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Structural Evolution of the Beaver Lodge Portion of the Nesson Anticline, North Dakota

Mark B. Friestad

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STRUCTURAL EVOLUTION
OF THE BEAVER LODGE PORTION
OF THE NESSON ANTICLINE, NORTH DAKOTA

by Mark B. Friestad

a thesis

Submitted to the Geology Department

of the

University of North Dakota

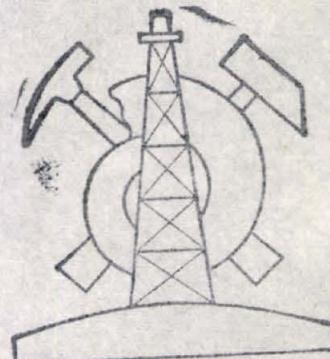
in partial fulfillment of the requirements

for the degree of

Bachelor of Science in Geology

Grand Forks, North Dakota

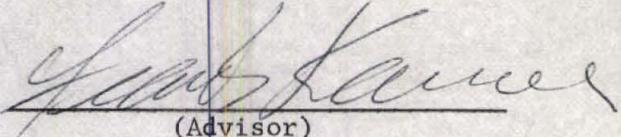
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whom the work has been done.


(Advisor)

ABSTRACT

The structural development in the area of Beaver Lodge Field, Williams County, North Dakota, has been determined from Cambrian (Deadwood) through Late Cretaceous (Greenhorn) time. Detailed structural data defines two areas of structural closure occurring along a basement structural trend. One of these is the site of a Precambrian topographic high. Detailed isopachous data indicates that this high was the site of structural activity during deposition of many of the units studied. Significant growth occurred during Cambrian, Ordovician, Silurian, Early Devonian, Pennsylvanian, Permian, and Jurassic times.

A possibility for petroleum accumulation exists along the flanks of the Precambrian high, where a productive sand zone in the Deadwood Formation is absent over the high.

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STRUCTURAL EVOLUTION
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INTRODUCTION

General

The purpose of this study is to determine the structural development of the Beaver Lodge portion of the Nesson Anticline in western North Dakota from Cambrian (Deadwood) through Late Cretaceous (Greenhorn) time. Thinning of sediments over the Beaver Lodge structure was the basis for determining periods of structural activity. Isopachous maps of the formations, groups, and systems were constructed at the bases of all the Paleozoic and Mesozoic sequences and at the top of the Greenhorn Formation.

Previous work

The structural activity in the area of Beaver Lodge Field has been noted in numerous stratigraphic studies that pertain to western North Dakota; however, no previous isopachous maps have been constructed on a scale detailed enough to show thinning of the various intervals.

A Beaver Lodge structure map constructed on the top of the Interlake Formation was published by Carlson and Eastwood (1962). Structure maps constructed on the tops of the Madison, Devonian, and Silurian Beaver Lodge pools were published by Carlson (1969). Thinning of the Winnipeg and Deadwood formations over the Beaver Lodge structure was noted by Carlson (1960); thinning of the Red River Formation over the Beaver Lodge structure was noted by Friestad (1969); and inactivity of the Beaver Lodge structure during Spearfish time was noted by Dow (1967).

Acknowledgements

The writer wishes to express his appreciation to A. Kirth Erickson for suggesting a problem involving structural development; to Sidney B. Anderson of the North Dakota Geological Survey for advising the area of study and making many helpful suggestions; to Drs. Walter L. Moore and Frank R. Karner of the University of North Dakota geology department staff for their helpful suggestions and criticisms; and to Dr. Edwin A. Noble, State Geologist of North Dakota, for use of the facilities of the North Dakota Geological Survey.

METHOD OF STUDY

The study was conducted at the University of North Dakota, with North Dakota Geological Survey well data and mechanical logs constantly at hand. The study was limited to Greenhorn and lower horizons, because mechanical logs were not usually run above the Greenhorn Formation. Interval tops were on file for the Precambrian, Deadwood, Winnipeg, Red River, Stony Mountain, Interlake, Winnipegosis, Prairie, Dawson Bay, Souris River, Duperow, Birdbear, Three Forks, Bakken, Madison, Kibbey Limestone, Triassic, Jurassic, Dakota, and Greenhorn units. The writer used most of these tops after checking them with mechanical logs. Tops which had not been picked, and thus had to be determined from mechanical logs by the writer, were the Kibbey Sandstone, Otter, Pennsylvanian, and Permian.

The study area is located in Townships 155 and 156 North, Ranges 95 and 96 West, in the eastern part of Williams County, North Dakota (Figure 1). In all there were 285 control wells used in the study area. Their locations are plotted on Plate 1. An appendix (p. 19) lists each

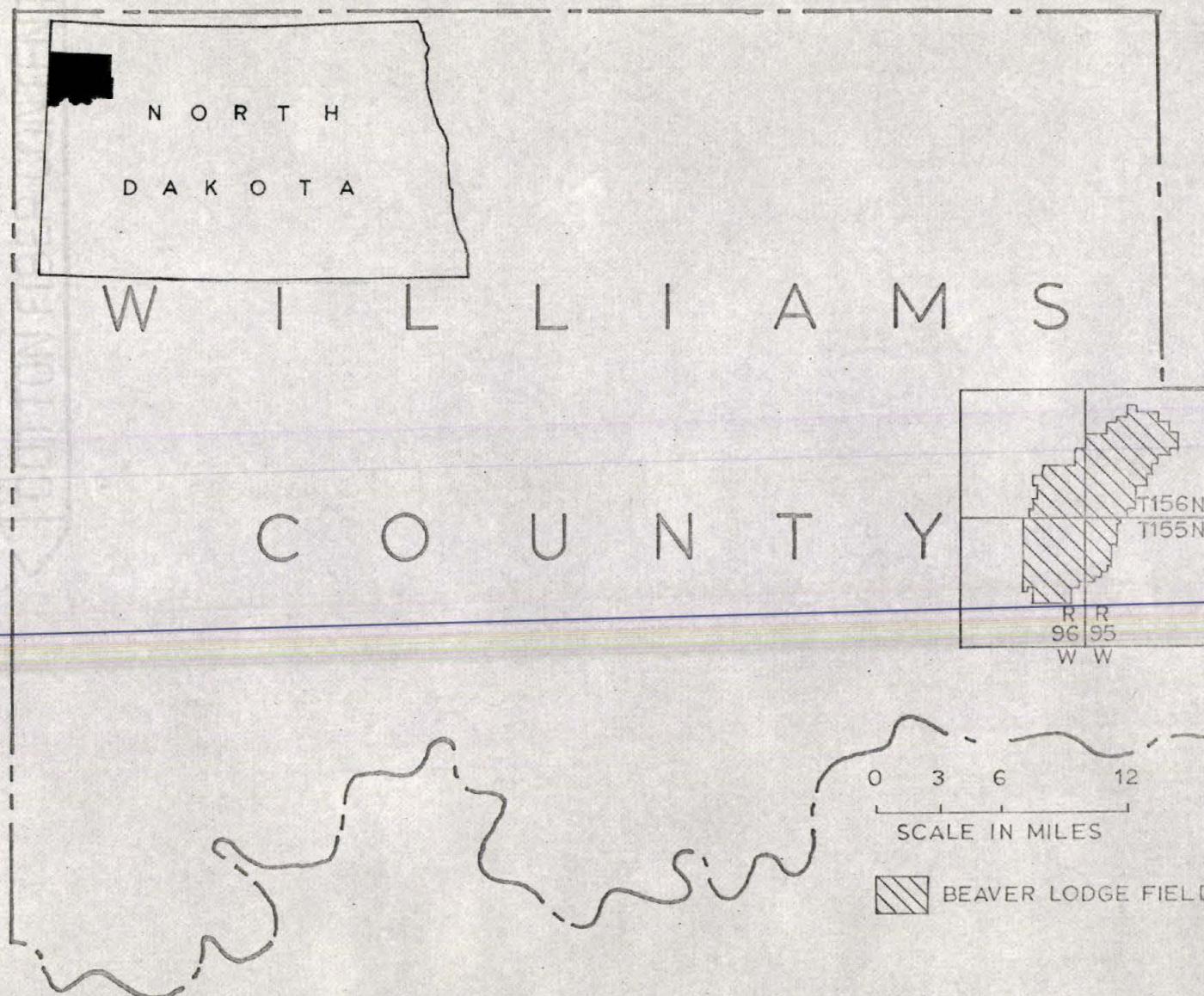


Figure 1 -- Map of Williams County, North Dakota, showing location of Beaver Lodge Field.

of the control wells according to North Dakota Geological Survey well number. Location, Kelly Bushing elevation (K. B.), and depths to tops of units are included. The appendix contains all the raw data used in constructing the isopachous and structure maps (Plates 2 - 30) and the cross sections (Figures 2, 3, and 4).

GENERAL STRUCTURAL SETTING

A record of Phanerozoic activity through Greenhorn time is summarized from Eardley (1962): The study area lies within the Algoman and Penokean Precambrian orogenic belts. In Cambrian time the Trans-continental Arch, a northeast-trending structure in eastern South Dakota and Minnesota, began rising, and remained active until Pennsylvanian time. The Williston Basin formed in Ordovician time, and the closely-allied Alberta Basin formed in Devonian time. The Ancestral Sweetgrass Arch located near the Montana-Alberta-Saskatchewan borders was active in Cambrian, Ordovician, Mississippian, Triassic, and Jurassic times. The Cambridge Arch of west-central Nebraska, western South Dakota, and southeastern Montana formed in Early Pennsylvanian time. The Sheridan Arch in southern Montana formed in Middle Jurassic time and remained active through late Jurassic time. The Belt Island Arch of western Montana was active in early Jurassic time. The Cordilleran Geanticline along the Montana-Idaho border became extensive in Jurassic time and was very active in early Cretaceous time.

The Cedar Creek Anticline, in the southwestern part of the Williston Basin, near the North Dakota-South Dakota-Montana borders, began to rise in Middle Devonian time and continued to grow in Late Devonian time (Sandberg and Hammond, 1958). Renewed uplift took place near the

end of Bakken deposition (Kume, 1963).

Ballard (1963) graphed the structural activity of four eastern North Dakota highs from Deadwood through Madison time, and found all of them to be active during deposition of the Winnipeg, Red River, Stony Mountain, Stonewall, and Duperow units. None of the highs were active during Three Forks and Bakken time. Two of the highs, the Stutsman and Foster highs, showed much thinning of Deadwood sediments, and did not migrate. The Burleigh and Cavalier highs did not show Deadwood thinning, and tended to migrate over large areas.

The Beaver Lodge structure, trending northeast-southwest, is a part of the southward-plunging Nesson Anticline complex. It is located near the center of the Williston Basin, and was the site of the first oil field discovered in the state with the Amerada-Iverson No. 1 discovery well (N. D. G. S. Well No. 25, Plate 1). The first well in Beaver Lodge Field drilled to the Precambrian (N. D. G. S. Well No. 1231, Plate 1) was drilled on a seismic high which turned out to be the site of a Precambrian topographic high or knob. This knob has by far the most relief of any Precambrian high yet discovered in the basin, and has been a center of structural growth throughout much of the Phanerozoic, as is evidenced by thinning of sediments over it.

STRUCTURAL HISTORY OF BEAVER LODGE AREA

Five wells penetrate the Precambrian in Beaver Lodge Field. N. D. G. S. Wells Nos. 1385 and 1231 define a Precambrian surface with 1151 feet of relief. The contour map on top of basement rocks (Plate 2) shows the Precambrian knob to be centered in NE $\frac{1}{4}$, Sec. 2, T. 155 N., R. 96 W. Due to lack of well control, the Precambrian surface map was

constructed with reference to the contour of the Interlake surface, which is penetrated by 38 wells (Plate 9). Basement closure is also present in the northeast portion of Beaver Lodge Field, centered in NE $\frac{1}{4}$, Sec. 19, T. 156 N., R. 95 W. Both areas of closure appear to occur along the same basement structural trend. Cross sections A - A', B - B', and C - C' (Figures 2, 3, and 4) show that the Precambrian knob is elongated in a northeast-southwest direction along this trend. The axis of Beaver Lodge Field also lies along this trend.

Deadwood sediments in the study area vary in thickness from 50 feet in N. D. G. S. Well No. 1231 on the Precambrian knob to 683 feet in N. D. G. S. Well No. 1385 (Plate 3). Mechanical logs from N. D. G. S. Well No. 1385 were compared with logs from the Precambrian wells in the southwestern part of Beaver Lodge Field. Individual beds within the Deadwood Formation were correlated and found to thin slightly over the Precambrian knob. Only the uppermost beds were present in wells directly adjacent to the knob. However, the lower Deadwood beds are present in N. D. G. S. Well No. 1385, about five miles northeast of the knob; therefore these beds presumably occur lower along the flanks of the knob. This indicates that most of the relief of the knob was present before deposition of the Deadwood Formation. The thinning of the upper Deadwood beds that are present over the high indicate structural activity during Deadwood time. (Though thinning of sediments can occur across an anticlinal axis by way of differential compaction, this process probably did not account for the thinning over the Beaver Lodge high, because the rocks are for the most part poorly compressible carbonates and sandstones. Such thinning presumably is due to structural uplift with respect to the basin.)

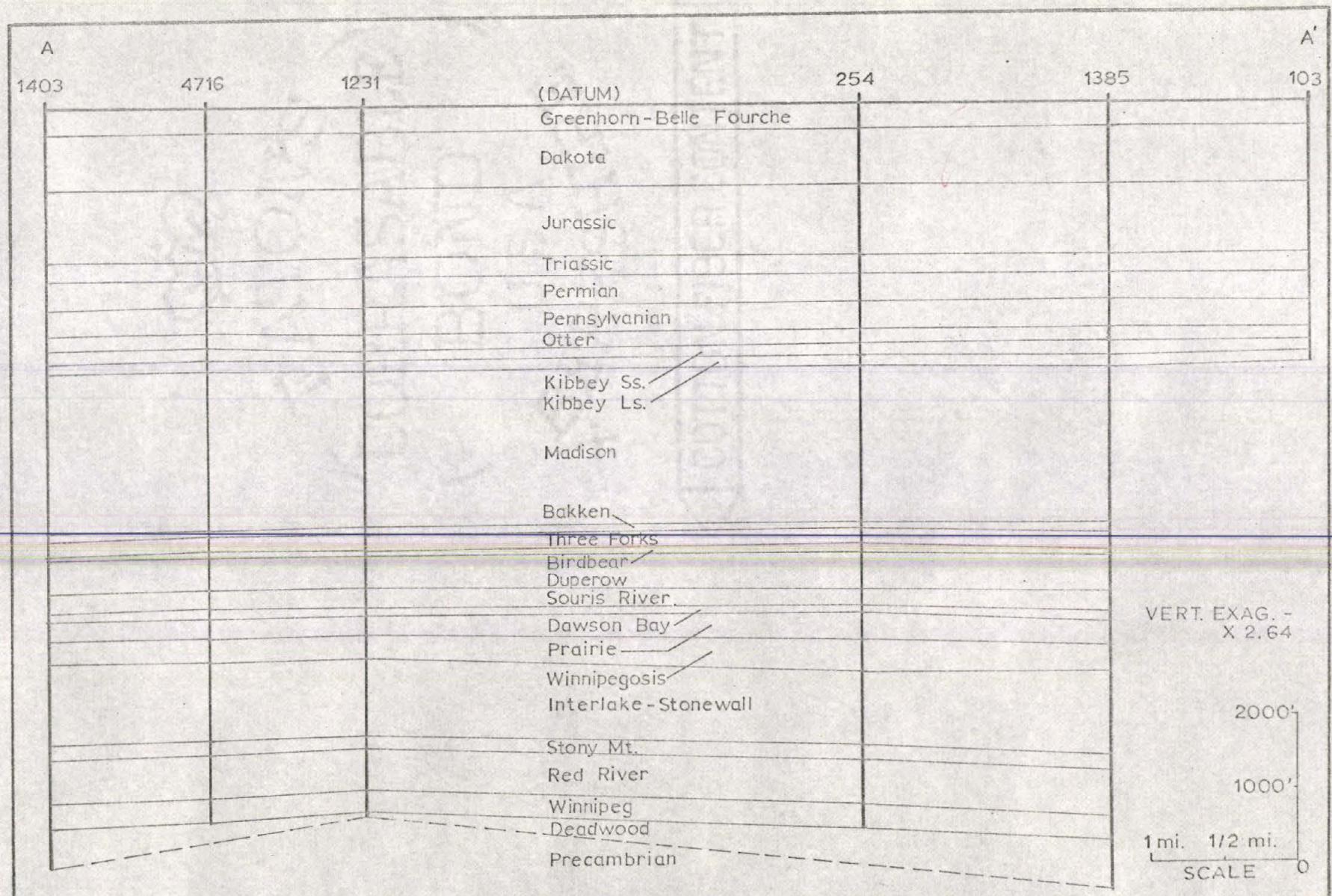


Figure 2 -- Structural Cross Section A - A'. (Location on Plate 1)

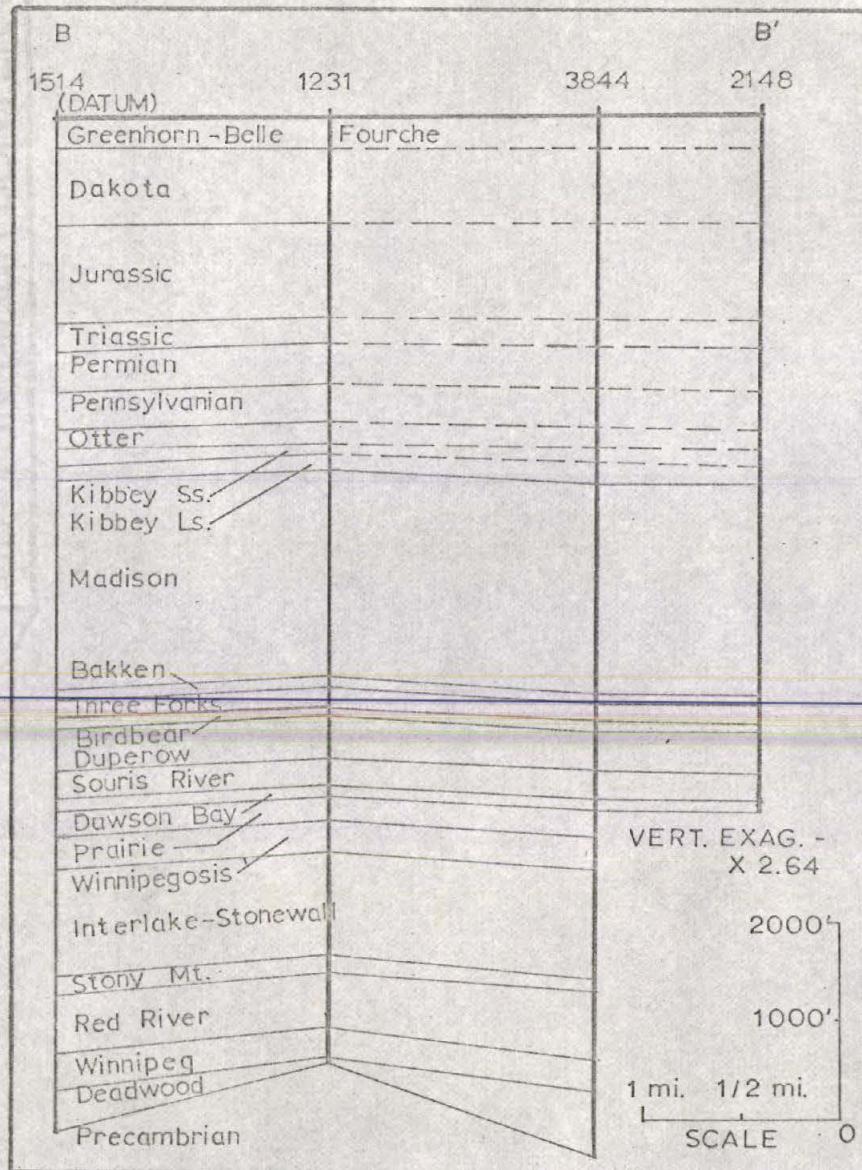


Figure 3 -- Structural Cross Section B - B'

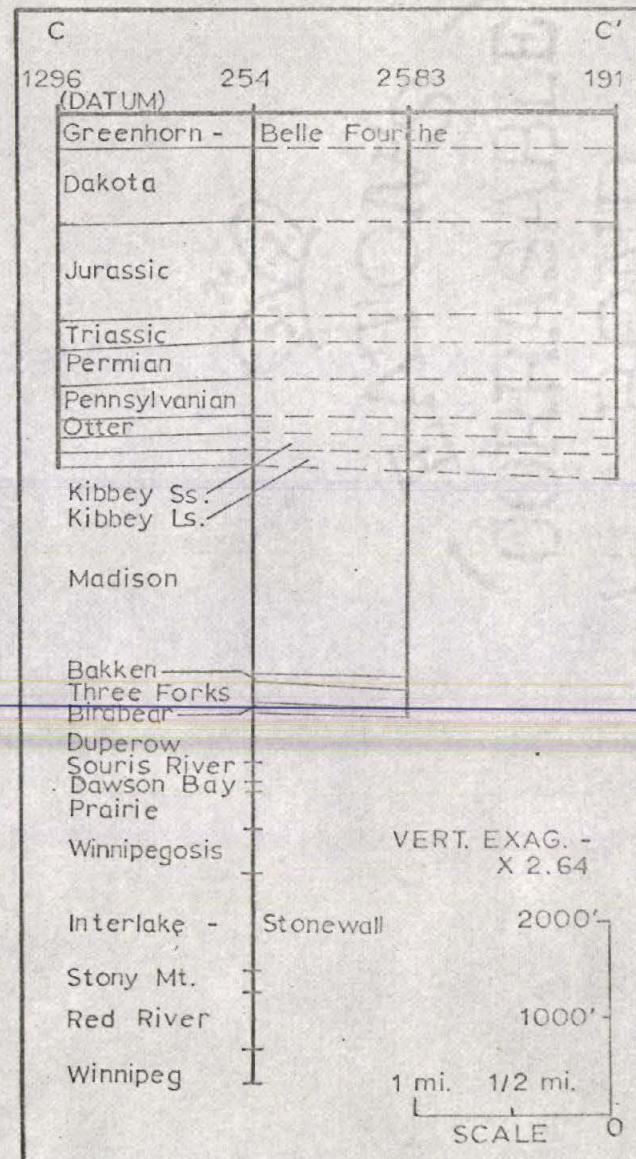


Figure 4 -- Structural Cross Section C - C'

The top of the Deadwood Formation is penetrated by six wells in Beaver Lodge Field. The Deadwood structure map (Plate 4) shows the structural high of the Deadwood surface to coincide with the Precambrian knob. Again there is closure in both the northeast portion and the southwest portion of the field, but in both areas it is much less than closure on the Precambrian surface.

