Heavy Mineral Associations in the Paleogene Systems of Some Coal Fields, North Kyushu, Japan

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https://doi.org/10.5109/1526199

出版情報：九州大學理學部紀要 : Series D, Geology. 11 (3), pp.381-418, 1961-12-15. Faculty of Science, Kyushu University

Mem. Fac. Sci., Kyushu Univ., Ser. D, Geology, Vol. XI, No. 3,
pp. 381-418, text-figs. 1-8, tables 1-2, plates 28-30, December 15, 1961

Heavy Mineral Associations in the Paleogene Systems of Some Coal Fields, North Kyushu, Japan*

By

Jyonosuke OHARA

Abstract

This paper deals with the heavy minerals observed in the sandstones from the Tertiary coalbearing formations and their basements in the northern Kyushu, with regard to amounts (per cent in weight), kinds, and frequencies.

In view of heavy minerals, the sediments of each coal field have several characteristic assemblages and may be mostly divided into several "Heavy Mineral Zones".

In this paper, such "Heavy Mineral Zones" are commented for the geological sequence of each coal field, and the relationship between the stratigraphical zoning and the mineralogical one is also discussed.

Further comment is made on the volcanisms inferred from tuffs and tuffites embedded often in the Paleogene.

Introduction

The Tertiary formations including many workable coal seams are widely distributed in the northern Kyushu, and have long been studied stratigraphically and paleontologically by many geologists. However, little is known of the petrological study of the Paleogene sediments of the northern Kyushu that treats the sedimentary rocks in qualitative and quantitative way. In this side, noteworthy results have only been published by K. KATO (1960) and Y. SATO (KAMISHIMA and SUGAI, 1959).

Since 1955, the author has also promoted the petrographical study about sandstones of the Paleogene sediments in the northern Kyushu, especially about the heavy minerals, and some of the results have already been published (OHARA, 1955-1961).

In this paper, amount (per cent in weight), kind, assemblage and frequency of heavy minerals in the sandstone specimens collected from the following coal fields are discussed, with reference to those of their basements, too. They are the Amakusa, Takashima, Asakura, Fukuoka, Munakata, Chikuho, Karatsu, and Sasebo coal fields.

Acknowledgements

I wish to express my most sincere thanks to Prof. Hisamichi MATSUSHITA, Prof. Ryuzo TORIYAMA and Assistant Prof. Ryohei TAKAHASHI of Kyushu University for their kind guidance and encouragements throughout this study and for reading over the typescript. I am also indebted to Assist. Prof. Haruo SHIROZU and to Messrs. Yoshifumi KARAKIDA and Hitoshi MOMOI of the same University for giving helpful

* Received June 30, 1961

advice on the identification of heavy minerals. Grateful acknowledgement is also due to Messrs. Harukiyo SATO and Shizumi ITO of the Hoshuyama Mine, Nippon Tangyo Coal Mining Co. Ltd. for their kind assistance to collecting the specimens in the Asakura coal field. I wish, further, to thank Miss Mutsuko IIO for careful preparation of the typescript.

Summarized notes on stratigraphy

From 1922 to 1928, T. NAGAO carried out the stratigraphical and paleontological studies on the Paleogene rocks in the northern Kyushu, and, following NAGAO's frameworks, H. MATSUSHITA restudied them from the paleogeographical point of view, and clarified the stratigraphy in much detail. Although there are some different opinions from his results, especially of the geological age, his conclusions are yet acceptable and are taken over by many geologists.

In this paper, therefore, the stratigraphical division of the Paleogene system is based on his results (MATSUSHITA, 1949a; MATSUSHITA and OHARA, 1961). The locations of the Tertiary coal fields and the brief outlines of the pre-Tertiary basement rocks are shown in Figure 1, and the standard diagramatic columnar sections of each coal field are illustrated respectively in Figure 2. Because it is outside the scope of this paper to discuss the geological structure and the contained fossils, only summarized explanations are given to the stratigraphical successions and main constituents of the strta as follows.

I. Amakusa coal field

The basement is the Cretaceous Himenoura group, but in Takahama and its surrounding area metamorphic rocks are exposed too.

The Paleogene is divided into three groups, the Akasaki, Kamishima, and Sakasegawa, which are conformable with each other.

A. Akasaki group

The group is represented by only a single formation, the Akasaki, developing typically in the Kamishima Island where it overlies unconformably the Himenoura group. It consists of conglomerates, ill-sorted sandstones and shales characterized by greenish purple in color. Its equivalent in the Shimoshima Island, on the other hand, is noticeably different in lithofacies and is named Fukami formation, in which greenish grey coarse-grained sandstones and brownish grey shales are main components. The speciments of the Fukami formation for heavy mineral analysis are collected from the upper part of this formation which is exposed on the route from Onabuchi to Rogi.

B. Kamishima group (corresponds to the Shimoshima group)

The group is divided into three formations, to the lower and middle ones of which the different formation names are given respectively in Kamishima and Shimoshima.

The lowest part, named the Shiratake formation in Kamishima and the Fukuregi formation in Shimoshima, is of marine and is composed mainly of massive white to

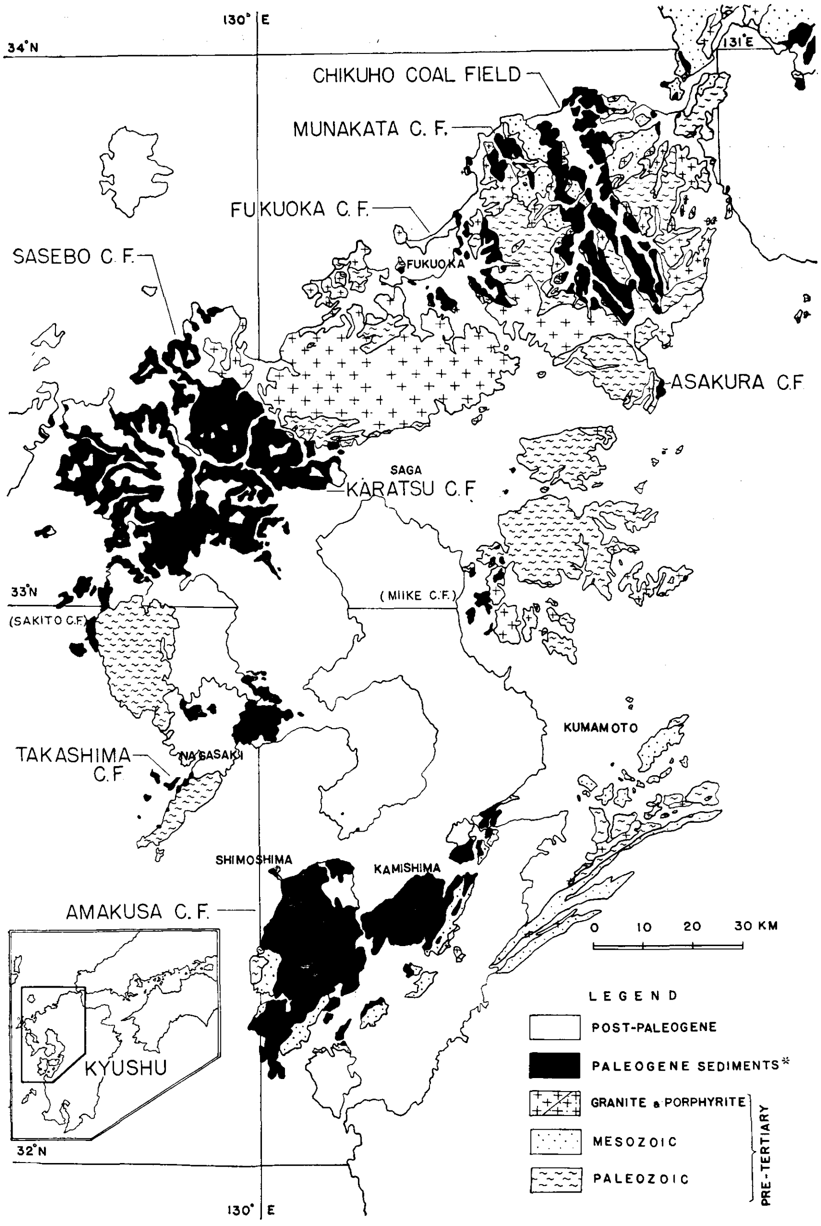


Fig. 1. Index and location map of the Tertiary coal fields and the basement rocks in the northern Kyushu, after 1:500000 Geologic map "Fukuoka" (1951) and "Kagoshima" (1953), Geological Survey of Japan.

(* partly include the Neogene sediments in the Sasebo coal field.)

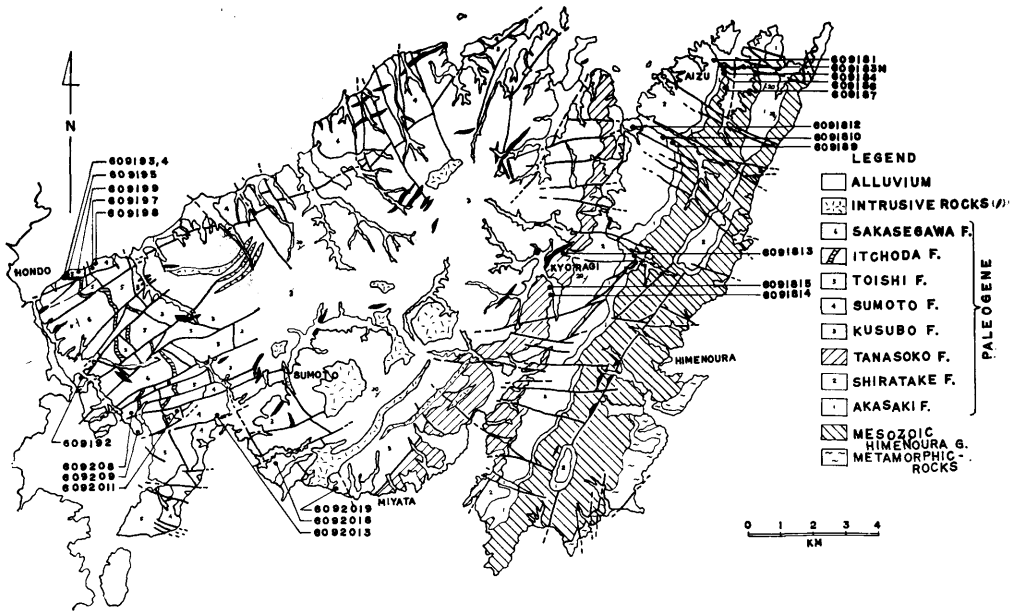


Fig. 3-A. Geologic map and localities of the sandstone samples of the Kamishima Island, Amakusa coal field, after MATSUSHITA (1949a), partly corrected by the author.

grey sandstones, in which the "lower Ariake fossil zone"* is found. In Kamishima are intercalated several thin coal seams which are commonly not persistent.

The middle part of the group is called the Shikiyama formation in Shimoshima. In Kamishima, because the middle part of the group exceeds 1000 meters in thickness, it is divided further into three formations, the Tanasoko, Kusubo and Sumoto in ascending order. Both in Shimoshima and Kamishima the formations are of marine, consisting mainly of thick shales and alternations of sandstone and shale, and containing abundant smaller foraminifers fossils.

The upper part is called the Toishi formation; it is terrestrial deposits, consisting of thick quartzose and arkose well-sorted sandstones and intercalating some workable coal seams. As the lithofacies is nearly the same in both the islands, the same formation name is used. Abundant molluscan fossils are concentrated in the middle and the upper part of this formation to which the "upper Ariake fossil zone" is named.

C. Sakasegawa group

The group is divided into two formations, the lower Itchoda and the upper Sakasegawa; the former consists of glauconite bearing green sandstones and yields many fossils of marine molluscs throughout the formation, and the latter is also marine sediments and is composed chiefly of thick black shales and alternations of

* The fossil zones marked off by quotation marks in this paper, are cited from H. MATSUSHITA (1949a). These "fossil zones" do not mean paleontologically defined fauni-zone nor biozone but are of "fossiliferous beds".

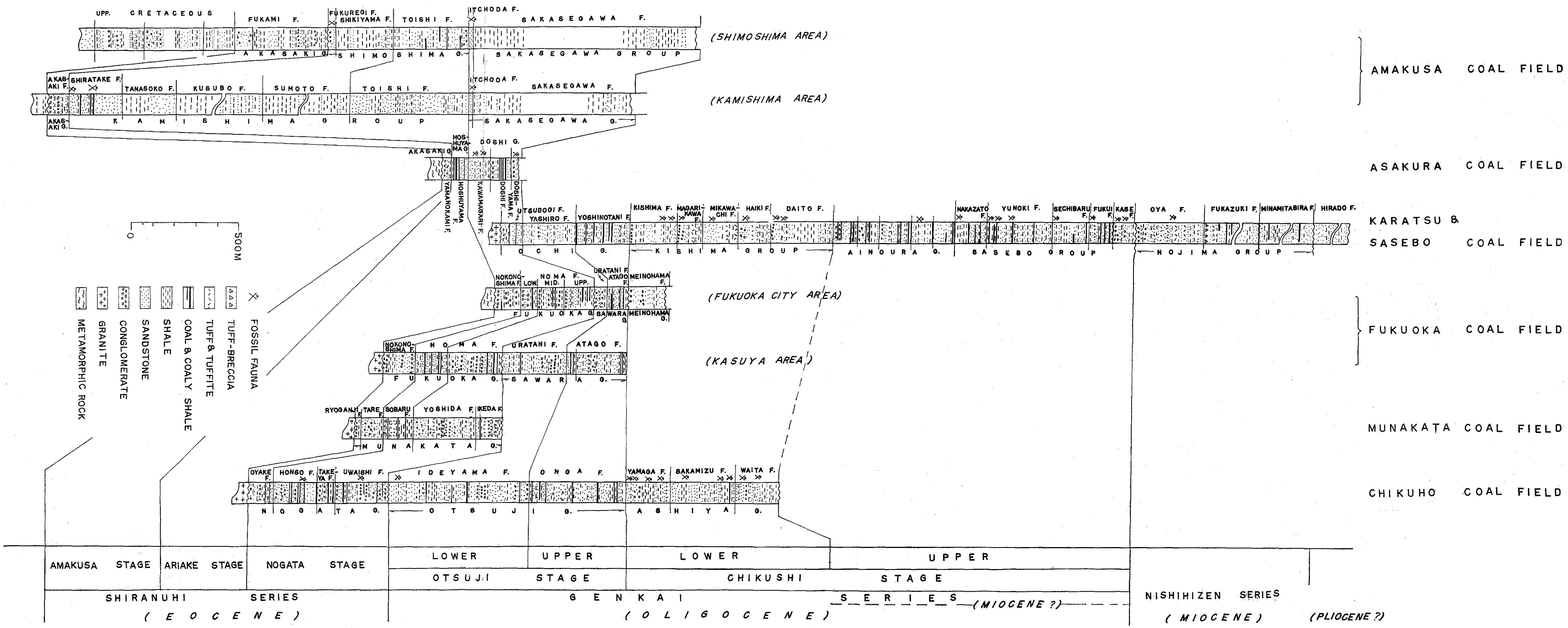


Fig. 2. Generalized columnar sections of the Tertiary coal fields in North Kyushu.

shale and well-sorted sandstone. Fossil marine molluscs and smaller foraminifers are also contained abundantly.

II. Takashima coal field

Because a part of the studies on heavy minerals in the sandstones from this coal field was already published (OHARA, 1960b), only a short note referring to the heavy minerals of the lower part of the Koyaki formation is added here. In the Nomo peninsula, eastern margin of the field, the Koyaki formation overlies unconformably the green metamorphic rocks and consists of conglomeratic sandstones, purplish grey shales and alternations of thick un-sorted sandstone and shale. In the lowest part of the formation a thin coal seam or coaly shale is very locally intercalated.

III. Asakura coal field

With an unconformity the Paleogene rocks overlie the mica-schist. Granite is exposed in the adjacent area of the coal field.

The Paleogene sediments are divided into the following three groups in ascending order; the Akasaki, Hoshuyama, and Doshi.

A. Akasaki group

The group comprises only a single formation, the Yamanokami, which is composed of conglomerates, conglomeratic sandstones, and micaceous grey to purplish grey sandstones and shales. In this group no fossil has hitherto been detected.

B. Hoshuyama group

The group also comprises a single formation, the Hoshuyama, being one of the main coal bearing formation in the field. It is composed of white quartzose medium grained sandstones and alternations of sandstone and shale. In the group are found several workable coal seams which are mined locally. The "upper Ariake fossil zone" is present in the upper part of the formation.

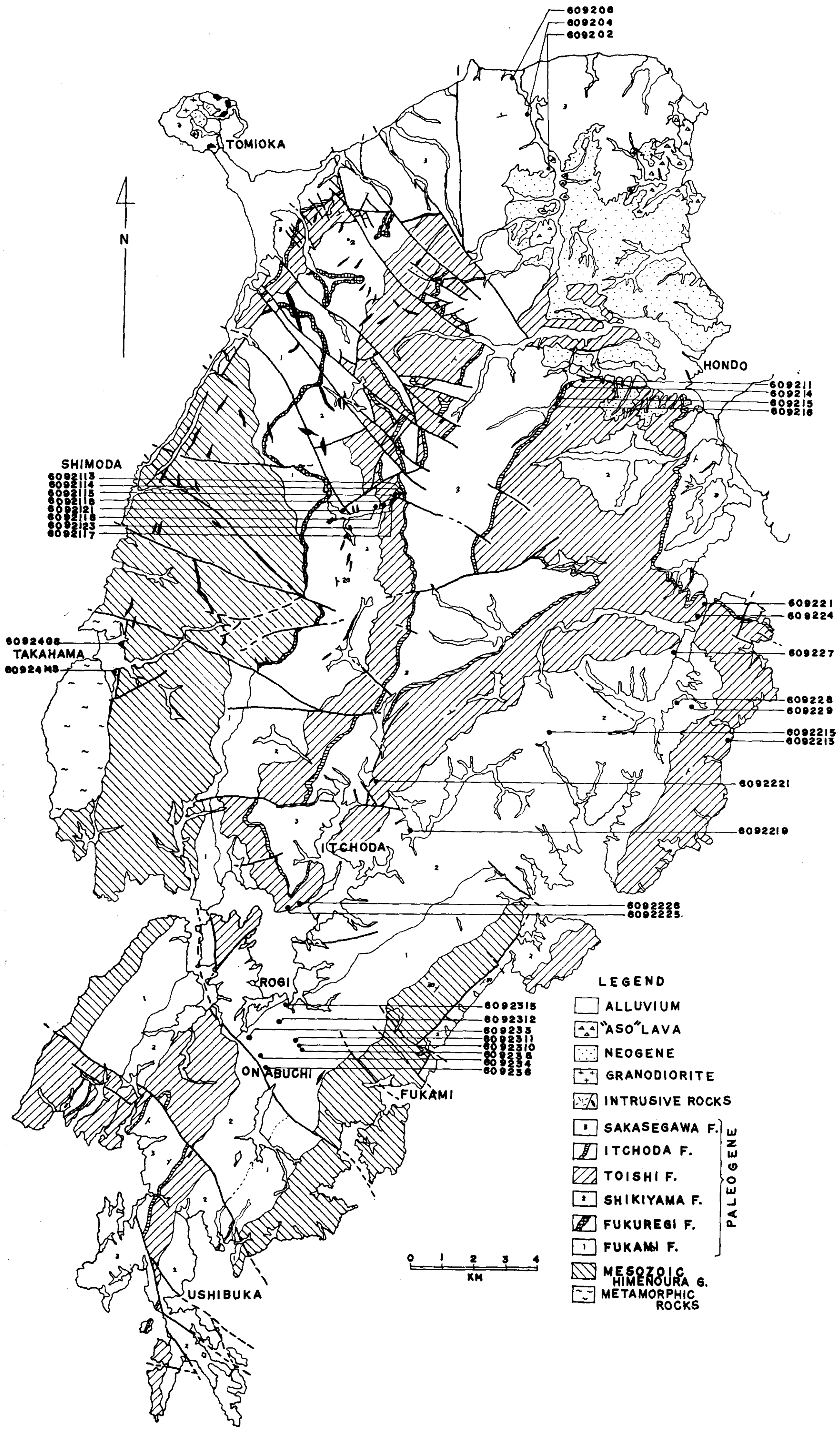
C. Doshi group

The group is divided into three formations; the Kawamagari, Doshi, and Doshiyama in ascending order.

The Kawamagari formation consists of muddy glauconite bearing sandstones and dark grey shales containing many fossils of marine molluscs (the "lower Nogata fossil zone").

The Doshi formation lies unconformably on the Kawamagari formation and, at the same time, it partly covers directly the Hoshuyama formation. This is also main coal bearing formation in this field, and is composed mainly of grey shales and sandstones, and conglomerates dominate in the lower part. Seven workable coal seams are intercalated and mined at the Hoshuyama Colliery.

The Doshiyama formation was once observed in the subsurface of the Hoshuyama Colliery, but it is now invisible. According to H. MATSUSHITA (1949a), the formation is marine deposits and composed of conglomeratic sandstones, sandstones, and shales. It contains many fossil molluscs belonging to the "upper Nogata fossil zone".



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ALLUVIUM
"ASO" LAVA
NEOGENE
GRANODIORITE
INTRUSIVE ROCKS
SAKASEGAWA F.
ITCHODA F.
TOISHI F.
SHIKIYAMA F.
FUKUREGI F.
FUKAMI F.
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MESOZOIC HIMENOURA G.
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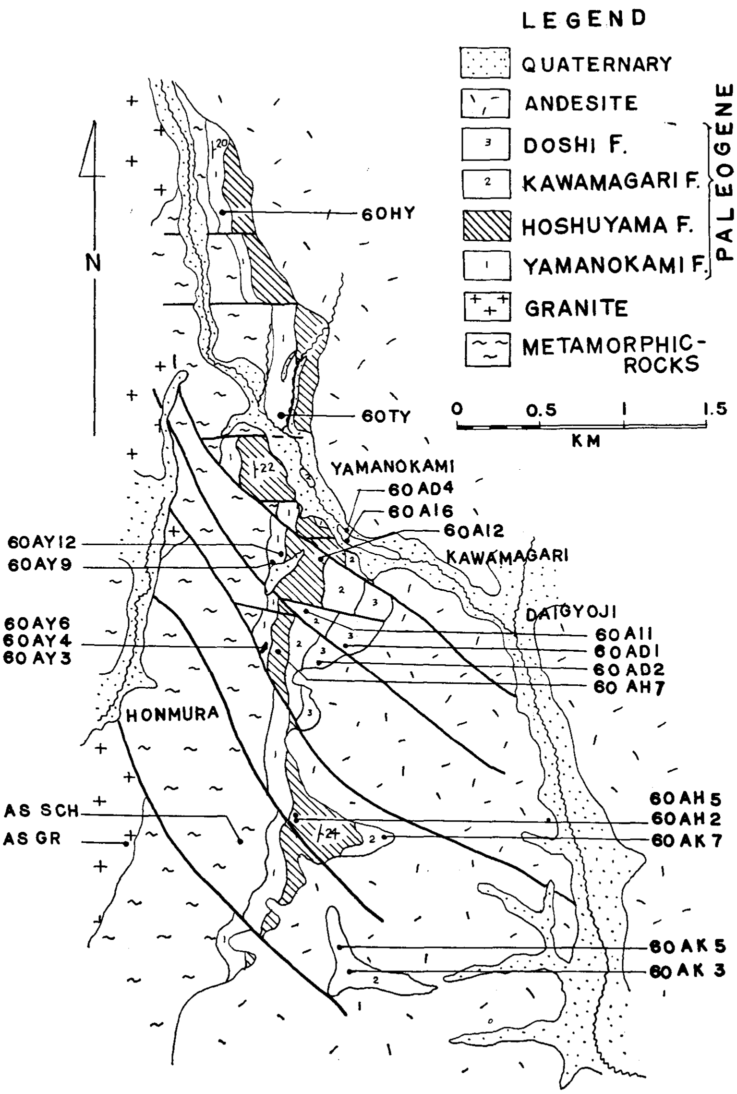

Fig. 3-C. Geologic map and localities of the sandstone samples of the Asakura coal field, after MATSUSHITA (1949a).

Fig. 3-B. Geologic map and localities of the sandstone samples of the Shimoshima Island, Amakusa coal field, after MATSUSHITA (1949a) and MATSUSHITA, OHARA et al. (1959).

IV. Fukuoka coal field

The field is separated into the following three areas, each of which has different kinds of basement rocks; the Fukuoka, south and north Kasuya.

The Paleogene system overlies different kinds of rocks in each area; in the Fukuoka and south Kasuya areas it lies unconformably on the granite which is called Sawara granite, whereas in the northern margine of the north Kasuya it overlies the other type, Itoshima granite. In the main part of the north Kasuya area and in the Nokonoshima Island of Fukuoka city, it covers the Sangun metamorphic complex.

