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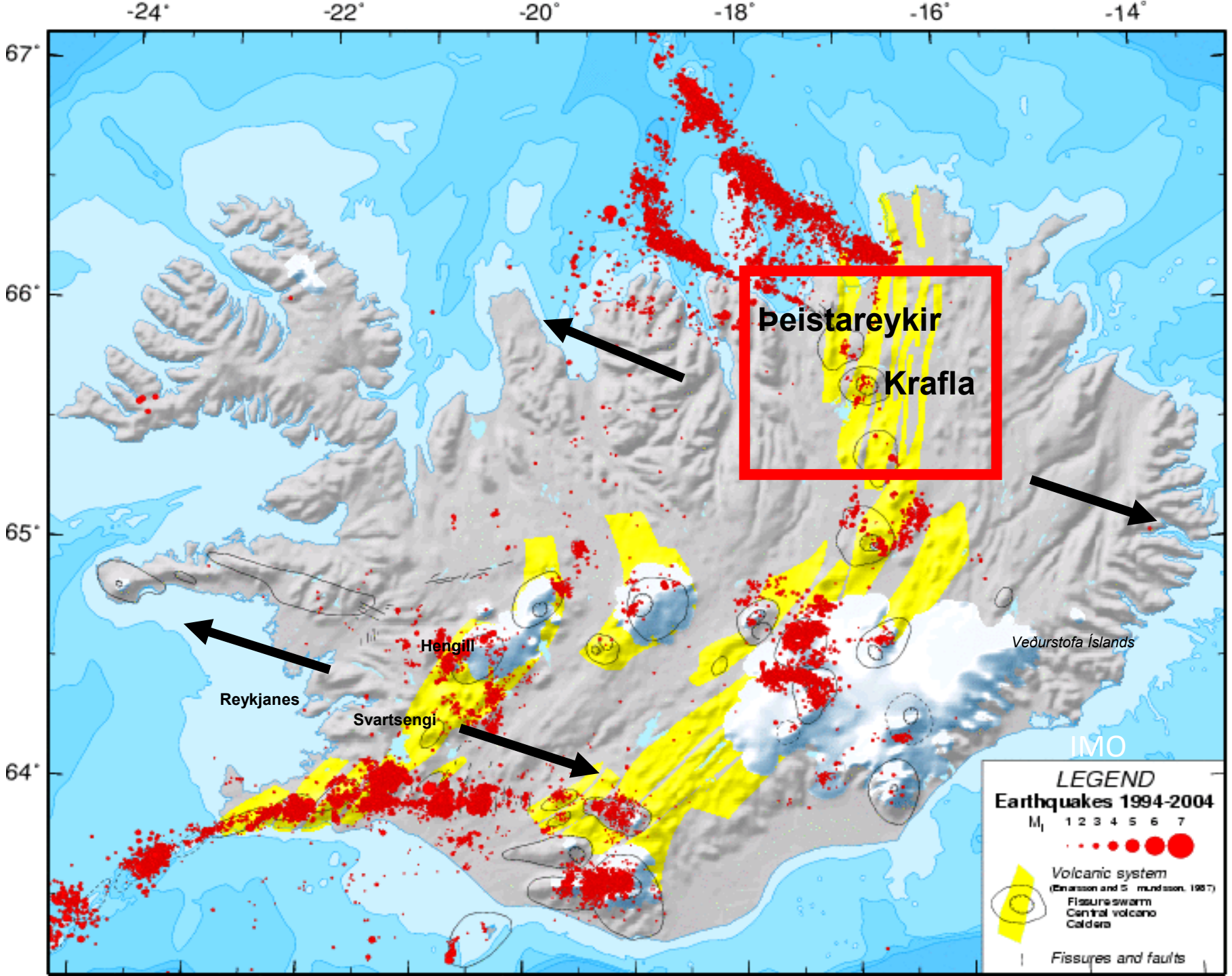
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

Krafla Magma Testbed:
„a „moon shot“ for the Geosciences“
Observe and Manage mass and stress transfer within geothermal systems using new methods

Philippe Jousset

* Contribution to a proposal with specific target Krafla/Theistareykir
* Focus of fibre optics and continuous gravity monitoring as new methodology that allows to probe T, strain and mass transfer

(HORIZON-CL5-2021-D3-03)



