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New Mexico Geology, v. 5, n. 3 pp. 52-55, Print ISSN: 0196-948X, Online ISSN: 2837-6420.
https://doi.org/10.58799/NMG-v5n3.52

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Bryozoan and crustacean from Fruitland Formation (Upper Cretaceous) of New Mexico

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Introduction

The Fruitland Formation of northwest New Mexico is a widely exposed coal-bearing sequence of predominantly nonmarine deltaic facies, deposited along the western shoreline of the Midcontinent epeiric sea as it regressed northeastward out of New Mexico near the end of Late Cretaceous time (Fassett and Hinds, 1971; Hutchinson, 1981). The biota of the Fruitland is extremely diverse. It includes 24 species of nonmarine mollusks (Stanton, 1916), 65 species of vertebrates (sharks, rays, bony fish, amphibians, turtles, lizards, snakes, crocodilians, dinosaurs, and mammals; see list in Lucas, 1981), and more than 80 species of plants (combined total for Fruitland and lower part of Kirtland Shale; Tidwell and others, 1981; Robison and others, 1982). Although earlier work on the Fruitland biota proceeded sporadically, paleontological investigations have intensified in the past six years. Recent collecting efforts have been primarily devoted to the area between Hunter and De-Na-Zin washes ("Bisti Badlands" area) and south of Split Lip Flats ("Fossil Forest" area) as a result of attempts to survey and study exposures that may be affected by coal strip mining in the near future. The purpose of this paper is to record the first occurrence of Bryozoa and second occurrence of Crustacea in the Fruitland and to discuss their paleoenvironmental implications.

In this paper, UNM refers to the University of New Mexico paleontology collections and USNM to the U.S. National Museum paleontology collections.

Location and stratigraphic setting

The fossils described herein were collected from the north side of a low ridge of Fruitland badlands in the NE 1/4 NE1/4 SE1/4 sec. 31, T. 24 N., R. 13 W. (University of New Mexico locality BUNM 77–25), 0.8 km (0.5 mi) south of the Bisti Trading Post site (now abandoned) and about 40 m (132 ft) east of NM–371, San Juan County (Fig. 1). At this locality a thin but persistent coal bed (Coal D of Hutchinson, 1981) is exposed low on the ridge. This coal is overlain by a dark-gray, organic-rich shale that because of decrease in organic content becomes lighter in color upsection. This shale, in turn, is overlain by an extensive channel sand deposit consisting of white, moderately well indurated quartzose sandstone with lenses of gray-brown, highly indurated, concretionary sandstone locally containing low-angle crossbeds (Figs. 2, 3). At the base of the channel sandstone is a transition zone consisting of thin, horizontally bedded white sandstone layers that are interbedded with carbonaceous laminae and blocky to pebbly greenish-gray claystones. This transition zone yielded a rich collection of vertebrate bone fragments, scales, and teeth, in addition to *Teredina* (Bivalvia) shell fragments and the crab claw described below. Examination of surface-collected and screened vertebrate specimens revealed hadrosaur teeth, turtle shell fragments, crocodilian scutes and teeth, gar scales, amiid (bowfin) teeth, small, rounded teeth tentatively referred to the pycnodont holostean fish *Anomaeodus*, and ray teeth (*Myledaphus* sp.).

The bryozoan specimen described below was collected from this locality during a brief paleontological survey (Froehlich and Kues, 1977), and exact stratigraphic information is not available. It came from a gray shale containing complete in situ *Teredina* shells and carbonized plant matter, probably a few meters below the coal bed.

Hutchinson (1981) measured a stratigraphic section a short distance south of this locality and placed the coal bed about 30 m (99 ft) above the base of the Fruitland and 50 m (165 ft) below the Fruitland–Kirtland contact. Deposition of the Fruitland occurred above and lateral to the shoreline sandstones of the Pictured Cliffs Sandstone as the "Pictured Cliffs Sea" retreated to the northeast (Fassett and Hinds, 1971; Flores and Erpenbeck, 1981). The lower part of the Fruitland has been recognized as consisting of coastal swamp, estuarine, and delta plain deposits (Fassett and Hinds, 1971; Hutchinson, 1981). Hutchinson (1981) assigned the lower 20 m (66 ft) of the Fruitland to an estuarine facies, and Hartman (1981) noted that brackish environments extend as much as 36 m (119 ft) above the base of the Fruitland, with a significant increase in diversity of freshwater mollusks above this level.

