REPORT ON A KYANITE DEPOSIT, 10 MILES S.W. OF BRIDGETOWN.

(Lands Dept. Litho 439/80.)

(H. A. Ellis, B.Sc., A.O.S.M.)

LOCALITY.

The deposit is situated on an area about 10 chains long by 2 chains wide, the central portion of which would be about 3 chains east of the north-eastern corner of Nelson Agricultural Location 1369. Location 1369 is situated approximately 10 miles south-west from the Bridgetown Post Office in the flat to gently undulating heavily timbered country at the head of a small tributary of the west branch of the Donnelly River.

ACCESS.

The locality can be reached in 14 miles by road from Bridgetown which is 173 miles by rail from Perth. The road is in good condition for the greater part of its length, with a few short rough sections near the south-western end.

HISTORY OF THE FIND.

Attention was drawn to this deposit of kyanite by the recent sale to The Newbold Silica Fire Brick Company, Limited, Sydney, of a parcel of approximately 50 tons of pure kyanite in the form of waterworn boulders. The material was sufficiently attractive in its refractory properties to cause a further demand for it to be made by this company, and the inspection on which this report is based was made on May 17th, 1939, with the object of determining the manner of occurrence of the deposit, and its possibilities of providing further commercial supplies.

TOPOGRAPHY AND GENERAL GEOLOGY.

The country for some distance in all directions from the locality of the deposit is devoid of rock outcrops, being flat to gently undulating and heavily timbered with jarrah forest and undergrowth. Ferruginous duricrust (laterite) is extensively developed and outcrops frequently on the gentle rises and soil covered flats. Although this part of the State is deeply dissected by the Blackwood and Donnelly Rivers, there is a considerable area of high level, peneplaned country in the watersheds, over which no bed-rock outcrops, and on which occurs an extensive development of ferruginous duricrust (laterite).

There was no evidence available by which the nature of the underlying rocks could be determined, but these can be reasonably inferred to be schists, quartzites, gneisses and possibly granite of the Pre-Cambrian complex, by virtue of the fact that similar rocks can be seen to occur in the vicinity of Bridgetown and westwards from that centre for some distance.

The locality in which the kyanite deposit was found is on flat to gently undulating laterite-covered country which is flanked to the west by gently rising ground for at least one mile. The country rises gently to the east and north, and falls very gently southwards. The drainage is southwards into a tributary of the west branch of the Donnelly River, and the deposit occurs practically on the old peneplaned surface, in a slight topographic basin very near the divide between the Blackwood and Donnelly Rivers in this locality.

MANNER OF OCCURRENCE OF THE DEPOSIT.

The material comprising the parcel of 50 tons sold to the Newbold Silica Fire Brick Company, Ltd., is reported by the buyer's agent and the person who loaded the kyanite on to the motor truck to have consisted of waterworn boulders and smooth semi-angular blocks of pure kyanite of from 2½ cwt. to a few ounces in weight. They state that the material was all waterworn, irrespective of its size, and that it was picked up from the surface of the ground or was lying partially buried in the soil.

A careful examination of the locality showed numerous holes in the soil of a rounded and sub-angular shape, from which the material had been removed. Several large pieces of pure kyanite were found during the course of the inspection, one of which was well rounded with one soled surface and weighed about 60lbs.

There are numerous outcrops of the ferruginous duricrust (laterite) on the area where the boulders of kyanite were found, and some of these large boulders were seen to be liberally studded with waterworn boulders of kyanite of varying sizes.

The area over which the material was obtained has a width of about 2 chains, and a maximum length of about 10 chains, extending in a north and south direction between the north-eastern corner of Location 1369 and the south-eastern corner of Location 1395.

The noteworthy features about this deposit are:—

(a) the waterworn nature of the hard resistant kyanite boulders set in an aluminous—and ferruginous—cemented laterite containing much small angular glassy quartz,

(b) the occurrence in close proximity of boulders weighing up to 1 cwt. and small pebbles of from one to two ounces in weight only,

(c) the common occurrence of one or more flattened sides to the boulders,

(d) the restricted area over which the deposit occurs,

(e) the almost complete absence of boulders composed of any other material than kyanite (only two waterworn boulders of quartzite could be found).

