Geology, geotechnics, hydrogeology
and scientific & technical services

MRS PILOT STUDY ON HANSBREEN GLACIER, HORNSUND, SW SPITZBERG, NORWAY

MAGNETIC RESONANCE SOUNDING SURVEY

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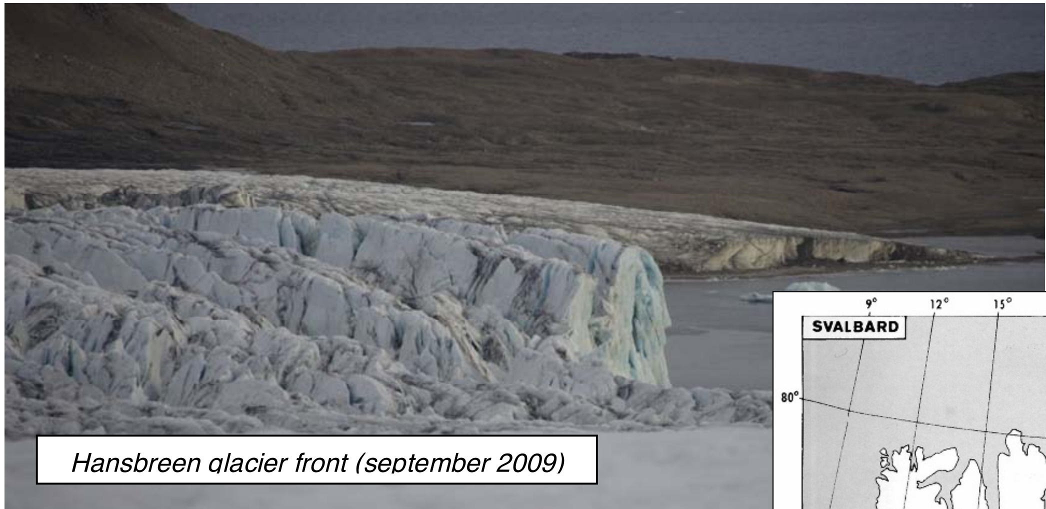
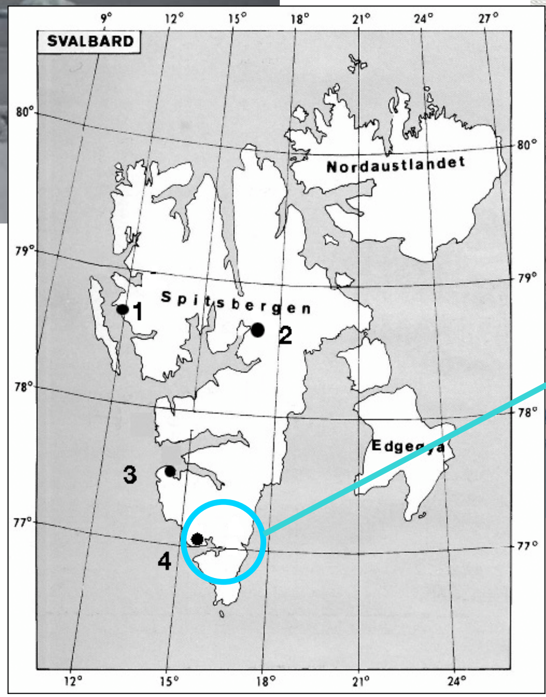
MRS SURVEYS IN HANSBREEN GLACIER, HORNSUND, SW SPITZBERG, NORWAY

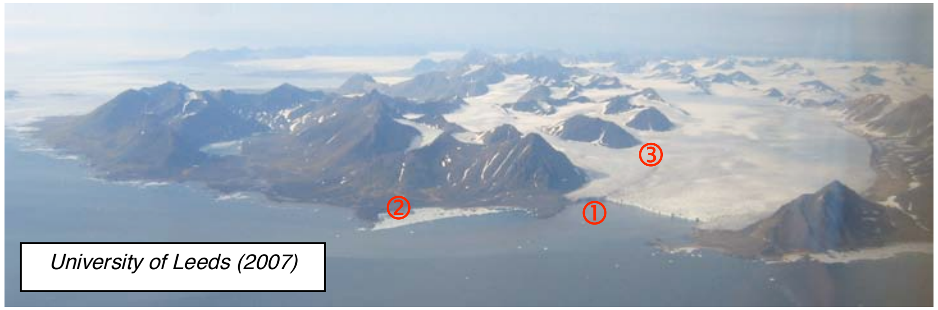
INTRODUCTION



Hansbreen glacier front (september 2009)



In the present report are present the results according to the magnetic resonance sounding (MRS, http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf) survey at southwest Spitzbergen (Svalbard). Svalbard is a cluster of Norwegian islands at the Arctic Ocean. The NMR survey was located at Hansbreen glacier on Hornsund fjord were the Polish Polar Station is present. The fjord is located at the subartic region of the main island of the Svalbard archipelago.



University of Leeds (2007)

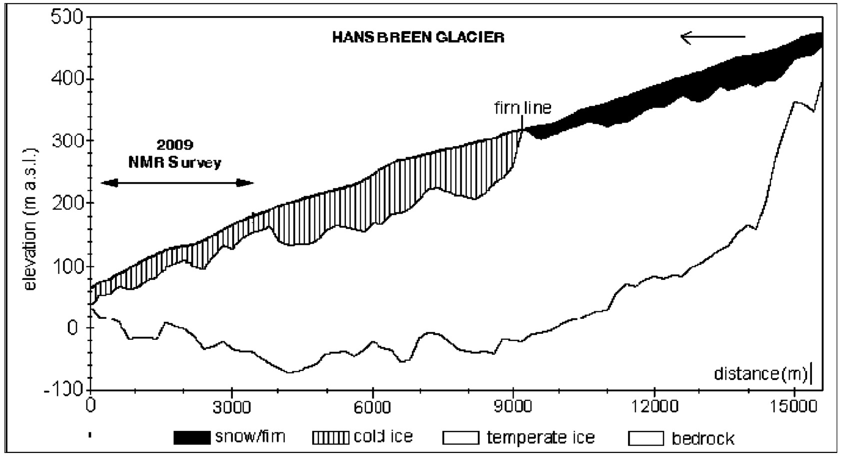
Hansbreen glacier is a medium size (56 sq. Km) Svalbard tidewater glacier located close to the Polish Polar Station (2). A surface NMR has been done on the ablation zone, between the front (1) on Siedleckivika bay and Tuva mountain (3). In Hansbreen it has been observed that the ablation depends on daily 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.

The geological mapping of fossil glacial sediments is well known in the whole Pyrenees range, the nature of the sediments in overdeeped valleys from that chain is also known, mostly by geophysical methods (see Turu et al. 2007). The last 15 years the main objective in the Pyrenees was to date the different glacial episodes (Delmas et al., 2008) and obtain the geomechanical behaviour of the glacial sediments present in the bottom of the glacial sediments (see Turu 2007a and Turu 2007b). The knowledge about that subject shows that the drainage system beneath, but also inside the glacier is directly related with the water content on ice. In that sense the next step is to investigate about the thermal structures of glaciers to explain the drainage pathways beneath the glacier, especially subglacial tunnels and subglacial lakes. For that study NMR techniques (Nuclear Magnetic Resonance) can be useful because is the only geophysical method that can detect directly water in the subsurface. Using the water content as a tracer the internal structure of polythermal glaciers can also be obtained, but no experiences has been done by the moment on such glaciers, only for sea ice in Antarctica (Ripeka Mercier et al. 2005) and in a thermal glacier in the Alps (Hertrich & Walbrecker 2008).

Delmas et al. (2008) Variability of Quaternary glacial erosion rates – A global perspective with special reference to the Eastern Pyrenees; *Quaternary Science Reviews* Volume 28, Issues 5-6, March 2009, Pages 484-498
Migała, K.; Piwowar, B.A. & D. Puczko (2006) Ablation on Hans glacier, SW Spitsbergen, Svalbard; Polish Polar Research, Vol. 27(3), 243 – 258
Ripeka Mercier et al (2005) Using Earth's Field NMR to Study Brine Content in Antarctic Sea Ice: Comparison with Salinity and Temperature Estimates; *Applied Magnetic Resonance*, 36, 1, 1-8
Turu et al. (2007) Structure des grands bassins glaciaires dans le nord de la Péninsule Ibérique : comparaision entres les vallées d´Andorre (Pyrénées Orientales), du Gállego (Pyrénées Centrales) et du Trueba (Chaîne Cantabrique); *Quaternaire*, 18, 309-325
Turu (2007a) Pressuremeter test in glaciated valley sediments (Andorra, Southern Pyrenees). Part one: An improved approach to their geomechanical behaviour; *Landform Analysis*, 5, 89-94
Turu (2007b) Pressuremeter test in glaciated valley sediments (Andorra, Southern Pyrenees). Part two: Fossil subglacial drainage patterns, dynamics and rheology; *Landform Analysis*, 5, 94-99
Hertrich & Walbrecker (2008) The potential of surface-NMR to image water in permafrost and glacier ice; *Geophysical Research Abstracts*, Vol. 10, A-06663

According to that, from august 21st, to September 10th 2009 it were carried out 19 NMR soundings (MRS) magnetic resonance soundings, supported by the Wroclawski University.

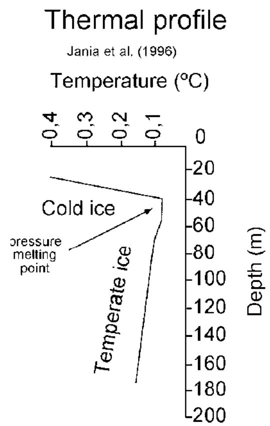
***Polythermal glaciers**:



Glaciers may be classified according to their relative temperature. In terms of temperature, a glacier may be "**warm,**" meaning that it is close to the pressure melting point, and because of this is relatively mobile. This kind of glacier contrasts with a "**cold," or polar, glacier**, in which the temperatures are well below the pressure melting point; in other words, despite the extremely high pressure, the temperature is so low that the ice will not melt. A third category of glacier, in terms of temperature, is a **subpolar glacier**, or ones in which the fringes of the glacier are colder than the interior.

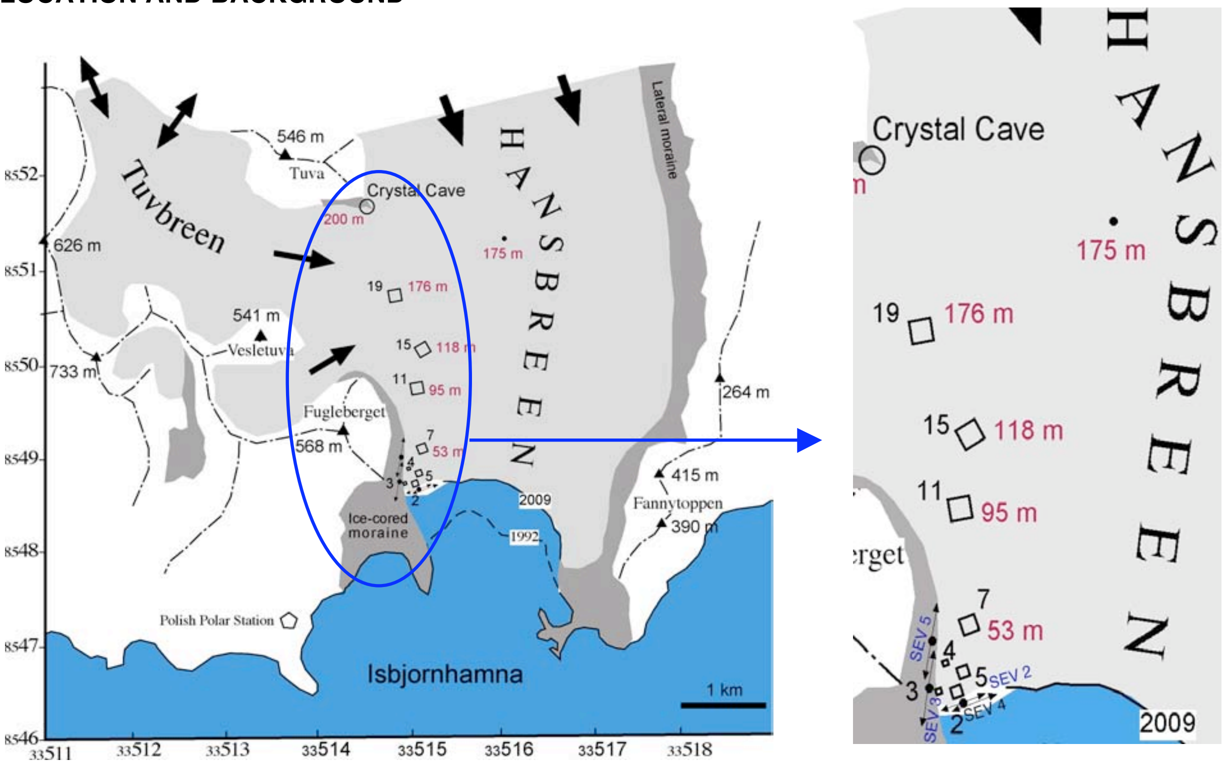
*Hansbreen glacier it is a a typical subartic, subpolar or polythermal glacier. Such glaciers had a polythermal structure from top to the frontal part: having a layer of **cold-ice** (temperature below melting point) on **accumulation zone** and **a temperate ice** layer in their **ablation zone**. The subpolar Svalbard-type polythermal glaciers have the particularity that are predominantly cold-ice glaciers with a thin layer of warm basal ice beneath, on centre and ablation areas (see figure).

Polythermal glaciers exhibit various thermodynamical and hydrological **discontinuities**: the **cold-temperate transition surface** (CTS), which separates cold ice from temperate ice, and the **basal thermal transition** (BTT) from sliding in the temperate ice to non-sliding in the cold ice. Ice is defined as temperate if a change in heat content leads to a change in water content alone, and is considered cold if a change in heat content leads to a temperature change alone.



There are few detailed studies of the velocity distribution in the glaciers of Svalbard, but much can be gleaned about their dynamic behaviour from a variety of geophysical techniques and by examining their surface structures. The focus has been to record ice-structures with a view to establishing how the dynamics of the glacier have changed through time. Glacier structures result from deformation of ice at, or close to, the melting point. Many of these structures in Svalbard glaciers are inherited from a time when the glacier was much more dynamic. Most polythermal glaciers in Svalbard have receded steadily since the early 20th century, and its internal structures reflect changing dynamics over this period. The three-dimensional structural style of this glacier and the sequential development of structures have been determined, in order of formation the structures observed today at the glacier surface are: (1) primary stratification that has become folded about flow-parallel axes; (2) axial plane longitudinal foliation associated with this folding; (3) several sets of intersecting crevasse traces; (4) arcuate upglacier-dipping fractures developed as part of a thrust complex near the snout; and (5) longitudinal splaying fractures in the snout area.

LOCATION AND BACKGROUND

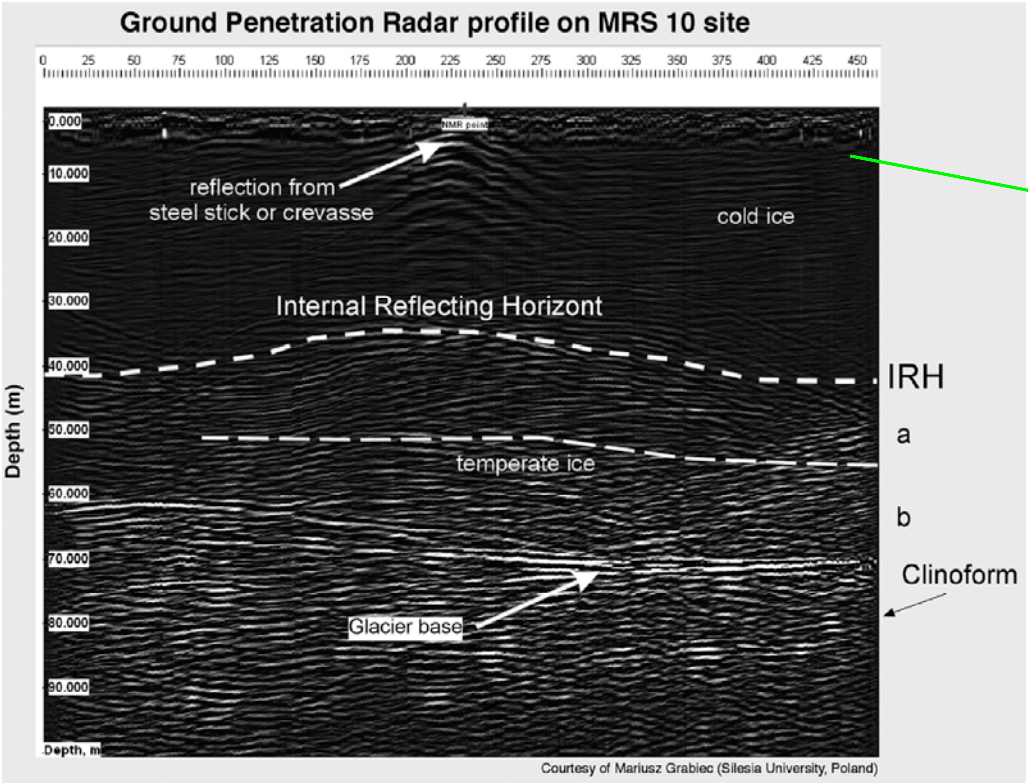


The surveyed area in their geographical context is located at Svalbard, which is a cluster of Norwegian islands in latitude 76° to 80ºN, that sit in the Arctic Ocean, well to the north of Scandinavia. The archipelago is 60% ice-covered, but most glaciers have suffered major recession since their 1900 AD maxima. Hansbreen glacier is located on the SW part of Spitsberguen, the main island of the archipelago and the research is geographically located in the surroundings of the Polish Polar Station. The polish polar station is located in UTM coordinates: 33513724E 8547178N (77º00'14''N 15º33'02''E) and its elevation its 2 metres.

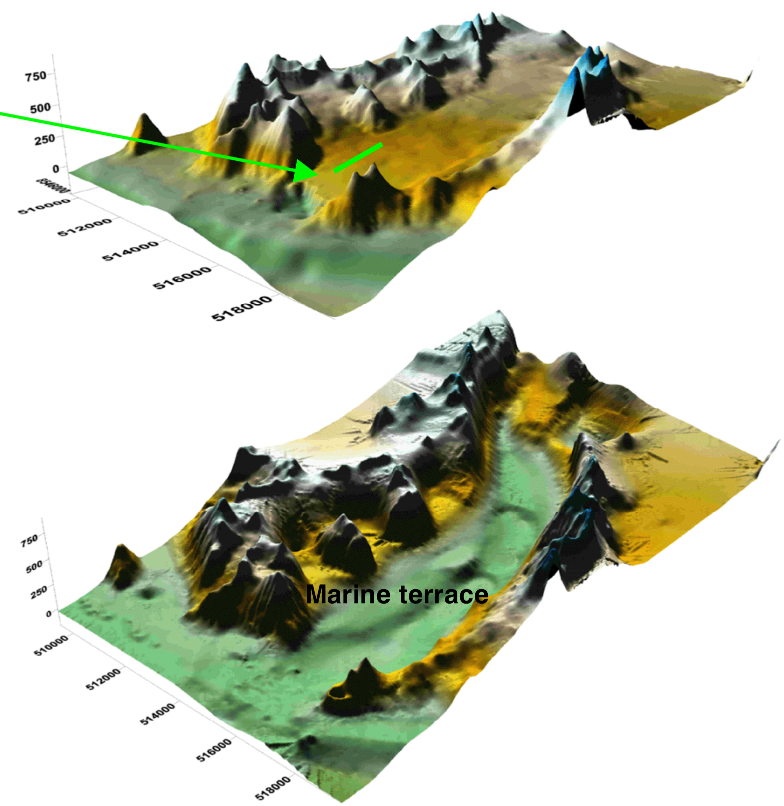
At the present figure the location of the different wire loop configurations used for the MRS sounding can be seen. Besides, is represented the location of the surveyed sector at VES (vertical electrical sounding), which is very close to the MRS 1-5 antennas, therefore the data acquired in them can be considered to be valid. The surveyed area has an elevation from 85 to 95 meters a.s.l.

It has been done 19 NMR soundings (MRS) supported by the Wroclawski University. For that a Numis Lite® device was used from Iris-Instruments and its available software as well (Prodiviner 3.04, Phar Lap's 386, Samovar 6.2). Those 19 MRS were placed on six stations and loops sizes range done were 30X30 m, 60X60, 90X90 and 120X120 m (http://www.igeotest.fr/RMP/Doc/A.04.MRS-Execution%20MRS.pdf). Five electrical vertical soundings (VES) with an ABEM device (courtesy of the Faculty of Earth Sciences, Silesia University) were done on the glacier margins, but also two resistivity measurements on the inner part of the Hansbreen glacier (on Ice on Stick number 4) and the front of the glacier, were done. Is important to note that a increasing loop size will integrate signals from different zones that have not been detected in the previous loop, so the average information is less particular and more general; also the accuracy in depth is lesser with large loops than with small ones and only common facies of the water signals can be correlated.

The background surveys developed on Svalbard have allowed establishing the geological subsurface model. From Ground Penetrating Radar data is possible to distinguish the boundary between cold ice and temperate ice by an Internal Refraction Horizon (IRH), but also different layers that are related with the water content on ice. From such data is possible to locate the substratum and also to distinguish some structures on it. It is known that marine terrace sediments are present beneath the glacier, so a potential aquifer is there present.



Surveyed transect on Hansbreen and Digital Elevation Model of the bottom from data of GPR surveys DEM courtesy of Dr. J. Jania, sept 2009.



The The geographical position of the 19 antennas used for the executed MRS surveys and of the 5 VES, in the UTM (30T) coordinates system is gathered in the following table:

REF.	Date	Location	Configuration Rx/Tx	X (UTM)	Y (UTM)	Z (m)	Observations
MRS a	24 Aug	Horsund polar station, loop E-W	60x30	33513724E	8547178N	2	Single loop
MRS b	25 Aug	Horsund polar station, permafrost	30x30	33513724E	8547178N	2	two antennas 60x60 Diods box
MRS 1	28 Aug	Hansbreen front, ice measurement	30x30	33515031E	8548689N	15	two turns loop
MRS 2	28 Aug	Hansbreen front, loop on ice	60x60	33515031E	8548689N	15	Single loop
MRS 3	1-sept	Hansbreen front, loop on ice	60x60	33514930E	8548733N	25	Single loop
MRS 4	3-sept	Hansbreen front, ice measurements	30x30	33514982E	8548884N	43	two turns loop
MRS 5	4-sept	Hansbreen front, measurement on ice	60x60	33515046E	8548872N	28	Single loop
MRS 6	4-sept	Hansbreen stick 1, loop on crevassed ice	60x60	33515078E	8549020N	53	Single loop
MRS 7	6-sept	Hansbreen stick 1, loop on crevassed ice	90x90	33515078E	8549020N	53	Single loop
MRS 8	6-sept	Hansbreen stick 1b, loop on moulins, dolines	60x60	33515023E	8549712N	95	Single loop
MRS 9	7-sept	Hansbreen stick 1b, dolines	30x30	33515023E	8549712N	95	two turns loop
MRS 10	7-sept	Hansbreen stick 1b, dolines on ice	90x90	33515023E	8549712N	95	Single loop
MRS 11	7-sept	Hansbreen stick 1b, dolines on ice	120x120	33515023E	8549712N	95	Single loop
MRS 12	9-sept	Hansbreen-Tuvbreen	30X30	33515058E	8550089N	118	two turns loop
MRS 13	9-sept	Hansbreen-Tuvbreen	60X60	33515058E	8550089N	118	Single loop
MRS 14	9-sept	Hansbreen-Tuvbreen	90X90	33515058E	8550089N	118	Single loop
MRS 15	9-sept	Hansbreen-Tuvbreen	120X120	33515058E	8550089N	118	Single loop
MRS 16	10-sept	Tuvbreen near Cristal Cave	30X30	33514702E	8550804N	176	two turns loop
MRS 17	10-sept	Tuvbreen near Cristal Cave	60x60	33514702E	8550804N	176	Single loop
MRS 18	10-sept	Tuvbreen near Cristal Cave	90x90	33514702E	8550804N	176	Single loop
MRS 19	10-sept	Tuvbreen near Cristal Cave	120x120	33514702E	8550804N	176	Single loop

**Coordinates in UTM (Datum Europe 79), Magellan GPS 320*

REF.	Date	Location	X (UTM)	Y (UTM)	Z (m)
VES 1a	26 Aug	Hansbreen, Stick 4, resistivity measurement on ice	33515005E	8551986N	179
VES 1b	28 Aug	Hansbreen front, resistivity measurement on ice	33515031E	8548689N	15
VES 1	24 Aug	Horsund polar station, E-W wings, test on permafrost	33516030E	8551348N	171
VES 2?	25 Aug	Horsund polar station, N-S wings, test on bedrock	33513724E	8547178N	0
VES 2	29 Aug	Siedleckivika beach, E-W wings	33515108E	85548688N	0
VES 3	31 Aug	Hansbreen Fuglelberget lateral moraine, N-S wings	33514894E	8548730N	28
VES 4	1-sept	Siedleckivika beach, E-W wings	33515123E	8548717N	0
VES 5	4-sept	Hansbreen Fuglelberget lateral moraine, N-S wings	33514905E	8548887N	37

CONFIGURATION AND PREVIOUS MEASURES

The soundings has been carried out by a Numis Lite[TM] equipment (see http://www.igeotest.fr/RMP/Doc/A.01.MRS-Introduction.pdf) with a receiver square shape antenna. The previous measures that have been considered are the geomagnetic field (measured daily at the polar station) and measure of the electromagnetic noise. The measure of the magnetic susceptibility couldn't be taken (see http://www.igeotest.fr/RMP/Doc/A.03.MRS-Tests%20initial.pdf):

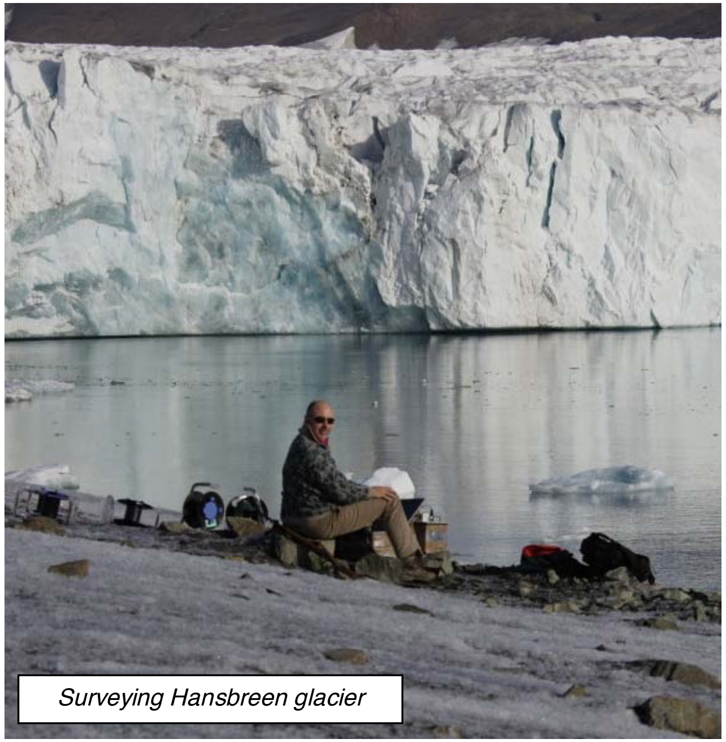
MRS	Latitude X	Longitude Y	Electromagnetic noise (EMN) Square 6 X 6	Square 60 X 60	Slope gradient	Magnetic Susceptibility
1	77º01'03"	15º36'22"	0,22 μV	1 μV	3,81º SE	Not measured
2	77º01'03"	15º36'22"	0,22 μV	1 μV	3,81º SE	Not measured
3	77º01'02"	15º36'08"	0,22 μV	1 μV	3,81º SE	Not measured
4	77º01'09"	15º36'05"	0,07 μV	0,32 μV	4º SE	Not measured
5	77º01'09"	15º36'05"	0,07 μV	0,32 μV	4º SE	Not measured
6	77º01'13"	15º36'18"	0,04 μV	0,20 μV	1º S	Not measured
7	77º01'13"	15º36'18"	0,04 μV	0,20 μV	1º S	Not measured
8	77º01'35"	15º36'11"	0,05 μV	0,23 μV	1º S	Not measured
9	77º01'35"	15º36'11"	0,05 μV	0,23 μV	1º S	Not measured
10	77º01'35"	15º36'11"	0,05 μV	0,23 μV	1º S	Not measured
11	77º01'35"	15º36'11"	0,05 μV	0,23 μV	1º S	Not measured
12	77º01'48"	15º36'17"	0,04 μV	0,20 μV	1º S	Not measured
13	77º01'48"	15º36'17"	0,04 μV	0,20 μV	1º S	Not measured
14	77º01'48"	15º36'17"	0,04 μV	0,20 μV	1º S	Not measured
15	77º01'48"	15º36'17"	0,04 μV	0,20 μV	1º S	Not measured
16	77º02'11"	15º35'27"	0,05 μV	0,23 μV	1º S	Not measured
17	77º02'11"	15º35'27"	0,05 μV	0,23 μV	1º S	Not measured
18	77º02'11"	15º35'27"	0,05 μV	0,23 μV	1º S	Not measured
19	77º02'11"	15º35'27"	0,05 μV	0,23 μV	1º S	Not measured

Geomagnetic field mesured at the HRN Polish Polar Station		
Date:	**Hour**	**Total magnètic field**
29/08/09	17H43	54.384 nT
29/08/09	17H53	54.386 nT
2/09/09	16H28	54.363 nT
2/09/09	16H36	54.355 nT
5/09/09	18H12	54.376 nT
5/09/09	18H20	54.378 nT
09/09/09	18H01	54.396 nT
09/09/09	18H25	54.389 nT
Average	54.378,4 ± 13,64	

Theoretical Regional Geomagnetic field		
Declination	**Inclination**	**Total field**
5,78º	81,56º	54.597 nT

The earth's magnetic regional field can vary depending on latitude and longitude of the location of the MRS. In this case the theoretical earth's magnetic field is around 54.597 nT, that implies a Larmor frequency of 2.326 Hz. However, the earth's magnetic measured field is about 54.378, that implies a Larmor frequency in the study area can vary from 2.315 Hz to 2.317 Hz, distant from the expected regional frequency 10 Hz. Therefore, the variation of the value of earth's magnetic field measured in the surveyed area is about 17 nT, so as the signal quality could be considered as excellent. The earth's magnetic regional field inclination is about 81º56'.

REALIZED SURVEY



Surveying Hansbreen glacier

From august 21st, to September 10th 2009, it has been done 19 NMR soundings (MRS) supported by the Wroclawski University, with the installation of several squared antennas placed on six stations and loops sizes range done were of 30X30 meters (MRS 1, 3, 4, 9, 12&16), 60X60 m (MRS 2, 5, 6, 8,13&17), 90X90 m (MRS 7, 10, 14&18) and 120X120 m (MRS 11, 15&19); reaching depths of 45, 90, 135 and 180 meters. In the case of 30X30 antennas it was necessary to use 2 turns of wire loop in other to increase the circuit inductance (http://www.igeotest.fr/RMP/Doc/A.03.MRS-Tests%20initial.pdf).

