

**Report 76-3**

**Hydrogeology of the Whitecourt area, Alberta**

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# HYDROGEOLOGY OF THE WHITCOURT AREA, ALBERTA

## ABSTRACT

The Whitecourt map area is only thinly covered by drift over most of the region northwest of the Athabasca River. The drift thickness may exceed 100 feet (30 m) in places in the southern, southeastern, and eastern parts of the area in buried valleys. Sand and sand and gravel within these valleys form important aquifers which may yield upwards of 25 igpm (about 2 l/sec) to a single well. Two formations, both continental shale-sand sequences - the Paskapoo Formation of Paleocene-Late Cretaceous age, and the Wapiti Formation of Late Cretaceous age - underlie most of the area. Single well yields from aquifers within these formations generally range between 5 to 25 igpm (0.4 to 2 l/sec) although areas of both higher and lower production are to be found.

Sodium bicarbonate waters with total dissolved solids contents from 500 to 2000 ppm are the rule within commonly utilized aquifers at depths of less than 500 feet (150 m). The total dissolved solids contents are lowest in wells in the areas with more rugged topography, and highest in the area of low relief.

## INTRODUCTION

The area is bounded by latitudes 54° and 55° north, and longitudes 114° and 116° west. Under the Alberta Land Survey system it includes most of townships 58 to 69 and ranges 1 to 14, west of the fifth meridian. The total area encompassed is approximately 5440 square miles (approximately 14,100 sq km).

The hydrogeological survey on which the accompanying maps are based was carried out in 1971 in conjunction with a survey of the adjoining sheet to the west (Iosegun Lake, NTS 83K). A previous hydrogeological study covering part of the area had been carried out by Jones (1962).

Much of the area is unsettled. Less than one-third, the southeast part, is cultivated. The town of Swan Hills was built to service nearby oil and gas fields. Lumbering and fur trapping are other important industries, although the latter has declined greatly in importance in recent years. As well, the area is fine for moose-hunting.

The only towns (populations as of 1971 are in brackets) are: Whitecourt (3202), Barrhead (2803), and Swan Hills (1376). Fort Assiniboine, with a population in 1970 of 166, is the only incorporated village. Of the other hamlets, railway sidings, and post offices, the largest are Blue Ridge, Greencourt, Fawcett, and Neerlandia. In these small centers water for domestic use is provided by individually drilled wells. The larger centers (towns and village) have central water distribution systems, and of these only Swan Hills uses a groundwater source of supply.

#### Acknowledgments

Field and office assistance and drill site supervision were ably handled by A. Beerwald who also compiled water well information on 1:50,000 scale maps prior to the start of the field work. I would like to thank all the fine people who were contacted during the course of this survey.

Supplying of drill cuttings of wells being drilled, drilling of observation holes, and carrying out of pump tests were made by arrangement with Jack Warehime. Jack and Frank Warehime, Robert Bablitz, Ralph Neumann, and René Boutin kindly allowed access to old drilling records.

Chemical analyses of water samples were performed by the Council's Geochemical Laboratory and by the Veterinary Services Division Laboratory of Alberta Agriculture.

The manuscript was edited by R. Bibby, G. Ozoray, and J. Tóth.

#### CLIMATE

The climate of the area is humid continental characterized by long, cool summers according to the Koeppen climatic zone classification (Longley, 1968). The mean annual temperature at Campsie is 34.8°F (1.55°C) and at Whitecourt is 34.2°F (1.2°C). The mean annual precipitation ranges from less than 18 inches to over 24 inches (46 to 61 cm).

Monthly rates of potential evapotranspiration have been approximated from maps prepared by Bruce and Weisman (1967) and are shown for the weather stations at Peavine, Campsie, and Whitecourt and for the Deer Mountain Lookout station. Potential evapotranspiration in the period April to October inclusive apparently exceeds rainfall in the months of May to September inclusive at Whitecourt, but exceeds rainfall only during May, June, and July at Deer Mountain Lookout.

A small area of climafrost (Lindsay and Odynsky, 1965) is to be found in the northwest corner of the area. In this area a frozen layer within organic soils may be encountered in shaded locations. The frozen condition is expected to be temporary but frequently lasts for more than one year. "The frozen layer ... could usually be penetrated with a steel probe, and occurred at an average depth of 24 inches." (Lindsay and Odynsky, 1965, p. 265).

#### PHYSIOGRAPHIC FEATURES

The physiographic features of the area are named as outlined in the Atlas of Alberta (Univ. and Govt. of Alberta, 1969). Most of the area, that is, the portion west and north of the Athabasca River, forms part of the Swan Hills Upland. The Lesser Slave Lowland, delimited on the west by the 2000-foot contour line (610-m), extends along the Athabasca River to the vicinity of Fort Assiniboine, and along the Pembina River. The intervening area and the area along the Athabasca River above Fort Assiniboine make up part of the Eastern Alberta Plains. A very small part of the area, the highlands in the southwest corner south of the Athabasca River, lies within the Western Alberta Plains.

The Swan Hills Upland and the Western Alberta Plains are characterized by rugged, hilly topography. The maximum elevation within the area is just over 4400 feet (1340 m) above sea level and is attained in the Swan Hills. Elevations below 1900 feet (580 m) above sea level are found within the Lesser Slave Lowland along the Athabasca River.

The main drainageways are the Athabasca River and its tributaries the McLeod, Pembina, Freeman, Sauliteaux, and the Sakwatamau Rivers. The Swan River flows northward into Lesser Slave Lake. All form part of the Mackenzie River system which drains to the Arctic Ocean.

