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PERMIANLAND:
THE ROCKS OF MONUMENT VALLEY

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From the flat red sea of sand rose great rock mesas, generally Gothic in outline, resembling vast cathedrals. They were not crowded together in disorder, but placed in wide spaces, long vistas between. This plain might once have been an enormous city, all the smaller quarters destroyed by time, only the public buildings left. . . .

—Willa Cather

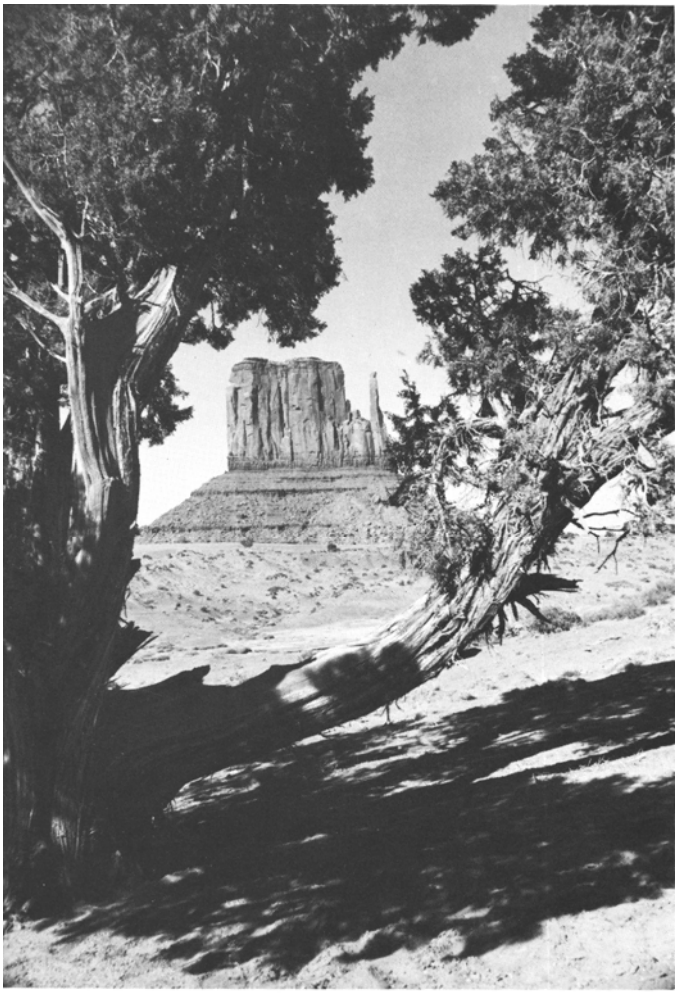
INTRODUCTION

The scenic grandeur of Monument Valley and much of the Monument upwarp is dependent upon the erosional sculpturing of sedimentary rocks of Permian age. The crags, spires, buttes and mesas within Monument Valley proper have been carved from the Permian Organ Rock Shale, which forms the beautiful red lower slopes, and the massive DeChelly Sandstone which forms the magnificent cliffs. The very uppermost caps of many of the buttes are composed of thin remnants of the Moenkopi Shale, overlain by the Shinarump Member of the Chinle Formation, both of Triassic age. Elsewhere on the upwarp the massive cliffs and red rock scenery are formed largely from other Permian layers; Cedar Mesa and the Valley of the Gods, for example, have been eroded from the cliff-form ing Cedar Mesa Sandstone and the underlying red slopes of the Halgaito Shale, which are older Permian in age. Only the innermost canyons of the San Juan River and the fringes of the upwarp are of rocks other than Permian age. These deep and enchanting canyons were carved into the stratigraphic column exposing strata of Pennsylvanian age (Hermosa Group), and the monoclinal boundaries of the upwarp represent rocks ranging to Late Jurassic in age. The remainder of the Monument wonderland owes its existence to the idiosyncrasies of Permian depositional environments and to the quirks of erosional processes.

