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OPEN FILE 7990**

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at Lac Dufresnoy, Quebec**

G.R. Brooks

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Abstract

As part of a reconnaissance sub-bottom acoustic profiling (SAP) survey, twenty-two and one SAP were collected from lakes Dufresnoy and Lac Petit Dufresnoy, Quebec, respectively, on July 19, 2014. There is good penetration of the sub-bottom along many of the profiles. Three depositional facies can be identified within the SAP returns that represent lacustrine, glaciolacustrine and mass movement deposits. In many profiles, multiple occurrences of mass movement deposits can be identified. The profiling reveals that Lac Dufresnoy is a suitable basin for follow-up detailed profiling and core collection to further investigate the mass movement deposit(s).

Introduction

Large areas of northwestern Quebec-northeastern Ontario were inundated by a succession of glacial lakes, known as Barlow, Barlow-Ojibway and Ojibway, that evolved within the Timiskaming and Hudson Bay basins between 10 570 and 8470 ± 200 cal BP (Vincent and Hardy 1979; Veillette 1994; Breckenridge et al. 2012). A legacy of these glacial lakes is the regional occurrence of glaciolacustrine deposits that form the Great and Lesser clay belts areas, as has been described in early geological reports (e.g., Coleman 1909, 1922; Wilson 1918; James 1923). Studies in the 1920s by Antevs (1925; 1928) interpreted that the rhythmically laminated couplets composing the deposits are varves which represent annual accretions. He recognized that the varves form a time series that can be correlated throughout the region, based on varve thickness patterns, as subsequent research has verified (Hughes, 1959; 1965; Breckenridge et al., 2012). Many reports mention the presence of beds of “contorted”, “deformed”, “disturbed” and “slidden” varves within the glaciolacustrine deposits (Wilson 1918; Antevs 1925, 1928; Hughes, 1959; Breckenridge, 2012). Some of these disturbed deposits have been interpreted or inferred to be stratigraphic evidence of paleoearthquakes that occurred during local deglaciation (Adams 1982, 1989; Doughty et al. 2011, 2013).

Recent literature indicates that lake basins are promising areas for investigating paleoseismicity, by identifying stratigraphic levels that contain the deposits of multiple, synchronous, submarine landslides and/or turbidity currents (e.g., Moernaut et al. 2007, 2009; Upton and Osterberg, 2007; Bertrand et al. 2008; Anselmetti et al. 2009; Beck 2009, 2011; Maloney et al. 2013; Morey et al. 2013; Strasser et al. 2013). Mass movement deposits have been recognized within the deposits of lake basins in eastern Canada, including northwestern Quebec-northeastern Ontario, that are attributed to both modern and prehistoric earthquakes (e.g., Shilts, 1984; Shilts and Clague, 1992; Shilts et al., 1992; Ouellet, 1997; Normadeau et al., 2013; Doughty et al., 2010; 2014). Brooks (2015) advocated applying an integrated seismo- and chrono-stratigraphic approach to investigating mass movement deposits as evidence of paleoseismicity preserved in lake basins.

To identify the occurrence of disturbed deposits (i.e., landslide, turbidity currents and/or soft sediment deformation) preserved in the sub-bottoms of lakes, reconnaissance sub-bottom acoustic profiling (SAP) surveys were collected by the Geological Survey of Canada in July 2014 at eight lakes in the Rouyn-Noranda-Kirkland Lake area, northwestern Quebec-northeastern Ontario (Fig. 1). The results allow an assessment of the extent and character of disturbed deposits in the region and can be used to identify lake basins (or portions thereof) for more detailed SAP surveys to investigate regional paleoseismicity.

This report contains the results of the reconnaissance SAP survey undertaken at Lac Dufresnoy, Quebec, on July 19, 2015 (Figs. 1 and 2). It summarizes the SAP methodology, includes a map of the profile lines, provides a generalized overview of the deposits contained in the sub-bottom, and a brief notation of the content of the individual profiles. The report contains digital data of the SAP profiles in .keb and .sgy formats, and raster images of the profile returns (bmp). It also contains .kea files that list the date and time of collection, water depth, and geographical coordinates for the profile routes. This report is one of eight that summarize the results of the July 2014 reconnaissance SAP surveys, as listed in Table 1.