The Winnipeg Group isopachous map (Plate 5) shows thinning of sediments occurring over the Precambrian knob and in the northeast portion of the field. Sediment thickness varies from 289 feet in N. D. G. S. Well No. 1231 to 368 feet in N. D. G. S. Well No. 1514. Sediment in the northeast area of the field is much thinner than that in N. D. G. S. Wells Nos. 1514 and 3844, and it is interpreted that the northeast area of the field rose during Winnipeg time. The centers of thinning in the northeast and the southwest areas of the field appear to occur along the basement structural trend mentioned earlier.

The Red River Formation (Plate 6) thins over the Precambrian knob. Sediment thickness varies from 575 feet in N. D. G. S. Well No. 1231 to 651 feet in N. D. G. S. Well No. 1385, indicating significant structural activity in the area of the knob during Red River time.

The Stony Mountain Formation (Plate 7) thins slightly over the Precambrian knob. Sediment thickness varies from 189 feet in N. D. G. S. Well No. 1231 to 200 feet in N. D. G. S. Well No. 1403, indicating structural growth in the area of the knob during Stony Mountain time.

The Interlake-Stonewall isopachous map (Plate 8) indicates structural growth in the area of the knob during deposition of that interval. Sediment thickness varies from 1037 feet in N. D. G. S. Well No. 1231 to 1156 feet in N. D. G. S. Well No. 1385.

Thirty eight wells penetrate the top of the Interlake Formation in Beaver Lodge Field. The Interlake structure map (Plate 9) shows the structural highs of the Interlake surface to coincide with the structural highs of the Deadwood surface. As a result of the structural activity that occurred during deposition of the Tippecanoe Sequence, there is much less closure on the Interlake surface than on the Deadwood surface.

The Winnipegosis Formation (Plate 10) thins in the area of the Precambrian knob and in the northeast area of the field. Sediment thickness varies from 296 feet in N. D. G. S. Well No. 2371, a short distance southwest of the Precambrian knob, to 358 feet in N. D. G. S. Well No. 2092, in the northeast area of the field.

The Prairie Formation (Plate 11) thins in the area of the Precambrian knob, and also thins southwestward regionally (Carlson and Anderson, 1966). Slight structural activity in the area of the knob is interpreted to have occurred during Prairie time.

All Devonian sediments deposited above the Prairie Formation (ie., the Dawson Bay, Souris River, Duperow, Birdbear, and Three Forks formations) thin southward regionally (Carlson and Anderson, 1966). Isopachous maps of these formations (Plates 12 - 16) indicate little or no evidence of structural activity during their deposition.

The Bakken Formation thins southward regionally (Carlson and Anderson, 1966), but thickens slightly in the area of the Precambrian high (Plate 17). The Madison Group (Plate 18) thins over the high in precisely the same place the Bakken Formation thickens. It is interpreted that the Bakken surface was slightly irregular before deposition of the Madison Group, and that neither the thickening of Bakken sediments

nor the thinning of Madison sediments is related to structural activity.

Well control increases sharply for Madison and younger sediments. The top of the Madison is penetrated by 257 wells in Beaver Lodge Field, an average of slightly more than seven wells per square mile. The Big Snowy Group (ie., Kibbey Limestone, Kibbey Sandstone, and Otter Formation) isopachous maps (Plates 19, 20, and 21) have numerous areas of thickening and thinning, but none are interpreted to have any relationship to structural activity.

The contour map on top of the Otter Formation (Plate 22) does not differ significantly from the contour map on top of the Interlake Formation (Plate 9). The major difference is that the northeast structure is 150 feet lower than the southwest structure on the Interlake surface, whereas the two structures are at the same elevation on the Otter surface. This results from the fact that most of the beds of the Kaskaskia Sequence thin southward regionally.

The Pennsylvanian and Permian systems thicken southward regionally (Carlson and Anderson, 1966), but thin considerably in the area of the Precambrian knob (Plates 23 and 24), indicating significant structural activity during the Pennsylvanian and Permian periods.

The Triassic System thickens southward regionally (Carlson and Anderson, 1966), and thins slightly in numerous places in Beaver Lodge Field (Plate 25). The areas of thinning do not appear to be related to structural activity.

The contour map of the top of the Spearfish Formation (Plate 26) differs significantly from the contour map of the top of the Otter Formation (Plate 22). Only one area of closure exists on the Spearfish surface, whereas two areas of closure exist on the Otter surface.

Regional thinning of the Absaroka Sequence northward results in disappearance of the northeast area of closure that is present below the sequence. The structural high on the Spearfish surface is about a mile and a half southeast of the Precambrian high. All deeper structure maps show structural highs directly above the Precambrian knob.

The Jurassic System (Plate 27) thins appreciably over the axis of the Beaver Lodge structure. The thinning is interpreted to be related to structural activity, because it occurs approximately along the northeast-southwest basement structural trend mentioned earlier.

The Dakota Group and Greenhorn-Belle Fourche isopachous maps (Plates 28 and 29) have numerous small thick and thin areas, but appear unrelated to structural activity.

The structure contour map drawn on the Greenhorn Formation (Plate 30) is almost identical with that on the Spearfish Formation (Plate 26).

A chart comparing thickness of sediment in N. D. G. S. Well No. 1231 to the average thickness of sediment in N. D. G. S. Wells Nos. 1514 and 3844 (Figure 5) was compiled to show structural activity of the high during deposition of the various intervals studied. Total net thinning over the high from Precambrian to Greenhorn time was $838\frac{1}{2}$ feet. A bar graph showing structural relief (Figure 6) was constructed from the chart, as was a bar graph comparing the structural relief of each unit to its average thickness (Figure 7). These graphs summarize the structural activity of the high quite well, but with two reservations. One is that the amount of Deadwood "structural relief" includes also the relief present on the Precambrian knob prior to Deadwood deposition. Actual structural growth during Deadwood time has not been determined by this study. The other reservation is that all thinning and thickening

Interval	Thick. #1514	Thick. #1231	Thick. #3844	Ave. thick. 1514 & 3844	Thinning over high (#1231)	Struc. grow./ thickness (%)
GH - BF	340'	343'	350'	345'	2'	0.6%
Dakota	810'	777'	778'	794'	17'	2.1%
Jurassic	989'	958'	977'	983'	25'	2.5%
Triassic	282'	287'	290'	286'	-1'	-0.4%
Permian	421'	415'	497'	459'	44'	9.6%
Penns.	406'	371'	399'	402½'	31½'	7.8%
Otter	200'	194'	189'	194½'	½'	0.3%
Kib. Ss.	162'	150'	158'	160'	10'	6.2%
Kib. Ls.	148'	152'	150'	149'	-3'	-2.0%
Madison	2143'	2118'	2142'	2142½'	24½'	1.1%
Bakken	100'	114'	104'	102'	-12'	-11.8%
Three F.	187'	193'	192'	189½'	-3½'	-1.6%
Birdbear	105'	98'	90'	97½'	-½'	-0.5%
Duperow	443'	438'	438'	440½'	2½'	0.6%
Sour. R.	277'	262'	252'	264½'	2½'	0.9%
Daws. B.	122'	133'	134'	128'	-5'	-3.9%
Prairie	265'	260'	282'	273½'	13½'	4.9%
Wpgosis.	340'	330'	325'	332½'	2½'	0.8%
Int.-St.	1085'	1037'	1119'	1102'	65'	5.9%
Stony M.	197'	189'	198'	197½'	8½'	4.3%
Red R.	606'	575'	620'	613'	38'	6.2%
Winnipeg	368'	289'	334'	351'	62'	17.7%
Deadwood	446'	50'	683'	564½'	514½'	91.1%

Figure 5 -- Chart showing thinning over Beaver Lodge high (well no. 1231).
(Sediment thicknesses in wells no. 1514 and no. 3844 used for comparison.)

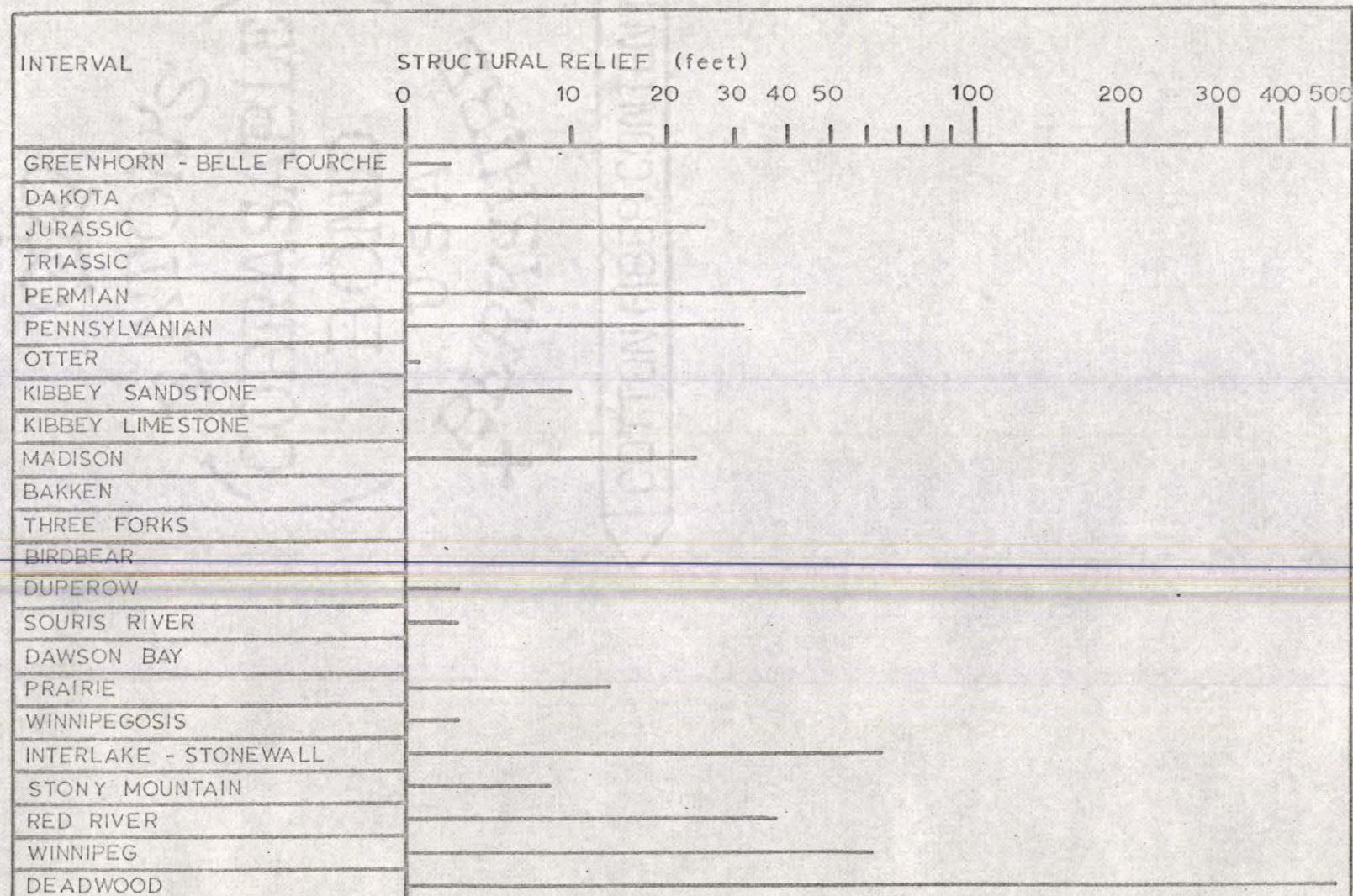


Figure 6 -- Structural growth of the Beaver Lodge high during Paleozoic and Mesozoic time.

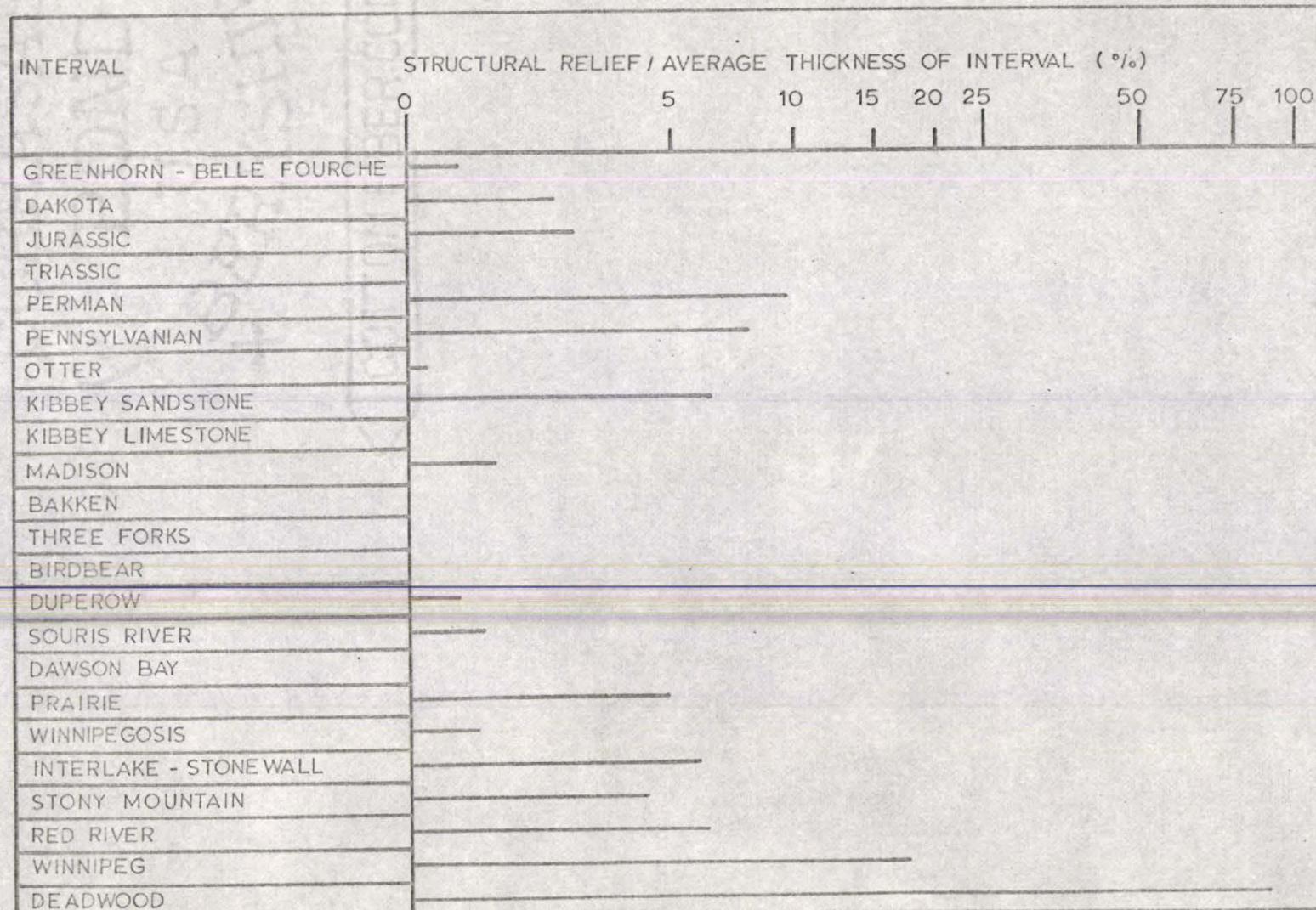


Figure 7 -- Structural growth of the Beaver Lodge high with respect to average thicknesses of the various intervals, expressed in percentage.

is shown to result from structural activity, with the assumption that the upper surface of each unit was flat before deposition of the next higher unit. In actuality these surfaces were probably not flat, in which case the thin and thick areas should not be considered to be related to structural activity.

The charts and isopachous maps discussed in this study indicate that significant structural growth occurred in the area of the Beaver Lodge high during Cambrian, Ordovician, Silurian, Early Devonian, Pennsylvanian, Permian, and Jurassic times. This compares very closely with the structural activity of the four eastern North Dakota highs studied by Ballard (1963), especially the Stutsman and Foster highs. Activity of the Cedar Creek Anticline is in no way correlative with the activity of the Beaver Lodge high.

PETROLEUM POSSIBILITIES

A commercial condensate-producing sand zone exists at a depth of 14,000 - 14,040 feet in N. D. G. S. Well No. 1636 in the northeast area of Beaver Lodge Field (Plate 1). The same sand zone should have occurred at a depth of about 13,587 - 13,627 feet in N. D. G. S. Well No. 1231 in the southwest area of the field. However, the Precambrian knob occurs in this well at a depth of 13,588 feet; thus the producing zone is absent in the well, but presumably occurs lower on the flanks of the knob. Approximately the upper 20 feet of this producing zone in N. D. G. S. Well No. 1636 contains impermeable shales, thus supplying a vertical seal. This shale is also present in the southwest portion of the field in N. D. G. S. Well No. 1403, so it is reasonable to assume that it is present along the flanks of the Precambrian knob, providing a seal for petroleum. Figure 8 illustrates how petroleum should be trapped beneath

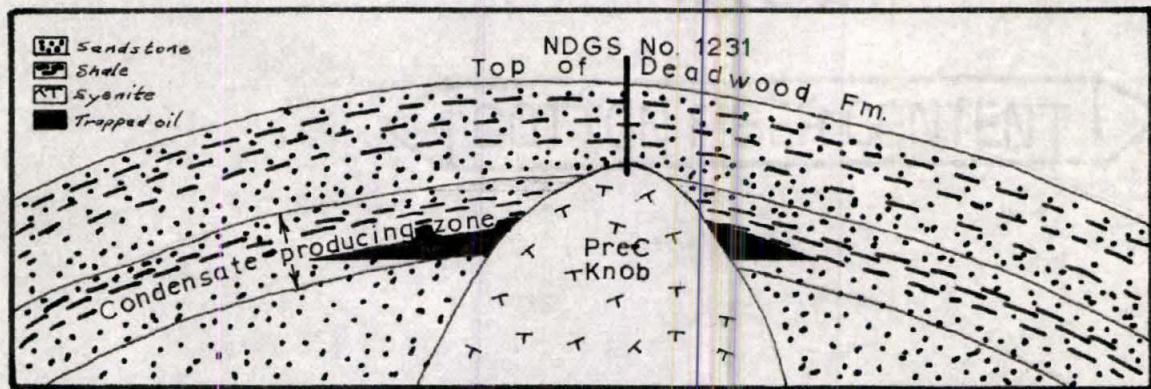


Figure 8 -- Cross-sectional sketch illustrating petroleum trapped along the flanks of the Precambrian knob in the study area.

this impervious shale along the flanks of the knob. From the structure map of the top of the Deadwood Formation (Plate 4), one can see that the southwest structure is a much more extensive collecting mechanism for petroleum than is the northeast structure.

