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Lithostratigraphy and Petrology of the Bertram Member of the Wapsipinicon Formation (Devonian) in East-central Iowa

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Abstract. Rock samples were collected from the Bertram Member of the Wapsipinicon Formation in six quarries in Linn County, Iowa. Polished sections and thin sections were made of selected samples and were studied by use of binocular and petrographic microscopes. Sample cuttings from selected wells in east-central Iowa were studied for the presence of Bertram lithologies. An isopachous and paleogeologic map of Bertram strata was prepared from the data obtained from surface and subsurface samples.

Prior to Bertram deposition east-central Iowa was exposed to subaerial erosion. The first sediments of the Middle Devonian transgressive sea were deposited on a supratidal mudflat which was occasionally flooded by abnormally high tides, as evidenced by the presence of very fine-grained dolomites, dessication features, traces of gypsum, intraclasts and scattered sand grains.

The Bertram Member of the Devonian Wapsipinicon Formation is a distinct lithologic unit which can be recognized in surface exposures in Linn County and in subsurface drill cuttings from Linn, Johnson and Benton Counties.

The Bertram was named by Norton in 1894 and was assigned to the Silurian together with the overlying Coggon. In 1916 Norton placed the Bertram in the Devonian on the basis of texture and brecciation. Since that time the Bertram has been considered equivalent to the Otis by Stainbrook (1935) and as a distinct member below the Coggon or part of the Coggon by Scobey (1938, p. 30). The Bertram is assigned by this author to the lowermost Wapsipinicon as shown on the columnar section (fig. 1).

METHODS OF INVESTIGATION

The writer visited six quarries in Linn County during the fall of 1965 and the field season of 1966. Detailed field sections were made of the rock at three of the quarries. Rock samples were collected and appropriately labeled from each of the six quarries. Twenty polished sections and seven thin sections were made from selected samples. Polished sections were studied both megascopically and by use of a binocular microscope. Thin sections were examined by use of a petrographic microscope.

Well logs from the Geological Survey files were examined for lithologic descriptions and correlations of Bertram strata. The locations of the wells which contain lithologies similar to the Bertram were plotted on a base map of east-central Iowa. The sam-

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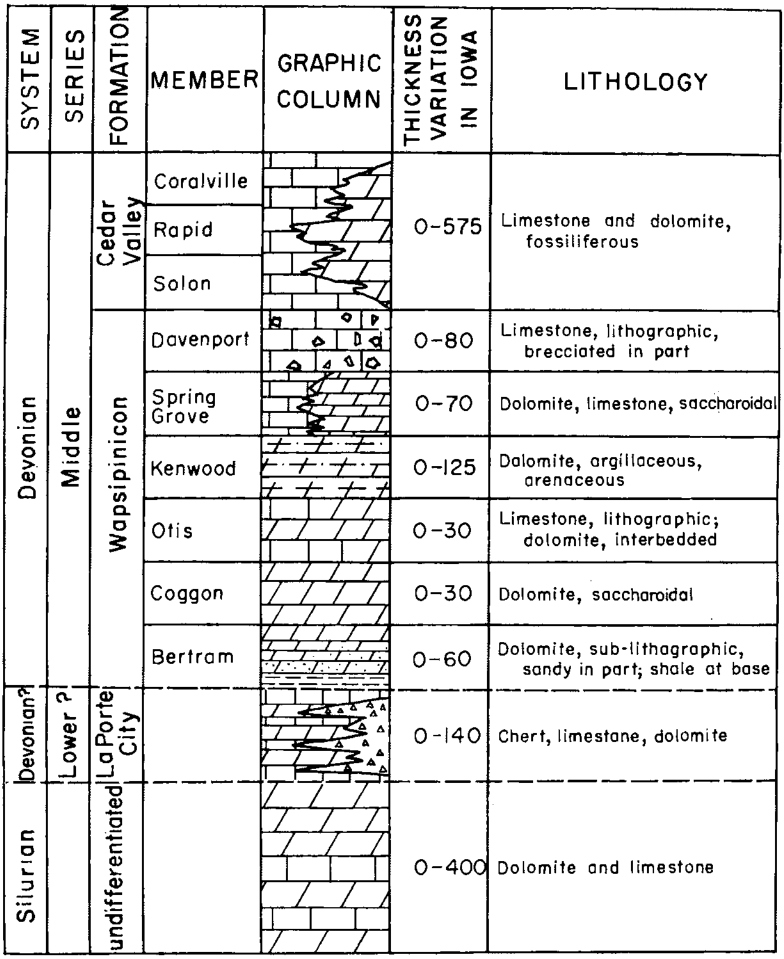


Figure 1. Generalized Columnar Section, east-central Iowa

ples from selected wells were restudied by the writer and an isopach map was prepared.