ÍSOR

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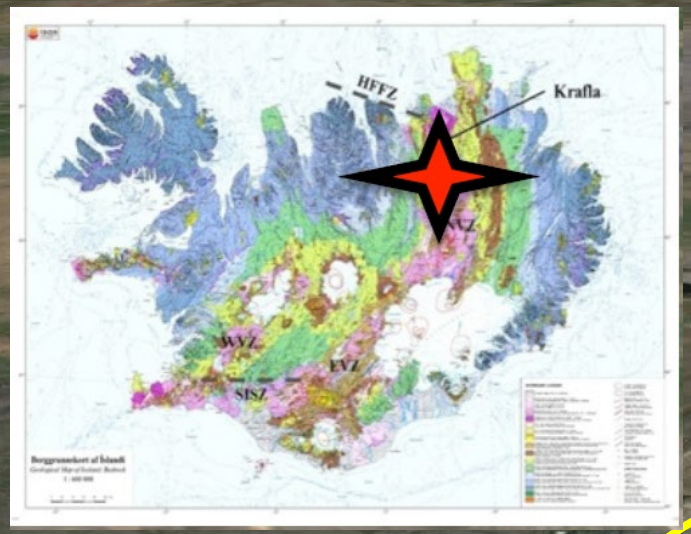
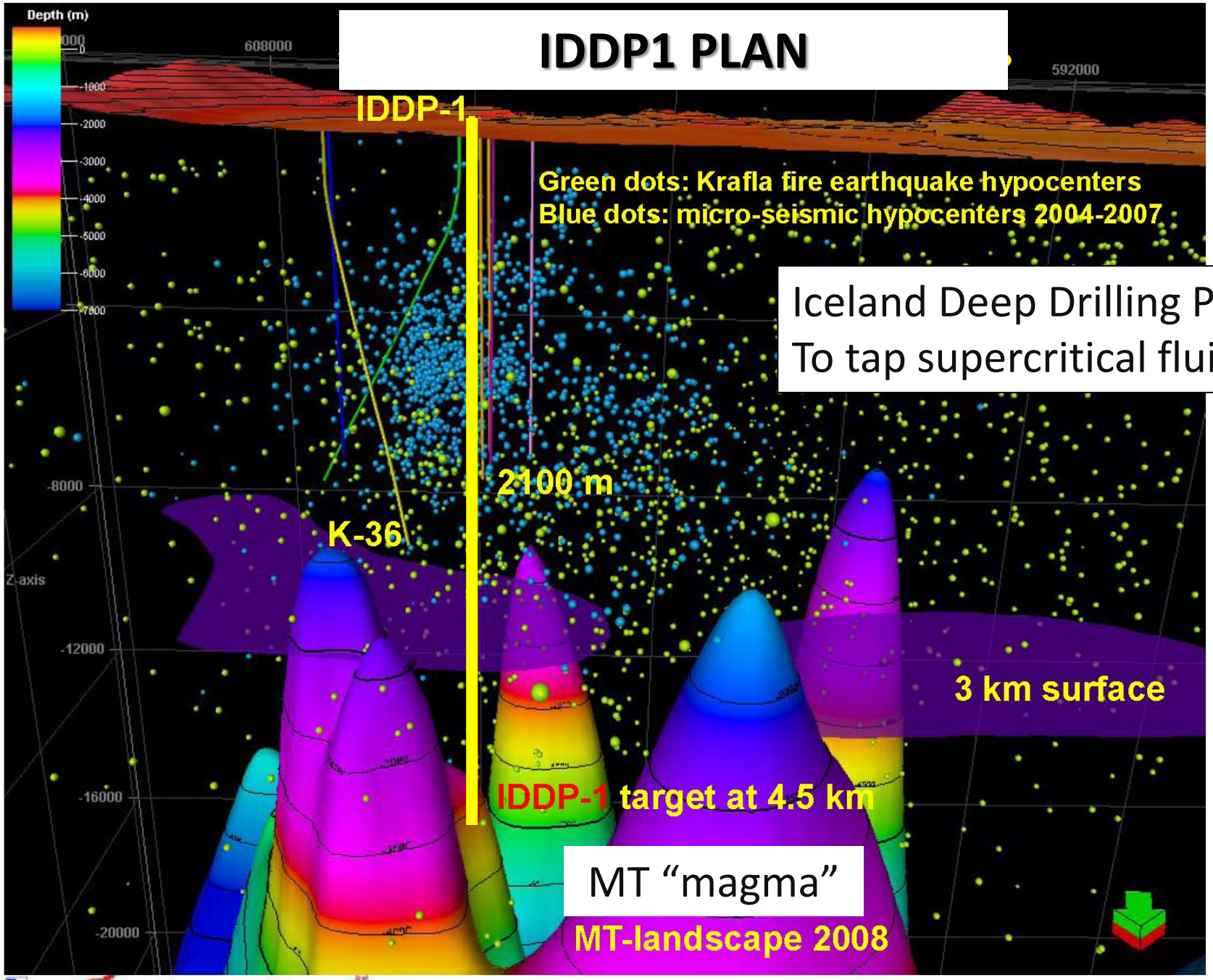
Krafla caldera, NE Iceland