Bryozoa

The bryozoan colony (Figs. 4, 5) was found attached to a fragment of the posterior area of a ceratopsian skull. The colony is a thin

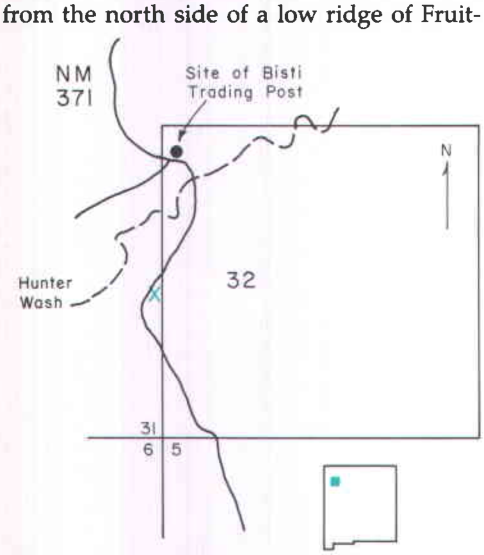


FIGURE 1—Location of bryozoan-crustacean locality (X) IN SEC 31, T. 24 N., R. 13 W., San Juan County, New Mexico. Each side of sec. 32 equals 1.6 km (1 mi).

FIGURE 2—View of Fruitland exposures in area of bryozoan-crustacean locality, looking west. Vehicle is parked along NM–371. X marks level of "Coal D."

encrustation approximately 75 cm^2 in area on the ledge below the occipital condyle, extends over the broken edge of the ledge, and covers several cracks in the bone. Growth of the zoarium thus occurred after fragmentation of the skull and after transport of the fragments. The bryozoan specimen was submitted to Dr. Alan Cheetham, Smithsonian Institution, who identified it as *Conopeum*? sp., a membraniporoid anascan cheilostome. Cheetham noted (written communication, 1981) that zooecial morphology is well preserved and includes distinct gymnocysts, crenulate cryptocysts, and small bases of distal spines. These features and the size of the zooecia (approximately 0.55 mm long) are comparable to living species of *Conopeum*. Precise identification of these simple membraniporids, however, depends on details of early colony development, especially zones of astogenetic change. These features are not present on the Fruitland specimen, which consists mainly of late multilamellar growth. The skull fragment with attached bryozoan has been donated to the Smithsonian Institution and bears the catalogue number USNM 297021.

Although most modern cheilostome bryozoans live in water of normal marine salinity, some genera are typically found in brackish water. The Recent species *Conopeum seurati* lives in environments less saline than 20‰ and can tolerate salinities as low as 1‰ (Ryland, 1970, p. 71). The presence of *Conopeum*? sp. in a certainly nonmarine facies of the Fruitland strongly suggests that Cretaceous representatives of the genus could also tolerate conditions of low salinity. According to Cheetham (written communication, 1981), *Conopeum* is fast growing and conceivably could have produced the colony encrusting the ceratopsian skull fragment during a single season. If the tolerances of the Fruitland bryozoan approached that of a modern *Conopeum* species, the Fruitland specimen could have settled and grown in estuarine waters of only slight salinity.

To assess more precisely the position of bryozoans in the estuarine communities of the Fruitland Formation is difficult at present. This is the first report of their presence in the Fruitland, and bryozoans are unknown in the marine sediments of the Pictured Cliffs Sandstone. Specimens of membraniporoid and pyripoid bryozoans have been observed attached to inoceramid and ammonoid shells in the offshore marine deposits of the Lewis Shale in the eastern San Juan Basin (W. A. Cobban, personal communication, 1983). Two explanations of the bryozoan's presence in the Fruitland are possible, and additional specimens from the Fruitland and equivalent marine units will be needed to determine which is probably the correct one. As the Lewis Shale was deposited in part contemporaneously with the Fruitland, the Fruitland bryozoan may have been a transitory inhabitant of a low-salinity Fruitland estuary, but derived originally from a population existing in the offshore marine environment many kilometers to the northeast. Alternatively, the bryozoan might have been a permanent inhabitant of brackish waters during Fruitland deposition. Possibly, because most studies of Fruitland paleontology have concentrated on the vertebrates, bryozoans have not been observed or identified as such by vertebrate paleontologists. Though bryozoans are certainly not common in the Fruitland, additional specimens will probably be found in the brackish-water facies of the formation as study of Fruitland faunas proceeds. ☞

