LITTLE-KNOWN MID-PALEOZOIC SALTS OF NORTHWESTERN NORTH DAKOTA

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David W. Fischer and Sidney B. Anderson

REPORT OF INVESTIGATION NO. 83

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ABSTRACT

Bedded salts have been identified and mapped in four Paleozoic formations. These salts, previously not described in North Dakota, are found in the Silurian Interlake Formation and in the Devonian Ashern, Souris River, and Duperow Formations.

A series of stratigraphically and areally discontinuous, thin, bedded salts have been identified in the Silurian Interlake Formation. As many as five, bedded, thin salts are present in the upper Devonian Ashern Formation; these salts are stratigraphically correlatable, but laterally discontinuous. A single, thin, bedded salt is present in each of the Devonian, Souris River, and Duperow Formations. These salts are laterally continuous with salts previously described in the Province of Saskatchewan.

Knowledge of the presence of these salts may be helpful in designing a drilling and testing program for wells in areas where they may occur. Furthermore, a knowledge of the presence of these salts is helpful in understanding the overall geological history of the Williston Basin.

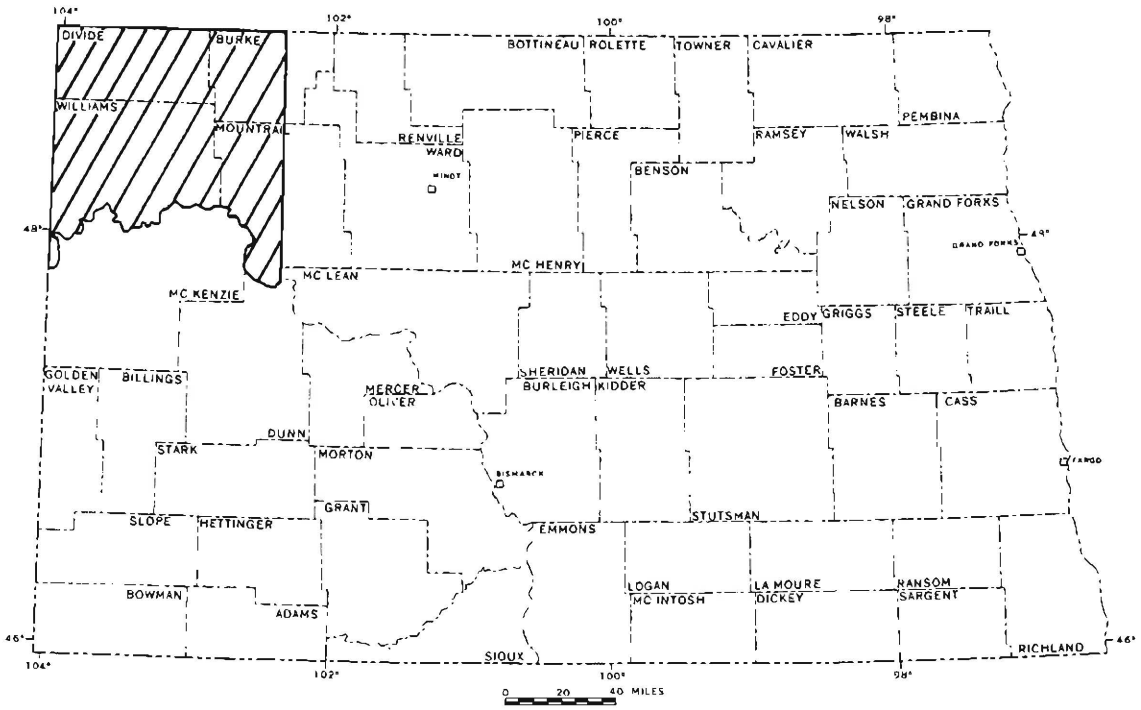

Figure 1. Study area.

INTRODUCTION

Pre-Mississippian salts, other than the well-documented Prairie Salt of Devonian Age, are present in the mid-Paleozoic section of the Williston Basin. These salts occur in the Silurian Interlake Formation and in the Devonian Ashern, Souris River, and Duperow Formations.

The study area (fig. 1) includes all of Divide and Williams Counties and parts of Burke and Mountrail Counties, North Dakota. It does not delineate the absolute areal extent of all the salts discussed, but rather was chosen because all the salts discussed occur within it. All wells located within the study area that have penetrated the Devonian Duperow Formation or deeper horizons (prior to approximately June, 1983) are shown on a penetration map (pl. 1) and are keyed by formation at total depth.

Porosity zones interpreted to be salt-filled or beds of salt too thin to be resolved on logs or found in sample cuttings are common throughout the study area. These zones are not necessarily continuous with the discussed salts, and have not been included in this report. Identification of the salts was done primarily from mechanical well logs with

cores[1] and sample cuttings[2] supplementing where available.

STRATIGRAPHY

Silurian Salts

Interlake Formation

Scattered, discontinuous beds of salt (fig. 2: cross section A-A') can be identified on logs by their occurrences near a prominent gamma-ray marker in the lowermost portion of the upper Interlake Formation. This marker was used by Carlson and Eastwood (1962) to divide the Interlake into upper and middle intervals. It has been interpreted by LoBue (1983) as a paleosol. The occurrences of these salts are restricted to the southwestern portion of the study area (fig. 3). The maximum salt thickness noted to date, during this study, 7 feet, was recorded in the Caroline Hunt Schoellkopf-Trend Exploration #1 Oyloe (NDGS #5992: sec 4, T154N, R103W, Williams County).

Interlake salts have been identified from log characteristics; however, they have not been cored or found in sample cuttings. The interval in which the salts occur is overlain, underlain, and laterally continuous with what LoBue (1983) describes as a sequence of calcretes and ferricretes.

Devonian Salts

Ashern Formation

A series of salts have been found in the Ashern Formation of North Dakota (fig. 2: cross section B-B'). These salts are restricted primarily to the south-central portion of the study area, flanking the Nesson Anticline (figs. 4 and 5). Stratigraphically, the salts are restricted to the upper part of the Ashern Formation, referred to by Walker (1957) as the "upper grey member."

A maximum thickness of 42 net feet of Ashern salt is known in the study area. This relatively thick section of salt was penetrated in the Kissinger Petroleum #1-9 Grondale (NDGS #7570: sec 9, T155N, R94W, Mountrail County). For the purpose of correlation and mapping, the Ashern salt has been informally subdivided into two submembers, M and N, in descending stratigraphic order (fig. 6), with each submember further subdivided into units. Submember M has been divided into units M_1 and M_2. The maximum thickness of M salt identified to date within the study area, 22 feet, was recorded in the #1-9 Grondale and included 10 feet of M_1 and 12 feet of M_2. Submember N has been subdivided into three informal units: N_1, N_2, and N_3. The maximum known thickness of

[1]Only one core that penetrates a discussed section in the study area includes a salt.

[2]Sample cuttings are not considered by the authors to be a preferred tool for lithologic determination, but, as always in such a study, the paucity of core data makes the use of sample cuttings necessary.