Last eruption: Krafla fires, 1975-1984,
0.25 – 0.30 km^3 basaltic lava

One of the most drilled
and instrumented
volcanoes of the world

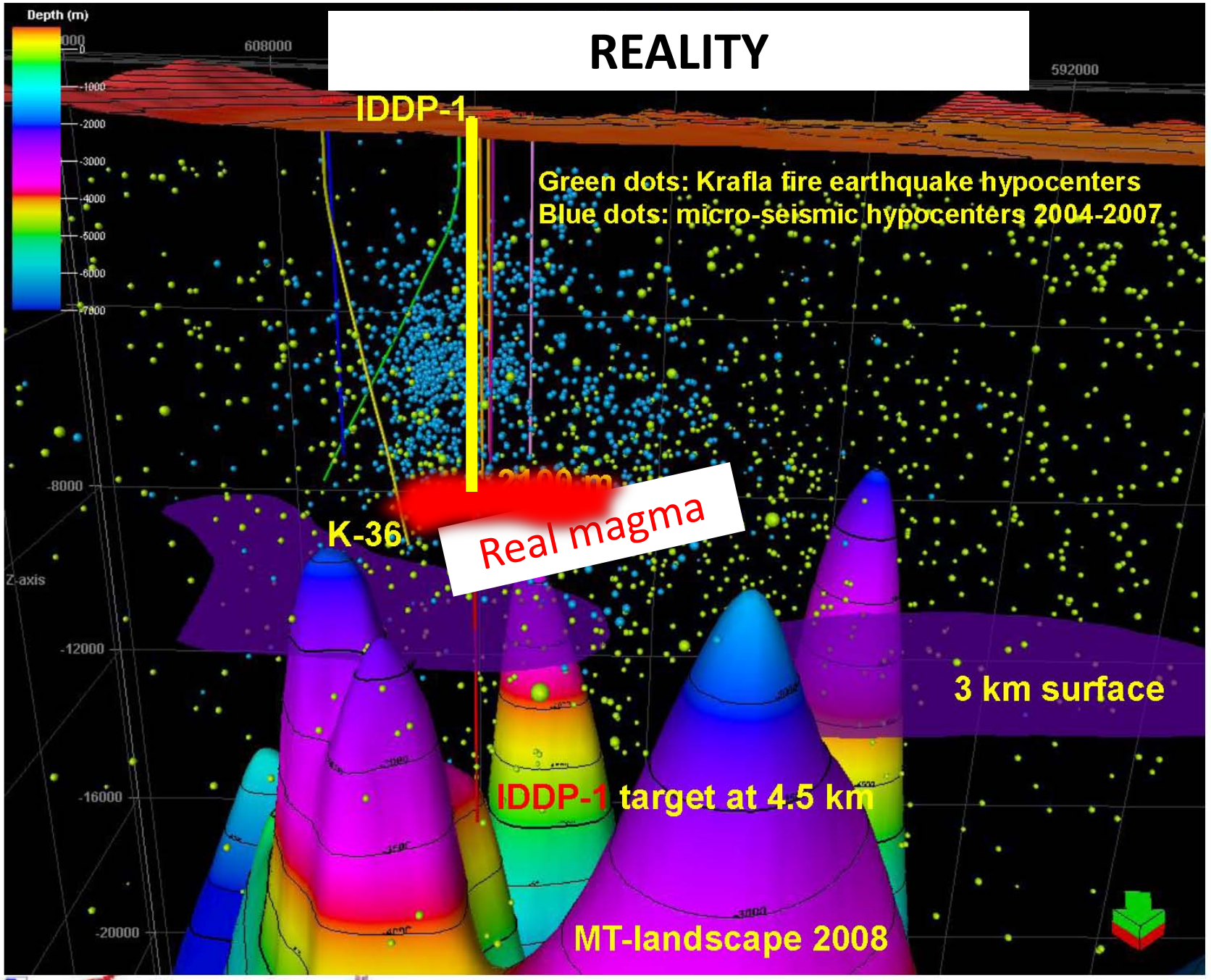
IDDP1 PLAN



Iceland Deep Drilling Project:
To tap supercritical fluids

TARGET@4500 m

REALITY



REALITY@2100 m

TARGET@4500 m

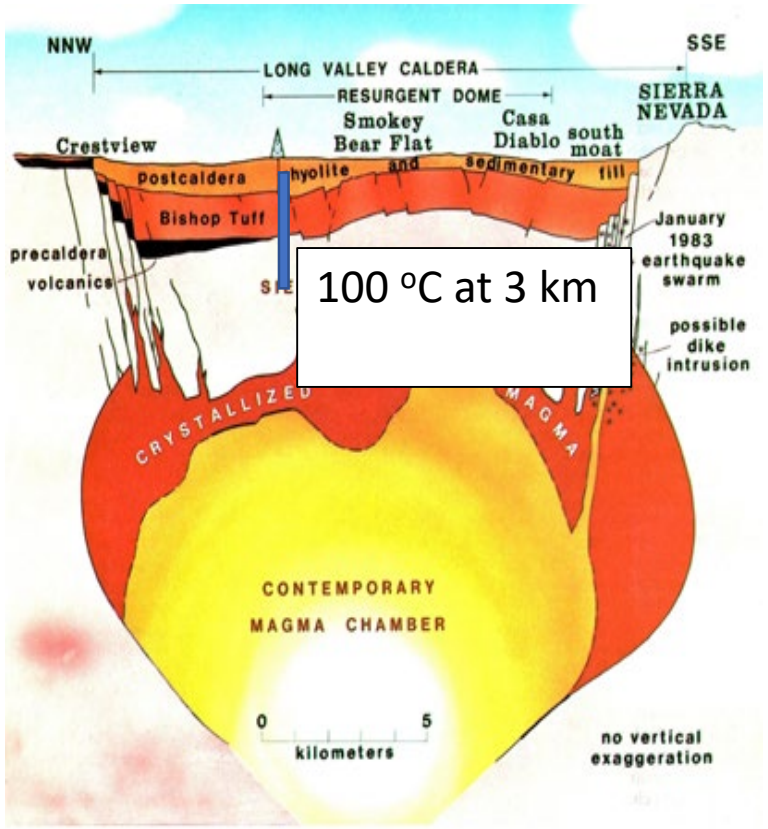
IDDP-1

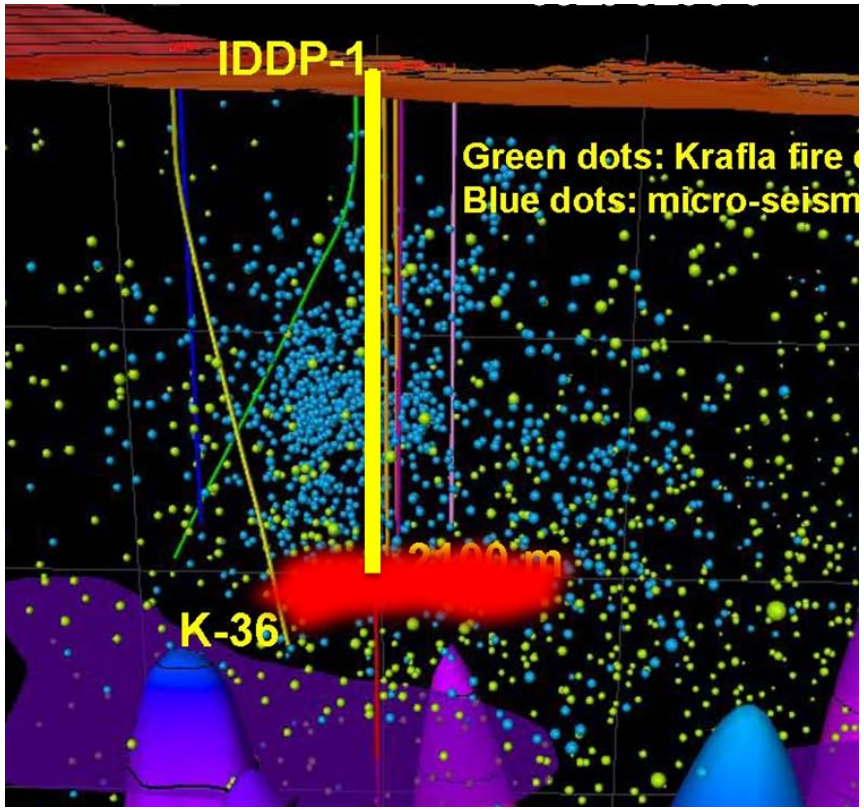
Hottest well ever: 850 ˚C
(450 °C at well head)

The issue of magma geophysics

It saw magma where there wasn't…

…and did not see it when it was there





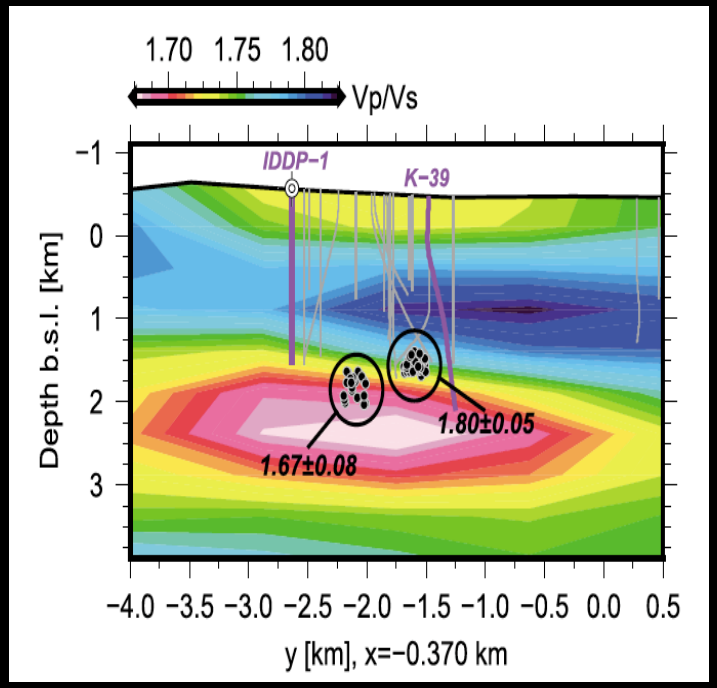
Rundle and Eichelberger, 1983

What is the problem with magma geophysics?

- It's never been tested against reality like geophysical prospecting for oil&gas.