The obtained EM noise is very low for a classical configuration of 60X60 Antenna (less than 1000 nV; http://www.igeotest.fr/RMP/Doc/B.04.MRS-Bruit%20EM.pdf). The surface of the glacier don't exceed 4° to the SE and it has been considered that no correction was needed for that topographical anomaly (http://www.igeotest.fr/RMP/Doc/B.02.MRS-Anomalies.pdf).

For that a Numis Lite® device was used from Iris-Instruments and its available software as well (Prodiviner 3.04, Phar Lap's 386, Samovar 6.2). It has been necessary to realise divers testing sounding(s) to try to achieve the best antenna configuration, these ones have been done in august 24th and 25th 2009. Finally, 19 sounding(s) MRS have been executed with a Larmor frequency of 2325,6 (for MRS 1&2), 2312,7 (for MRS 3&5) , 2315,6 (for MRS 9 to 19) and 2317 Hz (for MRS 4, 6, 7&8).

Numis Lite devices

As well five electrical vertical soundings (VES) with an ABEM device (courtesy of the Faculty of Earth Sciences, Silesia University) were done on the glacier margins, but also two resistivity measurements on the inner part of the Hansbreen glacier and the front of the glacier were done. Is important to note that a increasing loop size will integrate signals from different zones that have not been detected in the previous loop, so the average information is less particular and more general; also the accuracy in depth is lesser with large loops than with small ones and only common facies of the water signals can be correlated.

Magnetic Resonance Sounding:

The data (http://www.igeotest.fr/RMP/Doc/A.05.MRS-Inf%20obtenue.pdf) is recorded with Prodiviner software from Iris Instruments

MRS 1

At the magnetic resonance sounding eight excitation pulse moments (q) have been fulfilled, with 72 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a filter of 2000 nV (*stack under noise level*) was applied. Furthermore it has been applied a cutting filter type *(high cut filter)* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/RMP/Doc/B.01.MRS-Interpretation.pdf). We can see how without any signal filtering there is only one of the pulse moments which is without the range of 4 Hz < Δf < -4 Hz, even transmitting at the regional larmor frequency. The amplitude values obtained show a low S/N ratio and the ratio EN/IN (indicative of the quality of the sounding) is too high; owing to that we should consider this value as qualitative and any pulse value could be interpreted as a water signal without a former signal processing.

MRS 1		Auto stack number Weighted average Stack			Stack under noise level High cut filter				Regional Larmor 2325,6 Hz		
N	Moment	Ampl	Noise		Noise ratios		2 Pulse	1 Pulse	Udc	freq	phase
	q	e	Unstack	Stack	S/N	EN/IN	T*2	T*1	Dc/Dc	Hz	
1	102	78,65	593,2	48,7	1,61	9,74	1000	21	5	2312,65	70
2	173	63,87	604	75,5	0,85	15,1	791	20	7	2313,48	180
3	378	20,61	955	56,6	0,36	11,32	1000	37	12	2312,04	219
4	608	75,13	771,3	31,9	2,36	6,38	38	54	18	2310,32	117
5	1037	41,65	735,5	50,6	0,82	10,12	1000	29	29	2312,84	149
6	1665	36,54	661,8	62,7	0,58	12,54	1000	32	45	2311,34	136
7	2610	80,69	869,4	54,5	1,48	10,9	1000	31	70	2312,21	316
8	3811	49,67	830,3	68,7	0,72	13,74	1000	101	109	2321,5	318
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	°

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf

e = Measured signal amplitude (nanovolts) after being stacked and filtered.

S/N = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative.

EN/IN= Instrumental Noise (IN = 5 - 10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1.

T*2 = Decay time constant of the first pulse (single pulse), measured in milliseconds.

T*1 = Decay time constant of the second pulse (double pulse), measured in milliseconds.

Udc = Input voltage range in the loop (V).

freq = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water.

phase = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 2

At the magnetic resonance sounding eight excitation pulse moments (q) have been fulfilled, with 82 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 2000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/Enllacos/index.asp). We can see how without any signal filtering there is only two of the pulse moments which is out of range (4 Hz < Δf < -4 Hz), even trasmitting at the regional larmor frequency. The amplitude values obtained show a low S/N ratio and the ratio EN/IN (indicative of the quality of the sounding) is too high; owing to that we should consider this value as qualitative and any pulse value could be interpreted as a water signal without a former signal processing.

MRS 2		**Auto stack number Weighted average Stack**		**Stack under noise level High cut filter**					**Regional Larmor 2325,6 Hz**		
N	**Moment**	**Ampl**	**Noise**		**Noise ratios**		**2 Pulse**	**1 Pulse**	**Udc**	**freq**	**phase**
	q	**e**	**Unstack**	**Stack**	**S/N**	**EN/IN**	**T*2**	**T*1**	**Dc/Dc**	**Hz**	
1	111	45,3	764,9	15,3	2,96	3,06	296	19	5	2313,51	231
2	201	21,62	917,1	17,3	1,25	3,46	1000	47	7	2312,9	119
3	426	27,89	997,3	43	0,65	8,6	368	48	12	2313,96	283
4	680	33,11	900,1	29,9	1,11	5,98	1000	54	18	2312,41	302
5	1156	19,14	893,1	46,5	0,41	9,3	1000	85	29	2337,55	252
6	1850	60,07	968,5	24,8	2,42	4,96	487	34	45	2313,05	252
7	2831	12,05	978,3	16	0,75	3,2	1000	60	70	2322,25	328
8	4138	30,55	845,9	33,8	0,90	6,76	1000	35	109	2313,02	295
	A ms	**nV**	**nV**	**nV**	**(>2)**	**(≈1)**	**ms**	**ms**	**V**	**Δf < 4 Hz**	**°**

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf
e = Measured signal amplitude (nanovolts) after being stacked and filtered.
S/N = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative.
EN/IN= Instrumental Noise (IN = 10 - 5 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1.
T*2 = Decay time constant of the first pulse (single pulse), measured in milliseconds.
T*1 = Decay time constant of the second pulse (double pulse), measured in milliseconds.
Udc = Input voltage range in the loop (V).
freq = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water.
phase = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 3

At the magnetic resonance sounding eight excitation pulse moments (q) have been fulfilled, with 22 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 2000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/RMP/Doc/B.01.MRS-Interpretation.pdf). We can see how without any signal filtering nearly all the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio in the majority of the values and the ratio EN/IN (indicative of the quality of the sounding) is too high except in two values; owing to that we should consider this value as semi-quantitative.

MRS 3		Auto stack number Weighted average Stack	Stack under noise level High cut filter						Local Larmor 2312,7 Hz		
N	Moment	Ampl	Noise		Noise ratios		2 Pulse	1 Pulse	Udc	freq	phase
	q	e	Unstack	Stack	S/N	EN/IN	T*2	T*1	Dc/Dc	Hz	
1	95	35,02	190,5	24,2	1,45	4,84	1000	38	5	2311,89	14
2	179	35,7	189,8	23,7	1,51	4,74	335	21	7	2312,44	321
3	390	45,26	207,1	43,1	1,05	8,62	188	18	12	2302,83	238
4	625	12,1	245,6	20,8	0,58	4,16	1000	23	18	2309,08	116
5	1065	25,31	238,3	7,4	3,42	1,48	366	26	29	2312,7	112
6	1706	8,94	226,3	9,6	0,93	1,92	1000	14	45	2308,84	252
7	2654	13,82	199,1	18,9	0,73	3,78	293	13	70	2309,34	157
8	3850	12,8	183,2	11,2	1,14	2,24	1000	15	109	2320,05	290
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	º

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre Numis.pdf
e = Measured signal amplitude (nanovolts) after being stacked and filtered.
S/N = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative.
EN/IN= Instrumental Noise (IN =5 - 10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1.
T*2 = Decay time constant of the first pulse (single pulse), measured in milliseconds.
T*1 = Decay time constant of the second pulse (double pulse), measured in milliseconds.
Udc = Input voltage range in the loop (V).
freq = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water.
phase = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 4

At the magnetic resonance sounding twelve excitation pulse moments (q) have been fulfilled, with 22 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 2000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/Enllacos/index.asp). We can see how without any signal filtering nearly all the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio in the majority of the values and the ratio EN/IN (indicative of the quality of the sounding) is too high except in one value; owing to that we should consider this value as semi-quantitative.

MRS 4		Auto stack number Weighted average Stack			Stack under noise level High cut filter				Regional – Local Larmor 2317 Hz		
N	Moment q	Ampl e	Noise Unstack	Noise Stack	Noise ratios S/N	Noise ratios EN/IN	2 Pulse T*2	1 Pulse T*1	Udc Dc/Dc	freq Hz	phase
1	103	15,62	233,6	15,7	0,99	3,14	1000	14	5	2325,21	3
2	123	28,36	222	31,2	0,91	6,24	1000	17	5	2303,88	76
3	205	18,05	239,2	18,6	0,97	3,72	1000	12	7	2306,08	10
4	333	28,53	237,7	15,1	1,89	3,02	629	37	11	2306,32	73
5	485	16,3	246,2	34,6	0,47	6,92	1000	69	14	2320,48	286
6	685	55,83	249,3	20,6	2,71	4,12	518	31	20	2312,45	4
7	961	7,46	184,7	40,9	0,18	8,18	1000	26	27	2312,57	252
8	1287	20,65	194,8	55,4	0,37	11,08	1000	45	35	2314,56	120
9	1744	43,39	202,3	29,9	1,45	5,98	185	31	47	2312,78	348
10	2334	19,47	192,3	34	0,57	6,8	1000	74	62	2312,6	5
11	3044	18,77	195,8	18,5	1,01	3,7	483	38	83	2320,5	328
12	3814	20,78	182,7	9	2,31	1,8	1000	17	109	2319,78	39
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	º

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf
e = Measured signal amplitude (nanovolts) after being stacked and filtered.
S/N = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative.
EN/IN= Instrumental Noise (IN =5 - 10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1.
T*2 = Decay time constant of the first pulse (single pulse), measured in milliseconds.
T*1 = Decay time constant of the second pulse (double pulse), measured in milliseconds.
Udc = Input voltage range in the loop (V).
freq = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water.
phase = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 5

At the magnetic resonance sounding twelve excitation pulse moments (q) have been fulfilled, with 34 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 2000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/RMP/Doc/B.01.MRS-Interpretation.pdf). We can see how without any signal filtering, half of the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio except in five value which present a good S/N ratio. Moreover, the ratio EN/IN (indicative of the quality of the sounding) is too high except in three values; owing to that we should consider this value as semi-quantitative.

MRS 5		Auto stack number Weighted average Stack		Stack under noise level High cut filter				Local Larmor 2312,7 Hz		
N	Moment	Ampl	Noise		Noise ratios		2 Pulse	1 Pulse	Udc	freq	phase
	q	e	Unstack	Stack	S/N	EN/IN	T*2	T*1	Dc/Dc	Hz	
1	104	18,69	287,8	8,4	2,23	1,68	1000	14	5	2304,48	294
2	140	9,1	317,9	21	0,43	4,2	1000	19	5	2316,12	341
3	217	51,44	306,4	15,8	3,26	3,16	132	11	8	2308,8	81
4	340	24,27	307,7	10,4	2,33	2,08	338	17	11	2318,06	112
5	487	36,47	319,8	53,9	0,68	10,78	29	8	14	2320,97	67
6	684	7,98	321,8	24	0,33	4,8	989	8	20	2316,24	261
7	959	36,77	314,7	15,5	2,37	3,1	141	23	27	2305,82	254
8	1273	18,06	294,8	16,4	1,10	3,28	454	15	35	2315,98	31
9	1707	19,78	295,5	8,9	2,22	1,78	1000	37	47	2318,38	309
10	2221	15,99	320,5	9	1,78	1,8	1000	17	62	2321,54	259
11	2869	16,62	303,8	27,8	0,60	5,56	1000	17	82	2316,39	356
12	3651	15,67	317,9	19	0,82	3,8	1000	12	109	2309,82	323
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	°

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre Numis.pdf
e = Measured signal amplitude (nanovolts) after being stacked and filtered.
S/N = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative.
EN/IN= Instrumental Noise (IN = 5 - 10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1.
T*2 = Decay time constant of the first pulse (single pulse), measured in milliseconds.
T*1 = Decay time constant of the second pulse (double pulse), measured in milliseconds.
Udc = Input voltage range in the loop (V).
freq = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water.
phase = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 6

At the magnetic resonance sounding twelve excitation pulse moments (q) have been fulfilled, with 20 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/Enllacos/index.asp). We can see how without any signal filtering, half of the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio but three moments present a good S/N ratio. And the ratio EN/IN (indicative of the quality of the sounding) is too high for nearly all the values; owing to that we should consider this value as semi-quantitative.

MRS 6		Auto stack number Weighted average Stack			Stack under noise level High cut filter				Larmor 2317 Hz		
N	Moment	Ampl	Noise		Noise ratios		2 Pulse	1 Pulse	Udc	freq	phase
	q	e	Unstack	Stack	S/N	EN/IN	T*2	T*1	Dc/Dc	Hz	
1	107	12,47	186,5	25,5	0,49	5,1	1000	14	4	2313,6	189
2	144	21,5	189,7	14,3	1,50	2,86	1000	21	5	2305,24	165
3	230	25,02	181,6	10,9	2,30	2,18	297	14	7	2320,24	182
4	366	60,21	203,5	26,8	2,25	5,36	1000	39	11	2309,41	66
5	531	24,1	188,1	47,9	0,50	9,58	528	37	15	2308,09	298
6	746	23,47	196,2	9,7	2,42	1,94	1000	23	20	2312,14	120
7	1046	29,72	176,4	52,3	0,57	10,46	116	40	27	2310,55	27
8	1396	8,3	198,6	15,4	0,54	3,08	1000	41	35	2306,1	173
9	1890	26,98	188,5	14,7	1,84	2,94	272	8	47	2313,64	115
10	2508	31,63	181,6	16	1,98	3,2	133	33	62	2312,54	40
11	3242	20,79	172,3	19,3	1,08	3,86	691	10	82	2323,93	208
12	4091	18,77	203,1	13,6	1,38	2,72	1000	48	109	2313,82	119
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	º

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf

e = Measured signal amplitude (nanovolts) after being stacked and filtered.

S/N = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative.

EN/IN= Instrumental Noise (IN = 5 - 10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1.

T*2 = Decay time constant of the first pulse (single pulse), measured in milliseconds.

T*1 = Decay time constant of the second pulse (double pulse), measured in milliseconds.

Udc = Input voltage range in the loop (V).

freq = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water.

phase = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 7

MRS 7		Stack Auto/average			Stack under/High cut filter				Larmor 2317 Hz		
N	Moment q	Ampl e	Noise Unstack	Noise Stack	Noise ratios S/N	Noise ratios EN/IN	2 Pulse T*2	1 Pulse T*1	Udc Dc/Dc	freq Hz	phase
1	100	66,97	456,7	24,6	2,72	4,92	1000	17	5	2313,03	171
2	133	11,42	528,9	18,9	0,60	3,78	1000	13	5	2313,96	165
3	177	31,21	452,7	33,6	0,93	6,72	1000	15	7	2324,23	228
4	253	19,8	465,4	31,2	0,63	6,24	1000	23	9	2325,1	328
5	326	60,3	465,4	43,8	1,38	8,76	280	13	11	2325,17	163
6	441	30,12	472,8	9,6	3,14	1,92	389	34	14	2328,33	54
7	543	16,51	463,4	28,1	0,59	5,62	1000	16	16	2310,98	105
8	703	40,06	447,4	39,5	1,01	7,9	59	21	21	2328,88	0
9	877	64,06	470,1	34,7	1,85	6,94	475	46	26	2326,86	8
10	1111	22,04	464,7	21	1,05	4,2	259	18	32	2320,19	70
11	1367	26,97	454	27,6	0,98	5,52	997	57	39	2332,3	104
12	1680	8,32	469,4	45,5	0,18	9,1	1000	19	48	2330,25	265
13	2035	28,08	447,4	27,5	1,02	5,5	1000	33	59	2316,73	46
14	2426	31,86	462,1	14,8	2,15	2,96	270	10	72	2329,26	217
15	2919	14,83	464,7	27,4	0,54	5,48	565	24	89	2316,52	62
16	3167	42,94	490,1	14,6	2,94	2,92	1000	10	109	2330	289
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	º

At the magnetic resonance sounding sixteen excitation pulse moments (q) have been fulfilled, with 50 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 2000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/Enllacos/index.asp). We can see how without any signal filtering, only five of the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio except for four values that present a good S/N ratio. And the ratio EN/IN (indicative of the quality of the sounding) is too high for nearly all the values; owing to that we should consider this value as qualitative.

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf / **e =** Measured signal amplitude (nanovolts) after being stacked and filtered./ **S/N =** Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative. / **EN/IN=** Instrumental Noise (IN = 10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1. / **T*2 =** Decay time constant of the first pulse (single pulse), measured in milliseconds./ **T*1 =** Decay time constant of the second pulse (double pulse), measured in milliseconds. / **Udc =** Input voltage range in the loop (V). / **freq =** Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water. / **phase =** The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 8

At the magnetic resonance sounding twelve excitation pulse moments (q) have been fulfilled, with 22 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a cutting filter type *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/RMP/Doc/B.01.MRS-Interpretation.pdf). We can see how without any signal filtering, only three of the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio in nearly all the values. And the ratio EN/IN (indicative of the quality of the sounding) is too high for all the values except three of them; owing to that we should consider this value as qualitative.

MRS 8		Auto stack number Weighted average Stk	Stack under noise level High cut filter						Larmor 2317 Hz		
N	Moment q	Ampl e	Noise Unstack	Stack	Noise ratios S/N	EN/IN	2 Pulse T*2	1 Pulse T*1	Udc Dc/Dc	freq Hz	phase
1	106	21,24	213	16,7	1,27	3,34	734	7	5	2312,88	109
2	145	11,91	208,9	9,3	1,28	1,86	1000	14	5	2325,1	34
3	233	21,64	204,9	5,8	3,73	1,16	331	16	7	2311,71	210
4	373	8,89	231,8	7,9	1,13	1,58	1000	35	11	2302,34	114
5	539	12,09	224,9	23,7	0,51	4,74	1000	33	15	2320,95	216
6	757	12,61	228,9	12,3	1,03	2,46	186	57	20	2323,56	323
7	1064	28,53	231	14,6	1,95	2,92	420	32	27	2300,83	112
8	1419	27,59	212,6	37,3	0,74	7,46	1000	12	35	2302,94	331
9	1921	20,47	213,4	15,2	1,35	3,04	1000	17	47	2301,26	172
10	2538	21,27	216,7	25,8	0,82	5,16	1000	21	62	2305,74	314
11	3272	6,44	226,1	18,2	0,35	3,64	1000	32	83	2328,28	346
12	4128	12,34	211	20,8	0,59	4,16	1000	19	109	2317,88	137
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	°

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf
e = Measured signal amplitude (nanovolts) after being stacked and filtered.
S/N = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative.
EN/IN= Instrumental Noise (IN =5 - 10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1.
T*2 = Decay time constant of the first pulse (single pulse), measured in milliseconds.
T*1 = Decay time constant of the second pulse (double pulse), measured in milliseconds.
Udc = Input voltage range in the loop (V).
freq = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water.
phase = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 9

At the magnetic resonance sounding eight excitation pulse moments (q) have been fulfilled, with 16 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/Enllacos/index.asp). We can see how without any signal filtering half of the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio in all the values and the ratio EN/IN (indicative of the quality of the sounding) is too high except in two values; owing to that we should consider this value as qualitative.

MRS 9		Auto stack number Weighted average Stack			Stack under noise level High cut filter				Larmor 2315,6 Hz		
N	Moment	Ampl	Noise		Noise ratios		2 Pulse	1 Pulse	Udc	freq	phase
	q	e	Unstack	Stack	S/N	EN/IN	T*2	T*1	Dc/Dc	Hz	
1	121	13,39	121,5	11,7	1,14	2,34	1000	40	5	2312,56	208
2	209	15,36	127,3	9,8	1,57	1,96	187	15	7	2323,93	216
3	429	24,27	122	20,6	1,18	4,12	1000	10	12	2325,37	284
4	682	9,34	113,9	8,4	1,11	1,68	638	18	18	2328,08	49
5	1155	12,03	116,8	10,6	1,13	2,12	570	19	29	2318,86	33
6	1813	18,53	120,9	22,3	0,83	4,46	219	19	45	2321,75	35
7	2746	8,37	118,5	17,4	0,48	3,48	1000	16	70	2317,01	155
8	4109	8,01	132,5	23,1	0,35	4,62	1000	12	109	2312,58	321
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	º

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf
e = Measured signal amplitude (nanovolts) after being stacked and filtered.
S/N = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative.
EN/IN= Instrumental Noise (IN = 5-10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1.
T*2 = Decay time constant of the first pulse (single pulse), measured in milliseconds.
T*1 = Decay time constant of the second pulse (double pulse), measured in milliseconds.
Udc = Input voltage range in the loop (V).
freq = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water.
phase = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 10

MRS 10		Stack Auto/average			Stack under/High cut filter				Larmor 2315,6 Hz		
N	Moment q	Ampl e	Noise Unstack	Stack	Noise ratios S/N	EN/IN	2 Pulse T*2	1 Pulse T*1	Udc Dc/Dc	freq Hz	phase
1	99	12,32	255,5	13	0,95	2,6	1000	10	5	2319,02	250
2	131	18,62	239,1	9,6	1,94	1,92	1000	9	5	2318,47	71
3	176	5,92	242,2	12	0,49	2,4	1000	24	7	2309,54	214
4	252	14,62	220,4	16,1	0,91	3,22	1000	13	9	2312,44	312
5	324	18,62	228,6	8,3	2,24	1,66	70	9	11	2315,5	31
6	440	8,05	225,5	9,5	0,85	1,9	1000	18	14	2307,75	340
7	542	10,77	230,2	15,5	0,69	3,1	174	11	16	2319,08	198
8	698	21,44	228,6	16,9	1,27	3,38	173	8	21	2308,01	321
9	874	10,05	232,9	18,1	0,56	3,62	659	17	25	2312,79	313
10	1104	14,43	234,8	20,4	0,71	4,08	1000	28	32	2320,36	155
11	1362	8,48	234,4	24,3	0,35	4,86	305	17	39	2323,12	196
12	1673	19,8	235,6	7,8	2,54	1,56	51	16	48	2303,84	37
13	2027	20,77	238,3	19,3	1,08	3,86	144	19	59	2318,23	135
14	2417	11,1	237,9	10,6	1,05	2,12	1000	16	72	2308,49	145
15	2908	12,06	243	35,3	0,34	7,06	1000	11	89	2315,43	60
16	3152	11,16	240,3	5,8	1,92	1,16	532	12	109	2318,98	169
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	º

At the magnetic resonance sounding sixteen excitation pulse moments (q) have been fulfilled, with 24 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/Enllacos/index.asp). We can see how without any signal filtering, more than half of the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio except for two pulses which present a good S/N ratio. And the ratio EN/IN (indicative of the quality of the sounding) is good for three of the values; owing to that we should consider this value as semi-quantitative.

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf / **e =** Measured signal amplitude (nanovolts) after being stacked and filtered./ **S/N =** Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative. / **EN/IN=** Instrumental Noise (IN = 5-10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1. / **T*2 =** Decay time constant of the first pulse (single pulse), measured in milliseconds./ **T*1 =** Decay time constant of the second pulse (double pulse), measured in milliseconds. / **Udc =** Input voltage range in the loop (V). / **freq =** Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water. / **phase =** The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 11

MRS 11	Stack Auto/average				Stack under/High cut filter				Larmor 2315,6 Hz		
N	Mom	Ampl	Noise		Noise ratios		2 Pulse	1 Pulse	Udc	freq	ph
	q	e	Unstk	Stk	S/N	EN/IN	T*2	T*1	Dc/Dc	Hz	
1	85	11,16	425,2	16,2	0,69	3,24	1000	16	5	2304,44	293
2	86	6,13	419,9	8,5	0,72	1,7	1000	19	5	2318,29	68
3	111	26,32	442,6	8,7	3,03	1,74	151	13	6	2312,51	333
4	170	11,38	443,3	13,6	0,84	2,72	1000	35	8	2311,41	81
5	206	14,13	400,5	9,9	1,43	1,98	1000	13	9	2330,67	171
6	265	5,66	425,5	15,4	0,37	3,08	1000	54	11	2311,84	78
7	324	14,21	439,2	12,7	1,12	2,54	1000	15	13	2313,53	78
8	381	12,83	424,4	12,2	1,05	2,44	736	29	15	2311,6	193
9	475	18,94	422,1	10,4	1,82	2,08	105	20	18	2311,27	65
10	568	15,18	412,3	14,5	1,05	2,9	777	19	21	2306,04	198
11	651	16,35	444,1	12,8	1,28	2,56	314	16	24	2312,37	20
12	801	19,23	407,4	9,5	2,02	1,9	265	5	29	2312,29	264
13	950	31,86	419,1	17,1	1,86	3,42	466	23	34	2311,39	345
14	1118	8,02	425,2	5,5	1,46	1,1	734	6	40	2314,41	18
15	1315	5,79	440,7	39,2	0,15	7,84	1000	13	47	2319,86	63
16	1537	17,51	426,7	18,7	0,94	3,74	1000	13	55	2318,71	132
17	1807	20,03	424,4	13,4	1,49	2,68	147	12	66	2312,53	56
18	2083	31,11	413,8	19,4	1,60	3,88	132	30	77	2312,32	69
19	2430	18,05	421,7	23,4	0,77	4,68	1000	14	91	2311,84	13
20	2809	9,42	427	10,1	0,93	2,02	1000	18	107	2304,48	303
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	°

At the magnetic resonance sounding twenty excitation pulse moments (q) have been fulfilled, with 42 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/Enllacos/index.asp). We can see how without any signal filtering, nearly all the pulse moments (except: q1, q5, q10 and q20) are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio except for two moments which present a good S/N ratio. And the ratio EN/IN (indicative of the quality of the sounding) is good for five of the values; owing to that we should consider this value as semi-quantitative.

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf / **e** = Measured signal amplitude (nanovolts) after being stacked and filtered./ **S/N** = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative. / **EN/IN**= Instrumental Noise (IN = 5-10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1. / **T*2** = Decay time constant of the first pulse (single pulse), measured in milliseconds./ **T*1** = Decay time constant of the second pulse (double pulse), measured in milliseconds. / **Udc** = Input voltage range in the loop (V). / **freq** = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water. / **phase** = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 12

At the magnetic resonance sounding eight excitation pulse moments (q) have been fulfilled, with 16 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/RMP/Doc/B.01.MRS-Interpretation.pdf). We can see how without any signal filtering all the pulse moments, except two of them, are out of the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio in the majority of the values. However the ratio EN/IN (indicative of the quality of the sounding) is very good, except in two values; owing to that we should consider this value as semi-quantitative.

MRS 12		Auto stack number Weighted average Stack			Stack under noise level High cut filter				Larmor 2315,6 Hz		
N	**Moment**	**Ampl**	**Noise**		**Noise ratios**		**2 Pulse**	**1 Pulse**	**Udc**	**freq**	**phase**
	q	**e**	**Unstack**	**Stack**	**S/N**	**EN/IN**	**T*2**	**T*1**	**Dc/Dc**	**Hz**	
1	124	11,47	152,9	13,5	0,85	2,7	1000	22	5	2306,83	306
2	208	31,26	154,6	10,8	2,89	2,16	10	8	7	2327,48	218
3	428	6,96	157,9	8,3	0,84	1,66	1000	4	12	2312,46	335
4	675	11,16	155,7	8,4	1,33	1,68	104	4	18	2328,53	107
5	1139	18,23	165,1	8	2,28	1,6	165	6	29	2319	99
6	1793	4,31	141,3	9,3	0,46	1,86	1000	7	45	2303,46	294
7	2726	5,98	140,7	5,6	1,07	1,12	1000	6	70	2320,75	66
8	4117	9,38	159,6	6,8	1,38	1,36	1000	10	109	2320,68	122
	A ms	**nV**	**nV**	**nV**	**(>2)**	**(≈1)**	**ms**	**ms**	**V**	**Δf < 4 Hz**	**º**

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf
e = Measured signal amplitude (nanovolts) after being stacked and filtered.
S/N = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative.
EN/IN= Instrumental Noise (IN = 5-10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1.
T*2 = Decay time constant of the first pulse (single pulse), measured in milliseconds.
T*1 = Decay time constant of the second pulse (double pulse), measured in milliseconds.
Udc = Input voltage range in the loop (V).
freq = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water.
phase = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 13

At the magnetic resonance sounding twelve excitation pulse moments (q) have been fulfilled, with 16 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/RMP/Doc/B.01.MRS-Interpretation.pdf). We can see how without any signal filtering, only four of the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio in nearly all the values (except q1 and q7). And the ratio EN/IN (indicative of the quality of the sounding) is too high for all the values except (q6 and q12); owing to that we should consider this value as qualitative.

MRS 13		Auto stack number Weighted average Stk			Stack under noise level High cut filter				Larmor 2315,6 Hz		
N	**Moment q**	**Ampl e**	**Noise Unstack**	**Noise Stack**	**Noise ratios S/N**	**Noise ratios EN/IN**	**2 Pulse T*2**	**1 Pulse T*1**	**Udc Dc/Dc**	**freq Hz**	**phase**
1	109	38,52	200,3	12,1	3,18	2,42	10	9	5	2304,24	109
2	147	10,5	189	10,9	0,96	2,18	1000	22	5	2324,8	247
3	234	11,56	183,4	10,2	1,13	2,04	1000	10	7	2313,28	302
4	372	6,41	157,2	52,7	0,12	10,54	1000	11	11	2312,89	254
5	536	9,63	157,9	23,7	0,41	4,74	1000	13	15	2321,34	147
6	756	12,09	164,9	7,4	1,63	1,48	1000	15	20	2320,24	349
7	1060	30,41	169,9	15,2	2,00	3,04	63	11	27	2327,46	269
8	1410	5,28	167,8	12,9	0,41	2,58	1000	10	35	2304,51	254
9	1908	8,63	152,2	11,9	0,73	2,38	1000	10	46	2320,92	6
10	2530	9,88	162,8	12,3	0,80	2,46	820	8	62	2326,35	99
11	3264	14,17	162,8	10,5	1,35	2,1	1000	7	83	2315,33	7
12	4125	10,05	155,7	9,6	1,05	1,92	1000	13	109	2311,55	197
	A ms	**nV**	**nV**	**nV**	**(>2)**	**(≈1)**	**ms**	**ms**	**V**	**Δf < 4 Hz**	**°**

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf

e = Measured signal amplitude (nanovolts) after being stacked and filtered.

S/N = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative.

EN/IN= Instrumental Noise (IN = 5-10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1.

T*2 = Decay time constant of the first pulse (single pulse), measured in milliseconds.

T*1 = Decay time constant of the second pulse (double pulse), measured in milliseconds.

