Brady's Geothermal Field Computed Tomography Core Characterization

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Abstract: Enhanced geothermal systems (EGS) can expand energy production and be deployed in non-traditional areas. Optimizing injection in existing and prospective hydrothermal fields requires a thorough understanding of fluid and temperature distribution in fractured subsurface reservoirs. Limited public data exist for fractured hydrothermal systems, hindering the ability to develop optimized strategies for development of EGS systems. Brady's Geothermal Field in northwestern Nevada, which has been producing power since 1992, was the site of an early EGS demonstration aimed at testing potential production expansion in near-field unproductive wells (Akerley et al., 2020).

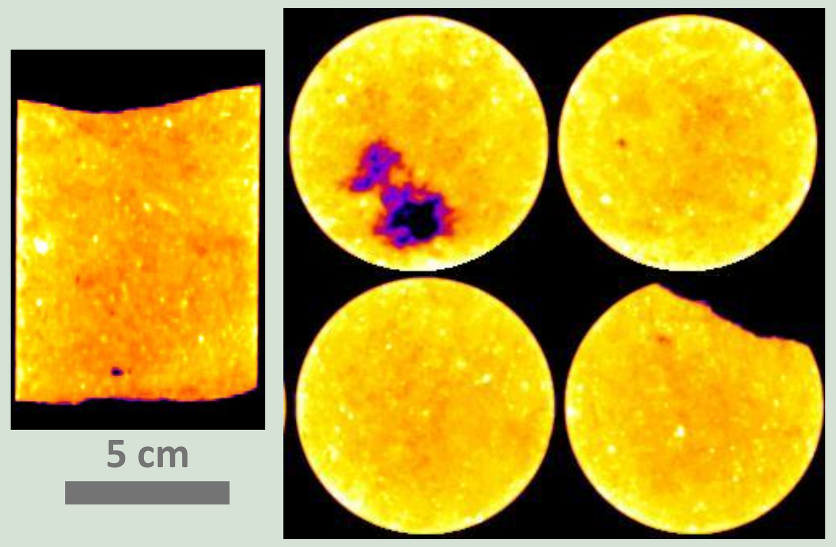
We present a publicly accessible database centered around multi-scale computed tomography (CT) imaging of samples from the BCH-03 well, supplemented by a wide range of supporting geological analyses (Brown et al., 2022). The data include detailed petrologic descriptions of core samples, CT scans at various resolutions, thin section photomicrographs, elemental abundance data from X-ray diffraction, velocity wave measurements, and helium porosimetry of the matrix.

Multiple data streams enable ground-truthing and validation of digitally derived porosity values with experimental porosimetry results and thin section estimates. This facilitates data upscaling for model development and testing, as well as correlation with adjacent well data to enhance field-scale understanding of subsurface fracture networks, connectivity, and controls on fluid flow.

This comprehensive dataset is available freely on NETL's Energy Data eXchange (EDX).

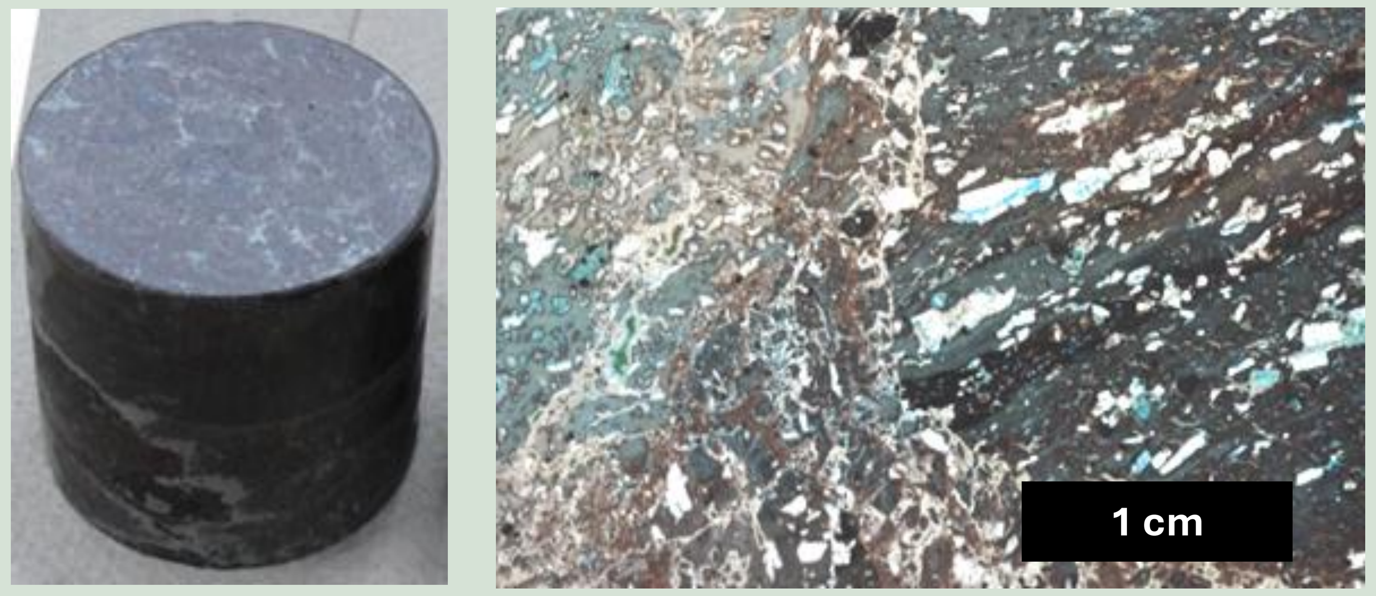
Demonstration Sample – 3,151 ft (960 m)

