GeoTerrace-2020-008

Layering of the ice caps on the islands Galindez, Winter, Skua (the Argentine Islands, West Antarctica)

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SUMMARY

This paper represents the results of GPR investigations of five ice caps on the islands Galindez, Winter and Skua. The research is aimed at counting the layers and finding similarities in the structure of the ice caps. Observations were done during different seasons with VIY3 GPR, 300 MHz antenna. 5-10 major layers are stretching along the ice caps.
Introduction

First glaciological observations in the area of the Argentine Islands (−65.249S; −64.247W) were started at the beginning of 20th century during the first French expedition in 1903—1905, when the islands were mapped and named for the first time (Charcot, 1905, 1930). During the British Graham Land Expedition (1934—1937) varied surveys were performed and more detailed topographic maps were published. Galindez, Winter and Skua Islands are three of the Argentine Islands group (fig.1). During several Ukrainian Antarctic expeditions glaciological investigations were also performed and authors of previous research pointed out that monitoring of glaciers on the Argentine Islands is important and should be done regularly (Glotov et al., 2003; Bakhmutov et al., 2006).

GPR method was proven as an informative method for investigation of the structure of the ice caps on the islands in Antarctica (Chernov, 2017). The ice thickness maps were obtained as a result of seasonal Ukraine-Latvia expedition (Karušs, 2019). First signs of seasonal variations in the structure of the ice cap on Galindez Island were obtained for September 2017 and September 2018 (Chernov, 2018a). Stable monitoring of the ice caps on Galindez, Winter and Skua islands was started in 2018. The first conclusions about the structure of the ice caps on Galindez, Winter and Skua islands were published in 2018 (Chernov, 2018b). Internal reflecting horizons (IRHs) represent isochronous layers that may be identified by ice radar and traced for hundreds of kilometers within the Earth’s largest ice masses. Siegert et al. (1998) applied this approach to extend the chrono-stratigraphy of the Vostok ice core to a potential drill site near Dome C, located ~ 200 km away. These IRHs are formed as a result of systematic vertical variations in ice permittivity, mainly due to changes in the impurity content of the ice and, to a lesser extent, its density and crystallography (Bryn, 2005). The represented research is aimed on counting the layers and finding of similarities in the structure of the ice caps.

![Figure 1 A – Location of the Argentine Islands (prepared using the Scientific Committee on Antarctic Research Antarctic Digital Database (ADD)), B – directions of the survey along the ice caps on Galindez Isl. (green line along the Woozle Hill), Winter Isl. (the ice cap Foot – yellow line, the ice cap Wordie – orange line) and Skua Isl. (the ice cap Tongue - violet line; the ice cap Solid – blue line).](image)

Method

The survey was done with VIY3-300 GPR. The settings of surveying: frequency of antenna: 300 MHz, step of surveying: 94-158 mm, time-window (depth of the survey): 330 ns (27.5 m, velocity of electromagnetic wave: 168-170 m/µs), vertical sampling: 500 points, average stacking: 2. Figure 1 B shows the survey directions. For the represented conclusions results from different seasons were considered: January 2018 (Woozle Hill, Solid); May 2018 (Woozle Hill, both on Winter Isl.), October 2018 and February 2019 (all ice caps), June 2019 (Woozle Hill, both on Winter), October
2019 and March 2020 (all islands). The deviation of the direction from the shown lines for the Woozle Hill is 5m, for Winter Isl. was 10 m and for Skua Isl. was 10 m. Synchro and Planner software were used for the survey, processing and interpretation. Processing flow: wavelet filter, windowed background removal, gain, frequency filter.

**Results and discussion**

After the processing, linear reflections of the higher amplitude are visible along the ice caps (fig. 2 A). Reflections are interpreted as the borders between snow-ice, interior ice layers and ice-rock border. On the fig. 2 B and C interpreted profiles are represented for the ice cap on the Woozle Hill and Wordie. Layers, which are stretching along the whole ice cap were counted. Yellow line shows the place where layers were counted. During the seasonal periods with above zero air temperature and after rain, interior anomalies become visible on the data (brown ovals and polygons on the fig.2).

The uppermost horizontal reflection is from the border between snow and ice. Amount of snow varies during the seasons and therefore during the winter depth to this layer is up to 2 meters. Reflections inside of the ice were distinguished and 5-12 major (those are stretching at least along the half of the ice caps were considered for the calculation) layers are visible. On the fig.2 yellow vertical line shows the place of layers calculation – the black and red lines, which are crossed by yellow vertical line, were considered as major borders between layers. Several shorter borders between sub-layers are marked with green and orange lines. The inclination of the reflective borders could be provoked by the topography of the bedrocks and intensity of the precipitations during different time periods; the thickness of the layers possibly depends on the complex effect of the amount and type of precipitation, and temperature conditions for the corresponding period. Similar layering of the ice is described as isochrones of the amplitudes on the GPR data and associated with the presence of volcanic ash (Blindow, 2010). For the mentioned five ice caps, not enough in-situ investigations were done to conclude exactly about the nature of these reflections.
Figure 2 The GPR profiles were recorded in North-South direction along the ice caps: A – on the Woozle hill without interpretation, B - along the Woozle hill with interpretation, C – Wordie; D – Foot; E – Solid; F – Tongue. Ovals and polygons mark anomalies on the profiles. Reflections between layers are marked: major - with black, red; minor - green and orange lines. Brown curve marks the reflection from ice-rock border.

Conclusions

1. As a result of this investigation, the number of layers in the ice was counted for each ice cap: Woozle Hill – 10, Wordie – 8, Foot – 5, Solid – 9, Tongue – 8.

2. Some similar features for the ice caps are visible. Layered structure and presence of interior anomalies closer to the edge of the ice caps is evident. The ice caps, which located closer to the outer waters around the Argentine Islands (on the Woozle Hill and Skua Island) are characterized by the presence of more layers. This phenomenon may occur because the islands Galindez and Skua shield Winter island from the wet air, however harsh winds blow out the fresh snow from the surface of ice caps Wordie and Foot. Meanwhile, more snow was accumulated on the sticky wet surface of the ice caps on the Woozle Hill, Tongue and Solid.

3. There is a similar correlative layer which is stretching along the whole distance of the ice
caps (red color on the fig.2). Layers above this one reflections are more tilted and are stretching on the less distance.

4. Further interior investigations should be done to trace chrono-stratigraphy of the ice cap layers.

References