SUMMARY

This study deals with the structural activity in the area of Beaver Lodge Field in Williams County, North Dakota, from Cambrian (Deadwood) through Late Cretaceous (Greenhorn) time.

Detailed isopachous and structural data define a Precambrian high in NE $\frac{1}{4}$, Sec. 2, T. 155 N., R. 96 W., which is elongated along a basement structural trend. Another area of basement closure exists to the northeast of the Precambrian high in NE $\frac{1}{4}$, Sec. 19, T. 156 N., R. 95 W., along the same trend. Both areas were structurally active during deposition of some of the intervals studied. Significant growth occurred during Cambrian, Ordovician, Silurian, Early Devonian, Pennsylvanian, Permian, and Jurassic times. This activity is very similar to the activity of four eastern North Dakota highs, but does not correlate with the activity of the Cedar Creek Anticline.

A productive sand zone occurring in the Deadwood Formation is absent over the top of the Precambrian high. A shale seal exists above the sand zone, so trapped petroleum should be present along the flanks of the high.

REFERENCES

- Ballard, F. V., 1963, Structural and stratigraphic relationships in the Paleozoic rocks of eastern North Dakota: N. Dak. Geol. Survey Bull. 40, 42 p., 32 pls.
- Carlson, C. G., 1960, Stratigraphy of the Winnipeg and Deadwood formations in North Dakota: N. Dak. Geol. Survey Bull. 35, 149 p.
- _____, 1969, Deep oil and gas possibilities of the Nessin Anticline area: Eastern Montana Symposium, Billings, Montana, p. 27-31.
- Carlson, C. G., and Anderson, S. B., 1966, Sedimentary and tectonic history of North Dakota part of Williston Basin: N. Dak. Geol. Survey Misc. Series No. 28, 14 p.
- Carlson, C. G., and Eastwood, W. P., 1962, Upper Ordovician and Silurian rocks of North Dakota: N. Dak. Geol. Survey Bull. 38, 52 p.
- Dow, W. G., 1967, The Spearfish Formation in the Williston Basin of western North Dakota: N. Dak. Geol. Survey Bull. 52, 28 p.
- Eardley, A. J., 1962, Structural geology of North America: 2nd ed., Harper and Brothers, New York, p. 12-90.
- Friestad, H. K., 1969, The Upper Red River Formation (Ordovician) in western North Dakota: Unpublished Master's Thesis, University of North Dakota, Grand Forks, N. Dak., 82 p., 16 pls.
- Kume, Jack, 1963, The Bakken and Englewood formations of North Dakota and northwestern South Dakota: N. Dak. Geol. Survey Bull. 39, 87 p., 3 pls.
- Sandberg, C. A., and Hammond, C. R., 1958, Devonian System in Williston Basin and central Montana: Amer. Assoc. Petrol. Geol. Bull. 42-10, p. 2293-2334.

APPENDIX

LIST OF SYSTEM, GROUP, AND FORMATION TOPS

The following is a list of system, group, and formation tops in wells in the area of Beaver Lodge Field. Some of the tops were taken from well files of the North Dakota Geological Survey and verified by mechanical logs, and some tops were determined from mechanical logs. The wells are listed in order according to North Dakota Geological Survey well number. Well location and Kelly Bushing elevation (K. B.) are included. Depths to the various tops are in feet. An absent top indicates that the top was questionable or that the interval was not logged.

Well No.	57	59	60	63	66	67	68	69	70	71	73
Location	12	25	18	25	7	14	31	30	10	5	10
	-155	-156	-155	-156	-155	-156	-156	-156	-156	-155	-156
	-96	-96	-95	-96	-95	-95	-95	-95	-96	-95	-95
K. B.	2388	2385	2321	2341	2385	2353	2335	2356	2427	2296	2295
TOPS - GH	3865	3934	3812	3907	3866	4000	3882	3897	4105	3844	3917
Dakota	4209	4267		4263	4212	4325	4231	4237		4198	4247
Jurassic	5004	5073	4980	5028	5007	5115	5017	5039	5258	4965	5037
Triassic	5968	6044		6010	5964	6093	5987	6010		5962	6010
Permian	6256	6333		6286	6257	6385		6300		6235	6288
Penns.	6762	6742		6683	6753	6775		6707		6656	6730
Otter	7153	7136		7080	7151	7133	7115	7103		7075	7119
Kib. Ss.	7341	7325		7265	7337	7335	7297	7290		7255	7289
Kib. Ls.	7508	7485	7447	7424	7504	7497	7461	7450	7690	7422	7447
Madison	7662	7631	7596	7567	7654	7649	7633	7595	7840	7575	7600

Bakken

Three F.

Birdbear

Duperow

Sour. R.

Daws. B.

Prairie

Wpgosis.

Interl.

Stony M.

Red R.

Winnipeg

Deadwood

Prec.

Well No.	74	75	76	79	80	81	85	86	87	88	90
Location	1	1	20	7	21	2	12	7	6	17	21
	-155	-155	-156	-155	-156	-155	-155	-155	-155	-156	-156
	-96	-96	-95	-95	-95	-96	-96	-95	-95	-95	-95
K. B.	2354	2373	2401	2342	2354	2343	2355	2393	2349	2378	2423
TOPS - GH	3852	3858	3967	3815	3960	3845	3838	3866	3857	3957	4028
Dakota	4196	4208		4164	4299	4192	4202	4214	4204		4370
Jurassic	4993	4986	5111	4985	5075	4990	4988	5010	5007	5083	5162
Triassic	5980	5963	6083	5965	6030	5967	5967	5993	6005	6054	6120
Permian	6253	6253		6245	6330	6240	6253	6277	6255	6332	6405
Penns.	6705	6750	6734	6700	6698	6679	6710	6763	6699	6703	6788
Otter	7097	7149	7131	7115	7098	7050	7121	7157	7093	7093	7194
Kib. Ss.	7282	7338	7318	7307	7288	7237	7306	7344	7271	7277	7386
Kib. Ls.	7437	7496	7474	7470	7450	7400	7473	7511	7427	7444	7544
Madison	7589	7646	7627	7620	7603	7543	7625	7663	7585	7594	7692

Bakken

Three F

Birdbear

Duperow

Sour. R.

Daws. B.

Prairie

Wpgosis.

Interl.

Stony M.

Red R.

Winnipeg

Deadwood

Prec.

Well No.	97	101	102	103	107	109	112	113	116	117	119
Location	17	30	20	10	2	3	9	36	20	21	31
	-156	-156	-156	-156	-155	-155	-156	-156	-156	-156	-156
	-95	-95	-95	-95	-96	-96	-95	-96	-95	-95	-95
K. B.	2378	2379	2435	2308		2225		2309	2418	2382	2336
TOPS - GH	3968	3933	4006	3930	3860	3788	3955	3842	3987	3964	3864
Dakota	4307	4273	4343	4270	4203	4143	4281	4195	4327	4292	
Jurassic	5087	5082	5130	5070	4991	4927	5096	4976	5108	5090	5010
Triassic	6075	6035	6105	6030	5947	5925	6082	5940	6088	6064	5982
Permian	6357	6325	6380	6308	6212	6172	6370	6222	6343	6343	6277
Penns.	6722	6725	6770	6684	6594	6609	6702	6618			6723
Otter	7100	7126	7149	7073	6968	6994	7077	7011			7112
Kib. Ss.	7281	7311	7335	7238	7160	7186	7257	7206			7300
Kib. Ls.	7446	7480	7496	7395	7324	7352	7418	7355	7458	7467	7452
Madison	7597	7617	7643	7547	7472	7504	7570	7501	7605	7600	7605

Bakken

Three F.

Birdbear

Duperow

Sour. R.

Daws. B.

Prairie

Wpgosis.

Interl.

Stony M.

Red R.

Winnipeg

Deadwood

Prec.

Bakken

Three F.

Birdbear

Duperow

Sour, R

Daws, B.

Prairie

Wpgosis

Interl.

Stony M.

Red R.

Winnipeg

Deadwood

Prec.

Well No.	144	150	152	153	159	160	161	163	165	168	169
Location	10	4	17	19	32	12	2	16	1	28	32
	-155	-156	-156	-156	-156	-155	-155	-156	-155	-156	-156
	-96	-95	-95	-95	-95	-96	-96	-95	-96	-95	-95
K. B.	2158	2275	2378	2403	2332	2346	2329	2360	2340	2465	2310
TOPS - GH	3737	3917	3982	3982	3887	3816	3850	3935	3848	4093	3866
Dakota	4094	4250	4320	4324	4237	4174	4188	4268	4197	4430	4210
Jurassic	4900	5057	5104	5108	5023	4972	4973	5054	4972	5218	5006
Triassic	5880	6054	6104	6092	5995	5952	5960	6037		6172	5990
Permian	6153	6332	6395	6368	6282	6240	6227	6317	6239	6472	6269
Penns.	6585	6685	6747	6748	6688	6706	6667	6700	6672	6851	6672
Otter	6971	7047	7113	7137	7116	7092	7037	7082	7040	7283	7095
Kib. Ss.	7173	7213	7303	7320	7301	7282	7232	7270	7227	7450	7277
Kib. Ls.	7335	7380	7473	7483	7458	7443	7385	7433	7387	7623	7447
Madison	7491	7540	7626	7628	7620	7600	7535	7590	7536	7772	7598

Bakken

Three F.

Birdbear

Duperow

Sour. R.

Daws. B.

Prairie

Wpgosis.

Interl.

Stony M.

Red R.

Winnipeg

Deadwood

Prec.

-31-

Weill No. 294 296 297 300 309 310 311 317 323 324 325

Location	10	17	8	10	35	10	20	20	36	20	17
-156	-156	-156	-155	-156	-155	-156	-156	-156	-156	-156	-156
-95	-95	-95	-96	-96	-96	-95	-95	-96	-95	-95	-95

K. B. 2307 2378 2344 2267 2314 2281 2441 2429 2341 2448 2403

TOPS - GH 3933 3966 3950 3834 3875 3841 | 4005 3865 4013 3974

Dakota 4270 4313 4300 4190 4209 4330 4337 4217 4354 4309

Jurassic 5050 5093 4975 4986 4975 5133 5135 5006 5162 5094

Triassic 6020 6092 6087 5943 5969 5946 6103 6100 5983 6120 6096

Permian 6300 6375 6375 6207 6260 6213 6382 6377 6270 6405 6362

Penns.	6688	6729	6732	6582	6656	6590	6768	6748	6677	6800	6733
--------	------	------	------	------	------	------	------	------	------	------	------

Otter 7083 7089 7092 6955 7045 6962 7185 7133 7074 7203 7103

Kib.	Ss.	7250	7388	7290	7147	7233	7167	7364	7314	7257	7385	7288
------	-----	------	------	------	------	------	------	------	------	------	------	------

Kib. Ls. 7410 7438 7444 7304 7393 7320 7526 7475 7415 7543 7436

Madison 7564 7592 7588 7450 7542 7479 7660 7608 7566 7673 7588

Bakken

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Inter.

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1966. The author wishes to thank Dr. J. R. G. Green for his help in the preparation of this paper.

Well No.	331	347	349	351	352	364	372	376	379	382	386
Location	31	6	24	29	1	10	29	6	9	8	12
	-156	-155	-156	-156	-155	-155	-156	-155	-156	-156	-155
	-95	-95	-96	-95	-96	-96	-95	-95	-95	-95	-96
K. B.	2346	2350	2407	2401	2334	2219	2475	2331	2319	2353	2359
TOPS - GH	3894	3863	4008	3945	3843	3778	4045	3855	3942	3973	3855
Dakota	4240	4206		4295	4186	4136	4384	4190	4280	4309	4203
Jurassic	5003	5010	5148		4980		5192	4979	5075	5113	4970
Triassic	6010		6136	6053	5953	5881	6148	5970	6046	6120	5975
Permian	6287	6246		6340	6230	6157	6446	6262	6332	6402	6255
Penns.	6691	6686		6750	6649	6547	6828	6696	6670	6760	6695
Otter	7107	7090		7157	7031	6925	7243	7110	7070	7125	7078
Kib. Ss.	7295	7267		7343	7228	7120	7430	7298	7234	7311	7265
Kib. Ls.	7450	7420	7543	7502	7378	7282	7588	7457	7394	7467	7431
Madison	7600	7571	7687	7658	7530	7422	7738	7612	7548	7618	7571

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Deadwood

Prec.

Well No.	420	424	428	429	433	439	442	443	444	445	475
Location	36	21	22	21	32	7	31	16	21	11	7
	-156	-156	-156	-156	-156	-155	-156	-156	-156	-155	-155
	-96	-95	-95	-95	-95	-95	-95	-95	-95	-96	-95
K. B.	2354	2373	2392	2360	2412	2334	2350	2365	2391	2326	2359
TOPS - GH	3897	3945	4027	3960	3980	3826	3875	3955	3974	3835	3862
Dakota	4242	4278	4354	4281		4174		4287	4319	4195	4224
Jurassic	5045	5090	5146	5093	5117	4975	4982	5082	5110	4995	5030
Triassic	6006	6050	6102	6045	6090	5960	5982	6057	6063	5982	6003
Permian	6291	6340	6398	6335		6255	6280	6342	6357	6251	6288
Penns.	6696	6715	6776	6710		6702	6690	6708	6747	6640	6726
Otter	7092	7100	7168	7114		7113	7090	7088	7150	7023	7151
Kib. Ss.	7280	7305	7385	7302		7304	7280	7276	7340	7217	7346
Kib. Ls.	7440	7466	7544	7458	7570	7463	7430	7430	7488	7375	7500
Madison	7595	7605	7698	7608	7700	7614	7583	7587	7638	7535	7654

Bakken

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Daws. B.

Prairie

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Deadwood

Prec.

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Daws. B.

Prairie

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Interl.

Stony M

Red R.

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Deadwood

Prec.

Well No.	514	525	526	533	562	570	575	593	595	603	604
Location	9	12	12	12	13	2	1	18	9	5	17
	-156	-155	-155	-155	-155	-155	-155	-155	-156	-155	-155
	-95	-96	-96	-96	-96	-96	-96	-95	-95	-95	-95
K. B.	2302	2379	2394	2375	2358	2346	2333	2309	2310	2271	2169
TOPS - GH	3934	3857	3863	3878	3860	3882	3814	3812	3936	3818	3685
Dakota	4276	4212	4221	4230	4231	4223	4183	4162	4280	4162	4038
Jurassic	5069	4998		5028	5018	5006	4954	4975	5088		4845
Triassic	6072	5952		6010	5996	5983	5932	5963	6076	5945	5835
Permian	6353	6252	6268	6291	6277	6254	6207	6240	6355	6233	6122
Penns.	6703	6743	6753	6716	6727	6665	6680	6700	6697	6708	6589
Otter	7087	7141	7155	7096	7130	7041	7054	7098	7079	7109	7002
Kib. Ss.	7250	7343	7347	7297	7325	7230	7253	7306	7252	7304	7203
Kib. Ls.	7408	7485	7502	7447	7483	7385	7403	7458	7410	7460	7353
Madison	7562	7636	7657	7607	7637	7538	7555	7610	7561	7612	7507

Bakken

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Birdbear

Duperow

Sour. R.

Daws. B.

Prairie

Wpgosis.

Interl.

Stony M.

Red R.

Winnipeg

Deadwood

Prec.

Well No.	759	787	788	789	790	799	812	841	865	870	887
Location	18	24	28	2	16	33	30	33	17	35	24
	-155	-155	-156	-155	-156	-156	-156	-156	-155	-156	-155
	-95	-96	-95	-96	-95	-95	-95	-95	-95	-96	-96
K. B.	2234	2204	2450	2296	2346	2443	2374	2415	2187	2293	2204
TOPS - GH	3733	3707	4050	3855	3942	4042	3910	4022	3727	3834	3705
Dakota	4082	4055	4391	4203	4288	4396	4256	4377	4077	4170	4061
Jurassic	4892	4870		4969	5084	5175	5045	5148	4880	4945	4877
Triassic	5872	5855	6145	5930	6038	6137	6020	6126	5870	5952	5855
Permian	6167	6151	6437	6225		6440	6310	6427	6165	6210	6135
Penns.	6617	6598	6837	6615		6858	6718	6832	6645	6612	6608
Otter,	7034	7012	7257	6989		7279	7117	7256	7058	6990	7015
Kib Ss.	7235	7208	7440	7188		7465	7305	7445	7259	7190	7212
Kib. Ls.	7388	7363	7603	7342	7422	7620	7463	7602	7410	7339	7367
Madison	7542	7515	7753	7493	7576	7776	7609	7755	7562	7496	7508

Bakken

Three F.

Birdbear

Duperow

Sour. R.

Daws. B.

Prairie

Wpgosis.

Interl.

Stony M.

Red R.

Winnipeg

Deadwood

Prec.

Well No.	890	934	937	954	963	970	982	998	1014	1017	1022
Location	28	15	8	15	19	17	35	20	16	19	18
	-156	-156	-155	-155	-155	-155	-156	-155	-156	-155	-155
	-95	-95	-95	-96	-95	-95	-96	-95	-95	-95	-95
K. B.	2418	2343	2317	2208	2265	2243	2283	2115	2334	2223	2258
TOPS - GH	4045	3985	3827	3747	3770	3755	3836	3644	3945	3724	3759
Dakota	4395	4330	4187	4103	4127	4120	4173	3997	4283	4084	4100
Jurassic	5163	5100	5000	4893	4944	4920	4975	4810	5076	4900	4920
Triassic	6130	6067	5962	5863	5920	5900	5942		6042	5878	5904
Permian	6436	6360	6257	6140	6212	6190	6232	6090	6318	6172	6195
Penns.	6832	6747	6713	6538	6686	6652	6614	6575	6678	6660	6658
Otter	7266	7127	7114	6913	7076	7045	7000	6975	7070	7050	7063
Kib. Ss.	7448	7314	7313	7113	7278	7246	7190	7180	7255	7253	7264
Kib. Ls.	7606	7469	7467	7267	7432	7388	7348	7330	7407	7405	7418
Madison	7757	7620	7615	7426	7586	7550	7498	7485	7574	7555	7566

Bakken

Three F.

Birdbear

Duperow

Sour. R.

Daws. B.

Prairie

Wpgosis

Interl.

Stony M.

Red R.

Winnipeg

Deadwood

Prec.

Well No.	1025	1031	1035	1039	1045	1046	1075	1113	1124	1160	1168
Location	19 -155 -95	17 -155 -95	18 -156 -95	19 -156 -95	15 -156 -95	20 -155 -95	18 -156 -95	20 -155 -95	19 -155 -95	20 -155 -95	20 -155 -95
K. B.	2230	2181	2355	2384	2332	2123	2360	2082	2232	2089	2198
TOPS - GH	3742	3708	3964	3957	3985	3640	3950	3635	3753	3640	3713
Dakota	4103	4061	4308	4297	4315	3997	4298	3987	4114	4001	4070
Jurassic	4913	4860	5090	5085	5090	4810		4808	4938	4799	4889
Triassic	5890	5848	6122	6074	6055	5793	6088	5828	5930	5812	5871
Permian	6183	6138	6410	6355	6335	6083	6368	6068	6194	6075	6158
Penns.	6664	6613	6780	6732	6716	6542	6757	6535	6680	6546	6625
Otter	7049	7020	7130	7104	7122	6963	7104	6938	7073	6944	7045
Kib. Ss.	7252	7220	7326	7293	7296	7164	7302	7140	7275	7145	7242
Kib. Ls.	7405	7371	7480	7459	7460	7310	7456	7289	7427	7296	7394
Madison	7558	7526	7628	7610	7608	7465	7608	7440	7580	7448	7546

Bakken

Three F.

Birdbear

Duperow

Sour. R.

Daws. B.

Prairie

Wpgosis.

Interl.

Stony M.

Red R.