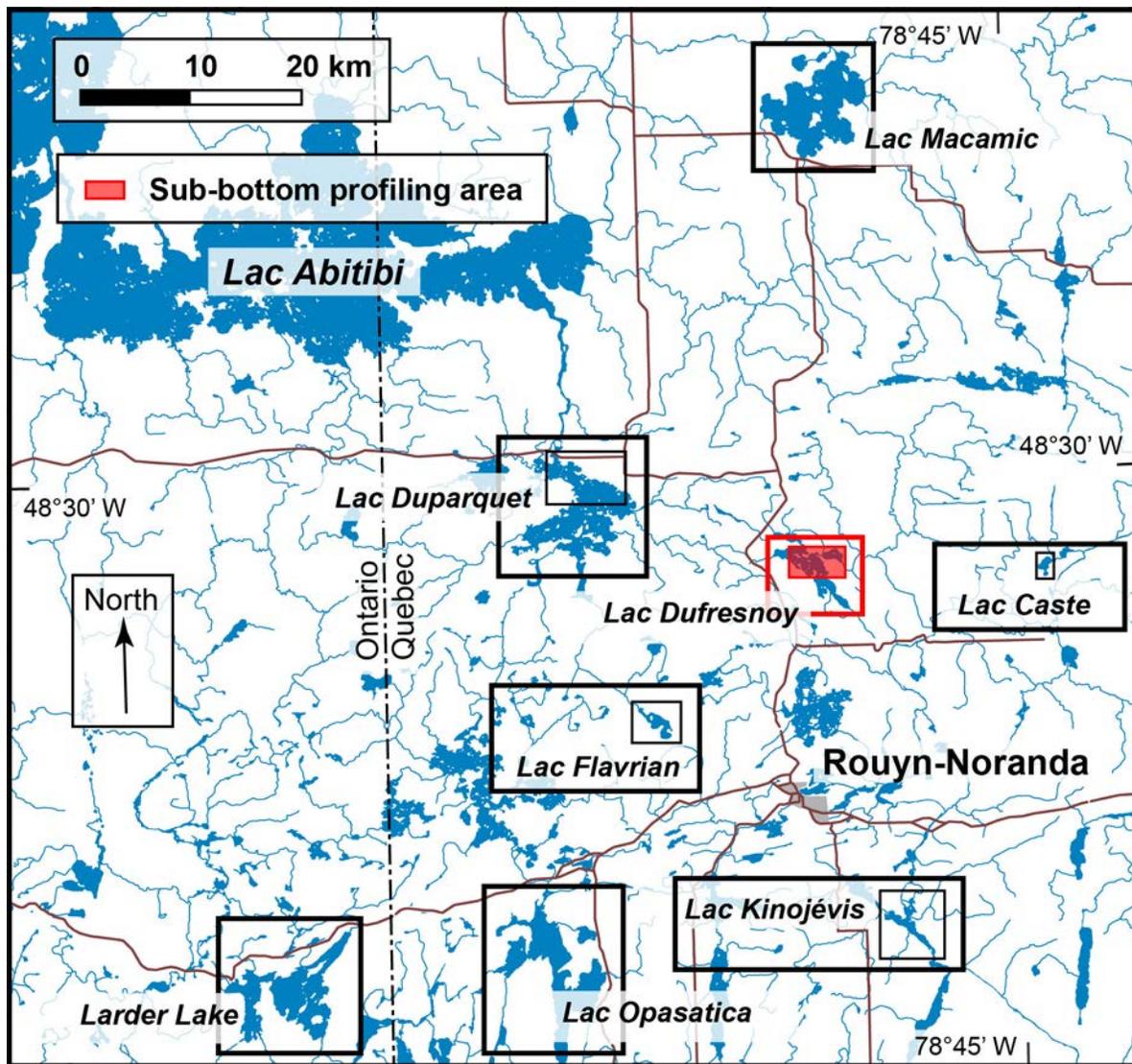


Fig. 1 Map showing the locations of Lac Dufresnoy and the other seven lake basins in the Rouyn-Noranda area, Quebec, where reconnaissance sub-bottom profiling surveys were conducted in July, 2014. The pink-shaded box over the northern area of Lac Dufresnoy shows the location of the map in Fig. 2.

