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Surface Microtopography of Pyrophyllite
— Photograph Collection —

By

Mayumi JIGE and Ryuji KITAGAWA

with, 4 plates

Abstract: The surface microtopographies of pyrophyllite crystals from various localities has been investigated by using transmission electron microscopy (TEM) with the Au-decoration technique. The pyrophyllite specimens investigated were collected from the southern Urals (Russia), California (USA), the north part of Vietnam, the southwestern part of Korean Peninsula and southwest Japan.

Gold-decoration successfully revealed growth steps (~1nm in height) on the crystal surfaces. Pyrophyllite specimens from schistose and massive ores exhibit characteristically parallel growth patterns with narrow step separation, whereas polygonal spiral growth patterns with wider step separation are observed on crystal surfaces of pyrophyllite in veins. The morphology of pyrophyllite crystals seems to reflect the growth processes under different conditions (temperature and/or supersaturation), e.g., parallel steps on the irregular particles, on the other hand, polygonal spiral steps on polygonal plates.

Contents

I. Introduction

The microtopography of surfaces of layered silicates such as kaolinite, mica, chlorite and rectolite have been studied by many investigators to elucidate crystal growth mechanisms (Baronnet, 1972, 1980, Sunagawa et al, 1975, Tomura et al., 1979 and Kitagawa, 1997; 1998). Growth induced step-patterns a few nanometers in height are revealed by the gold-decoration technique employed with transmission electron microscopy (TEM), as developed by Bassett (1958) and Gritsaenko and Samotoyin (1966). Such examination has revealed spiral and parallel-step patterns on the (001) crystal surfaces of various layer silicates, so that their growth mechanisms and conditions of growth could be inferred (Sunagawa et al., 1975, Tomura et al., 1979).

We have applied the decoration technique to the (001) surfaces of pyrophyllite crystals collected from genetically different localities in the southern Urals (Russia), California (USA), the north part of Vietnam, the southwestern part of the Korean Peninsula and southwest Japan. We here describe the observation results of the surface microtopographies.

II. Materials and Method

A: Specimens

Many sulfide deposits including porphyry-copper are developed in the southern Urals, with pyrophyllite alteration zones (Zaykov et al.,1988), Kuroko-type and vein-type deposits. Pyrophyllite specimens with sulfide ores in the Urals are formed as various modes of occurrence, e.g., in hydrothermal metasomatic zones with massive sulfide ores and in veins in gold deposits (Zaykov and Udachin, 1994). Pyrophyllite specimens were collected from the alteration zones of three sulfide deposits in the Urals, i.e. the Gay, Kul-Yurt-Tau and Chistogor deposits. An additional specimen was collected from a different occurrence in the Urals, from the hydrothermal veins of the Berezovsk gold deposit near Ekaterinburg and California (Fig. 1). Pyrophyllite in vein occurs as an aggregate of radiating clusters (Fig. 2).

Numerous massive pyrophyllite deposits occur in Cretaceous rhyolitic and/or dacitic rocks distributed in the East of Asia (Kitagawa et al., 1988, Kim and Nagao, 1992). We also collected pyrophyllite specimens from Tanmai deposit (the north part of Vietnam), Gussi deopisit (the southern part of the Korean Peninsula) and Uku mine and Shokozan mine (southwest Japan) in this study. (Fig. 1).

B: Observation Method

The decoration technique of electron microscopy was applied to observe the surface microtopography. In the Au-decoration technique, gold is flash-evaporated in a vacuum-evaporation apparatus onto the crystal surfaces. Minute grains of gold preferentially nucleate along the steps on the surfaces, thus revealing the surface microtopography of the crystal faces. Steps, the height of a unit cell or less can be clearly revealed by this technique with electron microscopy, if the coating is correctly applied. The Au-decoration technique applied in this study followed that by Kitagawa (1997 and 1998), as outlined below.

