Engineered Geothermal at Otaniemi and Basel: “end”-members in drilling and induced seismicity?

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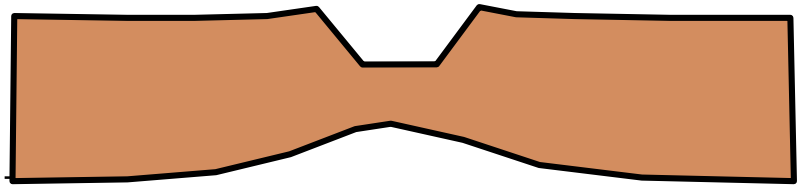
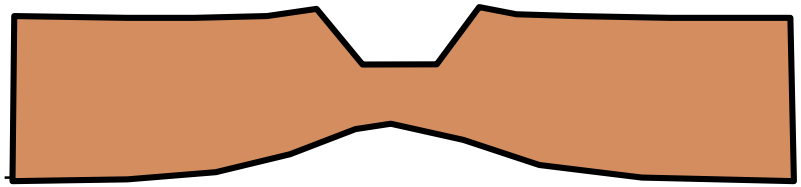




2006- A Critical EU EGS Project in

Downtown Basel, Switzerland!

5.5 km deep municipal heating wells

Hot/Dry Rock Drilling

Basel from space

Rotary/mud drilling:

1-5 m/hr

October 18, 2006

Basel emergency officials participate in earthquake preparedness exercise ....

December 9, 2006

Man-made tremor shakes Basel!

Drilling for geothermal power triggers small earthquake, causes minor damage...

.... City prosecutor launches investigation to find if the company should pay repairs.....

2018- Another Critical EGS Project

Aalto University, Finland!

6.4 km (target) deep municipal heating wells

Otaniemi from space

ry Rock Drilling

Air hammer drilling:

5-10 m/hr

(to 4500 m – rotary/mud to 5700 m)

The Otaniemi District Heat Plant – circa 1949

Helsinki District Heat Plant Networkall fossil fuel fired

Drill Bit Seismic imaging using MH air hammer drilling into PH array

For 80 m sensor spacing the number of sample points per wavelength along array are:

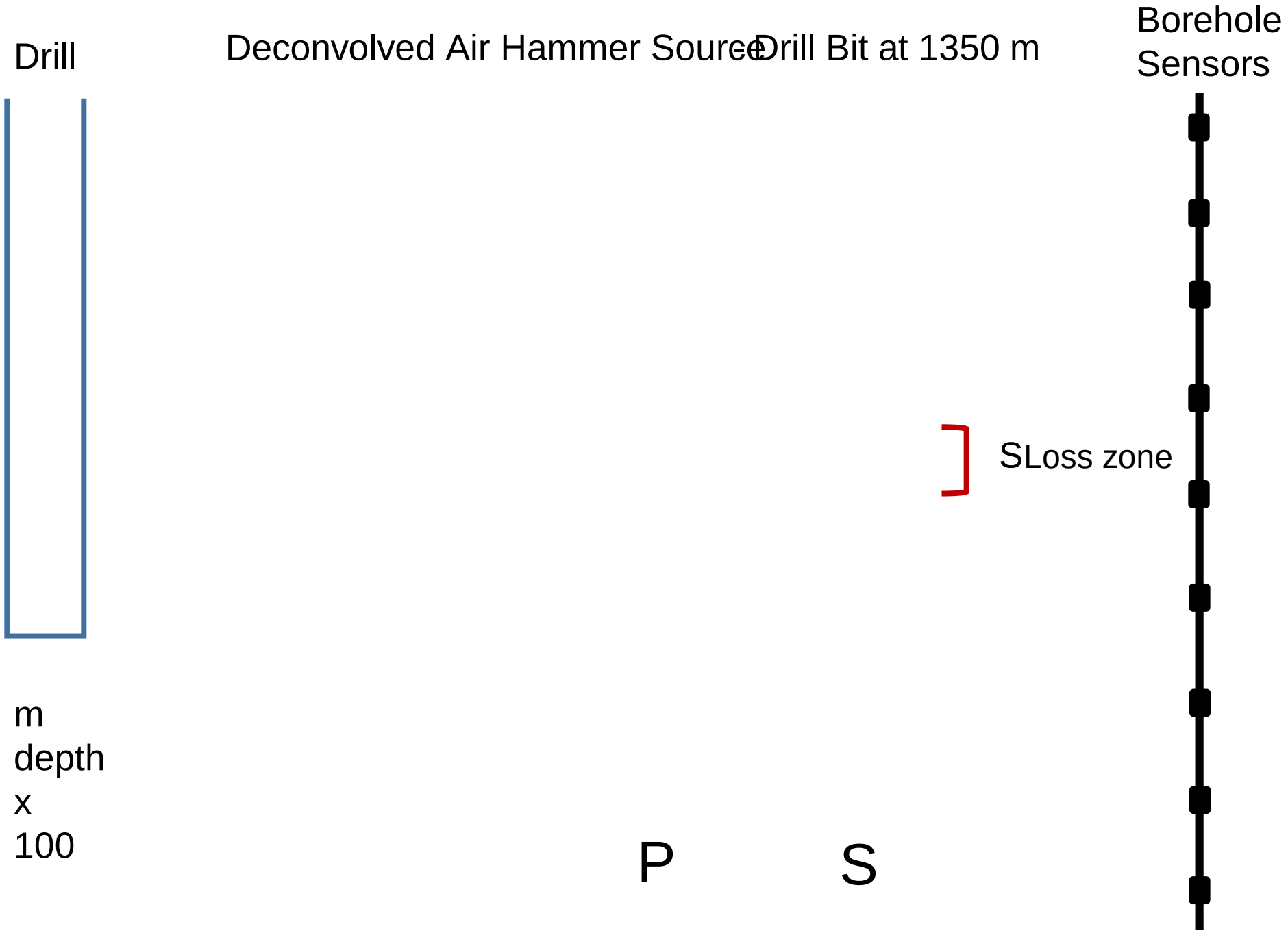
14 deg & 30 Hz	Æ10	excellent	resolution	Æ50 m (1/4 wave criterion)
14 deg & 60 hz	Æ5	very good		Æ25 m
70 deg & 30 hz	Æ2.4	usable?		Æ50 m
70 deg & 60 Hz	Æ	not usable		x

