

CONTRIBUTIONS FROM THE MUSEUM OF PALEONTOLOGY

THE UNIVERSITY OF MICHIGAN

VOL. 27, NO. 3, p. 73-85 (4 Figures)

August 16, 1985

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WYOMING**

BY

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NEWFOUND EARLY CRETACEOUS DINOSAURS AND OTHER FOSSILS IN SOUTHEASTERN IDAHO AND WESTERNMOST WYOMING

By

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Abstract—Early Cretaceous, wet alluvial fan deposits of the Gannett and Wayan formations in southeastern Idaho and westernmost Wyoming were derived by erosion from highlands uplifted by movements on the Paris Thrust in the Sevier Orogenic Belt. Newfound fossils indicate that the environment of deposition of the Wayan (and probably also the Gannett) formation provided conditions favorable for habitation by an abundant and diverse biota, including ferns and dicotyledonous plants, freshwater molluscs, aquatic turtles and crocodylians, and dinosaurs. Abundant eggshell fragments indicate that a variety of types and sizes of dinosaurs nested on the interfluves of the fan uplands, taking advantage of the combination of relatively low watertable, dry soil conditions, abundant plant food supply, and easily accessible, perennial, surface freshwater supplies. Analogous lithotopes and biotopes occur on the wet alluvial megafans of the modern Indogangetic Plain.

INTRODUCTION

The fragmentary fossil specimens listed below include the first identifiable remains of dinosaurs and certain other vertebrates to be reported from the Wayan Formation. They also include the first identifiable dinosaur remains of any kind to be reported from Idaho. Together with the fossil invertebrates and plants also listed, the fossils provide clues to the environment of deposition of the rocks in which they occur.

GEOLOGICAL SETTING

Recurrent movements on the Paris Thrust, first and westernmost of a progressive sequence of overthrusts (Figure 1), produced an episodically uplifted (Figure 2) sedimentary source area in southeastern Idaho. The Early Cretaceous, synorogenic clastic sediments derived from that highland were transported eastward and deposited in a tectonic foredeep in southeasternmost Idaho and westernmost Wyoming (Wiltshko and Dorr, 1983). Crustal subsidence beneath the foredeep mainly was caused by thrust loading (Jordan, 1981). The nonmarine sediments were deposited by braided streams proximal to the source area and by meandering streams distally (Schmitt, Sippel and Wallem, 1981; Sippel, Schmitt and Wallem, 1981; Schmitt and Moran,

