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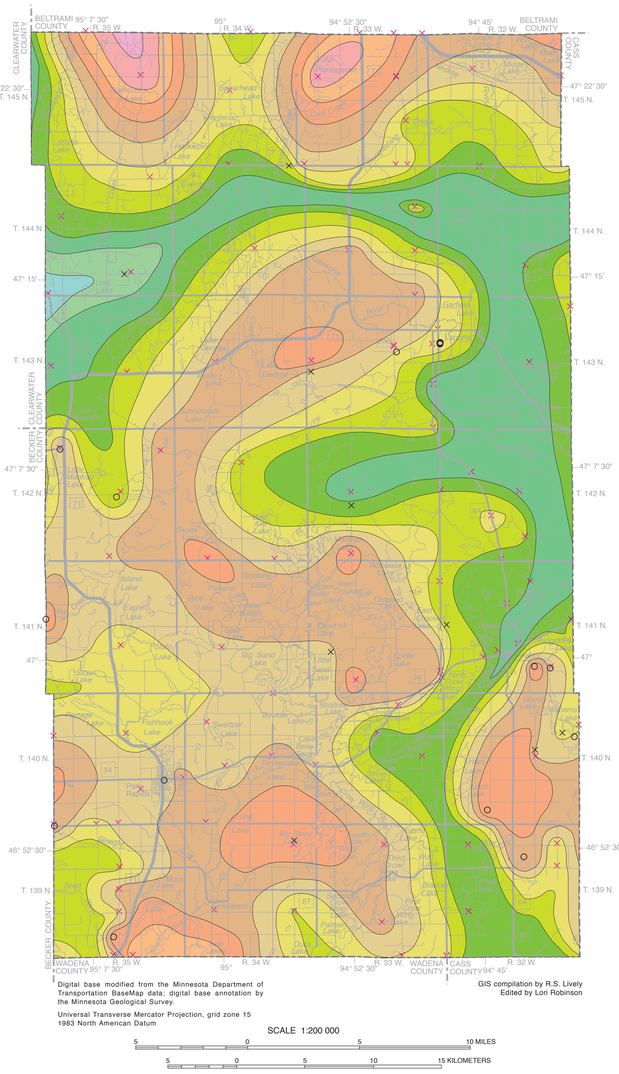
COUNTY ATLAS SERIES
ATLAS C-41, PART A
Hubbard County
Plate 6—Bedrock Topography
and Depth to Bedrock

BEDROCK TOPOGRAPHY

By

Amy L. Radakovich and V.W. Chandler

2018



Elevation of the bedrock surface in feet above mean sea level

EXPLANATION

The bedrock topography of Hubbard County was mapped using scientific and water-well drilling records, and both conventional and passive seismic soundings. Because all bedrock in the county is covered with thick deposits of unconsolidated sediment, the exact elevation of the bedrock surface could be determined only where bedrock was intersected in 16 drill holes. Nine conventional (active source, multi-channel refraction) seismic soundings and 105 passive seismic soundings within Hubbard County, as well as some soundings in neighboring counties, were used to make inferences about bedrock elevation in areas lacking drill hole coverage. Because the passive seismic method is relatively newer and less precise than conventional seismic methods, the latter method is given priority wherever available. Fifty-foot (15-meter) contours of the bedrock surface were drawn based on all available data. Accuracy of the bedrock topographic surface is directly correlated with data density and data type, as shown on the map. For example, the bedrock elevation depicted in any area is more reliable where there are numerous closely spaced wells that intersect bedrock than where widely spaced passive seismic data were used to interpret bedrock elevation.

