

**MINNESOTA GEOLOGICAL SURVEY**

*Matt Walton, Director*

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***Information Circular 14***

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**INDEX TO  
GEOPHYSICAL INVESTIGATIONS  
IN  
MINNESOTA**



**UNIVERSITY OF MINNESOTA**

Saint Paul

1978



**INDEX TO  
GEOPHYSICAL INVESTIGATIONS  
IN  
MINNESOTA**

**By  
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# INTRODUCTION

This report was prepared for the Conference on Geophysics in Minnesota, May 1-2, 1978, at the Radisson Hotel, St. Paul, Minnesota. The purpose of this conference is to discuss the future direction for applied geophysical investigations in the State of Minnesota. This report was prepared as a source of background information on the present status of geophysical studies in the State. A detailed search for information on all aspects of geophysical investigations in Minnesota was undertaken. This report is concerned primarily with geophysical studies involving one or more of the following methods: electrical; electromagnetic; gravity; magnetic; seismic; and radioactive. For the first five topics, an index map and a list of references to areas studied in the state are provided. An index map to Radioactive investigations was not compiled because the numerous small areas of investigations by several investigators make it unfeasible.

Also included in this report are selected references to miscellaneous geophysical investigations of a general nature, paleomagnetic studies, and references to studies on the Midcontinent Gravity High of which geophysics has played an important role.

## ACKNOWLEDGMENTS

My sincerest thanks to Thomas Geskermann for his endless library search for obscure references and to Phillip Davis for his diligent and patient drafting of the illustrations under the supervision of Betty Keeler. Richard Darling drafted the figure captions and title pages. John Spletstoesser edited the references and Linda McDonald typed several versions of the manuscript.

Thanks also to David Meineke who provided the information for the compilation of figures 3,5,8, and 13 and to Phillip Davis, Timothy Wahl, David Meineke, G.B. Morey, and Matt Walton for their many helpful suggestions.

This study was funded by the State of Minnesota, Legislative Commission on Minnesota Resources.

# **BEDROCK GEOLOGY INVESTIGATIONS**



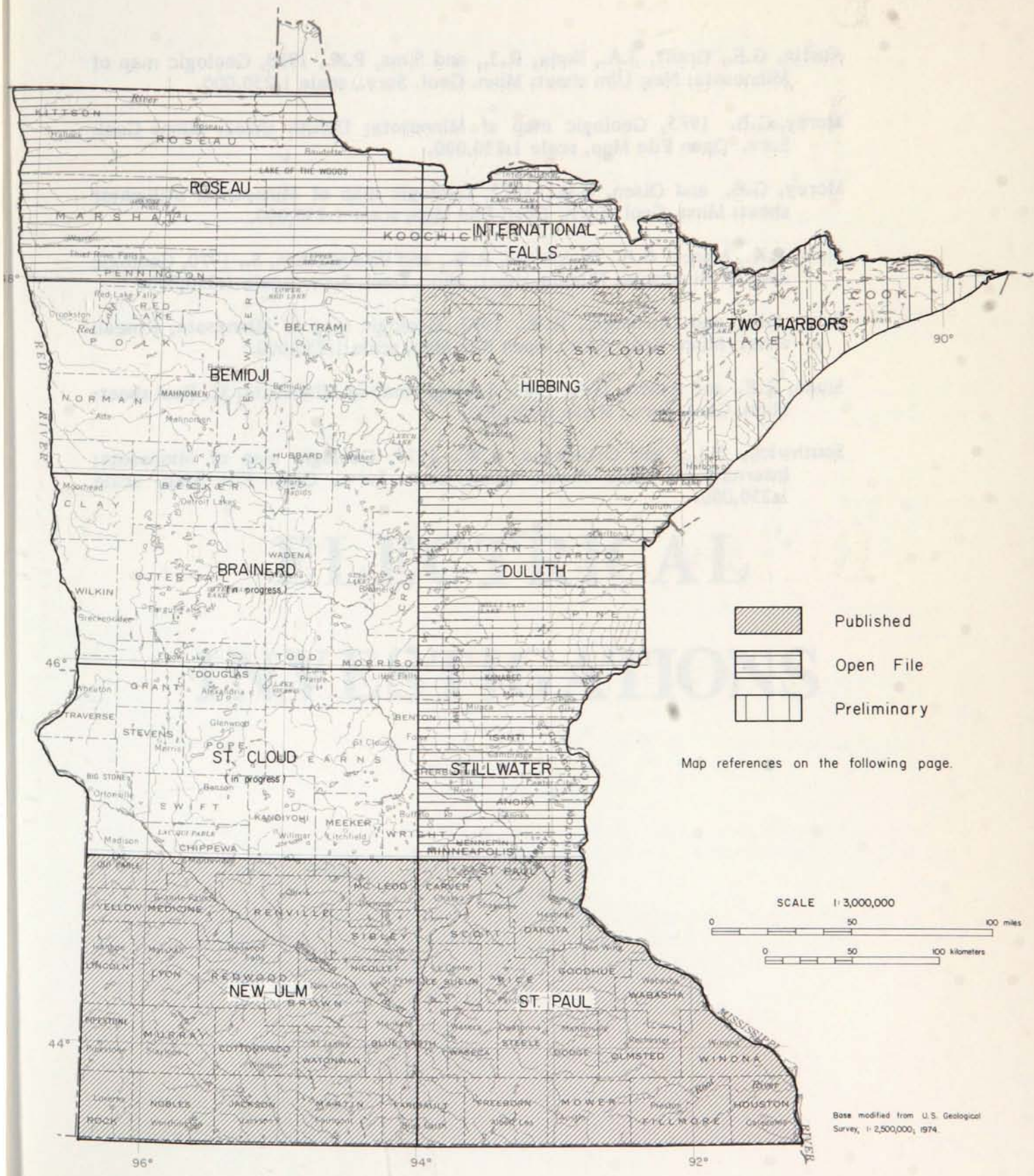
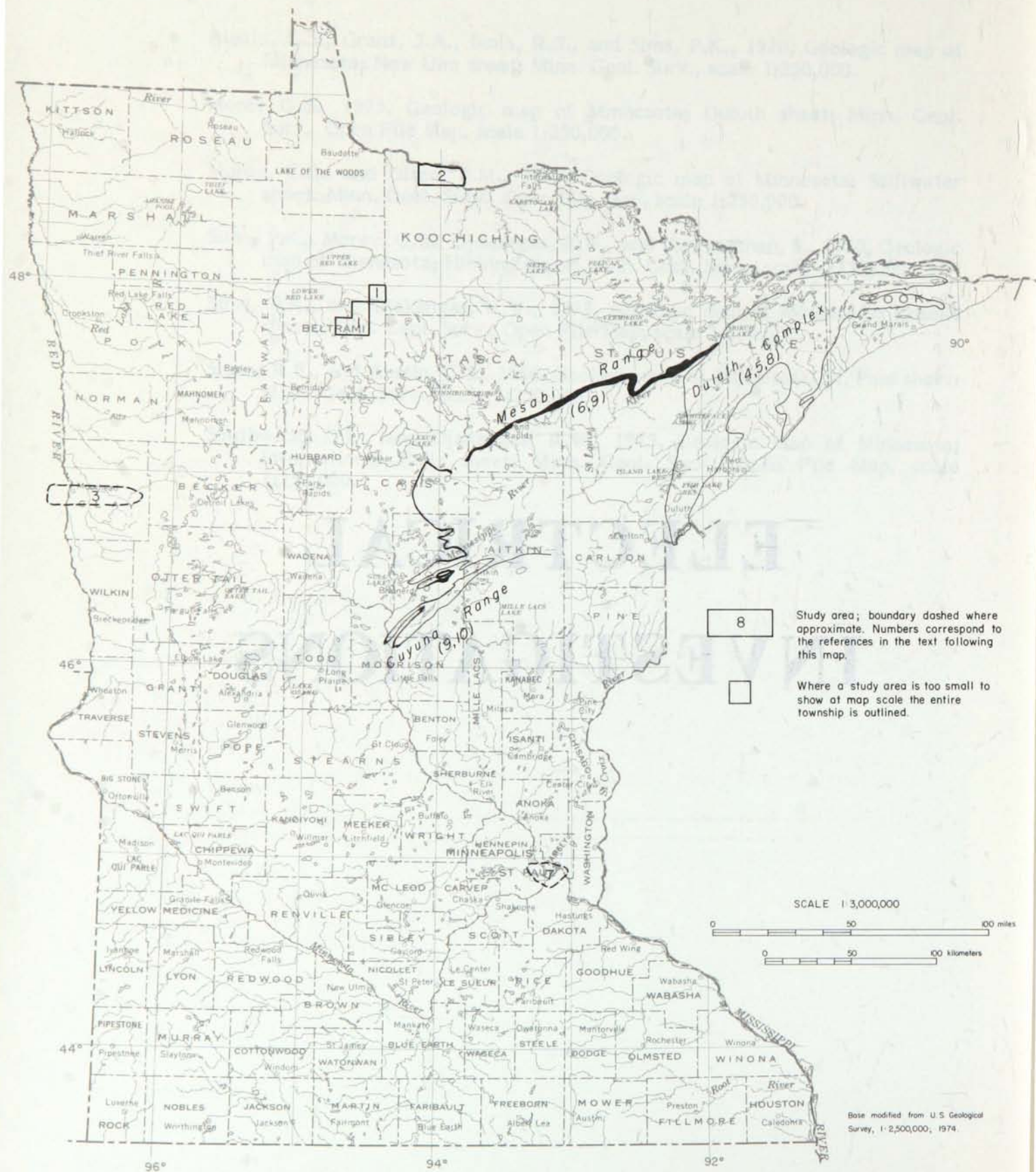


Figure 1 - Status of the Minnesota Geological Survey 1:250,000 Bedrock Geology mapping program.

- Austin, G.S., Grant, J.A., Ikola, R.J., and Sims, P.K., 1970, Geologic map of Minnesota; New Ulm sheet: Minn. Geol. Surv., scale 1:250,000.
- Morey, G.B. 1975, Geologic map of Minnesota; Duluth sheet: Minn. Geol. Surv. Open File Map, scale 1:250,000.
- Morey, G.B. and Olsen, B.M., 1975, Geologic map of Minnesota: Stillwater sheet: Minn. Geol. Surv. Open File Map, scale 1:250,000.
- Sims, P.K., Morey, G.B., Ojakangas, R.W., and Viswanathan, S., 1970, Geologic map of Minnesota; Hibbing sheet: Minn. Geol. Surv., scale 1:250,000.
- Sims, P.K., and Ojakangas, R.W., 1973, Geologic map of Minnesota; Roseau sheet: Minn. Geol. Surv., Open File Map, scale 1:250,000.
- Sloan, R.E., and Austin, G.S., 1966, Geologic map of Minnesota: St. Paul sheet: Minn. Geol. Surv., scale 1:250,000.
- Southwick, D.L., and Ojakangas, R.W., 1973, Geologic map of Minnesota; International Falls sheet: Minn. Geol. Surv., Open File Map, scale 1:250,000.

