Unusual Drilling-Induced Stress Features - What To Do With You?

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ABSTRACT

Drilling-induced features identified from borehole image logs provide direct constraints on in-situ stress orientations and magnitudes. Classic features such as drilling-induced tensile fractures and borehole breakouts have been extensively documented since the 1980s, predominantly in sedimentary rocks within hydrocarbon reservoirs. More recently, petal-centreline fractures have also been recognised. Their formation has been modelled as functions of stress state, borehole trajectory, rock properties, and drilling fluid parameters. In high-temperature geothermal borehole images of the rifted Taupō Volcanic Zone, Aotearoa New Zealand, we commonly identify a range of non-typical drilling-induced features alongside typical features. Those wells intersect diverse lithologies including silicic to andesitic volcanic and volcaniclastic rocks, and metasedimentary basement. We hypothesise that these unusual features arise from the interaction of drilling with complex rock textures, mechanical anisotropy, natural fractures and veins, fault density, thermal stress, and variations in hydrothermal alteration. Globally, recent studies have modelled some non-typical features on a well-by-well basis to derive stress constraints. With the increasing availability of borehole image data in geothermal environments, we aim to engage the broader geoscience community in recognising and interpreting these unusual features. They hold promise for refining stress and permeability models critical for drilling stable and productive geothermal wells. This understanding is vital for optimising conventional geothermal development and advancing next-generation systems such as superhot and enhanced geothermal systems.

1 INTRODUCTION

Understanding the present-day stress state is critical in geothermal settings to 1) understand why some fractures are permeable, 2) guide stimulation strategies, and 3) plan drilling stable boreholes. In addition, differentiating natural from induced features is critical in identifying which fractures are permeable.

Since the early 1980's, drilling induced stress features observed in borehole images, mainly borehole breakouts (BOs) and drilling-induced tensile fractures (DITF), have been used as indicators of stress orientation and for stress magnitude estimations (Rajabi et al., 2025; Ziegler, et al., 2024; Zoback et al., 2003, and references therein). Early interpretations were primarily developed in hydrocarbon wells within sedimentary rocks, as well civil engineering and storage applications across various rock types, though predominantly sedimentary and metamorphic. The World Stress Map (WSM) technical report (Rajabi et al., 2025) provides interpretation guidelines and a quality ranking system for BOs and DITFs. However, recent studies (e.g., Ask et al., 2024) have highlighted features that deviate from these established interpretations, and uncertainties in feature delineation arising from the subjectivity of the interpretation within the guidelines.

Borehole images from volcanic rocks and high-temperature geothermal reservoirs are increasingly common. While many stress features align with existing guidelines, we found that in borehole images of the Te Ahi Tupua/ Taupō Volcanic Zone (Aotearoa New Zealand), many do not. We hypothesise that discrepancies arise from the interaction of drilling processes (in both vertical and deviated boreholes) with complex rock textures, mechanical rock anisotropy and varied hydrothermal alteration that affect rock properties, interaction with natural fractures and veins, as well as active faults and thermal stress. Barton and Zoback (2002) wrote an important section about pitfall of interpretation of DITF and noted “Misinterpretation of wellbore images can lead to significant error in geomechanical modeling, and hence to inappropriate analyses of reservoir”. Those pitfalls are still of interest today globally (e.g., Schöpfer et al., 2024). Currently, a thorough assessment of whether borehole image features are natural, induced or enhanced takes time and potential errors can result in misinterpretation of fracture permeability and uncertain geomechanical models. Beyond known pitfalls, we question whether the combination of high-thermal stress conditions and high rock heterogeneities require additional guidelines for the robust interpretation of natural and stress features. The correct identification of fractures will become increasingly relevant for future automated feature detection using machine learning (Lee et al., 2025; Mamode et al., 2025).

This paper first discusses published examples of various stress features, some pitfalls and uncertainties in interpreting borehole images. Then, the paper shows examples of unusual features from geothermal borehole images in the TVZ. We aim to collaborate with the geothermal community to discuss: 1) have others observed similar features?; 2) how should these features be classified?; 3) can unusual features be used to determine the stress tensor — and if so, how?; and 4) if no such resource exists, should we develop a catalogue of numerical models that simulate the conditions under which these features form?