Winnipeg

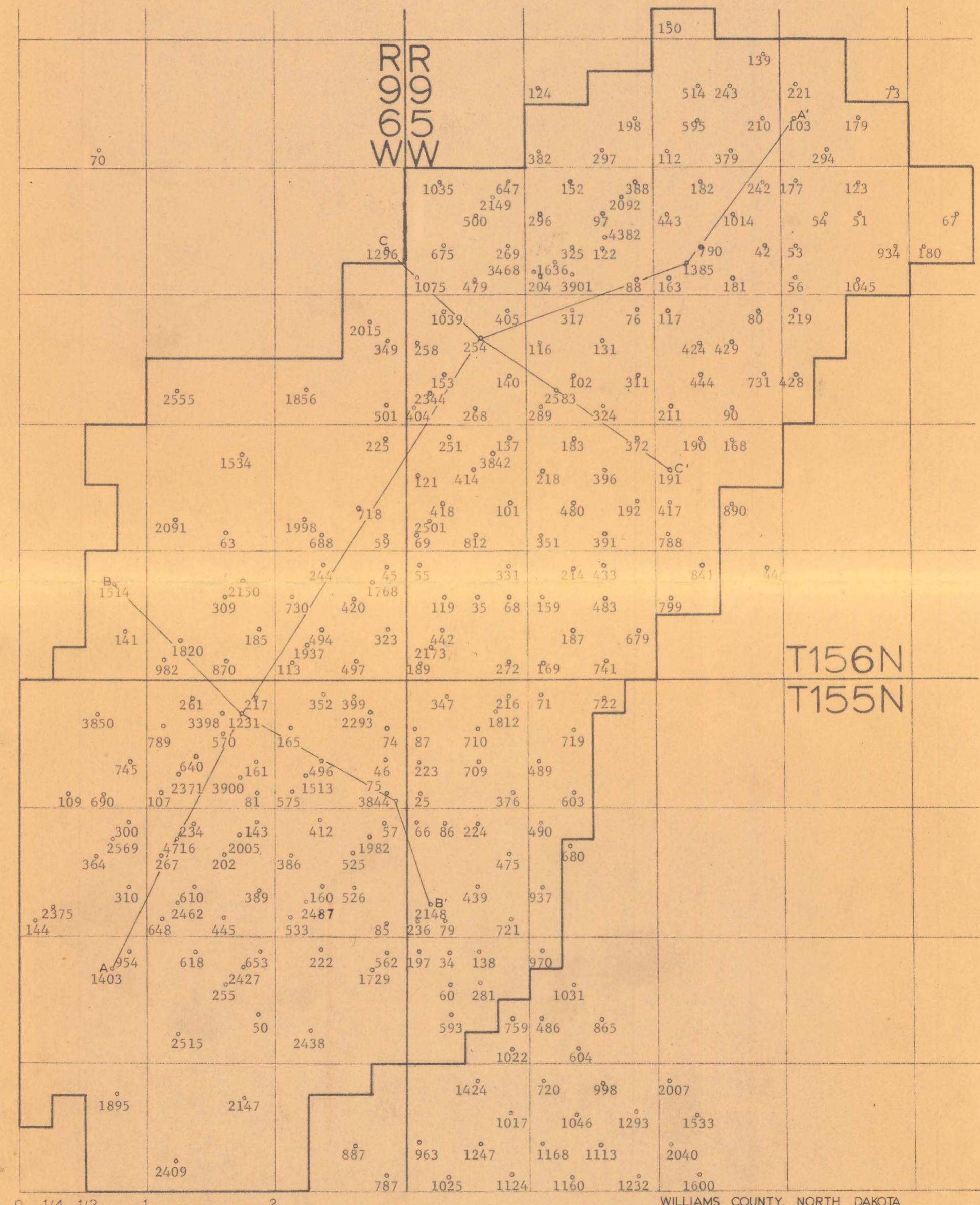
Deadwood

Prec.

Well No.	1231	1232	1247	1293	1296	1385	1403	1424	1513	1514	1534
Location	2 -155 -96	20 -155 -95	19 -155 -95	20 -155 -95	13 -156 -96	16 -156 -95	15 -155 -96	19 -155 -95	1 -155 -96	34 -156 -96	26 -156 -96
K. B.	2316	2053	2209	2167	2358	2360	2165	2257	2339	2286	2340
TOPS - GH		3624	3714	3735	3967		3716	3762	3828	3875	3914
Dakota	4198	3997	4068	4095	4316	4275	4068	4113	4174	4215	4250
Jurassic	4975	4807	4893	4920	5106	5069	4855	4915		5025	5037
Triassic	5933	5803	5870	5902	6103	6050	5833	5903	5943	6014	6033
Permian	6220	6062	6167	6175	6388	6328	6111	6193	6222	6296	
Penns.	6635	6522	6642	6645	6762	6698	6517	6680	6702	6717	
Otter	7006	6933	7034	7050	7127	7088	6885	7065	7072	7123	
Kib. Ss.	7200	7137	7236	7252	7310	7280	7090	7271	7260	7323	
Kib. Ls.	7350	7285	7389	7400	7471	7437	7245	7426	7422	7485	7450
Madison	7502	7437	7540	7553	7622	7588	7408	7575	7570	7633	7595
Bakken	9620					9735	9570			9776	9720
Three F.	9734					9864	9678			9876	9832
Birdbear	9927					10086	9870			10063	10025
Duperow	10025					10188	9954			10168	10122
Sour. R.	10463					10680	10393			10611	10573
Daws. B.	10725					10966	10655			10888	10842
Prairie	10858					11095	10789			11010	10971
Wpgosis.	11118					11417	11036			11275	11245
Interl.	11448					11770	11367			11615	11585
Stony M.	12485					12926	12457			12700	
Red R.	12674					13124	12657			12897	
Winnipeg	13249					13775	13262			13503	
Deadwood	13538					14100	13607			13871	
Prec.	13588					14783	14145			14317	

Well No.	2569	2583	3398	3468	3842	3844	3850	3900	3901	4716	
Location	10	20	2	17	30	1	3	2	17	11	
	-155	-156	-155	-156	-156	-155	-155	-155	-156	-155	
	-96	-95	-96	-95	-95	-96	-96	-96	-95	-96	
K. B.	2242	2409	2325	2395	2376	2370	2268	2329	2421	2294	
TOPS - GH				3975					3997		
Dakota	4154			4206	4303	4273			4200	4334	4195
Jurassic	4936			4984		5072			4985	5115	4994
Triassic	5914				6073				5964	6090	5970
Permian	6185				6352	6315				6370	6237
Penns.	6567				6717	6705				6737	6611
Otter.	6938				7087	7100				7110	6981
Kib. Ss.	7133				7272	7280			7305	7170	
Kib. Ls.	7296				7428	7441			7380	7454	7332
Madison	7437				7569	7593	7648	7518	7518	7588	7487
Bakken	9614	9802			9738	9790	9684	9669			9655
Three F.	9709	9912			9855	9894	9780	9768			9753
Birdbear	9903	10121	9947		10057	10086	9970	9957			9942
Duperow	9987	10223	10034		10160	10176	10054	10046			10036
Sour. R.	10430			10482		10633	10614	10506	10484		10476
Daws. B.	10693			10740			10866				10746
Prairie	10828			10874			11000				10872
Wpgosis.	11108			11140			11282				11139
Interl.	11409			11468			11607				11465
Stony M.							12726				12530
Red R.							12924				12723
Winnipeg							13544				13316
Deadwood							13902				13653
Prec.							14561				

LOCATION MAP SHOWING CONTROL WELLS
BEAVER LODGE FIELD



• CONTROL WELL

2409 NORTH DAKOTA GEOLOGICAL SURVEY WELL NUMBER

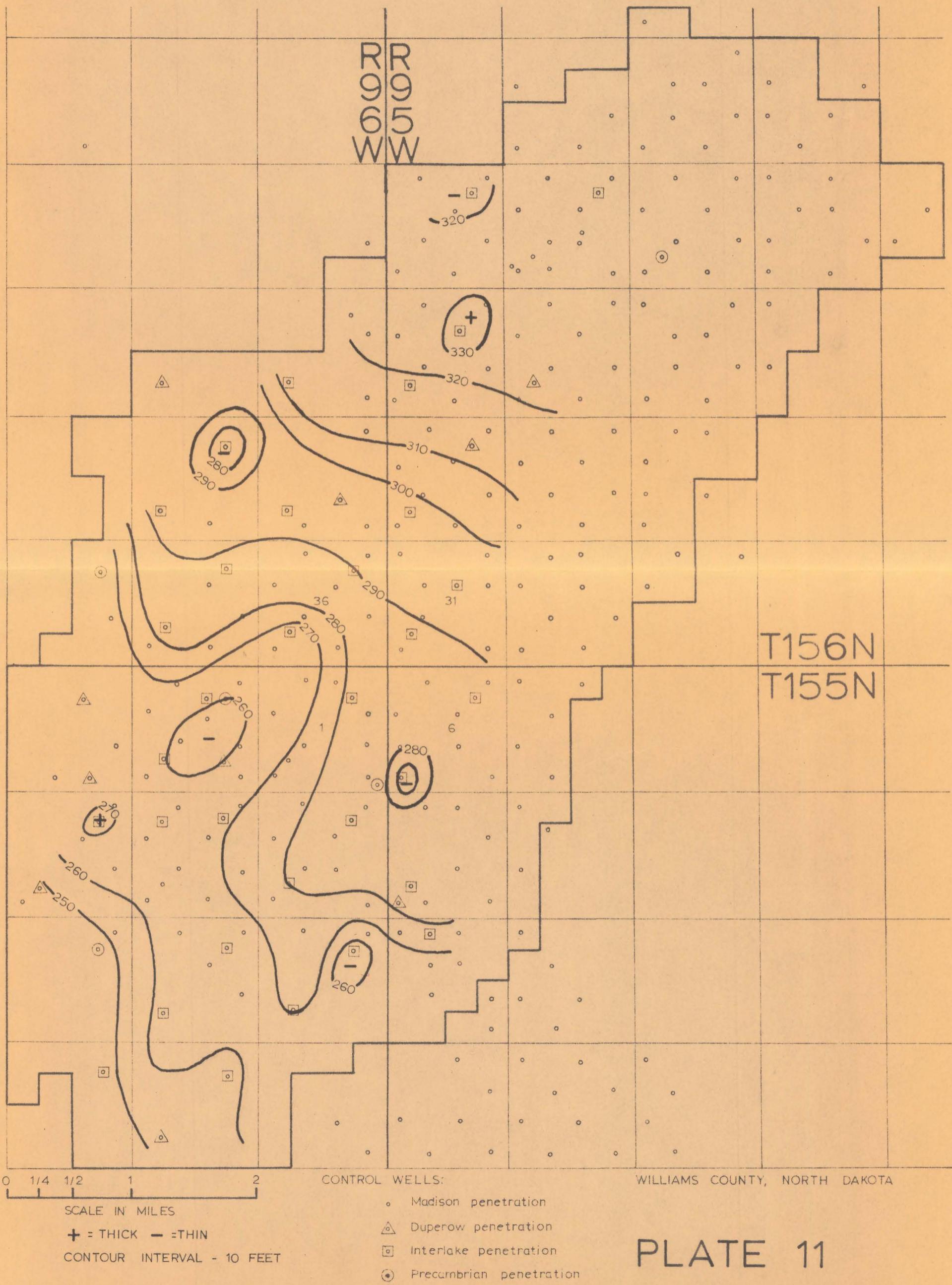
A ————— A' LOCATION OF FIGURES 2, 3, AND 4