Udc = Input voltage range in the loop (V).

freq = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water.

phase = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 14

MRS 14			Stack Auto/average		Stack under/High cut filter				Larmor 2315,6 Hz		
N	**Moment q**	**Ampl e**	**Noise Unstack**	**Stack**	**Noise ratios S/N**	**EN/IN**	**2 Pulse T*2**	**1 Pulse T*1**	**Udc Dc/Dc**	**freq Hz**	**phase**
1	103	25,58	172,9	8,5	3,01	1,7	161	6	5	2313,03	27
2	136	10,23	178,4	12,6	0,81	2,52	1000	16	5	2313,96	233
3	180	11,91	187,3	8,4	1,42	1,68	242	9	7	2324,23	185
4	254	17,25	173,6	6,5	2,65	1,3	251	10	9	2325,1	180
5	327	11,11	176,4	15,3	0,73	3,06	1000	25	11	2325,17	74
6	442	9,6	177,7	19,8	0,48	3,96	1000	6	14	2328,33	4
7	545	7,36	183,9	16,2	0,45	3,24	1000	7	16	2310,98	199
8	705	21,03	186,6	6	3,51	1,2	84	7	21	2328,88	43
9	880	12,82	183,9	16,6	0,77	3,32	1000	15	26	2326,86	341
10	1111	10,68	190	9	1,19	1,8	1000	10	32	2320,19	221
11	1367	10,83	175,7	23	0,47	4,6	362	11	39	2332,3	19
12	1681	36,49	191,4	7,7	4,74	1,54	78	6	48	2330,25	44
13	2035	17,43	174,3	12,1	1,44	2,42	1000	29	59	2316,73	22
14	2429	17,32	180,5	8,6	2,01	1,72	130	31	72	2329,26	359
15	2918	11,44	190	6,6	1,73	1,32	367	15	89	2316,52	346
16	3137	11,86	167,5	7,5	1,58	1,5	1000	6	109	2330	253
	A ms	**nV**	**nV**	**nV**	**(>2)**	**(≈1)**	**ms**	**ms**	**V**	**Δf < 4 Hz**	**°**

At the magnetic resonance sounding sixteen excitation pulse moments (q) have been fulfilled, with 16 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/Enllacos/index.asp). We can see how without any signal filtering, the third part of the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio except for five moments which present a good S/N ratio. And the ratio EN/IN (indicative of the quality of the sounding) is good for more than a half of the values; owing to that we should consider this value as semi-quantitative.

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf / **e** = Measured signal amplitude (nanovolts) after being stacked and filtered./ **S/N** = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative. / **EN/IN**= Instrumental Noise (IN =5-10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1. / **T*2** = Decay time constant of the first pulse (single pulse), measured in milliseconds./ **T*1** = Decay time constant of the second pulse (double pulse), measured in milliseconds. / **Udc** = Input voltage range in the loop (V). / **freq** = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be ∆f = ± 2 Hz. In case that this difference is greater, the signal detected is not water. / **phase** = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 15

MRS 15	Stack Auto/average				Stack under/High cut filter				Larmor 2315,6 Hz		
N	Mom	Ampl	Noise		Noise ratios		2 Pulse	1 Pulse	Udc	freq	ph
	q	e	Unstk	Stk	S/N	EN/IN	T*2	T*1	Dc/Dc	Hz	
1	86	9,38	238	15,7	0,60	3,14	1000	9	5	2311,96	81
2	112	24,28	249,7	31,6	0,77	6,32	1000	19	6	2318,6	214
3	146	16,61	207,3	22,4	0,74	4,48	167	19	7	2320,51	318
4	171	19,81	223,9	7,3	2,71	1,46	1000	10	7	2312,05	6
5	241	15,53	234,9	23,6	0,66	4,72	1000	16	11	2312,01	265
6	299	14,59	244,1	7,5	1,95	1,5	1000	13	12	2320,49	182
7	356	10,72	238	5,4	1,99	1,08	1000	11	14	2316,77	86
8	436	10,65	209,8	8,1	1,31	1,62	1000	21	17	2320,06	163
9	561	8,59	184,6	23,3	0,37	4,66	692	10	21	2322,4	92
10	677	11,38	198,1	6,7	1,70	1,34	1000	7	25	2323,51	298
11	826	12,88	174,8	7,6	1,69	1,52	108	14	30	2304,12	234
12	972	13,87	185,9	9,2	1,51	1,84	1000	27	35	2312,1	301
13	1195	23,8	193,8	5,3	4,49	1,06	180	17	43	2318,84	106
14	1409	9,39	165,6	15,9	0,59	3,18	1000	10	51	2315,26	29
15	1670	16,92	195,7	11	1,54	2,2	200	9	61	2314,24	16
16	1970	7,13	188,3	6,1	1,17	1,22	1000	11	73	2307,77	304
17	2328	29,1	247,2	5	5,82	1	154	7	87	2314,4	10
18	2729	18,69	186,5	18,3	1,02	3,66	514	10	104	2314,67	54
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	°

At the magnetic resonance sounding eighteen excitation pulse moments (q) have been fulfilled, with 20 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/Enllacos/index.asp). We can see how without any signal filtering, more than a half of the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio except for three moments which present a good S/N ratio. However, the ratio EN/IN (indicative of the quality of the sounding) is good for more than a half of the values; owing to that we should consider this value as semi-quantitative.

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf / **e =** Measured signal amplitude (nanovolts) after being stacked and filtered./ **S/N =** Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative. / **EN/IN=** Instrumental Noise (IN = 5-10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1. / **T*2 =** Decay time constant of the first pulse (single pulse), measured in milliseconds./ **T*1 =** Decay time constant of the second pulse (double pulse), measured in milliseconds. / **Udc =** Input voltage range in the loop (V). / **freq =** Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water. / **phase =** The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 16

At the magnetic resonance sounding eight excitation pulse moments (q) have been fulfilled, with 20 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/RMP/Doc/B.01.MRS-Interpretation.pdf). We can see how without any signal filtering nearly all the pulse moments (except two of them) are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio in the majority of the values, and the ratio EN/IN (indicative of the quality of the sounding) is too high, except in two values; owing to that we should consider this value as semi-quantitative.

MRS 16		Auto stack number Weighted average Stack			Stack under noise level High cut filter				Larmor 2315,6 Hz		
N	**Moment**	**Ampl**	**Noise**		**Noise ratios**		**2 Pulse**	**1 Pulse**	**Udc**	**freq**	**phase**
	q	**e**	**Unstack**	**Stack**	**S/N**	**EN/IN**	**T*2**	**T*1**	**Dc/Dc**	**Hz**	
1	122	8,48	210,7	7,5	1,13	1,5	1000	11	4	2316,2	139
2	210	11,2	215,4	46,2	0,24	9,24	528	11	7	2310,86	266
3	436	19,72	195,1	6,8	2,90	1,36	1000	9	12	2311,26	82
4	692	7,14	196,2	15,2	0,47	3,04	1000	9	18	2312,58	310
5	1170	7,9	211,2	17,7	0,45	3,54	1000	16	29	2312,6	216
6	1837	33,77	189,9	21,6	1,56	4,32	146	14	45	2312,2	330
7	2769	12,18	190,4	15,3	0,80	3,06	1000	12	70	2317,27	177
8	4134	13,25	188,9	12,9	1,03	2,58	1000	13	109	2304,37	244
	A ms	**nV**	**nV**	**nV**	**(>2)**	**(≈1)**	**ms**	**ms**	**V**	**Δf < 4 Hz**	**º**

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf
e = Measured signal amplitude (nanovolts) after being stacked and filtered.
S/N = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative.
EN/IN= Instrumental Noise (IN = 5-10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1.
T*2 = Decay time constant of the first pulse (single pulse), measured in milliseconds.
T*1 = Decay time constant of the second pulse (double pulse), measured in milliseconds.
Udc = Input voltage range in the loop (V).
freq = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water.
phase = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 17

At the magnetic resonance sounding twelve excitation pulse moments (q) have been fulfilled, with 20 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/RMP/Doc/B.01.MRS-Interpretation.pdf). We can see how without any signal filtering, more than a half of the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio in nearly all the values. However, the ratio EN/IN (indicative of the quality of the sounding) is too high for all the values except (q3, q5, q10 and q12); owing to that we should consider this value as semi-quantitative.

MRS 17		Auto stack number Weighted average Stk	Stack under noise level High cut filter						Larmor 2315,6 Hz		
N	Moment	Ampl	Noise		Noise ratios		2 Pulse	1 Pulse	Udc	freq	phase
	q	e	Unstack	Stack	S/N	EN/IN	T*2	T*1	Dc/Dc	Hz	
1	108	10,86	212,9	17,2	0,63	3,44	889	14	5	2332,53	217
2	145	9,01	228,3	27,9	0,32	5,58	1000	15	5	2308,18	276
3	234	11,88	207,5	8,2	1,45	1,64	1000	8	8	2324,7	202
4	368	24,36	212,9	22,3	1,09	4,46	164	16	11	2319,89	240
5	537	12,7	228,3	8,2	1,55	1,64	1000	22	15	2324,32	130
6	751	22,51	210,7	10,7	2,10	2,14	183	20	20	2312,48	188
7	1052	24,54	229,2	21,6	1,14	4,32	310	22	27	2312,72	320
8	1405	11,46	220,2	12,4	0,92	2,48	504	10	35	2318,79	233
9	1903	23,79	191,2	15,1	1,58	3,02	1000	11	46	2312,08	8
10	2523	7,81	196,6	6,6	1,18	1,32	1000	21	62	2318,93	135
11	3264	16,87	193,9	20,3	0,83	4,06	1000	16	83	2314,47	3
12	4122	15,61	193,4	9,4	1,66	1,88	1000	11	109	2311,53	194
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	°

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf

e = Measured signal amplitude (nanovolts) after being stacked and filtered.

S/N = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative.

EN/IN= Instrumental Noise (IN = 5-10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1.

T*2 = Decay time constant of the first pulse (single pulse), measured in milliseconds.

T*1 = Decay time constant of the second pulse (double pulse), measured in milliseconds.

Udc = Input voltage range in the loop (V).

freq = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water.

phase = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 18

MRS 18		Stack Auto/average			Stack under/High cut filter				Larmor 2315,6 Hz		
N	**Moment q**	**Ampl e**	**Noise Unstack**	**Noise Stack**	**Noise ratios S/N**	**Noise ratios EN/IN**	**2 Pulse T*2**	**1 Pulse T*1**	**Udc Dc/Dc**	**freq Hz**	**phase**
1	102	24,2	180,4	11,5	2,10	2,3	1000	16	5	2310,72	9
2	136	16,07	157,9	7,7	2,09	1,54	94	11	6	2326,36	168
3	180	6,07	172,6	12,3	0,49	2,46	1000	29	7	2301,23	14
4	255	9,22	188,5	15	0,61	3	1000	24	9	2310,09	183
5	328	18,91	161	35,6	0,53	7,12	466	13	11	2312,08	273
6	443	16,33	191,6	17,7	0,92	3,54	370	9	14	2319,38	112
7	546	18,36	204	20,2	0,91	4,04	178	12	16	2304,48	83
8	709	14,75	206,8	16,7	0,88	3,34	1000	7	21	2311,79	316
9	885	6,13	197,1	10,8	0,57	2,16	1000	13	26	2330,02	355
10	1119	52,37	198,6	9,5	5,51	1,9	110	6	32	2318,93	335
11	1376	14,6	196,7	9,1	1,60	1,82	1000	20	39	2309,16	104
12	1688	13,7	258,3	38,6	0,35	7,72	1000	5	48	2312,77	280
13	2039	23,59	255,2	10,4	2,27	2,08	107	13	59	2314,81	34
14	2431	51,79	227,7	5	10,36	1	20	12	72	2323,05	12
15	2923	12,28	239,3	5,9	2,08	1,18	1000	9	89	2310,47	106
16	3152	16,47	247,5	4,2	3,92	0,84	112	10	109	2311,08	350
	A ms	**nV**	**nV**	**nV**	**(>2)**	**(≈1)**	**ms**	**ms**	**V**	**Δf < 4 Hz**	**º**

At the magnetic resonance sounding sixteen excitation pulse moments (q) have been fulfilled, with 18 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/Enllacos/index.asp). We can see how without any signal filtering, only the third part of the pulse moments are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a good S/N ratio in nearly the half of the values, and the ratio EN/IN (indicative of the quality of the sounding) is as well good for nearly the half of the values; owing to that we should consider this value as quantitative.

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf / **e** = Measured signal amplitude (nanovolts) after being stacked and filtered./ **S/N** = Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative. / **EN/IN**= Instrumental Noise (IN = 5-10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1. / **T*2** = Decay time constant of the first pulse (single pulse), measured in milliseconds./ **T*1** = Decay time constant of the second pulse (double pulse), measured in milliseconds. / **Udc** = Input voltage range in the loop (V). / **freq** = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water. / **phase** = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

MRS 19

MRS 19	Stack Auto/average				Stack under/High cut filter				Larmor 2315,6 Hz		
N	Mom	Ampl	Noise		Noise ratios		2 Pulse	1 Pulse	Udc	freq	ph
	q	e	Unstk	Stk	S/N	EN/IN	T*2	T*1	Dc/Dc	Hz	
1	86	28,25	185,9	11,3	2,50	2,26	163	17	5	2311,05	78
2	86	10,61	223,2	25,5	0,42	5,1	1000	28	5	2311,82	145
3	111	24,63	188,8	12,3	2,00	2,46	1000	21	5	2312,41	4
4	170	10,36	195,2	13,5	0,77	2,7	1000	16	8	2311,89	279
5	205	32,94	206	6	5,49	1,2	30	21	9	2303,82	341
6	265	9,27	203,8	21,1	0,44	4,22	1000	11	11	2319,6	72
7	324	40,63	200,3	33,8	1,20	6,76	921	21	13	2312,43	186
8	382	14,33	200,3	6,9	2,08	1,38	671	9	15	2313,3	312
9	477	10,14	226,8	49,1	0,21	9,82	1000	4	18	2321,8	140
10	572	21,28	211,7	25,3	0,84	5,06	281	12	21	2312,61	64
11	691	12,2	201	33,7	0,36	6,74	1000	11	25	2323,65	27
12	806	17,35	231,1	10	1,74	2	154	11	29	2319,5	73
13	955	16,29	196,7	28,5	0,57	5,7	1000	13	34	2311,93	57
14	1126	28,91	289,3	10,6	2,73	2,12	133	13	40	2314,67	27
15	1322	29,79	257,7	14,7	2,03	2,94	91	20	47	2318,29	81
16	1567	9,29	273,5	38	0,24	7,6	1000	12	56	2312,24	182
17	1838	21,54	257,7	30	0,72	6	1000	25	66	2313,59	313
18	2124	17,53	252,7	15,1	1,16	3,02	425	22	78	2319,5	198
19	2461	27,78	285,7	14	1,98	2,8	211	19	91	2302,47	33
20	2866	30,09	198,1	33,6	0,90	6,72	548	20	109	2312,43	23
	A ms	nV	nV	nV	(>2)	(≈1)	ms	ms	V	Δf < 4 Hz	°

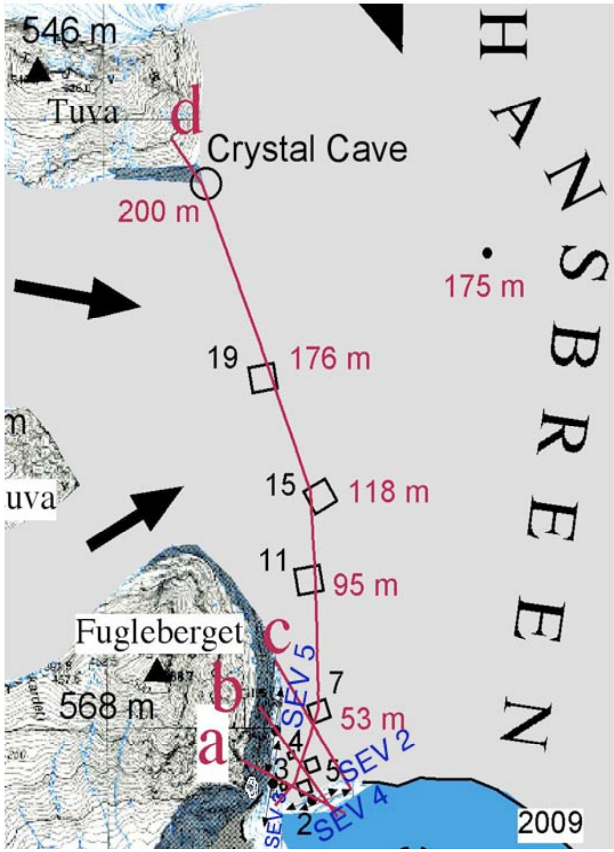
At the magnetic resonance sounding twenty excitation pulse moments (q) have been fulfilled, with 16 measures for every moment using a double pulse measurement. The stacking process employed it has been automatic *(Auto stack number)*, weighted *(Weighted average)* and besides, a cutting filter of 1000 nV (*stack under noise level*) was applied. Furthermore it has been applied a *high cut filter* by default. The pulse duration value was the usual (by default: 40 ms) as well as the recording time value (by default: 240 ms). We can observe the obtained results in the present table, acquired directly from the file .inp of the program PRODIVINER 3.0.4 by Iris Instruments (http://www.igeotest.fr/Enllacos/index.asp). We can see how without any signal filtering, nearly all the pulse moments (except: q1, q5, q9, q11 and q19) are within the range of 4 Hz < Δf < -4 Hz. The amplitude values obtained show a low S/N ratio except for five values which present a good S/N ratio. And the ratio EN/IN (indicative of the quality of the sounding) is too high for nearly all of the values; owing to that we should consider this value as semi-quantitative.

q = Excitation pulse moment (Amperes · milliseconds), which is a function of the pulse duration value (usually 40 ms). The more moments have been used, the greater depth of penetration. See http://www.igeotest.fr/RMP/Doc/B.03.MRS-Registre%20Numis.pdf / **e =** Measured signal amplitude (nanovolts) after being stacked and filtered./ **S/N =** Signal (S = e) / noise (N) ratio. For a quantitative valuation S/N < 2, otherwise is qualitative. / **EN/IN=** Instrumental Noise (IN = 5-10 nV) / noise stack (External Noise, EN) ratio. The sounding quality (acquisition data time and quality of them) is optimum if the measures that aren't a water signal present a ratio EN/IN ≈ 1. / **T*2** = Decay time constant of the first pulse (single pulse), measured in milliseconds./ **T*1** = Decay time constant of the second pulse (double pulse), measured in milliseconds. / **Udc** = Input voltage range in the loop (V). / **freq** = Frequency (Hz) of the detected signal. For a quantitative valuation the deviation with respect to the Larmor frequency (assuming that is correct) should be Δf = ± 2 Hz. In case that this difference is greater, the signal detected is not water. / **phase** = The gap of the electric current in the signal reception in the loop respect to the transmission. This value is measured in sexagesimal degrees. Aid to valuate the influence of the noise (EM) in the signal. In the case that has much variation between the measures, means that is influenced by the noise (EM noise).

SIGNAL INVERSION

To execute the inversion process of the MRS signal, it’s necessary to dispose of the subsurface resistivity model:

Subsurface resistive model



Owing to that it has been previously fulfilled a geoelectrical prospecting campaign at Hornsund Polar Station (VES 1&2), at Hansbreen Stick 4 (VES 1a), at Hansbreen front glacier (VES 1b), at Siedleckivika beach (VES 2&4) and at Hansbreen Fuglelberget lateral morraine (VES 3&5); from august 25th to September 4th, 2009. With the target of determine the subsurface structure and the depth in which is found the substrate so as the different geoelectrical units as well as their resistivity values, 8 vertical electrical sounding (VES) have been executed, the location of some of them, can be seen in the present figure. It has been provided a geological subsurface model considered plane-parallel. The general subsurface resisitivity model obtained resultant from doing the average of the subsurface geoelectrical model jointing the 8 VES surveying, is the following:

Layer	R_o	Depth max	Materials
1	12×10^{-6}	15-80	**Cold ice**
2	$2{,}5 \times 10^{-6}$	15-150	**Temperate ice**
3	160/550	22-135	**Till**
4	1000	37-160	**Aquifer**
5	21.000	50-100	**Dead ice (Till)**
6	5.500/500.000	45-180	**Bedrock**
Ut.	**Ohms*m**	**m**	**(Interpretation)**

The geological model shows how in the studied land we can distinguish 6 major geoelectrical units: first a level formed by Cold ice, second a level formed by Temperate ice (forming the polythermal glacier structure). On third place, we find a level interpreted as a Till, on the fourth place its detected a layer interpreted as a sedimentary aquifer, and finally we find the bedrock.

The subsurface resisitivity model obtained and the matrix resultant from the subsurface geoelectrical model, for every sounding VES surveying, is the following:

Siedleckivika		MRS 1	MRS 2	Siedleckivika
Layer	**R_o**	**Deepth max**	**Deepth max**	**Materials**
1	2.537.500	20	20	**Temperate ice**
2	161	23,6	23,6	**Till**
3	556	30,1	30,1	**Till**
4	215	37,2	37,2	**Till**
5	1121	45	99	**Aquifer**
6	28723	-	100	**Dead ice (Till)**
Ut.	**Ohms*m**	**m**	**m**	**(Interpretation)**

Siedleckivika		MRS 3	
Layer	**R_o**	**Deepth max**	**Materials**
1	2.535.500	15	**Temperate ice**
2	160	22	**Till**
3	500000	45	**Bedrock**
Ut.	**Ohms*m**	**m**	**(Interpretation)**

Siedleckivika		MRS 4	MRS 5	Siedleckivika
Layer	**R_o**	**Deepth max**	**Deepth max**	**Materials**
1	12.000.000	17	25	**Cold ice**
2	2.000.000	33	90	**Temperate ice**
3	160	45	-	**Till**
Ut.	**Ohms*m**	**m**	**m**	**(Interpretation)**

	MRS 6	Siedleckivika (Stick 1)	
Layer	**R_o**	**Deepth max**	**Materials**
1	12.000.000	17	**Cold ice**
2	2.000.000	33	**Temperate ice**
3	160	40	**Till**
4	21.000	50	**Dead ice (Till)**
5	5500	90	**Bedrock**
Ut.	**Ohms*m**	**m**	**(Interpretation)**

MRS 7	Siedleckivika (Stick 1)		
Layer	**R_o**	**Deepth max**	**Materials**
1	12.000.000	25	**Cold ice**
2	2.000.000	90	**Temperate ice**
3	500	100	**Till**
4	5.500	135	**Bedrock**
Ut.	**Ohms*m**	**m**	**(Interpretation)**

Stick 1b		MRS 10	
Layer	R_o	Deepth max	Materials
1	12.000.000	15	Cold ice
2	6.000.000	25	Temperate ice
3	3.000.000	54	Temperate ice
4	1.500.000	100	Temperate ice
5	500	135	Till
6	5500	180	Bedrock
Ut.	Ohms*m	m	(Interpretation)

Stick 1b		MRS 8	MRS 9	MRS 11	
Layer	R_o	Deepth max	Deepth max	Deepth max	Materials
1	12.000.000	90	25	25	Cold ice
2	2.000.000	-	45	150	Temperate ice
3	5.500	-	-	180	Bedrock
Ut.	Ohms*m	m	m	m	(Interpretation)

Tuva		MRS 12	MRS 13	MRS 14	MRS 15	Tuva
Layer	R_o	Deepth max	Deepth max	Deepth max	Deepth	Materials
1	12.000.000	45	50	50	50	Cold ice
2	2.000.000	-	90	90	90	Temperate ice
3	300.000	-	-	135	180	Bedrock
Ut.	Ohms*m	m	m	m	m	(Interpretation)

Crystal Cave		MRS 16	MRS 18	Crystal Cave	MRS 17	MRS 19	Crystal Cave
Layer	R_o	Deepth max	Deepth max	R_o	Deepth	Deepth max	Materials
1	12.000.000	80	80	12.000.000	80	80	Cold ice
2	2.000.000	130	130	2.000.000	130	130	Temperate ice
3	5.000	135	135	300.000	135	180	Bedrock
Ut.	Ohms*m	m	m	Ohms*m	m	m	(Interpretation)

Resistivity measurements on Stick 4, Hansbreen glacier.ABEM 4000 (above)

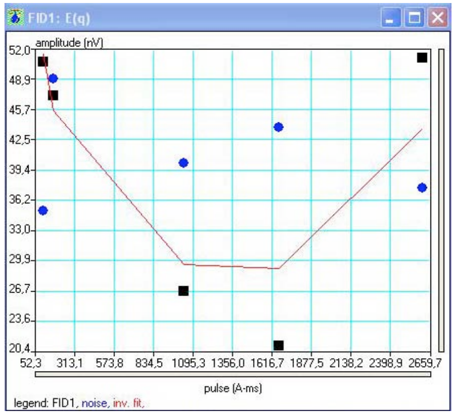
Image from Olivier Hengesch (august 2009)

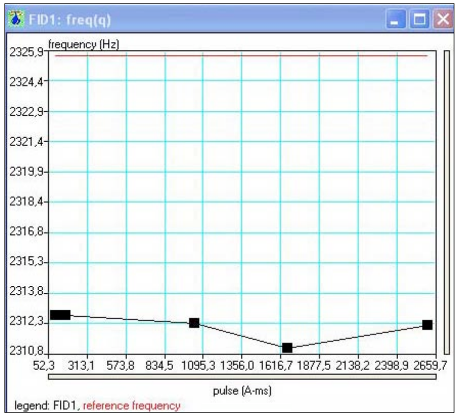
Subsurface Hidrogeophysical model

Once finished the subsurface resistivity model it was generated the data matrix with the program PHAR LAP'S 7.0 and with the result it was runed the program SAMOVAR 6.2 by Legchenko; to get the hidrogeophysical interpretation. In the latter program a signal processing by default has been accomplished which could be more or less studied in depth, as well as exists the possibility of modifying the inversion parameters. The results are showed below for every sounding:

MRS 1

Amplitude & Frequency

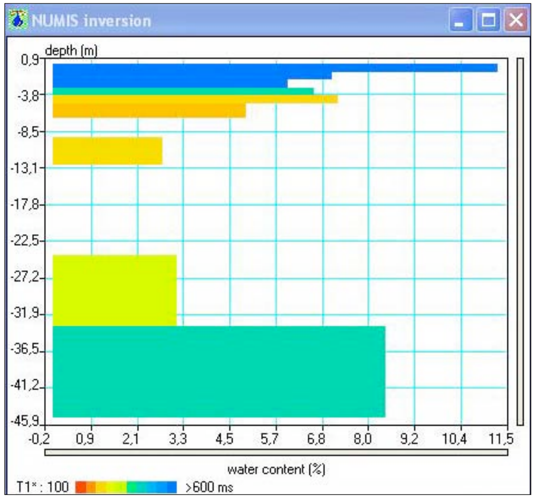


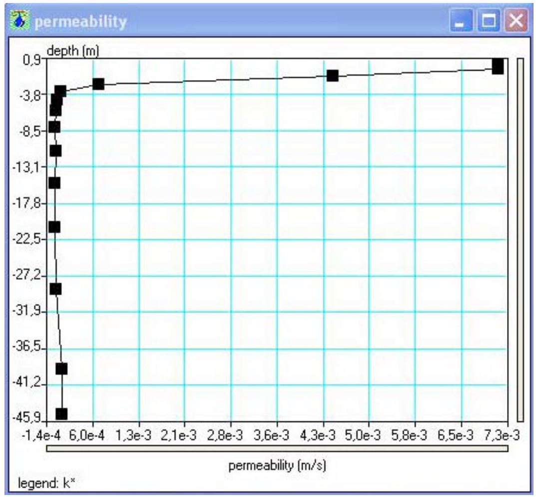


In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =100 and T1 =1) for 12 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q3, q4 & q8, have been eliminated from the interpretation.

MRS 1	Hansbreen glacier front			Hornsund	Spitsbergen		Larmor	2325,6	Hz
30x30	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	
Frequency	2312,8	2312,8	0	0	2312,3	2311,1	2312,3	0	Hz
	12,85	12,85	0	0	13,27	14,45	13,33	0	Δf < 4 Hz
Signal	50,66	47,21	0	0	26,76	21,10	51,15	0	nV
Noise	35,19	49,00	0	0	40,09	43,89	37,54	0	nV
S/N	1,44	0,96	0	0	0,67	0,48	1,36	0	> 2
EN/IN	3,52	4,90	0	0	4,01	4,39	3,75	0	≈ 1
File name:	RunningT100T1Layers12-Q3Q4Q8No.jpg								

With the signal treatment is observed that all pulse moment are within the range of 4 Hz < Δf < -4 Hz. The values of the obtained amplitude show a very low S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is too high in all the values. Because of this, we can only consider this interpretation as qualitative and it means that the water content is at the same range than the noise amplitude.





Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding (apart from q3, q4 & q8) is shown in the following figures. Depending on the chosen Larmor frequency (2325,6 Hz), the antenna configuration carried out (square 30x30 meters, it was necessary to use two loop turns to increase the impedance in the circuit), and the subsurface resisitivity model obtained (vertical electrical sounding); the matrix have been dimensioned for a depth of 45 meters (http://www.igeotest.ad/MRS/PDF/A.02.MRS-Metode.pdf). The NMR sounding have been done over the ice, and the glacier surface is inclinated towards the south 4º.

As can be extracted from the graphics, the sounding reflects the existence of three aquifers, the main one below 34 meters of depth (in green colour), which has a thickness of 11 meters. From 10 to 13 and from 25 to 34 meters of depth (in yellow colour), we detected two smaller aquifers with a thickness of 3 and 9 meters respectively. Hence, the represented model is present on graphics and would correspond to:

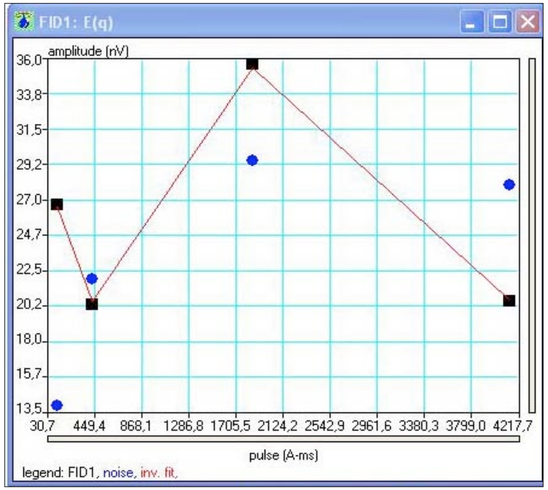
From 1 to 10 meters of depth we detected the more superficial layer of the terrain, the Cold ice, attributed to the Water facies Type 1 (see 1D model on the Hydrogeological interpretation), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of an important number of crevasses and seracs, over which the water is accumulated when the sun can melt the ice, but appears glaced other moments; giving or not water signals in the sounding. This layer has a very high permeability (about 600 m/day) and a high water content (from 5 to 11%) (from 6 to 10 metres of depth: 0%), although this porosity only corresponds with a highly fractured ice zone. A general decreasing pattern in water content can be observed along this section, according with the Cold ice (water facies type 1).

