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OPEN FILE 7991**

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at Lac Caste, Quebec**

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Abstract

As part of a reconnaissance sub-bottom acoustic profiling (SAP) survey, eleven SAP were collected from Lac Caste, Quebec, on July 10, 2014. The returns with the best penetration of the sub-bottom were collected in the small bay in the southern area of the lake and along the immediate south and west sides of the main basin. There was no penetration of the sub-bottom over most of the central and eastern areas of the main basin. Three facies are present within the SAP returns that represent lacustrine, glaciolacustrine and mass movement deposits. The profiles collected from Lac Caste demonstrate the presence of mass movement deposits within this basin.

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, 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 et al., 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 Caste, Quebec, on July 10, 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.

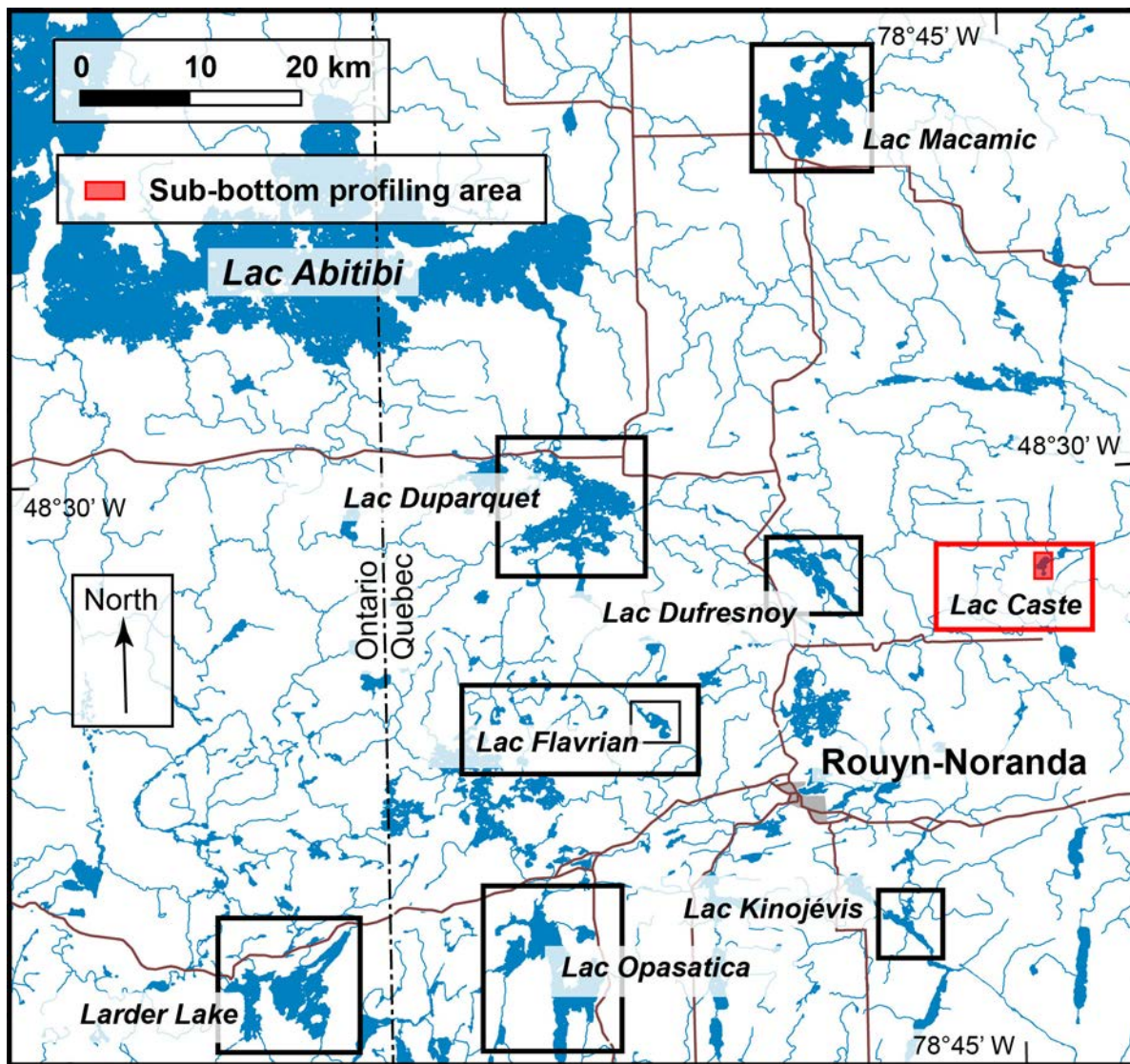


Fig. 1 Map showing the locations of Lac Caste and the other seven lake basins in the Rouyn-Noranda area, Quebec, where reconnaissance sub-bottom profiling surveys were conducted in July, 2014.

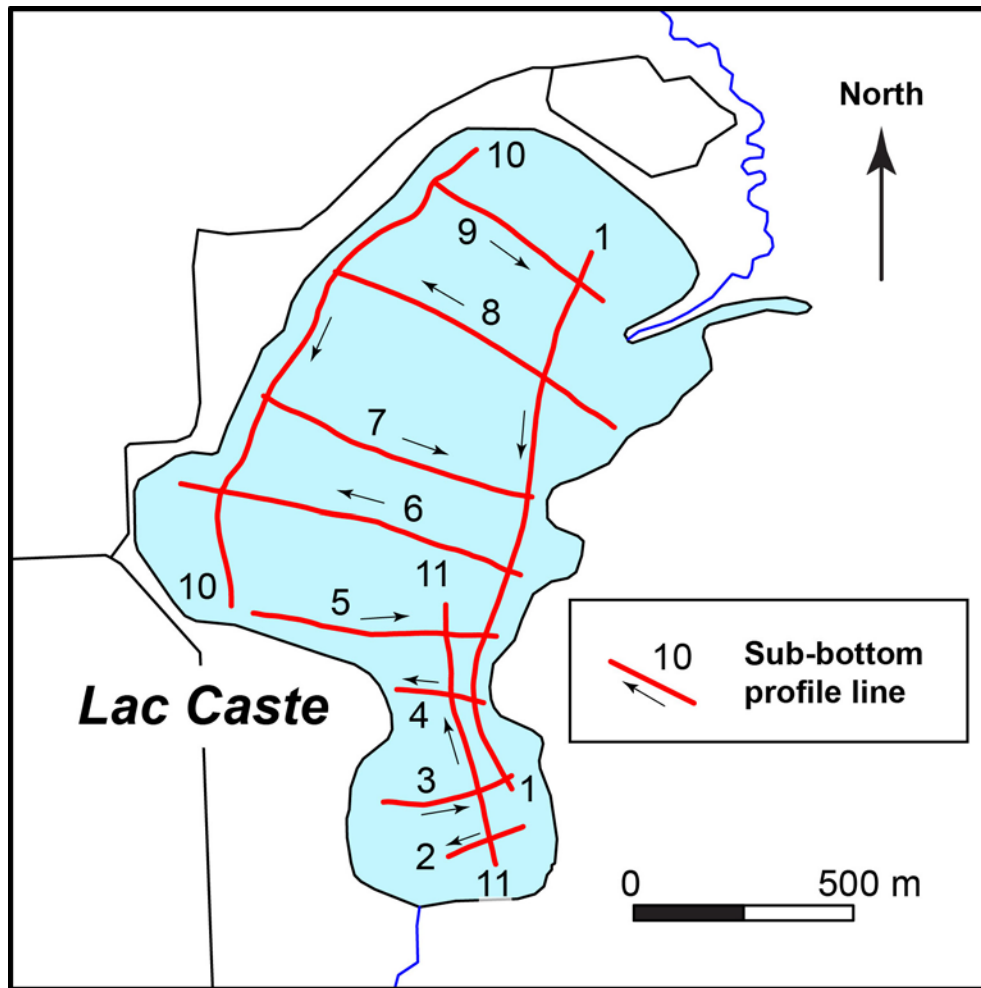


Fig. 2 Map of Lac Caste showing the locations and numbering of the eleven sub-bottom profile lines.