# **ELECTRICAL INVESTIGATIONS**





8

Study area; boundary dashed where approximate. Numbers correspond to the references in the text following this map.

□

Where a study area is too small to show at map scale the entire township is outlined.

SCALE 1:3,000,000



Base modified from U.S. Geological Survey, 1:2,500,000, 1974.

Figure 2 - Map index of Electrical investigations.

- Keller, G.V., Zablocki, C.J., and Frischknecht, F.C., 1958, Electrical methods of geophysical prospecting in the Lake Superior district (abstr.): in Inst. Lake Superior Geol., 4th Annu. Mtg., Minneapolis, April 21-22, 1958, Univ. Minn., Center for Continuation Study, p. 3.
- 1 Meineke, D.G., and Listerud, W.H., 1976, Mineral compilation of southern Beltrami County: Minn. Dept. Nat. Resour., Div. Minerals, Map 86.
  - 2 Meineke, D.G., Vadis, M.K., and Gilgosh, M.A., 1976, Geophysical surveys conducted in northwestern Koochiching County, Minnesota: Minn. Dept. Nat. Resour., Div. Minerals, Minerals Explor. Sect., Rep. 36-8, 10 p.
  - 3 Pye, W.D., 1957, Geological and geophysical studies, Red River Valley, Minnesota and North Dakota (abstr.): Geol. Soc. Am., Bull., v. 68, n. 12, pt. 2, p. 1871.
  - 4 Ryu, J., Ward, S.H., Nash, W.P., and Buzzell, D., 1973, K and Tan  $\delta$  spectra of dry lunar analog measured by various techniques: in The electrical parameters of rocks: Geophysics, v. 38, n. 1, p. 125-134.
  - 5 Seguin, M.K., 1972, Decouverte d'importantes reserves de sulfures de cuivre et de nickel dans le Gabbro de Duluth, region nord-est de l'état du Minnesota (Discovery of important reserves of copper and nickel sulfides in the Duluth gabbro, northeastern Minnesota): Nat. Can., v. 99, n. 1, p. 49-58.
  - 6 Walle, M.P., 1942, Research on the Iron Ranges: The Conservation Volunteer, v. 5, n. 27, p. 6-9.
  - 7 Wilcox, S.W., and Schwartz, G.M., 1934, Reconnaissance of buried river gorges by the earth-resistivity method: Econ. Geol., v. 29, n. 5, p. 435-453.
  - 8 Zablocki, C.J., 1961, Electrical properties of sulfide-mineralized gabbro, St. Louis County, Minnesota: in Geological Survey Research 1961: U.S. Geol. Surv., Prof. Pap. 424-C, p. C256-C258.
  - 9 Zablocki, C.J., 1966, Electrical properties of some iron formations and adjacent rocks in the Lake Superior region: in Mining Geophysics, Soc. Explor. Geophys., v. 1, p. 465-492.
  - 10 Zablocki, C.J., and Keller, G.V., 1957, Borehole geophysical logging methods in the Lake Superior district: in Seventh Annual Drilling Symposium; Exploration Drilling, Oct. 3-5, 1957, Univ. Minn., Center for Continuation Study, p. 15-24.



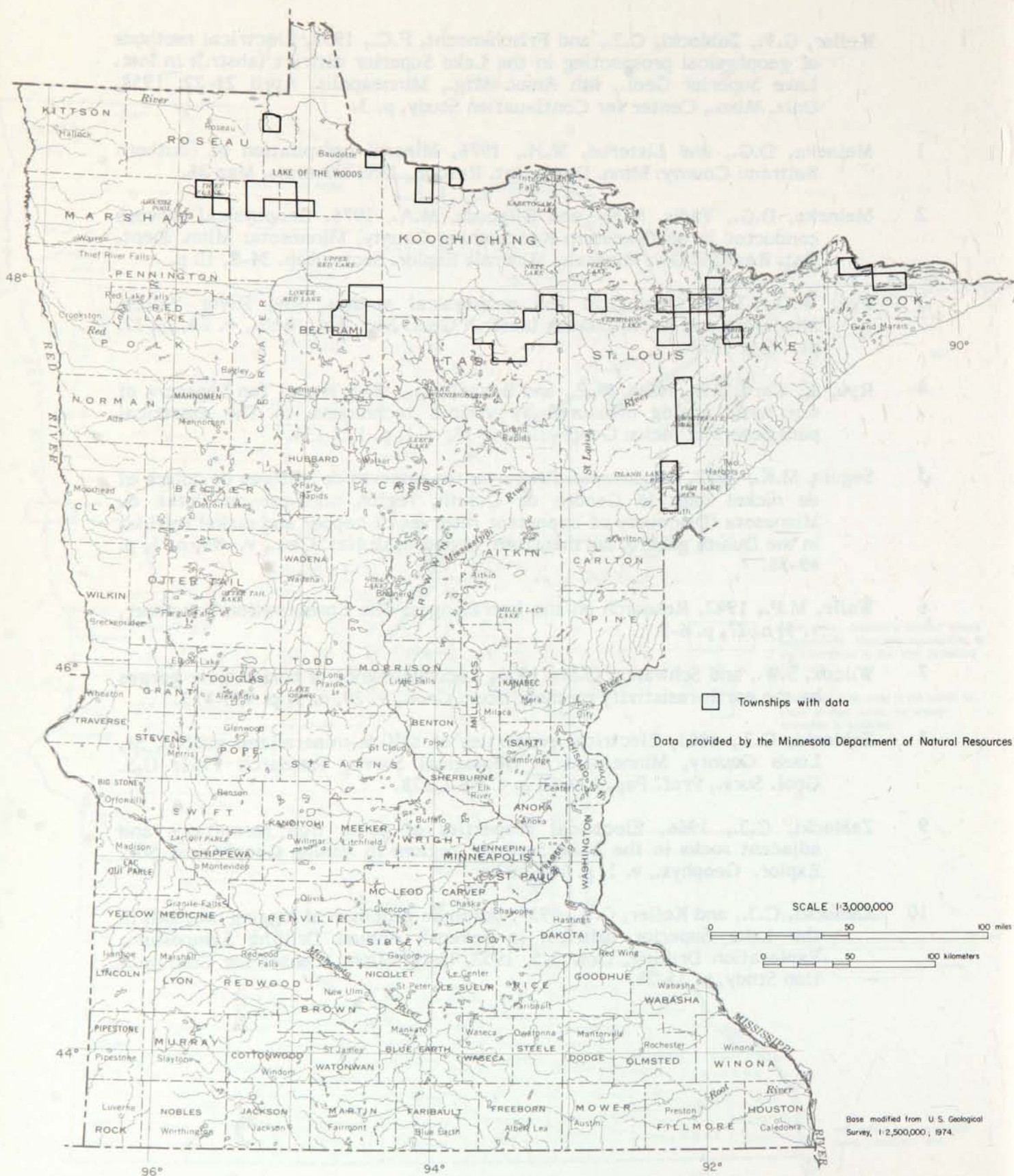
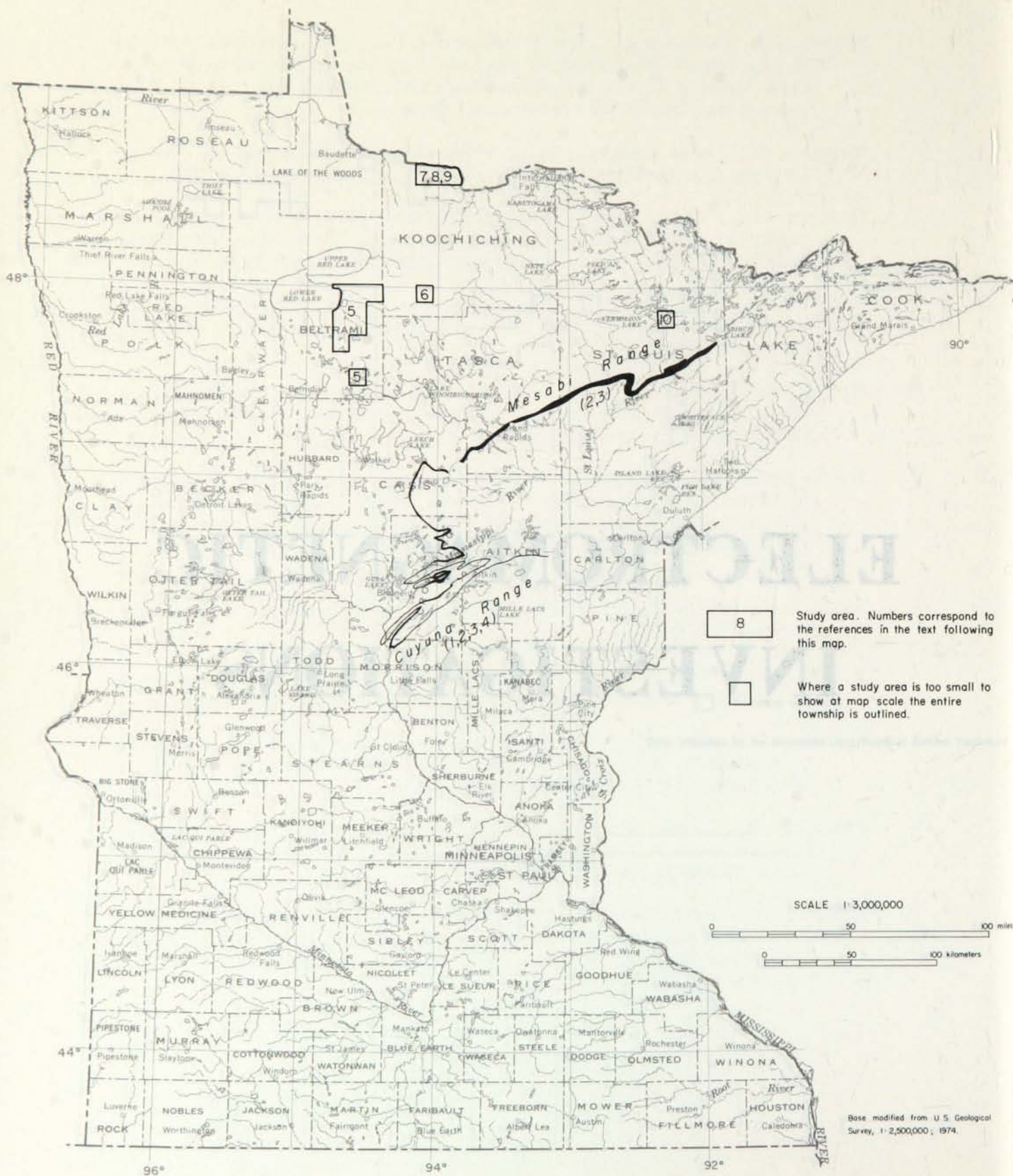


Figure 3 - Map index of Electrical data available at the Minnesota Department of Natural Resources, Division of Minerals.

