On the crack pattern formation in drying starch slurries

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Desiccation cracks are ubiquitous and exist commonly in everyday life. Examples include those that develop in dried mud, old paintings, ceramic glaze, and so on. These cracks usually exhibit a specific network structure, splitting the entire surface of the fractured media into many polygonal cells. Earlier studies have elucidated the mechanism of desiccation crack formation for various grain-liquid mixtures. Upon drying, liquid content evaporates from an air-exposed surface, which causes shrinkage in the volume of the solidified mixture. As a consequence, cracks occur when the tensile stress induced by shrinkage exceeds the bonding strength of grains. In particular, corn starch-water mixture under drying has been found to exhibit a regular array of tiny polygonal prisms, as a reminiscent of columnar joints, a type of impressing geological structure that spontaneously occurs in cooling lava flows.
Here we point out the possibility that the geometry of polygonal cracking network, which we commonly observe on the dried surface of starch slurries, will be affected by the degree of the irregularities with respect to the size and shape of the constituent starch grains. This is because the irregularities cause wide structural variations in the pore spaces between adjacent grains; the pores regulate the local transport of water content. Therefore, from a statistical perspective, it is anticipated that the irregularities are responsible for local volume shrinkage, and thus for the geometric properties of the polygonal cracks. To examine the conjecture, we performed the desiccation-cracking experiments using starches made from two different ingredients, potato and corn, which showed different grain shapes and different-sized distributions. It was experimentally confirmed that dried potato-starch slurries showed remarkable suppression of cracking at the initial stage as well as a strong dependence of the polygonal cell-area distribution on the slurry thickness, as manifestations of the large-sized, oval-shaped geometry of the constituent starch grains. We also found the predominance of pentagonal cells in the polygonal cracking, which is attributed to the relatively high drying rate of the starch under the present condition, as a reminiscence of pentagon-dominated columnar joints that typically occur in the fast-cooling lava flow.

[l] Y. Akiba et al. (2017), in press.
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[3] S. Kitsunezaki et al., EPL **114**, 64002 (2016).