that separates the bellows from the hearth and supports the usual wide hood. The hearth has no cover. Twelve operations are made in a day of ten hours; but on the day of our visit there were only four operations, ending before four o'clock. The charge in each operation is eight kamme of matte, about four kamme of the galena ore and two kamme of litharge from the cupellation, and five kamme of charcoal; and the the product of twelve operations is 40 kamme of blister copper besides about 18 kamme of matte. The charcoal is charged first and on it the matte with no charcoal on top; and the work consists in keeping the twee holes open. The matte melts and sinks to the bottom; and upon its surface floats some slag (which is thrown away) and about $1\frac{1}{2}$ kamme of matte, and at the very bottom is the blister copper; all three of which are removed only at the end of the operation.

The blister copper next passes to the nambambuki which is much like that of Mr. Adachi Soemon's place. The furnace proper is built of stone in front of a common back chimney wall or screen (behind which there is a single box bellows of the usual kind), and is two feet long at right angles with that wall and one foot wide and perhaps a foot deep at the back, from which a vaulted clay

cover slopes slightly forward. In the side of the cover there is a hole about 0.2 ft. in diameter, at about that distance from the back, and through it coals are put in and flames come out. The front end of the furnace is closed by a movable brick piece nearly semicircular in shape a foot wide and 0.6 ft. high having a hole a little above its centre about 0.06 ft. in diameter. Below the brick there is a gently sloping forehearth somewhat trough shaped, about 0.8 ft. wide at the back and perhaps half that in front and perhaps a foot and a half long, adjoined in front by a rather steep slope of perhaps a foot in length down to the ground. The forehearth is repaired a little every day; but the furnace proper is mended a little only once in about two months.

Two complete nambambuki operations lasted on the afternoon of my visit about six hours. In each complete operation the charge is three kamme of blister copper, $3\frac{1}{2}$ kamme of litharge and three kamme of charcoal. All the copper is charged at the beginning, but only two kamme of the litharge; and the result is 1.4 kamme of argentiferous lead (shiborinamari) of the first quality, which yields $2\frac{2}{10}$ per cent. in silver. Then $1\frac{1}{2}$ kamme more of litharge are added to the copper in the furnace, and the argentiferous lead obtained by the rest of the operation is of the second quality and yields one per cent. in silver. The copper is then withdrawn from the furnace and amounts to 2.8 kamme. It is called nambanshiboridoo, and is sold at Oosaka; and still contains a little silver. Also the other 200 me of copper remain in the form of slag, and are smelted again in the ginzambuki hearth, in charges of about eight kamme at a time. In the operation, after the melting together of the blister copper and litharge, portions of the mixture are from time to time raked forward as a pasty mass from the furnace upon the forehearth. The workman then almost continually presses it flatwise

with the bottom side of a wooden billet about a foot long and a quarter of a foot thick fixed lengthwise to the end of a long iron and wooden handle; but often with the point of the wood he pushes back the paste into rough cross furrows or irregular waves. Occasionally too with a small iron hoe he pushes the paste back into high cross ridges and deep furrows. Meanwhile the more fusible lead separates from the pasty copper, and carrying with it the silver trickles down the gentle slope of the forehearth and the steeper slope in front of that, and cools to an irregular solid mass on the ground below. When the half operation I saw was two-thirds finished, the furnace front was opened and the coals removed from over the metal there by means of a small iron shovel; and all the metal was pushed back from the forehearth into the furnace again. The furnace front was then closed once more and coals put over the opening and over the hole near the back of the furnace cover. In five minutes the front coals were taken away, as the metal had become hot enough again, and the wooden billet was used anew for pressing the pasty mass. Finally the operation ended with cooling the mass of metal remaining in the furnace after removing the coals from the front part.

The cupellation (*haibuki*) is similar to that at Mr. Adachi Soemon's furnaces; but I only saw a very small operation that was made as an assay of ten momme of *shiborinamari*. The cupellation hearth was made of ashes on the ground, and was about a foot in diameter at the bottom, about 0.3 ft. high and with a hollow of about half a foot in diameter at the top. There was a gentle blast given by a box bellows of the usual shape but very small, only about $1\frac{1}{4}$ ft. long, and worked with one hand.

In the first half of 1878, at the upper furnaces they smelted 20.4 tons (5,479.5 *kamme*) of ore, and made nearly $1\frac{1}{4}$ tons (330.8 *kamme*), or six per cent. of copper, sold

for \$301.47, and $45\frac{2}{3}$ lbs. (5.4795 kamme) or $\frac{1}{10}$ of one per cent., of silver, sold for \$828.20; or in all \$1,129.67. The expenses (besides \$3 taxes) are said to have been \$957.24, of which \$669.24 were for the mines, and \$288 for the dressing, roasting and smelting of the ore. The number of men employed is 40, of whom 24 are miners 13 are furnace men and ore washers, and three are in the office. At Mr. Adachi Soemon's places there are 22 men employed; namely, 12 miners, 7 furnace men and three in the office. Wood is brought from up stream, and costs 22 or 23 cents for 100 kamme. Charcoal comes from two or three leagues to the eastward, and costs 55 cents for 30 kamme (one load). One too (about half a bushel) of ashes costs about two cents. A miner's wages are 14 cents without rice; a furnace man's, 10 cents; and a woman's, at ore washing, eight cents. To mine a length of five feet by 1.5 ft. (or 1.3 ft.) in width and 4 feet in height costs in the hard places in the vein nine dollars; in a soft place six dollars; in the country rock six dollars; including the cost of rice, powder and oil.

With the present exceptionally low wages there is a little profit, as already seen. It is highly probable that the veins that have yielded so finely in former times would still be worth working below water level with modern appliances for raising water. It must however be borne in mind that the veins are very short ones, and even the three wide ones may not continue wide to a great depth; and that the greatest prosperity was very long ago, and that the workings of the last 300 years have perhaps been penetrating to gradually poorer and poorer places as they grew deeper. The mines seem to be well worthy of a careful and thorough geological and topographical survey, which would most likely prove to be a satisfactory guide to future working. It would be folly to undertake any great outlay without first making such a survey at com-

paratively little expense ; and no very costly works should be established without having first (by exploratory mining, if necessary) the certainty of a satisfactory amount of ore.

The mines are in one respect pretty conveniently situated, for they are only a couple of leagues from two small harbors on the sea shore. The road to Ooda is mostly down hill ; and, though only a bridle path, might without much difficulty be replaced by a waggon road. The road towards Hamada would be much more difficult to improve.

Our road from Ginzanmachi rose steeply about 250 feet higher and crossed a pass where the slightly decomposing andesite rock already described is much exposed, in some places crumbling; and then descended to Nishida a league distant to the northwest, near the sea shore. At Nishida we were shown specimens of alum stone that were said to come from a place a mile and a quarter to the northeast. It was said to be found in a hole about one foot in diameter in a rock as big as a house. The brown crumbling powder of the stone is said to be used instead of alum; and has its taste. The stone is likewise a decomposing andesite containing glassy triclinic feldspar (probably oligoclase), augite, magnetite and decomposing mica.

About two-thirds of a mile forward from Nishida, at a spot called Sakanezaka, just short of the top of a low hill there is at the road side an exposure of about a foot in thickness of quite unworkable, dark gray, slightly carbonaceous, heavy shale or extremely impure lignite. It dips 20° south 60° west. It is probably of about the age of the Toshibets group of rocks in Yesso.

At Nishida they told us about some hot springs at Ynnotsu, on the sea shore $1\frac{1}{2}$ leagues forward from Nishida, but not by the Hamada road that we took. There are two springs just alike about 120 yards apart,

They are hot, but you can hold your hand in the water where it issues from the mouth of the pipe, and no cold water is added for bathing ; probably about 43°C. They have a little saltish taste, and a little smell of sulphuretted hydrogen.

From Sakanezaka we went westward among rather low hills not very far from the sea shore, with exposures here and there of the same decomposing gray or greenish brown or light brown andesite, in some places firm, in others crumbling, often clearly about level, to Kuromatsu, by the sea three leagues from Nishida. From Kuromatsu the road three leagues to Goota ran a little south of west along the sea beach of light brown loose sand, or very near the sea over low hills of loose sand, or with occasional exposures further on of hard gray micaceous porphyry, or again of hard pebble rock like that near the Iwami and Idzumo boundary, quickly succeeded as there by greenish gray and greenish brown soft tufa sand rock for a short distance, and then by the hard gray porphyry again, to Goota, a small seaport at the mouth of a pretty large river three leagues from Kuromatsu. Near Goota there were some exposures of crumbling brown granite, and it was said that iron sand was washed a couple of leagues upstream, south-eastward. Such exposures with some brown shales and some of firmer granite continued here and there along the road over low hills to the sea beach at Hashi which we traversed for a distance of about a league. Thence passing some pale red tufa pebble rock and yellowish brown and reddish brown perhaps tufaceous sand we met with many more exposures of brown or gray and greenish brown crumbling granite and brown granitic sand till we reached Hamada a seaport of some importance, six leagues from Goota. Near Hamada we heard something of the great earthquake of 1872, which was felt most in that town though more or less through a space of

several hundred miles. It was said by some that out of a thousand houses there 850 were shaken down ; but that was probably an exaggeration, and it would appear that only poorly built houses fell.

From Hamada we went south-westward along the sea shore or near it over low hills with numerous exposures of gray and brown Kamoikotan shales, often crumbling, to Misumi ($5\frac{3}{4}$ leagues) and for a league or more beyond. Then still near the sea through a like hilly country to Tsuda on the shore some four leagues westerly from Misumi there were many exposures of brown or reddish brown crumbling granite and in one spot at least, near a low mountain pass, about 700 feet high a couple of leagues short of Tsuda there was a fine grained diorite with many minute specks of yellow iron pyrites and a very little dark brown mica. Then shortly beyond Tsuda brown and gray, level bedded shales were exposed here and there among low hills for a league or so south-westerly to near Masuda, five leagues from Misumi. Near Masuda there were a few exposures of brown and gray crumbling granite, and then there were brown shales again. Nearly a league beyond Masuda however there were exposures of level bedded greenish gray soft shaly sand rock containing at one point by the road side a streak of black shining bituminous coal about 0.1 ft. thick and five feet long, and the similar level shales east of Masuda probably belong to the same formation. From near Masuda we left the shore of the Japan Sea and went up southerly the hilly valley of the Takatsu River, a rather small stream. For half a league or so beyond the coalstreak there were exposures of like greenish gray soft level sand rock and then of pebble rock probably of the same formation. Thence brown and light gray and blackish Kamoikotan shales occurred here and there all the way to Tsuwano, eight leagues from Masuda. In approaching Tsuwano we had views of the conical,

volcanic looking Awano Mountain perhaps half a league south-easterly from Tsuwano; but as we did not meet with any volcanic rocks its eruptions probably were not very extensive. Its volcanic character however is confirmed by Mr. Takashima Tokuzoo, who has given much time to the study of the neighboring province of Nagato, and according to whom the rocks of the mountain are basaltic.

The old Sasagatani copper mines in Nakagoya, a part of Toyoka village, are said to be three leagues northerly from Tsuwano. It is said that their yearly product is $4\frac{1}{3}$ tons (1,360 kamme) of blister copper. As we were told, some arsenic is now found there.

From Tsuwano, which is about 550 feet above the sea, we travelled south-westward and crossed within a league a pass about 1,300 feet above the sea, and entered there the province of Nagato. Going thence six leagues south-westerly to Makidani descending a rather wide valley with a little alluvial land in its upper part, near Takanosu, $2\frac{1}{2}$ leagues from Tsuwano among the mountains, we then ascended a narrow branch valley westerly for two leagues and a half, past Shinome to a pass about 1,200 feet high above the sea, and entering there the province of Suoo went southerly down a steep narrow valley that gradually widened out and grew level until we reached the large town of Yamaguchi in the edge of a broad alluvial plain. There were many exposures along the road of gray and brown mostly crumbling quartz porphyry; containing, for example, at the Shinome pass much quartz in dark brown pea size crystals and very numerous, but minute decomposing white feldspar crystals in a scanty reddish and greenish gray decomposing matrix. About a league and a half short of Yamaguchi there was an exposure of dark gray shales; and the rest of the way was gently sloping ground without rock exposures.

The Zoomeki copper mines in Nagato, are four leagues

westerly from Takanosu, on the road to Hagi. We were told at Shinome that the blister copper was sent out by that village (no doubt on its way to Oosaka), and that there were about fifty loads of it a month amounting to about 1,600 kamme, or about $5\frac{1}{10}$ tons. They said that the ore of late had been more abundant than formerly and the product consequently greater ; but that the working of the silver and antimony (shirome) mine there had been abandoned.

At Yamaguchi we were shown by the prefecture a very neatly drawn and colored geological map of the two provinces of Nagato and Suoo made by Mr. Takashima Tokuzoo, who had for the purpose spent three years in visiting every part of those provinces. So far as my own observations go, the geographical limits of the different kinds of rock would seem to be very carefully given, and probably they are equally correct everywhere else. In addition to "basalts, porphyries and granites" he separately colors six divisions of sedimentary rocks, besides two subdivisions, and doubtless quite correctly as regards their relative superposition, though the French stratigraphical names he gives to them can hardly be exact. There was also a neat map by him that showed in five colors the limits of as many kinds of topography, such as plains, steep, high mountains and the like ; but without any heights given, as he had no barometer. It would be very advisable to publish the essential parts of both maps, especially the geological one.

In the western edge of the town of Yamaguchi there are some hot springs, seven in all, within a space of perhaps forty yards in length. The temperatures in the baths, over the points where the water issues from the alluvium, were 42° , 43° , 43° , 44° , 45° , 46° , and 51° C. The water contains enough sulphuretted hydrogen to smell decidedly of it and to blacken silver strongly. The

quantity of water that flows at each place appears not to be very great ; and the baths, about 45 cubic feet each, are emptied but three times a day, about five or six hours apart, only showing thereby a yield of at least about a gallon a minute.

From Yamaguchi we went south-westward by the main road about nine leagues to Funaki and eight from Shimonoseki. The road was in general very level and for the first league lay in the midst of the alluvial plain, then for half a league or so as far as Ogoori, it ran along the foot of low hills on the right and half a mile from high ones on the left, with a number of roadside exposures of dark gray mica schist that in parts had a great deal of white quartz. Thence the road had a more westerly course at first though nearly level ground but afterwards more hilly and across a low pass a couple of hundred feet high ; with exposures here and there of brown, greenish brown, gray, or reddish gray crumbling granite. Near the pass (where we entered Nagato again) the granite is reddish gray coarse grained and handsome with pale red orthoclase, greenish white nearly transparent triclinic feldspar (probably oligoclase), grayish quartz, blackish green mica and traces of magnetite. About a league short of Funaki there is an exposure of dark green coarse-grained diorite containing greenish triclinic feldspar (probably oligoclase) greenish black hornblende and a few minute specks of pyrites.

Coal is worked near Funaki at several mines in the village of Ariho, about a league to the south ; at some smaller ones in Onoda, a league further on, near the sea shore ; at others again in Ube, likewise on the seashore, perhaps still a league beyond southward ; and at a few small mines in other neighboring villages. There are two mining companies : one is called the Arikokaisha and has the mines of Ariho and Onoda, as well as one at

Hirabara, about a league south-west of Ariho, and one at Sue about a league and a half south of Ariho ; and the other company, called the Fukubara Hoosan has the Ube mines. The coal-rocks form a very small field, and rest upon the granite which is the only rock to be seen until you come close to the mines. According to the apparently careful outlines drawn on Mr. Takashima's map the extent of the field is about 22 square miles. The coal beds are said to lie in wave form, but with very gentle dips. There appear to be but two beds of coal that are worked at Ariho (or probably in the whole coal field): the Nakabori, containing $3\frac{1}{2}$ feet of coal ; and the Chiugoo, or Mashika, 25 (in some places 35) feet below, with $2\frac{1}{2}$ feet of coal exclusive of some refuse (some say about three feet of coal and one of refuse). The distance between the beds of coal varies from place to place ; and the quality of the coal varies too. Although the Mashika and Chiugoo are the same bed at separate places, their quality is different. The quality is said to be best near the Kawaraya mine in Ariho and for a few hundred yards up-stream ; thence further up-stream and down-stream the quality is inferior. The Nakabori coal is rather worse than the Chiugoo. Over the Nakabori there is said to be black hard stone ; and for 20 feet in thickness the stone is hard. The Chiugoo likewise is said to have a strong roof of hard black stone ; and to have hard stone all the way up to the Nakabori. There are also some three or four smaller seams of coal that are not worked. At Ube and Onoda they work only the Nanakoo coal bed (said to be probably the same as the Chiugoo, which it resembles) and the Niudoo about 15 feet above (corresponding therefore to the Nakabori). The Ube coal is called better than the Chiugoo, but the Onoda inferior. The coal that I saw in the heaps at the boat landing in Ariho (from the Chiugoo,

Mashika and Nakabori) was poor looking, slaty, small and dirty ; though there were many lumps a foot or more in size that seemed very firm. The following is an old section at Ariho shown us at Yamaguchi, as it had been prepared by the Ariho coal company :

Double Bed	{	Coal	0.6
		Dark yellow stone	0.2
		Coal	1.2
		Stone	20.0
		Purple stone.....	0.5
Four Ply Coal	{	Coal	0.6
		Black slate	0.2
		Coal	0.5
		Black slate	0.2
		Coal	0.5
		Black slate	0.4
		Coal	0.8
		Black slate	0.8
Nakabori Coal	{	Coal	1.3
		Black slate	0.4
		Coal	0.5
		Black slate	0.4
		Coal	0.8
		Black slate	0.3
		Coal	0.7
Sokobori Coal	{	Blackish stone.....	2.0
		Coal	1.5
		Stone	35.0
		Blackish stone.....	0.3
		Coal	0.3
Chingoo Coal	{	Blackish stone.....	1.0
		Coal	0.8
		Blackish stone.....	0.4
		Coal	0.7
		Blackish stone.....	0.3
		Coal	0.7
		Blackish stone.....	0.2
		Coal	0.2
		Stone	15.0
Santoku Coal	{	Coal	0.8
		Dark yellow stone	0.2
		Coal	0.9

The coal is mined in the post and stall or bord and pillar system ; but with very long narrow pillars.

The mines at Ariho are partly at least in the flat alluvial ground along the small river that flows past Funaki to the sea near Onoda. The mining is therefore carried on only in the winter half of the year, beginning in the middle of October and ending in April, when the paddy fields are not flooded. On the other hand the carrying of the coal takes place in the summer season, while the mines are full of water ; and meantime the coal is in piles in the open air. As the mines are below water level they have to be pumped, and Japanese pumps of bamboo are used. It is said that 5,600 koku of water are raised a height of sixty feet, on a slope, it must be, of 45° , as that of the Kawayaya mine, in one day by 80 men, that is 70 koku, or 3,360 American gallons, or 2,800 English gallons, or 1,176,000 foot pounds to each man, a very good result. It costs thirty dollars a day to pump the Kawayaya mine in the rice fields of Ariho ; and \$150 a day to pump the four mines of the company. As the mines were not yet pumped dry at the time of my visit in October I did not go into them. The mines have inclined shafts (slopes), in which the pumps are also inclined ; and the coal is brought out on the backs of men. The coal is carried from the mines to the small river at Ariho partly on two wheeled carts on roads that have, in places at least, planks laid lengthwise at each side for the wheels ; and partly on horseback, and partly on the backs of the men that lead the horses. From the Mashika mine at Ariho the coal is carried on horses about a third of a mile ; from the Nakabori mine in Ariho it is carried about a mile and a half, and even more than two miles from the farthest place. The Mashika and Nakabori mines produce coal about equally and both together about 300,000 piculs in a year. The Onoda mines yield about 100,000

piculs ; making about 400,000 piculs a year for the whole product of the two villages. The Ube mines yield, it is said, about 300,000 piculs a year ; making in all about 700,000 piculs, or 41,741 tons, as the yearly product of the whole coal field except some very small mines on the west.

It is obvious that the carrying of such considerable quantities of coal could be very much cheapened by improved methods, such as the use of tramways and cars, with shoots for loading and unloading. It is probable too that moderately costly improvements in the navigation of the river would make it navigable for the small coal boats to some distance further up stream so as very much to facilitate carriage from the upper mines. It is evidens too that with fuel so close at hand small steam pumps would be cheaper than the present pumping by human labor. There are, it is said, old abandoned mines under the rice fields adjacent to the mines now worked, and full of water that is liable, if approached too closely, to flood the present working and thereby add to the pumping labor that would be required. The precise position of such dangerous spots would seem to be known only by tradition, if at all ; and in time the uncertainty must become greater and greater. As the whole amount of workable coal in the 22 square miles would be 22 million tons for every foot of average thickness of the beds that can be worked, it is clear that the field, although it must contain less than a hundred million tons of such coal, (and probably not more that 35 millions according to the averages of our Yesso surveys) will be worked for a very great number of years ; and it is therefore highly important that all the facts in regard to the position of worked out, abandoned mines and other features of the coal beds should be ascertained as fully as possible by a thorough survey and recorded in maps and reports.

Returning up the narrow flat valley bordered by low hills, past numerous exposures of brown crumbling and reddish gray granite to the edge of Funaki, I went by the main road again, southwesterly to Shimonoseki, all the way among low hills, and the last third of the way near the seashore. The exposures of granite quickly came to an end, but first were seen to be overlain by some of the coal-rocks, a greenish gray soft sand rock with an inch or so of black coal slate that thinned out within ten yards, with a dip of 18° N. 55° W. ; and coal was said to be dug a short distance to the north of the road. Then there were exposures of light brown and greenish gray shales probably of the coal formation ; but at about a league from Funaki, at a pass a couple of hundred feet high, there was exposed a very fine grained, greenish brown weathering, greenish gray granite ; and after that there were brown and gray shales again for another league to near Fukuda. Thence all the rest of the way to Shimonoseki there were numerous exposures of brown crumbling granite. While waiting for a favorable tide to cross the strait, I went on a pleasure excursion to Ichinomiya a league or more to the northeast among hills a couple of hundred feet high, and found the brown crumbling granite here and there all the way.

From Shimonoseki we crossed the strait of a league in width to Dai-ri, in Buzen, on the Island of Kiusiu, seeing many exposures apparently of the same brown crumbling granite on the low hills to the north east of the town. From Dai-ri we went westerly to Kokura, a league and a half, along the seashore, with a level road most of the way, but passing over the side of a low hill soon after starting, where was exposed hard, dark brown Kamoikotan shales. Just beyond, there were exposures of fist and even head size pebble rock with hard feldspathic pebbles. Continuing westward from Kokura over gently rolling

ground without rock exposures, within a league or so we entered Chikuzen and came to an exposure of the head size pebble rock again, and immediately after that to large blocks of black slate or shale at the village of Ookura. Thence we went westerly over and among low hills with exposures of brown crumbling granite to Kurosaki, three leagues from Kokura; and then south-westerly another league through a like country with like exposures to Uenohara. Just beyond that village there was an exposure or two of coal rocks, dark gray shales with thin seams of rather rotten black slate and slight traces (about an eighth of an inch in thickness) of black shining coal. But the greenish brown and reddish crumbling granite and granitic sand and brown earth quickly recurred, and in a few hundred yards were followed by hard blackish Kamoikotan slates; and then with occasional brown granitic sand and earth the road reached Koyanose in a pretty wide alluvial flat at the side of a small river. Thence southerly though the plain in about a league we reached the Ootate coal mine at Shimma in the village of Naogata, at a small hill, where a gray, coarse granular limestone is quarried for building stone. The limestone contains several minerals: much calcite in white crystalline grains, some parts impure with greenish gray, some grains of limpid quartz, some of chalcedony and some small black specks containing magnetite. The small hill runs north-west and south-east with a gap through which the road passes, and within a score of yards of which on either side of the road are all the mines. The quarry is on the north-east side of the hill and the mines are on the south-west, with a north-east dip of about 15 degrees, it is said; so that the coal passes below the limestone, at least 45 or 50 feet below, it is said. On the south-western side of the hill at an exposure of the granular limestone I saw one dip of 9° N. 30° E. The following is the coal section downwards as it was given to me at the mines:

	ft.
White clay	45 to 50.0
Coal (Yamahari)	2.5
Clay	4.0
Coal (Suita)	2.5
Black slate	3.0
Coal (Kankan)	4.0
Sand	1.0
Coal (Five Foot)	5.0
Slate	0.4
Coal (Kusaishi)	2.5
Black slate	1.5
Coal (Sammai)	1.5
Black slate	2.0
Coal	2.0
White clay	13.0
Gray (grit ?)	2.0
Coal (Three Foot)	3.0
Slate	1.0
Coal (Oni or Banjita)	1.0
Gray shales, with no other coal below... —	
	101.9

The section when drawn and compared with a drawing of the section at Ariho in the Funaki coal field has so much resemblance in spite of some differences of thickness that it seems pretty certain that the two fields were once connected. The only two beds worked at Naogata are the Five Foot and Three Foot, twenty-five feet apart (some called the distance 35 feet, and it is doubtless variable, as at Ariho); corresponding therefore very well to the Nakabori and Chiugoo there both in relative thickness, distance apart and apparently in their superiority to the other beds in most of which there is likewise a good correspondence. The little coal left lying about the mines did not look very good, as it was rather small and dirty;

but a very good specimen was picked out for me, apparently better than the average. The Three Foot coal is the only one worked at present; but there is an old slope, ten fathoms deep with a dip of 20° , on the Five Foot, worked from August, 1877, to January, 1878. There are three slopes of about the same steepness on the Three Foot bed and, besides an abandoned shaft, a new one at which they had when we passed lately set a seven horse power steam engine at work pumping water. Owing to water in the down-cast shaft and consequently too bad air in the mine for the lamps to burn well I did not enter. The abandoned shaft is 36 feet deep, the new one 50 feet; the principal slope is 20 fathoms deep, reaching the coal in 15 fathoms. The working had been a suspended on account of water from June until within few days. The mining is done with narrow long pillars six or even only four feet wide and bords or stalls 20 or even 30 feet wide; and the pillars are taken out after reaching the limit of the lease, which is only one of 2,000 tsubo (or $1\frac{2}{3}$ acres). There are 30 miners employed Gunpowder is not used. The coal is brought out of the slope in a pair of baskets at the ends of a shoulder pole, the pair holding one picul. The miners are paid $2\frac{1}{2}$ cents for cutting one picul, or about 40 cents a ton. The coal is carried from the mine on horseback about 360 yards to the river bank at a cost of one cent a picul; and thence goes by boat seven leagues to Wakamatsu, (at the mouth of the small bay into which the right hand mouth of the river empties) at a cost of $2\frac{1}{2}$ cents a picul. The boats carry 100 to 140 piculs each, according to the varying depth of the water in the summer. The coal is mined in the summer as well as in the winter. They said that this was the only mine in Chikuzen that had a steam engine; but that there was one other at Akaji, up an easterly branch of the river, in the edge of Buzen. They

said too that the mines about Iidzuka (Chikuzen) had all been abandoned on account of getting too deep below water level; and that the mines at Naogata were the only ones at work in Chikuzen.

From Shimma we kept on a league and a half in a south-westerly direction (below the coal therefore) up the left bank of the river through the somewhat narrow alluvial plain with high hills or mountains on the left, along the boundary of Buzen, and low hills on our right, and occasionally close to us, with exposures of greenish brown or bright red crumbling granite or granitic earth, or possibly shales of the lower part of the coal formation, to the village of Kodake, two leagues short of Iidzuka. Near Kodake there were heaps of coal at boat landings along the river bank; but the quality seemed poor and dirty, and it was said to be sulphury and to fall readily into powder. Lime is used as a fertilizer near Kodake, and it is said to come from Akaji and from half a league northerly from Naogata. Our south-westerly course along the bank of the river in the alluvial flat continued yet a league or so further, to Koobukuro; and on the way we saw at boat landings numerous coal heaps all of the same poor appearance. A few hundred yards above Kodake, we passed near a coal mine on our right that was not at work, but was said to be four or five fathoms long with five or six feet in thickness of coal. There were said to be mines in the neighborhood 600 yards long, but none of them now at work. It was said too that the coal that it paid to work was found only here and there in spots, though the beds were much more widespread; and that granite occurred here and there excluding the coal formation. Coal was said to be mined at Aida about a league west of the river, and to be richer in bitumen than the other coal of the region, and to come from the Kankan Five Foot, probably the same as the Five Foot Bed of

Naogata. The coal of this region is used for salt boiling near Mitajiri, and is not reckoned good enough for steamer use.

Near Koobukuro we passed a small, idle coal mine, and an exposure of gray and brown soft sand rock with coal slate. Leaving the river there we continued in a south-westerly direction, and entered among low hills, passing in about a league, at Igisu, another small abandoned coal mine and within a mile of the Hanase coal mine, which some said was not actually yielding coal but was getting into working order. It had been opened in the spring of 1878, and worked until August, and now with a new slope of eight fathoms in length they were baling out the water. The dip was represented to be 45° north-easterly. The coal bed worked is also called the Kankan Five Foot, and said to be in two layers, one of three feet above and the other of two feet below separated by 0.8 ft. or 1.0 ft. of white soft clay. Over it is poor coal four feet thick; and ten feet below is the Eight Foot Bed (said to be all coal); below which are three feet of black slate; and below that again $2\frac{1}{2}$ ft. of poor coal overlying white clay. The Eight Foot coal is only used for salt boiling, and is said to be sold at Ashiya (at the left hand mouth of the river) for \$11.15 the hundred piculs (or $\$1.87\frac{1}{2}$ a ton); and the freight to Ashiya costs \$4; of which \$2.70 are for the carriage on horseback to the river, and \$1.30 thence by boat to Ashiya. To Wakamatsu the freight costs a dollar more the hundred piculs. It was expected that the Kankan Five Foot coal of Hanase would bring \$16 or \$17 the hundred piculs (or about \$2.80 a ton). The mine was said by its owner to be yielding already 50 or 60 piculs (or $3\frac{1}{2}$ tons) a day, with about 20 men at work. Northwest of Hanase and Aida there are no coal mines worked, and we saw nothing more of the productive part of the Chikuzen and Buzen coal field.

The coal leases of the field are scattered over a space of about 220 square miles, of which 160 square miles are in Chikuzen and 60 in Buzen. It is evident however that not by any means all that space is underlain by productive coal beds ; perhaps not one-half of it is, possibly not even a quarter. The coal beds seem to dip rather steeply so that they quickly reach a depth too great for the methods of pumping hitherto chiefly used, and perhaps become too deep even for any working ; and the ancient granitic rocks enter the field here and there ; so that the portions of the two beds of passable quality hitherto found workable are only comparatively small scattered patches. Reckoning eight feet in thickness of workable beds, and judging by the result of the measurements of our surveys in Yesso, there may be about five hundred million tons of workable coal in the whole field ; but that is scarcely better than a very rough guess. It is very well worth while and greatly to be wished that a careful topographical and geological survey should be made of the whole field, not merely to determine the quantity more precisely, but to ascertain and record fully the facilities for mining and every feature connected there with. What has already been said of the advantage there would be in using tramways and steam-pumps and conveniences for loading and unloading in the Funaki coal field applies of course with at least equal force here. Even common waggon roads by reducing seven-eighths the present cost of land carriage of the Hanase coal, for example, would save \$2.36 on every hundred piculs, or about forty cents a ton, in itself a handsome profit.

From Igisu, we kept on south-westward soon joining the main Iidzuka and Fukuoka road, and crossing low and not very steep hills, with exposures here and there of crumbling brown granite (which sometimes contained red and greenish brown pebbles and fragments), as far as

Sakanoshita some two leagues and a half from Kodake. Thence rising steeply and passing exposures of talcschist (about vertical with a north-north-easterly strike), brownish slate and dark brown shales we crossed a pass about 750 feet above the sea, with exposures of greenish black serpentine; and then without much descent traversed rolling ground for a league with exposures of brown and dark brown, crumbling, schistose felsite or hard shale, until we crossed another pass about 1,000 feet above the sea, near which talcschist was exposed again and, a little further on, some blocks of serpentine. Thence descending westward within a league, near Kido, we came to many exposures of greenish gray serpentine in place, which continued for nearly a league to Sasaguri. From that town the road went westerly three leagues to Hakata and Fukuoka through a very gently descending or level flat that soon became very wide after passing mountains of a thousand feet in height. About a league from Sasaguri we passed a small hill on our left with an exposure of pale green limestone, weathering brown, probably of the coal bearing formation. Near it we saw at houses small heaps of very dirty looking, powdery, slaty, sulphury coal, that was said to have been brought from an old coal mine a few hundred yards to the left, which had been abandoned for fifty years. There is no coal known thereabouts that is worth working; but the existence of its traces has given the impression that the Chikuzen productive coal field had a very wide extent. Soon thereafter we met with brown granitic sand and earth, but there were no more exposures of rock in place.

At the Fukuoka Prefecture we saw small pieces of poor-looking copper pyrites and tin ore from near Sasaguri; but the mine is not now worked, though green vitriol is made. We were also given a printed Japanese copy of a report on the Chikuzen and Buzen coal by Mr.

F. A. Potter, the mining engineer of the Miike Coal mines. It appears to be a valuable paper, and I hope to print a translation of it along with our special reports, as he has kindly assented to our doing.

On our leaving the large double town of Hakata and Fukuoka, we were shown in the western edge of the latter, at Nishishimmachi, perhaps a league from the Prefecture a place where soft brown crumbling sand rock, looking like crumbling granite, was exposed, and where at a lower level coal was dug for less than a year in 1874 or 1875. The dip was about level. It is said the coal bed was half a foot or three quarters thick and not of very good quality, falling to powder in the rain (on account of the decomposition of the iron pyrites); but the roof was firm. The working, with a slope and below water level, was abandoned because it did not pay; and clearly it could not be profitable.

Going thence westerly over level ground near the seashore, within a league we passed some low hills on our right where there were exposures of a greenish gray, hard grit with level dip, probably also a part of the coal formation. Thence westerly through a plain, or among very low sand hills for more than a league there were no exposures; but then along the seashore at the foot of low hills there were many exposures of crumbling gray and brown granite for more than half a league to Imajiku. The road then ran westerly through a plain without rock exposures for a couple of leagues, with views of Henasan or Chikushifuji, nearly before us on the right, a mountain perhaps a thousand feet high with volcanic shape. Then the road went still westerly by the side of or over low hills, crossing the neck of a pretty large peninsula, and then at times near the seashore, with many exposures of crumbling brown granite, in places holding hornblende, until we entered the province of Hizen; and at length with

a couple of leagues of flat ground near the sea we reached the large town of Karatsu ten leagues from Imajiku. At the south-west end of the peninsula just mentioned at Ootozaki in Keya village, there is said to be a very fine cliff of columnar volcanic rock with columns more than 200 feet high and with a cave among them accessible to small boats but never yet explored to the end. Having read that porcelain was made at Karatsu we made inquiries about it; but learned that none at all was made now, and that no fine pieces ever were made there, though formerly they did make coarse crockery.