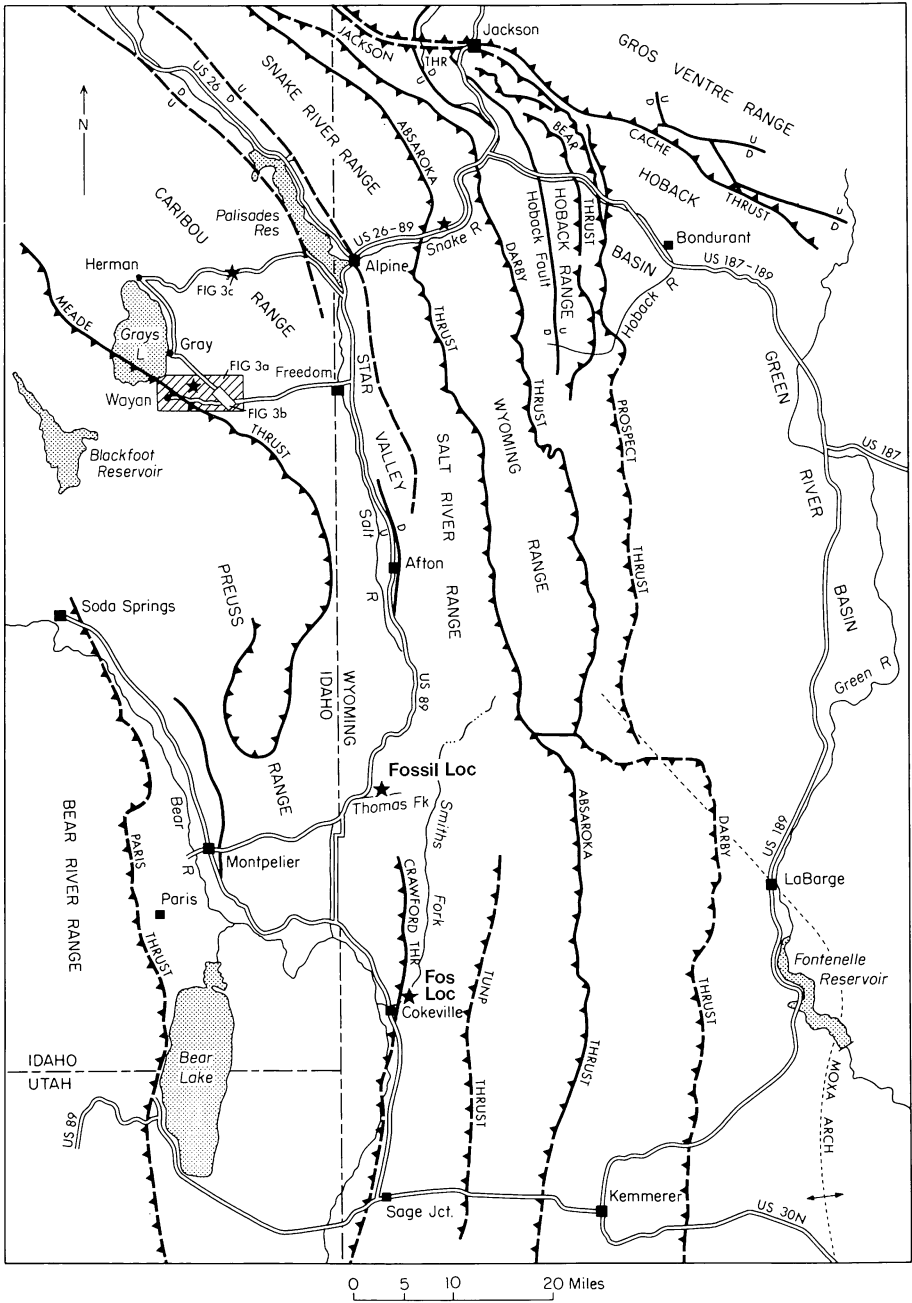


FIG. 1— Index map of Idaho-Wyoming thrust belt. Stars denote fossil localities.

