

Sulfur solubility to basaltic magma and fractional crystallization of silicate minerals: clues to the origin of HIMU source

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It has been widely accepted that subduction of oceanic crust and, growth and recycling of continental crust produced at least three enriched and one depleted components in the mantle (HIMU, EMI, EMII and DMM), and thus the processes are essential to understand the chemical evolution of the Earth. The origins of enriched components are usually explained by recycling of oceanic crust (HIMU) with variable amounts of sediments (EMI and EMII). The depleted component (DMM) is commonly explicated by melt extraction during the production of continental crust. As the continental crust is inferred to be formed at subduction zone, the chemical compositions of OIB source and continental crust could potentially be connected.

Although the growth rate of the continental crust is still in debated, much of the crust seems to be formed during Archean and early Proterozoic times. In such ancient time, the subducting oceanic crust would be much more likely to be melted due to high geothermal gradient and low average age of the crust. If this is the case, recycled material observed in OIB should have experienced melting rather than dehydration because the age of recycled material is inferred to be ca 1.0-2.0 Ga. Nevertheless, melt-extraction process can not produce the suitable isotopic composition of OIBs. Dehydration of oceanic crust is another major process in subduction zone especially at present. In addition, the process is widely accepted as the origin of HIMU source. It might follow that HIMU magmas could be a common type of OIB as the dehydrated oceanic crust should be a major constituent of subducting slab. In spite of this expectation, occurrence of HIMU magmas is quite rare: only observed in St. Helena in the Atlantic Ocean and the Cook-Austral islands in the South Pacific Ocean. These lines of evidence could suggest that simple dehydration reaction or melting event was not suitable to produce the OIB source.

It was shown that lead is leached out from the oceanic crust and deposited with sulfides on the surface of the oceanic crust by hydrothermal alteration. From this perspective, models that explain the origin of HIMU were proposed. Similarly, it was concluded that lead spike observed in the chemical composition of the continental crust was produced by selective dissolution of sulfide to aqueous fluid that promoted lead segregation from the subducting oceanic crust to the continental crust. These models strongly suggest the genetic linkage between HIMU source and continental crust. However, as mentioned earlier, production of HIMU magma is quite rare. Furthermore, these models mainly focused on lead isotopic composition and concentration.

For the comprehensive understanding of the relationship between OIB source and continental crust, geochemical modeling has been conducted using trace element composition and Pb, Nd and Sr isotopic ratios. The result suggests that dehydration melting of oceanic crust at shallow level (amphibole stability field) can produce melt of which trace element composition is similar to bulk continental crust. In addition, the residual oceanic crust can produce Pb, Nd and Sr isotopic composition that is consistent with FOZO component at the age of 10-20 billion years. HIMU component can only be produced by the dehydration melting of oceanic crust that suffered strong crystal fractionation. During the fractional crystallization, U and Th concentration are increased. Sulfur solubility is also enhanced during the crystal fractionation due to iron enrichment. High sulfur content in the evolved magma leads to distribute much more lead into sulfide compared to less evolved oceanic crust. This geochemical feature could be suitable to produce HIMU source via dehydration melting. We will present a geochemical model that is focused on origin of HIMU source and the relationship between continental crust and OIB sources.