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ABSITE, a new mineral related to brannerite.

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ABSTRACT

Absite, a new uranium mineral from Crocker's Well, South Australia, has the probable composition $2UO_3$, ThO_2, $7TiO_2$, $7H_2O$. It is a primary mineral found in intensely albitized zones in Pre-Cambrian granitoid rocks which form a province characterized by frequent occurrences of titania and rare earth bearing minerals. Absite is devoid of crystalline form and is a metamict mineral.

INTRODUCTION

In the latter part of 1951, an air-borne scintillometer survey in granitic country some 20 miles north of Manna Hill, South Australia, detected strong radio-activity over an area of 5,000 square yards in the neighbourhood of Crocker's Well. Detailed ground survey was then carried out by geologists of the South Australian Mines Department, who discovered a new mineral species of high radio-activity. The name "Absite" is proposed for this mineral, derived from the first letters in the term "air-borne scintillometer".

LOCALITY

Manna Hill is situated on the main north-eastern railway and highway between Adelaide and Broken Hill. (SUS 321) It is 230 miles from Adelaide. Figure 1. Numerous mineral prospects occur in the district, mostly associated with pegmatite. Rare earth and uranium bearing minerals occur in several places, including the important Radium Hill lodes.

MODE OF OCCURRENCE AND GENESIS

(1) Geological Environment.

The mineral absite is restricted to an irregularly shaped, somewhat elongated zone of peculiar granitoid rocks occupying some 5,000 square yards of country within an extensive region of porphyritic felspar and gneissic biotite granites of normal composition with the usual pegmatitic and aplitic phases.

This region, covering many square miles, resulted from the regional granitisation of pre-Cambrian sediments of the Willyama Series, remnants of which occur frequently amongst the granites as migmatites, injection gneisses, and virtually unaltered xenoliths.

Publications of The Geological Survey of South Australia, now in preparation, present maps and geological details relating both to Crocker's Well and the North East Province and the reader is referred to these for details.

The radio-active zone is localised at Crocker's Well and is comprised of a varying group of granitoid rocks characterised by richness in albite, a general paucity of mafic constituents and a peculiar pseudo-brecciated structure. Figure 2. The term leucoadamellite is applied to these rocks as a whole, but there are gradations from adamellite to granodiorite according to the ratio of albite to potash felspar. Leucocratic or normal forms of these rocks occur according to the content of mafic minerals.

Figure 2. Pseudo-breccia (x $\frac{1}{4}$) composed of angular fragments of various granitoid rocks enclosed in a biotite-apatite matrix.

Biotite is the major mafic mineral, but muscovite, apatite, zircon and rutile are nearly always present, as well as rarer minerals such as absite and xenotime.

These adamellites are light-coloured hypidiomorphic granular rocks of 0.5 c.m. grain size, and form a contact zone against the granitised country rocks, and at the same time completely enclose a centre of shattered, leucocratic, highly albitic uraniferous granitoid rocks.

The adamellite is inherently related to the country rock, as shown by variously altered sedimentary relicts which it contains. Microscopic textural features such as strain in quartz, bent felspar, twin lamellae and the presence of granoblastic quartzo-felspathic aggregates indicates post-granitisation stress. In the field some fracturing and brecciation is apparent, becoming increasingly severe towards the central zone where the pseudo-breccias are dominant. A large shear zone occurs adjacent to the uraniferous rocks and is disposed in parallel orientation to the shears within these rocks. This shear zone is partly filled by basic igneous rock of sodic composition.

The greatest amount of absite occurs in the central zone of severely brecciated rocks where leuco-adamellite, leuco-granite, leuco-syenite, etc., occur in proximity and frequently form porphyroblasts all together in the same breccia. Figure 2. Such rocks are not strictly breccias but show evidence of metasomatic modification, probably of an originally highly fractured granitoid rock with the albitization of porphyroblasts, the production of a biotitic matrix rich in apatite and quartz with rutile, absite and xenotime. The structure of the matrix suggests the passage of metasomatizing fluids or the fluxing of gases, but does not exhibit the cataclastic form proper to breccias. Figure 3.