From Karatsu we travelled southward up the left bank of the Matura river that was very wide (perhaps 600 yards) at first but very shallow. Even at the mouth it is said to be too shallow for large junks. The land on either side of the river was at first a wide flat with views of the conical Kagami mountain perhaps 800 feet high to the south-east and the conical higher Yoshidake beyond; but in less than a league we came to low hills on our right with many outcrops of light gray and light brown crumbling granite, which continued until we came within about half a mile of Tokusue, three leagues from Karatsu. Then we met with exposures of light brown coarse sandrock or grit, partly filled with pea size pebbles, and having a level dip. A few score yards further on, the sandrock was shaly.

I turned aside there from the main road, and visited the Takeari small coal mines about a mile to the south-west, though as it was a holiday they were not at work. The dip there is $21\frac{1}{2}^{\circ}$ N. 55° W. The section downwards is as follows :

	ft.
Shales, said to be some	8.0
Coal, called	0.8
Shales, said to be about	7.5

Firm sandstone ("whetstone") exposed	
about 4 ft. said to be	12.0
Rotten coal	0.1
Coal, called 0.8 or 0.9, but measures ...	1.3
Shales with no coal known below, exposed	2.5
	<hr/>
	32.2

The upper coal is not worked now, though opened by a short slope. The lower coal is said be all caking coal. It is in three layers of which the upper is called 0.45 ft. with a smooth dividing surface below, and is of good quality, though weathering dull; the middle is called 0.15 ft., and is sulphury, with copperas; and the lower layer is 0.3 ft., the best of all, very firm and bright and with small grains of amber. The bed has been worked with a slope for three years, and there is said to be room in the mine for 300 miners. There appear however to be but ten men commonly at work, five digging and five carrying out and they produce in all 75 loads (of $1\frac{1}{4}$ piculs each), or $93\frac{3}{4}$ piculs (or $5\frac{6}{10}$ tons) a day. The digger and the carrier are paid equally, each eight cents a day, besides 0.75 shoo of rice, worth 4.8 cents, and 0.25 shoo of sake, worth 3 cents, and 0.25 shoo of oil worth $12\frac{1}{2}$ cents, (to be burnt in a shell); and tools (picks) are furnished free at a cost of 3.2 cents (or more) in 20 days to each man. Gunpowder is not used. The coal is holed under across the whole breast, without any hole at the side, and broken down. The gangways are 2.2 ft. high; and the bords 1.3 or 1.5 ft. high and 30 ft. square; and the pillars are six feet wide and 30 ft. long. The coal is drawn out in shallow bamboo baskets 1.75 ft. wide by 1.9 ft. long on ironshod wooden runners 0.4 ft. apart, holding a picul and a quarter.

At Tokusue I was told by the owner's son about the Hieda mines, the principal ones then working in the

neighborhood, though idle that day. They are two-thirds of a league from Tokusue, up the south-westerly branch of the river which forks below that town. The section downwards at the mines, at Idenotani, is said to be as follows :

	ft.
Whetstone, about.....	8.0
Coal	0.6
Whetstone, averaging about	12.0
Coal (Ichimaimon)	0.8
Slate	0.6
	<hr/>
	22.0

There is no coal known above or below the section given. The Ichimaimon is the coal worked at Takeari. At Hieda, there is no slope but a level drift, and consequently no trouble from water. The mine is about 120 fathoms long. The number of miners is very variable ; but there are ten men at work on the average, five cutting coal and five drawing it out; and they produce all together about 70 piculs a day. The men are paid 11 cents for each basket or sledge load of $1\frac{1}{4}$ piculs; and the rice, sake and oil taken are subtracted from that price. The coal is carried from the mine on horse back about 500 yards to the boat landing on the river, at a cost of \$2.50 for the 100 piculs. Thence it goes by boat to Midzushima (at the mouth of the Matura river opposite Karatsu) for \$1.10 the 100 piculs from Hieda, \$1.20 or \$1.30 from more distant landings and about \$0.90 from Takeari. The mines are worked summer and winter. The Hieda mines are the largest mines near Tokusue, except the Kishiyama, "which are in fact the only large ones."

The Kishiyama mines are two miles from Tokusue up the main, south-easterly, valley on the road to Saga. They had been abandoned more than a year, owing to having become too deep under water, with which it was still

full; but they were about setting up a steam engine to pump it. The section there as given me at Tokusue is as follows, from above downwards :

	ft.
Poor coal including slate and bone	1.2
Shales, some 12 or 13 feet	12.5
Good coal	0.9
Whetstone.....	8.0
Coal (Three Foot)	3.0
Whetstone.....	15.0
Coal, Five Foot (including 1.5. ft. or 1.6 ft. of slate and bone)	5.0
	<hr/>
	45.6

The Five Foot bed with 3.4 or 3.5 ft. of coal is the one mainly worked. The Three Foot Coal is probably the same bed as that worked at Hieda and Takeari. In the whole region about Tokusue there are, it is said, 400 or 500 coal mines, and some of them at Iwayaguchi about three leagues up the south-east valley from Tokusue yield 200, 300 or even 400 piculs a day; and are said to have three coal beds, as follows, from above downwards ; the Ichimaimon about 1.0 ft.; the Nimaimon about 1.1 ft.; and the Sam-maimon, about 1.5 ft. or 1.6 ft. It is estimated that on the average, summer and winter, 5,000 (perhaps even 6,000) piculs of coal a day or 150,000 piculs a month (say 107,000 tons a year) go to Midzushima from the whole valley; an average of about 2,000 tons a year from each mine.

The coal mines of the whole Matsura valley appear to be scattered through a space of about 27 square miles ; and reckoning the thickness of the workable coal beds as averaging three feet in all, and judging, as before, by our Yesso averages, there may be at a rough guess something like 25 million tons of workable coal in the whole valley,

though it would hardly be safe to count with much confidence on so large an amount. The beds are mostly very thin indeed ; but owing to the softness of the underlying shales and to the firmness of the roof and to the facilities for shipment have been found workable at a thickness of one foot and a third, and nominally even less than one foot, at least for mines above drainage level and not very deep from the surface of the ground. It is evident that it must be very desirable to improve the means of carrying the coal from the mines to the river, and the means of loading and unloading ; to replace the bamboo hand pumps by steam ones, on the so called Five Foot bed at least ; and especially by a thorough geological and topographical survey to lessen to the utmost the uncertainties that are unavoidably connected with underground work. It is possible that with the maps of such a survey tram-roads might be planned that would conveniently carry the coal of several neighboring mines to the river, or even a railroad that would carry the whole product of the valley to a sea port more cheaply and satisfactorily than can be done by the small boats that require so much loading and reloading, before the coal finally reaches the hold of sea going vessels.

From Tokusue we travelled up the south-westerly narrow valley and between and across low hills, that on the road were about 200 feet above the sea, to Imari at the head of a long narrow north-west and south-east bay. There were numerous rock exposures along the road or near it, mostly of greenish sand rock weathering brown, probably a part of the coal formation ; but about the end of the first league there was gray and brown crumbling granite, or most likely similar sand rock to that at Fukuoka of granitic materials, and like the other harder sand rock with a level dip. After that there were brown shales and a greenish grit both also level, and no doubt likewise of the coal formation.

From Imari I went southerly three leagues and a half to Arita, across low hills with a pass 300 feet high just short of Arita and with numerous exposures of greenish brown and light brown shales probably of the coal formation, and with moderately steep northerly dips near the pass. A league or so short of that however there were high dark brown cliffs on the side of the mountain some distance to the west that may have been of Old Volcanic rocks; for Mr. Adachi who passed to the west of that mountain (Kaigashidake) picked up at the foot of one of its spurs some pieces of obsidian and was told that it was abundant on the mountain. He also thought that the mountain next to the west and near Oogi was likewise volcanic. At Oogi itself however coal is dug, as I learned, though not much, perhaps with ten men at work and with a bed about a foot thick. Also at Nakazato, a league or so to the north, coal is dug; but more important mines are those of Kubara, a league or more north-westerly from Nakazato, and there the coal is about a foot and a half thick. There are coal mining leases also for three or four leagues still further to the north-west near the shore of the bay and beyond Imabuku, the principal town of the region. The extent of the whole of that productive coal field may therefore be nineteen square miles, and if the coal averages 1.2 ft. in thickness, the whole amount, estimating in the same rough way as before, might be six millions tons; but it would hardly be safe to consider so much of such a very thin bed as really workable. On the south-west side of the same peninsula with that field, and nearly adjoining at the south-east end, there are also coal mining leases scattered through a space of about 24 square miles; which reckoning at the same rate, might contain about eight million tons of such thin coal.

At Arita nearly 300 feet above the sea I visited the large kaolin quarry or combination of eight or

ten quarries, in all about half a mile long from southwest to north-east, which furnishes the material for all the Arita porcelain. The kaolin would seem to be a part of the Old Volcanic rocks, which clearly are closely adjacent on the south also. The kaolin accordingly has no visible quartz grains, which are rare (if occurring at all) in the Old Volcanic rocks; but which could hardly fail to be found (as they are in other parts of Japan) in kaolin derived from the Kamoikotan porphyries or granites everywhere so rich in quartz. The kaolin is in general white, compact and amorphous and contains almost everywhere numerous grains or minute cubical crystals of iron pyrites, which decomposing has in some spots given a yellow rusty color to the surface; but at some points it is indistinctly in fine, flat layers like some of the neighboring grayer and less altered Old Volcanic rocks to be mentioned further on. When the kaolin is broken into fine grains it is gritty and rough feeling and looks much as if it might be the result of the decomposition of pumice beds such as are to be seen here and there in southern Yesso, though at Arita the pumiceous structure is no longer visible even with a pocket lens. The quality differs at different points throughout the quarries and is classified as superior and inferior porcelain clay and (at two places) glaze; but nearly the whole space seems to be filled with at least inferior clay, and the quantity therefore appears to be practically inexhaustible. The workings are not yet below water level or are only very slightly so in certain spots, and even there are far from being below the water level of the whole place. The yellow rusty color is generally very superficial, and forms in wet weather, and contains alum. The color is harmless, as it is removed by the preliminary washing and levigation, and so are the grains of pyrites in the underlying unruined stone. A quarter of a mile west of the main quarries there are two

small ones of rather ferruginous fine-layered clays (without alum) that give light yellow and green glazes. All the quarries are the property of the village of Arita (about 6,400 inhabitants), and the clay is paid for (exclusive of carriage) at the rate of four-tenths of a cent for every half load of 85 catties of superior and inferior alike ; but the glaze, including the green-glaze, is paid for at double that rate. The superior and inferior clay are in using mixed, say half and half which is a very good mixture or $\frac{7}{10}$ superior and $\frac{3}{10}$ inferior, also a very good mixture. In one day 34 piculs are dug in all on the average, including the green-glaze. About seven-tenths of the whole amount are used in Arita, and the other three-tenths are carried to the seven neighboring villages of Ookawachiyama, Ichinoseyama, Hiroseyama, Kuromotoyama, Oobooyama, Nangawara and Hokaoyama. The carrying is done on the backs of bullocks or horses, 170 catties to a load for either, and costs two cents a picul to the Arita furnaces, and on the average about five cents a picul to those other villages. The stone at Arita, for example, is first pounded fine by a water power trip hammer (at the end of a spoon shaped lever), two piculs in a day ; is passed through a bamboo sieve with meshes of about three-sixteenths of an inch ; is stirred up, 140 catties at a time, four times a day, with water in a vat ; and then the muddy water is dipped out and allowed to settle in two or three hours in another vat, yielding in three days 100 piculs of good fine, plastic material, twice washed. The coarse part left in the first vat is four-tenths of the whole, and is completely thrown away. Nothing is mixed with the levigated clay ; but with the levigated glaze the ashes of the Yusunoki are mixed, sometimes half and half, sometimes $\frac{3}{10}$ ashes and $\frac{7}{10}$ glaze. When the clay has been moulded on wheels, and sometimes pared on the wheel with a knife when dry, it undergoes the first baking (suyaki) for 24 hours with

a fire of 20 piculs of pine wood (matsu) in a small oven attached to each pottery house. Then the pieces are painted, if at all, with blue (socalled sometsuke); then the glaze, either white or green (socalled seiji), is put on; and then there is a second baking (jiyaki), which is the main one and lasts several days. The kiln (called nobori) is a very large one with a number of ovens, up to 22 and averaging 12 to 15, climbing up the natural slope of a hill side, the lower ones rather small and the upper ones large, with an average size of eight yards crosswise of the kiln by five yards by three yards high, and with a door about two feet high and half a foot wide to each oven, and a hole about half a foot in diameter for the smoke to come out of. The fire is kindled first in the lowermost oven after the pieces have with five days' labor been carefully stowed there (the finest pieces in rough earthenware cases), and it burns for 24 hours, consuming 100 piculs of pine wood. The flames or smoke and gas pass meanwhile through two or three of the next upper ovens; while still further on they may be shut off by paper pasted over the flues, and the packing of the fresh pieces may be going on. When the fire has burnt a day in the lowermost oven, that oven is closed, and a like fire with a like amount of wood is kindled in the next one; and so on day after day to the top of the kiln. The unpacking is not begun until the end of 20 days and takes for each oven only half a day or a day. If more elaborate painting in red or other colors or gilding is desired, it is now put on and produces the fancy colored or brocaded, the so called saishiki (with or without gilding) or nishiki (with gilding); and after that there is a third baking in a carefully closed case in a small oven for 24 hours with a fire of ten piculs of wood.

There are in Arita 80 houses that make pottery; and twelve kilns (nobori), which are owned by ten or twelve

different men, but are hired in turn by all the others. In the other seven villages named there are about 100 houses that make porcelain, and an average of about two nobori to each village; with an average of 12 to 14 ovens to each nobori. There are in Arita about ten houses that do fine work; and there is one at Ookawachiyama. At Ookawachiyama they use too a glaze found there that produces the crackle (*hibiyaki*). It is of two colors, white and pale green. The baking is the same; but the crackle takes place on removing the pieces warm to the hand from the kiln; and after the crackling they are rubbed with charcoal which enters the minute cracks in the glaze and makes them black. Such crackle is sometimes laid in spots upon a ground work of dark brown terra cotta, as, for example, a cloud in a picture. Some of the colors used at Arita are imported from China or from Europe; and there is a great variety of them. Each house, either at Arita or in the other villages, employs on the average about thirty men (including a few women): ten for moulding with the wheel; ten for painting; one kilnman; and nine for digging and carrying. They are paid according to the work done from 15 cents to a dollar a day, averaging perhaps 25 cents. The pine wood costs at Arita 25 cents a load of 150 catties. The ashes for the glaze come from Satsuma and cost \$3 a bag of five kamme or \$6 for enough for one oven full. The finished porcelain both from Arita and from the other villages is mostly carried to Imari where it is packed for carriage and sent to market by sea; and is therefore often called Imari porcelain, though none is made there. It is almost all carried to that port in baskets by men, as the road is rough; but some of the inferior articles go on packhorses. The carriage from Arita by men costs $12\frac{1}{2}$ cents a picul.

It is obvious that even a common waggon road would greatly lessen the cost of carriage of the fuel and of the

clay, but still more that of the finished ware by enabling it to be packed safely in large crates at the kilns instead of at Imari. As the whole saving on the carriage of the porcelain alone would amount to more than two dollars a day, or say to \$800 a year, that together with the manifold other advantages of such a road to all the inhabitants of the region would amply justify the expense of the construction. Perhaps the cheapest plan would be to carry the levigated clay to some place on the seashore and bake it there. Although the working of the quarries is comparatively a very simple matter, yet no doubt the information and increased certainty of methods that would arise from a thorough geological and topographical survey of the whole place would well repay its small cost.

From Arita we went southerly over another low pass through Hasami and thence through a little valley with a flat half a mile wide to the sea near Kawatana, about three leagues and a half. Just after leaving Arita we passed blocks of light brown soft tufa containing pebbles of pumice, and were told that it had been quarried close by to the southeast. A few score yards further on and for a few hundred yards there were exposures of gray schistose trachyte porphyry containing a few grains of glassy triclinic feldspar (probably oligoclase) and a little dark brown mica. The schistose structure comes from very thin flat layers of slightly different composition. In some parts the rock is almost white and there it closely resembles the kaolin of the quarries. Close beyond these exposures and only half a league from Arita, we found, in Toya village, bits of gray and black perlite; and a quarter of a mile beyond them in the bed of a brook and by the road side there were a couple of exposures of the hard gray sand rock, weathering brown, of the coal formation with a level dip; and exposures of similar light brown, but shaly, level dipping rock were frequent near the pass a few hundred

yards further on. They were however interrupted for a short space by dark gray and blackish gray shales with a dip of some 20° northerly, but probably of the same formation. Then as far as Hasami there were exposures of the brown weathered sand rock with a level dip. From Hasami to near the mouth of the valley and the seashore in the limits of Kawatana (about two leagues) there were a few more exposures of the sand rock, and here and there large blocks of Old Volcanic rock. Without entering the main village of Kawatana I turned eastward along the seashore crossing some low hills; and meeting at first with exposures of coarse, soft, crumbling gray tufa pebble rock weathering brown with head size pebbles of andesite containing glassy triclinic feldspar (probably oligoclase), augite and traces of magnetite in a slightly vesicular dark gray matrix with the vesicles thinly lined with a white soft mineral that is apparently neither a zeolite nor chalcedony, nor calcite. Like exposures occurred all the way, over low hills along the seashore, to Sonogi four leagues from Hasami and after we had passed a small flat there at the mouth of a little valley they occurred again within half a league, and were closely followed by an exposure of Old Volcanic rock of probably similar composition, but with the glassy triclinic feldspar crystals and grains in a dark gray fine grained matrix. Thence onward still over low hills near the seashore to Matsubara three leagues from Sonogi the exposures were fewer and were mostly of light brown tufaceous shales, passing however sometimes into the coarse pebble rock. From Matsubara south-south-easterly near the sea shore two leagues to Oomura there was a broad alluvial flat. From Oomura the road ran south-easterly over high rolling ground and then across a pass that I guessed to be 700 feet high (as both our aneroids were at that time out of order) three leagues to Eishoo in the outskirts of Isahai. There were

first some exposures of the tufa pebble rock, then of gray and brown shales apparently tufaceous, containing minute grains of feldspar and of magnetite ; but at the end of a league there was an exposure of buff, decomposed andesite that contained glassy triclinic feldspar (probably oligoclase), magnetite, decomposed pyroxene and empty casts of augite crystals in a yellowish white matrix of soft decomposed feldspar or kaolin. Thence across the pass there were exposures of buff and gray shales and soft sand rock probably tufaceous. From Eishoo, the road went south-westerly four leagues among low hills, and over rather level ground with similar exposures of gray and light brown, or buff, level dipping shales apparently tufaceous to Yagami on the south-eastern shore of the peninsula. On the way however at a couple of leagues from Isahai there was an exposure of hard, gray andesite containing glassy triclinic feldspar (probably oligoclase), hornblende, augite and magnetite in a dark grayish green matrix ; and a league further on there was another exposure of hard, gray andesite containing glassy triclinic feldspar (probably oligoclase), augite and magnetite in a gray compact matrix. From Yagami the road continued nearly a league south-westerly along the seashore to Himi near low hills with exposures of buff and dark gray tufaceous shales sometimes with head size pebbles; and then going westerly over a remarkably rough, bad road crossed a pass perhaps 800 feet high and descended to Nangasaki, two leagues and a half from Yagami. All along the mountain road and near it there were numerous exposures or cliffs of hard, dark gray andesite, containing, for example, near the pass, glassy triclinic feldspar (probably oligoclase), magnetite and grayish green pyroxene in a dark gray, compact matrix.

At Nangasaki we were shown specimens of rocks and minerals from Hirato, Tsushima and the Gotoo Islands.

Almost the only pieces of any economical interest were coals from all three of those places and some kaolin from the Gotoo Islands. The coal from Hirato was good looking, black, shining, bituminous coal from Iwaya village in Matsuuragoori; but the thickness of the bed could not be given. The coal from Tsushima was partly a good looking anthracite from the seashore of Sago village in Kamiagata District; and the bed was said to be about two feet thick, worked to a depth of twenty fathoms and near a great deal of volcanic rock, which had probably turned it to anthracite. There was another piece of very poor looking bituminous coal from Komoda village in Shimo-gata District in the same island; but the bed was only about a foot thick and not worked. The so called coal from the Gotoo Islands was merely a brownish black, carbonaceous, heavy stone said to come from a bed about a foot thick, and evidently quite too poor to work even if it were thick. From the same Islands there was reddish brown and yellow vesicular lava that is used for making cement at the Nangasaki dock. From Tsushima (Shimoagata District, Shimobari village) there was a poor looking specimen of copper pyrites from a very old abandoned mine, a hundred fathoms long, now full of water, and of unknown width of vein. From the same District, Ogata village, there was a still poorer looking specimen of like copper ore with iron pyrites, and it was said to have formerly been worked for silver to a length of twenty fathoms. From Hirato there were specimens of serpentine, and from the seashore there, some magnetic iron sand. We were told about coal beds that had recently been found by boring at Matsushima, an island near the sea-coast, eight leagues north-west of Nagasaki; one bed eight feet thick and one four feet, of quality rather inferior to the Takashima coal. But no foreigner had witnessed the boring through the beds, and I do not know how

experienced and trustworthy the borers may have been in the rather delicate matter of testing a coal bed in that way. We did not visit the celebrated Takashima coal mines at the mouth of Nangasaki harbor, as the owner had one or more foreign mining engineers in his service and so stood in no need of our advice, and as the government had already had reports upon the place from very competent men.

From Nangasaki we went northerly across the neck of the north-western branch of the main peninsula, over a pass about 200 feet high to Tokitsu at the head of a large bay or salt water lake. We passed first many exposures of similar andesitic rock to those we had seen just before, but of a light gray color, decomposing and crumbling and containing glassy triclinic feldspar (probably oligoclase), augite and magnetite in a gray fine grained matrix. Then there were exposures of gray and brown soft tufa shales and coarse pebble rock; and then, near Tokitsu, greenish and reddish gray slightly decomposing andesite, containing glassy triclinic feldspar (probably oligoclase), decomposing pyroxene, magnetite and pyrite in a fine grained grayish green or reddish matrix. From Tokitsu we went by boat eight leagues northerly across to Sonogi, the town we had recently passed through. On the way we had fine views not only of the celebrated volcano Onsengatake of the Shimabara peninsula to the south-east; but could distinctly perceive a very large somewhat ruined, volcanic outline to the mountains on our east, back of Matsubara, having their old crater apparently at Taradake, and including Kurogiyama northward. In passing along by land no such general outline had been made out. From the boat the mountain Kokuzooyama, directly in front of us beyond Sonogi, had somewhat less distinctly a volcanic outline.

From Sonogi we went three leagues north-easterly across a pass about 600 feet high to Ureshino, passing

numerous exposures of the same coarse tufaceous pebble rock that we had before seen near Sonogi; but near Ureshino there were exposures of gray and buff shales along with the pebble rock. At Ureshino I visited the hot spring and found its temperature to be 86° C. (2 Nov.) The water appeared to contain no sulphuretted hydrogen, and was said not to blacken silver. There was a snow-white deposit which seemed to contain lime, as it was said to. A great deal of gas (probably carbonic acid) bubbles up in the water. The yield of the spring was not easy to see, but seemed large and amounted perhaps to a cubic foot a second or 450 gallons a minute. It issues from the alluvium.

Thence we went three leagues and a half northerly across two or three hills of a couple of hundred feet in height and over pretty level ground between to Takeo; passing on the way many exposures of light brown, apparently tufaceous shales, sometimes with pebbles. At Takeo we saw another hot spring with much frequented baths. The temperature at the nearest accessible point to the original spring, now covered up, about ten feet distant in the solid, gray, volcanic rock like that of Nangasaki, was 47° C. Gas (probably carbonic acid) rises in large bubbles in the water. There is a slight deposit of white sulphury slime; and silver blackens if kept in the water about ten days, though not in two or three days; showing the amount of sulphur to be very little indeed. The yield of the spring is said to be 3 too (12 gallons) a minute.

Thence north-easterly to Kitagata, a league and a half, the road lay chiefly in flat alluvial ground or over very low hills without rock exposures. Kitagata is at the northern edge of the north-western branch of the great plain at the head of the Shimabara Gulf. There was a little coal mined close behind the village street, but it has long been abandoned and is said to have been only about a

foot thick and of poor quality. The rock there is a light brown, rather coarse grit, with a dip about level. I went on northerly past these exposures a league and a half across a hill about 400 feet high to the small town of Taku, passing many exposures of greenish gray and brown, level dipping, shaly, soft, sand rock. The shaly rock has the peculiarity of containing large concretion-like nodules that peel off in concentric shells, and is therefore called "dumpling stone" near Imari, where it also occurred. Taku again is in a plain; but passing one or two more exposures of light brown shales I went still northward a league among low hills to the coal mines of Hachinosu, with views of the conical, Old Volcanic looking Ameyama, a couple of thousand feet high some two leagues to the north-east. The Hachinosu mines are some 300 feet above the sea and near the head of a narrow valley between low hills with exposures and cliffs of gray and brown, nearly level dipping grit, similar to that seen between Tokusue and Imari. From Hachinosu to Tokusue it is but little more than three leagues. The Hachinosu mines are the principal ones in the Taku district (so-called after the neighboring town of Taku just mentioned); and all the mines of any importance at all (not counting some very thin workings down stream) are in one mountain within a diameter of about two-thirds of a mile (ten choo). The next largest mine to Hachinosu is the Karidani, then Enokibara, then Urakaridani, then Nitano. The dip at Hachinosu is said to be half a foot to the fathom, or nearly five degrees, north-west. The section as given to me is as follows, from above downwards :

	ft.
Very bad coal, 0.4 or 0.5	0.4
Gray shales,	13.0
Poor coal, not mined	0.8

	Shales	13.0
Ichimai	{ Coal, poorer than the Sammai ...	1.5
	Shales	3.0
	Sand rock, of variable thickness, about	10.0
	Soft shales	13.0
Sammai	{ Poor coal, left as roof.....	1.2
	Best coal, mined.....	0.8
	Red soft shales	0.4
	Best coal.....	1.2
	Gray slate	3.0
	Sand rock, about.....	10.0
		<hr/>
		71.3

The upper 0.8 ft. coal, the Ichimai and the Sammai are evidently the Ichimai, Nimai and Sammai respectively of Iwayaguchi already mentioned just across the mountain in the Tokusue region. On comparing drawings of the different sections it is clear that the Sammai is the same as the Five Foot bed of Kishiyama near Tokusue already mentioned; and the Ichimai the same as the Three Foot bed there, and the same as the Ichimaimon of Hieda and Takeari. It is barely possible that the Five Foot bed may not be worked at Takeari and at Hieda, not because it is wanting but because lying at a depth 15 to 25 feet lower it may not have been discovered in a place where the beds are so level and the lower outcrops consequently so little exposed. But the lower beds may be wholly wanting on the northern edge of the field. On comparing the drawings it is also striking how well on the whole the Hachinosu section agrees with that of Naogata in Chikuzen, given above; making the Hachinosu Sammai the same as the Sanjaku of Naogata, and replacing the great bed, so thick at Naogata, called in its various parts (only one of which appears to be coal of workable quality) the Kankan, Five Foot, Kusaishi, Sammai and Shakuuashi by

the Ichimai of Hachinosu; yet the total thickness and the number of completely separate beds is about the same. We have already seen that the Chikuzen section agrees well with that of Ariho, near Funaki, in Nagato. It is clear then that the Funaki, Buzen and Chikuzen, Karatsu and Taku fields were contemporaneous in formation and most likely once continuously united; and it is highly probable that the other coal fields of Kiushiu already spoken of were once a part of the same great field though now detached.

My own measurement of the Sammai at the mouth of one of the mines was as follows :

Poor soft coal, not mined.....	1.7
Harder coal, mined, (called 0.4).....	0.5
Good coal "0.8 ft.".....	1.4
Soft shale	0.3
Good coal ("1.2 ft.")	1.0

4.9

Making the mined coal to be 2.9 feet in all; though called 2.4 feet. But large lumps just mined showed the "1.2 foot" layer to have a thickness of 1.28 feet of good coal besides 0.05 feet of slate at top and bottom; and the "0.8 foot" layer to be 1.0 foot thick, all good coal; and the "0.4 foot" layer to be 0.5 foot thick, making a thickness in all of 2.78 feet of workable coal. The coal from the Sammai at Hachinosu in great part looks well, with large lumps up to 1.5 feet in diameter. There is some amber in grains of pea and bean size, and some thin plates apparently of gypsum, but no visible pyrites.

The Sammai and the Ichimai beds are worked at Hachinosu and at all the other neighboring mines. The Karidani are the oldest mines and were begun about twenty years ago or earlier. The Hachinosu mines have been worked eight years under the present lease; but

there was mining before that under the Prince. There are two mines there on the Sammai with one mouth each; and one on the Ichimai, which however has been worked out and abandoned. The roof is said to be quite firm, and to need but little propping, The mining is done with bords five fathoms wide and of variable length, say about forty fathoms; and with pillars of the same length and about four fathoms wide, but they are also taken away afterwards. No powder is used. As the bed dips into the hill from the mouth of the mines there is much water; and it is raised by forty tread-wheels, each one raising it $2\frac{1}{2}$ feet, making a height of 100 feet in all in a length of about 200 fathoms. There is one man to tread each wheel with two shifts a day, or 80 men in all. There are besides about 60 miners including thirty cutters and thirty carriers. The coal is drawn out on basket sledges like those at Takeari near Tokusue, holding 120 catties and even up to two piculs. Children and women sometimes help in drawing out the coal cut by the head of their family. The coal is carried from the mines, all the way down grade, mostly gentle, except about 5 yards slightly up grade at one point, to the river at Yamasaki, two miles (30 choo), in two-wheeled carts pushed by men or young women over a road that has planks laid lengthwise for each wheel. The wheels are $2\frac{1}{2}$ feet apart, 3.35 feet in diameter and made of boards, and have a thin rim of iron in short pieces. The body holds about six piculs with the large lumps piled on top about a foot and a half high. There are two thills ten feet long with a connecting horizontal cross-piece sixteen inches from the end and two short vertical cross pieces at the very end. The pusher inserts his neck between the ends of the thills, which are there 0.7 feet apart. At Yamasaki the coal is loaded on small flat-bottomed river boats, perhaps 15 feet long by three wide and

0.7 foot deep, and either carried direct to Suminoe at the river's mouth about $2\frac{1}{2}$ leagues, or generally is transferred on the way into larger boats at Kugatsu, $1\frac{1}{2}$ leagues from Yamasaki. Some of the poorer, rusty-looking coal is coked at the mine by the miners, not by the mine owners, and the custom has existed for more than twenty years. The coking is done in heaps and the coke is light, porous and good looking and for carriage is packed in straw bags of 13 catties each. The coal yields about 60 per cent. of its weight in coke. The coke sells for about 11 cents a picul, rather more than the value of the like weight of the raw coal it is made from, but less than that of the weight of good raw coal that would produce it. At Hachinosu about 8,000 piculs are mined monthly on the average, but more in winter than in summer, say 96,000 piculs a year. In the whole Taku district the yield is said to be 800,000 piculs (say 48,000 tons) a year. In a year about 6,500 piculs of coke are produced at Hachinosu. The best raw coal sells at Suminoe for \$18 or \$19 a hundred piculs; and the carriage to Yamasaki costs on the average \$3, thence to Kugatsu \$2, and thence to Suminoe \$1. The miners are paid three cents a picul of coal delivered at the dump. The men who tread the wheels are paid ten cents a shift. House room, but no food nor oil is given in addition, and food and oil are bought from the company's shop and subtracted from the wages.

The coal leases of the Taku field are scattered through a space of about six square miles; and reckoning the thickness of the two workable beds near Hachinosu as together 4.3 feet and estimating in the same way as before there might be in all about seven million tons of workable coal in the field. But in the opinion of the present coal mine owners that would be an enormous exaggeration for they suppose their two beds to be workable only through a space about two thirds of a mile in diameter at most.

It is however not wholly impossible that the lower and best bed may yet be discovered to underlie the thin bed worked at the mines down stream, and with such level bedding may have hitherto remained undetected on account of being generally or everywhere below water level and so with few or no outcrops. On the other hand it is possible that the lower bed there may be wholly wanting. Such a point could only be determined by a careful geological and topographical survey, which would be a most desirable thing both for that and for the other valuable information it would no doubt give. It is evident too that the handsome profits of coal mining near Hachinosu would be still further increased by steam pumps or water-power pumps and by tramways both inside and outside of the mines. The outside tramways would be especially profitable because all the neighboring mines would make use of the same line throughout the greater part of its length.

From Hachinosu I went down the valley south-eastward past Yamasaki to Beppu, two leagues, already in a wide alluvial plain ; and thence easterly past some low hills through Ushidzu, and over the very wide plain at the north and north-east of the Shimabara Gulf to Saga, four leagues and a half, without any rock exposures. From Saga we went eastward still through the plain, and crossing the large Chikugo River, entering Chikugo Province and going south-eastward through the large town of Yanagawa, went to the village of Miike, $9\frac{1}{2}$ leagues from Saga. The last league the ground was a little rolling, and there were exposures of brown earth apparently from crumbled granite. From Miike I turned aside for my own gratification to take a glimpse of the so-called Miike coal mines about a league distant, at Oura near the little seaport of Yokotsu, which have already been described to the government in a valuable report (dated 4

April, 1876, but not yet published) by my able and accomplished friend Mr. J. G. H. Godfrey. Although (owing probably to sanguine views of certain variations in the thickness of the coal beds) some apparently rather exaggerated statements have been made by others, and even published, what I learned on the spot (without entering the mines) fully confirmed his description, which is evidently a careful one, based on his own observation and measurements, except where the contrary is expressly mentioned. I take the liberty of quoting from a manuscript copy his account of the coal field and its beds, as follows :

“ The coal mines of Miike are situated in a tertiary coal basin which is limited on the east by a range of igneous rocks running nearly north and south ; on the north by a valley trending east and west from the village of Miike machi ; in the other directions by the sea. The total area of this coal basin is estimated at 24 square miles, of which the upper part, or 2,816 acres, form the concession belonging to the Miike coal mines. Of this area about 500 acres might be considered as already exhausted by former workings. It is stated that coal was discovered and worked in this district about 400 years ago. The general dip of the formation is between south-south-west and south-west and varies from two to three tenths of a foot per running fathom. Towards the sea the dip becomes more westerly, and is nearly west at the sea shore, and much steeper, about five-tenths of a foot per fathom. Up to the present time four distinct layers or seams of coal are known to exist in this formation. The first or upper seam is the best and most extensively worked. Its average section is as follows :

Sandstone

Sandstone intermixed with coal...12 to 18 inches

Coal, occasionally divided by 4

to 6 inches of stony coal72 ,,

Shale mixed with coal.....12 ,,

Sandstone

This coal is rather brittle, but of superior coking quality and consequently well adopted for the manufacture of gas and coke. An average sample taken from the seam yielded 0.2 per cent. of moisture, and the dried sample (212° F.) 9.7 per cent. of a yellowish white ash.

