INDUSTRIAL MINERALS IN EASTERN ONTARIO: CLARENDON SILLIMANITE OCCURRENCE[1]

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CLARENDON SILLIMANITE OCCURRENCE

Location and Access

The Clarendon sillimanite occurrence is situated northwest of Little Green Lake, 4 km north of the village of Ardoch, Clarendon Township, Frontenac County (Fig. 1). The site is approximately 105 km west-southwest of Ottawa, 240 km northeast of Toronto and 28 km northwest of Sharbot Lake. Access is by provincial secondary highways 506, 509 and the Ardoch road, connecting to a network of tourist and logging roads giving direct access to the site.

This report discusses the geology at the site as determined by our field and laboratory analysis and will present some background on the geology of the surrounding area. This report is accompanied by a detailed map (1:2500) of the occurrence.

Previous Work and General Geology

Although middle Proterozoic metamorphosed rocks of this part of the Grenville Province have been studied for well over a century, the overall stratigraphy of the region has only recently emerged in some detail. The area surrounding the site was first mapped at a scale of 1:63,360 by Smith (1956). Recent mapping by Moore (1967), Thompson (1972), Sethuraman and Moore (1973), Rivers (1976), Moore and Morton (1980), Moore and Thompson (1980), and Pauk and Mannard (1982), has detailed the geology of the area.

The site is located in the Central Metasedimentary Belt (Wynne-Edwards 1972) of the Grenville Province. Metavolcanic and metasedimentary rocks underlie most of the area surrounding the site. Plutonic rocks lie northeast and southeast of the site. Metavolcanic rocks and most of the metasediments in the surrounding area were correlated by Pauk and Mannard (1982) with the Hermon and Mayo groups (Lumbers 1967) and represent the oldest rocks in the area. Metasediments of the

Flinton Group (Moore 1967; Moore and Thompson 1972, 1980) are younger than the Hermon and Mayo groups, and are located in narrow northeasterly striking synforms running through the immediate area of the site. Pauk and Mannard (1982), Rivers (1976) and Moore and Thompson (1980) included the main unit at the Clarendon occurrence as part of the Flinton Group although it is situated 2 km northwest of the Fernleigh belt (Rivers 1976), the major exposure of the Flinton Group in this area.

In the Fernleigh belt the Flinton Group includes, in order of decreasing age, basal pelite of the Bishop Corners Formation (exposed on the northern limb of the syncline and at the site of the occurrence), marble metaconglomerate, marble, and graphitic schist, all of the Myer Cave Formation, and biotite-carbonate schist of the Fernleigh Formation occupies the core of the syncline (Moore and Thompson 1972, 1980, Pauk and Mannard 1982). Marble metaconglomerate of the Myer Cave Formation occupying the southern limb of the syncline changes laterally to quartz pebble metaconglomerate to the northeast.

Regional Metamorphic and Structural Geology

Metamorphism

Metamorphism has reached amphibolite facies throughout the area, with the temperature gradient increasing in a northeasterly direction. Moore (1967) defined three metamorphic zones on the basis of mineral assemblages in pelites throughout the area. They are characterized by the index minerals; A) chloritoid-staurolite, B) staurolite-kyanite and C) sillimanite (Fig. 2). Kyanite is also present in the lowest grade rocks (zone A). There is no separate kyanite zone as the appearance of sillimanite coincides with the disappearance of staurolite. Garnet is not a useful zone indicator because it is present along the length of the Fernleigh Belt. It was probably formed in a variety of metamorphic reactions. Rivers (1976) added a fourth zone, D, representing the replacement of muscovite and quartz by sillimanite-potash feldspar (Fig. 2). One of Rivers' (1976) sample locations, no. 312, lying north of the Fernleigh Belt, corresponds to the location of the site detailed in this study (Fig. 2).

Structural Geology

The complex structural pattern of the rock formations in the area around the site is due to at least two, possibly three, major phases of deformation (Rivers, 1976), all essentially producing structures with a predominantly northeast- southwest trend. The first phase of deformation produced isoclinal folds with northeast-trending (N40-60E) axial planes and steeply dipping axial plane foliation essentially parallel to the bedding, except in the fold hinges. Narrow folds of this type occupy a northeast-trending belt in the central part of the area (i.e. the Fernleigh Belt, Fig. 3) (Pauk and Mannard 1982).

A second phase of folding resulted in more open northeast-trending structures, i.e. the Plevna synform and antiform. The Clarendon sillimanite occurrence lies along the south limb of the Plevna synform. However, because of its proximity to the narrow first phase isoclinal folds to the southwest and northeast, its structural history may be very complex.

