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1966/221

A REPORT ON THE WEST KIMBERLEY HAWKSTONE KYANITE DEPOSIT
WESTERN AUSTRALIA.

by

G.M. Derrick and C.M. Morgan

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SUMMARY

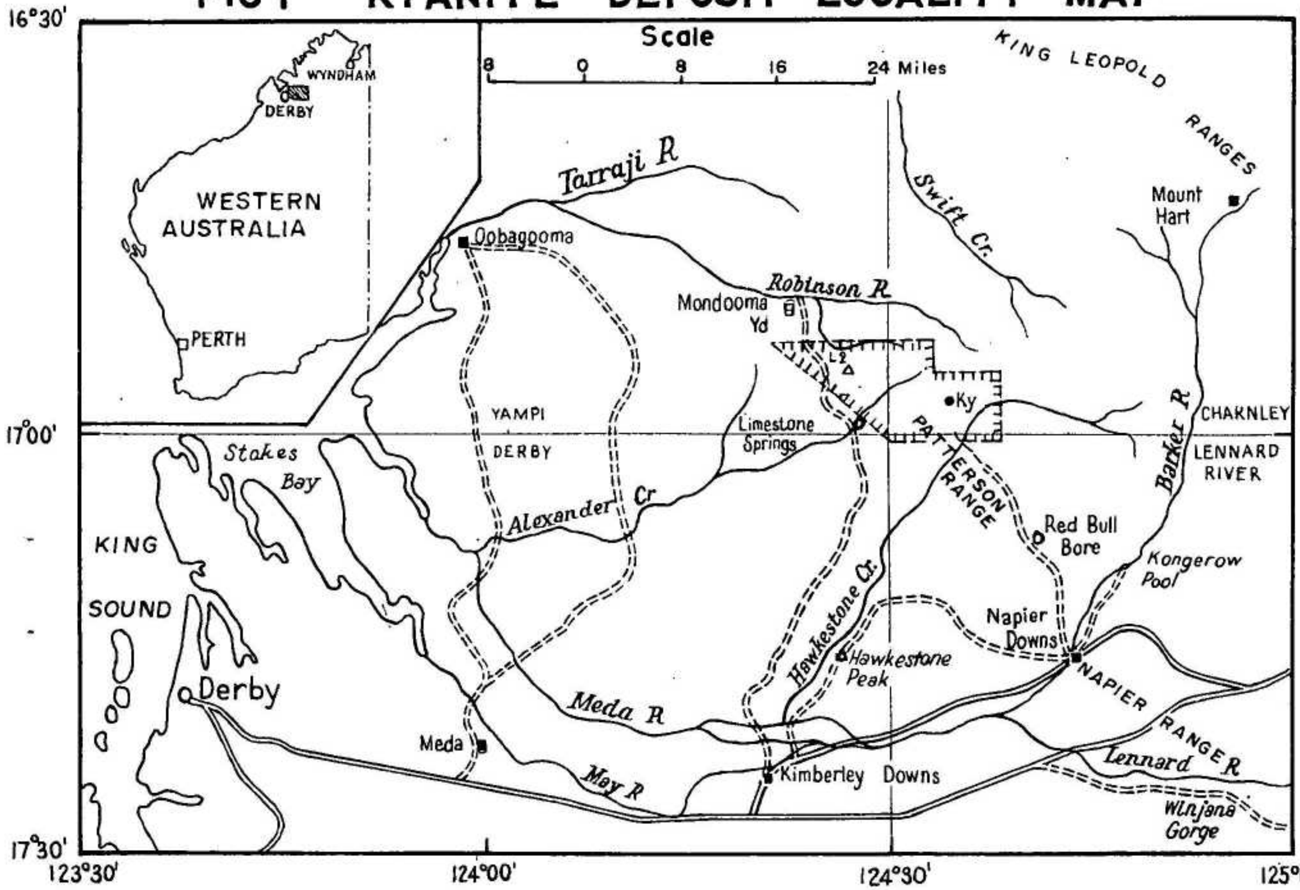
In the course of regional mapping in 1966 a kyanite deposit was located in the vicinity of the headwaters of Hawkestone Creek, about 90 miles north-east of Derby, Western Australia.

The deposit consists of a number of poorly defined lenses containing kyanite rock, kyanite schist, vein kyanite and minor corundum-bearing rock, all of which, excepting the vein material, contain appreciable quantities of micaceous mineral, rutile and tourmaline. The deposit is enclosed by phyllites and amphibolitized dolerite of the (?)Archaean Halls Creek Group.

The origin of the deposit is uncertain, but it is thought that regional metamorphism in the upper greenschist facies of suitably aluminous sedimentary material could account for much of the deformed kyanite crystal masses and kyanite schist. The undeformed vein kyanite is thought to be a product of metasomatic remobilisation of pre-existing kyanite, while the corundum development is attributed to thermal metamorphism of sediment by dolerite. The presence of tourmaline and dumortierite suggests formation of part of the deposit by a hydrothermal phase rich in boron. This may also have caused the alteration of kyanite to diaspore and micaceous minerals.

The deposit contains at least 11,000 tons of kyanite per vertical foot, but preliminary investigation indicates that the alumina content of the kyanite rock does not exceed 52 per cent, which is insufficient for commercial purposes. The deposit is considered to be of little economic significance at present, but further exploration and additional chemical analyses are warranted.

FIG I KYANITE DEPOSIT LOCALITY MAP



Reference

══════ Formed gravel road	o Bore
====== Graded vehicle track	o~ Spring
------ Track	Δ Trigonometrical station
■ Homestead	•Ky Kyanite locality
□ Yard	Area covered by geological map (Plate 1)

Registered plan No. E51/A4/4
To accompany Record 1966/221
Bureau of Mineral Resources, Geology and Geophysics

INTRODUCTION

The Hawkestone kyanite deposit was located and investigated by us in July and August, 1966, during regional mapping of the older Precambrian rocks of the west Kimberley area, Western Australia. This mapping was part of a programme designed to complete the mapping of the Lennard River, Yampi, and Charnley 1:250,000 Sheet areas, and was undertaken by a combined party from the Bureau of Mineral Resources and the Geological Survey of Western Australia.

