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Resolving Discrepancies Between Surface and Subsurface Studies of the Maquoketa Formation of Northeast Iowa[1]

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Abstract. The Maquoketa formation in the outcrop area has been assigned a maximum thickness of 257 feet by earlier surface workers. Recent subsurface study in the same area reveals a thickness of 300-320 feet of Maquoketa sediments. Until now the correlation of subsurface units to recognized surface members has been hampered by this discrepancy.

The recognition and identification of a new unit in the Elgin member of the Maquoketa formation, and a greater measured thickness of the *Isotelus* zone has resolved this difference.

The Maquoketa formation has been the subject of detailed surface study since Owen (1839) investigated the mineral lands of Iowa, Illinois, and Wisconsin. Exposures of the Maquoketa formation in Northeast Iowa have been studied by Savage (1904), Calvin (1905), Ladd (1928), Huffman (1941), Feulner (1953), Agnew (1955), and others. The Maquoketa shales were separated first by Calvin (1905) into the following distinct members, the type sections of which are located in northeast Fayette County and southwest Winneshiek County:

Maquoketa formation
- Brainard member
- Ft. Atkinson member
- Clermont member
- Elgin member

Ladd (1928, pp. 332-333) states: "Savage's General Section of the Maquoketa as developed in Fayette County . . . seems applicable to the entire Northwest Area (of the Maquoketa outcrop belt). The names of the members have been added to the section as originally published by Savage (1904, pp. 484-486)."

Ladd describes the members of the Maquoketa formation in detail and gives a maximum thickness of 257 feet for the formation. This section has been used since then as the basis for most of the studies of the Maquoketa formation.

Samples of cuttings from wells drilled in the Maquoketa outcrop area reveal a thickness of 300-320 feet of Maquoketa carbonates and shales as opposed to the 257 feet as given by Savage and Ladd. The additional portion of the section has, for a number of years, been a

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

problem for subsurface workers trying to conform to the classic surface sections and has hampered the recognition of member units and the correlation of these subsurface units with recognized surface sections. Some workers have failed to recognize the Clermont shale and have included it as a part of the Ft. Atkinson member along with a portion of the upper Elgin limestones, thereby dividing the Maquoketa formation into the Brainard, upper and lower Ft. Atkinson, and Elgin members; others have considered a facies change in the Clermont member, and still others have proposed the introduction of a new member.

The writers spent two weeks in the fall of 1958, in southwestern Allamakee, southern Winneshiek, northern Fayette, and northwestern Clayton counties (Figure 1) examining and correlating

