NOTE ON THE OCCURRENCE OF A NEW MINERAL AT BROKEN HILL.

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IT is only a few months since Professor Liversidge read a paper (by Mr. C. W. Marsh), before this Society, describing a new mineral which he named "marshite." The composition of the mineral was iodide of copper, and it was discovered by Mr. Marsh in the celebrated Aldridge Collection at Broken Hill. I have now much pleasure in recording the occurrence of another interesting mineral from the same district, viz., from the Australian Broken Hill Consols Mine. The composition of this mineral is sulph-antimonide of cobalt and nickel. The credit of discovering the mineral is due to Mr. George Smith, M.A.I.M.E., Sub-Manager of the Broken Hill Consols Mine, and it is at his request that I am bringing the mineral under the notice of this Society.

I propose to name the mineral Willyamite (pronounced Willy-ah'-mite) after Willyama the official name of the Broken Hill township, and the aboriginal word meaning a hill with a broken contour. Complete analyses in duplicate of the mineral have been made by Mr. J. C. H. Mingaye, F.C.S., Analyst and Assayer to the Department of Mines, and the results are as follow:—

		No. 1.	No. 2.
Sb	...	56·85	56·71
Co	...	13·92	13·84
Ni	...	13·38	13·44
Fe	...	trace	trace
Cu	...	minute trace	minute trace
Pb	...	minute trace	minute trace
S	...	15·64	15·92
		99·79	99·91

These analyses correspond almost exactly with the formula CoS_2, NiS_2, $CoSb_2$, $NiSb_2$, or a sulph-antimonide of nickel and cobalt. When first discovered the mineral was supposed to be a sulph-antimonide of cobalt, but Mr. Mingaye's analysis shows it to contain equal quantities of cobalt and nickel, although it is of course just possible that future discoveries may show that these two metals may replace one another in varying proportions. The mineral which agrees most closely with willyamite is ulmannite, a sulph-antimonide of nickel NiS_2, $NiSb_2$. In the last edition of Dana's "System of Mineralogy," several analyses of ulmannite are quoted which show that mineral to contain a trace of cobalt, and one specimen is quoted as containing 1·06 per cent. of cobalt in connection with twenty-six per cent. of nickel. The presence of equal quantities however of cobalt and nickel in willyamite appears to justify its recognition as a new mineral. Mr. Smith informs me that a small quantity of the new mineral only was found associated with a lump of dyscrasite in a gangue of calcite and siderite at a depth of one hundred and fifty feet (vertical).

I have tested the physical and pyrognostic characters of the mineral, and they are as follow:—System of crystallisation, isometric. Cleavage, cubic, perfect. Fracture uneven, brittle. Hardness, about 5·5. Specific gravity (mean of a number of experiments) 6·87. Lustre metallic. Colour between tin-white and steel-grey. Streak greyish-black. In the closed tube and next to the assay yields a dark red sublimate, which is orange coloured on cooling, and this is surmounted by a faint white sublimate. In the open tube decrepitates, yields antimonial and sulphurous fumes; near the assay the white sublimate shows in fern-like forms. Before the blowpipe on charcoal, fuses readily to a globule, which boils and emits sulphurous and antimonial fumes. With borax glass gives at first the cobalt blue colour, but after oxidising all the cobalt, the nickel reaction is subsequently obtained. Decomposed by nitric acid with separation of antimony trioxide.

The Australian Broken Hill Consols Lode in which this mineral was found, differs materially from the other lodes on the field,

and has more the appearance of a true fissure lode. It has an east and west course, and the working shaft is situated about three-quarters of a mile in an east-south-east direction from that part of the main Broken Hill Lode known as the British Mine. The width of the Consols Lode varies from a few inches up to ten feet and it dips to the south at an angle varying from 24° near the surface to 60° at a depth of five hundred and fifty feet. The lode traverses gneisses and schists and an intrusive (?) basic rock, which has been examined by Mr. J. B Jaquet, Geological Surveyor, and found to consist essentially of hornblende, triclinic felspar and bronzite. According to Mr. George Smith, the lode is productive only where it intersects this hornblende rock. The gangue or veinstuff consists chiefly of limonite down to a depth of one hundred and thirty feet, which appears to be about the limit of the zone of oxidation, below that depth the gangue consists of chalybite and calcite.

Mr. George Smith, who is an enthusiastic mineralogist, has dentified a considerable number of rare minerals occurring in this mine, and I am indebted to him for the following notes upon their occurrence, and also for specimens illustrating a number of the minerals :—

NOTES BY GEORGE SMITH, M.A.I.M.E., Sub-Manager,

Upon the minerals occurring in the Australian Broken Hill Consols Mine.

