ENVIRONMENT SASKATCHEWAN

REGIONAL GEOLOGY OF THE PCB SPILL SITE REGINA, SASKATCHEWAN

Report 0031-002 August 13, 1979

E. A. Christiansen Consulting Ltd.

CONSULTING GEOLOGIST

BOX 3087
SASKATOON, SASKATCHEWAN, CANADA
S7K 3S9

PHONE 374-6700

August 13, 1979

Environment Saskatchewan
1855 Victoria Avenue
Humford House
Regina, Saskatchewan
S4P 3V5

Attention: Mr. D.A. Fast

Dear Mr. Fast:

As agreed during our telephone conversation of August 9, I am enclosing four copies of Report 0031-002 on the "Regional Geology of the PCB Spill Site, Regina, Saskatchewan". The remaining four copies will be sent directly to Dr. J. Russell Roberts.

If you have any queries, please contact me.

Sincerely yours,

E.A. Christiansen

E. A. Christiansen Consulting Ltd.
CONSULTING GEOLOGIST
BOX 3087
SASKATOON, SASKATCHEWAN, CANADA
S7K 3S9
PHONE 374-6700

May 12, 1980

Mr. D.A. Fast
Water Quality Division
Water Pollution Control Branch
Department of the Environment
Humford House
1855 Victoria Avenue
Regina, Sask. S4P 3V5

Dear Mr. Fast:

My firm is presently studying the geology of the Regina area and, consequently, seeks permission to add the results of the deep PCB testholes to my data bank for use in this investigation and for future use in consulting and research in the area.

I would appreciate your consideration of this request.

Sincerely yours,

E.A. Chritiansen

Saskatchewan

Saskatchewan
Environment

5th flr. 1855 Victoria Ave.
Regina, Canada
S4P 3V5

File: F4-1-1
(FPL-6)

May 26, 1980

Mr. E. A. Christianson
Consulting Geologist
E. A. Christianson Consulting Ltd.
Box 3087
Saskatoon, Saskatchewan
S7K 3S9

Dear Mr. Christianson:

Deep Test Hole Data
near Federal Pioneer Limited

We agree to your May 12, 1980 request to add the results of the deep hydrogeology data that you obtained for two test holes near Federal Pioneer Limited in 1979, to your data bank.

Yours sincerely,

D Fast

D. A. Fast, P. Eng.,
Head, Water Quality Division
Water Pollution Control Branch

DAF/mf

SUMMARY

Extrapolation between testholes 100m northeast and southwest of the PCB Spill Site at Federal Pioneer Limited suggest the shallowest aquifer (Un-named Aquifer) beneath the spill site is overlain in descending order by:

(1) 21 to 28 feet (6.4-8.5m) of weathered Regina Clay,

(2) 10 to 23 feet (3-7m) of Condie Silt, the lower 10 feet (3m) of which is unweathered,

(3) 2 to 16 feet (.6-4.9m) of soft sandy, unweathered till of the Battleford Formation,

(4) 16 to 20 feet (4.9-6.0m) of hard, unweathered Upper Till of the Floral Formation,

(5) 55 to 72 feet (16.8-22m) of unweathered Interglacial Silts, and

(6) 0 to 52 feet (0-15.9m) of Interglacial Silts and Sands which rest on the Un-named Aquifer. Neither the Condie Sands and Gravels Aquifer nor the Regina Aquifer underlie the PCB Spill Site.

The vertical permeability of the above sediments depends on the texture and structure of the deposits. If the sediments are jointed (vertical fractures), the vertical permeability would be greatly enhanced over the intergranular permeability exhibited by unjointed deposits. If jointing is restricted to desiccation in weathered zones, then only the Regina Clay and upper part of the underlying Condie Silt would be expected to be jointed. There is no evidence that the first five deposits mentioned above were faulted.

LIMITATIONS

Geologic logs from Testholes 2,5,7,and 9 are based on cores, cutting samples, and electric logs, whereas the geologic logs from Testholes 1,3,4, and 10 are based on cutting samples and electric logs only. With the development of larger drilling equipment and the improvement of rotary drilling techniques, large, uncontaminated cuttings can be obtained from depths of more than 300m; consequently, cores are not required for the compilation of accurate logs. The electric logs, which are the only information available from Testholes 6 and 8, were used to identify bedrock structural marker beds.

Straight lines drawn between adjacent logs in cross sections are to quide the eye from contacts in one log to another, and irregular lines represent the available geologic models that best fit the information. These lines do not necessarily represent the actual contacts between geologic units nor do they necessarily imply that the nature of these units is the same as at the testhole sites. The degree of confidence of these interpretations depend on the nature and density of the information, on the complexity of the geology, and on the proposed land use.

The collapse model used to explain the structure in this study is schematic. The faults were placed halfway between the testholes; consequently, the fault beneath the PCB Spill Site, for example, is an inferred fault only. As more testholes are drilled in this structure, more fault blocks are required in the explanation indicating there are numerous faults rather than the few shown in the cross sections.

TABLE OF CONTENTS

Text | Page

TABLE OF CONTENTS

Text | Page

Illustrations

Appendices

1. INTRODUCTION

1.1 Terms of Reference and Objective

This investigation was conceived during a conference telephone call among Dr. J. Russell Roberts, National Research Council of Canada, Dr. F.W. Schwartz, University of Alberta, and Dr. E.A. Christiansen, E.A. Christiansen Consulting Ltd. Saskatoon. The investigation, in turn, was authorized by Environment Saskatchewan in Contract No. 28(79-80).

The objective of this study is to:

(1) Test drill, electric log, describe cutting samples, and prepare geological logs for two testholes about 100m northeast and south-west of the PCB Spill Site at Federal Pioneer Limited.

(2) Abondon testholes with bentonite plugs with 10-foot cement plugs at the surface. The final filling of the testholes with bentonite slurry, cementing the upper 10 feet, and the clean-up of the testhole sites were subcontracted to BBT Geotechnical Consultants Ltd., Regina.

(3) Obtain carbonate analyses to facilitate the correlation of tills.

(4) Prepare a cross section between DOE Regina 511 and DOE Regina 513 including the two new testhole logs (531,532).

(5) Relate the stratigraphy of the PCB Spill Site to the regional stratigraphy as shown in Figure 7 of E.A. Christiansen Consulting Ltd. (1979). Because of the new information obtained from the testholes drilled during this study, it was necessary to redraw this cross section.

(6) Prepare eight copies of the report on the regional geology of the PCB Spill Site to be submitted to Environment Saskatchewan by August 17, 1979.

1.2 Location

The PCB Spill Site, the two testholes drilled during this study (DOE Regina 531 or #4 in Drawing 0031-002-01, DOE Regina 532 or #3 in Drawing 0031-002-01), and the location of Cross Sections AA' and BB' are shown in Drawing 0031-002-01. DOE Regina 531 is about 100m northeast of the spill site (Fig. 1), whereas DOE Regina 532 is about 100m southwest of the spill site (Fig. 2).

