The Geology of Glen Canyon

Many million years ago in the area of the west now known as the colorado Plateau a slow change began that had its origin deep within the crust of the earth. Caused by forces believed to involve the very dynamics of the interior of the globe, a wide-spread uplifting of the sedimentary deposits dating back to the Paleozoic Era gradually raised them above the level of the shallow seas which intermittently occupied this region.

During the preceding several hundreds of milions of years from the first appearance of air-breathing vertebrates until the end of the age of reptiles, hundreds of feet of mud and gravel and sand were deposited, consolidated, and washed away in this area of ever changing landscape. The material of ancient mountains was spread by streams over low lying land and carried into the shallow lakes and encroaching oceans. Silt filled in swamps and covered eroded plains until massive layers built up to be themselves worn away with the rising of the land and the changing of climates. Wet periods were succeeded by dry

and swamps were replaced by deserts when aeolian ages came into being. For perhaps a thousand thousand years winds swept unimpeded across limitless spaces of rolling dunes. Timeless as these periods seem in terms of human lives, in geological measure they were but moments in the kaleidoscopic changes constantly altering the face of the earth. Seas gave way to deserts and deserts were inundated by advancing seas in an endless shifting sequence. Sediments from the dust and debris and rubble of crumbling mountains grew to ~~inconceivable~~ enormous depths as the earth's crust sank beneath their weight. Deep in the earth or buried under the waters of the seas these layers were transformed, by the cementing action of disolved lime and iron, into the yellow and red sandstones of the Entrada, Wingate, and Navajo formations. Where clay and mud predominated over desert sand the thinly-bedded, shaly Moencopi and maroon Kayenta strata, or gray and green, unanium-rich beds of Shimarump conglomerates ~~took form~~ were deposited.

At the beginning of the great upwarping the seas drained away and in their place a meandering river carried the waters of the plain into the western ocean. At first, no doubt, a sluggish stream, perhaps much like the Mississippi today, flowing through a still rich land, it carried little but the steepings of the soil. Its dark mahagony waters must have supported an abundance of life which in turn supplied the food needs of many of the riparian birds and animals of the Eosene. But as the continent continued to rise the character of the river changed. Tributaries loaded with debris flowing down the western slopes of the newly born Rocky Mountains ~~range~~ delivered to it the abrasive material needed to cut its way as fast downward through the uprising land as the land itself was heaving up. Had the river's cutting into the ancient beds of sandstone and shale been less rapid than the rate of uplift, its course would have been greatly changed and instead of emptying into the western ocean in the Gulf of California,

as today, it would have ended up in the Gulf of Mexico. But these processes did take place hand in hand through most of the Cenozoic era. The river, gouging its way back through time, first cut into the last deposits of the late Palaeocene layed down more than ten millinn years earlier; then into the shales and clays formed under the vast swamps of the Cretaceous, backwards for a hundred million years and more, and down through this unimaginable distance in history scrubbing away particle by particle through the climactic age of the reptiles. The hard sands of the Rocky Mountains were the first tools for this great channeling effort until the river made its own abrasives from the rocks through which it was flowing, the way diamond dust is used to cut diamonds.

And still restless forces from deep below pushed up the continental crust. Down into ever deeper layers the tireless river with its burden of grit and powdered rock ground its way. It dug into the consolidated sediments of the Jurassic, deposited under the shallow seas inhabited by ichthyosaurians and other marine reptilian monsters of that age; and on down into the sands of the Jurassic and Triassic deserts through the wind stratified and cross-bedded dunes of the aeolian period, leaving the age of the dinasaurs far behind, and on through the millions of years of the Permian to the steaming swamps of the Carboniferous - the time of the greatest burgeoning of plant life, when the world's major coal seams were formed and when the first land animals appeared. In places where previous erosion had removed vast thicknesses of Mesozoic or Paleozoic rock leaving wide unconforming gaps in geological history, the river dug through all the remaining sediments of the Paleozoic to reach and grind into the oldest of all formations on the earth, the hard metamorphic, archaic shists and granites that go back to the time before the appearance of life a ~~million~~ thousand million years in the past. Still today it is cutting into these rocks which can be

seen exposed on the somber walls of Granite Gorge at the bottom of the Grand Canyon.