Location and Access

The deposit is situated in the extreme south-west of the Charnley 1:250,000 Sheet area (fig. 1) at Lat. 16°56'50", Long. 124°33'40", or 2333E, 28651N on the Mercator grid reference. It lies about 2½ miles due east of the head of Alexander Creek, and 2 miles north-west of part of Hawkestone Creek, and is 40 miles by road from Kimberley Downs Homestead. The nearest town and port, Derby, is 90 miles by road from the deposit.

The kyanite body is accessible only to four-wheel-drive vehicles at present. It can be reached by vehicle track via Napier Downs and Red Bull Bore, or via Kimberley Downs and Limestone Springs. The latter track is graded regularly, and passes within eight miles of the deposit. Between the track and the deposit there are large hills of dolerite, small rises of metamorphic rocks and extensive soil plains, all of which are partly covered with a heavy growth of tall cane grass.

Previous Investigation

The only previous reference to kyanite in the Hawkestone area was made by Campbell (1908), who reported that pegmatites containing staurolite, tourmaline and kyanite were present in the area near Trig. Station L2. Since then, despite much prospecting for copper, mica, tin and wolfram, no other mention of kyanite has been made in the literature on the area.

General Geology

The area consists of older Precambrian rocks (?Archaean and Proterozoic) overlain unconformably by Devonian limestone and conglomerate. The older Precambrian rocks consist of phyllite and mica schist, acid volcanics, metadolerite, and granite. The distribution of these around the kyanite deposit is shown in Plate 1.

The kyanite is associated with the oldest rocks in the area - the Halls Creek Group and the Woodward Dolerite. The Halls Creek Group consists of metasediments of varying metamorphic grade. The rocks of lowest grade are chlorite-sericite schists, phyllite, and fine-grained phyllitic psammites, the latter containing amphibole and zoisite. These pass into garnetiferous schists containing chloritoid, and in some places andalusite and staurolite.

The Woodward Dolerite is a sill-like body which intrudes the Halls Creek Group. It appears to be conformable with the phyllites and schists of the Group, and has been folded with them. The dolerite is amphibolitized, and throughout the area contains layers which consist of very coarse (up to 6 inches diameter) aggregates of plagioclase and subordinate mafic mineral.

The Whitewater Volcanics consist of flows, autoclastic porphyry and interbedded tuffaceous sediments. They are generally rhyolitic in composition, and contain phenocrysts and xenocrysts of feldspar and glassy quartz set in a dark grey siliceous matrix. The volcanics are intruded by granite and granite porphyry.

The granitic rocks of the area occur mainly in an east-west trending belt north of the kyanite deposit, and in smaller areas to the west and south-east. Four types are recognized. These are the A, B, and C-type granites and Bickleys Porphyry, all names except the latter being informal field terminology.

Most abundant is the A-type granite, which crops out as large elongate "whalebacks". It is a coarse-grained, porphyritic, leucocratic granite with some biotite, and is generally gneissose. It is intruded by B-type granite, which occurs as veins and small bodies within the A-type. The B-type is a gneissose, coarse-grained, grey, porphyritic biotite granite, in which feldspar phenocrysts are generally larger and more discrete than in the A-type. Bickleys Porphyry is a coarse to medium-grained porphyritic biotite microgranite, and characteristically contains euhedra of glassy quartz in a crystalline acid groundmass. It crops out as high, rugged bouldery hills, and is moderately gneissose. The C-type granite is coarse to medium-grained, leucocratic, and generally muscovite-bearing, and commonly shows no gneissosity. Associated with it are numerous veins of tourmaline pegmatite, aplite, and aplite dykes, and it is probably the youngest intrusive phase present.

Isolated dolerite and aplite dykes and quartz veins also crop out throughout the area. Old mine workings include the King Sound Tin Mine, Stewart's Mica Show, and one small unnamed copper occurrence.

Detailed Geology

Plate 2 is a detailed geological map of the deposit, which is situated on a hill immediately to the north of a large outcrop of Woodward Dolerite (figs. 2 and 3). The hill is 1100 feet long from east to west, and 700 feet north to south. The centre and northernmost part of the hill are occupied by fine-grained arenite and chlorite-sericite phyllite of the Halls Creek Group, which dip to the south at 70°, and form the most prominent outcrops on the hill. The northern flank of the hill is also partly occupied by a small (150' x 80') lens of dolerite, which, like the main outcrop to the south, is poorly exposed. Several quartz veins up to three feet in width run in a general east-west direction through the hill, and are probably responsible for the two central ridges.

The southern flank of the hill is strewn with many angular boulders ranging in size from a few inches to over ten feet. They consist of medium and coarse-grained blue-grey kyanite-sericite-rutile-tourmaline and kyanite-sericite-rutile rock, and corundum-sericite rock. On the higher parts of the southern slopes the boulders of kyanite rock are lying on phyllite bedrock, whereas on the lower slopes the presence of abundant boulders of kyanite and absence of any outcrop other than kyanite rock suggests that this part of the hill is occupied by a kyanite lens.

Boulders of kyanite rock occur at the eastern end of the hill, and there is possibly another smaller lens of kyanite in this position.

The top of the hill is occupied by two prominent ridges, and the trough between these contains a few blocks of kyanite rock resting on phyllite outcrop, which is intruded along the southern ridge by thin quartz veins. Numerous kyanite boulders are also scattered about the western flank of the hill, where a quartz vein up to 12 feet thick is prominent (fig. 4). Blocks of kyanite also occur on the northern slopes of the hill, and for the most part these are erratics lying on phyllite and dolerite.