“About five to six feet of slate intervene between the upper and the second seam, and the following is an average section of the latter :

Soft coal, rich in gypsum, not worked...10 to 12 inches

Coal occasionally divided by seams (up

to 5) of bind, each varying from 1

to 3 inches in thickness. These

seams usually appear when the coal

bed is widening out..... 5 to 6 feet.

Shale with coal..... 2 to 3 inches.

Sandstone

The character of this coal is entirely different from that found in the upper seam. It is considerably harder, free burning, not caking, and richer in ash. An average sample taken from the seam yielded :

	Eastern portion of Seam.	Western portion of Seam.
Moisture	0.5 per cent.	0.2 per cent.
Ash in dry (212° F.)	17.9 ,, ,, violet.	12.5 ,, ,, light gray.

It has been observed by the Miike miners that the quality of the first and second seams is improving towards the west, and it is interesting to note that this observation has been borne out by the result of assays as regards the second seam, from the eastern and western portions of which we have been able to collect average samples.

“The third seam is found at about 20 feet in depth below the second, and consists on its outcrop of 1 to 1½

feet of bad coal. No exploration has been carried on yet to prove its character at a lower depth. A lower, fourth seam, said to consist of about three feet of bad coal was worked in former times at a short distance to the north of the Umedani adit ; but, owing to the large quantity of water met with, these workings had to be abandoned, and have now caved in. The rock intervening between this and the third seam might be estimated to be at least 50 feet thick.

“The outcrops of all the three upper seams can be traced on the road from the Umedani to the Ikuyama adit. Within a short distance from the latter to the east, nearly perpendicular outcrops of the first and second seams are to be seen, which as mentioned above have been lifted up here by the underlying igneous rocks (granite). Only the first and second seams have been and are worked at present in the Miike mines.”

On comparing a drawing of the section at Miike with the sections of Taku, Tokusue and Naogata the resemblance is sufficiently great to show pretty convincingly that the three upper Miike coal beds were once probably continuous with the beds of those other fields ; but the lowermost bed mentioned by Mr. Godfrey from hearsay evidence has nothing to correspond with it. If that bed be not the creation of an exaggerated tradition, and in reality perhaps merely a little black slate that has been neglected in the other sections, the measures at Miike would appear to be much thicker than in the more northern fields and the coal beds to have begun to form earlier. The section at Takashima near Nangasaki with four coal beds of seven, ten, five, and sixteen feet of coal in a thickness of 650 feet of rocks resting on 600 feet more of like measures, as given by Mr. Godfrey in his interesting “Notes on the Geology of Japan” (Quarterly Journal of the Geological Society for August, 1878) differs still

far more remarkably from the sections of all the other fields in respect to the thickness and number of coal beds and the amount of measures generally. In regard to Takashima the public has not yet any means of judging from detailed maps and reports what may have been the difficulties in making out the section, and whether there may fairly be any reason to be in the slightest degree suspicious of the correctness of the conclusions arrived at, so difficult to account for satisfactorily in consideration of the wide discrepancy with so many other coal fields of Kiusiu.

Since the date of Mr. Godfrey's report a steam winding engine of 70 horse power has been set at work at the Oura slope ; and at the time of my visit the output there was said to be about 100 tons a day. The government also has ten or eleven other smaller mines without engines which were said to yield all together about ninety tons a day ; and was sinking a new shaft at Mitsuyama to be 35 fathoms deep. The Oura slope is inclined perhaps 20° . The coal is drawn out of it in waggons that hold seven piculs, running with iron wheels half a foot in diameter on an iron track of $1\frac{3}{4}$ foot gauge ; and drawn by horses in the same waggons (four to a horse) on a light railroad to the port, Yokotsu, seven-tenths of a league distant. The coal from the small mines off the railroad line is carried in carts like those of the Taku region. In the mine at Oura there are, it is said, 140 tread-wheels for raising water each 1.0 to 1.3 ft., but they are commonly worked only one shift in the day. There are at Yokotsu four coke ovens, combined in one mass nine paces square ; but at the time of my visit they were not making any coke there, though apparently a little was made at Umedani. The mining of the coal of the upper bed is said to cost $4\frac{1}{2}$ cents a picul delivered at the slope waggons ; but the slack only four cents. The mining of the coal of the other bed is easier and costs $3\frac{8}{10}$ cents a picul, delivered

at the mine mouth close by the railroad. These prices are higher than those of the Taku region ; but the Oura miners are convicts. The coal of the upper bed is said to bring \$13 at Yokotsu ; and that of the other bed, \$11 a hundred piculs at the same port. At Mr. Godfrey's recommendation a careful topographical survey and map of the whole place was made before he left Japan early in 1877 ; but, as I understand, the dips, the contours of the coal beds and the outcrops have never yet been laid down upon it.

From Miike we kept on southward over hills up to a couple of hundred feet in height with many exposures of brown crumbled granitic earth and crumbling granite, passing in half a league near the Akitagami coal mines on our right, and a heap of coal slate close by the road, then meeting with exposures of purple, blue, gray, brown and blackish sandy shales, a nut pebble rock, black coaly shales ; and so on across the boundary line into Higo, with coal slate heaps by the road side where coal had been sought, and with the brown crumbling granite recurring near Fumoto two leagues from Miike. Less than half a league beyond that there were at Kaba, gray and light brown shales and a couple of small coal mines, slopes, begun in 1878, one of them inclined about 20° and 20 fathoms deep, another about 30° and five or six fathoms. The coal was said to be at the moment 0.8 ft. thick, but to thicken sometimes to 3.5 ft. The coal dug seemed poor, chiefly slack and sulphury. A few hundred yards further on, close by the road, there were at Nobarauchi, in Kanayama village, two or three very small coal mines, partly abandoned ; and the coal was said to be about 1.5 ft. thick. It seemed to be a very irregular deposit ; and the coal brought out was almost wholly fine slack, but with a few lumps of poor coal. These are the southernmost of the mines of the Miike field.

The productive portion of the Miike coal field, as near as I can judge, would seem to be not more than five square miles at most. If we reckon the thickness of the workable coal as amounting altogether to eleven feet, and if we estimate roughly in the same way as we have done for the other coal fields, it will appear that there may be about 15 million tons of workable coal in the whole field. But even that may be a very great exaggeration, for it seems to be only in the immediate neighborhood of the government mines that the beds are so thick or indeed workable at all. Whenever, the geological portion of the map of the Miike mines shall be laid down it will be easy to measure the amount of the coal there with some exactness. It is much to be wished that the topographical and geological survey should be extended to the lands outside of the government mines, so as to determine more exactly than is now known the limits of the productive field, the position of the workable coal wherever it exists and the natural facilities for working it. Although the government be directly interested in its own mines only, yet indirectly it has a very great interest in encouraging and aiding by surveys the working of outside mines too.

From Nobarauchi we kept on south-easterly through Ueki to Kumamoto, about eight leagues, across hills a couple of hundred feet high, but generally over pretty level ground, passing exposures of brown, soft, crumbling, tufaceous, level dipping sand and pebble rocks, sometimes pumiceous, in which the road a great part of the way was sunk six or eight or ten feet deep so as to cut off all view of the surrounding country. According to tradition the roads were dug so deep on purpose, for strategic reasons, by a warlike prince long ago ; but it seems more probable that they have gradually worn deep without any special design, as they may be seen to have done in similar soft

rocks in Satsuma, even on by-roads, where there would have been no military object in deepening them, and as may be seen in a less degree in many other parts of Japan where the surface materials are not quite so soft. We had occasional views of Hiboosan not far to the west of the road, and it seemed from its shape to be clearly an old volcano. The more hemispherical than conical mountain Konohadake, perhaps a mile to the east of the road and a thousand feet high, has Kamoikotan limestone quarries in it, as we found afterwards by specimens of white marble clouded and veined with black that were shown us at Kumamoto.

We were shown many rock specimens at Kumamoto chiefly serpentine, talc schist quartzite, granite, marble, and minute traces of copper pyrites from Mashikigoori ; serpentine and quartzite and traces of copper pyrites from Kamimashikigoori ; traces of copper pyrites from Shimomashikigoori ; granite, clay slate, jasper, marble, and porcelain clays from Yatsushirogoori ; black, shining coal (said to be little in quantity), fibrous brown lignite and kaolin from Kikuchigoori ; granite from Tamanagoori ; clay slate from Ashikitagoori ; porcelain clays and marbles from Amakusa ; mica schist and kaolin from Yamagagoori ; obsidian from Asogoori near the great volcano Asodake, at least eight leagues to the east of Kumamoto. From Asodake, as we were told, some 3,000 piculs of sulphur were taken in 1877 ; and it is constantly deposited by the sulphur fumes there. Around the mountain there is said to be a wide plain about 260 feet above the plain of Kumamoto. The maps hitherto have given a very incorrect impression of that and other parts of Higo ; but the prefecture was about publishing a much better map that had been made from the note books of old surveys begun sixty years ago, by Ikebe Yaichiroo, a friend of Ino, and finished about 1865, but neglected until 1877.

We could get no very definite information about the Higo copper mines. Apparently two of them are worked, but do not flourish.

At Kumamoto under the castle wall there were exposures of gray pumiceous tufa pebble rock. The mountain to the west was said to be granitic. We went south-westerly a league and a half over a wide alluvial plain to Kawajiri. There we saw a sample of the coal of the western shore of Amakusa, the large island at the mouth of the Shimabara Gulf, which is used at the bath houses for fuel. It is a rather dull, black very impure looking, heavy anthracitic coal, that glows in the fire without flame or smoke. We could get no information about the thickness of the bed or beds from which it is dug; and the general reputation as regards both quality and quantity seemed to be very low. The coal mining leases are scattered through a space of about sixteen square miles in one large and two small patches along nearly the whole western shore of the island. Mr. Henry S. Munroe, who visited a portion of the field in 1875, says in his paper on the "Mineral Wealth of Japan" (read before the American Institute of Mining Engineers, and published in the Engineering and Mining Journal Vol. XXII. p. 379, 9th Dec., 1876,) that "the beds are but two to three feet thick and two seams only are recognized;" and he seems to have in mind but a small portion of the whole field and perhaps the best part of it. If we reckon then the average thickness of all the workable beds together as three feet it will probably be no underestimate; and calculating in the same way as for the other fields we shall find that the whole amount of workable coal may be about thirteen million tons. Even that I fear may be a great exaggeration of the amount that is really worth working. This is the last of the workable coal fields of Kiushiu of which we obtained any information.

It is worth while to count up the amount of workable coal the Kiushiu fields contain altogether, rough as our estimates are ; for they are the most probable estimates that have yet been made in the matter, and indeed the only ones that have taken the number and thickness of the beds or their workable extent into account. Several statements have been published of the probable extent of the coal bearing rocks including all the shales and sand-rocks of the whole formation whether productive or not. The more probable, though the more moderate, of these statements seems to be that of Mr. Godfrey, which I have understood from him was based on a careful investigation of many months' duration made on the ground by a Japanese of the Mining Office who was well fitted for the work. Even thereby the productive area seems to be very much exceeded, as the rocks of the formation appear to be much more extensive than the workable coal beds. The number and thickness of the coal beds seem to have been in some cases very much overrated too, giving on the whole an extremely exaggerated impression of the importance of the fields. As we have seen, the workable beds are commonly only two or three, and often only one, and mostly very thin, and not of very good quality ; and as the sections of the different fields correspond very well, it is not in the least probable that any additional beds exist. Of course the workable beds crop out at the surface here and there leaving large portions of the whole area within which they occur barren of coal. Where the coal occurs too, the quantity that is workable depends somewhat on the different degrees of steepness of the dip. It is impossible therefore without a careful topographical and geological survey to tell with any exactness the amount of workable coal that would exist in the fields, even when the thickness of the beds is known ; but as there is some general resemblance between different fields

in those respects, I have for a rough estimate ventured to take for large areas the same average number of tons for each foot in thickness of workable coal and for each square mile that is the average in our somewhat carefully measured surveys of 17 square miles of the great Ishecari coal field in Yesso, namely 280,000 tons, only a little more than a quarter of what there would be if the layer of coal one foot thick were horizontal and underlay the whole mile. The estimate is of course very rough ; but no one can say at present whether the amounts arrived at by it are too small or too great ; as far as our present knowledge of the subject goes, they are just as likely to be too great as to be too small. The estimated number of square miles and of tons of workable coal in the fields already given separately above are, then, as follows (including the Funaki field of Nagato) :

Field.	Square miles.	Millions of tons.
Funaki	22.....	35
Buzen-Chikuzen	220.....	500
Tokusue (or Karatsu).....	27.....	25
Imabuku.....	19.....	6
Shidzutsu.....	24.....	8
Taku	6.....	7
Miike.....	5	15
Amakusa	16.....	13
	<hr/>	<hr/>
	339	609

There are in addition several small outlying patches of coal, which have coal mining leases scattered through the following areas, and would contain the following number of tons if we reckon the thickness of workable coal to be the same as in the nearest fields already estimated ; and Takashima may be added with the amount I have formerly understood from Mr. Godfrey it had been calculated to contain (between four and five million tons):

Field.	Square miles.	Millions of tons.
Takano (near Karatsu).....	2	2
Uigasaka	$0\frac{1}{2}$	$0\frac{1}{2}$
Fukushima.....	$1\frac{1}{2}$	$1\frac{1}{2}$
Kuroshio	1	$0\frac{1}{2}$
Hirado.....	1	$0\frac{1}{2}$
Shikamachi	3	1
Seto.....	1	$0\frac{1}{2}$
Matsushima	1	$0\frac{1}{2}$
Takashima	$0\frac{1}{5}$	5
	—	—
	$11\frac{1}{5}$	12
Adding the large fields.....	339	609
	—	—

In all there would be $350\frac{1}{5}$621

Until more exact surveys shall be made it seems far better to take the productive coal fields at 350 square miles than at the larger, even double extent, at which the fields have been publicly set down. To be sure those larger figures were probably meant to include all the rocks of the coal bearing formation whether productive or not ; but the number of miles of their area has no interest except as a rough indication of the amount of coal they contain. It is even to be feared very much that 350 square miles may be an exaggeration ; for the outlines have been drawn rather liberally so as to include the coal mining leases marked on our maps and many of them may contain (as often happens) mere traces of the mineral sought for. It is nearly hopeless to expect in general that workable coal will be found to any important extent outside of the fields so marked, for it must be considered that coal has been sought for during hundreds of years, and as the country is thickly inhabited every foot of ground is well known and the existence of a single inch in thickness of coal is known for

miles around. If workable coal beds exist it is almost certain that there would be outcrops of them, and that those outcrops would not be so completely concealed but that at least bits of coal would have been observed near by that would long ago have led to the discovery of the beds themselves. It is probable however that the Takashima coal may be mined to such a distance under the sea adjoining the island as to add considerably to the product of the field ; and it is possible that workable coal may some day be discovered at points beneath the great Saga alluvial plain from Taku to Miike, and perhaps in some other plains, since, as we have seen, the Kiushiu fields were once probably all continuous. Such additions to the productive fields may counterbalance any exaggeration there might otherwise be in the number now estimated.

It is obvious that any mere number of square miles gives but a very imperfect idea of the amount of coal, for very much indeed depends on the thickness of the beds, their dip and the shape of the surface. In comparing large areas there will be every degree of dip and every variety of surface and perhaps on the whole about the same average ; so that in those respects it seems fair to take what we have found to be the average result in the detailed surveys and measurements made in Yesso. The information gathered last autumn in regard to the number and thickness of the beds seems pretty satisfactory and corroboratory one part of another part, so that it appears very certain that the more extravagant (though not very precise) estimates hitherto published must have been great exaggerations, though of course unintentionally so, but probably founded on imperfect or inexact statements gathered through ignorant and possibly careless interpreters. It is safest then to consider our number of 620 million tons as probably not very wide of the truth, neither for example as twice too large nor twice too small.

It has seemed very important to arrive at as good an estimate of the whole amount of coal as the present state of our knowledge would justify ; for exaggeration would lead to wild expectations, a wasteful outlay of money and future disappointment, and might possibly even excite the cupidity of other nations ; whereas underrating would lead to undue neglect of valuable resources, and to unprofitable fear about turning them to account and would by lessening the country's reputation and credit lessen its strength. But nothing would lessen its credit, and strength abroad so much as an apparent desire to conceal or to exaggerate the real facts of the case, or an unwillingness to look at them. It is very much to be wished that all the coal fields should be thoroughly surveyed geologically and therefore topographically ; and the amount of coal already shown with great probability to exist there is ample to justify the outlay that would be required for the purpose. The same survey would beyond a doubt also give much valuable information that would be extremely useful for the working of the mines and determining lines of tramway, and perhaps would show the existence of workable beds at points where they have hitherto been quite unknown ; for example, near Tokusue and at the lower end of the Taku field, as already suggested, and possibly in the plains of the Chikuzen field.

It may well be urged too that the government is directly interested in facilitating by such means as much as possible the mining of coal, since a profitable revenue is derived from the export duty upon it ; and it might even be maintained that the miners of coal have a right to expect some assistance of the kind in compensation for such a tax. It is true that the government ten years ago relinquished the duty upon all coal exported by steamers, and in consequence, contrary to the expectation of the government and of foreigners, the carrying of coal has fallen almost wholly

to the lot of steamers, favoring them, whether foreign or native, to the disadvantage of sailing vessels ; but still the relief to the mining interest is only partial, as the cost of exportation must be more than if coal were carried by sail likewise free of duty. Clearly Japanese coal is to that degree placed at a disadvantage in foreign markets, and exporters of coal from other countries to the Chinese market must profit thereby and desire that the Japanese export duty should be as high as possible. It is not unreasonable that the nation should derive some direct profit (if it thinks best) from its natural stores of coal ; but would it not perhaps be well to replace the export duty altogether by a light tax on all coal mined, which would to be sure be burdening domestic industries, especially salt making, as well as coal mining to some extent, but would on the other hand encourage sailing ships and, as compared with the present, mining too ? Such a light tax could hardly fail to be assented to cheerfully and to be on the whole harmless to industries if only a portion of it were expended by the government in lessening the risks and increasing the profits of mining by surveys and by other means of equally wide public benefit.

At Kawajiri we were told of the custom of reclaiming land along the sea shore. The whole bay between the main land of Higo and Amakusa is very shallow, except certain narrow channels, and has long been observed to be growing shallower, partly no doubt through the silt brought down by the rivers that empty into it, and partly perhaps by a gradual rising of the land. The sea along shore is so shallow that in many parts vessels of any size can come no nearer than a league and a half from land ; and as the tide rises twelve feet, the ebbing lays bare wide flats. It has long been customary to make dikes to enclose such flats in part, not to low-water mark, nor so as to require pumping ; and the land so regained is called

shinchi. In three years it is possible to cultivate rice upon it, and it is very highly esteemed for rice land ; but before that, it is not fit on account of the salt, though barley is cultivated even then with success. The land has in that way grown seaward in many places half a league since the making of the maps on which all the maps down to the latest have been based. Even Kawajiri according to tradition and to the meaning of its name was formerly at the mouth of a river though now two leagues inland. On the coast of Tango somewhat similar land is made on a small scale ; but there it is by filling up with earth dug elsewhere.

At one point in such made land in Higo, Kagamishinchi, while sinking a drive-well (probably therefore ten or fifteen fathoms deep or less) the workmen found that gas issued which burned when kindled. The well was stopped up, and a report of the facts was made soon afterward to the Prefecture at Kumamoto, in the spring of 1878. The gas is no doubt just such as is often found in similar delta deposits, or in smaller quantity at the bottom of marshes, the result of the slow decomposition of organic matter among the alluvial beds ; and does not probably indicate the presence of any important body of oil.

The old Japanese drive-well method is to force down an iron bar of 0.2 ft. in diameter until a water vein is reached, then to withdraw the bar and to put a bamboo tube in its place. In order to force down the bar ladders are spliced together and raised vertically to a great height, and held in place by guide ropes ; and then by a pully a number of men pull the iron rod up and let it fall repeatedly until the object is gained. Sometimes in clayey ground the bar cannot be removed ; and if a stone be struck, the sinking has to be abandoned. The method is especially practised in the plain of Etchū, near Toyama, where we saw in passing many bamboo tubes rising two

or three feet from the ground and delivering a constant stream of water from such wells. At one place we saw men splicing ladders which had already risen 30 or 40 feet high for the purpose of making a drive-well. A well of that kind in Etchin is said to cost only ten or even only five dollars. The method is said to be practised also in the lower portions of Yedo. If the water does not rise above the surface the upper part of the well is made large like a common well, and does not differ in outward appearance.

Southward from Kumamoto and Kawajiri there are wide alluvial plains which are famous as yielding the second best quality of rice of all Japan, that of Kadzusa being the first. Over that plain and at times near the foot of the low hills at its inland edge I travelled southward ten leagues to the large town of Yatsushiro by the main road although there is now a by-path over the made lands that is said to be a league and a half shorter. Soon after starting we had views of Koosadake to the south-east apparently by its rather fresh conical shape a volcano. Near the five league post from Kumamoto we saw an exposure of pretty hard light brown rather fine grit passing below into reddish shale, apparently Kamoikotan rocks, with a dip of 50° south 40° east. A short distance beyond however the dark brown and gray tufaceous earth and sunken roads recurred; and at Ogawa, 2½ leagues further, there was dark gray pumice, as at Kumamoto. Half a league beyond that, in Oono village at a spot called Hitooyama, along the foot of the hills at the edge of the plain and a league or more from the seashore, there were a couple of ancient kitchen midden shell heaps, dug into and exposed to a height of from six to nine feet, and reaching to a height of some thirty feet from the lowest part of the exposure at the roadside. The deposit was mostly made up of two shells, a small oyster and an area, but there were a few broken

bits of old pottery, partly plain and partly ornamented with rude markings, and having small handles and the curvature of a large pot. Several were found loose at the bottom of the digging; but the pieces found in place were at 0.6 ft. and two feet, and about six feet from the surface of the ground. The men and women living near said that many human skulls and other bones and stone arrow heads had been found there, but had been thrown out upon the fields along with the shells; and we could find only one bone, a part of a human thigh bone, and a splinter of another bone. There were many quartzite stones but none that had been worked. Near the point where the bones were said to have been most numerous there was a half buried, carved block of the soft, dark gray pumice, probably a tomb stone, or vault cover, about seven feet long with a rough upper surface fashioned into a ring or eye at one point as if for lifting it up, and below cut into a concave cylindrical shape ornamented with six oblong square shallow panels in two rows. I have shown what I brought away to Prof. E. S. Morse, so well known for his kitchen midden researches, and he has since visited the place himself and examined it more thoroughly with a better result. It seems highly probable that, although there are no other such heaps known in this immediate neighborhood, many may be found along the shores of the Shima-bara Gulf so well suited by its shallowness for the growth of edible shell fish, which were consequently no doubt at one time a very large part of the food of the neighboring inhabitants.

About a league and a half short of Yatsushiro we passed a lime kiln, besides meeting before and after that with large blocks of bluish gray limestone and white marble. Just off the coast near Yatsushiro the island Shiroshima is said to be chiefly made up of snow-white marble, large blocks of which we saw near Yatsushiro,

and found to be of beautiful quality fit for the finest statuary. At Yatsushiro we crossed the wide Kuma River ; and keeping on southerly through the alluvial plain came at the edge of it within a league to the small village of Kooda and the potteries there.

The Kooda potteries claim to have been first established between 1592 and 1596 (Bunroku period). There are three houses or families with one, two and five, potters a-piece, eight in all ; but there is only one kiln, climbing up the hillside, and containing eight ovens, and all together about ten fathoms long by an average width of about six feet, widening from about four feet at the lower end to about eight feet at the upper. Only two kilnfuls a year are baked. The pottery is partly plain, uncrackled white and partly crackled gray, and the gray is sometimes ornamented with white and with brownish black. The white pieces are slightly greenish in parts, owing it is said to the ashes of the yusunoki wood used in its glazing. The gray is made from clay brought from a point in Hinagu about three quarters of a mile inland from the main village ; and the white is made from white stone brought from Shirato about half a league from the gray clay and from Hinagu village, which we passed through a league further on. For glazing the gray pieces oak (kashi) ashes are used, and come from Hinagu, Buiwa (northerly from Kooda) and Matsukumari. The pieces are baked twice and the painting is done before the first baking (suyaki). For the first baking a fire of 18 or 19 faggots of perhaps four catties each of pine (matsu) twigs and leaves is burnt for about three hours successively in each oven from the bottom to the top, 24 hours in all ; and the pieces are after that left in the closed ovens about a day before removal. The glazing is then put on, and the main baking (honyaki) takes place. Twenty-five faggots of about ten catties of pine wood (2.5 ft. in circumference

and about 1.8 ft. long,) are burnt for three hours in each oven successively from bottom to top, 24 hours in all. Then the ovens remain closed for about five days before the finished pieces are removed. The crackle of the glazing on the gray takes place before the ovens are opened. A faggot of leaves and twigs costs about one cent, and one of wood two cents.

From Kooda westerly along the edge of the plain at the foot of low hills on our left to Hinagu on the sea shore we saw but two or three rock exposures and they were of dark gray hard Kamoikotan shales. At Hinagu we saw the hot springs, of which there were eight in number within a couple of hundred yards east and west, among the houses of the village street, and a ninth on the sea beach (Hama) a couple of hundred yards further on. The names, temperatures and roughly estimated yield each second (where visible) of the springs were as follows :—

	Centigrade	Gallons
Hama	47°	1½
Aburaya	47°	3
Iseya	47°	little?
Nakamachishinyu	45°	little?
Motoshioya	45°	little?
Tsukiji, west	44°	1
„ east	43°	1½
Honyu	42°	little?
Kamenoyowai or } Kadoshioya }	41°	little?

The water is all of about the same quality, slightly sulphury, but so very little so that silver blackens in it only in four or five days. At the Honyu some gas bubbles up now and then. The water issues from the alluvium.

Going westward along the sea shore from Hinagu we within a few hundred yards (near the 15 league post from Kumamoto) passed exposures of egg and nut, hard Kamo-

kotan pebble rock with white, gray and black quartzite and greenish gray felsitic pebbles. Three hundred yards further on there were hard, dark reddish brown Kamoikotan shales, dipping 45° south 10° east ; and then the pebble rocks again and brown shales and flags once more, and in another 300 yards at Hatoyama, there was white kaolin partly ferruginous in streaks looking much like that of Kudani in Kaga. Close by there was a kiln of about six ovens for terra cotta pottery, rather smaller than the Kooda kiln ; but its kaolin was said to be dug further up the hill to our left. Then quickly the Kamoikotan dark brown shales and pebble rock recurred with a hard greenish gray grit ; and so past Shirato half a league from Hatoyama, where there are two more kilns for still rougher pottery of which the clay comes from the same place. Near the 16 league post there were outcrops of very quartzose mica schist. Then going still south-westward among and across low hills, we passed a few outcrops of level bedded light brown (apparently Kamoikotan) sandrock, and dark brown hard shales ; and a little short of the 17 league post met with exposures of light brown crumbling granite, soon followed however by dark brown and black shales. Half a league further on there were exposures of dark green and light greenish gray serpentine with talc schist weathered brown, near a pass some 500 feet high, and all down its further slope to the village of Tanoura at the 18 league post. Thence westerly, at first along the sea shore and afterwards among hills and over them to a height of about 850 feet with exposures of dark brown Kamoikotan shales and then brown flaggy sandrock or grit, we reached the town of Sashiki near the 20 league post. A league and a half up stream from Sashiki there is clay slate of which we saw a specimen at Kumamoto ; but it does not split very thin. Then in a league south-westerly we crossed a hill about 300 feet

high, with many exposures of the light brown grit and of the brown shales, with a dip near the summit of 70° south 10° east, to the village of Yunoura. There we saw a hot-spring with a temperature of 40° C., or a little more, and a yield of perhaps four gallons a second at lowtide; more, it was said, at hightide. It is however three furlongs to the nearest tide water and the spring has no taste of salt. There was a slight gray sulphury deposit, and silver was said to blacken in the water in two or three days' time. The spring issues from the alluvium.

Rising again southerly from Yunoura the first rock exposures, within half a league, were of soft brown tufa pebble rock with egg size, red and gray, apparently andesitic pebbles, containing decomposing glassy feldspar, augite and magnetite in a decomposing gray, soft matrix; and so on south-westerly across a pass about 850 feet high and down to the village of Tsunagi with numerous like exposures. Then with one or two exposures of the light brown Kamoikotan grit and brown shales the tufa pebble rock quickly recurred; and was exposed almost continuously south-westward across another hill about 250 feet high, giving rise at one point to some magnetic iron sand in the road, and across other low hills, interrupted on one of them for a few hundred yards by exposures of gray Kamoikotan limestone or coarse marble, dark gray quartzitic and calcareous Kamoikotan pebble rock, up to head size, and dark brown Kamoikotan shales; and then the road went down through a narrow gorge with vertical walls nearly a hundred feet high of light brown tufa sand containing a few bean size bits of long fibred white pumice, to the village of Minomata four leagues from Yunoura. Thence in three leagues and a half still south-westerly across low hills with numerous exposures of the tufa pebble rock, we reached Komenotsu near the sea shore in the edge of Satsuma, about 25 leagues short of Kagoshima.

The road then ran southerly for a league through a rather wide alluvial flat, and then south-westerly over gently rising ground without rocks ; but near the 21 league post from Kagoshima there were exposures of pebble rock containing pebbles of Kamoikotan light brown sand rock, black slate and quartzite, but the tufa soon recurred and was seen frequently as far as Agune on the sea shore a little short of the 19 league post. Just beyond that post there is a salt flat where salt is made, from the water of small springs that issue there though it was said to be weaker than sea water. The water is first concentrated to five per cent. in the sun on the flat with sand in the usual way. When the concentration is sufficient it is known by testing with a lotus nut which just floats then with its upper point at the surface of the brine. Not every lotus nut is of exactly the right specific gravity for that, and satisfactory ones are selected with great pains, about forty in half a bushel, and are valued very highly and preserved with much care. The five per cent. brine is boiled down in shallow pans over furnaces of which there are about a dozen in separate huts. The furnaces are seven feet long by six wide and about $1\frac{1}{2}$ feet high and made of clay ; and the pans are a little shorter and narrower and about 0.4 foot deep, and are made of woven bamboo slips smeared with clay, and stiffened by small bamboo rods across the bottom which hang by thin bamboo slips from larger bamboos laid across the top. Over the upper rods coarse straw mats are laid and the brine is put on by pouring over the mats and letting it trickle through them. Also the moist salt dipped out of the pans is put to dry in bamboo trays upon the upper rods. The fire is made with pine leaves and twigs, 24 faggots to one too (4 English gallons) of salt. The salt is sold for 24 cents a too ; and is all consumed in Satsuma. The faggots then must be cheaper than at Kooda (one cent apiece) ; and cost, if I have not misunderstood, $6\frac{1}{4}$ cents for ten.

Thence the road went southerly over low hills near the sea shore with many exposures of the brown, soft tufa pebble rock, to Nishikata on the coast near the 16 league post; then south-south-easterly inland over low hills of the same tufa, sometimes harder; and across the rather wide shallow Kawachi river and more level ground near Mukooda, to some small old silver and gold mines among the tufa hills again, near the 10 league post at Serigano (or Seigano; for the “r” is often dropped in the pronunciation of names in Kiushiu, as Aita for Arita, Kaidani for Karidani).

We merely saw by the roadside, in passing, the mouth of the drainage adit of the mines, which themselves are about a mile distant to the north-east; but at the adit and at the amalgamation mills a few hundred yards beyond we got some information about the mines. There is but one vein, and it is about vertical and runs about east and west, varying in width from three-quarters of a foot to seven feet; when we passed, the best place was two feet wide and $1\frac{1}{2}$ feet is a common width. The vein rock is white quartz which contains the ore (apparently stephanite) in several irregular clouded veins, partly ferruginous, about an eighth of an inch wide. According to Mr. Godfrey’s “Notes on the Geology of Japan” the country rock is propylite. The metal obtained from the ore is by weight about nine-tenths silver and one-tenth gold. Or in value, when pure, about two-thirds silver and one-third gold. The mines were first begun about 1663, were worked for about 150 years then abandoned for about 50 years and have now been worked since 1863. There are about 80 men employed, namely: 10 miners, 30 carriers, 10 timberers, 12 ore washers, 12 mill men, 4 wood choppers, 3 in the office. Each day 15 loads of 30 kamme each or a little over 28 piculs of ore are produced, which was yielding at the moment about 60 momme (or

$1\frac{1}{3}$ hundredths of one per cent.) of silver and $6\frac{2}{3}$ momme of gold ; but it was claimed that the daily yield had sometimes risen to 300 momme or even to 350 momme, and had never fallen below 40 momme. There are two mills a few hundred yards apart and said to be just alike and of equal force and product, sharing the ore equally, about 14 piculs a days to each ; and I particularly examined only the upper one. There the ore is first roasted in a heap in the open air, from six in the morning until six in the evening, with six piculs of wood. Then the ore is powdered by two batteries of four iron shod wooden stamps weighing about 30 catties a piece, with 28 strokes a minute, moved day and night by a water wheel. Then the ore is roasted with 5 shoo (2 English gallons) of salt in four shallow open pans about $2\frac{1}{2}$ feet square over a mud built furnace, with 14 piculs of wood, in small sticks, from about six in the morning until about three in the afternoon. Then the daily 14 piculs of ore are charged in two amalgamating barrels that are likewise moved by the water wheel, from 4 in the afternoon until the next noon. With the ore in the two barrels there are charged 12 or 13 catties of quicksilver, 11.4 catties of wrought iron in bits about 0.25 foot long by 0.05 foot in diameter, and 9.6 too (38.4 English gallons) of water. The quicksilver probably becomes 3 catties less in ten days, and is added a little each day according to the diminution. The charge of iron just mentioned is renewed in about thirty days. In fifteen days the product is 500 momme of silver and gold, of which 50 momme are gold. The wood is cut from land belonging to the mine owner, and so is not paid for. The miners' wages are 12 or 13 cents a day, and up to 15 cents. The value of the gold in the form obtained is said to be \$1.50 a momme, and of the silver 16 cents a momme ; so that the whole daily product of the mines and of both mills is about twenty

dollars. The wood burnt for roasting (40 piculs) would cost at the Kooda pottery about eight dollars; and would therefore be worth at Serigano probably at least six dollars. The daily consumption of quick-silver is six-tenths of a catty, or eight-tenths of a pound, worth there perhaps 60 cents; of iron $7\frac{1}{2}$ catties, worth say 15 cents; of salt one too, worth at least 25 cents, making the cost of all the materials then probably at least seven dollars. Without counting the wear and tear of machinery there would be then not more than thirteen dollars left for the wages (including mine lights, food and lodging) of the eighty men employed; or about 16 cents a piece, not a very high average. It is clear, then, not only that the mine (though a rather widely known one) is a very small affair in its resources and its total product, but that it barely pays its petty expenses, even if there be not in reality a little loss. Possibly the value of the wood is left out of account in order that the men may be kept at work. So poor a single vein of such poor ore would hardly justify the outlay of much capital to lessen some of the present expenses, such as that of carriage. But of course good waggon roads built for the public benefit would likewise be advantageous to the mines.