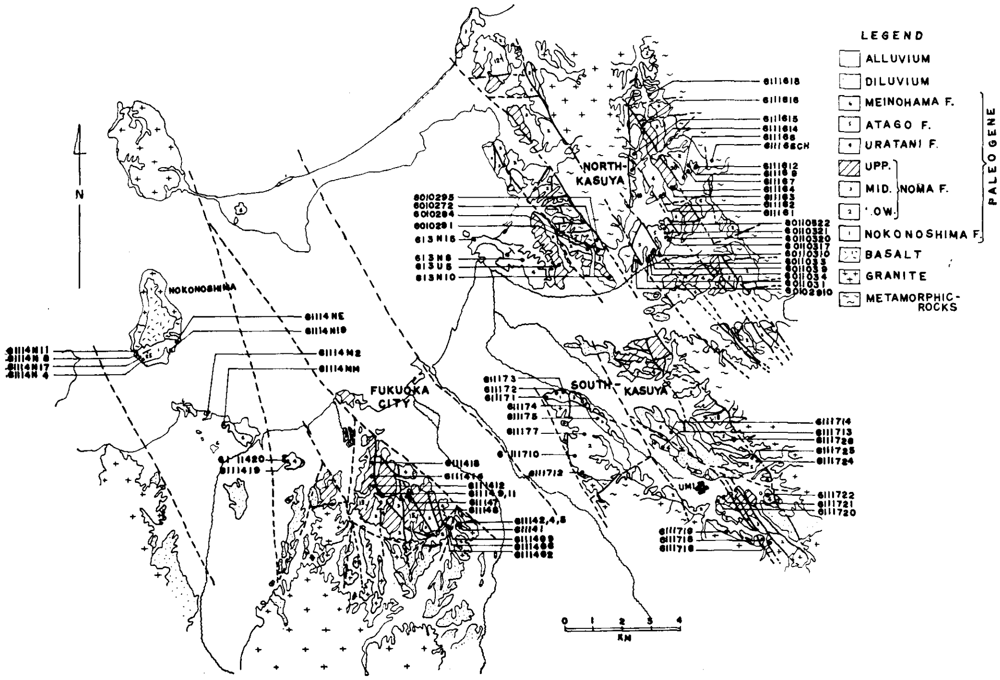

Fig. 3-D. Geologic map and localities of the sandstone samples of the Fukuoka coal field, after MATSUSHITA (1949a).

The sediments of the coal field are characterized by abundant pyroclastic matters such as andesitic or more acid volcanic rock fragments, and at the same time, by the intercalations of tuffs and tuffites in various horizons.

The Paleogene sediments of the field are divided into the following three groups in ascending order; the Fukuoka, Sawara, and Meinohama groups.

A. Fukuoka group

The group includes two formations, the lower Nokonoshima and the upper Noma; the former is exposed typically in Nokonoshima, comprising ill-sorted volcanic sandstones as a main component. Purple shales and tuffaceous shales are often intercalated. In tuffaceous shales of nearly the uppermost part of the formation well preserved plant remains are detected. A coal seam is also intercalated which is thin and not persistent.

The lower member of the Noma formation is chiefly composed of un-sorted sandstones, conglomerates, purplish grey shales and several coal seams; and thus it is main coal bearing formation in the field, especially in the Fukuoka area, in which two or three coal seams have been mined.

In the middle member of this formation, sandstones and shales are in alternation with interbedded conglomerates, and in addition, tuffaceous beds and thin coal seams are sometimes intercalated. In the coal seams blocks or fragments of silicified wood of various forms are abundantly contained.

The upper member of the formation is composed of sandstones and alternating layers of sandstone and shale, but, among which sandstones change easily to conglomerates. Fossil leaves- and silicified-woods bearing coal seams are interbedded in the member, most of them, however, are too thin to be worked.

B. Sawara group

This group is generally divided into two formations, the Uratani and Atago. The lower one, the Uratani, is overlying the Fukuoka group mentioned before with a slight unconformity, and consists predominantly of tuffaceous sandstones and shales of the same nature. The sediments are, as a whole, reddish brown to reddish white in color.

The upper formation, the Atago, is one of the important coal bearing formation in the Fukuoka area, however, it is not exposed on the ground but in the subsurface of the Sawara Colliery. It consists of thick white sandstones and often intercalates shales in small amount. Muddy sandstones in the lower part include marine fossil fauna abundantly.

C. Meinohama group

The group lies unconfomably on the above mentioned group. It consists, as a whole, of massive sandstones and conglomeratic sandstones. It is of marine and most sandstones contain many glauconite grains and fossils of marine mollusc, which are represented by the "Ashiya fossil fauna".

V. Munakata coal field

The Paleogene sediments, which are here lumped under the name of the Munakata group, overlie unconformably the basements (the Mesozoic Kwanmon group, porphyrite and granite) and are divided into the following five formations in ascending order, the Ryoganji, Tare, Sobaru, Yoshida, and Ikeda.

The Ryoganji formation is composed mainly of ill-sorted purplish green sandstones and shales, and sometimes intercalates thin coal seams in the southern part of the field, which, however, have never been worked at any colliery.

The Tare formation consists mainly of un-sorted sandstones of light brown in color and a few shales, sometimes intercalating several coal seams.

The Sobaru formation, overlying conformably the Tare formation, is the most important coal bearing formation in the field. Sandstones, shales, and alternating layers of sandstone and shale are predominant. Fragments of silicified wood are contained in coal seams in a few amount.

The Yoshida formation is represented by the succession of alternating layers of

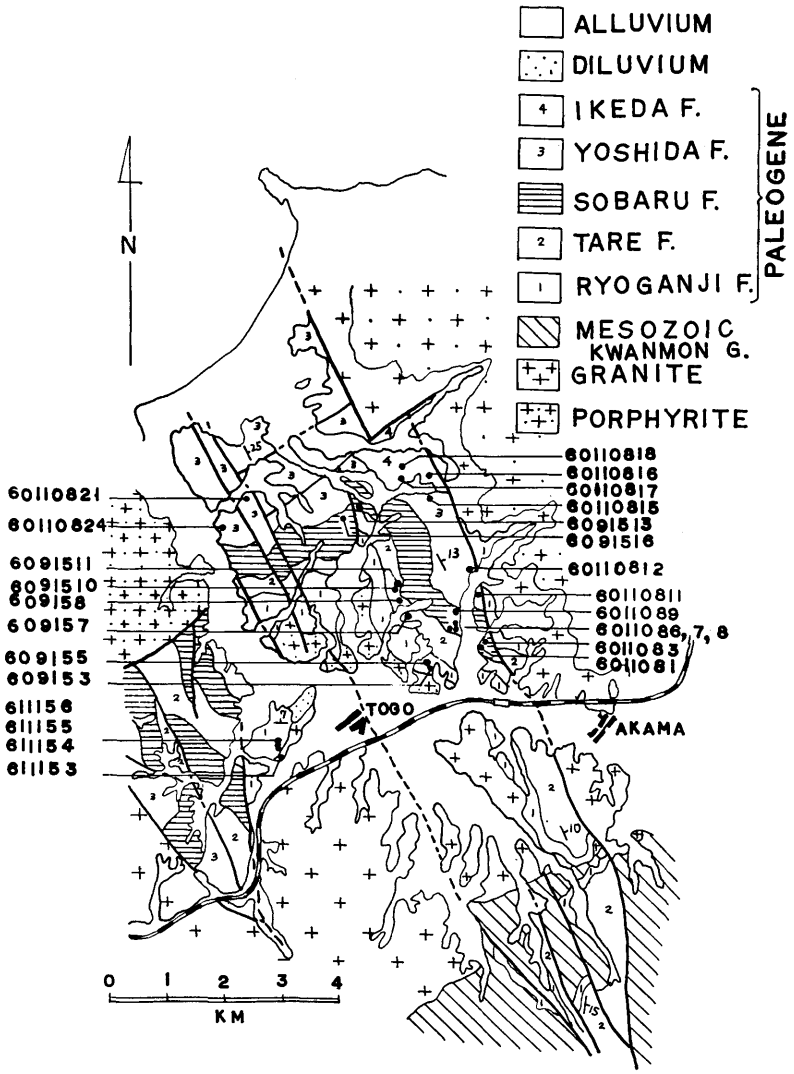

Fig. 3-E. Geologic map and localities of the sandstone samples of the Munakata coal field, after MATSUSHITA (1949a).

sandstone or conglomeratic sandstone and shale. Purple shales are often intercalated, but as their color changes easily into reddish brown by weathering, it seems to be of different nature from that of the Akasaki formation of the Amakusa coal field.

The Ikeda formation consists of a thin basal conglomerate and succeeding alternations of grey sandstone and shale, in which coal seams and flinty tuffaceous beds are intercalated.

VI. Chikuho coal field

In spite of the wide distribution of the Paleogene sediments throughout the coal field, the specimens for heavy mineral analysis have been taken from the southern

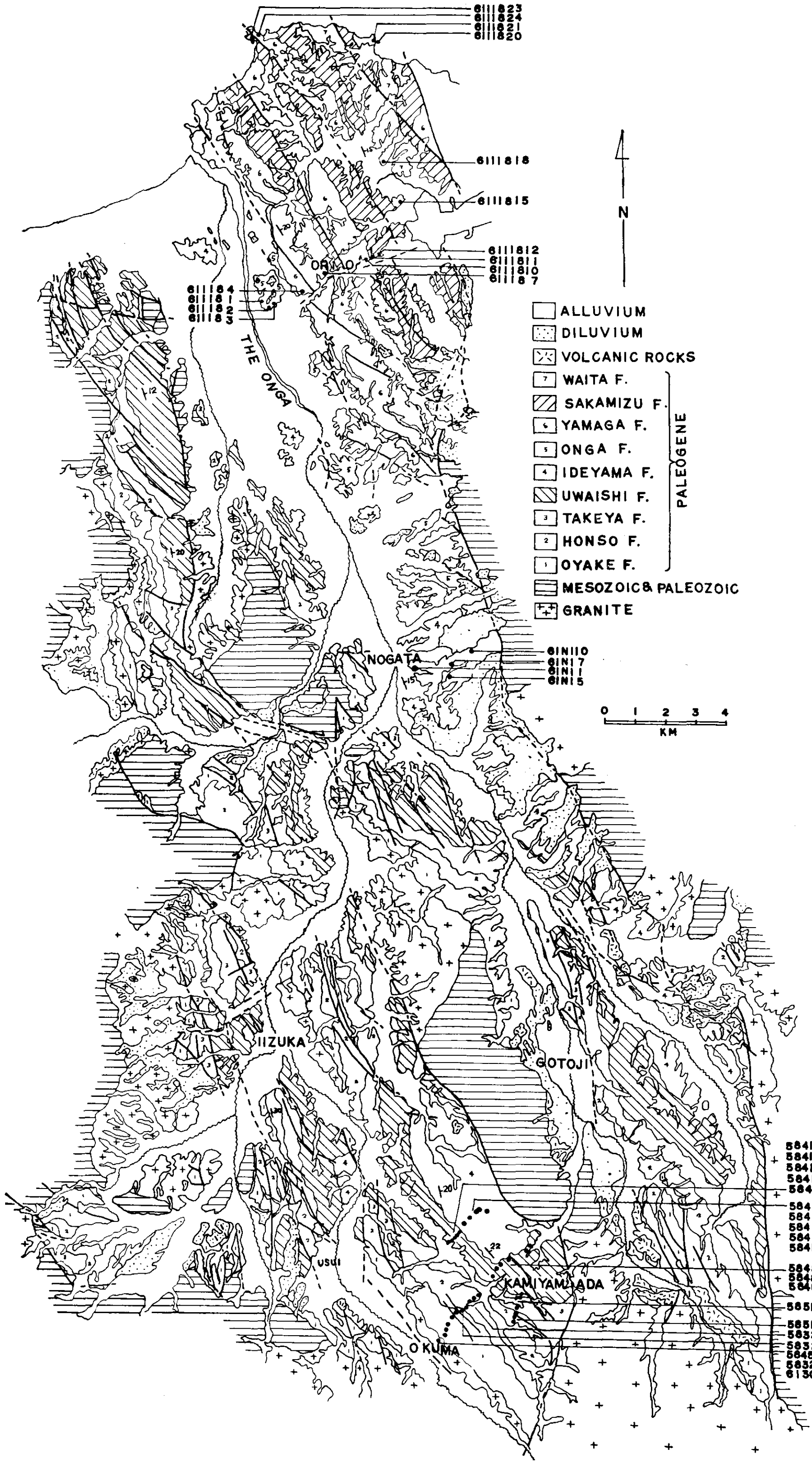

Fig. 3-F. Geologic map and localities of the sandstone samples of the Chikuho coal field, after MATSUSHITA (1949a).

and northern areas of this field. To clarify the stratigraphy the summarized explanation covers the whole area of the field.

The Paleogene sediments are divided into three groups; they are the Nogata, Otsuji, and Ashiya.

A. Nogata group

The group is divided into four formations, the Oyake, Honso, Takeya, and Uwaishi in ascending order. It overlies unconformably the basement granite in the area from Okuma to Kamiyamada, whereas in Usui village it overlies likewise the green schist.

The Oyake formation consists mainly of ill-sorted very coarse grained sandstones with intercalations of greenish blue grey shales and workable coal seams. The formation is mostly poor in fossil, excepting its lower part in which several sorts of molluscan fossil have been detected, and named by H. MATSUSHITA as the "Yoshikuma fossil zone".

The Honso formation is the most important coal measures in this field, especially in the central part of the field, including many thick workable coal seams. Prevailing lithofacies is sandstones and alternations of massive sandstone and shale. Besides, a conglomeratic sandstone bed is commonly intercalated in the basal part. Shale beds yield rarely marine fossil fauna and plant remains too.

The Takeya formation is overlying conformably the Honso formation mentioned above. It consists predominantly of reddish brown sandstones and shales accompanying with some workable coal seams.

In the Uwaishi formation ill-sorted sandstones and shales are its main component which alternate commonly with conglomeratic sandstones, conglomerates or sometimes with coal seams. So-called "Kamiyamada fossil zone" named by T. NAGAO is recognized in the middle part of the formation.

B. Otsuji group

The group is lying with a slight unconformity on the Nogata group, and is divided into two formations.

The lower Ideyama formation consists mainly of heavy bedded conglomeratic sandstones with intercalations of thin layers of shale and coal or coaly shale. Sediments have a tendency of changing color to reddish brown by weathering like those of the Takeya formation; and in addition, its lithofacies also tends to change laterally. As another noticeable feature, sandstones of this formation show mostly remarkable cross-laminations.

The Onga formation is economically important in production of coal, and is chiefly composed of massive white sandstones and shales, but toward the upper part bluish grey sandstones and grey shales become prevalent and intercalate few workable coal seams.

C. Ashiya group

The group comprises three formations, the Yamaga, Sakamizu, and Waita in ascending order, and it contains numerous characteristic fossils of marine mollusc throughout the group which are called "Ashiya fossil fauna".

The Yamaga formation is composed, in ascending order, of a basal conglomerate, bluish green banded thick sandstones containing glauconite grains, thick black shales alternated with thin layers of sandstone and alternations of sandstone and shale.

The Sakamizu formation is made up of glauconite bearing coarse to fine grained sandstones and grey shales with intercalations of thin layers of sandstone and tuffaceous shale.

In the Waita formation shales and white sandstones are predominant, but toward the upper horizon muddy fine grained sandstones become prevalent.

VII. Karatsu coal field

The Tertiary system, for the most part, is in contact with the basement granite and schist by the faults but in some localities it lies unconformably over them. It is divided into the lower Ochi and the upper Kishima group.

A. Ochi group (Oligocene)

The group is further divided into three formations, of which the lower one is named the Utsubogi, the middle Yashiro and the upper Yoshinotani.

The lower one is, in the most, of marine and composed of massive sandstones and shales, in which one workable coal seam and also many kinds of molluscan fossil are found.

The middle one is characterized by massive sandstones. Shales are of reddish brown color, containing abundant marine molluscan fossils, and to the sequence of

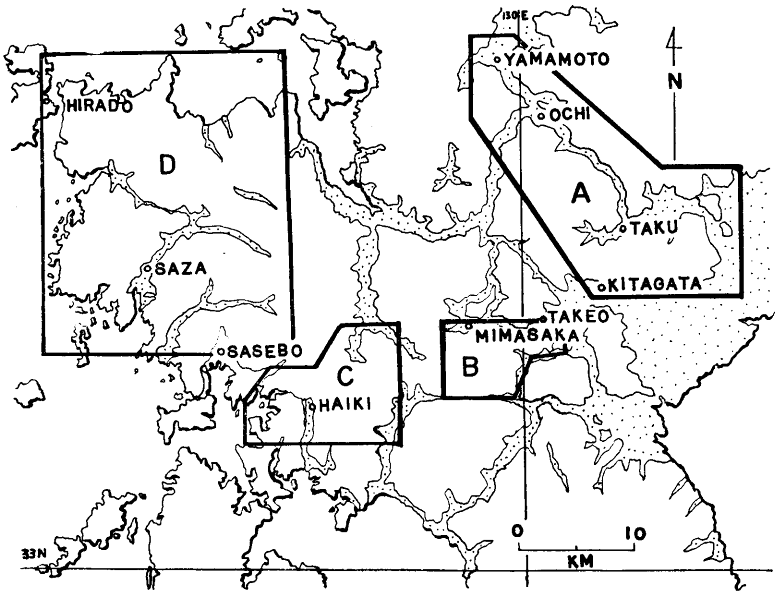

Fig. 3-G. Index map of sampling locality maps in the Karatsu and Sasebo coal field.

A. : Taku-Yamamoto area.
B. : Mimasaka area.
C. : Haiki area.
D. : Sasebo-Hirado area.

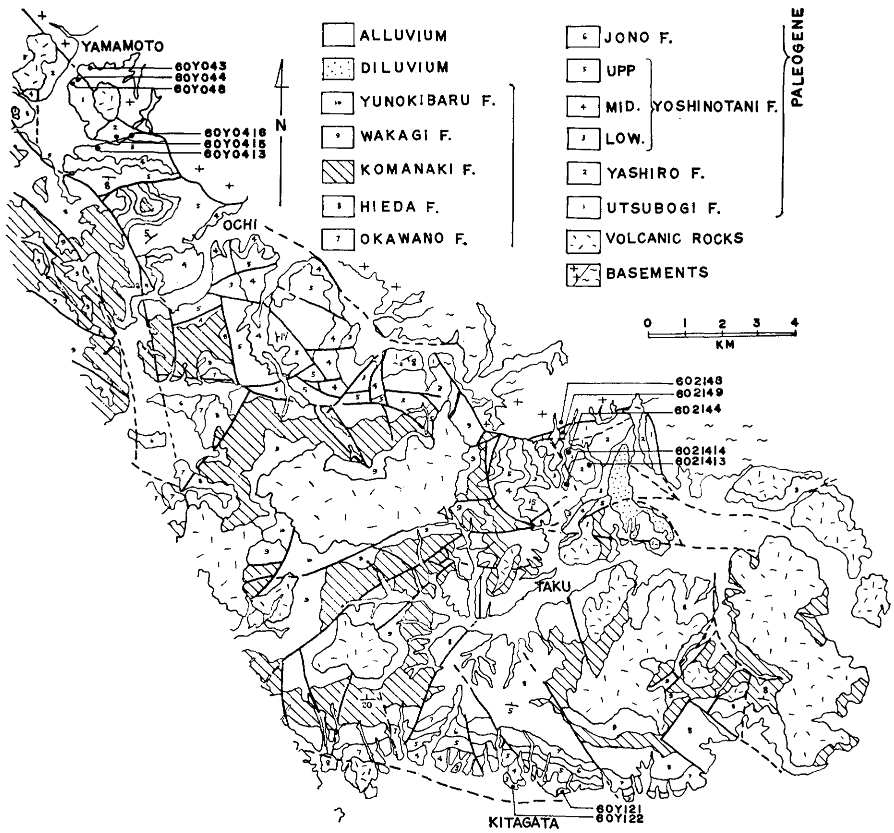

Fig. 3-G-A. Geologic map and localities of the sandstone samples of the Taku-Yamamoto area in the Karatsu coal field, after MATSUSHITA (1949a).
(Jyono F. + Okawano F. = Kishima F., Hieda F. ≅ Magarikawa F., Komanaki F. ≅ Mikawachi F., Wakagi F. ≅ Haiki F., Yunokibaru F. ≅ Daito F.)

fossil bearing shale the name "Karatsu fossil zone" is given.

The Yoshinotani formation is a coal bearing formation and is hence the most important in economical aspect. Consequently its stratigraphical sequence has been investigated in detail; it consists, in ascending order, of an alternation of white massive sandstones and shales associated with some coal seams, including fossil flora and fauna, cliff-making white medium grained sandstones accompanied with thin layers of shale and many coal seams, and massive white sandstones and alternations of sandstone and shale with intercalations of tuffaceous beds. Plentiful plant fossils are detected in the covered rock of the Kishima-goshaku coal seam.

B. Kishima group

The group is divided into the following five formations, the Kishima, Magarikawa, Mikawachi, Haiki, and Daito. They are mostly marine sediments.

The Kishima formation has a thin conglomerate or conglomeratic sandstone in the basal part and consists mainly of an alternation of muddy sandstone and grey to brown colored shale.

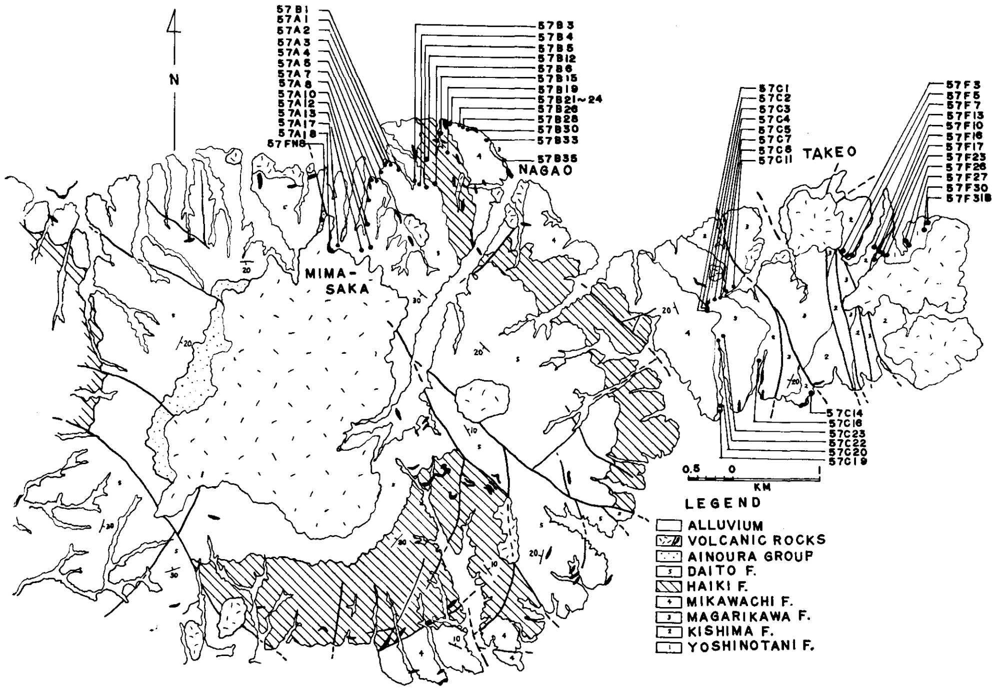

Fig. 3-G-B. Geologic map and localities of the sandstone samples of the Mimasaka area in the Karatsu coal field, after OHARA (1958) and INOUE (1958).

