RESEARCH COUNCIL OF ALBERTA

REPORT 71-3

HYDROGEOLOGY OF THE ROCKY MOUNTAIN HOUSE AREA, ALBERTA

by

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ILLUSTRATIONS

HYDROGEOLOGY

OF THE ROCKY MOUNTAIN HOUSE AREA,

ALBERTA

Abstract

The Plains portion of the Rocky Mountain House map-area and part of the Foothills, totalling about 90 per cent of the area, are underlain by the Paskapoo Formation of Late Cretaceous-Tertiary age down to and below the limiting depth of investigation, 1000 feet below ground level. Evaluation of pump and bail tests and interpretation of spring flow rates and other field phenomena indicate that the approximate average 20-year safe yield of wells completed in this formation is 25 to 100 igpm (approx. 100 to 500 l/min). Lower yields, of 5 to 25 igpm (approx. 25 to 100 l/min) and in places of 1 to 5 igpm (approx. 5 to 25 l/min), are predicted for smaller areas within this formation. These lower yields are due to: lack of clean, permeable, extensive sandstone beds; low available drawdown in recharge areas; and, in the Foothills, to probable destruction of primary porosity by cementation and by low temperature metamorphic effects due to diastrophism. Yields of 100 to 500 igpm (approx. 500 to 2500 l/min) and locally over 500 igpm are predicted for local, generally low-lying areas where the combination of extensive high permeability zones and high available drawdown exists. Occasionally, induced infiltration from lakes or streams may be effective.

The remainder of the map-area is underlain by deposits of Cambrian to Recent age in the Rocky Mountains and inner Foothills, and by deposits of Quaternary and Recent age in the Plains. Yields are generally low, mostly under 5 igpm (approx. 25 l/min), except in areas of thick alluvial deposits and in localized areas of Devonian-Mississippian carbonates where yields can be extremely high. Measured spring flows from alluvial gravels range up to 10,000 igpm (approx. 50,000 l/min), some being fed by underflow from streams up to 2 miles away. Sulfur springs with water temperatures of about 50°F (10°C), indicating a relatively deep source of groundwater, occur within the carbonate rocks and flow at up to 2500 igpm (approx. 12,500 l/min). Flow rates of springs from the Paskapoo Formation rarely exceed 100 igpm (500 l/min) except for one spring near Crammond which flows at from 2000 to 4000 igpm (approx. 10,000 to 20,000 l/min). This spring, however, appears to be fed from overlying thick gravels.

A definite relationship exists between aquifer lithology (and permeability), and water quality. Water quality is excellent over most of the area. Total dissolved solids rarely exceed 1000 ppm and waters are predominantly of the bicarbonate type. Sulfate-type waters in excess of 1500 ppm total dissolved solids occur only in springs from shale of the Alberta Group and from Paleozoic carbonates, and in wells in the southeast corner of the map-area.

INTRODUCTION

The purpose of this report is to direct attention to points of interest on the maps, to bring out significant details and to provide brief explanations of some of the features shown.

The map-area covers approximately 5750 square miles (approx. 14,700 sq kms). The hydrogeological survey, on which the accompanying maps are based, was carried out in 1969. Previous hydrogeological surveys covering portions of the area were conducted by Nielsen (1963) and by Clissold (1967). A soil survey over the southeastern part of the area was carried out by Peters and Bowser (1957).

The eastern half of the map-area is largely agricultural and water wells are numerous. The southwestern part consists of foothills and mountains, with heavily forested tracts broken by bogs and wet areas over the remainder of the map-area. Wells in this western half of the area have been drilled mostly to supply tourist campsites, lumber camps and oil-well drill sites for water injection in the secondary recovery of oil. The largest towns within the map-area (with populations as of 1970 bracketed) are: Rocky Mountain House (2802), Sylvan Lake (1494), Rimbey (1456), and Bentley (643). All communities within the area except Rocky Mountain House use groundwater for their water supply.

Acknowledgments

Field operations were financed jointly by the provincial and federal governments under the terms of the federal Agricultural and Rural Development Act (ARDA). This financial support is gratefully acknowledged.

The Water Resources Division, Alberta Department of Agriculture, supplied a drill rig and crew for part of the program. Structure test-hole information was obtained from the Alberta Oil and Gas Conservation Board.

Test drilling was ably carried out by Big Iron Drilling of Edmonton. Field assistance was provided by M. A. Nejabat of

Afghanistan, working under a United Nations exchange program.

Much of the information on which the maps are based was obtained from reports submitted by well drillers to the Water Resources Division, Alberta Department of Agriculture. A great deal of credit must go to these drillers for their very substantial contribution. Water well information, on file at the Research Council of Alberta, was plotted on 1:50 000 scale maps by G. M. Gabert prior to the start of field work. This data was indispensible in the planning of the field survey.

The manuscript was initially read and commented upon by R. Green, G. F. Ozoray, D. V. Currie, and R. Bibby. Cartographic editing by R. Green and Miss A. Badry and the painstaking draftsmanship of H. Weiss is gratefully acknowledged.

TOPOGRAPHY AND DRAINAGE

The front range of the Rocky Mountains, bounded on the east by the McConnell thrust fault, cuts across the extreme southwestern corner of the map-area. Maximum local relief in this region is about 2700 feet, from 5400 feet above sea level in the Ram River valley to 8073 feet in the Bighorn Range.

The Foothills belt lies to the northeast of the front ranges. Rugged northwest-southeast trending hills, valleys and outlying mountain ranges make up the inner Foothills, lying southwest of the Brazeau thrust fault. The outer Foothills, bounded by the Ancona and Brazeau thrust faults, have a much more subdued topography. Maximum local relief in the Foothills region is about 3000 feet, with a high point of 6783 feet above sea level in the Brazeau Range.

The remainder of the area forms part of the Western Alberta High Plains and has rolling to hilly topography. The Plains rise steadily in elevation to the southwest, reaching elevations in excess of 4200 feet above sea level at the Ancona thrust fault. The Medicine Lodge Hills rise to 3650 feet, the hills near Carlos to 3750 feet and the hills south of Buck Lake to 3650 feet above sea level. A maximum local relief of about 600 feet is attained in the Medicine Lodge Hills and the hills near Carlos. Battle Lake and the Battle River, at elevations of less than 2750 feet above sea level, are the topographically lowest points within the Plains part of the area.

