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Storm Deposited Fish Debris in the Cretaceous Mowry Shale Near Vernal, Utah

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ABSTRACT

Isolated, lens-shaped accumulations of fish bones, scales, teeth, and coprolites in a sandy matrix occur along a few bedding planes within the Cretaceous Mowry Shale in an outcrop along Highway 191 north of Vernal, Utah. These accumulations have previously been interpreted to be large coprolites or regurgitate material, but are actually storm lag deposits in a sediment-starved basin. Accumulations (lenses) vary in size: the largest measured is 15 x 10 cm in plan view and 2 cm thick. Matrix in these lenses consist of fine-grained, well-rounded quartz grains that are absent in the surrounding shale layers. The disarticulated fossil material is the size of coarse sand, with some bone fragments and fish scales over 1 cm. The material is compacted, but poorly cemented. Jaw fragments, teeth, and vertebrae found within the lenses are mostly from teleost fish, commonly from the genus Enchodus, an alepisauroid. Teeth from Carcharias amonensis, a lamniform shark, are also present. Phosphatic pebbles (1-5 mm), which are likely teleost microcoprolites, are also found in these lenses. The lenses were deposited by bottom, winnowing storm currents and trapped in bottom scours in an area of limited coarse sediment supply on a gently sloping shelf.

INTRODUCTION

While examining the Mowry Shale outcrops along U.S. Highway 191 north of Vernal, Utah (NW¼, SE¼, section 35, figure 1) during the course of the 2002 and 2003 BYU summer field camps, we discovered anomalous concentrations of disarticulated fossil debris that appeared to be mostly fish bones, scales and teeth. Although fish scales and isolated bones occur throughout the formation, concentrated lenses are found only along a few bedding planes. These lenses resembled fecal or regurgitate material from larger marine animals, but from field examination is was not possible to exactly determine their origin. We present evidence that these accumulations are not primarily fecal or regurgitate material, but are concentrations from storm currents on a shelf that was starved of coarse sediment, with the exception of the fish and other fossil material.

PREVIOUS WORK

As the Western Interior Cretaceous Seaway began to form, it spread southward from the Artic during

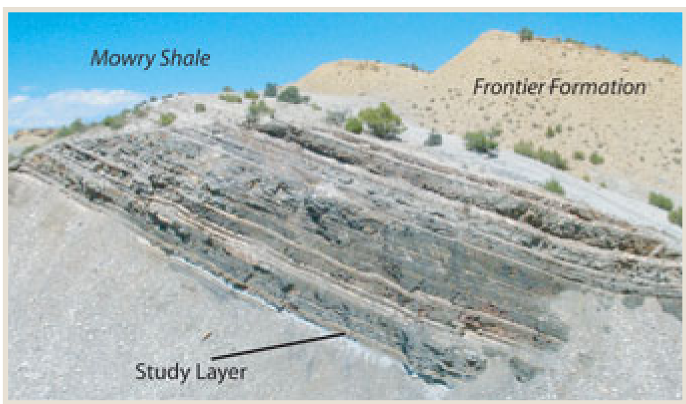

Figure 1. *Outcrops of Mowry Shale along U.S. Highway 191 north of Vernal, Utah, showing the stratigraphic position of most of the fossil accumulations in this study. The light layers in the darker gray shale are bentonite beds.*

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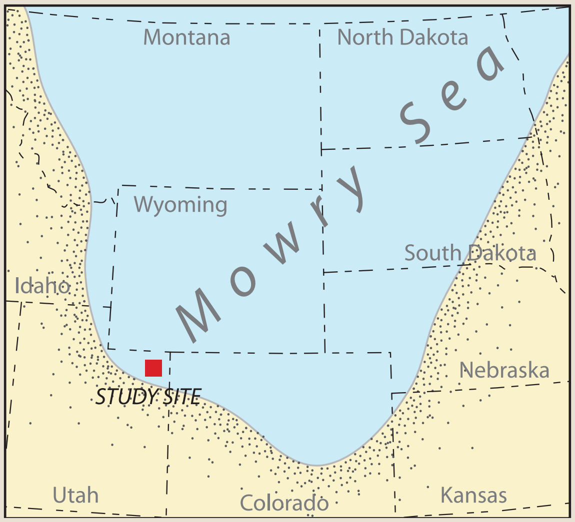

