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SUMMARY

This is a data release of the passive-seismic microtremor (ambient noise) data gathered at 384 stations north of Embrun, Ontario. 272 stations are clustered in an area of 147 acres (0.6 km^2) as seven parallel profiles which transect the buried Vars-Winchester esker.
This microtremor dataset has been processed using the Horizontal-to-Vertical Spectral Ratio (HVSR) method to estimate depth to bedrock or firm ground (e.g. gravel or diamicton).

RÉSUMÉ

Ce rapport est une publication de données sur les micro-tremblements sismiques passifs (bruit ambiant) recueillies à 384 stations au nord d'Embrun, en Ontario. 272 stations sont regroupées sur une superficie de 147 acres (0,6 km^2) sous forme de 7 profils parallèles qui traversent l'esker enfoui de Vars-Winchester.
Les données de micro-tremblements peuvent être traitées à l'aide de la méthode du rapport spectral horizontal-vertical (HVSR) pour estimer la profondeur du substrat rocheux ou d'un sol ferme tel que du gravier ou du diamicton.

1. INTRODUCTION

The Vars-Winchester esker near Embrun (Figure 1), in the watershed of the South Nation River east of Ottawa, Ontario has been extensively studied as part of the Geological Survey of Canada (GSC) and South Nation Conservation Authority collaboration completed between 2007 and 2009 (Pullan et al. 2007a,b; Pugin et al. 2007; Cummings & Russell 2007; Pullan et al. 2008; Pugin et al. 2008; Logan et al. 2009; Pugin et al. 2009a,b).

As a contribution to the GSC– Ontario Geological Survey (OGS) southern Ontario project on groundwater (2019 – 2024), more recent studies funded by the GSC's Groundwater Geoscience Program (Cummings et al. 2011; Yilmaz 2015, Crow et al. 2020, Pugin et al. 2020, Oldenborger 2022; Oldenborger & Paradis 2023) have re-emphasized the importance of this esker (Figure 2) in the regional water supply.