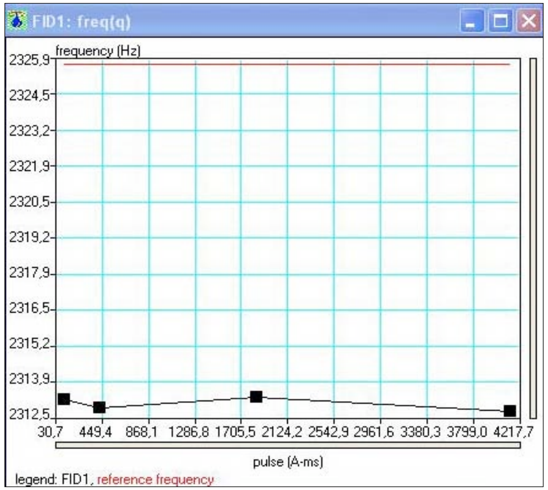
From 10 to 25 meters of depth there is a possible aquifer level, corresponding to the Temperate ice, attributed to the Water facies type 2 (see 1D model on the Hydrogeological interpretation), which has a moderate permeability of (12 m/day) and a low water content (3%) (from 13 to 25 metres of depth: 0%).

From 25 to 34 meters of depth we find a possible aquifer level interpreted as Permafrost (layer of soil or rock at some depth beneath the surface, in which the temperature has been continuously below 0ºC for at least several years and has been continuously frozen for a long time). This layer has a moderate permeability (12 m/day) and a low water content (3,2%).

Finally, from 34 to 45 meters it has been detected a level interpreted as a possible sedimentary aquifer, Which has a moderate permeability (12 m/day) but a high water content (8,5%). A general increasing pattern in water content can be observed beneath 25 metres of depth.

Amplitude & Frequency



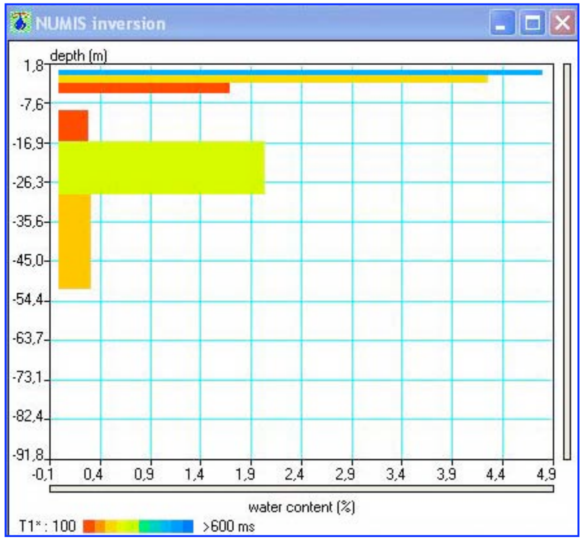


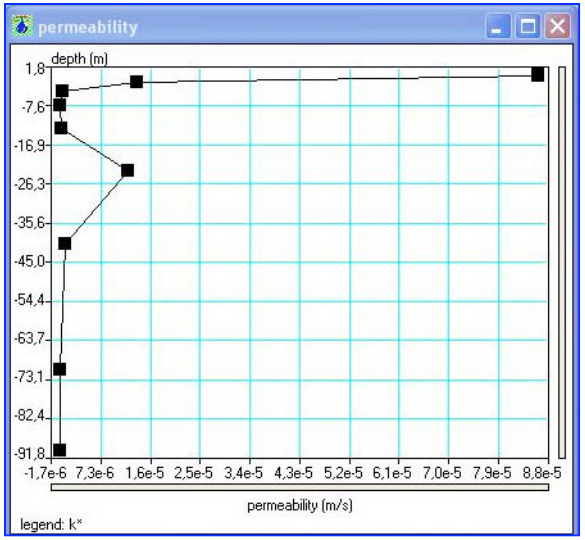
MRS 2

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =100 and T1 =1) for 8 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus. (http://www.igeotest.ad/MRS/PDF/B.05.MRS-Inversio.pdf). It should be stressed out that the pulse moments q2, q4, q5 & q7, have been eliminated from the interpretation.

MRS 2	Hansbreen glacier front		Hornsund		Spitsbergen		Larmor	2325,6	Hz
60x60	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	
Frequency	2313,2	0	2312,9	0	0	2313,3	0	2312,7	Hz
	12,40	0	12,72	0	0	12,32	0	12,85	Δf < 4 Hz
Signal	26,76	0	20,40	0	0	35,65	0	20,68	nV
Noise	13,98	0	21,97	0	0	29,53	0	27,98	nV
S/N	1,91	0	0,93	0	0	1,21	0	0,74	> 2
EN/IN	1,40	0	2,20	0	0	2,95	0	2,80	≈ 1
File name:	RunningT100T1Layers8-Q2Q4Q5Q7No.jpg								

With the signal treatment is observed that all of the selected pulse moments are within the rank of 4 Hz < Δf < -4 Hz. The values of obtained amplitude show a very low S/N ratio, only the first moment is close to an S/N = 2. The EN/IN ratio, which is indicative of the quality of the sounding, is too high in nearly all the values, only the first monent the EN/IN is close to 1. Because of this, we can only consider this interpretation as qualitative.





Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding (apart from q2, q4, q5 & q7) is shown in the following figures. This sounding was done in the same place as the first one, with the same Larmor frequency (2325,6 Hz), with a square antenna configuration carried out (60x60 meters), and the matrix have been dimensioned for a depth of 100 meters (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

As can be extracted from the graphics, the sounding reflects the existence of an aquifer, from 17 to 30 meters of depth (in yellow colour). Hence, the model is represented in the present graphics would correspond to:

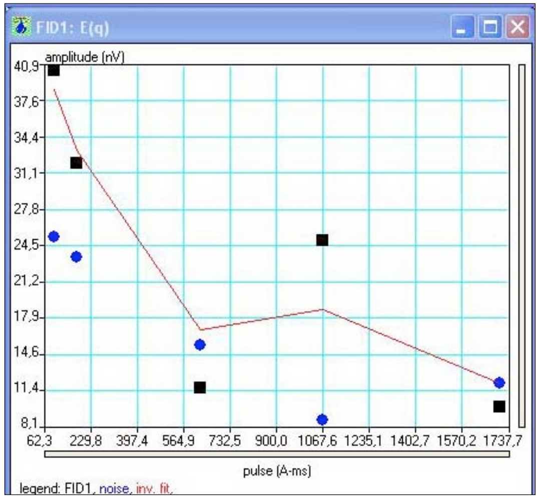
From 3,5 to 6 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of an important number of crevasses and seracs, over which the water is accumulated. This layer has a moderate permeability (from 0,1 to 7,6 m/day) and a high water content (from 2 to 5%), although this porosity only corresponds with a highly fractured ice zone. A general decreasing pattern in water content can be observed till 16 metres of depth, according with the Cold ice (water facies type 1).

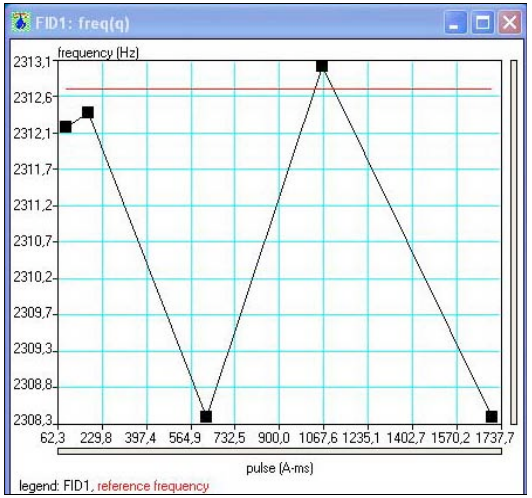
Underneath, from 6 to 17 meters of depth there is another layer corresponding to the Temperate ice (Water facies Type 2), which has a very low permeability of (0,1 m/day) and a low water content (0,2 %)(from 6 to 10 metres of depth: 0%).

Underneath from 17 to 30 meters of depth we find a possible aquifer level interpreted as Wet ice (water facies type 2) (see 1D model on the Hydrogeological interpretation). This layer has a moderate permeability (2 m/day) and a low water content (2%).

Finally, from 30 to 50 meters it has been detected a layer attributed to a Till deposit or to the Marine Terrace sediments (Eemian) (founded by marine shells at the glacier surface, Jaceck Jania com. pers.), present beneath the glacier. This layer has a very low permeability (0,1 m/day) and a low water content (0,2%). A general increasing pattern in water content can be observed beneath 17 metres of depth, this description is not according with the Wet ice (water facies type 2).

Amplitude & Frequency



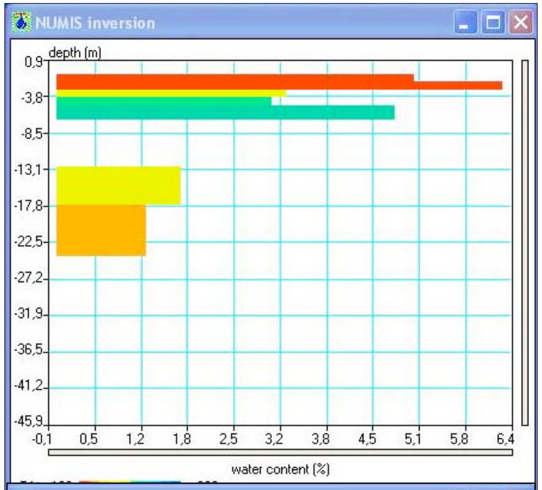


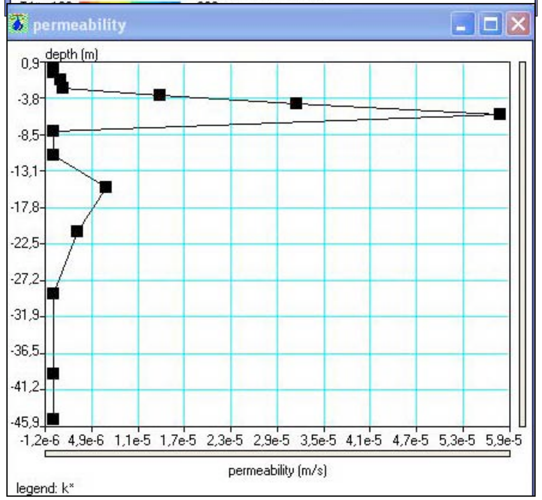
MRS 3

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =100 and T1 =5) for 12 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus. (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q3, q7 & q8, have been eliminated from the interpretation.

MRS 3	**Hansbreen glacier front**				**Hornsund**		**Larmor**	**2312,7**	**Hz**
30x30	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	
Frequency	2312,2	2312,4	0	2308,4	2313,0	2308,4	0	0	**Hz**
	0,46	0,27	0	4,29	-0,32	4,29	0	0	**Δf < 4 Hz**
Signal	40,40	32,04	0	11,74	25,03	10,00	0	0	**nV**
Noise	25,36	23,56	0	15,58	8,78	12,18	0	0	**nV**
S/N	1,59	1,36	0	0,75	2,85	0,82	0	0	**> 2**
EN/IN	2,54	2,36	0	1,56	0,88	1,22	0	0	**≈ 1**
File name:	RunningT100T5Layers12-Q3Q7Q8No.jpg								

With the signal treatment is observed that more than half of the pulse moments are within the range of 4 Hz < Δf < -4 Hz or close. However, all the values of obtained amplitude except one, show a very low S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in more than half of the values. Because of this, we can only consider this interpretation as semiquantitative.





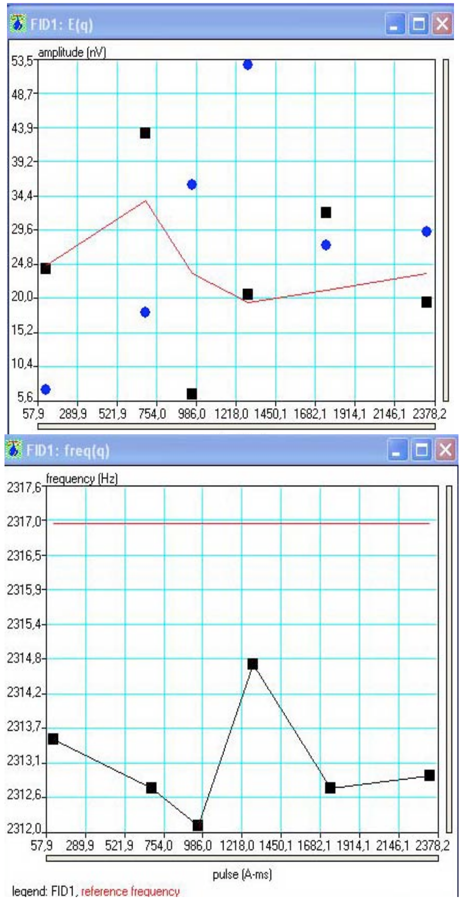
Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding (apart from q3, q7 & q8) is shown in the following figures. Depending on the chosen Larmor frequency (2312,7 Hz), the antenna configuration carried out (square 30x30 meters, it was necessary to use two loop turns to increase the impedance in the circuit), and the subsurface resisitivity obtained (vertical electrical sounding); the matrix have been dimensioned for a depth of 45 meters (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

As can be extracted from the graphics, in general the sounding reflects the existence of an aquifer from 13 to 25 meters of depth. Hence, the represented model would correspond to:

From 2,5 to 18 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of an important number of crevasses and seracs, over which the water is accumulated. This layer is divided in different sections according to its water content and has a moderate permeability (from 0,1 to 5 m/day) and a high water content (from 2 to 5%)(from 6 to 13 metres of depth: 0%). Although, this porosity only corresponds with a highly fractured ice zone. A general decreasing pattern in water content can be observed in all the sections, according with the Cold ice (water facies type 1).

Underneath, from 18 to 25 meters of depth we find a possible level aquifer, layer corresponding to Dead ice (see 1D model on the Hydrogeological interpretation), which has a low permeability of (1 m/day) and a low water content (1,2 %).

Amplitude & Frequency

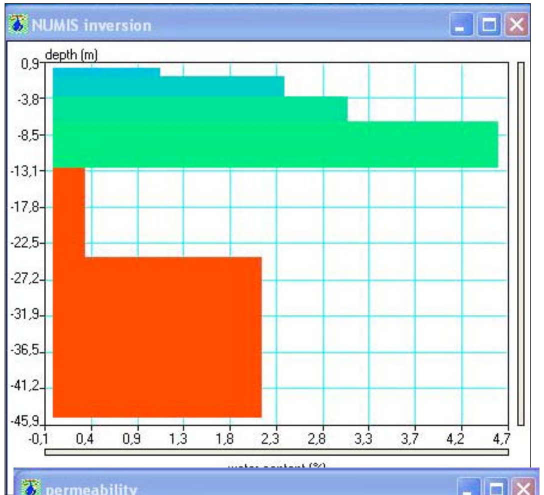


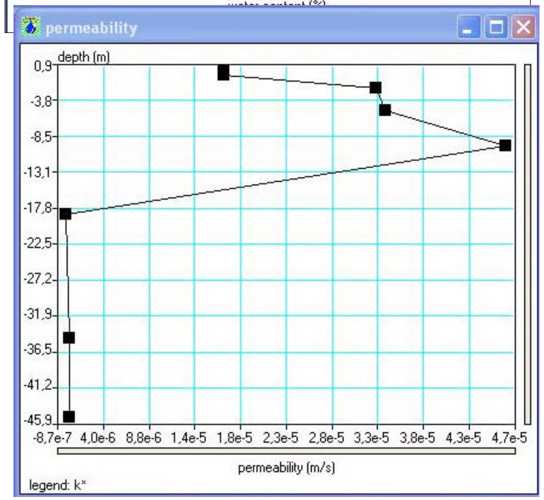
MRS 4

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =100 and T1 =5) for 12 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q3, q7 & q8, have been eliminated from the interpretation.

MRS 4	Hansbreen glacier front				Hornsund				Spitsbergen		Larmor	2317	Hz
30x30	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	
Frequency	2313,5	0	0	0	0	2312,7	2312,1	2314,7	2312,7	2312,9	0	0	**Hz**
	3,49	0	0	0	0	4,27	4,89	2,27	4,27	4,08	0	0	**Δf < 4 Hz**
Signal	24,20	0	0	0	0	43,24	6,66	20,65	32,10	19,52	0	0	**nV**
Noise	7,25	0	0	0	0	18,05	36,00	52,82	27,48	29,36	0	0	**nV**
S/N	3,34	0	0	0	0	2,40	0,19	0,39	1,17	0,66	0	0	**> 2**
EN/IN	0,72	0	0	0	0	1,80	3,60	5,28	2,75	2,94	0	0	**≈ 1**
File name:	RunningAUTOQ2Q3Q4Q5Q11Q12No.jpg												

With the signal treatment is observed that more than half of the pulse moments are within the 4 Hz < Δf < -4 Hz range. However, all the values of obtained amplitude except two, show a very low S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in more than half of the values. Because of this, we can only consider this interpretation as semiquantitative.





Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding (apart from q2, q3, q4, q5, q11 & q12) is shown in the following figures. Depending on the chosen Larmor frequency (2317 Hz), the antenna configuration carried out (square 30x30 meters, it was necessary to use two loop turns to increase the impedance in the circuit), and the subsurface resisitivity obtained (vertical electrical sounding); the matrix has been dimensioned for a depth of 45 meters (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

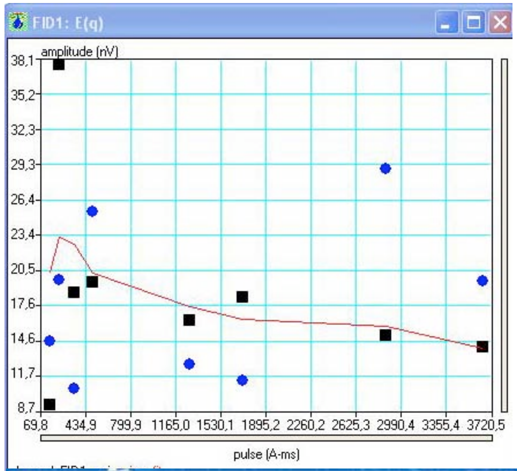
As can be extracted from the graphics, the sounding reflects the existence of an aquifer, from 25 to 45 meters of depth (in red colour). Hence, the model present on graphics would correspond to:

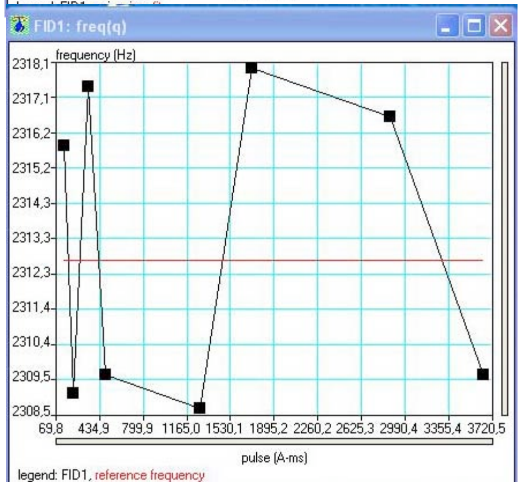
From 1,5 to 13 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of an important number of crevasses and seracs, over which the water is accumulated. This layer is divided in different sections according to its water content and had moderate permeability (from 1,5 to 4 m/day) and high water content (from 1 to 4,5%), although this porosity only corresponds with a highly fractured ice zone. A general increasing pattern in water content can be observed in the section. This description is not according with the Cold ice (water facies type 1).

Underneath, from 13 to 25 meters of depth there is another layer corresponding to Temperate ice (Water facies Type 2), which has a very low permeability of (10^{-2} m/day) and a low water content (0,4 %).

Underneath from 25 to 45 meters of depth we find a possible aquifer level interpreted as Wet ice (Water facies type 2). This layer has a very low permeability (10^{-2} m/day) and higher water content (2,1%). A general increasing pattern in water content can be observed beneath 13 metres of depth. This description is according with the Wet ice (water facies type 2).

Amplitude & Frequency



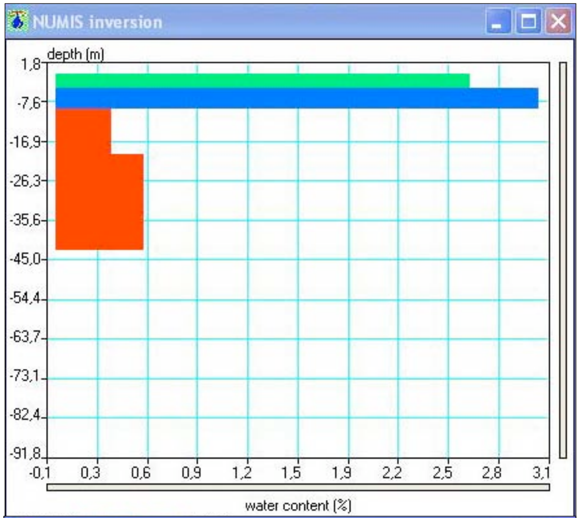


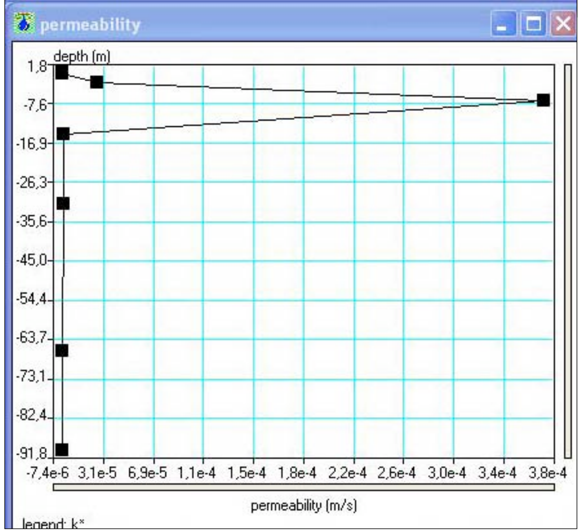
MRS 5

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =50 and T1 =1) for 6 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q1, q6, q7 & q10, have been eliminated from the interpretation.

MRS 5	Hansbreen glacier front				Hornsund		Spitsbergen				Larmor	2312,7	Hz
60x60	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	
Frequency	0	2315,9	2309,1	2317,5	2309,6	0	0	2308,7	2318,0	0	2316,7	2309,6	**Hz**
	0	-3,18	3,57	-4,78	3,08	0	0	3,99	-5,26	0	-3,95	3,08	**Δf < 4 Hz**
Signal	0	9,31	37,67	18,69	19,59	0	0	16,38	18,36	0	15,09	14,10	**nV**
Noise	0	14,62	19,76	10,68	25,46	0	0	12,69	11,36	0	28,97	19,59	**nV**
S/N	0	0,64	1,91	1,75	0,77	0	0	1,29	1,62	0	0,52	0,72	**> 2**
EN/IN	0	1,46	1,98	1,07	2,55	0	0	1,27	1,14	0	2,90	1,96	**≈ 1**
File name:	RunningT50T1Layers6-Q1Q6Q7Q10No.jpg												

With the signal treatment is observed that nearly all the pulse moments are within the 4 Hz < Δf < -4 Hz range or close, however, all the values of obtained amplitude show a very low S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in more than half of the values. Because of this, we can consider this interpretation as quantitative.





Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding (apart from q1, q6, q7 & q10) is shown in the following figures. This sounding was done very near from MRS 4 site, with the same Larmor frequency (2312,7 Hz), with a square antenna configuration carried out (60x60 meters), and the matrix have been dimensioned for a depth of 90 meters (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

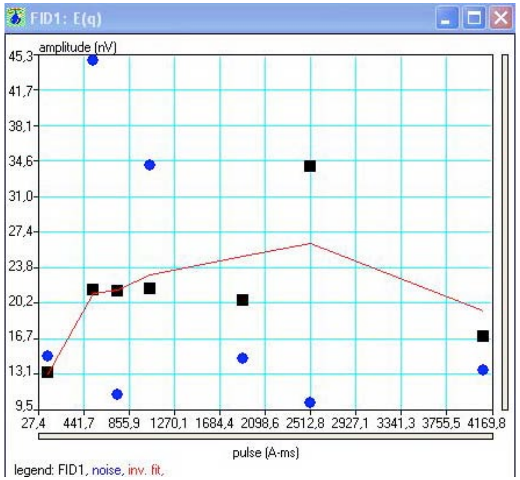
As can be extracted from the graphics, the sounding reflects the existence of an aquifer, from 10 to 43 meters of depth (in red colour). Hence, the represented model in graphics would correspond to:

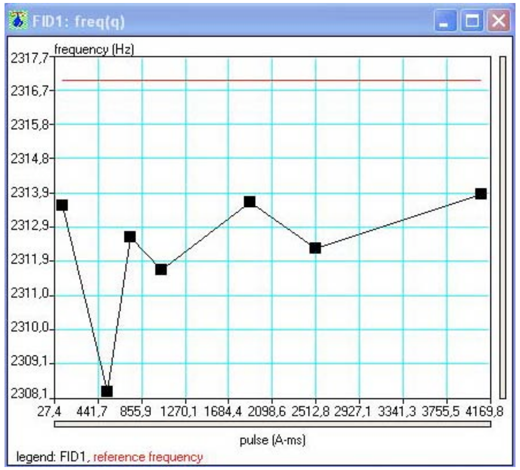
From 4 to 10 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of an important number of crevasses and seracs, over which the water is accumulated. This layer is divided in two trams according to its water content and has a moderate permeability (from 3 to 33 m/day) and a high water content (2,7- 3%), although this porosity only corresponds with a highly fractured ice zone. A general decreasing pattern in water content can be observed in that section. This description is according with the Cold ice (water facies type 1).

Underneath, from 10 to 20 meters of depth there is a possible aquifer level interpreted as Temperate ice (Water facies Type 2), which has a high permeability of (33 m/day) but a low water content (0,4 %).

Underneath from 20 to 43 meters of depth we find a possible aquifer level interpreted as Wet ice (Water facies type 2). This layer has a low permeability (0,6 m/day) and a low water content (0,6%). A general increasing pattern in water content can be observed beneath 10 metres of depth, according with the Wet ice (Water facies Type 1).

Amplitude & Frequency



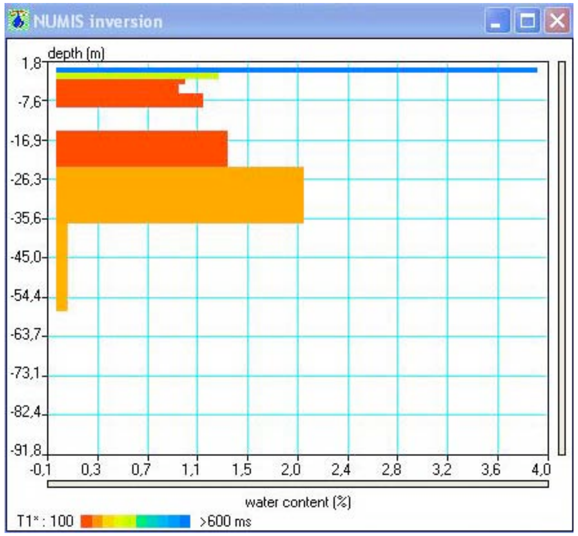


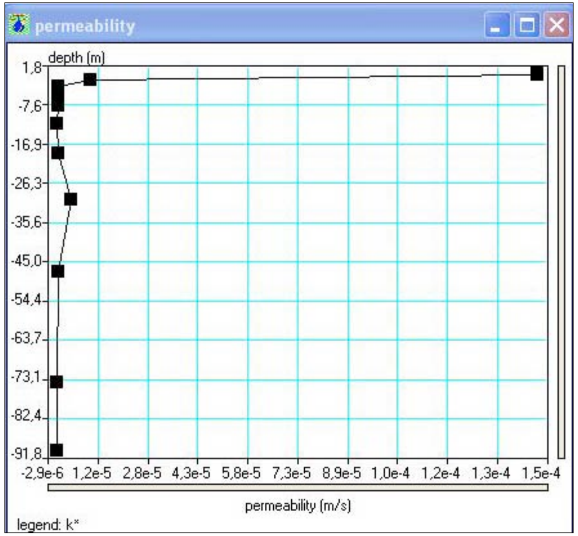
MRS 6

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer of 10 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q2, q3, q4, q8 & q11, have been eliminated from the interpretation.

MRS 6	**Hansbreen STICK 1**				**Hornsund**		**Spitsbergen**				**Larmor**	**2317**	**Hz**
60x60	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	
Frequency	2313,5	0	0	0	2308,3	2312,6	2311,7	0	2313,6	2312,3	0	2313,8	**Hz**
	3,47	0	0	0	8,69	4,36	5,28	0	3,39	4,67	0	3,16	**Δf < 4 Hz**
Signal	13,38	0	0	0	21,65	21,54	21,80	0	20,59	34,10	0	16,99	**nV**
Noise	14,93	0	0	0	44,75	11,08	34,20	0	14,68	10,27	0	13,53	**nV**
S/N	0,90	0	0	0	0,48	1,94	0,64	0	1,40	3,32	0	1,26	**> 2**
EN/IN	1,49	0	0	0	4,48	1,11	3,42	0	1,47	1,03	0	1,35	**≈ 1**
File name:	RunningAUTOLayers10-Q2Q3Q4Q8Q11No.jpg												

With the signal treatment is observed that nearly all the pulse moments are within the 4 Hz < Δf < -4 Hz range or close to that (values q5 & q7). However, all the values of obtained amplitude, show a very low S/N ratio, except q10. The EN/IN ratio, which is indicative of the quality of the sounding, is good in more than half of the values. Because of this, we can only consider this interpretation as semiquantitative.





Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding (apart from q2, q3, q4, q8 & q11) is shown in the following figures. Depending on the chosen Larmor frequency (2317 Hz), the antenna configuration carried out (square 60x60 meters), and the subsurface resisitivity obtained (vertical electrical sounding); the matrix has been dimensioned for a depth of 90 meters. (file://localhost/hhttp/::www.igeotest.fr:RMP:Doc:A.02.MRS-Methode.pdf).

As can be extracted from the graphics, the sounding reflects the existence of an aquifer, from 15 to 37 meters of depth (in red-orange colour). Hence, the model in the present graphics would correspond to:

From 3 to 15 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of an important number of crevasses and seracs, over which the water is accumulated. This layer is divided in several trams according to its water content and has a moderate permeability (from 0,25 to 13 m/day) and a moderate water content (1-4%)(from 10 to 15 metres of depth: 0%), although this porosity only corresponds with a highly fractured ice zone. A general decreasing pattern in water content can be observed in that section, according with the Cold ice (water facies type 1).

From 15 to 24 meters of depth there is a possible aquifer level interpreted as Temperate ice (Water facies Type 2), which has a low permeability of (0,25 m/day) but a low water content (1,4 %).

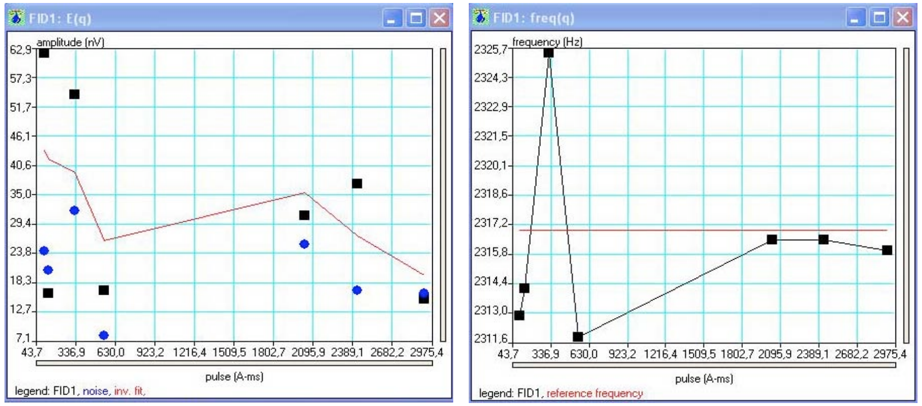
From 24 to 37 meters of depth we find a possible aquifer level interpreted as Wet ice (Water facies type 2). This layer has the same permeability (0,25 m/day) but a higher water content (2,1%). A general increasing pattern in water content can be observed from 15 to 37 metres of depth, according with the Wet ice (water facies type 2).