# **ELECTROMAGNETIC INVESTIGATIONS**





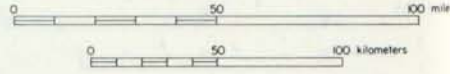
8

Study area. Numbers correspond to the references in the text following this map.

□

Where a study area is too small to show at map scale the entire township is outlined.

SCALE 1:3,000,000



Base modified from U.S. Geological Survey, 1:2,500,000; 1974.

Figure 4-Map index of Electromagnetic investigations.



- 1 Frischknecht, F.C., and Ekren, E.B. 1959, Electromagnetic studies of the Lake Superior iron ranges (abstr.): in *Inst. Lake Superior Geol., 5th Annu. Mtg., Minneapolis, April 13-14, 1959, Univ. Minn., Center for Continuation Study*, p. 5.
  - 2 Frischknecht, F.C., and Ekren, E.B.; 1960, Mapping conductive strata by electromagnetic methods: in *Geological Survey Research 1960: U.S. Geol. Surv., Prof. Pap. 400-B*, p. B121-B125.
  - 3 Frischknecht, F.C., and Ekren, E.B., 1961, Electromagnetic studies of iron formations in the Lake Superior region: *Min. Eng.*, v. 13, p. 1157-1162.
  - 4 Frischknecht, F.C., and Ekren, E.B., 1963, Evaluation of magnetic anomalies by electromagnetic measurements: *U.S. Geol. Surv., Prof. Pap. 475-C*, p. C117-C120.
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- 5 Meineke, D.G., and Listerud, W.H., 1976, Mineral compilation of southern Beltrami County: *Minn. Dept. Nat. Resour., Div. Minerals, Map 86*.
  - 6 Meineke, D.G., and Listerud, W.H., 1976, Mineral compilation of southwestern Koochiching County: *Minn. Dept. Nat. Resour., Div. Minerals, Map 87*.
  - 7 Meineke, D.G., and Vadis, M.K., 1977, Geophysical profiles; Manitou Rapids area: *Minn. Dept. Nat. Resour., Div. Minerals, Proj. 41, 22 p., maps*.
  - 8 Meineke, D.G., and Vadis, M.K., 1977, Geophysical and geochemical surveys; Indus school site: *Minn. Dept. Nat. Resour., Div. Minerals, Proj. 149, 15 p., map*.
  - 9 Meineke, D.G., Vadis, M.K., and Gilgosh, M.A., 1976, Geophysical surveys conducted in northwestern Koochiching County, Minnesota: *Minn. Dept. Nat. Resour., Div. Minerals, Minerals Explor. Sect., Rep. 36-8, 10 p.*
  - 10 Ward, S.H., Anderson, G.J., Randolph, E.R., and Blake, R.L., 1955, The inductive electromagnetic method applied to iron exploration: *Min. Eng.*, v. 7, n. 12, p. 1121-1126.

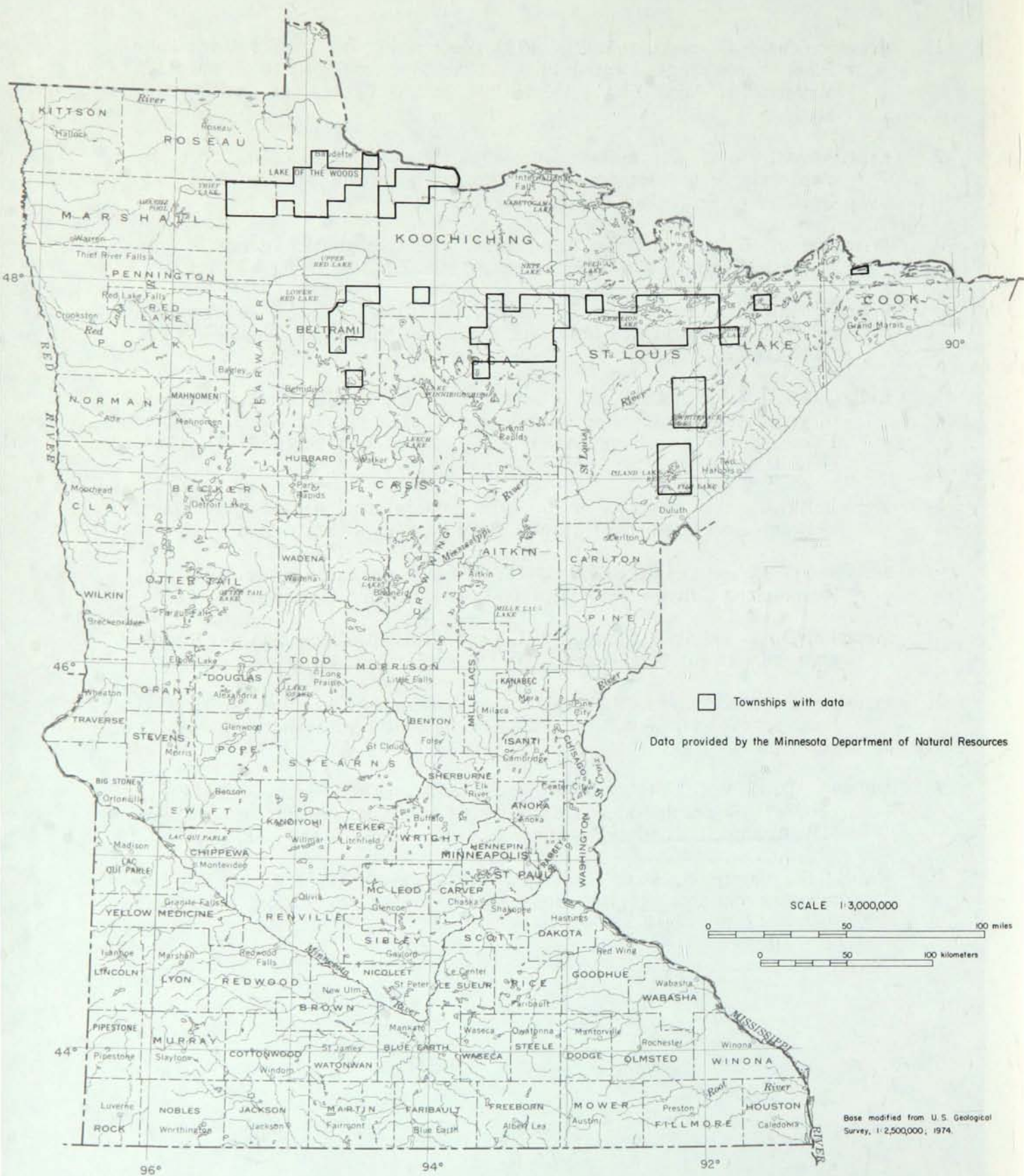


Figure 5 - Map index of Electromagnetic data available at the Minnesota Department of Natural Resources, Division of Minerals.

