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Conclusions

The proposed geological situation producing the Vincennes magnetic anomaly was obtained by a method which involves computing the magnetic field of a model rock mass and comparing it to the observed magnetic field. The interpretation of magnetic data is inherently ambiguous owing to the fact that an infinite number of combinations of magnetic susceptibility, depth of burial and geometric configuration of the body can produce the same observed magnetic field. The depth to the top of the Precambrian surface and presumably also the top of the body producing the magnetic anomaly is known from diamond drilling, however, and consequently reasonable values can be calculated for the approximate geometric configuration and the magnetic susceptibility of the rock mass.

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The Lime Creek Formation in the Area of Garner, Iowa[1]

Donald L. Koch

Abstract. The rock exposed in quarries southwest of Garner, Iowa, has been in question as to its stratigraphic position, having been correlated with both Middle and Upper Devonian formations with no supportng evidence. Stratigraphic control was established by comparing lithologies present in the Cedar Valley, Shell Rock, and Lime Creek formations in exposures and noting the changes that occur in the subsurface through a detailed study of well cuttings. Lithologic and paleontologic evidence supports a Lime Creek correlation.

[1] Presented with the permission of Dr. H. Garland Hershey, State Geologist and Director of the Iowa Geological Survey.

This study is presented in order to clarify the exact stratigraphic positioning of the rock sequence as exposed in a quarry southwest of Garner, Iowa, in the SE corner, Sec. 11, T. 95N., R. 24W. Various ideas have been expressed in the past, but for the most part little has been offered to substantiate them. A single similar characteristic might seem to indicate a Shell Rock or Lime Creek correlation to some, or Shell Rock and Cedar Valley to others. The evidence offered here appears to leave little doubt that the quarry exhibits the Owen and Cerro Gordo members of the Lime Creek formation.

Previous Work

Notice of this area was first made by Michael (1). The quarry face and several combined cores constituted the following composite section given in his report:

Bed No.	Description	Thickness in Feet
00	Overburden: brown silty clay loam	13–34
	Devonian system	
	Shell Rock formation	
	Mason City member	
1	Dolomite, calcitic, somewhat brecciated, light brown with redish cast mottled with gray, brecciated appearing in hand specimen, very hard, medium grained to coarse, calcite masses and green clay partings common, slightly arenaceous, few crinoid and tetracoral remains; beds average 0.7 foot thick.	0–3.1
2	Dolomite, calcitic, light gray-brown, very hard, fine grained, calcite masses, few crinoid fragments and tetracoral molds; beds average 0.2 foot thick.	1.8–3.5
3	Dolomite, calcitic, similar to bed No. 1 gray-brown mottling more apparent; beds become slightly thicker averaging 0.8 foot thick; bottom of unit very irregular with green clay on bedding plane.	9.7–11.0
4	Dolomite, calcitic, dark gray to black, very hard and dense, calcite masses, high pyrite content; grades into bed below without any abrupt change.	0.6–0.9
	This level is the present floor of the quarry.	
5	Siltstone and dolomite: ±3.0 feet	
	a. Siltstone, greenish-gray, argillaceous, slightly calcitic; grades into lower bed.	1.6
	b. Dolomite, calcitic, dark gray-brown mottled with black, very hard, fine grained; full of drusies, lenses of siltstone and mudstone run through rock, pyrite common.	0.8
	c. Dolomite, calcitic, light brownish-gray, hard, very fine grained, silty, pyrite common.	0.5–0.8
6	Dolomite, calcitic, brecciated, gray-brown mottled with various shades of gray, brown and white; recrystallized. Zones of limestone and white calcite masses, lenses of gray-green finely fragmental dolomitic limestone, lenses of cream-colored lithographic limestone, light green siltstone and shale on bedding planes; sparsely distributed crinoid and tetracoral fragments; bedding is uneven with various thicknesses of beds up to 1.5 feet thick.	±18.0
7	Dolomite, calcitic, gray-brown mottled with gray and black, medium hard, argillaceous, pyrite common; num-	

	erous unidentified small finely liarate brachiopod casts.	2.7
8	Siltstone, gray-green with some brown and black color mottling, some lensatic brown calcitic zones; brachiopods of overlying bed continue.	2.7
9	Dolomite, very similar in appearance to bed No. 6, brachiopods of overlying beds continue; grades into a dark brown silicified stone becoming argillaceous at bottom.	4.9
10	Siltstone, gray-green, very similar in appearance to bed No. 8 becoming almost a mudstone at bottom; brachiopods of overlying beds continue.	9.5

Due to the lack of any nearby stratigraphic control or any established faunal sequence, the correlation was tentatively given as the Mason City member of the Shell Rock formation for beds 1-5, and possibly the lower Mason City or upper Cedar Valley formation for beds 6-10.