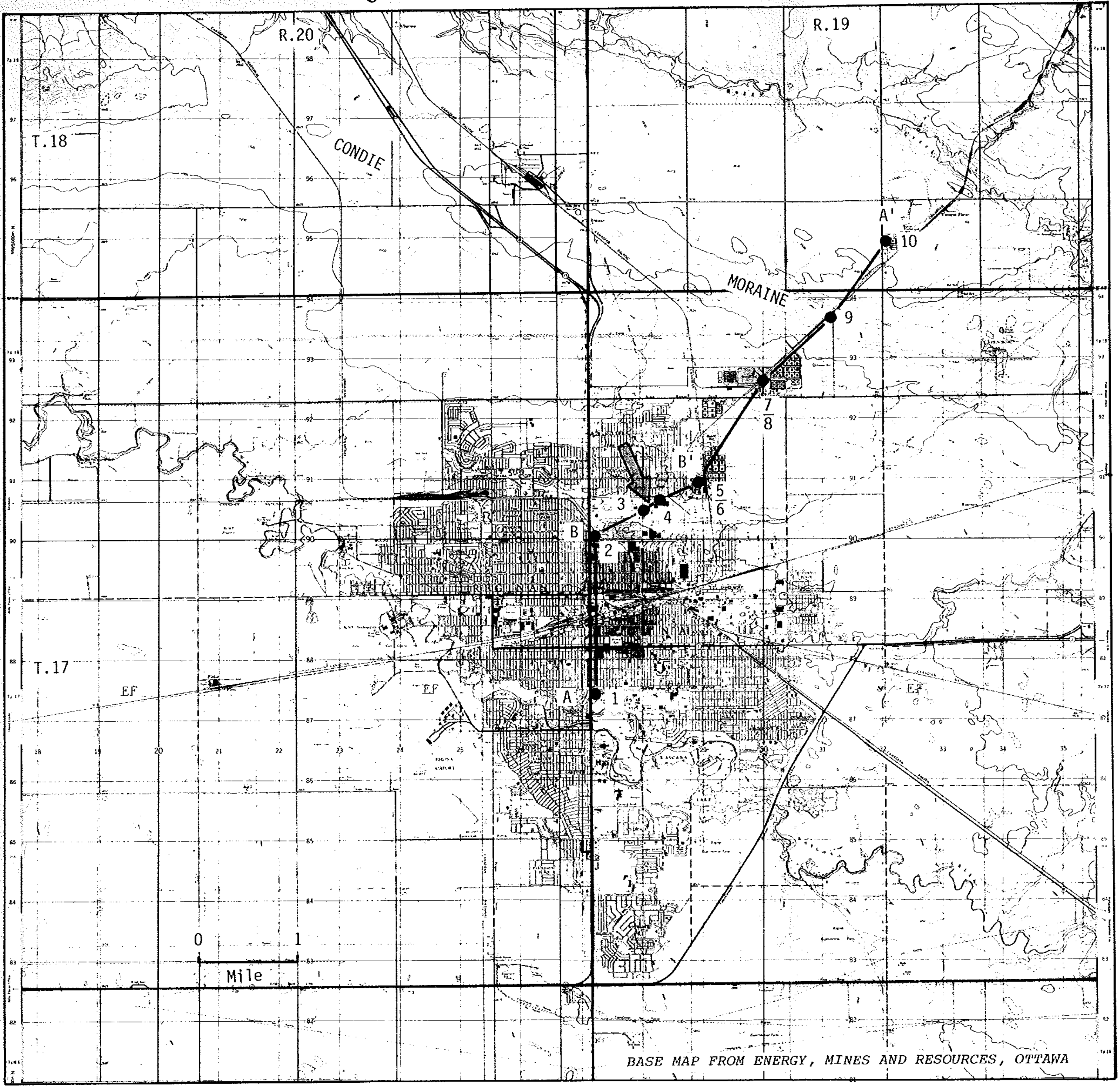
1.3 Previous Work

A geology and groundwater map, showing geology, bedrock surface topography, cross sections, and base of groundwater exploration, was published for the Regina area (Christiansen, 1971a). In addition, a cross section of drift and bedrock between Condie and Craven was published (Christiansen, 1972). The bedrock surface topography and the location of the Regina and Mound Spring Aquifers along with one north-south cross section for the city of Regina and surrounding area was published for Environment Saskatchewan (Meneley and Christiansen, 1975). The regional geology of the Regina-Moose Jaw region was published recently in which the bedrock and glacial geology are described (E.A. Christiansen Consulting Ltd., 1979).

Information on the surficial geology was obtained from Christiansen (1961, 1979). Detailed information on the upper metre of the surficial material was published by the Saskatchewan Institite of Pedology (Ellis *et al.* 1965).

1.4 Present Study

Testholes DOE Regina 531 and 532 were drilled with 1500 series rotary drilling equipment with dual pumps (Fig. 3) capable of delivering larger than 1cm diameter cutting from the maximum depth drilled during the study (660 feet, 201m). Cutting samples were takem from the drilling fluid by Mr. Carl Higgins, driller for Hayter Drilling Ltd. with strainers, washed clean, and placed on aluminum pans for sample selection (Fig. 4). From these pans, representative samples at 5-foot (1.5m) intervals were selected and placed in muffin tins for



DRAWING 0031-002-01. LOCATION OF THE PCB SPILL SITE AND CROSS SECTIONS AA' AND BB'.

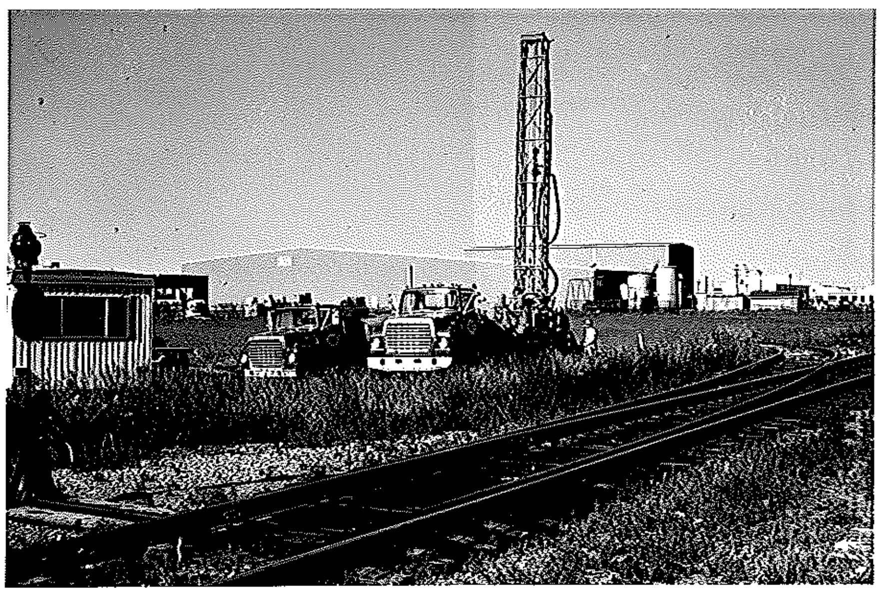


Figure 1. Location of DOE Regina 531 Testhole.

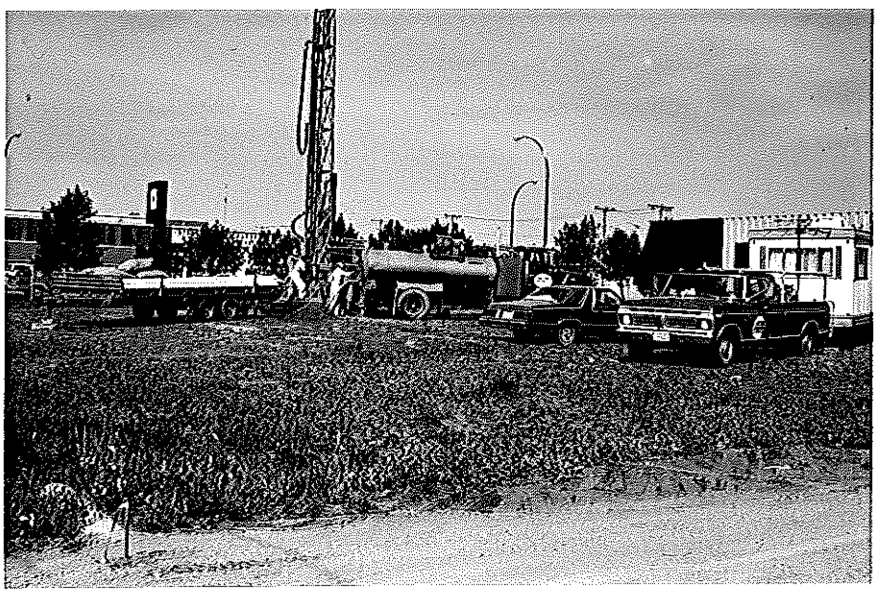


Figure 2. Location of DOE Regina 532 Testhole.

