Osmium isotope heterogeneity in Os-Ir-Ru inclusions within platinum-iron alloy placer grains from the Freetown layered complex; Sierra Leone

J. L. C. Stewart
I. C. Lyon
D. J. Vaughan
J. M. Saxton

Dept. Earth Sciences, The University of Manchester, Manchester, M13 9PL. UK

J. F. W. Bowles

Mineral Science Ltd. Chesham, Bucks, HP5 2PZ. UK.

The measurement of osmium isotope ratios has been used in previous studies to evaluate the origin and mode of formation of platinum-group element mineralisation. In particular, where platinum-group mineral (PGM) grains occur as placer deposits in areas of the Cordilleran mountain chains of the USA and Canada, in Kalimantan, and in Sierra Leone, osmium isotopes have provided useful insights into their possible origins. (Bowles *et al.*, submitted., Lyon *et al.*, 1997; Hattori and Cabri, 1992) In the present work, the genesis of PGM grains in placers associated with the Freetown igneous complex, Sierra Leone, is being investigated.

The Freetown intrusion is a roughly circular body approximately 30 km in diameter. It consists of five main cycles (zones) of troctolite, olivine-gabbro, norite, gabbro and anorthosite, four of which are exposed on the Freetown Peninsula and the fifth seen only in a borehole. Approximately one third of the intrusion is exposed on land with the four outcropping zones forming four arcuate ranges of hills on the Freetown Peninsula.

The PGM grains are found in soils, and in sediments in, or near, the rivers and streams draining the area. The grains are mostly 1-2 mm in diameter, with larger grains known to occur. The grains have been reported as exhibiting both euhedral and dendritic growth habits. (Bowles, 1995).

The main platinum-group minerals found in this locality occur as: (1) pyritohedra of erlichmanite (OsS_2) and (2) platinum-iron alloy grains (Pt_3Fe) with inclusions of Os-Ir-Ru alloy, erlichmanite (OsS_2), laurite (RuS_2), tulameenite ($CuFePt_2$) and cuprorhodsite ($CuRh_2S_4$).

The previously reported osmium isotope ratios measured on the Os-Ir-Ru phases within Pt_3Fe grains from Sierra Leone are within the range 0.15 - 0.25, when converted to equivalent $^{187}Os/^{188}Os$ ratios (Hattori, *et al.*, 1991). This variation was determined between inclusions from separate grains, not between inclusions within a single grain, and has been variously interpreted as resulting from magmatic, metasomatic or supergene processes.

The present study also concentrates on the Os-Ir-Ru alloys within Pt_3Fe grains, the emphasis being on collection of data from Pt_3Fe grains containing more than one Os-Ir-Ru inclusion to establish whether or not there is any detectable variation of the $^{187}Os/^{188}Os$ ratios within and between individual inclusions.

Data collection

The osmium isotope work was carried out using the Isolab 54 ion-microprobe at Manchester University (Saxton, *et al.*, 1996). The method used was as described in Lyon *et al.*, 1997.

Measurements were made on thirteen Os-Ir-Ru alloy inclusions found within platinum-iron alloy grains, mounted in resin on a glass slide and polished.

Four grains were selected which contained between two and six inclusions each; these grains are B, 1, 3 and 7. Grain B contains two inclusions, grain 1 also contains two, grain 3 has three and grain 7 has six inclusions. Multiple analyses of these inclusions were made over a six week period.

Results

The measured $^{187}Os/^{188}Os$ ratios lie in the range 0.14 - 0.23 and, hence, all are elevated above those expected for direct mantle derivation of the grains. Multiple analyses of individual inclusions also agree well. Two of the grains, 3 and 7, contain multiple inclusions which have the same $^{187}Os/^{188}Os$ ratios within error; these ratios are 0.172 for grain 3 and

0.153 for grain 7. Although within grain inclusions for these two grains have the same $^{187}Os/^{188}Os$ isotope ratios, the ratios between grains are distinctly different. The data collected for grain B, which contains two inclusions, show $^{187}Os/^{188}Os$ ratios that differ significantly. The $^{187}Os/^{188}Os$ ratios for the inclusions are 0.165 and 0.175 respectively. The data collected from the inclusions in grain 1 are even more intriguing. These two inclusions show very wide ranges of isotope ratios within a single inclusion. The variations within the inclusions for each of these are 0.168 to 0.234 and 0.184 to 0.237, respectively. These results suggest isotopic zonation of the Os-Ir-Ru inclusions, and further work is being undertaken to confirm this conclusion.

Discussion

As far as possible we have eliminated all sources of error in these $^{187}Os/^{188}Os$ isotope measurements. Thus we have evidence for (1) between-grain variations of $^{187}Os/^{188}Os$ in inclusions; (2) inclusions within a single Pt_3Fe grain with different $^{187}Os/^{188}Os$ isotope ratios within error, and (3) single inclusions with variable $^{187}Os/^{188}Os$ isotope ratios.

The meaning of these results is still being evaluated, and some preliminary interpretations will be presented.

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