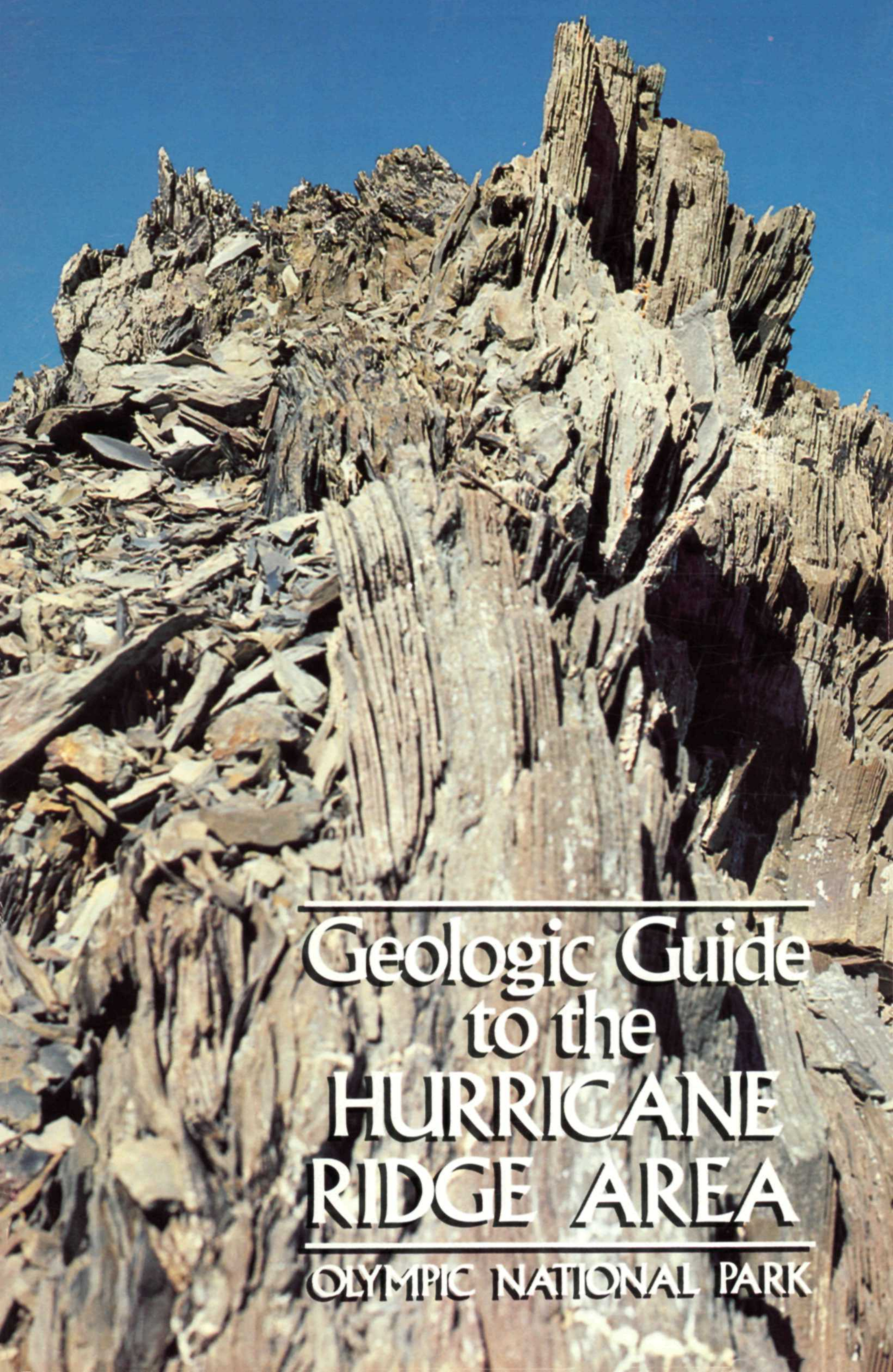


Geologic Guide to the HURRICANE RIDGE AREA

OLYMPIC NATIONAL PARK

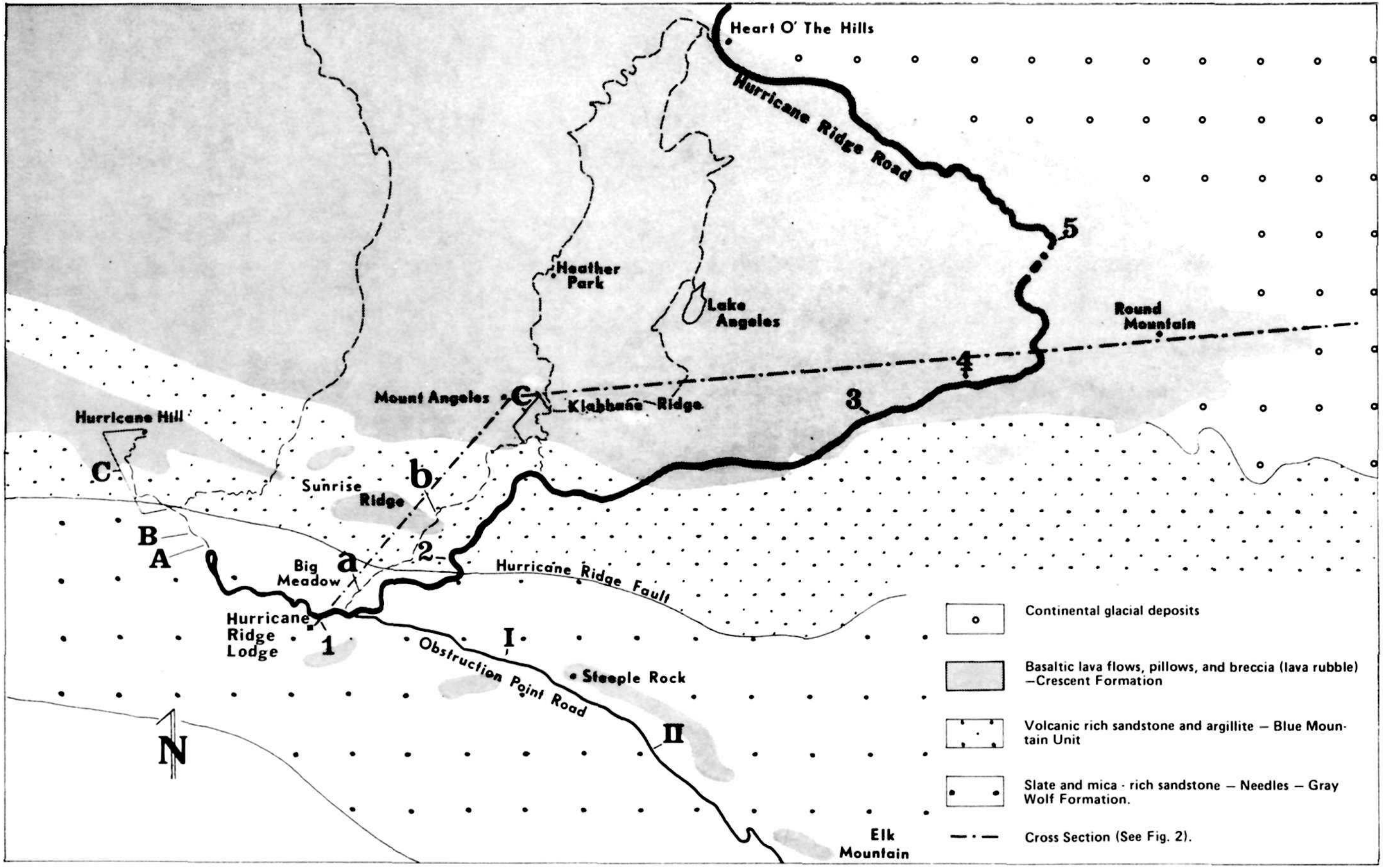


Fig. 1. Simplifed geologic map of the Hurricane Ridge area. The four tours are delineated by letter or number codes: Hurricane Hill Trail A, B, C; Klahhane Ridge Trail a, b, c; Obstruction Point Road I, II; Hurricane Ridge Road 1, 2, 3, 4, 5.

Geologic Guide to the HURRICANE RIDGE AREA

OLYMPIC NATIONAL PARK

Janet G. Scharf and John Wilkerson
based on material supplied by Roland W. Tabor

Drawings by Ed Hanson and Carole Kahler
Map by Carole Kahler

How to Use this Guide

This guide is divided into four tours. Each tour is identified on the map (Fig. 1) and in the text by a different number or letter symbol. For road safety, all tours start at the TOP OF THE RIDGE. Therefore, summit tours are listed first:

Tour:	Stops:
–Hurricane Hill Trail	(A, B, C)
–Klahhane Ridge Trail	(a, b, c)
–Obstruction Point Road	(I, II)
–Hurricane Ridge Road	(1, 2, 3, 4, 5)

SAFETY ALONG THE ROADS IS ESPECIALLY IMPORTANT. Be alert. Turnoffs require special caution. Please be aware of travelers behind you, and oncoming traffic. The roads have many curves, and the Obstruction Point Road is very narrow. Use extra care.

Other guides are available at Park visitor centers. They include guides to Hurricane Ridge, wildflowers, trees, and animal life.

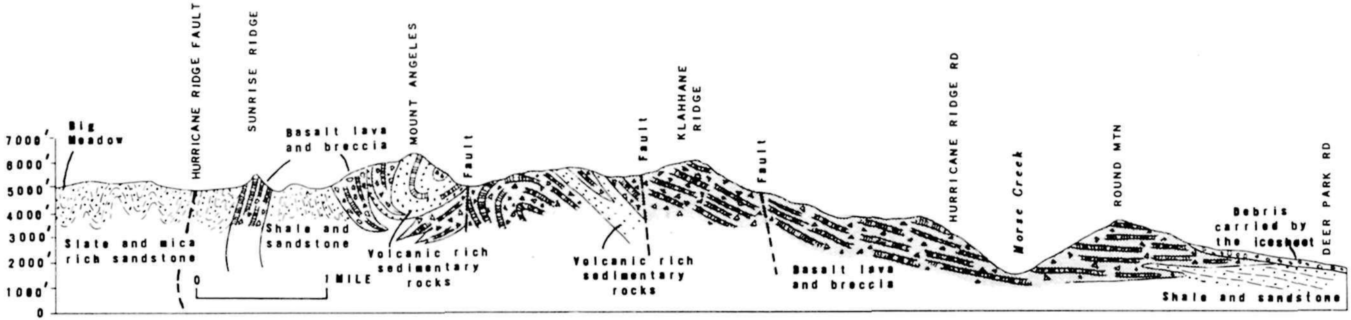


Fig. 2. Generalized cross-section from Hurricane Ridge to the Deer Park Road showing the rocks underlying the Mount Angeles-Klahhane Ridge massif.

