Characteristics of Hydrothermally Altered Wall Rocks from Modern Hydrothermal Fields

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Abstract

The mineralogy and geochemistry of hydrothermally altered wall rocks from different modern basaltic- and felsic-hosted hydrothermal fields at seafloor spreading centers and convergent margins have been studied to determine the characteristics of different types of alteration and to calculate the magnitudes of elemental exchanges between seawater and wall rock.

High-temperature water-rock reactions at the Bent Hill massive sulfide deposit in Middle Valley/Juan de Fuca Ridge resulted in the conversion of detrital-rich sediment to massive sulfides and authigenic chlorite ± quartz. Oxygen isotope measurements on the authigenic chlorite indicate formation temperatures up to 320°C. Fluid-rock reactions resulted in the formation of Zn- and Cu-rich Fe-chlorites below the massive sulfides. Close to the Bent Hill massive sulfide deposit (< 10 km), the present-day hydrothermal Area of Active Venting reflects several stages of high-temperature alteration without massive sulfide formation. Nearly pure chlorite/smectite mixed-layer and corrensite mainly occur below 20 mbsf. Formation temperatures of these nearly pure chlorite/smectite mixed-layer and corrensite were calculated as 250-270°C. In the deepest unit, Mg-chlorite is the dominant phyllosilicate coexisting with authigenic quartz. Chemical balance calculations suggest intense Mg metasomatism in a mixing zone at the Area of Active Venting where hydrothermal fluids interact with seawater and sediment at temperatures above 200°C. In contrast, the Fe-rich chlorites from the Bent Hill massive sulfide deposit reflect hydrothermal fluid-rock interaction at high temperatures (up to 320°C) below the zone of seawater mixing. The enrichment of Fe, Cu und Zn is related to the hydrothermal leaching of basalts from the Middle Valley.

Extensive hydrothermal alteration occurs also at a hydrothermal site in the Escanaba Trough at Gorda Ridge, where intensely altered sediment is almost completely replaced by authigenic

Ba-rich Mg-chlorite. The oxygen isotope composition of chlorite indicates intense Mg metasomatism at formation temperatures of 190°C.

In contrast, the felsic-hosted PACMANUS hydrothermal field in the eastern back-arc Manus Basin is characterized by a much larger range of alteration assemblages. Three main alteration stages have been identified: (1) chloritization at 220° to 260°C, (2) illitisation at 250° to 300°, and (3) bleaching (formation of quartz-pyrophyllite assemblages) at 260° to 310°C. Chloritisation, illitization and bleaching alteration stages each show different chemical changes in the altered samples relative to a calculated pristine precursor lava. The element Cr appears to have a general enrichment in the altered samples from PACMANUS. It seems likely that the retention of Cr in the alteration zones of felsic-hosted back-arc hydrothermal system is significant when compared to axial high-temperature basalt- and sediment-hosted hydrothermal alteration. On the other hand, enrichments of Cu and Zn in the high-temperature Fe-chlorites of basalt-hosted systems appear characteristic.

Studying the mineralogical and chemical composition of altered wall rocks in modern submarine ore deposits most likely provides useful indications for prospecting for ancient massive sulfide deposits.

Klas Lackschewitz

Klas Lackschewitz received a PhD from the University of Kiel in 1991 and spent 9 years as a research scientist at the former marine research center GEOMAR and the University in Kiel before moving to the University of Bremen. Since 2004 he is a member of the Research Division 4 at IFM-GEOMAR. His research combines the study of modern volcanic environments which host many of the best known submarine hydrothermal systems. During the last 15 years, Dr. Lackschewitz has been on 15 national and international research cruises to submarine volcanic and hydrothermal active areas on the Juan de Fuca Ridge, East Pacific Rise, Woodlark spreading system, Manus Basin and Mid-Atlantic Ridge. Together with an international team he has focused on the hydrothermal alteration processes and their physico-chemical conditions. Dr. Klas Lackschewitz is a member of the Exzellenzcluster "The Future Ocean" at the University of Kiel.