Present Study

The author first visited the quarry during the summer of 1962, when the floor of the quarry was near the base of bed 6. An excellent fossil fauna was collected from beds 1-6, yielding enough variety of forms to correlate this section with the Lime Creek formation.

Correlation is not dependent upon the fauna alone, however, as the lithology is very distinctive. It is not a lithology that one might necessarily be familiar with by comparing it with the Lime Creek where it can be observed in exposures to the east in Cerro Gordo county. But by following the changes that occur in the subsurface through a close study of well cuttings, one can readily recognize it as it occurs in the vicinity of Garner.

C.L. & M.A. Fenton 1923		
Hackberry Stage	Owen Substage	Acervularia zone
		Floydia zone
		Idiostroma zone
	Cerro Gordo Substage	Spirifer zone
		Striatula zone
Sheffield formation*		

*(now recognized as Juniper Hill)

Figure 1. Nomenclature of the Hackberry Stage (after Fenton & Fenton).

Paleontology

Recrystallization and dolomitization have destroyed most of the fossils in this area; consequently, they are rarely observed in well cuttings, cores, or exposures, at least in abundance enough to establish a faunal sequence. In this regard, the excellent fauna collected at this site is unique. Preservation is in the form of detailed casts and internal molds. All specimens were studied and compared with those described by Fenton and Fenton (2), and are maintained in the files of the Iowa Geological Survey. The nomenclature of the Hackberry Stage is given in figure 1.

Fossil specimens identified are as follows; bed numbers refer to Michael's generalized section given above:

Specimens from beds 1–3

a. *Idiostroma*
These beds are crowded with small, branching stromatoporoids belonging to the indefinite genus *Idiostroma.* They are representative of the Idiostroma zone, the lowest zone of the Owen.

b. *Tabulophyllum* sp.
A few poorly preserved *Tabulophyllum* species are present in bed 3. Species of this genus are present throughout the Spirifer zone and the lower Owen.

Specimens from bed 5 (units b and c)

a. *Pachyphyllum woodmani*
This species is relatively rare in this bed. It is absent in the Striatula zone, very abundant in the Spirifer zone and continues up through the Hackberry.

b. *Schizophoria iowaensis*
This is by far the most abundant form in this bed. The species appears in the lowermost Striatula faunule, becomes very abundant in the Spirifer zone, and disappears in the Owen.

c. *Spirifer hungerfordi*
A few specimens of this species may be found in this bed. *Spirifer hungerfordi* is common in the Spirifer zone, but uncommon to rare in the Owen.

d. *Spirifer whitneyi subsidus* (Fenton & Fenton)
This species is relatively rare. It occurs throughout the middle of the Spirifer zone and probably in the upper part as well.

e. *Spirifer whitneyi* Hall
One unidentified varietal form was found. This species occurs throughout the Hackberry, but is most abundant in the Spirifer zone.

f. *Atrypa rockfordensis?*
This form is quite common in this bed. It is abundant throughout the Spirifer zone.

g. *Floydia gigantea*
Specimens are comparatively few and represent immature forms. This species is common in the Spirifer zone and in the Owen.

h. *Cranaenella calvini*
Two specimens of this species were found. It occurs throughout the Spirifer zone.

Specimens from bed 6

a. *Tabulophyllum ehlersi* (Fenton & Fenton)

Specimens are rare in this bed. It is present throughout the Spirifer zone and lower Owen.

b. *Pachyphyllum woodmani*
This form is abundant in the top 3 feet of this bed. It appears in the lower Spirifer zone and continues throughout the Hackberry; generally replaced by varietal forms in the Owen.

c. *Laminar stromotoporoids?*
Much of this bed appears to contain recrystallized laminar stromotoporoid colonies, indicative of the Strophonella faunule within the Spirifer zone. At Bird Hill the Strophonella faunule contains abundant *Spirifer* species, stromotoporoids, and *Pachyphyllum.*

The fossil fauna described above compares most favorably with that of the Lime Creek. The *Idiostroma* in beds 1-3 clearly define the Owen in relationship to the lower beds. The majority of specimens from beds 5 and 6 are those that are present primarily in the Spirifer zone (Cerro Gordo) and are absent or rare in the Owen.

Well-Log Correlation

Correlation with well logs (fig. 2) also supports a Lime Creek relationship for the sequence of rocks at this quarry. Samples from well cuttings show that the lithology is somewhat changed from that shown at Bird Hill and Hackberry Grove (2) as a result of an increase of carbonate over shale and dolomitization.