Mean annual runoff (Neill *et al.*, 1970 Fig. 11) ranges from about 1 1/2 inches (4 cm) in the southeast corner to about 6 inches (15 cm) in the northwest corner of the area.

#### GEOLOGY

Geological units within the bedrock are shown as indicated by Green (1972). Green's description of these units is as follows:

### Paleocene and Upper Cretaceous

Paskapoo Formation (TKp): *grey to greenish grey, thick bedded, calcareous, cherty sandstone; grey and green siltstone and mudstone; minor conglomerate, thin limestone, coal and tuff beds;*

Scollard Member (Ksc): *grey, feldspathic sandstone; dark grey bentonitic mudstone; thick coal beds; nonmarine.*

### Upper Cretaceous

Whitemud and Battle Formations (Kwb): *pale grey, white-weathering bentonitic sandstone and mudstone (Whitemud Formation); purplish black, mauve-weathering bentonitic mudstone containing siliceous tuff beds (Battle Formation); nonmarine.*

Wapiti Formation (Kwt): *grey, feldspathic clayey sandstone; grey, bentonitic mudstone and bentonite; scattered coal beds; nonmarine.*

Lea Park Formation (Klp): *dark grey shale; pale grey glauconitic, silty shale with ironstone concretions; marine.*

All the above formations outcrop within the area. In the subsurface (sections A-A', B-B' and D-D') the sequence continues as follows (after Green, 1972):

### Upper and Lower Cretaceous

Labiche Formation (Klb): *dark grey shale and silty shale; ironstone partings and concretions; silty fish-scale bearing beds in lower part; marine.*

### Lower Cretaceous

Pelican Formation (Kpl): *fine-grained quartzose, silty and glauconitic in lower part; marine.*

Joli Fou Formation (Kj): *dark grey fossiliferous shale, silty interbeds in upper part; marine.*

Grand Rapids Formation (Kg): *fine-grained quartzose and feldspathic sandstone, laminated siltstone and silty shale; thin coal beds; shoreline complex.*

The Wapiti Formation, based on electrolog interpretation, can be divided into two informal units as indicated on the cross sections accompanying the map. The lower unit contains more, and more continuous, sandstone lenses than does the upper unit.

The fish-scale bearing beds within the Labiche Formation form a distinctive marker on electrologs. The base of the zone (BFSc) is indicated on cross section B-B'.

Structure contours have been drawn on the top of the Battle Formation and on the Lea Park Formation with the aid of J. W. Kramers. A general southwesterly dip of approximately 25 feet per mile (about 5 m/km) and of 30 to 35 feet per mile (about 6 to 7 m/km) is indicated by the respective contour lines. The Lea Park contours have only been drawn to about the point where the top of the Lea Park is 1000 feet (300 m) below ground level. They are not considered to be as reliable as the contours of the Battle Formation, because the interfingering between Lea Park Formation shales and lower Wapiti Formation sandstones makes an exact pick of the contact difficult.

Surficial geology has been mapped by St-Onge (1969). Carlson (in prep) has mapped the bedrock topography. Drift thicknesses are generally less than 50 feet (15 m), and exceed 100 feet (30 m) along courses of preglacial valleys in the eastern and southern parts of the area - along or near Athabasca, Pembina, Paddle, and Little Paddle Rivers, and Shoal, Romeo, and Bull Creeks.

## HYDROGEOLOGY

### Water Levels

Few wells have been drilled in the area and these have been completed at various depths within many different aquifers. It is therefore very difficult to construct meaningful or very accurate water level maps. Also, these water level contours must be shown on a topographic map with only 100-foot (30-m) contour intervals, so even less meaning can be read into such maps. However, in spite of all this, average water level contours for wells 100 to 400 feet (30 to 120 m) in depth have been constructed. These give an indication of groundwater flow direction, which in fact can almost as easily be obtained from the topographic contours since the water levels are more or less a subdued replica of the topography. Areas of presumed downward (recharge) and upward (discharge) groundwater movement are indicated along the water level contours. Contours have been drawn only for the southern and extreme eastern parts of the area.

### Flowing Wells

Areas of flowing wells have been delimited. Only the largest such areas could be shown. Smaller, more localized areas which are not shown, occur along streams, at the bases of hills, and at local breaks in slope. The areas outlined are generalized and may include smaller areas in which wells will not flow. Flowing wells or shotholes have been reported from all the areas delineated.

## Aquifers

The lithology of the principal aquifer underlying any area is indicated on the map. The main aquifer types are:

- 1) Recent alluvial gravels along the Athabasca, Freeman, Swan, and Moosehorn Rivers
- 2) sands along the Coutts and Sauteaux Rivers
- 3) buried valley gravels and sands along the Athabasca, Pembina, and Paddle Rivers and along Shoal Creek
- 4) high level gravels on the Swan Hills
- 5) Paskapoo Formation sandstones
- 6) bentonitic sandstones and coal seams of the Wapiti Formation and Scollard Member of the Paskapoo Formation.

Individual aquifers within both the Paskapoo and Wapiti Formations are lenticular and may have only limited lateral extent; however, aquifer-bearing zones are often traceable for many miles.

## Average Expected Well Yield

The average expected well yields shown on the map indicate the total quantity of water that can be obtained by a single, properly constructed and developed well that taps all water-bearing intervals within the upper 1000 feet (300 m) of strata, regardless of quality. In the majority of cases, most of the yield will be from a single zone and generally from depths of less than 300 feet (90 m).