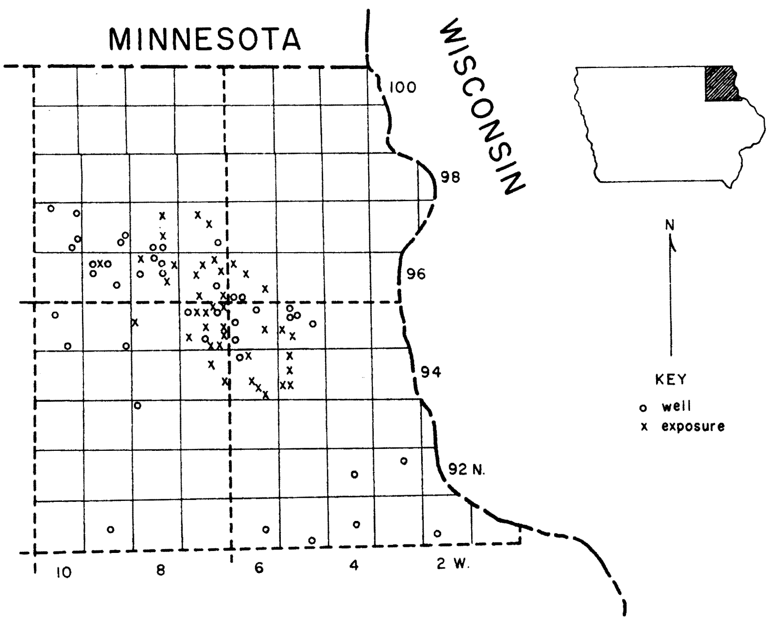
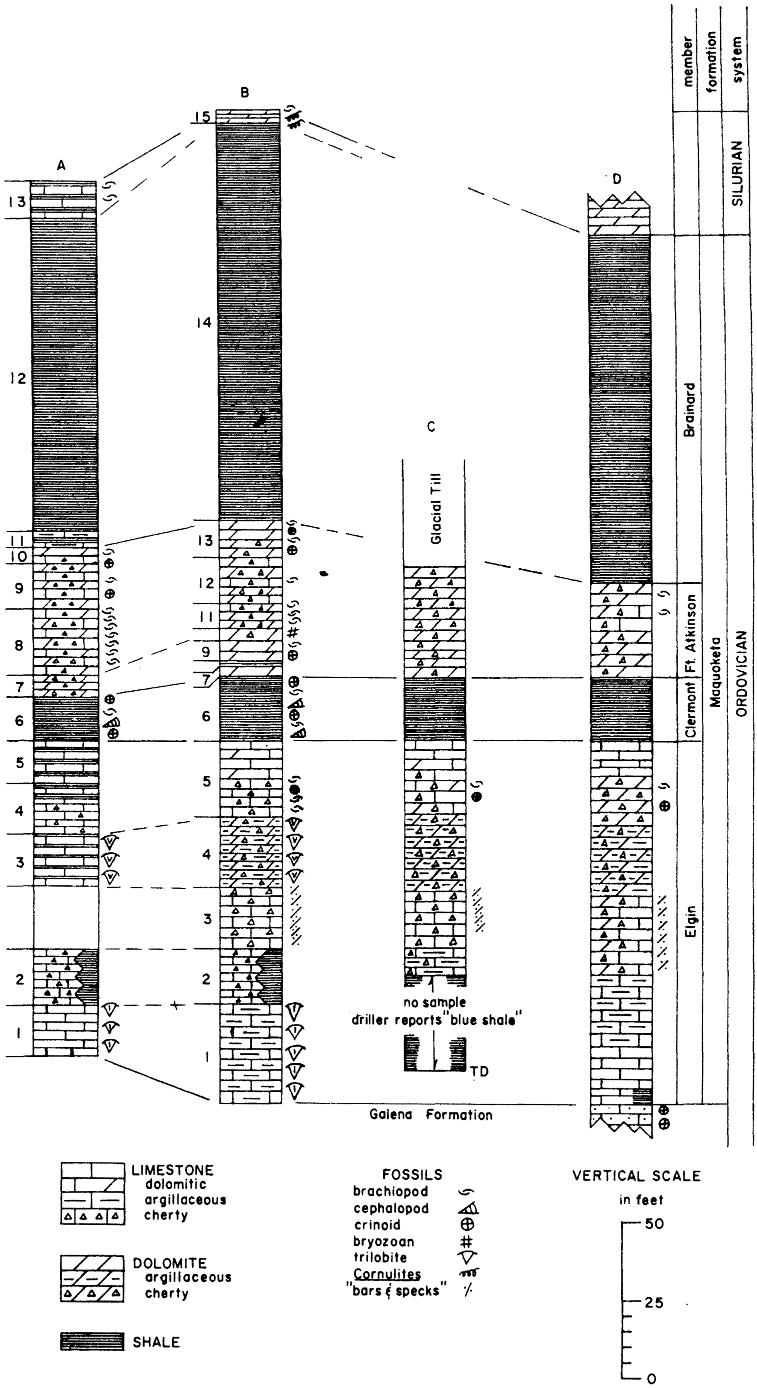


Figure 1. Index map of Winneshiek, Allamakee, Clayton, and Fayette counties showing location and distribution of wells and exposures utilized for this report.

strata of Ordovician Age in quarries and outcrops as a field check for a structural mapping program. The discrepancy between the results of the work of the subsurface and surface stratigraphers was noted early in the present field work, and a search for the missing portion of the surface section was begun.

The missing 40-50 feet were revealed along roadside and stream exposures in sections 8 and 9, T. 95N., R. 7W., northwest of Clermont, Fayette County. Here the Ft. Atkinson, Clermont, and Elgin members of the Maquoketa formation were recognized in a nearly


A
B
C
D
member
formation
system
SILURIAN
Brainard
Ft. Atkinson
Clermont
Elgin
Maquoketa
ORDOVICIAN
Glacial Till
no sample
driller reports "blue shale"
TD
Galena Formation
LIMESTONE
dolomitic
argillaceous
cherty
DOLOMITE
argillaceous
cherty
SHALE
FOSSILS
brachiopod
cephalopod
crinoid
bryozoan
trilobite
Cornulites
"bars & specks"
VERTICAL SCALE
in feet
50
25
0

uninterrupted exposure. Forty feet of Ft. Atkinson dolomites and chert and 20 feet of Clermont shale are exposed in the road cut in the SE¼ NW¼ sec. 8, T. 95N., R. 7W. The Clermont-Elgin contact and 117 feet of Elgin dolomites and shales can be observed along a tributary of Fitzgerald Creek from the center of the SE¼ section 8 to the center of the SW¼ section 9, T. 95N., R. 7W. The *Isotelus* beds are also exposed along the road in the SE¼ section 10 of the same township and the Dubuque beds are visible in close proximity in the valley wall of Dibble Creek. Portions of the members and contacts with each can be seen in a number of other exposures, but this locality presents the most complete section of the Elgin member.