Dyscrasite or antimonial silver has been found in slugs or masses at all depths. Photographs are exhibited of two of these masses known respectively as the Turtle and the Flitch of Bacon. The former weighed sixteen hundredweight, and contained eighty per cent. of pure silver. The latter weighed eighty-seven pounds and contained eighty-three per cent. of silver. A piece still larger than the Turtle was found weighing twenty-three hundredweight, but was not photographed. The proportions of silver and antimony have been found to vary considerably in different specimens of dyscrasite from the mine. The formulæ of the most common varieties were found to be Ag_3Sb, Ag_4Sb, Ag_6Sb, $Ag_{12}Sb$.

Argentite—Silver Sulphide (Ag_2S).—Very rare, only small specimens met with, contained generally in dyscrasite, sometimes in small crystalline masses, showing a well marked cubical structure; rarely in cubes possessing the peculiar shrivelled appearance reported by Cox and Ratte *(Mines and Minerals)*. The purest specimens were never tested; a typical piece gave seventy-eight per cent. silver, the impurity being probably lead sulphide. Very soft, sectile, but not perfectly so. Depth about one hundred and twenty feet (vertical); lode-gangue principally limonite.

Stephanite—Antimonial Silver glance (Ag_5SbS_4).—Found in one part of the mine only in small quantity, in soft puggy ground between two veins of mixed calcite and siderite. Specimens detached and small, all crystallised. Rhombic six sided prisms and tables; macles frequent. Specific gravity 6·23. Contains 67·1 per cent. silver; no silver compounds associated. Depth between three hundred and eighty and four hundred feet (vertical); lode-gangue calcite and siderite.

Pyrargyrite—Ruby silver ore, (Ag_3SbS_3). Also found in small quantity only; very rarely crystallised in hexagonal prisms. Small amorphous pieces apparently very pure, translucent on edges, gave 56·3 per cent. silver. Mostly in films in cleavages of siderite, rarely dendritic in calcite, the latter very dark in colour, rather sectile with the characteristic streak. Always with or near tetrahedrite, rarely with pyrite and pyrrhotite. Various depths; lode-gangue siderite and calcite.

Sternbergite—Sulphides of silver and iron ($AgFe_2S_3$).—Very rare, found encrusting a piece of dyscrasite weighing over fifty pounds, at a depth of one hundred and fifty feet. Several lumps (detached slugs) of dyscrasite were found in close proximity, but only with one was this rare ore associated. Amorphous and more or less impure through admixture with pyrargyrite. The purest piece tested gave silver 33·94 per cent., iron 30·76 per cent., and contained a little antimony, quantity not determined. Fused B.B. to metallic globule; marked paper slightly; streak black;

colour bronze tarnishing blue. Rather brittle, but some pieces almost sectile in places. S.G. 4·34, H. about three. Associated minerals dyscrasite and pyrargyrite. Lode-gangue siderite and calcite.

Stromeyerite—Sulphide of silver and copper ($Ag_2S.Cu_2S.$)—The principal ore of the mine and the most uninteresting mineralogically. Never crystalline, but very uniform in appearance, and fairly consistent in silver value, viz., about thirty per cent. Colour bluish- and greenish-black to black. Tough; often antimonial. So common in the past that no special tests were made of it. Depth (where it occurred in large quantities) one hundred to one hundred and forty feet (vertical); associated minerals principally azurite, malachite, volgerite and galena. Lode-gangue limonite and rarely siderite.

Argentiferous Tetrahedrite.—Sulphide of copper and antimony. This and stromeyerite are the only silver ores found in quantity (excepting the antimonial chloride mentioned later). The others are so rare as to be considered curiosities. The bulk of this ore contained about twenty per cent. of silver, though small deposits have been found at various parts of the mine giving about thirteen and a-half per cent. At our deepest level however some of this class of ore has been found containing the same amount as the bulk, viz., twenty per cent. Large quantities have been found in siderite, but the richest and largest masses have always been found enclosed in calcite. The rich varieties have a lighter colour and brighter lustre than the poorer kinds. An isolated imperfect tetrahedron was found, but this was the only appearance of crystalline form observed up to the present. Depth, various. Associated minerals galena, pyrargyrite, chalcopyrite, bournonite and dyscrasite. Lode-gangue siderite and calcite.

