

CAMBRIAN AND LOWER ORDOVICIAN EXPOSURES IN NORTHERN ILLINOIS*

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Drilling in central northern Illinois has revealed the presence of Cambrian and lower Ordovician strata beneath glacial drift in a large area south of the Sandwich fault zone, as shown on the state geologic map (Weller and others, 1945), and one exposure of Cambrian strata at Oregon, Ogle County, Ill., has long been known (Bevan, 1929, 1935, 1939). No other Cambrian exposures and no exposures of lowermost Ordovician have been recognized previously in Illinois.

The present study has shown that exposures west of the area mapped as Cambrian, formerly believed to be of Shakopee, Platteville, or Galena age, actually belong to the Cambrian Trempealeau formation and to the lower Ordovician Gunter and Oneota formations. The area underlain by Cambrian and lower Ordovician rocks has been extended westward from Rochelle nearly to Rock River, and the Sandwich fault zone has been traced west of Rock River (fig. 1). Outcrops near Millbrook, Kendall County, previously assigned to the Galena formation, now are known to be Oneota. The exposures show that at least the lower part of the Trempealeau formation in this region is a reef-type dolomite.

Identification of the formations has been based mainly upon lithology as revealed by samples from wells, but partly upon fauna. The

exposure at Oregon lies near the crest of the Oregon anticline, but all of the remaining exposures are near the crest of a major uplift on the south side of the Sandwich fault zone, herein named the Ashton Arch (figs. 1, 4). The exposures all are located on preglacial bedrock uplands (Horberg, 1950, plate 1, sheet 1). The absence of outcrops between the Fox River and Rochelle is explained by the presence of two major southward-trending preglacial valleys and deposition of a thick Wisconsin morainic belt over the site of the valleys.

STRATIGRAPHY

The exposed pre-St. Peter formations of central northern Illinois are shown in columnar section in figure 2, and are described below.

Franconia formation. — The Franconia formation, the oldest formation exposed in Illinois, is known to crop out only in the lower part of an abandoned quarry 3,700 feet from the north line and 1,100 feet from the east line of sec. 3 (elongate), T. 23 N., R. 10 E., Ogle County (Oregon quadrangle), one-half mile east of Oregon (fig. 1). The exposure is poor and has a total thickness of about 30 feet. It consists mainly of argillaceous, silty, glauconitic and muscovite-bearing, partly dolomitic, greenish-gray sandstone which ranges from very fine grained to coarse grained, but is

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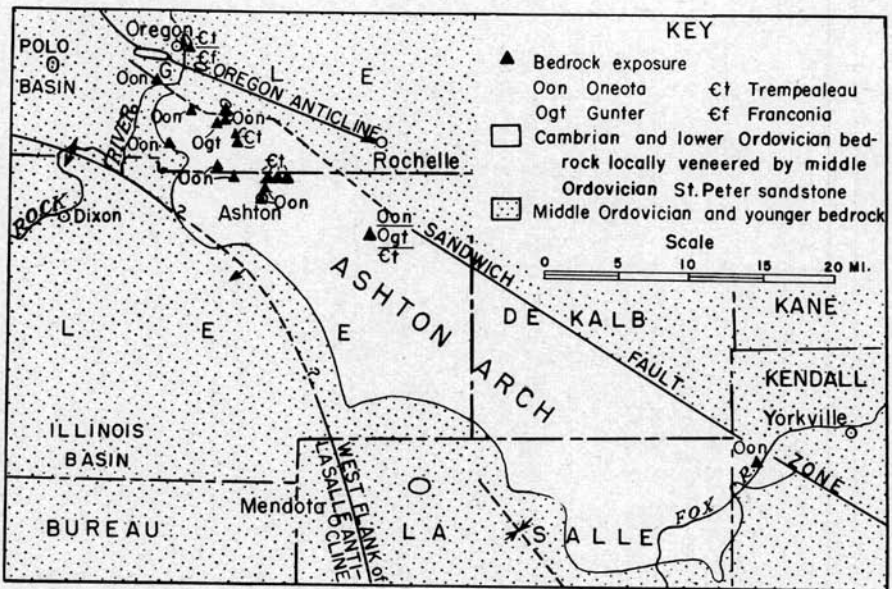


FIG. 1.—Location of Cambrian, Gunter, and Oneota exposures in northern Illinois.

mostly fine grained. The grains are clear and mainly angular, although the medium and coarse grades are rounded. Abundant scattered fine pellets of dark green glauconite give the rock a "salt-and-pepper" aspect. Green glauconitic clay occurs as partings between the beds and as streaks and mottlings within the beds. The heavy mineral suite consists of abundant garnet, with subordinate amounts of tourmaline and zircon. The sandstone is laminated and friable. It is in lenticular to regular beds from a fraction of an inch to 9 inches in thickness. A one-foot bed of impure, buff, chalky dolomite in thin irregular layers is present 20 feet below the top of the formation (fig. 3), and scattered dolomite lenses occur elsewhere. Partings of silty, partly dolomitic, olive-gray, laminated, friable shale are common.

The following fossils from the sandstone, identified by G. O. Raasch, show that the strata belong to the Bad Axe or highest member of the Franconia formation: *Dikelocephalus n. sp.*, *Iliaenurus n. sp.*, *Saukiella minor* Ulrich and Resser, and *Trilobita n. gen. and sp.* In addition, small fragments of oboloid brachiopod shells are common, andropy excremental worm-castings cover many bedding surfaces.

