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A Possible Explanation of the Genesis of the Mount Painter Uranium Deposits - Largely Based on Field Observations

by

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A POSSIBLE EXPLANATION OF THE GENESIS OF THE MOUNT PAINTER URANIUM DEPOSITS - LARGELY BASED ON FIELD OBSERVATIONS -

By C.J. Sullivan.

Report No. 1945/67.

INTRODUCTION.

This report describes the field evidence in support of a supergene origin for the torbernite deposits in the Mount Painter district. This origin is also emphasised by Stillwell and Edwards(1). The report was originally written in response to a preliminary report by Stillwell(2) in which a hydrothermal genesis was favoured.

BRIEF DESCRIPTION OF THE DEPOSITS.

Except for the autunite in the shoot mined in the No. 6 workings, the most important uranium mineral so far found at Mount Painter is torbernite - hydrated copper uranium phosphate. The torbernite occurs as stains or films coating cracks and partings in the rock. The majority of the deposits so far discovered are below 0.1 per cent U308 in grade. At the locality F (see geological map. Fig.1.), southwest of Paralana Hot Springs, these stains give a strong impression of having been formed by weathering of the granite boulder on which they occur. At the No.6 deposit, Mount Painter, however, a rich shoot of autunite and torbernite, which is thought to have contained about three (3) tons of uranium trioxide, was mined. At the No.5 deposit, East Painter, development has indicated about 320 tons of ore, possibly containing 0.38 per cent U308. Apart from these occurrences, no ore of minable grade has been found.

IRONSTONE (3).

Most of the torbernite deposits are associated with ironstone and sometimes with minor amounts of fluorite, barytes and quartz. Most of the ironstone concentrations occur in brecciated zones. At the No.3 and No.4 deposits at Mount Painter, the "Bentley" and probably the "Smiler" deposits at East Painter, the ironstone forms a surface capping from 3 to 10 feet thick. Underneath this is weathered granitic rock, usually containing spangles of torbernite sparsely disseminated in cracks and partings. A crosscut driven under No.3 deposit, Mount Painter, revealed weathered red granite with traces of torbernite, whilst under the ironstone capping of the No.4 deposit, Mount Painter, a weathered gneiss with traces of torbernite was encountered. In the case of the "Bentley", a solid red felspathic rock underlies the mantle of ironstone. The occurrence of the ironstone at the surface appears to be too marked to be an accident of erosion. In each of the cases cited, the iron-

(1) F.L. Stillwell and A.B. Edwards: Uranium Minerals from Mount Painter. -- ---

(2) F.L. Stillwell: Uranium Minerals from Mount Painter. Minerographic investigations of the Council for Scientific and Industrial Research. Report No. 315.

(3) The term "ironstone" is used in the sense of an aggregate of ferruginous minerals consisting chiefly of hematite with in some cases, limonite, psilomelane, magnetite and subordinate amounts of other minerals.

stone extends over hundreds of square feet at the surface. If these occurrences represented lodes formed by hydrothermal processes, one would not expect them to be so often localised along flat planes, which would enable them, on being exposed by erosion, to parallel the present surface.

In many cases the major structural planes present do not appear to have controlled the deposition of ironstone in the way one would normally expect, if it was of deep-seated origin. Thus, at the "Smiler" deposit, the major shears strike at about 340 degrees and dip at 60 to 70 degrees in an easterly direction. Test pits on these shears have, however, revealed that the manganiferous ironstone is largely confined to the first 3 to 5 feet from the surface, and that below this weathered granite predominates. There are no obvious structural planes which could have been expected to localise mineralisation parallel to the present surface. In many parts of the Mount Painter area stains and thin coatings of ironstone may be seen on the surface of granitic rocks.

