ART. XIII.—*Pottsville Formations and Faunas of Arkansas and Oklahoma*; by KIRTLEY F. MATHER.

Pottsville formations of the Boston Mountains.

THE Boston Mountains form an escarpment which overlooks the Ozark Plateau and extends from the vicinity of Muskogee, Oklahoma, eastward past Fayetteville, Arkansas, to Batesville, Arkansas. Their structure is monoclinical, the beds dipping gently toward the south. The strata exposed in the outlying erosion remnants and the terraced front of the mountains are in the main shales and sandstones with occasional limestones. Of these, the Morrow group embraces two units, the Hale formation and the Bloyd shale. The latter contains two limestone members, the Brentwood and the Kessler. The Morrow group rests unconformably upon the Pitkin limestone, or in places on the Fayetteville shale, and is overlain unconformably by the Winslow formation. Both unconformities are more pronounced toward the north and practically disappear toward the south where the group is lost to sight beneath the Winslow. From east to west there is a change in lithology; in Oklahoma the Morrow is largely limestone while toward Batesville it is dominantly clastic. Limestone lenses in the Hale formation and the Brentwood and Kessler limestone members of the Bloyd carry an abundant marine fauna which has been described elsewhere.* A thin seam of coal in the shales between the two upper limestone members contains a fossil flora of Sewanee affinities. The early Pottsville age of the group is further demonstrated by the marine fauna, in which a large number of residual Mississippian invertebrates are associated with forms of distinctly Pennsylvanian aspect.

Pottsville formations south of Arkansas River.

Arkansas River and its tributaries in eastern Oklahoma and western Arkansas occupy a geosynclinal basin composed of Pennsylvanian strata. The lowest beds of the series are exposed along the southern margin of the basin, between the Arbuckle Mountains in south central Oklahoma and the Ouachita Mountains farther east. Throughout this region the Atoka formation is especially conspicuous, both because of its great thickness, 3000 to 6000 feet, and because of the recurrence of massive sandstone beds in the midst of the shales of which it is dominantly composed. Toward the north it is

* Mather, K. F., The fauna of the Morrow group of Arkansas and Oklahoma. Denison Univ., Sci. Lab. Bull., vol. xviii, pp. 59-284, 1915.

overlain by the successive formations of the "Arkansas Coal Measures."*

Along the eastern flank of the Arbuckle uplift, the Atoka is underlain conformably by the Wapanucka limestone† which approximates 150 feet in thickness and rests with probable disconformity upon the Caney shale. Farther west, the Franks conglomerate is apparently the near-shore equivalent of the Wapanucka, Atoka, and possibly even higher strata as well. It overlaps the Caney and is found resting upon the early Paleozoic strata to the southwest.‡

Traced eastward, the Wapanucka limestone at first thickens slightly and then decreases in thickness and comes to an end north of the Ouachita Mountains near the Arkansas-Oklahoma line. In the Arbuckle region, the Caney is over a thousand feet in thickness and overlies the Woodford chert, of probably Devonian age. Over a part of the area, however, the Sycamore limestone intervenes between the Woodford and the Caney and is correlated with an undifferentiated lower division of the Caney in other localities.

In the vicinity of the Ouachita Mountains, the succession is somewhat different. The Wapanucka limestone disappears in southern Oklahoma and the Atoka formation rests directly upon the Caney shale, there about 800 feet thick. The Caney overlies with apparent, and probably real, conformity the Jackfork sandstone and Stanley shale, each about 5000 feet in thickness.§ Farther east, in Arkansas, the Caney also disappears, and the Atoka rests upon the Jackfork.||

The Fauna of the Wapanucka limestone.

Through the courtesy of Mr. C. R. Thomas, of the Oklahoma Geological Survey, I have been enabled to study a representative collection of fossils from the Wapanucka limestone. The fossils were obtained at several localities in and near the Atoka and Coalgate quadrangles midway between the Arbuckle and Ouachita Mountains.

* Collier, A. J., The Arkansas coal field, U. S. Geol. Survey, Bull. 326, p. 12, 1907. Snider, L. C., Geology of East Central Oklahoma, Okla. Geol. Survey, Bull. 17, p. 8, 1914.

† Wallis, B. F., Geology and economic value of the Wapanucka limestone of Oklahoma, Okla. Geol. Survey, Bull. 23, 1915.

‡ Taff, J. A., Geology of the Arbuckle and Wichita Mountains, U. S. Geol. Survey, Prof. Paper 31, p. 34, 1904.

§ Taff, J. A., Grahamite deposits of southeastern Oklahoma, U. S. Geol. Survey, Bull. 380, p. 289, 1910.

|| Purdue, A. H., The slates of Arkansas, Geol. Survey, Arkansas, p. 48, 1909.

