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# BEDROCK TOPOGRAPHY OF SOUTHWESTERN ALBERTA

by

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# ILLUSTRATIONS

# BEDROCK TOPOGRAPHY OF SOUTHWESTERN ALBERTA


## Abstract

This report isolates the two primary geologic divisions, the bedrock and the overlying unconsolidated material, by superimposing a topographic map of the present land surface upon a topographic map of the bedrock surface. To reconstruct the preglacial landscape it is necessary to identify and add to the existing bedrock surface the modifications effected by glacial and Recent erosion upon the preglacial surface. The preglacial drainage is then shown by marking the 'thalweg' (a line along the deepest part of the ancient valley) for various preglacial drainage-ways. The alluvial gravels of these ancient valleys are commonly of economic significance.


## INTRODUCTION

The purpose of this report is to make available information on the topography of the bedrock surface and the thickness of the overlying unconsolidated deposits in southwestern Alberta. The bedrock topography and the thickness and character of the unconsolidated deposits influence the shallow groundwater-flow configuration and determine the distribution of permeable reservoirs capable of storing and transmitting sizable amounts of potable groundwater. Knowledge of the bedrock topography has made possible a reasonably detailed interpretation of the preglacial drainage development. This report constitutes the first stage of a long-term research study concerning the groundwater geology of the drainage basins of the Oldman, Belly, and St. Mary Rivers.

The area studied is approximately 10,000 square miles and comprises the map-areas represented by the Alberta portions of National Topographic Series (NTS) map-sheets 82G and 87J/1, 2, 7 and 8, as well as all of NTS map-sheets 82H and 82I/3, 4, 5, and 6 (Fig. 1).

A contour map of the bedrock surface, on a scale of 1:250,000, has been prepared and superimposed on a contour map of the present land surface (Fig. 2). The bedrock contour interval is 100 feet. The differing contour intervals of the National Topographic Series map-sheets for the area has prevented the consistent use of a single surface-contour interval. East of the fifth meridian the surface-contour interval is 100 feet for elevations below 5,000 feet, and 200 feet for elevations above 5,000 feet. West of the fifth meridian the surface-contour interval is 500 feet. The bedrock contours are of

