MINERALOGICAL MAGAZINE, SEPTEMBER 1975, VOL. 40, PP 303–6

Microstructural interpretation of some fibrolitic sillimanite aggregates

R. H. VERNON

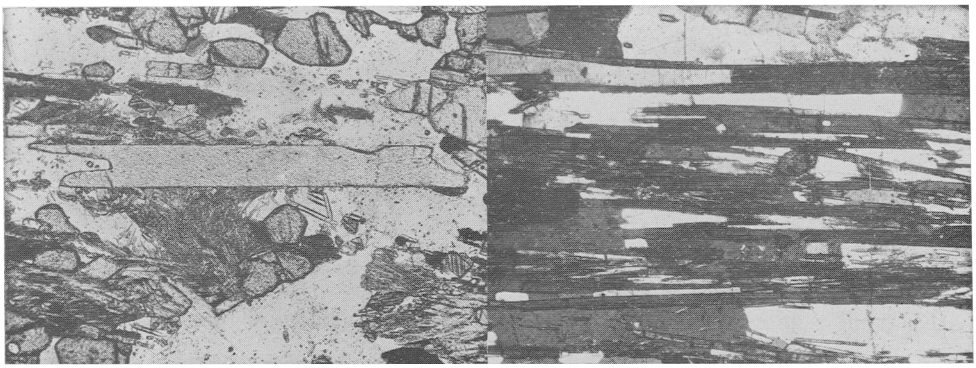
School of Earth Sciences, Macquarie University, North Ryde (Sydney), N.S.W. 2113, Australia

SUMMARY. Fibrolitic sillimanite in some high-grade gneisses from Broken Hill, Australia, shows microstructural features suggestive of compatibility with the main coarser-grained assemblage, namely: framework-silicate interfaces either meet (110)-sillimanite/framework-silicate interfaces at approximately 90°, or are attached to the ends of 'fibrolite' rods; framework-silicate interfaces are deflected by 'fibrolite' grains; and interfaces of inclusions of one framework silicate in another are deflected by 'fibrolite' grains, producing irregular, rather than rounded, inclusion shapes. These criteria suggest that the 'fibrolite' in some rocks is a compatible member of the main metamorphic assemblage. Its persistence as small grains may be due to a high proportion of relatively low-energy prismatic boundaries in the fibrolitic aggregates.

MANY medium to high-grade metapelitic rocks contain fine-grained, fibrous aggregates of sillimanite ('fibrolite'), although the other minerals present generally are much coarser-grained and show microstructural evidence of a close approach to grain boundary stability (Kretz, 1966; Vernon, 1968). The problem is to decide whether or not this fibrolitic sillimanite is a compatible member of the mineral assemblage and, if not, whether it was formed before or after the coarser-grained assemblage. Fine grain-size and the absence of reliable published criteria have hampered such interpretations. The aim of this paper is to present microstructural criteria for the recognition of compatible coexistence between 'fibrolite' and its enclosing and adjacent mineral grains, and to put forward the hypothesis that 'fibrolite' is a compatible member of the predominant assemblage in some rocks. A possible explanation for the fine grain-size is also presented. Available evidence indicates that 'fibrolite' is mineralogically identical to coarser-grained sillimanite (Cameron and Ashworth, 1972).

Fibrolitic sillimanite at Broken Hill, Australia. In the highest grade (lower granulite facies) metapelitic schists and gneisses at Broken Hill, New South Wales, fibrolitic sillimanite occurs in an otherwise coarse-grained assemblage of quartz, K-feldspar, biotite, sillimanite, garnet, cordierite, and ilmenite, commonly with plagioclase. All the coarse-grained minerals show microstructural evidence of a close approach to grain boundary stability (Vernon, 1968), as exemplified by the strong tendency for quartz inclusions in K-feldspar, garnet, and cordierite to have rounded shapes (fig. 5), smooth quartz/quartz and quartz/feldspar interfaces, and well-developed (110) faces in large sillimanite grains. A contrast between the very large sillimanite grains of the coarse-grained assemblage and adjacent very small fibrolitic grains (fig. 1) requires explanation. The coarse-grained sillimanite shows good evidence of microstructural compatibility with the other minerals (Vernon, 1968), and so the question arises as to whether or not the 'fibrolite' is equally compatible.