2 BRIEF OVERVIEW OF IN-SITU STRESS FEATURES IDENTIFIED FROM BOREHOLE IMAGES, SOME PITFALLS AND UNCERTAINTIES

2.1 Classifications of "usual" standard in-situ stress features and natural fractures

2.1.1 Borehole breakouts (BOs) and drilling-induced tensile fractures (DITFs)

The WSM provides guidelines for characterising two well-established stress indicators observed in borehole images: borehole breakouts (BOs) and drilling-induced tensile fractures (DITFs) (Heidbach et al., 2016; Rajabi et al., 2025) (Figure 1). These features form in response to stress concentrations around the borehole as material is removed. These stress features occur when the stresses around the borehole exceed that required to cause compressive failure of the borehole wall (BO) or to cause tensile failure of the wellbore wall (DITF) (Zoback et al., 2003). In vertical boreholes drilled through isotropic, intact rock formation where a principal stress direction is also vertical, BOs and DITFs can be used to infer the orientation of the minimum (S_{hmin}) and maximum (S_{Hmax}) horizontal stress, respectively. Where borehole deviation, stress conditions, and rock properties remain constant, stress features orientations are expected to be constant along the borehole. The WSM assigns quality rankings to stress orientations derived from BOs and DITFs using circular statistical analysis. These rankings incorporate the number of features, their cumulative length, and the standard deviation of their orientations.

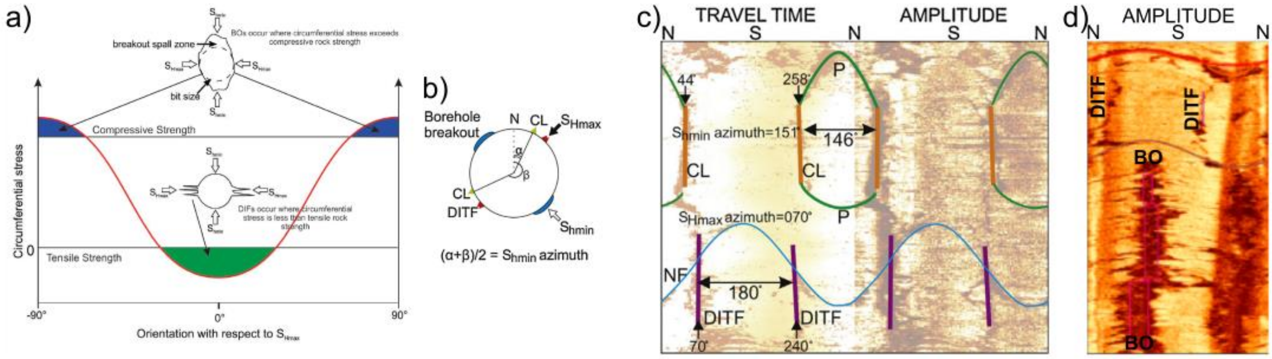


Figure 1: Usual in-situ stress features. a) Schematic cross-sections of BOs and DITFs with respect to the circumferential stress around the borehole (Rajabi et al., 2025). b) Schematic cross-section showing BO, DITF and PCF. c) Example of DITF and PCF (Massiot et al., 2015). d) Example of BO and DITF (this study).

However, in zones where stress orientations rotate, interpreting these features becomes more challenging—despite the importance of such rotations for understanding fracture permeability. Stress rotations are commonly observed near mechanically weak zones or recently reactivated fractures (Barton et al., 2009; Massiot et al., 2015, 2019; McNamara et al., 2019; Ziegler et al., 2024). As Ziegler et al. (2024) noted, identifying stress rotations and estimating material contrast, especially in the absence of supporting petrophysical core or downhole measurements, inevitably involves uncertainty. Furthermore, Schoenball and Davatzes (2017) demonstrated that in some cases, the standard deviation of stress indicators reflects tectonic stress field heterogeneity, rather than the quality of the stress measurement as defined by WSM criteria.

Local stress rotations near fractures have been linked to permeability. Wallis et al. (2023a, b) proposed a new category of DITF, namely 'interacting DITF', that tend to form on or between other discontinuities especially near non-haloed conductive fractures, occurring at a wider range of azimuths and tilts than axial and en-echelon DITF. High frequency of those interacting DITF was correlated with three quarters of permeable zones. In the Wairakei Geothermal Field (TVZ, New Zealand), 'active' natural fractures, where DITF rotate as they approach the fracture that has been interpreted as recently slipped so that the stress field is locally disturbed, were preferentially located in permeable zones (McNamara et al., 2019).

2.1.2 En-echelon DITF and BO

When one principal stress direction is inclined relative to the borehole axis, such as in a deviated well where a principal stress remains vertical, stress features may form at an angle rather than parallel to the borehole axis, and the stress feature azimuth can vary as a function of borehole deviation (Lai et al., 2018; Nian et al., 2016; Peska and Zoback, 1995; Thorsen, 2011), especially in normal faulting regimes (Wallis et al., 2023b). These en-echelon features typically appear as short, straight, inclined segments while in other cases, they may form as curved segments with opposite curvature on opposing sides of the borehole wall (Barton et al., 2009). In extreme cases, such as those documented by Nelson et al. (2005), transverse (horizontal) DITFs can appear as non-planar, bimodal fracture segments confined to the tensile region of the borehole wall. In the KTB pilot and the GPK1 boreholes (Germany and France, respectively), Brudy and Zoback (1999) inferred that the local en-echelon DITF morphology, superimposed on dominant axial DITF morphology, were caused by slip along faults intersecting the borehole. However, McNamara et al. (2015) observed borehole-axial DITFs in three deviated wells (16°-23°) within the Rotokawa Geothermal Field (TVZ, New Zealand), each drilled in different azimuth. This suggested either a coincidental alignment of the stress tensor inclination with each well trajectory, or another process. Clarifying this process is essential before using the DITF inclination to constrain the stress tensor.