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 | This report |
| Lac Dufresnoy | 7990 |
| Lac Duparquet | 7989 |
| Lac Flavrian | 7988 |
| Lac Kinojévis | 7987 |
| Lac Macamic | 7985 |
| Lac Opasatica | 7984 |
| Larder Lake | 7986 |

Lac Caste

Lac Caste is located ~31 km northeast of Rouyn-Noranda, Quebec. The lake is the smallest of the eight profiled lakes, at 1.8 km long, 0.7 km wide and 1.2 km² in area (Fig. 2). A small bay extends to the south from the main lake basin. A small delta is prograding into the northeast side of the lake and is located immediately beside the outlet channel that flows into nearby Lac Matissard, which in turn flows into the nearby Kinojevis River. Access to the lake was obtained using a boat launch at a private campground located at the north end of the lake.

Methodology

The SAP survey on Lac Caste was undertaken on July 10, 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 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

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-7991 with the permission of Knudsen Engineering Ltd.™. The software has been provided for the convenience of the OF-7991 user. A user of this software does so entirely at their own risk.

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.

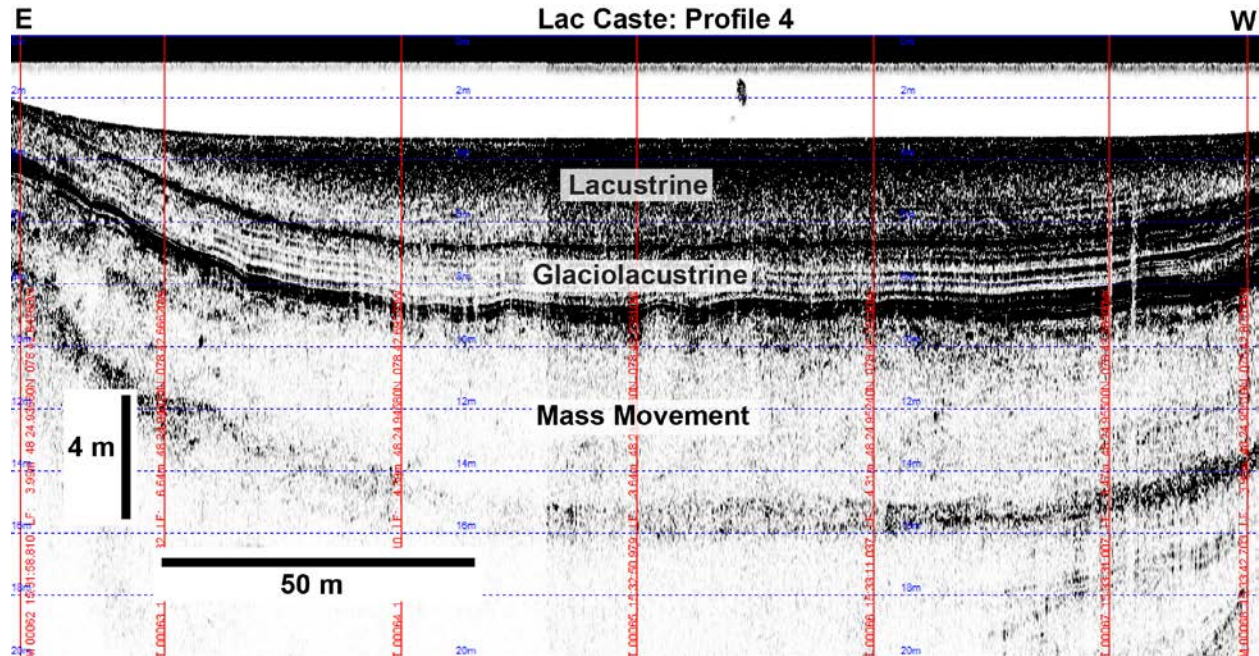


Fig. 3 Example of a sub-bottom acoustic profile (portion of profile 4) from Lac Caste, showing lacustrine, glaciolacustrine and mass movement facies. See Fig. 2 for the location of the profile. The horizontal dashed lines show depth at 2 m intervals and the vertical lines are time-geographical coordinates stamps. The slight change in contrast in the profile just to the left of centre was caused by a change in gain setting during the survey.