The yield values are 20-year estimates based largely on apparent transmissivity and available drawdown.

It should be stressed that this is an interpretative map based on limited control, which in the higher yield ranges especially (over 25 igpm or 2 l/sec), is often of dubious reliability. Areas in which a yield range is based on long-term pump tests, production tests, or numerous short-term bail and pump tests, are shown by a dark color. Where the yield range is less well established, that is, where test data is lacking or scarce or judged to be of low reliability, a light color has been used.

Even in areas where the expected yield is shown to be established, local areas of higher or lower expected yield can be found. This can be due to presence or absence of local,



relatively more permeable, lenses of sandstone, sand or gravel, to weathered zones at the drift-bedrock contact, or to other unsuspected conditions. A good understanding of the subsurface geology is essential when interpreting probable well yield.

When data are scarce, numerous assumptions have had to be made. Some of these are:

- 1) the geology largely determines rock permeability;
- 2) topography, and to a lesser extent geology, largely determine saturation and head conditions;
- 3) geology and topography together largely determine the yield to be expected and the areas of similar geology and topography will have similar yields;
- 4) the amount of precipitation has little effect on short-term well tests (on which this evaluation is largely based) in which water is drawn almost entirely from existing storage;
- 5) in rock masses containing "good" aquifers (Todd, 1959), expected yields are markedly lower in topographically high areas than in low areas due to large differences in available head of water, unless the high areas have a wide lateral extent;
- 6) in rock masses containing poor aquifers (for example, thick shale sequences and some sandstone-shale sequences) the yield range is not noticeably different under differing topographic situations;
- 7) alluvial gravels normally form good aquifers.

Detailed water level measurements for only four pump tests of 24 hours or more in duration were available at the time this study was made, and three of these were within one small area. Most of the yield values are based on calculations of apparent transmissivity. This was supplemented by well performance records as determined from drillers, farmers, and industrial or town records. The specific capacity or apparent transmissivity could sometimes be obtained from this information.

The two most important factors which determine the yield are the geological situation and the topographic position of favorable formations. Yield boundaries and lithology changes should, therefore, often be coincident. For various reasons, this coincidence occurs less often than might be expected. This, however, may be more apparent than real, due to shortcomings of test interpretation, well completion and development, to changes in facies and permeability with a single stratigraphic unit, and to lack of knowledge of stratigraphic details. The delineation of yield areas therefore is largely dependent on detailed knowledge of the geology of the area. In this area, the detailed stratigraphy of surficial materials especially is poorly known. Delineation of permeable beds and lenses by stratigraphic studies, along with some pump testing, is necessary to further evaluate yield

areas. In this area, this has been possible only in broad outline because of the limited time available for the study. The result is small patchy areas of varying probable yield, the highest yield areas reflecting more permeable zones, largely sand and gravel within the drift and permeable sandstone within the bedrock formations. The more permeable materials are generally river-sorted and deposited and, where buried beneath later deposits, can be very difficult to locate. Sorting and thickness of different grain size ranges can be quite variable which makes accurate predictions of long-term yields difficult.

Yields of over 100 igpm (8 l/sec) have not been assigned to any area, although such yields may be possible under favorable conditions at certain localities from alluvial gravels along the Athabasca River, from channel sands and gravels, and from some of the better bedrock aquifers.

Yields of 25 to 100 igpm (2 to 8 l/sec) are considered possible in situations similar to those mentioned above. Yields within this range have been demonstrated in all of the areas outlined and indications of locally higher yields have been obtained but are considered uncertain as yet.

Yields of 5 to 25 igpm (0.4 to 2 l/sec) are considered possible over most of the area from bedrock aquifers, thin alluvium and intertill, or near-surface sands and gravels. Areas of both higher and lower yield will undoubtedly be outlined within this larger area at a later time.

Yields of only 1 to 5 igpm (0.1 to 0.4 l/sec) are likely to be obtained in some areas. "Dry" wells with yields of much less than 1 igpm ( $>0.1$  l/sec) are to be expected locally within these regions.

### Springs

Springs are an indication of near-surface aquifers, and their rates of flow can give an idea of possible rates of production from wells tapping that aquifer. Selected springs are shown on the map, and their rates of flow as measured or calculated at the time of mapping is indicated. The largest spring observed in the area is located west of Whitecourt and originates from alluvial terrace gravels along the Athabasca River. The aquifer which feeds the spring is probably a local one although it would have to be of sufficient extent to provide a continual supply of water to the spring.

## HYDROCHEMISTRY

The hydrochemistry of the most commonly utilized aquifers within selected depth intervals is shown on the hydrochemical side maps, and changes with depth are further illustrated on the accompanying cross sections.

*Calcium-magnesium bicarbonate* waters with total dissolved solids contents usually below 600 ppm are the rule over much of the area in wells less than 50 feet (15 m) deep. However, in the southeast part of the area, in wells of this depth, *sodium bicarbonate* waters with total dissolved solids often exceeding 1000 ppm are more common.

*Sodium bicarbonate* waters are predominant in the 50 to 200 foot (15 to 60 m) depth range, although one small area of *sodium sulfate* waters also occurs. Total dissolved solids contents range from less than 500 ppm to over 2000 ppm; and exceed 2000 ppm in the area of sodium sulfate waters.