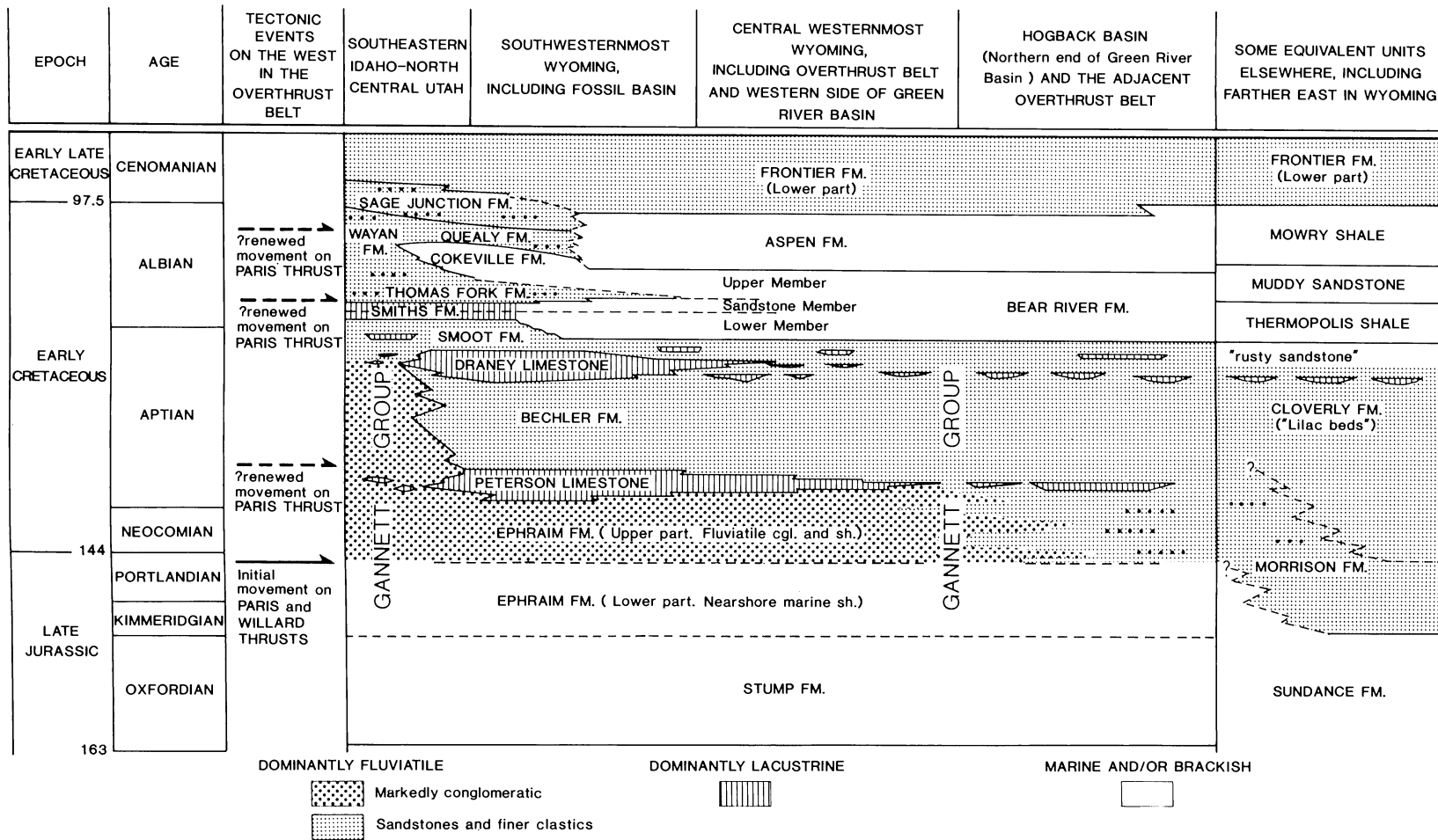


FIG. 2 Stratigraphic correlation chart. From Rubey, 1973; Schmitt and Moran, 1982; Wiltchko and Dorr, 1983; Derman, Wilkinson and Dorr, 1984.

1982; Schmitt and Sippel, 1983). The sediments accumulated on a succession of eastwardly and southeastwardly prograding alluvial fans (Armstrong and Oriel, 1965; Eyer, 1969) during deposition of the Ephraim, Bechler, Wayan (including Thomas Fork and Quealy), Sage Junction and lower part of the Frontier formations. Fan progradations were interrupted by lacustrine episodes of deposition (Peterson and Draney-Smoot) and by marginal marine incursions (Smiths and Cokeville). At first, during deposition of the Gannett Group, the alluvial fan deposits graded into the thinner, coeval Morrison and Cloverly formations deposited on a lowland alluvial plain (Figure 2). Later fan deposits (Wayan and Sage Junction) graded into marginal marine and marine deposits of the upper Bear River and Aspen formations.

The general locations of the fossil vertebrate sites reported here are indicated on Figure 1. More detailed locality data are given in the text. The fragmentary fossil remains, none worthy of separate catalogue number or detailed description, are conserved under a single number (UM78899) in the University of Michigan Museum of Paleontology. Fossils are listed by stratigraphic unit in ascending stratigraphic order.

GANNETT GROUP

The Gannett Group has yielded very little fossil vertebrate material, all of it very fragmentary and specifically unidentifiable, in contrast with the partially coeval Cloverly Formation which has produced abundant and diverse material of excellent quality in central Wyoming (Ostrom, 1970). Mansfield (1927) reported unidentified fossil bone from the Gannett Group along Tincup Creek (Figures 1 and 3) in southeastern Idaho, but the exact stratigraphic and geographic provenance of that material is uncertain. S.S. Oriel of the U. S. Geological Survey (pers. comm.) reports a recent discovery of dinosaur bone in the Gannett in the Blackfoot Range of Idaho, but that material has not been identified more exactly. I have found large, but unidentifiable reptile limb bone fragments and pieces of turtle carapace in the upper part of the group, close beneath the Smiths Formation, north of Idaho Rd. 34 and Pine Bar Campground, along Tincup Creek in the Caribou Range of Idaho (Figure 3a).

Paleontological evidence for the ages of the several formations of the Gannett Group was summarized by Eyer (1969). The basal 15 m of red shale, called "Lower Ephraim," contain belemnites and oysters of latest Jurassic age and marginal marine origin, but these shales might better be considered as representing the waning phase of deposition of the marine Stump Formation. Aptian charaphytes occur in the upper part of the Ephraim, Peterson, Bechler, Draney and lower part of the Smoot formations. The upper part of the Smoot contains charaphytes and ostracods of an age spanning the Aptian-Albian boundary. Unidentified freshwater molluscs have been reported (Wanless *et al.*, 1955) from the group within the Hoback Range south of Jackson, Wyoming. Collectively, the fossils indicate that deposition of the remainder of the group, after the "Lower Ephraim", occurred in nonmarine environments.

