HotRock Geothermal Research Consortium

GEMS 2024 San Antonio

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Bureau of Economic Geology

Jackson School of Geoscience The

University of Texas at Austin

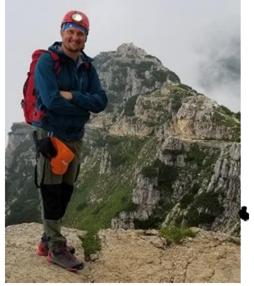
HotRock Industrial Affiliates Group

- Industry Consortium launched 2023
  - Initial membership: Shell, Chesapeake, SLB, and EDF
- Expertise in structural geology, petrophysics, geomechanics, rock physics, reservoir engineering, completions, and techno-economics
- Growing group- hiring post-docs and research professors
- Multiple projects and proposals on workflow development, characterization, modeling, and field monitoring

Dr. Ken Wisian

Dr. Shuvajit Bhattacharya

Dr. Nicola Tisato



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HotRock
Geothermal Research Consortium

- Industry-funded research consortium to find and **fill the science, technology, economics, policy, and entrepreneurship gaps** needed to further develop the **geothermal-anywhere ecosystem**

HotRock sponsors and collaboration with others

Environmental Defense Fund

slb

CHESAPEAKE ENERGY

Founding Members Circle

project innerspace

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SAGE GEOSYSTEMS

DEFENSE INNOVATION UNIT

CISR

Induced Seismicity Monitoring

CEO COMPARING ELECTRICITY OPTIONS

Full Life Cycle Environmental Impacts

AEC ADVANCED ENERGY CONSORTIUM

Environmental & Production Monitoring

GCCC GULF COAST CARBON CENTER

Carbon Capture Utilization and Storage

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HotRock Consortium Scope

Geothermal Focus Areas

Resource Assessment	Development Options		Techno Economics
Reducing Project Risk Direct High Resolution Temperature Data Machine Learning Artificial Intelligence	Rock Physics Fracture Characterization Subsurface Engineering	Induced Seismicity Integrity Monitoring	Techno-Economic Analysis & Policy Direct Use Heat Power Generation Power Storage Minerals Extraction

Scope includes studies in and beyond sedimentary rocks (e.g., igneous rocks) and basins

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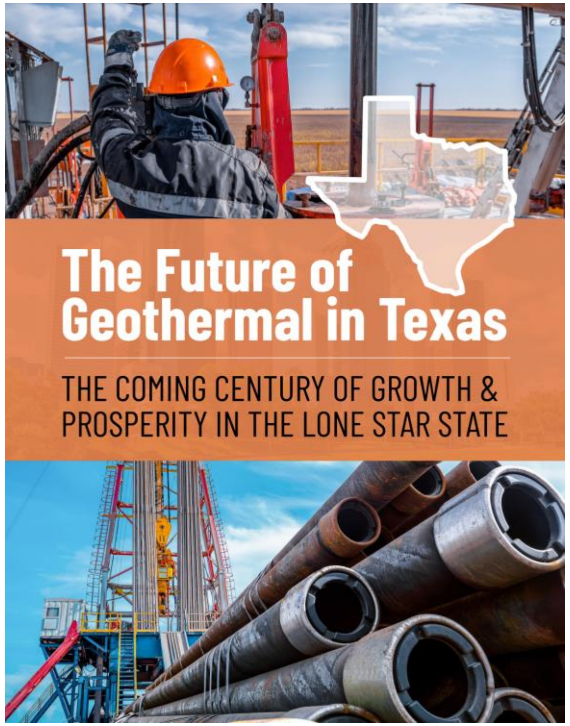
Relevant Bureau work in Geothermal

- **Exploration & resource assessments – USGS, local and private funding**
  - Sage Geosystems and DOD-funded study in El Paso and Corpus Christi, Texas (**EGS study**)
  - **Fault mapping and fault zone properties, fracture processes, evolution, and geochemistry**
  - **Lithium and geothermal** brine co-production and techno-economics
  - **Techno-economic feasibility** study for **geothermal power generation and direct use** in Trans-Pecos region (**EGS potential** in Presidio County, Southwest Texas).
  - **Corrected U.S. heat flow database with International- IHFC standards**
  - **Developing International Opportunities (Netherlands, Taiwan)**
- **Rock thermal and physical property measurements at high P/T conditions**
  - Installed **equipment for thermal conductivity and diffusivity** measurement at 300°C (572°F) and 3,500 psi (considering to increase upto 10,000 psi) **Perfect for hot dry rock geothermal**
  - Physical Properties Measurements
- **Techno-economic system modeling – GEOPHIRES V.X Extensions (Python)**
  - Completed EGS, Closed Loop, Direct Heat Use, and IRA (tax credits)
- **Heat Management in geothermal wells**
  - Numerical modeling, drilling heat maps, LSTM machine learning model
- **Induced seismicity monitoring – DoD and State funding**
  - Completed Case Studies in South Texas, Houston
- **New Opportunities: Grid decarbonization** and **EGS field pilot test**, Desalinization – various funding



https://cgmf.org/p/geothermal-energy-texas_report.html

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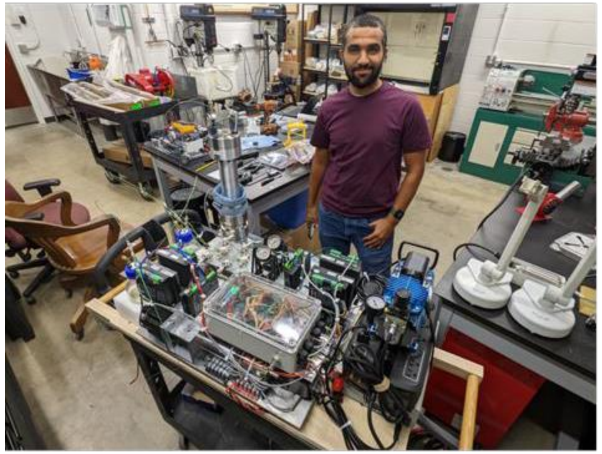
Research Facilities


