Portable ultralight ice core drilling system for high altitude and polar glaciers research: planned application in Sub-Antarctic Islands

Paolo Gabrielli
Ice Core Paleoclimate Research Group
E-mail: gabrielli.1@osu.edu
Byrd Polar and Climate Research Center
The Ohio State University, Columbus, USA

Victor Zagorodnov
Cryosphere Research Solution LLC, https://cryosphere.co/
E-Mail: victor.zagorodnov@gmail.com
Columbus, Ohio, USA

Mark Curran
Australian Antarctic Division
Australian Antarctic Program Partnership
Tasmania, Australia
Introduction

Light-and ultralight ice core drilling systems (< 50 kg) are needed for:

• Logistically difficult/“impossible” sites of high scientific interests:
  - high altitude glaciers
  - polar glaciers
  - drilling sites without helicopter support (above 6000 m)

• Reconnaissance for ice coring operations (site selection)

• Relatively inexpensive field projects to obtain relatively small size/volume ice samples
Potential application to low altitude Sub Antarctic Islands as observatories of changes of the polar front and the westerlies.

The area of land in the Subantarctic is 30,160 km², of which 26% is occupied by glacier ice (Section 32.4). Most of the islands lie on oceanic crust. Many are volcanic, and several are currently active or have been so recently (e.g., Bauer 1963, Lachlan-Cope et al. 2001, López-Martínez et al. 2002, Patrick et al. 2005, Stephenson et al. 2005).

The Subantarctic islands, scattered through 360°/C14 of longitude and 25°/C14 of latitude, have distinctly different climates. Weather stations are few and widely dispersed (Jacka et al. 2004). The main features of the evolution of temperatures in the Subantarctic during the 20th century can, however, be seen in Table 32.1 and Fig. 32.2.

Mean annual temperature decreases polewards. However, the potential for ablation by melting, as measured by the positive degree-day sum at or close to sea level (Fig. 32.2), remains substantial as far south as the South Orkneys at latitude 61°/C14. Subantarctic climate is strongly maritime. The mean annual range of temperature is small, but increases southwards from 4.6°C at Marion Island to 12.6°C in the South Orkney Islands. There is evidence from some islands of the expected contrast between windward and leeward coasts. On Heard Island, for example, flows winds are documented on the eastward side, in the lee of the main peak, and on...
Heard Island, Australian territory

Area: 368 km$^2$

Highest elevation: 2,745 m

Volcanic island

Population: 0 (unhabited)

Various past expeditions
Heard Island physical-climatic characteristics

- Latitude: 53 S
- Glaciers elevation: 0-2400 m
- Snow Equilibrium Line Altitude: 100-700 m
- Mean air temperature at 2400 m: -10 C
- Mean precipitation at sea level: 1380 mm/year
- Days of precipitation per year: 276
- Mean annual wind speed at sea level: 8.3 m/s
Concept of light-and ultralight ice core drill

- Lightweight equipment can be deployed by a small group of porters (3-4) up to 8000 m a.s.l.

- High ice coring production rate to reduce logistic (time on site and supplies)

- Power efficient drilling equipment (less fuel and pollution on site)

Ultra light system prototype constructed and lab tested by Victor Zagorodnov
## Characteristics and Performances of the Ultra Light Drilling System

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Maximum depth</td>
<td>170 m</td>
</tr>
<tr>
<td>Weight (rig+drill)</td>
<td>20 kg</td>
</tr>
<tr>
<td>Power (300-400 Vdc)</td>
<td>0.3-1.0 KW</td>
</tr>
<tr>
<td>Fuel</td>
<td>8 Liter/100 m core</td>
</tr>
<tr>
<td>Production rate</td>
<td>40 m/day</td>
</tr>
<tr>
<td>Core diameter</td>
<td>42...75 mm</td>
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</table>

![Graph showing weight of 100 m ice core](image-url)
Conclusions

Ultralight ice core drilling allows:

• Economical and quick field operations
• Reducing greatly the logistic
• Ice coring down to 170 m depth at logistically difficult sites

Additional perspectives......

1. Thermal drill for cold ice
2. Electro Mechanical drill for dry borehole (core <80 mm)
3. Electro Mechanical drill for fluid borehole
4. Compact controller
5. Hot point drills (borehole diameters: 15, 25, 35 mm)
6. Winch configuration for geophysical studies (560 meters depth; 2.5 mm cable)