The general section as described by Savage (1904) and Ladd (1928) is presented here as well as the composite section of Parker, Dorheim, and Campbell for comparison. The graphic representation of these sections as well as logs from two typical wells are shown in Figure 2.

General Section of the Maquoketa Shales
Savage and Ladd

Brainard member	
13. Bed composed of bands of soft, bluish-gray shale, two to four inches in thickness, which alternate with thin layers of limestone one to three inches in thickness, having a band of reddish shale two feet in thickness at the base. These materials are fossiliferous throughout.	8- 12′
12. Bed of blue colored, plastic shale, without distinct planes of bedding; containing small concretions of iron pyrites in the upper part and numerous large crystals of selenite below; bearing no fossils.	95-100′
11. Transition beds from the Middle to the Upper Maquoketa; consisting of layers of yellowish areaceo-magnesian limestone, three to eight inches in thickness, alternating with bands of dry, indurated, impure shale; without fossils.	3- 5′
Total thickness Brainard member	117′
Ft. Atkinson member	
10. Massive bed of yellow colored limestone, which in some places is dolomitic, sometimes showing indistinct planes of bedding that separate the ledge into perfect layers, six to twelve inches in thickness; bearing few fossils, and occasional concretions of chert.	5′
9. Bed of impure limestone (in some places dolomitic) made up of quite regular layers, two to six inches in thickness; containing a large quantity of chert in the form of nodules and imperfect bands; bearing fossils.	12- 14′

Figure 2. Generalized graphic sections. (A) Composite surface sections; Savage and Ladd, from several locations in Fayette County. (B) Composite surface section; Parker, Dorheim, and Campbell, along tributary of Fitzgerald Creek SE¼ section 8 and SW¼ section 9, T. 95N., R. 7W., and in the Eldorado road cut NE¼ section 18, T. 95N., R. 8W. (C) Well; Carmie Peterson property, SE¼ NW¼ section 8, T. 95N., R. 7W. (D) Well; Fayette County Home, center of section 6, T. 93N., R. 8W.

8. Bed of fine-grained, impure limestone, in even layers six to ten inches in thickness, consisting largely of chert nodules imbedded in the layers, or of chert bands segregated along the planes of bedding; containing large individuals of several types of brachiopods.	18- 21′
7. Massive bed of yellow colored, fine-grained dolomite, which in some places is divided into thin layers; containing a number of chert nodules.	5- 7′
Total thickness Ft. Atkinson member	47′
Clermont member	
6. Bed of bluish colored, plastic, rather fine-grained shale; in places containing numerous fossils.	10- 14′
Total thickness Clermont member	14′
Elgin member	
5. Bed of lean, yellowish-gray shale, in places somewhat arenaceous; containing, in the lower part, thin bands of impure limestone, three to six inches in thickness.	10- 13′
4. Bed composed of layers of yellowish-gray shale, three to six inches in thickness, separated by bands of impure limestone about equal in thickness to the seams of shale, becoming more calcareous below; bearing numerous nodules of chert.	14- 16′
3. *Vogdesia* beds*,; consisting of a bed of gray colored limestone in layers one to four inches in thickness, which are separated from one another by thin bands of gray shale.	13- 16′
2. Bed of bluish or yellowish colored shale, usually dry and indurated, in layers two or three inches in thickness, between which thin bands of limestone or irregular seams of chert nodules are intercalated.	15 18′
1. *Isotelus iowensis* zone**; composed of layers of bluish, fine grained argillaceous limestone, four to eight inches in thickness, alternating with bands of bluish-gray shale about the same thickness as the calcareous layers. The indurated materials break with a smooth fracture and contain very abundant fragments of the trilobite *Isotelus iowensis.*	14- 16′
Total thickness Elgin member	79′
Total thickness Maquoketa formation	257′

*Formerly called the *Nileus vigilans* zone.
**Formerly called the *Isotelus maximus* zone."

