

PLATINIRIDIUM — CONFIRMATION AS A VALID MINERAL SPECIES*

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ABSTRACT

Inclusions of platiniridium in a placer grain of iron-bearing platinum from the Tulameen River area, B.C. have been analysed. The retention of the species name platiniridium is proposed on historical grounds. The mineral is *cubic* (Ir,Pt), with Ir 50–80 atomic % of (Ir+Pt) and no other element greater than 10 atomic %.

Additional new analyses of iron-bearing platinum and tulameenite are also presented.

INTRODUCTION

Alluvial platinum often contains several metallic elements in solid solution. The commonest of these is Fe, but Ir, Ru, Os, Rh, Pd, Cu, Ni and Sb may occur in minor and variable quantities (Cabri *et al.* 1973; Harris 1974).

The history of the natural platinum-iridium alloys has unfortunately been obscured by the conflation of two early references in the 3rd (1850) and subsequent editions of *Dana's System of Mineralogy* and by an erroneous attribution of the name *platiniridium* to Svanberg by Hintze (1898); it may therefore be useful to summarize the early history of these minerals.

Breithaupt (1833a) examined a few metallic grains brought from Nizhnii Tagil in the Urals by I. Nikerin. One appeared to be a fragment of an octahedron and showed cubic cleavage; all had higher densities than platinum, and he suspected they might be native iridium ("gediegen Irid"). He made a semi-quantitative analysis (1833b) under the guidance of W. A. Lampadius, which showed Ir as principal constituent, with a little Os and no Pt. Breithaupt's papers were critically abstracted by Berzelius (1835).

G. Rose was interested in Breithaupt's mineral; he had a quantity of material from Nizhnii Tagil that agreed well with Breithaupt's description (colour, cubic crystallization, and a density of 22.8), and sent a 0.26 gram grain to Berzelius for analysis. Berzelius entrusted the

analysis to Svanberg, under his direction, apologizing for not undertaking it himself as he had developed an allergy to OsO₄. Svanberg's analysis, showing 77% Ir and 20% Pt, was published by Rose (1835) and by Berzelius (1836). The alloy with 77% Ir, termed "gediegen Iridium" by Rose (1835) was entered as *Platiniridium* or *Platinirid* by Glocker (1839); he wrote: "Iridium. Mit Einschluss des Platiniridiums", and lower on the same page "Platinirid von Newiansk" (Nevyansk), and no other names appear to have been used for it.

Meanwhile, a different platinum-iridium alloy had been found: Svanberg (1835) analysed, along with two iron-bearing platinum specimens from South America, an alloy with 55% Pt and 28% Ir; for this "Platina Iridium" he gave no locality (though America is implied by the title of his paper), and Berzelius (1836) in reporting the analysis only mentions America, yet Glocker (1839) gives Brazil as the locality, and this has been generally accepted. The alloy with 28% Ir, Svanberg's "Platina Iridium", was included by Glocker (1839) as an Appendix (Anhang) to the species Iridium, under the name *Iridplatin*, which Hintze (1898) modified to *Iridiumplatin*.

Genth (1853) found three rounded grains insoluble in aqua regia, "which, I suppose, were Platin-Iridium", in a Californian sample of gold plus platinum and iridosmine.

Platiniferous concentrates from Kannee (modern Kani) on the Kyendween (Chindwin) river, near Ava, Burma, were examined by Prinsep (1833). He summarized his analysis: "The platina constitutes 20 per cent of the cleaned ore, and . . . is accompanied with about twice its weight of iridium. The remainder appears to be chiefly oxide iron". His identification of iridium is not conclusive. Unfortunately the abstract in Poggendorff (1835, p. 383) which all later authors appear to have relied on is not quite accurate: "Beinahe 60 Procent des Erzes losten sich nicht in siedendem Königswasser, und diesen Rückstand erklärt Hr. Prinsep für

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Iridium". The abstract in *Neues Jahrb. Min.* cited by Hintze (1898) does not mention iridium. Heddle (1883) named Prinsep's material *avaite*.

