REDOX INTERACTIONS BETWEEN IRON AND CARBON IN PLANETARY MANTLES:
IMPLICATIONS FOR DEGASSING AND MELTING PROCESSES. A. Martin and K. Righter, NASA
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Introduction: Carbon stability in planetary mantles has been studied by numerous authors because it is thought to be the source of C-bearing atmospheres and of C-rich lavas observed at the planetary surface. In the Earth, carbonaceous peridotites and eclogites compositions have been experimentally studied at mantle conditions [1] [2] [3]. [4] showed that the fo$_2$ variations observed in martian meteorites can be explained by polybaric graphite-CO-CO$_2$ equilibria in the Martian mantle. Based on thermodynamic calculations [4] and [5] inferred that the stable form of carbon in the source regions of the Martian basalts should be graphite (and/or diamond), and equilibrium with melts would be a source of CO$_2$ for the martian atmosphere. Considering the high content of iron in the Martian mantle (~18.0 wt% FeO; [6]), compared to Earth’s mantle (8.0 wt% FeO; [7]) Fe/C redox interactions should be studied in more detail.

Experiments: Here we report new experimental results at 2 GPa (piston-cylinder) in a system containing CaO-MgO-SiO$_2$-CO$_2$ with various FeO content and oxidation conditions. By analyzing Fe in liquid and solid phases, we have determined Fe repartition and constrained Fe/C redox interactions during late differentiation processes in terrestrial planets.

Results and discussion: In the Fe-free system from 1100 to 1300°C, CO$_2$-rich melt forms in equilibrium with forsterite, clinopyroxene and CO$_2$. In the presence of Fe, forsterite disappears and Fe-opx is produced. Fe oxide (magnetite) is also found and part of the carbon is reduced to graphite (Fig.1).

Thus, a reaction occurs between iron- and carbon-bearing phases:

$$Fe^{2+} (\text{in silicate,carbonate,melt}) + CO_3^{2-} (\text{in carbonate,melt}) = Fe^{3+} (\text{in oxide,silicate,melt}) + C_{\text{graphite}}.$$  

Such supersolidus redox process will have an influence on the melting and degassing mechanisms. Especially, it may lower the contribution of late mantle degassing processes to CO$_2$ introduction into planetary atmospheres.