

The No. 1 and the No. 2 sample, when compared with the No. 3 sample, have coarser slip grain size and smaller dry strength. The No. 1, No. 2, and No. 3 samples should exhibit about the same properties because of the chemical compositions of the raw materials of which they are made; it is estimated that some abnormalities existed in the CSS raw materials. The No. 10 sample was made by replacing half of KBS with CM-2 in the No. 4 sample; different from the No. 1 through 7 and No. 9 samples, which are basic mixture samples, the No. 10 sample contains less kaolin but more clay. The cast body made from the No. 10 sample has a water content of as low as 18% and a dry shrinkage of as much as 3.75%. This shows that the packing density of the dry body is greater than that of other bodies. It is estimated that this led smaller firing shrinkage and bending against sintering.

This indicates the possibility of changing the base from the No. 10 sample into one with less shrinkage and bending against sintering by replacing part of the kaolin raw material component with finer-grained clay. However, the finer the replacement grains are, the slower the casting rate becomes. The mixed bodies used this time disperse widely in the results of the ink test (water absorption) on the sintered mixed bodies; therefore, although it cannot be definitely said, peculiar sintering properties are not observed among the CS-1, CM-2, CP-1, CS-1W, and CM-K2 samples. Therefore, the 5 types of raw materials are considered interchangeable as far as their firing properties are concerned, though they need adjustment to compensate for difference in chemical composition when they are used for actual mixing.

3.3 Results of Cross Check

Tests in Japan and Indonesia were conducted at the Saga Ceramics Research Laboratory (SCRL) and BBK, respectively.

(1) Raw material subjected to the cross check

Eight different materials were selected and subjected to tests in both Japan and Indonesia. 1) FP, 2) FB-1, 3) FN-1 as feldspar, 4) TP-4 as toseki and 5) CP-1, 6) CS-2, 7) CC and 8) KB as clay. The results obtained in both countries were compared and evaluated.

(2) Test items

- 1) X-ray diffraction
- 2) Ignition loss
- 3) Chemical analysis using the X-ray fluorescence method

4) Firing coloration

(3) Results of comparison

The following differences affect the results of cross check.

- a) Difference in sample preparation method
- b) Difference in test method
- c) Difference in test equipment
- d) Difference in the researcher (skillfulness) who evaluates test results

The relationship between these factors and test results is as follows:

1) X-ray diffraction

Results of X-ray diffractometry conducted in Japan and Indonesia are shown in Table 3-6.

X-ray diffractometry shows that in respect of Factor a) (difference in sample preparation method), the temperature for drying the sample was considered to affect the identification of mineral contents of the clay.

There is no significant difference in the testing method b) between the two institutions.

In respect of Factor c) (difference in test equipment), Indonesia used an equipment of an old manual type, which requires a longer time for analysis due to a rapid scanning speed and the absence of a noise-cut facility, which could cause a mistake in identification.

On the other hand, SCRL used the latest equipment with the least potential for error in identification because its operation is aided by computer. However, differences in a standard sample and data stored in computer, could cause differences in the interpretation of the data.

In respect of Factor d) (difference in skillfulness), even experienced Japanese researchers seem to have slight problems in identifying a trace amount of mineral and clay minerals. For example, they mistakenly identified Sericite in CC clay as Muscovite. However, it is very difficult to differentiate Sericite from Muscovite using X-ray diffraction alone, so that a comprehensive judgment with the use of other methods, such as microscopy and physical property (viscosity), is required. The difference in results is considered to be caused by the knowledge of researchers concerning substances to be evaluated and their awareness of the purpose of the test.

On the other hand, because the identification is done by members of the survey group instead of the BBK, the comparison cannot be said as comparison in a strict term.

However, BBK staff seemed to have considerable experience. It can be considered that BBK has sufficient identification ability, though there is a slight problem in the test equipment they use.

2) Ignition loss (Figure 3-3 (1))

Ignition loss measured in both Japan and Indonesia are shown in Table 3-7.

The difference in the raw material preparation method (Factor a)) gives the same, or an even stronger effect on the measurement results than the difference in X-ray diffraction. On the whole, measurement results obtained in Japan tended to be about 0.5% lower on average than those obtained in Indonesia. This may be attributable to the very rigorous drying conditions applied to the sample during pre-treatment or incomplete drying of the sample in Indonesia.

In respect of Factor b) (difference in test methods), the higher firing temperature in Japan of 50°C over that used in Indonesia and a difference in the quantity of sample between the two institutions may have led to the difference in measurements.

It is considered that Factor c) (difference in test equipment) had little affect due to the equipment being very simple.

Factor d) (difference in researchers) has no effect, since the measurement taken in Indonesia was conducted by members of the survey delegation.

As mentioned above, it may be considered that there is no problem in the measurement of ignition loss and, the use of identical sample pre-treatment and test methods in both institutions, should nullify the difference in measurements.

3) Chemical analysis using an X-ray fluorescence method (Figure 3-3 (2)~(9))

Chemical components measured in both Japan and Indonesia are shown in Table 3-7.

In respect of Factor a) (difference in sample preparation method), the BBK in Indonesia employed a powder method to prepare test pieces, which produced larger variations in their measurements than those obtained by a glass bead method used in Japan. This is explained by the fact that the data obtained by the pulverizing method includes those of particle size and ignition loss, which affect the measurement results.

In respect of Factor b) (difference in test method), the method used in Indonesia is manual, which is likely to cause human error in measurements. The method used in Japan is a fully-automated method using a computer, which seems to avoid any problems.

In respect of Factor c) (difference in test equipment), it is considered that the accuracy of a calibration curve drawn with a standard sample installed in the test equipment, may produce differences in measurements.

Factor d) (skillfulness of researchers) has no significant effect, as in the case of X-ray diffractometry. Examination of its effect on the measurements of each component of SiO_2 , showed no consistent trend in measurement differentials between Japan and Indonesia. It is therefore considered that measurements obtained in Indonesia are reliable.

However, in the measurement of Al_2O_3 , there is a trend in the range of lower content (25% or less) of Al_2O_3 , with measurements obtained in Indonesia being higher and vice versa.

In the measurement of Fe_2O_3 , measurements in the range of 1% or less are relatively compatible, while measurements obtained in Japan tend to be greater in the higher content range. Differences in measurements for CS-2 of clay were particularly high. Re-testing will be necessary to determine which measurements are correct.

In the measurement of TiO_2 , measurements in both institutions showed variations, especially when the content was a trace level of 0.5% or less, and there is a tendency, though not consistent, that in the range of 0.5% or higher, measurements obtained in both institutions agree relatively well.

Measurements of Na_2O in Indonesia were higher in the trace content, while those in Japan were greater in the higher range of content.

Measurements of K_2O concur very well over the whole range of content.

Measurements of CaO and MgO were not subjected to comparison and evaluation due to their lower content, lack of data and trivial importance.

On the whole, measurements in Indonesia showed that the total of CS-2 in clay is well below 100%, and the total of CC of clay is far above 100%. In view of these results, the chemical composition data analyzed in Indonesia can be used only as rough figure. The data can not be used when discussing a small difference such as effect of beneficiation. It is better to replace the X-ray fluorescence analyzer to modern one.

4) Firing coloration

Various types of raw material samples collected were fired in BBK's gas kiln (old type), and the color measured by BBK's new type color difference meter (made by Tokyo Denshoku Technical Center, ERP-80WX) was compared to color data obtained from the same samples fired at Saga Ceramic Research Laboratory in Japan. The results are shown in Table 3-5 and Figures 3-4 (1) - (3). While a strong correlation is identified in the L value between the two sets of color data, no association is observed in the values of a and b.

At the same time, the color of test pieces fired in Japan was measured in Japan and by BBK, and the results were compared. As shown in Table 3-14 and Figures 3-5 (1)

- (9), strong correlation are observed between two data sets in the values of L, a, and b.

Major findings from the above observations are as follows:

- a) There is virtually no difference between color data measured by BBK's color difference meter and that of SCRL.
- b) Firing in BBK's old gas kiln produces a different color from that made by SCRL. The difference comes from different firing conditions (oxidization and reduction), which can be controlled at SCRL's facility, while BBK's gas kiln is unable to vary firing conditions.
- c) While the value of L retains a similar trend in different kilns (different firing conditions) to reflect quality of raw materials, the values of a and b vary with firing conditions. Therefore, when quality of raw materials is evaluated in a firing kiln which cannot control firing conditions accurately, evaluation needs to be done on the basis of the L value alone. To perform detailed quality evaluation including the values of a and b, the kiln must be able to control firing conditions.
- d) In the gas kiln, firing conditions easily vary due to the changes in ratio of the rate of fuel supply to that of air supply, between oxidization and reduction. On the other hand, the electric kiln can maintain the same firing conditions, namely oxidization firing, unless the inside is filled with inactive gas atmosphere. Thus, the electric kiln is suitable for evaluation of firing color of raw materials.
- e) Nevertheless, evaluation based on reduction firing is also important since some impurities contained in a raw material produce color under reduction conditions, and actual ceramic production plants are often operated under reduction conditions. In this case, the gas kiln can be used by installing a fuel/air ratio adjuster and an oxygen concentration meter inside the kiln. If the electric kiln is used, an inactive gas supply source and an oxygen concentration meter will be required.

3.4 Results of the Raw Material Beneficiation Test

3.4.1 Water washing, crushing, and classification tests

3.4.1.1 Test methods

(1) FB-1

- 1) Ore was washed with water and crushed, and the grains obtained were classified into 11 portions ranging from 10 mm to 325 mesh; for the firing coloration test, grains of each grain size portion were fired in a gas kiln at SK7 \pm (about 1,230°C). At the same time, the state of melting was observed.
- 2) To disperse the clay mineral in the ore completely and suppress granulation of mica,

a pot mill with smaller balls was used to crush the ore into 11 different portions of grain size; subsequently, as described in Item 1), the firing coloration test was conducted and the state of melting was observed.

- 3) To suppress granulation of mica, a pot mill with larger balls was used to fine crush ore grains with about 3 ~ 5 mm grain size; the grains were sieved into 5 portions of grain size, a) +120 mesh, b) -120 ~ +200 mesh, c) -200 ~ +325 mesh, d) -325 mesh, and e) mica rich portion of -200 ~ +325 mesh portion obtained by table separation; the same test as that described in Item 1) was conducted.
- 4) To separate silica stone, a pot mill with smaller balls was used to suppress crushing of silica stone; ore grains with the 1 ~ 5 mm grain size range were crushed into -325 mesh grain size. After this, the sedimentation process was used to classify grains into 4 portions, that is, 5 min. sedimented grains, 20 min. sedimented grains, 60 min. sedimented grains, and supernatant fluid suspension; the same test as that described in Item 1) was conducted.
- 5) After ore grains with about 1 ~ 5 mm grain size were preliminarily crushed into grains below 200 mesh size by using a dry pot mill, the preliminarily crushed grains were fine crushed into grains below 325 mesh size by a wet pot mill. The sedimentation process was used to classify grains in the slip into 6 portions, that is, 5 min. sedimented grains, 20 min. sedimented grains, 1 hour sedimented grains, 5 hour sedimented grains, 12 hour sedimented grains, and supernatant fluid suspension; the same test as that described in Item 1) was conducted.
- 6) Ore grains with 3 ~ 5 mm grain size were subjected to acid treatment; a pot mill with larger ball was used to suppress crushing of silica stone and to remove them. After this, the sedimentation process was used to classify the grains into 5 portions, that is, a 325 mesh residue, 5 min. sedimented grains, 30 min. sedimented grains, 2 hour sedimented grains, and supernatant fluid suspension; the same test as that described in Item 1) was conducted.

(2) FB-3

- 1) Ore was washed with water and crushed, and the grains obtained were classified into 7 portions ranging from 19 mm to 230 mesh; for the firing coloration test, grains of each grain size portion were fired in an electric kiln at 1,250°C.
- 2) Ore grains with a grain size range from 1 to 10 mm were fine-crushed in a wet pot mill for 3 hours; to remove mica, grains were sieved to classify them into 6 portions, that is, a) +100 mesh grains, b) -100 ~ +200 mesh grains, c) -200 ~ +325 mesh grains, d) -325 mesh grains, e) -200 ~ +325 mesh grains cleared of the mica rich upper precipitate, f) -325 mesh grains cleared of the mica rich upper precipitate, with all

portions of grain the same test as that described in Item 1) was conducted.

- 3) The -200 ~ +325 mesh grains obtained through the mica removal test described in Item 2) were fine crushed in a wet pot mill for 6 hours; to remove silica stone, the sedimentation process was used to classify grains into 2 portions, that is, less than 20 min. sedimented grains and supernatant fluid suspension; the same test as that described in Item 1) was conducted.
- 4) The -325 mesh grains obtained through the mica removal test described in Item 2) were fine crushed in a wet pot mill for 6 hours; to remove silica stone, the sedimentation process was used to classify grains into 2 portions, that is, 20 min. sedimented grains and supernatant fluid suspension; the same test as that described in Item 1) was conducted.

In addition, some of the test samples used in Items 1), 2), 3), and 4) were chemically analyzed to determine changes in iron contents.

(3) FL-4

- 1) Massive ore was crushed by lightly breaking it up in a mortar to make a sample.
- 2) After adding water to 500 g of sample and stirring it, the supernatant fluid was discarded; sedimented grains were sieved into 3 portions, that is, grains with a size range of 5 - 3.3 mm, those with a size range of 3.3 - 2 mm, and those with -2 mm size.
- 3) After being fired at 1,250°C, the sieved grains of each portion of grain size were subjected to the firing coloration test to measure the whiteness (L value) and the state of melting was observed.
- 4) The sample of -2 mm grain size was subjected to chemical analysis to measure iron contents.

3.4.1.2 Results of the test

(1) Results of the Test on FB-1

The results by grain size of the chemical analysis and material balance of the FB-1 sample after water washing, crushing, and classification are shown in Tables 3-15 through 21, and the results of firing coloration tests in Table 3-22. The conclusions obtained from these results are as follows:

- 1) The whiteness (L value) of the coarse grain portion of the ore with large grain size is not less than 60, while that of the finer portion is as low as 40 - 50%.
- 2) The ore grain size is of coarse grains with size below 14 mm, consisting mainly of grains of 1 - 8 mm size, with fine powder also being included.
- 3) FB-1 is a mixture of white silica stone portions and bluish feldspar portions.

- 4) Since white silica stone contains relatively large grains, it tends to be contained in coarser portions of the ore.
- 5) The bluish feldspar portion consists not simply of feldspar but of cement comprising silica stone, mica, and feldspar. Although the appearance does not indicate the existence of feldspar, sintering the sample reveals the existence of feldspar; the feldspar exhibits the microcrystalline structure characteristic of tuff and differs greatly from pegmatite feldspar.
- 6) FB-1 contains clay and slight contamination by iron oxide is observed.
- 7) It is estimated that the FB-1 sample contains about 50% silica stone, that is, about 10% of white silica stone and about 40% of silica stone in the bluish feldspar.
- 8) A large content of silica stone combined with a smaller alkaline content results in the poor melting characteristic.
- 9) Because the silica stone in the feldspar portion is cemented with feldspar and mica, feldspar and silica stone cannot be completely separated.
- 10) Mica exists not only on the surface of feldspar but also inside, forming veins.
- 11) The white silica stone portion and the feldspar portion consisting of silica and feldspar exhibit good firing coloration.
- 12) Removing mica improves firing coloration.
- 13) Removing silica stone improves melting.
- 14) Because the silica stone removed has good firing coloration, it is very useful.
- 15) Because water washing removes a small amount of clay contents and fine powder mica, firing coloration improves slightly; however, melting characteristics tend to be poor.
- 16) When a pot mill with larger balls is used for crushing, mica is not fine crushed; this enables mica to be removed by the sedimentation process.
- 17) Because silica stone and feldspar are cemented, separating them requires crushing them into considerably fine grains.
- 18) Upgrading the quality of a product requires removing mica first and then silica stone; for this purpose, the stamper crushing is considered suitable.
- 19) Upgrading the quality of a product requires determining the crushing and sedimentation conditions.
- 20) Using a simple facility like a vinyl bag for sedimentation simplifies taking out the precipitation; however, a filter press is necessary to remove water from the supernatant fluid.
- 21) Using a pot mill with smaller balls for crushing prevents mica from becoming fine powder; this measure helps increase the whiteness (L value) of firing coloration by 4 - 5 points; however, the whiteness itself is not sufficient.

- 22) Using a pot mill with larger ball for crushing prevents mica from becoming fine powder; this allows mica to be removed, reducing iron contents to a 0.2% range. As a result, the whiteness (L value) of the portion containing +325 mesh grains exceeds 80% in the firing coloration test, showing a good result; however, a poor melting characteristic poses a problem.
- 23) A pot mill with smaller balls was used to crush the coarser portion (1 - 5 mm) of the ore; this prevents mica from being fine-crushed. The grains obtained by the sedimentation process exhibit good whiteness (L value) exceeding 74%; however, a poor melting characteristic poses a problem. The grains contained in the supernatant fluid obtained through the sedimentation process exhibit whiteness of about 71% with a relatively good melting characteristic.
- 24) The coarser grain portion (1 - 5 mm) of the ore is crushed into grains of not more than 200 mesh size; the grains thus obtained are further fine-crushed by the wet method. The grains thus obtained are subjected to the sedimentation process and the earlier precipitate exhibits whiteness of not less than 74% with a poor melting characteristic. By contrast, precipitate obtained after more than 1 hour's sedimentation process exhibits reduced whiteness of about 60% with a good melting characteristic.
- 25) After the coarse grain portion (3 - 5 mm) of the ore is subjected to the acid treatment, the grains are crushed by a pot mill with larger balls that prevents silica stone from becoming fine powder; the portion consisting of grains that settle within 2 hours 30 minutes in the sedimentation test exhibits whiteness of a 80% range with a poor melting characteristic. By contrast, the grains contained in the supernatant fluid exhibit whiteness of not less than 69% with a relatively good melting characteristic.

(2) Results of the Test on the FB-3 Sample

The results of the water washing, crushing, and classification tests on the FB-3 are shown in Tables 3-23, 24, and 25.

- 1) The whiteness (L value) of about 54% obtained by the firing coloration test conducted on the ore is not good; with the about 1% iron content and about 8.3% alkaline content, the sample cannot be said to be of high quality.
- 2) Removing mica improves firing coloration substantially; in other words, fine crushing 1 - 10 mm ore grains and separating -200 ~ +325 mesh grains and -325 grains, and removing mica from those grains by elutriation reduces the iron content from 1 - 2% to less than 0.3%; at the same time, the whiteness (L value) is increased from 45 - 54% to 67 - 77%.
- 3) The appearance does not always agree with the whiteness (L value) and iron content;

however, it is better to evaluate the results of the beneficiation test by referring the iron content.

- 4) The grinding sedimentation process reduces the alkaline content below that in the ore, promising no quality upgrading effect.
- 5) The results of the observation of the test pieces for the firing coloration test give the impression that crushing, sedimentation, and classification improve the melting characteristic and that the feldspar content has increased; as shown in Tables 3-23 through 25, however, the alkaline content remains about the same. It was found that this difference is due to the difference in grain size. Because silica stone and feldspar are finely cemented in the FB-3 sample, it is considered impossible to separate them by crushing and classification. Because the crushing time is short, it is necessary to lengthen the crushing time and conduct additional tests on the sedimentation process.
- 6) It is possible to reduce iron contents from the 1% range to about 0.3% with relative ease by washing ore, removing the clay content, crushing it into certain grain size, and sieving the grains.
- 7) Beneficiation by crushing and classification requires tests for determining conditions such as the crushing time, crushing method, grain size classification, and the like.
- 8) In reducing the iron content below 0.3%, the classification using sieves leaves part of the mica; this requires the mica removing method to be improved.
- 9) Mica can be removed by putting grains in cylindrical vinyl bags and subjecting them to the sedimentation process. Removing mica increases the whiteness (L value) from 60% to about 67%.
- 10) One of the measures to be examined in the future is to separate mica by applying vibration during the sedimentation process.

The material balance, crushing conditions, and other items in the washing, crushing, and classification tests are shown in Tables 3-23 through 25 by grain size.

(3) FL-4

The results of the water washing, crushing, and classification tests on the FL-4 sample are shown in Table 3-26; from Table 3-26, the following findings were obtained.

- 1) The alkaline content in the FL-4 sample after coarser grains with a grain diameter not less than 2 mm have been removed by the water washing, crushing, and classification tests is 8.41%, only about 1% increase compared with the alkaline content in ore of 7.39%.
- 2) Grains with a diameter of not more than 2 mm have a better melting characteristic than the ore.

- 3) Grains with a diameter of not more than 2 mm have slightly poorer whiteness (L value) than the ore.
- 4) Observation shows that much silica stone exists in the coarse grain portion; however, removing this does not improve the quality.
- 5) Upgrading the FL-4 sample requires other beneficiation methods such as the floatation method.
- 6) Although the FL-4 sample does not contain enough alkalis, it contains a relatively small content of iron and its whiteness is acceptable; therefore, it can be used as a common raw material for pottery; however, mixing and firing conditions require to be examined.

