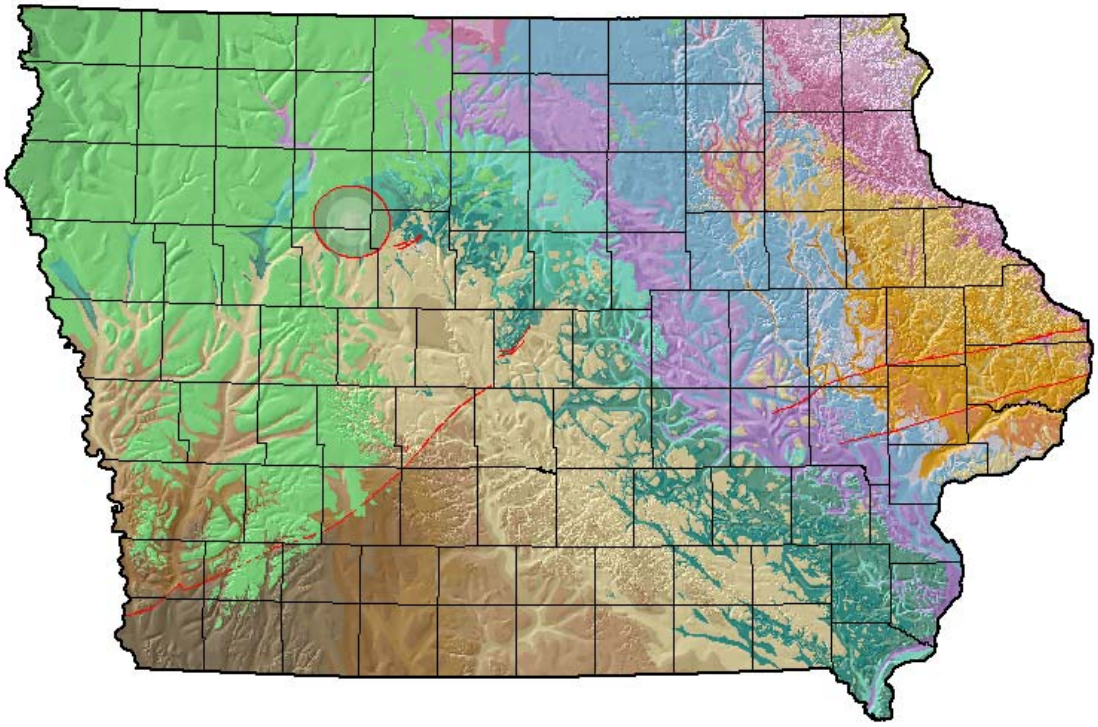
BEDROCK GEOLOGIC MAP OF IOWA



The bedrock geologic map portrays the current interpretation of the distribution of various bedrock stratigraphic units present at the bedrock surface. The bedrock surface is buried by unconsolidated surficial sediments (mostly Quaternary) over most of its extent, but this surface coincides with the modern land surface in areas of bedrock exposure. The map is consistent with all available data including drill records and well samples, as well as surface bedrock exposures (both natural and man-made) and shallow-to-bedrock soils units (NRCS county soils maps). Mapped stratigraphic intervals are portrayed primarily at the group level (i.e., a grouping of bedrock formations), each characterized by distinctive lithologies (rock types) summarized in the map key and associated metadata. The distribution of bedrock units was mapped to conform to the current map of bedrock topography (elevation of the bedrock surface). The structural configurations of relevant stratigraphic datums were intercepted with the bedrock topographic surface to produce the map contacts. The line style shown on the bedrock geologic map qualitatively reflects both data density and degree of certainty of individual stratigraphic contacts. Detailed line work is possible in areas of modern bedrock exposure, but more generalized line work (smooth and more sweeping forms) is portrayed in areas of sparser data control. The new bedrock map is, in part, a revised and updated compilation of seven multi-county bedrock maps prepared between 1998 and 2004 as part of Iowa's STATEMAP program (funded through U.S. Geological Survey). These maps were further supplemented with other STATEMAP bedrock compilations for portions of northeast and eastern Iowa, although much of the bedrock geology shown for northeast Iowa represents new and previously unpublished information. Bedrock faults are displayed in the map as sharp linear features offsetting mapped stratigraphic units.

LEGEND FOR BEDROCK GEOLOGIC MAP OF IOWA

Note: Given thicknesses and lithologic descriptions of individual map units apply only to areas of bedrock outcrop shown on the map unless otherwise indicated. Thicknesses and lithologies of units that are buried in the subsurface beneath younger strata (in areas outside of the mapped outcrop) will generally show greater regional variation than given in the legend.