# **GRAVITY INVESTIGATIONS**



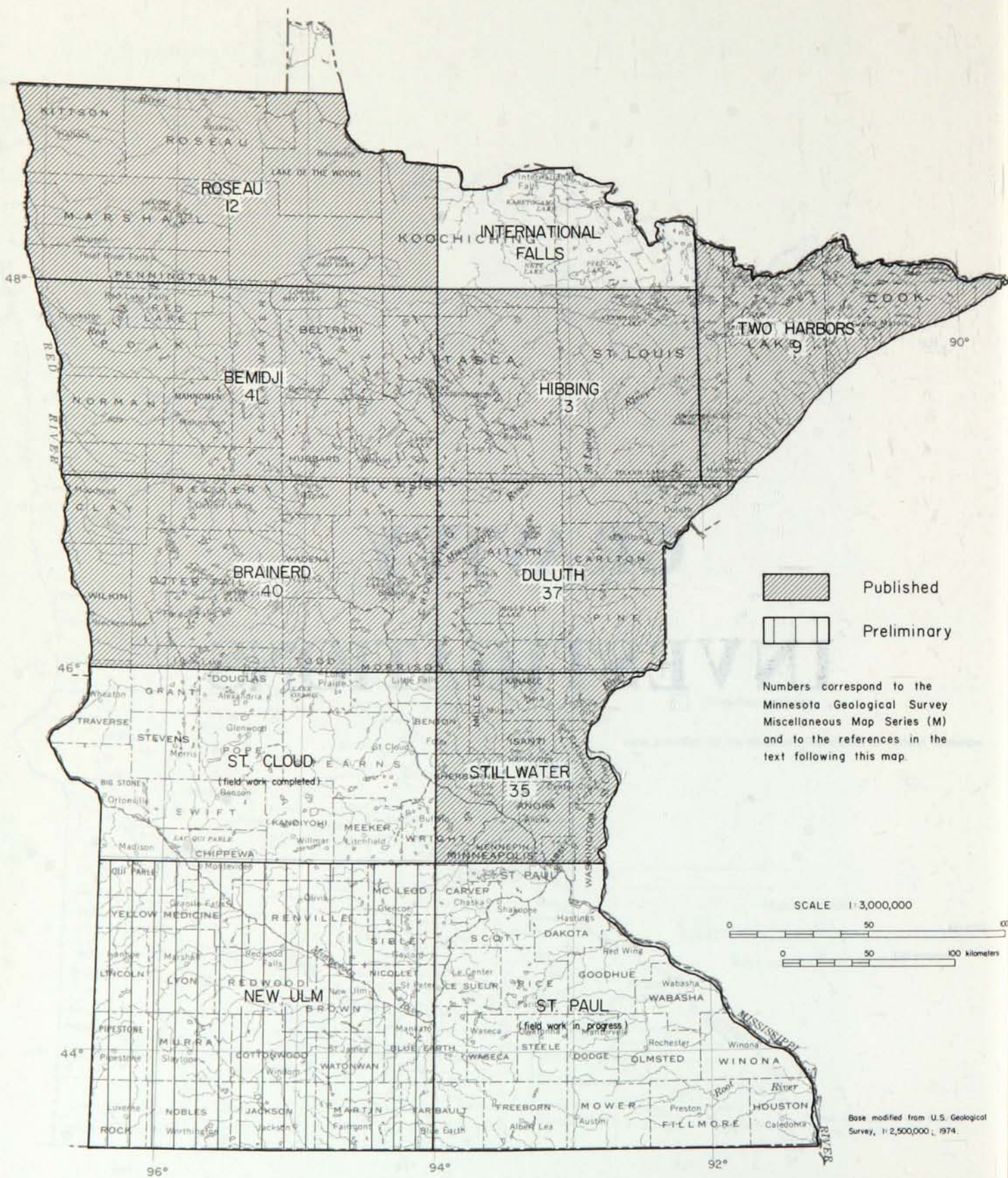
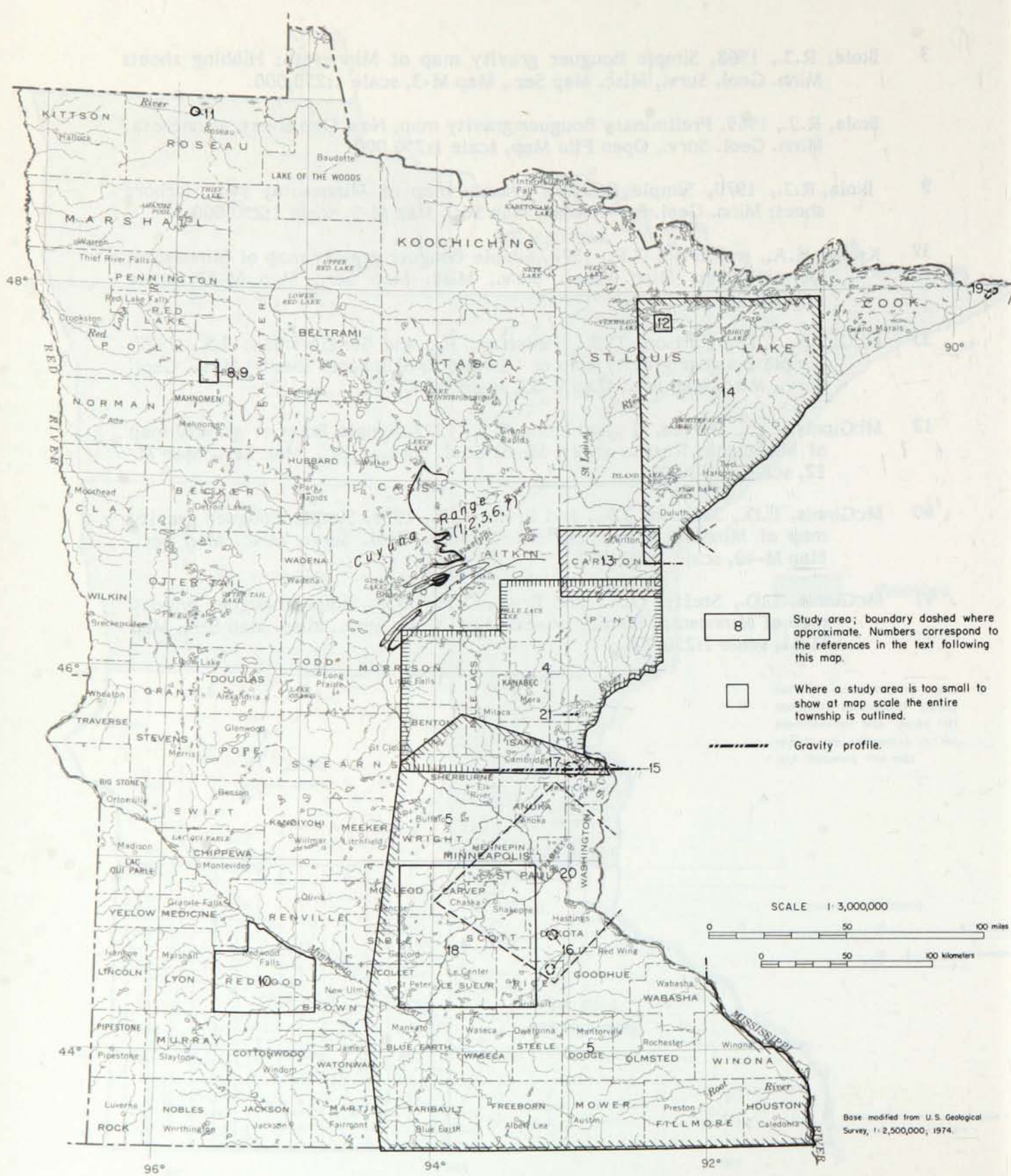


Figure 6—Status of the Minnesota Geological Survey 1:250,000 Bouguer Gravity mapping program.

- 3 Ikola, R.J., 1968, Simple Bouguer gravity map of Minnesota; Hibbing sheet: Minn. Geol. Surv., Misc. Map Ser., Map M-3, scale 1:250,000.
- Ikola, R.J., 1969, Preliminary Bouguer gravity map, New Ulm sheet, Minnesota: Minn. Geol. Surv., Open File Map, scale 1:250,000.
- 9 Ikola, R.J., 1970, Simple Bouguer gravity map of Minnesota; Two Harbors sheet: Minn. Geol. Surv., Misc. Map Ser., Map M-9, scale 1:250,000.
- 37 Krenz, K.A., and Ervin, C.P., 1977, Simple Bouguer gravity map of Minnesota; Duluth sheet: Minn. Geol. Surv., Misc. Map Ser., Map M-37, scale 1:250,000.
- 35 McGinnis, L.D., Carlson, D.R., Pederson, R., and Schafersman, J.S., 1977, Simple Bouguer gravity map of Minnesota; Stillwater sheet: Minn. Geol. Surv., Misc. Map Ser., Map M-35, scale 1:250,000.
- 12 McGinnis, L.D., Durfee, G., and Ikola, R.J., 1973, Simple Bouguer gravity map of Minnesota; Roseau sheet: Minn. Geol. Surv., Misc. Map Ser., Map M-12, scale 1:250,000.
- 40 McGinnis, L.D., Jackson, J.K., and Ervin, C.P., 1978, Simple Bouguer gravity map of Minnesota; Brainerd sheet: Minn. Geol. Surv., Misc. Map Ser., Map M-40, scale 1:250,000.
- 41 McGinnis, L.D., Steffy, D.A., and Ervin, C.P., 1978, Simple Bouguer gravity map of Minnesota; Bemidji sheet: Minn. Geol. Surv., Misc. Map Ser., Map M-41, scale 1:250,000.





Base modified from U.S. Geological Survey, 1:2,500,000, 1974.

Figure 7-Map index of Gravity investigations exclusive of the Minnesota Geological Survey Bouguer Gravity mapping program.

- 1 Adams, B.B., 1956, Structural studies based on gravimetric and geologic data in east-central Minnesota (abstr.): *Geol. Soc. Am., Bull.*, v. 67, n. 12, pt. 2, p. 1663
- 2 Adams, B.B., 1957, Regional gravity and geologic structure in east-central Minnesota: Ph.D. thesis, Univ. Wisc., 106 p.
- 3 Adams, B.B., 1957, Regional gravity and geologic structure in east-central Minnesota (abstr.): *Diss. Abstr. Int.*, v. 17, n. 9, p. 1980-1981
- 4 Carlson, D.R., 1971, Gravity and bedrock geology study of east-central Minnesota: M.S. thesis, Northern Ill. Univ., 31 p., plate.
- 5 Craddock, C., Thiel, E.C., and Gross, B., 1963, A gravity investigation of the Precambrian of southeastern Minnesota and western Wisconsin: *J. Geophys. Res.*, v. 68, p. 6015-6032.
- Craddock, C., Mooney, H.M., and Kolehmainen, V., 1970, Simple Bouguer gravity map of Minnesota and northwestern Wisconsin: *Minn. Geol. Surv., Misc. Map Ser.*, Map M-10, scale 1:1,000,000, text.
- 6 Durfee, G.A., 1956, A regional gravity survey of the Cuyuna iron range, Minnesota: M.A. thesis, Mich. College Min., 69 p., map.
- 7 Durfee, G.A., 1957, A regional gravity survey of the Cuyuna iron range, Minnesota: *U.S. Geol. Surv., Open File Rep.* n. 415, 26 p., map.
- 8 Ervin, C.P., and Mudrey, M.G., Jr., 1975, Extension of Vermilion district lamprophyres into western Minnesota from geophysical observations (abstr.): in *Inst. Lake Superior Geol., Tech. Sess. Abstr. Field Guides*, v. 21, p. 35.
- 9 Ervin, C.P., and Mudrey, M.G., Jr., 1976, Extension of a northern Minnesota lamprophyre province by geophysical studies: *J. Geophys. Res.*, v. 81, n. 26, p. 4917-4922.
- 10 Fogelson, D.E., 1956, A gravity survey of a portion of the Redwood Falls area, Minnesota: M.S. thesis, Univ. Minn.
- 11 Hammer, S., and Ervin, C.P., 1975, Crater or kettle? A geophysical study: *Geology*, v. 3, n. 3, p. 145-146.
- 12 Hinze, W.J., 1960, Application of the gravity method to iron ore exploration: *Econ. Geol.*, v. 55, n. 3, p. 465-484.
- 13 Ikola, R.J., 1967, A geophysical investigation of the geologic structure of Carlton County, Minnesota: M.S. thesis, Univ. Minn., 80 p., map.
- 14 Ikola, R.J., 1968, Simple Bouguer gravity map of southern part of the Duluth Complex and adjacent areas, Minnesota: *Minn. Geol. Surv., Misc. Map Ser.*, Map M-4, scale 1:125,000.