2.1.3 Incipient BO and DITF

In zones where stress conditions and rock properties are near the threshold for DITF or BO formation, stress features may appear incipient, i.e., partially developed and less distinct. Incipient BO can form as four vertical thin cracks at the edges of a potential breakout zone, where the failed material has not yet spalled into the borehole (Barton et al., 2009). These features may resemble narrow vertical “fractures” that can be mistaken for DITFs, particularly when only portions of the incipient BO are visible. Distinguishing between incipient BOs and DITFs is especially challenging in regions with stress rotations or where stress features are discontinuous along the borehole.

2.1.4 Natural fractures: full, partial and non-planar sinusoids

In a perfectly circular borehole with a smooth wall, a planar fracture will appear as a sinusoidal trace on borehole image logs (Figure 1). However, such ideal conditions are rarely encountered in practice. Borehole image analysts have long recognised that fractures may appear non-planar due to various factors. For example, rock fragments at the top and bottom of the sinusoid may break out ('spalling') resulting in irregular fracture traces (Paillet et al., 1985). Additionally, fractures may be inherently non-planar, such as those associated with unresolved dilational fault jogs (Davatzes and Hickman, 2010). Natural fractures that strike parallel to the maximum horizontal stress (S_{Hmax}) can be particularly difficult to distinguish from closely spaced concave and convex petal-centred features (PCFs) (see Section 2.2.1), further complicating interpretation.

2.2 Less standard stress-related features

2.2.1 Petal Centreline Fractures

Petal Centreline Fractures (PCFs) are a lesser-known type of drilling-induced fracture, commonly observed in the TVZ, where elevated thermal stresses and a normal to strike-slip faulting regime promote tensile failure in boreholes. PCFs initiate below the drill bit and are subsequently intersected by the borehole (Davatzes and Hickman, 2010; Kulander et al., 1990). Observations from oriented drill cores (Kulander et al., 1990; Li and Schmitt, 1998; Schmitt et al., 2012) and borehole images (Ask et al., 2024; Davatzes and Hickman, 2010; Hehn et al., 2016; Massiot et al., 2015; McNamara et al., 2019) show that PCFs are consistent with stress orientations inferred from BOs and DITFs. PCF development is facilitated by high mud and pore pressure, as well as irregularities at the bottom of the borehole (Li and Schmitt, 1998). Despite their prevalence in geothermal borehole images, the WSM does not currently provide guidelines for interpreting PCFs or assign a quality ranking. Ask et al. (2014) proposed three methods for interpreting PCF (alongside BO and DITF) in crystalline rocks, suggesting that the orientations of drilling-induced fractures are largely independent of the interpretation method. However, the choice of method for delineating BO can result in orientation differences of up to 10°.

In some cases, DITFs occurring on opposite sides of the borehole (180° apart) may merge into centerline features with slightly offset orientations, without displaying distinct petal fractures (Davatzes and Hickman, 2010). Nested petal fractures with a single set of centerlines can increase uncertainty in distinguishing natural partial fractures from PCFs. Petal fractures can appear concave or convex, and in some instances, both geometries are linked to the same centreline (Figure 1c; Davatzes and Hickman, 2010). When concave and convex petal fractures occur on opposite sides of the boreholes, they can resemble the geometry of a non-planar natural fracture.