Faults in the area parallel the Ottawa-Bonnechere graben system. The cross-cutting northwest-trending (N40W-N70W) Plevna fault is expressed by an abrupt change in topography, and is located approximately 1 km west of the site. The strike of the fault is parallel to the predominant major joint direction.

CLARENDON SILLIMANITE OCCURRENCE – Site Geology

Lithology

The area of the Clarendon sillimanite occurrence is dominated by three basic rock types: mafic to intermediate paragneisses, calcitic and dolomitic marbles, and pelitic schist.

The mafic paragneisses contain mostly hornblende and also significant amounts of biotite. They are well foliated and have a medium to fine grained texture.

The marbles in the area are dominated by calcitic marbles that can be white, buff, or grey-blue. They contain varying amounts of tremolite, quartz and diopside. There are also minor amounts of dolomitic marble. Recrystallization and coarsening of grain size during metamorphism and deformation has obliterated the original texture of the rock. The marbles are commonly massive, but can be interlayered with clastic siliceous metasediments, or contain high percentages of tremolite or diopside.

The main central unit of the Clarendon occurrence is a muscovite-biotite bearing pelitic shist. It is usually porphyroblastic, and its principal matrix minerals include quartz, plagioclase and opaque oxides, primarily magnetite. A variety of porphyroblastic minerals may be present, some of which may serve as indicators of metamorphic grade. These include: plagioclase, biotite, staurolite, kyanite, garnet, sillimanite and magnetite. Although this unit has been assigned to the Flinton Group, Bishop Corners Formation, by Moore and Thompson (1972) and Pauk and Mannard (1982), the justification for any correlation is solely lithological.

At the Clarendon sillimanite occurrence the pelitic schist varies greatly inside the mapped boundaries of the unit. It is characterized by three main sub- units. The first has a moderately high content of sillimanite in the form of clots, i.e. 15-35% sillimanite. The second is the same assemblage but with a lower percentage of sillimanite, i.e. 0-15%. The third subunit differs quite markedly from the first two in that it contains a high percentage, i.e. approximately 30%, of large plagioclase porphyroblasts, commonly 3-4 cm in diameter. These subunits at mapping scale resemble pods, more or less parallel to the foliation direction.

The first unit is the most important economically as far as sillimanite is concerned. Commonly the high grade zones have a high ratio of biotite to muscovite in the matrix, and may have a high percentage of garnet present as porphyroblasts. The sillimanite clots are commonly elongate ellipsoids usually 1-2 cm long, parallel to the foliation present. Sillimanite crystals within these clots are acicular with aspect ratios of 20:1 to 30:1 not uncommon. The sillimanite clots are quite clean, i.e. little or no quartz present within the clot. Some magnetite is present in the clots, i.e. 1-2%; however, this varies throughout the site and may or may not be present. Within this subunit, several other minerals of interest are present in minor amounts. Two isolated occurrences of kyanite blades, measuring up to 4-6 cm in length were noted. Sillimanite was not observed to be in close contact with the kyanite. Porphyroblasts of staurolite are present, particularly towards the northeast end of the deposit. These appear to be a retrograde feature and are surrounded by sillimanite needles.

At least two orders of garnet growth were noted throughout the site in the high grade sillimanite unit. Most common are garnets of approximately 1-2 cm in diameter, that are embayed, anhedral, with numerous inclusions. These account for at least 90% of the garnets at the site. However it was noted that of the remaining garnets, 10% are very clean, with little or no inclusions, and are only mildly fractured. These garnets are euhedral with good multiple facets visible in hand specimen and thin section, and are 1-2 cm in diameter and would be suitable as abrasive grade material of very good quality. The distribution of these garnets within the site is not uniform, and occasionally they are found along with other garnets that contain numerous inclusions.

They appear to be a retrograde product, and are usually found completely surrounded by sillimanite, with the sillimanite needles being truncated by the garnet boundary. The poikilitic garnets are not commonly found in close contact with the sillimanite needles. Work is currently underway to investigate the two different styles of garnet growth.

The second subunit also has a matrix dominated by muscovite and biotite. The sillimanite grade is much lower, and in some locations sillimanite is absent altogether. Muscovite is the most common matrix mineral in this unit with biotite usually much less abundant. Other porphyroblasts, i.e. garnet, kyanite, staurolite, are also much less common than in the high grade sillimanite unit.

The third subunit is remarkable in that it is dominated by large porphyroblasts of plagioclase feldspar up to 4 cm in diameter. These constitute up to 30-40% of the unit with the remainder matrix material, i.e. muscovite, biotite, quartz, and microscopic plagioclase. In several areas this unit also contains a high percentage of sillimanite. It is commonly in the form of prismatic bundles of sillimanite needles up to 3 cm in length. However it rarely exceeds 15% by volume, and usually is considerably less.