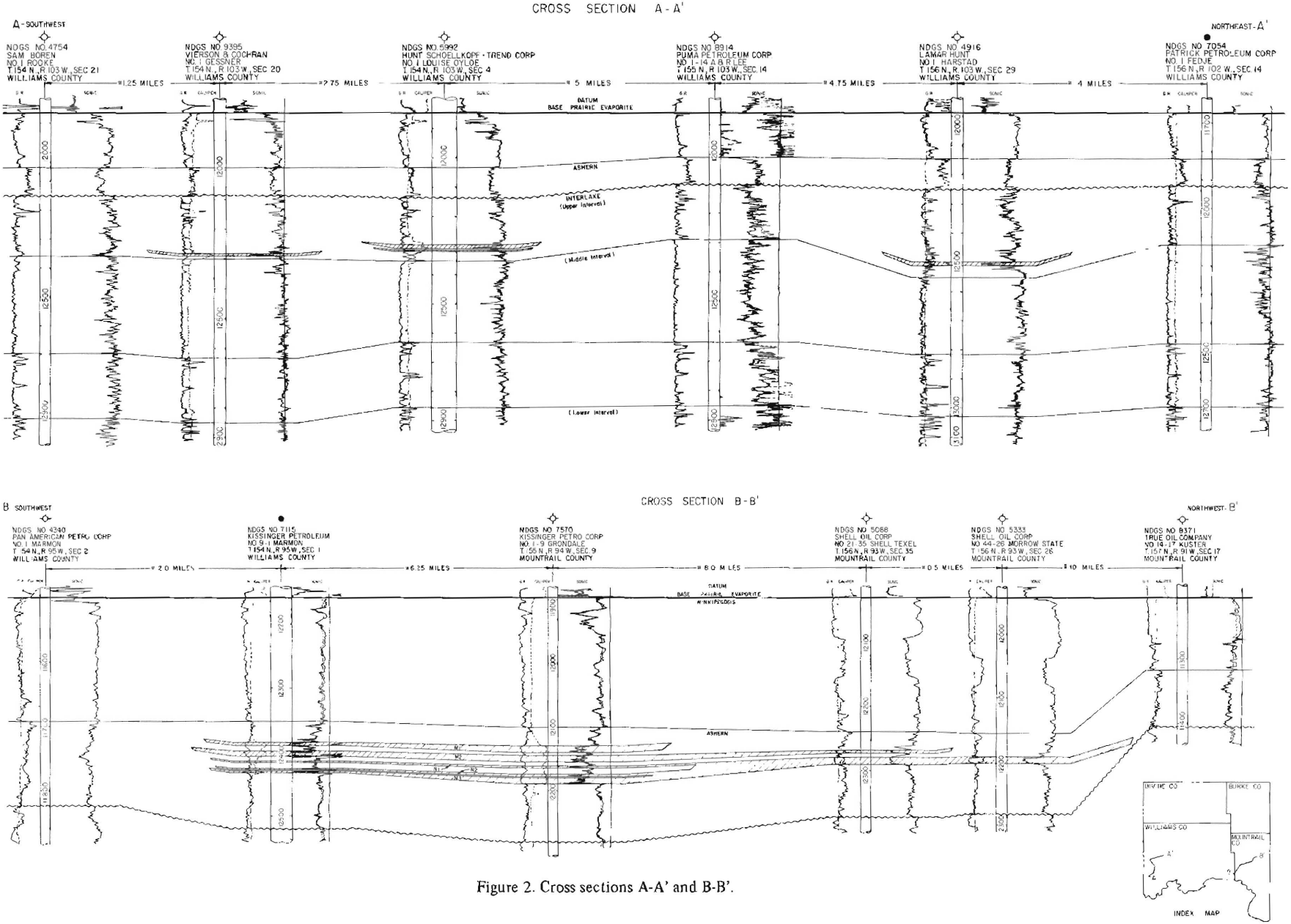

Figure 2. Cross sections A-A' and B-B'.

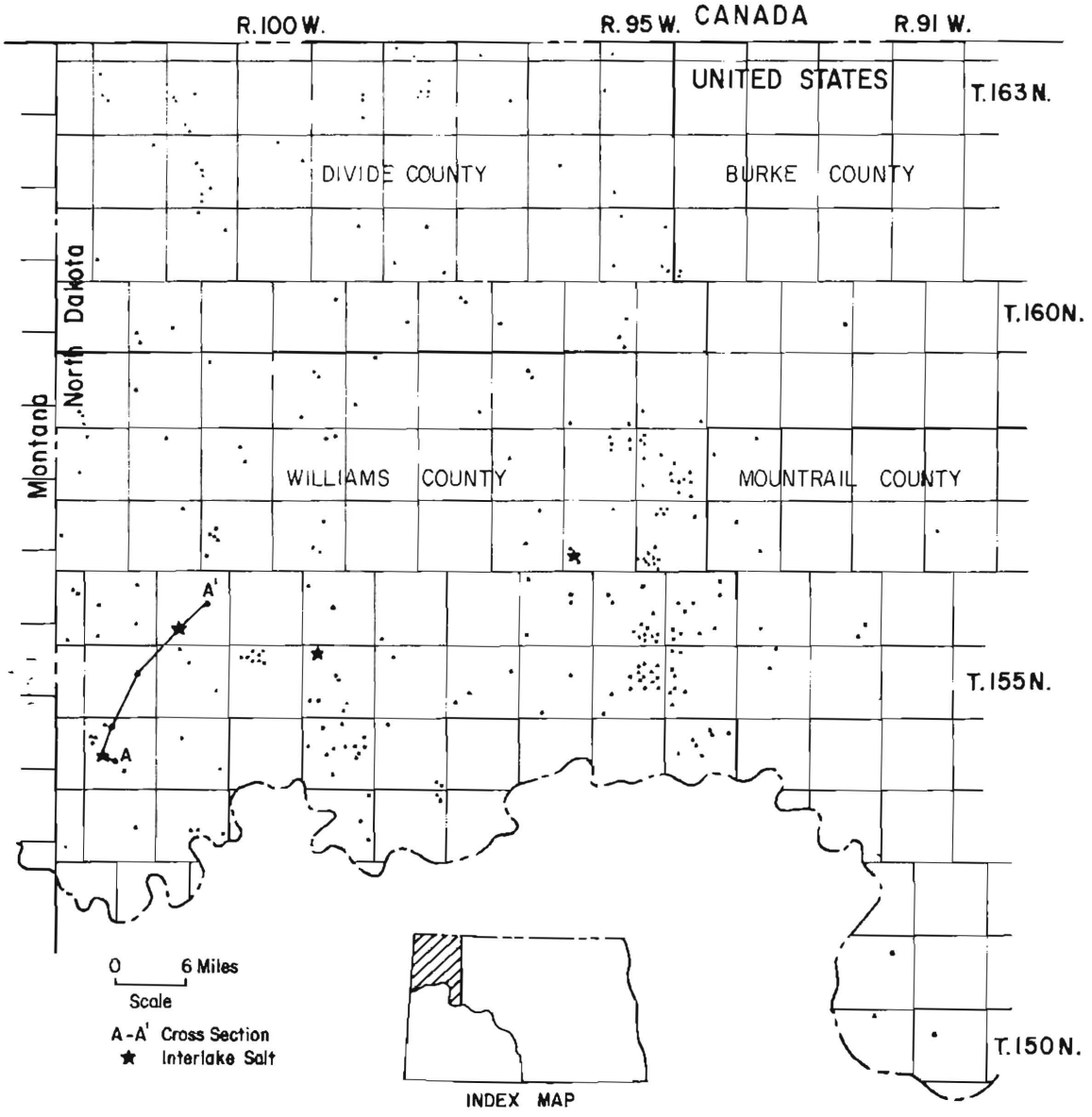

Figure 3. Aerial distribution of Interlake Salt, northwest North Dakota.