BEG Core Facility


BEG Well Logs Library

Rock Deformation Lab, led by Dr. Nicole Tisato

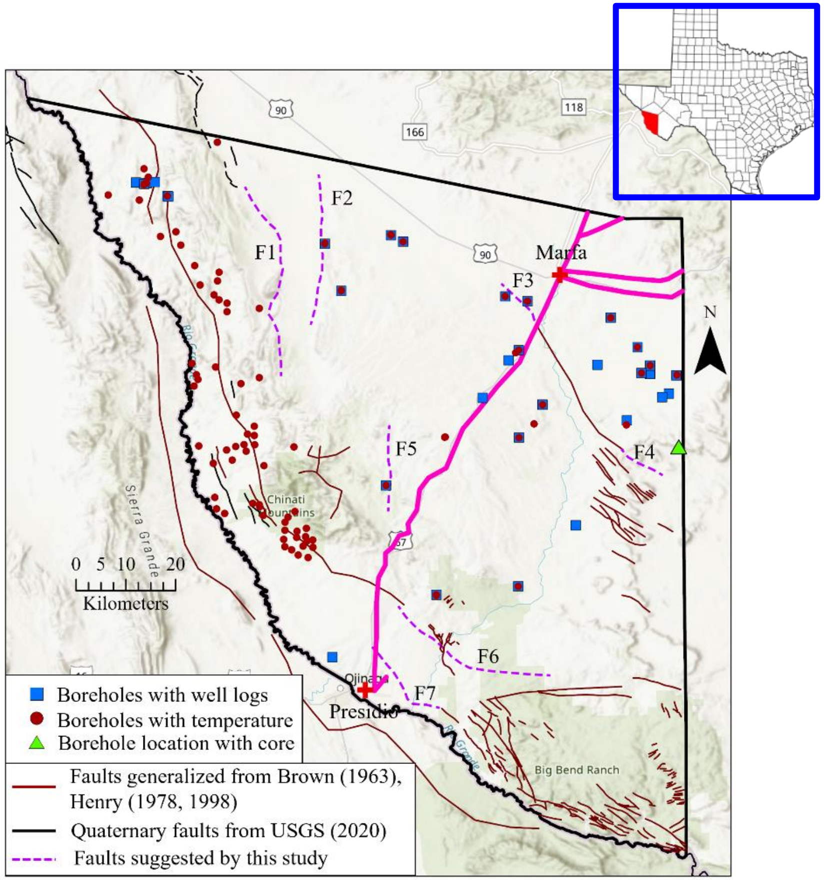


1-inch core, up to 40 MPa at 350°C

BEG Geothermal lab measures the **in-situ** thermal properties (such as thermal conductivity and diffusivity)

An example of a complete workflow for techno-economics for power generation and direct use

- Explore potential of geothermal energy in Presidio County, SW Texas (near Mexico border)
- Perform techno-economics to justify feasibility of geothermal energy
- High geothermal gradient (upto 47 °C/km, and in some cases, the proposed geothermal target is @~7k-8k ft depth
- Potential utilization opportunities- electricity generation, heating and cooling, industrial and agricultural/aquaculture process heat, and energy storage