PLATE 1

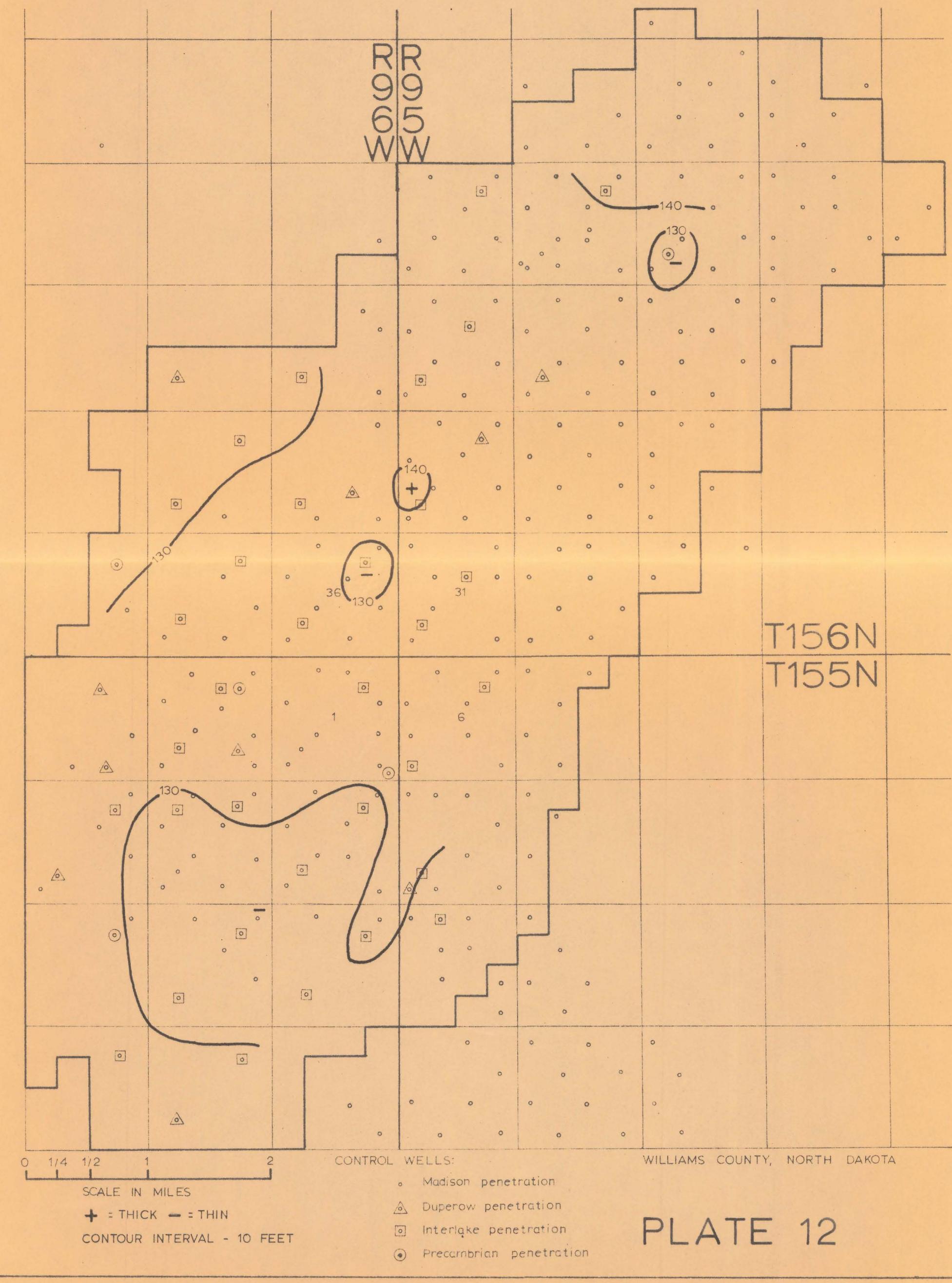
WINNIPEGOSIS FORMATION ISOPACHOUS MAP
BEAVER LODGE FIELD



PRAIRIE FORMATION ISOPACHOUS MAP
BEAVER LODGE FIELD



DAWSON BAY FORMATION ISOPACHOUS MAP
BEAVER LODGE FIELD



SOURIS RIVER FORMATION ISOPACHOUS MAP
BEAVER LODGE FIELD

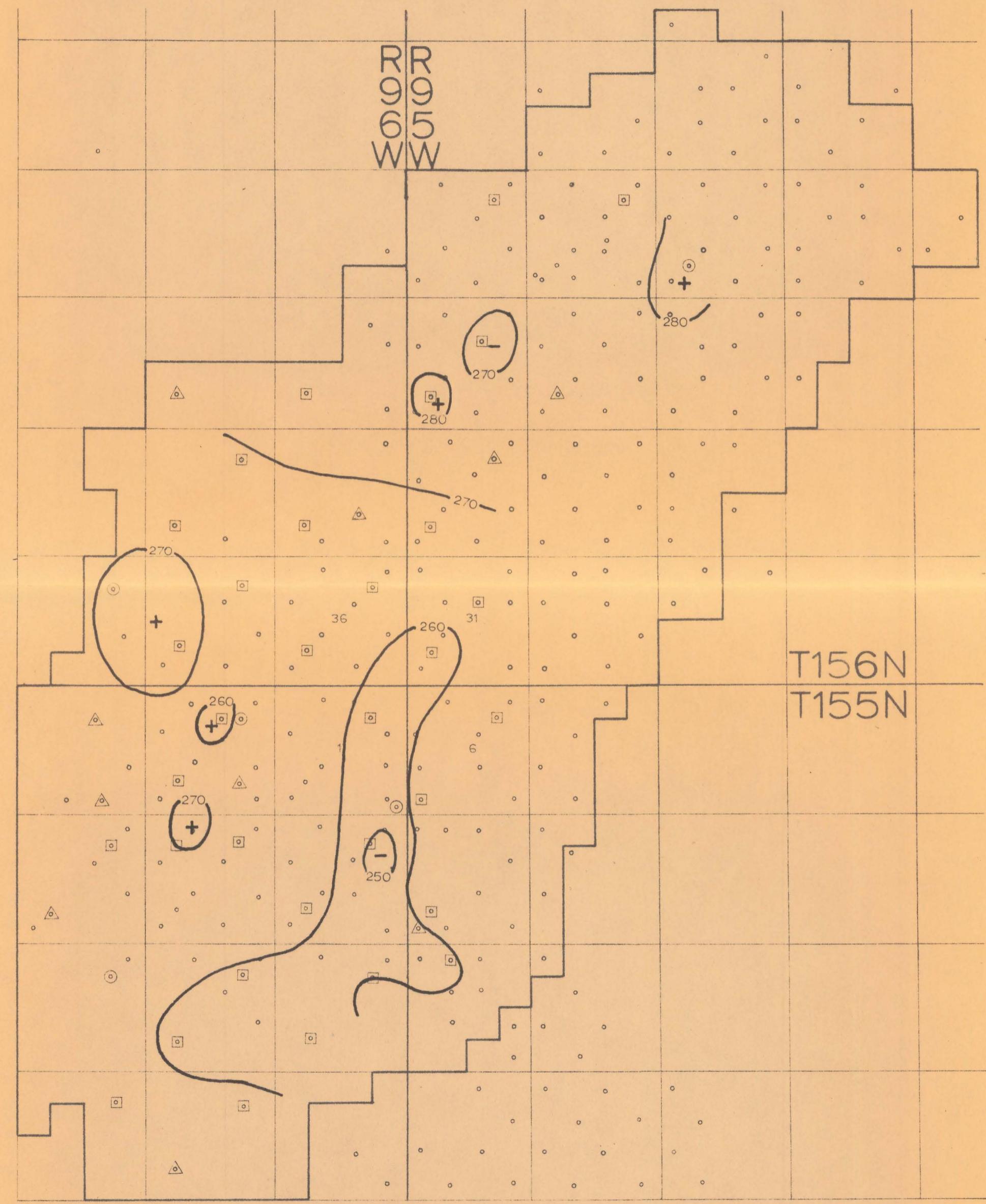
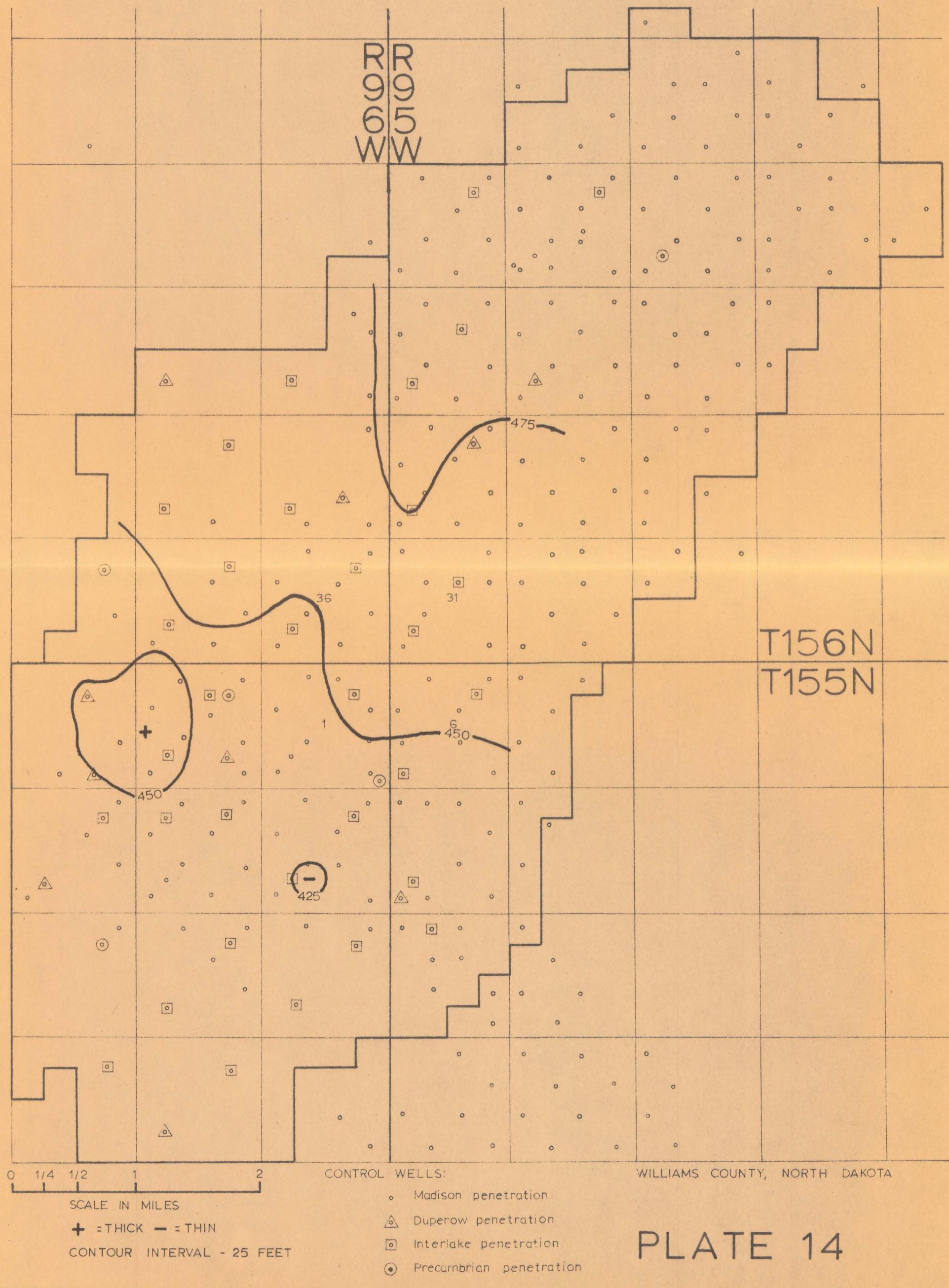
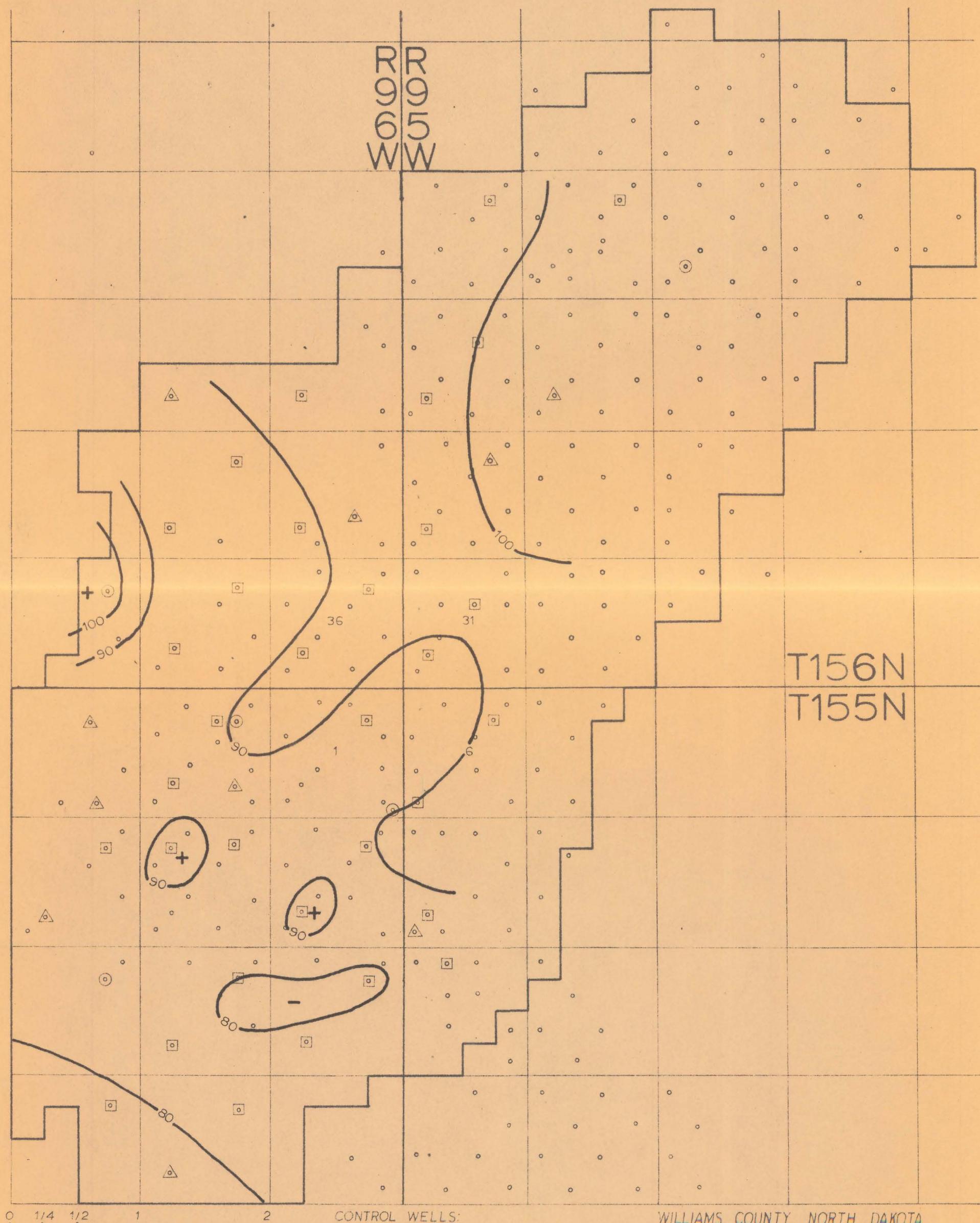


PLATE 13

DUPEROW FORMATION ISOPACHOUS MAP
BEAVER LODGE FIELD



BIRDBEAR FORMATION ISOPACHOUS MAP
BEAVER LODGE FIELD



0 1/4 1/2 1 2

SCALE IN MILES

+ = THICK - = THIN

CONTOUR INTERVAL - 10 FEET

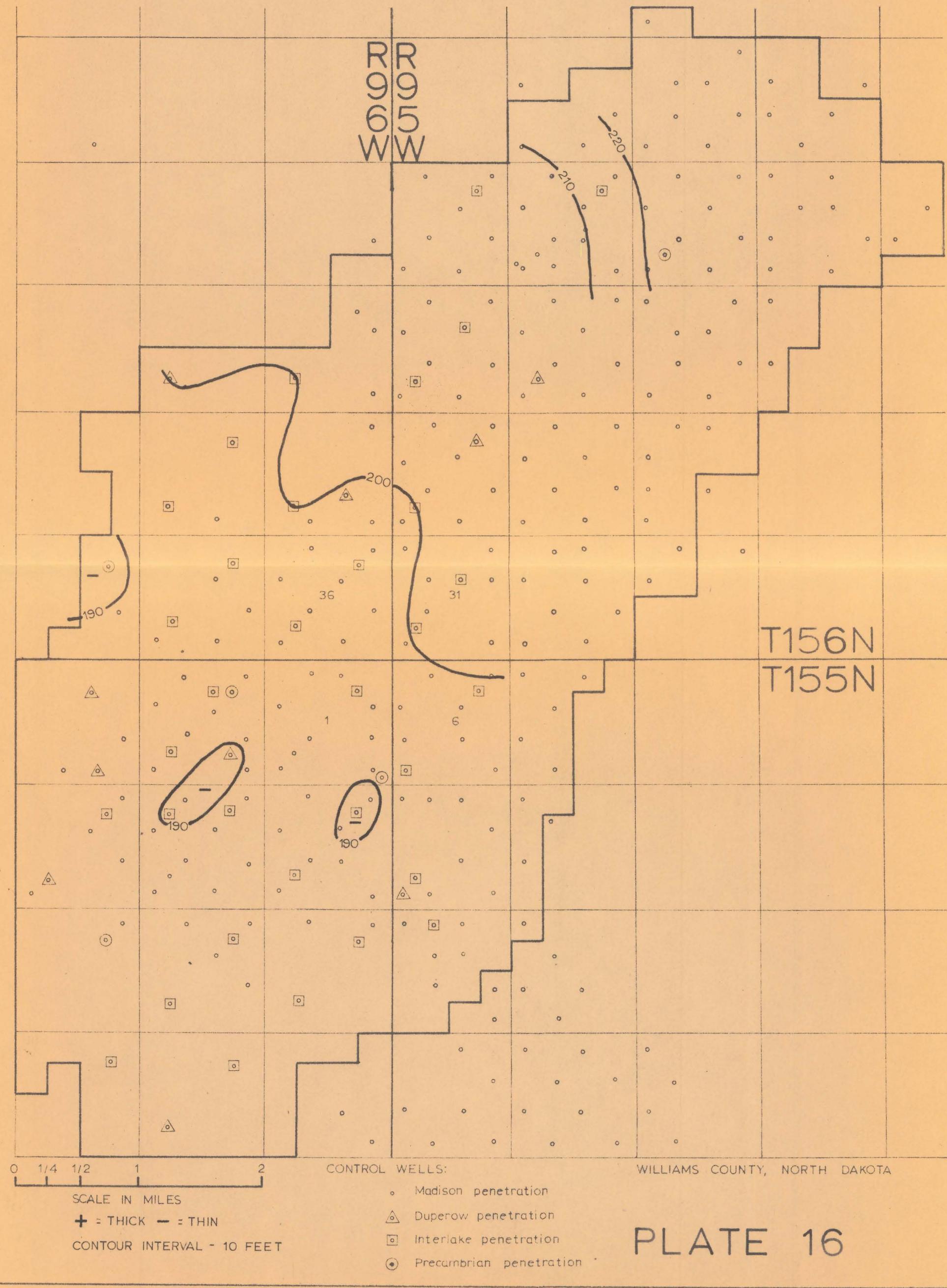
CONTROL WELLS:

- Madison penetration
- △ Duperow penetration
- Interlake penetration
- Precambrian penetration