3.4.2 Acid treatment test

3.4.2.1 Test method

(1) Sample

The test raw materials were crushed and washed with water, and sieved into necessary portions of grain size; after drying them at 100°C, they were used as acid treatment test samples. The raw materials subjected to the test were the FN-1, FB-1, and FB-3 samples.

(2) Acid treatment

A 300 cc beaker was used for the acid treatment using hydrochloric acid; the concentration of hydrochloric acid was 20%, the quantity of the samples 60 g, and that of the solution 180 cc; therefore, the solution/sample ratio was 3 cc/g. This solution/sample ratio allowed the entire sample to be soaked in the solution. After the hydrochloric acid solution in the beaker was heated to 50°C, the sample was put into the solution to start the acid treatment; the duration of the treatment was 2 hours. A glass lid was placed on the beaker to prevent the hydrochloric acid solution from evaporating. The sample treated with acid was washed, and placed in a dryer at 100°C for 12 hours to dry.

The FB-1 sample was subjected to the acid treatment test twice; the test flow for the first test is shown in Figures 3-6, and 7; the second test was conducted on the 4 samples, F1, F3, T4, and A4, described in 3.4.1 "Water washing, crushing, and classification tests."

(3) Measurement

Samples before and after being subjected to the acid treatment were crushed below 60

mesh (with fine powder samples left not crushed), formed into disks with a diameter of 30 mm and a thickness of 10 mm; after the disks were fired in an electric kiln or a gas kiln at the specified temperature, they were measured for the whiteness (L value) according to the firing coloration test method.

3.4.2.2 Results of the tests

(1) Results of the tests on the FN-1 sample

To carry out the deironation test on Narawita feldspar, a solution with hydrochloric acid concentration of 20% was used in the preliminary test; the samples were subjected to acid treatment at room temperature for 14 days. The firing coloration was visually measured. Other test conditions are the same as those for the test methods described in Item (1). The results of the acid treatment test are as follows:

Samples were taken from the white and red portions of Narawita feldspar; samples from the white portion were subjected to acid treatment in 15 - 20 mm masses and those from the red portion in 7 - 12 mm masses. When pieces of ore not subjected to the acid treatment were fired in a propane gas kiln at a temperature of 1,250°C, the white portion turned unacceptably gray, while the red portion turned blackish brown, exhibiting very poor firing coloration.

Visual observations conducted after the acid treatment show that the samples even from the red portion with very poor firing coloration, which turned blackish brown, turned white, indicating the possibility of high grade raw materials for high class tableware being obtained. In addition, the findings show that the high porosity of the ore (14%) allowing the acid to permeate inwards and deironate the ore is the cause for the satisfactory deironation effect obtained through the acid treatment of massive samples.

The feasibility of acid treatment of unprocessed massive pieces and the enhanced deironation by heating of the hydrochloric acid solution (60°C) suggest the possibility of utilizing the portion currently discarded and an increase in the usable quantity of ore; on the basis of these prospects, the acid treatment of Narawita feldspar is judged to lead to making it a promising feldspar raw material that provides a great economic effect. The best acid treatment method is to be looked for as a future theme of study.

(2) Results of the test on the FB-1 sample

The results of the test on the deironation effect of the acid treatment on the FB-1 sample are given in Table 3-27 for the 1st test, and in Table 3-22 for the 2nd test.

1) Results of the test on the FB-1 sample (1st test)

- a) The ore for the FB-1 sample was crushed into grains with a diameter of not more than 2 mm and washed; the grains obtained were subjected to acid treatment in the

sequence given in Figure 3-6 by grain size; the firing coloration test was conducted on samples before and after the acid treatment. The results are shown in No. 1 through No. 6 in Table 3-27.

1. The acid treatment of grains with grain size from 2 mm to 80 mesh increased the whiteness (L value) by 4.7% from 67.2% to 71.9%.
2. The acid treatment of grains with grain size from 80 mesh to 325 mesh increased the whiteness (L value) by 13.2% from 52.9% to 66.1%.
3. The ore for the FB-1 sample was crushed into grains with a diameter of not more than 200 mesh without washing; the whiteness of the sample treated with acid was 59.5, an increase of 8.1% over the value obtained before the treatment.

The results described above revealed that, with the ore for the FB-1 sample, the coarser grain portion exhibits greater whiteness than the finer grain portion and that acid treatment of the coarser grain portion makes it possible to change that portion into a raw material with whiteness exceeding 70%.

b) To remove mica, the ore for the FB-1 sample was crushed into grains with grain size of not more than 60 mesh and washed in the sequence in the flow sheet shown in Figure 3-7. Following this, the fine particle portion with grains ranging from 60 mesh to 325 mesh was subjected to the sedimentation process and the acid treatment; samples before and after the acid treatment were subjected to firing coloration tests; the results are shown under No. 7 through No. 11 in Table 3-27.

1. The sample from the grains smaller than 60 mesh into which the ore for the FB-1 sample was crushed exhibited whiteness of 54.2%.
2. The grains obtained by precipitating the 60 - 325 mesh finer grain portion exhibited an increase in whiteness from 60.7 to 61.5% due to the acid treatment; however, the rate of increase was very small.
3. The grains from the overflowing grain size portion, which occurred in the sedimentation process in the test described in the previous Item 2., exhibited a 3.5% increase in whiteness from 54.2 to 57.7% due to the acid treatment.

To summarize the results described above, the ore for the FB-1 sample was crushed into 60 - 325 mesh grains; the grains thus obtained was washed and subjected to the sedimentation process to remove mica; even the acid treatment of those grains could not increase whiteness upward of 57 - 61%, being unable to upgrade the grains to a raw material having satisfactory whiteness.

2) Results of the test on the FB-1 sample (2nd test)

The acid treatment deironation test of Banjarnegara feldspar was conducted on the following 6 portions of grain size; the results obtained from the test are as follows:

As shown in Tables 3-27 and 3-22, subjecting the 1 - 5 mm grains from the FB-1 sample to acid treatment increases the L value, an index of whiteness, from about 60% to about 71 - 73%; in other words, this degree of increased whiteness is not sufficient for a raw material for high grade pottery but is sufficient for a raw material for middle class products.

The acid treatment of the fine powder sample cleared of mica does not promise to increase whiteness; this is judged to be due to the fact that the whiteness has already reached as high as 71% with iron content as low as 0.3% and also to the fact that the fine powder portion is mixed with mica that is difficult to deironate. The acid treatment increases the whiteness by about 10%.

Reduction in the iron content is not confirmed because the test on this item was not conducted.

(3) Results of the test on the FB-3 sample

The acid treatment deironation test of Banjarnegara feldspar (FB-3) was conducted on granulated samples with 1 - 2 mm grain size obtained by water washing and crushing ore; the results are shown in Table 3-23.

Subjecting a granulated FB-3 sample to the acid treatment increased the L value, an index of whiteness, from 72.94% to 79.51%; in addition, the acid treatment enabled the iron content to decrease from 1% to 0.36%. Because of being the results of a single test, definite conclusions cannot be drawn from them; according to the evaluation, however, subjecting granulated Banjarnegara feldspar to acid treatment enables it to be used as a raw material for high grade pottery of which whiteness is required.

Furthermore, it is known that removing mica by subjecting Banjarnegara feldspar to the grain size sieving test improves firing coloration; however, the problem is that the process results in poor melting of grains.

3.4.3 Magnetic deironation test

3.4.3.1 Test methods

(1) Test sample

The test samples were made of a suspension obtained by adding 1 liter of water to 200 - 300g of the sample crushed into grains with a diameter of not more than 150 μ .

(2) Test equipment

A wet high magnetic flux testing unit (WFG type) manufactured by Nihon Magnetic Separation Co. was used as the magnetic separator for the deironation test; the magnetic pole case was filled with 2 kg of iron balls with a diameter of 6.35 mm.

(3) Method and others

- 1) The sample suspension was poured into an ore feeder tank; to prevent the test sample from being precipitated, a stirrer was operated at 500 rpm.
- 2) Using a voltage regulator, the specified current was passed to produce the specified magnetic flux density on the surfaces of the iron balls in the magnetic pole case.

The values for the current and magnetic flux are as follows:

2 Ampere	5,000 gauss
4 Ampere	15,000 gauss
14 Ampere	25,000 gauss

- 3) The gate valve mounted in the lower part of the ore feeder tank was opened to pass the sample suspension through the magnetic pole case at a rate of 0.5 L/min; the deironated sample suspension was recovered in a receiving box.

The Over Flow Type was adopted as the method for passing the suspension through the magnetic pole case.

- 4) The manipulations 1) through 3) were performed once at each of magnetic flux densities of 5,000, 10,000, and 25,000 gauss, three times in total.
- 5) The sample suspension recovered was heated and dried at a temperature below 100°C and weighed as the deironated sample, with its weight being expressed as A(g).
- 6) After the current was switched off, the sample containing magnetic materials sticking to the iron balls in the magnetic pole case was flushed with water to be recovered as the suspension of iron containing deposits in the receiving box.
- 7) The suspension of iron containing deposits was heated and dried at a temperature below 100°C and weighed as the iron-containing deposit sample, with its weight being expressed as B(g).
- 8) The yield of each sample was calculated using the following formula:
Yield of the deironated sample(%) = $A/\text{Weight of the sample} \times 100$
Yield of the iron containing deposit sample(%) = $B/\text{Weight of the sample} \times 100$
- 9) Evaluation was conducted by means of chemical analysis and firing coloration test.

3.4.3.2 Results of the test

The deironation test on the iron content in the raw material by using a magnetic

separator was conducted on 3 types of raw material, namely, Sukabumi clay, Banjarnegara feldspar, and Lampung feldspar. The Sukabumi clay was tested 5 times on deironation conditions and grade difference, with the total number of the tests to which the clay was subjected being 7. Table 3-28 shows the list of the results of the test.

(1) Results of the test on Sukabumi clay

As shown in Table 3-28, changes in deironation conditions did not cause the iron content to be reduced. Increase in the whiteness (L value) was not observed with the CSS sample but approximately 5 points improvement was observed with the CS-1 sample; however, the whiteness of both samples is below 60% in the absolute value, showing they are not suitable as raw materials for white pottery.

These results are considered that the iron in the clay can not be magnetized enough to be adsorbed on magnet balls because it is already oxidized and its particle size is small. It is possible to reduce the loss associated with the deironation test to not more than 15%.

(2) Results of the test on Banjarnegara feldspar

As shown in No. 5 in Table 3-28, the deironation test conducted on FB 1/3 sample by using a magnetic separator caused the iron content to decrease from 1 - 2% to 0.12%. Furthermore, the deironation test enabled the whiteness (L value), tested by the firing coloration test, to improve from 58.7% to 78.9%.

These results support the conclusion that deironation beneficiation improves the whiteness and therefore Banjarnegara feldspar can be used as an auxiliary raw materials for white pottery. To use this feldspar as a main feldspar raw material, some other beneficiation tests should be adopted to increase the alkaline content, because the feldspar contains as low as about 7% alkali.

(3) Results of the test on Lampung feldspar

As shown in No. 7 in Table 3-28, the deironation test conducted on the FB 3/4 sample by using a magnetic separator caused the iron content to decrease from 0.51% to 0.27%; however, the firing coloration test did not show improvement in the whiteness (L value). It is concluded that improving the whiteness requires the iron content to be decreased below 0.2% by the deironation process. For this purpose, reexamination of the deironating conditions or measures for decreasing the iron content and increasing the alkaline content by some other beneficiation test are required.

The absolute value of the whiteness (L value) of the raw material made from the FL 3/4 sample by deironation is about 68%; therefore, this material can be used as an extender for common grade pottery raw materials if it is to be used with other high

alkaline content feldspar raw materials or consideration is given to its mixing quantities.

3.4.4 Elutriation test of clay by water cyclones

3.4.4.1 Testing method

Samples: Five types of the Sukabumi clay (CS-1, CSS, CS 1st grade, CS 2nd grade, and CS red), and one type of the Monterado clay (CM-2), six types in total.

Testing equipment: Super 50, 25 made by Nihon Bunri Gijutsu

Test conditions: Amount of sample - 5kg
Solid concentration - 10%
Type of cyclone - Super-50
Nozzle diameter - 5mm (Sukabumi clay), 3mm (Monterado clay)

Note that the above test conditions are standard ones, and individual parameters (solid concentration, liquid pressure, and nozzle diameter) can be varied to attain the different status of separation.

3.4.4.2 Test results

Table 3-29 lists separation ratio, composition of grain size, chemical composition, and the results of color measurement on separated samples which were molded into pieces and fired under oxidization atmosphere at 1,250°C.

Table 3-30 shows general property data measured on the fired pieces made of various grades of the Sukabumi clay.

3.4.4.3 Evaluation of test results

- (1) Based on data in Tables 3-29 and 3-30, such as grain size, general properties, and color (external appearance), the water cyclone shows a significant effect on separation of sand particles mainly made of clay and quartz.
- (2) However, as seen in CS-1 and CS First Grade, while there is a significant difference in data between the overflow and underflow, except for data obtained from chemical analysis.

Judging from the separating capability of the water cyclone, i.e., unable to separate clay and quartz sand portions completely, there are two causes for this data inconsistency; when the underflow which should primarily consist of quartz sand is small in amount, and clay-based coarse particles enter to result in a higher Al_2O_3 content; or

when operating conditions set for the water cyclone are inappropriate, such as fluid pressure, nozzle diameter, and grain size. In the latter case, operating conditions need to be adjusted to check how the separation results vary.

(3) Generally, it is conceivable that iron compounds (detrimental constituent in ceramic materials) are concentrated in the overflow (mainly consisting of clay). However, an extremely high content of Fe_2O_3 (8.03%) in the underflow of CS-1 suggests that iron compounds such as oxidized iron may be present in the clay as coarse particles.

(4) The Monterado clay can be rated as follows:

- 1) Since the underflow portion mainly containing quartz sand accounts for only 10% of total, and its grain size is small the clay can satisfy quality requirements without further beneficiation.
- 2) The Al_2O_3 content of the crude clay is 36.28% (on a baked basis), indicating that it can be used as a refractory material without further beneficiation.
- 3) Contents of Fe_2O_3 and TiO_2 , considered to be unsuitable for whiteware production, are shown in Table 3-29, which indicates that the beneficiation has caused concentration of these constituents.

Thus, the water cyclone is not suitable for the Monterado clay (CM-2).

(5) To evaluate the separation effect of the water cyclone in terms of product quality, general property tests using the fired pieces are effective in measuring the effects of quartzite and clay, in addition to chemical analysis and grain size analysis.

The measurement results by the color difference meter agree with visual evaluation. While the color difference meter has a major advantage in excluding a risk of subjective judgment and varying results, it is not reliable enough to be used for evaluation of ceramic materials where the fired color is an important element of quality evaluation. It is desirable to supplement it with visual judgment.

3.4.4.4 Indication on detailed data collection and analysis

For the interest of collecting basic data for commercial application, the following points need to be considered:

- (1) To concurrently conduct tests to identify advantages and disadvantages of classification

When the Sukabumi clay is classified by the water cyclone, the clay content increases in the overflow portion, so that plasticity increases, whereas iron and other detrimental

constituents are concentrated and adversely affect firing color. On the other hand, the quartz sand content increases in the underflow portion, plasticity is completely lost, while firing shrinkage becomes zero or positive, and sinterability is poor, so that firing strength decreases considerably and firing color becomes more white.

Simply speaking, separation and beneficiation divide the crude clay into two types of materials in completely different composition.

From users of the Sukabumi clay, this leads to fundamental changes in production conditions, such as the blending ratio of the body, forming and firing. Thus, the classification test using the water cyclone does not produce useful results in the ceramic industries relying on the firing process unless the scope of research is extended to the body blending test.

(2) To improve classified products in grade and use them to maximum extent

Classification by the water cyclone entails a lower product yield due to beneficiation, and cost increase, both of which need to be dealt with.

The former problem should be dealt with by effectively using quartz sand in the underflow. To this end, it is important to develop applications and markets for beneficiated quartz sand and commercialize beneficiation and classification technology which combines the water cyclone with the screening equipment.

The additional cost should be absorbed by enabling the beneficiated clay to be suitable for a higher grade application. For instance, beneficiation of the Sukabumi clay must achieve a quality level that ensures its continuous use as a principal material for pre-mixed bodies of porcelain. In other words, quality improvement falling short of such target does not have any commercial value.

(3) To study actual cases to find out conditions under which clay or kaolin is suitable for treatment by the water cyclone or other washing method

Beneficiation is justified only when quality requirements by the user cannot be met without separating kaolin or fine particles from stone or sand particles such as kaolin or gairone clay. It is not desirable to beneficiate a raw material which quality can be used marginally without beneficiation.

3.4.5 Floatation test

(1) Objective

The objective of conducting beneficiation tests on Banjarnegara and Lampung feldspar is to upgrade the quality of these types of feldspar to that suitable for stable use

in porcelain body or glaze raw materials like high quality Indian feldspar.

To realize this objective, the target values for refining must be alkaline contents ($K_2O + Na_2O$) of 10 - 15% and the Fe_2O_3 content as a harmful coloration component of not more than 0.3%.

In connection with this viewpoint, even the FB 1/3 sample, said to be of relatively good quality among the materials produced in Indonesia, contains $K_2O + Na_2O \doteq 8.5\%$ and $Fe_2O_3 = 1.06\%$ while the FL 3/4 contains $K_2O + Na_2O \doteq 7\%$ and $Fe_2O_3 = 0.35\%$; therefore, there is no other way to concentrate alkaline contents but the floatation method. To increase the separation accuracy and cost effectiveness, the following pretreatments should be combined with the floatation method depending on the properties of ore (degree of weathering, mineral composition, crystal structure, and the like).

- 1) Ore is crushed and sieved into grain size which allows component minerals such as feldspar, silica stone, mica, and iron oxide to be separated as easily as possible.
- 2) Removal of harmful minerals (such as mica and iron oxide contents) by washing
- 3) Fine crushing into grain size suitable for the floatation process

In short, it is important to study pretreatment methods in the first place to grasp efficient floatation conditions. The test conditions and reagents shown in the attached table are items of standard practice; it is necessary to proceed with research work that will increase the separation effect through modifying pretreatment methods, grain size, types of reagent, treatment time, and other factors.

(2) Test Methods

Sample: Banjarnegara feldspar (FB-1, 2, and 3) and Lampung feldspar (FL-3 and 4)

Test machine: Kyoto University Type Flotation Test Machine

Test conditions: See Figure 3-8 and 3-9.

(3) Results of the Test

See Table 3-31.

(4) Evaluation of the Results of the Test

The test using the FB-2 sample is not evaluated because it was conducted as a training session. However, the weight proportions in the 1st and the 2nd floatation, excluding the loss, are as shown in the Table 3-31, not exhibiting large deviations.

The samples subjected to the separating process were checked for their mineral composition through a microscope for further confirmation; the microscopic investigation of the mineral compositions revealed the definite existence of muscovite in the 1st flotation sample, of feldspar in the 2nd flotation overflow sample, and of quartz in the bottom.

The results stated above demonstrated that the test references defined this time were correct.

Of the 3 regular tests conducted this time, the following ones should be provided with special remarks that follow:

- 1) The test case in which the FB-1 and FB-3 samples were used together with the reagents stored by BBK was excluded as producing abnormal values from the evaluation because the material balance was as high as 30.3% after the 1st flotation and as low as 4.6% after the 2nd flotation.
- 2) The test case in which the FB-1 and FB-3 samples were used together with Japanese-made reagents resulted in producing $K_2O + Na_2O \cong 9.8\%$ and a yield of about 27.9%, allowing the conclusion that tolerable results were obtained; however, because the chromaticity obtained is low in the L value, further deironation by modifying pretreatment conditions and the like or enrichment of $K_2O + Na_2O$ should be studied;
- 3) In the test case in which the FL-3 and FL-4 samples were used together with Japanese-made reagents, samples preliminarily deironated by magnetic ferro filters were used, with the effect of deironation shown in the Table 3-31.

On the basis of the figures appearing in the Table 3-31, the effect of deironation as a pretreatment cannot be said to be significant. Regarding the effect of the 2nd flotation, the $K_2O + Na_2O$ content is 6.62% in a deironated sample while the content is 7.54% in the 2nd flotation overflow and iron contents is 0.36% in it; this represents a considerable difference between the target quality and the reality.

Although the yield of 25.1% seems reasonable, it is lower than that of Banjarnegara feldspar as of $K_2O + Na_2O$, because less $K_2O + Na_2O$ is contained. By contrast, the L value of 70.6% is considerably higher than the 39.8% that Banjarnegara feldspar exhibits. As in the case of Banjarnegara feldspar, it is necessary to conduct additional tests with modified pretreatment conditions to explore the possibilities of raising the yield. At the same time, it is considered advisable to subject the 2nd flotation overflow samples both from Lampung and Banjarnegara feldspar to the melting test and evaluate them from various viewpoints including coloration.

