Geophysical survey in the Hansbreen glacial front (SW Spitsberguen): Nuclear Magnetic Resonance (SNMR), Magnetic Susceptibility and Electrical Resistivity facies: Permafrost and subglacial aquifers

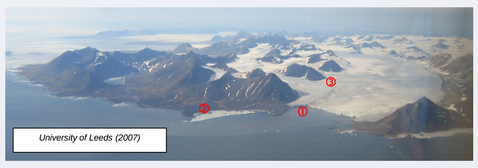
Valenti TURU i MICHELS (1) & Xavier ROS VISÚS (2)

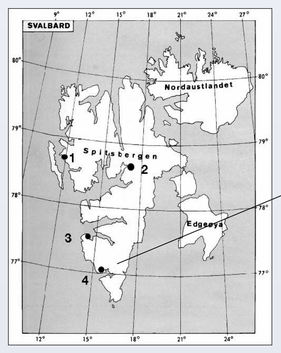
(1) Marcel Chevalier Foundation, Andorra la Vella, Principat d'Andorra, igeofundacio@andorra.ad

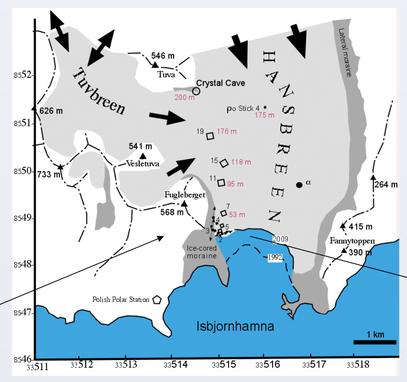
(2) GEO3 SL, Av. Príncep Benlloch 66, AD 500, Andorra la Vella, Principat d'Andorra

Setting

We present here the results form a geophysical survey carried out on the front of a subpolar polythermal calving glacier in Spitzberguen (Hansbreen in Isbjörnhamna 77ↄ00'N, 15ↄ40'E; [1]). Spitzberguen is the main island of the Svalbard archipelago at the Arctic Ocean in front of Norway. A grant stancy at the Polish Polar Station (2) by the Polish Academy of Science make possible the geophysical survey. Hansbreen glacier (3) is a medium size (56 sq. Km) Svalbard tidewater glacier located in Hornsund. Vertical Electrical Soundings (VES) and Magnetic Resonance Soundings (MRS) were carried out in august-september 2009.

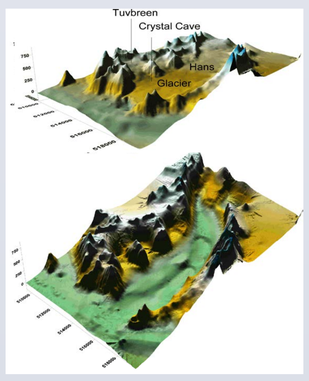




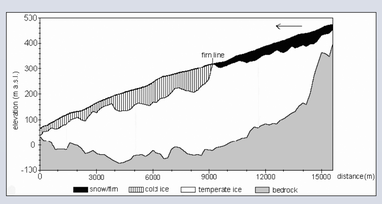


Geophysical survey: Water content and aquifers

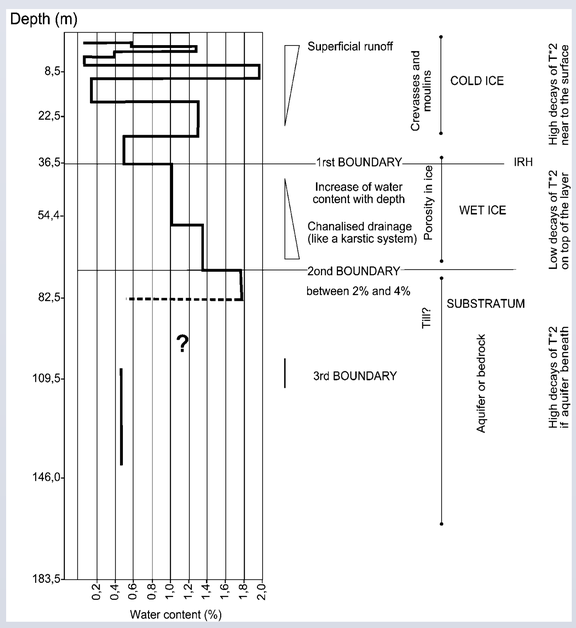
On the ablation zone of the glacierIt has been observed that the ablation in Hansbreen depends on daily mean and maximum air temperatures, but also in wind speed conditions (Migala et al. 2006) so the water flow through crevasses and moulins can change quickly from one day to other on the first 20 m depth; such water drains down until the glacier bottom through porous media (aquifer) or runoff to the glacier snout by interconnected cavities and subglacial tunnels. The goal of this study was to test MRS technique to identify aquifers beneath the glacier, nevertheless some conclusions can also be obtained about the frozen terrains in the glacier front from VES data.



