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**GEOLOGICAL SURVEY OF CANADA  
OPEN FILE 7984**

**Reconnaissance sub-bottom profiling survey  
at Lac Opasatica, Quebec**

**G.R. Brooks**

**2016**

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## **Abstract**

As a part of reconnaissance sub-bottom acoustic profiling (SAP) survey on Lac Opasatica, Quebec, 19 SAP were collected from the northern bay area and 27 SAP were collected within Baie Lamy on July 15 and 18, 2014, respectively. Good penetration of the sub-bottom was obtained in most of the two profiled areas. Three facies can be identified within the SAP returns that represent lacustrine, glaciolacustrine and mass movement deposits. The profiles collected from Lac Opasatica demonstrate the widespread presence of mass movement deposits within this basin. Baie Lamy is the better location for any follow-up detailed profiling and core collection because of water depths that are generally shallower than the northern bay.

## 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 the rhythmically laminated couplets composing the deposits as 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 surveys undertaken at Lac Opastica, Quebec, on July 15 and 18 (Figs. 1 and 2). It summarizes the SAP methodology, includes maps of 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.

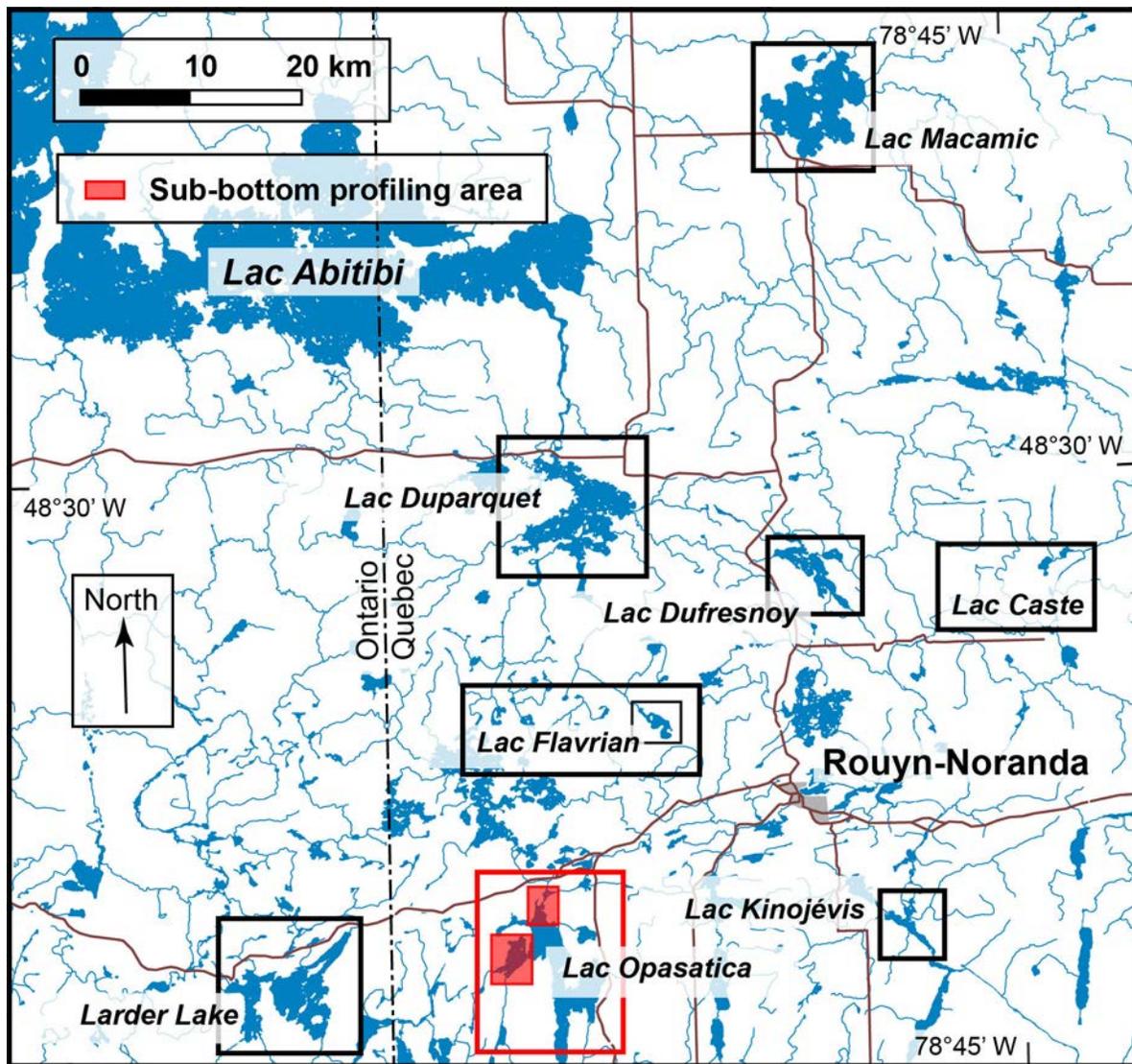


Fig. 1 Map showing the two locations within Lac Opasatica and the other seven lake basins in the Rouyn-Noranda area, Quebec, where reconnaissance sub-bottom profiling surveys were conducted in July, 2014.