- **Medical CT Scanning:** Provides bulk density characterization in whole core.
- **Micro CT Scanning:** High resolution; allows for segmentation and quantification of porosity and many matrix mineral components and features.
- **Helium (He) Porosimetry**: Porosity values of 9.47%
- **Thin Section and Micro-CT Porosity Estimates:** 0.43-0.73%
- **Thin Section Analysis:** Provides context on lithology – in this case an andesitic volcaniclastic breccia previously flooded with geothermal fluids which caused alteration, and vesicle and breccia filling.
- **XRD Results:** Additional lithological and mineral component information; sodium-rich plagioclase feldspar (Na-plagioclase), with minor (<25%) amounts of quartz and minor to trace amounts of K-feldspar. Trace amounts of illite/mica, hematite, and magnetite.
- **Autolab:** Permeability measurements show values in the range of 1-2 mD.
- **Geophysics:** P and S wave velocities, ultrasonic anisotropy, and testing to determine the dependence of rock property values on temperatures.



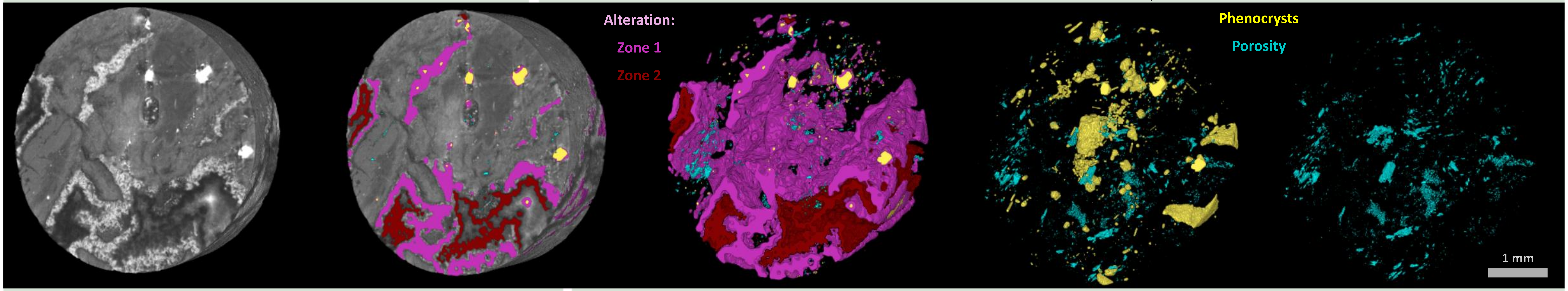
Left: False color medical CT scans (vertical cross-section through center of core and round cross-sections through core) show little high-level heterogeneity in sample.

Below: Thin section and micro-CT reveal heterogeneity on a much finer scale.



