Motion and remanent magnetization of particles in eruption-fed density currents: Late Eocene scoria deposits, Oga Peninsula, NE Japan

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Exposed on a large marine terrace of Oga Peninsula, an eruption-fed low-density current deposit occurs in-between Late Eocene wave-dominated offshore to foreshore succession. The deposit commonly contains basaltic andesite scoria blocks and lapilli, which partly retain fluidal externals with millimeters-thick skins and intermingle mainly with their finer fragments. Dense rock fragments locally concentrate at lower levels, and the basal part casts its load into the underlying sandstone-mudstone bed and locally contains rip-ups of mudstone and sandstone. Inversely-to-normally graded coarse beds (<4 m thick) and thinner and finer or fines-poor beds (<0.3 m thick) constitute large-scale cross-bedding developed over the total thickness of 40 m. Scoriae concentrate upwards where beds are thicker than 2 or 3 m, and sparse accretionary and/or armored lapilli occur in the associated finer beds. Internal channels and long axes of scoriae extend from NNW to SSE and cross beds dip to the SSE, indicating a current to the SSE.

Examined the ash matrix of scoria deposit and associated 43 block-to-lapillus size scoriae by stepwise thermal demagnetization, the magnetization direction of the ash matrix fluctuates significantly, whereas the magnetization directions of scoriae remain stable at temperatures above 200 to 300 degrees C and are almost completely demagnetized at above 500 to 600 degrees C. The stable magnetization directions are, however, different by individual scoria fragments, and all the directional data projected onto a sphere appear distributed along a small circle with the along-circle standard deviation of 26.2 degrees and the across-circle standard deviation of 15.0 degrees, smaller than 29.5 degrees of the standard deviation from the mean direction. The unstable magnetization direction of the ash matrix implies that the constituent ash grains were cooled and magnetized much earlier than scoriae and were carried by the current while being supported by turbulence with rotation in various directions. The large along-circle standard deviation relative to the across-circle standard deviation likely indicates that after magnetized, scoriae were carried by traction along the substrate with a limited range of rotation, mainly back and forth about the axis of a small circle on which magnetization directions concentrate. Conformably with this interpretation, the rotation axis lies in a direction, normal or slightly oblique to the inferred current direction. Where it entered shallow water, this hot and dilute current presumably decelerated and was transformed into a water-logged current, so scoriae were rapidly cooled and magnetized in direct contact with the water, and were soon saturated with water and came to rest on the substrate from the decelerating water-logged current. This case study shows potential application of remanent magnetization directions of individual fragments to infer the mechanisms and directions of eruption-fed density currents.