

AFI7/02
Geophysical exploration of a West Antarctic subglacial lake

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Rationale

Subglacial lakes are one of the few remaining unexplored environments on Earth. Found beneath the Antarctic Ice Sheet, these lakes are extreme environments thought to host unique life forms that may have been isolated for millions of years. Furthermore, the sediments that have accumulated at the bottom of these lakes are likely to contain records of Antarctic ice sheet history.

Subglacial Lake Ellsworth (SLE) is a subglacial lake beneath the West Antarctic Ice Sheet. This report will describe the second season of AFI-funded geophysical surveys, undertaken during the austral summer 2008-09, which completed the ground-based characterisation of the lake area begun in 2007-08. The main requirement for the second season was the re-survey of a stake network installed in 2007-08, to determine the ice flow. Flow speeds in the area are so low that it was not possible to achieve this with sufficient accuracy during a single season. The second priority was to complete the grid of radio-echo sounding in the area.

Lake Ellsworth

Lake Ellsworth is a small subglacial lake (12 km long by 3 km wide), which lies approximately 70 km west of the Ellsworth Mountains in West Antarctica, where the ice sheet surface elevation is approximately 1930 m. Existing radio-echo sounding data indicate that the lake lies in the bottom of a narrow, steep-sided, fjord-like subglacial valley, 3.2 km below the ice surface.

Aims of the project

During the Austral summer 2008/09 we undertook GPS and radio-echo sounding (RES) surveys on the ice sheet surface above the Lake Ellsworth and its subglacial catchment. The aims of this fieldwork were to:

1. Produce a detailed map of ice flow over the lake.
2. Complete mapping the outline of the lake and the subglacial topography of its catchment.
3. Finish mapping the geometry of internal layering within the overlying ice sheet.

Fieldwork

Personnel and equipment was deployed at Lake Ellsworth (Figure 1) from late-December 08 to late January 09. During this period, the field team:

- a) made GPS measurements of a stake network comprising 58 aluminium poles on the ice surface above the lake (Figure 2). Comparison with data from the 07/08 field season will permit the production of a detailed map of the rate and direction of ice flow over the lake.
- b) collected ~30 days of continuous GPS data from a GPS base station situated above the centre of the lake and 11 days of continuous GPS data from a base station located on slower-flowing ice approximately 11 km to the northeast of camp. These data will be used: i) as base-station data to correct other GPS measurements; ii) to determine the rate and direction of ice flow over the lake.
- c) resurveyed, using GPS, a series of stakes installed around Lake Ellsworth by Chilean scientists in January 2006 (Figure 2). These measurements will be used to complement ice flow measurements derived from the stake network (item a).
- d) acquired a regional grid of RES survey lines over the lake and its catchment using the ground-based DELORES radar system (Figure 3).
- e) acquired a series of closely-spaced RES lines at the bottom of the lake (Figure 3) where data from last season suggested the possible presence of a subglacial channel.

Preliminary results

Preliminary results based on the initial analysis of the field data reveal the following:

Global positioning systems (GPS):

- Ice flow over, and in the nearby vicinity of, Subglacial Lake Ellsworth is orientated between 310-325° (Figure 2). Ice accelerates as it travels down the length of the lake, with approximate annual rates of flow increasing from ~4.5 ma^{-1} at the top end of the lake to ~5.5 ma^{-1} further down lake.

Radio-echo-sounding (RES):

- The RES data establishes that Lake Ellsworth is located within a long, enclosed, deep, fjord-like subglacial trough that extends some 40 km from the ice divide to beyond the bottom of the lake.
- A flat, bright, radar reflection identified in the subglacial catchment upstream of Lake Ellsworth may represent a smaller, very localised area of subglacial water (Figure 4).
- Internal ice sheet layers are not apparent in the RES data below depths of ~2000 m. This is despite modifications made to the DELORES radar system prior to the 2008-09 field season that were designed to boost RES signal return (Figure 4).
- Localised buckling of internal reflecting horizons, initially identified and mapped during the 2007/08 field season, have now also been traced in RES data collected upstream of the lake (Figure 4). These buckles are generated as the ice sheet flows over areas of high subglacial topography to the east of the Lake Ellsworth catchment. The absence of these buckles in RES data acquired further upstream (towards the ice divide) suggests that the position of the ice-divide may have been stable over the last few ten thousand years.



