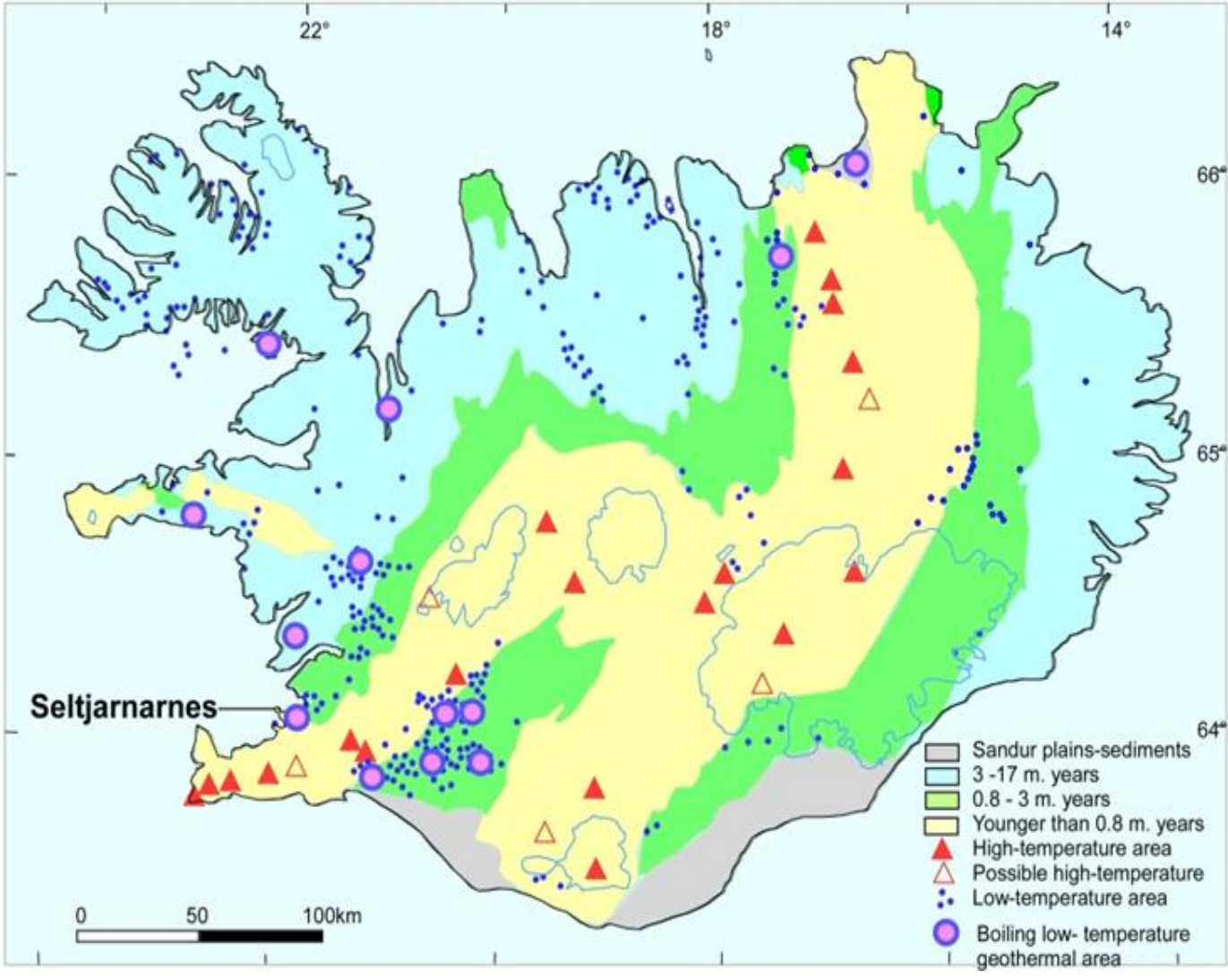
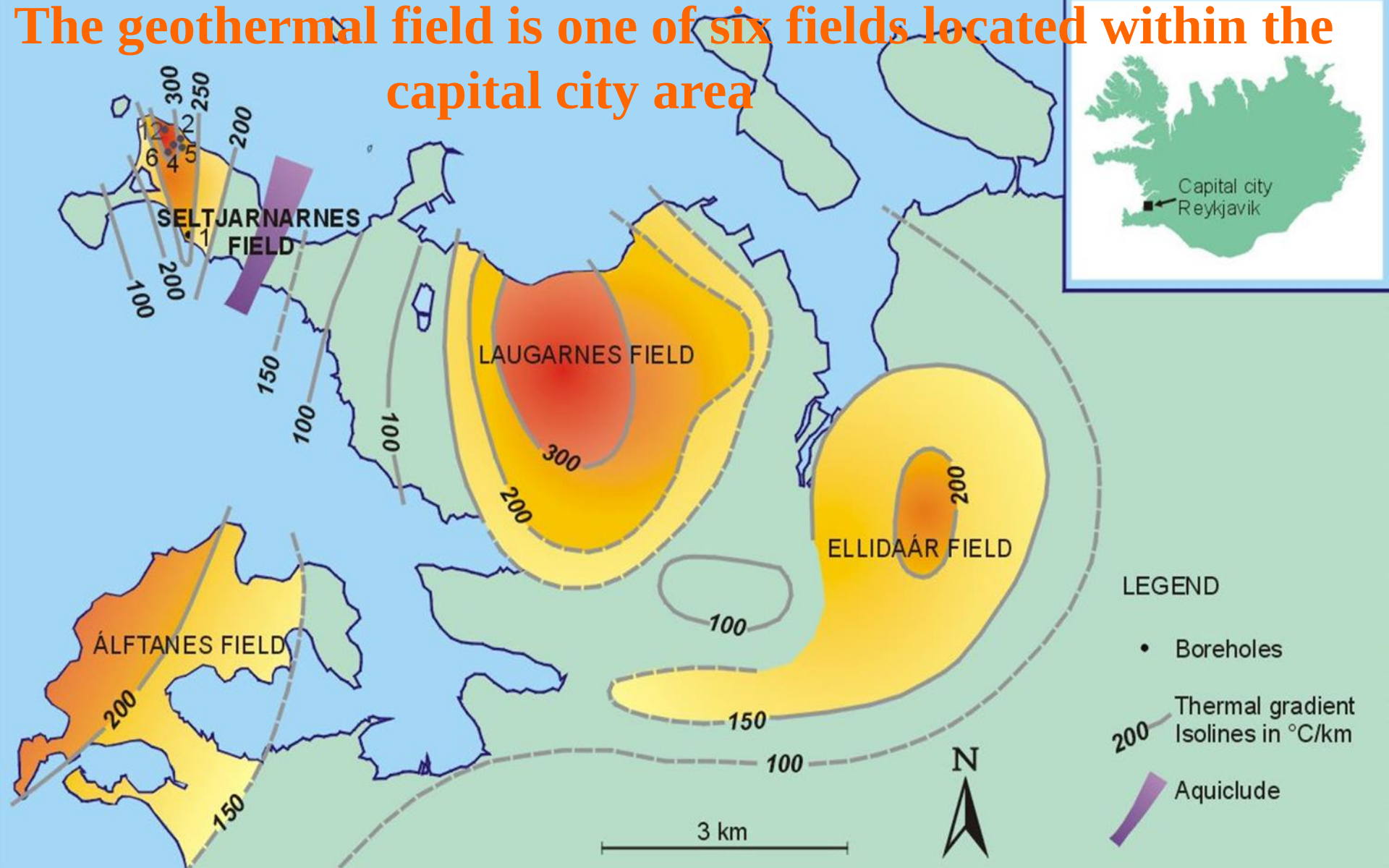
The Seltjarnarnes heating system and geothermal field

