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Scanning Electron Microscope Examination of Quartz Surface Textures from Kaolinized Granitic Rocks

By

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with 11 Figures

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Abstract: Observation of surfaces of quartz in kaolinized granitic rocks by scanning electron microscopy was applied to provide information on the environmental conditions of kaolinization. Comparing with the quartz grain surfaces from kaolinite and halloysite specimens each other, quartz crystals from kaolinite specimens show extremely rough surfaces caused by deep dissolution pits, while the surfaces from halloysite are relatively smooth surfaces. Quartz surfaces in hydrothermal kaolinized granitic rocks are extremely rougher than those in weathered granitic rocks.

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I. Introduction

Kaolin deposits formed in granitic rocks are originated from weathering and/or hydrothermal activities. However, kaolin minerals such as kaolinite and halloysite are formed under relatively low temperature and low pressure conditions. Therefore, as regards the genesis of kaolin deposits, two origins have been proposed and discusses. It has been considered that halloysite transforms to kaolinite under the tropical weathering condition. However, the mineralogical evidences have been uncleared yet. In some hydrothermal kaolin deposits, it is possible to divided into kaolinite and halloysite zones based on the constituent kaolin minerals. The clear differences of the formation condition between kaolinite and halloysite have not been established yet.

Plagioclase and biotite are altered easily to kaolin minerals under the weathering or acidic hydrothermal conditions. Quartz and K-feldspar, however, are slowly changed. Therefore, we inferred that some important information might be remained on the overgrowth surfaces of quartz and K-feldspar. In this study, the crystal surfaces of unaltered minerals such as quartz in kaolinized granitic rocks were investigated to obtain information about environmental conditions during kaolinization by using Scanning electron microscopy.

II. Specimens

Quartz specimens were collected from some hydrothermal and residual kaolin deposits which are formed in granitic rocks, and also weathered granitic rocks (Fig.1). Based on the genesis, kaolin minerals (kaolinite and halloysite) in kaolinized granitic rocks are divided into three types, i.e. hydrothermal, residual or weathering, and mixed hydrothermal and weathering. Some different factors on genesis of some kaolin deposits have been proposed by many investigators as follows.

According to Kitagawa and Kameoka (1986), the Komaki halloysite deposit were formed by hydrothermal activity. However Sudo and Takagi (1993) interpreted that the Komaki halloysite deposit was produced due to weathering.

There has always been considerable debate the origin of the Cornwall kaolin deposit(china clay deposit). Some have thought that tropical weathering was responsible while others considered that hydrothermal solutions were the kaolinising agents. Advocates of the supergene origin include Hickling (1908), Coon (1911), Konta (1969), Keller (1976a,b) and Sheppard (1977), A hydrothermal origin was argued by Exley (1959) and Bristow (1977). Generally speaking the accepted view in this deposit has been that hydrothermal formation is likely. Murray (1988) reviewed that this kaolin deposit was formed by both weathering and hydrothermal agences.

As regards the genesis of the Tirschenreuth kaolin deposit, two origins have been proposed and discussed, i.e. hydrothermal (Strobel, 1969) and weathering (Lipper et al., 1968; Koster, 1974, 1977, 1980; Kitagawa and Koster, 1991).

Therefore, the genesis of kaolin minerals collected for this study, as mentioned below, was followed by generally acceptable view.

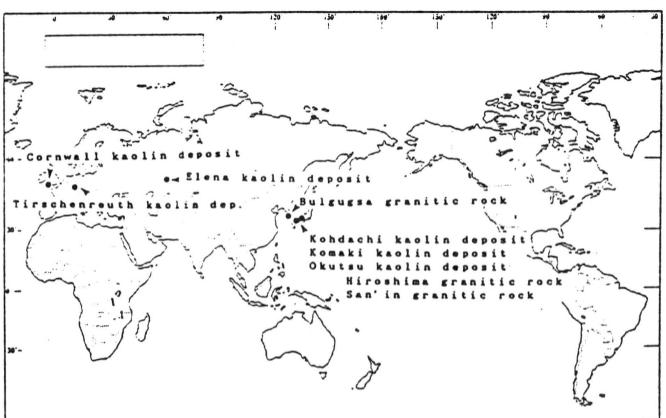

Fig. 1. Sampling localities

A. Hydrothermal deposit.
  1. kaolinite
    *specimen from the Kohdachi kaolin deposit in Hiroshima prefecture, Japan (Matsumoto, 1965; Kitagawa and Kakitani, 1979)(Fig.2).
  2. halloysite
    *specimen from the Kohdachi kaolin deposit at Hiroshima prefecture, Japan (Kitagawa and Kakitani, 1979)(Fig.3).
    *specimen from the Komaki halloysite deposit at Shimane prefecture, Japan (Kitagawa and Kameoka,1984) (Fig.4).
    *specimen from the Okutsu kaolin deposit at Okayama prefecture, Japan (Fig.5).

B. Residual(weathered) kaolin deposit.
  1. kaolinite
    ***specimen from the Tirschenreuth kaolin deposit in Bavaria, Germany (Kitagawa and Köster, 1991)(Fig.6).**
    ***specimen from the Elena kaolin deposit in Urals, Russia (Kitagawa et al., 1992)(Fig.7).**

C. Weathered granite
  2. halloysite
    *Hiroshima granitic rock in Hiroshima prefecture, Japan (Fig.8).
    *San'in granitic rock in Shimane Prefecture, Japan (Fig.9).
    *Bulgugsa granitic rock in Pusan, Korea (Fig.10).

D. Mixed hydrothermal and residual kaolin deposit
    *specimen from the cornwall kaolin deposit in Cornwall, England (Murray, 1988)(Fig.11).

III. Method

Quartz grains were picked up from the kaolinized specimens and they were washed in the distilled water with the ultrasonic generator and then were observed by Scanning electron microscopy. K-feldspar grains were also performed by same method.

In this study, kaolinite and halloysite are characterized to be platy and tubular in shapes, respectively. The grain size of investigated quartz is 0.65-2mm in diameter.

