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Geological Mapping of a Composite Rhyolitic Sill Intrusion, Þeistareykir Geothermal Field, Northeast Iceland

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INTRODUCTION

GEOLOGICAL CONTEXT

- Partial melting of altered basaltic crust produces rhyolitic magma at central volcanoes
- Shallow rhyolitic intrusions are key elements in high-temperature geothermal systems

ÞEISTAREYKIR CASE STUDY

- A shallow rhyolitic intrusion has been intersected by several wells (Fig. 1).
- 3D geological modeling is used to define intrusion geometry, size, and petrophysical characteristics relevant to permeability and geothermal fluid flow (Figs. 2-6).

BROADER IMPLICATIONS

1) GEOTHERMAL ENERGY RELEVANCE

- Margins of rhyolitic intrusions are often permeable and store fluids
- Valuable resource for geothermal power generation

2) VOLCANIC HAZARD RELEVANCE

- Shallow rhyolitic intrusions can trigger volcanic eruptions
- Understanding magma emplacement improves knowledge of volcanic systems and supports hazard mitigation

METHODS

PETREL SOFTWARE (2017 VERSION)

WELL LOGS

- Boundaries of rhyolitic intrusions are defined by high gamma count in well logs (positively correlated with SiO_2 content; Fig. 1).
- Correlated across well logs to determine depth, thickness, and extent of intrusions (Fig. 1).

FAULT MODEL

- 3D fault model built on from existing stratigraphic model and major faults from topographic data (Fig. 2).
- Faults extended vertically to create fault planes (Fig. 2).

INTERPOLATION

- Rhyolitic intrusion extent interpolated based on well log horizons and fault model (Figs. 3-4).
- Petrophysical property models of intrusions were created by extrapolating gamma and porosity logs to estimate silica content and porosity respectively. These properties are used as proxies for identifying potential permeable zones along intrusion margins (Figs. 5-6).

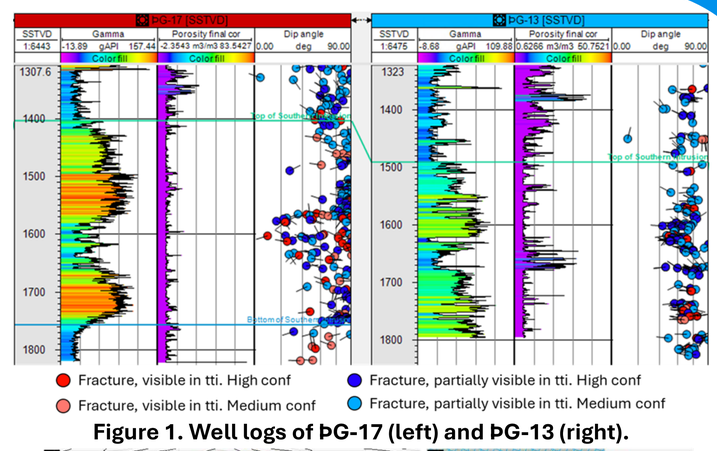


Figure 1. Well logs of ÞG-17 (left) and ÞG-13 (right).

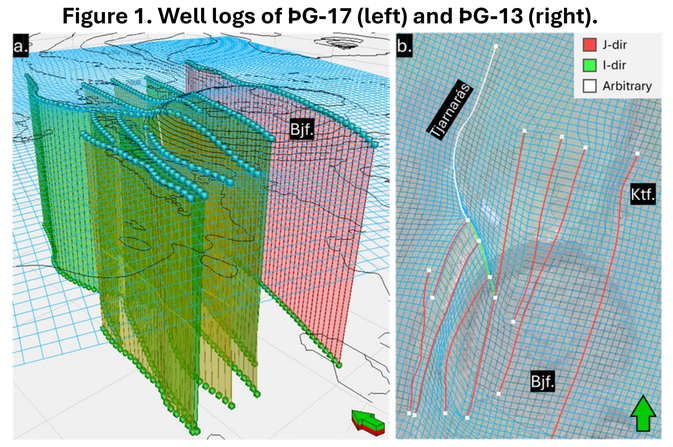


Figure 2. 3D Fault Model.

