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Phosphatic Microfossils
from the Ordovician of the United States

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ABSTRACT

Phosphatic fossil fragments, commonly having less than 2 mm. maximum size, occur in acid residues of Ordovician rocks. A variety of fossil shapes has been found in the El Paso Group of west Texas, Simpson Group of Oklahoma, Dutchtown Formation of Missouri, and Maquoketa Group of Indiana. Excluding atremate brachiopods and conodonts, the collection reported here has greatest affinity to early ostracoderm fish and arthropods. Focus on these phosphatic microfossils can enhance our knowledge of the early evolution of phosphate-bearing organisms and their biostratigraphic significance.

Discovery of phosphatic microfossils in Ordovician rocks from several new collections in the United States adds to the search for evidence of the earliest vertebrate fossil remains. The tiny, fragmentary fossils come from stratigraphic and geographic localities from which they have not been reported previously. Some of the fragments resemble ostracoderm (Agnatha, Heterostraci) phosphatic skeletal material from the Harding Formation of Colorado and its equivalents elsewhere.

Stratigraphic distribution of our four collections ranges from Lower to Upper Ordovician (fig. 1): geographic distribution is from west Texas to Indiana (fig. 2). Figures 1 and 2 show the distribution of these collections in relation to the classic exposures of the ostracoderm-bearing Harding Formation (Middle Ordovician) in Colorado. Our samples have been obtained from (1) El Paso Group (Canadian) of the Franklin Mountains,

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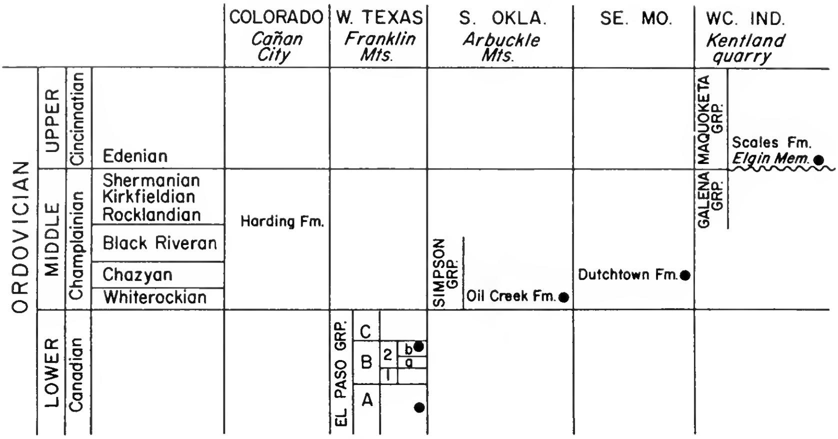

FIG. 1. Stratigraphic and geographic distribution of phosphatic microfossils from four new Ordovician occurrences in the United States. The classic Harding Sandstone fossil fish deposits of Colorado are given for reference. Although it is generally considered Middle Ordovician Blackriveran, Lehtola (1973) regards the Harding as Rockland-Kirkfield.

west Texas; (2) Simpson Group, (Oil Creek; Whiterockian) in the Arbuckle Mountains, southern Oklahoma; (3) Dutchtown Formation (Chazyan), western edge of the Illinois Basin, southeast Missouri; and (4) Maquoketa Group (basal Scales Formation; Cincinnatian) in a quarry near Kentland, Indiana.

Phosphate occurs in the hard parts of many modern and ancient organisms and in some of their tubular domicile structures (Vinogradov, 1953). A number of organisms in the early Paleozoic might have contributed phosphatic hard parts to the fossil record (Rhodes and Bloxam, 1971). For the Ordovician, the list of suspects includes conularids, inarticulate brachiopods, hyolithelminthes (tubes and operculae), annelid polychaete tubes, arthropods (trilobites), merostomes (aglaspids, xiphosurids, eurypterids, possibly limulids; Fischer, 1973), conodonts, agnaths, possibly other unknown taxa, and any fossil diagenetically replaced by phosphate mineralization through post-mortem substitution. Phosphatic organic remains of uncertain affinities include the conodonts (Hass, 1962; Lindström, 1964; Rhodes, 1972), spiny, tuberculate fragments (Ethington and Clark, 1965) assigned to the genus *Milaculum* by Müller (1973), and other examples cited and discussed by Müller (1973; and in abstract, 1974).