All of Hubbard County is covered by at least 150 feet (46 meters) of unconsolidated glacial sediment, beneath which there is competent Precambrian bedrock, Precambrian saprolite (weathered bedrock), Cretaceous sedimentary strata, or combinations of these depending upon location. Precambrian bedrock forms the basement across the entire county, but almost everywhere, fresh bedrock transitions upward into a significant thickness of saprolite. Much younger, poorly lithified sedimentary rocks deposited during the Cretaceous period, and subsequently variably eroded, overlie weathered Precambrian rocks in many areas, particularly along walls of preexisting valleys cut into the Precambrian surface. By geologic convention, the soft, flat-lying Cretaceous strata are considered to be bedrock, even though the Quaternary–Cretaceous contact is not normally detectable by seismic methods. More likely, conventional and passive seismic methods will detect the surface of competent Precambrian rocks beneath the Cretaceous strata and any saprolite. Thus, the bedrock elevation shown in a specific location is a minimum elevation for the top of the bedrock, and in some locations the bedrock may be higher.

Two separate bedrock surfaces were contoured; the surface presented on the Bedrock Topography map represents a composite surface of all bedrock types encountered (sound Precambrian rock, saprolite, and Cretaceous strata), and shows the highest bedrock elevation detected in a given location. A second topographic map of just the Precambrian surface (either fresh bedrock or saprolite), with all Cretaceous rocks removed, is presented in Figure 1.

The bedrock surface in Hubbard County forms a north-trending, high-standing area in the western and central parts of the county. A significant valley feature runs northward along the eastern side of the county from northeastern Wadena County to northeastern Hubbard County. Based on recent mapping (Jirsa and others, 2010; Radakovich and Chandler, 2016a, b, 2018), this valley merges with a west-deepening valley exiting northwestern Cass County and continues to deepen west through west–northwestern Hubbard County into neighboring Clearwater County. It is possible that this valley eventually joins the large, deep bedrock valley that exits northern Becker County (Radakovich and Chandler, 2016a) and deepens northwestward toward the North Dakota border. This interpretation is tentative because it is largely guided by seismic data and lacks strong drill-hole evidence.

Bedrock was intersected in drill core as high as 1,085 feet (331 meters) above mean sea level in southeastern Hubbard County, but passive seismic data indicated that bedrock elevations approach 1,200 feet (366 meters) above mean sea level in the northwestern part of the county. In a valley near the west–northwestern part of Hubbard County, Precambrian bedrock reaches its lowest elevation of less than 700 feet (213 meters) above mean sea level. The walls of this and other deeply incised valleys in the Precambrian surface locally preserve some Cretaceous strata. As discussed, Cretaceous bedrock is likely present in many more such valleys than depicted by the five drill-hole intersections in the county.

Many features of the bedrock topography in Hubbard and adjacent Becker, Cass, and Wadena Counties are readily correlated with the lithologic and structural characteristics of bedrock when observed at a regional scale (Fig. 2). Segments of several bedrock valleys, including one in central Hubbard County, coincide with a package of metasedimentary rocks (unit Avs, Plate 2, *Bedrock Geology*) south of the Leech Lake Structural Discontinuity. Water may have taken advantage of these relatively more erodible rocks subparallel to a well-developed fault zone to erode rock more deeply. The Leech Lake Structural Discontinuity is bounded on the north by units of metavolcanic rocks (unit Amv) and interbedded iron formation (unit Aif). Valleys cut across the Leech Lake Structural Discontinuity in locations where these units are thinner or are dissected by intrusive bodies, suggesting that water might have exploited a possible "zone-of-least-resistance" related to rock composition. The development of the north-trending valley in eastern Hubbard County is likely related to the valley's origin within soft, easily erodible Paleoproterozoic sedimentary rocks in northeastern Wadena County (unit Pas).

The topography of the bedrock surface and land surface do not correlate because of the thick Quaternary sequences between them. Broad bedrock highs in southern and central Hubbard County give way to deeply incised valleys in the eastern and north-central parts of the county, but the land surface elevations are highest on the east–west trending Itasca moraine located in the center of the county (see Plate 3, *Surficial Geology*), and elevation decreases both north and south of the moraine.

