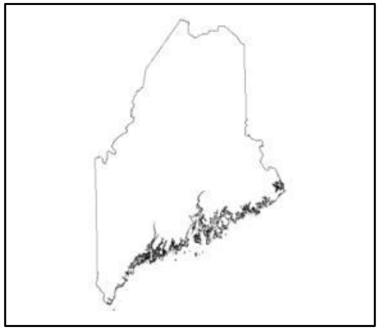
Maine Geologic Facts and Localities

March, 2005

Digital Elevation Models: Maine Geology in a New Light



Text by
Woodrow Thompson

Introduction

A digital elevation model (DEM) uses computer-processed elevation data to produce an image of the earth that mimics a shaded-relief map. The DEM shows terrain features as they might appear from an airplane or satellite if all the vegetation were stripped away. Artificial lighting of the image resembles sunlight raking across the earth's surface at a low angle, creating shadows behind elevated areas such as hills, ridges, and mountains. Unlike real sunlight, the illumination can be varied to "shine" from any direction. So if you want to search for linear topographic features trending east-west, you would specify lighting from the north or south. By examining the topography in this way - free of vegetation cover and other clutter - it is often possible to detect or emphasize interesting geologic features that otherwise might not be obvious.

Introduction

The density of available elevation data determines the largest scale of image enlargement that can be achieved while still maintaining a sharp view of the landscape. If the image is enlarged too much, it will become "pixelated" (like a digital camera photo that is overly enlarged). The DEM images included here mainly represent natural terrain features. Similar imagery from other parts of Maine shows man-made features that are large enough to modify the topography, such as linear strips where highways have been elevated by filling in across low areas.

The following DEM images are from southern Washington County, Maine, not far inland from the coast. They show some of the large and spectacular glacial features for which this area is famous. Among these features are east-west ridges (moraines) formed along the margin of the most recent glacial ice sheet as it retreated from Maine. The ocean flooded the coastal lowland at this time, and in many places the southern edge of the ice sheet stood in the sea. Large deposits of sand and gravel, known as deltas and submarine fans, accumulated where glacial meltwater streams washed into the ocean. These streams issued from tunnels beneath the ice, and eventually the tunnels became choked with gravelly sediments. The tunnel fillings were later exposed when the surrounding ice melted, and now appear as long north-south ridges called eskers.

Pineo Ridge area

Figure 1 is a DEM image illuminated from the west. It includes a large flat-topped marine delta northeast of Cherryfield, known as Pineo Ridge. The south side of the delta is incised by gullies resulting from postglacial erosion, while the north side drops off abruptly into a vast peat bog called the Great Heath. This steep northern margin is where the Pineo Ridge delta lay against the front of the glacial ice sheet.

