UNIVERSITY OF MINNESOTA

MINNESOTA GEOLOGICAL SURVEY
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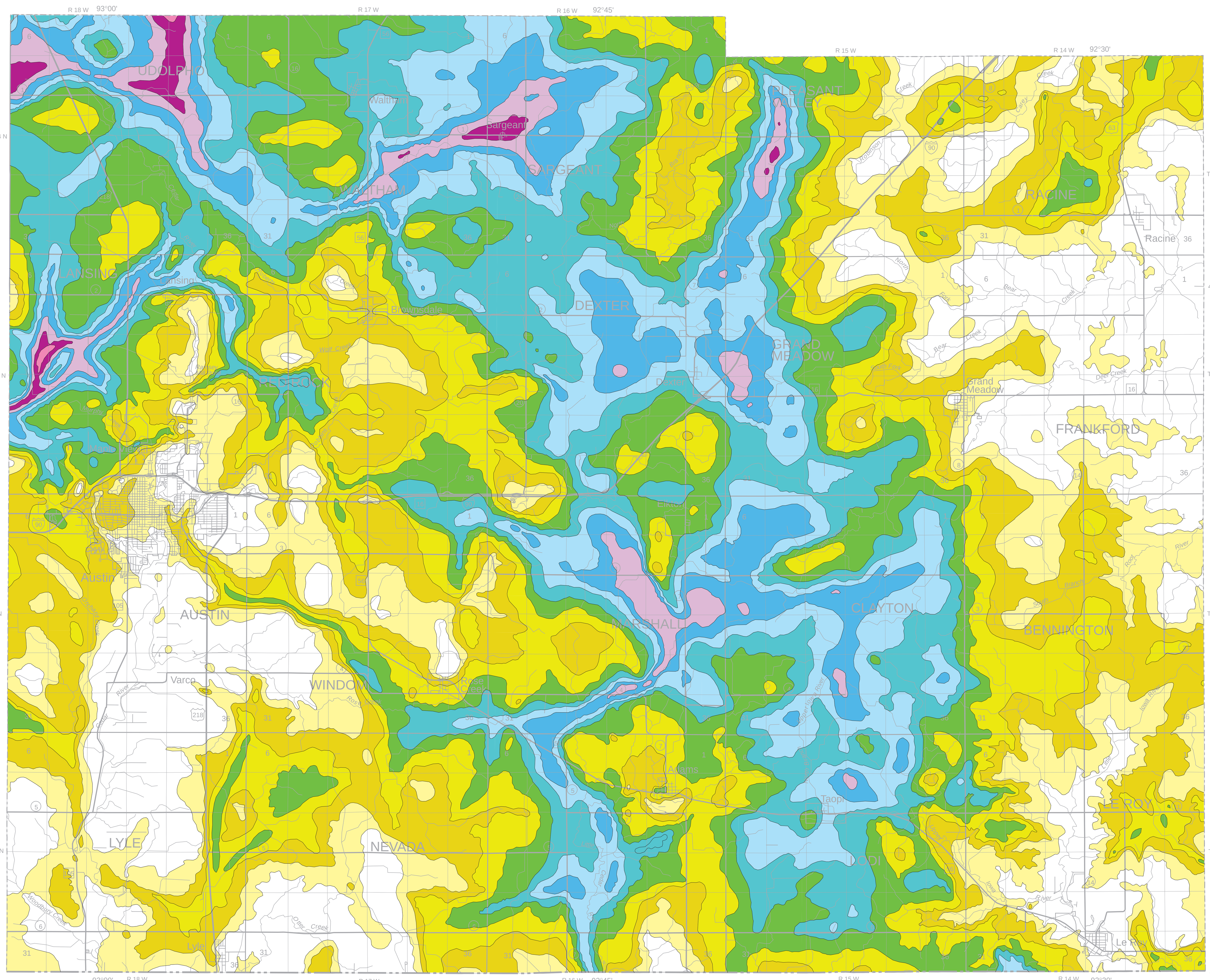

Digital base modified from 1990 Census TIGER/Line Files of U.S. Bureau of the Census (source scale 1:100,000); county border files modified from Minnesota Department of Transportation files; digital base annotation by Minnesota Geological Survey

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

DEPTH TO THE PRE-CRETACEOUS BEDROCK SURFACE

By

John H. Mossler

1998

EXPLANATION

Intervals of equal depth (in feet) to the pre-Cretaceous bedrock surface

25
50
75
100
125
150
175
200
225
250

INTRODUCTION

The landscape of Mower County is the product of a long, complex interaction of glacial, fluvial, and eolian deposition and erosion from the beginning of the Quaternary Period, about two million years ago, to the present. Those processes produced an almost continuous mantle of glacial drift, loess, and alluvium overlying bedrock. The Quaternary glacial deposits that cover the county are mainly pre-Wisconsinan in age (prior to 70,000 years ago) and consequently were exposed to extended periods of post-depositional erosion and redeposition. Therefore, the present land surface contains no clues about the pre-Quaternary bedrock topography. Nearly all information about bedrock topography is derived from subsurface geologic and geophysical data (Plate 1).