RESULTS

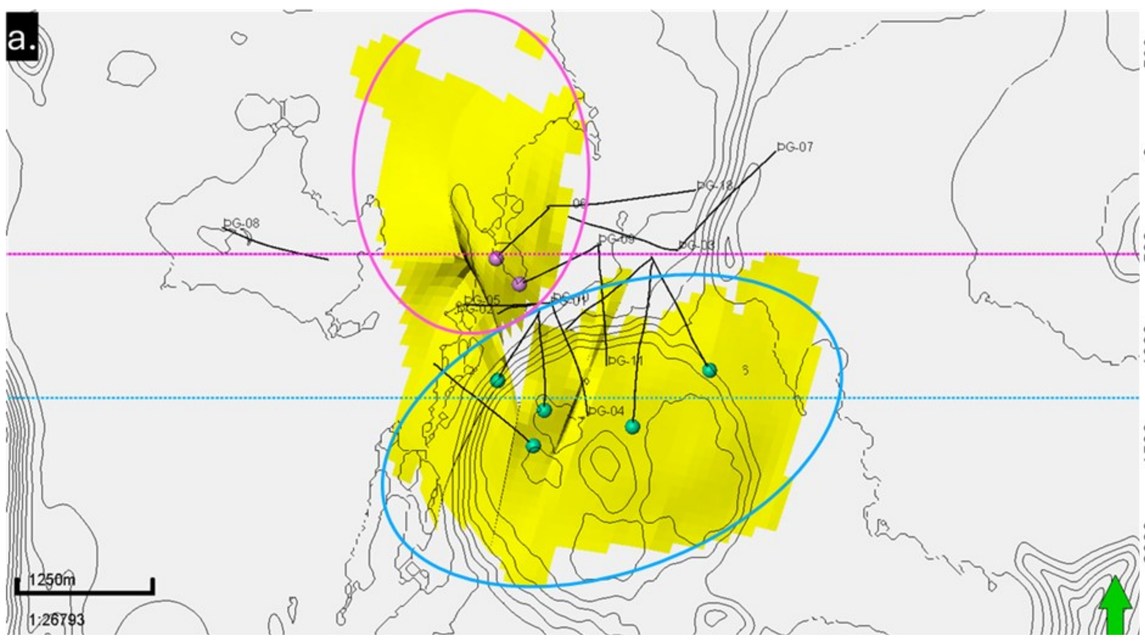


Figure 3. Map view of well locations and extent of rhyolitic intrusions in Þeistareykir geothermal field.

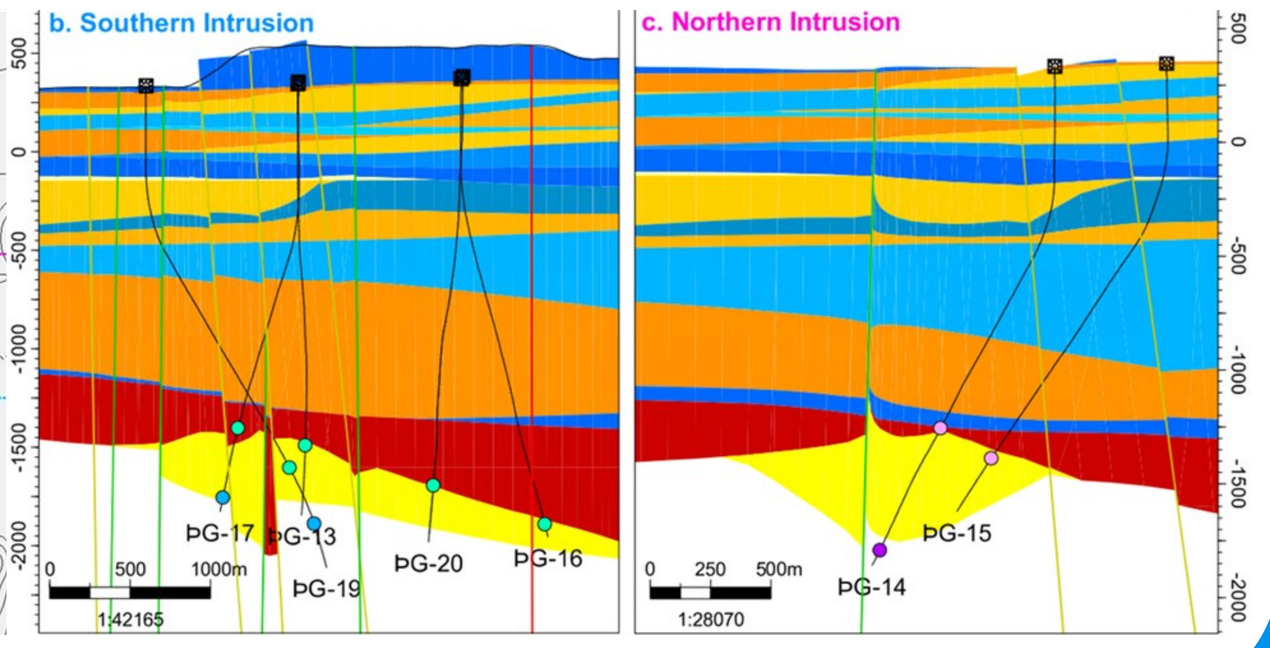


Figure 4. Cross-sections of interpreted intrusion geometry constrained by fault model and well logs.