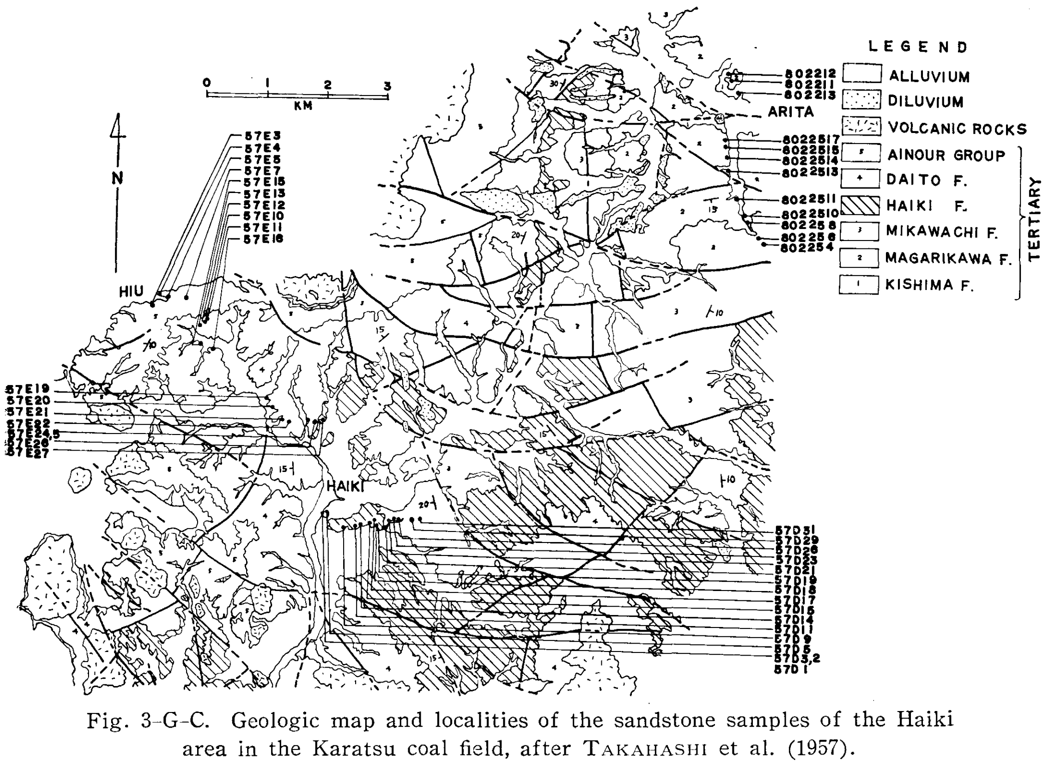

Fig. 3-G-C. Geologic map and localities of the sandstone samples of the Haiki area in the Karatsu coal field, after TAKAHASHI et al. (1957).

The lower part of the Magarikawa formation laying on the Kishima formation is composed of massive coarse grained sandstones with intercalations of thin conglomerates, whereas in the middle and upper parts of the formation black shales and alternations of sandstone and shale gradually prevail. The alternation often intercalates tuffs and tuffites.

The Mikawachi formation is predominantly composed of massive fine to medium grained muddy sandstones including plant drifts and alternating layers of sandstone and shale with intercalated tuffaceous shales.

The Haiki formation is chiefly composed of muddy sandstones, very fine grained tuffaceous sandstones and alternating layers of sandstone and shale.

The Daito formation consists of basal conglomerate and successive alternations of sandstone and shale. Sandstones are mostly well-sorted quartzose in nature and white to grey in color, and differ from those of the lower four formations.

VIII. Sasebo coal field

The Tertiary sediments of this field comprise three groups, the Ainoura, Sasebo, and Nojima, and one formation, the Hirado.

A. Ainoura group (Miocene ?)

The group overlies conformably the Kishima group, but in the north-eastern margin of the field the group lies directly with an unconformity on the basement granite. Cliff-making white quartzose sandstones are mostly prevalent and often cross-laminated, with intercalation of conglomeratic sandstones, shales and several workable coal seams. As a whole, the group is relatively fossiliferous, and indeed, the " Masaru fossil zone " is present in the upper part.

B. Sasebo group (Miocene ?)

The group comprises five formations, and in each of which a few workable coal seams are intercalated. In general, well-sorted and quartzose sandstones like those of the Ainoura group are predominant.

The Nakazato formation consists mainly of massive sandstones and shales, and in the uppermost horizon the coal seam, Yunoki-sanmai, is intercalated. The " Oze " and the " Fukushima fossil zone " are recognized in the formation.

In the overlying formation, the Yunoki, white to light brown sandstones are dominant, and very frequently conglomerates and shales are intercalated. Of the coal seams in this formation the Yunoki-nimai is the most wide-spread and important, and the roof of this coal seam includes many fossils of marine fauna which is named the " Ikeno fossil zone ".

The Sechibaru formation is occupied mainly by dark colored shales with intercalated white sandstones. The " Sechibaru fossil zone " needs special attention to its contents, because it is characterized by fresh water molluscs and plants.

The Fukui formation is also characteristic in predominance of dark grey shales with white sandstones, whereas alternation of sandstone and shale become predominant upward, in which coal seams, coaly shales, and tuffite are frequently intercalated. The " Yatake fossil zone " situated above the Sunaban coal seam contains many sorts of fossil mollusc and fossil plants.

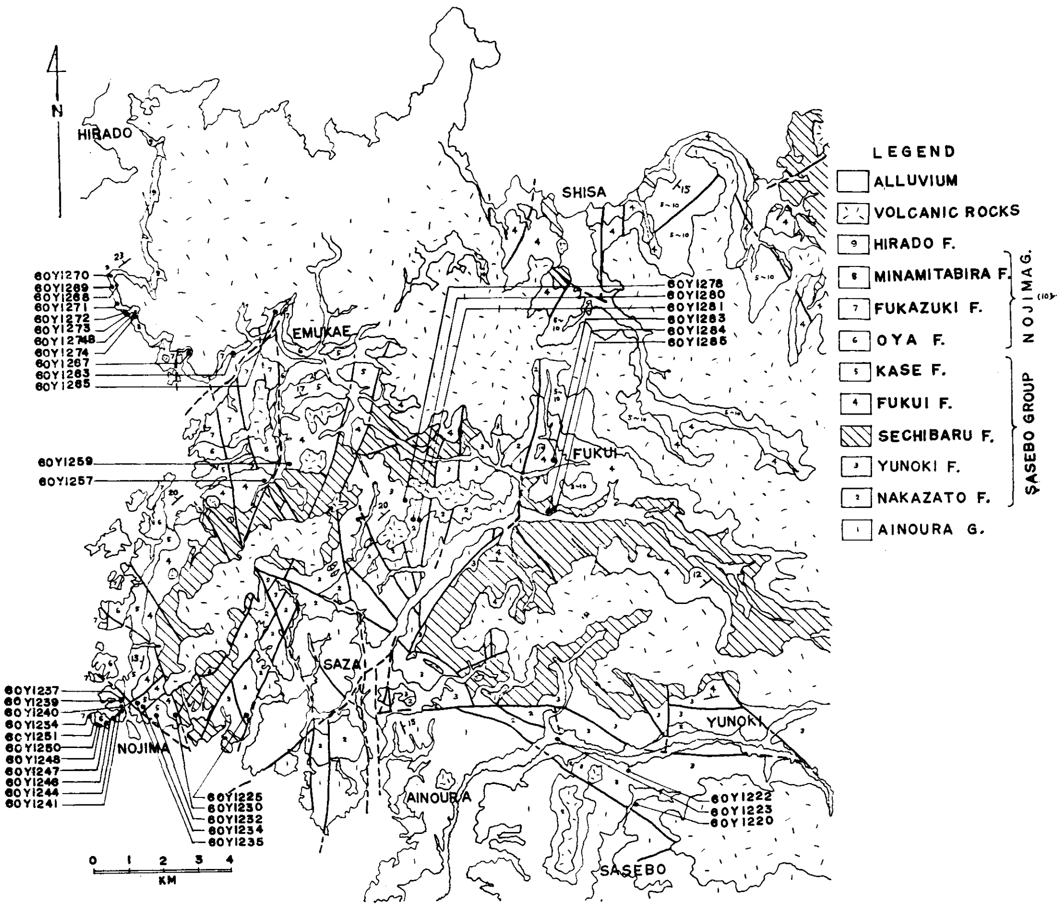

Fig. 3-G-D. Geologic map and localities of the sandstone samples of the Sasebo-Hirado area in the Sasebo coal field, after MATSUSHITA (1949a) and URATA (1956).

The Kase formation is composed mainly of white medium to fine grained sandstones with interbedded conglomeratic sandstones, black shales, and alternations of sandstone and shale. The sandstones are in general massive and sometimes cross-laminated and on the bedding planes of the sandstone obvious ripple marks are often met with.

C. Nojima group (Miocene)

The group overlies with a slight unconformity the Sasebo group, and is composed of the following three formations in ascending order, the Oya, Fukazuki, and Minamitabira.

The Oya formation is striking in enrichment of tuff and tuffite, but, as a whole, it consists mainly of alternations of sandstone and shale with interbedded thin coal seams or coaly shales. It contains also many fossils of fresh water mollusca such as *Lamprotula*, *Bellamya* etc., in the lowest horizon which is called the "Nojima fossil zone".

In the Fukazuki formation massive sandstones and alternations of sandstone and shale are mostly dominant, but in the basal part andesitic tuff breccia is the prevailing component.

The Minamitabira formation is chiefly composed of alternations of medium to fine grained well-sorted sandstone and blue shale with intercalated thin coal seam or coaly shale.

D. Hirado formation (Pliocene ?)

The formation lies unconformably on the Nojima group. It is predominant of well-sorted loose quartzose sandstones, sandy shales, and shales.

Brief notes on sampling and preparation

The sandstone specimens for heavy mineral analysis have been carefully selected among many typical sandstone samples collected from the exposures in respective coal field, and moreover several rock specimens from the basements have been added. The total number of the samples studied is 400.

Each specimen of about 200～300 gr. in weight is crushed with stamp-mill till crushed grains pass through a sieve of 60 mesh (0.25 mm. opening). After repeated quartering, the crushed specimen of 15 gr. is weighed out, and afterwards cleaned up by water. Then it is gently boiled with dilute HCl for about 10～15 minutes on a waterbath. Thus the sample for separating heavy minerals is ready, and for this procedure Thoulet's solution of S.G.=2.9 is used.

The frequency of heavy minerals is obtained in the following ways; first, respective frequency is calculated with regard to mica, chlorite, iron ores, and "other translucent havy minerals (zircon, garnet, tourmaline etc.)", excepting authigenic minerals such as glauconite and/or anatase; and second, "other translucent minerals" mentioned above are furthermore sorted out. The frequencies of zircon, garnet, tourmaline etc. are obtained in this way. On the other hand, frequencies of authigenic glauconite and authigenic anatase are calculated in the following way; (No. of authigenic mineral grain/No. of authigenic mineral grain+No. of "other translucent minerals" grain)×100 (%). To check the ratio of amount of authigenic mineral and that of other detrital minerals, it is better to except micas and chlorite from detrital minerals, because these micas and chlorite tend to often appear in excess in sandstone.

Descriptive notes on kinds and natures of heavy minerals

The kinds and natures of heavy minerals obtained from sandstones in the coal fields mentioned above are summarized in the Table 1. They are apparently common rock forming minerals such as zircons, garnets, tourmalines, epidote, rutile etc., but sometimes staurolite, piedmontite, glaucophane etc. are rarely found. These minerals seem to be particularly noteworthy.

Zircon; It is largely euhedral prismatic colorless grain, but sometimes rounded colorless, needle shaped colorless, purple and brown grains appear. With regard to crystal form and color, two varieties of purple zircon are distinguished; the one is of dark purple and mostly rounded, and the other is of light pinkish purple and euhedral or rounded. In brown zircon zonal structure is generally recognized. Authigenic outgrowth is sometimes met with.

Tourmaline; It occurs as angular fragment or prismatic crystal, or frequently as rounded form, too. According to color and form, tourmaline can be divided into the following fourteen varieties; at first, due to color; brown (light brownish orange), green, greenish brown, dark brown, reddish brown, blue, grey, bluish grey, greenish grey, light purple, dark green (light pink [E] to dark green or nearly black [O]), and greenish blue; the last two of which are further divided into two varieties respectively regarding to its form; namely, the dark green tourmaline comprises fragmental or prismatic crystal and fibrous varieties, and in the greenish blue tourmaline, prismatic crystal-grain and aggregation of minute crystal are found.

Garnet; It mostly occurs as angular fragment but rarely as rounded crystal and due to its color five varieties are discriminated; colorless, pink, orange to brown, yellow, and green.

Hornblende; It is found in color of green, greenish brown, and brown, and is mostly common-hornblende, but rarely tremolite (?). They occur as subangular prismatic fragments and sometimes as very angular fragments with hack-saw terminal.

Pyroxene; It is represented by rhombic pyroxene (hypersthene? and enstatite?) and monoclinic pyroxene (augite?) and occurs as angular grains or rounded prisms. Grains are usually larger in diameter than those of other associated heavy minerals.

Epidote group (epidote and zoisite); It is found as angular or subangular grain; it is mostly colorless, yellow or light greenish yellow in color but one grain collected from the Munakata coal field is light pink.

Piedmontite; A very small and angular grain is found in the sandstone from the Sasebo coal field.

Glaucophane; It is rarely found as subangular grain.

Monazite; It is a rare component but universally occurs in the specimens, being mostly as rounded crystals. Its color is light yellow or greenish yellow. Many scratches are usually found on the crystal surface.

Staurolite; It is characterized by hackly fracture, high index, weak magnetism (nearly equal to those of tourmaline and epidote), special pleochroism (X=colorless, Y=pale yellow, Z=golden yellow), and many inclusions etc. It is found in the restricted horizons of the Tertiary (the Minamitabira and the Hirado formation of the Sasebo coal field). Although staurolite is common in sediments of foreign countries such as U. S. A., Germany or Britain, it has hitherto been found very rarely in the Japanese sediments (ICHIMURA and AOKI, 1957; AOKI, 1957 and 1958).

Rutile; It occurs as rounded or angular grain, and according to color some varieties are distinguishable; it is mostly golden yellow and blood-red, rarely purplish grey, brownish grey and yellowish green. Rounded geniculate twin is rarely found.

Titanite; It is found as angular and brownish grain.

Micas; It includes muscovite and biotite (varieties of brown, reddish brown, and green in color are recognized). Some of them include numerous needle shaped rutiles.

Ripidolite (?) (=iron-magnesium chlorite); It occurs as mica-like flakes and is light green or green in color. Retardation is very low and the interference color is abnormal (deep indigo-blue or dark brownish blue, or almost isotropic).

The mineral+ in the sandstone of the Sakito coal field (in the Kakinoura formation, written as "green mica-like mineral", [OHARA, 1961b]) has been determined as the chlorite mineral by X-ray diffractometer, and through the measurements of the [d] spacings of (060) and (0010) reflections, the following cell dimensions have been determined: d(001)=14.14Å, b_0=9.29Å. From these values the chemical composition of the chlorite can be estimated as Fe : Mg ≅ 1 : 1 and Al no. in 4(Si, Al)=1.37 (Figure 3. in [SHIROZU, 1960]). (+Frantz Isodynamic Separator was used for separation.)

The green mineral in the sandstones of the present study, shows optically very similar nature to the chlorite (ripidolite) described above. (In the Sakito coal field, ripidolite is found not only as separated flakes but also as rock-forming minerals of the schist grains in the sandstone).

Iron ores; Limonite, ilmenite (partly changes to leucoxene), magnetite, hematite, and authigenic pyrite appear as opaque matter.

Glauconite and Anatase; They are authigenic in origin and occur in the most of sandstone specimens. Anatase is of tabular or acute bipyramidal form in which several color-varieties are distinguished, such as nearly colorless, light yellow, brown, blue, and dark blue.

Heavy mineral content

The amounts of heavy residues in the specimens studied are shown in Table 1 and Figure 4. The sandstones from the Tertiary coal fields in the northern Kyushu mostly include heavy residues of less than 1 per cent in weight. In some specimens such as tuffs or tuffites and sandstones which bear authigenic glauconite and/or pyrite abundantly, the amount of heavy residues is larger than that in the other sandstone specimens of the same formation in which such tuffites or sandstones are interbedded.

The average content (per cent in weight) of heavy residues for each formation will be commented in detail as follows, but it must be noticed that in calculating procedure a number of samples of sandstones containing abundant authigenic minerals and of tuffs or tuffites are omitted.

I. Amakusa coal field

A. Kamishima area

Basement; The specimen is a very-fine grained sandstone taken from the Mesozoic Himenoura group. Its heavy mineral content amounts to 0.1 per cent in weight.

Akasaki formation; shows generally very high content being 11.2 per cent on the average, while that of one specimen exceptionally runs up to 17.2 per cent, being the largest value among those of the sandstones observed in the present study.

Shiratake formation; presents extremely small content, ±0.05 per cent.

Tanasoko formation; represents only 0.3 per cent.

Kusubo and Sumoto formations; Each shows nearly the same amount, counting 0.4 per cent.

Toishi formation; contains rather large amount of 0.5 per cent.

Itchoda formation; shows large content rising up to as much as 1.4 per cent, but it is in part due to content of various authigenic pyrite and glauconite.

B. Shimoshima area

Basement; The mica-schist in Takahama includes heavy residues of only 0.3 per cent, but the other green-schist in the same area presents large amount of heavy mineral content, being 36.6 per cent.

Fukami formation; counts 0.2 per cent for heavy minerals and it is extremely and significantly small, if compared with that of the corresponding formation, the Akasaki in Shimoshima.

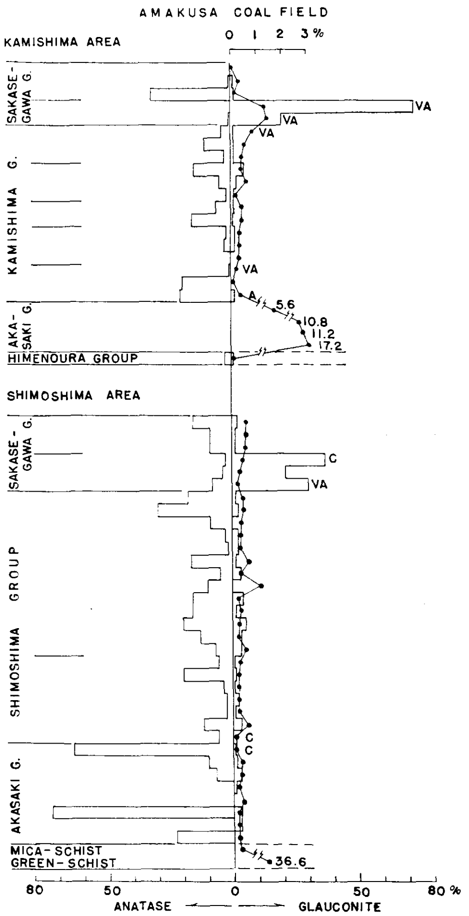

Fig. 4-A.

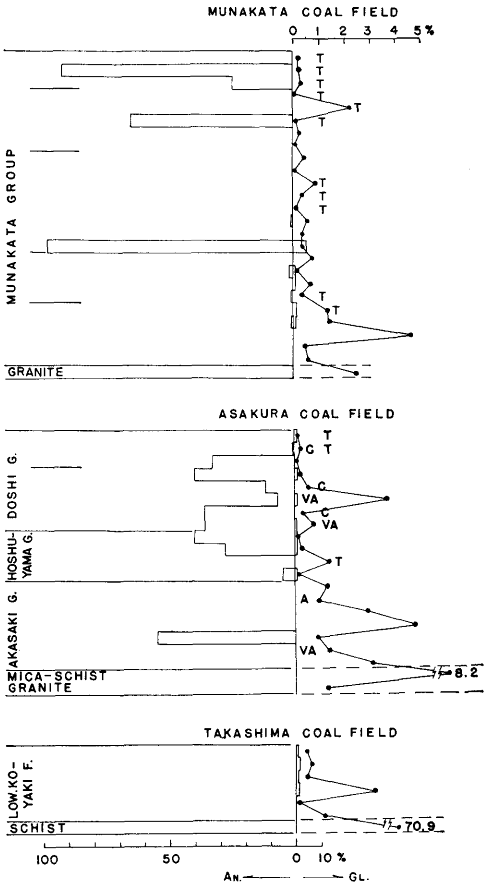

Fig. 4-B.

Fig. 4. Graphs showing amounts of heavy minerals and frequencies of authigenic minerals.

Top scale: for amount of heavy minerals. Bottom scales: right; for frequency of glauconite, left; of anatase. T: Tuff or tuffite. Pyrite: C; common, A; abundant, VA; very abundant.

Shikiyama formation; shows 0.3 per cent, almost equal to that of the Tanasoko or the Sumoto formation.

Toishi formation; presents a content of heavy residues 0.3~0.5 per cent.

Itchoda formation; occupies nearly 0.3 per cent for heavy minerals excepting for authigenic minerals.

Sakasegawa formation; shows 0.5 per cent heavy mineral content, being higher than that of the same formation in Kamishima.

II. Takashima coal field

In the basement schist the content of heavy minerals amounts to as much as 70.9 per cent in weight.

Koyaki formation; shows relatively high content, being 0.95 per cent, which is higher than those of the sandstones in the other formations of the same field.

III. Asakura coal field

Basements; In the granite the content of heavy minerals runs up to 1.2 per cent, and in the mica-schist it rises up to as much as 8.2 per cent.

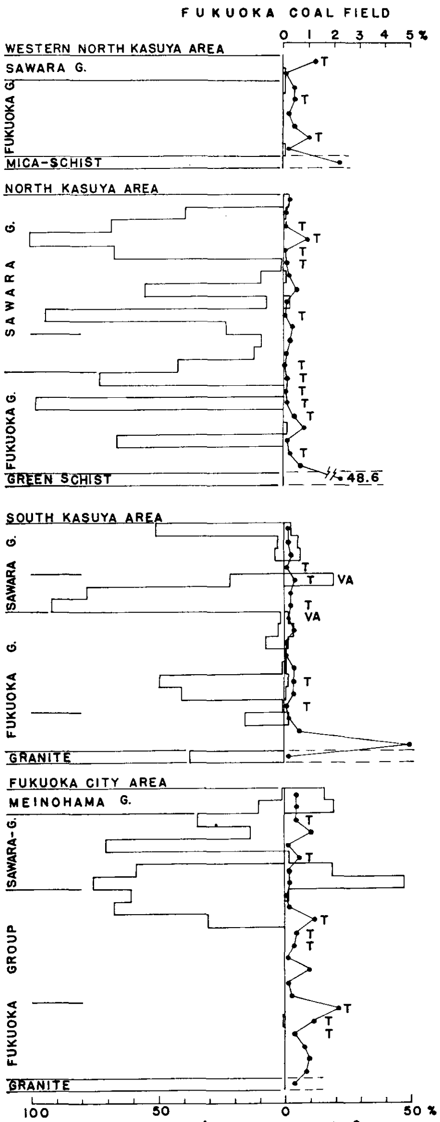

Fig. 4-C.

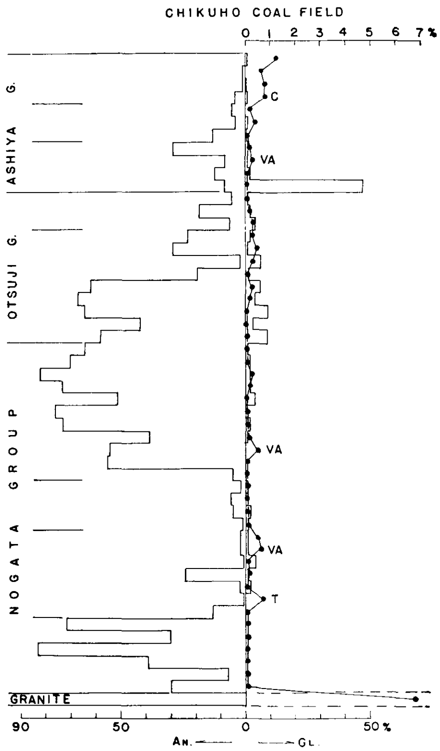

Fig. 4-D.

Yamanokami formation; shows the highest content among the formations of this coal field, being 2.5 per cent.

Hoshuyama formation; contains heavy minerals of about 0.1 per cent.

Kawamagari formation; counts ±0.3 per cent for heavy minerals, showing a higher amount than that of the Hoshuyama formation.

Doshi formation; presents the minimum value of 0.1 per cent heavy minerals.

IV. Fukuoka coal field

Basements; The granite contains heavy minerals of 0.1 to 0.3 per cent, but the schists present extremely high percentage as 2.2 (in the northeastern Kasuya) and 48.6 (in the northwestern Kasuya).

A. Fukuoka city area

Nokonoshima formation; shows one of the highest content of heavy minerals in the area, being 1.0 per cent.

Noma formation; presents a content of 0.2 per cent heavy minerals.

Uratani formation; presents likewise 0.3 per cent in weight.

Meinohama formation; contains a large amount of heavy residues of 0.4 per cent, compared with the others.

B. Kasuya area

Nokonoshima formation; shows the largest amount in this coal field, being 1.8 per cent.

Noma and Atago formations; The lower member of the Noma formation counts 0.2 to 0.4 per cent for heavy residues. The middle and upper members and the Atago formation present common value of 0.1 to 0.3 per cent.

V. Munakata coal field

The basement granite contains heavy residues of 2.4 per cent.

Ryoganji formation; shows the highest content of heavy minerals in the sandstones of this coal field, being 1.6 per cent on the average.

