Role of a Geoscientist

The Geothermal Institute
University of Auckland

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GEOTHERMAL INSTITUTE

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Presentation outline

Role of a geoscientist in geothermal
exploration
development
production

Role of geologist
geophyscist
geochemist

Geothermal Energy Development involves geoscientists and is multi-disciplinary

Geology
Geochemistry
Geophysics

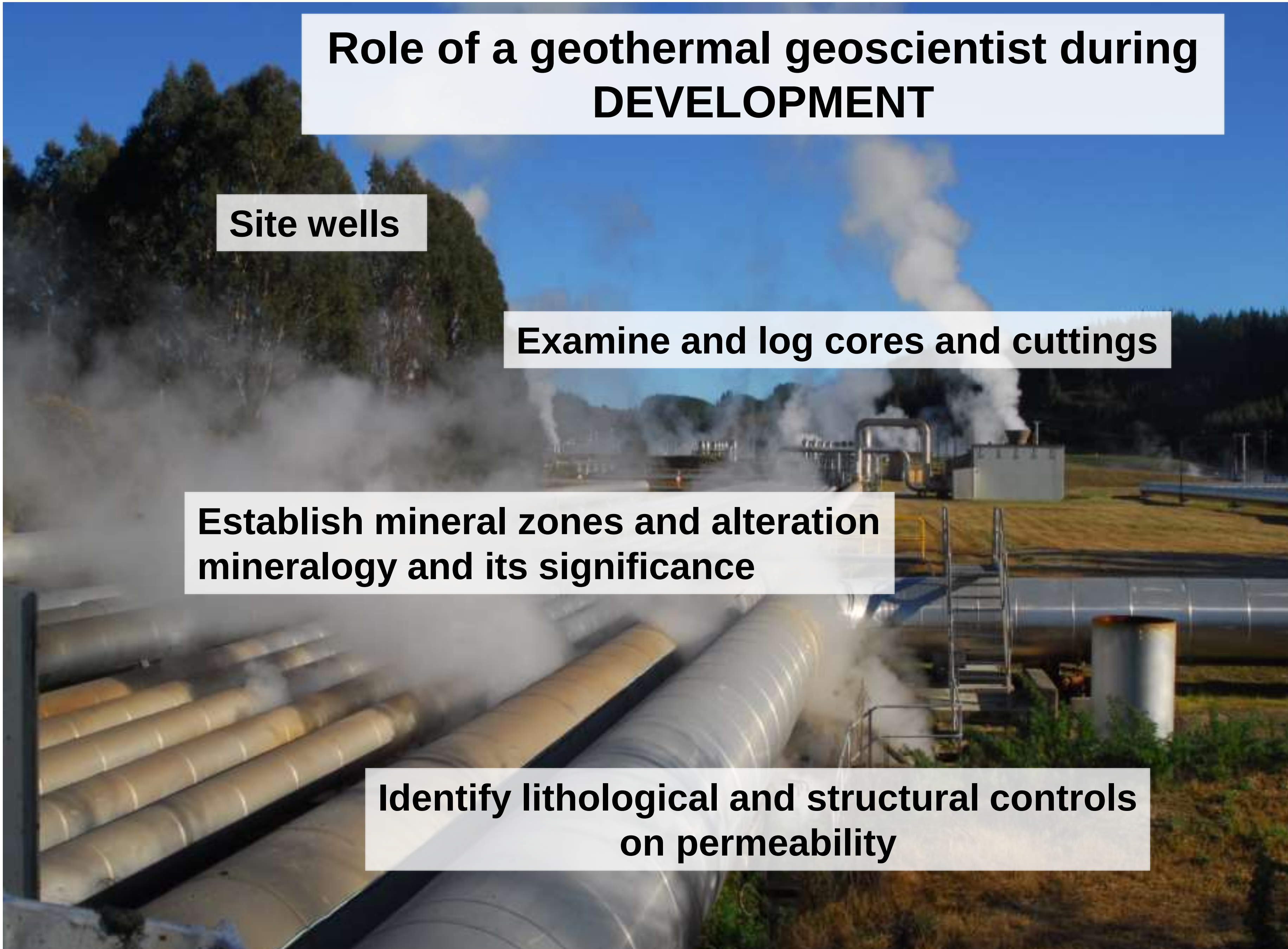
Geoscientist has a role at the **Exploration Phase**

Geoscientist has a role during **Development**

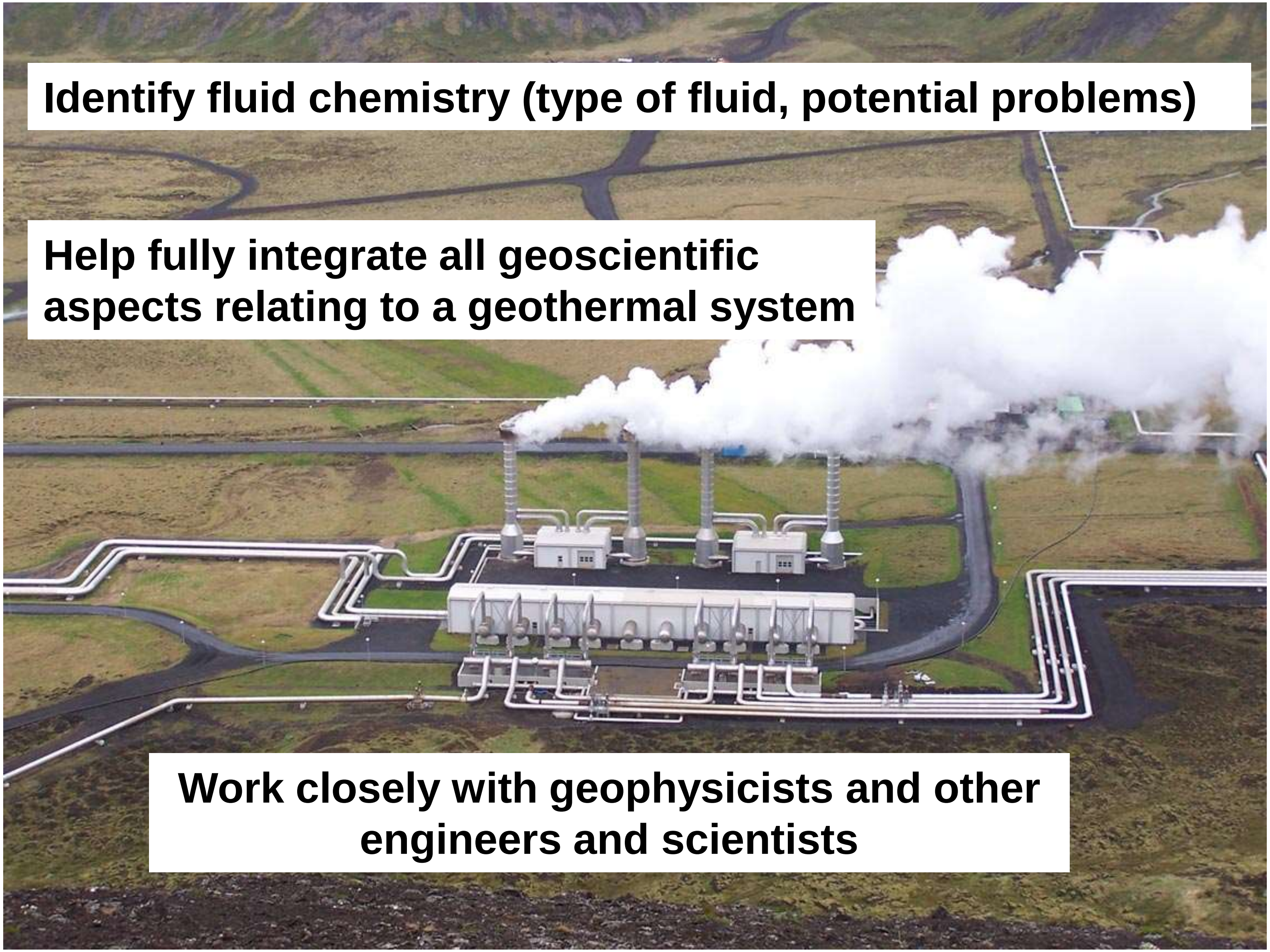
Geoscientist has a role during **Production**

Role of a geothermal geoscientist during EXPLORATION

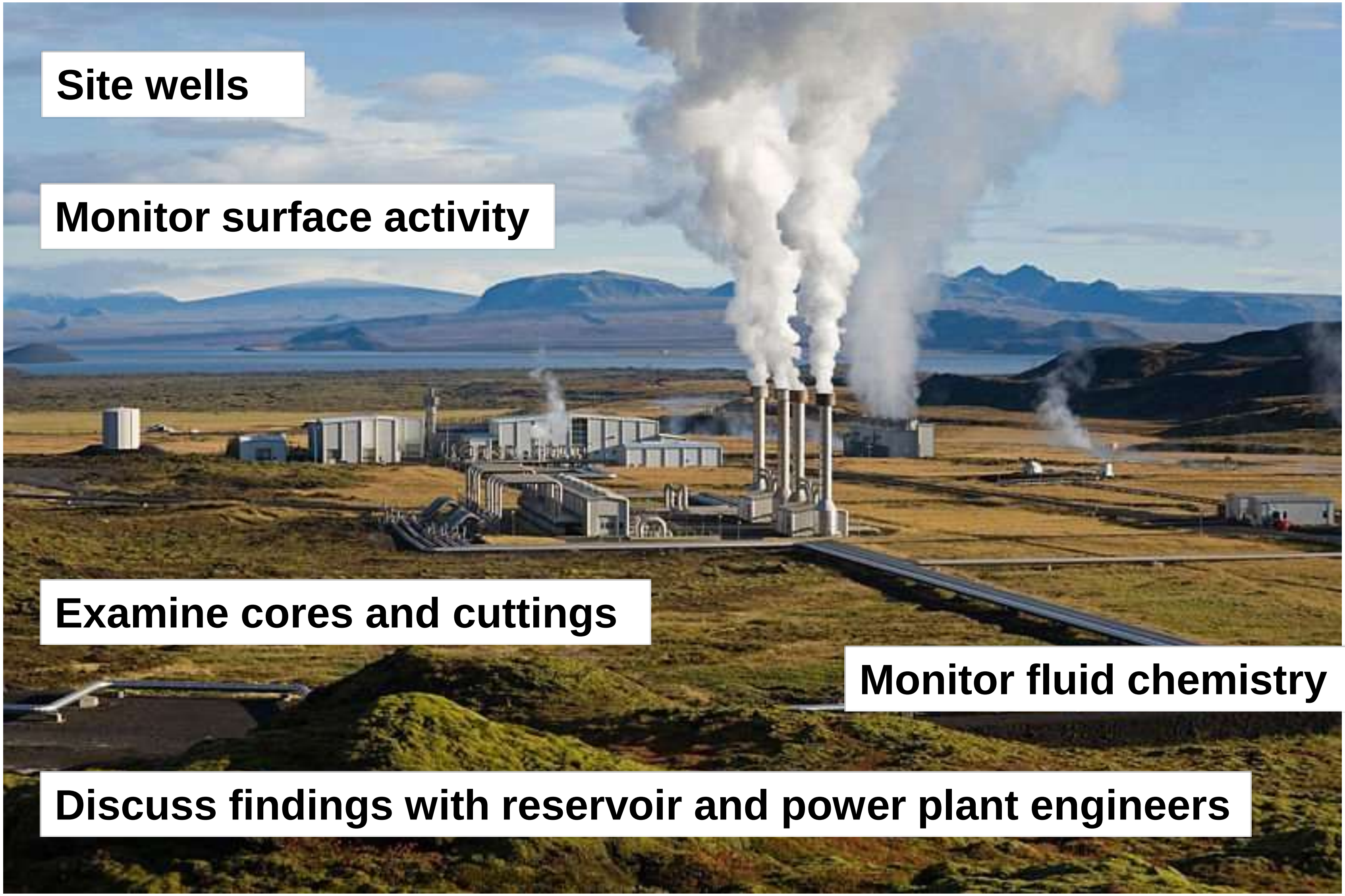
- Literature Review
- Map geology, surface activity, hydrological characteristics
- Sample and characterise thermal features
- Map surface alteration
- Determine equilibration temperatures

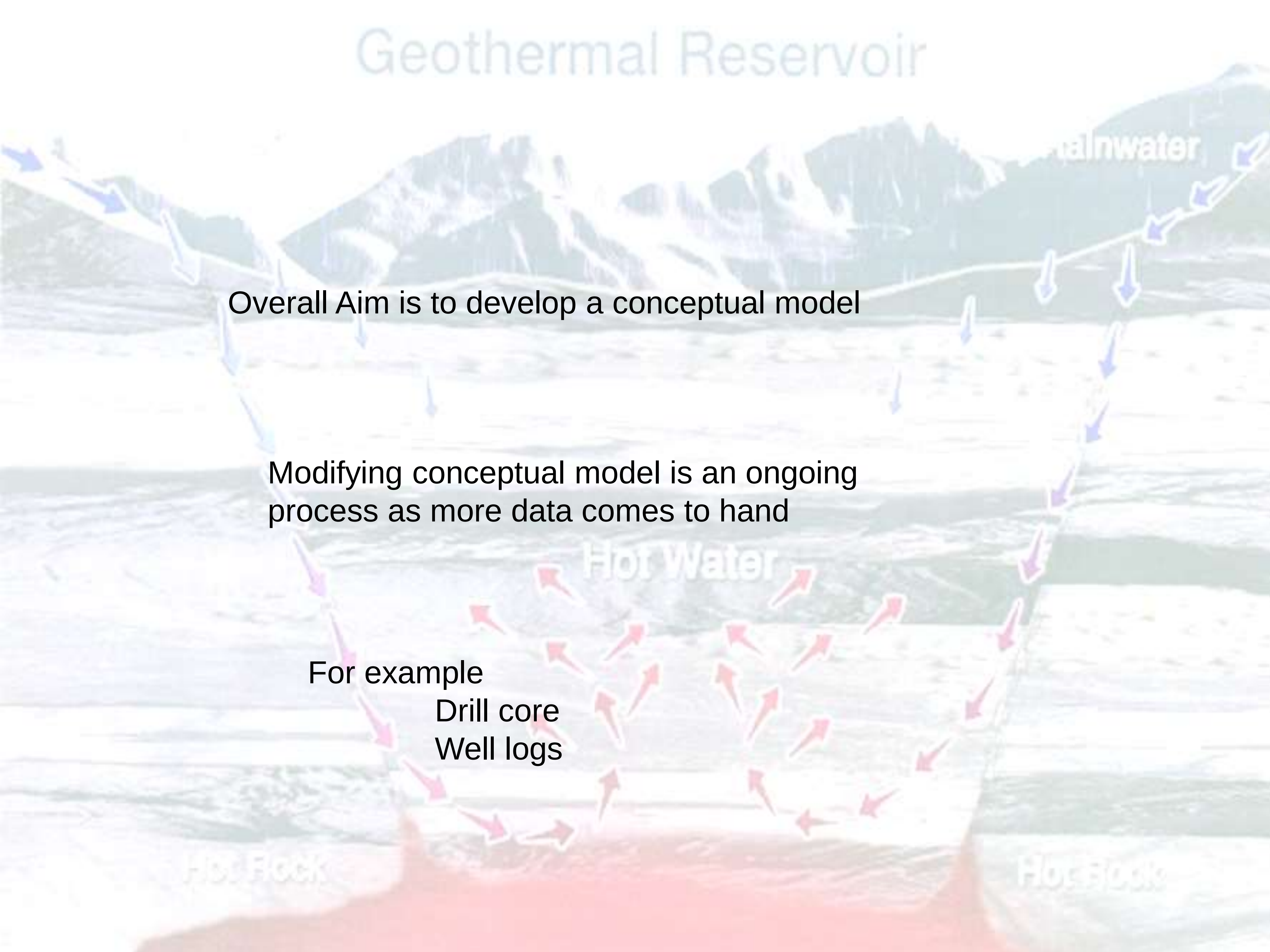

Role of a geothermal geoscientist during DEVELOPMENT
Site wells
Examine and log cores and cuttings
Establish mineral zones and alteration mineralogy and its significance
Identify lithological and structural controls on permeability

Role of a geothermal geoscientist during DEVELOPMENT



Role of a geothermal geoscientist during PRODUCTION





Overall Aim is to develop a conceptual model

Modifying conceptual model is an ongoing process as more data comes to hand

For example
- Drill core
- Well logs

Role of a geologist

Let's look at the tasks of a **geologist**

Map geology and surface manifestations
(hot springs, fumaroles etc)