CONTENTS

Introduction

Olympic geology is an exciting episode of global plate tectonics and glaciology. Approximately 25-65 million years ago sand and mud, carried in rivers from the North American continent to the sea, accumulated in layers on the ocean floor. Lava rose through fissures and from broad volcanoes beneath the sea and became intermixed with sediments. As lava cooled and hardened, it formed basalt, while sediments were gradually compacted and cemented into sandstones and shales. The ocean crust, with its load of sediments and volcanic rock, began slowly moving toward the edge of the ancient North American continent, presumably propelled by convection currents in the fluid rock beneath the rigid crust (Fig. 3). Upon collision with the continental margin, sedimentary layers and basalts were folded, squeezed, and faulted (Fig. 4). Some layers were tilted or even overturned, and some shales were metamorphosed to slate and phyllite. Oceanic rocks were forced against and beneath the continental margin. Eventually movement of the oceanic crustal plate slowed, allowing subducted sedimentary rocks to gradually rise. This added more land mass to the forming peninsula.

Today, these folded, tilted, and partially metamorphosed sedimentary rocks form the core of the Olympic Mountains, visible to the south from Hurricane Ridge. Less deformed basalts and sedimentary rocks make up the horseshoe-shaped Crescent Formation along the north and east sides of the Olympic Peninsula. These peripheral rocks are visible along the Hurricane Ridge Road.