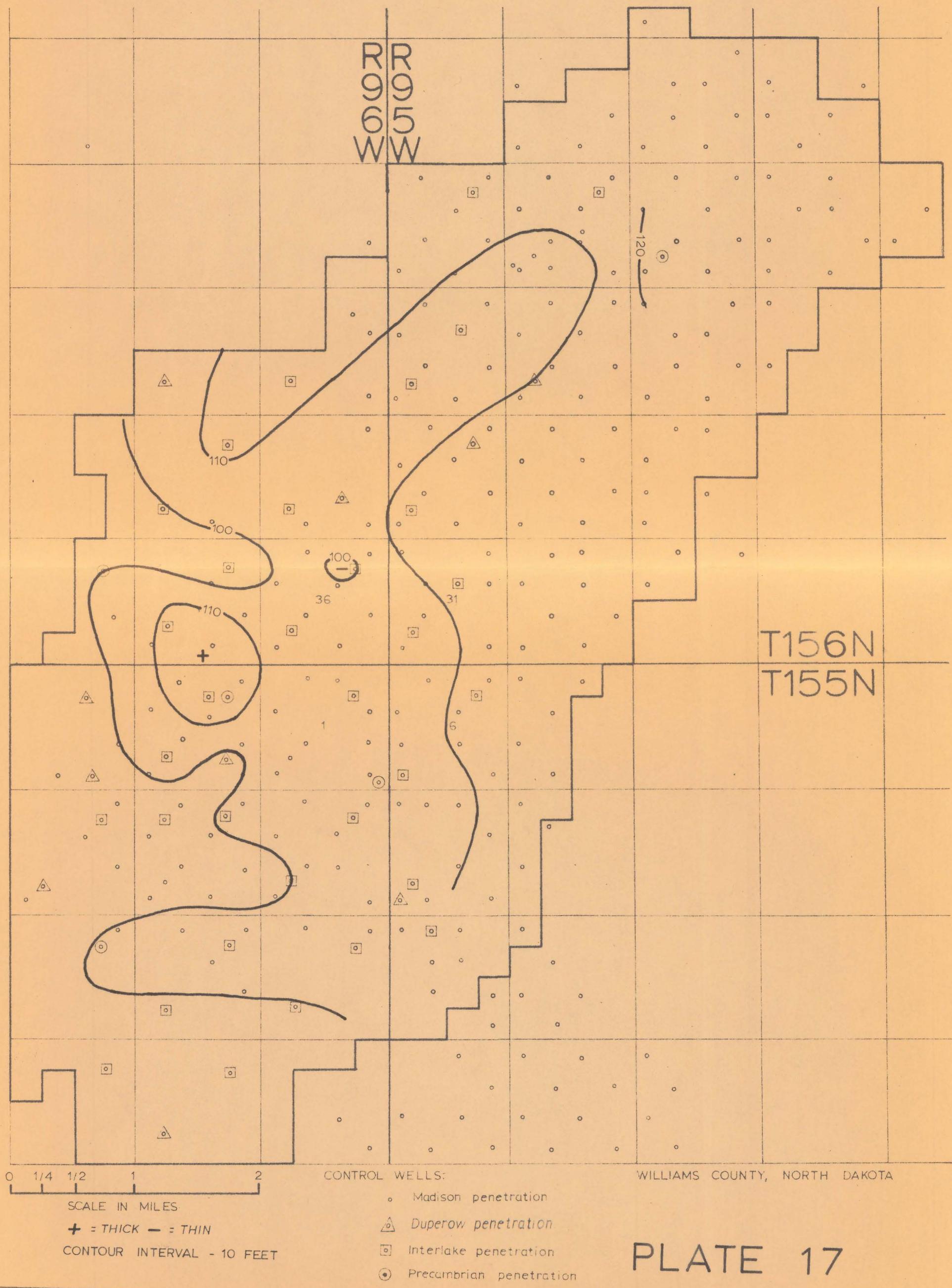
WILLIAMS COUNTY, NORTH DAKOTA

PLATE 15

THREE FORKS FORMATION ISOPACHOUS MAP
BEAVER LODGE FIELD



BAKKEN FORMATION ISOPACHOUS MAP
BEAVER LODGE FIELD



MADISON GROUP ISOPACHOUS MAP
BEAVER LODGE FIELD

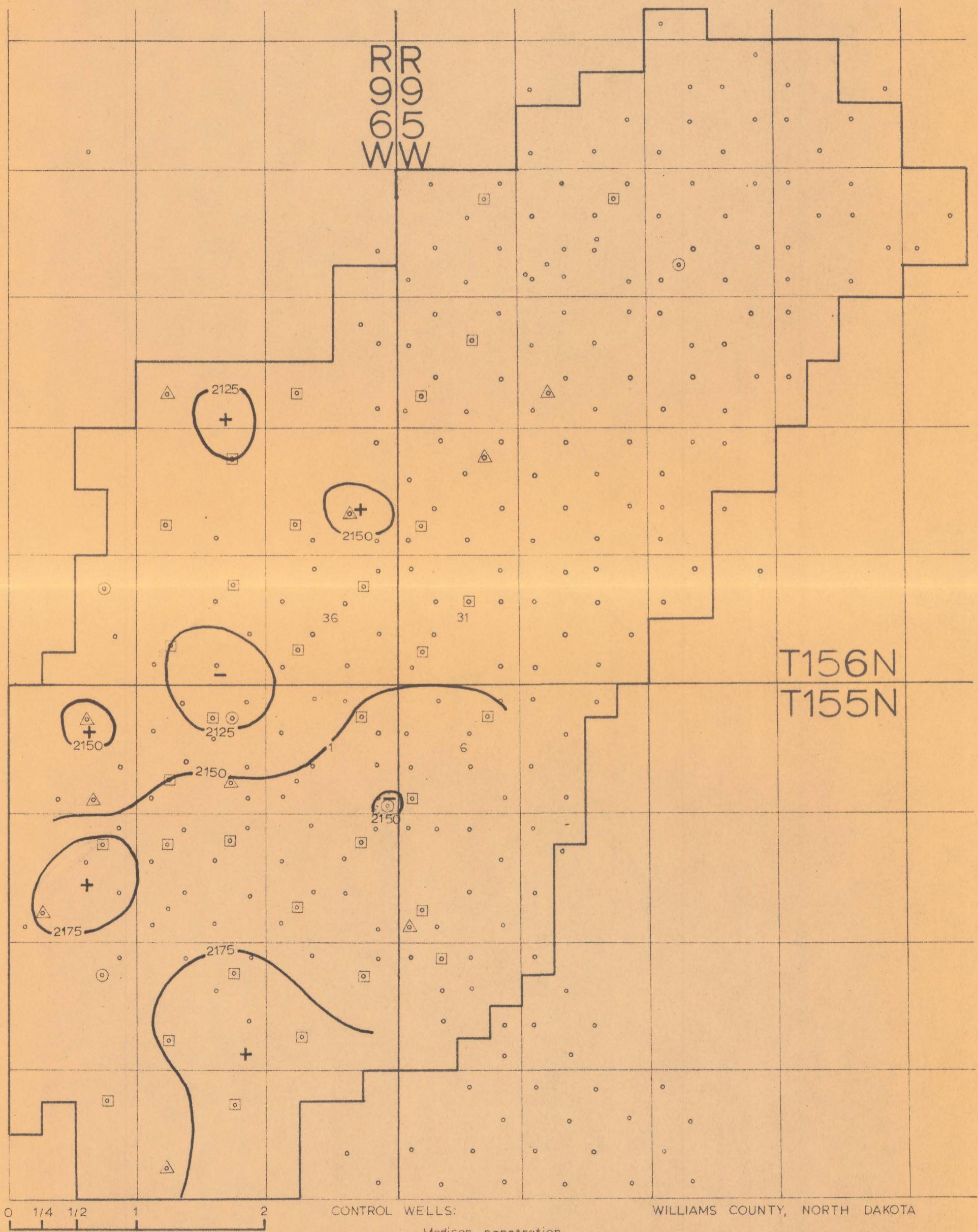


PLATE 18

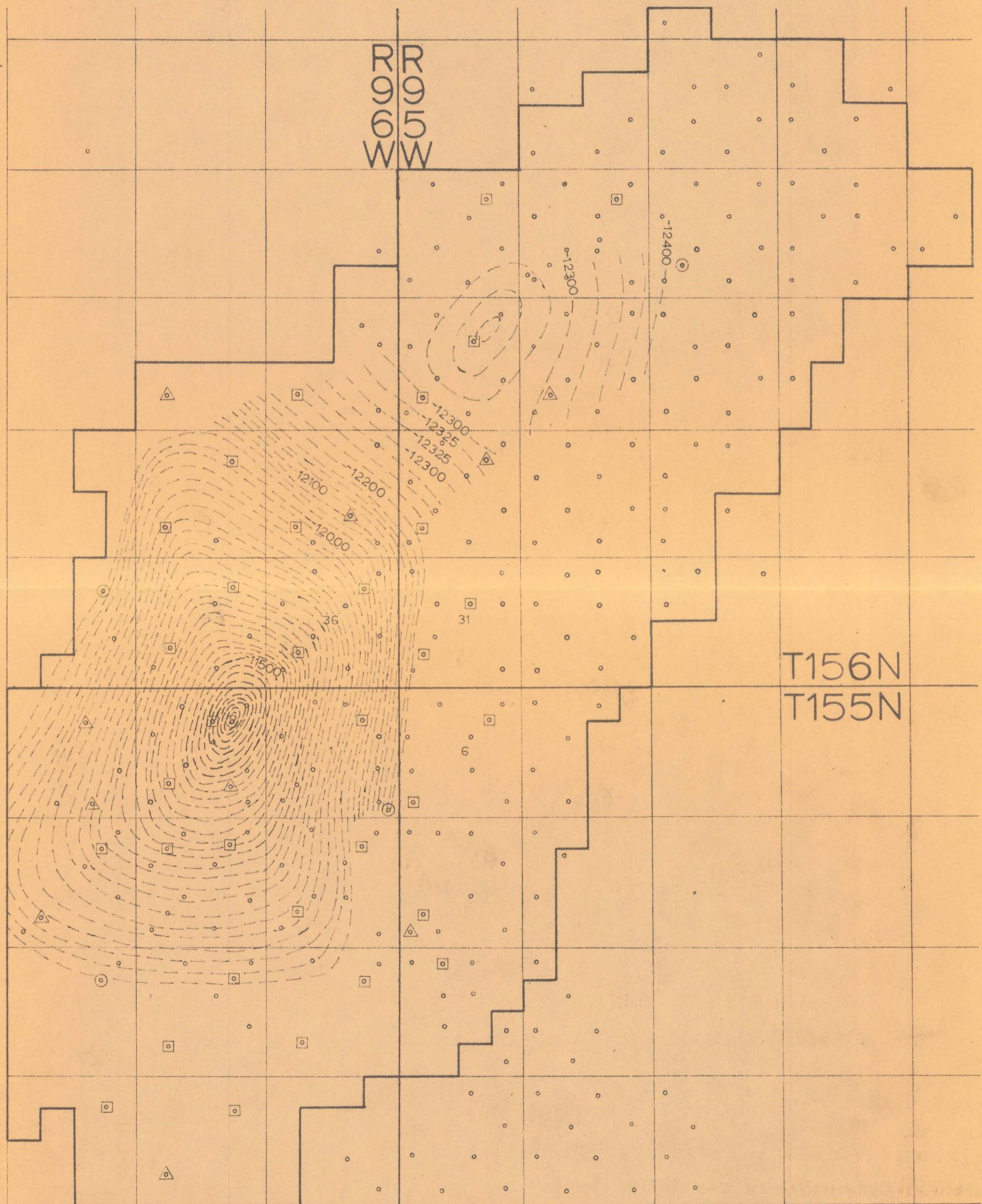
KIBBEY LIMESTONE ISOPACHOUS MAP BEAVER LODGE FIELD



WILLIAMS COUNTY, NORTH DAKOTA

PLATE 19

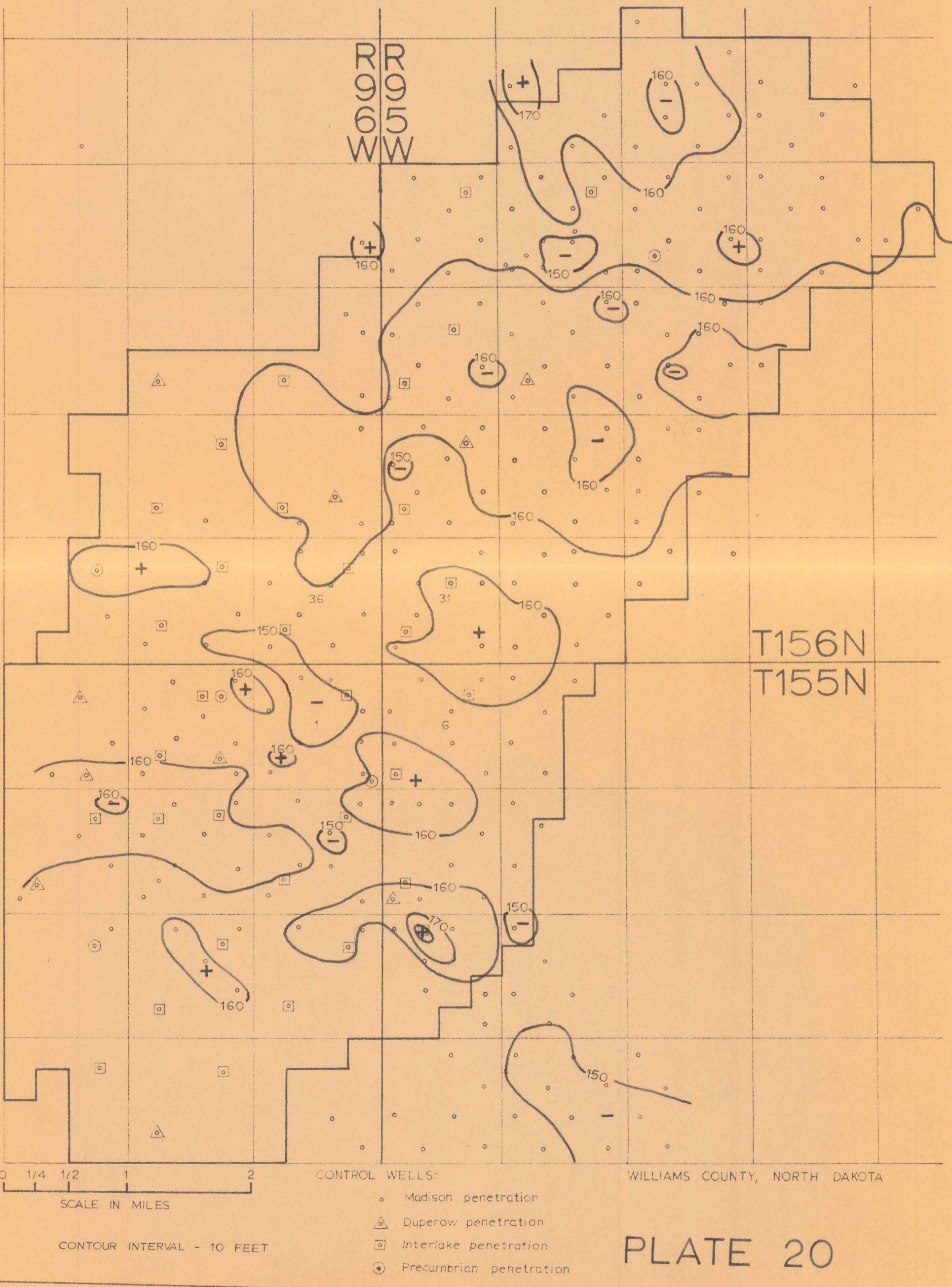
CONTOUR MAP TOP OF PRECAMBRIAN
BEAVER LODGE FIELD



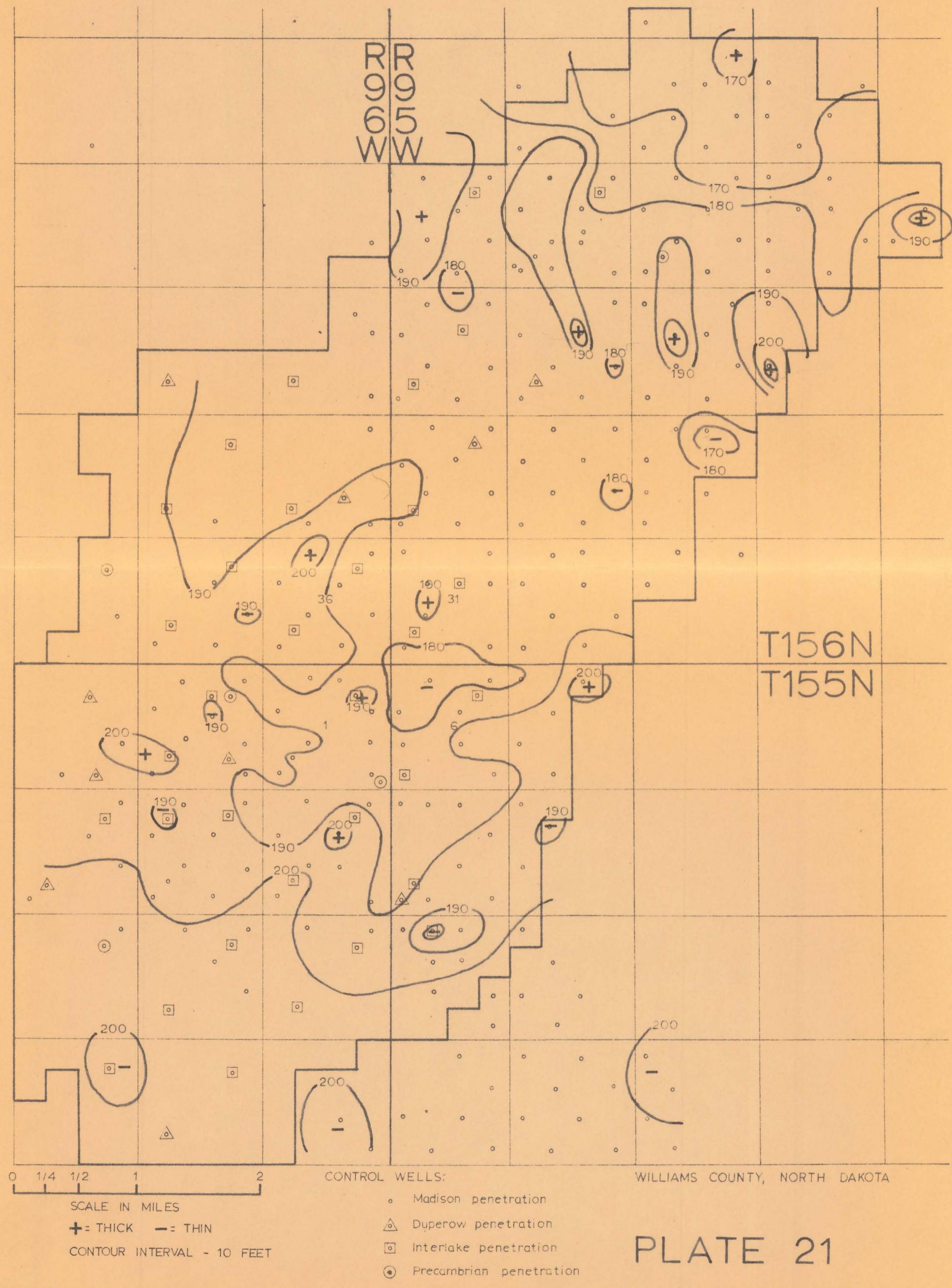
WILLIAMS COUNTY, NORTH DAKOTA

PLATE 2

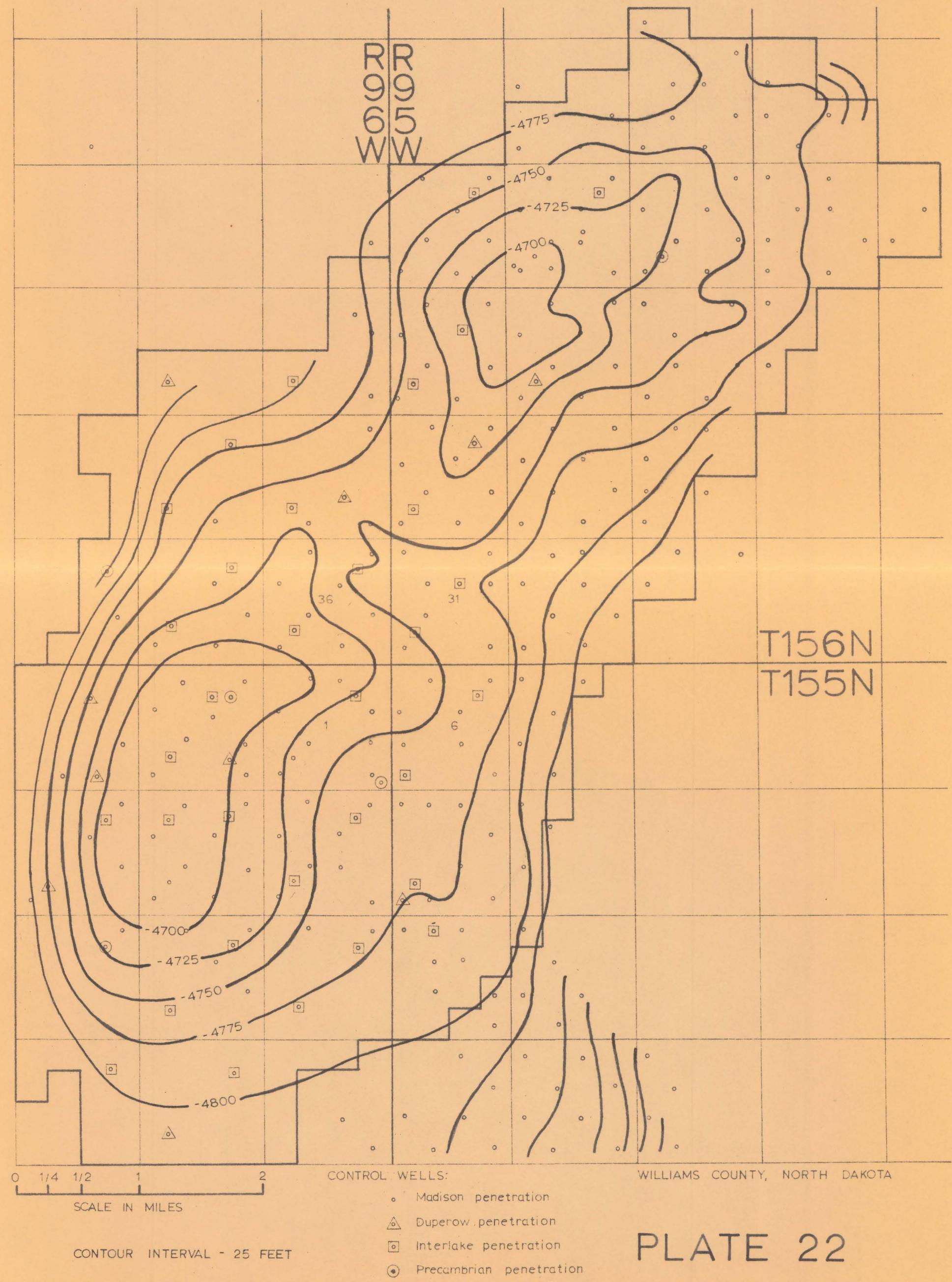
KIBBEY SANDSTONE ISOPACHOUS MAP
BEAVER LODGE FIELD



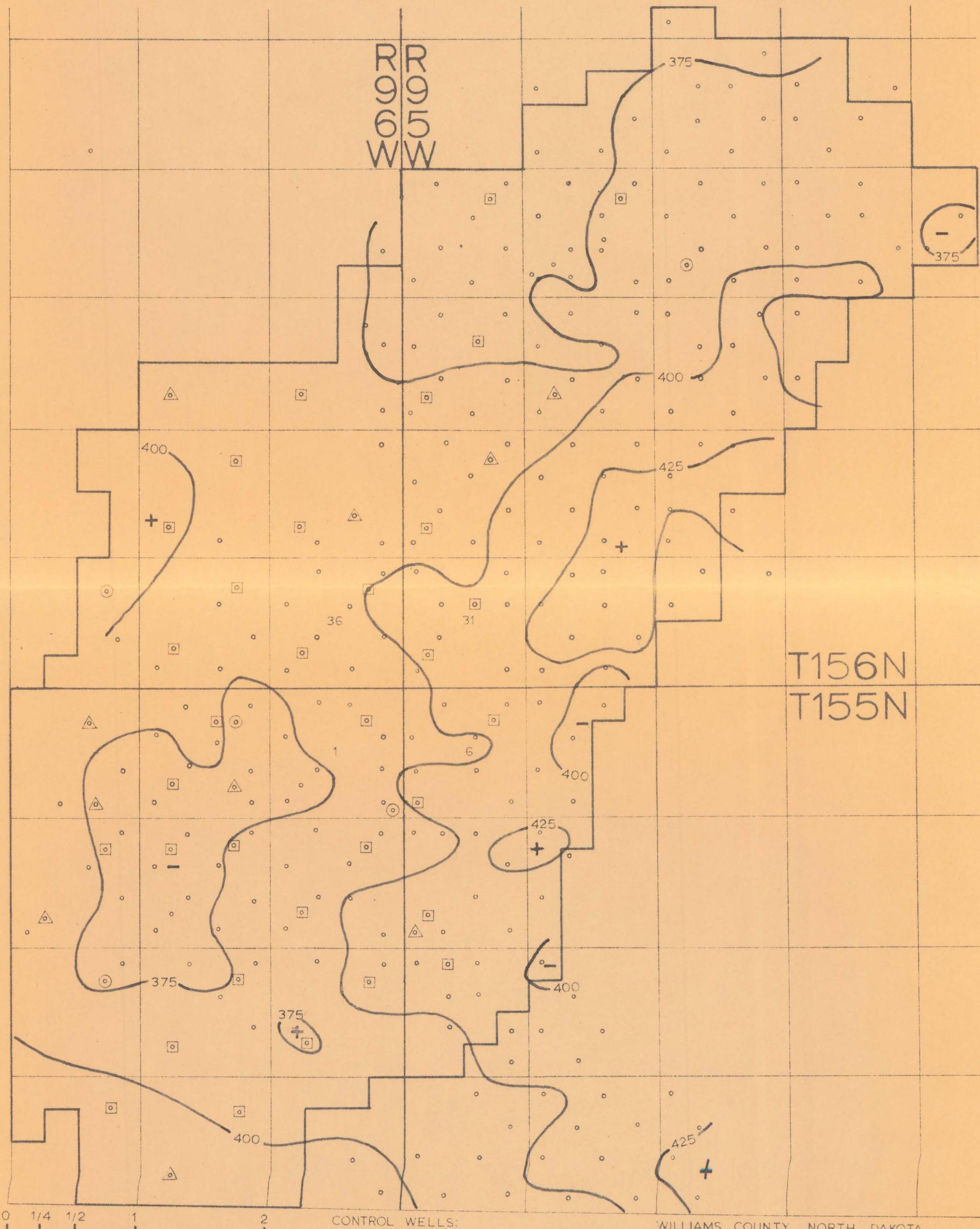
OTTER FORMATION ISOPACHOUS MAP BEAVER LODGE FIELD



CONTOUR MAP TOP OF OTTER
BEAVER LODGE FIELD



PENNSYLVANIAN SYSTEM ISOPACHOUS MAP
BEAVER LODGE FIELD



SCALE IN MILES
+ = THICK - = THIN
CONTOUR INTERVAL - 25 FEET

CONTROL WELLS:

- Madison penetration
- △ Duperow penetration
- Interlake penetration
- Precambrian penetration

