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GEOTHERMAL DIRECT HEAT PROGRAM ROUNDUP TECHNICAL CONFERENCE PROCEEDINGS

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PAPERS PRESENTED

STATE COUPLED RESOURCE ASSESSMENT PROGRAM

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An Evaluation of the Hydrothermal Resources of North Dakota, the Final Phase

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Our previous work has involved developing maps to summarize aquifer characteristics for Paleozoic and Mesozoic aquifers in North Dakota, as well as temperature logging of test holes to expand the available heat flow data. The WELLFILE and WATERCAT computer data bases we developed have required continual validations and updating, but have proved to be effective data management systems.

Currently we are summarizing the available data on Cenozoic aquifers. These aquifer systems have the largest potential for development by individuals and small towns. Although they constitute a low-temperature resource of variable water quality, they are widely distributed and occur at economic depths.

Maps of Tertiary aquifers have been prepared by Ray Butler, formerly with the United States Geological Survey Water Resources Division (USGSWRD) in Bismarck, North Dakota. Joint publication of Ray's maps by the North Dakota Geological Survey, USGSWRD and the North Dakota State Health Department is in progress. Although we do not now have preliminary copies of these maps, they should be published in a few months. Ray's maps summarize structural, water quality, and piezometric data for Tertiary aquifers in North Dakota.

Data relative to aquifer locations, temperature, and water quality for Pleistocene aquifers has been collected and preliminary interpretations of this data are presented here.

Figure 1 shows the occurrence of sand and gravel within 100 meters (330 feet) of the surface in the glaciated area of North Dakota. This map was prepared using data from USGSWRD county groundwater resource studies and a geologic map of North Dakota (Bluemle, 1977). Aquifers within the upper 100 meters, as well as surface sand and gravel, were mapped.

