

Discovery of greigite from Archean rock?

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The ferrimagnetic greigite (Fe₃S₄) was identified in Tertiary lacustrine sediment in California (Skinner et al., 1964). In the 1990s, early diagenetic greigite has been widely identified in marine sediments (e.g. Horng, et al., 1992; Roberts & Turner, 1993; Takatsugi & Hyodo, 1995), and thus, was recognized as an important magnetic remanence carrier of sediments (Hilton, 1990; Fassbinder & Stanjek, 1994; Roberts, 1995). The world oldest greigite is reported from Cretaceous marine sediments from northern Alaska (Reynolds, 1994).

Greigite is both an inorganic mineral in sedimentary rocks and a biogenic product formed by magnetotactic and sulfate-reducing bacteria. Magnetotactic bacteria contain intracellular magnetic minerals (greigite, magnetite, or both). Magnetosomes and their fossils (magnetofossils) of magnetites have been identified using transmission electron microscopy (TEM) in sediments dating to ~510-570 Ma, and possibly 4 Ga carbonates in Martian meteorite ALH84001 (e.g. Griscorn, 1950; 1984). On the other hands, Demitrack (1985) reported possibility of magnetofossils of greigite from modern coastal marshes. Then intracellular Fe sulfides are known to be produced by a many-called, magnetotactic prokaryote (MMP) and single-celled bacteria (Bazylinski et al., 1994). Only greigite was observed in the rod-shaped single-celled species (Heywood et al., 1991), whereas in MMP Mann et al. (1990) found greigite and pyrite (FeS₂), and Farina et al. (1990) identified monoclinic pyrrhotite (Fe₇S₈).

Sulfur isotope of sulfide minerals in the 2.77 Ga Mt. Roe black shale suggested that microbial activity of sulfate-reducing bacteria (Kakegawa and Nedachi, 2004). Rock magnetic study indicates existence of ferromagnetic sulfide minerals similar to greigite (Niitsuma et al., 2004). Under a TEM, sulfide minerals shows complex texture in crystal, and many defects exist in the crystals. Single crystals of greigite cannot be found out in the sample, and magnetic extracts from black shale and sulfide nodule are only pyrite and pyrrhotite. Also analytical transmission electron microscopy (AEM) analyses shows crystals with similar to the composition of greigite, however the crystals did not shows clear electron diffraction of greigite. The results of mineralogical analyses suggest that greigite does not exist as simple single crystals but coexist within pyrite and pyrrhotite. And also, Greigite crystallized at Archean age is not completely conserved and part of the crystal changed to pyrite and pyrrhotite.