SASKATCHEWAN HIGHWAYS AND TRANSPORTATION

LOCATION OF INTERTILL GRAVEL DEPOSITS

Report 0111-004          October 16, 2003
October 17, 2003

Saskatchewan Highways and Transportation
350 Third Avenue North
Saskatoon, SK S7K 2H6

Attention: Mr. P. Jorge Antunes, P. Eng.

Re: Location of intertilt gravel deposits

Dear Mr. Antunes

Enclosed please find one copy of the "Location of intertilt gravel deposits". I would welcome any comments that you may have to offer, particularly regarding the recommendations and Figure 3 on Page 11.

Sincerely yours,

E. A. Christiansen, P. Eng., P. Geo.
Location of Intertill Gravel Deposits
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LOGIC FOR LOCATION OF INTERTILL GRAVEL DEPOSITS

(From E. K. Sauer and E. A. Christiansen 2001)

1. Gravel is deposited over till during the advance and/or retreat of a glacier. Gravel formed during the most recent glaciation in eskers, kames, outwash, etc., can be observed on the present ground surface (air photos, field reconnaissance, etc.)

2. There have been at least 8 glaciations. Gravel deposits from the 7 earliest glaciations cannot be observed from the surface. Subsurface exploration procedures are required to locate these deposits.

3. For subsurface exploration purposes, it is assumed that gravel was deposited during each glaciation in the same manner as the most recent glacial event. In other words, the frequency and areal distribution of gravel deposited were similar during the recent and each of the 7 preceding glaciations.

4. Each glaciation deposited a more or less continuous layer of till with unique properties preceding the deposition of gravel. Thus, the gravel deposits overly a till associated with the same glaciation. Subsequently, a till from the next glaciation is deposited over the gravel.

5. Consequently, the gravel deposited by each glaciation lies between two tills that have unique properties. These are referred to intertill gravels. However, there is randomness to the location of the gravel deposits during each glaciation. More than one intertill gravel may occur at the same geographic location, or there may be none at all.

6. Tills associated with separate glaciations must be present for the potential for intertill gravels to exist. Classification of the tills (stratigraphy) is the framework for defining continuity and areal extent of the intertill gravel deposits. In addition, the thickness of the tills overlying the intertill gravels and the possible presence of surface clay deposits
govern the suitability of intertill gravel for exploitation. Thus, the first requirement of the exploration process is to classify the tills and determine the thickness of surface materials in the area.

**Exploration Program**

**Phase No. 1**

1. Terrain analyses utilizing 1:100,000 base maps produced from 1:50,000 topographic sheets, soil maps, aerial photographs and mosaics, and other pertinent information which may be available.

2. Construct borehole data sheets on 1:100,000 maps utilizing SHT*, SRC, SWC, SIP, and EAC data banks.

3. Select, in a flexible grid, as many cross sections as the data permits.

4. Construct preliminary cross sections at a vertical scale of 1:1000 and a horizontal scale of 1:20,000 or less.

5. Fieldwork to check terrain analyses, to integrate the terrain analyses with the cross sections, and to locate and stake borehole locations.

6. Testhole drilling and geophysical logging on a flexible grid with a borehole at promising sites on or near the grid in item 2.

7. Examination of borehole cutting samples, selection of till samples for carbonate analyses, and compilation of geologic logs on milars produced photomechanically or by computer.

8. Update preliminary cross sections.

9. Assessment of regional study and recommendations for additional drilling at the promising sites discovered in Phase 1.

*SHT Saskatchewan Highways and Transportation

SRC Saskatchewan Research Council
Phase 2
Sufficient test drilling at promising sites discovered in Phase 1 to provide a stratigraphic framework for a pit assessment by SHT in Phase No. 3.

Phase 3
Pit assessment of sand and gravel by SHT of the sand and gravel sites outlined in Phase 2.

OCCURRENCE

Ice contact stratified deposits

Eskers
Eskers are long, narrow, steep-sided ridges of sand and gravel deposited by subglacial or englacial streams flowing between ice walls or in an ice tunnel of a continuously retreating glacier. Eskers are thought to fine upward in response to the time regressive headward erosion of the subglacial valley. Eskers are common in the Canadian Shield where the crystalline rocks prevent much erosion by subglacial channels. Consequently, the subglacial ice-walled fills appear as ridges in the terrain. In southern Saskatchewan where both the bedrock and glacial sediments are more easily eroded by subglacial streams, the eskerine deposits may extend below the general ground surface.

Subglacial channels
Subglacial channels associated with eskers and kames are common in Saskatchewan. Both subglacial and surface glacial meltwater contribute to the formation of these channels. During deglaciation, a zone of fractured stagnant ice occurs in the
perimeter of glaciers. As the meltwater drains down the surface of the glacier, it
disappears into crevasses to form subglacial channels which eroded deep valleys into the
glacial and bedrock sediments (Christiansen 1987). The fining-upward sequence in the
sediments in the Venendrye valley (Christiansen 1987) suggests that this subglacial valley
was formed time transgressively in response to headward erosion of the subglacial
channel.

**Kames**

Kames are steep-sided mounds or short irregular ridges composed mainly of
poorly sorted sand and gravel deposits. Kames in the Kisbey area of Saskatchewan are
up to 40 m high and cover up to 5 square miles (Christiansen 1956). Kames are thought
to have been deposited by subglacial streams in fans or deltas against or on the terminal
margin of a melting glacier.