CRETACEOUS

Kmt **MANSON GROUP**, Terrace Terrane (Megablock Zone); Manson Impact Structure (Upper Cretaceous; upper Campanian). *Upper Interval* (bedrock surface): sedimentary-clast breccia with shaly matrix, clasts and blocks of Cretaceous shale and varied Paleozoic lithologies entrained in silty-sandy clay matrix; minor clasts/grains of Proterozoic "red clastics " (mudstone/siltstone), crystalline basement rock, devitrified melt rock. *Lower Interval* (variably present, locally forms bedrock surface): overturned ejecta flap, breccias of Paleozoic lithologies and Proterozoic "red clastics" preserved in general inverted stratigraphic order. Breccias overlie down-dropped blocks (ring graben) of Cretaceous and Paleozoic strata in normal stratigraphic succession. Maximum thicknesses: upper shaly breccia up to 700 ft (210 m); lower interval approx. 1000 ft (300 m).

Kmm **MANSON GROUP**, Crater Moat area; Manson Impact Structure (Upper Cretaceous; upper Campanian). *Primary Lithology*: sedimentary clast breccia with shaly matrix; clasts and blocks of Cretaceous shale and varied Paleozoic lithologies in silty-sandy clay matrix. *Minor Lithologies*: grains or clasts of Proterozoic "red clastics" (mudstone/siltstone), Proterozoic crystalline basement, devitrified melt grains. Maximum thickness unknown, may reach thicknesses to 10,000 ft (3000 m).

Kmc **MANSON GROUP**, Central Peak; Manson Impact Structure (Upper Cretaceous; upper Campanian). *Primary Lithology* (at bedrock surface): sedimentary clast breccia with shaly matrix; clasts and blocks of Cretaceous shale and varied Paleozoic lithologies in silty-sandy clay matrix (see above; thickness 0-200 ft; 60 m). *Secondary Lithologies*: crystalline rock megabreccia (locally forms bedrock surface), fractured and brecciated Proterozoic basement lithologies, dominantly gneiss but including granite and other igneous-metamorphic rocks (maximum thickness unknown). Suevite and impact-melt breccias (locally forms bedrock surface), clasts of Proterozoic crystalline basement rocks, melt-rock, and minor Proterozoic "red clastics" in a matrix of melt-rich material (devitrified) and/or sandy-silty debris (thicknesses to 380 ft; 115 m). Keweenawan shale-clast breccia (locally forms bedrock surface), dominated by gray to black shale clasts (small to large) derived the lower "red clastics" sequence, common melt clasts, minor basement and Phanerozoic clasts, in a silty-sandy shaly matrix or melt-rich matrix (thicknesses to 250 ft, 75 m).

Kn **NIOBRARA FORMATION** (Upper Cretaceous; ?Santonian, lower Campanian). *Primary Lithologies*: shale, gray, silty, calcareous to marly. Estimated maximum thickness 50 ft (15 m). Present only in Lyon County.

Kf **FORT BENTON GROUP** (Upper Cretaceous, upper Cenomanian-Turonian). Interval includes "Graneros" Shale, Greenhorn Formation, Carlile Shale. *Primary*

Lithologies: shale, medium to dark gray, variably silty, calcareous to very calcareous. *Secondary lithologies*: chalk, marl, argillaceous limestone, with skeletal (inoceramid) packstones; shale, gray, silty, noncalcareous. *Minor*: siltstone; calcite and siderite concretions. Maximum thickness 265 ft (80 m).

Kd **DAKOTA and WINDROW FORMATIONS** ("Mid" Cretaceous; upper Albian-upper Cenomanian). Dakota Formation widespread in western Iowa, lower sandstone-dominated Nishnabotna Member, upper mudstone/shale-dominated Woodbury Member. Correlative Windrow Formation found as erosional outliers in northeastern and north-central Iowa. *Primary lithologies*: sandstone, quartzose, very fine to medium grained; mudstone/shale, light to dark gray, variably silty-sandy, noncalcareous (Woodbury Mbr.). *Secondary lithologies*: sandstone, medium to very coarse grained, part pebbly to gravelly, locally cemented by iron oxides (Nishnabotna Mbr., Windrow Fm.), gravel, quartz and chert clasts; siltstone; mudstone, red, pink, yellow-brown, black (carbonaceous). *Minor*: lignite; siderite (concretions, pedogenic sphaerosiderite pellets, cemented siltstone); massive iron ore, silty to sandy (Windrow Fm.). Maximum thickness Dakota Fm. 500 ft (150 m), commonly 100-300 ft (30-90 m); Windrow Fm. 40 ft (12 m).

JURASSIC

Jf **FORT DODGE FORMATION** (Middle or Upper Jurassic, possibly Oxfordian). Present only in Webster County. *Primary lithologies*: gypsum, mostly alabastrine (lower unit, Gypsum Creek Mbr.); redbeds including mudstone/claystone (red to green-gray), sandstone (very fine to medium and coarse grained) (upper unit, Soldier Creek Mbr.). *Secondary lithologies*: basal conglomerate and sandstone, carbonate clasts (Shady Oak Mbr.). *Minor*: quartz crystals. Maximum thicknesses: gypsum bed to 32 ft (10 m), upper redbeds to 52 ft (16 m).