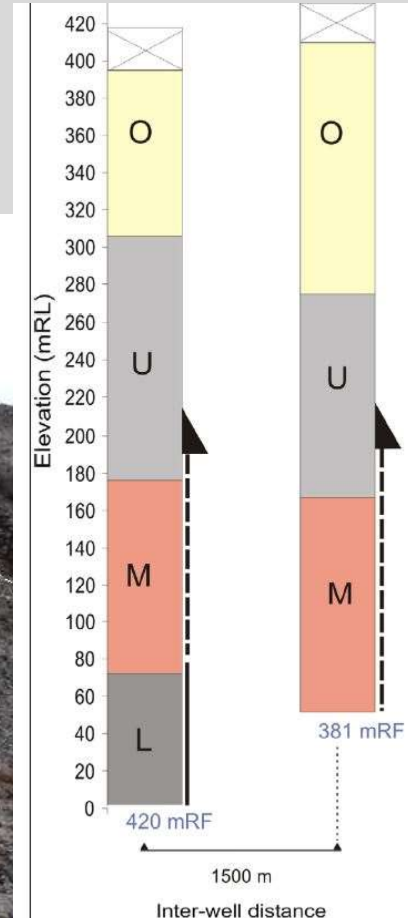
Map surface features

- water temperature
- flow rate
- feature size
- analyse water chemistry
- measure velocity of steam from fumaroles

- **Determines hydrology**
- **Heat & mass flow**
- **Provides pre-exploration data base**
- **Determines fluid chemistry etc**

Another task of a **geologist**

Stratigraphy



Determine lithologic vs structural controls

We need permeable rocks

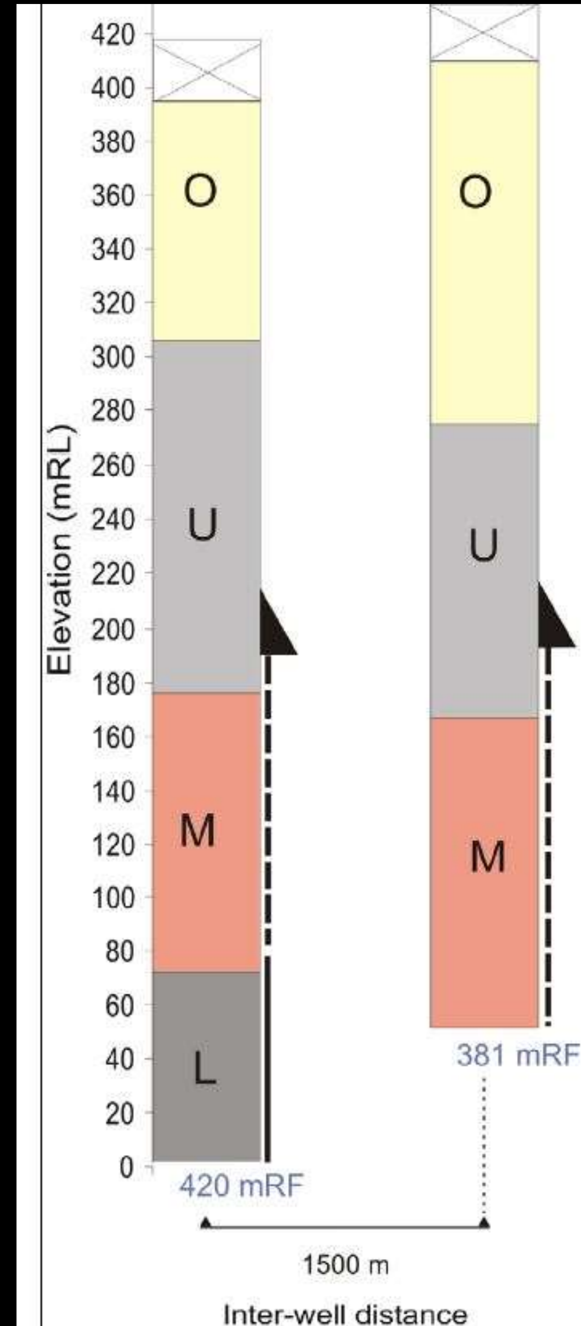
Surface rocks tell us what we can expect in the subsurface

Impermeable rocks are not good host rocks for geothermal energy as they can’t move fluid

Look for evidence of fractures and fluid flow
Can the rock hold a fracture?

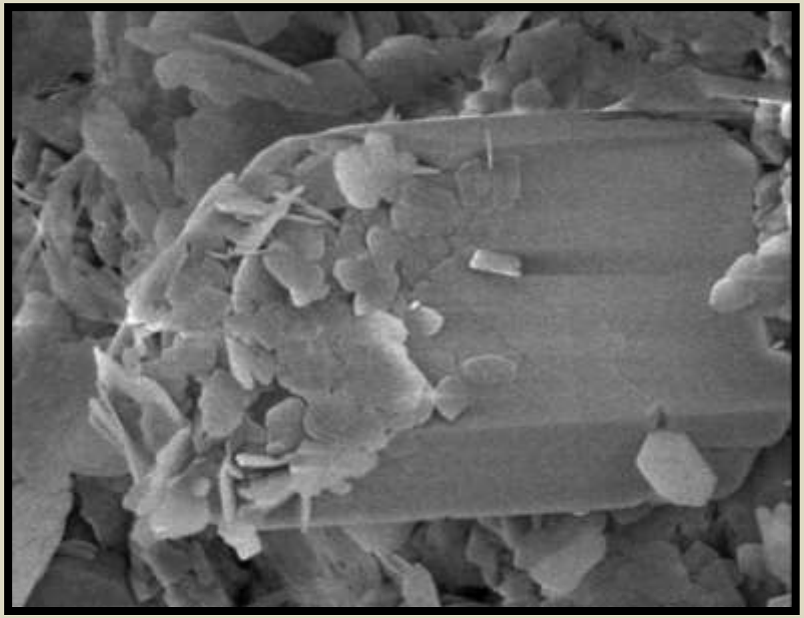
Examine core

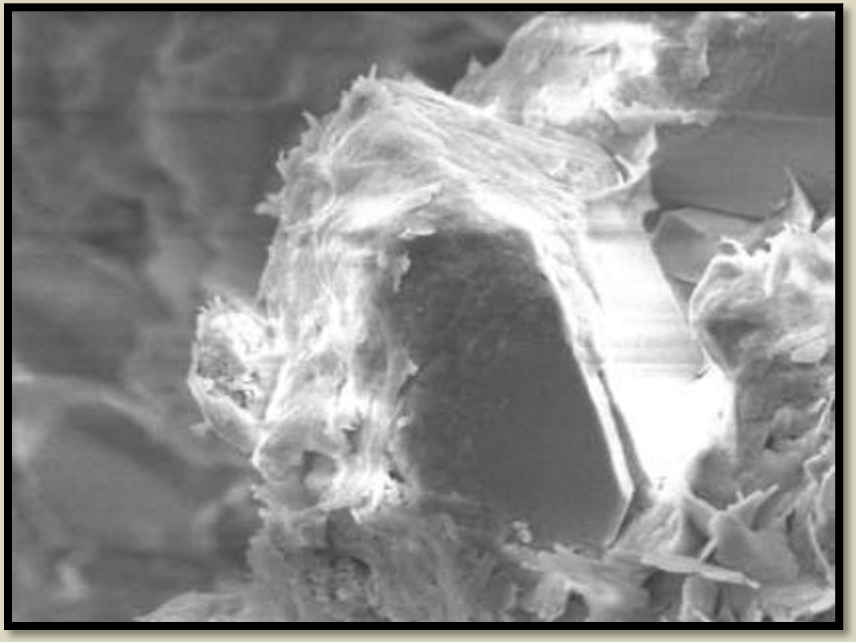
Map subsurface rock units (stratigraphy)



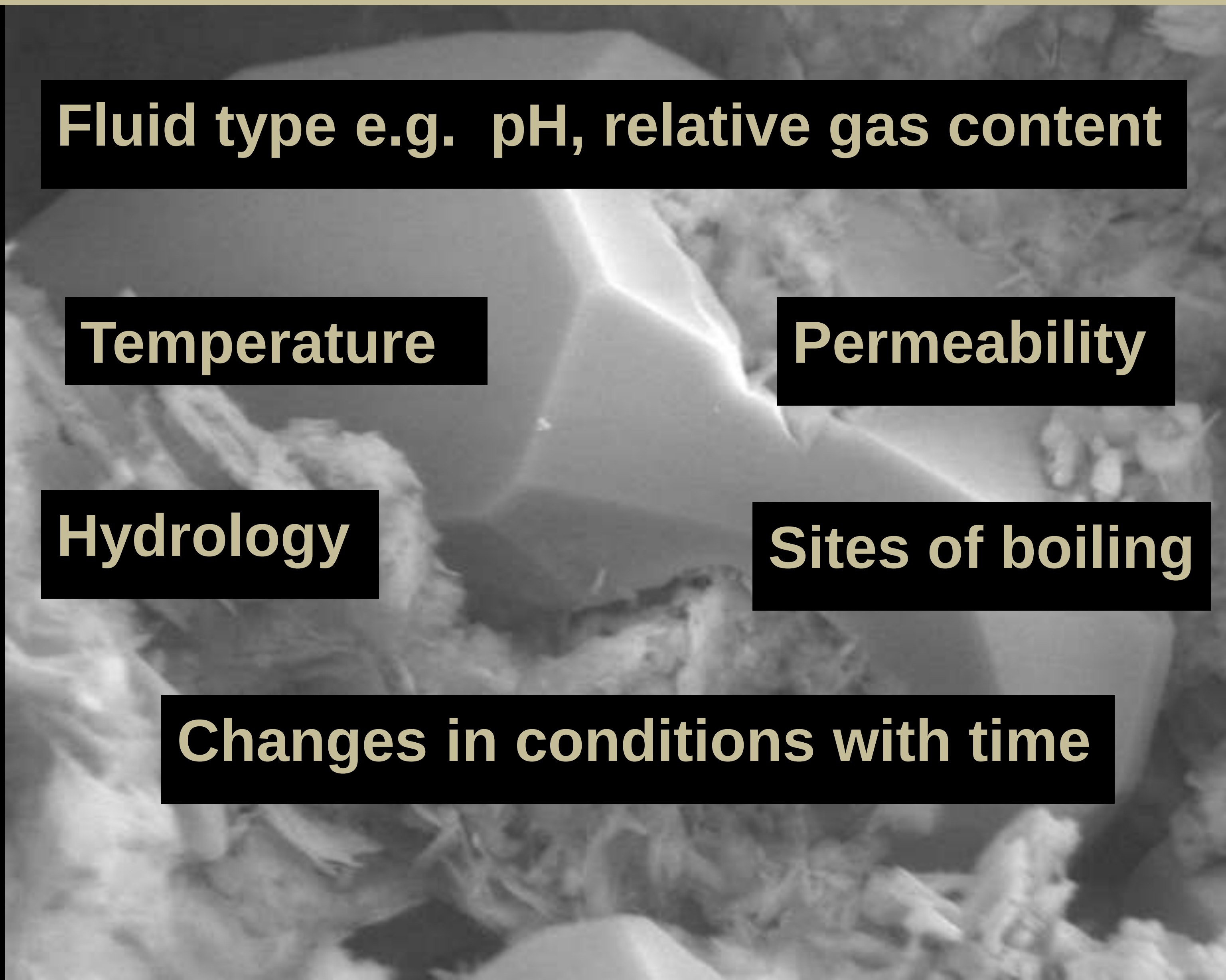
Examine hydrothermal alteration of rocks

Tells us about fluid-rock interaction and reservoir conditions such as temperature and permeability



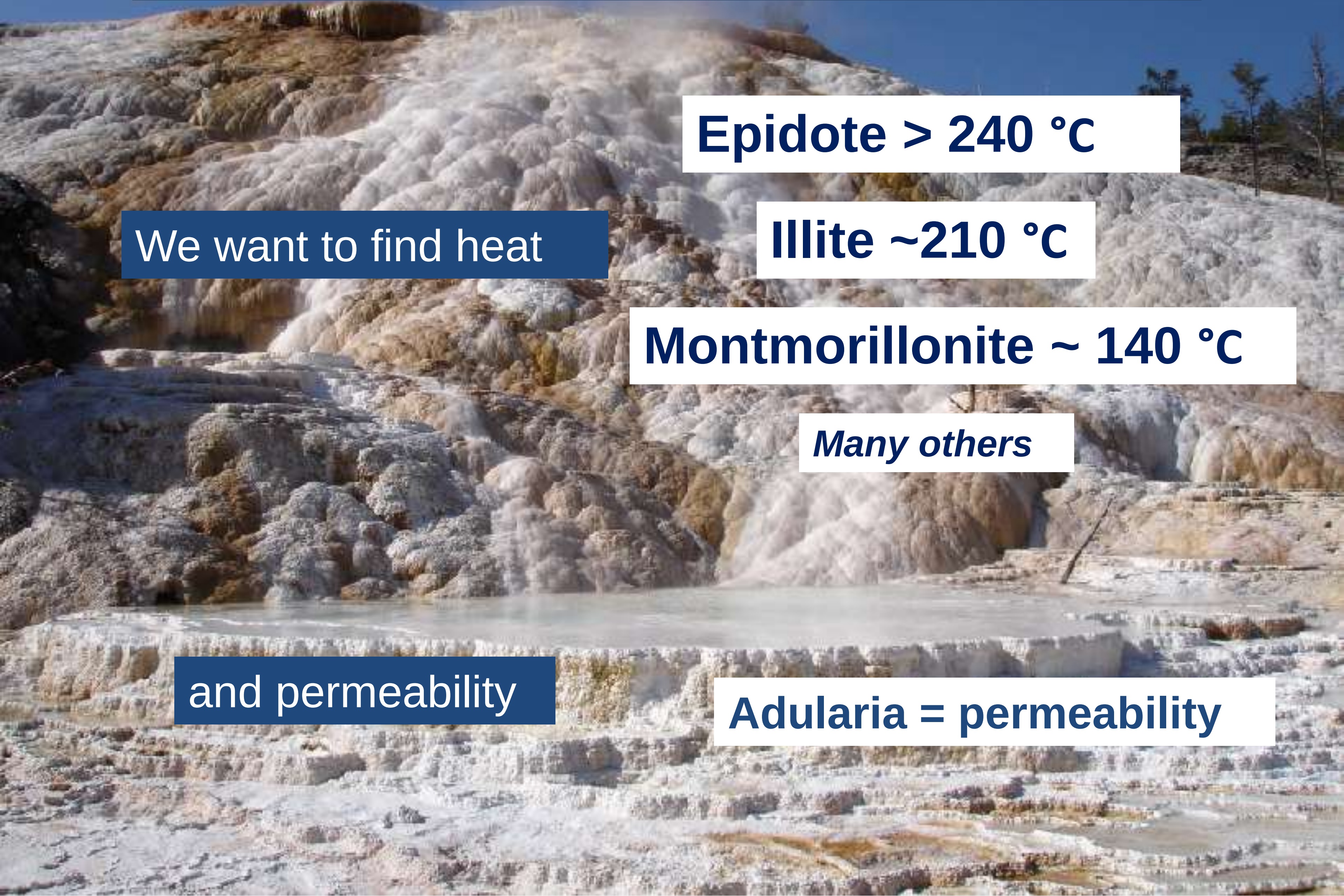


What do the minerals tell us about the reservoir?

