Make your own causeway: recipe for corn starch columns

Lucas Goehring (lg352@cam.ac.uk)
BP Institute for Multiphase Flow, University of Cambridge, Madingley Road, Cambridge

INTRODUCTION

Columnar joints are a common, yet spectacular pattern that can be easily seen in volcanic areas. The names associated with these types of features, such as the Giant's Causeway (N. Ireland), the Devil's Postpile (California), the Devil's Tower (Wyoming), or Samson's Ribs (Edinburgh), reflect the impression that such near-perfect order could not be caused by nature, but only by supernatural agents. This is far from true. The beautiful hexagonal pillars, common to all these places, were formed by the gradual cooling, and cracking, of lavas, the products of volcanoes. Anyone can set up a simple experiment to demonstrate how these remarkable landscapes form.

MAKING YOUR OWN STARCH COLUMNS

Columnar joints can be made in any well-equiped kitchen. You will need to mix:

- 250 ml (1 cup) corn starch (aka corn flour)
- $\sim$ 150 ml water
- 1 tbs. bleach

Actually, the proportions don't matter too much. Also, potato starch can be used in place of corn starch. The resulting liquid should be well-mixed and somewhat runny, but you should still be able to feel some resistance when stirring. If it is too difficult to stir, add a little extra water. If it is too runny, add a little more starch.

Handle the bleach with care, as it is caustic, and even small spills will quickly cause clothes to fade, and skin to become dry and irritated. Wash any exposed areas immediately with plenty of water.

Pour the mixture into a clean dish, so that you have a layer 2 to 4 cm thick. If it will not pour readily, you will need to mix in more water. The container should be about 10 cm or more across, and the mixture should come up to near the lip of the container, to get the best effect. If you can, use a glass container, so you can see what's going on inside. Put your creation in a warm (but not hot) place , where it can dry, such as 10-20 cm underneath an incandescent lamp.

It will take a couple days to fully dry your starch-cake. Before any columns even begin to grow, the mixture must be dried for at least several hours. A few large, deep cracks will form first. These will be a few centimeters away from each other, as shown in Figure 2(a). Also, before the columns start, the surface of the starch-cake should be thoroughly dry, and will tend to get covered with little flakes of starch (these can also be seen in Figure 2(a)). If you can see both the large cracks, and flakes, then your starch should have *begun* to form columns.

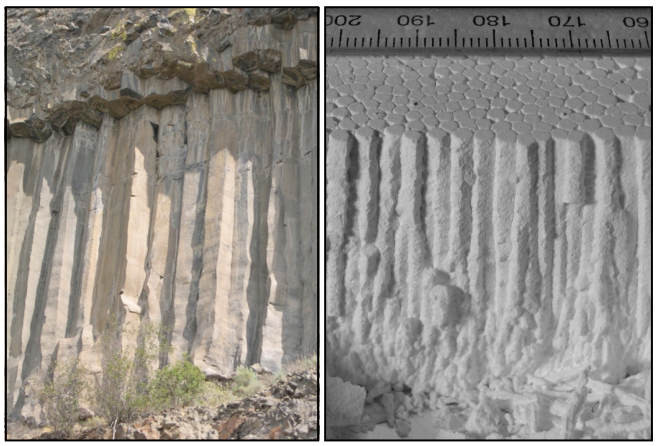

FIG. 1: Columnar joints in lava (left) and starch (right) form in the same way, and share the same structure, even though columns in lava are a hundred times larger than those in starch.

If you dried the mixture in a glass dish, there are several things that will indicate when the experiment is done. As the columns grow down from the drying surface, they will separate from the container walls. This will look appear as a color change, when you look through the glass walls, like that shown in Figure 2(b). When this color change reaches the base of the container, you will be able to see a network of polygons through the underside of the dish, and the starch-cake will be done.

If you did not dry the mixture in a glass container, try to leave the experiment at least a day after the point when you can see that the surface has fully dried.

When you want to remove the starch-cake, cover the container with a hard surface, such as a cutting board, or a piece of stiff cardboard. Carefully turn the container upside down. The whole sample should slide out onto the board. If it does not, tap on the base of the container, or shake the container a little.

Once removed, the starch-cake should ideally have kept the shape of the container, although some columns may have fallen down around the edges. The colonnade will be very fragile at this point, so handle it with care. The best columnar joints will be near the middle of the starch-cake. You can try pick off columns from one side, to expose these. Alternatively, try hold the whole sample