The peaks and ridges we see today are rugged - sculpted by running water and ice. During the Ice Age, mountain glaciers were much larger. In fact, almost every major valley and northside tributary in the Olympics was carved by massive glaciers. From Hurricane Ridge, shining ice and snow of glaciers on Mount Carrie, Mount Olympus and Mount Anderson suggest how the whole range looked 18,000 years ago.

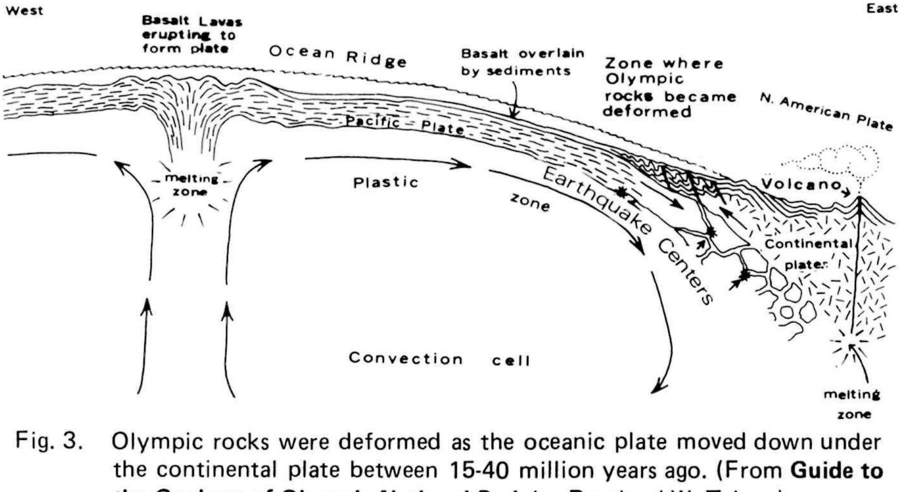


Fig. 3. Olympic rocks were deformed as the oceanic plate moved down under the continental plate between 15-40 million years ago. (From **Guide to the Geology of Olympic National Park** by Rowland W. Tabor.)

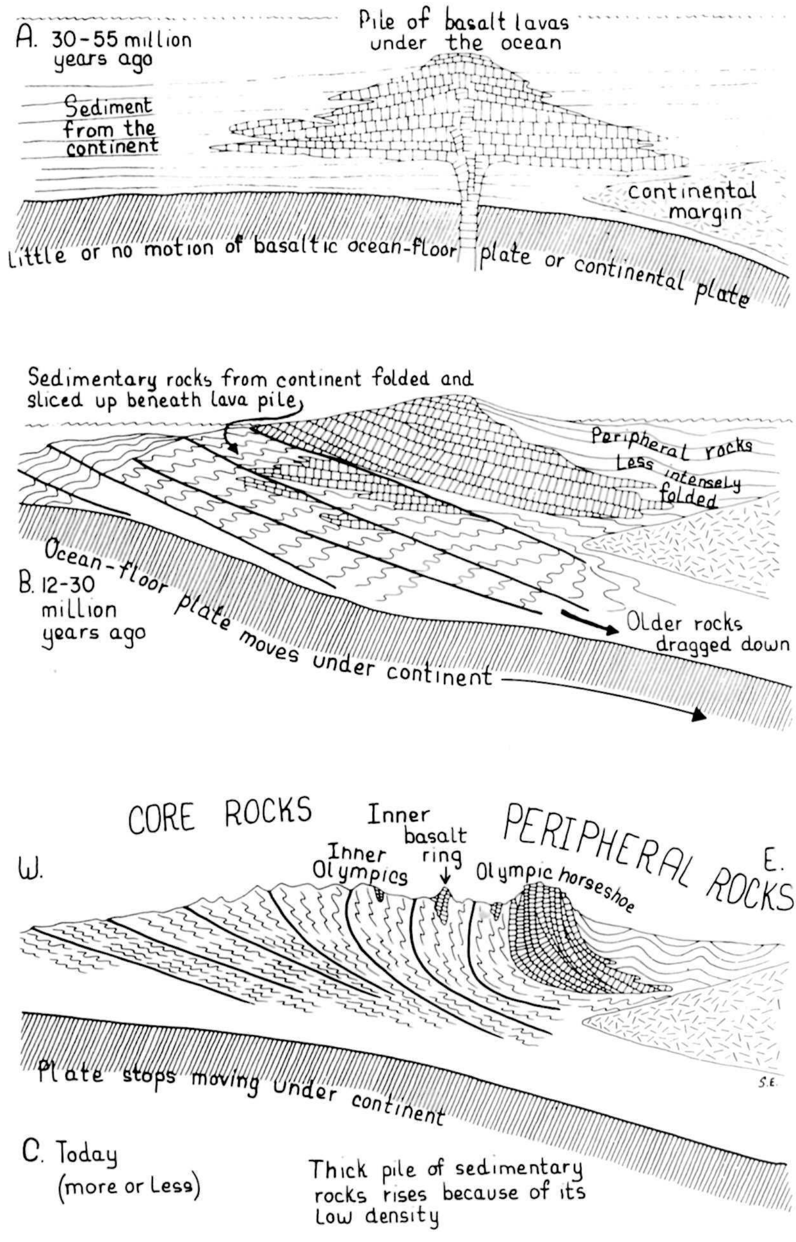


Fig. 4. Development of the Olympic Mountains. (From **Guide to the Geology of Olympic National Park** by Rowland W. Tabor.)

HURRICANE HILL TRAIL:
A Close View of the Ancient Ocean Bottom

To reach the Hurricane Hill Trailhead, continue 1.3 miles past the Hurricane Ridge Lodge on the paved road to the trailhead parking area. The 1.5 mile trail climbs approximately 650 feet in elevation to the 5757 foot summit. A leisurely stroll along this paved trail offers rewarding vistas of glacier-clad peaks in the distance, and nearby views of flowers and rock formations. To locate the following stops, see map (Fig. 1).

