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RADIOACTIVE CONGLOMERATE FROM 130 MILES SOUTH-SOUTH-EAST
OF HALLS CREEK, W.A.

by

W.B. Dallwitz and W.M.B. Roberts.

The information contained in this report has been obtained by the Department of National Development, as part of the policy of the Commonwealth Government, to assist in the exploration and development of mineral resources. It may not be published in any form or used in a company prospectus without the permission in writing of the Director, Bureau of Mineral Resources, Geology and Geophysics.

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SUMMARY

A slightly radioactive rock from a locality 130 miles south-south east of Halls Creek, Western Australia, was identified as a silicified coarse conglomeratic sandstone.

The specimen examined assays 0.23% U_3O_8 , and the uranium is contained in xenotime, which occurs as aggregates of minute grains in the matrix.

A mineral resembling florencite and svanbergite is associated with the xenotime which appears to be of epigenetic origin.

INTRODUCTION

A specimen of radioactive "grit" or silicified conglomeratic sandstone from about 130 miles south-south east of Halls Creek, Western Australia, was submitted for examination by Mr. J. H. Lord, of New Consolidated Gold Fields (Australasia) Pty. Ltd., to determine the cause of radioactivity. The occurrence has been called the "Killi Killi No.1 Prospect".

A specimen from the same locality was assayed in the Bureau's Radiometric Laboratory in Darwin, and was found to contain 0.18% eU_3O_8 ; uranium, not thorium, was stated to be the cause of radioactivity.

In the investigation recorded in this report, Roberts carried out the X-Ray spectrographic and X-Ray diffraction determinations, and the acid leachings, and Dallwitz was responsible for the petrographic and optical observations, the separation of a pure mineral sample for X-Ray determination, the speculations as to the identity of one of the minerals, and the speculations as to the origin of the mineral responsible for the radioactivity.

PETROGRAPHY

The specimen is a hard, somewhat porous, reddish brown "grit" or silicified conglomeratic sandstone containing a few fragments which generally measure up to 0.5 cm., but exceptionally up to 2 cm.. The rock is strongly cemented, and mostly breaks across the fragments. A freshly cut surface shows patchy pale blue fluorescence under long-wave ultraviolet light; scattered specks fluoresce bright blue, and a small concentration of specks fluoresces dull golden buff. The weathered surface mostly shows no fluorescence, but some patches fluoresce dull golden to pale buff, and specks which fluoresce bright blue are prominent but very scattered. The fluorescence on the cut surface appears to be confined to the matrix.

Radioactivity measured on the cut surface ranged from 400-450 c.p.m. against a background of 80. Maximum radioactivity on a bedding plane or rough joint was 800-850 c.p.m. The instrument used was an "Austronic" ratemeter, Type BGR 1.

In thin section the rock was found to consist of grains of quartz and a few fragments of siltstone, shale, chert, and quartzite in a matrix which amounts to 10-15% of the whole rock. Accessory minerals are hydrated iron oxide, muscovite, zircon, biotite, chlorite, and tourmaline (the last seen in "superpanner" concentrates only - see below); all these occur in extremely small quantity except the hydrated iron oxide, which strongly impregnates the minerals of the matrix.

The quartz grains are mostly well rounded, and some are bordered by a shell of secondary silica which is in optical continuity with that of the original detrital grains. The grains are not well sorted, and their sizes range from 0.1 mm. upwards, the average being about 1 mm. Many of them show strain shadows. Some quartz grains are composite, and have the appearance of vein-material.

The matrix consists of three minerals which are unevenly distributed, and any one of which may be dominant locally. One of these minerals is quartz. The other two are not readily identifiable; both are fine-grained, and have rather high refractive indices. One of them occurs as perfectly euhedral rhomboid or pseudo-cubic crystals - less commonly as aggregates of anhedral grains - whose size ranges from 7 to 70 microns, and whose average size is about 30 microns. The double refraction of these crystals is less than that of quartz, and their refractive indices range from slightly above 1.660 to above 1.670. Their sign is uniaxial positive. Most of the crystals have a prominent core whose shape conforms exactly to the outlines of the complete crystal, and whose width may range from $\frac{1}{4}$ to $\frac{3}{4}$ of the total width of the crystal; generally, the larger the crystal, the greater the proportion of its width occupied by the core. The core is in optical continuity with the surrounding material, and its refractive index is markedly less than 1.66. In nearly every grain the core is darkened by closely crowded extremely minute specks of a red-brown substance which is most likely hydrated iron oxide; it is not known for certain whether this is an alteration-product or simply included material, but the latter possibility seems the more likely, because cores containing only a few of the dark specks appear to be completely fresh, and, except for lower refractive index, have optical properties identical with those of the shell.

The second of the two fine-grained minerals in the matrix is coloured pale buff, and is commonly strongly impregnated with red-brown, hydrated iron oxide. It generally occurs as aggregates of subhedral to anhedral grains whose size ranges from 3.5 to 35 microns. These grains have high double refraction, and their refractive indices are considerably greater than those of the pseudo-cubic crystals. Both minerals, but especially the pseudo-cubic one, may occur within the secondary shells of quartz which have been formed round the original detrital grains, and they may, much less commonly, occur within the detrital grains.

The mineral with high double refraction is commonly present, and in places extremely plentiful, within the fragments of sedimentary rock; only very rarely is it accompanied by isolated grains of the pseudo-cubic mineral.

The rock is a silicified coarse conglomeratic sandstone.

X-RAY RESULTS

A qualitative X-Ray spectrographic analysis showed that radioactivity is due entirely to uranium, thus confirming the radiometric result obtained in the Darwin office. A quantitative analysis for this element gave 0.23% U_3O_8 .