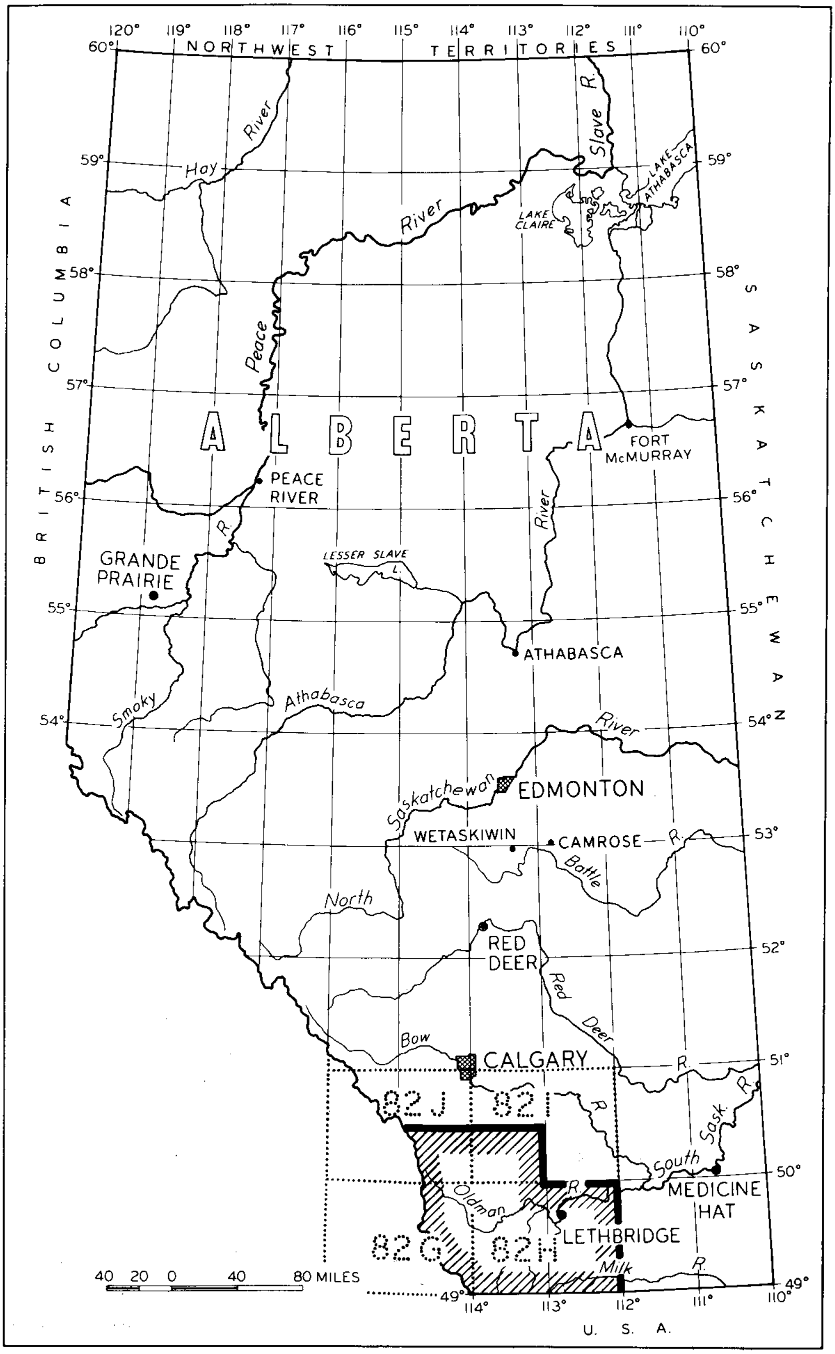


Figure 1: Location of the area.

necessity generalized. Nevertheless the location and general shape of important bedrock-surface features are believed to be reliable.

Several similar contour maps of the bedrock surface have been produced for various areas in Alberta (Farvolden, 1961; Le Breton, 1963; Farvolden, 1963a, 1963c; Meyboom, 1963; Campbell and Almadi, 1964; Westgate, in press). A preliminary bedrock-surface map based mainly on subjective interpretation has also been constructed for the Oyen map-area (Kunkle, 1962).

## Compilation, Interpretation, and Accuracy

Most of the information has been taken from seismic shot-hole logs on file with the various oil companies in Alberta. Supplementary information has been gained from exploration holes drilled in the search for coal and in the evaluation of dam-site locations, from drill logs submitted by water-well drilling contractors, and from observation by the author of exposed sections along some present-day valleys.

Although a shot-hole log may be considered an unreliable source of stratigraphic information since such logs are recorded by the driller only, the writer has found in most logs that the changes from till to gravel and from till or gravel to bedrock are indicated fairly precisely. Data from logs in marked disagreement with most of the other logs of nearby holes have not been used.

Compilation of information from shot-hole or drill-hole logs was done quite efficiently by university students. The bedrock topography of the area was then contoured at 50-foot intervals by the writer. On the final map only 100-foot bedrock contours have been retained, except in one or two cases where the 50-foot contours were necessary to define the shape of the bedrock surface.

The locations of drill holes from which useful information was obtained are indicated on figure 2 as an index of the control and therefore of the precision of the contours. In the area east of the fifth meridian the bedrock contours have been modified, where necessary, to conform generally to the surface topography. These changes were necessary mainly in parts of the area with poor control where present-day valleys have cut deeply into the bedrock. Because of the difficulties arising from the greater difference in contour interval between the surface and bedrock contours west of the fifth meridian no significant modification of this type has been made in the bedrock contours in this part of the area.

## Acknowledgments

The following companies and agencies contributed the data used in the compilation of the enclosed maps and their co-operation in this project is gratefully acknowledged: Alberta Coal Ltd.; Alberta Department of Agriculture, Colonization Branch; Amerada Petroleum Corp.; Bow Valley Oil and Gas Ltd.; British American Oil Company Ltd.; California Standard Company; Canada Department of Agriculture, Prairie Farm Rehabilitation Administration; Canadian Oil Companies, Ltd.; Canadian Pacific Oil and Gas Ltd.; Canadian Superior Oil Ltd.; Colorado Oil and Gas Ltd.; French Petroleum Company of Canada Ltd.; Home Oil Company Ltd.; Hudson's Bay Oil and Gas Company Ltd.; Imperial Oil Ltd.; Monsanto Oils Ltd.; Pan American Petroleum Corp.; Richfield Oil Corp.; Royalite Oil Company Ltd.; Shell Canada Ltd.; Socony Mobil Oil of Canada Ltd.; Texaco Exploration Company; and Union Oil Company of Canada Ltd.

The writer gratefully acknowledges the efficient and reliable help during the compilation period of Mr. M. Vrskovy in 1962 and Mr. Kaye Anderson in 1962 and 1963. Mr. Anderson, under the general guidance of the author, developed the compilation method used herein.