Stop A
Sand and Mud on the Ocean Bottom

As you begin the hike, look for a wall of rocks exposed in the trailcut. The rocks are distinguished by an even alternation of light sandstone and dark slate layers (Fig. 5). They are relatively intact and reveal their sedimentary history. Examine a few of the sandstone layers to see tiny sand grains that once settled on the ocean floor. A close look at the darker slate reveals the hard and smooth mud — grains bound so tightly they are indistinguishable. These sand and mud grains were compressed by the weight of overlying sediment and cemented by minerals which precipitated from water. The rocks you see today are the result of these processes.

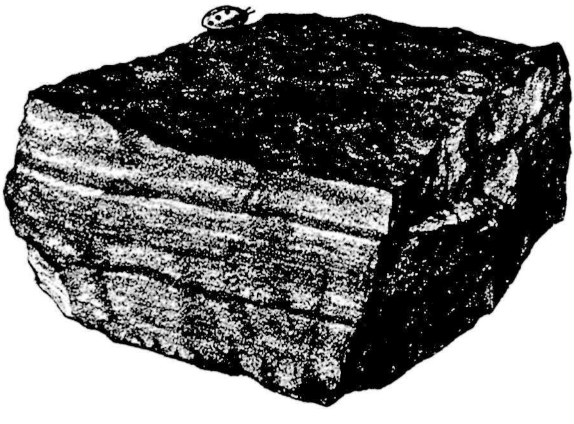


Fig. 5. Sandstone.

Stop B
Disrupted Rocks

Since layers of sediment are deposited horizontally on the ocean floor, something truly remarkable must have occurred to fold, tilt, and lift these beds (see introduction). Earth forces that produced this phenomena are seen in almost every mountain range in the world. Along the trail, you can see beds that are not only folded and tilted but also highly fractured and deformed along small faults (Fig. 6).

Fig. 6. Fold in sandstone and slate along the Hurricane Hill Trail.

Stop C
Beginning of Volcanism

From the head of Little River, where the trail crosses the hard-to-find Hurricane Ridge Fault, you leave the area of disrupted sedimentary rocks and begin a traverse of relatively unbroken, undisturbed rocks. Toward the summit of Hurricane Hill, you stroll past increasingly younger beds. Rocks representing many thousands of years of slow sediment accumulation are traversed as the trail rounds a point and emerges from a grove of trees – the summit of Hurricane Hill in sight. At the last climb, where the trail zig-zags, you reach the first thin beds of volcanic rock that spilled out across the ocean floor about 50 million years ago. To the left, these lavas appear as small rugged cliffs.

Rubble, weathered from alternating layers of dark volcanic and sedimentary rocks, is encountered all the way to the top of Hurricane Hill. Much of the volcanic rock here is sprinkled with white dots; small cavities filled with white minerals, mostly calcite and zeolites. The cavities were formed by gas bubbles escaping from the once molten rock. Later, zeolite and calcite precipitated from mineral solutions in the rock, filling these fossil bubbles. At the very summit is a ledge of basaltic pillow lava (see Stop 4, Hurricane Ridge Road). Mount Angeles can be seen across the valley to the east. The mountain is the main mass of a huge submarine seamount (underwater volcano) forced against the margin of an ancient continent and tilted on end.

KLAHHANE RIDGE TRAIL:
Lavas and the Landscape

There are two ways to reach Mount Angeles: from Big Meadow near Hurricane Ridge Lodge and from Hurricane Ridge Road directly below Mount Angeles (about 9.7 miles from Heart O' the Hills). The former is round about and more scenic; the latter is short, steep, and direct. To locate the following stops, see map (Fig. 1).

Stop a
Cirque Overview–the Sculpturing of the Earth's Crust

The crest of the long ridge joining Big Meadow with Mount Angeles is made of rocks formed on the bottom of the ocean and pushed up to their present height by crustal forces. Peaks and valleys were sculptured by water and ice. Over hundreds of thousands of years, erosion has torn down the mountains. Hard rocks remain as bold ribs or rugged ridges; soft rocks wear away to form gullies and valleys.

Progressing along the trail, you look down to the north into glacier-carved cirques (bowl-shaped valleys) above Little River. Sunrise Ridge, a rugged rib of rock, forms a west-trending spur between these cirques and Mount Angeles. Since Sunrise Ridge is made of basaltic lava, it is more resistant to erosion than soft shales and sandstones on either side. Beyond Sunrise Ridge are the resistant volcanic masses of Mount Angeles and Klahhane Ridge. Blue Mountain, to the distant right (southeast), also owes its height to resistant volcanic rocks. The view to the south is dominated by Steeple Rock, an imposing spine of erosion-resistant basalt (Fig. 7).

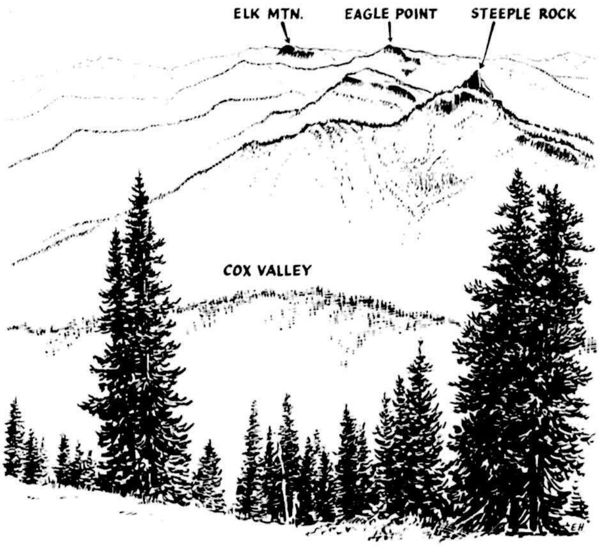


Fig. 7.
View of Hurricane Ridge from the Klahhane Ridge Trail. The boldest cliffs along the crest are made of basalt.

Stop b
Sunrise Ridge - Rare Minerals from the Ocean Bottom

On the south side of Sunrise Ridge are patches of dark rock debris, composed of red limestone, jasper (dark red quartz), and manganese. Manganese minerals also occur in thin red limestone beds between lava flows, on the west end of the ridge.

