

MINERALOGICAL NOTES

A PLATINUM-METAL NUGGET FROM TRINITY COUNTY, CALIFORNIA

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ABSTRACT

The nugget was found in stream gravels of the South Fork of the Trinity River. Laths of anisotropic ruthenium-rich iridosmine make up 80 volume percent of it; the rest is iron-rich platinum. This assemblage is probably not primary in the sense of having crystallized from a molten state, owing to the prohibitively high temperature involved. Rather, the metals may have been brought together by a low-temperature, perhaps hydrothermal process.

INTRODUCTION

Platinum sands have been recovered as a byproduct of placer gold mining in a number of California localities (Clark, 1970), but nuggets are apparently rare. Recovery of the one described here was recently brought to the writer's attention by Mr. E. A. Snetsinger, Palo Alto, California, who found it in 1930 during panning operations on the South Fork of the Trinity River, Trinity County, California. Chemical analysis of the minerals in it and procedures used are given below, together with a suggested origin.

DESCRIPTION

The nugget weighed about 0.75 gram, was very slightly ferro-magnetic, 5 mm long, 3 mm thick and egg-shaped, but somewhat flattened. Crystals of a tabular mineral (found to be iridosmine), arranged roughly parallel to the plane of flattening, protruded slightly from the surface of the specimen, giving it a roughened appearance.

After immersing the nugget and a percussion mortar in liquid nitrogen the sample was smashed, resulting in several large fragments and some dust; the fragments were mounted and polished for electron microprobe analysis, the dust being retained for X-ray diffraction work.

A polished section shows closely-spaced, roughly-oriented, 0.1 mm-thick laths of iridosmine 1 mm in longest dimension, set in a matrix of platinum. The laths are clearly cross-sections of tablets, their preferred orientation perhaps being due to crystallographic influence of the surrounding platinum; arrangement of the tablets is responsible for the "flattening" of the nugget. Point counting of the sections gives 79.9 volume percent iridosmine; the rest is platinum.

ANALYTICAL PROCEDURES

The minerals were analyzed with an ARL-EMX electron microprobe. For the platinum, quantitative estimates of Pt, Fe, Au, Cu, Ni, Ir, Rh, and Ru were made. Pure metals were used as standards for the first five of these. Three alloys, each containing 90 weight percent of Pt and 10 percent each of Ir, Rh and Ru, were used as standards to determine those metals.

In the iridosmine, Ir, Ru, Pt, Ag, Fe, Rh, and Os were determined. Standards used were: pure Pt, Ag, and Fe; two alloys containing 20 weight percent each of Ir and Rh, the rest being Pt; and the Pt 90 Ru 10 alloy. Difficulty was experienced with osmium because the metal is apparently not available in alloyed form, nor is pure osmium metal satisfactory: the final purification step results in a finely-divided state which cannot easily be altered by melting or compressing, as the metal has a very high melting point and is very brittle. Recourse was therefore made to briquettes of the finely-divided pure osmium thoroughly mixed and bonded together (1) with finely-divided pure palladium in approximately a 9-to-1 Os to Pd weight ratio (Os 89.73, Pd 10.27%), and (2) with finely-ground pure KBr in precisely a 4-to-1 Os to KBr ratio. These mixtures were pumped on under high vacuum before briquetting, and were briquetted under high vacuum to keep porosity at a minimum. During analysis the standard briquettes were moved continuously under the electron beam to reduce the effects of inhomogeneity. Uncorrected Os values obtained using these briquettes as standards were put through a computer correction program just as though the briquettes represented combined compounds of the elements involved. After all instrumental and matrix corrections were calculated, using Os 89.73 Pd 10.27 the Os value of 34.2 weight percent was obtained for the iridosmine; Os 80 KBr 20 gave Os 33.8 percent; Os by difference would have been 33.5. Agreement is as good as can be expected under the circumstances, and 33.8 was taken as the Os value.

The computer program corrected for background, drift, deadtime, mass absorption, fluorescence, and atomic number. Frazer's (1967) data were used in the mass absorption calculations, and Wittry's (1964) formula, slightly modified, was applied to obtain secondary fluorescence corrections. Duncumb and Reed's (1968) backscatter-effect results were used in the atomic number calculations. The whole program was similar to the format of Frazer *et al.* (1966).

Measurements were made at 20 kV for all elements except iron, for which 10 kV was used to reduce mass absorption and atomic number corrections, the difference between sample and standard being large in this case. L_{α} lines were used for all elements except iron; K_{α} was used for iron.

The noble-metal alloy standards were obtained from Englehard Industries, Inc.; pure Pt, and finely-divided pure Os and Pd were from Johnson, Matthey and Co. Other metals and reagents were 99.99 percent pure samples from various sources.

RESULTS

Analytical data for iridosmine¹ and platinum are given in Table 1. Numbers of metals have been calculated for these alloys to allow comparison of relative amounts of metals of widely different atomic number.

¹ Although intended to apply only to alloys of osmium and iridium, the nomenclature of Hey (1963) is applied here, rather than devise new usage. For this purpose, presence of ruthenium is ignored and osmium is calculated as constituting 55 weight percent of the sum of osmium and iridium. Following the suggestion of Mandarino (1964), a varietal name is not used.

