Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SRD42-03 Room:102B Time:May 21 16:50-17:10

Magmatic fluid leading to epithermal gold deposits; probability of porphyry copper deposits in Japan

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Epithermal gold deposits (<1km depth) have spatial and temporal links to porphyry style deposits (2-5km depth) associated with hydrous magmatisms. The magmatic fluids containing significant vapor after physical phase separation within porphyry style deposits could effectively transport gold to epithermal environments, which has theoretically been inferred by recent thermodynamic data.

However, the ore-forming fluid passes connecting porphyry to epithermal environments and gold contributor into epithermal environments is still in the debate. Moreover, there are two main types of epithermal gold deposit composing high- and low-sulfidation styles which are characterized by the presence of enargite as well as luzonite, and adularia and calcite, respectively; this diversification have not substantially been proven yet.

In this study, epithermal gold deposits such as Hishikari deposit (low-sulfidation) and Kasuga and Akaishi deposit (high-sulfidation) in Kagoshima Prefecture, in addition to Furikusa sericite deposit in Aichi Prefecture were studied using Laser Ablation ICPMS (LA-ICPMS) analysis based on microthermometry. The results demonstrate major and minor elements in fluid inclusion, ore-forming fluids which were trapped in hydrothermal gangue minerals such as quartz, paying special attention to Au and S concentrations. I discuss that spatial and chemical affinities between epithermal gold deposits and porphyry style deposits with a focus on the formation depth of porphyry style deposits.

Here I report magmatic epithermal fluids readily transported S, Cu, Au, As, and Sb which lead to high and low-sulfidation epithermal gold deposits. For example, the concentration of major elements in the fluids for mineralized epithermal gold deposits has ranges of 1.5-6.5 ug/g Au, several tens ug/g As and Cu, several hundred ug/g Sb. Especially, the magmatic vapor in barren hydrothermal system of Furikusa deposit has similar chemical compositions to a hypothetical process described by an ascending magmatic vapor to a shallower high-sulfidation gold deposit. This represents gold transported through the barren alteration zone containing sericite-pyrite-quartz, closely resembles to the later stage of QSP veins in typical porphyry copper deposits.

For sulfur contents, ore-forming fluid for high-sulfidation gold deposit shows several thousand ug/g, while several hundred for low-sulfidation. The difference in sulfur content directly reflects the difference in sulfur fugacity between both styles of epithermal gold deposits. Compared with the vapor phase in porphyry copper deposits, the epithermal fluids show similar gold concentrations, two to three orders of magnitude lower concentration of copper, and very low sulfur concentration in the low-sulfidation style.

The following formation process can be assumed; 1) boiling fluid derived from the magma associated with porphyry style deposit, 2) separated vapor phase, enriched in S and Au, rises to shallow environment and forms sulfide and hydrothermal minerals corresponding to QSP-vein (Quartz-Sericite-Pyrite vein) in a porphyry copper deposit, suggesting that gold is transported as thio-complexes. During the process of 1) and 2), copper and sulfur in the fluid were consumed and decreased. In other words, it suggests that high-sulfidation gold deposit was formed at distance relatively close to the magma, whereas low-sulfidation style was far from the magma. This probably indicates that porphyry style deposit can be present at deeper level from the low-sulfidation style gold deposits relative to a depth from high-sulfidation style.

Therefore, I propose a paradigm as ”discrimination between low- and high-sulfidation style gold deposits can be attributed to the difference in formation depth of porphyry style deposits”. This findings may have vital implications that might give rise to further potential for undiscovered porphyry style deposits underneath (>2-3km depth) the epithermal gold deposits in Japan.

Keywords: Epithermal gold deposit, Porphyry copper deposit, Magmatic fluid, LA-ICPMS, Fluid inclusion