Stop c
Mount Angeles-Klahhane Ridge - The Edge of an Upside-Down Seamount

At the junction with the Switchback Trail, you begin to climb an uptilted volcanic seamount. Uphill are rugged cliffs of lava, while downhill shales and sandstones dominate. The trail is red with dust of iron and manganese-rich ocean muds.

At the ridge crest, look to the northwest (the shoulder of Mount Angeles). Layers of sedimentary rocks alternate with beds of volcanic breccia (rock composed of fragments) and lean toward the Strait. Differences in resistance to weathering have produced startling ribs and flutes. Thick beds of hard volcanic breccia stand up in straight walls; soft beds of red shale make deep gullies.

At this point, you can hike down to Heather Park, or over Klahhane Ridge to Lake Angeles.

On the way to Heather Park, examine volcanic rocks. When dumped into the ocean, heavier materials settle to the bottom first, so you would expect to find them at the bottom of formations. But a close look at these rocks reveals that the bigger fragments sometimes do not lie at the bottom. (Fig. 8). These formations have been tilted! (Fig. 2).

If you are bound for Lake Angeles, you traverse a pinnacled ridge of volcanic breccia and pillow basalt. Once over the first hump east of the trail junction, you can view Morse Creek valley and a giant fold in the bedded rocks composing Klahhane Ridge.

Fig. 8. Graded breccia on Mount Angeles. The largest fragments of volcanic debris are concentrated in a column on the left, the original bottom of the now upturned bed.

OBSTRUCTION POINT ROAD: The History of Landscape

Obstruction Point Road is a 7.8-mile narrow gravel road – please drive with caution! It forks to the right off the Hurricane Ridge Road, ¼ mile down from the Lodge, as you travel towards Port Angeles. Spectacular mountain views and delicate subalpine meadows add to the splendor seen along this high country road. This section of the guide highlights two features: an ancient landslide and sidehill depressions. The junction of the Obstruction Point Road with Hurricane Ridge Road is mile 0.0; each stop is indicated by a mile mark in the booklet. These marks are located by small pull-offs. Please use these pull-offs for safety.

Mile 1.4
Stop I – A Collapsed Mountain

This mile mark is located at the low spot of the Obstruction Point Road. Park to the right just after you come out of the winding descent through the forest. Look off the road to the right (southwest). Below lies a small valley bordered on the south by a forested ridge. Along the ridge crest you should see some hulking forms of dark rock sticking out from the trees. Among these monoliths of pillow basalt (not easily accessible by foot) is a fantastic jumble of rock walls, blocks, and rubble piles (Fig. 9). It is like the ruins of a gigantic city, overgrown and partially hidden by trees. What caused this ruin? You would expect to find such debris fallen from the heights of a huge cliff, but there is no such cliff near here.

Up the road is a clue to the ruin in the form of Steeple Rock, an erosion-resistant pinnacle of basalt standing high above the rolling meadows of slate and sandstone. It is part of an uptilted layer of basalt extending several miles to the southeast (Figs. 1 and 7). The rocky ruin lies approximately along the same line to the northwest. Could this rubble once have stood as a pinnacle like Steeple Rock? From the amount of debris you can surmise that the pinnacle was even larger before it collapsed from landsliding. Slippage of surface layers of rock, especially in weak areas of slate or shale, is very common in the Olympics. This movement of rock, underlying a giant pinnacle, could bring the whole mass tumbling down. You can only guess what triggered the slide – heavy rains, an earthquake, or both could have been responsible.

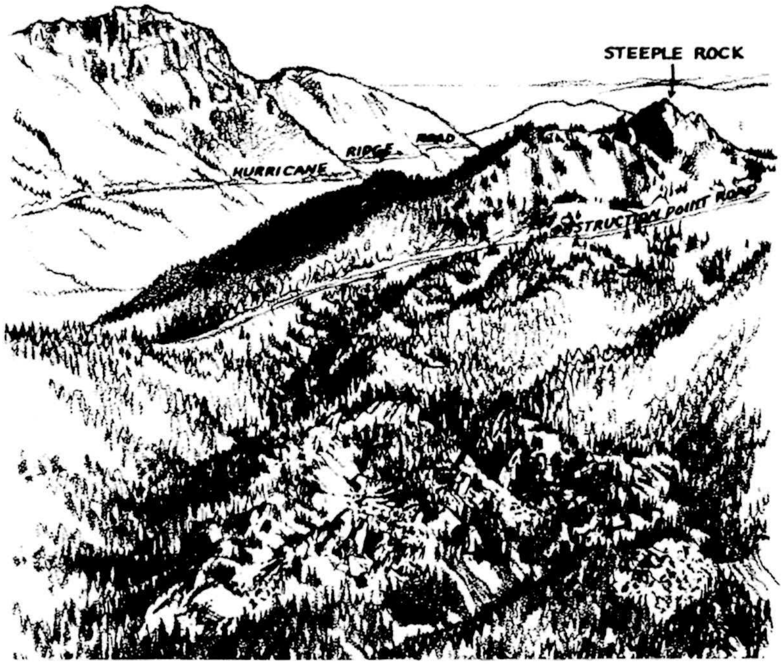


Fig. 9. Hurricane Ridge and Obstruction Point Roads. Note rubble in foreground.

Relics of Ancient Scenery

This is not a specific mile mark stop because the features described are visible at several points along the road, or from the air (Fig. 12).

When a mass of the earth's crust is uplifted high above the ocean, streams form and begin cutting v-shaped valleys. Eventually valleys reach a maximum depth (sea level) and ridge crests reach maximum sharpness. Rain, downhill creeping of loose soil and rock debris, and landsliding now become dominant agencies in lowering the mountains. Sharp ridges become round and smooth; steep valley sides become flat. Jagged peaks and ridges therefore provide clues to the youthfulness of a mountain range.

Apparently, sometime in the past the Olympics had reached the stage where ridges were smoothed into rolling highlands. Before erosion reduced them to lowland hills, the following occurred: the range was glaciated and uplifted again. The glaciers removed all traces of gentle upland on the north sides of the ridges. This uplift, however, gave streams new vigor and they once again began steepening valleys and sharpening ridges. Much of Hurricane Ridge preserves the old gentle upland, but here and there energetic streams have completely removed the meadows. The break in slope between ancient meadows and newly-made steep valley sides is best observed from the air (Fig. 12), but is also visible at various points along this road.