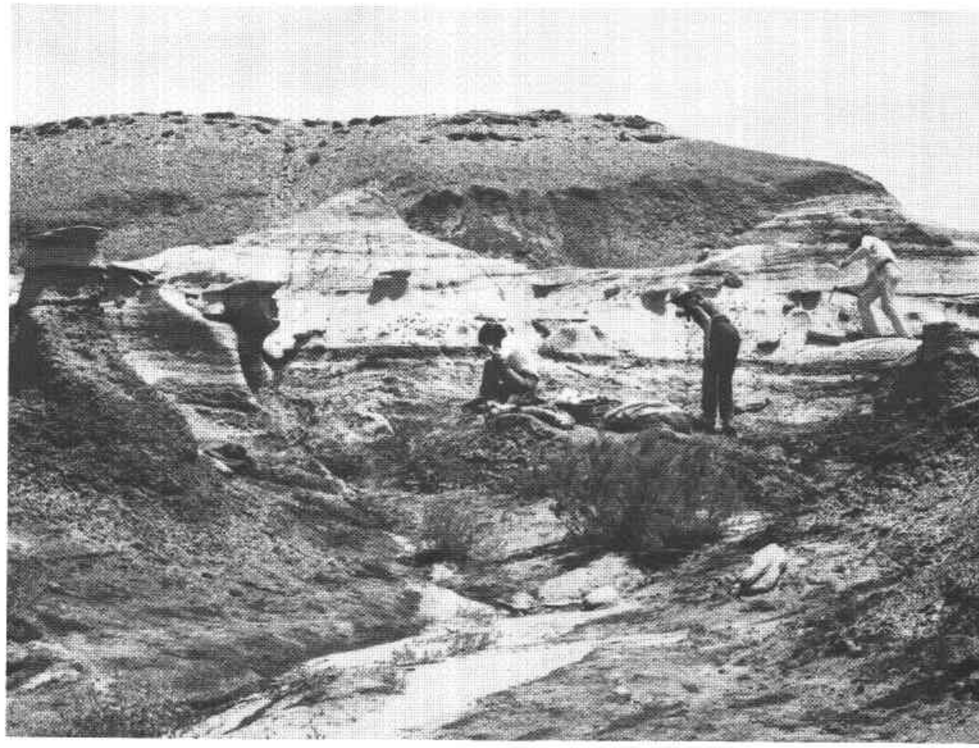
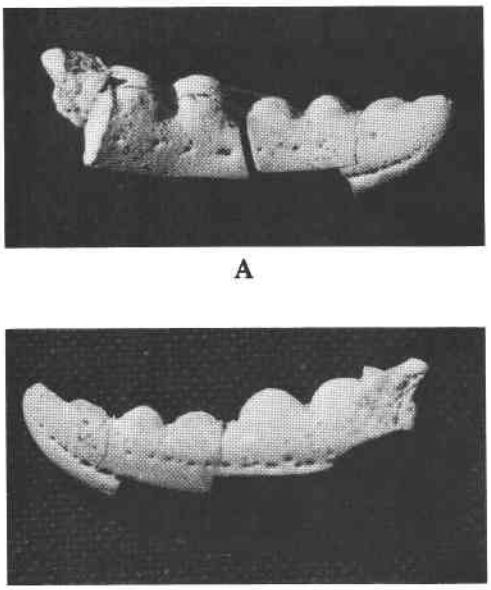


FIGURE 3—Bryozoan-crustacean locality, showing white channel sandstone eroded into small pinnacles, and underlying dark shale. Fossil-rich transition zone between sandstone and shale is at highest thin dark band, at shoulder level of figure to left.

FIGURE 4—Occipital condyle of ceratopsian dinosaur (USNM 297021). Bryozoan colony is below condyle, around ledge to left of cm scale.

