Rare gases systematics and mantle structure

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About ten years ago we published a general review of rare gases systematic in the atmosphere–mantle–crust system. Our model at that time was self consistent, based on the available data and explained as well helium, as argon and xenon isotopic signatures. It is today certainly not the only possible model, since new data have been obtained and experimental progress was made.

We will emphasize the following points:

One of the most important ones is certainly the first set of experimental data on the solubility of noble gases in metal phases at intermediate pressures (Matsuda *et al.*, 1993), since the core was certainly not formed at ultra high pressures, as emphasized by Ahrens and confirmed by trace elements systematics reported by Wänke. The experimental data clearly show that the core can not be a major reservoir for terrestrial rare gases.

The second point is a more elaborate reconsideration of the ^{40}K–^{40}Ar budget of the Earth. This shows that ^{40}Ar contained in continental crust + upper mantle + atmosphere is at maximum half of the ^{40}Ar inventory of the whole earth. This implies the existence of a two layered mantle (Allègre *et al.*, 1994).

The third point is the discovery by the Australian noble gas group of the existance of high $^{20}Ne/^{22}Ne$ and low $^{21}Ne/^{22}Ne$ isotopic ratios in Loihi seamount samples (ex. Honda *et al.*, 1991, 1993). These results, which are different from the MORB ratios (Sarda *et al.*, 1986), confirm the idea of a two layered model, but suggest the existence of a primordial solar type Ne reservoir.

Several possibilities about the origin of this ^{20}Ne excess in the mantle will be discussed.

Finally, the high $^{40}Ar/^{36}Ar$, $^{129}Xe/^{130}Xe$ and $^{134}Xe/^{130}Xe$, $^{136}Xe/^{130}Xe$ are confirmed by new data. The corresponding ratios for the lower mantle will be discussed. $^{40}Ar/^{36}Ar$ ratios up to 6000 can be accepted and will not modify the general model of the mantle. They confirm the atmosphere chronology, about 85% of the atmosphere was formed in the first 50 My and 15% later on.

We will also discuss the results obtained on xenoliths or phenocrysts in different lava types and try to constrain the information they carry, using the simple idea that xenocrysts in hot spots do not derive from the deep source as the magma which carry them.

References

Allegre C.J. (1994) *Earth Planet. Sci. Lett.*, in press.Matsuda S., Sudo M., Ozima M., Ito K., Ohtaka O. and Ito E. (1993) *Science*, **259**, 788–90.

Honda M., McDougall I., Patterson D.B., Doulgeris A. and Clague D.A. (1991) *Nature*, **349**, 149–51.

Honda M., McDougall I., Patterson D.B., Doulgeris A. and Clague D.A. (1993) *Geochim. Cosmochim. Acta*, **57**, 859–74.

Sarda *et al.* (1988) *Earth Planet. Sci. Lett.*, **91**, 73–88.