

Host rock alteration caused by multiple hydrothermal activities in the Shimokawa massive sulfide deposit, Hokkaido, Japan

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Many base metal ore deposits were formed by ancient submarine hydrothermal activities, most of which have been considered to form on the seafloor as strata-bound deposits. However, a replacement model, in which sulfide minerals were precipitated and concentrated by alteration and replacement of sediments beneath the seafloor, has been proposed to form some massive sulfide deposits in both ancient and modern submarine hydrothermal systems. The Shimokawa Cu-Zn massive sulfide ore deposit in the northern Hokkaido, Japan, which is suggested to have been formed by sub-seafloor replacement, has undergone multiple hydrothermal activities based on their ore mineral assemblages. Whereas pyrite was the only sulfide mineral precipitated in the early stage, Cu and Zn were mainly concentrated as chalcopyrite and sphalerite, respectively, in the later stage. In this study, we focus on alterations of host rocks both in hanging wall and footwall, which are mostly slate, to (1) clarify the alteration patterns of the host rocks and (2) elucidate the roles of multiple hydrothermal activities on the formation of massive sulfide ores in the Shimokawa ore deposit.

Microscopic observation and XRD analysis of the host rock samples show that most hanging wall and footwall in the Nakanosawa ore body contain chlorite and illite, suggesting that the overlying sediments were also affected by hydrothermal activity. However, samples exhibiting only early-stage hydrothermal activity contain talc and dolomite as the main gangue minerals. Since no detrital material or their alteration product was observed in the samples, the early-stage hydrothermal activity likely occurred near the seafloor. On the other hand, samples affected by both early- and late-stage hydrothermal activities contain Mg-Fe chlorite with high Mg# ($Mg/(Mg+Fe) = \sim 0.8$) whereas Mg-Fe chlorites in ore samples that exhibiting only the late-stage mineralization have lower Mg# (0.6 – 0.2). Therefore, we propose that the formation of Mg-Fe chlorite with a high Mg# might have been associated with the dissolution of talc and dolomite formed in the early stage, which enriched Mg in the chlorite. This further implies that massive sulfide mineralization might have occurred by replacing these minerals in the sub-seafloor.