Welcome

WEEK OF INDONESIA-NETHERLANDS EDUCATION AND RESEARCH

WINNER
WEEK OF INDONESIA-NETHERLANDS
EDUCATION AND RESEARCH

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GEOCAP

Modern ways of exploring geothermal resources in Indonesia and the Netherlands to boost the Energy Transition

Winner conference 2020

25 November 2020

09.00 CET / 15.00 WIB

WEEK OF INDONESIA-NETHERLANDS EDUCATION AND RESEARCH

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Agenda

09.00 – 09.05	Aim of the session ‘Drafting a research agenda on geothermal exploration from the GEOCAP experience’ - Prof. Dr. Freek van der Meer / Tia den Hartog, MSc
09.05 – 09.15	Remote sensing: spatial is special Dr.Eng. Ir. Suryantini , S.T., Dipl Geothermal EnTech., M.Sc Dr. Chris Hecker Dr. Eng. Ir. Asep Saepulloh, S.T., M.Eng
09.15 – 09.20	Geothermal Exploration using Regional geologic modeling - Dr. Fred Beekman
09.20 – 09.25	Geophysics: know your subsurface - Dr. Eng. Yunus Daud, Dipl. Geotherm.Tech.,
09.25 – 09.30	De-risking exploration by integrating exploration know how- Prof. Dr. Jan-Diederik van Wees
09.30 – 09.45	Q&A moderated by Prof. Dr. Freek van der Meer
09.45 – 09.50	Wrap up preliminary research agenda and outlook to WINNER June 2021 by Prof. Dr. Freek van der Meer / / Tia den Hartog, MSc

Geothermal Capacity Building Programme Indonesia – the Netherlands (GEOCAP)

Prof. Dr. Freek van der Meer

Dean and GEOCAP Project Leader

University of Twente

University of Utrecht

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GEOCAP Geothermal Capacity Building Program Indonesia - Netherlands

Geothermal Capacity Building Program Indonesia – the Netherlands (2013-2022)

11 partnering organisations
90+ researchers
500+ beneficieries

Objective of GEOCAP:

Increase the capacity of Indonesian Ministries, Local Government, Agencies, Public and Private Companies, and Knowledge Institutions in developing, exploring and utilization of geothermal energy resources and to assess and monitor its impact on the economy and the environment

Partners

University Twente, Delft, Utrecht, Bandung, Indonesia, Gadjah Mada

Company: TNO, IF, DNV (Star, Supreme, Geodipa, PT APG)

Ministry: Foreign Affairs NL, MEMR, BAPPENAS

Branch organisation: INAGA

Rationale

There is not enough skilled personnel to work on the development of geothermal fields particularly in prospective areas outside Java

Many operational research challenges related to the uptake of geothermal ranging from low drilling success to nature conversation

‘Paris Agreement’ no more coal!

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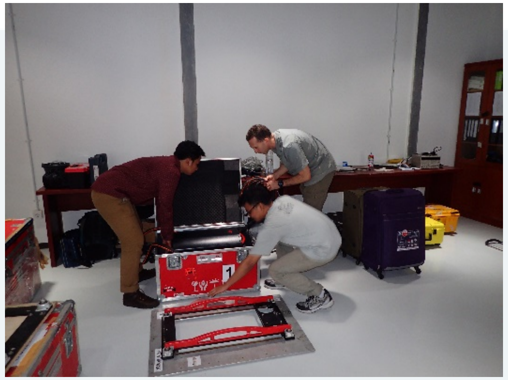
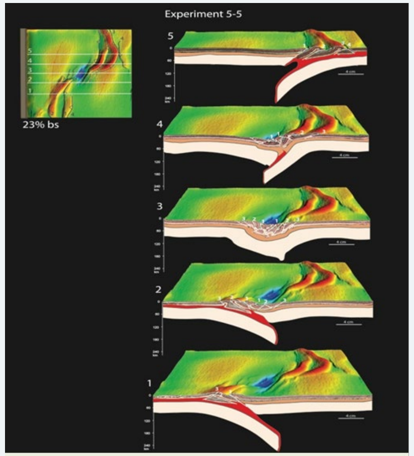




mechanical models

Education & Training	Research	Others
1.01 – Geothermal exploration knowledge and skills deepening	**2.01** – Techno-economic risk assessment	**3.0** – Use of low-medium enthalpy resources
1.02 – GGG regional and site exploration workflows	**2.02** – Geomechanics and reservoir modeling	**4.0** – Geothermal database integration
1.03 – Drilling skills	**2.03** – Advanced geothermal drilling (detailed drilling data logging and analysis)	**5.0** – Management and coordination
1.04 – Geothermal exploitation knowledge and skills	**2.04** – Improvement of exploration concepts	
1.05 – Operation and maintenance skills for geothermal power plants	**2.05** – Hydro-fracturing and acidizing	
1.06 – Master class course/training for high level decision makers for geothermal projects	**2.06** – Geothermal power plant efficiency systems development	
1.07 – Project decision and risk management and financing	**2.07** – Geothermal geodynamics (e.g. geothermal 2050)	
1.08 – Environmental assessment (EIA, SEA, PGIS)	**2.08** – Rules, regulations, policy and governance	
1.09 – Development of integrated training materials (compilation)		
1.10 – Dissemination of project outcomes		

Aim of the session

- ‘Drafting a research agenda on geothermal exploration from the GEOCAP experience and real time needs’
- What are the really pressing issues?
- What techniques for exploration are required and need further development?
- What type of geothermal systems need to be explored?

Remote Sensing for Geothermal Exploration

Dr.Eng. Ir. Suryantini , S.T., Dipl Geothermal EnTech., M.Sc

Lecturer and Researcher Institut Teknologi Bandung

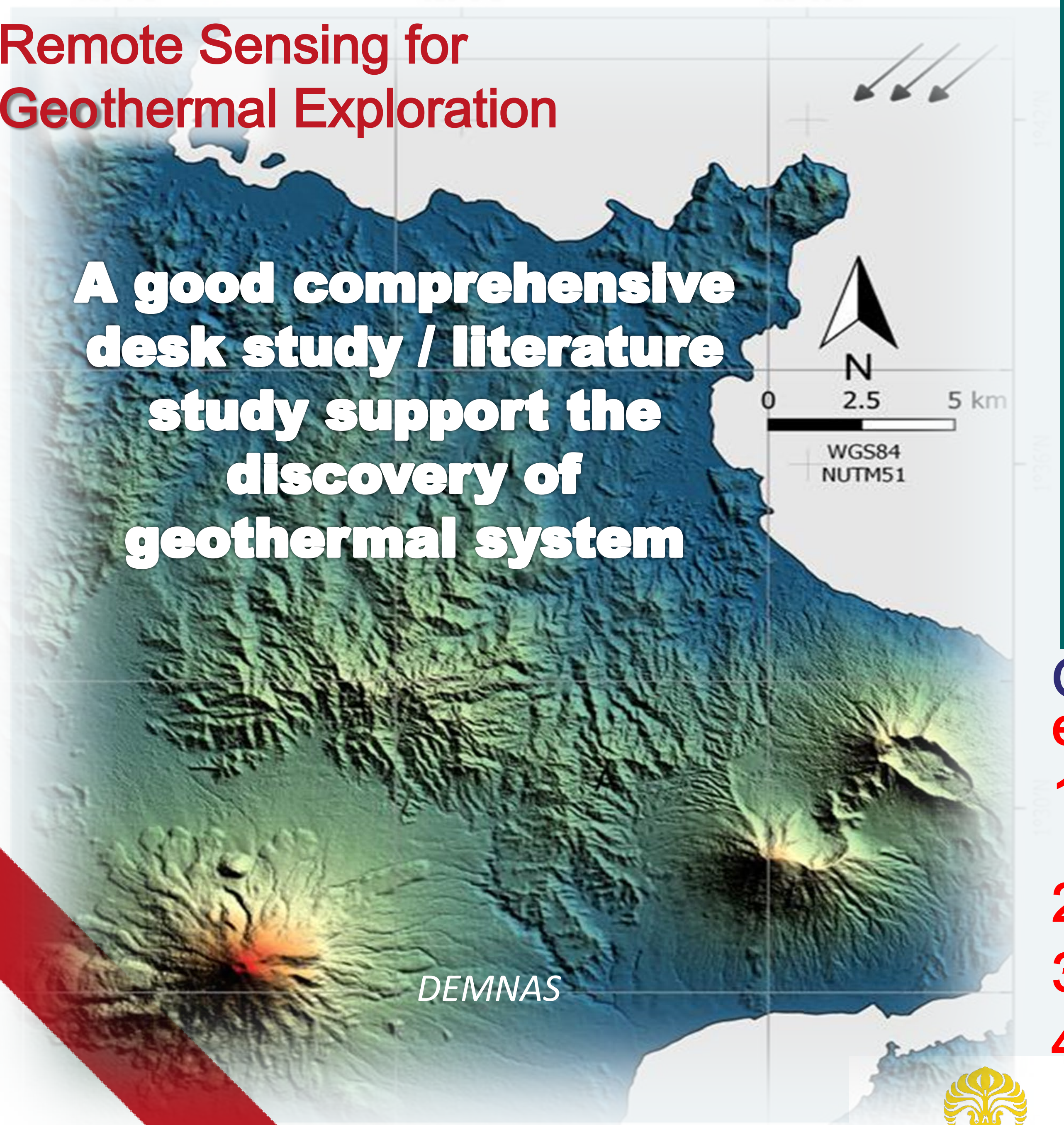
Dr. Chris Hecker

Associate Professor - University of Twente

Dr. Eng. Ir. Asep Saepulloh, S.T., M.Eng

Lecture and Researcher Institut Teknologi Bandung

Remote Sensing for Geothermal Exploration



A good comprehensive desk study / literature study support the discovery of geothermal system

- All available data is useful
- Do not underestimate the importance of data (for instance knowledge of local people, published literature, etc.)
- Remote sensing is one of the tools at this stage
- Start with cheap or free data

Objectives of RS analysis during exploration

1. Interpreting regional/ detail geology of geothermal system
2. Interpreting faults as permeability
3. Locating thermal anomaly area
4. Future planning

Public domain Remote Sensing data

It is free and can be downloaded from the following website

https://earthexplorer.usgs.gov/
- SRTM: ~30m
- EO-1 Hyperion: 30m, 10m pan, 220 ch, 0.357-2.576um, 10nm bandwidth
- Landsat 7 ETM+ (1999-2003): 30m, 15 m pan, 8 ch, 4 VNIR, 2SWIR, 1 TIRS
- Landsat 8 OLI/TIRS (2013-..): 30m, 15 m pan, 11 ch, 3 Vis, 1 NIR, 2 SWIR, 2 TIRS, Coastal, Cirrus
- Sentinel-2 (2015): 10m, 20m, 60m, 3 Vis, 5 VNIR, 4 SWIR, coastal
- ASTER (1999-2008): 15m,30m,90m, 2 Vis, 2 NIR, 6 SWIR, 5 TIR

https://scihub.copernicus.eu/
- Sentinel-1 (2014): SAR, 5m
- Sentinel-2 (2015): 10m, 20m, 60m, 3 Vis, 5VNIR, 4 SWIR, coastal

https://asf.alaska.edu/data-sets/derived-data-sets/alos-palsar-rtc/alos-palsar-radiometric-terrain-correction/
ALOS PALSAR (2006-2012): 12.5m

http://tides.big.go.id/DEMNAS/index.html
DEMNAS: ~8m

https://e4ftl01.cr.usgs.gov/ASTT/ASTGTM.003/2000.03.01/
ASTER DEM: ~30m

1) **NDVI** – to find vegetation stress associated with ground thermal anomaly

2) **LST** – to find temperature anomaly of an area

3) **Band Ratio** to map clay minerals on the bare ground area, associated with thermal fluid activities

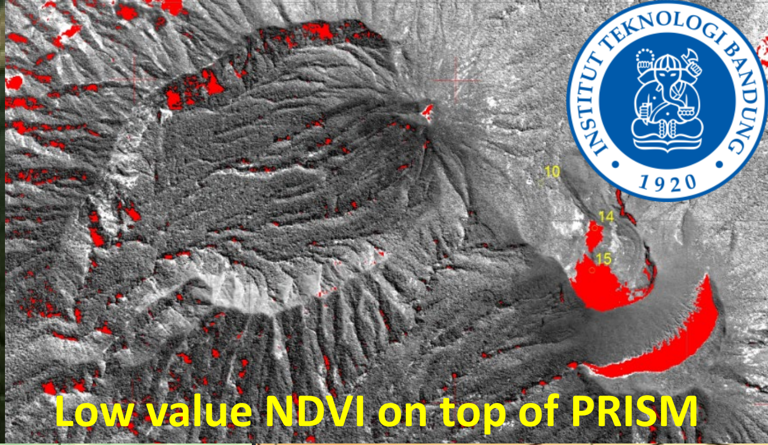
Others…….

