MINERALOGICAL MAGAZINE, MARCH 1984, VOL. 48, PP. 53-63

The obliquity of K-feldspar from schists, gneisses, and granites in the north-eastern part of the Hida metamorphic belt, central Japan

AKIRA FUJIYOSHI

Geological Institute, Faculty of Education, Shizuoka University, Shizuoka, Japan

ABSTRACT. Most of 325 K-feldspars from the Hida metamorphic belt are characterized by diffuse 131 and 1$\bar{3}$1 reflections. These K-feldspars are classified into eight obliquity types on the basis of the width of the 131 peak or the ratio of mean height of two outer peaks (131 and 1$\bar{3}$1) to that of the middle composite peak. From the distribution of obliquity types and the microscopic characteristics of K-feldspars, this area is divisible into six zones.

The feature of each zone is shown by the frequency distribution of eight obliquity types in each zone, which reflects the strength of later retrogressive effects. The frequency distribution of Δ values in each of the types IV–VIII provides further information on later events.

The result of the K-feldspar study possibly indicates that the inversion of monoclinic to triclinic K-feldspar, characterized by the development of perthitic texture or crosshatched twinning, is sensitive to the degree of later retrogressive events. Some data on 2θ values of $\bar{2}$04, 060 and $\bar{2}$01 reflections in each types are presented.

SINCE Goldsmith and Laves (1954*b*) and Mackenzie (1954) recognized the existence of transitional phases between the monoclinic and triclinic modifications of K-feldspar and Goldsmith and Laves (1954*a*) proposed using Δ values, defined by the difference between 131 and 1$\bar{3}$1 spacings of K-feldspar, as a measure of triclinicity, this mineral has received much attention as a possible petrogenetic indicator.

However, obliquity determinations for K-feldspars from metamorphic and igneous rocks in various areas (e.g. Heier, 1957; Nilssen and Smithson, 1965; Touret, 1967; Budding, 1968; Fujiyoshi, 1970) revealed that most K-feldspars are characterized by diffuse 131 and 1$\bar{3}$1 reflections and such K-feldspars were called 'randomly disordered' by Christie (1962*a*). These K-feldspars were conveniently classified by some authors (Christie, 1962*b*; Budding, 1968; Fujiyoshi, 1970, 1977; Gorbatschev, 1972; Fujiyoshi and Nakagawa, 1978) into five to eight types based on the characteristics of their X-ray diffraction patterns. Fujiyoshi (1970), Fujiyoshi and Nakagawa (1978), and Fujiyoshi and Onuma (1982) used a circle representation, in which the measure of the obliquity is expressed by the inner solid circle, and indicated that it is an effective tool in elucidating the thermal and tectonic history of metamorphic and igneous rocks.

Wright and Stewart (1968) and Wright (1968) described the method for determining the structural state and composition of alkaki feldspars from refined unit cell parameters and from spacings of $\bar{2}$01, 060, and $\bar{2}$04 reflections. Stewart and Ribbe (1969) related cell parameters to Al/Si ordering. These methods have been developed and refined, and the ordering process in alkali feldspars has been discussed (Stewart and Wright, 1974; Stewart, 1975; Cherry and Trembath, 1979). However, in the K-feldspar samples whose 131 reflections are broadened or indistinct, the significance of the determined unit cell parameters seems to be obscure, as indicated by Wright and Stewart (1968) and Stewart (1975); this matter is now under study. In this paper some data from the 2θ values of $\bar{2}$04, 060, and $\bar{2}$01 reflections are described.

The main purpose of this paper is to show that the combination of the circle representation of obliquity and the classification of diffraction patterns is effective in disclosing the thermal and tectonic history of a metamorphic complex.

Geological outline

The north-eastern part of the Hida metamorphic belt is made up of metamorphic and igneous rocks as shown in fig. 1. The metamorphic rocks, intruded by five igneous masses, are divided into two groups, the Eboshi-yama group of schists and gneisses and the Yatazo-dani group of agmatites (Ishioka and Suwa, 1956; Fujiyoshi, 1970). A considerable part of these metamorphic rocks was changed to augen gneisses by K-feldspathization, accompanied by mylonitic deformation and related to the Iori granite (Fujiyoshi, 1970; Kano, 1973).