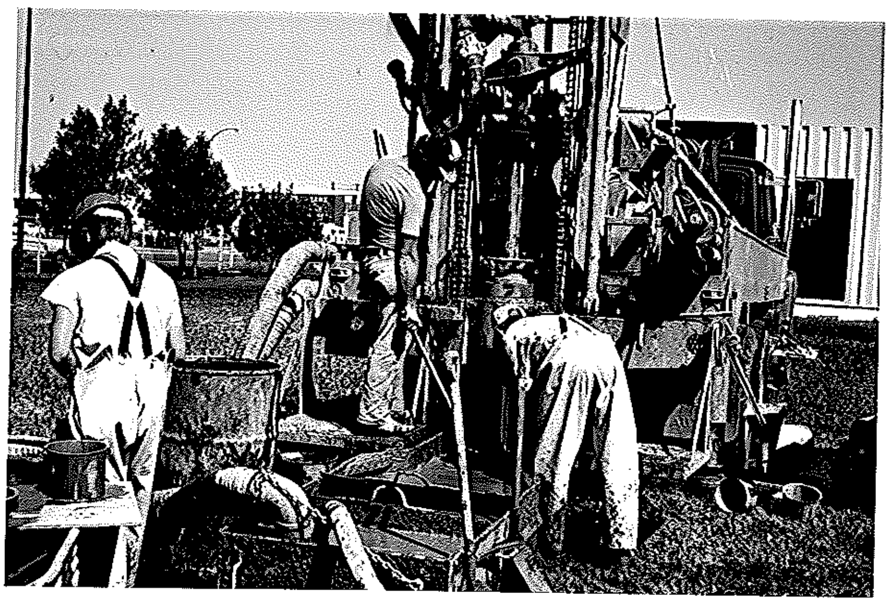


Figure 3. 1500 series rotary drilling equipment with dual pumps capable of delivering 1cm cutting samples from more than 1000 feet (300m).

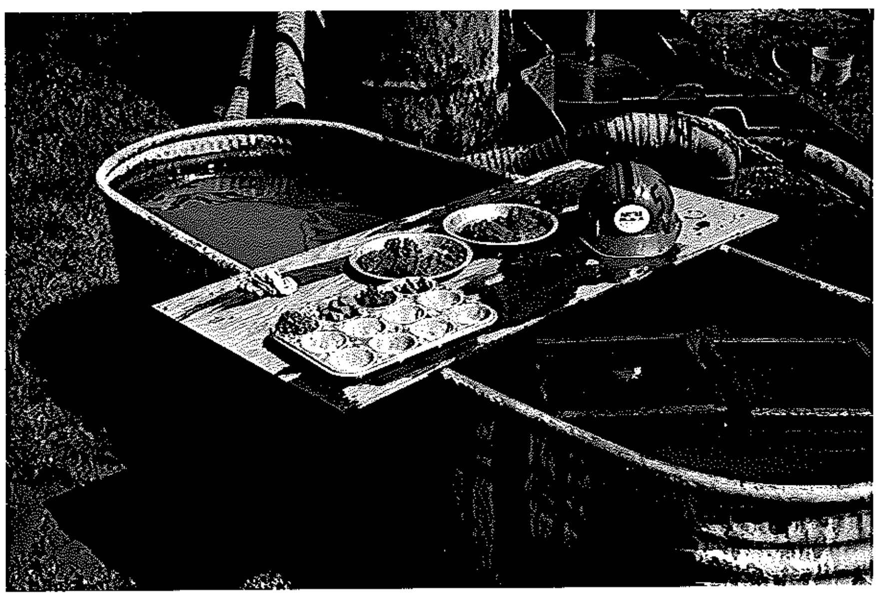


Figure 4. Cutting samples in muffin tins and sands on aluminum pans.

drying and describing prior to bagging. Sand and gravel samples were caught in pails, washed, and placed on pans for drying and describing.

From eight geological and electric logs including DOE Regina 531 and 532 (Drawing 0031-002-01; Testholes 1-5, 7,9,10) and two electric logs (Drawing 0031-002-01: Testholes 6,8), Cross Sections AA' and BB' were prepared (Drawings 0031-002-02;03, in back). These cross sections were constructed by taping matte positive logs on cross section paper and photo-mechanically reducing the original manuscript. This technique enables the geologist to have all of the information before him when interpreting the stratigraphy and to show the reader the bases for these interpretations.

2. BEDROCK STRATIGRAPHY

2.1 Introduction

The bedrock in the study-area is the Bearpaw Formation which includes two bentonitic zones and the Ardkenneth Member. One of these bentonitic zones and the Ardkenneth Member are used as structural marker beds.

2.2 Bearpaw Formation

The Bearpaw Formation in the study-area is composed of gray, non-calcareous, silt and clay with a gray, noncalcareous marine silt and sand (Ardkenneth Member). Locally, the sand in this member is cemented with white calcite to form 1 to 2-foot (.3-.6m) sandstone beds. The bentonitic zones are marked on the electric logs by a sharp decrease in both the spontaneous potential (SP) and the resistance (R).

DRAWING 0031-002-02. CROSS SECTION AA′.

SEE DRAWING 0031-002-01 FOR LOCATION OF CROSS SECTION

SEE APPENDIX 1 FOR NAME AND LOCATION OF LOGS

3. GLACIAL STRAIGRAPHY

3.1 Introduction

The glacial deposits (drift) in the study-area have been divided into the Empress, Sutherland, and Saskatoon Groups.

3.2 Empress Group

The Empress Group, which was named by Whitaker and Christiansen (1972) and which was used in a cross section between Condie and Craven by Christiansen (1972), is composed of 0 to 25 feet (0-7.6m) of silt,sand, and gravel lying between bedrock and till. Although preglacial deposits are known to occur in the Empress Group in the Regina area (Christiansen, 1972),it is not known whether any preglcaial sediments exist in this group in the study-area.

3.3 Sutherland Group

The Sutherland Group, which was named by Christiansen (1968a) and which was traced to the Regina area by Christiansen (*in* Westgate *et al.* 1977), is composed of 0 to 192 (0-58.5m) of till and stratified drift. The tills of the Sutherland Group are less calcareous and have a lower electrical resistance than tills of the Floral Formation of the Saskatoon Group (see electric logs and carbonate curves plotted on electric logs in Cross Sections AA' and BB'). The upper part of the Sutherland Group in the study-area is weathered producing an olive gray color with yellowish brown staining on joint surfaces. The lower part of the Group is gray and unweathered.

3.4 Saskatoon Group

3.4.1 Introduction

The Saskatoon Group in the study-area is composed of the Floral and Battleford Formations, Condie Moraine, and Regina Clay. The Saskatoon Group and the Floral and Battleford Formations were named by Christiansen (1968a,b). The Condie Sands and Gravels and Condie Silt are informal stratigraphic units.

3.4.2 Floral Formation

The Floral Formation is composed of: Lower Till; Lower Glacial Sands and Gravels; Interglacial Silts, Sands, and Gravels; Interglacial Silts, Upper Glacial Sands and Gravels; and Upper Till (Drawings 0031-002-02, 03).

The Lower Till of the Floral Formation lies between the Sutherland Group and the Lower Glacial Sands and Gravels (Drawings 0031-002,02,03). The Lower Till unit is composed of 0 to 322 feet (0-98m) of till and sand. The till is gray except for the upper 10 feet (3m) in Testhole 4 (Drawing 0031-002-03) where the till has weathered to an olive color. In the rest of the testholes, this weathered zone was removed presumably by glacial erosion.