In the interval 200 to 500 feet (60 to 150 m), *sodium bicarbonate* waters are still dominant although now two areas of *sodium sulfate* waters appear, and a fairly large area of dominantly *sodium chloride* waters is also present. Total dissolved solids contents typically exceed 2000 ppm only in the areas of sodium chloride waters and sodium sulfate waters.

Analyses of water are lacking for the interval 500 to 1000 feet (150 to 300 m). At depths greater than 1000 feet (300 m) below ground level, *sodium chloride* waters with high contents of total dissolved solids are the rule except perhaps in the area of the Swan Hills where data are scarce. Even in this latter area, at some greater depth, sodium chloride waters are to be expected.

## CONCLUSIONS

The highest expected well yields within the map area are to be found within buried valley sands and gravels, present-day alluvial gravels, and more locally, within bedrock aquifers (mostly sandstone or coal).

Sodium bicarbonate waters with total dissolved solids contents of between 500 and 2000 ppm are most commonly utilized.

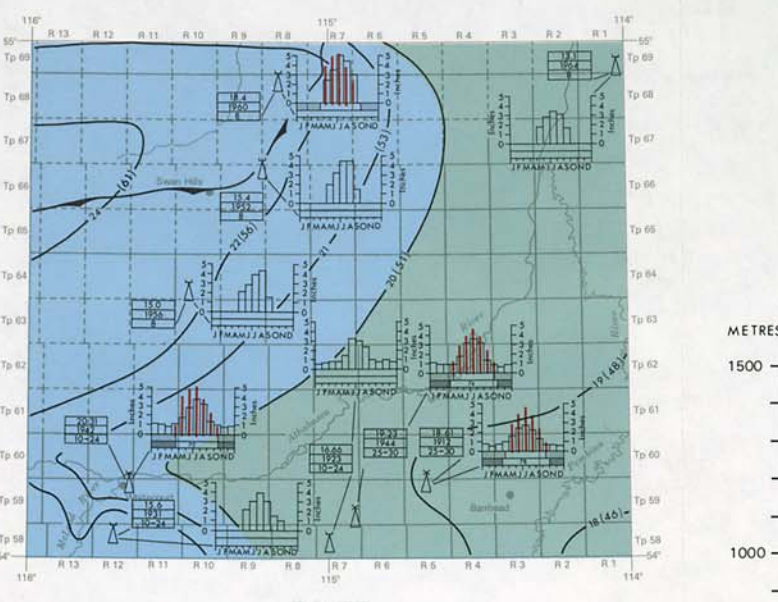
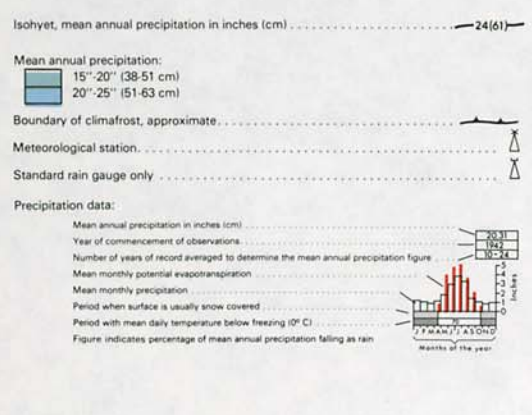
More, and more detailed, subsurface geological information is required and many detailed pump tests are needed in order to evaluate the area more fully.

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METEOROLOGY

LEGEND



MAIN MAP LEGEND

Topography

Surface contours and elevation in feet

Geology

Geological boundary

- QUATERNARY  
Unconsolidated deposits
- CRETACEOUS - TERTIARY  
TKp Palisade Formation  
Kec Scotford Member of Palisade Formation
- CRETACEOUS  
Kwb Whitecourt and Battle Formations  
Kw1 Whitecourt Formation  
Kip Lead Park Formation  
Kib Leduc Formation

Lithology

- Gravel  
Sand and gravel  
Sand  
Sandstone  
Sandstone, bentonitic  
Shale  
Coal

Hydrography

- Lake or slough, perennial  
Lake or slough, seasonal  
Marsh, meadow  
Stream, perennial  
Stream, intermittent  
Surface water divide

Hydrometry

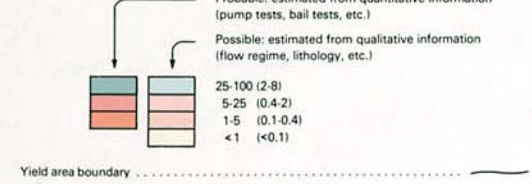
- Stream gauging station  
Average annual discharge  
Year of commencement of observations  
Channel area in square miles (km<sup>2</sup>)

Hydrogeology

- Spring, flow rate unknown  
Spring, flow rate known in gpm (l/sec)  
Hypothetical water level contour (elevation in feet followed by metres in brackets) and vertical component of groundwater movement  
Boundary of area of seepage flow

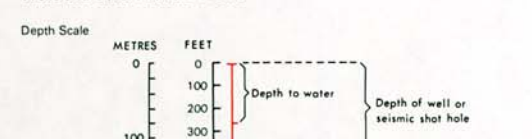
Groundwater Probability

Range of average yield of wells in gpm (l/sec)