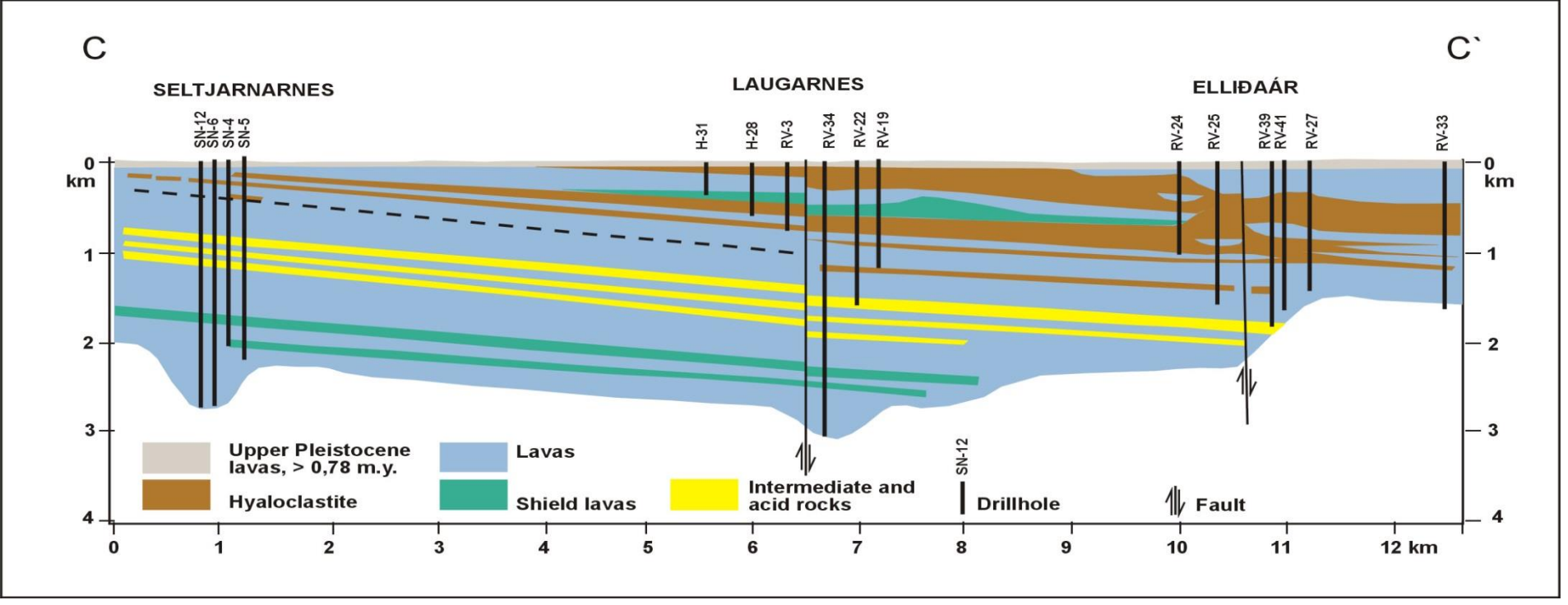
Sustainable and environmentally benign production through 50 years

Seltjarnarnes is a suburb of the capital city in Iceland, Reykjavík, with its own municipal heating system utilizing a boiling low-temperature geothermal field or medium enthalpy field located within the border of the town. (4800 inhab.)