Study area in SW Texas

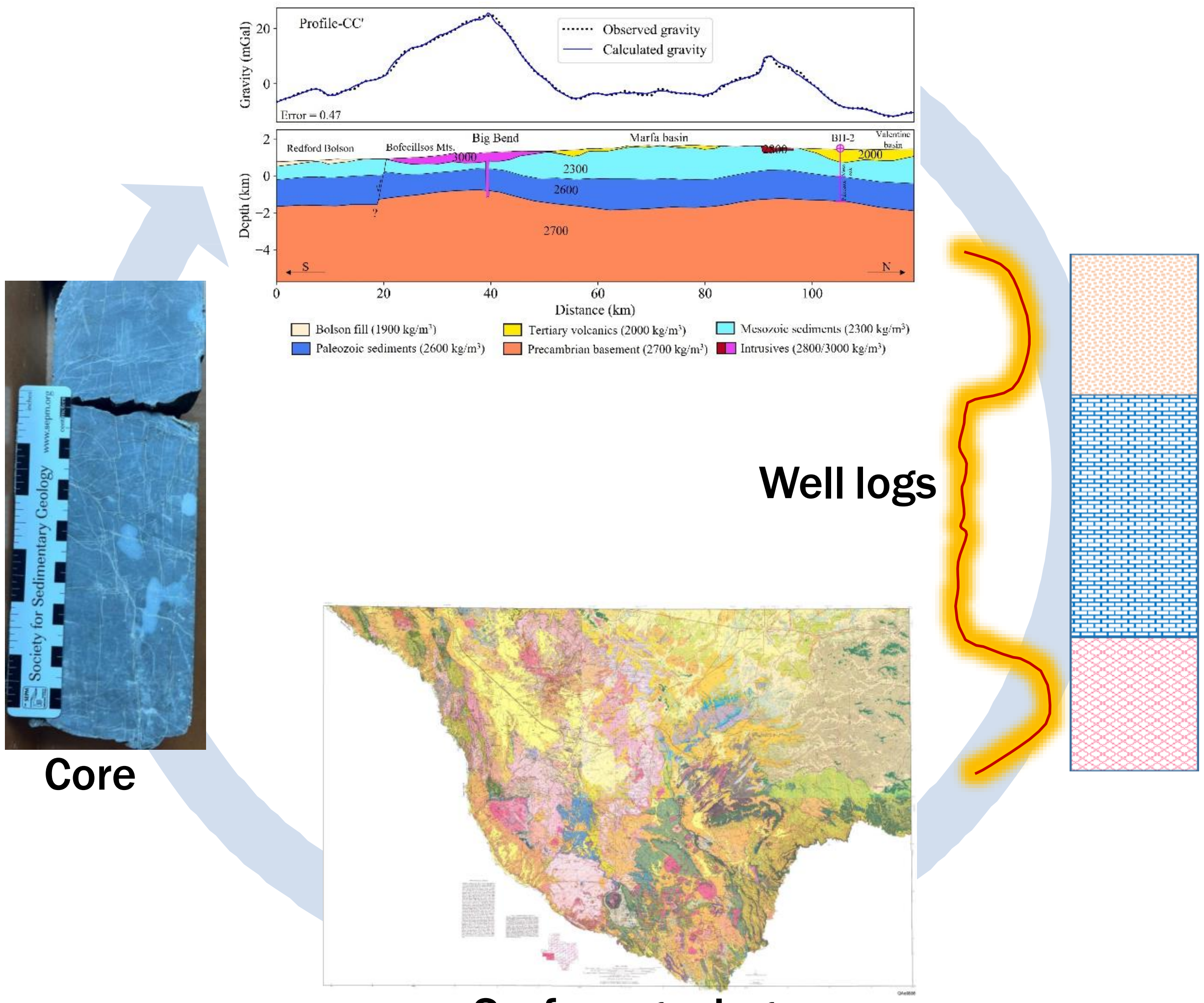
Subsurface challenges

- Extreme lack of subsurface data, compared to other places in Texas and US
- Most of the O&G wells drilled here found to be dry and abandoned.
- Complex geology due to polyphase tectonic movement, faults, uplift, volcanism, large range of basement depth
- A few outcrop studies done (Parry, 1857; Lonsdale, 1940; Goldich and Elms, 1949; Dietrich, 1965; Kopp, 1977).
- Similar challenges can be found in other parts of the US and world.

Available data

- Gravity data
- Conventional well logs and mud logs from 14 wells
- One deep well with core (depth: ~16,000 ft)
- Surface geology maps

