NATIONAL COOPERATIVE GEOLOGIC MAPPING PROGRAM (STATEMAP)

TECHNICAL REPORT

Project 1 Title: DEVELOPING AREAS MAPPING—CERRO GORDO COUNTY Phase 3: Surficial and Bedrock Geologic Mapping of Cerro Gordo County, Iowa (1:100,000)

Project 2 Title: IMPAIRED WATERSHED MAPPING—MITCHELL COUNTY Phase 2: Surficial and Bedrock Geologic Mapping of the New Haven Quadrangle (1:24,000)

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STATEMAP Award Number: G14AC00229

Award Recipient: Iowa Geological Survey

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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 broad support from the Iowa-Cedar Watershed Interagency Coordination Team (ICWICT) and the Cedar River Watershed Coalition (CRWC). Bedrock mapping efforts were successful in subdividing the Devonian mapping units used by Witzke et al. (2010) into formations, which provided more detailed geologic information. The Cerro Gordo County Department of Public Health (CGCDPH) has used these maps and newly refined data to help identify the source of elevated arsenic in groundwater and to place regulations on water well construction. From a Quaternary perspective, characterizing and identifying the extent of the Mid-Wisconsin Sheldon Creek Formation is a fundamental question, as this unit extends much farther east than was previously mapped. The mapping location also includes the Des Moines Lobe margin, and has helped to further identify and characterize sand and gravel resources associated with glacial outwash plains and channels. 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 $150,766 from the United States Geological Survey (USGS) to map all of Cerro Gordo County at 1:100,000 scale and the New Haven Quadrangle in Mitchell County at 1:24,000 scale (both bedrock and surficial for each project; four total maps) in north-central Iowa (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 third phase of a multi-year program to map critical areas in the Upper Cedar River Watershed.

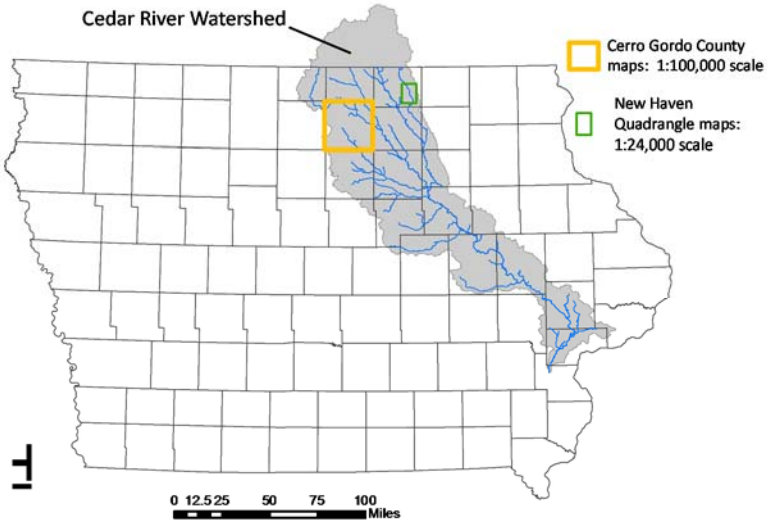

Figure 1: Map showing the location of the Cedar River Watershed and the mapping areas: Cerro Gordo County (1:100,000 scale) and the New Haven Quadrangle (1:24,000 scale) in Mitchell County. Both bedrock and surficial maps were completed for each project.

The Cerro Gordo County map is the third and final phase to complete mapping in that county. The New Haven Quadrangle is phase two of a multi-year program to map all of Mitchell County. IGS will complete a 1:100,000 scale map for Mitchell County in FY15. 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 map users and our STATEMAP Advisory Committee for using this approach. All maps were produced using ArcMAP and will be available as both pdfs files on the IGS publications website and as shapefiles on the Iowa Department of Natural Resources NRGIS library. All deliverables were submitted to USGS on June 30, 2015.

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 and others (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 and others (1988, 2010).

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 resulting in significant erosion of the Sheldon Creek Formation and Pre-Illinoian till surface as the Iowan Surface landform formed. 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 glacial advance into Iowa, the Des Moines Lobe, was active from approximately 15,000 to 12,000 years ago. Two advances (the Altamont and older Bemis) and the associated moraines are recognized in the map area. Prior to the recent STATEMAP projects, the only Quaternary geology maps 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 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 has 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 actively worked with the CGCDPH and local well drillers to identify arsenic-bearing zones in the bedrock package. The CGCDPH now has rules in place to help with well construction.

Issues in Mitchell County include groundwater protection in shallow-rock areas, flood mitigation, watershed protection, 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 reposited at the IGS. Lithologic and stratigraphic information from these samples are 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 1,000 public and private wells in GeoSam were reviewed, and this geologic information was used for the map. 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. More than 165 outcrops, including quarries, were visited and described. Cutting samples for 149 unstudied wells totaling 32,949 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 with delineating areas with loess cover, thin or no loess cover, most recent till sheet (Des Moines Lobe) materials, shallow bedrock, 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 36 holes (975 total feet) were drilled using a mix of solid-stem flight auger and continuous core methods. To date, 186 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 August, 2015. 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 1:100,000 scale for Cerro Gordo County and 1:24,000 scale for the New Haven Quadrangle in Mitchell County.

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 pdf files 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.
- Compared with the previous bedrock mapping units used in Witzke et al. (2010), these maps subdivide the Devonian Cedar Valley Group into the Shell Rock, Lithograph City, Coralville, and Little Cedar formations; and the Wapsipinicon Group into the Pinicon Ridge and Spillville 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, especially in Mitchell County. Mapping funded by the USGS STATEMAP program for FY15 in Mitchell County will continue to characterize these units.
- 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 the formations of the 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 the Lime Creek Formation, most notably when the groundwater level fluctuates within the shale units of the lower Lime Creek Formation that contain pyrite minerals. Stratigraphic information derived from STATEMAP will help county officials and well drillers reduce arsenic levels through better well siting and construction methods. Cerro Gordo County has recently adopted an ordinance placing rules on water well construction based on the stratigraphy.
- 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 1,000 data points for locational and stratigraphic accuracy; 165 new outcrop points and 36 new core holes will be added to the database; and 32,949 feet of cutting samples were logged.

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