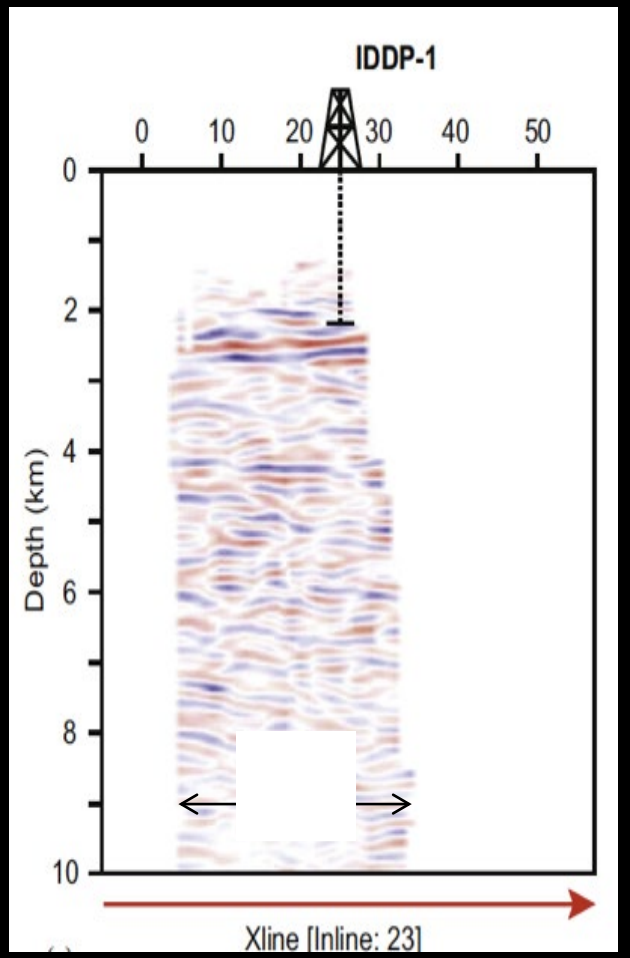
- Therefore, techniques have only been improved by better data analysis, not by the ultimate test of ground truth.

Once the location of a magma body is known, magma geophysics can be tested and improved



Tomography *(Schuler et al, 2015)*

Reasonable minimum estimate: 1 km^3 of magma

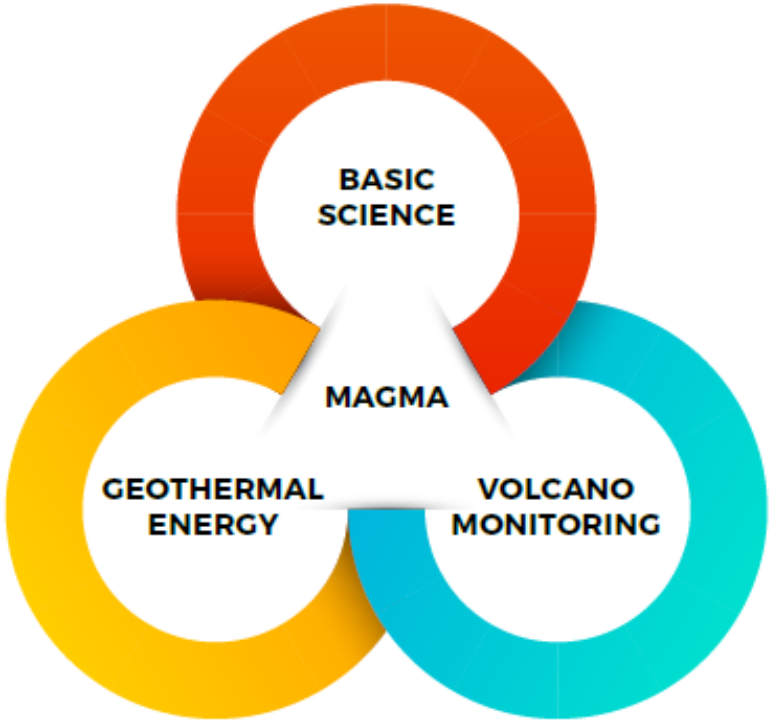


Reflection *(Kim et al, 2018)*

KRAFLA MAGMA TESTBED

KMT: Krafla Magma Testbed

THE FOUR KMT PILLARS



SCIENTIFIC **PLANETARY SCIENCE**

creating a world-class research facility that will advance the scientific knowledge of the migration of magma and fluid, furthering volcanology, seismic and geothermal research.

PUBLIC SAFETY **GEOHAZARDS**

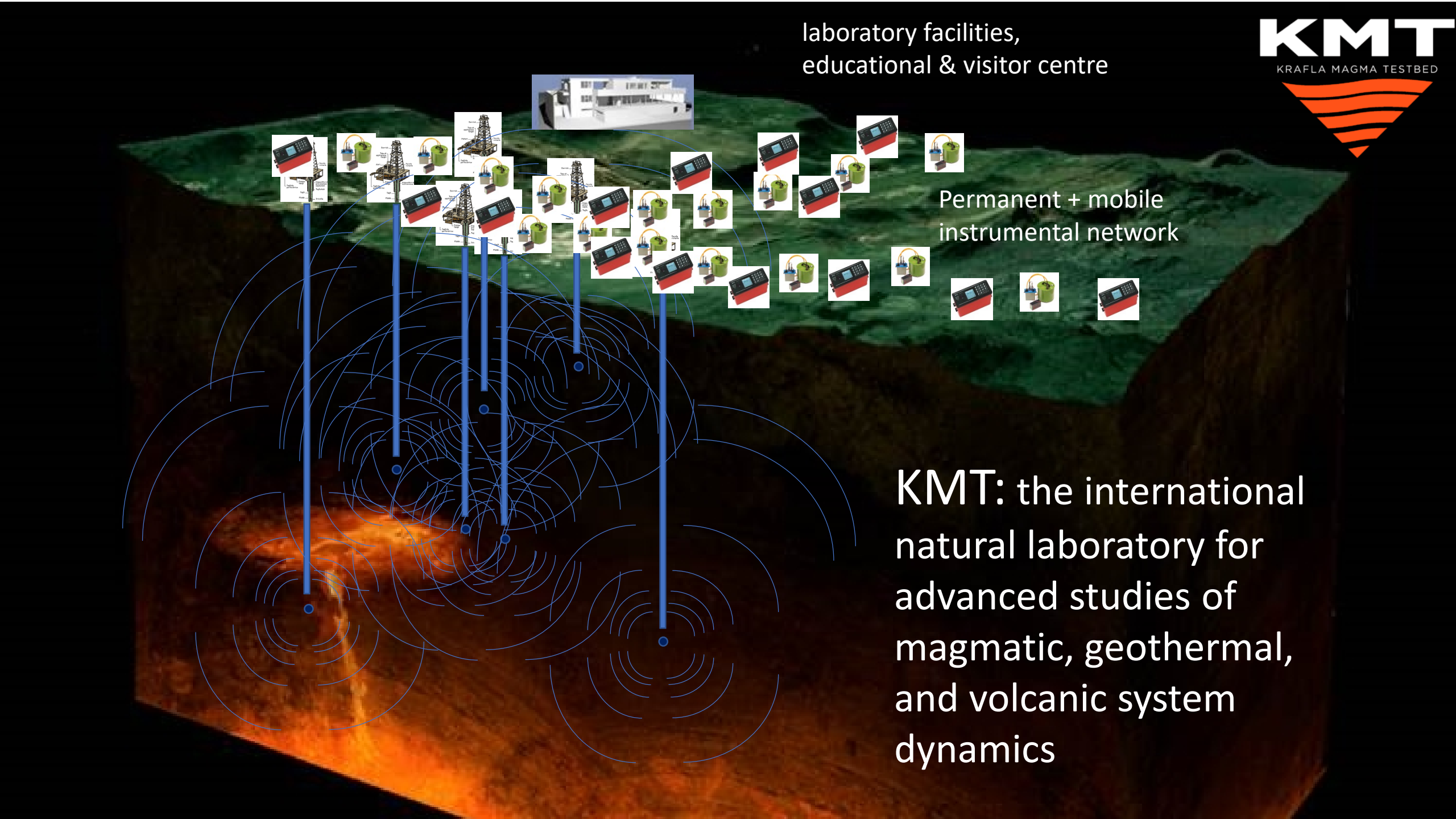
improving civil protection for hundreds of millions of people living within 100km of an active volcano.