Results

Eleven profiles were collected from Lac Caste, as shown in Fig. 2 and summarized briefly in Table 2. Note, the direction of boat travel during profile collection alternates in direction from one profile to the next.

The returns with the best penetration of the sub-bottom were collected in the small bay in the southern areas of the lake (profiles 2, 3, 4 and 11) and along the immediate south (profile 5) and west sides (especially profile 10) of the main basin. There was no penetration of the sub-bottom over most of the central and eastern areas of the main basin, possibly because of sand sediment delivered into the basin from the tributary creek entering from the northeast.

Where there was penetration of the sub-bottom, 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 commonly well defined by a strong impedance layer. Deposits of this facies are interpreted to have aggraded in the post-glacial basin of Lac Caste.

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. The deposits of this facies in Lac Caste deposits 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.

Deposits of the mass movement facies in Lac Caste are best captured in profiles 2, 3, 4, 5 and 10. The deposits are overlain by glaciolacustrine deposits, indicating that the movement(s) occurred within glacial Lake Ojibway.

Summary and conclusions

Eleven SAP were collected from Lac Caste, Quebec, on July 10, 2014.

The returns with the best penetration of the sub-bottom were collected in the small bay in the southern areas of the lake and along the immediate south and west sides of the main basin. There was no penetration of the sub-bottom over most of the central and eastern areas of the main basin.

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

The profiles collected from Lac Caste demonstrate the presence of mass movement deposits within this basin. The south bay is the best area for any follow-up detailed profiling and core collection to further investigate the mass movement deposit(s).

Acknowledgements

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Table 2 Summary listing of the Lac Caste sub-bottom profile lines

| Profile Number | Direction of boat travel | Length (m) | Comments |
|----------------|--------------------------|------------|---|
| 1 | SSW then SSE | 1302 | <ul style="list-style-type: none"> - No penetration over first two-thirds of profile, good penetration over last one-third of profile - Returns show lacustrine, glaciolacustrine and mass movement deposits |
| 2 | WSW | 186 | <ul style="list-style-type: none"> - Short profile - Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and mass movement deposits |
| 3 | ENE | 309 | <ul style="list-style-type: none"> - Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and mass movement deposits |
| 4 | W | 204 | <ul style="list-style-type: none"> - Short profile - Good penetration along entire profile - Returns show lacustrine, glaciolacustrine and mass movement deposits |
| 5 | E | 567 | <ul style="list-style-type: none"> - Good penetration along most of profile, but the reflectors become faint towards the end - Returns show lacustrine, glaciolacustrine and mass movement deposits |
| 6 | WNW | 817 | <ul style="list-style-type: none"> - No penetration along most of profile, but shallow penetration at beginning and at three quarters along profile - Returns show lacustrine, glaciolacustrine and mass movement deposits |
| 7 | ESE | 667 | <ul style="list-style-type: none"> - Good penetration at beginning of profile, but no penetration elsewhere - Returns show lacustrine, glaciolacustrine and mass movement deposits |
| 8 | NW | 743 | <ul style="list-style-type: none"> - No penetration along most of profile, but partial penetration at end - Returns show lacustrine, glaciolacustrine and mass movement deposits |
| 9 | SE | 473 | <ul style="list-style-type: none"> - No penetration along most of profile, but partial penetration at beginning - Returns show lacustrine, glaciolacustrine and mass movement deposits |
| 10 | SW then S | 1285 | <ul style="list-style-type: none"> - Good penetration along most of profile but there is a zone of no penetration along last quarter - Returns show lacustrine, glaciolacustrine and one, possibly two, mass movement deposits |
| 11 | N | 615 | <ul style="list-style-type: none"> - Good penetration over first half of profile, but returns become faint and eventually stop penetrating towards the end - Returns show lacustrine, glaciolacustrine and mass movement deposits |

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