

The formation of micro-diamonds in cracks caused by a C-O-H rich fluid under medium to low pressure conditions

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There is new evidence that micro-diamonds not only formed at high pressure and high temperature conditions in the diamond window. We found that, under favorable thermodynamic, stoichiometric and kinetic circumstances, micro diamonds can be synthesized by polycondensation of light carbon bearing molecules at medium to low pressure conditions, even close to the Earth's surface in the studied eclogites from the Victor Diamond Mine, South Africa. The studied eclogites contain OH, CO₂, CO, CH₄, CH₂O and CH₃OH around totally embedded micro-cracks in nominally anhydrous minerals (NAMS). Micro cracks act like monomineralic and interphase grain boundaries, and can also be interpreted as two dimensional defect structures. We used high-resolution synchrotron based FT-IR to detect C-O-H bearing volatiles around two-dimensional defect structures in NAMS as garnet. At micro diamond bearing defect structures, a correlation between the different C-O-H bearing volatiles is visible, whereas in inclusion free defect structures no correlation of the different C:O:H containing volatiles can be recognized. The findings from our study show that the C:O:H bearing volatiles, and their distribution pattern around the studied micro cracks, are indicative for the formation of micro diamonds in natural eclogites. Our outcomes confirm the results from experimental studies on the growth and synthesis of diamond crystals as a consequence of polycondensation of light carbon molecules.

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Iron mineralization in anoxic, non-sulphidic systems

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It has long been considered that Earth's early oceans were anoxic and rich in dissolved Fe (ferruginous). The evidence for this comes from the widespread preservation of banded iron formations (BIF) in the geologic record. Although BIF deposition occurred in pulses, recent reconstructions of oceanic redox conditions during deposition of marine shales have increasingly provided evidence for persistent deep water ferruginous conditions throughout the Archean. It has been proposed that following the termination of global BIF deposition ~1.8 billion years ago, the oceans underwent a fundamental change in response to rising Earth surface oxygenation. The most recent reconstructions suggest that this may have led to widespread euxinia along continental margins and in epicontinental seas, with the deep ocean remaining ferruginous. Deep ocean ferruginous conditions have also been advocated for much of the Neoproterozoic, while recent high resolution reconstructions of ocean redox conditions during Phanerozoic oceanic anoxic events have also shown distinct orbital timescale cycling between deep water euxinic and ferruginous conditions.

Yet, despite the significance of ferruginous conditions during past periods of ocean anoxia, very little is known about biogeochemical cycling of elements and nutrients under such conditions. To address this we have recently focussed on assessing Fe mineralization in anoxic, non-sulphidic settings, in particular Lake Matano, Indonesia, and Golfo Dulce, Costa Rica. At Lake Matano, we find clear evidence for water column precipitation of the mixed ferrous-ferric mineral, green rust, at the oxycline. This is the first identification of green rust in a natural water body and we propose that this mineral would have played a major role in elemental cycling during precipitation (through adsorption/co-precipitation) and during subsequent transformation processes. At both Lake Matano and Golfo Dulce, we also find evidence for authigenic magnetite formation on an unprecedented scale, both in the water column and during diagenesis. This new insight ultimately provides process understanding of mineralization pathways and associated elemental cycling under anoxic, ferruginous conditions, and provides insight into the genesis of BIFs, while also aiding the reconstruction of environment conditions based on BIF geochemistry.