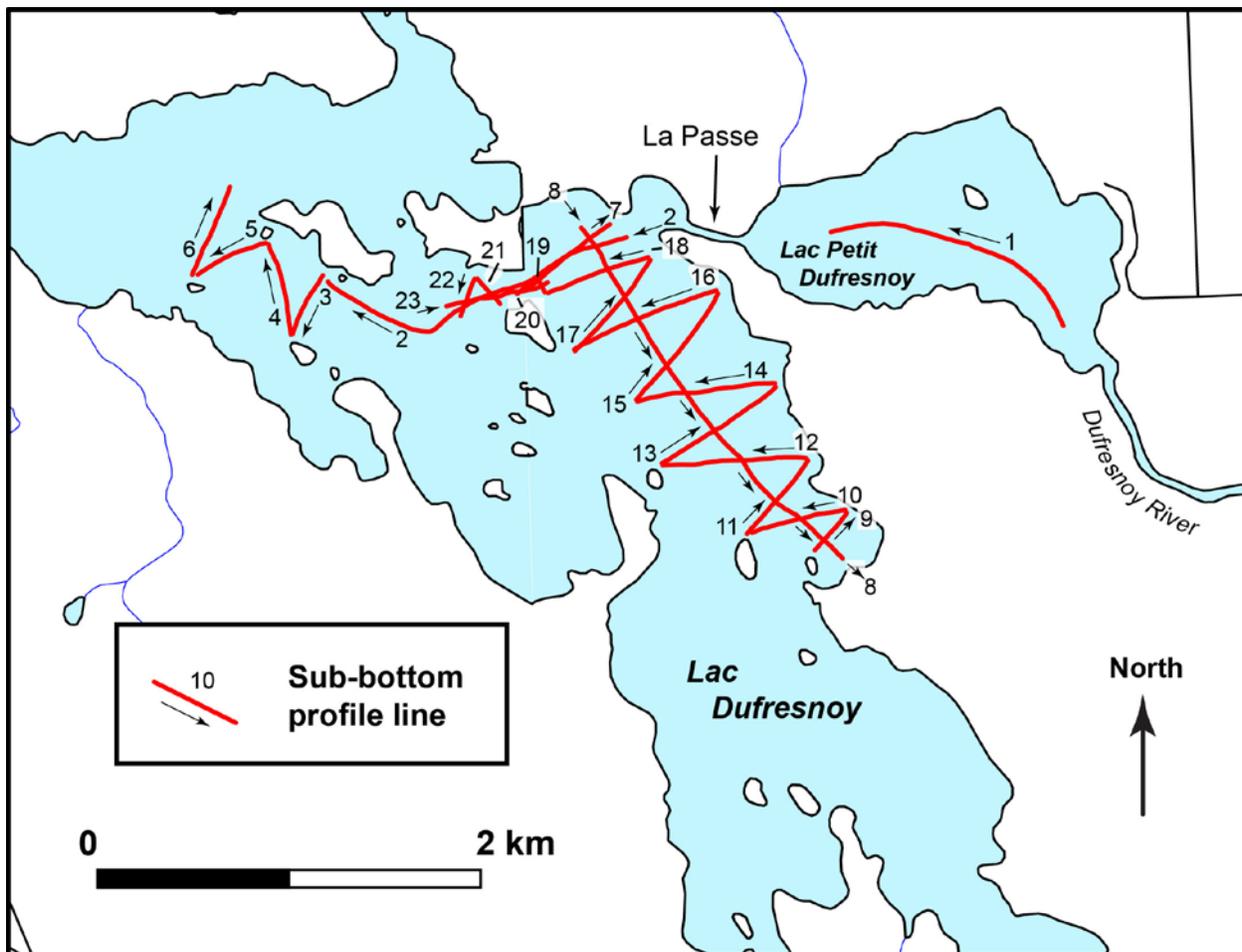


Fig. 2 Map showing the locations and numbering of the 22 SAP surveyed along the northeastern area of Lac Dufresnoy and the single profile from Petit Lac Dufresnoy. Note, portions of profiles 2, 7, 20 and 23 overlap and are difficult to differentiate from each other on the map. There are errors in the outlines of some sections of shorelines and islands on Lac Dufresnoy, where there is misalignment between polygons of NTS topographic maps 32 D/6 and 32 D/7.

Table 1 List of Open Files containing reconnaissance sub-bottom profiling of eight lakes in the Rouyn-Noranda-Kirkland Lake area, northwestern Quebec-northeastern Ontario.