Structural Geology

The detailed structural geology of the site is still under investigation. The main pelitic schist unit is dominated by a well developed foliation trending 050-060 NE with a consistently steep northwest dip of approximately 70°-80°. A well developed system of cross fractures or joints is visible throughout the site, particularly in the central section. These parallel the trend of the Plevna fault 1 km southwest of the site. The cross fractures in the central part of the site are expressed topographically as ravines up to 30-50 m deep. With the excellent outcrop exposure in the ravines it is possible to follow the units to some depth, leading to the conclusion that the high grade/low grade pelitic schist continues to a considerable depth below the surface, with little or no narrowing of the schist as a whole.

Conclusions

The Clarendon sillimanite occurrence is about 2.5 kilometres long and averages 250 metres wide. Within this area approximately 40% of the material contains more than 20% sillimanite by volume. When the overall steep dip is taken into consideration along with these figures, the total volume of material of economic interest is substantial.

Although there is substantial outcrop of the same formation within the area, it appears that the site described here contains the highest grade of sillimanite. There could be a number of reasons for this, i.e. change in lithology, structural enhancement, etc., but information leading to any definitive conclusions is inadequate at this time.

Acknowledgments

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Figures and Captions

1. Regional geology of the Tweed-Ompah area, showing the distribution of Flinton Group rocks. Modified from Moore and Thompson (1980).

2. Distribution of isograds in pelitic schist of the Fernleigh belt (stippled). Station No. 312 (from Rivers 1976) corresponds to the location of the site detailed in this study.