Mile 3.0
Stop II – The Marks of Gravity

Slow erosional processes that produced the previously mentioned ancient upland are still active today.

Look along the downhill side of the road for a shallow swale (Fig. 10). This is a creep depression formed when soil or masses of bedrock move slowly downhill by gravity (Fig. 11). Creep and landslide processes have also produced flat benches on the steep valley side, and may have caused the collapse of the giant pinnacle northwest of Steeple Rock.

Fig. 10 Sidehill depression caused by creep along the Obstruction Point Road.

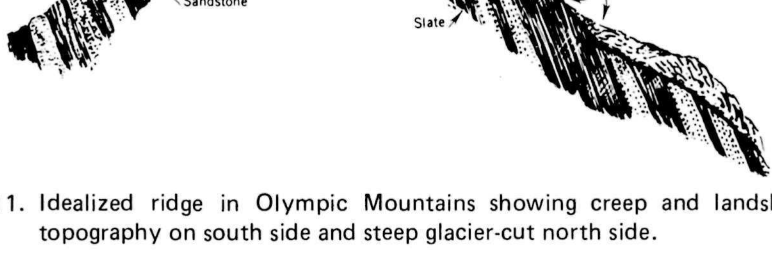


Fig. 11. Idealized ridge in Olympic Mountains showing creep and landslide topography on south side and steep glacier-cut north side.

HURRICANE RIDGE ROAD:
A Journey Through Geologic Time

This section of the guide highlights five stops along the Hurricane Ridge Road. START AT THE SUMMIT and work down towards Port Angeles. Please drive with caution. Remember to pull completely off the roadway before stopping. Hurricane Ridge Lodge is mile 0.0; each stop is indicated by a mile mark in the booklet.

As you proceed down the mountain you are actually travelling up, figuratively speaking, through a stack of ancient ocean floor lava flows and marine deposits. The beds of sedimentary rock and lava have been tilted up, and in some cases even turned partly over during collision of the oceanic and continental crustal plates.

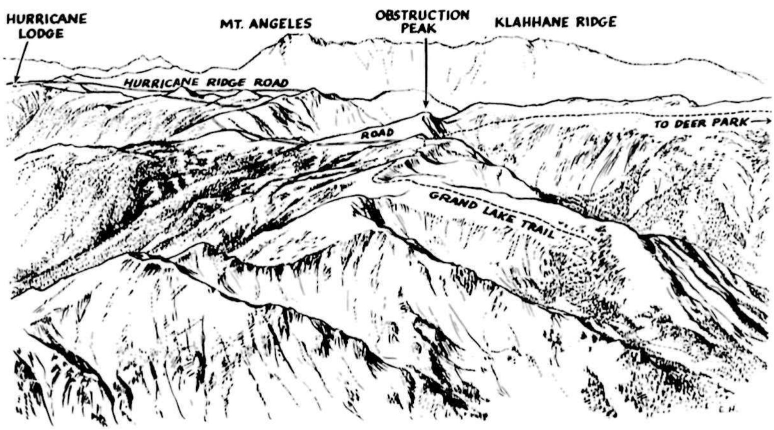


Fig. 12. Aerial view of Hurricane Ridge, looking north. The old upland surface, and steep valley sides below can be seen to the left near the ridge crest. Newly cut glacial cirques are visible on the east side of the foreground ridge.

Mile 0.0
Stop 1 – View From Hurricane Ridge Lodge Terrace

Southwest of Hurricane Ridge, ridges, valleys, and snowy peaks create an impressive panorama. At the lodge, you stand near the margin and on the upturned edge of a series of very large rock slices (measured in miles). These have been swept off the ocean floor and piled under and against a large and resistant basaltic mass that has been eroded into Mount Angeles, Hurricane Hill, and other peaks to the east and south. There is nothing visible to suggest this monumental event, which probably took place between 20 and 40 million years ago. It is difficult even to see the rocks exposed under trees and snow banks. However, geologists have visited most of these ridges and determined the distribution of rock types, their ages, and style of deformation. As far as the eye can see are beds of sandstone and shale, contorted and sheared, sliced apart and stacked up. The area of most intense deformation, where original sediments have recrystallized to slate, phyllite, and other metamorphic rocks, is near the headwaters of the Elwha River and its tributaries.

The panorama of mountains viewed from Hurricane Ridge is a small, new welt of material at the continent's edge. Olympic rocks have not been recrystallized and changed chemically enough to qualify as bona fide continental rocks. Geologists therefore assume they are only a temporary welt, probably soon to be eroded and returned to the ocean for another episode of collision.

Mile 1.8
Stop 2 – Hurricane Ridge Fault Zone – Small Paved Pull-off

Uproad about 30 yards, dark slates and micaceous sandstones (core rocks) lie in broken, discontinuous layers. A short distance downroad, gullies mark the locations of small faults that indicate we are now within the Hurricane Ridge fault zone. About 100 yards downroad, rocks contain less slate. These shales and dark sandstones (peripheral rocks), although folded and cut by small faults, lie in beds that are essentially intact. You have now left the fault zone. Thus, you have moved from the more intensely deformed sedimentary rocks of the core toward the less disturbed peripheral rocks. The Hurricane Ridge Fault zone marks the contact of these major rock groups.

Fig. 13. Mount Angeles

Mile 6.2
Stop 3 – Ancient Lake Morse – Upper Double Parking Overlook

Look to the east to see tree-covered flats on a broad, low divide between the ridge of Blue Mountain and Round Mountain (Fig. 14). The edge of the Cordilleran Ice Sheet, a huge ice sheet which pushed southward from Canada during the Ice Age about 15,000 years ago, moved across the divide between the two mountains. This area is covered with debris left by the ice. Slopes leading westward into Maiden Creek are veneered with sand and gravel carried by meltwater streams from former glaciers. You can also see rounded outcrops of lava on Round Mountain, smoothed by the scraping of ice.