The Lower Glacial Sands and Gravels are restricted to Testholes 2,3, and 4 (Drawing 0031-002-03). The sediment, which ranges in thickness from 0 to 145 feet (0-44m), is mainly sands and gravels but includes minor amounts of silt and till. The Lower Glacial Sands and Gravels constitute the only aquifer beneath the PCB Spill Site. It is called herein the Un-named Acquifer.

The Interglacial Silts, Sands, and Gravels are up to 266 feet (81m) thick and, locally, contain an abundance of snail and clam shells.

These deposits, which were derived presumably from the Lower Glacial Sands and Gravels, are believed to have been deposited in a collapsing lake which occupied an area including Testholes 4 and 5 (Drawing 0031-002-03).

The Interglacial Silts, which are up to 84 feet (26m) thick, are composed of silts, silty sands, and sandy silts which, locally, are highly calcareous and rich in carbonaceous material. The contact between this unit and the underlying Interglacial Silts, Sands, and Gravels is gradational.

The Upper Glacial Sands and Gravels, which are up to 105 feet (32m) thick, contain a few till and silt interbeds. This unit extends from Testholes 5 to 9 (Drawing 0031-002-02) where it comprises the Regina Aquifer. This aquifer does not occur beneath the PCB Spill Site.

The Upper Till is the youngest unit in the Floral Formation of the study-area. It ranges in thickness from 0 to 17 feet (0-5m) and is gray, calcareous, and hard.

3.4.3 Battleford Formation

The Battleford Formation is composed of 3 to 32 feet (.9-6.7m) of soft, massive gray, sandy till which is composed of less carbonate than the underlying Upper Till of the Floral Formation (Drawing 0031-002-02,03). The lower contact with the underlying harder till is disconformable, whereas the upper contact is conformable.

3.4.4 Condie Moraine

The Condie Moraine, which is used herein as a morphostratigraphic unit, is composed of a ridge of sand and gravel (Condie Sands and Gravels) and flanked to the south by silts (Condie Silt). These unit names are used informally.

The Condie Sands and Gravels are up to 142 feet (43m) thick (E.A. Christiansen Consulting Ltd., 1979, Drawing 0016-003-22). In the study-area, this unit is up to 87 feet (26.5m) thick in the ridge of the moraine and pinches-out gradually to the south (Drawing 0031-002-02). The Condie Sands and Gravels were covered by a 2-foot (.6m) till sheet during a re-advance of the glacier (Drawing 0031-002-02).

The Condie Silt forms and apron south of the Condie Moraine crest. This deposit lies between either till of Battleford Formation or till deposited by the glacial re-advance and the overlying Regina clay. The silts are sandy near the ridge of the moraine and become less so to the south. The Condie Silt in the study area ranges in thickness from 0 to 20 feet (0-6m). The Condie Silt as well as the Condie Sands and Gravels were derived from the glacier when it stood along the Condie Moraine.

The Regina Clay, which was named by Christiansen (1961), is up to 24 feet (7.3m) thick in the study-area (Drawing 0031-002-02, Testhole 7). The contact between the Regina Clay and the underlying Condie Silt is conformable.

4. GEOLOGICAL STRUCTURE

4.1 Introduction

Although the absence of weathered zones in the upper parts of the Lower and Upper Tills of the Floral Formation as well as missing beds suggest strongly that glacial erosion has taken place in the study-area, the most important structure exhibited in the cross sections (Drawing 0031-002,02,03), however, is collapse.

4.2 Collapse Structure

Christiansen (1967) showed that the bedrock deposits in the Saskatoon Low were collapsed and inferred that the depression on the bedrock surface above the collapse structure was also caused by collapse. Christiansen (1971b) demonstrated that Crater Lake lies in a collapse structure which formed about 13,600 years ago. Gendzwill and Hajnal (1971), in a companion paper,showed that the collapse was caused by the removal of salt (Fig. 5) from the Devonian, Elk Point, Prairie Evaporite Formation (Fig. 6).

The variations in elevation of the bentonite marker bed and the Ardkenneth Member of the Bearpaw Formation indicate a collapse structure with the center of the structure in the vicinity of Testhole 5 (Drawing 0031-002-02). The base of the Ardkenneth Member is 375 feet (114m) lower at Testhole 5 that at Testhole 2 (Drawings 0031-002-02,03). These testholes are about 1.2 miles (1930m) apart.

The model used to explain the structure is taken from Christiansen (1967,1971b). The vertical faults are schematic with the vertical movement between adjacent testholes being accounted for along one fault halfway between them. It is very possible that the collapse was accommodated by numerous faults rather than the few shown.

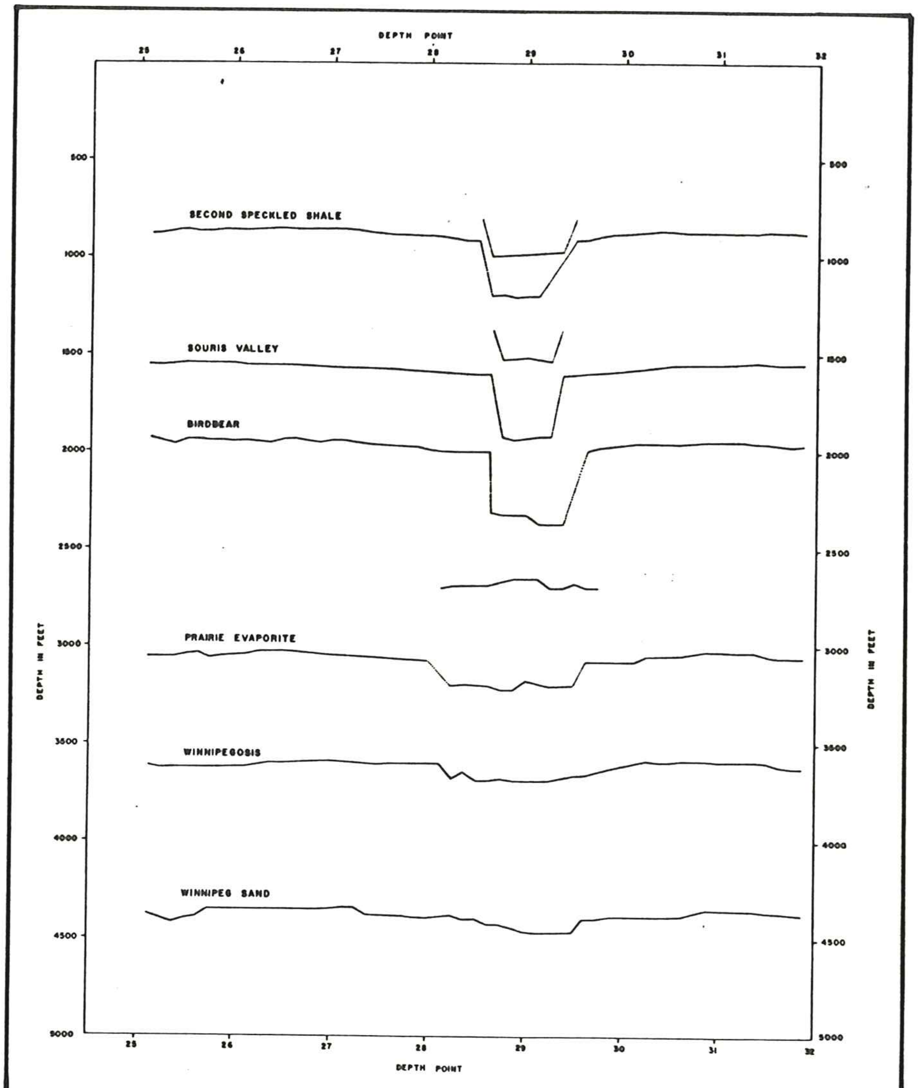


Figure 5. Seismic cross section of Crater Lake structure which formed as a result of dissolution of salt from the Devonian, Elk Point, Prairie Evaporite Formation. From Gendzwill and Hajnal (1971).

