XXXIII.—Examination of the Raw Materials Used for the Arita Porcelain.

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It has been asserted by several writers, that the raw materials used in the manufacture of porcelain, in Japan and China, are somewhat different from those chosen for the same purpose in Europe; but, as this assertion seems to owe its origin to the examination of a few isolated specimens, and, also, to the casual observations made by the travelers in those countries, it is exceedingly interesting for us to make a more extended and complete examination of them, and to compare them with those used in Europe, after long years of experience. The samples that form the subject of my present investigation have come from Koransha, a large porcelain manufacturing company of Arita, in the province of Hizen. As this locality has been the great centre of this industry in Japan for about three hundred years, the examination of the raw materials used there will also give a tolerably good idea of those generally used in Japan, although in other places a slight variation in their choice may naturally be expected. The native minerals are all said to be found in the neighborhood of the village Arita, and mostly in one hill, called Idsunuyama. They are all white, varying considerably in hardness, and apparently showing different stages of the decomposition of the felspathic rocks. They are as follows:

1. Tsuji-ishi,
2. Shiro-tsuchi,
3. Midsuana-ishi,
4. Kudakè-ishi,

} For the body of the ware.

5. Composition for the body of the superior kind of the ware.
6. Composition for the body of the inferior kind of the ware.

7. Genyemon-ishi,
8. Rikita-ishi,
9. Haruji-ishi,
10. Tai-ishi,

} For the glaze.

11. Seiji-ishi, for the glaze of the Seiji, or the Seladon ware.
12. Yusu-bai, or the ash obtained from the bark of the *Ficus pyrifolia*, used in compounding the glaze.
13. The glaze composition for the ordinary ware.
14. The Seiji glaze composition.
15. Nakadaru-tsuchi, used in a thin layer between the body and the glaze.
16. Gosu, or the pigment for the cobalt blue.

In order to obtain the average composition as nearly as possible, it was deemed advisable to take about one-half pound of each sample, and to crush it by the Blake's crusher when necessary, and then to grind by means of the steel plane-roller used in assaying; the ground mineral was then sifted, taking care to use all the material, and then the powder was well mixed. A small quantity of each was specially ground to an impalpable powder, in an agate mortar, and was used for the analysis. It is not necessary to give the detailed description of the method of the analysis pursued in the following examinations, but it may be stated, that the general scheme for the analysis of iron slag was followed, except the precipitation of the $Al_2O_3 + Fe_2O_3$, for which $(H_4N)HO$ was used, instead of $Na_2C_2O_4$, and the filtrate was evaporated to dryness and ignited, to drive off the H_4N salts, in order to precipitate MnO_2 by Br. The Al_2O_3 and Fe_2O_3 were weighed together, and were afterward fused with $NaHSO_4$ and brought into solution, from which the iron was titrated with $K_2Mn_2O_8$. S was determined in the filtrate from the MgO precipitate. It was found necessary to deduct a small quantity of S from each result, as the flux always contained some sulphur. For the alkali determination, Wurtz's modification of Dr. J. Lawrence Smith's method (described in the *American Chemist*, 7, 6) was followed. After weighing KCl and NaCl together in a platinum dish, KCl was precipitated with $PtCl_4$, and was weighed as $Pt + 2KCl$. This last process was found, after a trial, to give as accurate a result as weighing Pt alone, and saves us the trouble of washing away KCl, and also from the danger of losing some Pt in that operation. The densities were all determined in powder at 15° C., and those given in the following pages are each the mean of two or more determinations.

1. Tsuji-ishi. This is used for making the body of the best kind of the Arita ware, after it is crushed and washed, mostly mixed with other minerals. It is a grayish-white mineral, showing distinctly soft and hard layers. In powder it turns slightly pink on ignition. The fresh surface does not soil the finger when touched. It has an odor somewhat resembling that of chalk, and feels gritty between the teeth. Small crystals of pyrite are found disseminated through the mass. It adheres very slightly to the tongue, but is quite tough. When heated with dilute HCl, it gives off H_2S. The fracture is sometimes uneven and sometimes conchoidal. Hardness = 4; den-

sity = 2.679. This is the most refractory mineral in the whole series. The following is the composition.