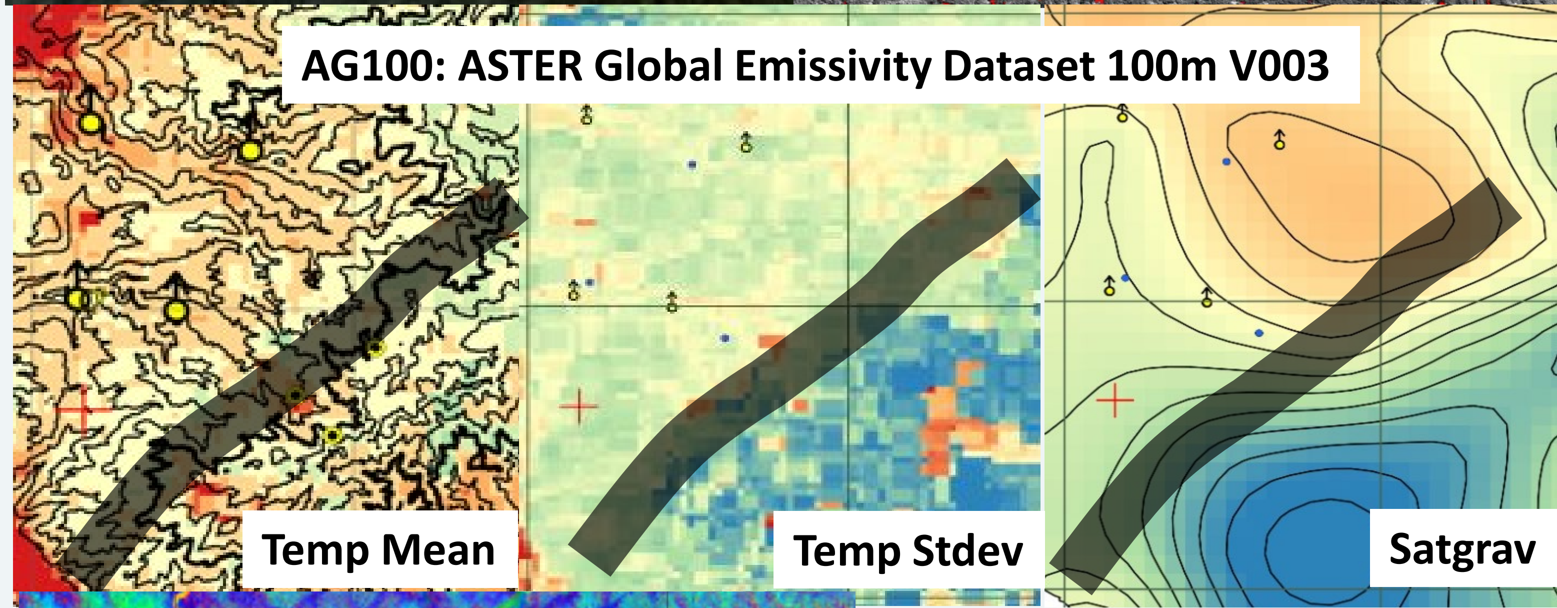
1) *Litology mapping* ; very useful in volcanic regions

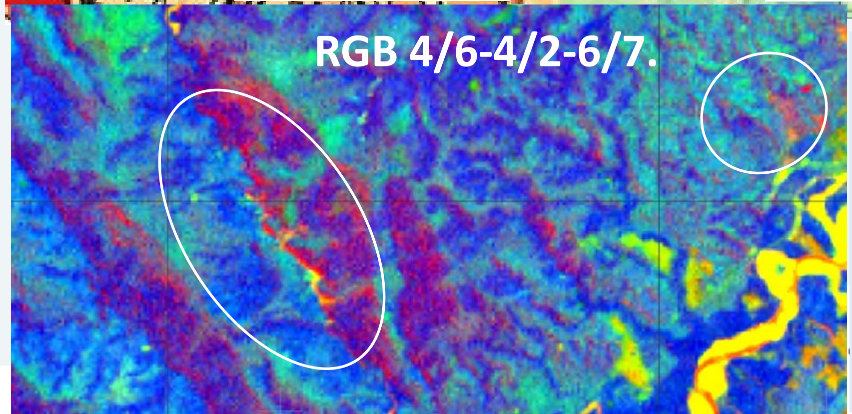
2) *Structural geology* ; powerfull using Radar

3) *Geologic Hazard*

4) And many more…





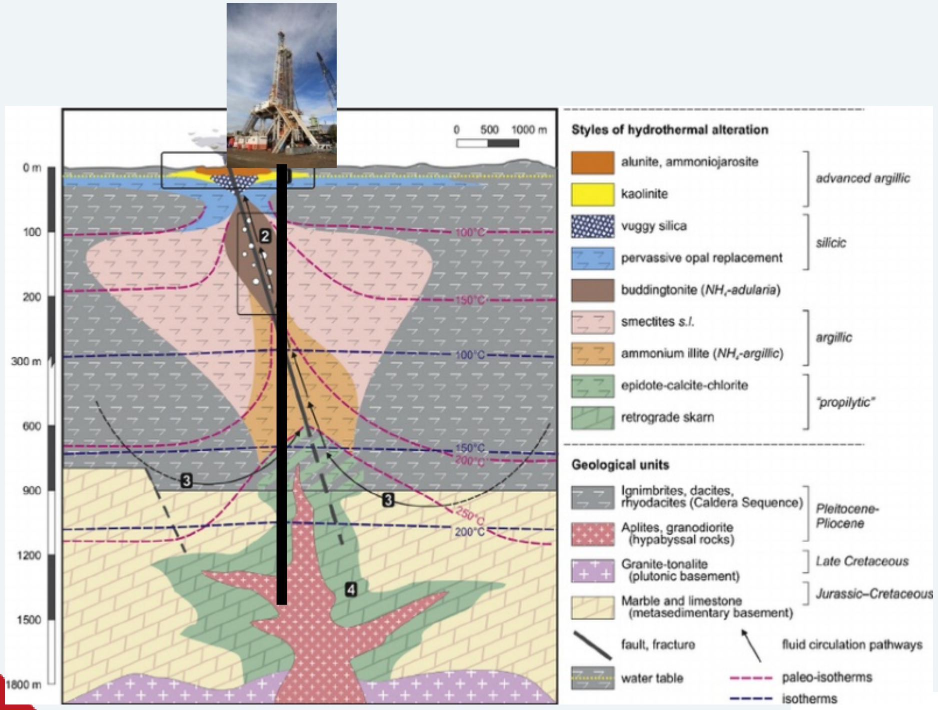


Optimize your data!!

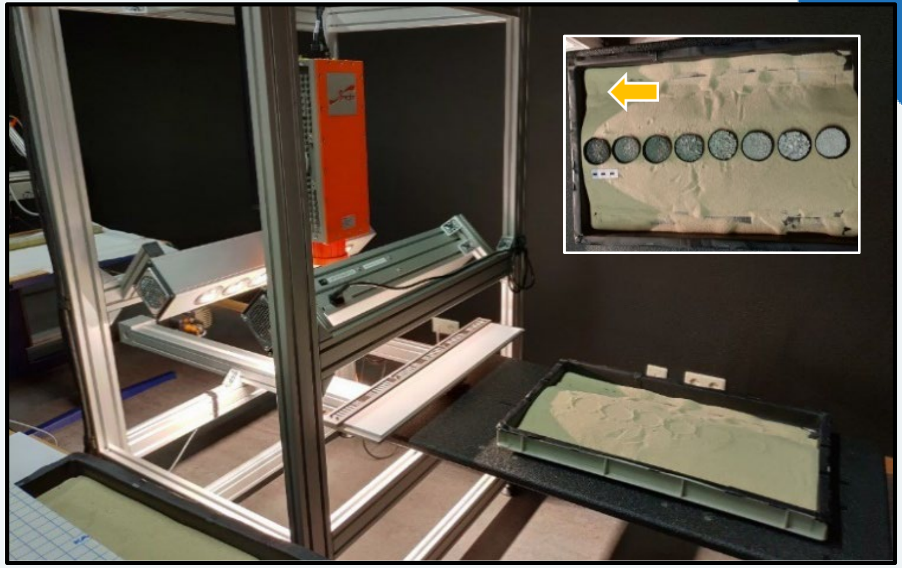
Ground Check is required

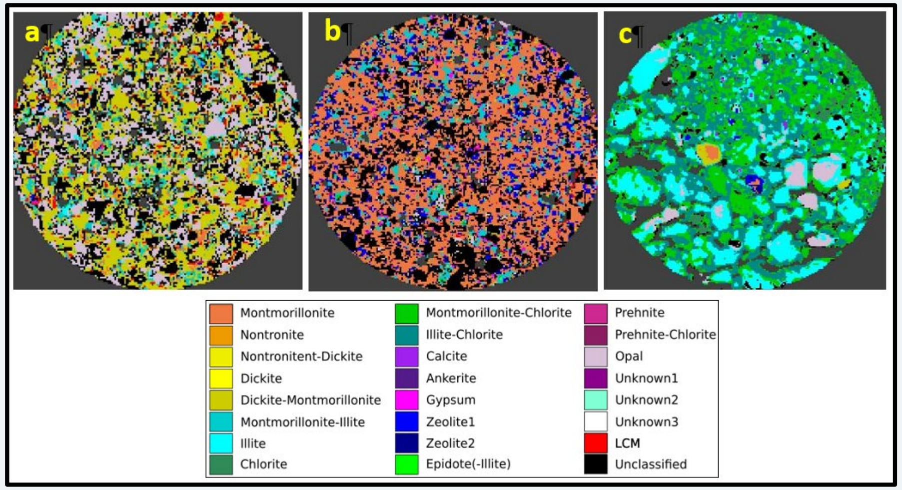
PROXIMAL “REMOTE” SENSING OF DRILL SAMPLES

- Drilling in right place saves millions
- Alteration of rocks indication of favourable conditions
- Infrared analysis improves understanding and speed



Source: Canet et al (2015)





PhD Kartika Savitri (in prep)

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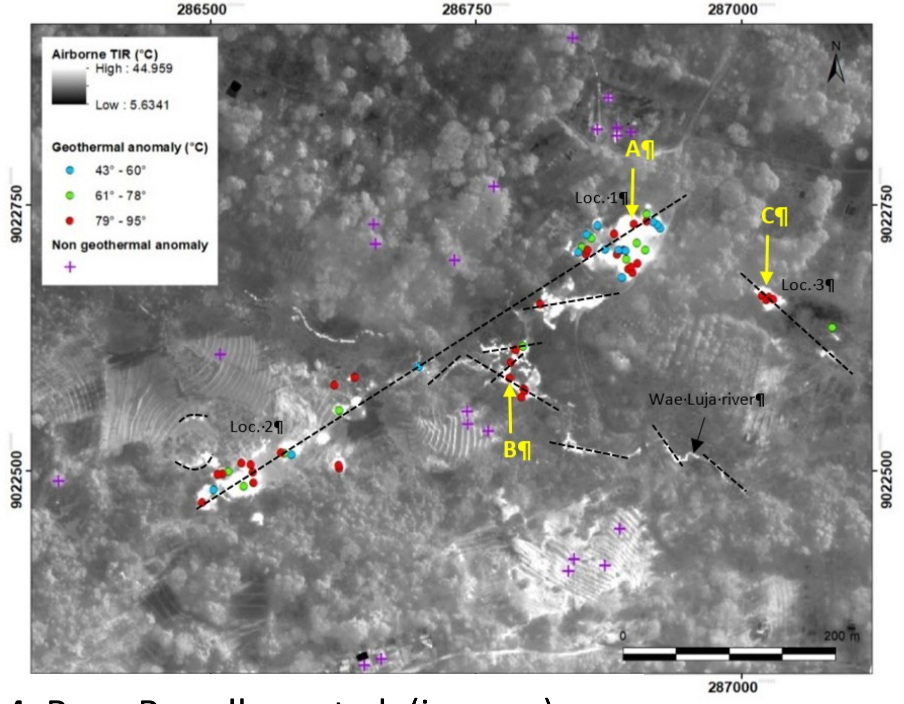
AIRBORNE THERMAL REMOTE SENSING

- Detects heat from geothermal surface expressions
- Airborne survey has sub-meter resolution
- Discovery of unknown expressions and structural alignments possible



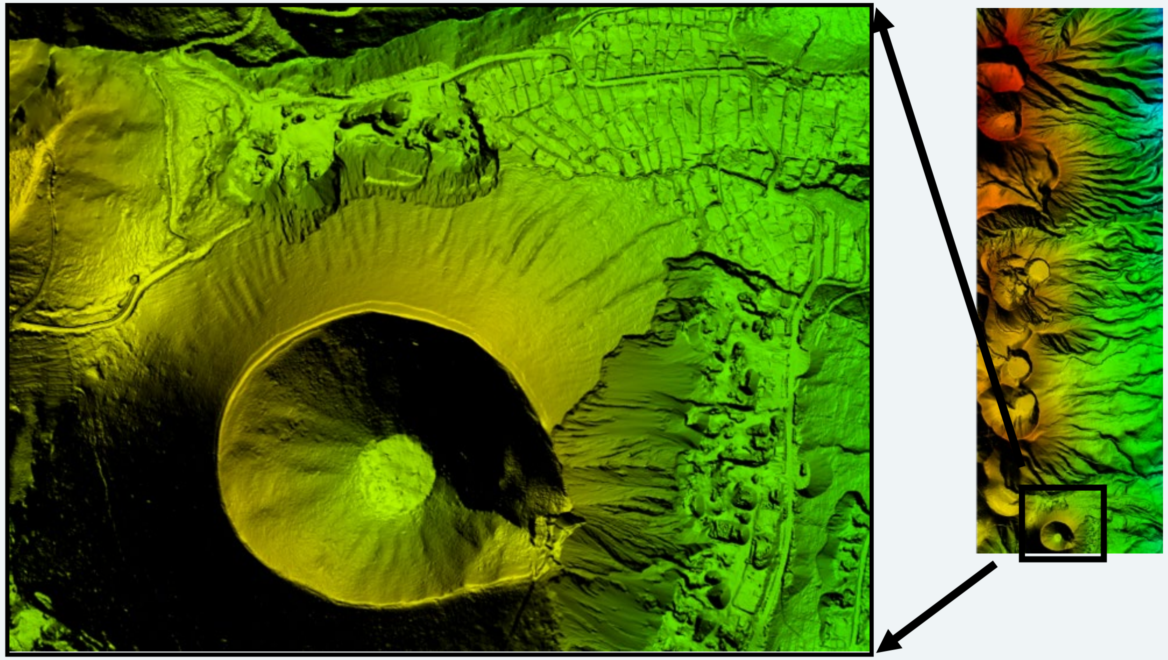
M. Reza Ramdhan et al. (in prep)

