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Origin of black cherts from the Marble Bar Drill Core #1 (Pilbara, W-Australia)

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Black carbonaceous matter bearing cherts are abundant in Archean hydrothermal environments and may host traces of early life. In order to elucidate their origin, we studied black cherts from the Marble Bar drill core #1 (Archean Biosphere Drilling Project depths: 75.1 m, 94.2 m, 96.7 m, 100.4 m). Two types of black chert can be distinguished: (1) laminated black chert having preserved its sedimentary texture (75.10 m) and (2) hydro-brecciated black chert (94.2 m, 96.7 m, 100.4 m). The laminated chert is composed of alternating bright and dark layers, separated by wavy mat-like surfaces. Each layer is characterized by a pyroclastic texture with preserved protomineral shapes (100–500 μm). In dark layers, protominerals are more abundant showing grain contacts and are less-matrix supported than in bright layers. Protomineral shapes reveal the presence of former amphiboles and plagioclase. Rapid silicification preserved the texture and led to the precipitation of micro-quartz, disseminated μm Ni–Co–As bearing pyrite, Ti- and Fe-oxides, sphalerite, galena, Fe–Mn–Mg carbonates, monazite and xenotimes. A second and third fluid influx occurred parallel and perpendicular to the lamination. Due to these fluids, K-feldspars, mica and illite precipitated around secondary pyrite and at the interface between dark lamina and a quartz vein. Laminated cherts have lower Se/S-ratio (10^{-5}) compared to brecciated ones (10^{-4}), indicating an increased hydrothermal influx. C1-normalized REE patterns of laminated and brecciated cherts show a strong positive Eu anomaly. The REE patterns and $La_{(N)}/Yb_{(N)}$ ratios (0.75–1.6) of the laminated cherts resemble those of silicified basaltic precursor rocks. ($La_{(N)}/Yb_{(N)} = 1.51$); and clearly differ from those of black cherts with black shale precursors ($La_{(N)}/Yb_{(N)}$: 6.7–9.06, Orberger et al., 2006). Brecciated black cherts ($La_{(N)}/Yb_{(N)} = 3.25$–6.3) are enriched in LREE compared to the laminated ones. The studied cherts have a pyroclastic precursor of basaltic composition, silicified during hydrothermal fluid-rock interaction under reducing conditions. Si-CO_2 bearing fluids remobilised metals (LREE, Fe, S, Pb, Zn.) from the laminated facies and mineralized the brecciated black chert.

Reference

Orberger, B., Rouchon, V., Westall, F., De Vries, S., Pinti, D.L., Wagner, C., Wirth, R., Hashizume, K., 2006. GSA Special Paper, No. 405.

doi:10.1016/j.gca.2006.06.928

Biomarkers in Archaean banded iron formations from Pilbara and Dhawar Craton

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The origin of Archeaen banded iron formations (BIF) and the role of biosphere in Fe precipitation is still highly debated. In order to elucidate these processes, detailed mineralogical and textural analyses combined with $\delta^{15}N$, $\delta^{56}Fe$ and $\delta^{13}C$ data were obtained on Fe-oxide bands from Marble Bar chert Unit (MB, 3.46 Ga, Pilbara craton, W. Australia) and a BIF from the Bababudan Group (BG, 2.7–2.9 Ga, Dhawar Craton, Southern India). Both samples are composed of alternating quartz and Fe-oxide bands with wavy micro-textures. CI-normalized REE patterns show that MB reflects hydrothermal fluid/basalt interactions, while BG precipitated from a hydrothermal fluid/seawater mixture. In MB, nano-crystalline hematite replaced magnetite, Mg-calcite and Fe-sulfides producing a matlike surface, preserving nanometric N-bearing amorphous carbon nodules. Measured C/N ratios (2.3–52) are typical of Precambrian organic matter. The $\delta^{56}Fe$ of -0.40 ± 0.02‰ suggests MOR-hydrothermal fluids as a Fe-source, while a $\delta^{15}N$ of $+7.4 \pm 0.4$‰ is compatible with nitrification-denitrification processes. BG is composed of intergrown magnetite and hematite. Disseminated grunerite and magnetite grew during low T metamorphism. Fe-oxide spherules compose vermicular-filaments that nucleated perpendicular to quartz surfaces. Fe-oxide spherule bunches are perfectly preserved in the silica bands forming micrometric mats, which contain heterogeneously distributed N (~0.09 atm%) and C (0.51 atm%, C/N = 5.73). Bulk $\delta^{13}C$ of -15.35‰ ± 0.10 points to an organic origin for C. The $\delta^{56}Fe$ in Fe and Si layers (0.75‰ to 2.16‰) is compatible with a chemical precipitation for BIF. A negative correlation between $\delta^{56}Fe$ and the Th/U ratio suggests that Fe isotopic variations are related to fluid circulation and re-precipitation of Fe-oxides. High $d^{15}N$, on one Fe-oxide layer, of $+21.8 \pm 0.7$‰, corresponds to that observed for Archeaen BIFs and may be related to nitrate-dependent microbial oxidation of Fe.

doi:10.1016/j.gca.2006.06.929