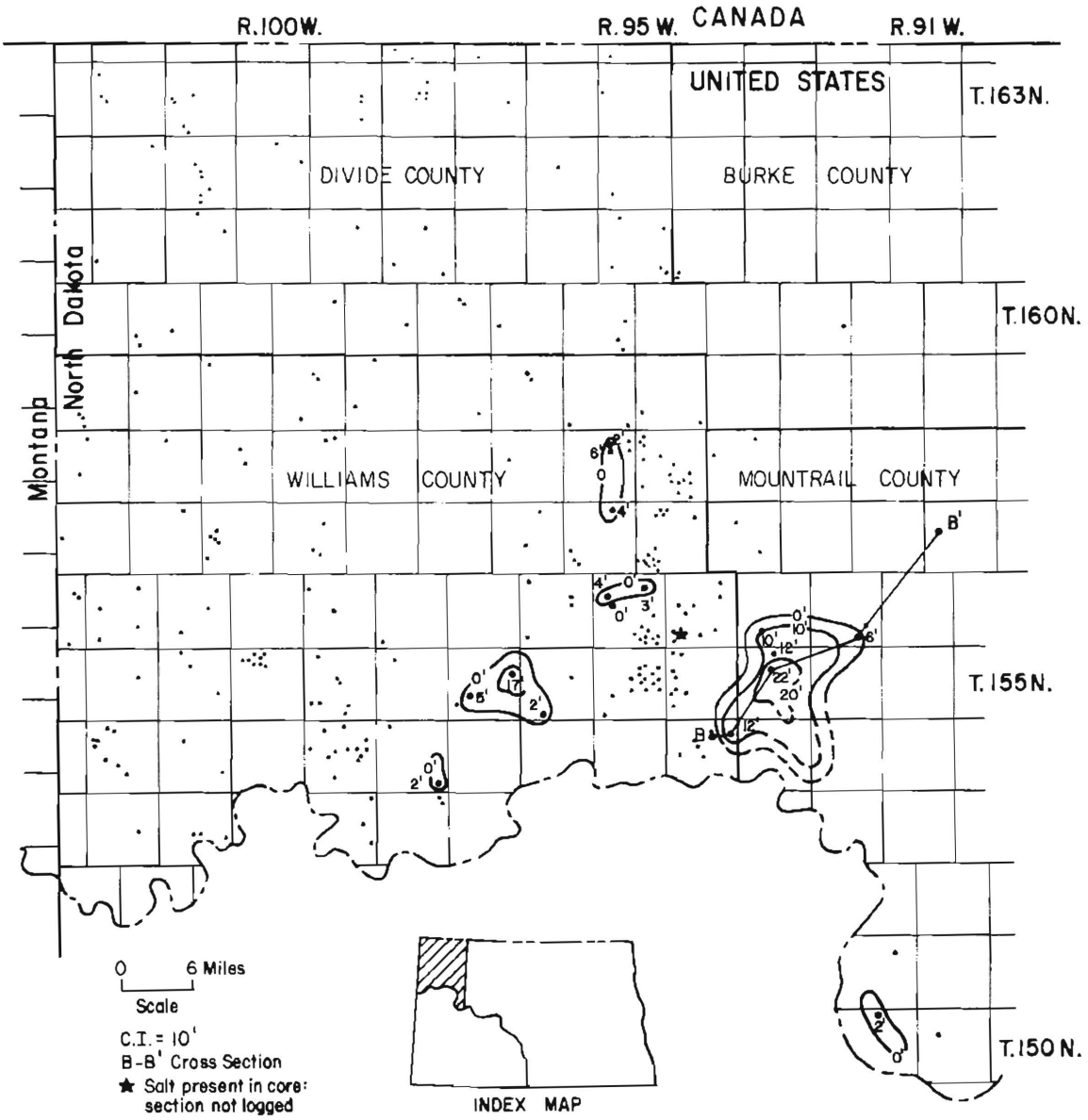

Figure 4. Isopach: "M Salt," Ashern Formation, northwest North Dakota.

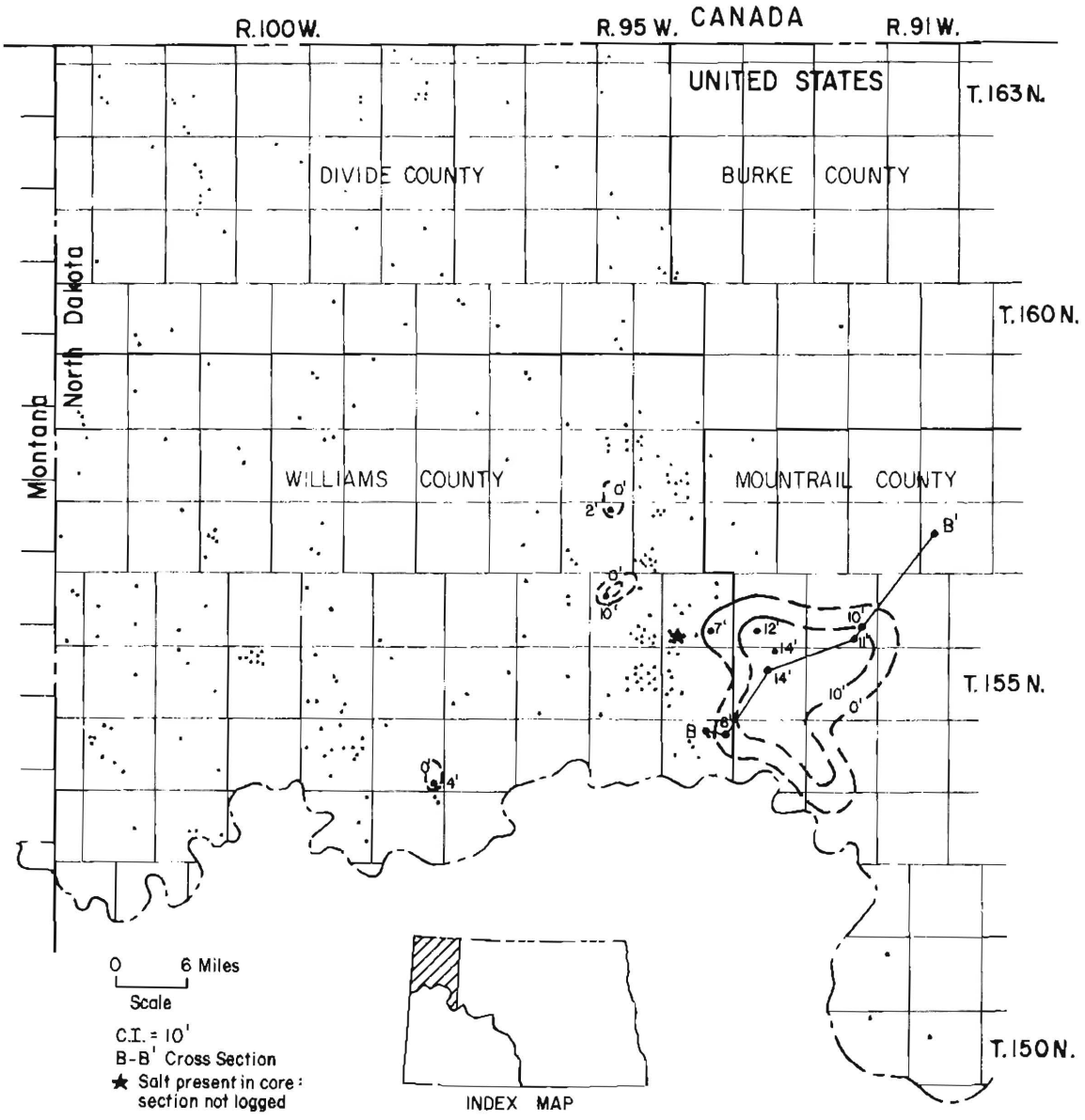

Figure 5. Isopach: "N Salt," Ashern Formation, northwest North Dakota.

