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THE GEOLOGY ABOUT MILLS SPRINGS, MONTICELLO QUADRANGLE, KENTUCKY

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The Monticello Quadrangle of the U. S. Geol. Survey is bounded by the meridians 84° 45′ W. and 85° W. and by the parallels 36° 45′ N. and 37° N. The northeast quarter of this district may be reached by automobile from Burnside, a station on the main railroad between Cincinnati and Cumberland Falls, Ky. Sections were made and fossils collected within the forty-nine square miles of the area. During the three weeks which were spent in studying the stratified rocks enough data were collected to give a comprehensive idea of the physiography, structure, and historical geology of the region.

The field work was done under the direction of Professor E. C. Case of the University of Michigan from the summer camp at Mill Springs. The writer is under deep obligations to Dr. Chester A. Reeds of The American Museum of Natural History, at whose suggestion this study was begun and who gave helpful advice and assistance in the writing of the paper. Negotiations for doing the field work and publication were conducted by Dr. E. O. Hovey. Acknowledgements are also extended to Mr. Charles Butts of the United States Geological Survey for information concerning the stratigraphy of an area nine miles to the southwest of Mill Springs.

PHYSIOGRAPHY

The area possesses the nature of a late mature to old plain on stratified rocks, slightly uplifted and moderately dissected. The Cumberland River flows generally from east to west through several prominently incised meanders (Fig. 1). The relief is striking, the highest hills being more than seven hundred feet above the Cumberland River. These hills present beautiful undulating patches of woods and open glades. At their bases broad areas of upland appear dotted with farms. The river flats or "bottoms" are composed in large part of alluvium which furnishes, when cleared of timber, rich soil for farming. The shifting of the channel in meandering streams to the outside of the bend has left steep