A tough, blue-grey, fine-grained corundum rock is found in several places on the hill, and it usually appears to crop out near dolerite contacts. It is seen in several places along the southern border of the hill, where it occurs near the margin of the kyanite lens. It is also seen near the north-eastern margin of the dolerite lens on the northern slope of the hill, and this provides further evidence that a lens of kyanite rock may be present there.

Mineralogy of the Deposit

Four major types of kyanite and corundum rock have been recognized:-

Type 1. Coarse-grained kyanite rock R66161012

In hand specimen, this is a massive and very dense rock which appears to consist almost entirely of kyanite. The kyanite is very coarse-grained, and occurs as grey crystal masses with crystals up to 6mm. long, and pale blue bladed masses with blades up to 8cm. in length. The blue kyanite appears to form veins and segregations. In some veins the blades of kyanite change sharply in colour from blue to grey, and appear similar in colour, though different in form, to the grey kyanite crystal masses which form the bulk of the rock. Fine-grained interstitial sericite is also present.

Thin section : Mode (estimated from thin section)

Kyanite (60% to 75%), sericite (20%), rutile and iron oxide (5%).

a. Areas of blue kyanite:-

Kyanite is present as subhedral elongated crystals 3 to 15mm. long in this particular section. Most grains contain thin films of an unidentified blue-grey to brown mineral along cleavage planes, but mineral inclusions are absent. The crystals are unstrained.

The matrix is also free from inclusions, and consists of sericitic material showing a rough plumose structure.

b. Areas of grey kyanite:-

Kyanite crystals are subhedral, and are generally shorter than the blue variety. They show abundant inclusions of iron oxide, and, to a lesser extent, rutile, and it is highly likely that these inclusions are responsible for the colour differences between the two types of kyanite. Many of the crystals are bent and show strain lamellae. Films along cleavage planes are common.

Rutile and iron oxide are present as small scattered inclusions in kyanite, and as vaguely defined trails which cut across the matrix.

The matrix is composed of a fine aggregate of sericite and a muscovite-like mineral which is almost uniaxial. This latter mineral is possibly damourite.

Fig. 2. Aerial view of kyanite deposit, looking WNW.

k = kyanite boulders
p = phyllite and schist
q = quartz veining
d = dolerite and amphibolite
NS = north-south line

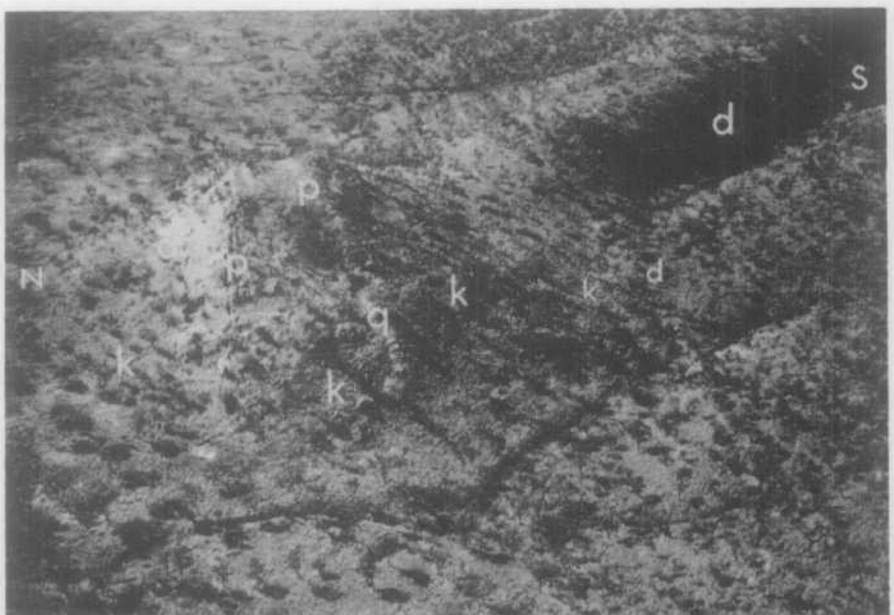


Fig. 3. Aerial view of kyanite, looking ESE. Legend as for figure 2.

ig. 4. Western end of kyanite deposit. Height of kyanite boulder is 12 feet. Legend as for figure 2.

Type 2. Kyanite-tourmaline rock R66161010

In hand specimen, this rock is massive and dense, grey when fresh and orange-brown and grey on weathered surfaces. It consists of coarse-grained, randomly intergrown grey kyanite crystals from 1mm. to 5mm. in length, and fine-grained grey interstitial material, probably sericite. Large parts of some of the kyanite crystals show a salmon pink coloration. Scattered through the rock are small (0.5mm. to 1mm.) brown crystals, probably tourmaline.

Thin section : Mode:- Kyanite (55% to 60%), tourmaline (15%), micaceous mineral (25%), accessories (5%).

Kyanite occurs as colourless, euhedral, prismatic crystals up to 3mm. long, with abundant inclusions of corundum, rutile, and dumortierite. Many grains contain films along cleavages of an unidentified grey-brown mineral.

Tourmaline occurs as faintly zoned euhedral crystals forming hexagons up to 0.5mm. across and 2mm. long. It is pleochroic, with e= colourless and o= yellow, indicating that the tourmaline is the magnesian variety, dravite.

Dumortierite occurs as small subhedral prismatic crystals arranged in radiating clusters which occur in kyanite crystals and in the cores of tourmaline crystals. It is pleochroic from pink to colourless, and the maximum absorption occurs when the crystal length is parallel to the lower nicol. Most of the dumortierite shows an anomalous Berlin blue interference colour, generally at the extinction position of the host mineral. This feature is probably a result of interference due to wedging of kyanite and tourmaline beneath the dumortierite in the thin section.