## BEDROCK SURFACE

### General Statement

In Tertiary time weathering and erosion had produced a much more mature topography than the present-day youthful topography of southwestern Alberta. The most recent evolutionary stage of this preglacial landscape, since modified somewhat by glacial erosion, is now buried and preserved under the surficial deposits left upon the retreat of the continental ice sheet and the mountain glaciers. Modification of the preglacial landscape has continued in certain areas where glacial and Recent streams have cut into the bedrock, particularly where preglacial drainage patterns have been disrupted by glacial action and probable Recent uplift.

### Previous Work

Relatively little attention has been given to the buried bedrock topography of southwestern Alberta as such until very recently. Early work on this subject was incidental to investigations either of the surficial deposits or of the bedrock. Dawson (1885) recognized the existence of buried preglacial valleys where present river valleys crossed them. Dowling (1917) mentions the thick surficial deposits in the Lethbridge area. Williams and Dyer (1930) describe some aspects of the buried channels crossed by the Oldman River at Lethbridge and by the Milk River within the area of this report. Allan (1934) mentions the presence of a few sections of buried channels in southwestern Alberta including that underlying the city of Lethbridge. Horberg (1952) describes several Pleistocene sections along the Oldman River in which the Saskatchewan Gravels and Sands (Rutherford, 1937; Westgate and Bayrock, 1964) are exposed and discusses in a general way the preglacial land surface. Horberg (1954) interprets the positions of several preglacial valleys in the Waterton region of southwestern Alberta on the basis of geomorphic evidence.

Within the last few years considerable interest has been shown by geologists in the bedrock surface and the preglacial drainage of Alberta. Two papers (Stalker, 1961; Farvolden, 1963b) have been published outlining the major preglacial valleys. Stalker (1961) based his interpretation on field observation between 1946 and 1959 augmented with data from water-well and seismic shot-hole drillers' logs, topographic maps, and air photos. Farvolden compiled his map mainly from water-well and seismic shot-hole data but incorporated observations made during four years of field work. This map was first published in a report by Gravenor and Bayrock (1961), and later as a separate report by Farvolden (1963b).

Studies of the physiography of parts of Alberta, Saskatchewan, and Montana by such workers as McConnell, Darton, Lambe, Williams and Dyer, Collier and Thom and others indicated the presence of remnants of several ancient land surfaces which are also present in the area of this report. Alden (1932) studied a large area in northwestern United States and southern Alberta east of the continental divide and summarized the findings of the earlier workers. In this area he postulated the presence of four plains, now preserved as benches or terraces, that he considered to be the product of stream erosion and deposition during successive long periods of freedom from uplift or deformation. These are the Cypress Plain, the Flaxville Plain (or No. 1 bench), No. 2 bench, and No. 3 bench. This classification appears subsequently to have been unchallenged except in detail. Horberg (1954) discusses several remnants of these old benches in the southwest corner of the present area.

## Topography of the Bedrock Surface

### Four Regional Divisions

Four large-scale physiographic divisions or units are readily discernible on the bedrock-contour map. They comprise: (1) the 10- to 25-mile wide mountain belt along the Alberta-British Columbia border; (2) the foothills belt, 5 to 25 miles wide, lying immediately to the east; (3) the lowland valley or plains areas covering most of the area to the east of the foothills belt; and (4) the erosional remnants comprising upland areas separating these wide, gentle preglacial valleys. These same units, though differing in detail, form subdivisions of the present-day topography.

The eastern boundary of the first regional division, the mountain belt, is roughly coincident with a line along the 5,000-foot bedrock-topography contour, except where large valleys indent the mountain front. The main modern river and creek valleys within the mountain belt probably follow the same courses as in preglacial time, but very possibly have been deepened by glacial and Recent erosion.

The second regional division, the foothills belt, was, in preglacial time as it is today, a relatively narrow belt across which drained a series of consequent streams flowing northeastward across the strike of the belt and of the geologic structure. The consequent bedrock valleys are separated by bedrock ridges commonly several hundred feet high. The eastern boundary of the foothills belt is where the foothills ridges terminate quite abruptly at the edge of a broad plain. This abrupt change in the character of the bedrock topography coincides almost exactly with the structural edge of the foothills as shown on a geological map.

The author has done insufficient detailed mapping to check the interpretations of Alden and Horberg regarding the various upper bench levels and their ages.

The Saskatchewan Gravels and Sands (Rutherford, 1937; Westgate and Bayrock, 1964) are largely confined to the valleys and have either been let down from higher and older benches or have been carried in from the mountains by the preglacial and possibly early glacial rivers which flowed in these valleys.

The latest developmental stage of the preglacial topography is readily discernible in some places but not in others. For example, at the confluence of the Lethbridge and Stand Off valleys (Fig. 3) the course of the Stand Off channel is quite well defined, but whether the river occupying the Lethbridge Valley at that time flowed north or south of the bedrock high in Tp. 9, Rs. 24 and 25, W. 4th Mer. is not obvious.