IV. Results

Many etch pits on the overgrown surfaces of all quartz and k-feldspar crystals are observed (Figs.2-11). These etch pits resemble to the chemical dissolution pits showing by Wilson (1978).

The etch pits show circular, triangular and hexagonal shape patterns. Although etch pits have various size distribution, almost pits have smaller than 5 um in size.

Three alteration zones could be distinguished in the Kohdachi and the Komaki kaolinized bodies by their clay mineral assemblages: a kaolinite zone, a kaolinite-halloysite zone, and a halloysite zone. Both deposits were formed by hydrothermal activities (Kitagawa and Kakitani, 1979; Kitagawa and Kameoka, 1986; Kitagawa and Koster, 1991). Much more and deeper dissolution pits are observed on the surfaces of quartz crystals from kaolinite zone than those from halloysite zone as shown in Figs. 2, 3 and 4.

The quartz grains from the weathered

granite such as Hiroshima, San'in and Bulgugsa granitic rocks have generally shallow and small etch pits (Figs.8,9 and 10). On the other hand, wide and deep etch pits are found on the quartz surfaces collected from the Tirschenreuth and the Elena deposits (Figs.6 and 7). The quartz grains from the Cornwall deposit have deepest and widest etch pits among all specimens observed (Fig.11).

As shown in Figures , overgrowth surfaces of quartz collected from hydrothermal kaolinite samples appear rough (Figs.2 and 11), on the other hand quartz grains from kaolinite specimens originated by weathering show relatively smooth surfaces (Figs.6 and 7). In addition, the former one has deeper etch pits than the latter. Dissolution pits on surfaces in hydrothermal halloysite specimens are also characterized by rougher surfaces (Figs. 3,4 and 5) than them from weathered halloysite (Figs. 8, 9 and 10).

Comparing with the quartz grain surfaces from kaolinite and halloysite specimens each other, quartz crystals from kaolinite specimens show extremely rough surfaces caused by deep dissolution pits, while the surfaces from halloysite, however, are relatively smooth surfaces.

Dissolution pits on quartz surfaces are usually considered to be depended on various conditions of each solution, by which kaolinite and halloysite were formed in host granitic rocks. For example, it is considered as follows; pH value, temperature, chemical composition and duration time and etc.

In this study, the most suitable condition for phenomena as mentioned before was not decided.

V. Conclusion

Observations of surfaces of quartz by scanning electron microscopy have been applied in geological studies to provide information on the environmental conditions of sedimentation and diagenesis (Krinsley and Donahue, 1968; Pant et al., 1978; Wilson, 1978). By the detail observations of the crystal surfaces of unaltered minerals such as quartz, it is possible to also get some information about environmental conditions during kaolinization of granitic rocks.

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Fig. 2. KOHDACHI KAOLIN DEPOSIT

