Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SCG16-01 Room:201A Time:May 28 12:00-12:30

Kinetics of carbide rim growth and the diffusion of carbon in the Earth's upper mantle

STAGNO, Vincenzo[1*]

[1]Geodynamics Research Center, Ehime University (Japan), [2]Earth-Life Science Institute, Tokyo Institute of Technology, Tokyo 152-8550, Japan

The speciation of carbon in the interior of the Earth is mainly controlled by temperature, pressure and the oxygen fugacity (fo2) buffered by the surrounding abundant Fe-bearing silicates. Within a peridotitic mineral assemblages the fo2 is thermodynamically predicted to decrease with the depth until the precipitation of Fe-Ni metal alloy occurs at about 250-300 km down in the mantle. In addition, the application of a recently calibrated oxybarometer for eclogites suggests that subducted carbonates will be reduced to diamonds at about 200-250 km depth. Therefore, at such conditions the speciation of subducted carbon will be mainly affected by the local Fe(Ni)/C ratio, with diamond, Fe3C and C-bearing Fe-Ni alloys being the most likely stable phases. To date, however, no experiments are available 1) to constrain the transport of carbon by diffusion in iron metal at pressures and temperatures of the Earth′ s upper mantle and 2) to test the formation of carbide phases at the interface between diamonds/graphite and Fe metal.

We performed multi-anvil experiments between 3 and 10 GPa and temperatures of 700-1200 oC with the aim of measuring C diffusion in γ-Fe. Glassy carbon, graphite rods and synthetic diamonds were used as diffusants, placed directly in contact with pure iron rod with a thickness of 800-1400 μm. FE-SEM was used for accurate analyses of the Fe-C interface and concentration profiles of carbon in iron were measured by electron microprobe.

Results show that the diffusion coefficient for carbon in iron metal (~3x10-11 m2s-1) and the activation energy (~62 kJ/mol) are similar to previous data from much lower pressures. The activation volume (~1.5x10-6 m3/mol) obtained from isothermal runs is in agreement with that determined for other elements for which the interstitial diffusion mechanism in iron has been established. In addition, experiments revealed the formation of carbide as reaction rim between the diffusant and Fe metal. Time series experiments were, therefore, performed to investigate the growth kinetics of iron carbide (Fe3C) rim. Results allow to improve our understanding of the C storage in the Earth's interior. In addition, our data provide an experimental constraint on the formation of carbide phases during subduction, with implications for the deep carbon cycle and the C isotopic signature of eclogitic diamonds.

Keywords: carbide, diffusion, diamonds, eclogites, oxygen fugacity, high pressure