## Drainage Basins of the Preglacial Topography

The preglacial drainage basins and their major and many of their secondary valleys have been reconstructed by marking the thalweg (line through the lowest points of a valley) of each valley (Fig. 3). The exact extent of erosion and modification of the preglacial land surface that was accomplished by glacial erosion and by any glacial or Recent fluvial erosion is uncertain. A few of the minor tributary valleys shown may well be of glacial or Recent origin.

Two major drainage systems, the Lethbridge and the Whisky, drained most of the region (Fig. 3), the Lethbridge being much the larger system. In those parts of the map-area north of the 50° parallel of latitude, only upstream tributaries of the Lethbridge basin or of the ancestral basin of the Bow River to the north are present.

The nomenclature of Stalker (1961) for the various river and stream valleys of the preglacial drainage has not been retained because each name was taken from a present-day river or stream. Current geologic usage, adopted by the Research Council of Alberta, dictates that preglacial valley names should not be the same as those of present streams or stream valleys because of the confusion that naturally results from such duplication. Farvolden's (1963b) use of the proposed valley names "Stavely" and "Carmangay" has been retained. Other names were chosen from local communities, physical features or historical locations (Appendix A).

A revised picture of the main valley trends and divides of the preglacial land surface in southern Alberta is presented in figure 4. The information is obtained from the work of Stalker (1961), Farvolden (1963b), Meyboom (1963), Campbell and Almadi (1964), and Westgate (in press), and from the present study. The information from Westgate in NTS sheet 72E and from the present paper, having been produced from considerable data in large areas, is more detailed and is thought to be more reliable.

## Whisky System

A portion of the Whisky system lies in the southeast corner of the map-area (Fig. 3). The divide between the preglacial Lethbridge and Whisky systems runs generally along the highest bedrock prominences on the Milk River Ridge to the north and west of the Whisky and North Whisky valleys. In the vicinity of Ross valley the preglacial divide is indefinite. The present bedrock divide lies to the south of this valley. When the erosion by the glacial meltwaters and recent streams in the valley of Lonely Valley Creek (Fig. 2) is taken into account along with the trend of Ross valley it seems probable that the preglacial divide lay to the north of that valley (Fig. 3). Ross valley is believed to have drained south-eastward and joined the North Whisky valley in township 2, range 20. The two major preglacial tributary valleys are North Whisky valley and Whisky valley. Just which of the two distinct bedrock channels in townships 1 and 2, ranges 18, 19 and 20 carried the Whisky River is uncertain.

## Lethbridge System

The Lethbridge system which comprises several major and numerous minor tributaries drained the entire area of the mountain and foothills belts between the United States border and at least the north boundary of township 11. Drainage was concentrated into a major valley - about 10 miles wide in township 11, range 15 - which led out of the area to the east-northeast.

Three major and one minor tributary basins drained the western part of the Lethbridge system in preglacial time. The major basins were the Lethbridge, Stand Off, and Whoop-Up basins and the minor basin was the Blood basin. They joined to form the one main valley in the area between Fort MacLeod and Coaldale. A sizable tributary joined the Lethbridge valley from the north, in township 10, range 18 near where the present-day Little Bow and Oldman Rivers join; this quite possibly was the preglacial Teepee valley.

In the area of the east-central border of NTS sheet 82H control is not dense enough to indicate how much of the drainage off the northeastern side of the Milk River Ridge was into the Lethbridge valley and how much drained into a tributary of the Lethbridge (Skiff valley) to the east.

The Whoop-Up basin occupied approximately the same position as the present St. Mary River basin. The northwest corner of the present basin area was apparently occupied in preglacial time by a small separate drainage basin herein called the Blood basin. Along the southwestern border of the St. Mary basin the divide has probably been shifted 3 to 5 miles northwestward from preglacial to present time and the Cardston valley, now occupied by Lee Creek (Fig. 2) which flows into the St. Mary River just above the St. Mary reservoir, probably drained into Stand Off valley in preglacial time. The preglacial eastern divide was from 0 to 12 miles farther east than the present one in the area north of township 3. In townships 2 and 3 the eastern preglacial divide, as interpreted and previously discussed (p. 7) ran a few miles northwest of the present bedrock divide. In township 1 the eastern divides are essentially coincident.

In townships 5, 6, 7, and 8 the Whoop-Up valley ran several miles east of the present St. Mary River. A few miles northeast of Spring Coulee the preglacial valley formed a narrow gorge which suggests that the broad upstream part of the Whoop-Up basin may at an earlier time have belonged to the Stand Off basin and have been captured by headward erosion of the Whoop-Up valley.

