

IMPLICATIONS OF THE VENERA 13 SURFACE ANALYSIS FOR THE CO<sub>2</sub> CONTENT OF THE INTERIOR OF VENUS; J. Longhi<sup>1</sup> and V. Pan<sup>2</sup>, 1: Lamont-Doherty Geological Observatory, Palisades, NY 10964; 2: Dept. of Geology, Arizona State University, Tempe, AZ 85287-1404.

Typically, when comparisons of the bulk carbon contents of the Earth and Venus are made, carbon abundances in the Earth's mantle, crust, oceans, atmosphere, and biosphere are integrated, but in the case of Venus only atmospheric carbon (CO<sub>2</sub>) is integrated (e.g., 1). These comparisons show the carbon contents of the two planets to be roughly comparable ( $1.5\text{--}4.5 \times 10^{-5}$  kg/kg for the Earth vs  $2.7 \times 10^{-5}$  kg/kg for Venus). Explicit assumptions of the estimate for Venus are that little or no carbon remains in the mantle or is bound up in crustal minerals. Given that CO<sub>2</sub> may affect the proportions of major elements in silicate melts at high pressure (2), it is possible to test the first assumption by examining the compositions of Venusian basalts. Unfortunately, we have available only two analyses of basaltic materials. These are surface analyses with large uncertainties obtained from spectrometers on the Venera 13 and 14 landers (3). Because it may be decades before samples are actually returned for high quality analyses, we believe it is worthwhile at least to point out the implications of the data in hand.

The upper mantles of the terrestrial planets are generally believed to consist primarily of a lherzolite assemblage: olivine, orthopyroxene, clinopyroxene  $\pm$  an aluminous phase (4). The most important effect of CO<sub>2</sub> on high pressure melting is to expand the stability range of orthopyroxene (2). This expansion means that at a given pressure CO<sub>2</sub>-bearing melts in equilibrium with olivine, orthopyroxene, and clinopyroxene will have lower SiO<sub>2</sub> and higher CaO contents than similarly saturated CO<sub>2</sub>-free melts. In terms of mineral components this means that CO<sub>2</sub>-bearing melts saturated with the lherzolite assemblage will have lower proportions of normative orthopyroxene and higher proportions of Ca-silicate components. The effect of H<sub>2</sub>O is nearly opposite with H<sub>2</sub>O tending to produce SiO<sub>2</sub>-rich melts (5). Increasing alkalis at high pressure decrease both the orthopyroxene and Ca-silicate components (6). The effects of CO<sub>2</sub>, H<sub>2</sub>O, and alkalis are shown as vectors in Fig. 1. Unfortunately, the effects of CO<sub>2</sub> are best known for simpler systems and have not yet been quantified on natural compositions. Nevertheless, Fig. 1 shows a sharp divergence between the "main sequence" of silica-undersaturated terrestrial lavas compiled by (7) and the compositions of experimental liquids in equilibrium with the lherzolite assemblage generated at 10 to 35 kb under fluid-absent conditions (8,9). Given that the release of CO<sub>2</sub>-rich volatiles with the eruptions of silica-undersaturated lavas is well documented (10), that carbonates are common accessory minerals in undersaturated rocks (11), and that carbonatites are commonly associated with silica-undersaturated rocks (12), it seems reasonable to attribute the divergence of the main sequence of lava composition from the range of high-pressure fluid-absent melts primarily to the influence of CO<sub>2</sub>.

Fig. 2 contrasts the compositions of the Venera 13 and 14 soils with the main sequence of terrestrial lavas. The Venera 14 analysis is generally similar to terrestrial tholeiites (silica-saturated), however, the Venera 13 analysis, shown as an ellipse to illustrate the uncertainties in SiO<sub>2</sub> and CaO reported by (3) and including a conservative estimate of 1.5 wt % Na<sub>2</sub>O, is strongly silica-undersaturated and projects distinctly below the terrestrial main sequence as do the compositions of the fluid-absent high-pressure melts illustrated in Fig. 1. We interpret the Venera 13 composition to imply a potential lack of influence of CO<sub>2</sub> on melting relations in the upper mantle of Venus. If the Venera 13 surface analysis is an accurate (within stated limits) representation of a typical silica-under-saturated volcanic protolith, then the upper mantle of Venus contains much less CO<sub>2</sub> than the Earth's and the assumption that the Venusian mantle is extensively degassed at least with respect to CO<sub>2</sub> seems well-founded.