SMITHS AND LOWER BEAR RIVER FORMATIONS

Rubey (1973) and Durkee (1979) described the stratigraphy and sedimentology of the Smiths Formation. The Bear River Formation is discussed in Wanless *et al.* (1955). The Smiths Formation is a coeval, western, stratigraphic extension of the black shales and overlying

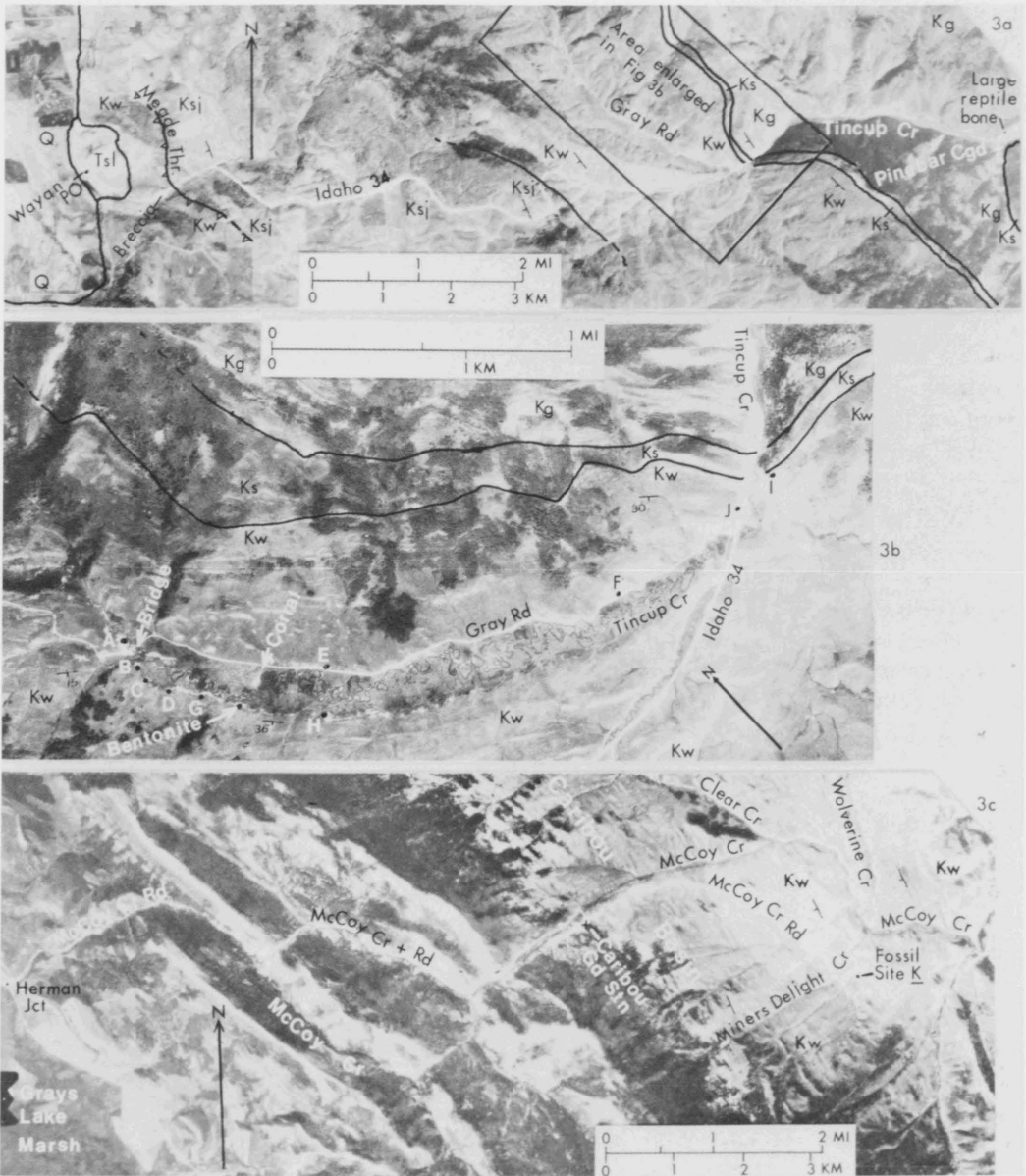


FIG. 3— Aerial photographs, enlarged (see bar scales) from U.S.Department of Interior, Geological Survey, EROS Data Center images INHAP80000096 (7/27/1980) and INHAP80000198 (9/22/1980).
 (a) Fossil sites A-J in Wayan Formation and a single site in Gannett Group.
 (b) Detail of 3a. Sites A-J along upper part of Tincup Creek, Sections 14, 15, 22, 23 and 24, T5S-R44E, Caribou County, Idaho.
 (c) Site K in Wayan Formation on Miners Delight Creek, Caribou Basin, W 1/2, Sec. 23, T3S-R44E, Bonneville County, Idaho.
 Kg-Gannett Group, Ks-Smiths Formation. Kw-Wayan Formation, -- Bentonite, Ksj-Sage Junction Formation, Q-Quaternary, Tsl-Late Cenozoic Salt Lake Formation, Capital letters (white or black)-Fossil sites.

sandstones of the lower part of the Bear River Formation. Rubey (1973) and McGookey (1972) place the Smiths and Bear River formations in the Early Cretaceous (Albian).