The complete faunal list is as follows:—

Pentremites angustus Hambach
Cromyocrinus n. sp.
Archeocidaris sp.
Rhombopora lepidodendroides Meek
Cystodictya sp.
Rhipidomella pecosi (Marcou)
Productus nanus Meek and Worthen?
Productus morrowensis Mather?
Spirifer opimus Hall
Spirifer goreii Mather
Squamularia perplexa (McChesney)
Spiriferina transversa (McChesney)
Composita ozarkana Mather
Composita gibbosa Mather
Nucula parva McChesney
Parallelodon sp.
Myalina orthonota Mather
Aviculopecten arkansanus Mather?
Aviculopecten sp.
Euphemus carbonarius (Cox)
Griffithides morrowensis Mather?

All the genera listed above are present in the fauna of the Morrow group, and 17 of the 21 species have been found in the limestones of that group. This includes all the forms specifically identifiable with the exception of the new species of *Cromyocrinus*.

It is significant that none of these is known from the Kessler horizon without also being present in the Hale or Brentwood, while several of the Wapanucka forms are not known to occur in the Boston Mountains region above the Brentwood member. Moreover, none is recorded from the Hale limestone lenses, which is not also known from the Brentwood or higher strata. (*Nucula parva* is frequently found in the "Coal Measures" of the Mississippi Valley.) That the Wapanucka is the homotaxial equivalent of the Brentwood is further indicated by the association of *Pentremites angustus* and *Spiriferina transversa*, residual Mississippian types, with *Rhipidomella pecosi*, *Productus nanus*?, *Spirifer opimus*, *Squamularia perplexa*, and *Euphemus carbonarius*, proemial Pennsylvanian forms, and *Composita gibbosa*, a characteristic Brentwood species. It necessarily follows that the Wapanucka is of early Pottsville age.

The fauna of the Atoka formation.

The Atoka formation is nearly everywhere barren of fossils; indeed it is highly probable that the formation is in part of non-marine origin. There are, however, local beds of calcareous sandstone near the base of the formation, which are crowded

with the remains of marine organisms. These are known to outcrop near Clarita, Oklahoma, in the northwest corner of the Atoka quadrangle. The fossiliferous strata were discovered by Dr. L. C. Snider, formerly Assistant Director of the Oklahoma Geological Survey, and to him I am indebted for the opportunity of studying their fauna.

The fossils are preserved entirely as casts and moulds in the weathered portion of the outcropping beds from which all calcareous material has been leached. The individual specimens are indiscriminately intermingled and many were broken before fossilization took place. It is quite clear that most of the shells were transported by waves and currents until they collected in quiet water, where they were buried beneath sandy sediments.

No less than forty-two identifiable forms have come to hand from the one locality. These are listed below.

Campophyllum torquium (Owen)
Rhombopora sp.
Prismopora concava Mather
Chonetes choteauensis Mather
Chonetes laevis Keyes
Productus fayettevillensis Mather
Productus gallatinensis Girty?
Spirifer rockymontanus Marcon
Squamularia perplexa (McChesney)
Composita wasatchensis (White)
Nucula parva McChesney
Yoldia glabra Beede and Rogers?
Parallelodon pergibbosus Mather
Caneyella? n. sp.
Pseudomonotis precursor Mather
Myalina cuneiformis Gurley?
Myalina orthonota Mather
Schizodus affinis Herrick
Schizodus wheeleri (Swallow)?
Schizodus telliniformis Girty
Deltopecten occidentalis (Shumard)
Aviculopecten arkansanus Mather
Plagiostoma? *acosta* Cox
Pleurophorus subcostatus Meek and Worthen?
Pleurophorus n. sp.
Pleurophorus sp.
Astartella n. sp.
Euphemus carbonarius (Cox)
Worthenia tabulata (Conrad)
Orestes sp.
Euconospira turbiniformis (Meek and Worthen)
Strophostylus remex (White)
Platyceras parvum (Swallow)

Aclisina ? sp.
Orthoceras sp.
Metacoceras sp.
Pronorites cyclolobus var. arkansasensis Smith
Gastrioceras listeri (Martin)
Gastrioceras hyattianum Girty
Gastrioceras angulatum Girty
Gastrioceras carbonarium von Buch
Gastrioceras kesslerense Mather

The Atoka fauna as thus made known includes six forms not specifically identifiable and three new species, so that there remain thirty-three species known to occur elsewhere. Twenty of these have been described among the Morrow fauna of the Boston Mountains. One additional form, *Pronorites cyclolobus* var. *arkansasensis*, is known elsewhere only from the upper strata of the Morrow group in Carroll County, Arkansas. Another species, *Strophostylus remex*, occurs in the Lower Aubrey group of Utah, a horizon which may be closely correlated with the Morrow. The remaining forms are present in somewhat higher strata in this and adjoining regions.

Four of the Atoka species, *Prismopora concava*, *Myalina cuneiformis*?, *Worthenia tabulata*, and *Gastrioceras kesslerense*, are especially characteristic of the Kessler member of the Morrow as distinct from the lower fossiliferous beds of that group. The last named of these four is the most common species in the Atoka fauna. On the other hand, two species, *Pseudomonotis precursor* and *Parallelodon pergibbosus*, are noteworthy as representative Brentwood forms.

The evidence is quite conclusive that this fossiliferous portion of the Atoka formation cannot be much, if any, younger than the upper beds of the Morrow group. The deposition of the Atoka sediments must, therefore, have begun in early Pottsville time.