Figure 1: Lake Ellsworth field camp during the 2008-09 season.

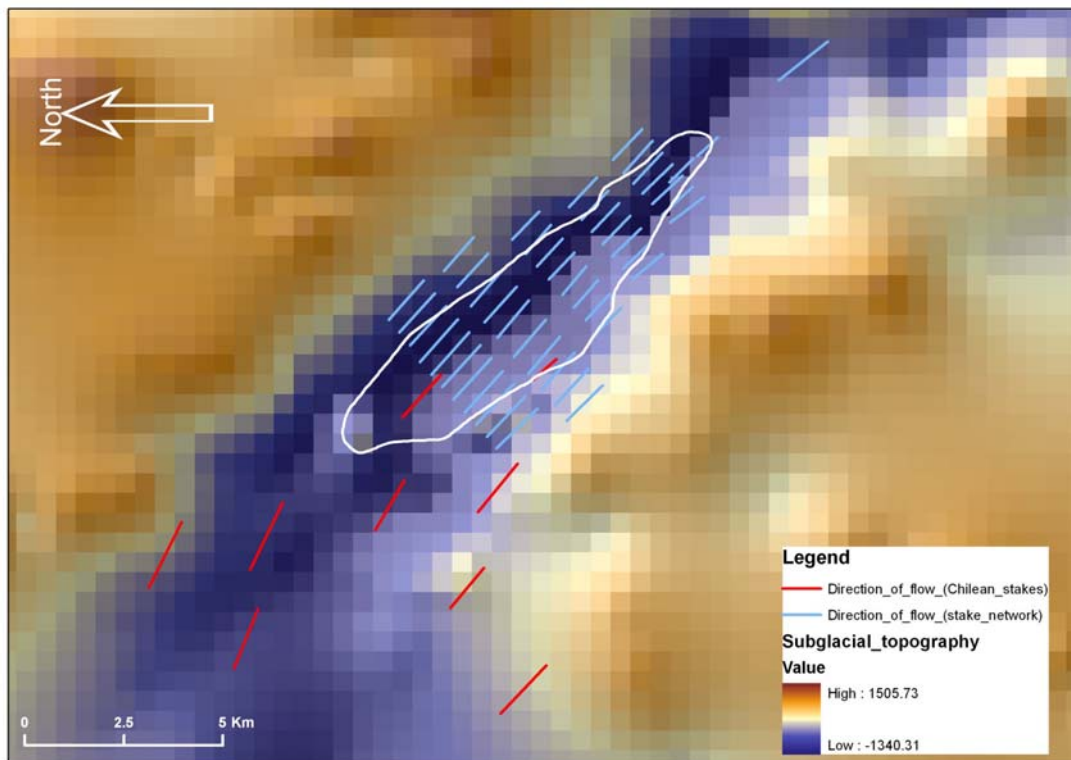


Figure 2: Map of the direction of ice flow over Subglacial Lake Ellsworth determined from GPS measurements of metal 'glaciopole' stake network deployed in 2007 (those so far processed) and wooden stakes installed by a Chilean field party in January 2006. Note that the lengths of the lines in the figure **are not representative** of rates of ice flow.