Geophysics



Surface geology

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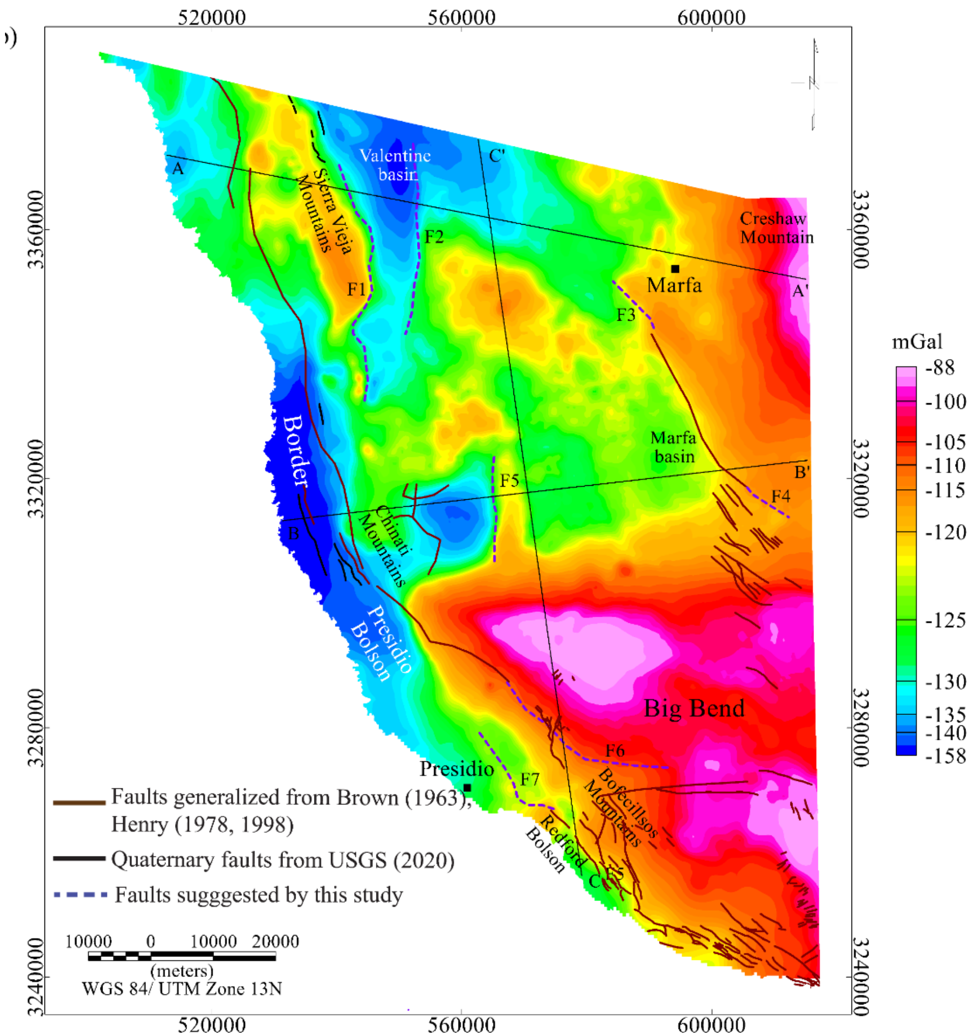
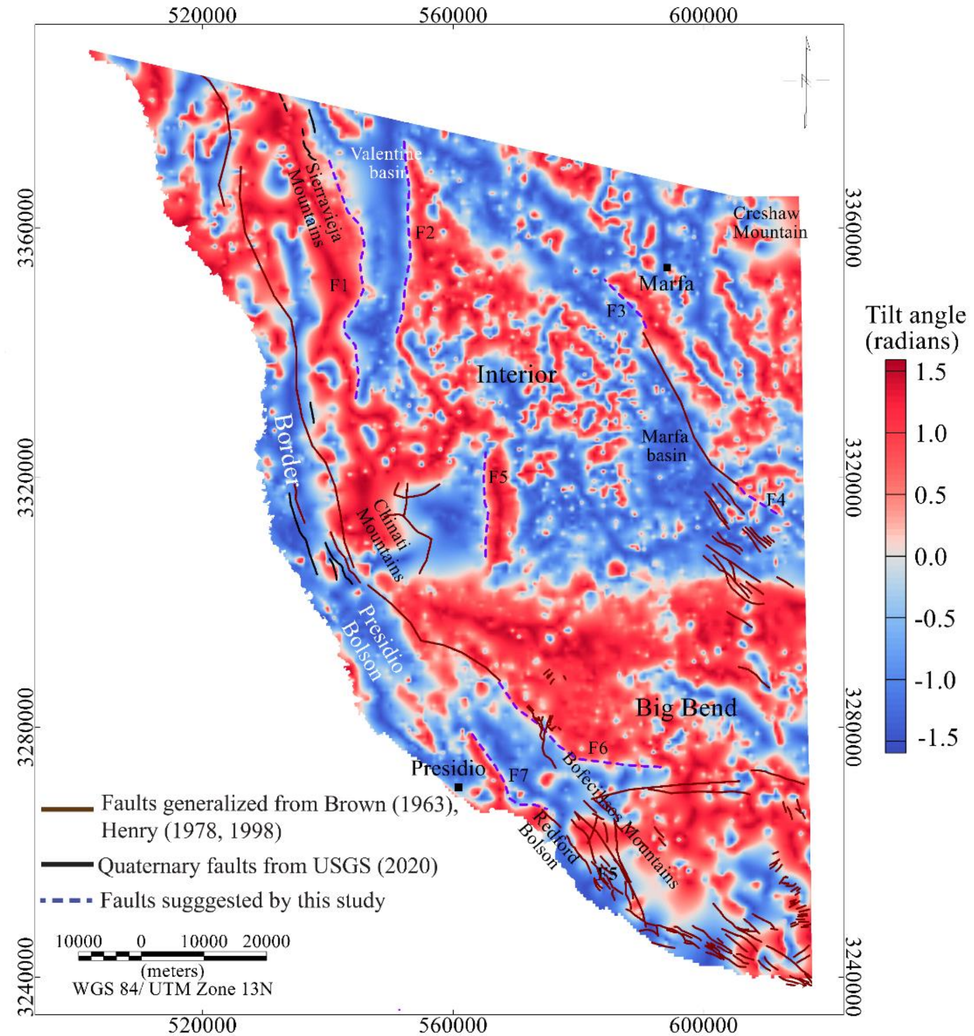