The area is drained by the North Saskatchewan and Red Deer River systems, both of which are part of the Nelson River drainage into Hudson Bay. The drainage divide between these two systems trends approximately north-south and lies just east of the center of the map-area. Near the northern boundary of the map-area, this divide swings to a northeasterly direction. Most of the major tributaries of the North Saskatchewan River flow in a general easterly to northeasterly direction. The tributaries of the Red Deer River consistently flow in a general southeasterly direction.

CLIMATE

According to the Köeppen climatic zone classification (Longley, 1968), the map-area has a humid, continental climate, grading from short, cool summers in the western part to long, cool summers in the extreme eastern part.

The mean temperature in January, the coldest month, ranges from more than 12°F in the southwestern part of the map-area to about 7°F in the northeastern part. The mean temperature in July, the hottest month, ranges from about 56° to 61°F (after Longley, 1968) in the same direction across the area. The mean annual temperature at Rocky Mountain House is 34.8°F.

Monthly rates of potential evapotranspiration have been approximated from maps prepared by Bruce and Weisman (1967) and are shown for the weather station at Rocky Mountain House. Potential evapotranspiration exceeds precipitation for the months of May to August and for October, is apparently less than precipitation in September and is essentially negligible in other months.

Isohyets, modified from Longley (1968), are shown on the meteorological map.

GEOLOGY

Bedrock formations of Upper Cambrian to Tertiary age are exposed within the map-area. The work of Allan and Rutherford (1923), Bally, Gordy and Stewart (1966), Douglas (1958), Erdman (1946; 1950), Henderson (1944; 1945) and Thomas and Best (1958) should be referred to for details of stratigraphy and structure.

For the purposes of the hydrogeological map, the bedrock formations of the Foothills and Rocky Mountains may be conveniently divided into four units: 1) the Paleozoic carbonates, of which Upper Cambrian, Upper Devonian and Mississippian strata are exposed; 2) the Lower Cretaceous Blairmore Group, a thick sandstone-shale sequence, and older Mesozoic clastics of Jurassic and Triassic ages; 3) the Upper Cretaceous Alberta Group, made up of two thick marine shale sequences, the Blackstone and Wapiabi Formations, separated by a thinner sandstone-shale sequence, the Bighorn Formation; 4) the Upper Cretaceous Brazeau Formation, a non-marine shale-sandstone sequence.

Only one bedrock formation is exposed in the Plains portion of the map-area. This is the continental, Upper Cretaceous-Tertiary Paskapoo Formation, a thick sandstone-shale sequence, which is correlative to the upper part of the Brazeau Formation of the Foothills. The Paskapoo is underlain in the subsurface by the Upper Cretaceous Edmonton Group and the Belly River Formation (equivalents of the lower part of the Brazeau Formation). Structure contours of the top of the Kneehills tuff zone, which separates the Edmonton Group and Paskapoo Formation (Irish, 1970), drawn by R. Green, are shown on the geological side map.

The formations of the Foothills and Rocky Mountains are deformed by folding and thrust faulting, while the strata within the Plains dip to the southwest at shallow angles, the angle of dip increasing steadily in that direction.

A map showing bedrock topography and drift thickness has been prepared by Carlson (1971). The surficial geology of the northeastern part of the area has been mapped by Reimchen.

Drift cover is thin (less than 50 feet) over most of the region and consists mainly of till. Buried sands and gravels are irregularly distributed in the southern three townships of the area, from about range 3 westward, and are less common in other parts of the area.

Terraces of sand and gravel are numerous along the North Saskatchewan River west from Rocky Mountain House, and along the South Ram River through Tp. 36, Rs. 13 and 14.

The Clearwater River flows in a broad, gravel-floored floodplain which extends downstream almost to Dovercourt where the river valley narrows considerably. The North Ram River flows within a similar, although somewhat narrower, gravel-floored valley to just below its confluence with the South Ram River. These valley and terrace gravels are very permeable (refer to hydrogeology section).

HYDROGEOLOGY

Water level elevations were determined, for the eastern half of the map-area, from wells of about 300 feet or less in depth. Nearly all wells are completed in bedrock. Water levels are close to the surface in low-lying areas and on the lower slopes of hills, where flowing wells and seismic shot holes are common. On the upper slopes and crests of hills water levels are deep. The depth to water is dependent largely on the depth and thickness of the various aquifer zones. Thick permeable zones in high areas may be only partially saturated. In some places, where aquifers at different depths are used, there is a great variation in water levels from well to well. In these cases it was necessary to determine either the most commonly used aquifer or the aquifer that gave the greatest yield (generally the deepest one) and to use the corresponding water levels in the contouring.

Thousands of wells have been drilled or dug within the map-area, mostly in the eastern half. Only selected wells and springs are shown. All wells are shown in which long-term pump tests were carried out or in which head changes with drilling depth were recorded. Other wells were selected for various reasons. Wells giving different yield values (usually lower) than those considered regionally significant were favored. Deeper drilling or multi-aquifer completion, or both, would, in most cases, be expected to give regionally representative yields. In some cases, the anomalous value is higher than the regional value. In these cases the area near the well has not been assigned the higher yield value for one of several reasons: a) the yield calculation has been based on a short-term bail test, from which only an apparent transmissivity (see p. 7) could be calculated, and the reliability is questionable; b) nearby wells of similar depth, lithology and completion indicate lower yields; c) the yield value was determined for a well located in a high-permeability zone of limited areal extent and may therefore be expected to be an over-estimate.

Areas in which flowing wells may occur are shown on the map. These have been delineated largely on the basis of the distribution of flowing shot holes, most of which are less than 100 feet deep. Even within the areas outlined, completed wells that flow are not common because wells are usually located on local high areas, often specifically to avoid flowing conditions. In some cases, flowing shot holes record temporary flowing conditions, and that flow would have ceased with time if the hole had been left open, or would have occurred only at periods of high water levels. In many of the areas outlined, flow appears to be derived largely from shallow, local flow systems because deeper wells do not flow.

