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COUNTY ATLAS SERIES
ATLAS C-11, PART A
Plate 2—Bedrock Geology

BEDROCK GEOLOGY

By

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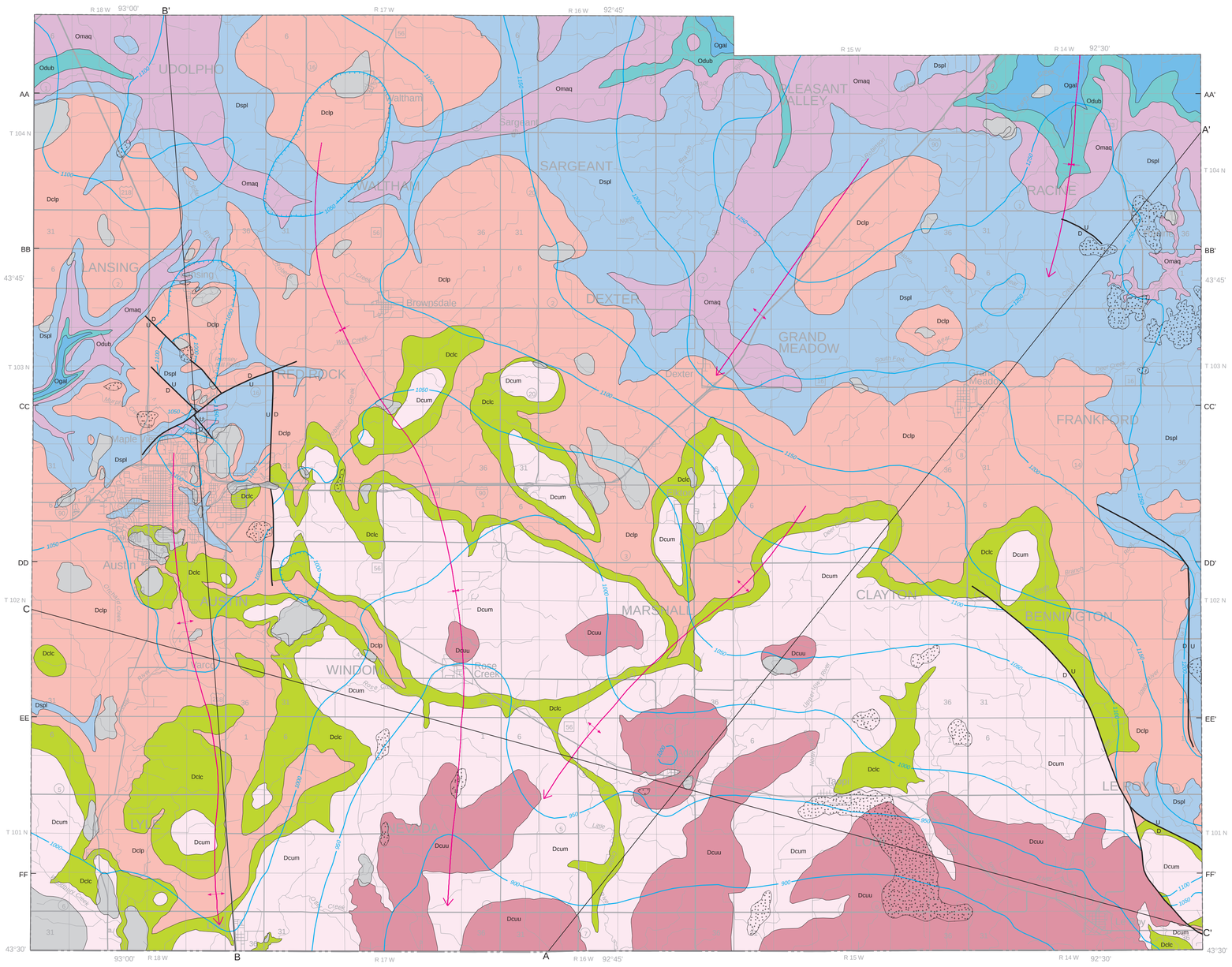
1998



Digital base modified from 1990 Census TIGER/Line Files of U.S. Bureau of the Census (source scale 1:100,000); county border files modified from Minnesota Department of Transportation files; digital base annotation by Minnesota Geological Survey

Universal Transverse Mercator Projection, grid zone 15
1927 North American Datum

SCALE 1:100 000
1 0 1 2 3 4 5 MILES
1 0 1 2 3 4 5 6 7 8 KILOMETERS

Cartography by Joyce Meints and Philip Heywood
Graphic design by Philip Heywood

INTRODUCTION

The map on this plate shows the bedrock formations that crop out or lie immediately beneath Quaternary sediments. The information used to create this map was compiled from examination of exposures of bedrock and from subsurface data, including water well drillers' logs, geologists' descriptions of water-well cuttings, wireline geophysical logs, engineering drawings, and geotechnical logs. Unpublished sources that were consulted include geologic field notes by R.E. Sloan (1954–1960), D.W. Kohls (1959–1960), Nikola Prokopovich (1955), and W.E. Parham (1966). J.A. Green, Minnesota Department of Natural Resources, and G.N. Meyer provided the author with locations and descriptions of outcrops and sinkholes.