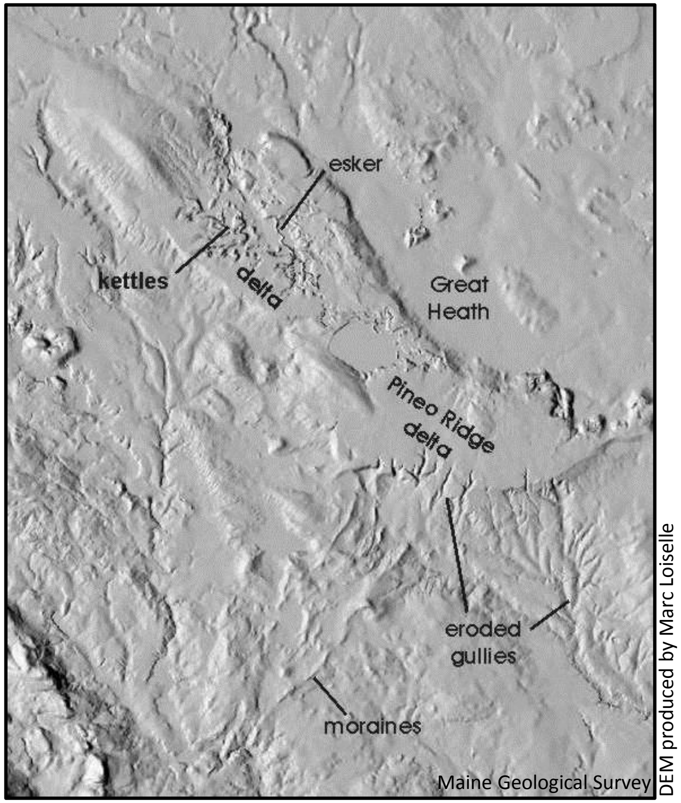


Figure 1. DEM image of Pineo Ridge, Cherryfield, illuminated from the west.

Pineo Ridge area

Another delta, located immediately northwest of Pineo Ridge, is deeply pockmarked by kettle holes left by the melting of buried ice blocks. The image also shows a narrow, sinuous esker ridge marking where the subglacial meltwater stream flowed through the kettle zone. Figure 2 was taken from a plane and looks west across this same area. Note the kettle holes, some of which extend below the water table and contain ponds. The esker passes between the two largest ponds (center-right). The flat, undisturbed delta top is seen on both sides of the kettle zone, where there are large blueberry fields.

Figure 2. Kettles on northwest part of Pineo Ridge delta complex, looking west.

Pineo Ridge area

Two types of landforms are prominent in the area south of Pineo Ridge (Figure 1). A dendritic pattern of modern stream gullies has been eroded into the fine-grained marine sediments that cover the area seaward of the delta. There is also a group of parallel moraine ridges extending southwest from the delta front. Each ridge accumulated along the glacier margin over a period of one or more years as it retreated step-wise toward the northwest. Figure 3 shows the front side of one of these bouldery moraines.

Photo by Woodrow Thompson

Figure 3. Moraine, northwest of Ridge Road, Cherryfield, Maine.

Columbia Falls delta

The Columbia Falls delta straddles the town line between Columbia Falls and Jonesboro. It is smaller but otherwise similar to Pineo Ridge, and probably formed at the same time. The shadows in the DEM image of this area (Figure 4; illuminated from the north) accentuate a series of moraine ridges that connect the two deltas and which form part of the Pineo Ridge Moraine system that can be traced eastward all the way to Lubec. Shadows in the image highlight the kettle holes left by melting of ice masses that were formerly buried under sand and gravel in the central part of the delta.

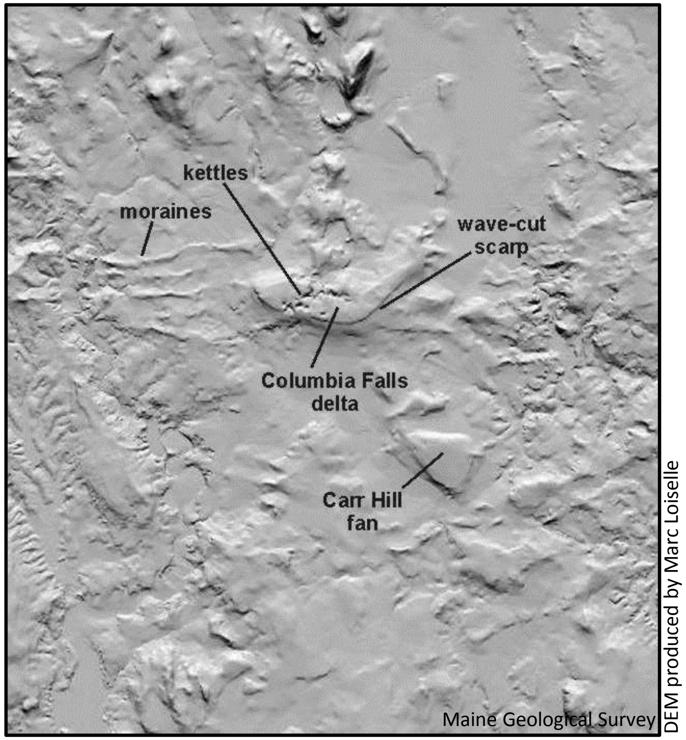


Figure 4. DEM image of the Columbia Falls delta illuminated from the north.