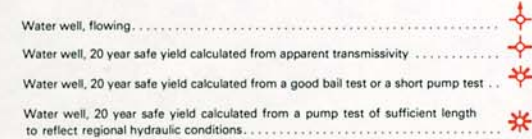


Wells and Other Artificial Works

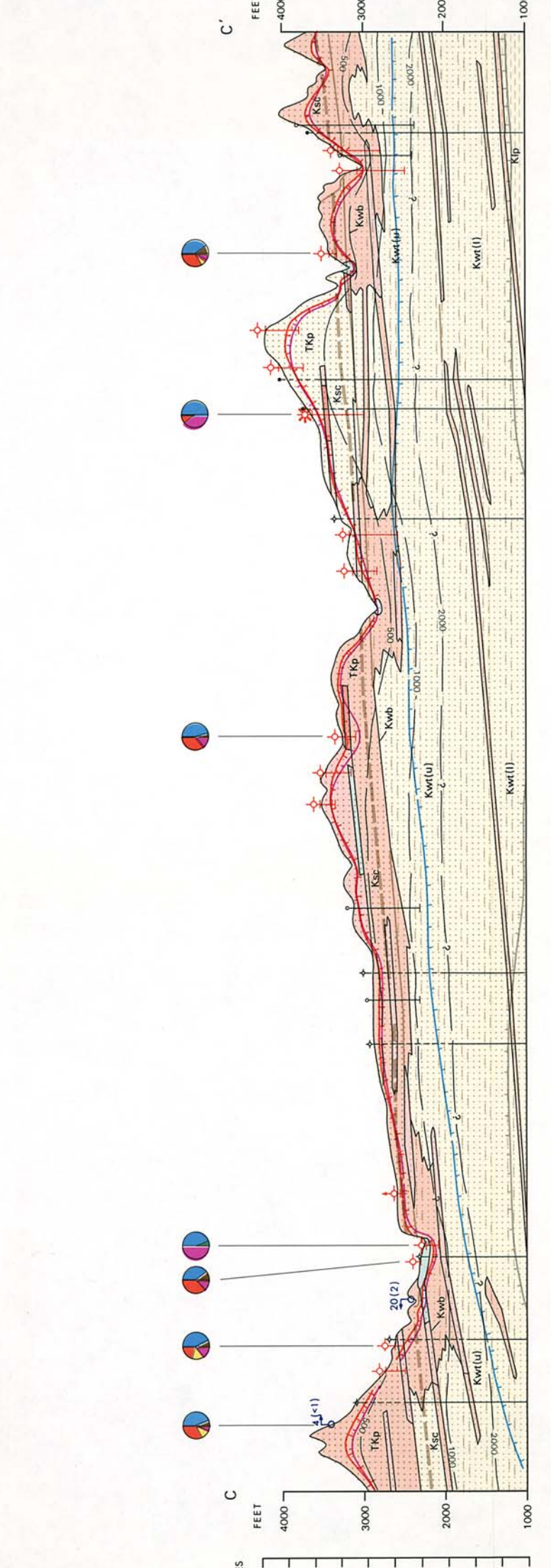
Depth Scale



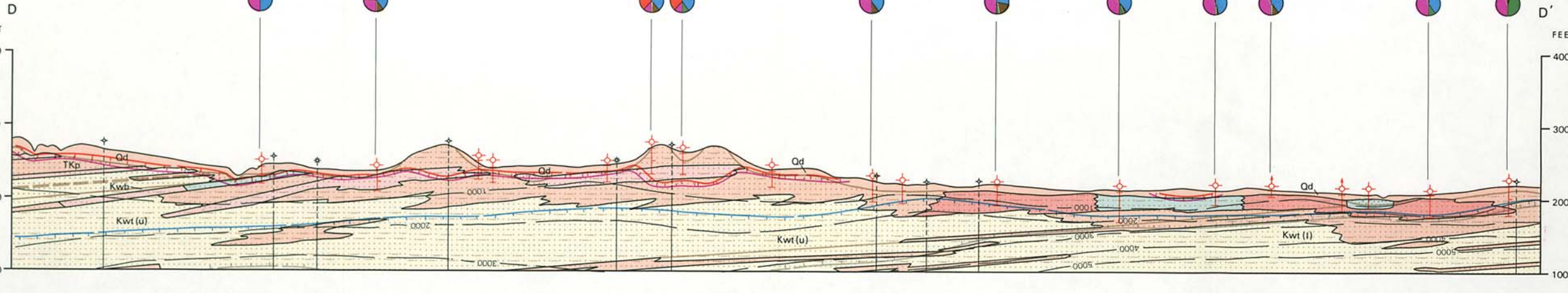
