THE ROLE OF CO_2 IN THE FORMATION OF THE NAKHLITES: METASOMATISM IN THE MARTIAN MANTLE?; V. Pan.[1], J. R. Holloway[1,2] and C.M. Bertka[3] ([1]Dept of Geology and [2]Dept of Chemistry, Arizona State University, Tempe, AZ 85287, [3]Geophysical Laboratory, Carnegie Institute of Washington, Washington D.C. 20008)

Mars is a volatile-rich planet with an atmosphere composed of greater than 95% CO_2. Investigations of the SNC meteorites together with the analysis of their possible parent magma compositions suggest that Martian magmatism involves complex conditions which include interaction with volatiles. Recent studies of the Chassigny meteorite indicate that as much as 3wt% H_2O may have been in the parent magma [1]. The presence of amphiboles in shergotites suggests that H_2O was also involved in their genesis [2]. The nakhlites, however, do not contain any hydrous phases but they are special in that they are enriched in LREEs with a negative ε_{Nd}, similar to the signatures of terrestrial metasomatized silica-undersaturated alkaline lavas. Estimates of the parent magma composition of the nakhlites [3,4] produced compositions that are high in normative wollastonite relative to the parental magmas of the shergotites and chassignites which is indicative of the influence of CO_2 during its genesis [4]. We will examine the effects involving CO_2 in the melting of the martian mantle.

Possible origins of the metasomatic CO_2 phase may be the decarbonation products of a carbonated mantle assemblage [5]. An experimental investigation on the carbonate-melting relations in the Martian mantle at 25 kbar and 1200°C produced an immiscible carbonate melt that is enriched in Fe, Mg, and the incompatible elements K and P [6]. This phase is likely to be enriched in the incompatible REEs from the mantle assemblage. The oxygen fugacity of this phase is in equilibrium with the carbonated mantle assemblage which is buffered by the reaction: 2 enstatite + 0.5 dolomite = forsterite + 0.5 diopside + graphite + 2 oxygen (GEDOD) [7]. This oxygen fugacity buffer is approximately 0.5 $\log_{10}$ units below the Ni-NiO oxygen buffer. Another metasomatic agent may be a CO_2-rich fluid.

Figure 1 illustrates compositions projected from Olivine. Plotted are 1 atm liquidus boundaries from [4] , the Nakhla parental magma compositions D [3] and N [4]. The shaded field encompasses the compositional range for the parental magmas of the shergotites and the Chassigny. The circled field traces the liquid compositions in equilibrium with olivine and orthopyroxene from volatile-free Martain mantle melting experiments at 15 kbar and 1350-1500°C (40-55% partial melting). DW is the estimated Martian mantle bulk composition [8]. The volatile-free liquid compositions show that high pressure melting of the martian mantle will not drive melt compositions to higher normative Wollastonite compositions. Previous experimental studies show that H_2O has the effect of driving compositions toward the OPX apex [1], whereas the effect of CO_2 on mantle melting relations will expand the orthopyroxene liquidus field thereby driving liquid compositions to higher Wollastonite compositions [9].

Upon fusion, the melt will simultaneously dissolve CO_2 until saturation is achieved. This attainment of fluid-saturation is difficult to assess due to the unknown quantities of carbon available for dissolution as well as the unknown pressure of generation that formed these melts. We can place an estimate on the maximum amount of dissolved carbon as a function of pressure by utilizing an experimentally derived CO_2 solubility model for tholeiitic basalts [10]. (Previous CO_2 solubility experiments on the shergotite parent magma Eg (from [4]) indicate that the solubility is similar to tholeiites despite their compositional difference [11]). Figure 2 shows the temperature independent nature of the CO_2 solubility as a function of pressure from 1- 20 kbars. The maximum solubility if melt formed at 20 kbar is 1.65 wt%. Segregation of the magma from depth will carry the dissolved CO_2 to its magma chamber at some shallow depth (as suggested for these cumulate meteorites) and the exsolution of its CO_2 will occur thereby removing CO_2 from the planetary interior.

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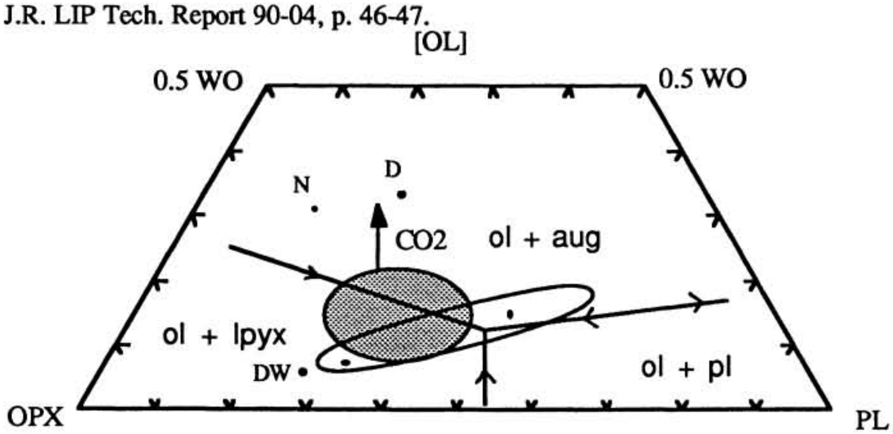

Figure 1 The projection from Olivine as in [4]. Shaded field is the range in parent magma compositions of shergotites and Chassigny, N [4] and D [3] are parent magmas for Nakhla. The circled field is the range in experimental liquid compositions at 15 kbar saturated with olivine and orthopyroxene. The arrow shows the effect of CO2 during melting on liquid compositions. DW is the estimated Martian bulk composition [8].

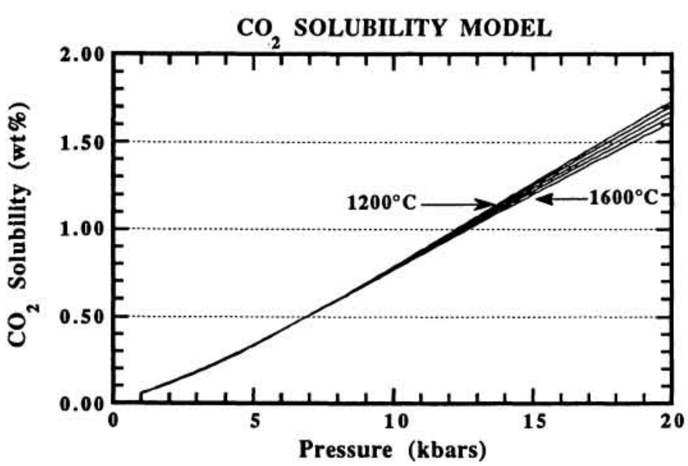

Figure 2. CO2 solubility in wt% vs. total pressure for a tholeiitic basalt [10]