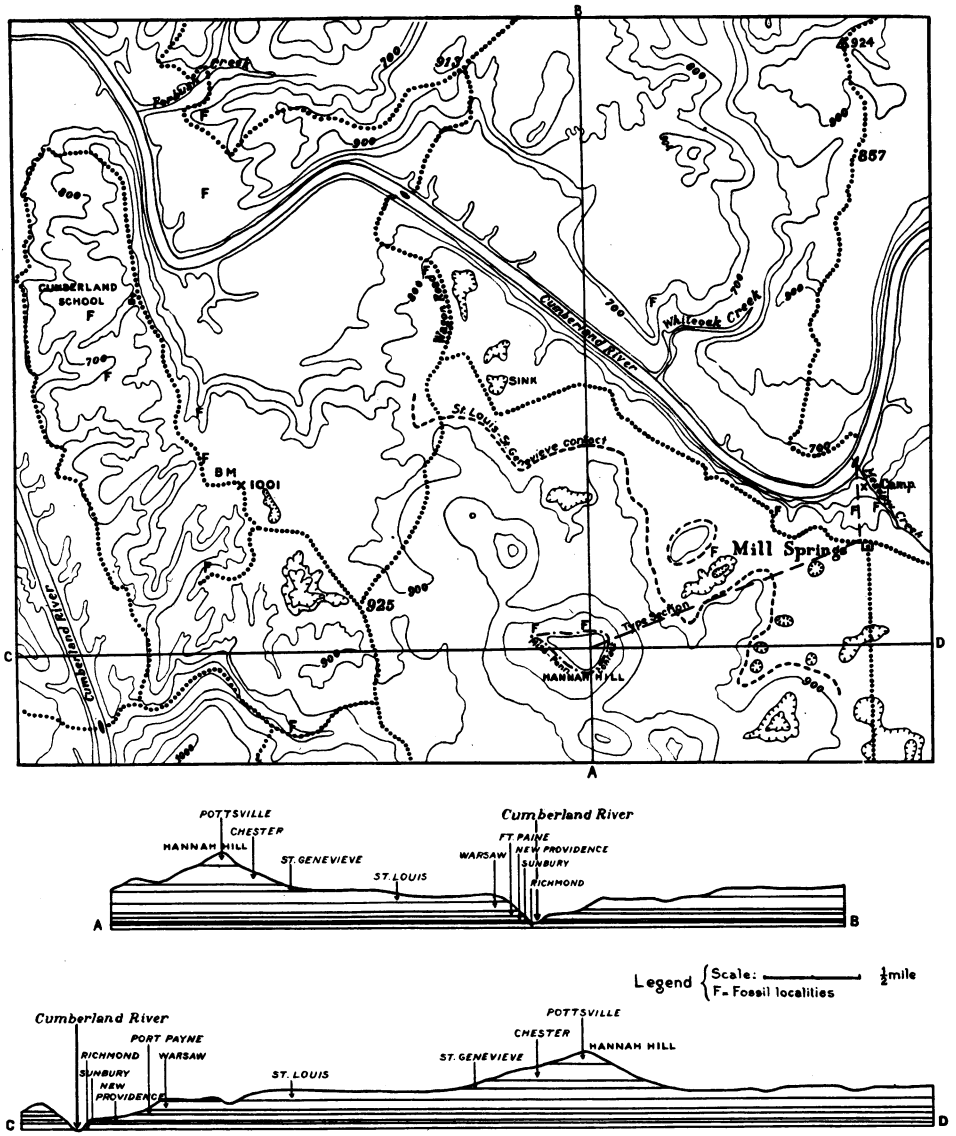

Fig. 1. Sketch Map of the northeast quarter of the Monticello Quadrangle, Wayne County, Kentucky, with profiles along the lines A–B and C–D.

Culture and Topography from U. S. Geol. Surv., Monticello Sheet. Profiles and Geology by E. J. Foyles.

cliffs along the Cumberland and small creeks. This natural phenomenon has interfered with the establishment of good lines of communication along the stream courses and has obliged the settlers to live in more or less isolated communities.

Where the Cumberland River crosses the Monticello Quadrangle it presents the characteristics of a rejuvenated stream flowing on nearly horizontal strata. Three cycles of erosion (Fig. 2) are represented in the area. The top of Hoozer Hill and other outlying knobs are the manifestation of the oldest cycle. The flat upland is representative of the second cycle. The narrow canyons and intervening level stretches along the Cumberland River represent the third cycle.

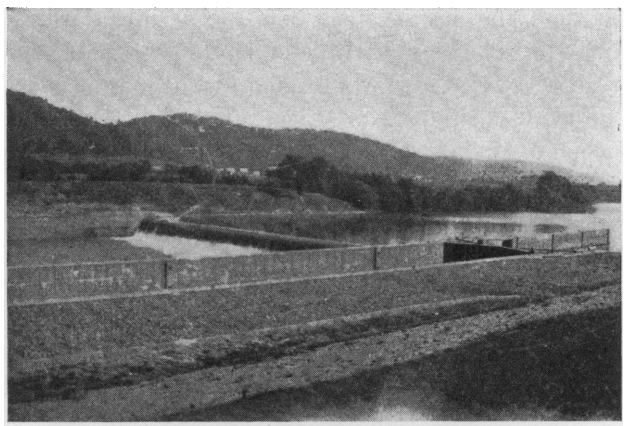

Fig. 2. Lock at Palace, Cumberland River. In the background may be seen the first, second, and third cycles of erosion.

This area exhibits not only surface but also underground drainage in a limestone plateau where the climate is moist and the strata are nearly horizontal. The sinks form a special feature of the region. Some of these depressions are over 100 feet deep. Short creeks flow into several of them and disappear, indicating that their waters pass through underground channels and issue at the surface elsewhere in the form of springs. Some of these sinks may have been produced by the collapse of the roofs of caves. The field evidence would seem to indicate that the subterranean watercourses were developed, in the main, before the third cycle of erosion or post-Tertiary trenching of the Cumberland valley took place.

STRUCTURAL GEOLOGY

The rocks of the region are nearly horizontal, a fact which may be seen by observing the sections along the lines A-B or C-D on the map (Fig. 1). The only departures from the level character of the strata are caused by low domes and basins. The mouth of Forbush Creek is the center of a dome whose strata rise high enough to expose the Ordovician rocks above the surface of the Cumberland River. Mill Springs is in the center of a broad basin from which the strata rise toward the north, west, and south. The dip of the beds between Forbush Creek and Mill Springs is 15 feet per mile southeast. A greater dip is exposed at the mouth of Cub Creek.