In all cases where the ironstone forms a mantle only, the degree of brecciation has been relatively slight. At the No.6 deposit at Mount Painter, hematite extends to depths exceeding 100 feet but there is a concentration of hematite at the surface and the proportion of hematite decreases with increasing depth. The main crush zone at East Painter has been tested to a depth of only 50 feet, and hematite persists to that depth. In both these localities the degree of brecciation has been relatively great, thus allowing the deep penetration of iron-bearing solutions from above. However, some of the hematite of No.6 deposit appears to be of hydrothermal origin.

It is thus concluded from the field evidence, that a large proportion of the ironstone was deposited near the land surface from meteoric waters[1]. The striking scarcity of hydrothermal gangue minerals such as quartz or carbonates, also supports this mode of origin.

ASSOCIATION OF THE SECONDARY URANIUM MINERALS WITH IRONSTONE.

The ironstone and the secondary uranium minerals (torbernite, etc.) appear to have a close genetic relationship, as they are usually found closely associated in the field. As in the case of ironstone the greater concentrations of torbernite found so far appear to be confined to shallow depths below the surface. For example the shoot in the No.6 deposit commenced approximately 25 feet from the surface and petered out at a depth of 50 feet. Extensive exploration to a depth of 100 feet revealed material carrying only traces of torbernite. In the No.7 and No.8 workings at Mount Painter, impoverishment begins at about 30 feet below the surface. Radiation surveys by Messrs. Thyer and Dooley[2] indicated that most of the ironstone masses have a higher degree of

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(1) There is evidence that there are at least two types of ironstone at Mount Painter.
The above discussion deals with the ironstone chiefly associated with the occurrences of secondary uranium minerals. In most cases this is manganiferous, contains limonite and is rarely bladed. It shows a close association with the present land surface. The second type mainly consists of bladed hematite and is closely associated with the Mount Gee quartz mineralisation. It occurs on the slopes of Mount Gee, on Radium Ridge, on spurs leading from Mount Painter and in many other places. This type of hematite shows little tendency to be concentrated at the surface and is usually associated with large quantities of quartz. The No.2 deposit on Radium Ridge may represent a third type. Here a mass of hematite (after magnetite) is associated with monazite and fergusonite. It is reported by Kleeman that the fergusonite has a high lead content. This appears to connect the deposit with the granites in which it may be in the nature of a segregation.

(2) R.F. Thyer and J.C. Dooley, elsewhere in this bulletin.

radio-activity than the surrounding rocks. Many specimens of ironstone exhibit radio-activity, but chemical assay proves that they contain no uranium.

LEACHING OF URANIUM.

The observed radio-activity could be due to the disintegration products of uranium left behind in the ironstone after the uranium had been leached out[1]. In this connection the relative solubilities of radium and uranium should be noted. Nearly all common salts of radium are practically insoluble, e.g. $RaSO_4$ has a solubility of .000002 grams per 100 c.c. of water at 25^oC, while common uranium salts are relatively soluble in water, e.g. UCl_3 is very soluble, $UO_2SO_4.3H_2O$ has a solubility of 20.5 grams per 100 c.c. at 15^oC and $UO_2SO_4.7H_2O$ is very soluble.[2] Thus, when a uranium mineral containing radium is exposed to dissolving waters, radium tends to remain in situ, while uranium salts go into solution.

AGE OF THE TORBERNITE.

On the basis of mineralogical studies, Stillwell[3] suggested the possibility that the formation of the torbernite was contemporaneous with the Mount Gee quartz mineralisation. Stillwell and Edwards [4] give it as an alternative explanation to the supergene origin. The radium/uranium ratio of torbernite and autunite from the No.6 deposit, Mount Painter has been estimated, by R.G. Thomas[5] from the results of a number of analyses and tests at the experimental treatment plant and refinery of Australian Radium Corporation N.L. which worked the deposits at Mount Painter between 1926 and 1934, at 2.7×10^7 against an equilibrium ratio of 3.4×10^7. Uranium-radium equilibrium is reached in approximately 10^6 years,[6] so that the above results strongly suggest that the torbernite is less than 10^6 years in age. This is supported by the low lead content of the torbernite[7]. Later analyses by Mr. Dalwood Analyst and chemist of the South Australian Mines Department have proved that the lead content of a sample of autunite and torbernite from No.6 Deposit, was less than 0.0001 per cent. but have revealed a higher lead content (0.045 per cent.) corresponding to an age of more than 7 million years, for a sample of torbernite from No.5 Deposit, East Painter. This result is very interesting and will be referred to later.