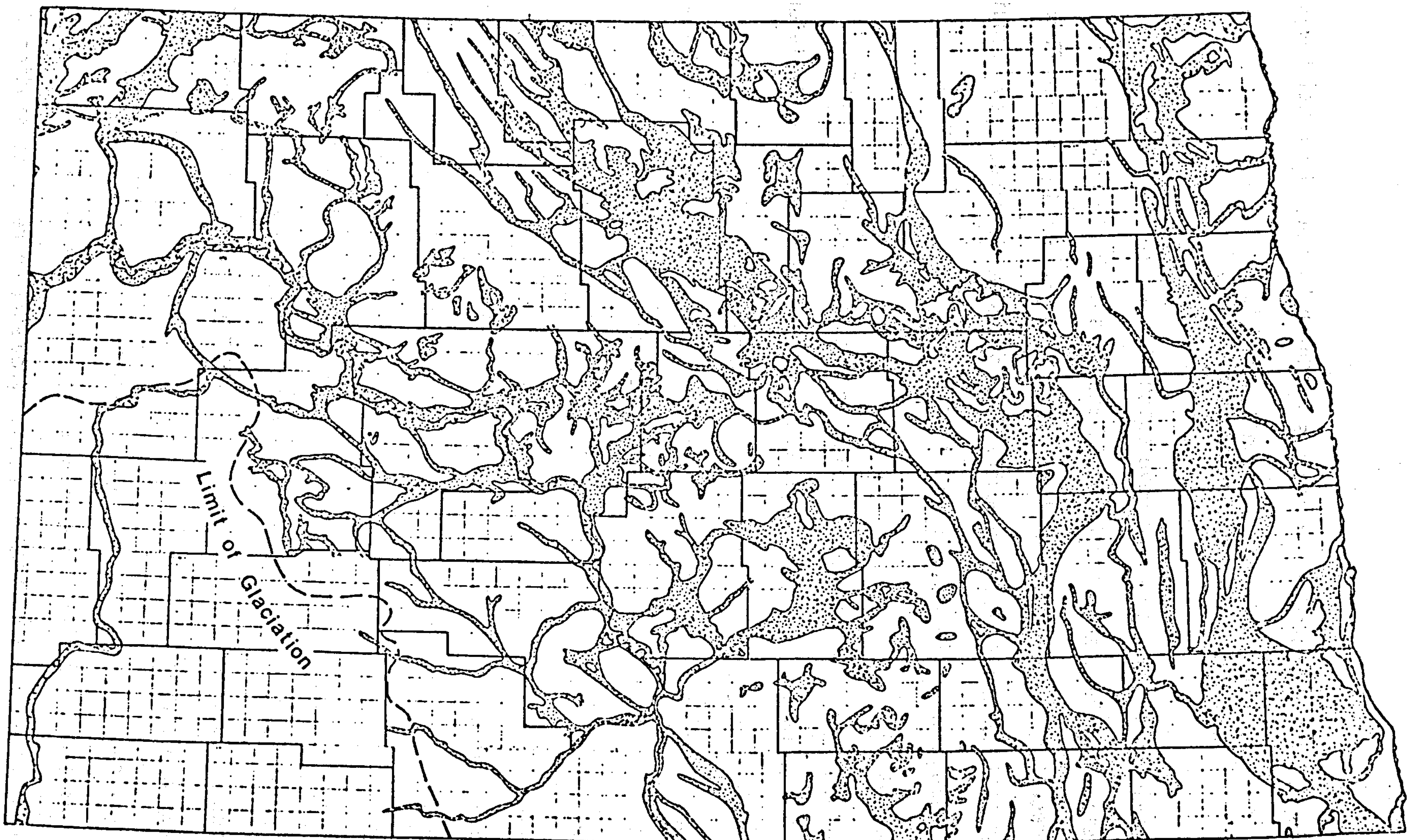
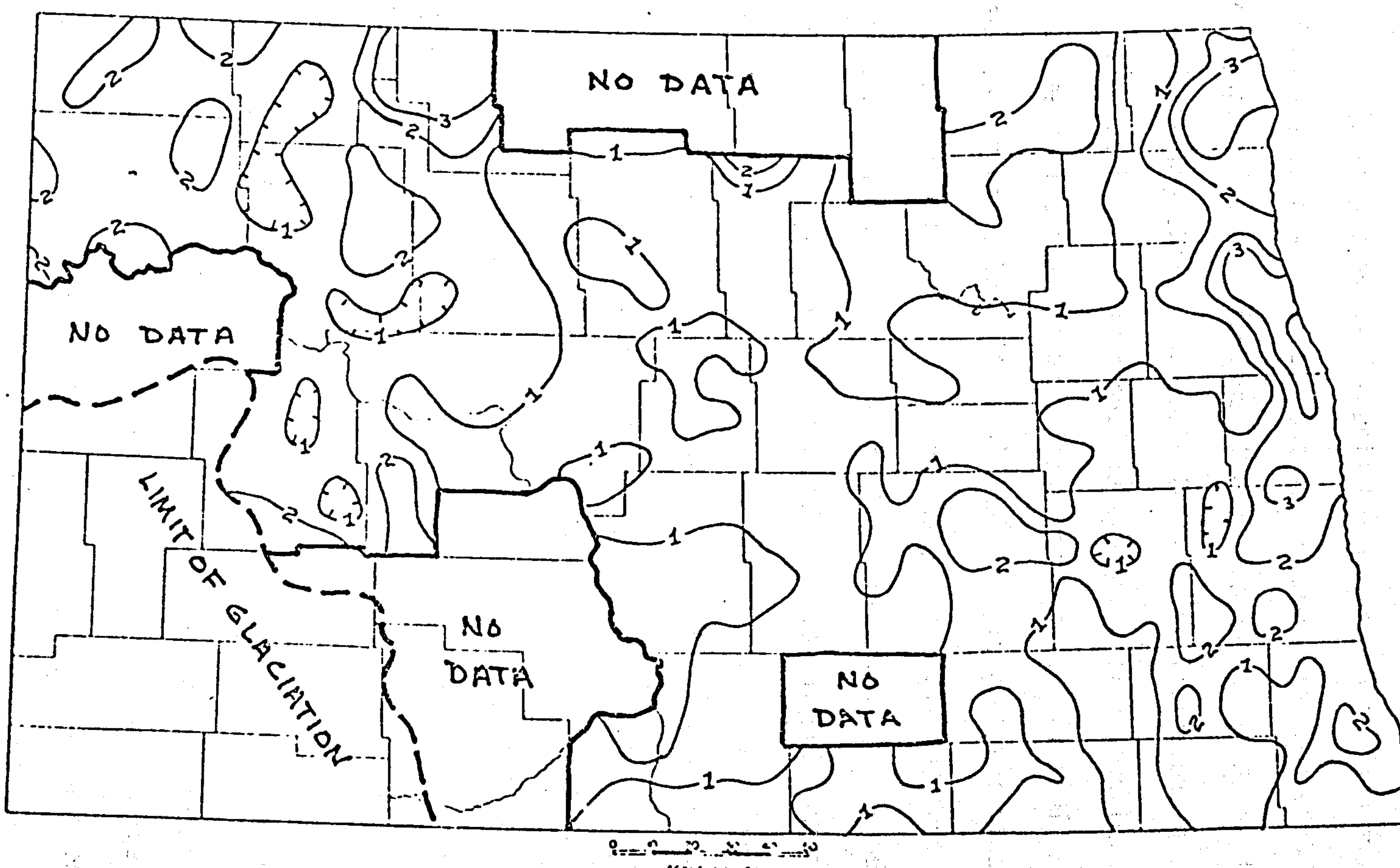


Figure 1. Occurrence of sand and gravel within 100 meters (330 feet) of the surface in the glaciated area of North Dakota.

