METAMORPHIC TOURMALINE OVERGROWTHS IN THE OAK HILL SERIES OF SOUTHERN QUEBEC

M. J. RICKARD
Australian National University, Canberra, A.C.T.

ABSTRACT

Overgrowths on detrital tourmaline grains in the Oak Hill Series of Southern Quebec are shown by an inclusion fabric not to be of authigenic origin. Other features also indicate that the tourmaline developed during a late metamorphic episode without introduction of material.

Genesis of tourmaline in low grade metamorphic rocks has been the subject of some controversy (see Read 1957, p. 232 and Hutton 1940, p. 64). Three different processes may operate:—(i) *authigenesis*—growth in a cold state during sedimentation and compaction, (ii) *metamorphism*—recrystallization of tourmaline dust in the goundmass or fixation of boron trapped in mica or clay minerals, (iii) *metasomatism*—introduction from an outside source e.g. boron-rich emanations from a centre of granitization.

Tourmaline crystals, many of which form overgrowths on old detrital grains, occur throughout the meta-sediments of the Cambrian Oak Hill Series (see Clark 1934) in southernmost Quebec (Fig. 1) and extend up

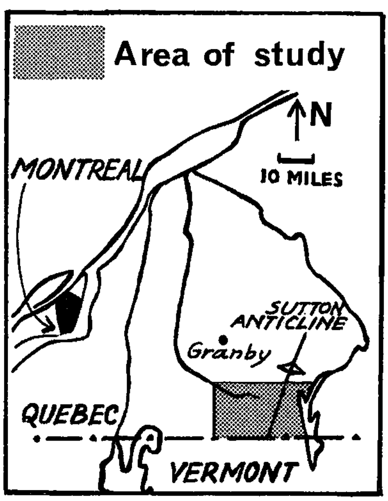

FIG. 1. Location of area.

into very low grade Middle Ordovician (Trenton?) slates. In many cases the overgrowths resemble those of authigenic origin, but an inclusion fabric proves that they were formed by metamorphism associated with a late deformation episode. This is of particular interest because Krynine (1946) has noted the widespread development of authigenic tourmaline and Barth (1936, p. 792) has reported metasomatic tourmaline in the low grade Paleozoic rocks of the Appalachian Geosyncline.

A section (Fig. 2) through the Sutton mountains displays a mixture of

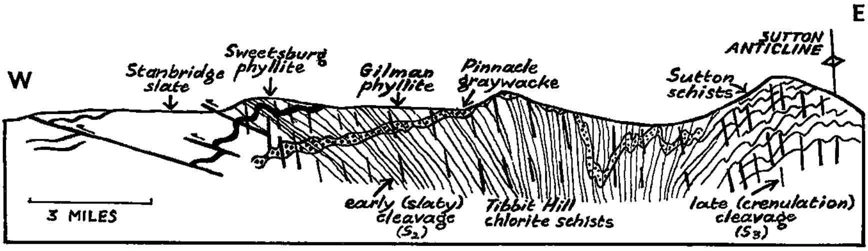

FIG. 2. Diagrammatic section; showing early and late cleavage structures.

pelitic, carbonaceous, chloritic and albitic schists (Sutton group) that has been folded into a major anticline—the Green Mountain-Sutton anticline. To the west these schists trace into tightly folded formations of green schist (Tibbit Hill), greywacke (Pinnacle), phyllite and slate (Gilman) and carbonaceous phyllite (Sweetsburg) which comprise the Oak Hill Series. Other minor formations of slate and dolomite occur but do not concern this discussion. Further to the west, the Oak Hill Series is separated from the Middle Ordovician Stanbridge slates by a thrust. The stratigraphic relations are described in detail by Clark (1934) and Cady (1960).

The folds in the rocks of the Oak Hill Series are upright in the east and overturned in the west where they are thrust westwards against the miogeosynclinal and foreland sequences (see Cady, 1960); a strong axial-plane slaty cleavage is developed throughout. The Sutton anticline was formed slightly later and its associated steeply-dipping crenulation cleavage is everywhere superimposed on the slaty cleavage (Rickard, 1961). The crenulation cleavage is strong in the Sutton schists and weak in the Gilman formation, which outcrops from six to eight miles away from the anticlinal core; it becomes stronger again in the Sweetsburg formation some fourteen miles away, however (see Fig. 2).