The Blood basin is a small tributary basin of about 200 square miles, with a series of minor valleys running from bedrock divides on the Blood Indian Reserve northeastward to join the Lethbridge valley southwest of the city of Lethbridge. It lies between the Whoop-Up and Stand Off basins.

The Stand Off basin is almost the same as the present basin of the Belly River. The basin divides of preglacial and present times are approximately coincident with two exceptions. The first exception is in the vicinity of Lee Creek where, as previously discussed in connection with the Whoop-Up basin, Cardston valley is interpreted as belonging in the preglacial Stand Off River basin. Secondly, southeast of the town of

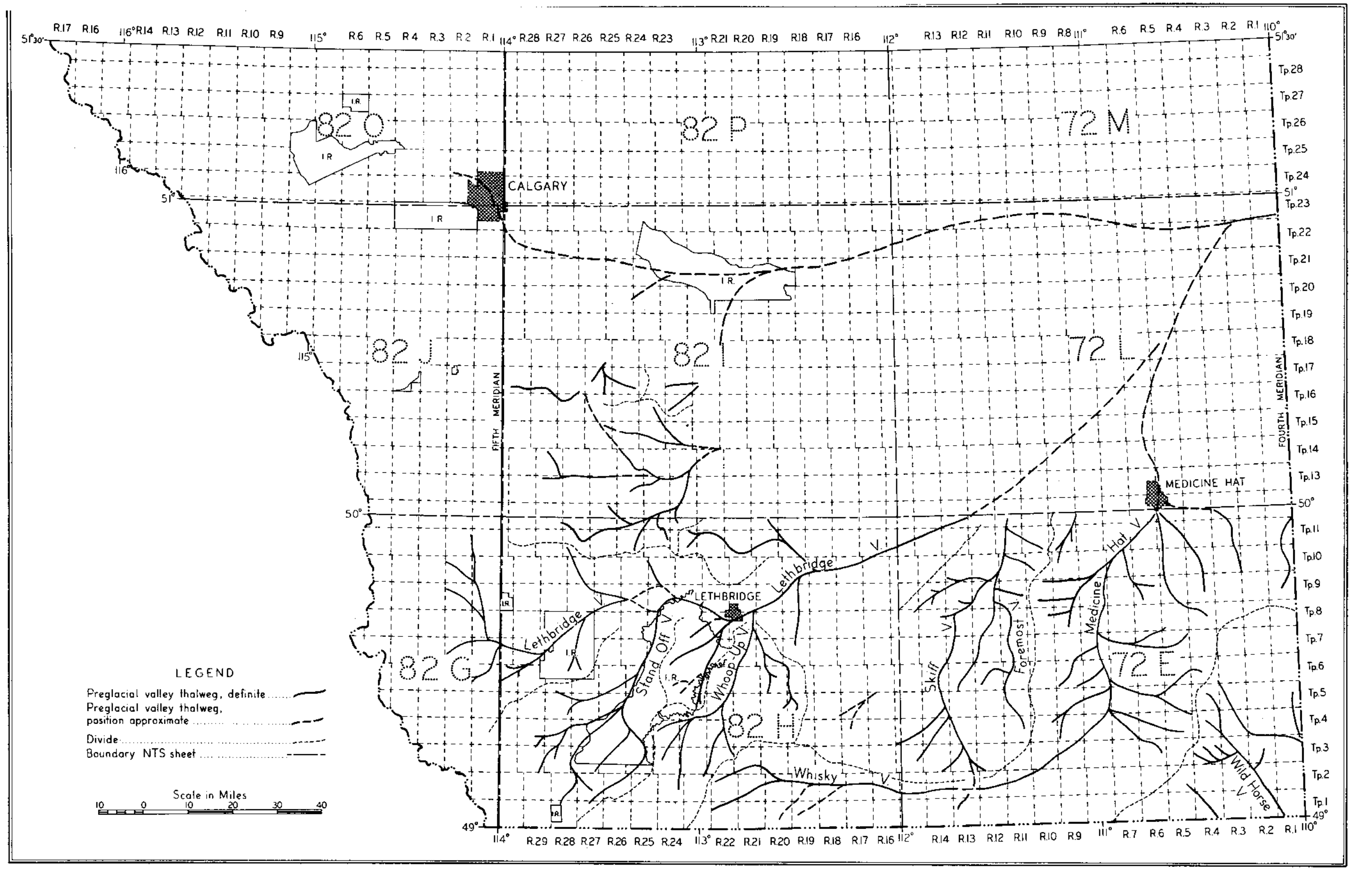


Figure 4: Main established preglacial valley and divide locations, southern Alberta

Pincher Creek, the location of the preglacial divide is uncertain, but is interpreted as running to the west of Halifax Lake (Tp. 6, R. 28), 2 to 3 miles northwest of the present divide. Stalker (1961) shows the Halifax valley and its northern tributary as the "Interglacial Oldman Valley (?)." The present bedrock-contour map (Fig. 2) indicates that the downstream part of this inferred tributary valley is a well-defined valley probably of preglacial origin. The broad valley in the vicinity of Halifax Lake may be of interglacial or interstadial origin. It may also be the remnant of an older preglacial valley which at one time carried the Southfork or the Pincher valley drainage, or both, and which in more recent preglacial time was cut off from the upstream portion by headward-eroding tributaries of the Lethbridge River.