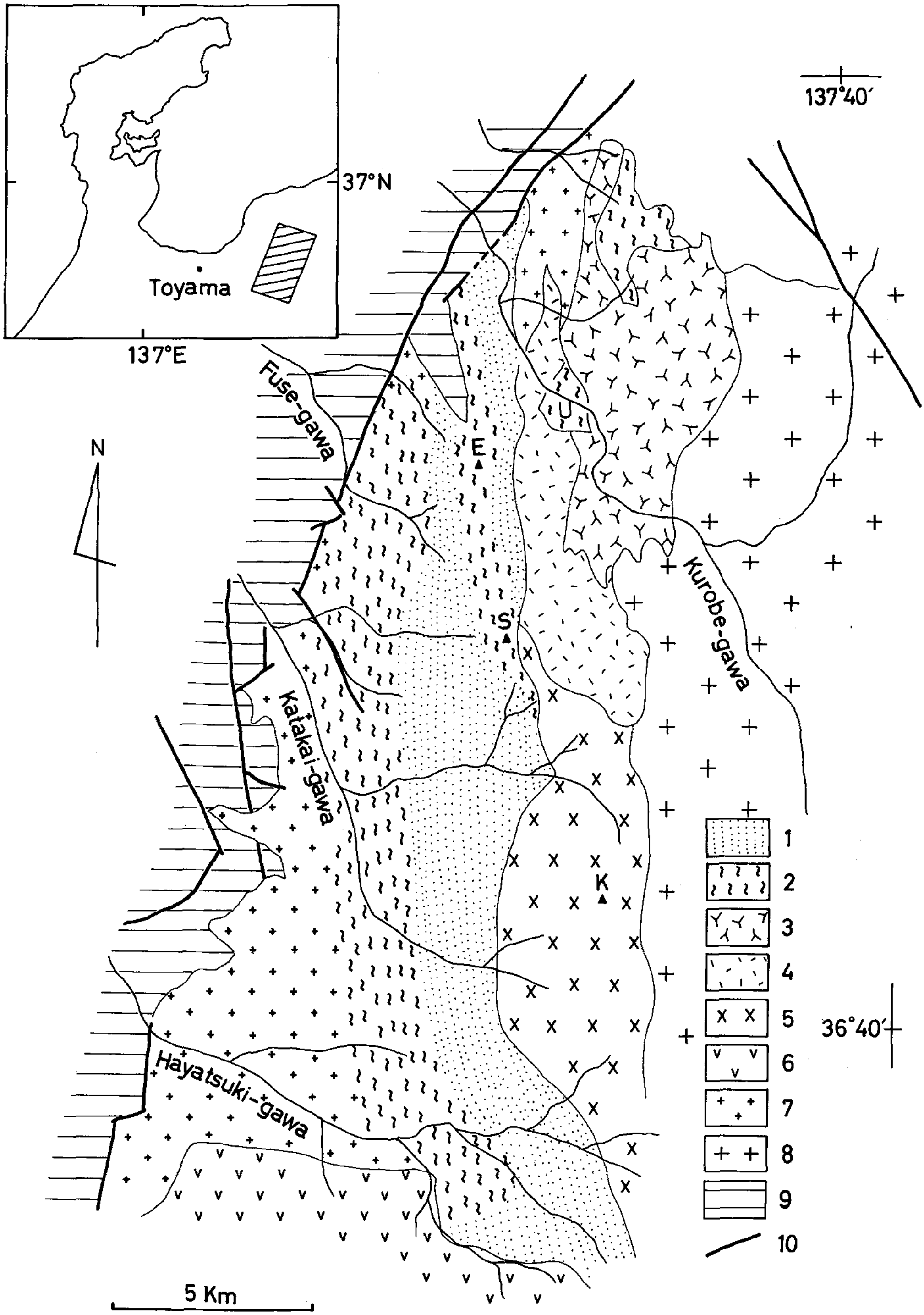

FIG. 1. Simplified geologic map of the north-eastern part of the Hida metamorphic belt after Ishioka and Suwa (1956), Fujii *et al.* (1970), Fujiyoshi (1970), Kano (1973), and Fujiyoshi and Nakagawa (1976). 1, schists and gneisses; 2, augen gneisses; 3, agmatites; 4, Komaga-dake gabbroic rocks; 5, Kegachi-dake granite; 6, Okuma-yama tonalite; 7, Iori granite; 8, Kitamata-dani granite; 9, Tertiary and Mesozoic (volcanic and sedimentary rocks); 10, fault; U, Unazuki; E, Eboshi-yama; S, Soga-dake; K, Kegachi-dake.

The Eboshi-yama group consists of schists and gneisses of variable composition. In the lower Kurobe-gawa area, the schists belong to the amphibolite facies (Ishioka and Suwa, 1956). In the upper Hayatsuki-gawa area, they change to gneisses and marble associated with leucogranite, which belong to the higher part of the amphibolite facies or granulite facies (Fujiyoshi, 1970, 1973).

Most of these schists and gneisses suffered various degrees of retrogressive dislocation metamorphism with hydrothermal alteration (Fujiyoshi, 1970; Fujiyoshi and Nakagawa, 1978). The Kegachi-dake granite caused further retrogressive contact metamorphism of gneisses and leucogranite, accompanied by hydrothermal alteration (Fujiyoshi, 1970).

The Yatazo-dani group consists of agmatitic schists, amphibolites, gneisses, and microcline granite; these rocks also show the effect of the retrogressive metamorphism.

Augen gneisses are characterized by porphyroblastic K-feldspar augen and secondary biotite, chlorite, and epidote, although they sometimes contain brownish hornblende; some augen gneisses around the Iori granite show mylonitic texture. Along the faults in the Fuse-gawa area these rocks show cataclastic texture characterized by fractures and partings, which superposes on the earlier mylonitic and/or deformation texture.

Intrusive rocks consist of four older masses, the Komaga-dake gabbroic rocks, Okuma-yama tonalite, Kegachi-dake granite and Iori granite, and of one younger mass, the Kitamata-dani granite.

The Komaga-dake gabbroic rocks are made up mainly of plagioclase and hornblende, and were affected by the Iori granite (Fujii *et al.*, 1970). The Okuma-yama tonalite has a granodioritic composition, near that of the Iori granite, indicating the effect of K-feldspathization by the Iori granite.

The Kegachi-dake granite is a biotite granite. In the Katakai-gawa and the northern part of the Hayatsuki-gawa areas, this rock suffered from dislocation metamorphism with hydrothermal alteration, although it is free from dislocation metamorphism in the major part of the Hayatsuki-gawa area. The Iori granite is a medium-grained biotite adamellite. In the Hayatsuki-gawa area it shows weak deformation with hydrothermal alteration. In the Katakai-gawa area the deformation and hydrothermal alteration become more conspicuous. In the northern part of the Katakai-gawa area and to the north of Unazuki, the Iori granite shows the superposition of cataclastic texture of partings and fractures on the deformation texture along the faults.

The Kitamata-dani granite consists of various rocks ranging from biotite granodiorite to hornblende tonalite.

The obliquity of K-*feldspar*

Samples for X-ray study were collected from various kinds of schists, gneisses, and granites. The 325 K-feldspar samples separated from the crushed samples by means of a heavy liquid were X-rayed using Cu-K_α radiation. The Δ value was calculated by the formula of Goldsmith and Laves (1954*a*), $\Delta = 12.5\ (d_{131}-d_{1\bar{3}1})$.

