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A Preliminary Stratigraphic Study of the Galena Group of Winneshiek County, Iowa

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SYNOPSIS: The rocks of the Galena Group have proved to be problematic in correlation. This problem is due to a variable lithofacies development. A preliminary investigation, although based upon exposures studied just within Winneshiek County, provides a method for field identification in Iowa of stratigraphic units currently used by the Illinois State Geological Survey within Illinois. Units under consideration at this time are restricted to the Dunleith, Wise Lake, and Dubuque Formations. Methods of identification and correlation employ in part such physical features as sequences of nodular chert bands, discontinuity surfaces, and sparry calcarenite bands. Investigation has disclosed a close relationship of these three features. A composite graphic column is provided, with key identification factors, for each of the subdivisions together with reference localities where the strata under investigation may be observed in sequence.

Within Iowa, the Galena Group has received only limited study since it was named by Hall (1851), modified by Kay (1935), and remodified by Templeton and Willman (1963). As a result, the fossil assemblages of this important Middle Ordovician group within Iowa have also received only cursory attention. The present study was initiated to determine the exact stratigraphic position of abundant crinoid crowns collected by the authors from about the middle of the group. It was evident from the paucity of reference material that a need existed for stratigraphic information about the Galena rocks within Winneshiek County, Iowa. Future taxonomic and biostratigraphic study will rely upon reliable stratigraphic units which can be recognized in the field. Various individuals interested in the Galena have expressed their desire for a detailed stratigraphic study. The authors were thus encouraged to publish their preliminary findings in this particular area.

Stratigraphically the Galena Group lies superadjacent to the Platteville and subadjacent to the Maquoketa Groups. Templeton and Willman (1963), here-in-after referred to as T.&W., claim the Galena to be entirely Champlainian (Middle Ordovician) in age. The Galena rocks are particularly well exposed within the Upper Mississippi Valley. Here, the rocks consist of carbonates and shales showing considerable lithofacies variation. These variations include a shale-limestone facies in Minnesota and a limy facies in northeastern Iowa. Dolostones prevail in Illinois and Wisconsin. The argillaceous content of the limy facies of the Galena is extremely variable. Previous studies were generally limited to a single lithofacies and were made within a restricted geographic area. For example, those of Weiss (1955, 1956, 1957), and others relate principally to Minnesota: while Agnew (1955, 1956), and others relate principally to Illinois. Valid as these studies may be within their particular area, there is only limited application in northeast Iowa, especially where fine subdivision is desired for the more than 235 feet of strata. T.&W. (1963), provide the desired subdivisions, but their study has had only limited usage in Iowa and their subdivisions are not easily recognizable. The principal objective of this study is to provide a basis for field recognition of the stratigraphic units of T.&W.

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PREVIOUS INVESTIGATION

The various publications listed within the "references" of this report provide the history of previous investigation. Only the more recent and/or those most closely related to the rocks of the County are discussed.

With the Galena reduced to the rank of formation, Weiss (1955, 1957), subdivided the unit (in ascending order) to the Cummingsville, Prosser, and Stewartville Members; their respective thicknesses 63 feet, 51 feet, and 75-85 feet. Weiss and Bell (1956), relate these member subdivisions to strata within the Decorah area, where recognition of the members may have practical application, as well as within nearby Fillmore County, Minnesota where their study was conducted.

Agnew (1955), subdivided the Galena into a lower 105 feet of cherty strata and an upper 120 feet of non-cherty strata. The upper non-cherty unit included Zone-P (Agnew, et al., 1956, p. 298) the 35-40 feet of strata subadjacent to the Stewartville.

With this interpretation, Agnew identified the 35-40 feet of section as Prosser (1956, p. 44, Fig. 10), and gave his reasons for this preference. From our experience, practical application of the terms "cherty" and "non-cherty" within Winneshiek County is questionable; however, in the subsurface, where only drill cuttings may be examined, a practical usage is served.

It is now believed that the extremely detailed study of the Galena rocks of Illinois by T.&W. (1963), can be used as a basis for field work within Iowa. This 1963 study is currently in use in Illinois, with no changes having been introduced since its publication. T.&W. (p. 236), provide a detailed section at Guttenberg, Iowa, and a measured sequence of a portion of their subdivisions to members at Decorah, Iowa (p. 116).

T.&W. (1963, p. 95), followed Kay (1935), and raised the Galena in rank to Group but also lowered the base. The Galena Group then subdivided into a lower Decorah Subgroup, the Kimmswick Subgroup, and the Dubuque Formation at the top.

The problem of defining a top of the Decorah Subgroup is explained in detail by T.&W. (p. 101). Because of the progressive increase in shale in a northerly direction, they applied the principal of vertical cut-off, which within Illinois places the top of the Decorah strata, where it can be recognized as Ion, within the base of the Kimmswick Subgroup. The Ion they subdivided into 2 members, the lower Buckhorn and the St. James.

Due to the shaly facies of the Decorah within Winneshiek County, the Buckhorn and St. James are not recognizable.

Therefore, within this report, the Decorah is recognized as a Subgroup, subdivided into 3 formations which in ascending order are: the Spechts Ferry, Guttenberg, and Ion. (See Fig. 1-A.)

Overlying the Decorah Subgroup is the Kimmswick Subgroup of T.&W. (1963, p. 114), subdivided to the Dunleith Formation (p. 114), and the superadjacent Wise Lake Formation (p. 125). As employed within our report a revised Dunleith Formation is to be used within northeastern Iowa, consisting of 8 members. The members in ascending order are: Beecher, Eagle Point, Fairplay, Mortimer, Rivoli, Sherwood, Wall, and Wyota.

Similarly, the Wise Lake Formation of T.&W. is subdivided into 2 members, the basal Sinsinawa and the overlying Stewartville. The Sinsinawa is equivalent to the "noncherty" portion of the Prosser, Agnew (1955, p. 1713, also Agnew, et al., 1956, p. 297-298, "Zone P").

Subdivision of the Dunleith Formation by T.&W. was based upon persistent alternations of pure and argillaceous units, which provided the best regional correlation (p. 117). Their seqence consisted of a pure carbonate unit at the base and a thinner argillaceous unit above. Such a division is not always recognizable within the limestone facies of Winneshiek County, for the clay content is variable in stratigraphic position within relatively short distances. Similarly, as one follows the strata in a northwesterly direction into Minnesota, the shaliness increases, making it more difficult to recognize subdivisions based upon pure and impure units.

The present authors have not had opportunity to visit exposures in other states, although spot checks have been made at a few localities within Clayton and Allamakee Counties in Iowa. There it was noted that a decrease in argillaceousness led to an increase in the quantity of nodular chert bands. Nevertheless, individual layers seem readily recognizable, after preparation of hastily made sections noting the correlatives used within Winneshiek County.

Approach to Problem

During the periods of study and investigation, hundreds of hours have been spent in the field to achieve bed-to-bed correlation. In many instances the authors worked independently of one another at a particular locality. The conclusions reached by them usually coincided, but when not, common conclusions were reached with discussion and further observation.

Strata equivalent to the Cummingsville in Minnesota (Weiss, 1955, 1957), in the Decorah area are likely to exfoliate at any stratigraphic position because of the argillaceous content. Often this exfoliation produces persistent shaly bands across the face of an exposure. Initially a reliance was placed upon these bands for correlation, but it was found that stratigraphic identity was sometimes lost within a few miles distance. Distinctive lithologies were then traced, but in many cases the varying degrees of argillaceousness caused an entirely different appearing rock at similar stratigraphic positions. With the general consensus that chert alone should not be used as a correlative, initial observation tended to discount its use.