Stratigraphic Relations

The Bertram overlies the Devonian LaPorte City Chert (Parker, 1967) or the Silurian dolomites and underlies the Coggon Member of the Wapsipinicon Formation in east-central Iowa. In the western and northern portions of the Bertram depositional area the LaPorte City Chert directly underlies the Bertam as shown by the shaded portion in figure 2. In the eastern part of the area Silurian dolomites are subjacent to the Bertram.

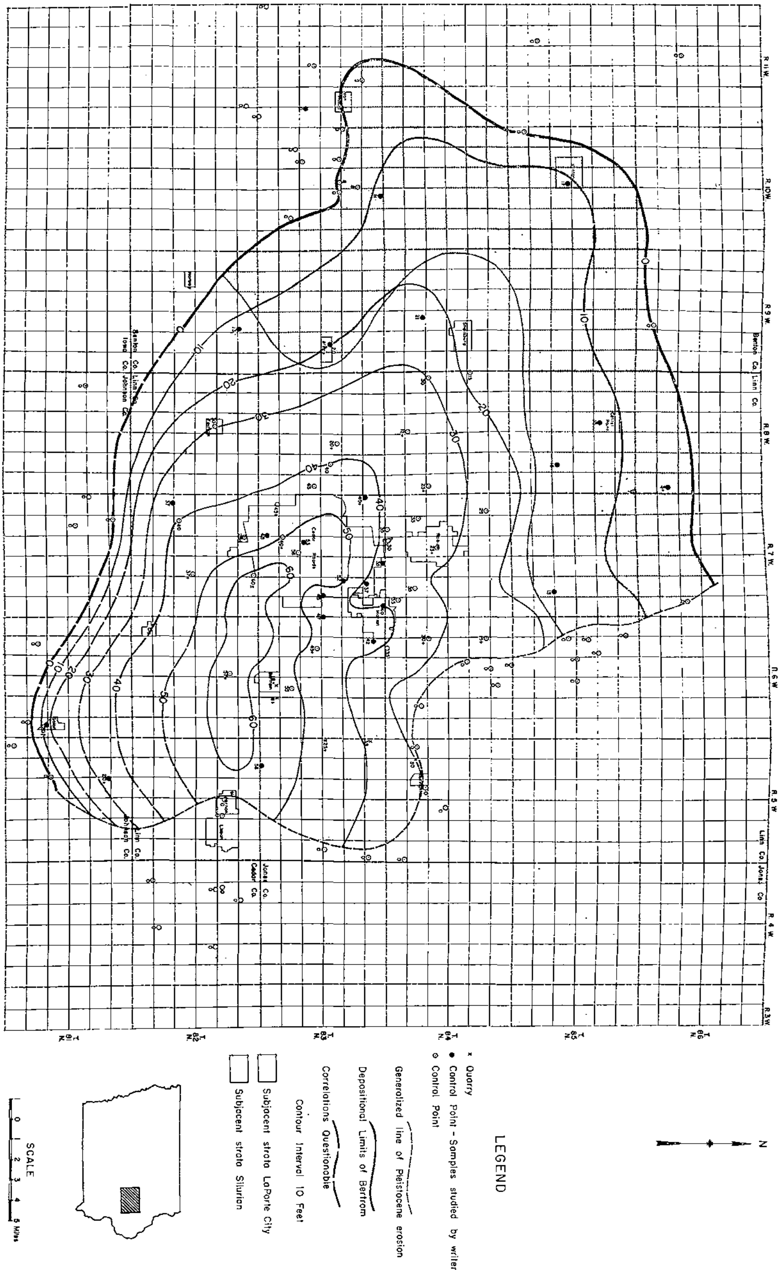


Figure 2. Bertram Isopachous and Paleologic Map

Southeast of Cedar Rapids the Bertram attains a thickness of nearly sixty feet. The unit thins toward its depositional margins and pinches out in northern Linn, central Benton and northern Johnson Counties. Portions of the unit have been removed by erosion in central and eastern Linn County. Generally the entire unit has been removed by erosion north and east of the generalized line of erosion.

