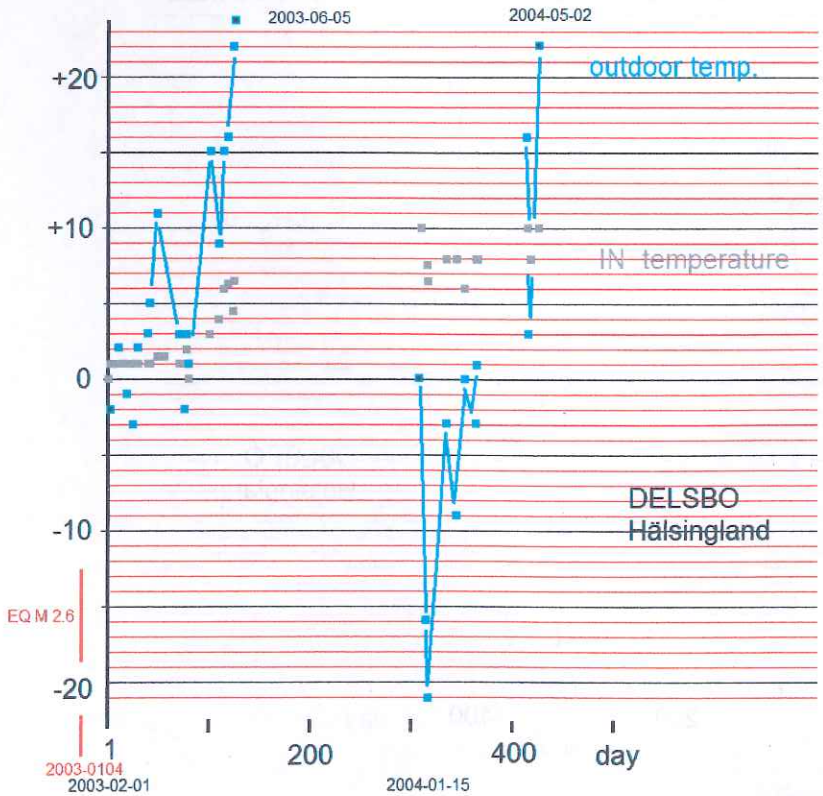
Temperature registrations at geothermal small scale heat pump imediately south of Delsbo in Hälsingland (by Sixten Hällgren), **after a nearby earthquake in Jan 2003**

Datum	IN temperature °C	outdoor temp. °C	day
2003-02-01	0		1
03	+1	-2	3
11	+1	+2	11
19	+1	-1	19
25	+1	-3	25
03-02	+1	+1	30
12	+1	+3	40
13	+1	+5	41
21	+1.5	+11	49
28	+1.5		56
04-12	+1.0	+3	71
17	+1	-2	76
19	+2	+3	78
21	0	+1	80
05-12	+3	+15	101
20	+4	+9	109
26	+6	+15	115
30	+6.3	+16	119
06-03	+4.5	+22	123
05	+6.5	+24	125
2004-01-15	+10	0	309
21	+7.5	-16	315
23	+6.5	-21	317
30	+8	-3	334
02-09	+8	-9	344
18	+6	0	353
28	+8	-3	363
03-02	+8	+1	365
04-20	+10	+16	414
23	+8	+3	417
05-02	+10	+22	426



3.1 January

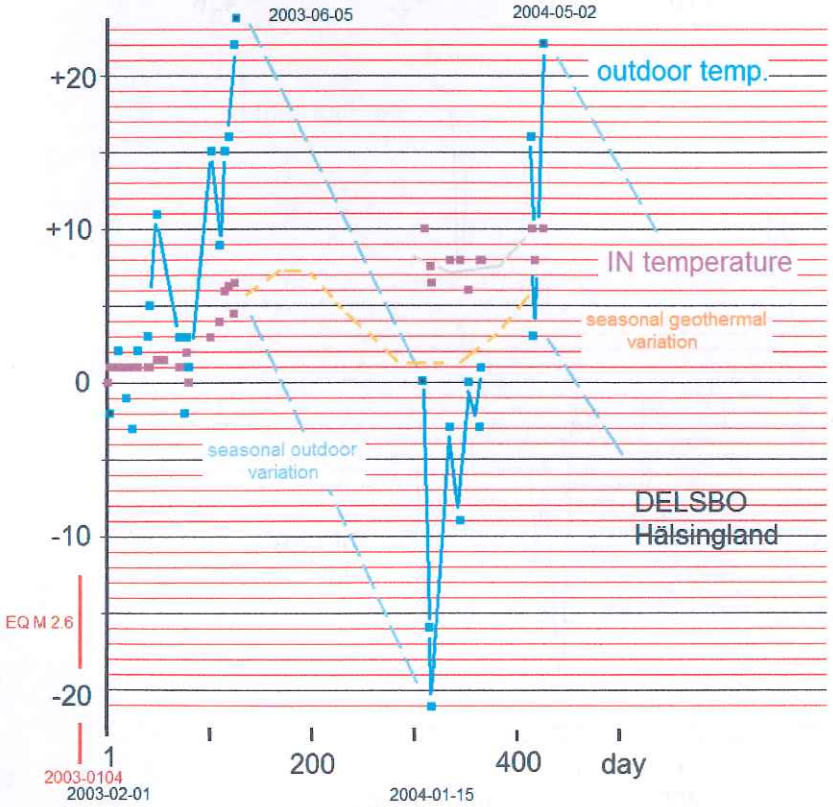
Event list for January is given in Table 3-1 with date, time, latitude, longitude, X (RT90), Y (RT90), depth and local magnitude (ML). In January 17 events were located whereof 1 with magnitude above 2.0 and additional 4 larger than 1.0. The depth range varies between 5.1 and 31.3 km.