Figure 2. *Regional view of Mowry Sea and the location of the study site. Modified from Davis. (1989).*

Albian time to form the Mowry Sea (Davis and Byers, 1989; figure 2). The Mowry Shale, deposited in this seaway about 97 Ma (Obradovich, 1993), was home to marine life that is characteristic of northern cool- to mild-temperature Cretaceous biotas and brackish, oxygen-restricted water (Byers and Larson, 1979; Kauffman and Caldwell, 1993). Fish scales and bones have been known as a characteristic of the Mowry Shale for many years (Reeside and Cobban, 1960). Reeside and Cobban (1960) reported that in Wyoming and Montana calcareous concretions occur in the formation that range from 8 cm to 2 m in diameter and contain abundant disarticulated fish remains, which must have once been "a sludge of scales and bones." They also reported that fossils other than the disarticulated fish remains are normally rare, and speculate that the calcareous concretions are accumulations of "fecal matter of some large carnivore—reptile, fish, or cephalopod." The accumulations of fish debris that we found near Vernal, Utah appear to be similar to the material examined by Reeside and Cobban (1960), with the exception that our accumulations are not part of concretionary masses, and they are generally smaller than their described concretions. In addition, their concretions contained, in places, abundant ammonite remains, while we have found only a few ammonites at our locality. The lenses also resemble masses that Davis (1963) called coprolites in the Mowry Shale. Davis (1963) states that, "coprolites are present on many bedding plane surfaces in the Mowry Shale." He continues, "They are in the form of slightly raised oval patches…usually they are lighter in color than the surrounding shale and contain a greater proportion of silt-sized material. They are extremely rich in organic matter, mostly indigestible substances such as scales and bones." Both marine and non-marine coprolites have also been found in other Cretaceous formations in the western interior (Texas, Kansas, and South Dakota) (Martin, 1982; Feldman and others, 1985; Freidman, 2002).

SAMPLE COLLECTION AND PREPARATION

After the initial discovery of the fossil accumulations, the authors spent one additional day at the site collecting material. The sizes of the fossiliferous masses varies, but they are usually lens-shaped (thicker in the middle and tapering to thin edges). The smallest lenses are < 1 cm across and about 1 mm thick, while the largest lens was 15 x 10 cm

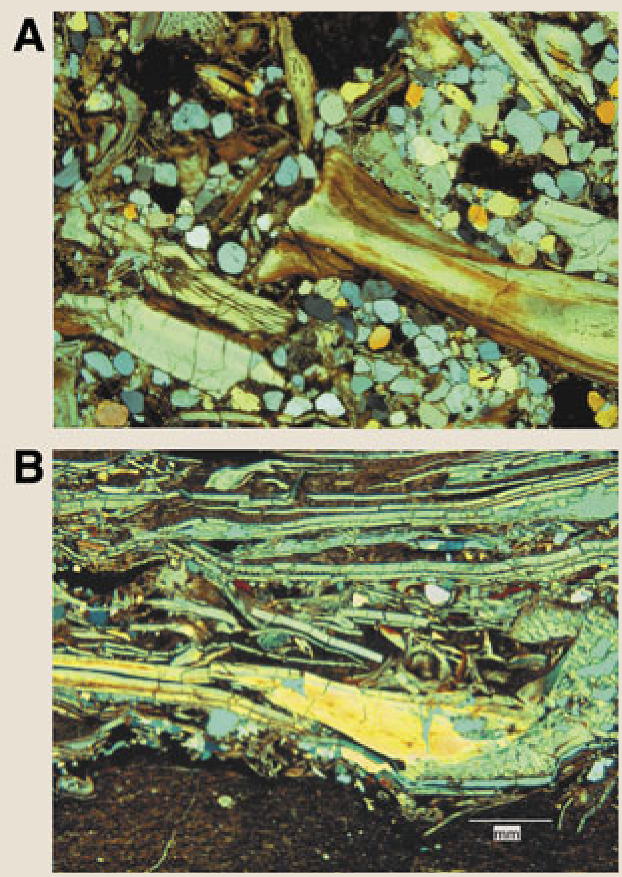

Figure 3. *Thin sections in crossed polarized light cut (a) parallel and (b) perpendicular to bedding through fossil accumulations. The top photo shows some of the larger fish bones and rounded quartz grains, while the bottom photo shows many thin fish scales, some bones, and the contact with the underlying, fine-grained shale. Scale bar shown in B is the same in both photos.*