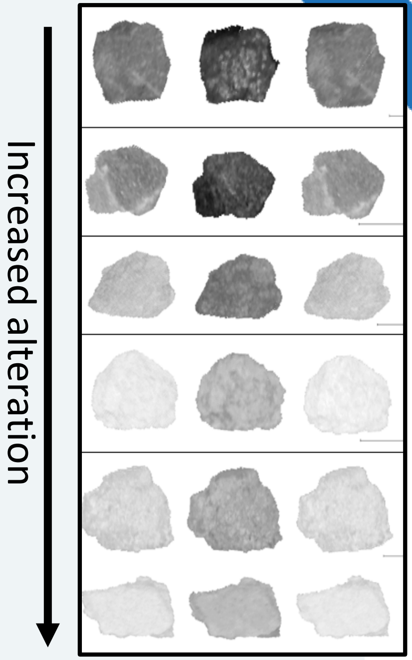
Extreme example: boiling mudpool

New discoveries: small outcrop hot ground

AIRBORNE LIDAR MAPPING

- LiDAR 3d-model:
  - structural mapping ;
  - detailed planning of infrastructure and well pads
- Latest development: mapping of alteration below canopy

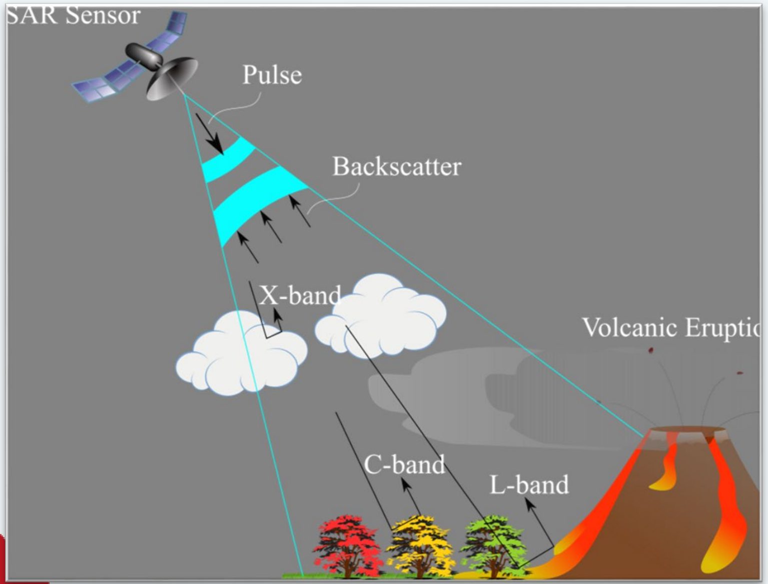




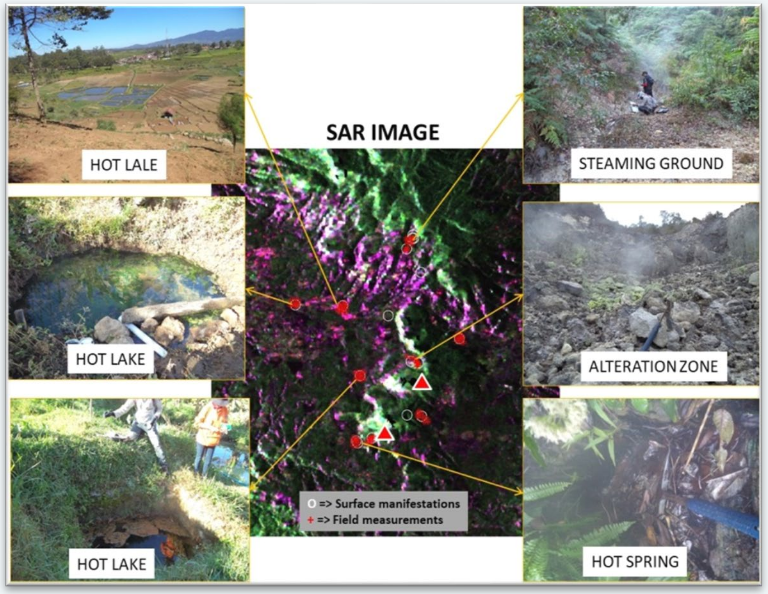
Laboratory investigation of LiDAR reflection intensity. PhD Yan Freski (in prep)

SAR REMOTE SENSING

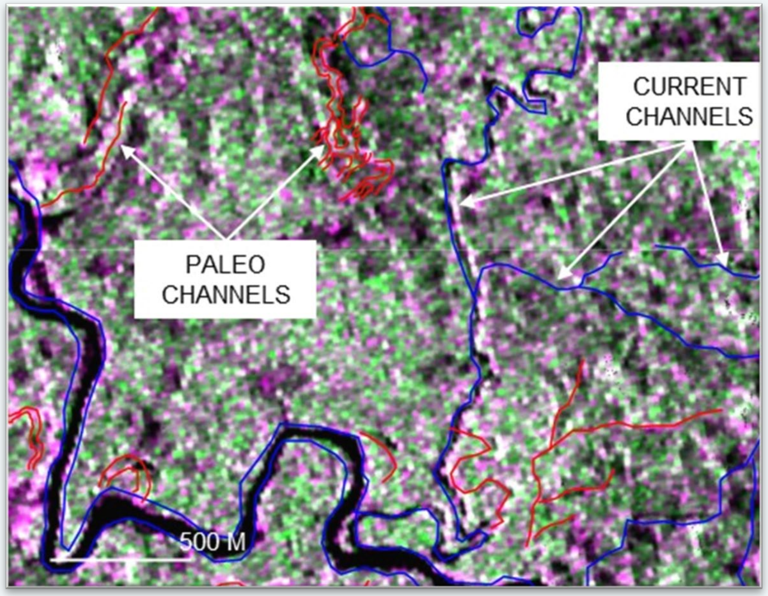
- OPERATES IN ALL SEASONS
- CLOUD-FREE IMAGES
- GEOMETRY AND REFLECTIVITY
- SUB LAYERS PENETRATION



OFF NADIR OBSERVATION OF SAR SENSOR



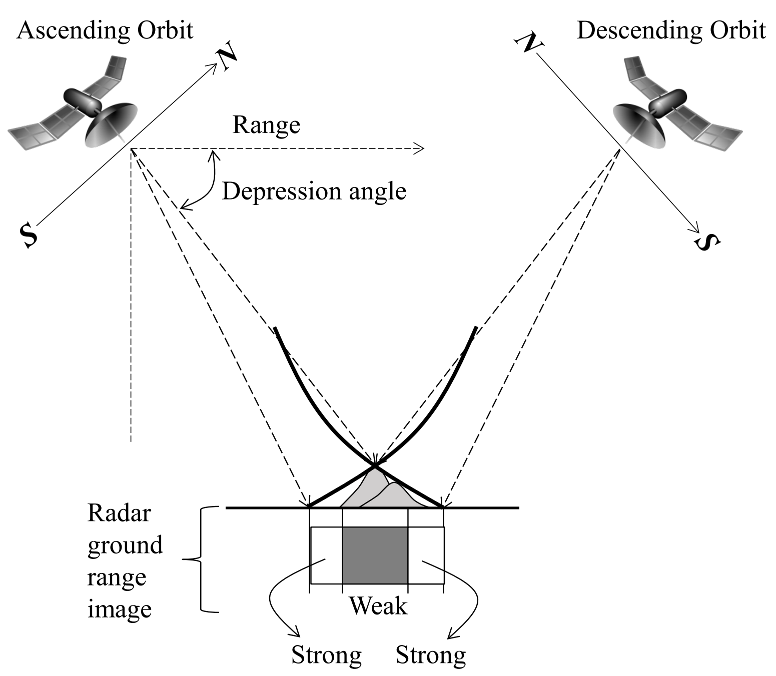
ECHOING SIGNAL OF SURFACE REFLECTIVITY

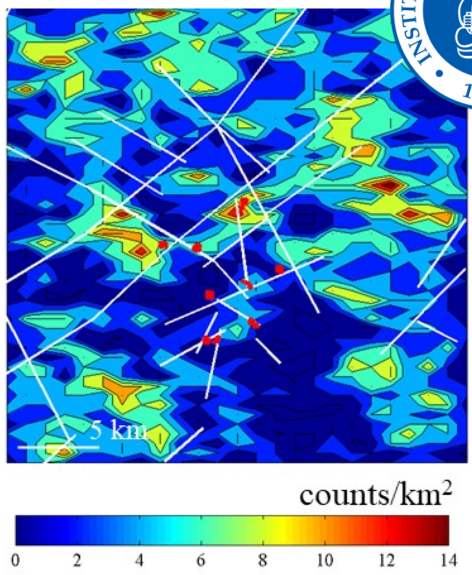


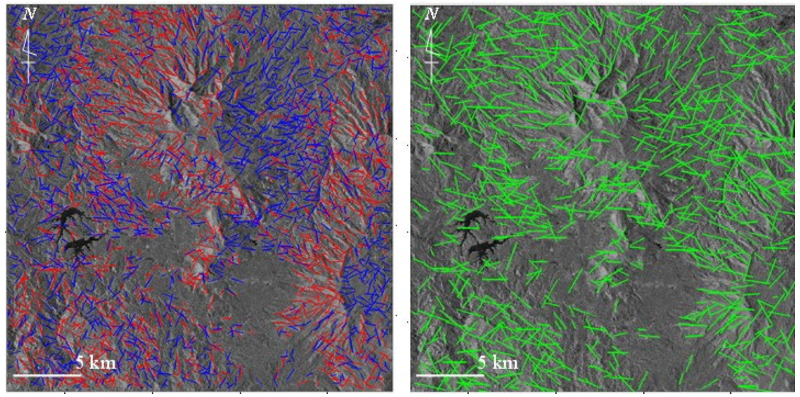
ECHOING SIGNAL OF SURFACE GEOMETRY

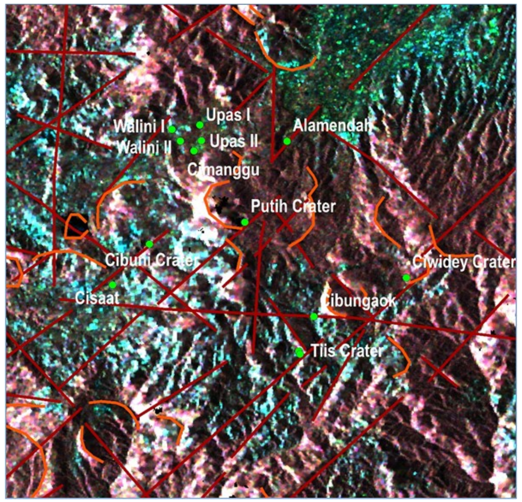
GEOLOGICAL STRUCTURES ON SAR IMAGES

- ASCENDING – DESCENDING ORBITS
- LINEAMENT RELATED STRUCTURES
- SURFACE FRACTURES PERMEABILITY
- POLARIMETRIC SAR IMAGES FOR VISUAL STRUCTURES









Geothermal Exploration Using Regional Geologic Modelling

Dr. Fred Beekman

Assistant Professor

Utrecht University

Current geothermal energy exploitation in Indonesia

Muara Laboh geothermal power plant (Sumatra)

Aerial view of Jakarta's coast line

Most geothermal power plants in Indonesia are located close to volcanoes:

$\Rightarrow$ lot of heat in the subsurface

$\Rightarrow$ relatively easy and cheap exploitation

But many Indonesian cities are situated in coastal areas, far away from the volcanoes.

And transport of energy is:

$\Rightarrow$ expensive

$\Rightarrow$ inefficient

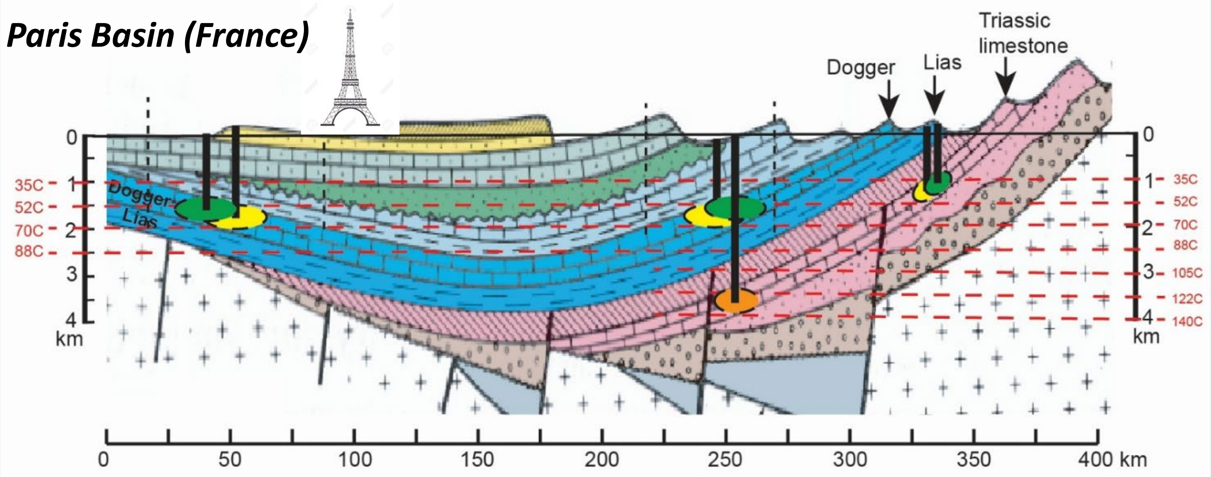
Alternative?