The earliest known vertebrates, which have been found in the western United States, have phosphatic hard parts. Information on them is summarized in Denison (1967), and their distribution is shown in Figure 2.

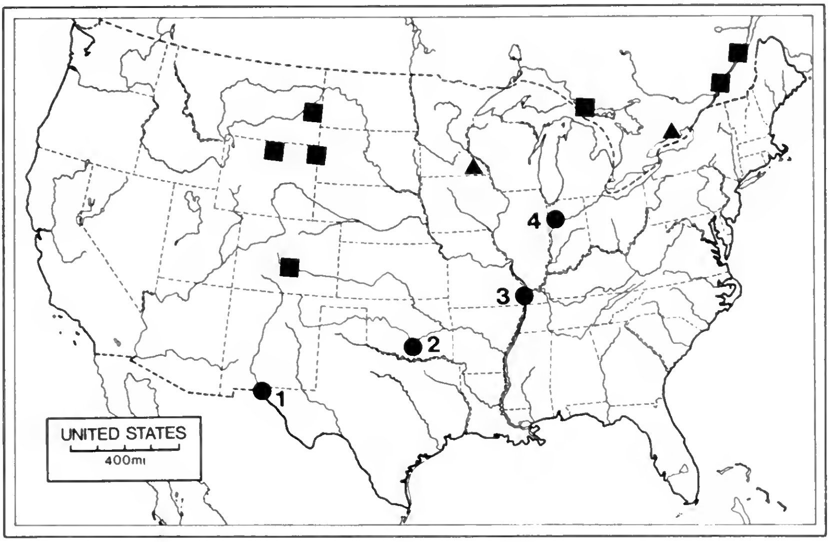

FIG. 2. Map showing new Ordovician phosphate-microfossil localities (solid circles), previously reported fossil fish localities (squares), and previously reported problematica (triangles).

References to those from the Harding Formation of Colorado, other than Denison, are Bryant (1936), Spjeldnaes (1967), and Fischer (1973). Data from other Ordovician strata in the Rocky Mountains, Black Hills, and Williston Basin of Montana are given in Darton (1906), Furnish et al. (1936), Ross (1957), Ørvig (1958), Stone and Furnish (1959), and Cygan and Koucky (1963). Recent accounts of fish fragments found in Middle Ordovician carbonate rocks of Quebec and Ontario, respectively, are given in Eliuk (1973) and Lehtola (1973) (see fig. 2).

Our collections include a variety of tiny phosphatic specimens recovered from acid and water-washed residues. The fossils are disassociated parts of organisms; they are most often fragmentary and very small; only a few exceed 2 mm. in largest dimension. Some specimens are water worn as part of a sandy lag concentrate; others show little evidence of abrasion. There are A) both sculptured and unsculptured tuberculate plate fragments; B) individual dermal tubercles or studs; and C) other fragments whose morphology may loosely be characterized as discs, cups, spiny shells, and tooth-shaped forms. The specimens were recovered in the heavy fractions after separation with tetrabromoethane (density $\cong$ 2.9; density of apatite group minerals = 3.1-3.2). X-ray and optical analyses have confirmed the phosphatic composition of the Oil Creek specimens. Since most of the fragments are unique and very small,