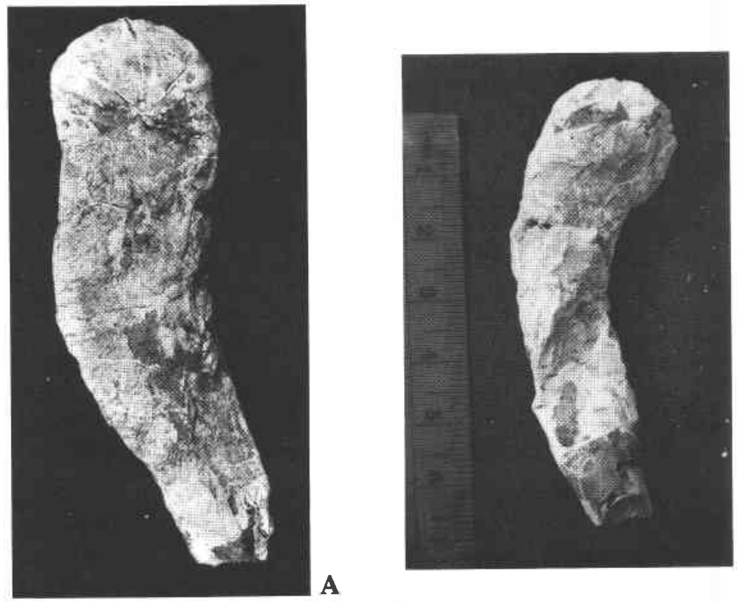
FIGURE 5—Close view of part of *Conopeum*? sp. colony, × 2.



A

B

FIGURE 6—Partial crab cheliped (UNM 6749); **A,** inner surface, × 2; **B,** outer surface, × 2.



A

B

FIGURE 7—*Teredina* sp.; **A,** UNM 6944, ventral view, showing articulated primary valves (top) and long calcareous tube that extends posteriorly from valves; **B,** UNM 6943, distorted specimen showing thickened calcitic area at posterior end of tube (bottom of specimen). Fragments of this part of tube were abundant in microvertebrate lag deposits in transition zone. Scale is same for both specimens.

Crustacea

A single partial crab claw (UNM 6749) from the basal microvertebrate-rich layer of the channel sandstone documents the occurrence of decapod crustaceans in the Fruitland Formation. The specimen (Fig. 6) is 24 mm long and appears to be part of the fixed finger of a left cheliped. It is relatively massive, gently arcuate, and includes five blunt, rounded teeth on the occlusal surface, the two back teeth being nearly twice the size of the anterior teeth. Because most Cretaceous crab taxa are distinguished by features of the carapace, and chelipeds are not known for many species, precise identification of this isolated partial cheliped must await the discovery of additional crab remains in the Fruitland. The specimen resembles the chelipeds of some xanthoid brachyurans in its general proportions and rounded teeth. It is definitely not *Callianassa*, whose presence in the shoreline marine deposits of the Pictured Cliffs Sandstone is indicated by the occurrence of its burrows (*Ophiomorpha;* see Reeside, 1924; Kues and others, 1977; Flores and Erpenbeck, 1981). The fingers of *Callianassa* chelipeds are shorter and sharper than the Fruitland specimen and lack the prominent rounded teeth. Previously, Armstrong-Ziegler (1980, p. 30) reported unidentified crab claws from a locality northwest of Bisti, on the Navajo Reservation.

As with cheilostome bryozoans, most modern crabs live in fully marine environments, but some do prefer brackish conditions. A few modern species live in conditions of very low salinity (Pearse and Gunter, 1957), and this may have been true of the Fruitland crab as well. No crabs of this type have been reported from the Lewis Shale or Pictured Cliffs Sandstone, so, until evidence to the contrary appears, this crab is considered to be a brackish-water form. It is unlikely, in view of the unworn condition of the cheliped, that the specimen came from a crab that lived and died along the Pictured Cliffs shoreline and was subsequently transported several kilometers inland to its final site of deposition. The only other crab known by body fossils from the Upper Cretaceous of New Mexico is a marine genus *Necrocarcinus* from the Mancos Shale (Kues, 1980).