NDGS # 7570
KISSINGER PETROLEUM CORPORATION #1-9 GRONDALE
9-155-94 W

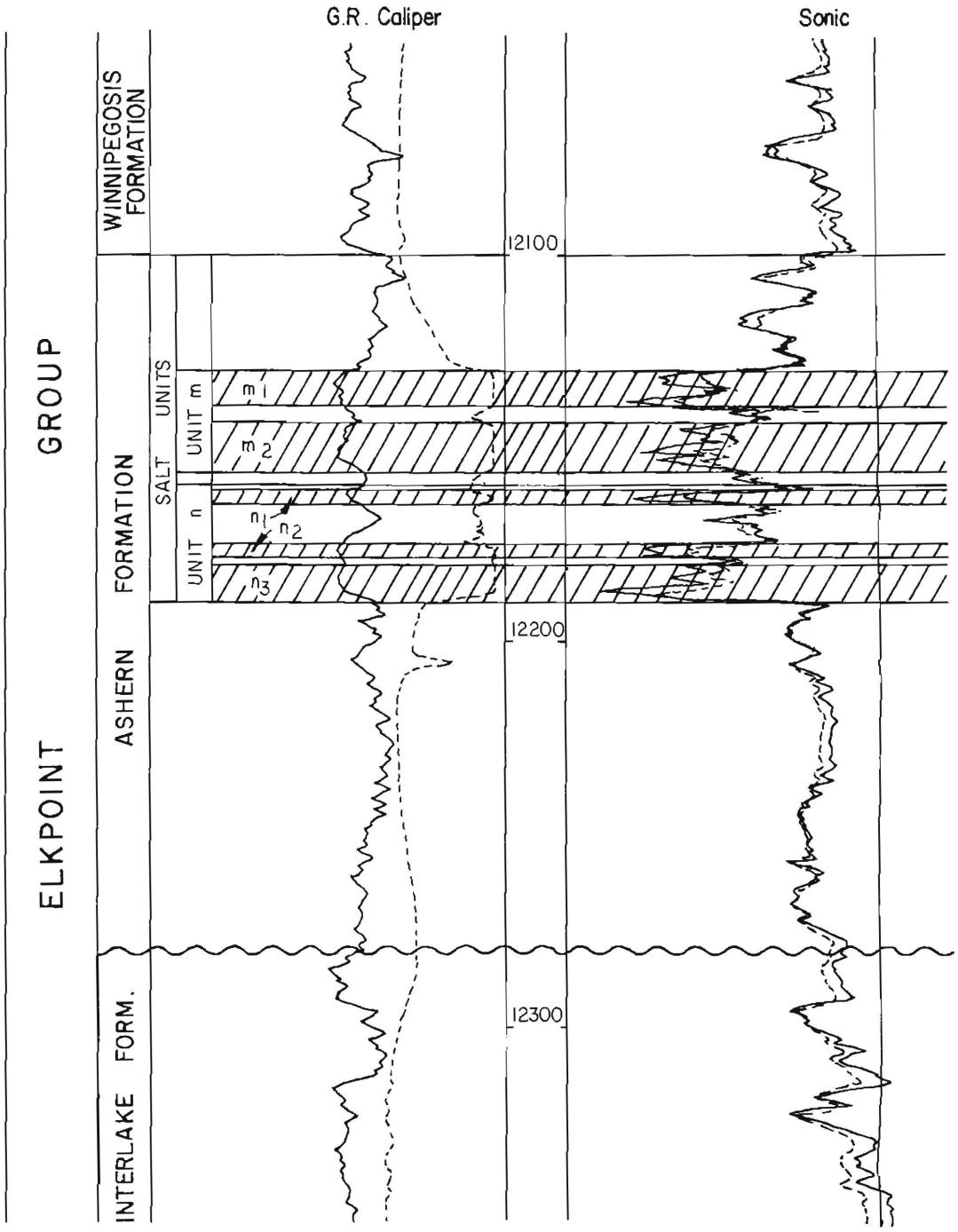

Figure 6. Log character: Ashern Salt, Ashern Formation.

N salt, recorded in the #1-9 Grondale, is 14 feet. This salt section had 2 feet of N_1, 4 feet of N_2, and 8 feet of N_3 salt.

The salt of the Ashern Formation is overlain, underlain, and laterally continuous with the upper grey member. Lobdell (1983) considers the upper grey member to be a subaqueous carbonate sequence composed of dark-gray to grayish-black, micro-crystalline dolostones. The salt is clear and nodular, with large (up to 1 inch) euhedral crystals (fig. 7). It was cored in the Amerada Petroleum Corporation #1 Dilland, 11,585 feet (NDGS #35: sec 31, T156N, R95W, Williams County). Because the cored interval was not logged, exact submember correlation is not possible.

Souris River Formation

The Davidson Evaporite[3] (Baillie, 1953) of the Souris River Formation (fig. 8: cross section C-C') is present over a large portion of Saskatchewan and was shown to extend into North Dakota (Lane, 1964). Lane (1964) observed that the maximum thickness of Davidson Evaporite encountered in Canada exceeds 200 feet in the Duval Sulphur and Potash #1 Viscount (12-24-34-27W2, Saskatchewan). In North Dakota the salt is depositionally restricted to the northwestern part of the state (fig. 9). A maximum thickness of 8 feet of Davidson salt (fig. 10) has been recorded to date in the study area in both the Conoco #20-1 Moore (NDGS #9528: sec 20, T163N, R102W, Divide County) and the Louisiana Land and Exploration #22-3 Dahl (NDGS #9588: sec 3, T162N, R100W, Divide County).

In cuttings, the Davidson salt is clear to amber, probably massive and crystalline, and is laterally continuous with a thin anhydrite in the study area. The salt is overlain by a ferruginous, noncalcareous claystone and underlain by a light-gray, slightly argillaceous, dolomitic limestone (fig. 11).

Duperow Formation

Dunn (1975), while working in southern Saskatchewan, formally named a salt present in what he proposed to be unit 3 of the Devonian Duperow Formation. He referred to this salt as the Flat Lake Evaporite (figs. 8 and 12). The Flat Lake Evaporite extends southward into the United States (fig. 13). Within the study area, two lobes of salt seem to be present; these lobes represent the southern depositional limit of the salt. One lobe lies in the north-central portion of the study area, the other in the very northwest corner, probably extending a short distance into Montana.

In southern Saskatchewan, the Flat Lake Evaporite attains a maximum reported thickness of over 100 feet in

[3]"Flat Lake Evaporite" and "Davidson Evaporite" are Canadian terms equivalent to United States terminology "Flat Lake Salt" and "Davidson salt."

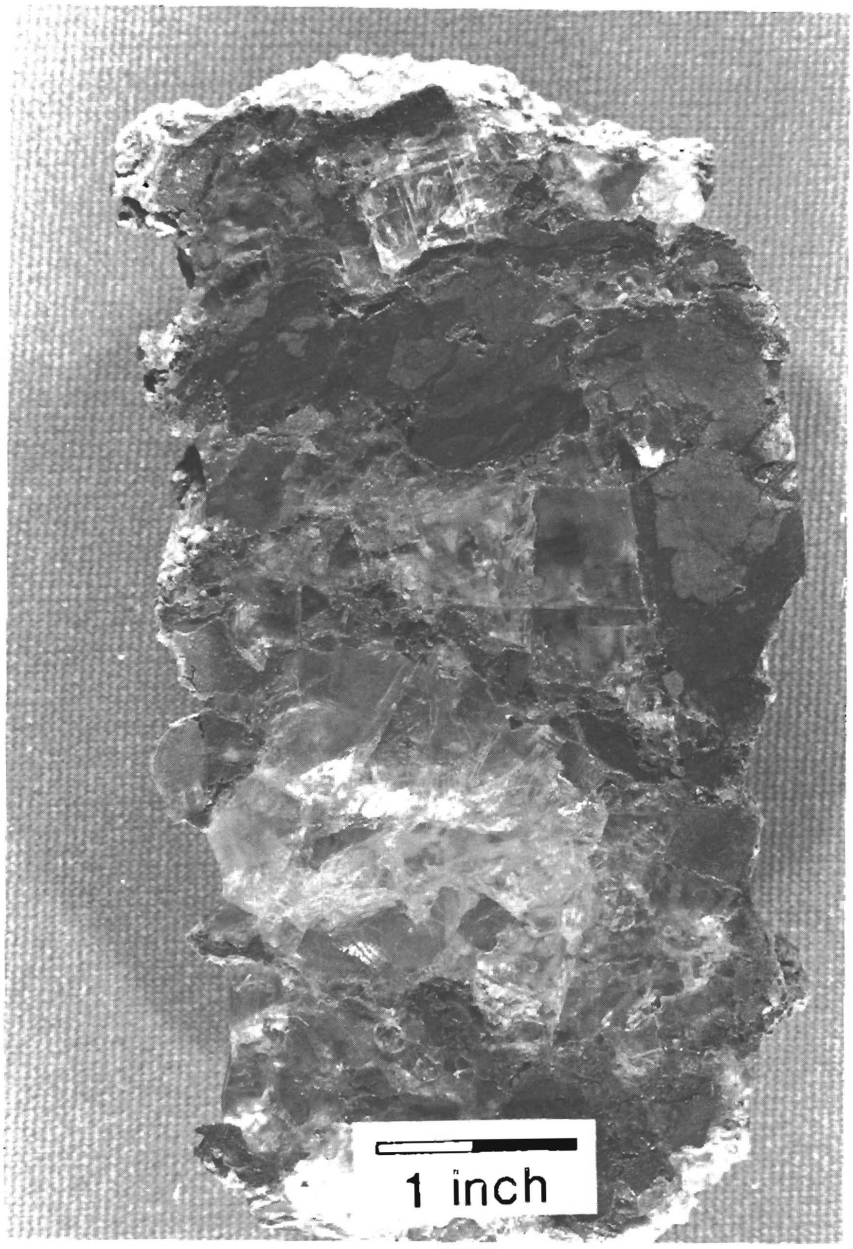

Figure 7. Ashern Salt.

