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The effects of contrasting Ti and Al activities on Mn/Fe systematics in pyroxene from lunar mare basalts

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ABSTRACT

The usefulness of the Mn/Fe ratios of olivine and pyroxene to identify a sample's host parent body is well established. Although there is an overarching, defining slope for each planetary body, there is some scatter, or "dispersion" around the defining slope. This dispersion reveals important facts relating to the planetary body. The source regions of the three main types of lunar basalts (very high-Ti, low-Ti, and very low-Ti) have f_{O_2} values near IW-1 or below, and all iron is either ferrous or metallic. The dispersion in the Mn/Fe ratios of pyroxene from the Moon is largely caused by differences in the Ti and Al concentrations in the mantle source regions and the resulting differences in Ti activity of the primary basaltic melts derived from those sources. Ti displaces ferrous iron in the pyroxene M1 site (in a coupled substitution with Al for Si in the tetrahedral site), and therefore, with increasing Ti activity the Mn/Fe ratio in pyroxene increases in all three suites studied. For lunar mare basalts, the effect of Ti activity on the occupancy of the pyroxene M1 site, and crystallization sequence differences among high-Ti, low-Ti, and VLT basalts account for almost all of the observed dispersion in the Mn/Fe ratios.

Keywords: Pyroxene, basalt, manganese, iron, titanium, aluminum