The specimens were dispersed in distilled water and collected on a thin cover glass. After drying, these mounts were heated at 400~500° C in a vacuum of 10^{-4} torr for 2-3 hours. Heating the

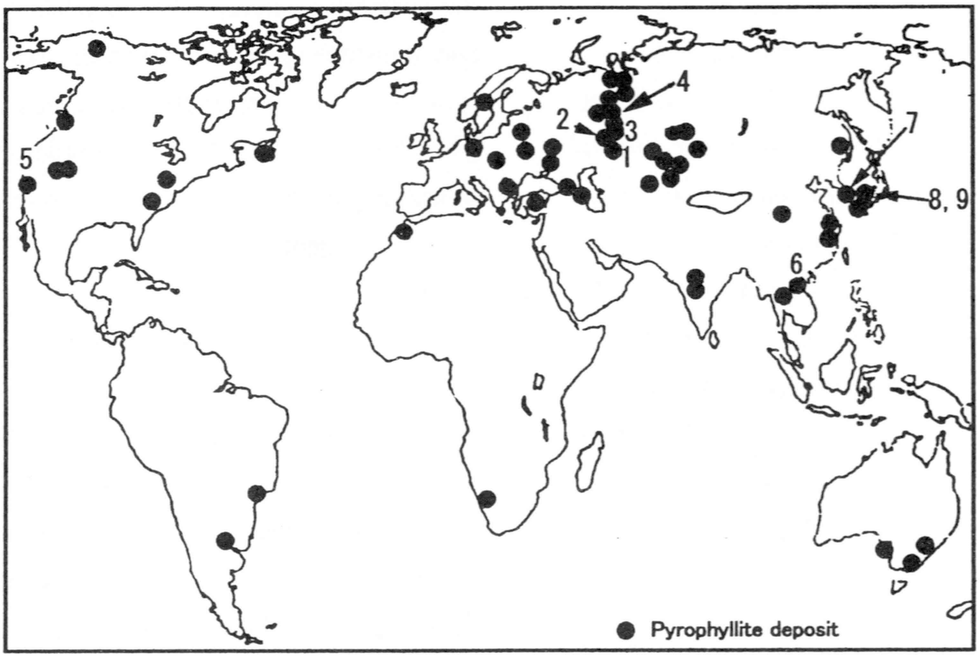

Fig1. Distribution map of main pyrophyllite deposits in the world and sampring points in this study.1.Gay(Southern Urals),2.Kul-Yurt Tau(Southern Urals),3.Chistogor(Southern Urals), 4.Berezovsk(Southern Urals),5.California(USA),6.Tanmai(north part of Vietnam), 7.Gussi(Korea Peninsula),8.Shokozan(Japan),9.Uku(Japan).

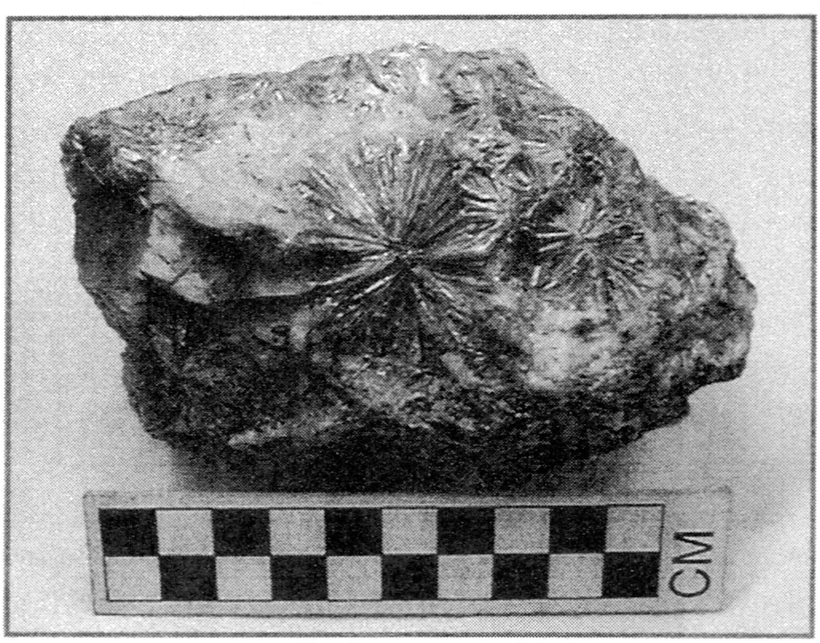

Fig.2 Hand Specimen showing aggregate of radiating clusters collected from Berezovsk deposit in Southern Ural.

