

**PALEOCENE PALEONTOLOGY AND STRATIGRAPHY IN NORTH DAKOTA:
EARLY CONTRIBUTIONS BY A.G. LEONARD**

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The North Dakota Geological Survey was founded with the intention that it be involved in the practical utilization of the state's energy and mineral resources. Almost from the inception of the Survey, Arthur Gray Leonard, its second director, devoted much of his life to the field study and interpretation of the lignite deposits of North Dakota. This communication focuses on Leonard's contribution to an understanding of western North Dakota's Paleocene stratigraphy on the basis of his coal bed observations and mollusk collections. Leonard's work on coal stratigraphy represented the framework upon which immediate subsequent research would build. Interestingly, Leonard, and thus North Dakota's fossils and rocks, rendered a formative role in the contentious debate on the age and relations of strata on either side of the Cretaceous-Tertiary boundary (K/T).

After his appointment as State Geologist in 1903, Leonard conducted field studies from 1904 to 1909 in the Paleocene coal-bearing strata of western North Dakota. His extensive stratigraphic work resulted in the recognition of coal bed sequences, tied to lithic units, that were of far greater detail and correlative value than his predecessors (1). Leonard first designated coal beds by letter or name (e.g., Bed I or Harmon coal) to facilitate correlation and discussion of regional extent and resource potential. In addition, Leonard (2) organized coal sequences into named groups. One such designation, the Sentinel Butte coal group, would serve as the basis for distinguishing the Sentinel Butte Formation as the upper unit of the Fort Union Group.

Leonard's collections of freshwater mollusks, found mostly in the Bullion Creek and Sentinel Butte Formations in Billings, Golden Valley, McKenzie, Morton, McLean, and Burleigh Counties, were frequently tied to stratigraphic markers, representing the first stratigraphically controlled collections available for more rigorously documented biostratigraphy (3). The locations of earlier collections made by F.V. Hayden (3) are difficult to relocate and use with high confidence. Leonard's published data (4), field notes (5), and fossil locality field labels (6) permit extensive use of his observations and collections (3). The mollusks collected by Leonard were examined by T.W. Stanton, paleontologist for the U.S. Geological Survey. Stanton's identifications were reported by Leonard in a number of publications and used to confirm the "Fort Union" (Paleocene) age of the strata in the badlands of the Little Missouri River and rolling hills and drainages of the southeastern portion of the Williston Basin. Also, Leonard's pre-Lake Sakakawea measured sections and collections are important as a source of now unobtainable data (7).

In 1907, Leonard (2, 8) discovered oysters on the high bluffs on the west side of the Little Missouri River, in Slope County (this occurrence is probably in sec. 10 and not sec. 16 as reported, in T. 135 N., R. 105 W.). This discovery represented the first record documenting a tongue (Three V Tongue) of the Cannonball Formation. As far as Stanton was concerned, the oysters were proof-positive that no significant unconformity or hiatus existed at the Fox Hills-Lance (= Hell Creek) formational contact and that the strata below the Fort Union, including the oysters, should be included in the Cretaceous Lance Formation (9, 10). Leonard (2) had distinguished an underlying "somber-" and overlying light-colored separation of the Fort Union Formation, which represented all post-Fox Hills strata. His placement of the contact between his F (= Yule, 11) and G (= H, 11) coal beds approximates the Slope-Bullion Creek formational contact of today. Leonard did not recognize a lithic break or sedimentological change between dinosaur-bearing beds (= Hell Creek Formation) and the overlying nondinosaur-bearing Tertiary strata (2), which included the oyster deposits. Without the expected unconformity (and concomitant hiatus), the general absence of freshwater shells typical of the Fort Union Group in the lower part of the section, and the presence of marine shells in "somber beds" indicating a supposed extension of Cretaceous deposits, a number of decades would lapse before the presence and absence of dinosaurs and coal deposits would be established as a useful method for recognizing the K/T boundary. Thus besides providing an important and detailed account of the economic resources of North Dakota, Leonard contributed, if inadvertently, to the debate on the age of strata now interpreted to be of lower Paleocene age. This research was supported by the Philip McKenna Foundation and the U.S. Bureau of Mines.

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