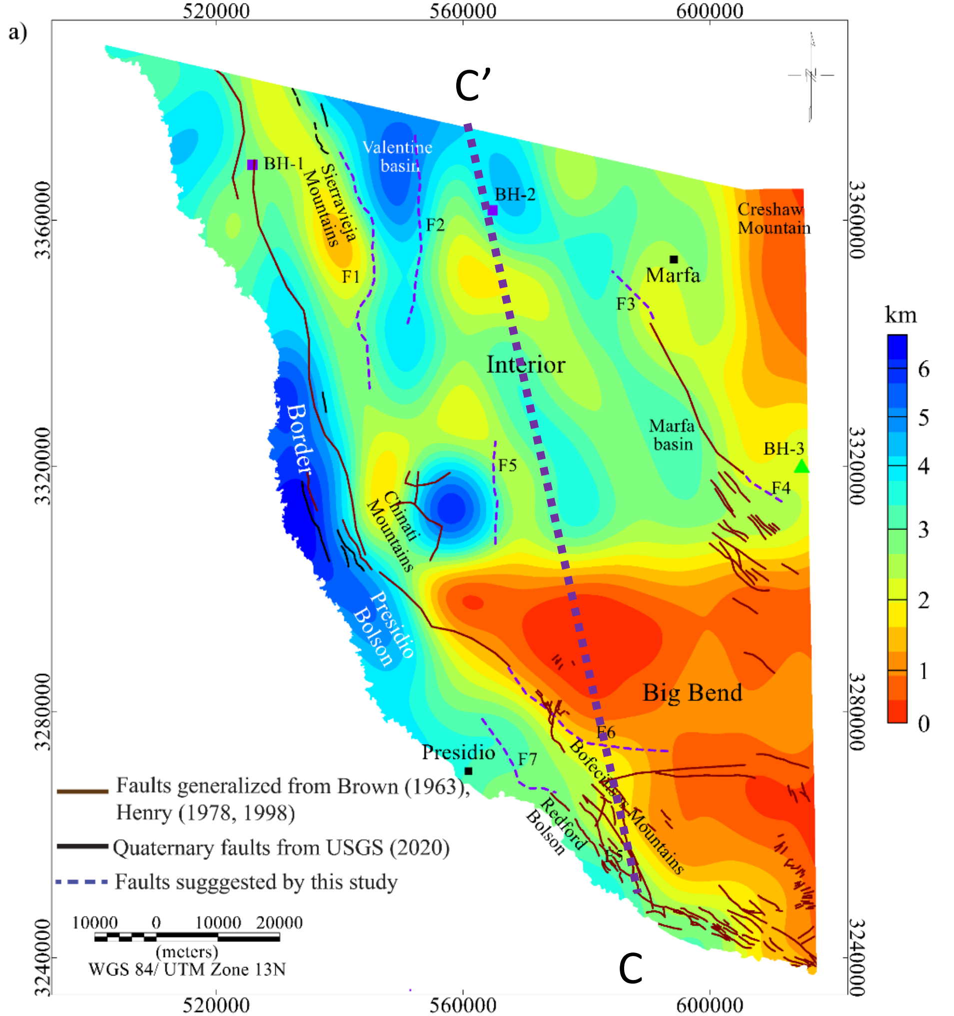
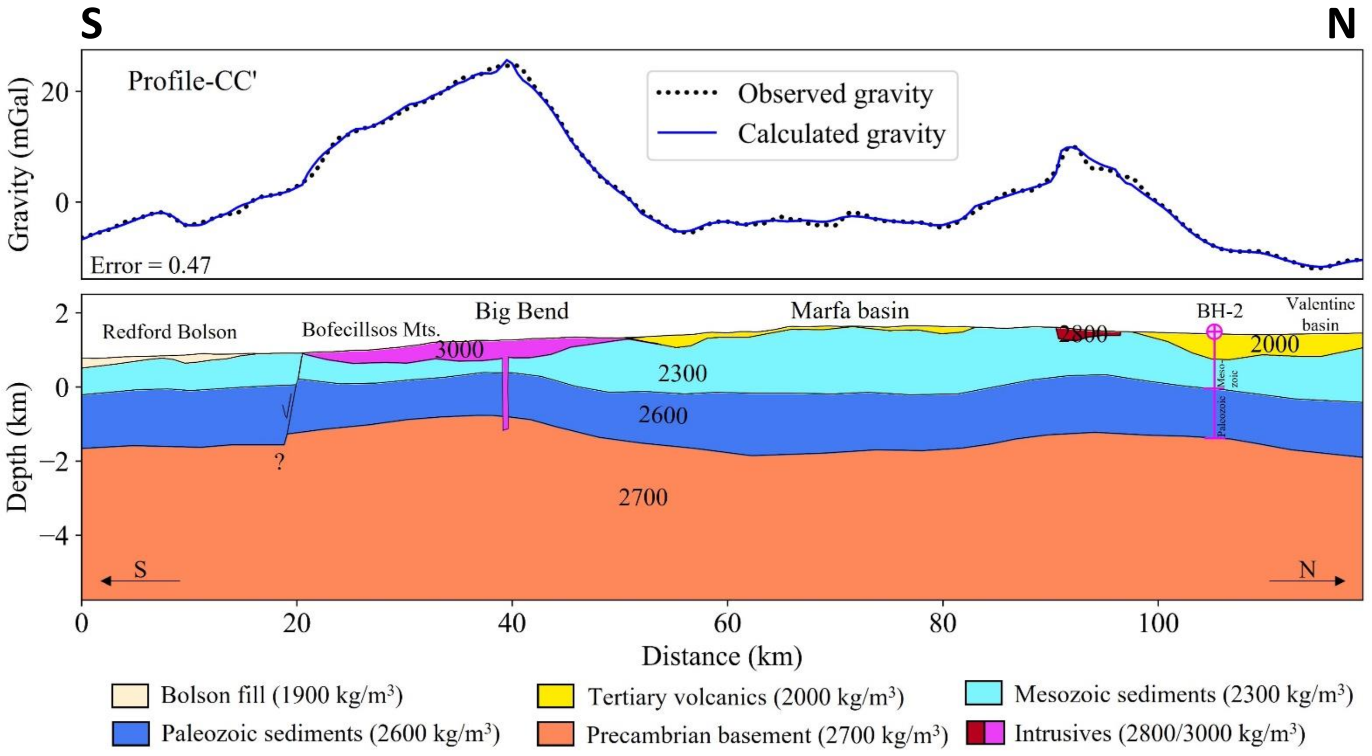
Bouguer anomaly and tilt derivative maps