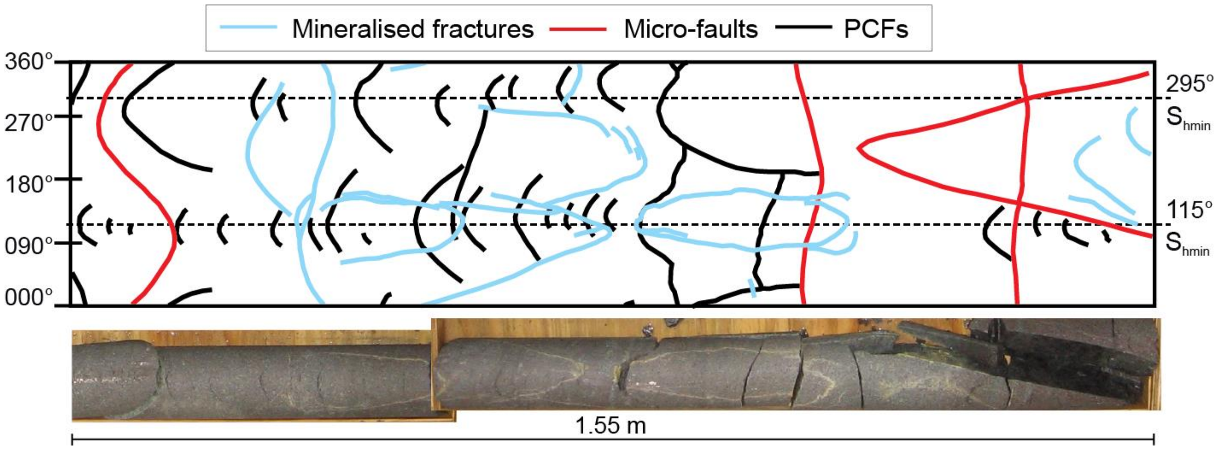


Figure 2: Fractures traced on an andesite drill core from the Rotokawa Geothermal Field (New Zealand) oriented using an acoustic image. The core shows PCFs, fractures filled with hydrothermal minerals, and micro-faults that have slickenslides and/or interacted with PCF. Adapted from McNamara et al. (2015).

2.2.2 Drilling-enhanced fractures

Drilling-enhanced fractures form where pre-existing natural fractures or foliation planes are preferentially opened, either in pure tension or in tensile shear, within the tensile regions of the borehole (Barton et al., 2009). Unlike en-echelon DITFs, these fractures are better represented by flexible sinusoidal traces that fit short, visible segments. Their strike often aligns closely with S_{Hmax} (Barton et al., 2009), and their orientations have been found to be consistent with those of DITFs and BOs (Seithel et al., 2015). However, drilling-enhanced fractures cannot be used to estimate stress magnitudes like inclined DITFs, because their inclination relative to the borehole axis is governed by the orientation of the pre-existing plane of weakness (Barton et al., 2009).

In our interpretations of TVZ geothermal images, we have broadened the definition of enhanced fractures to deal with features that are not clearly either stress-induced or natural but may provide low-confidence indicators of stress orientations. These enhanced features include cases where: 1) a single sinusoid fits both limbs of a feature, 2) a curved partial sinusoid fits one limb and its apex, 3) a feature resembles a PCF but lacks clear centerlines. This interpretation is strengthened when such features occur near a well-defined axial DITF or PCF. This pragmatic approach allows for rapid differentiation between natural partial fractures that may be permeable and those that appear only due to drilling processes, while limiting feature type categories.

2.2.3 Other unusual features

Several features observed in borehole image logs do not strictly conform to the classic definitions of DITFs or BOs, particularly in sedimentary settings that have been extensively studied. For example, J-shaped DITF have long been documented (Lofts and Bourke, 1999), while other morphologies, such as feather-shaped and transitional states (“V-shaped”, and “M-shaped”), have been numerically modelled to form under a strike-slip stress regime and varying well trajectories (Song et al., 2024). In the Kupua Depression (China), Nian et al. (2016) document a range of drilling-induced fracture morphologies occurring over short intervals, including: classic DITF, discontinuous symmetrical sinusoids, discontinuous asymmetrical sinusoids, and discontinuous asymmetrical curves, independent and associated with natural fractures. Despite their varied geometries, the strike of these curved drilling-induced fractures was generally found to align with the S_{Hmax} orientation.

The interaction of natural fractures, layering, induced features, and enhanced features under complex drilling conditions, such as high- and low-side furrows (keyseats) or spiral borehole shapes, can result in complex geometries that challenge interpretation (e.g., Davatzes and Hickman, 2010).

2.3 Role of anisotropy

Anisotropic rocks are common in geothermal fields, e.g., layered ignimbrites, flow-banded lavas, sediments, and foliated metamorphic rocks. Transverse anisotropy can significantly alter stress concentrations around the borehole, leading to the formation of asymmetrical en-echelon tensile fractures (Jia and Schmitt, 2014). We note that the theoretical tensile trajectories presented by (Jia and Schmitt, 2014) are curved enough that the features resemble drilling-enhanced fractures, complicating interpretation. Recent numerical modelling of failure in anisotropic rocks shows that failure along weak planes can distort the stress field around the borehole, causing breakout orientations to misrepresent S_{hmin} (Wang et al., 2022, 2023). These effects have been studied in shales by the hydrocarbon industry (e.g., Heng et al., 2021) where extreme cases in highly deviated wells with weak bedding planes can result in quadruple BOs (Kowan et al., 2021). This extreme case may not be applicable to geothermal reservoirs which are typically hosted in stronger rock types.

2.4 Influence of Temperature

The preferential occurrence of drilling-induced features in geothermal wells is strongly influenced by temperature differences between the borehole fluid and the formation (ΔT) (Brudy and Zoback, 1999; Zoback et al., 2003). In the Rotokawa Geothermal Field (New Zealand), laboratory studies on andesite have shown that thermal fracturing can be induced in low-strength rock by instantaneous cooling of as little as 15–60°C (Siratovich et al., 2015). During drilling, ΔT commonly exceeds 150°C at production depths, making DITFs and PCFs more likely to form than BOs due to the enhanced tensile stress around the borehole (Davidson et al., 2012).