Evidence of the ice sheet's visit can be seen in granite boulders scattered throughout Morse Creek Valley and other forested valleys south of Hurricane Ridge Road, to 3500 feet in elevation. There is no granite exposed in the Olympic Mountains; these boulders must have been carried from Canada by the ice sheet. We find no other evidence that the glacier filled the valley. If the ice stopped at Round Mountain at the low divide, how did the boulders get into the valley? The most plausible answer is that the valley was filled with a meltwater lake at the edge of the ice sheet (Figs. 15, 16). Icebergs, embedded with foreign rocks and gravels, broke from the ice and floated into the lake. The icebergs slowly melted and dumped their debris far from the edge of the ice.

With ice pressed close around the mountain front, it seems logical that the streams draining the mountain would be dammed. On the hillside below Round Mountain are mud deposits typical of quiet lake waters at the front of glaciers.

Before leaving this stop, be sure to see the wayside exhibits.

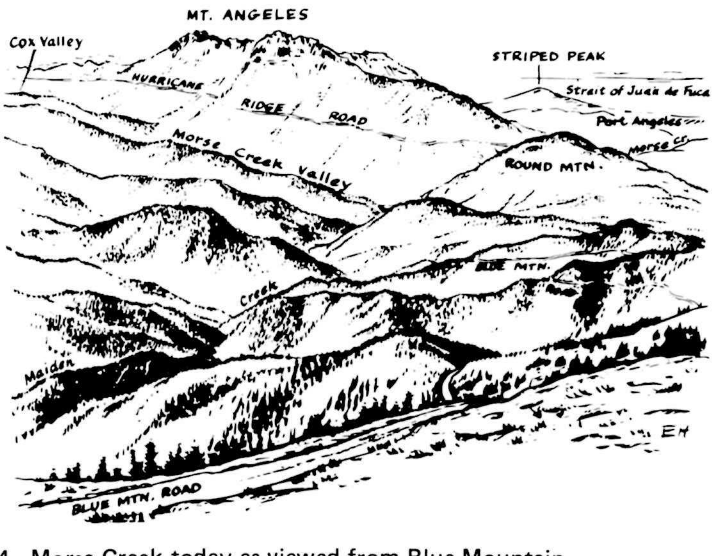


Fig. 14. Morse Creek today as viewed from Blue Mountain.

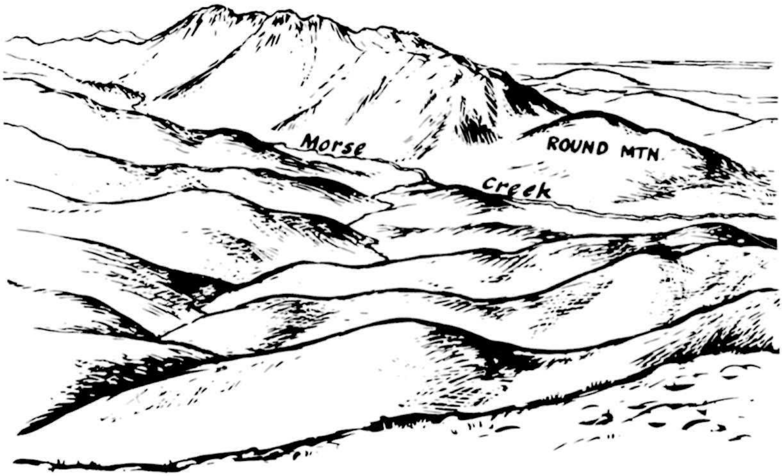


Fig. 15. Before ice age glaciation. Morse Creek flows east by Round Mountain.

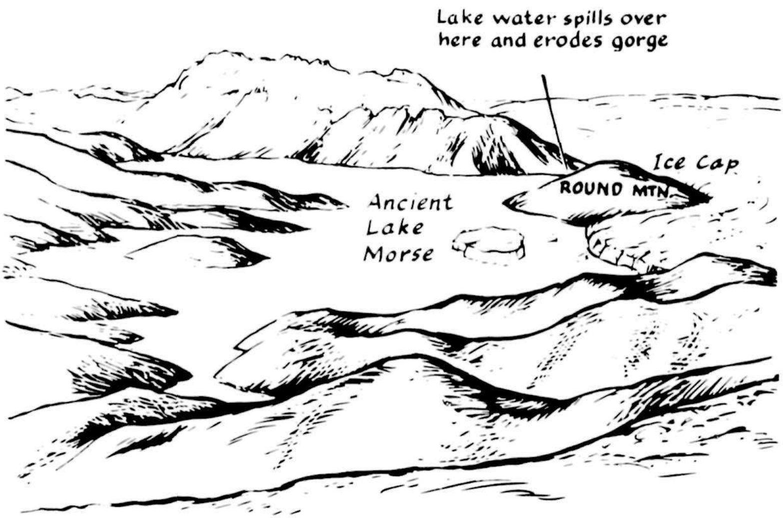


Fig. 16. Ancient Lake Morse formed at edge of Cordilleran Ice Sheet. (Ice Cap)

Mile 7.0
Stop 4 – Pillow Basalt – Small Paved Pull-off

Walk a few yards uproad or downroad for good views of pillow basalt. These curiously rounded basalt pillows indicate that the lava erupted underwater. The first bit of hot lava to come in contact with the sea water forms a globule, or pillow, its surface quickly cooled and hardened by the sea water. Often single pillows form and roll down the side of a pile of accumulating volcanic debris to be mixed with the ocean muds. Fragments of pillows and basalt flows, all glued together in a jumble (called a volcanic breccia), are even more common than pillows. Look for outcrops of this volcanic breccia between layers of pillows (Fig. 17).

Fig. 17. Cliffs of lava and volcanic debris high on Klahhane Ridge. The rocks near the man are breccias; the rounded masses above are pillow lavas.