Table 3-1 List of Samples of Ceramic Raw Materials Collected for Evaluation

Sample No. ¹⁾	Quarrying Site	Name of Quarrying Company	Remarks	Quantity (kg)
1. Feldspar			Standard feldspar of BBK	
* FLS	Lodoyo	PT. Mica Nic Maduma	(Collected by BBK)	40
O FP	Pangaribuan	Perusahaan Daerah (Kalitengah)	(Collected by BBK)	50
O FB-1	Banjarnegara	-ditto-	(Collected by the Team)	50
# FB-2	-ditto-	-ditto-	(-ditto-)	50
# FB-3	-ditto-	-ditto-	(-ditto-)	50
# FB-4	-ditto-	-ditto-	(-ditto-)	50
# FB-5	-ditto-	-ditto-	(-ditto-)	50
# FB-6	-ditto-	-ditto-	(-ditto-)	50
# FL-1	Lampung	Mr. Agus Sunaryo (Kebon Dalem)	(Collected by BBK)	12
# FL-2	-ditto-	-ditto-	(-ditto-)	6
O FN-1	Narawita	Pusaka Jaya	(Collected by the Team)	50
# FN-2	-ditto-	-ditto-	(-ditto-)	50
FN-3/QN	-ditto-	-ditto-	(-ditto-)	50
# FJ	Jepara	-ditto-	(Collected by BBK)	50
2. Clay				
O CP-1	Parungpanjang	Mr. H. Makmun	(Collected by BBK)	50
# CP-2	-ditto-	-ditto-	(-ditto-)	50
# CP-3	-ditto-	-ditto-	(-ditto-)	50
# CP-4	-ditto-	-ditto-	(-ditto-)	50
# CM	Montrado	PT. Tarumanegara Bumi Yasa	(Collected by BBK)	2
CM-2	-ditto-	(Sent from PT. Sumberaya Kendimasindo)		
* CSS	Sukabumi	Desa Sirmaesmi	(Collected by the Team)	50
# CS-1	-ditto-	-ditto-	(-ditto-)	50
O CS-2	-ditto-	-ditto-	(-ditto-)	50
O CS-3	-ditto-	-ditto-	(-ditto-)	50
O CC	Cipeundeuy	Bumi Kita	(Collected by the Team)	50
3. Kaolin				
* KBS	Belitung		(Collected by BBK)	50
O KB	-ditto-		(Collected by BBK)	50
4. Toseki (China stone)				
TP-1	Pacitan	Mr. Misani (Ds. Karanggade)	(Collected by BBK)	50
TP-2	-ditto-	-ditto-	(-ditto-)	50
TP-3	-ditto-	-ditto-	(Collected by the Team)	20
O TP-4	-ditto-	-ditto-	(-ditto-)	20
5. Quartz				
* QBS	Belitung		(Collected by BBK)	50

Note 1): The samples with mark O are those selected for cross test in Japan. Those with mark # are the samples to be tested for further clarification in Japan. Those with mark * are standard sample of BBK.

Table 3-2 Summary of the 1st Screening Test (1) (Firing Coloration Test)

Sample No.	Color before firing	Color after firing		Remarks
		at 1,000°C (electric kiln)	at 1,250°C (gas kiln) (with mix of Indian feldspar)	
1. Feldspar				
FLS	Light yellow	-	Light black	Melt at 1,250°Cx1hr
FP	Light gray	White	Light gray	
FB-1	Light green-gray	Beige	Light brown	
FB-2	Light green	Beige	Beige	
FB-3	Yellowish gray	-	Beige	
FB-4	Beige	-	Light brown	
FB-5	Light green-gray	-	Beige	
FB-6	Yellowish brown	-	Beige	Melt at 1,250°Cx1hr
FL-1	Beige	Light red	Black	Melt at 1,250°Cx1hr
FL-2	Beige	Light orange	Gray with black spot	
FN-1	White	White	Gray (1)	
FN-2	Yellowish brown	Light orange	Black gray	
FN-3/QN	Yellowish brown	Light orange	Gray (2)	
FJ	Beige	Light red	Black	Melt at 1,250°Cx1hr
2. Clay				
CP-1	Gray	Light orange	Gray (2)	
CP-2	Brown-gray	Light red	Brown	
CP-3	Light red	Light red	Reddish brown	
CP-4	Red	Red	Dark red	
CM	Light gray	-	Gray	
CM-2	Light gray	-	Gray	
CSS	Dark gray	-	Beige	
CS-1	Orange-yellowish brown	Light red	Brown	Yellow-green
CS-2	yellowish brown	Red	Dark red	Dark red
CS-3	Beige	Light orange	Cream	Cream
CC	Light green-gray	Cream	Cream	Gray
3. Kaolin				
KBS	White	-	Cream	QBS (White→Cream)
KB	White	White	Light gray	
4. Toseki (China Stone)				
TP-1	White	White	Cream	Not sinter at 1,000°Cx1hr
TP-2	White	White	Cream	Not sinter at 1,000°Cx1hr
TP-3	Gray	-	Cream	
TP-4	Yellowish Brown	-	Cream	
5. Quartz				
QBS	White	-	Cream	

Table 3-3 Summary of the 1st Screening Test (2) (Mineral Composition Analysis)

Sample No.	Mineral Composition	Remarks
1. Feldspar		
FP	Microcline	Lesser quartz content
FB- 1	Albite, Quartz, Microcline	
FB- 2	Albite, Quartz, Microcline	
FB- 3	Albite, Quartz, Microcline	
FB- 4	Albite, Quartz, Microcline	
FB- 5	Albite, Quartz, Microcline	
FB- 6	Albite, Quartz, Microcline	
FL- 1	Albite, Quartz, Microcline, Cristobalite	
FL- 2	Albite, Quartz, Microcline, Mica	
FN- 1	Sanidine, Tridymite, Cristobalite, Sericite(?)	
FN- 2	Sanidine, Tridymite, Cristobalite	
FN- 3/QN	Sanidine, Tridymite, Cristobalite, Quartz	High SiO ₂ content
FJ	Albite	Lesser quartz content
2. Clay		
CP- 1	Halloysite, Quartz, Montmorillonite, Cristobalite	A little mica content
CP- 2	Halloysite, Quartz, Montmorillonite, Cristobalite	CP- 1 and CP- 2 have almost same quality in X- ray analysis
CP- 3	Halloysite, Quartz, Montmorillonite, Cristobalite	
CP- 4	Halloysite, Quartz	High quartz content
CM		
CS- 1	Kaolinite, Sericite (Mica?), Quartz	
CS- 2	Kaolinite, Sericite (Mica?), Quartz	
CS- 3	Kaolinite, Sericite (Mica?), Quartz	High quartz content
CC	Kaolinite, Cristobalite, Sericite	
3. Kaolin		
KB	Kaolinite	Mica is contained a little
4. Toseki (China Stone)		
TP- 1	Quartz, Sericite, Pyrophyllite	
TP- 2	Quartz, Sericite, Pyrophyllite	TP- 1 and TP- 2 have almost same quality in X- ray analysis
TP- 3	Quartz, Sericite	
TP- 4	Quartz, Sericite	

Table 3-5 Color Data of Test Pieces after Firing

Sample	1,250°C-OF E-Kiln in Japan			1,250°C-RF E-Kiln in Japan			1,300°C-RF G-Kiln in Japan			1,250°C-RF G-Kiln in BBK			Remarks
	L	a	b	L	a	b	L	a	b	L	a	b	
FP	84.3	0.5	4.3	89.9	-0.3	1.0	80.8	-0.7	0.3	64.5	-0.7	0.2	O
FB-1	54.2	9.5	16.9	63.0	-1.4	0.7	61.0	4.0	16.5	58.6	3.2	8.4	O
FB-2										65.4	1.3	8.4	#
FB-3	55.3	9.2	17.7	68.4	-1.2	10.8	62.3	4.9	19.0	70.5	1.3	5.6	#
FB-4	54.6	7.3	16.4	72.1	-1.3	9.5	56.4	13.1	24.3	71.5	0.4	6.3	#
FB-5	51.7	8.0	15.3	70.1	-1.2	9.1	50.1	10.2	24.1	64.6	0.2	9.4	#
FB-6	62.2	6.9	17.7	79.2	-1.7	9.0	69.7	6.1	21.3	59.5	-0.2	8.2	#
FL-1										34.3	0.1	1.0	#
FL-2	63.8	3.6	11.6	72.0	-0.7	7.6	71.1	-0.8	6.6	70.9	0.3	7.1	#
FN-1	79.7	-0.1	13.0	80.4	-0.1	1.0	77.0	-0.9	2.5	65.7	-0.9	4.6	O
FN-2	56.2	5.8	18.7	64.7	-0.6	7.8	56.7	3.4	18.3	49.0	-0.1	3.0	#
FN-3/QN										59.3	-0.3	7.5	#
FJ	32.7	8.6	21.2	19.1	1.5	6.6	26.1	3.1	12.0	25.0	-0.3	-2.6	#
FLS										40.4	0.8	4.0	#
CP-1	72.8	0.2	16.8	60.4	1.7	3.5	56.8	0.3	8.7	61.5	0.1	10.9	O
CP-2	50.3	13.5	15.4	32.1	0.4	2.0	42.9	11.7	11.4	46.7	9.7	13.4	#
CP-3	46.3	14.7	13.6	33.3	0.7	2.9	43.2	7.8	3.8	42.9	7.3	8.2	#
CP-4	46.3	15.0	16.8	30.9	3.0	5.3	38.2	10.5	9.5	39.3	2.8	3.1	#
CM	87.1	0.0	15.0	72.7	1.2	14.1	88.3	0.8	12.7	70.5	0.1	6.2	#
CM-2										66.0	0.1	9.8	#
CSS										60.5	0.6	14.9	#
CSS-A										75.5	-1.0	10.8	#
CSS-B										60.0	0.8	15.1	#
CS-1	48.4	3.4	10.0	40.6	1.3	4.2	43.0	3.9	5.3	50.7	5.0	16.1	#
CS-2	41.3	18.3	20.1	26.7	0.3	-1.2	40.1	3.2	0.0	37.8	3.0	2.3	O
CS-3										80.0	0.7	10.8	#
CC	88.0	0.0	12.5	60.6	1.3	4.6	85.4	2.1	17.1	87.9	0.1	11.7	O
KBS										77.3	0.6	1.9	#
KB	96.9	-0.6	4.4	92.1	0.0	1.6	97.2	-0.7	4.4	96.0	-1.0	8.4	O
QBS										93.6	-0.7	9.6	#
TP-1										87.3	-0.4	10.6	#
TP-2	85.9	1.6	9.6	78.4	0.3	-0.2	83.9	1.7	8.9	84.3	0.0	9.7	#
TP-3										84.7	0.9	10.6	#
TP-4	90.0	1.3	9.4	84.9	0.4	1.6	89.4	1.0	9.4	87.2	0.8	10.6	O

Notes: OF and RF mean firing condition, oxidation and reduction respectively. E-Kiln and G-Kiln mean electric and gas kiln.

The samples marked by O are cross check samples and marked by # are additional samples.

Samples are fired by Taiko Refractory Co. and measured by Saga Ceramic Research Laboratory in Japan, and fired and measured by BBK in Indonesia.

**Table 3-6 Comparison of X-ray Analysis Results
between BBK and Japan**

Sample	Analysis Results	
	in BBK	in Japan
FP	Micro.	Micro., Q., Albi.
FB-1	Albi. Q. Micro. (Sani.)	Q., Albi., Micro., Mica (Zinnwaldite)
FB-2	Albi. Q. Micro. (Sani.)	
FB-3	Albi. Q. Micro. (Sani.)	Q., Albi., Micro., Musco.
FB-4	Albi. Q. Micro. (Sani.)	Q., Albi., Micro.
FB-5	Albi. Q. Micro. (Sani.)	Q., Micro., Musco.
FB-6		Q., Albi., Micro.
FL-1	Albi. Q. Micro. Cris.	
FL-2	Albi. Q. Micro. Mica.	Q., Albi., Micro., Musco.
FN-1	Sani. Tri. Cris. Seri.	Tri., Sani., Cris.
FN-2	Sani. Tri. Cris. Seri.	Sani., Cris., Micro., Tri.
FN-3	Sani. Tri. Cris. Q.	
FJ	Albi.	Sani. Albi.
CP-1	Hall. Q. Mont. Cris.	Q., Kaol. (Hall.), Musco./Seri., Cris., Mont.
CP-2	Hall. Q. Mont. Cris.	Q., Kaol. (Hall.), Cris., Mont.
CP-3	Hall. Q. Mont. Cris.	Q., Cris., Kaol. (Hall), Mont.
CP-4	Hall. Q.	Q., Cris., Kaol. (Hall.)
CM		Q., Kaol. Gibb.
CS-1	Kao. Seri. (Mica), Q.	Q., Musco./Seri., Kaol.
CS-2	Kao. Seri. (Mica), Q.	Q., Musco./Seri., Kaol.
CS-3	Kao. Seri. (Mica), Q.	
CC	Kao. Cris. Seri.	Hall., Cris., Musco./Seri.
KB	Kao.	Kaol. (Kao.), Gibb.
TP-1	Q. Seri. Pyro.	
TP-2	Q. Seri. Pyro.	Q., Musco.
TP-3	Q. Seri.	
TP-4	Q. Seri.	Q. Musco. (Seri.)

Notes: Micro.: Microcline, Albi.: Albite, Q.: Quartz, Cris.: Cristobalite, Tri.: Tridymite
 Sani.: Sanidine, Musco.: Muscovite, Seri.: Sericite, Mont.: Montmorillonite
 Kao.: Kaolinite, Kaol.: Kaolin, Gibb.: Gibbsite, Pyro.: Pyrophyllite

Table 3-7 Chemical Composition Analysis Results

Sample	Chemical Composition																			
	Ignition loss		SiO ₂		Al ₂ O ₃		Fe ₂ O ₃		TiO ₂		CaO		MgO		Na ₂ O		K ₂ O		Total	
	BBK	Japan	BBK	Japan	BBK	Japan	BBK	Japan	BBK	Japan	BBK	Japan	BBK	Japan	BBK	Japan	BBK	Japan	BBK	Japan
FLS	1.15	76.45	11.87	1.11	0.25	0.09	0.02	Tr.	0.09	0.04	0.29	Tr.	0.32	8.95	100.10					
FP	1.27	66.98	20.06	0.09	0.09	19.31	1.90	0.09	0.09	0.04	0.29	0.40	0.54	11.56	100.52	14.05	5.83	100.05	100.00	100.22
FP-3*	3.87	73.42	14.15	0.96	1.00	13.90	1.99	0.07	0.05	0.03	0.33	0.09	3.92	4.34	98.06	4.03				
FB-1	0.96	71.47	16.12	0.96	1.00	13.90	1.99	0.07	0.05	0.03	0.33	0.09	3.92	4.34	98.06	4.03				
FB-2																				
FB-3	1.56	73.28	15.52	1.12	1.12	15.52	1.12	0.08	0.08	0.03	0.04	0.04	3.88	4.80	100.31	4.80				
FB-4	2.76	69.96	17.06	1.46	1.46	17.06	1.46	0.09	0.09	0.07	0.09	0.09	3.21	4.85	99.55	4.85				
FB-5	2.29	75.55	13.84	1.61	1.61	13.84	1.61	0.25	0.25	0.08	0.36	0.36	1.29	5.15	100.42	5.15				
FB-6	2.33	71.08	16.97	0.99	0.99	16.97	0.99	0.09	0.09	0.11	0.12	0.12	3.24	5.07	100.00	5.07				
FL-1																				
FL-2	0.49	74.84	14.65	0.58	0.58	14.65	0.58	0.04	0.04	0.39	Tr.	Tr.	4.77	4.52	100.28	4.52				
FL-3/4*	1.60	77.33	13.51	0.35	0.35	13.51	0.35	0.04	0.04	0.22	0.01	0.01	2.48	4.45	100.01	4.45				
FN-1	2.13	74.63	16.85	0.37	0.40	13.13	0.37	0.27	0.24	0.24	0.28	0.03	0.62	5.01	99.52	4.65	99.86			
FN-2	2.99	75.33	13.67	1.54	1.54	13.67	1.54	0.35	0.35	0.20	0.07	0.07	1.46	4.07	99.68	4.07				
FN-3																				
FJ	1.48	63.30	21.01	1.76	2.15	21.01	1.76	0.08	0.08	0.44	Tr.	Tr.	5.62	6.64	99.72	6.64				
CP-1	9.83	58.59	27.36	1.76	2.06	28.01	1.76	0.76	0.37	0.36	0.44	0.85	0.55	1.87	101.49	2.10	101.49			
CP-2	8.51	56.64	22.86	8.38	8.38	22.86	8.38	0.98	0.98	0.66	1.07	1.07	0.11	0.50	99.71	0.50				
CP-3	8.70	54.91	22.79	10.88	10.88	22.79	10.88	0.89	0.89	0.60	0.91	0.91	0.09	0.72	100.49	0.72				
CP-4	8.25	59.41	17.77	12.72	12.72	17.77	12.72	1.18	1.18	0.18	0.29	0.29	0.04	0.33	100.27	0.33				
CM	11.55	51.39	32.40	1.14	1.14	32.40	1.14	1.29	1.29	0.04	0.23	0.23	0.19	1.28	99.51	1.28				
CM-2*	12.99	51.81	31.57	1.15	1.15	31.57	1.15	1.14	1.14	0.02	0.18	0.18	0.17	0.90	100.01	0.90				
CMK-2*	13.85	48.19	33.89	1.25	1.25	33.89	1.25	1.32	1.32	0.02	0.19	0.19	0.16	1.05	100.01	1.05				
CSS	6.29	69.62	20.23	1.40	1.40	20.23	1.40	0.74	0.74	0.09	0.76	0.76	0.35	2.57	102.05	2.57				
CS-1	6.38	63.62	20.90	4.18	4.18	20.90	4.18	0.89	0.89	0.03	0.69	0.69	0.16	2.74	99.59	2.74				
CS-2	11.84	46.31	23.85	9.84	14.91	23.40	9.84	1.27	0.05	Tr.	0.93	0.22	0.35	0.75	95.18	0.66				
CS-3																				
CC	11.70	63.41	26.91	1.92	2.28	29.66	1.92	1.12	0.06	Tr.	0.62	0.27	0.35	0.07	106.16	0.03				
KBS	13.90	44.17	38.39	0.64	0.64	38.39	0.64	0.22	0.03	0.30	0.30	0.30	0.56	98.77	98.77					
KB	14.80	44.16	38.64	0.63	0.62	39.53	0.63	0.22	0.03	Tr.	0.29	Tr.	0.56	0.54	99.87	0.56				
TP-1																				
TP-2	2.47	75.61	16.35	0.23	0.23	16.35	0.23	0.63	0.63	0.06	0.09	0.09	0.51	3.62	99.57	3.62				
TP-3																				
TP-4	2.09	73.09	19.61	0.09	0.08	12.79	0.09	0.43	0.06	0.04	0.28	Tr.	0.55	3.86	99.91	3.15				
QBS	0.40	96.41	2.72	0.09	0.19	2.72	0.09	0.29	0.46	0.31	101.23									

Note: The samples marked by * are analyzed by Taiko refractory Co. in Japan, and the other samples are by BBK and SCRUL in Japan.

Table 3-8 Particle Size Distribution of Clays

Sample	Particle Size (μ)												
	1	2	3	5	7	10	15	20	25	30	44		
CP-1	63.3	76.0	81.6	89.8	92.2	95.0	97.5	98.9	99.7	99.8	99.9		
CP-2	71.3	82.1	87.5	92.1	92.9	93.8	95.7	97.3	98.5	99.2	99.7		
CP-3	68.5	79.4	85.4	91.6	92.8	95.0	97.2	98.6	99.4	99.8	99.8		
CP-4	58.3	65.4	67.6	73.7	75.2	78.0	82.2	86.0	89.0	91.3	95.7		
CM	65.3	75.3	79.9	86.5	88.9	89.6	91.4	93.0	94.4	95.8	98.3		
CS-1	58.5	71.4	76.2	85.1	88.7	92.2	95.2	96.7	97.6	98.5	99.5		
CS-2	61.0	68.1	69.7	76.8	79.2	82.1	85.5	88.0	90.1	91.7	95.4		
CC	23.9	30.3	35.1	41.2	46.0	52.4	58.3	63.0	66.0	68.5	75.6		
KB	35.7	42.0	49.4	63.0	74.7	87.2	94.2	96.3	97.0	97.3	97.8		

Note: Specific gravity of clay are fixed as 2.6, measured by SCRL.

Table 3-9 Results on Dispersivity and Viscosity Evaluation of Clay Samples

1. All the samples can be dispersed by adding appropriate quantity of water and water glass for individual sample clay. Water and water glass consumption to obtain good dispersiveness are different because of clay characteristics.
2. CS- 1 and CSS, KB and KBS, and CM and CM- 2 are almost same in dispersiveness and viscosity
3. Water glass solution should be diluted from 25% to 5% to obtain more accurate data of its net consumption in this test.
4. It is possible to carry on the slip making of all the sample clays for wall thickening test and drying shrinkage & strength test.