Exploiting geothermal heat from sedimentary basins

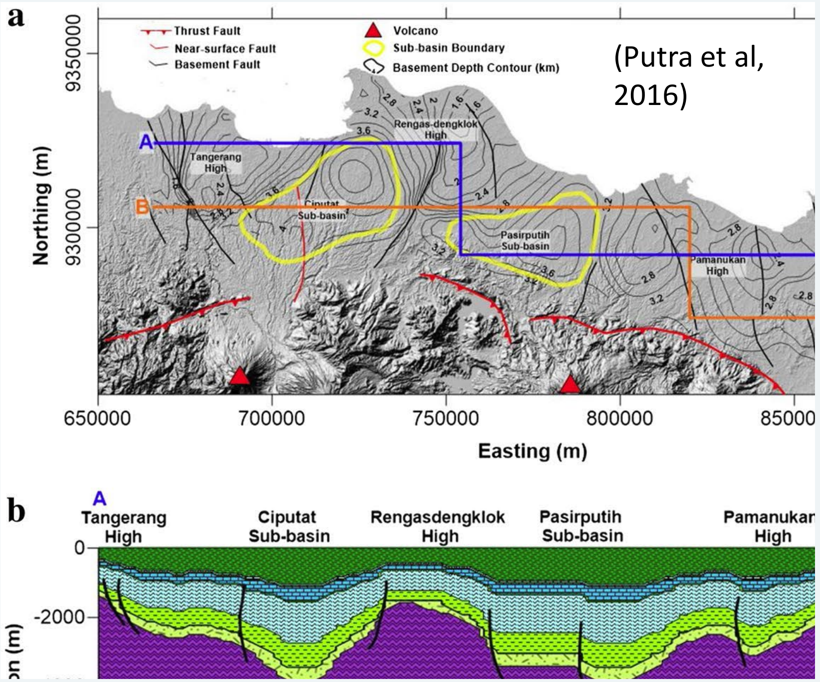
Successful examples in Europe, including:

- Netherlands: green house heating
- Germany: district heating
- France: district heating and electricity generation

Paris Basin (France)



West Java Basin



(Putra et al, 2016)

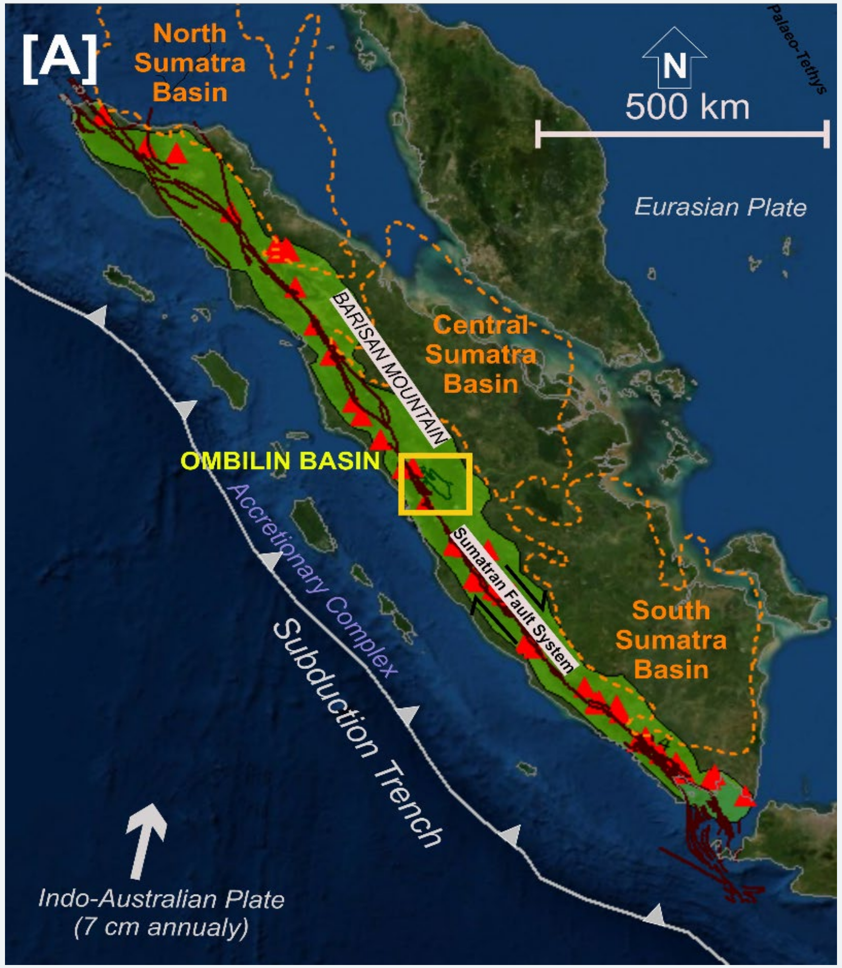
Exploring the geothermal energy potential of sedimentary basins is challenging:

- Which rocks have good reservoir properties?
- How much heat is stored?
- What is the best location to drill?

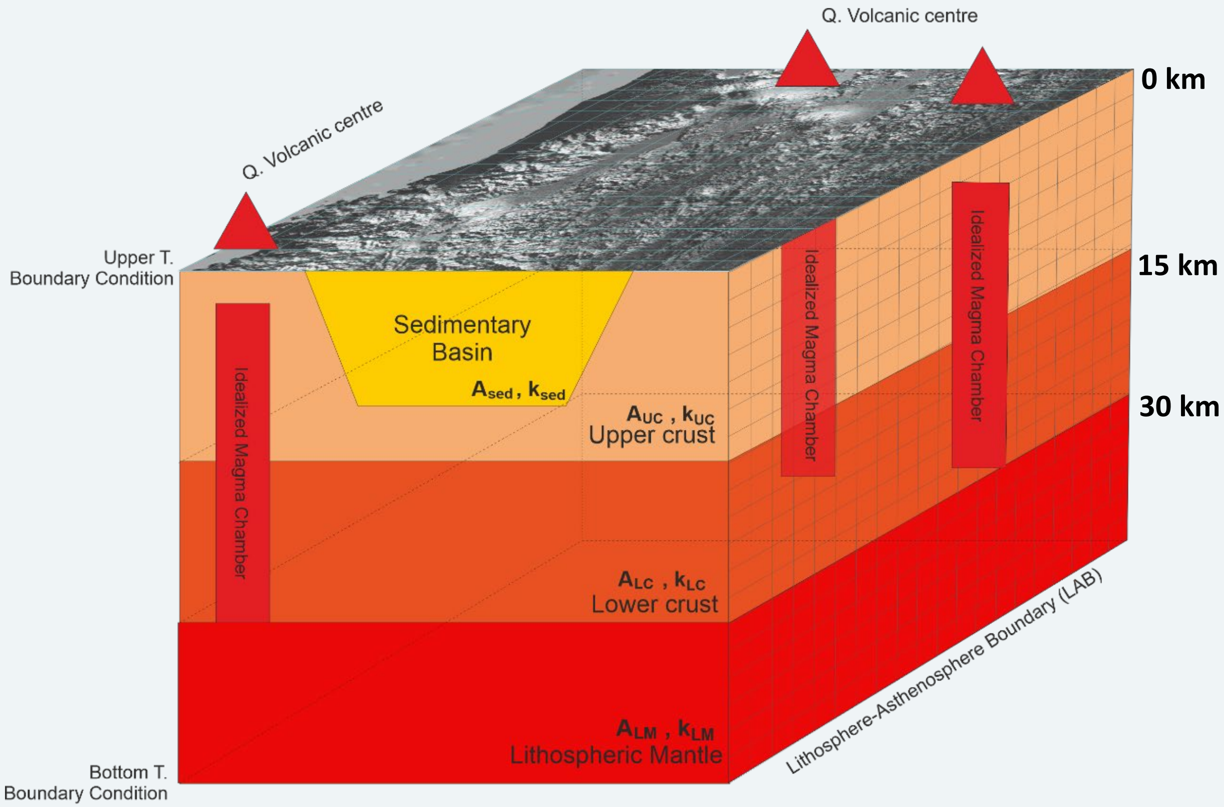
Successful exploration requires an integrated workflow, combining:

- existing knowledge and expertise
- high-quality geological data
- modern modelling methods

Geologic modelling to better understand the subsurface heat

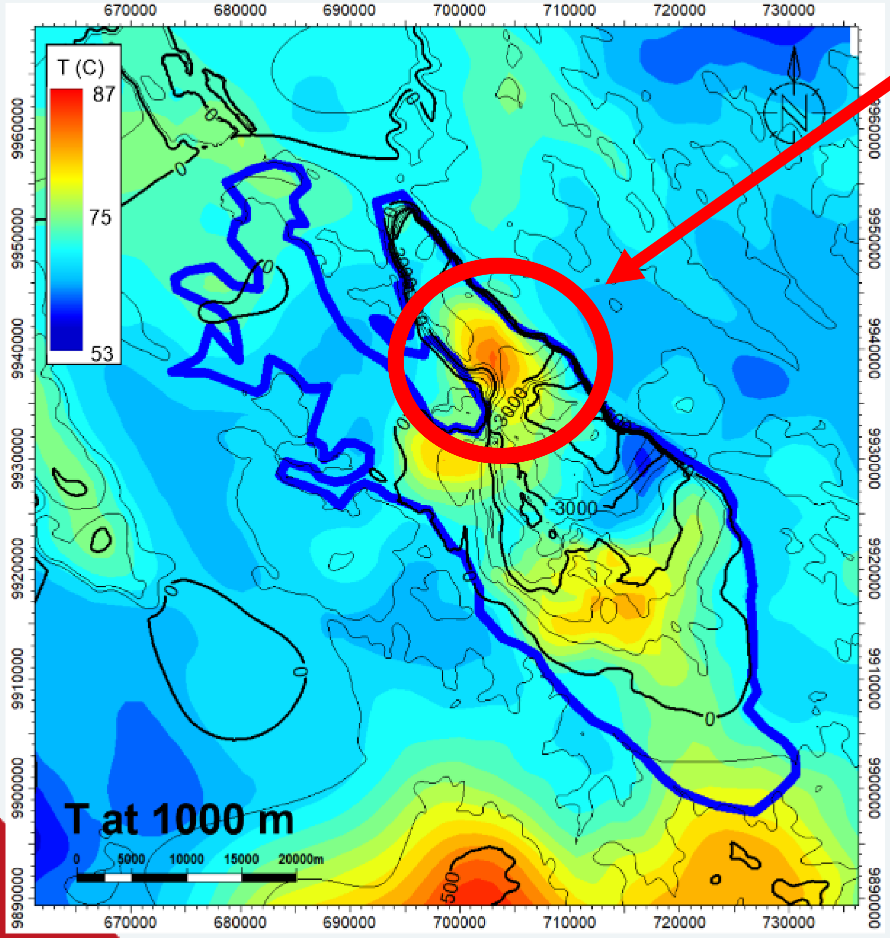


Regional 3D geological computer model of the Ombilin Basin and underlying crust (Santoso, 2020)



- Good surface data
- Very little deep data

Modelled subsurface temperature in the Ombilin Basin



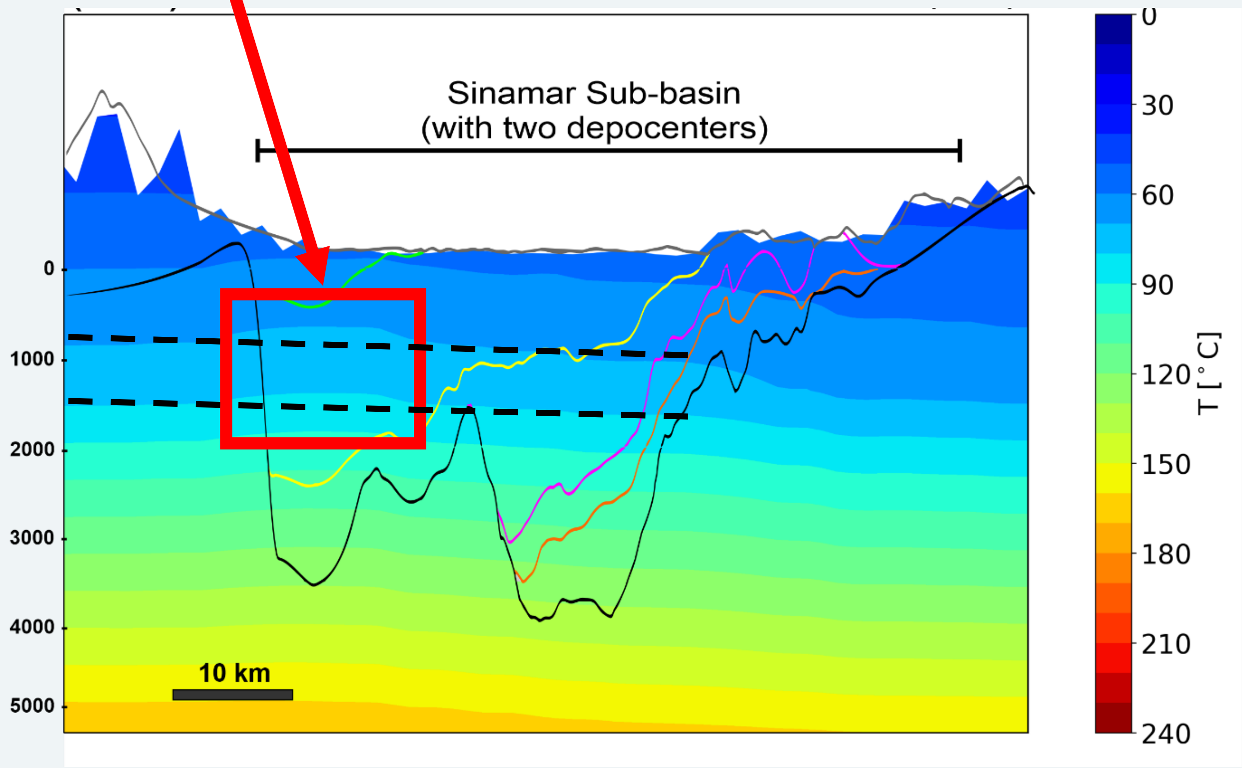
(Santoso, 2020)