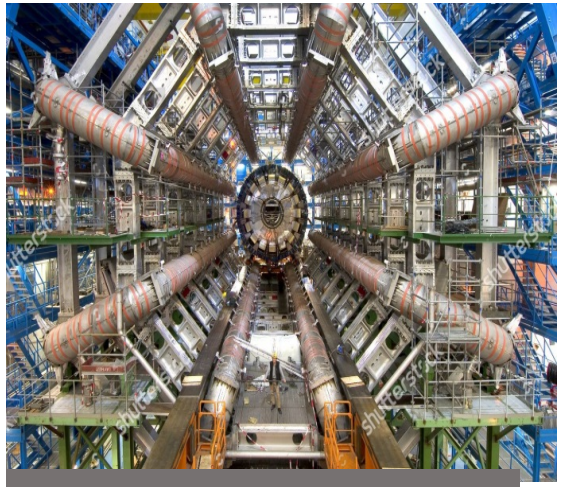
ECONOMIC **GEOTHERMAL ENERGY**

providing more effective geothermal energy production at lower cost.

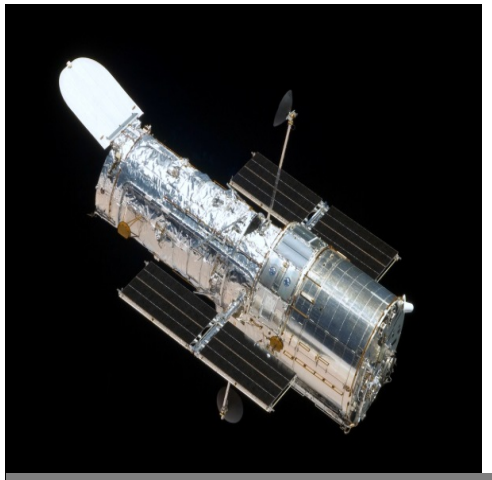
TECHNOLOGICAL **INNOVATION**

advancing extreme sensing and drilling technologies in support of the economic, social, and scientific benefits.


laboratory facilities,
educational & visitor centre
Permanent + mobile
instrumental network
KMT: the international natural laboratory for advanced studies of magmatic, geothermal, and volcanic system dynamics