From 37 to 50 meters of depth we find a level interpreted as the mentioned Marine Terrace (Eemian). This layer has the same permeability (0,25 m/day) but a very low content (0,2%)

MRS 7

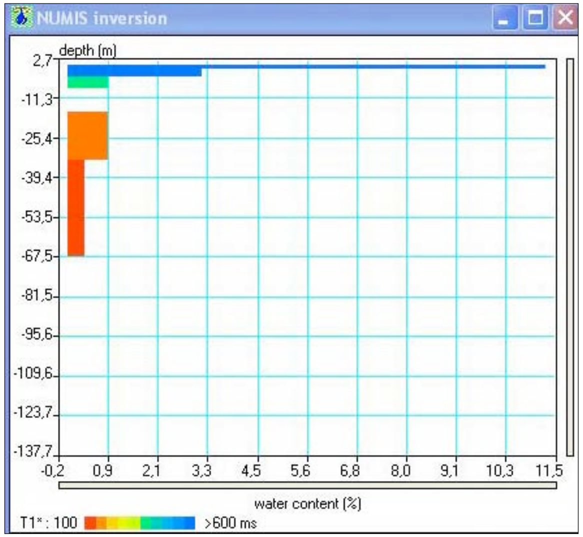
In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters weren't modified and the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q3, q4, q6, q8, q9, q10, q11 & q12, have been eliminated from the interpretation.

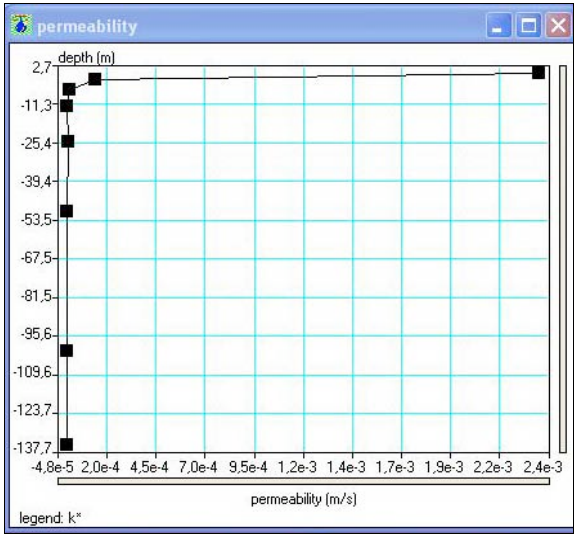
Amplitude & Frequency



MRS 7	Hansbreen STICK 1	Hornsund	Larmor		2317	Hz
Moments	**Frequency**	**Variation**	**Signal**	**Noise**	**S/N**	**EN/IN**
Q1	2312,9	4,08	62,0	24,40	2,54	2,44
Q2	2314,2	2,77	16,4	20,66	0,79	2,07
Q3	0	0	0	0	0	0
Q4	0	0	0	0	0	0
Q5	2325,5	-8,50	54,2	32,13	1,69	3,21
Q6	0	0	0	0	0	0
Q7	2311,9	5,10	16,8	8,33	2,02	0,83
Q8	0	0	0	0	0	0
Q9	0	0	0	0	0	0
Q10	0	0	0	0	0	0
Q11	0	0	0	0	0	0
Q12	0	0	0	0	0	0
Q13	2316,6	0,44	31,3	25,66	1,22	2,57
Q14	2316,6	0,44	37,3	16,91	2,21	1,69
Q15	2316,0	0,95	15,4	16,20	0,95	1,62
Q16	0	0	0	0	0	0
	Hz	**Δf < 4 Hz**	**nV**	**nV**	**>2**	**≈ 1**
File name :	RunningAUTO-Q1Q2Q5Q7Q13Q14Q15Si.jpg					

With the signal treatment is observed that nearly all the pulse moments are within the 4 Hz < Δf < -4 Hz range, however, more than a half of the values of obtained amplitude, show a very low S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is too high in more than half of the values. Because of this, we can only consider this interpretation as semiquantitative.





Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding (apart from q13, q4, q6, q8, q9, q10, q11 & q12) is shown in the following figures. According to the results of the MRS 6 in where in the last pulse moment (q12) could be observed how, even at this depth the sounding seems to presents a water signal, which means that in this punt the water could be founded at more than 90 meters of depth. For this reason, at the same place as MRS 6 it was done the sounding MRS 7, using the same Larmor frequency (2317 Hz), but with an antenna configuration carried out (square 90x90 meters), and with a matrix dimensioned for a depth of 135 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

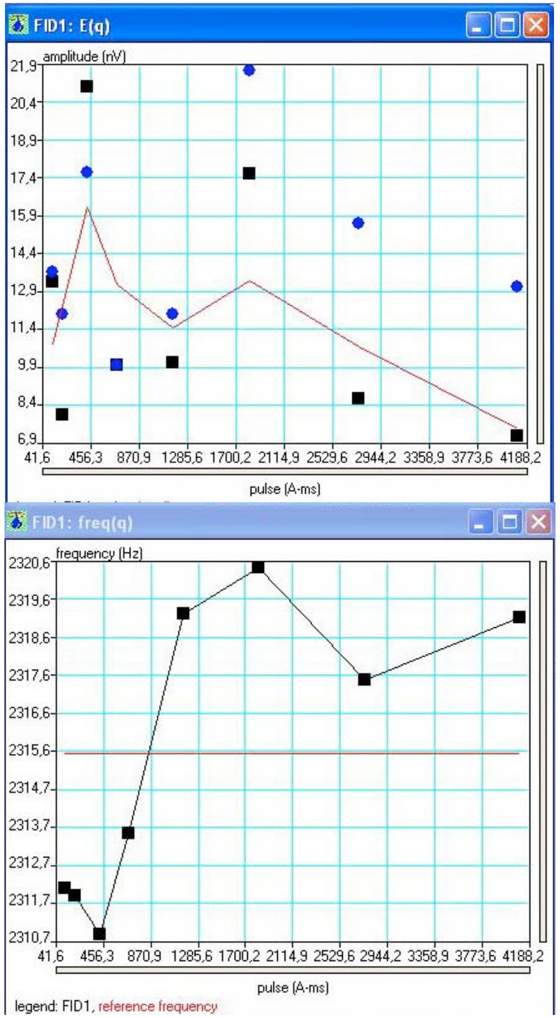
As can be extracted from the graphics, the sounding reflects the existence of an aquifer, from 17 to 67,5 meters of depth (in red-orange colour). Hence, the model in the present graphics would correspond to:

From 5 to 17 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of several seracs, over which the water was accumulated. This layer is divided in two trams according to its water content and has a high permeability (17-200 m/day) and a moderate water content (1-11%) (between 9 to 17 metres of depth: 0%), although this porosity only corresponds with a highly fractured ice zone. A general decreasing pattern in water content can be observed along the section, according with the Cold ice (water facies type 1).

Underneath, from 17 to 33 meters of depth there is a possible aquifer level interpreted as Temperate ice (Water facies Type 2), which has a moderate permeability (4 m/day) but a low water content (0,9 %).

Underneath from 33 to 67,5 meters of depth we find a possible aquifer level interpreted as Wet ice (Water facies type 2) and which could terminate in the mentioned Marine Terrace . This layer has the same permeability (4 m/day) but a lower water content (0,5%). A general decreasing pattern in water content can be observed beneath 17 metres of depth, according with the Wet ice (water facies type 2).

Amplitude & Frequency

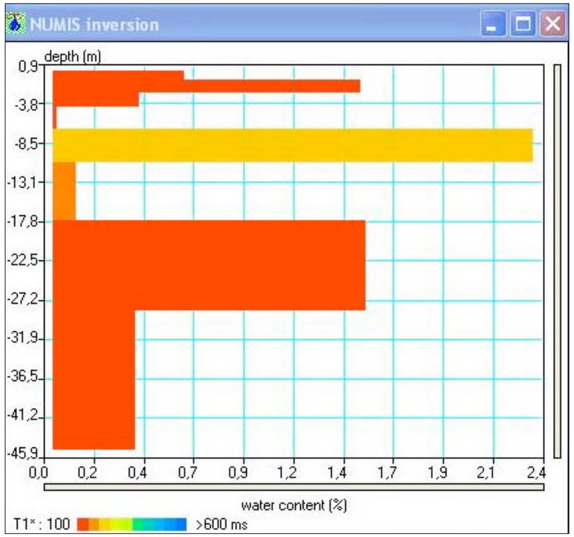


MRS 9

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters weren't modified and the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf).

MRS 9	Hansbreen STICK1b		Hornsund		Spitsbergen		Larmor 2315,6 Hz		
30x30	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	
Frequency	2312,1	2311,9	2310,9	2313,5	2319,2	2320,4	2317,5	2319,1	Hz
	3,50	3,68	4,69	2,07	-3,64	-4,83	-1,93	-3,54	Δf < 4 Hz
Signal	13,36	8,06	21,07	10,03	10,13	17,62	8,71	7,22	nV
Noise	13,70	12,04	17,67	10,03	12,04	21,69	15,63	13,13	nV
S/N	0,98	0,67	1,19	1,00	0,84	0,81	0,56	0,55	> 2
EN/IN	1,37	1,20	1,77	1,00	1,20	2,17	1,56	1,31	≈ 1
File name:	RunningAUTOAllPoints.jpg								

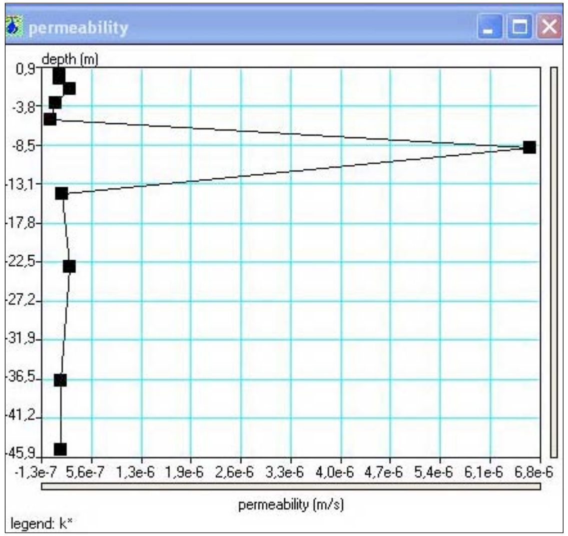
With the signal treatment is observed that nearly all the pulse moments are within the 4 Hz < Δf < -4 Hz range, and the rest of the values (q7) approaches much that range. However, none of the values of obtained amplitude, show a good S/N ratio. Therefore, the EN/IN ratio, which is indicative of the quality of the sounding, is good in nearly all the values. Because of this, we can consider this interpretation as quantitative.



Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding is shown in the following figures. In the surveyed area Stick 1b, four loop configurations have been done, in order to compare the results obtained using different loop sizes in the same area (MRS 8, MRS 9, MRS 10 & MRS 11). In this case using the Larmor frequency (2315,6 Hz), an antenna configuration carried out (square 30x30 meters, it was necessary to use two loop turns to increase the impedance in the circuit), and with a matrix dimensioned for a depth of 45 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

As can be extracted from the graphics, the sounding reflects the existence of an aquifer, from 6 to 11 meters of depth (in yellow colour) and from 18 to 45 metres of depth (in red colour). Hence, the model who is represented in the present graphics would correspond to:

From 1,2 to 45 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of several extensional moulins on the surveyed area, on which the water was accumulated.



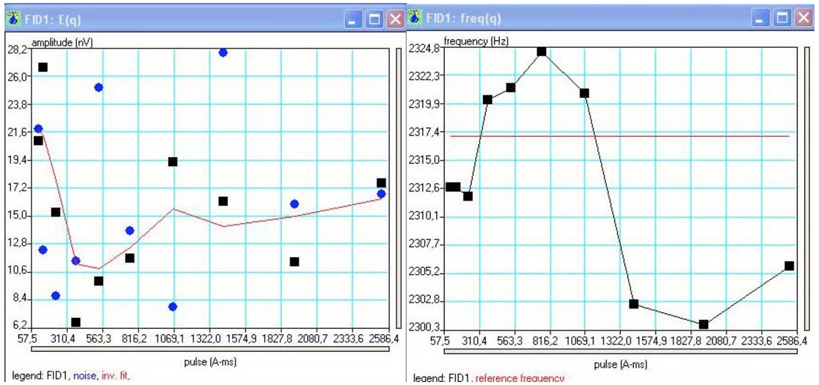
This layer is divided in eight trams according to its water content and permeability: Between 1,2 to 1,6 meters of depth, which has a low permeability (10^{-2} m/day) and a low water content (0,7 %). From 1,6 to 2,1 meters of depth, which has a low permeability (10^{-2} m/day) and a low water content (1,5 %). From 2,1 to 4 meters of depth, which has a low permeability (10^{-2} m/day) and a low water content (0,4 %). From 4 to 6 meters of depth, which has a low permeability (10^{-2} m/day) and a very low water content (0,05 %). From 6 to 11 meters of depth we find a possible aquifer level, which has a higher permeability (0,6 m/day) and a moderate water content (2,35%). From 11 to 18 meters of depth, which has the same permeability (0,6 m/day) and a low water content (0,1%). From 18 to 28 meters of depth we find a possible aquifer level, which has a low permeability (from 10^{-2} to 0,6 m/day) and a low water content (1,5%). From 28 to 45 meters of depth we find a possible aquifer level, which has a low permeability (10^{-2} m/day) and a low water content (0,4%). As we can observe, the water content on the subsurface is low but reach values above 2%.
Anyway, this porosity only corresponds with a highly fractured ice zone.

A general decreasing pattern in water content can be observed along all the section. Decays (permeability) are above the 100 ms on the layers with more water content. This description is according with the Cold ice (water facies type 1), specially for the first meters depth.

MRS 8

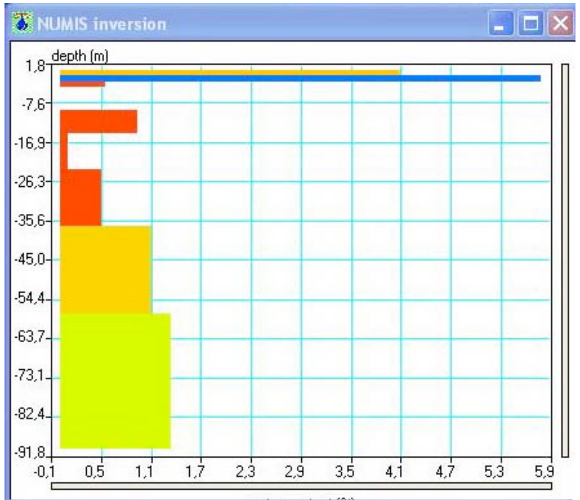
In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters weren't modified and the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q11 & q12, have been eliminated from the interpretation.

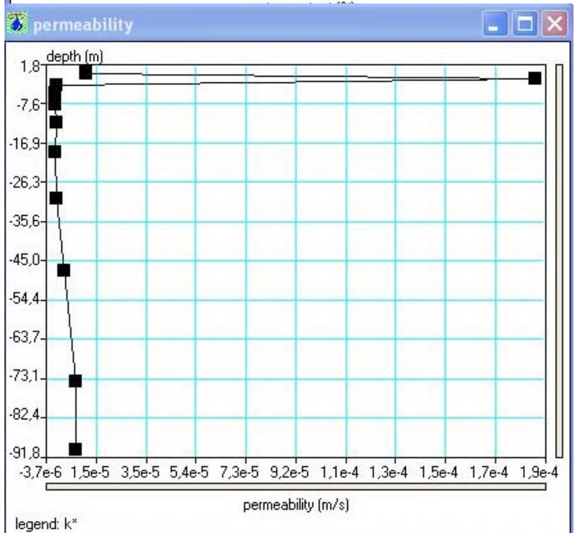
Amplitude & Frequency



MRS 8	Hansbreen STICK 1b				Hornsund		Spitsbergen				Larmor	2317	Hz
60x60	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	
Frequency	2312,7	2312,7	2311,9	2320,3	2321,4	2324,4	2320,9	2302,6	2300,8	2305,9	0	0	Hz
	4,30	4,30	5,10	-3,27	-4,35	-7,44	-3,87	14,42	16,15	11,07	0	0	Δf < 4 Hz
Signal	20,99	26,76	15,33	6,65	9,91	11,73	19,30	16,18	11,42	17,64	0	0	nV
Noise	21,90	12,37	8,77	11,51	25,15	13,91	7,91	27,89	15,98	16,78	0	0	nV
S/N	0,96	2,16	1,75	0,58	0,39	0,84	2,44	0,58	0,71	1,05	0	0	> 2
EN/IN	2,19	1,24	0,88	1,15	2,51	1,39	0,79	2,79	1,60	1,68	0	0	≈ 1
File name:	RunningAUTO-Q11Q12No_MATRIU8B.jpg												

With the signal treatment is observed that only two of the pulse moments are within the rank of 4 Hz < Δf < -4 Hz, but the values q1, q2 & q5 approaches much that rank. Besides, only two of the values of obtained amplitude, show a good S/N ratio. Therefore, the EN/IN ratio, which is indicative of the quality of the sounding, is good in nearly all the values. Because of this, we can only consider this interpretation as semiquantitative.





Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding (apart from q3, q4, q6, q8, q9, q10, q11 & q12) is shown in the following figures. In the surveyed area Stick 1b an antenna configuration (square 60x60 meters) was carried out, using the Larmor frequency (2317 Hz) and with a matrix dimensioned for a depth of 90 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf). Enlarging the loop we obtain water signals in depth but also from other superficial runoff streams.

As can be extracted from the graphics, the sounding reflects the existence of an aquifer, from 37 to 90 meters of depth (in yellow colour). Hence, the model in the present graphics would correspond to:

From 3 to 37 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of several extensional moulins on the surveyed area, on which the water was accumulated. This layer is divided in six trams according to its water content and has a moderate permeability (0,3-16 m/day) and a moderate water content (0,25-6%) (between 5 to 10 metres of depth: 0%). Anyway, this porosity only corresponds with a highly fractured ice zone. As we can observe, at the firsts meters high water contents is detected (close to 6% values) and also high decays (more than 500 ms, blue colours), big antennas done at that place detect until 8.5% of water content on shallow depths. A general decreasing pattern in water content can be observed till 24 m depth. This description is according with the Cold ice (water facies type 1).

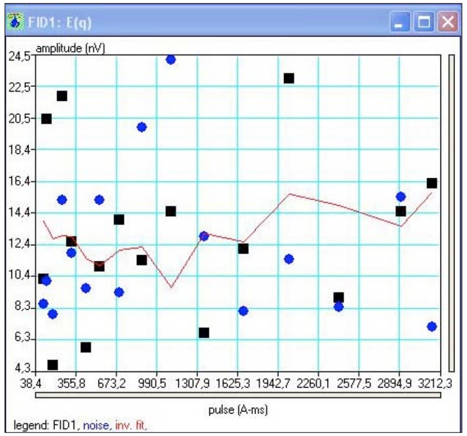
Underneath, from 37 to 56 meters of depth there is a possible aquifer level interpreted as Temperate ice (Water facies Type 2), which has a moderate permeability (0,3-1,3 m/day) and a low water content (1,1 %).

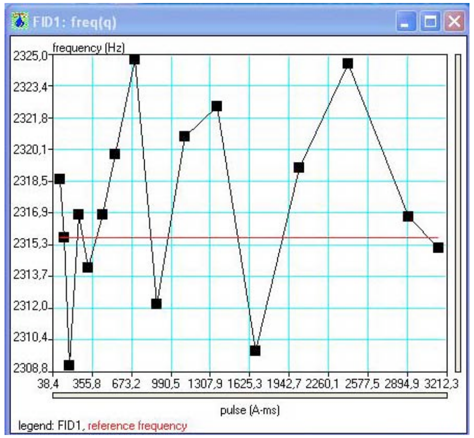
Underneath from 56 to 90 meters of depth we find a possible aquifer level interpreted as Wet ice (Water facies type 2). This layer has the same permeability (0,3-1,3 m/day) but higher water content (1,25%). Beneath 24 meters depth, the water content increase but under a 2%, also the decays (permeability) increase with depth, this means that probably the last pulse of measurement the device detect something different and the survey should be enlarged. The increase of permeability, but in ranges below 2% on water content, could be interpreted as the presence of a channelized stream at depths below 35 m. At that point is important remember that the loop cross few moulins in that place.

MRS 10

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =10 and T1 =1) for 10 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf).

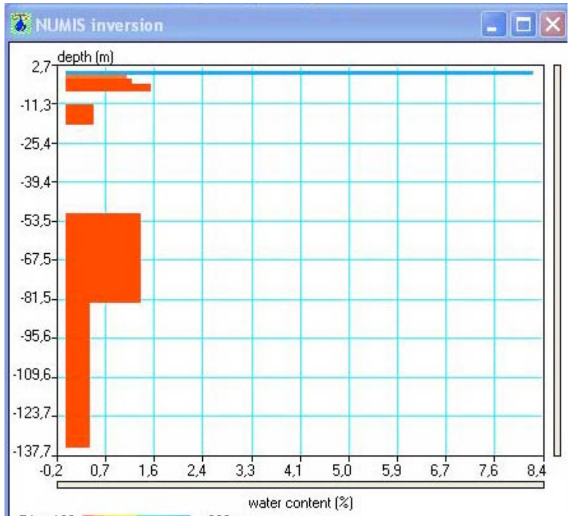
Amplitude & Frequency

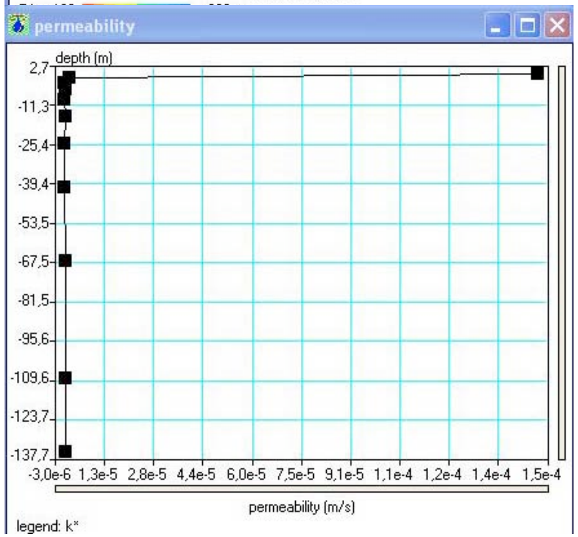




MRS 10	Hansbreen STICK 1b		Hornsund	Larmor 2315,6 Hz		
Moments	**Frequency**	**Variation**	**Signal**	**Noise**	**S/N**	**EN/IN**
Q1	2318,7	-3,08	10,23	8,68	1,18	0,87
Q2	2315,7	-0,09	20,44	10,12	2,02	1,01
Q3	2309,2	6,43	4,74	7,98	0,59	0,80
Q4	2316,9	-1,25	21,94	15,30	1,43	1,53
Q5	2314,1	1,46	12,65	11,90	1,06	1,19
Q6	2316,9	-1,25	5,87	9,65	0,61	0,96
Q7	2319,9	-4,34	11,04	15,30	0,72	1,53
Q8	2324,8	-9,19	13,99	9,37	1,49	0,94
Q9	2312,3	3,28	11,42	19,90	0,57	1,99
Q10	2320,9	-5,25	14,55	24,23	0,60	2,42
Q11	2322,4	-6,79	6,78	12,97	0,52	1,30
Q12	2309,9	5,71	12,13	8,19	1,48	0,82
Q13	2319,3	-3,68	23,07	11,51	2,00	1,15
Q14	2324,6	-9,00	9,12	8,45	1,08	0,84
Q15	2316,8	-1,16	14,55	15,49	0,94	1,55
Q16	2315,1	0,48	16,35	7,20	2,27	0,72
	Hz	**Δf < 4 Hz**	**nV**	**nV**	**>2**	**≈ 1**
File name :	RunningT10T1Layers10-100msAllpoints.jpg					

With the signal treatment is observed that nine of the pulse moments are within the 4 Hz < Δf < -4 Hz range, and the value q1,q7,q13 are close. However, just three of the values of obtained amplitude, show a good S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in nearly all the values. Because of this, we can consider this interpretation as quantitative.





Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding, is shown in the following figures. In the surveyed area Stick 1b an antenna configuration (square 90x90 meters) was carried out, using the Larmor frequency (2315,6 Hz) and with a matrix dimensioned for a depth of 135 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf). Next loop reach depths below 90 m but low water signals still appears (<2%).

As can be extracted from the graphics, the sounding reflects the existence of an aquifer above 53 meters of depth (in red colour). Hence, the model who is represented in the present graphics would correspond to:

From 4 to 53 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of several extensional dolines on the surveyed area, on which the water was accumulated. This layer is divided in four trams according to its water content and has a moderate permeability (0,3-13 m/day) and a moderate water content (0,5-8,2%) (between 18 to 53 metres of depth: 0%). Anyway, this porosity only corresponds with a highly fractured ice zone. As we can observe, at the firsts meters high water contents is detected (close to 8% values) and also high decays (more than 500 ms, blue colours). till 18 m depth. This description is according with the Cold ice (water facies type 1).

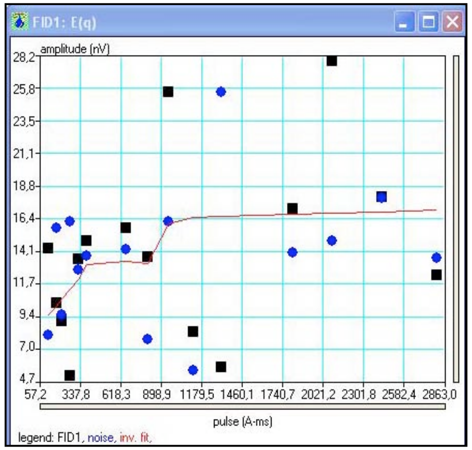
Underneath, from 53 to 81 meters of depth there is a possible aquifer level interpreted as Temperate ice/Wet ice (Water facies Type 2), which has a low permeability (0,3 m/day) and a low water content (1,4 %).

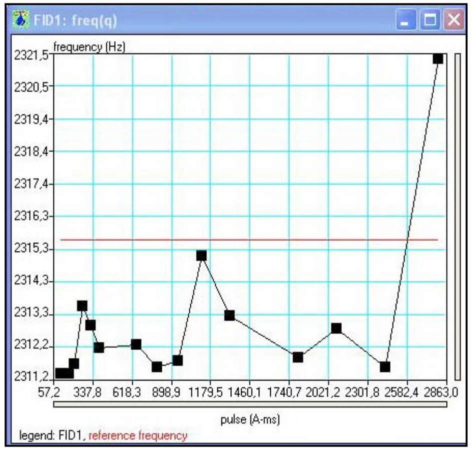
Underneath from 81 to 135 meters of depth we find a possible aquifer level interpreted as Wet ice (Water facies type 2) or a sedimentary aquifer. This layer has the same permeability (0,3 m/day) but lower water content (0,5%). Beneath 53 meters depth, a general decreasing pattern in water content can be observed (and is under a 2%). This description is not according with the Wet ice (water facies type 1).

MRS 11: Interpretation 11a

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =1 and T1 =0) for 6 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q1, q2. q9, q10 & q16, have been eliminated from the interpretation.

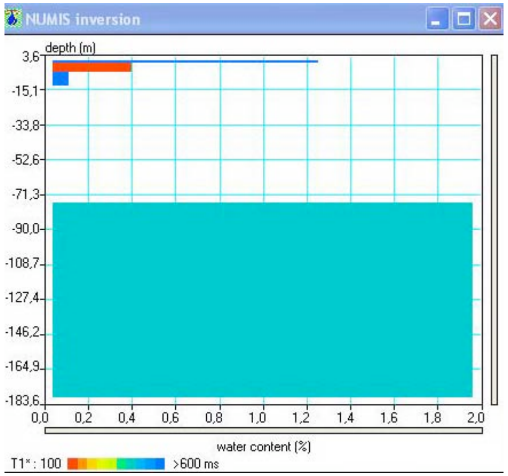
Amplitude & Frequency

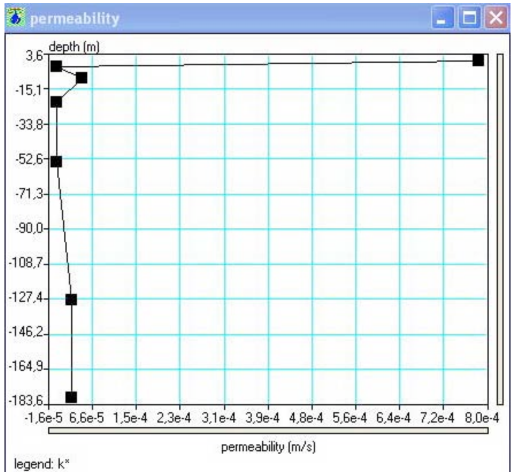




MRS 11a	Hansbreen STICK 1b		Hornsund	Larmor	2315,6	Hz
Moments	**Frequency**	**Variation**	**Signal**	**Noise**	**S/N**	**EN/IN**
Q1	0	0	0	0	0	0
Q2	0	0	0	0	0	0
Q3	2311,4	4,17	14,36	8,15	1,76	0,82
Q4	2311,4	4,17	10,42	15,86	0,66	1,59
Q5	2311,7	3,86	9,14	9,53	0,96	0,95
Q6	2313,6	2,04	5,20	16,29	0,32	1,63
Q7	2312,9	2,67	13,61	12,82	1,06	1,28
Q8	2312,2	3,35	14,95	13,85	1,08	1,39
Q9	0	0	0	0	0	0
Q10	0	0	0	0	0	0
Q11	2312,4	3,25	15,91	14,30	1,11	1,43
Q12	2311,6	3,98	13,77	7,80	1,76	0,78
Q13	2311,8	3,78	25,61	16,29	1,57	1,63
Q14	2315,2	0,45	8,35	5,58	1,50	0,56
Q15	2313,2	2,35	5,80	25,61	0,23	2,56
Q16	0	0	0	0	0	0
Q17	2311,9	3,67	17,19	14,05	1,22	1,40
Q18	2312,8	2,75	27,85	14,90	1,87	1,49
Q19	2311,6	3,98	18,02	18,02	1,00	1,80
Q20	2321,4	-5,75	12,40	13,67	0,91	1,37
	Hz	**Δf < 4 Hz**	**nV**	**nV**	**>2**	**≈ 1**
File name :	RunningT1T0Layers6-Q1Q2Q9Q10Q16No.jpg					

With the signal treatment is observed that nearly all the pulse moments are within the 4 Hz < Δf < -4 Hz range. However, none of the values of obtained amplitude, show a good S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in nearly all the values. Because of this, we can consider this interpretation as quantitative.