Fossils from the lower, black shale member of the Smiths Formation include the following (Durkee, 1979; Rubey, 1973): plant fragments, small, abundant, widespread; thin coal lenses, small, local; worm burrows, trails and other extensive bioturbation features; mollusks including *Corbicula*, *Unio* (2 types), *Viviparus*, "Lioplacodes" (may be *Viviparus*), *Goniobasis*, and *Campeloma*. The first two mollusks are clams, the others snails. *Corbicula* may have been a brackishwater form, but the rest of the mollusks are freshwater types.

Wanless *et al.* (1955) reported a scant, poorly preserved, freshwater mollusk fauna from the lower Bear River Formation along Greys River in the Snake River Range. Thin coals are present in the lower Bear River. I have found the following in it: plant fragments, abundant, widespread, including stem, twig and leaf impressions; worm trails and burrows; fish bone fragments including a lower jaw with a few teeth from a roadcut on the north side of U.S. 26-89 in the Snake River Canyon just west of Keyser Creek which lies east of the Absaroka Thrust (Figure 1).

WAYAN AND SAGE JUNCTION FORMATIONS AND COEVAL UNITS

General Description

During the middle and late Albian, the margin of the Mowry Sea way fluctuated in an east-west direction across much of western Wyoming, as recorded in the upper part of the Bear River Formation and the overlying Aspen Formation in the Hoback, Wyoming and Snake River ranges. Freshwater and brackishwater mollusks, including *Ostrea*, alternate stratigraphically there (Wanless *et al.*, 1955). Roysse *et al.* (1975) reported abundant marine microfossils of several types and from several levels elsewhere in the upper part of the Bear River Formation.

Contemporaneously, accelerated clastic sediment influx off the reelevated Paris Thrust (Sippel *et al.*, 1981; Wiltschko and Dorr, 1983) generated a second alluvial fan complex. In the Caribou Range of southeastern Idaho, this clastic wedge consists of the Wayan and Sage Junction formations and the basal part of the Frontier Formation. It prograded eastward, excluding the rising Mowry Sea from much of westernmost Wyoming and southeastern Idaho. This second wedge (the first was that formed by the Gannett Group) graded into the upper Bear River and Aspen formations (Rubey, 1973), but uplift and erosion of the Absaroka Thrust plate during the latest Cretaceous and Paleocene subsequently disrupted the original continuity of that facies relationship and at the same time telescoped the facies eastward from their original relationship to one another (Wiltschko and Dorr, 1983). The Thomas Fork and Quealy formations are southwardly and southeastwardly extended tongues of the Wayan Formation (Rubey, 1973; Schmitt and Moran, 1982) separated by the Cokeville Formation of both brackish and freshwater origin which records a minor, temporary, fluctuating, westward transgression of the coastal environments of the Mowry (upper Bear River and Aspen) Sea.

The Thomas Fork, Cokeville, Quealy, and Sage Junction formations are best exposed along the Smiths Fork and Thomas Fork rivers in westernmost Wyoming (Figure 1 and Rubey, 1973). Detailed lithologic descriptions, measured sections and discussions of stratigraphic and facies relationships for the above units are given by Rubey (1973). Most significantly, for the purposes of this paper, the Wayan, Thomas Fork, and Quealy formations are distinctly color-variegated, commonly reddened, and include abundant calcareous soil nodules at frequent intervals, all indicating the presence of numerous paleosols. These ancient soils formed by weathering under

oxidizing conditions in well drained areas where watertables were relatively low and where sedimentation was interrupted for significant periods of time. The Gannett Group similarly contains reddened and color-variegated strata. In contrast, the Smiths, Cokeville, Bear River, and Aspen formations are drab colored and lack paleosols and calcareous soil nodules.

Thomas Fork Formation

The type locality of the Thomas Fork Formation (Rubey, 1973) lies along the north side of Thomas Fork Creek, about 23 miles (37 Km) south of Afton, Wyoming. The following fossils have been found there, those with asterisks being new reports, the others previously reported by Rubey:

-Gastropods, small, unidentified.

*Unionid pelecypods, partial shells and shell fragments, indicating perennial freshwater environment of deposition.

-Fish scales, unidentified.

-Bone fragments, unidentified.

*Gastroliths, 2 to-3 mm. sized.

*Turtle carapace fragments of two types:

a. Patterned; surface ornamentation of "trionychid type " but not trionychid. Imply presence of perennial, surface freshwater, at least locally.

b. Unpatterned type. May or may not have been aquatic turtles.