Figure 3. Biotite-apatite-quartz rock (x ½) which forms the matrix of the pseudo-breccia.

Much absite is found in sagenitic quartz veins (Figure 4) related genetically to alaskite, a coarse hypidiomorphic granular rock containing equal amounts of orthoclase and albite with quartz, zircon, apatite, rutile, xenotime and absite. The alaskite was locally mobilized and may be seen penetrating the "pseudo-breccia" and surrounding granitoid rocks. Quartz albite pegmatite and deuteric blue opalescent quartz veins, both of which are related to alaskite, are the principal products of the localized soda metasomatism responsible for the introduction of uranium and rare earth minerals and the general albitization of granitic rocks at Crocker's Well.

Figure 4. Sagenitic quartz vein, natural size, containing grains of absite and rutile.

Although thelarger individuals of absite, several centimetres in size, occur in quartz veins or in the biotite-rich matrix of the pseudo-breccias, a considerable amount is present as smaller, disseminated individuals in the various leucocratic granitoid rocks. In most cases absite is intergrown with rutile and closely associated with apatite.

(2) <u>Genesis</u>.

Absite is rich in titania and rare earths. This is genetically significant, inasmuch as absite occurs in a province characterized by many deposits of these metals. Highly titaniferous uranium deposits, with a rare earth content, occur not far distant at Radium Hill, and still within the same granitised Pre-Cambrian belt a number of occurrences of uncommon rare earth minerals as well as rutile have recently been discovered in pegmatites. Amongst these, coarsely crystallized, in some cases euhedral minerals such as xenotime, monazite, melanocerite and florencite occur in copious quantities indicative of high rare earth and titania content in the host rock.

The salient feature which is of basic genetic significance in the origin of absite is its direct association with albite rich rocks of magmatic origin, for it is characteristic of this province as well as of others in South Australia, that uraniferous minerals are found in a sodic environment. It has been observed, on the other hand, that those minerals whose radioactivity is derived essentially from rare earth content are found in potash rich pegmatite or granitic rock. Thus, in the case of absite, the uranium content exceeds that of the rare earths and the associated rock is albitic.

The age relations of absite are as yet uncertain. It is known that its introduction post-dates the regional granitization of Archaean rocks and that it is syngenetic with the local albitization of these granites. In its immediate association absite belongs to a closing stage of the metasomatic sequence as an accessory constituent in late quartz veins.

CRYSTALLOGRAPHY OF ABSITE.

(1) Morphology.

Absite is commonly found in grains of irregular shape, 1 c.m. or less in size, but occasionally individuals several centimetres in size occur in the quartz veins intergrown with rutile. No form indicative of a true crystal habit is exhibited by absite except where it is pseudomorphous after "books of biotite" when it assumes the shape of the hexagonal prism. In the absence of evidence to the contrary the mineral is thought to be amorphous.

(2) X-Ray Studies

Dr. Norrish of C.S.I.R.O. Division of Soils, Adelaide, made a study of absite, and reported as follows.

"A small amount of the mineral was hand picked to be as pure as possible for an X-ray examination. The sample was powdered and mixed with twice its own weight of gum tragacanth to obtain a diffraction pattern. The gum was added to minimize absorption in the sample which was 0.25 mm. in diameter. The first diffraction pattern, taken with CuK radiation, gave only the diffuse bands due to gum tragacanth. The background of the pattern was great, presumably due to fluorescence of the titanium in the sample.

To reduce the background of the pattern, another exposure was made with the nickel filter placed in front of the film. The sample this time consisted of powdered absite mounted on a fine Lindemann glass fibre. The specimen was made approximately 0.1 mm. in diameter so that absorption would not be serious. The diffraction pattern obtained by exposing the sample for twice the normal time had a relatively clear background with very weak lines at 3.26, 2.94 and 1.686 k x. These lines correspond to the most intense lines of rutile, and it is probable that a very small amount of rutile is present as an impurity in the absite. The only diffraction effects which could be attributed to the bulk of the sample, i.e. absite, were several very diffuse bands indicating that the mineral was amorphous to X-rays.