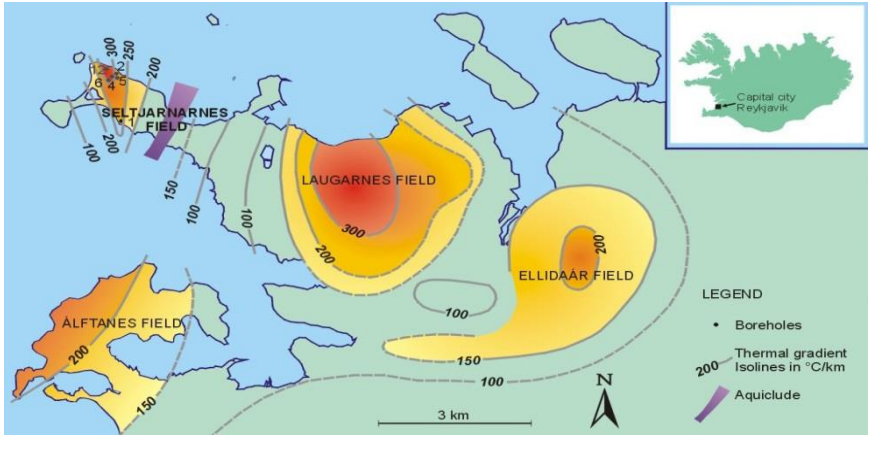


The geothermal field is one of six fields located within the capital city area

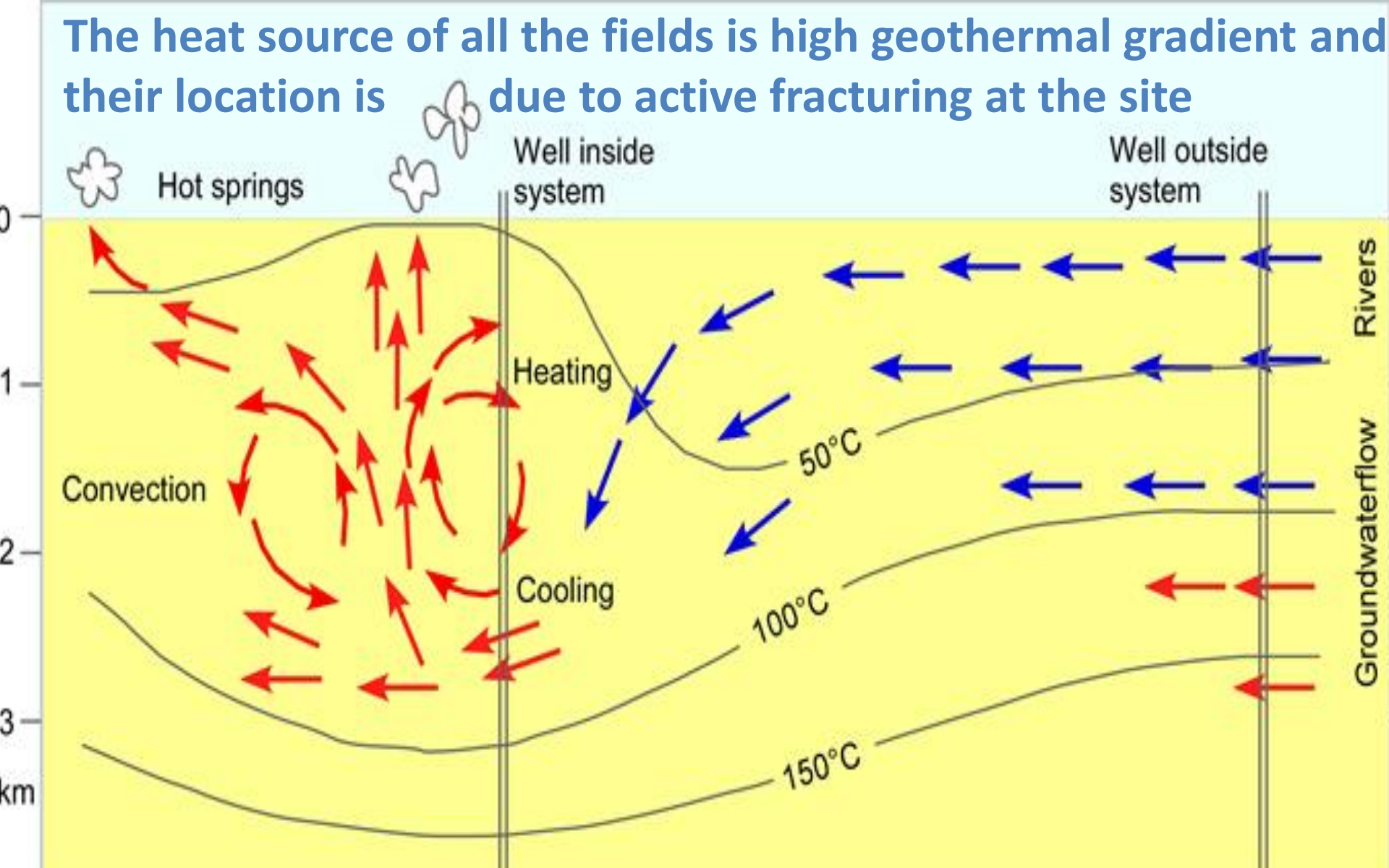




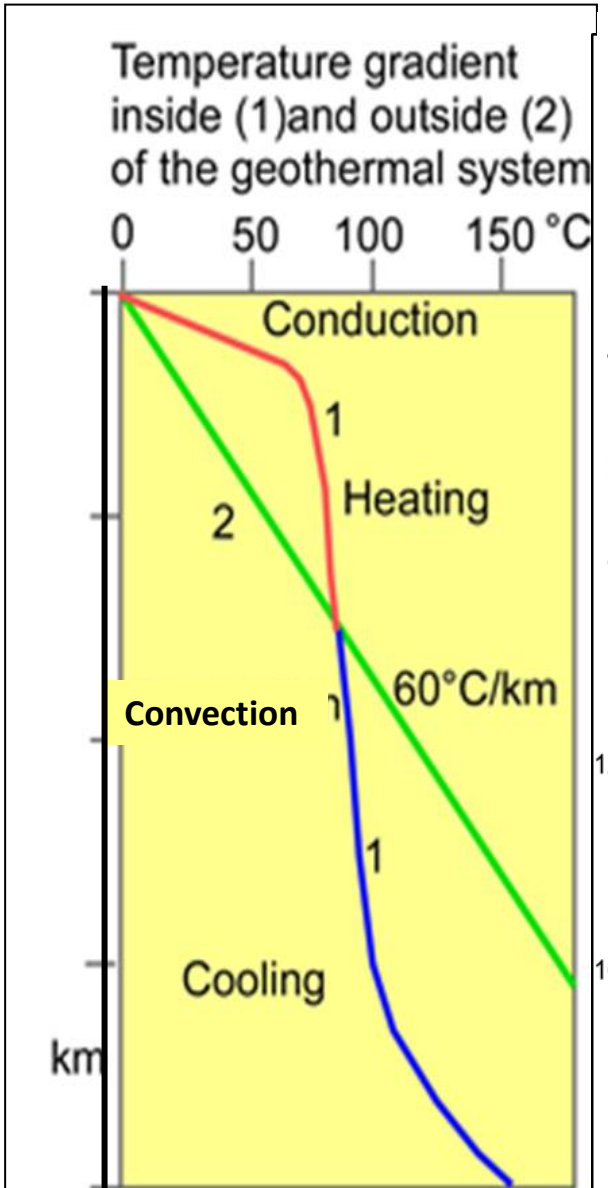
Seltjarnarnes geothermal field is located in the same Quaternary rock formation within the Kjalarnes caldera as the five other geothermal fields within the Reykjavík region.

