

**NATIONAL COOPERATIVE GEOLOGIC MAPPING PROGRAM
(STATEMAP)**

TECHNICAL REPORT

Project 1 Title: DEVELOPING AREAS MAPPING—CERRO GORDO COUNTY Phase 2: Surficial and Bedrock Geologic Mapping of the Mason City and Nora Springs Quadrangles (1:24,000)

Project 2 Title: DEVELOPING AREAS MAPPING—MITCHELL COUNTY Phase 1: Surficial and Bedrock Geologic Mapping of the Osage and St. Ansgar Quadrangles (1:24,000)



Iowa Geological Survey, IIHR-Hydrosience & Engineering, University of Iowa, Iowa City, Iowa

Robert D. Libra, State Geologist, Iowa Department of Natural Resources

STATEMAP Award Number: G13AC00175

Award Recipient: Iowa Geological Survey

Principal Investigator: Deborah Quade, Iowa Department of Natural Resources

STATEMAP Coordinator: Stephanie Tassier-Surine, Iowa Geological Survey

Contact Information: Iowa Geological Survey
The University of Iowa
300 Trowbridge Hall
Iowa City, IA 52242
319-335-1575
stephanie-tassier-surine@uiowa.edu



ABSTRACT

Recently completed mapping by the Iowa Geological Survey (IGS) provides much needed geologic maps in the Upper Cedar River Basin. The basin has been the subject of water quality projects in the past, but there was a renewed focus on the Cedar River Basin following catastrophic flooding in 2008. Several cities and developing areas are located in this basin. Many new partners are concentrating efforts on water supply, water quantity and quality, land-use planning, and flood protection studies. Geologic mapping is crucial and foundational for many of these studies and the project enjoys wide support from the Iowa-Cedar Watershed Interagency Coordination Team (ICWICT) and the Cedar River Watershed Coalition (CRWC). Bedrock mapping subdivided the Cedar Valley Group into four formations which provided more detailed geologic information. The Cerro Gordo County Department of Public Health (CGCDPH) is using this information to help identify the source of elevated arsenic in groundwater. From a Quaternary perspective, characterizing and identifying the extent of the Mid-Wisconsin Sheldon Creek Formation is a fundamental question. The close proximity to the Des Moines Lobe margin also creates significant sand and gravel resources that mapping has further identified and characterized. Combining the bedrock and surficial map information is allowing stakeholders to address key questions related to shallow rock areas, aggregate resource potential, and groundwater vulnerability.

INTRODUCTION

The IGS received \$173,488 from the United States Geological Survey (USGS) to map four quadrangles (both bedrock and surficial; eight total maps) at 1:24,000 scale in north-central Iowa in Cerro Gordo, Mitchell, and Floyd counties (see Figure 1). This year's maps were part of the Impaired Watershed and Developing Areas mapping initiatives of the IGS. The mapping summarized here represents the second phase of a multi-year program to map critical areas in the Upper Cedar River Watershed.