MAP SYMBOLS

- Drill hole that reached bedrock
- Passive seismic sounding
- Conventional seismic sounding

REFERENCES

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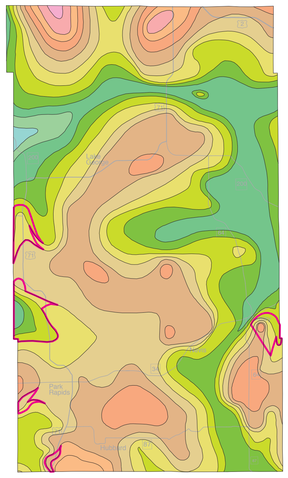

Figure 1. Map of the Precambrian bedrock topographic surface of Hubbard County with 50-foot (15-meter) elevation contours. Colors are the same as on the Bedrock Topography map. Magenta lines indicate generalized areas where the Precambrian bedrock topographic surface differs from the higher general bedrock topographic surface by an amount significant enough to exceed the contour interval. The polygons represent areas where there are known Cretaceous strata. These areas are smaller than the Cretaceous bedrock coverage polygons shown on the Bedrock Geology map (Plate 2) that were enlarged at the authors' discretion to show the inferred extent of Cretaceous bedrock. Scale 1:400,000.

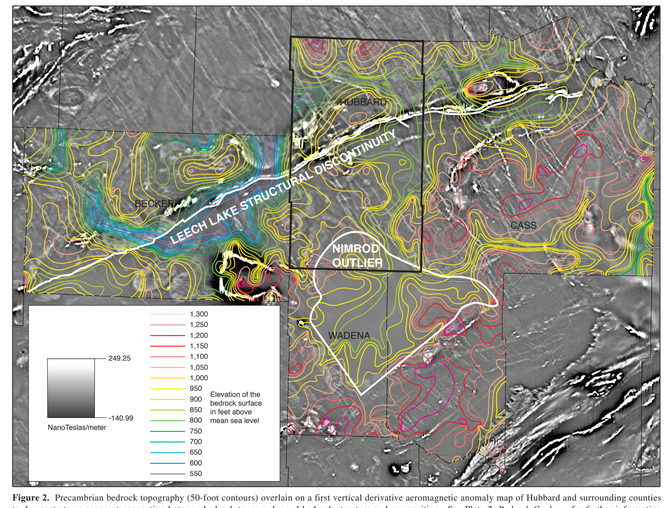

Figure 2. Precambrian bedrock topography (50-foot contours) overlain on a first vertical derivative aeromagnetic anomaly map of Hubbard and surrounding counties to demonstrate an apparent connection between bedrock topography and bedrock structure and composition. See Plate 2, *Bedrock Geology*, for further information on lithologic units. This image highlights: 1. The topographic highs associated with thick packages of highly magnetic metavolcanic rocks and iron-formations (units Amv, Aif); 2. The propagation of bedrock valley trends subparallel to and south of the Leech Lake Structural Discontinuity in bedrock units inferred to be softer (unit Avs); 3. Bedrock valleys that cut across the Leech Lake Structural Discontinuity in locations of thin or absent metavolcanic rocks and iron-formation (units Amv, Aif); and 4. A prominent valley in Wadena County underlain by more easily eroded Paleoproterozoic metasedimentary strata of the Nimrod outlier (unit Pas).