The Sutton schists in the core of the anticline have suffered extensive metamorphic reconstitution. Albite porphyroblasts are ubiquitous, and in certain bands tourmaline needles are prominent, and quartz "segretation" veinlets are fairly common. Only minor amounts of biotite—both green and brown—are developed however, and the greenschist assemblage of chlorite, albite, epidote, and calcite suggests that the rocks are not high grade. Metamorphism dies out rapidly to the west and the Gilman and Sweetsburg formations are composed of very fine-grained slates and phyllites. The Sweetsburg phyllites, however, display well-developed double cleavage relationships. The Pinnacle greywacke lies between the Sutton schists and the Gilman formation (see Fig. 2) and its matrix has been completely recrystallized so that muscovite and chlorite lie prominently in the early cleavage planes. In certain beds, however, rock fragments and even feldspars still show their clastic outlines, and well-rounded detrital grains of magnetite, zircon and tourmaline are preserved in the common black sand layers so typical of this greywacke (see Fig. 3a).

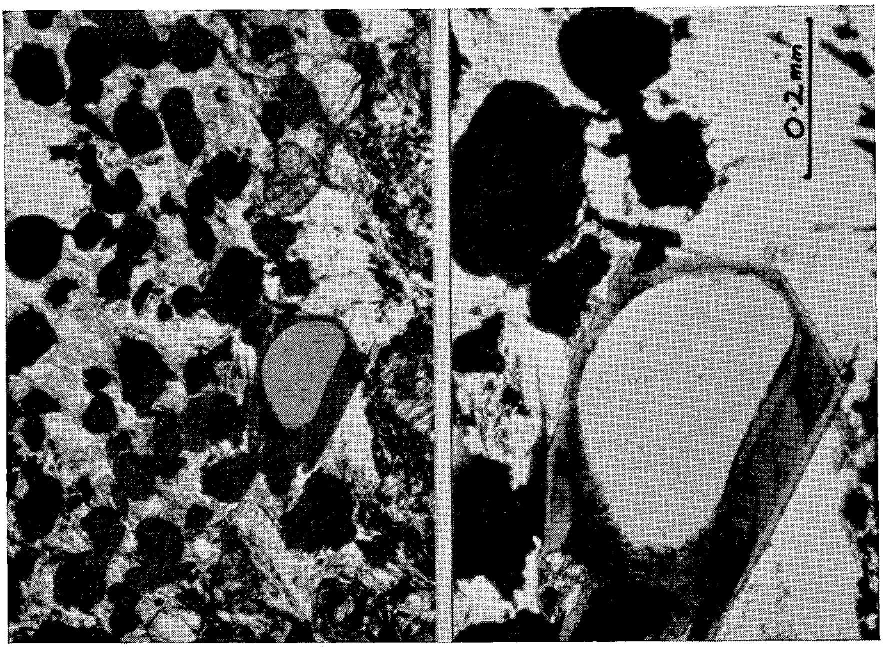

FIG. 3 (left). Black sand layer in Pinnacle Greywacke; showing detrital magnetite, zircon, and tourmaline with overgrowth. (right) Tourmaline overgrowth on detrital grain.

Tourmaline is most abundant in the Pinnacle greywacke but occurs as small crystals in the other formations. The detrital tourmaline grains are usually a golden or pale yellow colour, and they are commonly engulfed by blue or greenish-blue to colourless overgrowths which, judging from their pleochroism and extinction, are in optical continuity with the detrital cores; in addition the basal partings of the prismatic overgrowths cut the old grains (see Fig. 4). The very fine-grained altered mudstones or siltstones of the Gilman formation contain very small blue tourmaline overgrowths on tiny yellow cores, but yellow detrital grains and new blue prisms also occur independently. The Sweetsburg phyllites are very fine-grained and dirty with carbonaceous matter; a little tourmaline is present but it is hard to find because it is very small and either colourless or a dirty yellow brown. The tourmalines in the Sutton schists show a