Subsurface data indicate that the Franconia formation, exclusive of Ironton strata, ranges from 65 to 120 feet thick in north-central Illinois. The middle portion of the formation consists of sandy, glauconitic dolomite and limestone, but the lower part is composed of sandstone and sandy dolomite like the higher, exposed beds. A thin, dolomitic, coarsely glauconitic, coarse-grained sandstone, formerly regarded as the

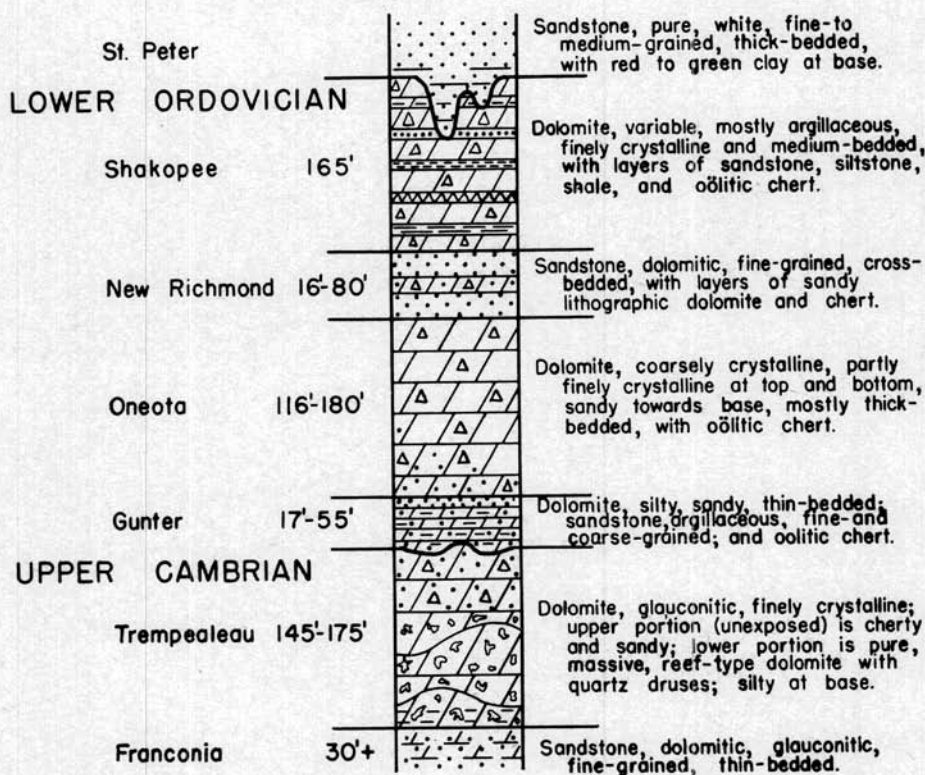


FIG. 2.—Pre-St. Peter formations exposed in northern Illinois.



FIG. 3.—Franconia strata in quarry at Oregon, Illinois; hammerhead is at base of dolomite bed lying 20 feet below top of formation.



FIG. 5.—Trempealeau dolomite in quarry at Prairie Star School, SW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$ Sec. 5, T.22 N., R.11 E., Ogle County, Ill.

basal member of the Franconia, now is considered the top unit of the Iron-ton formation. The Franconia formation is correlated tentatively with the Davis, Derby, and Doerun formations of Missouri (Workman and Bell, 1948, p. 2053).

Trempealeau formation. — Twenty-three feet of basal Trempealeau dolomite overlies Franconia sandstone in the quarry at Oregon. An extension of this exposure is found in a low ridge littered with Trempealeau float $\frac{3}{4}$ mile northwest of the quarry, 500 feet from the north line of sec. 3 and 1,700 feet from the west line. The major Trempealeau exposures found in this study are as follows (fig. 4):

(1) Quarry at Prairie Star School, 7 miles southeast of Oregon, SW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 5, T. 22N., R. 11 E., Ogle County (Dixon quadrangle), where 18 feet is exposed (fig. 5).



FIG. 6.—Trempealeau and Gunter dolomites in quarry south of Rochelle, N. line NE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 26, T. 39 N., R. 1 E., Lee County, Ill.