INTERPRETATION

TWO SEPARATE AND DISTINCT INTRUSIONS

- Well ÞG-05b served as the clear divider between the two intrusions, with ÞG-05 and ÞG-04 also lacking indicators of an intrusion

NORTHERN INTRUSION (FIGURES 4C AND 5)

- Intersected by wells ÞG-14 and ÞG-15
- Both wells present a clear upper boundary of the intrusion, but only ÞG-14 presents a clear lower boundary
- Upper boundary at approximately 1200 m depth, 2 x 2 km area, and up to 800 m thick
- Possible overlap with Southern Intrusion
- Silica content varies between sublayers of the intrusions, with gamma values ranging from 50-80 API

SOUTHERN INTRUSION (FIGURES 4B AND 6)

- Intersected by wells ÞG-13, ÞG-17, ÞG-19, and ÞG-20
- Indicators of a lower boundary of the intrusion only found in ÞG-17 and ÞG-19
- The bottoms of wells ÞG-13 and ÞG-20 are thought to end in the intrusion itself
- Upper boundary at approximately 1400 m depth, 3.7 km (E-W) x (2.2) km N-S, 600 m thick
- ÞG-17 located in the centre of wells intersecting the intrusive body and has exhibits the highest gamma values
- ÞG-17 thought to be centre of intrusive body
- Silica content varies both vertically and horizontally, with gamma values ranging from 40-100 API

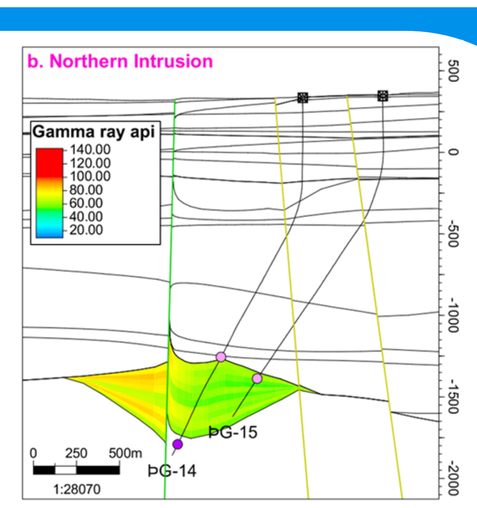


Figure 5. Northern Intrusion Petrophysical Model.

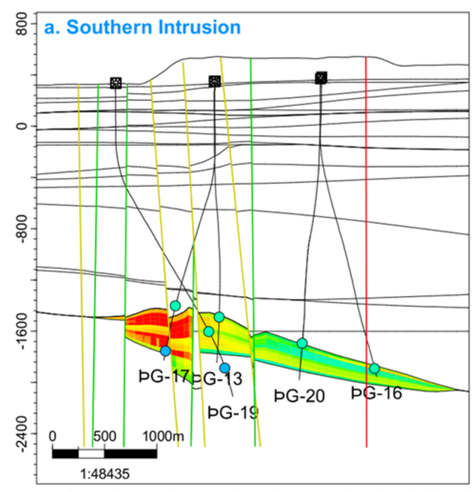


Figure 6. Southern Intrusion Petrophysical Model.

CONCLUSION

CURRENT MODEL

- The model presented represents a theoretical working interpretation of the subsurface geology at Þeistareykir.
- Current understanding is limited to available drill paths, well logs, and previous field surveys, and the geometry of the intrusions should therefore be considered preliminary.

FUTURE DRILLING

- Future drilling should target the hypothesised margins of these intrusions, where increased fracturing and permeability may enhance geothermal steam production.
- Additional wells in these areas will also help refine and validate the geological model.

SILL EMPLACEMENT MECHANISMS

- Emplacement of the rhyolitic sills was likely controlled by the local stress field, which influenced both the geometry of the intrusions and the surrounding fracture network.

FUTURE WORK

- Further investigation of the contact boundaries between intrusions and host rock, combined with additional geophysical surveys and drilling, will help improve understanding of the geothermal system and refine the working model.

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