As shown in fig. 2, the diffraction pattern in the 131 and $1\bar{3}1$ reflection range is often complex and diffuse, and therefore the obliquity cannot be expressed sufficiently by the Δ value alone. The writer tried to classify the K-feldspars into eight obliquity types based on the diffraction pattern in this range as shown in fig. 2. The feature of the

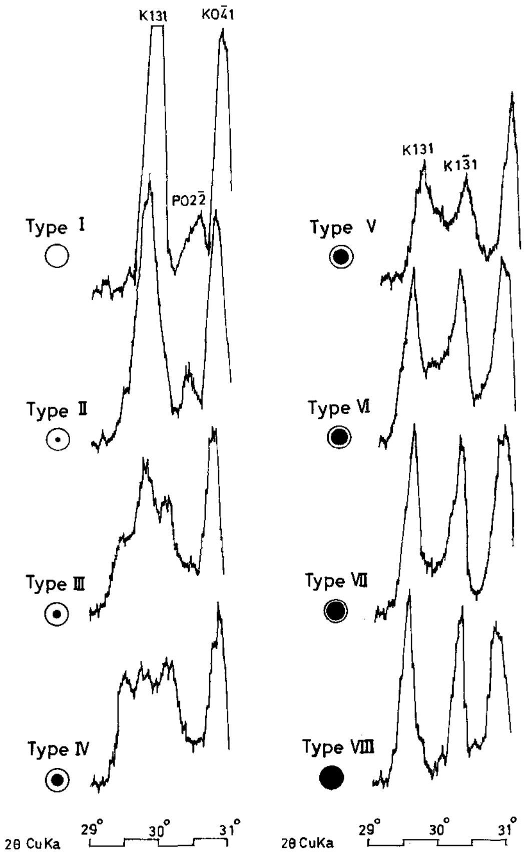

FIG. 2. Examples of diffraction patterns of 131 and $1\bar{3}1$ reflections of K-feldspar representing eight types found in the studied area. Major reflections of K-feldspar and plagioclase are labeled K and P, respectively.

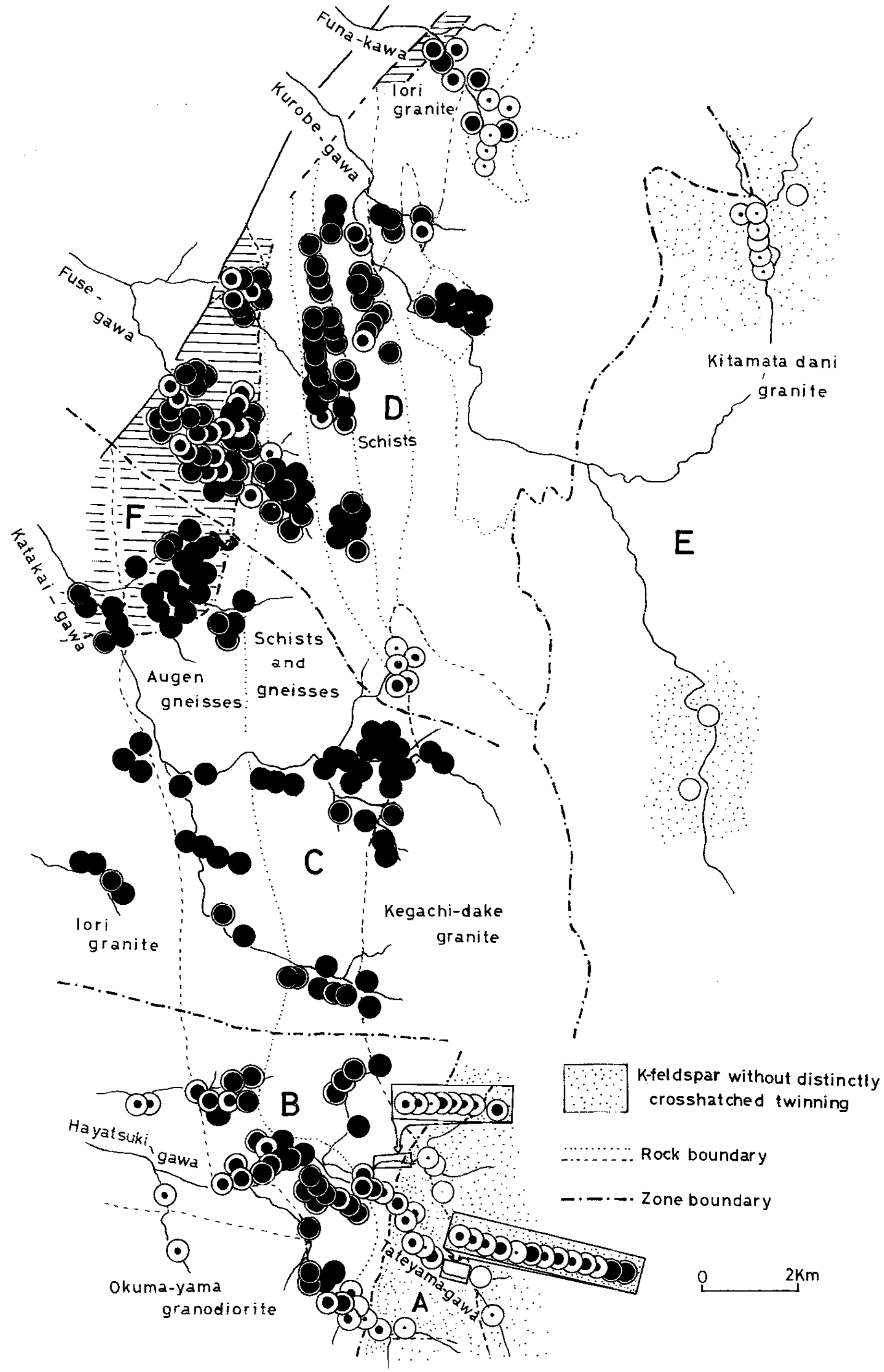

FIG. 3. Map showing variation of K-feldspar obliquity in the north-eastern part of the Hida metamorphic belt (that in the upper Hayatsuki-gawa, upper Katakai-gawa, and lower Kurobe-gawa areas is based on Fujiyoshi, 1970, Fujiyoshi and Nakagawa, 1978, and Fujiyoshi and Onuma, 1982, respectively). A, B, C, D, E, and F show zones distinguished from the feature of distribution of K-feldspar obliquity plotted and microscopic characteristics of K-feldspar.