For further information on the bedrock geology of Mower County, see Mossler (1998).

DESCRIPTION OF MAP UNITS

Windrow Formation (Upper Cretaceous?)—The Windrow Formation unconformably overlies Devonian carbonate rocks; the contact is generally marked by a zone of weathered rubbly rock several feet thick at the top. The mapped extent of the two members as shown on the map and sections is approximate.

Kwos *Ostrander Member*—Conglomerate consisting of rounded pebble-sized clasts of quartz and chert set in matrix of fine to coarse quartz sand grains. Generally very friable and unconsolidated; some thin siltstone and very fine sandstone layers. Goethite cement imparts distinctive brown to orange color. Generally less than 10 ft thick. Commonly overlies Iron Hill but may lie directly on older strata. The unit labeled (Kwos) is only shown on the cross sections.

Kwih *Iron Hill Member*—Clayey, noncalcareous, white to variegated light-brown, grayish-orange, and yellowish-green siltstone in scattered occurrences throughout most of county; includes some iron-formation (mainly goethite and minor hematite), especially in extreme eastern Mower County. Generally 5–15 ft thick.

The Ostrander is generally very porous and permeable, though locally goethite cementation may occlude porosity. Much of the Iron Hill is clayey siltstone, giving it relatively low permeability; it may form confining unit. The unit labeled (Kwih) is only shown on the cross sections.

Dcuu **Lithograph City Formation (Middle Devonian)**—Limestone and dolostone layered in thin to medium beds; a few scattered 1–3-in-thick gray-green shale beds. Dolostone is very finely crystalline, yellowish-brown. Limestone is yellowish gray, has distinctive, very fine grained equigranular (lithographic) texture. Limestone forms upper part of unit. Unit thickness as great as 50 ft near Le Roy, thinner or eroded elsewhere.

The unit contains many joints, fractures, and bedding planes enlarged by dissolution (Green and others, 1997) and possesses high permeability.

Dcum **Coralville Formation and Hinkle and Eagle Center Members of Little Cedar Formation, undivided (Middle Devonian)**—Dolostone, shale, limestone. Dolostone is thin to thick bedded, generally finely crystalline, yellowish gray or light brown. Light-gray lithographic limestone is very minor component. Unit thickness as much as 61 ft in Le Roy area.

Gray and gray-green shale beds as thick as several feet are present in upper and middle Coralville; they lack sufficient continuity to form regional confining unit (Libra and Hallberg, 1985). Most permeability is fracture related, present as joints or bedding planes; significant fossil-moldic, vuggy porosity present in lower Coralville. Dissolution-related permeability is less developed than in Lithograph City (Coralville dolostone much less soluble than Lithograph City limestone).

Dclc **Chickasaw Member of Little Cedar Formation (Middle Devonian)**—Silty, light-gray to medium-gray shale. In southeastern Mower, where it is 36–43 ft thick, the Chickasaw Member may form an important confining unit owing to its very low permeability (Green and others, 1997). Unit thins westward and is only 15–20 ft thick in western Mower County, where it is also dissected by buried stream valleys.

Dclp **Bassett Member of Little Cedar Formation and Pinicon Ridge Formation, undivided (Middle Devonian)**—Total unit thickness, 75–85 ft.

Bassett Member of Little Cedar Formation—Finely crystalline, thick-bedded to very thick bedded dolostone; light gray to brown gray; 40–70 ft thick.

Pinicon Ridge Formation—Mainly finely crystalline, silty or sandy dolostone; light gray to yellowish gray; 20–47 ft thick. In its medial part are nodules of light-gray chert, thin beds of gray shale and siltstone, and minor beds of dense yellowish-gray limestone.

The Bassett Member, though very thick bedded to massive, is jointed and contains a few large, open vugs. This relatively permeable unit forms a minor aquifer (J.A. Green, pers. commun., 1997). The medial limestone member of Pinicon Ridge, which farther south in Iowa is broken, possibly brecciated, and cavernous (Libra and Hallberg, 1985), may form an aquifer. Shaly dolostone and shale in the upper and lower parts of Pinicon Ridge have been interpreted to be confining units (Libra and Hallberg, 1985).