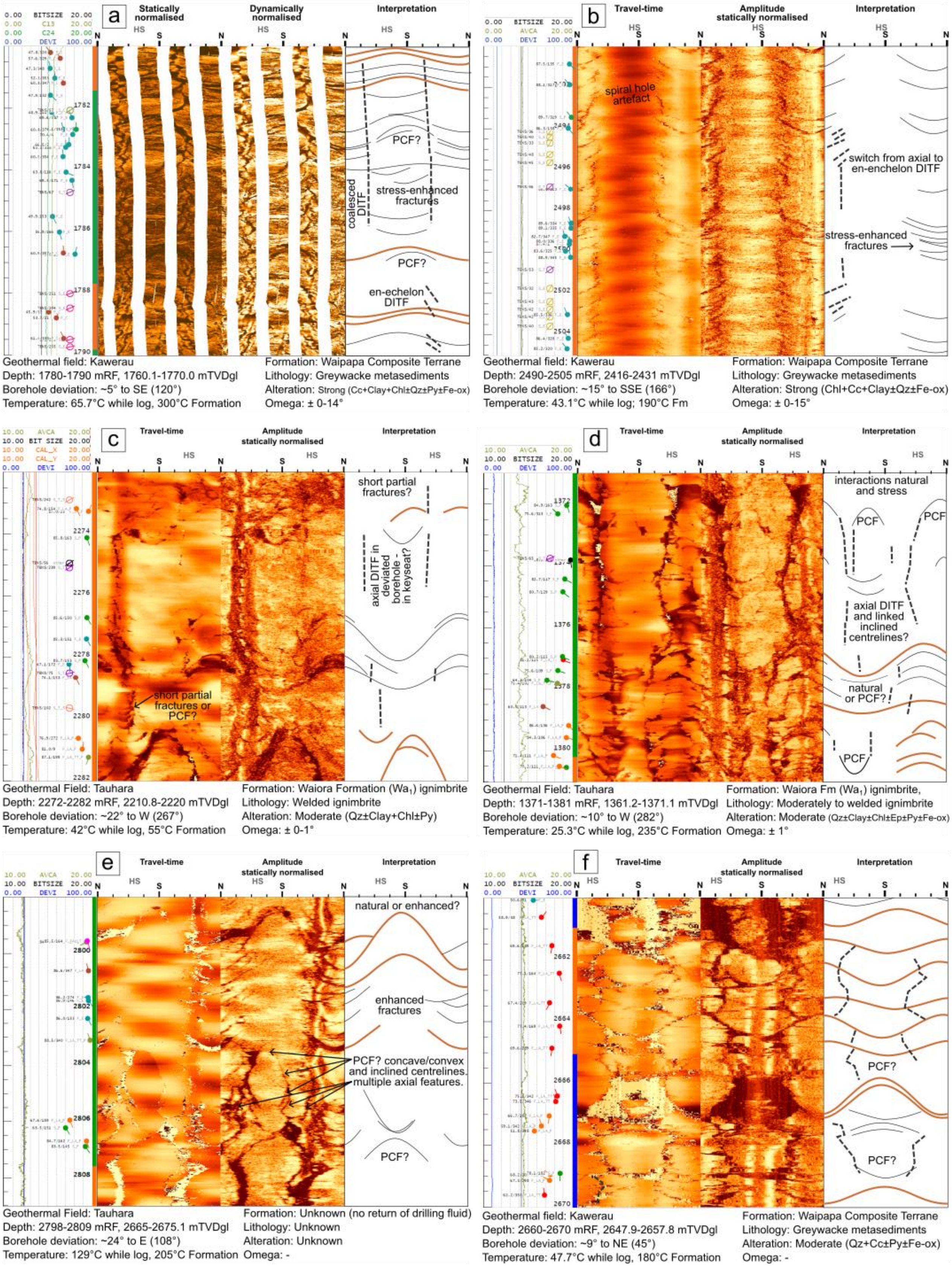
Unusual thermal stress-related features could lead to misinterpretations of stress orientations. At Soultz (France), thermal elongations resembling BOs, but aligned with DITF orientation, were inferred to result from a pervasive, cooling-induced tensile microcracking prior to macroscopic failure (Bérard and Cornet, 2003). In well RN-15/IDDP-2, which reached 4.5 km depth with estimated formation temperature of 536-549°C, modeling showed that the high thermal flux produced tortuous pathways for induced fractures, which could explain caving perpendicular to the expected BO direction (Peter-Borie et al., 2018). However, this modeling was limited by long computational times, and future studies were recommended to adopt a 3D modelling approach. As geothermal exploration advances into superhot drilling, modelling the effects of thermal stress will become increasingly important for both well planning and data interpretation (Reinsch et al., 2017; Jones, 2024).

