^{210}Pb-^{226}Ra disequilibria: Mantle melting or gas fractionation?

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Disequilibria between nuclides of the U-decay-series have been used to date volcanic eruptions. However, where eruption dates are known, existing disequilibria at the time of eruption can also be used to infer the time since fractionation of the respective isotope pairs by magmatic processes. Most elements, particularly those of the longer lived nuclides are very incompatible and difficult to fractionate magmatically. In many systems, disequilibria require dynamic melting models which rely on the unique ability of these isotopes to be constantly produced by decay. A significant database of (^{230}Th/^{238}U), (^{231}Pa/^{235}U), (^{226}Ra/^{230}Th) data has been amassed, decreasing the timescale of magma formation and ascent further with each isotope pair. Most recently, (^{210}Pb/^{226}Ra) disequilibria in MORB have been suggested to result from mantle melting [1], requiring magma to move from source to surface in less than 100 years. However, disequilibria between ^{226}Ra and ^{210}Pb can also be produced by fractionation of ^{226}Ra and intermediate isotope ^{222}Rn during volatile exsolution and transport [2].

A review of published and unpublished (^{210}Pb/^{226}Ra) data from magmas of different tectonic settings reveals distinct differences; while the global distribution of (^{210}Pb/^{226}Ra) is normally distributed around unity, magmas from plume and ridge environments have almost exclusively ^{210}Pb deficits and magmas from arc settings have both ^{210}Pb deficits and excesses. Furthermore, plume settings have a normal distribution with a median value less than unity (and a single peak of data in unity, due to decay), while arc magmas have a lognormal distribution towards ^{210}Pb excess with a median value of unity. We interpret this and additional arguments in favour of a young (^{210}Pb/^{226}Ra) mantle signature in plume environments, which, though potentially also present in arcs, is overprinted by gas-melt fractionation of Ra-Rn. For ocean island basalts to carry such a signature, source to surface transport of magma occurs on a timescale of decades.

[1] Rubin K.H., van der Zander I, Smith M.C. & Bergmanis E.C. (2005) *Nature* **437,** 534-538 [2] Gauthier PJ & Condomines M (1999) *Earth Planet. Sci. Lett.* **172,** 111-126.