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Geomorphic Expression of Stratigraphic Units in the Great Plains

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Research into geomorphology of the Great Plains, using published geological mapping, Google Earth, and field work, is underway, with a goal of understanding processes that lead to large-scale flatness. Apart from interruptions by Laramide domal uplifts (e.g. Black Hills) and volcanic stocks (e.g., Devil's Tower), the plains constitute an erosional surface cut into nearly flat-lying sandstones and shales of the foreland basin, stratigraphic units that are orders of magnitude more laterally extensive than they are thick. Alternating hard (generally sandstone) and soft (generally shale) units into which rivers have incised have produced a low-budget cliff-and-bench topography, somewhat similar to that of the Colorado Plateau, but greatly attenuated in the vertical dimension and covered with grass.

South of the limit of Laurentide ice, the plains can be envisioned as a series of nearly flat areal segments at varying elevations, each segment defined by the stratigraphic unit cropping out at ground level. The most resistant segments are broad areas of fluvial gravel that have been cemented by pedogenic carbonate; these segments stand high as minor plateaus, above surrounding landscapes cut into sandstone and shale. There is little to no relief on the actual gravel surfaces as streams generally do not form on the cemented plateau caps, and if they do are unable to incise. Erosion of these segments occurs in sideways fashion as softer rocks under the gravel caps are removed on the sides of the plateaus.

Areas where sandstone is at the surface may show low relief in the form of small undulating hills. In extreme cases, units such as the Tensleep Sandstone in Wyoming, composed of sandstone and limestone, may show relief of up 150 m due to incision of streams running over the formation.

In shales high relief cannot be maintained without the protective effect of remnants of sandstone or limestone layers upsection. Moderate badland relief can persist as long as local base level keeps dropping, but if base level remains static badland relief does not last long. This is illustrated in the Pierre Shale of Montana: badlands are common where the shale crops out on relatively steep slopes adjacent to higher plateaus, but local relief diminishes greatly close to streambeds that serve as local base levels. Shale relief is also minimal where the shale is thin and erosion is constrained by the underlying Niobrara Formation.

The obvious erodibility of shale units combined with the persistence of remnants of sandstone layers leads to the conclusion that erosion in the Great Plains proceeds mainly laterally. Away from incising rivers, shale layers erode headward and undercut overlying sandstone layers, which in turn retreat headward.