T.&W. (1963, p. 15), pointed out the practicality of sections drafted at a scale of 1/4 inch or 1/2 inch to the foot. Sections at various scales were used in our study. We found it necessary for the scale to be at least 1/4 inch to the foot to enable placement of detailed features necessary for identification.

Of course, rock stratigraphic units should be distinguished and defined on the basis of lithologic characteristics. However, we found if the rocks of the Kimmswick Subgroup were subdivided within Winneshiek County upon the basis of each lithologic change, there would be too many subdivisions, many of short lateral extent with no practical use.

As our familiarity with the rocks increased, it was observed that certain persistent layers of rock could be traced readily from one locality to another. As diagrammatic sections were prepared and compared with the sections and descriptions of T.&W. (1963), all members could be recognized although frequently, an arbitrary decision was necessary in determining an exact member contact. To overcome the arbitrary placement of a contact, persistent features were sought that could be consistently used. There are many "discontinuity surfaces" (corrosion surfaces of T.&W.) within the Galena. The authors' familiarity with one in particular from the Upper Devonian Shellrock Formation as discussed by Koch and Strimple (1968), led them to believe they could be used for correlation. Also, our graphic columns prepared of the various localities now indicated nodular chert bands to occur persistently at the same stratigraphic positions, but in some instances they were absent. When absent, the anticipated cherty layers were usually replaced in the column by a "discontinuity surface," corrosion surface (discussed later in this report), "hard ground," or a sparry calcarenite band. Repetitious field checks found this relationship to be relatively constant, so correlations could be based upon these features. In no instance have such correlations, in combination with other normal stratigraphic principles, failed to locate key strata. After these confirmations, it was only then decided to identify contacts of the various members of T.&W., based upon those characteristics which could be used in the field.

During the latter part of this preliminary investigation, Dr. H. B. Willman generously furnished the authors sections from the Decorah area prepared by him and J. S. Templeton during 1950-1951. The member contacts which we had chosen from our field work, in all instances fell within inches of those chosen by T.&W., at least from the base of the Beecher to the top of the Rivoli Members. Above the Rivoli, more definite characteristics were needed to establish the member contacts within the County. Also, their sections did not include the Sinsinawa-Stewartville contact, nor any of the Dubuque strata.

Materials and Methods

Clays and Bentonites

The usefulness of bentonites as tools of correlation is widely known. For the purpose of this particular investigation, it was generally impractical for field identification of bentonites without laboratory analysis for confirmation. Sardeson (1928),

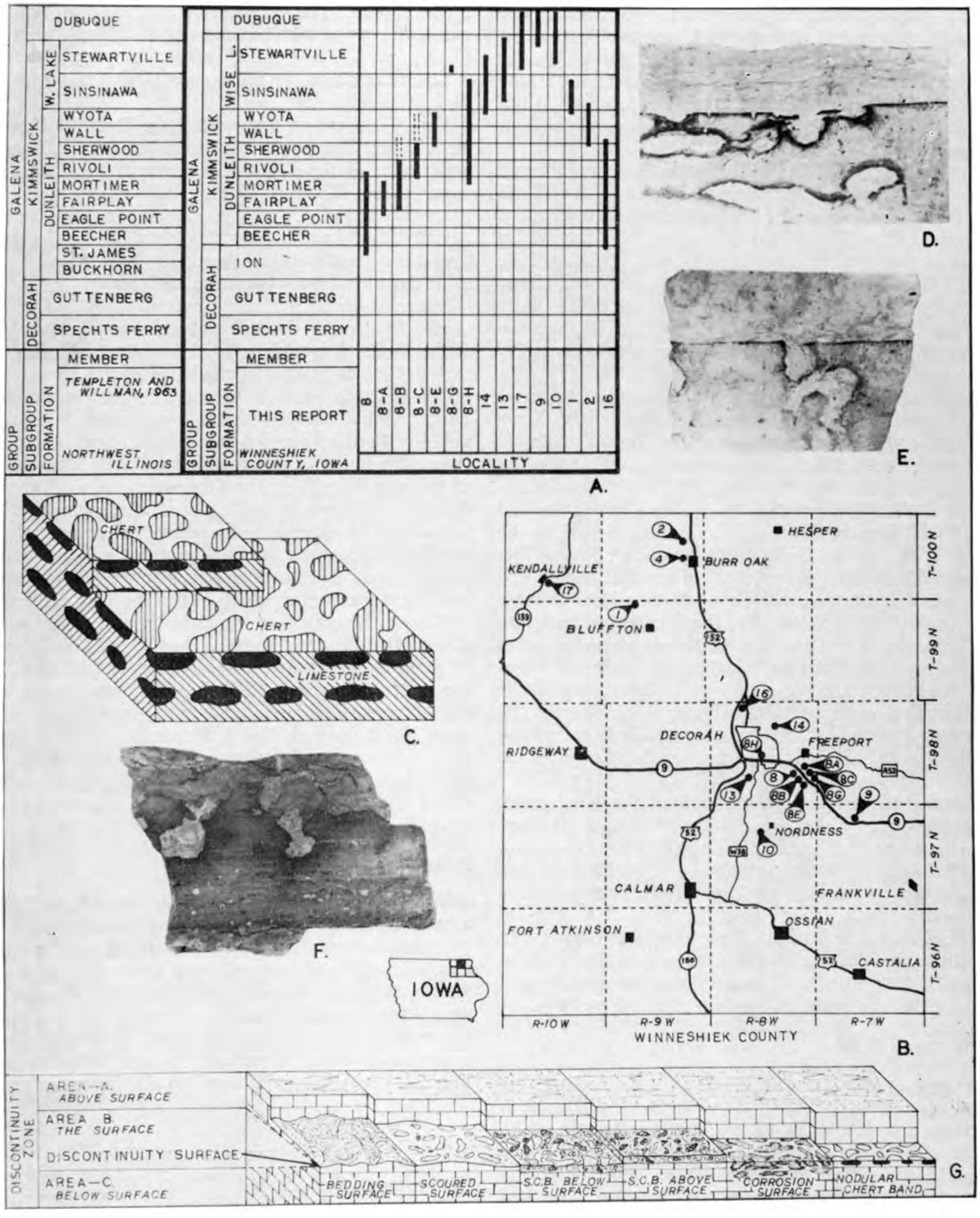

Figure 1.

A. Chart showing member subdivisions of Galena strata of N.W. Illinois and Winneshiek County subdivision with reference localities.

B. Locality Map.

C. Cutaway diagram showing typical Winneshiek County nodular chert band.

D. Typical Corrosion Surface from within the Dunleith Formation.

E. Typical Corrosion Surface from within the Wise Lake Formation, Sinsinawa Member.

F. Typical Sparry Calcarenite Band (S.C.B.) from within the Stewartville Member.

G. "Discontinuity Zone," new term, showing relationship of various types of Discontinuity Surfaces and other features.

Weiss (1954, et al.), Mossler & Hayes (1966), and others have discussed thoroughly the use of Ordovician bentonites for correlation. Within the Kimmswick Subgroup, Mossler and Hayes (1966, p. 417), have verified the presence of three bentonites, which they number in ascending order I-5, I-6, and I-7. They also verify one, I-8, within the overlying Dubuque Formation.