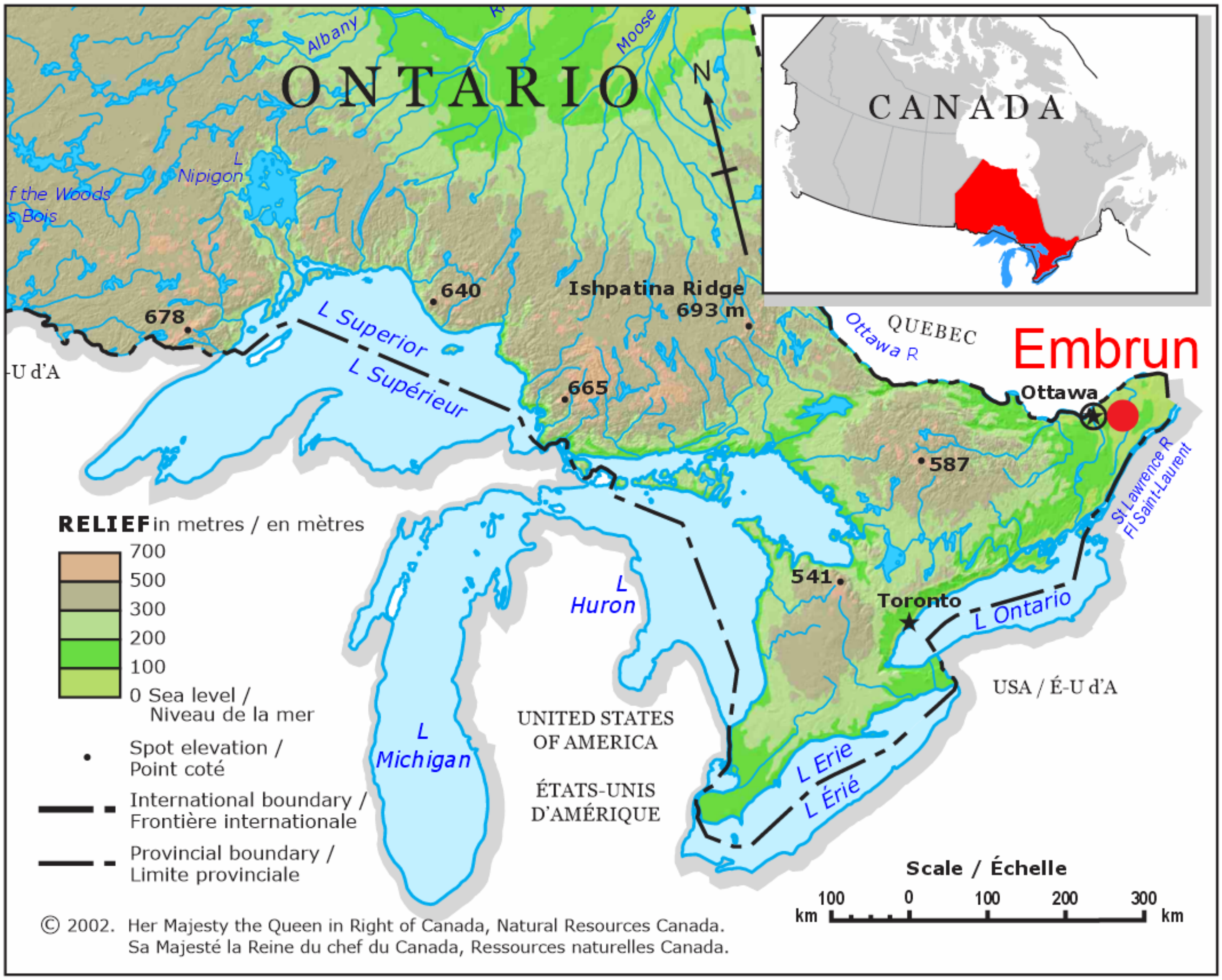

Figure 1: Map of Southern Ontario with the study area near Embrun.