The youngest magmatic activity known in the district is not later than Palaeozoic. It has been suggested that the Paralana Hot Spring indicates magmatic activity but this seems most unlikely as the spring is situated on a fault near the margin of the Great Artesian Basin, and the temperature and chemical composition of the water is comparable to that issuing from adjacent artesian bores. Investigations by the South Australian Mines Department of the Mesozoic beds to the eastward and westward of the Mount Painter field reveal that they have not been intruded by igneous rocks or been subjected to mineralisation.[8] There is no

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(1) R.F. Thyer and J.C. Dooley, elsewhere in this bulletin.

(2) Handbook of Chemistry and Physics 28th Ed.,Chem. Rubber Publishing Co., Cleveland, Ohio. pp.442-3, 482-3.

(3) F.L. Stillwell. Report No.315. C.S.I.R. etc.

(4) F.L. Stillwell and A.B. Edwards. Elsewhere in this bulletin.

(5) R.G. Thomas, "The Processing of Radium Ores in South Australia". Aust. Chem. Inst. Jour. and Proc. Vol.IX, 6th June, 1942.

(6) Danas System of Mineralogy, Centennial Anniversary Issue, 1844 - 1944, Vol.I, John Wiley and Sons, New York. 1944. p.617.

(7) F.L. Stillwell and A.B. Edwards, in this Bulletin.

(8) R.C. Sprigg, Verbal communication.

quartz mineralisation along the Tertiary fault bounding the eastern side of the range. The quartz of the Mount Painter field is confined to the late Proterozoic and early Palaeozoic rocks and appears most likely to be genetically connected with the old granitic intrusives of that field. The above evidence indicates that the torbernite is of Cainozoic age. It is therefore doubtful if it could have been deposited with the Mount Gee quartz, which is presumably pre-Mesozoic in age.

TEMPERATURE OF FORMATION OF TORBERNITE.

As pointed out by Stillwell,(1) the torbernite must have been deposited below 60°C, as above this temperature it loses water and forms meta-torbernite. This very low temperature of deposition suggests a supergene origin though it does not preclude an epithermal origin as stated by Stillwell.

ASSOCIATION OF THE URANIUM DEPOSITS WITH GRANITE.

The uranium deposits are confined to the area shown as granite on the geological map (see Fig). None has been found in the adjoining areas of folded and faulted sedimentary rocks which have been intruded by the granite. There is evidence to suggest that in places, the granite contains primary radio-active minerals. Thus Mawson(2) states that - "the red aplitic granite from certain localities, for instance from No.16 contains particles of hematite and other black specks, some of which were found by autoradiographic test to be radioactive." Both radioactive ilmenite(3) and a mineral similar to fergusonite(4) have been reported from the field. At a point 55 chains northeast of the East Painter camp, a specimen of granite was found to be radio-active though it contained no torbernite or cavities after torbernite. At locality D west of Paralana Hot Spring, torbernite was found in small cavities in uncrushed coarse granite and it is believed that the torbernite was most likely derived from the oxidation of a primary mineral. At locality E it was found in a crushed granite, apparently unaccompanied by hematite or by any hydrothermal minerals. Much useful work could be done by collecting radio-active granites and identifying the minerals showing this property.

TORBERNITE DEPOSITS IN OTHER PARTS OF THE WORLD.