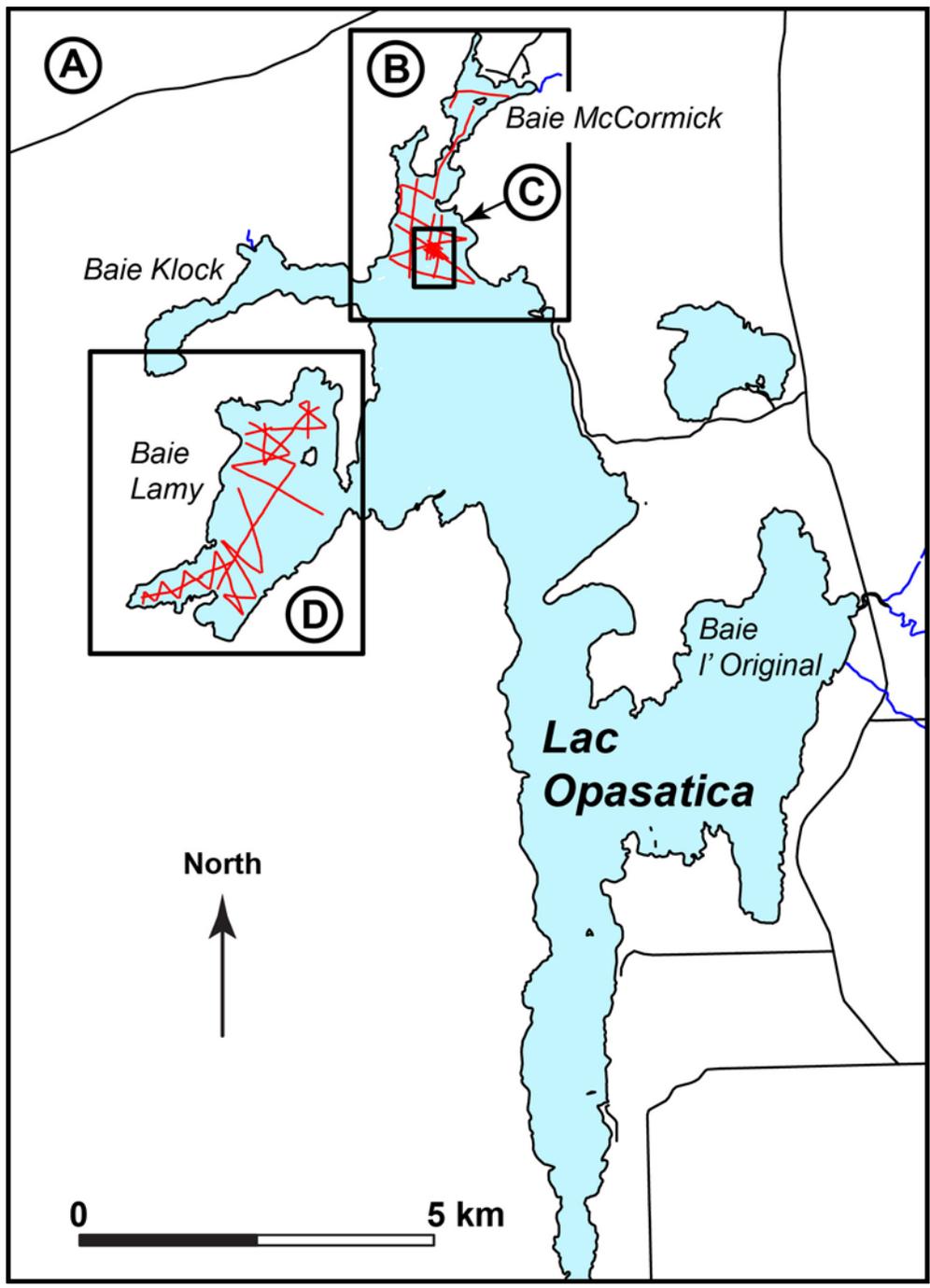


Fig. 2A Map of Lac Opasatica showing the general location of the northern bay (B) and Baie Lamy (D) where sub-bottom profile lines were collected on July 15 and 18, 2014, respectively.

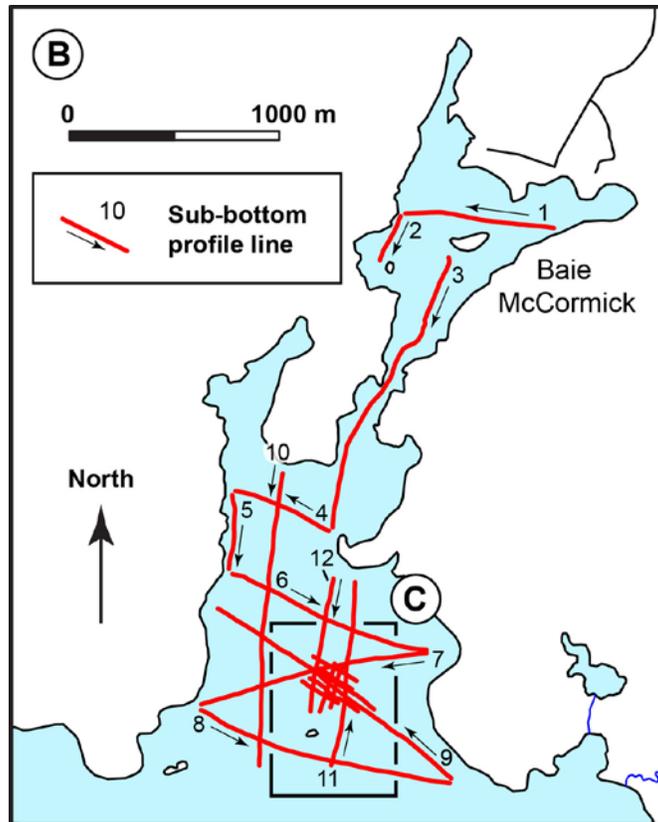


Fig. 2B Inset map of the northern bay of Lac Opasatica, which includes Baie McCormick showing the locations and numbering of the sub-bottom profile lines 1 to 12. Refer to Fig. 2C for the locations of profiles 13 to 19 which are concentrated within the southern area of the bay. All of the profiles in Fig. 2B (and 2C) were collected on July 15, 2014.

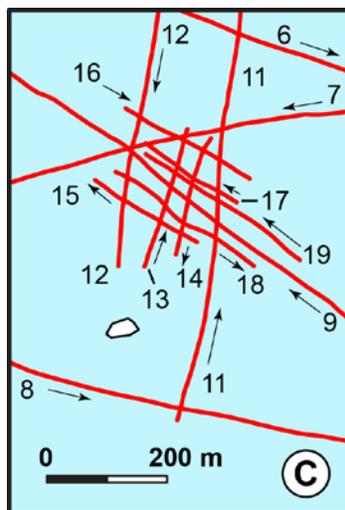


Fig. 2C Inset map of the southern area of the northern bay showing the locations and numbering of the sub-bottom profile lines 13 to 19. See Fig. 2B for location.