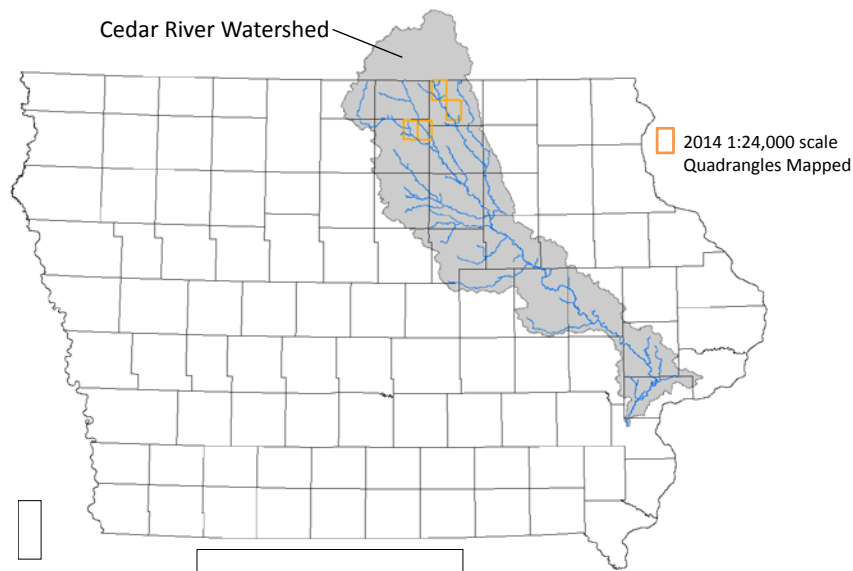


Figure 1: Map showing the location of the Cedar River Watershed and the four quadrangles (bedrock and surficial, eight total maps) mapped at 1:24,000 scale during 2014.

The Mason City and Nora Springs quadrangle maps represent the second phase of a three-year program to map all of Cerro Gordo County. The St. Ansgar and Osage quadrangles are phase one of a multi-year program to map all of Mitchell County. The IGS takes a paired mapping approach, mapping the surficial and bedrock geology in the same area at the same time. This is a more efficient use of resources and allows mappers to utilize each other's data, especially in counties with extensive shallow rock areas like Cerro Gordo and Mitchell. The IGS has also received very favorable feedback from our STATEMAP Advisory Committee for using this approach. All maps were produced using ArcMAP and will be available as both pdfs on the IGS publications website and as shapefiles on the Iowa Department of Natural Resources NRGIS library. All deliverables were submitted to USGS on September 24, 2014.

GEOLOGIC SETTING

Paleogeographically, the mapping area is within the northern portion of the Devonian Iowa Basin, a region of thickened shelf carbonate and shale deposits. Middle and lower Upper Devonian rocks form the major bedrock surface and upper bedrock aquifer in this area. Due to its stratigraphic completeness, the stratigraphy and depositional environments of the Devonian Iowa Basin have been intensively studied. Bedrock geology of the surrounding area was recently mapped by Witzke et al. (2010) at 1:500,000 scale. Results from these studies and other STATEMAP bedrock mapping projects in adjacent areas provide an important stratigraphic framework for north-central Iowa. The bedrock stratigraphic nomenclature and correlation for this map follows the stratigraphic framework proposed by Witzke et al. (1988).

The Quaternary geology of the map area has a rich and complex history punctuated by at least seven periods of glaciation between 2.6 million and 500,000 years ago (Boellstorff, 1978a, b; Hallberg, 1980). In this area, Pre-Illinois Episode glacial deposits and associated buried soils are overlain by much younger Wisconsin-age glacial deposits. During the earlier and mid Wisconsin-age, ice advances dating from approximately 40,000 to 26,000 years before present were deposited throughout the map area. In Iowa, this glacial deposit is formally recognized as the Sheldon Creek Formation (Bettis et al., 1996) and in earlier literature is referred to as the "Tazewell till" (Ruhe, 1950).

A period of intense cold that occurred during the Wisconsin full glacial episode from 21,000 to 16,500 years ago (Bettis, 1989) led to upland erosion and the development of the distinctive landform recognized as the Iowan Surface (Prior, 1976). A periglacial environment prevailed during this period with intensive freeze-thaw action, solifluction, strong winds, and a host of other periglacial processes. The result was that surface soils were removed from the Iowan Surface landform, and the Sheldon Creek Formation and Pre-Illinois till surface were significantly eroded. Thick packages of stratified loamy and sandy sediments located low in the upland landscape and adjacent to streams are remnants of solifluction lobes associated with the formation of the Iowan Surface. The most recent maps of the Quaternary geology of Iowa were compiled 30 years ago and published over 20 years ago as regional compilation maps (Hallberg et al., 1991).