diffraction diagram for each type is as follows: type I shows a sharp single peak; type II shows a broad single peak; types III and IV show broader composite peaks, either resolved into three or not; types V–VIII consist of two outer peaks and a middle peak, the latter becoming weaker from type V to VIII. For classifying into types I–IV, the widths at $\frac{1}{2}$ and $\frac{1}{3}$ heights of broad composite peak, denoted as a and b respectively, were used as criteria; type I has $a \leqq 0.25°\ 2\theta$ and $b \leqq 0.375°\ 2\theta$, type II $a = 0.275–0.375°\ 2\theta$ and $b = 0.40–0.50°\ 2\theta$, type III $a = 0.40–0.625°\ 2\theta$ and $b = 0.525–0.75°\ 2\theta$, and type IV $a \geqq 0.65°\ 2\theta$ and $b \geqq 0.775°\ 2\theta$.

Division into types V–VIII was made by determining the ratio of the mean height of the two outer peaks, c, to that of the middle composite peak, d; type V has $d/c = 0.80–0.50$, type VI $d/c = 0.50–0.30$, type VII $d/c = 0.30–0.15$, and type VIII $d/c = 0.15–0.00$.

The 131 and $1\bar{3}1$ reflections for seventy-four of the K-feldspar samples were measured and 2θ values of $\bar{2}04$, 060, and $\bar{2}01$ reflections determined using CaF_2 ($a = 5.4620$ Å; annealed at 700 °C for 48 hours) as an internal standard.

Results of K-*feldspar obliquity determination*

To facilitate the consideration of obliquity in the studied area, the circle representation is employed to denote the obliquity types (fig. 2). For type IV in which the height of the middle peak is nearly equal to that of the two outer peaks (131 and $1\bar{3}1$), the diameter of the inner solid circle is about a half of the outer circle; the size of inner solid circle decreases from type IV to I and increases from type IV to VIII.

The distribution of the obliquity of 325 K-feldspar samples in the studied area is shown in fig. 3. The area is divisible into six zones based on the obliquity of the K-feldspars together with their microscopic characteristics: A, the Tateyama-gawa zone characterized by abundance of types I–III and non-crosshatched K-feldspar which sometimes show well-developed perthite texture; B, the Hayatsuki-gawa zone characterized by abundance of types VI and VII and crosshatched K-feldspar; C, the Katakai-gawa zone characterized by prevailing distribution of type VIII and crosshatched K-feldspar; D, the Fuse-gawa and lower Kurobe-gawa zone characterized by abundance of types VI–VIII and crosshatched K-feldspar; E, the Kitamatadani granite zone characterized by abundance of types I and II and non-crosshatched K-feldspar; F, the fault zone characterized by the cataclastic K-feldspar in the Katakai-gawa and the Fuse-gawa areas.

The distribution of K-feldspar obliquity in zones A–E is more clearly shown by the frequency distribution of the eight obliquity types in fig. 4. The distribution of types in the fault zone (zone F) does not have its own characteristic pattern, but shows a similar pattern to that in the neighbouring area, C and D in fig. 4.

As is evident from fig. 4, few Δ values of K-feldspars in zones A and E have been determined, because the Δ values cannot be determined in types II–IV except for a few of type IV. The frequency distribution of Δ values for the individual types in the remaining three zones are shown in figs. 5, 6, and 7. These zones have different patterns of frequency distribution. Although the Δ values are generally distributed over a wide range, they gradually shift to a higher Δ value range from type IV to VIII as typically represented by the mean Δ value for each type.

The frequency of types, mean Δ values and rock types in each zone are summarized in Table I.

The 2θ values of $\bar{2}04$ and 060 reflections in each type are plotted on diagram of 2θ (060) against 2θ ($\bar{2}04$) from Wright (1968) (fig. 8). The mean 2θ values of $\bar{2}01$ reflection are 21.03° in types I–V and 21.04–21.05° in types VI–VIII.

Discussion

Zones. The presence of K-feldspars of types I and II with $2V_x = 45–56°$ in the leucogranite and gneisses of the Tateyama-gawa zone, which belong to the higher temperature part of the amphibolite facies or the granulite facies and are practically free from the later retrogressive contact metamorphism, suggests that the K-feldspar of the leucogranite and gneisses was formed by regional metamorphism with a monoclinic form (Fujiyoshi, 1970). This is in good agreement with the inversion of microcline to orthoclase under conditions at the high-temperature part of the amphibolite to granulite facies reported from many other areas (e.g. Heier, 1957, 1961; Budding, 1968; Hipple, 1971; Collerson, 1976).

