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POTENTIAL OF HYDROTHERMAL CIRCULATION FOR DEMAGNETIZATION ON MARS

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Crustal magnetism on Mars is difficult to interpret in terms of its dynamo history and mechanisms of magnetization / demagnetization[1]. Demagnetization due to hydrothermal circulation is one mechanism to explain the absence of magnetization in some regions. The transport of hot fluid could influence on demagnetization in two ways. First is thermal demagnetization, which is caused by heating the minerals above Curie temperature (Tc). Second is chemical demagnetization, caused by the reaction of minerals with water (e.g. oxidation of magnetite). We address these two processes by calculating the effect of hydrothermal circulation on demagnetization on Mars.

We numerically simulate the interaction of magma and water in an aquifer using the HYDROTHERM code [2] (developed by USGS). When hot magma above several hundred C contacts the aquifer at the depth of several hundred meters, the heated pore-water necessarily evaporates. We study the 2-phase porous flow within the aquifer as well as within the hot magma in two dimensions. We calculate a case of a sill penetrating into aquifer on Mars [3]. Based on previous studies and consideration of analogs on Earth, we assume the following situation; a sill 4 km in length and 500 m in thickness intrudes into an aquifer at a depth of 3.5 km. Initial temperature is 1140 C. The porosity and permeability of the sill is set as 0.05 and 10ˆ-18 mˆ2, respectively. We vary the permeability (k) of the aquifer from 10ˆ-13.5 to 10ˆ-18 mˆ2. The porosity is fixed as 0.1. In this study, the Earth's gravity is applied.

We track the heat and fluid flow in response to the penetration of hot magma into aquifer. In our figures, we show isotherm contours of the highest temperature ever reached (Tmax) when a sill intrudes comparatively highly permeable (10-14.5 m∗∗2) host rocks. We also plot the area ratio (Tmax .gt.Tc=320 C: pyrrhotite) for various k. The area ratio is the area heated above Tc divided by area of aquifer. The value (0.0164) for conduction-only case is also shown as a reference. When Tc is above 580 C (for magnetite), we find that almost none of the aquifer is overheated and no effect of changing k. We present the contours of the so-called Water-Rock ratio (W/R ratio) for some cases. W/R ratio is an indicator of water transport and defined by the total water flux divided by the mass of matrix rock. The water flux is integrated for 10000 years. We show how the averaged W/R changes with various permeability. Here we consider two ways for measuring water migration. One is limited to the water above Tth=250 C. Another measures all the water regardless of temperature.

We find that only about 2% of the total area is heated above Tc=320 C even at its maximum, which is the case of k=10ˆ-15.25 mˆ2. Unless k is very small (k.lt. 10ˆ-15 mˆ2), thermal demagnetization would be insignificant. The typical permeability of granite or basalt is around 10ˆ-(18-20) mˆ2. However, even if the thermal demagnetization occurs, it is limited to only minerals with lower Tc, such as pyrrhotite (Tc=320 C). On the other hand, chemical demagnetization (water reaction) could contribute to demagnetization, given the large volume of heated water that passes through the rock (assuming a favorable oxidation state for weathering). The effect increases with k.

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