PENNSYLVANIAN (subsystem)

Pw **WABAUNSEE GROUP** (Upper Pennsylvanian, middle-upper Virgilian). Interval includes Howard, White Cloud, Scranton, Bern, Auburn, Emporia, Willard, Zeandale, Pillsbury, Stotler, Root formations. *Primary Lithologies*: shale, light to dark gray; mudstone, gray, part laminated silty to sandy. *Secondary Lithologies*: limestone, fossiliferous, part coated grain/Osagia; pedogenic mudstone, part red to maroon, part calcareous/nodular; siltstone to very fine sandstone. *Minor*: black shale; coal. Maximum thickness 320 ft (98 m) in Fremont County.

Ps **SHAWNEE GROUP** (Upper Pennsylvanian, lower-middle Virgilian). Interval includes Oread, Kanwaka, Lecompton, Tecumseh, Deer Creek, Calhoun, Topeka formations. *Primary Lithologies*: limestone, fossiliferous, part coated grain/Osagia; shale/mudstone, light to dark gray. *Secondary Lithologies*: pedogenic mudstone, part calcareous/nodular; siltstone to very fine sandstone; black shale, phosphatic. *Minor*: chert; coal, coaly shale; red-brown mudstone. Maximum thicknesses 190-220 ft (58-67 m).

Pd **DOUGLAS GROUP** (Upper Pennsylvanian, upper Missourian-lower Virgilian).

Interval includes Stranger, Cass, Lawrence formations. *Primary Lithologies*: shale and mudstone, light to dark gray, part silt laminated. *Secondary Lithologies*: limestone, fossiliferous, part coated grain; siltstone to very fine sandstone; pedogenic mudstone, part red-brown, part calcareous/nodular. *Minor*: coal, carbonaceous shale; black shale. Maximum thicknesses 90-135 ft (27-41 m).

Pl **LANSING GROUP** (Upper Pennsylvanian, upper Missourian). Interval includes Plattsburg, Vilas, Stanton formations. *Primary Lithologies*: limestone, fossiliferous; shale/mudstone, light to dark gray. *Secondary Lithologies*: limestone, coated grain/Osagia; mudstone to siltstone, gray. *Minor*: black shale, phosphatic; mudstone, red-brown. Maximum thicknesses 45-78 ft (14-24 m).

Pk **KANSAS CITY GROUP** (Upper Pennsylvanian, middle Missourian). Interval includes Cherryvale, Nellie Bly, Dewie, Chanute, Iola, Liberty Memorial, Wyandotte, Lane formations. *Primary Lithologies*: limestone fossiliferous; shale/mudstone, light to dark gray. *Secondary Lithologies*: limestone, coated grain/Osagia. *Minor*: mudstone, red-brown to green-gray; siltstone; black shale, phosphatic; thin coal, carbonaceous shale. Maximum thicknesses 100-140 ft (30-43 m).

Pb **BRONSON GROUP** (Middle to Upper Pennsylvanian, uppermost Desmoinesian-lower Missourian). Interval includes Pleasanton, Hertha, Elm Branch, Swope, Galesburg, Dennis formations. *Primary Lithologies*: limestone, fossiliferous; shale/mudstone, light to dark gray. *Secondary lithologies*: mudstone to siltstone, gray to green-gray; limestone, coated grain. Minor: black shale, phosphatic; red/maroon mudstone; coal; chert. Maximum thicknesses 100-130 ft (30-40 m).

Pm **MARMATON GROUP** (Middle Pennsylvanian, upper Desmoinesian). Interval includes Morgan School, Mouse Creek, Labette, Pawnee, Bandera, Altamont, Nowata, Lenapah, Memorial, Lost Branch formations. *Primary Lithologies*: shale/mudstone, light to dark gray; limestone, fossiliferous. *Secondary Lithologies*: mudstone, green-gray to red/maroon; shale, black, phosphatic; sandstone, very fine to medium grained. *Minor*: coal; siltstone, conglomerate. Maximum thicknesses: 125-175 ft (38-52 m).

Pcu **UPPER CHEROKEE GROUP** (Middle Pennsylvanian, middle Desmoinesian). Interval includes Verdigris and Swede Hollow formations; base of map unit drawn at the widespread Whitebreast Coal. *Primary Lithologies*: shale/mudstone, light to dark gray, part silty to sandy; siltstone, gray. *Secondary Lithologies*: limestone, part fossiliferous, part sandy; sandstone, very fine to fine-grained. *Minor*: mudstone, red/maroon to brown; shale, black, phosphatic; carbonaceous shale; coal (beds locally > 2 ft); ironstone/siderite concretions; limestone concretions (may be septarian); pyrite. Average thickness 100 ft (30 m); maximum thicknesses to 130 ft (40 m).

