Sulphur isotopic composition of volcanic-hosted sulphide deposits at the Neoarchaean greenstone belts and the Belomorian mobile zone (Baltic Shield): A comparative study

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In the NE Baltic Shield the Late Archaean (2.81 – 2.76 Ga) greenstone belts and the Belomorian mobile zone (BMZ) comprise massive sulphide deposit associated with host volcanics. Sulphur isotopes in pyrite from the ores have been studied.

Generally the two types of Late Archaean greenstone belts are distinguished in the Baltic Shield: 1 – with prevalence of basic– ultrabasic metavolcanics; 2 – with predominance of felsic volcanic rocks. Within the BMZ the massive sulphide ore are associated with medium to felsic metavolcanics. In all the mentioned structures the sulphide ores constitute thick extensive bodies.

Discussion of results

Sulphur isotope composition in pyrite from the massive sulphide deposit of the 1- type greenstone belts resembles that of meteorite. In the latter $\delta^{34}S$ insignificantly varies within –2 – +1$^{o}/_{oo}$. In the massive sulphide deposit from the 2- type greenstone belts, dominated by felsic volcanics, the sulphur isotopes range more considerably $\delta^{34}S$ = –6 – +4 $^{o}/_{oo}$. The sulphide ore of the BMZ has even wider span of sulphur isotope composition $\delta^{34}S$ = –12 – +6 $^{o}/_{oo}$.

Conclusions

Pronounced variance of sulphur isotope compositions in the massive sulphide deposits associated with different volcanics of the Neoarchaean greenstone belts has been revealed. This may be explained by divergent depth of ore-producing magmatic chambers, which caused discrepant fractionation of sulphur isotopes.

In the BMZ the widest range of sulphur isotope compositions with evident trend to lighter isotope enrichment is caused by variable sulphur influx from both crustal and upper mantle sources in the spreading zone tectonic setting.

Ghost primordial He and Ne

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The canonical view of He isotope geochemistry holds that high $^3He/^4He$ and solar Ne in oceanic basalts fingerprint hidden undegassed mantle sources. Competing evidence of recycled material processed next to the Earth's surface being present in the source of Hawaiian basalts is nevertheless very strong, whether it be carried by oxygen or Hf isotopes.

We here discuss the marble-cake paradigm in the light of Shuster *et al*.'s (2003) diffusion data on olivine. The closure temperature for diffusion of ^3He is ~200°C and the data show that He moves around remarkably fast, e.g., more than 1 km at 1500 K and more than 5 km at 2000 K within 1 Gy. Ever since the accretion of the Earth, He and Ne originally hosted in primordial material therefore pervaded all the lithologies coexisting on length-scales typical of a marble-cake mantle (1-100 m), and, in particular, contaminated U- and Th-poor refractory residues tightly folded in with streaks of primitive mantle. Dunite and harzburgite residues left by ridge activity, and their high-pressure equivalents, therefore act as long-term sinks for 'ghost' rare gases. Conversely, such restites also act as a source of primordial rare gases for whichever recycled material gets subsequently folded in during the rest of the Earth's history, even long after most of the primordial material has been removed by processing at mid-ocean ridges. A numerical marble-cake diffusion model with suitable parameters can reproduce the uptake of primordial gases initially present in the primordial lower mantle by background refractory residues and its subsequent transfer to younger 'layers' of recycled pyroxenite. Both low- and high-$^3He/^4He$ hotspots may be produced by changing the duration of the diffusion process and the U and Th contents of refolded pyroxenite layers.

Upwelling beneath mid-ocean ridges happens much too fast (<100 My) for the refractory material to be flushed clean of primordial gases by diffusion. However, once back into the deep mantle, primitive-looking He and solar Ne from these refractory layers have plenty of time to permeate into all sorts of newly neighboring layers, whether recycled or primitive. Decoupling by diffusion certainly explains the lack of coherence between $^3He/^4He$ and lithophile isotopic tracers. Although rare gas isotopes require that the upper mantle is more outgassed than the lower mantle as a whole, neither He with high $^3He/^4He$ nor solar Ne in basalts are diagnostic of the presence of primordial material in the source itself. Likewise, the missing terrestrial ^{40}Ar is likely to be another ghost rare gas hosted largely by refractory residues, thus essentially voiding a widely used constraint on the proportion of undegassed solid mantle.

References

Shuster D.L *et al.* (2003), *Earth Planet. Sci. Lett.* **217**, 19-32.