- Ikola, R.J., 1969, Gravity investigations in Minnesota: in Sims, P.K., and Westfall, I., eds., Summary of field work, 1969: Minn. Geol. Surv., Inf. Circ. 7, p. 10-11.
- 15 Li, F.S., 1971, Interpretation of a gravity profile across the Midcontinent Gravity High at latitude 45° 30': M.S. thesis, Univ. Minn., 81 p., maps.
- 16 Mack, J.W., et al., 1964, Gravity survey, Northfield and Farmington areas, Minnesota: Northern Natural Gas Company, Underground Storage Department, Omaha, Nebraska.
- Ocola, L.C., and Meyer, R.P., 1973, Central North American rift system; 1, Structure of the axial zone from seismic and gravimetric data: J. Geophys. Res., v. 78, n. 23, p. 5173-5194.
- Schwartz, G.M., 1958, Geological implications of magnetic and gravity data of the Lake Superior basin (abstr.): in Inst. Lake Superior Geol., 4th Annu. Mtg., Minneapolis, April 21-22, 1958, Univ. Minn., Center for Continuation Study, p. 7.
- 17 Sharma, B., 1964, The vertical gradient of gravity in gravitational interpretation: M.S. thesis, Univ. Minn., 225 p.
- Sims, P.K., 1970, Gravity investigations in Minnesota: in Sims, P.K., and Westfall, I., eds., Summary of field work, 1970: Minn. Geol. Surv., Inf. Circ. 8, p. 5-6.
- Sims, P.K., 1972, Regional gravity field: in Sims, P.K., and Morey, G.B., eds., Geology of Minnesota: A centennial volume: Minn. Geol. Surv., St. Paul, Minn., p. 581-584.
- 18 Sloan, R.E., and Danes, Z.F., 1962, A geologic and gravity survey of the Belle Plaine area, Minnesota: Minn. Acad. Sci., Proc., v. 30, n. 1, p. 49-52.
- 19 Stevenson, R. J., Chase, C. G., and Weiblen, P.W., 1975, Geologic interpretation of a gravity study in the Grand Portage area, northeastern Minnesota (abstr.): in Eos (Am. Geophys. Union, Trans.), v. 56, n. 9, p. 603
- Thiel, E.C., 1955, A gravity study of the Lake Superior syncline (abstr.): in Inst. Lake Superior Geol., Minneapolis, April 1-2, 1955, Univ. Minn., Center for Continuation Study.
- Thiel, E.C., 1955, The structural geology of the Lake Superior syncline as revealed by gravity measurement: Ph.D. thesis, Univ. Wisc.



- Thiel, E.C., 1956, Correlation of gravity anomalies with the Keweenawan geology of Wisconsin and Minnesota: Geol. Soc. Am., Bull., v. 67, n. 8, p. 1079-1100.
- 20 Veith, K.F., 1966, A geophysical study of a portion of the Midcontinent Gravity High: M.S. thesis, Univ. Minn., 56 p., 4 plates.
- 21 Welch, G.I., 1941, Geophysical study of the Douglas Fault, Pine County, Minnesota: J. Geol. v. 49, p. 408-413.

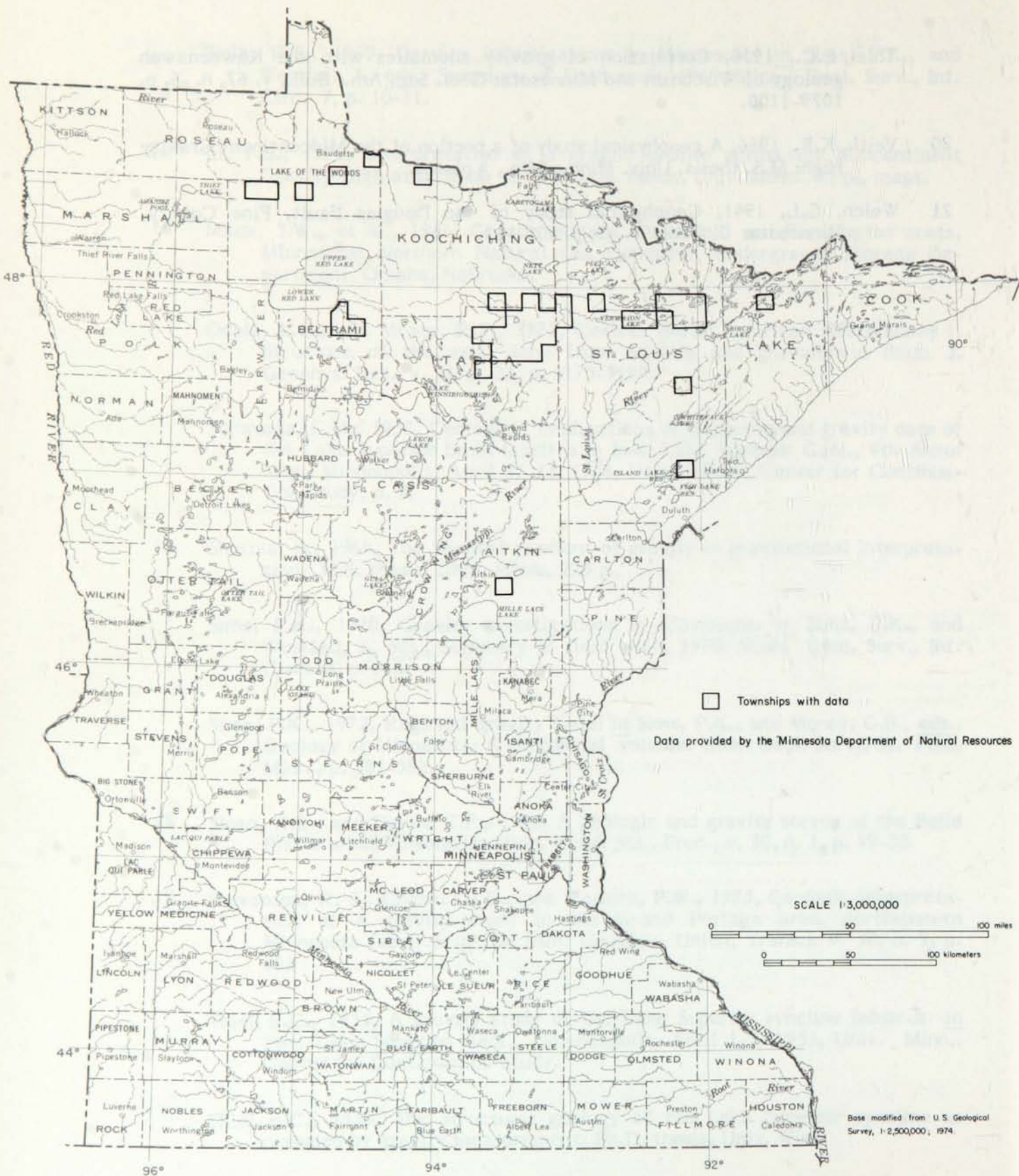


Figure 8-Map index of Gravity data available at the Minnesota Department of Natural Resources, Division of Minerals.

# **MAGNETIC INVESTIGATIONS**



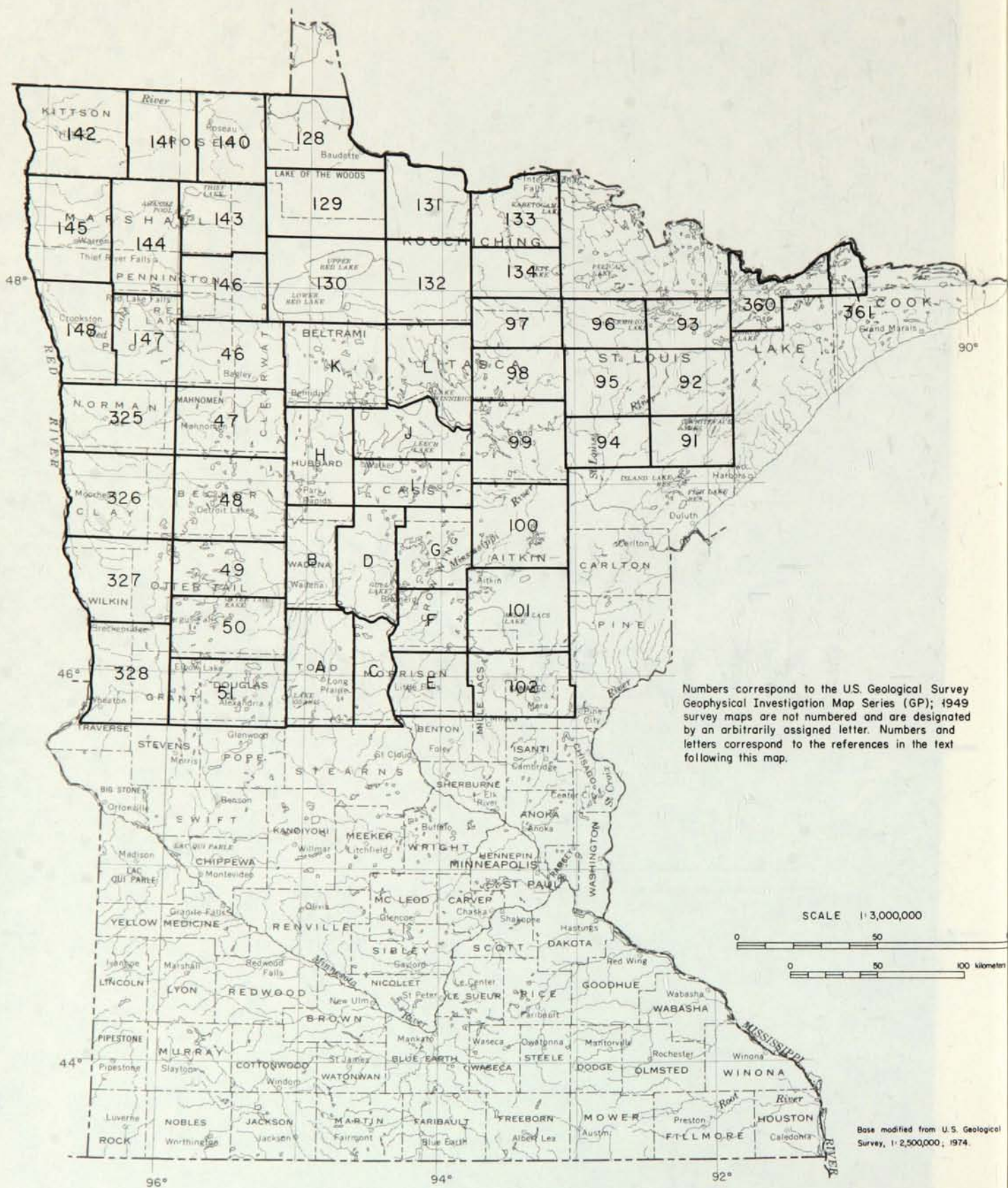


Figure 9-Map index of the U.S. Geological Survey 1:63,360 Aeromagnetic Surveys, 1949-1963.