Torbernite-autunite occurrences in other parts of the world are attributed to the action of weathering agents on primary minerals such as uraninite (including pitchblende), euxenite, samarskite and betafite. In Madagascar, it was found that waters draining an area intruded by pegmatites containing betafite, samarskite, euxenite and other uraniferous titano-columbo-tantalates, deposited their uranium content as autunite in peaty clay beds resting on the ancient granite (5). In Portugal, primary uranium minerals in quartz and pegmatite veins, were found to weather into torbernite.(6)

At the important deposit of Shinkolobwe, Belgian Congo, more than half of the uranium in the oxidised zone was in the form of torbernite. In parts of the deposit, the torbernite

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(1) F.L. Stillwell. Report No.315 C.S.I.R.

(2) Douglas Mawson. The Nature and Occurrence of Uraniferous Mineral Deposits in South Australia. Trans.Roy. Soc. Sth.Aust. Vol.68, Pt. 2 1944, p.355.

(3) Douglas Mawson. Op.Cit. p.356.

(4) F.L. Stillwell and A.B. Edwards, in this bulletin.

(5) Ore Deposits of the Western United States. Lindren Volume. New York 1923, p.476.

(6) Alteration des Minerais Noirs D'Uranium Portugais. Chimie et Industrie. 30:805 June, 1933.

occurred at considerable distances from the primary lode containing pitchblende together with iron, copper and nickel sulphides(1).

SUGGESTED HISTORY OF THE FORMATION OF THE DEPOSITS.

The above evidence suggests that the history of the formation of the uranium deposits at Mount Painter may have been somewhat as follows:-

The sedimentary rocks of the Pre-Cambrian series were intruded by granite in late Pre-Cambrian or early Palaeozoic time. This granite contained disseminated uranium-bearing minerals such as uraninite and minerals of the pyrochlore-fergusonite-samarskite type, which were most concentrated in the highly felspathic and pegmatitic fractions. Fracturing and brecciation of the rocks of the area were followed by the deposition of quartz (and possibly some primary hematite) with some magnetite, pyrite, fluorspar, barytes and perhaps uraninite from hydrothermal solutions. The centre of the quartz mineralisation was Mount Gee, but it also impregnated though to a lesser degree, the crush zones which now contain the uranium deposits. This primary mineralisation was probably associated with the granite referred to above.

The history of the area in the Palaeozoic era is not well known. It is possible that Mesozoic sediments were deposited over the area and have since been removed by erosion. In any case, the area, in common with the remainder of Australia, was probably reduced to a peneplain by early or middle Tertiary time. Weathering of the crush zones began as soon as any overlying Mesozoic sediments had been removed, and continued during the remainder of the peneplanation. In Kosciusko(2) (Late Pliocene) time, considerable earth movements began and resulted in the uplift of the Mount Painter block; erosion was intensified and the dissection of the area began. The crush zones formed suitable channels for the circulation of ground waters and it is suggested that these waters have thoroughly leached and kaolinised the granite in these zones; they have taken iron, manganese and uranium into solution and concentrated them in the form of the present manganiferous ironstone-uranium deposits, mainly as cappings over the crush zones.

The leaching of the uranium content of the ironstone cappings is proceeding at the present time. The observed radioactivity of much of the ironstone which does not now contain uranium and the dissemination of torbernite in sheared granite immediately below some of the ironstone masses point to this. Leached cavities after torbernite, may be seen at the surface in several deposits. The torbernite at No.6 Deposit has apparently been deposited during late Cainozoic times.

The origin and history of the individual deposits may be interpreted as follows:-

(1) The torbernite at a point 2½ miles southwest of Paralana Hot Spring is definitely associated with pegmatitic granite. There is no sign of hydrothermal activity. There appears to be little doubt that the primary uranium-bearing minerals from which the torbernite was derived by weathering, occurs sparsely disseminated in the pegmatitic granite.

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(1) Minerals Year Book, 1934, United States, Department of the Interior, Bureau of Mines. p.498-502.