Several explanations can be given to account for this remarkable occurrence, but none can be convincingly proved.

From an economic point of view it is important to be able to decide whether these boulders of kyanite have been transported from a long distance or whether they have a source in the immediate vicinity of where they were found.

Their extremely well worn appearance suggests that they have been subjected to the action of running water, but their great diversity in size indicates that they have not been sorted by this agency.

Samples of the ferruginous laterite collected 10 chains away from any laterite containing boulders of kyanite were found to contain extremely small grains of kyanite, staurolite (a mineral allied to kyanite), zircon, tourmaline and ilmenite, a feature which suggests that the laterite has been formed on a surface of metamorphic schists. Kyanite occurs in lenses in rocks of this nature in the Chittering Valley north of Perth, hence it is a reasonable conclusion that the

rocks which originally contained the kyanite *in situ* are not very far away from the site of the present boulder deposit.

The highly waterworn nature of the boulders has to be accounted for, and it is likely that when all the circumstances enumerated above are considered, it is possible that the boulder deposit represents a boulder-beach deposit of an ancient shore line.

If this hypothesis is not acceptable, then probably the best alternative is that the deposit is a residual accumulation produced from the weathering of a lens or lenses of kyanite in schists. It is difficult, however, to reconcile the rounded nature of the kyanite boulders with this latter conception.*

Practically all of the visible kyanite has been obtained from this deposit, and the 50 tons obtained was all found on the surface. Further supplies would most likely be found in the form of boulders buried in the soil and encased in the laterite, over the area from which the first material was gathered.

There is sufficient doubt about the mode of origin of the deposit to warrant the cutting of a series of trenches in an east-west direction through the laterite and soil into the underlying rock in an endeavour to locate the source of the bouldery kyanite.

The question arises as to whether the deposit is worthy of prospecting in view of the fact that, notwithstanding the great ease with which the material was obtained, the price paid for it would not permit of any mining operations being carried out in the course of production unless the deposit proved to be extremely large. The vendors state that the margin of profit on the 50-ton parcel sold was very small.

The present position (May, 1939) with regard to the possibilities of this deposit being able to supply an immediate demand for even small supplies of kyanite, is that there is no ore developed and that the probable ore is a most uncertain factor. Further, much exploratory work is necessary in order to locate the possible source of the material *in situ,* and from the experience gained in the production and sale of the 50-ton parcel it appears that the deposit will not stand exploration or mining treatment.

It will thus be seen that the deposit cannot be regarded as an immediate source of commercial kyanite, and that the future development of it depends on the success of locating the material *in situ,* the size of the deposit when located, and the price obtainable for the material when found.

SUMMARY AND CONCLUSIONS.

A deposit of waterworn boulders of high-grade kyanite recently found about 10 miles south-west of Bridgetown occurred as loose boulders embedded in and resting on the soil in association with ferruginous laterite over an area of about 20 square chains.

A parcel of 50 tons of these boulders was sold to a firm in the Eastern States at a price which the vendors state left only a small margin of profit.

The manner of occurrence of the material cannot be definitely determined without further prospecting involving extensive trenching down to bed-rock, and there are no further commercial supplies of kyanite immediately available, while the probable ore is a very uncertain factor.

The deposit in its present condition cannot be regarded as a source of commercial quantities of kyanite, and its future possibilities depend on the locating of the original source of the material and the size of the ore body when found, together with the market price available.

The situation of the deposit, the destination of the material (Sydney), and the price of the product, make it appear that only the most easily obtainable material (such as loose boulders found on the surface) can be profitably handled at present, and this source of supply no longer exists.

A sufficiently attractive price would need to be offered for the kyanite to encourage further prospecting, and it is problematical whether this price would not exceed the price of the material at present being imported from India.

It is possible for deposits of a similar nature to this one to be found in the district and an intensive search among the laterite outcrops for pieces of contained kyanite would be the best means of conducting this search.