As is obvious from fig. 3, the K-feldspar of the Kegachi-dake granite had been monoclinic or nearly monoclinic before the dislocation. The presence of type II K-feldspar in the Iori granite and augen gneisses weakly affected by the retrogressive dislocation metamorphism (Fujiyoshi and Nakagawa, 1978) suggests that the K-feldspar of the Iori granite and augen gneisses grew as monoclinic or nearly monoclinic unless it suffered from the dislocation metamorphism with hydrothermal alteration. K-feldspars from schists and gneisses in the Katakai-gawa and lower Kurobe-gawa zones, belonging to the amphibolite facies and showing the effect of the K-feldspathization, show similar types to those of Kegachi-dake granite, Iori granite,

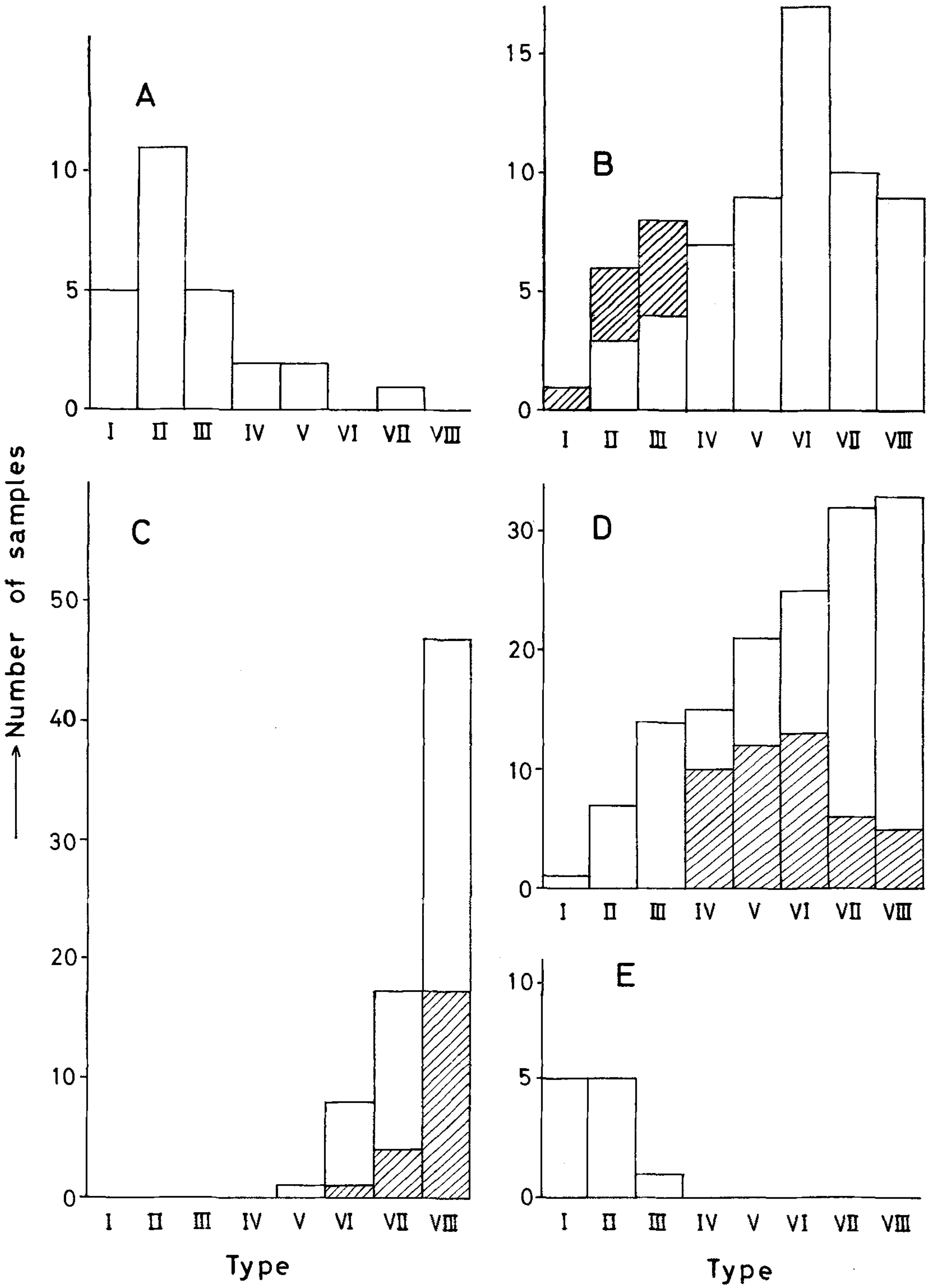

FIG. 4. Histogram showing the distribution of type of diffraction pattern for K-feldspars separated by a heavy liquid. A. Tateyama-gawa zone. B. Hayatsuki-gawa zone. C. Katakai-gawa zone. D. Fuse-gawa and lower Kurobe-gawa zone. E. Kitamata-dani granite zone. Shaded fields in B show samples from border between the Tateyama-gawa and Hayatsuki-gawa zones (along the Shirahagi-gawa); those in C and D show samples from the fault zone in the Katakai-gawa and the Fuse-gawa and lower Kurobe-gawa zones.

and augen gneisses in the same zones, and therefore are considered to have grown as more-monoclinic feldspars and their present states to have been controlled by the strength of the retrogressive dislocation metamorphism. Whether the more-monoclinic K-feldspars were formed by regional metamorphism or the effect of K-feldspathization is not known.

Each zone in this area might indicate the difference in the later retrogressive metamorphism or its strength; the Tateyama-gawa zone suffered from retrogressive contact metamorphism, the Hayatsuki-gawa zone suffered from retrogressive dislocation metamorphism, and the Kitamata-dani granite zone was hardly affected by the later events.

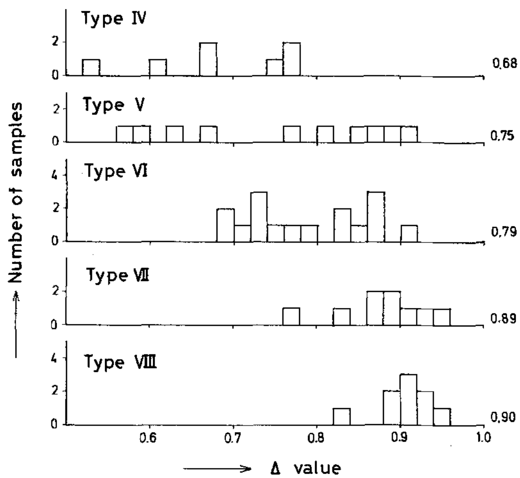

FIG. 5. Histogram showing the distribution of Δ value for each of types IV–VIII in the Hayatsuki-gawa zone. Arabic numerals of right margin show the mean Δ value.

