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Remagnetization during hydrothermal process: paleomagnetic data and geodynamic consequences

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It well known that the fixation of magnetic minerals by magnetic minerals of the direction of the ancient geomagnetic field occurs at the time of their introduction or outpouring, and subsequent changes in the composition of the magnetic fraction are the result of later tectonic-thermal events. At the same time, numerous publications have shown that in mid-oceanic ridges, when interacting with seawater, the transformation of magnetization carrier minerals begins almost immediately.

For island-arc systems, such a transformation mechanism has been poorly studied. We tried to consider and systematize such secondary transformations using the example of the Middle Jurassic volcanic complex of Cape Fiolent (Heraclea plateau, Crimea).

The Middle Jurassic volcanites in the area of Cape Fiolent are described as an ophiolite association, including serpentinized ultrabasites and serpentinites, stratified basite-ultrabasite complex, gabbro and gabbro-dolerites, fragments of a complex of parallel dikes, pillow lavas, siliceous black layered formations and jaspers. The chemical composition, including the distribution of rare earths and a wide range of other trace elements, cushion lavas and dolerites from the ophiolites of the Cape Fiolent area, indicates their suprasubduction nature and belonging to the back-arc basin, which has reached the spreading stage in its development (Promyslova et al., 2014). These rocks are penetrated by extrusive domes, rods and dikes of plagioriolites (Promyslova et al., 2016).

Plagioriolites are porphyritic rocks of light greenish-gray color. Porphyry secretions up to 1.5−2.0 mm in size are represented by tabular acid plagioclase and isometric quartz crystals immersed in a cryptocrystalline quartz-plagioclase bulk (Promyslova et al., 2014). According to petro-geochemical characteristics, plagioriolites belong to low- or moderate-potassium silicic acid rocks of the calcareous-alkaline series with a flat distribution spectrum of rare earth elements and a quite distinct negative Eu anomaly (Kuznetsov et al., 2022; Promyslov et al., 2014). According to the U-Pb zircon dating data (SHRIMP-II, VSEGEI, St. Petersburg), the age of plagioriolites is defined as 168.3±1.3 million years (Kuznetsov et al., 2022).

Numerous publications have shown that rocks of different composition containing different magnetization carrier minerals can be magnetized in different ways [1 and references in this work]. The opposite is also true – magnetic minerals in different composition (acidic ↔ basic) and genesis (igneous ↔ sedimentary) rocks under the same conditions are most often remagnetized in different ways.

According to [2], the mechanisms of chemical remagnetization can be divided into two groups: changes caused by the influence of fluids, and changes associated with the process of diagenesis. Fluid motion is often associated with orogeny, according to [3] this mechanism is typical for many examples of residual chemical magnetization (CRM).

The study of the samples revealed several factors contributing to chemical remagnetization due to the formation of secondary single-domain magnetite: (1) the mineral composition of the rock and (2) the concentration of sodium chloride in solution. In highly concentrated solutions, the formation of magnetite occurs faster. With increasing temperature and pressure, the rate of magnetite formation increases. The rate of magnetite formation in olivinite and pyroxenite samples is proportional to the square root of time, which corresponds to the model of diffusion control of metasomatic reactions.