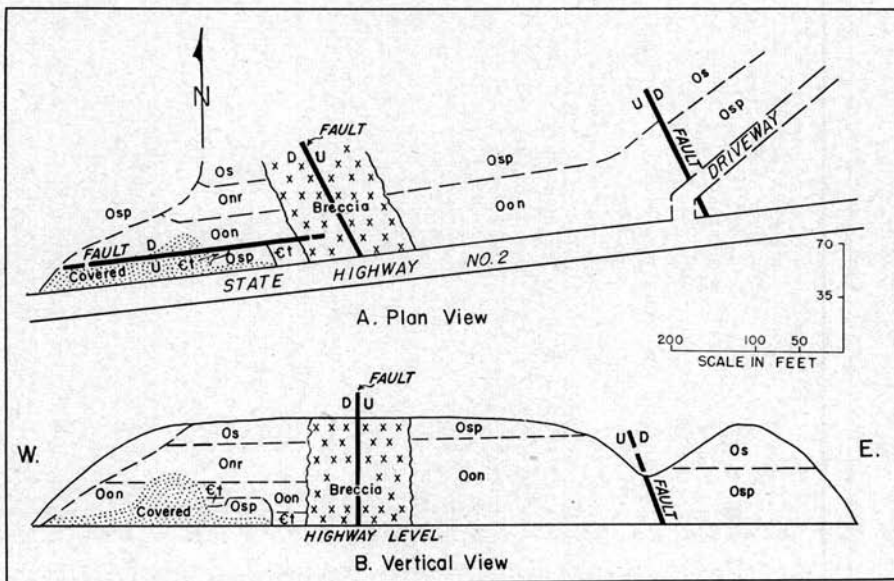


FIG. 7.—Diagrammatic sketch of pre-St. Peter exposures in hill on north side of State Highway No. 2, NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ Sec. 17, T.23 N., R.10 E., Ogle County, Ill. Ct, Trempealeau; Oon, Oneota; Onr, New Richmond; Os, Shakopee; Osp, St. Peter, mainly filling pre-St. Peter channels.

(2) Three quarries $1\frac{1}{2}$ miles northeast of Ashton, NW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 22, SE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 23, and NE corner sec. 23, T. 22 N., R. 11 E., Lee County (Rochelle quadrangle), where 14 to 22 feet of dolomite is exposed.

(3) Quarry 6 miles south of Rochelle, N. line NE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 26, T. 39 N., R. 1 E., Lee County (Rochelle quadrangle), where 6 feet of dolomite is exposed, with 5 additional feet below water level (fig. 6).

(4) Bank on north side of State Highway 2, $2\frac{1}{2}$ miles southwest of Oregon, NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 17, T. 23 N., R. 10 E., Ogle County (Dixon quadrangle), where 4 feet of dolomite is exposed at road level and 3 feet is exposed 15 feet above road level (fig. 7).

A few small outcrops of Trempealeau dolomite occur in the vicinity of the principal exposures (fig. 4). The area has not been mapped in detail, and other outcrops may be present.

The Trempealeau formation is composed of light buff, finely crystalline to medium crystalline, reef-type dolomite, which is finely porous to vuggy, and occurs mainly in irregular beds from 1 to 4 feet thick. The basal beds at Oregon are glauconitic and silty, but the dolomite in the remaining and stratigraphically higher exposures is pure. Many vugs are lined with white to pink crystalline quartz which readily differentiates the Trempealeau from other formations in this region. In places the bedding disappears into or is draped over structureless columnar

masses of dolomite more than 10 feet thick, which are interpreted as reef-cores of algal origin. Weathered bedding surfaces commonly are covered with a network of low, narrow, vertically-sided ridges, and weathered faces are marked by narrow, irregular, vertical flutings; these phenomena also may be of algal origin. The rock contains algal domes and rare trilobite and gastropod remains. G. O. Raasch has identified the following forms: *Cryptozoon* sp. *Hypseloconus* sp. nov., and *Saukiella* sp., cf. *indenta* Ulrich and Resser.

In the subsurface of central northern Illinois the Trempealeau formation ranges from 145 to 175 feet thick where not reduced by pre-St. Peter erosion. It consists of (1) a lower, partly glauconitic dolomite containing quartz-lined vugs, without disseminated sand except in places at the base, and (2) an upper, cherty, mostly sandy dolomite which lacks quartz-lined vugs and commonly is non-glauconitic. All of the exposed Trempealeau belongs to the lower unit, which is correlated with the Potosi formation of Missouri (Workman and Bell, 1948, p. 2053) and with the St. Lawrence and Lodi members of the Trempealeau formation in Wisconsin.

South of the area of Trempealeau exposures glauconite in the lower unit occurs in three discontinuous zones of irregular thickness (Willman and Payne, 1942, pp. 56-57). The upper unit apparently is not exposed. Although it is encountered in wells at Ashton and Dixon, Lee County, it lenses out northward and is absent at Rochelle and elsewhere in Ogle County. The upper unit is

correlated with the Eminence formation of Missouri (Workman and Bell, 1948, p. 2053) and with the Jordan and Madison members of the Trempealeau formation in Wisconsin. Continuous subsurface tracing of the Illinois Trempealeau units into the Wisconsin outcrop area is prevented by the presence of a major westward-trending pre-St. Peter valley just north of the Cambrian exposures, along which much or all of the Trempealeau formation has been removed (Meyer, 1948).

In Wisconsin the Franconia-Trempealeau contact is marked by a diastem (Twenhofel, Raasch and Thwaites, 1935, pp. 1705-1706, 1717), but in the Illinois subsurface, Franconia-Trempealeau relations are conformable and nearly gradational. The contact at Oregon is concealed by a short covered interval. The Trempealeau-Oneota¹ contact in Wisconsin seems unconformable (Twenhofel, Raasch and Thwaites, 1935, pp. 1712, 1718). In the Illinois subsurface the Trempealeau-Gunter contact is abrupt, and in the quarry at Rochelle it is sharp and undulatory, with a relief of six inches. These features, together with the absence of upper Trempealeau (Eminence) strata in Ogle County, suggest that a diastem or unconformity also separates the Trempealeau and Gunter formations in northern Illinois.

