

64. AGE OF THE EVANSTON FORMATION, WESTERN WYOMING

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Renewed interest has arisen concerning the age of the Evanston formation because it provides a means for dating precisely some tectonic events in the thrust belt of western Wyoming. The formation was long of interest because of its bearing on the Laramie problem and therefore on the boundary between the Cretaceous and Tertiary systems (Veatch, 1907, p. 86-87; Schultz, 1914, p. 70-71).

The Evanston formation was formally named by Veatch (1906, p. 332) and defined (1907, p. 76) to include strata that were earlier referred to informally as the "Evanston beds" and "Evanston coal series." No type section was designated. Veatch's criteria (1907, p. 77) for distinguishing the formation from the underlying Adaville formation and from overlying strata, which he assigned to the Wasatch group, are still valid. Veatch failed to recognize the Evanston over much of its extent, however, and distinguished it (see his pl. 3) in only a few small areas near the town of Evanston.

Disagreements among paleontologists regarding the age of fossils found within the Evanston formation led Veatch (1907, p. 84-87) to discuss the problem at length. The age, he concluded tentatively, was early Tertiary, but he used the symbol KTe to designate the unit on maps and cross sections.

Geologists other than Schultz (1914, p. 68) have not made use of the Evanston formation as a mappable lithologic unit. Beds north of the type area formerly assigned to the Evanston by Schultz were defined as the Hoback formation by Eardley and others (1944).

Extensive exposures of the Evanston formation have been mapped by us in the Cokeville, Kemmerer, and Sage quadrangles, Lincoln County, and Big Piney quadrangle, Sublette County, Wyo. The belt of the rocks assigned by Veatch (1907, pl. 3) to his Almy formation in the eastern part of the Fossil basin belongs in the Evanston formation as well as scattered exposures well within the basin which he assigned to his Knight formation. Our assignment of these rocks to the Evanston is supported both by Veatch's published description and by comparison of certain distinctive rock types in the quadrangles mentioned with those in exposures at the type area. Exposures of the unit in both areas are

similar in gross aspect and in some details, although not identical because of facies differences typical of continental strata.

Fossils in the Evanston formation in the Kemmerer, Sage, and Cokeville quadrangles include vertebrates, fresh-water invertebrates, leaves, and pollen. Ages inferred from these varied fossil forms are in agreement.

Vertebrates from near the base of the formation include the jaw of *Triceratops* cf. *T. flabellatus* Marsh, indicating probable Lance (=Hell Creek), latest Cretaceous age (G. E. Lewis, written communication, 1958), and numerous unidentifiable dinosaurian bone fragments indicative only of Mesozoic age. Mollusca from strata near but above the vertebrate horizon are different from those of Paleocene age and are regarded of probable Cretaceous or early Paleocene age (D. W. Taylor, written communication, 1960).

Leaves found about 50 feet above the base of the Evanston formation, about 20 miles north of the vertebrate localities, were identified by J. A. Wolfe (written communication, 1959) as *Dryophyllum subfalcatum* Lesquereux, *Cinnamomum linifolium* Knowlton, and *Dombeyopsis obtusa* Lesquereux and assigned a Lance (latest Cretaceous) age. A collection from a nearby locality yielded *Protophyllocladus subintegrifolius* (Lesquereux) Berry, *Ficus planicostata* Lesquereux, and *Cinnamomum affine* Lesquereux, also of Late Cretaceous age (R. W. Brown, written communication, 1958).

Fourteen species of pollen were identified from mudstone samples collected at one of the leaf localities. The presence of *Proteacidites annularis* Cookson, as well as other forms, indicates the samples are no younger than Late Cretaceous (E. B. Leopold, written communication, 1959).

Pollen species identified in samples from mudstone close to the *Triceratops* locality are even more varied; 32 species were recognized. The species *Schizaeisporites pseudodorogensis* Potonié, *Osmundacidites wellmannii* Couper, *Proteacidites annularis* Cookson, and associated forms confirm the Late Cretaceous age of these rocks (E. B. Leopold, written communication, 1959).

Fossils found near the middle of the Evanston formation include Paleocene, possibly middle Paleo-

cene, leaves (R. W. Brown, written communication, 1958) and pollen (E. B. Leopold, written communication, 1959).

A varied vertebrate fauna has been reported 250 to 300 feet below the top of the unit by Gazin (1956, p. 708) who interprets the presence of *Plesiadapis* cf. *P. fodinatus* Jepsen, *Pheocodus* sp., and other genera to indicate an early late Paleocene (Tiffany) age. No fossils have been found in uppermost strata assigned to the formation.

Additional collections of leaves and pollen from exposures in other parts of the Sage, Kemmerer, and Cokeville quadrangles confirm the Cretaceous and Paleocene age of the Evanston formation in this area.

Cretaceous age assignments for parts of the Evanston formation in the quadrangles under study are not in accord with the Paleocene age inferred for the unit in its type area some 30 miles to the south in earlier reports (for example, Brown, 1949; Eaton, 1955, p. 116).

The apparent discrepancy in age led us to re-examine exposures of the formation in its type area. The thickest section reported by Veatch (1907, p. 80) lies along the boundary between the western parts of secs. 18 and 19, T. 16 N., R. 120 W., north of the old settlement at Almy and is regarded by us as the informal reference section.

Fossils were collected by us directly below and above a main coal bed north of the old No. 7 mine (Veatch, 1907, pl. 3). Leaves were examined by R. W. Brown (1958), mollusks by D. W. Taylor (1960), and pollen by E. B. Leopold (1959, 1960), who conclude they indicate a Paleocene age.

No megascopic fossils were found considerably below the main coal bed. Samples of mudstone col-

lected directly above and below the horizon of the lowest conglomerate layer mentioned by Veatch (1907, p. 80), however, contain an assemblage of pollen of latest Cretaceous age (E. B. Leopold, written communication, 1961). Among the more critical species are *Aquilapollenites quadrilobus* Rouse, *Appendicisporites tricornitatus* Weyland and Greifeld, and *Proteacidities annularis* Cookson. The possibility that these forms are reworked from older rocks is considered unlikely.

Collections from the type area, therefore, seem to confirm the Cretaceous and Paleocene age of the Evanston formation, to verify the age assignments made by Knowlton and Stanton some 60 years ago (Veatch, 1907, p. 86-87), and to support Veatch's use of the map symbol KTe.

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65. PERMAFROST AND THAW DEPRESSIONS IN A PEAT DEPOSIT IN THE BEARTOOTH MOUNTAINS, NORTHWESTERN WYOMING

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The discovery of permanently frozen ground in a peat deposit in the southeastern part of the Bear-tooth Mountains, northwestern Wyoming, is of interest because permafrost is of infrequent occur-

rence this far south in the Rocky Mountains. Associated with it are numerous thaw ponds, which indicate the presence of permafrost.

The Sawtooth peat deposit, named from Sawtooth