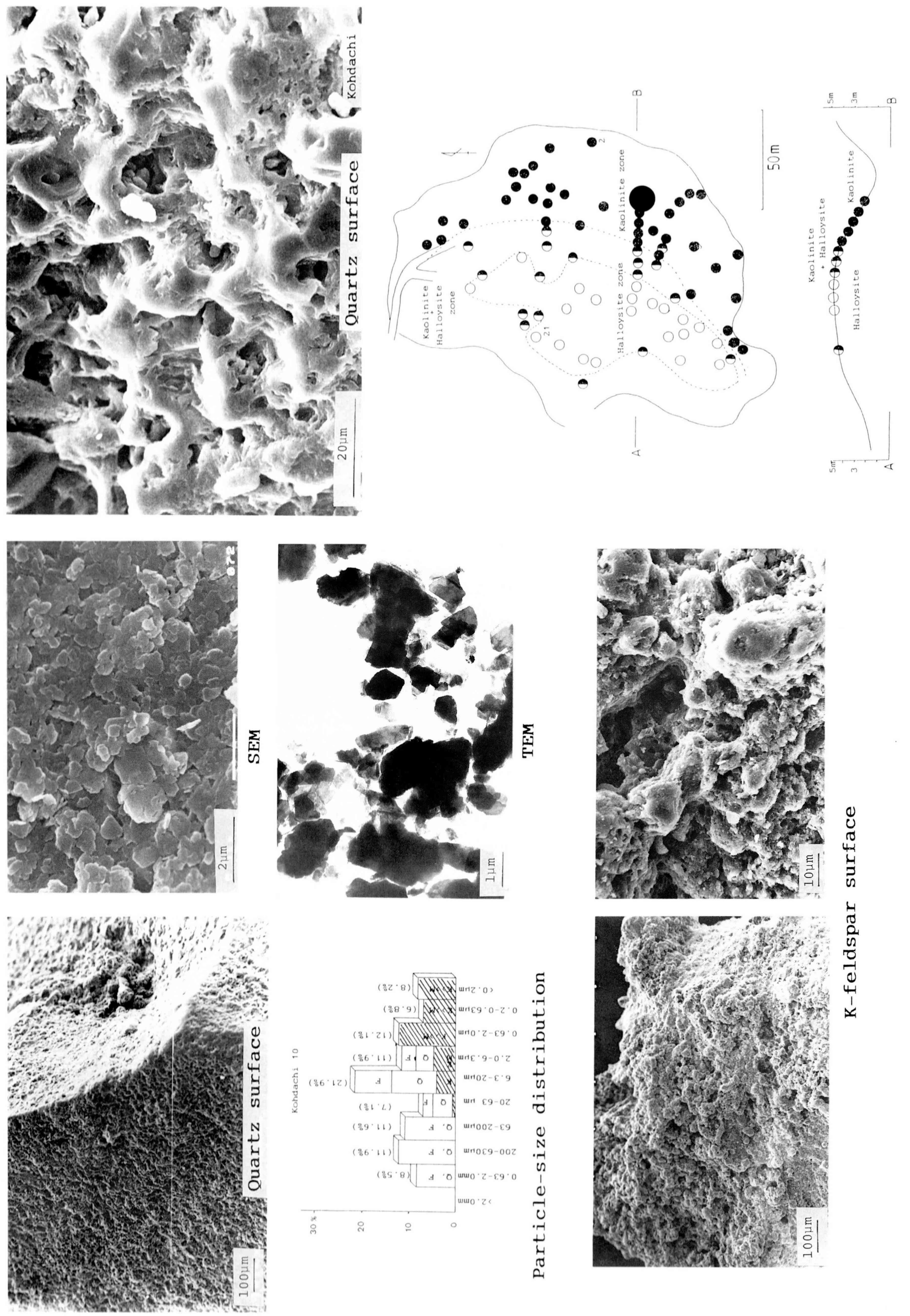


Fig. 3. KOHDACHI KAOLIN DEPOSIT

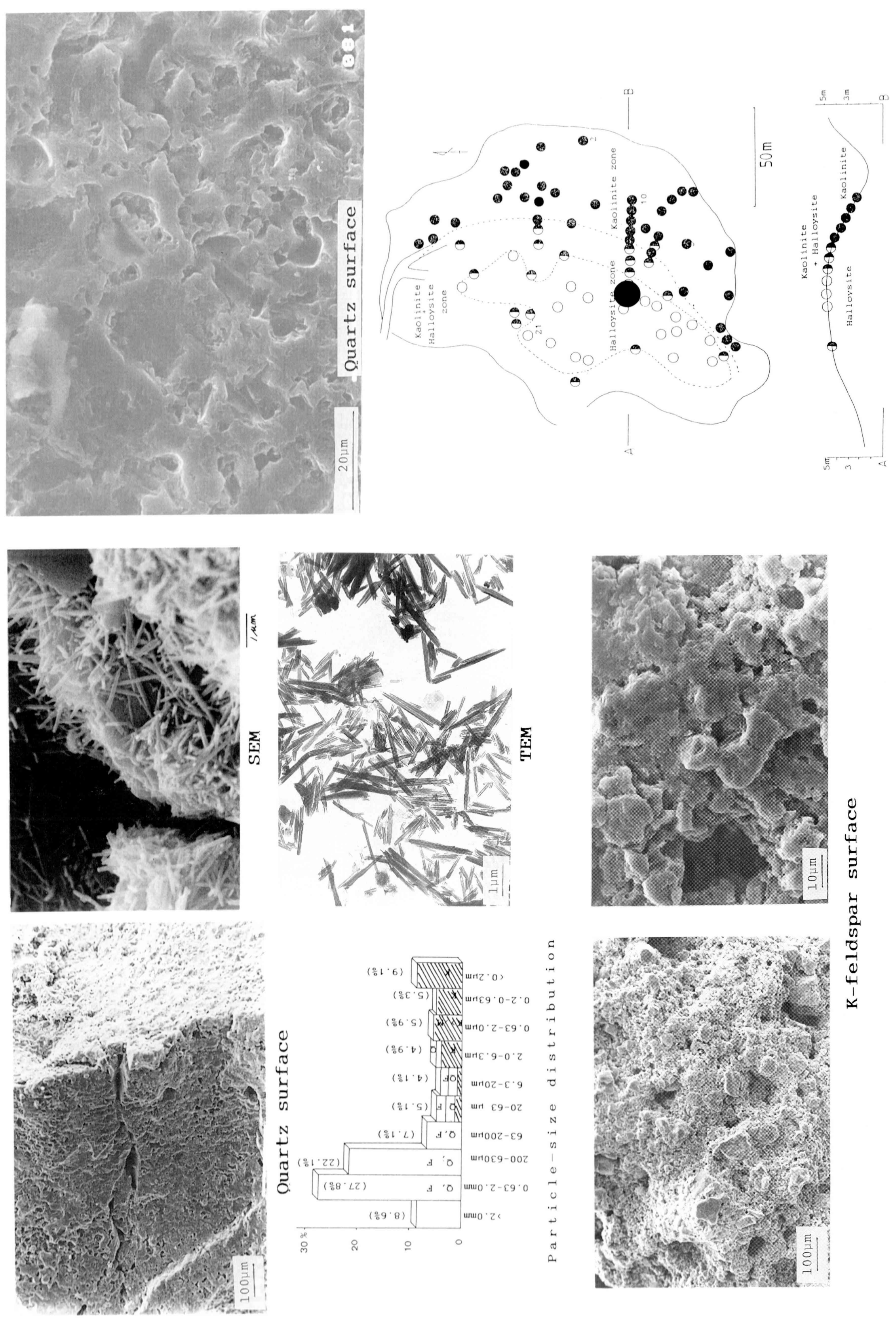


