Tholeitic Basalts of Venus as Compared to Normal Mid-0cean Ridge Basalts of Earth in Terms of K-U-Th Systematics.

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On Earth, tholeitic Basalts of Normal (non-hotspot) segments of Mid-Ocean Ridges (N-MORB) is a usual petrological reference point as melts from the upper mantle depleted in incompatible elements including K, U, and Th. Literature-derived data base for 288 N-MORB samples was compiled and the set of 67 samples qualified as fresh and representative was selected. Comparison of K, U, Th data on four Venus' tholeitic-basalt materials[1,2] with K-U-Th systematics of the set of N-MORB shows the venusian basalts are much richer in K, U, and Th than Earth' N-MORB. This result suggests the tectono-magmatic setting of the venusian tholeite formation was different from those of Earth' N-MORB in enrichment of the venusian magmas in incompatible elements.

Introduction. On Venus, five materials were measured in only K, U and Th by GRS[1-3]. Bulk chemistry of high-K material analyzed in the Venera 8 landing site is still controversial. In contrast, the general consensus seems to be that the materials measured in Venera 9, 10 and Vega 1, 2 landing sites are similar chemically to tholeitic (low-K) basalts[1,2,4,5]. Tholeitic basalts from different tectonic settings of Earth have nearly the same major-element composition (e.g.,[6]), but may differ profoundly from one to another in their K, U, and Th contents. Compare, for example, Oceanic Island Tholeites and N-MORBs: K2O (%), 1.45 *vs.* 0.07; U(ppm), 1.02 *vs.* 0.05; and Th(ppm), 4.00 *vs.* 0.12, respectively[7]. The case is that K, U, and Th belong to incompatible elements which are concentrated into the magma during partial melting of mantle peridotite. It has long been recognized that distinctive incompatible-element signatures tend to be characteristic of particular tectonic settings due to particular magma sources and/or magma generation processes (e.g.,[10]). Certainly, for Earth' igneous rocks, the tectono-magmatic systematics by only K, U, and Th it is not a traditional approach. But this systematics would allow to put the K, U, Th-measured rocks of Venus in the context of Earth' igneous rock petrology. I begin with K-U-Th systematization of Earth' N-MORB to compare it with measured tholeitic-basalt materials of Venus.

Data Base Analysis and Result. Data for 288 of N-MORB samples were obtained from a large literature search. They are presented in detailes in[8] and briefly here.

The samples might suffer seawater alteraton upon which K and U are known to be mobile. So the major challenge was to select only fresh samples. To do it I used criteria of three types. Chemical criteria: a sample was treated as fresh if it showed <0.3% H_2O^+, <0.3% H_2O^-, <0.9% LOI, <0.25% CO_2, Fe_2O_3/FeO <0.3, and K_20/P_2O_5 <1, and as altered if it did not satisfy at least one of these conditions. For 35 samples there are no data on any of these parameters. Petrographic criteria: a sample was attributed to be "fresh" or "altered weakly , "moderately", or "highly", based on the term definitions adopted me and applied to author's thin section descriptions. Since jump of value scatter of Th/U (immobile/mobile elements) ratio was revealed to begin with moderately altered samples, fresh and weakly altered samples were selected as actually fresh. For such samples with no data on chemical criteria, a sample was considered as fresh if it put within the Th/U-K field for the samples fresh in chemistry and fresh/weakly altered in petrograpy. The final set is 67 N-MORB samples qualified as fresh for the K-U-Th systematics (Fig.1).

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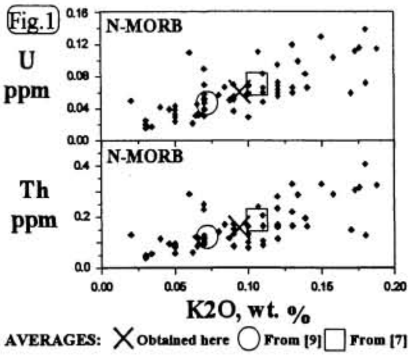
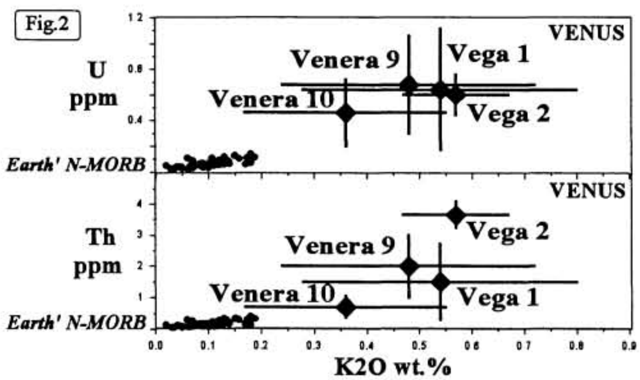


The set shows the average contents and standard deviations as following: K_2O, 0.09±0.04 wt.%; Th, 0.16 ±0.08 ppm, and U, 0.06±0.03 ppm. As seen in Fig.1, these average values are between estimates used typically for normalization on N-MORB[9,7] and cover them within one standard. The set involves 46 quenched glasses, 18 basalts, and 3 dolerites, which are derived from Atlantic (28 samples), Pacific (36 samples), Indian (2 samples) Oceans, and Red Sea (one sample). 90% of the samples are recent in age. As shown in[8], Th/U ratio within the set increases with increasing Th, while K_2O/U ratio are nearly constant with increasing K_2O. These trends are in full accord with known order of the element incompatibility for oceanic tholeites: Th>U ≈K(e.g.,[7]). So, the set is recognized to be rather representative of Earth' N-MORB.



Result of Comparison of Venus' Tholeitic Materials with Earth' N-MORB in K, U, and Th are demonstrated in Fig 2 which is the diagram of Fig.1 enlarged to include venusian data from[1,2]. As seen in Fig.2, none of four Venus' tholeitic materials measured is similar to Earth' N-MORB being much richer in all the measured incompatible elements, K, U, and Th.

Discussion. On Earth, N-MORB is derived from the upper mantle depleted in incompatible elements by episodes of previous melting (e.g.,[10,7]). The depleted mantle is characteristic of the mantle beneath basaltic crust of the oceans (e.g.,[6,7]).

On Venus, like on Earth, there is a crust[3]. Most of the surface of Venus, like the ocean floor of Earth, is covered by variously aged products of basaltic volcanism (e.g.,[11]). So the upper mantle of Venus, like the suboceanic upper mantle of Earth, might be incompatible-element-depleted and produce depleted basalts too. However, according to the result above, this is not the case. Instead, all of the K, U, Th-measured tholeitic basalts of Venus evidence a strong enrichment of their magmas in incompatible elements. K, U, Th comparison of these enriched basaltic materials of Venus with Earth' enriched basalts from the characteristic tectonic settings would gain insight into the Venus' basalt genesis. This requires further work on K-U-Th systematics of Earth' igneous rocks.

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