In the surveyed area Stick 1b an antenna configuration (square 120x120 meters) was carried out, using the Larmor frequency (2315,6 Hz) and with a matrix dimensioned for a depth of 180 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf). The dimension of big loops can be influenced by the anisotropy of the geological system and different signals can be detected. So the inversion of the data can have more than one solution (Interpretations 11a, 11b &11c) and it means that in essence we are reaching a non layered boundary (sharp contact?). In the interpretation 11b it was taken into account all the measured points. However in the interpretations 11a &11c are used the same data but without pulses (black square data) witch are at the bad frequency or not near from the Larmor frequency. Both solutions are possible, because if one pulse is far from the Larmor frequency it means that is no water is at given depth, but the mean result can be different.

Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding, (apart from q1, q2, q9, q10 & q16) is shown in the following figures. As can be extracted from the graphics, the sounding reflects the existence of an aquifer above 75 meters of depth (in blue colour). Hence, the model in the present graphics would correspond to:

From 6 to 40 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of several extensional moulins on the surveyed area, on which the water was accumulated. This layer is divided in three trams according to its water content and has a high permeability (5,7 -70 m/day) but a low water content (0,1-1,25%) (9 to 40 metres of depth: 0%). Anyway, this porosity only corresponds with a highly fractured ice zone. As we can observe, at the firsts meters low water contents are detected (above 2% values) but high decays (more than 500 ms, blue colours) till 15 m depth. A general decreasing pattern in water content can be observed till 14 m depth. This description is according with the Cold ice (water facies type 1).

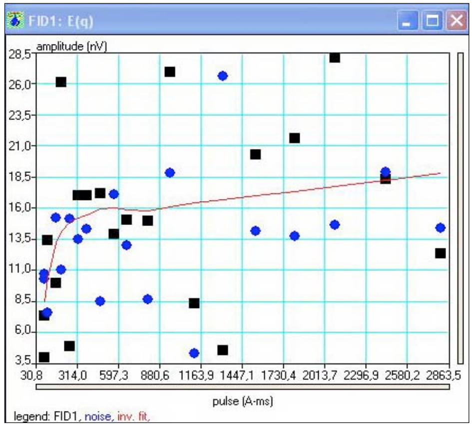
Underneath, from 40 to 75 meters of depth appear a level correlated as Temperate ice, which doesn't presents any water content.

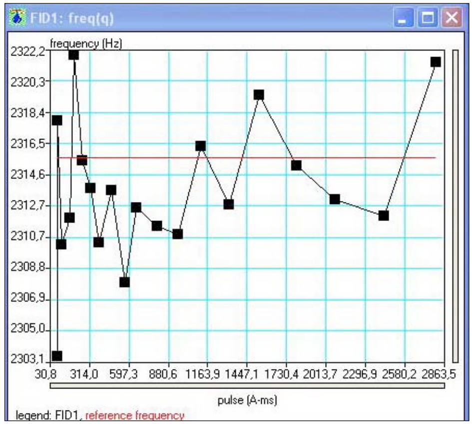
Underneath from 75 to 180 meters of depth we find a possible aquifer level interpreted as Wet ice (Water facies type 2) or a sedimentary aquifer. This layer has a permeability of (1,4-6 m/day) but moderate water content (2%). A general increasing pattern in water content can be observed till 75 m depth. This description is according with the Wet ice (water facies type 2).

Interpretation 11b

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =10 and T1 =0) for 10 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus. (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf).

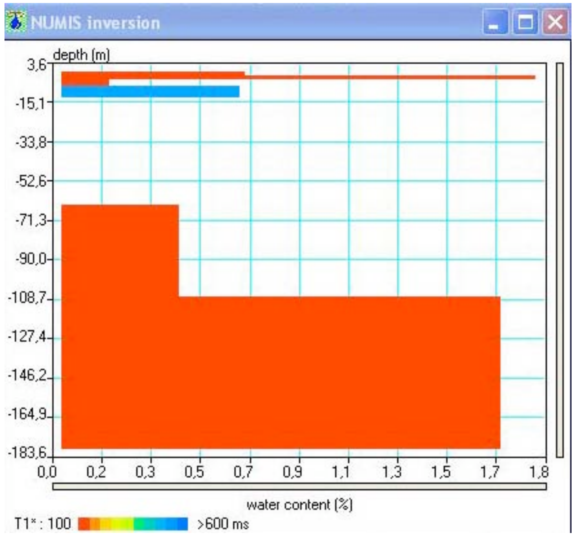
Amplitude & Frequency

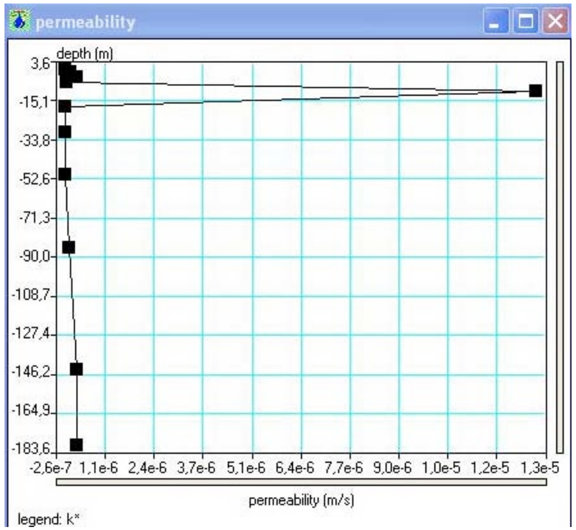




With the signal treatment is observed that nearly all the pulse moments are within the 4 Hz < Δf < -4 Hz range, and the values q2 & q16 approaches much that range. However, just three of the values of obtained amplitude, show a good S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in nearly all the values. Because of this, we can consider this interpretation as quantitative.

MRS 11b	Hansbreen STICK 1b		Hornsund	Larmor	2315,6	Hz
Moments	**Frequency**	**Variation**	**Signal**	**Noise**	**S/N**	**EN/IN**
Q1	2303,5	12,13	7,05	10,36	0,68	1,04
Q2	2318,0	-2,36	4,09	10,75	0,38	1,08
Q3	2310,4	5,23	13,49	7,62	1,77	0,76
Q4	2311,9	3,65	10,07	15,27	0,66	1,53
Q5	2321,9	-6,34	26,19	11,06	2,37	1,11
Q6	2315,5	0,09	4,97	15,19	0,33	1,52
Q7	2313,8	1,79	17,09	13,54	1,26	1,35
Q8	2310,5	5,13	17,09	14,39	1,19	1,44
Q9	2313,7	1,93	17,26	8,56	2,02	0,86
Q10	2308,0	7,56	13,93	17,18	0,81	1,72
Q11	2312,6	2,98	15,10	13,03	1,16	1,30
Q12	2311,5	4,11	15,00	8,71	1,72	0,87
Q13	2311,0	4,63	27,02	18,88	1,43	1,89
Q14	2316,4	-0,78	8,42	4,38	1,92	0,44
Q15	2312,8	2,81	4,63	26,68	0,17	2,67
Q16	2319,5	-3,91	20,34	14,22	1,43	1,42
Q17	2315,1	0,45	21,65	13,78	1,57	1,38
Q18	2313,1	2,49	28,14	14,71	1,91	1,47
Q19	2312,1	3,48	18,40	18,98	0,97	1,90
Q20	2321,5	-5,91	12,43	14,46	0,86	1,45
	Hz	**Δf < 4 Hz**	**nV**	**nV**	**>2**	**≈ 1**
File name :	RunningT10T1Layers10-150ms.jpg					





In the surveyed area Stick 1b an antenna configuration (square 120x120 meters) was carried out, using the Larmor frequency (2315,6 Hz) and with a matrix dimensioned for a depth of 180 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding, is shown in the following figures. As can be extracted from the graphics, the sounding reflects the existence of an aquifer above 60 meters of depth (in red colour). Hence, the model in the present graphics would correspond to:

From 6 to 60 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of several extensional moulinss on the surveyed area, on which the water was accumulated. This layer is divided in three trams according to its water content and has a high permeability (10^{-2} -1 m/day) but a low water content (0,2-1,8%) (from 15 to 60 metres of depth: 0%). Anyway, this porosity only corresponds with a highly fractured ice zone. As we can observe, at the firsts meters low water contents are detected (above 2% values, with a change on water content at 100 m), but high decays (more than 500 ms, blue colours) till 15 m depth. A general decreasing pattern in water content can be observed till 15 m depth. This description is according with the Cold ice (water facies type 1).

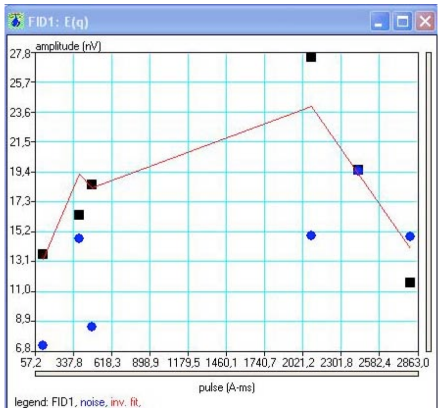
Underneath, from 60 to 108 meters of depth appear a level correlated as Temperate ice, which has a low permeability of (10^{-2} m/day) and a low water content (0,4%).

Underneath from 108 to 180 meters of depth we find a possible aquifer level interpreted as Wet ice (Water facies type 2) or a sedimentary aquifer. This layer has a permeability of (10^{-2} m/day) but moderate water content (1,7%). A general increasing pattern in water content can be observed till 60 m depth. This description is according with the Wet ice (water facies type 2).

Interpretation 11c

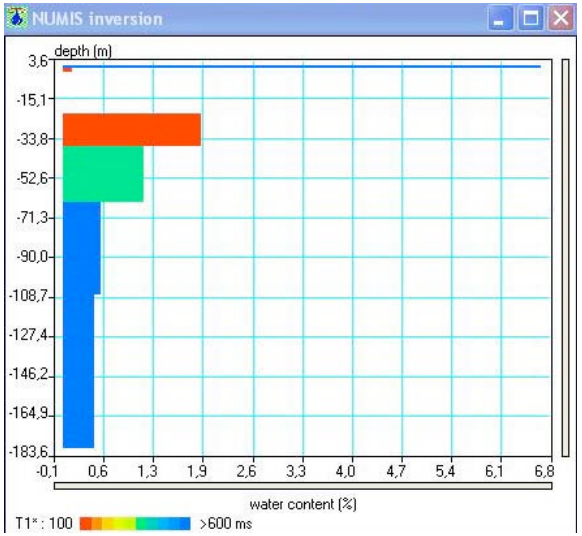
In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =10 and T1 =1) for 10 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus. (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moment: q1,q2, q4, q5, q6, q7, q10, q11, q12, q13, q14, q15, q16 & q17; have been eliminated from the interpretation.

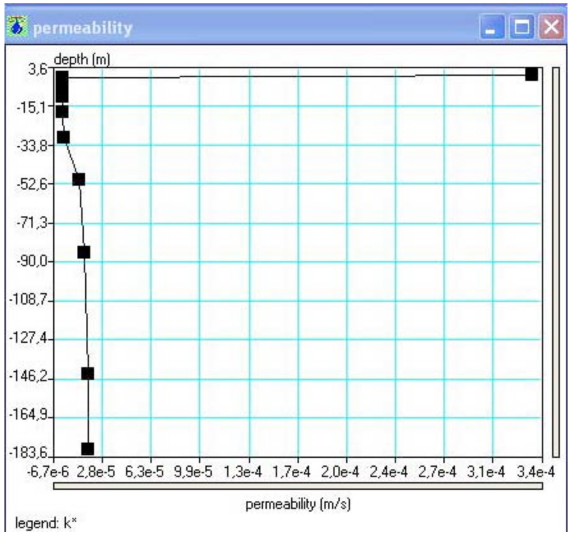
Amplitude & Frequency



With the signal treatment is observed that half of the pulse moments are within the 4 Hz < Δf < -4 Hz range, however, just one of the values of obtained amplitude, show a good S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in all the values. Because of this, we can consider this interpretation as quantitative.

MRS 11c	Hansbreen STICK 1b		Hornsund	Larmor	2315,6	Hz
Moments	**Frequency**	**Variation**	**Signal**	**Noise**	**S/N**	**EN/IN**
Q1	0	0	0	0	0	0
Q2	0	0	0	0	0	0
Q3	2310,7	4,95	13,65	7,23	1,89	0,72
Q4	0	0	0	0	0	0
Q5	0	0	0	0	0	0
Q6	0	0	0	0	0	0
Q7	0	0	0	0	0	0
Q8	2310,0	5,55	16,41	14,76	1,11	1,48
Q9	2313,4	2,18	18,55	8,54	2,17	0,85
Q10	0	0	0	0	0	0
Q11	0	0	0	0	0	0
Q12	0	0	0	0	0	0
Q13	0	0	0	0	0	0
Q14	0	0	0	0	0	0
Q15	0	0	0	0	0	0
Q16	0	0	0	0	0	0
Q17	0	0	0	0	0	0
Q18	2312,9	2,69	27,48	14,97	1,84	1,50
Q19	2313,0	2,58	19,58	19,58	1,00	1,96
Q20	2309,0	6,65	11,70	14,91	0,78	1,49
	Hz	**Δf < 4 Hz**	**nV**	**nV**	**>2**	**≈ 1**
File name :	RunningT10T1Layers10-150ms.jpg					





In the surveyed area Stick 1b an antenna configuration (square 120x120 meters) was carried out, using the Larmor frequency (2315,6 Hz) and with a matrix dimensioned for a depth of 180 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf). The last two interpretations do not take care about the tendency of the three last points (amplitude graph), so if the inversion is forced to obtain that decreasing tendency then only the result at the deeper depths should be taken into account.

This interpretation is obtained from the permeability and water content taking into account all the measured pulse moments in the sounding, (apart from q1, q2, q4, q5, q6, q7, q10, q11, q12, q13, q14, q15, q16 & q17), (see figures). As can be extracted from the graphics, the sounding reflects the existence of four aquifers above 25 meters of depth (in red colour). Hence, the model in the present graphics would correspond to:

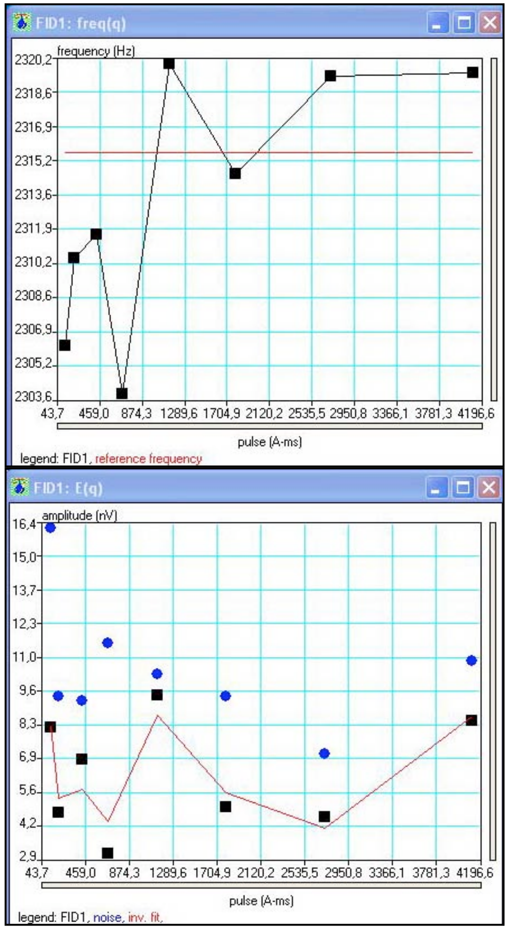
From 25 to 62 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of several extensional moulins on the surveyed area, on which the water was accumulated. This layer is divided in two trams according to its water content and has a high permeability (0,6-30 m/day), but low water content (1,1-1,9%). Anyway, this porosity only corresponds with a highly fractured ice zone. As we can observe, at the firsts meters (till 38 m depth) low water contents (above 2% values) and a general decreasing pattern in water content, were detected. This description is according with the Cold ice (water facies type 1).

Underneath, from 62 to 108 meters of depth appear a level correlated as Wet ice (water facies type 2), which has a low permeability of (2,5 m/day) and a very low water content (0,6%). A general decreasing pattern in water content can be observed till 60 m depth. This description is not according with the Wet ice (water facies type 2).

Underneath from 108 to 180 meters of depth we find a level interpreted as a possible sedimentary aquifer. This layer has a permeability of (2,5 m/day) but moderate water content (0,5%).

MRS 12

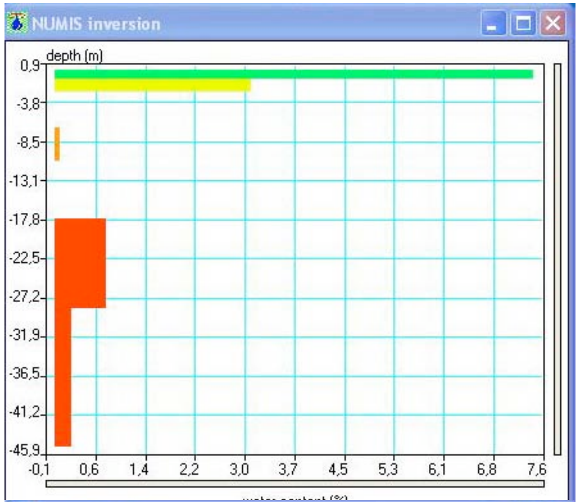
Amplitude & Frequency

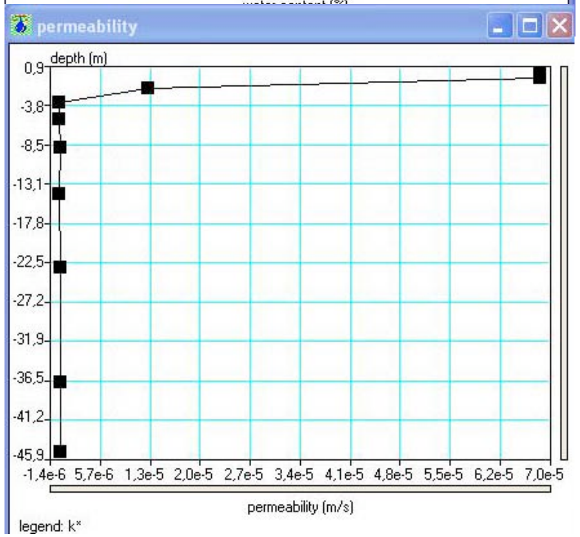


In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =10 and T1 =1) for 8 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus. (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf).

MRS 12	Hansbreen -Tuvbreen				Hornsund (Spitsbergen)		Larmor 2315,6 Hz		
30x30	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	
Frequency	2306,3	2310,6	2311,7	2304,0	2320,0	2314,7	2319,3	2319,5	Hz
	9,31	5,04	3,93	11,63	-4,36	0,94	-3,75	-3,90	Δf < 4 Hz
Signal	8,21	4,84	6,95	3,19	9,53	5,06	4,64	8,48	nV
Noise	16,22	9,47	9,31	11,59	10,37	9,47	7,18	10,91	nV
S/N	0,51	0,51	0,75	0,28	0,92	0,53	0,65	0,78	> 2
EN/IN	1,62	0,95	0,93	1,16	1,04	0,95	0,72	1,09	≈ 1
File name:	RunningT10T1Layers8Allpoints.jpg								

With the signal treatment is observed that half of the pulse moments are within the 4 Hz < Δf < -4 Hz range, and the value q7 & q8 approaches much to that range. However, all the values of obtained amplitude show a very low S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in all the values. Because of this, we can consider this interpretation as quantitative.





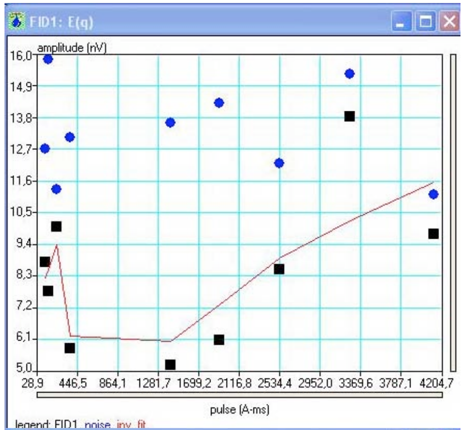
Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding is shown in the following figures. In the surveyed Tuvbreen area, four loop configurations have been done, in order to compare the results obtained using different loop sizes in the same area (MRS 12, MRS 13, MRS 14 & MRS 15). In this case using the Larmor frequency (2315,6 Hz), an antenna configuration carried out (square 30x30 meters, it was necessary to use two loop turns to increase the impedance in the circuit), and with a matrix dimensioned for a depth of 45 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

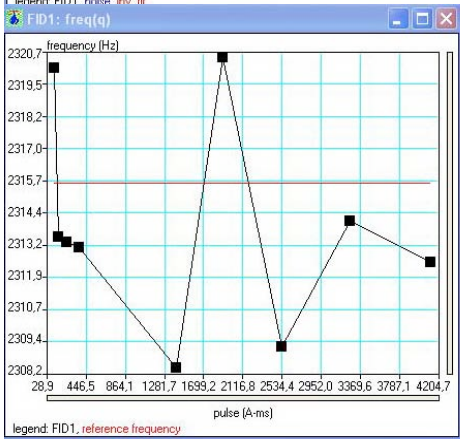
As can be extracted from the graphics, the sounding reflects the existence of an aquifer, from 18 to 45 meters of depth (in red colour). Hence, the model in the present graphics would correspond to:

From 1,2 to 45 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of an extensional moulins near the surveyed area, on which the water was accumulated. This layer is divided in five trams according to its water content and permeability. The trams with water signals are: from 1,2 to 3 meters of depth, which has a moderate permeability (1-6 m/day) and a high water content (3-7,4 %). From 5 to 11 meters of depth, which has a low permeability (0,12 m/day) and a very low water content (0,1 %). From 18 to 29 meters of depth, which has a low permeability (0,12 m/day) and a very low water content (0,7 %) From 29 to 45 meters of depth, which has a low permeability (0,12 m/day) and a very low water content (0,25 %). Anyway, this porosity only corresponds with a highly fractured ice zone. A general decreasing pattern in water content can be observed along all that section. This description is according with the Cold ice (water facies type 1).

MRS 13

Amplitude & Frequency





In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =1 and T1 =1) for 13 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus. (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q5, q6 & q7, have been eliminated from the interpretation.

MRS 13	Hansbreen - Tuvbreen				Hornsund		Spitsbergen				Larmor	2315,6	Hz
60x60	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	
Frequency	2320,2	2313,6	2313,4	2313,2	0	0	0	2308,5	2320,6	2309,3	2314,2	2312,6	Hz
	-4,58	2,01	2,22	2,43	0	0	0	7,14	-4,97	6,31	1,40	3,01	Δf < 4 Hz
Signal	8,80	7,78	10,04	5,83	0	0	0	5,26	6,10	8,55	13,86	9,80	nV
Noise	12,74	15,86	11,31	13,15	0	0	0	13,66	14,35	12,23	15,35	11,15	nV
S/N	0,69	0,49	0,89	0,44	0	0	0	0,38	0,43	0,70	0,90	0,88	> 2
EN/IN	1,27	1,59	1,13	1,32	0	0	0	1,37	1,44	1,22	1,54	1,12	≈ 1
File name:	RunningT1T1Layers13-Q5Q6Q7No.jpg												

With the signal treatment is observed that more than a half of the pulse moments are within the 4 Hz < Δf < -4 Hz range or close. However, all the values of obtained amplitude, show a very low S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in all the values. Because of this, we can consider this interpretation as quantitative.

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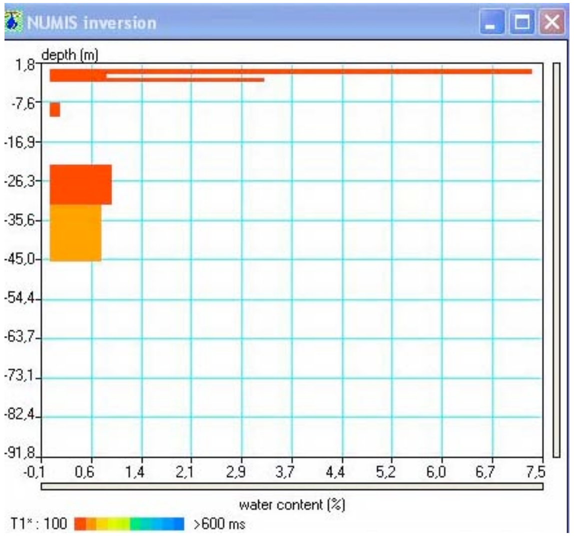

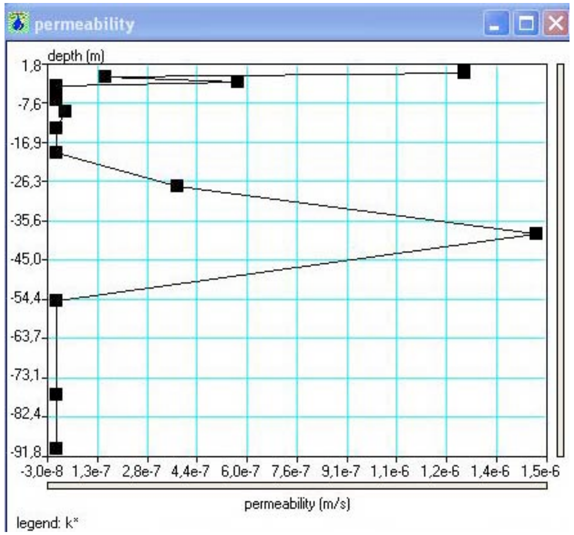

Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding (apart from q5, q6 & q7) is shown in the following figures. In the surveyed Tuvbreen area, an antenna configuration (square 60x60 meters) was carried out, using the Larmor frequency (2315,6 Hz) and with a matrix dimensioned for a depth of 90 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf). Enlarging the loop we obtain water signals in depth but also from other superficial runoff streams.

As can be extracted from the graphics, the sounding reflects the existence of an aquifer, from 22 to 45 meters of depth (in red & orange colours). Hence, the model in the present graphics would correspond to:

From 1,8 to 45 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of an extensional moulines on the surveyed area, on which the water was accumulated. This layer is divided in four trams according to its water content and permeability: From 2,5 to 5 meters of depth has a very low permeability (10^{-2} m/day) and moderate water content (0,9-7,4%) (5 to 7,6 metres of depth: 0%). From 7,6 to 10,3 meters of depth a very low permeability (10^{-3} m/day) and a low water content (0,3%) (0,3 to 21,6 metres of depth: 0%). From 21,6 to 31,6 meters of depth a low permeability (0,13 m/day) is present and low water content (0,9%) From 31,6 to 45 meters of depth has a low permeability (0,13 m/day) and a low water content (0,7%). Anyway, this porosity only corresponds with a highly fractured ice zone. As we can observe, at the firsts meters high water contents is detected (close to 8% values) and a general decreasing pattern in water content can be observe. These descriptions are according with the Cold ice (water facies type 1).

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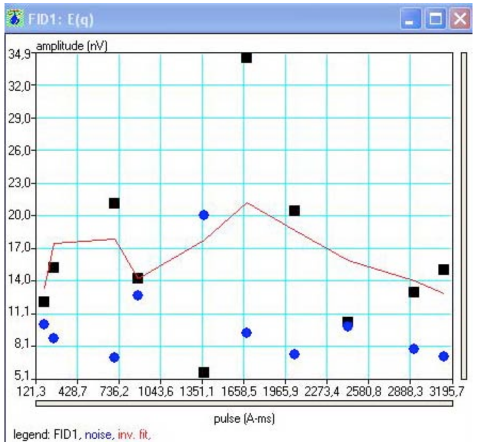
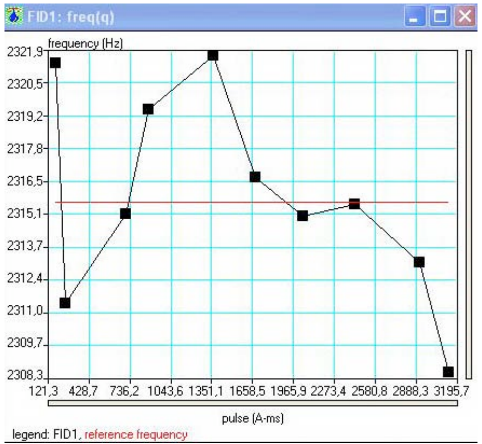
MRS 14

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =100 and T1 =1) for 14 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q1, q2, q5, q6, q7 & q10, have been eliminated from the interpretation.

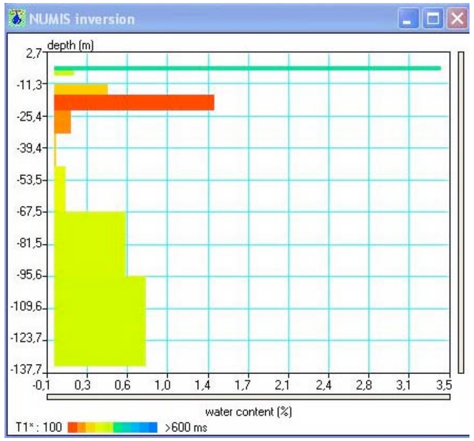
Amplitude & Frequency

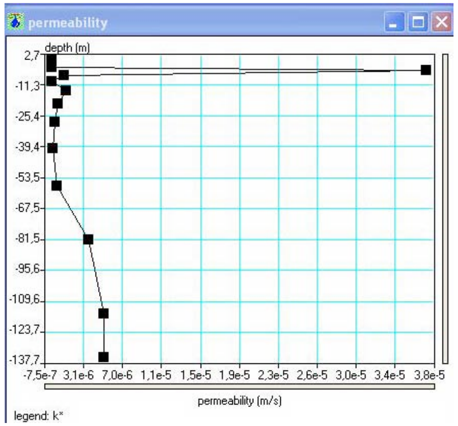




With the signal treatment is observed that more than half of the pulse moments are within the 4 Hz < Δf < -4 Hz range. However, just four of the values of obtained amplitude, show a good S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in nearly all the values. Because of this, we can consider this interpretation as quantitative.

MRS 14	Hansbreen-Tuvbreen		Hornsund	Larmor 2315,6		Hz
Moments	**Frequency**	**Variation**	**Signal**	**Noise**	**S/N**	**EN/IN**
Q1	0	0	0	0	0	0
Q2	0	0	0	0	0	0
Q3	2321,4	-5,76	12,21	10,12	1,21	1,01
Q4	2311,5	4,15	15,22	8,84	1,72	0,88
Q5	0	0	0	0	0	0
Q6	0	0	0	0	0	0
Q7	0	0	0	0	0	0
Q8	2315,2	0,45	21,22	7,12	2,98	0,71
Q9	2319,5	-3,86	14,29	12,84	1,11	1,28
Q10	0	0	0	0	0	0
Q11	2321,7	-6,08	5,75	20,09	0,29	2,01
Q12	2316,7	-1,09	34,39	9,37	3,67	0,94
Q13	2315,1	0,53	20,50	7,46	2,75	0,75
Q14	2315,5	0,05	10,37	10,01	1,04	1,00
Q15	2313,2	2,43	13,05	7,92	1,65	0,79
Q16	2308,6	7,00	15,14	7,21	2,10	0,72
	Hz	**Δf < 4 Hz**	**nV**	**nV**	**>2**	**≈ 1**
File name :	RunningT100T1Layers14-Q1Q2Q5Q6Q7Q10NO.jpg					





Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding, is shown in the following figures. In the surveyed Tuvbreen, an antenna configuration (square 90x90 meters) was carried out, using the Larmor frequency (2315,6 Hz) and with a matrix dimensioned for a depth of 135 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf). Next loop reach depths below 90 m but low water signals still appears (<2%).