3 EXAMPLES FROM TE AHI TUPUA (TVZ), NEW ZEALAND

We present examples of unusual features or features difficult to classify from both acoustic and resistivity images obtained in geothermal boreholes of the TVZ (Figure 3). Different types of unusual features occur on various panels of Figure 3 and are listed in Table 1, alongside the challenges they present. Other examples are available by contacting the authors.

Table 1: Unusual feature types and questions regarding their classification and use. The "Panel #" refers to the panel letter on Figure 3 where the feature type is shown.

Type of unusual feature	Panel #
A) DITF angle to borehole axis.	
A1- DITF switch from axial to en-echelon over short distance, without clear fault or fracture nearby that would cause a stress rotation, nor change in lithology.	a, b
A2 - Axial DITF in vertical and deviated wells of varied azimuth.	a, b, c, d
B) Distinguishing between natural fractures, enhanced fractures and stress features.	
B1- PCFs: classification when centrelines are short or inclined, or with only one centreline, or with one centreline coinciding with one of the DITF pair. Should they be included in the World Stress Map? Which uncertainty/quality rankings? Are there conditions that favour S_P over S_T?	c, d, e, f, g, k
B2 - Differentiating between non-planar fractures and combination of convex/concave PCFs; differentiating between PCFs, partial natural fractures and spalling near the apex of a continuous sinusoid fracture.	a, d, f, i, j, k
B3 - Can stress-enhanced natural fractures be reliably used as stress orientation indicators? Are they worth delineating, at least to distinguish from potentially permeable fractures?	a, b, c, e, h, j, l
B4 - Multiple axial features laterally: difficulties in classifying; pitfall in confusing with drilling artefacts; and uncertainty of derived stress orientations.	d, e
B5 - Are "pancake" features stress-enhanced natural fractures? possible role of host rock anisotropy?	l
C) Interactions between features: induced, natural fracture, enhanced fracture and layers. What can be learned from those zones about rock properties, tectonics and permeability?	a, c, d, e, f, l
D) Non-circular borehole artefacts (keyseat/furrows in deviated wells, spiral hole): do they affect where the stress-induced features form? does it affect confidence levels?	b, c, e, h, i



Geothermal field: Kawerau
Depth: 1780-1790 mRF, 1760.1-1770.0 mTVDgl
Borehole deviation: ~5° to SE (120°)
Temperature: 65.7°C while log, 300°C Formation

Formation: Waipapa Composite Terrane
Lithology: Greywacke metasediments
Alteration: Strong (Cc+Clay+Chl±Qz±Py±Fe-ox)
Omega: ± 0-14°

Geothermal field: Kawerau
Depth: 2490-2505 mRF, 2416-2431 mTVDgl
Borehole deviation: ~15° to SSE (166°)
Temperature: 43.1°C while log; 190°C Fm

Formation: Waipapa Composite Terrane
Lithology: Greywacke metasediments
Alteration: Strong (Chl+Cc+Clay±Qz±Fe-ox)
Omega: ± 0-15°

Geothermal Field: Tauhara
Depth: 2272-2282 mRF, 2210.8-2220 mTVDgl
Borehole deviation: ~22° to W (267°)
Temperature: 42°C while log, 55°C Formation

Formation: Waiora Formation (Wa_1) ignimbrite
Lithology: Welded ignimbrite
Alteration: Moderate (Qz±Clay+Chl±Py)
Omega: ± 0-1°

Geothermal Field: Tauhara
Depth: 1371-1381 mRF, 1361.2-1371.1 mTVDgl
Borehole deviation: ~10° to W (282°)
Temperature: 25.3°C while log, 235°C Formation

Formation: Waiora Fm (Wa_1) ignimbrite,
Lithology: Moderately to welded ignimbrite
Alteration: Moderate (Qz±Clay±Chl±Ep±Py±Fe-ox)
Omega: ± 1°

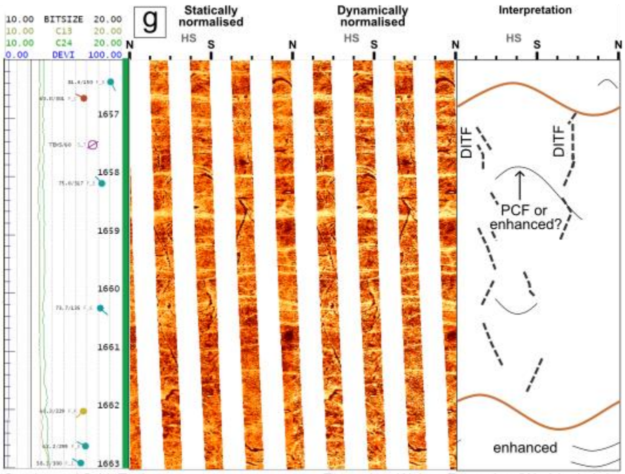
Geothermal Field: Tauhara
Depth: 2798-2809 mRF, 2665-2675.1 mTVDgl
Borehole deviation: ~24° to E (108°)
Temperature: 129°C while log, 205°C Formation