THE REGIONAL SETTING IN PERMIAN TIME

The Permian Period in the Colorado Plateau was largely a time of continental environments, with only an occasional incursion of the sea as far inland as Monument Valley. Far to the northeast in the vicinity of Grand Junction and Pagosa Springs in Colorado, a massive mountain range, the Uncompahgre uplift, was high and shedding clastic sediments westward onto what was to become the plateau country. The fault-block mountain range did not originate in Permian time, but was already in existence and a major source of sediments in the Pennsylvanian. Streams carrying coarse debris from the granitic and gneissic upland flowed from the steep mountain front onto coastal lowland plains that lay to the west and southwest. Most of the boulders and pebble-sized sediments were deposited near the mountain front as streams flowed sluggishly onto the plains. Salt anticlines, rising into the paths of the streams in the vicinity of Moab, Utah, partially dammed the westward flow of sediments. Thus, through topographic restrictions and the gradient of the streams, the coarse Permian sediments were trapped near their source. Due to the nature of the rocks exposed on the upland, the sediments were necessarily arkosic.

The plains bordering the Uncompahgre Range extended westward to the seas of the Cordilleran geosyncline. Toward the northwest, these seas reached as far onto the Plateau country as the present confluence of the Green and Colorado rivers



H. L. James

The West Mitten—Gothic beauty in Permianland.

and sporadically almost to Moab. Farther south in the Monument Valley-Grand Canyon region, the seas were restricted to the main trough west of the Kaibab uplift. These Early Permian (Wolfcampian) marine deposits are known as the Elephant Canyon Formation in the Canyonlands and the Pakoon Limestone west of Grand Canyon. The lowlands in between were coursed by sluggish streams, dotted by lakes, and occasionally the sites of coastal tidal flats, now called the Halgaito Formation.

The seas advanced eastward in later Early Permian (upper Wolfcampian) time and gradually spread over the Halgaito coastal lowlands. Arkosic debris was continuously available from the Uncompahgre uplift, but the marine incursion brought a new supply of clean quartzose sand to the vicinity of the Colorado Plateau from the northwest. These sands, distributed by longshore, wind-driven currents, reached a position which now approximates the eastern monocline of the Monument upwarp. It is probable that the Monument upwarp was already forming in an incipient stage, for the facies change at the eastern margin of the clean sand deposition coincides with the eastern monocline of the Monument upwarp. The resulting deposits, known as the Cedar Mesa Sandstone on the Monument upwarp and the Esplanade Sandstone Member of the Supai Formation in Grand Canyon, interfingers with fluvial arkosic sandstones on the northern Monument upwarp (Canyonlands) and grade eastward into lagoonal gypsiferous red shales and siltstones on top of the Lime Ridge anticline (northeastern margin of the upwarp.) The broad lagoon extends eastward into the Four Corners country and southeastward into the Holbrook region.

The shoreline receded to the west and northwest into the depths of the Cordilleran geosyncline in early Leonardian time and coastal lowland environments again dominated the Plateau country. The resulting red beds extend from the Canyonlands southward through Monument Valley, where they are known as the Organ Rock Shale, and toward the west into the Grand Canyon region, where they are called the Hermit Shale. As on the Halgaito lowlands, various types of tetrapods roamed the Organ Rock lowlands.

By late Leonardian time (approximately Middle Permian time) the seas again made a feeble attempt to crowd back the continental lowlands, but reached only the western limits of the Monument upwarp. The resulting deposits, called the Toroweap Formation in Grand Canyon, and the marginal marine littoral and sub-littoral sands, known as the White Rim Sandstone west of the Monument upwarp, mark this marine cycle. Meanwhile, in Monument Valley and the country toward the east into the Defiance uplift and beyond, a sandy

The Three Sisters (foreground) cast their spiny shadows across the floor of Monument Valley. This magnificent scenery is formed by the prominent cliff-forming DeChelly Sandstone (Middle Permian), being gradually eroded back on the soft slopes of the Organ Rock Shale. The buttes and mesas are capped by shaly beds of the Triassic Moenkopi Shale protected in turn by thin remnants of the Shinarump Member of the Chinle Formation. Air view is to the northwest; Cedar Mesa escarpment is visible to the north.

desert developed. The resulting eolian sandstones are known as the DeChelly Sandstone, which comprise the prominent cliffs in Monument Valley and Canyon de Chelly.

