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Experiments on samples carrying a sum of laboratory induced TRM and TCRM imparted perpendicular each other

Valeriy P. Shcherbakov[1] , Sergey K. Gribov[1] , Vladimir A. Tselmovich[1] , Natalia A. Afinogenova[1]

[1] GO "Borok" IPE RAS , Russia

shcherbakovv@list.ru

The experiments reported here simulate a situation where the primary magnetization is represented by TRM acquired on the original titanomagnetite, which has undergone significant magneto-mineralogical changes during the cooling of the igneous rock. Subsequently, this rock experienced secondary heating and gained a secondary magnetization. To simulate these processes, we took a block of tholeiitic basalt raised from the Reykjanes Ridge; rock age does not exceed 1 Ma. The block was cut into cubic samples with 1 cm size. Then, four samples were taken and heated in air in a two-component rotating thermomagnetometer to a maximum temperature T_{max} = 600 °C in nonmagnetic space. Upon reaching 600 °C an external field B = 50 μT was turned on and the samples were annealed for 0, 4, 20 and 80 minutes, correspondingly. On further cooling in the field all samples acquired total TRM in Y-direction. Then a sample was rotated in the horizontal plane at an angle of 90° and, in the absence of an external field, was heated to 400 °C where the field was turned on in X-direction and the sample was kept at this temperature for 200 hours, during which it acquired TCRM.

Then four duplicate samples were cut into a number of small specimens which were subjected to similar experimental procedure which however was stopped at different stages of the thermal treatment. Then each of small specimens was studied using scanning electron microscopy, X-ray electron probe, X-ray diffractometry and thermomagnetic analysis and measurement of the magnetic hysteresis loop parameters.

As occurred, the intensity of the TCRM for the sample with no annealing at 600 °C is three times more than the TRM_{rem} intensity, but it sharply decreases with increasing exposure time so that for t = 80 minutes the ratio TRM_{rem}/TCRM ~ 0.1.

Analysis of the Arai-Nagata and Zijderveld diagrams showed that two straight segments can be distinguished there located in (400-530) °C and (530–580) °C temperature intervals. The segment (400 < T < 530–540 °C) is associated with the TCRM formed at 400 °C likely by the mechanism of growth of single-phase oxidized volumes. The values of calculated field B_{calc} are ≈50% less then the true value of the field. The orthogonal plots for these samples demonstrate a deflection by (10–20)° from the X-axis along which the external magnetizing field was directed during the TCRM formation. The high-temperature segment most likely corresponds to the combination of TRM_{rem}, the carriers of which are near-magnetite cells and that part of the TCRM that was formed due to subsequent oxydecomposition of newly formed metastable titanomaghemites. The values of calculated field B_{calc} here are strongly underestimated for the samples with short annealing time t = 0 and 4 min but they are close to the true intensity for the samples with long exposure t = 20 and 80 min. For the orthogonal plots, a deflection of the magnetization direction from the Y-axis (TRM formation field) reaches 53° and 26° for the samples with short annealing time t = 0 and 4 min but decreases to 8° and 3° for the samples with t = 20 and 80 min.

In the practice of paleomagnetic studies, it is usually accepted that straight sections on Zijderveld plots indicate the direction of primary and secondary components. However, the data reported clearly show that such a concept can produce significantly erroneous results that do not reflect the true direction of the field generated one or another component. For the most important case of high-temperature component, the errors are increasing as the contribution of the TCRM component to the resulting magnetization increases.

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