H_2O	3.31
SiO_2	76.74
Al_2O_3	13.75
FeS_2	.81
FeO	.55
MnO	.06
CaO	none
MgO	.11
K_2O	3.87
Na_2O	.69
	99.89

Calculating the proportions of SiO_2 and Al_2O_3 necessary to saturate the alkalies above found, in order to form felspar $[(KNa)_2O.Al_2O_3.6SiO_2]$, and then estimating again the necessary proportions of H_2O and SiO_2, combined with the remaining Al_2O_3 in kaolin, whose formula is here assumed to be $Al_2O_3.2SiO_2.H_2O$, we have obtained the following remarkable result:

Felspar	$(KNa)_2O$	4.56	28.73
	Al_2O_3	5.37	
	SiO_2	18.80	
Kaolin	Al_2O_3	8.38	21.09
	SiO_2	9.78	
	H_2O	2.93	
Free SiO_2			48.16
FeS_2, FeO, MnO MgO and H_2O			1.91
			99.89

This cannot be considered as a mere coincidence, as a similar result can be obtained from each of the following analyses. It is more remarkable if we reflect for an instant that the compositions of these minerals (kaolin and felspar) are somewhat variable, even when the purest specimens are selected. The excess of .38 per cent. of H_2O may be due to the hygroscopic moisture, or it may be in combination with SiO_2.

2. Shiro-tsuchi. This is also used for compounding the body, and is whiter and less refractory than No. 1. It becomes slightly pink on ignition. It contains hard, irregular grains scattered through the mass. It is softer than No. 1, and the fresh surface soils the finger. It has

chalky odor and crushes grittily between the teeth. It gives off H_2S when heated with diluted HCl. Pyrite is found in irregular masses. Fracture, uneven. Hardness = 3. Density = 2.657. The analysis gave:

H_2O	3.58
SiO_2	74.28
Al_2O_3	15.14
FeS_2	1.69
FeO	.50
MnO	.07
CaO	.23
MgO	.03
K_2O	4.02
Na_2O	.71
	100.25

By calculating as before, we obtain:

Felspar	$(KNa)_2O$	4.73	29.79
	Al_2O_3	5.57	
	SiO_2	19.49	
Kaolin	Al_2O_3	9.57	24.17
	SiO_2	11.27	
	H_2O	3.33	
Free SiO_2			43.52
FeS_2, FeO, MnO, CaO, MgO, H_2O			2.77
			100.25

3. Midsuana-ishi is used, like the two preceding minerals, for compounding the body, and is added to make it more fusible. It is almost white, having less grayish tinge than Nos. 1 and 2, but turns decidedly pink on ignition. The fresh surface soils the finger when touched, and crushes grittily between the teeth. It has an earthy odor and adheres to the tongue. By scratching with a knife hard and soft layers can easily be detected. Small crystals of FeS_2 are found on the surface, and the specimen is, in some portions, colored yellowish-red with the hydrated oxide of iron. It gives off H_2S when heated with diluted HCl. Fracture, uneven. Hardness = 4. Density = 2.541.

The analysis gave:

H_2O	3.05
SiO_2	75.76
Al_2O_3	13.56
FeS_2	.36
FeO	.62
MnO	.18
CaO	.29
MgO	.12
K_2O	5.03
Na_2O	1.50
	100.47

From which, calculating as before, we get:

Felspar	K_2O	5.03	42.45
	Na_2O	1.50	
	Al_2O_3	7.98	
	SiO_2	27.94	
Kaolin	Al_2O_3	5.58	14.04
	SiO_2	6.51	
	H_2O	1.95	
Free SiO_2			41.31
FeO, FeS_2, etc			2.68
			100.48

On comparing this result with the two preceding, it is evident that the greater fusibility of this mineral is due to the presence of the larger percentage of felspar and the less of kaolin, while the refractory character of No. 1 is greatly enhanced by the large amounts of the free SiO_2.