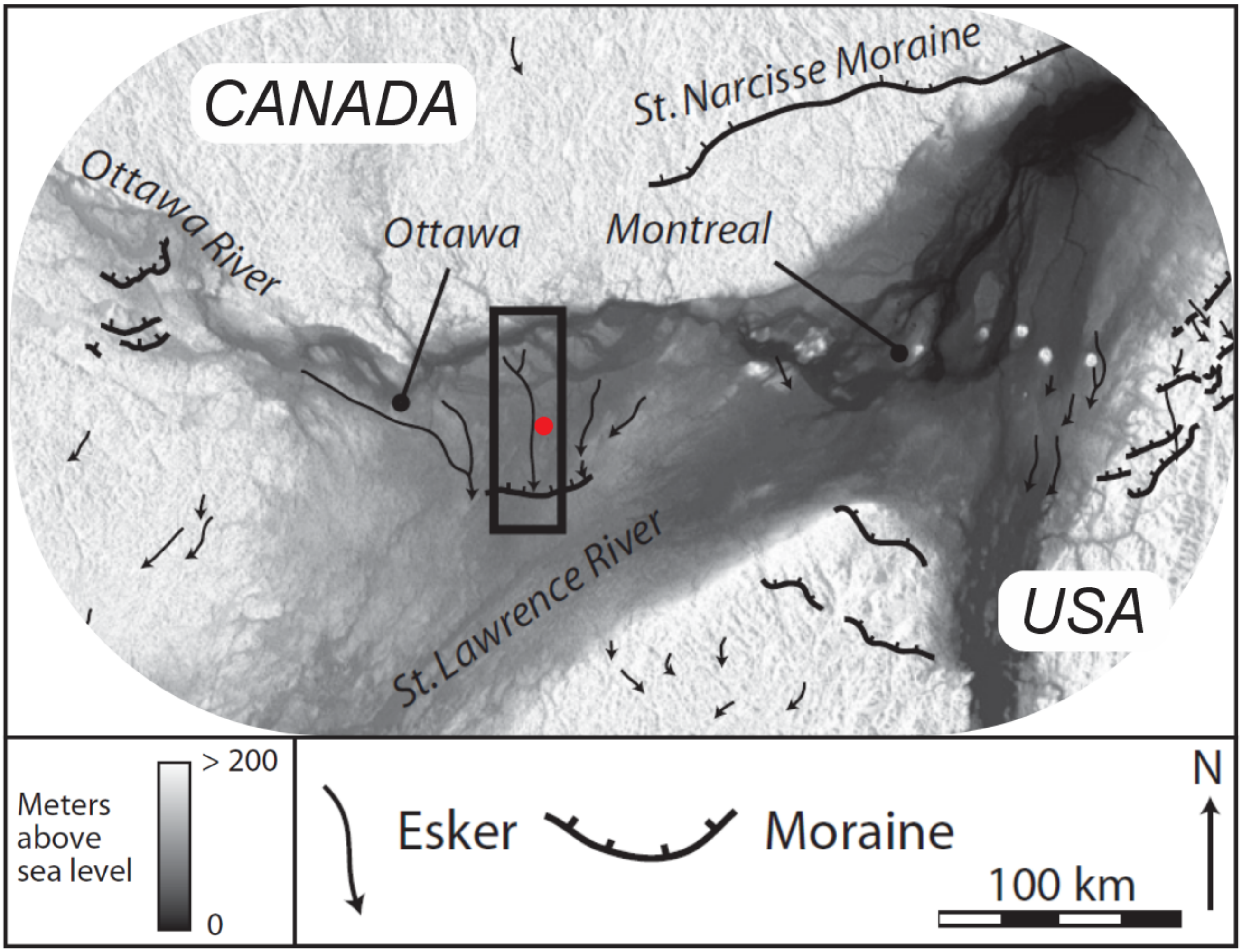

Figure 2: Location of the Vars-Winchester Esker (black rectangle) within the St. Lawrence Lowlands (after Cummings et al. 2011). The town of Embrun is marked by the red dot.

As part of these new investigations, passive-seismic microtremor data were recorded in several transects. Some of these transects are co-located with seismic reflection (Pugin et al. 2020) and resistivity profiles (Oldenborger 2022).

Microtremor data can be processed using the Horizontal-to-Vertical Spectral Ratio (HVSR) method, which is most often used for an assessment of earthquake site characteristics (seismic microzonation, e.g., SESAME 2004, Molnar et al. 2018). It is also used for hydrogeological studies to gain information on bedrock depth (e.g., Ibs-von Seht and Wohlenberg 1999; Chandler and Lively 2016).

As this report focuses on the data collection and release, the detailed description of the HVSR methodology is referred to other authors (e.g., Lermo and Chavez-Garcia 1994; Konno and Ohmachi 1998; Lachet and Bard 1994; Nakamura 2000; Fäh et al. 2001; Bonnefoy-Claudet et al. 2006). This dataset was collected with the intention to process for HVSR – novel methodology development is ongoing.

2. SITE LOCATION

Microtremor records were acquired traversing the previously identified Vars-Winchester esker. Some of the stations were co-located with seismic reflection profiles (Pugin et. al. 2020).

In October 2018 micro-seismic measurements were recorded at 98 sites along three transects at the roadside of Route 300 (Rte300), Route 200 (Rte200) and Route Saint-Pierre (RteStP). Locations are displayed in Figure 3 and summarized in Excel files (Appendix 1) and Google Earth files (kml, Appendix 1).

Figure 3: Microtremor stations collected in October 2018 along Route 200 (orange), Route St. Pierre (red) and Route 300 (yellow), north of Embrun, On.

In 2021 the **Trail** transect was recorded which consists of 82 stations (rose coloured dots in Figure 4). In the same year, four transects were acquired south of, and parallel to, Route 300 (called "**parallels"**: blue dots Figure 4). A total of 96 stations were recorded at a distance of roughly 30 m (28 stations, labelled **30-…**), 100 m (26 stations, labelled **100-…**), 150 m (16 stations, labelled **200-…**) and 250 m (23 stations, labelled **300-…**).