*Reptilian bone fragments, large enough to have been of dinosaurian origin but not specifically identifiable. Found as weathered-out fragments near base of formation, between 10 and 30 meters above road along north side of Thomas Fork Creek in Unit 5 of type section in center of N-1/2, Sec. 26, T28N-R119W, Lincoln County, Wyoming (for location see Rubey, 1973, p. 14 and Figure 4).

*Dinosaur eggshell fragments, abundant, ubiquitous, resembling those described below from the Wayan Formation, probably ornithischian and possibly ornithopodan dinosaur (iguanodontid or hadrosaurid). *Also occur* in upper 49 meters (160 feet) of the same formation along Smiths Fork River east of Cokeville.

Cokeville Formation

Porcelanites within the Cokeville Formation suggest a temporal correlation principally with the Aspen Formation to the east, although a single, thin porcelanite bed occurs in a limited area in the uppermost part of the Bear River Formation below. The type locality of the Cokeville Formation is along the north side of the Smiths Fork River, 2 miles (3.2 Km) northeast of Cokeville, Wyoming, in the SW 1/2 of Sec. 36, T25N-R119W, Lincoln County, Wyoming (Figure 1 and Rubey, 1973). No fossil vertebrates have been found in the formation, although gastroliths (possibly of reptilian origin) are abundant at many levels. Fossil invertebrates found at the type locality are:

-*Ostrea*, 1 foot thick bed of coquina, in upper third of formation. Oyster beds also occur in the coeval Aspen and upper part of the Bear River formations.

-*Pyrgulifera*, freshwater snail, near top of lower third of formation, also occurs in upper part of Bear River Formation.

-*Campeloma*, freshwater snail, occurs just below *Pyrgulifera*. Also occurs in Smiths Formation.

FIG. 4— Some fossil vertebrate specimens, mentioned in text, from the Early Cretaceous Wayan Formation. All specimens collectively numbered UM78899 in University of Michigan Museum of Paleontology, Ann Arbor, Michigan.

A, B, and C. Caudal vertebra of ornithopodan ornithischian dinosaur, right and left lateral and articular views, approximately 1/3 natural size (see cm scale), from Site *I*.

D, E, and F. Tooth of ankylosaurian dinosaur, right and left lateral and occlusal views, approximately 10 times natural size, from Site *A*.

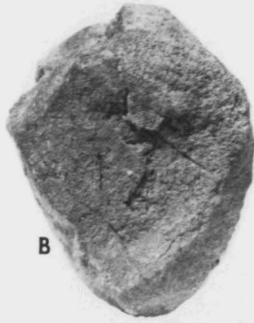
G and H. Tooth of the iguanodontid dinosaur, *Tenontosaurus*, right and left lateral views, approximately 2.5 times natural size, from Site *C*.

I and J. Crocodilian crushing tooth, lateral and crown views, approximately 2.27 times natural size, from Site *B*.

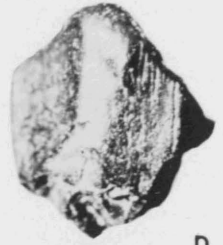
K, L, and M. Two typical examples of dinosaur eggshell fragments from the Wayan Formation. K, cross-sections; L, convex exteriors with ornamentation; M, concave interiors, minutely pebbled. All approximately 2.5 times natural size (see cm scale).



A



B



D

0 5 10 CM



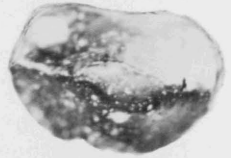
C



G



H



E



F



K



I

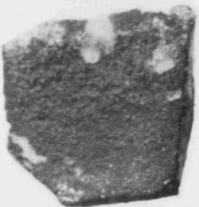


L

METRIC cm 1



J



M



Quealy Formation

I found no fossils in this redbed-rich, color-variegated deposit in which calcareous soil nodules and paleosols are common. However, Rubey (1973) reported the presence of fossil "false trunks" of the Early Cretaceous fern, *Tempskya*, which also occurs in the Sage Junction Formation above, as well as in the Wayan and Aspen formations.

Wayan Formation

The Wayan Formation occurs in the Caribou Range and along the western flank of that range in southeastern Idaho. The type locality is along upper Tincup Creek, about 5 miles (8 Km) east of the town of Wayan, Idaho (Figures 1 and 3). Most of the strata that yielded the fossils listed below lie west of the structurally complex Caribou Range, although one locality (Site K, Figure 3c) is in the Caribou Basin within that range. The Wayan Formation is fluvial in origin. Fossil-producing strata are conspicuously color-variegated, including bright red siltstones and claystones which dominate the sequence, alternating with relatively thinner sandstones and conglomeratic sandstones ranging in color from medium brown to reddish-brown. Calcareous soil nodules abound in both red and gray, fine-grained, clastic units throughout the formation. Nodules are more rare in the sandstones, but do occur as basal channel lag deposits, reworked from soils of upstream or adjacent levee and overbank deposits.