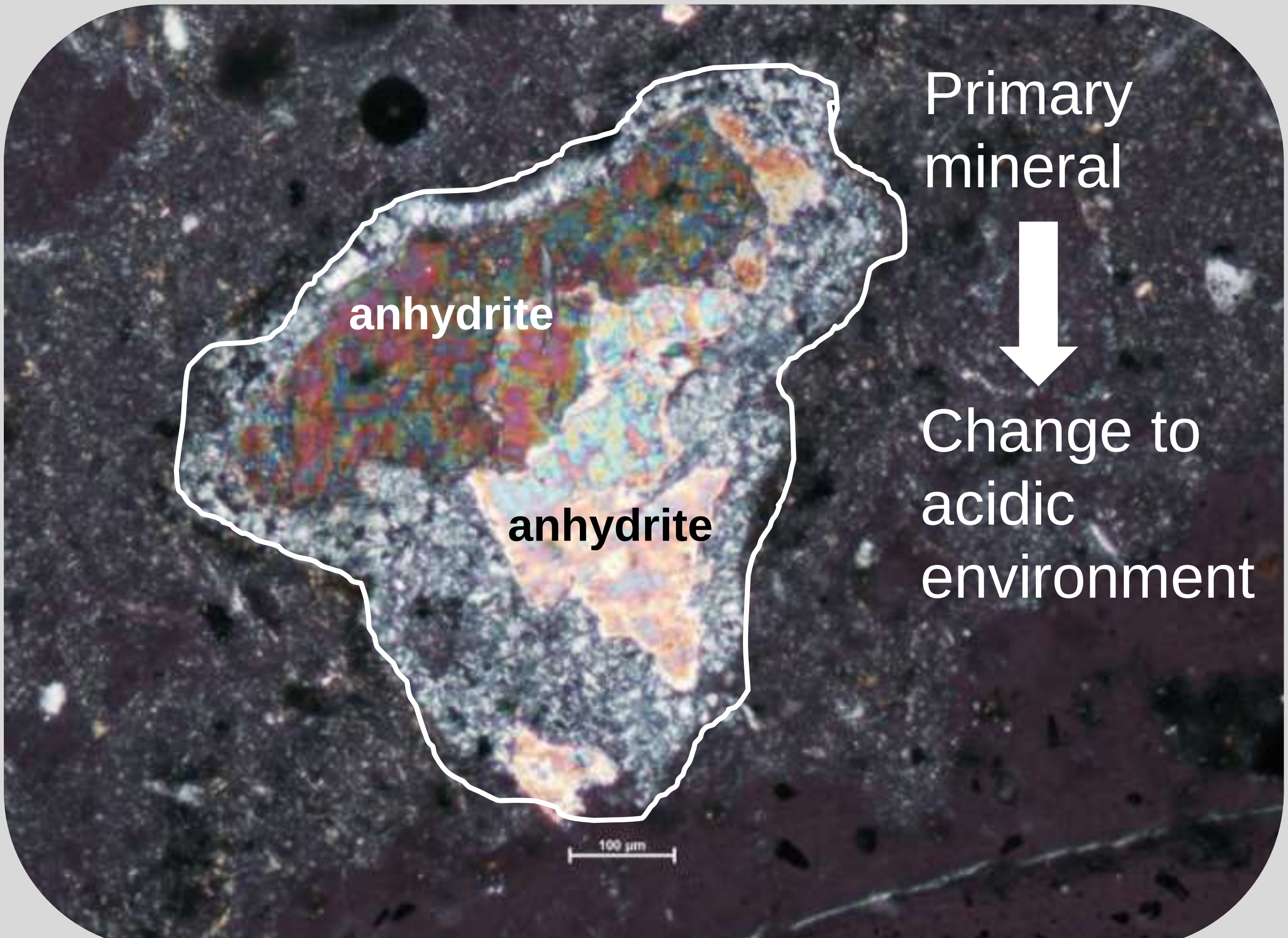


- Fluid type e.g. pH, relative gas content
- Temperature
- Permeability
- Hydrology
- Sites of boiling
- Changes in conditions with time

Temperature indicating minerals



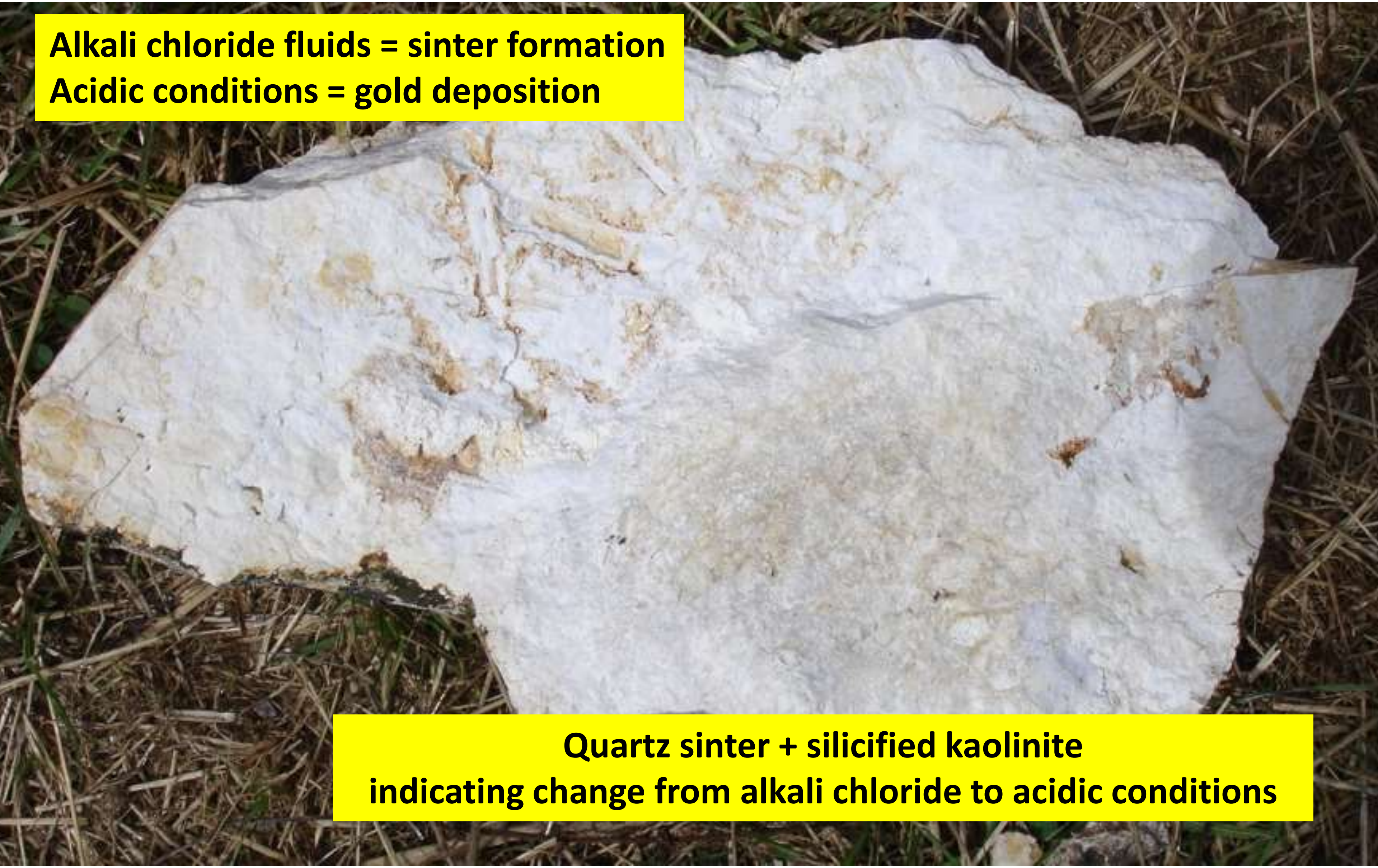
Reservoir conditions change – geologists track them by examining the minerals



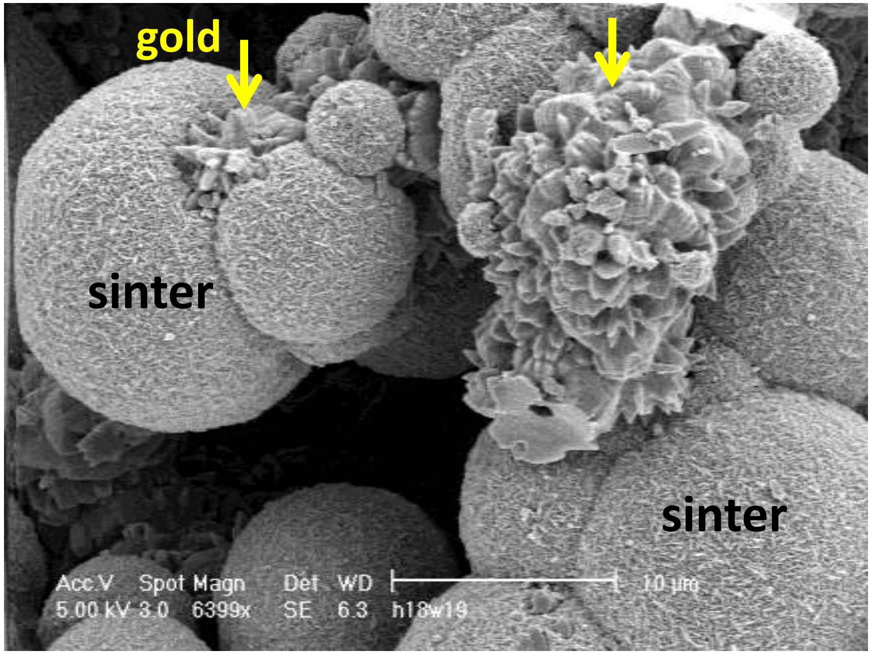
Acidic conditions are not ideal

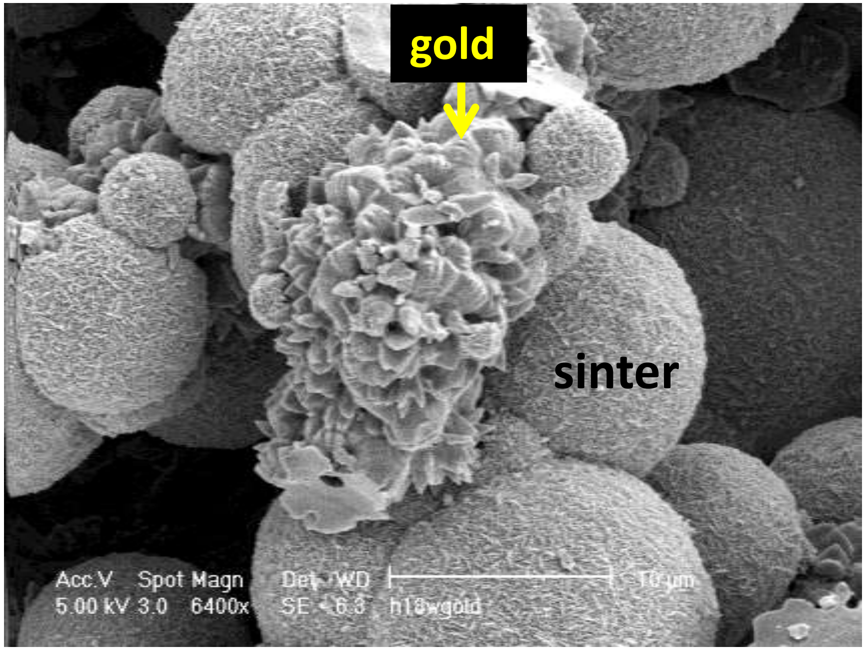
Casing corrosion

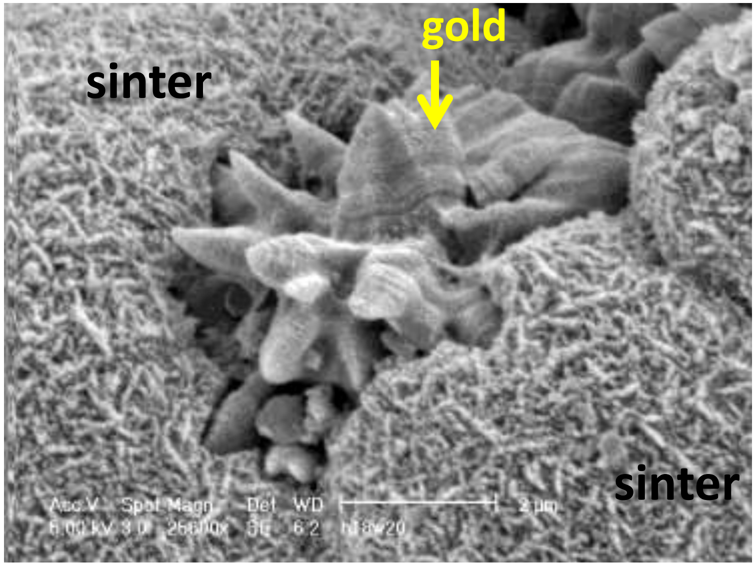
Sinter located directly above NZ gold mine



Scanning electron microscope images of sinter within a gold mining area in USA







In summary, geologists

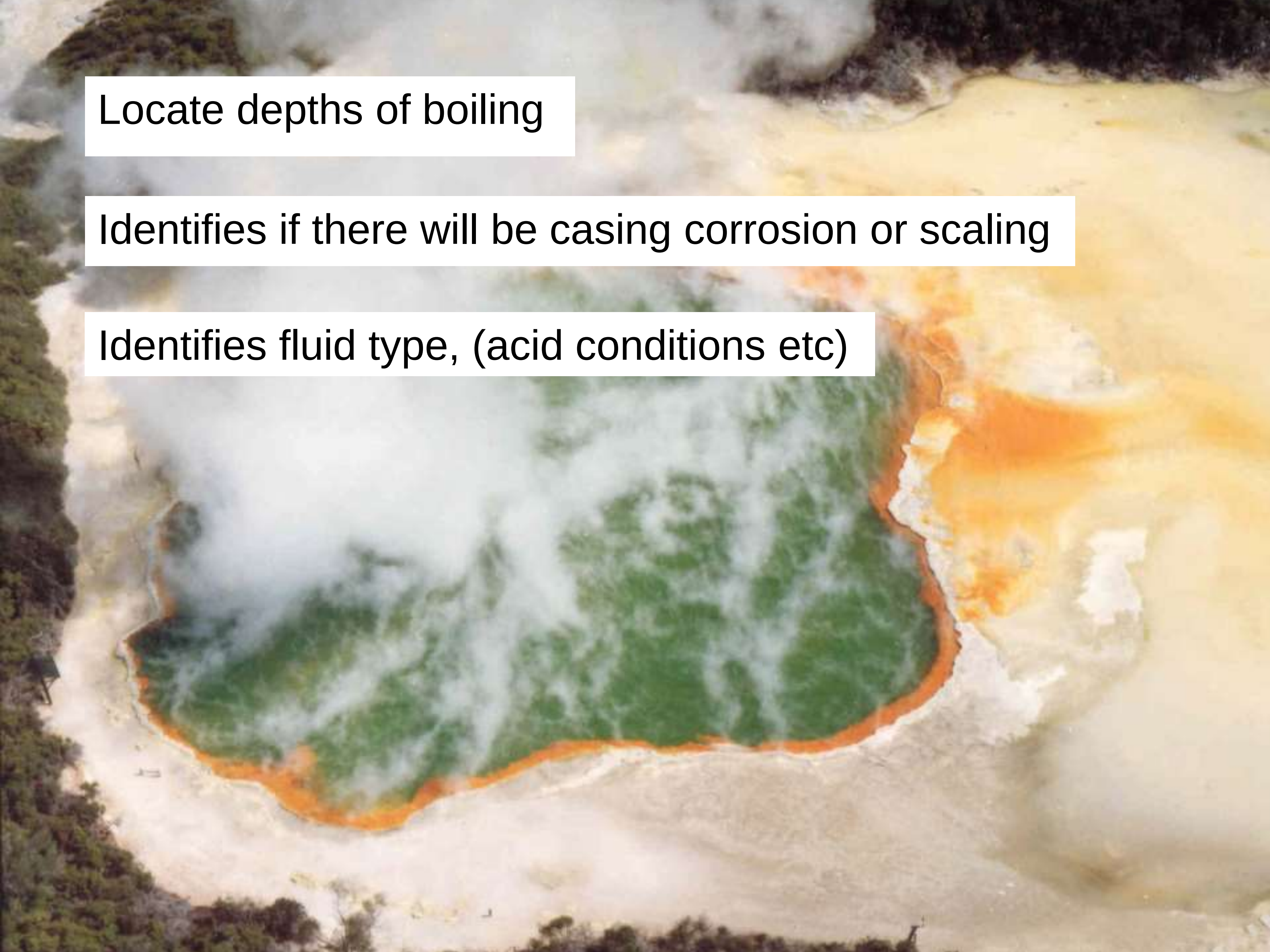
Decide depths of production casing and well depth