The frequency distribution of obliquity types and Δ values. By the circular representation of K-feldspar obliquity (fig. 3) the Fuse-gawa and lower Kuroba-gawa zone shows a similar type of obliquity distribution to the Hayatsuki-gawa zone. The frequency distribution of obliquity types (fig. 4), however, indicates a greater abundance of more-triclinic K-feldspar in the former zone, which is due to a stronger effect of the retrogressive dislocation metamorphism. Thus, the frequency distribution of obliquity types in each zone is more effective in clarifying the strength of later retrogressive metamorphism. K-feldspars in the Katakai-gawa zone and the Tateyama-gawa zone have the strongest and weakest later effect, respectively.

The result indicated by the frequency distribution of obliquity types is also shown in the frequency distribution of Δ values (figs. 5, 6, and 7). K-feldspars in the Fuse-gawa and lower Kurobe-gawa zone show a similar distribution range of Δ values in each type to those in the Hayatsuki-gawa zone, but the former indicates an increase of the proportion of higher Δ values in each type; those in the Katakai-gawa zone have higher Δ values in almost each type. This fact indicates that the Δ value increases with the strength of later events, and suggests that the frequency distribution of the Δ value in types IV–VIII is also useful in disclosing these strengths.

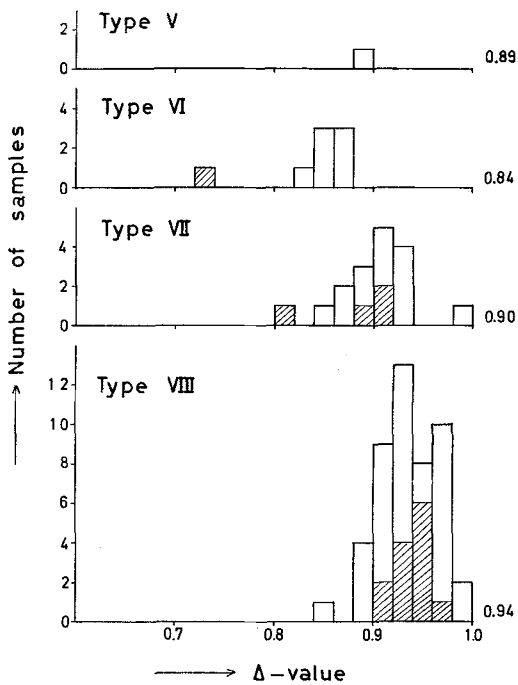

FIG. 6. Histogram showing the distribution of Δ value for each of types V–VIII in the Katakai-gawa zone; shaded fields show samples from the fault zone in this area. Arabic numerals of right margin show the mean Δ value.

The frequency distribution of obliquity for the fault zone in the Katakai-gawa zone and the Fuse-gawa and lower Kurobe-gawa zone does not show the characteristic pattern but is similar to that in the respective zones (C and D in fig. 4, and Table I). This relation is clear in the frequency distribution of Δ values and the mean Δ values as shown in figs. 6 and 7, and Table I, respectively. These results suggest that the K-feldspars in the fault zone have hardly been affected by the fault movement on their inversion.

Textures and K-feldspar transformation. On the inversion of K-feldspar from monoclinic to triclinic, two different textures are developed: the perthite texture observed in the Tateyama-gawa zone suffering from the retrogressive contact metamorphism with hydrothermal alteration, and crosshatched twinning observed in the Hayatsuki-gawa zone, the Katakai-gawa zone, and the Fuse-gawa and lower Kurobe-gawa zone suffering from the retrogressive dislocation metamorphism with hydrothermal alteration. Fujiyoshi (1977) reported from the metamorphic rocks in northern Colombia that microcline showing crosshatched twinning was formed during deformation and that microcline showing ambiguous crosshatched twinning and containing abundant second generation albite was formed during retrogressive contact metamorphism with hydrothermal alteration. These facts might indicate that the deformation has played an important role in the development of crosshatched twinning as suggested by Eskola (1952).

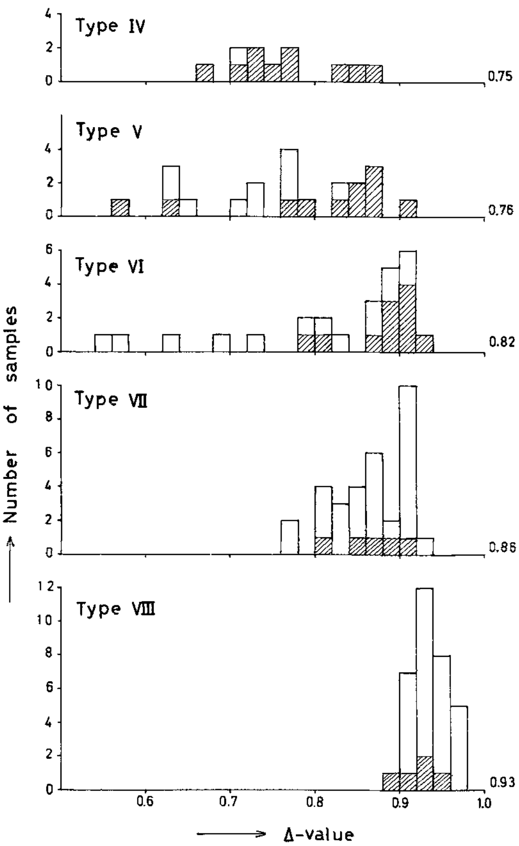

FIG. 7. Histogram showing the distribution of Δ value for each of types IV–VIII in the Fuse-gawa and lower Kurobe-gawa zone; shaded fields show samples from the fault zone in this area. Arabic numerals of right margin show the mean Δ value.