WATERCAT was interrogated for the water quality data available for Pleistocene aquifers. The total dissolved solids recorded for each water analysis were machine contoured and figure 2 shows a generalized contour map of the expected water quality of the Pleistocene aquifers in North Dakota. Figure 3 shows the location of the well control used in constructing this map. Areas of relatively high total dissolved solids (generally greater than 2000 ppm) occur along the eastern and northern borders of the state. The higher values in the east are attributed to vertical movement of water from Paleozoic and Mesozoic aquifers (fig. 4), and along the northern border to water production from shale-rich gravels. Most of the Pleistocene aquifers can be expected to produce water of about 1000 ppm total dissolved solids.

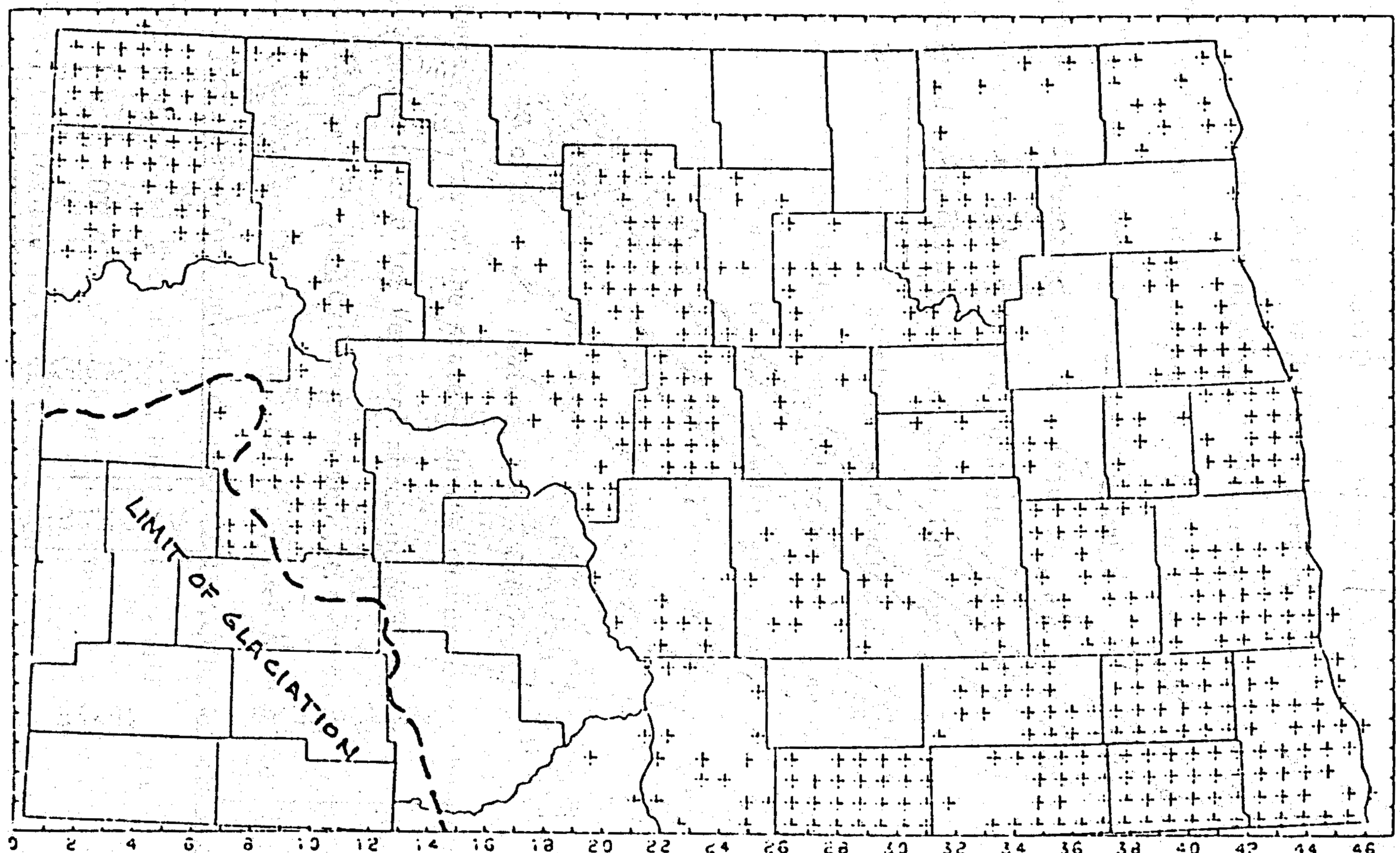
Temperature logging of existing groundwater observation wells provided the temperature and depth data required to produce a shallow geothermal gradient map and slice maps of observed temperatures at various depths.