Determines if reservoir is heating up or cooling down

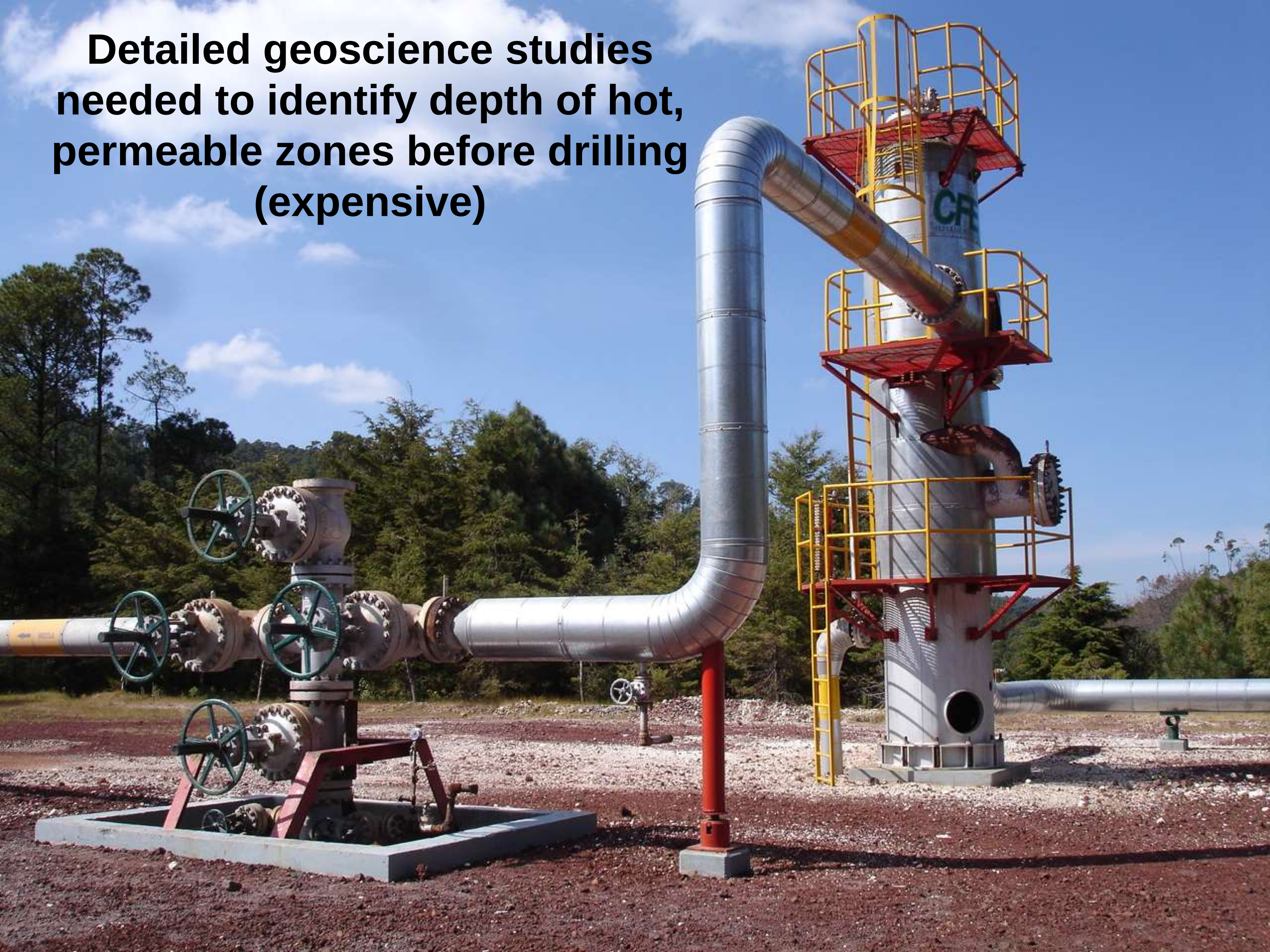
Helps determine if the well will be a good producer

Identifies production depths

Identifies aquifers and aquitards

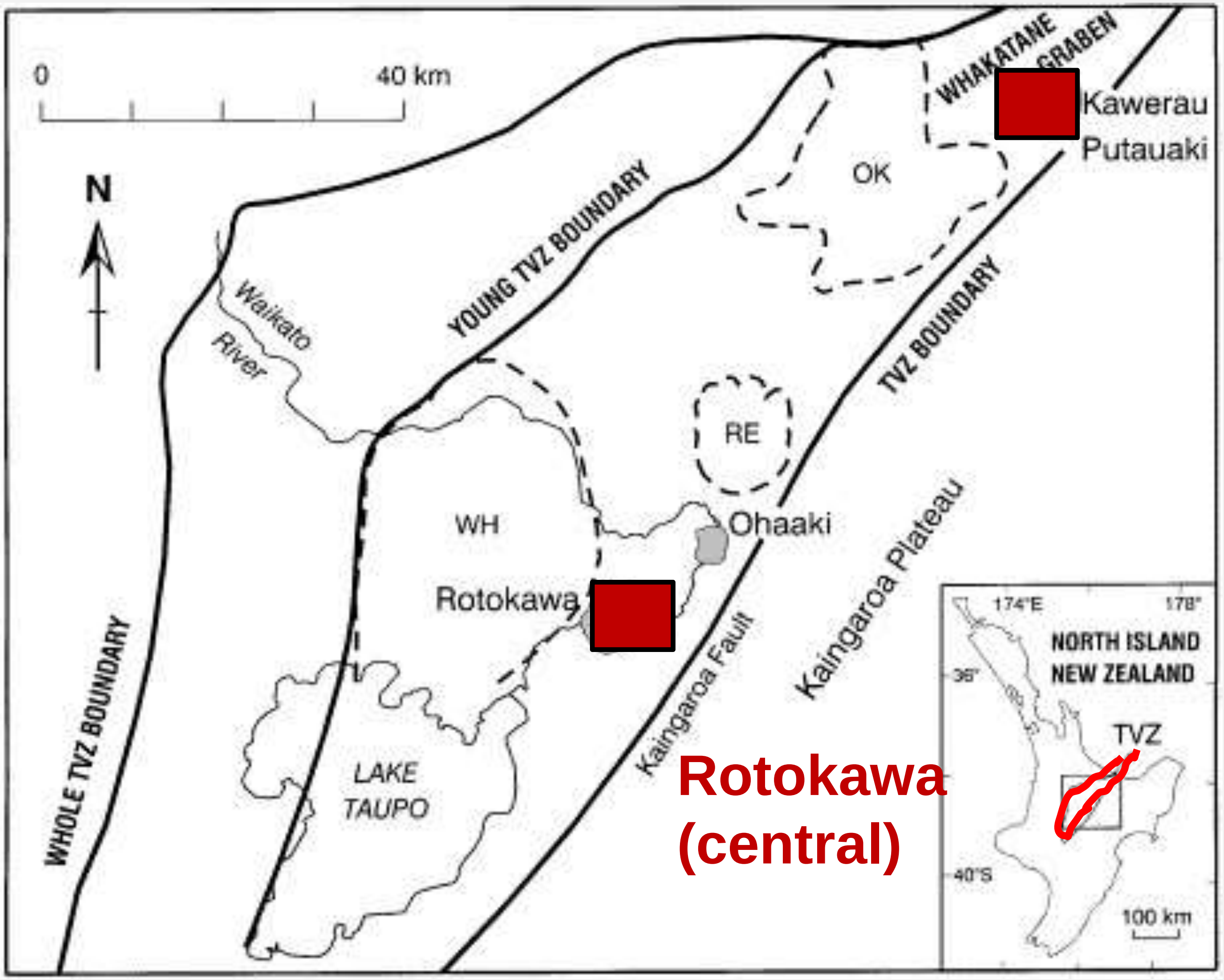

Locate depths of boiling
Identifies if there will be casing corrosion or scaling
Identifies fluid type, (acid conditions etc)

Detailed geoscience studies needed to identify depth of hot, permeable zones before drilling (expensive)



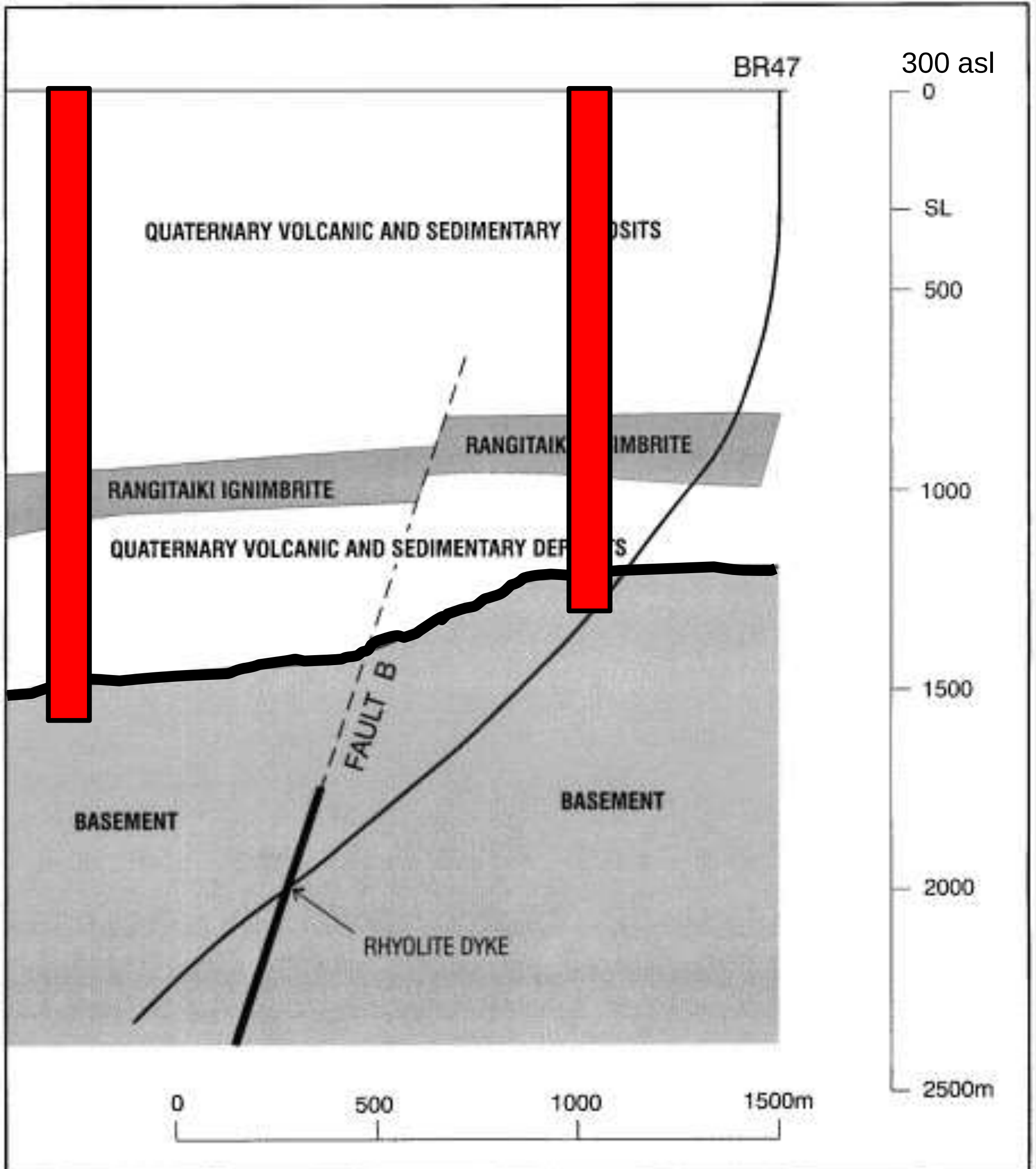
Example of why a geologist's role is important

2 NZ geothermal fields with different reservoir depths but produce from the same formation



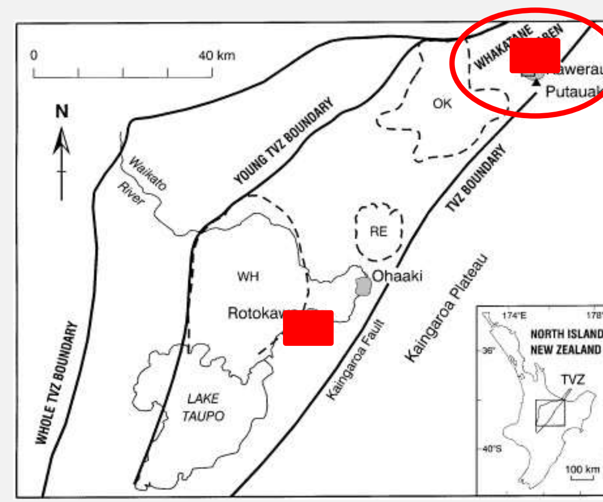
Kawerau (north)

Rotokawa (central)



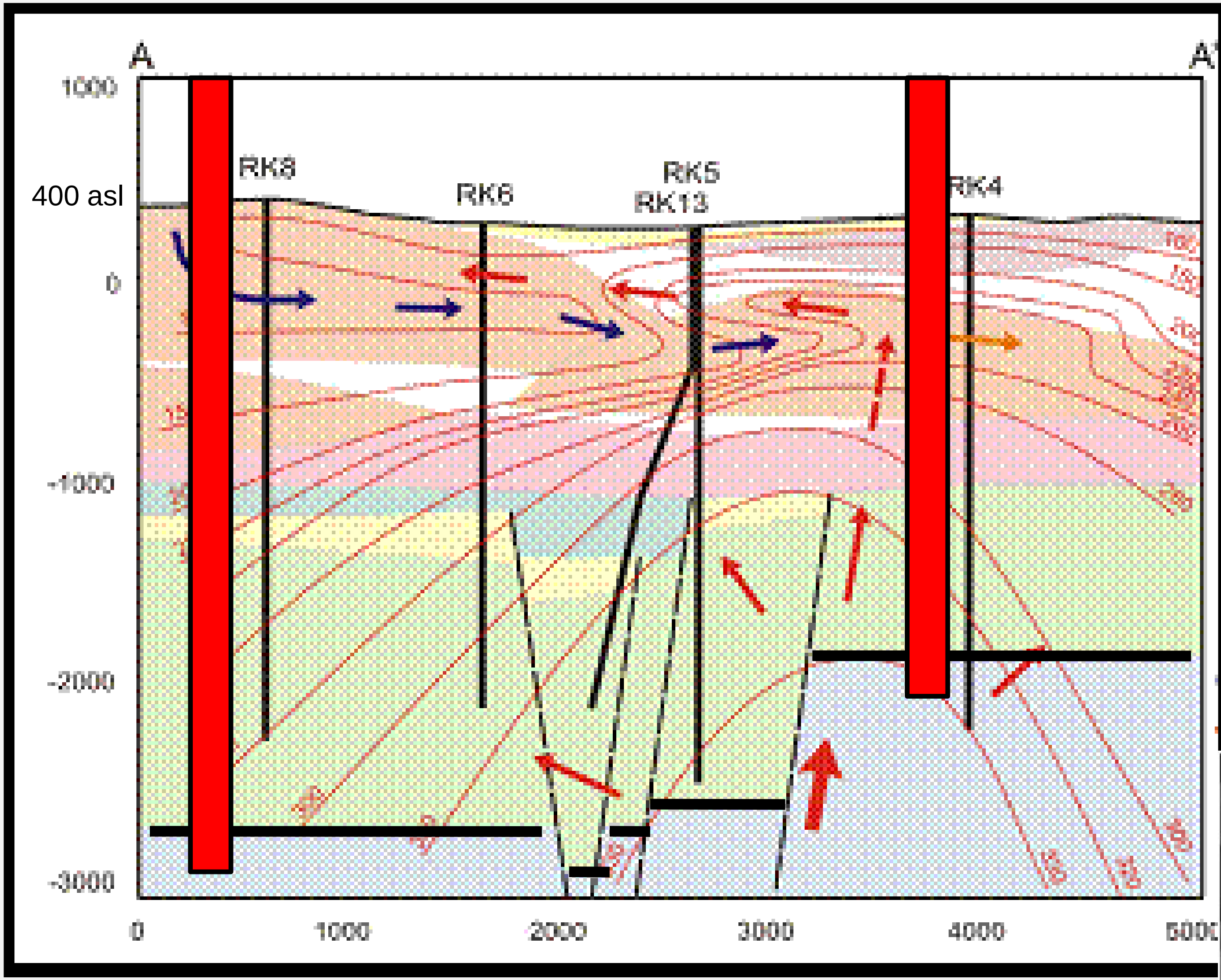
Kawerau (north)

Greywacke Basement
1500 -1800 m depth

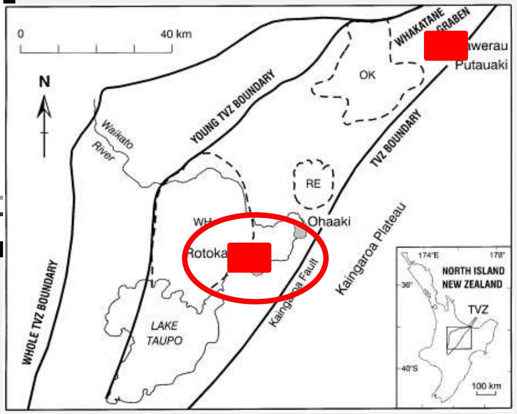


From: Wood, C.P., Brathwaite, R.L., Rosenberg, M. 2001. Basement structure, lithology and permeability at Kaweru and Ohaaki geothermal fields, New Zealand. Geothermics, vol. 30, issue 4, 461-481

Rotokawa (central)