Pcl **LOWER CHEROKEE GROUP and RACCOON CREEK GROUP** (Lower-Middle Pennsylvanian; Morrowan-lower Desmoinesian). Lower Cherokee Group in southern, central, and western Iowa includes Kilbourn, Kalo, Floris formations (primarily Atokan-lower Desmoinesian, locally Morrowan at base); Raccoon Creek Group in eastern Iowa includes "Caseyville" and Tradewater formations (primarily Morrowan at most localities; locally includes Atokan-lower Desmoinesian Tradewater Formation in upper part). *Primary Lithologies*: shale/mudstone, light to dark gray, part silty to sandy; sandstone, very fine to medium grained; siltstone, gray. *Secondary Lithologies*:

carbonaceous shale/mudstone, gray to black; phosphatic black shale; limestone, dense, part fossiliferous, part sandy; coal (beds locally > 2 ft). *Minor*: sandstone, coarse-grained to granular, part conglomeratic; mudstone, red to pink; limestone concretions (may be septarian); cone-in-cone limestone; siderite/ironstone concretions and pellets; pyrite. Maximum thicknesses Raccoon Creek Group in Muscatine-Scott counties: 230-250 ft (70-75 m). Maximum thicknesses Lower Cherokee Group across outcrop belt: 200-370 ft (60-113 m). Maximum thickness in southwest Iowa subsurface: 650 ft (200 m).

MISSISSIPPIAN (subsystem)

Ms **"ST. LOUIS" and PELLA FORMATIONS** (Middle-Upper Mississippian, Meramecian-lower Chesterian). Interval includes lower "St. Louis" (Meramecian) Croton and Yenruogis members; upper "St. Louis" (lower Genevievian) Verdi and Waugh members (interval does not correlate with type St. Louis of Missouri); Pella Fm (upper Genevievian); base includes Sonora Fm (Meramecian) in parts of southeast Iowa (Lee, Van Buren, Henry, Des Moines, Jefferson counties). *Primary Lithologies*: dolomite, part silty/sandy, part fossiliferous; limestone, part sandy to fossiliferous; part "sublithographic," part argillaceous. *Secondary Lithologies*: dolomite/limestone breccia; shale/marl, green-gray, calcareous; sandstone, fine to medium-grained; siltstone; gypsum/anhydrite (south-central Iowa). *Minor*: limestone, oolitic; shale, gray; shale, red to pink; chert/chalcedony. Croton Member contains gypsum-anhydrite in subsurface outside of outcrop belt. Interval is erosionally beveled to locally absent beneath Pcl; Pella Formation absent over broader areas. Maximum thicknesses for total interval 60-150 ft (18-45 m); maximum thickness Pella Formation 75 ft (23 m); maximum thickness "St. Louis" Formation 75 ft (23 m); maximum thickness Sonora Formation 35 ft (11 m).

Ma **AUGUSTA GROUP** (Middle Mississippian, Osagean; upper Warsaw strata locally preserved at top of interval in extreme southeast Iowa are lower Meramecian). Interval includes Burlington, Keokuk, and Warsaw formations. *Primary Lithologies*: dolomite, part argillaceous to shaly; dolomitic limestone, fossiliferous; fossiliferous limestone (especially crinoidal packstone-grainstone). *Secondary Lithologies*: glauconitic limestone/dolomite; shale, gray to green-gray, part dolomitic, part silty; chert, nodular to bedded. *Minor*: quartz crystals, quartz geodes, chalcedony; phosphatic dolomite/limestone ("bone bed"); siltstone, dolomitic. Lithologies noted only in northern Iowa: oolitic limestone; "sublithographic" limestone; dolomite/chert breccia. Interval is erosionally beveled beneath sub-"St. Louis" and sub-Pennsylvanian unconformities. Maximum thicknesses in northern Iowa: 85-105 ft (26-32 m). Maximum thicknesses in southern Iowa: 155-240 ft (47-73 m).

Mg **GILMORE CITY FORMATION** (basal unit Lower Mississippian, upper Kinderhookian; most of interval is Middle Mississippian, lower Osagean). Interval includes lower Marble Valley Member, upper Humboldt Member; "Iowa Falls Dolomite" (dolomite facies); formation shares partial regional facies relationships with Burlington Formation; not present in southeastern Iowa. *Primary Lithologies*: limestone, primarily coated grain/oolitic to peloidal, variably fossiliferous to intraclastic. *Secondary Lithologies*: dolomite; dolomitic limestone; limestone, dense,

"sublithographic." *Minor*: shale, gray, calcareous; oncolitic limestone; glauconite; chert; breccia. Maximum thicknesses in northern Iowa 150-170 ft (45-52 m); interval thins to south and southeast 20-70 ft (6-21 m).