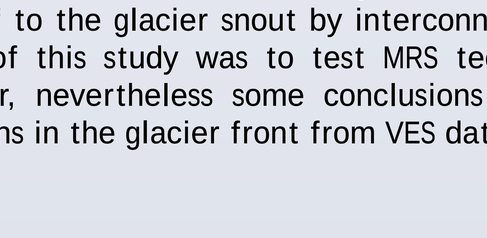
Bed topography of Hansbreen
Courtesy of Mariuz Grabiec (2010)



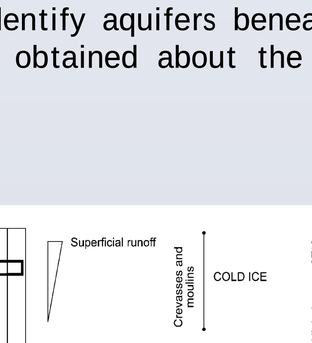
Polythermal structure of Hansbreen
Jania et al. (1996)



Synthetic model of water content of Hansbreen

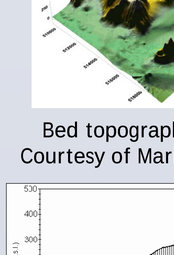


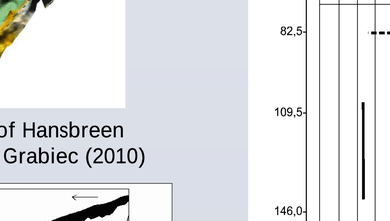
Crystal Cave: Large conduits connecting surface and bed glacier (Benn, 2009)



NMR survey at glacier front

Crevasses and ablation at glacier front and supraglacial melting



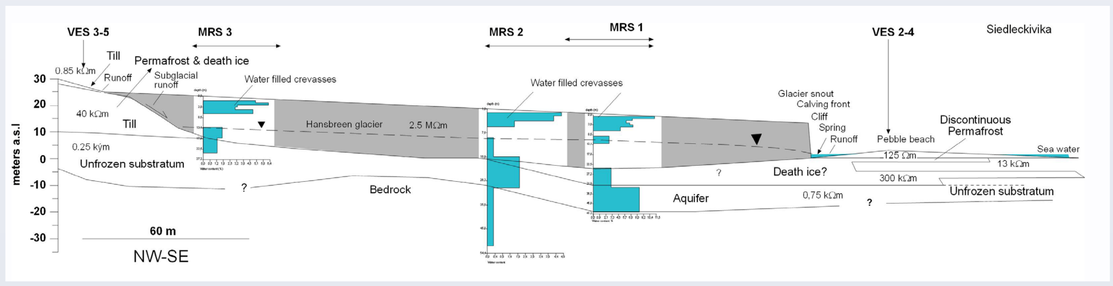


NMR survey at Crystal Cave

Vertical Electrical Soundings (VES) and NMR data

Six electrical vertical soundings with an ABEM device (courtesy of the Faculty of Earth Sciences, Silesia University) were done on the glacier margins. One of them far away to test the resistivity of the basement rock out of the glacier influence. Also two resistivity measurements directly on the Hans glacier surface. In that sense the ice on the glacier front has an electrical resistivity six times lesser than the cold ice at the inner part of Hans glacier (12 Mega Ohms meter).