We kept on down a narrow valley to Ichiku (often called Minato) on the seashore, at the 8 league post, past many exposures of the brown soft tufa pebble rock, and sometimes of sandy and partly pumiceous level bedded tufa like that near Minomata. Thence the road went inland south-eastward over low hills across the Satsuma peninsula to Kagoshima, with the same tufaceous sandy or pebbly, often pumiceous beds everywhere, and with the road frequently deeply sunken. The land is unsuited for rice, and was cultivated a great part of the way with sweet potatoes.

A league and a half from Ichiku I turned aside three quarters of a mile north-easterly from the road to see the Yuda hot-springs. There are three within about fifteen feet in one bath house and one (the Yamada Shoodaiyu) in another bath house a hundred yards off. This one has a temperature of 43° C., is sulphury in smell and quickly blackens silver, and apparently has a very small flow, though the quantity is not visible. The other three have the following temperatures and roughly estimated quantities :

Godzu..... 43° C.....30 gals. a minute.

Gozen..... 41° C.....Very little, yield not visible.

Jito..... 40° C.....5 gals. a minute.

The water of all three is likewise sulphury in smell, and leaves a white sulphury deposit. The soft brown tufa is exposed close by ; but the water seems to issue immediately from alluvium.

At Tsuboya on the main road $5\frac{1}{2}$ leagues short of Kagoshima I saw some potteries. They date from the Keichoo period, (1596 to 1615), and were occupied then by Koreans whose descendants have held them ever since, and have kept up the Korean customs and language (for interpreting purposes) until within about ten years, though now the customs are dropped and there is no separation from the Japanese. There are 12 houses or families in the pottery business and 12 kilns (nabori, or hill-climbing) of seven to twelve ovens each ; but nine of the kilns are used merely for red and black, coarse earthenware that is made of clay dug from small holes at several points less than a league distant. One of the nine kilns has 12 ovens but eight have about ten apiece. A 12 oven kiln is seven feet across at the lower end and about nine at the upper ; and each oven six feet wide lengthwise of the kiln. Three kilns of the whole twelve are alone used for fine work, the famous Satsuma crackle,

which has been made here from the beginning of the potteries. The clay for the crackle ware comes from Ibusuki, 18 leagues to the southward, and from Kirishima mountain on the edge of Hiuga and Oosumi, twenty leagues or more to the north-east; and the glaze comes from Kaseda, ten leagues to the south. In a year about 100 piculs of clay are used. Of the three kilns, one that I saw had 12 ovens, similar to those of Arita, six feet crosswise of the kiln at the lower end and $7\frac{1}{2}$ feet at the upper end, seven feet at the middle; and five feet each lengthwise of the kiln. There is one baking without glazing (suyaki), and then the main baking for the glazing, both in the same kiln; and if there be any painting (nishiki or saishiki) still a third baking in a small furnace. The suyaki lasts as long as the honyaki and requires the same amount of fuel in the lower oven, but only a third as much in the others. For the honyaki 50 loads of about 160 catties or in all about 80 piculs of wood (matsu) is needed in a 12 oven kiln. Of that amount 38 piculs are charged in the lowermost oven (in which there is no pottery), and burns there during 48 hours. In each of the other ovens on the average about 320 catties of wood are charged during about two hours, one oven after the other from the lower end to the upper. The ovens are all closed during the 48 hours except where the fire is kindled, and for one day afterwards. Then they are opened, still hot, and the cold air entering makes the glaze crackle. After 24 hours more the porcelain, still warm to the bare hand, is taken out, and the crackling still continues a little. The baking, then, takes four days in all. The saishiki or nishiki baking lasts from six to 24 hours according to the size of the furnace. There are five such furnaces in the village, of which three belong to one house and one each to two other houses. The largest is five feet in diameter and the small ones are two

feet in diameter. The five foot one is cylindrical and $4\frac{1}{2}$ feet high, and has at the botton in front a projecting covered fire place about four feet long by $1\frac{1}{4}$ feet wide and high, rising only half a foot above the earthen floor of the building in which it stands. The cylindrical part is nearly filled with an earthenware receptacle of the same shape outside of which the flames circulate and inside of which the painted porcelain is placed and protected by a large cover over all. The smaller furnaces are built in much the same way. The largest furnace needs 10 piculs of wood at a baking and the smallest 120 catties. In a year there are six suyaki and six honyaki bakings ; but now-a-days there is no saishiki or nishiki baking at all. The fine ware is all sent to Kagoshima or Yedo to be painted. The number of men at work for all three kilns is about 30, besides about 15 carriers (and about five painters not now employed). For the rough pottery of the nine kilns there are about 200 workmen. There is also a kiln for blue porcelain ; but it has been abandoned. It is evident that the profit of the potteries might be materially increased if the now heavy cost of carriage of clay and fuel were lessened seven-eighths, as it would be if there were good waggon roads instead of the present bridle paths.

At Tanoura in the northern edge of Kagoshima on the sea shore there is also a pottery for fine work that was originally set up more than 200 years ago (after the Keichoo period) under the instruction of twenty Coreans from Tsuboya. At that time however the pottery was at Tateno, and it was removed to Tanoura only about 1869. The clay comes from three places in Ibusuki, about 11 leagues southerly, namely : Bara, Neba, and Matsugakubo. Also from Odori, near Kirishima mountain, 16 leagues distant, where there are some hot springs. Much clay also comes by sea from Amakusa ; but the name of

the village where it is dug is not known. Some comes too from Kominato in Kaseda. Glaze clay comes from Nomagatake in Kaseda, 20 leagues distant; and is mixed with the ashes of nara wood (*Quercus crispula*?) from Kurino, 13 leagues to the north, near Kirishima mountain. There is but one hill-climbing kiln (*nobori*), with eleven ovens, each about nine feet crosswise of the kiln, six feet lengthwise and five feet high. The process is much the same as at Tsuboya. For the main baking (*honyaki*) 15 bundles of large wood, each bundle 8.5 feet in circumference by about 2.15 feet long (or say $12\frac{1}{2}$ cubic feet), are charged in the lowermost oven in the course of 24 hours. Then in each of the other ten successively from the lower end to the top during about an hour there are charged eight faggots of small split wood (about 0.15 foot in diameter), weighing perhaps 20 catties apiece, and measuring 3.4 feet in circumference, loosely packed, somewhat less than 2 cubic feet. The firewood is first dried in a large kiln some ten feet square and eight high. The firing is completed in about 34 hours. Then the kiln is all closed during the following night and one more night, that is a day and a half. For the previous unglazed baking (*suyaki*) four of the large bundles of wood are charged in the lower oven in about three hours and five of the smaller ones in each of the upper ovens in half an hour, successively, beginning at six in the morning and ending about four. The crackling begins after the firing of the main baking has ended but before the opening of the furnace, and continues after the opening, but not after the taking out, which is begun immediately upon the opening. Neither here nor at Tsuboya is the crackle rubbed with charcoal as it is near Arita. About a third of all the baking is either cracked or underdone or overdone and is consequently quite lost or sold cheaply. Before painting (for the *nishiki*), the glazed ware is smeared

with rice paste which gives a sufficiently rough surface to take the colors but disappears in the baking. There are six furnaces for the nishiki similar to those of Tsuboya and of various sizes from five feet in diameter down to 1.2 ft. The largest however is not in use, and one of two feet in diameter inside seemed to be the one principally used. It is six feet high from the bottom of the two foot high fire place ; and has walls 0.3 ft. thick. There is a large unglazed earthen pot inside to hold the articles. About five of the smaller faggots are used for one firing, which begins at seven in the morning and lasts until about five in the evening. A small bit of painted porcelain is put near an opening in the pot to test the baking from time to time. From five until the next morning the furnace is left closed and then having sufficiently cooled is opened and emptied. The gilding is of course burnished after the baking. Only little nishiki is made here, chiefly very small pieces, and apparently there is but one painter. The crackled ware is mostly sent to Yedo to be painted at Asakusa. At Tanoura there are five or six bakings of glazed ware in a year, sometimes ten, and only seven or eight men are employed. The whole quantity of clay used is not known. The clay from Odori cost in 1878 for digging (on land that belongs to the pottery) and carrying to the kiln 14 cents a too (half a bushel) ; but the cost varies from year to year according to the difficulty of digging. Clay from the other places is rather dearer. The horse load is two bags of two too each. The Tsuboya potteries get clay from the same places but have their own holes. The large bundle of wood costs at Tanoura 40 $\frac{8}{10}$ cents.

At Kagoshima we were shown specimens of rocks from Satsuma, Oosumi and Hiuga; from Satsuma, there were black slate and graphite from Koshikijima ; limestone, marble, calcspar, quartz, quartzite and graphite from Kaseda ; marble and dolomite from Midzuhiki; kaolin from Imaizumi; from

Oosumi, there were granite from the south-east shore of Sakurajima (the picturesque, high, conical, chiefly volcanic island just opposite and overhanging Kagoshima) ; tourmaline and quartz with minute traces of copper pyrites from Tarumidzu ; black slate from Tashiro: from Hiuga, there were calcspar, marble, limestone, flint, serpentine, talc, copper pyrites, stibnite, from Usukigoori ; limestone with fossil shells from Morokatagoori : all doubtless from Kamoikotan rocks. There were also coal specimens, black and shining, from Hiuga ; one from Minamigata, from a bed said to be 0.08 ft. thick ; and one from Kagamidzu, from a bed said to be 0.15 thick ; both of course wholly unworkable, though apparently the best coal beds in all the three provinces. There are also several specimens of pumice tufa and other volcanic rocks from various places, especially in Satsuma and Oosumi. We were told also of a shell heap, perhaps kitchen middens, about a quarter of a mile from the seashore and separated from it by a gentle slope at Wago, in Kunakibara village, Tarumidzugoo, Oosumi. The shells (small oysters and others) are water-worn and form a deposit about a foot deep and are much used for making lime ; but our informant knew of no bones nor pottery as found there. The fact that the shells are water-worn would go to show that the heap was formerly within reach of the sea waves. Mr. Aoi Shiu, who has been writing and elaborately illustrating a history of the tobacco plant and its cultivation and manufacture in Satsuma, has inserted in his book the dates of the volcanic eruptions there for the past 1300 years so far as known. He said that in the space between Sakurajima and Kirishimayama there were every 10, 15 or 20 years eruptions of water called the mountain tide (yamashio) by the farmers, and that it spoiled the farming land thereabouts. He had been very much struck by the degree to which the volcanos and ponds (supposed to be of volcanic

origin) of southern Kiushiu were ranged in nearly north and south lines.

From Kagoshima I went to see the Taniyama tin mines, five leagues to the south-westward, the only tin mines now worked in all Japan. The first three leagues of the road were near the sea shore and mainly in flat alluvial ground with some low hills near on the right and exposures of the gray pumiceous tufa; towards Taniyama reddish gray. Then, beyond the main town of Taniyama the road for two leagues westerly climbed some twelve hundred feet and ran over high, rolling ground to the mines in the midst of the mountain summits; at first with more exposures of the tufa; but afterwards with many of brown (apparently Kamoikotan) shales and some of a (doubtless likewise Kamoikotan) gritty arkose containing grains of quartz, feldspar and kaolin, sometimes white, sometimes a little ferruginous, and rarely with traces of silvery mica. The tufa however occurred here and there close up to the mines; though the country rock of the mines was the white arkose of varying hardness. The dip at the mouth of the second principal mine, Motoyama, was 40° N. 20° W. The number of veins is said to be twelve or thirteen, all running east and west and all within a space of less than half a mile (5 or 6 choo) in diameter. In the Motoyama mine the vein is said to be about vertical; and the ore is said to be 0.45 ft. wide and sometimes even one foot, but that is unusual; and sometimes only 0.05 ft. The average was thought to be about 0.1 ft. In the Higashidani mine the ore is said to be 0.6 ft. wide at the best place. The tin ore is of course cassiterite, quite visible in the richer specimens sprinkled irregularly through quartz gangue and associated with a little pyrite and traces of copper pyrites. Neither copper, silver, gold nor other metal except tin has ever been worked at Taniyama.

The tin mines have been worked for 230 or 240 years

without interruption. There are now nine mines worked, besides 40 or 50 old abandoned ones. The longest one of the nine is 350 fathoms long. The Higashidani mine is said to be 60 fathoms deep and 30 fathoms long horizontally. The Motoyama mine is the only one that has pumps, and it has seven wooden ones, each raising the water ten feet, or 70 feet in all, worked by thirty men in the 24 hours. At its mouth it is about three feet wide and four feet high, and is said to be very narrow inside, though in places up to five or even ten feet wide. It is the second mine for the number of men, and (aside from the pumps) there are about 20 workmen, of whom two-thirds mine and one-third carry the ore out on their back.

The ore is all roasted in seven kilns built roughly of stone and of various sizes and shapes, round or square. Sometimes it is roasted twice or even (rarely) three times. The first roasting lasts 24 hours; the second, nearly as long. Commonly from three to five piculs are roasted in one kiln; but ten piculs at most. For four piculs of ore perhaps a picul and a half of (pine and other) wood is needed. The roasted ore is pounded to powder by foot trip hammers, and is then all ground fine by rude stone handmills. The mill is a rough stone some two feet in diameter that is set on the ground and has a shallow cup-shaped top in which is turned a similar stone of nearly the same diameter with two handles. After the grinding the ore is washed, and thereby reduced in weight to about one-twelfth, it is said. The ore is then smelted in one of three hearths of which two are of one size and the other rather smaller; all of them below hoods made of bamboos and mud that are $4\frac{1}{2}$ feet wide, about four feet deep and $6\frac{1}{2}$ ft. above the ground tapering upwards into a chimney, of which the back wall reaches to the ground. The hearths are made of clay and charcoal powder. The two larger hearths are close to the front of the wall and of a

nearly semi-circular horizontal section at the top, 1.5 ft. across from right to left and 0.7 ft. from front to back, and 0.75 deep, with a narrow rounded bottom. The back wall of the hearth however is nearly vertical and slopes even backward, while the front wall has consequently a gentler slope in the same direction. There are two common box hand bellows behind the chimney wall, worked by one man each; and two tweers 0.45 ft. apart and 0.09 ft. in diameter, and 0.05 ft. below the upper back edge of the hearth and aimed at points 0.25 ft. below the front edge. The smaller hearth is of similar shape 1.1 ft. across from right to left and 0.6 ft. from front to back, and 0.7 ft. deep; and is nearly two feet from the back chimney wall, which has also side walls of about two feet in width. There is but one box bellows and one twee, about 0.1 ft. in diameter. The ore is smelted, they say, about 20 days in the month (not at all on the day of my visit); and commonly only with one hearth, one of the larger ones with two bellows; and a day's product is 50 catties, 30 catties or even only 10 catties of tin. In a day there are two operations, beginning at about seven o'clock in the morning and ending about three in the afternoon with about an hour between the two. From 100 to 125 catties of washed ore are charged each time (about 250 catties a day); and about eight bags of 25 lbs. (3 kamme) each of charcoal are used for the two operations. First a part of the charcoal is charged, and on it rice straw is loosely spread, and on that the ore powder, on which again straw is laid with charcoal at the top. The twee blows into the lower bed of charcoal. From time to time black slag is removed; and it is afterwards pounded, washed and smelted again. The clay of the wall above the hearth is now and then pounded up, washed and smelted. The hearth is mended in the afternoon, only once for the whole day's work.

In the year ending 30 September, 1878, 341,029 catties of ore were mined and $10,656\frac{1}{2}$ catties (17.90 tons), or three per cent., of tin was produced. The product of the different months varied from 291 catties to 1,859, and the monthly amount of ore, though more uniform, varied from 15,610 catties to 54,100, but not according to the season, perhaps rather chiefly according to the holidays in February and November or at other times. If the number of days of blowing averages 20 in each month, the daily product would be about 44 catties; and if the daily charge of ore is 250 catties, the yield of the washed ore is 18 per cent., and the concentration by washing is six times instead of twelve. The information obtained was not quite accurate nor full.

Ninety men mine, roast and wash the ore; and seven men more smelt it; and there are besides five overseers and two in the office; making 104 men employed in all. Charcoal costs eight cents a bag (25 lbs.); and wood is worth about ten cents a picul, but is cut on land that belongs to the mines

If the value of the tin be reckoned in round numbers at twenty dollars a picul, the whole yearly product is worth about \$2,130. Subtracting from that the value of the wood used for roasting, say \$127, and of the charcoal for smelting say \$153, both together \$280, there would be left \$1,850, from which the cost of the straw and other cheaper materials as well as mine lights, the repairs of tools, the deterioration of buildings and other property should still be subtracted; so that there is at any rate less than \$17 a year on the average left for each man employed. It seems then hardly possible that the mines are not worked at a loss. Some saving might no doubt be effected if the stamping and grinding were done by water power instead of wholly by human labor; and if the cost of carriage could be reduced by carrying in waggons instead of on

the backs of men ; though the small product would not alone justify any great outlay of capital for the improvement of roads. A careful geological and topographical survey of the small area within which the ore veins occur would not be very costly but would lessen the uncertainties and risks of mining and would probably show decisively, if it be not already clear from actual trial, whether the veins could be worked with profit or ought to be abandoned without further loss.

Starting from Kagoshima again we travelled north-easterly five leagues and a half to Kajiki in Oosumi, round the shore of the bay with the Sakurajima volcano always on our right. We were told that four small islands on its north-east side arose first in 1779 (the eighth year of Anei), and that two or three others near the mainland to the north arose in like manner 1300 years ago. Our road at first for nearly four leagues, as far as Shigetomi lay close by the sea shore at the foot of high cliffy hills on our left with numerous rock exposures; beginning near the Tanoura pottery with reddish gray, very light, porous andesitic tufa containing glassy triclinic feldspar (probably oligoclase), augite and magnetite in a reddish gray sandy matrix; but after that, much brownish gray and gray andesite containing a great deal of glassy triclinic feldspar (probably oligoclase), very little visible dark green pyroxene, in half melted grains and extremely minute grains of magnetite, in a dark brownish gray or dark gray matrix which was sometimes slightly glassy. At one point the rock was a perlite in gray grains, but contained even then a little of the glassy triclinic feldspar, the scanty dark green half melted pyroxene grains and very little magnetite. Then near Shigetomi the tufa recurred with pumice here and there and with egg size pebbles. The rest of the way to Kajiki, still on the seashore, lay through an alluvial plain at the mouth of some small

valleys, surrounded by mountains of volcanic material. From Kajiki we went northward on the Higo road four leagues as far as Futamune in Yokogawa, rising very soon after starting some 350 feet above the sea, and afterwards through hilly ground to some 800 feet. At and near the first ascent there were cliffs of blackish andesite containing triclinic feldspar (probable oligoclase), augite and magnetite in a vesicular black matrix, with the vesicles thinly lined with a soft bluish white mineral (perhaps a delicate film of opal), and occasionally filled with opal and with white steatite. But elsewhere there were numerous exposures of greenish gray, light gray and reddish gray tufa, containing pumice, sometime in lumps as large as two fists and with long, silky, white fibres. From Futamune our road ran north-westward two leagues among the hills to the Yamagano gold mines about 1,000 feet above the sea; passing numerous exposures of the soft nearly level bedded tufa.

At the Yamagano gold mines the rock that was pointed out as the dominant country rock was a hard, brownish black andesite, containing glassy triclinic feldspar (probably oligoclase), augite and magnetite in a compact black matrix that weathered brown. There was also associated with it one exposure of white quartz porphyry, in which the feldspar crystals had turned to kaolin. Near by, there were also exposures of the tufa, partly a bluish gray trachytic tufa that contained small carbonaceous bits. There are 41 veins, about parallel and vertical and running about east and west. They are said to vary in width, and often to be about 0.1 ft., sometimes 0.01 ft., sometimes 1.0 ft., averaging perhaps 0.03. The ore is native gold, occasionally, though rarely, visible in minute yellow nuggets in the quartz gangue; but 40 or 45 per cent. of the whole weight of metal is silver. The mines have been worked for about 250 years; but up to

1875 had been abandoned, some 50 years, some 20 years and others less. There are about 100 old mines ; but only half-a-dozen are now worked ; of which three are at Yamagano : the Uranotani and the Takatsuka, on the Takatsuka vein, and the Kusuriya Ogi, crosswise of the veins (the Shinsaku, Takatsuka and others) ; and the Gomotsu is a little worked ; and three are at Nagano, a short league to the west, in the edge of Satsuma, across a dividing ridge about 1,300 feet above the sea, namely ; the Yamano, upper and lower, on the Sudzuri vein and the Gomame on the Sarashiu vein. The mines at the time of our visit were worked under able foreign guidance, that of Mr. Paul Ozier, a Frenchman, who had however been there but a short time and of whose presence we had not heard until our arrival on the spot. With such narrow, poor, veins in such hard rock no portions of the mines had yet been found worth working ; but it was expected that shortly the Takatsuka vein would be reached, which according to tradition was very wide (some 25 feet) and rich. The mines are provided with practical, light, iron tramways with a gauge of 45 centimetres, made with strap iron set on edge and weighing $3\frac{1}{2}$ kilograms to the metre. The waggons are oblong boxes that hold half-a-ton of ore ; and have wheels about half a foot in diameter. At the time of our visit the old refuse ore heaps of the former miners furnished almost the only material and were getting worked over. It is in large heaps in different hollows in the mountain and has a dull, dirty surface ; it is first washed quickly in a hand sieve, and then slightly picked over by hand, so far as the external appearance renders possible, and then wet stamped. At Yamagano there are ten stamps of 230 kilograms each, with a steam-engine of 12 or 14 horsepower, burning stone coal ; and at Nagano there are 15 stamps of the same weight, run by a turbine of 25 horsepower with a head of about 38 feet,

making 25 strokes a minute ; all set up within the last two years. At both places the stamps run only in the day time, 12 hours, and the water is stored up at night ; but with plenty of water, 34 or 35 tons could be stamped in 24 hours. At present however they stamp all together only about 12 tons (2,000 piculs) a day. There is some quicksilver in the boxes below the stamps, and the powdered ore passes with the water from the stamps over amalgamized copper plates three or four feet long, and then, successively over two woollen cloths spread at the bottom of shallow inclined troughs perhaps ten feet long each by a foot and a-half wide and 0.2 ft. deep. It was said however that some of the gold escaped into the pool below, as the cloth was not of quite satisfactory quality. The sand and gold from the cloths is ground in a stone mill with quicksilver. The silver and gold are not separated at the mines. At Yamagano they were beginning to try a small cradle for testing some of the ore by hand.

In a year about ten kamme (or 100 pounds troy) of bullion are produced, of which 55 or 60 pounds are gold and the rest is silver ; worth then all together about \$15,000, not counting the cost of separating the two. There are 170 workers employed at Nagano, namely : 59 ore washers, men ; 53 sorters, (30 women and 23 children), 23 miners ; 4 miners' aids ; 14 carriers (with the waggons) ; 8 mill men ; 5 overseers ; 4 in the office. At Yamagano there are about the same number of miners as at Nagano ; 15 carpenters ; 6 coolies ; 23 in the office ; making perhaps 375 workers in both places together. The workmen and waggon men get about 16 cents a day ; inside the mines about 18 cents ; the women from 7 to 10 cents, but generally 8 cents, about half the men's wages ; and the children from 4, 5, 6 or 7 cents to 10 cents, averaging about 7 cents. Neither food nor lodging is given in addition. The coal used for the steam-engine is Karatsu coal of inferior

quality and costs at the mines \$4 for 100 kamme ($833\frac{1}{3}$ lbs.), say \$10.73 a ton. It is carried from the seashore at Kajiki to the mines on horseback, for 75 cents a load of two piculs, or say \$6 a ton.

The yearly product of 100 pounds troy of metal gives a daily one of nearly four ounces ; which would indicate that the 2,000 piculs of ore daily stamped yields less than $\frac{1}{1000}$ of one per cent. of its weight in metal, or less than a third of an ounce, or \$4, to the ton. The average value of the ore freshly mined is not yet known. It is admitted that the mines do not now pay expenses, and that the working over the old ore costs more than it yields ; but it is allowed to go on in order to keep the workmen occupied. It seems hardly probable, unless the stories about the Takatsuka vein should prove to be not wholly fabulous, that such thin veins in such hard rock should be worth working ; and it is likely that the former miners who finally abandoned mining did not do so unwisely nor before they had by thorough trial and even by considerable losses fully satisfied themselves that so enticing an occupation could not be remunerative. As for keeping the men employed, are there no hillsides that could be made cultivable by terracing, no horse waggon roads that could be built ? There is not one such road now within a hundred miles ; but if some should be built near the mines not only would the whole farming population be greatly benefitted but the expenses of working the ore would be lessened, so that the present loss would be decreased, even if not converted into profit.

From Kajiki again, we went easterly over two hills a couple of hundred feet high, across an alluvial plain a couple of leagues wide and over another hill of like height to Ku-yama, still on the seashore. On each hill there were many exposures of the gray soft, pumice tufa ; and on the last hill also some dark brown and greenish gray shales,

about vertical, with some nut size quartzite pebbles, apparently a Kamoikotan rock. Soon after entering the plain we passed through the town of Hamanoichi in Kokubu on the seashore ; and it is said that within the limits of Kokubu, at a place called Uchinono there was a very old copper mine, that was worked for three years about 20 years ago, and again a little about five years ago, but is now quite idle, evidently a mine that does not pay.

From Kuyama we struck inland eastward, rising at once steeply to the brow of a table land or broad-topped mountain about 1,300 feet above the sea, passing many exposures of the gray, soft, pumice tufa, and among them two or three of hard, dark brown, apparently Kamoikotan shales. After rising soon some fifty feet higher, the road, gradually descended, eastward and north-eastward into Hinga, with exposures of the pumice tufa in many places, where the road was deeply sunken, but in other places where it ran over the surface of the gently sloping ground there were fine views of the rather conical outline of the volcanic mountain Kirishimayama, (which is said still to send out a little smoke, once a month or so from the peak called Higashidake) ; but we saw a very wide, low plain to the east of it towards the Hinga sea coast. At Miyakonojoo, a short distance inside that province we were told of an antimony mine at Shikamura, in Takajoo-goo, five leagues to the north-north-east, where specimens of stibnite had been taken out during a couple of years up to 1876, but none had been reduced to metal, and since that there had been no mining. The vein was said to be a foot wide at most and from that down to nothing. For about three leagues our road north-eastward from Miyakonojoo was in a nearly level plain with rare exposures of the tufa : but then from near Yamanokuchi we crossed within three leagues a triple pass some 1,400 feet high above the sea with exposures of dark brown and greenish gray, apparent-

ly Kamoikotan shales, dipping at first south-easterly 35° and then northerly about as much and followed by a greenish brown grit, with the pumice tufa here and there also. Then in five leagues more with a pretty level road among low hills with exposures of the pumice tufa and latterly some of greenish gray soft sand rock and shales doubtless of the coal bearing formation, (with a dip, for example of 15° south 35° east) underlying the tufa we reached Miyazaki, one of the principal towns of Hiuga, near the seashore at the mouth of a pretty large river.

We were shown there some bits of carbonaceous shale and of very poor bony coal, black and shining, from Tachigurai in Kamikita village Miyazakigoori, but they appeared to be parts of single plants merely, though there was thought to be "over a foot of it," probably in length. In any case the coal would be wholly unworkable. Small bits of good looking black, shining coal were shown from Takatsuki, in Minamigata village, Koyugoori, from a bed said to be 0.2 ft. or 0.3 ft. thick, which was then worked in the vain hope of its growing to workable thickness. From Miyagemura in the same village there was a bit of black shining, heavy coal said to be from a bed one foot thick, but not worked on account of its inferior quality. Near Minamigata there are said to be many coal exposures but all very small. There were also bits of coal from Kitagata village, Koyugoori, from a bed called 0.7 ft. or 0.8 ft. thick. We had been told at Kagoshima that there was iron sand on the beach not far from Miyazaki.

We travelled thence northward, generally by a sandy road through wide flats near the seashore, without rock exposures except some greenish gray cliffs apparently of the coal rocks on our left at about five leagues and a half, and other exposures of similar, soft rocks with a few very fragile bivalve fossil shells near Takanabe, at seven leagues, and of like sand rock and shale dipping 15° south 50° east

at Sakamoto, about eight leagues, where we crossed some gently rising ground, a couple of hundred feet high, and then descended as gradually to the seashore at Mimidzu, about $13\frac{1}{2}$ leagues from Miyazaki. Meantime, two or three streams of some size had been crossed near their mouth; and the shingle upon their shores was made up of Kamoikotan pebbles, quartz porphyry, quartzite grit and a little black slate without granite nor limestone, but with a very few pebbles of brown and gray old volcanic rocks. We were told at Mimidzu that five leagues distant, between Yamage and Tsuboi, antimony had been mined in 1876; but that the work had been abandoned. It was also said that the owners of that mine owned the Osudzuyama gold mine a league and a half from the antimony, and that it was worked and abandoned at the same time with it.

At Mimidzu there were exposures and numerous pebbles of the very hard, blackish gray, oligoclase quartz porphyry, containing large quartz grains, glassy triclinic feldspar (probably oligoclase) and minute magnetite crystals and grains in a very hard grayish black, compact matrix. On going still northward we came at once to a hill a couple of hundred feet high, with exposures of brown decomposing or crumbling quartz porphyry, containing quartz and feldspar crystals, decomposed to white kaolin, in a greenish gray, compact matrix that weathered brown. The road descended soon to the seashore and quickly again crossed low hills with like rocks to come once more to the beach. Then there were exposures of very hard, light greenish gray quartz porphyry like that of Mimidzu, but rudely columnar and with a dip of 10° north 20° west at right angles with the columns. With many more exposures of like rock over nearly level ground we reached Tomitaka, 17 leagues from Miyazaki. Then, going still over nearly level ground not far from the sea, the crumbling light brown porphyry recurred, soon followed by blackish, fine

grained quartzite, and that quickly by brown hard Kamoikotan shales, which are exposed frequently all the way, (latterly of a gray color) over pretty level ground to Nobeoka, 22 leagues from Miyazaki.

Going northward from Nobeoka there was soon an exposure of brown granitic sand, or possibly crumbled quartz porphyry but then many exposures of gray and light brown Kamoikotan shales, up along the banks of a rather wide stream in a narrow valley. From the end of four leagues however there were many exposures of dark gray quartz porphyry like that of Mimidzu with occasional ones of the hard brown shales, as far as Kumata, at the forks of the river, about five leagues from Nobeoka. We were told that at Yato in Kawachimiyoo, copper and possibly other ores were dug formerly, but the mines had been abandoned perhaps a hundred years. From Kumata northward the road was impassable for even pack horses, and I went forward by boat up the easterly fork, two leagues and a half to the hamlet of Kudzuba, passing exposures of gray shales and quartz porphyry or perhaps quartzite. Mr. Adachi, who walked, found much of the same rocks, including blackish gray shales or clay slate; and some 600 yards from Kumata we met with a quarry of gray pumice tufa by the roadside some 20 feet above the river. From Kudzuba we all walked up stream, among high mountains, and soon met with very hard dark gray quartzite, dipping 35° north 20° west; and just beyond with dark gray hard slates, dipping 43° north 15° west, which after many exposures was followed again by quartzites as far as to the boundary of Bungo. The same quartzites with occasional brown or gray hard shales, sometimes with a vertical dip and a strike of south 80° east, were exposed frequently all the way across a pass, some 1,300 feet above the sea, to Shigeoka, three leagues and a half from Kudzuba. From Shigeoka there was a

better, more level road down stream and over low hills, still in a valley among high mountains, a couple of leagues north-westward to Ononoichi, with exposures of quartzose grit or arkose and of dark brown, hard shales; both Kamoikotan rocks, but with some exposures also of dark gray pumice tufa. Thence we ascended north-westward by narrow valleys to the Mikuni Pass, some 2,000 feet high, seeing on the way numerous exposures first of quartz porphyry then hard brown Kamoikotan shales, and near the pass some of greenish gray serpentine, of which there were several exposures on both sides of the summit with the brown shales, quartzite and grit between. At the pass they showed us a lump of chromate of iron, and told us that it was found at Washidani, half a league to the north where at government request some children had picked up five piculs of it as specimens in a single day. It occurs, so far as yet known, only in lumps scattered over the ground or in the surface loam; and the bed or vein or nodules in place from which it came have not yet been discovered. Some specimens shown us afterward at Ooita had a little serpentine sticking to them, showing that they occurred originally in that rock. Descending again steeply north-westward past exposures of the dark gray quartzite, brown shales and serpentine, in about a league and a half we came to exposures of gray limestone associated with the serpentine and dipping 75° north 10° west; but it was soon followed by quartzite again, as far as Ichiba in a pretty wide, nearly flat valley, about five leagues from Ononoichi, and perhaps 800 feet above the sea. Thence our road went northerly, pretty level, but mostly descending gently, among low hills nearly three leagues to Oosabu (about 400 feet above the sea); with hardly a rock exposure for the first league and a half, but many of dark gray pumice tufa for most of the rest of the way. Just short of Oosabu however we crossed a river

in a deep ravine, on the sides of which was exposed in cliffs a dark gray hard andesitic tufa containing glassy triclinic feldspar (probably oligoclase), augite magnetite and obsidian in a dark gray fine grained matrix. From Oosabu we went northward down a large stream by boat, winding about among high cliffy hills about four leagues to Shirataki, just below Nakahetsugi. There were such violent rapids in several places that the boatmen used a long rudder at the bow as well as one at the stern. At the landing place where we started, near the andesitic tufa cliffs, there was exposed at the river's edge a dark gray, hard, gritty quartzite, dipping 38° south 50° east; and the same rock occurred here and there near the water further down stream, but more conspicuous were numerous high cliffs about it of volcanic rocks, partly with columns about vertical. My horse boy who went by land over a difficult mountain road brought me a couple of specimens of hard brown weathered quartzite grit from Sakahara the only place where he had met with rocks. From Shirataki our road ran three leagues north-westerly, in general nearly level, among low hills and small flat valleys, and at last across a wide plain to Ooita; with very few rock exposures, but some near Shirataki of soft shaly greenish gray and brown sand rock, dipping 15° north 85° west, and soon after some of dark gray and brown shaly sand rock dipping 8° north 80° west, both resembling the Toshibets or Horumui rocks, but no doubt of like age with the dark gray, soft pumice tufa, which recurred in several places a little short of Ooita; for similar sand rock afterwards seen near Tsuruzaki contained some pebbles of the pumice.

