Native gold and silver with other minerals from the Old West mine, Penhalonga, Southern Rhodesia.[1]

(With Plate III.)

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LARGE specimens of native gold showing crystalline form are not at all common in Southern Rhodesia, but the recently discovered gold with adherent silver from the Old West mine, Penhalonga, would be outstanding wherever it had been found.

About the middle of December 1940, Mr. D. V. Burnett, Director and Consulting Engineer to the Rezende Mines Limited, the owners of the property, lent two specimens to the Geological Survey for examination. The following week Mr. B. Lightfoot, Director of the Southern Rhodesia Geological Survey, visited the mine and examined the cavity where the specimens had been found. He made notes and collected specimens of the associated minerals, and borrowed a few other specimens which had been retained at the mine.

In a description of the Rezende Old West mine Mr. A. E. Phaup[2] explains that the ore-body is a sheet of quartz-porphyry averaging 20 feet in thickness, dipping at an average angle of 30° to the south, and intruding into a boss of quartz-diorite. The quartz-porphyry has been shattered and riddled with stringers of vein quartz containing pyrite, galena, a little chalcopyrite, pyrrhotine, and gold. The gold in the ore is confined to the mineralized quartz stringers which assay about an ounce to the ton, but the quartz-porphyry body as a whole is treated as low-grade ore, and is worked to yield a recovery of approximately 2 dwt. per ton. The mineralization has not been even and tends to be greatest near one or other of the walls. The ore-body is cut by strike faults which dip vertically and throw the reef down on the southern side. The vug in which the specimens were found adjoined one of these faults, being inclined upward into the down-faulted hanging-wall country-rock on the south side of the fault.

[1] By permission of the Director, Geological Survey of Southern Rhodesia.

[2] A. E. Phaup, The geology of the Umtali gold belt. Bull. Geol. Surv. Southern Rhodesia, 1937, no. 32, pp. 132–134. [M.A. 7-432.]

The position of the vug is shown in the attached plan and section (figs. 1 and 2), and is explained in the following description by Mr. Lightfoot: 'The vug was found in no. 6/2 E. stope drive, 42 feet above the 6th level at a vertical depth of 490 feet below the collar of no. 2 shaft. A fault forms the southern wall of the stope drive and of the box-

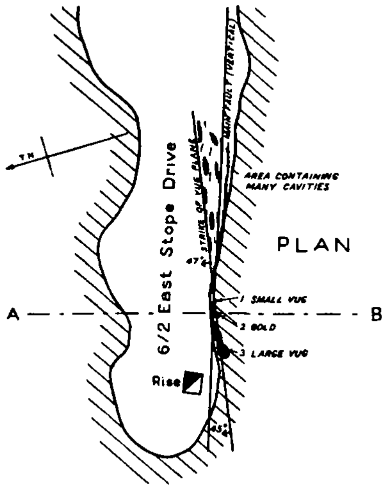


FIG. 1.

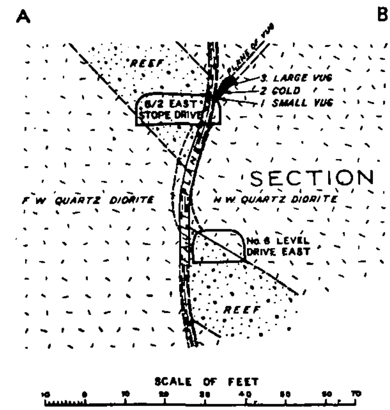


FIG. 2.

FIGS. 1 and 2. Plan and section of 6/2 East stope drive, Old West mine, Penhalonga, Southern Rhodesia.

hole connecting it with the main drive below. A series of vugs carrying quartz and calcite had previously been noticed along this fault plane, particularly at the junction of another fault which meets at a small angle. On December 10, 1940, after a blast, a boss-boy was barring down bits of loose hanging wall to make the stope safe for the on-coming shift, when he brought down one piece which opened up a cavity in a corner of the roof in which shining leaves of gold could be seen. He went to fetch the shift boss, Mr. T. Lines, who could scarcely believe his eyes. Here were the biggest pieces of visible gold he had ever seen in his life, three shining sheets of gold, about a quarter of an inch apart, sandwiched between white glistening crystals of calcite. Mr. Lines set to work with a chisel. It then became obvious that this was no ordinary gold, but was ornamented with triangular markings each with a black spot embossed upon it. Two selected specimens were sent to Mr. D. V. Burnett at the head office in Salisbury, and the remainder was smelted down. 33 oz. of gold plates gave 33 oz. of bullion containing 789·7 parts of gold and 180·0 parts of silver per thousand.'