A last attempt by the seas to inundate the Plateau country almost completely failed, as the Kaibab sea reached only as far east as the eastern margin of the Kaibab uplift, the Waterpocket Fold and the San Rafael Swell, all west of Monument Valley. The Monument upwarp lay as a coastal lowland that was either being gently eroded or with little or no sedimentation occurring. The great Uncompahgre mountain mass had been nearly leveled by erosion and even fine-grained sediments were no longer available.

STRATIGRAPHY

Permian strata along the eastern limits of the Colorado Plateau are mainly coarse arkosic and conglomeratic sandstones that cannot be segregated into distinctive formations. Consequently, the Permian section in that region, near the source area, is referred to as the Cutler Formation. In regions more distal from the Uncompahgre uplift, where the light-colored sandstones punctuate the sequence, a number of formations can be distinguished. These are usually referred to as formations within the Cutler Group; they are, in ascending order, (1) the Halgaito Shale, (2) the Cedar Mesa Sandstone, (3) the Organ Rock Shale and (4) the DeChelly Sandstone.

The Halgaito Shale

Stratigraphically the lowest formation of the Cutler Group in Monument Valley is the Halgaito Shale that rests disconformably on the Hermosa Group, here of Missourian age. The Halgaito is a reddish-brown shale and siltstone unit containing local cut-and-fill sandstones that apparently represent ancient stream or tidal channel deposits. It is probable that the Halgaito is composed mainly of continental lowland deposits that include stream channel and point bar deposits, floodplain deposits and tidal flat accumulations. Vertebrate fossil remains are not uncommon.

The Halgaito Shale can be traced eastward into the arkosic undifferentiated facies of the Cutler through numerous wells drilled for oil in the underlying Pennsylvanian strata. Therefore, it is reasonable to conclude that the red sediments were derived from the Uncompahgre uplift, as were the other red and arkosic Cutler sediments. The age of the Halgaito is more difficult to determine. It lies disconformably on the Late Pennsylvanian Hermosa Group, strongly suggesting a post-Pennsylvanian age for the Halgaito. It is generally included in the lower Wolfcampian Series of the Permian System because the red sediments interfinger toward the northwest, in Cataract Canyon, with the fusulinid-bearing marine strata of the Elephant Canyon Formation that are lower Wolfcamp in age.

The Halgaito Shale is best seen in the bottom of the Mexican Hat syncline; in Mexican Hat rock; as the bases of the buttes and spires in the Valley of the Gods; and as the lower, red, slope-forming unit underlying Cedar Mesa north of the Goosenecks. It forms the middle member of the Supai Formation in Grand Canyon.

The Cedar Mesa Sandstone

The light-colored, fine-grained, marine sandstone that caps Cedar Mesa and forms the concealed floor of Monument Valley is known as the Cedar Mesa Sandstone. It is about 800 feet thick in the type section, which is along Utah Highway 261 leading to Cedar Point and Natural Bridges National Monument north of Mexican Hat, where the sedimentary structures suggest a nearshore, littoral to sub-littoral environment of deposition for the formation. Although it is typically a massive, cliff-forming unit, it grades abruptly to a gypsiferous red siltstone and shale sequence where it crosses the Lime Ridge anticline (Comb Ridge monocline) east and northeast of Monument Valley.