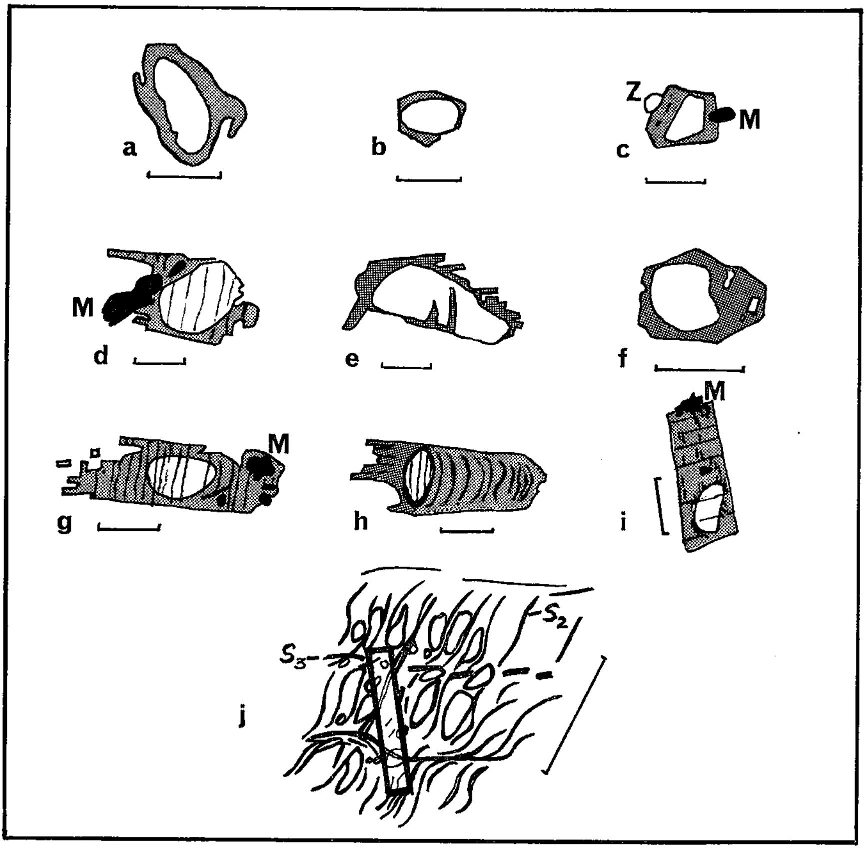

FIG. 4. Tourmaline overgrowths in Pinnacle graywacke. M = magnetite, Z = zircon. Blue tourmaline stippled, yellow tourmaline blank. Bar scale = 0.2 mm. d.g.h. & i. show basal parting of overgrowth cutting detrital core. i, Shows small inclusions aligned parallel to slaty cleavage in greywacke. j, Tourmaline needle growing across early S_2 and ate S_3 cleavage planes in Sweetsburg phyllite.

greater variety of colour—green to black detrital cores occur in addition to the usual yellow ones, and the overgrowths are sometimes pleochroic in black to pink; also, yellowish-green as well as blue new prismatic crystals occur.

It is unusual for metamorphic tourmaline to occur as overgrowths and these tourmaline prisms could at first sight be easily mistaken for authigenic growths, especially those in the black sand layers of the Pinnacle formation (see Figs. 3 & 4). There are, however, several important differences: (i) They are larger than the authigenic prisms recorded by Krynine (1946, p. 71) as up to 0.25 mm. long. (ii) The colour, although blue, is darker than that of normal authigenic growths. (iii) New growth occurs at both ends of the detrital grains; the two ends are often of different colour, however—one brown or greenish instead of blue—and one end is usually poorly developed (see Figs. 3 & 4). In a few cases in the greywacke the overgrowths include particles of the groundmass (Fig. 3b) which in some cases are aligned parallel to the slaty cleavage (Fig. 4i). This indicates that the tourmaline overgrowths developed at least later than the first period of orogenic deformation. This is convincingly confirmed by a small tourmaline needle in the Sweetsburg phyllite that grows across both early and late cleavage planes and includes the groundmass fabric in a "ghost-like" condition (Fig. 4j). Thus the tourmaline clearly grew after the development of the *late* cleavage and cannot therefore be authigenic.

The albite porphyroblasts in the core of the Sutton anticline can also be shown, by their internal inclusion fabric, to have formed after the development of the late (crenulation) cleavage. The association of tourmaline with albite is considered by Read (1957, p. 232) to be indicative of movement of material (metasomatism) during granitization. In this case, however, there would seem to be good evidence that metasomatism has not occurred. Tourmaline is certainly prominent in the albite schists but its development, even in beds of the same apparent composition, is extremely irregular. Moreover, there is no tourmaline in the late quartz "segregation" veinlets, the greenschist layers in the Sutton schists, or in the wide outcrop of Tibbit Hill greenschist that lies between the Sutton schists and the rest of the tourmaline-bearing Oak Hill rocks (see Fig. 2). Even in the Pinnacle greywacke, tourmaline was not found in the bands of basic derivation containing abundant chlorite and epidote.

The occurrence of exotic tourmaline in greenschist has been used by Hutton (1939, p. 599) as conclusive evidence for the action of permeating boron vapours. His arguments can be used in reverse here to suggest that the tourmaline developed by recrystallization around the larger detrital nuclei of material already present in the rock.

Similar tourmaline prisms were noted in the Middle Ordovician Stanbridge slates some twenty miles away from the only obvious centre of metamorphism—the Sutton anticline—and this indicates that the metamorphic effect of the late deformation phase is much more widespread than has hitherto been realized.

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