d31 Great Plains and Central Lowlands < Badlands, drying >

> A Faustian bargain with the water is now coming due; it created a prosperous irrigation economy based on levels declining ten times faster than any recharge. But we have no historical experience from which to predict the future of high-production industrial agriculture or the small-time farmer on the High Plains without the continuous massive infusions of groundwater. Nor have pragmatic alternatives been devised, much less tested. Pumping the Ogallala remains a one-time experiment. — John Opie, 1993.[1]

> As a global average, people typically drink 1 cu meter of water each per year, and use 100 cu meters per year for washing and cleaning. Each of us also accounts for 1,000 cu meters per year to grow the food we eat. In arid regions, imported food, in particular, saves on the water required to cultivate crops.[2]

Raised toward the continental divide in Rocky Mountains by Pliocene uparching, the Great Plains are now subject to erosion where earlier in the Cenozoic continental sediments of the American Platform had extensively accumulated (***Footnote d31.1***). The arch is so gentle that in these sediments (***Figure d31.1***) the bedding still appears to be horizontal where it can be seen in outcrop. Here, in the semiarid west, where vegetation is sparse and the stream channels are flashy (like gutters, which dry out between rainfalls), rainwash of slopes and steam-bed gullying carves badland scenery. Spectacular natural sections are exposed in the Badlands of South Dakota.

The Back Hills of western South Dakota is a dome structure that was raised in several stages during the Cenozoic. Erosion has exposed (in an oval 125 miles long in the north-south direction and 69 wide) its core of crystalline Precambrian basement rocks.[3] The high standing Black Hills, catch summer rain and winter snow and naturally support a dense Ponderosa pine cover and so, as seen from the pale-colored grassy plains about, are *paha sapa* (Lakota Sioux for "hills that are black"). From its crannies, Indians had brought quantities of gold to the trading posts. Acquisitive interest aroused in Lieut-Colonel George A. Custer led him in 1874 to lead an exploration of the region (designated a "Military Expedition," for, at the time, "whites" had no treaty rights therein). In the terrain, Ross and McKay, two miners attached to this expedition, "discovered" gold on French Creek (near the present city of Custer). This triggered the Gold Rush of 1876. In that year, we learn from the official history of the Homestake Mining Company, which, when it closed December 2001, had reached a record, in North America, shaft depth of 8000 feet:

> On April 9, Manuel Brothers, Moses and Fred, together with Hank Harney, discovered a ledge, an out-cropping of [gold quartz-vein] ore termed a "lead" [pronounced *leed* [4]], in what is now the Open Cut. They named their claim "Homestake" and the mining camp which soon leaped to life took the name of Lead [usually mispronounced as the metal *lead*] City.

Profits from placer gold and, after 1883, from an annoying black sludge that clogged sluicebox riffles and which upon being analyzed was found to be cassiterite (tin oxide) ore! drew the attention of New York financiers who in 1885 dispatched Charles Rushmore, an alumnus of City College and with a law degree from Columbia University, to explore the possibility of purchasing mineral rights to the hills in the area later called *Keystone*.[5] Harold Shames anecdotally reminds (in a letter to *The NY Times*, 2002.12.22), "He became friendly with the workers in the area. As legend has it, when someone pointed to a hill [any granite promontory singularly barren of ore] and inquired about it, a worker jokingly replied, 'That's Mount Rushmore.' And so it has been ever since."[6]