WILLIAMS COUNTY, NORTH DAKOTA

PLATE 23

PERMIAN SYSTEM ISOPACHOUS MAP
BEAVER LODGE FIELD

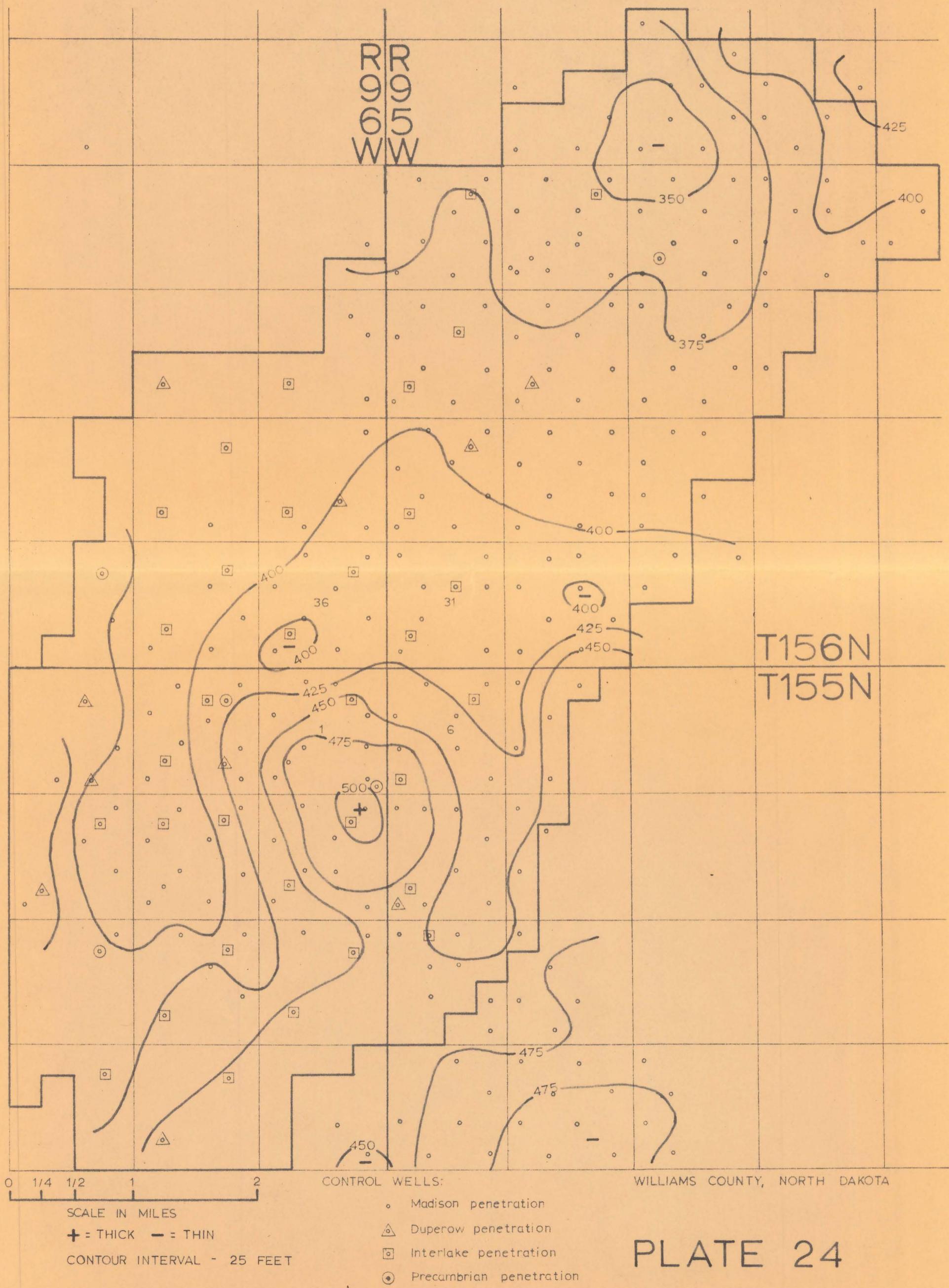
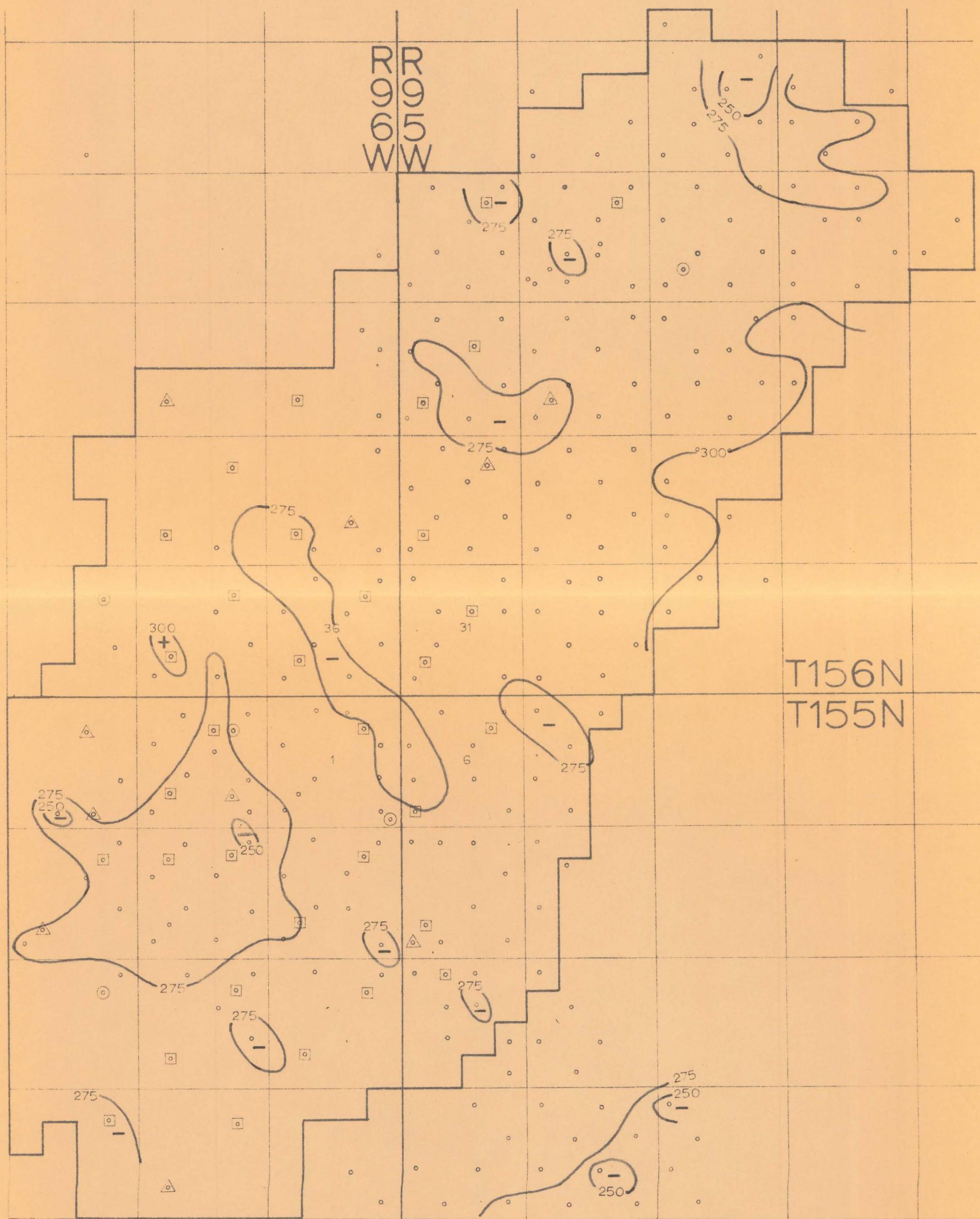


PLATE 24

TRIASSIC SYSTEM ISOPACHOUS MAP

BEAVER LODGE FIELD



0 1/4 1/2 1 2

SCALE IN MILES

+ = THICK - = THIN

CONTOUR INTERVAL - 25 FEET

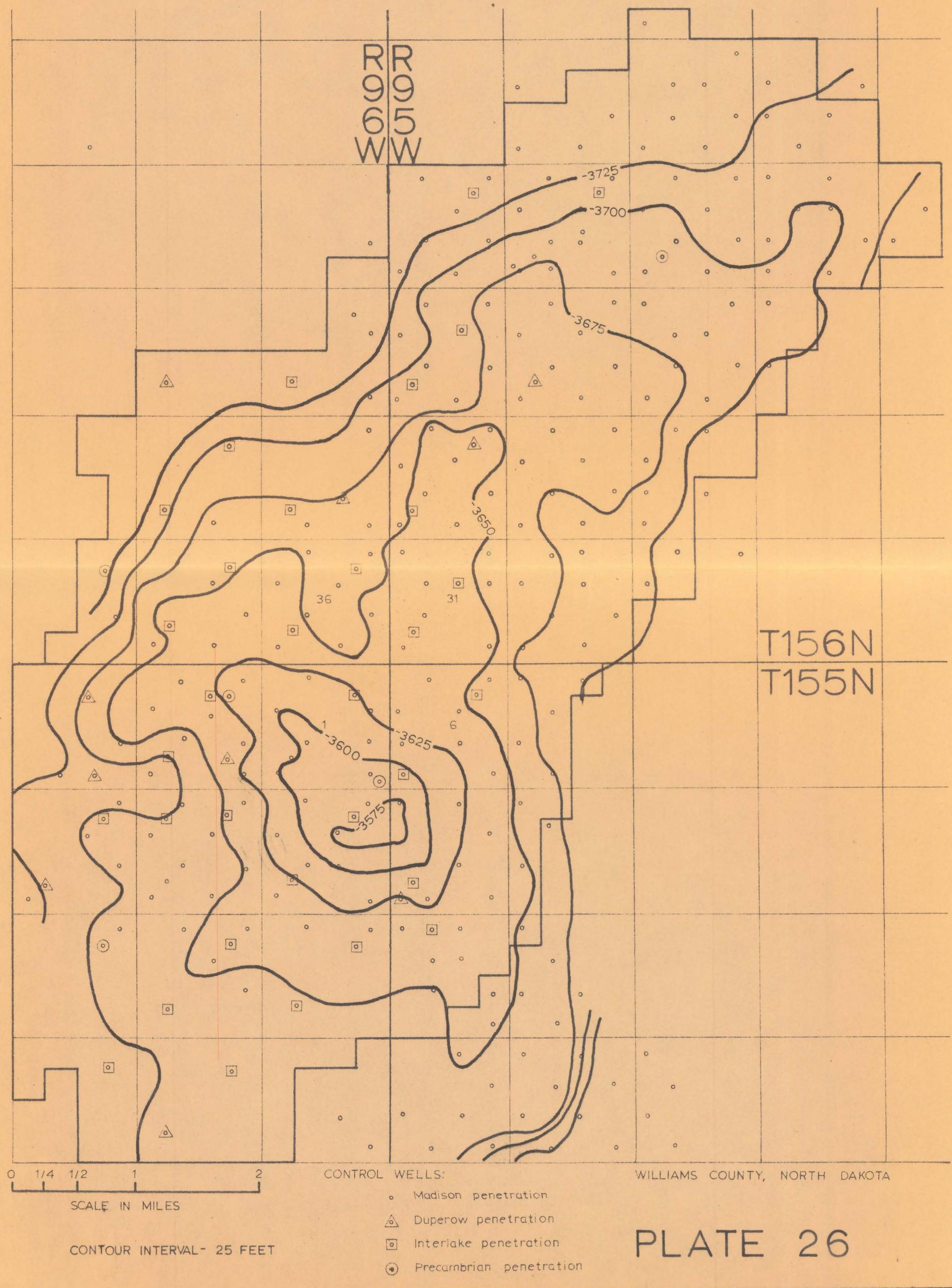
CONTROL WELLS:

- Madison penetration
- △ Duperow penetration
- Interlake penetration
- ◎ Precambrian penetration

WILLIAMS COUNTY, NORTH DAKOTA

PLATE 25

CONTOUR MAP TOP OF SPEARFISH BEAVER LODGE FIELD



JURASSIC SYSTEM ISOPACHOUS MAP
BEAVER LODGE FIELD



DAKOTA GROUP ISOPACHOUS MAP
BEAVER LODGE FIELD

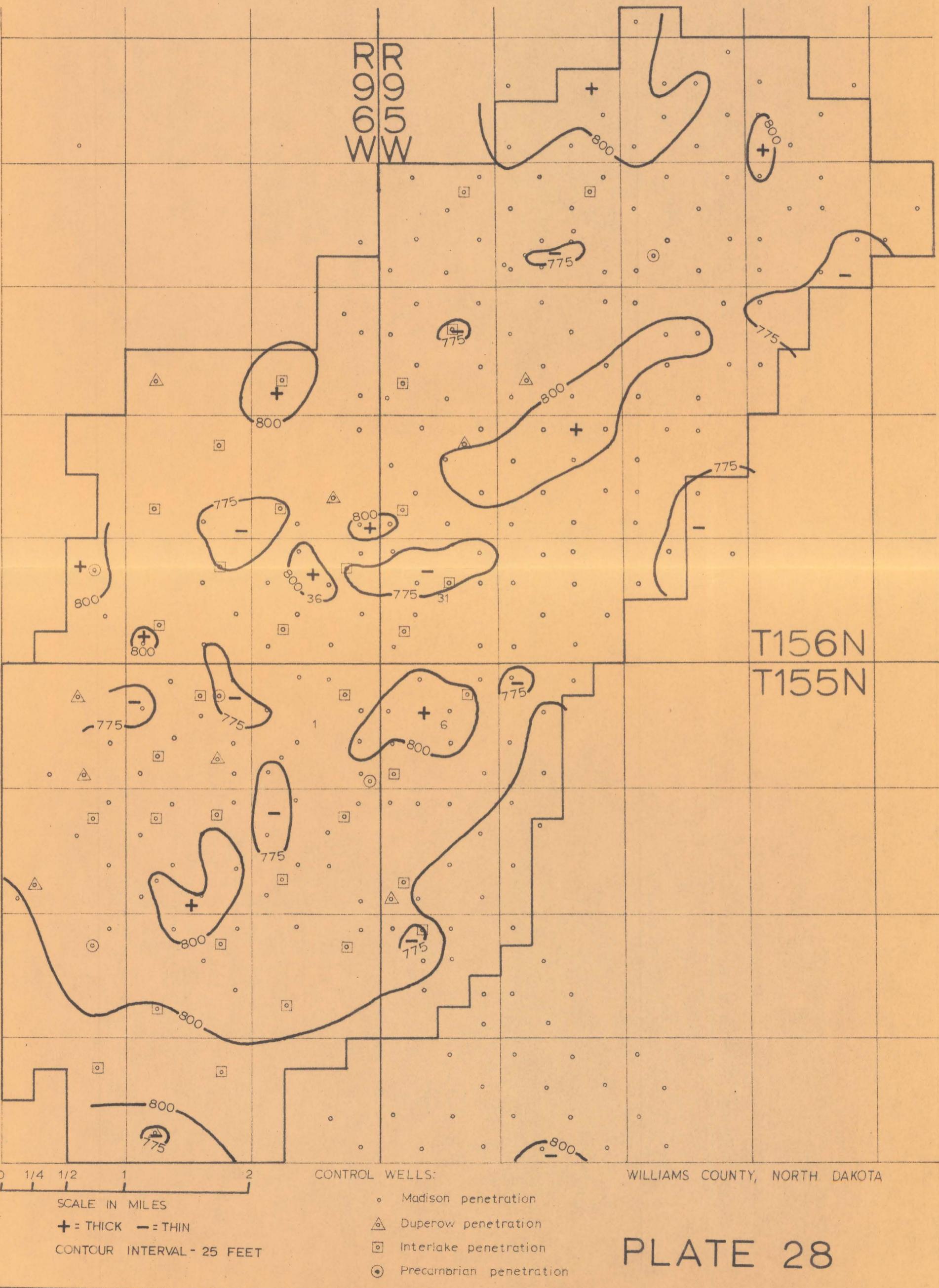
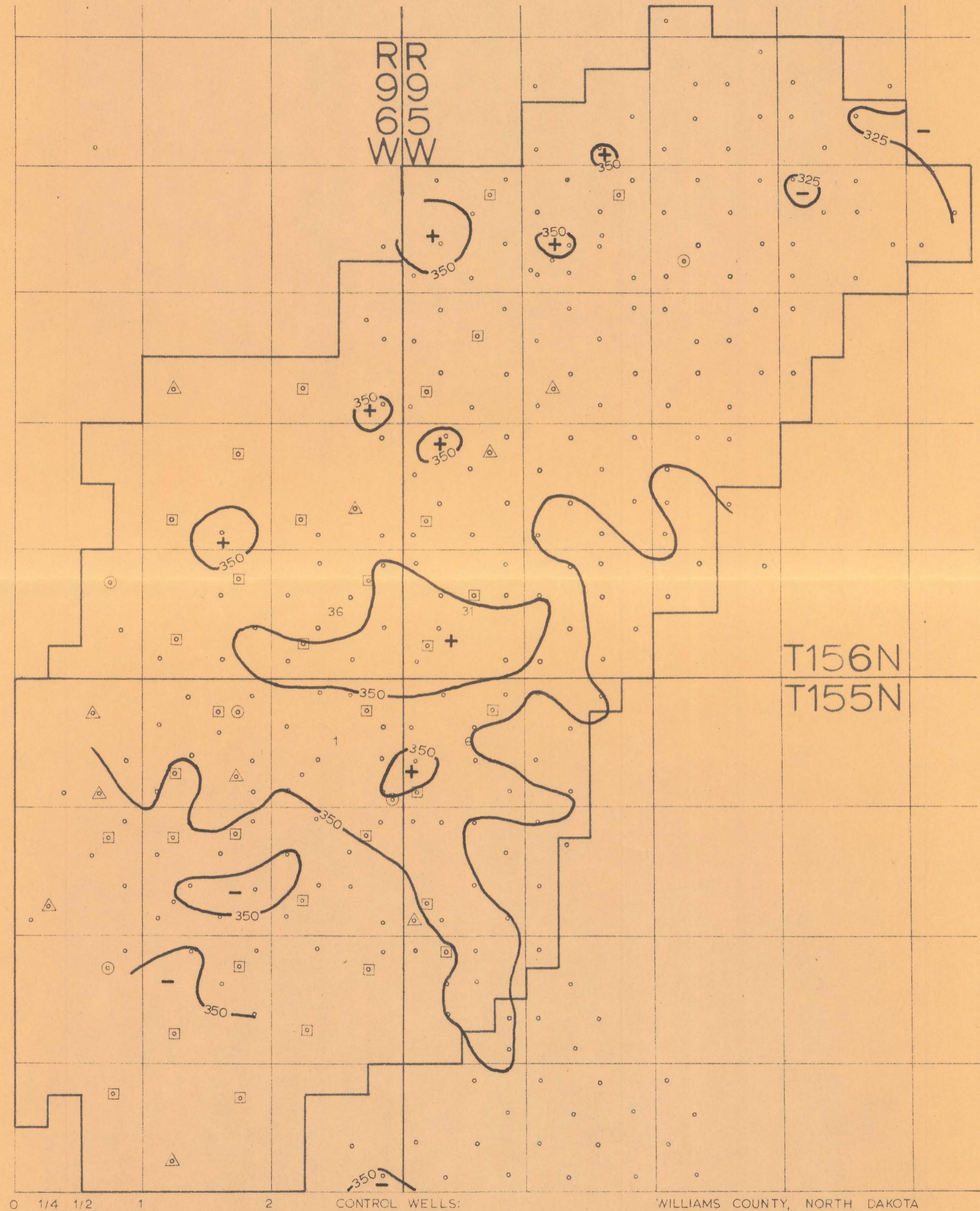


