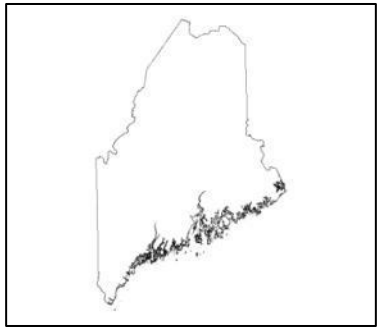
Geologic Site of the Month

September, 2000

Beach Pebbles Tell a Story



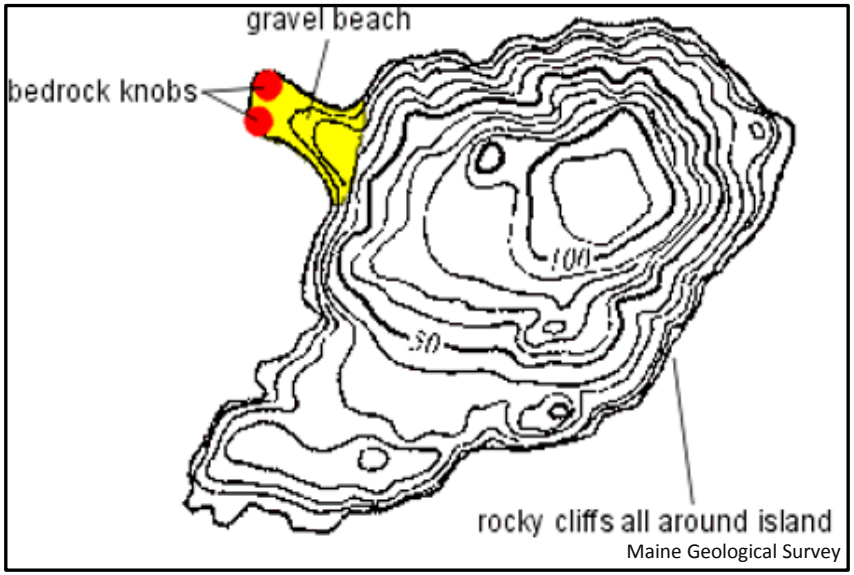
Text by
Maine Geological Survey

Introduction

The smooth, sandy beaches of southern Maine are popular with summer sun-seekers. In contrast, most beaches along the middle and eastern Maine coast are made of stones. This month we look at a typical small, uninhabited island off the Maine coast with a well-preserved gravel beach. By looking closely at the shape of the beach and at the stones themselves, we can learn about the coastal processes that continually shape and re-shape beaches in Maine.

A Look at the Beach

The beach is at one end of the island sheltered by the main part of the island to one side, and protected by small bedrock knobs to the other (see map of the island and photo of the beach in Figure 1). This means that waves cannot move the stones very far to either side where they might be washed out to deeper water. Instead, the stones are caught in a "pocket" framed by bedrock.



Map and photo by Maine Geological Survey

Figure 1. (Left) Map of a small island with a gravel beach. (Right) Pocket beach confined by main island to the left and small bedrock knob to the right.

A Look at the Beach

As waves continually wash the stones up the sloping beach and roll them back down again, the stones (Figure 2) become naturally rounded and polished. Believe it or not, geologists use particular names for stones depending on their size. The term "pebble" is precisely defined as a stone between 4 millimeters and 6.4 centimeters across. So technically, this is a pebble beach.

Figure 2. Rounded and polished stones on the beach.

A Look at the Beach

The stones on the beach are neatly arranged in a series of flat-topped deposits, (Figure 3, Left) called storm berms, that are stacked on each other. A view looking back along the beach (Figure 3, Right) from the end of the point shows that each berm has a steeper lower slope, a flatter upper slope, and a line of seaweed and other debris along its top edge. The next higher berm then repeats the shape: steeper lower, flatter higher, with debris on top.

Photos by Maine Geological Survey

Figure 3. (Left) The beach is made up of deposits in a series of horizontal levels called berms. (Right) Each storm berm has a steeper lower slope and flatter upper slope. There are at least five storm deposits preserved here.

A Look at the Beach

A straight-on view of the beach face (Figure 4) shows another interesting feature. In the lower, steeper part of each deposit the stones are slightly smaller than the stones in the upper, flatter part of the deposit.