In the 1st (1837) and 2nd (1844) editions of *Dana's System of Mineralogy* the Pt-Ir alloys are not mentioned (the index entry "Native iridium" refers in fact to iridosmine). In the 3rd (1850), 4th (1854) and 5th (1868) editions the name *platiniridium* (wrongly attributed to Svanberg) is used to cover both Svanberg's analyses, for which the reference is given as *Jahresber*, xv, 205 (with the incorrect date 1834 in the 5th edition). Mention is also made of Genth's "probably platiniridium"; and of Prinsep's material (for which no reference is given). The 6th (1892) edition prefers the name *iridium*, but the 7th (1944) returns to *platiniridium*; only the 7th edition mentions Glocker's name *irid-platin*, and that only as a synonym; the errors of the 3rd and 5th editions remain uncorrected.

Hintze (1898), who uses *platiniridium* for (Ir,Pt) and *iridiumplatin* for (Pt,Ir), gives the clearest and best account of the Pt-Ir alloys, but he, too, relied on the erroneous abstracts of Prinsep's paper.

Hey (1963) proposed that the name *platiniridium* be retained for iridium-platinum *cubic* alloys but Cabri (1972) suggested that this term may be unnecessary because no data were available to justify use of the term. Cabri was unaware, at the time, of a paper by L. V. Razin (1968) which will be discussed later in more detail. Also, nomenclature for such alloys was complicated by the lack of data for natural alloys in the Os-Ir-Ru and Os-Ir-Pt systems. The nomenclature of Harris & Cabri (1973) for these systems is also helpful for the Pt-Ir-Ru system. Because the mineral names *iridium*, *ruthenium*, and *osmium* are now restricted to alloys with ≥ 80 at.% of the appropriate element, it is obvious that an Ir-Pt alloy with (Ir+Pt) between 20 and 80 at.% should follow the accepted nomenclature of the Os-Ir alloys, *osmiridium* and *iridosmine*, because of historical precedence for the name.

MATERIAL AND METHOD OF INVESTIGATION

The study of platiniridium evolved from the mineralogical work on the platinum-bearing placers of the Tulameen River (Cabri *et al.* 1973). Iridium-rich inclusions, too small to analyse with confidence, occur with moderate frequency in grains of iron-bearing platinum. One sample, from the south bank of the Tulameen River, roughly midway between the village of Coalmont and the town of Princeton, contained a grain with larger inclusions. The sam-

ple probably came from older "terrace" gravels.

The platinum-bearing grains were separated from the other minerals by using a sieve, hand magnet, and heavy liquids. The grain containing the platiniridium was found in a non-magnetic fraction. The concentrates were mounted in cold-setting plastic, polished on lead laps, and lightly buffed on a cloth lap using minus 0.05- μ alumina. Compositions were determined with a Materials Analysis Company Model 400 electron probe using, as standards, synthetic PtFe and Pt₂FeCu, and the pure metals Ir, Os, Ru, Ni, and Sb. Corrections to the x-ray data were applied with the EMPADR VII computer program of Rucklidge & Gasparrini (1969). Additional corrections were applied for interference between Cu and Ir.

PLATINIRIDIUM AND ASSOCIATED MINERALS

Platiniridium was found in a grain of iron-bearing platinum, for the most part as micron-