- 328 Anderson, L.A., Hawkins, D., and others, 1963, Aeromagnetic map of parts of Wilkin, Otter Tail, Grant, and Traverse Counties, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-328, scale 1:63,360.
- 327 Anderson, L.A., Petrafeso, F., and others, 1962, Aeromagnetic map of parts of Clay, Wilkin, and Otter Tail Counties, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-327, scale 1:63,360.
- 361 Anderson, L.A., Tyson, N.S., and others, 1963, Aeromagnetic map of the northwestern part of Cook County, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-361, scale 1:63,360.
- 325 Anderson, L.A., Zandle, G.L., and others, 1962, Aeromagnetic map of Norman and part of Mahnomen Counties, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-325, scale 1:63,360.
- 326 Anderson, L.A., Zandle, G.L., and others, 1963, Aeromagnetic map of parts of Clay and Becker Counties, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-326, scale 1:63,360.
- A Balsley, J.R., Jr., Hill, M.E., and Meuschke, J.L., 1949, Total intensity aeromagnetic map of Todd County, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map, scale 1:63,360, magnetic profiles, scale 1:126,720.
- B Balsley, J.R., Jr., Hill, M.E., and Meuschke, J.L., 1949, Total intensity aeromagnetic map of Wadena County and part of Hubbard County, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map, scale 1:63,360, magnetic profiles, scale 1:126,720.
- 46 Balsley, J.R., Jr., Hill, M.E., and Meuschke, J.L., 1951, Total intensity aeromagnetic map of parts of Clearwater, Polk, and Red Lake Counties, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-46, scale 1:63,360, aeromagnetic profiles.
- 47 Balsley, J.R., Jr., Hill, M.E., and Meuschke, J.L., 1951, Total intensity aeromagnetic map of parts of Clearwater and Mahnomen Counties, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-47, scale 1:63,360, aeromagnetic profiles.
- 48 Balsley, J.R., Jr., Hill, M.E., and Meuschke, J.L., 1951, Total intensity aeromagnetic map of part of Becker County, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-48, scale 1:63,360, aeromagnetic profiles.
- 49 Balsley, J.R., Jr., Hill, M.E., and Meuschke, J.L., 1951, Total intensity aeromagnetic map of the northern part of Otter Tail County, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-49, scale 1:63,360, aeromagnetic profiles.

- 50 Balsley, J.R., Jr., Hill, M.E., and Meuschke, J.L., 1951, Total intensity aeromagnetic map of the southern part of Otter Tail County, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-50, scale 1:63,360, aeromagnetic profiles.
- 51 Balsley, J.R., Jr., Hill, M.E., and Meuschke, J.L., 1951, Total intensity aeromagnetic map of Douglas County and part of Grant County, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-51, scale 1:63,360, aeromagnetic profiles.
- 140 Books, K.G., Schwartz, G.M., Meuschke, J.L., and Dempsey, W.J., 1958, Aeromagnetic map of eastern Roseau County, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-140, scale 1:63,360.
- 141 Books, K.G., Schwartz, G.M., Meuschke, J.L., and Dempsey, W.J., 1958, Aeromagnetic map of western Roseau County, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-141, scale 1:63,360.
- 142 Books, K.G., Schwartz, G.M., Meuschke, J.L., and Dempsey, W.J., 1958, Aeromagnetic map of Kittson County, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-142, scale 1:63,360.
- 143 Books, K.G., Schwartz, G.M., Meuschke, J.L., and Dempsey, W.J., 1958, Aeromagnetic map of eastern Marshall and northwestern Beltrami Counties, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-143, scale 1:63,360.
- 144 Books, K.G., Schwartz, G.M., Meuschke, J.L., and Dempsey, W.J., 1958, Aeromagnetic map of central Marshall and western Pennington Counties, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-144, scale 1:63,360.
- 145 Books, K.G., Schwartz, G.M., Meuschke, J.L., and Dempsey, W.J., 1958, Aeromagnetic map of western Marshall and northwestern Polk Counties, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-145, scale 1:63,360.
- 146 Books, K.G., Schwartz, G.M., Meuschke, J.L., and Dempsey, W.J., 1958, Aeromagnetic map of parts of Pennington, Red Lake, Beltrami, Clearwater, and Polk Counties, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-146, scale 1:63,360.
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Summary of  
U.S. Geological Survey, 1:63,360  
Aeromagnetic Survey, 1949-1963

- 1949 Total intensity aeromagnetic maps and accompanying magnetic profiles.  
Scale 1:63,360 maps, 1:126,720 profiles.

Southern part of Beltrami County.  
Central part of Cass County.  
Northern part of Cass County.  
Southern part of Cass County.  
Northern part of Crow Wing County and part of Cass County.  
Southern part of Crow Wing County.  
Part of Hubbard County.  
Western part of Itasca County.  
Eastern part of Morrison County.  
Western part of Morrison County.  
Todd County.  
Wadena County and part of Hubbard County.

- 1951 Total intensity aeromagnetic map and accompanying aeromagnetic  
profiles. Scale 1:63,360.

GP-46. Parts of Clearwater, Polk, and Red Lake Counties.  
GP-47. Parts of Clearwater and Mahnommen Counties.  
GP-48. Part of Becker County.  
GP-49. Northern part of Otter Tail County.  
GP-50. Southern part of Otter Tail County.  
GP-51. Douglas County and part of Grant County.

- 1952-3 Total intensity aeromagnetic and geologic map (and accompanying  
aeromagnetic profiles). Scale 1:63,360.

GP-91. Part of southeastern St. Louis County.  
GP-92. East-central St. Louis County.  
GP-93. Part of northeastern St. Louis County.  
GP-94. Part of southwestern St. Louis County.  
GP-95. West-central St. Louis County.  
GP-96. Part of northwestern St. Louis County.  
GP-97. Northeastern Itasca and southeastern Koochiching Counties.  
GP-98. East-central Itasca County.  
GP-99. Southeastern Itasca County.  
GP-100. Northern Aitkin County.  
GP-101. Southern Aitkin County and northern Mille Lacs County.  
GP-102. Parts of Kanabec, Mille Lacs, and Pine Counties.

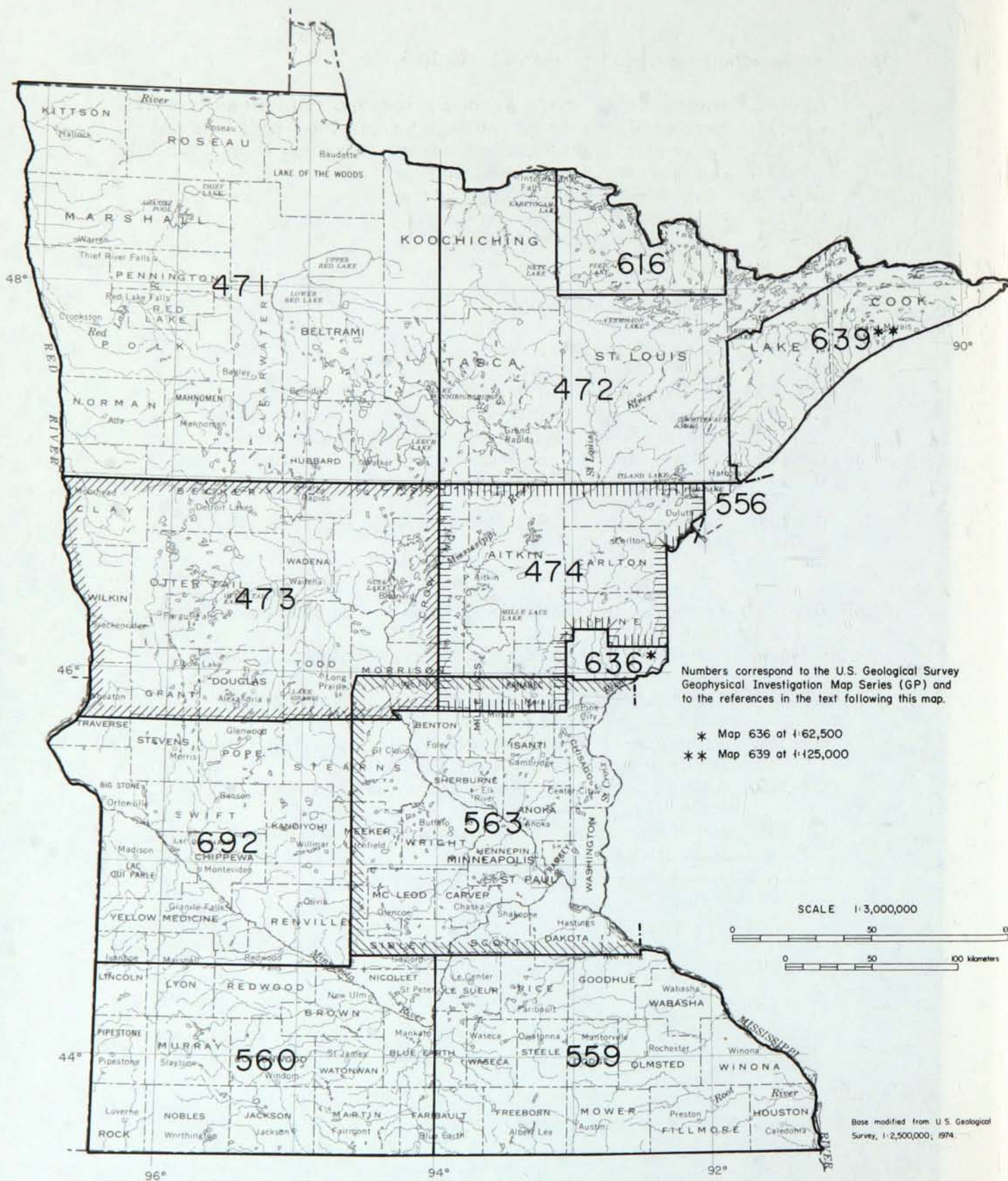
1957 Aeromagnetic and geologic maps. Scale 1:63,360.

- GP-128. Northern Lake of the Woods and northeastern Roseau Counties.
- GP-129. Northern Beltrami and southern Lake of the Woods Counties.
- GP-130. North-central Beltrami and northeastern Clearwater Counties.
- GP-131. Northwestern Koochiching County.
- GP-132. Southwestern Koochiching County.
- GP-133. Northeastern Koochiching County.
- GP-134. Southeastern Koochiching County.