The modelling results help to identify:

- where to drill best
- and how deep

optimise exploitation:

max production at lowest cost



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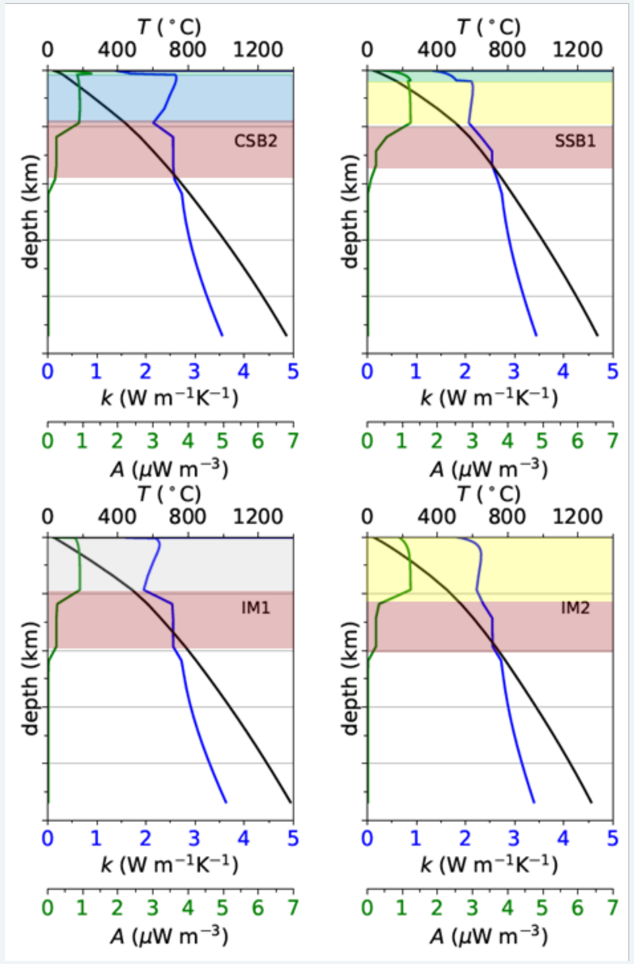
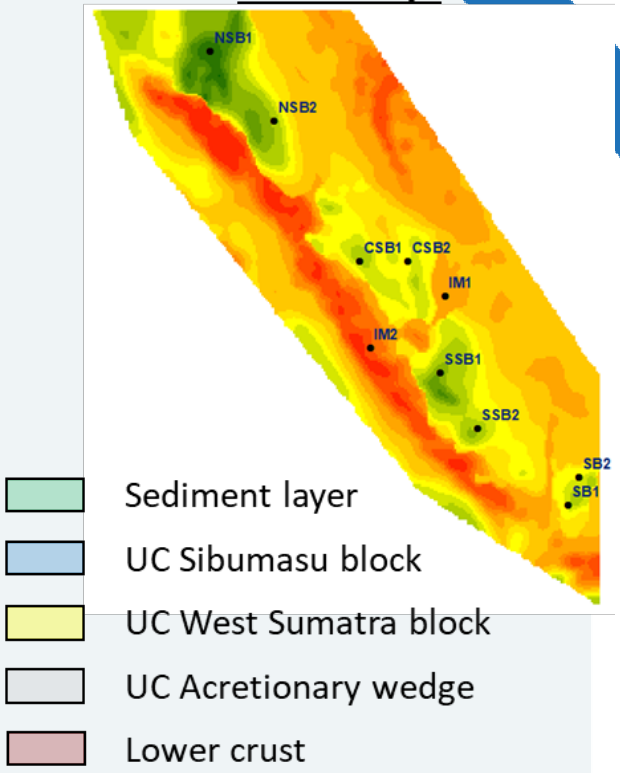
Power of geologic modelling

(Ruliansatri, 2020)

- Compute temperatures at depths where they cannot be measured.
- Complex basin geometries in 2D and 3D.
- Multiple types of rocks and fluids.
- Fast and cheap.
- Test multiple models and scenarios.



Index map:



The usefulness of modelling depends on the availability and quality of geological data!

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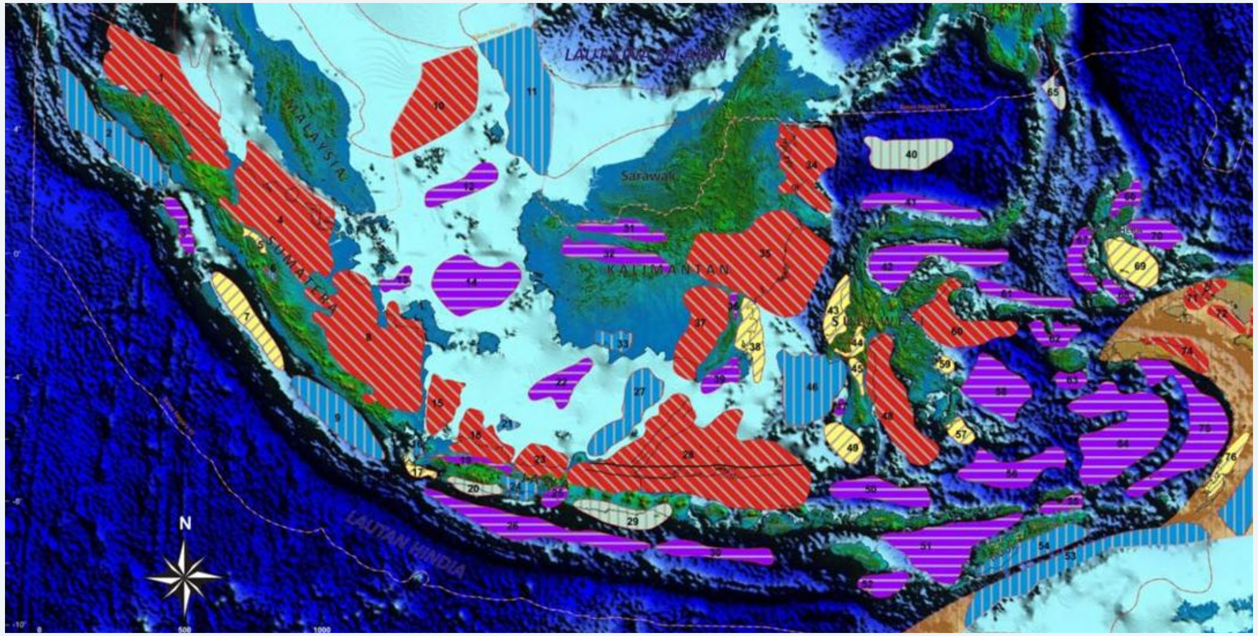
Geothermal energy in sedimentary basins in Indonesia



Main sedimentary basins in Indonesia
(BP MIGAS-IAGI, 2008)

- There are many sedimentary basins in Indonesia, which have a large potential to produce geothermal energy for the main cities.
- Exploring this potential requires an integrated approach, combining geological knowledge and modern modelling tools.
- High quality geological (sub)surface data is critical.

Geophysics: Know Your Subsurface

Dr. Yunus Daud

Head of Geothermal Research Centre

Universitas Indonesia

What Is Geophysics?

- The **non-invasive investigation** of **subsurface** conditions in the earth through **measuring, analyzing and interpreting physical fields** at the surface.

Why Using Geophysics

1) Only means to obtain deep/subsurface structure other than drilling
2) Low cost
3) Quick
4) Cover large area easily

**) No 2, 3, 4 if compared to drilling*

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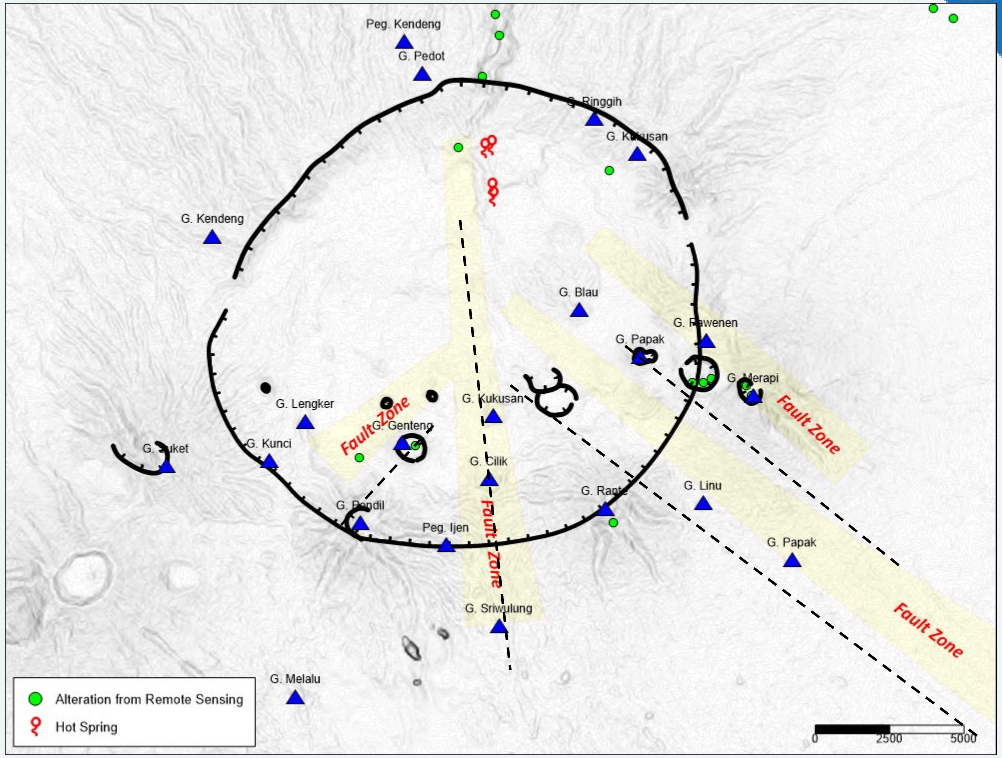
Objectives of Geophysical Exploration

1. Where is the **center of reservoir**?
2. What is the **boundary of reservoir**?
3. What is the **depth of reservoir**?
4. Can **major structural features** be identified?
5. Can **outflow structure** be recognized?
6. Are there **shallow/deeper structure**?
6. Where to locate **best drilling locations**?



Geophysical Methods:

MT/TDEM, Gravity, Magnetic, MEQ & ANT

Geophysical Data Workflow

Raw Data

MT Data

Gravity Data

Magnetic

MEQ/ANT Data

Advanced Processing

MT

- Time-series Analysis
- Crosspower Selection
- Static-shift Correction
- 1D, 2D, 3D Modeling/Inversion

Gravity/MAgnetic

- Gravity/Reduction Reduction
- Regional-Residual Separation
- 2D/3D Modeling/Inversion

MEQ/ANT

- Picking P-wave & S-wave
- Hypocenter Determination
- Visualization (map or 3D model) of Hypocenter

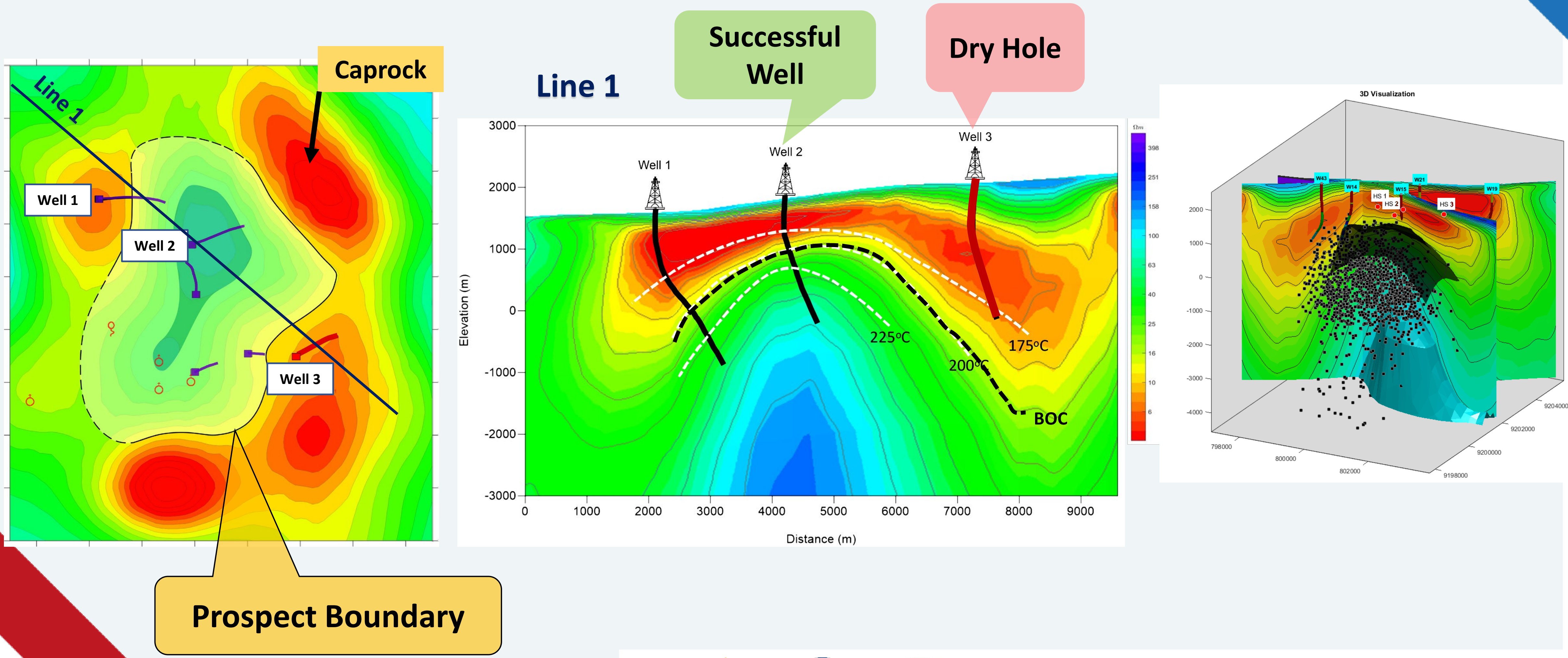
Geophys. Assessment

- Conductive Clay Cap
- Boundary of Reservoir
- Top of Reservoir
- Analysis of Geological Structure and fracture/permeable zone
- Geophysical Model