T.&W. (1963, p. 116, 122), state that, within the Decorah area, a bentonite occurs 7 feet below the top of the Rivoli Member, and is the lower of two bentonites 13 feet apart. However, neither T.&W. nor Mossler and Hayes located the Rivoli bentonite within the Guttenberg area (1963, p. 236, Sec. 27: 1966, p. 415, 426, Loc. 10). Mossler and Hayes assigned numbers to the Sherwood (I-5) and Wall (I-6) bentonites at Guttenberg (Loc. 10 & 11), but because the Rivoli bentonite was not identified, it does not have an "I" number: in our investigation it is designated as "K" (Fig. 2).

During the course of this investigation, samples taken of presumed bentonites were generously subjected to X-ray diffractometer tests by John Mossler. The Rivoli bentonite (K, Fig. 2) was thus verified as bentonite, as well as another layer in the mid-Sinsinawa Member (I-7).

After many visits to the field, the authors have now had an opportunity to verify the Rivoli bentonite, as well as the layer T.&W. observed to be in the Sherwood (5 to 7 feet above base). These bentonites, particularly the one in the Rivoli, are very distinctive; they consist of a bright-orange and gray "greasy" clay. When dry, the bentonite has a tendency to withdraw from the face of the exposure so as to become barely visible. Conversely, when the rocks are saturated with moisture following a rain or in the spring of the year, considerable swelling of this bentonite is noted. The clay layer then protrudes and may be visible from several hundred feet away. Normal shale-partings in the limestone do not react in this manner.

Thin clay layers are common throughout the Kimmswick of Winneshiek County, and are found to be most often associated with major bed partings. The clays are, therefore, valuable references for field correlation of the major beds. The clays are also important because they offer a soft protective coating for the fossils, accounting for their fine state of preservation. Not all major beds have clay separations, but normally they are dark ocherous brown in color, with a thickness of 1/4 to 1 inch. The clays weather rapidly and may not be observed without digging into bed partings.

Sparry Calcarenite Bands

A sparry calcarenite band consists of a distinctive thin layer averaging between 1/2 to 2 inches in thickness. It is coarsely crystalline detrital limestone. The sparry calcarenite band (abbr., SCB) should also be easily distinguished in a core. The SCB is not a continuous layer; however it appears to recur at the same stratigraphic position. The bed is an effective correlative marker which, in addition to other stratigraphic details, provides a means of correlating Stewartville strata within the County. The SCB is closely associated with a corrosion surface, usually immediately above, and occasionally obscures the corrosion surface completely. A typical example of the SCB and its relationship to the corrosion surface may be observed east of Decorah, at Locality 8-G of this report. At the east end of the exposure there are 2 prominent SCB's 29 inches apart. At the west end of the exposure only one is present, the other replaced by a corrosion surface. The relationship can be observed by tracing individual strata from the east end to the west end. Jaanusson (1961, p. 233-234), indicates this same situation exists within recent seas, in discussions of the eastern coast of the Florida Keys.

The SCB's are present within the Dunleith Formation but are of short lateral extent. Therefore, the authors have not used those of the Dunleith in correlation because of other more usable features. Within the Stewartville strata the sparry layers are of much greater importance, because of the sparsity of other correlative features. Also, in the upper units they have greater lateral continuity and have been observed to be associated with corrosion surfaces.

Many of the SCB's have been sectioned to facilitate closer study. The coarse detrital material is made up of fragments of the shells. A notable crinoidal content is shown within the SCB's of strata nearing upper levels of the Stewartville; those of lower levels show fragments of brachiopods, *Receptaculites*, crinoidal debris, plus a great amount of unidentified pebbles. Both within the upper and lower levels, the SCB's show grains of sand intermingled with the fossil debris. Those of the upper levels of the Stewartville also show much finer detritus, and finer crystallization than those within the lower. In weathered exposures characteristic textures of the SCB's are difficult to identify, but because they do not weather as rapidly as strata above or below, close examination will reveal them protruding slightly from the face of the exposure.

During the course of this investigation 8 distinctive SCB's of considerable lateral extent have been located within the Wise Lake Formation. One of these is 12 inches below the top of the Sinsinawa (SCB-1). The remaining 7 are within the Stewartville, these being numbered in ascending order from No. 2 through No. 8. Perhaps, after further investigation, still more such layers will be located which will aid in even closer correlation. No Stewartville exposures have been noted within Winneshiek County which could not be correlated with one or more of the 8 SCB's (See Fig. 2).

Discontinuity Zone

The term "Discontinuity Zone" is new. The authors feel that a term is necessary which will provide a thickness dimension to those features previously described and used by other authors such as: *Corrosion Zones, Corrosion Surfaces, Discontinuity Surfaces, Scoured Surfaces, Hard Ground*, etc. The term "Discontinuity Zone" is broader in application and covers the necessary interval several inches above and below a particular type of surface. It is a collective term (See Fig. 1-G) which is subdivided in the following manner:

DISCONTINUITY ZONE

Discontinuity Surface
- Corrosion Surface
- Scoured Surface
- Hard Ground
- Bedding, or any distinctive surface.

The necessary area used *above the surface* is designated "Area A." The *surface* itself is designated Area B, and that *below the surface* is designated Area C. The necessity of the term is evidenced by work which has been previously published. Weiss (1958), recognized the necessity of a "zone," but called them *Corrosion Zones.* With this term, only a zone

