Evolution of Highly Siderophile Elements in the Convecting Upper Mantle

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Purpose

To constrain the evolution of geochemical conditions in the convecting upper mantle by comparing Os isotopic composition and highly siderophile element (HSE) concentration of ophiolites which crystallized between 1.95 and 0.006 Ga.

Re-Os and HSE Systematics

$^{187}Re \rightarrow {}^{187}Os + \beta$

- Comparison of Os isotopic composition is based on the γOs notation which denotes the percent deviation of a sample's initial $^{187}Os/^{188}Os$ to the evolution of chondritic $^{187}Os/^{188}Os$

The HSE are Re Os Ir Ru Pt and Pd

Partial melting of the convecting upper mantle will fractionate the incompatible HSE (Re, Pt and Pd) from the compatible HSE (Os, Ir, Ru)

Geological Context

Ophiolites are sections of oceanic lithosphere which contain peridotites thought to be from the convecting upper mantle.

- Jormua Ophiolite (1.95 Ga)- Located in Finland. 10 samples from this ophiolite were analyzed.
- Albanian Ophiolite (0.165 Ga)- 16 samples analyzed. Some samples of this ophiolite were crystallized in a supra-subduction zone (SSZ) setting. They were found to not significantly deviate from the rest of the ophiolite which formed in a mid-ocean ridge (MOR) setting.
- Taitao Ophiolite (0.006 Ga)- Located in Chile. Samples from the Jormua and Albanian ophiolites were compared to 8 samples analyzed by Schulte et. al, 2009.

Methods

- Samples were digested in aqua regia and HSE were isolated by micro-distillation and anion exchange column chromatography
- Isotopic ratios were measured on N-TIMS (Os) and ICP-MS (Re, Ir, Ru, Ot and Pd)
- The isotope dilution method was used to determine the concentration of HSE in each sample
- The major source of error for this project is blank correction which removes the contribution of a spike to an isotopic ratio

Hypotheses

1. There will be a greater variance of γOs values in the Albanian and Taitao ophiolites compared to the Jormua ophiolite
2. The γOs values of the Albanian and Taitao ophiolites will average lower than the γOs values of the Jormua ophiolite
3. The HSE concentrations of the Albanian and Taitao ophiolites will be more variable than that of the Jormua ophiolite when normalized to the primitive upper mantle (PUM)

Osmium Isotopic Compositions

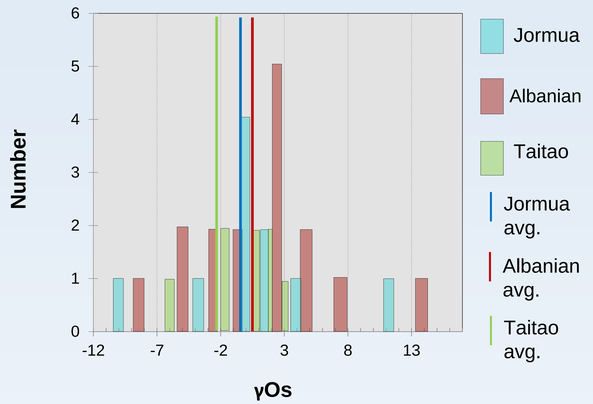

Fig. 1 Plot shows the modal distribution plot of γOs in the Jormua, Albanian and Taitao ophiolites with the averages of each indicated.

Re-Os Fractionations

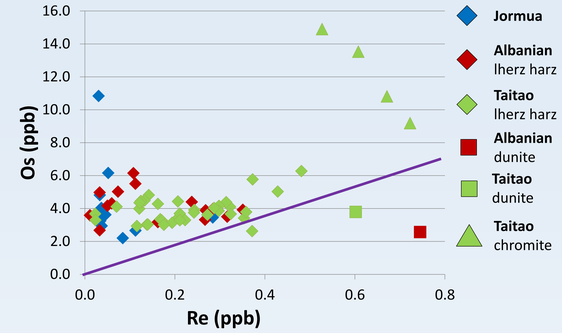

Fig. 5 Plot shows Os and Re concentrations (ppb). Average Os/Re for Earth's upper mantle from Becker et. al, 2006 are indicated by the purple line