Fig. 4. KOMAKI HALLOYSITE DEPOSIT

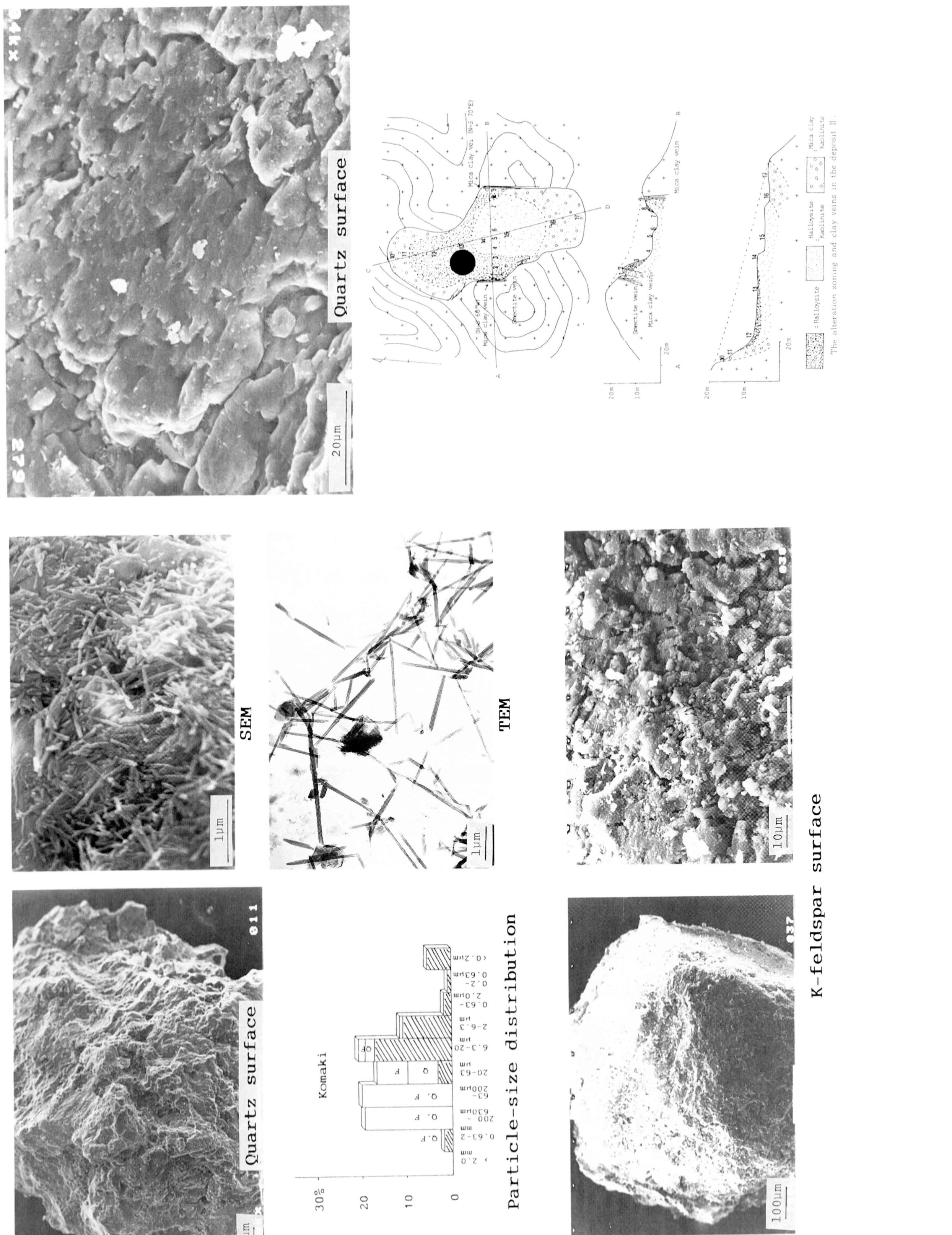


Fig. 5. OKUTSU KAOLIN DEPOSIT

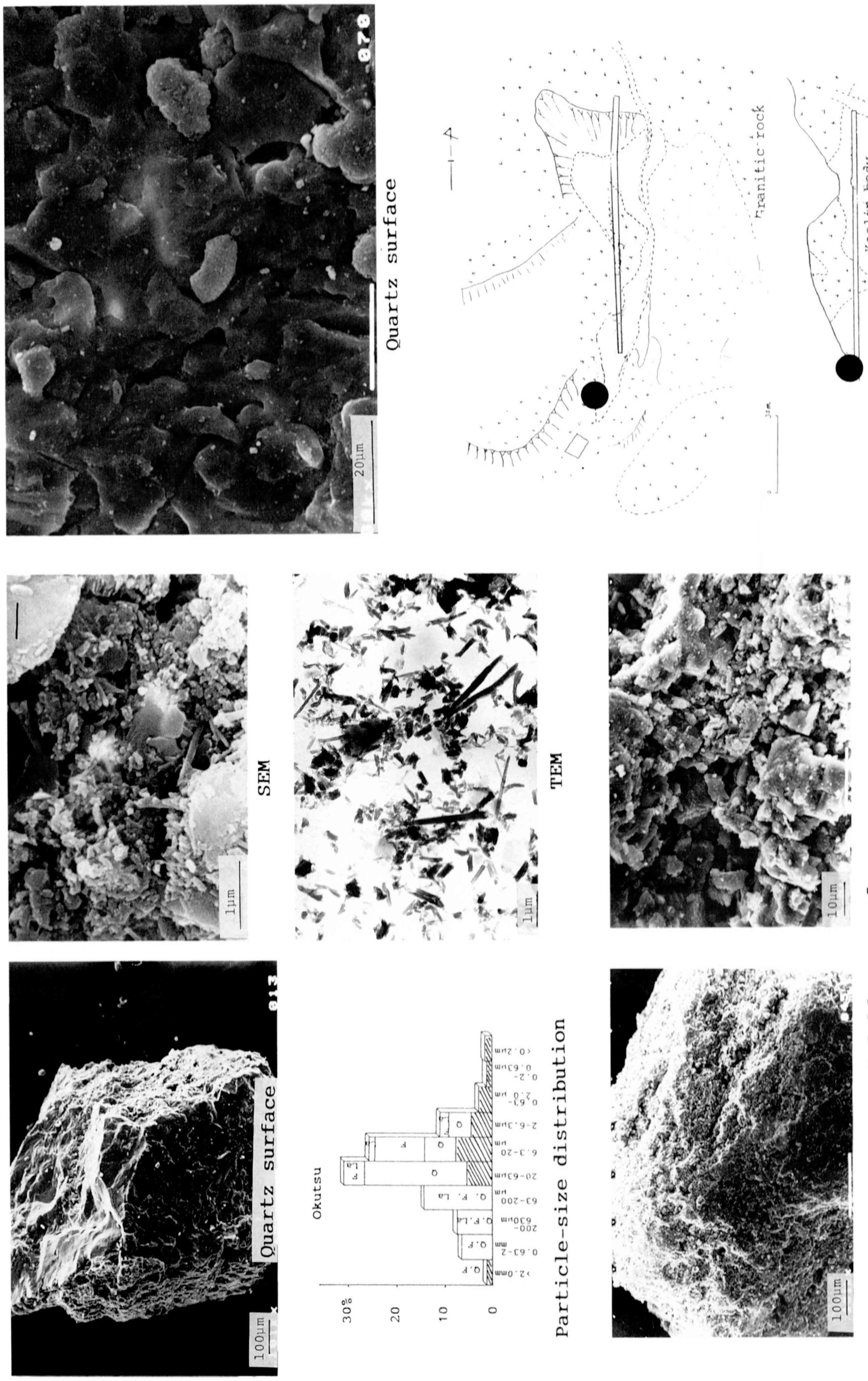