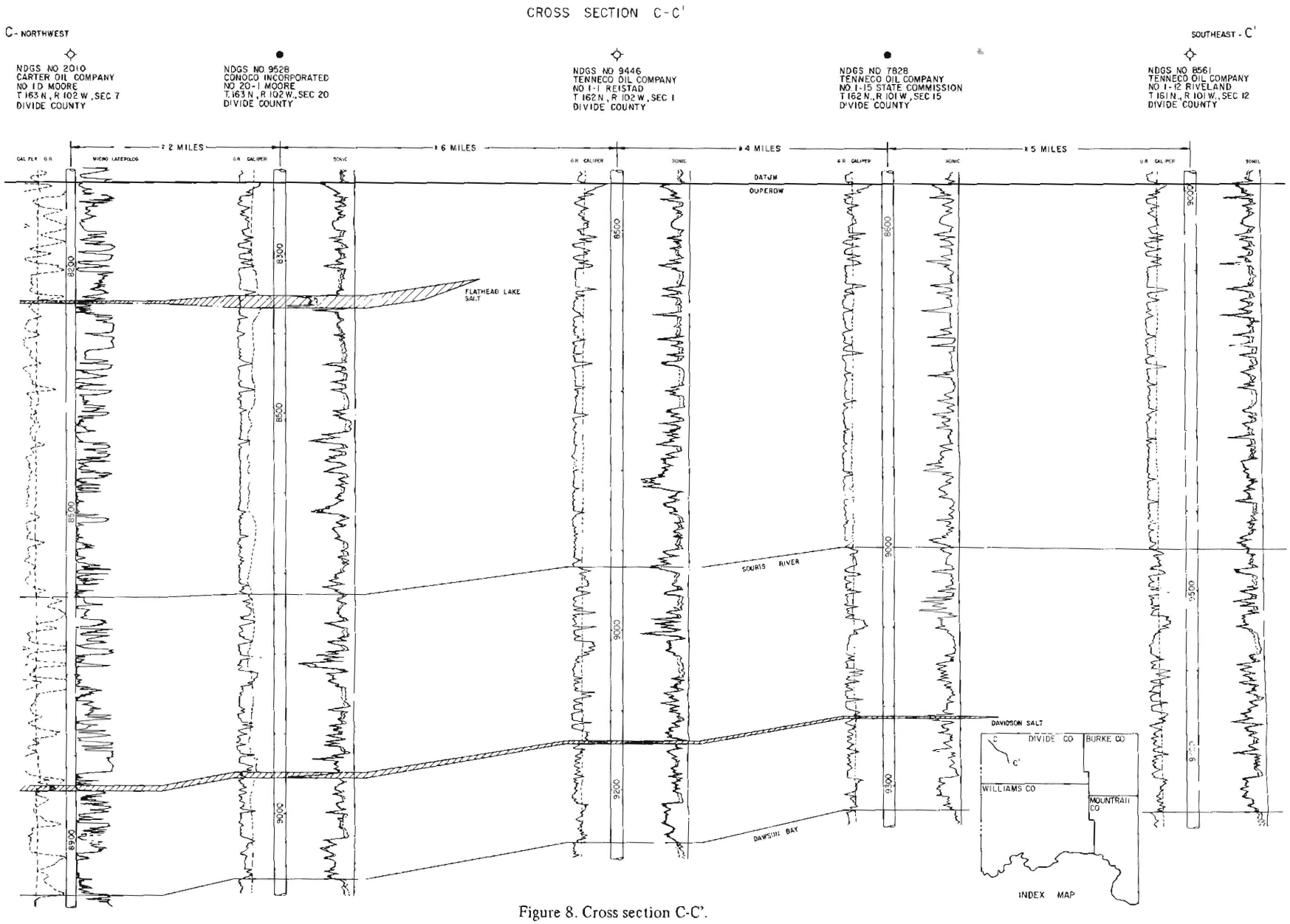

Figure 8. Cross section C-C'.

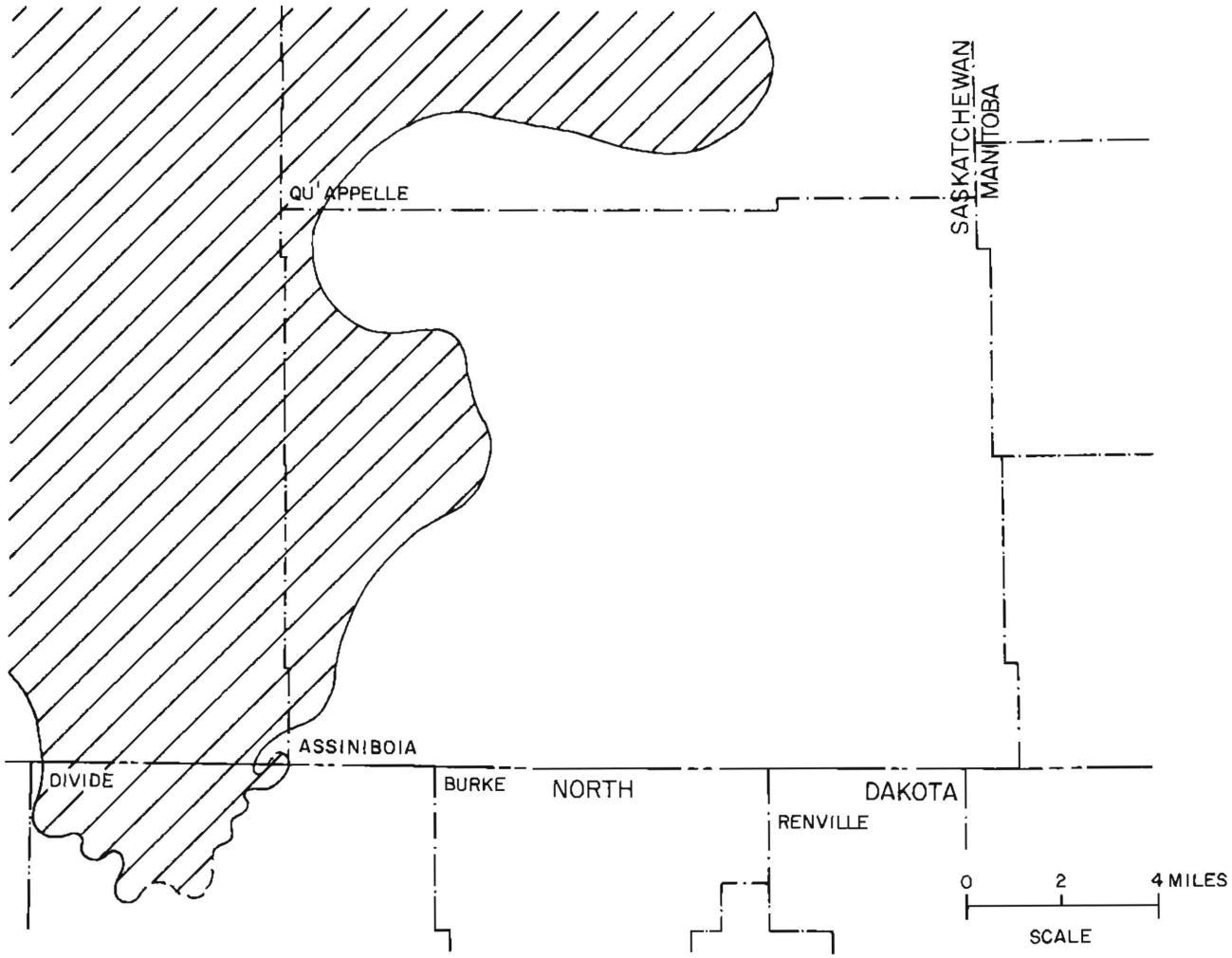

Figure 9. Aerial distribution of Davidson Salt in southern Saskatchewan and North Dakota shown by lined area.