The following spring of 2022 transects were extended westwards called "**parallels_extended**" (cyan dots in Figure 4). Parallel 30- was extended by 16 stations (labelled **30_e…**). 17 stations were added to parallel 100 (**100_e…**) and 19 stations extended the parallel transect at 150 m (**200_e…**). Parallel 300 was not extended because of construction. However, an additional parallel line was added roughly 440 m south of Rte300 consisting of 56 stations, labelled **500_e…**.

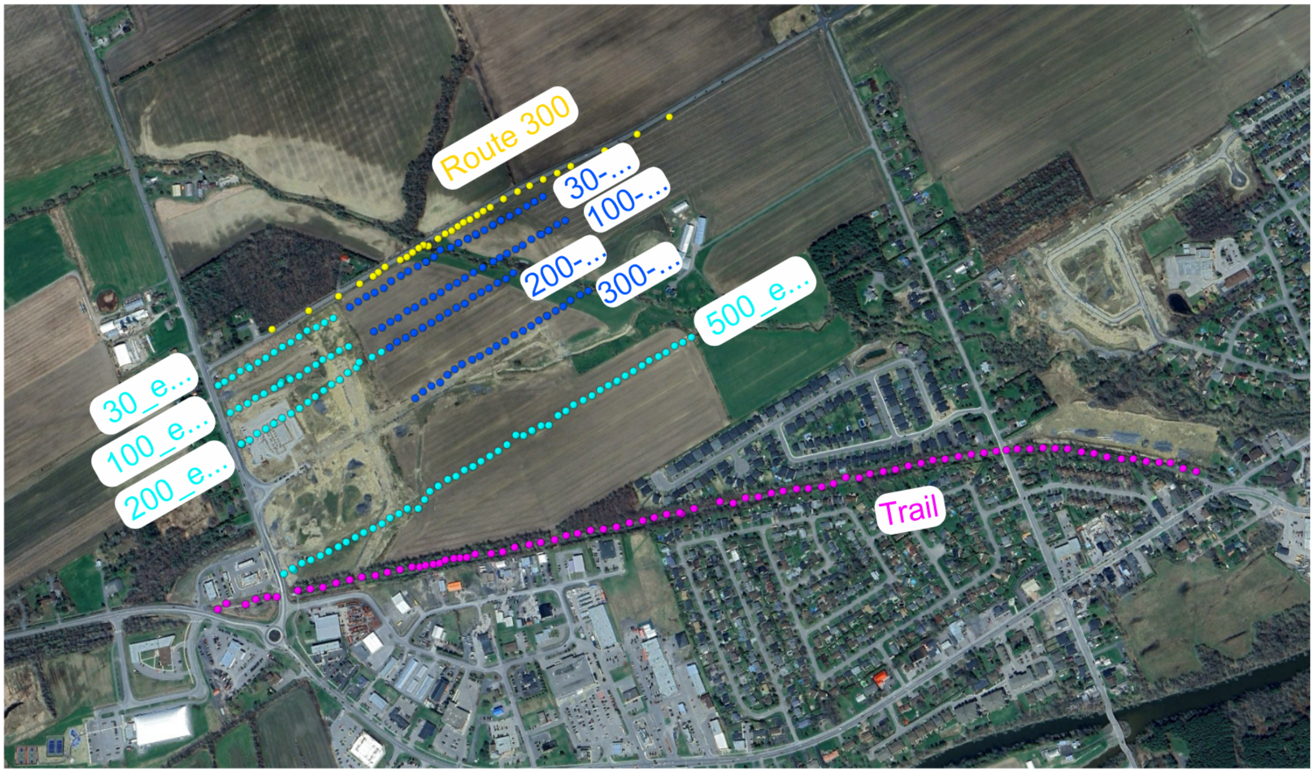

Figure 4: Microtremor stations recorded in 2021 and 2022.