Columbia Falls delta

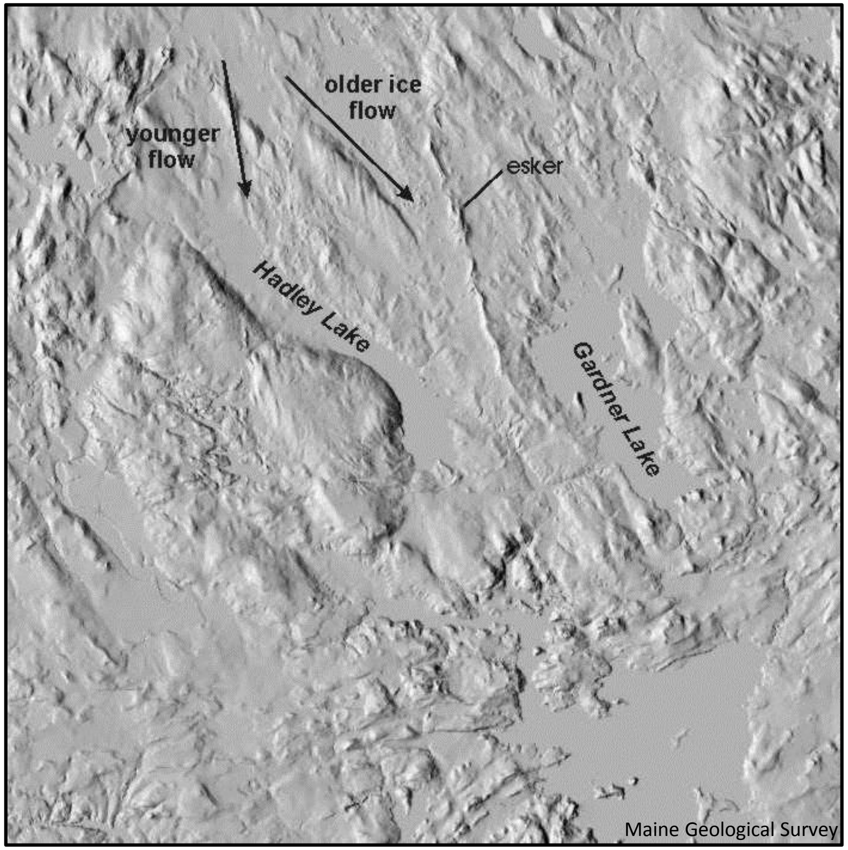
A linear northeast-trending feature is visible on the delta front. This is a low scarp that was eroded by wave action, probably as postglacial uplift of the land caused the sea to drop below the level of the delta top. Figure 5 looks east across part of the delta top (left), wave-cut scarp (center), and former shoreline (right). The DEM also shows a triangular feature to the south of the Columbia Falls delta, which has been identified as a submarine fan (Carr Hill fan). This deposit likewise consists of sand and gravel that washed into the ocean at the glacier margin, but it didn't quite build up to the water surface. The fan is crossed by U. S. Route 1, where there is a State rest area on the south side of the road.

Photo by Woodrow Thompson

Figure 5. Wave-cut cliff on face of Columbia Falls delta, Columbia, Maine.

Hadley Lake area, East Machias

This area is shown from two perspectives, first with illumination from the west (Figure 6, Left) and then from the north (Figure 6, Right).