## REFERENCES

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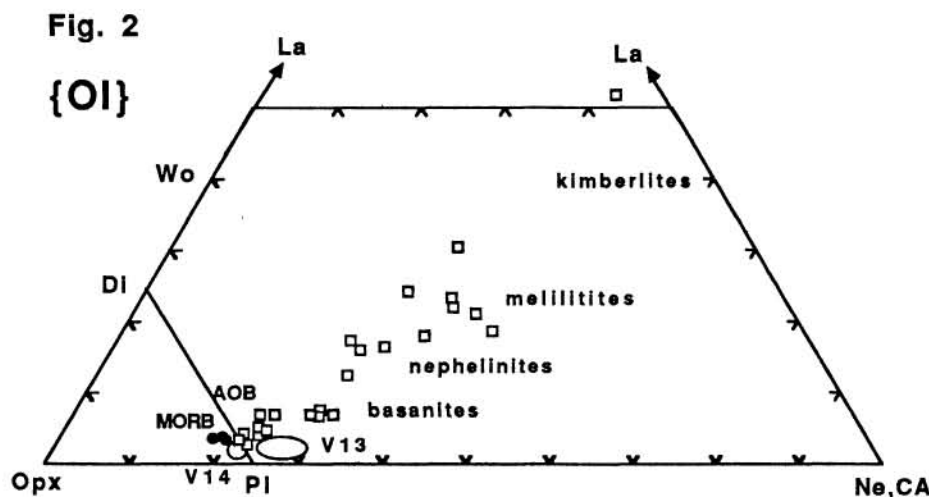
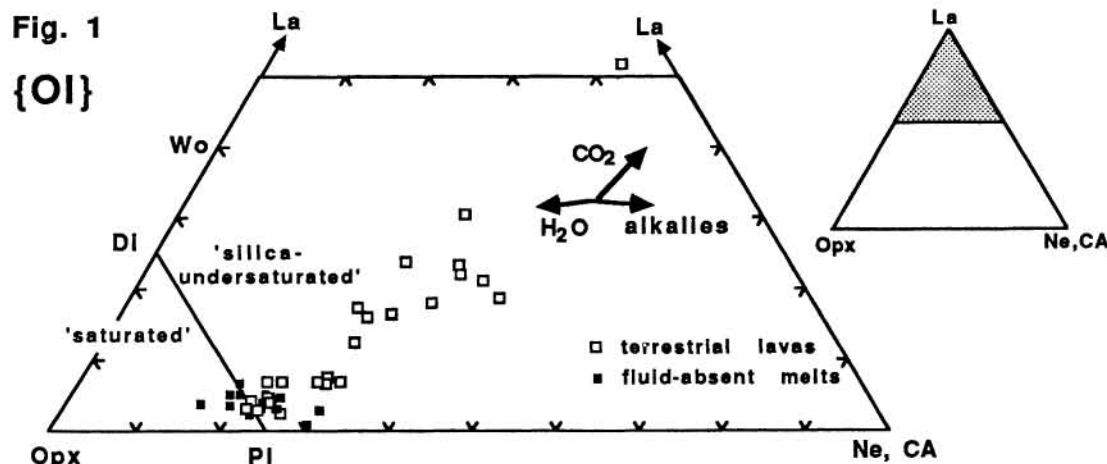


Fig. 1 Comparison of natural terrestrial lavas (7) with high-pressure (10-35 kb) fluid-absent melts in equilibrium with olivine, orthopyroxene, and clinopyroxene (8,9). Vectors show the effects of various components on the projection of compositions of liquids saturated with the Iherzolite assemblage. Compositions are projected from the Olivine component (OI) onto a portion of the plane Orthopyroxene (Opx) - Larnite (La) - Nepheline (Ne), Calcium-aluminate (CA) after (7). The Di-PI join separates silica-saturated (tholeiitic) from silica-undersaturated compositions. Fig. 2 Comparison of Venera 13 (ellipse) and Venera 14 (circle) surface analyses (3) with terrestrial lava compositions. Projection as in Fig. 1.