Quaternary and Cretaceous deposits are grouped together for purposes of map construction on this plate owing to their similar appearance and density: Well drillers' logs commonly fail to differentiate the two, and, when modeled using the gravity-geologic method described below, they have nearly the same density.

MAP PREPARATION

The topographic expression of the bedrock surface must be mapped before the contacts on the geological map (Plate 2) are drawn or the depth to bedrock map contoured. Several sources provide information on elevations of specific points on the bedrock surface: they include bedrock outcrops and water-well logs, Giddings soil-auger holes, and exploratory or engineering drill holes that penetrate to bedrock. Areas that contain karst features like sinkholes that have topographic expression on the present-day land surface are commonly underlain by shallowly buried bedrock that has less than 50 feet and generally less than 25 feet of overburden. Soil maps (Carlson, 1989) delineate areas underlain by soil associations that developed on shallow bedrock, which is defined on soil maps as generally less than 5 feet below land surface.

Because information on the elevation of the bedrock surface in some rural areas in Mower County is insufficient for accurate mapping, it is necessary to supplement that data with information derived from geophysics. Refraction seismic soundings give profiles showing the elevation of the buried bedrock surface along lines that are as long as 800 to 900 feet. However, even these profiles do not adequately define the buried topography over a broad area. A geophysical method that is particularly useful to bedrock-overburden studies is the gravity-geologic method (Imbrahim and Hinze, 1972; Adams and Hinze, 1990), which is a regional residual anomaly separation scheme that incorporates geologic control from drill holes, outcrops and seismic studies. The residual anomaly signature is subsequently transformed into estimates of bedrock topography and depth to bedrock. The usefulness of this method lies in its suitability for mapping broad areas, in contrast to other geophysical methods that are often very site specific. In Mower County, gravity analysis relies on use of a representative density contrast between Paleozoic carbonate rocks and overlying Cretaceous and Quaternary deposits (Chandler, in press). Cretaceous and Quaternary deposits differ little in density, ranging from 1.99 to 2.10 grams per cubic centimeter (gm/cc). The underlying Paleozoic carbonate rocks average 2.55 gm/cc. The probable average contrast between till and underlying carbonate rock is about 0.45 gm/cc. Existing gravity data from previous studies (Chandler and Schaap, 1991) and data collected specifically for the Mower County atlas (see Plate 1 for the location of gravity data) were used to make the gravity-geologic maps. The procedures involved in data collection are described in Chandler (in press).

Isolating local gravity anomalies from a regional field is a classical problem for gravity interpretation. In this study the regional field was removed by the gravity-geologic method, which incorporates geologic control from outcrops, drill holes, and seismic soundings to produce a regional field. In Mower County, the regional field is dominated by signatures associated with rocks of the Middle Proterozoic Midcontinent rift system. Comparison of the large anomalies and strong gradients associated with Precambrian rocks beneath Mower County with the small signatures of buried bedrock valleys presents a stringent test for regional residual anomaly separation. After subtracting the regional field, the resulting residual anomalies can be used directly to estimate bedrock elevation and overburden thickness (Chandler, in press). Computer-generated maps showing variations in bedrock topography and overburden thicknesses were printed using this methodology. The computer-generated maps were then used as guides in contouring the bedrock topography map on this plate, which was compiled manually at a scale of 1:24,000. Manual contouring was required because computer-generated contouring showed patterns of elliptical depressions and highs instead of the elongated valleys and ridges known to underlie the county.

After bedrock surface elevations were contoured to show the bedrock topography, the bedrock surface values of the resulting contours were subtracted from topographic contours on the land surface where the respective contours intersect on the topographic maps. The resulting values were contoured along with overburden values from water wells, engineering borings, and seismic lines to create a map that depicts depth to bedrock across the county. Accuracy of the depth to bedrock map therefore is dependent on the accuracy of the bedrock topographic map.

