Unique W-rich alloy of Os and Ir and associated Fe-rich alloy of Os, Ru, and Ir from California

ANDREI Y. BARKOV,1,* MICHAEL E. FLEET,1 ROBERT F. MARTIN,2 MARK N. FEINGLOS,3 AND BART CANNON4

1Department of Earth Sciences, University of Western Ontario, London, Ontario N6A 5B7, Canada
2Department of Earth and Planetary Sciences, McGill University, 3450 University Street, Montreal, Quebec H3A 2A7, Canada
3Box 3921, Duke University Medical Center, Durham, North Carolina 27710, U.S.A.
4Cannon Microprobe, 1041 NE 100th Street, Seattle, Washington 98125, U.S.A.

ABSTRACT

A shell-like polycrystalline grain (ca. 1 mm) of W-(Mo)-bearing Os-Ir alloy (11.4–18.6 wt% W; up to 1.5% Mo) is present in a very old collection (probably the 1890s) of tiny nuggets from Trinity Co., California. An extensive compositional series [(Os0.43–0.80Ir0.28–0.05)W0.12–0.18], and inverse Ir-Os correlation, are observed; the mean composition [Os0.65W0.15Ir0.12Fe0.02Mo0.01Ru0.01], based on results of 50 electron-microprobe analyses, displays a ratio (Os + Ir):W of 5:1. The observed variations and element correlations suggest that (W + Mo) contents are controlled by Ir, and incorporated via the following substitution scheme: [(W + Mo) + Ir] ↔ Os. The X-ray diffraction data indicate that the W-rich alloy has a hexagonal close-packed structure, related to that of osmium and allargentum, with a = 2.7297(4) Å, c = 4.3377(6) Å, and V = 27.99(1) Å³; the c:a ratio is 1.59. The probable space-group is P63/mmc, and Z = 2; the calculated density is 21.86(1) g/cm³. The W-rich alloy is associated with an Os-Ru-Ir alloy rich in Fe (7.0–9.7 wt%), which exhibits atomic Fe ↔ [Os + Ru] and Ir ↔ [Os + Ru] mechanisms of substitution. We suggest that these W-(Mo)- and Fe-rich alloys formed by metasomatic alteration of a primary Os-Ir-Ru alloy, associated with mineralized ultramafic-mafic rocks of ophiolite affinity. A fluid phase may have well have remobilized and transported W, Mo, and Fe. The W-rich alloy likely crystallized from a reducing fluid under conditions of low fugacities of O₂ and S₂, thus promoting the observed siderophile behavior of W and Mo. These unusual W-(Mo)- and Fe-rich alloy grains were likely derived, as a placer material, from the Trinity ophiolite complex of northern California.

Keywords: W-rich Os-Ir alloy, Fe-rich Os-Ru-Ir alloy, platinum-group minerals, Trinity ophiolite complex, California, U.S.A.

INTRODUCTION

In this paper, we report the discovery in California of a new variety of Os-Ir alloy, containing W (11.4–18.6 wt%) and substantial Mo (up to 1.5 wt%); it is associated with an unusual Os-Ru alloy enriched in Fe (7.0–9.7 wt%). Previously, W and Mo had never been reported as a constituent of terrestrial platinum-group minerals, PGM (cf. Cabri 2002). We describe characteristic properties, discuss crystallochemical and genetic implications, and suggest a likely primary source for these two alloys of the platinum-group elements (PGE), W, Mo, and Fe.

These W-(Mo)- and Fe-rich PGE alloys were found during an examination of tiny nuggets and grains of various PGE alloys, presumably placer grains, from the collection of one of the authors (MNF). These grains are preserved in an original, very old vial with a hand-written label, probably from the 1890s, indicating that they were collected in California. The exact location of these samples is not stated. However, the more recent label provided with these PGM samples records the locality as “Trinity Co., California.”

ANALYTICAL METHODS

Electron-microprobe (EMP) analyses of the PGE-rich alloys were carried out using a JEOL JXA-8600 electron microprobe (A.D. Edgar laboratory, University of Western Ontario, London, Ontario) in wavelength-dispersive mode (WDS) at 25 kV and 30 nA, with a finely focused beam (<2 μm) and CITZAF on-line correction procedures. Pure Os, Ir, Ru, Pt, Pd, Fe, W, Mo, and synthetic Pt90Rh10 were used as standards. All possible peak-overlaps among the X-ray emission lines employed were checked and corrected. Copper, Ni, Co, Nb, Ta, S, and As were not detected.

The X-ray-diffraction (XRD) data for the W-rich alloy of Os and Ir were obtained in situ with a Bruker D8 Discover diffractometer (XRD laboratory, University of Western Ontario), at 40 kV and 40 mA, using CuKα radiation (λ = 1.54184 Å), a finely focused beam (50 μm), and 9 hour scans for each of the two spots analyzed.

TEXTURES AND COMPOSITIONS

The W-rich alloy of Os and Ir occurs as a ring-like grain about 1 mm in diameter (Fig. 1A). Because of its brittleness and polycrystalline nature, this grain is extensively fragmented; the domains of individual micrograins, observed in cross-section in a polished mount, are about 5–10 μm across.

The mean composition of the W-rich alloy grain shown in Figure 1A, based on a total of 50 point analyses, is listed in Table 1 (anal. 1). The following ranges (in wt%) were observed: Os = 46.84–81.68, Ir = 4.95–30.68, Ru = 0.28–3.87, Fe = 0.33–1.92, W = 11.42–18.60, and Mo = 0.33–1.92. There are strong covariations in the contents of Os and Ir. In contrast, W varies only slightly (anal. 2–6, Table 1); elevated W contents are invariably present in this extensive compositional series, which is rather continuous (Fig. 2). Note that all of these compositions...