Table 1 shows the interplanar spacings with estimated intensities of a diffraction pattern of absite after the absite had been heated at 900°C for 3 hours in air. An attempt to assign miller indices to the lines of the diffraction pattern was unsuccessful, indicating that the heated absite was either a mixture or a material of low symmetry. The diffraction pattern is not consistent with the presence of TiO_2, UO_2, U_3O_8, or ThO_2 as pure components. The diffraction pattern of the heated absite is recorded as empirical data on the mineral. It is very doubtful if the crystalline material formed by heating a metamict mineral would ever be the same as the mineral from which the metamict formed. The elements of metamict minerals may have changed their states of oxidation while other chemical differences with respect to the parent mineral may have taken place. The process of radioactivity will insure a certain chemical change. Even with a close chemical similarity to the parent material, the metamict will probably require specific but unknown physical conditions to crystallise as the parent mineral.

In classifying (metamict) minerals the properties of the mineral itself, and not those of the parent mineral or the treated mineral, are important. Thus, while information on the crystal habit of the parent material and data on the heated mineral may be interesting and useful, it would seem that the optical properties and the chemical composition of the metamict mineral are the most important criteria for describing it.

TABLE 1.

Diffraction pattern of heated abaite.

(900°C for 3 hours in air.)

d/m k X	I *
6.06	w
4.79	m
4.34	w
3.43	s
3.36	v v w
3.24	v w
3.04	v w
2.93	w
2.78	v w
2.70	v v w
2.54	v w
2.46	w
2.29	w
2.17	v w
2.049	v w
1.930	w
1.877	w
1.718	v w
1.636	w
1.575	w

* = Intensity estimated visually
s = strong
m = medium
w = weak
v = very

CHEMICAL PROPERTIES

(1) Pyrognostics

Absite does not fuse when heated in the flame to redness, but expands, splits and breaks along fractures which form parallel to and normal to the edge being heated. On cooling colour banding develops ranging from black at the point of highest temperature, grading to amber below and finally into the normal yellow-green of the mineral. Absite is a poor conductor of heat. Hydrochloric nitric and sulphuric acids readily decompose absite, producing solutions with an intense uranium reaction.

(2) Chemical Composition.

Absite was carefully selected for chemical analysis by hand-picking impurities such as rutile, alteration products and quartz, felspar, etc., from the enclosing granitic rock. The analysis was carried out at the Public Assay Laboratory, Adelaide, under the direction of the Chief Analyst, T.W. Dalwood, from whose report the analysis is quoted.

Chemical Analysis of Absite

Water	(H_2O)	9.95
Titanium dioxide	(TiO_2)	35.13
Uranium tri-oxide	(UO_3)	31.83
Thorium dioxide	(ThO_2)	12.81
Scandium oxide	(Sc_2O_3)	0.19
Cerous oxide	(Ce_2O_3) etc.	1.43
Yttrium oxide	(Y_2O_3) etc.	3.71
Zirconium oxide	(ZrO_2)	0.38
Ferric oxide	(Fe_2O_3)	1.37
Phosphorous pentoxide	(P_2O_5)	0.13
Lead monoxide	(PbO)	2.79

Chromium, vanadium, beryllium, manganese, calcium, magnesium, tantalum, and niobium were not present.

Assuming that lead replaces uranium and that rare earths can replace thorium and the ratio Ce-Y-Th is 1:2:7 (from the above analysis) eliminating scandium and zirconium, the following formula suggests itself.

$$2\ UO_3,\ ThO_2,\ 7TiO_2,\ 7H_2O$$

PHYSICAL PROPERTIES

Absite is commonly yellow, yellow-brown, or brownish olive green, according to its weathered condition. The material from underground is yellow whereas progressively weathered absite becomes increasingly brownish green in colour, duller in lustre, and takes on powdery encrustations.

The hardness of the purest obtainable samples is between 5 and 6 (Mohs. Scale) and the density between 4.0 and 4.2 gms. per CC. These physical properties vary somewhat with the degree of alteration attained in the mineral. Hardness is difficult to judge because of the extremely brittle nature of the mineral.

The fracture is irregular with a slight tendency to be sub-conchoidal with the production of concave and convex surfaces of fracture which are not continuous over more than an area of about ¼". The lustre of the freshly fractured surface is quite resinous, but on weathering it becomes very dull and covered with an encrustation which is variously white, yellow or brown and earthy.