(2) ~~For an account of Post-Tertiary earth-movements and changes in climate, see~~ W.R. Browne: An Attempted Post-Tertiary Chronology for Australia. Proc. Linn. Soc. N.S.W., Vol.LXX, Parts 1-2, 1945.

(11) At a point 110 chains southwest of Paralana Hot Spring the pegmatitic granite is somewhat crushed and sheared, but is not greatly altered. A few flakes of torbernite and thin coatings of ironstone occur along shearing planes. This may represent the early stages of the development of a torbernite deposit by ground water leaching of granite. The No.8 and parts of the No.7 deposits at Mount Painter, where little ironstone is present, may also belong to this stage.

(111) Deposits such as the "Smiler" and "Bentley" at East Painter and the No.3 and No.4 deposits at Mount Painter, in which surface cappings of ironstone are underlain by more or less sheared granite containing a few flakes of torbernite, may represent the next stage in the development of torbernite deposits by the leaching of granite. If so, no primary ore of minable grade could normally be expected. However, hydrothermal minerals such as barytes, fluorite, some pyrite and a little quartz have been noted in this type of deposit and it is not impossible that a primary uranium mineral was introduced with these minerals. The amount, however, of secondary uranium mineralisation so far found in these deposits is small and could have been derived from primary minerals in the granite and pegmatite.

(1V) The nature of the primary mineralisation from which were derived the torbernite and autunite deposit at No.6 working, Mount Painter and the torbernite deposits in the East Painter crush zone, is not clear. As in the above cases, there is a concentration of ironstone at the surface and there has been widespread leaching of the granitic rocks in the crush zones. The degree of circulation of ground water in the brecciated granitic rocks appears to have been sufficient to have leached out their uranium content and re-deposited it in the form of the present torbernite and autunite shoots. Drilling to a depth of approximately 245 feet in the No.6 deposit revealed kaolinised granite with occasional veinlets of hematite.

However, there is considerable evidence of hydrothermal activity in the East Painter crush zones. This, in the vicinity of Nos. 1 and 2 deposits, East Painter numerous cavities and pseudomonphs after pyrite sometimes filled with torbernite have been noted(1). A prominent ironstone outcrop, containing traces of torbernite, which occurs to the north of No.5 prospect, East Painter, consists mainly of hematite, but contains numerous boxworks of limonite which may represent former sulphide crystals. It is evident that the crush zones have been deeply and thoroughly leached and many primary minerals which might have been present would have been removed in solution or very much altered. The No.5 deposit at East Painter, possesses particularly interesting features. A rich torbernite seam is largely confined to a narrow channel which on the footwall side, is seamed with quartz. As stated previously, torbernite from this deposit shows a considerably higher lead content than that from No.6. Assuming no admixture of lead from other sources the lead/uranium ratio of the ore indicates an age of approximately 7 million years. This torbernite could have been produced by the oxidation of a uranium-bearing vein, (the primary mineral possibly being uraninite) more or less in situ. This possible origin is in contrast with the leaching of uranium from large bodies of granite and the formation of torbernite even up to the present time. It seems likely at least, that the torbernite has not been in solution in the past 7 million years.

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(1) F.L. Stillwell and A.B. Edwards:- Uranium Minerals from Mount Painter .... in this bulletin.

CONCLUSIONS.

The above evidence strongly suggests that the torbernite deposits are of supergene origin. It is believed that in many instances, their uranium content was derived from primary minerals sparsely disseminated in the granite and pegmatite and that in these cases, there is little hope of finding workable deposits of primary ore(1).

There is evidence of hydrothermal mineralisation in the East Painter crush zone and one small torbernite shoot (No.5) and two rather promising torbernite-bearing outcrops (Nos.1 and 2) have been found in this section. Further testing in the East Painter area, particularly below the zone of weathering, will indicate more precisely the origin of these deposits.

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(1) The writer is referring to ore averaging 0.25 to 0.5 per cent U_3O_8. It is possible that future scientific developments will render much lower grade ore attractive.