3. PASSIVE-SEISMIC MICROTREMOR DATA ACQUISITION

Portable and lightweight seismometers (brand name: Tromino®) were used to measure and record microtremors which are ground vibrations in the range 0.1 to 60 Hz with velocities of micrometers per second. Seismic motion is recorded in three components, one vertical and two mutually perpendicular horizontal components (Castellaro et. al. 2005). Ground motions were recorded for 30 minutes at a sampling frequency of 128 Hz. Further information regarding data acquisition and processing can be found in Dietiker et. al (2020).

Ideally, the Tromino® is positioned to point exactly northwards such that the horizontal components are aligned with geographic N and E. During set-up, the instrument was planted roughly northwards, and the actual instrument orientation or misalignment from precise north was measured and noted. An orientation correction is readily integrated into the data processing. This procedure is not only faster but more precise, which is important when data is used for azimuthal HVSR analysis.

An example of the azimuth convention is given in Figure 5. The instrument is pointing 35˚ to the west of north (red arrows in Figure 5) which is noted in the Excel spreadsheet as a counterclockwise misalignment of 35˚ (Figure 5C). In mathematical terms (5A), the same misalignment corresponds to 125˚. In the geographical/geological convention (5B), the same azimuth corresponds to 325˚.

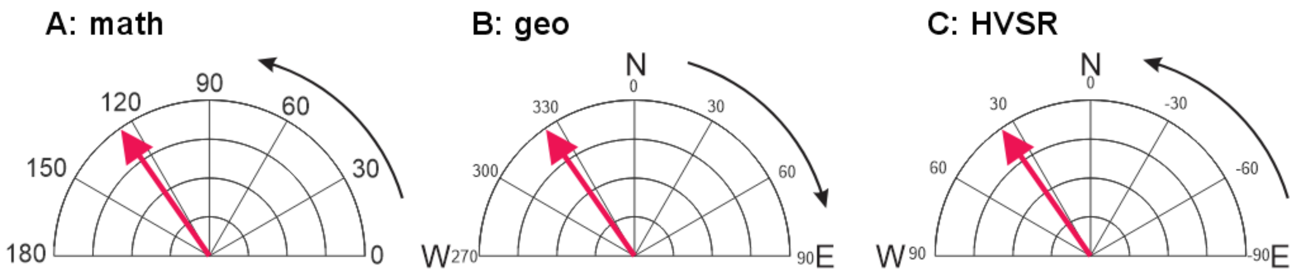

Figure 5: Azimuth convention for A: mathematical (rotation is counterclockwise) or B: geographical/geological formulation (azimuth in degrees with clockwise rotation). C: Convention used to describe instrument azimuth for microtremor recordings.

To allow for easy correction in the mathematical sense, western misalignments are positive in the microtremor HVSR convention. Correcting for the 35˚ westward misalignment (example in Figure 5) the rotation would be -35˚ (against mathematical rotation). For an eastern misalignment (for example −20˚ or 20E), the rotation would be -(-20) => 20, matching mathematical convention.

5. DATA ORGANIZATION

Data is organized into three main folders as depicted in Figure 6. "**kml**" contains Google Earth files; station coordinates and azimuths are in Excel files within the "**locations**" folder. Raw, three-component time series data for each recording station are in folders based on transects within the "**raw_data**" folder.