(plan view) and 2 cm thick. The lenses are friable and so had to be carefully handled and transported in order to preserve them. In the laboratory, the samples were examined carefully under a binocular microscope. This allowed the identification of the best preserved material and the discovery of several fish jaws, vertebrae, and shark teeth that were not observed in the field. Samples were photographed and the smaller ones prepared and examined with the scanning electron microscope.

DESCRIPTION OF FOSSIL-RICH LENSES

Thin sections of the fossil lenses reveal that they contain a high concentration of fish bones, teeth, and scales (figure 3). The matrix of the lenses consists of fine-grained, rounded to subrounded, well-sorted quartz grains. Bones within these lenses are not etched, a common characteristic of bones within coprolites, and may sometimes be abraded. The lenses show no obvious grading or fining upward, either in the field or in thin section. The lenses do have fairly distinct margins (figure 3b), but with occasional coarser quartz grains and bone fragments in the surrounding shale. In cross section, the lenses appear to occupy very low amplitude depressions in the shale.

Several lenses contain teeth and partial jaws (figure 4) from alepisauroid teleost (*Enchodus* sp.), sometimes called the “saber-toothed” fish of the Cretaceous (Green, 1913; Goody, 1976; Shimada and Everhart, 2003; Everhart and others, 2003). Teeth from *Carcharias amonensis* a shark common in the Mowry Sea (Welton and Farish, 1993; Cicimurri, 2000; Everhart and others, 2004) are also present (figure 5).

Small pellets within the lenses have the appearance and characteristics of coprolites (Martin, 1982; Shimada, 1997), but on a microscopic scale (Lamboy and others, 1994; figure 6). The pellets are 5 mm or less in largest dimension, have a cohesive phosphatic groundmass, and contain occasional larger fragments of what is probably bone or teeth. They also have distinctive surface morphologies similar to macrocoprolites (figure 7).

Figure 4. *Fish teeth mostly probably from Enchodus and jaw fragments. The jaw fragment on the top left is not from within one of the main fossil lenses, but from within the shale layers nearby. The jaw fragment on the upper right is from one of the fossil-rich lenses.*

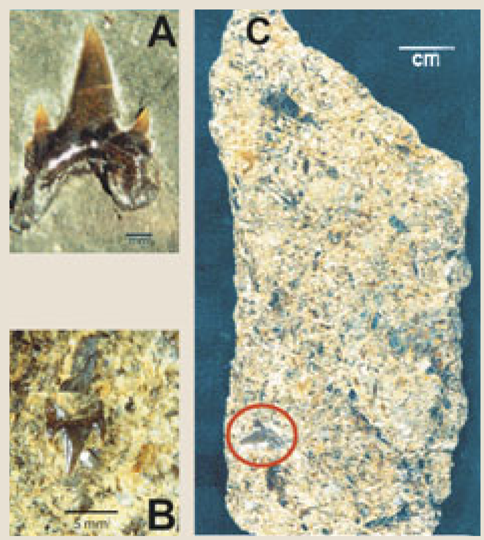

Figure 5. *Shark teeth (Carcharias amonensis). The teeth in B and C are embedded within two of the fossil-rich lenses surrounded by other bone, scale, and tooth fragments. The tooth in A is not from one of the lenses, but is an isolated tooth found in the shale.*

DISCUSSION

We began this study with the idea that the lens-shaped accumulations of fossil debris in the Mowry Shale are fossilized fecal or regurgitate material. Coprolites nearly always have a very fine-grained, cohesive, phosphatic matrix (Voelcker, 1860;