Profiled lake basin	GSC OF number
Lac Caste	7991
Lac Dufresnoy	This report
Lac Duparquet	7989
Lac Flavrian	7988
Lac Kinojévis	7987
Lac Macamic	7985
Lac Opasatica	7984
Larder Lake	7986

Lac Dufresnoy

Lac Dufresnoy is located ~22.5 km north of Rouyn-Noranda, Quebec. The lake is elongated, and irregularly-shaped, ~9 km long, up to 3 km wide and 13.7 km² in area (Fig. 2). Lac Petit Dufresnoy is a small lake located just to the east of Lac Dufresnoy (Fig. 2). Baie Destar is well-defined bay located at the north end of Lac Dufresnoy. The shoreline of the lake is commonly composed of bedrock outcrops and there are numerous bedrock islands within the lake. The major inflow into the lake occurs via the Dufresnoy River, which enter through Lac Petit Dufresnoy. The major outlet is Ruiss Destor located at the head of Baie Destar; it eventually flows into Lac Duparquet. The profiled areas of both Lac Duparquet and Lac Petit Duparquet are weedy and shallow (commonly less than 3 m deep).

Access to Lac Dufresnoy was obtained using a public boat launch located on the eastern side of Lac Petit Dufresnoy and entering the larger lake via a creek known as La Passe (Fig. 2).

Methodology

The SAP survey on Lac Dufresnoy was undertaken on July 19, 2014, using a Knudsen 320M™ profiler coupled to low (28 kHz) and high (200 kHz) frequency transducers. The pole-mounted transducers were attached on the side of a 4.9 m (16 ft) aluminum boat powered by a 30 hp motor. Traversing speed during profiling ranged between 5 to 7 km.hr⁻¹. Profiling routes were mapped using streamed differentially-corrected GPS coordinates collected with a Novotel Smart-V1 antenna-receiver and recorded in combination with the digital SAP data. The active depth window of the profiler was set to 0-20 m. The profiling routes are depicted in Fig. 2.

Profiler and GPS data for each profile were recorded digitally on a notebook computer as .keb and .kea files. A .keb file is a Knudsen proprietary format that can be opened with Knudsen PostSurvey™ v1.61¹ software, which is included with the download of this Open File. In the .keb format, the profile returns include a depth scale and vertical line stamps which display time

¹ PostSurvey v1.61 is proprietary property of Knudsen Engineering Ltd.™ and is intended for authorized use only. Any use, other than the specific purpose of playback/displaying Knudsen data is prohibited. PostSurvey v1.61 has been included in the download of OF-7990 with the permission of Knudsen Engineering Ltd.™. The software has been provided for the convenience of the OF-7990 user. A user of this software does so entirely at their own risk.

and geographical coordinates (degree-decimal minutes). The vertical line stamps are made at the start/end of the profiles as well as at 20 sec intervals during profiling (Fig. 3).

To further facilitate profile viewing, the .keb file of the 28 kHz channel returns for each profile has been converted to a .sgy format file as well as a .bmp raster image. The .kea file contains the date and time of data collection, water depth, and geographical coordinates of the profile routes. The .kea files are an ASCII format and can be opened through a spreadsheet software, such as Microsoft Excel®. Depths on the profiles in the .keb and .kea files are based on a sound velocity in water of 1500 m.s⁻¹.

The .keb, .sgy, .bmp and .kea files for each profile are contained in designated profile folders. The folders form a digital Appendix that accompanies the download of this report.