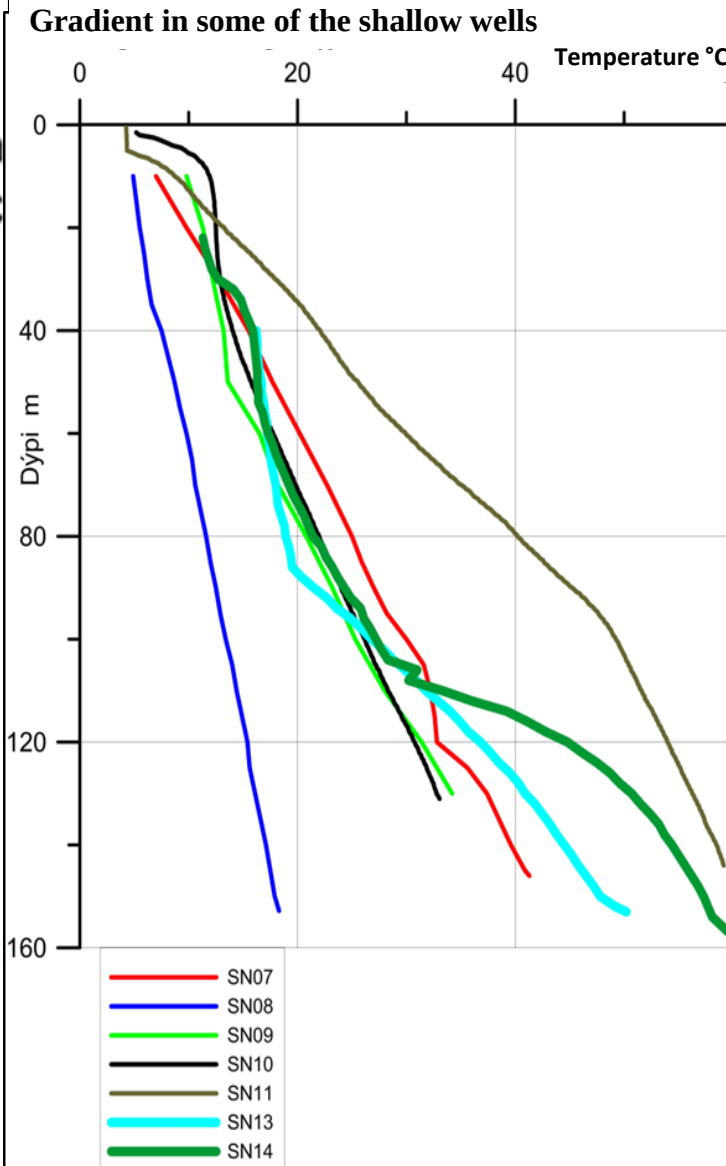


The heat source of all the fields is high geothermal gradient and their location is due to active fracturing at the site

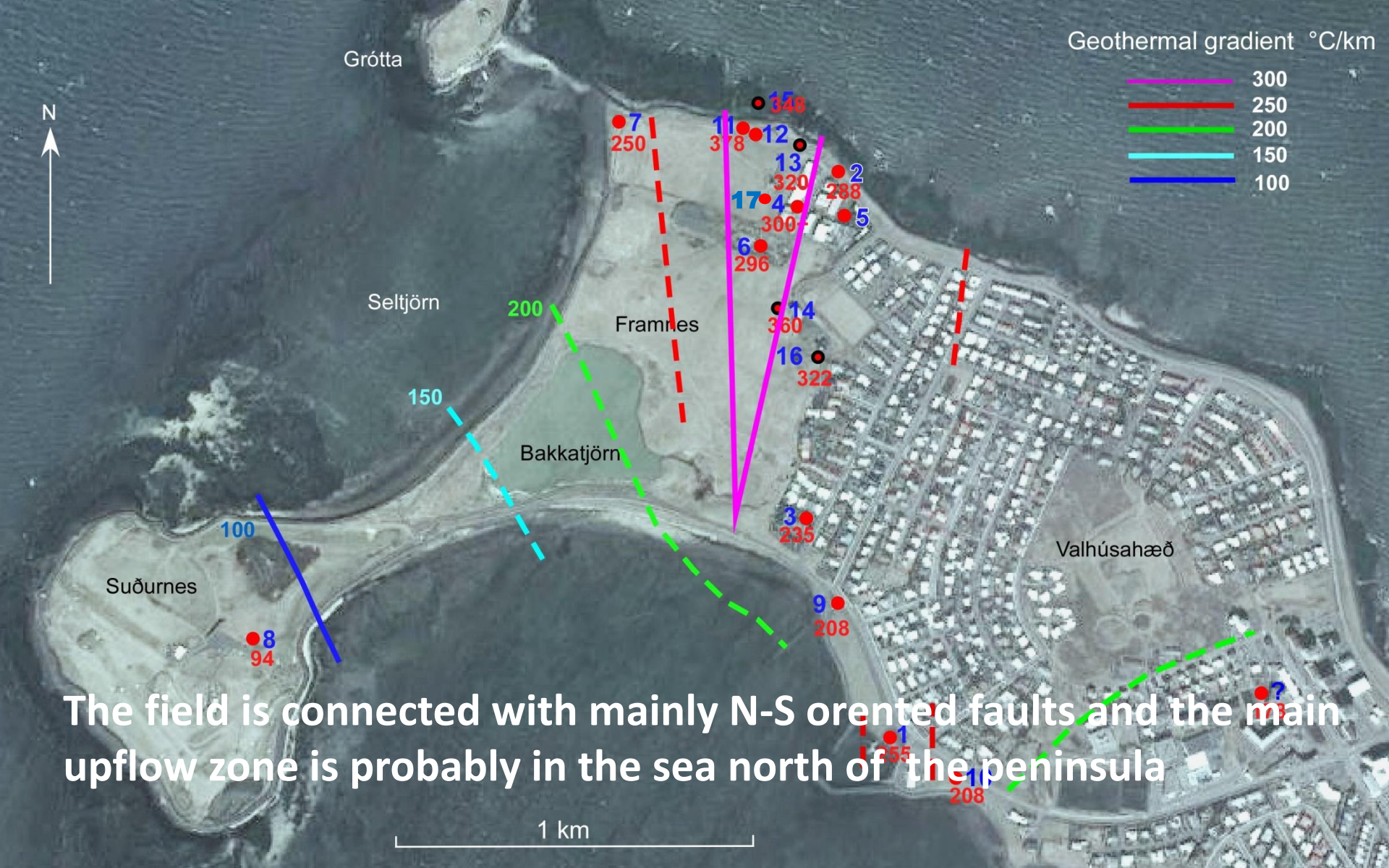


No geothermal activity was known in the Seltjarnarnes area before drilling. The first two gradient wells (1965-1967) revealed a thermal gradient near to a 300 °C/km. Later nine gradient wells have been drilled.





17 wells have beem driled – 6 for intended production
10
1
9
3
14
16
2
5
13
12
6
15
4
11
17
7
8
Exploration well
Productiontion well