At Ooita, the Prefecture, we were shown specimens of rocks from different parts of Bungo and Buzen. The principal mining region is the one of Kiura and Obira, on the Hinga and Bungo boundary, a few leagues west of

the point where we crossed. The boundary there for about ten leagues has somewhat the shape of the letter S with its axis north-west and south-east, and runs along the mountain summits. Near the top of the S is the mountain Soobasan, called the highest one in Kiushin ; and to the south of it are the Obira mines, while the Kiura mines are near the lower tip of the S. Both these places are surrounded by several others of subordinate mining importance. Both of them had principally tin ore : and the copper ores associated with it were rejected, but have been tried now for two or three years past, without much success on account of the presence, it is said, of antimony (or more probably arsenic.) The country rock at Obira is represented to be a gray hard grit (apparently like that of the Taniyama tin mines), in which there are but two veins, one of tin ore and one of copper pyrites. The copper vein is said to have been about two feet thick at most and 0.8 ft. at least. A freshly mined specimen of the copper ore was brought to us and contained perhaps one-third of its bulk of copper pyrites in a vein 0.3 ft. wide at most, and one-fourth of mispickel and the rest of black quartz. The vein was said to be even thicker with ore up to 1.4 ft. or 1.5 ft. Another specimen contained a fifth of its bulk of copper pyrites with much fluor spar and grayish green amphibole and ferruginous quartz. The tin vein would seem to be very thin ; but was mined from the Temmei period (1781-1788) until about 1873. The Kiura tin mines were still older. Obira and Kiura together yielded 200 piculs of tin a year, and even 394 piculs in 1825 (12th year of Bunsei). At Obira there was much arsenic present, and the ore had to be roasted 30 days ; at Kiura there was none. At Kiura the copper ore is said to be in small pockets up to two feet in diameter, scattered irregularly through the rock without any proper vein. The country rock there is likewise a grit but rather coar-

ser and flaggy or shaly, so that it is easily split down. A little copper is still made at Obira from the Hachimanyama and a little at Hibira near Kiura in the edge of Hiuga, and at Uchinokuchi, north-east of Kiura, galena (said to be in scattered masses 0.2 ft. or 0.5 ft. in diameter) and cerussite are worked now, but only by a single family of miners. It is said that native silver also occurs sometimes with the galena. No metal is made now anywhere else in the whole region. At Ooshirodani, easterly from Kiura, a copper pyrites vein said to be 0.2 ft. wide is just beginning to be mined with 14 or 15 miners in hopes of its becoming wider. Formerly the mines there were worked eight fathoms below water level. There are also near Obira the Toroko silver mine, the Jookooji thought to be on the same vein, the Naruse lead mines, the Sugiiwadani lead mine, the Tsubakiwara antimony mine, and a mine of half lead and half antimony (?), producing a metal very brittle and fusible; but none of them is worked at present, and they are perhaps of insignificant importance. The Sugiiwadani vein however is thought to be the same at that of Ookura, and is said to be about two feet wide with ore mixed with gangue. From Ooidzuki at Obira specimens of brownish black nearly pure zinc blende were shown us, and said to come from a vein by itself about four feet wide, cutting across the lead vein. From Obira also was shown a specimen of dark gray, soft steatite in a large block, headsize, and other smaller green ones. There was also some granite from near Kiura, and there is white limestone at Ooshirodani. The rocks of Kiura and Obira evidently all belong to the Kamoikotan Group. The mining region appears to be the most important metallic one in Kiushiu, and is said now to be almost wholly abandoned merely because the mines have been worked down to water level (not below it except at Ooshirodani). Though the accounts given of

them are not on the whole very promising, it seems worth while to have them examined more carefully than would have been possible to me so late in the season (December) and with still so much travelling to do, and if the result of such a reconnaissance should be encouraging it would be best to make a topographical and geological survey of the whole region with a view to working the mines if the survey should prove them to be worthy of it.

We were shown some samples of iron sand from Kunisakigoori in Bungo and from Buzen; but none of it is worked, nor indeed is any in all Kiushiu. There was granite too from Kunisakigoori. There was also some gold ore, so called, from Machida village in Kusugoori, Bungo, where gold is said to have formerly been washed on a small scale. There were specimens of graphite, said to be in small quantity and apparently unworkable, as it was not very pure looking, from Amabegoori; and some gray limestone from the same district.

From Ooita we travelled eastward a couple of leagues through the alluvial plain to Tsuruzaki near the mouth of the large river we had lately descended, and coming there to low hills on our right passed an exposure of the soft, greenish brown weathered sand rock and nut pebble rock with a little pumice in lumps up to the size of a fist, and with other pebbles of Old Volcanic and Kamoikotau rocks. Keeping on eastward near the seashore with the low hills to our right we came to the village of Nakanose five leagues and a half from Ooita, and I turned aside from the main road about a mile southward among the hills to see the copper mines of Koozaki, though it turned out that they had long been idle. All along the side road there were exposures of tale schist, dipping for example 22° south 10° east, or at another point 41° south 20° east.

But close around the mines the rocks exposed were dark green and greenish gray serpentine, with a dip at one

point of 22° south 20° east, the country rock of all the veins of copper ore. The veins are reckoned to be five in number, and the mines as many, all within a space of perhaps 150 yards in diameter. Two of the veins run north and south, one of them without ore, and one (it is said) with about 1.4 ft. of ore, which is mostly mispickel and in very small part copper pyrites. The other three appear to be all north-east and south-west veins. One of them, the Tenjoo has been worked out. Another, the Number Two Mine, is said to have a little ore. But the principal mine with the best ore was the Number Four Mine, which however is said not to be good to the south-west, but to have elsewhere a width of 1.2 ft. of ore. Some samples of the ore showed it to contain much mispickel and iron pyrites and very little copper pyrites. The vein is very hard to dig, but the country rock not very much so. The mines were first opened about 1827, were worked for about a year and a half, then abandoned until about 1876, then worked for seven months and abandoned again for lack of ore. The present owners took them up in 1877 with about ten miners, and stopped the working again in May, 1878, after making only about twenty piculs of blister copper (or less). For that, 200 piculs or more of ore were dug; but the average yield of the ore mined is said to have been $4\frac{1}{2}$ or 5 per cent. With a hand hammer it was picked over, and so reduced in amount that the yield of the remainder was something less than ten per cent. of copper, say seven or eight per cent. There was no washing of the ore. It was roasted three times, ten days each time, in six stone kilns of various shapes and sizes, all about four feet high, three of them about five feet in diameter and three rectangular about $4\frac{1}{2}$ feet long by three feet or $2\frac{1}{2}$ feet wide. It seems pretty clear that the mines cannot pay, tested as they have been repeatedly in the surest, though costliest,

method of actual mining and smelting; and they belong no doubt to that numerous class of Japanese mines where there is enough ore to tempt overhopeful men to the waste of money every few years, as often as the losses, originally concealed as far as possible, or variously excused, have been forgotten. At any rate, before resuming work here again a careful geological survey should be made, which at small expense would be very sure to prevent far greater useless outlays.

Returning to the main road we went from Nakanose eastward along the seashore and on the flank of the mountains at our right to Saganoseki, at the end of a long promontory. There were many exposures along the road of greenish gray, sometimes weathered dark brown talc schist, often very quartzose with white quartz, and dipping for example, 22° north 10° west; but near the end there was much dark green serpentine.

The cape of Saganoseki is separated from the end of the westernmost, long, narrow promontory of Shikoku by a strait only three leagues wide, with strong currents. The Shikoku head land is wholly mountainous, and has only very difficult roads. We crossed just south of it in a junk to Yawatahama, in Iyo, thirteen leagues, and in passing could see that the narrow ridge as well as an island in the strait was made up of serpentine and talc schist, a continuation of the rocks we had just passed on the same line in Kiushiu. We were told at Yawatahama of an old copper mine so called at Hidzuchi, which had been abandoned about 1873; and had more recently been visited by Mr. Frecheville, whose report upon it, wholly unfavorable though it is, will soon, I trust, be published.

From Yawatahama we travelled north-eastward up a small valley between high hills, with exposures at first of talc schist dipping 65° north 25° west, but soon a few of gray Kamoikotan limestone with some lime kilns and then

again many more of talc schist very quartzose with white quartz dipping 40° north 35° west, to the top of a pass about 1,100 feet high. Descending thence steeply in the same direction with many exposures of talc schist for the first half league or more we came down into a narrow, flat valley between the mountains and reached Oodzu on a large stream, four leagues from Yawatabama. Thence over a pretty level road in a narrow flat valley among mountains, we travelled a league and a half north-easterly; and then ascending a narrow valley with talc schist exposures we crossed a pass some 300 feet high to Uchiko; and up another ravine climbed over another pass twice as high, with many like exposures; and ascended a large brook, still with much talc schist exposed, past Nakayama to Saridani. There, as we were told, there was at one point a copper mine abandoned more than forty years ago and at another a couple of leagues distant there was a copper mine opened about 1871, abandoned about 1874, reopened in 1876, and still worked a little, having formerly produced a picul of copper a day, but now less, as the vein has become poor. Keeping on northerly we at once crossed a pass about a thousand feet high and descending still past many talc schist exposures came soon to nearly level wide alluvial ground, which we crossed for a league or less to Gunchiu on the northern seashore. At Toyama, near Gunchiu, a hard white rock, probably feldspathic is dug and used for making porcelain, as we were told, and is also used for whetstones, that are rather celebrated in the central provinces. From Gunchiu a level road north-easterly through a wide alluvial flat near the seashore brought us in three leagues to Matsuyama, the principal town of Iyo, and a Prefecture.

We were shown there specimens of rocks and ores from Iyo and Sanuki. From Iyo there were : stibnite, worked a little, copper pyrites from several old abandoned mines,

traces of poor coal, pyrolusite, serpentine, talc, mica, limestone, dolomite, quartzite, from Uwagoori ; copper pyrites, stibnite, worked a little, coal from small abandoned workings, traces of graphite, limestone, dolomite, traces of gypsum, talc and granite from Kitagoori ; granite and kaolin from Iyogoori ; grit and kaolin from Kumegoori ; copper pyrites and a trachytic rock from Numagoori ; stibnite, steatite, serpentine, white marble and gypsum from Niigoori ; about 50 specimens of the copper pyrites ores and talc schist of the famous Besshi mines, in Umagoori, of which there was also a large wooden rough model ; talc schist and kaolin from Ukenagoori ; dolomitic marble from Kazahayagoori ; black clay slate from Kitagoori ; all Kamoikotan rocks, except the trachytic one and the coal. The copper pyrites specimens were all fine grained and apparently mixed more or less with iron pyrites. From Sanuki there were iron pyrites, quartzite and a trachytic rock from Toyoodagoori ; small garnet grains, used for polishing, and coal, not mined, from Minogoori ; quartz from Shoodoshima (sometimes written Shoodzushima), where there was said to be coal mined, apparently the only workable coal in either of the two provinces, but, according to Mr. Frechville's unpublished report, at best only $1\frac{1}{2}$ ft. thick and of rather poor quality, and in some places only one foot and of very bad quality. Our intention had been to visit the Besshi copper mines nineteen leagues easterly from Matsuyama, apparently the most profitable metallic mines of all Japan ; but, owing to the lateness of the season (the last week of December) and the fact that according to a good and detailed manuscript report on them by Mr. Frecheville (which made our going there less important) they were 4,000 feet above the sea, and as snow had already fallen there to the depth of a foot and was almost certain to fall at that stormy season much deeper before we could arrive there,

we decided to go to Koochi by the direct road, fifteen leagues shorter.

Before leaving Matsuyama we visited the Doogo hot spring rather more than half-a league to the east, one of the most celebrated in Japan. The water issues from a stone cylinder some four feet in diameter and covered with a dome, and was of the temperature of 40° C. It is a little sulphury in smell and taste and blackens silver. The quantity is enough to supply eight or more large baths. No rocks were exposed at the spring ; but Mr. Adachi took a specimen of one from a neighboring hill, which was a light brown decomposing, rather fine grained granite.

From Matsuyama we travelled southward by the Koochi road, over an alluvial plain to Kutani, at the edge of the mountains, three leagues and a half. There we began, for some distance gently, but afterwards steeply to ascend a pass some 2,500 feet high above the sea, (with snow half-a-foot deep on the 26th of December) ; whence we descended to Kumamachi, among the mountains, on the head waters of a river that flows southward into Tosa, and seven leagues from Matsuyama, and some 1,750 feet high and reckoned one of the two coldest towns in Shikoku. At first we had met with exposures of arkose, then with a first and head size hard dark brown Kamoikotan pebble rock ; with some syenitic pebbles, and at last with blocks of talc schist. They told us at Kumamachi that there had been a small copper mine at Uchiai half-a league to the north-east, but that it had been abandoned in the spring of 1878, because the ore had been worked out. From Kumamachi we crossed in four leagues and a-half south-easterly two passes about 2,500 and 2,350 feet high and a hill some 1,800 feet high over rough, difficult mountain roads with numerous exposures of talc schist, often very quartzose to Higashikawa, still about

1,500 feet high in the midst of high mountains. The thermometer was at 12° F. there on the morning of the 28th of December. We then climbed south-eastward over one more pass some 2,850 feet high, and descended into Tosa to Ikegawa, and then by a pretty level road in a narrow valley to Kawaguchi, $18\frac{1}{2}$ leagues from Matsuyama and 11 leagues from Koochi, on the main stream of which we had seen the head waters at Kumamachi. There were numerous exposures of talc schist all the way. From Kawaguchi we went down the river with tremendous rocky rapids by boat with a bow rudder, three leagues easterly to Ochi. There were high mountains on all sides all the way and much talc schist and some serpentine and apparently some quartzite were exposed ; but at the Ochi landing place there were dark green hard Kamoikotan shales, dipping 75° south 80° east. From Ochi we went by land five leagues easterly to Ino, by a comparatively level road among low hills, with exposures at first of dark brown hard shales, then of crumbling quartz porphyry, then of the shales again, then more of the porphyry and some serpentine (near the village Kuzaka) then the shales once more and at last some very quartzose talc schist at Ino. Thence our road ran three leagues easterly, at first among low hills with exposures of dark brown Kamoikotan shales and then over a wide alluvial plain to Koochi ; where we arrived on the 30th of December and staid until after new year's day to see the minerals of the Prefecture.

The account of the rest of the journey belongs more properly to the next report of progress. The present one is already too lengthy, as the temptation has been too strong to mention one detail after another that might be of interest or bear out conclusions of some importance. A somewhat more minute description of the rocks along our road has been given than in one or two of my last reports

of progress, because there has been more leisure for it and there might be some delay in getting maps printed that would show many more details including the position of nearly every rock exposure and a good many dips that it would have been far too tedious to cite here. As in the journeys of former years a continuous rough sketch of the road was made on a scale of about $\frac{1}{2500}$, a part of which was reduced to about $\frac{1}{30000}$ while travelling. At the different Prefectures a good deal of information was gained in regard to the minerals and mines in their provinces, and a great many other facts were gathered here and there elsewhere that could not very conveniently be given in this report without maps and drawings, but that will find their place in more detailed special reports of the different mines and regions. The notes about mines were fuller than might be supposed from the brief accounts of them given here ; but the visit to each place was necessarily very short, rarely more than a very few hours, the notes had to be written down hastily and in great confusion, and no doubt in reducing them to order and writing them out completely many additional points of more or less importance may be made out, some corrections of details may be discovered, and more or less weighty deductions may be drawn from further comparisons.

Perhaps even now it may not be too soon to consider what may be roughly estimated to be the chief mining interests of Japan ; for through the rest of our journey we met with no important mines, and found there was no workable coal on the main island of Shikoku, in spite of the large extent of coal that some have supposed to exist there ; and we only heard of some small coal mines in Kii and Ise. Reckoning as we have done the western coal as amounting perhaps to six hundred and twenty million tons, and supposing one-third to be lost in mining there would be a net product of about 400 million tons, which

would be worth at the sea board, at two dollars and a-half a ton, a thousand million dollars. Insignificant as this may seem in comparison with other larger and richer fields it is yet probably as much as the value (excepting iron) of all the metallic mines of Japan put together. In regard to the amount of metallic ores, it is too soon to speak at all positively, but we are likely to be making a liberal estimate if we put the amount of workable copper ore as not greater than what would be contained in 150 veins with an average width of half a foot of ore and an average length of 150 fathoms of ore that would hold fourteen per cent. of copper. Such a vein would contain down to a depth of 4,000 feet 66,667 cubic yards and something like five million dollars' worth of copper; so that the whole amount of copper in all the workable mines together could hardly be more than 750 million dollars, much less than the value of the western coal. No doubt a disproportionate amount of copper has already been mined in Japan, but it has probably come in great part from the very numerous veins that would not now be workable at greater depth and with higher wages, and I strongly suspect was in very large measure produced at a decided loss. The eight or ten gold and silver mining places of any consequence that were formerly worked and that may still be more or less workable in the future, owing to the high value of the ore and the great width of the veins as reported in several cases may be very important, but all together could hardly be equal in value to more than 250 million dollars. Indeed to make up that amount we might freely throw in also the four or five formerly workable lead mining places (now doubtfully so, especially with the present low price of lead), the several antimony places, as yet, scarcely found workable, and the two or three tin places, if any one of them be really workable. On the other hand, as to the iron, if our extremely rough conjectures

in regard to the amount that possibly exists in a workable condition and position in the central provinces be anywhere inside the truth, and if we reckon its value, like that of the other metals, in its finished form, as wrought iron or Bessemer steel, at say fifty dollars a ton, and supposing the ore to yield only fifty per cent., it would be worth at least 250 thousand million dollars or 250 times the whole value of the coal in question. We can then set it down roughly that the relative importance of the coal and metal mining interests of Japan (exclusive of Yesso and of the small Kii, Ise and Iwaki coal fields) as likely to turn out to be something like this: iron 1,000; coal 4; copper 3; all other metals, (chiefly gold and silver) 1; perhaps worth altogether \$252,000,000,000, or about the same as the value of the coal I formerly estimated very roughly to exist in Yesso. Although these too exact looking figures are but rough guesses, based on imperfect information that it has not yet been possible to scrutinise fully, and though they will doubtless be changed by more thorough investigation, yet the relative order of the minerals is at least not likely to prove very different. It would appear then that in Japan as in the rest of the world, the cheap and homely coal and iron are by their far greater abundance very much more important after all than gold, silver, copper and the other metals.

It may have been noticeable that my sketch of the different mining places visited on the journey has in almost every case ended with the recommendation that waggon roads should be built and a topographical-geological survey be made; for indeed it has seemed that such advice could not be too often repeated. It has been shown by several striking illustrations what a heavy tax upon all mining and metallurgical industries is the enormously heavy cost of carriage on the wretched roads, mere bridle paths, that alone exist near the mines at present with

scarcely an exception. The modern cheap methods of mining and metallurgy with which Japan has to compete require not merely cheap capital, but cheap carriage in order to accumulate and work with fuels, ores, fluxes, and other material in large quantities by mechanical means, and especially so as to have the aid of freely given natural forces; and more particularly in the case of coal and iron is it necessary to reduce the cost of carriage to the lowest possible point. But every mineral industry suffers in its own degree from the same cause; and for example, as long as it costs as much to carry rock oil ten leagues over country roads as it does to bring it all the way from New York to Yokohama, it is hopeless to look for great profits from our wells, or to expect their product to be much used outside of their immediate neighborhood.

The importance too of surveys in which the geological details are made out as thoroughly as may be by instrumental, topographical surveys so as to understand as fully as possible beforehand the extent, position and all the circumstances of the mineral deposits to be worked can hardly be too highly estimated. Of course it is possible to go on proving their merits merely by actual trial as has been done in Japan for hundreds of years; but the cost would be far greater without gaining more satisfactory information than would be obtained from surveys combined sometimes with a little inexpensive trial digging. Exploring underground deposits by actual mining is very costly, especially when there has been no survey beforehand as a guide. It is not like testing by trial the value of soils on the surface of the ground, a method that the dense and active population of Japan has in the course of thousands of years so thoroughly carried out that doubtless there is not in the whole country (this side of Yesso) a single rood of ground of which the agricultural capability is not well understood by the neighboring villagers. The

same method has been applied to the mines, but with less definite result because miners are always hoping very strongly that the portion of a vein not yet seen and tried is better than what has already been mined, and the owner, aside from his honest hopefulness in regard to the unseen, is strongly interested, consciously or not, in maintaining a high estimate of the value of his mine and in concealing or palliating any lack of success in trials that have already been made.

It is perhaps hardly necessary to urge the manifold utility of geological surveys in a country where in their first six years of work on the humblest scale, while scarcely passing beyond the preliminary stage of a hasty general reconnaissance they have made known, what had never in the least been suspected before, the probable existence of the mineral basis of five hundred thousand million dollars of wealth ; but it should be borne in mind that their immediate advantage has been no less decided in preventing mining ventures that would have been ruinous and far more costly than the surveys.

It is but justice to our geological assistants to say that the government has now in them a small body of intelligent, careful, and honest men capable of carrying on the detailed surveys that we have shown to be so important, and still better able to map any district in colors according to its principal rock formations. It is true their experience is still limited, and in particular they have had nothing yet to do with ore veins ; and even to the wisest and longest experience there are at times points that are too difficult to understand. No doubt the assistants would make more rapid progress under the guidance of greater knowledge and experience than their own ; but, even without that aid, they can get along with mutual help, especially in coal and iron surveying, which is really, as we have seen, the most important, and is of the kind

they are more accustomed to, and much less difficult than their oil surveying. They are by this time so far advanced that by degrees even without guidance they can gain in that work additional skill, and at length can doubtless become able fairly well to master the more difficult problems of any deposits. In some sort then, if there be no impatience in regard to mining, what six years' ago I hoped would be brought about "within a few years" has already come to pass, and Japan may be considered strictly speaking to be already independent of other countries in practical geology.

I have the honor to be,

Sir,

Your most obedient servant,

BENJ. SMITH LYMAN,

Chief Geologist and Mining Engineer.

Kooji Machi, 30th July, 1879.

GEOLOGICAL SURVEY OF JAPAN.

REPORT ON THE PROGRESS OF THE GEOLOGICAL SUR-
VEY OF JAPAN DURING THE FIRST HALF OF 1879;
BY BENJAMIN SMITH LYMAN.

To His Excellency

K. INOUE,

Public Works Minister.

SIR.

I beg to make the following report on the progress of the Geological Survey of Japan during the first seven months of 1879, while it was in my charge.

The assistants (the same men as in 1878) were throughout the whole time occupied with the mapping of their oil surveys; except that Messrs. Sugiura and Ban made a trip from 25th March to 15th April to the Tootoomi oil field in order to explain its features on the spot to Messrs. Yamao, Public Works Vice Minister and Otori, Chief Secretary to the Public Works Department, and at the same time to do a little additional surveying; and Mr. Akiyama was in Echigo managing the three government oil wells there, for which purpose in February he was temporarily detached from the Geological Survey. Messrs. Sugiura and Ban brought back word from Tootoomi that

a number of additional wells had been dug in places recommended by them according to our mapping, and with good success.

My own time was spent in travelling from New Year's until 3rd of February, and since that in office work. It is best to give at once an account of the journey from Koochi homeward in continuation of the report for last year.

At Koochi we were shown a few mineral specimens of Tosa by the Prefecture. They were almost wholly fine grained copper pyrites apparently mixed more or less with iron pyrites and associated with talc schist, with calcite and in one place with traces of gypsum, from eight places in Hongawagoo, in Tosagoori (of which Mominoki was said to have the best copper mines of the two provinces Tosa and Awa, and according to Mr. Frecheville's unpublished reports is a decidedly profitable one, and the only one that is so); from two places in Nagaokagoori; one in Agawagoori; and one from Kamitanokuchi in Hatagoori (apparently the second most promising mine of the two provinces). There were also specimens of metamorphic black clay slate from Akigoori; black slightly graphitic shale from Kamigoori; serpentine from Nagaokagoori, and from Tosayama, in Tosagoori; very small bits of stibnite from Komugise, in Tosagoori, and from Ninagawa in Hatagoori. We were also shown a specimen of blackish shale from Harami in Nagaokagoori, about two miles from the Mitsu Bishi Steamship Company's Koochi landing place, and were told that the shale was standing vertical and three feet thick, and contained irregular lenticular masses of coal up to 0.2 foot or 0.3 foot thick, of which some small blackish and shining bits were shown. It was strongly hoped that it might be worth while to mine the coal; but of course it would not be. There was also a coal mining lease at a mile and a half from there but

apparently only on account of some dark green serpentine of which a specimen was shown.

We learned that the shorter road from Koochi across the mountains to Tokushima in Awa was impassable on horseback on account of snow and ice ; so that we must go round by the southern coast. Starting, then, from Koochi on the third of January in the beautiful clear and mild weather that makes the winter climate there such a remarkable contrast to that of the northern side of Shikoku so near to it, we went by boat nearly three leagues easterly to Inae, formerly called Shimodajima. At first we were on a canal, then on a wide river that flows from the north but is only a short one, and then we ascended a small branch stream. To the south there was a wide alluvial plain ; but on our left, after fairly getting outside of Koochi, there were low hills with exposures here and there of what appeared to be light brown shales of the Kamoikotan series. At Shimodajima however we found lime kilns and quarries of gray lime rock, with a dip of 65° north 50° west. Then still eastward passing here and there low hills we went through a wide alluvial plain at length not far from the sea shore, two leagues and a half to Akaoka. On the way we crossed the broad but nearly dry bed of the Menobe River ; and found the pebbles there to belong apparently all to Kamoikotan rocks, dark gray quartzite, white quartz, brownish gray grit, gray lime stone, and dark red jasper.

Thence the road ran still easterly among and over not very high hills, not far from the sea shore, about a league and a half to Haseori ; the first league or so with exposures of gray and dark red quartzite, and the rest of the way many of hard brown Kamoikotan shales, near the beginning with nodules of hard brown grit and with a dip 80° south 30° east. From Haseori easterly about a league and a half to Akano the road was sandy without rocks,

near the sea beach, with high hills a short distance to the left. Then for a league eastward, over low hills, there were exposures of the greenish brown and gray shales apparently of the Kamoikotan series with nearly vertical dip; but followed on the road easterly along the sea beach by greenish gray soft sand rock, no doubt of the same lignitic formation to be met with near Naari further on, generally about level dipping, with some very fragile fossil shells near Ananai; soon followed again however by extremely hard, but partly shaly, gray quartzite grit, dipping 67° north 55° west. So the road ran on eastward over flat ground near the sea under moderately high hills to the left through Aki as far as to the nine league post from Koochi. At that point there was a natural bridge, or a crooked cavern some 30 feet high and 15 feet wide piercing the hill, with a brook flowing through it. The rock was a greenish gray, partly brownish gray rather hard sand rock doubtless of the same lignite formation as before with here and there fist size nodules or pebbles and dipping 25° south 60° west, and with great numbers of fossils. A couple of hundred yards beyond, however, there were light brown and dark brown, apparently Kamoikotan shales, and some 600 yards still further, dark brown and gray, partly blackish, very hard Kamoikotan shales, partly a gray metamorphic grit, the shales much contorted, but at one point dipping 65° north 50° west (nearly at right angles to the fossil bearing rocks); and close beyond that and for several hundred yards, numerous exposures of dark brown Kamoikotan quartzite and shales, and pea pebble rock, on the sea shore. Then the road crossed a low hill rough with cliffs of gray hard quartzite grit, dipping on the near side 35° north 45° west; and descended to the hamlet of Ooyama on the sea shore again. Thence the road went still easterly, but level, near the shore, with hills on the left, and at first

with many large blocks of the same hard Kamoikotan rocks, three leagues to Naari. Half a mile beyond Naari near the seashore we saw in passing an adit dug and abandoned about 1871, said to be about 960 yards long, and dug for coal of which a weathered specimen lying near proved to be woody-fibred lignite like that of the Toshibets rocks in Yesso. The adit was too full of water to enter far and I did not see the lignite in place; but from the description given on the spot it would appear to be only 0.3 ft. or 0.4 ft. thick, and of course would be wholly unworkable, as it had proved on trial. The rock was a greenish brown clayey shale with layers of egg sized pebbles; and the dip was about 15° north about 55° west. There was said to have been two other holes close by, on either side but both were now fallen in, and they had found only the same amount of lignite. This thoroughly worthless deposit is a main part of the foundation of the most extravagant impressions that have got abroad in regard to the existence of a very large coal field in southern Shikoku, whereas there would appear to be not a single ton of workable coal in the whole island. Too implicit faith in such heedless exaggerations might encourage oversanguine, ignorant men to waste enormous sums of money, and thereby might do immense harm.

Thence the road went south-easterly along the seashore five leagues and a half to Morotsu Ukitsu at first and occasionally afterwards over a narrow flat, but often over the foot and side of high hills on our left; with many exposures of Kamoikotan hard metamorphic grit, dark brown shales, and dark brown quartzite; and the dips were, for example, 30° south 30° east, and at a saddle in the rocks 20° north 50° west and 70° south 40° east, and in another place 60° south 20° east. Then going north-easterly up a narrow valley and across a pass about 650 feet high, with some exposures of the brown Kamo-

kotan shales ; we descended in two leagues to Shima on the south-easterly seashore of Shikoku, having cut across the southernmost promontory of the island. At Shima on the shore there were big blocks again of the quartzite grit, and, near by to the north, exposures of like rock in place. The shore there for many miles is extremely rough with rocks, at the foot of high hills and at some points almost impassable even to an unloaded horse. We therefore went by boat with the westerly wind that almost always blows in the winter, nine leagues (as it was called) to the little harbor of Shijikui, in the south-western corner of Awa, passing near its entrance and for some miles beforehand islands and cliffs of dark brown flaggy or greenish gray massive hard grit and occasionally dark brown shales, all apparently Kamoikotan rocks. The grit all along there has the peculiarity of having its surface much honeycombed on a very large scale.

Thence going north-easterly by land near the sea, sometimes on the shore, sometimes over hills up to 400 feet in height, past many exposures of the grit with a dip of 45° north 20° east, and of Kamoikotan dark brown hard shales and flags with dips of 75° north 10° east and 60° north 40° west we came through Takazono in a league and a half to Asakawa, just beyond the 21 league post from Tokushima. Half a league short of Asakawa I found in hard green shales traces of what seemed to be a fossil somewhat like an orthoceras, but slightly curved, resembling what occurred near Muraoka in Tajima. We were told that for about half a month in 1875 or 1876, some digging for copper ore was done near Asakawa, but without any success. As the road beyond that village was called impassable for loaded horses, with "eight hills and eight beaches" to cross, we went by boat a couple of leagues to Mugi, passing near the rocky shore,

under low hills with many cliffs, apparently of Kamoikotan dark brown and dark gray shales. Thence sending the baggage round by boat we walked two leagues and a half to Hiwasa by a path among rather low hills, crossing a couple of passes about 500 feet high, and passing exposures of the same dark brown and light brown hard shales and then of the gray, partly buff, grit again. Thence our road went northerly, soon among high hills, over passes 300, 600, and 350 feet high, with many exposures, at first of the dark gray grit, dipping at one point about 65° south 20° west, then of the dark brown hard shales, then of flaggy grit with a dip of 65° north 20° west, then of red shales and flags (near the village of Kaneuchi), then of the flaggy grit with here and there shales, past Kuwano in an alluvial plain, and then down a river bank with low hills to the left and many exposures of the grit to Kamiarai or Nagaike. Near Kuwano they told us that lime was obtained at Tsunomineyama, one league distant. Then our road went northerly across a pretty large river and over a very wide alluvial plain six leagues and a half to Tokushima, the principal town of Awa. In the town itself, at the Kompiler Temple there was a small hill with cliffs of dark green very quartzose talc schist dipping 20° north 10° west.

The branch Prefecture office at Takashima showed us specimens of the rocks and minerals of Awa. There was copper pyrites fine grained, apparently like all the copper ore of Shikoku, and generally impure with iron pyrites and associated with talc schist, from four places in Oogoori, two in Mimagoori, two in Miyoshigoori, one in Nagagoori, one in Kaifugoori and one in Miyooosaigoori; traces of black shining coal from two places in Katsuura-goori and one in Nagagoori; traces of stibnite from Nakamura in Kaifugoori, where there was a mine; gray metamorphic limestone from four places in Nagagoori, and two

in Katsunuragoori ; talc schist from three places in Mima-goori, one in Miyoshigoori and one in Miyootoogoori, dark chocolate, brownish black, grayish black, or black, apparently Kamoikotan shales from two places in Nagagoori, two in Katsunuragoori, one in Kaifugoori ; and plasma from Ooi village in Nagagoori. None of the copper mines seem to be very promising ; and none of the coal at all workable. The rocks appear to belong almost wholly to the Kamoikotan series.

From Tokushima I went northerly through the wide alluvial plain and across a couple of wide mouth branches of the Yoshino River, the principal stream of eastern Shikoku, to Okazaki, on the seashore ; passing the last part of the way some low hills on the left, and finally on the right too, with exposures of brown Kamoikotan shales and greenish gray grit flags. Thence we crossed in a junk three leagues easterly to Fukura on Awaji Island ; passing at both ends of the voyage dark brown cliffs of similar rocks on our left ; and midway not far off on the same side a famous and much dreaded whirlpool caused by the currents at certain stages of the tide in the narrow strait between Shikoku and Awaji. From Fukura we went by land across the island north-easterly five leagues and a half to Sumoto by a pretty level road, going almost at the start over a pass about fifty feet high, and then over a broken country on the head waters of the principal river of the island, in a broad, for the most part gently sloping valley with high hills in the distance. The rocks exposed were at first dark brown Kamoikotan shales, with a dip near the pass of 35° south 50° east ; but beyond that there were few exposures, and they, near Nakasuji (about four leagues from Fukura) seemed to be of comparatively recent age (perhaps of like age with the Horumui or Toshibets rocks), light greenish gray and brown, soft sand rock and clay with silicified wood, dipping 20° north

20° west ; and near by 25° south 57° east ; yet still nearer and beyond Nakasuji the dark brown shales were exposed again. From Sumoto I walked over the low hills and along the seashore two leagues and a half easterly to Yura ; passing numerous exposures of Kamoikotan rocks, at first very hard sand rock weathered dark brown and greenish gray, shaly, coarse, grit weathering brown, rather hard, with bean size quartzite pebbles, dipping 55° south 25° east, and again, near by, 75° south 70° west ; then light gray crumbling arkose much resembling crumbling granite ; then coarse pebble rock with quartzite and hard grit pebbles ; then dark brown and dark gray hard shales dipping, for example, 35° south 50° east, with very hard gray grit flag. From Yura we crossed in a junk three leagues easterly to the mainland of Nippon at Kata, in Kii province ; passing more of the dark gray and brown shales and flags on Awaji and on the southern end of the large island with low hills in the strait. At Kata too there was a small hill with a cliff of hard dark gray Kamoikotan sand rock and dark brown and blackish gray hard shales, dipping 35° south 15° east. From Kata our road ran easterly three leagues to Wakayama, over a pass scarcely 75 feet high and across a wide alluvial plain, with only one or two exposures of dark brown Kamoikotan shales. In the plain there were very many shallow wells with sweeps for watering the rice fields.

