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FRONTIERS OF NEBRASKA GEOLOGY

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At this bicentennial time, it is appropriate to reflect not only upon geological progress, but also to consider the future.

Historically, many themes could be developed, such as has been done recently by Challinor (1971). British geology also was just beginning in 1796 when James Mackay, a Scot in the employ of the Spanish, made perhaps the earliest geological observation in what is now Nebraska. Soon after, by 1812, the Yellowstone Expedition line of forts was planned for the western frontier of the United States, along the Missouri River border; only two forts were established. One of these was Fort Atkinson (1820), the largest and farthest outpost. Geological descriptions multiplied thereafter. By 1863, the period of initial geological exploration ended with the work of Jules Marcou along the Missouri River. He was the last of the French explorers, bringing to an end three centuries of effort (beginning with Coronado, for the Spanish, in 1541).

Looking ahead, we should take pride in the richness of the geologic record for this region, especially with regard to the Quaternary, Tertiary, Cretaceous, and Late Paleozoic. Refined global correlations and stage-reclassification should be primary objectives. Buried soils and unconformities punctuate the record, suggesting that "event stratigraphy" rather than Ager's "golden spike" should be given emphasis. Climatic fluctuations probably have been with us always, to be linked with advances and retreats of the sea here or elsewhere.

† † †

INTRODUCTION

The earliest frontier in Nebraska geology was intimately associated with the discovery and exploration of a new land, but the later frontiers have been of a wholly different character. They have consisted of progressive reassessments, in entirely new ways, of accumulated information, so that now we must attempt to place Nebraska geology in a global perspective. The approach to problems at any given time is dependent to a considerable extent upon the way the *tradition* has developed and how our experience has prepared us. To look at them differently requires much effort and the application of the method of multiple working hypotheses. Or, like putting on a variety of colored spectacles (Rudwick, 1975), we must try to observe through each other's eyes. However, we must all confess to experiencing periods of "blindness" as we attempt to solve certain problems, by not observing carefully enough what we later consider to have been obvious.

Historically, we can trace numerous *themes* that have dominated the development of Nebraska geology, as with any

region (see Challinor, 1971, and his method of treating British geology; also Porter and Poulton, 1977), but we should pay particular attention to the chronologic development of ideas. I am reminded of the often-quoted aphorism of George Santayana that seems to me to be appropriate here: "Those who cannot remember the past are condemned to repeat it." (1914, *The Life of Reason*, Vol. 1).

EXPLORING THE MISSOURI

In the early days of last century, the Missouri River was the western boundary of the United States; there keen competition existed among the American, Spanish, French, and British furtrappers. These were the "beaver men" (Sandoz, 1964; Nasatir, 1952) who, both before and after the Lewis and Clark Expedition of 1804-1806, found their way up the Missouri and even farther west. Among the most interesting of the later group were Jim Bridger and James Clyman (Camp, 1928), but of the pre-Lewis and Clark men, two require special mention.

James Mackay (Diller, 1955; Nasatir, 1952) was a Scot employed by the British and then by the Spanish, and John Evans had come up the Missouri in search of a tribe of supposed "Welsh Indians." The explorations of these two frontiersmen are difficult to differentiate, but Mackay reported in 1796 finding a thigh-bone, seemingly of a mastodont or mammoth, along what is now the Keyapaha River of north-eastern Nebraska (Diller, 1955:127). The history of the maps of Mackay and Evans, some copies of which were carried by Lewis and Clark, has been brought up-to-date by Wheat (1957, 1:161-164, 245-246). So much has been written concerning the latter expedition that reference need only be given here to two recent summaries (Jackson, 1962; Osgood, 1964). Several fossils were collected and a few geological observations were made by them along the upper Missouri in 1804.

By 1812, the Yellowstone Expedition line of forts was planned for this western frontier, but only two forts were established. One of these was Fort Atkinson, the largest and farthest outpost, established in 1820 at the Council Bluffs, just north of what is now Omaha. It was built on higher ground, only a short distance from the Engineer Cantonment which had been constructed a year earlier.

The first steamboat to ascend the upper Missouri was the *Western Engineer* in the late summer of 1819 (Dillon, 1967:96). On board were Stephen H. Long and his men, who wintered at the Council Bluffs (Engineer Cantonment). The following spring, they were joined by Edwin James, who succeeded Thomas Say as the geologist, zoologist, and botanist of the Long Expedition. His report of the journey up the Platte to the Rocky Mountains (James, 1822-1823) is chiefly a descriptive narrative, best known for the notion of a Great American Desert (Dillon, 1967:100-104).

Geological observations increased rapidly after 1819 along the rivers of what is now Nebraska, and, after the 1830's, overland. European visitors included three that are of considerable interest.