3. Structural map of the Fernleigh-Ompah area. Modified from Rivers (1976).

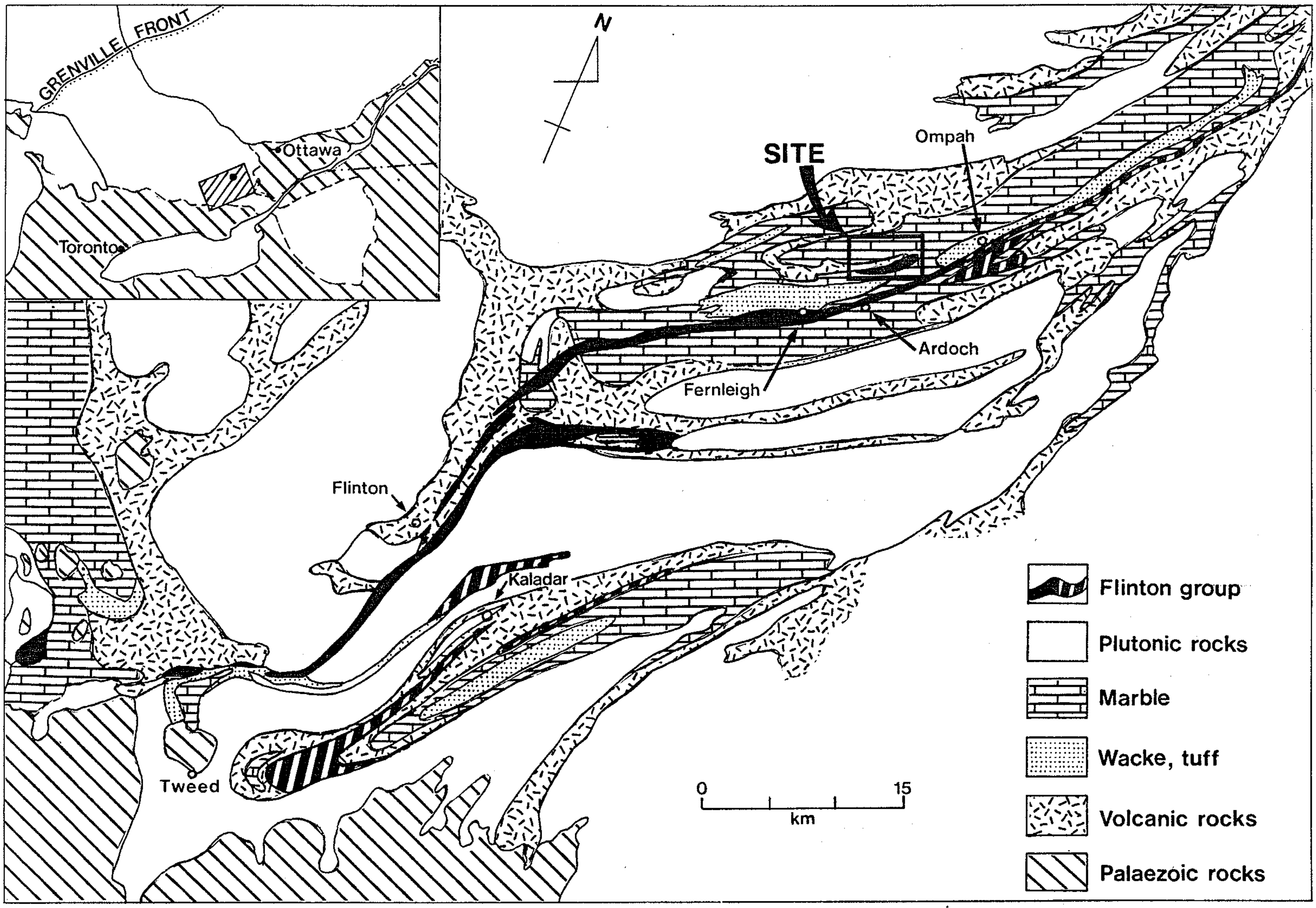

Figure 1. Regional geology of the Tweed-Ompah area, showing the distribution of Flinton Group rocks. Modified from Moore and Thompson (1980).

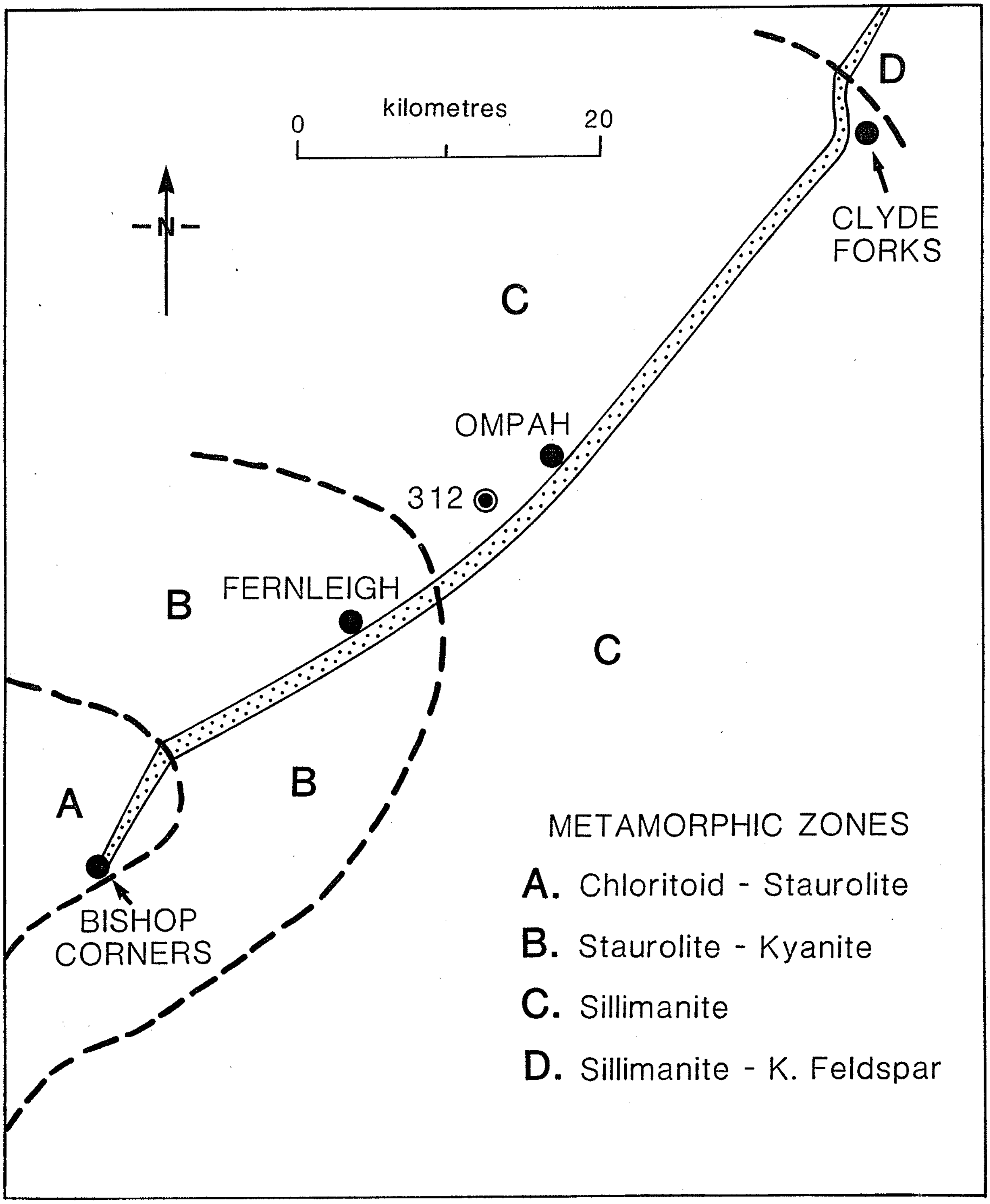

Figure 2. Distribution of isograds in pelitic schist of the Fernleigh belt (stippled). Station No. 312 (from Rivers 1976) corresponds to the location of the site detailed in this study.