Close examination shows that individual 'fibrolite' grains enclosed in quartz or feldspar have identical shapes to larger sillimanite inclusions, namely parallel-sided rods with rounded terminations, suggesting a close approach to microstructural stability, inasmuch as relatively low-energy prismatic faces are preserved and high-energy corners are 'rounded off' (Vernon, 1968, p. 17). These 'fibrolite' shapes are shown in figs. 2, 3, and 6, for grains lying parallel to the section; examination with a universal

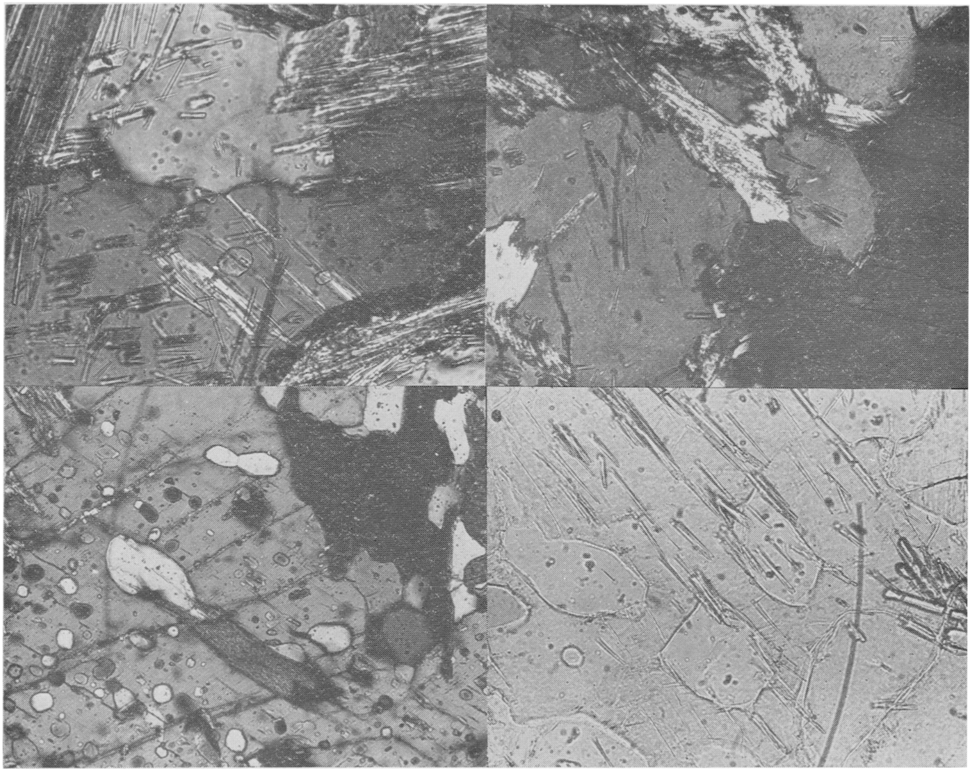


FIGS. 1 and 2: FIG. 1 (left). Large sillimanite grain adjacent to fine-grained aggregate of 'fibrolite' in quartz–K-feldspar–biotite–garnet–sillimanite gneiss, Broken Hill, Australia. Plane-polarized light, ×15. FIG. 2 (right). Strongly aligned aggregate of small, elongate sillimanite grains intergrown with quartz. Quartz/quartz interfaces either meet sillimanite/quartz interfaces at close to 90°, or are attached to the corners or ends of sillimanite grains. Crossed polars, ×44.

stage is necessary for the others. Some of the larger grains appear to show basal pinacoidal as well as prismatic boundaries, but still with rounded corners.

Examination of quartz–sillimanite aggregates shows that quartz–quartz interfaces either meet (110)-sillimanite/quartz interfaces at approximately 90°, or are attached to the ends of sillimanite needles (fig. 2). These features are characteristic of coarser-grained quartz–sillimanite aggregates (Vernon, 1968, pp. 16, 17) and quartz–biotite aggregates (Voll, 1960, 1961; Kretz, 1966; Vernon, 1968), that appear to have attained a high degree of microstructural stability in metamorphic rocks.