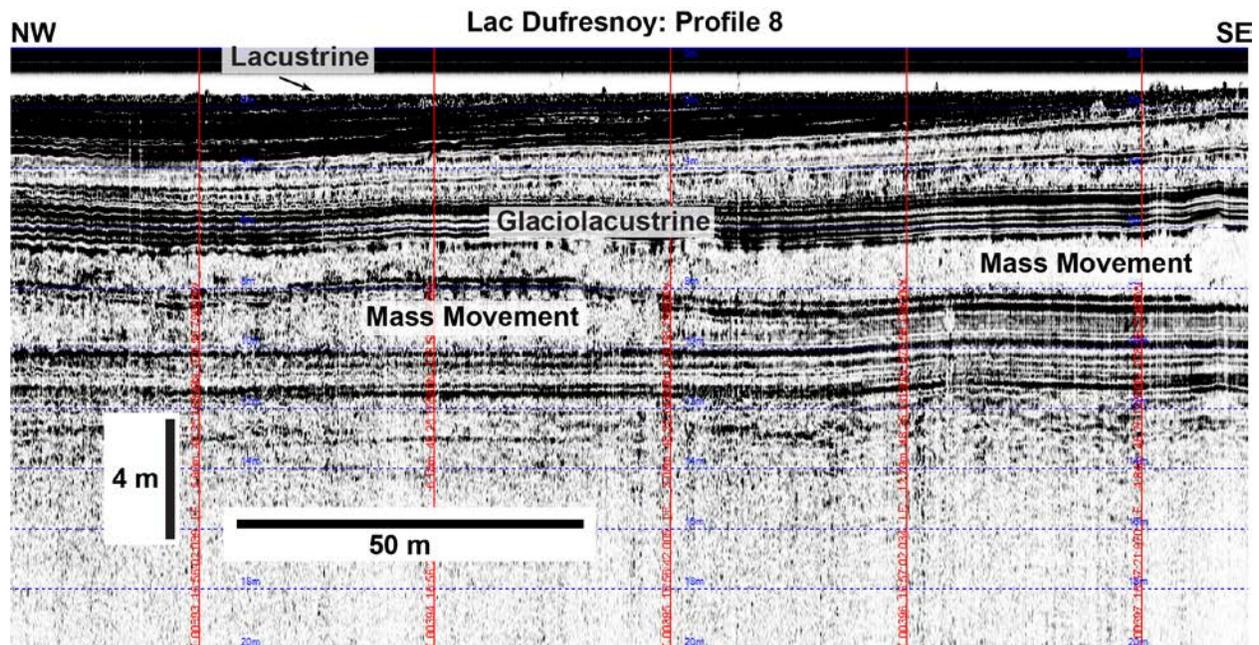


Fig. 3 Example of a sub-bottom acoustic profile (from the southern portion of profile 8) from Lac Dufresnoy, showing lacustrine, glaciolacustrine and mass movement facies. See Fig. 2 for the location of the profile. At least four beds of mass movement facies separated by glaciolacustrine facies are visible in the profile. The lacustrine facies forms a thin veneer overlying glaciolacustrine facies at the immediate top of the sub-bottom. There is a shimmering to the returns in the left third of the profile that was caused by wave-induced boat heave. The horizontal dashed lines show depth at 2 m intervals and the vertical lines are time-geographical coordinates stamps.

Results

Twenty-two SAP profiles were collected from Lac Dufresnoy along the northern area of the lake basin and one profile was collected from Lac Petit Dufresnoy (Fig. 2). Profiles 2 to 7 and 19-23

are located along the shore and between bedrock islands across the northern area of the lake. This is significant overlap between some of these profiles, especially 2, 7, 20 and 23. Profiles 8 to 18 are a series of zig-zagging profiles within bay along the northeastern side of the lake. Profile 1 was collected while traversing Lac Petit Dufresnoy to the larger lake.

Penetration into the sub-bottom was generally good along the profiles collected from Lac Dufresnoy, except for profiles 3 to 6 and the western sides of profiles 11 to 15 where there was little to no penetration (see Table 2). As a result of the the poor quality of the returns along profiles 3 to 6, profiling was shifted from the northern area of the lake to the northeastern bay.

The returns in profiles 7 to 9, 12 to 14, and 16 to 18 exhibit a shimmering that was caused by wave-induced boat heave.

Up to three depositional facies are present in the SAP profiles, as exemplified in Fig. 3 and summarized as follows:

Lacustrine facies – consists of transparent to weakly bedded deposits (Fig. 3); bed spacing is variable. The basal boundary is conformable and can be either defined by a strong impedance layer or indistinct. Deposits of this facies are interpreted to have aggraded in the post-glacial basin of Lac Dufresnoy.

Glaciolacustrine facies – consists of multiple, decimetre-scale, parallel reflectors that are draped on the underling topography (Fig. 3). Deposits exhibiting this facies are common to many lakes on the Canadian Shield and reflect sedimentation within a glaciolacustrine depositional environment. The deposits of this facies in Lac Dufresnoy deposits are interpreted to have aggraded within glacial Lake Ojibway (see Breckenridge et al., 2012).

Mass movement facies – consist of transparent or diffuse returns (Fig. 3), possibly including blocks (clasts) of intact glaciolacustrine deposits the bedding of which may be rotated with respect to the glaciolacustrine facies. The upper surface of the facies may be smooth or irregular. Bed thickness is variable from decimetres to several metres in scale and may pinchout laterally. Basal contact can be conformable or erosive along a given profile. Multiple deposits of mass movement facies are visible in some of the facies.

A localized occurrence bedrock facies is present in profiles 12 and 15, as noted in Table 2. This facies generally forms a strong, opaque reflector with a smooth, curved, or irregular surface topography.