So far as is known only five plates of gold, including the two which were sent to Mr. Burnett, escaped the holocaust; but a few specks of crystalline gold were found among other minerals in the specimens collected by Mr. Lightfoot. The largest specimen is the plate of which photographs of the two sides are shown in plate III. It measures roughly 9×10 centimetres and averages 0·44 millimetre thick. Mr. E. Golding estimates that the weight of gold is 41·1 grams (1·32 oz. Troy). Part of the plate is enclosed in a crystal of clear calcite. The second specimen is smaller, and consists of gold associated with galena partly embedded in a gangue of calcite, quartz, and laumontite. The remaining three specimens are plates with maximum dimensions of 4×3, 5×2, and 2×2 centimetres respectively. The gold is of rather pale colour. It is mostly bright, but in places it is stained with an iridescent tarnish.

As may be seen in the photograph (pl. III), the large surfaces of the sheet are broken by small projecting pyramids rising in steps or terraces with sloping edges on equilateral triangular bases. Many of these pyramids are surmounted by dark grey nodules or studs, which are found on examination to be native silver. A small crystal was detached and measured on a goniometer. The faces unfortunately are not very smooth and give indifferent reflections, particularly as the crystals are all somewhat bent. Three zones were measured. As might be expected the large surfaces belong to the octahedron. The angle read between this and the terrace slope faces averaged 29° 27′ for four readings, which is sufficiently near to 29° 30′, the theoretical value, to leave little doubt that the terrace slopes belong to the four-sided trisoctahedron (icositetrahedron) (311). There is no evidence of the presence of cube faces, nor of the rhombic-dodecahedron, but reflections were observed indicating the presence of forms (221) and (811). A conventional drawing of these forms is shown in fig. 3.

The smaller specimen, measuring 5×2 cm., is one of exceptional beauty. It is very similar to the large specimen except that some of the pyramids are surmounted by beautifully faceted little crystals on short stalks. One of these, about 1 mm. diameter, has the form shown in fig. 4. It consists of the octahedron and the form (311) which has been reduced to small crosses about the cubic axis by a form which may be described as a four-faced dodecahedron (hexakisoctahedron). Dana[1]

[1] E. S. Dana, Amer. Journ. Sci., 1886, ser. 3, vol. 32, p. 137, fig. 6; System of mineralogy, 6th edit., 1892, p. 14, fig. 5.

figures a very similar crystal from California, in which he indexes the faces between the angles of the crosses as x (18.10.1).[1] In the Penhalonga specimen the faces are too dull to be measured, but the plane angles on the octahedron faces indicate that the form must be near to (951). Twins are visible in some of the small crystals.

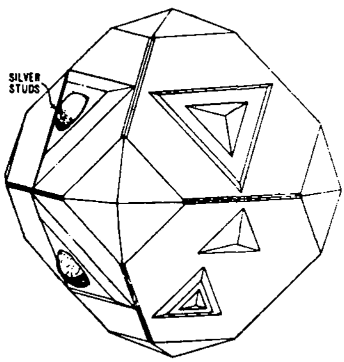


Fig. 3.

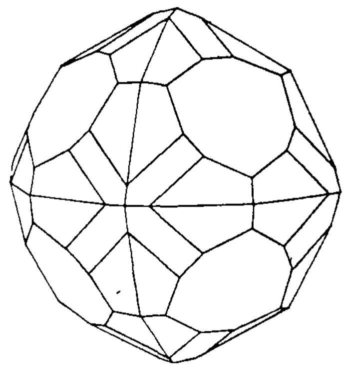


Fig. 4.

Fig. 3. Conventional sketch to show crystal form of gold with adhering silver.
Fig. 4. Crystal of gold from Old West mine, Penhalonga, Southern Rhodesia.

In the photographs (pl. III) the effects of twinning may be seen in places where the triangular pyramids are oriented 180° from those in the main part of the specimen.

The bending of the crystals was probably caused by movements of the walls of the vug. Mr. Lightfoot was able to collect a specimen of calcite preserving a mould of the curved gold surface of a large specimen with casts of the triangular ornamentation clearly preserved.

