Isotopic Variations in the Northern Galápagos Volcanic Province

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The Northern Galápagos Volcanic Province (NGVP), located between the Galápagos Archipelago and the Galápagos Spreading Center (GSC), is ideally located to provide insight into the mechanisms of plume-ridge interaction. The plume is located south of the GSC, close enough to have profound geochemical and geophysical influences on the ridge. During the 2010 MV1007 research cruise, we collected geophysical data and >40 dredges across the NGVP, in a survey bounded by the Wolf-Darwin Lineament (WDL) to the west and Genovesa Island to the east.

Preliminary Sr, Nd, and Pb isotopic data reveal several important observations about the composition of lavas in the NGVP: a) most NGVP lavas are more enriched than those from the northern margin of the Galápagos Platform; b) consistent with previous work in the archipelago [1, 2], geochemical variations of Nazca Plate lavas require 3 distinct isotopic endmembers, a dominant one with elevated $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ for a given $^{206}Pb/^{204}Pb$ (like WD from [2]), one with moderate Sr, Nd, and Pb ratios (like PLUME from [2]), and a depleted MORB-like composition; c) lavas from Pinta Island eastward are binary mixtures of WD and depleted mantle; d) lavas erupted on the Cocos Plate may be influenced by a 4th endmember with elevated $^{206}Pb/^{204}Pb$ and $^{87}Sr/^{86}Sr$ (i.e., FLO from [2]); and e) there are no systematic spatial variations in isotopic ratios along volcanic lineaments on the Nazca Plate (e.g., the WDL).

Our results have implications for plume-ridge interaction and the composition of the Galápagos plume. The NGVP is dominated by the elevated $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ component, with only minor influence of the material supplying the western Galápagos shields, the locus of the plume. This suggests that the plume is strongly spatially zoned or that there is an additional source of enriched mantle material limited to the GSC area. The lack of spatial patterns in geochemistry across the Nazca Plate in the NGVP further indicates that enriched material is distributed throughout the mantle between the ridge and the plume and reaches the surface through crustal weaknesses generated by regional stresses [3, 4]. The presence of enriched material in Cocos Plate lavas suggests plume-related material is bypassing the zone of upwelling beneath the GSC as it flows to the north. These results confirm that the Galápagos system may be mirroring Hawaii and other plumes that exhibit strong north/south spatial zonation [5], The Galápagos are distinct from Hawaii, however, in that the more radiogenic Pb component is in the northern arm of the plume instead of the south.

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Manganese, Fenton Chemistry, and Disease: The proof is in the inflammation.

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Exposure related diseases can be, for the most part, broken down into two categories, mutagenic and toxic. While a mutagenic disease results from disruption of normal cell replication, an illness based on particle toxicity is derived from the ability of the material to generate an inflammatory stress response (ISR), dysregurate the cell, and possibly lead to cell death. Particle-derived cellular oxidative stress is likely a key contributor to many occupational health diseases, such as silicosis and coal workers' pneumoconiosis.

Reactive oxygen species (ROS), and the hydroxyl radical in particular, are known to cause oxidative stress. Earth materials can generate ROS in two different ways, via surface defects and oxidative dissolution. The oxidative dissolution of minerals allows for metal cations to enter the solution. Once in solution, these cations can partake in Fenton chemistry.

While iron is the most recognized Fenton metal, new research indicates that chromium, copper, vanadium, recently manganese can also generate ROS, although the reaction mechanisms are not well understood [1-3]. Originally only taking iron into account, the Fenton reaction can now be generalized to [4]:

$$H_2O_2 + M^{n+} \rightarrow M^{(n+1)+} + {}^{\cdot}OH + OH^-$$

where M is a metal cation which can donate one electron and be stable at this new oxidation state [4].

Exposure to manganese is thought to be the root for many neurological diseases, such a Parkinson's, Alzheimer's and Huntington's. However, its role in the development of pulmonary diseases through stimulating inflammation is unknown. In the present study, the ability of different species of manganese to generate ROS and an ISR at the cellular level is examined. Furthermore, the confounding effects of having iron and/or quartz in the system are investigated.

Experiments using dissolved manganese and iron species are performed to compare their abilities to generate ROS and an ISR. These tests are performed utilizing an array of geochemical and biochemical techniques [5,6]. More intricate experiments will be performed using iron and/or manganese as co-contaminates and co-precipitates onto synthetic quartz.

Initial experiments have demonstrated the ability of manganese to elicit an ISR. Furthermore, the higher solubility of manganese compared to iron, which precipitates out into a relatively inert ferric phase, allows for a considerably steady ISR over time and a response that continuously increases with loading.

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