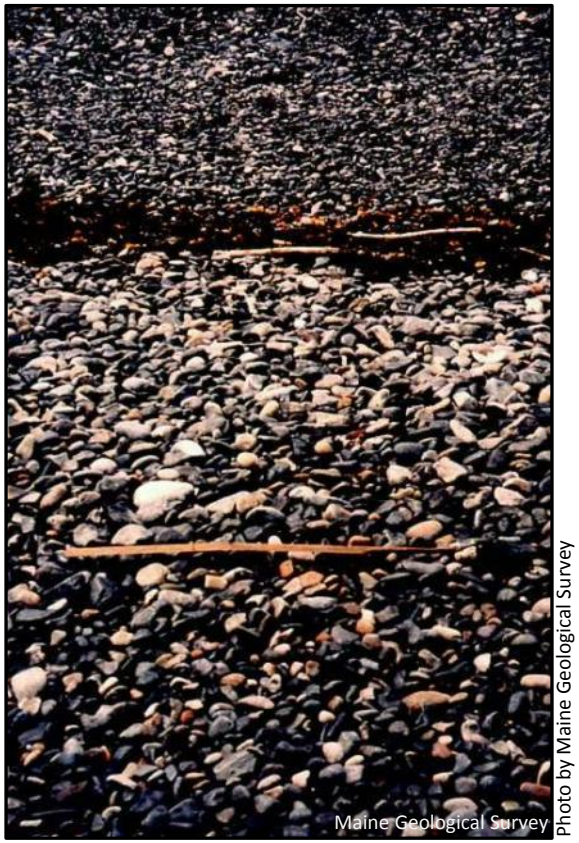


Figure 4. Stones in the lower part of the berm are smaller than stones in the upper part of the berm. Seaweed marks the upper limit of a storm deposit.

A Look at the Beach

Then, above the line of seaweed, the lower part of the next deposit again has smaller stones. The differences are subtle, but consistent all along the length of the beach. Furthermore, the stones on the steeper, lower slope are quite round, whereas there are several flat stones on the flatter top area (Figure 5).

Photos by Maine Geological Survey

Figure 5. (Left) Rounder, smaller stones on lower slope. (Right) Larger, flatter stones on upper part of berm.

A Look at the Beach

Each storm berm represents a deposit from a single storm. As the waves break, they release enough energy to scour rocks from the base of the beach and throw them up on the shore. As the tide increases, the waves reach higher and higher levels, pushing stones, seaweed, and driftwood up the beach. As each wave crashes it propels large and small stones up the beach, but as it recedes, it has less energy and can only pull the smaller and rounder stones back down the slope. In this way, the larger, flatter stones are sorted out from the smaller, rounder ones, ending up at the top of the deposit. As the height of the storm passes and the tide begins to fall, the large stones and floating seaweed are stranded at the height of the deposit.

If the next storm is larger than the first one, then the older berm will be wiped out and the stones will be re-formed into the new one. Only the deposit from the larger storm will be preserved. On the other hand, if the next storm is smaller than the first one, only the lower part of the first berm will be affected, and the upper part will be preserved. In this case, the younger, lower berm will rest partway up the older, higher berm. On the beach we are looking at, there are at least five berms preserved, with the highest one being the oldest, and the lowest one being the youngest. Notice that the highest berm is about 15 feet above normal high tide, which would have flooded the whole beach. Most storms of this magnitude in Maine occur in the winter months. Some of the higher berms may be many years old.

Where did the Stones Come From in the First Place?

On this particular beach, any handful of stones is likely to include several different types of rocks. For example, some stones are dark-colored volcanic rocks, (Figure 6, Left) some are light-colored volcanic rocks, (Figure 6, Right) some are volcanic rocks containing broken rock fragments, (Figure 7, Left) and some are granite of different types (Figure 7, Right).

Figure 6. (Left) Beach pebbles of dark-colored volcanic rock. (Right) Beach pebbles of light-colored volcanic rock.

Where did the Stones Come From in the First Place?

The obvious place for the stones to have come from is the bedrock next to the beach. After all, every stone was once part of some bedrock before it was broken loose.

Photos by Maine Geological Survey

Figure 7. (Left) Beach pebbles of volcanic rocks containing broken rock fragments. (Right) Beach pebbles of different types of granite.

Where did the Stones Come From in the First Place?

The bedrock (Figure 8) next to the beach is dark-colored volcanic rock It is broken by many cracks, so it probably has broken apart to supply some stones to the beach. But most of the stones on the beach are different from the bedrock on the island, so they must have come from somewhere else.