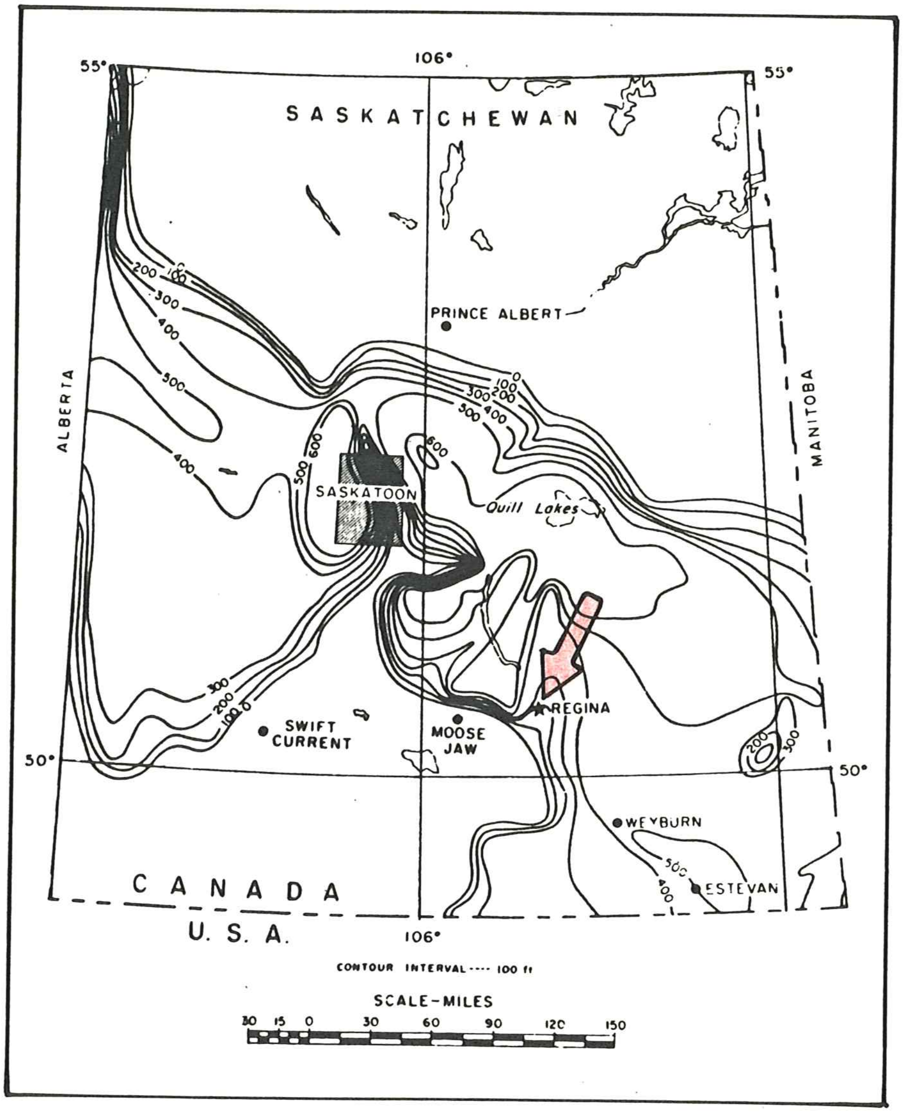


Figure 6. Thickness of salt in the Devonian, Elk Point Group. From Pearson (1963).

The cross sections (Drawings 0031-002-02,03) suggest that collapse was initiated before glacial time and continued until the deposition of the Upper Till of the Floral Formation. Although it has not been demonstrated that the collpase was caused by the dissolution of the Prairie Evaporite Formation or other salts,this seems to be the only credible cause of the collapse structure in the study-area. The age of this structure will be discussed further in the next chapter.

5. GEOLOGICAL HISTORY

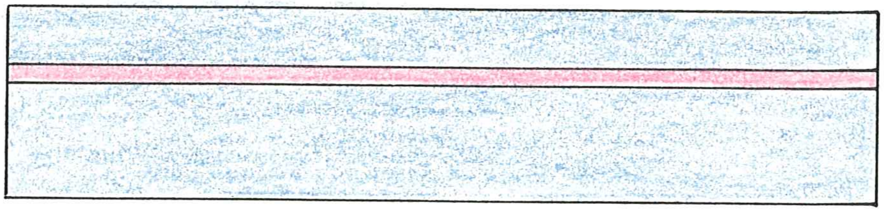
5.1 Cretaceous Period

During the late Cretaceous, the study-area was covered by shallow seas into which rivers from the Cordillera emptied to form deltas. These deltas regressed eastward as the sea levels fell and transgressed westward as the sea levels rose. The sandy Ardkenneth Member of the Bearpaw Formation represents such a deltaic deposit formed in a marine environment, whereas the clayier part of the Bearpaw Formation was deposited in shallow seas eastward from such deltas. The Cretaceous Period came to a close about 64 million years ago (Obradovitch and Cobban, 1975).

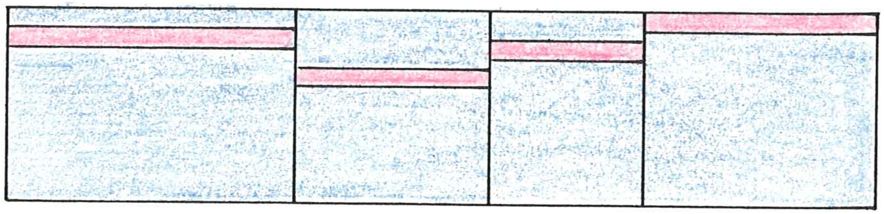
Between the deposition of the Bearpaw Formation and the advent of glaciation,the study-area collapsed (Fig. 7, Phase 2).

5.2 Tertiary Period

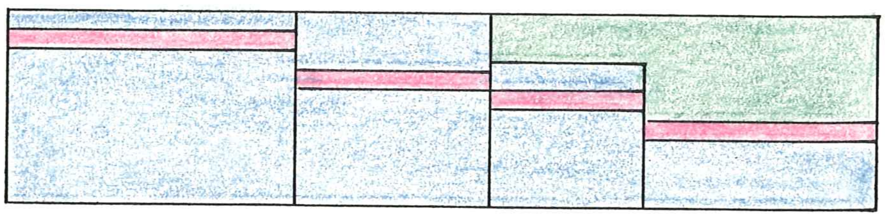
During the Tertiary Period, from about 64 million to 3 million years ago, the Regina area received nonmarine clay, silt, and gravel from streams originating in the rapidly rising Cordillera (Christiansen, 1972). Whether the silt, sand, and gravel of the Empress Group in the study-area are preglacial (Tertiary), glacial Quaternary, or both has not been determined.



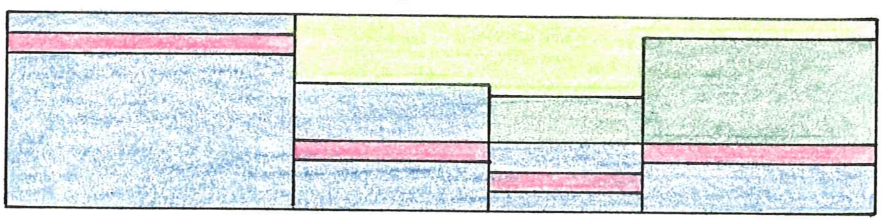
Phase 1. Late Cretaceous-early Quaternary.