The Prefecture at Wakayama showed us specimens of ores and rocks from different parts of the province of Kii. There was fine grained copper pyrites, generally impure with iron pyrites and sometimes associated with talc schist from four places in Itagoori, all worked a little, two since 1874, one since 1878, and one, the best, at Maruyama, in Gosho village, since 1863 or 1864 ; also from two villages in Nagagoori, one with a small mine since 1873, and the other without any ; from one place in Hidakagoori, work-

ed from 1876 to 1878 and abandoned ; and two in Nagasagoori, both abandoned. There was black shining coal, partly bituminous and good looking, partly anthracite and rather impure with slate, from three places near together (perhaps half a league apart) in Minogoori, where the bed is said at one place at least to be three feet thick. There was stibnite from one place in Hidakagoori, said to be 0.6 ft. wide and to have been discovered in 1870 and mined in 1878 to a length of five fathoms, with five holes.

There were traces of galena from one place in Murogoori, said to have been discovered in 1875 and worked in 1878. There was dark gray metamorphic limestone from two places in Amegoori, and one in Aritagoori ; two of kaolin from Aritagoori ; and one of dark green steatite from Minogoori. There are said to be 62 mining places in the portion of Kii that is under the Wakayama Prefecture, of which 22 are worked ; but they are mostly very small.

From Wakayama we went through the wide alluvial plain by a good road easterly and north-easterly for a league or more up the left bank of a broad but nearly dry stream and at length across it to Yamaguchi ; then northerly a couple of leagues across a mountain range by a pass about 700 feet high to Shindachi, in Idzumi, seeing many exposures of dark greenish gray metamorphic grit weathering dark brown, with dark brown shales interbedded, dipping for example, 50° north 85° east, 70° north 80° east and 60° south 85° east, and further on 75° south 55° east and 70° south 15° east. Near Shindachi there were exposures of light gray soft shales like those of the Toshibets Group, about level. Thence the road went north-easterly, not far from the sea shore on our left seven leagues and a half through a very wide alluvial plain, with many shallow wells for watering the rice fields, to Sakai.

The Prefecture there showed us specimens of rocks and minerals from Yamato, Kawachi and Idzumi. From Sakai, there was fine grained copper pyrites, generally impure with iron pyrites, sometimes with talc schist and often quartz and occasionally traces of calcite, from 26 places in Yoshinogoori; and in traces from three places in Kitagoori; besides traces of malachite from two other places in Yoshinogoori. There was a little fine grained cinnabar in quartz from Komagaeri, and some black, shining bony looking coal from Kandani; both in Kitagoori. From Kawachi, there were small garnet grains (used for cutting and polishing quartz) from Yamada in Furuichigoori; dark brown fibrous lignite from Saragoori; and an account of the discovery of some oil gas in a well at two places in Fushie village, in Wakaigoori, about May, 1877; apparently an unimportant affair. It was said there were in the three provinces under the rule of the prefecture, 77 mining places, of which 48 were merely trial diggings and 29 were mining leases. Of the 29 leases, 24 were for copper, two for cinnabar, two for coal, one for antimony; and of the 48 trial places, 40 were for copper, three for cinnabar, 2 for coal, one for silver and lead, one for gold, one for oil.

From Sakai we went northerly near the seashore through the very wide alluvial plain, three leagues to Oozaka, in Settsu. The city government there showed us two specimens of very poor looking copper pyrites that had been dug in its territory, one with a little zinc blende and the other with a little galena and both with quartz gangue. Both places are in the village of Hagitani; and after an unsuccessful trial they had been abandoned in 1877. It was said however that there were three other places still worked under mining leases, though none profitably.

We went by rail road through the alluvial plain eight leagues and a half westerly to Hiyoogo, with views to

our right of rather low mountains, evidently made up of Kamoikotan rocks with the peculiar brown earth exposures that come from the crumbling granite or syenite ; which we found exposed near the Nunobiki waterfall back of the town, with a dip of 60° south 30° east. At the Hiyoogo Prefecture we saw a few rock and ore specimens from Settsu, Awaji, Harima and Tajima. There was fine grained copper pyrites mostly with quartz gangue from Harima : three places in Takagoori ; one in Shikito-goori, with arsenopyrite and talc schist ; one in Shisoo-goori ; and one in Issaigoori, with galena ; likewise from Settsu : two places in Yabegoori ; one in Mukogoori ; and one in Kawabegoori. There was also black shining coal from one place in Yabegoori, apparently not reckoned workable ; and one in Awaji, near the northend of the island, lately discovered and supposed not to be at all workable. There was gray Kamoikotan limestone from half a dozen places in Jindoogoori, Harima ; and from one in Kawabegoori, Settsu ; and coarsely crystalline calcite from one place in Issaigoori, Harima. There were dark gray steatite and dark brown shales with pyrite, Kamoikotan rocks, from Nushima, an island off the southern end of Awaji.

From Hiyoogo we went by rail road, through Oozaka again, to Kiyooto in Yamashiro ; most of the way still in the wide alluvial plain, but with some low hills and higher ground, perhaps of Old Alluvium, on the left or on the road ; and with low mountains further to the left with brown exposures of crumbling granitic rocks or dark gray shales. At Kiyooto we were shown by the city government rock specimens from its territories in Yamashiro, Tamba and Tango. There was dark gray compact or fine-grained Kamoikotan limestone from Yamashiro : eleven places in Otagigoori, nine in Kadonogoori, four in Tsudzukigoori, two in Ujigoori, and one (dark red) in

Otokunigoori; and from Tamba: two places (one of them light gray) in Funaigoori, one (light gray) in Ikarugagoori. There were metamorphic fine grained shales used for whetstones, of various colors, light or dark greenish gray, light brown, red, pale red and tea color, from 16 places in Kadonogoori; and similar Kamoikotan shales from one place in Ujigoori, one in Kuwadagoori (Tamba), eight in Funaigoori. There were 18 specimens of porcelain clays from Doosemboo, in Sagaragoori (Yamashiro); and one from Otagigoori. There was talc schist from one place in Tsudzukigoori, one in Amadagoori (Tamba), one in Ikarugagoori, and one in Yosagoori (Tango); and serpentine from two places in Ikarugagoori, and one in Yosagoori. There were syenite and granite from one place in Tsudzukigoori, one in Kuzegoori (Yamashiro), one in Takanogoori (Tango). There was fine grained copper pyrites, mostly mixed with iron pyrites, from the Kanazaki mines and (with galena) from the Nobara mines both in Kasagoori (Tamba), both mentioned in the report for 1878; and from four other places in Kasagoori and one place in Kumanogoori (Tango). There was magnetic iron sand from three places in Yosagoori (Tango). There was graphite with talc schist from Kasagi, in Sagaragoori. There were also a number of specimens of clays for plastering and of soils from the alluvium; and of river sands, almost wholly of Kamoikotan materials. We were told moreover of a very little oil gas that issues from a hole six feet deep in a rice field at Omuro, in Kadonogoori a league or two from Kiyooto, and burns with a blue flame when kindled; but it is probably unimportant.

The season was very late and inclement, and without making any excursions in the interesting neighbourhood of Kiyooto we pushed on to Ootsu, in Oomi, about three leagues easterly, first across a pass a couple of hundred feet high above the town, then through a gently sloping

wide valley and then across another pass 200 feet still higher just short of Ootsu at the south-western corner, of Lake Biwa. At and beyond the first pass there were many exposures of dark brown, and gray Kamoikotan shales dipping, for example, 45° north 10° west; and I had seen similar shales in the eastern edge of Kiyooto itself at the Kiyomidzu Temple. Near the second pass also there were many exposures of gray and black, hard Kamoikotan shales, with a dip of 45° south 45° east at the north end of the newly begun railroad tunnel. The Prefecture at Ootsu showed us a few minerals and rock specimens from Oomi and Wakasa. There were three topaz crystals, from Ootaniyama, in Sato village, in Awadagoori (Oomi); one of them 0.3 ft. across, much flawed inside, but with some pretty large parts clear, nearly colorless in the middle, white on two corners pale reddish longitudinally and pale brown transversely; one of them of egg size, slightly brown and much flawed inside; and one of nut size, pale green. Fine specimens from the same place were also shown at the Exhibitions of Ueno, in 1877, and of Paris, in 1878. The precise place where the topaz was found is said to be a secret. There were also small (0.05 ft. and 0.08 ft.) imperfect smoky quartz crystals and large (0.1 ft.) greenish silvery mica plates and a fragment (0.1 ft.) of a pale reddish feldspar crystal from the same place; showing that the topaz (like the fine quartz crystals of Kai) probably occurs in a vein in granite. From the same village too there was a plate of pale brown mica about 0.2 ft. square, with traces of pale green talc. Also from Oomi there were: traces of malachite from Sugaura, in Asaigoori; fine grained galena, pure looking, in lumps up to the size of a double fist, from Mandokoro in Aichigoori; black, slightly shining dull brown, fibrous lignite from Iwane, in Koogagoori, and from Hirako, in Kamoogoori; and gray fine grained

marble from Ishiyama in Shigagoori, and from Kitahata, in Gamoogoori. From Wakasa there was washed silvery mica in small spangles from Nekogawa, in Mikatagoori; and some blister copper and green vitriol and ferruginous ore from Nojiri in Ooigoori.

From Ootsu we went with a nearly level road, the Tookaïdoo, round the southern end of Lake Biwa and across its outlet there, and easterly through a wide alluvial plain, just south of the Mikamiyama of perhaps 800 feet in height (from some points of view rather conical, but apparently of crumbling granitic materials, such as are exposed also on the hills near the right of the road), to Ishibe, six leagues and a half, where dark blue compact Kamoikotan limestone is quarried, dipping 65° north 15° west, without fossils, as it seemed. Lake Biwa with its general north-easterly and south-westerly direction appears to be in the main about parallel to the general strike of the Kamoikotan rocks that wholly surround it, and to be upon the outcrop of soft crumbling granitic rocks or Kamoikotan shales that have been comparatively easy to scoop out, as already suggested (in the report for 1878) in regard to the deeply indented seacoast of similar materials between Tsuruga and Miyadzu (see p. 39). From Ishibe our road went east-south-easterly three leagues to Minakuchi passing midway a number of exposures of crumbling granite, and before that, many of granitic sand. From Minakuchi the road went still east-south-easterly gradually ascending in a pretty flat valley passing at the end of a league or so, near Omba, an outcrop or two of light gray, hard Kamoikotan sand rock veined with black lines; and in a couple of leagues more, at Matsuno, just short of Tsuchiyama, one of greenish gray, hard fine grained quartzite; and in another league at the Inohana hill, some 900 feet above the sea, there were exposures of greenish gray and brown, level shaly sand rock and coarse

pebble rock with a soft sandy matrix, apparently of the brown coal formation. At the small village of Inohana just beyond, we were told of an old lead mine at Kurotaki two leagues to the east, high up in the mountain, deep in the snow. The country rock was said to be black and very hard indeed, probably Kamoikotan quartzite. There was but one vein, about 1.5 ft. wide at the widest place, about vertical, with a strike about east and west, and worked on two sides of a valley. The mine is about 20 fathoms long. There was some mining done there about 1871, for a couple of years ; but it was abandoned, as it did not pay ; and in July, 1878, it was begun again, to be suspended, however, during the winter snows. The lead is said to contain three per cent. of silver.

The road from Inohana was hilly in a broken country for a league or less to the top of the Shidzuka Pass and the boundary line of Ise, some 1,200 feet above the sea ; with a very few exposures of the pebble rock and of the hard Kamoikotan sand rock on the way. At the pass there were exposures of gray, very quartzose granite, partly brown and crumbling. Thence descending rather rapidly into Ise south-easterly in a hilly, broken country, with many exposures of the crumbling, brown granite and granitic sand ; and with a mountain view where (as the inhabitants relate with pride) Kooboo Daishi had to throw his pencil away in despair and gave the name Fudesuteyama (Pendrop Hill) to the place ; we came in a couple of leagues from the pass, or in four leagues from Tsuchiyama, to the town of Seki. There we left the Tookaidoo, which turns towards the east, and kept on south-easterly half a league or so to Kusuwara, still descending in a hilly country, and passing exposures of the greenish brown soft sand rock of the brown coal formation.

Thence I turned aside half a mile north-westerly to see a small coal mine at Hagiwara, about 300 feet above the

sea. The rock exposed there in the bank of a small brook was hard grey sand rock weathering dark brown, with some gray shales, exposed to a thickness of some thirty feet, and dipping 35° north 80° east. The section near the coal was given me roughly by the miners as follows, from above downwards :

Feet.

Hard (sand) rock	—
Soft greenish gray shales, about	0.50
Slate or black shale ("gichi").....	0.70
"Soft coal," about	0.40
Slate	0.40
"Good coal," about	0.75
Slate	0.40
"Good coal," about	0.75
Slate	0.40
"Good coal," about	0.75
Hard [sand] rock	—

5.05;

but in all, from the upper coal layer to the bottom, 2.7 ft. or 2.8 ft., including the slate, sometimes 3.0 ft., sometimes only 2.0 ft. At about 15 fathoms in from the mouth of the adit I measured the coal 3.75 ft. thick including the slates; and that was a thick place. The upper layer of coal there is about 0.8 ft. thick and the bottom one 0.2 ft. ; the upper slate is about 0.6 ft., and the two others thin (one of them concealed by timbering). When the middle layers of coal are thick the lower one is thin to correspond. Perhaps the whole thickness of the better coal may be taken in general as a foot and a half or including the upper soft coal about two feet. The coal bed is said to be visible half a mile (about ten choo) distant to the south on the other side of the hill, and also a furlong or two to the southwest. The coal is black and shining.

The first mining done here was from the second to the ninth month in 1875 or 1876 ; but it did not pay and was abandoned. In May, 1878, it was taken up again. The mine is a very low adit about 15 fathoms long, with about twenty fathoms of old abandoned workings beyond that. There is mining to a depth of about 15 fathoms below the adit, and to a height of about 17 fathoms above, to the surface of the ground. There is a set of three bamboo pumps, each four fathoms long. It is said that at times as many as thirty men are at work digging coal. From May, 1878, to the end of the year about 600 piculs of coal were mined, and carried away ; and it sold at Oozaka, they say, for \$25 or \$26 a hundred piculs (say \$4.30 a ton). It is carried by hand-carts to Tsu, five leagues and a half, for seven cents a picul (or bag) ; and from Tsu to Oozaka by junk for \$8 a hundred piculs. There would seem then to be a chance for a little profit, in spite of the thinness of the bed and its poor quality. It would be best to make a geological and topographical survey of the whole place, and see thereby whether the bed could not be worked for a considerable time without pumping, and whether there is enough to justify a tramway to Tsu. Even carrying in horse waggons, if the short distance from the mine to the main road at Kusuwara were made passable, would save a large part of the seven dollars a hundred piculs now lost. There is said to be a coal mine now idle, not far off, near Hino, in Oomi.

Returning to the good, main road we followed it still south-easterly to Tsu, at first descending a little rapidly for several hundred yards, and then by degrees very gently, and at length traversing a very wide alluvial plain. The Prefecture there showed us a number of specimens of of the rocks and minerals of Ise, Iga, Shima and the small part of Kii that is under its government. There was

copper pyrites (fine grained and apparently mixed with iron pyrites, and in one case associated with magnetic pyrites) from four places in Ishidzure village, Inabegoori, Ise ; and from three places (two of them coarse grained, with talc) in Yoojikawa village, Murogoori, Kii ; and there were traces of malachite from three places in Ishidzure. There were traces of galena (mostly fine grained, and associated sometimes with talc, quartz or magnetic pyrites) from six places in Ishidzure, and from one in Yamada-goori, Iga. There was black shining coal from the Hagiwara mines (above mentioned) ; and dull black coal from Kusuwara near them ; black and shining coal from Koobeyama, Ahaigoori, Iga ; dull black bony coal from Shimagahara, Ahaigoori ; and it was said that the Kii anthracite, already spoken of at Wakayama, extended across the line in Murogoori, in the part of the province governed from Tsu. There was magnetic iron sand from Adashika village in Murogoori, and from Nabarigoori, in Iga. There was gray Kamoikotan limestone from Ise : four places in Wataraigoori, two in Inabegoori, in Iitakagoori, from two in Murogoori, Kii, and from one in Ahaigoori, Iga ; and there was concretionary limestone, probably of later age, from three places in Ishidzure, and two in Iitakagoori. There was talc or steatite from one place in Ichishigoori, Ise ; one in Inabegoori, Ise ; one in Nabarigoori, Iga ; three in Igagoori, Iga ; and serpentine from one place in Tooshigoori, Shima. There was mica schist from one place in Kuwanagoori. There was granite from one place in Ichishigoori ; one in Iitakagoori ; one in Miegoori, Ise ; one in Inabegoori ; four in Nabarigoori ; There was fossil wood (called "umoregi," and similar to wood so named near Sendai) from Ishidzure ; and there was a little pale green and greenish brown and white fluorspar from Ishigureminami village in Inabegoori. There were blackish hard Kamoi-

kotan shales from three places in Inabegoori, and from one in Ichishigoori. There were also many specimens of tile clay, wall plastering clay, sands for sprinkling on wall plaster, mica for wall paper, grayish kaolin and terra cotta earth (particularly used for the famous Kuwana terra cotta, called "Banko" from the name of the original maker). The principal mine within the limits of the Prefecture is a copper mine at Yoojikawa, Murogoori, Kii; and it is said to have been worked from the Hooreki period (1751-63), to have been abandoned about 1852; and then worked again since 1872. Inabegoori is reckoned the richest district of Ise in useful minerals; and at Ishidzure there was a mine worked under lease for silver and lead from the Tenshoo period (1573-91); often abandoned and taken up again; and now worked since about 1876.

From Tsu we travelled northward twelve leagues and a half near the sea shore, through Yokkaichi (where we rejoined the Tookaidoo), to Kuwana. The road lay wholly in a very wide alluvial plain; but near Kuwana we passed some low hills, perhaps 100 feet high, near by on our left, apparently made up of greenish gray shales like those of the Toshibets Group. At Kuwana they told us that the clay for Banko ware or terra cotta came from those hills just south of the town; that the ware was first made by Banko about fifty years ago, who was succeeded by Yusetsu; and that there are now three houses that make it there, with three or four kilns. Some of the pieces are very ornamental; and some extremely thin, so as to be translucent.

We went by river boat northerly two leagues to Maegasu; and thence seven leagues easterly through a very wide alluvial plain, near the sea shore at the northern end of the Ise Gulf, across several streams, to Nagoya, in Owari. The Prefecture there showed us a few

mineral and rock specimens from Owari and Mikawa : and information was given about the potteries, the principal industry connected with minerals, both porcelain (setomono or ishiyaki) and terra cotta or rough pottery (tsuchiyaki). There are ninety houses that make porcelain in Seto village, in Kasugaigoori, Owari, five leagues and a half northeast of Nagoya, the village that began the manufacture about a hundred years ago and has given its name to all such ware throughout the northeastern part of Japan) ; and fifty houses that make tsuchiyaki, which was begun there 600 or 700 years ago ; and there are others that make porcelain at Akadzu, a short league east of Seto, and some at Shimoshinano and Midzuno. But these smaller places learned the art later from Seto, and their tsuchiyaki kilns are more numerous than the ishiyaki ones. They produce at Seto \$120,000 to \$150,000 worth yearly. The Seto porcelain is also called sometsuke from its blue color. The blue was produced by earthy cobalt that covered the peaseize pebbles of quartz in a grayish black pebble rock or grit found at Seto. The stone was first roasted, and thereby fell readily to powder. It was then put with water into a mortar, and rubbed so as to separate the cobalt from the pebbles and sand, which fell to the bottom. The muddy water was poured off, and the earthy cobalt, now of a tea color, settled to the bottom, and the water was poured off. For a fine product the washing was repeated several times. It was used for coloring porcelain in that state and turned blue in baking. The pea pebble rock with earthy cobalt is no longer found, but one is found with nut pebbles containing a little cobalt. The digging and preparing now costs more than the product is worth and so foreign cobalt called "egusuri" or "Shinagosu" is generally used. The best quality of the stone for porcelain used at Seto comes from Sanage village, in Kamogoori, Mikawa three or four leagues

south-east of Seto. A specimen shown was a white, hard, undecomposed, triclinic feldspar without any visible quartz. But sometimes very dark smoky quartz crystals occur in it up to 0.1 ft. in diameter, and a specimen was shown about 0.15 ft. in diameter. The stone is reduced to powder with a water wheel, washed twice at Sanage and about twice more at Seto ; but for rather rough ware they wash it less than for the fine. Some of the Seto porcelain is made from a light gray stone found there and at Akadzu and all through the region. It appears to be an extremely quartzose kaolin, looking like a grit or very coarse sandstone, rather loosely coherent and made up of gray quartz grains covered with a white powder of decomposed feldspar. It is pounded up fine by hand and washed ; the sand falls to the bottom and the muddy water is drawn off and allowed to settle successively in three tubs arranged in step form ; and in the third the sand is least and the settled mud purest, and that is used. The first of the three is the best for strength, and the last of them is very plastic indeed. The three products however are mixed in the proportion of one part of each of the two former and two parts of the last ; but the proportions are a little different at different houses and according to the size of the articles, large or small. The first of the three is also used sometimes for glaze, mixed half and half with the stone next to be mentioned (or the next but one), which is however used in larger proportion or alone for glazing inferior articles. From Toogokusan in Kamishidami village, there was a nearly pure, snow-white, hard quartz porphyry, made up of glassy colorless quartz and snow-white feldspar (perhaps mixed with quartz). It is said to be used also with good success for making glass. From Sanage, there was gray glassy quartz ; reckoned of equal quality with the last. Both are first broken fine with hand-hammers and then powdered with a water wheel, and then washed

like the Sanage feldspar. From the village of Kamihadagawa, in Kasugaigoori, about three leagues from Sanage, there was pure white (in parts a little brownish or black from iron), earthy, decomposed feldspar, without any visible quartz, and it is likewise powdered with a water wheel, levigated and used for making porcelain. In Mino a few leagues to the north-east they also make porcelain or earthenware to the value, it is said of \$400,000 yearly, but not equal in quality to that of Seto.

At Nagoya they ornament the Seto porcelain beautifully in the so called cloisonné (or shippoo) way ; and a little such work is also done at Tooshima village in Kaitoogoori, Owari. At first, about ten years ago, that art was learned from articles brought from China and the ornamental work was then only laid upon copper, and still some is made in that way ; but in 1875 it began to be applied to porcelain. The principal manufacturers at present, the Shippoo Company of Nagoya, first began work in 1872, and now employ thirty men. Mr. Hara Fujii also has an establishment at Nagoya for such work, where about ten men are employed, and ornaments porcelain only. The outlines of the design are marked out upon the surface of the unglazed Seto porcelain by little strips of thin, narrow brass ribbon or flat wire (about 0.001 ft. thick), cut to the right length, bent to the proper shape, set edgewise and held by a paste called “bankuniu.” In laying upon copper, some solder is added with the paste, and melts in the following baking. A little glazing is then put on, and the piece is baked about eight hours in a small furnace of some $2\frac{1}{2}$ ft. in diameter and three or four feet in height, like those described in the report for 1878 as in use for the Satsuma porcelain. Then still more glazing is put on, and the piece is baked again, the same as before ; and so with more glazing it undergoes a third baking. By this time the brass ribbon is covered up ; and the whole is then

polished down by hand with whetstones until the edge of the ribbon comes just to the surface, and looks like a golden wire. Sometimes instead of the brass a very little silver wire is used. The brass does not very noticeably tarnish in a number of months at least ; but perhaps a still better effect might be produced at small expense by electro-gilding or electro-plating with silver the edge of the wire, (or with both gold and silver in different parts of the design). The polishing down the glaze takes a great deal of time and manual labor, which might perhaps be saved in great part by water power, if whetstone wheels were used. In polishing, defects sometimes occur from the chipping off of small portions of the glaze ; but such blemishes are concealed by wax of a suitable color. The different portions of the design are filled with glaze of different colors ; but the cobalt blue has hitherto been the most usual color, though now several other pleasing ones are coming very much into use.

We were also shown a specimen of fine grained copper pyrites mixed apparently with iron pyrites, and associated with a little galena in fine grains, from Oono village in Yanagoori, Mikawa. A mine was worked there for lead from old times (perhaps 100 years ago), but was abandoned about 1872. In 1878 it was taken up again for copper; but the vein came to an end, and the working was given up. From Dandoson in Shitaragoori, Mikawa; there was brownish black wad, or manganese ore, but impure. It is said to be five feet thick on the outcrop, but to be in a place in the mountain very difficult for carriage. From Nagakute village, Kasugaigoori, Owari, there was a piece of earthy looking, brown, fibrous lignite, from a bed said to be about level and about a foot in thickness, but sometimes only half a foot, exposed at several places. It is mined in the summer season in the rice fields from one fathom to three fathoms deep; and is sold at one dollar for

360 kamme ($1\frac{1}{3}$ ton). It can hardly be workable with such a quality and thickness and price, below water level. From Nagamine village in Nukatagoori, Mikawa, there was silvery mica in plates 0.2 ft. long piled to a thickness of about 0.07 ft. It was said that at Inui village, in Kaitoogoori, Owari, through a wide space, in making drive-wells in the rice fields, a tea colored water bubbled up with gas that burned when kindled. The old Oil Company tried to get oil there in 1876, and 24 villages claimed to yield it, but traces of it were found only at that one.

From Nagoya we travelled rapidly eastward by the Tookaido through wide alluvial plains or over very gently sloping ground, with however some low hills on our left about the end of four leagues, with two or three exposures of light brown, and greenish gray soft shales, resembling those of the Toshibets Group. The small rivers crossed here and there and the large Yahagi river in Mikawa, had much brown granitic sand, and it was sometimes to be seen on the road, for several leagues short of that; and just beyond Okazaki (on that river), ten leagues from Nagoya, cliffs of brown and light gray, crumbling granite were to be seen on hills a couple of hundred feet high, half a mile or so to the right. Half way from there to Fujikawa, a town twelve leagues from Nagoya, there was a roadside exposure of grayish white and glassy quartz (with perhaps a little feldspar and mica) dipping 40deg. north 80deg. east. At Fujikawa we learned that some places near by that were formerly worked for mica had been abandoned owing to a fall in the price of mica. Along there we passed low hills on either side; and in half a league or more crossed a low pass (perhaps a couple of hundred feet above the sea), where there were exposures of dark brown, partly blackish Kamoikotan shales, partly sandy and micaceous with minute golden mica, with a dip of 75deg. north 10deg. west. Half a league further

on there was another pass, a hundred feet higher with an exposure of level bedded, greenish gray and brown soft sand rock like that of the Toshibets Group. Thence descending gently through a rather broken country we soon found ourselves once more in a wide alluvial plain with moderately high mountains to the left. But near Ooiwa village (about twenty leagues from Nagoya), the ground became uneven again and there were a few exposures of gray and brown granitic and quartzitic gravel, and a little off the road, apparently some brown Kamoikotan shales. From Futagawa (half a league further on) we turned to the left from the Tookaidoo, and going north-easterly two leagues over gently rising ground, and passing near one exposure apparently of brown weathered gray quartzite, we descended abruptly past numerous exposures of level, brown, gray, red and yellowish brown gravel and earth beds to Shinjo on the shore of the Hamana Lake, in the south-western corner of Tootoomi, a bay nearly shut out from the sea by sand bars. Thence we crossed by boat five leagues and a half easterly to Hamamatsu, the last league or so through a narrow river or canal, with here and there low hills not far off to the left with exposures of greenish gray and brown shales like those of the Toshibets Group. Thence the road (the Tookaidoo again) ran easterly through a wide alluvial plain, and across the large Tenriu River; and at Nakaidzumi (nearly four leagues from Hamamatsu) ascending to rather higher ground passed an exposure of level bedded fist size gravel of fine grained gray granitic pebbles, and again in another league, beyond Mitsuke, and half a league still further on, in descending, passed other similar exposures; and then crossed another wide alluvial plain to Kakegawa (eight leagues from Hamamatsu). Thence it was but a couple of leagues further to Nissaka with a low hill to cross, where hard greenish gray Kamoikotan shales weathering brown were

exposed. Thence we crossed once more (as in 1877) the Nissaka hills with exposures of greenish gray hard Kamoikotan shales weathering dark brown to Kanaya a league and two-thirds ; and then (as in 1877 and 1878) past Fujieda and through the Uchinoya tunnel, where and for some miles on either side Kamoikotan shales are likewise exposed, we came to Shidzuoka.

We arrived there on a Saturday night, and did not wait over Sunday to see any rocks or minerals there might be at the Prefecture. But Messrs. Sugiura and Ban a few weeks later in passing looked at them ; and the office there has lately been so kind as to send us specimens for our convenient examination here. They are mostly building stones, one-half of them very hard, dark gray andesites containing triclinic feldspar (probably oligoclase), augite, magnetite and sometimes pyrite ; doubtless very durable, but difficult to cut and sombre looking ; and the other half are tufas apparently likewise andesitic and containing magnetite and comparatively soft, possibly in some cases rather too soft for strength. Of nine specimens of the andesites, from Suruga province, four come from Abegoori, three from Suntoogoori, and one from Masudzugoori, and one very vesicular andesite, or lava, from near Mount Fuji in Fujigoori ; and three from Idzu province all come from Kamogoori. Of seven specimens of the tufas from Suruga five came from Suntoogoori (three light grey and one light brown), and two from Shidagoori ; and of four from Idzu, three came from Kimizawagoori (two of them light brown and light gray), and one from Kamogoori (light gray). Such building stones may be of great importance not only to the towns of those provinces, but even here in the capital, if the quarries are not so inaccessible that carriage to the seashore would be too costly. There is also a very easily worked greenish gray sandstone like what is found in

the Toshibets Group of Yesso, that comes from Sanagoori in Tootoomi ; but perhaps it would generally be rather too soft for building purposes though the specimen is pretty firm. There is a piece of dark brown serpentine, and there is one of dark greenish gray steatite from Toyodagoori, Tootoomi ; and one of Kamoikotan clayslate from Abegoori, Suruga. There is a little kaolin, and there is a little sulphur impregnating a light brown tufa (apparently andesitic) from Kamogoori, Idzu. There are specimens of copper pyrites associated with pyrite and talc schist from three places in Toyodagoori, Tootoomi ; all but one of them very poor looking ; and traces of copper pyrites with pyrite and quartz from Fujigoori, in Suruga. There are specimens of gold quartz with the gold partly visible from Aono, in Kamogoori ; and with the gold scarcely visible from two other places in Kamogoori ; and one from Abegoori.

From Shidzuoka we came very rapidly home by the Tookaidoo, passing once more the rather few road side rock exposures seen in 1877 and 1878. In the bed of the brook just west of Yokosuna village the pebbles were dark brownish gray, apparently Kamoikotan quartzite ; and in the brook just east of that village there were like pebbles, but larger, fist size, with the addition of some light gray, apparently granitic ones. The pebbles of the stream at the long bridge just east of Okitsu were mostly light gray fine grained granitic ones of head size. In the cliffs just east of that was exposed pudding rock, partly of granitic and other Kamoikotan pebbles, but interbedded apparently with Old Volcanic andesite and tufas ; and a few hundred yards still further east near Kurosawa, there was at the road side dark brown andesite, containing triclinic feldspar (probably oligoclase), augite and magnetite in a rather coarse grained matrix of apparently similar materials. Just east of Numadzu there was ex-

posed some dark brown (weathered doubtless from greenish gray), pebbly tufa, level bedded; and at the beginning of the ascent of the Hakone mountain, some level, greenish gray, soft tufa like the beds near Yokohama and probably of nearly the same age. At the first hill east of Hakone Lake there was an exposure of gray, slightly vesicular andesite, containing glassy triclinic feldspar (probably oligoclase), magnetite and augite in a vesicular light gray matrix; and at the first road side quarry below Yumoto on the way to Sammaikashi a very light-gray andesite tufa containing glassy triclinic feldspar (probably oligoclase), magnetite and augite in a light gray fine grained matrix, apparently of decomposing pumice. At Odawara there were some more exposures of greenish gray vesicular volcanic rock, and for a couple of leagues short of Oiso there were a few exposures of the greenish gray, tufaceous sand rock sometimes with fist size pebbles.

After arrival here (3 Feb., 1879) my time was spent in report writing, in helping at the geological mapping and at other office work; particularly in writing up the report of progress for 1878, which was however interrupted near the beginning for the preparation of some rough notes (one-third as much as that report in amount) on mines and furnaces in the central provinces, for the use of Messrs. Yamao and Otori on their journey. After the first of May the work was done a little more leisurely, since by agreement at the outset I was to have three months of holidays at any convenient time, and only so much remained of my term. Although the work was still too hurried it was less so than in the case of former reports, which have only been written while travelling, or yet more hastily at home; and a little time was taken to look at rock specimens, which had formerly been neglected in favor of matters of

more pressing importance. I hope before long to examine in the same way the rock specimens we gathered in Yesso, and to correct errors that doubtless occurred in regard to them while in the field; and perhaps make in consequence some changes in the limits of the Old Volcanic and Kamoikotan rocks on the colored geological sketch map of the Island.

The assistants worked busily upon their maps of the oil surveys, having before my return begun the re-drawing of large portions, owing to the fuller and more exact information they had taken the time to acquire in the field last season. The maps in general are on a scale of $\frac{1}{60,000}$; but certain portions near the crowded oil wells have had to be drawn on a scale of $\frac{1}{100,000}$, and the minuter details of the geology worked out, as far as possible, with a great number of measured dips in addition to the more or less imperfect well-sections. The oil-bearing rocks appear generally to be in folds that have axes running nearly north-east and south-west; sometimes so sharply waving as to form perfectly closed folds with the dip reversed on one side. The reversed dip is in all cases towards the neighboring seashore, to the north-west in Echigo and to the south-east in Tootoomi. But the structure is still further complicated by folding with nearly north and south axes, which causes the strike of the north-easterly and south-westerly set of axes to have a wave form, and shows them to have existed earlier than the north and south ones. The two sets of axes were also observed by us in our Yesso coal surveys; and their relative age appeared there to be the same as here, though our surveys there did not happen to make it quite so clear. The north and south direction already remarked in regard to the volcanic mountains of Kiushiu would seem likely to be of the same late date as the later folding of the oil-fields. The Kamoikotan rocks, which in Yesso

and northern Nippon seem to have nearly north and south axes (the result apparently of much earlier folding than that of the oil-bearing rocks), toward central and western Japan have axes that gradually run more nearly north-east and south-west or east and west, but that are yet possibly of the same age as the northern ones.