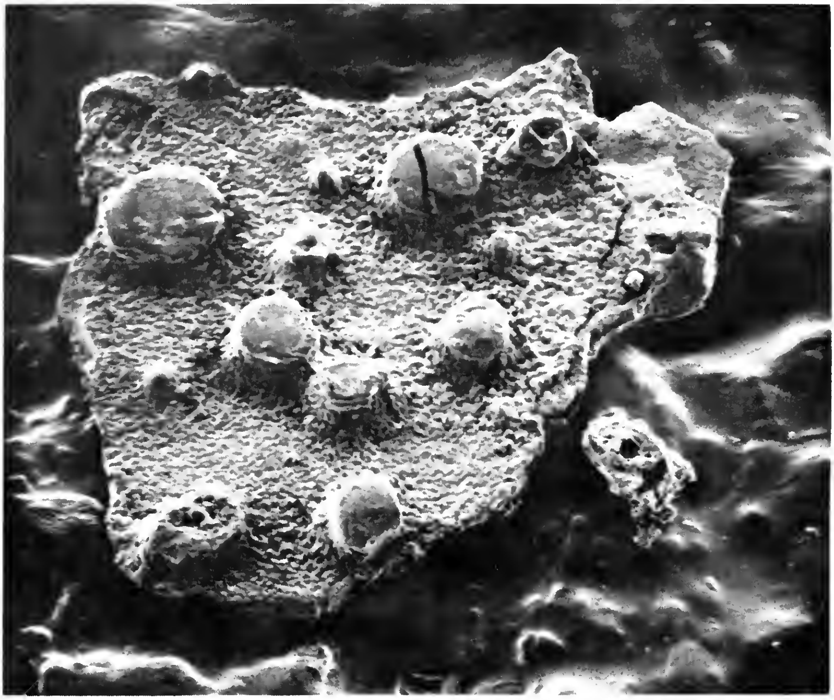

FIG. 3. Tuberculate plate fragment. El Paso Group, Sierrite Fm. basal 1 ft., El Paso, Texas, × 340.

sectioning is difficult and must await the recovery of more material. External morphology is well revealed by SEM photography; however, histology is still critical for identification of the fragments.

Taxonomic placement of most of these problematic fossils is difficult because of their fragmentary nature and because of our lack of knowledge of their internal structure; however, some can be identified with previously described taxa. Tubercles and some other forms (figs. 3, 6, 7, 8) resemble dermal elements of the ostracoderm *Astraspis,* known from the Harding Formation and elsewhere. Some of the forms illustrated here (figs. 3, 4, 8) also appear similar to merostome fragments figured by Raasch (1939) and by Grant (1965). It should be noted also that Flower (1968) recovered merostomes from low in the B2b subdivision of the El Paso Group (the fragments figured here as figs. 4 and 8 are from high in B2b). However, Flower's merostomes are silicified rather than phosphatic. The form illustrated in Figure 7 does appear to be assignable to *Astraspis,* although this interpretation is tentative pending histological study. Other spiny, thin-walled fragments, including that shown in

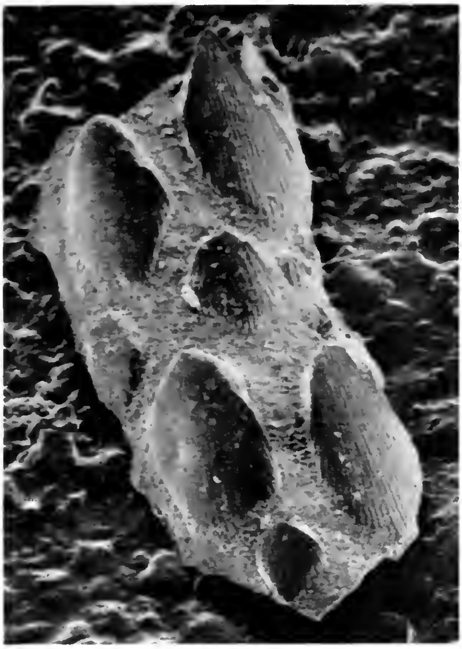

FIG. 4. Sculptured fragment with well-embedded projections that have parallel and branched venation. El Paso Group, 1,279 ft. above base, El Paso, Texas, × 210.

Figure 5, are identified as *Milaculum* Müller 1973, of unknown affinity. Unfigured tooth-like specimens from the Dutchtown Formation are assigned to *Archaeognathus* Cullison, another form of questionable affinity.

The fossils from the Oil Creek and Scales Formations occur in calcareous sandstones and sandy lag concentrates, both of which are generally basal deposits within a transgressive unit following a hiatus. However, the fossils from the El Paso Group and the Dutchtown Formation occur in carbonate successions with only minor quartz, sand, or clay. The fossils from the Scales Formation commonly occur with clasts in association with burrowing or boring activities. The enclosing rocks are of marine origin. This would support the interpretation (Denison, 1956, 1967; Eliuk, 1973; Lehtola, 1973) that the very early fish inhabited marine waters, if it can be shown that any of our specimens are fish remains.