Basement depth and basin cross-section





Basement depth from gravity inversion and well integration

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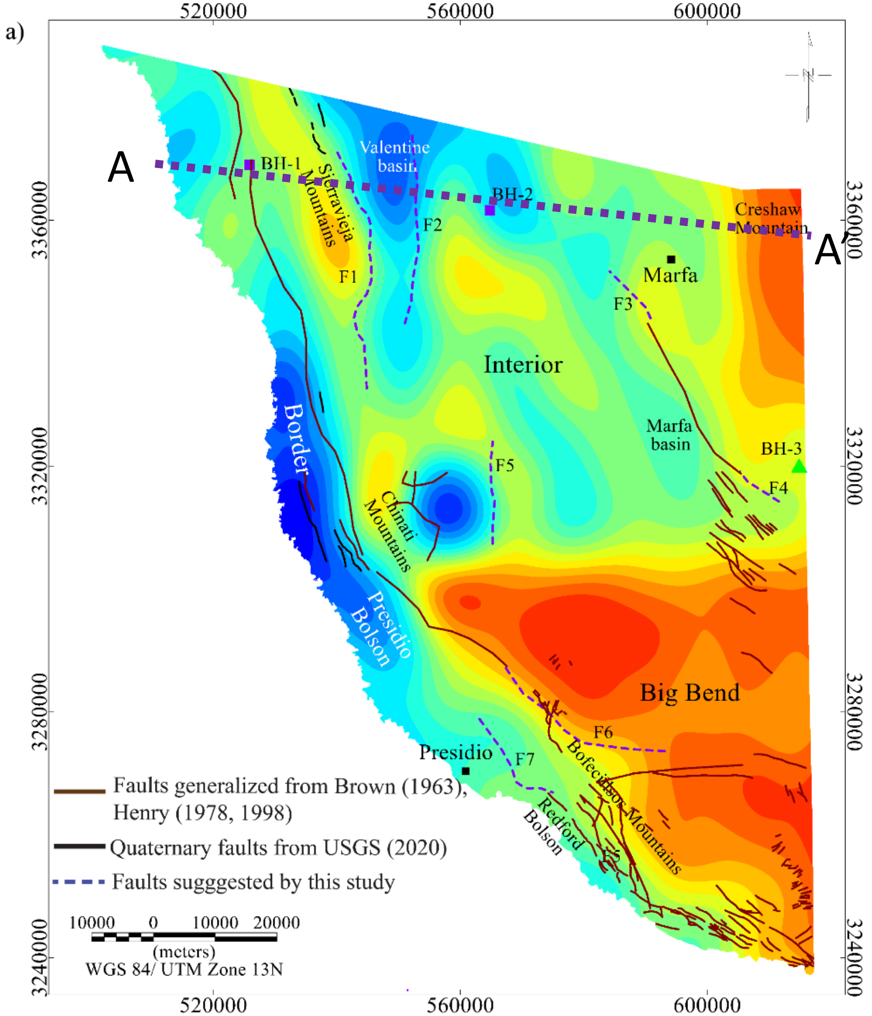
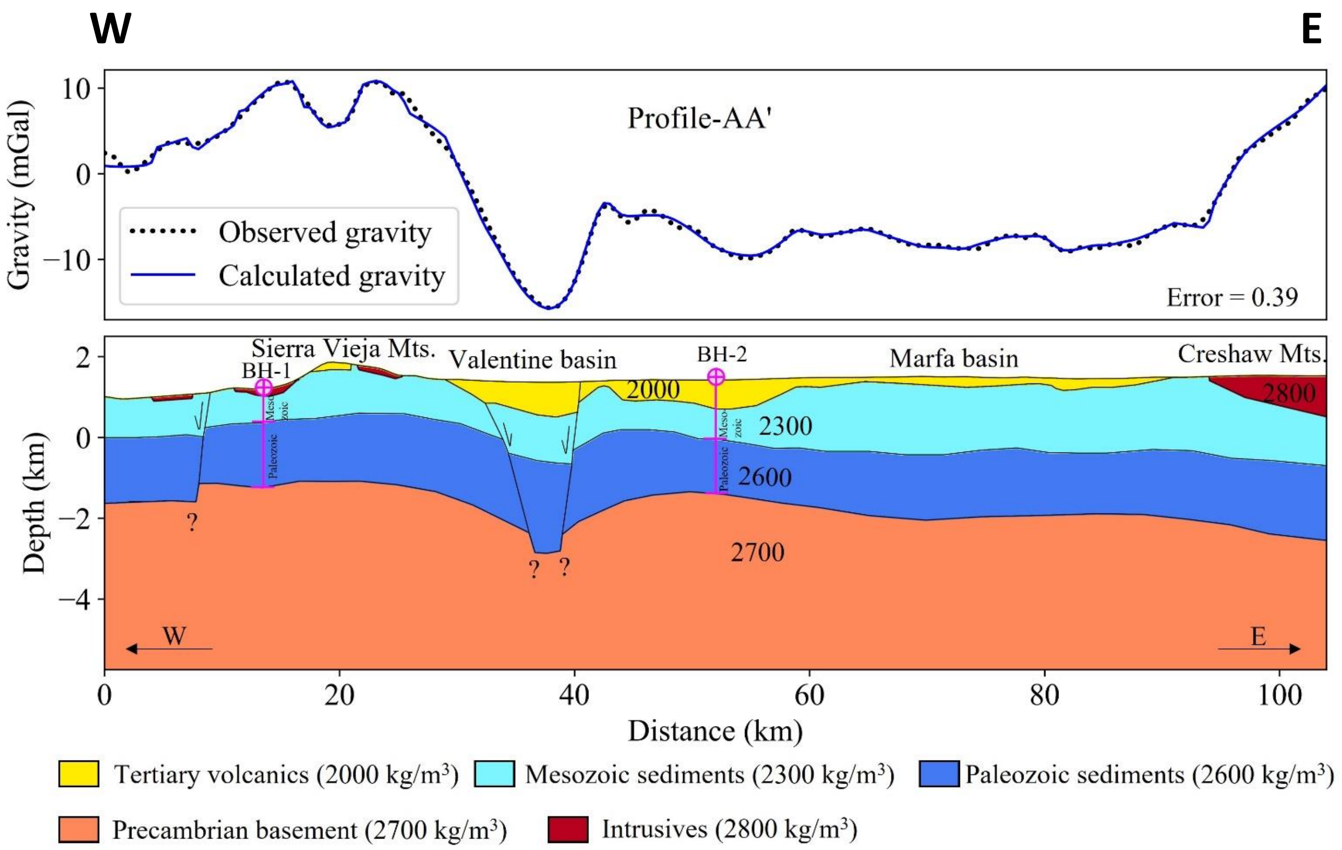
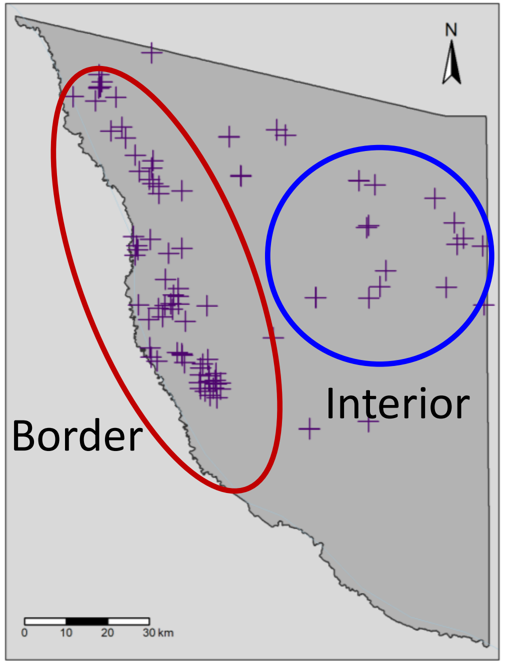
Basement depth and basin cross-section