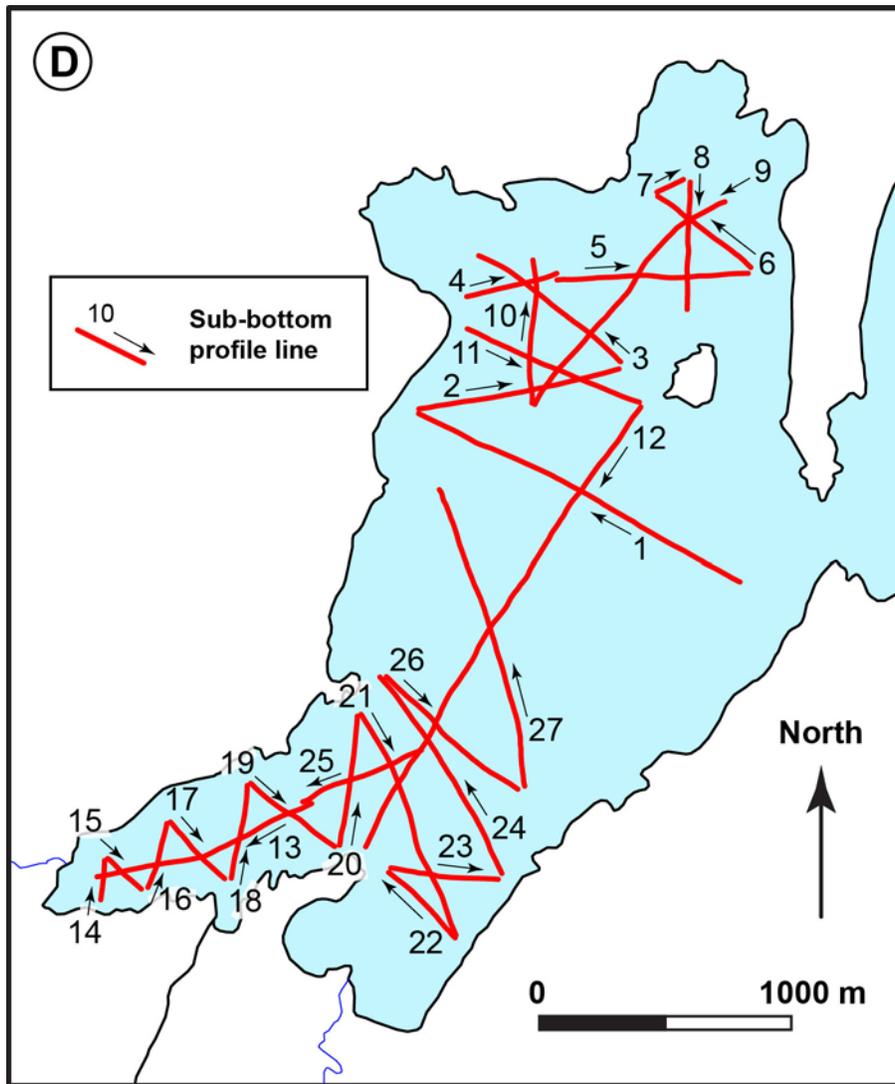


Fig. 2D Inset map of Baie Lamy showing the locations and numbering of the sub-bottom profile lines 1 to 27 collected on July 18, 2014.

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 Opasatica	This report
Lac Dufresnoy	7990
Lac Duparquet	7989
Lac Flavrian	7988
Lac Kinojévis	7987
Lac Caste	7991
Lac Macamic	7985
Larder Lake	7986

### Lac Opasatica

Lac Opasatica is located ~26 km southwest of Rouyn-Noranda, Quebec. The elongated lake is about 23 km long, up to 4 km wide, and 43 km<sup>2</sup> in area (Fig. 2). The longitudinal axis of the lake is oriented approximately in the north-south direction. Three large bays extend from the main lake; Baie L'Original to the east, and Lamy and Klock bays to the west. Access to the lake was obtained using a public boat launch at a marina located head of Baie McCormick on the northern end of the lake.