Except at Rochelle the exposed Trempealeau is overlain unconformably by St. Peter sandstone or by glacial drift. At Oregon the upper Trempealeau beds in places have

¹ Although the Gunter formation is present in Wisconsin, it has not been differentiated from the Oneota formation.

been leached and altered to siltstone to a depth of at least 4 feet by pre-St. Peter weathering, and just south of the quarry the Cambrian strata abut against a channel-filling of St. Peter sandstone. Post-St. Peter thrust-faulting has altered the sandstone overlying the Trempealeau formation to a quartzite-breccia (Bevan, 1935, p. 384).

Gunter formation.—In wells in central northern Illinois, 17 to 55 feet of impure dolomite and sandstone lies between the Trempealeau and Oneota dolomites. In the past these beds have been variously assigned to the Jordan, Gunter-Jordan, or Oneota formations. Recent studies have shown that they are very similar lithologically to the type Gunter formation of Missouri, and can be traced into that formation; they also can be traced to southern Wisconsin, where they overlie the latest Cambrian Madison sandstone and are included in the Oneota formation. Differentiation of Gunter strata thus involves a slight redefinition of the term Oneota as used in Iowa and Wisconsin. In Minnesota the Kasota and Blue Earth formations (Powell, 1935) probably are equivalent to all or part of the Gunter formation.

Known Gunter exposures in Illinois are confined to the quarry 6 miles south of Rochelle, described above under Trempealeau formation, and to a small exposure in a prospect pit and ravine, NW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 31, T. 23 N., R. 11 E., Ogle County (Dixon quadrangle), 5 miles southeast of Oregon (fig. 4). In the Rochelle quarry (figs. 6, 8) the Gunter formation is 10 feet 3 inches thick, and consists principally



FIG. 8.—Gunter and Oneota dolomites in quarry south of Rochelle, N. line NE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 26, T. 39 N., R. 1 E., Lee County, Ill.

of argillaceous, silty, finely glauconitic, greenish-gray to cream, chalky dolomite which contains very fine muscovite flakes, and is slightly sandy in the lower 2 feet 9 inches. The dolomite is in irregular, laminated beds from 1 to 12 inches thick, separated by green clay partings. Some layers are algal and have highly undulatory bedding surfaces. Irregular masses of oolitic chert are common near the base and middle of the formation. Five feet below the top of the Gunter is a 30-inch bed of buff, medium crystalline, vuggy, cherty dolomite which closely resembles the overlying Oneota formation. The exposure 5 miles southeast of Oregon is very poor, and is composed of eight feet of impure, thin-bedded dolomite like that at Rochelle, but partly maroon. The

Gunter here is overlain by two feet of Oneota dolomite, but no Trempealeau strata are exposed.

In subsurface (Workman and Bell, 1948, pp. 2054-2055) the Gunter formation consists of (1) very fine- to coarse-grained, poorly sorted to locally well sorted, incoherent sandstone, (2) varicolored dolomite which is chiefly chalky to lithographic and dense, and is partly argillaceous, silty or sandy, (3) varicolored, oolitic to locally sandy chert which is principally white to orange, and (4) small amounts of slightly sandy, blue-green and dark-red, laminated, hard, smooth shale.

The sandstone ordinarily is clean and white, but locally is argillaceous and gray-green. The fine sand is angular; the medium and coarse sand is mostly rounded, although some grains have been made angular by secondary crystalline quartz. The poorly sorted sandstone normally contains free, medium to coarse, siliceous oolites. A five-foot bed of argillaceous, fine- and coarse-grained sandstone marks the top of the Gunter in wells between Dixon and Oregon, but lenses out eastward before reaching Ashton.

Small *Cryptozoön* domes in the quarry south of Rochelle are the only fossils observed in Gunter strata.

Oneota formation.—The principal exposures of the Oneota formation in northern Illinois are as follows (figs. 1, 4):

(1) On the west side of Fox River opposite Millbrook, Kendall County, where 12 feet crops out in a stream channel at a breached earth dam, SE $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 8, T. 36 N., R. 6 E. (Sandwich quadrangle); 10 feet is exposed in a small

quarry, SE corner NE $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 8, and 2 feet is exposed in an abandoned quarry, SW corner SW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 9.

(2) In the quarry 6 miles south of Rochelle, where 31 feet is exposed (fig. 8), and in a shallow quarry $\frac{1}{4}$ mile eastward.

(3) At Ashton, Lee County, in three quarries in the NW $\frac{1}{4}$ sec. 27, in two quarries on opposite sides of the road along the north line of the E $\frac{1}{2}$ sec. 27, just east of State Highway 330, and in a shallow quarry in the center of the NE $\frac{1}{4}$ sec. 27, T. 22 N., R. 11 E. (Rochelle quadrangle). Here from 10 to 31 feet of rock is exposed in the individual quarries, and the total stratigraphic interval represented in the quarries exceeds 50 feet.

(4) Shallow quarries 2 and 3 $\frac{1}{2}$ miles northwest of Ashton, W. line NE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 20 and NW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 18, T. 22 N., R. 11 E., Lee and Ogle counties, exposing 8 and 16 feet of dolomite, respectively.

(5) Quarry 5 miles southeast of Oregon, S. line SE $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 31, T. 23 N., R. 11 E., Ogle County, exposing 12 feet of deeply weathered rock.