The Lethbridge basin above the junction with Stand Off valley generally occupied the same area as the present Oldman basin. The southern preglacial divide is, as previously described, nearly coincident with the present divide. The northern preglacial divide runs from a point almost directly under the village of Nobleford westward underneath the town of Granum and thence to the Porcupine Hills in the vicinity of Meadow Creek - generally south of the present divide. At the eastern front of the Porcupine Hills the distance between the preglacial and present divides is over 20 miles. West of this point the location of the northern Lethbridge divide is unknown although it must run northward some distance along the Porcupine Hills in order to be north of preglacial Northfork valley in its headwater region. The extensions of Northfork, Middlefork, and Southfork bedrock valleys into the mountain belt may contain no remnants of the preglacial surface and therefore they have not been shown as parts of the preglacial valley system.

East of Coaldale the Lethbridge valley has two defined preglacial tributary valleys and probably some as yet undefined tributary valleys (undefined because of a lack of control data in townships 7 to 11, ranges 16 to 18). The major tributary (for the present unnamed) entering from the north in township 10, range 18 is joined from the west by Keho valley, another tributary drainage basin.

Teepee Basin

In the northern part of the area are a number of tributary valleys whose relationship to major downstream valleys is uncertain. The Kirkcaldy, Champion, Teepee, and Carmangay valleys are thought to be all part of the Teepee basin.

The Stavely valley is interpreted as the "interglacial Willow Creek valley (?)" by Stalker (1961). Whether or not this valley is preglacial, interglacial or interstadial is still in question.

In the general area of the Teepee, Champion, Silver, and

Vulcan valleys, interpretation of the most recent preglacial drainage is very difficult. Silver valley may have joined a tributary of the Vulcan valley or may have joined the Teepee or Champion valley, although field relationships suggest the former. The drainage to the southeast may have been through either Champion valley or Teepee valley.

## ECONOMIC GEOLOGY

An important economic byproduct of a study of the bedrock topography lies in its help in locating the gravel deposits called the Saskatchewan Gravels and Sands (Rutherford, 1937; Westgate and Bayrock, 1964). These deposits overlie much of the bedrock in southwestern Alberta and they are potential sources of gravel and sand as well as potential reservoirs suitable for the production of groundwater. The major, and to some extent the minor, preglacial valleys contain the main accumulations of these gravels and sands. Where the preglacial valley floors are lower than the present river valleys, as on the Blood Indian Reserve in townships 7, and 8, range 24, any Saskatchewan Gravels in them are potential reservoirs for groundwater. In most of southwestern Alberta this potential has not been tested. Where the present rivers have cut beneath the old valleys, as for instance along the Oldman River at Lethbridge, the deposits are potential sources of sand and gravel for industrial purposes. Comparison of the contours on the preglacial and present surfaces will indicate promising situations in any particular area.

