Tracing palaeocurrents from the Arctic Realm into the Tethys Ocean: the use of glendonite as an indicator for cold bottom water masses

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Today, the global conveyor belt of ocean currents is controlled by the configuration of continents and the climate. Conversely, ocean currents influence water and air temperatures as well as the amount of rainfall on a regional to local scale. In addition, they govern species distribution patterns, sedimentation patterns and the dispersal of nutrients in both oceans and epeiric seas. Therefore, the reconstruction of palaeocurrents is crucial for the understanding of ancient environments and the past climate.

An important driver for the global ocean circulation is the formation of deep water. However, deep-water production is difficult to estimate, and its circulation is difficult to reconstruct, not only today but especially in the geological record. Palaeocurrent reconstructions are often based on the temporal and spatial distribution of marine species. In this presentation, a new approach is proposed which uses the occurrence of glendonites as a proxy for cool bottom currents. Glendonites are pseudomorphs after the hydrous carbonate mineral ikaite ($CaCO_3 \cdot 6H_2O$) which only forms in environments characterised by near-freezing temperatures. Throughout the Phanerozoic, glendonites can be found in successions which were deposited in high latitudes. However, examples of glendonite occurrences in mid-latitudinal sections are also reported. One of these examples are upper Pliensbachian (Lower Jurassic) glendonites from a shallow-marine succession in South Germany which was located in the European epicontinental sea – an area, where it was technically too warm to form the precursor mineral ikaite. Based on petrographical and sedimentological investigations as well as stable isotope analyses it is concluded that a low temperature was the main factor for ikaite formation in the studied section. To explain the low water temperatures, a model for a thermohaline circulation in the European epicontinental sea is proposed. The cool climate in the late Pliensbachian initiated the growth of sea ice in high latitudes, leading to the formation of cold and saline bottom waters analogous to the modern formation of North Atlantic Deep Water (NADW) and Antarctic Bottom Water (AABW). The cold bottom current flowed southward from the Arctic Realm through the Viking Corridor into the European Epicontinental Sea, thereby causing a massive cooling of the deeper parts of the epeiric sea, which led to the formation of ikaite in temperate areas. After passing the shelf, the bottom current entered the Western Tethys, probably forming a deep water mass.

The proposed model can help to explain mid-latitudinal glendonite occurrences not only in the Pliensbachian, but also in other areas and time slices which are characterised by cooling. Moreover, it enables the use of the pseudomorph as a tracer for cold bottom currents which can be a helpful tool for the reconstruction of global ocean current patterns.

 eISSN 2353-3641 | ISSN 1731-0830