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Ultra-acid volcanic waters: origin and response on volcanic activity. A review

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Some active volcanoes host thermal springs with ultra- ($1 < \text{pH} < 2$) and even hyper- ($\text{pH} < 1$) acidic waters with composition corresponding to a mixture of HCl and H₂SO₄ acids and with cations where Al and Fe are often the major components. Such springs sometimes are known as inferred drainages from active crater lakes (e.g., Rios Agrio at Poas and Copahue volcanoes). However, there are a number of acidic volcano-hydrothermal systems of Cl-SO₄ composition at volcanoes without crater lakes. At least ten groups of manifestation of this type are known for Kuril Islands. Several groups of acid volcanic springs including the famous Tamagawa springs are described in Japan. Most of the acid Cl-SO₄ volcano-hydrothermal systems are characteristic for island volcanoes, probably due to specific hydrological conditions of small volcanic islands. Maybe most known are coastal acid springs at Satsuma Iwojima volcano, Ryukyu arc, Japan. The accepted idea about the origin of such systems is scrubbing (dissolution) of magmatic HCl, HF and SO₂ by groundwaters above magmatic conduits. If so, the composition of acid springs must reflect the state of activity of a volcano. This review describes case histories that are known from the literature and from authors' studies. Most of the volcanoes hosting acid systems show frequent phreatic activity. We show that in contrast to crater lakes (Poas, Ruapehu, Copahue, White Island), acid springs on slopes of active volcanoes generally do not response on the preparing or ongoing volcanic eruptions. The aquifers and flow paths of the acid waters in volcanic edifices can be not associated with active conduits but with other degassing magmatic bodies and/or with deeper aquifers. One of the examples of such a complicated system is Ebeko volcano with Yuryevskye springs in Kuril Islands. These springs have a hydrochemical record since 1950s, and during this period Ebeko volcano had at least 10 strong phreatic eruptions.