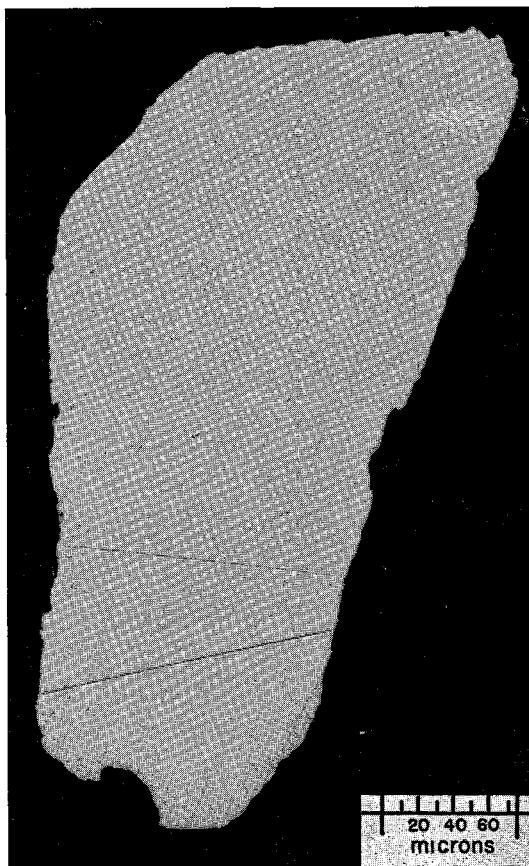


FIG. 1. Photomicrograph of an iron-bearing platinum grain with very fine white inclusions of platiniridium at the bottom and a larger inclusion at the top right.

TABLE 1. ELECTRON PROBE ANALYSES OF PLATINIRIDIUM, IRON-BEARING PLATINUM, AND TULAMEENITE

Name and dimensions in microns	Weight per cent									Atomic proportions								
	Pt	Ir	Os	Ru	Fe	Cu	Ni	Sb	Total	Pt	Ir	Os	Ru	Fe	Cu	Ni	Sb	Σ
Composite grain, 185 \times 412																		
1. <i>platiniridium, 80\times30</i>	14.7	72.3	5.3	4.5	1.9	0.33	0.14	----	99.17	0.52	2.68	0.20	0.32	0.23	0.04	0.01	----	4.00
2. <i>iron-bearing platinum matrix</i>	78.2	8.0	---	---	12.6	0.66	0.23	----	99.69	2.35	0.25	----	----	1.32	0.06	0.02	----	4.00
3. <i>iron-bearing platinum, 110\times190</i>	88.1	0.45	---	---	7.7 (7.0-8.3)	1.73 (0.85-2.47)	0.14	0.86 (0.48-1.34)	98.98	2.88	0.01	----	----	0.88	0.18	0.01	0.04	4.00
4. <i>iron-bearing platinum, 55\times170</i>	90.7	0.64	---	---	5.3	0.66 (0.55-0.89)	0.11	----	97.41	3.24	0.03	----	----	0.65	0.07	0.01	----	4.00
Composite grain 30 \times 110																		
5. <i>iron-bearing platinum</i>	76.7	9.0	---	---	12.6	0.43	0.19	----	98.92	2.32	0.28	----	----	1.34	0.04	0.02	----	4.00
										Pt	Ir	Σ		Fe	Cu	Ni		Σ
6. <i>tulameenite</i>	70.5	6.3	---	---	12.5	10.0	0.31	----	99.61	1.85	0.17	2.02		1.14	0.81	0.03		1.98

N.B. A few analyses showed inhomogeneity for some elements. The range of values for these is shown, in brackets, below the average value.

sized inclusions (Fig. 1). One inclusion, however, about 20 microns across, permitted quantitative analysis. The mineral, which is isotropic and appears much whiter than the isotropic matrix of iron-bearing platinum under reflected light, also seems to be harder than the matrix.

Microprobe analyses for platiniridium, iron-bearing platinum, and tulameenite are shown in Table 1. The analyses for iron-bearing platinum and tulameenite are consistent with those reported by Cabri *et al.* (1973) and Harris (1974), with a few exceptions: the tulameenite contains higher Ir (6.3 wt %); the iron-bearing platinum in Analyses 2 and 5 contains more Fe (12.6 wt %) and significant Ir (Analysis No. 5 with 9.0 wt % Ir is higher than values found previously).

DISCUSSION

The significance and relationship of the compositions of such natural alloys is best understood by plotting them on a ternary diagram of their three major elements in atomic %. This method was used originally by Cabri (1972) for Os-Ir-Ru alloys and extended into a scheme for nomenclature by Harris & Cabri (1973) for Os-Ir-Ru and Os-Ir-Pt. An analogous situation is applicable to platiniridium and the iron-bearing platinum of Analyses No. 2 and 5. The compositions of the platiniridium inclusions are plotted on the Ir-Pt-Ru ternary because these three elements constitute about 88 atomic % of the seven elements in the alloy. The compositions of iron-bearing platinum, as shown in Analyses 2 and 5, are therefore plotted on the Pt-Ir-Fe ternary diagram for similar reasons. To be consistent with Cabri *et al.* (1973) Fe + Cu + Ni atom % is plotted as Fe because Cu and Ni are very minor. These three analyses are plotted on Figure 2.