Tare formation; presents considerably high amount, that is 0.5 per cent.

Sobaru formation; contains 0.3 per cent for heavy residues.

Yoshida and Ikeda formations; show the smallest amount in the field, being 0.2 per cent.

VI. Chikuho coal field

The formations of this coal field mostly contain the small amount of heavy residues, being 0.2 per cent or less in weight. Their amounts are really small compared with those of the other formations in different coal fields in the northern Kyushu, but in the Ideyama and Waita formations, they rise up exceptionally to large amount.

The basement granite contains amount of 6.8 per cent for heavy minerals in weight.

Oyake and Takeya formations; show likewise small amount, being 0.08 per cent in the former and 0.06 per cent in the latter.

Honso, Uwaishi, Onga, Yamaga, and Sakamizu formations; present about 0.2 per

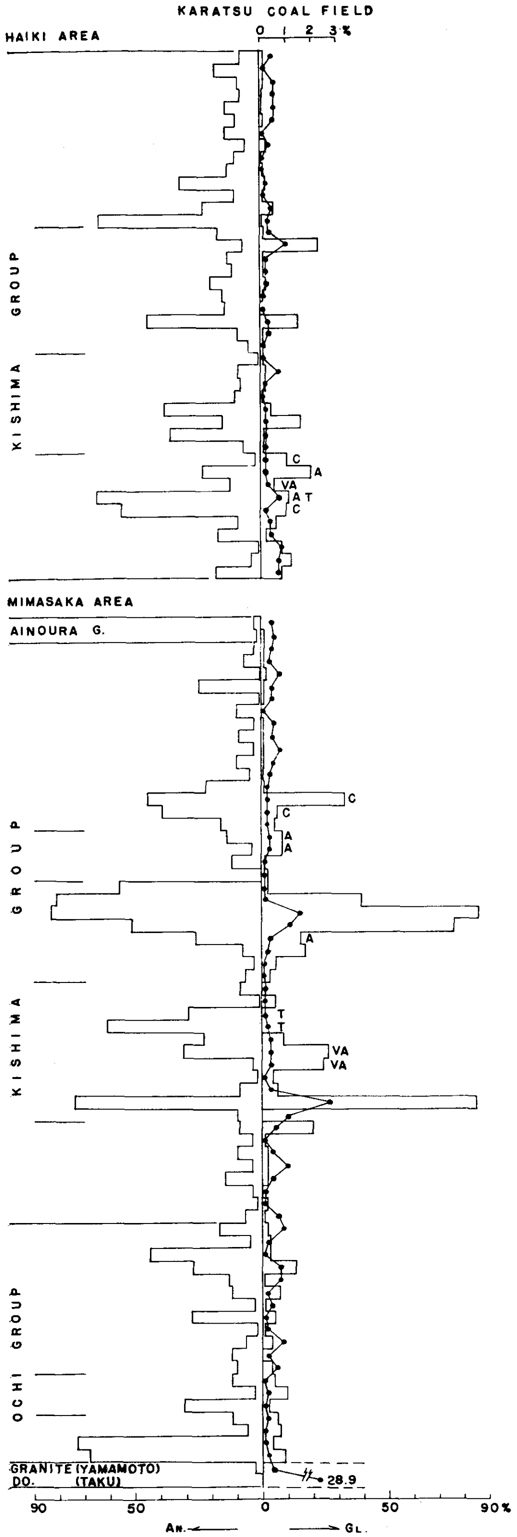

Fig. 4-E.

cent for heavy mineral indices.

Ideyama formation; shows 0.1 per cent in the lower part and 0.4 per cent in the upper.

Waita formation; presents the largest amount of 0.9 per cent as above mentioned.

VII. Karatsu coal field

The amount of heavy minerals in the basement granite varies place to place as being 0.4 per cent at Yamamoto and 28.9 per cent at Taku.

In general, heavy residues are abundantly contained in the sandstones of the lower formations of the coal field, ranging from the Utsubogi to Kawamagari formation. Their amounts show 0.4 to 1.3 per cent, but toward the upper part in the Kawamagari formation (=the Haruake member) they

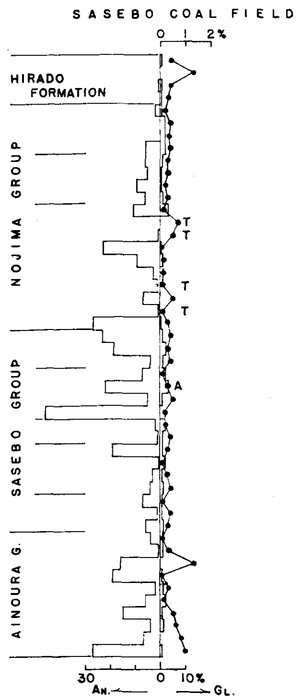

Fig. 4-F.

decrease to 0.1 to ±0.05 per cent.

The upper formations of the coal field (the Mikawachi, Haiki, and Daito formations) show 0.1 to 0.3 per cent for heavy mineral content.

VIII. Sasebo coal field

The most of sandstones include commonly 0.3 to 0.4 per cent heavy minerals, but those of the Oya formation are of relatively small amount such as 0.2 per cent on the average. In the Hirado formation, the upper most one of the coal field, abundant heavy residues of 0.6 per cent in weight are contained.

Heavy mineral composition

In the Tertiary coal fields of the northern Kyushu, the successive sequences are generally divisible into some "heavy mineral zones" by means of "heavy mineral composition". The term "heavy mineral composition" in this paper is used in the meaning of "combination or association of heavy minerals and at the same time their frequencies". A "heavy mineral zone" means therefore that in the sandstones within a limited part of the stratigraphical succession, closely similar "heavy mineral compositions" are being kept; in another word, such a stratigraphical succession has special heavy mineral composition which is distinguishable from the others. Generally, in this study, one heavy mineral zone has tendency of covering one or more formations, but it is rarely limited to only half or a smaller part of a formation. A "heavy mineral zone" is discriminated from the other by means of revolution of

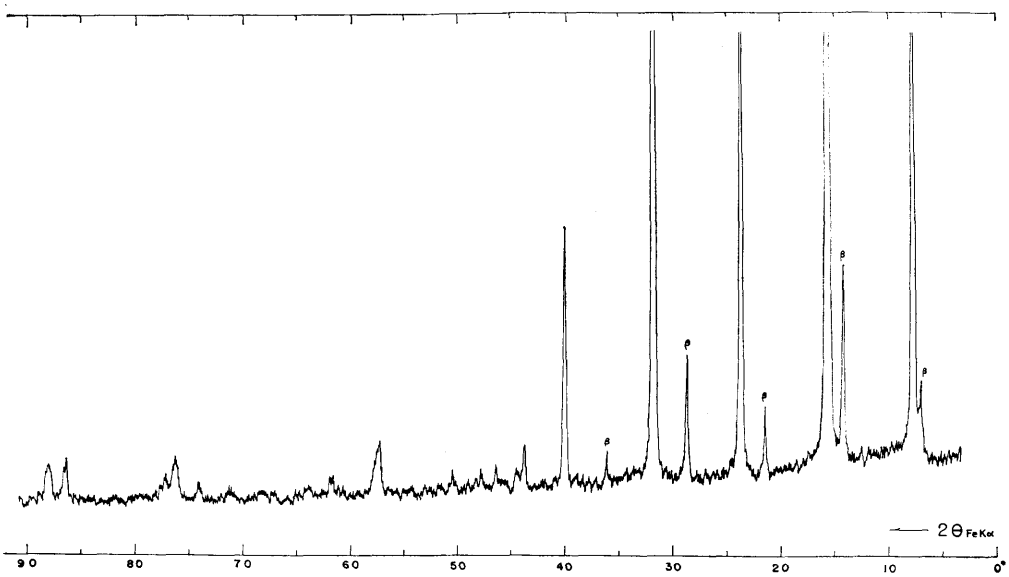

Fig. 5. X-ray diffractometer patern for chlorite (ripidolite) in the sandstone from the Sakito coal field.

Sample No.: 930, Hor.: the upper Kakinoura formation, Fe, 30 KV, 10 mA, Scan.: 2°/min., Mn filter.

index minerals and/or by difference of not less than 20 per cent in frequency of a certain heavy mineral.

The recognized heavy mineral compositions and zones are shown in Table 1 and Figure 6. The explanatory remarks of these heavy mineral compositions and zones in each coal field are as follows.

I. Amakusa coal field

Basements; One specimen of very fine grained sandstone from the upper Cretaceous Himenoura group is observed for heavy mineral analysis. Its heavy mineral composition is characterized by abundance* of colorless zircon and greenish brown tourmaline. As accessory component glauconite, anatase, and especially outgrowth zircon are found. Garnet is not present. The data concerning the heavy mineral composition of the Himenoura group in Kamishima are so scanty that it is extrmely difficult to establish any "heavy mineral zone" in the basement Himenoura group. But it is not impossible to give a rough outline of the heavy mineral composition of the sandstones in this group through the studies of OKADA (1961) and OHARA (1959 and 1960a). From the generallized data, it seems that there is a remarkable difference between the heavy mineral composition of the Himenoura group and that of the overlying Akasaki formation.

Fig. 6-A.

Fig. 6. Graphs showing heavy mineral compositions and heavy mineral zones.

* Dark green tourmaline: dark green, dark green (fibrous), greenish blue etc.

** Brown & green tourmalines: brown, green, greenish brown, and reddish brown.

The heavy mineral composition of the mica-schist in Takahama consists of predominant muscovite and colorless garnet, and less predominant epidote, and that of the green schist is composed exclusively of epidote. Garnet in the mica-schist is rather small (±0.03 mm. in diameter), euhedral, and colorless crystal.

Five heavy mineral zones, AM-1 to AM-5, in ascending order, are recognized in the Paleogene system of this coal field.

AM-1 zone; It corresponds to the Akasaki formation, and is characterized by extreme abundance of epidote. In all of the specimens observed the frequency of epidote reaches to 100 per cent. Colorless zircon, tourmaline, garnet, rutile, and magnetite are none or very rare if present. Glauconite, anatase, and outgrowth zircon are absent.

For the following reasons the heavy mineral composition of the Fukami formation is temporarily dealt with in this paper as AM-1′ zone; the first, the observation

* In this paper, the following terms are used to explain the heavy mineral composition.
"abundant" or "predominant" means approximately ±20~100 per cent in frequency.
"common"; ±10 per cent.
"present"; several per cent.
"rare"; ±1 per cent or less.
For further details, refer to Table 1 and Figure 6.

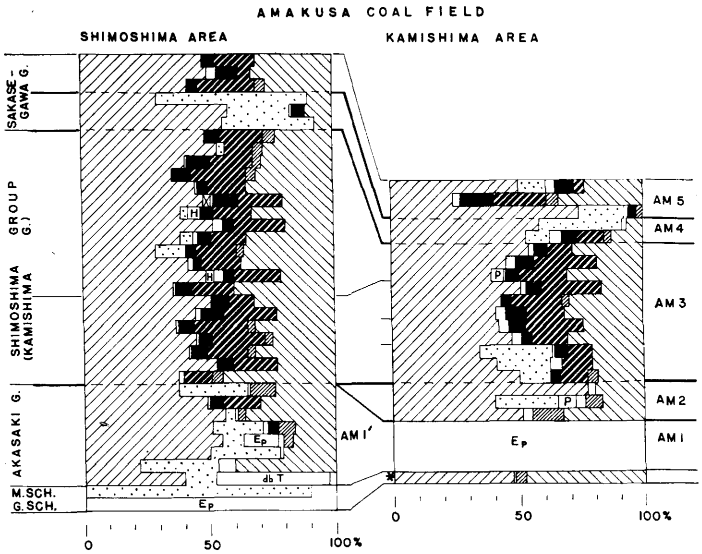

Fig. 6-B. (* Cretaceous Himenoura group)

of heavy mineral composition of this formation is limited to the specimens collected from the uppe part exposed on the route of Onabuchi to Rogi; the second, it represents a dominance of colorless zircon, green to brown tourmaline, and garnet, and characteristic presence of epidote and dark brown tourmaline. This composition is most similar to that of the main part of this formation in the Fukami area, but is different from that of the same formation in the Shimoda area (OHARA, 1959 and 1960a), and is still distiguished from that of the Akasaki formation excepting common property for the presence of epidote.

The Fukami formation has hitherto been correlated to the Akasaki formation, but the above mentioned differences in the heavy mineral composition are clearly found between these two formations, on the other hand, the dissimilarity of heavy mineral composition between the Fukami and the Fukuregi formation is also recognized (OHARA, ditto.).

AM-2 zone; It is recognized in the Shiratake formation and also occupies the Fukuregi formation (OHARA, ditto.). This heavy mineral composition is characterized by abundance of euhedral colorless zircon and tourmaline. Sometimes garnet is common, and pyroxenes and hornblendes are present, but purple zircon, rutile, and epidote are scarce. Outgrowth zircon in authigenic origin is rarely found.

AM-3 zone; The Tanasoko, Kusubo, Sumoto, Shikiyama, and Toishi formations are included in this zone. The heavy mineral composition of this zone has a special character in abundance of rounded colorless zircon, rounded tourmalines (especially, green, blue, and dark green ones), and rutile, and in commonness of purple and brown zircons. Garnet is scarcely found excepting in the Tanasoko formation. Outgrowth zircon is recognized in most specimens. Pyroxenes and hornblendes which are considered to be pyroclastic in origin are sporadically found.

Such a composition characterized by abundance of rounded colorless zircon, rounded tourmaline, rutile, and purple and brown zircons is found not only in the AM-3 zone but also predominantly in the sandstones from the Tertiary coal fields situated in the western margin of the northern Kyushu as will be shown in the later description.

AM-4 zone; It occupies the Itchoda formation. Euhedral colorless zircon, garnet, glauconite, and pyrite are predominant, and tourmaline is common but blue, green, and dark green colored varieties are scarce. Purple zircon and rutile are also rare. This type of heavy mineral composition noticeably differs from the above mentioned one in the AM-3 zone.

AM-5 zone; This zone is represented in the Sakasegawa formation. The composition of heavy residues is quite the same to that of the AM-3 zone, but in the Kamishima Island the frequency of purple zircon is rather low.

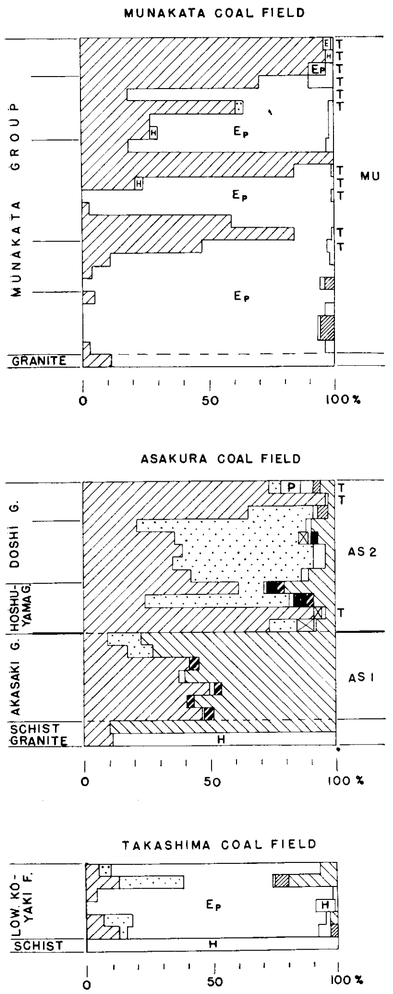

Fig. 6-C.

Each heavy mineral composition of the zones AM-2 to AM-5 is nearly uniform in lateral direction throughout Kamishima and Shimoshima.

II. Takashima coal field

The heavy residues in the basement schist consist mainly of green hornblende.

The heavy mineral compositions in the sandstones of the Koyaki formation in the Nomo peninsula are grouped in one which is characterized by abundance of epidote and commonness of colorless zircon, garnet, and tourmaline. Glauconite and titanite are rarely found but anatase is not present. This composition generally resembles that of the main part of the Koyaki formation excepting for authigenic minerals (OHARA, 1960b).

III. Asakura coal field

Basements; (a) In the mica-schist muscovite including a host of black mineral, and slight and euhedral prism of greenish brown tourmaline having black inclusions are very abundant. Colorless zircon (small crystal) and biotite are common. (b) The heavy minerals in the granite consist predominantly of green hornblende. Colorless zircon and monazite are also present.

The Paleogene strata of this coal field are divided into two major heavy mineral zones by means of their compositions.

AS-1 zone; It is represented by the Yamanokami formation and is characterized by abundance of muscovite, colorless zircon, and greenish brown tourmaline. Rutile, and pyrite are present, but glauconite is absent. In this zone the frequencies of colorless garnet and green biotito are larger in the northern area than in the southern area of the coal field. The features of muscovite, colorless zircon, and tourmaline resemble very much those in the basement mica-schist.

AS-2 zone; It includes the Hoshuyama, Kawamagari, and Doshi formations. This zone is distinguished from the AS-1 zone in abundance of colorless zircon and garnet. Greenish brown tourmaline is common but its nature differs from that in the basement mica-schist. Purple zircon, dark green tourmaline, monazite, and glauconite are present. Hornblendes and pyroxenes are also found though rare, and they are considered to be of pyroclastic origin.

In the AS-2 zone two minor boundaries are recognized; the one is between the Hoshuyama and the Kawamagari formation, and the other between the Kawamagari and the Doshi formation; the Kawamagari formation is distinguished from the Hoshuyama formation in remarkable appearance of blue tourmaline and pyroxenes, and additionally in plentifulness of pyrite; on the other hand, in the Doshi formation above the second boundary, colorless zircon is noticeable, and frequencies of purple zircon, garnet, titanite, and monazite decrease extraordinarily.

As a whole, epidote disappears in any sandstones from this coal field.

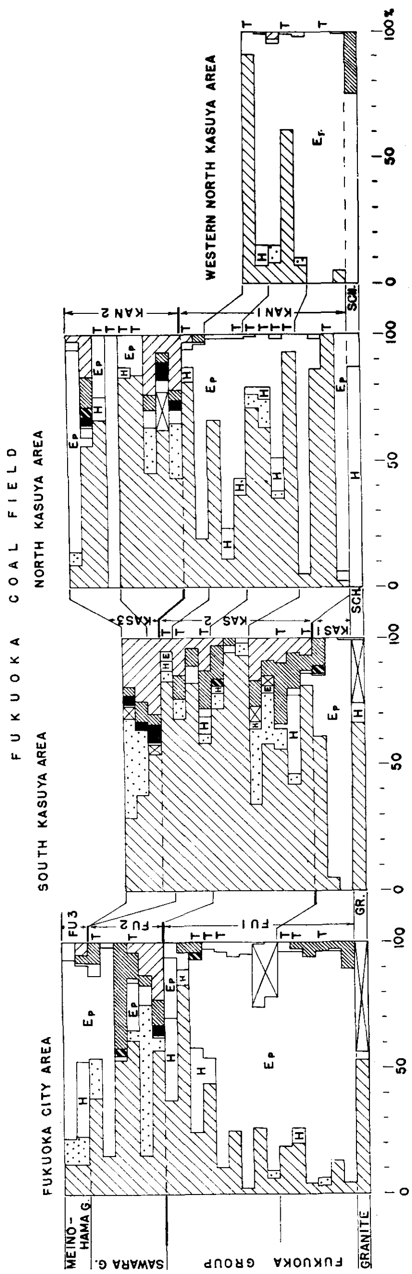

Fig. 6-D.

IV. Fukuoka coal field

The heavy minerals in the basements: (a) Granite in the Fukuoka city area; The heavy residues are composed of abundant colorless zircon, monazite, and muscovite, the first of which is in forms of short prism and needle shaped crystal. Green and brown biotites are also found. (b) Granite in the south Kasuya area; The heavy minerals in this granite are nearly the same to the above mentioned one but commonly associate with green hornblende. (c) Green-schist in the eastern north Kasuya area;

Green hornblende and epidote are predominant. (d) Schist in the western north Kasuya area; Epidote, dark green tourmaline (prismatic crystal), muscovite, and chlorite (ripidolite ?) are very abundant.

Generally, the heavy mineral composition of the sandstones from this coal field is characterized by abundance of epidote, magnetite, ilmenite, and colorless zircon, and in addition by frequent appearance of hornblende and by very scarcity of pyrite.

The Paleogene sediments of the Fukuoka coal field are divisible into two or three zones regarding to their heavy mineral compositions in respective area, and on the other hand, the following four types of heavy mineral composition are broadly recognized throughout the field.

1st type; is characterized by abundance of epidote and colorless zircon. Garnet is present but rather rare. Dark green tourmaline and hornblendes are present.

2nd type; is composed mainly of colorless zircon and dark green tourmaline. Garnet and the other varieties of tourmaline are common and hornblendes are present.

In both the types above mentioned, purple zircon and brown zircon are characteristically very scarce.

3rd type; is characterized by the presence of rounded colorless zircon, purple and brown zircon, and rounded tourmaline, being nearly similar to that in the AM-3 or AM-5 zone of the Amakusa coal field. But in this type, epidote, angular tourmaline, and euhedral colorless zircon are also found and rutile is rather low in frequency. This composition is therefore presumed to be not a type but a sub-type of the AM-3 zone.

4th type; is found in the tuffaceous sandstone and is characterized by abundant existence of magnetite or ilmenite, colorless euhedral zircon and sometimes hornblendes. These minerals associate with a few detrital heavy minerals.

The mutual relationship in each area between the stratigraphical sequence, the heavy mineral zones, and the characteristic features of heavy mineral composition is shown in Table 2. The 4th type is not limited in occurrence to a definite horizon but is frequently intercalated at random in respective heavy mineral zone, because

Table 2. Mutual relationship in each area between the stratigraphical sequence, the heavy mineral zones, and the characteristical features of heavy mineral composition in the Fukuoka coal field.

Fukuoka city area			South Kasuya area			North Kasuya area		
Formation	Heavy Mineral Zone	Heavy Mineral Composition Type						
Meinohama F.	FU-3	1						
Atago F.			Atago F.	KAS-3	3	Atago F.	KAN-2	3
Uratani F.	FU-2	3	Uratani F.	KAS-2	2	Uratani F.	KAN-1	1
Noma F.	FU-1	1	Noma F.			Noma F.		
Nokonoshima F.			Nokonoshima F.	KAS-1	1			

it is not detrital but pyroclastic in origin.

As shown in Table 2, the 1st and 3rd types are dominant in the sandstones from Fukuoka city and north Kasuya areas, but the 2nd type is limitedly present, in the most, in those from the south Kasuya area.

V. Munakata coal field

The heavy minerals included in the basement granite are composed mainly of magnetite, epidote, and colorless zircon.

Among the material from the Munakata coal field many tuffaceous sandstone specimens are also recognized which are likewise met with often in the Fukuoka coal field.

The Paleogene deposits have a simple association of heavy minerals which is put in only a single heavy mineral zone, the *MU zone*. This zone is characterized by predominant magnetite, epidote, and euhedral colorless zircon, and by presence of dark green tourmaline. Green hornblende, other varieties of tourmaline, and garnet are scarcely found, whereas pyrite is not seen. Glauconite occurs throughout the Tare formation but is limited in occurrence to a part of the Ryoganji and the Sobaru formation.

As mentioned before, the composition of MU zone is very similar to that of the 1st type in the Fukuoka coal field.

VI. Chikuho coal field

In the basement granite greenish brown hornblende is dominant, but colorless zircon is scanty.

The Paleogene strata are divided into four heavy mineral zones in ascending order such as CH-1 to CH-4 zone.

CH-1 zone; It occupies the Oyake formation and the lowest part of the Honso formation. Colorless zircon, greenish brown tourmaline, and garnet are abundant, and monazite is common, but glauconite and purple zircon are not or very scarcely found.

CH-2 zone; It ranges from the main part of the Honso formation to the lower half of the Ideyama formation. In this zone colorless zircon and dark green tourmaline are predominant, and on the other hand, garnet and other varieties of tourmaline are low in frequencies. Glauconite, purple and brown zircons, and rutile are commonly found. In the upper part of the Oyake formation and the lowest part of the Honso formation a few sandstones are intercalated, which have transitional features of heavy mineral composition from the CH-1

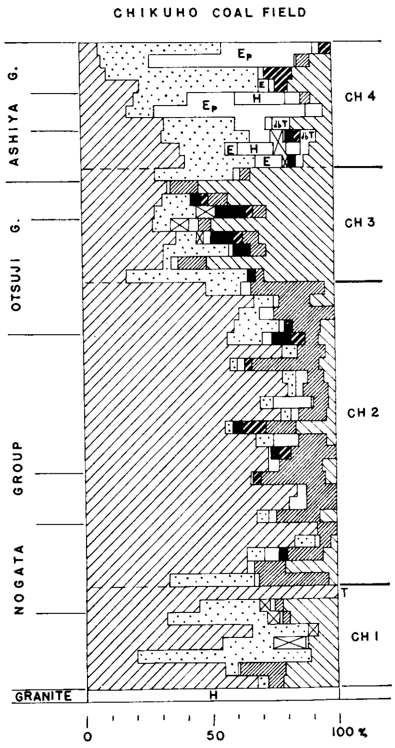

Fig. 6-E.

to CH-2 zone.