### Methodology

The SAP surveys on Lac Opasatica were undertaken on July 15 and 18, 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<sup>-1</sup>. 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 20 or 50 m, as necessary, depending on the depth of water. 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™ v1.61<sup>1</sup> 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 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.

<sup>1</sup> 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-7984 with the permission of Knudsen Engineering Ltd.™. The software has been provided for the convenience of the OF-7984 user. A user of this software does so entirely at their own risk.

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<sup>-1</sup>.

The .keb, .sgy, .bmp and .kea files for each profile are contained in designated profile folders. The folders are contained in appendices A and B that accompanies the download of this report and are organized by date of collection.

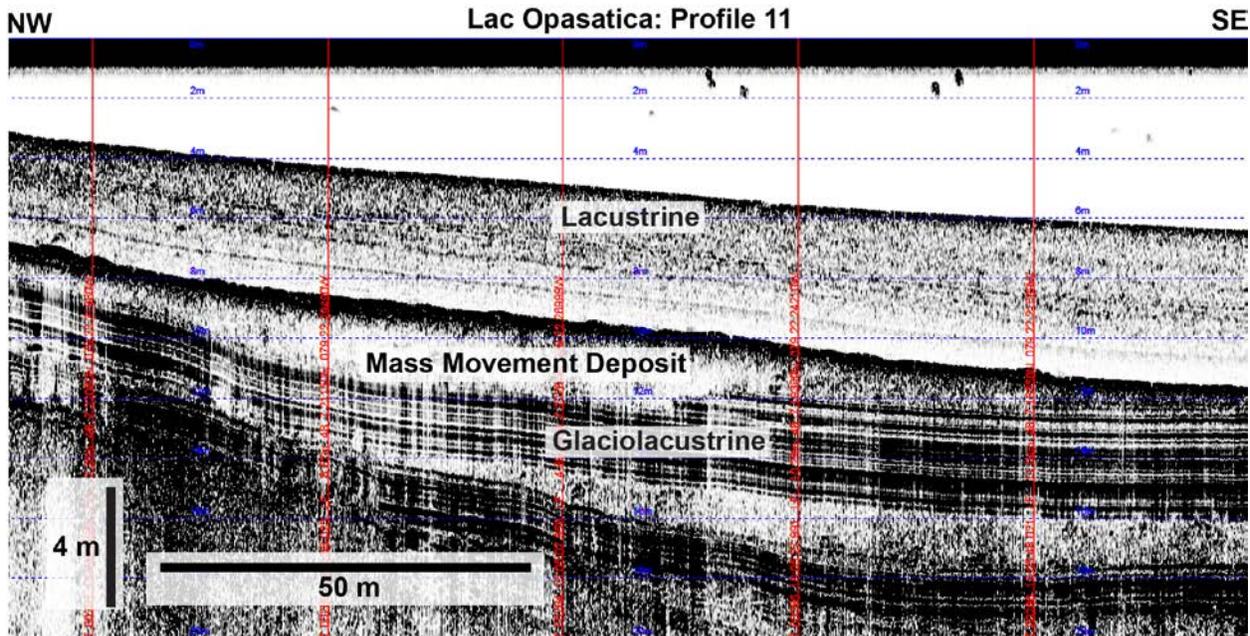


Fig. 3 Example of a sub-bottom acoustic profile (portion of profile 11) from the Baie Lamy, Lac Opasatica, collected on July 18, 2014, showing lacustrine, glaciolacustrine and mass movement facies. See Fig. 2D for the location of the profile. There are two obvious beds of mass movement deposits within the profile, possibly a third is along the lower right corner. The horizontal dashed lines show depth at 2 m intervals and the vertical lines are time-geographical coordinates stamps.

## Results

Sub-bottom profiles with Lac Opasatica were collected on July 15 and 18, 2014, within the northern bay and Baie Lamy, respectively (Figs. 1 and 2B and D). Nineteen profiles were collected from the northern bay and 27 from Baie Lamy.