The upper part of Figure 2 (Pt-Ir-Ru) shows a very extensive *cubic* solid solution field, separated by a miscibility gap from the smaller area of *hexagonal*, Ru-rich solid solution. The boundaries for the Ir-Ru two-phase region are as defined by the experimental work of Raub (1964). The limit of Ru solid solution in Pt to

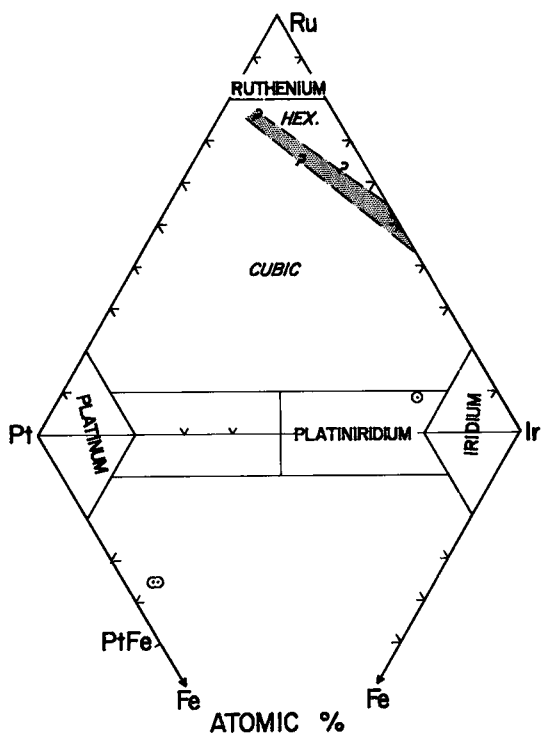


FIG. 2. The Pt-Ir-Ru system showing one analysis in the platiniridium field, and the partial Pt-Ir-Fe system showing two analyses of iron-bearing platinum.

"exceed 79 at. (66.2 wt) % Ru" is the statement made by Hansen & Anderko (1958) from the work by Nemilov & Rudnizky (1937). Therefore, the exact direction and width of the miscibility gap extending from the Ir-Ru binary to the Pt-Ru binary is tentatively indicated, from the limited data available, by the area bounded by broken lines in Figure 2.

It can be seen easily that the analysis of platiniridium lies in a field whose boundaries can be well-defined and that are consistent with the nomenclature proposed by Harris & Cabri (1973). Platiniridium is defined as *cubic* (Ir,Pt) alloys having Ir at 50-80 atomic % (Ir + Pt) and no single other element greater than 10 at.% of the total. It should be emphasized, however, that the name is retained for historical reasons only, in the same manner as *osmiridium* and *iridosmine* were retained. The logical name should have been *platinian iridium*, a variety rather than a species, in the same manner as *ruthenian iridium* was used by Harris & Cabri (1973).

The extensive work by Razin (1968) on the platinum-group alloys from the Inagli massif of southern Yakutia has been available only recently to the authors. Razin described natural alloys similar to those above, but was able to work with a greater number of samples and thus had a greater range of compositions. None of these is plotted on Figure 2 because, regretfully, all the determinations were made using bulk analytical methods. Razin, however, clearly distinguished between iridium, platinum-bearing iridium, iridium-bearing platinum, and platinum on the basis of spectral reflectance, x-ray powder diffraction, and micro-indentation hardness measurements. Likewise, his description of exsolution-type features of the iridium-rich alloys in a platinum-rich matrix applies very well to the occurrence from the Tulameen River area. It is also interesting to note that the reports that these exsolution textures were observed in polished sections of the platinum-bearing dunite of the Inagli massive, as well as in those of cemented alluvial concentrates. He further states explicitly that "This dunite is, furthermore, the primary source of the alluvial platinum placers and at the same time their bedrock."

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