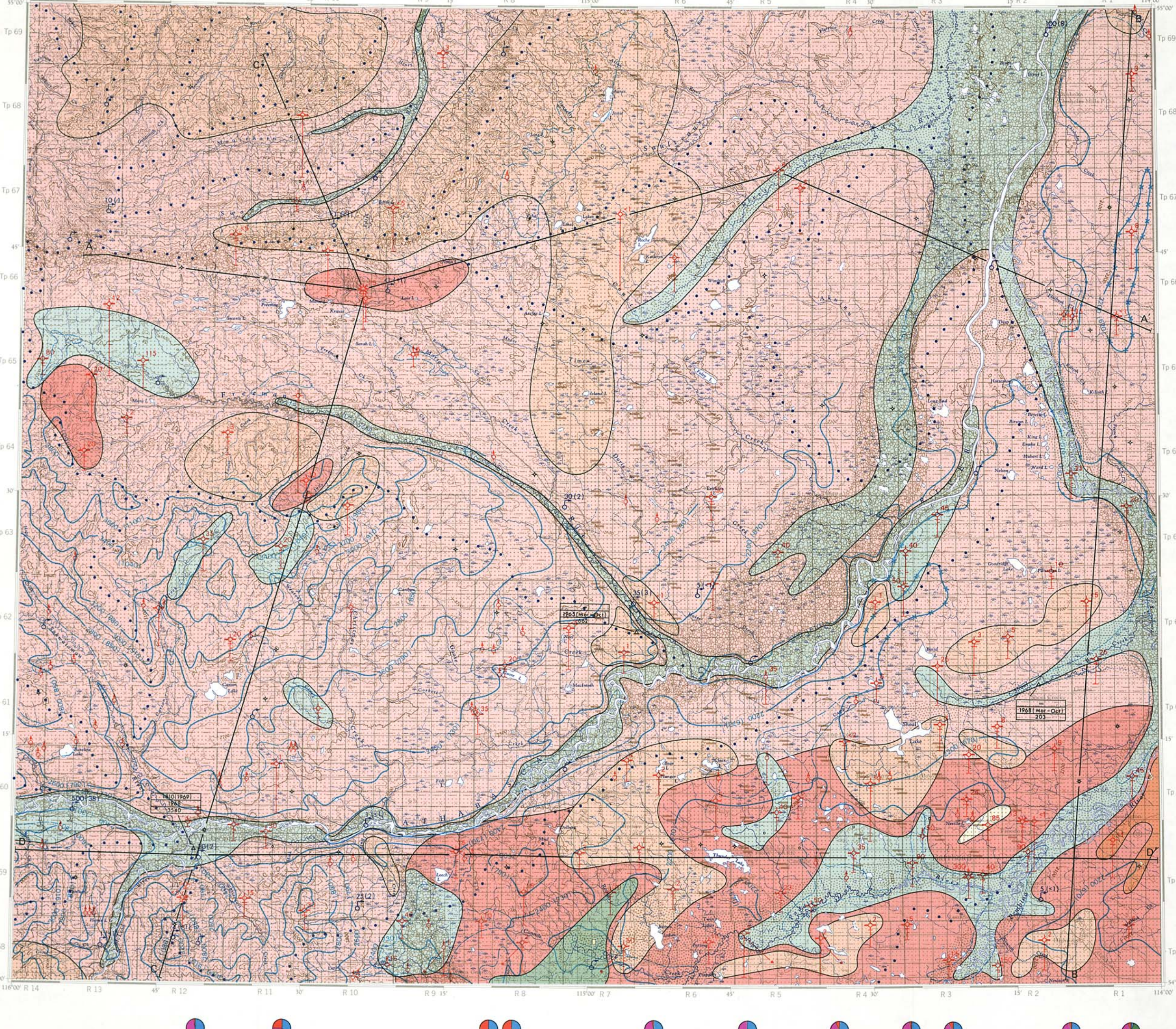
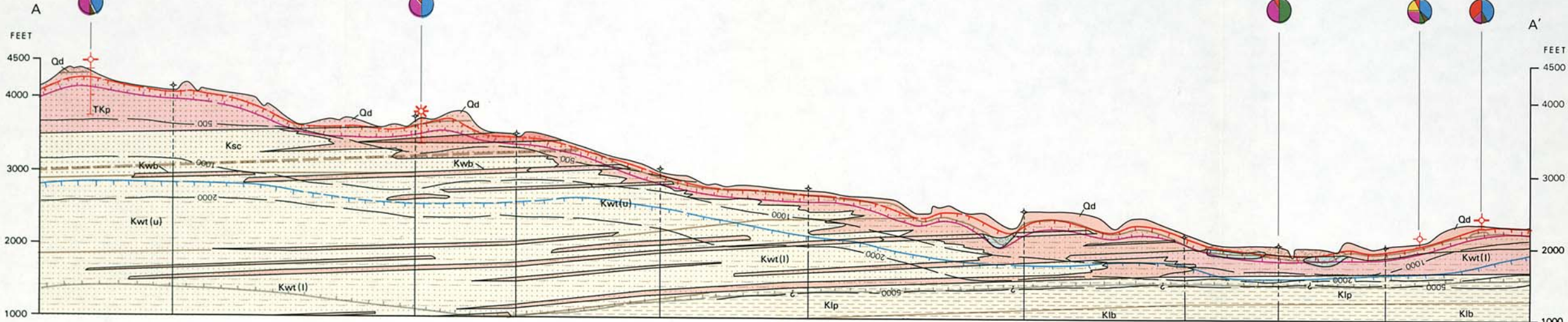
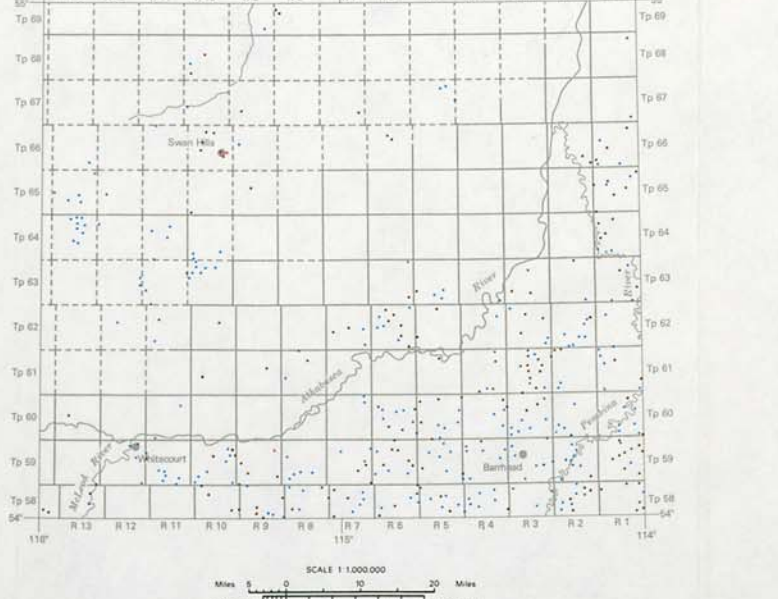
Hydrochemistry