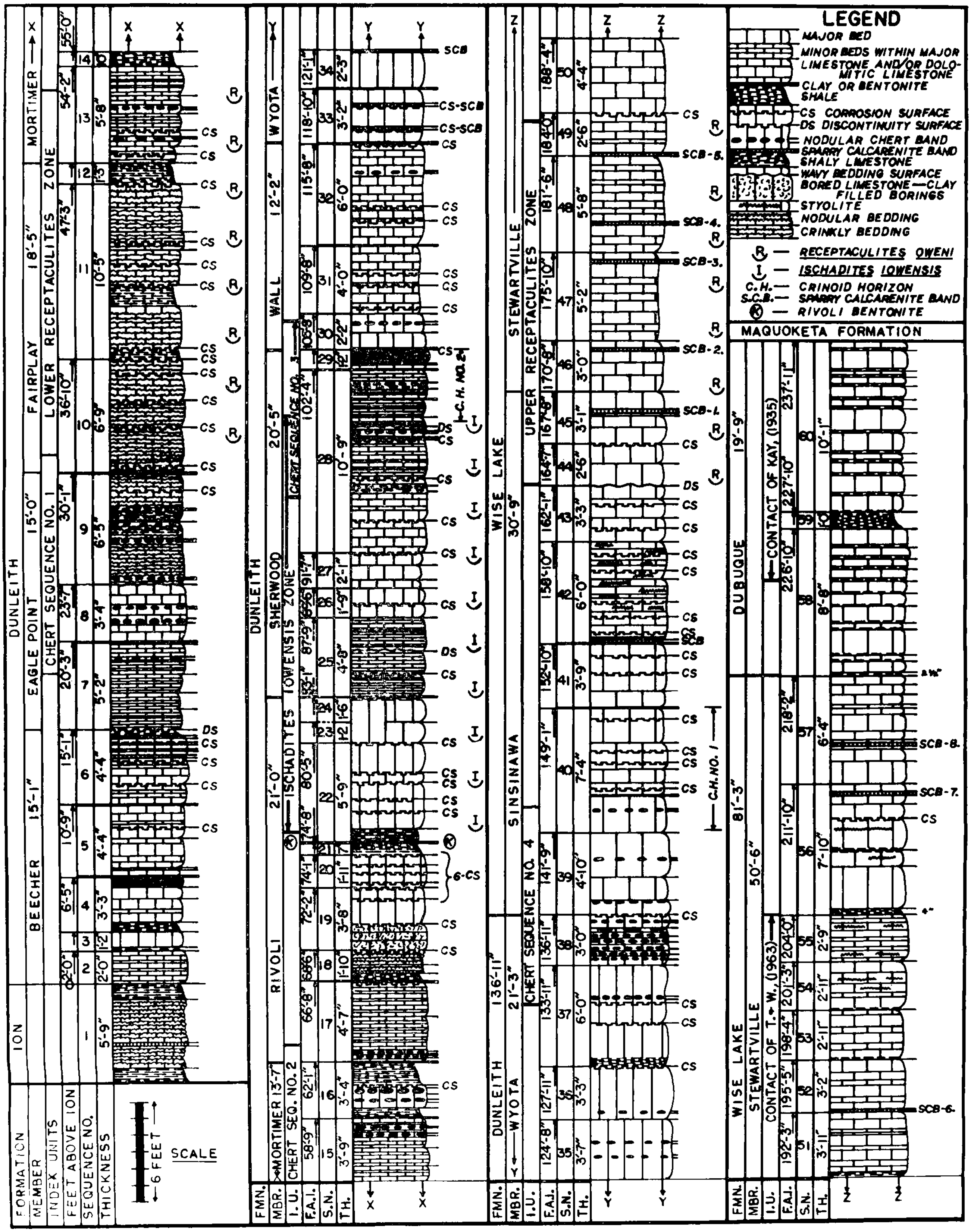

Figure 2. Composite graphic column of Galena strata within Winneshiek County, Iowa.

within which corrosion has taken place is provided for, although there is a surface within the zone. T.&W. (1963), relate to *Corrosion Surfaces* in a manner which would indicate only that there is a surface upon which corrosion has taken place, but does not include any thickness above or below that surface. Jaanusson (1961), identifies a *Discontinuity Surface,* but the term, "discontinuity" could evidence a surface formed by any means from a minor hiatus to a major disconformity and does not seem adequately definitive. The usage of the term "Discontinuity Zone" is intended to be broad in application so that strata within the zone whether of major or minor origin, may be described and related to. The terms of Weiss, Jaanusson, T.&W., and others should definitely be included as subdivisions of the Discontinuity Zone, for they represent a particular event which has taken place upon the sea floor at a particular time and place.

The sea floor presently varies from place to place, some areas being abraded, some depositing silt, some having corrosion taking place, etc. The sea floor of the past should have been no different in this respect. If precise stratigraphic control could be maintained, the evidence within the Discontinuity Zone upon a particular surface could be mapped, and be of considerable value in a study of depositional environment. A surface within the discontinuity zone will vary, but valid correlation can be maintained with the completely different-appearing characteristics. Figure 1-G shows the relationship of these features.

Corrosion Surfaces

Within the Galena there are many corrosion surfaces. As Jaanusson (1961, p. 221), points out, after the work of Kupffer in 1876, the corrosion surface indicates a break in sequence, or a discontinuity. The time element is unknown, but during that period however long or short in duration, many and varied events could have occurred. These could have been: the corrosion evidenced by the surface, the concentration of silica resulting in formation of chert, etc. During the same time element, at areas where chemical agents were not present to corrode the surface, abrasion may have been taking place to provide the scoured surface so frequently observed today. The sea may have retreated to indurate a surface, form hard ground, or turbulent conditions may have disarticulated and broken numerous shells of animals to produce the calcarenite observed in the SCB's.

The corrosion surfaces are of no more importance as a correlative than any of the other features described in this report, but they are second only to chert bands in ease of recognition. Within the Kimmswick of Winneshiek County, there are two distinct types of corrosion surface. Those within the Dunleith have concentration of pyrite or marcasite. They appear as a very dark gray or black distinctive pattern upon the face of a lighter colored rock. Within the Sinsinawa Member, however, the time element of corrosion taking place appears to be of shorter duration, and rather than a high pyrite content, consists principally of limonite. The surfaces may be observed within the Sinsinawa as a faint, ocherous brown color upon the face of a buff colored rock. In either case, when subjected to weathering, they oxidize down leaving a stain of limonite upon the face of the rock. Extended weathering eventually separates the rock along the corrosion surface. A more detailed study of these surfaces is needed. Several examples were cleaned to the surface with an airbrasive machine to find the surface had an associated fauna, but how distinct it was from fauna above or below was not observed.

Sections cut perpendicular to the corrosion surface have been made of samples taken from several localities. It was found that the strata overlying the surface (Area A) also provided filling for the deep pits. It some cases, the surface of the rock area (Area B) had been scoured previous to the corrosion taking place, and these smooth surfaces had fallen into some of the corroded pits. Only a preliminary type of study has been done on these surfaces by the writers, but it has been observed that there are borings from area A into area C. This could explain how the deeply pitted areas could corrode and allow a scoured piece to fall into one of the pits.

As previously discussed, the corrosion surface represents a period of discontinuity in deposition. The intricate patterns of corrosion surfaces are remarkably similar in design to the patterns of mottling within most of the strata of the Kimmswick. This mottling is particularly evident within the Fairplay and Stewartville Members. Within the Fairplay up to 50 percent of the rock is mottled, the mottled area being filled in most instances with a semi-friable finely crystalline rock. Within the Stewartville, the mottled areas show differential weathering. Here samples of rock were taken, sectioned, and cleaned with the airbrasive machine. Tiny fossil fragments such as crinoid stem ossicles, were found within the areas of mottling. Evidence of corrosion also exists there, but not so extensively as upon the corrosion surface; thus, there appears to be a definite relationship between the mottling and the corrosion surface. The possibility exists, therefore, that corrosion was a continuing situation; as deposition was taking place layer upon layer, various little patches continued to corrode in the newly deposited material. At a time when there was no deposition, or a discontinuity, the same agents causing the mottling were then allowed to work upon the surface causing the corrosion surface we observe today.

Nodular Chert Bands

Within the carbonate rocks of the Galena there are many nodular chert bands. In some cases where nodules are sparse, they are observed as individual oblate spheroids. More commonly, the nodules are abundant, to the extent that they coalesce to form a nodular layer (Fig. 1-C). This coalescence may be so complete that a uniform band of chert is present. The thickness of the nodular chert band rarely exceeds 6 inches, most frequently from 1 1/2 to 3 inches in thickness, and the chert bands are always parallel to bedding planes. Where the nodular bands of chert are observed upon a bedding surface, they appear sharply set off from the surrounding matrix (Fig. 1-C).

There has been much controversy relating to the subject of the origin of chert. It is not intended here to point out a genesis of the chert within the Galena, but to offer explanations why the nodular chert band may be used for correlation.

That the chert is stratigraphically controlled is evidenced within the Dunleith Formation of Winneshiek County, where there are 4 distinct horizons of nodular bands. These occurrences are situated within the Dunleith as follows: upper two-thirds of Eagle Point Member, most of the Mortimer Member, upper one-half of Sherwood, and upper one-half of the Wyota Member. Although not all chert is restricted to these sequences, individual nodules sporadically situated are uncommon otherwise. Similarly, there are individually situated nodular bands which are at the same stratigraphic positions at various localities. The Beecher is observed to have no chert at all, while chert is very limited in other members not listed as having a sequence.

After preparation of many graphic columns and correlating beds of definite stratigraphic equivalence, a particular band of nodular chert may be found not to be present at all localities. When this occurs, the locality lacking the chert will have a corrosion surface, a SCB, or a bedding plane at the corresponding position in the column where the chert band should be. Such a relationship occurs not only with individual bands, but also within 4 chert sequences.