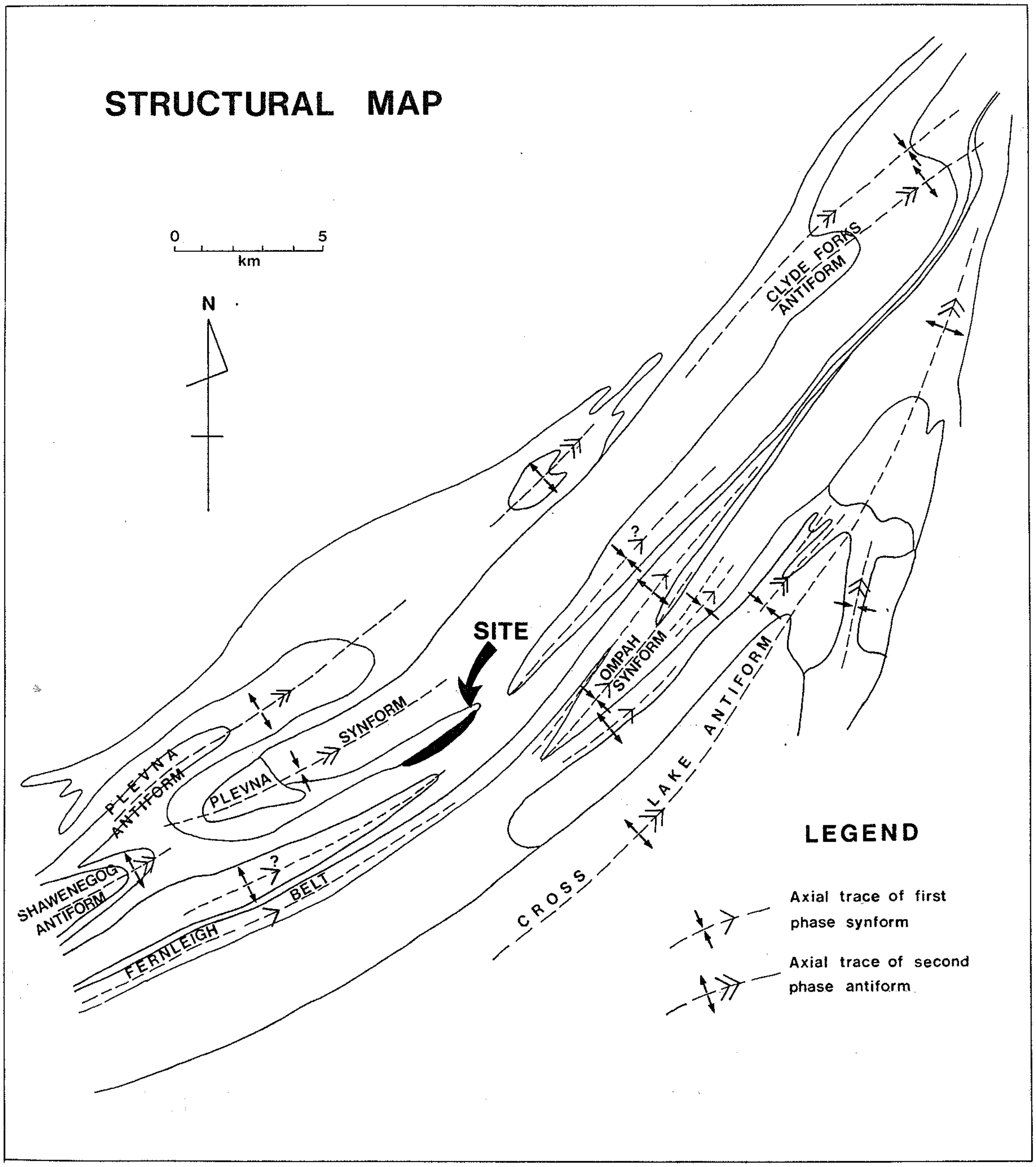

Figure 3. Structural map of the Fernleigh-Ompah area. Modified from Rivers (1976).