DATA DENSITY



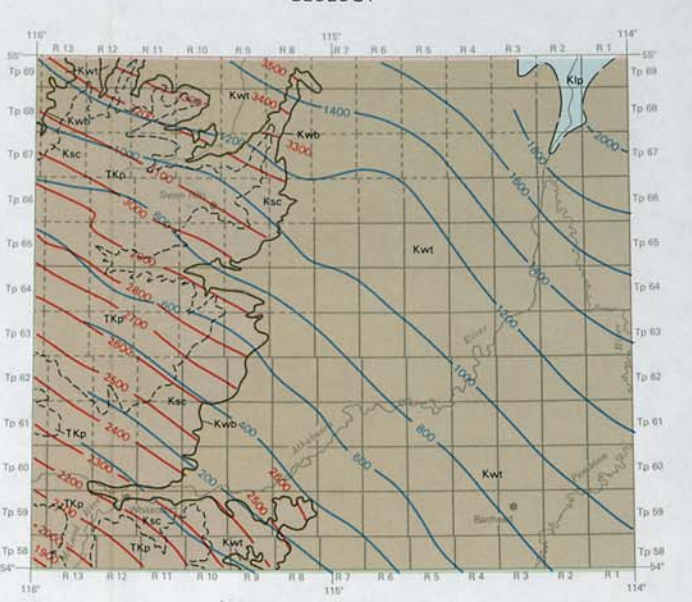
DATA DENSITY



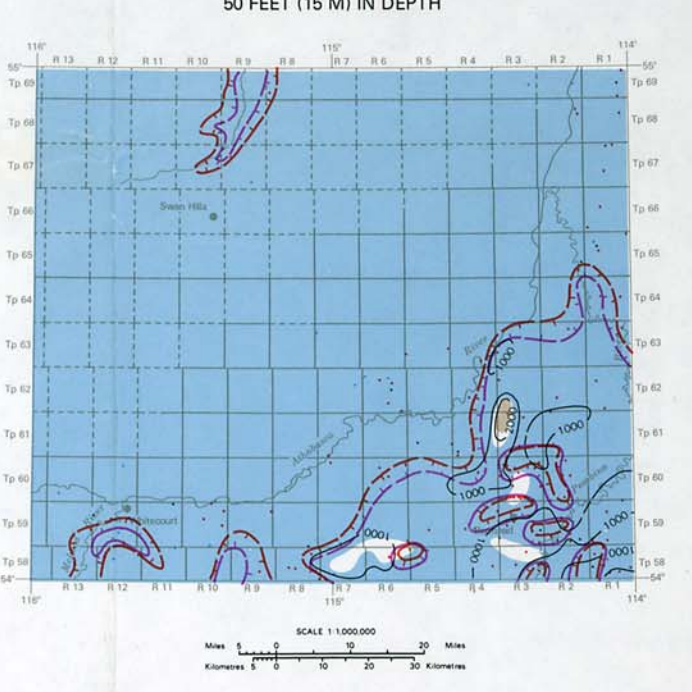
LEGEND

- Palisade Formation: grey to greenish grey calcareous sandstone, siltstone, mudstone, minor conglomerate, limestone, coal, and fat beds. Scotford Member: Red grey to blackish sandstone, bentonitic mudstone, thin coal beds, nonconformity.
- Whitecourt Formation: grey to blackish calcareous sandstone, bentonitic mudstone and bentonitic sandstone, bentonitic shale, nonconformity.
- Whitecourt and Battle Formations: pale grey, bentonitic sandstone and mudstone. Whitecourt Formation: purple-black bentonitic beds containing siliceous sulf beds (Battle Formation) nonconformity.
- Formation: dark grey shale, glauconitic clay shale with nonconformity, nonconformity.
- Rock unit boundary
- Structure contour on top of the Battle Formation (Kwanituk Turf Zone): 1000, 2000, 3000, 4000, 5000
- Structure contour on top of the Lead Park Formation: 1000, 2000, 3000, 4000, 5000

