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The influence of buried nodules on the mobility of metals in deep sea sediments

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Hydrothermal fluids can extract significant amounts of heat from oceanic lithosphere by lateral fluid flow through permeable basaltic crust of an age of up to 65 Ma. Fluid recharge and discharge occur at basement outcrops in between impermeable pelagic deep sea sediments. Recharge of oxic seawater causes upward oxygen diffusion into sediments overlying the permeable basalt in areas proximal to recharge sites. It is suggested that this oxygen has a strong impact on sediments and Mn-nodules during fluid exposure time. The aim of this study is to investigate if/how fluid flow through oceanic crust influence the distribution and element budget of Mn-nodules.
Nodules occur widespread at the seafloor of the Clarion-Clipperton Zone (CCZ) in the equatorial North Pacific and were analyzed in many studies worldwide. Nodules buried in the deep sea sediments could be found only rarely (von Stackelberg, 1997, Geol. Soc. Spec. Publ., 119: 153-176). High resolution side-scan sonar recordings (unpublished Data BGR Hannover) indicate that there exist a coherent layer of nodules buried in the sediments of the working area. During the expedition SO 240/FLUM nodules were found on the sediment surface in 4200 to 4300 m water depth as well as in the sediment down to 985 cm below seafloor.
In general, nodules consist of different nm- to μm-thick, dense and porous layers. The geochemical composition of bulk nodules and single nodule layers were determined by XRF, ICP-MS/OES, XRD and by high resolution analyses with electron microprobe and LA-ICP-MS. Dense layers have low Mn/Fe ratios (<4) and high concentrations of Co, Zr and REY, while porous layers are characterized by high Mn/Fe ratios (> 10) and high Ni+Cu and Li concentrations. The different compositions depend on different formation processes of the layers. They were formed by metal precipitation from oxic (hydrogenetic) and suboxic (diagenetic) bottom-near seawater and/or pore water (Wegorzewski and Kuhn, 2014, Mar. Geol. 357, 123-138).
Preliminary results show that there are significant differences between the geochemical composition of nodules grown at sediment surface and those found within sediments. Compared to surface nodules, buried nodules are enriched in Co and W, but have lower concentration of Mo, Ba, Zn and Li. The distribution of Rare Earth Elements and Y(REY) is also different. Furthermore, the locations of the buried manganese nodules correlates with increased contents of Mn, Co and other elements in the suboxic pore water. It seems that the hydrogenetic layers of the buried nodules were dissolved and/ or recrystallized due to diagenetic processes in the sediment. As a result, a new Fe-rich layer type was formed, with Mn being released into the pore water and/or being used to form todorokite in the nodules. The mineralogical analyses of surface and buried nodules support this assumption.
Until now, it couldn′t be proven that the hydrothermal fluid flow in the basalts underneath the sediments has an influence on the nodule geochemistry.