The stability of carbon and carbonate within eclogites

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The redox conditions at which carbon and carbonate are stable in eclogitic settings are still relatively uncertain with respect to temperature and pressure of stability for these rocks. A comparison between the oxygen fugacity defined by carbon/carbonate equilibria in peridotite [1] and eclogite assemblages [2] indicates that diamond-bearing eclogites might be stable at conditions where only carbonates would be stable in peridotite rocks. However, these conclusions are suggested by thermodynamic predictions involving possible equilibria in eclogitic rocks, while an experimentally calibrated oxybarometer is still not available.

We conducted experiments to determine the oxygen fugacity at which elemental carbon coexists with carbonate minerals and melts in synthetic eclogites representative of natural assemblages. We performed experiments at both above and below the solidus of a carbonated eclogite in the Na-Ca-Mg-Al-Si-Fe-O-C system at pressures between 3 and 25 GPa and temperature of 800-1600 °C. Iridium powder was added to the starting mixture to act as redox sensor. Experiments were run in piston cylinder and multi anvil devices. Further, we were able to measure the ferric iron of omphacite and garnet equilibrated with graphite (or diamond) and carbonate (solid or melt) in the eclogitic assemblages using Mössbauer spectroscopy. Experimental results of the oxygen fugacity at which graphite/diamond and carbonate are equilibrated within an eclogitic assemblage, were parameterized as a function of pressure and temperature.

Results from this study improve our knowledge regarding the origin of diamonds in eclogitic rocks as well as the fate of carbon when subducted back into the mantle. Further, the results allow us to determine the ferric iron contents of eclogitic minerals, such as garnet and omphacite, as a function of pressure and temperature in presence of carbon-bearing phases, and they are used to develop an oxygen thermo barometer for eclogitic rocks.

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Carbon cycling in oil sands tailings ponds mature fine tailings under sulphate - reducing and methanogenic conditions: A microcosm study

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Oil sands tailings ponds are considered as a permanent storage and remediation approach for the extraction waste of the oil sands industry in the Athabasca Basin in northeastern Alberta (Canada). The anaerobic biodegradation of organic contaminants as well as the microbially mediated methane production, which can enhance the densification of the fine tailings, have been studied for many years. Thereby the anaerobic degradation of hydrocarbons is proposed to be accomplished by a complex microbial consortium, including syntrophic and methanogenic microorganisms as well as microbes of the iron,- nitrogen- and sulphur cycle.

Using selective cultivation, we detected heterotrophic and autotrophic sulphate reducers, thiosulphate oxidisers, and iron reducers in frequencies similar to those of natural lakes. To understand the interactions of indigenous methanogenic and sulphate-reducing communities, we conducted a 6 month microcosm experiment with mature fine tailings (MFT) supplemented with different carbon sources as well as molybdate and/or BES as specific inhibitors for the processes of sulphate reduction and methanogenesis. The carbon sources comprised low molecular weight electron donors (e.g. acetate, lactate, ethanol) that are and typically generated during hydrocarbon degradation and serve as easily available carbon sources[1].

We found that sulphate reduction was more limited by the presence of sulphate than by the availability of extra carbon sources, since considerable sulphate reduction occurred in microcosms without additional organic carbon, when sulphate was available. Methanogenesis increased when microcosms were supplemented with extra carbon sources, but was completely inhibited by the addition of BES. Molybdate not only inhibited sulphate reduction, but also methanogenesis, indicating a positive relation between the two processes. The turnover of the extra carbon sources differed between microcosms treated with molybdate and BES. Acetate and propionic acid were not consumed in microcosms amended with molybdate, indicating that sulphate–reducing communities were most responsible for the metabolization of these carbon sources, and that methane was rather produced by hydrogenotrophic instead of acetoclastic methanogens. In microcosms without molybdate, concentrations of lactate, ethanol and propionic acid decreased, while acetate accumulated during the first weeks and was consumed afterwards, indicating the occurrence of both, incomplete and complete oxidizing sulphate reducers. Ethanol and lactate were consumed in microcosms even when treated with BES and molybdate together, demonstrating that other processes than methanogenesis and sulphate reduction are involved in carbon cycling in the MFT.

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