1958 Aeromagnetic maps. Scale 1:63,360.

- GP-140. Eastern Roseau County.
- GP-141. Western Roseau County.
- GP-142. Kittson County.
- GP-143. Eastern Marshall and northwestern Beltrami Counties
- GP-144. Central Marshall and western Pennington Counties.
- GP-145. Western Marshall and northwestern Polk Counties.
- GP-146. Parts of Pennington, Red Lake, Beltrami, Clearwater, and Polk Counties.
- GP-147. Western Red Lake and central Polk Counties.
- GP-148. Western Polk County.

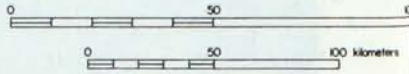
- 1962-3 GP-325. Aeromagnetic map of Norman and part of Mahnomen Counties. Scale 1:63,360.
- GP-326. Aeromagnetic map of parts of Clay and Becker Counties. Scale 1:63,360.
- GP-327. Aeromagnetic map of parts of Clay, Wilkin, and Otter Tail Counties. Scale 1:63,360.
- GP-328. Aeromagnetic map of parts of Wilkin, Otter Tail, Grant, and Traverse Counties. Scale 1:63,360.
- GP-360. Aeromagnetic map of the northern part of Lake County. Scale 1:63,360.
- GP-361. Aeromagnetic map of the northwestern part of Cook County. Scale 1:63,360.



Numbers correspond to the U.S. Geological Survey Geophysical Investigation Map Series (GP) and to the references in the text following this map.

- \* Map 636 at 1:62,500
- \*\* Map 639 at 1:125,000

SCALE 1:3,000,000



Base modified from U.S. Geological Survey, 1:2,500,000, 1974.

Figure 10-Map index of the U.S. Geological Survey 1:250,000 Aeromagnetic Surveys, 1964-1970.

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- 474 Bath, G.D., Schwartz, G.M., and Gilbert, F.P., 1964, Aeromagnetic and geologic map of east-central Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-474, scale 1:250,000.
- 472 Bath, G.D., Schwartz, G.M., and Gilbert, F.P., 1965, Aeromagnetic and geologic map of northeastern Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-472, scale 1:250,000.
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- 563 Sims, P.K., and Zietz, I., 1967, Aeromagnetic and inferred Precambrian paleogeologic map of east-central Minnesota and part of Wisconsin: U.S. Geol. Surv., Geophys. Invest. Map GP-563, scale 1:250,000, text.
- 616 U.S. Geological Survey, 1968, Aeromagnetic map of the Kabetogama Lake-Grassy Lake area, St. Louis County, Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-616, scale 1:250,000.
- 636 U.S. Geological Survey, 1968, Aeromagnetic map of central Pine County, Minnesota, and adjacent parts of Wisconsin: U.S. Geol. Surv., Geophys. Invest. Map GP-636, scale 1:62,500.
- 639 U.S. Geological Survey, 1969, Aeromagnetic map of the McNair-Grand Portage area, northeastern Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-639, scale 1:125,000.
- 692 U.S. Geological Survey, 1970, Aeromagnetic map of a part of western Minnesota: U.S. Geol. Surv., Geophys. Invest. Map GP-692, scale 1:250,000.

Summary of  
U.S. Geological Survey, 1:250,000  
Aeromagnetic Survey, 1964-1970

- 1964-5 GP-471. Aeromagnetic and geologic map of northwestern Minnesota. Scale 1:250,000.
- GP-472. Aeromagnetic and geologic map of northeastern Minnesota. Scale 1:250,000.
- GP-473. Aeromagnetic and geologic map of west-central Minnesota. Scale 1:250,000.
- GP-474. Aeromagnetic and geologic map of east-central Minnesota. Scale 1:250,000.
- 1966-7 GP-556. Regional aeromagnetic map of western Lake Superior and adjacent parts of Minnesota, Michigan, and Wisconsin. Scale 1:250,000.
- GP-559. Aeromagnetic map of southeastern Minnesota. Scale 1:250,000.
- GP-560. Aeromagnetic map of southwestern Minnesota. Scale 1:250,000.
- GP-563. Aeromagnetic and inferred Precambrian paleogeologic map of east-central Minnesota and part of Wisconsin. Scale 1:250,000.
- 1968-70 GP-616. Aeromagnetic map of the Kabetogama Lake-Grassy Lake area, St. Louis County, Minnesota. Scale 1:250,000.
- GP-636. Aeromagnetic map of central Pine County, Minnesota and adjacent parts of Wisconsin. Scale 1:62,500.
- GP-639. Aeromagnetic map of the McNair-Grand Portage area, northeastern Minnesota. Scale 1:125,000.
- GP-692. Aeromagnetic map of a part of western Minnesota. Scale 1:250,000.
- GP-725. Aeromagnetic map of Minnesota. Scale 1:1,000,000.



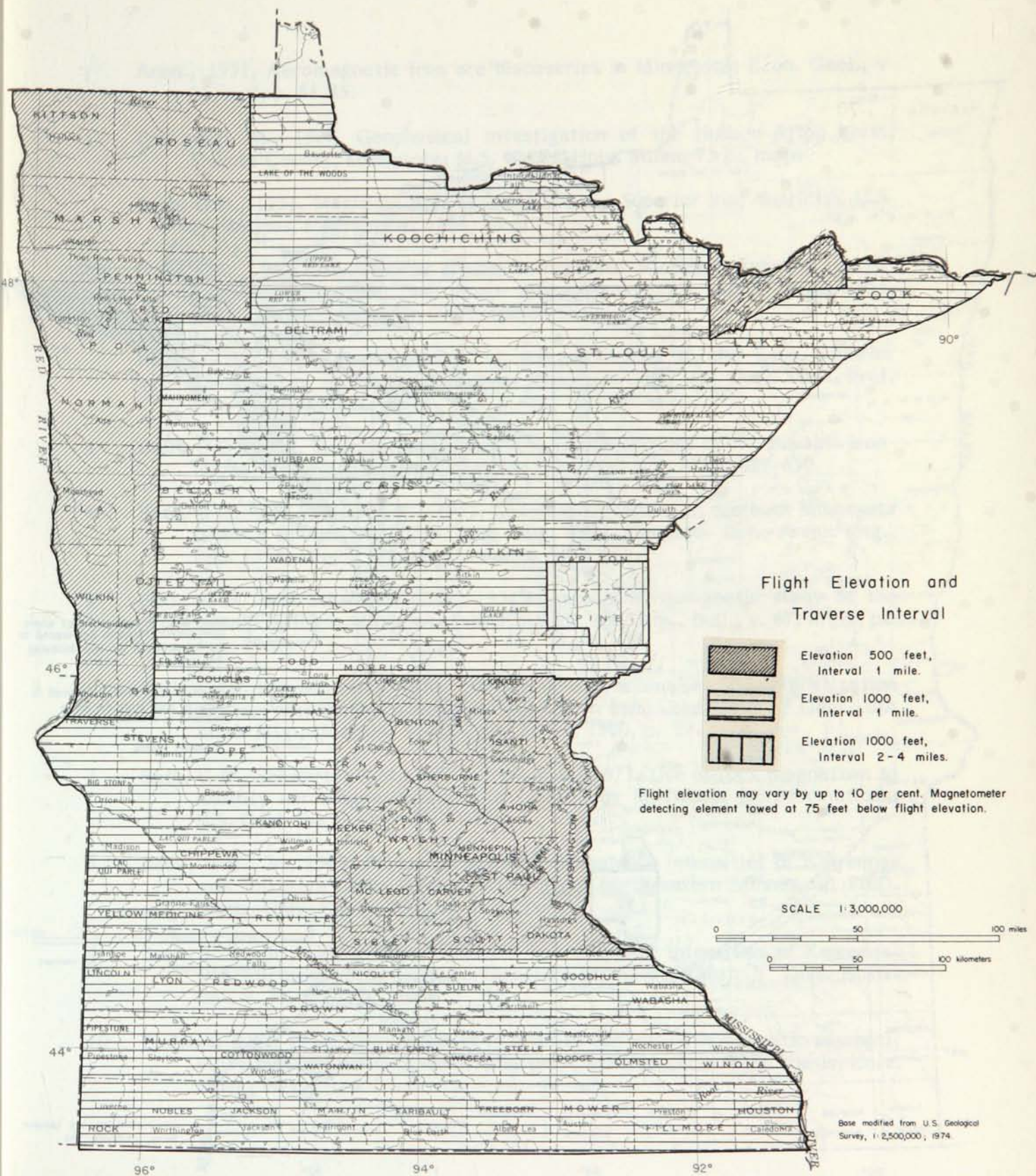


Figure 11-Map showing Aeromagnetic Flight Parameters used by the U.S. Geological Survey, 1949-1970.