HSE Concentrations

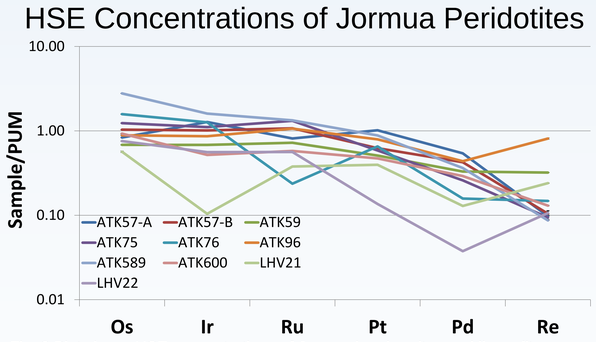

Fig. 2 Plot shows HSE concentrations of Jormua harzburgites and lherzolites normalized to PUM (values from Becker et. al, 2006).

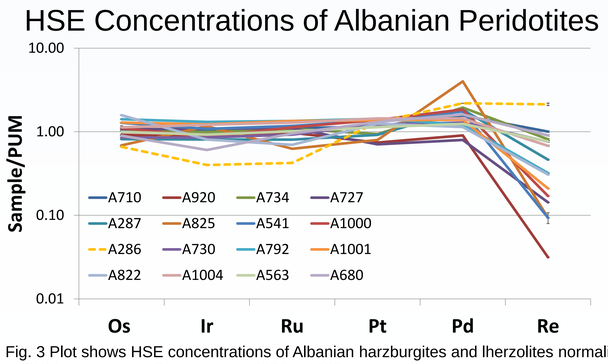

Fig. 3 Plot shows HSE concentrations of Albanian harzburgites and lherzolites normalized to PUM (values from Becker et. al, 2006). A286, a dunite, is indicated by the dashed line.

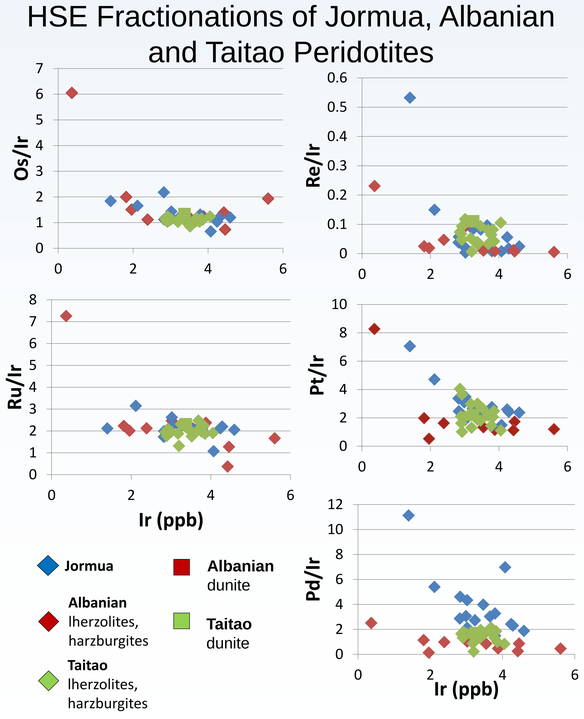

Fig. 4 Plot shows the inter-element ratios for Jormua, Albanian and Taitao peridotites.

Discussion

- The average and modal γOs are identical in all three ophiolites (Fig. 1)
- The range of γOs is slightly greater in the Albanian ophiolite than in the Jormua ophiolite (Fig. 1)
  - The Taitao ophiolite demonstrates a slightly narrower range of γOs than the other ophiolites
- The inter-element ratios of HSE show no significant variation in the concentration of HSE among the three ophiolites (Fig. 2, 3, 5)
  - With the exception of Jormua samples with low Ir, all samples show similar variability between incompatible and compatible HSE (Fig. 4)

Conclusion

- The hypothesis that the variance of γOs in the Albanian and Taitao ophiolites would be greater compared to the Jormua was not supported
- The hypothesis that the Albanian and Taitao ophiolites would have a lower average γOs compared to the Jormua was not supported
- The hypothesis that the HSE concentrations of the Albanian and Taitao ophiolites would be more variable than in the Jormua was not supported
- The average deviance of the convecting upper mantle from chondritic $^{187}Os/^{188}Os$ did not change over time
- The abundance of incompatible HSE relative to compatible HSE did not change over time