+ Geology
+ Geochemistry

Resource Assessment & Well Targeting

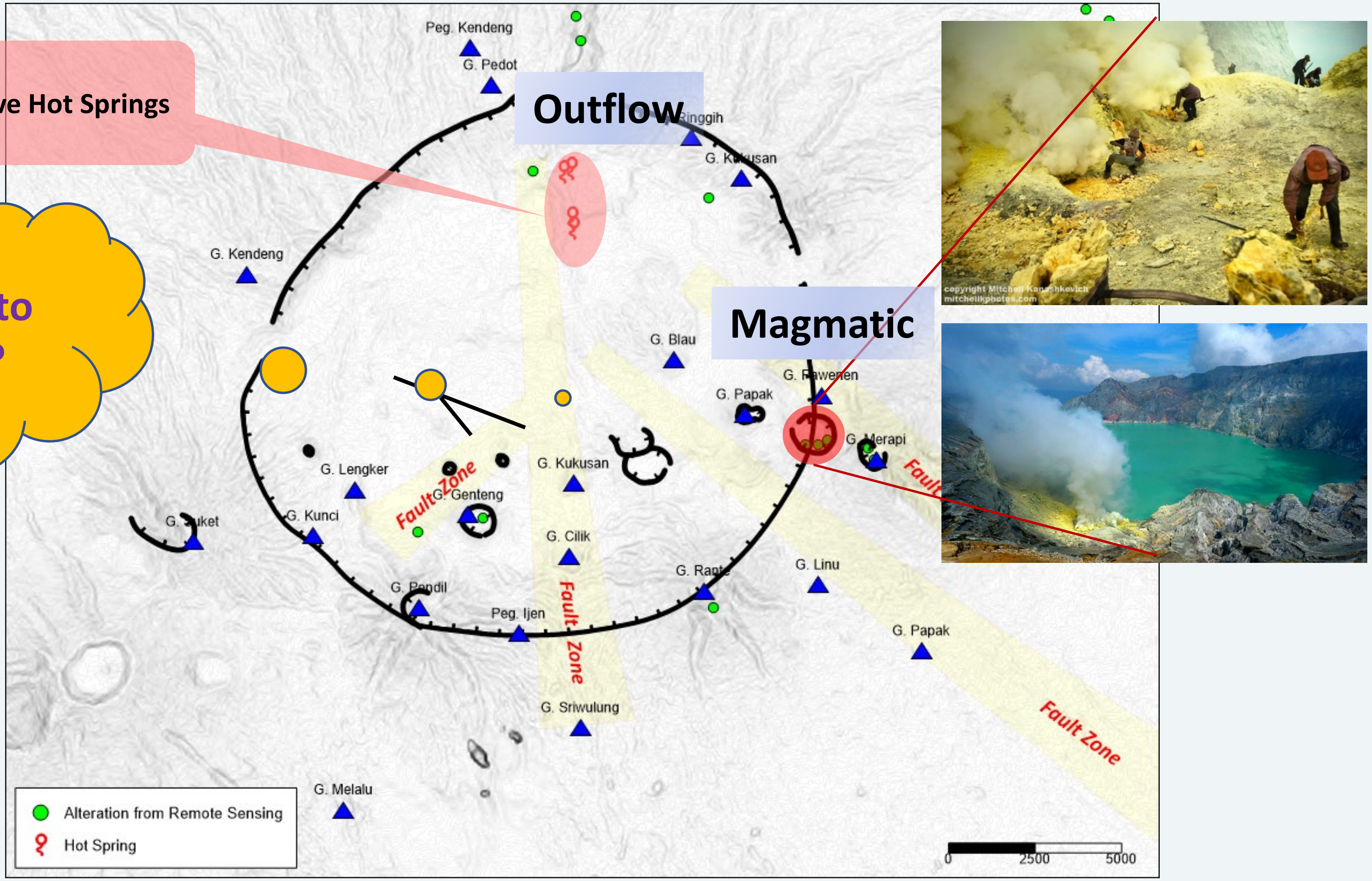
Example #1: 3D MT & MEQ Data for Delineating Reservoir Boundary and Geometry



Example #2: 3D MT for Delineating Hidden Geothermal Reservoir

Unimpressive Hot Springs

Where to Drill??

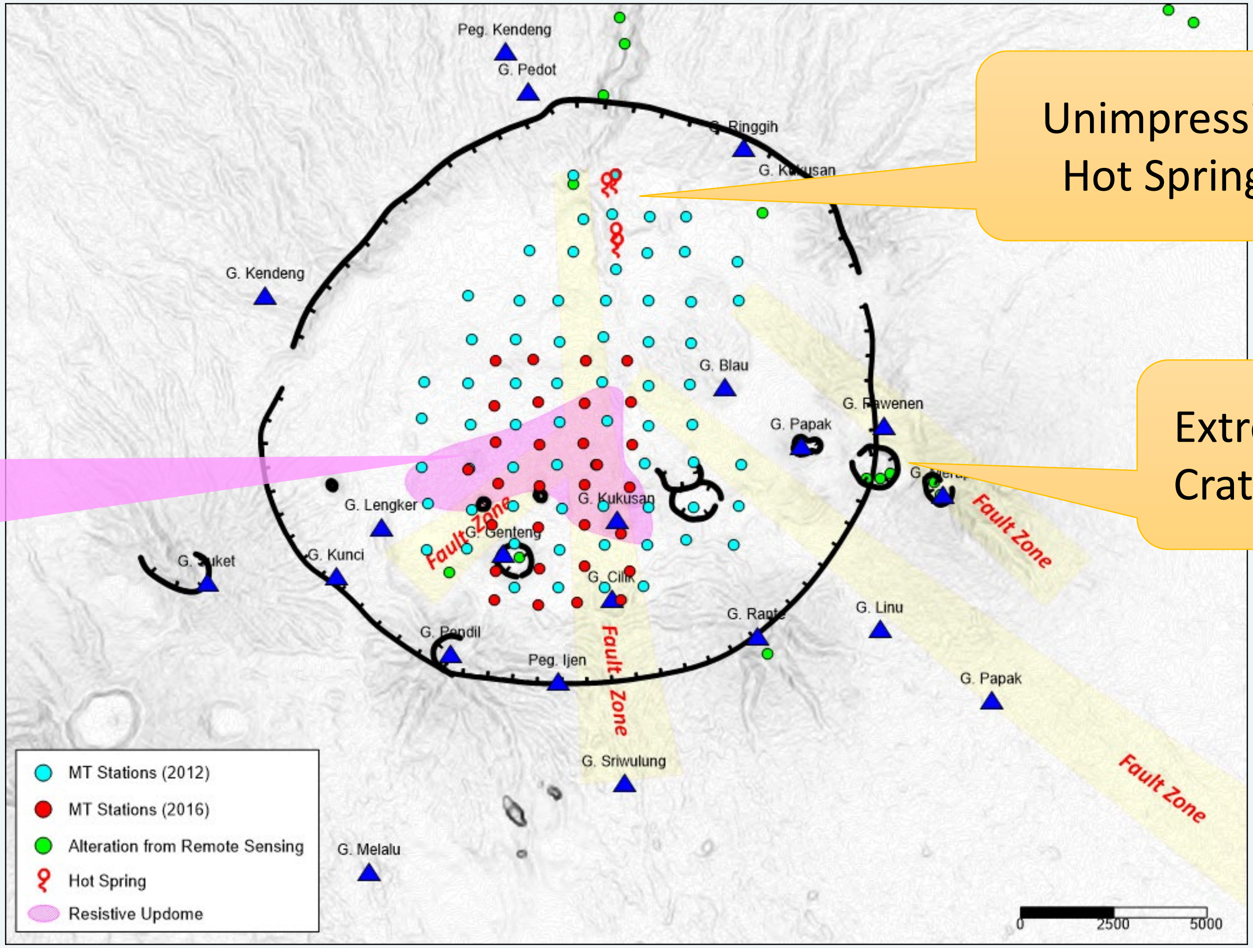


Best Drilling Target:

- High Temperature
- High Permeability
- Neutral Fluid

Example #2: 3D MT for Delineating Hidden Geothermal Reservoir

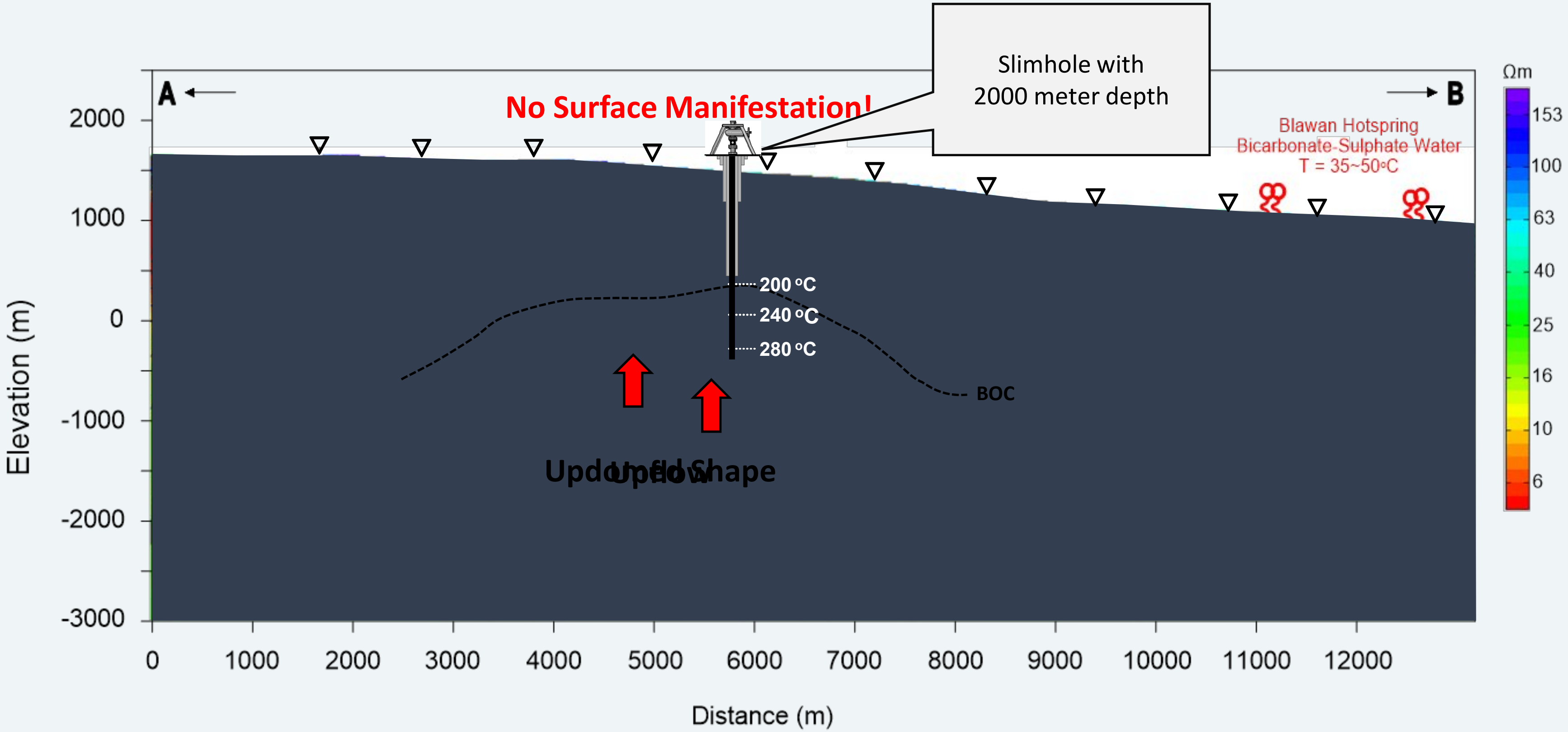
Area of Well Targeting



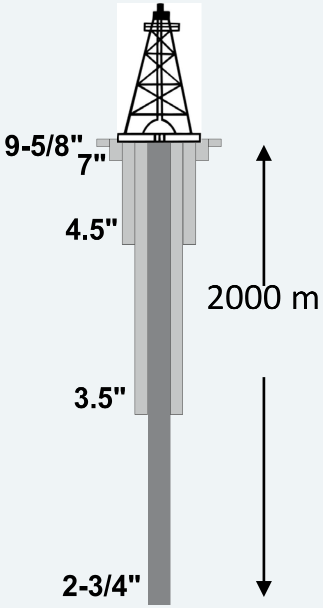
Unimpressive Hot Springs

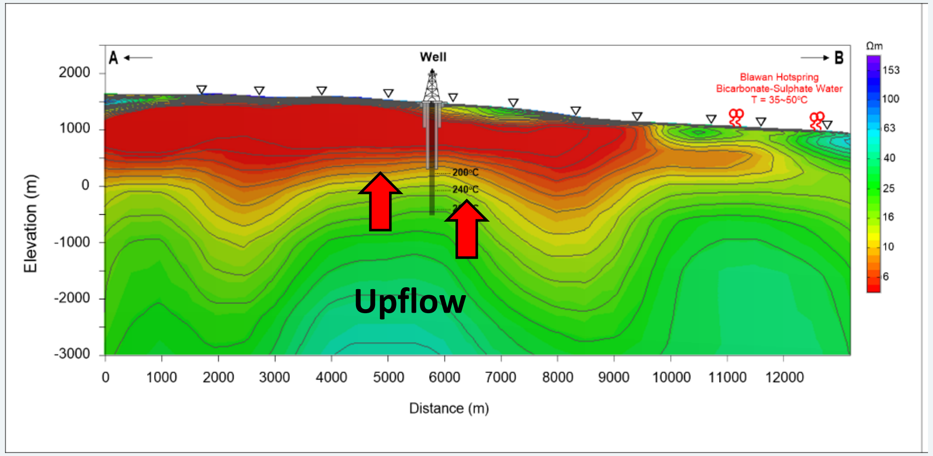
Extremely Acidic Crater (pH < 0.3)