CH-3 zone; It is represented by the upper half of the Ideyama formation and the Onga formation. The heavy mineral composition is distinguished by abundance of greenish brown tourmaline, colorless zircon, and magnetite, nevertheless the frequency of colorless zircon is lower than in the CH-2 zone. Garnet and dark green tourmaline are common.

CH-4 zone; It indicates the sequence ranging from the Yamaga to the Waita formation. But the composition of the sample from the basal part of the Yamaga formation does not belong to the type of the CH-4 zone but to that of the CH-3 zone. Epidote, garnet, colorless zircon, and magnetite are abundant. Tourmaline and sometimes hornblende or dark green tourmaline or rutile are common. The frequency of colorless zircon decreases gradually toward the upper horizone.

In both the CH-3 and CH-4 zone, the specimens having the sub-type composition of the AM-3 zone (like as the 3rd type of the Fukuoka coal field) are intercalated characteristically.

The heavy mineral composition in the CH-2 zone is very similar to that of the 2nd type of the Fukuoka coal field, and this fact leads us to conjecture that the heavy minerals of the CH-2 zone and of the 2nd type might have been supplied from the same or very similar source rocks.

VII. Karatsu coal field

The heavy minerals in the basement granite: (a) In the Taku area; Green hornblende and magnetite are extraordinarily abundant, but colorless zircon and titanite are rare. (b) In the Yamamoto area; Colorless zircon and magnetite are dominant; dark brown tourmaline, green hornblende, and monazite are common.

In general, the heavy mineral composition in the Tertiary of this coal field is characterized by predominant existence of colorless zircon, tourmaline, and garnet (but the last one is absent in part), common presence of hornblende and pyroxene indicating volcanic activities, and frequent appearance of glauconite and anatase.

The deposits are divisible into the following four heavy mineral zones in ascending order.

KA-1 zone; It includes the Utsubogi and Yashiro formations, and is characterized by dominance of colorless zircon and greenish brown tourmaline, and commonness of dark green tourmaline. Garnet is partly abundant in the present zone.

KA-2 zone; It is represented by the Yoshinotani formation excepting for the upper part. In this zone the heavy mineral composition belonging to the type of AM-3 zone is dominant, but dark green tourmaline is common.

KA-3 zone; It ranges from the upper part of the Yoshinotani formation to the lowest part of the Daito formation. In this zone colorless zircon and greenish brown tourmaline are distinctively dominant. Garnet is abundant excepting in the lower part of this zone. Outgrowth zircon is rarely found.

KA-4 zone; It includes the main part of the Daito formation and the lower part of the Ainoura group distributed narrowly in the Mimasaka area. Although garnet is rather dominant, the heavy mineral composition of this zone is pertinently

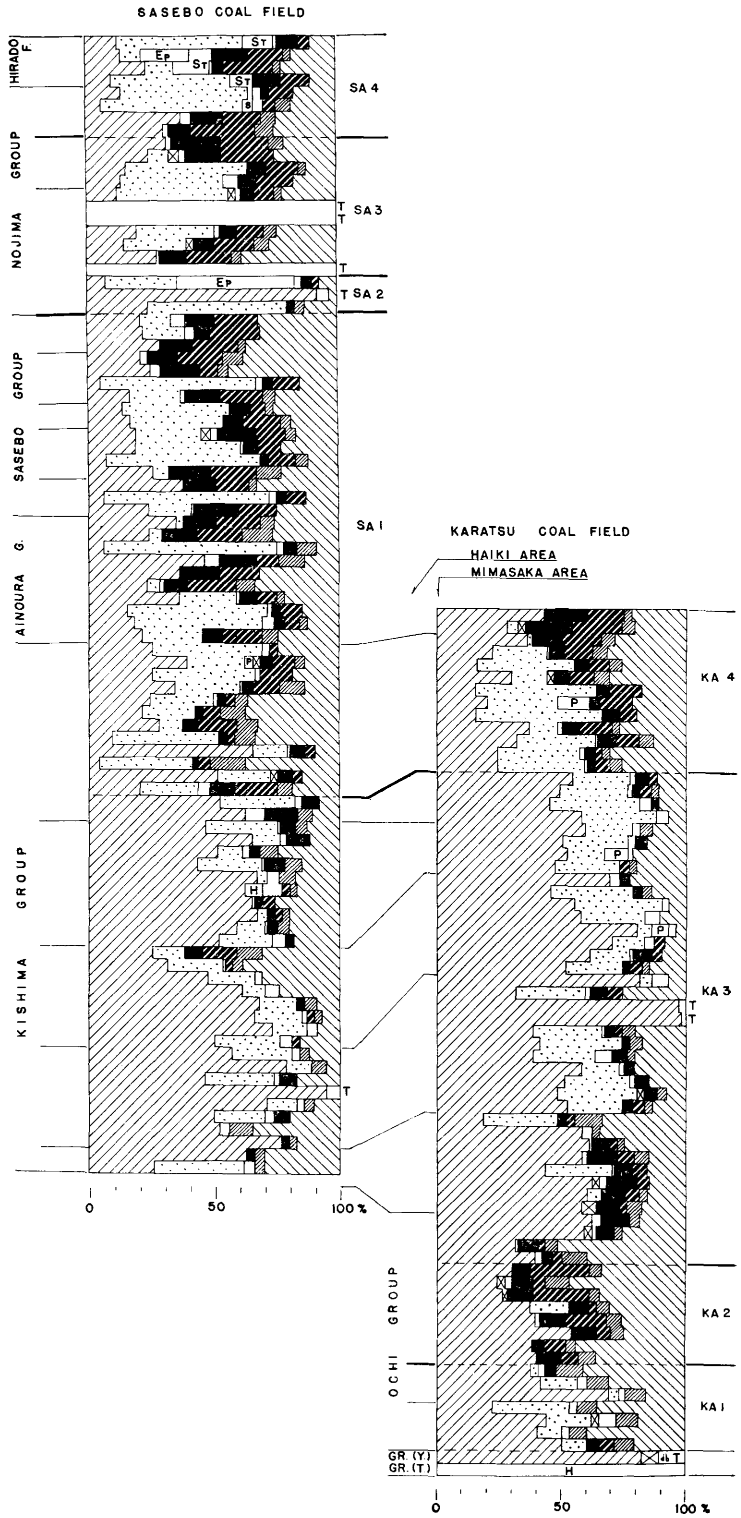
SASEBO COAL FIELD
HIRADO F.
GROUP
NOJIMA
GROUP
SASEBO
AINOURA G.
GROUP
KISHIMA
SA 4
SA 3
SA 2
SA 1
ST
EP
P
H
T
0
50
100 %
KARATSU COAL FIELD
HAIKI AREA
MIMASAKA AREA
KA 4
KA 3
KA 2
KA 1
OCHI GROUP
GR. (Y)
GR. (T)

Fig. 6-F.

identified to that of the AM-3 zone of the Amakusa coal field. The KA-4 zone is quite succeeded by the SA-1 zone described below.

VIII. Sasebo coal field

On the whole, in the sequence of this coal field nearly similar heavy mineral compositions continue from the basal part (the Ainoura group) to the top (the Hirado

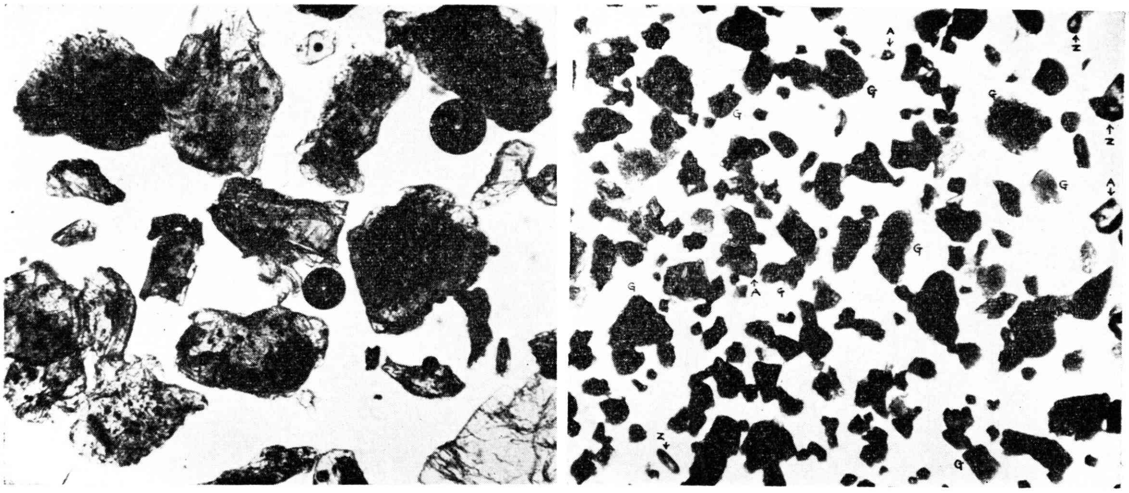

Fig. 7. Photomicrographs showing chlorite (left) and glauconite (right).
Left: Kakinoura formation, Sakito coal field, spl. no. 930, (all grains: chlorite [ripidolite]), ×50.
Right: Mikawachi formation, Karatsu coal field, spl. no. 57B23, (A: anatase, G: glauconite, Z: zircon), ×50.

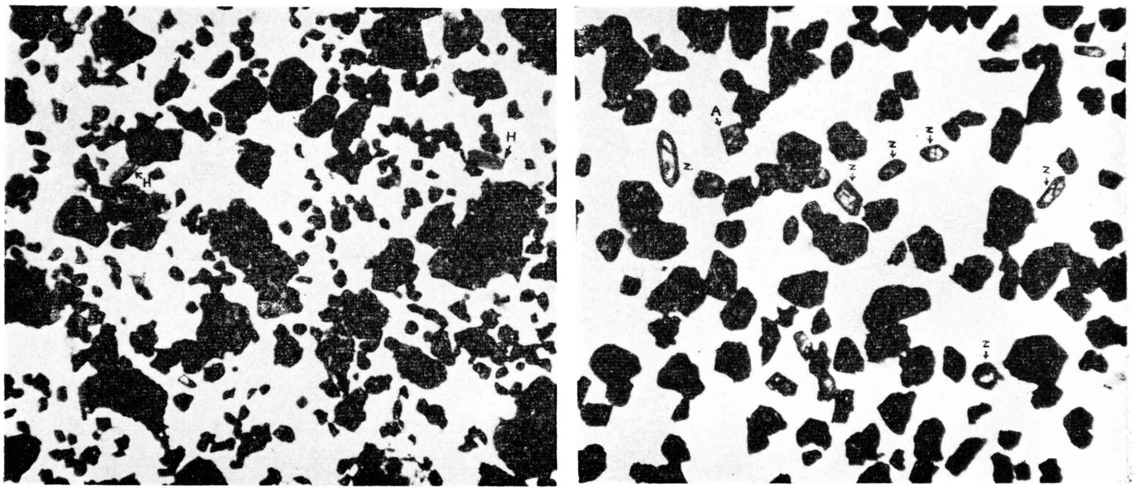

Fig. 8. Photomicrographs showing the heavy residues in tuffites.
Left: Noma formation, Fukuoka coal field, spl. no. 611142, (H: hornblende, others: magnetite), ×50.
Right: Magarikawa formation, Karatsu coal field, spl. no. 57C20, (A: anatase, Z: zircon, others: magnetite), ×50.

formation) in spite of their enormous thickness. But only a part of the Oya formation has a different heavy mineral composition from the others.

The strata are divisible into the following four heavy mineral zones from SA-1 to SA-4 in ascending order.

SA-1 zone; It occupies the part ranging from the Ainoura to the Sasebo group. The heavy mineral composition is just the same to that of the above mentioned KA-4 zone of the Karatsu coal field and of the AM-3 zone of the Amakusa coal field. However, the frequency of garnet is rather high, but it is unstable being so frequently changed to small value. Outgrowth zircon is also present.

SA-2 zone; It presents the lower part of the Oya formation. It is characterized by presence of epidote, euhedral colorless zircon, and angular tourmaline, and also by scarcity of rutile and purple zircon.

SA-3 zone; It is represented by the most of the Oya formation and the Fukazuki formation. Its heavy mineral composition quite agrees with that of the SA-1 zone, but in the Oya formation some tuffaceous sediments are intercalated.

SA-4 zone; It occupies the Minamitabira and the Hirado formation. It has also the same heavy mineral composition to that of the lower zone, but associated with epidote and staurolite. Staurolite has never been found in any Tertiary sediments of the northern Kyushu, and this fact is very interesting and also important.

Volcanic activity

Volcanic activities are inferred by the existence of tuffs and tuffites intercalated in the Tertiary strata of the northern Kyushu. These tuffs and tuffites show the feature in heavy mineral composition such as of extreme abundance of iron opaques (especially magnetite or ilmenite), euhedral colorless zircon, and hornblende and/or pyroxene having sharp edges, and as an additional feature inclusion of a few detrital heavy minerals at sometimes.

The horizons or areas in which tuffs or tuffites are intercalated so frequently in the Tertiary strata of the northern Kyushu are as follows.

1) The Hoshuyama and Doshi formation in the Asakura coal field.
2) The Fukuoka coal field.
3) The Munakata coal field.
4) The lower part of the Honso formation in the Chikuho coal field.
5) The Magarikawa formation in the Karatsu coal field.
6) The Oya formation in the Sasebo coal field.

Problems on the volcanic activity during the Tertiary in the northern Kyushu, especially during the Paleogene period, must be more closely discussed after more detailed data concerning other coal fields in the northern Kyushu become available.

Conclusive note

1) The heavy mineral analysis has been carried out for the selected specimens taken from several Tertiary coal fields in the northern Kyushu such as the Amakusa,

Takashima, Asakusa, Fukuoka, Munakata, Chikuho, Karatsu, and Sasebo.

2) On the amount of heavy residues contained in the specimens, a distinctive tendency is well recognized that the lowest formations usually contain larger amount of heavy minerals than the succeeding upper formations in respective coal field. This tendency may be attributed to the kind of basement rocks and also to the distance from the source area to the depositional basin.

3) The kind of heavy minerals is shown in Table 1. They are largely common rock-forming minerals, but piedmontite, glaucophane or staurolite etc. are rarely recognized. Especially, staurolite is detected for the first time in the Tertiary sandstones of the northern Kyushu. The chlorite in the sandstones from the Sakito coal field is identified as ripidolite (one of iron-magnesium chlorite group) by X-ray diffractometer.

4) The successive sequence of Tertiary is divisible into several " heavy mineral zones" in regard to the type of composition of heavy minerals as shown in Fig. 6. Among the heavy mineral zones which are contemporaneous but developed separately in various coal fields different heavy mineral compositions are recognized. This fact may be attributed to that they deposited in separated basins in which completely different materials were transported. The similar compositions are, on the other hand, recognized in some heavy mineral zones of different horizons or of different coal fields, which leads us likewise to an inference that such horizons had similar or the same rocks as their sources.

Of such multiple types of heavy mineral composition, the one characterized by significant high frequencies of rounded colorless zircon, purple and brown zircons, rounded tourmalines, and rutile is widely spread in the most part of the coal fields distributed in the southwestern and western margins of the northern Kyushu.

Glauconite and anatase are commonly detected, but in the lowest successions of some coal fields such as Asakura, Fukuoka, Munakata, and Chikuho, they are extremely rare or not present. Authigenic pyrite and outgrowth zircon are exceptionally visible in the limited horizons.

Postscript

The states of horizontal and vertical distributions of heavy minerals and their associations are described in detail, but as the specimens observed are collected from the limited areas in the coal fields, it seems to be insufficient to draw any conclusions here concerning the provenances, paleogeography, volcanisms, and historical geology during the Paleogene period in North Kyushu. It is not doubtful, therefore, more available data are need to clarify the problems stated above.

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Jyonosuke OHARA

Heavy Mineral Associations in the Paleogene Systems of Some Coal Fields, North Kyushu, Japan

Plates 28–30

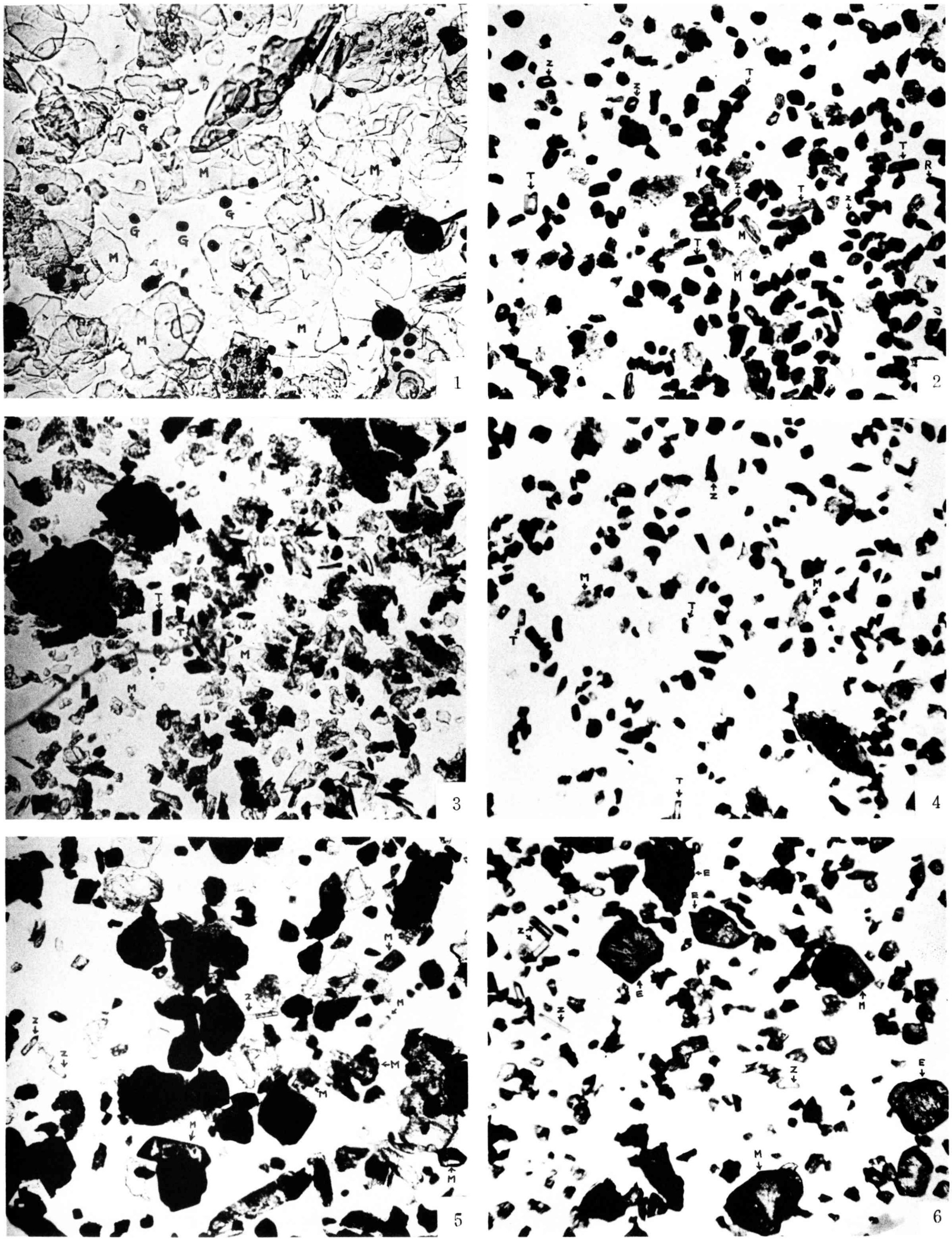
Plate 28

Explanation of Plate 28

Photomicrographs showing the heavy residues in the Paleogene sandstones and the basement rocks of the northern Kyushu (all figures: ×50).

1. Mica-schist, Amakusa coal field, spl. no. 60924MS, (G: garnet, M: muscovite).
2. Cretaceous Himenoura group, Amakusa coal field, spl. no. 609187, (M: muscovite, R: rutile, T: tourmaline, Z: colorless zircon).
3. Mica-schist, Asakura coal field, spl. no. AS-Sch, (M: muscovite, T: tourmaline).
4. Yamanokami formation, Asakura coal field, spl. no. 60AY6, (M: muscovite, T: tourmaline, Z: colorless zircon).
5. Granite, Fukuoka coal field, spl. no. 611141, (M: monazite, Z: colorless zircon).
6. Noma formation, Fukuoka coal field, spl. no. 611142, (E: opidote, M: monazite, Z: colorless zircon).

Photos by J. OHARA.



J. OHARA: Heavy Mineral Associations in the Paleogene Systems, North Kyushu

Plate 29

Explanation of Plate 29

Photomicrographs showing the heavy residues in the basement rocks of the Paleogene coal fields of the northern Kyushu (all figures: ×50).

1. Green schist, Fukuoka coal field, spl. no. 61116Sch, (E: epidote, H: green hornblende).
2. Schist, Fukuoka coal field, spl. no. 601029-5, (C: chlorite, T: dark green tourmaline).
3. Granite, Munakata coal field, spl. no. 61115-3, (E: epidote, Z: colorless zircon).
4. Granite, Chikuho coal field, spl. no. 61305-2, (H: hornblende, Z: colorless zircon).
5. Granite, Karatsu coal field, spl. no. 60Y043, (Z: colorless zircon).
6. Granite, Karatsu coal field, spl. no. 602148, (B: biotite, Z: colorless zircon).