Discussion

The horizon that yielded the bryozoan and crab fossils described here is approximately 30 m (99 ft) above the base of the Fruitland, near the middle of the formation in the Bisti area. The presence of these invertebrates, which could probably live successfully in low-salinity environments but almost certainly not in fresh water, provides additional evidence indicating a slight marine influence in the Fruitland distributary and associated delta-plain environments. Brackish-water habitats thus extended many kilometers inland from the Fruitland–Pictured Cliffs shoreline and persisted through at least the first half of Fruitland deposition. Documentation of bryozoan and crustacean occurrences at other localities and levels in the Fruitland may provide a reliable basis for indicating brackish environments and for distinguishing brackish from freshwater facies.

The most conspicuous invertebrate associated with both the bryozoan and the crab is *Teredina* (Figs. 7–9), an infaunal bivalve first reported in the Fruitland by Stanton (1916). *Teredina* shells have an elongate conical shape and groups of a dozen or more shells are often found in their vertically oriented life positions in the Fruitland. Complete shells are relatively common but have not previously been figured. *Teredina* apparently lived near the edges of stream channels and in muds deposited in aqueous environments on the delta plain lateral to the streams. These bivalves were able to tolerate a wide range of salinities, for they occur with numerous oysters at the base of the Fruitland where the salinity was relatively high, as well as in environments higher in the Fruitland where the salinity was very low. Detailed determination of their ecological and depositional preferences must await further study, but these large, easily identifiable invertebrates are particularly useful as indicators of sites where rare constituents of the Fruitland fauna, such as bryozoans and crustaceans, might be found. The discovery of these two invertebrate groups in the Fruitland suggests that the Fruitland biota is still incompletely known, and it is hoped that attention will be devoted in future studies to collecting and documenting these and other uncommon elements of the fauna.

The presence of Bryozoa in the Fruitland also has implications for precisely determining the age of the formation. Numerous bryozoans are known from Campanian and Maastrichtian strata in the Gulf Coast region, and many species have very short range zones (Shaw, 1967). This suggests that if bryozoan

FIGURE 8—In situ cluster of posterior ends of several *Teredina* tubes in transition zone, about natural size.

specimens identifiable to species are found in the Fruitland, they might aid in solving the long-standing problem (Russell, 1975) of the exact age of the formation.

ACKNOWLEDGMENTS—I thank Will Gavin, who found the bryozoan, and Georgianna Kues, who discovered the crab, for their careful collecting in the Fruitland. The bryozoan was discovered during a paleontological survey of the Bisti area supported by Western Coal Company (now Sunbelt Mining Company). I am grateful also to Alan Cheetham, Smithsonian Institution, for identifying the bryozoan and providing comments on the ecology of modern and ancient membraniporoid bryozoans. Spencer Lucas, University of New Mexico; William Cobban, U.S. Geological Survey; and Jiri Zidek and Donald Wolberg, New Mexico Bureau of Mines and Mineral Resources, reviewed the manuscript and offered helpful suggestions.

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(*continued on p. 68*)

Review

EARTH RESOURCES, ENERGY, AND THE ENVIRONMENT, by *Douglas G. Brookins*, C. E. Merrill Publishing Company, Columbus, Ohio, 1981 (this book can be purchased at the University Bookstore, University of New Mexico, Albuquerque, NM), $7.95

This text provides a broad yet concise description of our diminishing earth resources and considers the effect on selection of energy alternatives. *Earth resources, energy, and the environment* is not a detailed all-encompassing technical reference, but is an elementary text that will provide a scientist, student, or layman with the facts and figures necessary to evaluate energy alternatives.

Brookins, a geology professor at the University of New Mexico, draws heavily on his geochemical background and work experience in New Mexico. Almost half of the plates (pictures) are taken in New Mexico and cursory descriptions of New Mexico mineral production, the Albuquerque water system, and Grants mineral belt are included.

Earth resources, energy, and the environment is a particularly useful reference for those of us engaged in any aspect of natural resources, impacts on the environment as a result of mining or urban development, or energy development. The book is also useful to those who do not have the time to read the voluminous literature (since 1972), or to learn all the technical details for these related, yet diverse, subjects. Brookins provides enough geochemical background to enhance his discussions, yet avoids most of the political and emotional discussions on these sensitive issues.