PURPOSE AND GOALS

Within the last several years there has been much interest in the hydrogeologic setting of Cerro Gordo County. During 2008, the Cedar River Watershed experienced its largest flood of record. The Cedar River Watershed Coalition (CRWC) was founded in 2010 to facilitate cooperation within the watershed and to organize and advocate for land practices and policies (federal, state, and local) that will reduce future flood damage and improve water quality. A refined understanding of the bedrock and surficial geology of this region will assist those cooperative groups in achieving the goals of their evolving watershed management plans. In addition, the CGCDPH is currently engaged in a county-wide, multi-year study to examine the hydrogeologic source of elevated arsenic in drinking water supplies within the county. As part of a Center for Disease Control (CDC) study, the IGS is actively working with the CGCDPH and local well drillers to identify arsenic-bearing zones in the bedrock package.

Issues in Mitchell County include groundwater protection in shallow-rock areas, flood mitigation, watershed protection issues, soil and water conservation, and aggregate resource protection. A better understanding of the distribution of fractured Devonian carbonate deposits and the overlying Quaternary map units will provide important hydrostratigraphic information for models that are being developed under the efforts of the watershed coalition for the purpose of flood mitigation in both the upper and lower portions of the watershed.

Additionally, it is anticipated that the information developed by this STATEMAP project will be used to address a variety of problems related to development and the impact of increasing population density on geologic resources. Possible applications include evaluating surface and subsurface drainage problems, water resources management, groundwater vulnerability, suburban expansion into areas of sinkholes (karst), better informing geotechnical/engineering activities, sanitary landfill siting, wetland protection, and aggregate resource potential. Recent STATEMAP work in adjacent Worth County has illustrated the importance of detailed geologic mapping in shallow rock regions on the Iowan Surface. In these areas it is important to not only preserve the high-quality aggregate resources for future development, but also to protect groundwater from surface contamination. The Quaternary Iowan Surface materials are highly variable and poorly consolidated and therefore do not provide good groundwater quality protection in shallow rock areas. It is necessary to identify areas of either better consolidated Quaternary materials or bedrock aquitards.

METHODS

Numerous sources of geologic information were utilized in the production of these maps including subsurface information, USDA Natural Resources Conservation Service (NRCS) soil survey data, aerial photography, satellite imagery, and LiDAR. Subsurface information was mostly derived from analysis of water well cutting samples repositated at the IGS. Lithologic and stratigraphic information from these samples is stored in the IGS online GEOSAM database. Where available, engineering borings from public utilities, the Iowa Department of Transportation, and monitoring well records of the USGS were used. A total of 405 public and private wells in GEOSAM were reviewed, and this geologic information was used for the mapping. New geologic information was obtained from field investigations of outcrops and quarry exposures, logging of unstudied well cutting samples, and core drilling. The locations of data points in the IGS GEOSAM database were checked for accuracy and updated where needed. 125 outcrops, including quarries, were visited and described. Cutting samples for 105 unstudied wells totaling 18,422 feet in the project area were studied and logged. Bedrock mappers also used the digital soil surveys to help delineate areas of shallow rock outcrop prior to field reconnaissance.

Quaternary mappers used available NRCS digitized soils data to assist mappers in delineating areas with loess cover, thin or no loess cover, bedrock outcrops, and extent of alluvium. Quaternary geologists worked with a contract driller to drill deeper cores to sample the unconsolidated material package at selected locations across the study area. A total of 28 holes (greater than 800 total feet) were drilled using a mix of solid-stem flight auger and continuous core methods. To date, 99 samples have been submitted to the Quaternary Materials Lab at the University of Iowa's Earth and Environmental Sciences Department for grain-size analysis. Results are expected in October, 2014. Project geologists combined information from many different sources, including water well logs, shallow landscape/sediment package drilling, deeper (to bedrock) drilling, digital elevation models, field mapping, data from soil surveys, and morphological characteristics viewed on aerial imagery to delineate surficial geologic mapping units at 1:24,000 scale.