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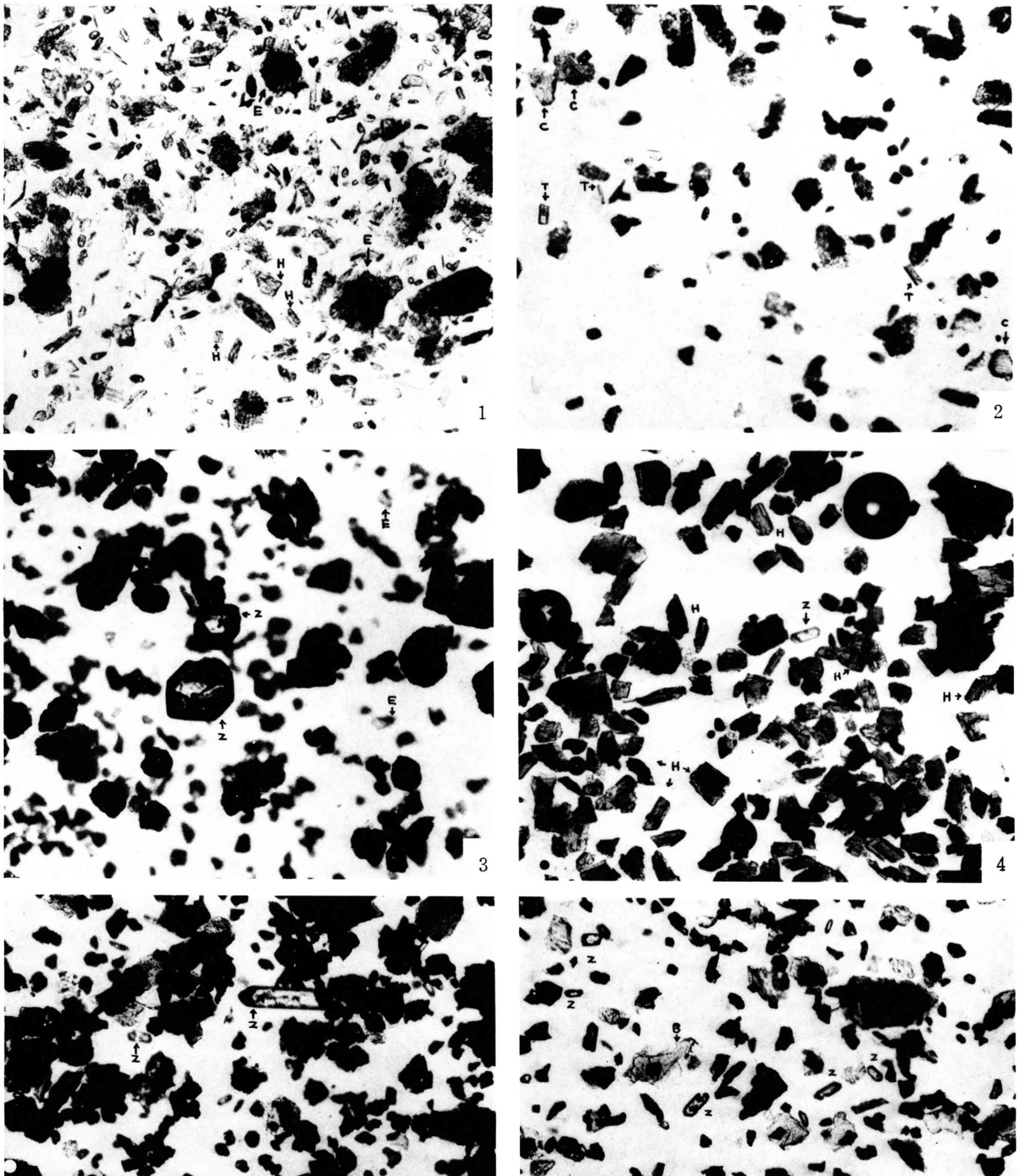


J. OHARA: Heavy Mineral Associations in the Paleogene Systems, North Kyushu

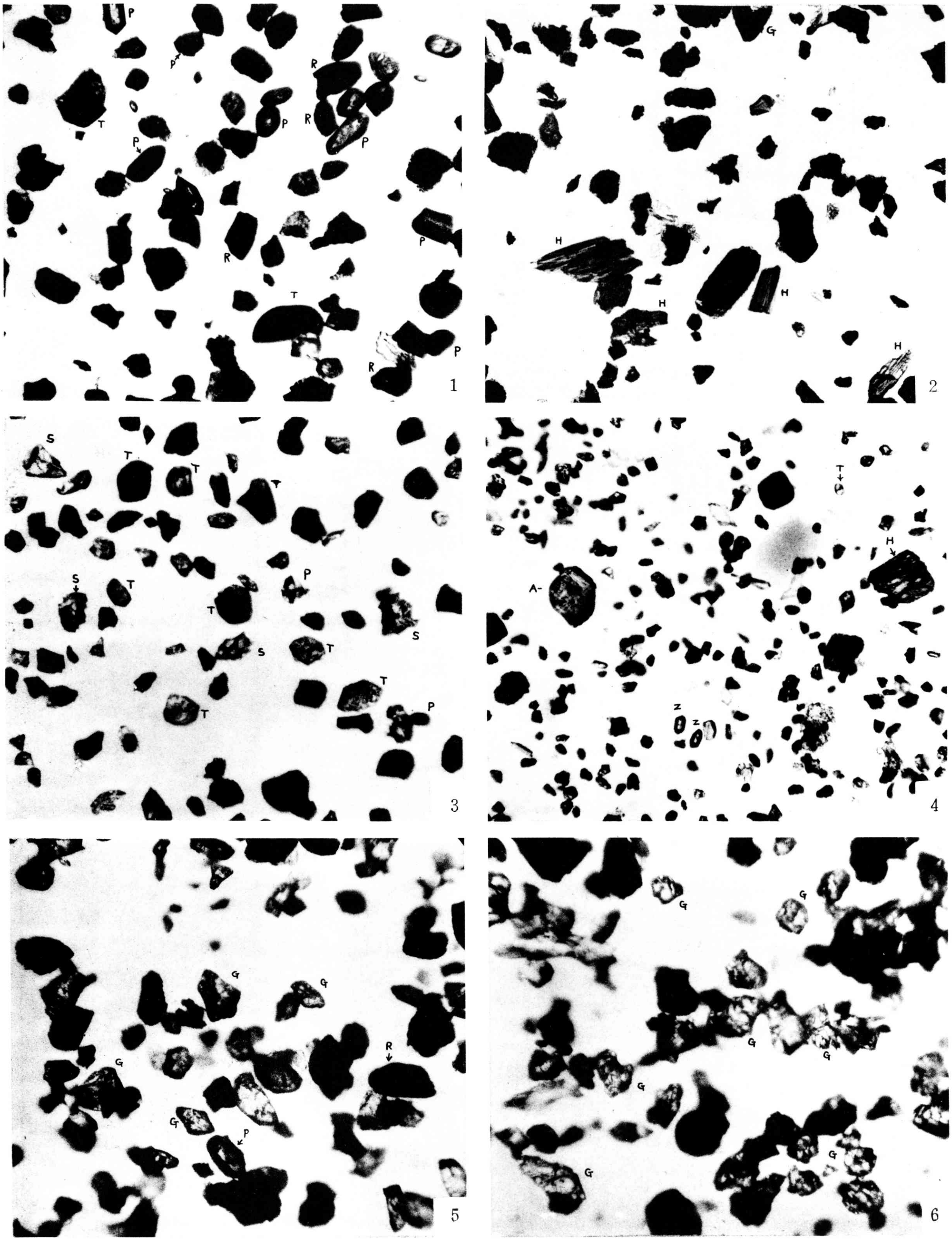
Plate 30

Explanation of Plate 30

Photomicrographs showing the heavy residues in the Tertiary sandstones of the northern Kyushu (all figures: ×50).

1. Yoshinotani formation, Karatsu coal field, spl. no. 60Y121, (T: tourmaline, P: purple zircon, R: rutile).
2. Meinohama formation, Fukuoka coal field, spl. no. 61114M2, (G: pink garnet, H: hornblende).
3. Minamitabira formation, Sasebo coal field, (P: purple zircon, S: staurolite, T: tourmaline).
4. Daito formation, Karatsu coal field, spl. no. 57A7, (A: augite, H: hypersthene, T: tourmaline, Z: colorless zircon).
5. Ainoura group, Sasebo coal field, spl. no. 60Y128, (G: subangular colorless garnet, P: purple zircon, R: rutile).
6. Fukui formation, Sasebo coal field, spl. no. 60Y1230, (G: angular colorless garnet).

Photos by J. OHARA.



J. OHARA: Heavy Mineral Associations in the Paleogene Systems, North Kyushu

Table 1-A. Heavy mineral compositions of the sandstones from the Amakusa coal field.

Area	Stratigraphic division	Formation	Specimen No.	Zircon (colorless, light purple, deep purple, brown)	Tourmaline (brown, greenish brown, green, dark brown, reddish brown)	Tourmaline (dark green, dark green (fibrous), greenish blue, greenish blue (aggregate))	Tourmaline (blue, bluish grey)	Tourmaline (grey, greenish grey, light purple)	Garnet (colorless, pink, brown)	Garnet (green, light purple)	Hornblende (green, brown, greenish brown, dark green)	Pyroxene rhombic (Hypersthene (?), Enstatite (?))	Pyroxene monoclinic (Augite (?))	Epidote+Zoisite, Piedmontite, Monazite	Rutile (red+yellow, purplish grey, brownish grey, yellowish green)	Titanite, Anatase, Apatite	Cassiterite, Staurolite, Glaucophane, unknown mineral	others, Iron ores, Muscovite, Chlorite (Ripidolite ?)	Biotite (brown, reddish brown, green)	Authigenic minerals (Anatase, Glauconite, Carbonate (?), Pyrite, Outgrowth zircon)	Magnetite & Ilmenite (Leucoxene), Tuff & Tuffite	Weight % of heavy residue	Color & grain size of sandstone
Kamishima Area	SAKASEGAWA GROUP	SAKASEGAWA F.	609192	50 6 1	7 14 3	1	1		11		2				4			49 31 19 1		+	r	0.01	d. gy. vf.
			609209	24 7 1 5	9 20 5	4	1		1					—	21 1	—		34 23 39 3	—	1 — r +		0.3	wh. m.
			609208	74 2 1	— 2	1	2		18						2	—		38 60 1 1	—	32 1	r	0.1	gy (l. gr.) m.
		ITCHODA F.	609193	58 — 2	2 5				33					1				16 83 1		73 VA		1.3	d. gr. gy. c.
			609194	53 1 2 3	4 6 3	3			9					2	11 —	1		20 77 3 —		1 20 VA		1.4	gy. m.
	KAMISHIMA GROUP	TOISHI F.	609195	54 1 4	9 19 1	—	1				—		1		7 — 3			25 54 21 1—		4 1 VA		0.8	gy. f.
			609199	45 4 3	4 11 3	—	1						1	2	25 1			42 37 21 1—		11 1	C	0.5	gy. m.
			6092011	39 1 4	7 22 2	1—	1						5		19		1—	52 35 12 1		3 1	C	0.4	gy. f.
		SUMOTO F.	609198	51 2 — 4	4 11 2	—	1								24			38 39 23 —	—	15 5 +	r	0.4	br. c.
			609197	43 5	1 23 6	1	2						?		20			28 28 43 —		5 2 +	r	0.6	gy. f.
			6092013	41 1 7	11 19 2	2	1—		1—					1	15 —		—	34 33 32 1—		2 1 +		0.2	br. f.
		KUSUBO F.	6092018	42 1 5	4 17 3 —	1	1							1	24			34 37 28 1—		6 1 +	r	0.4	br. m.
			6092019	47 1 3	10 15 6	1 —	1		1						14	1		28 25 46 —	—	16 — +		0.4	gy. m.
		TANASOKO F.	6091815	34 2 2	3 16 2	1—	1—		29						10 1—	1—	—	34 27 39 1—		2 1		0.3	gy. f.
			6091814	41 1 1	4 13 4 —	2 —	—		21 1—		—			1—	12	1—		41 29 30 —	—	3 1—		0.3	y. gy. m.
			6091813	50 1 4	2 15 2	2 —	2		12				—		10 1			35 28 36 —	1 —	+	C	0.3	gy. f.
		SHIRATAKE F.	6091812	77	4 14 2						2 —		1	? 1			—	12 71 17	—	1 VA +	C	0.2	wh. vc.
			6091810	40 1	3 11 3	7 —			22 3		—	7		1	1	1		42 30 28		20	C	0.04	wh. gy. vc.
			609181	51 1	14 16 3 —	9	3		1						1	?	2	12 56 32	—	21 1 A		0.3	wh. c.
	AKASAKI GROUP	AKASAKI F.	609189	—	—	1								100				78 22 — —			C	5.6	y. gr. gy. c.
			609183M											100				86 14 — —			C	10.8	y. gr. gy. m.
			609184			—			—					100	—		—	76 24 — —			C	11.2	gr. gy. c.
			609186	—									?	100	—			85 15 — —			?	17.2	gy. y. c.
	CRETACEOUS HIMENOURA GROUP		609187	47 — 1	3 40 5	3					1				2			39 50 11	—	3 — +	C	0.09	l. gy. vf.
Shimoshima Area	SAKASEGAWA GROUP	SAKASEGAWA F.	609206	48 1 1 3	4 21 6	1	— —								16			28 25 45 2		16 2		0.5	wh. gy. m.
			609204	50 3 1 4	10 19 4	1	1							—	5 — 1			31 36 32 2		9 1 +		0.5	do.
			609202	42 1 1 2	7 19 1	2	2								17 1 6			35 32 32 3	—	9 1 +		0.5	do.
		ITCHODA F.	609216	30 — —	5 4 1				60 1						—			48 41 11 1—	— 1—	3 37 C		0.4	d. gy. f.
			609215	58 2 3	5 5 1		—		24 1		2				2			46 42 12		4 21	C	0.3	d. br. m.
			6092113	56 1	2 5	—			36 — 1 (y.)						—			33 63 3	—	8 30 VA		0.2	d. gy. m.
	SHIMOSHIMA GROUP	TOISHI F.	6092213	49 3 4	5 15 3	3	2								16 1			34 30 36		18 1 +		0.4	gy. br. m.
			6092221	54 — — —	6 16 6	1 —	3		4						11			35 36 29		30 2 +		0.4	gy. m.
			609221	41 5 2 2	6 17 6	1	2							1	17 —	1		46 40 14		9 +		0.3	wh. gy. m.
			609224	36 2 1 6	8 15 8 —	1 —	2				—			1	22			33 48 19 —	—	3 2 +		0.3	wh. gy. m.
			6092226	45 2 2	5 20 10	2 —	—								15			24 37 40		2 2 +		0.3	l. br. gy. f.
			6092225	48 5 2 3	6 11 3	1	—		1					3	18			47 37 15 —		17 1— +		0.6	br. gy. f.
			609214	39 1 1 3	2 26 5	1	1		3		— 5	1 —			14 1	—		32 41 26 —		5 3 +	r	0.3	gy. m.
			609211	52 1— 1— 4	5 11 3	—	1— —							2	21	1—		46 40 14		10 +		1.1	wh. br. f.
			6092114	39 1 1 3	3 26 6	2	—		5						14	1		23 40 37 1—	—	16 4 +		0.2	gy. m.
			6092115	29 1 2 1	8 24 4	2 —	1		13						16	1		44 36 20		16 1 +		0.3	wh. m.
			6092116	42 1 — 2	5 23 9	—			1		—			—	16	1	—	28 56 16		20 5 +		0.2	wh. gy. m.
			6092117	49 2 — 2	5 11 5 —	— 1	1		2		3			1	19	1		33 47 20 —		13 3 +	r	0.2	gy. m.
			6092123	36 — 1 5	7 25 8	2 —	— —								17	1		47 47 6	—	7 3 +		0.5	wh. br. m.
		SHIKIYAMA F.	609229	51 2 6	5 20 7	1 —	—								9 — —		—	46 22 32 —		6 — r +		0.3	wh. gy. f.
			609228	45 4 1 4	4 12 7	— 1—	1		1						21	1	1—	44 43 12 1—	1—	20 1— +		0.2	gy. br. m.
			6092219	37 3 1 2	7 20 5	2	1		1						21 —	1		46 36 17 1		4 — +		0.2	gr. gy. f.
			609227	45 3 1 1	4 15 6	2 1	—		1						21 —	1	—	40 29 30 1—		3 2 +		0.2	gy. f.
			6092215	42 2 1 3	4 21 7 —	2	1	—	1		?				15 — 1	1—	1—	40 27 32 1—	— —	3 1— +		0.2	do.
			6092118	53 4 2 3	4 16 3	1	1							1	18	1	1	31 34 35 —		12 3 +		0.6	gy. m.
			6092121	38 1 1	5 33 7	3	1		1					1	9 — 2	1	—	35 41 23 —		6 C +	C	0.1	gy. f.
	AKASAKI GROUP	FUKAMI F.	609233	38 — 1	4 11 9 1	9 — 1			25 2		—							24 72 4 —		64 — C		0.1	gy. c.
			609234	49 2 1— 2	5 19 6	1	—		1—					1 1—	15	1		38 43 19 —	— —	10 1		0.3	br. gy. gr. f.
			609236	56 1 —	5 22 9 1	3 —		—	4									10 88 3 —	—	7 3 VA		0.3	gy. c.
			6092315	51 2 2	5 9 2 —	7			16 2 2 (y.)		—			?		?		10 87 3	—	1 VA		0.2	d. gr. gy. vc.
			6092312	55 1	3 9 5 1	4 —			.8 — (y.)					14				44 51 5	—	VA		0.4	gr. gy. vc.
			6092311	50 --	3 14 4	2 —			24 4					?				15 79 6	—	73 3 r		0.2	gy. c.
			6092310	22 — —	11 19 10 2	1 — —	1		28 3		—			—		3		23 70 7		3		0.2	do.
			609238	40	— — 2 45	— —	1		11 1		— —		—	—		—		23 70 7	—	23	r	0.2	do.
	BASEMENT		60924MS	—	—				90					9				11 — 89			?	0.3	mica schist
			60924GS								—			100				100	—			36.6	green schist

(y.) : yellow

Table 1-A~F.; 1-: less than 1 per cent, —: present, +: present, r: rare, C: common, A: abundant, VA: very abundant, vf.: very fine grained, f.: fine, m.: medium, c.: coarse, vc.: very coarse, l.: light, d: dark, wh.: white, y., yell.: yellow, gy.: grey, gr.: green, br.: brown, pp.: purple.

Table 1-B. Heavy mineral compositions of the sandstones from the Takashima, Asakura, and Munakata coal field.

Coal Field	Group	Formation (STRATIGRAPHIC DIVISION)	Specimen No.	Zircon (colorless, light purple, deep purple, brown)	Tourmaline (brown, greenish brown, green, dark brown, reddish brown)	Tourmaline (dark green, dark green (fibrous), greenish blue, grenish blue (aggregate))	Tourmaline (blue, bluish grey, grey, greenish grey, light purple)	Garnet (colorless, pink, brown)	Garnet (green, light purple, yellow)	Hornblende (green, brown, greenish brown, dark green)	Pyroxene (rhombic: Hypersthene (?), Enstatite (?); monoclinic: Augite (?))	Epidote + Zoisite, Piedmontite, Monazite	Rutile (red + yellow, purplish grey, brownish grey, yellowish green)	Titanite, Anatase, Apatite	Cassiterite, Staurolite, Glaucophane, unknown mineral	others, Iron ores, Muscovite, Chlorite (Ripidolite ?)	Biotite (brown, reddish brown, green)	Authigenic minerals (Anatase, Glauconite, Carbonate (?), Pyrite, Outgrowth zircon)	Magnetite & Ilmenite (Leucoxene), Tuff & Tuffite	Weight % of heavy residue	Color & grain size of sandstone
Munakata Coal Field	MUNAKATA GROUP	IKEDA F.	601108-18	96						1		3				8 92			r T	0.2	wh. br. vc.
			601108-17	97	—			1		3						10 85 5		92	T	0.2	wh. br. c.
			601108-16	90	1 1							7	1 1			— 99 —		24	VA T	0.3	br. m.
		YOSHIDA F.	601108-15	80±		1 1						20±				2 98			VA T	0.03	l. br. m.
			601108-21	18±								82±				— 96 4		—	VA T	2.2	br. m.
			601108-12	61		1		1 1	1	1		34				6 93 1		65	A T	0.1	l. br. gy. c.
			601108-11	27		2		1				71				38 61 1			A	0.2	do.
			601108-24	27		1		1		3		68				23 76 1			VA	0.1	br. m.
		SOBARU F.	601108-9	21		—				1		79				24 76 —			VA	0.4	wh. br. c.
			601108-7	100								—				24 72 4			VA T	0.04	wh. vc.
			601108-6	84	—	1				—		15				18 81 1	—	? VA	VA T	0.8	wh. c.
			601108-8	18		2				3		76				2 98			VA T	0.3	gy. br. m.
			601108-3	1						—		99				39 61 1			A	0.07	wh. br. c.
			601108-1	3		—				—		97 —				79 15 6		—	r	0.5	gy. br. vc.
			60915-16	59						—		41				32 66 1			VA	0.3	gy. br. c.
			60915-13	84	—	—		1				15 —				2 92 6		98 5	C T	0.3	wh. br. c.
		TARE F.	60915-11	47		2				1		50				3 93 4			C T	0.7	wh. br. m.
			60915-10	11		2 —						87				68 31 1		2 —	r	0.1	wh. m.
			60915-8	4		—	—		—	—		96				60 40	1	—	A	1.1	l. gy. br. m.
			60915-7	2		4		—	—	—		94	—			34 66 —	—	1	VA	0.3	wh. br. m.
		RYOGANJI F.	60915-5	5 —	—	— — —						95 —	1			52 48 —		1	A	1.3	gy. pp. m.
			60915-3	2		1 — —						96	1			49 49 2	—	— —	A	1.4	gy. m.
			61115-6	1		6 —	—					93*				73 27 —			A	4.6	gy. pp. m.
			61115-5	1	— —	6	—					93			—	82 16 1			C	0.4	gy. pp. c.
			61115-4	3	— 2	2		—		—		93	—			67 32 1	—		VA	0.5	l. br. c.
	BASEMENT		61115-3	11								89				24 75 1			VA	2.4	granite

* one grain of pink epidote

Coal Field	Group	Formation (STRATIGRAPHIC DIVISION)	Specimen No.	Zircon (colorless, light purple, deep purple, brown)	Tourmaline (brown, greenish brown, green, dark brown, reddish brown)	Tourmaline (dark green, dark green (fibrous), greenish blue, grenish blue (aggregate))	Tourmaline (blue, bluish grey, grey, greenish grey, light purple)	Garnet (colorless, pink, brown)	Garnet (green, light purple, yellow)	Hornblende (green, brown, greenish brown, dark green)	Pyroxene (rhombic: Hypersthene (?), Enstatite (?); monoclinic: Augite (?))	Epidote + Zoisite, Piedmontite, Monazite	Rutile (red + yellow, purplish grey, brownish grey, yellowish green)	Titanite, Anatase, Apatite	Cassiterite, Staurolite, Glaucophane, unknown mineral	others, Iron ores, Muscovite, Chlorite (Ripidolite ?)	Biotite (brown, reddish brown, green)	Authigenic minerals (Anatase, Glauconite, Carbonate (?), Pyrite, Outgrowth zircon)	Magnetite & Ilmenite (Leucoxene), Tuff & Tuffite	Weight % of heavy residue	Color & grain size of sandstone
Asakura Coal Field	DOSHI GROUP	DOSHI F.	60AD2	73 1	1 4 1	1 1 —	1	4 1		— 1	2 6	1	1			9 91 —	—	1	r T	0.1	wh. c.
			60AD1	96	2 1		2	— —					—			6 92 2	—	— C	r T	0.2	wh. vc.
			60AD4	65	1 2	2 1	1	23 3		2	—	1	—			21 67 12	—	33	r	0.06	do.
		KAWA-MAGARI F.	60A16	21 — 1	3 6 1	1	1	57 10 —				—	1	1		46 34 18 1		40 1 r	r	0.2	br. gy. m.
			60A11	36 1 1 1	1 6 — —		—	46 3		—	— —	4	1 1			30 43 27 1	—	12 C	C	0.5	gy. f.
			60AK3	39 1 — 1	1 3 —		—	41 10 1				— 2	2	3		13 83 4		7 1 VA		3.6	gy. m.
			60AK7	35 — — 1	1 3	—	—	51 5		—	— —	1	2	1		43 45 12 1		36 C	r	0.3	do.
			60AK5	42 1 1	3 7 1		—	42 2	—			— 1	1			21 69 10		36 — VA		0.7	do.
	HOSHU-YAMA G.	HOSHUYAMA F.	60A12	61 1 3 —	4 16 1	1 1		9 1				1	2 1			31 41 28	—	40 1		0.1	wh. br. c.
			60AH7	24 4 1	2 4 3	1		55 1 1				1	3			41 47 11		28 1	r	0.2	wh. gy. m.
			60AH2	91	4	1		1				3	1			3 95 2			T	1.3	wh. br. c.
			60AH5	73	1 7		1	10 1		—		7	—	—		19 66 15	—	5 —		0.1	br. c.
	AKASAKI GROUP	YAMANO-KAMI F.	60HY	9	5 69 4			13					—	—		25 33 34	7			1.2	gy. f.
			60TY	17	8 57 8			10						—		17 44 29	10	— A		0.9	do.
			60AY12	41 —	49 6			—					4			11 32 57		—		2.8	l. br. gy. m.
			60AY9	37	55 6			1						1		5 20 75		—	r	4.7	gy. c.
			60AY6	49 2	1 41 4								3	—		12 39 49		55 r		0.9	do.
			60AY4	40	53 4			1					3			7 30 63		VA		1.3	gy. vc.
			60AY3	46	48 1								4	?		4 23 73	—	r	r	3.0	br. m.
	BASEMENT		AS Sch	10	85 5											7 19 62 4	8			8.2	mica-schist
			AS Gr	11						89		—				100 —	—		?	1.2	granite

Coal Field	Group	Formation (STRATIGRAPHIC DIVISION)	Specimen No.	Zircon (colorless, light purple, deep purple, brown)	Tourmaline (brown, greenish brown, green, dark brown, reddish brown)	Tourmaline (dark green, dark green (fibrous), greenish blue, grenish blue (aggregate))	Tourmaline (blue, bluish grey, grey, greenish grey, light purple)	Garnet (colorless, pink, brown)	Garnet (green, light purple, yellow)	Hornblende (green, brown, greenish brown, dark green)	Pyroxene (rhombic: Hypersthene (?), Enstatite (?); monoclinic: Augite (?))	Epidote + Zoisite, Piedmontite, Monazite	Rutile (red + yellow, purplish grey, brownish grey, yellowish green)	Titanite, Anatase, Apatite	Cassiterite, Staurolite, Glaucophane, unknown mineral	others, Iron ores, Muscovite, Chlorite (Ripidolite ?)	Biotite (brown, reddish brown, green)	Authigenic minerals (Anatase, Glauconite, Carbonate (?), Pyrite, Outgrowth zircon)	Magnetite & Ilmenite (Leucoxene), Tuff & Tuffite	Weight % of heavy residue	Color & grain size of sandstone
Takashima Coal Field	AKASAKI GROUP	KOYAKI FORMATION, LOWER MEMBER	60N14	5 1 —	2 5 1	1 —	—	4 1 —				83				65 32 3	—	—	C	0.4	gr. gy. vc.
			60N16	13 1	11 9 — 3	1	4	18 5 2		—		36		—		37 60 4		1	A	0.6	gy. gr. m.
			60N9	4	— 1 1	—		—				94	1			50 50 —	1— —	—	A	0.4	gy. f.
			60N6	1—	—			—		8		91	1—	1—		61 38 1		1—	C	3.1	gy. c.
			60N2	7 —	1 2 1	—	—	9 2		1		77	1	1		72 27 1			r	0.1	wh. br. c.
			60K8	13	1 1 —	3		2 1		1	—	76	1	3		33 67 1 —		?	VA	1.1	l. br. gy. c.
	BASEMENT		60K1							100					—	100			?	70.9	schist

Table 1-C. Heavy mineral compositions of the sandstones from the Fukuoka coal field.