The late Early Cretaceous (Albian) age assigned to the Wayan Formation (Figure 2) is based partly on its stratigraphic position above the Gannett Group and below the Sage Junction Formation, and its inferred intergrading relationship with the well-dated upper Bear River and Aspen formations. In addition, a nonmarine black shale within the Wayan Formation, about 440 meters above the base along McCoy Creek in the Caribou Basin, has been dated as Middle Albian (upper Bear River-lower Aspen) on the basis of the palynomorphs *Taurocusporites spackmani* and cf. *Verricosisporites obscurilaesuratus* (Schmitt and Moran, 1982). Also, the fossil fern, *Tempskya minor*, occurs in both the Wayan and Aspen formations. Although the newfound fossil vertebrates from the formation appear to have their closest affinities with those from the Cloverly Formation of Aptian age, this does not necessitate age equivalence because the fossils are too fragmentary for specific identification and terrestrial vertebrates are unknown from the succeeding Bear River and Aspen formations.

The fragmentary fossils from the Wayan Formation are from 11 sites (Figure 3a,b,c). Ten sites (A-J) occur close together in roadcuts and meander scars along upper Tincup Creek for about 2.5 miles (4 Km) from Idaho Road 34 northwestward along the gravel side road to Gray to the first bridge crossing Tincup Creek. The 11th site (K) is about 12 miles (19 Km) due north from there, along Miners Delight Creek within the Caribou Basin (Figure 3c). Fossils were first found at Site A by surface prospecting and subsequently by washing 50 burlap sacks of matrix through flyscreen, then sorting the concentrate under a binocular microscope. Fossils from all other sites were found by surface prospecting alone. Fossils, in the following categories, occur at one or more of the lettered sites as indicated. All are new reports for the Wayan Formation.

-Snail operculae, calcareous, 5mm maximum diameter, numerous in screenwashed concentrate, indicate perennially available surface water at least at some places on the Wayan alluvial fans. Site A.

-Turtle, carapace fragments, unpatterned type, average 5.5 mm. thick, probably aquatic. Sites A and K.

-Reptilian limb bone fragments, large, probably dinosaur or large crocodylian, otherwise unidentifiable, Sites D, E, F, H, K.

-Crocodilian teeth of two types, (a) small, conical, resembling the "*Goniopholis*" type from Morrison and Cloverly formations (Ostrom, 1970), Sites *A* and *G*; (b) large, blunt, low-crowned, similar to type from Cloverly Formation (Ostrom, 1970), Site *B*.

-*Tenontosaurus*, sp. indet., an iguanodontid dinosaur, single tooth, genus also occurs in Cloverly Formation (Ostrom, 1970), Site *C*.

-Ankylosaurian dinosaur, single, small tooth, possibly juvenile but worn, genus and species indeterminate. Ankylosaurs also occur in the Cloverly Formation (Ostrom, 1970), Site *A*.

-Ornithopod, ornithischian dinosaur, caudal vertebra, very large, weather-checked and abraded prior to burial, hence transported downstream from higher on alluvial fan upland. Site *I*.

-Reptilian caudal vertebrae, identity indeterminate, 2 specimens (left *in situ*). Site *K* on Miners Delight Creek.

-Miscellaneous, indeterminate, medium-sized bone fragments, probably dinosaurian or crocodilian. Sites *G*, *H*, *J*.

-Very small, hollow, thin-walled vertebrate limb bone fragments found only in screen-washed concentrate from Site *A*. Possibly frog bones.

-Gastroliths?, possibly reptilian, pinhead sized to about 2 cm. in maximum diameter. Site *A*.

-Dinosaur eggshell fragments. (Note that these also occur in the Thomas Fork Formation, see earlier in this paper.)

(a) Sites *A*, *G*, and *H*. Very abundant; ranging in thickness from 0.2 to 2.0 mm.; curvatures suggesting whole egg minimum diameters ranging from robin egg size up to 7.7 cm. (3 inches); including at least six varieties of exterior surface textures ranging from pebbled to ridged. Large types probably from iguanodontid eggs.

(b) Sites *I*, *J*, and *K* (Miners Delight Creek), occasional fragments.