Dspl **Spillville Formation (Middle Devonian)**—Finely crystalline, light-brown to grayish-orange dolostone; abundant fossil-moldic porosity; dog-tooth calcite spar in larger vugs. Very thick to thin bedded. Basal few feet are sandy to silty and may contain minor amounts of shale or shaly dolostone. Middle to upper parts of unit have thin-bedded, light-olive-gray, dense dolomitic limestone. Unit thickness is as much as 78 ft in eastern Mower County; unit thins in western Mower County, where it is 21–66 ft thick.

Fracture porosity and permeability dominate upper part of unit; fossil-moldic, vuggy porosity is prominent in lower part. The basal shaly dolostone of low permeability may function as confining unit locally, as studies suggest it may in northern Iowa (Witzke and Bunker, 1985); however, gamma logs indicate the zone is discontinuous in Mower County.

Omaq **Maquoketa Formation (Upper Ordovician)**—Mostly silty, fine to medium crystalline, light-olive-gray, slightly fossiliferous dolostone; scattered beds of light-olive-gray shale and very light gray dense limestone. Vugs are lined with drusy quartz. Scattered light-olive-gray chert nodules. Principal fossils: crinoids and brachiopods. Unit thickness, 61–78 ft.

The dolostone in the upper part may have enhanced permeability owing to fracturing and brecciation that are related to the development of the pre–Middle Devonian unconformity on Ordovician rocks (Witzke and Bunker, 1985). The many thin shale beds in the lowest part are similar to those in the underlying Dubuque Formation; together, the lower part of the Maquoketa and the Dubuque form a regional confining unit.

Odub **Dubuque Formation (Upper Ordovician)**—Light-gray limestone; subordinate dolostone. Limestone interbedded with thin to medium beds of light-olive-gray to light-gray calcareous shale; fossiliferous (abundant echinoderms, brachiopods). Unit thickness, 23–35 ft thick.

Ogal **Galena Group (Upper Ordovician)**—Total unit thickness, 200–205 ft.

Stewartville Formation—Dense limestone and finely crystalline dolostone; mottled yellowish gray and pale olive gray. Few fossils compared to overlying Dubuque. Thickness, 75–85 ft.

Prosser Limestone—Fine-grained, fossiliferous, yellowish-gray limestone. Fossils in thin coquina layers (some silicified). Thickness, 40–50 ft.

Cummingsville Formation—Yellowish-gray dense limestone, green-gray, calcareous shale; fossiliferous (bryozoans, articulate brachiopods). Chert nodules, particularly in the upper part. Thickness, about 70–75 ft.

Owing to its shale beds, the Cummingsville is less permeable than the Prosser and Stewartville, which together form a unit of relatively greater permeability; however, enhancement of fracture permeability and porosity by karst-related dissolution of carbonate is spotty and is probably best developed where the formations were subjected to pre-Quaternary–Holocene nearsurface weathering, as in the northeastern and northwestern corners of the county.

Odpg **Decorah Shale, Platteville Formation, and Glenwood Formation (Upper Ordovician)**— Total unit thickness, about 70 ft.

Decorah Shale—Green-gray shale; thin beds of commonly fossiliferous limestone; about 45–50 ft thick.

Platteville Formation—Fine-grained, fossiliferous, yellowish-gray limestone; 20–30 ft thick.

Glenwood Formation—Green-gray, phosphatic, sandy shale; some quartzose sandstone beds; generally 5–6 ft thick.

Taken together, the three formations have low permeability because of their high shale content, but the Platteville may have minor permeability along joints and bedding planes.

Ostp **St. Peter Sandstone (Upper Ordovician)**—Very fine to medium-grained, light-gray sandstone; poorly cemented; quartzose. Regional unconformity at base. Generally 70–80 ft thick.

The St. Peter is considered an important regional aquifer, but drillers in Mower County report that its fine sand grain size and friability make well completion difficult (sandstone is hard to screen off and wells commonly pump sand). Also, a low-permeability regional confining layer at the bottom of the formation—found farther north and west in the state—is missing in Mower County (Woodward, 1986). Confining layers may be present locally.

Opdc **Prairie du Chien Group (Lower Ordovician)**.

Shakopee Formation—Dense to finely crystalline, light-gray to light-olive-gray dolostone. Locally sandy (medium to coarse quartz sand grains); siliceous oolites present locally. Oolitic dolostone possesses moldic porosity in places. Minor amount of white chert. Thickness about 150 ft.