Stratigraphic division	Specimen No.	Zircon (colorless, light purple, deep purple, brown)	Tourmaline (brown, greenish brown, green, dark brown, reddish brown)	Tourmaline (dark green, dark green (fibrous), greenish blue, greenish blue (aggregate))	Tourmaline (blue, bluish grey, grey, greenish grey, light purple)	Garnet (colorless, pink, brown)	Garnet (green, light purple, yellow)	Hornblende (green (Tremolite)*, brown, greenish brown, dark green)	Pyroxene (rhombic: Hypersthene (?), Enstatite (?); monoclinic: Augite (?))	Epidote+Zoisite, Piedmontite, Monazite	Rutile (red+yellow, purplish grey, brownish grey, yellowish green)	Titanite, Anatase, Apatite	Cassiterite, Staurolite, Glaucophane, unknown mineral	others, Iron ores, Muscovite, Chlorite (Ripidolite ?)	Biotite (brown, reddish brown, green)	Authigenic minerals (Anatase, Glauconite, Carbonate (?), Pyrite, Outgrowth zircon)	Magnetite & Ilmenite (Leucoxene), Tuff & Tuffite	Weight % of heavy residue	Color & grain size of sandstone	Area
SAWARA G. URATANI F.	613N15	91	1 —				—	—(—)*	—	9				8 89 3			VA T	1.2	wh. gy. c.	Western North Kasuya Area
SAWARA G. URATANI F.	613N8	7				—	—	5 3	1	84		—	—	11 89 —		—	VA	0.1	gr. gy. m.	
FUKUOKA G. NOMA F. MIDDLE & UPPER	613U5	8 1 1 —	2 1 —	1	—	6 1				80 —				80 12 8 —		—	C	0.4	wh. gy. c.	
FUKUOKA G. NOMA F. MIDDLE & UPPER	6010296	61	—	1	1	1				38				4 96			VA T	0.4	br. wh. c.	
FUKUOKA G. NOMA F. MIDDLE & UPPER	613N10	7	2	2	—	2 —	1			88				35 65			A	0.2	gy. m.	
FUKUOKA G. NOMA F. LOWER	601027-2	—								100				4 96 —			VA	0.4	do.	
FUKUOKA G. NOMA F. LOWER	601029-1						—			100				4 96			VA T	1.0	pp. gy. c.	
FUKUOKA G. NOMA F. LOWER	601029-4	5		1	—	—				94				82 17 1		1	r	0.2	br. c.	
BASEMENT	601029-5			25 —				—		75				26 26 35 13			r	2.2	mica schist	
SAWARA GROUP ATAGO F.	601029-10	9 1 —	1 2 —	1 — —	1 —	3 2 —				80 1	1			68 26 5 —	1—	2 r		0.2	wh. gy. m.	North Kasuya Area
SAWARA GROUP ATAGO F.	601103-1	56 — 2 1	5 12 —	9 —	3	1 —		1		3 4	4			44 52 4	1	39 1		0.1	gr. gy. m.	
SAWARA GROUP ATAGO F.	601103-4	66	— — 1	1				9		25				28 72 —		67	A T	0.04	wh. red. c.	
SAWARA GROUP ATAGO F.	601103-9	+	+							+				— 100 —		100	VA T	0.9	l. br. c.	
SAWARA GROUP ATAGO F.	601103-3	83						4		13				14 86		67	C T	0.02	wh. red. m.	
SAWARA GROUP ATAGO F.	601103-10	84	— —	1						16	—			43 56 1		1	VA T	0.1	wh. vc.	
SAWARA GROUP ATAGO F.	601103-17	45 1 1 1—	6 16 2	6 —	1—	18 1—				1 1	1 1—			29 54 14 1	2 —	9 1	A	0.2	gr. gy. m.	
SAWARA GROUP ATAGO F.	601103-20	62 1 5 1	2 5 —	4 —	—	1				2 15	2			45 53 2		55	r	0.5	l. br. m.	
SAWARA GROUP ATAGO F.	601103-21	43 2 2 —	5 15 2 —	3 — 1	—	20 2		—		2 2	2			44 41 12 1	2 1—	7 2	C	0.1	gy. f.	
SAWARA GROUP ATAGO F.	601103-22	81	2 1	1 1		2		5 (1)		7				24 76 —	—	94	C T	0.04	wh. m.	
SAWARA GROUP ATAGO F.	61116-14	19	—	3			—	1		77				17 82 2		23	VA	0.3	br. c.	
SAWARA GROUP URATANI F.	61116-15	66	1	1		—		1		32				15 85 — —		9	A	0.2	br. vc.	
SAWARA GROUP URATANI F.	61116-1	11	1	1				12		75				21 76 3		12	C	0.07	l. gy. br. m.	
SAWARA GROUP URATANI F.	61116-2	36	1					6 (1)	1	55				11 89		42	C T	0.03	br. gy. vc.	
FUKUOKA GROUP NOMA F. MIDDLE & UPPER	61116-16	71	—	2		3	2	3(—)		20				4 96		73	C T	0.1	gy. gr. m.	
FUKUOKA GROUP NOMA F. MIDDLE & UPPER	61116-3	63				8	3	5		22				6 94	—		VA T	0.05	wh. gy. m.	
FUKUOKA GROUP NOMA F. MIDDLE & UPPER	61116-4	35	1 1	1		3		13		47				2 98		98	C T	0.1	l. gy. br. vc.	
FUKUOKA GROUP NOMA F. MIDDLE & UPPER	61116-6	93	— 1							7				2 97 1		—	VA T	0.4	gr. gy. c.	
FUKUOKA GROUP NOMA F. LOWER	61116-18	5	—							95				42 58	—	1	C	0.8	br. m.	
FUKUOKA GROUP NOMA F. LOWER	61116-7	86		1				8		12				26 74		66	A	0.1	br. c.	
FUKUOKA GROUP NOMA F. LOWER	61116-9U	100	—	—		— —								15 85			VA T	0.2	gy. c.	
FUKUOKA GROUP NOMA F. LOWER	61116-12	2	—	2		2 — —				94	—			84 16			r	0.6	br. c.	
BASEMENT	61116-SCH							27		13				100			?	48.6	green schist	
SAWARA G. ATAGO F.	61117-26	29 1 1 1	3 16	1 — —	3	31 8		—		5	1			35 33 30 1	1 —	51 2		0.1	wh. c.	South Kasuya Area
SAWARA G. ATAGO F.	61117-25	38 1 2 —	7 17 1	7 —	1	21 5 1				— 2	1			30 46 22	1	3 5		0.1	br. m.	
SAWARA G. ATAGO F.	61117-24	54 2 5 —	8 20 2	2	2 —	1 —	—			— 4	—			25 52 23	—	4 6		0.2	gy. m.	
SAWARA G. ATAGO F.	61117-14	83	1 3 1			4		3 (1)		4				7 93 —			VA T	0.07	wh. f.	
SAWARA G. URATANI F.	61117-22	68	2 8 5	9 —		8	—			—				7 90 3 —		22 19 VA	T	0.4	gy. f.	
SAWARA G. URATANI F.	61117-13	82 1	2 1 1	7		1	1	(1)		4				33 66 1—	— —	78	C	0.2	br. m.	
SAWARA G. URATANI F.	61117-4	58	4 9	15		1 3		4 (3)		1				2 98 —		92	C T	0.2	red. br. c.	
FUKUOKA GROUP NOMA F. MIDDLE & UPPER	61117-21	72 2	1 2 —	12	1	6 —		3(—)		1 —	3			19 78 2	—	2 1 VA		0.1	gy. c.	
FUKUOKA GROUP NOMA F. MIDDLE & UPPER	61117-20	94	1 —	3 —						1		1		31 69 —		3 3	r	0.3	wh. m.	
FUKUOKA GROUP NOMA F. MIDDLE & UPPER	61117-5	93		—		5		2		—				12 88		8 1	r	0.05	wh. br. m.	
FUKUOKA GROUP NOMA F. LOWER	61117-19	34 —	9 7 1 —	9	1	26 4		3		6	1 —			27 66 6	1—	—		0.06	br. c.	
FUKUOKA GROUP NOMA F. LOWER	61117-18	58	1 8	6	—	19 1		1		3 4				23 45 31	1	1 —	C	0.3	br. m.	
FUKUOKA GROUP NOMA F. LOWER	61117-7	56	9 1	23 1		7 1		4		?				2 97 1		50 1	VA T	0.3	gy. br. m.	
FUKUOKA GROUP NOMA F. LOWER	61117-10	42	1 3 2 3	11 1	2	4		28 (3)	?	1	—			26 74 —		41 —	C	0.3	gy. m.	
FUKUOKA GROUP NOMA F. LOWER	61117-12	81	3 4 —	5 1		1				5	1			5 90	—	— +	A T	0.03	wh. br. c.	
FUKUOKA GROUP NOKONOSHIMA F.	61117-3	61	1	7 2 2		1		1		24	3	—		25 74 1—		16 1	A	0.1	br. c.	
FUKUOKA GROUP NOKONOSHIMA F.	61117-2	5	—	— —						95				56 44 1			A	0.5	l. red. br. m.	
FUKUOKA GROUP NOKONOSHIMA F.	61117-1	1	—	—						99	—			82 18 —			r	4.9	yell. gr. gy. c.	
BASEMENT	61117-16	66				— —		8		25				38 38 24	1	38	r	0.1	granite	
MEINOHAMA G. MEINOHAMA F.	61114MM	12 1— —	— 2	1—	1—	8		1— 2		71 2		1—		41 54 5 —	—	1 15 r	VA	0.4	gr. gy. m.	Fukuoka City Area
MEINOHAMA G. MEINOHAMA F.	61114M2	12 —	3 2	1 1 1	—	9		2 3 25		38 1		1		41 55 3 1	—	11 19	VA	0.4	gr. gy. c.	
SAWARA G. URATANI F.	6111411	38	1	8		16		1	?	33 3	—			4 95 1 —		35	A T	0.4	gr. gy. vc.	
SAWARA G. URATANI F.	611149	15		2						83 —	—			30 70		14	VA	1.0	l. br. m.	
SAWARA G. URATANI F.	611148	53	1 1	41 1	—			—		—	3			42 58 1		71	C	0.1	br. c.	
SAWARA G. URATANI F.	611147	61	— 4	9 —	1	4				19	2			3 97	—	1	VA T	0.5	wh. vc.	
SAWARA G. URATANI F.	6111420	15 — 1 1	6 7	2 1	1 —	47 12 1		1 (1)		1 2	1			46 51 3 1—	1—	59 18		0.1	gy. c.	
SAWARA G. URATANI F.	6111419	57 2 2	9 13 1	5 — 1 1	2 1	4 1		—		5	—			27 67 6	1—	76 47	r	0.1	br. m.	
FUKUOKA GROUP NOMA F.	6111418	37	1	2	—	—		28 (5)		24 1	2	1		62 37 2		61 1	r	0.03	wh. vc.	
FUKUOKA GROUP NOMA F.	6111414	83	1 1	4 —		1 1		6		1 2	1			20 78 1 —		68	C	0.1	d. br. c.	
FUKUOKA GROUP NOMA F.	6111412	24	— 1	4		—		34		35 —	3			5 95 —		31	VA T	1.1	gy. m.	
FUKUOKA GROUP NOMA F.	61114G2	44	1	2		1		6 4		43	—			8 92 —			VA T	0.4	yell. br. c.	
FUKUOKA GROUP NOMA F.	61114G6	10		1		2 —				86	1			5 95	—		VA T	0.3	l. br. m.	
FUKUOKA GROUP NOMA F.	61114G9	25	2	2 —		1 1		1		69 1				17 83		1	C	0.01	l. br. c.	
FUKUOKA GROUP NOMA F.	611145	2	—	2				—		93 2				77 23 —	—		C	0.9	br. c.	
FUKUOKA GROUP NOMA F.	611144	26	—	1		1 1				48 25				67 18 16				0.03	l. br. c.	
FUKUOKA GROUP NOMA F.	611142	6				1 2				69 24	—			71 26 3				0.2	wh. vc.	
FUKUOKA GROUP NOKONOSHIMA F.	61114N19	19	1	—			2	1		77 1				5 95 —			VA T	2.1	gy. c.	
FUKUOKA GROUP NOKONOSHIMA F.	61114N4	20	1	3				4 2	—	70			2	3 97		1	VA T	1.1	br. gy. vc.	
FUKUOKA GROUP NOKONOSHIMA F.	61114N17	4		6				—		91 —				20 80 —		r	C	0.3	gy. m.	
FUKUOKA GROUP NOKONOSHIMA F.	61114N8B	3		3 1		3		—		90 1	—			17 83 —			VA T	0.7	gr. gy. c.	
FUKUOKA GROUP NOKONOSHIMA F.	61114N11	13 —	— —	— 3 —	—			—		83 1				75 25			C	0.9	gr. gy. m.	
FUKUOKA GROUP NOKONOSHIMA F.	61114NE	4		11		—		—		84 1	—	—		95 4 1 —				0.8	gy. vc.	
BASEMENT	611141	53	—					—		3 44				24 51 23	— 2		C	0.3	granite	

Table 1-D. Heavy mineral compositions of the sandstones from the Chikuho coal field.

STRATIGRAPHIC DIVISION		Specimen No.	Zircon: colorless, light purple, deep purple, brown	Tourmaline: brown, greenish brown, green, dark brown, reddish brown	Tourmaline: dark green, dark green (fibrous), greenish blue, greenish blue (aggregate)	Tourmaline: blue, bluish grey, grey, greenish grey, light purple	Garnet: colorless, pink, brown	Garnet: green, light purple, yellow	Hornblende: green, brown, greenish brown, dark green	Pyroxene: rhombic: Hypersthene (?), Enstatite (?); monoclinic: Augite (?)	Epidote+Zoisite, Piedmontite, Monazite	Rutile: red+yellow, purplish grey, brownish grey, yellowish green	Titanite, Anatase, Apatite	Cassiterite, Staurolite, Glaucophane, unknown mineral	others: Iron ores, Muscovite, Chlorite (Ripidolite ?)	Biotite: brown, reddish brown, green	Authigenic minerals: Anatase, Glauconite, Carbonate (?), Pyrite, Outgrowth zircon	Magnetite & Ilmenite (Leucoxene), Tuff & Tuffite	Weight % of heavy residue	Color & grain size of sandstone
ASHIYA GROUP	WAITA F.	6111821	7 1 1 —	1 1	— —		46 3 —				36 —	5			66 30 4 1	— —	—	A	1.2	gr. gy. m.
		6111820	8 — 1	2 6 1 1	1 2	2	17 2				58 2	1			55 30 12 1	1 1—	1	A	0.6	gy. f. (x̊)
		6111818	10 2 — 1—	4 11 1	1	1	56 4 1				1— —	11			49 43 7 1	— —	1 —	A	0.8	wh. br. m.
		6111815	23 2	4 12 2	—	—	45 2 1		1		4 1	5 —			42 40 16 2	— — —	4 1	A	0.8	gy. f.
	SAKAMIZU F.	6111823	21 — — 1	1 6 1 5 1	1 1	2	18 1 1	1	1 19		19 2	2	1		31 67 2 —	1— —	5	VA	0.2	wh. m.
		6111812	18 — 2	1 3 — 1	—	— —	8 2 1	—	1		60 1	1		—	41 56 1	2 —	4 1	VA	0.4	wh. br. gy. f.
		6111811	33 1	3 11 3 7	—	2	24 2 1	1	1		12 1	1			38 37 6 —	18 2	13 —	C	0.04	wh. c.
	YAMAGA F.	6111824	32 3 —	1 6 7 —	1		29 3 3		—		8 5	3	—	—	33 60 2 1	2 1—	29 1	A	0.2	gr. gy. f.
		6111810	39 1	2 7 3 1	1 1 —	1	15 1 2		— 14		5 5	1	2	1	23 72 4 —	1— —	8 1 VA	A	0.3	gy. f.
		611187	41 1 1 1	5 7 3 —	1	—	25 3		— 2		11 3	— —		—	40 49 9 1	1 —	12 2	VA	0.1	gr. gy. f.
		611184	29 1 —	10 20 3	1 —	3	23 7 1				1	2			46 44 10	1 —	8 47		0.1	l. gr. gy. c.
OTSUJI GROUP	ONGA F.	611183	34 — 1	6 48 —	4 1 — 1	4 1	1			—	— 1	—			32 45 22	1 1	5 1	r	0.1	wh. c.
		611182	32 1 2 1	4 37 1	4 1 1	2 —	10 1 —				4	3			29 47 24	1— —	18 2		0.2	l. br. m.
		611181	29 2 9 1	4 21 2	3 1	1 —	14 1 1				— 8	3			34 50 15	1	6 4	r	0.3	br. gy. m.
	IDEYAMA F.	61NI10	28 1 1	4 44 1	1 1 1	2	4 2 —		?		7	2			28 62 10	1—	23 2		0.3	gy. c.
		61NI7	37 1 7 1	4 25 1	4 1 —	1	8				1 5	4			28 67 6		29 1	r	0.5	wh. br. m.
		61NI5	32 1 5 1	4 22 1	3 1 1	1	25 1				3	1			30 45 23	1 —	2 6	C	0.3	gy. br. m.
		5842603	32 1 — 1	2 44 5	4 1 1	5	3 — —				1	1			44 40 16		19 1		0.06	br. gy. c.
		5841247	17 — 2 1	2 25 1	2 —	1 —	38 11 3				—	1			25 51 22 2	1 —	62 6	r	0.3	l. y. gy. c.
		61NI1	49 1	4	20 6 1 1	1 —	13 1				2 1	1			22 75 2	1	67 4	A	0.2	l. br. m.
		5842607	68 2 —	— 10	7 1 1 1	2 —	7 —	1			1 —	1			27 71 1 1	1—	64 9	r	0.07	br. gy. c.
		5841242	62 1 1	2	18 — 6		6 2 —		1		— 1	2		—	31 68 1 —	1—	42 3		0.03	l. br. gy. c.
		5841237	60 3	2 3 1	9 —	2	14 4				2	1			24 70 3 1	2	58 9	r	0.1	gy. br. c.
NOGATA GROUP	UWAISHI F.	5841230	57 6 1	2 4 1	2 1	2	10 1 3		1		2	6			30 68 2	—	64 1	r	0.05	br. c.
		5841224	79 — —	2 2	7 2	2	7		1		— —				35 65		70 2	r	0.1	wh. br. c.
		5841218	58 1 1	1 5 1 1	18 — 1 4	3	3 —		1		—	3			36 62 1	—	82 2		0.3	wh. c.
		584129	79 —	— 5	4 — 1	1 —	4 1 —		1 1		1	1			35 63 2 —	1	73 2	r	0.2	do.
		584121	81	— 2 1	8 2	—	3		1 2		1	1			31 68 1	1	51 4		0.06	br. c.
		584818	70 1 —	1 1 1 —	4 1 1	—	5		15	—	—	—	—		38 56 6		76 ?	r	0.1	br. vc.
		584816	78	1 3 — 1	9 —	1 1	4 —		—			2			42 57 1	1	73 2 r		0.1	gy. vc.
		584812	58 1 2 —	1 12 2 1	7 1 2	2 —	5				—	9			37 61 2		38 1	C	0.2	wh. c.
		584807	68 —	3 1 —	6 1	2	6 1 —		1	—	—	1		12	24 75 2 —	—	54 VA	r	0.5	gy. c.
		584805	73 2 1	1	13 3	2	1				—	5	—		34 65 1	—	55		0.1	br. c.
		584802	73 1 —	1 5 — —	12 1 — 4		1		—		1	2	1		29 69 1	—	5		0.05	do.
	TAKEYA F.	585181	66 1	4 1	8 7 9	1	—		—		—	3	1		28 72 1	—	2 1	r	0.07	wh. br. c.
		585183	84 1	1	7 — 4	1					1	1			29 69 1	1	6	r	0.04	br. gy. c.
		585184	81 1	1 1	7 1	4	1 —				— 1	2	—		33 65 1	2	5 2		0.02	br. vc.
		585186	68	1 6	6 1 1 9		5 —		1	—	2	1			28 72 —		1 1	r	0.1	wh. c.
	HONSO F.	585187	92	—	4 — 1 2	1			—			1			14 86 1		2 1		0.5	br. c.
		585188	83 1	— 3	4		8	—			1	1			13 85 2 —		2 — VA	r	0.6	d. gy. f.
		5851810	64 — 3	2 4	12 1	1 —	6 1 —	—	1		2	1	—		21 76 3 —	—	1 4	C	0.1	wh. c.
		583242	64 — 1	1 20 —	8	1 3	—				1	1			25 65 7 3		24 —	r	0.2	wh. gy. br. m.
		583247	33	4 —	7 — — 14	5 1	29 5	—	1		—	—			31 63 6	—	2 2 r	A	0.04	gy. vc.
		5832412	100		—										5 92 3		—	C T	0.7	br. c.
		583294	45 2 —	4 17 1	2 —	1	22 2 —	—			— 4	2 —	1		37 36 26		13	r	0.05	wh. c.
	OYAKE F.	583296	32 2	3 15 1	2 — 1	—	36 3 —		?		5	—			42 48 10 —		72		0.1	do.
		584502	66	— 7 1		—	21 1				4		—		20 29 51 —	—	30	r	0.1	wh. vc.
		584505	54	11 1	1	—	17 2 —	1			13		1		29 23 48		83	r	0.1	wh. br. gy. c.
		583209	20	1 10	—		61 8 —				1				53 17 30 —	1— —	39		0.1	wh. vc.
		583207	55 —	4 17 —	8 2	8 —	5 —		— —	—	1				39 29 32		7	C	0.03	wh. c.
		583202	68	1 20 1	— —	5 1	4 1				1			—	34 24 42	1—	30	r	0.05	do.
BASEMENT		61305-2	—						100						87 13			VA	6.8	granite

Table 1-E. Heavy mineral compositions of the sandstones from the Karatsu coal field.