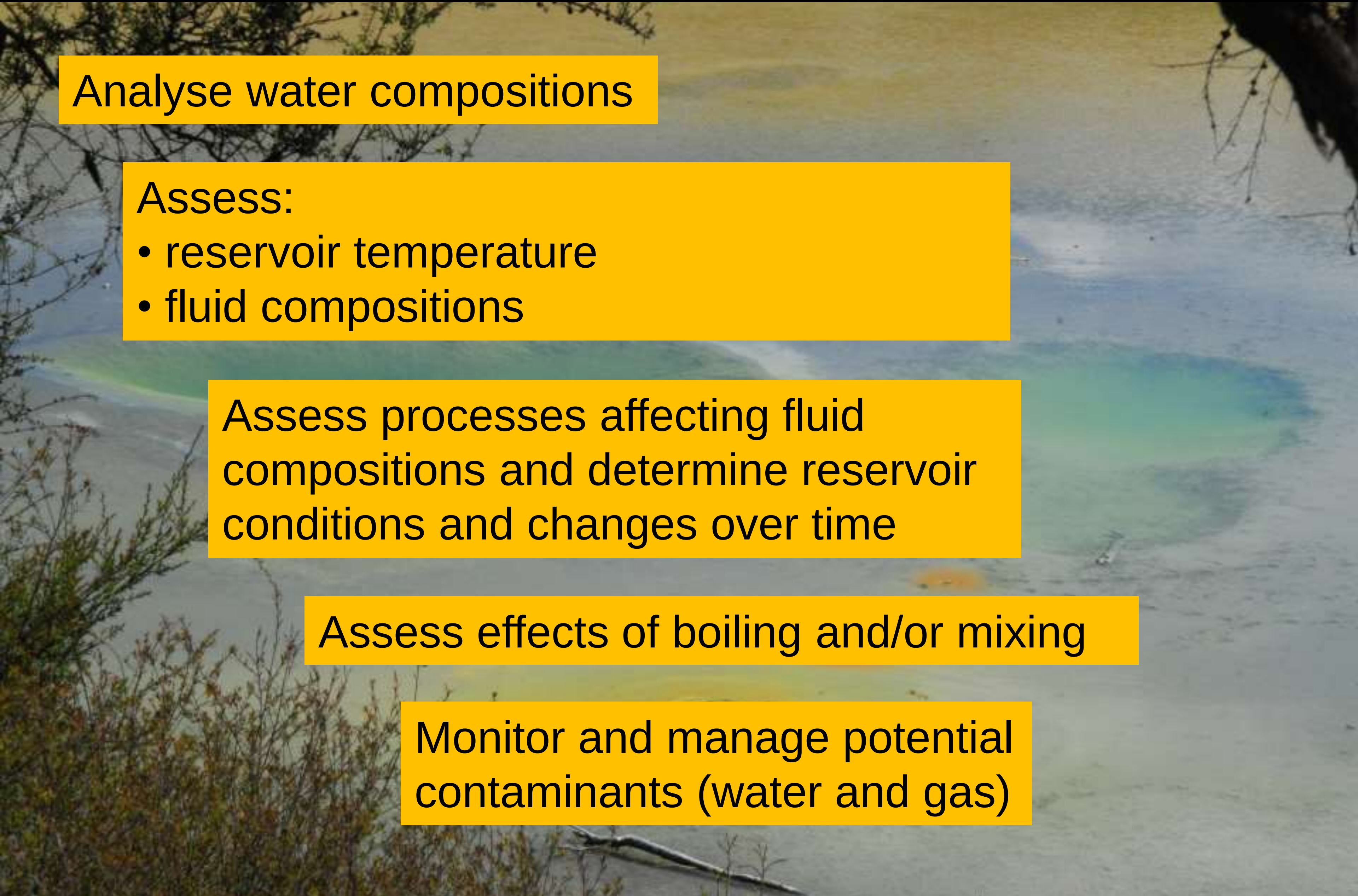
Greywacke Basement 2500 – 3000 m depth



From: NZ Geothermal Association Website

Let's look at the tasks of a **geochemist**

Role of a GEOCHEMIST



Analyse water compositions

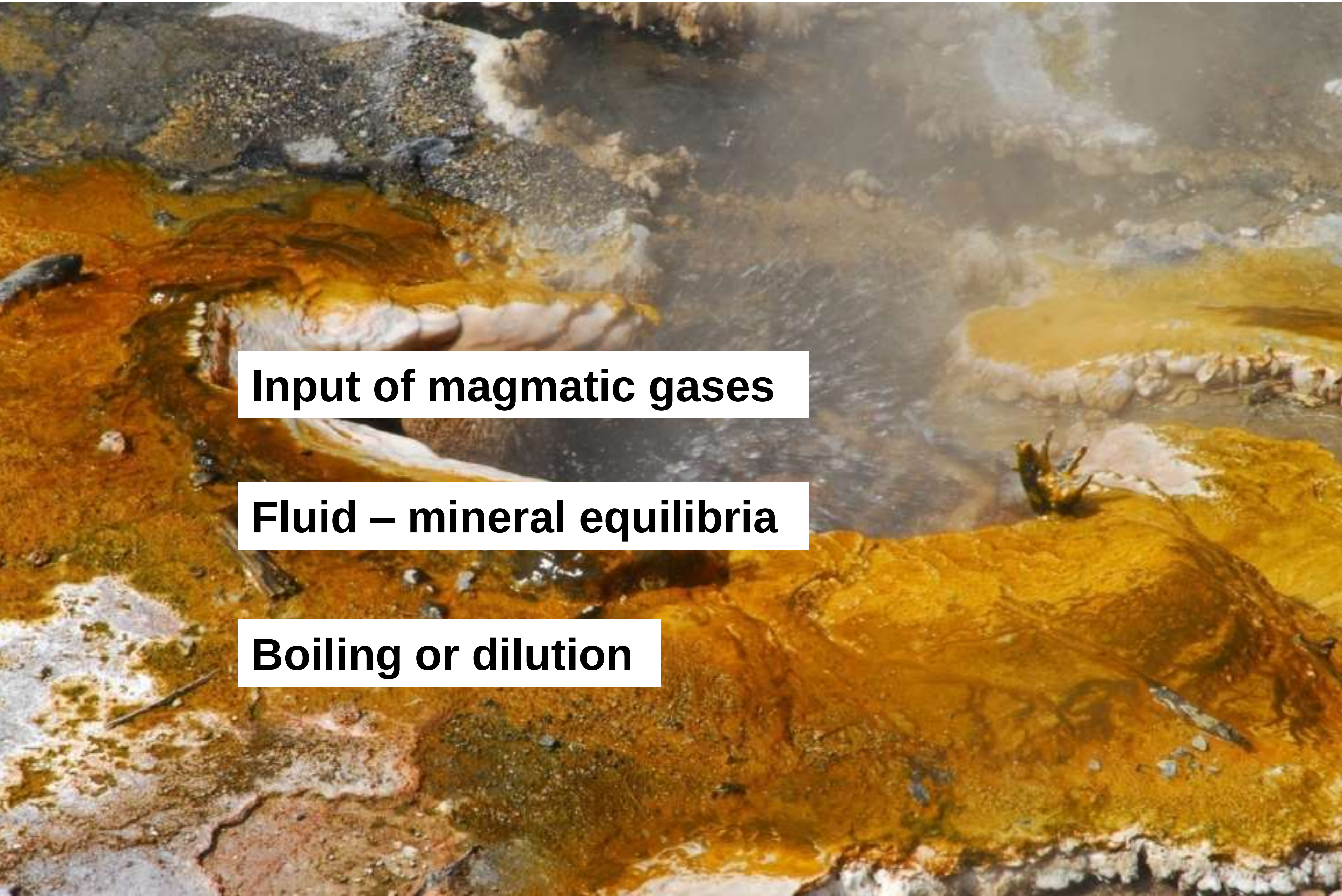
Assess:
- reservoir temperature
- fluid compositions

Assess processes affecting fluid compositions and determine reservoir conditions and changes over time

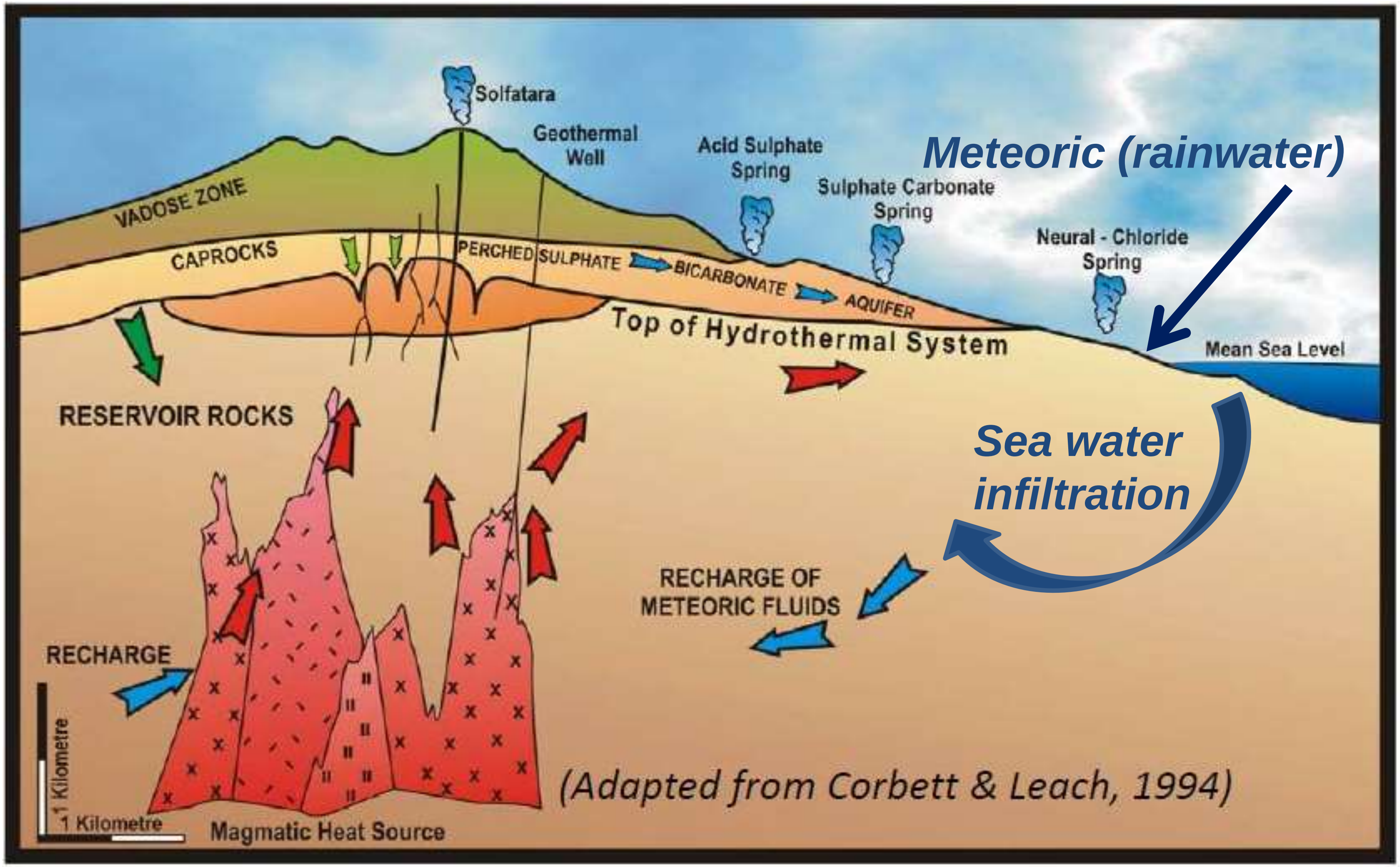
Assess effects of boiling and/or mixing

Monitor and manage potential contaminants (water and gas)

Factors influencing fluid chemistry

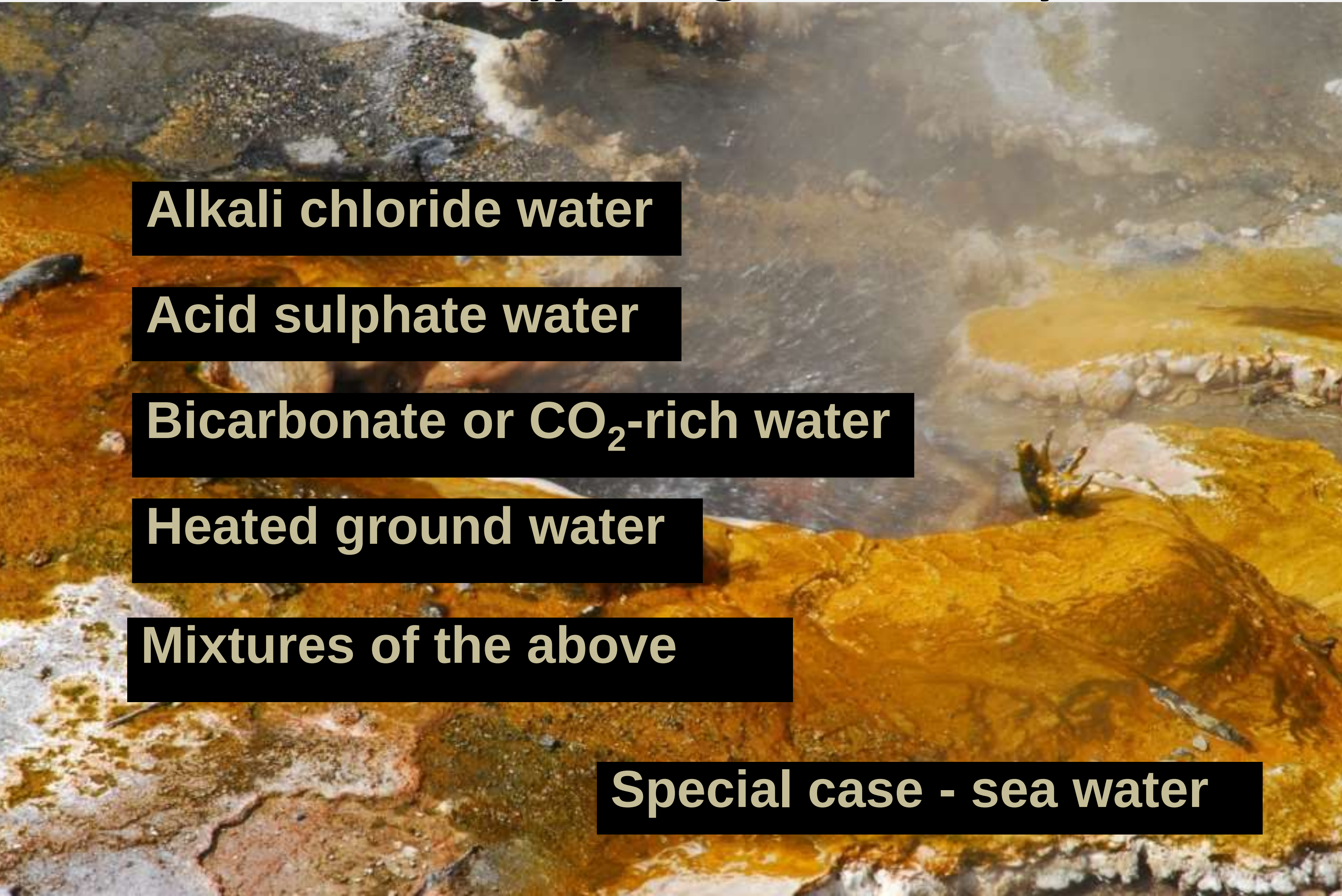


Water origin



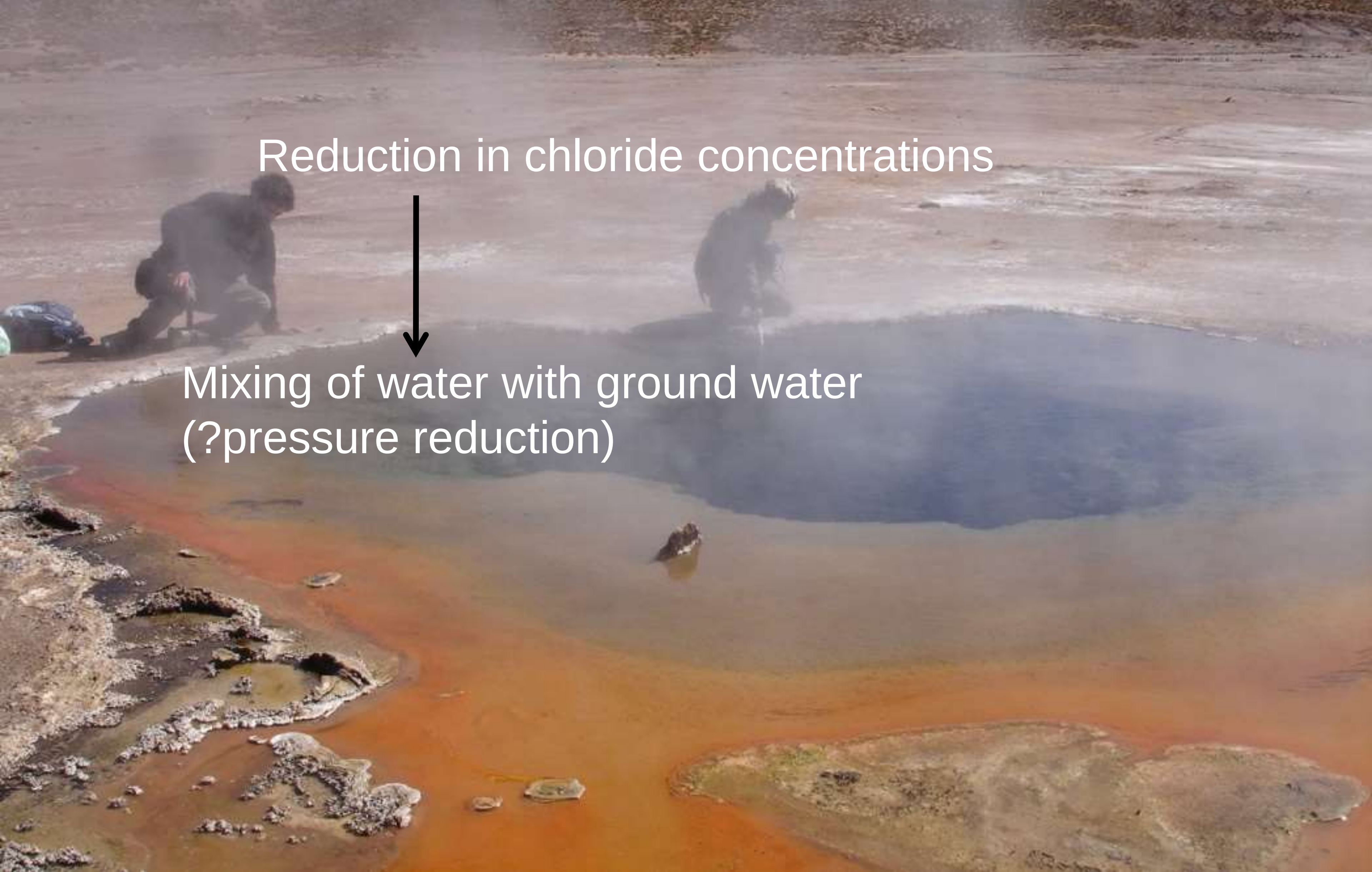
Volcanic system geothermal model schematic