Quartz/quartz and quartz/feldspar interfaces are planar to smoothly curved where 'fibrolite' is absent (Vernon, 1968), but are irregular and stepped where 'fibrolite' is present, deflections in the interfaces coinciding with the presence of 'fibrolite' grains or aggregates (figs. 3, 4). This appears to be due to the strong tendency for quartz/quartz and quartz/feldspar interfaces to attach themselves to the ends of sillimanite grains, as discussed above. If so, the 'fibrolite' grains must have existed *before* the final adjustment of the quartz and feldspar grain boundaries. The same reasoning can be applied to quartz inclusions in feldspar, which have smoothly curved quartz/feldspar boundaries where 'fibrolite' is absent (fig. 5), but are much more irregular where 'fibrolite' is present (figs. 5, 6).



FIGS. 3 to 6: FIG. 3 (top left). Boundary between two large quartz grains (different shades of grey), showing changes in direction caused by attachment of the boundary to small sillimanite grains. At the right, the boundary takes a right-angled bend, owing to the tendency of quartz/quartz interfaces to meet (110)-sillimanite/quartz interfaces at 90°. Crossed polars, ×82. FIG. 4 (top right). Marked and local deflections, caused by fibrolitic sillimanite grains and aggregates, of a boundary between large grains of quartz (left) and K-feldspar (right, with cleavage). Crossed polars, ×82. FIG. 5 (bottom left). Microstructurally well-adjusted inclusions and included aggregates of quartz in a large grain of K-feldspar. Also present is a fine-grained aggregate of fibrolitic sillimanite. A quartz grain adjacent to this aggregate has a lenticular shape apparently controlled by the sillimanite. Crossed polars, ×32. FIG. 6 (bottom right). Approximately elliptical inclusions (left) of quartz in K-feldspar, close to more irregularly shaped inclusions (centre), the shapes of which appear to have been controlled by the attachment of quartz/feldspar interfaces to fibrolitic sillimanite grains. Plane-polarized light, ×82.

Interpretation. All the above observations suggest that in these rocks the 'fibrolite' grains existed *before* the *final* adjustment of quartz/quartz and quartz/feldspar boundaries. They conceivably could be metastable relics, but, because coarse-grained sillimanite also is present, and because the 'fibrolite' grain shapes and relationships are identical to those shown by the larger sillimanite grains, a more likely interpretation is that the 'fibrolite' is equally as compatible chemically as the coarser-grained sillimanite with the other minerals in the rock. If so, why did some 'fibrolite' grains grow into large sillimanite grains, while the majority remained small? A possible answer is that most of the interface area of the 'fibrolite' grains is occupied by rational prism or pinacoid faces, which should reduce the driving force for growth, inasmuch as a relatively low total interfacial energy has been attained, despite a relatively large interfacial area. The reason for the selection of a few grains for growth (fig. 1) remains unknown, but possibly it may be connected with local concentrations of impurities, affecting interfacial energies.

Conclusion. The following criteria suggest that grains of fibrolitic sillimanite existed before the final adjustment of boundaries of coarser-grained framework silicates: framework-silicate interfaces either meet (110)-sillimanite/framework-silicate interfaces at approximately 90°, or are attached to the ends of 'fibrolite' rods; framework-silicate interfaces are deflected by 'fibrolite' grains; and interfaces of inclusions of one framework silicate in another (e.g. quartz in K-feldspar) are deflected by 'fibrolite' grains, so that inclusion shapes are irregular, rather than rounded.

The application of these criteria to 'fibrolite' in some Broken Hill metapelitic rocks suggests that it was a chemically compatible member of the otherwise coarse-grained assemblage, remaining fine-grained possibly because of a relatively low interfacial energy associated with an abundance of prismatic boundaries.

Observation of some metapelitic rocks from other areas has revealed 'fibrolite' aggregates with no effect on framework-silicate interfaces or on the shapes of quartz inclusions in feldspar. A cautious interpretation is that this 'fibrolite' may have grown after the coarser-grained assemblage, but more detailed work is needed. The above criteria are offered in the hope that they will assist others working on 'fibrolite'-bearing rocks.

REFERENCES

CAMERON (W. E.) and ASHWORTH (J. R.), 1972. *Nature Physical Science*, **235**, 134–6.
KRETZ (R.), 1966. *Journ. Petrology*, **7**, 68–94.
VERNON (R. H.), 1968. Ibid. **9**, 1–22.
VOLL (G.), 1960. *Liverpool and Manchester geol. Journ.* **2**, 503–67.
—— 1961. *Geol. Rundsch.* **51**, 395–405.

[*Manuscript received 5 September 1974*]