KYANITE DEPOSIT AT SMITHFIELD.

(By E. S. Simpson, D.Sc., B.E., F.A.C.I., Government Mineralogist and Analyst.)

The Acting Government Geologist and myself inspected the kyanite deposit at Smithfield to the south-west of Bridgetown on 17th May, 1939, and the former has already reported fully on the field occurrence. There is very little that I can add to his notes in this respect.

Briefly, the deposit occurs in gently undulating forest country in the south-eastern corner of Loc. 1395, extending southwards over the border of that block. Over an area of 10 x 2 chains large and small boulders of kyanite from a few ounces to two hundredweight in weight, and all worn smooth on the surface, have been found loose in the soil, and to a less extent embedded in primary laterite. Fifty tons of boulders were collected this year in a few days and sold to the Newbold Silica Firebrick Co., of N.S.W., and used in their factory at Waratah in the manufacture of super-refractory bricks. This parcel seems to have almost exhausted the visible supply of mineral, not more than half a ton more being seen by us on our visit. By burning off the scrub and ploughing the outcrop a few more tons could possibly be obtained. No boulders were to be seen beyond the area of 10 x 2 chains defined by Mr. Ellis. Microscopic grains of kyanite were however detected in a concentrate from a stream about ¾ mile east of this area, and in primary laterite samples collected within that area and up to half a mile to the north and south of it. No kyanite has yet been detected in its original rock matrix, that known up to the present being found in alluvial or eluvial material. In similar material small fragments have been found at Bunbury, Greenbushes, Fly Brook, Pemberton, and Jasper Lake in this district.

*Since compiling this report it has occurred to the writer that a lens of massive, jointed kyanite, may weather *in situ* in a manner similar to that seen in the case of some epidiorite dykes of the Darling Ranges, where many rounded and smooth semi-angular boulders of epidiorite can be seen associated with dyke outcrops.

To my mind there is a strong probability that the mineral is derived from lenses in the Chittering Series of metamorphic sediments, which extend for several hundreds of miles along the western portion of the Darling Range. In the Chittering Valley itself, kyanite is extremely plentiful in this series, both in lenses of almost pure mineral, and in small crystals scattered freely through certain beds of rock, which I feel certain will ultimately be concentrated by oil flotation for a yield of commercial kyanite. In the Chittering Valley staurolite is often associated with kyanite, and it is important to note that I found this mineral associated in granules with kyanite at various spots at Smithfield.

Owing to the extensive beds of laterite and great depth of soil in the district no outcrops of bedrock are visible anywhere near the Smithfield deposit. This will make prospecting for further supplies of the mineral very difficult. I would suggest as a preliminary step that from carefully marked spots within a radius of 2 miles of the outcrop concentrates should be obtained from creek beds, beds of swamps and surface soils for examination in the Government Laboratory. At the same time samples of laterite should be collected for detailed mineralogical examination. This may lead to the location of concentrations of granular kyanite, where prospecting could be carried a further step by costeaning or sinking. At the same time a look out should be kept for further surface pebbles along a north and south line through the present known outcrop.

The demand for kyanite in Australia and abroad is likely to increase owing to its suitability for the manufacture of super-refractories for use in the steel and other industries employing high temperatures. The Smithfield mineral is of good commercial quality for such a purpose, being well over 95 per cent. pure.

REPORT ON LATERITE SPECIMENS FROM KYANITE LOCALITY, SOUTH-WEST OF BRIDGETOWN.

(Litho. 439/80, Loc. 1395.)

(By Dr. Dorothy Carroll, Department of Geology, University of Western Australia.)

List of specimens examined.

1. Laterite surrounding the kyanite pebbles.
2. Laterite 5 ch. north of kyanite pebbles.
3. Laterite 10 ch. north of kyanite pebbles.
4. Laterite boulders near kyanite occurrences with no free kyanite visible.
5. Breccia with angular quartz fragments and rounded pebbles of kyanite.

Method of examination.