Accessories are rutile, corundum, and minor iron oxide. The rutile occurs as small single grains or in small clusters.

The matrix is highly micaceous. Most of the mica appears to be sericite and muscovite, but some damourite may be present. Coarser-grained patches with flakes up to 0.4mm. long are prominent.

Type 3. Porphyroblastic kyanite-sericite schist R66161011

In hand specimen, this is a massive, dense, fine-grained pale grey rock containing numerous steel grey crystals of kyanite. Most of the fine-grained material is finely schistose, and is probably sericite. The kyanite crystals are euhedral tablets elongated in the c direction, and they occur in clusters or as individuals up to 3cm. long.

Thin section : Mode:- kyanite (50%), (?)sericite (40%), rutile (5 to 10%).

Kyanite occurs as large bladed crystals up to 6mm. long, generally fresh, but in places partly or wholly replaced by a patchwork of diaspore. The crystals commonly show deformation lamellae, and contain inclusions of rutile.

The matrix is highly micaceous. It is finely schistose, and consists of fine-grained subparallel sericite flakes which contain numerous small dark inclusions outlining the schistosity. The schistosity "flows" around lenticles or augens up to 7mm. long of aggregated sericite, which is coarser-grained and contains fewer inclusions than the enclosing material. Rutile grains are common.

Type 4. Corundum-sericite rock R66160301

In hand specimen, this is an extremely tough,massive, dense, and fine-grained steel-grey rock, with small amounts of pale grey sericitic material coating irregular joints.

Thin section: Mode:- Corundum (40%), sericite or paragonite (50%), rutile (5% to 10%), apatite (1% to 2%), (?)damourite (5%).

Corundum grains are small (0.02mm.) and equant, and occur in clusters separated by areas of micaceous mineral.

Rutile is scattered through the rock.

The matrix consists mainly of sericite, paragonite, and damourite. Lath-like areas of these minerals indicate the former presence of prismatic grains which have been pseudomorphed. Square and rectangular areas also consisting of micaceous mineral contain some fine-grained grey, possibly carbonaceous, material, and are bordered by clusters of rutile and corundum grains. These areas may be relict interstitial areas, or more probably they may represent pseudomorphs after chiastolite.

X-ray and Chemical Investigation, Specific Gravity Measurement

X-ray diffractometer patterns were obtained from various samples of the kyanite rock, using Cu K radiation. Samples of blue and grey kyanite were tested, but no appreciable differences in pattern were obtained. A sample of the light fraction of the corundum rock was examined, and the presence of paragonite, a sodic mica, was deduced from the X-ray pattern.

Partial chemical analyses for K_2O, and in one case, Na_2O, were carried out by J.R. Beevers (B.M.R.) to determine the amount and type of micaceous mineral present. Results are as follows:-

		K_2O	Na_2O
R66161010	Kyanite-tourmaline rock	0.82%	-
R66161011	Kyanite-sericite schist	2.44%	-
R66161012	Kyanite rock	0.19%	-
R66160301	Corundum-sericite rock	0.70%	1.50%

Analyses presented by Deer et al (1962) show that K_2O in kyanite ranges from 0.20% to 0.97% (8 analyses). In two specimens from the Hawkestone deposit, the kyanite rock (1012) and the kyanite-tourmaline rock (1010), the K_2O values for total rock fall within the range quoted above for kyanite mineral. In these two rock types the estimated mode indicates a mica content (?sericite) of 20 and 25 per cent respectively. If, as is likely, the variation in potassium content reflects the abundance of sericite (fine-grained muscovite) in the specimens analysed, then the micaceous minerals forming a substantial part of the kyanite rocks are extremely poor in potash. These micaceous minerals are probably paragonite, or the chlorite pyrophyllite, rather than sericite as first thought.

The specific gravity of two types of kyanite and the corundum-sericite rock were measured, using a Berman microbalance and temperature correction graphs. Results were

Blue kyanite 3.58 (average of 3 readings)
Grey kyanite 3.62 (" " 5 ")
Corundum-sericite rock 3.58 (average of 3 readings)

The higher S.G. of the grey kyanite crystal sample is probably due to abundant inclusions of rutile (S.G. 4.25) and iron oxide, while the lower S.G. of the corundum rock is due to the abundance of micaceous mineral in the sample.

Origin of the Deposit

The origin of the deposit is undoubtedly due to interaction of the effects of regional and thermal metamorphism, and metasomatism. These effects are considered in turn below.

Metamorphism (Regional)

Many kyanite deposits are thought to result from regional metamorphism of a bed or lens of favourable composition, e.g. a highly aluminous argillite. This idea implies that rocks enclosing the kyanite body and the kyanite body itself are of similar metamorphic grade.

In rocks of suitable composition kyanite has been used as an index mineral of progressive regional metamorphism, e.g. the Barrovian kyanite zone, where staurolite becomes unstable and is replaced by the mineral pair kyanite-almandine (Harker (1952), Deer et al (1962), Turner and Verhoogen (1960), and many others). Other minerals present in this zone include quartz, plagioclase and muscovite, and the assemblage constitutes a subfacies of the almandine-amphibolite facies of Turner and Verhoogen (op. cit). Myashiro (1961) places kyanite in the amphibolite facies, where it forms a part of the kyanite-sillimanite facies series.

The metamorphic rocks in the vicinity of the Hawkestone kyanite deposit vary in metamorphic grade from the amphibolite facies to the greenschist facies of regional metamorphism. Phyllitic rocks of the amphibolite facies crop out three miles south-east of the deposit, and contain staurolite, andalusite (pseudomorphed in some cases by corundum and sericite), chloritoid and garnet. Metapsammites of the greenschist facies are exposed one mile west of the deposit, and contain zoisite, small garnet crystals, and amphibole with Z= pale khaki green, indicating the rocks there to be of the upper greenschist facies (Myashiro, op. cit.). The pelitic metamorphic rocks close to and within the kyanite deposit are sericite phyllites and schists of the same facies.