Within the graphic column where an argillaceous lithology character is shown, the nodular chert bands tend to be absent. This generalization applies to the Galena in a broad sense, for as dolomitization of the rocks increases to the southeast of Winneshiek County so does the prevalence of nodular chert bands and the 4 chert sequences become difficult to trace individually. Northerly, into Minnesota, as argillaceousness increases a decline to near absence of chert is noted.

Within the County, the Galena chert has not been observed to contain as many macrofossils, as does the chert of the super-adjacent Maquoketa Formation. The seeming near absence of fossils within the chert could indicate primary precipitation. The presence of bentonites throughout the Galena with their presumed volcanic origin (Sardeson 1928, Mossler and Hayes 1966, and others) would indicate adequate silica to be reprecipitated later as chert. Regardless of their origin, the nodular chert bands provide reliable correlatives (See also Dunbar and Rodgers, 1967, Chap. 14).

Graphic Column of the Kimmswick Subgroup and Dubuque Formation

The graphic column shown in Figure 2 was prepared to a scale of 1/4 inch to a foot, then reduced for publication. It should again be enlarged to 1/4 inch scale for comparison with future sections prepared of like strata. The column is a composite of the several localities of this investigation in Winneshiek County which best show the characteristics of the member subdivisions of T.&W. (1963).

Index Units

The index units shown under their respective column, Fig. 2, may be used for general field orientation. The two *Receptaculites* Zones and the *Ischadites* Zone have been used in previous publications. They are used herein restrictively as an index where peak occurrence has been noted, because *Receptaculites* and *Ischadites* are known to range throughout the Kimmswick. The chert sequences are principally indicative of strata just within Winneshiek County, but may find application elsewhere.

The Rivoli bentonite (designated K in Fig. 2) as has been previously discussed, is perhaps one of the most important indices of the lower Kimmswick. It is identifiable in the field due to its distinctiveness.

The "crinoid horizons" (abbr. C.H.) shown in the column are the only levels where complete crinoid crowns have been found in the Galena. Evidence from the occurrence of comparable detrital material indicates other horizons should be present; perhaps near the Rivoli bentonite. Fossil crinoids within the Sinsinawa are much less common than those at the top of the Sherwood, while complete crowns are rare in both positions. Frequently associated with the crinoids in about equal scarcity, are several species of cystoids, generally the genus *Pleurocystites.* Even in localities where complete crowns have not been found at these two horizons, there is crinoidal debris consisting of lengths of column, rather than the jumbled ossicles frequently observed within the Galena strata.

Ischadites is common within the crinoid horizon at the top of the Sherwood and is noted throughout that member in particular abundance.

Sequence Numbers

No effort has been made to define the lithology of each unit shown by a sequence number. That number, in most instances, relates to a major bed. T.&W. (1963), define the lithology of each member so that field recognition is generally possible. Although there is much dolomitic limestone represented within the column (Fig. 2), it has all been shown as limestone. Whether it is dolomitic or not does not particularly assist or detract from field identification in this area. Although the Fairplay and Stewartville Members are more dolomitic than the other members, other features are more critical. Also, the dolomitic nature of the Fairplay is associated with the mottling rather than the overall rock itself.

Reference Localities

All changes in lithologic character in a given stratum reflect changes in conditions of deposition of the rocks in section. The pure and impure units upon which T.&W. (1963), based their member contacts have not been recognizable in all cases, to us within Winneshiek County. This lack of definition is due principally to facies differences, when rocks within that county are compared to the basic area of investigation, i.e., northwestern Illinois.

After close observation in attempting to utilize the work done by others, the stratigrapher realized the importance of choosing distinctions that are convenient to observe. The present authors are dealing strictly with a relatively small area, while much greater regional correlations were the stated objective of T.&W. (1963). The objectivity of any means of correlation is indeed very much dependent upon the method employed by the stratigrapher. T.&W. found the argillaceous and non-argillaceous units convenient and objective, while others have not found this to be the case. Upon observing many graphic columns drawn to 1/4 inch scale, one may readily determine why member subdivisions were based upon purity of the rock. The principal problem noted in this method when working with many sections within a small map area is that occasionally an arbitrary decision is necessary to position the member contact, because the argillaceous zone at the top is sometimes variable. All contacts from the Ion-Beecher to the Rivoli-Sherwood are quite readily identifiable. Conversely, the contacts from the Sherwood-Wall through the Stewartville-Dubuque, have proved somewhat problematic. Here, correlations of this investigation should aid in establishing member contacts of T.&W. for Winneshiek County.

Within the sections received by the authors from H. B. Willman, late in this study, strata of the Stewartville and

Dubuque Members were not shown. Of these sections only two show strata above the top of the Rivoli Member, the first being "Engineers Old Stream Diversion Cut" (NE 1/4, SE 1/4, Sec. 18, T.98N., R.8W.). Here is a complete sequence from 9 feet-11 inches below the top of the Fairplay to the approximate top of the Wyota, plus 15 feet of Sinsinawa too poorly shown to describe. The upper 12 inches of an 18 feet-6 inches Wyota, was cherty rubble. By comparing the T.&W. section with the top beds of the Wyota in the near vicinity (Loc. 8-H, Loc. 14, and along Hwy. 52 bypass), it is now believed that T.&W. are between 14 to 18 inches below the top of the Wyota, because the cherty sequence could not be observed closely within the rubble. At their "South Quarry" section (NE 1/4, SW 1/2, Sec. 21, T.98N., R.8W.) they show strata from 5 feet-4 inches below the top of the Mortimer to 26 feet above the base of the Sinsinawa. Within this section there was an inaccessable 16 feet of strata which included the Wall-Wyota contact, plus another 8 feet of strata immediately below that could not be closely observed, which included the Sherwood-Wall contact. This quarry today is a poor exposure due to rubble at the bottom, being inaccessible in the middle and overgrown and rubbly at the top; so close observation and detailed sectioning cannot be accomplished. To the northeast of the quarry by approximately 1,000 feet is Loc. 8-H of this investigation. Here the same strata may be observed closely, and the locality provides the member contacts which were not observed by T.&W. at the old quarry, *i.e.*, Sherwood-Wall and Wall-Wyota contacts and the others.

All localities studied have not been described and plotted; likewise, all localities sectioned have not been listed as reference localities for this report. No less than 4 and frequently more have been studied for each of the member contacts. The contacts fall at the top or within the argillaceous zone designated the member break by T.&W.

These reference localities provide two complete sequences of strata from the upper few feet of the Ion Formation to the top of the Dubuque Formation. The exposures are correlated with one another upon the findings of this investigation, as well as those of T.&W. (1963).

One complete sequence is shown with localities 8, 8-A, 8-B, 8-C, 8-H, 13, and 10. Another is shown with localities 16, 2, 1, and 9. Other combinations can be worked out to show well a sequence of the Kimmswick and Dubuque strata. Most all of the exposures listed below and in Figs. 1-A, 1-B, are readily accessible, particularly those of localities No. 8. Here the effects of weathering are well shown.

Locality No. 1

Quarry, 2 miles NW Bluffton, Iowa. NE 1/4, NE 1/4, Sec. 5, T.99 N., R.9W. Sequence: Wyota 7'8", Sinsinawa 25'-9".

Locality No. 2

Quarry, 1 mile N., 1/4 mile W. Burr Oak, Iowa. SW 1/4, SE 1/4, Sec. 14, T.100 N., R.9 W. Sequence: Sherwood 3'-9", Wall 12'-4", Wyota 17'-11", Sinsinawa 8'-0". At this locality the chert at the top of the Wyota is spread over a thickness of 5 to 8 feet, with the bands widely spaced and less abundant than within the Decorah area.