(6) Quarry and ravine 4 miles south of Oregon, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 26, T. 23 N., R. 10 E., Ogle County, exposing 45 feet of dolomite.

(7) Cut on north side of State Highway 2, two miles south of Oregon, NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 17, T. 23 N., R. 10 E., Ogle County.

(8) Ravine 6 miles south of Oregon, SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 4, T. 22 N., R. 10 E., Ogle County, where 35 feet of dolomite crops out.

Localities 4 through 8 are located in the Dixon quadrangle. A few other small, scattered exposures less than 5 feet thick also occur near the principal localities listed above (fig. 4).

Most of the Oneota formation consists of light-gray to blue-gray, uniformly coarsely crystalline, dense, cherty dolomite in massive beds as much as 15 feet thick. Most individual crystals range from 1 to 2 mm. in diameter, and make the rock the most coarsely crystalline dolomite in the Illinois Paleozoic sequence. Upon weathering the dolomite breaks down into regular, friable, 6- to 24-inch beds with dull brown-gray, coarsely "sandy" surfaces, and the interior turns light buff with white flecks representing decayed cement between the dolomite crystals. Vertical faces generally are regular, although occasional beds have a brecciated or pseudofucoidal structure and a rough face. Bedding surfaces are rough but have low relief. Except for occasional green clay films within the beds the rock is pure. At one locality (No. 8) thirty-five feet of upper Oneota dolomite is mainly finely crystalline and weathers to a coarsely pitted face; these features have not been noted elsewhere and apparently reflect local facies-change.

Basal Oneota strata exhibit considerable differences from the main body of the formation. Much of the lowermost 9 to 10 feet is lithographic to finely crystalline, is in regular 2- to 8-inch layers with smooth bedding surfaces, and weathers deep buff. In the quarry south of Rochelle some boulder-like, algal masses of lithographic limestone are present in

this basal zone; greenish-gray to buff shale partings are common, and the upper 6 inches of the zone are silty and laminated. Here the basal zone represents a transition from Gunter to typical Oneota sedimentation.

Gray, white, and light yellow to pink or red chert, most of which is sandy, oolitic, conglomeratic, or strongly banded, occurs throughout the Oneota formation. In places the chert forms layers, lenses, or spheroidal masses as much as 1 foot thick, but in others it consists of numerous small, irregularly shaped and oriented, angular fragments which locally form a disconnected meshwork within the beds. The lower 12 to 60 feet of the formation ordinarily are finely glauconitic and somewhat sandy; a few sandy streaks are found at higher horizons.

Cryptozoön is present to common in nearly all Oneota exposures and forms conspicuous small domes on the floor of the quarry at Ashton, center NE $\frac{1}{4}$ sec. 27 (part of Locality 3). Gastropod molds preserved mainly in chert from the quarry at Ashton, SW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 22 (part of Locality 3) have been identified as: *Gasconadia putilla* (Sardeson), *Ophileta* sp., *Rhachopea* sp., and *Sinuopea* sp. Identifiable fossils other than *Cryptozoön* have not been seen elsewhere. The fauna is typical of the Oneota formation of Wisconsin and the Gasconade formation of Missouri (Ulrich, Foerste and Bridge, 1930, pp. 186-222; Branson, 1944, pp. 35-47). Correlation of this exposure with cuttings from two Chicago and North Western Railway wells at Ashton (Illinois Geological Survey, sample sets 289 and 402), $\frac{1}{2}$ mile

south, show that the quarry floor is not less than 60 feet above the Gunter-Oneota contact. Part or all of this concealed interval is believed equivalent to the Van Buren formation of Missouri (Workman and Bell, 1948, p. 2056).

The total thickness of the Oneota dolomite in central northern Illinois ranges from 116 to 180 feet. The formation shows pronounced thinning along the crest of the western part of the Ashton arch.

The contacts of the Oneota dolomite with the adjacent Gunter and New Richmond formations seem conformable. Although Payne (Willman and Payne, 1942, pp. 58-59) reports an unconformity between the Gunter ("Jordan") and Oneota formations to the southward, the presence of such an unconformity has not been confirmed by recent studies.

New Richmond formation.—The New Richmond formation superficially resembles the St. Peter sandstone. However, it generally (1) has finer, more angular, less frosted grains, which more frequently are enlarged by secondary crystalline quartz, (2) is less well sorted, (3) contains free siliceous oolites and grains or nodules of chert, (4) has a much higher proportion of heavy minerals, with abundant accessory tourmaline, considerable ilmenite and leucoxene, and some garnet, (5) is much thinner-bedded and more strongly cross-bedded, and (6) is better cemented. It contains beds of lithographic dolomite and dolomite-cemented sandstone, has green argillaceous streaks in the upper part, and has gray, blue, or red shale layers in the lower portion

(Willman and Payne, 1943, pp. 532-533; Workman and Bell, 1948, pp. 2057-2058). In central northern Illinois its thickness ranges from 16 to 80 feet, and increases rapidly to a known maximum of 190 feet at Starved Rock State Park, LaSalle County. It is correlated with the Roubidoux formation of Missouri, which carries the distinctive *Lecanospira* fauna.