Common fluid types in geothermal systems

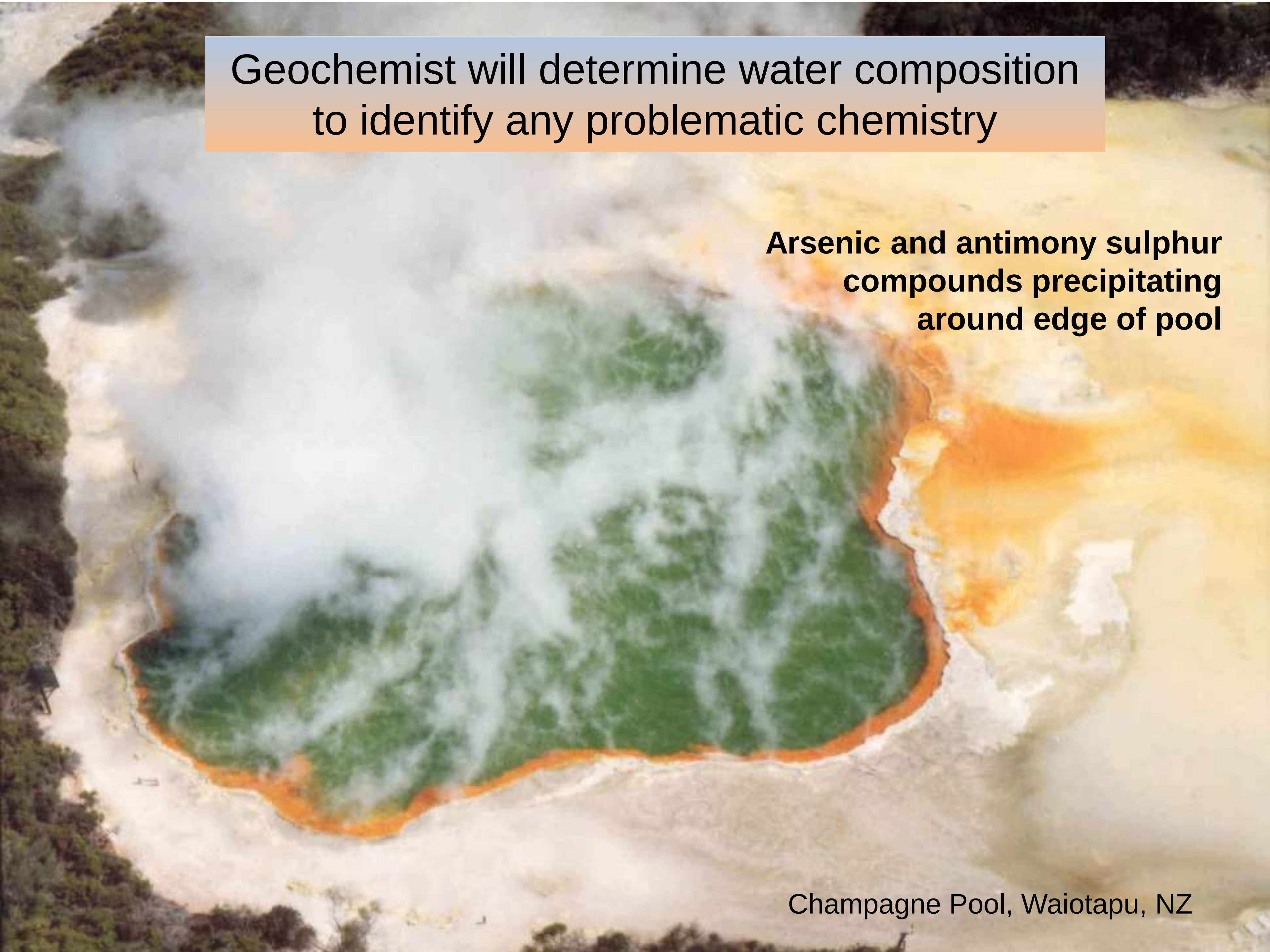


Different types of water

Geochemists follow any change in water chemistry

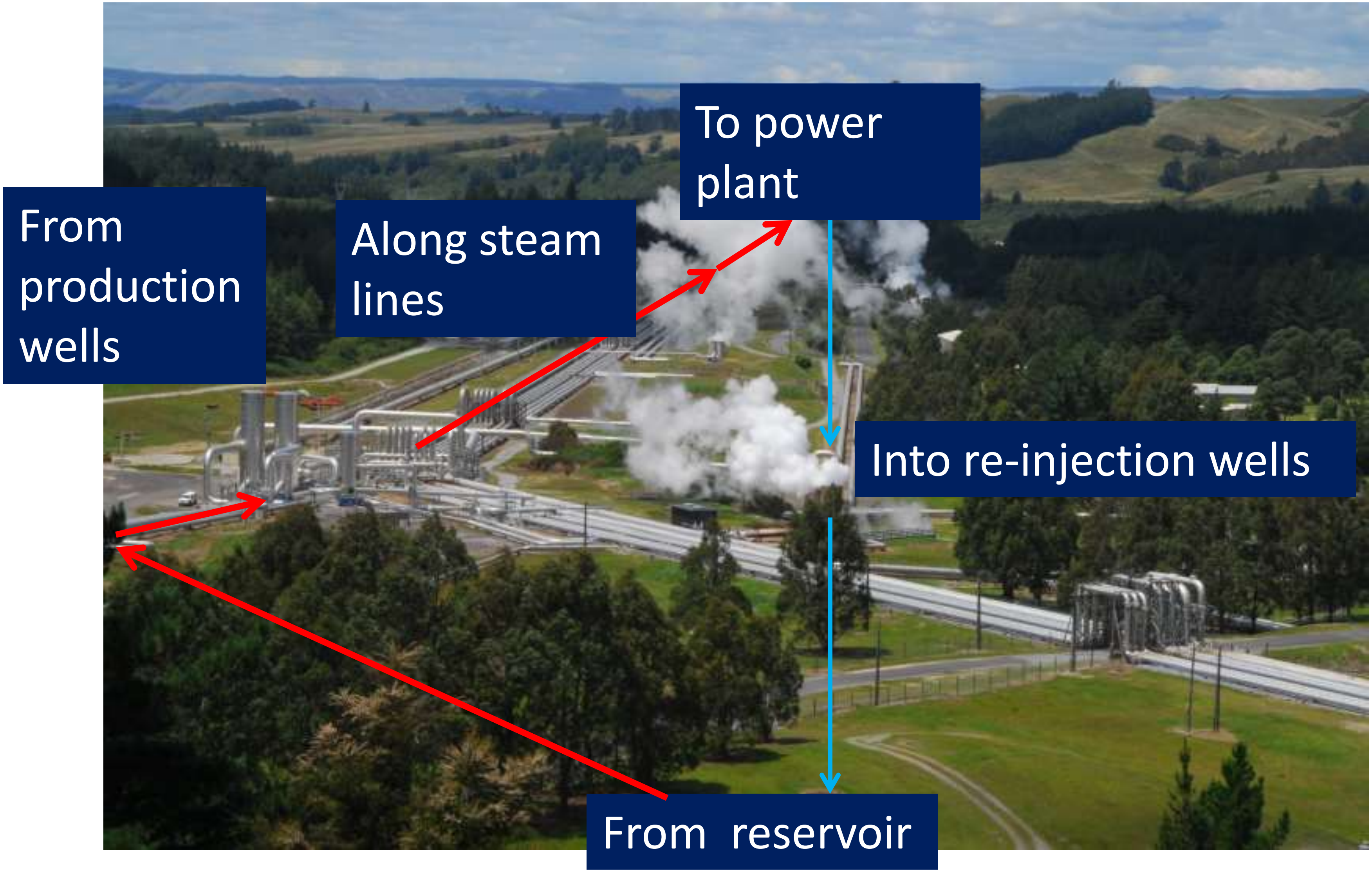


Geochemist will determine water composition to identify any problematic chemistry



Champagne Pool, Waiotapu, NZ

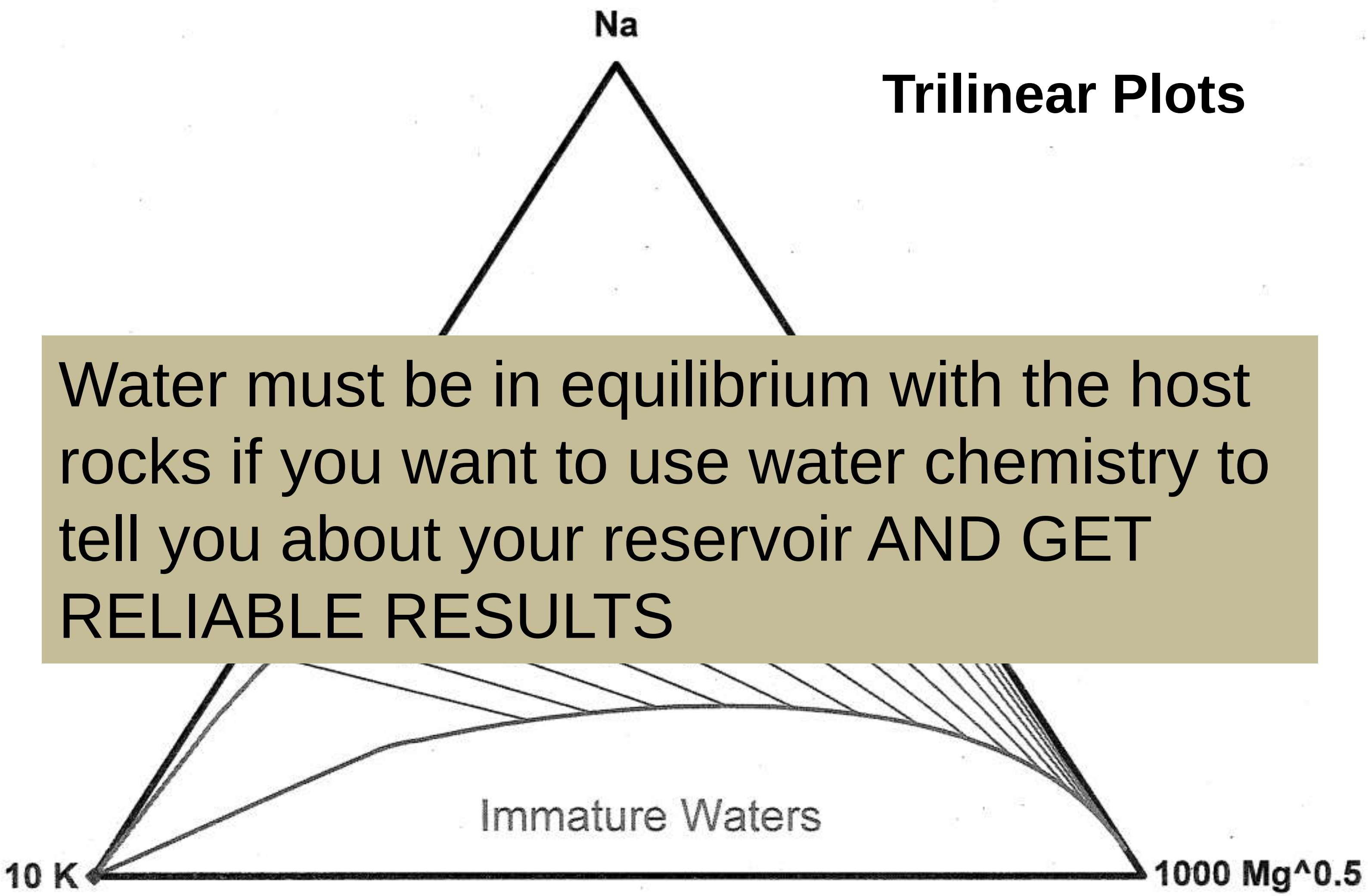
From reservoir to production wells to re-injections wells



Geochemistry can determine if any nasty chemical constituents are going to be a problem for the development of the power plant

Silica scale rich in gold and silver

Trilinear Plots



Water must be in equilibrium with the host rocks if you want to use water chemistry to tell you about your reservoir AND GET RELIABLE RESULTS

Geochemists use plots of the water composition to tell them information

Geothermometry calculations

Using chemical equations based on the water chemistry to determine the deep reservoir temperatures

Many rules on where and when you can use geothermometry to get accurate results

Toxic gases

Main gases discharging from geothermal systems are:

H_2S
CO_2

Monitor toxic gases

TOXIC GASES – CO_2

Lake Nyos – crater lake located in the NW region of Cameroon

Within the Oku Volcanic Field Lake Nyos is located high on flanks of inactive volcano

August 21, 1986

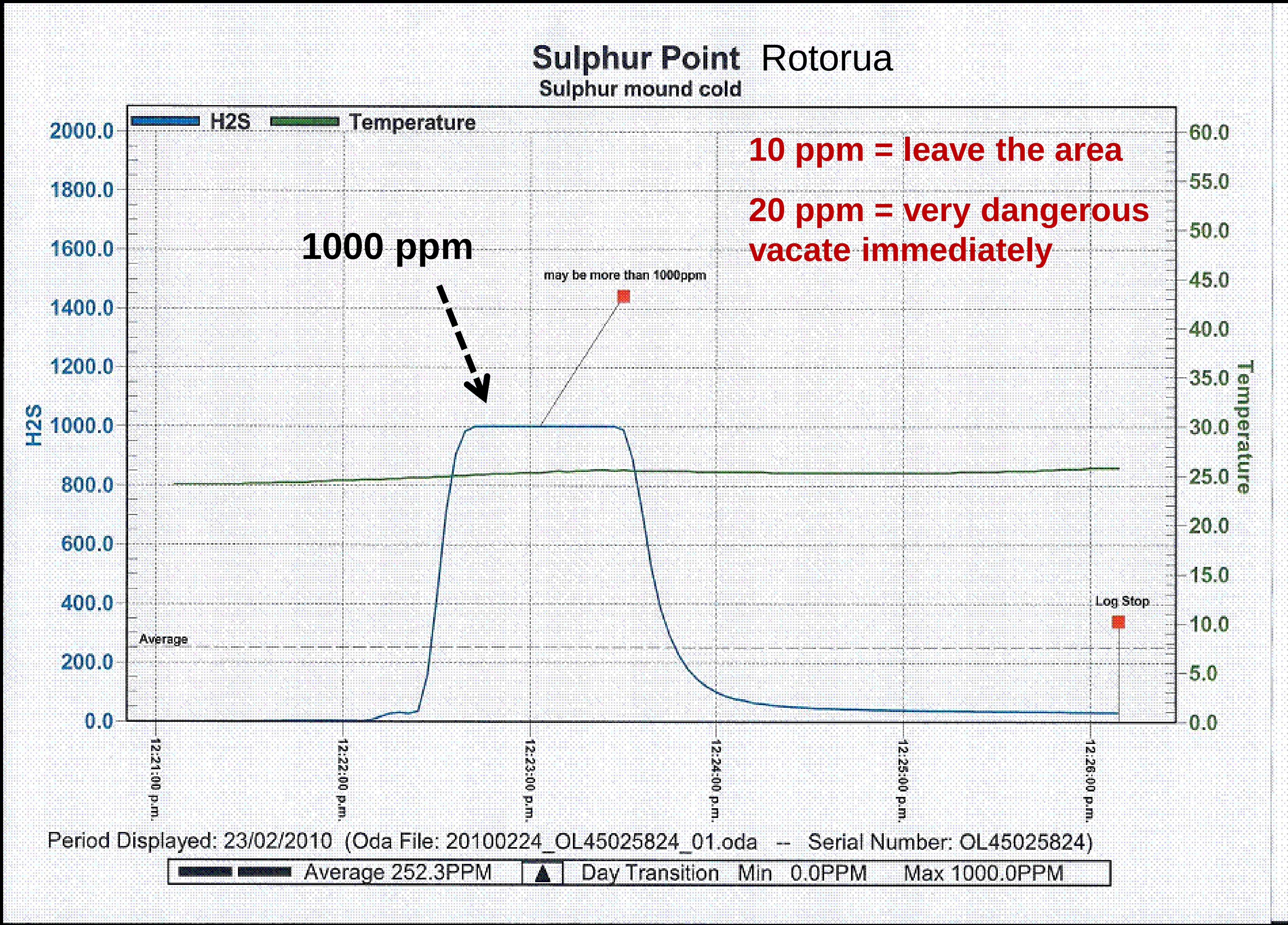
Magma beneath lake leaked CO_2 into the water and Lake Nyos discharged large quantities of CO_2