4. Kudakè-ishi, or the powder stone, probably so named from the readiness with which it is ground. Although it is used for the same purpose as the three foregoing, it comes from Shirakawayama, and differs from them in this respect as well as in some physical characters. It is a white mineral with a light grayish tinge, and becomes slightly yellow on ignition. It easily breaks to powder, which is unctuous to the touch. It is not at all gritty between the teeth, and the fresh surface soils the finger. It has an earthy odor, and adheres to the tongue strongly. The fracture is sometimes even and sometimes uneven. Pyrite is not visible, though it gives off H_2S. It is quite fusible. Hardness = 1.5. Density = 2.602.

The analysis gave the following composition :

H_2O	3.60
SiO_2	73.36
Al_2O_3	14.03
FeS_2	.06
Fe_2O_3	1.38
MnO	.07
CaO	.24
MgO	.43
K_2O	4.99
Na_2O	1.62
	99.78

From which we obtain :

Felspar	K_2O	4.99	43.16
	Na_2O	1.66	
	Al_2O_3	8.08	
	SiO_2	28.47	
Kaolin	Al_2O_3	5.95	14.98
	SiO_2	6.95	
	H_2O	2.08	
Free SiO_2		37.92	
FeS_2, Fe_2O_3, etc.			3.72
			99.78

5. and 6. These are both the prepared materials, ready to be made into any desired shape. They are both white, 6 being slightly yellower than 5. They are slightly gritty between the teeth. Boiled with diluted HCl, 5 gives off H_2S, but 6 gives none.

The analysis gave :

	5.	6.
H_2O	4.70	4.64
SiO_2	72.96	72.19
Al_2O_3	16.84	16.53
Fe_2O_3	.46	.76
SO_3	.52	.67
MnO	trace	trace
CaO	.27	.31
K_2O	3.87	4.03
Na_2O	.29	.44
MgO	.07	.07
	99.98	99.64

From which, by calculation as before, we derive the following:

	5.	6.
Felspar	25.35	27.23
Kaolin	30.56	28.43
Free SiO_3	42.31	41.27
Fe_2O_3, SO_3, etc.	1.77	2.71
	99.99	99.64

It is here to be remarked that, though the percentage compositions of these prepared materials do not materially differ from those of the previous minerals, the effects of crushing and washing, which these minerals have undergone in reaching this state, are more clearly seen from the figures above given. It is hardly necessary to say that the proportion of kaolin has been considerably increased, and that of felspar decreased, as would naturally be expected; while the amount of SiO_2 remains about the same as before in both specimens. However, it must not be passed unnoticed that the foreign impurities, like MnO_2 and FeS_2, have been largely removed, and the remaining iron and sulphur are in the oxidized state.

The difference observed between 5 and 6 is apparently very slight; yet the inferiority of 6 to 5 is no doubt due to the greater fusibility, and also to the little more iron contained in 6, which would probably make it less white.

7. Genyemon-ishi. This is used for making the glaze, together with the three others which follow it, and is the most refractory of all the glaze stones. It is grayish-white and remains so after ignition. It is apparently homogeneous in texture, except that the black grains of pyrite are found disseminated through it. It is not so tough as 8 and 9. It attracts the tongue and feels gritty between the teeth. Its odor is earthy, and the fresh surface does not soil the finger. It gives off H_2S when heated with diluted HCl. Its fracture is even. Density = 2.574. Hardness = 3.5. Its composition is as follows:

H_2O	2.40
SiO_2	77.74
Al_2O_3	13.35
FeS_2	.05
FeO	.71
MnO	.01
CaO	.21
MgO	.05
K_2O	5.05
Na_2O	1.29
	100.30

Computing as before, we have:

Felspar	40.71
Kaolin	14.35
Free SiO_2	43.81
FeO, CaO, etc.	1.43
	100.30

8. Rikita-ishi is used for compounding the glaze as the preceding It has about the same color as 7, but turns very slightly pink on ignition, owing to the presence of pyrite. It is apparently homogeneous, except that FeS_2 is found in thin layers on the surface. It slightly adheres to the tongue, and feels gritty between the teeth. The fresh surface does not soil the finger, and its fracture is sometimes even and sometimes uneven. Boiled with diluted HCl, it gives off H_2S. It has an earthy odor. Hardness = 4. Density = 2.608. The following is the composition:

H_2O	2.42
SiO_2	77.38
Al_2O_3	13.30
FeS_2	.24
FeO	.73
MnO	trace
CaO	.39
MgO	.08
K_2O	4.62
Na_2O	1.15
	100.31

Calculating as before, we obtain:

Felspar	37.06
Kaolin	15.98
Free SiO_2	45.63
FeO, CaO, etc.	1.64
	100.31

9. Harujisugu-ishi. This is also used for the glaze, and is added to the preceding to make the mixture more fusible. It is grayish-white, but turns slightly pink on ignition, like 8. When it is scratched with a knife, the distinct layers of hard and soft matter can be easily made out The fresh surface does not soil the finger, but

slightly adheres to the tongue. It has an earthy smell, and feels gritty between the teeth. The mineral is covered with the black spots of pyrite and also a soft yellow mineral, containing iron and sulphuric acid, which is probably melanterite, formed by the oxidation of pyrite. The fracture is sometimes uneven and sometimes conchoidal. It gives off H_2S when heated with diluted HCl. The harder portion of this mineral is the hardest in the whole series, its hardness varying between 4.5 and 5.5. Density = 2.447. The analysis gave:

H_2O	2.56
SiO_2	75.10
Al_2O_3	13.64
FeS_2	.96
FeO	.59
MnO	trace
CaO	.49
MgO	.15
K_2O	4.53
Na_2O	2.39
	100.41

Computing as before, we have :

Feldspar	43.42
Kaolin	12.03
Free SiO_2	41.88
FeS_2, etc.	3.08
	100.41

10. Tai-ishi. This is also used for the glaze, although it differs in many respects from the preceding three minerals. It is the whitest mineral in the whole series, and shows no change of color on ignition, as the amount of iron is very small. It is homogeneous in texture, and breaks to powder readily. It feels slightly gritty between the teeth, and smells earthy. No pyrite is visible, but gives off a trace of H_2S when treated with diluted HCl. It is very porous and adheres strongly to the tongue. The fresh surface smears the fingers. Its fracture is uneven. Hardness = 3. The powdered mineral is

unctuous to the touch and is quite fusible. Density = 2.618. The analysis gave:

H_2O	2.72
SiO_2	77.74
Al_2O_3	13.64
FeO	.37
S	trace
MnO	.08
CaO	.23
K_2O	.73
Na_2O	4.36
MgO	trace
	99.87

From which we derive:

Felspar	41.25
Kaolin	14.18
Free SiO_2	43.01
FeO, etc.	1.43
	99.87

11. Seiji-ishi. This is used for the light green glaze of the Seiji or Seladon ware. It is laminated, and the softer laminæ are highly colored with the hydrated oxide of iron. In powder it somewhat resembles litharge in color, and its color becomes darker on ignition. Its fresh surface does not soil the finger, but sticks slightly to the tongue. It is tougher than the preceding glaze minerals, and is gritty between the teeth. It is quite fusible, and is probably less decomposed than any mineral in the whole series. Fracture, uneven. When treated with HCl, it gives off H_2S. Hardness = 3.5. Density = 2.596. The analysis gave the following result:

H_2O	1.84
SiO_2	74.45
Al_2O_3	13.45
FeS_2	.19
Fe_2O_3	1.60
MnO	.05
CaO	.63
MgO	.03
K_2O	4.54
Na_2O	2.75
	99.83

From which we obtain:

Felspar	49.63
Kaolin	10.18
Free SiO_2	37.10
Fe_2O_3, etc.	2.92
	99.83

12. Yusu-bai, or the lixiviated ash obtained from the bark of the *Fiscus pyrifolia*. This is used in compounding the glaze to make the washed glaze stones much more fusible. It looks like common wood-ash and contains some unburnt charcoal. Water dissolves out $CaSO_4$ and a small quantity of K_2CO_3 and Na_2CO_3. This was ignited in a platinum dish in order to burn up all the charcoal, and the resulting substance was analyzed. The following composition was obtained:

SiO_2	32.83
Al_2O_3	3.83
Fe_2O_3	.99
SO_3	1.27
MnO	trace
CaO	29.57
MgO	trace
K_2O	.35
Na_2O	.07
CO_2 (calculated)	23.44
H_2O and loss	7.65
	100.00

13. The glaze composition. It is grayish compared with the body compositions, owing, no doubt, to the presence of the Yusu-bai. It effervesces when treated with HCl. The analysis gave:

H_2O	3.66
SiO_2	56.23
Al_2O_3	13.48
Fe_2O_3	.59
SO_3	.93
MnO	trace
CaO	5.14
MgO	.05
K_2O	2.43
Na_2O	2.69
CO_2 (combined with CaO, and calculated)	4.10
	99.20

From the comparison of the above analysis with the compositions of the preceding glaze minerals and the ash, it may safely be inferred that the great increase in fusibility, resulting from the addition of the ash to the washed glaze minerals, is due to the presence of 5.14 per cent. of CaO which has come almost entirely from it. Omitting from the foregoing analysis the H_2O, SO_3 and CO_2, which will no doubt be expelled in the oven, and computing the remainder to 100, we get the following for the approximate composition of the glaze mixture after fusion:

SiO_2	73.09
Al_2O_3	14.88
Fe_2O_3	.65
CaO	5.67
MgO	.06
K_2O	2.68
Na_2O	2.97
	100.00

It will be seen that this does not differ materially from the composition of ordinary glass, though in the latter Al_2O_3 is much lower, and the alkalies are generally higher in the percentage.

In order to find out the approximate composition of the washed glaze mineral before the addition of the ash, 17.5 per cent. of each constituent of the ash has been subtracted from the corresponding one of the glaze composition, to eliminate nearly all the CaO which has come from it; and for the remainder, computed to 100, we have:

H_2O	2.96
SiO_2	73.31
Al_2O_3	15.53
Fe_2O_3	.52
SO_3	1.19
MnO	trace
CaO	.29
MgO	.06
K_2O	2.88
Na_2O	2.26
	100.00

From which we obtain, as before :

Felspar	44.66
Kaolin	17.55
Free SiO_2	35.21
Fe_2O_3, etc.	2.58
	100.00

Here it must be remembered that this does not show the composition of any one of the washed glaze minerals, but rather that of the mixture of two or more ; yet I think it is sufficient to show the change which the native minerals undergo during the process of crushing and washing, and it is safe to conclude that kaolin and felspar are increased, while the percentage of SiO_2 is decreased.

14. The composition for the Seiji glaze. It is grayish-yellow in color, and feels slightly gritty between the teeth. It effervesces with acid. The analysis gave :

H_2O	4.12
SiO_2	65.69
Fe_2O_3	1.46
SO_3	1.27
MnO	trace
CaO	5.39
MgO	trace
K_2O	3.90
Na_2O	2.37
CO_2 (calculated)	4.28
	100.01

Omitting the H_2O, CO_2 and SO_3, and computing the remainder to 100, we obtain the following for the composition of the Seiji glaze after fusion :

SiO_2	71.71
Al_2O_3	13.89
Fe_2O_3	1.67
CaO	5.88
K_2O	4.26
Na_2O	2.59
	100.00

It will be seen from the above analysis that the light green color of the Seiji glaze is due to the Fe_2O_3, whose quantity in this glaze exceeds that in the ordinary white glaze, by about one per cent.

By subtracting the ash, amounting to 17.5 per cent. of the glaze composition, and then computing the result to 100, we obtain for the composition of the mineral after washing:

H_2O	3.44
SiO_2	72.48
Al_2O_3	14.48
Fe_2O_3	1.60
CaO	.60
K_2O	4.58
Na_2O	2.82
	100.00

From which we derive:

Felspar	50.98
Kaolin	12.08
Free SiO_2	32.98
FeO_2, etc	3.96
	100.00

The concentration of kaolin and felspar is here less than in the case of the ordinary glaze, but the free SiO_2 has been removed to nearly the same extent as before.