**Kame moraine**

A kame moraine is a group of kames along the front of a glacier. The Kisbey
kames moraine is up to 11 km long (Christiansen 1956).

**Proglacial stratified deposits**

**Outwash**

Outwash is mainly sand and gravel “washed out” by meltwater streams and
deposited in front of or beyond the margin of an active glacier. Most outwash deposits in
southern Saskatchewan were related to discharge from subglacial channels. The Welby
sand plain, for example, was formed where the Deerhorn channel exited from an
interlobate area in the glacier margin (Christiansen 1960).

**Deltas**

A delta is a low, nearly flat, alluvial tract of land deposited at or near the mouth of a
stream. In southern Saskatchewan, deltas from where glacial and extraglacial rivers and
glacial channels and spillways enter glacial lakes, mainly Lake Saskatchewan. Deltaic sediments up to 77 m thick were penetrated in a borehole in the Saskatoon Low south of Saskatoon (Christiansen and Sauer 2001).

The deltaic sediments are composed of gravel, sand, silt, and clay facies which grade from gravel in the apex to clay in the outer periphery of the delta. As the delta progrades outward into the glacial lake, the facies shift lakeward resulting in an upward coarsening of the sediments. In such a sequence, the prograding gravel facies will form the upper part sequence.

**Meltwater channels**

Meltwater channels conduct water directly from melting glacier into glacial lakes. Gravels occur mainly in point bars and fills that are formed by a fluctuating base level.

**STRATIGRAPHIC POSITION OF INTERTILL GRAVEL**

**Sequence**

A sequence is defined as a relatively conformable, genetically related succession of strata bounded by unconformities (Mitchum 1977). For the purpose of this report, the sequences are named after the tills, and only the Lower and Upper Floral and the Battleford sequences are considered herein.

(Fig. 1).
Fig. 1. Lower Floral, upper Floral and Battleford sequences. It is assumed that all tills and intertill gravels are present.
Stratigraphic association of intertill gravels and tills

(slightly modified from Christiansen 1992)

1. If an intertill gravel is oxidized, fossiliferous, or carbonaceous and the overlying till is unoxidized, the intertill gravel is associated with the underlying till.

2. If an intertill gravel is unoxidized and the underlying till is oxidized, the intertill gravel is associated with the overlying till.

3. If the lower part of the intertill gravel is oxidized and the upper part of the gravel is unoxidized, the lower part is associated with the underlying till and the upper part is associated with the overlying till.

4. If an intertill gravel and the underlying and overlying tills all are either oxidized or unoxidized, the intertill gravel is associated with either the underlying or overlying till, depending on the nature of the lower and upper contacts of the intertill gravel which may be ascertained from the regional stratigraphy. For example, if the lower contact of the intertill gravel is conformable and the upper contact is nonconformable, the gravel is associated with the underlying till. Conversely, if the lower contact of an intertill gravel is nonconformable and the upper contact is conformable, the gravel is associated with the overlying till.

5. Deltaic sediments deposited in glacial lakes by meltwater channels coarsen upward as a result of progradation. Deltaic deposits are conformable with the underlying till and nonconformable with the overlying till.
RECOMMENDATIONS

1. Augerhole samples should be collected at one half metre intervals and placed on canvass strips marked in 30 cm partitions (Fig. 2). These samples can be described by the driller after drilling has been completed. The driller's field log should include also a description on "how the hole drilled." The following are examples of field logs. (a) Till, stony, sandy or clayey, gray or brown, unstained or Fe stained, soft or hard to drill, and anything else worth noting. (b) Clay or silt, gray or brown, unstained or Fe stained, soft or hard to drill and anything else worth mentioning. (c) Sand or gravel, fine medium, or coarse, gray or brown, unstained or Fe stained, easy or difficult to drill and anything else worth mentioning.

2. Drilling beyond 10 m with augering equipment is not recommended because the rate of augering and quality of samples is diminished with depth.

3. The base of exploration for auger drilling should be the top of a till in the Floral Formation which can be identified by a sharp increase in difficulty to drill. This depth would enable the examination of gravels belonging to the Battleford sequence and the upper gravel of the Upper Floral sequence (Fig. 1).

4. For exploring for intertill gravel to depth greater than 10 m, rotary-drill and geophysical logs such as those provided by Lyle Sinclair (SHT), are recommended. For the rotary-drill technique of exploration, the base of exploration should be till the Sutherland Group or a depth beyond which it would be uneconomic to research for gravel.

5. It is recommended that someone go out with the drillers and show them how to handle and describe samples and how to prepare a borehole strip log on logs provided by SHT. The SHT field logs should show a location system, surface elevation, date drilled, a strip log column, name of driller, brief description of deposits opposite the strip log. See an example of a field log form in Fig. 3.
Fig. 2. Plan of canvass sampling intervals.
REFERENCES


Christiansen, E. A. 1960. Geology and ground-water resources of the Qu'Appelle area, Saskatchewan. Saskatchewan Research Council, Geology Division, Report No. 1.


Figure 3. An example of a borehole log form.
APPENDIX Geologic logs 101 - 108 compiled for study