The main section, upon which this report is based, was run from the ferry below the Camp up the steep slope of the hill to Mill Springs and thence to the top of Hannah Hill, a mile and one-half distant to the southwest. This section is shown by a dashed line on the map.

Two disconformities were observed. The first is demonstrated by a mass of decomposed material between the Ordovician and Mississippian beds at the mouth of Forbush Creek. The second, which is between the Warsaw and St. Louis formations, may be seen at Mill Springs where the hard gray limestone of the St. Louis rests on the shale at the top of the Warsaw. An unconformity (Fig. 4) was observed in the Warsaw beds near Mill Springs. The red residual soil at Mill Springs is interpreted as being the natural product of weathering of the St. Louis limestone.

STRATIGRAPHIC GEOLOGY

This area possesses many favorable outcrops for the study of its stratigraphy. Shinbone Cliff on the Cumberland River is one of the finest and largest. Plenty of exposures and some fossils are to be found along the smaller streams. In the deforested uplands rounded boulders appear in the fields and ledges along the roads, while on the slopes of the hills are rocks which have been loosened by frost action. Most of the hills rising above the uplands are densely covered with trees and soil, yet enough outcrops are available for a successful study of the geology.

ORDOVICIAN

RICHMOND BEDS.—At the mouth of Cub Creek the Richmond beds of Ordovician age, some fifty-six feet thick, are represented by thin layers of gray limestone which represent the Arnheim subdivision of this period. The rocks contain sun-cracks, ripple-marks, intraformational mud conglomerate, and miniature cross-bedding, criteria which indicate

that these beds were deposited in shallow water followed by occasional emergence. Aside from dolomite, sphalerite, and calcite crystals in geodes, a few fossils (*Columnaria vacua* Foerste and *Platystrophia cyphaconradi* Foerste) were found at the base of these beds. The 23.5 feet of covered rocks, 12 feet of finely-crystalline gray limestone, and 5 feet of decomposed material underlying the Sunbury black shale near the mouth of Forbush Creek may represent the Saluda horizon, as suggested by Mr. Butts.

Mississippian

At the University of Michigan Geological Camp in the vicinity of Mill Springs, the Mississippian is by far the most extensive and fossiliferous group of rocks, having a total thickness of more than 600 feet. Beginning at the base the formations are the Sunbury shale, the New Providence shale, the Fort Payne shales, cherts and limestones, the Warsaw shales and limestones, the St. Louis limestone, the St. Genevieve colitic limestone, and the Chester limestones.

Sunbury Shale.—One-quarter mile up Forbush Creek occurs an exposure of the black carbonaceous Sunbury shale superimposed disconformably on 5 feet of decomposed Saluda material, the highest Richmond exposed in the area. Although the total known thickness of the Sunbury is 28 feet, only 5 feet appear on Forbush Creek. A careful search for fossils revealed *Ctenacanthus* species, *Pisces* indeterminable, and *Phillipsia* species. It is the teeth of *Ctenacanthus*, a shark, which made it possible to recognize the Sunbury at this place.

New Providence Formation.—Directly overlying the Sunbury on Forbush Creek is the New Providence formation which consists of 29 feet of greenish-gray crumbly shale containing phosphatic concretions the size of marbles and also carbonate of iron concretions. This formation yields the fossils *Cyathaxonia cynodon* Rafinesque and Clifford, *Cliothyridina glenparkensis* Weller, *Platycrinus sculptus* Hall, and *Phillipsia* species. The crinoid *Platycrinus sculptus* Hall is represented in great abundance by its stem-plates which are locally known as "fossil buttons" and "Indian beads."

Fort Payne Formation.—On the road leading from the Camp to Mill Springs the Fort Payne or Keokuk is exposed vertically for 97 feet at a low-water stage of the Cumberland River. In general, this formation is composed of a stiff dark shale, chert bands, and lenses of coarse, gray and sometimes crinoidal limestone (Fig. 3). The character of these rocks varies greatly in short distances. In the immediate vicinity of the camp

22 feet of gray, nodular, impure shale are exposed at the base, followed by 11 feet of limestone with solution cavities, then 25.5 feet of gray geodic shale. On top of this appear a five and one-half foot lens of gray compact limestone, 21 feet of gray shale with two six-inch chert layers near the top, and 12 feet of gray limestone containing the fossils *Chonetes* species, *Spirifer biplicoides* Weller, *Productus magnus* Meek and Worthen, and *Rhynchopora cooperensis* Shumard.