5 km MH & 2 km PH

Buried MEQ St

PH array with 80 m spacing

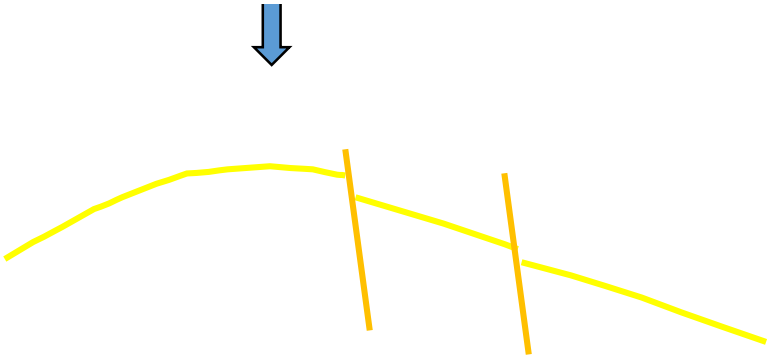
ST	Depth
24	1920
23	1840
22	1760
21	1680
20	1600
19	1520
18	1440
17	1360
16	1280
15	1200
14	1120
13	1040
12	960
11	880
10	800
9	720
8	640
7	560
6	480
5	400
4	320
3	240
2	160
1	80
	0


Drill
Deconvolved Air Hammer Source
Drill Bit at 1350 m
Borehole Sensors
SLoss zone
m
depth
x
100
P
S

Faulted Reflector at ~2140 m

Drill Bit Depth (file no.)

