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Subglacial Lakes

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Abstract

Subglacial lakes are important components related to ice sheets and have likely played important roles in shaping past environments, especially as the result of sudden catastrophic drainage. Herein, brief summaries are given to describe this phenomenon. Evidence for subglacial lakes from prior glaciation periods are examined and accounts for subglacial lakes that have actively been researched in Antarctica and Greenland are observed.

General Background

- Subglacial lakes are large freshwater reservoirs that exist beneath ice sheets and are found in areas of basal melting[1]
- Basal melting is a result of the following influences: (1) the weight/pressure of ice reduces the melting point, (2) The ice sheet insulates the bottom of the ice from cold surface temperatures, (3) Geothermal processes keep the base of the ice warm, and (4) meltwater collects in topographic low areas[12]
- Dowdeswell and Siegert (2002) characterized subglacial lakes into three categories: (1) lakes in basin that are in the ice sheet interior, (2) lakes that are perched on the side of subglacial mountains, and (3) lakes close to the start or beginning of enhanced ice flow[2]
- Subglacial lakes pose flooding risks for sudden catastrophic drainage with potential to cause significant damages[13]

Subglacial lakes in Greenland

- Few subglacial lakes have been observed or reported in Greenland Ice Sheet[7]
- Using radio echo sounder measurements (RES), Palmer et al. (2013) were able to detect two subglacial lakes with areas of ~8 and ~10 km^2 and below 757 and 809 m of ice in the northwestern portion of the ice sheet[10]
- Likely a consequence of rising global temperatures and a changing climate, sudden drainage of subglacial lakes are triggered by increased meltwater runoff and are expressed on surficial ice sheets by deep circular depressions[5]
- Surface melt waters are then able to filter down and recharge subglacial lakes and allowing for isostatic processes to rebound ice sheet elevation[14]

Subglacial Lakes in Antarctica

- Subglacial lakes were first discovered in Antarctica in the late 1960s using RES measurements[12]
- More than 150 known subglacial lakes exist under the Antarctic ice sheets[12]
- These lakes are connected by networks of subglacial streams and rivers that allows subglacial water to travel rapidly between individual lakes[1]
- The largest known subglacial lake is Lake Vostok which occurs under the eastern Antarctic ice sheet beneath 3500 to 4200 m of ice and is more than 250 km long, 80 km wide, 1 km deep and is estimated to hold 5000 km^3 of water[11]
- Current research at Lake Vostok is focusing on evidence for life in the subglacial waters and/or sediments at the lake's bottom[13]

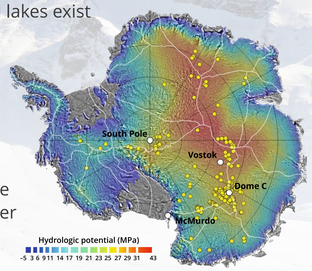

Figure 1: Subglacial lakes in Antarctica[13]

Map of Antarctica showing the locations of known subglacial lakes (yellow circles) in relation to ice divides (white lines) and hydrologic potential (coloured contours). Modified from Singh *et al*. (2011).

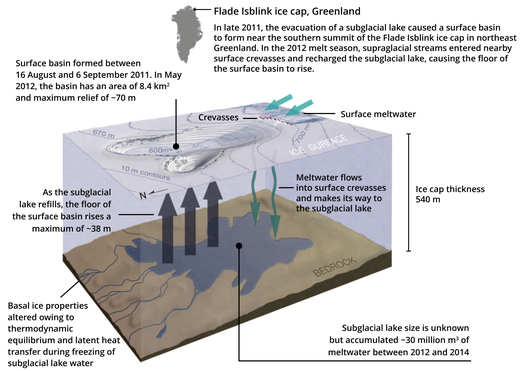

Figure 2: Conceptual model of subglacial lake recharge from supraglacial streams at the Flade Isblink ice cap[14]

Graphic not to scale. Modified from Willis (2015).

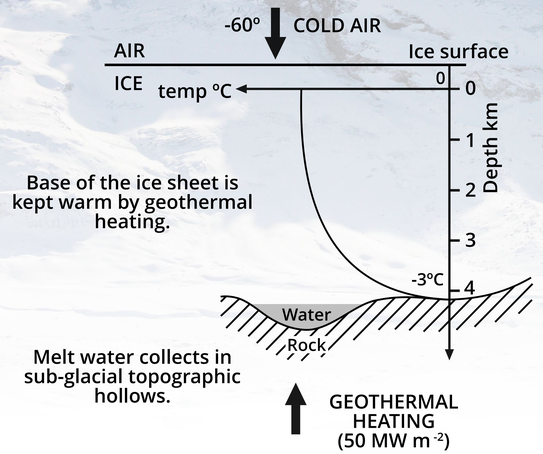

Figure 3: Relationship of pressure due to depth, temperature and geothermal heating in glacers[11]

Ice sheet thermal conditions and the maintenance of warm subglacial conditions in East Antarctica resulting in geothermal heating. Modified from Seigert (2005).

Evidence for Subglacial Lakes from Previous Glaciations

- Models predict that subglacial lakes were repeatedly formed and emptied during the last glaciation in North America[6]
- These models also predict 1000 km^3 of water beneath the Laurentide and Cordilleran ice sheets[6]
- Subglacial lakes may have aided in subglacial flooding events and may have helped create regional drumlinized landscapes and tunnel valley features during the Fraser Glaciation in the Okanagan Valley[9]
- Paleosubglacial lakes are rarely documented because of the difficulty of separating common features between them and proglacial lakes which have similar depositional features[6]
- The meteoric impact that created the Pingualuit Crater Lake in northern Quebec existed prior to recent glaciations and because of its significant depth (410 m) is likely to have remained liquid during these glaciated periods[4]

Conclusions

- Subglacial lakes occur beneath glaciers under appropriate conditions that allow for melted water to collect and remain liquid and are typically collected in a basin[13]
- Subglacial lakes have important consequences for ice dynamics such as decreased basal friction and accelerated ice flow[14]
- Though most research is focused on Antarctic subglacial lakes, considerable research has been performed exploring subglacial lakes influence on past environments as well as its influence as a result of a changing climate[5, 8, 9, 13, 14]

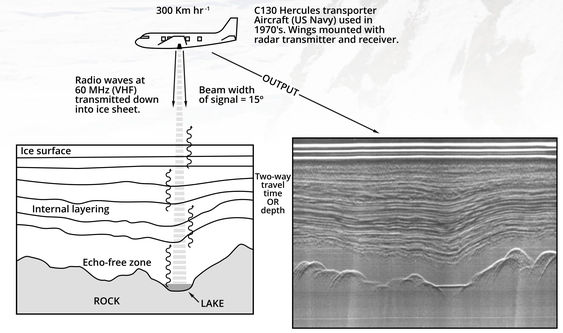

Figure 4: The technique of airborne radar sounding, and its application to identifying Lake Vostok and other subglacial lakes[11]

Subglacial lakes are identified on airborne radar records by their uniformly strong and flat appearance while bedrock perturbations are recorded as hyperbolae in radar data. Modified from Seigert (2005), airplane graphic by Andrew Fortnum.

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