The only known exposure of the contact between the Bertram and the underlying strata is in a 30 foot square pit in the Springville Quarry (NW¼ SW¼ sec. 29, T. 84N., R. 5W., Linn County). The contact is overlain by a green and brown shale which ranges in thickness from five to seven feet. Beneath the contact is a brown dolomite which is thought to be Silurian in age. The lower dolomite has a relief on its upper surface of three to five feet within the restricted area of the exposure. The shale contains blocks of the overlying Bertram dolomite and of the underlying Silurian dolomite. Upper Devonian conodonts have been recovered from a bulk sample of the shale according to Dorheim (1967). At least a part of this shale represents a condition of stratigraphic leak and is equivalent to the Upper Devonian Lime Creek Formation (Dorheim, 1967). The pit containing this exposure will be enlarged in the spring of 1967 at which time a more complete understanding of the nature of this contact may be derived.

Stratigraphy

SILURIAN SYSTEM: The Silurian rocks subjacent to the Bertram are composed primarily of orange or light- to dark-gray dolomites. The dolomites usually are medium to coarse grained and exhibit a vugular and intergranular porosity. Some facies of the Silurian rocks are composed of fine-grained, dense dolomite. The dolomites contain very little argillaceous or detrital material.

LAPORTE CITY CHERT: The LaPorte City Chert is composed of chert, limestone and/or dolomite. The relative amounts of each of these constituents vary. The chert is the most diagnostic lithology of the LaPorte City and distinguishes the LaPorte City from the overlying Bertram. The chert is smoky gray and white to very pale-orange in color. It may have a rough or smooth surface in drill cuttings and it usually breaks with a conchoidal fracture. The limestone in the LaPorte City is usually pale orange in color and has a very fine-grained texture. The dolomite is fine grained and ranges in color from gray to pale orange. There are no surface exposures known of the LaPorte City Chert. Therefore, our knowledge of the relationship of the Bertram to the LaPorte City strata is limited to the study of drill cuttings from a few isolated wells in Benton and Linn Counties.

BERTRAM MEMBER: At the base of the Bertram a sandy shale occurs that is nearly everywhere present in the subsurface, is green and brown in color, and ranges in thickness from a few inches to about five feet. In some wells the shale contains angular granules of limestone and dolomite. In two wells in Benton County this interval is represented by an argillaceous sandstone.

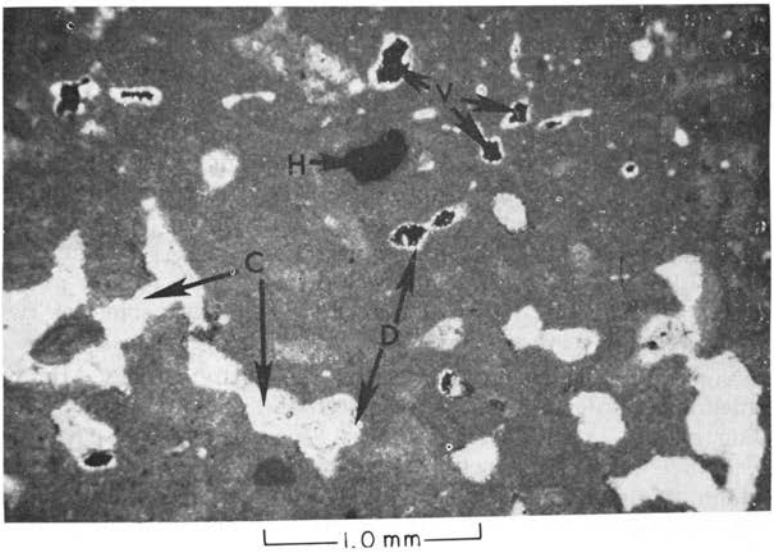
The shale in some localities may represent a condition of stratigraphic leakage as is evidenced at the Springville Quarry. However, the lateral extent of this shaley interval indicates that the unit is in its true stratigraphic position in most places. The shale always is associated with the zone which separates the lithologies of the Bertram from the lithologies of the LaPorte City and Silurian strata.