Example #2: 3D MT for Delineating Hidden Geothermal Reservoir



Example #2: 3D MT for Delineating Hidden Geothermal Reservoir





Drilling Results:

- Total Depth (TD) = 2000 meter
- Temperature @TD = 280 ^{o}C
- Neutral Fluid

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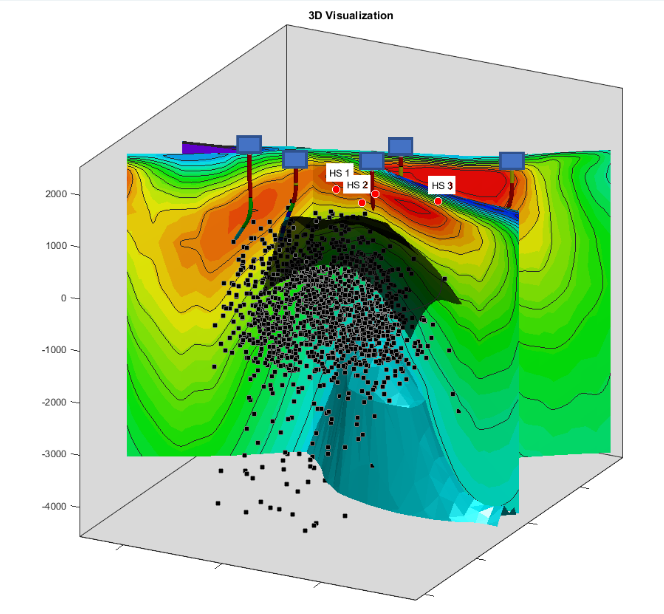
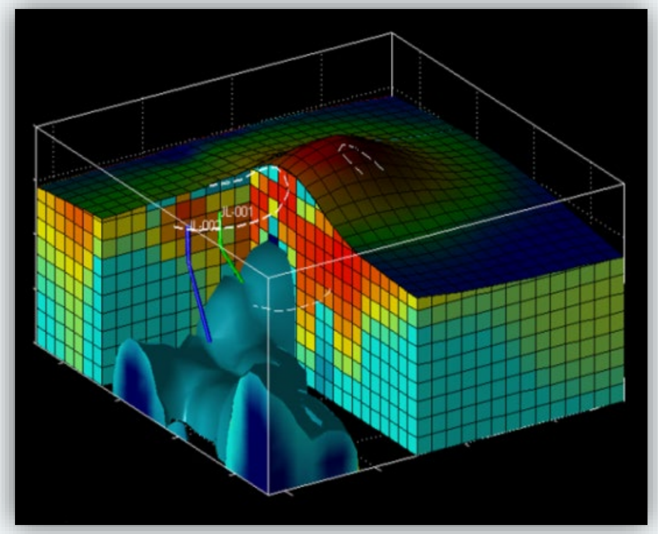
Digital WINNER-Conference 24-26 November 2020

THANK YOU

Geophysics: Know Your Subsurface





Contact: Dr. Yunus Daud (ydaud@sci.ui.ac.id)

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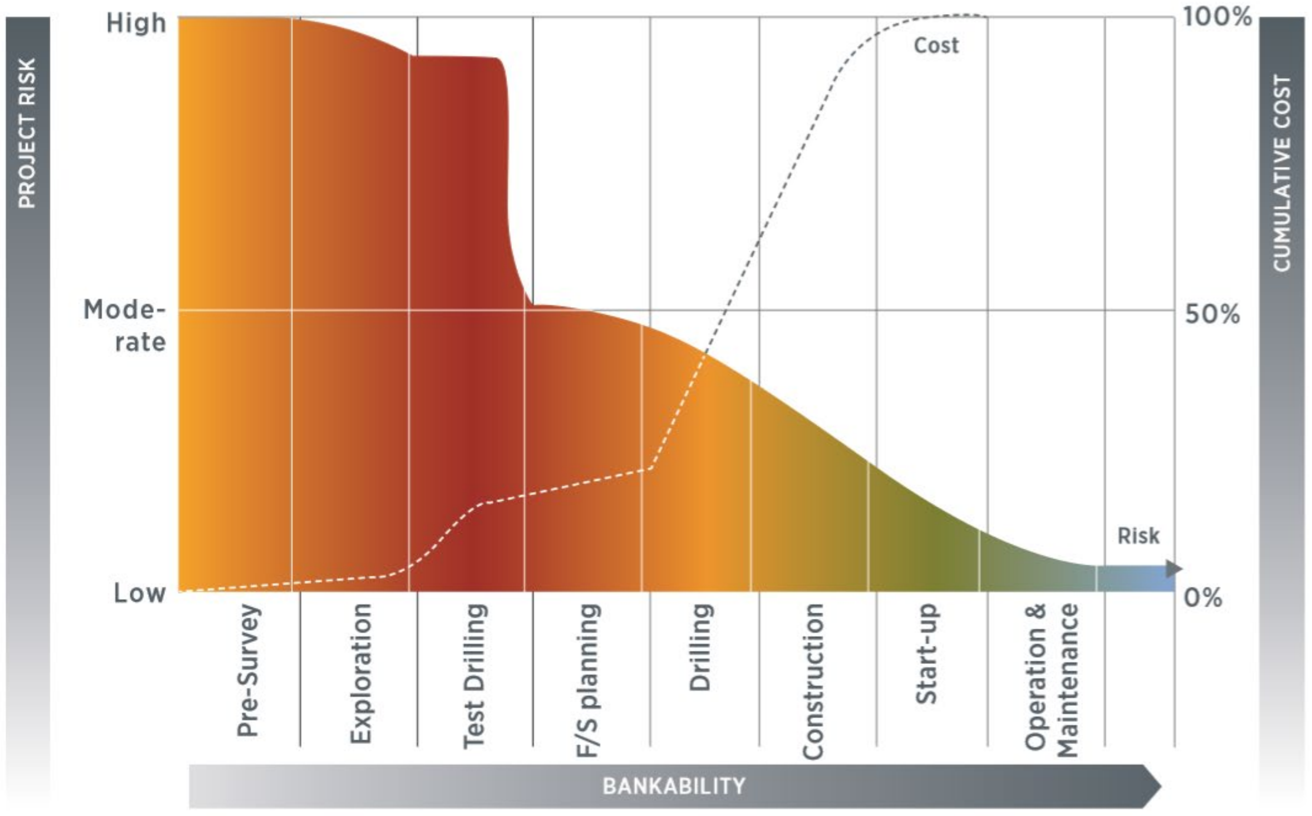
De-risking exploration by integrating exploration knowhow-

Prof. Dr. Jan-Diederik van Wees

TNO principal scientist & Professor at Utrecht University

DE-RISKING EXPLORATION

- Progressive reduction of project risk
- progressive more investement



Source: Gehringer and Loksha, 2012

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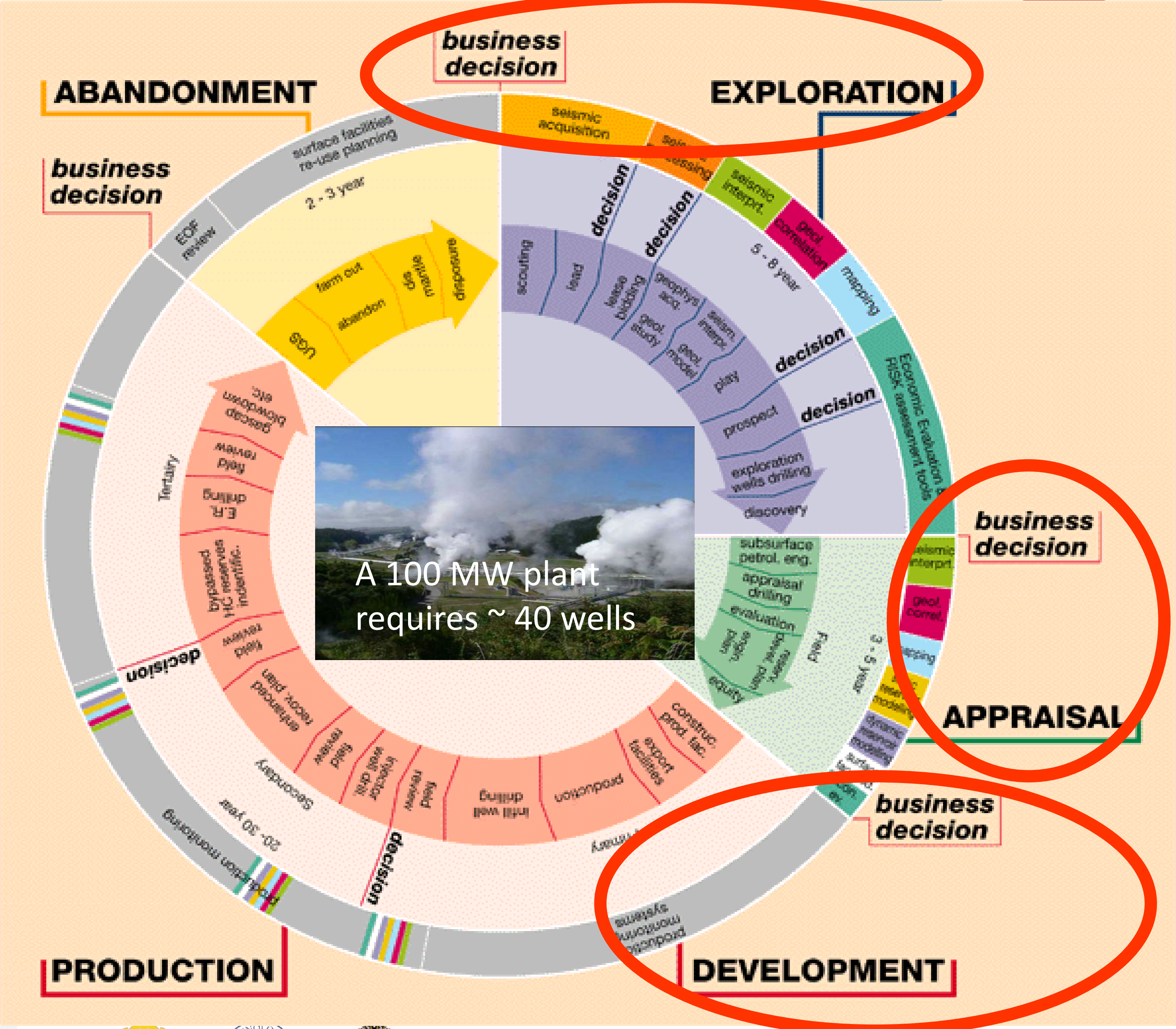
Geothermal Asset Lifecycle

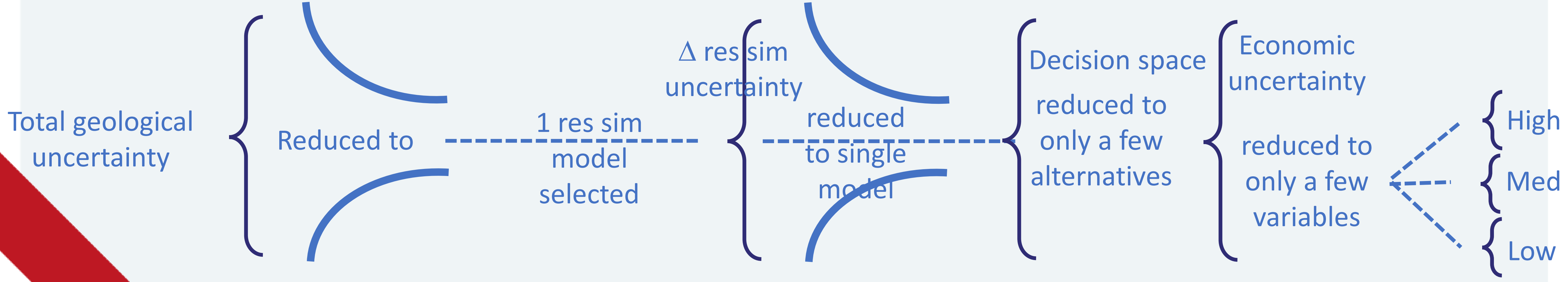
- 5 main phases
  - + 6th: Monitoring
- Many major decisions:
  - Inter-phase
- And minor decisions:
  - Intra-phase



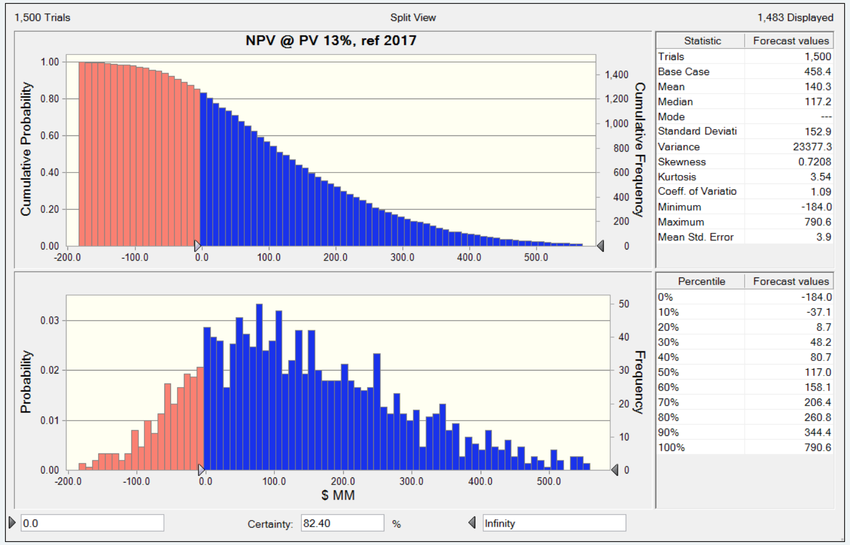
Modelling practice in Geothermal often observed