Fig. 6. TIRSCHENREUTH KAOLIN DEPOSIT

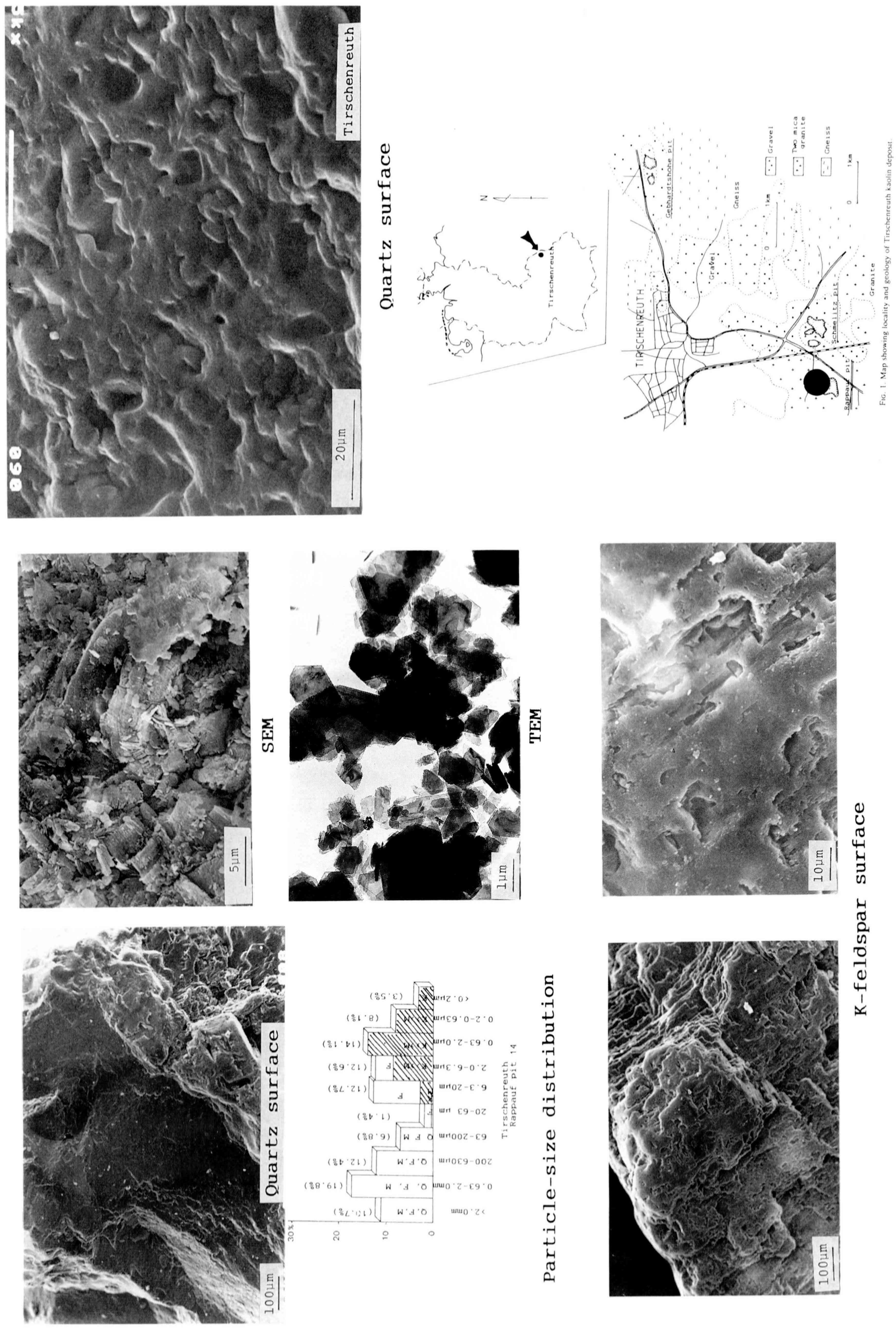
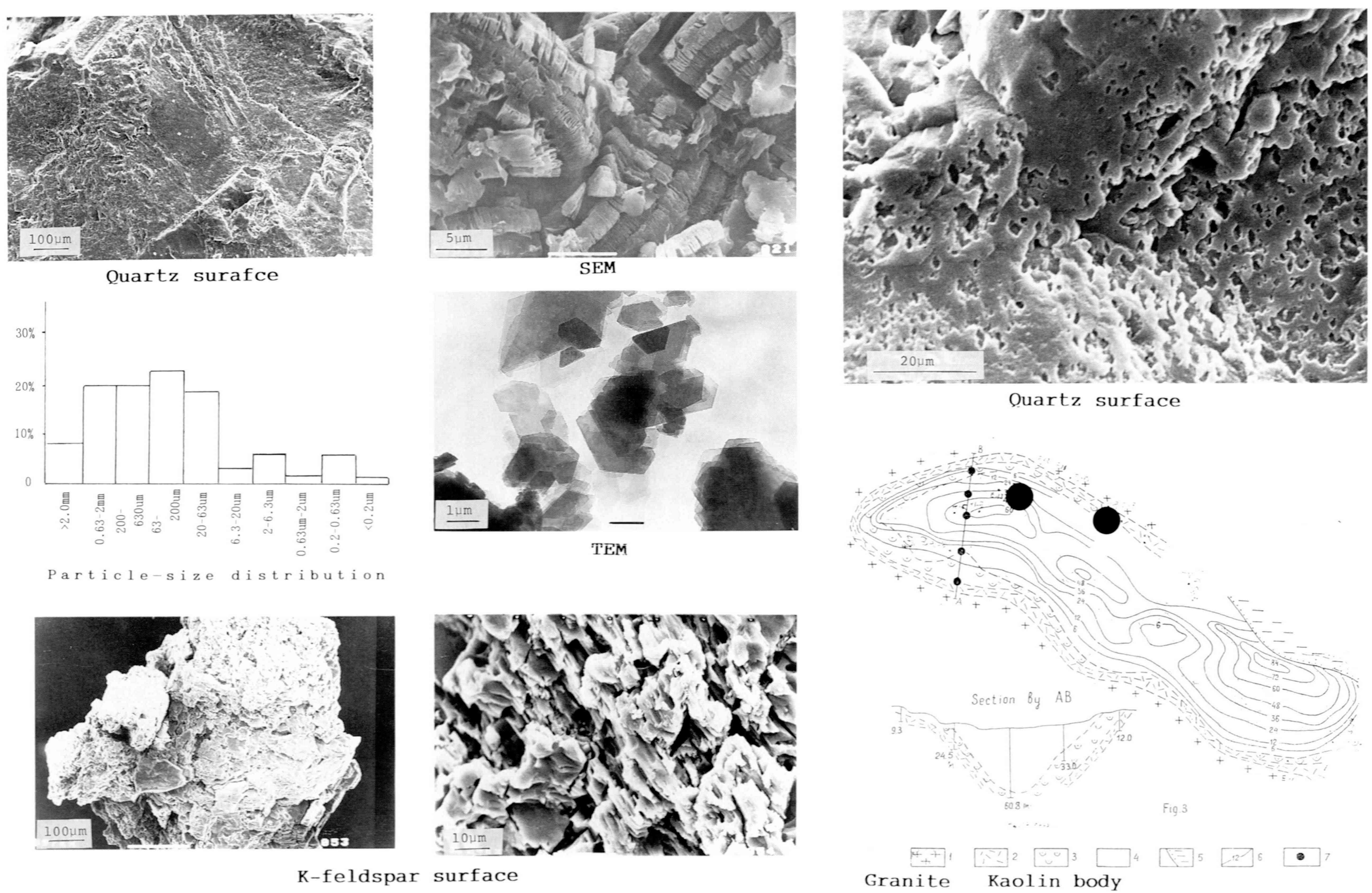