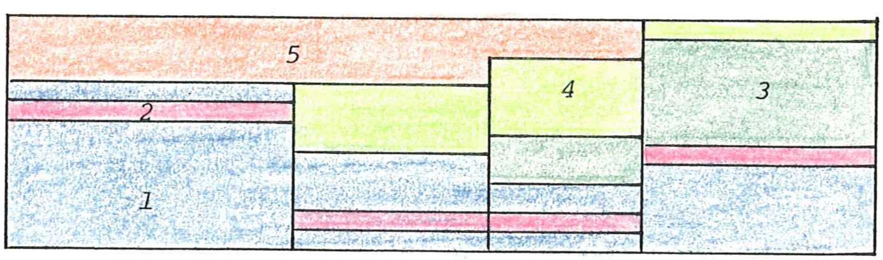
Phase 2. Collapse and erosion prior to deposition of glacial deposits.



Phase 3. Collapse during or prior to deposition of the Empress and Sutherland Groups.

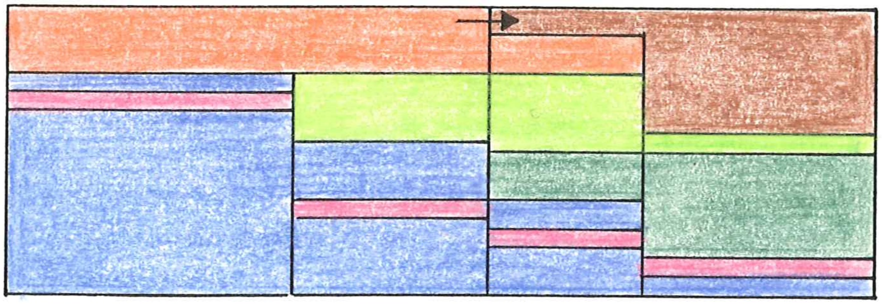


Phase 4. Collapse during or prior to deposition of the Lower Till of the Floral Formation.

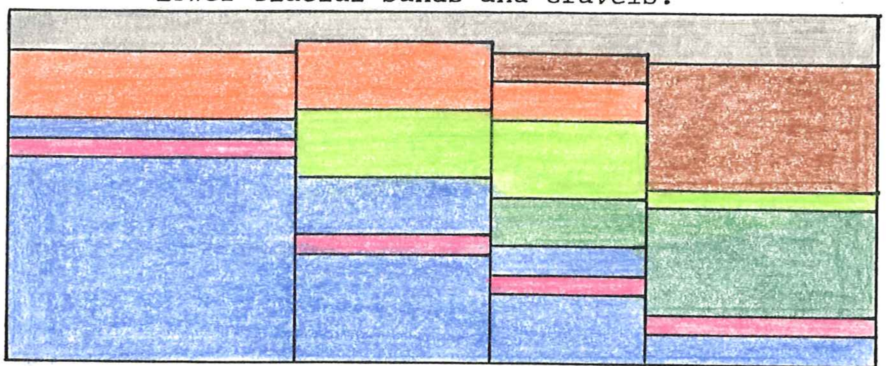


Phase 5. Collapse during or prior to deposition of the Lower Glacial Sands and Gravels.

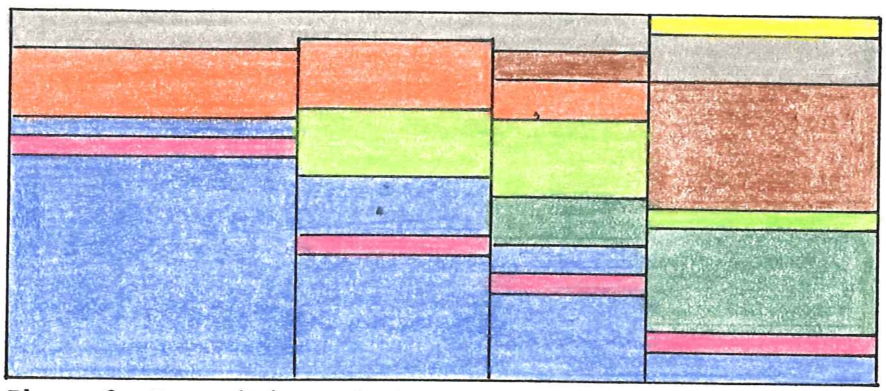
Figure 7. Evolution of the collapse structure in Cross Section BB' (Drawing 0031-002-03). (1) Bearpaw Formation, (2) Ardkenneth Member, (3) Empress and Sutherland Groups, (4) Lower Till, (5) Lower Glacial Sands and Gravels, (6) Interglacial Silts, Sands, and Gravels, (7) Interglacial Silts, (8) Upper Glacial Sands and Gravels, (9) Upper Till, (10) Battleford Formation, and (11) Condie Silt and Sand and Regina Clay.



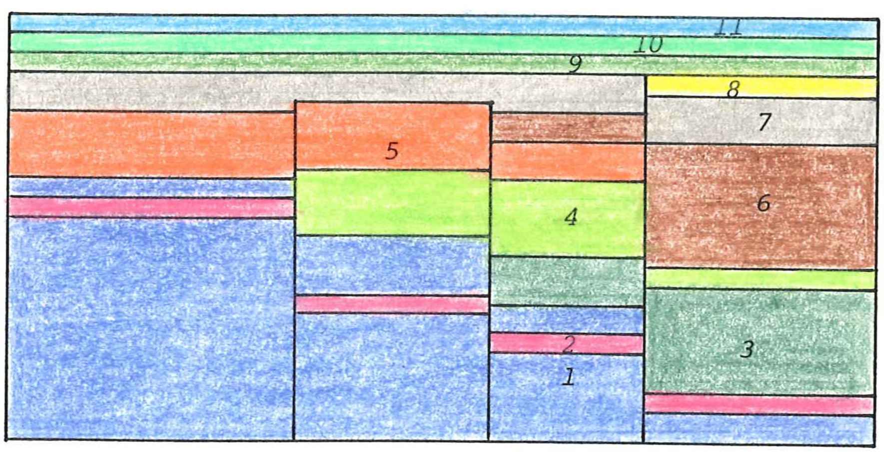
Phase 6. Deposition of Interglacial Silts, Sands, and Gravels from the Lower Glacial Sands and Gravels.



Phase 7. Deposition of the Interglacial Silts.



Phase 8. Deposition of the Upper Glacial Sands and Gravels.



Phase 9. Deposition of Upper Till of the Floral Formation, Battleford Formation, and Condie Silt and Sand and Regina Clay.

5.3 Quaternary Period

5.3.1 Introduction

The Quaternary Period covers about the last three million years of the earth's history and is composed of the Pleistocene and Recent Epochs.

5.3.2 Pleistocene Epoch

As the first continental glacier advanced southwestward across southern Saskatchewan, it eroded the Cretaceous and Tertiary bedrock deposits; consequently, the Lower Till of the Sutherland Group, which was deposited by this initial glaciation in the Saskatoon area, is not present in the study-area.

The Upper Till of the Sutherland Group, which is believed to be the only till of this Group in the study-area, was deposited during the second glaciation. Collapse in the study-area either took place between the deposition of the Empress Group and the advent of this glaciation or during this glaciation (Fig. 7, Phase 3). The presence of a well-developed weathering zone in the upper part of the Sutherland Group suggests a long weathering interval between the deposition of this Group and the overlying Floral Formation.

The presence of carbonaceous, fossiliferous interglacial sediments between the Lower and Upper Tills of the Floral Formation suggests the Floral Formation was deposited by two glaciations. The Lower Till and Lower Glacial Sands and Gravels were deposited during the third glaciation. Collapse either took place prior or during the deposition of the Lower Till to account for the great changes in thickness of this deposit (Fig. 7, Phase 4). During the retreat of the third glacier, the Lower Glacial Sands and Gravels were washed into a collapsed or collapsing depression (Fig. 7, Phase 5).