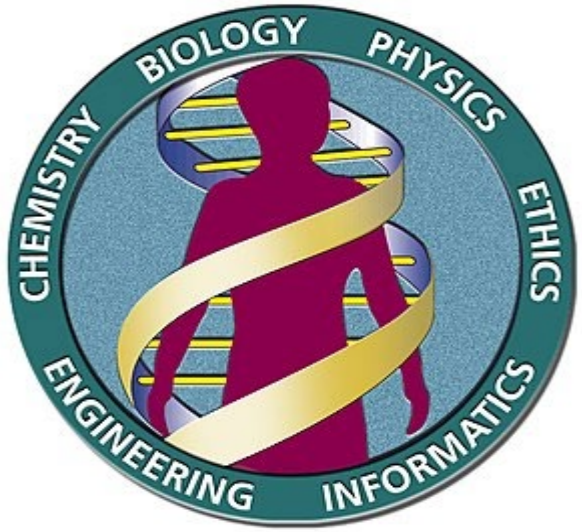


Large Hadron Collider



Hubble telescope

Gran Sasso laboratories



Human Genome Project

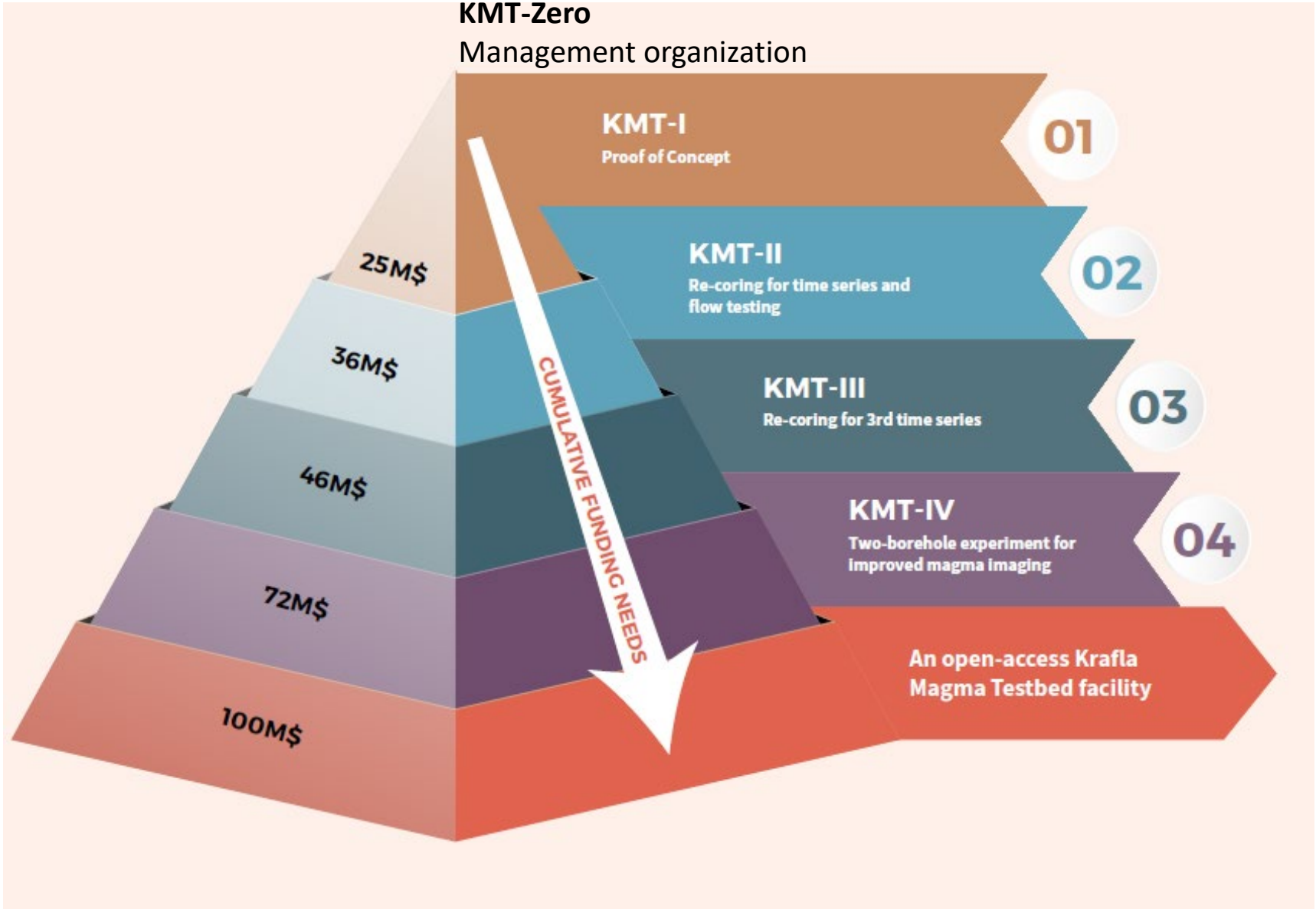
BIG SCIENCE

- BIG budgets
- BIG staff
- BIG machines
- BIG laboratories

Long-term project

Where are we?

KMT-Zero
Management organization



KMT current funding situation

Financial commitments

Formal commitments from:

- Government of Iceland
- UKs NERC
- EPOS-IT

} ~ 3 M$

- May be DOE and NSF – working on it

Project funds raised:

- EU/H2020 MSCA-ITN «IMPROVE»
- EU/H2020 ERC «EAVESDROP»
- EU/H2020 ERC «MODERATE»

} ~ 9 M€

ICDP proposal accepted } ~ 3 M€

Discussions within GFZ to make North Iceland a Focus area/light house

KMT
KRAFLA MAGMA TESTBED

GeoHazards

Planetary Sciences

Geothermal Energy

Technology & innovation

Which methods ?

- Geochemistry
- Geophysics
- Geology + metallogenic processes
- Modelling
- Drilling technologies
- New technologies for deep processes and resources
- New techniques to be developped