In contrast with the gold, the native silver is rarely distinctly crystalline. It is usually rounded and often occurs as nearly perfect hemispheres (fig. 5). The surface is tarnished to a dark lead-grey, and is always dull. Crystal faces can be seen on some of the studs and a few have definite modified triangular outlines, orientated approximately parallel to the sides of the gold pedestals on which they stand. The triangle sides are convex and are due to a combination of two four-sided trisoctahedral (icositetrahedral) forms. That this mineral is chemically silver was determined on three of the studs from two specimens. It is soft and malleable, but harder than the gold and it does not bend as readily. Some of the studs are broken with irregular fractures when the

[1] The indices (18.10.1) cannot be correct with (311) lying in the zone [$(hkl)(hlk)$] as shown in the drawing.

supporting gold has been severely bent. In other places the silver studs have wholly or partly broken free from the gold, leaving hollow scars nearly as deep as the projection of the silver above the gold surface.

FIG. 5. Photomicrographs by reflected light of hemispherical studs of native silver on crystalline gold from Old West mine, Penhalonga, Southern Rhodesia. ×30.

This is interesting, as it shows that the gold and silver were deposited simultaneously, and were incompletely isomorphous under the conditions of temperature and pressure reigning at the time of deposition.

The assay values quoted above show that the bullion produced from the vug contained 78·97 % of gold and 18·0 % of silver, some of which must have been in the native state. To ascertain the purity of the gold crystals, some small pieces weighing about half a gram in all were carefully scraped free of all adhering silver with a dentist's tool, and assayed by the Government Metallurgist. Separate portions gave Au 80·615, Ag 18·463, and Au 81·093, Ag 18·193%. These figures are rather surprisingly similar to those of the bullion. Unfortunately it has not been possible to collect sufficient of the silver to determine how much gold is contained in it. The Mining Commissioner's returns show that the ratio of gold and silver produced by the mine is 65·8: 34·2.

Other minerals associated with the gold and silver in the vug include galena, pyrite, quartz, calcite, laumontite, and chlorite. The larger vugs in which no gold was found are lined with the same minerals with the exception so far as is known of galena.

Galena occurs in contact with the gold in several small specimens. It shows only as cleavage masses and no external form has been observed.

Pyrite does not seem to occur in contact with the gold in any specimen, although small crystals may be found entirely embedded in the associated calcite. It is abundant in the altered country-rock. In the larger vugs small pyrite crystals are very numerous, and are among the last to form, occurring frequently on the outer surface of the laumontite.

Quartz crystals are generally singly terminated prisms, and water-clear. They were the earliest crystals to form on the walls of the vugs.

Calcite usually shows the form of a somewhat obtuse rhombohedron combined with the base. All the faces are rough, the base being particularly mottled. The rhombohedral faces are striated parallel to their intersections with the base. They tend to have a convex cylindrical curvature with axes parallel to the striae. Cleavage fractures truncate the edges radiating from the corners of the base. Contact-goniometer readings suggest several forms are present between (331) to (221). There is frequently a sharp change in colour in the crystals from bluish-white in the older parts to pale yellow in the later formed portions, but all effervesce freely with cold dilute hydrochloric acid.

Chlorite as minute crystals of vermicular form is present in some gold-bearing specimens, and forms an abundant deposit as a greyish-green powder in the interior of the large vugs. Small crystals of the same mineral are also enclosed in the outer parts of clear crystals of quartz. The powder is composed of isolated, sensibly hexagonal prisms elongated perpendicular to a perfect basal cleavage, and usually curved into a U or spiral. The refractive indices are α 1·607, γ 1·611, $\gamma-\alpha$ 0·004. No optic axial figure could be recognized in the very thin lamellae, but viewed laterally they show negative elongation. The mineral is therefore optically positive. The pleochroism is strong, $\alpha = \beta$, dark sage-green, γ pale yellow. Specific gravity is 2·90, varying slightly. The optical properties and crystal form agree with prochlorite as defined by Winchell.[1] A chemical analysis by Mr. E. Golding of the powder washed free from lighter constituents in bromoform is given below. The composition works out as amesite 32, antigorite 29, daphnite 21, ferroantigorite 18, with a small excess of silica.

SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MnO.	MgO.	H_2O+.	H_2O-.	Total.
27·55	19·74	0·66	20·68	0·23	18·42	11·39	0·31	98·98

Also traces of Na_2O, K_2O; absence of TiO_2, CaO, CO_2.

Laumontite is the last mineral to form. It is generally soft and fibrous, and usually forms a mat separated from the surface of the main mass of rock by an air space a few millimetres deep. It appears to have crystallized near the top of standing, or gently flowing, water. The same mineral occurs in joint faces in the rock and in the gold-bearing specimens. The common shape is a prism (110) with angles near 90°, terminated obliquely by a single face, perhaps ($\bar{2}$01), inclined at about 60° to the prism axis. Silky striations on the faces made measurement of the angle impossible. Under the microscope the most noticeable feature is the high extinction-angle, which reaches 43° from the prism axis. The following characters were determined: α 1·5048, γ 1·5176, $\gamma-\alpha$ 0·0128, $\gamma: c$ 43°; sp. gr. between 2·26 and 2·32. The mineral reacts for CaO, Al_2O_3, SiO_2, and H_2O. It fuses with swelling, and gelatinizes with HCl.