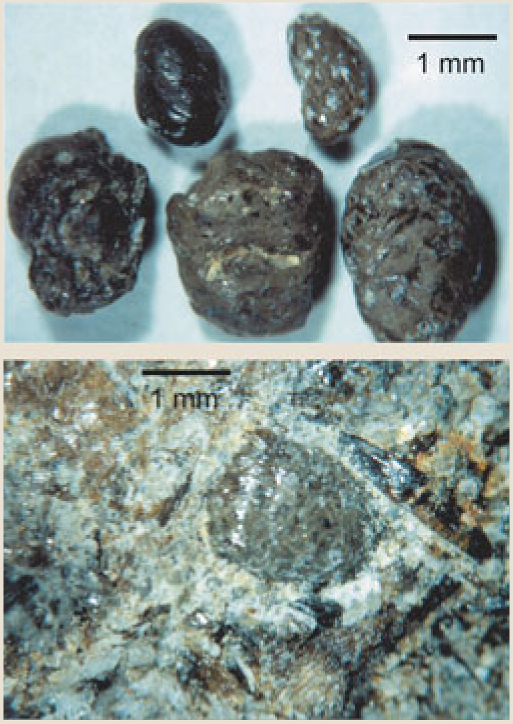

Figure 6. *Microcoprolites (top) found within fossil lenses have been cleaned of matrix to show their distinct morphologies. Bottom photo shows a microcoprolite embedded within a fossil lens.*

Bradley, 1946; Feldman and others, 1985; Lamboy and others, 1994). Bones and teeth within the matrix are often etched and usually occur in low concentrations. In addition, coprolites usually have distinct surface morphologies (McAllister, 1985; Shimada, 1997). None of these characteristics are evident from the material collected from the lenses of Mowry Shale. On the contrary, they do not have distinct surface morphologies, they are composed of coarse fossil debris and fine-grained quartz, and they do not have a fine-grained, cohesive phosphatic matrix; therefore, we do not believe that they are coprolites.

A second hypothesis was that these are regurgitates. Regurgitates generally have a higher bone/matrix ratio (Hattin, 1996), but it is unlikely that they would have a fine-grained quartz matrix and contain microcoprolites.

An alternative idea is that these accumulations could be storm deposits. Davis and others (1989) discuss the evidence for bottom storm currents in the Mowry Shale. They separated the storm deposits into distal, intermediate, and proximal types. The distal facies is characterized by "pelagic sedimentation that is infrequently interrupted by dilute remnants of far reaching bottom flows that deposited thin silt layers." The silt is composed of quartz and phosphatic fish debris and often preserved in discontinuous layers. This sounds similar to our accumulations, except that the grain size in our accumulations is not silt sized, but fine sand and coarser fossil debris. Davis and others (1989) also describe an intermediate facies that is characterized by interlaminated silt-lean mudstone fining upward into mudstone, but with occasional coarser, graded sequences with a scoured base. They show that the deeper scours are commonly overlain by coarse fish debris. These deeper scours are still only centimeter scale features, but they contain pods or lenses of coarse fish debris

