The Mantle Zoo: New species, endangered species, extinct species

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It has been 29 years since Allegre introduced the field of Chemical Geodynamics, and 25 years since Zindler and Hart formalized the concept of geochemical mantle components, with an attendant, to some odious, concoction of acronym soup. Work on this marriage of mantle geochemistry and mantle dynamics continues unabated to this day, with many Sisyphean heroes along the way. In 1986, we had a chondritic Earth model that we believed (give or take a minor problem with oxygen), and plumes ruled the dynamics of the mantle. Today we don't know what Earth is made of, and there is a vocal (albeit misguided) faction that repudiate plumes! We know unequivocally that the mantle is chemically heterogeneous, but we do not know the scale lengths of these heterogeneities. We know unequivocally that these heterogeneities have persisted for eons (Gy); we don't know where they were formed or where they are stored.

The most accessible and well understood mantle reservoir is the upper depleted MORB mantle (DMM). Classically, this mantle was depleted by extraction of oceanic and continental crust from a "chondritic" bulk silicate Earth. In this post-Boyet and Carlson world, the complementary enriched reservoir may instead be hidden in the deepest mantle. If the Earth is non-chondritic, DMM will be an endangered species. It is widely believed that the DMM is a mixture of peridotitic and mafic lithologies; I think this is an open question.

Radiogenic Pb mantle (HIMU) was argued by Hofmann and White (1982) to be re-cycled ocean crust, and this is still the most viable of existing models. It does require some *ad hoc* chemical manipulations during subduction to satisfy the isotopic constraints (e.g. Th/U fiddling). Given 2 Gy of likely aggregate mantle strains, the mafic component in HIMU will be of small scale length (< 50 m), possibly subsumed into the dominant peridotitic lithology. This mantle species is widespread (Atlantic, Pacific and Antarctic hotspots).

Enriched mantles (EM1 and EM2) almost certainly reflect recycling of enriched continental material. This was verified spectacularly by Jackson *et al* (2007), with the report of EM2 Samoan lavas with $^{87}Sr/^{86}Sr$ up to 0.721. The lithology and scale length of EM1 and EM2 is unconstrained. EM1 is present in Atlantic, Pacific and Indian hotspots; EM2 is confined to the SW Pacific hotspots.

In 2007, FOZO was split into 2 new subspecies (A and B). Many would like to see both become extinct!

Enhanced weathering – Not only CO_2-consumption

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Artifically enhanced weathering at the terrestrial surface by spreading olivine powder on land is one posibillity to contribute to the drawdown of CO_2 from the atmosphere. However due to limitations it is assumed that possibly not more than 1 Gt C a^{-1} can be sequestered by this technique .[1]

Further "effects", which may contribute additionally to the CO_2-sequestration by this technique, have been less analysed, and quantified.[2] At the same time as CO_2-is bound in the water, in the form of bicarbonate or carbonate, silica is released into the aqueous system. In case the propoposed technique would be excersised to its limits, the release of dissolved silica would be a multiple of the natural dissolved silica fluxes from the terrestrial system to the river systems and thus of the land-ocean fluxes.

Dissolved silica is a beneficial nutrient to many crop species, and harvest as well as biomass of these plants are likely to increase significanlty.[3] Additional biomass of plants due to additional silica uptake could be used in strategies to recarbonize the soil-carbon pool. In addition, increased levels of dissolved silica will likely increase the biomass of silica uptaking species in limnic systems, specifically in those, which are eutrophied, and/or are characterised by low silica concentrations. Some proportion of the biomass is sedimented and stored in the river systems, like in lakes or flood plains, and it is not known how much this could be. Further, instead of the mineral olivine one could use less soluble, grinded rocks, which contain significant amounts of phosphorus. In this case P-limited ecosystems might increase their biomass and add to the CO_2-sequestration by artifically enhanced weathering.

[1] Köhler, P., Hartmann, J., Wolf-Gladrow, D. The geoengineering potential of artificially enhanced silicate weathering of olivine. *Proc. Nat. Acad. Sciences* **107**(47), 20228-20233 (2010) [2] Hartmann, J., Kempe, S. What is the global potential for CO_2 sequestration by "stimulated" weathering? *Naturwissenschaften* **95**,1159–1164 (2008) [3] Alvarez, J., Datnoff, L.E. The economic potential of silicon for integrated management and sustainable rice production. *Crop Protection* **20**(1), 43–48 (2001)