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Composite basaltic andesite lava in Iwanuma (Miyagi, Japan): Differentiation along segregation veins and columnar joints

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Occurrence of thin (3-5 m) composite lavas with central phenocryst-rich layers was reported by Kuno (1950; JGSJ, 56, 167-172) and others, but we found very thick (>110 m) composite lava comprising a single cooling unit (with penetrating columnar joints) but consisting of some distinct chemical layers with segregation veins at the layer boundaries.

The basaltic andesite lavas of the middle Miocene age (15˜13 Ma) occur in Iwanuma City, Miyagi Prefecture, Japan. Thickness of the main lava flow measures more than 110 m. Vertical columnar joints of 1 or 2 m intervals are well developed through the outcrop. This lava flow is a composite lava flow with the lower layer (0˜42 m from bottom) having rather felsic composition (SiO_2 55 wt. %) and the upper layer (45˜110 m from bottom) having more mafic compositions (SiO_2 52˜54 wt. %).There are no macroscopic differences between the two layers, but the size of plagioclase in the nearly holocrystalline groundmass of the upper layer is larger (<0.5 mm) than that of the lower layer (<0.3 mm) under the microscope. Red clinker is seen at the bottom of the outcrop, but the top of the flow has been eroded.

Many horizontal segregation veins are observed at the limited portions in the intervals of 6˜14 m (lower vein zone), 45˜64 m (central vein zone) and 80˜95 m (upper vein zone) from bottom. The lower veins are 1 mm in thickness at intervals of 1˜10 cm, have glassy structure and contain plagioclase and augite. The central veins are 5˜15 mm in thickness at intervals of 10˜15 cm at 45 m from bottom and 3˜5 mm at intervals of 5˜15 cm at 52˜64 m from bottom, have crystalline structure and contain plagioclase, pigeonite and subcalcic augite. The upper veins are 3˜5 mm in thickness at intervals of 5˜7 cm and have similar structure and mineral assemblage to the central veins. The segregated melt of the central veins forms after the approximately 70 % crystallization of the host magma. The segregation veins are apparently formed by the migration of the residual melt into the subhorizontal fractures (platy joints) which resulted from the shear deformation and cooling contraction in the crystallizing lava flow, especially near the bottom of the flow and at the bottom part of the flow and relatively mafic layers in the upper part of the composite lava flow. Rare en echelon segregation veins are the evidence for shear deformation.

The columnar joints always perpendicularly cut segregation veins, and the rocks adjacent to the columnar joint plane show low density and increase of vesicles in comparison with the rocks in the middle of the column. This suggests that columnar joints developed far later than the segregation-filled platy joints, but some melt was still present at that time so as to allow its vesiculation promoted by the columnar joint fracturing.

Keywords: composite lava flow, segregation vein, platy joint, colunmar joint, basaltic andesite, crystallization differentiation