Oneota Dolomite—Very light gray to yellowish-gray, finely crystalline, nonfossiliferous. Thickness, about 170 ft.

Coon Valley Member—Heterolithic basal unit; medium- to coarse-grained quartzose sandstone, very fine grained, feldspathic sandstone and siltstone, and sandy to silty dolostone.

Most permeability and porosity in the Prairie du Chien is related to fractures (joints, bedding planes), but intergranular porosity is present in sandstone beds. Fractures near the sub–St. Peter unconformity are possibly solution enhanced through weathering that occurred prior to deposition of the St. Peter. Strongly cemented, very fine grained sandstone and siltstone beds in the basal Coon Valley form a leaky unit of relatively low permeability (Setterholm and others, 1991).

Cjdn **Jordan Sandstone (Upper Cambrian)**—Total unit thickness, 65–70 ft.

Quartzose facies—Fine- to coarse-grained, very light gray, very friable sandstone; trace of calcite cement.

Feldspathic facies—Very fine grained, very light gray sandstone; calcite and minor pyrite cement.

Porosity and permeability are intergranular. The Jordan, which is considered an important regional aquifer, is generally much thinner in Mower County than where present to the north and east in Minnesota. The permeable quartzose facies is possibly only 20–25 ft thick in most of the county. The tight feldspathic facies has low relative permeability (Runkel, 1996).

Cstl **St. Lawrence Formation (Upper Cambrian)**—Very finely crystalline, very light gray to light-olive-gray, silty dolostone; glauconitic, especially near base of unit. Minor gray-green shale and light-brown-gray, sandy siltstone beds interspersed in dolostone; thin, light-brownish-gray silty shale about 20 ft thick at top. Generally 110–120 ft thick.

The carbonate rocks of the St. Lawrence are tightly cemented and have few open fractures; therefore, the formation is relatively impermeable.

THE FOLLOWING APPEAR ON THE STRATIGRAPHIC COLUMN ONLY

Franconia Formation (Upper Cambrian).

Reno Member—Slightly micaceous, glauconitic, light-olive-gray siltstone; minor amounts of green-gray shale; 75–80 ft thick.

Tomah Member—Green-gray, micaceous siltstone, shale; 25–30 ft thick.

Birkmose Member—Light-olive-gray, highly glauconitic siltstone and very fine sandstone; 35–40 ft thick.

Together with the St. Lawrence, the Franconia forms a relatively impermeable unit in Mower County. Vertical flow in the Franconia is impeded by many silty and shaly beds (Delin and Woodward, 1984).

Ironton Sandstone and Galesville Sandstone (Upper Cambrian)—Fine- to coarse-grained, friable, silty, yellowish-gray quartzose sandstone; minor amounts of green-gray shale partings. Total unit thickness, 40–45 ft.

The presence of intergranular porosity and permeability warrant investigation of the two units as a possible aquifer in Mower County; however, they may lack the permeability present farther north and east in the state, where average sand size is greater (Woodward, 1986).

Eau Claire Formation (Upper Cambrian).

Upper part—Green-gray, glauconitic siltstone and shale; 75 ft thick.

Lower part—Light-brown, very fine grained sandstone, shale, and siltstone; 120–125 ft thick.

The many shale beds and tightly cemented siltstone beds give the Eau Claire low permeability; in Minnesota it forms an important confining unit (Delin and Woodward, 1984).

Mt. Simon Sandstone (Upper Cambrian)—Not penetrated by any wells in Mower County. To the west in adjacent Freeborn County, the Mt. Simon is fine- to coarse-grained, light-gray to yellowish-gray sandstone containing many scattered beds of siltstone, very fine sandstone, and shale. Total thickness in Mower County estimated less than 200 ft.

Many zones of well-cemented siltstone and shale may reduce yields of wells developed in the Mt. Simon. The effect of Precambrian bedrock highs and structure on unit thickness is uncertain, but they may dramatically reduce the amount of sandstone available for well development: to the south in Cerro Gordo County, Iowa, the Mt. Simon is absent locally due to nondeposition (Hershey and others, 1970).

Fond du Lac and Solor Church Formations (Middle Proterozoic)—Not penetrated by any wells drilled in Mower County. Interpreted from adjacent areas to consist of red-brown siltstone, sandstone, and shale having low permeability.

Contact—Approximately located; generally concealed.

Fault—Inferred; U, upthrown side, D, downthrown side.

Anticline—Showing trace of axial surface and plunge of fold.

Syncline—Showing trace of axial surface and plunge of fold.