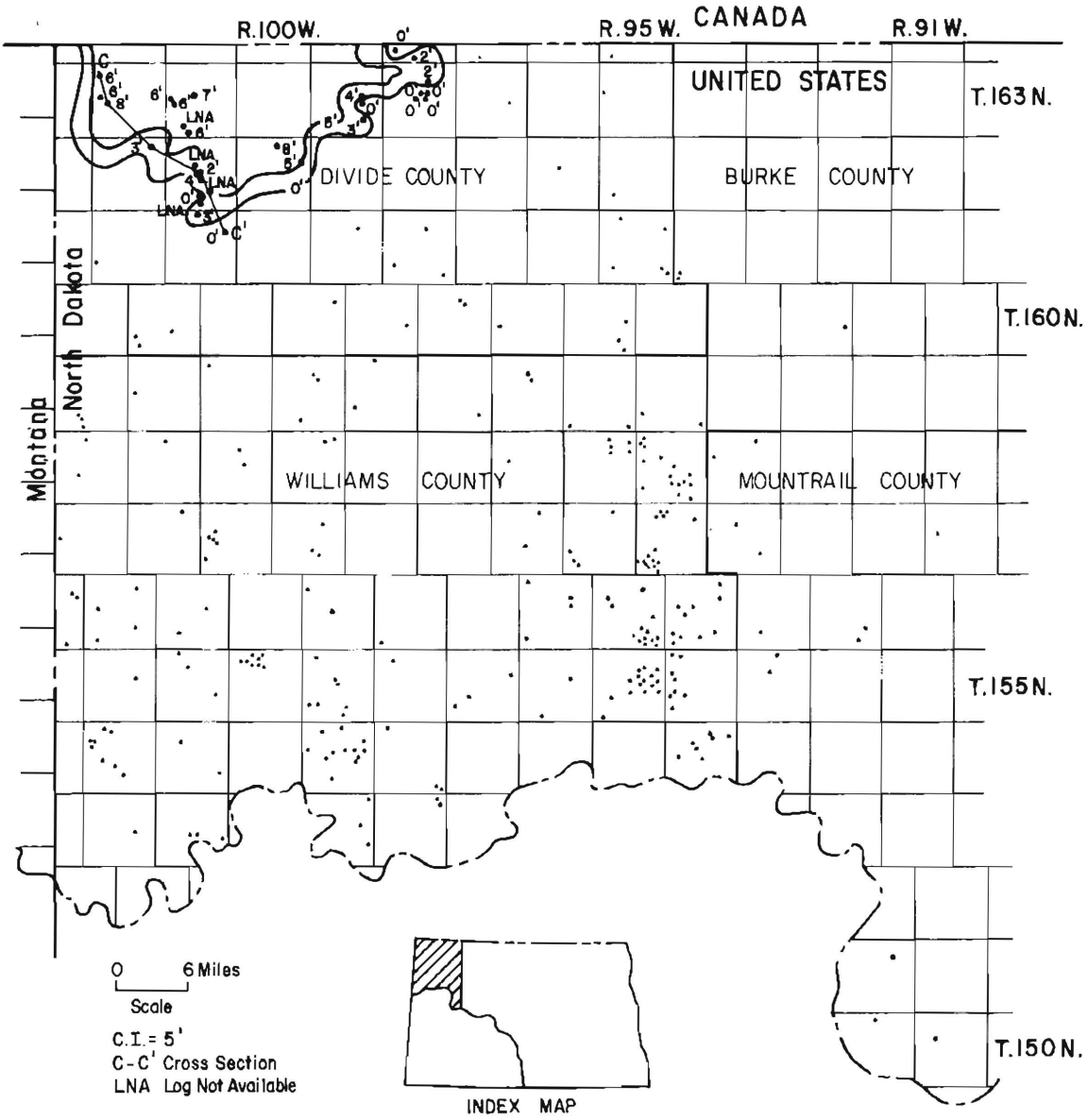

Figure 10. Isopach: Davidson Salt, Souris River Formation, northwest North Dakota.

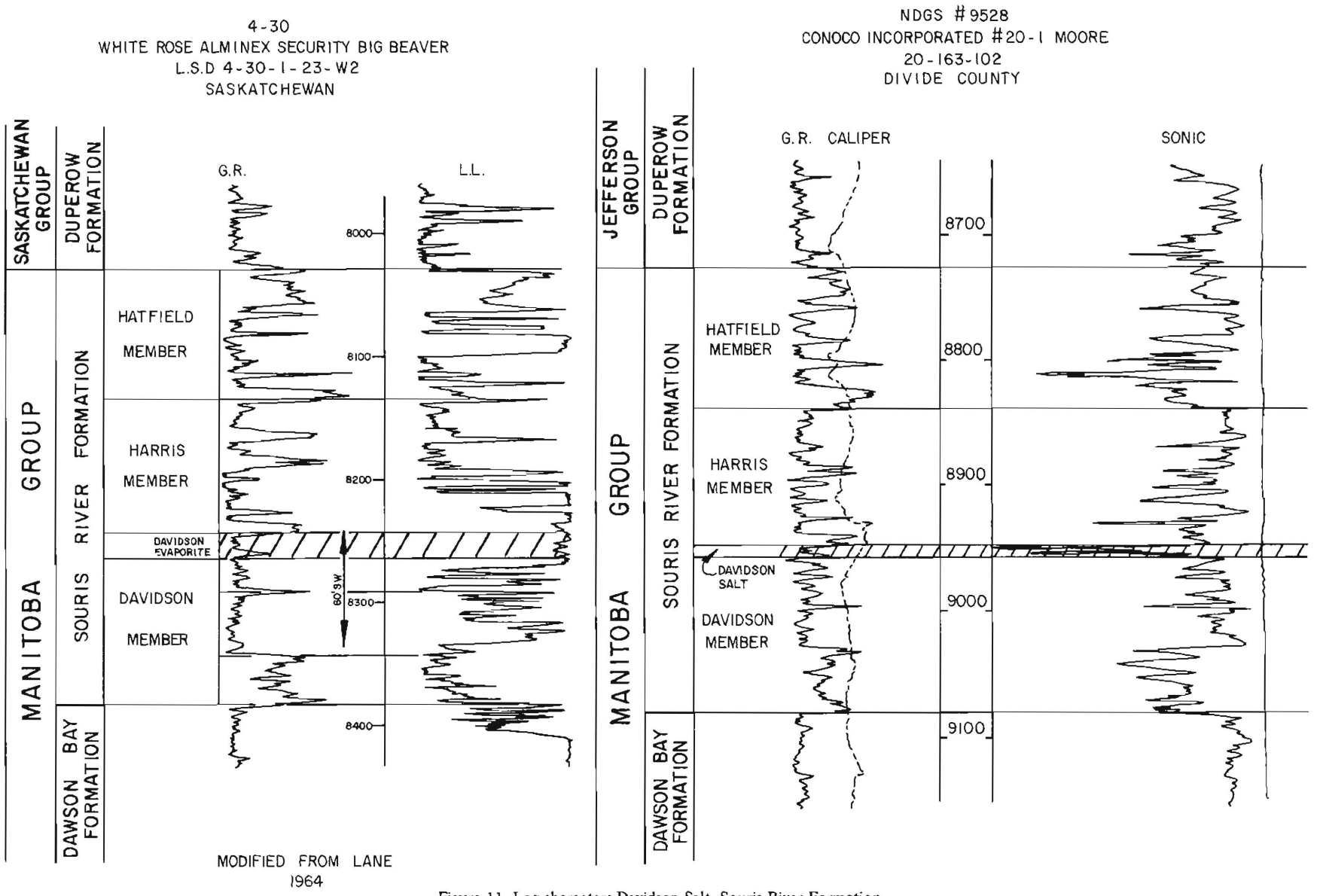

Figure 11. Log character: Davidson Salt, Souris River Formation.