GEOLOGY



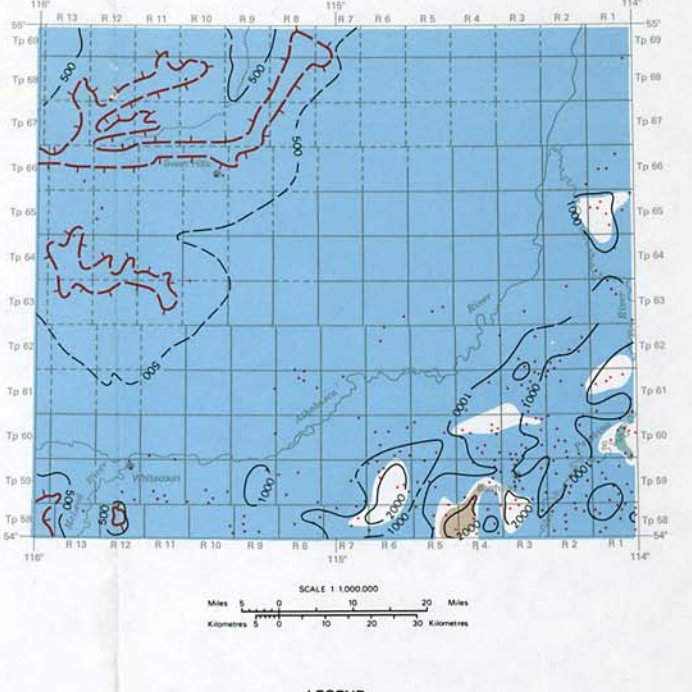
HYDROCHEMISTRY: WELLS LESS THAN 50 FEET (15 M) IN DEPTH



LEGEND

- Data control point marking location of a well  
Data control point marking location of a spring  
Data control point marking location of a well with high nitrate content  
Total dissolved solids:  
defined: 1000-  
approximate: 100-  
Carbonate + bicarbonate constituting over 60 percent of total anions  
Sulfate constituting over 60 percent of total anions  
Isogram along which calcium + magnesium constitute 60 percent of total cations; teeth indicate direction of lesser calcium content  
Isogram along which sodium + potassium constitute 60 percent of total cations; teeth indicate direction of lesser sodium content  
Isogram along which carbonate + bicarbonate constitute 60 percent of total anions; teeth indicate direction of lesser carbonate content  
Isogram along which sulfate constitutes 60 percent of total anions; teeth indicate direction of lesser sulfate content

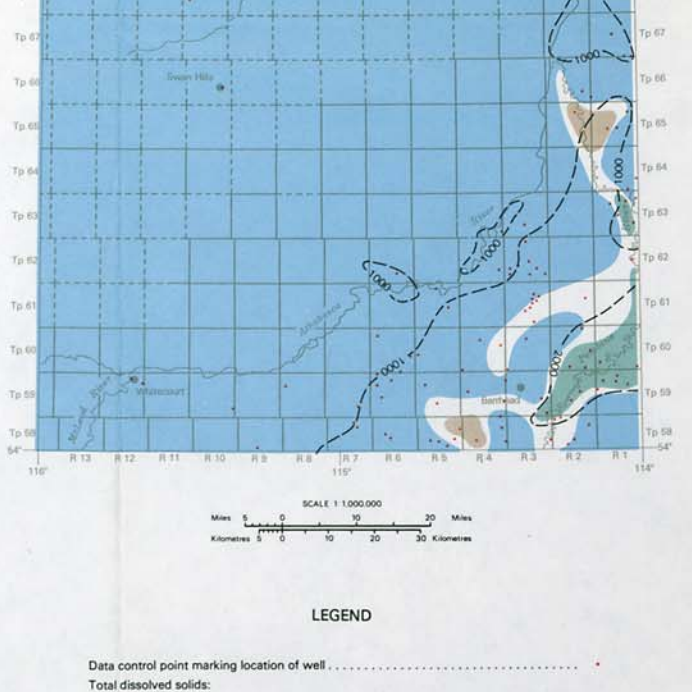
HYDROCHEMISTRY: WELLS 50 TO 200 FEET (15 TO 60 M) IN DEPTH



LEGEND

- Data control point marking location of a well  
Total dissolved solids:  
defined: 1000-  
approximate: 100-  
Carbonate + bicarbonate constituting over 60 percent of anions  
Sulfate constituting over 60 percent of anions  
Chloride constituting over 60 percent of anions

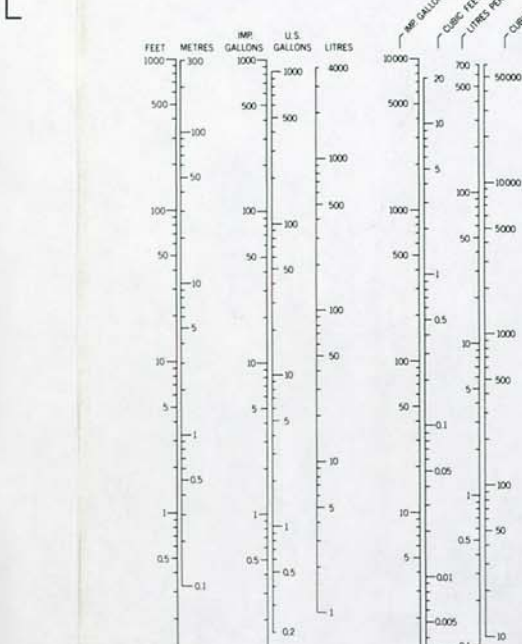
HYDROCHEMISTRY: WELLS GREATER THAN 200 FEET (60 M) IN DEPTH



LEGEND

- Data control point marking location of well  
Total dissolved solids:  
approximate: 1000-  
Carbonate + bicarbonate constituting over 60 percent of anions  
Sulfate constituting over 60 percent of anions  
Chloride constituting over 60 percent of anions

CONVERSION TABLE



HYDROGEOLOGICAL MAP  
WHITECOURT  
ALBERTA

NTS 83 J

All elevations in feet above mean sea level.  
Vertical exaggeration of the hydrogeological profiles is approximately 21X.  
An expanded legend and explanatory notes for use with this hydrogeological map series is available from the Alberta Research Council, Edmonton, Canada.  
Map to accompany Report 76-3.  
Hydrogeology by O. Tokarski, 1972.  
Drafted by R. W. Swanson.  
Edited by A. R. Campbell.