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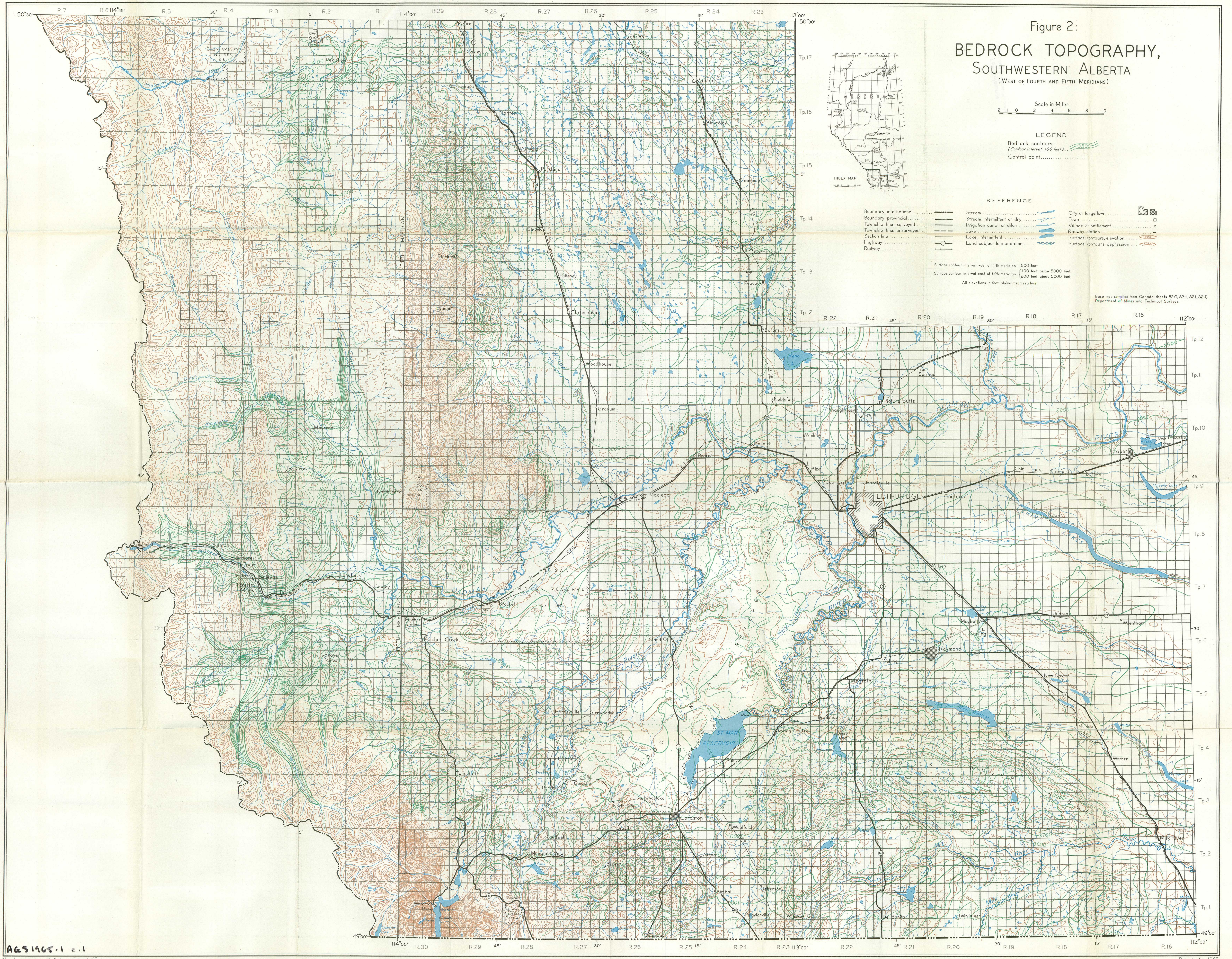
## APPENDIX A. DERIVATION OF PREGLACIAL VALLEY NAMES

The preglacial valleys described in this report have all been named after nearby population centers, lakes, peculiar physical features, or historical locations. The spelling and location of all the population centers, lakes, and streams, where possible, were taken from the Alberta section of the Gazetteer of Canada published in 1958. A tabular summary of name sources and their locations is given below.

| Valley Name | Named After | Location Tp. | R. | Mer. |
|---|---|---|---|---|
| 1. Cardston | Town of Cardston | 3 | 25 | W.4 |
| 2. Carmangay | Village of Carmangay | 13 | 23 | W.4 |
| 3. Champion | Village of Champion | 15 | 23 | W.4 |
| 4. Chin | Hamlet of Chin | 9 | 19 | W.4 |
| 5. Cochrane | Cochrane Lake | 4 | 27 | W.4 |
| 6. Halifax | Halifax Lake | 6 | 28 | W.4 |
| 7. Jensen | Jensen Dam | 4 | 22 | W.4 |
| 8. Keho | Keho Lake | 11 | 22,23 | W.4 |
| 9. Kimball | Hamlet of Kimball | 1 | 24 | W.4 |
| 10. Kirkcaldy | Hamlet of Kirkcaldy | 16 | 24 | W.4 |
| 11. Lethbridge | City of Lethbridge | 8,9 | 21 | W.4 |
| 12. Middlefork | Local name for Crowsnest River | 7 | 1,2 | W.5 |
| 13. Mountain View | Hamlet of Mountain View | 2 | 27 | W.4 |
| 14. Mud | Mud Lake | 9 | 27 | W.4 |
| 15. Northcliffe | Railroad station | 3 | 26 | W.4 |
| 16. Northfork | Local name for the upstream portion of Oldman River above Tp. 7, R. 1, W. 5. | 8,9 | 1 | W.5 |
| 17. Pincher | Town of Pincher Creek | 6 | 30 | W.4 |
| 18. Ross | Ross Lake | 2 | 22 | W.4 |
| 19. Silver | Silver Lake | 16,17 | 28 | W.4 |
| 20. Southfork | Local name for Castle River | 6,7 | 1 | W.5 |
| 21. Stand Off | Post office of Stand Off (also historical fort) | 6 | 25 | W.4 |
| 22. Stavely | Town of Stavely | 14 | 27 | W.4 |
| 23. Stirling | Stirling Lake | 6,7 | 19 | W.4 |
| 24. Teepee | Location of Indian teepee rings at a provincial camp ground near Carmangay | 13 | 23 | W.4 |
| 25. Vulcan | Town of Vulcan | 15 | 24 | W.4 |
| 26. Whisky | Hamlet of Whisky Gap | 1 | 23 | W.4 |
| 27. Whoop-Up | Site of historical fort | 8 | 22 | W.4 |