The IGS mappers used ArcGIS and on-screen digitizing techniques developed during previous STATEMAP projects. All maps will be stored and available as shapefiles in the Iowa Department of Natural Resources NRGIS library and as pdfs on the IGS Publications website.

RESULTS SUMMARY

- Update of the bedrock topography map using new data acquired since regional (Witzke et al., 2001) and state wide compilation mapping (Witzke et al., 2010) were completed.
- Bedrock mapping subdivided the Cedar Valley Group into the Shell Rock, Lithograph City, Coralville and Little Cedar formations.
- Quaternary mapping further refined the extent of the Sheldon Creek boundary in northeastern Iowa. The Sheldon Creek till extends much farther east than has been previously documented and includes extensive basal sands and gravels that need additional study. Mapping funded by the USGS STATEMAP program for FY14 in Cerro Gordo and Mitchell counties will help address these questions.
- Delineation of shallow to bedrock areas critical to groundwater vulnerability issues.
- Identification and characterization of significant sand and gravel (outwash) deposits.
- Mapping the extent, thickness, and elevation of Devonian stratigraphic units such as the Lime Creek Formation and Cedar Valley Group serves as vital components for the Cerro Gordo County Arsenic study. There appears to be a strong relationship between elevated arsenic levels in groundwater and the presence of Lime Creek Shale, most notably when the groundwater level interacts with the Lime Creek Formation. Stratigraphic information derived from STATEMAP will help county officials and well drillers reduce arsenic levels through better well siting and construction methods.
- Mapping has allowed for a better understanding and characterization of Iowan Surface materials and their relationship with groundwater protection in shallow rock areas near river valleys and in upland areas of shallow bedrock.
- Updates to the IGS GEOSAM database: Review of over 400 data points for locational and stratigraphic accuracy; 125 new outcrop points and 28 new core holes will be added to the database; and 18,422 feet of cutting samples were logged.

BIBLIOGRAPHY OF PUBLISHED MAPS

- Liu, H., McKay, R., Rowden, R., Clark, R., Tassier-Surine, S., Quade, D., Galer, R., and Streeter, M.T., 2014, Bedrock Geology of the Mason City 7.5' Quadrangle, Cerro Gordo County, Iowa: Iowa Geological Survey, Open File Map 14-1, 1:24,000 scale map sheet.
- Tassier-Surine, S., Quade, D., Streeter, M.T., Kerr, P., Rowden, R., McKay, R., Liu, H., Clark, R., and Galer, 2014. Surficial Geology of the Mason City 7.5' Quadrangle, Cerro Gordo County, Iowa: Iowa Geological Survey, Open File Map 14-2, 1:24,000 scale map sheet.
- Liu, H., McKay, R., Rowden, R., Clark, R., Tassier-Surine, S., Quade, D., Galer, R., and Streeter, M.T., 2014, Bedrock Geology of the Nora Springs 7.5' Quadrangle, Cerro Gordo, Mitchell, and Floyd Counties, Iowa: Iowa Geological Survey, Open File Map 14-3, 1:24,000 scale map sheet.
- Tassier-Surine, S., Quade, D., Streeter, M.T., Kerr, P., Rowden, R., McKay, R., Liu, H., Clark, R., and Galer, 2014. Surficial Geology of the Nora Springs 7.5' Quadrangle, Cerro Gordo, Mitchell, and Floyd Counties, Iowa: Iowa Geological Survey, Open File Map 14-4, 1:24,000 scale map sheet.
- Rowden, R., McKay, R., Clark, R., Liu, H., Tassier-Surine, S., Quade, D., Galer, R., and Streeter, M.T., 2014, Bedrock Geology of the St. Ansgar 7.5' Quadrangle, Mitchell County, Iowa: Iowa Geological Survey, Open File Map 14-5, 1:24,000 scale map sheet.
- Tassier-Surine, S., Quade, D., Streeter, M.T., Kerr, P., Rowden, R., McKay, R., Liu, H., Clark, R., and Galer, R., 2014. Surficial Geology of the St. Ansgar 7.5' Quadrangle, Mitchell County, Iowa: Iowa Geological Survey, Open File Map 14-6, 1:24,000 scale map sheet.
- Rowden, R., McKay, R., Clark, R., Liu, H., Tassier-Surine, S., Quade, D., Galer, R., and Streeter, M.T., 2014, Bedrock Geology of the Osage 7.5' Quadrangle, Mitchell County, Iowa: Iowa Geological Survey, Open File Map 14-7, 1:24,000 scale map sheet.