WARSAW FORMATION.—In the vicinity of Mill Springs the Warsaw, which is well exposed for 92 feet, is divided into six zones. The basal member is composed of 16.5 feet of gray geodic shale containing carbona-

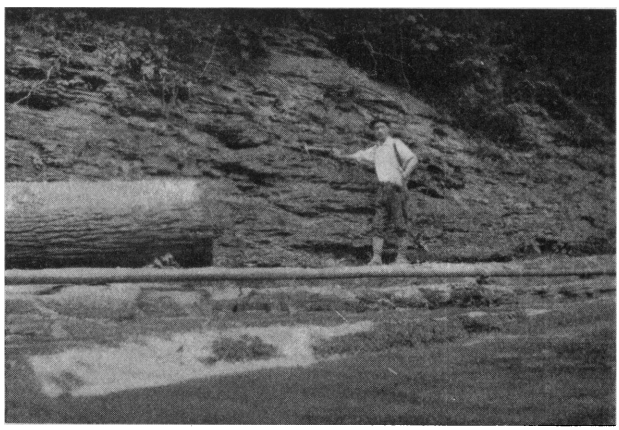

Fig. 3. Outcrop of the Fort Payne Formation, Mississippian, on Meadow Creek, showing limestone lens above hammer and flaggy shale below.

ceous concretions. The next zone consists of 18 feet of brownish-yellow to gray compact limestone. On this lie 16.5 feet of decomposed gray shale which yielded the fossils *Pustula biseriatus* Hall and *Chonetes illinoisensis* (Worthen). At the top of this bed, on the road between the camp and Mill Springs, appears a local unconformity (Fig. 4). Overlying this are 22.5 feet of yellow, impure limestone containing *Triplophyllum* species. Then follow 13 feet of limestone in which are found the fossils *Spirifer bifurcatus* Hall and *Reticularia pseudolineata* Hall. The last and uppermost member is a gray fissile shale 5.5 feet thick in which no fossils were found.

ST. LOUIS FORMATION.—Lying disconformably on the Warsaw formation is the St. Louis, a hard gray limestone containing the fossils

Lithostrotion basaltiforme Owen, *Lithostrotion proliferum* Hall, *Spirifer bifurcatus* Hall, *Mesoblastus glaber* Meek and Worthen, and *Nautilus* species. Although 34.5 feet of the St. Louis are exposed at Mill Springs, it is probable that the overlying covered rock, 80 feet in thickness, is also a part of the St. Louis. Caverns, sink holes and underground drainage characterize this formation. Due to the soil cover, the contact with the overlying St. Genevieve was not observed. The probable line of differentiation is shown on the map (Fig. 1).

ST. GENEVIEVE FORMATION.—Superimposed on the St. Louis at Hannah Hill 1.5 miles southwest of Mill Springs is the Fredonia forma-

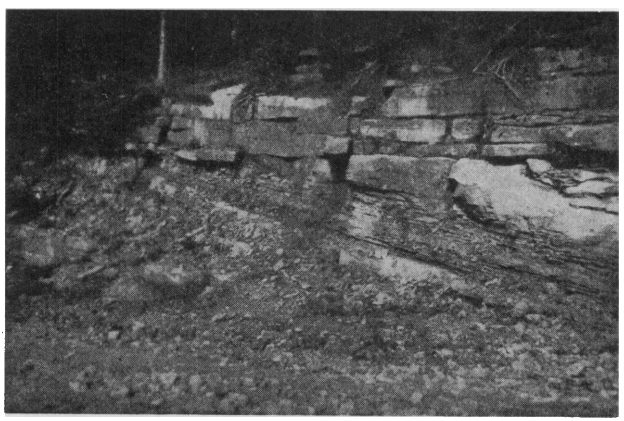

Fig. 4. Local unconformity in the Warsaw beds, Mississippian, on the road between Mill Springs and the University Camp.

tion of the St. Genevieve. Although no contact between the St. Genevieve and the St. Louis was to be seen, it is estimated that the St. Genevieve is 60 feet thick. It is composed of oölitic limestone containing the fossils *Girtyella indianensis* Girty, *Eumetria verneuiliana* Hall and *Lithostrotion harmodites* Edwards and Haime.

