Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SIT42-P02 Room:Convention Hall Time:May 22 17:15-18:30

Factors controlling entablature formation in columnar joints: Suggestions from the analogue experiments

HAMADA, Ai[1*], TORAMARU, Atsushi[2]

[1]Earth and Planet. Sci., Kyushu Univ., [2]Earth and Planet. Sci., Kyushu Univ.

Columnar joints of lava and ignimbrite have two types of structure within one flow unit: colonnade and entablature. Colonnade have relatively wide, straight and directionally ordered columns, on the other hand, entablature have relatively narrow, curved and disordered columns in different directions. Columnar joints are formed by volume contraction due to temperature decrease during cooling. The fractures in colonnade are thought to develop perpendicular to the isotherm. In entablature, however, how the complex structure is related to the isotherm and what causes such a complex structure is still unclear. It has been well known that in desiccation experiments using starch-water mixtures, structures similar to colonnade form, but structures similar to entablature have not been reproduced so far. Therefore, this study aims at reproducing the entablature structure with additional conditions different from experiments before. We conducted consisting of three experiments: Experiment 1: To reproduce the typical threefold structure: upper colonnade, entablature and lower colonnade, we designed an experimental setup in which water can evaporate from upper and lower surface of mixture by attaching a membrane. The drying rate is controlled by changing the distance between the lamp to the starch surface. For a monotonic drying rate with a constant distance being 10cm, the colonnade structure developed from upper and lower surface. Experiment 2: Under the same condition of Experiment 1, after the colonnade structure developed partially, we suddenly increased the drying rate by shortening the distance between the lamp and the mixture surface from 10cm to 1.5cm. As a result, the colonnade structure developed discontinuously correlating with the sudden change of the drying rate. A curved structure to the rim of the container developed after changing the drying rate. To observe the whole structure by Experiment 2 in detail, we took images by Micro-focus X-ray CT (manufactured by Tesco at 119 micro meter resolution, at Fukuoka Industrial Technology Center). From analysis of images, we found following three facts: 1) the number of fractures suddenly increase after changing the drying rate, 2) the widths of columns, which developed before changing the drying rate, become smaller and 3) the new columns form at the triple or quadruple junctions of cracks constructing columns which developed before changing the drying rate. Experiment 3: To examine the cause that forms a curved structure, we conducted the experiment under the constant drying rate with the distance being 1.5cm. From the images which we took before the mixture dried perfectly, the curved cracks develop perpendicular to an iso-surface of water concentration. From these results, we concluded that a sudden increase in contraction rate forms new columns at the triple or quadruple junctions to release accumulated tensile stress, which remains after the growth of pre-existing cracks. The inhomogeneous concentration distribution with a curved iso-surface results in the formation of curved cracks. We could substantiate the possibility that the entablature structure in columnar joints is caused for the inhomogeneous temperature distribution of rocks. As formation processes of new columns, two cases are expected 1) the case that one column was divided into multiple columns by forming new cracks inside the columns and 2) the case that new columns nucleate at triple and quadruple junction of cracks, although it was difficult to distinguish these two cases with conventional X-ray CTs. In order to closely observe the columns nucleation at triple and quadruple junctions, we use High Resolution 3D X-Ray Microscope VersaXRM-500 (manufactured by Xradia (U.S) at 3.7 micro meter resolution). As a result, it was confirmed that columns nucleations take place at triple and quadruple junction of cracks.

Keywords: columnar joint, analogue experiment, crack, formation process, Micro-focus X-ray CT, 3D X-ray Microscope