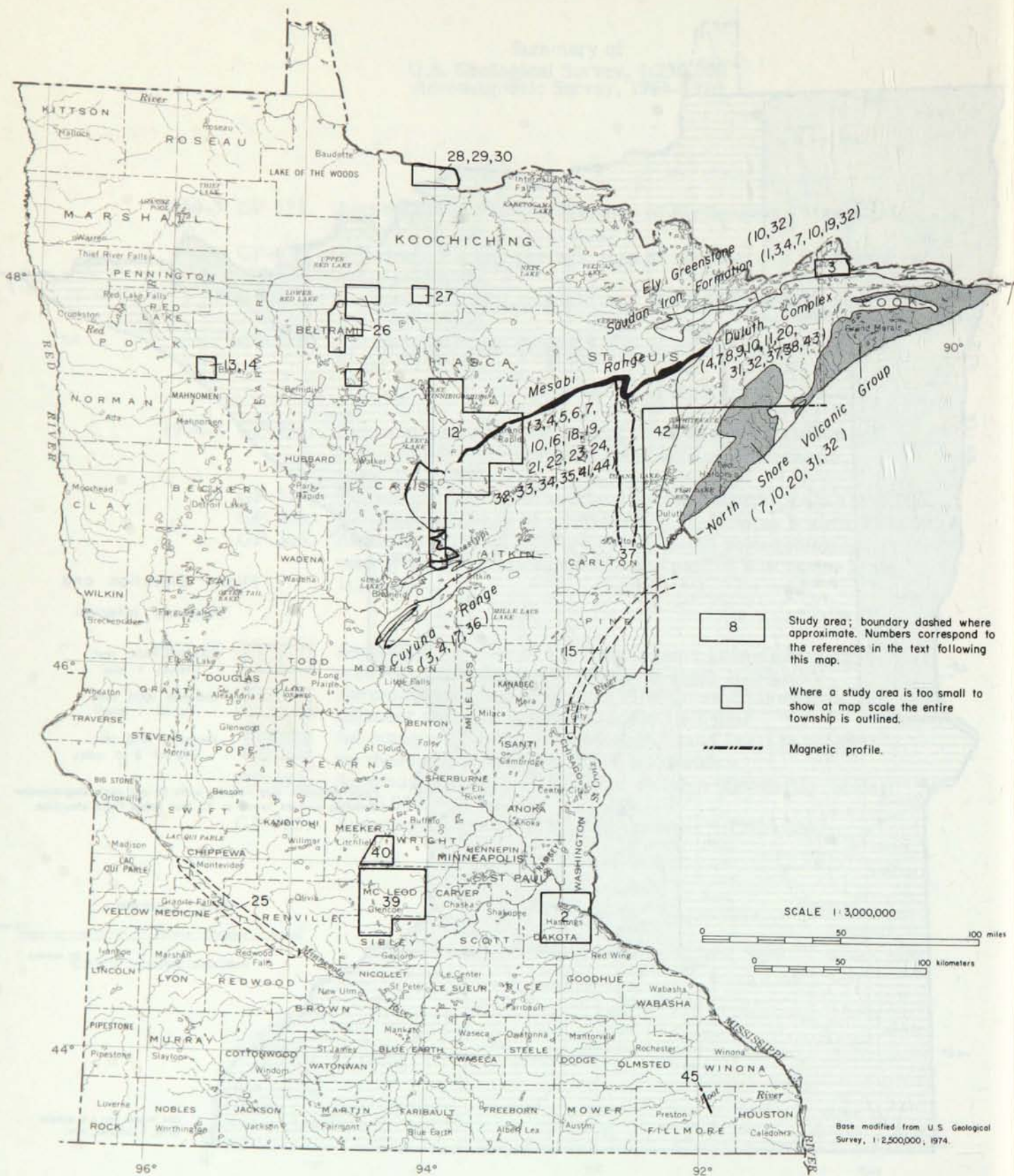


Figure 12 - Map index of Magnetic investigations exclusive of the U.S. Geological Survey Aeromagnetic Surveys.



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  - 13 Ervin, C P., and Mudrey, M.G., Jr., 1975, Extension of Vermilion district lamprophyres into western Minnesota from geophysical observations (abstr.): in *Inst. Lake Superior Geol. Tech. Sess. Abstr. Field Guides*, n. 21, p. 35.
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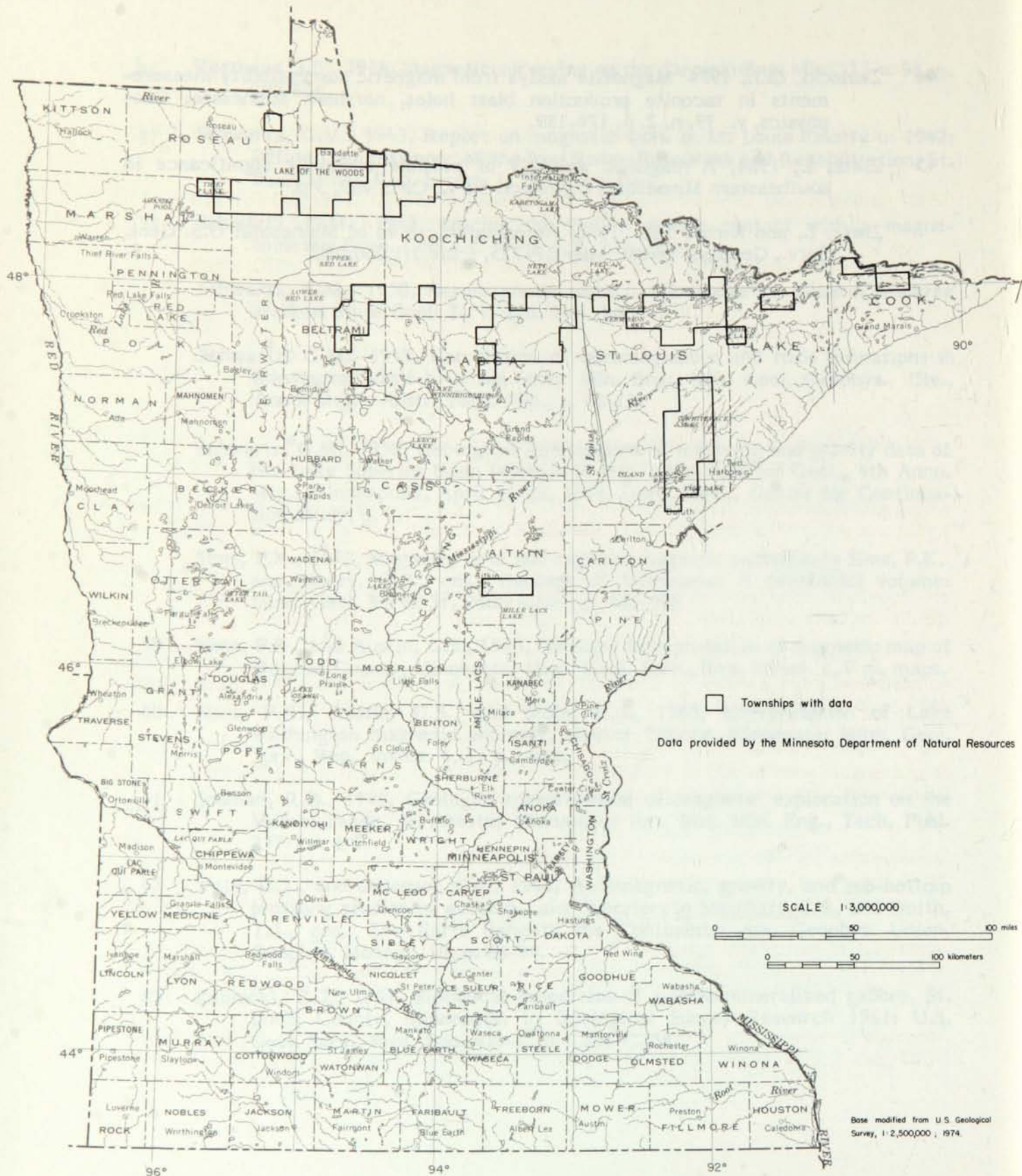


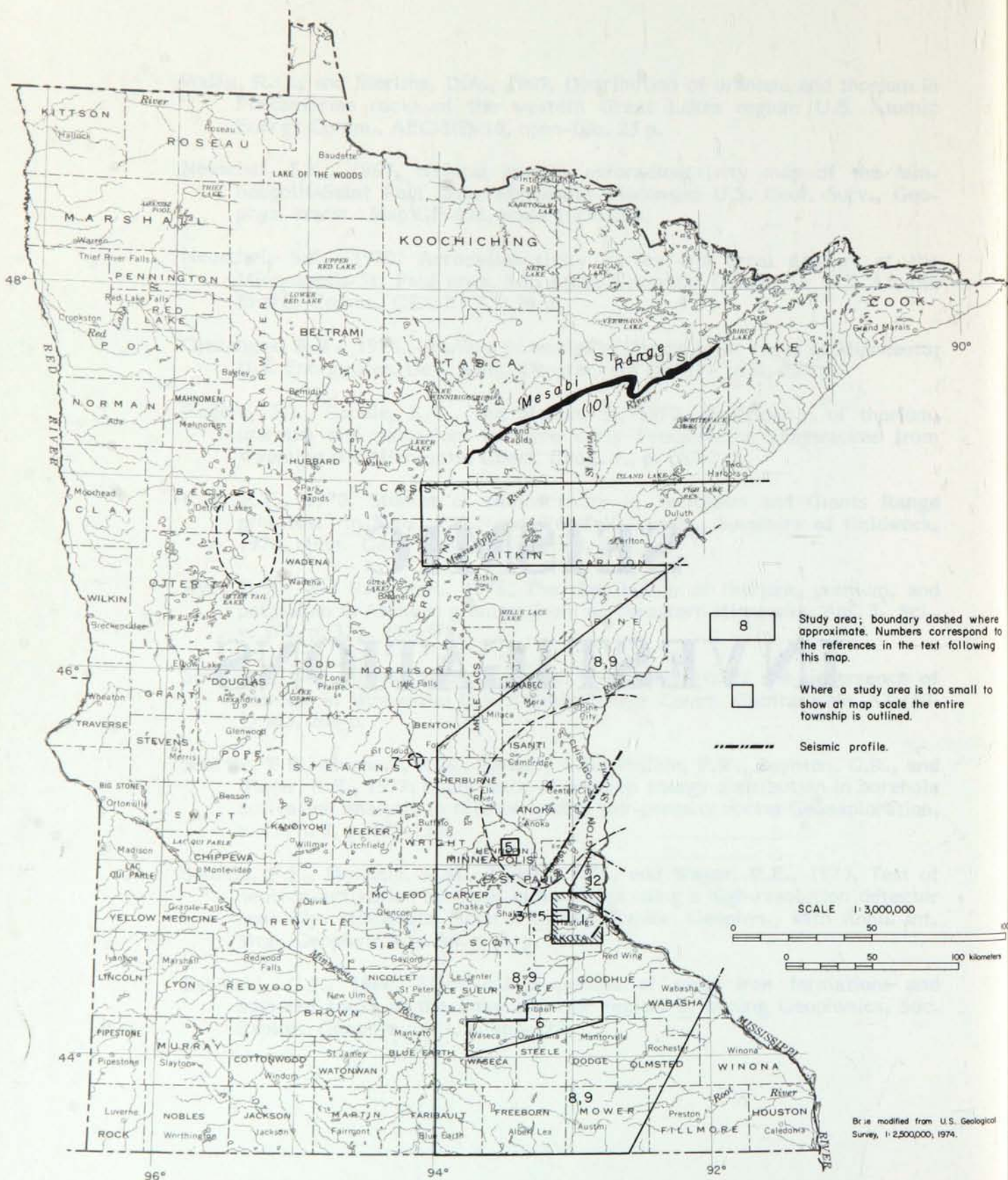
Figure 13-Map index of Magnetic data available at the Minnesota Department of Natural Resources, Division of Minerals.

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Base modified from U.S. Geological Survey, 1:2,500,000, 1974.

Figure 14-Map index of Seismic investigations.

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