Test No.	D1	D2	D3	D4	D5	D6*	D7	D8*	D9*	D10*	D11*
Sample	CP-1	CP-2	CP-3	CS-1	CS-2	CSS	CM	CC	KB	KBS	CM-2
Water required for getting good dispersivity	215.8	218.5	285.0	210.0	285.0	210.0	210.0	235.0	210.0	235.0	232.0
Quantity	43.2	43.7	57.0	42.0	57.0	42.0	42.0	47.0	42.0	47.0	46.4
Quantity (cc)	2	3.5	2.5	2.0	6.0	5.0	1.0	2.5	2.0	2.0	2.0
good dispersivity	0.100	0.175	0.125	0.100	0.300	0.250	0.050	0.125	0.100	0.100	0.100
Sec/100cc	53	95	36	44	13	70	22	27	31	26	26
Density	348.5	345.0	329.0	351.8	322.5	347.5	353.9	329.2	347.9	337.8	339.6
Evaluation result on dispersivity of the sample clay	0	0	0	0	0	0	0	0	0	0	0

Note: * marked samples are prepared with mix of 200 mesh quartz sand

Clay slurry preparation condition: Mixing quantity of the sample: clay: 125g
 quartz powder (325 mesh): 375g
 initial water: 210cc
 Water glass solution: concentration: 25g/100cc

Table 3-10 Wall Thickening Test Result

Test No.	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 9	No. 7	No. 10	No. 11	No. 12	No. 8
Clay sample	C.S.S	KB	CS-1	CM 2	CP-1	CS-1W	CS-1/CP-1 (=1/2)	CM-K2	KB/CM-2 (=1/1)	Kijara Condong Slip	Kijara Condong Plastic	Malang
Weight of mixture	5,000	5,000	5,000	6,000	5,000	5,000	4,000	6,000	4,600	2,000	4,000	4,000
Water	44	42	45	43	50	45	44	41	37	53	55	55
Water glass required	0.465	0.275	0.325	0.208	0.560	0.325	0.357	0.229	0.190	1.000	0.394	0.394
Slip temperature	27	25	23	26	25	24	26	25	27	25	24	24
Concentration	342	342	342	342	333	342	342	350	358	333	332	332
Viscosity	54	60	63	46	59	48	56	54	44	47	57	57
Viscosity after 30min.	78	90	77	87	82	51	75	114	111	101	59	59
Particle size under 10 μ	47	43	53	75	62	64	64	66	70	61	46	46
Wall thickness 20min (20/30min)	6	8	4	6	3	4/4	3/4	3/4	3/4	x / x	5/6	4/5
Water content 20min (20/30min)	22	22	22	21	22	20/20	20/20	19/19	18/18	-	25/25	21/22
Dry shrinkage	2.0	2.5	2.5	3.5	4.0	2.5	3.0	3.0	3.75	-	-	2.5
Dry strength	15.2	13.6	19.4	19.5	29.0	24.5	16.8	14.0	17.5	-	-	18.0
Cast article condition	soft	soft	soft	Good	Good	Good	Good	a little hard	Good	too soft	soft	Good
Firing shrinkage	9.75	9.75	10.5	8	8.75	9.5	9.5	6.75	6.0	-	-	8.5
Firing strength	535	476	575	390	547	575	536	462	377	-	-	520
Bending test	24.5	30.5	25.5	12.0	22.5	20.0	22.0	13.0	9.0	-	-	17.0
Water absorption (ink test)												
for firing shrinkage test piece	22.0	26.0	3.5	42.5	11.5	4.0	16.5	44.0	31.0	-	-	40.0
for bending test piece	20.0	25.0	2.5	36.0	8.5	3.0	7.0	37.0	26.0	-	-	31.0
Firing coloration	70.6	75.0	63.3	84.1	71.6	65.5	66.8	85.4	83.1	-	-	78.2
a	1.5	1.0	1.4	1.1	1.2	0.6	1.4	0.7	0.8	-	-	1.6
b	14.3	14.1	14.4	13.5	14.3	14.2	15.0	12.6	14.9	-	-	13.9
Over all evaluation result	3	2	2	1	3							
in order												

Notes: Body composition: FLS = 30%, CSS (Clay to be tested) = 20%, KBS (KB) = 30%, QBS = 20%. x means not to be able to obtain a casting article.

**Table 3-11 Chemical Composition of Sample Mixture Calculated from Mixing Ratio
and Analysis Result of Material Component**

Sample No.	Ig loss	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	CuO	MgO	Na ₂ O	K ₂ O	Total	Total alkali
No.1 (CSS)	5.84	69.40	19.65	0.81	0.30	0.07	0.33	0.23	3.41	100.04	3.86
No.2 (KB)	6.11	69.38	19.13	0.80	0.34	0.07	0.32	0.23	3.41	100.39	3.87
No.3 (CS-1)	5.86	68.20	19.79	1.36	0.33	0.07	0.31	0.19	3.44	99.55	3.85
No.4 (CM-2)	7.18	65.84	21.92	0.76	0.38	0.06	0.21	0.19	3.08	99.62	3.51
No.5 (CP-1)	6.55	67.19	21.08	0.88	0.29	0.13	0.26	0.27	3.27	99.92	3.75
No.6 (CS-1W)	0.00	71.13	22.31					0.28	3.46		
No.7 (CM-K2)	7.36	65.11	22.38	0.78	0.42	0.06	0.21	0.19	3.11	99.62	3.55
No.8 (Malang)	0.00	70.28	24.15					0.20	3.35		
No.9 (CS-1/CP1)	6.03	67.94	20.07	1.23	0.32	0.06	0.30	0.18	3.40	99.53	3.80
No.10 (KB/CM-2)	6.99	67.35	20.55	0.86	0.56	0.05	0.18	0.19	3.15	99.88	3.58
	0.00	72.41	22.09					0.20	3.38		

Notes : 1) The data below in each column are the data when Ig. loss are deleted

2) The data for No.6 and 8 samples are to be excluded due to lack of analysis data.

Table 3-12 Al₂O₃, SiO₂ and Total Alkali (Na₂O+K₂O) Calculated from Mixing Ratio and Analysis Result of Sample Mixture

Sample No.	Clay sample	Al ₂ O ₃ %	SiO ₂ %	Na ₂ O + K ₂ O %	Sintered condition of fired pieces*1	Ink test (mm)		Bending test mm
						Bending test piece	Shrinkage test: piece	
6	CS-1W				A	3.0	4.0	20.0
1	CSS	20.86	73.70	3.86	A	20.0	22.0	24.5
2	KB	21.01	73.88	3.87	A	25.0	26.0	30.5
3	CS-1	21.02	72.44	3.85	A	2.5	3.5	25.5
9	CS-1/CP-1	21.35	72.29	3.80	B	7.0	16.5	22.0
5	CP-1	22.31	71.13	3.75	B	8.5	11.5	22.5
10	KB/CM-2	22.09	72.41	3.58	C	26.0	31.0	9.0
4	CM-2	23.61	70.93	3.51	D	36.0	42.5	12.0
7	CM-K2	24.15	70.28	3.55	D	37.0	44.0	13.0
8	Malang				D	31.0	40.0	17.0

Note: *1 A is the best and D is the worst in sintering. B and C are the middle in order.

Figure 1 Ink Test vs Total Alkali

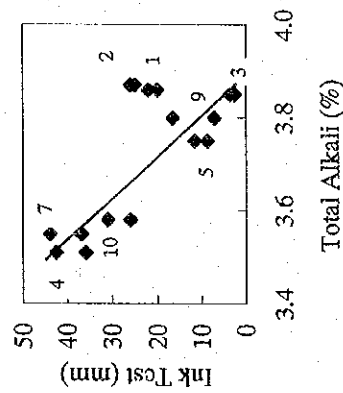


Figure 2 Ink Test vs Shrinkage

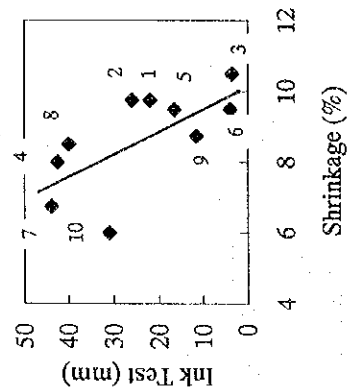


Figure 3 Ink Test vs Bending Test

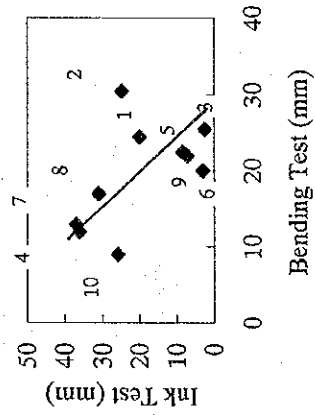


Table 3-13 Analysis Results on Particle Size Distribution of Clay

Sample Particle size μ	KB				CC				CM				CS-1				CS-2				
	Volume base		Area base		Volume base		Area base		Volume base		Area base		Volume base		Area base		Volume base		Area base		
	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	
20.00-<	33.9	100	2.9	100	16.7	100	0	100	-	-	-	-	-	-	-	-	-	-	-	-	-
20.00-19.00	0	66.1	0	97.1	0	83.3	0	100	-	-	-	-	-	-	-	-	-	-	-	-	-
19.00-18.00	0	66.1	0.6	97.1	0	83.3	0	100	-	-	-	-	-	-	-	-	-	-	-	-	-
18.00-17.00	0	66.1	0	96.5	0	83.3	0	100	-	-	-	-	-	-	-	-	-	-	-	-	-
17.00-16.00	0	66.1	0.5	96.5	0	83.3	0	100	-	-	-	-	-	-	-	-	-	-	-	-	-
16.00-15.00	0	66.1	0	96	0	83.3	0.1	100	-	-	-	-	-	-	-	-	-	-	-	-	-
15.00-14.00	0	66.1	0.2	96	0	83.3	0.5	99.9	-	-	-	-	-	-	-	-	-	-	-	-	-
14.00-13.00	0	66.1	0.3	95.8	0	83.3	0.7	99.4	-	-	-	-	-	-	-	-	-	-	-	-	-
13.00-12.00	0	66.1	0.2	95.5	4	83.3	0.6	98.7	-	-	-	-	-	-	-	-	-	-	-	-	-
12.00-11.00	6.9	66.1	0.2	95.3	7	79.3	0.9	98.1	-	-	-	-	-	-	-	-	-	-	-	-	-
11.00-10.00	2.7	59.2	0.5	95.1	7.1	72.3	0.1	97.2	-	-	-	-	-	-	-	-	-	-	-	-	-
10.00-<	43.5	-	5.4	-	34.8	-	2.9	-	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
10.00-9.00	1.7	56.5	2.6	94.6	7.0	65.2	0.0	97.1	11.8	100.0	0.8	100.0	6.0	100.0	1.1	100.0	2.7	100.0	0.0	100.0	1.1
9.00-8.00	2.2	54.8	1.2	92.0	2.1	58.2	0.8	97.1	11.4	89.0	2.4	99.2	5.9	94.0	1.6	98.9	9.8	97.3	9.8	98.9	0.7
8.00-7.00	6.2	52.6	3.7	90.8	3.8	56.1	1.5	96.3	7.1	77.6	1.2	96.8	6.0	88.1	1.0	97.3	9.4	87.5	9.4	87.5	1.0
7.00-6.00	4.3	46.4	0.8	87.1	5.4	52.3	1.5	94.8	4.5	70.5	0.5	95.6	4.9	82.1	1.7	96.3	7.0	78.1	7.0	78.1	1.0
6.00-5.00	6.5	42.1	0.0	86.3	4.7	46.9	2.2	93.3	3.4	66.0	1.5	93.6	5.1	77.2	1.6	94.6	4.7	71.1	5.1	71.1	0.8
5.00-4.00	2.5	35.6	1.0	86.3	5.0	42.2	3.3	91.1	4.7	62.6	2.0	93.6	9.3	72.1	1.8	93.0	6.0	66.4	6.0	66.4	0.9
4.00-3.00	8.0	33.1	4.5	85.3	8.0	37.2	6.0	87.8	5.8	57.9	1.6	91.6	14.8	52.9	3.6	91.2	9.7	60.4	9.7	60.4	2.0
3.00-2.00	8.4	25.1	8.4	80.8	10.8	29.2	8.0	81.8	10.6	52.1	5.2	90.0	22.8	38.1	7.6	87.6	14.6	50.7	14.6	50.7	7.2
2.00-1.00	9.6	16.7	18.1	72.4	12.5	18.4	24.1	73.8	19.9	41.5	18.3	84.8	15.3	15.3	27.1	80.0	16.3	36.1	16.3	36.1	18.6
1.00->	7.1	7.1	54.3	54.3	5.9	6.75	49.7	49.7	21.6	21.6	66.5	66.5	2.81	2.81	52.9	52.9	19.8	19.8	19.8	19.8	66.7
Center of size	7.58	7.58	0.92	1.01	6.75	6.75	1.01	1.01	2.80	2.80	0.75	0.75	2.81	2.81	0.95	0.95	2.95	2.95	2.95	2.95	0.75
D-median	2.96	2.96	1.06	0.78	2.17	2.17	0.78	0.78	2.49	2.49	0.83	0.83	2.56	2.56	0.70	0.70	0.85	0.85	0.85	0.85	0.71

Sample Particle size μ	CP-1				CP-2				CP-3				CP-4				CM-K1				CM-K2				CM-K3			
	Volume base		Area base		Volume base		Area base		Volume base		Area base		Volume base		Area base		Volume base		Area base		Volume base		Area base		Volume base		Area base	
	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)	F(%)	U(%)		
10.00-<	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0
10.00-9.00	7.3	100.0	1.7	100.0	9.8	100.0	0.9	100.0	9.7	100.0	1.0	100.0	4.2	100.0	0.0	100.0	4.2	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0
9.00-8.00	8.1	92.7	1.6	98.3	4.6	90.2	1.3	99.1	5.8	90.3	1.0	99.0	6.2	95.8	0.0	100.0	6.2	95.8	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0
8.00-7.00	5.0	84.6	0.8	96.7	2.7	85.6	1.1	97.8	6.0	84.5	1.1	98.0	8.8	89.6	0.0	100.0	8.8	89.6	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0
7.00-6.00	7.4	79.6	1.8	95.9	4.2	82.9	0.0	96.7	3.6	78.5	1.3	96.9	5.5	80.8	0.7	100.0	5.5	80.8	0.7	100.0	1.0	0.5	0.6	0.6	0.6	0.6	0.6	0.6
6.00-5.00	4.4	72.2	2.1	94.1	4.6	78.7	0.8	96.7	5.9	74.9	0.6	95.6	5.6	75.3	1.1	99.3	5.6	75.3	1.1	99.3	1.0	0.4	1.0	1.0	1.0	1.0	1.0	1.0
5.00-4.00	7.2	67.8	2.6	92.0	6.3	74.1	1.8	95.9	4.9	69.0	2.5	95.0	7.0	69.7	1.7	98.2	7.0	69.7	1.7	98.2	1.2	0.9	3.1	3.1	3.1	3.1	3.1	3.1
4.00-3.00	9.9	60.6	4.4	89.4	8.8	67.8	5.9	94.1	8.2	64.1	3.3	92.5	8.4	62.7	2.7	96.5	8.4	62.7	2.7	96.5	4.0	3.1	5.1	5.1	5.1	5.1	5.1	5.1
3.00-2.00	14.8	50.7	9.0	85.0	10.9	59.0	6.1	88.2	11.5	55.9	8.9	89.2	9.7	54.3	4.1	93.8	9.7	54.3	4.1	93.8	4.8	4.7	7.7	7.7	7.7	7.7	7.7	
2.00-1.00	21.9	35.9	27.6	76.0	24.0	48.1	18.6	82.1	24.0	44.4	20.2	80.3	21.2	44.6	17.7	89.7	21.2	44.6	17.7	89.7	23.2	16.4	26.2	26.2	26.2	26.2	26.2	
1.00->	14.0	14.0	48.4	48.4	24.1	24.1	63.5	63.5	20.4	20.4	60.1	60.1	23.4	23.4	72.0	72.0	23.4	23.4	72.0	23.4	58.8	70.3	50.7	50.7	50.7	50.7	50.7	
D-median	2.96	2.96	1.06	0.78	2.17	2.17	0.78	0.78	2.49	2.49	0.83	0.83	2.56	2.56	0.70	0.70	0.85	0.85	0.85	0.85	0.71	0.71	0.99	0.99	0.99	0.99	0.99	0.99

Notes: F: Distribution
U: Accumulation
Measured by BBK

Table 3-14 Color Meter Comparison between SCRL and BBK

Sample	1,250°C-OF E-Kiln						1,250°C-RF E-Kiln						1,300°C-RF G-Kiln					
	L		a		b		L		a		b		L		a		b	
	SCRL	BBK	SCRL	BBK	SCRL	BBK	SCRL	BBK	SCRL	BBK	SCRL	BBK	SCRL	BBK	SCRL	BBK	SCRL	BBK
FP	84.3	82.8	0.5	0.1	4.3	4.5	89.9	87.7	-0.3	-0.3	1.0	2.2	80.8	70.1	-0.7	-0.6	0.3	1.1
FN-1	79.7	78.1	-0.1	0.0	13.0	12.4	80.4	79.1	-0.1	-0.3	1.0	2.4	77.0	73.8	-0.9	-1.0	2.5	2.9
FN-2	56.2	55.4	5.8	6.1	18.7	17.6	64.7	65.5	-0.6	-0.5	7.8	7.1	56.7	58.2	3.4	3.3	18.3	16.6
FB-1	54.2	55.5	9.5	8.9	16.9	14.8	63.0	64.0	-1.4	-1.3	0.7	1.9	61.0	60.0	4.0	4.3	16.5	15.9
FB-3	55.3	58.9	9.2	7.2	17.7	14.1	68.4	69.9	-1.2	-0.8	10.8	9.3	62.3	65.3	4.9	4.4	19.0	15.2
FB-4	54.6	53.6	7.3	7.5	16.4	15.5	72.1	70.9	-1.3	-1.0	9.5	9.8	56.4	58.9	13.1	10.3	24.3	17.0
FB-5	51.7	56.4	8.0	6.9	15.3	15.2	70.1	69.7	-1.2	-0.8	9.1	9.3	50.1	52.5	10.2	7.8	24.1	13.9
FB-6	62.2	60.5	6.9	6.6	17.7	15.7	79.2	77.3	-1.7	-1.3	9.0	9.9	69.7	70.6	6.1	5.8	21.3	19.0
FJ	32.7	37.6	8.6	7.2	21.2	14.6	19.1	15.1	1.5	0.5	6.6	10.4	26.1	55.2	3.1	3.4	12.0	11.1
FL-2	63.8	64.6	3.6	3.4	11.6	10.5	72.0	70.3	-0.7	-0.4	7.6	7.6	71.1	68.6	-0.8	0.0	6.6	7.2
TP-4	85.9	87.7	1.3	1.3	9.4	10.6	84.9	84.7	0.4	0.2	1.6	3.2	89.4	87.7	1.7	0.8	9.4	10.3
KB	96.9	98.2	-0.6	-0.6	4.4	6.3	92.1	90.7	0.0	-0.1	1.6	3.1	97.2	96.5	-0.7	-0.5	4.4	6.6
CC	88.0	87.2	0.0	0.2	12.5	14.5	60.6	62.3	1.3	1.2	4.6	5.5	85.4	85.0	2.1	2.8	17.1	18.2
CM	87.1	90.7	0.0	0.3	15.0	13.6	72.7	71.1	1.2	0.8	14.1	15.4	88.3	89.9	0.8	0.4	12.7	14.1
CS-1	48.4	49.9	3.4	2.8	10.0	9.2	40.6	45.3	1.3	1.0	4.2	4.1	43.0	49.9	3.9	3.6	5.3	5.2
CS-2	41.3	42.0	18.3	17.3	20.1	16.6	26.7	30.2	0.3	0.9	-1.2	0.6	40.1	38.8	3.2	3.6	0.0	1.1
CP-1	72.8	72.5	0.2	0.9	16.8	17.7	60.4	60.0	1.7	1.5	3.5	4.6	56.8	58.5	0.3	0.5	8.7	9.6
CP-2	50.3	44.0	13.5	9.6	15.4	9.3	32.1	33.2	0.4	0.2	2.0	3.3	42.9	41.6	11.7	12.3	11.4	12.7
CP-3	46.3	42.3	14.7	8.1	13.6	8.3	33.3	33.8	0.7	0.8	2.9	4.2	43.2	44.2	7.8	6.2	3.8	2.8
CP-4	46.3	46.5	15.0	15.1	16.8	15.1	30.9	33.7	3.0	3.2	5.3	6.1	38.2	38.0	10.5	9.8	9.5	8.2
TP-2	90.0	84.4	1.6	1.5	9.6	9.3	78.4	78.5	0.3	0.1	-0.2	0.8	83.9	86.5	1.7	1.5	8.9	10.1

**Table 3-15 Chemical Composition Analysis Result (X-ray fluorescence spectrometer)
of Upgrading Test Sample for Banjarnegara Feldspar**