TABLE 1. IRIDOSMINE AND PLATINUM ANALYSES

IRIDOSMINE		
Metal	Weight percent	Number of metals on basis of 2 metals per unit cell
Os	33.8	0.52
Pt	4.0	0.06
Ir	27.9	0.42
Pd	2.8	0.08
Ru	29.8	0.86
Fe	0.2	0.01
Rh	1.7	0.05
Total	100.2	

Looked for but not found: Ni, As, S, Au, and Re: Ag was measured at 0.3%, but this small amount is probably due to interference from an osmium satellite peak occurring near Ag L α .

PLATINUM		
Metal	Weight percent	Metals; basis of 4 per unit cell
Fe	15.5	1.50
Pt	80.1	2.20
Ir	1.7	0.05
Au	0.2	0.01
Rh	1.9	0.11
Ru	0.3	0.02
Ni	1.4	0.11
Cu	0.2	0.02
Total	101.3	

Looked for but not found: Os, Re, Pd.

The iridosmine is exceptionally high in ruthenium. An incompletely analyzed osmium-iridium alloy, however, with values apparently uncorrected for matrix effects, has been recorded by Leonard *et al.* (1969); it contains 33.5 ± 2.0 weight percent Ru. Aside from this, the most Ru-rich, fully-analyzed such alloy is one cited by Palache *et al.* (1944) containing 21.080 percent Ru. Palladium content of the iridosmine is noteworthy: analyses quoted by Palache *et al.* (1944, p. 112) do not record the element, although a number of the summations there are low, and palladium may have been present. It happens that the numbers of metals of atomic number 76 and higher in the iridosmine have a 1:1 ratio to metals of atomic number 46 and lower; this is considered fortuitous.

The platinum contains much iron, approaching the highest value to be

found (16.50%) in the analyses cited by Palache *et al.* (1944, p. 107), although other values quoted by them are much lower. For comparison, the writer's unpublished data on platinum sands from a number of California localities show platinum grains never contain more than 7 percent Fe, the average being about 4 percent Fe; and native platinum studied by Stumpfl and Clark (1965) does not contain more than 10.3 percent Fe. Presence of Cu and Ni in the current example appears to be a standard feature of others: small but variable amounts of these metals have been cited by Palache *et al.* (1944) and Stumpfl and Clark (1965). Both the iridosmine and platinum show small compositional variations, unrelated to grain boundaries; these variations are only slightly outside the precision of the method.

An X-ray film pattern of the platinum shows no features of special interest; *d*-spacings of the iridosmine are intermediate between those of pure ruthenium and pure osmium, cell dimensions being *a* 2.73, *c* 4.30, both ± 0.01 Å.

ORIGIN

As appears to be the case with platinum-metal flakes and nuggets elsewhere in California, the present example is (1) closely associated with ultrabasic rocks, mainly serpentines; (2) has presumably been derived from these rocks; but (3) is not found in place. The latter makes it difficult to give a detailed account of origin. It does seem likely, however, that the mineral assemblage is not primary in the sense of having crystallized from a dry melt; the temperature that would be involved is prohibitively high. Probably the nugget formed during a low-temperature, perhaps hydrothermal process; fluids available during serpentinization of the host rock may have provided a means of transport and localization of the metals.

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SYNTHESIS OF SCANDIUM PSEUDOBROOKITE, Sc_2TiO_5 ¹

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ABSTRACT

Synthesis of small crystals (1×1×2 mm) of Sc_2TiO_5 , scandium pseudobrookite, has been effected by slow cooling from 1,460°C-1,000°C using sodium tungstate, Na_2WO_4 , as a flux. Complete solid-solution series were obtained between pseudobrookite, Fe_2TiO_5 , and scandium pseudobrookite, Sc_2TiO_5 , by heating at 1,150°C gels in air.

Isostructural compounds R_2^{3+} with ortho-rhombic space group *Bbmm* include Al_2TiO_5 (Yamaguchi, 1944; Lang, Filmore, and Maxwell, 1952; Kim and Hummel, 1960; Goldberg, 1968), Ga_2TiO_5 (Goldberg, 1968), and $\text{Fe}^{3+}\text{TiO}_5$, pseudobrookite (Akimoto, Nagata and Katsura, 1957; Karkhanavala, 1959; McChesney and Muan, 1959; Goldberg, 1968; Buddington and Lindsley, 1964).

Synthesis of small crystals of Sc_2TiO_5 , scandium pseudobrookite, has been effected by slow cooling (2°C/hr.) from 1,460-1,000°C in Pt crucible of Sc_2O_3 and TiO_2 in sodium tungstate, Na_2WO_4 , as a solvent. Optimum charge ratio of the oxides and flux was found to be in the vicinity of $\text{Sc}_2\text{O}_3 = 22.0$, $\text{TiO}_2 = 22.0$ and $\text{Na}_2\text{WO}_4 = 56.0$ (in mole per cent).

The tabular to prismatic crystals are faintly yellow due to Fe_2O_3 (0.17 percent). They are elongated on [001], measure approx. 1×1×2 mm and often show terminal faces. At the end of the runs, only Sc_2TiO_5 remained after dissolving the flux in hot water. Previously reported

¹ Mineralogical Contribution No. 480.