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Os isotopic composition of steels: Constraints on the ^{186}Os- ^{187}Os evolution of the crust

Chatterjee, R.[1], Lassiter, J[1].
rudra025@gmail.com
1. Jackson School of Geosciences, The University of Texas at Austin, Austin, TX

The Os isotopic composition of the continental crust is difficult to constrain owing to the extremely low concentration of osmium in the Earth's crust (few 10's of ppt) and its extreme susceptibility to contamination due to such low concentrations. Existing data [1] indicate that the mean ^{187}Os/^{188}Os of the continental crust is highly radiogenic (1.05). Limited data on ^{186}Os/^{188}Os of crustal materials [2] is inconclusive with a few loess samples showing supra-chondritic values (0.119849-0.119866) although a number of analyzed black shales are within error of chondritic values. Clearly more data is required in ^{186}Os-^{187}Os space to better understand the Os isotopic evolution of crustal materials.

The Os isotopic compositions measured from steel can be used to constrain the Os isotopic composition of the crust. This is because three of the major components used in making steel namely iron, carbon & chromium, are extracted from crustal reservoirs. Steel is chosen for Os isotopic analysis of the crust because high precision ^{186}Os/^{188}Os requires several 10's of ng of Os. Steel can contain several ppb of Os and extracting enough Os for the high precision ^{186}Os/^{188}Os analysis is feasible.

In this study, we have examined different varieties of steel (3 stainless steels, 2 alloy steels and 1 steel of unknown composition). The Os concentration in the steels range 11-22 ppb for the stainless, high Cr and 0.03-2 ppb in the alloy, low Cr steel varieties. Os concentration is positively correlated with Cr concentration in the steels, suggesting that the osmium budget in the steels is dominated by chromium. The ^{187}Os/^{188}Os for these steels are highly radiogenic (0.1435-1.4129). Two separate analyses of a high Cr-steel of unknown composition show ^{186}Os/^{188}Os – 0.1198363$\pm$ 28 and 0.1198391$\pm$ 23, indistinguishable from the chondritic ^{186}Os/^{188}Os of 0.1198398 [3] but have highly radiogenic ^{187}Os/^{188}Os (0.1711). Literature data suggests that the source for Cr (chromitites) can have very high Os concentrations (average 87 ppb) relative to the source for Fe (e:g laterites) and C (terrestrial coals) with 0.29 and 0.04 ppb respectively. The average Os isotopic composition in terrestrial coals and laterites is highly radiogenic (1.9316 & 1.499) compared to chromitites (0.1312). Clearly there can be a range of isotopic composition in ^{186}Os-^{187}Os space between our current estimates for DMM (^{186}Os/^{188}Os - 0.1198350 [4]) and the model continental crust (^{186}Os/^{188}Os -0.119885 [1]) controlled by the position in Fe-C-Cr ternary. Future ^{186}Os-^{187}Os studies on varieties of steel with different proportions of these components would help in deciphering their composition and put additional constraints on the isotopic composition of the crust.

We modeled varieties of alloy and stainless steels, with variable proportions of iron, carbon and chromium, for their Os concentration and isotopic composition. The modeled steels, with Os concentrations (1.3-65 ppb) and isotopic composition (0.1447-1.5579), closely reproduce the Os-Cr & ^{187}Os/^{188}Os-Cr trends as shown by the analyzed steels. This suggests that our estimates for the Os concentration & isotopic compositions in the different components of steel are robust and no additional reservoir for Os may be present in steel.

Keywords: Osmium, continental crust, steel, ^{186}Os/^{188}Os, ^{187}Os/^{188}Os

Citations:

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