A detailed log of the Garner town well as is follows:

Description	Thickness (feet)	Depth Range (feet)
Pleistocene System		
Undifferentiated beds	79	0–79
Devonian System		
Lime Creek formation		
Cerro Gordo member		
Dolomite, grayish-orange pink (5 YR 8/2) stromotoporoidal (?), and dark yellowish-brown (10 YR 4/2) to dusky yellowish-brown (10 YR 3/2), finely to coarsely crystalline, hard; and very light-gray (5 Y 7/1), finely crystalline, very argillaceous, shaley dolomite; crystalline calcite.	6	79–85
Dolomite, pale yellowish-brown (10 YR 6/2) to dark yellowish-brown (10 YR 4/2) and dusky yellowish-brown (10 YR 2/2), medium crystalline; some grayish-orange pink (5 YR 8/2), finely to very finely crystalline	9	85–94
Shale, light greenish-gray (5 GY 8/1), silty, very calcareous to dolomitic, soft	1	94–95
Dolomite, light olive-gray (5 Y 6/1), finely crystalline, argillaceous	5	95–100
Dolomite, light gray (N7) to very pale yellowish-brown (10 YR 7/2), finely crystalline, medium hard to hard; some finely disseminated pyrite	5	100–105
Dolomite, very light olive-gray (5Y 7/1),		

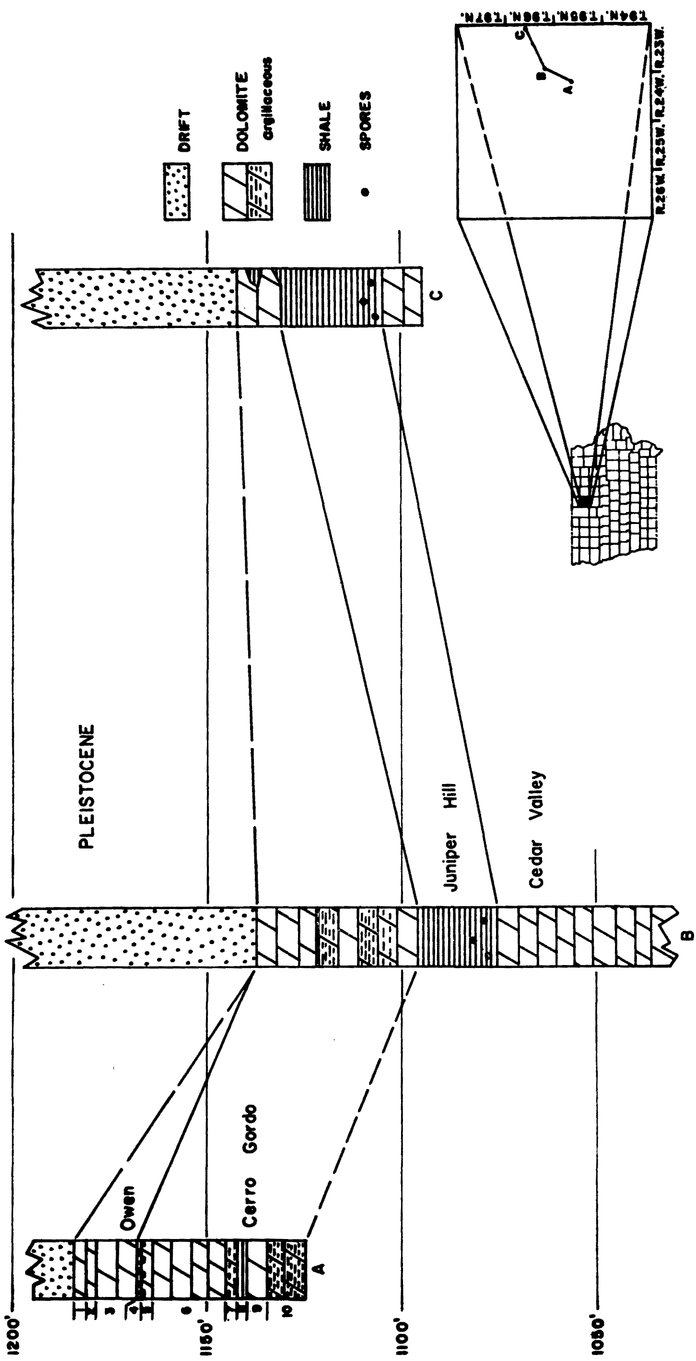

Figure 2. Cross-section, Garner area from southwest to northeast. (A) Michael's section, modified by Koch; (B) Garner town well, SW¼ sec. 30, T. 96N., R. 23W.; (C) Domestic well, E¼NE¼, Sec. 13, T. 96N., R. 23W. Consideration should be given to any changes in direction of dip and the possibility of any minor structural high in correlating these units.