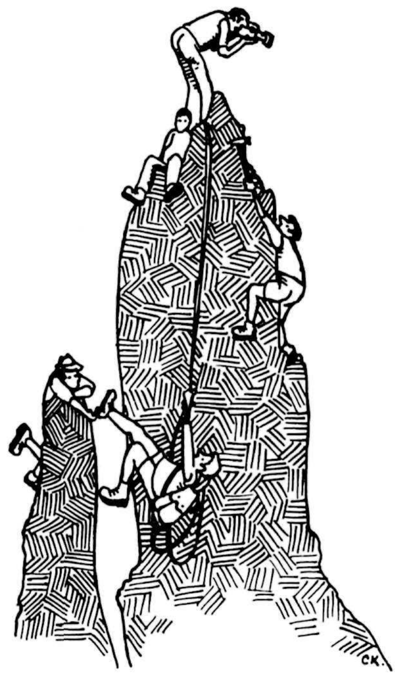
Mile 8.9
Stop 5 – The Cordilleran Ice Sheet – Tunnels Overlook

The dramatic story of the great Cordilleran Ice Sheet that came from the north and was dammed by the Olympics can be contemplated from several places in the Hurricane Ridge area. The summit of Hurricane Hill, Klahhane Ridge, and this stop allow you to imagine how the ice sheet lay over present-day plains, valleys, and waterways thousands of years ago.

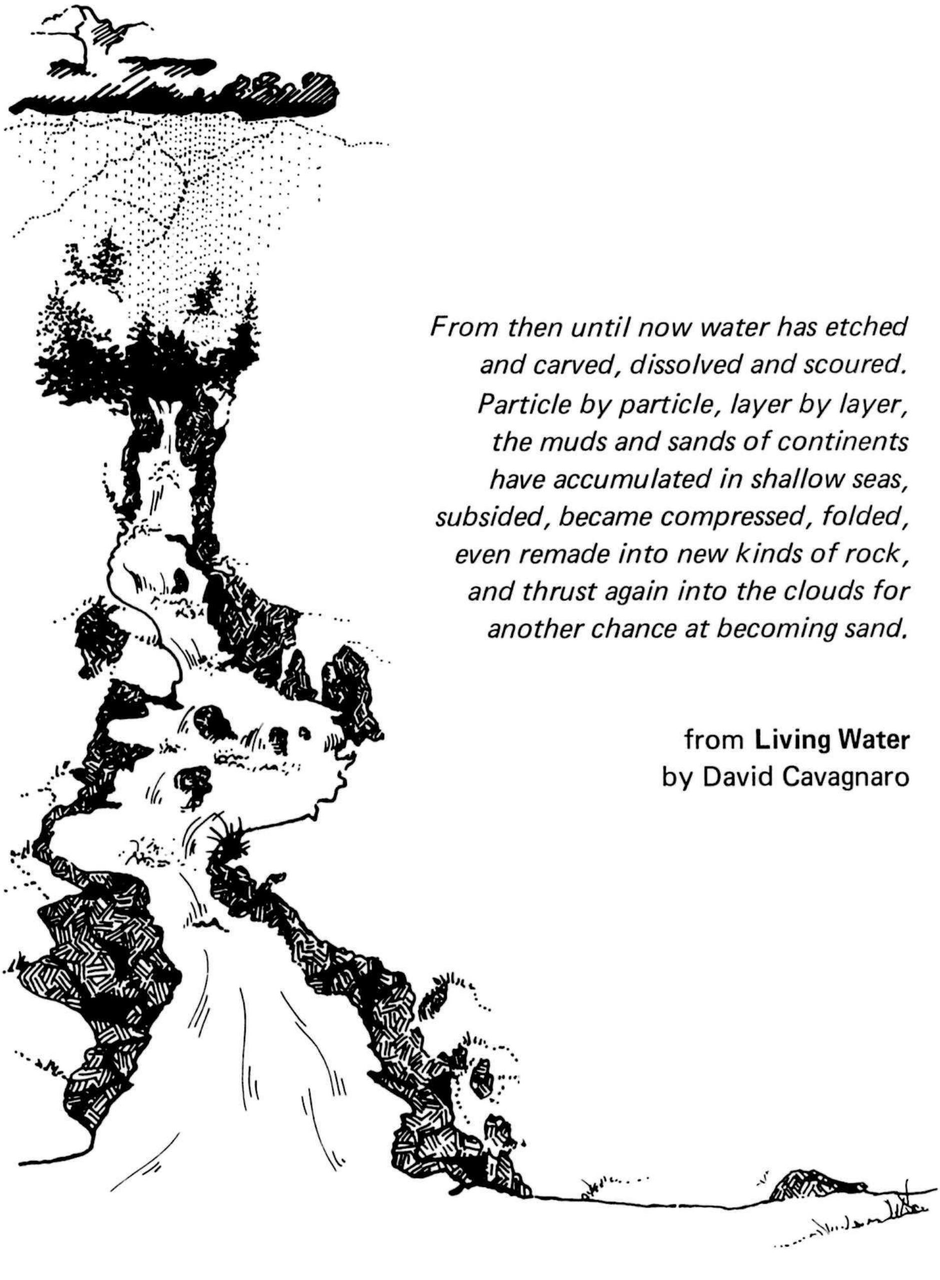
Before leaving this stop, be sure to see the wayside exhibits.

Conclusion

You have had a brief look at some of the complicated processes of mountain evolution. If you were to spend a lifetime in the Olympics studying these changes, you would see but an instant of geologic time. Sediment accumulation, rock formation, folding, mountain uplift, and erosion are continually interacting processes that make up the life of our earth. From a geologic standpoint, the earth is like a moving, changing organism, which man in his short span of time sees only as a still photograph. A vigorous imagination will bring it to life.



For a more expansive treatment of the geology of the Olympics, please see **Guide to the Geology of Olympic National Park**, by Rowland W. Tabor (University of Washington Press, Seattle, WA, 144 pages).



From then until now water has etched
and carved, dissolved and scoured.
Particle by particle, layer by layer,
the muds and sands of continents
have accumulated in shallow seas,
subsided, became compressed, folded,
even remade into new kinds of rock,
and thrust again into the clouds for
another chance at becoming sand.

from **Living Water**
by David Cavagnaro

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ON THE COVER: Elk Mountain, Vertical Bedding – photo by Janet G. Scharf.