IS MARTIAN MANTLE TOO REDUCED TO ALLOW CARBONATED SILICATE MELT GENERATION? R. Dasgupta[1], [1]Rice University, Department of Earth Science, 6100 Main Street, MS 126, Houston, TX 77005, USA. Rajdeep.Dasgupta@rice.edu

Introduction: Partial melting of silicate mantles is the single most important process by which terrestrial planets continue to chemically differentiate. The presence of carbon in the form of carbonates in the mantle have significant impact on this melting processs, both in affecting the depth and extent of melting [e.g., 1-3] and in modifying the major and trace element chemistry of the generated magma [e.g, 4-6]. Experiments and natural observations on terrestrial rocks and analogs over the past four decades have established that the role of carbonated melting of the Earth's upper mantle is critical in understanding the compositional range of basalts on our planet and flux of incompatible elements and volatiles from the interior. But the question remains whether such framework of carbonated manle melting is applicable to sister planet Mars. Furthermore, does the chemistry of Martian basalts call for carbonated melting in the mantle of Mars and if yes, can the estimated conditions of Martian mantle be reconciled with generation of carbonated magmas?

The Role of Oxygen Fugacity: One of the most critical parameters that affect the stability of carbon in the form of carbonates at high-temperature mantle rocks (an assemblage of olivine + opx + cpx + garnet) is oxygen fugacity, fO_2. The stability of carbon in the form of CO_2-rich fluids or carbonates relies on the two well-established buffer reactions [7, 8] –

$2C + O_2 = 2CO$; $C + O_2 = CO_2$ (CCO) (1)

$MgSiO_3+MgCO_3 = Mg_2SiO_4+C+O_2$ (EMOG/D) (2)

These reactions suggest that CO_2-rich fluids or mineral carbonates (such as dolomite and magnesite solid solution; XCO_2 ~0.5) can coexist, in equilibrium with graphite/diamond, with Earth's upper mantle rocks at fO_2 as low as ~1.6 log units below the FMQ buffer. At fO_2 lower than such, graphite/diamond becomes stable. However, this fO_2 limit of carbonate stability does not take into account the effect of dilution of CO_2/carbonate component (XCO_2<0.5) that may be plausible, if the phase of interest is a melt rather than crystalline carbonate. Recent experimental work [9] allows fO_2 estimates in diamond/graphite and carbonated melt bearing mantle assemblages with the knowledge melt CO_2 content. Application of such calibration to new and existing experiments on partial melting of carbonated peridotite from our group and from literature suggests that a carbonated silicate melt with CO_2 content as high as ~5 wt.% can be stable in equilibrium with graphite at logfO_2 ~FMQ-3.2 and at pressures ≥2 GPa.

Generation of Carbonated Melt in the Martian Mantle?: fO_2 estimated from SNC meteorites suggests that Martian basalts span a range of 4-5 log units, logfO_2 ~FMQ-4.5 to FMQ [e.g., 10-12], potentially reflecting similar range for their mantle sources. However, if fO_2 estimates of only primitive (e.g., Y980459) and isotopically depleted samples are considered to be relevant for most of the mantle, then logfO_2 becomes restricted to FMQ-4.5 to FMQ-2.5 [e.g., 10, 11]. Because this range of fO_2 is distinctly lower those imposed by the CCO and/or EMOG/D buffers at magmatically relevant depths, recent studies [e.g., 13] suggested that carbon storage in the Martian mantle occurs in the form of graphite/diamond and a strongly carbonated melt (such as strongly alkalic basalt or carbonatite) generation is not likely. Although this may be the case for some domains, complete absence of carbonated melt stability in the Martian mantle may be potentially at odds with distinctly alkalic, silica-undersaturated basalts such as Wishstone class of rocks, which can be explained by carbonated melting [14]. The estimated fO_2 condition of graphite-present, carbonated silicate melt stability as stated above, however, suggests that carbonated silicate melt with ~5 wt.% CO_2 can be stable at fairly reduced condition, not too dissimilar from the fO_2 estimated from primitive Martian meterorites. Therefore, future studies will need to consider carbon-present redox melting of the Martian mantle, which generates low-degree carbonated silicate melt potentially primary to some of the Gusev crater basalts.

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