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Chemical comparison between terrestrial ferropicrites and Martian shergottites and soils

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Ultramafic volcanic rock called ”ferropicrite” occurs in some terrestrial large igneous provinces (LIPs) of various ages such as Pechenga (Kola Peninsula, Early Proterozoic), Siberia (Permo-Triassic), Parana-Etendeka (Early Cretaceous), and East Greenland (Early Cenozoic). Recently, we found ferropicrites and related ferrobasalts (rarely with olivine spinifex texture) from Permian greenstones occurring as basal part of a nappe in the Jurassic accretionary complex in Obama City, Fukui Prefecture (Ichiyama et al. 2006; Ichiyama et al. 2007). Filiberto (2008) pointed out close chemical resemblance between these terrestrial ferropicrites and Martian meteorites (especially shergottites), which includes ferrobasaltic, ferropicritic and ultramafic cumulate rocks. In general, terrestrial basaltic rocks and Martian shergottites plot in separate fields in the Mg/Si-Al/Si, Ca/Si-Mg/Si, and Fe-Si diagrams, but terrestrial ferropicrites plot in the same field as the Martian rocks. The ferropicrites containing 20 wt.% or more FeO cannot be produced by partial melting of ordinary terrestrial mantle rock (peridotite), but can be produced by high-pressure partial melting of Fe-rich eclogite that may be recycled material of the subducted ancient oceanic crust (Ichiyama et al. 2006). The origin in the analogous ”heavily processed mantle” may be applicable to the Martian shergottites (Filiberto 2008). However, the Martian shergottites are distinctly richer in Mn and Cr than the terrestrial ferropicrites, and this characteristics is also shared by the Martian soils analyzed by ”Spirit” in Gusev Crater (Gellert et al. 2006). The two elements behave contrastingly through partial melting and magmatic differentiation processes (incompatible and compatible, respectively), and the fact that the Martian rocks are rich in both elements suggests chemical uniqueness of the Martian mantle. The Martian rocks are also rich in Co but poor in Ni. This does not favor the magmatic origin in the mantle doped with metallic iron or iron sulfide. The Cr-rich and Ni-poor feature of the Martian mantle suggests that it mainly consists of pyroxene rather than olivine. The chemical resemblance between Martian soils and shergottites suggests widespread occurrence of ferropictiric rocks on Mars, contrasting to their scarcity on the Earth. It is possible that the Martian mantle is more pyroxenitic or eclogitic than the terrestrial mantle, and the Mars produced much more ferropicritic magmas. Melting temperature of iron-rich eclogite is lower than peritotite, and this may have merited the ancient, long-term, voluminous magma production that is unlikely in the rapidly cooling, small planet.

Keywords: ferropicrite, LIP, oceanic plateau, mantle, Mars meteorite, shergottite