Though the road sketching including the rock exposures of the long journey of last year and of other previous journeys has not yet been wholly mapped it seems probable that it will give a fairly satisfactory means of subdividing the rocks of the Kamoikotan Series, and possibly too of estimating roughly the thickness of the different parts, which no doubt will in all amount to far more than the former rough guess of 3,000 feet. The series appears to be made up of the following subdivisions, from above downwards :

c.—Hard light brown and gray sandrock, or quartzite.

b.—Hard shales, partly black and slaty, containing in some places, near the bottom, limestone and serpentine, talc schist and mica schist.

a.—Granite, sometimes syenitic, sometimes diorite, passing upwards in some places into quartz porphyry.

The succession seems in general a natural one, growing more and more like sandrock upwards : first granite ; then quartz porphyry ; then shales, slates and schists, with limestone and serpentine ; then sandrock. The granite and porphyry appear from their very distinct bedding and the numerous cases noted of included shales or slates to be metamorphic, like all the rest of the series. The granite contains large quartz crystals, graphite, magnetite (occurring also in all the volcanic rocks probably) ; and is generally much inclined to crumble so that the ore can be worked. The quartz porphyry and the schists contain apparently the greater part of the gold, silver, copper, tin and lead ores and iron pyrites (though some of each,

except the tin, occurs in volcanic rocks.) The porphyry and perhaps the adjoining part of the granitic rock contains beds of magnetite. The serpentine contains chrome iron in Buzen. There is a notable abundance of quartz grains throughout almost all the Kamoikotan rocks, even the porphyry, and only excepting the limestone and serpentine ; while such visible quartz is extremely rare in the volcanic rocks. The predominance of triclinic feldspar (probably oligoclase) not only in the volcanic rocks and in the diorite but in the porphyry and syenite and probably in the granite too (making it more readily decompose and crumble) and the consequent rarity of potash feldspar and perhaps in many large regions a lack of sufficient lime are very likely the explanation of the general poorness of Japanese soil that some foreign agriculturists have remarked, in comparison with that of western countries where volcanic rocks are abundant.

The seeing of the maps of our Yesso survey though the press has been continued, until now lately four more have at length been published since the appearance of the General Report of that Island ; namely, a small map of the eastern part of Asia, and the maps of the Kayanoma, Nuppaomanai and Bibai coal fields ; making fifteen maps in all that have been printed. The Ichikishiri coal field is now the only one surveyed of which the map has not yet been lithographed. There remain in addition ten other unpublished maps of that survey ; but as most of them are very large, and as they are mainly topographical merely and their geological importance is not so very great (except some of them in a negative way), they will perhaps not be printed at all.

I have the honor to be,

Sir,

Your most obedient servant,

BENJ. SMITH LYMAN,

Chief Geologist and Mining Engineer.

Kooji Machi, 9th Sept., 1879.

REPORT ON INFORMATION OBTAINED THROUGH MESSRS.
KUWADA AND NISHIYAMA ASSISTANT GEOLOGISTS,
GEOLOGICAL SURVEY OF JAPAN : BY BENJAMIN SMITH
LYMAN.

To His Excellency

K. INOUE,

Public Works Minister.

SIR :

I beg to report as follows the substance of certain information lately communicated to me by Messrs. T. Kuwada and S. Nishiyama, Assistant Geologists, and chiefly based on observations made by them in 1878.

KUSAKURA COPPER MINES.—The Kusakura copper mines are in Kambaragoori, Echigo, now a part of Fukushima Ken ; and are about two leagues and a half north-east of Tsugawa, and about a league and a half from the Aka River.

The rocks of the neighbourhood according to specimens brought back and shown to me are of the Kamoikotan series and are mainly white or light gray or pale green oligoclase-quartz-porphry containing sometimes minute grains and crystals of pyrite and chalcopyrite ; but in some places (not as country rock) there is a metamorphic nut pebble rock of gray and black quartzite pebbles in a brown weathering grit, and in others gray shales (not shown me) are exposed, like those of the small coal field of Akadani, near by, and doubtless of the same age. There are said to

be two veins, but only one is worked. The strike of that one is north and south with a dip about vertical. The width of ore as stated to me at Tsugawa was about 0.25 feet ; but at the best points observed by Messrs. Kuwada and Nishiyama it was 0.5 foot (on level No. 4 of the Sankakukoo mine); 1.0 foot (in level No. 5); 1.2 feet (in level No. 6); and on level No. 7, 0.5 foot on one side of a horse perhaps a couple of fathoms across and 0.3 foot on the other side. They were told that the greatest width was 1.5 feet. The ore is copper pyrites associated with pyrite and with quartz gangue ; and is said to yield (probably when carefully washed) 20 or 30 per cent of copper. The country rock is light gray hard oligoclase-quartz-porphry, that contains a few minute specks of copper pyrites.

The mines were first begun in the Gembun period (1736-40); were worked by the Prince of Aidzu until ten years ago ; after that by the Wakamatsu Ken ; but since 1875 had been owned and worked by Mr. Furukawa, a merchant of Yedo. They told me at Tsugawa that there were 19 mines; but Messrs. Kuwada and Nishiyama found only four still worked, and a fifth (probably the Oogiri) a new mine that had not yet reached the vein. The Sankakukoo called also the No. 21 Mine (the only one they entered) is 500 feet long, and 170 feet deep from top to bottom, and for the upper 130 feet has been worked out. At least one of the other three mines is on the other side of the mountain, a league or so distant by road. There is no pumping, and the water is said to drain away into crevices in the rock without any deep drainage level. At Tsugawa they told me they were digging a new low drainage level called the Oogiri with two hour shifts, and that it was soon to be finished. The rock is so firm that apparently no timbering at all was used. The drifts were very narrow indeed, in the old style, and the ore was carried out on the backs of boys, sometimes with serious accidents where

very narrow, vertical shafts have to be climbed up and down by means of rude ladders or rather stairways made of steps cut roughly in a small inclined log of wood, according to the usual custom of Japanese mines. Powder, however, is now used for blasting. The lighting is done with oil in Japanese made lamps arranged somewhat like the French mine lamps, but smaller.

The ore is broken up by hand and washed in the ordinary Japanese methods. The ore is then roasted in iron pots holding 300 kamme of ore, and $1\frac{1}{2}$ tana of wood (one tana there is probably $5 \times 6 \times 2$ feet). There are 75 such pots. The men who have charge of the roasting are said to suffer much from the sulphurous smoke, and to be in consequence very short lived. The roasted ore is smelted to coarse copper (aradoo) in two hearths ; and the charge for each is 100 kamme of roasted ore and 150 kamme of charcoal. The coarse copper is sent to Yedo on horseback. The charcoal is brought to the furnace on the backs of men from the mountain and from across the mountain a league in all directions, and it is expected that in five years it will become very scarce.

According to returns made to the Government Mining Office for December, 1876, the ore on hand at the beginning of the month was 11,210 kamme, the ore mined during the month was 8,890.25 kamme, the ore smelted during the month was 10,457.73 kamme, and the ore left on hand at the end of the month was 9,642.52 kamme ; and in the same month the coarse copper produced was 2,981.1 kamme (or $187\frac{1}{2}$ piculs), which was sold for \$3,312.33 (or \$17.66 $\frac{1}{2}$ a picul) ; and the number of working days was 31 in the mines, and 31 at the furnaces ; and the number of days' work was 3,604 for the mining (probably including the washing), and 623.4 for the smelting, or 4,227.4 days' work (making the number of workers average $116\frac{1}{4}$ for the mining and $19\frac{3}{4}$ for the smelting or 136 in all) ;

and the expenses were \$1,482.58 for the mining and \$420.92 for the smelting, or \$1,903.50 in all ; besides a tax of \$4.347. According to statements made at the mines the average monthly production of washed ore at the time of the visit (4th September 1878) was 6,500 kamme ; and in 1876 the whole yield was 1,496 piculs, worth (at Yedo) \$26,928 ; in 1877 it was 1730 piculs, worth \$31.140 ; in the first half of 1878 it was 860 piculs, worth \$15,480. There were at the time of the visit in all 183 workers, namely : 50 miners in the new mine ; 38 miners in the four old mines : 25 boys (from 12 to 16 years old) for carrying ore ; 40 men for roasting the ore ; 10 smelters, men ; 30 women for powdering and washing the ore. There must be some in the office besides. At Tsugawa they told me that the whole number of workers including the charcoal burners, was about 500.

The wood costs sixty cents a tana, and the charcoal 25 cents for 10 kamme. The washed ore is reckoned to be worth \$8.37½ the 100 kamme ; and the cost of smelting 300 kamme of it is said to be \$10.61 ; or probably these are the rates reckoned in the accounts between the mine owner and the miners who lease portions of the mine. The carriage of the coarse copper to Yedo costs 90 cents a picul. The wages of the workmen are 12 cents a day and and seven goo of white rice (worth probably six cents) and 40 me of miso (worth probably three quarters of a cent, making the whole pay 18¾ cents) ; and the women and boys have about one-half as much. For example, for powdering one shoo of ore the pay is \$0.006 ; or for one too, about a day's work, six cents. For mining five feet in length by four in height and two feet in width from eight to thirty dollars are paid. The coarse copper is said to sell at Yedo for about \$18 a picul.

They said at Kusakura that the mines were at present yielding a pretty good profit, though a great outlay was

needed for improvements, and in five years fuel would become very scarce. The profit however is said to come in great part from the mine owner's store, where the necessities and comforts of life are sold to the working men. The owner however wishes to sell the mines, and therefore is probably disposed to make them appear quite as profitable as they are ; and he complains particularly of a lack of capital. According to the returns to the Mining Office the yield of coarse copper in December, 1876, was $28\frac{1}{2}$ per cent. of the ore smelted, a highly improbable result, since pure copper pyrites contains only $34\frac{6}{10}$ per cent. of copper and the yield at other Japanese mines with like ore and like methods is only about twelve or fourteen per cent. of the washed ore. The statement that 6,500 kamme of washed ore was produced at present monthly, would give the wholly impossible yield of $35\frac{1}{4}$ per cent., unless in smelting more ore was added from the reserves, which, however would seem likely by this time to have been exhausted since December, 1876, at the high rate they were then drawn upon. In any case the monthly yield of ore since that month would seem to have diminished by over one-fourth, while the yield of copper has increased by about one-fourth, though very constant through 1877 and 1878. It is clear that there are some gross errors in the statements, and it would appear that the yield of copper was overrated ; for with two hearths only and a daily charge of 100 kamme for each, the amount of ore smelted monthly, even without any days of rest, would be only about 6,000 kamme. Moreover 30 women who powder the ore, even allowing for no days of rest, would at one too, or half a bushel, or say 92 lbs., a day each, prepare in all only 10,000 kamme a month ; and it must be very safe to reckon that the whole product is really not two-thirds of that. Supposing the monthly consumption of ore to be only 6,500 kamme, and the yield of it to be

about $12\frac{1}{2}$ per cent., there would be about 800 kamme or 50 piculs of copper produced monthly, worth, at eighteen dollars a picul, \$900 ; or in a year \$10,800. The fuel for the same ore at half a tana of wood and 150 kamme of charcoal for every 100 kamme of ore would amount to \$3,150 a year, and the carriage of the copper to market would cost \$540 ; the cost of the oil and powder and tools used in the mines, which would amount probably, as at other mines (namely powder 80 cents, one shoo of oil 35 cents, tools say 90 cents) to about two dollars a month, for each miner (neglecting the carriers), or say \$176 for them all, or \$2,112 a year ; leaving not more than \$5,000 as the yearly product (or $\$416\frac{2}{3}$ monthly) of the labor of the 183 workers, or \$27.32 a piece, or $\$2.27\frac{1}{2}$ a month. Again if the monthly product of ore was in September, 1878, less than three-fourths what it was in December, 1876, and the number, of smelters and of miners in the Oogiri were the same, but the other workers less in the same proportion, then the reported number of days' work in 1876, would show that in the mining workers were busy on the average just two-thirds the whole number of days, and in the roasting and smelting one-half. At those rates the 40 roasters and smelters and 143 others at the remarkably low wages stated would earn over \$545 a month, or \$2.97 a piece, or all together about \$6,550 a year ; and something has yet to be added for those who work in the office (probably four or five men) with pay of say \$10 a month, making the whole amount perhaps \$7,030. Moreover something should be reckoned for various incidental expenses, for deterioration of buildings and other property, to say nothing of interest on capital. But that amount is already much more than the income we found even on the supposition that the smelting hearths were worked full time with more than full charges, and that the ore dressers worked two-thirds of full time

with full skill and industry on the average. There would seem then to be the decided loss of more than \$2,000 a year at present. It should be borne in mind, to be sure, that the fifty miners in the Oogiri low drainage level are doing "dead work," though some such work should be allowed for at all times; but even subtracting all that (say \$2,250 a year, at the rates just reckoned) there would on the whole scarcely be a profit from the other work. Indeed the mines could hardly be expected to yield a profit with only so thin a vein in such very hard rock.

At Funauchizawa, half a mile south of Kusakura, there is also a copper mine (apparently not very old) with its own furnaces; but it was unprofitable and has been abandoned since 1877.

Also at Nameradaki about five furlongs still further south, there is yet another copper mine apparently not very old; and it was likewise unsuccessful (for lack of capital it was said), and was abandoned at least as early as the spring of 1878. There are said to be five veins of copper pyrites there, one of which is called a foot wide. It is said that the mine is 300 feet long, and extends 100 feet below drainage level; that 20 miners were employed, and 150 to 200 kamme of ore produced daily; and that the ore yielded 23 to 25 per cent. of copper (also probably a great exaggeration). The smelting place was on the north bank of the Aka River, half a league south of the mine.

Messrs. Kuwada and Nishiyama think that a tramway could be built without serious difficulty from the Kusakura mines down the valley to the Aka River, about a league, and say that it would pass the Funauchizawa and Nameradaki mines too, so as to be of like benefit to them. Furnaces for all the mines could then be built near the river bank, and could be supplied with fuel from higher up the main river. If the mines should be found to be worth working at all, no doubt it would be highly desirable to build such a road.

AKADANI COAL FIELD.—Messrs. Kuwada and Nishiyama spent three or four days at the beginning of September, 1878, in making a rough survey of the Akadani coal field in Kambaragoori, Echigo, about two-thirds of a league south of a village of the same name and $4\frac{1}{2}$ leagues south-east of Shibata. They had also in 1876, made a little survey inside the principal mine there, Kandoriyama, which however in 1877 and 1878 was broken down and could not be entered. The coal is exposed at about ten places within a length of about two-thirds of a mile, with a thickness from 0.2 ft. to 10 feet (but of very bad quality at the thickest place); bedded mainly between light gray shales and clay, but in one place resting immediately on granite, and in one with a dip of 83deg., separated from the granite below by half a foot of shales, and with $7\frac{1}{2}$ feet of granite above and two feet of coal above that, covered by gray shales again; and the dips were generally of 45deg. to 83deg. north-easterly. The number of beds has not yet been studied out, but may be three or four, or possibly more. The quality of the coal did not seem to be good. It is black, shining and bituminous; but when exposed in a heap to the weather falls to pieces readily.

The coal was first discovered in 1867 and the working was begun in 1869, on a small scale. There are now two mines at work at Sugikozawa, one of them nine fathoms long and the other just below that eleven fathoms long. The yearly yield is about 10,000 piculs or about thirty piculs (or bags) a day. A man can generally dig eight piculs a day; so that there would therefore appear to be only about four miners. The digging costs $1\frac{3}{4}$ cents a picul, including the propping; but food is given besides. The coal is carried by men or on horseback to Shibata, $4\frac{1}{2}$ leagues and thence seven leagues by boat to Niigata; and the carriage from the Sugikozawa mines to Akadani village by men (19 choo) or nearly $1\frac{1}{2}$ mile costs 2.7 cents;

thence by horse to Yonekura ($2\frac{1}{4}$ leagues) 4.8. cents; thence to Shibata (over $2\frac{1}{2}$ leagues) 3.6 cents; thence by boat to Niigata 2.4 cents; or in all $13\frac{1}{2}$ cents a picul. The bag for each picul is made of straw, and costs $1\frac{1}{2}$ to two cents. The coal sells at Niigata for 28 or 30 cents a picul. The net profit allowing for the cost of the miners' food, oil and tools, for office and incidental expenses, is five cents a picul; or about \$500 a year.

It is evident that with a waggon road from the mines or with navigable water a greater part of the way the profit would be much more.

FUDOODAKI AND UNODAIRA COAL.—On the fifth of September, 1878, the two assistants visited the Fudoodaki coal exposures a mile (15 choo) north-east of Kiyokawa, a village on the bank of the Aka River about a third of a league below Tsugawa; and likewise visited the Unodaira coal exposure, 500 or 600 yards north of Fudoodaki. The Fudoodaki coal proved to be only 0.2 ft. or 0.3 ft. in thickness, bedded between the gray shales and sand rock with a dip of 20deg. north 70deg. east. The Unodaira coal was of about the same thickness; and appeared to be the same bed with a section that corresponded well; and it dipped 28deg. north 70deg. east. Both places are of course wholly unworkable.

KUSOODZU OIL.—On the 6th of September, 1878, they visited the Kusoodzu oil exposures on the northern bank of the Aka River, 500 or 600 yards west of the village of that name; about four leagues and a half below Tsugawa; but there was only a trace of oil in the gravel. At Watarito, about 600 yards north of Murasugi, a village about three leagues north-easterly from Kusoodzu they were shown some fossil fishes in the gray shales.

HOT SPRINGS IN SHIMOTSUKE, IWASHIRO, UZEN AND UGO.—Messrs. Kuwada and Nishiyama have likewise prepared lately the following table and notes in regard to hot springs visited by them in 1877, in the provinces of Shimotsuke, Iwashiro, Uzen and Ugo;

TABLE OF 24 HOT SPRINGS, IN SHIMOTSUKE, IWASHIRO, UZEN, AND UGO PROVINCES,

By MESSRS. T. KUWADA AND S. NISHIYAMA, ASSISTANT GEOLOGISTS, (1877.)

No.	Province.	District.	Village.	Hot Spring.	Temperature.		Character.	Rock.	Yield.	Uses.
					F.	C.				
1	Shimotsuke.	Tsuga.	Yumoto.	Donsu.	100°	37 7/9°	Very sour, a little sulphur smell.	Pumice?	Little.	Baths.
2	"	"	"	Naka.	100°	37 7/9°	{ Very sour, no smell. Milky white, with yellowish white deposit.	"	"	—
3	"	"	"	Taki.	100°	37 7/9°		"	"	—
4	"	"	"	Sasa.	130°	54 4/9°	Bitter; clear; no smell.	"	"	—
5	"	"	"	Gosho.	140°	60°	Clear; no taste; nor smell.	"	"	—
6	"	"	"	Uba.	133°	56 1/9°	"	"	"	—
7	"	"	"	Jizai.	152°	66 2/3°	A little sour; clear.	"	Much.	—
8	"	"	"	Kawara.	135°	57 2/9°	Sour; clear; sulphur smell.	Volcanic rock?	Moderate.	—
9	"	"	"	Hadaka.	137°	58 1/3°	"	"	"	—
10	"	Shioya.	Kawachi.	Kawachi.	110°	43 1/3°	No taste; nor smell; clear.	"	"	{ Baths, wounds, and burns.
11	Iwashiro.	Aidzu.	Higashiyama.	Yumoto.	110°	43 1/3°	"	"	Much.	—
12	"	Yama.	Ooshio.	—	100°	37 7/9°	Very salt; turbid; reddish brown.	" ? ?	{ Say 100 koku a day	For salt.
13	"	"	"	—	102°	38 8/9°	"	" ? ?	"	"
14	"	Shinobu.	Iizaka.	Taki.	135°	57 2/9°	No taste; clear.	"	Much.	—
15	"	"	"	Hako.	130°	54 4/9°	"	"	"	—
16	"	"	"	Tooda.	125°	51 2/3°	"	"	"	—
17	"	"	"	Ko.	105°	40 5/9°	"	"	"	—
18	"	Date.	Yunomura.	Senki.	114°	45 5/9°	No taste; clear; little sulphur smell.	"	"	—
19	"	"	"	Kiri.	110°	43 1/3°	No taste; clear.	"	"	—
20	"	"	"	Kitsune.	104°	40°	"	"	"	—
21	Uzen.	Okutama.	Akayu.	Ooyu.	136°	57 7/9°	Clear; sulphur smell; salt; and sour.	"	Moderate.	—
22	"	Murayama.	Kaninoyama.	—	140°	60°	Very clear; traces of salt?	"	Much.	—
23	Ugo.	Akita.	Ogashima.	—	118°	47 7/9°	Very salt; bitter; reddish yellow.	"	Moderate.	—
24	"	"	Horinouchi.	—	cold.	—	Salt; turbid.	{ Gray shales weathering brown.	{ 5 koku a day.	—

REMARKS ON THE FOREGOING HOT SPRINGS, BY MESSRS. KUWADA AND NISHIYAMA.—“Nos. 1-9.—About six leagues west-north-west of Nikkoo, and about three leagues west of Lake Chiuzenji; within a length of 120 yards. All issue from very recent looking pumice. No. 7 boils up through a hole $1\frac{1}{2}$ yards square in great quantity. The springs are said to be good for diseases of the loins. We were told that about fifteen years ago Mount Shirane, about two leagues distant, had an eruption and showered down much pumice on the surrounding country.

“No. 10.—On the right side of Ikarigawa, opposite to Takahara. Said to be good for wounds.

“No. 11.—On both sides of Yugawa, in Higashiyama, about a league east of Wakamatsu. [See also page 26.]

“Nos. 12-13.—On the right side of the stream near the road in Ooshio village, about $5\frac{1}{2}$ leagues north-north-east of Wakamatsu. From this mineral water common salt was made. [See also page 29.]

“Nos. 14-20.—On both sides of Surukamigawa, which is about 200 feet wide, between Iizaka and Yunomura, three leagues north-west of Fukushima, said to be good for swellings and wounds. A suspension bridge here adds much to the scenery.

“No. 21.—Akayu village is about five leagues north-east of Yonezawa.

“No. 22.—Kaminoyama is a small town about three leagues south of Yamagata.

“No. 23.—Yunomura is about 1,200 yards west of Kitanoura on the northern coast of Ogashima. The water is said to be good for eye-diseases and wounds.

“No. 24.—On the side of the stream near Horinouchi, about a league east of Ookubo.”

I have the honor to be,

Sir,

Your most obedient servant,

BENJ. SMITH LYMAN.

Kooji Machi; 9th September, 1879.

REPORT ON SOME OIL WELL STATISTICS GATHERED
THROUGH THE ASSISTANT GEOLOGISTS OF THE GEO-
LOGICAL SURVEY OF JAPAN; BY BENJAMIN SMITH
LYMAN.

To His Excellency,

A. YAMADA,

Public Works Minister.

SIR :

I beg to make the following report of statistical information gathered by the Assistant Geologists of the Geological Survey of Japan while in my charge, and lately communicated to me. It would have been highly desirable on many accounts to obtain much more complete statistics ; but our force was small and very fully occupied with matters that were still more important and that could less easily be attended to by men not specially trained for geological surveying.

The statistics of the oil wells of Akita Ken and of the Kurokawa field were gathered by Messrs. T. Kuwada and S. Nishiyama ; those of the Kanadzu field and of the Aburaden and Miyamoto field by Messrs. T. Inagaki and S. Maeda ; those of the Amaze and Sakata field and of the Matsudai field and of Shisharishinkooji, in Shinano, by Messrs. T. Kada and J. Shimada ; those of the Miyookooji and Tootoomi field by Messrs. J. Sugiuira and I. Ban ; and those of the Betsuyama and Dooyama field, of the Tateno field and of Shinano (except

Shisharishinkooji) by Messrs. T. Yamauchi (Chief Assistant Geologist), E. Yamagiwa, M. Maeda and Y. Akiyama. Except in the case of Messrs. Kuwada and Nishiyama, the statistics of 1878 concern only the wells dug after 1876, the new wells; and those of 1876 have been revised only in the office here.

The following tables give the principal facts in regard to the oil wells of Akita Ken, and of all Japan. In Akita ken: Menagata is in Yamamotogoori; Masugawa, Nigorikawa, Yabase, Kurokawa, Riuge and Tsukinoki are in Akitagoori; and Oguni, Iseichi, and Yokooka are in Yurigoori. Of the Menagata wells, Nos. 2 and 5 are at Ishizaka Kawabata, and the rest, at Kuwanoki Yauchi. The wells of Masugawa are at Kusoodo; of Nigorikawa, at Higashidaira; of Yabase at Otsukaminami; of Kurokawa, at Kusoozawa, of Oguni at Kureki; of Iseichi, at Hodogasawa; and of Yokooka at Ooyachi. The Menagata, Masugawa, Nigorikawa, Yabase, Kurokawa and the numbered Oguni wells belong to the Akita Oil Company; the unnumbered Oguni wells to Abe Giemon; and the Iseichi and Yokooka wells to Ooba. The oil of Masugawa, Nigorikawa No. 1, Oguni No. 1, 5 and 1 (new) are dark green and opalescent; those of Menagata No. 9 and Kurokawa No. 2 are greenish black and opalescent; and those of the Kurokawa, Riuge and Tsukinoki shallow holes are black. Those of Menagata No. 9, Masugawa No. 1, Nigorikawa No. 1, Oguni No. 1, 5 and 1 (new) are thick and heavy; and those of Kurokawa No. 2 and of the shallow holes very thick and heavy. The Oguni oil marks 38° Beaumé.

At Miyoochooji there were in 1876 four other wells of which no description could be obtained.

The average depth given is for those finished wells whose depth is known. The numbers with a star are only approximate.

AKITA KEN.

Village.	Name of Well.	Begun.	Abandoned.	Depth to oil rocks. (feet.)	Depth below oil rocks. (feet.)	Present depth. (feet.)	Daily yield at first. (shoo.)	Daily yield at present. (shoo.)	Remarks.
Menagata...	No. 1	March '74	Immediately.	0	0	?	0	0	Only much water.
" ...	No. 2	"	Oct. '75	104.	135.	239.	10.	0	
" ...	No. 3	April '74	"	111.	38.	149.	45.	0	
" ...	No. 4	June '74	Immediately.	0	0	?	0	0	Only much water.
" ...	No. 5	"	Oct. '75	120.5	114.5	235.	10.	0	
" ...	No. 6	"	July '74	0	0	96.	0	0	Much water.
" ...	No. 7	July '74	Sept. '74	0	0	120.	0	0	"
" ...	No. 8	Oct. '74	Immediately.	0	0	36.	0	0	"
" ...	No. 9	Nov. '74	Oct. '75	112.3	23.7	136.	26.	15.	{ Reopened February 1877. Only well now productive.
Masugawa...	No. 1	Jan. '74	March '74	24.	36.	?	?	?	
" ...	No. 2	March '74	April '74	0	0	74.5	0	0	Much water.
" ...	No. 3	April '74	May '74	0	0	95.	0	0	"
" ...	No. 4	May '74	Immediately	0	0	55.	0	0	"
Nigorikawa.	No. 1	July '74		0	203.	53.	256.	150.	40.
" ...	No. 2	Nov. '74		0	224.5	119.7	344.2	30.	20.
" ...	No. 3	Dec. '74		0	224.	35.5	259.5	330.	35.
" ...	No. 4	April '75		0	212.2	28.5	240.7	370.	130.
" ...	No. 5	Feb. '76		0	138.	30.	168.	200.	90.
" ...	No. 6	Sept. '76		0	198.	18.	216.	40.	30.
" ...	No. 7	Oct. '76	Nov. '76	0	0	84.	0	0	Much water.
" ...	No. 8	Dec. '76		0	198.	30.	228.	35.	25.

AKITA KEN.—(Continued.)

Village.	Name of Well.	Begun.	Abandoned.	Depth to oil rocks (feet.)	Depth below oil rocks. (feet.)	Present depth. (feet.)	Daily yield at first. (shoo.)	Daily yield at present (shoo.)	Remarks.
Nigorikawa.	No. 9	?	0	0	0	?	0	0	Now digging.
Yabase	No. 1	Aug. '73	Immediately	0	0	?	0	0	Much water.
Kurokawa...	No. 1	Aug. '74	Sept. '74	0	0	180.	0	0	"
"	No. 2	Sept. '74	0	191.	49.5	240.5	50.	15.	Only well now productive.
"	No. 3	"	Oct. '74	0	0	?	0	0	Much water.
"	No. 4	Dec. '74	Feb. '75	0	0	?	0	0	"
"	—	—	—	0	0	0	}	25.	Many shallow holes.
Riuge	—	—	—	0	0	0			
Tsukinoki...	—	—	—	0	0	0	}	25.	Many shallow holes.
Oguni	No. 1	Nov. '73	0	44.7	8.	52.7	250.	40.	
"	No. 2	Dec. '73	Jan. '74	0	0	68.	0	0	
"	No. 3	Feb. '74	Feb. '76	?	?	102.	280.	?	
"	No. 4	Mar. '74	Aug. '74	72.	72.	144.	?	?	
"	No. 5	April '74	0	145.	8.	153.	210.	60.	
"	No. 6	May '74	Sept. '74	0	0	126.	0	0	Much water.
"	No. 7	May '74	Aug. '74	72.	0	90.	?	0	
"	No. 1 (new)	Oct. '76	0	54.	7.	61.5	150.	40.	
"	No. 2 (new)	Dec. '76	0	78.5	6.2	84.7	200.	50.	
"	No. 3 (new)	Sept. '77	Oct. '77	0	0	51.0	0	0	
"	(U 2221 a)	Aug. '77	Immediately	0	0	54.0	0	0	Much water; no oil.
"	(U 2221 b)	June '77	0	72.	18.	90.	100.	30.	
"	(U 2221 c)	Sept. '77	0	0	0	59.	0	0	No oil; now digging.

AKITA KEN.—(Continued.)

Village.	Name of Well.	Begun.	Abandoned.	Depth to oil rocks (feet.)	Depth below oil rocks. (feet.)	Present depth. (feet.)	Daily yield at first. (shoo.)	Daily yield at present (shoo.)	Remarks.
Oguni	..... (U 2221 d)	?	?	0	0	102.	0	0	Much water.
"	... (U 2221 f)	?	?	0	0	78.	0	0	"
"	... (U 2221 g)	?	?	?	?	72.	0	0	Much water, but trace of oil.
"	... (Q 2193 b)	July '76	?	?	?	192.	20.	?	?
"	... (Q 2193 aa)	?	?	0	0	42.	0	0	Much water.
"	... 0	?	?	0	0	90.	0	0	Large stones prevent work.
Iseichi	..... No. 1	Aug. '75	After two months	66.	84.	150.	10.	0	At 150 feet oil stopped issuing.
"	... No. 2	"	Immediately	0	0	150.	0	0	
"	... No. 3	"	"	0	0	42.	0	0	Much water.
"	... No. 4	"	"	0	0	192.	0	0	"
"	... No. 5	Jan. '76	"	0	0	150.	0	0	
"	... No. 6	"	"	0	0	18.	0	0	Large stones prevent working.
"	... No. 7	"	"	0	0	12.*	0	0	
"	... No. 8	"	"	0	0	105.	trace	0	
Yokooka	... (Q 2248 a)	Oct. '77	0	0	0	60.*	"	0	Digging.
"	... (Q 2248 aa)	Aug. '75	?	0	0	60.	no oil	0	
"	... (U 2264 a)	'75 ?	Soon	0	0	30.	trace	0	
"	... (U 2264 b)	" ?	"	0	0	48 ?	no oil	0	
"	... (U 2268 b)	" ?	"	0	0	48.	0	0	Stones prevent working.
"	... (U 2268 c)	" ?	"	0	0	12.	0	0	"

ALL JAPAN.

EXAMINED.		PLACE.			NO. OF WELLS.					SHOO OF OIL.			FEET.			PERCENTAGE.				
Year.	Mon.	Prov.	Dis't.	Village.	Still	P'tive.	Once	P'tive.	Willy	B'ren.	Unf.	nish'd.	Daily	Av'rage	Grea't	A'rage	Least	Grea't	P'tive	Bar.
													Yield.	Daily	Daily	Dep'h.	Dep'h.	Dep'h.	Wells.	
1877...	Aug.	Ugo.	Akita.	Menagata (Yamamoto dist.)	1	3	5	0	15.00	15.00	45	189.8	36	239	44.4	55.6.				
"	"			Masugawa ...	0	0	4	0	0.00	0.00	0	?	0	0	0	100.				
"	Sept.			Nigorikawa ...	7	0	1	1	370.00	52.86	370	244.6	84	344	87.5	12.5.				
"	"			Yabase ...	0	0	1	0	0.00	0.00	0	?	0	0	0	100.				
"	"			Kurokawa ...	1	0	3	0	15.00	15.00	50	240.5	180	306	25.0	75.0				
"	Oct.			Oguni...	5	2	11	1	220.00	44.00	280	105.1	42	144	38.9	61.1.				
"	"			Iseichi ...	0	1	7	0	0.00	0.00	0	150.0	18	192	12.5	87.5.				
"	"			Yokooka ...	0	0	5	1	0.00	0.00	0	?	12	60	0	100				
1876...	June			Kurokawa ...	94	29	34	0	585.85	3.89	430	74.5	1	125*	75	22				
1878...	Oct.			"	57	55	82	0	630.7	3.35	430	75.8	1	125*	58	42				
1876...	Nov.	Echigo.	Kambara.	Kanadzu ...	23	0	2	0	82.41	3.64	103	9.2	1	55	92	8				
1878...	Oct.			"	0	0	22	0	0.00	0.00	0	45.7	9	232	0	100				
1876...	Nov.			Asahi...	22	2	0	0	26.00	1.18	200	14.8	3	128	91.67	8.3				
1878...	Oct.			"	2	1	6	3	200.00	100.00	300	88.4	18	106	33.33	66.67				
1876...	Nov.			Shiotani ...	37	8	14	0	27.91	0.75	55	16.3	3	78	76.27	23.73				
1878...	Oct.			"	11	5	5	4	227.0	206.36	1000	100.9	32	174	76.19	23.81				
1876...	Nov.			Higashijima ...	1	3	2	0	5.00	5.00	50	149.4	249	249	67	33				
"	"			Koguchi ...	15	10	5	0	2.21	0.15	20	14.1	3	75	83	17				
"	"			Tae Kusoodzu ...	23	29	20	0	31.25	1.62	50	48.5	3	24.4	72	28				
1878...	Oct.			"	7	3	7	7	31.50	4.50	20	70.2	26	261	59	41				
1876...	Nov.			Maruta ...	1	1	0	0	.10	.10	?	5.3	3½	7	100	0				

ALL JAPAN.—(Continued.)

