during initial deposition of the Chadron Formation (Retallack, 1983). A variety of landforms was produced by pre-Chadron erosion but they are difficult to interpret from the map of the base of the Cenozoic (Fig. 8) because of later structure. The general pre-Chadron landscape appears to have been an east-northeastward sloping plain with moderate local relief. The more resistant Upper Cretaceous Fox Hills Sandstone, Lance Formation, and Transition zone of the Pierre Shale (Fig. 9) were eroded to a more dissected topography in the southwestern part of the study area (DeGraw, 1969). Uplift along the Chadron Arch from Late Cretaceous into Early Cenozoic time caused the erosion of as much as 1800 ft (549 m) of Late Cretaceous rocks from the arch. Sparse data allow only a very generalized reconstruction of paleotopographic features along the arch.

Chadron Formation-Lower Part of Orella Member of the Brule Formation

Significant erosion, completely removing the Interior Paleosol from some lowland areas, established a drainage system prior to deposition of Chadron-lower part of Orella (Early Oligocene) sediments. The initial phase of deposition was dominated by alluvial processes as the valleys were filled. Basal sands with some gravels overlain by bentonitic clays (mostly altered pyroclastic material) typify deposits of the valleys. Clays and interbedded sands fill paleotopographic lows if coarse clastics are absent. Similar clay beds, generally thinner and probably representing paleosols (Retallack, 1983), occur on the uplands. Figure 10 is a reconstruction of the Early Oligocene paleogeography at the end of this fluvial phase (Chadron Formation, Fig. 6). The major drainage feature was a west-east through-flowing valley about 25 mi (40 km) wide entering present day Nebraska in northwest Sioux County and turning southeast in western Dawes County. Net sandstone thicknesses exceed 200 ft (61 m) in northeast Sioux County and may represent deposition in locally subsiding basins or in inner channels (Schumm, 1977). A major tributary paleovalley cuts across the southwest part of the study area parallel to the subcrop contact between the Transition zone of the Pierre Shale and the Pierre Shale (Fig. 9). This paleovalley has sand-filled tributaries originating in uplands developed on the Upper Cretaceous Fox Hills Sandstone and Lance Formation. The major paleovalley diverges east of Cheyenne County (Fig. 9). A tributary drainage system also trends from eastern Dawes into Sheridan County but it cannot be extended southeastward because of lack of control.

Filling of paleovalleys was followed by deposition of pyroclastic air-fall debris, including discrete ash beds (M ash, Fig. 6), over most of western

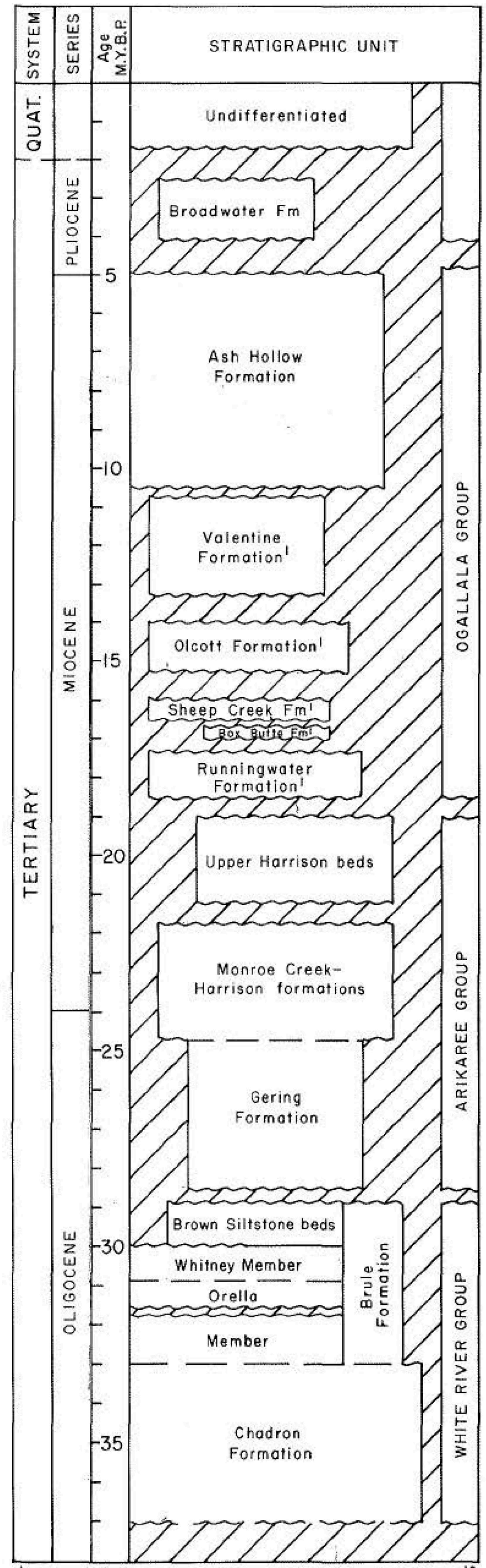

Figure 4. Time stratigraphic chart of Cenozoic units in western Nebraska. Units positioned on bases of superposition, fossil mammals and available age dates. Width of unit box indicates approximate extent of unit from south to north across study area. Slanted lines indicate a hiatus.