Formation: Unknown (no return of drilling fluid)
Lithology: Unknown
Alteration: Unknown
Omega: -

Geothermal field: Kawerau
Depth: 2660-2670 mRF, 2647.9-2657.8 mTVDgl
Borehole deviation: ~9° to NE (45°)
Temperature: 47.7°C while log, 180°C Formation

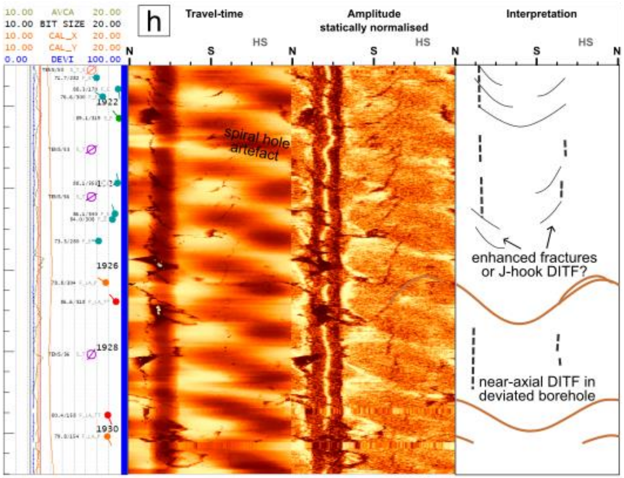
Formation: Waipapa Composite Terrane
Lithology: Greywacke metasediments
Alteration: Moderate (Qz+Cc±Py±Fe-ox)
Omega: -

Figure 3: Example of unusual features from TVZ geothermal boreholes displayed unrolled. Refer to Table 1 for explanation of features. mRF: measured depth below rig floor in meters. mTVDgl: true vertical depth below ground level in meters. Alteration mineralogy, abundance and intensity from cuttings description (Qz: quartz; Chl: chlorite; Ep: epidote; Fe-ox: iron oxide; Py: pyrite). All reservoir pressures close to hydrostatic. 'HS': high side. Brown sinusoids: confidently interpreted natural fractures. Black sinusoids: uncertain planar feature (natural or drilling-induced). Dashed: drilling-induced stress-related feature.



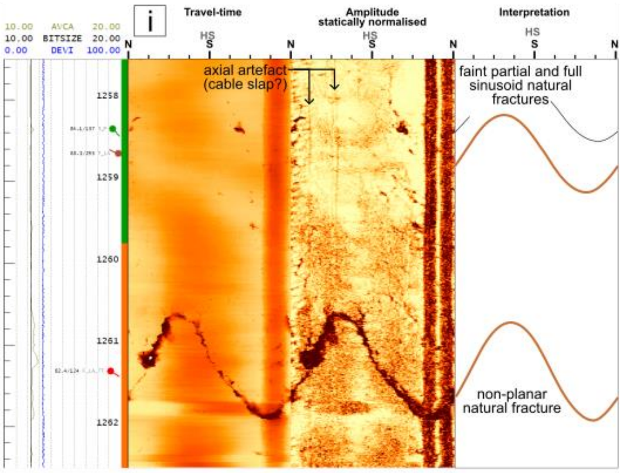
Geothermal field: Tauhara
Depth: 1656-1663 mRF, 1165.4-1172.4 mTVDgl
Borehole deviation: ~3° to SE (131°)
Temperature: 136.8°C while log, 130°C Fm

Formation: Waiora Formation (Wa_1) ignimbrite
Lithology: Partially-welded ignimbrite
Alteration: Strong (Chl+Cc±Clay±Qz±Py±Fe-ox)
Omega: ± 1°



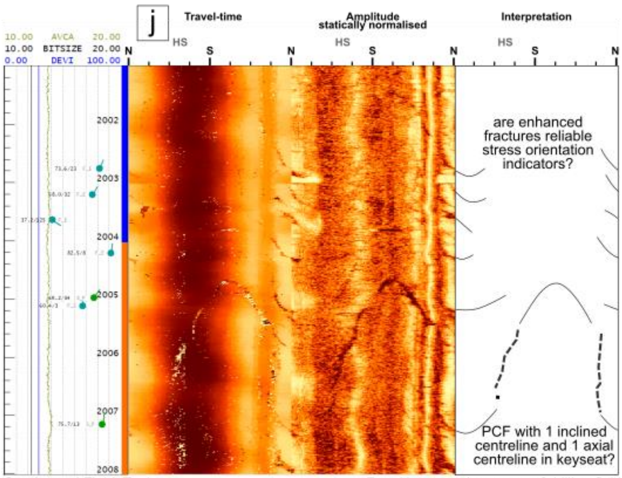
Geothermal field: Tauhara
Depth: 1921-1931 mRF, 1890.4-1899.4 mTVDgl
Borehole deviation: ~25° to W (281°)
Temperature: 38.5°C while log, 50°C Formation