Line of equal elevation on the surface of the Maquoketa Formation—Contour interval 50 ft; ticks point into area of lower elevation.

A—A' **Line of section shown on this plate**—Vertical exaggeration x 20.

AA—AA' **Line of section shown on Plate 4**—Vertical exaggeration x 40.

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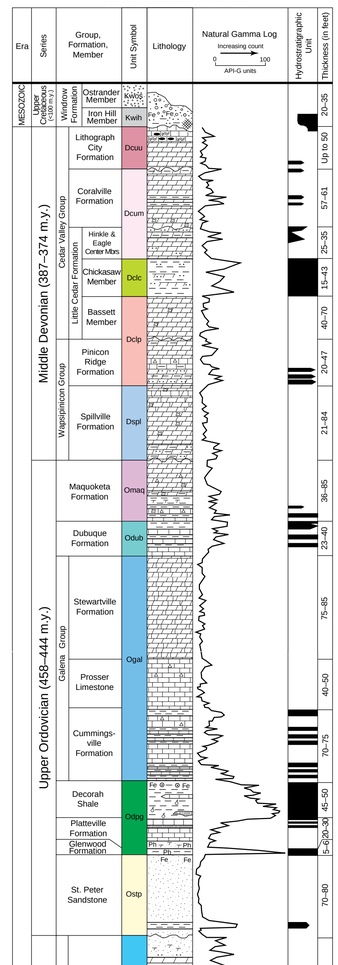
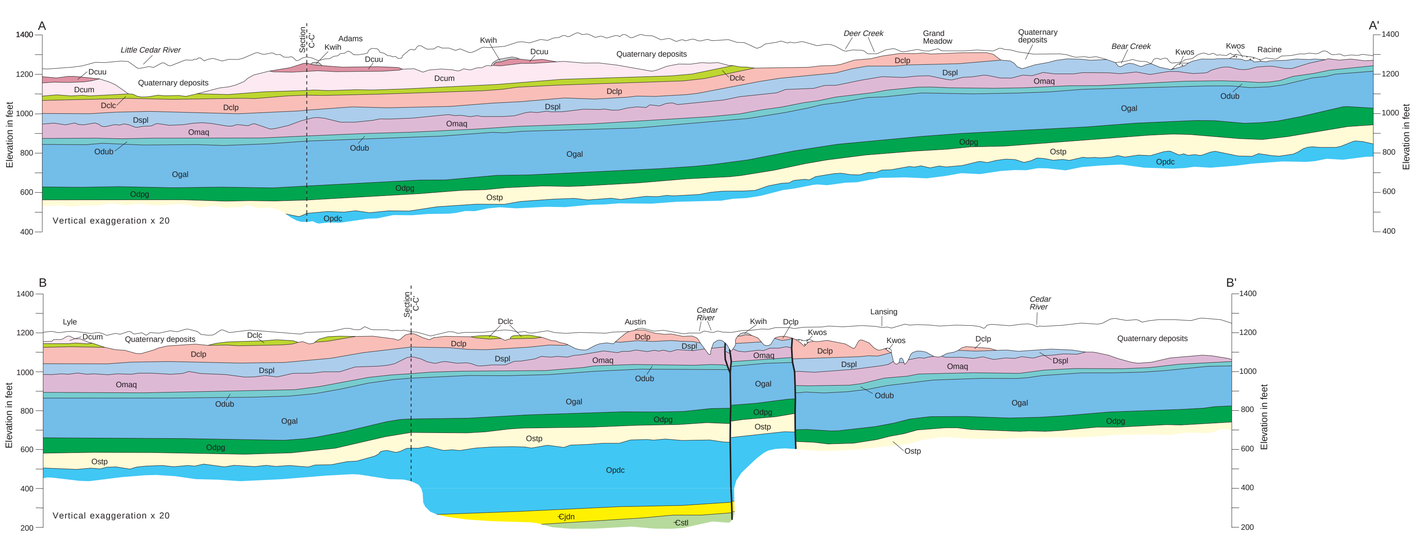
Every reasonable effort has been made to ensure the accuracy of the factual data on which this map interpretation is based; however, the Minnesota Geological Survey does not warrant or guarantee that there are no errors. Users may wish to verify critical information; sources include both the references listed here and information on file at the offices of the Minnesota Geological Survey in St. Paul. In addition, effort has been made to ensure that the interpretation conforms to sound geologic and cartographic principles. No claim is made that the interpretation shown is rigorously correct, however, and it should not be used to guide engineering-scale decisions without site-specific verification.

STRATIGRAPHIC COLUMN





GEOLOGIC ATLAS OF MOWER COUNTY, MINNESOTA