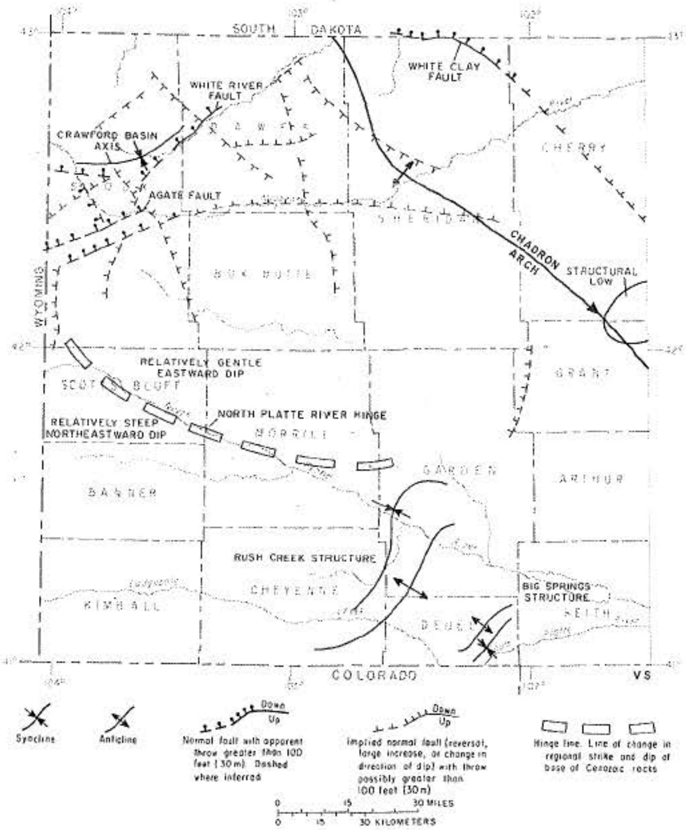

Figure 22. Significant known and suspected Cenozoic structural features of western Nebraska primarily compiled from overlays of maps of the base of the Cenozoic (Fig. 8), Ogallala Group (Fig. 15), and from the configuration of Lower Ash of the Whitney (Fig. 11).

As outlined above, local structural control of post-Ogallala drainages is apparent in parts of the study area. The magnitude of regional uplift is indicated most strongly by the large amount of erosion that has occurred in the region since deposition of the Ogallala Group. Scott (1982) noted a similar situation in northeastern Colorado. The North Platte River in central Scotts Bluff County is at least 1000 ft (305 m) lower than the Ogallala-capped tablelands on either side of the valley (Fig. 2). In the north near the Wyoming border, the Pine Ridge escarpment rises 1200 ft (366 m) above Pierre Shale hills (Fig. 5, A-A') and relief gradually decreases to about 400 ft (122 m) at the east end. All Tertiary rocks were eroded from the area north of the ridge while most of the Ogallala Group and much of the Arikaree Group were removed from the western part of the uplands between the Pine Ridge and the North Platte River valley (Fig. 2).

Cenozoic structural events and associated geographic features are certainly more complicated than discussed here. Generally speaking, episodic regional uplift and local adjustments took place throughout the Cenozoic and presumably are expressions of varying degrees of structural movements in the Rocky Mountains to the west. The approximate times and relative magnitudes of post-Laramide uplift are represented in an oversimplified, qualitative fashion by the negative slopes on the cumulative graph (Fig. 23). Trimble (1980) suggests a simpler picture of Cenozoic tectonic history of the Southern Rocky Mountains and Great Plains. Figure 23 furthermore illustrates the importance of pyroclastic air-fall material in the construction of the High Plains of westernmost Nebraska.

Climatic conditions and internal sedimentary controls (Schumm, 1977) can greatly influence erosion and sedimentation, so every instance of downcutting within the Cenozoic cannot be attributed to tectonic activity. Nevertheless, we believe structural movements, combined with pre-Ogallala volcanic activity to the west, were the primary determining factors in shaping the past and present landforms of western Nebraska.

ACKNOWLEDGEMENTS

We gratefully acknowledge Frank Smith, Conservation and Survey Division, for his hard work in obtaining test hole information in western Nebraska. We also thank John Boellstorff, formerly of the Conservation and Survey Division, for his ideas and efforts both in the field and lab. Morris Skinner and Richard Tedford, American Museum of Natural History, and Michael Voorhies and Robert Hunt, University of Nebraska State Museum, participated in many stimulating discussions on the Cenozoic of the Great Plains with the authors over the past decade.

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