Exposures of New Richmond in Illinois previously had been known only along Franklin Creek, Lee County, and Fox River, LaSalle County (Cady, 1920, p. 107; Knappen, 1926, pp. 40-43; Willman and Payne, 1943, pp. 532-533). The present study revealed poor exposures in (1) a small quarry $3\frac{1}{2}$ miles east of Grand Detour, SE $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 9, T. 22 N., R. 10 E., Ogle County (Dixon quadrangle), where 3 feet of sandstone is exposed beneath Shakopee dolomite, and (2) a cut on the north side of State Highway 2, two miles south of Oregon, NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 17, T. 23 N., R. 10 E., Ogle County (Dixon quadrangle), where 11 feet of sandstone, with covered intervals above and below, crops out between Oneota and Shakopee strata. Samples from both outcrops are slightly dolomitic and show the typical New Richmond heavy mineral suites (table 1). It is very probable that other outcrops of New Richmond exist in the northeast quarter of the Dixon quadrangle, where they have not been differentiated from St. Peter sandstone. Because the New Richmond offers little resistance to erosion, exposures not on major stream channels are mostly veneered by soil or Shakopee float.

TABLE 1.—HEAVY MINERAL ANALYSES OF
NEW RICHMOND SANDSTONE IN
NORTHERN ILLINOIS, IN
PERCENT

Locality	1	2	3	4
Garnet.....	3.0	17.0	3.0	0.6
Ilmenite.....	17.0	17.0	20.0	4.4
Leucoxene.....	22.0	10.0	18.0	13.5
Magnetite.....	1.0	6.0	2.0
Tourmaline....	42.0	35.0	36.0	55.5
Zircon.....	12.0	10.0	15.0	26.2
Miscellaneous..	3.0	5.0	6.0
Percent of heavy minerals by weight.....	0.006	0.003	0.006

Locality 1: 5' below top of sandstone in bluff on north side of Franklin Creek, N. line SE $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 34, T. 22 N., R. 10 E., Lee County. *Locality 2:* 2' below top of sandstone in quarry, SE $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 9, T. 22 N., R. 10 E., Ogle County. *Locality 3:* 15' below top of sandstone in bluff on west side of State Highway 2, NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 17, T. 23 N., R. 10 E., Ogle County. *Locality 4:* Average of 19 samples from upper 23 feet of sandstone at ravine mouth, NW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 8, T. 35 N., R. 5 E., LaSalle County. Analyses for localities 1, 2 and 3 by T. C. Buschbach; analyses for locality 4 by Paul Herbert, Jr.

Shakopee formation.—The Shakopee formation consists of irregular, alternating, varicolored beds of dolomite, shale, siltstone, and sandstone, with dolomite greatly predominating. The dolomite shows great variation in purity, color, crystal size, porosity, and bedding. Most of it is argillaceous, silty, sandy, cherty, locally glauconitic, light gray to yellow-buff, chalky to finely crystalline, dense, and thin-bedded. Brecciated and conglomeratic beds are very

common. Bedding surfaces generally are ripple-marked and mud-cracked, and show occasional molds of cubic salt crystals. Beds of relatively pure, medium crystalline dolomite, as much as 18 inches thick, are common in the lower part of the formation. Although such beds locally resemble Oneota dolomite they lack the distinctive chert layers, chert fragments, and coarsely "sandy" weathered surfaces of the latter formation, are thinner-bedded, and contain thin interbeds of typical Shakopee argillaceous dolomite. The chert is mostly oolitic, but partly sandy or conglomeratic. The sandstone heavy mineral suites have a higher percentage of garnet and ferromagnesian minerals than do those of the New Richmond sandstone (Willman and Payne, 1943, p. 535). Several layers of bentonite are present in a quarry in the SW $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 6, T. 23 N., R. 10 E., Ogle County (Oregon quadrangle), 2 $\frac{1}{2}$ miles west of Oregon.

The thickness of the Shakopee in central northern Illinois ranges from zero to about 165 feet, but increases rapidly to more than 600 feet in south-central Illinois. The Shakopee is correlated with the Jefferson City and Cotter formations of Missouri (Workman and Bell, 1948, pp. 2058-2060), although equivalents of younger Missouri formations may be included locally.

The Shakopee dolomite rests conformably on New Richmond sandstone, but is separated from the overlying St. Peter sandstone by a major unconformity.

Known exposures of the Shakopee formation in Illinois are found (1) along the Illinois River and its tribu-

taries from LaSalle east to Utica, LaSalle County (Cady, 1919, pp. 35-36), (2) along Fox River near Sheridan and Millington, in LaSalle and Kendall counties (Willman and Payne, 1943, pp. 534-538), and (3) along Rock River and its tributaries between Franklin Grove, Lee County, and a point 2½ miles west of Oregon, Ogle County. Its distribution in the latter area is shown in fig. 4.

STRUCTURAL GEOLOGY

Ashton arch.—Most of the Cambrian and lower Ordovician exposures described above lie on the crest or flanks of a major anticline which trends N. 60° W. across northern Illinois from central western Will County to central Ogle County, and which is here named the Ashton arch (figs. 1, 4). The name is derived from the town of Ashton, Lee County, which is located near the crest of the western portion of the arch, and near which Cambrian and lower Ordovician formations, brought to the surface by the arch, are well exposed.

