Active and fossil geothermal systems in Iceland

Exploration for epithermal deposits

Hjalti Franzson
Iceland GeoSurvey
Main points

• Geological framework
  – Geological structures
  – Geothermal systems

• Exploration for epithermal deposits

• Projects
  – What can we contribute
  – What do we need
Mantle plume position through time

North Atlantic Large Igneous Province, Saunders et al., 1997.
Fissure swarm, formation of a lenticular lava series
Lenticular lava formation
cross-section
Central volcano

- Evolved rocks
- Caldera
- Shallow intrusives
- Magmatic volatiles
- Heatsource
- High-T systems

Diagram showing geological features related to a central volcano.
Fossil eroded high-temperature areas

Active high-temperature systems
General model of a high-T reservoir

FRACTURED ZONE OR VOLCANIC CENTER (WITH CALDERA)

PRECIPITATION

THERMAL AREA

VOLCANIC FISSURES

GROUNDWATER

RISING HOT WATER

HEAT

MAJOR INTRUSION

UPPER CRUST

LOWER CRUST

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Geothermal systems

• Dominantly freshwater
• Temperatures 200-400°C
• Magmatic volatiles present but less than porphyry systems

• Extensive studies of structures, alteration and fluid chemistry of drilled systems
• Scalings in pipes (controlled by fluid composition, pressure and temperature)
Reykjanes Ridge
Spreading rate ~2 cm/yr

Kolbeinseyj Ridge
40 M y
30 M y
20 M y
Today

Greenland

Today

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First, downhole temperature and pressure measurements:
Samples collected at 284-296°C, below depth of first boiling
Borehole – pressure logging – clogging

- Black smoke
- Seawater
- Ca\(^{2+}\)
- SO\(_4^{2-}\)
- Anhydrite (CaSO\(_4\))
- Lateral vent (horizontal fracturing)
- Fe-Zn-sulfides
- Chalcopyrite (CuFeS\(_2\))
- Remnant Anhydrite
- 350 - 400°C
- High-temperature fluid

Sph, cpy, gn, (bn, cv, py, Am SiO\(_2\))
Zn: 48-43 wt%
Cu: 11-18 %
Fe: 3-4 %
Pb: 0.3-1%
SiO\(_2\): 3-2%
S: 30-28%
Ag: 890-3500 ppm
Au: 110-80 ppm

Poster No.3.8 – 7
Black smokers and Reykjanes
Exploration for epithermal gold in Iceland

- Early exploration in early twentieth century
- Exploration started again in about 1990 and has been ongoing intermittently to present.
Older prospect areas (now discarded)

Present prospect areas

Málmis- Melmi prospect areas.
"Flateyjarskagi"
Main results of exploration

Base metals

Viðidalur-Vatnsdalur
Quartz float up to 32.6 g/t

Hafnarfjall
Jaspers up to 4.7 g/t

Mógilsá
Veins up to 9 g/t

Reykjanes
Saline high-T area
Sinters up to 2.55 g/t
Well scales up to 950 g/t

Laxárdalur
Stream sands up to 1205 ppb Au
Rock chips up to 0.24 g/t

Flateyjardalur
Py-rich rhyolite up to 0.25 g/t

Vopnafjörður
Veins up to 0.45 g/t

Breidavik
Veins up to 0.16 g/t

Breiðdalur
Py-rich rhyolite
Up to 0.86 g/t

Álftafjörður
Veins up to 1.6 g/t

Slaufrudalur
Veins up to 0.37 g/t

Lón
Veins up to 0.93 g/t

Kálfafellsdalur
Veins up to 0.27 g/t

Hveragerði
Quartz veins up to 0.46 g/t

Pormóðsdalur prospect
Quartz-adularia veins up to 400 g/t
Thormodsdalur anomaly

Low sulphide quartz-adularia-sericite
Au concentration up to 400 ppm
Our accomplishment so far

• We have proven that low- and high-salinity geothermal systems in Iceland precipitate gold

• Iceland has as yet no proven Au-minable resource but several low- to high value prospects have been located

• Most of these have, however, only been studied in a preliminary way
This presentation has aimed at introducing the ore forming environment in Iceland. This environment is in many respects different from that of Scandinavia and Greenland.

BUT

It has important similarities.
Ore formation is closely linked to magmatic processes and geothermal activity.

• Iceland is a natural laboratory of magmatic and geothermal processes. These are both present as active ones as well as fossil and eroded, some all the way down to the magmatic heatsource of the geothermal system.

• We can see projects both as part of student training or as part of specific research projects.
Epithermal environment of ore formation

• We have eroded sections with ore formation in fossil geothermal systems where we can supply the background data

• We have the natural laboratory of the active Reykjanes saline high-temperature system which is precipitating high concentrations of gold and base metals. We have the same opportunity with other freshwater high-T systems
We would need input such as:

• Research answers on the hydrothermal evolution of the known epithermal ore locations.

• What would be the best Au extraction processes e.g. in the Thormodsdalur prospect?

• What are the environmental issues in the mining processes that would best apply to Icelandic environment.
Thank you