DEPTH TO BEDROCK

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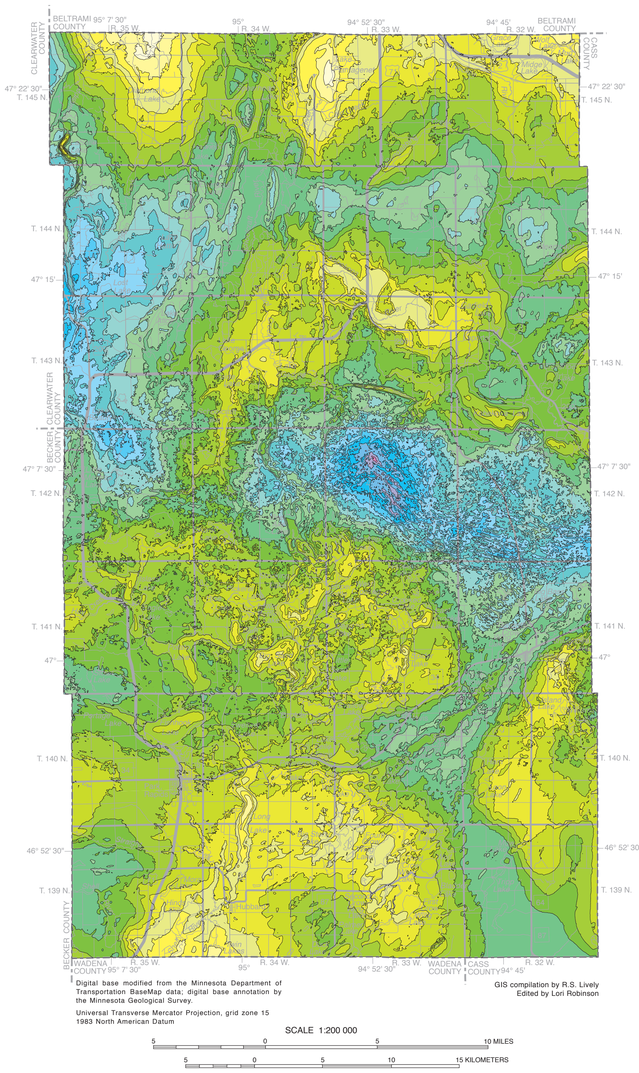

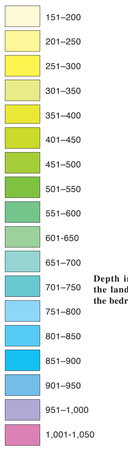

Depth in feet from the land surface to the bedrock surface

EXPLANATION

The Depth to Bedrock map shows the thickness of unconsolidated sediment above bedrock in Hubbard County. The depth to bedrock is calculated by subtracting a grid of bedrock surface elevations from a grid of land surface elevations, each with a 98-foot (30-meter) cell size. The land surface elevation grid, obtained from the Minnesota Department of Natural Resources, was derived from 3-foot (1-meter) lidar data resampled to 98 feet (30 meters), and is highly detailed. In contrast, the bedrock surface elevation grid was created from much more generalized bedrock surface elevation contour lines drawn as a part of this atlas. As discussed in the Bedrock Topography section, available data resolution requires that bedrock contours be generalized; thus the Bedrock Topography grid produced using these contours is necessarily generalized. As a result, the intricate contours shown on the Depth to Bedrock map imply an artificial level of detail, which is the result of subtracting the smoother, generalized bedrock surface from the detailed surface elevation grid. It is important to note that the accuracy of this map remains directly tied to and limited by the type and density of data as shown on the Bedrock Topography map. Mapping at a 1:200,000 scale typically cannot resolve variations in sediment thickness that occur over very short distances.

All bedrock in Hubbard County is buried beneath unconsolidated Quaternary sediment. The thickness of sediment atop bedrock is shown in colored 50-foot (15-meter) intervals on the Depth to Bedrock map. The thickness of overlying sediment varies by almost 900 feet (274 meters) across Hubbard County, from 155 feet (47 meters) to more than 1,025 feet (312 meters). Quaternary sediment is thickest in the east-central and west-central parts of the county, where bedrock valleys lie beneath the elevated land surface of the Itasca moraine (see Plate 3, *Surficial Geology*). It should be noted that the estimated thickness of Quaternary sediment in some of these deeper valleys may include some poorly consolidated Cretaceous sedimentary strata or saprolite that was not recognized in drill-hole data or with geophysical methods. Sediment is thinnest and bedrock is closest to the land surface in the northern and southern extents of the county, where relatively low land-surface elevations overlie bedrock highs.

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GEOLOGIC ATLAS OF HUBBARD COUNTY, MINNESOTA