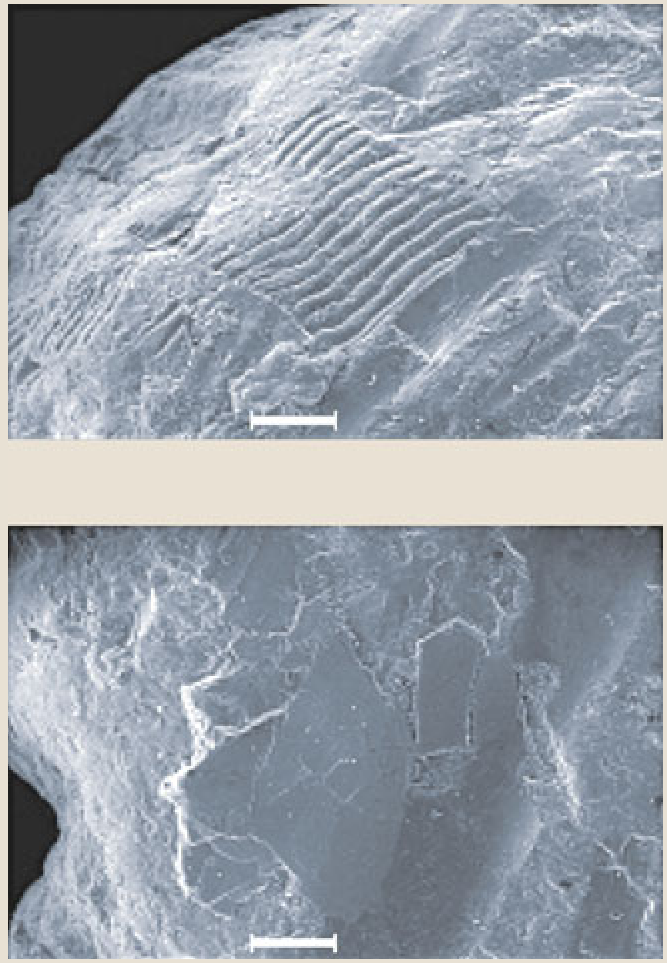

Figure 7. *Scanning electron microscope images of microcoprolites found within the Mowry Shale fossil-rich lenses. The photos show the fine-grained, cohesive phosphatic matrix. Scale bars are 0.2 mm. Top photo shows a fish scale impression, while the bottom photo has an indentation probably produced by a fish bone.*

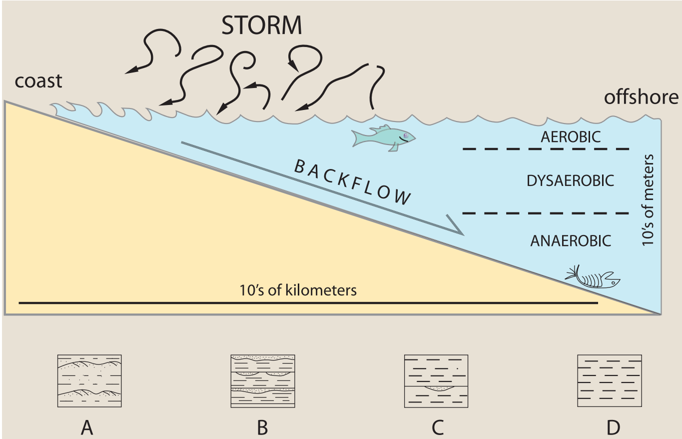

Figure 8. *Storm current model for formation of lens shaped accumulations of fossil fish debris. The storm surge onto the coast stirs up the bottom and picks up quartz sand from the shore. The backflow current carries this debris and picks up bones and teeth carrying them out into the zone of normal pelagic sedimentation. The farther from the coast, the less common and more discontinuous the storm layers become. Our accumulations near Vernal, Utah are probably from the B or perhaps C zones shown in the figure. Modified from Davis and others (1989).*

and quartz silt that match our accumulations in composition and morphology.

CONCLUSIONS

The lenses of sandy disarticulated fossil fish material found in the Mowry Shale near Vernal, Utah were deposited by bottom, winnowing storm currents (figure 8). The coarse material was probably trapped in bottom scours in a region of limited coarse sediment supply. The lenses include fish bones, teeth, and scales, shark teeth, microcoprolites, and fine-grained, well-rounded quartz. This part of the Mowry Sea was probably a gently sloping shelf, starved of coarse sediment, but provided with a limited amount of coarse organic detritus to form the lenses.

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REFERENCES

Bradley, W. H., 1946, Coprolites from the Bridger Formation of Wyoming–their composition and microorganisms: American Journal of Science, v. 244, p. 215-239.

Byers, C.W., and Larson, D.W., 1979, Paleoenvironments of Mowry Shale (Lower Cretaceous), western and central Wyoming: American Association of Petroleum Geologists Bulletin, v. 63, p. 354-361.

Cicimurri, D., 2000, Early Cretaceous Elasmobranchs from the Newcastle Sandstone of Crook County, Wyoming–the Mountain Geologist, v. 37, p. 101-107.

Davis, H.R., and Byers, C.W., 1989, Depositional mechanisms and organic matter in the Mowry Shale (Cretaceous), Wyoming: American Association of Petroleum Geologists Bulletin, v. 73, p. 1103-1116.