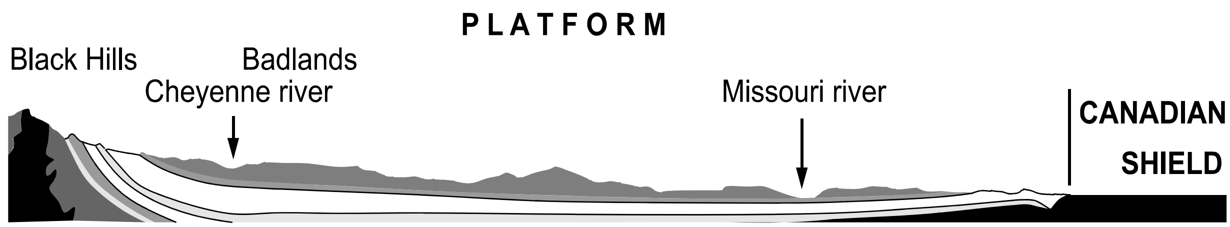
Now separated by erosion from its continuity with its sources to the west, are the 20 million year old porous and permeable gravels and sands of the Ogallala formation. This High Plains aquifer named the "Ogallala" by Nelson Horatio Darton in 1899 after a town in Nebraska with that name, extends from the Dakotas to Texas. Once filled with water, its area of 10,000 sq miles and thickness ranging 1 to 1,300 (average 200) feet, it held the equal of Great Lakes. This resource, that at first flowed by artesian pressure out of bore holes and then was greedily engine-pumped after cheep oil became available, transformed an otherwise hostile frontier and unproductive semiarid environment into a highly productive farming region. Unsurprisingly, replenishment of the millions-of-years old water by soaked in natural precipitation has fallen woefully behind extraction.

The Central Lowlands, during the Cenozoic, have not been raised or significantly flexed. There, inherited from the beginning of the Paleocene, an old-age landscape persists. Before the Pliocene the extensive lowland included the area of the Great Plains. On this, terrestrial-sediments shed east from the Paleocene Laramide mountains were deposited by meandering streams. Fossils and paleosoils in these clayey floodplain and oxbow-lake sediments record for the region a climate that became progressively drier.[7]

During the Neogene, grasslands, beginning in the Late Oligocene, replaced a humid-forest habitat of the Paleogene. That more ancient habitat is well recorded by the early-horse bearing Late Eocene White River Clastic Wedge in South Dakota.

In the Paleocene, a remnant of a Cretaceous (Zuni) epeiric sea retreated, having reached briefly to North Dakota (as recorded there by the Cannonball Formation) from the Gulf. The surface on which Paleocene terrestrial sediments rest in the Great Plains and Central Lowlands area is a continuation of the Rocky Mountain peneplain. ❑

Figure d31.1 [8] Cross section of the Great Plains from the Black Hills of South Dakota northeast to the Canadian shield.



Footnote d31.1 **Geology of the Black Hills, South Dakota** [9]
Beginning about two million years ago, rivers flowing fast enough to carry cobbles of hard Black Hills rock began to deposit these as the Medicine Root Gravels in the valleys of the Badlands.

Before the Pleistocene, Miocene sediments are absent, but exposed in section in the Badlands buttes and canyons are the Brule and Sharps formations deposited by rivers and wind during the Oligocene between 23 and 34 million years ago. Much sediment in these formations is volcanic ash, now claystone, from eruptions associated with the creation of the Rocky Mountains. Between floods, sediments had time to develop into soils that have since fossilized. The most prominent paleosol is the Interior Paleosol, which in the present scenery is a rich red layer that tops yellow mounds. During the Oligocene, rivers and forested riparian flanking these traversed savannah-type habitat. Titanotheres, huge in size and with long horns on their snouts, browsed in the forested drainages and grazed in the savannas between, where also were swift herds of oreodonts, small sheep-sized mammals with fanglike display teeth. Floodplain forests were home for the Oligocene horse, *Mesohippus,* that with three-toed feet walked on the soft soil in river bottoms and glades. Saber-toothed cats, hungry for blood, stalked. Lizards and snakes were present. Land turtles fed on the abundant plants surrounding ponds.

At the base of the Sharps formation is a thick layer with a very high ash content, the Rockyford Ash. This is conformable upon the Chadron Formation, deposited between 34 and 37 million years ago (end Eocene). In the present scenery, the Chadron erodes into low, regular mounds. In it, fossils of alligators indicate a riverine floodplain and small ancestral browsing-titanotheres indicate that a lush subtropical-forest covered the land.[10]

The Badlands terrestrial sediments are disconformable upon a marine formation containing fossil clams and ammonites, the Pierre Shale, deposited during the Upper Cretaceous.[11] This shallow, inland sea, stretched across what is now the Great Plains. Its black, sea mud, since hardened into shale, weathers yellow in outcrop.