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

Lacustrine facies – the deposits consist of transparent to weakly bedded deposits (Fig. 3); bed spacing is variable. The basal boundary is conformable and commonly well defined by a strong impedance layer. Deposits of this facies are interpreted to have aggraded in the post-glacial basin of Lac Opasatica.

Glaciolacustrine facies – consists of multiple, decimetre-scale, parallel reflectors that are draped on the underlying topography (Fig. 3). Deposits exhibiting this facies are common to many lakes on the Canadian Shield and reflect sedimentation within a glaciolacustrine depositional environment. In Lac Opasatica, the deposits forming this facies are inferred to have aggraded within glacial Lake Ojibway.

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.

A bedrock facies is present in many profiles, as noted in tables 2 and 3. This facies generally forms a strong, opaque reflector with a smooth, curved, or irregular surface topography. Where occurring near the start or end of a profile, the bedrock likely outcrops along the shoreline, island or shoal.

### ***Northern bay***

Within the northern bay, profiles 1 to 12 characterize the general sub-bottom in this area of the lake. Profiles 1 to 2 are located in McCormick Bay and are dominated by lacustrine sediments overlying bedrock. Profile 3 extends from within McCormick bay into the larger area of the northern bay. Profiles 4 to 12 are in the broader bay that opens into the main part of the lake. Water depths within the profiled area are up to about 28 m deep.

Good penetration of the sub-bottom was obtained over profiles 1 to 12, although in some cases, exposed bedrock in the lake bottom locally forms an opaque reflector (e.g., profile 3)

Deposits of the mass movement facies are present in profiles 7 and 8. The deposits of the glaciolacustrine facies are erosively truncated in profiles 6 to 9 and 16, where the erosion surface is overlain by lacustrine deposits. Lacustrine deposits locally are up to 12 m thick.

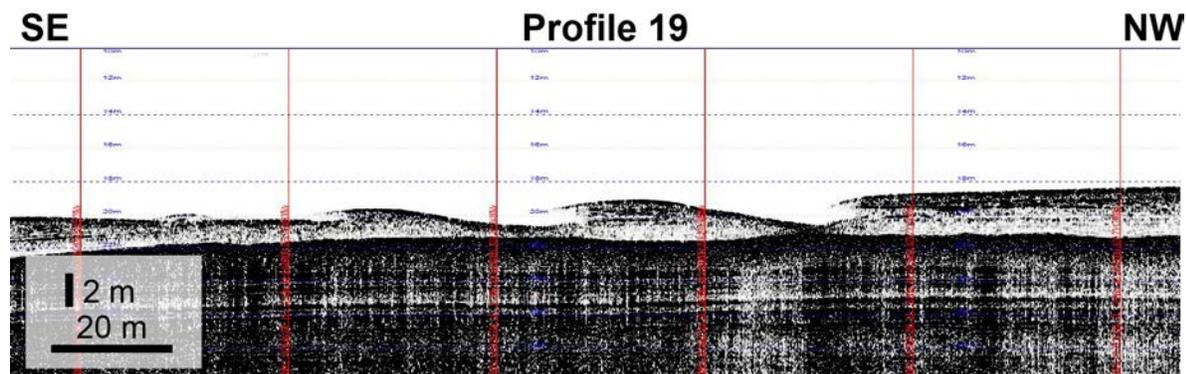


Fig. 4 Example of the low-angled, dune-like features encountered in profile 19 within the southern part of the northern bay, Lac Opasatica, as mentioned in the text.

Three low-angled ‘dune-like’ features were encountered in profiles 9 and 11 at water depths of 18 to 20 m. Profiles 13 to 19 were collected at relatively dense grid to better image the features,

which are present in profiles 14, 15, 18 and 19. The features are situated on the surface of the modern lake bed, are eroded into the lacustrine deposits, and have a step face on one side (Fig. 4). The origin of the features may be related to erosion by modern lake currents.

### ***Baie Lamy***

Twenty-seven SAP were collected within Baie Lamy (Fig. 2D). Profiles 1 to 11 were collected in the northern portion of the bay and profiles 13 to 27 in the southern portion; profile 12 ties the two areas together. Water depths within the profiled areas are variable and locally up to about 10 m deep.