The Bertram is composed primarily of fine-grained to sublithographic dolomite. In subsurface cuttings the rock is brown and light to dark gray. Rounded quartz grains and fine pyrite crystals are disseminated throughout the rock.

In outcrop the Bertram is usually grayish-yellow to light brownish-gray. In some exposures the rock weathers into white bands one to two feet thick which alternate with bands of grayish-yellow dolomite. Limonite and hematite occur as void fillings and as dendritic growths in minute cracks in the rock. The iron minerals found in surface exposures probably represent an alteration of disseminated pyrite grains which are common in subsurface drill cuttings.

Clay, detrital quartz, gypsum and hematite are the most common constituents of insoluble residues from the Bertram according to Scobey (1938). Each of the five samples studied by Scobey contained less than five percent insoluble residue. The insoluble residue from two of the samples contained thirty-five percent gypsum and in one sample sixty-five percent gypsum was reported. No gypsum was reported from the remaining two samples.

The most striking characteristics observed from thin sections and polished sections of the Bertram rocks are: convolute and wavy laminations, crystal lined vugs, scattered intraclasts and localized breccias, very fine-grained and pelletal dolomites, and numerous cracks. The laminations are thought to represent algae and algal heads. The algal heads range from one to twenty millimeters in diameter and often contain numerous fragments of the surrounding dolomite. These fragments are usually rounded to some degree and are referred to as intraclasts by Folk (1965). The clasts have been eroded from the floor of the depositional basin under high wave energy conditions and have been redeposited during periods of weak to moderate current activity. In



Crossed nicols x 24

Figure 3. Photomicrograph, Very finely crystalline dolomite containing irregular wavy vugs. Vugs are usually lined with fine clear dolomite anhedra (D) The remainder of each vug is left as open voids (V), partially or completely filled with calcite spar (C), or filled with hematite (H)

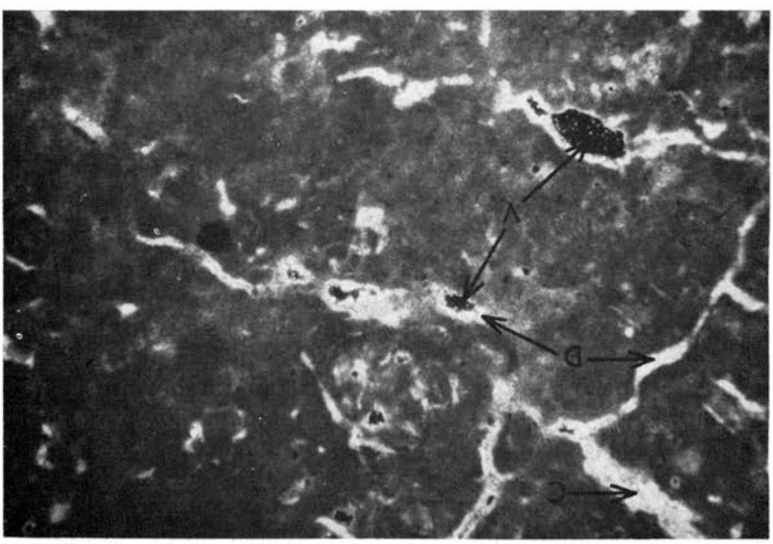


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Figure 4. Photomicrograph, Very finely crystalline pelletal dolomite containing irregular wavy vugs. Vugs are lined with fine grained clear dolomite anhedra (D). Those not filled with dolomite are left as open voids (V) or filled with calcite spar (C)

certain layers these intraclasts are numerous and they form discontinuous small scale breccias.