Fig. 7. ELENA KAOLIN DEPOSIT



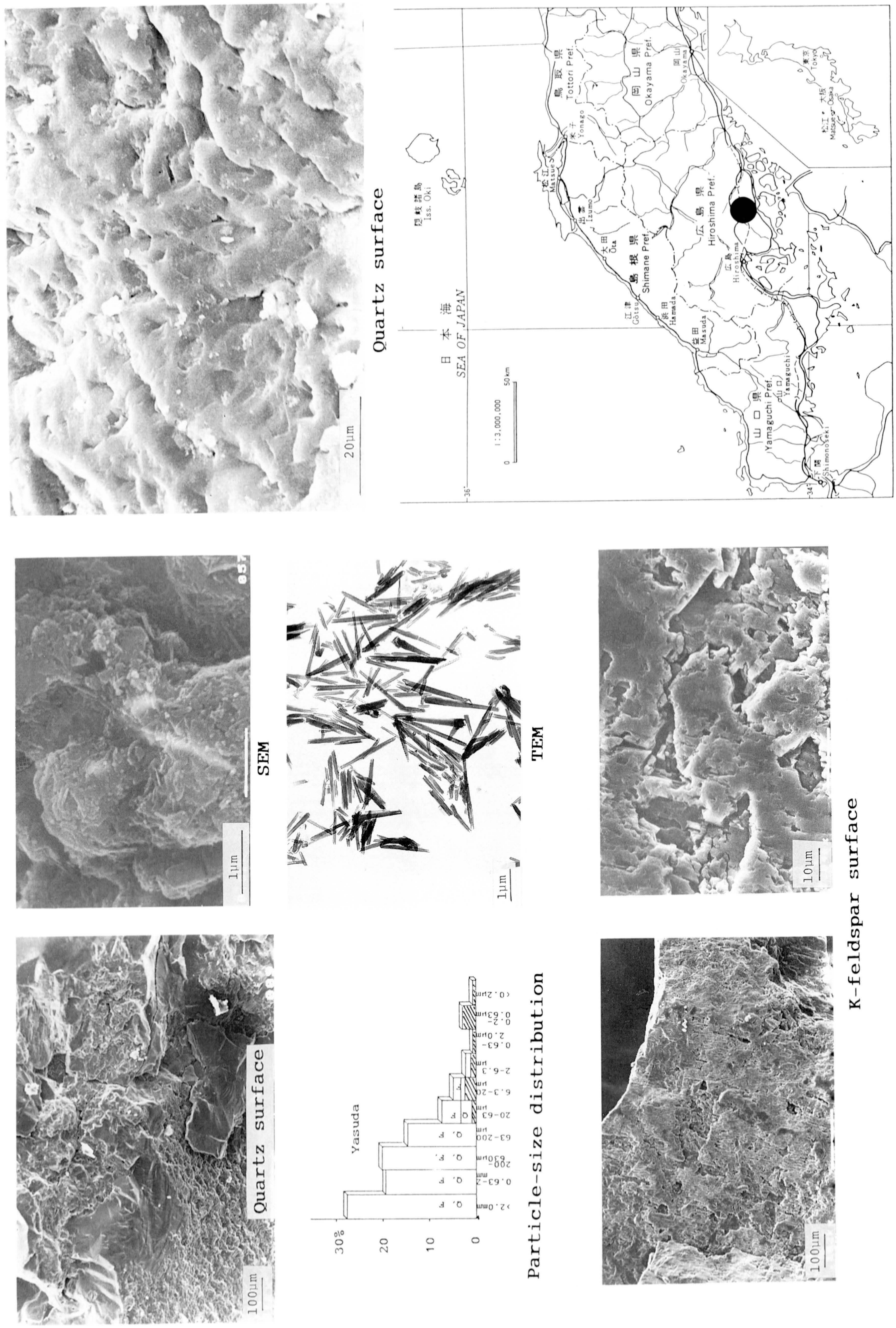


Fig. 8. Hiroshima granitic rock