The efficacy of deformation in facilitating the inversion of K-feldspar from monoclinic to triclinic had been emphasized by some authors (Eskola, 1951, 1952; Karamata, 1961; Budding, 1968; Fujiyoshi, 1970, 1977; Gorbatschev, 1972; Wilson and Coats, 1972; Fujiyoshi and Nakagawa, 1978). The catalysing effect of water on feldspar inversion was pointed out by Donnay *et al.* (1960), McConnell and McKie (1960), and Budding (1968). These facts are in agreement with the results of the present study.

Most K-feldspars in the area are characterized by the broad peak, that is they can be called 'randomly disordered' (Christie, 1962*a*); Δ values in each type range widely; and $2V_x$ values in a single grain of most K-feldspars are variable (Fujiyoshi and Nakagawa, 1978; Fujiyoshi and Onuma, 1982). These facts might indicate that orthoclase was transformed through 'randomly disordered' K-feldspar into microcline, and might substantiate Goldsmith and Laves's suggestion (1954*a*) that the inversion of K-feldspar is very sluggish and that an equilibrium is hardly attained.

The 2θ values of $\bar{2}04$, 060, and $\bar{2}01$ diffraction peaks. As shown in fig. 8, type I K-feldspars are orthoclases plotted between 'Spencer B' and 'P50-56F', mostly between 'Spencer B' and 'SH 1070'. Type VIII K-feldspars are maximum microclines plotted between 'Amicr' and 'SH 22500'.

The 2θ values of 060 diffraction peak increase regularly from type I to type VIII. The 2θ values of $\bar{2}04$ reflection are divided into two groups separated by a large gap: one is a monoclinic group consisting of types I–III and a part of type IV and the other a triclinic group consisting of types V–VIII and a part of type IV. A part of type IV has 2θ ($\bar{2}04$) values intermediate between the two groups, giving the value of intermediate microcline in fig. 8.

The difference ($\Delta_{\bar{2}01}$) between the 2θ value of $\bar{2}01$ reflection derived from fig. 8 and the directly measured value is below 0.12° in types I–II and V–VII and a part of types III and IV K-feldspars, but above 0.12° in many type III and a part of type IV K-feldspars. Stewart and Wright (1974) defined the K-feldspar with $\Delta_{\bar{2}01} > 0.12°$ as 'anomalous' (= strained) feldspar. Stewart (1975) stated that cryptoperthites are more strained than microperthites and also that monoclinic feldspars are more strained than triclinic feldspars, and suggested that inversion to a triclinic structure of the potassium feldspars reduces coherency between the sodic and potassic phases of perthites. In this area, the $\Delta_{\bar{2}01}$ values increase from type I to IV in the monoclinic

Table 1. The relation between frequency of types and mean Δ value in each zone.

Zone	Frequency of types	Mean Δ value	Rock type
A	type I, 19.2%; type II, 42.3%; type III, 19.2% type IV, 7.7%; type V, 7.7%; type VII, 3.8%	0.65	granites, gneisses
B	type I, 1.5%; type II, 9.0%; type III, 11.4%; type IV, 10.4%; type V, 13.4%; type VI, 25.4% type VII, 14.9%; type VIII, 13.4%	0.81	granites, gneisses, augen gneisses
C*	type V, 1.4%; type VI, 10.9 (14.5) %; type VII, 23.3 (18.2)%; type VIII, 64.4 (77.3)%	0.92 (0.89)	granites, schists and gneisses, augen gneisses
D*	type I, 0.7%; type II, 4.7%; type III, 9.5%; type IV, 10.1 (21.7) %; type V, 14.2 (26.1) %; type VI, 16.9 (28.3) %; type VII, 21.6 (13.0)%; type VIII, 22.3 (10.9)%	0.84 (0.82)	granites, schists and gneisses, augen gneisses
E	type I, 45.5%; type II, 45.5%; type II, 9.1%		granite

* The values in paretheses are for cataclastically deformed K-feldspars in C and D zones.

The area composed of these K-feldspars is designated as zone F (see text).

group, since, from type I to IV in this group, 2θ values of 060 increase but those of $\bar{2}04$ are nearly constant. The change of type I to IV is based on two different processes expressed by the development of the perthitic texture and crosshatched twinning.

Wright (1968) demonstrated that 2θ values of the $\bar{2}01$, 060, and $\bar{2}04$ diffraction peaks can be related to the *a*, *b*, and *c* cell parameters, respectively. The significance of the cell parameters of the K-feldspars with the broad 131 peaks, indicating strained feldspars, intermediate microcline, and others, is now under study.

Some concluding remarks

The geographical distribution and frequency distribution of obliquity types and the Δ values of K-feldspar obliquity are effective in disclosing the thermal and tectonic events of metamorphic and igneous rocks along with conditions of each event; the result is as follows:

1. The distribution of obliquity types in the studied area is shown in the map as fig. 3. It shows that the area can be divided into five zones and enables us to elucidate the thermal and tectonic history of the metamorphic and igneous rocks as already pointed out (Fujiyoshi, 1970; Fujiyoshi and Nakagawa, 1978). For instance, the Kegachi-dake granite intruded before the Iori granite and gave the retrogressive contact effect to the gneisses and leucogranite.

2. The frequency distribution of types and Δ values of K-feldspar obliquity is effective in clarifying the degree of strength of later retrogressive events as follows. Among three zones suffering from retrogressive dislocation metamorphism with hydrothermal alteration its effect is the strongest in the Katakai-gawa zone, intermediate in the Fuse-gawa and Kurobe-gawa zone, and the weakest in the Hayatsuki-gawa zone. The later effect in the Tateyama-gawa zone suffering from the retrogressive contact metamorphism is weaker in comparison with the three zones.