The glaciolacustrine facies deposits along many profiles (profiles 2, 7 to 11, 13 to 18; Fig. 2) are truncated erosively at the modern lake bed. As a result, stratigraphically older glaciolacustrine deposits occur relatively close to the lake bed in many areas because of the truncation.

Summary and conclusions

On July 19, 2014, twenty-two and one SAP were collected from lakes Dufresnoy and Lac Petit Dufresnoy, Quebec, respectively.

There is good penetration of the sub-bottom along many of the profiles.

Three depositional facies can be identified within the SAP returns that represent lacustrine, glaciolacustrine and mass movement deposits. In many profiles, multiple occurrences of mass movement deposits can be identified.

The reconnaissance profiling reveals that Lac Dufresnoy is a suitable basin for follow-up detailed profiling and core collection to further investigate the mass movement deposit(s). The area on the northeastern bay covered by profiles 8 to 18 is a good area to target.

Acknowledgements

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Table 2 Summary of Lac Dufresnoy sub-bottom profile lines

Profile Number	Direction of boat travel	Length (m)	Comments
1	NW then W	1423	<ul style="list-style-type: none"> - Only profile located in Lac Petit Dufresnoy - Good penetration at the beginning and along a short portion of the middle of the profile but no penetration elsewhere - Returns show lacustrine and glaciolacustrine deposits
2	SSW then NW	1765	<ul style="list-style-type: none"> - Good penetration along most of profile but some short zones with no penetration - Returns show lacustrine, glaciolacustrine and several mass movement deposits
3	SW	344	<ul style="list-style-type: none"> - Shallow penetration along the beginning of the profile, but no penetration elsewhere - Returns show lacustrine and glaciolacustrine deposits
4	NNW	490	<ul style="list-style-type: none"> - Good penetration at the end of the profile, but no penetration elsewhere - Returns show lacustrine and glaciolacustrine deposits
5	WNW	394	<ul style="list-style-type: none"> - Faint penetration at the beginning of the profile, no penetration in middle portion and short zones of good penetration at the end - Returns show lacustrine and glaciolacustrine deposits
6	NNE	500	<ul style="list-style-type: none"> - Faint and shallow penetration at the very beginning of the profile, but no penetration elsewhere - Returns show lacustrine and glaciolacustrine deposits
7	NE	541	<ul style="list-style-type: none"> - Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and mass movement deposits
8	SE	2232	<ul style="list-style-type: none"> - Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits
9	NE	257	<ul style="list-style-type: none"> - Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits
10	WSW	504	<ul style="list-style-type: none"> - Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits
11	NE	499	<ul style="list-style-type: none"> - Good penetration along most of the profile, but no penetration at the very end - Returns show lacustrine, glaciolacustrine and several mass movement deposits
12	W	759	<ul style="list-style-type: none"> - Good penetration along the first two thirds of the profile, but no penetration along the last third - Returns show lacustrine, glaciolacustrine and several mass movement deposits, and bedrock
13	NE	719	<ul style="list-style-type: none"> - No penetration along first quarter of profile but good penetration elsewhere - Returns show lacustrine, glaciolacustrine and several mass movement deposits

14	W	736	<ul style="list-style-type: none"> - Good penetration along most of profile but no penetration at the very end - Returns show lacustrine, glaciolacustrine and several mass movement deposits
15	NE	703	<ul style="list-style-type: none"> - Good penetration along most of profile but zone of no penetration at very beginning of profile - Returns show lacustrine, glaciolacustrine and mass movement deposits, and bedrock
16	WSW	815	<ul style="list-style-type: none"> - Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and mass movement deposits
17	NE	622	<ul style="list-style-type: none"> - Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and mass movement deposits
18	WSW	561	<ul style="list-style-type: none"> - Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and mass movement deposits
19	NW	80	<ul style="list-style-type: none"> - Very short - Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and mass movement deposits
20	SW	126	<ul style="list-style-type: none"> - Very short - No penetration at the very beginning of the profile, but good penetration elsewhere - Returns show lacustrine, glaciolacustrine and mass movement deposits
21	NW	178	<ul style="list-style-type: none"> - Short profile - Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and mass movement deposits
22	SSW	209	<ul style="list-style-type: none"> - Good penetration at beginning and end of profile, zone of no penetration in middle portion - Returns show lacustrine, glaciolacustrine and several mass movement deposits
23	ENE	550	<ul style="list-style-type: none"> - Good to no penetration along first third of profile, good penetration elsewhere - Returns show lacustrine, glaciolacustrine and several mass movement deposits

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