The book is divided into eight chapters. The introductory chapter defines many of the terms used throughout, for example, possible, probable, proven reserves, MACD, and others. Chapter 2, Ores, production, and mining, contains a brief geochemical discussion on why some rocks contain ores that can be economically mined and why others do not. Short sections on open-pit and solution-pit mining also are included. The chapter on water (Water: The most valuable resource) emphasizes water as our most valuable world resource and shows the need of careful planning for effective future use. Subsections include the hydrologic cycle, water reservoirs, desalination, and uses of water in the United States. Chapter 4, entitled Metals, includes descriptions of the properties, uses, major minerals, geologic associations, locations of major districts, and import-export facts for the elements Fe, Al, Mg, Ti, Mn, Cu, Ni, Co, Pb, Zn, Nb, Mo, Hg, Cr, Sn, W, Be, Ta, V, Au, Pt, and Ag.

Chapter 5, Nonmetals for agriculture and the chemical industry, is a relatively short chapter that includes discussions on nonmetals "used for reasons other than their metallic properties." Evaporites, potassium, nitrogen, phosphorus, and sulfur (with sections on sulfur from salt domes, petroleum, and metal-sulfide mining) are major topics; halite, chlorine, bromine, fluorine, and barite are discussed briefly. Building materials, which include building stones, sand and gravel, and light-weight aggregates (for example, pumice, scoria) are major subjects in Chapter 6; minor sections on clays, cement, calcium sulfates, asbestos, and abrasives are included.

Chapter 7 (Energy), the longest and one of the most interesting chapters in Brookins' book, is filled with pertinent facts and figures, geochemical discussions, and the pros and cons for many of the energy alternatives available today. Major subsections include discussions about coal, nuclear energy, petroleum, and uranium (mostly on uranium deposition in a sedimentary environment, for example, Grants mineral belt). Brief sections on other energy sources, including hydrothermal, geothermal (including the Hot Dry Rock program at Los Alamos), ocean and solar energy are included. Most of the latter topics are not discussed at great length because Brookins states they will not be feasible until at least the 21st century.

Brookins finishes his book with a chapter on "Geochemistry and human impact on the environment." In this chapter, subsections cover environmental geochemistry, land use, coal-based versus nuclear-based technology, and chemical wastes. A table of 18 trace elements, with their toxicity effects, is included. Brookins does stress that medical expertise needs to be collated with the voluminous trace-element data on soils and waters, and that the future type of health and trace-element studies needed are those that monitor a mining or urban activity before, as well as during and after, initialization.

Covering the breadth of material Brookins has covered, and yet being coherent without overwhelming the reader, is very difficult. Still, I have few complaints with this book; most of these are of a personal nature. For example, the section on coal-based versus nuclear-based technology (in Chapter 8) would fit better in Chapter 7 (Energy); the small section on milling (in Chapter 4) would fit better in Chapter 2 (Ores, production, and mining); a brief definition of light water reactor and fast breeder reactor would be useful. A few figures (for example, p. 4) may be difficult for the layman to interpret; however, the majority of figures are legible and easy to understand. My major complaint is that many of the plates are poorly reproduced.

To summarize, the book is well organized and inexpensive; the type is easy to read, and there are few typographical errors (I found only one). I would recommend it for those scientists and students engaged directly or indirectly in the fields of earth resources, energy, environmental concerns, or nuclear development. The book is not a "stand-alone" comprehensive text on all of the above subjects, but it does provide the facts and figures as well as the pros and cons associated with future energy development. The book is written for an audience with a broad nonscientific background, and most New Mexicans will find it enjoyable reading.

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STRATIGRAPHY AND PALEOENVIRONMENTS OF AN UPPER CRETACEOUS MARINE TO FLUVIAL FACIES TRANSITION, SIERRA COUNTY, NEW MEXICO, by *E. Timothy Wallin*, Department of Geology, New Mexico Institute of Mining and Technology, Socorro, NM