specimens gives clear surfaces lacking impurities and greater gold mobility, enabling selective nucleation of Au along the growth steps (Basset, 1958, Tomura et al., 1979). Gold was flash-evaporated from a tungsten coil heater. A carbon coat was then applied. Following this, the specimens were immersed in a solution of ~10% HF for 8-10 days (occasionally one week), to completely dissolve the specimens. After soaking the remains in distilled water, the thin carbon films and their gold grains were collected on copper mesh grids for observation with a TEM (JEM2000ES, 120kV).

III. Results

The electron micrographs in Plate. I to IV show that the grains of gold preferentially nucleated along steps on the crystal surfaces. However, these are clearly not cleavage patterns (Kitagawa, 1997). The single steps are assumed to be the height of a unit-cell layer, based on the shadowing technique.

Parallel step patterns with narrow step separations and polygonal spiral growth patterns with wider step separation are characteristically observed. The former pattern observed on pyrophyllite crystals from massive and schistose-textured specimens associated with sulfide ores. In contrast, the later pattern observed on pyrophyllite from veins. However, circular spiral growth patterns, which are generally observed on illite, kaolinite and chlorite (Kitagawa, 1998), are not found on these pyrophyllite crystals.

Pyrophyllite crystals in massive and schistose specimens are observed as irregular formed plates in morphology. However, crystals in veins occur as polygonal plates. Parallel steps are observed on the surfaces of pyrophyllite crystals from massive and schistose specimens, whereas polygonal spiral growth patterns are found on crystals from veins. Therefore, it may be considered that the morphology of the crystals is controlled by the growth mechanisms.

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REFERENCES

1. A. Baronnet (1972): Growth mechanism and polytypism in synthetic hydroxyl-bearing phlogopite., *Am. Mineral.*, 57, 1272-1293.
2. A. Baronnet(1980): Polytypism in mica: A survey with emphasis on the crystal growth aspect., In Current Topics in Material Sci., 5 (E. Kaldis, ed.), North-Holland, Amsterdam, 447-548.
3. I. Sunagawa, Y. Koshino, M.Asakura and T.Yamamoto (1975) Growth mechanism of some clay minerals., Fortschr. Mineral. 52, 217-224.
4. S. Tomura, M. Kitamura and I. Sunagawa (1979) Surface microtopography of metamorphic white micas., Phys. Chem. Minerals., 5, 65-81.
5. R. Kitagawa, Surface microtopography of rectorite (allevardite) from Allevard, France., Clay Mineral., 32 , 89-95.
6. R. Kitagawa (1998) Surface microtopography of

illite crystals from different modes of occurrence., Canadian Mineral., 36, 1559-1567.
7. G. A. Bassett (1958) A new technique for decoration of cleavege and slip steps on ionic crystal surfaces., Phil. Mag., 3 1042-1045.
8. G. Gritsaenko and N. Samotoyin (1966) The decoration method applied to the study of clay minerals., Proc. Int. Clay Conf. Jerusalem, 3, 91-400.
9. V.V.Zaykov, V. N. Udachin and I. V. Sinyakovskaya (1988) Pyrophyllite deposits., International Geology Review, 30, 90-103.
10. V. V. Zaykov and V. N. Udachin (1994) Pyrophyllite and Pyrophyllite raw materials in the sulfide-bearing areas of the Urals., Applied Clay Sci., 8, 417-435.
11. R. Kitagawa, H. Nishido, and S.Takeno (1988) K-Ar ages pyrophyllite ("Rouseki") deposits in the Chugoku district, Southwest Japan., Mining Geol., 38, 357-366.
12. I. J. Kim and K. Nagao (1992) K-Ar ages of the ydrothermal clay deposits and the surrounding igneous rocks in southwest Korea., J. Petrol. Soc. Korea, 1, 58-70.
13. R. Kitagawa (1997) Surface Microtopographies of clay minerals by Au-decoration method and its technical problems., Jour. Mineralogical Soc. Japan, 26, 215-220.