Brongniardite—Sulphide of lead, silver and antimony ($PbS.Ag_2S.Sb_2S_3$).—Very rare; only met with associated with the upper portion of a large deposit of stromeyerite. Gave very distinctive reactions before the blowpipe, but contained a large quantity of silver—thirty-four and a-half per cent. Encrusted with a grey

carbonate of lead into which it was being changed. Purest specimens crypto-crystalline, structure somewhat resembling argentite but very indistinct. Depth about one hundred feet; associated mineral stromeyerite; lode-gangue limonite.

Antimonial Silver Chloride—Silver chloride (or chloro-bromide) is of comparatively rare occurrence, considering the quantities found elsewhere on this field. A silver chloride has been found in large masses which differs from the ordinary chloride of the other mines, and in fact from any yet reported. This ore is always massive and antimonial; of a uniform grey colour and fairly constant value of about fifty-five per cent. silver. Some lumps enclosed veins of the ordinary chloride, and others patches of dyscrasite; some of the latter showed that it had undoubtedly, in my opinion, been altered from the dyscrasite. A specimen in my collection shows the antimonial chloride enclosing a kernel of unaltered dyscrasite, round the edge of which can be seen the chloride in the granular form of the other. A very interesting mineral deserving further attention and analysis. Associated minerals stromeyerite, bindheimite, azurite and volgerite; lode-gangue limonite. Depth one hundred to one hundred and forty feet (vertical). A round lump (detached slug) of this mineral was found in a soft formation, and was coated with small crystals of ordinary chloride. A large slug was unearthed before I came to the mine, and which I did not see, weighing four hundred and seventy-five pounds. These pieces were shipped to London intact and were presumably homogeneous.

Bournonite—Antimonial lead and copper ore. Entered here on account of its high silver value. Occurs in limited quantity in upper portion of vein forming small bonanzas in limonite, often perfectly isolated from other ores; always impure containing from about five to seven per cent. silver. Generally associated with various lead ores and malachite; sometimes showing mechanical mixture with tetrahedrite from which the silver has doubtless been derived. An analysis gave a friend who kindly undertook to determine a specimen of this ore, the following:—

Pb.	29·0
Cu.	8·9
Sb.	25·0
Fe.	3·0
Ag.	5·7
S.	22·5
	94·1
Insoluble	3·0
Moisture by difference ...	2·9
	100·0

Always amorphous; too impure to be interesting. Associated minerals galena, anglesite, cerussite, bindheimite, tetrahedrite, malachite, and rarely brochantite; lode-gangue limonite. Depth about eighty to ninety feet, vertical.

Kerargyrite—Silver chloride—Comparatively scarce. Some very pure specimens were found with the antimonial chloride, which were colourless, and in thin pieces quite translucent. Assayed 73·1 per cent. Depth various; lode-gangue limonite.

Iodyrite—Silver iodide—Fairly plentiful in various parts of the mine. Always with limonite. Some found at shallow depth was associated with a bright red mineral readily tarnishing on exposure to sunlight, which was found to be sulphide of mercury. No special tests made. Various depths.

Galena including Anglesite—Almost all grades of granular form have been met with, from the finest grain—very like chalcocite—to cubes six inches across, but contrary to the general opinion, comparatively little assistance in discrimination was afforded by the differences in crystalline structure. Some samples very rich in silver were exactly similar in appearance to many of the poor ores, occurring sometimes within a short distance of each other in the same matrices. As an instance of their similarity might be mentioned two classes of galena which were being stoped simultaneously within a short distance of each other, and which

could not be separated by any difference in their appearance, and yet their respective assays were (bulk samples) one thousand and forty-five ounces and forty ounces, the richer ore in silver strangely enough containing about seventy-five per cent. of lead as compared with sixty-five per cent. in the other ore. Some fine crystals were found, principally cubo-octahedrons, the finest specimens occurring in calcite. Pseudomorphs of anglesite, after galena, were found rather plentifully in the upper portion of the vein, some specimens showing a kernel of unaltered galena when broken, the sulphate often containing a crust of carbonate into which it was being altered. A few assays show the great range in silver value:—

Coarse grain—	Ag.	10 ozs.	fairly plentiful	... Pb.	83%
,,	,,	40 ,,	plentiful ...	... ,,	65 ,,
,,	,,	389 ,,	rare	... ,,	77 ,,
Fine grain	,,	40 ,,	plentiful ...	... ,,	65 ,,
,,	,,	720 ,,	found in fair quantity,	,,	80 ,,
,,	,,	900 ,,	,, ,,	,,	80 ,,
,,	,,	1080 ,,	,, ,,	,,	76 ,,
Very fine grain	,,	690 ,,	very rare ...	... ,,	79 ,,

Cerussite—Carbonate of lead ($PbCO_3$)—Very little found. Few crystals in upper levels. Grey variety resulting from the alteration of other ores was found near the rich ore assaying over one thousand five hundred ounces silver, and about sixty per cent. lead.