3. The geographical distribution of obliquity types and the frequency distribution of types and Δ values are useful in elucidating more clearly the history of the metamorphic complex as follows. The K-feldspars of augen gneisses in the Hayatsuki-gawa zone show the increasing proportion of monoclinic K-feldspar from type VIII in the mylonitic zone to type IV towards the Iori granite with types II–III K-feldspars, while those of augen gneisses and the Iori granite in the Katakai-gawa

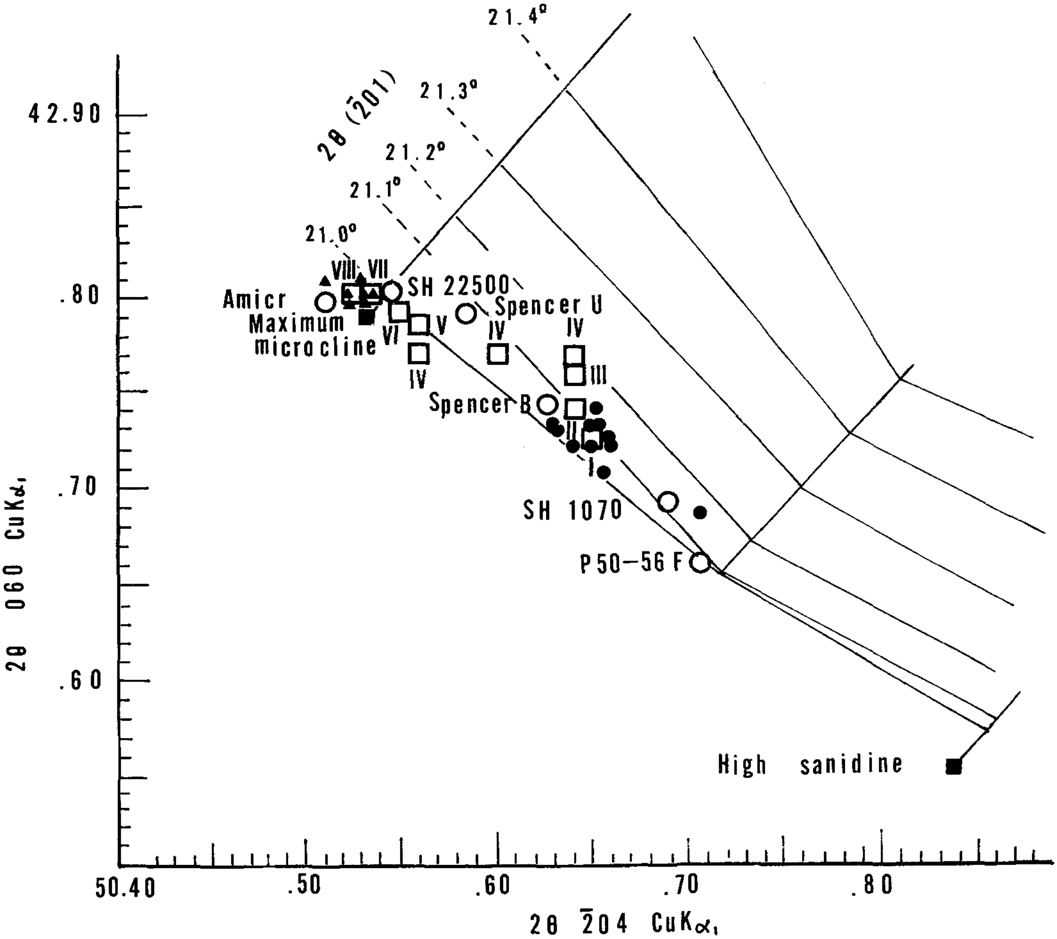

FIG. 8. Plots of 2θ (060) against 2θ ($\bar{2}04$) for K-feldspars from the northern part of the Hida metamorphic rocks. Solid lines are from Wright (1968); counters parallel to the maximum microcline-high sanidine give estimated 2θ ($\bar{2}01$) values. Open circles are based on Wright (1968) and Wright and Stewart (1968): Orthoclase, P50-56F, SH1070 and Spencer B; intermediate microcline, Spencer U; maximum microcline, Amicr SH22500. Solid circles are type I K-feldspars and solid triangles type VIII ones obtained in this area. Open squares are plots of mean 2θ values of 060 and $\bar{2}04$ in each type of K-feldspars in this area.

zone were almost entirely changed to triclinic by the retrogressive dislocation metamorphism with hydrothermal alteration. Augen gneisses and Iori granite in the fault zone of the Katakai-gawa zone and the Fuse-gawa and lower Kurobe-gawa zone hardly show the effect of fault movement on the inversion of K-feldspar unlike the inference by Fujiyoshi and Nakagawa (1978). These results suggest that the dislocation metamorphism started from the stage of K-feldsparthization related to the Iori granite and that it continued until a time after the intrusion of the Iori granite; the dislocation metamorphism might be related to the upheaval movement of the metamorphic complex and the fault zone might be formed by the upheaval movement at a shallower place. The Kitamata-dani granite, which is a younger mass, appears to have been emplaced after the retrogressive dislocation metamorphism with hydrothermal alteration.

Finally, the obliquity of K-feldspar, which is a common mineral in the metamorphic complex, is effective in clarifying the later retrogressive events and the degree of their strength. The result of this study might indicate that the inversion of monoclinic to triclinic K-feldspar, characterized by the development of perthitic texture or crosshatched twinning, is sensitive to the degree of later retrogressive effects.

Acknowledgements. Many thanks are due to Professor K. Nagasawa of Shizuoka University for valuable comments and critical reading of the manuscript. Thanks are extended to Professor K. Ishioka and Associate professor K. Suwa of Nagoya University for valuable suggestions and encouragement.

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[*Manuscript received 7 June 1982;
revised 25 March 1983*]