During Phase 6 (Fig. 7), major collapse took place at the site of Testhole 5. The Lower Glacial Sands and Gravels were presumably the main source for the Interglacial Silts, Sands, and Gravels which were deposited in this collapsed depression. As the depression became shallower, fossiliferous silts were deposited at Testhole Sites 4 and 5.

During Phase 7 (Fig. 7), Interglacial Silts were deposited over the entire area shown in this Phase. The poorly sorted sandy silts and the presence of till suggest a colluvial origin for part of these deposits. The presence of carbonaceous zones, marls, and mollusc shells suggest a shallow water environment during those times. The deposition of these Interglacial Silts brought this Interglacial Stage to to a close. Collapse of the PCB Spill Site also ceased during the deposition of these silts.

During the advance of the fourth ice sheet, the Upper Glacial Sands and Gravels were deposited at Testhole Site 5 (Fig. 7, Phase 8). This deposit thickens to the northeast (Drawing 0031-002-02). As this glacier advanced across the study-area, the Upper Till of the Floral Formation was deposited which terminated the evolution of the collapse structure in the study-area (Fig. 7, Phase 9). This termination took place prior to 38,000 ±560 year B.P. (GSC-1041) which is the oldest finite radiocarbon date in intertill deposits between the Floral and Battleford Formations. If the Interglacial Silts are correlative with the Wascana Creek Ash, then these sediments may have been deposited as much as 600,000 to 700,000 years ago (Westgate *et al.* 1977). The cessation of collapse in the study-area took place between these dates, probably more closely to the older one.

The Battleford Formation was deposited by the fifth and last glaciation. This glacier advanced across the study-area about 20,000 years ago (Christiansen, 1968b) and stood at the Condie Moraine during its retreat about 14,000 years ago (Fig. 8). While the glacier stood in this position shown in Figure 8, the Condie Sands and Gravels were deposited as a wedge along the ice margin, and the Condie Sand and

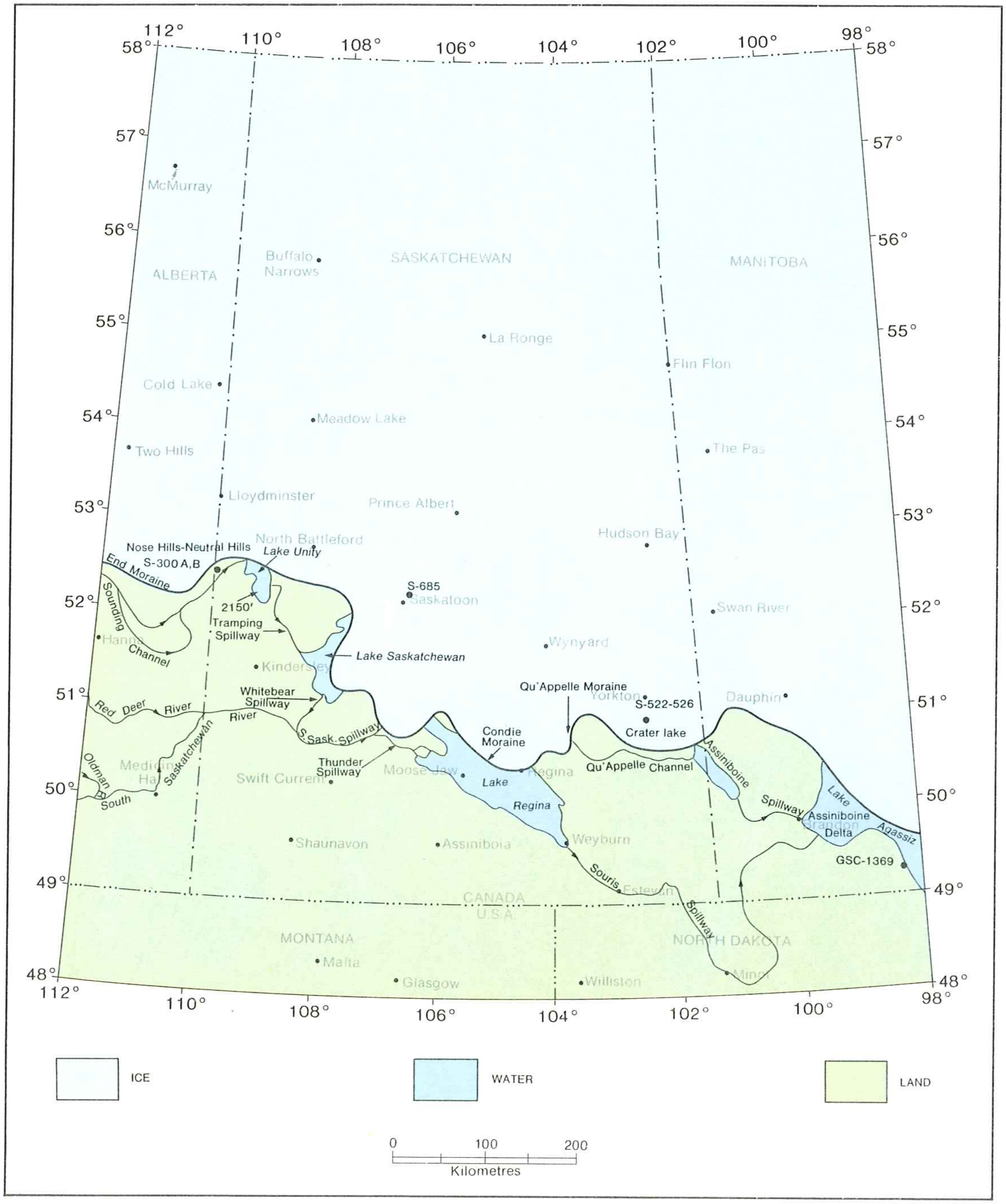


Figure 8. Phase 4 of the history of deglaciation of southern Saskatchewan and adjacent areas showing the glacier standing at the Condie Moraine with Lake Regina to the south. From Christiansen (1979).

Silt were deposited as an apron farther out into Lake Regina. After the Condie Moraine was formed, the glacier over-rode it and deposited a thin till sheet over the Moraine (Drawing 0031-002-02). As the glacier retreated from the study-area, Lake Regina followed it, and Regina Clay was deposited on the Condie Moraine and throughout the Lake Regina basin.

5.3.3 Recent Epoch

Natural processes of erosion and deposition have only slightly modified the landscape of the study-area. Man, however, has more extensively modified the area both physically and chemically. Much of the Condie Sands and Gravels, for example, have been removed for construction material, and two refineries and a waste disposal site have been built in the study-area.

6. GEOTECHNOLOGY

6.1 Introduction

This discussion is restricted to the application of geology to geotechnology and does not include engineering nor geohydrological aspects except as it applies in the latter case to the occurrence of groundwater.

6.2 Un-named Aquifer

The PCB Spill Site is underlain by the Un-named Aquifer at a depth of 120 to 194 feet (37-59m) depending on the amount of collapse that has taken place at the site since the deposition of the Lower Glacial Sands and Gravel (Drawing 0031-002-03). According to this Drawing, the Un-named Aquifer is the only aquifer underlying the PCB Spill Site.

6.3 Interglacial Silts

The Interglacial Silts are composed mainly of silts, sandy silts, and silty sands. Locally, fairly clean sands were obtained from the sample pail, but it is believed that these sand samples had lost part of their fines during washing. It is concluded, therefore, that silty, fine-to medium-grained sand was probably the most permeable sediment encountered in the Interglacial Silts.

6.4 Regina Aquifer

The Regina Aquifer (Upper Glacial Sands and Gravels) does not occur beneath the PCB Spill Site.