Figure 5 shows the shallow geothermal gradient map, which was constructed using site averages of point-to-point temperature gradients in the wells logged. Figure 6 shows the location of the well control for the shallow gradient map. Major gradient features ($>20°C/km$) are present in the eastern and southwestern parts of the state. In the eastern area the gradient features are thought to be due to the vertical movement of water from Paleozoic and Mesozoic aquifers. In the southwestern area, the gradient features are thought to be caused by the tendency for these wells to be completed in Tertiary, regional aquifers which are less susceptible to local recharge events. The majority of the shallow, Pleistocene aquifer systems exhibit a relatively low ($<20°C/Km$) temperature gradient. Most Pleistocene aquifers are relatively shallow and local in extent, and consequently influenced by the cooling effect of local recharge events.



Total Dissolved Solids in Pleistocene Aquifers (TDS/1000,CI=1)

Figure 2. Generalized contour map of the expected water quality of Pleistocene aquifers in North Dakota (Total Dissolved Solids, PPM).



Township Control for Total Dissolved Solids in Pleistocene Aquifers

Figure 3. Location of well control used to construct Pleistocene water quality map.

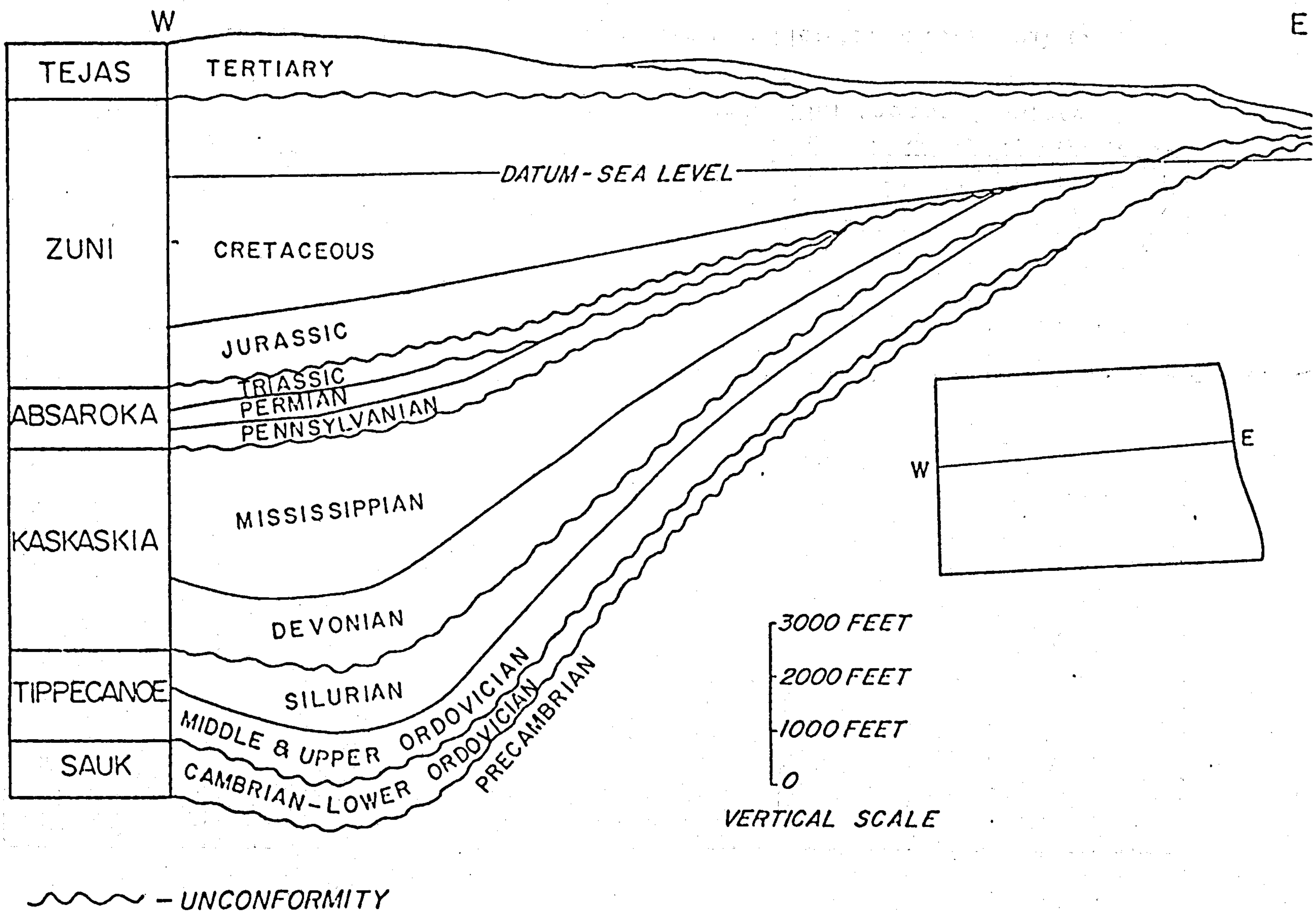


Figure 4. Cross section showing major unconformities in the North Dakota stratigraphic column. (After: Carlson, C. G., and Anderson, S. B., 1966).