The Cedar Mesa Sandstone contains large scale, but generally low-angle, cross-stratification that consistently dips toward the southeast. This suggests a northwesterly source for the sand, but a specific source area has not been found. It is probable, from regional correlations, that the Cedar Mesa is stratigraphically equivalent to the Weber Sandstone of the Uinta and Wasatch mountains region, so the source must be farther to the northwest than Salt Lake City. The formation is prominent in the San Rafael Swell and Waterpocket Fold and comprises the Esplanade Sandstone Member of the Supai Formation in Grand Canyon. It interfingers with the arkosic, fluvial sandstones of the Cutler Formation in the heart of Canyonlands National Park (the Needles district) and grades eastward into lagoonal red beds east of Monument Valley, thus terminating the formation.

The age of the Cedar Mesa Sandstone is based on observations that the formation interfingers with the fossiliferous Elephant Canyon Formation in Cataract Canyon, which is approximately middle Wolfcampian in its upper tongues, and underlies the Organ Rock (Hermit) Shale that contains Leonardian plant and vertebrate remains. Thus, it is considered to be late Wolfcampian in age in the Monument Valley area.

The Organ Rock Shale

The red beds that overlie the Cedar Mesa Sandstone throughout the Monument upwarp are in the Organ Rock Shale, named for Organ Rock, a prominent spire northwest of Monument Valley. The formation forms the lower slopes of the monuments in Monument Valley and the red slopes above Cedar Mesa in the White Canyon-Natural Bridges region to the north. It correlates with the upper Cutler arkoses toward the northeast and the Hermit Shale in Grand Canyon, as shown by abundant well data. The persistent thin-bedded nature of the formation suggests that it was deposited on Permian tidal flats that bordered the Cordilleran sea to the west. Plant remains in the equivalent Hermit Shale in Grand Canyon indicate a lower Leonardian age for the formation and an arid environment of deposition.

The DeChelly Sandstone

The massive, reddish-colored cliffs in the buttes and mesas of Monument Valley have been carved from the next overlying formation, the DeChelly Sandstone. This impressive formation is composed of fine-grained, quartzose sandstone that derives its reddish color from orange-red coatings on the individual grains. The large-scale, high-angle cross-stratification and the high ripple-index ripples suggest a windblown origin for the sandstone. The tracks of tetrapods found near Canyon de Chelly confirm this interpretation.

The DeChelly Sandstone is between 300 and 400 feet thick in Monument Valley, but thins northward and pinches out before reaching the San Juan River near Clay Hills Crossing and immediately north of the river in Comb Wash. It thickens

southward into the Black Mesa basin, where it atttains a maximum thickness of over 1,000 feet. It is 825 feet thick in its type locality at Canyon de Chelly, but thins dramatically on the top of the Defiance uplift between Canyon de Chelly and Hunters Point.

The regional correlations of the DeChelly Sandstone have prompted considerable debate. Because of the similar stratigraphic position above the Organ Rock-Hermit Shale, it has been correlated directly with the White Rim Sandstone and with the Coconino Sandstone of Grand Canyon. However, recent drilling west of the Monument upwarp provides sufficient information to suggest that the White Rim Sandstone is a marginal marine facies of the Toroweap Formation and that it is younger than the Coconino Sandstone. Furthermore, Irwin (1971) believes that the White Rim overlies the DeChelly in the well drilled by Skelly Oil Company on Nokai Dome, the westernmost anticline on the Monument upwarp. To further complicate the issue, the author interpreted the section on top of the Defiance uplift neart Fort Defiance and Hunters Point to contain Coconino equivalents above the DeChelly, a situation that is duplicated in two old wells drilled near Cameron, Arizona, immediately east of the Kaibab uplift (Baars, 1962). However, it should be said that petrology and cross-stratification studies indicate a source for the DeChelly to have been toward the northeast (Cutler sediments) and not toward the south as in the Coconino, or the northwest as in the White Rim Sandstone. Thus it has a separate source and should be treated as a distinct formation. It is believed to be of Leonardian age on the basis that it apparently underlies the fossiliferous Leonardian Toroweap and Kaibab formations of Grand Canyon.

CONCLUSIONS

The Monument upwarp and Monument Valley are Permianland. You cannot visit this spectacular region without trodding through the ancient environments of Permian time. Thank Vishnu for providing this colorful scenery.

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