Mk **KINDERHOOKIAN formations** (Lower Mississippian, Kinderhookian). Interval includes Prospect Hill, Chapin, Maynes Creek, and Wassonville formations; locally includes basal Crapo ("McCraney") Formation in southeastern Iowa. *Primary Lithologies*: dolomite, part cherty to very cherty, part fossiliferous (Maynes Creek-Wassonville formations); limestone, skeletal to oolitic (Chapin Fm; lower Wassonville Fm/Starrs Cave Member; middle Maynes Creek/"Eagle City" member; basal Crapo Fm); siltstone (Prospect Hill Fm). *Secondary Lithologies*: shale, gray, silty (Prospect Hill Fm of southeastern Iowa); limestone, dense, "sublithographic" to stromatolitic (upper Maynes Creek Fm); limestone and dolomite, dense, nodular to banded, part silty (Crapo Fm). Maximum thicknesses for total interval: 100-175 ft (30-53 m). Thickness variations: Crapo ("McCraney") Fm, 0-65 ft (20 m); Prospect Hill Fm, 0-90 ft (27 m), generally < 25 ft (8 m); Chapin Fm, 0-30 ft (9 m), generally < 10 ft (3 m); Maynes Creek Fm, 35-155 ft (11-47 m), thickest in central to northern Iowa; Wassonville Fm (southeast Iowa only), 0-70 ft (21 m), replaced to northwest by Maynes Creek and Chapin formations, beveled beneath sub-Burlington unconformity to southeast.

DEVONIAN

Df **FAMENNIAN formations** (Upper Devonian, lower to upper Famennian). Interval includes Grassy Creek Shale, Saverton Shale, "Maple Mill" Shale, English River Formation, Louisiana Limestone (Lee County only), Aplington Formation (northern and western Iowa only), Sheffield Shale (central and northern Iowa). Famennian strata onlap Lime Creek Fm to the northwest. *Primary Lithologies*: shale, gray to green-gray, part silty; siltstone (especially English River Fm). *Secondary Lithologies*: shale, olive-brown and medium to dark brown, part laminated (Grassy Creek Fm, southeast Iowa); dolomite, part fossiliferous, part cherty, part argillaceous (Aplington Fm). *Minor*: interstratified dolomite and limestone, part fossiliferous (Louisiana Limestone); ooidal ironstone and phosphorite; phosphatic siltstone ("bone bed"); shale, red-brown. Maximum thicknesses in outcrop belt: southeast Iowa, 135-310 ft (41-95 m), thickest in Washington, Louisa, Des Moines counties; northern and central Iowa, 25-135 ft (8-41 m).

Dl **LIME CREEK FORMATION** (Upper Devonian, upper Frasnian). Interval includes Sweetland Creek Shale in southeast Iowa, and "Amana beds" of Iowa County. Lime Creek Fm onlaps eroded Ordovician surface in northwestern Iowa. *Primary Lithologies*: shale, gray to green-gray, dolomitic to calcareous; limestone, variably argillaceous, fossiliferous, part biostromal; dolomite, variably argillaceous, part fossiliferous. *Secondary Lithologies*: limestone, dense, "sublithographic" (upper part of carbonate-dominated facies in central and northwestern Iowa); shale, green-gray to brown, silty (Sweetland Creek Shale). *Minor*: siltstone; chert; oolitic limestone, carbonate breccia (central to northwestern Iowa). Thickness variations in outcrop belt: Sweetland Creek Shale of southeastern Iowa, 3-30 ft (1-9 m); Lime Creek Fm of southeastern to north-central Iowa, 40-200 ft (12-60 m); Lime Creek Fm of

northwestern Iowa, 200-350 ft (60-105 m).

Dc **CEDAR VALLEY GROUP (**Middle-Upper Devonian, middle Givetian-middle Frasnian). Interval includes Little Cedar, Coralville, Lithograph City, and Shell Rock formations; Shell Rock Fm in northern Iowa only. *Primary Lithologies*: limestone, fossiliferous, variably argillaceous, part biostromal; dolomite, part fossil-moldic to vuggy, variably argillaceous. *Secondary Lithologies*: limestone, dense, "sublithographic"; dolomite/limestone breccia (evaporite collapse); limestone, sparse to unfossiliferous, argillaceous to shaly; shale, gray to green-gray, dolomitic. *Minor*: anhydrite/gypsum (outcrop belt only in Grundy, Tama, Poweshiek counties; extensive in subsurface of central and southern Iowa); chert; glauconite; sandy limestone/sandstone. Maximum thicknesses in outcrop belt: southeast Iowa, 80-135 ft (24-41 m); east-central Iowa 130-210 ft (40-64 m); northern Iowa 250-350 ft (76-107 m). Cedar Valley Group thins and is overstepped by Dl westward in Winnebago County.