DEMs produced by Marc Loiselle

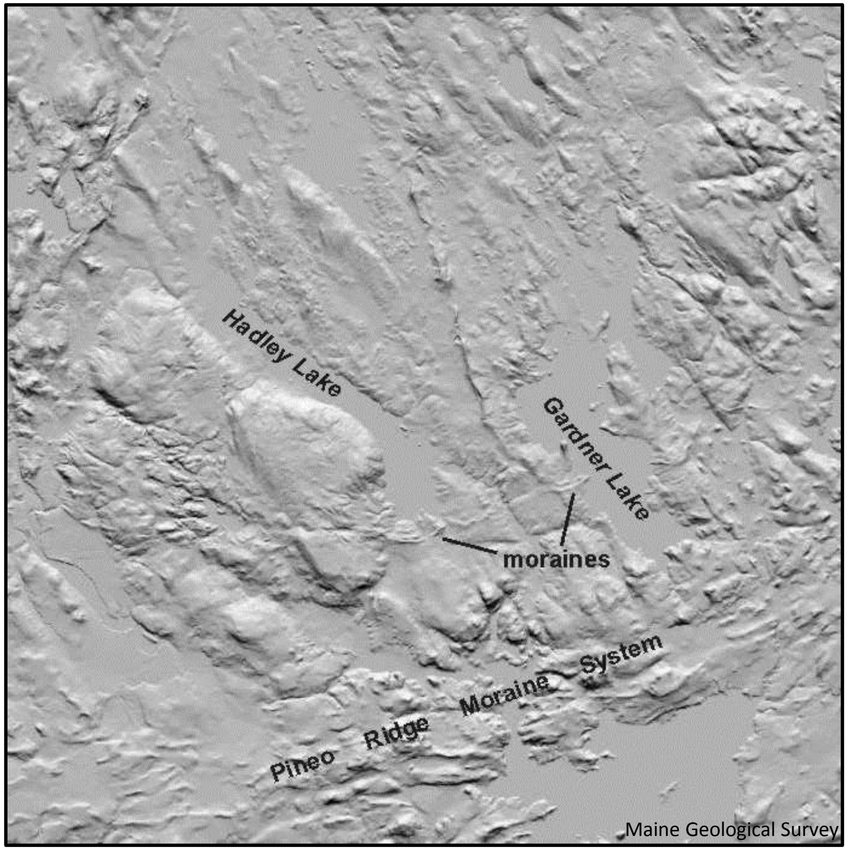


Figure 6. DEM images of the Hadley Lake area illuminated from the west (Left) and north (Right).

Hadley Lake area, East Machias

The westerly "sun angle" (Left) brings out a surprising revelation. Studies of glacial striations in this part of the state have shown that the dominant southeast flow of the most recent ice sheet was followed by a shift to southward flow in late-glacial time. This shift is generally not obvious in the grain of the topography, which preserves the elongate NW-SE hills sculpted by ice flow during the glacial maximum. However, the DEM shows hills north and west of Hadley Lake with north-south ridges carved by the younger ice flow. In the example north of the lake, these lineations are superposed on a hill that still retains the earlier southeast orientation.

The right-hand image, illuminated from the north, reveals the moraine ridges to much better advantage. Note the east-west moraines just south of Hadley Lake, and on either side of Gardner Lake to the east, which are only faintly visible in the left-hand image. Conversely, the topographic evidence of younger glacial flow is not so clear in the right-hand image, because the "sun angle" is parallel to the narrow ice-sculpted ridges and doesn't create strong shadows. Both images show a major south-trending esker ridge, which is followed by Route 191 midway between Hadley Lake and Gardiner Lake.

Summary

DEM imagery can be very useful for spotting previously unrecognized geologic features if they have topographic expression. It provides a means of looking at the land surface without the distraction of vegetation cover. Large areas can be examined at various scales to get the "big picture" of the landscape. As we have seen here, DEM's also give a fresh perspective on features that are already known from previous field studies and map analysis. Having recognized some familiar glacial deposits on the DEM imagery, geologists can then search more effectively for other examples that may have been overlooked during earlier mapping. This tool is best used together with topographic map interpretation, other types of remote sensing (such as air photos, satellite imagery, or LIDAR), and ground-truth observations in the field.