Localities No. 8

Several roadside exposures on alternating sides of Iowa Highway No. 9, commencing with No. 8 on the south side of the highway 3.1 miles east of the junction of U.S. 52 and Iowa 9. These are designated 8, 8-A, 8-B, etc., in an easterly direction, as strata rise from 5'-9" below the contact of the Ion and Dunleith Formations to within 5 feet of the top of the Dunleith at Loc. 8-E on the south side of the highway as is 8-D and 8-F which were not sectioned. Loc. 8-G is .3 mile east of 8-E on the north side of the curve in highway. Localities 8 through 8-G are situated within NE 1/4, NE 1/4, Sec. 26, T.98N, R.8 W, and SE 1/4, Sec. 23, T.98N., R.9 W. The sequence of Loc. 8 is very nearly the equivalent of the Minnesota Cummingsville.

Sequence Loc. 8: Ion Formation 5'-9", Beecher 13'-2", Eagle Point 14'-11", Fairplay 19'-2", Mortimer 12'-2", Rivoli 1'-9".

Sequence Loc. 8-A: Eagle Point 4'-10", Fairplay 18'-5", Mortimer 7'-7" of strata which is too rubbly above to detail.

Sequence Loc. 8-B: (Lower 8'-6" measured in ditch to west) Fairplay 19'-0", Mortimer 13'-7 1/4", Rivoli 20'-9 3/4". 24'-8" rubbly area above which cannot be detailed. Top of Rivoli is within rubble, which can be located by digging 2'-4" above a small ledge to locate a 1/2" to 3/4" tan-buff clay parting. The Rivoli bentonite is 5'-9" below this ledge near the top of the measured sequence.

Sequence Loc. 8-C: Mortimer 3'-3", Rivoli 20'-9 3/4", Sherwood approx. 21' with contact in rubbly area below uppermost ledge at east end of exposure. 25'-0" rubble above ledge which cannot be detailed. At 6'-5" below the small ledge are two chert bands 4" apart. The lowest of these is used as a correlative to a chert band at level of ditch floor at west end of Loc. 8-E. This was verified with a transit sighting.

Sequence Loc. 8-E: Sherwood 6'-5", Wall 12'-0", Wyota 14'-3" to ledge, above which is rubble and not measured. The ledge is approx. 4-5 feet below Wyota-Sinsinawa contact.

Sequence Loc. 8-G: Stewartville 9'-9", 5'-0" rubble overlain by an unmeasured thickness of soil, drift and rubble. The lower of the two SCB's at this locality is 45'-2" above the upper ledge at Loc. 8-E. These two SCB's would indicate the strata to be approx. 8 feet above the base of the Stewartville, for they would represent SCB No. 2 and 3 of column shown in Figure 2.

Locality No. 8-H

Situated along either side of Highway No. 9 about 1,000 feet NE of T.&W. "South Quarry." Located NW 1/4, SE 1/4, Sec. 21, T.98N., R.8W. Sequence, south side of highway, west end: Mortimer 5'-3", Rivoli 20'-11", Sherwood 19'-6", Wall 4'-8". Sequence north side of highway: Sherwood 12'-7", Wall 12'-0", Wyota 21'-3", Sinsinawa 26'-7". The exposed Sinsinawa is approximately 3'-0" below the contact with the Stewartville.

Locality No. 9

Sequence: Stewartville 18'-4", Dubuque 19'-8". Situated 7 miles SE Decorah, Iowa on either side of Iowa Highway 9, in SW 1/4, SW 1/4, Sec. 4 and NW 1/4, NW 1/4, Sec. 9, T.97 N., R.7 W. This is the exposure where Kay (1935), placed the Stewartville-Dubuque contact at 4 beds below the wide (12") shaly parting. T.&W. (1963), contact would be at 4" shale parting near base of exposure. Within this investigation, the contact is placed at the 2 1/2" shale parting 47" above the upper of two sparry calcarenite bands, SCB 7 and 8.

Locality No. 10

Quarry located about 1 mile west of Nordness, Iowa.

NE 1/4, SE 1/4, Sec. 9, T.97 N., R.8 W. Sequence: Stewartville 32′-2 1/2″, Dubuque 20′-2″. The SCB 6′-9″ above floor is SCB No. 6.

Locality No. 13

Quarry, located 1 1/2 miles south of Decorah, Iowa. NW 1/4, SW 1/4, Sec. 28, T.98 N., R.8 W. Sequence: Sinsinawa 22′-7″, Stewartville 48′-1″. Contact of Sinsinawa-Stewartville is 14″ above SCB No. 1. (See Fig. 2.) Within quarry SCB's No. 1, 3, 5, 6, 7, 8, are present with 7 and 8 indistinct at top of exposure.

Locality No. 14

Quarry, 1/2 mile NE Decorah, Iowa. NW 1/4, SE 1/4, Sec. 10, T.98 N., R.8 W. Sequence: Wyota 8′-0″, Sinsinawa 30′-9″, Stewartville 24′-4″. SCB's present: 1 thru 5. Here is perhaps the finest locality for study purposes of a complete section of the Sinsinawa Member. It is typical of the member.

Locality No. 16

Quarry along "old" U.S. 52, 1 1/4 miles north of Decorah, Iowa. NW 1/4, NE 1/4, Sec. 5, T.98 N., R.8 W. Below quarry a drainage cut provides the lower strata to the top of the Eagle Point. Sequence: Ion Formation 3′-2″, Beecher 15′-4″, Eagle Point 14′-10″, Fairplay 20′-2″, Mortimer 12′-9″, Rivoli 18′-0″, Sherwood 21′-3″, Wall 3′-2″. Upper portion of Sherwood and of the Wall is above strip surface of quarry at southwest corner within rubbly zone.

Locality No. 17

Quarry situated on north side of river at Kendallville, Iowa. SW 1/4, NE 1/4, Sec. 33, T.100 N., R.10 W. Sequence: Sinsinawa 6′-10″, Stewartville 48′-1 1/2″, Dubuque 6′-9 1/2″. SCB's present within quarry are Nos. 1 through 5.

MEMBER CONTACTS

As was discussed above, the member contacts of T.&W. (1963), from the Ion-Beecher to the Rivoli-Sherwood, are readily recognizable. Above this, as based upon the findings of this investigation, the remaining member contacts should be easily recognized. T.&W. (1963, p. 19), point out, *"Some units have a gradational contact, but even this is characteristic of the specific unit."* Field placement of the precise member contact is sometimes difficult because of the gradational character which is occasionally present. With a graphic column prepared at 1/4 inch scale, this problem seems to be minimal when matched to the column of Fig. 2. Familiarity with the rocks also assists in recognition of contact in the field. The Kimmswick and Dubuque strata are clearly unlike many formations where distinct lithic contrast at member contacts assists in their location. Where a gradational situation exists, strata should be examined closely. Occasionally an arbitrary decision as to the contact must be made.

Stewartville-Dubuque Contact

The Stewartville-Dubuque contact problem is strongly evidenced by the various positions at which each of the previous authors have placed the contact. There is no sharp contact that can be readily and consistently recognized within the county, except where the shaly partings of the Dubuque rock cease. Kay (1935a, p. 78), placed the contact at 4 beds below the cessation of the shaly partings at Locality 9 of this report. This is perhaps the most easily recognized position within the county. At this locality, Kay shows 15 feet-0 inches of Dubuque strata in contact with the superadjacent Maquoketa Formation.