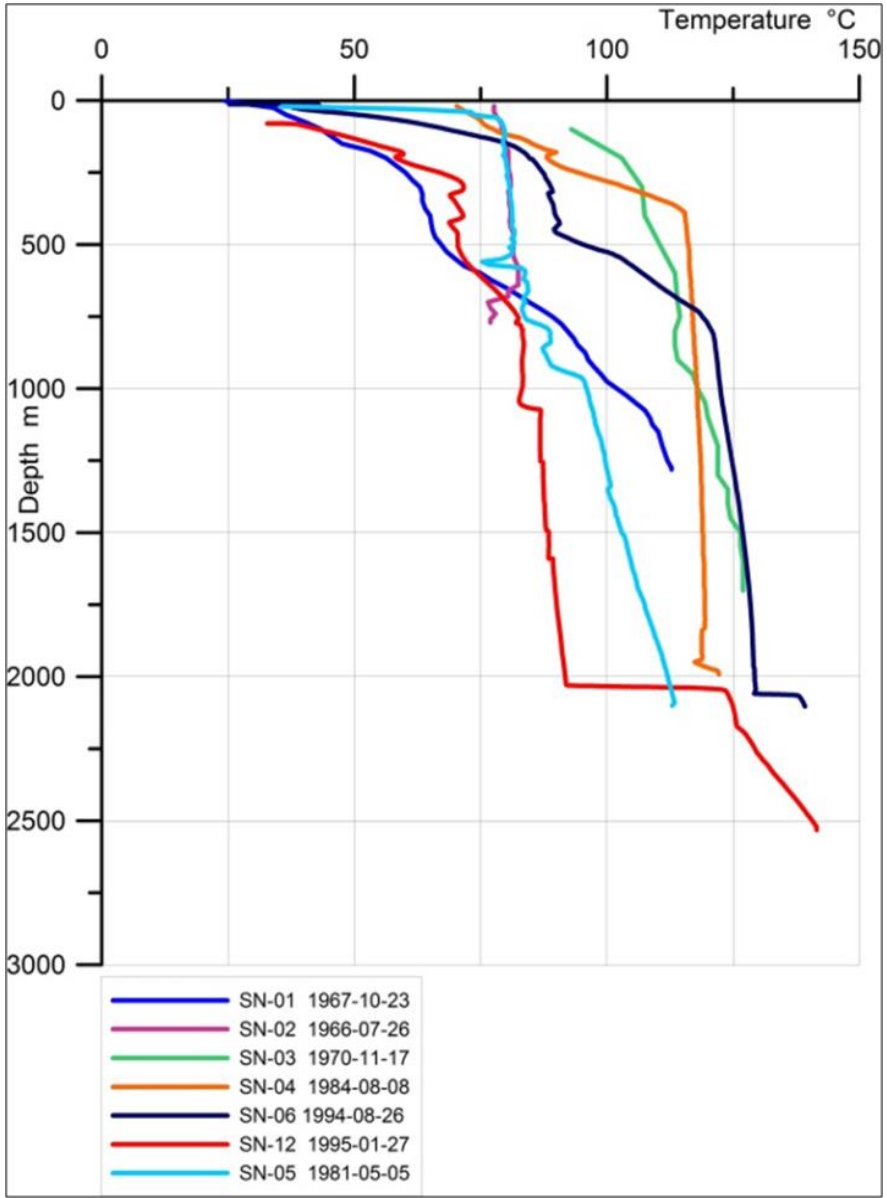

Geothermal gradient °C/km
300
250
200
150
100
N
Grótta
Seltjörn
Framnes
Bakkatjörn
Suðurnes
Valhúsahæð
7
250
11
12
13
320
2
288
17
4
5
6
296
14
360
16
322
3
235
9
208
8
94
1
208
1 km
The field is connected with mainly N-S orented faults and the main upflow zone is probably in the sea north of the peninsula

The last production well was drilled in the autumn of 2021 and has still not been harnessed. It was drilled in the wake of an accident destroying a production well drilled in 1972

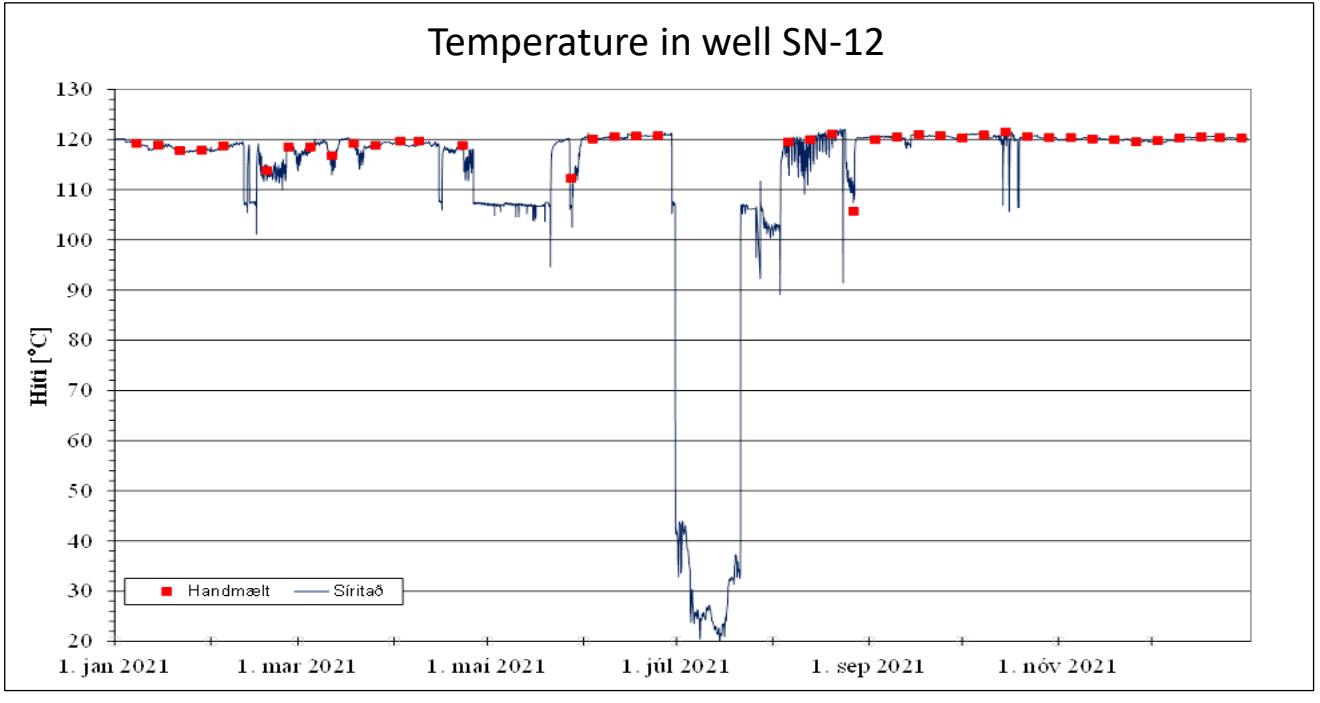
Three main feedzones in the geothermal field:

- The uppermost is 60-80 °C hot and extends to about 400-600 m depth.
- A 90-110 °C hot reservoir extends down to 1500 m depth
- At 1700-2200 m a reservoir with 120-140 °C hot water is encountered.