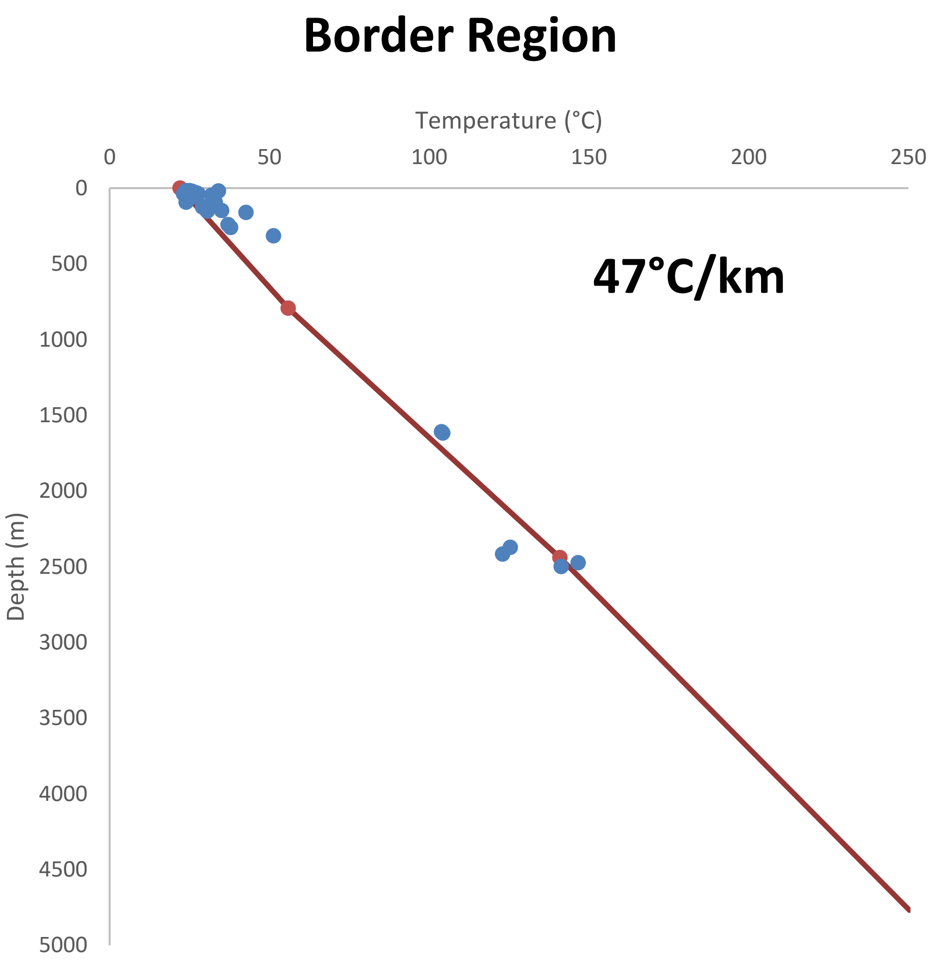


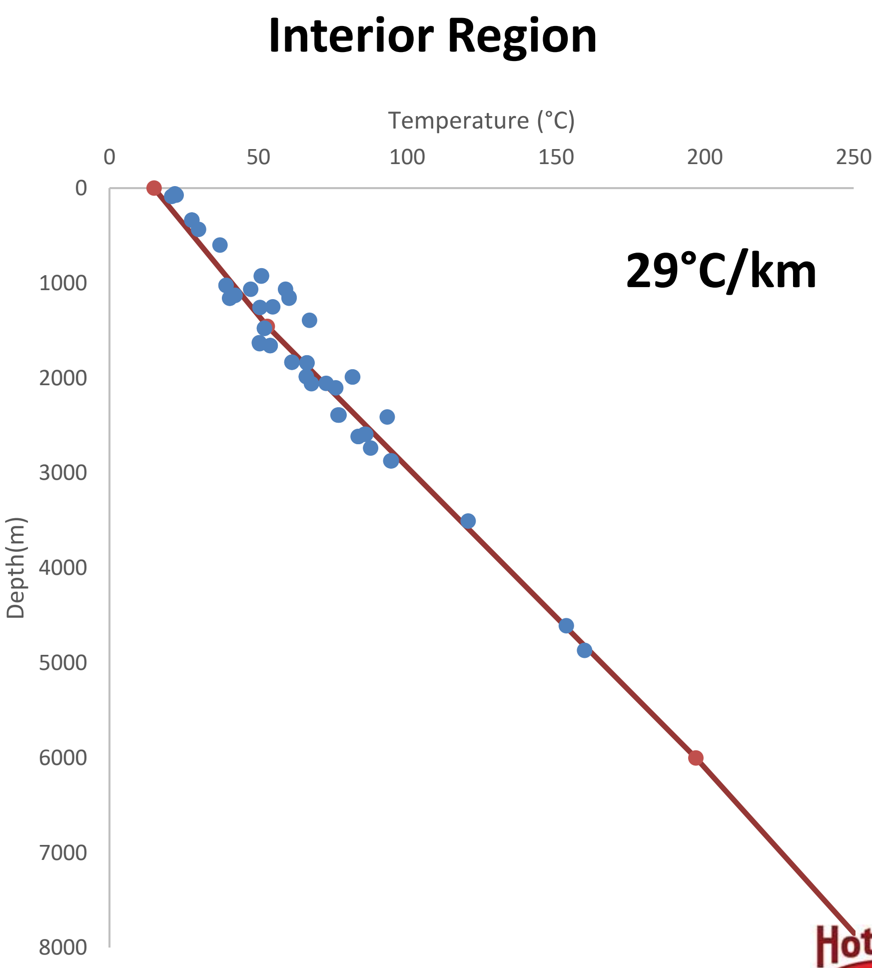


Basement depth from gravity inversion and well integration

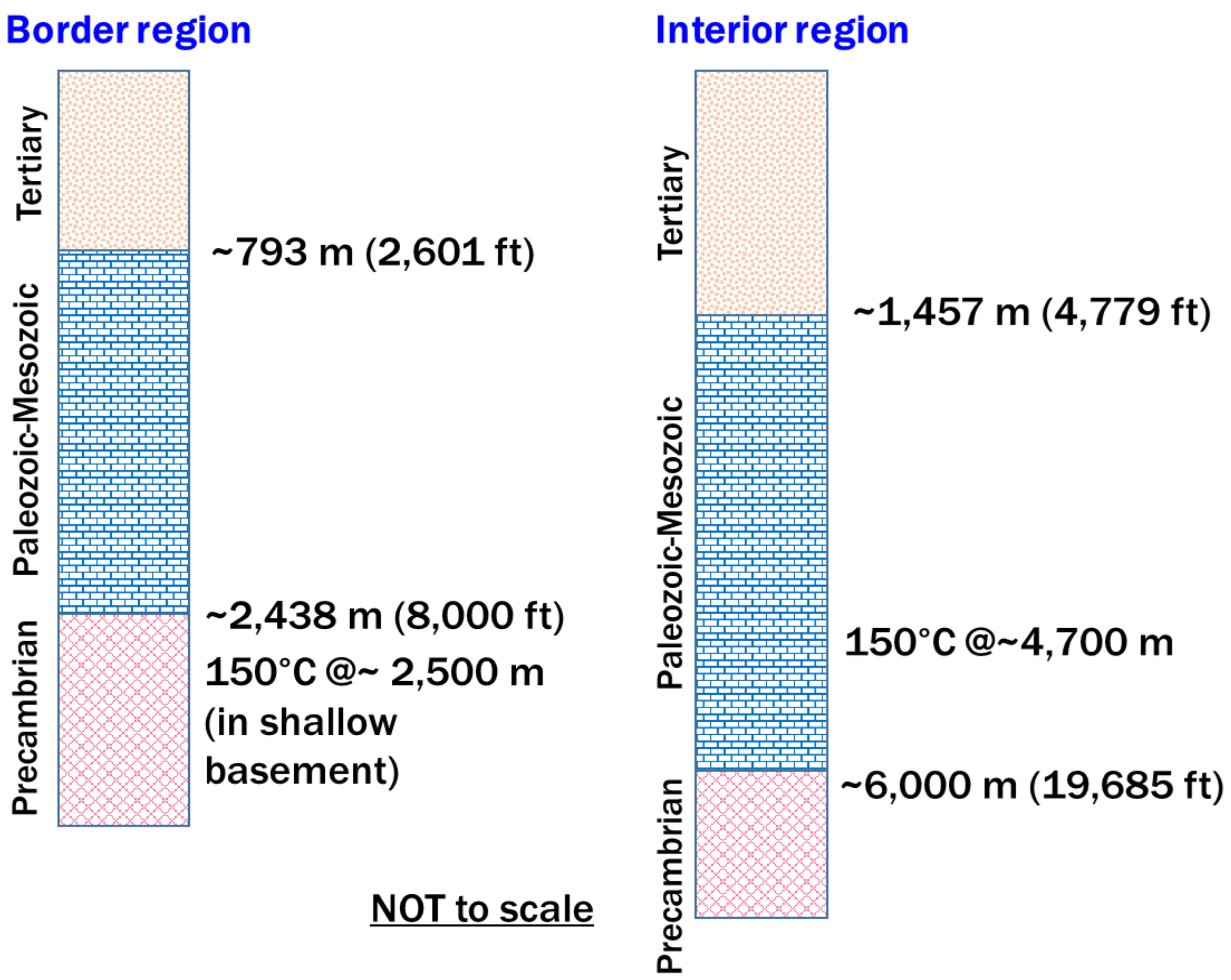