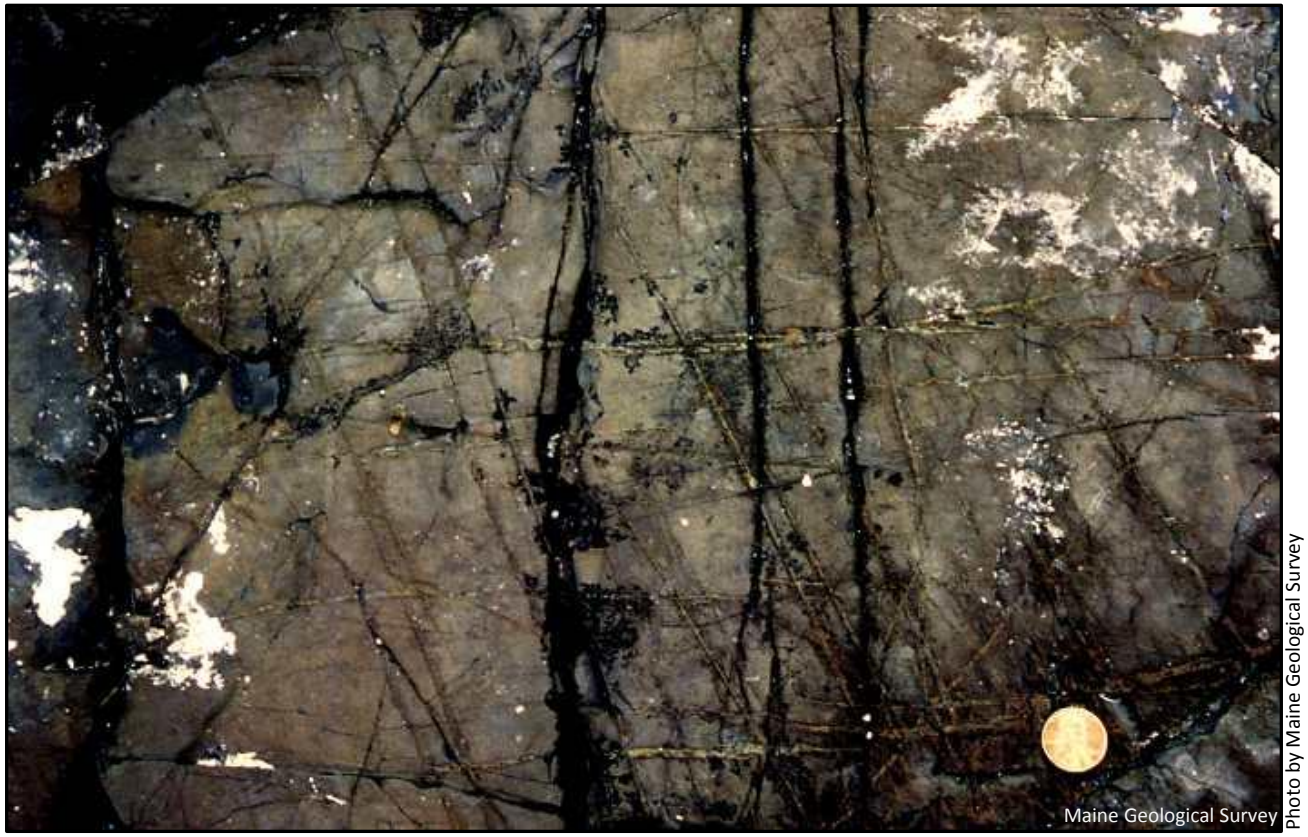


Figure 8. Dark-colored volcanic bedrock next to the beach.

Where did the Stones Come From in the First Place?

In fact, there are more prominent out-of-place rocks on the beach, (Figure 9) and on the bedrock next to the beach, (Figure 10) namely, boulders of granite. These boulders, like thousands and thousands of boulders strewn across Maine, were deposited by the glacier that covered New England in the last Ice Age.

Figure 9. This granite boulder on the beach was deposited by a glacier.

Where did the Stones Come From in the First Place?

About 14,000 years ago, as the ice melted, it dropped a mixture of stones of all shapes and sizes across the landscape. The stones that make up this island beach must have been part of a glacial deposit that has since been washed by modern ocean waves.

Figure 10. Boulder of granite nestled among dark volcanic bedrock. This boulder was left by a glacier.

So What's the Story?

By looking carefully at the shape and elevations of the beach deposits, the sizes of the stones, and the kinds of stones on the beach, we can deduce that:

- The stones that now make up the beach were originally deposited here by the continental glacier.
- Waves acting on the glacial deposit washed the mud and sand into deeper water, leaving behind a "clean" deposit of stones.
- Over time, as the stones have rolled up and down the beach, they have become rounded and polished. Solid bedrock anchors the ends of the beach, keeping the stones in a pocket.
- The shape of the beach changes when storms rearrange the stones on the beach into berms. The largest storms reconfigure the entire beach, whereas smaller storms may only affect the lower portions.
- Each storm leaves a characteristic berm shape, with a lower sloped beach and a higher flatter top.
- Even stone beaches are dynamic systems that are continually changing.

This small pocket beach is one of hundreds on the Maine coast. Each one has a similar story, although the details may be different.

References and Additional Information

Shape evolution and fabric in a boulder beach, Monument Cove, Maine, by Charles J. Waag and David E. Ogren. Journal of Sedimentary Petrology, volume, 54, number 1, 1984, p. 98-102.

Orientation of cobble and boulder beach clasts, by David E. Ogren and Charles J. Waag. Sedimentary Geology, volume 47, 1986, p. 69-76.

Morphology and stratigraphy of small barrier-lagoon systems in Maine, by William Duffy, Daniel F. Belknap, and Joseph T. Kelley. Marine Geology, volume 88, 1989, p. 243-262.

Don't touch that rock! - Maine's cobblestone beaches, by Tammis Coffin. Coastal Journal, July 1986, pp. 30-31, 58-60.

Jasper Beach, Maine