CO_2 heavier than air and settled in low lying areas

1700 people died

3500 livestock died

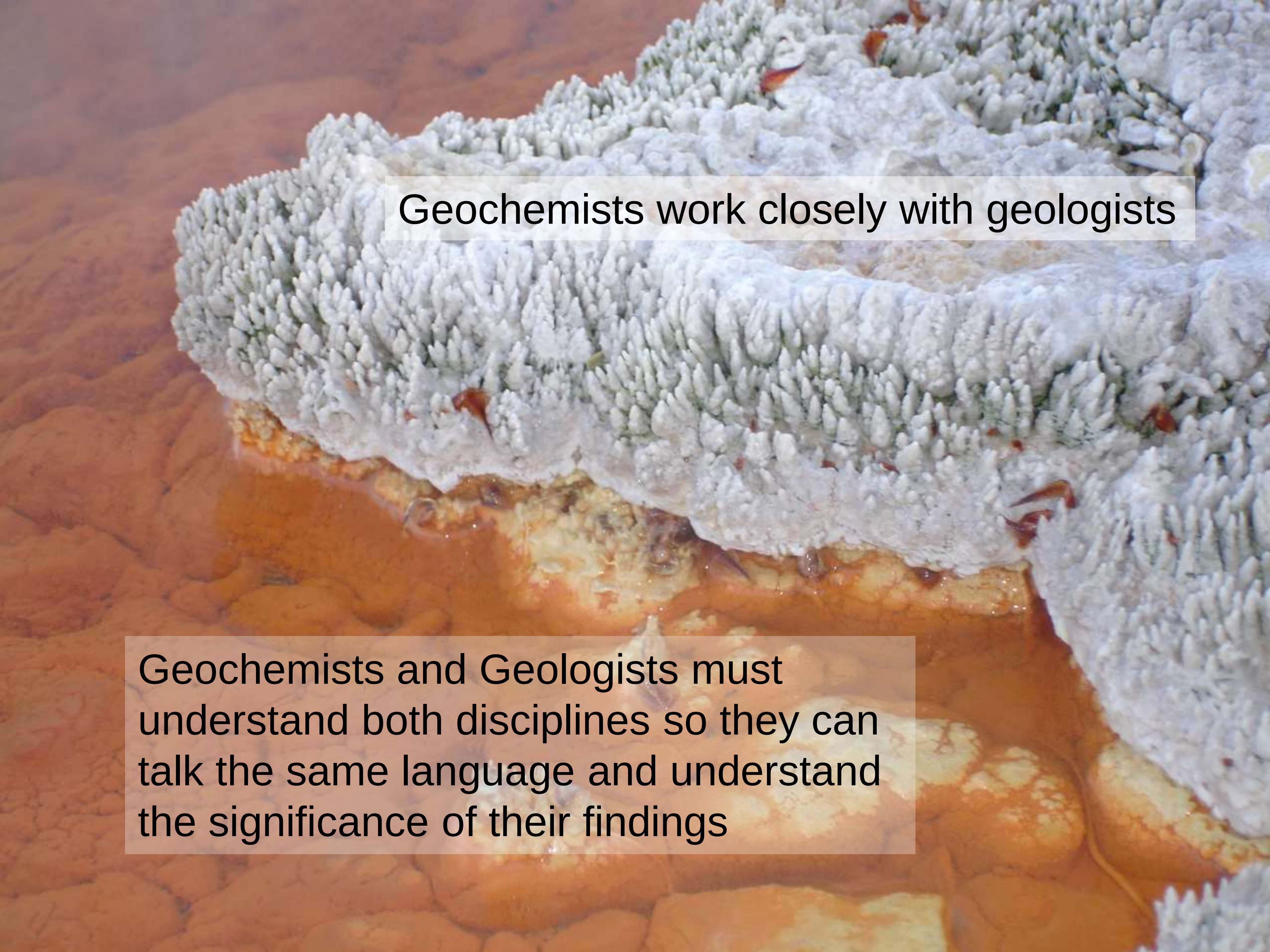

Rotorua H_2S case study



Sulphur Point Rotorua
Sulphur mound cold
H2S
Temperature
10 ppm = leave the area
20 ppm = very dangerous vacate immediately
1000 ppm
may be more than 1000ppm
Log Stop
Average
2000.0
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
12:21:00 p.m.
12:22:00 p.m.
12:23:00 p.m.
12:24:00 p.m.
12:25:00 p.m.
12:26:00 p.m.
Period Displayed: 23/02/2010 (Oda File: 20100224_OL45025824_01.oda -- Serial Number: OL45025824)
Average 252.3PPM
Day Transition Min 0.0PPM Max 1000.0PPM

Clues to significant H_2S emissions

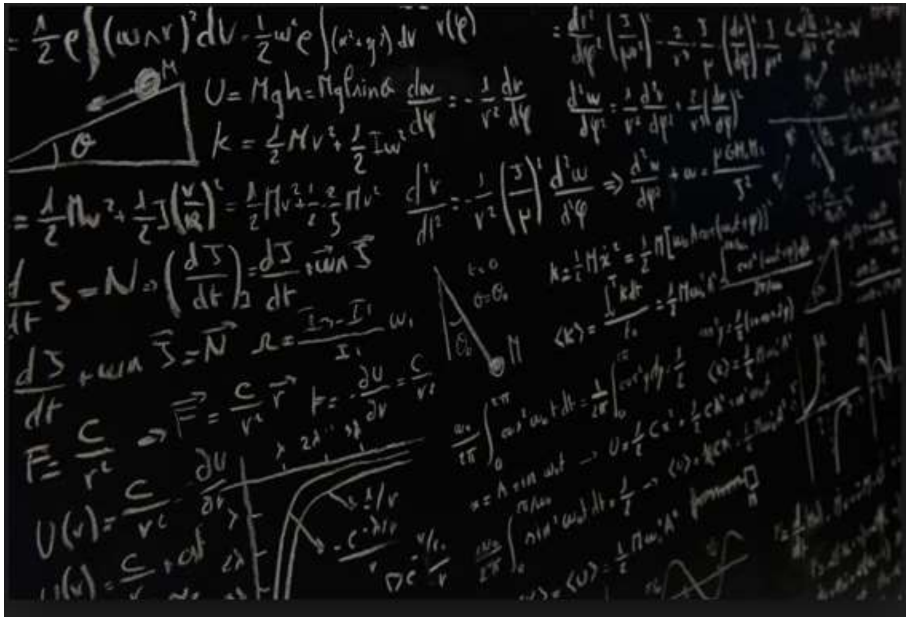
5 ppm


Geochemists work closely with geologists
Geochemists and Geologists must understand both disciplines so they can talk the same language and understand the significance of their findings

Role of a geophysicist

Geophysics uses the principals of physics to study and understand the Earth's subsurface to several km deep

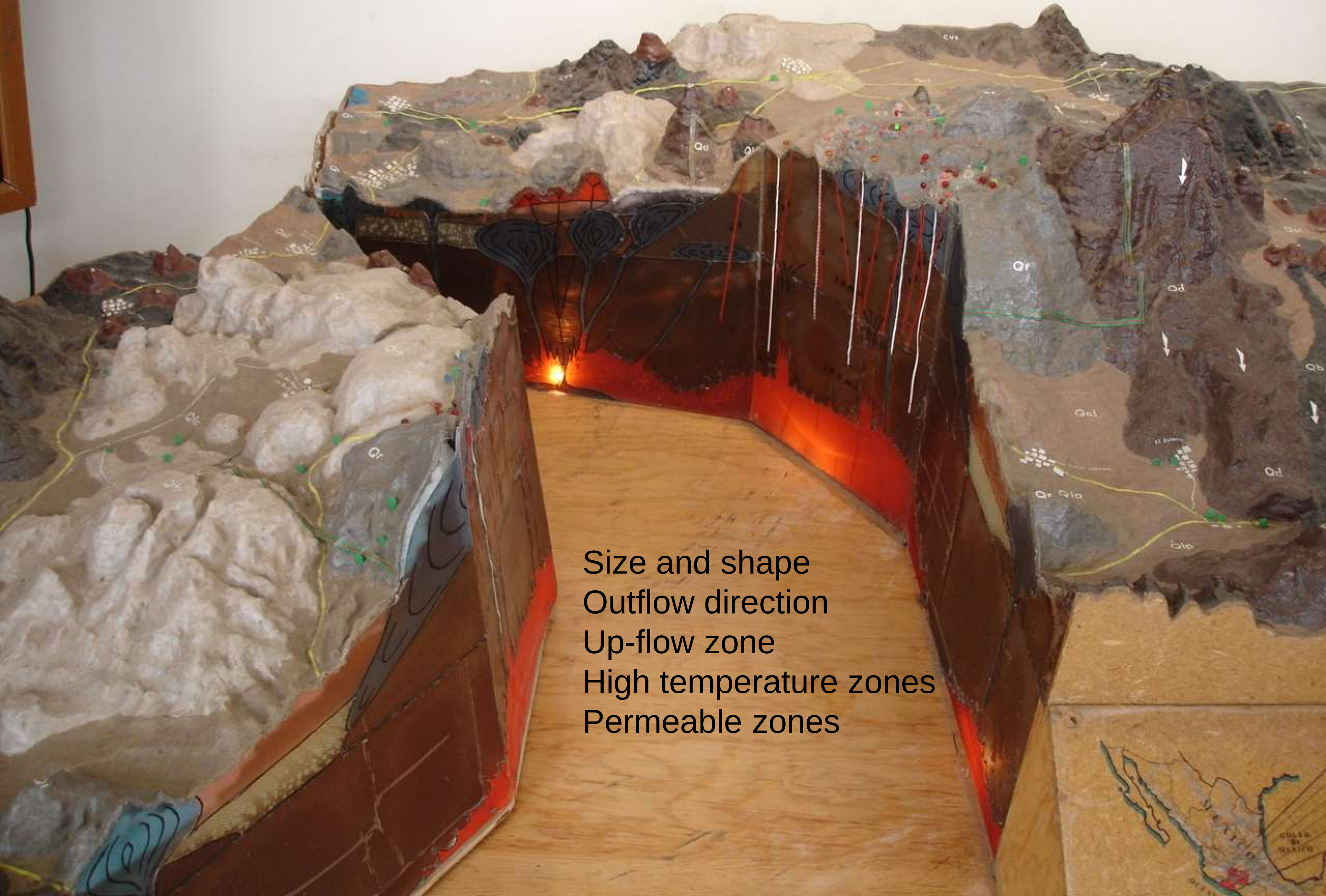
Otherwise only accessible by drilling (expensive)



Use a variety of techniques to image the subsurface

X-ray vision

Geophysics is used to image subsurface



- Size and shape
- Outflow direction
- Up-flow zone
- High temperature zones
- Permeable zones

What properties of geothermal systems are we interested in?

Subsurface temperature

Subsurface fluid

Permeability of rocks (faults and fractures)

Reservoir size

Reservoir rocks

What can we measure?

Density

Magnetism

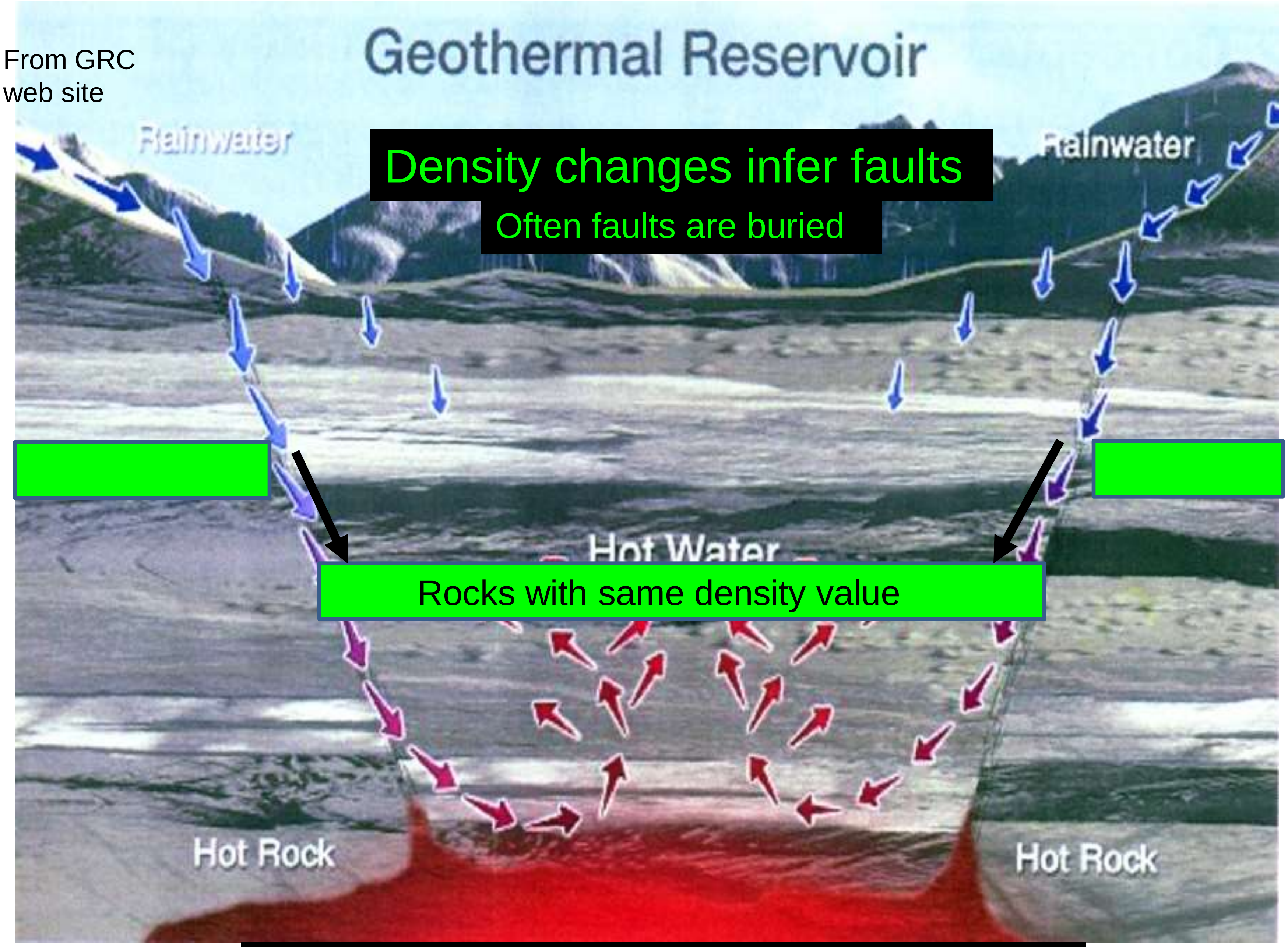
Resistivity

Elastic properties of rocks (hard or soft)