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EXPLANATION OF PLATES

Plate. I Surface microtopographies showing malformed circular parallel growth patterns on pyrophyllite crystals. A and B: Gay (Southern Urals), C and D: Kul-Yurt-Tau (Southern Urals).

Plate. II Surface microtopographies showing malformed circular parallel growth patterns on pyrophyllite crystals. A and B: Chistogor (Southern Urals), C and D: Tanmai (North part of Vietnam).

Plate. III Surface microtopographies showing malformed circular parallel growth patterns on pyrophyllite crystals. A: Gussi (Korea Peninsula), B: Shokozan (Japan), C and D: Uku (Japan).

Plate. IV Surface microtopographies showing Polygonal spiral growth patterns on pyrophyllite crustals. A and B: Berezovsk (Southern Urals), C and D: California (USA).

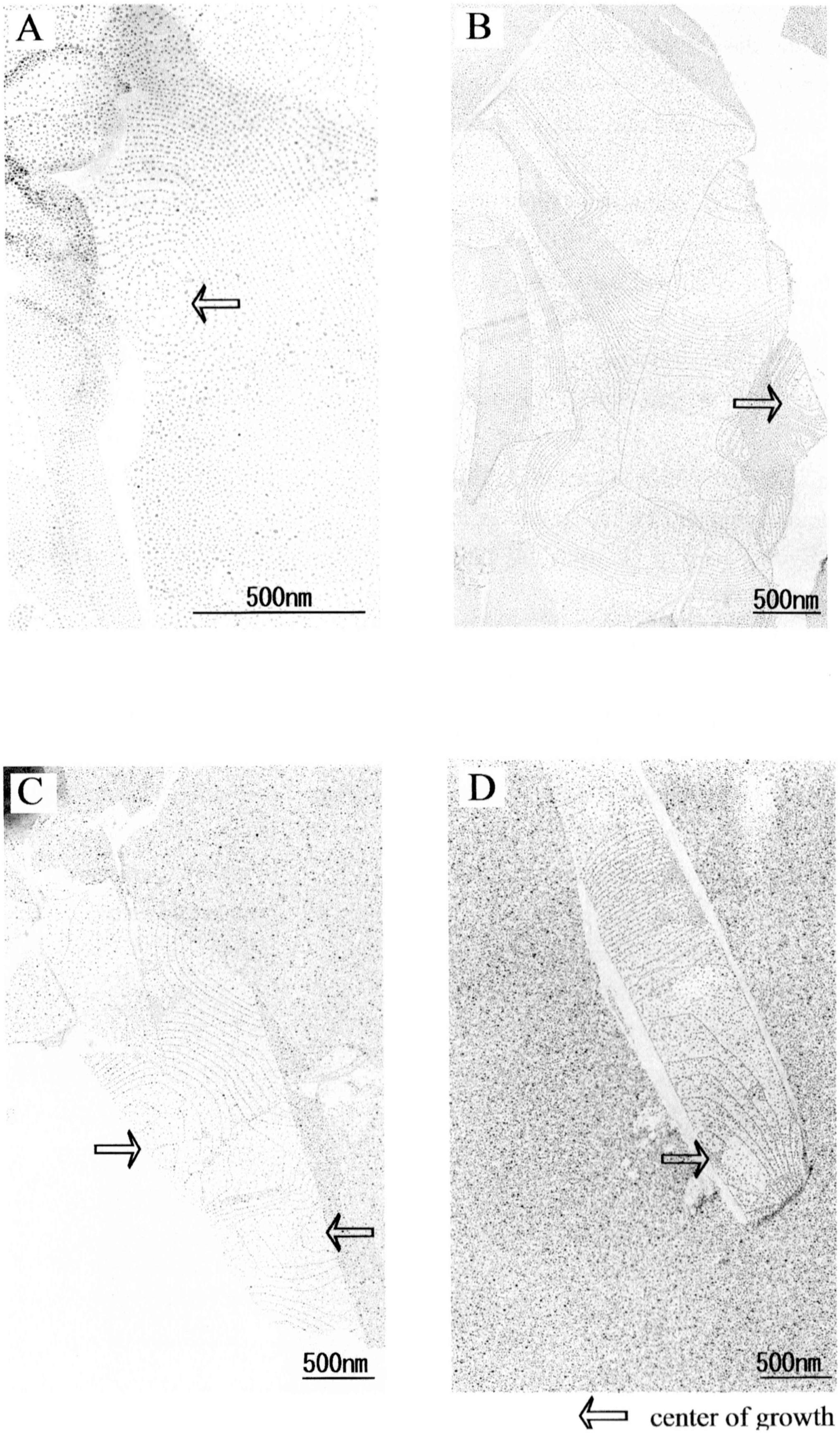


Plate I

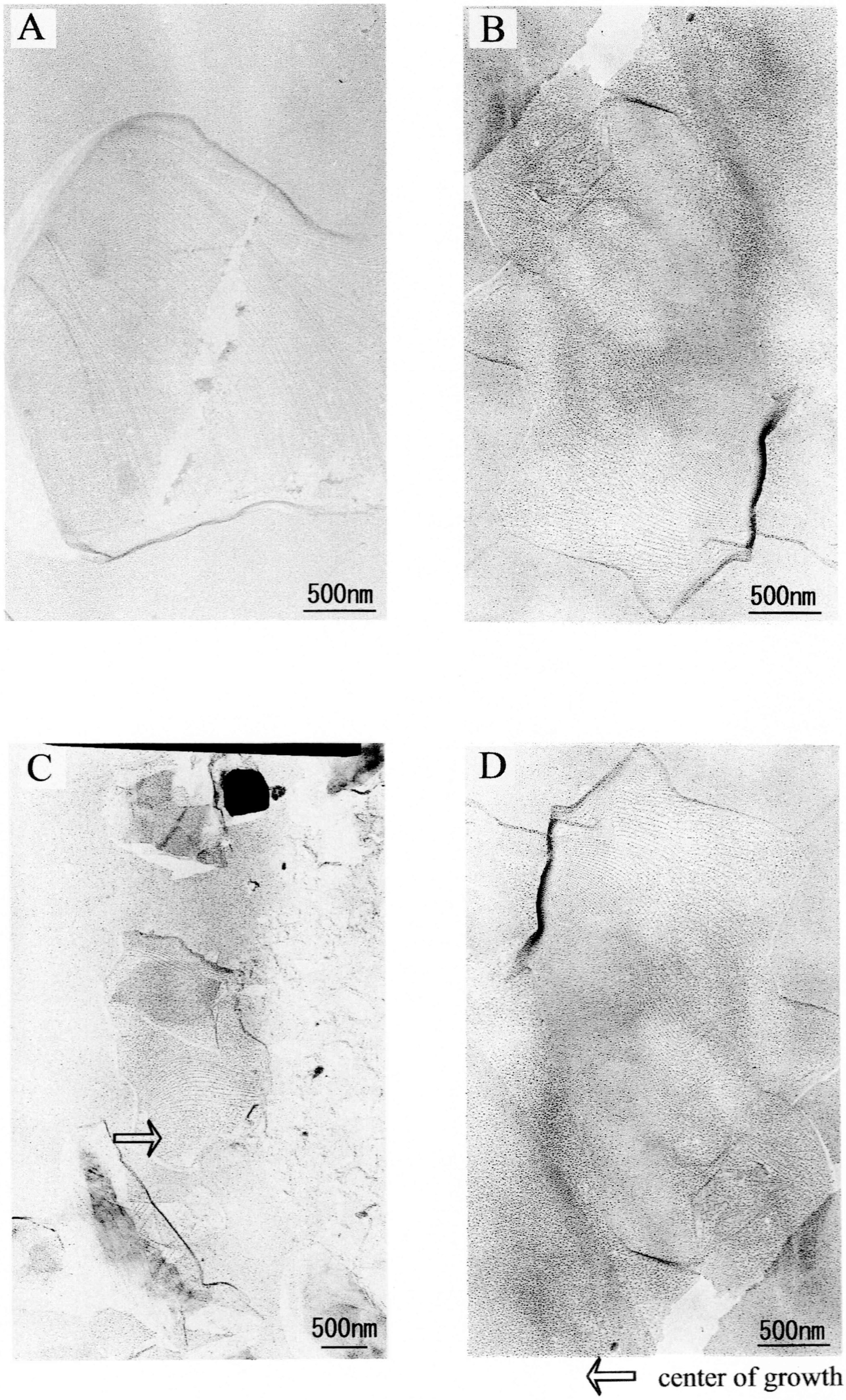


Plate II

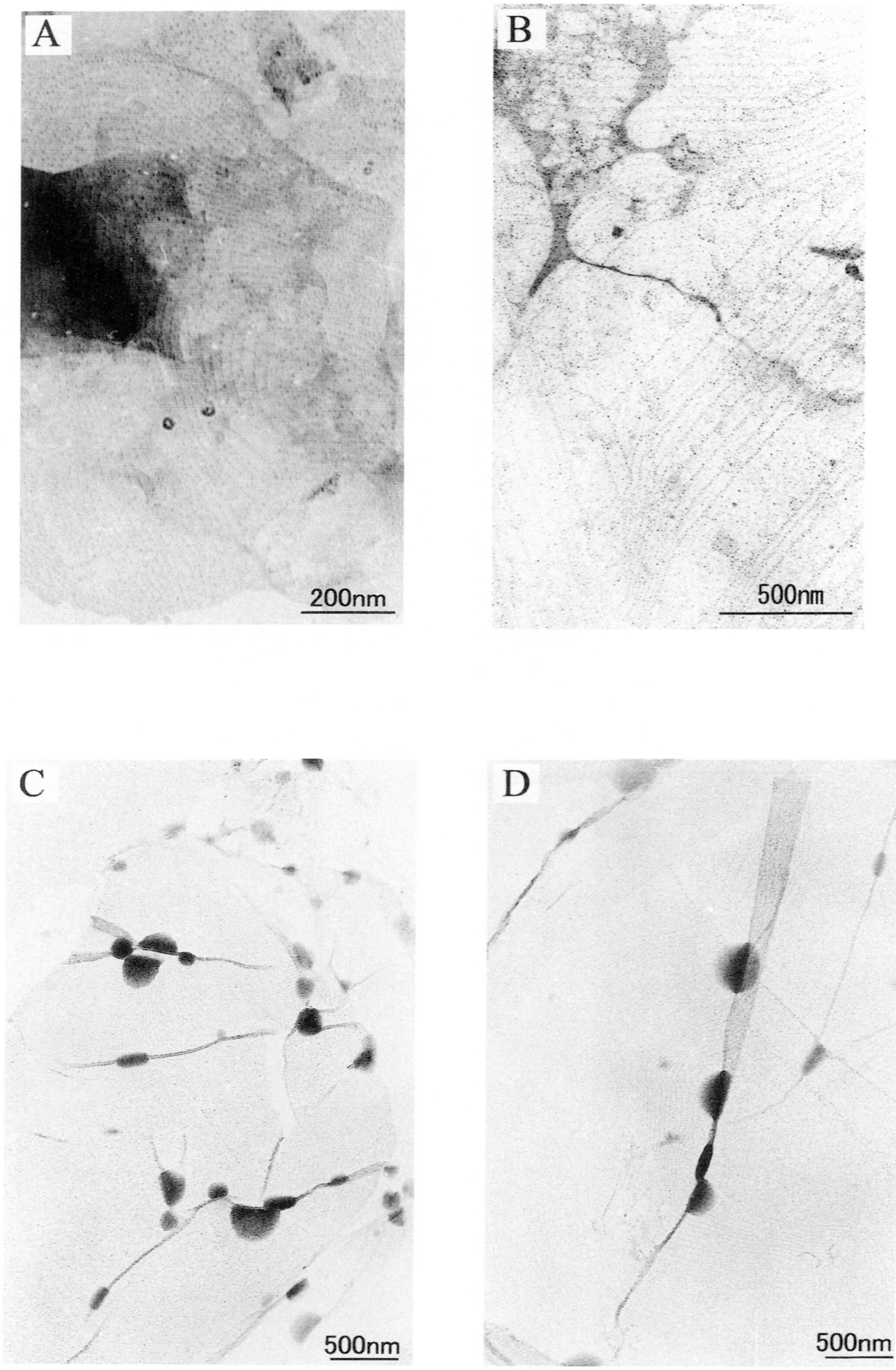
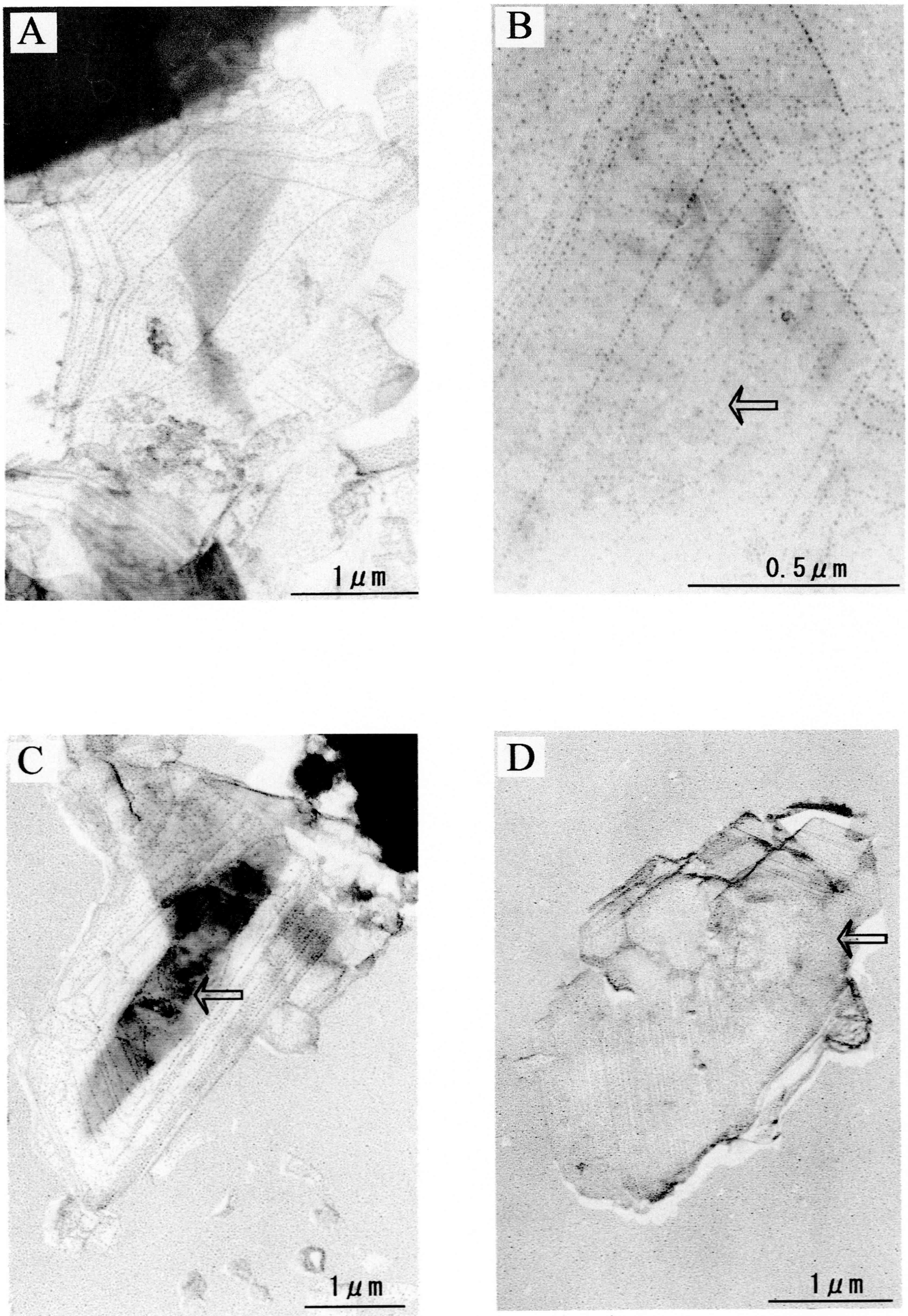


Plate Ⅲ



⇦ center of growth

Plate IV