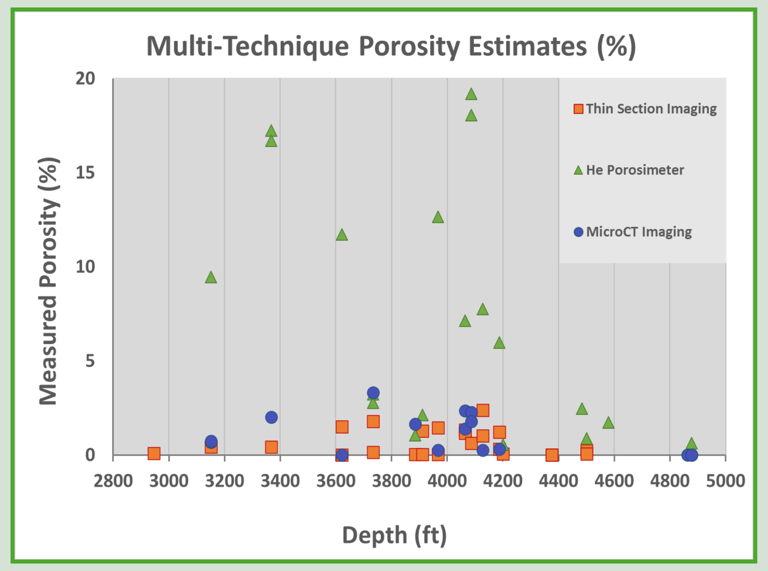
Left: Core from 3,151 ft (960 m) in well BCH-O3; Right: Backlit thin section of the same sample.

Below: Micro-CT (4.39 µm resolution) scan of sample from 3,151 ft (960 m). Dense phenocrysts (yellow), minor isolated pores (blue), and two distinct zones of secondary mineralization/alteration (red and pink) are highlighted.

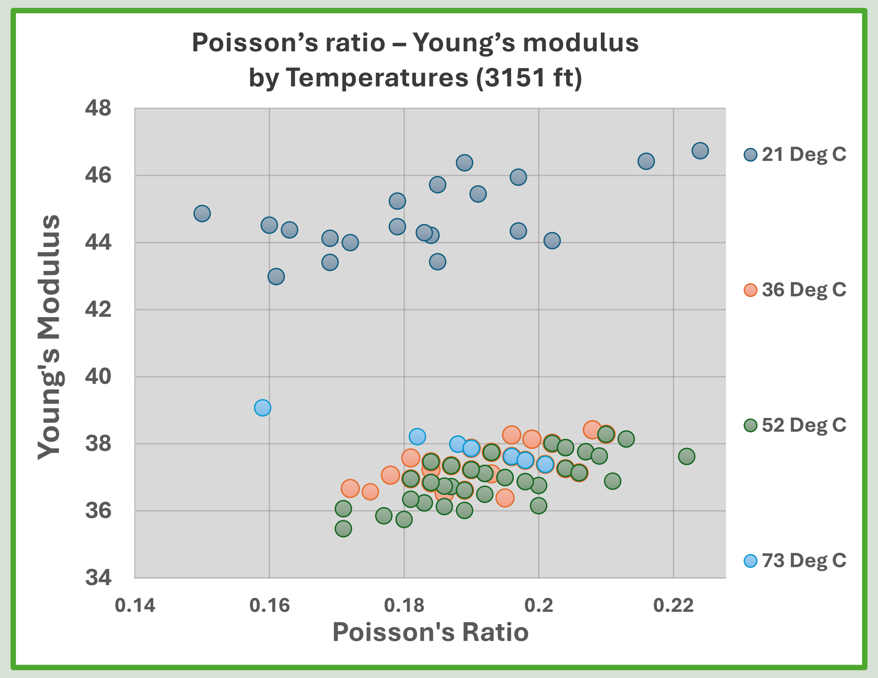


Multiple Data Streams: Variable Cross-Verification

Porosity is consistently low (0–3.33%) in micro-CT and thin section analyses. Helium porosimetery measures microporosity not captured by these techniques, typically returning higher values. These micropores are below the maximum scan resolution of 0.78 µm