In 1823, Paul Wilhelm, Duke of Württemberg (nephew of King Friedrich of Württemberg), traveled up the Missouri beyond the mouth of the White River, a journey that he repeated from December, 1829 to February, 1830 (Lottinville, 1973). Inquiry in Stuttgart some years ago (personal communication from Karl Adam) revealed that his journals and other records have survived and are preserved in the archives there.

In 1833-1834, Prince Maximilian zu Wied-Neuwied journeyed up the Missouri, accompanied by his talented artist, Karl Bodmer, and they left a precious record of their travels that has been in the custody of the Joslyn Art Museum in Omaha since 1962 (Goosman in Thomas and Ronnefeldt, 1976). The vivid watercolors of Bodmer, together with the work of other early painters such as Alfred Jacob Miller and George Catlin, allow us to see through their eyes what this region and its Indian inhabitants were like nearly a century and a half ago.

The 1863 visit by the geologist Jules Marcou (1864) to Nebraska City and Omaha, as well as to other sites along the Missouri River, may be taken as the end of the long period of French exploration of this region, a period that had begun with De Bourgmond in about 1724 (Folmer, 1937; 1939). The centennial observance of this event was on the occasion of the 1963 "mission" to Nebraska by René Lavocat of the Paris Museum (Muséum d'Histoire naturelle de Paris). He accepted my invitation, on behalf of colleagues at the University of Nebraska State Museum, to join us in obtaining a comparative collection of fossil mammals from the "Badlands" of northwestern Nebraska, and to celebrate officially the renewed interest of French scientists in this region after a century. It turned out that Marcou had once been a curator at the Paris Museum and a professor at the Sorbonne, and that he had been born at Salins (Jura) not far from where Lavocat's family also had been established.

BADLANDS' EXPLORATIONS

Although the French expeditions which were led by the

la Vérendrye's (1738-1739, 1742-1743) may possibly have reached the Badlands areas of South Dakota and northwestern Nebraska, other early French and Spanish explorers probably did not. Despite some claims to the contrary, the Spanish group under Coronado (1541) seems not to have entered Nebraska. The Mallet Brothers (French, 1739) probably explored only the upper Missouri and Republican rivers, and the Villasur (Spanish) expedition was massacred along the Platte in 1720.

Aside from occasional penetrations by Spanish or French voyageurs, the Badlands remained virtually unknown to Americans until the 1840's. Thaddeus Culbertson's diary, as republished (Culbertson, 1952), fully and vividly records his steamboat trip in 1850 up the Missouri to Fort Pierre and from there into the Badlands. He brought back fossils that were deposited with the Smithsonian Institution and described in 1854 by Joseph Leidy as a contribution to "The Ancient Fauna of Nebraska." In 1869, after studying additional fossils collected by Hayden and Warren, Leidy was able to prepare a more extended treatment of "The Extinct Mammalian Fauna of Dakota and Nebraska." This made the Badlands a classical area for the collecting and study of fossil mammals, as it is even today (Schultz and Stout, 1955).

MODERN GEOLOGY AND PALEONTOLOGY

Since the early 1850's, there has been a gradual development of rather extensive knowledge concerning Nebraska's geology and its fossils. The official expedition of 1857—which was led by G.K. Warren and F.V. Hayden, but which was based on earlier individual efforts by them, F.B. Meek, and a few others—resulted in a general understanding of the rock succession in Nebraska. This was expanded, especially by Hayden and Meek, during and immediately after the period of the Territorial Surveys.

Nebraska was quickly settled after it became a Territory (May 30, 1854), and especially after it was declared a State (March 1, 1867). However, the truly immense region once embraced by the territorial boundaries was greatly reduced with its establishment as a State. The University of Nebraska was founded on February 15, 1869, with the first classes beginning about two years later. Samuel Aughey, a scientific promoter (Manley, 1967), developed the first State geological efforts and founded the Museum Cabinets (Nicholson, 1971; Schultz, 1957). Erwin H. Barbour, George E. Condra, and Eck F. Schramm were dominant figures at the University in the development of the Geology Department, the Geological Survey, and the State Museum (Schultz, 1948; Schramm, 1933; Nicholson, 1971).

GLOBAL CORRELATIONS

New frontiers of essentially global character now have emerged, so that Nebraska geology and paleontology must be viewed in this world perspective. Stratigraphic re-classifica-

tion, probably best considered on a stage/group basis, is indicated as part of the "International Geological Correlation Programme."

The Nebraska rock column is punctuated by unconformities and also, in most of the exposed sections, by buried soils. These surely document episodes of some significance locally and regionally ("event stratigraphy") as well, so that Ager's (1973) concept of a "golden spike" as necessary for correlation purposes seems to be here of little value. Climatic fluctuations probably have been with us always, as recorded particularly in the Carboniferous-"Early Permian" and all younger sediments of the State. These I believe can be tied in with transgressive and regressive stands of the sea, both here and in other parts of the world.

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