Tassier-Surine, S., Quade, D., Streeter, M.T., Kerr, P., Rowden, R., McKay, R., Liu, H., Clark, R., and Galer, R., 2014. Surficial Geology of the Osage 7.5' Quadrangle, Mitchell County, Iowa: Iowa Geological Survey, Open File Map 14-8, 1:24,000 scale map sheet.

REFERENCES

- Bettis, E.A., III, 1989, Late Quaternary history of the Iowa River Valley in the Coralville Lake area *in* Plocher, O.W., Geologic Reconnaissance of the Coralville Lake area: Geological Society of Iowa Guidebook 51, p. 93-100.
- Bettis, E.A. III, Quade, D.J., and Kemmis, T.J., 1996, *in* Hogs, bogs, and logs: Quaternary deposits and environmental geology of the Des Moines lobe: Bettis, E.A., III, Quade, D.J., and Kemmis, D.J. (eds.): Iowa Department of Natural Resources-Geological Survey Bureau, Guidebook Series No. 18, 170 p.
- Boellstorff, J., 1978a, North American Pleistocene Stages reconsidered in light of probable Pliocene-Pleistocene continental glaciation: *Science*, v. 202, p. 305-307.
- Boellstorff, J., 1978b, Chronology of some late Cenozoic deposits from the central United States and the ice ages: *Transactions of the Nebraska Academy of Science*, v. 6, p. 35-49.
- Hallberg, G.R., 1980, Pleistocene stratigraphy in east-central Iowa: Iowa Geological Survey Technical Information Series, v. 10, 168 p.
- Hallberg, G.R., Lineback, J.A., Mickelson, D.M., Knox, J.C., Goebel, J.E., Hobbs, H.C., Whitfield, J.W., Ward, R.A., Boellstorff, J.D., and Swinehart, J.B., 1991, Quaternary geologic map of the Des Moines 4° x 6° quadrangle, United States: U.S. Geological Survey, Miscellaneous Investigations Series, Map I-1420, 1:1,000,000 scale map sheet.
- Prior, J.C., 1976, Landforms of Iowa: Iowa City, Iowa, University of Iowa Press, 154 p.
- Ruhe, R.V., 1950, Reclassification and correlation of the glacial drifts of northwestern Iowa and adjacent areas: University of Iowa Department of Geology, Iowa City, unpublished Ph.D. thesis, 124 p.
- Witzke, B.J., Bunker, B.J., and Rogers, F.S., 1988, Eifelian through lower Frasnian stratigraphy and deposition in the Iowa area, central midcontinent, U.S.A. *in* McMillan, N.J., Embry, A.F., and Glass, D.J. (eds.): *Devonian of the World*, Canadian Soc. of Petroleum Geologists, Memoir 14, vol. I, p. 221-250.
- Witzke, B.J., Anderson, R.R., Bunker, B.J., Ludvigson, G.A., and Greeney, S., 2001, Bedrock geology of north-central Iowa, Digital geologic map of Iowa, Phase 3: North-Central Iowa, scale 1:250,000, Iowa Geological Survey Open File Digital Map OFM-01-3.
- Witzke, B.J., Anderson, R.R. and Pope, J.P., 2010, Bedrock Geologic Map of Iowa, scale: 1:500,000, Iowa Geological and Water Survey, Open File Digital Map OFM-10-1.