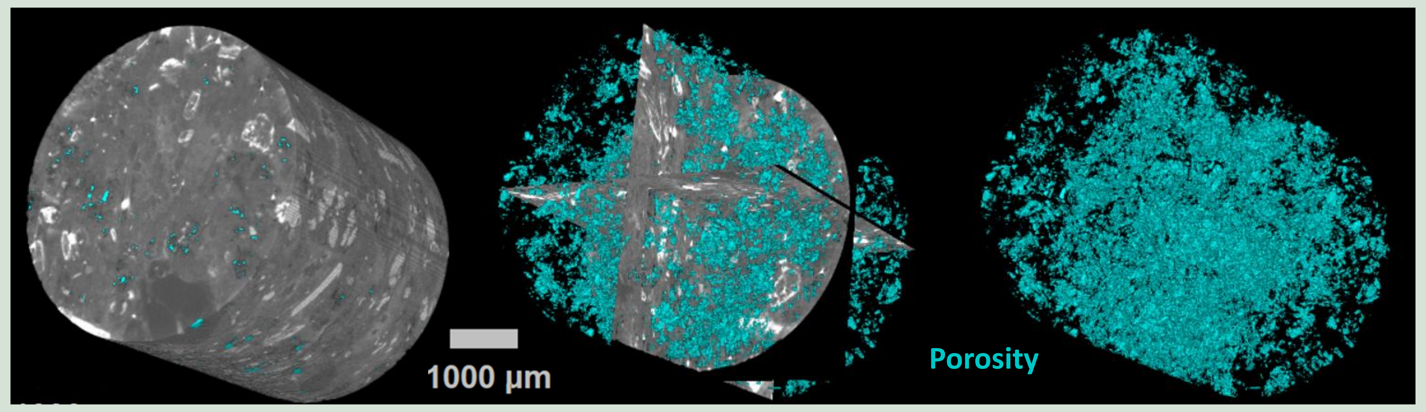


Geophysical data is collected for many samples: P and S wave velocities were measured, and Poisson's ratio, Young's modulus, Lamda Rho, and Mu were calculated for various temperature conditions.

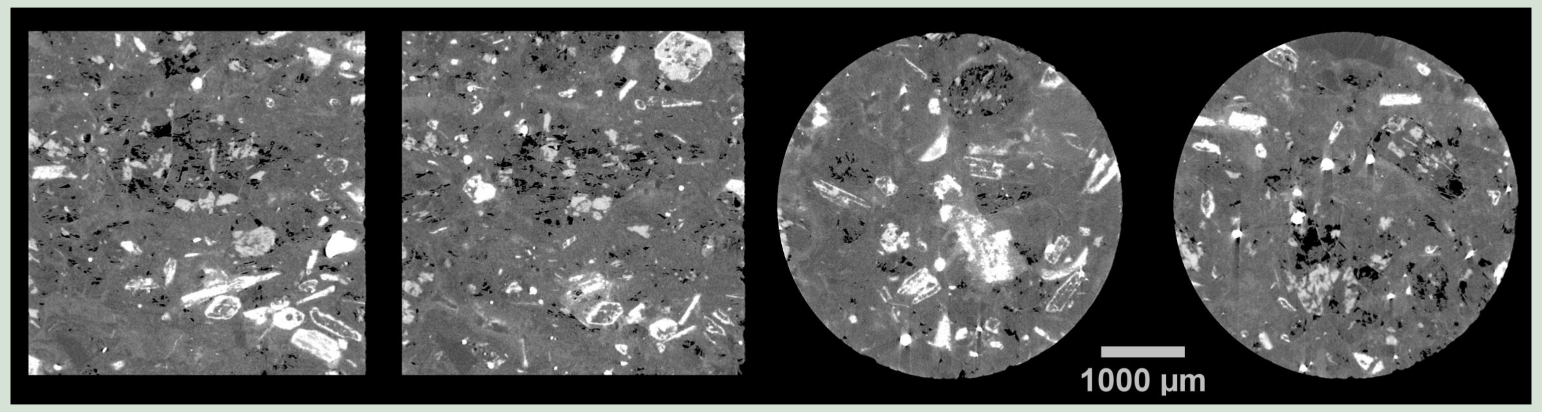


Three-Dimensional Analysis Insights from Computed Tomography

The tuff sample below, from a depth of 3,884 ft (1,184 m), shows an above-average porosity of 1.65% in CT analysis, while helium porosimetry reveals one of the lowest values in the well (1.04%). This departure from the typical pattern of higher helium porosimetry values is explained by 3D image analysis, which shows that secondary porosity forms within altered phenocrysts. It is locally interconnected within individual phenocryst grains but is isolated at the sample scale, and likely not accessible to helium porosimetry measurements.



Above: Micro-CT scan of sample from 3,884 ft with porosity highlighted (blue).



Above: Detail cross-sectional views of micro-CT data, showing intro-granular porosity.

Find the Data on EDX

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Geoimaging and Characterization Lab Fact Sheet

References:

Akerley, J. H., Robertson-Tait, A., Zemach, E., Spielman, E., Drakos, P. Near-field EGS: A Review and Comparison of the EGS Demonstration Projects at Desert Peak and Bradys. *Proceedings World Geothermal Congress*, 2020.

Brown, S., Gill, M., Crandall, D., Bromhal, G., Haljasmaa, I., Harbert, W., Disenhof, C., Dataset documenting rock core evaluation from Brady's Hot Springs well BCH-03. *Energy Data eXchange*, 2022. https://edx.netl.doe.gov/dataset/dataset-documenting-rock-core-evaluation-from-brady-s-hot-springs-well-bch-03, DOI: 10.18141/1897530

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