If one were to place the contact at Loc. 9 in accordance with T.&W. (1963, p. 129), *"lowest strong shaly parting,"* 15 feet below that of Kay, it would necessarily be at a 4 inch shale parting 19 feet-10 inches below Kay's contact. This would provide 33 feet-11 inches total of Dubuque strata at Loc. 9, which seems to be too thick.

It is observed, however, that both the contacts of Kay and T.&W. can be recognized, with good reason for each to place the contact where they did. Physical features now tend to indicate a preference for a more consistent position of contact. Reasons for determination follow: 1. Although the strata from the contact of T.&W. to the contact of Kay are transitional, lithic similarities seem more closely related to the Stewartville than to the Dubuque. 2. SCB's No. 7 and 8 as used within this investigation are present at Loc. 9 at a distance of 7′ and 9′-7″ respectively, above the contact of T.&W. At all localities where Dubuque strata may be observed there has been no calcarenite; the rock of the Dubuque is highly argillaceous even when one does not consider the shaly partings.

The authors have not had time to pursue the following point to the desired or necessary degree; however its mention may be of assistance to future workers. At Loc. 9, at a point 19 feet-6 inches below the contact with the Maquoketa, is a 2 1/2 inch prominent shale parting. This can be correlated to the several exposures observed. The Mason City District Office of the Iowa State Highway Commission has allowed the authors to examine sections prepared of various quarries that include the Stewartville-Dubuque strata. Within these sections, they have noted the "Freeze and Thaw Alcohol Tests" of their subdivisions. The authors have been able to correlate their sections with those of the Highway Commision, and at the point of the 2 1/2″ shale parting a sharp change is noted within the tests of several localities, some of which are within Clayton County. Above the 2 1/2 inch shale parting, the tests always exceed 4.0, while below they are considerably less. A typical example of this is a quarry near Osterdock, Iowa (NW 1/4, SE 1/4, Sec. 2, T.91 N., R.3 W.). Here the unit immediately overlying the shale parting which is considered to be the 2 1/2 inch parting at Loc. 9, tests 5.2, next above 5.3, and the next above 7.8. Those immediately below the shale parting test downward, 3.1, 3.5, 3.9, 2.1, 1.6, 1.9, etc. This seems to be the situation of all the sections examined, several of which were within Winneshiek County. In not all cases is the variation so great, but it is always adequate enough to verify a sudden change in clay content.

In view of these three points, the Dubuque-Stewartville contact is placed at 19 feet-6 inches below the Maquoketa-Dubuque contact at Loc. 9, and at equivalent position in the strata elsewhere within the county. In surface exposure, this correlation may be extended without difficulty.

Sinsinawa-Stewartville Contact

Differentiation of the Stewartville Member, which averages about 48 feet in thickness within the county, is like that of T.&W. (1963, p. 127), except for contact with the overlying Dubuque. Problems at both base and top with the contact as well as correlation of the two members of the Wise Lake Formation have resulted in some workers following the subdivisions of Weiss (1955, 1957), *i.e.*, Stewartville, Prosser, and Cummingsville. With his scheme the Stewartville equals the Wise Lake of T.&W. Others prefer the subdivision of Agnew (1955). Effectually, this latter terminology defines the members of the Wise Lake, when Stewartville and non-cherty Prosser are used.

Within the county, each of the Wise Lake members may be recognized in the field to be a highly usable subdivision. Subsurface recognition will prove more difficult, but if cores could be obtained, the subdivision would also be practical there.

Correlation within the Stewartville has been maintained by the use of 7 SCB's (Fig. 2, Nos. 2-8). SCB No. 1 is situated 12" to 14" below the contact with the Sinsinawa. Being stratigraphically consistent but recurring in nature, one or more of the SCB's may be absent at some localities. An adequate number however, have always been present in observed Stewartville to position the strata.

Receptaculites (Upper Zone), is first noted about 4 feet below the contact, SCB No. 1, 12 feet to 14 inches below the contact, and the contact is occasionally soft or shaly. It is frequently shown with a considerable amount of secondary calcite. This may be well observed at Locality 14. At Locality 13, the contact shows a water-tube 1 foot to 2 feet in diameter which is filled with clay, sand, boulders and surface debris. Apparently at one time this portion of the Wise Lake served as an aquifer, which in turn would account for the calcite shown at the contact.

At Locality 14, a slight color change in rock at the contact is shown. Here the rock is a buff to tan color, but above the contact is more drab in appearance. This change was not noted in all exposures.

The Sinsinawa Member within the County is about 30 feet in thickness. At Locality 14, the full thickness is shown at 30 feet-9 inches. Within the lower 8 feet there are usually 3 or 4 chert bands which are spaced about 30 inches apart, while above this to the top of the member are numerous corrosion surfaces. Fourteen are noted at Loc. 14. At 15 feet-11 inches above the base of the member is bentonite (I-7 of Mossler and Hayes). This differs from the Dunleith bentonites in outward appearance, which in Mossler's words (personal communication 1/2/72), "Instead it reminds me of a thin bentonitic shale that sometimes occurs immediately beneath the Carimona K-bentonite of the Plattville Formation. Perhaps it is a similar bentonitic shale bed of the Galena."

The rock of the Sinsinawa is gradationally more dolomitic upward. Between 4 to 12 feet above the base, crinoid crowns may occasionally be collected. (Designated Crinoid Horizon 1, Fig. 2.)

Wyota-Sinsinawa Contact

The contact of the Wyota with the Sinsinawa is adequately distinguished everywhere as the top of the Prosser of Weiss, (1955, 1957). Generally the Wyota is cherty throughout, but within the county usually only the upper portion is cherty with a distinctive zone at the top which contains 5 or 6 nodular bands of chert confined to a 26 inches to 48 inches thickness. This "zone" (Chert Sequence No. 4) is frequently shaly and sharply defined lithologically from the overlying Sinsinawa.

The thickness of the Wyota provided by T.&W. (1963, p. 116), as 18 feet-0 inches, as also their sections of the Decorah area provided, does not include quite all of the member. Bed to bed correlations to the two T.&W. sections which show Wyota strata, indicate that elsewhere, when the top of the member may be observed closely, there are several inches to a few feet below. Lithic evidence, quantity of chert, and preparation of numerous sections indicate the Wyota to be up to 21 feet-3 inches in thickness. Locality 8-H, which is about 1,000 feet to the northeast of their "South Quarry Section," shows this thickness. At the contact of most localities is a prominent, rusty, discontinuity surface which should not be confused with a greater disconformity frequently shown at the base of the cherty horizon at the top of the Wyota.

Within the Burr Oak area the cluster of chert at the top of the Wyota is absent. Instead, the chert bands are spread out. This may be observed at Locality 2, also a quarry 1/4 mile west of Burr Oak (SE 1/4, SE 1/4, Sec. 23, T.100 N., R.9 W.) where the contact is not sharply distinguished as in the Bluffton and Decorah areas. At this locality the sequence is: Wyota 7 feet-8 niches, Sinsinawa 30 feet-0 inches, Stewartville 5 feet-0 inches.

