Significance of bimodal magmatism in seafloor massive sulfide (SMS) ore-forming systems in the middle Okinawa Trough, Japan

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Extensional tectonic settings and bimodal lithostratigraphic assemblages are of significance in volcanogenic massive sulfide (VMS)-hosted lithology. In the case of modern seafloor massive sulfide (SMS) deposits in arc-related settings, the majority of deposits have been discovered in association with cauldrons formed by the voluminous explosive eruption of silicic volcanoes. However, silicic lithologies normally contain only small amounts of metallic elements, whereas mafic rocks contain significant amounts of metals. Thus, the origin of metallic elements in SMS deposits associated with silicic host rock remains unclear.

Igneous rocks from three distinct morphological areas, Iheya North Knoll, Iheya Minor Ridge, and Izena Hole, in the actively rifting middle Okinawa Trough, Japan, were investigated to understand petrogenetic relations among SMS mineralization (including sources of metals), igneous processes, and tectonics. Mafic rocks in the Iheya Minor Ridge form mountain-chain-like morphology due to eruption of low-viscosity magma through normal faults formed by the extensional regime. The normal faults also play a role as major pathways of seawater recharge and induced basalt-hosted hydrothermal circulation and mineralization. While felsic rocks in Iheya North Knoll form lava dome-like morphology due to periodic ascent of felsic magma, Izena Hole is a subsidence caldera formed by voluminous eruption of felsic magma. In both cases, felsic magma is essentially formed by water-fluxed melting of basaltic materials formed by the previous mafic magmatism. Geochemical modelling well reproduced observed silisic rock compositions by water-saturated batch melting of basaltic materials under an existence of peritectic hornblende. Introduction of seawater into the deep crust and water-fluxed melting in these areas inevitably involves high-temperature hydrothermal alteration and leaching of metal elements from mafic materials and produces Cu-rich, bimodal-mafic type mineralization. Since the magmatism produces voluminous felsic rocks in the upper crust, the Cu-poor but Zn- and Pb-rich, bimodal-felsic type mineralization is an expected as a result of felsic magmatism.