SN-01	SN-02	SN-03	SN-04	SN-05	SN-06	SN-12	SN-17
aq. d in m.	aq. d in m.	aq. d in m.	aq. d in m.	aq. d in m.	aq. d in m.	aq. d. In m.	aq. d in m.
185		230	200				
380		400	390	450			
620	560			560	535		
	710			700			700
							790
950		930		950	900		920
1180			1190			1080	1280
		1700					
			1980	2100	2070	2040	1940
					2400		



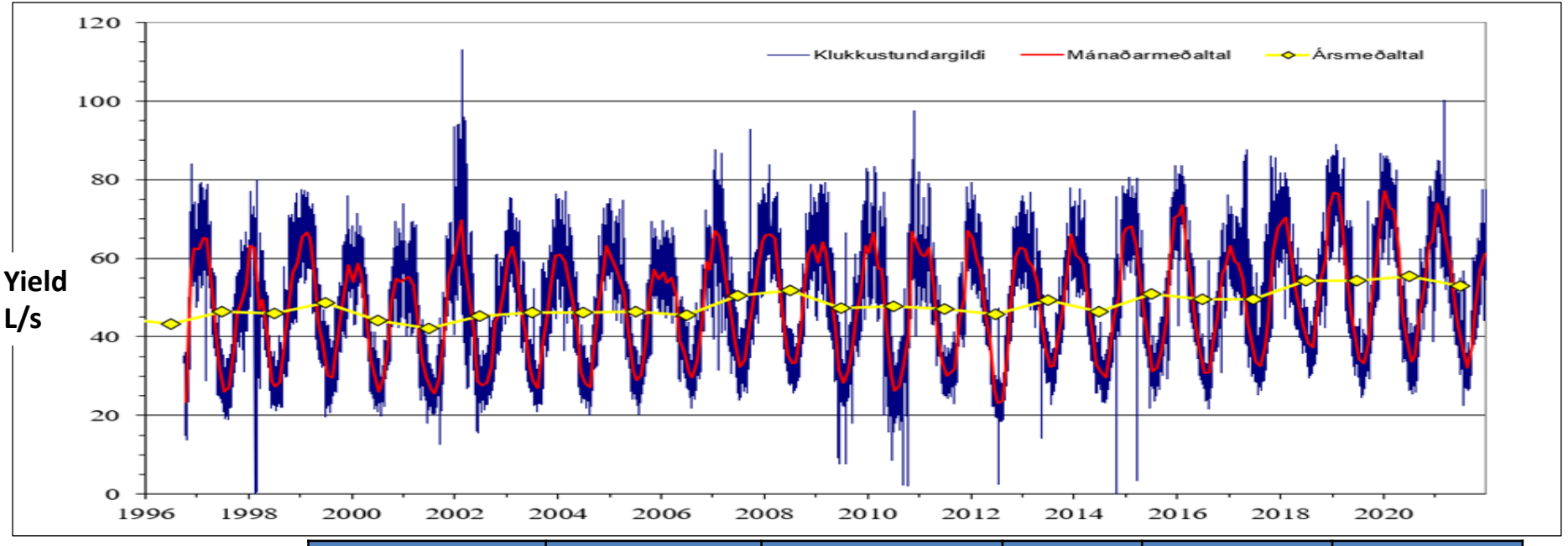
The mean production temperature for water from the wells is 100-120 °C, depending on well and pumping rate.



Due to the high production temperature the water has to be mixed with return water before distribution to the net.

Reservoir monitoring has been regular through production time

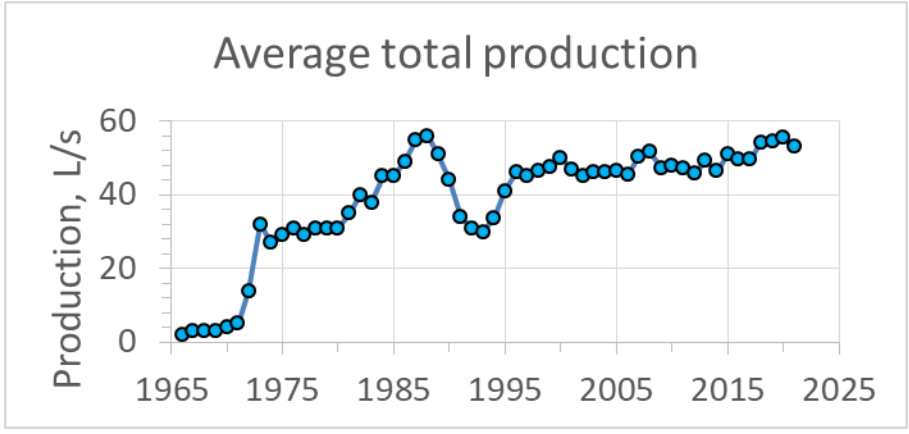
Total production from Seltjarnarnes wellfield 1996-2021

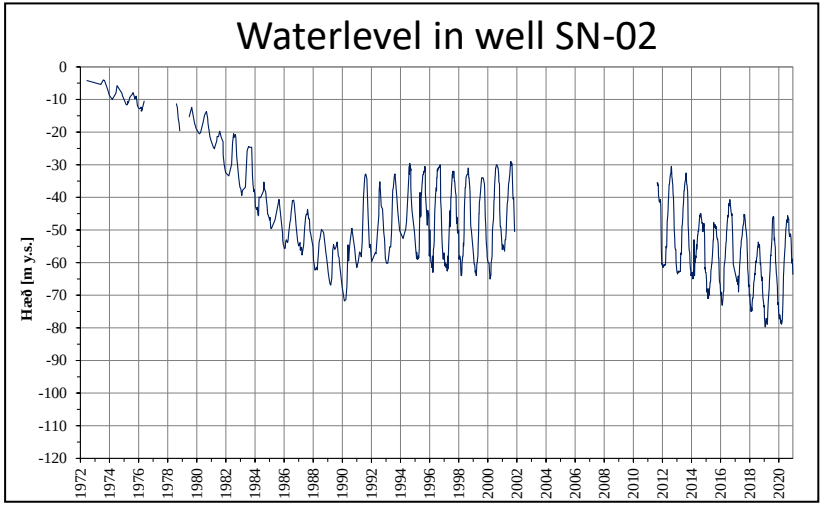


Yearly mean -last 2 years

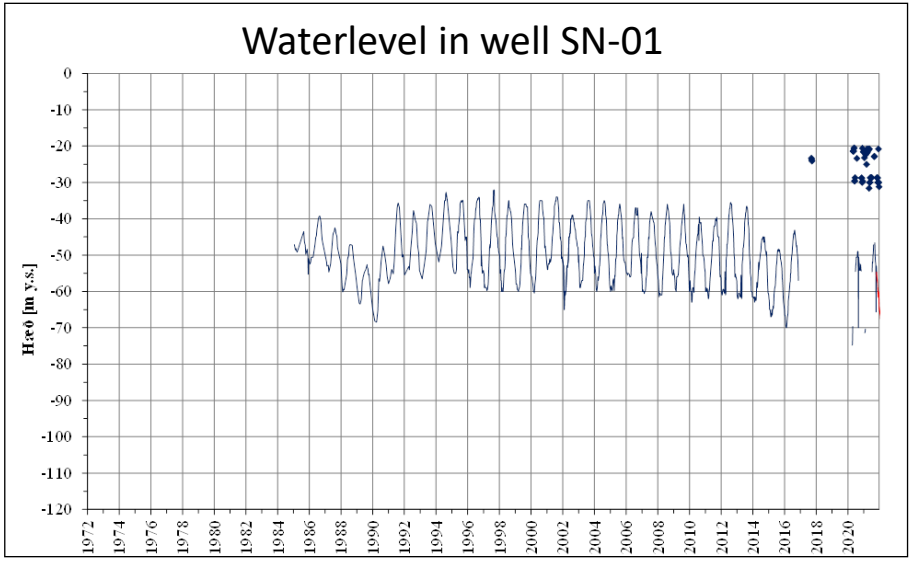
Pumped from field L/s/ °C	Return water L/s/°C	Out from pumping station L/s/°C	Sold L/s	Out from pumping station m^3	Sold m^3
55,4/105,2	32,5/36,3	87,9/81,9	78,8	2.772.014	2.484.075
53,0/105,1	29,7/33,6	82,7/81,1	75,7	2.608.027	2.387.096