Wall-Wyota Contact

The upper contact of the Wall Member is not always sharply distinguished. General characteristics of the Wall assist in locating the contacts. There is usually little chert within Wall of the county except one or two bands, the lower of which is persistently at 12-18 inches above the base. Uniform 18-24 inch beds are thinner than overlying Wyota and thicker than the upper 6-8 feet of Sherwood. The most persistent feature noted in several sections of Wall strata at the top and bottom of the member is a prominent brown clay parting. These are 12 feet-0 inches to 12 feet-4 inches apart. At mid-point between them is a third brown clay parting. Elsewhere, the middle clay parting is a bentonite (T.&W. 1963, p. 123), but within the county it checked out to be only a marine clay. These clays average from 1/2 inch to 1 1/2 inches in thickness.

Generally, the Wall is less argillaceous than the upper part of the Sherwood, but the Wall-Wyota contact may seldom be distinguished in this manner. Two persistent corrosion surfaces spaced 4 to 8 inches apart are commonly 8 to 12 inches below top of the Wall. As many as 8 above have been observed within the member, most strong, dark, and rusty. Much less crinoidal debris is noted within base of Wall than in top of Sherwood. *Ischadites* has not been observed within the Wall, while it is common throughout the Sherwood and upper Rivoli.

Sherwood-Wall Contact

The general features of the Wall assist in the placement of the contact. Rarely, the gray calcarenitic limestone at the top of the Sherwood is in thick, massive, beds to the contact as is the Wall. When this occurs however, a thin shale parting 3 inches thick is present at the top of the Sherwood which contains many crinoid and cystoid remains, frequently preserving complete specimens.

Usually the upper 6 to 8 feet of the Sherwood consists of numerous thin, calcarenitic beds, the surfaces of which are a virtual coquina of well preserved brachiopods, gastropods, many crinoidal remains, and rarely a small starfish may be collected.

Several nodular chert bands are commonly present within the upper 8 feet of the Sherwood (Chert Sequence No. 3, Fig. 2), while only a few nodular chert bands are uncommonly situated within the remainder of the member. At Loc. 8-H, the top of the Sherwood is distinguished as an argillaceous horizon 21 inches in thickness, with a corrosion surface at the top. Below this horizon the upper 8 feet consists of the thin coquinoid beds within which are 5 prominent 1 inch to 1 1/2 inches thick chert bands. Numerous corrosion surfaces, beautiful black or dark grey upon the face of a lighter grey rock, are present within the Sherwood. These are very pyritic, and much less common than those within the subadjacent Rivoli Member.

Below the Sherwood the various members and their contacts are quite readily distinguished by using the study of T.&W. (1963). The following general identification keys have been useful.

Rivoli Member

Numerous corrosion surfaces. Bentonite, which is commonly recognizable in the field, 5 to 7 feet below top. Frequent shaly band 7 to 10 inches thick immediately below bentonite. *Ischadites iowensis* common above the bentonite. Averages 21 feet in thickness within county of usually non-cherty strata. Occasionally one or two nodular chert bands near base.

Mortimer Member

Large chert bands frequently 6 inches thick. Numerous chert bands throughout (Chert Sequence No. 2, Fig. 2), most common upper half of member. Frequently shaly band in middle and top, respectively 10 inches and 16 inches in thickness, which is variable. Member averages 12 to 13 feet in thickness.

Fairplay Member

Usual highly argillaceous, laminate limestone band, 15 inches thick at top. Many faint corrosion surfaces hidden by crinkly bedding. Heavily dolomite mottled, about 40 to 50 percent. *Receptaculites* common throughout (Lower *Receptaculites* Zone). Member averages 18 to 19 feet in thickness.

Eagle Point Member

Upper 6 to 7 feet resembles rock of Fairplay. Many nodular chert bands throughout (Chert Sequence No. 1, Fig. 2) which are not observed in the Fairplay. In weathered exposure, sharp bedding contrast when compared to the much thinner beds of Beecher. Averages 15 feet in thickness.

Beecher Member

Many SCB's which are of short lateral duration. Top bed massive, averages 15 inches in thickness frequently showing alternating layers of sparry calcarenite and limestone. Sharply distinguished from shaly Ion Formation below. Averages 15 feet in thickness except at Loc. 8, where it is 13 feet-2 inches thick.

RESULTS OF INVESTIGATION

Where rocks of the Galena are exposed within Winneshiek County, many fossils are present which will provide large taxonomic collections. The need for biostratigraphic and paleontologic study is evidenced by the sparsity of published material relating to these studies. Numerous well preserved fossils previously unknown from the Iowa Galena strata have been collected by the authors. To supplement these studies, stricter stratigraphic control and finer subdivisions of geologic units were required than those currently in use in Iowa. T.&W. (1963), provide the desired subdivisions which are currently in use in Illinois. Their study, with minor exception, has been found to be applicable to the Iowa rocks of this investigation, and should be used as a basis for future work within Iowa. Subsurface application of these subdivisions is more difficult than with exposed rocks; however, taxonomic and biostratigraphic work is seldom completely accomplished with work done solely in the subsurface. It is believed that the index units provided as a result of this investigation will assist subsurface workers.

Because of facies changes, within which the lithic similarity of Decorah strata is non-recognizable when compared to that of Illinois or Minnesota, it is recommended that previous subdivision should be retained in Iowa, *i.e.,* Spechts Ferry, Guttenberg, and Ion (Kay, 1935b, and others). Within this investigation, each of these subdivisions has been considered as a formation of the Decorah Subgroup.

The use of nodular chert bands, corrosion surfaces, and sparry calcarenite bands as correlatives, in conjunction with normal stratigraphic principles used by T.&W. (1963), provide for stratigraphic control not previously achieved. These correlatives have been concluded to be inter-related and to evidence a relationship to other physical features that must be given attention under a needed time-stratigraphic study.

Sections prepared of Galena strata, particularly that of the Kimmswick Subgroup, the basic subject of this preliminary investigation, should be prepared with a graphic column drawn to 1/4-inch scale for comparison with Fig. 2, in order to include the correlatives of this investigation which assist in definite stratigraphic control.

The high degree of stratigraphic variability of the argillaceous content of a portion of the rocks of the Kimmswick within the county, equivalent to the Minnesota Cummingsville, makes a considerable problem if stratigraphy is to be based purely upon lithology; conversely, where many sections are prepared, the subdivision to members by T.&W. (1963), as based upon "pure" and "impure" units may be readily noted. Generally at the top of each unit is a much thinner argillaceous bed than the remainder of a less argillaceous unit. This is not always sharply distinguished when individual sections are prepared. The purpose of Fig. 2 of this investigation is to assist in recognition of these units, for it is a composite of many sections prepared within Winneshiek County.

Nodular chert bands have been found to be more common in carbonate rocks than shales, and vary with the degree of argillaceous content of the rock. Southeast of Winneshiek County where clay content decreases, an increase of chert is noted.

Although within this preliminary investigation, adequate study has not been afforded the Dubuque Formation, the placement of the contact with the Stewartville has been positioned at a point between that of Kay (1935a), and that of T.&W. (1963), because of features of relationship and lithic factors which presently appear to necessitate such placement. A sharp contrast is noted in argillaceous content at the new position of contact, as based upon the freeze and thaw tests conducted by the Iowa State Highway Commission for determining quality rock for concrete aggregate.

The stratigraphic positioning of Stewartville strata is possible within the county by using 8 sparry calcarenite bands, the lower of which is 12 to 14 inches below the contact with the Sinsinawa Member. These layers have been noted to be of considerable lateral extent and to maintain their particular stratigraphic positions.

This report is based upon observations of a preliminary nature. Particular effort has been applied to avoid the mention of factors noted where inconclusive evidence exists. Several of the features involved will require further study, as stated in text. Future workers should most certainly elaborate upon these points, for strict stratigraphic control is essential within the Galena of Winneshiek County.

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