Fig. 9. San'in granitic rock

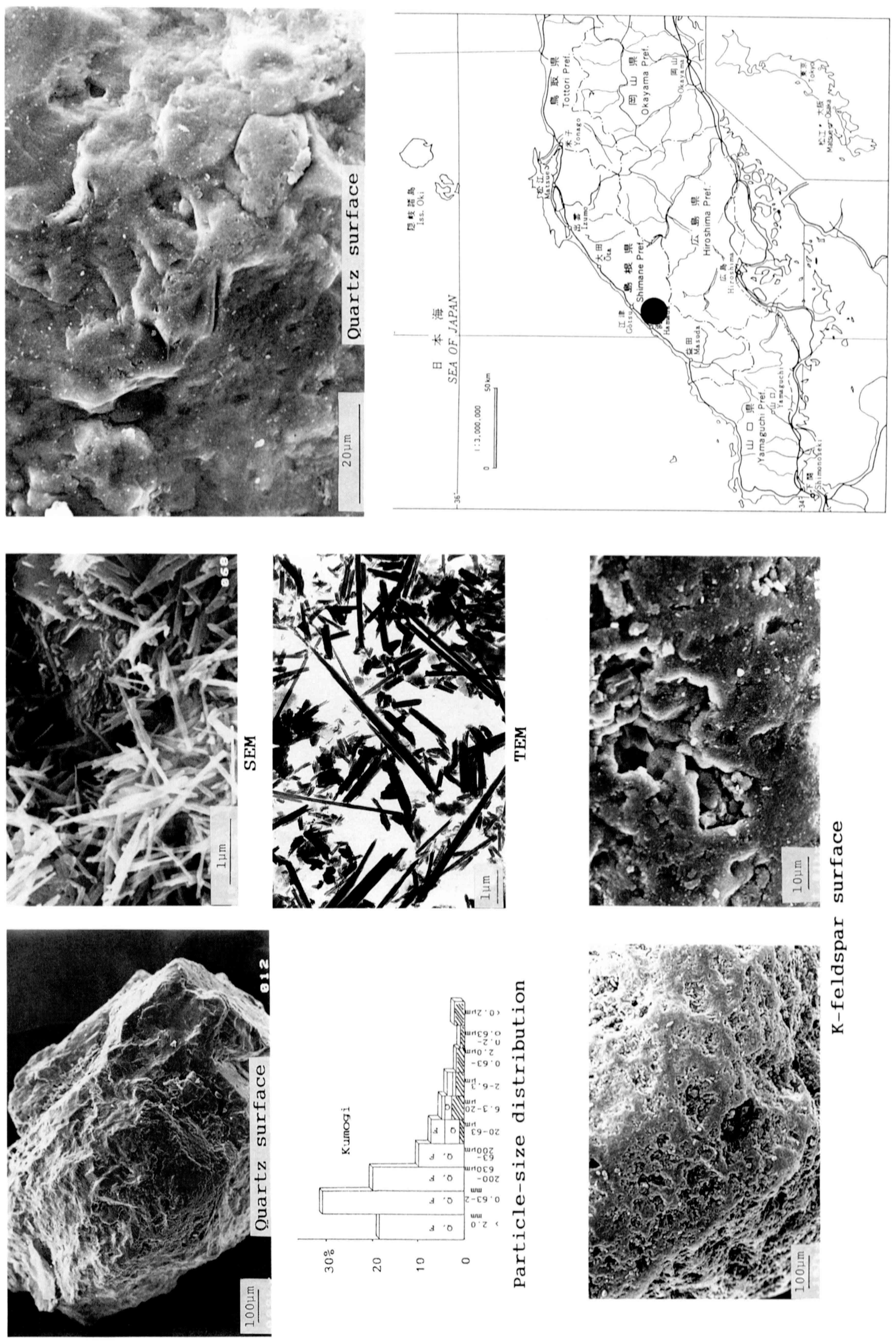
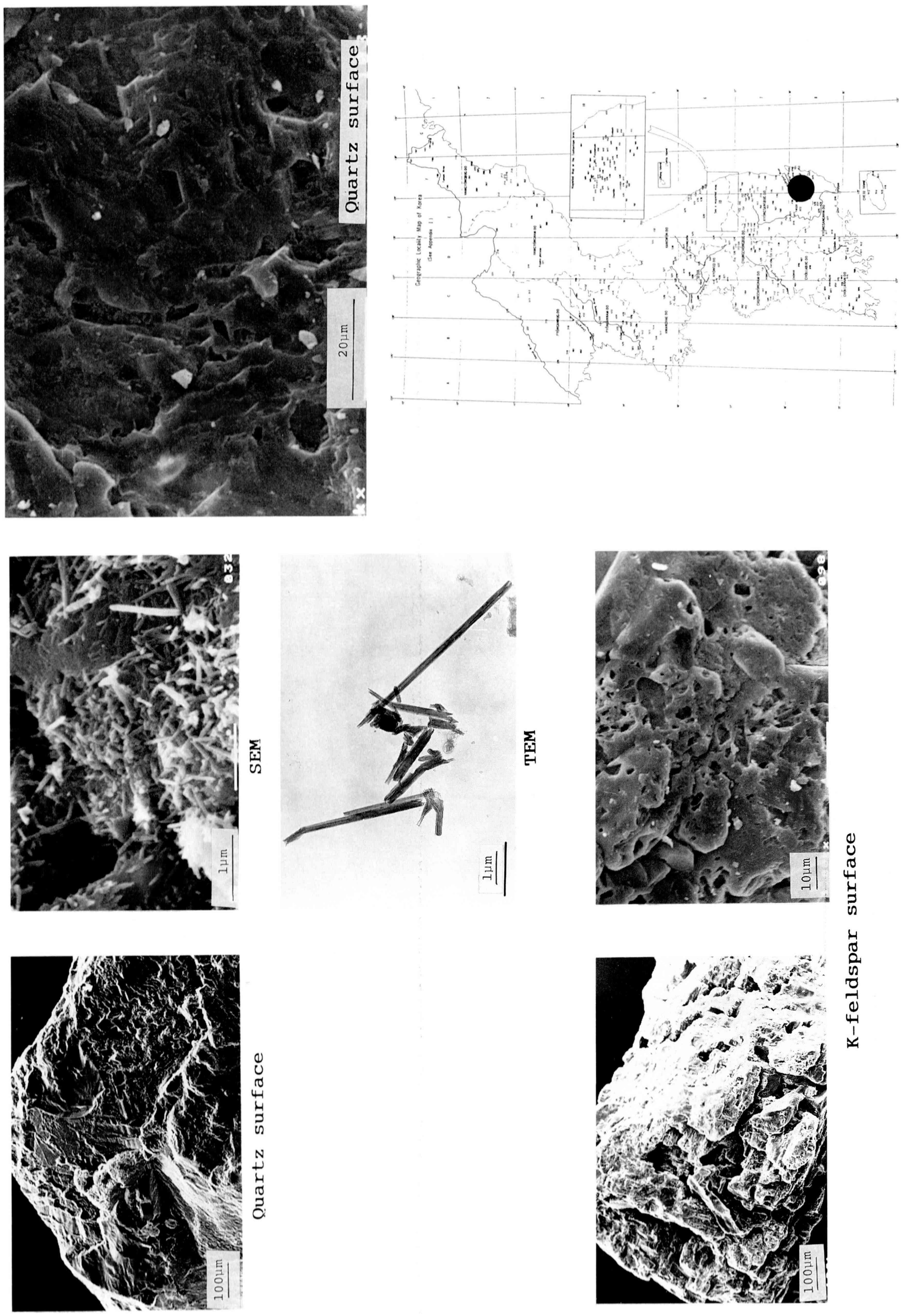