The mineral assemblages observed in the kyanite body itself are kyanite-sericite-rutile, and in some areas corundum-sericite. These assemblages cannot be readily placed into any of the standard facies, and it would appear that the occurrence of kyanite and corundum-bearing rocks (usually considered to be of relatively high metamorphic grade) in a belt of greenschist facies rocks, is anomalous. However, Turner and Verhoogen (op. cit) state that in the quartz-albite-epidote-almandine subfacies of the greenschist facies, kyanite, though by no means a common mineral, has been recorded sufficiently often in highly aluminous rocks to suggest that it, rather than pyrophyllite, is the stable aluminosilicate. It is therefore possible that most of the

Hawkestone kyanite deposit (e.g. the grey kyanite crystal masses and kyanite-sericite schists) could have formed through simple regional metamorphism under upper greenschist facies conditions. A regional metamorphism of this type would account for the small-scale deformation (bending of crystals and strain twinning) observed in parts of the kyanite deposit, but it cannot satisfactorily account for the presence of corundum rock and abundance of kyanite veins.

The Yanmah kyanite deposit in Western Australia described by Foreman (1945) appears similar in type to the Hawkestone deposit. It is considered to be a regionally metamorphosed lens, but is enclosed by garnetiferous quartzites and kyanite-quartz schists.

<u>Metamorphism</u> (thermal)

Most writers are in agreement that commonly corundum is a product of high-grade thermal metamorphism of highly aluminous sediments. The corundum-bearing rock in the kyanite deposit is probably due to metamorphism by the Woodward Dolerite, and significantly all but one of the outcrops of such rock found so far are immediately adjacent to dolerite contacts. The corundum rock also appears to contain micaceous pseudomorphs after chiastolite, which commonly occurs in hornfels. The corundum is probably metastable in this environment, since the Woodward Dolerite appears to have been amphibolitized during the regional metamorphism.

In the Mount Broome area, 70 miles east-south-east of the Hawkestone deposit, corundum rocks assaying 92% Al_2O_3 (C.S.I.R., 1942) are also associated with outcrops of the Woodward Dolerite. Smith (1965) describes the development of emery deposits in Argyllshire, Scotland, by thermal metamorphism of pelites by dolerite, and considers them to be aluminous residues after a granitic fraction has been selectively refused and removed.

<u>Metasomatism</u>

The Hawkestone kyanite deposit contains many features which are best explained by metasomatism. The most striking feature is the abundance of kyanite veins (figs. 5, 6, 7), in which blades of blue kyanite ranging in length from 0.5 to 10cm. are generally found developed at right angles to the wall of the vein. The kyanite in these veins is undeformed and free from inclusions (mainly rutile and iron oxide), unlike the grey masses of kyanite which are cut by the veins. Similar veins have been recorded at Williamstown, South Australia, by Alderman (1942), who cites them as evidence for alumina-rich fluids, and Vail (1966), who found kyanite crystals up to 20cm. long in veins cutting kyanite-staurolite-garnet schists. The undeformed vein kyanite of the Hawkestone deposit is paralleled by the large undeformed kyanite masses in New Mexico, described by Schreyey and Chinner (1966), who attribute this feature to crystallization after deformation, during an essentially static phase of the thermal history of the deposit.

The lack of inclusions in the Hawkestone vein kyanite is also typical of the many small lenticles in the Indian kyanite deposits. These small inclusion-free features are considered by Dunn (1929) to be segregations, in contrast to the large masses of inclusion-rich grey kyanite which Dunn considers to be a result of regional metamorphism in situ of bauxitic clays.

Further evidence of metasomatism is provided by the presence of tourmaline and dumortierite. These minerals, which occur together, are sporadically developed in small areas of the deposit. The tourmaline is the magnesian variety, dravite, which Barth (1936) notes is characteristic of low grade metamorphism. The tourmaline crystals are euhedral, and show no overgrowths, and have probably crystallized from low temperature hydrothermal fluids rich in boron. The alteration of some of the kyanite to diaspore, damourite, paragonite and sericitic material indicates that alkalis were also active in the hydrothermal metasomatism.

The tourmaline and rutile have almost certainly been derived from the metasediments of the Halls Creek Group. Thin section examination of some very low grade rocks of the Group revealed abundant quantities of these minerals, as well as some zircon, but the mechanism of redistribution and recrystallization of them through the kyanite deposit is not clear. It is doubtful that the tourmaline is a result of acid pegmatite activity. The nearest tourmaline-bearing pegmatites observed are 7 miles to the west and north-west of the deposit, and the tourmaline is the iron-rich variety, schorlite.

The relationship between the corundum and kyanite rocks is obscure. Kyanite, although considered by many authors to be a stress mineral, can develop under the influence of hydrostatic or load pressure in the absence of shearing stress (Khitarov (1963), Clark (1961), Shams (1965), Deer et al (op. cit.)). Thus it is possible that the thermal metamorphism postulated for the formation of corundum also formed the kyanite rock, and kyanite metacrysts in hornfels, recorded by Barker (1964), are a good example of such a process.