Generalized section of the Maquoketa formation for Northeast Iowa
Parker, Dorheim, and Campbell

Brainard member	
15. Shale, soft, bluish-gray, calcareous, fossiliferous, with red iron concretions and with *Cornulites.*	4′
14. Shale, greenish-blue, chunky, soft.	123′
Total thickness Brainard member	127′
Ft. Atkinson member	
13. Dolomite, yellowish-brown, massive, chert free in the upper 5′ containing scattered chert in the lower portion. Very fossiliferous, containing a coquina-like assemblage of crinoid stems and brachiopod fragments.	11′
12. Dolomite, calcareous, in regular layers, containing large quantities of chert in the form of nodules and irregular beds, sparcely fossiliferous.	14′

11. Dolomite, fine-grained, in even layers, containing nodular chert and many large brachiopods.	8′
10. Dolomite, massive, containing nodular chert; bryozoan abundant.	4′
9. Dolomite, massive, very fossiliferous; crinoidal zone at base.	6′
8. Shale, gray-green, dolomitic.	2′
7. Dolomite, argillaceous, fine-grained, thin-bedded.	3′
Total thickness Ft. Atkinson member	48′
Clermont member	
6. Shale, bluish-green with numerous crinoid stems, brachiopods, and straight cephalopods.	20′
Total thickness Clermont member	20′
Elgin member	
5. Limestone, yellowish-brown to grayish-brown, fine to medium grained; in places dolomitic, chert free in upper portion, lower portion contains light-gray chert nodules and numerous fossil fragments.	24′
4. *Vogdesia* beds: Dolomite, grayish-brown, argillaceous, with scattered nodules of light gray chert.	22′
3. Limestone, dark brown to gray, earthy, containing numerous black bars and specks and light to medium gray mottled chert.	20+′
2. Limestone or dolomite, bluish-tan, thinly bedded, grading into shale, bluish-tan, containing rust colored trilobite fragments and some smooth, tan chert.	18′
1. *Isotelus iowensis* zone: Limestone, tan, fine-grained argillaceous which parts on laminae of shale; contains abundant fragments of *Isotelus iowensis* and large *"Orthoceras"*.	32+′
Total thickness Elgin member	116+′
Total thickness Maquoketa formation	311+′

Several differences can be noted by comparing the general section of Savage and Ladd with the revised section of Parker, Dorheim, and Campbell. Greater observed thicknesses of the Brainard shale, Clermont shale, *Vogdesia* and *Isotelus* zones account for an additional 38′ in the revised section. Perhaps more importantly, unit 3 of the revised section appears to have no correlative in the section as given by Savage and Ladd. This unit is composed of beds of earthy limestone, mottled dark brown to gray, containing numerous black bars and specks. (This term is used by the Iowa Geological Survey for the black and dark brown spiculoid particles which are thought to be graptolite fragments and/or particles of a hydrocarbon quite possibly an asphaltic residue, such as gilsonite. Furnish and Tester, 1959 personal communication.) The chert is especially diagnostic. It is mottled light to dark gray, smooth and contains darker spicules. This unit is very well exposed in its entirety in the Fitzgerald Creek section. It also can be seen in the dry channel of Sandy Creek east of Clermont in the SW¼ section 35 and the SE¼ section 34, T. 95N., R. 7W., Fayette County. More than 20 feet of these beds are exposed in a road-side exposure in the center of the SW¼ SE¼ section 10, T. 94N., R. 7W., along the road between Clermont and Elgin. This unit can be seen directly under the Clermont shale in a road cut near Ft. Atkinson, in the SE/C section 9, T. 96N., R. 9W., Winneshiek County.

In samples of well cuttings in the four-county study area this unit is easily recognized and has been observed in over 50 wells.

Typical Localities

Savage (1904, pp. 465 & 467) obtained his general section of the Maquoketa formation from exposures in the channel and walls of Cascade gulch, near Eldorado where "A continuous section of the Maquoketa beds from the base of the *Nileus vigilans* zone (*Vogdesia* beds) to the contact of the Maquoketa with the overlying Niagara limestone, can be seen. . . ." Savage described the contact of the Galena formation with the overlying *Isotelus* zone and exposures of unit 2 at Dover Mills. Unfortunately these outcrops are not readily accessible today owing to slumping and overgrowth, and the writers were not able to observe these type sections; however, many exposures are available in this area. A tabulation of the 50 exposures studied for this report follows:

Brainard member	2
Ft. Atkinson member	10
Clermont member	8
Elgin member	30

Some of the better exposures, in addition to those already mentioned are given below. The complete listing of locations and descriptions are on file in the Iowa Geological Survey county section books.