The Ashton arch first was recognized by Cady under the name Ogle, Lee, and LaSalle counties anticline (Cady, 1920, pp. 90, 127-128, fig. 8), although later studies modified the original concept of its location and extent. It formerly was considered to mark the crest of the Kankakee arch, a broad uplift which connects the Cincinnati and Wisconsin arches and separates the Illinois and Michigan basins (Pirtle, 1932, p. 149, fig. 1; Ekblaw, 1938). However, it has been found (1) that the pre-St. Peter axis of the Kankakee arch passes through the north-

east corner of Illinois (Bays and others, 1945; Cohee, 1945, fig. 4; Meyer, 1948) and (2) that the post-St. Peter axis (Cohee, 1945, fig. 5; 1948, p. 1441, fig. 1) merges into the east flank of the Hersher anticline which is separated from the Ashton arch by a northward-trending syncline (fig. 9). Accordingly it appears desirable to introduce a separate name, Ashton arch, for the relatively local uplift between Will and Ogle counties.

The Ashton arch is bounded on the north throughout most or all of its length by the Sandwich fault zone. A graben and a syncline separates the western part of the arch from the smaller, parallel Oregon anticline on the north (fig. 4). A syncline also separates the eastern portion of the arch from the LaSalle anticline (fig. 9). The LaSalle anticline merges into the arch along the LaSalle-Lee County boundary, and cannot be distinguished farther north. However, a southward prong of the arch, which may represent a continuation of the LaSalle anticlinal trend, extends northwestward from Dixon to the Savanna-Sabula anticline. The southwestward flank of the Ashton arch dips steeply into the Illinois basin. The western end plunges into the small but deep Polo basin, named herein from the town of Polo, Ogle County, which lies on the west side of the basin.

The Ashton arch has a length of 80 miles and a width of 17 to 25 miles. The structural relief on the southwestern side is about 1,900 feet, and the maximum relief on the northern side at least 900 feet. The axis of the arch is at, or a short distance south of, the Sandwich fault

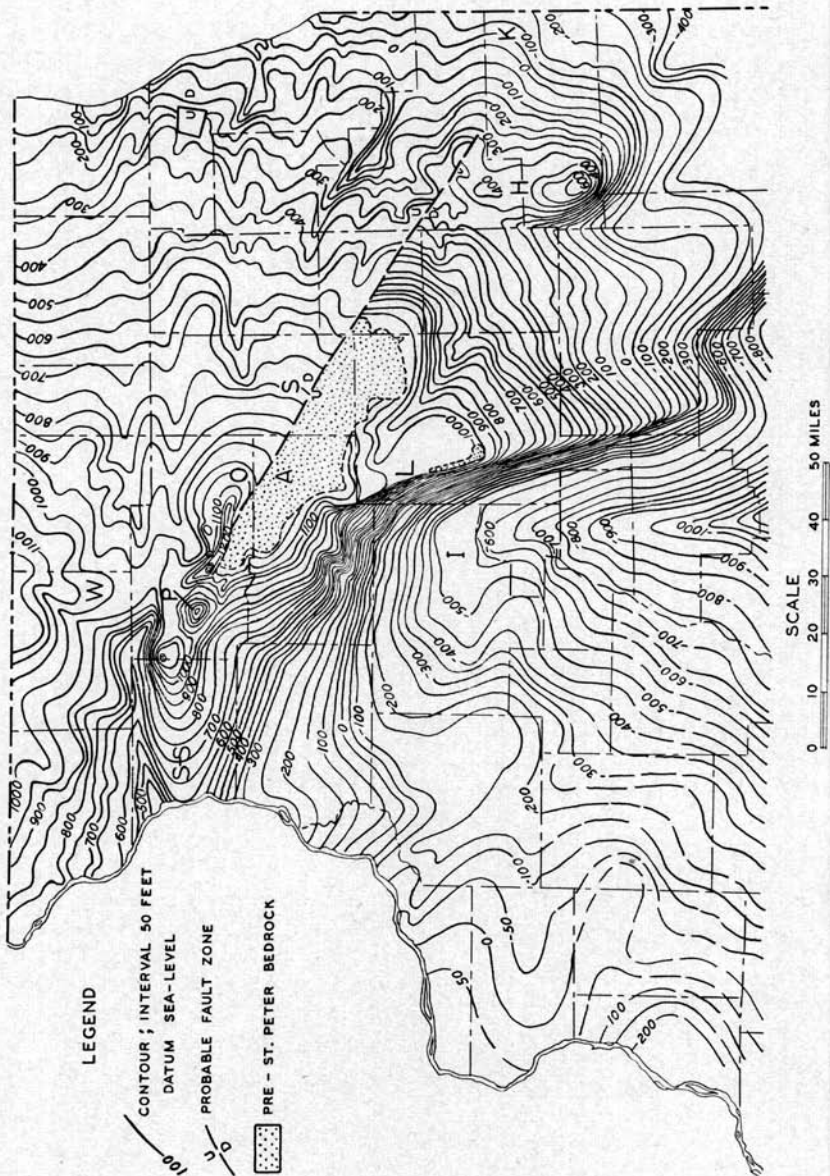


FIG. 9.—Structure contours on top of Galena dolomite in northern Illinois, modified from Horberg, 1946. A, Ashton arch; H, Hersher anticline; I, Illinois basin; K, Kankakee arch; L, LaSalle anticline; O, Oregon anticline; P, Polo basin; S, Sandwich fault zone; S-S, Savanna-Sabula anticline; W, Wisconsin arch.

zone. The arch has a broad, nearly flat summit area, most of which dips very gently southward. The steepest dips on the structure, found on the southwest flank, are only from 1° to 3° .