Parts of the depth to bedrock map were prepared digitally. The contours from the bedrock topography map on this plate were digitized, and a grid (cell size 30 meters) was generated from those points. The U.S. Geological Survey 7.5-minute digital elevation model (cell size 30 meters) (U.S. Geological Survey, 1990) was used to represent the land surface. The bedrock topography grid was then subtracted from the land-surface elevation grid to yield a depth-to-bedrock data grid from which a machine generated the contoured depth to bedrock map. The initial digital elevation model had to be resampled and refiltered because of strong north-south lineation or stripping in contoured values of the land surface topography on the initial version. Although the digitally generated map had acceptable accuracy in areas of thick drift, it was necessary to contour areas with thin drift (less than 50 feet) manually to provide acceptable accuracy. The vertical accuracy of the digital elevation model was not sufficiently accurate in these areas, particularly after the additional filtering.

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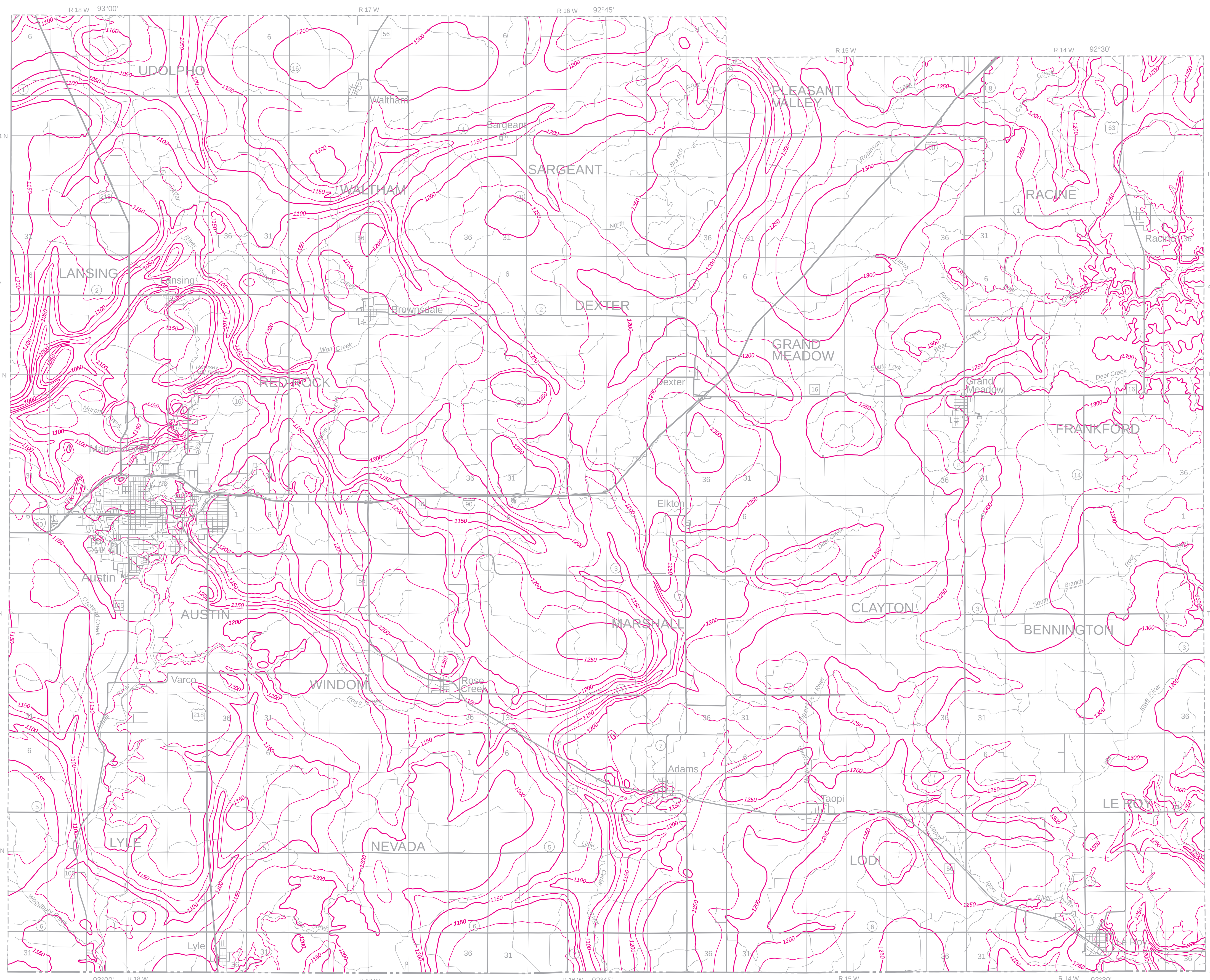

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TOPOGRAPHY OF THE PRE-CRETACEOUS BEDROCK SURFACE

By

John H. Mossler

1998

EXPLANATION

1150

Lines of equal elevation of the pre-Cretaceous bedrock surface; contour interval 25 feet. Contours interrupted in areas of very steep slope. Datum is mean sea level.