In summary, a variety of interesting morphological types of phosphatic fossil remains are found in the lower Paleozoic, particularly in the Ordovician, in North America and elsewhere (Müller, 1973; 1974). Their zoological affinities and identity are of interest in the study of the early evolution of animals having phosphatic skeletons, especially agnath fish,

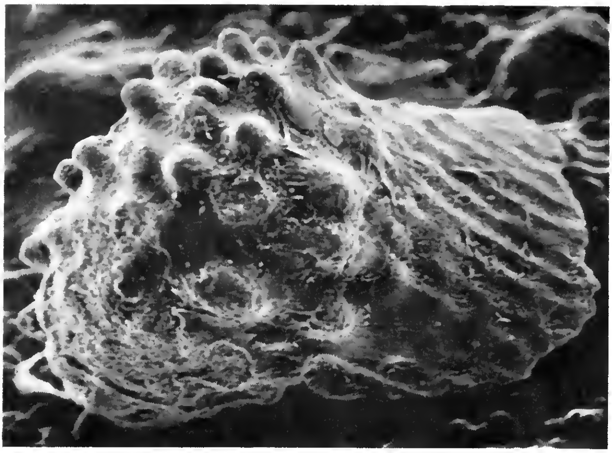

FIG. 5. *Milaculum* sp. Simpson Group, Oil Creek Fm., 50 ft. above the base, Arbuckle Mts., Oklahoma, × 355.

FIG. 6. Water-worn tuberculate fragment. Maquoketa Group, Scales Fm., Elgin Member, basal lag fossil concentrate, Kentland quarry, Indiana, × 70.

and could contribute to biostratigraphic knowledge of the sediments enclosing them.

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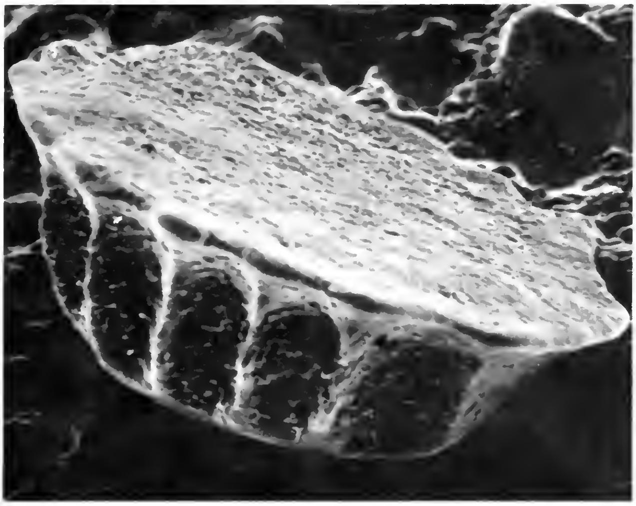

FIG. 7. Ornamented, abraded(?) *Astraspis?* tubercle. Simpson Group, Oil Creek Fm., 50 ft. above the base, Arbuckle Mts., Oklahoma, × 450.

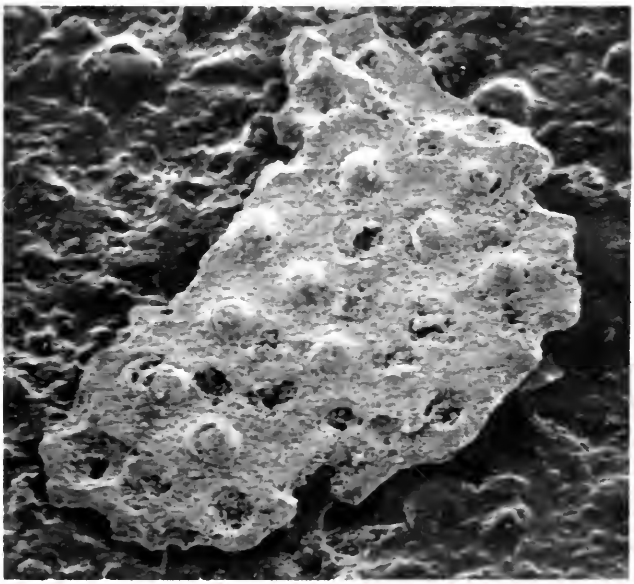

FIG. 8. Fragment with tuberculate surface. El Paso Group, 1,279 ft. above base, El Paso, Texas, × 170.

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