With the exception of specimen 5 the laterites were crushed to pass an 85 B.S. sieve (approx. 70 I.M.M.) and decanted to remove the bulk of the clay. The residue was then boiled in concentrated HCl to remove the red colouring matter. The cleaned material was then separated in bromoform to obtain the heavy minerals, i.e., those above S.G. 2.9. In each specimen this heavy fraction was quite large in amount, but this was further reduced in bulk by separation with a small electro-magnet. The remaining material was mounted in clove oil for examination under the microscope. Specimen No. 5 was not crushed but the individual grains were freed from the clayey and ferruginous cement by boiling in KOH and various acids. The grains were then sieved and the finest material separated in bromoform to obtain the heavy minerals as above.

The following heavy minerals were identified:—Magnetite, ilmenite, limonite, leucoxene, zir on, staurolite, kyanite, tourmaline, rutile, sillimanite, and pale green spinel (? gahnite).

Of these minerals, magnetite, ilmenite, limonite and staurolite were the most abundant. Zircon is scarce in these residues, and spinel extremely rare. Kyanite is moderately abundant. Nearly all the grains are angular and unworn, thus signifying little transport. Staurolite grains show many crystal faces, and the tourmaline is prismatic. Zircon alone shows signs of abrasion. The general appearance suggests some source near at hand for these heavy minerals.

The light fraction is made up of clay material and quartz. The grains are angular to sub-angular in shape, but there are also a few rounded ones, and a number with regrowth rims. Specimen 5 has extremely angular and "chippy" grains showing no wear; but here, too, a couple of rounded grains were noticed.

The following is a tabulation of the heavy mineral assemblages:—

Sample No. ...	1.	2.	3.	4.	5.
Magnetite	A	A	A+	+	+
Ilmenite	+	A	A	+	+
Limonite	A+	A+	A+	A+	A
Leucoxene	+	+	+	+	+
Zircon	S	+	+	S	S
Staurolite	A	A	+	+	+
Kyanite	+	+	+	+	+
Tourmaline	+	+	+	+	+
Rutile	+	+	+	+	...
Sillimanite	...	...	S	...	...
Spinel	...	...	S	...	...

A+ = very abundant; A = abundant; + = present in fair amount, but not abundant; S = scarce, one or two grains only. (These refer to the heavy residue only, and *not* to the total sample.)

NOTES ON THE OCCURRENCE OF KYANITE IN COMMERCIAL QUANTITIES IN INDIA.

(By Dr. Dorothy Carroll, Department of Geology, University of W.A.)

Rec. Geol. Survey India, LXIII., p. 114, 1930.

"Dr. Dunn's suggestion is that these highly aluminous rocks do not owe their formation to the alteration of once less aluminous schists, but represent original bauxitic or other highly aluminous clays occurring interstratified in the succession of sediments from which the series of schists has been derived."

Rec. Geol. Survey India, LXIV., p. 403, 1930, *J. A. Dunn.*

"At Lapsa Buru the kyanite-quartz rock is found in enormous beds, the massive kyanite apparently occurring as segregations in the more acid rock.

Some large deposits are, however, entirely of kyanite rock. The pure kyanite-rock is massive, never cleaved; it is usually medium to coarse-grained, and even in those rocks which, in the hand-specimen, appear to be fine-grained, are found to consist under the microscope of quite coarse crystals full of fine inclusions. Kyanite is almost the sole constituent. It is often of the radiating columnar variety, and blades of crystals over 12 inches long may be seen sometimes in the large boulders. Such coarse kyanite indicates the action of at least a certain amount of metamorphic migration. Usually the only other constituent is rutile, which is often plentiful; fine corundum is present occasionally. Other places at which massive kyanite occurs in workable amounts in Singhbhum are Ghagidih, Rakha Mines, Badia-Bakra, and Kanyaluka. The minimum quantities of these present, calculated to a depth of one yard, are:—

	tons.
Lapsa Buru	214,000
Ghagidih	20,000
Badia-Bakra	10,000
Kanyaluka	8,000

Analyses of typical specimens of these rocks are:—

	Lapsa Buru. %	Ghagidih. %
SiO_2	30·2	36·0
Al_2O_3	65·35	60·7
Fe_2O_3	3·19	2·3
TiO_2	0·76	1·2
CaO	Tr.	0·8
MgO	1·37	0·4
H_2O	0·61	0·9
	100·78	102·3

Rec. Geol. Survey India LXV, part 2, *pp.* 285-305, 1931.