Dw **WAPSIPINICON GROUP** (Middle Devonian, upper Eifelian-middle Givetian). Interval includes Pinicon Ridge, Otis, Spillville, and Bertram formations. Otis and Bertram formations restricted to east-central Iowa only; Spillville Formation in northeast Iowa only. Pinicon Ridge Formation oversteps Spillville and Otis edges in Fayette, Bremer, Black Hawk, Buchanan, southern Chickasaw counties to directly overlie Sh, Sw, or Om. *Primary Lithologies*: dolomite, part laminated, variably argillaceous, part fetid; limestone, dense, "sublithographic", part laminated to intraclastic; dolomite, fossil-moldic to vuggy (Otis-Spillville fms). *Secondary Lithologies*: limestone/dolomite breccia (evaporite collapse); dolomitic shale and shaly dolomite, gray to green-gray, part silty-sandy; limestone, part peloidal to fossiliferous (Otis Fm). *Minor*: chert and chalcedony nodules (Pinicon Ridge Fm); sandstone; oolitic limestone (Otis Fm). Extensive anhydrite/gypsum in subsurface outside of outcrop belt. Maximum thicknesses in outcrop belt: east-central Iowa, 60-160 ft (18-49 m); northern Iowa, 10-130 ft (3-40 m), locally absent in Bremer County beneath Dc.

SILURIAN

Sg **GOWER FORMATION** (Lower-?Upper Silurian, Wenlock-?Ludlow). Formation includes Anamosa, Brady, LeClaire (Scott-Muscatine counties) members; Brady and LeClaire members are carbonate mound facies. Erosionally beveled and truncated beneath Dw. *Primary Lithologies*: laminated dolomite (Anamosa Mbr), part fetid/organic to east (Scott-Clinton counties); dolomite mudstone, dense, featureless. *Secondary Lithologies*: dolomite, fossiliferous to vuggy, moldic, part brachiopod-rich (Brady Member); dolomite, part coarsely crystalline, vuggy, fossiliferous to sparsely fossiliferous, part crinoidal (LeClaire Member). *Minor*: chert; intraclastic dolomite. Maximum thickness: 180 ft (55 m); beveled and truncated beneath Dw.

Ss **SCOTCH GROVE FORMATION** (Lower Silurian, upper Llandovery-lower Wenlock). Formation includes Welton, Buck Creek Quarry, Waubeek, Palisades-Kepler, Johns Creek Quarry members; Palisades-Kepler and Johns Creek Quarry members contain carbonate mound facies. Erosionally beveled and truncated beneath Dw. *Primarily Lithologies*: dolomite, porous, fossil-moldic to vuggy, part very

crinoidal (includes Welton Mbr); dolomite, cherty to very cherty, dense (Buck Creek Quarry Mbr). *Secondary Lithologies*: dolomite, sparsely fossil-moldic, dense, part vuggy (includes Waubeek Mbr); dolomite, coarsely crystalline, part very crinoidal (within Johns Creek Quarry, Palisades-Kepler mbrs); dolomite mudstone, dense. *Minor*: dolomite, slightly argillaceous; quartz druse, chalcedony, silicified fossils. Maximum thicknesses: 94-240 ft (29-73 m); may reach thicknesses to 300 ft (90 m); beveled and truncated beneath Dw.

Sh **HOPKINTON, BLANDING, TETE DES MORTS, MOSALEM formations** (Lower Silurian, ?Rhuddanian, Aeronian-upper Llandovery; recent work has proposed correlation of Mosalem and Tete des Morts formations with ?uppermost Ordovician, upper Hirnantian). Mosalem Formation infills erosional paleovalleys incised into Maquoketa Shale; absent outside of paleovalleys. Lower Hopkinton Formation locally contains carbonate mound facies in Bremer County. Blanding Formation oversteps Tete des Morts-Mosalem edge in southern outcrop area. *Primary Lithologies*: dolomite, fossil-moldic to vuggy, fine to coarse crystalline; dolomite, dense to porous, cherty to very cherty, nodular to bedded chert (especially Blanding Fm). *Secondary Lithologies*: dolomite, dense, sparsely fossiliferous; dolomite, argillaceous, part laminated (Mosalem Fm). *Minor*: chalcedony, silicified fossils. Maximum thicknesses total interval: 160-330 ft (49-100 m), thickest in Dubuque, Jackson, Jones counties where Mosalem present; southern outcrop total thickness 65-130 ft (20-40 m). Formation thicknesses: Hopkinton, 65-160 ft (20-49 m); Blanding, 25-65 ft (8-20 m); Tete des Morts, 0-35 ft (11 m); Mosalem, 0-100 ft (30 m).