The production was more or less stable for over 20 years, but has increased the last 4 years

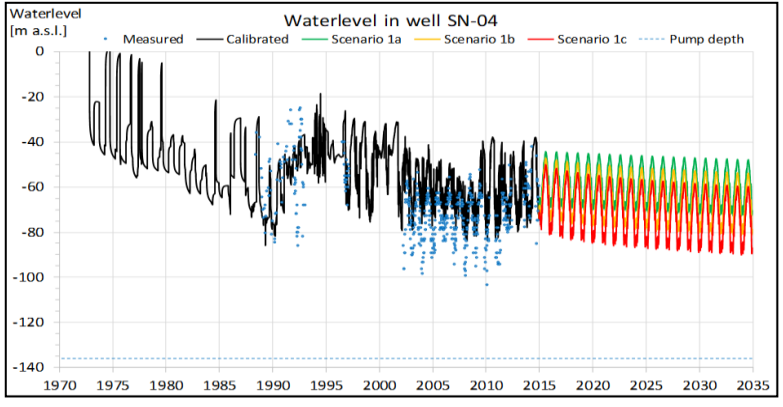


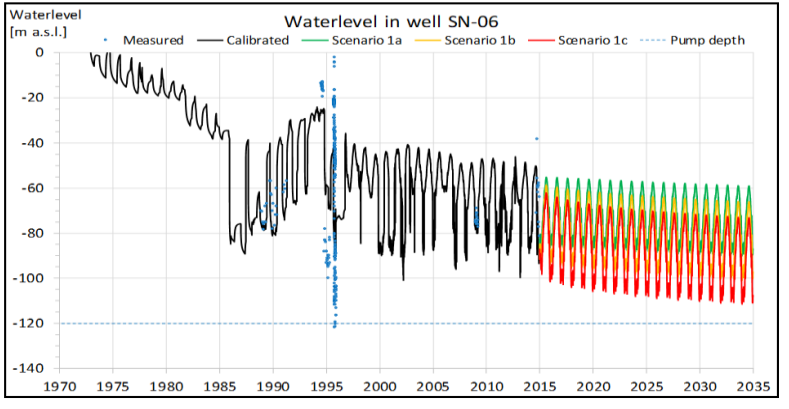


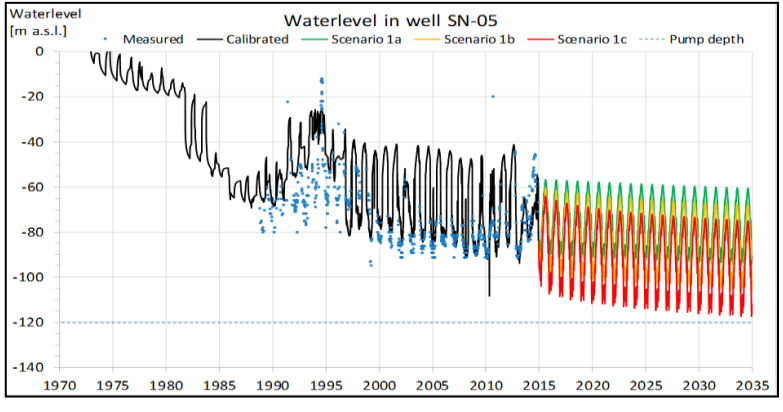
The regional water level has changed in rhythm with the production

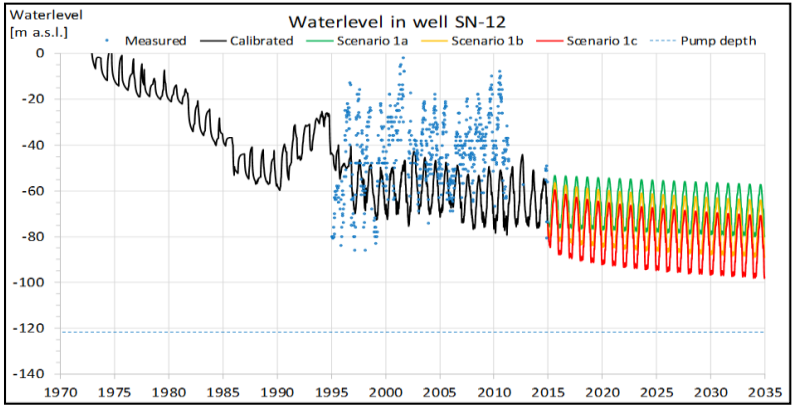


A three-dimensional numerical reservoir model of the Seltjarnarnes geothermal reservoir was updated in 2016 indicating that a production increase of 10 L/s was sustainable for the next 20 years using all the current production wells. This increase has already happened.