OPTICAL PROPERTIES

Under the microscope, absite is greenish yellow in thin chips, non-pleochroic and quite isotropic. It has high relief and its refractive index measured in phosphorous solutions in methylene iodide is 1.96. The variable degree of alternation influences the refractive index so that it may be as low as 1.95 and somewhat above 1.96. When immersed in oil, or when examined in thin section, the mineral, although completely black under crossed nicols, exhibits its alteration products as ultra-fine translucent material of bright yellow colour dispersed through the host grain of clear yellow mineral. This material may be a lead compound formed by internal radioactive disintegration. Absite is non-fluorescent.

NOMENCLATURE

The mineral described in this paper appears sufficiently distinct to be classed as new, but has sufficient similarity to brannerite to suggest that it and brannerite belong to the same series. Of importance in this connection are the results of chemical analysis, differential thermal analysis, and X-ray study.

The analyses of the two minerals are as follows:

	Absite, Australia	Brannerite, Idaho
TiO_2	35.13	39.0
ZrO_2	0.38	0.2
FeO	-	2.9
Fe_2O_3	1.37	-
Sc_2O_3	0.19	-
UO_2	-	10.3
UO_3	31.83	33.5
ThO_2	12.81	4.1
PbO	2.79	0.2
Ce_2O_3	1.43	-
Y_2O_3 etc.	3.71	3.9
BaO	-	0.3
SrO	-	0.1
CaO	-	2.9
H_2O	9.95	2.0
CO_2	-	0.2
SiO_2	-	0.6
P_2O_5	0.13	-
	99.72	100.2

The two analyses are similar enough to suggest that the two minerals are related. Absite containing UO_3 to the exclusion of UO_2 is probably in a completely oxidised condition, i.e. it has reached an advanced stage of supergene alteration. Since no material from deeper levels is available, the original UO_2 content of the mineral is indeterminable. Brannerite is in part oxidised, but retains some UO_2 in the molecule, hence comparisons must be made with the relative states of supergene oxidisation in mind. This point is further borne out by comparison of the water content in each of the minerals as well as by the ratio of FeO to Fe_2O_3. The discrepancy in UO_3 in the two analyses is compensated for by 2.79% of lead oxide in absite.

The major distinction between the analyses is that of the thorium-uranium ratios, and since ThO_2 and UO_2 are interchangeable, this immediately implies that the minerals probably belong to a substitution series. Thus absite is a member towards the thorium rich end whereas brannerite is a member towards the uranium rich end.

X-ray investigations do not provide a sound basis for comparison because it is only after heating and probable dissociation of the minerals that comparable patterns are obtained. This aspect of the question is dealt with under Crystallography. Nevertheless, the behaviour of both minerals at elevated temperatures as shown by X-ray and differential thermal analysis does tend to indicate comparable fundamental properties and a possibility that at high temperature, with loss of characteristics incurred by metamictization, both minerals tend to assume identity of structure and behaviour in keeping with two members of a series. No differential thermal analytical work was done in Australia, but personal communications from the laboratories of the United States Atomic Energy Commission, where such work has been performed, indicate similarities in the curves given by the two minerals.

When factors such as internal change by the process styled metamictization, the conversion of part or all of UO_2 to UO_3 by supergene alteration and the substitution of ThO_2 for UO_2 in the original molecule, are taken into account, it is a precarious undertaking to name a mineral of this type. It would seem therefore that the mineral described herein is a member of the same series as that to which brannerite belongs, but that its physical and optical properties in the natural condition are sufficiently distinctive to justify its being named as a species.

ACKNOWLEDGEMENTS

This mineral was first discovered by R.C. Sprigg and K. Seedsman as the result of an Air-Borne Scintillometer Survey. There followed immediately a detailed geological survey of the area by R.C. Sprigg, K. Seedsman, L.W. Parkin, D. King, and others with concurrent petrographic and mineralogical investigation by the writer. All work was carried out under the ultimate direction of S.B. Dickinson, Director of Mines. Adelaide.

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FIGURES
ARE
MISSING