To suppose that all these sedimentary layers from the Precambrian up to the present could be visible anywhere along the river's length is to forget that the processes of building up and tearing down never cease. New rocks are always born from the destruction of the old. Sediments deposited for milleniums out of the debris of older sediments are themselves in turn disintegrated to appear later in still younger deposits, to become consolidated, to be heaved up by tectonic forces, sculptured and weathered away again. The outcome of these sequelae is to produce great geological unconformities in which one finds sediments in contact with highly eroded underlying formations separated from them by scores of millions of years. Faulting and folding of the crust, interleaved in time with weathering processes, further mixes the strata, and produces situations of such complexity that the exact sequence of events is difficult to read.

Forces of erosion were at work on the land above reducing it too, while the river dug into the past at the bottom of its trench. It was a meandering trench roughly parallelling the path of the primeval stream, but which had here and there been straightened temporarily by cutting through the narrowing neck of a loop leaving behind a dry arc of river bed, evidence of its once longer course. Much material was blown and washed away, most of it into the river itself through its many tributary canyons. Many of the most recent sediments in the surrounding country have largely disappeared. Their foundations have been deeply carved, leaving today a ragged land of corniced buttes, of deep canyons, of towering castles whose fretted and sculptured battlements appear to glow with internal fires in the evening light. It is a land, too, of wide valleys

and sandy, arid basins and steep-walled, juniper-covered mesas.

The superficial history of this country has probably changed more in recent geological times than the history of the river itself which would be less effected by climatic changes than the plateaus. During the last glacial epoch this country was much more lush than today. Forests of pines clothed the high land where now are found only a dwarf forest of juniper and pinion. Clear streams flowed in all the valleys and canyons which are today watered by occasional, mud-laden flash-floods of summer. Grass grew thick and high where now rock-strewn, sandy wastes exist and a sparce desert growth only holds on.

Lying between the Sierra Nevada range on the west and the Rocky Mountains to the east and encompassing all of Nevada and Utah, the northern half of Arizona, and parts of Colorado, New Mexico, and California is a great sweep of arid land called the North American Desert. Included in it is the Great Basin of Nevada and the Colorado Plateau. Broken by scattered mountain islands, many volcanic in origin which record a violent geological history of this part of the United States, but crossed by no great mountain chains, except the Uintas in the north, this enormous area takes in the whole upper drainage basin of the Colorado River. All the waters that enter its eastern half, which is the Colorado Plateau, whether from the sky as rain or from melting snow on the peaks of its periferal mountains, except that which sinks into the soil to appear, perhaps, lower down in a spring to join from there the flow again (or which evaporates into the skys) all these flow finally into the Colorado to be carried thousands of miles to their ultimate destiny in the Gulf of California where they at last mingle with the salts of the ocean.

The most difficult of access and sparsely populated part of the upper Colorado water system lies along either side of the river from Moab south through southern Utah and into northern Arizona as far as the

beginning of Grand Canyon. Throughout this whole length the Colorado flows between high canyon walls for a distance of well over three hundred miles. These boardering lands are among the most rugged, eroded and impassable in the whole nation. They are cut through and through by innumerable canyons having such precipitous sides that into most of them few trails lead. The surface consists in many places merely of rolling mounds of bare rock, more or less literally petrified and dunes. Two major tributaries join the Colorado in this desiccated land: the Green River first, up stream on the right, and below it the San Juan from the left, both through formidable canyons. The physiography and historical geology of the canyon divide it naturally into distinct parts named by the early explorers. Starting just below the confluence with the Green River the gradient increases steeply, the river becoming turbulent and full of rapids for the next ninety miles until it smooths out above the ferry crossing at Hite. This section John Wesley Powell called Cataract Canyon. The cable ferry at Hite was, until construction a few years ago of the high bridge at the Glen Canyon dam site, the only point except Lee's Ferry and subsequent Navajo Bridge where the Colorado River could be crossed by automobile between Moab and Boulder Dam. At Hite, where White River canyon enters on the left, Glen Canyon begins. It extends a winding course for one hundred and thirty miles through the Wingate and Navajo sandstones to Lee's Ferry at which point, emerging between the Vermilion Cliffs of the Paria Plateau to the west and Echo Cliffs on the east, the river enters the older rock formation of Marble Canyon, which gradually deepens to become Grand Canyon at the mouth of the Little Colorado River.

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