Good penetration of the sub-bottom was obtained along all of the profiles, except along the southeastern portions of profiles 22 to 27 where there was poor penetration into the glaciolacustrine deposits.

Deposits of the mass movement facies are present in most of the profiles in Lamy Baie, except 3, 4, 7 and 22, as noted in Table 3. Notable examples of the facies are in profiles 2, 5 6, 8, and 11, and 13 to 19, which are in several azimuthal orientations.

The deposits of the glaciolacustrine facies locally are erosively truncated in profiles 1 and 5. Lacustrine deposits locally are up to 10 m thick in the profiled areas of Baie Lamy.

### **Summary and conclusions**

Nineteen SAP were collected from the northern bay area of Lac Opasatica, Quebec, on July 15 , 2014. An additional 27 SAP were collected within Baie Lamy on July 18, 2014.

Good penetration of the sub-bottom was obtained in most of the profiled areas.

Three facies can be identified within the SAP returns that represent lacustrine, glaciolacustrine and mass movement deposits.

The profiles collected from Lac Opasatica demonstrate the presence of mass movement deposits within this basin. The Baie Lamy is the better location for any follow-up detailed profiling and core collection because of the generally shallower water depths.

### **Acknowledgements**

I thank Jim Hunter for reviewing this report. Matt DeGeer assisted with the collection of the SAP profiles. Figures 2 and 3 were made by Katie MacDonald, who also compiled Table 2. This research was supported through the Public Safety Geoscience Program, Earth Sciences Sector, Natural Resources Canada.

Table 2 Summary listing of the Lac Opasatica sub-bottom profiles collected from the northern bay on July 15, 2014.

Profile number	Direction	Length (m)	Comments
1	W	714	<ul style="list-style-type: none"> <li>- No penetration at beginning, good penetration elsewhere</li> <li>- Returns show lacustrine and glaciolacustrine deposits overlying strong bedrock reflector</li> </ul>
2	SW	234	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine and glaciolacustrine deposits overlying strong bedrock reflector</li> </ul>
3	SW	1442	<ul style="list-style-type: none"> <li>- No penetration at the start of profile, good penetration elsewhere</li> <li>- Returns show lacustrine and glaciolacustrine deposits and there is a strong bedrock reflector present</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
4	NW	486	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine and glaciolacustrine deposits overlying a strong bedrock reflector</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
5	S	355	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine and glaciolacustrine deposits with a strong bedrock reflector</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
6	SE	1000	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine and glaciolacustrine deposits, some bedrock</li> <li>- Strong reflector above the glaciolacustrine deposits</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
7	WSW	1104	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine, glaciolacustrine and mass movement deposits, some bedrock</li> <li>- Strong reflectors on top of glaciolacustrine/mass movement/bedrock</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
8	ESE	1245	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine, glaciolacustrine and mass movement deposits</li> <li>- Strong reflectors on top of glaciolacustrine/mass movement/bedrock</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
9	NW	1378	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine and glaciolacustrine deposits, some bedrock</li> <li>- Strong reflectors on top of glaciolacustrine/bedrock</li> <li>- Unusual "wave-like" features on lake bottom in middle of profile</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
10	S	1400	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine and glaciolacustrine deposits, some bedrock</li> <li>- Strong reflectors on top of glaciolacustrine/bedrock</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
11	N	884	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine and glaciolacustrine deposits, some bedrock</li> <li>- Strong reflectors on top of glaciolacustrine/bedrock</li> <li>- Unusual "wave-like" features on lake bottom</li> </ul>