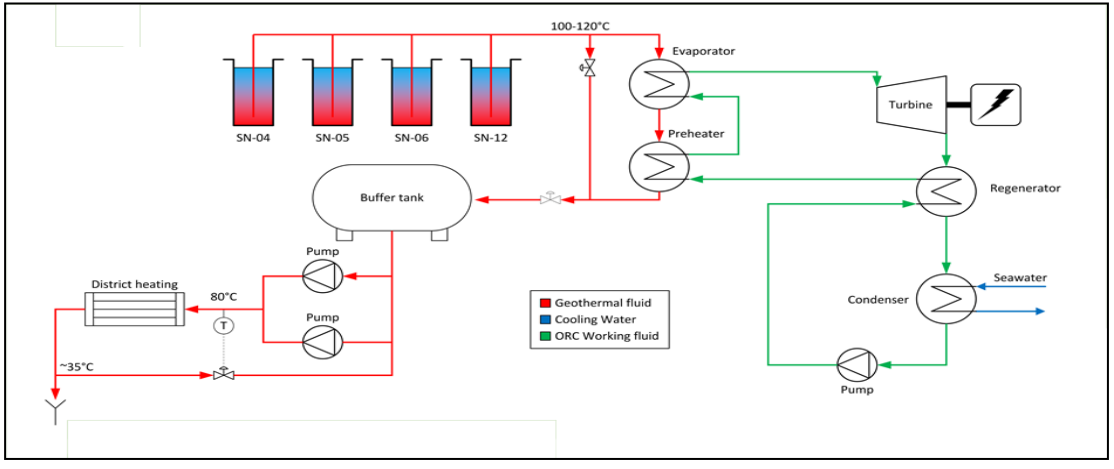






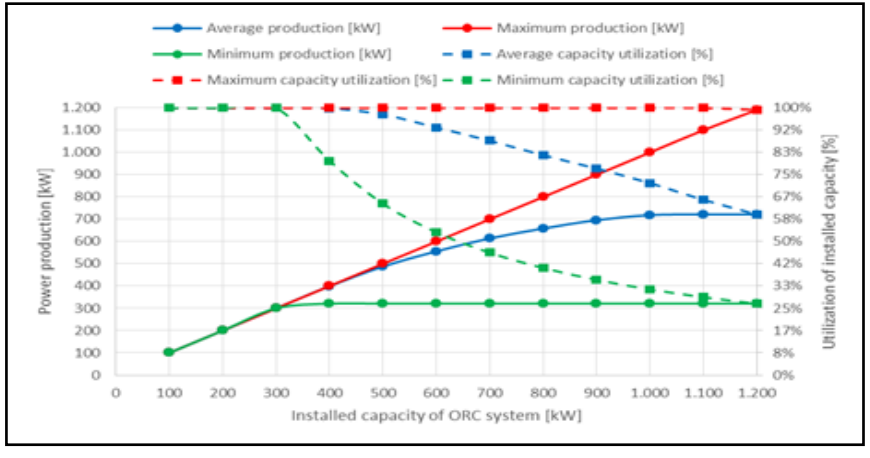


Extended use of the system by installing a small binary plant has recently been considered and a feasibility study made.



The maximum installed capacity of the ORC cycle in the model was set to 100 kW to 1200 kW with 100 kW interval in each step.

The optimal size of the ORC cycle should be around 700 kW where the average utilization of the ORC system is 88% or 614 kW.

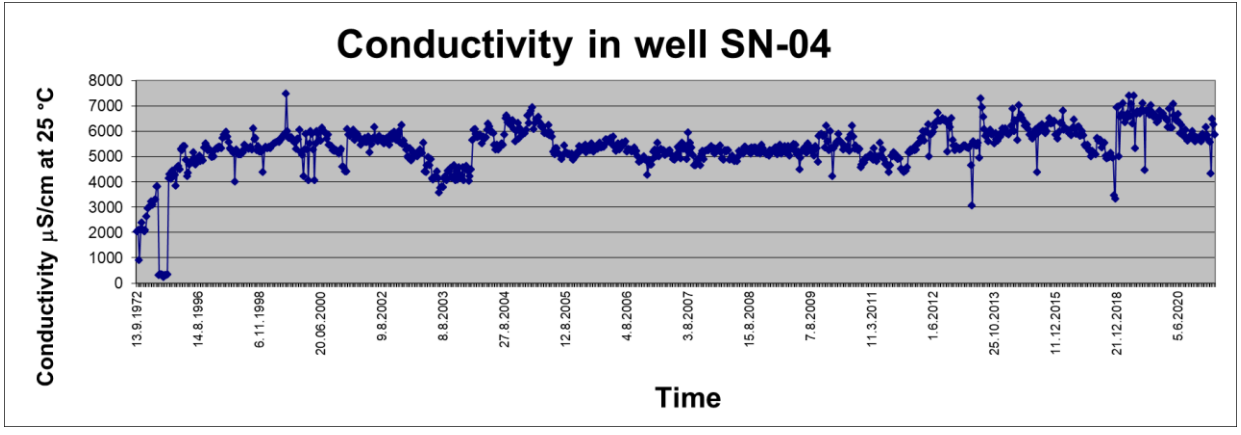


The geothermal water has higher salinity (3-4‰) than water of other geothermal fields within the capital city due to closeness to the sea

	Well SN-4	Well SN-5	Well SN-6	Well SN-12
Temp. °C	108	100	118	108
pH/°C	8.34/19	8.44/19	8.39/20	8.38/22
Conduct. µS/cm	5945	5000	5210	65300
TDS mg/L	3430	2730	3200	3720
Tot. carb. as CO_2	4.9	6.2	4.5	4.4
H_2S mg/L	0.21	0.22	0.26	0.13
B mg/L	0.25	0.22	0.25	0.25
SiO_2 mg/L	125	116	147	103
Na mg/L	683	578	577	704
K mg/L	16.0	12.9	14.2	14.8
Mg mg/L	0.505	0.311	0.485	0.38
Ca mg/L	480	363	486	552
F mg/L	0.6	0.7	1.1	0.6
Cl mg/L	1800	1410	1650	2010
SO_4 mg/L	316	244	320	332
Al mg/L	0.015	0.022	0.036	0.015
Fe mg/L	0.003	0.013	0.006	0.006
Mn mg/L	0.011	0.008	0.010	0.013
Salinity ‰	3.2	2.5	3.0	3.6
δ^2H ‰	-73.59	-71.55	-72.48	-70.18
$\delta^{18}O$‰	-10.47	-10.56	-10.39	-10.56

Minor uptake of oxygen makes the water very corrosive and the high salinity also enhances possible precipitation and scaling of calcite

Chemical monitoring has been regular during production time –as well as monitoring of corrosion-and scaling



The water has become increasingly saline by time, but no significant changes have occurred in composition of stable isotopes - indicating diffusion rather than a direct inflow of seawater.

No scaling nor corrosion has occured at well heads

The water is believed to have balneological potential-similar to water in some famous European spas.

Found to be relieving for psoriasis.

The cost of heating is very advantageous-the least expensive in any urban area in Iceland.

The price is about 0,86 €/m^3 of 82 °C hot water or about 0,02 €/ kWh

Main facts about the Seltjarnarnes field

- **The Seltjarnarnes field has been produced for fifty years**
- **There are three main feed zones yielding 60-140°C hot water**
- **The water is saline and salinity is slowly increasing**
- **The average production from the field was been very stable for 20 years (≤50 L/s), but has increased the last four years**
- **It is a sustainable and environmentally benign production**
- **The regional drawdown in the field has not increased much during this time**
- **So far no general cooling of the field has been observed**

Main facts about the Seltjarnarnes field

- **The production has never put much strain on the system, even though the production characteristics have changed somewhat over the years**
- **The main general change of the field has been increased salinity of the produced water, mainly in the uppermost reservoir**
- **The present production can be increased considerably without putting any strain on the field**
- **The future possibilities for production of the field are manifold and much care has been taken to study the possibilities for a future environmentally beneficial utilization of the resource**

Main facts about the Seltjarnarnes field

- **A tracer test suggested that up to 10 L/s can be reinjected into the field for twenty years without considerable cooling**
- **Exploration wells are beeing drilled to map the outlines of the geothermal area and locate a future production wells**
- **The last well drilled was to replace an old damaged well**
- **Possibilities for electricity generation in a moderate scale are also being considered.**
- **The aim is to maintain a sustainable and environmentally sound production of the field for future generations**

Thank you!
Any questions?