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Biominerals of nanocrystalline greigite (Fe_3S_4) in sediments of the Black Sea and the sill at the Bosporus

Anton Preisinger (1), Selma Aslanian (1), Roman Beigelbeck (2), Namik Çagatay (3), Wolf-Dieter Heinitz (4), and Johann Wernisch (5)

(1) Institute of Chemical Technologies and Analytics, Vienna University of Technology (anton.preisinger@tuwien.ac.at), (2) Institute for Integrated Sensor Systems, Austrian Academy of Sciences, Austria (roman.beigelbeck@oeaw.ac.at), (3) Geological Engineering Department, Istanbul University of Technology, Turkey (cagatay@itu.edu.tr), (4) Institute of Automation, University of Rostock, Germany (wd@wdheinitz.de), (5) Institute for Solid State Physics, Vienna University of Technology (johann.wernisch@tuwien.ac.at)

The biomineralization of iron sulfide is a biologically controlled mineralization where single spinel crystals of greigite (Fe_3S_4) are formed intracellularly by magnetosomes in sulfate reducing bacteria (SRB). Each single crystal is surrounded by a protein-containing lipid bilayer membrane shaping a cuboctahedral 3D-nanocrystalline greigite. We analyzed sediment cores taken from the Black Sea and the sill of the Bosporus regarding their greigite content. Two different types of clusters of twinned ferrimagnetic nanocrystalline greigites (magnetotactic and framboidal greigites) were found. Their amount within a reference volume was quantitatively analyzed by counting clusters on ore microscopy photographs and scanning electron microscopy pictures. Ferrimagnetic greigite clusters are only stable in anoxic environments and change under oxic conditions to non-magnetic pyrite (FeS_2)+FeOOH. We utilized these properties in order to answer hitherto unsolved questions about the climate and the paleohydrology of the Black Sea, the Marmara Sea, and the sill of the Bosporus. In particular, detailed scientific knowledge regarding water level, sediment in- and outflow, and oxic/anoxic-state of the Black Sea during the last 20.000 years can be obtained. The formation, occurrence, and distribution of ferrimagnetic greigites in SRB in anoxic sea water allow inferences about cold/warm-periods of this region as well as the paleohydrological history of the Black Sea.

The entrance of water to the Black Sea from the Danube (NW-site) and from the Marmara Sea over the Bosporus (SW-site) is subjected to a periodicity: During glacier melt in the Alps, higher water content enters the Black Sea resulting in a lower concentration of SO_4^{2-} ions. This process is reversed during glacier growth. Such a rhythmic behavior can be observed and reproduced for the last 8000 years directly by analyzing framboidal greigite clusters taken from gravity cores of the Black Sea. The last change from a cold to a warm period took place about 1833 yearsBP, which can be seen in our analysis because in a warmer period, the occurrence of the greigite clusters is statistically lower than in a colder one.

Between 16 and 12 kyearsBP, water and sediments coming from the Danube and the Strait of Kerch entered the Black Sea. Water and sediment particles were transported by counter-clockwise acting Coriolis- and centrifugal forces. These sediments were deposited in the shelf zone parallel to the Bulgarian coast. At the end of the Younger Dryas (11.7 kyearsBP), the sea level of the Black Sea increased and a sublacustrine river valley parallel to the Bulgarian coast in direction towards to the Bosporus was formed. We analyzed five representative cross sections of this river valley regarding the determination of the cold/warm-periods by utilizing our greigite-based method as well as a Sediment-Echo-Sounder (SES 2000).

Nowadays, the water exchange between the Black and the Marmara Sea takes place through the Bosporus strait with sill depths of $32-34$ m (southern end) and 60 m (northern end). We analyzed the sedimentation at the sill of the Bosporus and the Golden Horn by means of an SES 2000. The results provide detailed information about the historical evolution of the water flow between both seas during the last 10.000 years. The sill of the Bosporus is separated into two channels where water enters on the Asian side from the Marmara Sea and on the European side from the Black Sea. Measurements of clusters of magnetotactic 3D-nanocrystalline greigites in gravity cores of the Black Sea indicate the change of the velocity of the water entrance from the Marmara in the Black Sea between $8-10$ kyearsBP. The entrance starts sporadic at 10 kyearsBP with a maximum between 9600-8800 yearsBP.

Concluding, all our results contradict the "catastrophic flood"-hypothesis of the Bosporus by Ryan and Pitman.