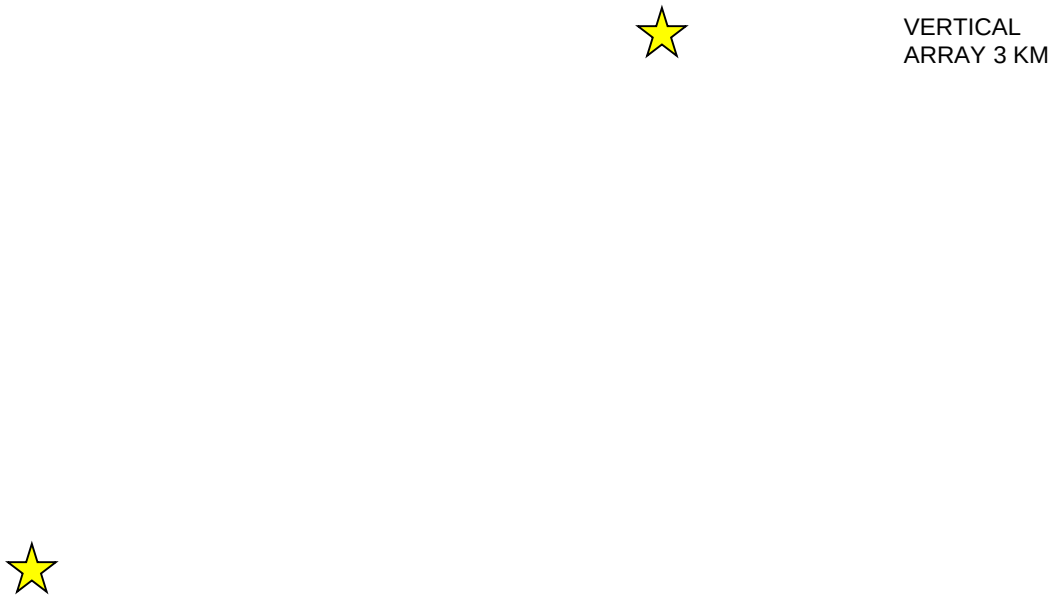
Borehole sensor at 1840 m



Induced Seismicity: The difference in Traffic Light Systems

Basel Æ6 borehole seismic stations

Otaniemi Æ12 surface; 12 borehole; 12 level VS



st1 OtaniemiHeat Mine 3C borehole seismic net

This diagram shows the design principles for the network and calibration shots.

The design criteria are:

1. 3-C borehole seismometers to record both P & S for epicenter and depth control.

2. Progressive station radial

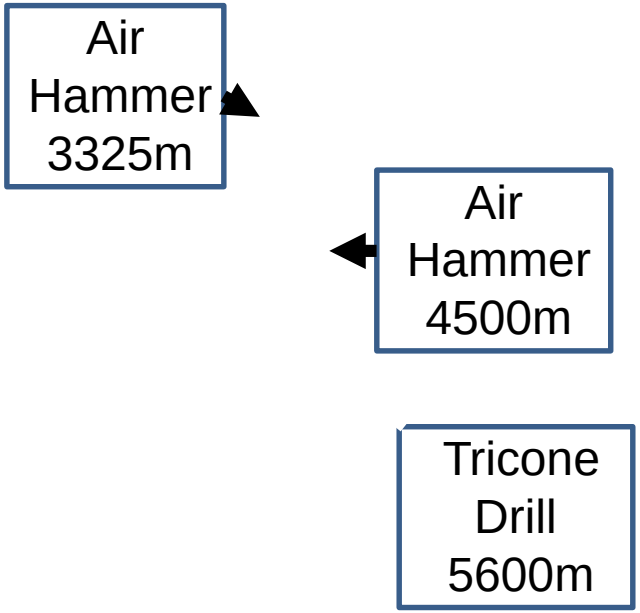
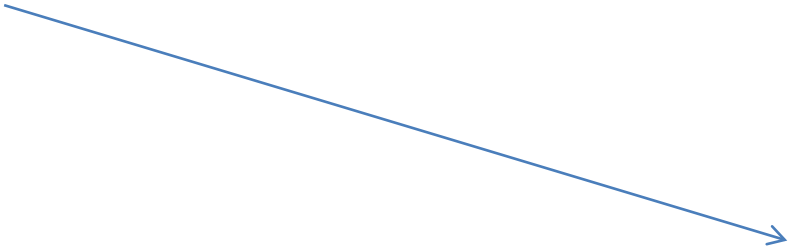
Owner	Network Name	Purpose	Locations	Details	Status
				Geophone locations and number to be confirmed.	
	Surface	To monitor surface vibrations for the TLS	Twelve	Network to be installed by Kalliotekniikka.	
st1 Deep Heat					

Activity	Expected	Maximum
Stimulation Duration	20 days	40 days
Daily Pumping Period	12 hours / day	24 hours / day
Post Pumping Rest Perio	12 hours	12 hours

Where is the project at:

- Today, Peter Malin isn't here because he is serving on a public panel on Finnish national TV to discuss the upcoming frack (likely in March or April) and the potential for induced seismicity.

- Hole 1 was "air hammered" to 3325m, Hole 2 to 4500m.

- Tricone Drilling has proceeded on Hole 2 to 5600m

- March - Hydrofrack will be made in hole 2 at ~6000m depth, then hole 1 will be drilled to intersect fracture network