Phosgenite—Chloro-carbonate of lead ($PbCO_3 PbCl_2$)—Very rare; amorphous. No special trials made. Contains little silver, about five ounces. Found in upper levels.

Bindheimite—Hydrous antimonate of lead.—Found in good quantity; generally earthy; always amorphous; sometimes very rich in silver. No special tests made of any specimens from this mine. Found in upper levels associated with all the silver ores.

Caledonite—Cupreous sulpho-carbonate of lead.—Very rare and impure, mixed with carbonate and sulphate of lead; amorphous. No special tests made.

Vanadinite—Vanadate of lead.—Occurs as an incrustation on the crystals (pseudomorphs after siderite) of limonite, not plentiful.

A qualitative determination showed presence of phosphoric acid, chlorine, a little sulphuric acid, and antimony.

Johnstonite ?—Variety of galena—Some peculiar pieces of galena were found from which some of the lead had been eliminated leaving the sulphur free. This variety is possibly identical with the "Johnstonite" reported by Dana.

Stibnite—Antimony trisulphide (Sb_2S_3)—Rare, in fine capillary crystals on siderite associated with mispickel.

Volgerite—Hydrous antimonic acid.—A white earthy oxide of antimony, occurring in small quantities with stromeyerite and sometimes chloride of silver; earthy. Quantity too small to test thoroughly. Contains nine or ten per cent. water. Rather a doubtful species; insoluble or nearly so in HCl. The only sample assayed for silver gave one hundred and seventy-four ounces.

Stibiconite—($Sb_2O_4H_2O$.)—Very rare, earthy. Found enclosed in one lump of silver chloride.

Mispickel—Arsenical pryites.—Rather rare, found scattered in small amorphous lumps through siderite.

Cobaltite—Sulph-arsenide of cobalt (CoS_2CoAs_2)—Rarely in crystals. Amorphous variety common; generally argentiferous through admixture with dyscrasite and sometimes fahlerz. Occurs at various depths in calcite. On exposure soon oxidises to the arsenate (erythrite).

Erythrite—Hydrous cobalt arsenate.—One specimen found only *in situ*, crystallised in stellate form on siderite.

Copper ores—None interesting; only small quantities found. Varieties consist of malachite, azurite, chenevixite, brochantite, bornite and chalcopyrite, the latter most plentifully.

Aurichalcite—Basic carbonate of zinc and copper.—Rare; very handsome specimens were found forming stalactite shaped masses in a vugh near the deposit of rich ore. The inside of these specimens was filled with dyscrasite, iodide of silver and gossan.

Calamine—Carbonate of zinc.—Rare; in small globules on limonite.

Willyamite—Curiously enough this mineral was found associated with one lump of dyscrasite only, about forty pounds. This lump was found near the piece which contained the sternbergite, although other lumps were found in the near vicinity, none of this mineral was found with them, a remarkable coincidence, seeing that the lumps were so close *in situ*. Associated mineral dyscrasite; depth one hundred and fifty feet vertical. Lode-gangue calcite and siderite.

Calcite, Siderite, Limonite—Vein material, often well crystallised. The limonite being of course pseudomorphous after siderite; the change taking place at about one hundred and thirty feet, which may be considered the water level.

Aragonite—In well developed crystals; rare. The best specimens being found at about three hundred feet in a cleft of the enclosing country, viz., amphibolite. All the above minerals were found enclosed by this rock in which the whole shoot of ore exists.

Mercury—Sulphide.—Found as a red hard mineral associated with iodide of silver in limonite in one locality, in upper levels; also three hundred feet lower, coating dyscrasite of a brownish-red colour. All varieties readily tarnish on exposure to sunlight.

Manganese—Manganese dioxide, pyrolusite and wad?—Rather plentiful in upper levels. The former sometimes in stalactitic and branch-like forms, making good cabinet specimens.

Quartz—Small perfect crystals with double terminations; rather rare. Agate and amethyst, both well coloured; the former was common in upper workings.

Native Sulphur—In small crystals associated with cerussite in vughs in galena, from the decomposition of which it has no doubt been derived.