Fig. 10. Bulgugsa granitic rock



Quartz surface

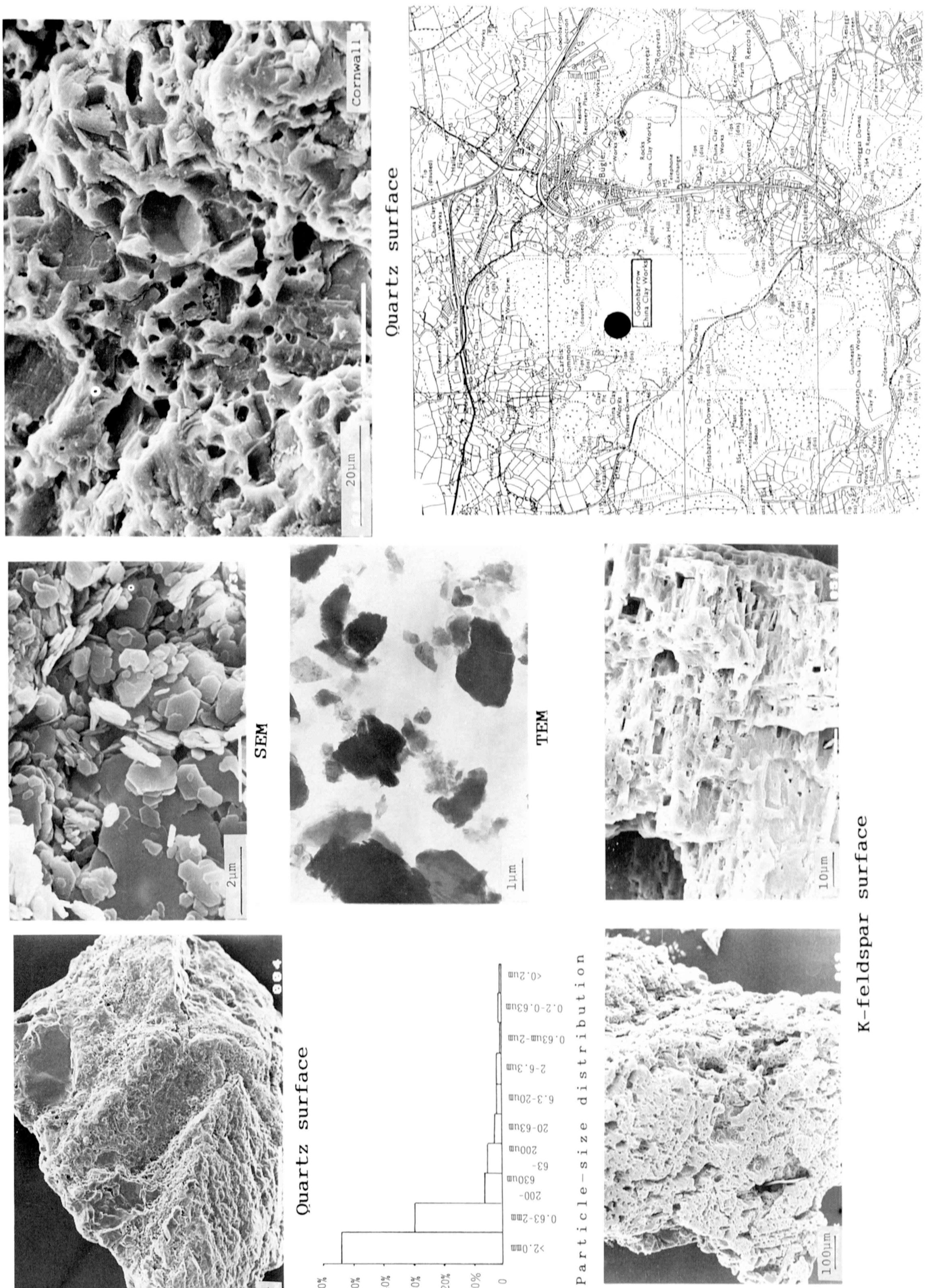


Fig. 11. CORNWALL KAOLIN DEPOSIT