Sandwich fault zone and Oregon anticline.—The Sandwich fault zone parallels the strike of the Ashton arch and bounds the northeastern side of the arch for most or all of its length. It has been traced from southern Will County to a point in northeastern Lee County 6 miles south of Rochelle, a distance of 68 miles, and probably continues at least 20 miles farther, to a point $2\frac{1}{2}$ miles southwest of Oregon, in central Ogle County (figs. 1, 4, 9). The fault zone has a maximum downthrow of at least 900 feet on the northeast side. Because the fracture appears to be compound rather than single the term fault zone is applied.

Between Rochelle and Oregon the structure on the northeastern or downthrown side of the fault is complicated by a sharp uplift called the Oregon anticline (Bevan, 1935), the crest of which approximately parallels the Ashton arch and Sandwich fault zone and lies from 2 to 3 miles northward from the latter. The Cambrian exposure at Oregon, a small Oneota exposure in the $SE\frac{1}{4} SE\frac{1}{4} NE\frac{1}{4}$ sec. 30, T. 22 N., R. 11 E., Ogle County (Dixon quadrangle), and a Shakopee exposure in the $SW\frac{1}{4} SE\frac{1}{4} NW\frac{1}{4}$ sec. 6, T. 23 N., R. 10 E., Ogle County (Oregon quadrangle), are located on the anticline. The Oregon anticline continues northwestward to join the Savanna-Sabula anticline. A synclinal belt separates the Oregon-Savanna-Sabula anticlines and associated

branch uplifts from the main body of the Wisconsin arch on the north.

A narrow graben and a tightly compressed syncline, bounded on the south by the Sandwich fault zone, separate the Oregon anticline from the Ashton arch (fig. 4). The graben is well exposed in the cut on the Chicago, Burlington, and Quincy Railroad, just south of the center of sec. 7, T. 23 N., R. 10 E., where a dropped block of Galena dolomite is bounded by faults which bring the top of the St. Peter sandstone on the southwest and lower Platteville beds on the northeast to the same elevation as the Galena strata. The throw on the south side of the block is more than 165 feet and that on the north side is over 130 feet. The block is about one-half mile wide and is cut by numerous minor step-faults. Sharp synclinal folding within the graben is well developed in Platteville strata exposed at intervals from the $NW\frac{1}{4} SW\frac{1}{4} SE\frac{1}{4}$ sec. 26, T. 23 N., R. 10 E., to the $NE\frac{1}{4} NW\frac{1}{4} NE\frac{1}{4}$ sec. 31, T. 23 N., R. 11 E., Ogle County (Dixon quadrangle), where northward dips range from 2° to 10° and southward dips from 14° to 30° .

Structural history. — The major movement along the LaSalle anticline in northern Illinois was post-Mississippian, pre-Pennsylvanian, followed by lesser uplift in post-Pennsylvanian time (Payne, 1939). On the Ashton arch, Sandwich fault zone and Savanna-Sabula anticline, and probably on the Oregon anticline as well, the principal movement was at least post-Silurian, and may have taken place at about the same time as uplift on the LaSalle anticline. It is uncertain whether the

Ashton arch owes its present form solely to downthrow along the northern side of the Sandwich fault zone, or whether the arch formed prior to the faulting.

The general northwestward to westward structural grain of northern Illinois (fig. 9) is affected by subordinate northeastward-trending cross folds of uncertain age. It is possible that the post-St. Peter Kankakee arch of northwestern Indiana, uplifted mainly in post-Pennsylvanian time, once was continuous with the Ashton arch, but was separated from it by later cross folding.

There is considerable evidence for pre-St. Peter deformation in the area occupied by the Ashton arch, although generally it cannot be proved that the trend of the deformation paralleled that of the present structure. Upper Trempealeau (Eminence) strata thin or wedge out northward over the arch, but reappear in northernmost Illinois and southern Wisconsin, across a major pre-St. Peter valley. The Oneota formation thins conspicuously over at least the western part of the arch, parallel to its general trend. The earlier movements culminated in uplift, folding, and erosion in post-Shakopee, pre-St. Peter time. At places in Lee and Ogle counties Shakopee strata are thrown into close folds which do not affect the overlying St. Peter sandstone (Knappen, 1926, pp. 83-84, 111); although formerly attributed to pre-St. Peter slumping, the folding is considered diastrophic by the writers. Along Fox River in LaSalle and Kendall counties the Shakopee shows steep dips which do not accord with the gentler post-St. Peter

structure in amount or direction (Willman and Payne, 1943, fig. 1). At Oregon, Ogle County, a post-Shakopee, pre-St. Peter fault cutting Cambrian strata has a downthrow of 285 feet on the western side. Where adequate subsurface control is available the interval between the top of the Glenwood formation and pre-St. Peter horizons in central northern Illinois shows sharp irregularities which cannot be explained by variation in the thickness of the formations, and which are attributed to post-Shakopee, pre-St. Peter deformation. Unfortunately the amount or trend of such deformation along most of the Ashton arch cannot be estimated because (1) the deeply incised pre-St. Peter drainage system makes the base of the St. Peter valueless for structural control, and (2) erosion has stripped away the post-St. Peter formations.

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