The Engle coal field of south-central New Mexico contains approximately 3,000 ft of interbedded Upper Cretaceous pebble conglomerates, sandstones, siltstones, mudrocks, and coals. These terrigenous clastics represent a marine to fluvial facies transition deposited during the widespread late Turonian–early Coniacian regression of the Western Interior seaway. The Rio Salado Tongue of the Mancos Shale is overlain by the tripartite Tres Hermanos Formation. The Atarque Sandstone Member represents deposition of a distributary mouth bar in a very shallow epeiric sea. Deposition of the Atarque provided a near sealevel platform upon which thin channel and crevasse-splay sandstones and carbonaceous mudrocks were deposited. Transgression of the seaway across these marginal marine and fluvial deposits is recorded by the Fite Ranch Sandstone Member, which consists of a thin transgressive lag deposit, and a thicker, regressive coastal barrier sandstone. The D-Cross Tongue of the Mancos Shale represents open marine conditions and contains three unnamed tongues of the Gallup Sandstone deposited during several minor progradational episodes. The overlying Mesaverde Group consists of nearshore marine and continental deposits. Well-developed shoreface and beach deposits of the Gallup Sandstone overlie the D-Cross Tongue of the Mancos Shale. The Crevasse Canyon Formation consists of a lower coal-bearing member, a middle barren member, and the Ash Canyon Member. Marginal marine and continental deposits of the Crevasse Canyon represent lagoonal, washover fan, coal swamp, and fluvial environments. Fluvial subenvironments are represented by channel thalweg, point bar, natural levee, crevasse-splay, swamp, and overbank deposits.

GEOLOGY OF COPPER OCCURRENCE AT COPPER HILL, PICURIS MOUNTAINS, NEW MEXICO, by *Michael L. Williams*, Department of Geology, University of New Mexico, Albuquerque, NM

Copper Hill, in the Picuris Mountains of northern New Mexico, is the expression of a west-plunging anticline of Ortega Quartzite. The Ortega Quartzite at Copper Hill has been divided into three stratigraphic units: massive quartzite (Og_1), kyanite quartzite (Og_2), and andalusite quartzite (Og_3). During structural deformation, the lower two quartzite units behaved brittlely, while Og_3 and the overlying Rinconada schists behaved ductilely. These ductile units formed an impermeable cap to a series of N. 10° east-trending quartz veins that cut the lower quartzite units. Oxidized copper minerals with silver, arsenic, and antimony occur in Og_1 and Og_2 quartzite and in the quartz veins on Copper Hill. The deposit, of probable Precambrian age, has been subjected to considerable metamorphism, deformation, and oxidation. Although a genetic model involving original strata-bound copper mineralization must be considered for the deposit, most evidence supports an origin involving epigenetic, although pre- or synmetamorphic, emplacement of copper minerals from a source at depth. □

Bryozoan and crustacean *(continued from p. 55)*

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1982 bibliography released

The New Mexico Bureau of Mines and Mineral Resources has issued a second bibliographic publication in cooperation with the American Geological Institute and GeoRef Information System, *Bibliography and index of New Mexico geology*. This edition, containing approximately 1,000 references and cross references, represents published and unpublished material that was added to the GeoRef database in 1982. The components of this annual bibliography are: serials list, citations by senior author with cross references, subject index, county index, and rock-unit index.

Collecting and formating the references contained in this volume were done entirely by the staff of GeoRef Information System. Many publications released in 1982 are included; however, nearly 1/3 of the papers cited were released in 1981. Consequently, this volume is a valuable supplement to the previous edition, *Bibliography and index of New Mexico geology* for 1981, the first bibliography to be produced by GeoRef for the New Mexico Bureau of Mines and Mineral Resources. Neither volume is a comprehensive annual bibliography. Both contain additional citations for papers and reports released in earlier years; therefore, many citations may duplicate those appearing in earlier Bureau bibliographies or in its forthcoming bibliography for 1976–1980 (Bulletin 109).

The editors recognize the need for an annual reference volume to give researchers access to the most current literature on New Mexico geology. The New Mexico Bureau of Mines and Mineral Resources will continue to issue an annual bibliography as a supplement to its other bibliographic literature. Users of this volume and our other bibliographies are encouraged to contact the Bureau editing staff when errors or omissions are discovered and to comment critically on scope and format. We anticipate that annual coverage of the literature will become increasingly more comprehensive with each successive edition.

This 1982 edition of *Bibliography and index of New Mexico geology* sells for $6.50 and is available from the Publications Office, New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico 87801.

—Jane Calvert Love

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