The average expected yield of individual wells is indicated on the map. This value is based on calculations of 20-year safe yield using the formula (Farvolden, 1959, p. 8):

$$Q_{s20} = \frac{TH}{2110} \tag{1}$$

where,
Q_{s20} = safe yield supplied from existing storage for 20 years in igpm,
T = coefficient of transmissivity in igpd/ft,
H = total available drawdown in feet. (For confined aquifers, H = depth to top of aquifer minus depth to static water level; for unconfined aquifers, H is rather arbitrarily taken at two thirds of the difference between static water level and the base of the aquifer.)

The coefficient of transmissivity was calculated from bail and pump test data using the formula (Todd, 1959, p. 94):

$$T = \frac{264Q}{\Delta s} \tag{2}$$

where,
Q = pumping rate in igpm
Δs = drawdown in ft/log cycle, the data being plotted on semi-logarithmic paper.

Formula 2 was also used to calculate "apparent transmissivity" (Farvolden, 1961, p. 9) from bail tests in which only the initial or static water level and the water level at the end of the test had been reported.

In the case where pump tests had been carried out and observation wells utilized, graphical methods for calculating the coefficient of transmissivity (Walton, 1962) were used.

The average expected well yields shown on the map indicate the total quantity of water that can be obtained by a single well from all water-bearing intervals within the upper 800 to 1000 feet of strata. In the majority of cases, most of the yield will be from a single aquifer within the bedrock at depths of less than 300 feet. It should be made clear that the boundaries between yield areas, and the areal yields themselves are often poorly established. In many places unsuspected zones of higher or lower permeability, and consequent higher or lower yields, will certainly be located with time. Thus a greater variability, and therefore lower predictability, of yields is to be expected in the Foothills area, because much of the permeability within the bedrock is probably due to fracturing. It should also be noted that projected yield values are based on relatively short pump and bail tests and not on long-term sustained yields. Errors in yield values are therefore to be expected, especially within local areas of high permeability. Water pumped out of a highly permeable zone or lens has to be replaced by leakage from the adjoining less permeable material and, in the final analysis, the sustained yield is dependent upon this rate of leakage. In cases where the aquifer extends to or near the surface, the sustained yield is dependent upon the rate of infiltration of precipitation or surface water. It should also be kept in mind that as only one year's study of the area was undertaken, a detailed evaluation was not possible.

In summary, the map presents an estimate of probable well yields based on an evaluation of existing well data and taking into account various field phenomena and geologic conditions. It should be used with some degree of caution.

The highest two categories of expected well yields shown on the map, 100 to 500 igpm (approx. 500 to 2500 l/min) and over 500 igpm, are discussed together. Yields of this order of magnitude may be obtained from different types of earth materials occurring in different hydrologic and geologic situations, as listed below.

1) Recent alluvial gravels in the broad, gravel-floored valleys of the Clearwater and North Ram Rivers and in the most westerly parts, within the map-area (i.e. the braided aggrading parts), of the North Saskatchewan and South Ram Rivers may yield over 500 igpm (approx. 2500 l/min) to a single well. Production test data are available only for a well in the gravels along the Clearwater River (Lsd. 9, Sec. 9, Tp. 35, R. 10), where a transmissivity value of 36,000 igpd/ft was obtained from a 6-hour pump test. That the gravels along the Clearwater River are extremely permeable is indicated by: a) streams, including some flowing at about 1000 igpm (approx. 5000 l/min), that flow out onto the valley floor, only to disappear over a short distance as the water of the stream infiltrates into the underlying gravels (e.g. Seven Mile Creek in Tp. 35, R. 10); b) springs flowing out of these gravels at a few thousand gallons per minute, fed by underflow of river water (e.g. springs near Butte). Production rates of over 500 igpm (approx. 2500 l/min) from gravels along the forementioned rivers will only be possible at places where a sufficient saturated thickness is present. Assuming transmissivity values of between 40,000 and 30,000 igpd/ft for the gravels and maximum allowable drawdowns of two thirds of the saturated thickness in a pumping well, then a saturated thickness of at least 40 to 50 feet, respectively, of gravels is necessary to obtain

a production of 500 igpm or more over a 20-year period. Test drilling by the Water Resources Division, Alberta Department of Agriculture, across a one-quarter mile width of the floodplain of the Clearwater River, in Sec. 2, Tp. 35, R. 10, indicates gravel thicknesses ranging from 35 to 84 feet.

Alluvial gravel and sand along Prairie Creek and Red Deer River and along the North Saskatchewan River below Rocky Mountain House, may locally yield 100 to 500 igpm (approx. 500 to 2500 l/min) of water to a single well. These rivers have relatively broad sand- and gravel-floored floodplains. The thickness and lateral extent of these materials along the rivers is either unproven or is known to be less than that of the alluvial deposits assigned a higher yield.

2) Moderately deep sandstone aquifers within the Paskapoo Formation and situated in low-lying areas or adjacent to sources of induced infiltration may yield large amounts of water to a well. Yields in excess of 500 igpm (approx. 2500 l/min) might be obtained, for example, in an area near Washout Creek (Tp. 46, R. 7) and an area near Caroline (Tp. 36, R. 6). Transmissivity values obtained from pump tests at these places range from 6000 to nearly 12,000 igpd/ft. These values are not exceptionally high, but, when combined with a high head, the safe yield can be considerable. The high expected yield near Caroline may be influenced in part by recharge from the Raven River. A few wells near Sylvan Lake, completed in bedrock, have given transmissivity values as high as 120,000 igpd/ft from short pump tests, 24 hours or less in duration. These wells may be influenced by induced infiltration from the lake. Areas where it might be possible to obtain 100 to 500 igpm (approx. 500 to 2500 l/min) from this type of aquifer include small areas along or near Rose Creek, Washout Creek, Buck Lake, North Saskatchewan River, Sylvan Lake, Rainy Creek and Medicine River.