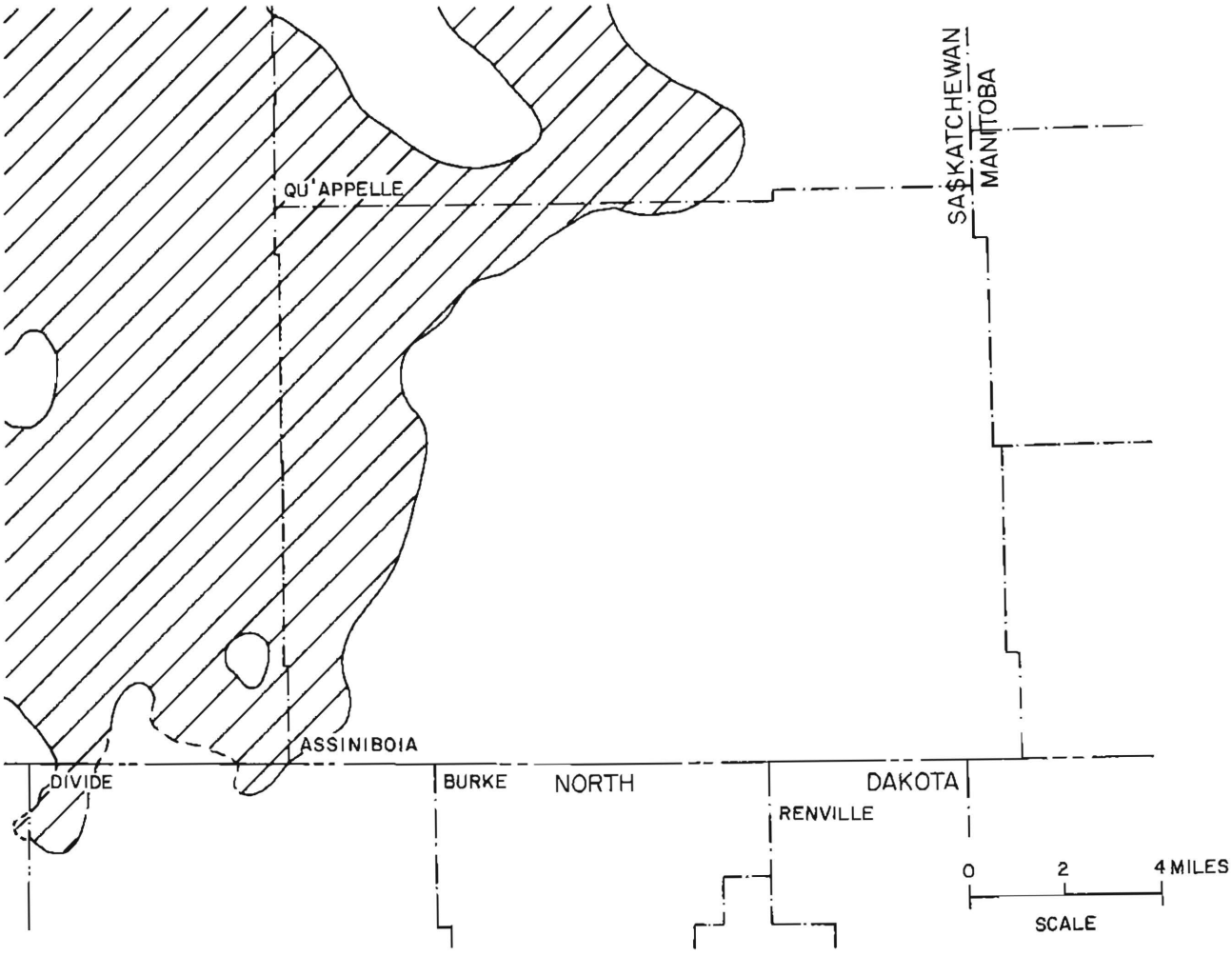

Figure 12. Aerial distribution of Flat Lake Salt in southern Saskatchewan and North Dakota (modified from Dunn, 1975).

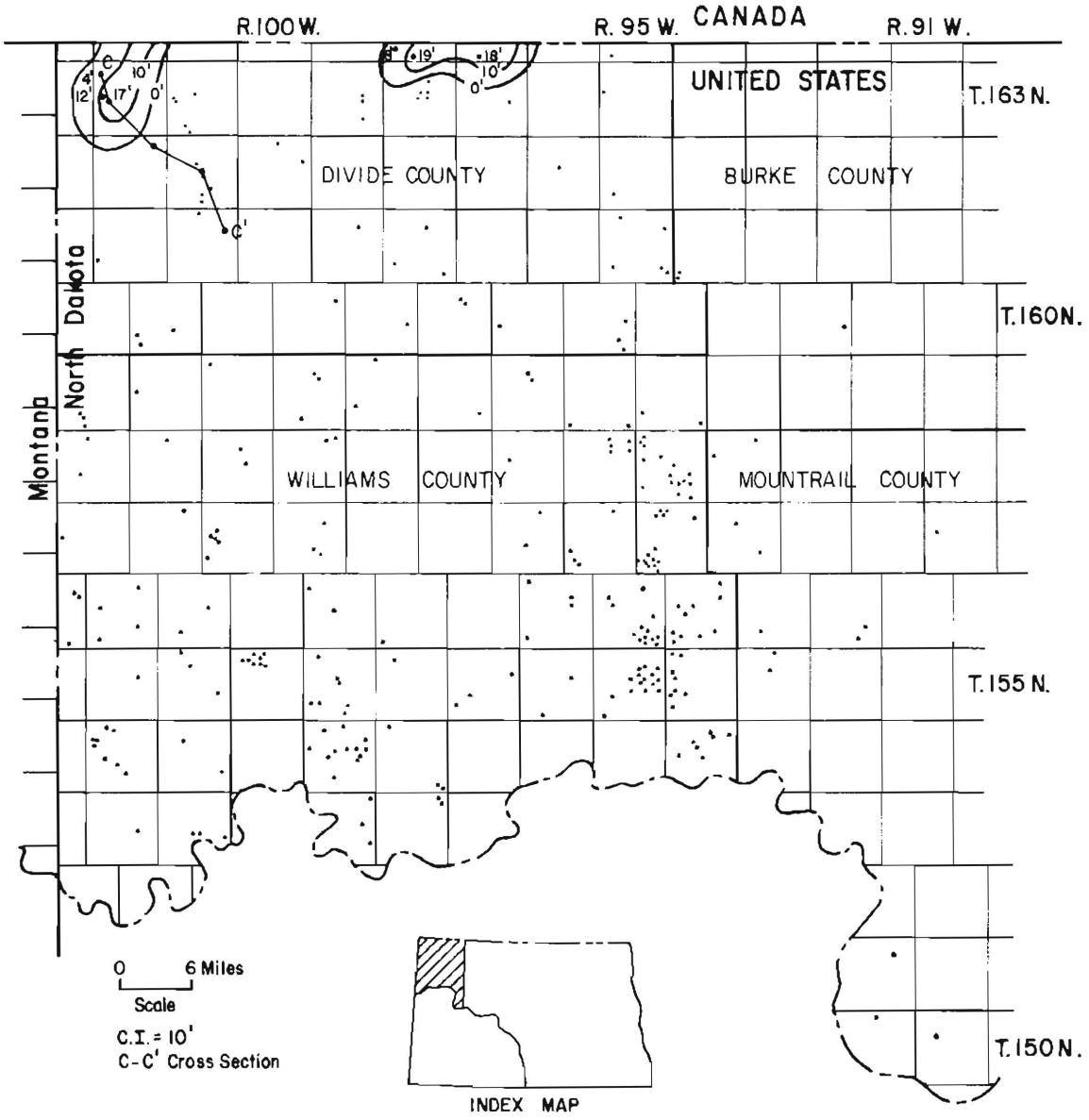

Figure 13. Isopach: Flat Lake Salt, Duperow Formation, northwest North Dakota.

the Richfield Husky #14-11 Normandin (14-11-14-16 W2) (Dunn, 1975). Within the study area the salt is known to attain a thickness of 19 feet (fig. 14) in the Texaco #1 Hanson (NDGS #5992: sec 33, T164N, R98W, Divide County).