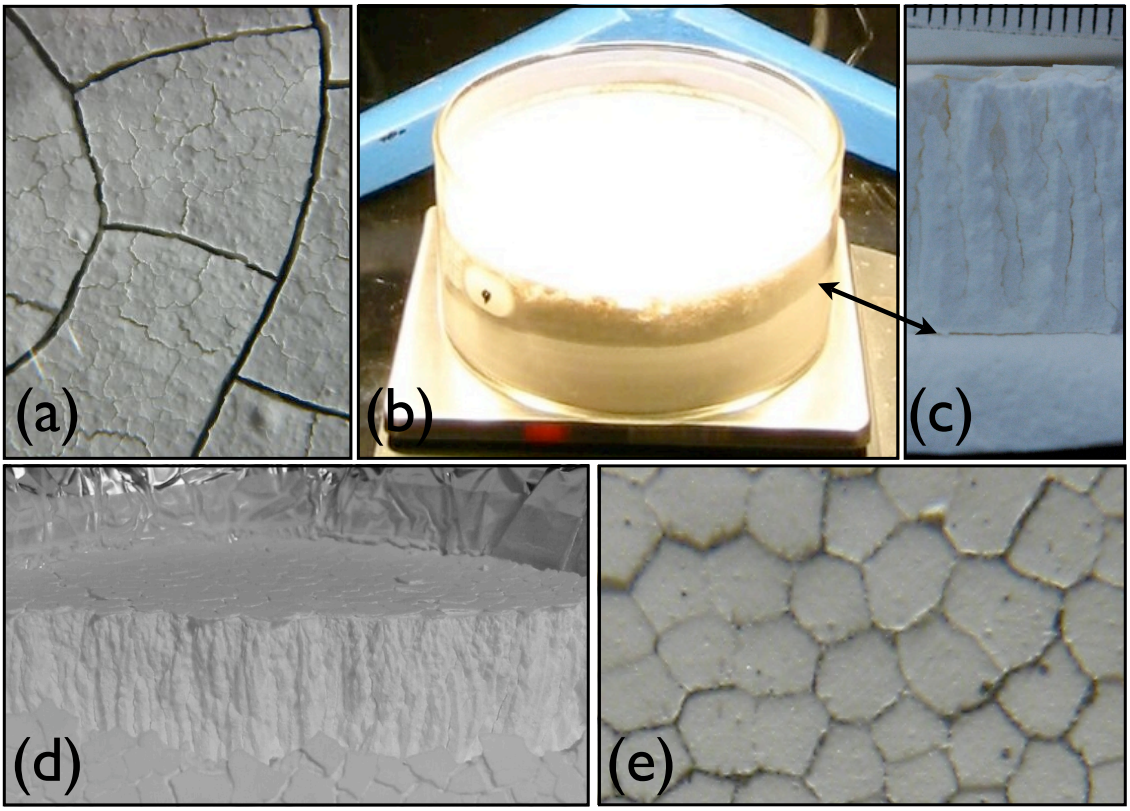

FIG. 2: (a) At the surface of a drying starch-cake, large cracks open first, breaking the cake into a handful of separate pieces. These cracks often meet a right angles. The top of the starch may also become somewhat flakey, as salts and impurities tend to get left at the drying surface. (b) The side of a drying starch-cake should have a change in color where it unsticks from the container walls. (c) The columnar joints in a drying experiment will have reached down from the surface to this color change. (d) When fully dried, you may break your sample in half to expose the center of the colonnade, which is usually best formed. (e) In cross-section, the pillars will be mostly hexagonal polygons.

together, by gently squeezing it from all sides with both hands, and pull apart two halves of it, to expose the centre. If the experiment was successful, you should see a colonnade of regular pillars, such as shown in Figure 1(a).

You should also be able to see a beautiful polygonal pattern of cracks on the exposed base of the starch-cake. Each of these polygons is the end of a single column, which will stretch into the sample. On average, these columns are hexagonal, but there will be many pentagons and heptagons, and a few other shapes. When seen from the side, this appears as a collection of pillars, which will gently taper as you look closer to the drying surface.

Potential difficulties

Heat: Corn starch is used to thicken many sauces and soups. Chemical changes happen when its temperature is raised above about 60°C (140°F). Too much heat will make your experiment into a big mess. The starch should be kept warm, but not be hot to the touch.

Mold: By creating a warm, moist starch mixture, you are making a perfect environment for incubating mold. Bleach is a good antiseptic, and you should not see any mold grow during your experiments. If you do, stop the experiment immediately. It may take the form of tiny spots, growths, or discoloration. You may try again, doubling the bleach given in the recipe.

Haste: Under ideal conditions, columns may take several days to fully develop. If the experiment is disrupted during this time, or broken open too soon, you may not see any columns, or the columns may only appear in part of the starch-cake (as in Figure 2(c)), and you will have to begin again.

WHAT'S GOING ON

Columnar jointing happens in lava when something (like a volcano) leads to the pooling of molten lava. In Hawaii, people have studied the cooling of deep lava lakes, and slowly watched as they have solidified. The cooling lava surface first hardens into a dark, brittle ma-

terial (most commonly, this is basalt). However, beneath this insulating crust, the bulk of the lava remains fluid. As cooling continues, the surface crust grows thicker, and, since cooling things shrink, the crust begins to crack. While the solid layer of lava continues to thicken, this network of cracks is slowly driven deeper and deeper into the lava lake. The polygonal pillars of the columns are what are left behind as the polygonal network of cracks has traced its way through the entire lava formation. In a drying starch-cake, the individual grains of starch get pulled together as the cake dries out. The physics which describes how the cake dries is analogous to that of cooling, and both lead to a slowly advancing crack network. The size of the columns depends on the speed that the cracks advance (if you try drying another cake more slowly, you should get bigger columns).

You may have noticed that your columns angle, or curve, slightly towards the edges of your container. The columns will always grow perpendicularly to the drying, or cooling, front. Due to the container walls, this front will tend to be slightly convex, causing the columns to curve. Since lava lakes will actually cool from all sides, they will tend to have more complex patterns than a starch-cake. Typically, for example, colonnades come in pairs, one cooling up, and one cooling down. In the field, curving columns can be used to show exactly how a lava flow cooled.