A continuous section of the Maquoketa beds from their contact with the overlying Silurian down through the upper portion of the Elgin can be seen in a fresh road cut southwest of Eldorado in the NE¼ section 18, T. 95N., R. 7W. A nearly uninterrupted exposure of the Ft. Atkinson, Clermont, and Elgin members can be observed at the Fitzgerald Creek section.

The contact of the Elgin member with the underlying Galena dolomite is very well exposed in a quarry east of the railroad at Nordness just west of the center NE¼ section 10, T. 97N., R. 8W. Here the dark blue-gray to brown fissile shales and argillaceous limestones containing fragments of *Isotelus* are seen overlying the coquina-like assemblage of crinoid and brachiopod fragments which marks the top of the Dubuque member of the Galena formation in this area. Nearly identical exposures also can be seen in a quarry on the William Livingood property in SE¼ NW¼ section 7, T. 96N., R. 6W., and in the Cooney quarry in the center SW¼ section 16, T. 96N., R. 6W.

The units of the Elgin member are exposed at a number of places. The *Vogdesia* beds can be seen in a creek exposure east of the road near the center of NE¼ section 16, T. 96N., R. 7W., and in the ditches on either side of the road in NE¼ SE¼ SE¼ section 2, T. 96N., R. 7W. The upper portion of the Elgin member is exposed in a quarry south of the road in SW/C SE¼ section 5, T. 94N., R. 5W., and in a quarry north of the road in the center SW¼ section 17 of the same township.

The Elgin-Clermont contact is exposed in the ditch along the east side of the road near the center of the west line section 36, T. 96N., R. 7W., as well as in an abandoned quarry east of the road in the NW/C section 1, T. 95N., R. 7W.

The contact of the Clermont with the overlying Ft. Atkinson is well exposed on the right bank of the stream south of the road in the center of the north line of section 4, T. 94N., R. 6W., and at the quarry floor in the center SW¼ NW¼ section 21, T. 95N., R. 7W. This quarry also exposes approximately 45 feet of Ft. Atkinson dolomite and chert.

More than 30 feet of Ft. Atkinson cherty dolomite is exposed in quarries on either side of the road in the center section 5, T. 96N., R. 8W. Also in the SW¼ NE¼ section 23 of the same township there is a creekside exposure and a quarry in which 25 feet of Ft. Atkinson can be seen.

The contact of the Ft. Atkinson beds with the overlying Brainard shales can best be seen at the Eldorado road cut. The upper contact of the Brainard *Cornulites* zone with the Silurian limestone can also be seen at this location.

Conclusion

Ladd (1928, p. 335) reports that the *Vogdesia* beds are exposed beneath the Clermont shale at the eastern edge of Ft. Atkinson south of the bridge over Rogers Creek. However, it is at this locality that unit 3 of the Parker, Dorheim, and Campbell section can be seen directly underlying the Clermont shale. This unit has been identified underlying the Clermont shale in samples from four wells drilled within the town of Ft. Atkinson. This miscorrelation is the key to the entire problem.

In outcrop, unit 3 of the revised section and unit 4, *Vogdesia* beds of Ladd, are similar in appearance; yet they have characteristics which permit recognition and differentiation. Unit 4 is composed of hard, brown to gray calcareous dolomite with quantities of disseminated calcite and contains an abundance of fragments of the trilobite *Vogdesia vigilans*. Unit 3 is composed of dark brown to gray mottled limestone, in some places quite dolomitic, and it also contains sparse *Vogdesia* fragments. Both units contain light gray chert; however, the chert in unit 3 is more like the limestone in appearance and in some instances it is difficult to distinguish between the chert and the enclosing limestone. The mottled appearance of both chert and limestone of unit 3 is distinctive, as is the presence of the black bars and specks.

Perhaps Savage, Ladd and others observed this unit, but considered it to be equivalent to the *Vogdesia* beds, and as they did not observe a continuous section of the Elgin member they did not realize the existence of the additional unit. The presence of unit 3 has been definitely established in both surface exposures and subsurface well cuttings. The recognition and description of this unit and greater observed thickness of the *Isotelus* zone and other units has resolved the discrepancy and has brought the surface and subsurface stratigraphy into accordance.

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