As can be extracted from the graphics, the sounding reflects the existence of an aquifer above 68 meters of depth (in yellow colour). Hence, the model who is represented in the present graphics would correspond to:

From 7 to 68 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of an extensional moulins on the surveyed area, on which the water was accumulated. This layer is divided in seven trams according to its water content (low: 0,15-3,4%) and permeability (low: 10^{-2} m/day). Anyway, this porosity only corresponds with a highly fractured ice zone. A general decreasing pattern in water content can be observed all along this layer, this description is according with the Cold ice (water facies type 1).

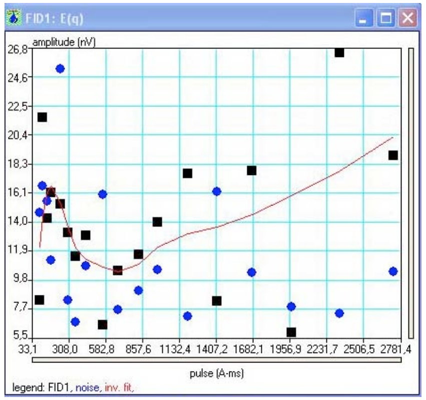
Underneath, from 68 to 96 meters of depth there is a possible aquifer level interpreted as Temperate ice (Water facies Type 2), which has a low permeability (0,3 m/day) and a low water content (0,8 %).

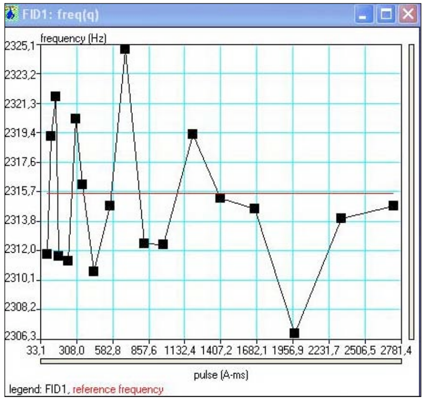
Underneath from 96 to 135 meters of depth we find a possible aquifer level interpreted as Wet ice (Water facies type 2) or as a sedimentary aquifer. This layer has nearly the same permeability (0,34 m/day) but a lower higher content (0,8%). Beneath 68 meters depth, a general decreasing pattern in water content can be observed (and is under a 2%). This description is according with the Wet ice (water facies type 2).

MRS 15

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =50 and T1 =1) for 12 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus. (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf).

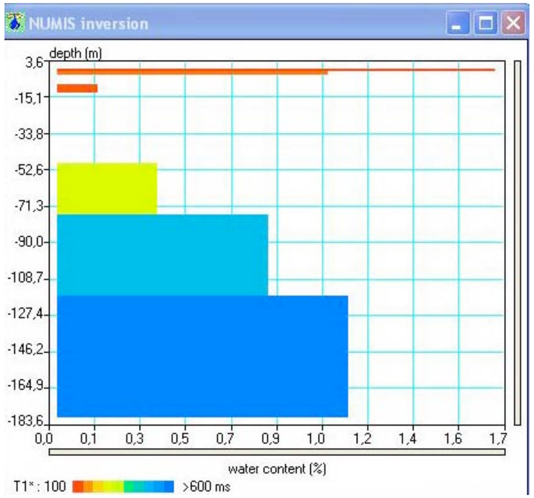
Amplitude & Frequency

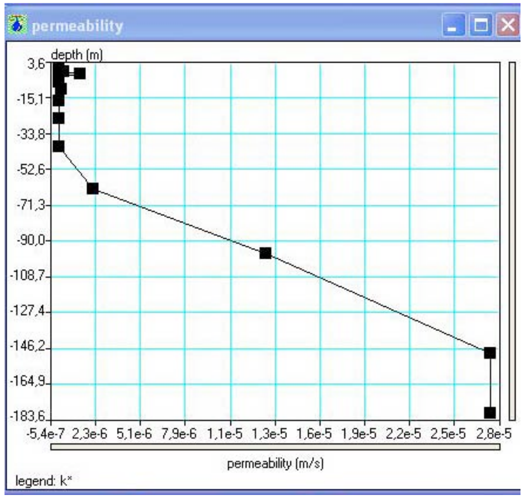




With the signal treatment is observed that half of the pulse moments are within the 4 Hz < Δf < -4 Hz range, however, just two of the values of obtained amplitude, show a good S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in all the values. Because of this, we can consider this interpretation as quantitative.

MRS 15	Hansbreen - Tuvbreen		Cristal cave	Larmor 2315,6 Hz		
Moments	Frequency	Variation	Signal	Noise	S/N	EN/IN
Q1	2311,8	3,83	8,33	14,77	0,56	1,48
Q2	2319,3	-3,69	21,74	16,71	1,30	1,67
Q3	2321,8	-6,24	14,30	15,60	0,92	1,56
Q4	2311,6	3,95	16,20	11,27	1,44	1,13
Q5	2311,4	4,24	15,40	25,31	0,61	2,53
Q6	2320,4	-4,80	13,28	8,33	1,59	0,83
Q7	2316,2	-0,63	11,52	6,73	1,71	0,67
Q8	2310,7	4,94	13,09	10,86	1,21	1,09
Q9	2314,9	0,75	6,53	16,09	0,41	1,61
Q10	2324,8	-9,24	10,50	7,63	1,38	0,76
Q11	2312,4	3,17	11,67	9,02	1,29	0,90
Q12	2312,4	3,21	14,06	10,58	1,33	1,06
Q13	2319,4	-3,80	17,61	7,14	2,46	0,71
Q14	2315,3	0,30	8,26	16,31	0,51	1,63
Q15	2314,7	0,91	17,82	10,36	1,72	1,04
Q16	2306,7	8,88	5,95	7,84	0,76	0,78
Q17	2314,1	1,55	26,46	7,35	3,60	0,74
Q18	2314,8	0,77	18,94	10,43	1,82	1,04
	Hz	Δf < 4 Hz	nV	nV	>2	≈ 1
File name :	RunningT10T1Layers10-150ms.jpg					





In the surveyed tuvbreen area an antenna configuration (square 120x120 meters) was carried out, using the Larmor frequency (2315,6 Hz) and with a matrix dimensioned for a depth of 180 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

This interpretation is obtained from the permeability and water content taking into account all the measured pulse moments in the sounding (see fegures). As can be extracted from the graphics, the sounding reflects the existence of three aquifer levels above 50 meters of depth: from 50 to 75 meters of depth, from 75 to 118 meters of depth and from 118 to 180 meters of depth. Hence, the model who is represented in the present graphics would correspond to:

From 2 to 50 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of an extensional moulins on the surveyed area, on which the water was accumulated. This layer is divided in two trams according to its water content and has a low permeability (10^{-2} m/day), and low water content (0,1-1,7%). Anyway, this porosity only corresponds with a highly fractured ice zone. As we can observe, this layer presents low water contents (above 2% values) and a general decreasing pattern in water content. This description is according with the Cold ice (water facies type 1). (From 4-8, and 10-50 meters of depth water content: 0%).

Underneath, from 50 to 75 meters of depth appear a possible aquifer level, correlated as Temperate ice (water facies type 2), which has a low permeability of (0,2 m/day) and a very low water content (0,4%).

Underneath, from 75 to 118 meters of depth appear a possible aquifer level correlated as Wet ice (water facies type 2), which has a low permeability of (1 m/day) and low water content (0,85%).

Underneath, from 118 to 180 meters of depth we find a level interpreted as a possible sedimentary aquifer. This layer has a permeability of (2,4 m/day) and moderate water content (1,1%). A general increasing pattern in water content can be observed till 50 m depth. This description is according with the Wet ice (water facies type 2).

Geology, geotechnics, hydrogeology, environmental and scientific & technical services.
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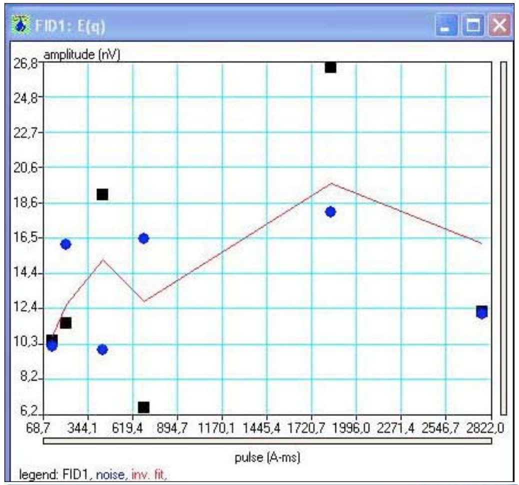
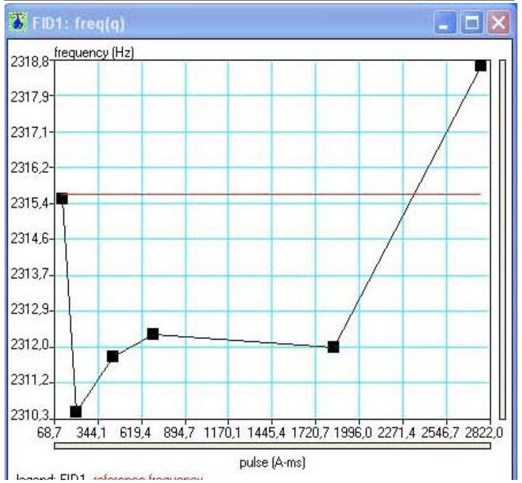
E-MAIL: igeotest@myp.ad, igeofundacio@andorra.ad, WEB page: http:\\www.igeotest.ad

Amplitude & Frequency



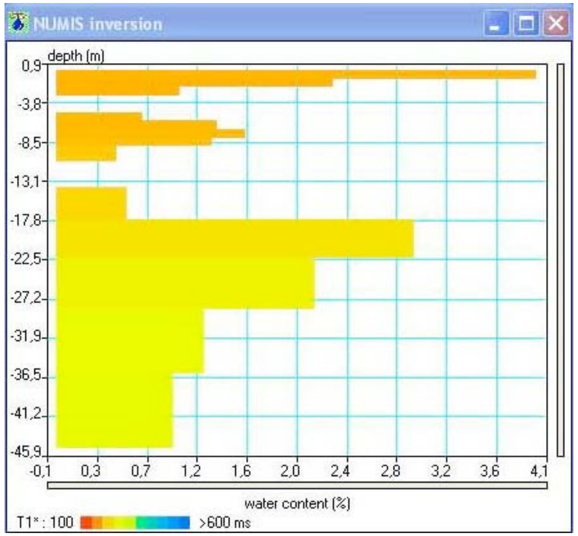


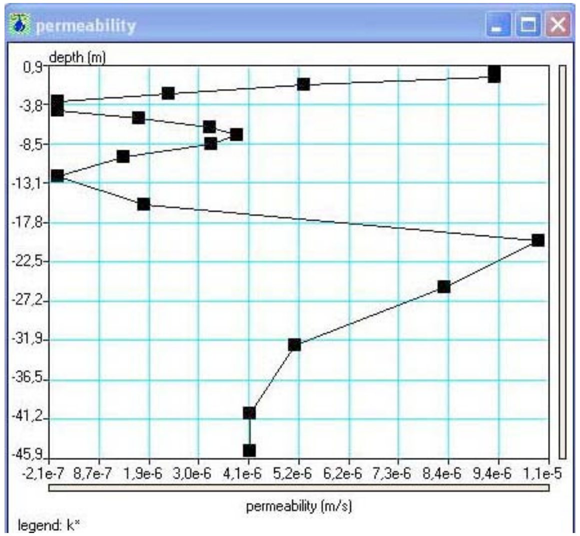
MRS 16

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =500 and T1 =10) for 16 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus. (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q5 & q8, have been eliminated from the interpretation.

MRS 16	**Tuvbreen-Cristal Cave**				**Hornsund (Spitsbergen)**		**Larmor 2315,6 Hz**		
30x30	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	
Frequency	2315,5	2310,5	2311,8	2312,3	0	2312,0	2318,7	0	**Hz**
	0,07	5,12	3,80	3,28	0	3,60	-3,07	0	**Δf < 4 Hz**
Signal	10,51	11,55	19,11	6,65	0	26,50	12,20	0	**nV**
Noise	10,23	16,16	10,00	16,49	0	18,06	12,12	0	**nV**
S/N	1,03	0,72	1,91	0,40	0	1,47	1,01	0	**> 2**
EN/IN	1,02	1,62	1,00	1,65	0	1,81	1,21	0	**≈ 1**
File name:	RunningT500T10Layers16-Q5Q8NO.jpg								

With the signal treatment is observed that nearly all the pulse moments are within the 4 Hz < Δf < -4 Hz range, however, all the values of obtained amplitude show a low S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in all the values. Because of this, we can consider this interpretation as quantitative.





Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding is shown in the following figures. In the surveyed Crystal cave area, four loop configurations have been done, in order to compare the results obtained using different loop sizes in the same area (MRS 16, MRS 17, MRS 18 & MRS 19). In this case using the Larmor frequency (2315,6 Hz), an antenna configuration carried out (square 30x30 meters, it was necessary to use two loop turns to increase the impedance in the circuit), and with a matrix dimensioned for a depth of 45 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

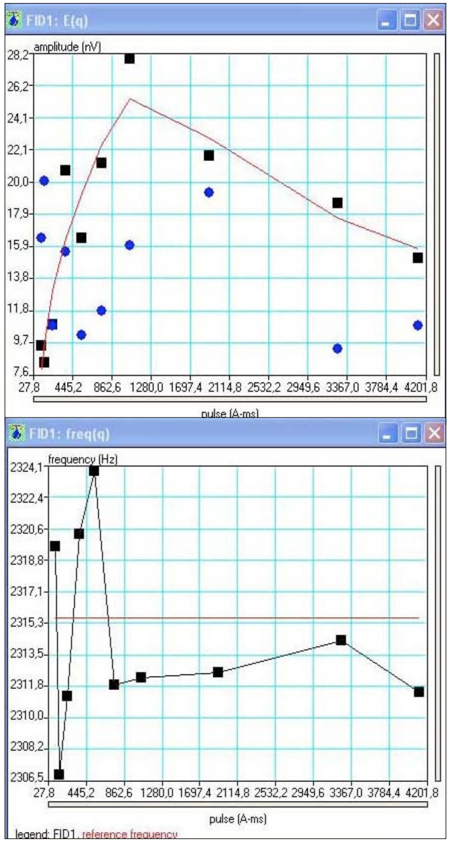
The model in the present graphics would correspond to:

From 1,2 to 45 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of several extensional moulins on the surveyed area, on which the water was accumulated. Anyway, this porosity only corresponds with a highly fractured ice zone.

This layer is divided in three big trams according to its water content and permeability: From 1 to 3,5 meters of depth, which has a low permeability (0,8 m/day) and moderate water content (1-4%). From 5 to 11 meters of depth, which has a low permeability (0,3-10^{-2} m/day) and low water content (0,45-1,6 %). From 15 to 45 meters of depth, which has a low permeability (0,1-1 m/day) and low water content (0,5-3 %).

A general decreasing pattern in water content can be observed along all the trams, according with the Cold ice (water facies type 1).

Amplitude & Frequency

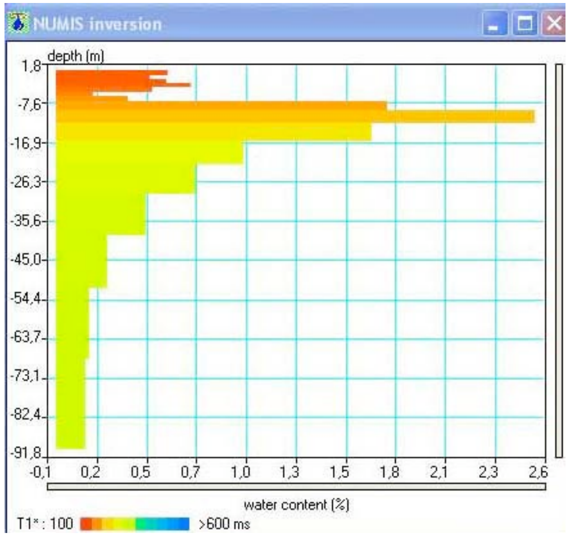


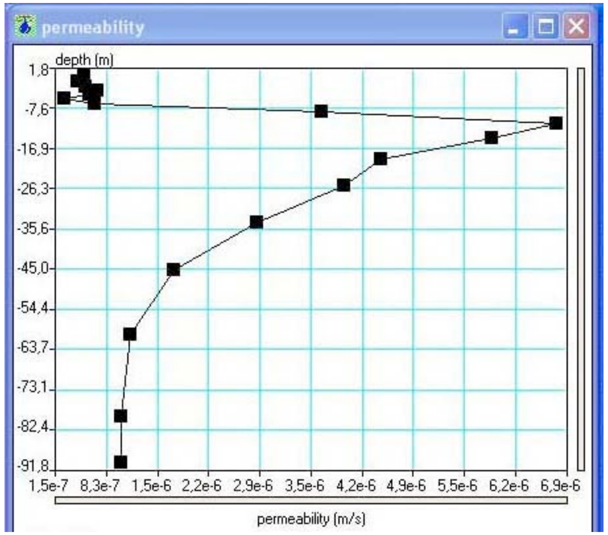
MRS 17

In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =500 and T1 =10) for 16 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus. (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q8 & q10, have been eliminated from the interpretation.

MRS 17	**Tuvbreen - Cristal cave**						**Spitsbergen**				**Larmor**	**2315,6**	**Hz**
60x60	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	
Frequency	2319,6	2306,9	2311,3	2320,3	2323,8	2311,9	2312,3	0	2312,6	0	2314,4	2311,5	**Hz**
	-4,02	8,71	4,34	-4,70	-8,23	3,69	3,30	0	3,01	0	1,23	4,08	**Δf < 4 Hz**
Signal	9,55	8,44	10,90	20,77	16,40	21,23	27,87	0	21,70	0	18,64	15,13	**nV**
Noise	16,40	20,08	10,86	15,52	10,21	11,74	15,94	0	19,31	0	9,33	10,83	**nV**
S/N	0,58	0,42	1,00	1,34	1,61	1,81	1,75	0	1,12	0	2,00	1,40	**> 2**
EN/IN	1,64	2,01	1,09	1,55	1,02	1,17	1,59	0	1,93	0	0,93	1,08	**≈ 1**
File name:	RunningT500T10Layers16-Q8Q10No.jpg												

With the signal treatment is observed that only six of the pulse moments are within of 4 Hz < Δf < -4 Hz, therefore the values q1 approaches much to that range. However, all the values of obtained amplitude, show a very low S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in nearly all the values. Because of this, we can consider this interpretation as quantitative.





Next the interpretation obtained for the permeability and water content taking into account all the measured pulse moments in the sounding is shown in the following figures. In the surveyed Crystal cave area, in this case using the Larmor frequency (2315,6 Hz), an antenna configuration was carried out (square 60x60 meters), and with a matrix dimensioned for a depth of 90 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

The model in the present graphics would correspond to:

From 2 to 90 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. Water signals area attributed to the superficial runoff streams, due to the direct observation on the ice surface of several extensional moulins on the surveyed area, on which the water was accumulated. Anyway, this porosity only corresponds with a highly fractured ice zone.

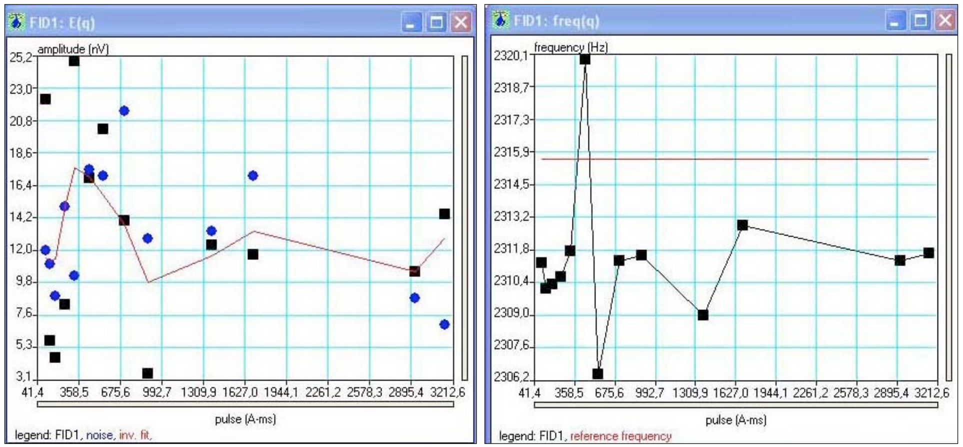
This layer is divided in two big trams according to its water content and permeability: From 2 to 7,6 meters of depth, which has a low permeability (10^{-2} m/day) and low water content (0,2-0,7%). From 7,6 to 90 meters of depth, which has a low permeability (0,6-10^{-2} m/day) and low water content (0,2-2,5 %).

A general decreasing pattern in water content can be observed along all the trams, according with the Cold ice (water facies type 1).

MRS 18

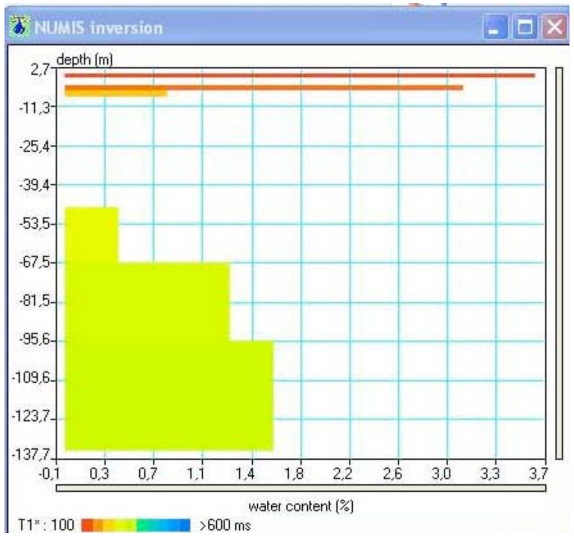
In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =100 and T1 =5) for 12 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf). It should be stressed out that the pulse moments q10, q13 & q14, have been eliminated from the interpretation.

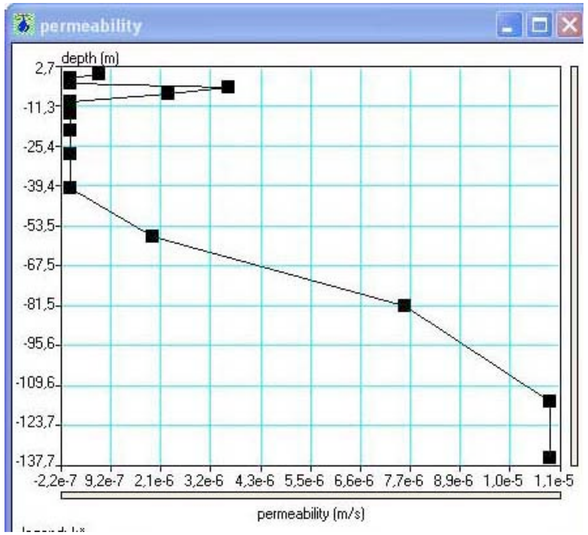
Amplitude & Frequency



MRS 18	Tuvbreen	Cristal	Cave	Larmor	2315,6	Hz
Moments	**Frequency**	**Variation**	**Signal**	**Noise**	**S/N**	**EN/IN**
Q1	2311,2	4,35	22,27	12,00	1,86	1,20
Q2	2310,1	5,46	5,81	11,01	0,53	1,10
Q3	2310,3	5,30	4,65	8,86	0,53	0,89
Q4	2310,6	4,95	8,30	14,95	0,56	1,49
Q5	2311,8	3,85	24,85	10,23	2,43	1,02
Q6	2319,9	-4,30	16,90	17,48	0,97	1,75
Q7	2306,5	9,11	20,24	17,05	1,19	1,70
Q8	2311,3	4,25	14,00	21,47	0,65	2,15
Q9	2311,5	4,06	3,57	12,75	0,28	1,27
Q10	0,0	0	0	0	0	0
Q11	2309,0	6,58	12,31	13,28	0,93	1,33
Q12	2312,8	2,75	11,68	17,05	0,69	1,70
Q13	0,0	0	0	0	0	0
Q14	0,0	0	0	0	0	0
Q15	2311,3	4,25	10,55	8,71	1,21	0,87
Q16	2311,7	3,94	14,49	6,90	2,10	0,69
	Hz	**Δf < 4 Hz**	**nV**	**nV**	**>2**	**≈ 1**
File name :	RunningT100T5Layers12-Q10Q13Q14NO.jpg					

With the signal treatment is observed that only three of the pulse moments are within the 4 Hz < Δf < -4 Hz range, therefore the values q7 also approaches to that range. However, just two of the values of obtained amplitude, show a good S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in nearly all the values. Because of this, we can consider this interpretation as quantitative.





In the surveyed Crystal cave area an antenna configuration (square 90x90 meters) was carried out, using the Larmor frequency (2315,6 Hz) and with a matrix dimensioned for a depth of 135 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

This interpretation is obtained from the permeability and water content taking into account all the measured pulse moments in the sounding (apart from q10, q13 & q14) (see figures). As can be extracted from the graphics, the sounding reflects the existence of three aquifer levels above 50 meters of depth: from 50 to 68 meters of depth, from 68 to 95 meters of depth and from 95 to 135 meters of depth. Hence, the model who is represented in the present graphics would correspond to:

From 3 to 50 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. This layer is divided in three trams according to its water content and has a low permeability (10^{-2} m/day), and low water content (0,8-3,5%). Anyway, this porosity only corresponds with a highly fractured ice zone. As we can observe, this layer presents a general decreasing pattern in water content. This description is according with the Cold ice (water facies type 1). (From 10-50 meters of depth water content: 0%).

Underneath, from 50 to 68 meters of depth appear a possible aquifer level, correlated as Temperate ice (water facies type 2), which has a low permeability of (0,2 m/day) and a very low water content (0,4%).

Underneath, from 68 to 95 meters of depth appear a possible aquifer level correlated as Wet ice (water facies type 2), which has a low permeability of (0,7 m/day) and a low water content (1,25%).

Underneath, from 95 to 135 meters of depth we find a level interpreted as a possible sedimentary aquifer. This layer has a low permeability (1 m/day) and moderate water content (1,6%). A general increasing pattern in water content can be observed till 50 m depth. This description is according with the Wet ice (water facies type 2).

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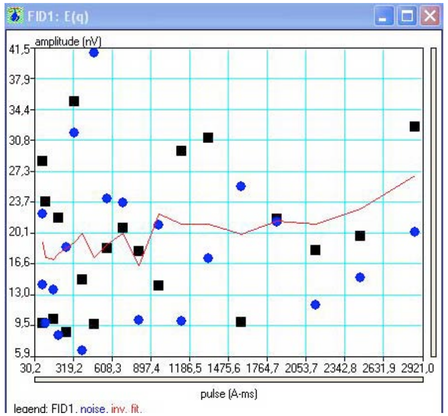
MRS 19

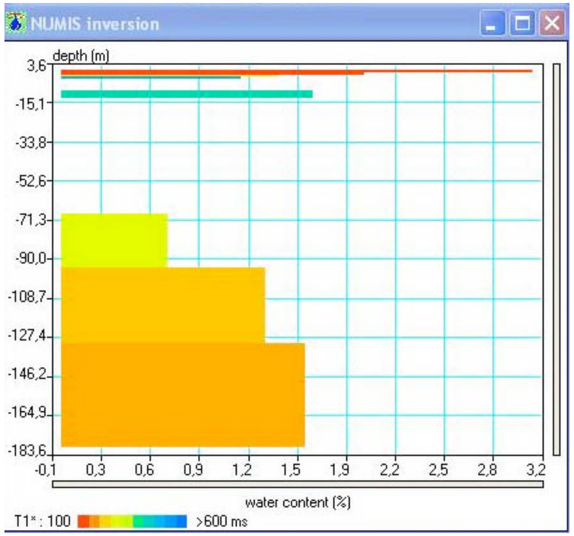
In this interpretation, it was made a signal processing to the data obtained from MRS sounding, applying an harmonic average of the signal in order to attenuate its amplitude (*Running average filter* a 15 ms). The inversion parameters have been modified specifically the regularization ones, thinking of a subsurface with a multilayer aquifer (Cond A de T2 =50 and T1 =1) for 16 layers *(Regularization and number of layers*), but the Cpx coefficient (permeability coefficient) was conserved by default in automatic modus. (http://www.igeotest.fr/RMP/Doc/B.05.MRS-Inversion.pdf).

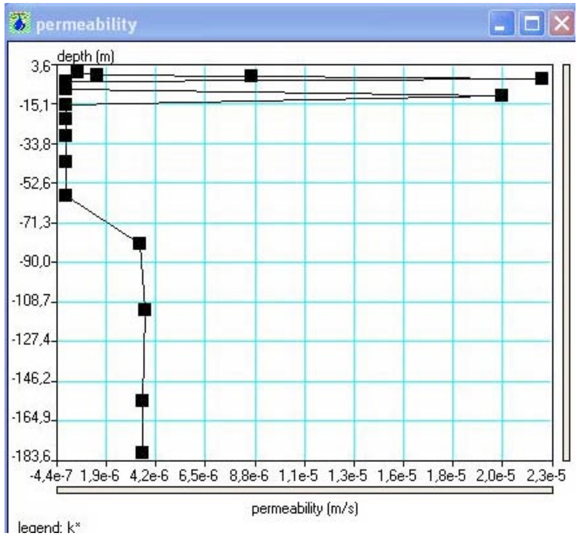
Amplitude & Frequency



With the signal treatment is observed that thirteen pulse moments are within the 4 Hz < Δf < -4 Hz range, but another five values (q12 & q15) approaches to that range. However, just four of the values of obtained amplitude, show a good S/N ratio. The EN/IN ratio, which is indicative of the quality of the sounding, is good in half of the values. Because of this, we can consider this interpretation as quantitative.

MRS 19	Hansbreen -Tuvbreen		Hornsund	Larmor	2315,6	Hz
Moments	Frequency	Variation	Signal	Noise	S/N	EN/IN
Q1	2311,0	4,63	9,82	14,26	0,69	1,43
Q2	2311,4	4,16	28,55	22,42	1,27	2,24
Q3	2312,0	3,55	23,82	9,82	2,42	0,98
Q4	2311,4	4,20	10,29	13,66	0,75	1,37
Q5	2311,8	3,82	21,97	8,40	2,61	0,84
Q6	2318,9	-3,34	8,73	18,58	0,47	1,86
Q7	2311,9	3,72	35,42	31,78	1,11	3,18
Q8	2313,4	2,19	14,81	6,65	2,23	0,67
Q9	2321,1	-5,49	9,71	41,00	0,24	4,10
Q10	2312,2	3,41	18,45	24,17	0,76	2,42
Q11	2313,6	2,05	20,78	23,72	0,88	2,37
Q12	2319,7	-4,11	18,10	10,15	1,78	1,02
Q13	2311,8	3,80	14,14	21,13	0,67	2,11
Q14	2314,0	1,55	29,70	10,09	2,94	1,01
Q15	2319,1	-3,48	31,17	17,30	1,80	1,73
Q16	2312,0	3,59	9,96	25,58	0,39	2,56
Q17	2313,2	2,40	21,81	21,47	1,02	2,15
Q18	2320,1	-4,46	18,19	11,90	1,53	1,19
Q19	2301,5	14,08	19,89	15,04	1,32	1,50
Q20	2312,3	3,33	32,46	20,31	1,60	2,03
	Hz	Δf < 4 Hz	nV	nV	>2	≈ 1
File name :	RunningT50T1Layers16All Points.jpg					





In the surveyed Cristal cave area an antenna configuration (square 120x120 meters) was carried out, using the Larmor frequency (2315,6 Hz) and with a matrix dimensioned for a depth of 180 meters. (http://www.igeotest.fr/RMP/Doc/A.02.MRS-Methode.pdf).

