LIGHT TOUCH

Sandbow or Rainbow?

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Water droplets and ice crystals create beautiful rainbows that paint the sky. Can other natural particles produce similar arcs of color?

In the morning there was khamsin [a sandstorm] and we saw a sandbow. It was on a level with the sun, and not opposite it as in rainbows, but about 30° from it; not the shape of a rainbow, but of a nebula; all the colours perfect. It had a most singular effect; it was about midday, so that the top of the pillar of sand must have reached that height.

Florence Nightingale
29 December 1849

Florence Nightingale—yes, *that* Florence Nightingale—reported having observed a "sandbow" while she was on a boat trip down the Nile. It's one of only a handful of references I have found to the phenomenon of the sandbow, which has fascinated me for some time.

My interest was stirred when I considered what other materials, besides water droplets and ice crystals, might create "bows" of color. There are many cases of halos around the sun or moon caused by grains of pollen or droplets of plant oils after forest fires, or even by grains of volcanic dust. But I hadn't heard of any instances of these materials creating bows. I decided to delve deeper.

From salt to sand

It occurred to me that salt crystals—such as those found in the salt flats of Utah (U.S.A.)—might fit the requirements. Alas, NaCl won't work. The crystals have 90° edge angles, which are too large to create a salt halo or arc. For such an angle to work, the refractive index of the material must be less than 1.414, and that's a pretty severe restriction.

While looking into salt crystals, I stumbled on an unexpected possibility—sand. It is mainly composed of silicon dioxide, which has many crystalline forms with a variety of refractive indices—although most are greater than 2.5. Sand grains have facial angles that might allow for interesting prismatic effects. However, they are rarely crystalline and probably don't have the uniformity required to produce a bow. Still, I was intrigued.

I found an article in the 21 June 1901 issue of *Science* entitled, "A sandbow: An unusual optical phenomenon." Its author, James E. Talmadge, a professor of geology at the University of Utah, related that he had been on an island in the Great Salt Lake when he saw a

rainbow twice the width of a normal bow, yet there was no rain present. He guessed that it had been caused by the oolitic sand in the area. Uniform and spherical in shape, oolitic sand grains are composed of calcareous material with a polished, pearly luster. Talmadge's sandbow was about 40° from the antisolar point (about where a rainbow should be). He also witnessed a faint secondary bow, with the colors in reverse order.

Are they real?

Although Florence Nightingale's account doesn't mention oolitic sand, it is present in Egypt. But her report is also a perfect description of a sundog or parhelion—an effect caused by horizontally refracted sunlight from ice crystals in the air. It is more common than a simple rainbow, but rarely noticed. Nightingale may have thought this effect was due to sand because no rain was present. However, sundogs are often seen when there is no ice in the vicinity, just as rainbows can form in the absence of rain.

Wikimedia Commons

Sundogs (or parhelions) in Fargo, N.D., U.S.A.

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I entertained ideas of thin films on the individual 2-mm oolitic grains, or of light passing through one layer of the concentric shells. I could imagine interference between the reflections from one such grain causing an angle-dependent rainbow, but it was hard to see how a vast collection of such grains could have the uniformity of thickness required to give the same effect, not to mention to create a secondary bow.

Talmadge's so-called sandbow was in the same location, give or take a couple of degrees, as a typical rainbow, with the same order of colors in both the primary and secondary bows. Thus, it is highly probable that Talmadge witnessed nothing more than an ordinary rainbow.

So both of the reports of sandbows I found from the last 100 years appear to be cases of mistaken identity. Maybe it's the dreamer in me, but I still hold out hope that we may one day find another bow-forming particle in nature—somewhere over the rainbow, perhaps? OPN

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BEYOND THE RAINBOW?

A material needs a refractive index of less than 1.414 to create a bow.

ICE
1.309

WATER
1.33

VOLCANIC ASH FROM EYJAFJALLAJÖKULL
1.50-1.56

SALT
1.516

YEW POLLEN
1.53

SAND
Usually > 2.5