			- Scale range in profile adjusted to account for changes in depth
12	S	643	- Good penetration along entire profile - Returns show lacustrine and glaciolacustrine deposits - Strong reflector at top of glaciolacustrine deposit - Scale range in profile adjusted to account for changes in depth
13	NNE	240	- Good penetration along entire profile - Returns show lacustrine and glaciolacustrine deposits - Strong reflector at top of glaciolacustrine deposit - Scale range in profile adjusted to account for changes in depth
14	SSW	203	- Good penetration along entire profile - Returns show lacustrine and glaciolacustrine deposits - Erosional pocket in lacustrine deposits - Strong reflector at top of glaciolacustrine deposit
15	NW	199	- Good penetration along entire profile - Returns show lacustrine and glaciolacustrine deposits - Strong reflector at top of glaciolacustrine deposit - Unusual "wave-like" features on lake bottom
16	SE	238	- Good penetration along entire profile - Returns show lacustrine and glaciolacustrine deposits - Strong reflector at top of glaciolacustrine deposit
17	NW	182	- Good penetration along entire profile - Returns show lacustrine and glaciolacustrine deposits - Erosional pocket in lacustrine deposits - Strong reflector at top of glaciolacustrine deposit
18	SE	281	- Good penetration along entire profile - Returns show lacustrine and glaciolacustrine deposits - Strong reflector at top of glaciolacustrine deposit - Unusual "wave-like" features on lake bottom
19	NW	312	- Good penetration along entire profile - Returns show lacustrine and glaciolacustrine deposits - Strong reflector at top of glaciolacustrine deposit - Unusual "wave-like" features on lake bottom

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Table 3 Summary listing of the Lac Opasatica sub-bottom profiles collected from Baie Lamy on July 18, 2014.

Profile number	Direction	Length (m)	Comments
1	NW	1448	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and mass movement deposits - Scale range in profile adjusted to account for changes in depth
2	ENE	814	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits
3	NW	709	- Good penetration along entire profile - Returns show lacustrine and glaciolacustrine deposits
4	ENE	370	- Good penetration along most of profile - Returns show lacustrine and glaciolacustrine deposits
5	E	763	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits
6	NW	468	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits
7	NE	116	- Good penetration along entire profile - Returns show lacustrine and glaciolacustrine deposits
8	S	509	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits
9	SW	1126	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and mass movement deposits
10	N	574	- Good penetration along most of profile - Returns show lacustrine, glaciolacustrine and mass movement deposits
11	SE	745	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits
12	SW	2075	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits - Scale range in profile adjusted to account for changes in depth
13	WSW	913	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits
14	N	157	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits
15	SE	181	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits
16	NNE	267	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits
17	SE	314	- Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and several mass movement deposits

18	NNE	376	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine, glaciolacustrine and several mass movement deposits</li> </ul>
19	SE	421	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine, glaciolacustrine and several mass movement deposits</li> </ul>
20	NNE	519	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine, glaciolacustrine and several mass movement deposits</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
21	SE	964	<ul style="list-style-type: none"> <li>- Good penetration along entire profile, but shallow and faint returns beneath strong reflector at base of lacustrine deposits along last third of profile</li> <li>- Returns show lacustrine, glaciolacustrine and mass movement deposits</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
22	NW	373	<ul style="list-style-type: none"> <li>- Good penetration along entire profile, but shallow and faint returns beneath strong reflector at base of lacustrine deposits</li> <li>- Returns show lacustrine and glaciolacustrine deposits</li> </ul>
23	E	431	<ul style="list-style-type: none"> <li>- Good penetration along entire profile, but shallow and faint returns beneath strong reflector at base of lacustrine deposits</li> <li>- Returns show lacustrine deposits</li> </ul>
24	NW	926	<ul style="list-style-type: none"> <li>- Good penetration along entire profile, but shallow and faint returns beneath strong reflector at base of lacustrine deposits along first quarter of profile</li> <li>- Returns show lacustrine, glaciolacustrine and several mass movement deposits</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
25	WSW	519	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine, glaciolacustrine and several mass movement deposits</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
26	SE	694	<ul style="list-style-type: none"> <li>- Good penetration along entire profile, but shallow and faint returns beneath strong reflector at base of lacustrine deposits near end of profile</li> <li>- Returns show lacustrine, glaciolacustrine and several mass movement deposits</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>
27	NNW	1235	<ul style="list-style-type: none"> <li>- Good penetration along entire profile</li> <li>- Returns show lacustrine, glaciolacustrine and mass movement deposits</li> <li>- Scale range in profile adjusted to account for changes in depth</li> </ul>

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