Formation: Waiora Formation (Wa_1) ignimbrite
Lithology: Welded ignimbrite
Alteration: Moderate (Qz+Chl+Cc±Fe-ox)
Omega: ± 0-1°



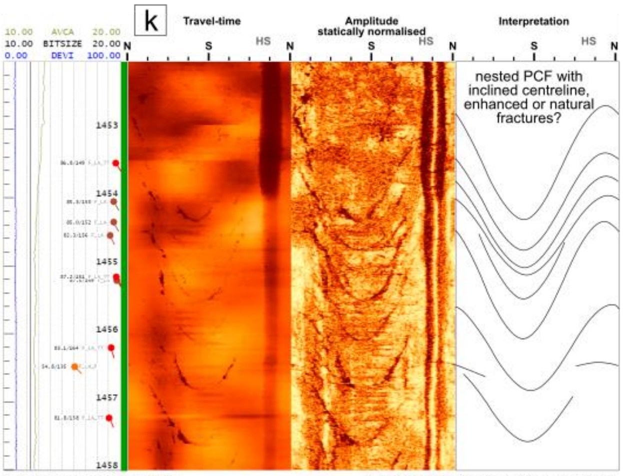
Geothermal Field: Tauhara
Depth: 1257.5-1262.5 mRF, 1226-1230.2 mTVDgl
Borehole deviation: ~32° to S (170°)
Temperature: 28.5°C while log, 250°C Formation

Formation: Middle Earth Rhyolite
Lithology: rhyolite
Alteration: Strong (Qz±Clay+Chl±Py)
Omega: -



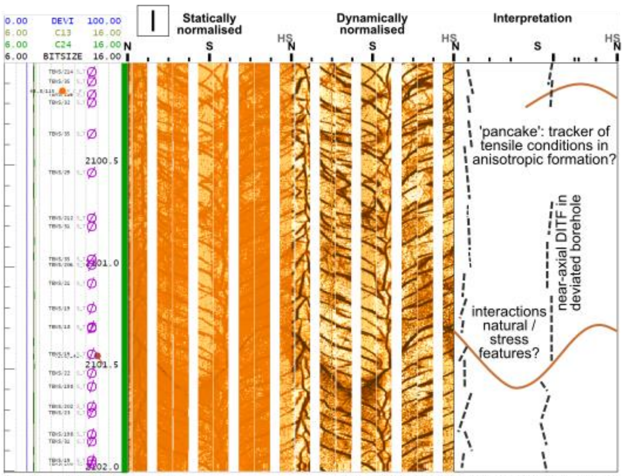
Geothermal Field: Tauhara
Depth: 2001-2008 mRF, 1747.7-1953.8 mTVDgl
Borehole deviation: ~29° to E (111°)
Temperature:135.5°C while log, 210°C Formation

Fm.: Unknown (no return of drilling fluid)
Lithology: Unknown
Alteration: Unknown
Omega: -



Geothermal Field: Tauhara
Depth: 1452-1458 mRF, 1442.6-1448.5 mTVDgl
Borehole deviation: ~9° to NW (301°)
Temperature: 30.7°C while log, 60°C Formation

Formation: Waiora Fm (Wa_1) ignimbrite
Lithology: Strongly welded ignimbrite
Alteration: Moderate (Qz+Clay±Chl±Cc±Ep)
Omega: -



Geothermal field: Wairakei
Depth: 2100-2102 mRF, 2018.3-2020.1 mTVDgl
Borehole deviation: 19° to NW (348°)
Temperature: 98.2°C while log, 260°C Formation

Formation: Rhyolite (Tahorakuri Formation)
Lithology: Rhyolite lava
Alteration: Moderate (Qz+Clay±Chl±Ep)
Omega: ± 0-26°

Figure 3 (continued)

4 CONCLUSION

The diversity and ambiguity of drilling-induced features observed in geothermal borehole images, particularly in the complex volcanic and altered lithologies of Te Ahi Tupua/ Taupō Volcanic Zone, highlight the need for a more nuanced approach to their interpretation. While the currently established guidelines for stress feature classification have served the geoscience community well, they can fall short in high-temperature, heterogeneous geothermal environments.

We believe that resolving the questions raised here, such as how to classify unusual features, whether and how they can inform stress models, and how to distinguish them from natural or enhanced fractures, will significantly reduce the time required for manual fracture picking and increase the interpretive value of these datasets. This is especially important as technology moves toward machine learning-assisted workflows and next-generation geothermal developments.

We are actively seeking collaborators: those who may have already encountered and resolved similar challenges, and those who are interested in working with us to develop new approaches. Whether through shared datasets, modelling tools, or collaborative interpretation, we welcome contributions that can help advance our collective understanding. Together, we can build a more robust framework for interpreting borehole images in geothermal systems.

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