# Re-examination of origin of the variety in magmatic-hydrothermal fluids

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A variety of magmatic-hydrothermal fluids, including volcanic gases, hot spring waters and geothermal waters, is created from a magma and we will re-evaluate those origins with particular interest on variation of Cl/S ratios. Giggenbach (1996) classified fluids in a magmatic-hydrothermal system as 1) Acid Cl-$SO_4$ water, 2) Neutral NaCl water, 3) Bicarbonate water and 4) Steam heated acid $SO_4$ waters. The acid Cl-$SO_4$ waters are formed by condensation of magmatic gases discharged from a magma. The neutral NaCl waters are formed from the acid water through neutralization and S-mineral deposition due to water-rock interaction at lowering temperature. The bicarbonate waters and acid $SO_4$ waters are formed by mixing of $CO_2$ or $H_2S$ derived from vapor separation of a deep hydrothermal system with meteoric water or the neutral NaCl waters. The principal differentiation process is the neutralization and S-mineral deposition of the acid Cl-$SO_4$ water under a temperature gradient to create the neutral NaCl water. However, we also need to consider other factors than the temperature dependence.

Water-rock reactions also have pressure dependent. HCl content in hydrothermal fluids has a negative pressure dependence; a hydrothermal solution has a larger HCl content at a lower pressure than at a higher pressure (Shinohara and Fujimoto, 1996; Botcharnikov et al., 2015). The pressure dependence implies that hydrothermal fluids discharged from a magma at a high pressure tend to have less acid than volcanic gases discharge at the surface. The average Cl/S ratio of the Japanese volcanic gases is about 0.2 (Shinohara 2013), whereas the ratio is about 0.5 in melt inclusion of basaltic magmas and is about 10 in those of silicic magmas. Therefore, a hydrothermal fluid formed by a complete solidification of the magma will have Cl/S ratio much larger than those of volcanic gases or the acid Cl-$SO_4$ waters. These evidences suggest that the acid Cl-$SO_4$ waters and the neutral NaCl waters have distinct origins with different condition of a magma degassing. Compilation of chemical compositions of hot spring waters and hydrothermal waters in Japan show a clear two frequency peaks of acid and near neutral pH with a gap at pH 4-5 (Muraoka et al., 2007). This pH distribution also suggests that the distinct origin of the two types of the hydrothermal fluids.

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