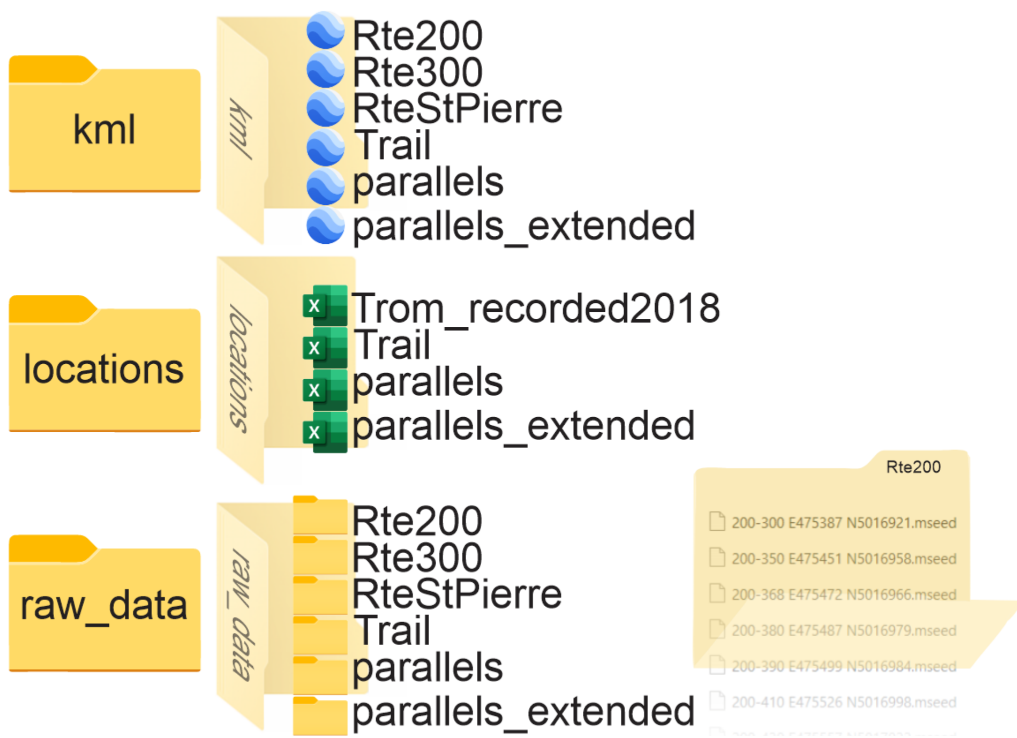

Figure 6: Diagram to outline data organization.

6. PRELIMINARY RESULTS

Preliminary results were reported at the Ontario Geological Survey Open House in 2022. A one-page abstract is found in Burt et al. (2022) and the video presentation is available at the Groundwater Geoscience Program's YouTube channel (https://www.youtube.com/watch?v=gsAp6nTvsaI; accessed Dec. 4, 2024).

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APPENDIX: DATA ORGANISATION

Data is organized into 3 folders:

1) **kml** contains kml (google Earth) files of measurement locations
2) **locations** has Excel files with site name, location (UTM NAD83 Zone 18) and instrument azimuth
3) **raw_data** has subfolders with single stations files described in Appendix 2.

APPENDIX 1: LOCATIONS - STATION COORDINATES

Measurement locations are listed in Excel files with columns titled station name, x, y (coordinates in UTM NAD83, Zone 18) and instrument azimuth measured during set-up (see HVSR convention in Figure 5). When working with azimuthal data, all azimuths (e.g., -8 for 8E, 12 for 12 W) need to be subtracted when correcting before rotating to true north (Figure 5).
Microtremor data from single measurement stations are organized into several groups based on their location and acquisition date. The earliest measurements were recorded in 2018 along seismic profiles (Pugin et al. 2020) on Route St. Pierre (red), Route 200 (orange) and Route 300 (yellow in Figure 3). They are summarized in Trom_recorded2018.xlsx.
Trail and parallels transects were acquired in 2021, parallels_extended transects were collected in 2022.

Each group of microtremor transects has a kml file with station locations (Figure 3 and Figure 4).

APPENDIX 2: RAW MICRO-SEISMIC DATA

For each station the raw data is saved in the miniSeed file format (mseed; Ahern et al. 2012) Velocity values are recorded in time domain (30-minute time series in m/s at 128 Hz sampling frequency) for the EW-, NS- and vertical component.
The mseed file names include station name and UTM coordinates in NAD83 Zone 18. Examples of file names from the Route 200 transect are displayed in Figure 6.
Data files are organized into **folders** based on their acquisition time and location, similar to the coordinate files:

- 2018: **Rte200**
  Rte300
  RteStPierre
- 2021: **Trail**
- 2021: **Parallels**
  30-
  100-
  200-
  300-
- 2022: **Parallels extended**
  30_e
  100_e
  200_e
  500_e