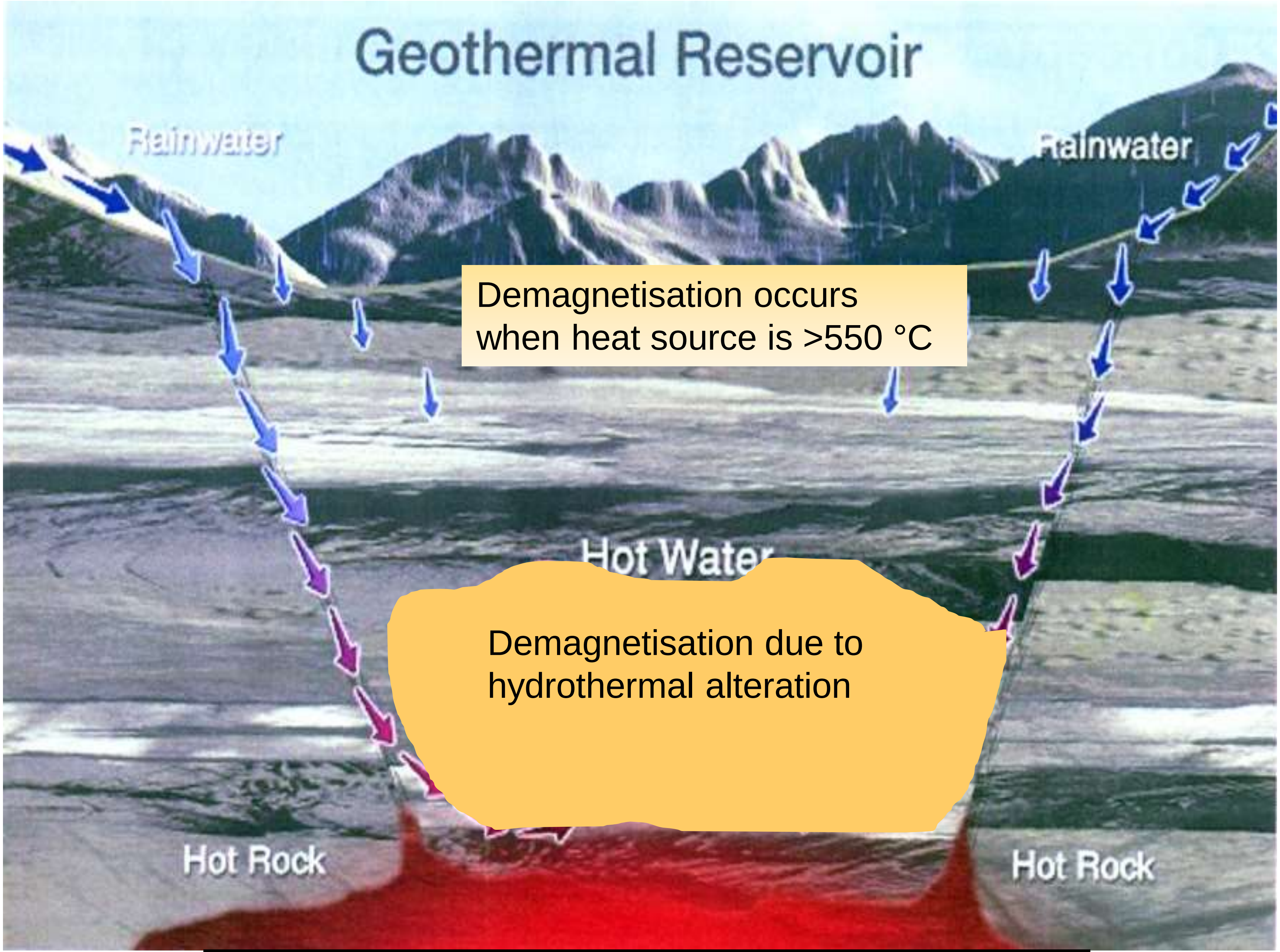
Geophysics tools

- Gravity
- Magnetics
- Resistivity (DC and Electromagnetic)
- Seismicity (Passive and Active)

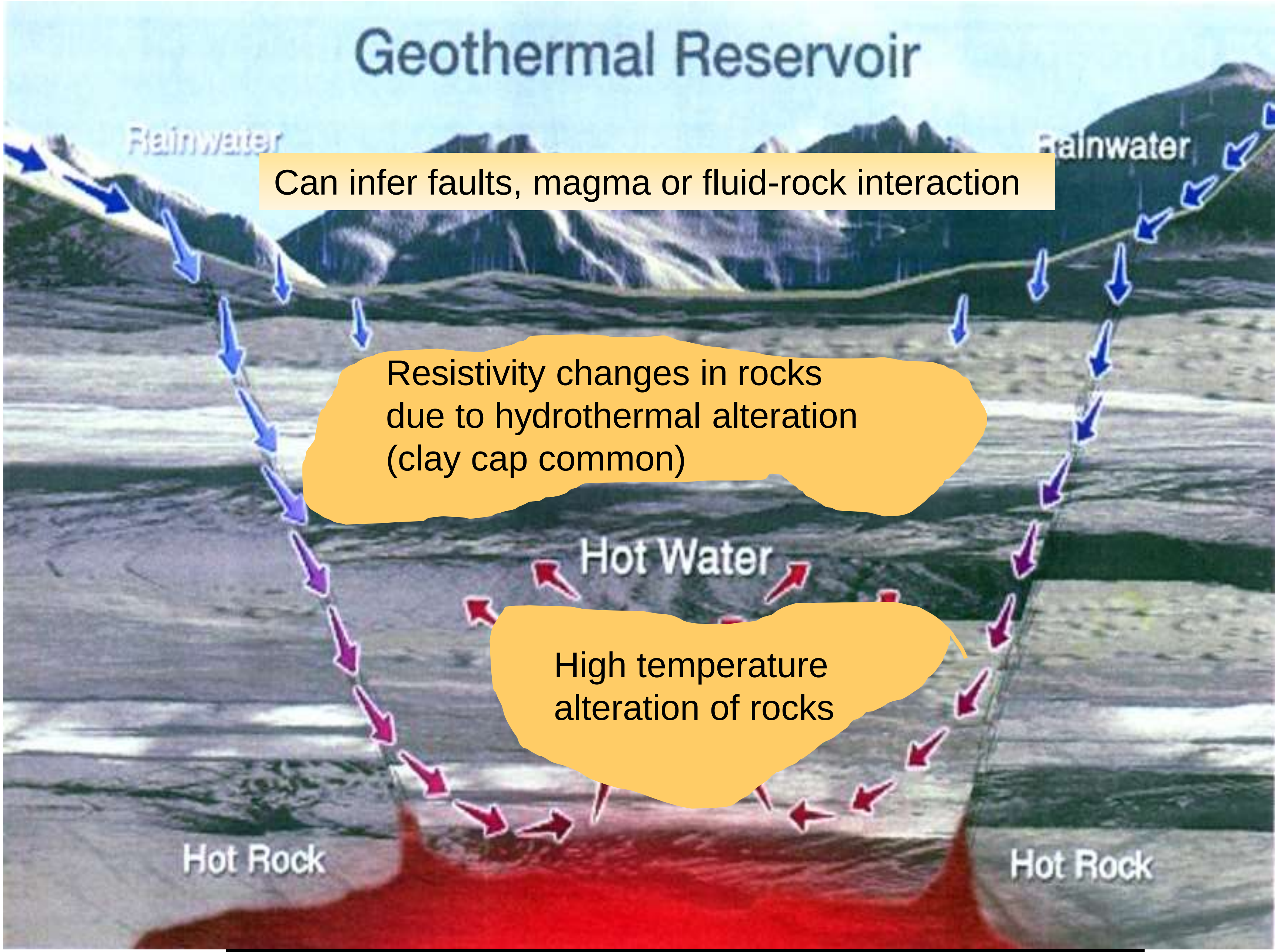
From GRC
web site



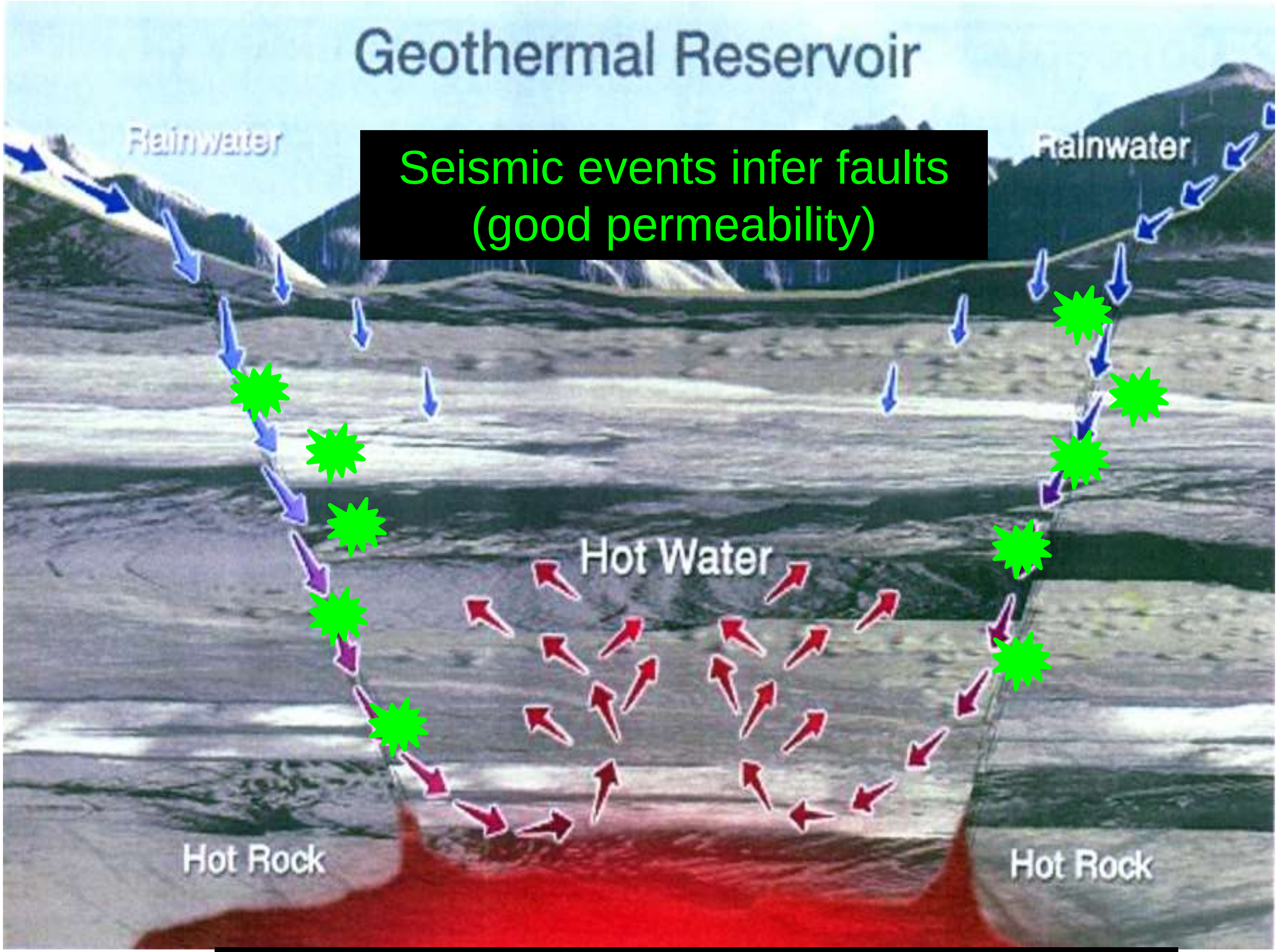
Basic Conceptual Model: Density changes



Basic Conceptual Model: Magnetic changes

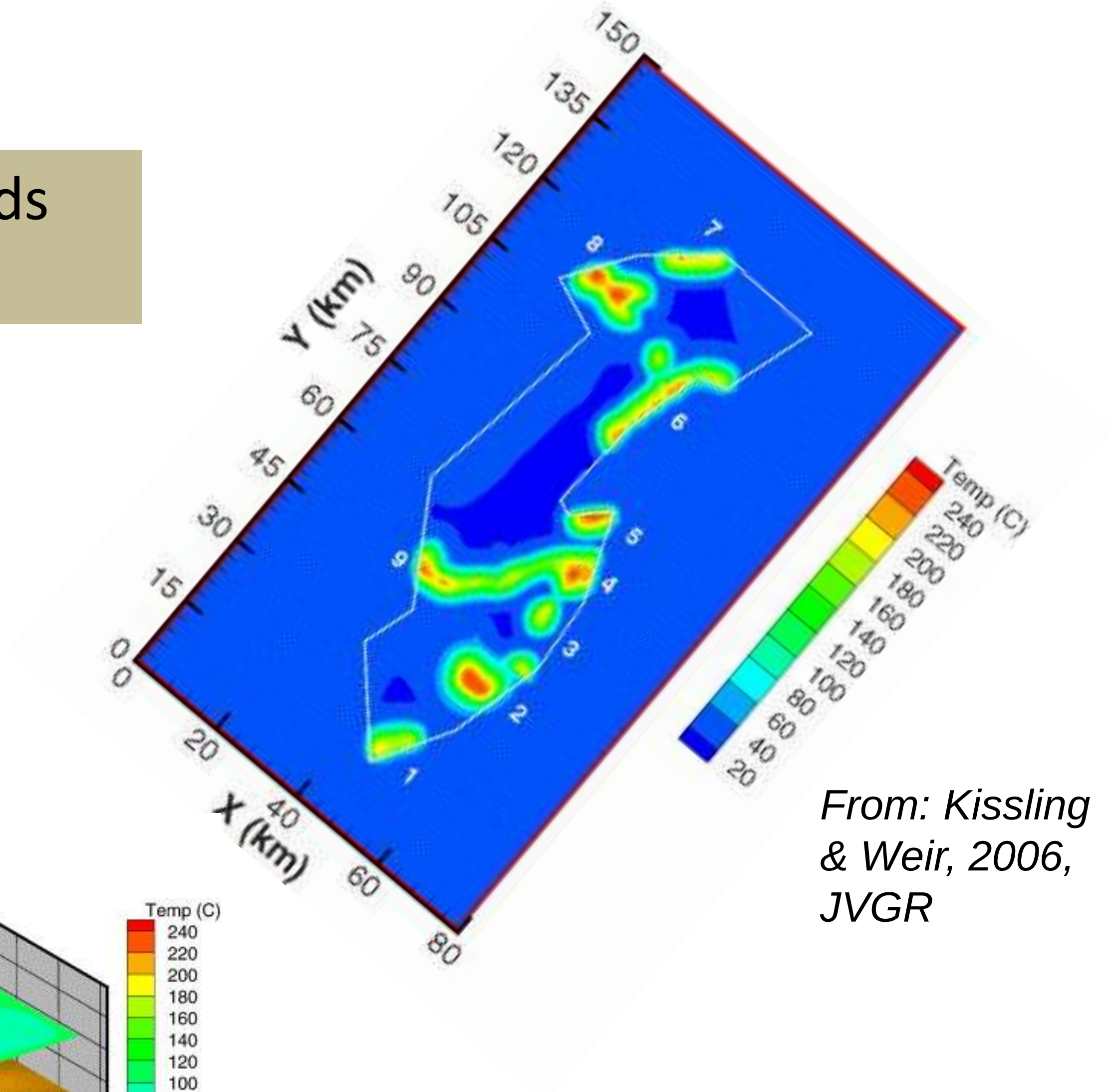


Basic Conceptual Model: Resistivity changes

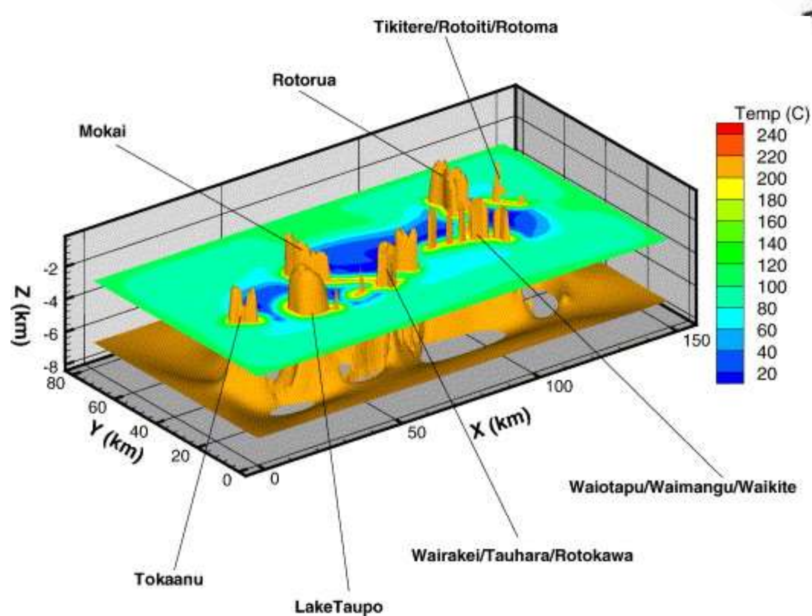


Basic Conceptual Model: Seismicity recordings

How geophysics methods image the subsurface



From: Kissling & Weir, 2006, JVGR



In summary:

Team of geoscientists prove resource

↓

Drilling

↓

Engineers develop pipelines, power plant, etc

↓

Reservoir modelling helps manage resource

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