Table 3-1. Date, time, latitude, longitude, X (RT90), Y (RT90), depth and local magnitude (ML) of recorded earthquakes in January.

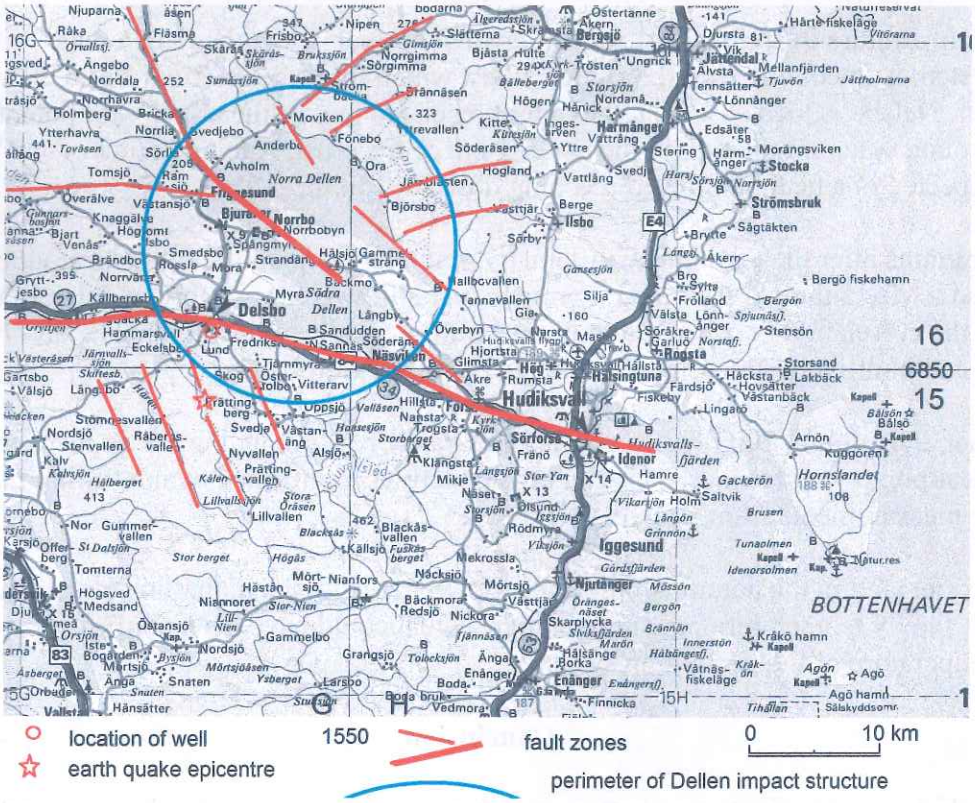
Date	Time	Latitude	Longitude	X RT90 Km	Y RT90 Km	Depth Km	ML Local Magnitude
20030102	051653.4	62.715	17.629	6957.2	1593.1	17.1	0.9
20030103	041534.6	61.205	17.067	6788.3	1567.7	20.8	–0.1
20030103	110639.5	62.257	17.366	6905.9	1580.9	12.1	0.4
20030103	195807.3	61.779	16.957	6852.1	1560.6	5.1	–0.3
20030104	003545.9	61.701	16.876	6843.3	1556.5	6.9	–0.3
20030104	174759.0	61.745	16.540	6848.1	1538.7	10.9	2.6
20030105	063155.1	64.811	22.670	7207.2	1825.4	13.9	0.7
20030107	031541.8	62.618	17.501	6946.2	1586.9	22.3	0.7
20030109	162301.3	63.041	18.554	6995.2	1638.9	13.5	0.6
20030109	214636.5	61.748	16.541	6848.3	1538.7	6.8	1.0
20030112	104125.6	62.219	17.520	6901.7	1589.1	7.4	0.2
20030114	222323.4	61.905	17.304	6866.5	1578.6	13.4	1.2
20030115	214736.4	62.145	17.105	6893.0	1567.6	25.2	0.4
20030118	112810.2	58.436	18.587	6482.5	1662.3	5.8	1.0
20030123	113559.4	60.529	15.169	6712.4	1464.9	31.3	0.7
20030125	032622.8	60.175	19.598	6678.9	1710.2	18.7	0.3
20030130	080525.3	62.728	17.259	6958.2	1574.2	18.7	1.1