Davis, J.C., 1963, Origin of the Mowry Shale: Contributions to Geology, v. 2, p. 135-146.

Everhart, M.J., Everhart, P., Manning, E.M., and Hattin, D.E., 2003, A Middle Turonian marine fish fauna from the Upper Blue Hill Shale Member, Carlile Shale, of north central Kansas: Journal of Vertebrate Paleontology, v. 23 supplement, p. 49A.

Everhart, M.J., Everhart, P.A., and Ewell, K., 2004, A marine ichthyofauna from the Upper Dakota Sandstone (Late Cretaceous) [abs.]: Abstracts of oral presentations and posters, Joint Annual Meeting of the Kansas and Missouri Academies of Science, p. 48.

Feldman, H.R., Maliva, R.G., and Hattin, D.E., 1985, Classification, skeletal content, petrology, and mineralogy of phosphatic coprolites from the Smoky Hill Member, Niobrara Chalk (Upper Cretaceous) of western Kansas [abs.]: Geological Society of America Abstracts with Programs, v. 17, no. 5, p. 287.

Friedman, V., 2002, The coprolites of the lower Eagle Ford Group in north central Texas [abs.]: Geological Society of America Abstracts with Programs, v. 34, no. 3, p. 5.

Goody, P. C., 1976, Enchodus (Teleostei: Enchodontidae) from the Upper Cretaceous Pierre Shale of Wyoming and South Dakota with an evaluation of the North American Enchodontid species: Palaeontographica Abt. A., v. 152, p. 91-112.

Green, W. R., 1913, A description of the specimens of the teleostean genus Enchodus in the University of Kansas museum: Kansas University Science Bulletin v. 7, no. 2, p. 71-107.

Hattin, D. E., 1996, Fossilized regurgitate from Smoky Hill Chalk Member of Niobrara Chalk (Upper Cretaceous) of Kansas, USA: Cretaceous Research, v. 17, p. 443-450.

Kauffman, E. G., and Caldwell, W. G. E., 1993, The Western Interior basin in space and time, ***in*** Caldwell, W. G. E., and Kauffman, E. G., editors, Evolution of the Western Interior Basin: Geological Association of Canada Special Paper 39, p. 1-30.

Lamboy, M., Purnachandra Rao, V., Ahmed, E., and Azzouzi, 1994, Nannostructure and significance of fish coprolites in phosphorites: Marine Geology, v. 120, p. 373-383.

Martin, J. E., 1982, Coprolites from the Pierre Shale in South Dakota: Proceedings of the South Dakota Academy of Science, v. 61, p.171.

McAllister, J. A., 1985, Reevaluation of the formation of spiral coprolites: University of Kansas Paleontology Contributions Paper 114, 12 p.

Obradovich, J. D., 1993, A Cretaceous time scale, ***in*** Caldwell, W. G. E. and Kauffman, E. G., editors, Evolution of the Western Interior Basin: Geological Association of Canada Special Paper 39, p. 379-396.

Reeside, J. B., Jr., and Cobban, W. B., 1960, Studies of the Mowry Shale (Cretaceous) and contemporary formations in the United States and Canada: U. S. Geological Survey Professional Paper 355, 126 p.

Shimada, K., 1997, Shark-tooth-bearing coprolite from the Carlile Shale (upper Cretaceous), Ellis County, Kansas: Kansas Academy of Science Transactions, v. 100, p.133-138.

Shimada, K., and Everhart, M. J., 2003, Ptychodus mammillaris (Elasmobranchii) and Enchodus cf. E. schumardi (Teleostei) from the Fort Hays Limestone Member of the Niobrara Chalk (Upper Cretaceous) in Ellis County, Kansas: Kansas Academy of Science Transactions, v. 106, p.171-176.

Voelcker, A., 1860, On the chemical composition and commercial value of Norwegian apatite, Spanish phosphorite, coprolites and other phosphatic materials used in England for agricultural purposes: Journal of the Royal Agricultural Society, ser. 1, v. 21, p.350-81.

Welton, B. J., and Farish, R. F., 1993, The collectors guide to fossil sharks and rays from the Cretaceous of Texas: Dallas, Horton Printing Company, 204 p.