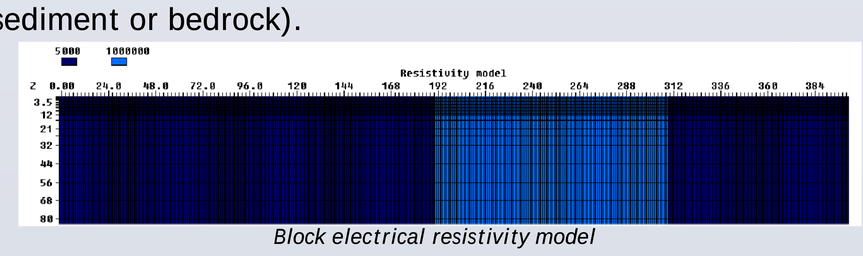
Permafrost at six meters depth has been recognized in the basement rock by the electrical resistivity data (200 – 400 Kilo Ohms m) near to the Polish Polar Station in Hornsund, also an 60 cm active layer (7.6 KOhms m) between half meter depth and one meter and half. Ice core moraines where identified following the fronto-lateral complex between Hansvika bay and the Fugleberget mountain; here half meter of sediment is above melting death ice from the recent retreat of Hansbreen (1984 – 2009) in this area. Interbedded permafrost (13 KOhms m) and death ice (300 KOhms m) has been identified in the first ten meters below sea level in the calving front beach of Hansbreen. An interconnected acquifer has been identified under this resistivity body using SNMR beneath the glacier and the lateral moraines.



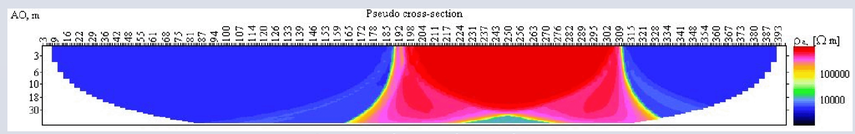
Interpreted profile of the western termination of the Hansbreen glacier in the Baranowskiodden cap

Electrical Resistivity Inversion model

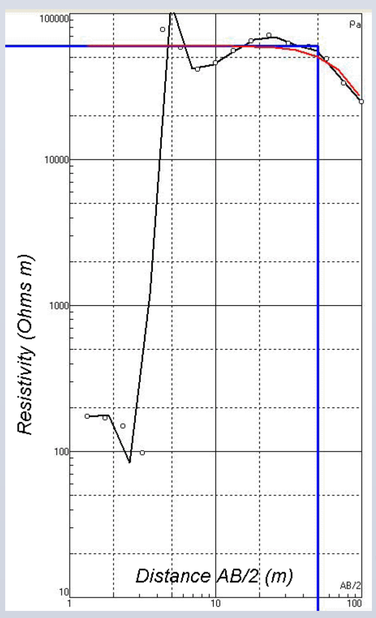
In all cases the resistivity behaviour is KH type ($\rho 1 < \rho 2 > \rho 3 < \rho 4$) sometimes very sharp between the two last resistivities ($\rho 3$ & $\rho 4$), much more than 45º between the surface soil resistivity and the permafrost usualy observed on frozen soils (Haeberli, 1985). Because this kind of sharp contacts are also compatible with metallic mineralizations related with sulfides in metamortphic rocks, a Magnetic Susceptibility survey has been done in 2012, nevertheless the results of such survey do not identified any magnetic anomally in the Isbjörhamna surrounding rocks. So to explain these sharp resistivity contacts a synthetic model has been computed, the results shows that is compatible with very high resistive patched bodies (ice or non-continous permafrost) embedded in a conductive layer (unfrozen sediment or bedrock).



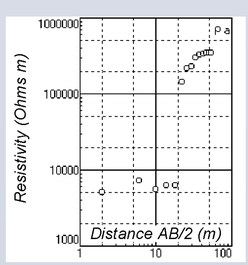
Block electrical resistivity model



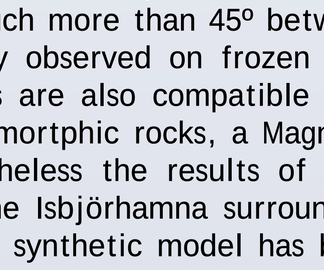
Inverted pseudosection



VES 4 obtained in field



Synthetic 1D model



Resistivity measures on glacier

Bibliography

Benn D., Gulley J., Luckman, A., Adamek, Glowaki, P. (2009). Englacial drainage systems formed by hydrologically driven crevasse propagation. Journal of Glaciology, 55, 191, 513-523

Haerbeli, W. (1985) *Creep of mountain permafrost: internal structure and flow of Alpine rock glaciers*. Mitt. Versuhchsanstalt für Wasserbau, Hidrologie un Glaziologie, ETH Zürich, 77, 142 pp

Jania J., Mochnacki D. and Gadek B. (1996). The thermal structure of Hansbreen, a tidewater glacier in southern Spitsbergen, Svalbard. Polar Research 15(1), 53-66

Migala, K.; Piwowar, B. & Puczko, D. (2006) A meterological study of the ablation process on Hans Glacier, SW Spitsbergen; *Polish Polar Research*, 27, 243-258