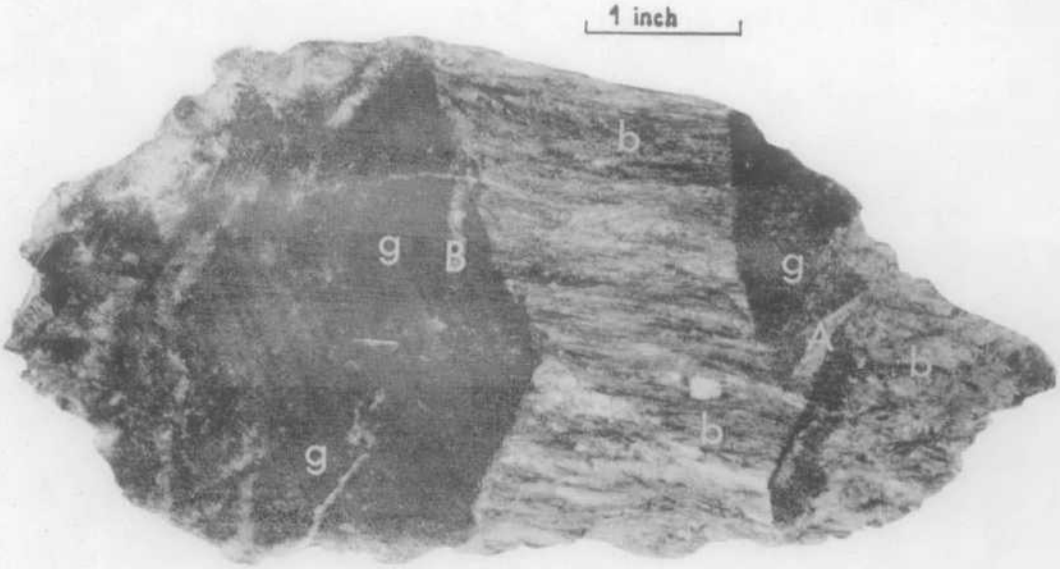


Fig. 5. Veins of fibrous blue kyanite (b) cutting grey kyanite (g). Note the development at right angles to the vein wall, and also the small connecting veinlets at A and B.

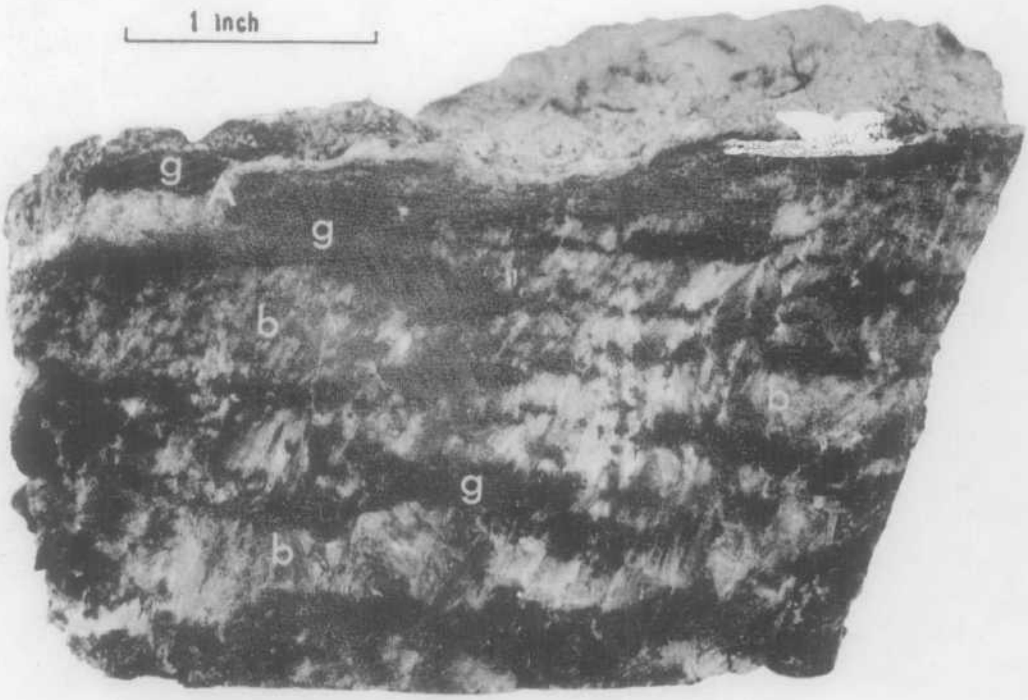


Fig. 6. Veins of blue kyanite (b) cutting masses of grey kyanite (g). Note the marked cross-cutting at A.

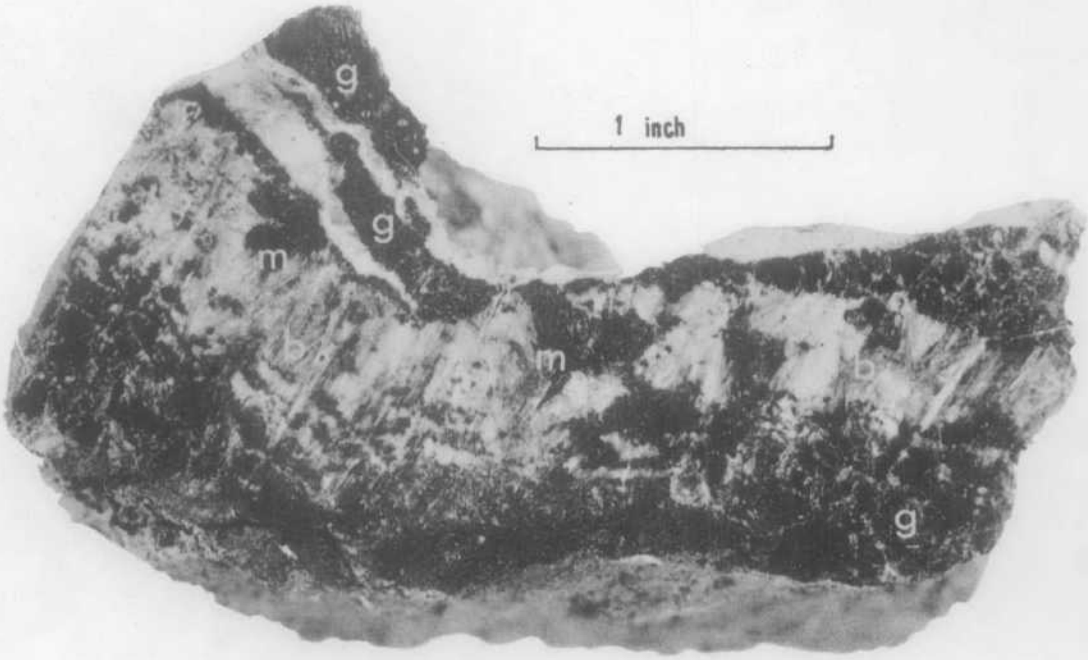


Fig. 7. Veins of blue kyanite (b) in grey kyanite (g). Note the large plates of browm micaceous mineral (m) in the veins.