Sample No.	Ig. loss	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	MnO	CaO	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	Cr ₂ O ₃	ZrO ₂	Total
1	FB-1	Original	1.15	79.07	11.76	0.71	0.06	0.02	0.05	3.44	3.69	0.01	0.02	100.01
2	F-3	5-3 mm	0.47	82.66	9.97	0.43	0.04	0.01	0.03	3.08	3.27	tr	0.01	99.99
3	F-1	2-1 mm	0.51	80.21	11.33	0.48	0.04	0.01	0.03	3.59	3.96	tr	0.02	100.01
4	F-325	#60-325	1.67	69.07	17.56	1.85	0.09	0.05	0.20	5.00	4.41	tr	0.03	100.00
5	T-3	3-1 mm	0.20	83.51	9.44	0.21	0.02	tr	tr	3.26	3.35	tr	0.01	100.00
6	T-4	-325	0.42	82.54	10.15	0.37	0.04	0.01	0.01	3.23	3.20	tr	0.01	100.01
7	FT-1	FT-1	2.29	72.98	15.37	1.26	0.11	0.02	0.13	3.08	4.67	0.01	0.01	99.99
8	FT-2	De-iron	1.83	74.49	14.55	0.92	0.09	0.01	0.09	3.31	4.61	0.01	0.02	100.01
Reference	MF-100	Standard	1.08	72.05	16.09	0.25	0.01	-	0.03	1.79	8.63	-	-	100.11
	MF T	Special	0.96	66.32	18.59	0.07	tr	-	0.04	10.76	-	-	-	100.06

Notes: FP (Fundamental Parameter) method using glass bead

Research Institute of Technical Division, Taiko Refractory Co. (Registered No. H. 8-1)

Table 3-16 Particle-size Distribution and Property of Feldspar
(Classification by washing in water)

Test No.	Size	Silica (g)	Feldspar (g)	Sub total (g)	Ratio (%)	Silica (%)	Firing coloration	Sintering condition	SiO ₂	Fe ₂ O ₃	K ₂ O	L value
FB 1 Raw ore							×	△	79.07	0.71	7.13	
F 10	+10mm	1.6	3.2	4.8	0.3	33.0						
F 8	+8mm	9.5	26.7	36.2	2.4	26.2						
F 5	+5mm	34.5	263.0	297.5	19.8	11.6	▲	▲				
F 3	+3mm	38.1	362.0	400.1	26.7	9.5	▲	▲	82.66	0.43	6.35	
F 2	+2mm	6.5	91.0	97.5	6.7	6.5	▲	▲				
F 1	+1mm			325.0	21.7		▲	▲	80.21	0.48	7.35	
Sub total				1,161.1	77.4							
F 80	+60mesh			102.0	6.8		×	◎				
F 325	+325mesh			140.0	9.3		×	◎	69.07	1.85	9.41	
F -325	-325mesh			30.0	2.0		×	▲				
Loss				66.9	4.4							
Total				1,500.0	100.0							

Notes: 1) Firing coloration and sintering condition judged on the basis of MF100 are indicated as follows:
better ◎, Same ○, a little worse △, worse ▲, much worse ×

			SiO ₂	Fe ₂ O ₃	Na ₂ O	K ₂ O	Na ₂ O + K ₂ O
MF100	MASADA Feldspar	10mm	72.05	0.25	1.79	8.63	10.42
MF T	MASADA Feldspar	prime quality	66.32	0.07	3.26	10.76	14.02

- Silica shows a good firing coloration, which is much whiter than that of Belitung silica sand.
- Feldspar is not a simple substance but a combination of silica, mica and feldspar. Feldspar itself, however, is difficult to identify. When the feldspar is fired, silica and feldspar become apparent, though the reddish brown color of mica is more conspicuous. Mica exists not only on the surface but also inside the ore in a vein-like formation. Firing coloration of silica and feldspar are good.

Table 3-17 Mica Elimination Test

(Prevent to pulverize mica into fine powder by using small ball)

Test No.	Size	Silica (g)	Feldspar (g)	Sub total (g)	Ratio (%)	Silica (%)	Firing coloration	Sintering condition	L value
FB 1 Raw ore							×	△	
F ₂ 10	+10mm	2.1	-	2.1	0.2	100.0			
F ₂ 8	+8mm	7.0	8.6	15.6	1.5	44.9			
F ₂ 5	+5mm	11.8	86.0	97.8	9.8	12.1	▲	▲	
F ₂ 3	+3mm	14.4	112.0	126.4	12.6	11.3	▲	▲	
F ₂ 2	+2mm	3.4	29.1	32.5	3.3	10.5	▲	▲	
F ₂ 1	+1mm			80.0	8.0				
Sub total				354.4	35.4				
F ₂ 80	+80days/inch			7.3	0.7		×	⊙	
F ₂ 120	+120days/inch			40.0	4.0		×	⊙	
F ₂ 200	+200days/inch			135.0	13.5		×	⊙	
F ₂ 325	+325mesh			190.0	19.0		▲	⊙	
F ₂ -325	-325mesh			170.0	17.0		▲	⊙	
Sub total				542.3	54.2				
Loss				103.3	10.3				
Total				1,000.0	100.0				

Notes: 1) Preparation conditions

Raw ore FB-1 (not washed in water)...2kg pot, Amount pulverized: 1,000g

Spherulite stones: small 10-25g, Standard 10-100g, water 65% = 650cc

Pulverization time 30 minutes

2) 80-200 days/inch makes it possible to remove mica, but is not enough.

3) Many coarse-granules are left over.

Table 3-18 Mica Elimination Test

(Prevent to pulverize mica into fine powder using large ball)

Test No.	Particle Size	Quantity (g)	Ratio (%)	Firing coloration	Sintering condition	SiO ₂	Fe ₂ O ₃	Na ₂ O K ₂ O
F 3 Original				▲	▲	82.66	0.43	6.35
T-1	+120days/inch	1.7	0.6	×	×			
T-2	+200days/inch	10.9	23.6	×	○			
T-3W	T-3 (Mica)	11.5	3.8	×	×			
Sub total		24.1	28.0					
T-3	+325mesh	80.0	26.7	◎	×	83.51	0.21	6.61
T-4	-325mesh	178.0	59.3	△	×	82.54	0.37	6.43
Sub total		258.0	86.0					
Loss		17.9	6.0					
Total		300.0	100.0					

Notes: 1) Eliminate mica from T-3 by the same method as collecting gold sand. The mica over 325mesh size could be eliminated with table separation method.

2) Milling condition

Original material: F1 109g, F3 191g, Total 300g

Pot mill: 500g Ball: 105~175g/ball = 670g (normally 10~50g)/ball

Water: 70% Milling time: 3 hours

3) Mica seems to be almost eliminated, because iron content in test sample becomes around 2%.

Table 3-19 Silica Elimination Test

(Prevent to pulverize silica into fine powder by using small ball)

Test No.	Sedimentation condition	Quantity (g)	Ratio (%)	Firing coloration	Sintering condition	L value	Preparation conditions
F1~F5 Raw ore				×	×		1) Raw ore F2-1, F, F2-2
A-0	325mesh residuum	80.0	2.0	-	-		2) Small number of spherulite stones (10-0-25)
A-1	Sedimentation within 5 min	40.0	10.0	◎	×		3) Preparation amount 400g
A-2	Sedimentation within additional 20 min	112.0	28.0	◎	×		4) Water 65% - 260cc
A-3	Sedimentation within additional 1 hour	45.0	11.2	◎	△		5) A-0 +325mesh residuum (coarse grain and mica) after 6.5 hours of pulverization
A-4	Supernatant liquid	195.0	48.8	○	○		6) Twice as much water of 800°C was added to fractionate the sedimentation after additional 30 hours of pulverization
Total		400.0	100.0				

Table 3-20 Wet Milling after Preparatory Dry Milling (200mesh)

Test No.	Sedimentation condition	Quantity (g)	Ratio (%)	Firing coloration	Sintering condition	L value	Preparation conditions
F1~F5 Raw ore in powder				×	×		1) Raw ore F1~F5 Test powder to be fired (dry pulverization-200mesh) 2) Standard spherulite (10-50g) 3) Water 70% 4) Pulverization time 15 hours 5) After pulverization, add 800cc of water to fractionate the sedimentation
E 1	325mesh residuum	0.1	0.0	-	-		
E 2	Sedimentation within 5 min	75.0	15.0	⊙	×		
E 3	Sedimentation within additional 20 min	225.0	45.0	⊙	△		
Sub total		300.1	60.0				
E 4	Sedimentation within additional 1 hour	100.0	20.0	○	○		
E 5	Sedimentation within additional 5 hour	35.0	7.0	△	⊙		
E 6	Sedimentation within additional 12 hour	25.0	5.0	△	⊙		
E 7	Supernatant liquid	20.0	4.0	△	⊙		
Sub total		180.0	36.0				
Loss		19.9	4.0				
Total		500.0	100.0				

* Sintering condition
 Better sintering condition than the comparison
 -36% (estimate)
 Almost same sintering condition than the comparison
 -52% (estimate)
 Silica separation - good

Table 3-21 Acid Treatment and Silica Elimination
 (Prevent to pulverize silica into fine powder by using large ball)

Test No.	Sedimentation condition	Quantity (g)	Ratio (%)	Firing coloration	Sintering condition	L value	Preparation conditions
Mine ore F3H							1) Acid treated product of raw ore F3
D 1	325mesh residuum	0.9	0.9	×	×		2) Amount: 100% of 100gm water (because of a small amount)
D 2	Sedimentation within 5 min	12.0	12.0	◎	×		3) Spherulite stone: Large: 100-175g for 750g Standard: 10-50g
D 3	Sedimentation within additional 30 min	13.0	13.0	◎	×		4) Pulverization time: 6.5 hours. 325 meshcut is followed afterward
D 4	Sedimentation within additional 2 hour	17.0	17.0	◎	×		5) Cut product is pulverized for additional 11 hours
D 5	Supernatant liquid	56.0	56.0	○	○		6) Sedimentation after adding 800cc water
Loss		1.1	1.1				
Total		100.0	100.0				

Table 3-23 Beneficiation Test Result by Crushing & Water Washing and Acid Treatment of FB-3

Original material is milled for 6 Hrs without ball.

Sample	Material Balance				Chemical composition					Firing coloration					
	Feldspar	Quartz	Total (g)	Ratio (%)	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Na ₂ O	K ₂ O	L	a	b			
					75.88*	13.99*	1.00*	4.34*	4.03*	54.3	4.5	11.7			
1. Original															
FB-3					75.88*	13.99*	1.00*	4.34*	4.03*	54.3	4.5	11.7			
2. Screened after washing															
FNK 10	10-19 mm	290	0	290	4.8					59.1	5.9	13.9			
FNK 5	5-10	933	tr	933	15.6					65.3	3.8	10.7			
FNK 2	2-5	1,276	tr	1,276	21.3					68.4	2.9	9.4			
FNK 1	1-2	652		652	10.9	(75.88*	13.99*	1.00*	4.34*	4.03*)	72.9	3.0	9.4
FNK 1S		1,242		1,242	20.7					76.3	1.0	5.7			
				4,393	73.3										
(Sub-total of FNK 10 - 1S															
FNK +230	+230 #	326		326	5.4					43.3	13.0	15.1			
FNK -230	-230 #	1,184		1,184	19.7					42.2	12.1	12.1			
loss		97		97	1.6										
Total				6,000	100.0										

Sample	Material Balance				Chemical composition					Firing coloration			
	Feldspar	Quartz	Total (g)	Ratio (%)	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Na ₂ O	K ₂ O	L	a	b	
					(75.88*	13.99*	1.00*	4.34*	4.03*)	72.9	3.0
2. Acid treatment													
FNK 1H	1-2 mm				82.89	11.36	0.36			79.5	1.4	7.5	

Note: The data marked with * were analyzed by Taiiko Refractory Co. in Japan. The others were by BBK

Table 3-24 Test Result of Mica Elimination by Screening after Crushing

Sample No.	Size	Material balance		Chemical composition						Firing coloration			Mica content
		Weight (g)	Ratio (%)	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Na ₂ O	K ₂ O	L	a	b		
1. Original													
FNK 1-10													
2. Screened after crushing													
M 1	+100mesh	16.6	0.6						45.8	8.6	12.2	+++	
M 2	+200mesh	293.0	10.3						74.2	1.1	7.9	++	
M 3	+325mesh	712.0	25.0	84.63*	8.73*	0.19*	2.61*	3.68*	77.5	2.1	6.2	-	
M 3M	*1	141.4	5.0									+	
M 4	-325mesh	1,088.6	38.3	84.00*	9.10*	0.23*	2.65*	3.65*	66.6	0.3	7.5	-	
M 4M	*2	338.4	11.9						59.0	0.6	14.0	+	
loss		252.0	8.9										
Total		2,842.0	100.0										

Sample preparation condition:

1. The samples of FNK 1-10 in Table-1 are used as original material.
2. FNK 10-5 are crushed into 5 mm under, then mixed with FNK 2 and FNK 1.
3. 1,421 g of above sample mixture, 3 kg of large size ball (80-100 g/piece) and 995 cc of water (70% of material) are put in a pot mill.
4. The sample is milled for 3 Hrs.

Notes:

- *1: Upper layer of sedimentation of sample No. M 3.
 - *2: Upper layer of sedimentation of sample No. M 4.
- The data marked with * were analyzed by Taiko Refractory Co. in Japan. The others were in BBK

Table 3-25 Test Result of Quartz Elimination by Sedimentation

1. Test - 1												
Sample No.	Size	Material balance		Chemical composition					Firing coloration			Quartz content
		Weight (g)	Ratio (%)	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Na ₂ O	K ₂ O	L	a	b	
(1) Original												
M 3				84.63*	8.73*	0.19*	2.61*	3.68*	77.5	2.1	6.2	
(2) Sedimentation												
Q 1	+325mesh	0.0	0.0									
Q 2	Bottom after sedimentation for 20 min.	186.4	28.1	85.71	9.19	0.27			71	-0.6	5.9	++
Q 3	Upper layer loss	434.1	65.6	83.00*	9.66*	0.21*	2.65*	3.81*	72.0	-1.1	6.5	+
		41.5	6.3									
	Total	662.0	100.0									
2. Test - 2												
Sample No.	Size	Material balance		Chemical composition					Firing coloration			Quartz content
		Weight (g)	Ratio (%)	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Na ₂ O	K ₂ O	L	a	b	
(1) Original												
M 4				84.00*	9.10*	0.23*	2.65*	3.65*	66.6	0.3	7.5	
(2) Sedimentation												
Q 4	+325mesh	0.0	0.0									
Q 5	Bottom after sedimentation for 20 min.	322.0	30.8	85.93	9.05	0.31			67.3	-0.1	7.5	++
Q 6	Upper layer loss	656.7	62.8	82.87*	9.81*	0.25*	2.73*	3.81*	67.3	-0.9	8.7	+
		67.3	6.4									
	Total	1,046.0	100.0									

Sedimentation condition:

1. The samples of M 3 and M 4 in Table-2 are used as original materials.

2. 662 g & 1,046 g of M 3 & M 4, 4 kg of small ball and 430 cc & 680 cc (65%) of water are put in a pot mill.

3. The samples are milled for 6 Hrs.

Note: The data marked with * were analyzed by Taiko Refractory Co. in Japan. The others were in BBK.

Table 3-26 Beneficiation Test Result by Crushing & Water Washing of FL-4

Original material is milled for 6 Hrs without ball.

Crushing & water washing	Sample	Material balance *1		Chemical composition *4				Firing coloration			Sintering condition			
		Feldspar	Quartz	Total (g)	Ratio (%)	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Na ₂ O	K ₂ O		L	a b	
													79.00	12.10
1. Original	FL-4													
2. Screened after washing	FL4K 3 3-5 mm	0	21	21	4.2					81.7	1.1	6.2	X ^{*2}	
	FL4K 2 2-3	14	122	136	27.2					82.0	1.4	6.5	X ^{*2}	
	FL4K 2U -2	-	-	308	61.6	76.98	13.31	0.27	3.51	4.90	71.3	1.2	7.1	△ ^{*3}
	loss		35	35	7.0									
	Total		500	500	100.0									

Notes: *1 Feldspar and quartz were visually separated and weighed by electric balance.

*2 X means poor sintering condition.

*3 △ means slightly poor sintering condition.

*4 The samples were analyzed by Taiko Refractory Co. in Japan.

**Table 3-27 Firing Coloration Data of Beneficiation Test Sample
of Banjarnegara Feldspar**

Sample	L	a	b
1 Crush (200mm) + Water wash + Screen (2mm-#80)	67.2	0.5	11.4
2 Crush (200mm) + Water wash + Screen (#80-#325)	52.9	12.1	20.3
3 Acid treatment of No. 1 sample	71.9	-0.8	8.0
4 Acid treatment of No. 2 sample	66.1	2.6	13.7
5 Crush (#200)	51.4	12.3	22.8
6 Acid treatment of No. 6 sample	59.5	7.1	19.5
7 Crush (#60)	54.2	11.2	18.6
8 Crush (#60) + Water wash + Screen (#+325) + Elutriation (S)	60.7	7.5	15.5
9 Acid treatment of No. 8 sample	61.5	4.3	18.0
10 Crush (#60) + Water wash + Screen (#+325) + Elutriation (O)	54.2	10.5	18.2
11 Acid treatment of No. 10 sample	57.7	6.9	20.7
12 FP	65.6	-0.3	3.0
13 Crush (#80) + Acid treatment	69.6	-1.0	7.6
15 Crush (#80) + Acid treatment + Mill (#-325) + Settle (5min.)	75.8	-0.9	4.3
17 Upper layer of No. 14 sample	64.6	-0.7	11.7
19 Crush (#80) + Acid treatment + Mill (#-325) + Settle (15min.)	73.3	-0.6	5.2
20 Add dolomite to No. 19 sample	71.4	-1.2	8.4

Table 3-28 Deironing Test Result by Magnetic Ferro-Filter

No.	Sample Name	Test condition	Material balance			Chemical composition*4							Firing coloration		
			Collected on magnetball	Deironed material	Loss	Total	Sample	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Na ₂ O	K ₂ O	L	a	b
1.	Sukabumi clay (BBK standard) CSS	5,000 G x 1 pass	25.5	156.1	18.4	200	*1	65.83	24.38	2.47			58.0	1.6	12.2
			(12.7 %)	(78.1 %)	(9.2 %)	(100 %)	*2	65.02	22.15	3.08			47.3	1.7	8.2
							*3	66.74	24.55	2.26			59.1	0.4	11.8
2.	Sukabumi clay (BBK standard) CSS	24,000 G x 2 pass	38.1	150.9	11.0	200	*1	65.83	24.38	2.47			58.0	1.6	12.2
			(19.1)	(75.4)	(5.5)	(100)	*2	63.53	24.93	3.83			50.0	1.7	9.7
							*3	62.94	27.16	2.41			60.8	0.4	12.8
3.	Sukabumi clay (BBK standard) CSS	10,000 G x 1 pass	28.0	172.0	0.0	200	*1	65.83	24.38	2.47			58.0	1.6	12.2
			(14.0)	(86.0)	0.0	(100)	*2	67.24	21.54	3.30			53.3	2.0	10.8
							*3	65.76	24.97	2.28			57.5	0.6	12.8
4.	Sukabumi clay (collected by team) CS-1	5,000 G x 1 pass	27.6	261.5	10.9	200	*1	62.83	16.84	5.40			38.5	2.7	8.2
			(9.2)	(87.2)	(3.6)	(100)	*2	56.89	15.39	9.64			30.4	6.7	4.8
							*3	65.11	16.46	3.28			44.9	3.3	10.6
5.	Banjarnegara (collected by team) FB-1/3	5,000 G x 1 pass	32.0	253.7	14.3	300	*1	81.25	11.70	1.99			58.7	4.9	10.7
			(10.7)	(84.6)	(4.7)	(100)	*2	60.12	21.25	5.59			41.8	9.6	11.8
							3	83.24	9.62*	0.12*	3.25*	3.58*	78.9	0.5	5.2
6.	Sukabumi CS-1, over flow of water cyclone test	5,000 G x 1 pass	17.7	276.5	5.8	300	*1	63.27	17.12	3.37			42.5	4.2	10.3
			(5.9)	(92.2)	(1.9)	(100)	*2	59.89	16.24	5.83			33.9	3.9	4.8
							*3	64.28	16.66	3.42			47.9	3.8	12.8
7.	Lampung feldspar (collected by team) FL-3/4	25,000 G x 1 pass	31.8	1,428.2	40.0	1,500	*1	78.14	13.95	0.51			68.5	0.0	6.8
			(2.1)	(95.2)	(2.7)	(100)	*2	56.65	25.06	5.65			38.1	4.6	8.5
							*3	79.73	11.88	0.27	2.24	4.38	68.9	-0.5	8.1

Notes: *1 is original sample

*2 is the sample collected on magnet ball

*3 is the sample passed through magnetic box

*4 Chemical composition analysis was conducted by DSM except the samples marked by *, which were analyzed by Taiko Refractory Co. in Japan.