"Brick wall" approach: much information is being lost, dependencies are being lost:

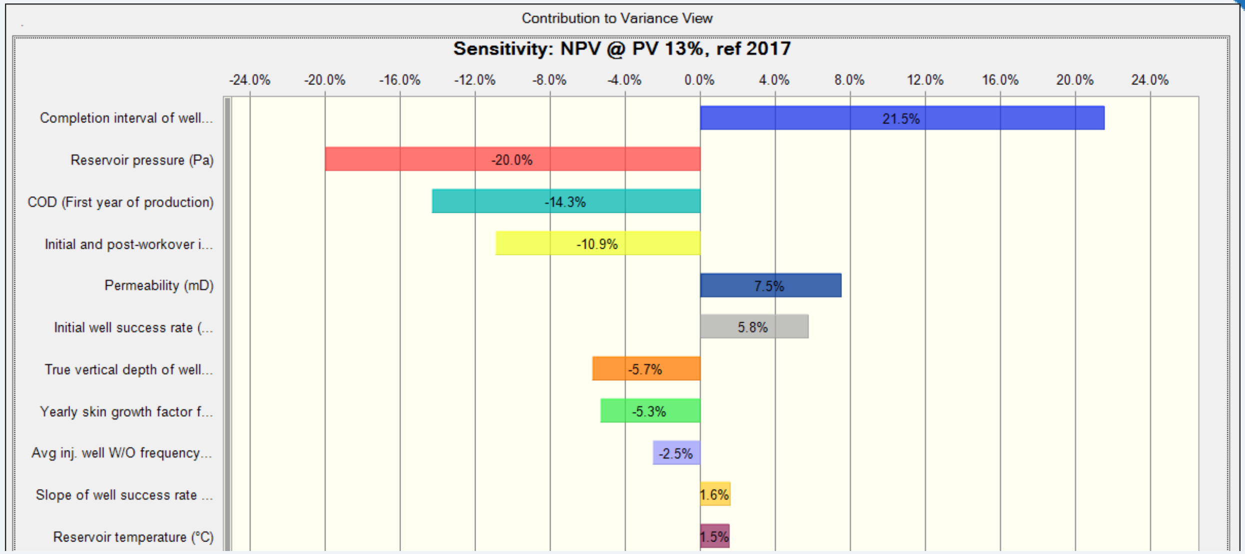
1. Following an exploration discovery and after a few wells have been drilled, geologists, based on limited (geophysical + well) and analogue information, construct a few deterministic representations / maps of the reservoir parameters (depth, faults, por/perm etc.)
2. Reservoir engineers pick a "most likely case", and construct a deterministic 3D reservoir simulation flow model. Assuming a Plan for Development & Operation (installations, # wells, etc.) they make a deterministic production forecast.
3. This forecast is used by economists to assess NPV, IRR, break-even tariffs etc.

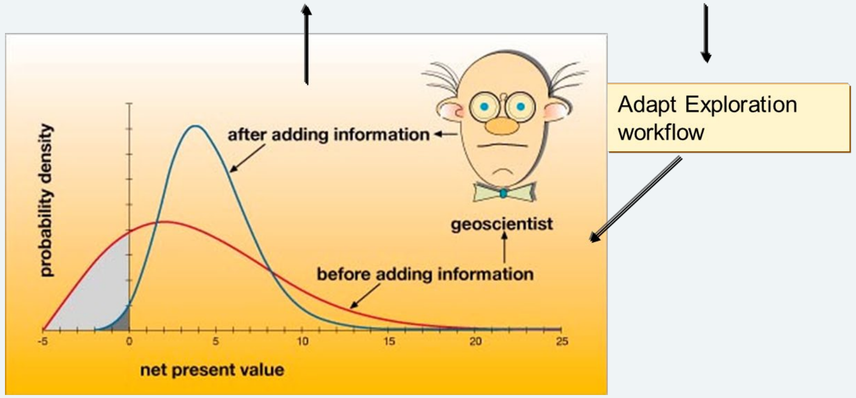


STEER EXPLORATION WORKFLOW BY VALUE OF INFORMATION

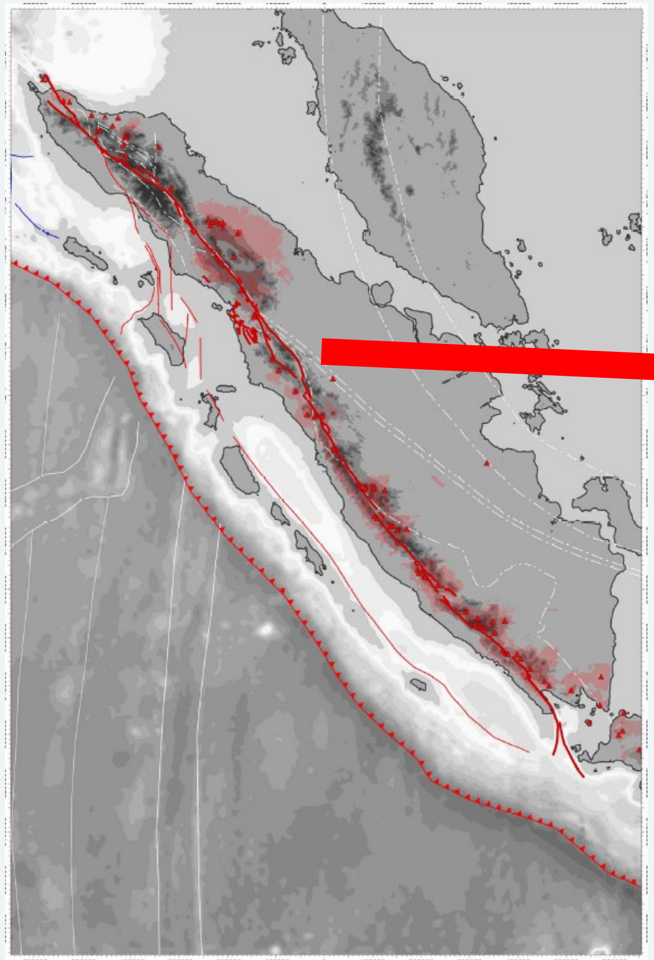


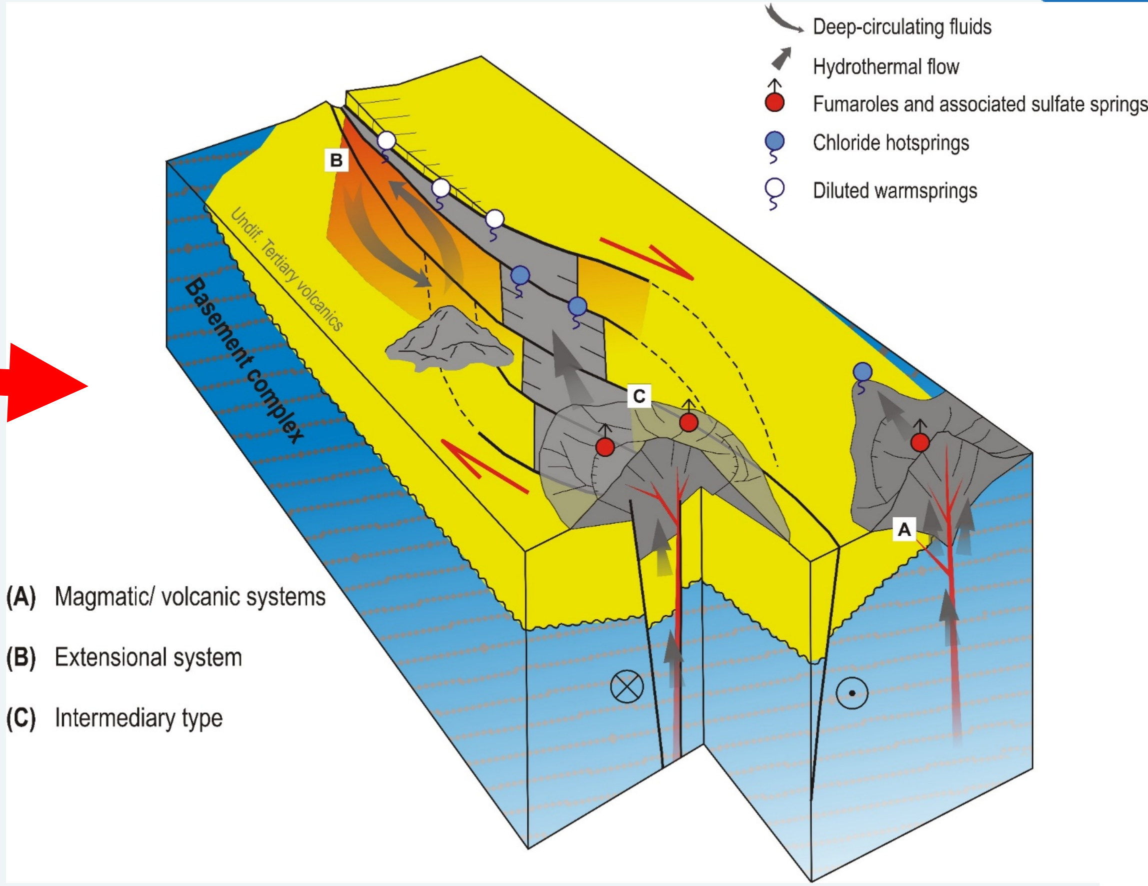
Geocap XL tool for GT assets





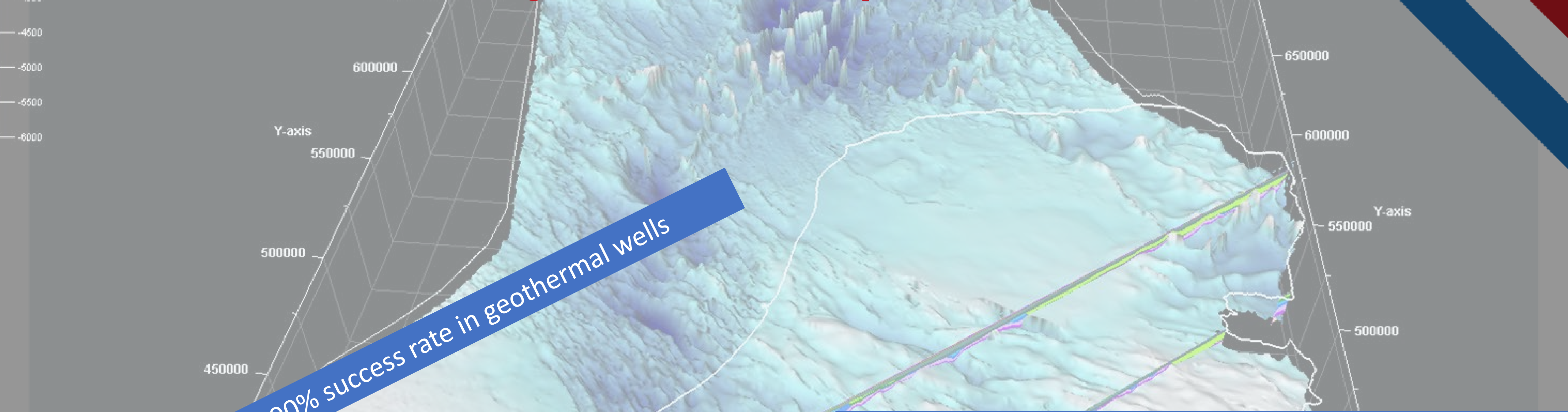
Understanding fault controls and well success-rate





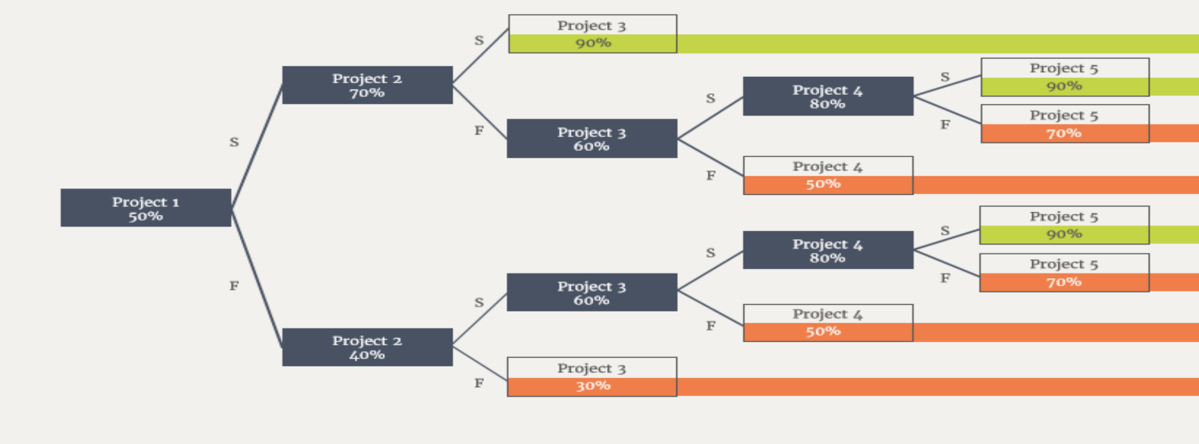
Geocap PhD L. Sutrisno (2019)

Government funded geothermal exploration & data base



IMPACT: 90% success rate in geothermal wells

exploration campaigns: play based portfolio approach



Thank you

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