Map to accompany Preliminary Report 65-1

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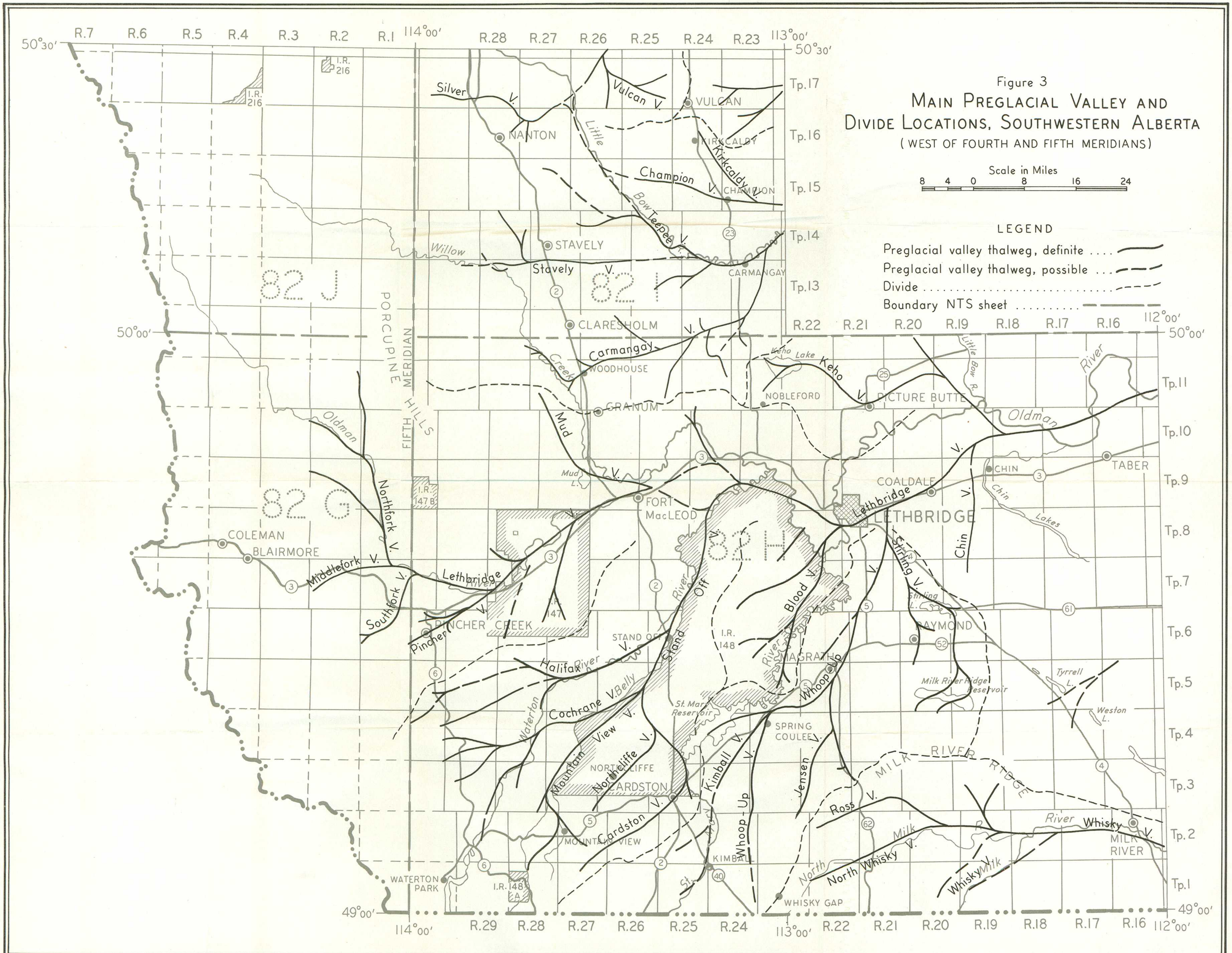


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