Conclusions

The Hawkestone kyanite deposit appears to be of uncertain origin. It is possible that regional metamorphism in the upper greenschist facies has produced the kyanite-muscovite rocks in which kyanite crystals and intergrowths are generally deformed and full of inclusions. The veins of kyanite have probably been produced by metasomatism in the absence of shearing stress, probably by a remobilisation of pre-existing kyanite, or possibly be selective removal of alkalis and water from aluminous sediments, followed by migration of an alumina-rich fluid phase. The presence of tourmaline and dumortierite suggests formation of parts of the deposit by a hydrothermal phase rich in boron. This may also have caused the alteration of kyanite to diaspore and micaceous minerals. The tourmaline, as well as rutile, has probably originated from sediments. The corundum rock has probably been produced by thermal metamorphism of sediments by dolerite, but whether this metamorphism accompanied by metasomatism developed some or all of the kyanite body remains conjectural.

Estimated Reserves

The area of the hill possibly underlain by kyanite rock is about 200,000 square feet. Assuming the rock has an average specific gravity of 3.55, and consists of 55 per cent kyanite (a minimum value) there would be about 18,000 tons of kyanite rock per vertical foot, and of this about 11,000 tons would be kyanite. Probably between 1,000 and 2,000 tons of kyanite rock are present as loose boulders scattered over the hill.

Economic Considerations

Kyanite is used in the manufacture of high alumina refractory bricks and spark-plug insulators, and in the ceramic industry generally. The bulk of Australia's needs are met by producers at Broken Hill and Williamstown, where sillimanite, not kyanite, is the chief product. Over 4000 tons of sillimanite and kyanite were consumed in Australia during the period 1963-64, and this figure has increased slightly since. Over 1000 tons of kyanite, valued at $65,000, were imported from India during this period. At present the market value of kyanite in Australia is $48-$50 per ton.

The requirements of the industry are for a product containing in excess of 60 per cent Al_2O_3, delivered in large lump form for ease of calcination. (Kalix, pers. comm.). Impurities such as K_2O, Na_2O, and TiO_2 should each be less than 1 per cent.

The Hawkestone deposit contains abundant rutile, which would probably give a TiO_2 content greater than 1 per cent. Chemical analyses for K_2O indicate that it is at an acceptably low level in most cases, but calculation of the amount of Al_2O_3 present in the highest grade of kyanite rock indicates a maximum value for Al_2O_3 of around 50 per cent. However, until full chemical analyses are available, these estimates and calculations should be treated with reservation. Prospects of using rutile and corundum as marketable by-products are not good, mainly because of difficulties in milling and extraction, and because of the abundant rutile available from beach sand manufacture.

These facts, when considered along with the relatively isolated situation of the deposit and consequent high transport costs, indicate that the Hawkestone kyanite deposit is of little economic significance at the present time.

Recommendations

It is recommended that more detailed exploration work be carried out, to determine the extent of the kyanite lenses and corundum rock, and also to examine in more detail the associated dolerite, phyllites, schists and quartz veins.

A series of north-south costeans at least 4 feet deep and about 100 feet apart should be cut across the possible lens of kyanite on the southern flank of the hill. Other costeans should be cut on the northern slopes at and adjacent to areas of kyanite boulders. This work would define the kyanite lenses and phyllite bands more accurately, and indicate their distribution at depth.

Diamond drilling of the deposit would be most desirable, and two north-facing drill holes of up to 600 feet length inclined at 45° to the horizontal would provide an almost complete picture of the deposit, as well as much information on its genesis. The tough nature of the corundum rock, the suggested length of holes and drilling costs could impose serious limitations on such a drilling programme, and alternatively a series of shorter holes, 10 to 50 feet in length, should be drilled across dolerite and phyllite contacts with the postulated kyanite lenses.

Although the deposit appears to be of little economic significance at present, implementation of some or all of the recommendations may indicate the possibility of future exploitation of this deposit.