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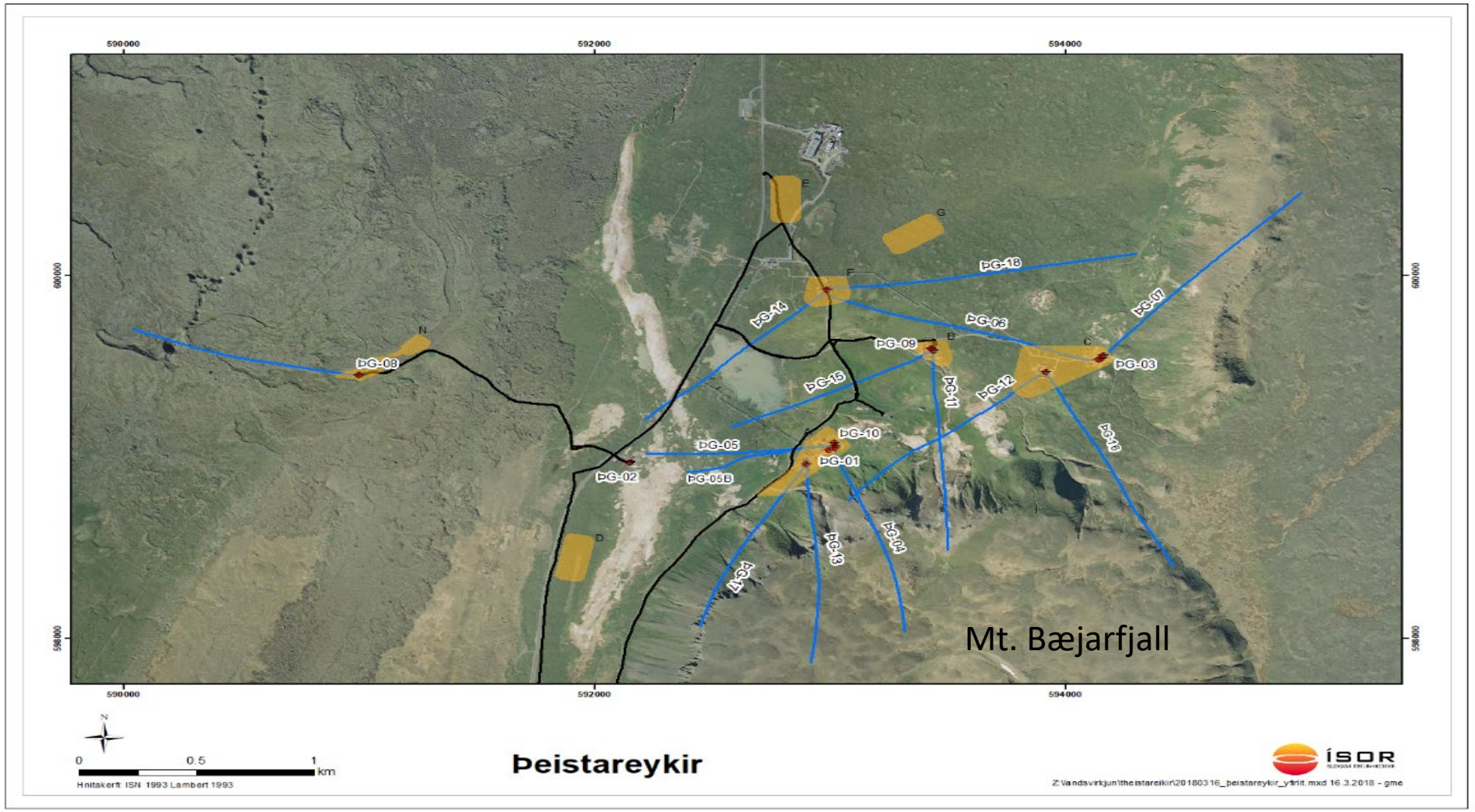
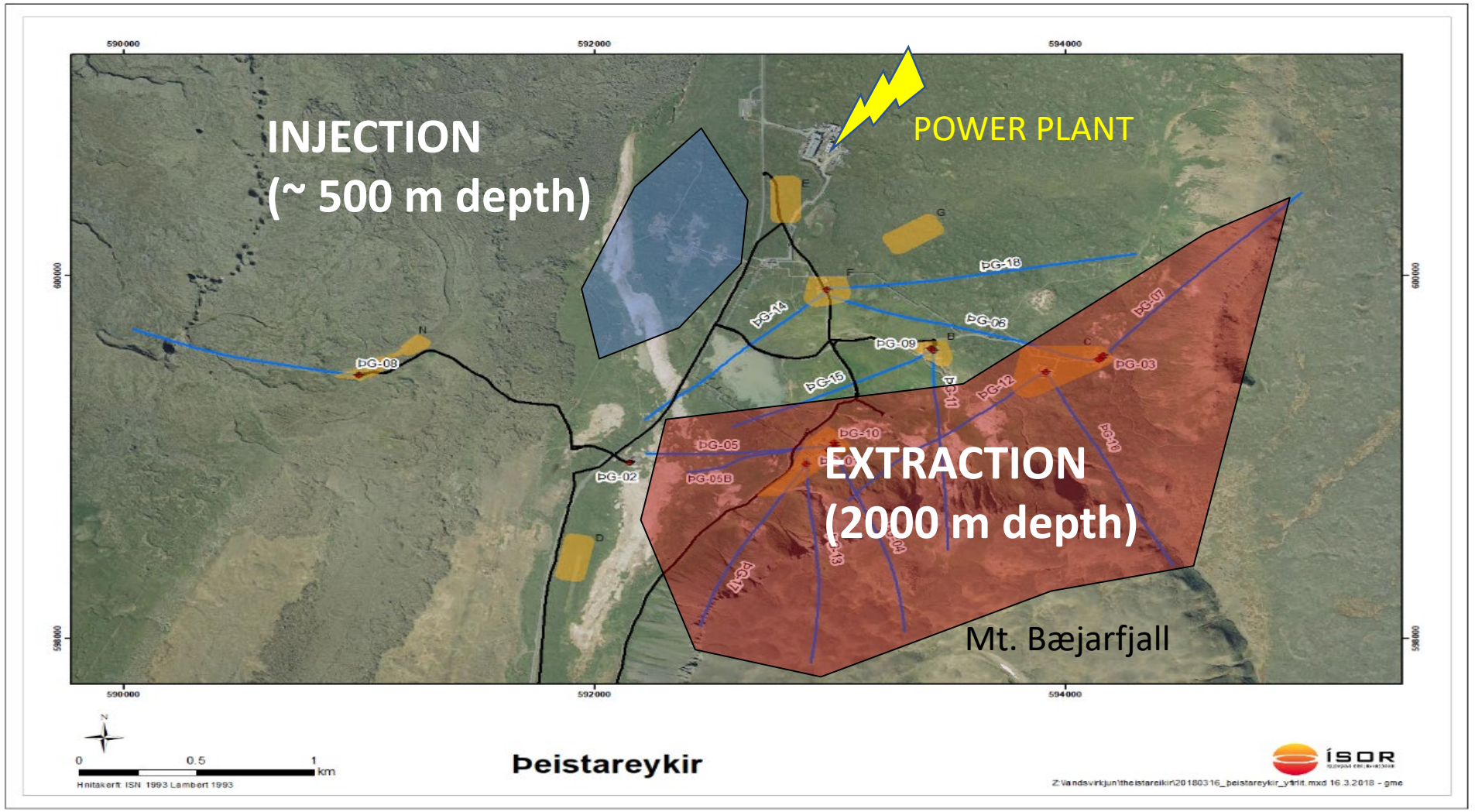
Example of multiparametric geothermal & volcanological network: Theystareykir geothermal newly exploited system

- Scientific objectives : quantify mass and stress balance in exploited geothermal system.
- Started 4 years ago
- Initial target: Krafla –> shift to Theistareykir (25 km away)

Geothermal wells in Þeistareykir (~2000 m depth)



Geothermal wells in Þeistareykir (~2000 m depth)



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Geophysical methods for tracking mass and stress in the reservoir

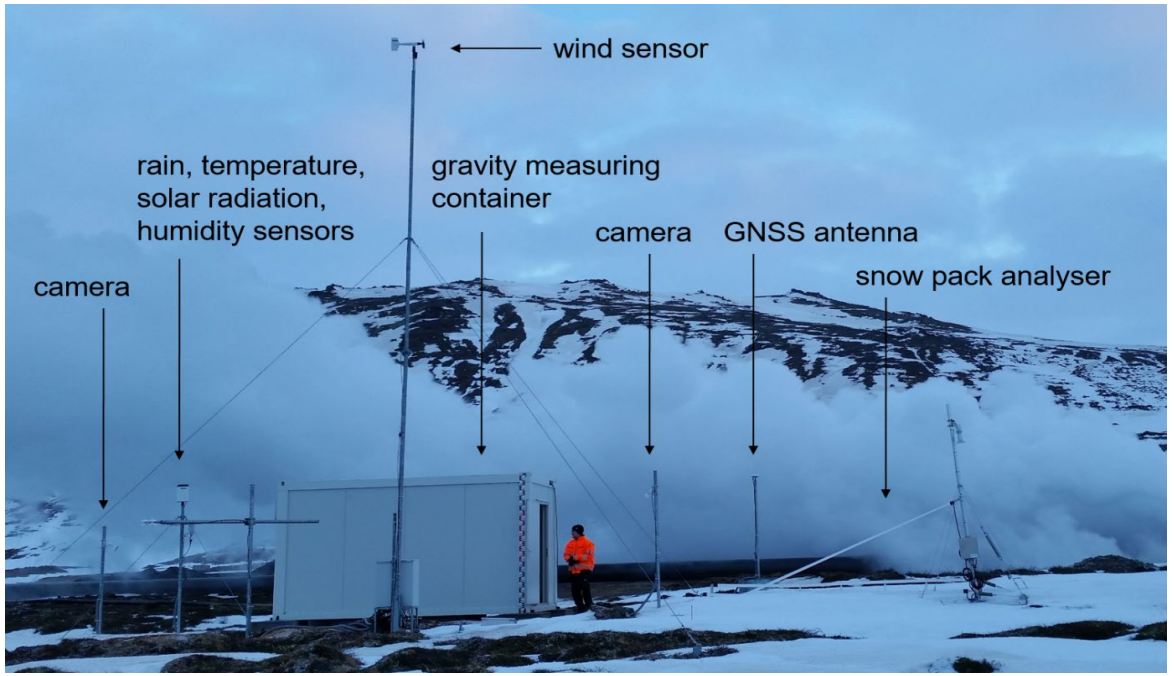
- Gravity methods (density, mass distribution)
  - Reservoir location
  - Sustainability of the reservoir (fluid extraction and recharge)
- Seismic methods (seismic velocities, attenuation, stress)
  - Fractures and reservoir location
  - Fluid content
  - Fluid dynamics
- Electromagnetic methods (resistivity)
  - Rock permeability, porosity, fractures and fissures
  - Temperature, Fluids
- Additional methods that may influence gravity:
  - Elevation, deformation (GNSS, tiltmeters, InSAR ...)
  - Hydrological parameters

