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Integration of TEM/Hrtem onservations and C-isotope geochemistry to characterize organic matter in early Archaean rocks

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TEM was applied to observe and characterize carbonaceous materials (CM) extracted from black cherts in the 'white smoker type' deposit of the ca.3.5Ga (model Pb/Pb ages =3.49-3.51Ga) Dresser ormation, and the overlying black argillites of the 3.46Ga Salgash Subgroup, in the Pilbara of Western Australia. These were characterized by Transmission Electron Microscopy (TEM) coupled with electron dispersive spectral analysis (EDS), High Resolution TEM (HRTEM) to determine molecular ordering, and C-isotope geochemistry. Observations using TEM and HRTEM enabled morphological and fine structure distinctions between the various populations of CM both in the Dresser and Salgash samples. These formed the basis for their interpretations. Organic petrology using reflected light microscopy was applied to whole rock samples to observe mineral-organic relationship and structure relative to host rock texture. These supported insitu, syn-depositional mode for the Dresser Formation CM. Reflectance % (Ro) of CM determined on polished whole rock samples and polished resin-embedded CM concentrates enabled the reconstruction of its thermal history. These yielded several Ro populations in the Dresser Formation samples: probable microbial cells preserved in fluid inclusions within quartz crystals, severely thermally degraded CM possibly originally belonging to microbial cells, CM coating mineral grains and reworked CM particles. On the other hand, the Salgash suite of samples from the Apex Basalt Formation yielded consistent very high Ro values corresponding to graphite stage organic metamorphism. the weak optical anisotropy of the graphite points to a defferent mode of formation than regional metamorphism. Two main graphite forms have been identified, namely a platy and tubular. The tubular form when observed in HRTEM showed nano-tubes and fullerenes.
Dresser Formation samples are isotopically light in the range of -32.1 to -38.2per mil supporting a biological source. Although in TEM four distinct types of CM could be identified and characterized, C-isotope analysis was done on mixed CM concentrates where all types were present. Nevertheless, the isotopically lighter samples contained a notable input from the nonm thermally degraded microbial cells entombed within fluid inclusions, liberated during the demineralizing process. On the otther hand the "heavier" samples contained predominantly thermally degraded high Ro CM.
C-isotope compositions of the Salgash CM are relatively heavy, prodiminantly between 22.5 and 28.6 per mil consistent with very high thermal stress. Furthermore, the Salgash suite of samples show a C-isotope trend where in the top part of the section the CM becomes "lighter" with depth, down to 143m depth. The latter having the "lightest" values. An inversion of this trend occurs below this depth, where CM becomes increasingly isotopically heavier. The upper part of the section is characterized by platy graphite with rare occurrence of nanotubes observed. Predominantly tubular graphite/nanotubes and fullerenes characterize sample SAL-13 at 142. depth coinciding with the isotopically lightest values. From then downwards CM becomes increasingly "heavier" signifying highest temperatures experienced. Observations in TEM and HRTEM showed an increase in the presence of void-enclosed carbon nano-spheres possibly fullerenes detached from platy graphite, often forming a condensed mess with few recognisable fused tubular structures.