This interpretation is obtained from the permeability and water content taking into account all the measured pulse moments in the sounding (see figures). As can be extracted from the graphics, the sounding reflects the existence of three aquifer levels above 68 meters of depth: from 68 to 95 meters of depth, from 95 to 130 meters of depth and from 130 to 180 meters of depth. Hence, the model in the present graphics would correspond to:

From 5,5 to 68 meters of depth we detected the more superficial layer of the terrain, the Cold ice (Water facies Type 1), which reflects the humidity of the most superficial part of terrain. This layer is divided in three trams according to its water content, and has a low permeability (10^{-2}-2 m/day), and low water content (1,2-3,1%). Anyway, this porosity only corresponds with a highly fractured ice zone. As we can observe, this layer presents a general decreasing pattern in water content. This description is according with the Cold ice (water facies type 1). (From 14-68 meters of depth water content: 0%).

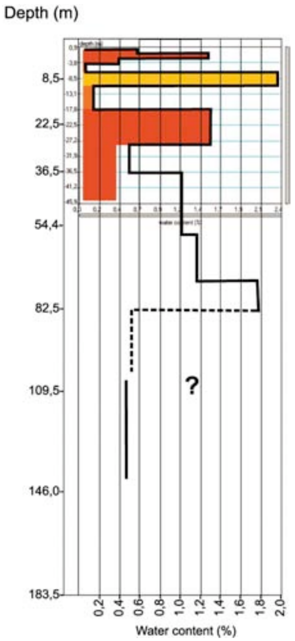
Underneath, from 68 to 95 meters of depth appear a possible aquifer level, correlated as Temperate ice (water facies type 2), which has a low permeability of (0,4 m/day) and a low water content (0,7%).

Underneath, from 95 to 130 meters of depth appear a possible aquifer level correlated as Wet ice (water facies type 2), which has a low permeability of (0,4 m/day) and low water content (1,3%).

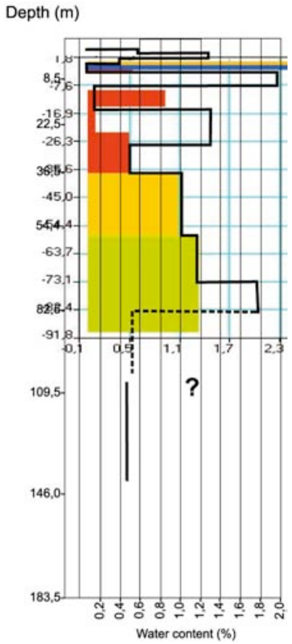
Underneath, from 130 to 180 meters of depth we find a level interpreted as a possible sedimentary aquifer. This layer has a low permeability (0,4 m/day) and moderate water content (1,6%). A general increasing pattern in water content can be observed till 68 m depth. This description is according with the Wet ice (water facies type 2).

HYDROGEOLOGICAL INTERPRETATION OF THE OBTAINED DATA:

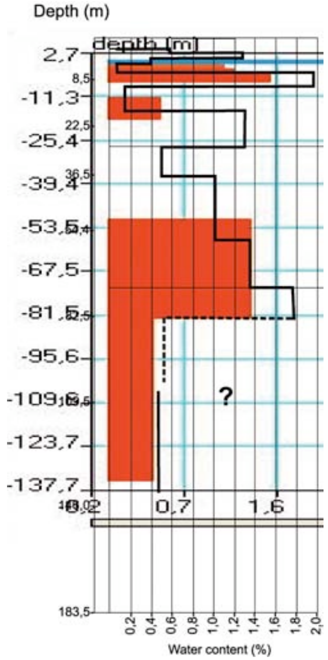
I expose here the means results from the study. For that proposal I show here the interpreted data obtained between 85 and 95 m a.s.l. a half place location on the surveyed glacier. Here four loops of different size were done (30x30, 60x60, 90x90 and 120x120) reaching depths of 45 m, 90 m, 135 m and 180 m. We obtain from the 30X30 loop the water content of the subsurface reaching values above 2% of water content. A general decreasing pattern in water content can be observed. Decays of the signals are above 100 ms. With large loops we obtain water signals with depth but also from other superficial runoff streams. In that sense at the firsts meters high water contents are detected (close to 8,5% values) and also high decays (more than 500 ms). A general decreasing pattern in water content can be observed until 36 m depth. At deeper depths the water content increase but under a 2%. Next loop (90 X 90 m) reach depths below 90 m but low water signals still appear (<2%). The growing behaviour of the decay with depth is also observed. Finally the dimension of the biggest loop (120x120 m) can be influenced by the anisotropy of the geological system and different signals can be detected, in consequence the data can have more than one solution and it means that in essence we are reaching a non layered boundary (substratum).



MRS 8 (30x30)

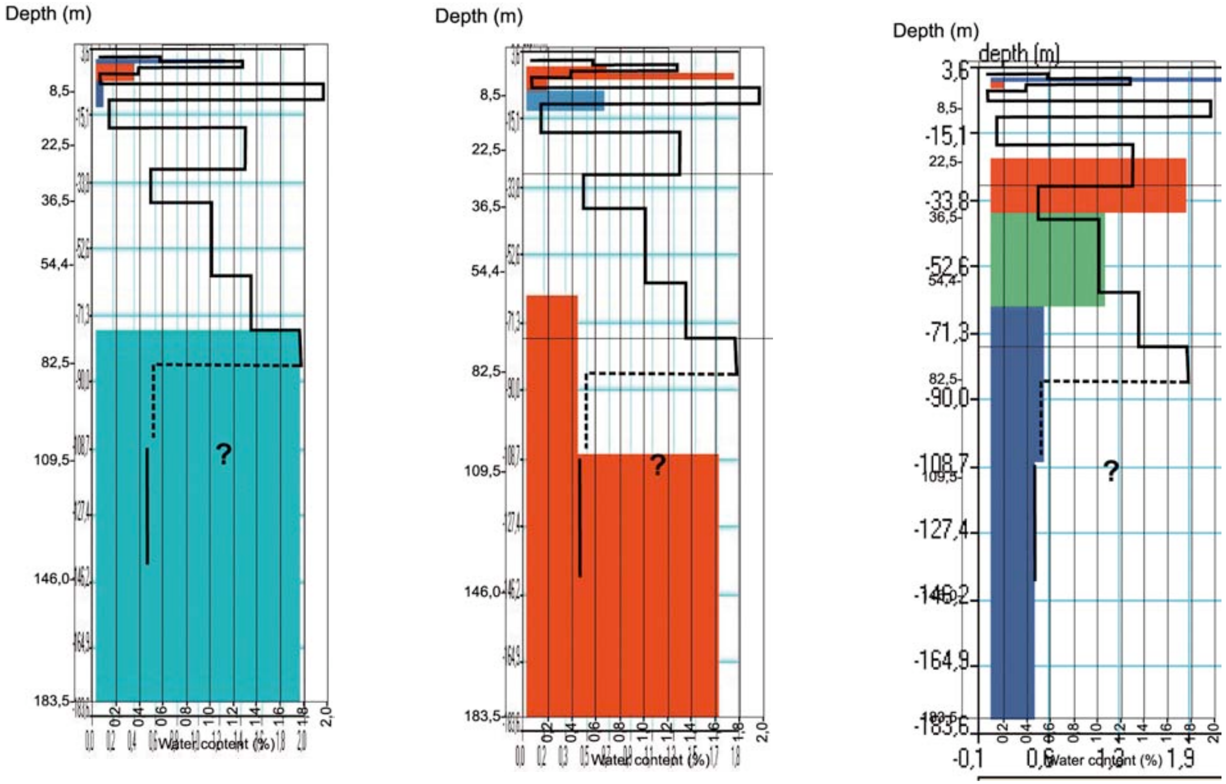


MRS 9 (60x60)



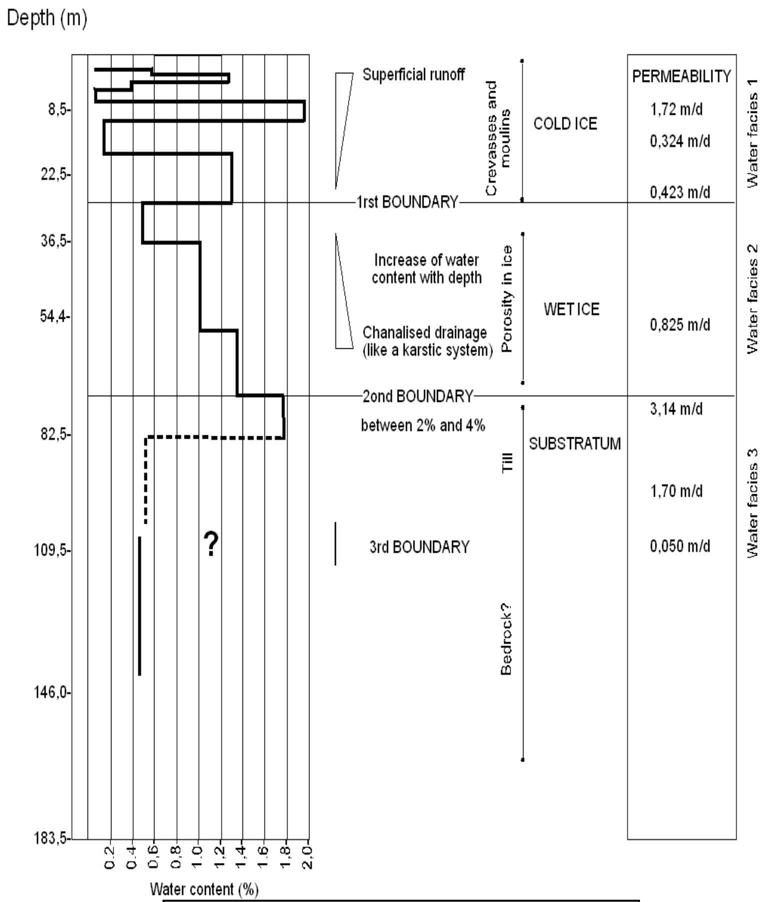
MRS 10 (90x90)

Geology, geotechnics, hydrogeology, environmental and scientific & technical services.
Av. Príncep Benlloch 66-72, Office 407, AD500-Andorra la Vella, Phone and fax: 00376-321815 / 00376-820323,
E-MAIL: igeotest@myp.ad, igeofundacio@andorra.ad, WEB page: http:\\www.igeotest.ad



MRS 11 (120x120)

1D SYNTHETIC MODEL



Synthetic 1D model of water content in the polythermal glacier of

The general conclusion it is possible to distinguish between three types of water signals:

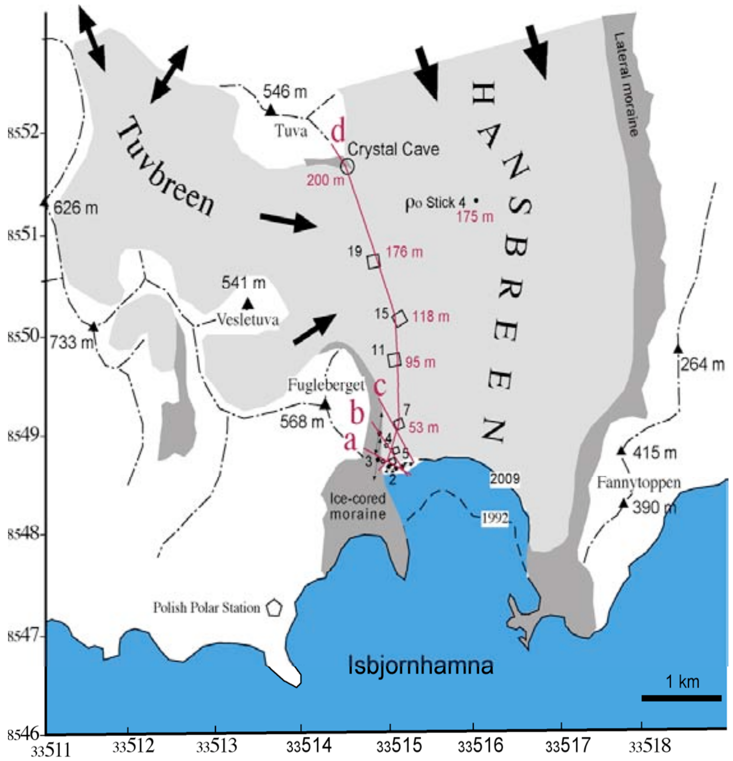
Water facies 1: Superficial signal until 25 m with high water contents, until 8% on water content. Here a general decreasing water content shape is observed from the surface to the bottom and medium decays can also be obtained (more than 100 ms).

Water facies 2: Deeper signal with low to very low water contents, less than 2% on water content. In general the water content increase with depth if a channeled drainage net is present (englacial tunnels, facies 2a), but if not the water content seems to be constant with depth (facies 2b) and low decays are always obtained (less than 150 ms). Only when a channeled flowpath is present the decays can be larger.

Water facies 3: A high water content (more than 2%) are present at the deepest depths had and also large decays can be observed (more than 200 ms).

The first water facies can be easily detect on zones where the ice is highly fracturated (crevasses and seracs) or were the superficial runoff is present. The second water facies is always below the first one where the water is present on a medium of low permeability and low porosity. Both facies are present on the glacier ice, while the third water facies is interpreted as an aquifer beneath the glacier (subglacial till, preglacial aquifers, subglacial drainage pattern flows, subglacial lakes).

Following the shape of the observed water facies is possible to place two main boundaries with depth, the first one (between 25 and 36 m depth) is interpreted as the interface between cold and thermal ice (wet ice on the figure), while the second boundary is interpreted as an irregular contact between the ice bottom and the rocky substratum. GPR surveys carry out at the second half of September 2009 by Mariusz Grabiec from the University of Silesia confirm those boundaries.



Hansbreen cold ice structure:

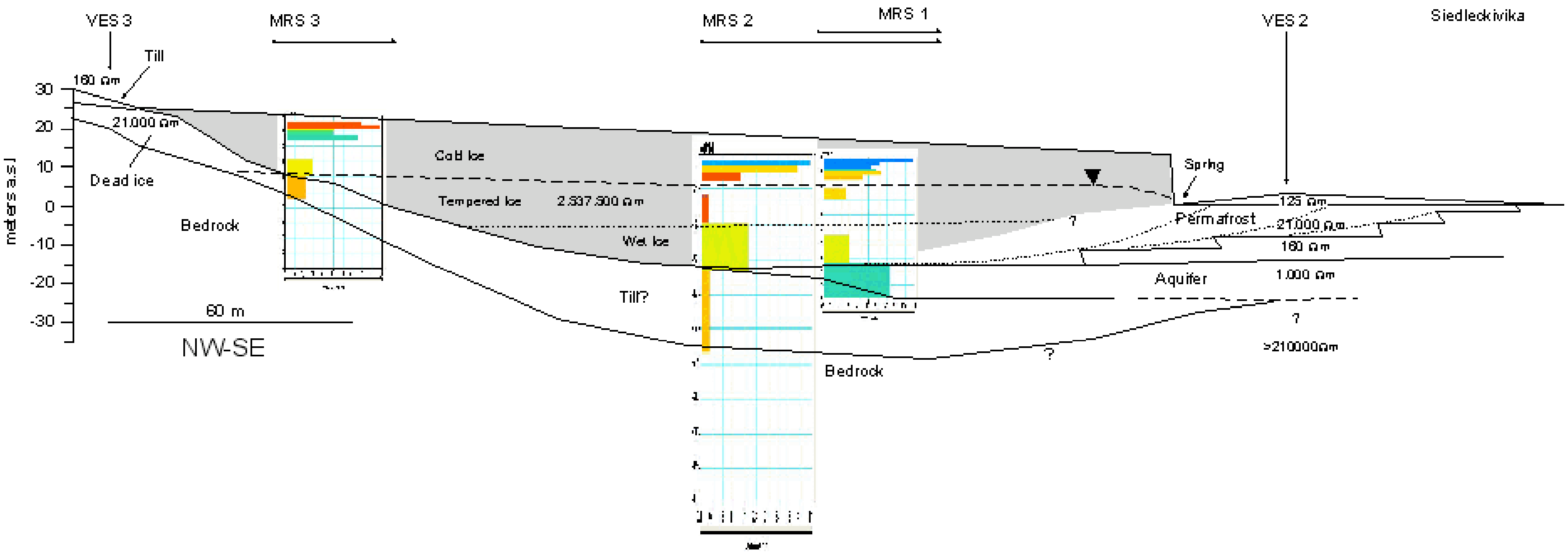
Hansbreen ablation zone has a cold ice layer above temperate ice. Such boundary is reached below 20 m depth, reaching the pressure melting point in which an inversion of the thermal structure is observed (figure 2). High values of water content are observed from GPR (Ground Penetration Radar), tipically 4% (Moore et al., 1999) associated with surface crevassing and moulins. Those authors also observe that saturated crevasses overlays dryer ice. The surface NMR survey done (see profiles a to d) usually had a decreasing water content trend with depth above the IRH (internal Reflecting Horizon). Water content obtained with NMR data show values higher than 3% indistinctly from the location in the surveyed area.

Hansbreen temperate ice structure:

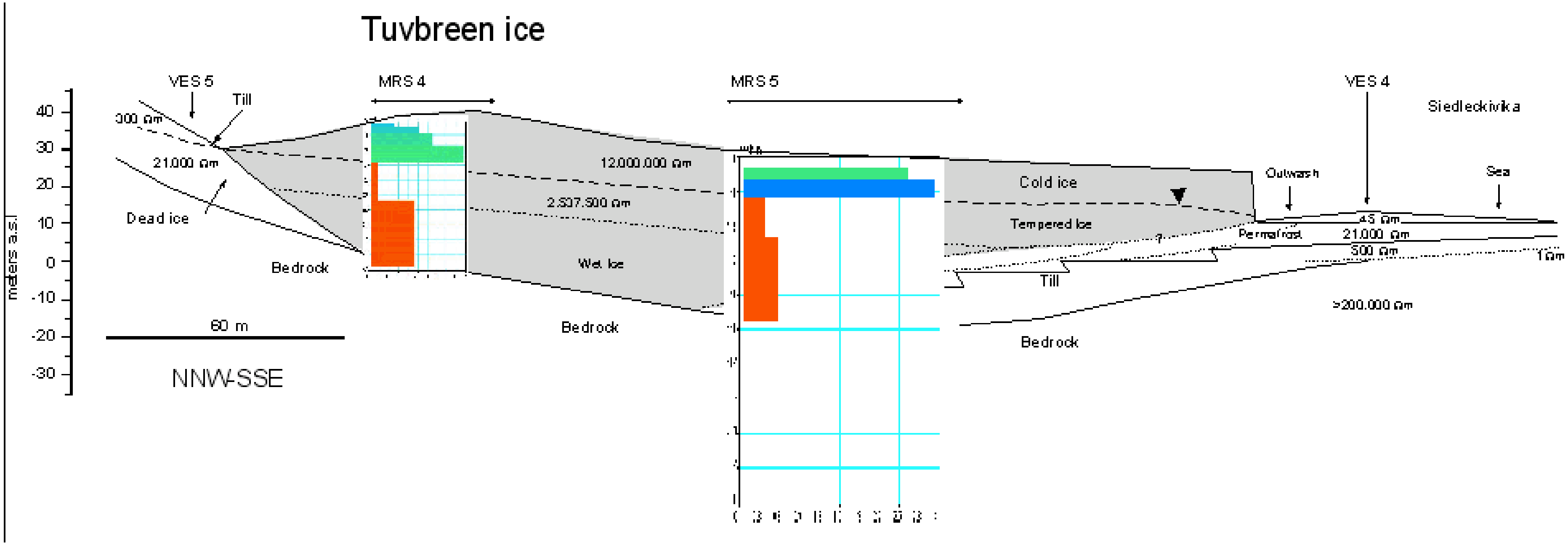
Hansbreen ablation zone has a complex temperate ice structure, up-lighted by the surface NMR survey done on September 2009 (see profiles a to d). Below the IRH (Internal Reflecting Horizon) a general increasing water content trend with depth can be observed, but also from top (Tuva and Crystal Cave zone) to front (Sieldleckivika bay). Such thermal structure has been also recognised on Crystal Cave (Tuva) by Benn et al (2009), where at 60 m depth those authors locate the boundary between cold and tempered ice. Also from GRP data is possible to distinguish, regarding the reflection densities, two levels on the tempered ice layer related both with the water content quality on ice. Water content obtained with NMR data, using specific software (Samovar 6.2 from Anatoly Legchenko), showed values lesser than 3%. Such results agree with GPR data (Moore et al. 1999) in Hansbreen. Similar values are obtained on the Rhone glacier in the Alps (Walbrecker et al., 2008), a tempered glacier recently surveyed with surface NMR techniques.

Based on the data obtained in the geophysical subsurface survey, it was established the geometry of the sector of Hansbreen glacier developing four subsurface interpretative profile sections: three transversals to the ice tongue (a, b and c) and one longitudinal (d) form the front to Crystal cave. Profiles illustrate the subsurface geological structure. In the present figure this profiles, almost perpendicular, have been located.

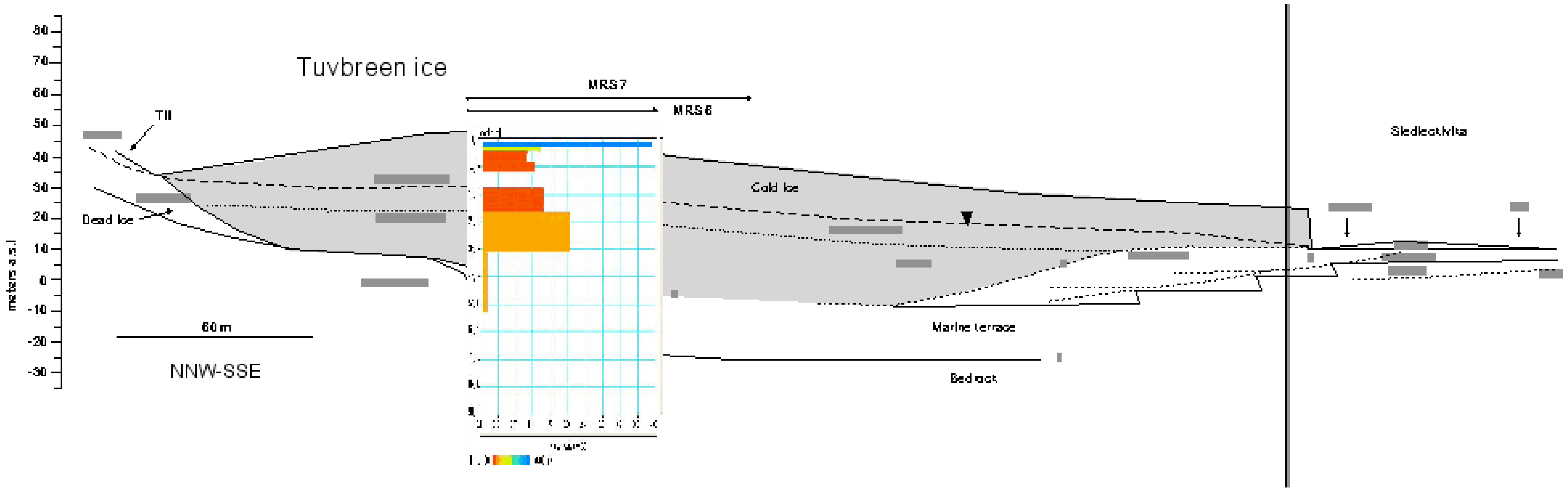
The profile 'a' has been carried out in the area of study in transverse disposition to the glacier tongue in a direction approximately NW-SE, from the data obtained in the MRS 1, 2 &3 realised in Siedleckivika zone, which have been projected in the profile situated in its real elevation. At sector the glacial structure shows the same disposition of layers showed at the 1D model: Cold Ice, Tempered Ice, possible Permafrost, possible Till, sedimentary aquifer and Bedrock .

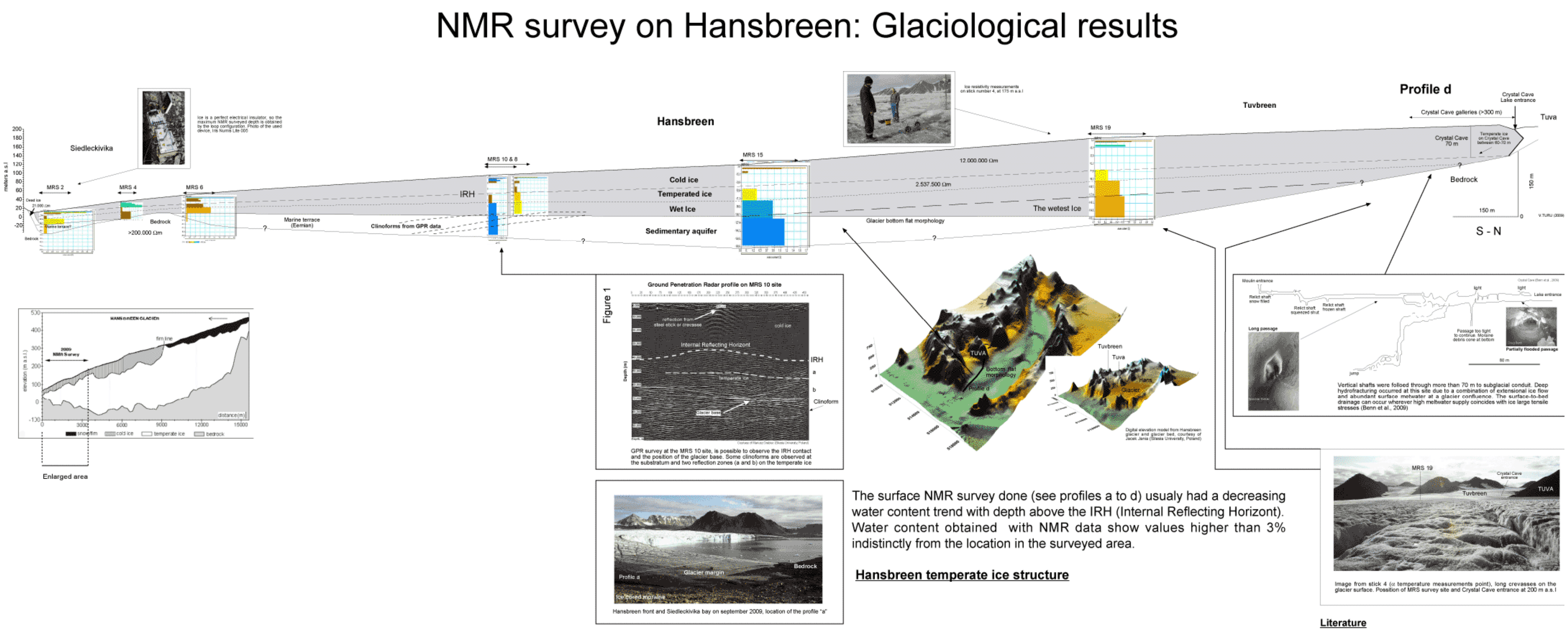


The profile 'b' has been carried out in the area of study in transverse disposition to the glacier tongue in a direction approximately NW-SE, from the data obtained in the MRS 4&5 realised in Siedleckivika zone, which have been projected in the profile situated in its real elevation. At sector the glacial structure shows the same disposition of layers showed at the 1D model: Cold Ice, Tempered Ice, possible Permafrost or Till and Bedrock .



The profile 'c' has been carried out in the area of study in transverse disposition to the glacier tongue in a direction approximately NW-SE, from the data obtained in the MRS 6&7 realised in Tuvbreen zone, which have been projected in the profile situated in its real elevation. At sector the glacial structure shows the same disposition of layers showed at the 1D model: Cold Ice, Tempered Ice, possible Permafrost, Till, sedimentary aquifer and Bedrock.





In that longitudinal profile is possible to see a sketch of the internal structure of the Hansbreen - Tuvbreen glacier, from the front to Crystal cave. Beneath the glacier an aquifer or a subglacial lake is detected because the water signals at such depth had large time decays.

ABSTRACT AND CONCLUSION

In the present report the results corresponding to the magnetic resonance sounding (MRS) prospecting realised at Svalbard, are exposed. Hansbreen glacier is located on the SW part of Spitsberguen, the main island of the Svalbard archipelago near Polish Polar Station of Hornsund. The background surveys developed on Svalbard have allowed establishing the geological subsurface model. From Ground Penetrating Radar data is possible to distinguish the boundary between cold ice and temperate ice by a Internal Refraction Horizon (IRH), but also different layers that are related with the water content on ice.

From august 21st, to September 10th 2009, it has been done 19 NMR soundings (MRS) supported by the Wroclawski University, with the installation of several squared antennas placed on six stations and loops sizes range done were of 30X30 meters (MRS 1, 3, 4, 9, 12&16), 60X60 m (MRS 2, 5, 6, 8,13&17), 90X90 m (MRS 7, 10, 14&18) and 120X120 m (MRS 11, 15&19); reaching depths of 45, 90, 135 and 180 meters. The aim of the study is to achieve the water content inside Svalbard glaciers, in order to confirm the knowledge of the operation of the hidrogeological system of Hansbreen glacier. The prospecting was considered very helpful to determine the hydrogeological properties of the aquifers beneath the ice.

The general conclusion it is possible to distinguish between three types of water signals: **Water facies 1**: Superficial signal until 25 m with high water contents, until 8% on water content. Here a general decreasing water content shape is observed from the surface to the bottom and medium decays can also be obtained (more than 100 ms). **Water facies 2**: Deeper signal with low to very low water contents, less than 2% on water content. In general the water content increase with depth if a channeled drainage net is present (englacial tunnels, facies 2a), but if not the water content seems to be constant with depth (facies 2b) and low decays are always obtained (less than 150 ms). Only when a channeled flowpath is present the decays can be larger. **Water facies 3**: A high water content (more than 2%) are present at the deepest depths had and also large decays can be observed (more than 200 ms).

The first water facies can be detect on zones with (crevasses and seracs) or were the superficial runoff is present. The second water facies is always below the first one where the water is present on a medium of low permeability and low porosity. Both facies are present on the glacier ice, while the third water facies is interpreted as an aquifer beneath the glacier (subglacial till, preglacial aquifers, subglacial drainage pattern flows, subglacial lakes). Following the shape of the observed water facies is possible to place two main boundaries with depth, the first one (between 25 and 36 m depth) is interpreted as the interface between cold and thermal ice (wet ice on the figure), while the second boundary is interpreted as an irregular contact between the ice bottom and the rocky substratum. GPR surveys carry out at the second half of September 2009 by Mariusz Grabiec from the University of Silesia confirm those boundaries.

Andorra la Vella, December 9th, 2009

Valentí TURU i MICHELS
Geologist