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Magneto-spectroscopic Properties of Sediments of Benguela Upwelling System

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A b s t r a c t

Upwelling systems along the western margin of continents are the most productive marine ecosystems on the earth. In such systems the wind along the coast causes off-shore movement of surface water which results in upwelling of cold, highly CO_2 concentrated, nutrient-rich water to the illuminate zone where photosynthesis occurs (Fig. 1a). Nutrients and CO_2 concentrations are essential for photosynthesis and their rise results in increased primary productivity in the water surface (growing amount of organic matter). Dead organisms sink to the water/sediments zone where they are decomposed by microbes. In this process oxygen is consumed and strongly reducing conditions are established. The fate of magnetic phases in such an ecosystem is poorly resolved, despite the fact that upwelling systems are widespread and are active over millions of years. Considering such system magnetic phases can be formed, e.g., by biogenic processes or be destroyed by reductive dissolution.

In our study we use the Benguela upwelling system along the Namibian coast in SW Africa. The sampling sites are showed in Fig. 1b) and we present preliminary magnetic results from a 20 cm profile at the sediment/water boundary in 128 m depth at site 23020 (23°S, 14°04’E).

The content and properties of the magnetic phases in the profile were obtained from freeze-dried samples using Kappa bridge and Ferromagnetic Resonance (FMR) spectroscopy. FMR is a sensitive tool to detect magnetic phases and their anisotropy properties.

The susceptibility varies from $1.36 \cdot 10^{-8}$ to $5.88 \cdot 10^{-8}$ and reaches maximum for sample 5–10. The FMR spectra show a broad signal that is superimposed by sharp signal at around 3.5 kOe. The latter stems from free electrons in clay minerals. The FMR spectra from the upper 3 cm have two relatively broad maxima in the low-field range (left of the sharp peak). With depth this feature disappears and the signals get a Lorentzian-like shape. The two maxima could be an effect of uniaxiality stemmed from Magnetotactic Bacteria or a result of a superposition of a broad signal and a signal from paramagnetic Fe^{3+} species at 1.5 kOe.

All spectra have in common that they lose most of their intensity upon heating to 400°C (Fig. 2b). This indicates that the magnetic phase is unstable at this temperature.

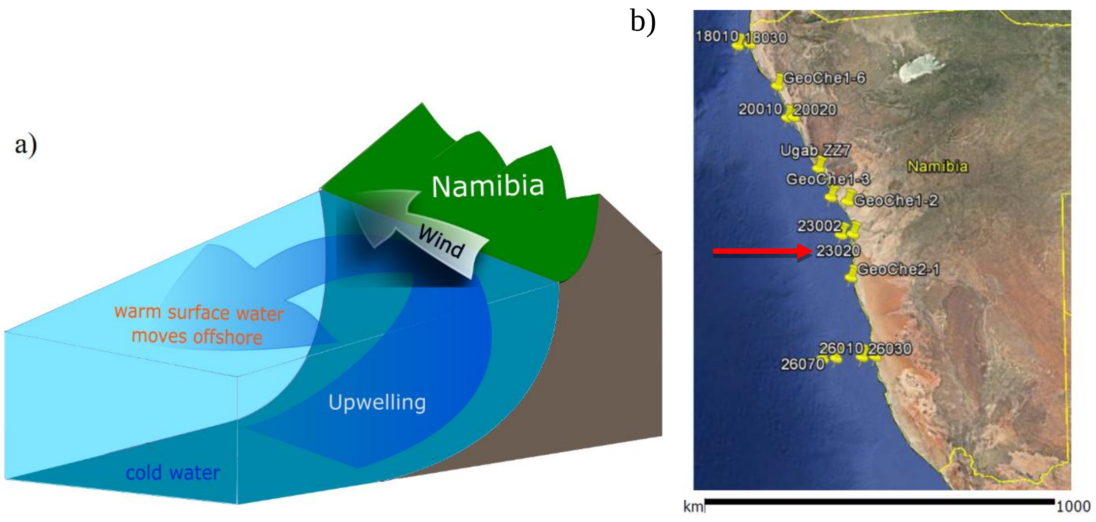

Fig. 1. a) Basic scheme of upwelling phenomena, b) sampling sites along the Namibian coast, red arrow shows analyzed profile 23020.

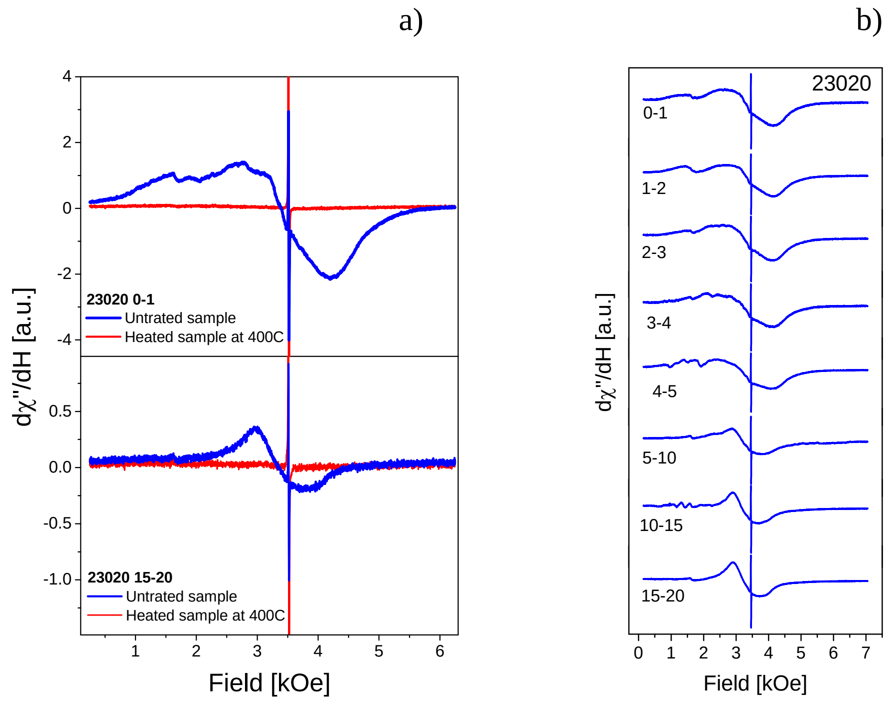

Fig. 2. a) Ferromagnetic resonance spectra profile with depth, b) comparison of signal before and after heat treatment at 400°C for samples 0–1 cm and 15–20 cm.

Among the magnetic minerals that provide a relatively strong FMR signal and are unstable at about 400°C is greigite (Fe_3S_4) or fine-grained maghemite (γ-Fe_2O_3).

In summary, content in the sediments from the Benguela upwelling zone is carried by a phase with a thermal stability of less than 400°C, that could be maghemite or greigite. The prevailing reducing conditions in upwelling systems argue in favor of greigite, because under such conditions maghemite undergoes reductive dissolution.

Keywords: Benguela upwelling, magnetic content, ferromagnetic resonance spectroscopy.