Other elements present, apart from silicon, phosphorus (detected chemically), aluminium, and probably calcium (all of which have too low an atomic weight to be detected by the X-Ray spectrograph), are yttrium, ytterbium, strontium, and iron (in order of decreasing abundance), together with progressively smaller quantities of uranium, dysprosium, erbium, gadolinium, lead, samarium, copper, neodymium, terbium, holmium, cerium, and possibly gold.

Treatment with hot 50% HCl strongly leached uranium from the rock, and leaching with 5% H_2SO_4 for 30 minutes also removed uranium, but less strongly.⁴ Qualitative X-Ray spectrographic analysis of the leachate from treatment with hot 50% HCl showed that virtually all of the elements identified in the powdered sample had gone into solution in some degree. A distinct trace of copper was found in the leachate; the presence of this element was somewhat doubtful when the powdered sample was analysed, but copper was apparently strongly leached by the acid, and therefore showed up in solution.

Part of the rock crushed to pass through a 170 - mesh B.S.S. sieve was put over a Haultain "superpanner", and the heaviest fraction was found to consist entirely of granular aggregates of the pale buff mineral with high double-refraction. By means of an X-Ray powder pattern photograph, this mineral was identified as xenotime, and a qualitative X-Ray spectrographic test showed that it contained, among numerous other elements, yttrium, uranium, and strontium. Xenotime is essentially a phosphate of yttrium and erbium, but small amounts of other rare earths, thorium, uranium, iron, aluminium, manganese, beryllium, and the alkaline earths (Ba, Sr, and Ca) may substitute for yttrium and erbium.

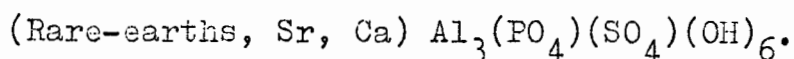
PROBLEMATICAL MINERAL

The pseudo-cubic crystals with refractive index about 1.660 to 1.670 have not been satisfactorily identified. However, taking into consideration their distinctive crystal form, their optical properties, and the strong possibility that they contain the phosphate radicle, their identity seems to fall within rather narrow limits. The mineral florencite ($CeAl_3(PO_4)_2(OH)_6$) has properties which appear to fit, more closely than those of any other, the observed properties of these crystals. However, their refractive indices do not correspond sufficiently closely to those of florencite to make the comparison strictly valid, nor does the small quantity

of cerium revealed in the X-Ray spectrogram. However, it is stated on page 839 of Dana's System of Mineralogy, Vol. II, Seventh Edition, that "some calcium and yttrium may substitute for the cerium earths in florencite", and that "the distribution of the several rare earths in florencite has not been fully determined". Other minerals whose crystal form is closely similar to that of florencite, and whose chemical formulae may be compared with that of florencite, are

goyazite $(\text{SrAl}_3(\text{PO}_4)_2(\text{OH})_5\text{H}_2\text{O})$
 svanbergite $(\text{SrAl}_3(\text{PO}_4)(\text{SO}_4)(\text{OH})_6)$
 and woodhouseite $(\text{CaAl}_3(\text{PO}_4)(\text{SO}_4)(\text{OH})_6)$.

The recorded refractive indices of different specimens of florencite range from 1.670 to 1.705, whereas the mean indices of goyazite, svanbergite, and woodhouseite are about 1.635, 1.64, and 1.64, respectively. All four of these minerals are isostructural. As the measured refractive index of the outer shell of the pseudo-cubic crystals is about 1.665, it is tentatively suggested that they represent a mineral species similar to florencite in which cerium may have been partly replaced by other rare earths and/or strontium and/or calcium. A small quantity of sulphate was detected in the aqueous extract from a sodium carbonate fusion carried out on the rock; this suggests that the mineral is of the svanbergite-woodhouseite type rather than the goyazite-florencite type. The lower refractive index of the cores of the pseudo-cubic crystals shows that their composition is not uniform, and so does the fact that the maximum and minimum refractive indices of the material in the outer shell are inconstant (the range of refractive indices is greater than the double refraction of the shell). The tentative conclusion from all these observations is that the pseudo-cubic mineral is one whose chemical formula might be represented as follows:



CONCLUSIONS

The rock is a silicified coarse conglomeratic sandstone or a silicified "grit". The matrix consists mainly of xenotime, quartz, and a mineral probably related to florencite and svanbergite. The specimen assays 0.23% U_3O_8 , and the uranium is contained in xenotime. According to the literature xenotime may contain up to 5% or so of uranium oxide, but it is impossible to determine the percentage of xenotime in the slide because it is commonly strongly impregnated with iron oxide.

Because of the perfect crystal form of the florencite-svanbergite mineral, and because of the presence of xenotime and a few of the pseudo-cubic crystals within detrital quartz grains, it is likely that these minerals are epigenetic. Another possible explanation of their mode of occurrence is that they represent detrital minerals which have been recrystallized and partly redistributed during subsequent metamorphism, but this seems less likely on the available evidence. Minerals of the goyazite-florencite

and svanbergite-woodhouseite types have been variously recorded as occurring in several different environments - in veins, in metamorphic rocks, as syngenetic growths, and as detrital fragments. Field evidence will be important in helping to decide the most likely mode of emplacement of the xenotime and the pseudo-cubic mineral in this deposit, but on present indications they appear to be of hydrothermal origin.

As it is not recorded in the literature that florencite, goyazite, svanbergite, woodhouseite, or xenotime fluoresce, the rather weak fluorescence, which, on a freshly cut surface, appears to be confined to the matrix, can not be explained in terms of present knowledge of the rock.