A small area near Cygnet Lake, where expected yields of 100 to 500 igpm (approx. 500 to 2500 l/min) may be possible, is situated on or near the edge of a buried, largely clay-filled, channel. The relatively high yields to be expected may be due, in part, to increased permeability caused by preglacial slumping or sliding of bedrock formations at the edges of the channel. An increase in permeability by such a phenomenon has been postulated by Tóth (1966, p. 24-27) for an area near Olds, Alberta, approximately 15 miles south of the southeast corner of the map-area. A thick sandstone interval within the Paskapoo Formation is also known to be present in this area (G. M. Gabert, pers. comm.).

3) A large spring, flowing at a few thousand imperial gallons per minute (in the order of 10,000 l/min) emerges from sand-

stone underlying thick gravels near the Raven River in Sec. 5, Tp. 36, R. 5, and provides water for a government-operated fish-rearing station. The gravels are assumed to represent a buried valley deposit of "pre-glacial" age (i.e. prior to the main till deposition in the area). The extent and exact position of this buried valley is not known. Buried gravels are irregularly distributed in other places near the Raven River and south of it. Their extent and possible yield have not been determined.

4) Proglacial and postglacial terraces along the North Saskatchewan River east of Rocky Mountain House may be capable of local yields of 100 to 500 igpm (approx. 500 to 2500 l/min). Contact springs from the base of the terraces flow at rates of up to 500 igpm (approx. 2500 l/min) for a single spring and have extensive calcareous buildups associated with them. The terraces along the South Ram River are assigned a lower yield, over most of their extent, than those along the Saskatchewan because they appear to be thinner and somewhat better drained.

Other areas in which aquifers capable of yielding over 500 igpm (approx. 2500 l/min) may exist within the map-area. These would probably be mostly of the second category listed above. Locally, portions of the areas rated at 100 to 500 igpm (approx. 500 to 2500 l/min) may be capable of higher production.

Most of the area underlain by the Paskapoo Formation is capable of producing 25 to 100 igpm (approx. 100 to 500 l/min). This can be considered to be the regional yield value for this formation.

Yields of 5 to 25 igpm (approx. 25 to 100 l/min) are assigned to an area near Gull Lake and to an area in the southeastern corner of the map-area. These areas are underlain by relatively thick shaly sequences of the Paskapoo Formation.

In the western part of the map-area, yields of 5 to 25 igpm (approx. 25 to 100 l/min) are assigned to the Paskapoo beds west of the Ancona fault. This value is based on a few bail tests. The relatively low yields may be due, in part, to better cementation of sandstone beds in this area.

West of the Brazeau thrust fault, yields of 5 to 25 igpm (approx. 25 to 100 l/min) are assigned to the Brazeau and Blairmore Formations. These beds have not been tested for yield. However, numerous sandstone beds are present and springs with flow rates of up to 60 igpm (approx. 270 l/min) are known to occur.

Yields of less than 5 igpm (approx. 25 l/min) are assigned to an area in the southeastern part of the map-area, where permeable beds within the Paskapoo Formation are lacking; and to shales and hard, well-cemented sandstones of the Alberta Group in the Foothills. The Jurassic Fernie and Nikanassin Formations are also unlikely to yield more than 5 igpm except locally.

The Paleozoic carbonates present a special situation. It is probable that these beds will not produce water except from joints, fractures, bedding planes or local vuggy or cavernous porosity. A few large sulfur springs are associated with the upper Paleozoic beds in the outlying ranges. The springs occur at places where streams have cut through uplifted, folded Paleozoic rocks, e.g. near the North Ram River, Fall Creek and Prairie Creek. Springs were not observed at "The Gap", where the North Saskatchewan River cuts through the Brazeau Range nor were they observed in the Front Range of the Rocky Mountains. However, sulfur springs are reported to be present not far from Shunda Creek, near to where that creek flows through the Brazeau Range in Tp. 41, R. 15, and near the Clearwater River, in the southwest corner of Tp. 35, R. 9. These latter localities are immediately adjacent to the map-area.

Of the three sulfur spring localities within the map-area, two are not far above river level (as are the two outside the map-area), while the one near the North Ram River is situated approximately 500 feet above river level. The temperatures of the springs range from 43 to 50°F (6 to 10°C), some 4 to 10°F warmer than the temperature of the majority of the springs in other parts of the inner Foothills. Flow rates were estimated at 300 to 400 igpm (approx. 1350 to 1800 l/min) for the springs near North Ram River, 2500 igpm (approx. 11,350 l/min) for those at Fall Creek and about 800 igpm (approx. 3625 l/min) for those at Prairie Creek.

The stratigraphic positions of the springs suggest that they originate from solutionally enlarged joints and bedding planes in the upper part of the Paleozoic carbonates. Recharge could be provided from groundwater percolation through Lower Cretaceous clastic rocks and through joints and fractures within carbonates at elevations above the springs.

Other indications that water is readily available within the Paleozoic carbonates are as follows:

1) A well drilled for oil (Ram River #3) in Lsd. 12, Sec. 1, Tp. 37, R. 11, near Prairie Creek, encountered a flow of water between 933 and 1112 feet below the surface, from Devonian carbonates. The water quality was not reported.

2) A well just south of the map-area (Altoba and Canyon #1 Clearwater), located in about Lsd. 5, Sec. 31, Tp. 34, R. 9,

encountered a flow of sulfur water at 545 feet, from Devonian carbonates.

Areas of exposed or near-surface carbonates in topographically low positions have been assigned a relatively high yield of 100 to 500 igpm (approx. 500 to 2500 l/min) due to the possibility of recharge from surface waters and from upward moving groundwater into open joints and bedding planes. It should be recognized, however, that the absence of open joints, or similar openings, at any particular locality, could result in a dry hole.

HYDROCHEMISTRY

Groundwaters within the map-area seldom exceed 1000 ppm of total dissolved solids (see hydrochemical map) and are basically of the bicarbonate type. Potable groundwater is easily obtainable almost everywhere within the area.

