JOHN RAKOVAN
Department of Geology
Miami University
Oxford, Ohio 45056
rakovajf@muohio.edu

Pillow Basalt

Basalt is a fine-grained igneous rock that is primarily composed of the iron- and magnesium-rich minerals pyroxene and olivine and calcium-rich plagioclase feldspar. It forms from the rapid cooling of mafic (SiO_2 concentration between 48 and 52 wt. %) magma. When basaltic magma is extruded slowly into water (picture extrusion of toothpaste from a tube), a chilled rind will form on all sides of the extrusion. The hot rind is solid but elastic (like a balloon), and continuous injection of lava into it leads to bulbous, spherical, or tubular lobes that eventually solidify to form pillow-shaped masses of basalt. Not surprisingly these masses are called *pillow basalts*, or sometimes *pillow lavas*. This process is analogous to the formation of pahoehoe lava toes or lobes on the earth's surface through a process known as inflation or endogenous growth (e.g., Walker 1991; Hon et al. 1994). A wonderful video clip showing live footage of pillow lavas forming off the coast of Hawaii can be downloaded from the National Oceanic and Atmospheric Administration Web site: http://www.pmel.noaa.gov/vents/geology/video_other.html.

As the process of pillow formation repeatedly continues, sheets or layers of pillows, called *pillow flows*, are created. The individual pillows in a layer are typically close fitting, with concave portions of one matching the convex portions of others. They range in size from a few centimeters to a meter or more in greatest dimension (commonly between 30 and 60 cm). Although pillows are abundant on the ocean floor close to active midoceanic ridges, they are also found at the bottom portions of continental lava flows that were emplaced into shallow bodies of water. The morphology of pillows can be used as a stratigraphic "way-up" indicator. Pillows are emplaced with their convex portions facing upwards. If a sequence of rocks in a complexly deformed area contains pillow lavas, it is possible to determine whether the sequence has been inverted due to the deformation. In this context, pillows serve the same purpose as ripple marks in sedimentary rock.

This issue features an article on minerals found in the pillow basalts of Paterson, New Jersey (see pages 234–41). These minerals are found in void spaces within and between pillows. The spaces within the pillows form by the enrichment of the lava in gasses such as H_2O and CO_2 and the migration of these gasses toward the center of the pillow as it cools from the outside toward the center in a roughly concentric fashion. Eventually, the gasses exsolve, forming vesicles, which may coalesce to form a central cavity in the pillow. Some pillows also show the presence of a radial arrangement of pipe vesicles. As a pillow cools, the solidification front moves inward, toward the center of the pillow. During this process, gasses may diffuse into bubbles that are attached to the solidification front, leading to the pipe-like cavities that extend from the base of the chilled rind to the center of the pillow (Philpotts and Lewis 1987). Central cavities may also form as cooling fractures. Metasomatic alteration of the basalts by ground waters (Rakovan 2005) often leads to the formation of calcite, quartz, and zeolites in vesicles and cavities, for which trap rocks such as those in Paterson, New Jersey, and the Deccan plateau, India, are so famous (Rakovan 2004).

Pillow basalts on a slope off Hawaii. Photo courtesy of the National Oceanic and Atmospheric Administration/Department of Commerce.

Dr. John Rakovan, an executive editor of Rocks & Minerals, *is author of the News from Japan article series.*

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