Table 3-29 Test Result on Water (Liquid) Cyclone of Clay

Clay sample	Material balance (%)		Particle size distribution		Chemical composition (%)			Firing coloration			Plasticity	
	(%)		+325# (%)	D-median (μ)	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	L	a	b	Quartz-%	
1. CS-1												
>2mm	0.0											Original: 70
Over flow	90.9		0.0	0.9	63.03	16.80	3.71	45.5	4.0	11.4		72
Under flow	9.1		29.7	0.8	65.41	12.16	8.03	37.8	5.8	7.3		
2. CSS												
>2mm	1.7											
Over flow	55.7		0.8	1.0				59.9	0.2	12.0		
Under flow	42.6		41.9	1.0				68.5	1.5	12.3		
3. Sukabumi 1st grade												
>2mm	9.0											
Over flow	38.2		1.2	0.9	62.90	17.55	3.32	44.4	2.9	10.4		
Under flow	52.7		62.5	0.9	71.06	14.86	3.3	58.4	4.8	12.9		
4. Sukabumi 2nd grade												
>2mm	11.8											
Over flow	71.6		0.4	0.8				43.6	4.5	11.5		
Under flow	16.6		59.5	0.9				50.4	8.0	12.8		
5. Sukabumi red												
>2mm	10.3											
Over flow	42.4		1.6	0.8				35.5	4.5	6.4		
Under flow	47.3		57.4	0.8				38.2	6.3	7.5		
6. CM-2												
>2mm	0.0											
Over flow	89.3							(51.81	31.57	1.15	1.14)*
Under flow	10.7		51.2	0.9	48.46	29.40	2.10	82.9	0.5	15.7		
					89.90	4.65	0.85	74.8	2.0	11.4		

Note: The data marked with * were analyzed by Taiko Refractory Co. in Japan. The others were in BBK.

Table 3-30 Firing Test Result on Water (Liquid) Cyclone Test Samples

Clay sample	Physical characteristic				Shrinkage after firing		Firing coloration		
	Apparent porosity	Water absorption	Apparent density	Bulk density	(%)	Observation	L	a	b
1. CS-1									
Over flow	2.8	1.3	2.23	2.17	6.7	grayish brown	45.5	4.0	11.4
Under flow	15.8	7.1	2.64	2.22	3.9	black	37.8	5.8	7.3
2. CSS									
Over flow	1.0	0.4	2.35	2.33	8.7	light gray	59.9	0.2	12.0
Under flow	18.3	8.8	2.53	2.07	1.4	nearly white	68.5	1.5	12.3
3. Sukabumi 1st grade									
Over flow	2.7	1.2	2.27	2.21	5.1	grayish brown	44.4	2.9	10.4
Under flow	25.2	13.0	2.59	1.94	1.0	reddish white	58.4	4.8	12.9
4. Sukabumi 2nd grade									
Over flow	1.1	0.4	2.47	2.44	9.9	gray brown	43.6	4.5	11.5
Under flow	27.1	14.4	2.59	1.89	1.0	reddish white	50.4	8.0	12.8
5. Sukabumi red									
Over flow	2.0	0.8	2.44	2.39	8.7	dark brown	35.5	4.5	6.4
Under flow	27.0	13.6	2.72	1.98	0.3	more reddish whit	38.2	6.3	7.5

Table 3-31 Test Result of Floatation Separation

Sample	Material balance		Chemical composition							Mineral observed by micro scope					Firing coloration		
	g	(%)	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	N ₂ O	K ₂ O	Muscovite	Quartz	Feldspar	Magnetite	Limonite	Organic M.	L	a	b	
Test 1 (FB-2, Japan-1)																	
(1) Original	500.0	100.0															
(2) 1st floatation																	
Over flow	32.2	6.4					++++	++			+						
Test 2 (FB-2, Japan-2)																	
(1) Original	500.0	100.0												52.9	7.5	15.2	
(2) 1st floatation																	
Over flow	30.2	6.0	80.11	12.63	2.22		++++	++			+			43.2	6.8	13.1	
(3) 2nd floatation																	
Over flow	94.5	18.9	70.31	16.01	4.47		++	++	++++			+		41.4	8.4	13.3	
Bottom	358.4	71.7	84.57	10.25	0.28		+	++++	+					74.5	2.3	5.9	
(4) Loss	16.9	3.4															
Test 3 (FB-2, BBK)																	
(1) Original	500.0	100.0															
(2) 1st floatation																	
Over flow	25.5	5.1					++++	++									
(3) 2nd floatation																	
Over flow	108.7	21.7					++	++	++++								
Bottom	307.0	61.4					+	++++	+								
(4) Loss	58.8	11.8															
Test 4 (FB-1/3, Japan-2)																	
(1) Original	500.0	100.0	(74.58)*	(14.71)*	(1.06)*	(4.11)*								(56.4)	(3.8)	(13.4)	
(2) 1st floatation																	
Over flow	52.4	10.5	71.70	16.84	2.22									42.8	5.8	12.6	
(3) 2nd floatation																	
Over flow	139.6	27.9	72.08*	15.47*	1.23*	4.27*								39.8	11.6	15.7	
Bottom	296.0	59.2	86.63*	7.62*	0.11*	2.50*								80.2	1.3	5.0	
(4) Loss	12.0	2.4															
Test 5 (FB-1/3, BBK)																	
(1) Original	500.0	100.0															
(2) 1st floatation																	
Over flow	151.4	30.3															
(3) 2nd floatation																	
Over flow	22.9	4.6															
Bottom	295.1	59.0															
(4) Loss	30.6	6.1															
Test 6 (FL-3/4, Japan-2)																	
(1) Original	500.0	100.0	77.33*	13.51*	0.35*	2.48*								76.1	-0.8	7.2	
(2) 1st floatation																	
Over flow	61.4	12.3	75.92	15.36	0.48									70.5	-0.4	7.8	
(3) 2nd floatation																	
Over flow	125.5	25.1	75.50*	13.87*	0.36*	2.52*								70.6	-0.6	10.7	
Bottom	304.9	61.0	84.39*	8.89*	0.10*	1.99*								83.7	-1.1	5.8	
(4) Loss	8.2	1.6															

Note: The data marked with * were analyzed by Taiiko Refractory Co. in Japan. The others were in BBK.