6.5 Upper Till of the Floral Formation

The Upper Till of the Floral Formation is gray and unweathered. If jointing of till is restricted to the weathering zone, then this till should not be jointed. It was not possible to determine whether this till was jointed on the basis of cutting samples. Cores and exposures would be required to determine whether the Upper Till of the Floral Formation is jointed.

6.6 Battleford Formation

The Battleford Formation is a soft massive, gray, sandy, unweathered till. Wherever the Formation has been examined in cores and exposures in Saskatchewan, it is found to be unjointed. It seems reasonable to conclude that the Battleford Formation beneath the PCB Spill Site is not jointed.

6.7 Condie Sands and Gravels

According to Cross SectionBB' (Drawing 0031-002-03), the Condie Sands and Gravels do not occur beneath the PCB Spill Site.

7. LITERATURE CITED

Christiansen, E.A. 1961. Geology and ground-water resources of the Regina area, Saskatchewan. Saskatchewan Research Council, Geology Division, Report 2.

Christiansen, E.A. 1967. Collapse structures near Saskatoon, Saskatchewan, Canada. Canadian Journal of Earth Sciences, v.4, p. 757-767.

Christiansen, E.A. 1968a. Pleistocene stratigraphy of the Saskatoon area, Saskatchewan, Canada. Canadian Journal of Earth Sciences, v.5, p.1167-1173.

Christiansen, E.A. 1968b. A Thin till in west-central Saskatchewan, Canada. Canadian Journal of Earth Sciences. v.5, p.329-336.

Christiansen, E.A. 1971a. Geology and groundwater resources of the Regina area (72I), Saskatchewan. Saskatchewan Research Council, Geology Division, Map 13

Christiansen, E.A. 1971b. Geology of the Crater Lake collapse structure in southeastern Saskatchewan. Canadian Journal of Earth Sciences, v.8, p.1505-1513.

Christiansen, E.A. 1972. Cross section of drift and bedrock between Condie and Craven, Saskatchewan. Saskatchewan Research Council, Geology Division, Cross section 1.

Christiansen, E.A. 1979. The Wisconsinan deglaciation of southern Saskatchewan and adjacent areas. Canadian Journal of Earth Sciences, v.16, p.913-938.

E.A. Christiansen Consulting Ltd. 1979. Geology of the Regina-Moose Jaw region, Saskatchewan. Saskatchewan Municipal Affairs, Part A, Regional Studies Program.

Ellis, J.G., Acton, D.F., and Clayton, J.S. 1965. The soils of the Regina map area (72I). University of Saskatchewan, Saskatchewan Institute of Pedology Publication S1, Extension Publication 176, 133p.

Gendzwill, D.J. and Hajnal, Z. 1971. Seismic investigation of the Crater Lake structure in southeastern Saskatchewan. Canadian Journal of Earth Sciences, v.8, p.1514-1524.

Meneley, W.A. and Christiansen, E.A. 1975. Hydrogeology of the Regina area. Saskatchewan Research Council, Geology Division, Preliminary Report 9 of 10.

Obradovich, J.D. and Cobban, W.A. 1975. A time-scale for the late Cretaceous of the Western Interior of North America. *In* The Cretaceous System in the Western Interior of North America. *Edited by* W.G.E. Caldwell. The Geological Association of Canada Special Paper 13, p.36.

Pearson, W.J. 1963. Salt deposits of Canada. Northern Ohio Geological Society Symposium on salt, p. 196-239.

Westgate, J.A., Christiansen, E.A., and Boellstorff, J.D. 1977. Wascana Creek Ash (Middle Pleistocene) in southern Saskatchewan: characterization, source, fission track age, paleomagnetism and stratigraphic significance. Canadian Journal of Earth Sciences, v. 14, p. 357-374.

Whitaker, S.H. and Christiansen, E.A. 1972. The Empress Group in southern Saskatchewan. Canadian Journal of Earth Sciences, v.9, p.353-360

APPENDIX 1. NAME AND LOCATION OF LOGS

Log No.	Name	Location
1	SRC Museum-Wascana Park	NW13-18-17-19-W2
2	DOE Regina 511	SW12-30-17-19-W2
3	DOE Regina 532	SW15-30-17-19-W2
4	DOE Regina 531	NE15-30-17-19-W2
5	DOE Regina 513	NW4-32-17-19-W2
6	IMP Regina	4-32-17-19-W2
7	DOE Regina 514	NW1-5-18-19-W2
8	Co-op WDW Regina	1-5-18-19-W2
9	DOE Regina 515	SE14-4-18-19-W2
10	DOE Regina 519	SW12-10-18-19-W2


DOE REGINA 511
SW12- 0-17-19-W2
1
DOE REGINA 532
SW15-30-17-19-W2
2
DOE REGINA 531
NE15-30-17-19-W2
3
DOE REGINA 513
NW4-32-17-19-W2
4
IMP REGINA
4-32-17-19-W2
5
RING ROAD
PROPOSED TESTHOLE
DOE REGINA 514
NW1-5-18-19-W2
6
COOP REGINA
1-5-18-19-W2
7
DOE REGINA 515
SE14-4-18-19-W2
8
DOE REGINA 519
SW12-10-18-19-W2
9
2000
1500
1000
FEET ABOVE SEA LEVEL
BATTLEFORD FORMATION
REGINA CLAY
CONDIE SAND
CONDIE SILT
INTERVAL TO BE CORED
FLORAL FORMATION
BEDROCK SURFACE
EMPRESS GROUP
BENTONITE MARKER BED
SASKATOON GROUP
MILES
VERTICAL EXAGGERATION
TESTHOLE
COREHOLE
REGINA
E.A. CHRISTIANSEN
CONSULTING LTD.
CONSULTING GEOLOGIST
Box 3087
Saskatoon, Sask.
S7K 3S9
Phone: 374-6700
Drawing No. REGINA CROSS SECTION
Drawn By E.A.CHRISTIANSEN
Date JUNE 30, 1932


DOE REGINA 511
SW12-0-17-19-W2
1
DOE REGINA 532
SW15-30-17-19-W2
2
DOE REGINA 531
NE15-30-17-19-W2
3
DOE REGINA 513 / IMP REGINA
NW4-32-17-19-W2 / 4-32-17-19-W2
4 5
RING ROAD
SEE MAP
PROPOSED TESTHOLE
DOE REGINA 514 / COOP REGINA
NW1-5-18-19-W2 / 1-5-18-19-W2
6 7
DOE REGINA 515
SE14-4-18-19-W2
8
DOE REGINA 519
SW12-10-18-19-W2
9
FEET ABOVE SEA LEVEL
2000
1500
1000
600m
500m
400m
300m
BATTLEFORD FORMATION TILL
REGINA CLAY
CONDIE SAND
CONDIE SILT
INTERVAL TO BE CORED
UPPER GLACIAL SANDS AND GRAVELS
LOWER GLACIAL SANDS AND GRAVELS
UPPER TILL
MIDDLE TILL
LOWER TILL
SUTHERLAND GROUP
FLORAL FORMATION
INTERGLACIAL DEPOSITS
SILT AND SAND
SAND AND GRAVEL
SILT AND CLAY
BEARPAW FORMATION
ARDKENNETH MEMBER
SAND
SILT
EMPRESS GROUP
BEDROCK SURFACE
BENTONITE MARKER BED
MILES
KILOMETRES
VERTICAL EXAGGERATION
TESTHOLE
BOREHOLE
REGINA
CONDIE
E.A. CHRISTIANSEN CONSULTING LTD.
CONSULTING GEOLOGIST
Box 3087
Saskatoon, Sask.
S7K 3S9
Phone: 374-6700
Drawing No. REGINA CROSS SECTION
Drawn By E.A.CHRISTIANSEN
Date JUNE 30, 1982

DRAWING 0031-002-03. CROSS SECTION BB'.

SEE DRAWING 0031-002-01 FOR LOCATION OF CROSS SECTION