5 locations:

3 in Theystareykir

1 in Krafla

1 remote



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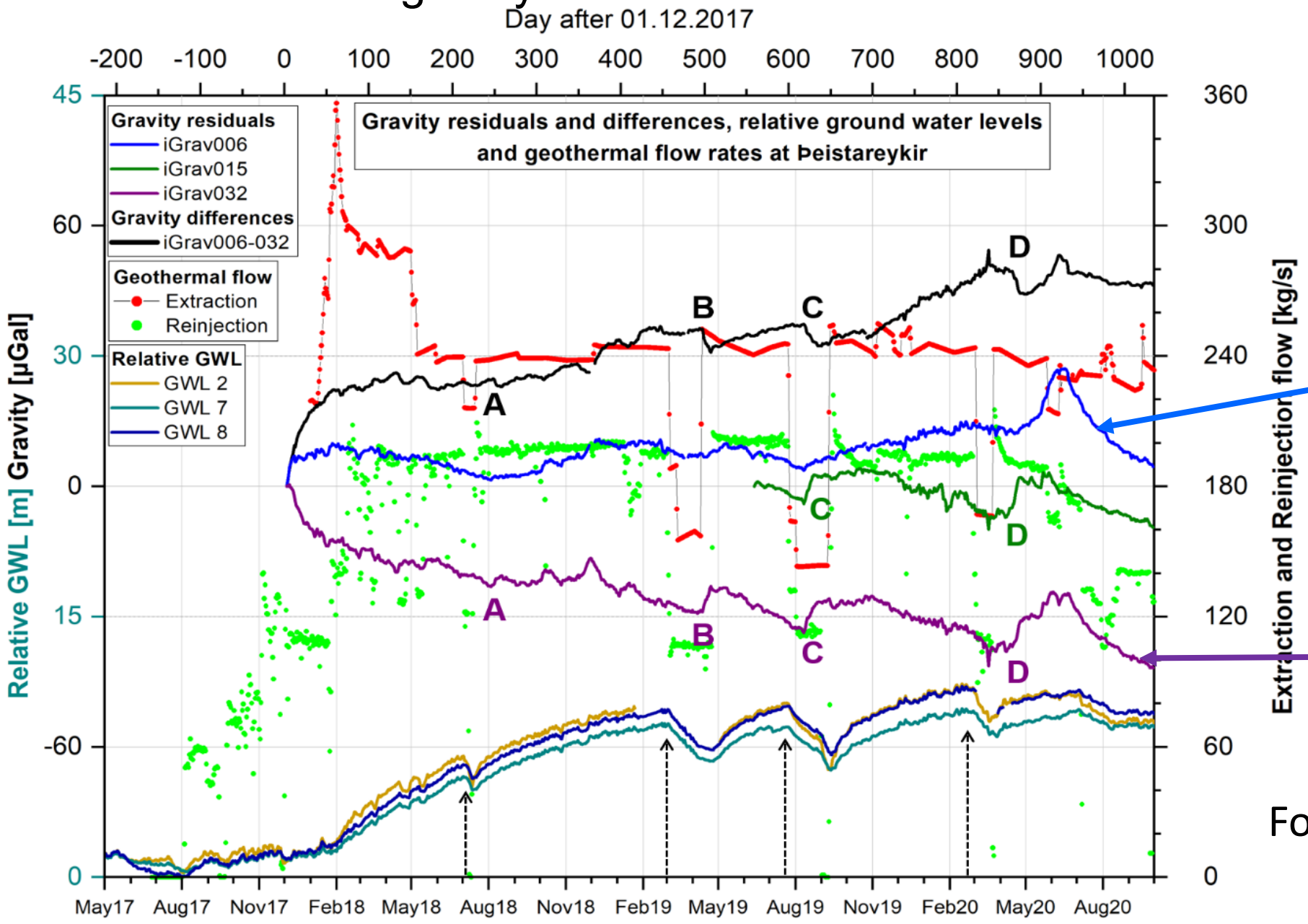
iGrav residuals and gravity differences



INJECTION

EXTRACTION

Forster et al., in press

Addresses

- Leverage new monitoring tools (e.g., fibre optic tools, gravity meters?) for better assessment of geothermal reservoirs and mitigate processes (induced seismicity, seismic detection, e.g., DAS) in various geological environments.
- Better exploitation infrastructure observation (borehole stability, DTS, pipe monitoring,…) for improving performance and reliability of geothermal installation, considering they integration and acceptability within the human and natural environment.
- Data management, processing and dissemination integrated in sociology aspects.

Scope

- The proposal is expected to develop and validate innovative sustainable circular-by-design solutions that can reduce environmental impact and increase the overall circularity of geothermal energy. The following can be considered:
  - Techniques for reservoir development and exploitation in a wider range of geological settings, including complex and/or untested geological conditions.
  - Potential introduction and demonstration of the innovative technologies as part of existing geothermal plants in Europe and abroad.
  - Novel methods and technologies to find and develop productivity from near magmatic, superhot/supercritical zones that are currently unexploitable and non-commercial.

Link with existing projects

- ITN network IMPROVE (Marie-Curie Early Stage Researcher position)
  - https://www.gfz-potsdam.de/karriere/stellenangebote/job-detail/5531/

- Krafla Magma Testbed – unique opportunity to develop research in new direction for "*leading the development of key digital, enabling and emerging technologies, sectors and value chains to accelerate and steer the digital and green transitions through human-centred technologies and innovations;*"

KMT alone cannot get through this call

or various reasons…

- But

it can be a potentialy good asset for a proposal, as it brings answers to questions addressed in the call for proposal

Ideal project:

- KMT – magmatic place
- EGS/ link with cities and deep geothermal energy , and other and recycling CO2
- Smart cities, sedimentary basin, research on how to make cities greener, more sustainable, etc.

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Fibre optic methodologies/ largest continuous monitoring gravity network

- Set of instruments (DAS interrogators, instruments already deployed, …)
- Data set for research and demonstration
- Modeling
- …