Sl **LaPORTE CITY FORMATION** (Lower Silurian, upper Llandovery-lower Wenlock). Interval is a northwestern limestone facies that correlates with dolomite strata (upper Hopkinton-lower Scotch Grove formations) to the south and east; locally interfingers with dolomite to south; it overlies progressively higher stratigraphic levels southward within the Hopkinton to Scotch Grove formations. Sl forms highest Silurian unit throughout its extent; unconformably overlain by Dw. *Primary lithologies*: limestone, dense, fossiliferous, part cherty to very cherty. *Secondary lithologies*: dolomitic limestone, dolomite. *Minor*: argillaceous to shaly chert residuum at top (may be basal Dw); shale, green-gray. Maximum thickness, 140 ft (43 m); average thicknesses: 20-60 ft (6-18 m).

Sw **WAUCOMA FORMATION** (Lower Silurian, ?Rhuddanian-Aeronian-lower Llandovery). Interval is a northwestern limestone facies that correlates with dolomite strata (Tete des Morts, Blanding, lower Hopkinton formations) to the south and east. Sw forms the highest Silurian unit throughout most of its extent, generally overlain by Dw; locally interfingers with Sh dolomite strata to south. *Primary lithology*: limestone, dense, fossiliferous. *Secondary lithologies*: limestone, dense, cherty to very cherty; dolomitic limestone, dense; dolomite (locally at base). *Minor*: dolomite, silty to sandy (locally at base above Om). Maximum thickness, 80 ft (25 m).

ORDOVICIAN

Om **MAQUOKETA FORMATION** (Upper Ordovician; Richmondian [upper Katian]). Includes Elgin, Clermont, Fort Atkinson, Brainard, and Neda members. Overlain by

Silurian strata in east-central Iowa, incised paleovalleys beneath Mosalem Fm.; truncated beneath Devonian strata in northern-most counties. *Primary lithologies*: shale, green-gray, variably dolomitic, mostly unfossiliferous; dolomite, argillaceous, part shaly, variably fossiliferous (part with common trilobites); dolomite, part argillaceous, part cherty to very cherty (northern Iowa). *Secondary lithologies*: shale, brown to brown-gray, organic, part graptolitic, part finely laminated (lower strata); dolomitic limestone to limestone, argillaceous, part cherty to very cherty, variably fossiliferous, part crinoidal (northern Iowa); interbedded dolomite and shale, part nodular, part fossiliferous. *Minor*: phosphorite, granular to massive (basal unit); dolomite, phosphatic to very phosphatic, argillaceous (Elgin Mbr.); ooidal ironstone and red shale (Neda Mbr.); pyrite, finely disseminated to nodular, pyrite cements. Maximum thicknesses: generally 200-275 ft (60-85 m) beneath Silurian, locally 100-200 ft (30-60 m) beneath Mosalem Fm.; 75-180 ft (23-55 m) where capped by Devonian strata in northern Iowa.

Og **GALENA GROUP and PLATTEVILLE FORMATION** (Upper Ordovician, Turinian-basal Richmondian [upper Sandbian-upper Katian]). Galena Group includes Decorah, Dunleith, Wise Lake, Dubuque formations; Platteville Formation includes Pecatonica, McGregor members; Glenwood Shale forms thin basal shale unit. *Primary lithologies*: dolomite, part porous to vuggy, fossiliferous, part cherty; limestone and dolomitic limestone, fossiliferous, part cherty (note: Galena Group entirely limestone to north, entirely dolomite to south, interstratified limestone-dolomite in intervening areas). *Secondary lithologies*: shale, green-gray, calcareous, with thin to nodular limestone, part fossiliferous (Decorah Sh); limestone, wavy-bedded to nodular, part fossiliferous (Decorah-Platteville); dolomite and limestone, slightly argillaceous. *Minor*: shale partings and thin beds, green-gray to brown-gray, part fossiliferous (Dubuque Fm); shale partings and thin beds, light to dark brown, part organic-rich (Decorah-Platteville); dolomite, sandy to very sandy (Pecatonica Mbr); shale, green-gray, noncalcareous, unfossiliferous, part sandy (Glenwood Sh); thin sandstone to siltstone (Glenwood Sh); dark phosphatic grains (primarily Glenwood, Pecatonica, Decorah); phosphate-pyrite-iron oxide crusts (on some hardground surfaces); pyrite nodules; thin K-bentonite beds (Galena Gp); ironstone ooids (Decorah Sh). Maximum thicknesses total interval: 330 ft (100 m); Galena Group, 250-280 ft (76-85 m); Platteville Formation, 25-55 ft (8-17 m); Glenwood Shale, 3-10 ft (1-3 m).