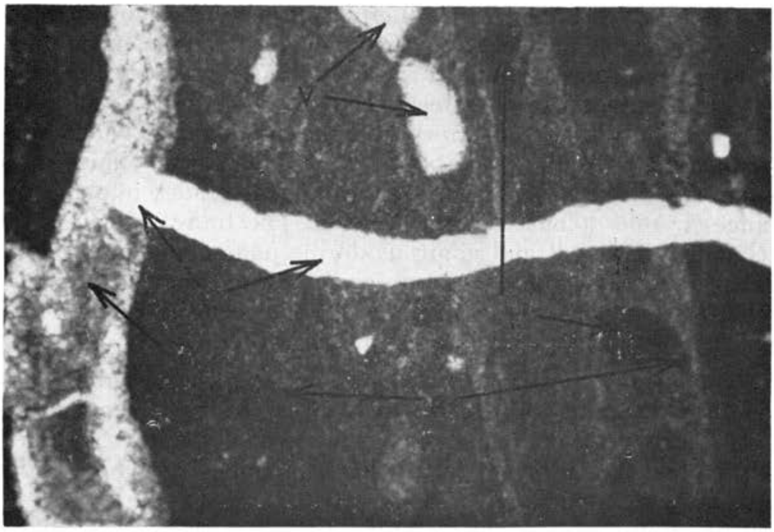
Irregular wavy vugs which are lined with clear dolomite anhedra commonly are observed in thin section. The crystals are smaller near the cavity wall and they increase in size towards the center of the void. The dolomite has probably replaced acicular drusy calcite crystals (see Shinn, E. A., Ginsburg, R.N., and Lloyd, R. M., 1965, p. 119, fig. 7 a,b). The remainder of the cavity may be empty or partially to completely filled with dolomite anhedra or calcite spar in optical continuity. The vugs occur in pelletal or very fine-grained dolomite (figs. 3 and 4). Structures similar to these have been interpreted by LaPorte (1967) as internal shrinkage or dessication features. At least some of the vugs probably were produced by burrowing organisms.

Numerous fine cracks characterize the Bertram rocks. Minute polygonal dessication cracks may be found on some of the bedding planes. In thin section at least two sets of cracks can be recognized. The first set is filled with fine-grained dolomite which may contain a few scattered intraclasts. Secondary cracks cut the primary ones and also transect the contained intraclasts. The secondary cracks usually are lined with fine clear dolomite and are filled with fine-grained dolomite or calcite spar. Most of the larger cracks are filled with calcite spar (figs. 5 and 6).

In five of the thin sections the rock exhibits a vague pelletal texture. The pellets are embedded in a matrix of very fine-grained dolomite. In two of the thin sections the rock is composed entirely of very fine-grained dolomite.

Except for algae, ostracods are the only other fossils that have been found in the Bertram. A few poorly preserved ostracod specimens have been recovered from drill cuttings. The specimens are of a smooth shelled variety and cannot be used for age determinations (Kessling, R. V. 1966, personal communication).

The features observed in Bertram rocks seem to suggest deposition on a supratidal mudflat. Vugs, laminations, clasts and pellets are common to present day supratidal mudflats in the Bahamas (Shinn, E. A. et. al., 1965). Mudflats which are now forming on South Bonaire Island in the Netherland Antilles are characterized by very restricted faunas, very fine grain size, an association with gypsum and the presence of thin extensive dolomite beds and dolomite clasts broken from these beds (Deffeyes, K.S., et al., 1965). LaPorte (1967) has interpreted dessication cracks and irregular vugs which occur in Lower Devonian pelletal limestones of the Manlius Formation of New York to represent features which developed on supratidal mudflats. The Manlius also contains stromatolites, ostracods, intraclasts, dolomite, clay and quartz according to LaPorte. The laminated structures observed in Bertram rocks may represent algal mats which could have developed on this flat.



Plain polarized light x 24

Figure 5. Photomicrograph, Finely crystalline intraclastic dolomite. Secondary cracks cutting primary breccia. Crack is partially filled with fine clear dolomite anhedra (D) and calcite spar (C). Note dolomite intraclasts (I) in dolomite matrix. Open voids (V) are lined with fine clear dolomite crystals.