Sulfate type waters in excess of 1500 ppm of total dissolved solids occur in wells only in the extreme southeast corner of the map-area and in the inner Foothills, in springs from shales of the Alberta Group and from Paleozoic carbonates.

The water is generally hard (calcium and magnesium cations dominant) in upland areas and soft (sodium and potassium cations dominant) in topographically low areas. Even in upland areas, the hard water initially encountered by drilling soon gives way to soft waters in lower aquifers. The contours on the hydrochemical map, therefore, should be considered as representative only of shallow bedrock aquifers. Hydrochemical changes with depth are indicated on the hydrogeological cross sections. Sodium-bicarbonate type water with a chloride content of 10 to 25 per cent of total anions and total dissolved solids content of 800 to 900 ppm, persists to depths of 800 to 1200 feet in thick sandstones of the lower part of the Paskapoo Formation east of Gilby, in the eastern part of the map-area. Locally and at slightly greater depths, near Gilby and Eckville, the chloride content may increase to 40 to 50 per cent of total anions and total dissolved solids to 1000 to 1200 ppm. Waters have been sampled from the Belly River Formation at depths of 3500 to 5000 feet. These are consistently of the sodium chloride type with total dissolved solids generally in excess of 10,000 ppm. Waters from the Edmonton Group have not been sampled but are assumed to be of the sodium chloride type.

Water from surficial sands and gravels is generally hard and is low in total dissolved solids. Water from most springs is also generally quite hard and relatively low in total dissolved solids and may be considered to represent the discharge points of short, shallow, active groundwater flow systems.

CONCLUSIONS

Well yields to be expected within the map-area range between 25 and 100 igpm (approx. 100 and 500 l/min) as a regional average over the Plains part of the area and between 5 and 25 igpm (approx. 25 and 100 l/min) in the Foothills and Rocky Mountains. The main aquifers are bedrock sandstones. Yields above the regional average can be expected from alluvial or buried sands and gravels, from confined aquifers in topographically low areas, from aquifers receiving water by induced infiltration from surface waters and probably from jointed or fractured carbonates in topographically low positions.

Yields below the regional average can be expected in areas underlain by thick shale sequences and, more locally, in upland areas where the available head of water may be insufficient to provide a yield as high as the regional average.

Water quality is generally excellent. Groundwaters of the bicarbonate type with a total dissolved solids content of less than 1000 ppm are the usual case. Hard water is found in upland areas and in most springs, and soft water in low-lying areas and at depth. Water quality deteriorates in shale areas.

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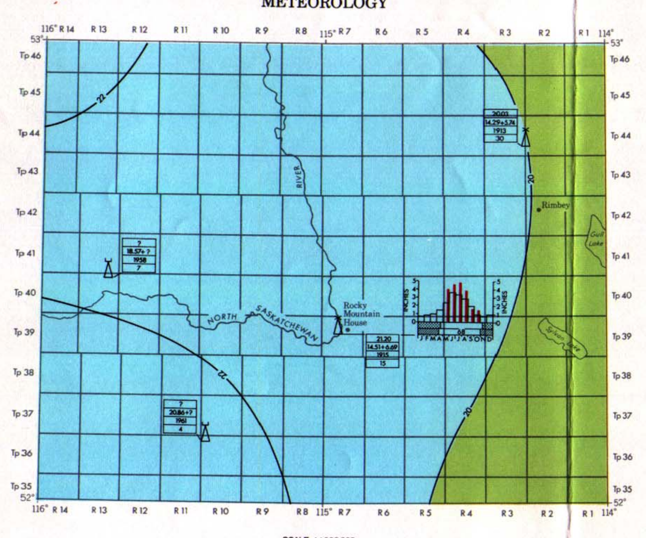
METEOROLOGY



LEGEND

Isohyet, mean annual precipitation in inches

Mean annual precipitation:

- more than 20 inches
- less than 20 inches

Meteorological station

Standard rain gauge only

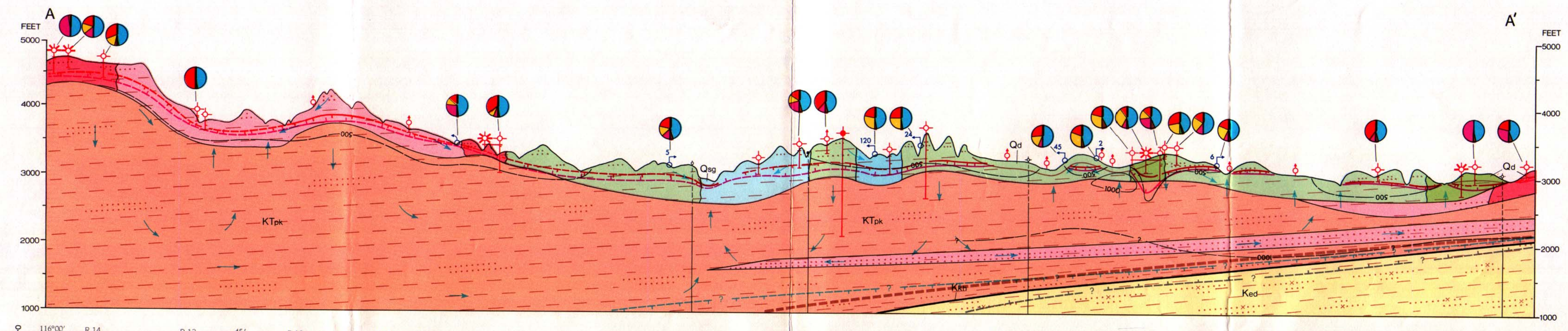
Precipitation data:

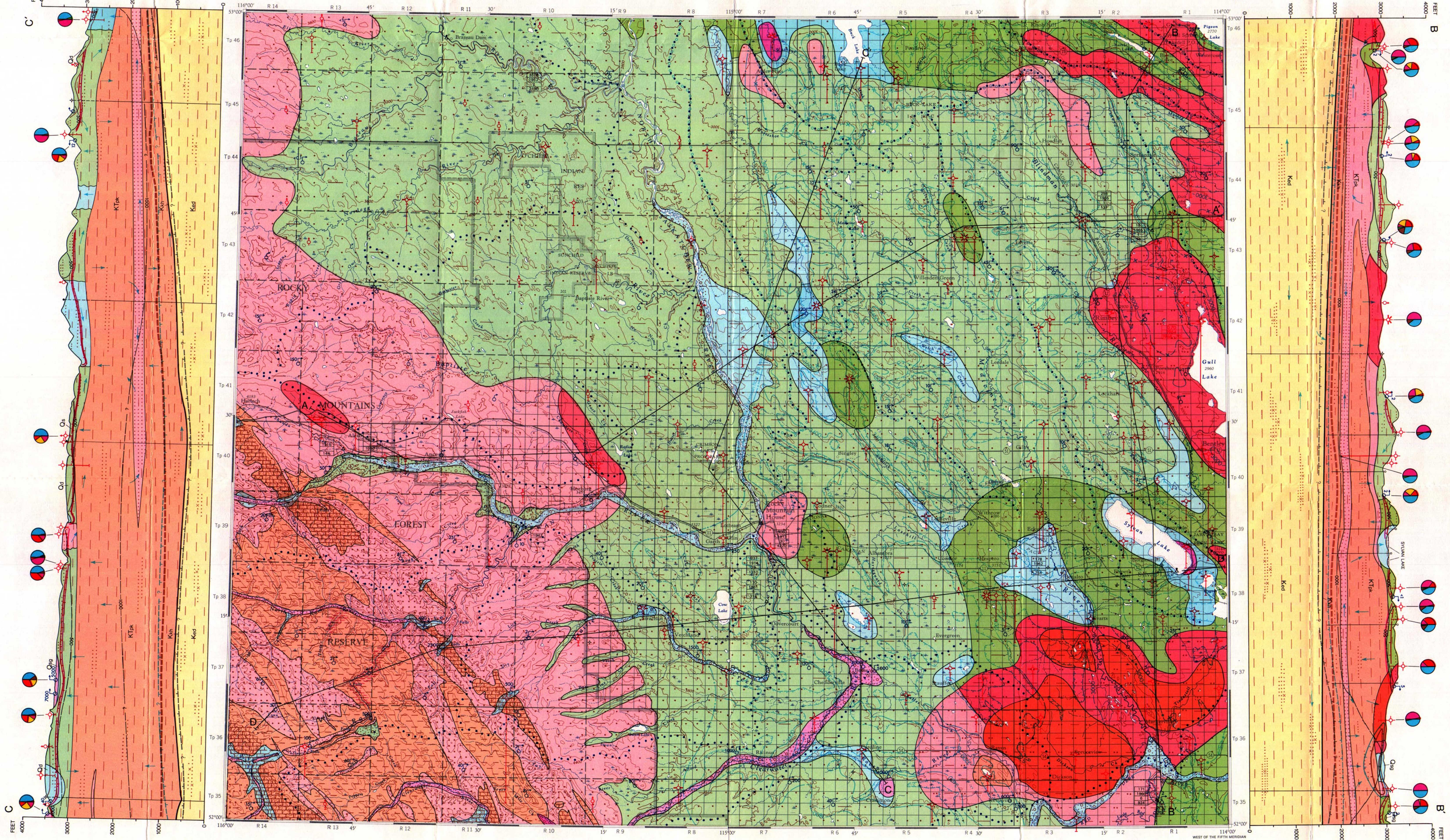
- Mean annual precipitation in inches
- Mean annual rainfall plus 1/10th of mean annual snowfall in inches
- Year of commencement of observations
- Number of years of record used to calculate mean annual precipitation (or rainfall)
- Mean monthly potential evapotranspiration*
- Mean monthly precipitation
- Period when surface is usually snow covered
- Period with mean daily temperature below freezing (0°C)
- Figure indicates percentage of mean annual precipitation falling as rain

Sources of data:

Climatic Maps of Alberta (Longley, 1968); Monthly Record of Meteorological Observations (Meteorological Branch, Canada Department of Transport); and Provisional Evaporation Maps of Canada, Department of Transport Circular 4531 (Bruce and Weisman, 1967).

*Evapotranspiration estimates are based on the Provisional Evaporation Maps of Canada





MAIN MAP LEGEND

Topography

Surface contours (interval 200 feet below 5000 feet; interval 500 feet above 5000 feet):

- elevation
- depression
- approximate

Geology

Geological boundary

Fault (on profiles only)

Fold (on profiles only)

QUATERNARY

- Qd Undifferentiated deposits
- Qs Sand
- Qsg Sand and gravel

CRETACEOUS-TERTIARY

- KTpk Paskapoo Formation

CRETACEOUS

- Kkh Kneehills Member
- Ked Edmonton Formation
- Kbz Brazeau Formation
- Ka Alberta Group
- Kbl Blairmore Formation

MESOZOIC

- Mz Undifferentiated Triassic-Jurassic strata and Lower Cretaceous pre-Blairmore formations

PALEOZOIC

- Pz Undifferentiated Paleozoic strata

Lithology

Sand and gravel

Shale

Siltstone

Sandstone

Bentonitic sandstone

Carbonate rocks

Coal

Hydrography

Stream, intermittent

Lake, intermittent

Rapids, falls

Marsh, muskeg

Surface water divide

Area of noticeable salt precipitates

Hydrometry

Stream gauging station (values shown are to end of 1968 water year)

- Average annual discharge in cubic feet per second
- Year of commencement of observations
- Number of years averaged for annual discharge figure
- Drainage area in square miles

Lake-level recording station

Hydrogeology

Spring, flow rate unknown

Spring and approximate rate of flow in imperial gallons per minute (measured or approximate in fall, 1969)

Nonpumping water-level contour (elevation in feet) and vertical component of groundwater movement

Direction of groundwater flow

Groundwater divide

Boundary of area of artesian flow (dotted pattern lies within area of artesian flow)

Groundwater Probability*

Range of average expected yield of wells (in imperial gallons per minute)