Interpretation

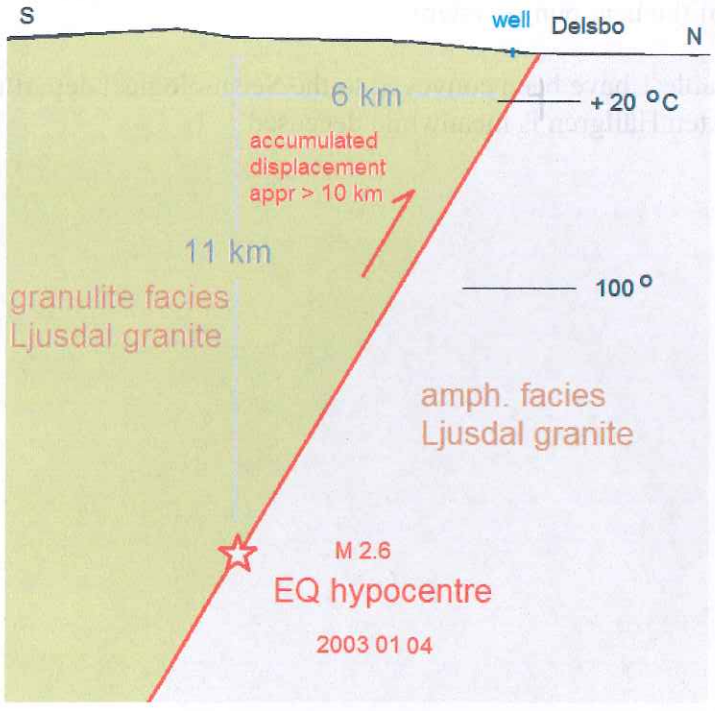
Assumed seasonal temperature variations added to the diagram



Location of observation well and major tectonic features



South – north section to illustrate hypocentre location



INTERPRETATION

Observed IN temperature difference: +8 °C
Assumed geothermal gradient: 1.5 °C per 100 meter
Depth of well: 150 meter.
Approximate connection to ground water of 8 °C higher temperature: 700 meter.

Discussion

The rise in temperature in spring 2003 follows, with a normal delay, the rise in outdoor temperature. The fault system is in contact with the Dellen lakes, which form the interior of a ca 20 km diameter impact crater. Delsbo is located within the outer brecciated part of the crater with potentially enhanced ground water circulation in the upper 1 km of the crust. A temperature of + 8 °C is normally expected in a heat pump well reaching down to 150 m.

About two months after the earthquake in January 4, the IN temperature of the heatpump system was observed to rise although the outdoor temperature still was low. A certain delay in time is expected in the correlation between outdoor temperature and IN temperature. The observed rise was unexpected and intuitively suggested to be related with the earth quake.

If the summer and autumn 2003 was very warm, extra energy is stored in the uppermost crust to where the heat pump well reaches. This can be retroactively confirmed by consulting historical temperature measurements from SMHI.

If the energy demand in the autumn 2003 and early winter is less than that in autumn and early winter 2002, the IN temperature may remain high – (that could have been confirmed by also noting the OUT temperature of the heat pump system).

Conclusion

A potential shift in water circulation pattern may have occurred soon after the 2003 earth quake and was still observed in the winter season ca 1 year later, connecting the heat pump well with water from deeper sources (up to ca 700 m) with higher temperature. To confirm this requires a comparison with the outdoor temperature during the missing second half of year 2003 and a log of the OUT temperature of the heat pump system.

The measurements in table 1 have been conveyed to the Seismological department at Uppsala University in 2003. Sixten Hällgren is meanwhile deceased.

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