CHESTER SERIES.—On the slope of Hannah Hill the Chester is represented by the Gasper and Glen Dean formations totalling a thickness of 146 feet. The Cypress and Golconda formations of this series were not observed. Due to soil cover, the upper and lower contacts of the Gasper, which is a fine-grained crystalline limestone, are difficult to determine. The Glen Dean consists of dark coarsely-crystalline limestone. These formations yielded the fossils *Productus ovatus* Hall,

TABLE OF ROCKS AND FOSSILS OF THE NORTHEAST QUARTER OF THE MONTICELLO QUADRANGLE, WAYNE COUNTY, KENTUCKY

Group	System	Series	Stage	Sub-stage	Characteristics of Rock	Fossils	Thickness in feet
Paleozoic	Pennsylvanian			Pottsville	Yellowish-brown sandstone. Bituminous Pockets		130
	Mississippian	Chester		Glen Dean	Coarse Limestone	*Eumetria vera* Hall *Diaphragmus elegans* Norwood and Pratten	146±
				Gasper	Finely-crystalline limestone	*Productus ovatus* Hall	
		Mammoth Cave	St. Genevieve	Fredonia	Oölitic Limestone	*Lithostrotion harmodites* Edwards and Haime *Eumetria verneuiliana* Hall *Girtyella indianensis* Girty	60±
			St. Louis	Salem?	Hard gray limestone. Cherty veins	*Lithostrotion basaltiforme* Owen *Lithostrotion proliferum* Hall *Spirifer bifurcatus* Hall *Nautilus* species *Mesoblastus glaber* Meek and Worthen	34.5+
			Warsaw		Gray fissile shale Grades into limestone		5.5
					Limestone	*Reticularia pseudolineata* Hall *Spirifer bifurcatus* Hall	13
					Yellow impure limestone. Local unconformity	*Triplophyllum* species	22.5
					Incompact gray shale with brown clay	*Chonetes illinoisensis* Worthen *Pustula biseriatus* Hall	16.5
					Brownish-yellow to gray compact limestone		18
					Gray geodic shale Carbonaceous concretions		16.5

					Gray limestone Weathers to a rough white	*Chonetes* species. *Productus magnus* Meek and Worthen *Rhynchopora cooperensis* Shumard *Spirifer biplicoides* Weller	12
					Gray shale merges into limestone. Two six-inch chert layers at top		21
		Waverly	Ft.Payne		Gray compact limestone lens		5.5
					Gray geodic shale		25.5
					Limestone. Solution cavities in bed of Meadow Creek		11
					Gray nodular impure shale. Cumberland River	*Platycrinus* species	22
			Cuyahoga	New Providence	Greenish-gray crumbly shale Phosphate of lime and carbonate of iron concretions	*Cyathaxonia cynodon* Rafinesque and Clifford *Cliothyridina glenparkensis* Weller *Phillipsia* species *Platycrinus sculptus* Hall	29
			Kinderhook	Sunbury	Black Carbonaceous shale	*Phillipsia* species *Ctenocanthus* species Pisces indeterminable	5
	Ordovician		Richmond		Decomposed material		5
				Saluda	Finely-crystalline gray limestone		12
					Forbush Creek		23.5
				Arnheim	Thin layers of gray limestone Sun-cracks Ripple-marks Intraformational mud conglomerate Miniature cross-bedding Dolomite, calcite and sphalerite in geodes	*Columnaria vacua* Foerste *Platystrophia cypha-conradi* Foerste	56

Diaphragmus elegans Norwood and Pratten and *Eumetria vera* Hall. *Archimedes laxus* Hall and *Prismopora serrulata* Ulrich are diagnostic fossils of the Glen Dean.

PENNSYLVANIAN

POTTSVILLE FORMATION.—Succeeding the Glen Dean is the Pottsville, which consists of a medium-grained yellowish-brown sandstone. On the south side of Hannah Hill there is a bituminous pocket about 8 feet in diameter from which fuel has been dug. This formation, which is 130 feet thick, contains no fossils and caps Hannah Hill.

SUMMARY

The order of superposition, character, thickness, and names of the fossils of each of the beds which have been discussed are summarized in the preceding table.

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