The abiogenic generation of low $\delta^{13}C$ reservoirs in the deep Earth

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The stable isotopes of carbon from mantle diamonds (expressed as $\delta^{13}C$) provide a direct proxy used to understand the Earth's deep carbon cycle (carbon speciation, reservoir identification and exchanges between such reservoirs). Carbon speciation is highly dependent upon the local fO_2 and variations of this parameter in an open system can result in isotopic fractionation of carbon where two species are stable and one is mobilised and removed [1]. The largest measured fractionation factor in nature for ^{13}C under mantle conditions is between graphite and Fe-carbide (circa +12 ‰) [2] and at a higher temperature between diamond and Fe-carbide (circa +7 ‰) [3]. This system may have a large impact on the BSE deep carbon cycle and if not considered, and well quantified, may cause significant errors in the interpretation of low $\delta^{13}C$ values determined from terrestrial and extra-terrestrial mantle samples. This system requires fO_2 conditions to be lower than the IW buffer and also requires the presence of Fe^{O}. Frost *et al.* [4] provided experimental evidence for the stability and predicted existence of Fe^{O} with magnesium silicate perovskite and ferropericlase in the lower mantle. More recently Rohrbach *et al.* [5] demonstrated that from depths < 250 km, the upper mantle can also host stable Fe^{O} with subcalcic pyroxene and majoritic garnet buffering the fO_2 to IW -2. Therefore it is plausible that two solid phases of carbon could be stable; diamond and Fe-carbide. We present new data for a measured fractionation factor between natural and synthetic diamond and Fe-carbide samples and place constraints upon the P-T effects of ^{13}C fractionation from 2-25 GPa and 14-2000 K in the system Fe-C. This data probes conventional ideas surrounding the modelling of ^{13}C fractionation during mantle-core differentiation, geodynamic cycling of carbon as inferred using empirical data from mantle xenoliths and xenocrysts and the nature and source (abiogenic vs. biogenic) of low $\delta^{13}C$ values determined from terrestrial and extra-terrestrial mantle samples.

[1] Cartigny *et al.* (1998) *Science* **280**, 1421. [2] Deines & Wickman (1975) *GCA* **39**, 547. [3] Mikhail *et al.* (2010) AGU Abstract [4] Frost *et al.* (2004) *Nature* **428**, 6981. [5] Rohrbach *et al.* (2010) *J. Petrol* **52**, 717-731.

Kirschsteinite exsolution lamellae in olivine from young angrites: Implications for their thermal history

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Angrites are among the oldest known basaltic rocks in the solar system characterized by unique mineralogy and chemistry. They can be mainly divided into two subgroups by difference in texture and crystallization ages (~4564 Ma 'quenched' angrites and ~4558 Ma 'plutonic' angrites) [e.g. 1]. Among them, young plutonic angrites are important to understand prolonged igneous activity in the angrite parent body (APB), and understanding of their geological settings can offer good information about the crustal evolution of APB. Kirschsteinite exsolution lamellae present in olivine from LEW86010 (LEW) plutonic angrite could be used to estimate its cooling rate and burial depth by calculating Ca diffusion profiles [2]. Similar exsolution was found in recently discovered plutonic angrite NWA4590 (NWA) [3], and we performed the same calculation. The obtained cooling rate of NWA olivine is 0.15 ºC/year, corresponding to the burial depth of 240 m. This cooling rate is ~1 order of magnitude slower than that of LEW (1.7 ºC/year: 75 m depth [2]). The lamella growth in NWA was from 975 to 700 ºC, and the LEW lamellae grew in a similar temperature range (1000-700 ºC) [2, 4]. Amelin *et al.* [5] obtained a cooling rate of 540±290 ºC/Ma for NWA by using the Pb-Pb age difference of pyroxene and silico-apatite. This cooling rate is too slow and will homogenize pyroxene zoning observed in NWA, and thus the age difference is unrelated to cooling as also suggested by [5]. A geological setting for the 75~240 m depth might be in a lava lake or hypabyssal intrusion. Although LEW and NWA share similar mineralogy and crystallization ages [1, 2, 5], their cosmic-ray exposure ages are different [6], suggesting sampling from different regions of APB. If this is the case, a rock unit with the lithology similar to LEW and NWA may show wide and deep spatial distribution in the crust of APB.

[1] Amelin (2008) *GCA* **72**, 221–232. [2] McKay *et al.* (1998) *MAPS* **33**, 977–983. [3] Kuehner & Irving (2007) *LPSC* **XXXVIII**, #1522. [4] Davidson & Mukhopadhyay (1984) *Contrib. Mineral. Petrol.* **86**, 256–263. [5] Amelin *et al.* (2011) *LPSC* **XLII**, #1682. [6] Nakashima D. *et al.* (2008) *MAPS* **43**, Suppl. A112.