finely crystalline, very argillaceous, soft; shale, very light olive-gray (5 Y 7/1), slightly silty, dolomitic (less than 5%)	5	105–110
Dolomite, brownish-gray (5 YR 5/1), finely crystalline, very slightly argillaceous, slightly porous; fragment of brachiopod mold	5	110–115
Dolomite as above (20%); and yellowish-gray (5Y 8/1) to very light olive-gray (57 7/1), finely crystalline, very argillace-, ous, shaley, soft dolomite	5	115–120
Juniper Hill member		
Shale, very light olive-gray (5Y 7/1), lumpy, dolomitic, very soft; fossil spore carps in lower 10′	21	120–141
Cedar Valley formation		
Dolomite, light gray (N7) to pale orange (10 YR 7/2), medium to coarsely crystalline with trace of embedded quartz sand; trace of moderate yellowish-green (10 GY 6/4) clay	4	141–145
Dolomite, light gray (N7) to medium light-gray (N6) and very pale orange (10 YR 8/2), medium to finely, some coarsely crystalline; calcite	5	145–150
Dolomite, very pale yellowish-orange (10 YR 9/2) to pale yellowish-brown (10 YR 6/2), medium to finely and very finely crystalline, slightly mottled with calcite; and light greenish-gray (5G 7/1), finely crystalline, slightly clayey dolomite (less than 10%)	5	150–155
Dolomite, light greenish-gray (5G 7/1), finely to medium crystalline, very clayey; and yellowish-gray (5Y 8/1) to very light olive gray (5Y 7/1), sublithographic, very dense, dolomite; and very pale orange (10 YR 9/2), medium to coarsely crystalline dolomite (10 to 15%); calcite	5	155–160
Dolomite, yellowish-gray (5Y 8/1), faintly mottled with light gray (N7), medium to coarsely crystalline, porous, individual rhombs weakly cemented	5	160–165
Dolomite, yellowish-gray (5Y 8/1) to very pale orange (10 YR 9/2), coarsely crystalline, 20% disseminated rhombs; about 7% mixed with moderate yellowish-green (10 GY 6/4) clay	10	165–175
Dolomite as above and very light-gray (N8) to medium light-gray (N6), sublithographic to very finely crystalline dolomite (less than 5%); trace of very pale yellowish-brown (10 YR 7/2), very finely crystalline, dense dolomite	5	175–180
Dolomite, very pale yellowish-brown (10 YR 7/2), very finely to finely crystalline (80%); and light greenish-gray (5GY 7/1), medium to finely crystalline, slightly clayey dolomite.	5	180–185
Dolomite, pale yellowish-brown (10 YR 6/2), finely crystalline, calcareous; interstitial calcite and white, crystalline calcite	5	185–190

At this location the Owen member of the Lime Creek formation has been completely eroded. (figure 2). Bedrock here is equivalent to bed 6 of Michael's section, with 15 feet of similar lithology occurring in this well (79-94′). The stromotoporoid-like dolomite in this interval is probably the "brecciated gray-brown dolomite" described by Michael (1). This same heavy, strom-like bed as seen in the quarry might be thought of as "brecciated" in appearance in a core, since there seems to be repeated depositional interruption of colony growth.

Restudies of additional wells in this area, along with the Garner town well, show an increasingly argillaceous carbonate sequence, with variable small intervals of dolomitic shales before penetrating the Juniper Hill shale. It should be noted that the "siltstone" referred to in beds 5a, 8, and 10 of Michael's section is a textural term, and the units are actually very argillaceous dolomites and/or dolomitic shales rather than quartz siltstone. If bed 10 is an argillaceous dolomite the Juniper Hill shale should be the next unit encountered. When the full thickness of this shale has been penetrated, crushed spore carps are found to persist in the lower 10 feet and have proven to be an excellent subsurface stratigraphic marker.

Conclusion

There can be little doubt that the sequence of beds at this quarry is the Owen and Cerro Gordo members of the Lime Creek formation. In the quarry face the Owen is represented by the Idiostroma zone (beds 1-3), and the Cerro Gordo is represented by the Spirifer zone (beds 4-6). Beds 7-10 would then be equivalent to the Striatula zone. The brachiopods described by Michael (1) in beds 7-10 are probably *Atrypa* sp. similar or identical to those that occur throughout the lowest division of the Hackberry (Striatula zone). A concentrated subsurface study of the Shell Rock formation indicates that the Lime Creek formation at Garner and at the quarry is beyond the southern margin of the Shell Rock depositional basin and lies directly upon the Cedar Valley formation.

Acknowledgements

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