Area	Group	Stratigraphic division	Specimen No.	Zircon: colorless, light purple, deep purple, brown	Tourmaline: brown, greenish brown, green, dark brown, reddish brown	Tourmaline: dark green, dark green (fibrous), greenish blue, greenish blue (aggregate)	Tourmaline: blue, bluish grey, grey, greenish grey, light purple	Garnet: colorless, pink, brown	Garnet: green, light purple, yellow	Hornblende: green (Tremolite)*, brown, greenish brown, dark green	Pyroxene rhombic: Hyperthene (?), Enstatite (?)	Pyroxene monoclinic: Augite (?)	Epidote+Zoisite, Piedmontite, Monazite	Rutile: red+yellow, purplish grey, brownish grey, yellowish green	Titanite, Anatase, Apatite	Cassiterite, Staurolite, Glaucophane, unknown mineral	others, Iron ores, Muscovite, Chlorite (Ripidolite ?)	Biotite: brown, reddish brown, green	Authigenic minerals: Anatase, Glauconite, Carbonate (?), Pyrite, Outgrowth zircon	Magnetite & Ilmenite (Leucoxene), Tuff & Tuffite	Weight % of heavy residue	Color & grain size of sandstone
Haiki Area	KISHIMA GROUP	DAITO FORMATION	57E10	25 1 1	3 19 3	1	1	43 — 1		—		1		3			38 26 35	1	8 1		0.4	br. m.
			57E11	39 1— 2 3	4 9 1	3	1—	23 1—		—	1	2	3	9			45 30 24 —	1 —	18 1		0.1	do.
			57E12	25 1 1 —	5 11 3	2	—	38 3					1	13			51 33 15 —	—	9 1 +		0.5	br. f.
			57E13	34 2 2	2 11 1	8	1 1	26		2				11			57 21 22 1—	—	8 —		0.5	do.
			57E15	24 1 2	4 29 4	4	1	25					1	4			39 40 21 —		14 —		0.5	do.
			57E16	21 — 3	6 30 2	7	2 1	21					1	7			34 24 41 1		10 1		0.5	do.
			57E19	28 2 1 5	6 24 3	4 1	3	8 1					1	15			51 46 3		14		0.1	do.
			57E20	9 1 — 3	3 27 4	6	2	41 2					—	3			30 27 42 1	—	6 2		0.3	wh. m.
			57E21	65 4 1 1	4 6 1—	— 1	—	14 —					1—	4			88 11 1		10 —		0.1	br. f.
			57E22	4 1 1 1	6 27 5 —	8	5 1	36 1						5			53 40 6 —	— —	13 1		0.1	do.
			57E24	51 3 1 2	3 9 3	2	—	20 1		—			1	4		—	46 39 16		32 2		0.2	gy. f.
			57E25	20 2 5 3	5 12 2 1—	4 1	2	22 1— 1					3	17			60 39 1 —	—	10 1— +		0.1	do.
			57E26	52 4 2 1	1 6 1 — —	2	—	25 5					3	—		—	48 44 8		23 5 VA	r	0.4	do.
			57D1	62 6 6 1	1 9 2 —	5 1		—			—		6	1 —	—	—	50 41 9		64 — +	r	0.3	l. br. gran. cgl.
		HAIKI FORMATION	57E27	46 1 2 3	4 8 1	3	2	29 —		— —			— 1	2			61 31 8 —	—	17 1		0.3	gy. m.
			57D2	65 2 3 4	2 9 1	1 —	1	11					2	1			30 33 37	—	7 23 +		1.0	br. m.
			57D3	51 2 1 1	6 16 3	4 1	2	10 —					1	1			41 30 29		13 1		0.2	br. f.
			57D5	43 3 2 3	4 9 2	5 —	2	23 2	1	1	—	—	1	1 1		—	51 27 22 —	—	11 1 +		0.2	gy. f.
			57D9	67 1 — 1	4 13 1	5	1	4		1				2			36 33 31	—	20 2 +		0.2	br. f.
			57D11	62 1— 1— 1—	5 10 2	2	1	2		1 6	1	1	1—	3			34 51 15	—	15 1 +	C	0.1	l. br. vc.
			57D14	65 — 1 2	4 20 2	2 1	2	1					— —	1			52 30 18 —		14 +		0.1	l. br. f.
			57D15	67 — 1 2	4 15 1	2 1	—	4					1	3			45 34 21		45 15 +		0.3	gy. f.
			57D17	59 1 3	6 13 1	4	1	11					1	1			51 26 23		9 1		0.3	br. f.
			57D18	52 1 1 1	4 11 3	1	— —	20 1		1—				2 —			49 31 20	—	5 1	C	0.1	br. gy. f.
		MIKAWACHI F.	57D19	25 4 1 2	3 25 3	7 1	2	13 1 1					1	14			34 29 36 —	—	1 1		0.1	br. f.
			57D21	31 1 1	3 32 4	3	1	22					1	3			34 21 45	—	9 2		0.7	gy. f.
			57D23	47 — 1	6 20 5		1	19					2	1			38 31 31		8 2		0.2	br. gr. f.
			57D26	61 1 1	8 15 1 — —	1	—	9 —			1	1	1	1		—	43 32 25		10 —	r	0.1	gy. f.
			57D29	68 1 1 1	1 7 1	5		14 1 —	—					2			50 45 6		38 4		0.2	l. br. f.
			57D31	66 1 1	3 3 1	2	1	18 1						3		—	44 42 13		15 16 +		0.2	do.
			80225-4	73 — 1	1 8 —		1	13 1					1	1	—		58 34 9		36 1		0.2	l. br. gy. f.
			80225-6	50 1 1—	3 12 1	1—	1	26 1—					1—	3			51 37 12	—	7 1		0.2	gy. f.
		MAGARIKAWA F.	80225-8	57 — —	3 9	3	1	21 3			1		1	—		—	42 49 8	1—	2 10 C	r	0.2	d. gy. f.
			80225-10	79	— 5	5	1	8 1 1		—					—		31 61 8		23 20 A		0.2	gy. c.
			80225-11	46 3 1 3	1 14 2	1 —	—	28 —					1	—		—	29 58 13	—	12 6 VA		0.3	d. gy. f.
			80225-13	95 —	2	1	—	2					—				38 59 3		65 11 A	T	0.7	gy. vc.
			80225-14	71 2	— 10	4		10 1 1		1			1				33 59 9		55 10 C		0.2	gy. m.
			80225-15	50 4 1 1	3 16 1	1	1	20			1—		1—	1			35 33 32		9 6		0.4	l. br. f.
			80225-17	52 1	4 28 3	3 1	5	2					1	1			34 38 28		17 2		0.4	wh. m.
			80221-1	77 3 1	1 14 2	2	1	1					2	2			44 40 16		1 8		0.8	l. br. m.
		KISHIMA F.	80221-2	63 2 1 1	4 23 3	—	4	1						1	1		42 28 30		4 12		0.7	do.
			80221-3	26 1 — 1	3 21 6	1 —	3	35 1					1	1			31 22 45 1—	—	18 8		0.7	l. gr. gy. c.
Mimasaka Area	AINOURA GROUP		57FNS	43 2 11 6	6 15 1	2 —	1	1					4	15			50 35 13 1	—	3		0.4	l. br. m.
			57A18	28 6 7 6	5 12 4	4	1	4 —			—		3	20		—	50 32 17	1	2 1		0.5	do.
	KISHIMA GROUP	DAITO FORMATION	57A17	36 2 7 3	9 18 2	3 1	1	2					— 1	16 —			34 30 36 —	— —	3 1		0.4	do.
			57A13	22 2 3 1	5 23 3 —	2 1	3 —	21 1					2	11	—	1	38 34 29 —	—	7 1		0.3	do.
			57A12	16 2 1 3	6 18 2	4 1—	1	34 5 1—		—			1	8			47 24 29	— —	— 2		0.7	l. br. gy. f.
			57A10	30 — 3 3	3 25 3 —	3 2	1	14 —			—		4	10			52 28 20	—	25 1		0.4	l. br. f.
			57A8	15 3 2	2 14 2	1	1	46 1						13			64 24 13		1 1		0.4	gy. f.
			57A7	20 1 3	5 14 3	—	— —	27 1		—	5	10		12 1			53 33 14		10	C	0.06	gy. vf.
			57A5	15 2 2 3	3 16 1	1	— —	50 1		—			—	7			75 22 2		3 —	C	0.5	br. f.
			57A4	37 4 1 2	5 18 4 —	1 1	2	11 —					1	13			46 33 20 1	—	9 1		0.4	l. br. f.
			57A3	32 2 3 3	1 11 1	2 1	2 1	31 —					1	9			70 25 5	—	3 1 r	r	0.7	do.
			57A2	24 2 2	4 23 4	2	1	32 1		—			—	3 —			38 23 39 —	—	10 1		0.4	gy. vf.
			57A1	24 1— 1 2	3 21 2	3 1—	2	35						6			47 27 26		5 —		0.3	gy. f.
			57B1	54 — 3 3	3 9	1 —	1	20 3					1	3			56 26 18		22 1 r		0.2	do.
			57B3	49 3	4 6 1	1	1 1	21 6					1	5			53 36 12	1—	45 33 C +		0.2	gr. gy. f.
			57B4	45 1 1 1	3 7 1	1	— 1	34 2					—	1			56 28 16	—	39 6 C		0.2	gy. f.
			57B5	58 1 — 1	3 3 1	1	1	30					1	— 1			60 24 17		16 5	r	0.2	do.
		HAIKI F.	57B6	59 1	4 10 — —	4	1 —	19					—	2 —			39 41 19 —	—	14 8 A		0.3	do.
			57B12	50 1 1 3	4 11 1	1	1	25 1 —		—			1	1 —			41 44 14 —	—	4 8 A		0.3	l. br. gy. f.
			57B15	52 1	10 11 1	1	1	15			1 1	7	—				46 30 24		12 1	C	0.1	gy. f.
			57B19	47 — 1	6 11 3	2	1	26 1		—			1	3 1			42 30 28 —	—	— 2		0.1	do.
		MIKAWACHI F.	57B21	69 1 1 2	13 9 1 —	1	—	1			—	—	1	2			48 45 9		56 2	C	0.05	l. br. c.
			57B22	45 1 3	3 10 1		4	30 3		—			—	1		—	47 44 9 1—		81 39	C	0.1	gy. c.
			57B23	55 1 1	4 1 2	1		33 2 —					1				68 7 26	—	83 86		1.5	do.
			57B24	57 1 1	4 4 3	2		22 4 —		— 1	1	—	—	—			51 20 27 2	—	51 76		1.1	do.
			57B26	80 — 1	2 1 1	1 —	1	6 —		— 1 1	2 2	3	—	1			43 55 2		26 15 A	r	0.3	wh. m.
			57B28	70 — 2	2 7 —	1 —	— — —	13					1	4	—	—	54 36 10		8 17		0.2	br. gy. f.
			57B30	61 3 2 3	2 6 2 1	—		16 —						4	1	—	58 35 7		3 5 +	r	0.05	l. br. f.
			57B33	51 2 — 1	5 8 2 —	2	1 —	23 1 1		—			1	5			48 37 14 —	1	7 3	C	0.05	br. gy. f.
		MAGARIKAWA F.	57B35	81 1	1 5 1 —	2	—	5 —		1 1	1	1		1	1	— —	50 39 11 —	— —	9	C	0.1	gy. vf.
			57C19	31 2 2 3	5 19 2	1	—	27 1			—		2	5 1		1 —	32 64 3 1—	—	1 5	A	0.1	d. gy. f.
			57C20	97	—			1		2							30 68 4		29	A T	0.1	gy. vc.
			57C1	98	—			1		—	1						57 37 6		61	A T	0.2	gy. c.
			57C2	38 1 1 2	4 16 1	3	2	27 1						3			37 19 44 —		23 8		0.3	gy. f.
			57C22	41 1 — 2	4 11 3	2	2 1	32 1					1 1	—			26 59 15 —	—	31 26 VA	r	0.3	d. gy. f.
			57C3	38 3 2 1	4 12 5	2	1	24 1					— 1	1			32 49 19 —		4 24 VA		0.3	gy. f.
			57C4	58 2 1 1	5 12 4	2	—	15		—			—	2			38 38 24 —	— —	2 4	C	0.05	gy. vf.
			57C23	51 2 2 2	4 9 2	1	1	23 3					1	2 —			37 30 33	—	9 6	r	0.3	d. gy. f.
			57C5	48 1 3 1	1 6 1	1	3	29 3					3	1			64 6 30		74 85		2.6	br. m.
			57C7	52 1 3	5 8 1	2	1	21 1 1						5			56 31 12		10 r	r	1.0	d. gy. f.
		KISHIMA F.	57C7	18 3 —	10 21 3	8 1	2	25 5 —					1	4			51 22 27	—	9 20		0.5	br. m.
			57F3	58 2	12 20 3	2	1							2			57 40 3		4 1	r	0.1	l. br. f.
			57F5	61 3 4	7 15 3	2	1						1 1	3			52 33 15		10 2		0.4	l. br. gy. f.
			57C11	58 4 2 6	2 12 1 1	4 1	1						1 2	6 1			50 34 16		4 2		1.0	l. br. f.
			57F7	43 1 3 3	4 10 2	1 —	—	26 1					1	5 1			53 35 12		15 2	r	0.4	l. gr. br. f.
			57C16	62 3 4 5	5 9 1	1	—	—					4	5 1—			80 17 3		4	r	0.1	br. f.
			57C14	60 1 1 7	7 8 1	2	1	8 1					1	6		?	45 47 8		2 2	C	0.1	d. gy. vf.
			57F13	58 2 5 2	6 10 2	5	1						7	3	1		46 36 19		7 1	r	0.6	br. f.
	OCHI GROUP	YOSHINOTANI F.	57F10	62 5 4 2	2 13 4	2	2						1 1	1			34 29 37	—	17 2		0.8	br. f.
			57F16B	59 1 4 2	7 18 1	2 —	1						3	1			43 30 27	—	5 3		0.2	l. br. f.
			57F17	31 3 3 2	11 35 6 —	3 1	1	—					1	3			43 25 32		44 3		0.1	wh. m.
			57F23	39 2 1 1	9 27 4	5 1	4	1					1	4			29 32 39		27 13		0.7	wh. c.
			57F31B	30 1 4 2	6 23 5	1	4						1	24			39 20 40		13 —	r	0.7	do.
			60Y122	24 1 3 4	12 28 7 —	6 1	3	1 —		1	1	1	3	5			31 44 25		12 7	r	0.2	gy. m.
			60Y121	26 3 5 2	10 23 2 1—	1 1—	3						3	23	—		51 43 6		3 1— +	r	0.4	l. br. m.
			6021414	38 3 3	12 16 3	3 —	2 —	13 1 1	— 1				1 1	3			32 41 25	1	28 5		0.1	do.
			60Y0413	39 3 5 2	7 16 3	2 1	3						1— 1	17 —			32 47 19 1—	—	2 —	r	0.2	wh. br. c.
			57F26	54 2 2 8	5 19 1	3 1	1						? —	6	1		38 28 35		6 4		0.9	wh. m.
			57F27	38 1 2 2	6 34 5	2	1						1	9			54 31 15		12	r	0.2	wh. f.
			57F30	40 1 6 3	6 24 7	4 —	1 1	2		—			—	7			30 42 27		10 4		0.6	wh. m.
Taku-Yamamoto Area		YASHIRO F.	6021413	37 1 3	10 26 6	4 1 1	4 1	3 —		1			1 2	1			34 42 23 1	1	12 4		0.1	l. br. m.
			60Y0415	41 1	5 24 2	4	4 1	15					— 1	2			17 39 44 —	— —	3 10	r	0.2	do.
			60Y0416	69 1 1	4 12 1	4 1	3	1 1 1	1				2	1			38 55 6 1	— —	31 2		0.1	l. red. br. c.
		UTSUBOGI F.	602144	22 1 —	4 27 5	4 1	2 1	28 3 —		1(—)* — 1			— 1	1			33 55 12 —	—	12 6	r	0.2	wh. br. m.
			602149	44 1	6 10 2 1 1	6 1	1 1	18 —	—	—(—)* 6			3	2			31 63 3 2	1	6 7		0.1	l. br. gr. m.
			60Y048	40 1 — 1	5 33 2	6 1	—	9 1 —					—	2			35 42 23	1 —	73 4		0.1	l. br. m.
			60Y044	50 2 — 2	8 10 3	7 — 1	—	10 —					2	6			27 52 20 —	1 —	68 9	r	0.2	gy. gr. m.
	BASEMENT		60Y043	82	11					—			? 7		3		48 49 2 1	—		VA	0.4	granite
			602148	—						100					—		100 —	—		C	28.9	do.

Table 1-F. Heavy mineral compositions from the sandstones the Sasebo coal field.

SATRATIGRAPHIC DIVISION		Specimen No.	Zircon: colorless / light purple / deep purple / brown	Tourmaline: brown / greenish brown / green / dark brown / reddish brown	Tourmaline: dark green / darkg green (fibrous) / greenish blue / greensih blue (aggregate)	Tourmaline: blue / bluish grey / grey / greenish grey / light purple	Garnet: colorless / pink / brown	Garnet: green / light purple / yellow	Hornblende: green / brown / greenish brown / dark green	Pyroxene: rhombic: Hypersthene (?) / Enstatite (?); monoclinic: Augite (?)	Epidote+Zoisite / Piedmontite / Monazite	Rutile: red+yellow / purplish grey / brownish grey / yellowish green	Titanite / Anatase / Apatite	Cassiterite / Staurolite / Glaucophane / unknown mineral	others / Iron ores / Muscovite / Chlorite (Ripidolite ?)	Biotite: brown / reddish brown / green	Authigenic minerals: Anatase / Glauconite / Carbonate (?) / Pyrite / Outgrowth zircon	Magnetite & Ilmenite (Leucoxene) / Tuff & Tuffite	Weight % of heavy residue	Color & grain size of sandstone
	HIRADO F.	60Y1270	13 1 6 1	1 6 3 —	1		40 10			—	— 2	5		12	47 51 1 1—		—	VA	0.4	gy. m.
	HIRADO F.	60Y1268	14 4 7 3	5 10 3	2	1	7	1			20 1	14	1	9	36 63 1 —			VA	1.3	l. red. wh. c.
	HIRADO F.	60Y1269	24 2 1 1	7 12 2 1	1	2	10 1				1	20 1		15	39 56 4 1—		1 1	A	0.4	l. wh. br. m.
	HIRADO F.	60Y1271	10 — 10 1	6 4	— 1	1	41 6 1					12		8	43 56 1	—	—	A	0.3	l. yell. wh. c.
NOJIMA GROUP	MINAMI-TABIRA F.	60Y1272	14 1 2 —	4 10 2 1	1	1	43 7 1				2	10 1		2	60 38 2	—	2 — +	r	0.2	l. gy. br. c.
NOJIMA GROUP	MINAMI-TABIRA F.	60Y1273	6 — 1 1—	5 10 3 1—	3 1— 1—	3	39 17 1					5		4	52 46 1 1		2	A	0.4	l. pp. gy. m.
NOJIMA GROUP	MINAMI-TABIRA F.	60Y1274B	38 1 8 4	3 16 4 — 1	3	3	1 —				2	15		2	59 39 1		2	r	0.3	wh. m.
NOJIMA GROUP	MINAMI-TABIRA F.	60Y1274	31 2 4 3	5 17 2 1	5 1	1	1				2	26		2	53 44 3		6 2 +	r	0.4	wh. br. m.
NOJIMA GROUP	FUKA-ZUKI F.	60Y1267	32 7 9 4	6 13 2	2	4			—		2	19 1—			58 40 2		6 1 +	r	0.3	l. yell. br. f.
NOJIMA GROUP	FUKA-ZUKI F.	60Y1265	25 3 8 3	8 12 5 1—	1—	1	7 1		—		— 4	21 —			63 35 1	—	5 —	r	0.3	l. gr. gy. m.
NOJIMA GROUP	FUKA-ZUKI F.	60Y1263	16 2 5 2	3 8 1 1	2	1	40 6 3				2	13			61 37 2 1	—	9 —	r	0.2	wh. gy. c.
NOJIMA GROUP	FUKA-ZUKI F.	60Y1254	14 4 3 —	3 12 2	1 1—	1	38 2 1				2	15 —			62 31 6 —		6 1—	r	0.3	gy. c.
NOJIMA GROUP	OYA FORMATION	60Y1251	12 2 3 1	1 17 4	1 1	1	39 6			—	3	8			58 35 6		11 3	C	0.1	gy. m.
NOJIMA GROUP	OYA FORMATION	60Y1250	+ +				+		+						— 100 —			A T	0.7	gr. gy. vc.
NOJIMA GROUP	OYA FORMATION	60Y1248	+						—		+				— 100 —		—	A T	0.5	gy. c.
NOJIMA GROUP	OYA FORMATION	60Y1247	20 1 3 3	4 16 4	4	1	26 5		—		— 1	11 —			50 34 15 1		23 —	C	0.06	do.
NOJIMA GROUP	OYA FORMATION	60Y1246	15 2 4 2	6 17 4	4 1	1	22 3 —		—		3	16			51 44 5		9 1 +	C	0.1	l. br. gy. m.
NOJIMA GROUP	OYA FORMATION	60Y1244	28 6 3 2	9 24 5	3	1					— 2	18			52 42 6 —		3 +	C	0.1	do.
NOJIMA GROUP	OYA FORMATION	60Y1241	+				+	+	+	+	+				— 100		+	A T	0.06	gr. vc.
NOJIMA GROUP	OYA FORMATION	60Y1240	7 1 3 —	2 4 1 —		—	29 —				47 2	3			74 24 2		7	r	0.5	l. br. gr. gy. m.
NOJIMA GROUP	OYA FORMATION	60Y1239	92	3			5								3 96 1		—	A T	0.1	l. gr. gy. c.
NOJIMA GROUP	OYA FORMATION	60Y1237	24 — 1 2	2 9 2	2	2	54 2				—	2 —	—	—	32 64 4	—	27 —	C	0.3	bl. gy. f.
SASEBO GROUP	KASE F.	60Y1235	21 3 6 3	10 19 3	2	—	12				1	19 —			37 35 25 3		23 1 r +	C	0.4	wh. gy. m.
SASEBO GROUP	KASE F.	60Y1234	22 1 4 1	4 25 2	2	—	16 1				—	20			41 31 27 1	— —	19 2 +	C	0.3	do.
SASEBO GROUP	KASE F.	60Y1232	29 5 6 3	7 26 4	1	2					— —	18	—		37 33 30		4 1 +	r	0.4	l. br. m.
SASEBO GROUP	FUKUI F.	60Y1259	21 2 4 6	11 22 5	4 1	3	1				— 1	18 1	—		44 40 15		7 2 +	r	0.1	wh. br. c.
SASEBO GROUP	FUKUI F.	60Y1257	25 7 9 —	9 28 6 1	1 1	2					3	7 1			38 47 15		22 3 A +	r	0.3	wh. m.
SASEBO GROUP	FUKUI F.	60Y1230	5 1 2 1	7 6 2	1	—	57 5	—			2	11 1			70 25 6		5 — +	r	0.5	l. gr. gy. m.
SASEBO GROUP	FUKUI F.	60Y1283	17 1 8 6	3 18 4	1 1	3	16 4				2	17 —			60 35 3 1	1	46		0.2	br. m.
SASEBO GROUP	SECHI-BARU F.	60Y1285	14 3 5 1	11 12 3	—	3	41 2		—		—	6			58 36 6 —	— —	2 2		0.2	wh. f.
SASEBO GROUP	SECHI-BARU F.	60Y1284	17 2 2 5	3 12 4 —	2	2	34 2	— 1	—		—	15			55 37 6 —	—	1 1	C	0.4	gy. f.
SASEBO GROUP	YUNOKI F.	60Y1278	19 4 10 1	4 11 2 —	2 1	1	25 1				4	17			64 30 6		19 1	r	0.3	l. gy. br. c.
SASEBO GROUP	YUNOKI F.	60Y1225	19 3 2 1	1 17 5	1 —	—	42 —				— 1	9 —	1		48 31 21		— 2	r	0.1	l. gr. br. m.
SASEBO GROUP	YUNOKI F.	60Y1222	7 — 2 2	5 7 — —	2 1	2	58 4	—			1	11			58 34 6 3	— —	3 —	r	0.2	l. gy. br. m.
SASEBO GROUP	YUNOKI F.	60Y1220	26 3 14 2	4 13 6	5	5	5 1				1	18			46 43 10 1	—	4 1 +	r	0.4	do.
SASEBO GROUP	NAKA ZATO F.	60Y1280	38 2 5 6	6 21 6	1 1	1				—	2	13		—	52 38 10		7 — +	r	0.08	wh. gy. c.
SASEBO GROUP	NAKA ZATO F.	60Y1281	6 2 2	3 8 2 —	1	1	62 4		—		2	8			74 19 7 —		1 —		0.4	l. gr. br. gy. m.
SASEBO GROUP	NAKA ZATO F.	60Y1223	24 6 7 5	4 17 4 —	1 —	1	16 1	1			1	15			55 38 7 1—		6 — +	r	0.3	br. m.
AINOURA GROUP		60Y1219	35 4 4 6	6 15 5	3 —	2	3 —		—		1	18 —			38 39 22		4 1		0.07	wh. br. c.
AINOURA GROUP		60Y1216	24 4 12 4	7 15 5	5 1	1 —	3 2				2	18 —			41 44 13 1	1	1 1	r	0.3	br. c.
AINOURA GROUP		60Y1208	6 4 1	2 5 2 1—	1—	1—	61 7 1				1	8			67 31 2	—	16	r	1.3	do.
AINOURA GROUP		60Y1215	46 4 4 7	4 6 4	8 —	2	2	2			2	9		—	47 38 15 1—	—	19 —		0.03	l. red. wh. c.
AINOURA GROUP		60Y1206	36 4 8 4	4 21 7	—	1					1	16	1		45 41 14 1	— —	2 1	r	0.3	l. br. f.
AINOURA GROUP		60Y1203	23 2 4 3	8 23 3 —	3 —	4	5				1	20	1		35 50 12 2	2 —	6 2		0.1	gy. m.
AINOURA GROUP		57E3	36 1 4 2	4 14 4	1	2	20 2 1		—	—	? — 2	8 —			57 32 11	1	15 — +		0.5	br. c.
AINOURA GROUP		57E4	15 — 2 1	4 10 1	1	1	52 4				1	9			48 21 31	—	4 1		0.6	br. m.
AINOURA GROUP		57E5	18 1 3	2 10 1	1 1	1	48 3				1	6			76 23 — 1—		7	C	0.8	br. f.
AINOURA GROUP		57E7	21 3 5 1	6 18 1	4 1	1 —	22 2				—	16			42 39 20	—	27 —		0.1	wh. gy. c.