On certain rocks bearing kyanite and sillimanite in the Bhandara district by S. K. Chatterjee.

This paper gives an account of the schistose rocks of the district and method of formation of these schists by metamorphism. The kyanite here also occurs in a massive form. "The rocks carrying kyanite and sillimanite are distributed sporadically. The outcrops are small and discontinuous, give rise to slightly elevated features, and are disposed in parallel belts with a roughly north-south trend." "The thickness of the formations is variable and irregular. At Sonekhari it is about five feet; at Miregaon and Ganglewara about 15 feet; and at Sarathi about 30 feet. At the two hills at Pohra the maximum thicknesses are 50 feet and 125 feet, respectively. At Magra the thickness ranges up to 100 feet; whilst at Girola it is from 250 to 400 feet."

". . . . a consideration of all the outcrops reveals the following three salient features:—

1. Chlorite-muscovite-schist is invariably associated. In certain instances . . . . a gradation between chlorite-muscovite-schist and the kyanitic or the sillimanitic rocks . . . . could be recognised.

2. Although these rocks are restricted to the zone of chlorite-muscovite-schist, there is apparently no definite stratigraphic horizon at which they occur. At Girola there seem to be two bands at different horizons.

3. Each of the outcrops is intersected by myriads of quartz-veins, carrying among other accessory ingredients tourmaline, rutile, and occasionally roscoelitic mica. Granite is found to emerge out of the alluvial mantle at a distance, but pegmatites are occasionally seen quite close to these rocks" (not a commercial occurrence, as the kyanite is mixed with other minerals).

REPORT ON A BISMUTH CARBONATE DEPOSIT IN A PEGMATITE DYKE, M.C. 173H, YINNIETHARRA STATION (GASCOYNE RIVER).

(Lands Dept. Litho. 78/300, S.W. Quadrant.)

(H. A. Ellis, B.Sc., A.O.S.M.)

LOCALITY.

The deposit is situated on M.C. 173H in a very coarsely grained pegmatite dyke forming a low rise in which two quartz reefs ("blows") are prominent about 10 chains west from the western bank of Nardoo Creek and about seven miles on a bearing of 285 degrees from Morrissey Hill. M.C. 173H is situated in approximate latitude 24° 31′ S. and approximate longitude 116° 03′ E.

Nardoo Creek is a southerly trending dry watercourse, tributary to the Gascoyne River, and joins the river near the most northerly point of the big bend convex to the north some eight miles a little south of east from the Lockier Range. (See Plate I.)

ACCESS.

The locality can be reached from Carnarvon by a road which passes through Gascoyne Junction, Dairy Creek, Mooloo Downs and Yinnietharra, or from Perth by travelling in a northerly direction, via Mullewa, Byro Station and Dairy Creek. The latter is the most direct from places south of Mullewa. The distance to Carnarvon, the nearest port, would be about 250 miles by road.

HISTORY.

The deposit was discovered in October, 1938, by a prospector named Thompson, and the inspection on which this report is based was made on 20th and 21st April, 1939.

GENERAL GEOLOGY.

The area in which the deposit is situated is shown on the most recent geological map of the State (1933) as being composed of granite, but which actually consists of a gneiss and mica schist complex liberally invaded by very coarsely crystalline pegmatite dykes composed of quartz, microcline felspar and muscovite mica.

The regional strike of this area of gneiss and schist, at least as far south as latitude 25° 15′ S., is about 15 degrees west of north, and the same direction of regional strike prevails as far east as longitude 117° 50′ E. in these outcrops noted in a traverse from Dairy Creek to the Egerton gold mining centre, in the valley of the Gascoyne River.