The aquatic snails, turtles and crocodilians suggest that surface water was perennially available at least locally on the alluvial fans. A variety of small to large dinosaurs also lived there. The eggshell fragments indicate that dinosaurs of several sizes and types nested there, probably on the relatively dry, better-drained interfluvies adjacent to more heavily vegetated stream banks, oxbow lakes and sloughs. Such physical conditions and features exist in close proximity to one another and support ecologically similar biotas on the wet alluvial megafans of the modern Indogangetic Plain (Dorr, 1983).

SAGE JUNCTION FORMATION

The type locality of the Sage Junction Formation is 1.5 miles (2.4 Km) west of Sage, Wyoming (Rubey, 1973) where the formation now is only poorly exposed. Numerous thin porcelanite beds occur throughout the formation there and a few beds of coal are present in the lower part. Porcelanites also occur in the formation east of Wayan, Idaho, 85 miles (137 Km) to the north. There it is described by Oriel and Platt (1980, Preston Quadrangle) as "gray and tan siltstone and sandstone, minor quartzite, porcelanite, limestone, conglomerate and coal." In contrast with the underlying Wayan Formation, it lacks the variegated bright red, pink and brown hues typical of the former, and calcareous soil nodules occur only as basal channel lag deposits. No eggshells were found in the Sage Junction Formation despite intensive search. My interpretation is that by Sage Junction time the alluvial fan environment had contracted well to the west, closer to the by then erosionally much reduced highlands of the Paris Thrust, hence the environment of deposition of the Sage Junction Formation was relatively distal on the fans or perhaps even had become an alluvial plain of much lower elevation and gradient.

The following fossils occur in the formation, those with asterisks being new reports, the others previously reported by Rubey (1973):

-Nonmarine mollusks, unidentified.

-“False trunks” of the Cretaceous fern, *Tempskya*, which also occurs in the Aspen Formation to the east.

-Leaves of *Nilssonia*, *Platanus*, *Artocarpus* and *Liriodendron*, and fragments of stems and roots.

*Unionid clams

*Bone fragments, rare, unidentifiable.

*Crayfish burrows, probably excavated in stream channel banks or levees.

The porcelanites and *Tempskya* suggest an age correlation with the Aspen Formation. According to Rubey, the leaves in the upper part of the formation could be young enough to make the uppermost part of the formation early Late Cretaceous, but the temporal ranges of the taxa extend back into the late Early Cretaceous. The clams and crayfish burrows indicate the presence of perennial bodies of freshwater at the surface, at least locally.

SUMMARY AND CONCLUSIONS

The Early Cretaceous Gannett Group and the Wayan-Sage Junction couplet with its related tongues are two successive, complex, synorogenic clastic wedges comprised of sediment that was derived from highlands produced by uplift of the Paris Thrust plate. Deformation occurred during an early phase of the Sevier Orogeny. Deposition took place in a foredeep created by crustal loading by that overthrust plate. The eastwardly prograding, wet alluvial fans in that tectonic setting encompassed both relatively dry interfluves and adjacent, perennial surface freshwater environments at least locally.

The fossil record now available indicates that those physical conditions favored a rich and diverse biota. The Gannett record is sparse, but indicates the presence of charaphytes, mollusks, ostracods and large reptiles including turtles and probably also dinosaurs. The Wayan-Sage Junction biota included ferns, various dicotyledonous plants, freshwater clams and perennially aquatic snails, crayfishes, aquatic turtles, two types of crocodylians, and a variety of other small to large reptiles such as iguanodontid and ankylosaurian dinosaurs. Dinosaur eggshell fragments, ranging from small to large and of a variety of surface ornamentation types are abundant and ubiquitous in both the Wayan Formation and in its lower tongue, the Thomas Fork Formation. Those formations characteristically are reddened, color-variegated, and contain abundant and widespread calcareous soil nodules at many levels indicating the presence of paleosols formed under conditions of low soil moisture, relatively low watertable and oxidizing environment. Numerous dinosaurs of various types and sizes favored these conditions for reproductive purposes, nesting on the interfluves of the alluvial fan uplands adjacent to the Paris Thrust.

The inferred sedimentologic and biologic features of that ancient setting are closely analogous to those on the wet alluvial megafans of the Quaternary Indogangetic Plain.

ACKNOWLEDGMENTS

I thank the following for help in identifying fragmentary fossil material: F. Fursich, University of Munich; R.M. Galton, Yale University; J.R. Horner, Montana State University-Bozeman; J.H. Hutchison, University of California-Berkeley; N. Hotton, U.S. National Museum; F.A. Jenkins, Jr., Harvard University; J.H. Ostrom, Yale University; Hans-Dieter Sues, Harvard University; H. Van der Schalie, University of Michigan. Partial support for field work came from the Turner Fund, Dept. of Geological Sciences, The University of Michigan.

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