EXAMINED.		PLACE.			NO. OF WELLS.				SHOO OF OIL.			FEET.			PERCENTAGE.	
Year.	Mon.	Prov.	Dis't.	Village.	Still P'tive.	Once P'tive.	W'ly B'ren.	Unfini'd.	Daily Yield.	Av'rage Daily Yield.	Grea't Daily Yield.	A'rage Dep'h.	Least Dep'h.	Grea't Dep'h.	P'tive Wells.	Bar.
1876...	Nov.	Echigo.	K'ara	Amagasawa ...	2	0	0	0	10?	10.00?	?	4.5	3 ³ / ₄ ?	6 ³ / ₄ ?	100	0
" ...	"			Urase (Koshi dist.) ...	6	1	0	0	8.00	1.33	40	130.5	116	156.6	100	0
" ...	Aug.		Mishima.	Torigae ...	0	3	1	0	0.00	0.00	130	71.2	1	378	75	25
" ...	"			Kumoido ...	0	0	3	0	0.00	0.00	0	47.4	41	56	0	100.
" ...	"			Miyamoto ...	1	1	1	0	0.30	0.30	7	35.9	6	93	66.67	33.33
1879...	May			Amaze ...	5	1	0	13	229.9	26.00	240	246.0	156	498	100	0
1876...	Sept.			Kusoodzu ...	6	18	13	1	23.8.*	3.97*	1570	131.2	0	324	64.86	35.14
" ...	"			Dooyama ...	6	20	8	0	6.08*	1.00*	96	186.0	0	498	76.47	23.53
" ...	Aug.			Sakata ...	32	21	2	1	43.0	1.30*	40.0	349.4	20	525	96.4	3.6
1878...	Sept.		Kariha.	" ...	9	4	1	4	19.5	2.20	22	305.9	61	481	92.86	7.14
1876...	Aug.			Tazawa ...	4	2	2	0	7.95	2.00	20	267.7	54	480	75	25
" ...	"			Betsuyama ...	10	7	3	0	2.6	0.26	1	137.9	50	342	85	15
" ...	"			Miyoochooji ...	49	65	22	2	96.0	2.00	545	349.0	30	660	83.82	16.18
" ...	"			Ootsubo ...	6	14	1	0	6.9	1.15	198	237.7	54	450	95.31	4.69
" ...	"			Akada ...	21	120	35	1	191.4	9.11	3046	383.2	84	780	80.11	19.89
" ...	"			Sochi ...	1	7	1	0	2.0	2.00	100	340.2	90	597	88.98	11.11
" ...	"			Aburaden ...	29	36	4	0	24.8	.86	200	297.0	44	678.6	94.20	5.80
" ...	Oct.			Ooarato ...	21	3	0	1	296.55	14.12	72 ¹ / ₂	471.4	366	528.	100	0
" ...	"			Kotani ...	2	3	1	0	4.21	2.15	3 ¹ / ₄	425.0	168	630.	83.4	16.6
" ...	"		Kubiki.	Kawaguchi ...	2	0	0	1	6.5	3.45	5	251.0	264	309.	100	0
" ...	"			Kannonji ...	1	2	0	0	3.	3.00	3	284.0	258	300.	100	0
1878...	Sept.		"	" ...	7	0	0	0	38.	5.43	10	124.1	91	141	100	0

ALL JAPAN.—(Continued.)

EXAMINED.		PLACE.			NO. OF WELLS.				SHOO OF OIL.			FEET.			PERCENTAGE.	
Year.	Mon.	Prov.	Dis't.	Village.	Still P'tive.	Once P'tive.	W'ly B'ren.	Unfi- nish'd.	Daily Yield.	Av'rage Daily Yield.	Grea't Daily Yield.	A'rage Dep'h.	Least Dep'h.	Grea't Dep'h.	P'tive Wells.	Bar.
1876...	Oct.	Echigo.	Kubiki.	Toonaimiyoo...	6	0	1	0	19.	3.17	10	146.0	90	210	85.7	14.3
1878...	Sept.			"	11	0	0	1	28.5	2.41	7	215.6	180	300	100	0
1876...	Oct.			Hashidzume...	1	0	1	0	2.	2.00	2	180.0	180	180	50	50
1878...	Sept.			"	3	0	0	0	?	?	?	215.0	171	300	100	0
1876...	Oct.			Gimiyo...	2	0	0	0	15.	7.50	8	360.0	288	432	100	0
"	"			Kamoo	1	0	0	0	4.	4.00	4	186.0	186	186	100	0
1878...	Sept.			"	3	0	4	0	4.	1.10	4	163.3	58	283.5	24.9	57.1
1876...	Oct.			Koike	2	4	0	0	3.	1.50	2	32.0	48	150	100	0
1878...	Sept.			"	2	0	0	2	15.	7.50	10	178.0	172	304	100	0
"	"			Matsudai	5	1	2	0	9.5	1.90	3	189.8	60	312	75	25
1878...	Sept.			Inomiyoo	4	0	0	2	43.	10.75	20	319.4	264	374	100	0
1876...	Oct.			Iwagami	3	1	1	0	8.8	2.93*	15	307.8	204	396	80	20
1878...	"			"	3	9	17	8	9.	3.00	290	194.3	15	318	41.4	58.6
1876...	"			Ogawa and	6	10	1	0	8.	1.33*	30	234.0	150	396	94.12	5.88
1878...	"			Kokugawa	3	10	5	9	3.2	.65	21	254.4	8	426	72.23	27.77
1876...	"			Tajima	2	4	3	0	3	1.50	100	177.3	102	378	66.67	33.33
1878...	"			"	0	0	9	0	0	00	0	269.0	18	320	0	100
1876...	"			Sawada	7	1	1	2	11.57	1.63*	80	276.6	198	438	87.5	12.5
"	Nov.			Gendooji Shinden	8	2	0	1	135.33	16.90*	100	477.0	390	618	100	0
1878...	Oct.			"	4	0	5	0	220.	55.00	130	445.5	18	474	4.44*	5.55*
1876...	Sept.			Fukazawa	29	4	1	23	988.8	34.97	120	400.7	108	540	97.1*	2.9*
1878...	Oct.			"	128	1	3	229	2523.	19.56*	500	423.3	6	504	97.73*	2.27*

ALL JAPAN.—(Continued.)

EXAMINED.		PLACE.			NO. OF WELLS.				SHOO OF OIL.			FEET.			PERCENTAGE.	
Year.	Mon.	Prov.	Dis't.	Village.	Still P'tive.	Once P'tive.	W'ly B'ren.	Unfini'sh'd.	Daily Yield.	Av'rage Daily Yield.	Grea't Daily Yield.	A'rage Dep'h.	Least Dep'h.	Grea't Dep'h.	P'tive Wells.	Bar.
1876...	Sept.	Echigo.	Kubiki.	Tateno ...	33	22	0	0	18.34	.56	900	308.2	144	540	100	0
" ... "	"			Nagawa Shinden ...	0	2	0	0	0	.00	650	210.0	180	240	100	0
" ... "	"			Oomine Shinden ...	4	2	0	0	1.7	.45	120	240.7	156	276	100	0
" ... "	"			Kurizawa ...	48	1	22	0	30.6	.64	280	468.5	270	732	97.96	2.04
" ... "	"			Oono Shinden ...	18	1	2	0	17.6	.98	100	387.9	246	630	95.24	4.36
" ... "	"			Maya ...	7	5	5	4	111.4	15.90*	190	312.2	84	588	70.59	29.41
1878... Oct.	"			" ...	17	0	1	96	1005.8	99.16*	400	393.0	6	588	94.5	5.5
1876... Sept.	"			Doogata ...	14	0	1	0	8.5	.67	150	278.0	138	702	93.33	6.67
1878... Oct.	"			Aramaki ...	0	0	2	0	0	.00	0	279.0	212	340	0	100
" ... "	"			Tono ...	2	0	2	10	.4	.20	0	96.0	18	312	50	50
" ... "	"	Tootomi. S'nano.	Mino-chi.	Tanada ...	0	0	1	1	0	0	0	204.0	150	204	0	100
" ... "	"			Birigo ...	0	0	9	3	0	0	0	42.0	12	72	0	100
" ... "	"			Matsunoki ...	0	0	7	6	0	0	0	136.3	24	210	0	100
" ... "	"			Tajima (n'r Iwagami)	3	2	8	11	5.5	1.83*	8	122.7	137	249	38.5	61.5
1876... July	"			Tomikura ...	8	4	3	2	94.	11.75	160	247.0	90	354	80	20
" ... "	"			Sekiguchi Shinden ...	1	1	0	1	20.	20.00	20	39.0	30	48	50	50
" ... Aug.	"			Shishari Shinkooji ...	16	6	16	4	585.0	36.56*	500	154.9	27	216	57.1	42.9
1877... Apr.	"			Shirowa ...	0	1	1	0	0	0	?	363.0	?	?	50	50
" ... "	"			Asahina ...	0	1	1	0	0	0	10	198.0	?	?	0	100
" ... "	"			Saisanji ...	0	2	0	0	0	0	?	?	?	?	100	0
" ... "	"	Haibara.		Ebie ...	0	6	0	0	0	0	60	382.0	324	594	100	0
" ... "	"			Sugegaya ...	27	5	4	4	9.6	9.00*	400	295.8	72	450	69	31

SUMMARY:

Year.	PLACE.		NUMBER OF WELLS.				SHOO OF OIL.			FEET.			PERCENTAGE.	
	Province.	District.	Still productive.	Once productive.	Wholly barren.	Unfinished.	Daily yield.	Average daily yield.	Greatest daily yield.	Average depth.	Least depth.	Greatest depth.	Productive wells.	Barren.
1877	Echigo	Akita Ken.	14	6	37	3	620.00	31.71	370	179.8	12	344	35.09	64.91
1876		Kambara	218	82	77	0	770.73	3.54	430	45.8	1	249	79.58	20.42
1878		"	77	64	122	14	2,932.20	38.08	100	75.4	1	174	53.61	46.39
1876		Koshi	6	1	0	0	8.00	1.33	40	130.5	116	156.6	100.00	0.00
1876	"	Mishima	165	314	96	5	404.83	2.45	3,046	121.5	0	780	83.30	16.70
1878		"	9	4	1	4	19.50	2.20	22	305.9	61	481	92.86	7.14
1879		"	5	1	0	13	229.90	26.00	240	246.0	156	498	100.00	0.00
1876		Kubiki	222	68	42	32	441.25	1.99	900	354.0	48	732	87.35	12.65
1878	Shinano...	"	200	22	73	378	3,894.20	19.47	500	262.9	6	588	75.25	24.75
1876		—	25	11	19	7	699.00	27.96	500	175.7	27	354	65.45	34.55
1877		Tootoomi.	27	15	6	5	9.00	9.60	400	305.0	72?	594?	87.23	12.77
1876		All Japan	636	476	234	44	2,323.81	3.65	3,046	163.0	0	780	82.61	17.39
1877	"	"	41	20?	43	8	629.00	15.34	400	269.2	12?	594?	58.65	41.35
1878		"	286	90	196	396	6,845.90	23.93	500	215.6	1	588	65.73	34.27
1879		"	5	1	0	13	229.90	26.00	240	246.0	156	498	100.00	0.00
		" (except ' 1876 Kurokawa")	874	739	439	461	9,442.76	10.80	3,046	177.9	0	780	78.56	21.44

Messrs. Kuwada and Nishiyama also learned the following facts in regard to the Akita Oil places: “About two miles, north-west of the Monagata oil wells, in the sea, 5 furlongs from shore, oil issues through a space of 80 fathoms long by 50 fathoms wide. At Tsubaki village in Yamamotogoori there was said to be oil; but they could not find any there. At Fudoogasawa in Komagata village, Yamamotogoori, in the spring of 1874, 6 holes were dug, but only one, 45 feet deep, had any oil; it yielded at a depth of 40 ft. about 4 too of oil, and within the next, two months only two too more, and was therefore abandoned. The oil was very thick, tarry, and greenish black. At Takinosawa in Kamiwagawa village, Yamamotogoori, $4\frac{1}{2}$ leagues north-east of Kado, there is a slight trace of oil.

“At Ringe there was asphalt through a space 900 ft. long by 100 to 150 ft. wide and 3 to 5 ft. thick, about 119,340 square feet or 456,800 cubic feet; but 15,000 kamme have already been dug. At Tsukinoki also there is asphalt in 5 or 6 places, with an area in all of 38,900 square feet and a thickness of one to ten feet; amounting to 1,420,000 cubic feet or more. At Urayama, too, there are three or four asphalt places with an area in all of about 2,000 square feet, or 4,000 cubic feet. Again, at Kurokawa (800 ft. south of the oil wells) there is asphalt through a length of 100 feet by a breadth of 50 feet and thickness of one to three feet; amounting to 5,000 square feet or 10,000 cubic feet. In all four villages then there are within a length of about three miles 1,891,000 cubic feet of asphalt. The Tsukinoki asphalt was first worked some eighty years ago, and after several experiments in other directions was found useful for making lampblack. There are two kilns there, which burn each 700 kamme

of asphalt a week and produce 14 kamme (two per cent.) of lampblack, worth at Kubota 30 to 60 cents a kamme; so that the yearly product would be some \$650. A laborer's wages are 12 cents a day, and he digs four loads a day on the average. There is also a lampblack kiln at Riuge, dating from September, 1872, which burns 120 loads or 3,000 kamme a month and produces 30 kamme (one per cent.) of lampblack, worth 50 cents a kamme. The yearly product then would be less than \$200. A laborer's wages there are $11\frac{1}{2}$ cents, a day; and he digs 14 or 15 loads a day. The asphalt, is also used for spreading on roads. The lampblack is used in dye stuffs, lacker and plastering; but not for making ink, as it was once tried unsuccessfully. Thick oil is gathered at several places in Riuge and is used in its crude state by the country people for lighting and for painting roofs and fences to keep them from rotting.

“At Torinosu in Nakamaguchi, Akitagoori, about 450 feet above sea level and half way up the Samukaze Mountain, there is a shoo or two of oil (similar to that of Masugawa) on the water of a hole some six feet deep and wide of unknown date. The oil of Masugawa issues through a length of 800 ft., along a small valley; but three wells were dug 20 to 50 ft. deep without success, and were abandoned. The oil is like that of Funagawa, thick, tarry, green and a little opalescent. At Funagawa only a little oil issues at two or three places in the valley, half a league from the main village. At Inugawara in Yabase there are 5 or 6 spots where oil is found on the east bank of the Omono River, commonly covered up by sand, but on digging two or three fathoms two or three koku of oil are got. At Bishamonyachi in the same village oil was obtained from about 1842 until about 1874 but none is got now. At Ooyachi, in Yokooka, although the wells were dug unsuccessfully, there lies

alongside of them some unpure asphalt about 350 feet long by 100 feet wide and a foot thick."

PRICES.—Still according to Messrs. Kuwada and Nishiyama's information : " Five laborers are employed at the Nigorikawa oil wells on wages of 10 to 12½ cents a day besides probably food, at least the morning and noon meals. The cost of well-digging at Oguni is about \$2 a fathom (of 5.8 ft.) or \$20 for 10 fathoms ; but for 20 fathoms, about \$50, it is said."

Messrs, Kuwada and Nishiyama found the cost of well digging in the Kurokawa field to be generally \$4 for five fathoms (5.8 ft. each) to the depth of 15 fathoms ; and below that the cost of the next five fathoms is double or, if very difficult, treble. The wells there are seldom more than 21 or 22 fathoms deep. A well 20 fathoms deep costs (with timbering) about \$30. The well crib costs 40 cents a fathom ; the well hut and bucket, \$6 ; the oil tub (holding 22 shoo) 16 cents ; the oil tank (holding 700 shoo or 280 English gallons), \$2.50 ; and a laborer's daily wages are 12½ cents besides two meals of food, morning and noon, say 15 cents in all. The crude oil sells for five or six cents a shoo (in 1876 it was only one-tenth as dear) ; and refined oil for 17 cents (29 Aug., 1878). The oil refineries of Kurokawa were idle at that time on account of the high price of crude oil ; but one was at work at Nakajo.

Mr. Kada reports that he found the prices, at Ooarato, in September, 1878, to be as follows :

" 1 Board, nine feet long, enough for one	
length of timbering.....	\$0.136
4 Posts, each four feet long for do. do.	0.125
12 Cross pieces for do. do.	0.168

Material for one length (4 ft.) timbering.	0.429
1 Hut	5.00

1 Pair bellows, eight feet long	5.00
1 Length air-pipe, six feet	0.166
1 Wheel (2 are needed for one well).....	1.26
1 Large bucket.....	1.25
1 Well bucket (4 are needed for one well)	0.74
60 ft. Straw rope (each well needs 3 as long as its depth)	0.13
1 Pick (2 or 3 are needed for one well ; a large one weighs 20 lbs.; a small one 15 lbs.)	?
1 Rake	0.75
1 Rope net (for raising earth ; 3 are need- ed for every 5 fathoms)	0.15
1 Oil paper for sky-light.....	0.31
1 Digger's daily wages (without food) ...	0.25
1 Common laborer's do. do. do. ...	0.08
1 Shoo rice beer (one must be given daily to the workmen all together) about..	0.065
“ Number of workmen needed, according to depth :	
From 1 to 20 fathoms...4 men.	
„ 20 „ 30 „ ...6 „	
„ 30 „ 40 „ ...7 „	
„ 40 „ 50 „ ...8 „	
„ 50 „ 60 „ ...9 „	
„ 60 „ 70 „ ..9.5 „	
“ At Kannonji :	
4 Posts	0.100
1 Board (6 ft. by about one foot)	0.120
12 Cross pieces.....	0.96 to 0.216...
“ Materials for one length (4 ft.) of tim- bering	0.376
“ Materials for hut :	
Wood	1.00
Rushes	0.63
	<hr/> 1.63

(Besides that a little straw rope is needed)

1 Pair bellows (seven feet long).....	3.75
1 Length air-pipe (six feet)	0.14
1 Wheel (2 needed for one well)	1.20
1 Tank (diameter 6 ft.; height 6 ft. ? 27 koku ?)	15.00
1 Well-bucket	0.50
6 ft. Straw rope, .....0.01—0.013...	0.012
10 soku (5,000 ft.?)small straw rope (all needed for one well).....	0.45— 0.50...0.475
1 Pick (large one 16 $\frac{2}{3}$ lbs., small one 6 $\frac{2}{3}$ lbs.)	?
1 Rake	0.50
3 Rope nets.....	0.35
1 Oil paper	0.32
1 Pot for boiling the laborers' rice or water	0.62
1 Digger's daily wages (without food)	0.125—0.25 0.18 $\frac{3}{4}$

(Each well needs three.)

1 Common laborer's wages (without food)	0.10
1 Shoo rice beer (saké) daily for the work- men of one well, about.....	0.065

“Number of workmen needed, according to depth :

From 1 to 10 fathoms	3 men
„ 10 „ 30 „	4 „
„ 30 „ 40 „	5 „
„ 40 „ 50 „	6 „

“In that village the wells are rarely 50 fathoms deep ; so the table does not extend further. The earth here is firmer than at Ooarato, and the timbering consequently slighter and cheaper.

“When the hut is first built or the digging first begun ten shoo of saké must be given to the workmen ; and when oil is struck ten or twenty shoo must be given them.

“The laborers here do not commonly work all day, but only half a day or less ; yet when the well is still shallow

the same men go down into it after the noon meal. When a well is 30 or 40 fathoms deep, and there is not very much oil gas, two laborers will do the work of both morning and afternoon, and share the money that the owner may have promised for a third man's wages at the depth of 40 fathoms. When the owner promises to furnish food and less pay in money, he commonly gives them rice and miso for food.

"They tell the story that at Ooarato in 1877 the price of oil fell to 27 tubs of 20 shoo each for \$10, and the owner of well No. 21, which produced ten to fifteen koku daily, and of No. 25 which produced five to eight koku daily, finding difficulty in selling even at that price had several tanks made at \$5 apiece ; so that he lost money by producing too much oil. But it is only here that such a thing could have happened for there never was another village so inconvenient for carriage. The oil has to be sent to Nagaoka ; and the first six leagues (to Tookamachi) it must be carried by horses or men over a very hilly road at ten cents a tubful (20 shoo) ; but from Tookamachi it is sent down the Shinano River to Nagaoka by boat. Owing to the cost of carriage oil has to be sold a little cheaper than in other regions."

Mr. Kada gives also the following particulars in regard to the Shishari Shinkooji and Uematsu oil lands :

"Rock oil was first found in this region at Uematsu, and was gathered from a pond, beginning it is said 165 years ago, and the yearly tax was $12\frac{1}{2}$ cents. The oil from the pond was used for lamps in fifty houses near it ; but the great Shinano earthquake, about 35 or 36 years ago, covered the pond with rocks, and those houses had difficulty in regard to oil. Since that time they conceived the idea of digging for oil, and gradually things came to their present condition. The whole number of wells is about fifty and 27 or 28 of them have no hut over them.

At first the well-diggers knew nothing about rocks, and when they met with a hard one the work was stopped ; but now they dig to a depth of 42 fathoms. The longest time that any well has been productive is eleven years. At present the wells cost about \$15 a fathom, when the rocks are hard. A laborer's wages for one day are 12 cents and one shoo of rice.

“ At Shishari Shinkooji about thirty years ago a farmer named Arai Tohachi found some gas on fire; and built a hut for medical baths there, and boiled mineral water that was brought from Kitago, a village near by on the north. But as visitors did not come as much as he had hoped he gave up the plan of baths. Afterwards he heard that such gas was associated with rock oil, and he then dug shallow wells without any success and thereby threw away all his property. At length on his promising his family and friends that he would give up oil well digging they made a lottery (mujin) for him ; but in spite of his promise he did dig a rather deep well with the money he got from the lottery ; and as he got a great quantity of oil by it he became a first class farmer in the village, as his son still is.”

Mr. Inagaki while in the Kanadzu field obtained from a member of the Ishizaka Oil Company the following rough estimate of the expense of boring a well with a steam engine :

“ It is assumed that the depth of the well is 100 fathoms, and that the boring is done at the average rate of one fathom a day. The daily expense would then be :—

“ Fuel and charcoal for engine	\$2.00
Seed oil , , 	0.90
Blacksmith's charcoal	0.25
8 Laborers @ 12½ cents	1.00
2 Blacksmiths @ 16⅔ cents	0.33⅓
Miscellaneous	1.00
	<hr/>
	5.48⅓

Or for 100 days.....	\$548.33 $\frac{1}{2}$
Add cost of building derrick.....	200.00
	<hr/>
	748.33 $\frac{1}{2}$

“Besides that, add the expense of carrying the engine a distance of say 1,200 yards.”

Moreover there must be borne in mind the interest on the cost of the machinery and other capital, and the gradual deterioration in value of the whole plant. It is clear enough then that the cost of boring a well with a steam engine would be much more than that of digging one by hand; but there is supposed to be some magic in the use of costly machinery that would ensure the striking of rich oil veins. On the contrary the narrow bore-hole would have many disadvantages as compared with the larger dug-well, which could be entered for cleaning or repairs and would receive its oil from a larger surface, and would be far less liable to total loss from accidents.

For the farther benefit of those who still imagine that it would be cheaper to bore holes than to dig wells notwithstanding the much less satisfactory character of the result obtained, it is worth while to compare the cost of the mere boring of 2 $\frac{1}{2}$ inch wells in England in rocks that are soft or at worst of only moderate hardness. According to Spon's "Practice of Sinking and Boring Wells," p. 80, the cost of such a boring is \$10 (reckoning three shillings nine pence to the dollar) for the first five fathoms (30 feet); \$20 for the second, \$30 for the third, \$40 for the fourth (more than treble the cost of digging in the Kurokawa region), and so on. "This does not include tubing, conveyance of plant and tools, superintendence, or working in rock of unusual hardness." At the same rate a well fifty fathoms deep would cost for the mere boring \$550, instead of the \$300

that a dug-well (including the timbering) of that depth costs a company in Tootoomi when not specially difficult, or the \$200 or thereabouts it would probably cost the villagers there or generally in Echigo.

OIL REFINING.—In regard to oil refining Messrs. Kuwada and Nishiyama report as follows :

‘ At Menagata there is a refinery with one still that holds 8 too, and refines that amount in 60 hours, with a yield of 20 per cent. first-class, 10 per cent. second-class and 15 per cent. third-class oil, in all 40 per cent., worth on the average (as it was understood) at wholesale 14 cents a shoo. In 24 days it is said, one tana of wood is burnt, worth, \$3 a tana of 5 ft. \times 5 ft. \times 5 ft., or 125 cubic feet, or say 13 cubic feet for one operation. At Kurokawa the oil yields from 7 too of crude oil, only 4 shoo first-class, 5 shoo second-class and 5 shoo third-class refined oil, or two per cent. in all. The refuse, 5.6 too, is used for covering roofs. The refining is done at Terauchi village in Tsuchizakiminato $3\frac{1}{2}$ leagues distant, and the carriage costs 20 cents a load (of probably 6 too). The Nigorikawa oil is refined at that place, too, and yields from 3.6 koku of the crude oil 1.4 koku of refined oil about 40 per cent. in all. There are 4 stills, but only three in use, holding 1.2 koku each and refining that amount of crude oil daily, with one hari (or 5 ft. \times 5 ft. \times 2 ft.) of wood for the three, worth 75 cents. At retail one shoo of first class oil is worth 22 cents ; of second class, 18 cents ; of third class, 12 cents ; and of fourth class, 8 cents. The product would therefore be some \$800 a month. The Akita Oil Company has a refinery there with 4 stills that hold one koku each ; and the 4 koku crude oil are refined every 24 hours, with a yield of 68 shoo first-class, 40 shoo second-class and 32 shoo third-class refined oil, or 35 per cent. in all. The value of one shoo refined oil is : first-class

about 22 cents ; second-class, about 20 cents ; third-class, about 18 cents. According to that the monthly product would be worth some \$400.”

Mr. Inagaki learned the following facts in regard to oil refining at Kanadzu in the summer of 1878 :—

“ The still now used holds 2 koku ; and the charge of oil is 120 shoo. In about 13 hours, 60 shoo of refined oil are obtained ; and are divided into three classes of : 30°, 26° and 22°. To obtain 60 shoo of refined oil one-fourth of a tana of firewood is burnt (one tana there is five feet square by about 1½ ft. deep, or say 37½ cubic feet, and costs 60 cents) ; and two laborers are employed, at daily wages of 12½ cents each. To purify the oil 60 momme of sulphuric acid are used for every ten shoo of oil. One pound of the acid, containing 120 momme, costs nine cents. To separate the acid from the oil, calcined gypsum (as they said) is used at a cost of about five cents to ten shoo of oil. The price of crude oil was in the summer of 1878, three to four cents a shoo ; and of refined oil, 11 to 12½ cents.”

Mr. Kada gives the following as the results of oil refining at Ooarato :

Naphtha	15 per cent.
Refined oil.....	60 „ „
Heavy oil.....	10 „ „
Asphalt.....	15 „ „

100

The asphalt is used as fuel in refining, but in addition ten cents' worth of wood (maki) must be burnt in refining 1.4 koku of crude oil.

ASSAY.—It may be well to add here the following report of an assay by Mr. T. Shimidzu (formerly Saitoo, assistant with us at the beginning of our Yesso survey) which is the only information of so precise a character

that I have as to the composition of any of the Echigo oils. The assay and report appear to have been very carefully made, but were not made under my oversight, and I know nothing whatever of the assayer's skill in such work.

“Tokio, Japan ; December 25th, 1876.

“I present the following experimental results in regard to one oil from Echigo.

“The specimen, about 400 cubic centimetres in a well corked bottle, was taken by Mr. I. Ban from the middle well of Y. Nishimura in the village of Miyooohooji, Echigo.

“The petroleum is of a dark olive green color, and in thin films transmits a yellowish brown. At the ordinary temperature (60° F.) it is moderately limpid, and has a slight odor of naphtha. Its specific gravity is 0.813 or $43\frac{1}{2}^{\circ}$, of Beaumé's scale, at 52° F., barometer 29.60 inches; and it burns at 90°—114° C. or 194°—237° F. It burns in the natural state in a common lamp with a bright flame, a little smoky, and with a strong light, about five minutes. After ten minutes the wick begins to coal, and after twenty minutes it smokes and goes out.

“The oil was subjected to slow distillation by a careful application of regulated heat of different degrees until the vapor had completely escaped; and a series of hydrocarbons were separated. This was done as follows :

“In the first place, just 300 c.c. of the oil weighing 24.39 grammes or 65.4 momme were placed in a tubulated glass retort holding about one litre ; and in the tubulure a Celsius thermometer was inserted with a good perforated cork, as usual, to indicate the temperature of the liquid within. The following table shows the results :

	Temperature and time.	Color.	Specific gravity.	Per cent to weight.	Per cent. to volume.
1	Below 100°C. 11 hours.	colorless.	0.737	19.45	21.66
2	100°—145°C. 19½ hours.	light yellow.	0.797	31.98	32.00
3	145°—310°C. 8½ hours.	bright yellow.	0.847	17.61	12.67
4	Without thermometer, 10 hours.	yellow.	not taken.	21.92	13.64
5	coke.	black.	...	6.11	} 20.03
	loss.	...	...	2.93	
				100.00	100.00

“The portions No. 1, and No. 2 were submitted to fractional condensation according to the method of C. M. Warren (see American Journal of Science, Second Series, Volume XXXIX, No. 117, May 1865, p. 327); and continuing the temperature 93°—98° C. (or 199.4°—208.4° F.) 92.34 per cent. of benzine were obtained from No. 1, or 20 per cent. of the original volume, and 4.06 per cent. from No. 2, or 1.30 per cent. of the original volume. It is highly volatile and takes fire from a match at the common temperature, and burns with a smoky flame.

“No. 2 is a good burning oil; it is slightly colored and has little smell, and burns with a bright flame.

“No. 3 is a common burning oil; it is colored yellow and has a rich smell, and burns with a bright red flame and a strong light. After obtaining this oil I transferred the tarry matter into a weighed earthen retort and distilled.

“No. 4 is a dark yellowish, heavy liquid which is used for lubricating machinery. This oil was obtained by distilling from the earthen retort to dryness.

“No. 5 is hard compact coke, and was determined by subtracting the weight of the retort from the weight of the retort and its contents.

“After treating with sulphuric acid and soda, the oils No. 2 and No. 3 became quite colorless. No paraffine could be detected by refrigerating the heavy oils in a mixture of salt and ice.

“T. SHIMIDZU.”

I annex some brief tables of Japanese weights and measures compared with foreign ones, for convenience in reading or translating our reports.

I have the honor to be,

Sir,

Your most obedient servant.

BENJ. SMITH LYMAN.

Koojimachi, 25th Sept., 1879.

MEASURES OF LENGTH.

The shaku in common use by the public and by the Post Office is called kanejaku. By my own trial I find 3.012 kanejaku=1 English yard ; and 3,294 kanejaku=1 metre=3.280899 English feet=3.280709 United States feet. Hence :

0.996 feet=1 shaku=10 sun=100 bu=1,000 rin=10,000 moo.

1 ken=6 shaku=5.976 feet=1 fathom nearly.

1 choo=60 ken=360 shaku=358.56 feet=120 yards, nearly=
6/11 furlong.

1 ri=36 choo=2,160 ken=12,960 shaku=12,908.16 feet=2.4447
miles=about 200 feet less than $2\frac{1}{2}$ miles=3,934.43
mètres=very nearly 4 kilomètres, the lieue de poste.

The Surveyor General's Office (Chirikiyoku) has adopted for its own use (probably for greater convenience of computation in its measurements with foreign rods) a shaku that is slightly shorter, so that 3.3 shaku=1 mètre.

For measuring cloth the kujira shaku is used, and is equal to 1.25 kanejaku.

MEASURES OF CAPACITY.

The shoo is the base of all measures of capacity, and is a box 0.49 shaku (kanejaku) square, by 0.27 deep, containing 0.064827 cubic shaku. For dry measure it has, for convenience in striking, a rectangular metal rod 0.0195 shaku thick by 0.018 shaku wide diagonally across the top ; and the depth of the box is 0.271, so that the contents, subtracting the rod, are likewise 0.064827.

1 Shoo=10 goo=100 shaku.

1 Shoo=0.3992 British gallon=.4792 U.S. liquid gallon=.4118
U.S. dry gallon.

1 Too=10 Shoo=3.992 British gallons=4.792 U.S. liquid gallons
=4.118 U.S. dry gallons.

1 Koku=10 Too=100 Shoo=39.92 British gallons=47.92 U.S.
liquid gallons=41.18 U.S. dry gallons.
=4.99 British bushels=5.1475 U.S. bushels.

WEIGHTS.

It is commonly reckoned that 120 momme=1 pound avoirdupois, and 160 momme=1 catty. Then :

1 shoo of pure water at 62° F. with bar. at 30 ins.
weighs 479.904 momme=3.992 lbs avoirdupois.

58 $\frac{1}{3}$ grains=1 momme=10 fun=100 rin=1,000 moo.

8.22855 momme=1 oz. troy.

98.7406 momme=1 lb. troy.

7.5 momme=1 oz. avoirdupois.

120 momme=1 lb. avoirdupois.

160 momme=1 $\frac{1}{3}$ lb. avoirdupois=1 kin=1 catty.

1,600 momme=133 $\frac{1}{3}$ lbs. avoirdupois=100 kin=1 picul.

1,000 momme=1 kamme=8 $\frac{1}{3}$ lbs. avoirdupois=10.127546 lbs.
troy.

240 kamme=2,000 lbs. avoirdupois.

268.8 kamme=2,240 lbs. avoirdupois=1 ton.

1,600 kamme=100 piculs=5.952 tons.

According, however, to a pamphlet on Coin Laws published by the Oozaka Mint under government orders in January, 1875, the mean of various Japanese weight standards is given provisionally as such that “one momme=57.971 grains, and=3.756521 grammes;” so that 120.751757 momme=1 lb. avoirdupois, and 99.360025 momme=1 lb. troy; and one shoo of pure water at 62° F. with barometer at 30 in. would weigh 482.038 momme. But a table published by Muroda Yoshibumi in March, 1875, says (on how good authority I do not know) that “121.03505 momme=1 lb. avoirdupois,” so that 99.5949 momme=1 lb. troy; and again (in the Kaitakushi English-Japanese dictionary of 1872) it is stated that “121.6 momme=1 lb. avoirdupois, and 100.05942 $\frac{6}{7}$ momme=1 lb. troy.”

B. S. L.

25th Sept., 1879,