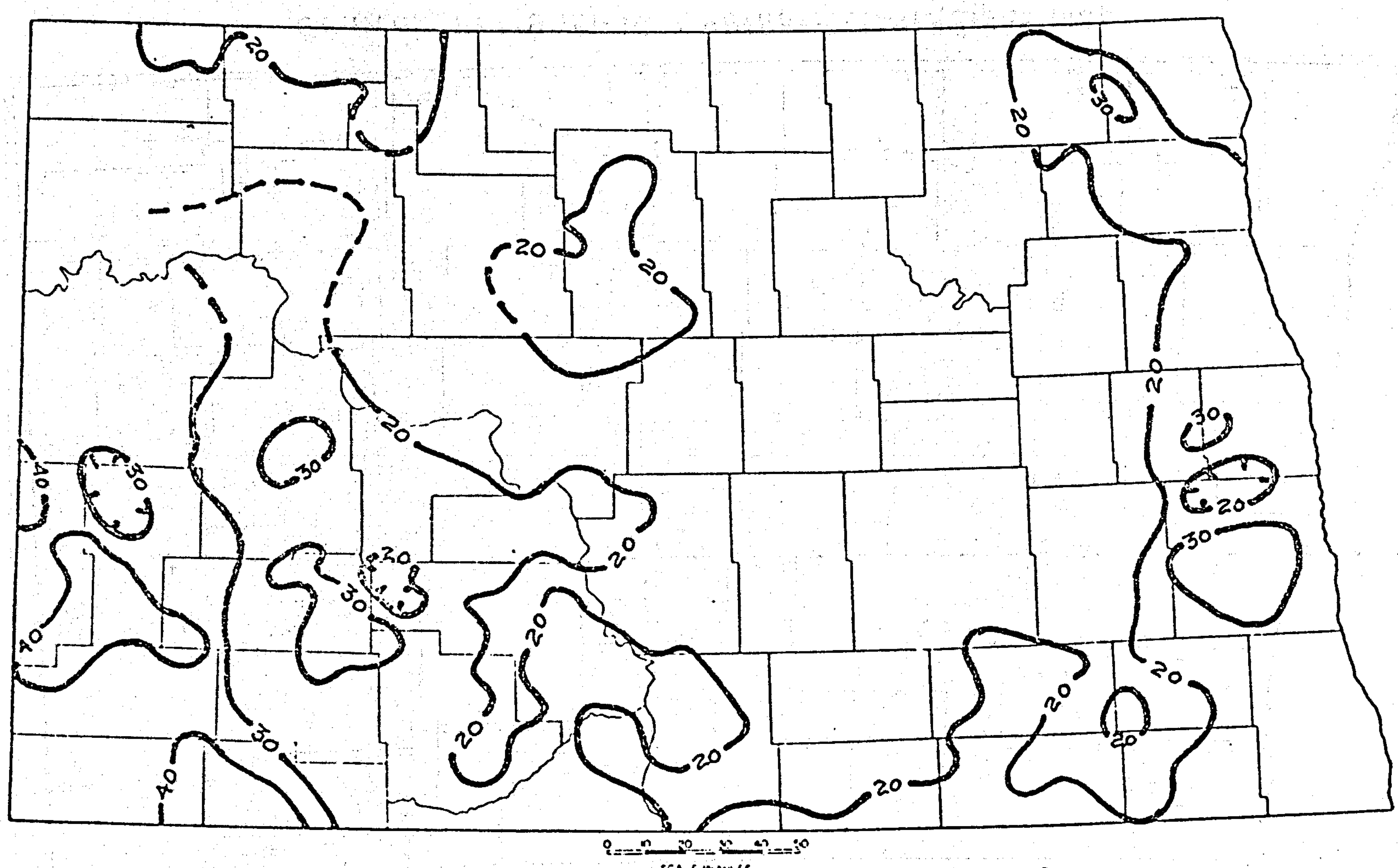
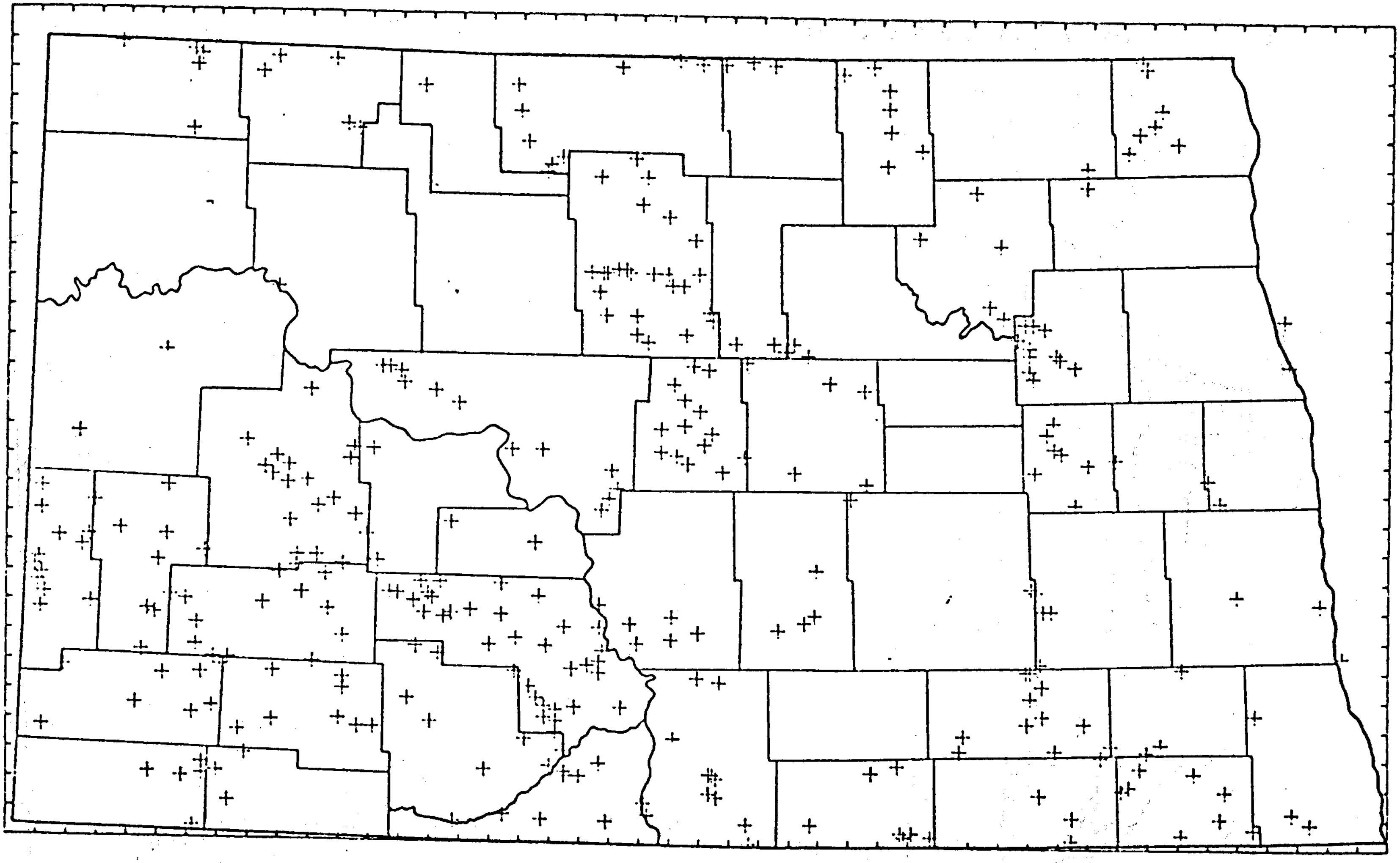


Figure 5. Shallow geothermal gradient map of North Dakota.