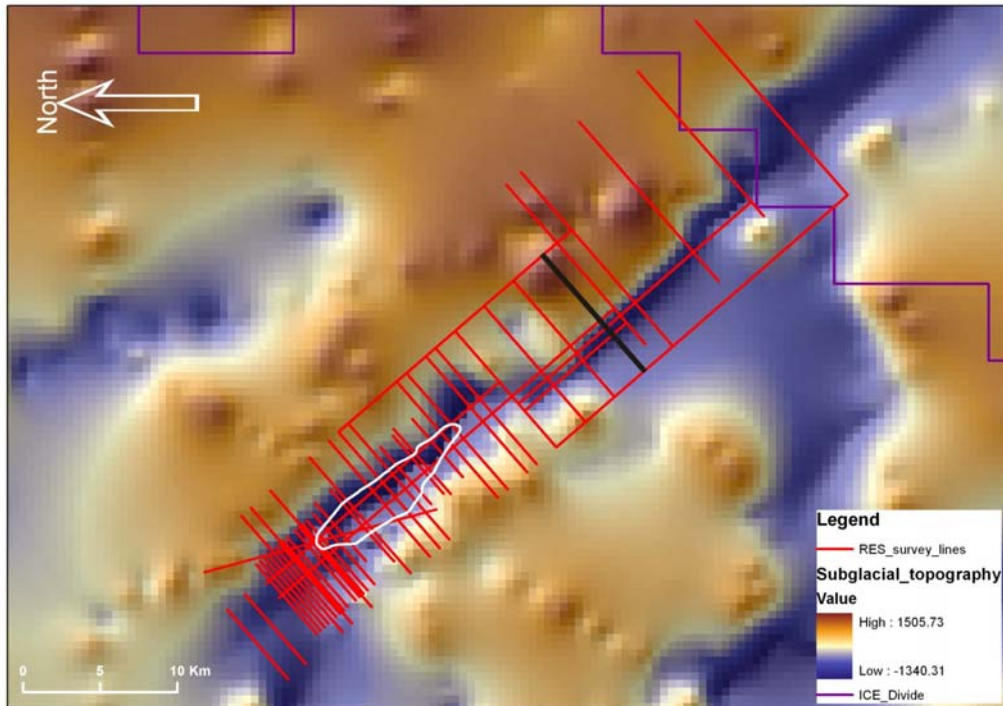


Figure 3: Map of radio-echo sounding survey lines acquired during the 2008/09 season, overlaid on subglacial topography derived from datasets acquired prior to these surveys. The black line represents the location of the radar data displayed in Figure 4.

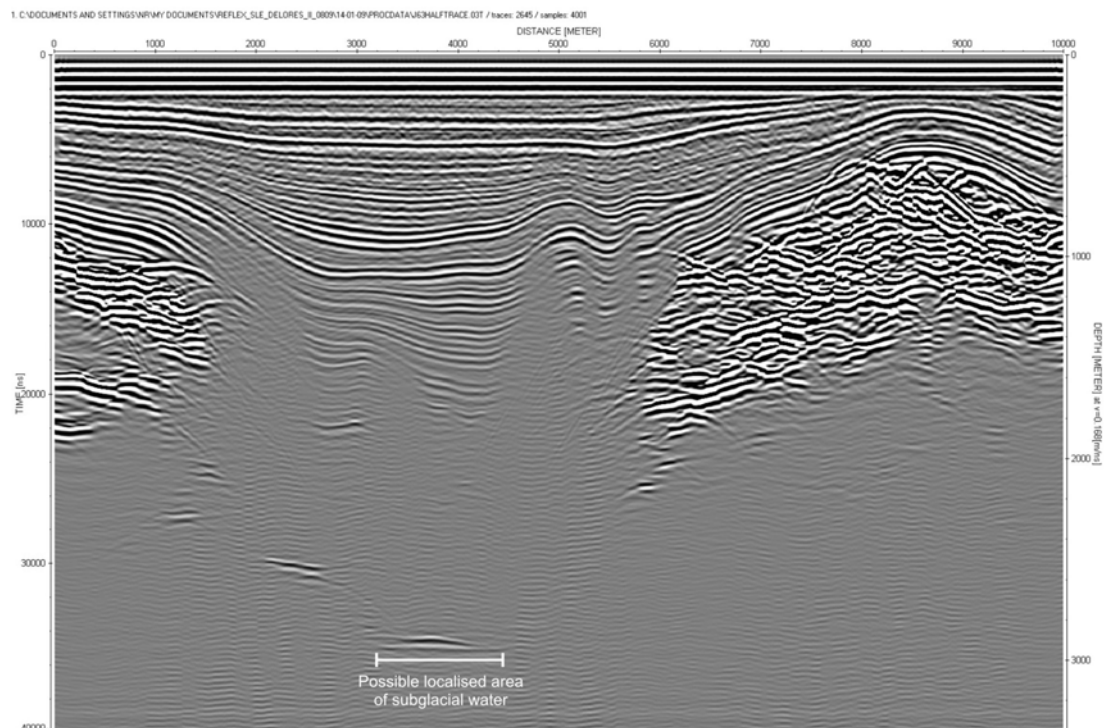


Figure 4: Example of DELORES radio-echo-sounding data acquired over the subglacial catchment upstream of Lake Ellsworth. Image is 10 km wide by 3.3 km high. Internal layer buckling can clearly be seen just right of centre at depths of 0.75-1.5 km. Radargram is orientated southwest to northeast, providing a view to the northwest (down ice flow), towards Lake Ellsworth.