In cuttings, the Flat Lake Salt is clear, and probably massive and crystalline in nature. It grades laterally into an anhydrite along its southern edge. The salt is overlain by a medium- to dark-gray calcareous to dolomitic claystone and underlain by a light- to medium-gray dolostone.

DISCUSSION

The repeated occurrences of salt in the mid-Paleozoic carbonate section of the Williston Basin are not surprising. In fact, the existence of such salt units fits well into current geological models for the development of the basin. Documentation of these salts may help to explain certain production problems associated with the Interlake Formation as well as some anomalous drilling breaks with no associated shows of hydrocarbons. These salts would have little effect on seismic travel times, but they may possibly be seen as a character change on seismic lines.

As previously mentioned, bedded Interlake salts are associated with what has been interpreted to be a paleosol sequence. It is suggested that these salts are eogenetic, forming in what LoBue (1983) describes as supralittoral ponds found on islands in the Interlake sea. Dissolution of the salt may be partly responsible for halite cement LoBue found occluding secondary porosity in the paleosol sequence. Brines, enriched by the dissolution of the salt, may be partially responsible for salt plugging and associated production problems in the formation.

Salts occurring in the Ashern Formation require a more comprehensive study to be fully understood. The aerially discontinuous nature of the Ashern salts, as well as the apparent lack of a laterally equivalent anhydrite facies, is uncommon for evaporitic cycles in the study area, but it can be explained in a number of ways. Deposition of the evaporitic interval may have occurred under anaerobic conditions where bacterial reduction of precipitated sulfides formed micrite as brines collected in basinal lows. Another model would include the partial dissolution of an aerially larger body of salt by more normal sea waters. Such a dissolution episode might not only explain the isolated nature of the salt bodies, but might better explain the large amount of salt-occluded porosity in the Interlake Formation.

Salts occurring in the Duperow and Souris River Formations are the result of the restriction of an Elk Point sub-basin (Lane, 1964). The salts, as mapped in North Dakota, represent only the southern depositional margins of these sub-basins. Exploration along the sub-basinal margin has recently met with some success, and should be considered in future exploration attempts.

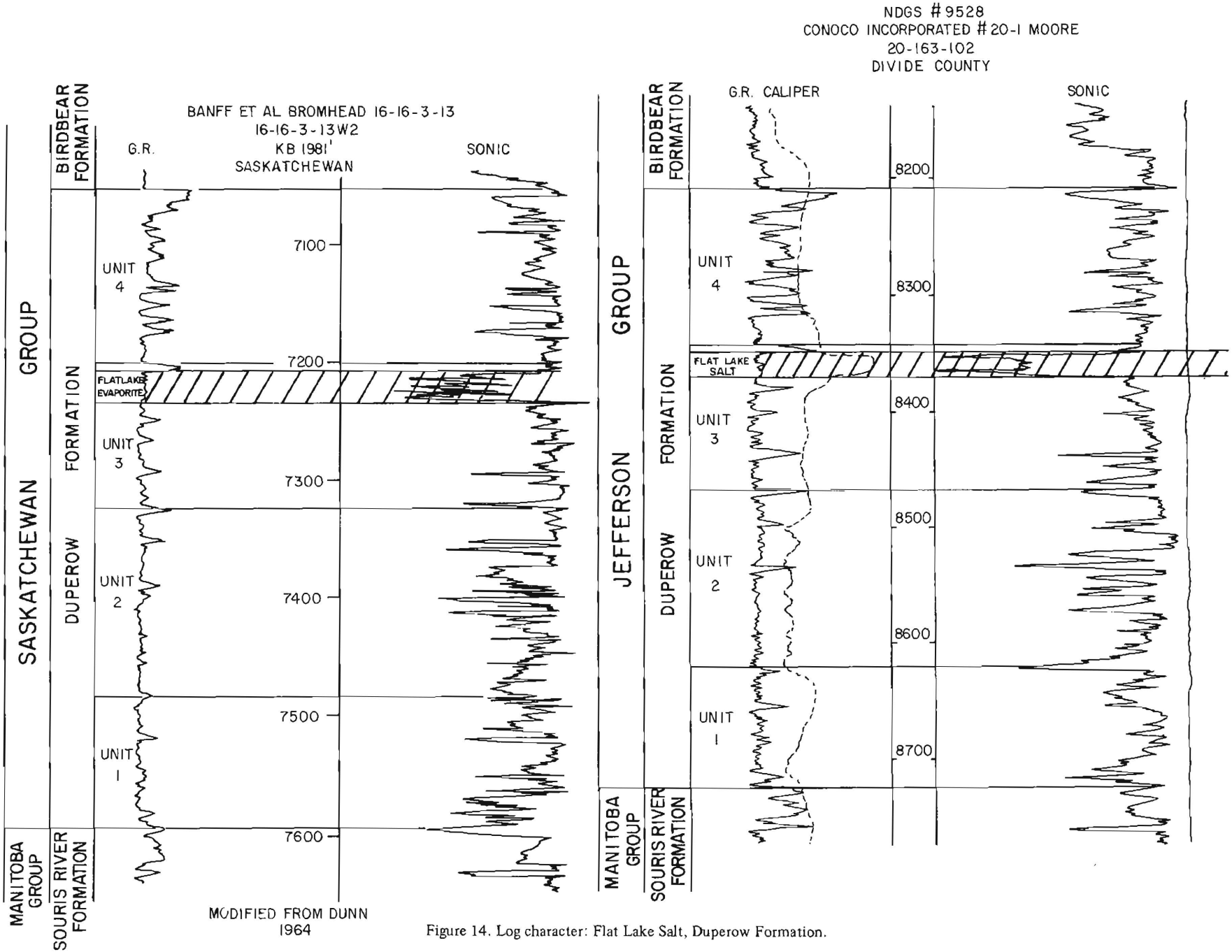

Figure 14. Log character: Flat Lake Salt, Duperow Formation.

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PLATE I. PENETRATION MAP OF NORTHWEST NORTH DAKOTA

CANADA

103 102 101 100 99 98 97 96 95 94 93 92 91

163 162 161 160 159 158 157 156 155 154 153

NORTH DAKOTA

MONTANA

DIVIDE COUNTY

WILLIAMS COUNTY

BURKE COUNTY

MOUNTRAIL COUNTY

LNA

NSL

SNL

152 151 150

LEGEND

- DUPEROW TEST
- RED RIVER TEST
- BASEMENT TEST
- SOURIS RIVER TEST
- WINNIPEGOSIS TEST
- LOWER INTERLAKE TEST
- ASHERN TEST
- UPPER INTERLAKE TEST
- MIDDLE INTERLAKE TEST

NSL NO SALT LOG

SNL SECTION NOT LOGGED

LNA LOG NOT AVAILABLE

0 2 4 MILES

SCALE

INDEX MAP