15. Nakadaru-tsuchi. This mineral differs considerably from the preceding series in being more thoroughly decomposed. Its use is also peculiar, and it is applied in a thin layer between the body and the glaze, in order to give the smooth surface necessary to fine porcelain, and also to make it possible to obtain the beautiful blue of the Gosu. It has light cream color, and shows no apparent change in color on ignition. It crushes to soft powder between the fingers, and the fresh surface soils the finger. Its powder is unctuous to the touch. It has chalky odor and is not gritty between the teeth. It falls to powder in water and is almost as plastic as true clays. It adheres to the tongue strongly, and has a slight astringent taste like alum, owing to the presence of sulphate of iron, which can be extracted with water. It gives off no H_2S with acid. Fracture, uneven. Density = 2.716, being the highest in the series. Hardness = 1.5.

The analysis gave :

H_2O	8.79
SiO_2	47.38
Al_2O_3	33.24
FeO	1.68
SO_3	1.95
MnO	trace
CaO	.59
MgO	.04
K_2O	5.31
Na_2O	1.38
	100.36

From the large percentages of Al_2O_3 and H_2O in the above analysis, it is clear that this mineral is very rich in kaolin. After deducting 60 per cent. of kaolin, containing 8.35 per cent. H_2O, and also all FeO and SO_3, from the above analysis, that which remains has about the same composition as oligoclase, in which K_2O largely takes the place of Na_2O. Hence it may be inferred that this mineral is a mixture of the following :

Felspar	35.66
Kaolin	60.00
FeO, etc.	4.70
	100.36

16. Gosu, or the substance used for the beautiful cobalt blue that is applied generally under the glaze. This has no connection with the foregoing minerals. It is imported into Japan from China, and the mode of manufacturing it is not known. It comes to market in dark olive green lumps, and is very hard to grind. It is almost insoluble in acid, and had to be fused with soda to get it in solution.

The analysis gave the following composition:

H_2O (moisture)	1.68
SiO_2	4.97
$Fe_2O_3 + Al_2O_3$	28.70
Mn_3O_4	45.24
CoO	19.05
	99.64

It is astonishing what a large percentage of Mn_3O_4 there is in the substance, and that it does not seriously interfere with the blue color imparted by 19.05 per cent. of CoO.

Though no analysis of the Arita porcelain itself has been made in the present investigation, the approximate composition may be obtained by subtracting from the analysis of the body compositions given under 5 and 6, SO_3 and H_2O, which are no doubt driven off during the process of baking, and then computing the results to 100. They are as follows.

	5	6
SiO_2	77.00	76.53
Al_2O_3	17.77	17.52
Fe_2O_3	.48	.86
CaO	.29	.33
MgO	.07	.07
K_2O	4.08	4.27
Na_2O	.31	.47
	100.00	100.00

ANALYSES OF EUROPEAN AND ORIENTAL PORCELAIN.

Analysts.	Laurent.	Laurent.	Müller of Prague.	Vielguth.	Salvétat.	Salvétat.	H. Wurtz.	H. Wurtz.
Kind of Ware.	Sèvres.	Vienna of 1806.	Berlin.	Nymphenberger.	Chinese, 1st Qual.	Chinese, 3d Qual.	Japanese Egg-shell Ware.	Japanese Thick-bodied.
SiO_2	58.0	61.5	71.34	72.80	69.00	73.3	78.763	74.545
Al_2O_3	34.5	31.6	23.76	18.40	23.60	19.3	17.847	19.315
Fe_2O_3	....	.8	1.74	2.50	1.20	2.0	.638	.916
CaO	4.5	1.8	.57	3.30	.30	.6	.213	.106
MgO	....	1.4	.19	.30	.02	trace	.029	.176
Na_2O	....	....	.58	1.84	2.90	2.9	1.975	2.832
K_2O	3.0	2.2	2.00	.65	3.30	2.5	.203	.566
Totals	100.0	99.3	100.18	99.79	100.32	100.6	99.668	99.568