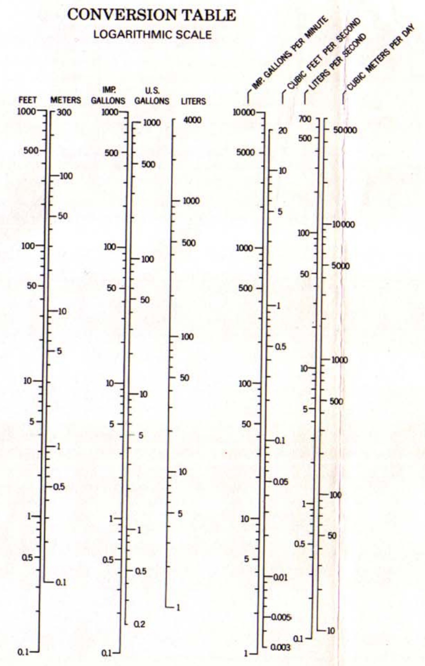
- Probable estimated from quantitative information (pump tests, bail tests, etc.)
- Possible estimated from qualitative information (flow regime, lithology, etc.)

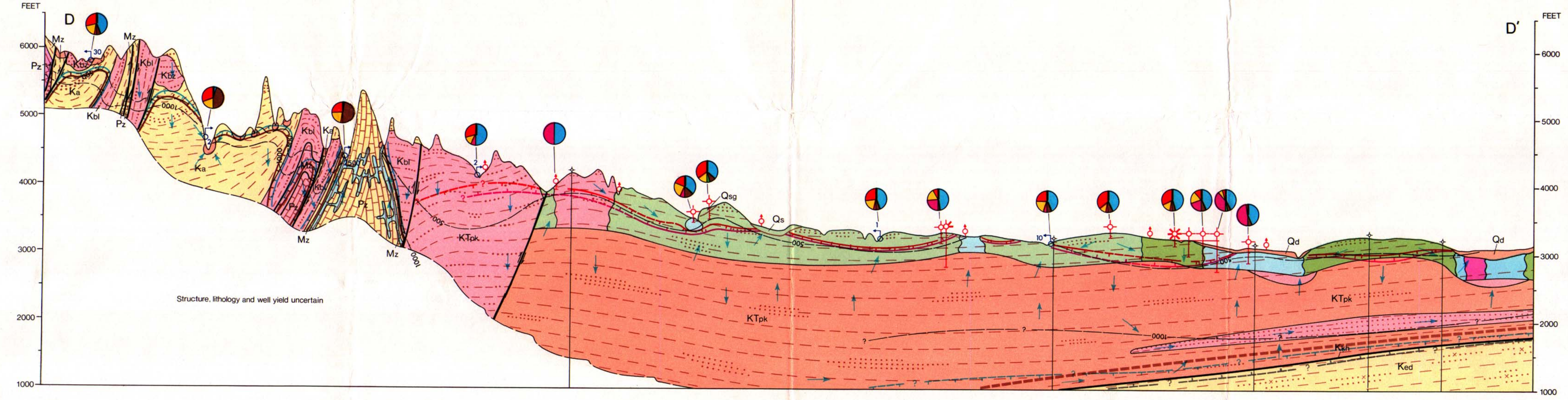
>500, 100-500, 25-100, 5-25, 1-5, <1

Yield area boundary

CONVERSION TABLE

LOGARITHMIC SCALE





All elevations in feet above mean sea level.

Vertical exaggeration of the hydrogeological profiles is approximately 20x.

An expanded legend and explanatory notes for use with this hydrogeological map series is available from the Research Council of Alberta, Edmonton, Canada.

Hydrogeology by O. Tokarsky, 1970, based on data collected in 1969

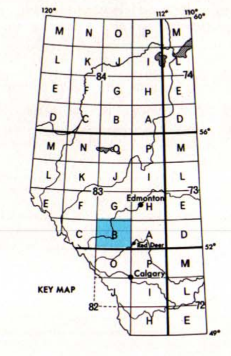
Cartographic editing by A. Badry and R. Green

Drawn by H. Weiss

SCALE 1:250,000

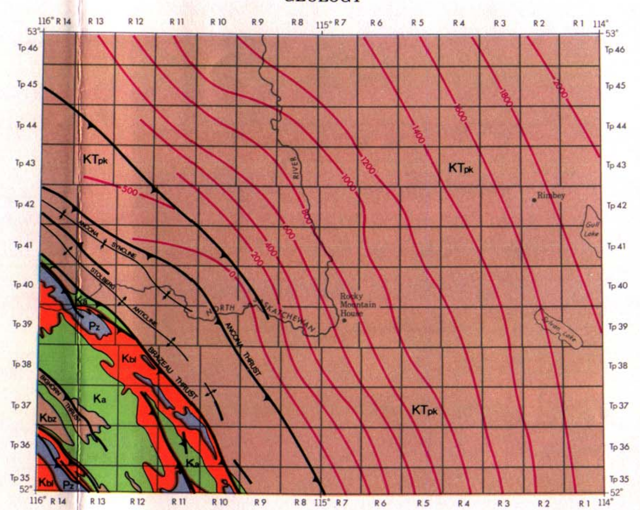
HYDROGEOLOGICAL MAP ROCKY MOUNTAIN HOUSE ALBERTA

NTS 83B



KEY MAP

GEOLOGY



LEGEND

- KTpk Paskapoo Formation: *sandstone, siltstone, shale; coal near base*
- Kbz Brazeau Formation: *sandstone, siltstone, shale, minor coal*
- Ka Alberta Group: *mainly shale, some hard sandstone*
- Kbl Blairmore Formation and older Mesozoic formations: *sandstone, shale*
- Pz Paleozoic: *limestone, dolomite, argillaceous limestone, calcareous shale*