The age of the Caney, Jackfork, and Stanley formations.

The proper correlation of the Caney shale, the Jackfork sandstone, and the Stanley shale present unusual difficulties because of the somewhat conflicting nature of the data available. G. H. Girty in his description of the Caney fauna* has presented all phases of the problems involved. There have been found in the Stanley shale obscure plant remains which David White states are of Carboniferous age; he concludes that "it is probable that they belong either in the upper part of the Mississippian or in the lower Pottsville, but this point

* Girty, G. H., The fauna of the Caney shale of Oklahoma, U. S. Geol. Survey, Bull. 377, 1909.

requires additional paleontologic data for its determination.”* Six or seven thousand feet above the Stanley plant horizon there is found the marine invertebrate fauna of the Caney shale. This fauna is undoubtedly of Upper Mississippian age and the Caney shale may be correlated directly with the Moorfield shale, Batesville sandstone, and Fayetteville shale of the Boston Mountains.† It is further demonstrable that the Caney of the Arbuckle region and the Caney of the Ouachita Mountains are one and the same formation.

So carefully did Girty entertain all possible solutions of the really baffling problem, which would be presented if the Stanley flora should prove when better known to be of Pottsville age, that his conclusions have been misinterpreted. J. B. Woodworth states, “The fauna of the Caney shale is marine. Girty very guardedly referred the beds to the Pottsville, which reference Ulrich (in a note to the author) later proved to be correct on stratigraphic and faunal evidence.”‡

Ulrich considers the Caney shale to be of Pennsylvanian age,§ but the evidence upon which his conclusions are based has not been published. Upon his authority, also, Purdue has referred the Jackfork and Stanley to the Pennsylvanian.|| In this regard he follows the lead of Branner, who long ago included all the strata above the Arkansas novaculite in the “Lower Coal Measures,” and reported the total thickness of Pennsylvanian sediments in Arkansas as 23,780 feet.¶

With the facts now available concerning the faunas of the Wapanucka and Atoka formations, the chain of evidence would appear complete. The correlation of the Caney fauna with late Mississippian faunas in northern Arkansas is further strengthened by the determination of the early Pottsville age of the immediately overlying strata. Pennsylvanian sedimentation in the Arbuckle and Ouachita regions evidently began with the deposition of the Wapanucka and Atoka formations. The Jackfork and Stanley must be of middle or late Mississippian age, and their enormous thickness is the result of unusual conditions of sedimentation maintaining in the Ouachita region at that time.

The accurate placing in the time scale of the initiation of Stanley sedimentation must await further paleontologic discov-

* Quoted by Girty, loc. cit., p. 8.

† Girty, G. H., The fauna of the Moorfield shale of Arkansas, U. S. Geol. Survey, Bull. 439, p. 25, 1911.

‡ Woodworth, J. B., Boulder beds of the Caney shales at Talihina, Oklahoma, Bull. Geol. Soc. America, vol. xxiii, p. 457, 1912.

§ Ulrich, E. O., Revision of the Paleozoic systems, Bull. Geol. Soc. America, vol. xxii, p. 352, foot-note; also pl. 29, 1911.

¶ Purdue, A. H., The slates of Arkansas, Arkansas Geol. Survey, p. 48, 1909.

¶ Branner, J. C., Thickness of Paleozoic sediments in Arkansas, this Journal (4), vol. ii, pp. 229-236, 1896.

eries, but it is now evident that that sedimentation could not have been contemporaneous with the uplifting of the Arbuckle region.* The orogenic disturbance which resulted in the rapid accumulation of the ten or twelve thousand feet of clastic beds composing the Stanley and Jackfork cannot be included with the "Culmides" of Chamberlin. It probably was a feature of the events which mark the transition between the Waverlyan and Tennessean systems of Ulrich. Instead of one great orogenic revolution closing the Paleozoic era there would appear to be at least four such disturbances: Waverlide, Culmide, Hercynian, and Appalachian.

It is perhaps significant that the relation between the epoch of refrigeration implied by the ice-borne bowlders in the lower portion of the Caney shale† and the Waverlide disturbance is analogous to that between the much more extensive "Permo-Carboniferous" glaciation and the more violent Hercynian revolution.

Finally, it should be stated that the third leg of the paleontological tripod, the evidence accorded by vertebrate fossils, supports the conclusions which have been based upon the invertebrate remains. According to Eastman‡ the character of the Caney fish remains indicates their Upper Mississippian age so far as the evidence goes, though it is admittedly slight.

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October 20, 1916.

* Chamberlin, R. T., Periodicity of Paleozoic orogenic movements, *Jour. Geol.*, vol. xxii, p. 333, 1914.

† Taff, J. A., Ice-borne boulder deposits in mid-Carboniferous marine shales, *Bull. Geol. Soc. America*, vol. xx, pp. 201-202, 1907.

‡ Eastman, C. R., Brain structures of fossil fishes from the Caney shales, *Bull. Geol. Soc. America*, vol. xxiv, pp. 119-120, 1913.