Figure 3-1 L vs. b of the Data (1,250°C OF E-Kiln) in Table 3-5

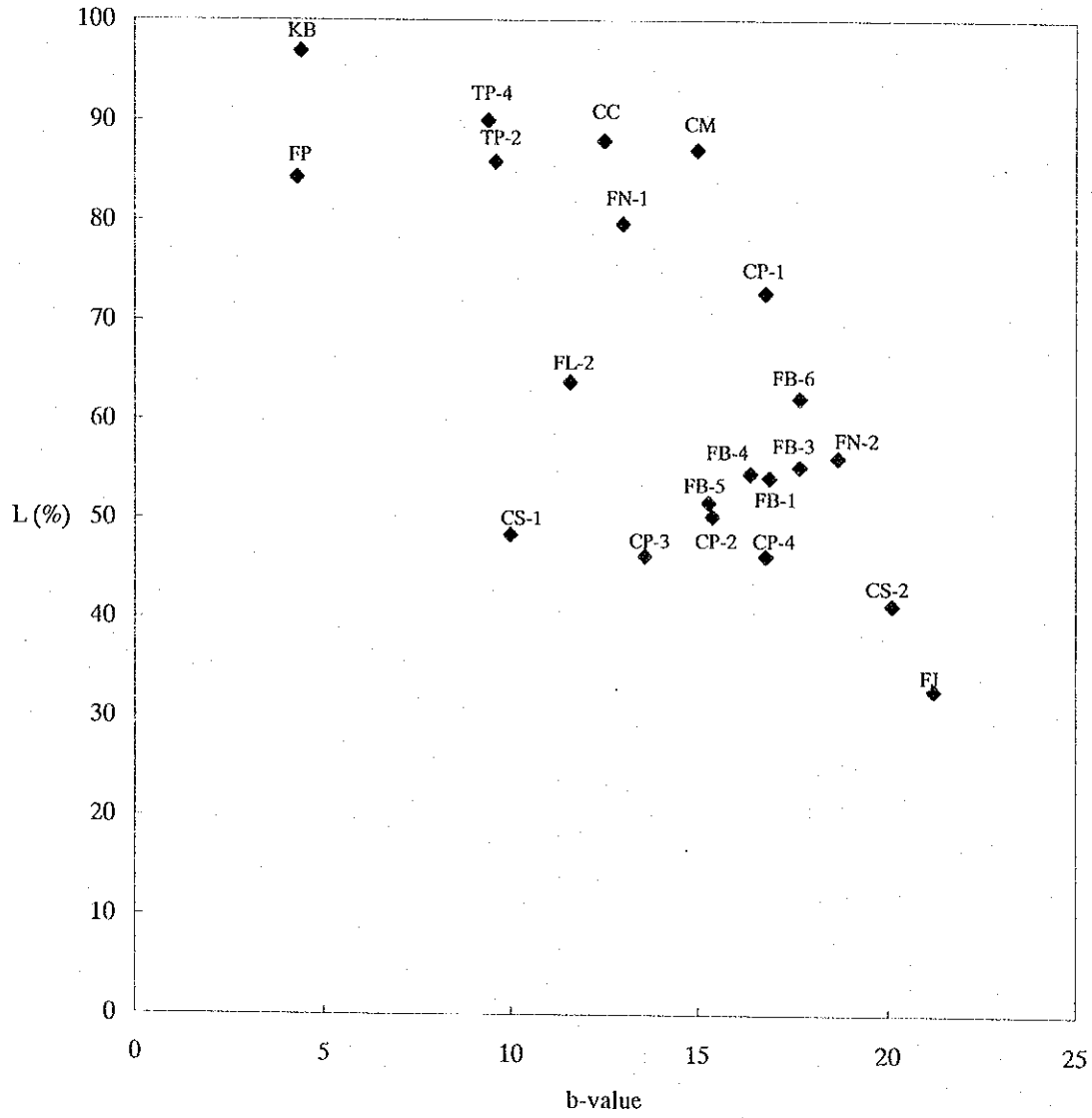


Figure 3-2 L vs. a-value of the Data (1,250°C OF E-Kiln) in Table 3-5

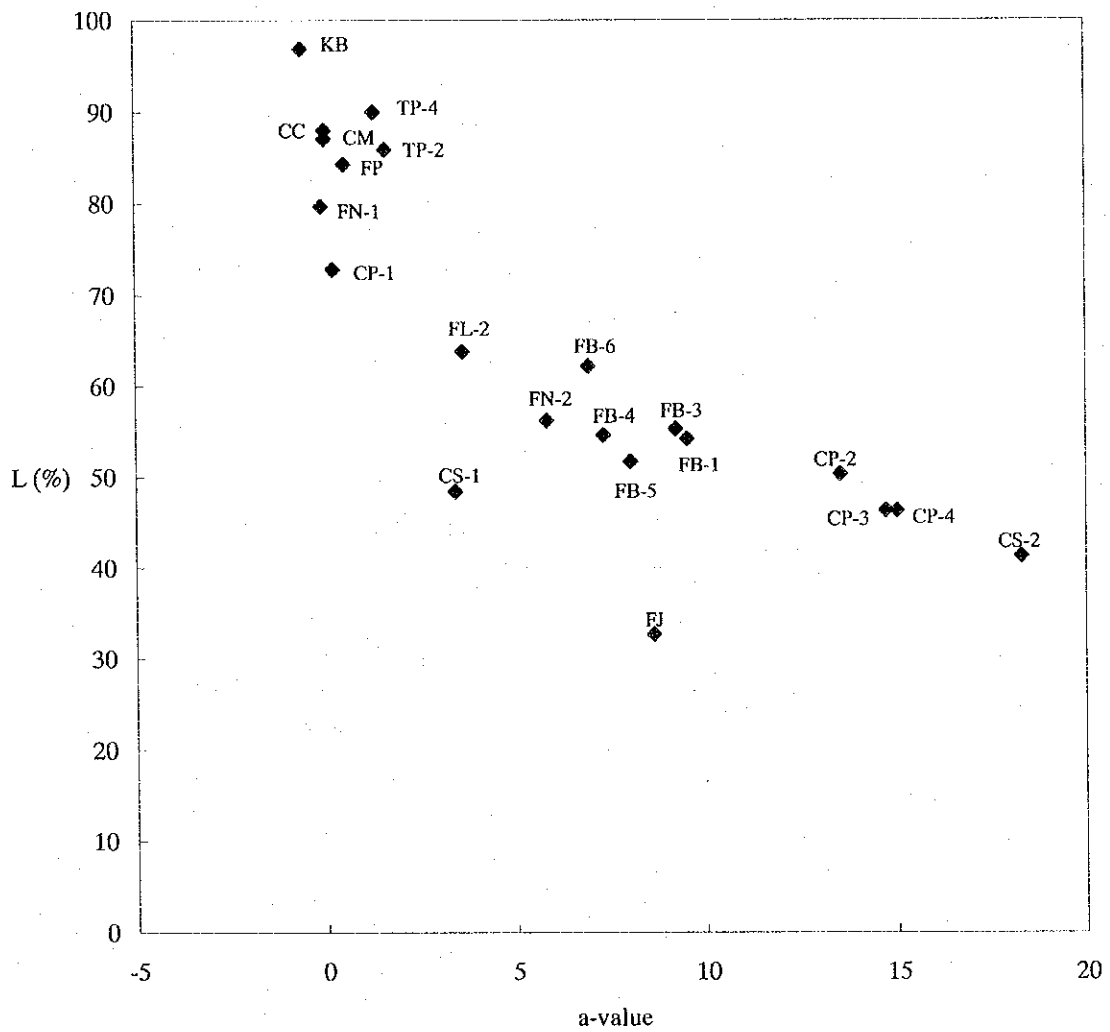


Figure 3-3 (1) lg. loss

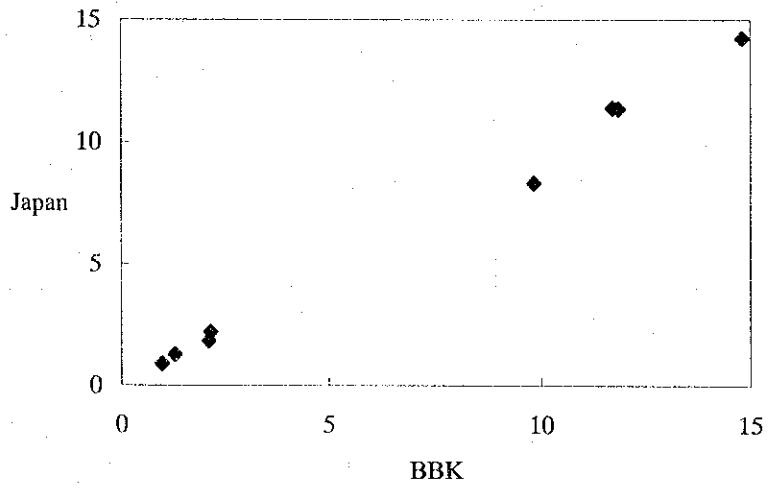


Figure 3-3 (2) SiO₂

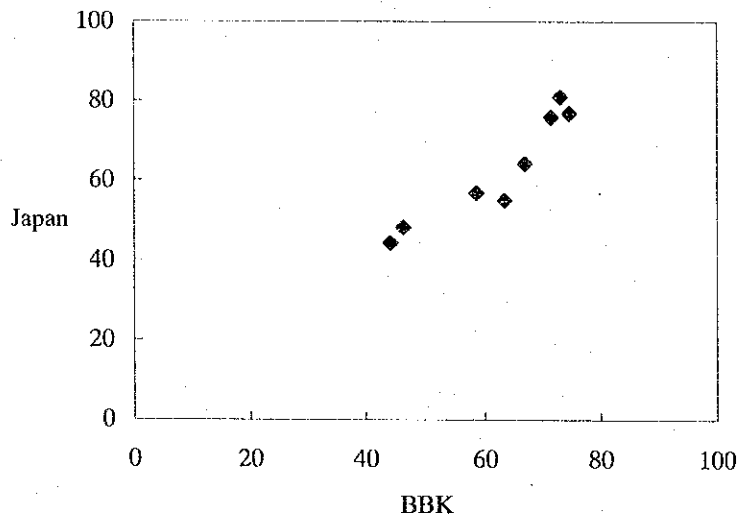


Figure 3-3 (3) Al_2O_3

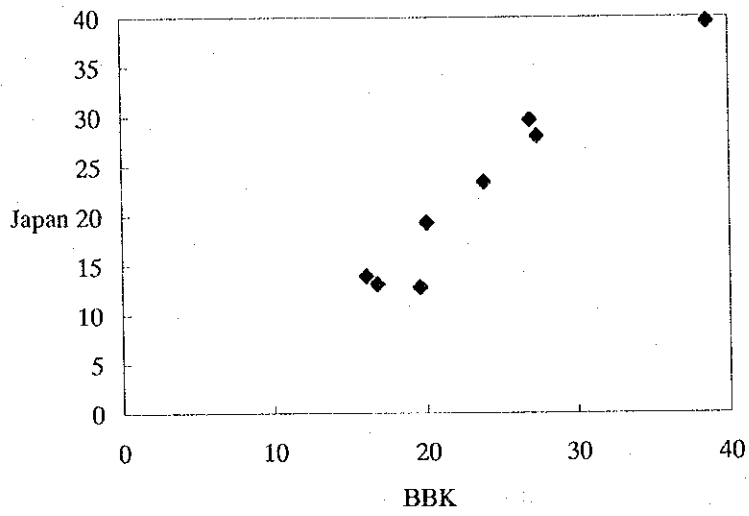


Figure 3-3 (4) Fe_2O_3

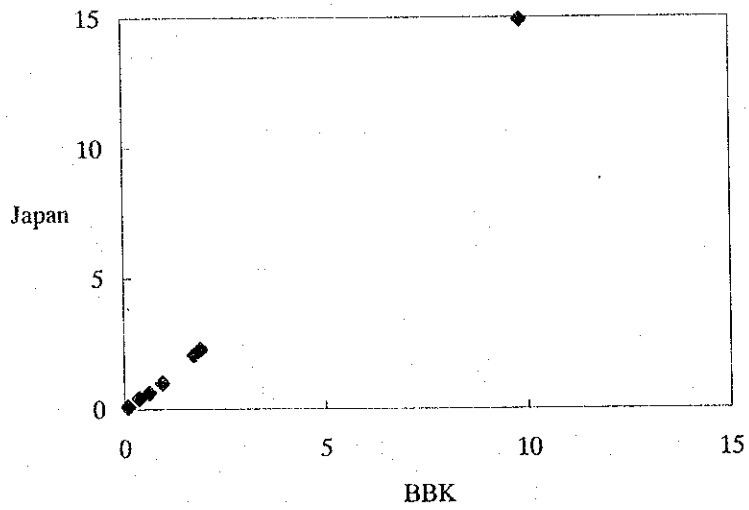


Figure 3-3 (5) TiO₂

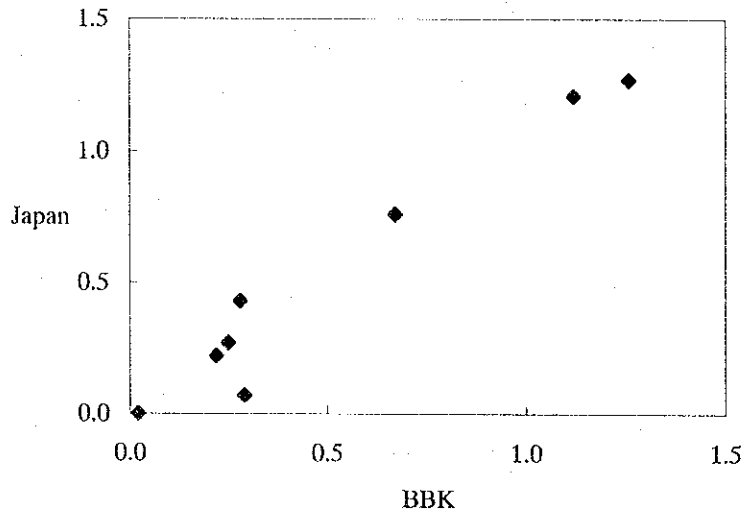


Figure 3-3 (6) CaO

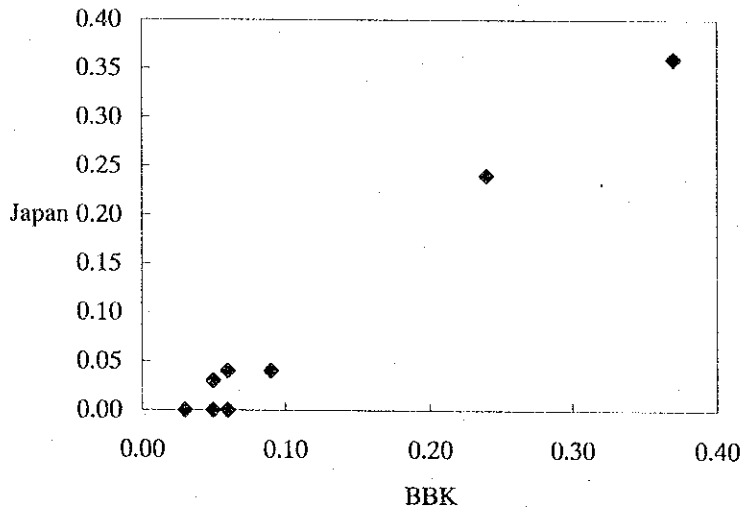


Figure 3-3 (7) MgO

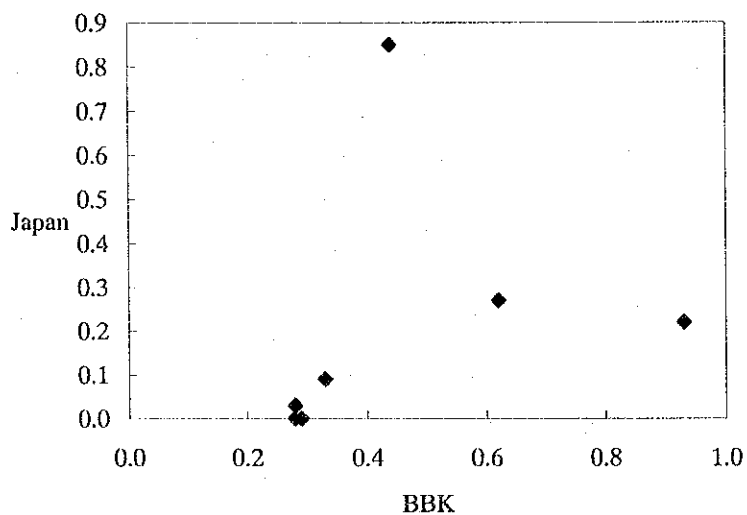


Figure 3-3 (8) Na₂O

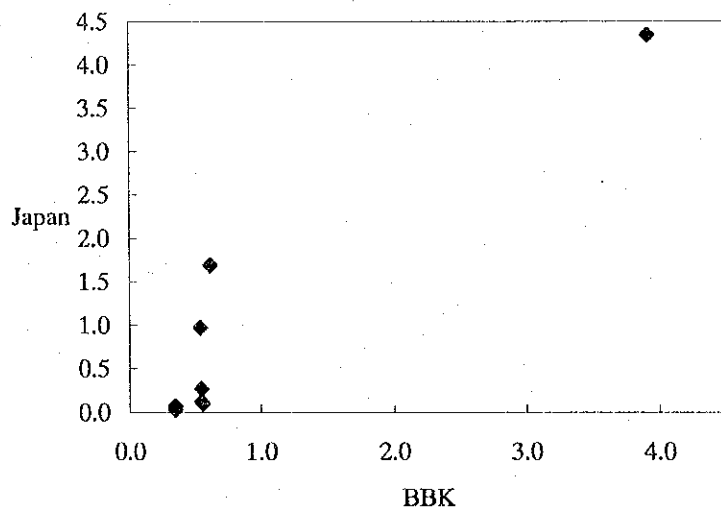


Figure 3-3 (9) K_2O

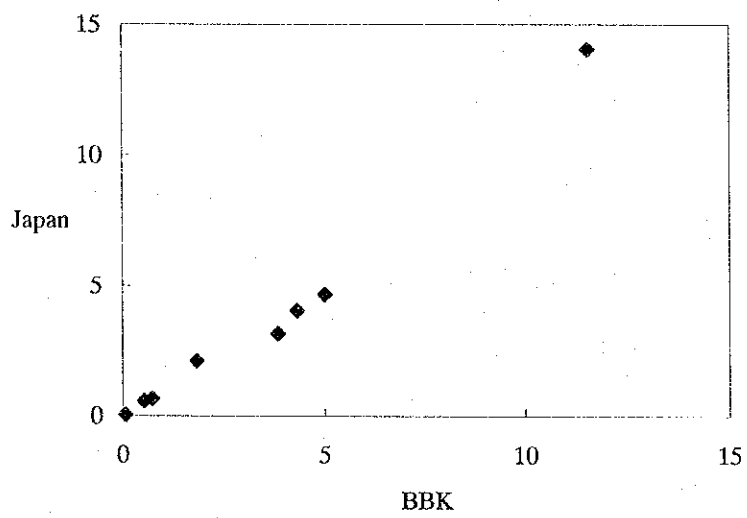


Figure 3-4 (1) Comparison of L-value between Japan and BBK

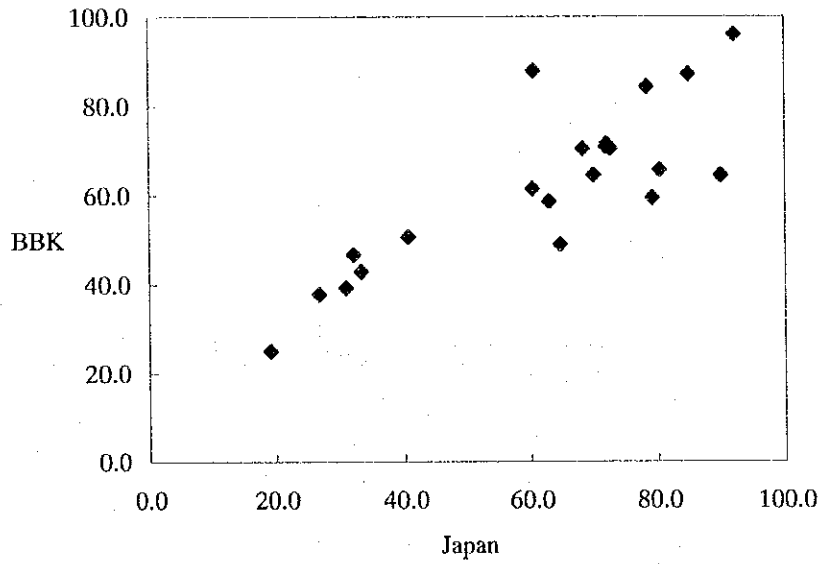


Figure 3-4 (2) Comparison of a-value between Japan and BBK

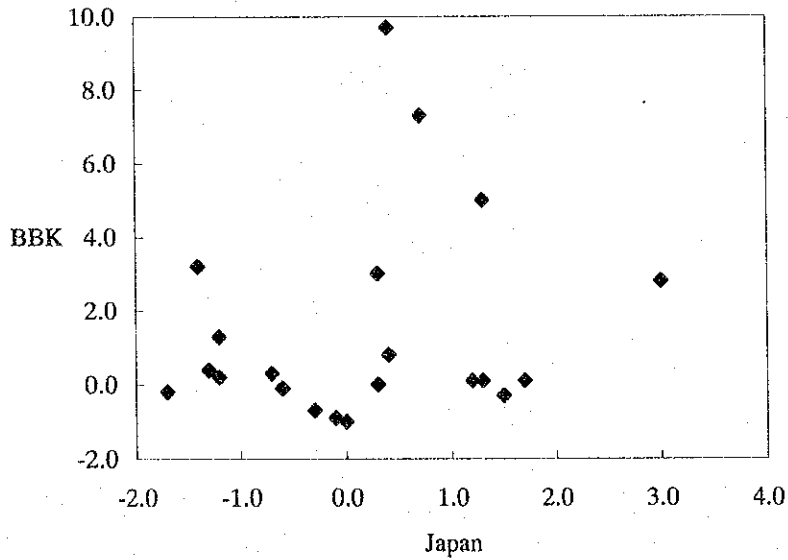


Figure 3-4 (3) Comparison of b-value between Japan and BBK

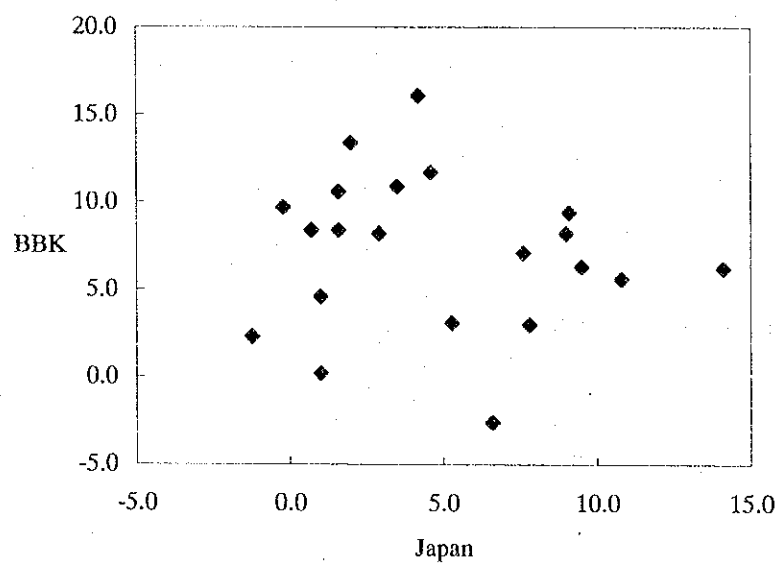


Figure 3-5 (1)
Comparison of Color Meter between SCRL and BBK
(L/1,250°C-OF E-Kiln)

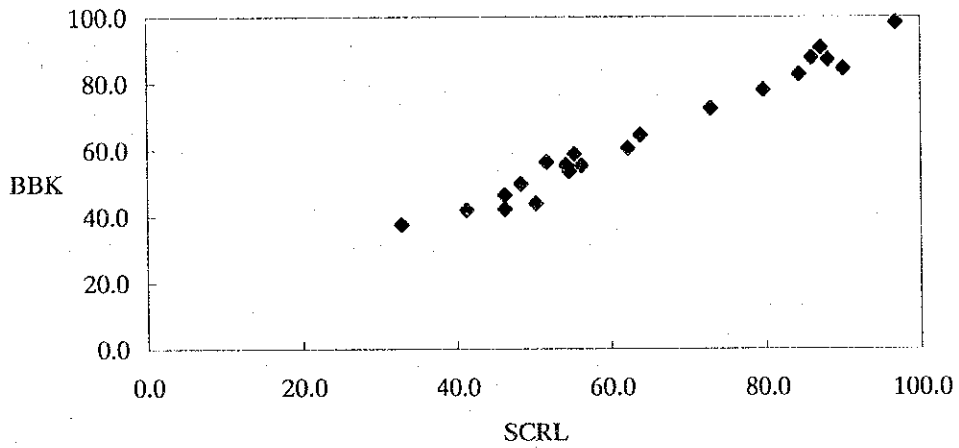


Figure 3-5 (2)
Comparison of Color Meter between SCRL and BBK
(a/1,250°C-OF E-Kiln)

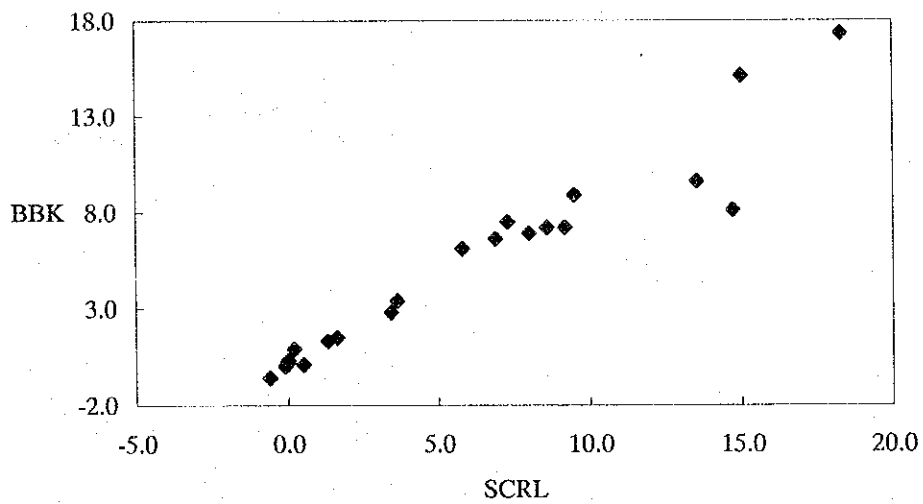


Figure 3-5 (3)
Comparison of Color Meter between SCRL and BBK
(b/1,250°C-OF E-Kiln)

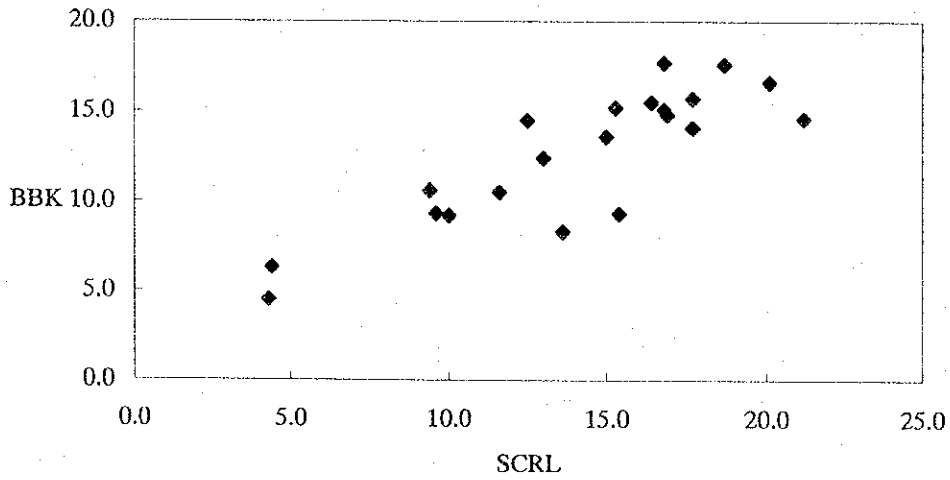


Figure 3-5 (4)
Comparison of Color Meter between SCRL and BBK
(L/1,250°C-RF E-Kiln)

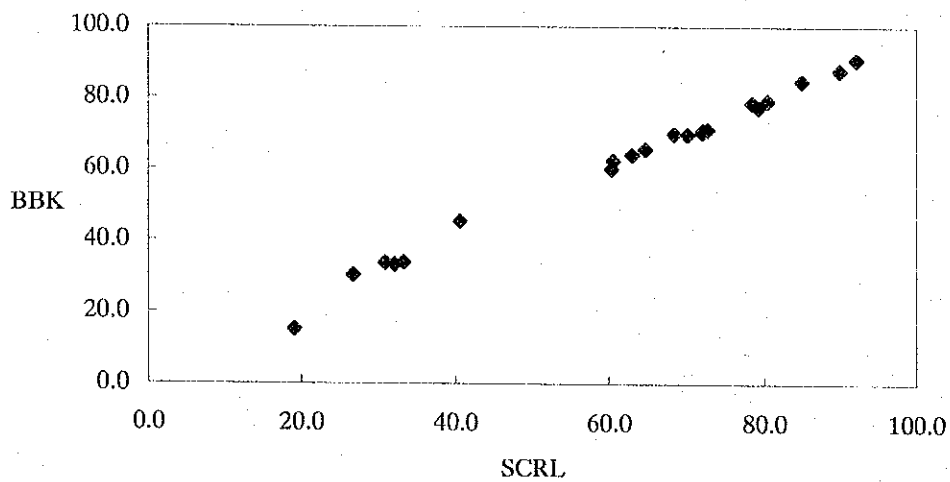


Figure 3-5 (5)
Comparison of Color Meter between SCRL and BBK
(a/1,250°C-RF E-Kiln)

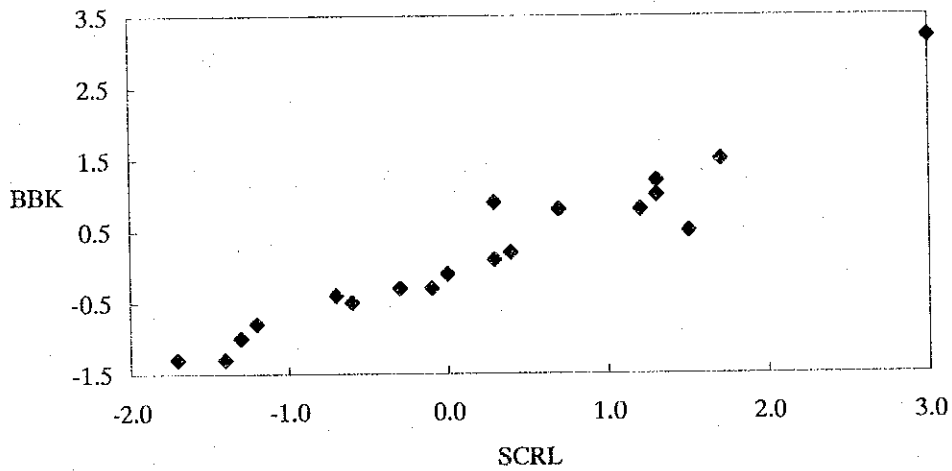


Figure 3-5 (6)
Comparison of Color Meter between SCRL and BBK
(b/1,250°C-RF E-Kiln)

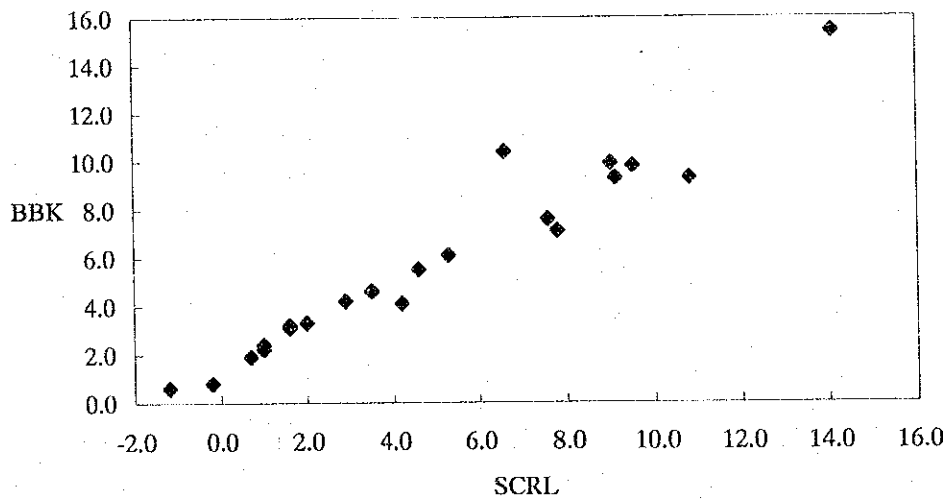


Figure 3-5 (7)
Comparison of Color Meter between SCRL and BBK
(L/1,300°C-RF G-Kiln)

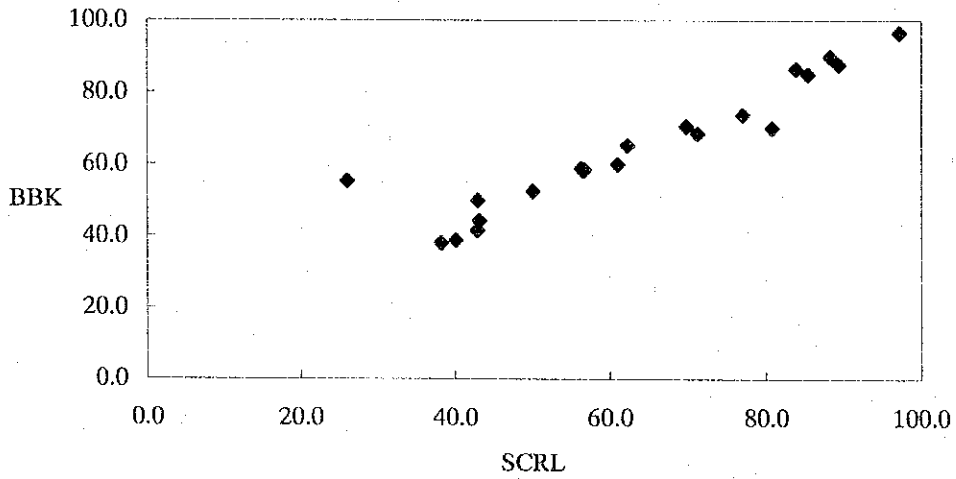


Figure 3-5 (8)
Comparison of Color Meter between SCRL and BBK
(a/1,300°C-RF G-Kiln)

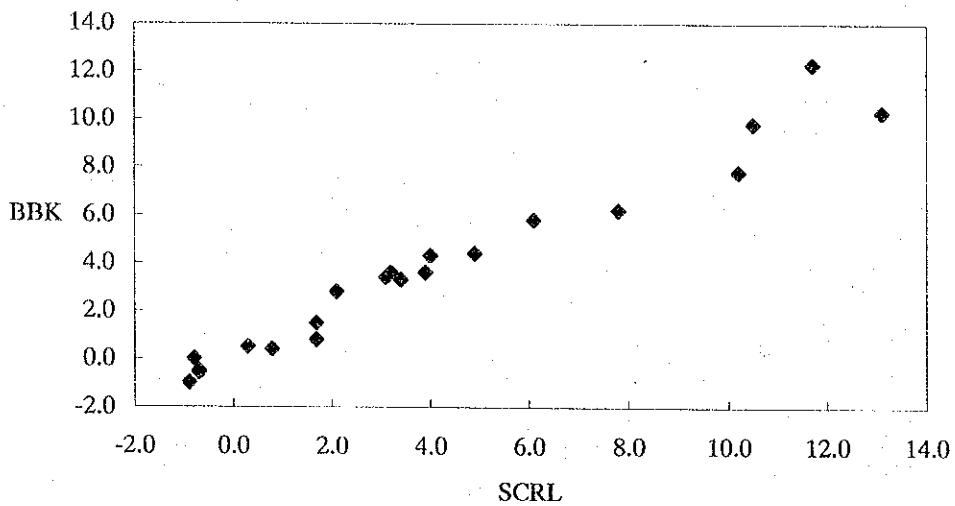


Figure 3-5 (9)
Comparison of Color Meter between SCRL and BBK
(b/1,300°C-RF G-Kiln)