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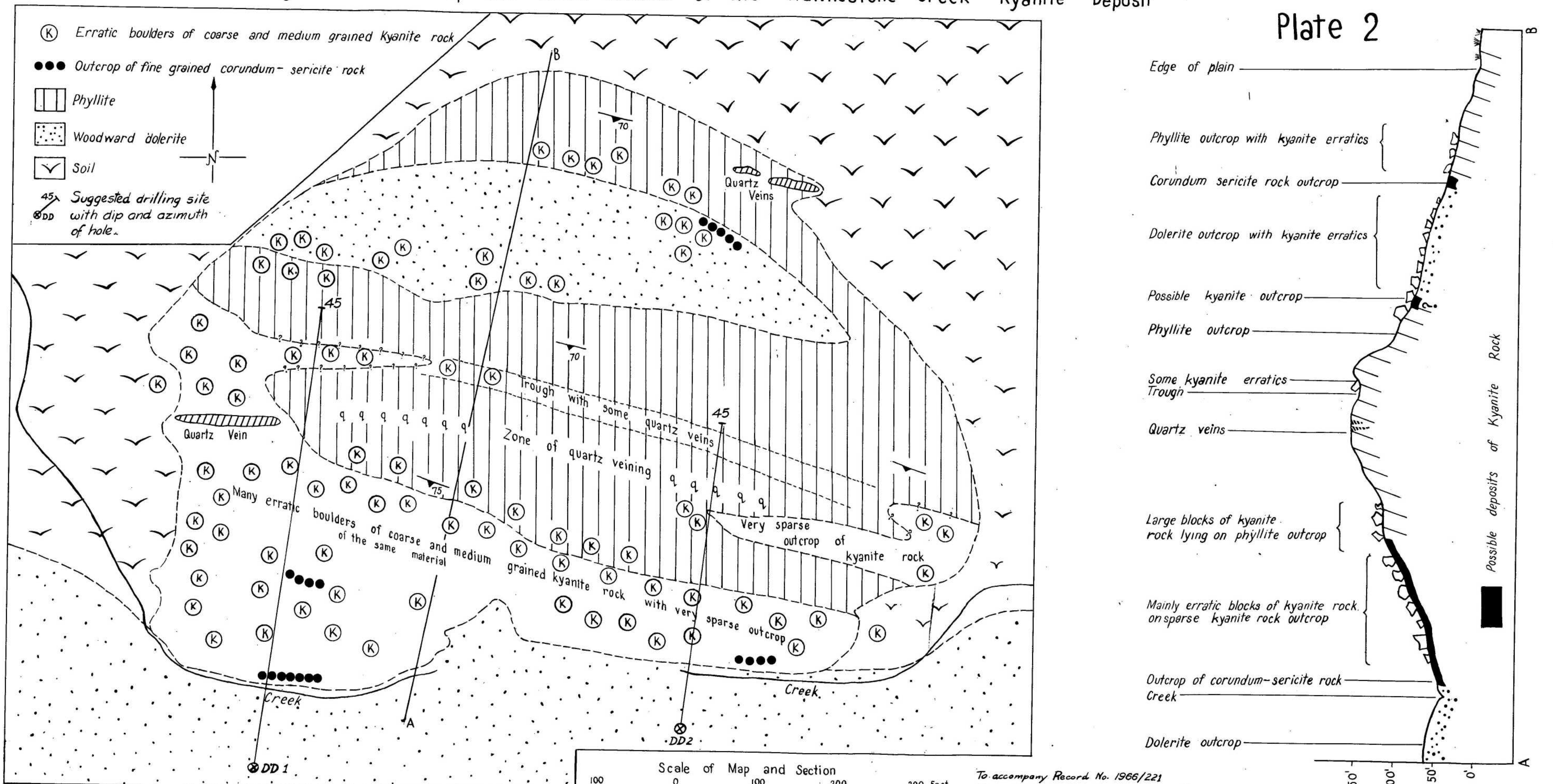
Plate 1

Geological Map of the Hawkestone Creek Kyanite Deposit and Adjacent Areas
WEST KIMBERLEY AREA
Scale
2 1 0 1 2 3 4 5 6 Miles
Geology 1966 by D. C. Gellatly, C. M. Morgan, G. M. Derrick, J. F. Ivanac (B.M.R.) R. Farbridge (G.S.W.A.)
N
124°30'
17°00'
Reference
CAINOZOIC QUATERNARY Qa Alluvium
UNDIFFERENTIATED Czs Residual red and grey soil and sand
Czb Black soil
PALAEOZOIC DEVONIAN UNDIFFERENTIATED D Massive limestone, bedded limestone and calcarenite, conglom. minor quartz sandstone
PROTEROZOIC ?CARPENTARIAN Lamboo Complex
C Coarse to medium-grained, even grained muscovite granite, aplite, pegmatite
Bickleys Porphyry Ɛbb Grey coarse to medium-grained porphyritic microgranite, granite porphyry
B Grey coarse-grained porphyritic granite, gneissic granite
A Massive coarse-grained porphyritic biotite granite, gneissic granite
Woodward Dolerite Ɛbd Coarse to medium-grained dolerite and amphibolite. Very coarse-grained plagioclase segregations
Whitewater Volc. (Undiff.) Ɛw Autoclastic porphyry, rhyolite, porphyritic rhyolite, tuffaceous greywacke
ARCHEAN OR PROTEROZOIC Halls Creek Group Undifferen. Ɛh Phyllitic sandstone, chlorite-sericite schist, garnet-sericite schist, andalusite-staurolite-garnet schist.
Geological boundary
Fault, position accurate
Established fault, position approximate
Fault concealed
Plunge of minor anticline
Plunge of drag fold
F.A. Plunge of fold axis
Shear zone
Igneous banding
Metamorphic foliation
Vertical foliation
Strike and dip of bedding
Vertical bedding
Strike and dip of cleavage
Vertical cleavage
Cleavage and bedding coincident
Lineation on cleavage
Lineation on foliation
Direction and plunge of lineation
Horizontal lineation on foliation
Strike and dip of joints
Vertical jointing
Joint pattern (air-photo interpretation)
Dyke dL dolerite q quartz ap aplite
Prospect - little or no production
Mine; not being worked
Quartz feldspar pegmatite
Kyanite deposit
Minor mineral occurrences
Ky Kyanite
Cn Corundum
mu Muscovite
mi Mica (usually sericite)
ch Chlorite
cl Chloritoid
an Andalusite
g Garnet
st Staurolite
am Amphibole
zo Zoisite
bio Biotite
cu Copper
Sn Tin
L2 Trigonometrical station
Waterhole
Spring
INDEX TO ADJOINING SHEETS
Mondooma Cr.
Alexander Cr.
Limestone Springs
Hawkestone Cr.
King Sound
Bureau of Mineral Resources, Geology and Geophysics. To accompany Record 1968/221 Regd. Plan No. E 51/A4/2

Plate 2

Geological Sketch Map and Cross Section of the Hawkestone Creek Kyanite Deposit



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