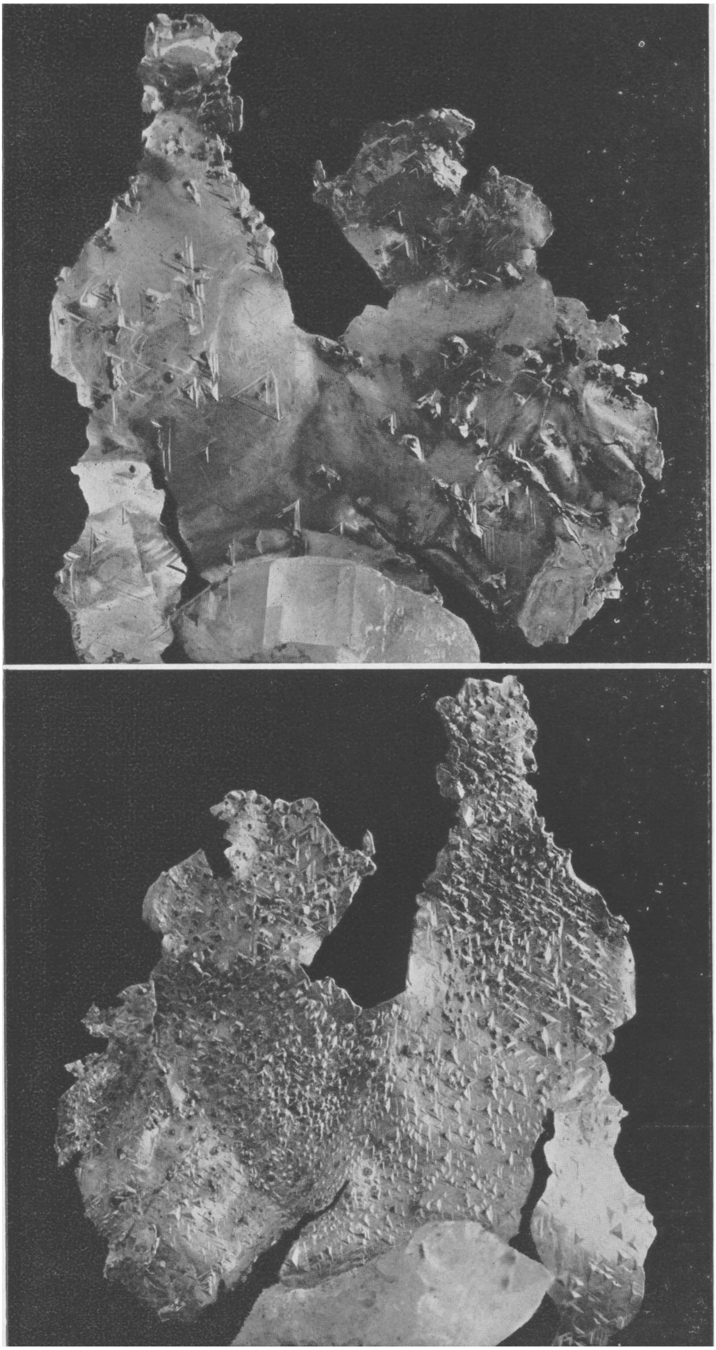
Conclusion.—There can be little doubt that the deposition of this gold is due to a secondary process. The strains which formed the vug were connected with the strike faulting which was subsequent to the emplacement of the auriferous quartz veinlets in the quartz-porphyry. These perhaps resulted from the contraction of the latter during cooling. The presence of pyrrhotine indicates that the temperature at that time was high. The association of the minerals in the vugs, however, suggests a very much lower temperature, which may account for the simultaneous crystallization of gold and silver in contact with each other.

[1] A. N. Winchell, Elements of optical mineralogy, 3rd edit., 1933, pt. 2, p. 276.

It appears probable that the mutual solubility of gold and silver in the crystalline state decreases with fall of temperature.

EXPLANATION OF PLATE III.

Photographs of the two sides of a sheet of crystallized gold with adhering silver, from Old West mine, Penhalonga, Southern Rhodesia. (Photo. A. M. M.) Slightly reduced.



A. M. MACGREGOR : GOLD FROM SOUTHERN RHODESIA