Control For Shallow Geothermal Gradient Map

Figure 6. Location of well control used to construct shallow geothermal gradient map.

Figure 7 shows a contour map of observed temperatures at 100 meters (330 feet). The temperatures observed ranged from less than 7°C (45°F) to greater than 13°C (55°F). The features shown on the observed temperature map are similar to those seen on the shallow geothermal gradient map. Figure 8 shows the location of well control used to construct the 100 meter temperature map.

Numerous requests for site specific information have been filled to date using data from our data management systems. Proposed applications have ranged from water-to-air heating systems for homes and community centers to a subdivision heating system combined with a reverse osmosis water treatment plant to supplement city water.

We will be combining our Paleozoic, Mesozoic and Cenozoic aquifer data into a catalog of North Dakota aquifers. It is hoped that this catalog will provide potential exploiters of geothermal energy in North Dakota with useful information.

References

Bluemle, John P., 1977, Geologic Highway Map of North Dakota: North Dakota Geological Survey, Miscellaneous Map 19.

Carlson, C. G. and Anderson, S. B., 1966, Sedimentary and Tectonic History of North Dakota Part of Williston Basin: North Dakota Geological Survey, Miscellaneous Series No. 28, p. 1933-1946.

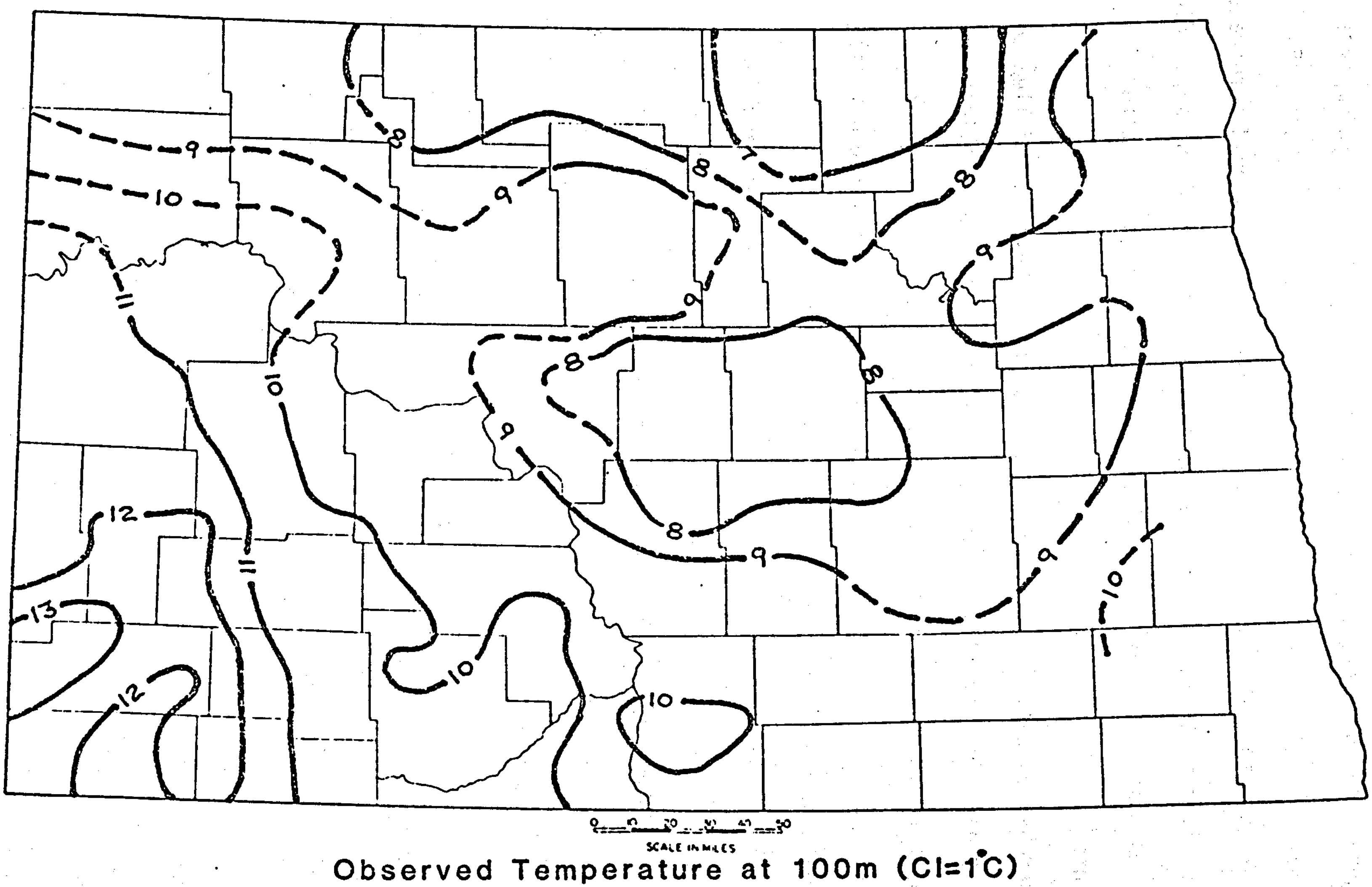
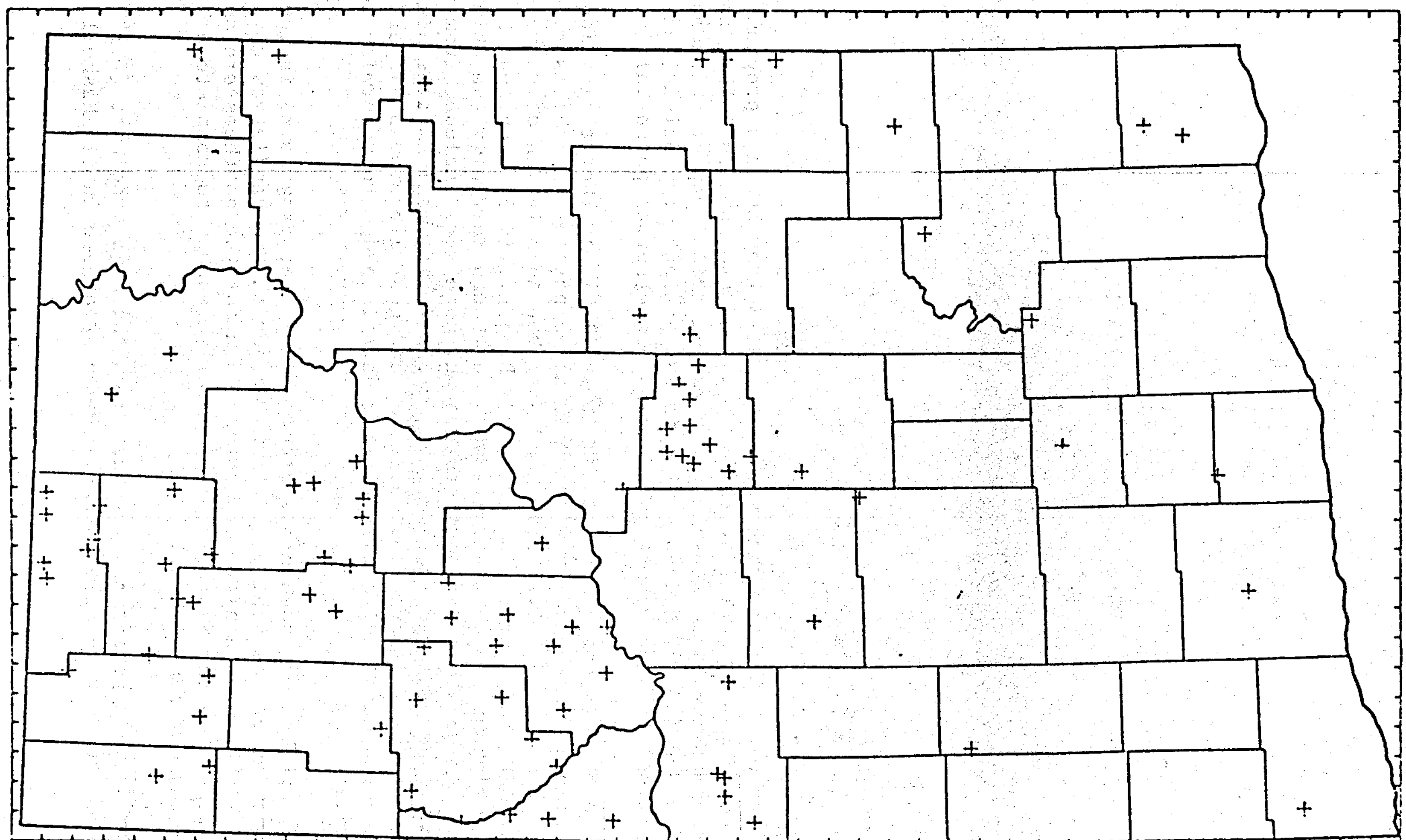


Figure 7. Contour map of observed temperatures at 100 meters (330 feet).



Control For Observed Temperature Map

Figure 7. Contour map of observed temperatures at 100 meters (330 feet).