PLATE 28

GREENHORN-BELLE FOURCHE ISOPACHOUS MAP
BEAVER LODGE FIELD



+ = THICK - = THIN

PLATE 29

DEADWOOD FORMATION ISOPACHOUS MAP
BEAVER LODGE FIELD

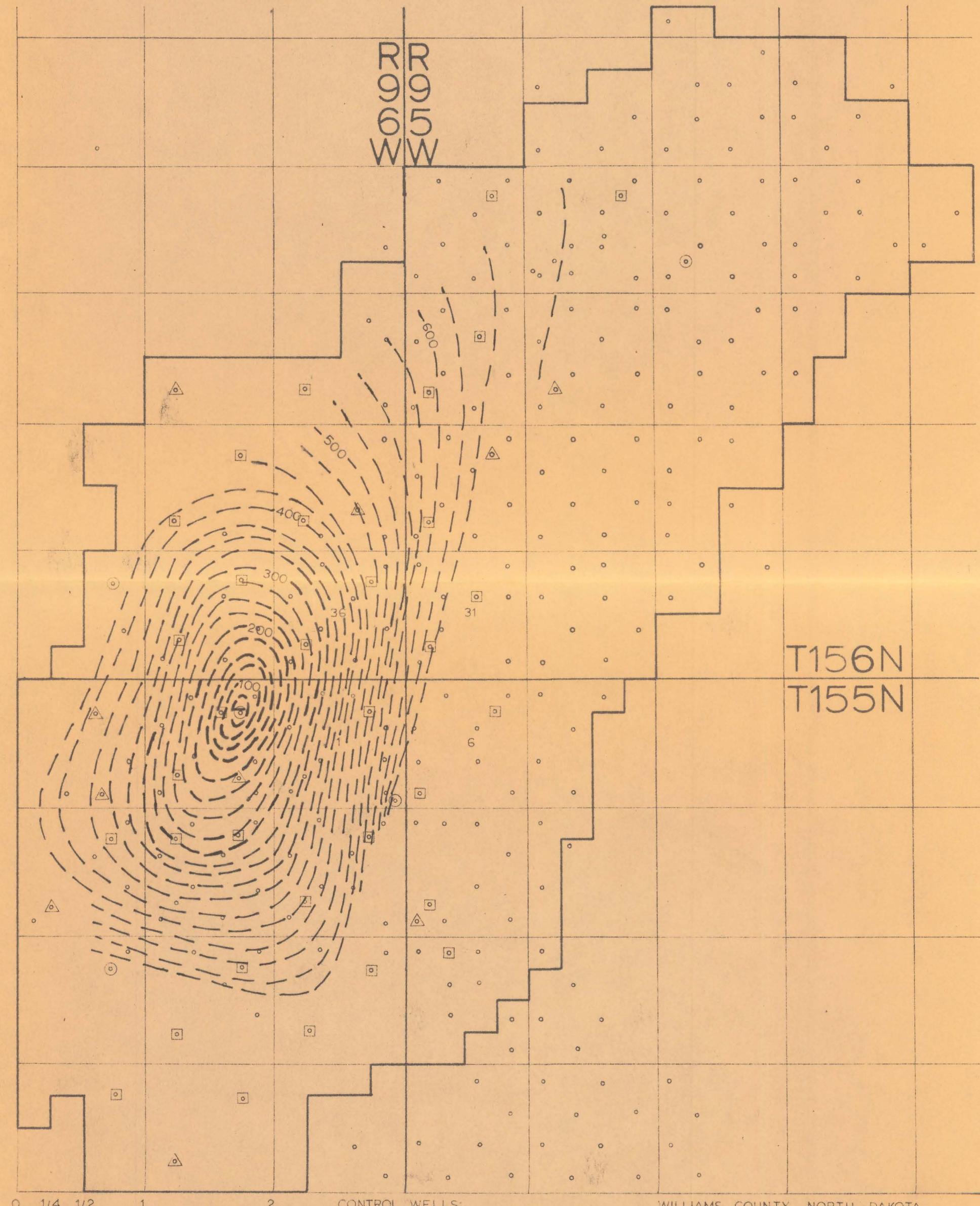


PLATE 3

CONTOUR MAP TOP OF GREENHORN
BEAVER LODGE FIELD

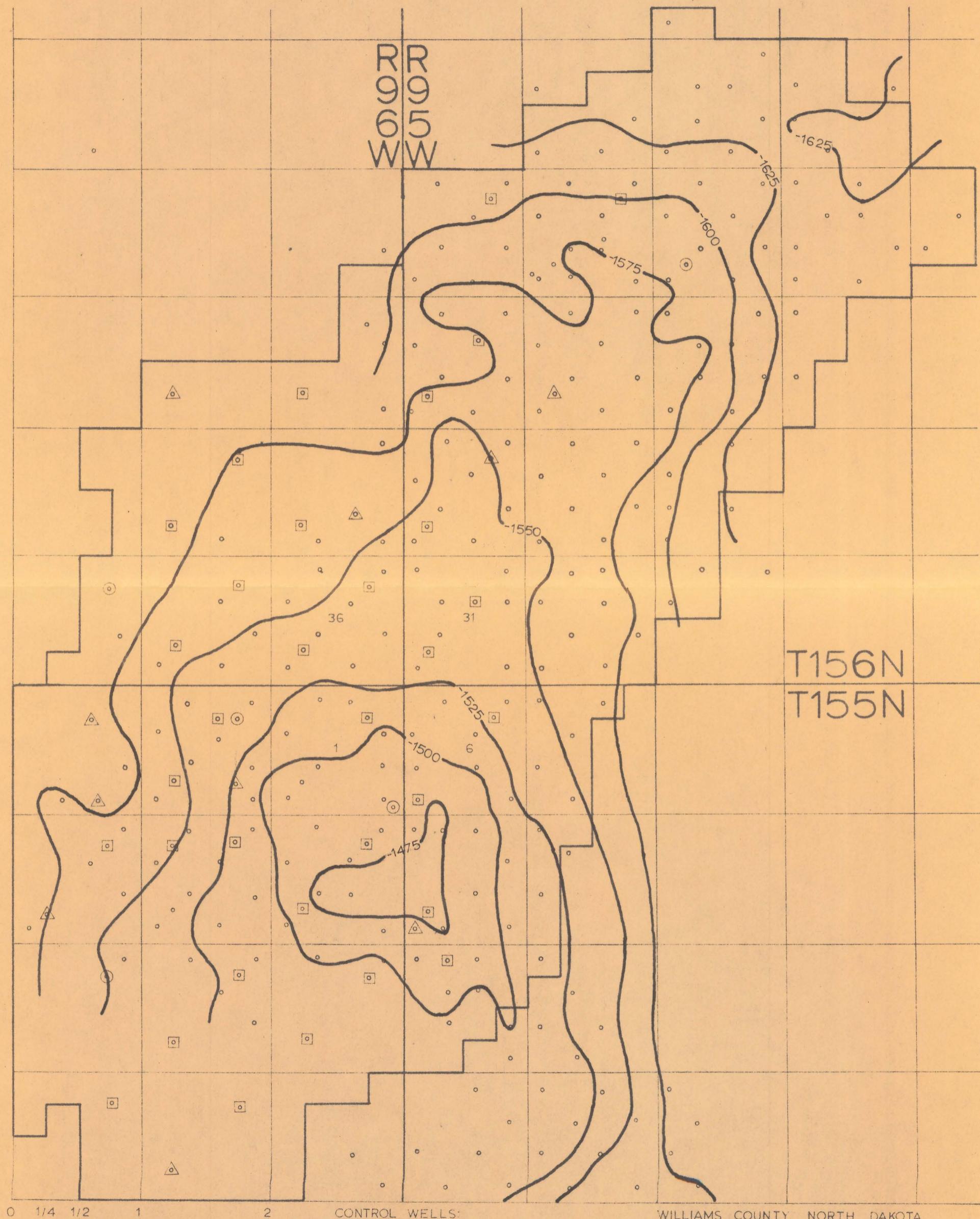
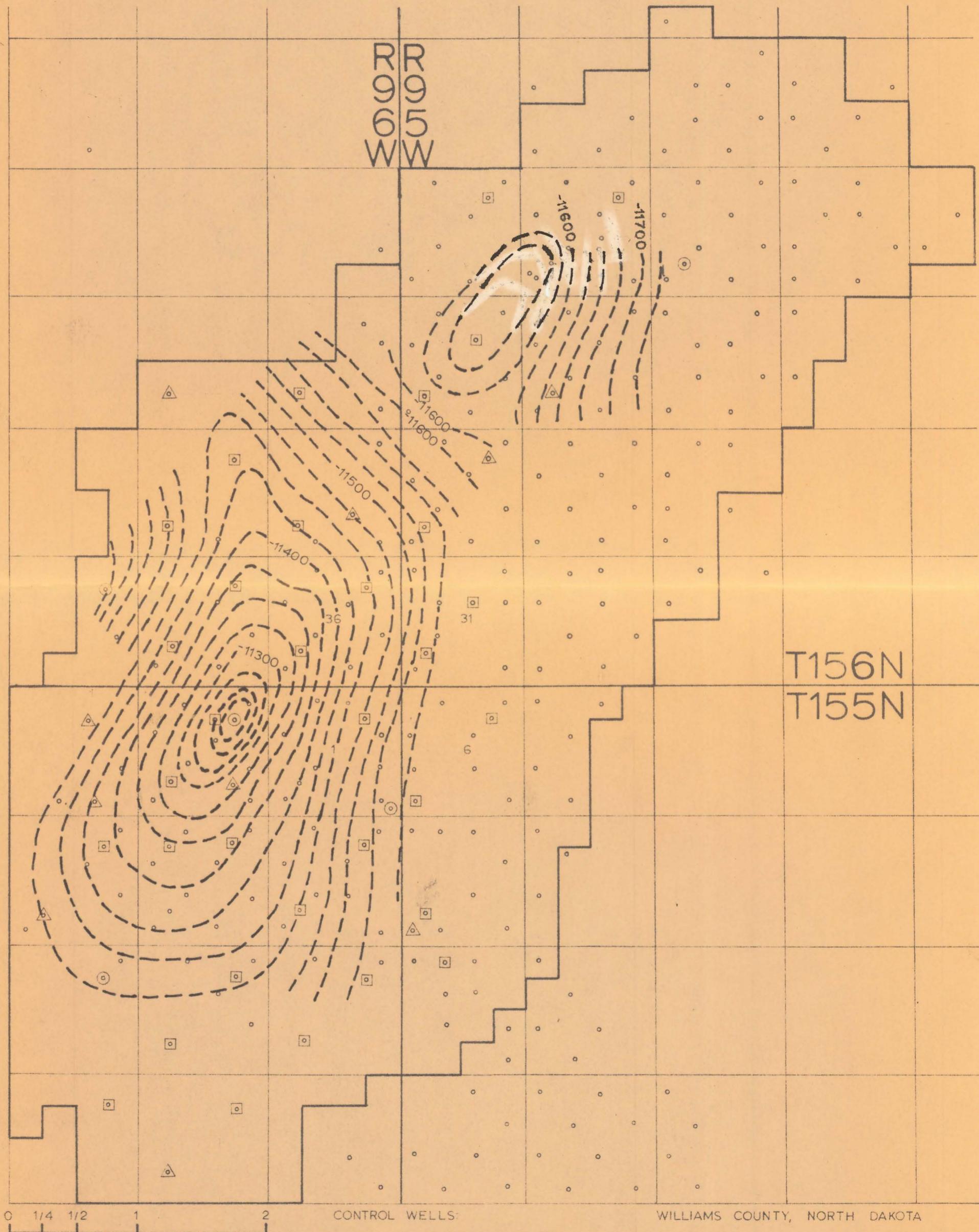


PLATE 30

CONTOUR MAP TOP OF DEADWOOD
BEAVER LODGE FIELD



0 1/4 1/2 1 2

SCALE IN MILES

CONTOUR INTERVAL - 25 FEET

CONTROL WELLS:

- Madison penetration
- △ Duperow penetration
- Interlake penetration
- Precambrian penetration

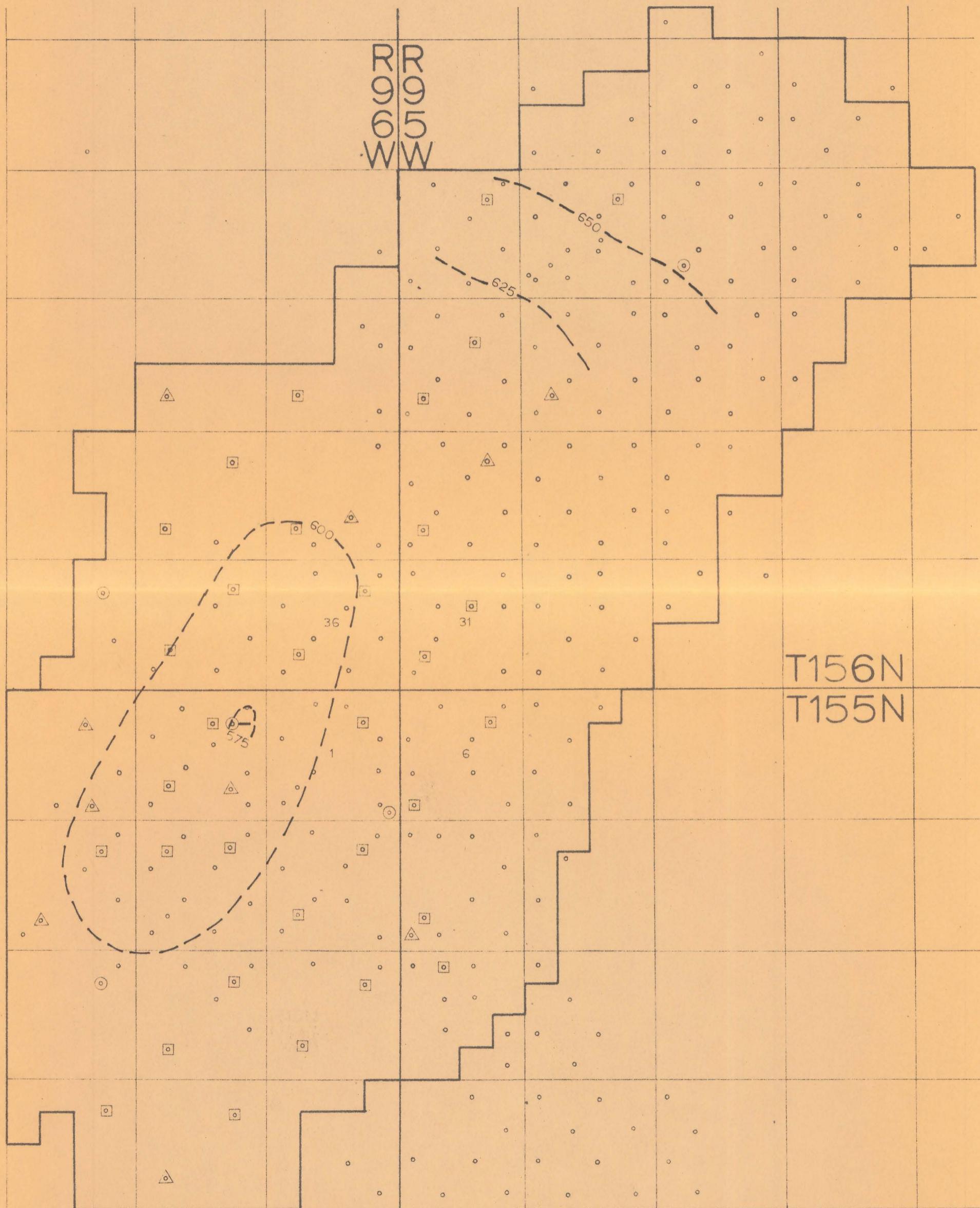
WILLIAMS COUNTY, NORTH DAKOTA

PLATE 4

WINNIPEG GROUP ISOPACHOUS MAP
BEAVER LODGE FIELD



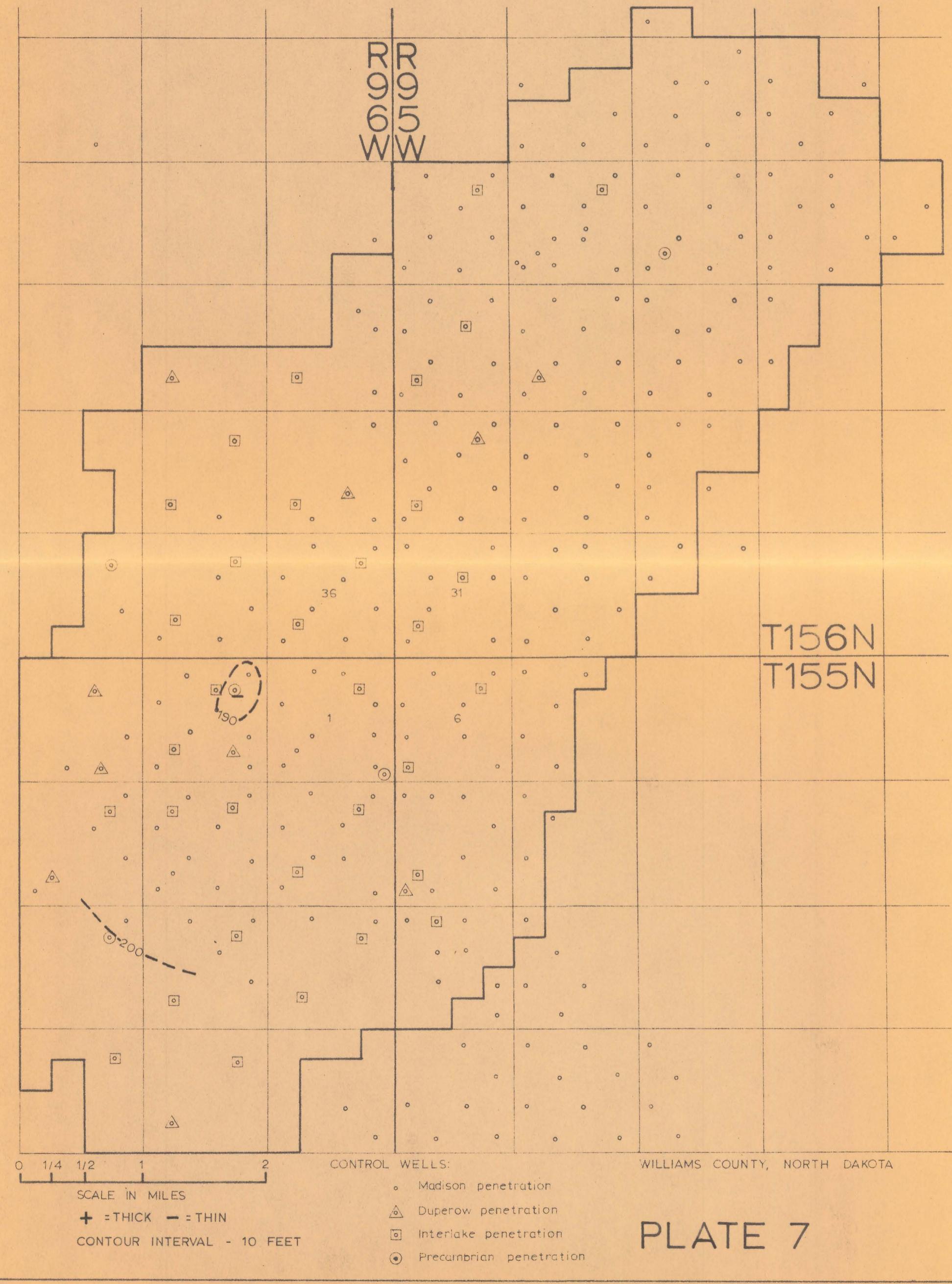
RED RIVER FORMATION ISOPACHOUS MAP
BEAVER LODGE FIELD



WILLIAMS COUNTY, NORTH DAKOTA

PLATE 6

STONY MOUNTAIN FORMATION ISOPACHOUS MAP
BEAVER LODGE FIELD



INTERLAKE-STONEWALL ISOPACHOUS MAP
BEAVER LODGE FIELD

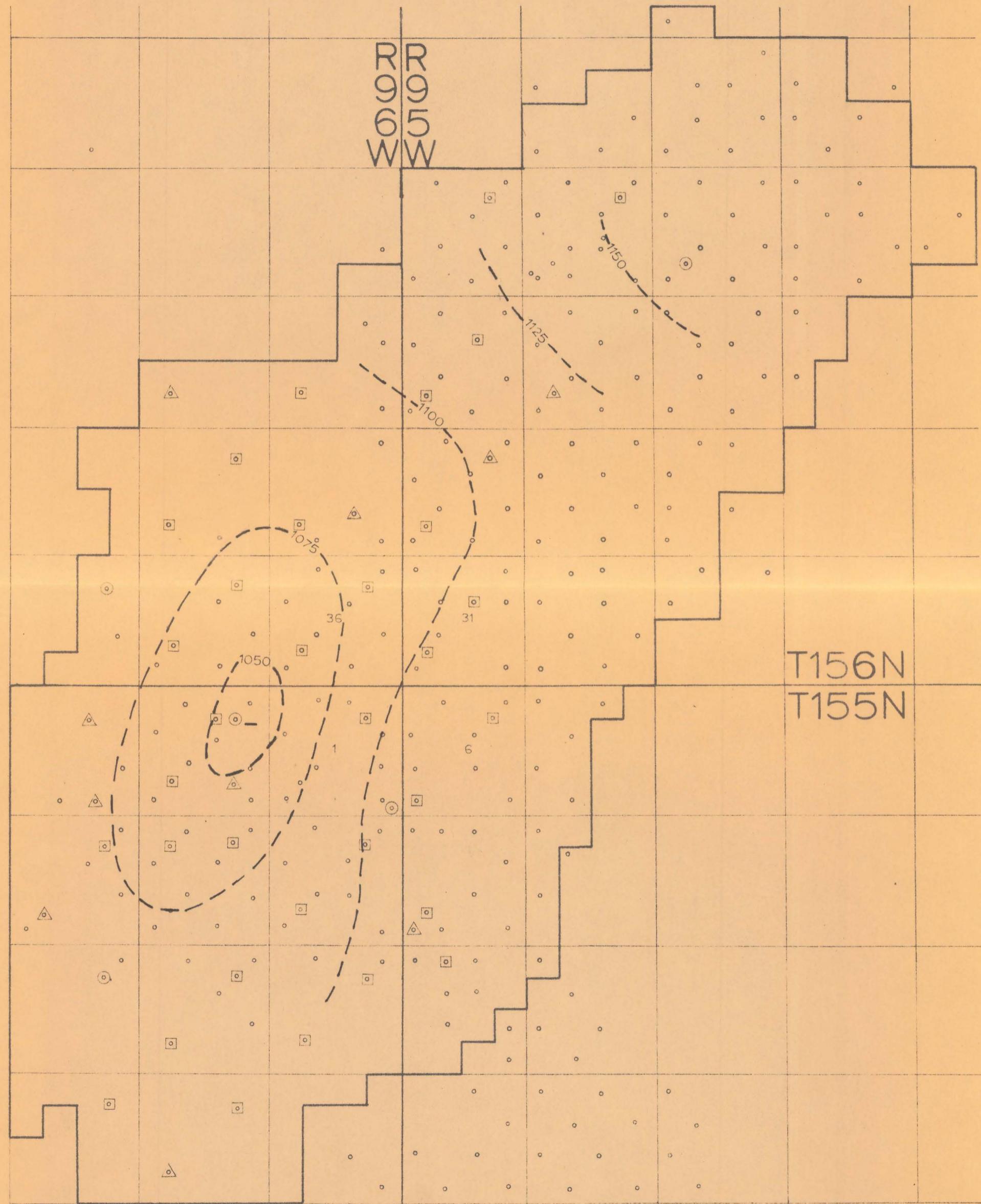


PLATE 8

CONTOUR MAP TOP OF INTERLAKE
BEAVER LODGE FIELD