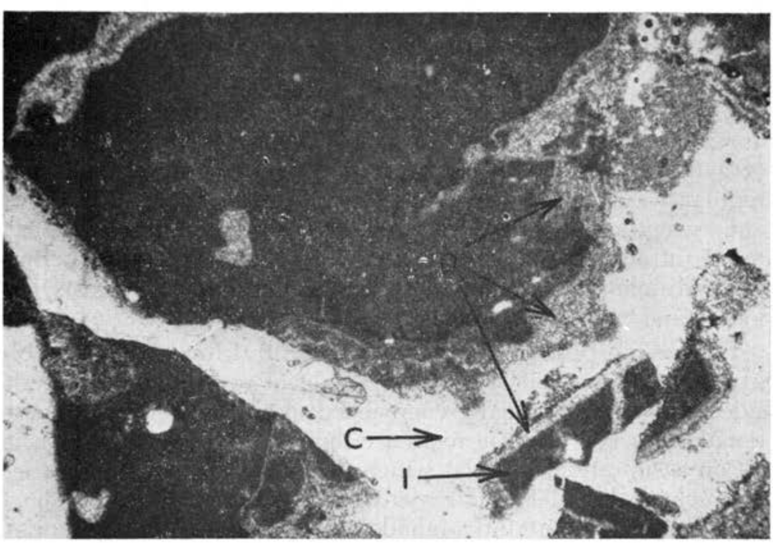


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Figure 6. Photomicrograph, Very finely crystalline dolomite. Fracture is lined with clear fine dolomite anhedra (D). The remainder of the fracture is filled with calcite spar (C) which contains embedded intraclasts (I), which also are lined with clear dolomite anhedra (D).

COGGON MEMBER: The Bertram is everywhere overlain by the Coggon Member of the Wapsipinicon Formation. In field exposures and cores the contact is transitional and conformable over a vertical interval of a few feet. The base of the transitional interval is usually a grayish-brown lithographic dolomite which contains scattered vugs, some of which are filled with orange, saccharoidal dolomite. The top of the interval grades into the orange, friable dolomite of the Coggon. The transitional interval contains scattered sand grains as do the units above and below. The grains are rounded and are composed of quartz and smoky chert. No evidence of an unconformity between the Bertram and Coggon strata has been observed by the writer.

The Coggon is composed of an orange, saccharoidal, fine-grained dolomite. Most of the rock is very friable except for occasional lenses of dense, grayish-brown dolomite. Scattered throughout the rock are soft molds of a small brachiopod from the genus *Emanuella.*

SUMMARY

The Bertram is placed in the Wapsipinicon Formation on the basis of its lithologic similarities and its conformable relationships to the overlying Coggon Member. The Bertram is lithologically dissimilar to the underlying LaPorte City and Silurian rocks. Evidence obtained from subsurface drill cuttings suggest that an unconformable relationship exists between the Middle Devonian Bertram and the Lower Devonian and Silurian strata. Bertram type lithologies can be recognized and mapped in three counties in east-central Iowa.

The following features characterize the Bertram rocks which are exposed at the surface in Linn County: 1. Small quantities of gypsum, 2. Rounded detrital quartz and chert grains, 3. Irregular wavy vugs lined with dolomite crystals, 4. Convolute and wavy laminations which resemble algal structures, 5. Scattered intraclasts and local breccias, 6. Pelletal and very fine-grained dolomite 7. Numerous cracks filled with intraclasts, dolomite and calcite.

Previous to Bertram deposition east-central Iowa was probably exposed to subaerial erosion. As sea level rose or the land subsided the water gradually encroached upon the Bertram depositional area. The Bertram rocks are thought to have been deposited on a supratidal mudflat which developed as the sea invaded east-central Iowa. The flat was usually exposed above sea level but it was intermittantly inundated by abnormally high tides. During such tides clasts were eroded from the flat and entrapped along with detrital quartz grains in algal mats which occupied portions of the flat. During intertidal periods evaporation of the entrapped water resulted in the formation of gypsum. Penecontemporaneous dolomitization of the sediment may have have taken place by the reflux process described by Deffeyes, K.S., et. al., 1965. Burrowing organisms may have reworked some of the sediment into pellets. As portions of the flats dried dessication cracks and shrinkage features developed in the sediment. Some of these cracks were later filled with clasts which were eroded during the next high tide.

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