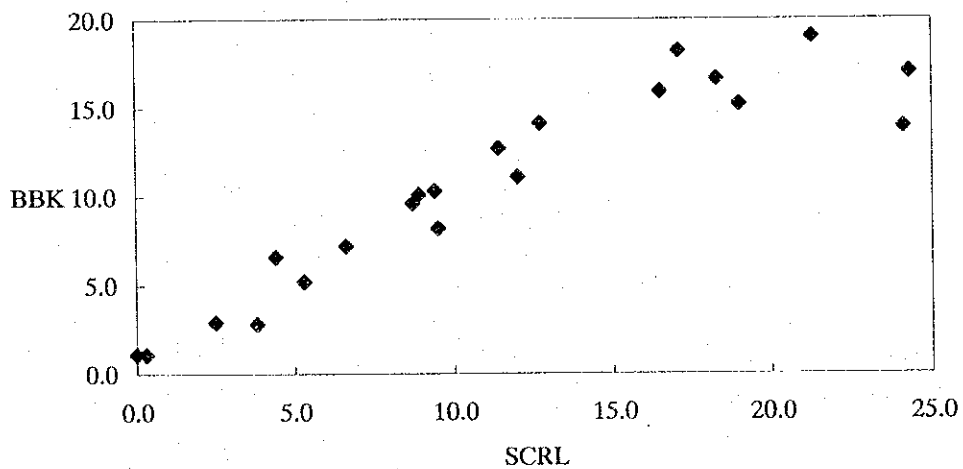
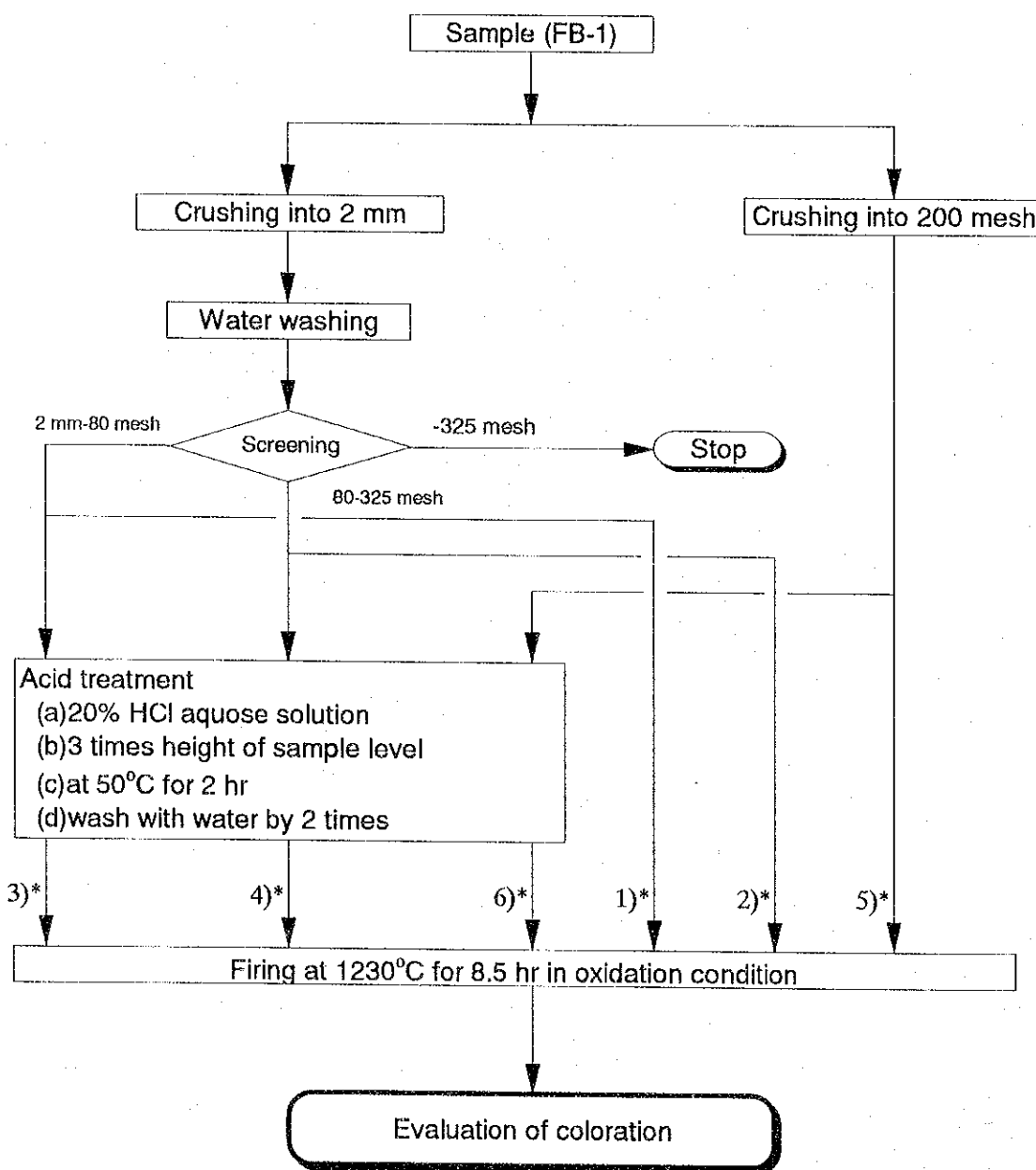


Figure 3-6 Test Procedure on Quality Improvement of Banjarnegara Feldspar

Test procedure

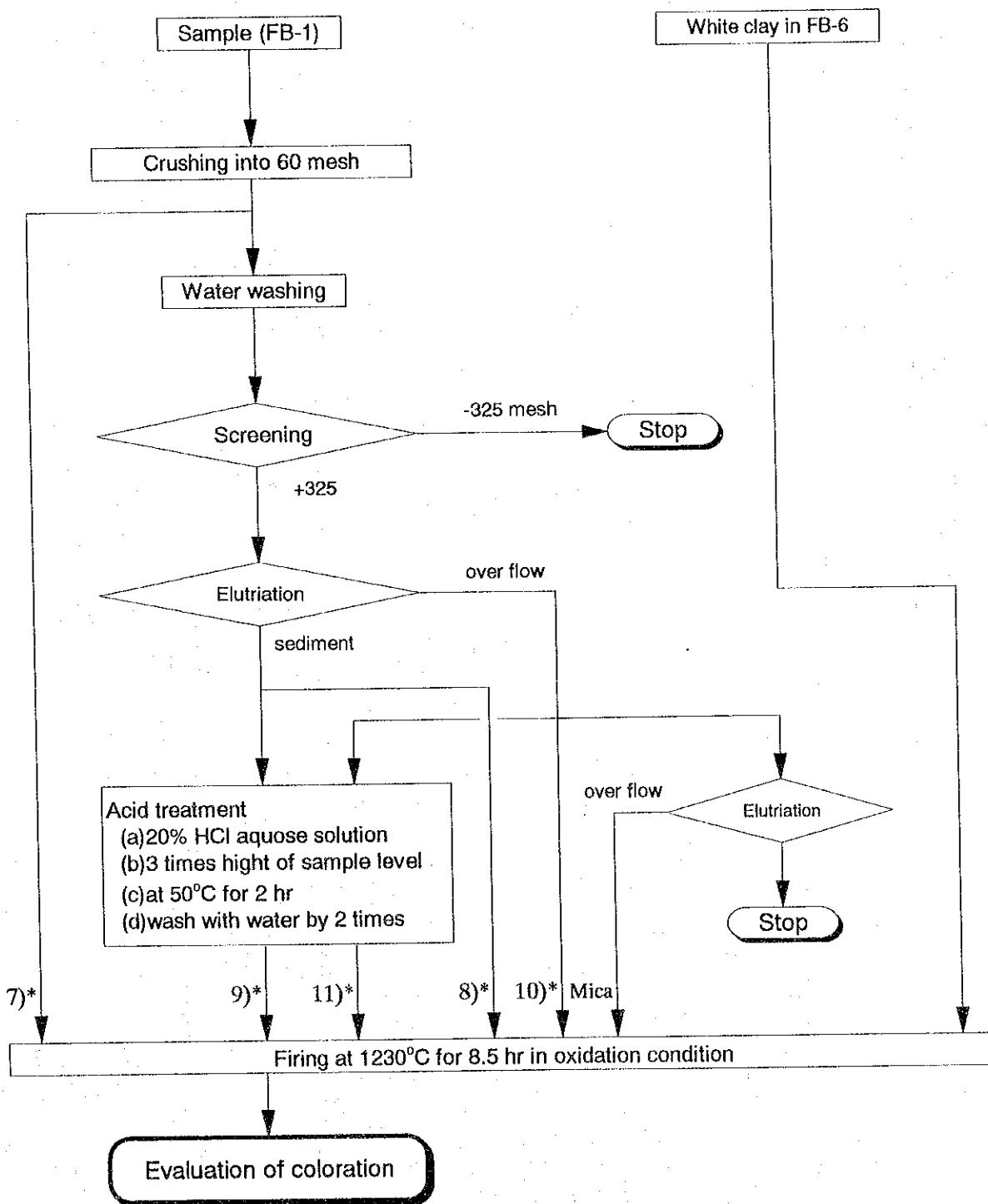
(1) Water washing and acid treatment



Note: * No. are sample no. of Table 3-27.

Figure 3-7 Test Procedure on Quality Improvement of Banjarnegara Feldspar

(2) Elimination of mica



Note: * No. are sample no. of Table 3-27.

Figure 3-8 Test Procedure of Flotation Separation (1st Flotation)

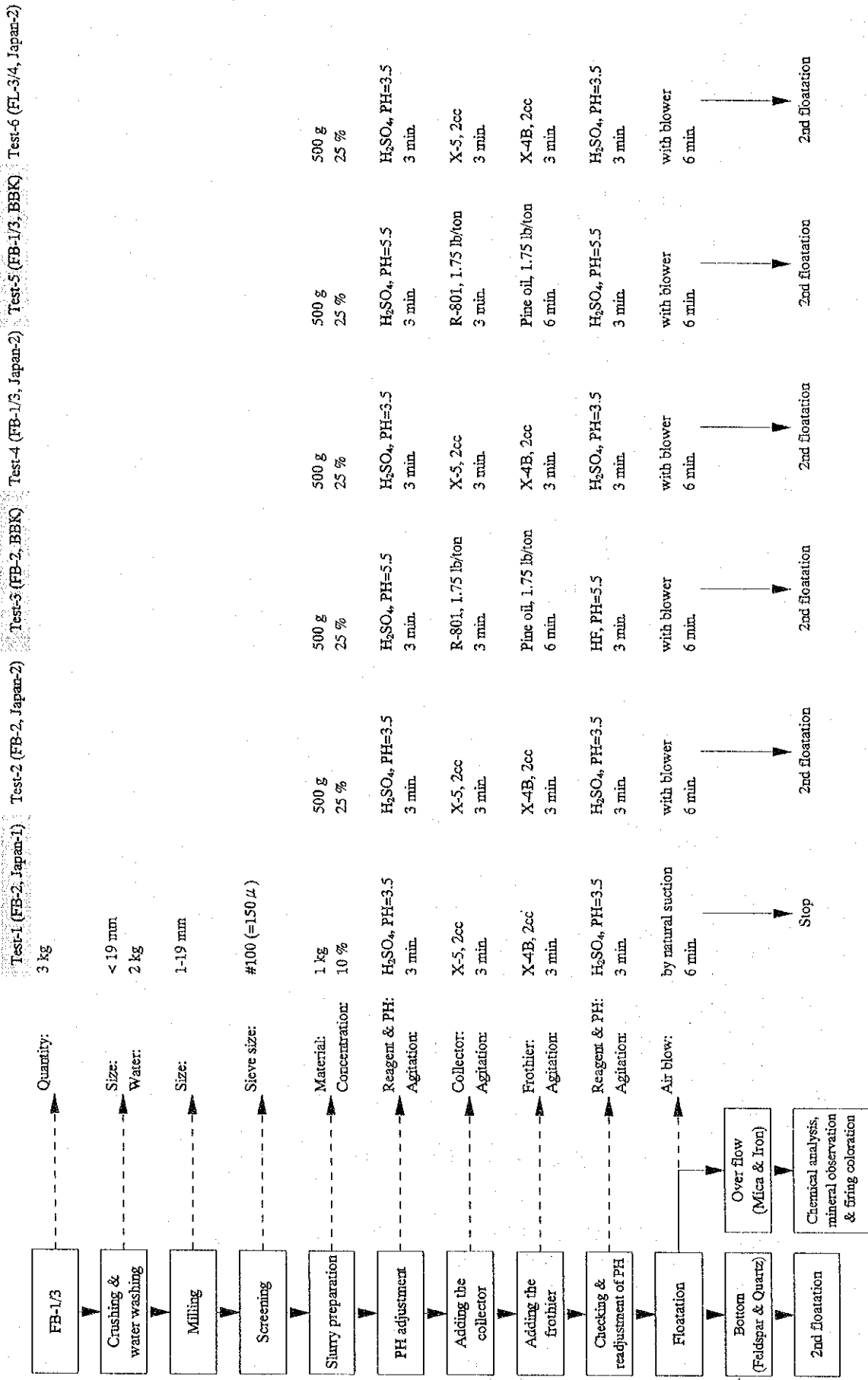
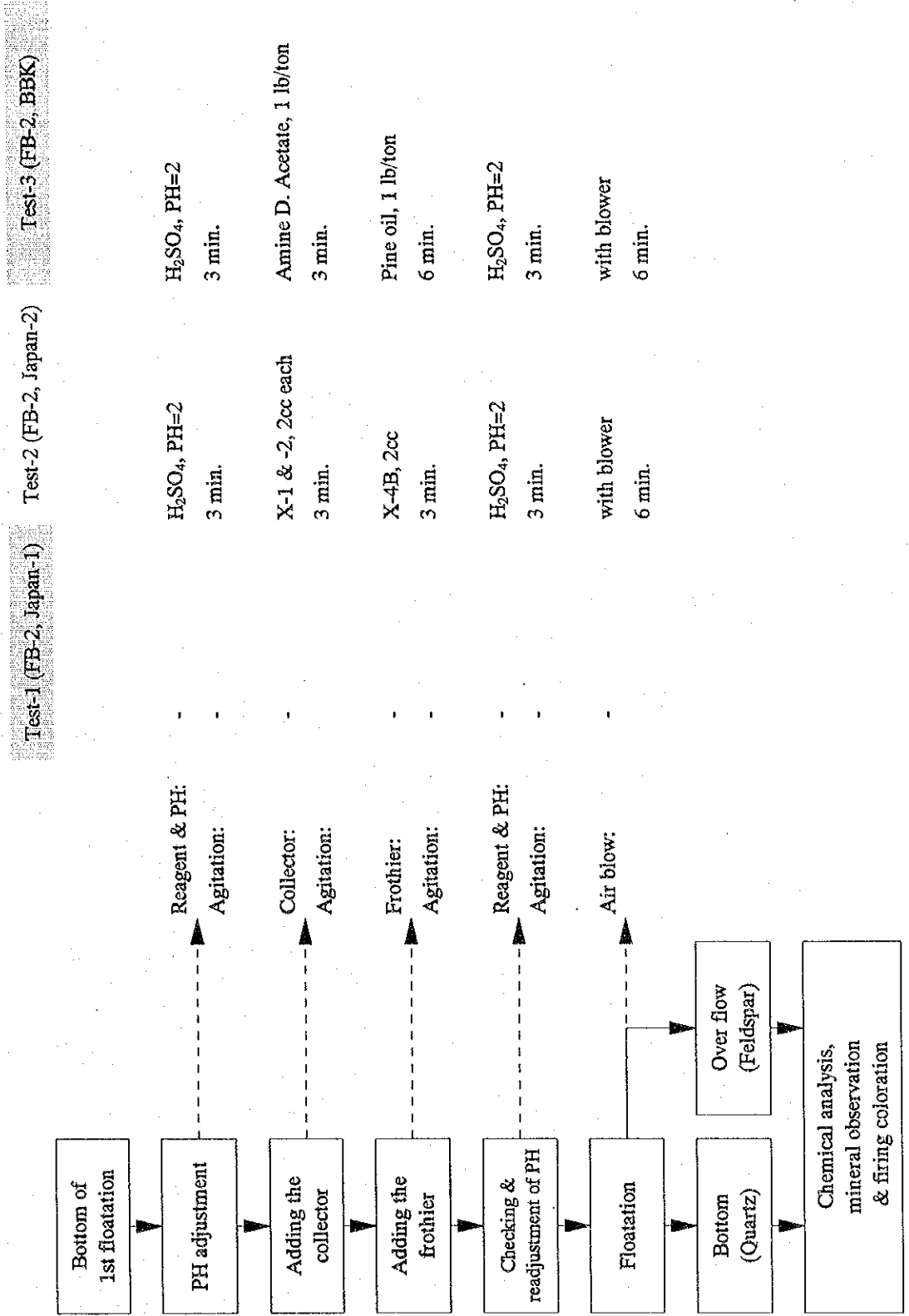
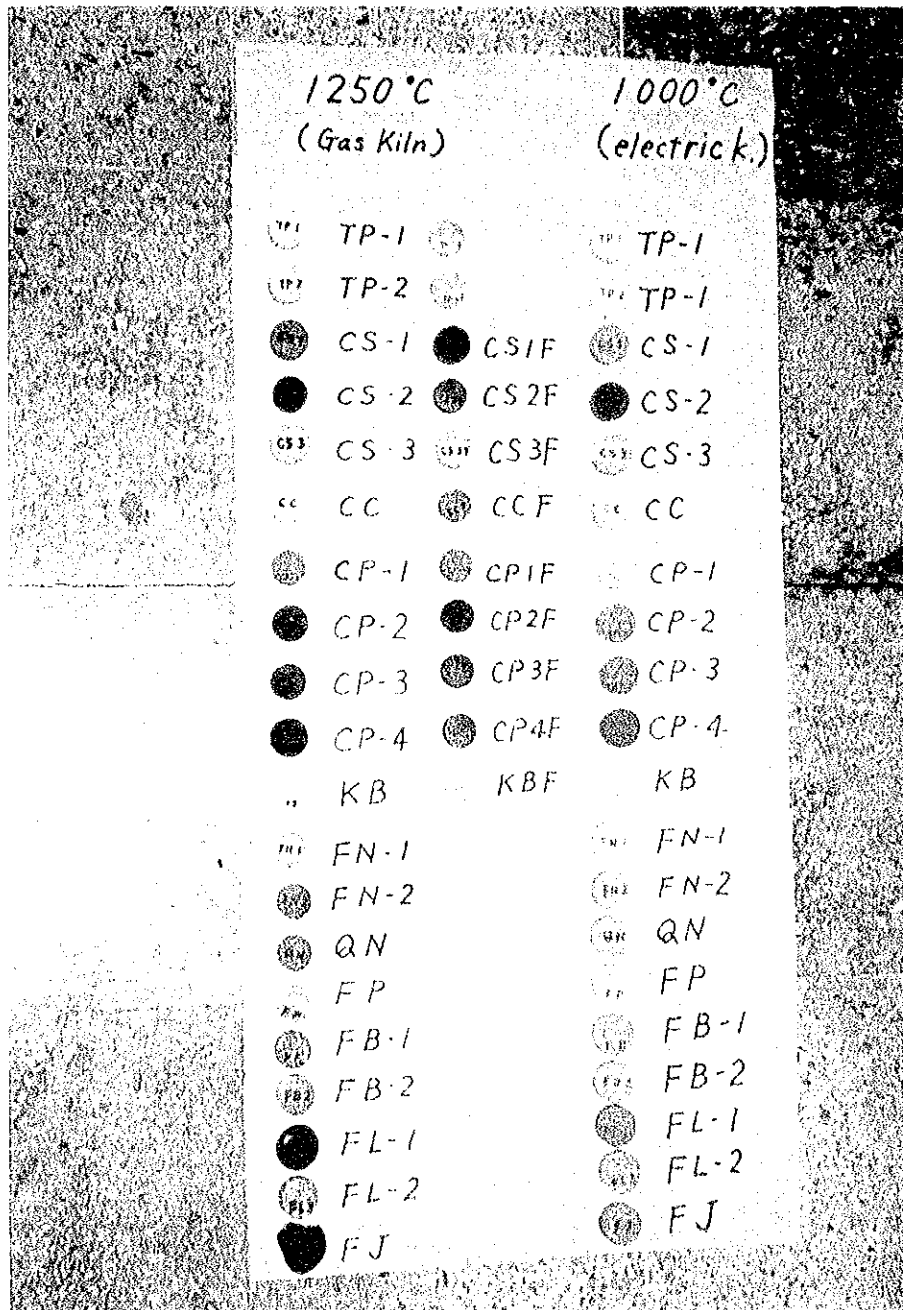


Figure 3-9 Test Procedure and Condition of Flotation Separation (2nd Flotation)







Picture 3-1