Rock unit boundary

Structure contour on top of Kneehills Member

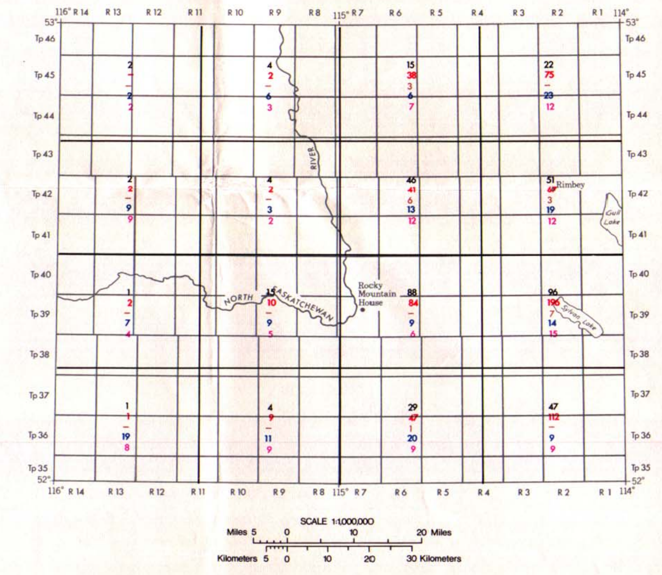
Axis of anticline

Axis of syncline

Fault

Overthrust fault (teeth on upper plate)

DATA DENSITY



LEGEND

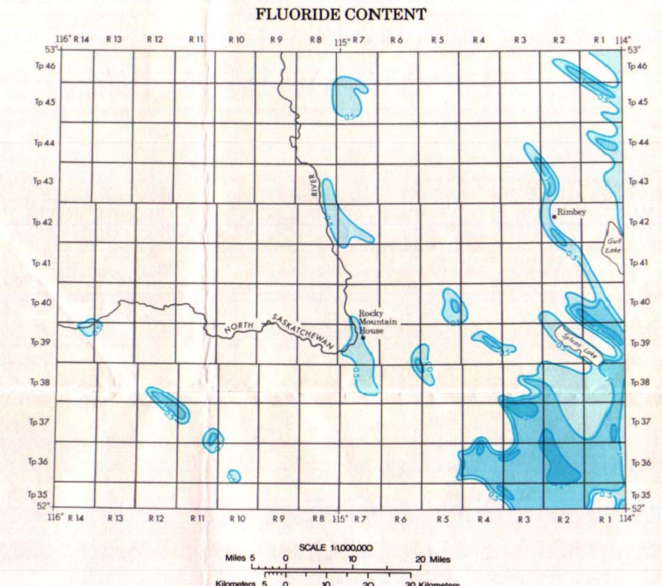
Figures indicate the number of data control points in each section of the map area used in construction of:

(a) yield areas on the main map (i.e. production tests) 29

(b) hydrochemical maps:

- wells and test holes 47
- deep wells (over 500 feet) 1
- springs 20
- trace element analyses 9

FLUORIDE CONTENT



LEGEND

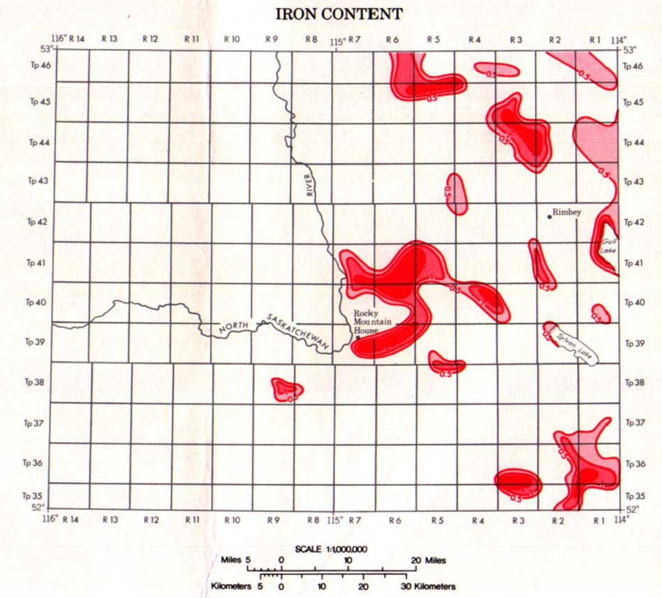
Fluoride content in parts per million

Fluoride content ranging between 0.5 and 1 part per million

Fluoride content ranging between 1 and 2 parts per million

Fluoride content over 2 parts per million

IRON CONTENT



LEGEND

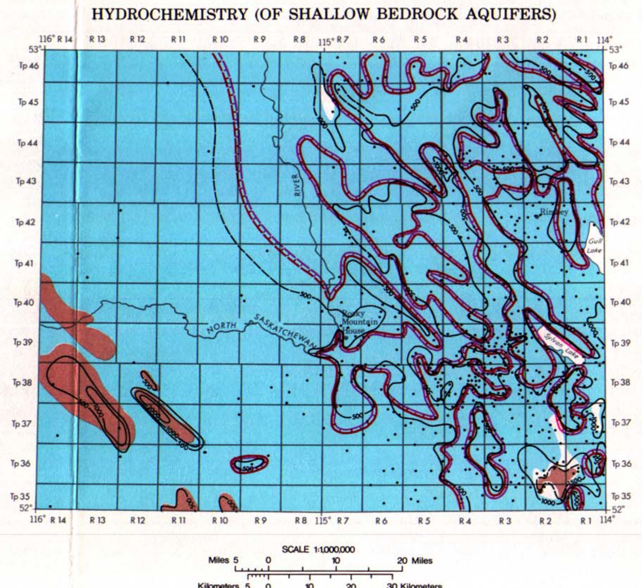
Iron content in parts per million

Iron content ranging between 0.5 and 1 part per million

Iron content ranging between 1 and 2 parts per million

Iron content over 2 parts per million

HYDROCHEMISTRY (OF SHALLOW BEDROCK AQUIFERS)



LEGEND

Data control point

Total dissolved solids in parts per million:

- defined
- approximate

Bicarbonate + carbonate constituting over 60 per cent of total anions*

Sulfate constituting over 60 per cent of total anions*

Isogram along which calcium + magnesium constitute 60 per cent of total cations*; teeth indicate direction of lesser calcium + magnesium content

Isogram along which sodium + potassium constitute 60 per cent of total cations*; teeth indicate direction of lesser sodium + potassium content

*Determined on equivalents per million basis.