Op **PRAIRIE DU CHIEN GROUP and ST. PETER SANDSTONE** (Prairie du Chien, Lower Ordovician, Ibexian [Tremadocian-lower Floian]; St. Peter, Middle-Upper Ordovician, Whiterockian [upper Darriwilian-lower Sandbian]). Prairie du Chien Group includes Oneota Fm (Coon Valley, Hager City members) and Shakopee Fm (New Richmond Sandstone, Willow River members); St. Peter Sandstone includes Readstown and Tonti members. Sub-St. Peter erosional surface bevels and locally truncates Prairie du Chien strata. *Primary lithologies*: dolomite, part cherty, part sandy, mostly unfossiliferous, common voids and vugs (Prairie du Chien); sandstone, quartzose, very fine to medium grained (St. Peter, Shakopee). *Secondary lithologies*: dolomite, laminated to stromatolitic, part intraclastic; dolomite, fossil molds (primarily mollusks); interbedded very fine to fine sandstone and dolomite (Coon Valley, Shakopee); conglomerate, dolomite and chert clasts in sandy matrix (Readstown). *Minor*: oolitic dolomite and oolitic chert (Shakopee); shale, green, part sandy

(Shakopee); shale, green-brown to gray, part laminated, silty to sandy, part fossiliferous (locally in St. Peter of Winneshiek Co.); coarse sand grains (St. Peter, Shakopee); breccia, dolomite-chert clasts; chalcedony/quartz nodules. Maximum thicknesses total interval: generally 300-400 ft (90-120 m), may reach thicknesses to 700 ft (210 m) (locally thick St. Peter in Winneshiek Co.). Unit thicknesses: Prairie du Chien Group, 225-335 ft (69-102 m), locally thinner where overlain by thick St. Peter; Oneota Fm, 130-225 ft (40-69 m), locally thinned beneath thick St. Peter; Shakopee Fm, 55-100 ft (17-30 m), locally thinned to absent beneath thick St. Peter; St. Peter Sandstone, generally 40-75 ft (12-23 m), varies 25-225 ft (8-69 m), may locally reach thicknesses to 700 ft (210 m) in Winneshiek Co.

CAMBRIAN

Cj **JORDAN SANDSTONE, ST. LAWRENCE and LONE ROCK formations** (Upper Cambrian, upper Steptoean-Sunwaptan-lower Skullrockian [formerly middle Franconian-Trempealeauan]). Surface exposures limited to Allamakee and northeast Clayton counties; subcrops beneath Mississippi River alluvium in southern Allamakee and Clayton counties. *Primary lithologies*: sandstone, very fine to coarse grained, quartzose to feldspathic (Jordan); silty dolomite to dolomitic siltstone (St. Lawrence); sandstone, very fine to fine grained, glauconitic to very glauconitic, common greensands (Lone Rock). *Secondary lithologies*: siltstone, part argillaceous (St. Lawrence, Lone Rock). *Minor*: silty shale partings (St. Lawrence, Lone Rock); dolomite, part sandy; intraclastic dolomite, sandstone, and siltstone. Maximum thicknesses of total interval: 260-310 ft (79-95 m). Formation thicknesses: Lone Rock Fm, 110-140 ft (34-43 m); St. Lawrence Fm, 60-80 ft (18-24 m); Jordan Sandstone, 80-110 ft (244-34 m).

Cw **WONEWOC FORMATION** (Middle-Upper Cambrian, upper Marjuman-Steptoean [formerly upper Dresbachian-lower Franconian]). Surface exposures limited to northeastern Allamakee County; subcrops beneath Mississippi River alluvium in Allamakee County. Includes Ironton and Galesville members. *Primary lithology*: sandstone, fine to coarse grained, upper part fossiliferous (Ironton). Thicknesses: 125-155 ft (38-47 m).

Ce **EAU CLAIRE FORMATION** (Middle Cambrian, upper Marjuman [formerly Dresbachian]). Subcrops beneath Mississippi River alluvium in Allamakee County; surface exposures absent. *Primary lithologies*: sandstone, very fine to fine grained, part argillaceous; shale, silty, gray to green-gray, part glauconitic. *Secondary lithology*: siltstone, part argillaceous, part dolomitic. *Minor*: dolomite. Thicknesses: 120-145 ft (37-44 m).

Cm **MT. SIMON SANDSTONE** (Middle Cambrian undifferentiated). Subcrops beneath Mississippi River alluvium in northeastern Allamakee County; surface exposures absent. Overlies erosional surface on Precambrian granitic basement rocks. *Primary lithology*: sandstone, very fine to very coarse grained, part iron-stained. *Minor*: shale, silty to sandy, gray, red, green; quartz granules; granitic pebbles. Thicknesses: 365-405 ft (111-123 m).

PRECAMBRIAN

Xs **SIOUX QUARTZITE** (Lower Proterozoic). Crops out in northwestern Lyon County; buried beneath Cretaceous strata to south and east. Primary lithology: quartzite, fine to coarse grained, pink, red, purple (low-grade metamorphic rock). Minor: conglomerate; claystone/argillite, red. Estimated thickness <500 ft (150 m).