The preceding analyses show that the peculiarity of the Japanese porcelain consists in the relatively large amount of SiO_2, together with the small percentage of Al_2O_3, while CaO is present only in a very small quantity. It is to be remarked that this last peculiarity is shared by the Chinese porcelains also, at least, of the superior quality. Thus far I have occupied myself with the description and the analysis of each individual sample, without much reference to their relation to each other; and I now pass on to the discussion of their relative fusibility. This was determined by heating the same quantity (.5 grm) of each sample in powder, over a blast lamp, for a given time (7 min.), in a platinum crucible, conducting the experiment in the same way as much as possible. The resulting masses were examined carefully as to the relative coherence. The most refractory minerals were found after the above operation to be in about the same condition as before, while the most fusible one turned partly to white enamel. The numbers given in the succeeding table indicate nothing more than the order in which they stand with regard to refractory character.

Minerals.	Densities.	Kaolin.	Felspar.	Free SiO_2	CaO.	Hardness.	Fusibility.
15. Nakadaru-tsuchi...	2.716	60.00	35.66	....	.59	1.5	9
5. Body composition..	2.664	30.56	25.35	42.31	.27	...	1
1. Tsuji-ishi.....	2.679	21.09	28.73	48.16	....	4.0	2
6. Body composition..	2.663	28.43	27.23	41.27	.31	...	3
2. Shiro-tsuchi.....	2.657	24.17	29.79	43.52	.23	3.0	4
8. Rikita-ishi	2.608	15.98	37.06	45.63	.39	4.0	7
7. Genyemon-ishi....	2.574	14.35	40.70	43.81	.21	3.5	5
10. Tai-ishi.....	2.618	14.18	41.28	43.30	.23	3.0	11
3. Midsuana-ishi	2.541	14.04	42.45	41.31	.29	4.0	6
4. Kudakè-ishi.....	2.602	14.98	43.16	37.92	.24	1.5	10
9. Haruji-ishi.....	2.447	12.03	43.42	41.88	.49	4.5-5.5	8
11. Seiji-ishi.....	2.596	10.18	49.63	37.10	.63	3.5	12

On carefully examining the above table, it will be observed that the higher the percentage of kaolin and the lower that of felspar, the greater the density; and that the larger the amount of felspar, the

greater is the fusibility. There are some remarkable exceptions to these general rules, which are only apparent, and in reality conform to them. Thus, in the case of Nakadaru-tsuchi (15), notwithstanding the large percentage of kaolin, and consequently the high density, it is very fusible, owing to the large amount of the alkalies contained in the felspar. In Tai-ishi (10), the comparatively high density and the great fusibility are both due to the presence of the large amount of the soda-felspar, which is more fusible and has generally higher density than the potash-felspar; while in Kudakè-ishi, the high density is caused by kaolin. For the high density of the Seiji-ishi, no reason is apparent but the probable difference in the manner of the composition, and hence in the molecular structure, as this, together with Nakadaru-tsuchi (15) and Kudakè-ishi (4), do not come from the Idsumigama quarries like the rest. It is also to be remarked that though the absolute quantity of CaO in these minerals is small, it seems to have some influence on the fusibility, for the relatively high percentage of CaO is here associated with the more fusible of the minerals, while the most refractory raw mineral does not contain it at all.

Most careful search for crystalline structures in the thin sections of these minerals, by the aid of a microscope with ordinary light, has been in vain; but polarized light brought to view a very few small fragments, which are probably broken crystals of felspar, in only three specimens, viz.: Tsuji-ishi (1), Genyemon-ishi (7) and Rikita-ishi (8). As these fragments are found not in the least decomposed, they rather seem to be the accidental than the normal constituents. It is surprising to find how thorough is the loss of crystalline structures in these minerals, while so much of the alkalies, and presumably the felspar, is retained.