Spatial variation of geothermal gradient

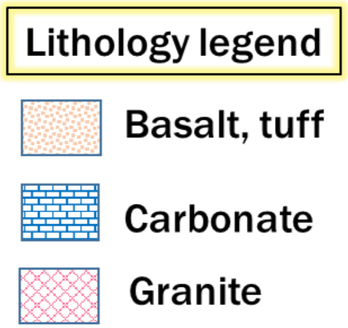




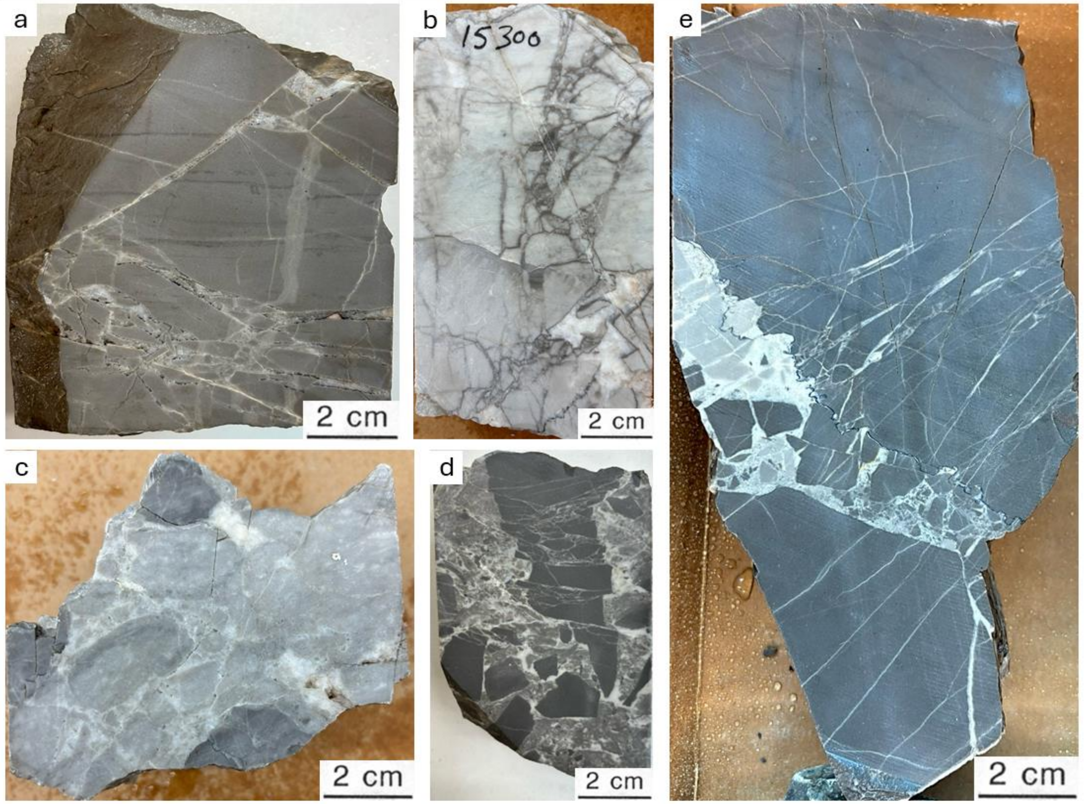


Simplified lithology of the study area

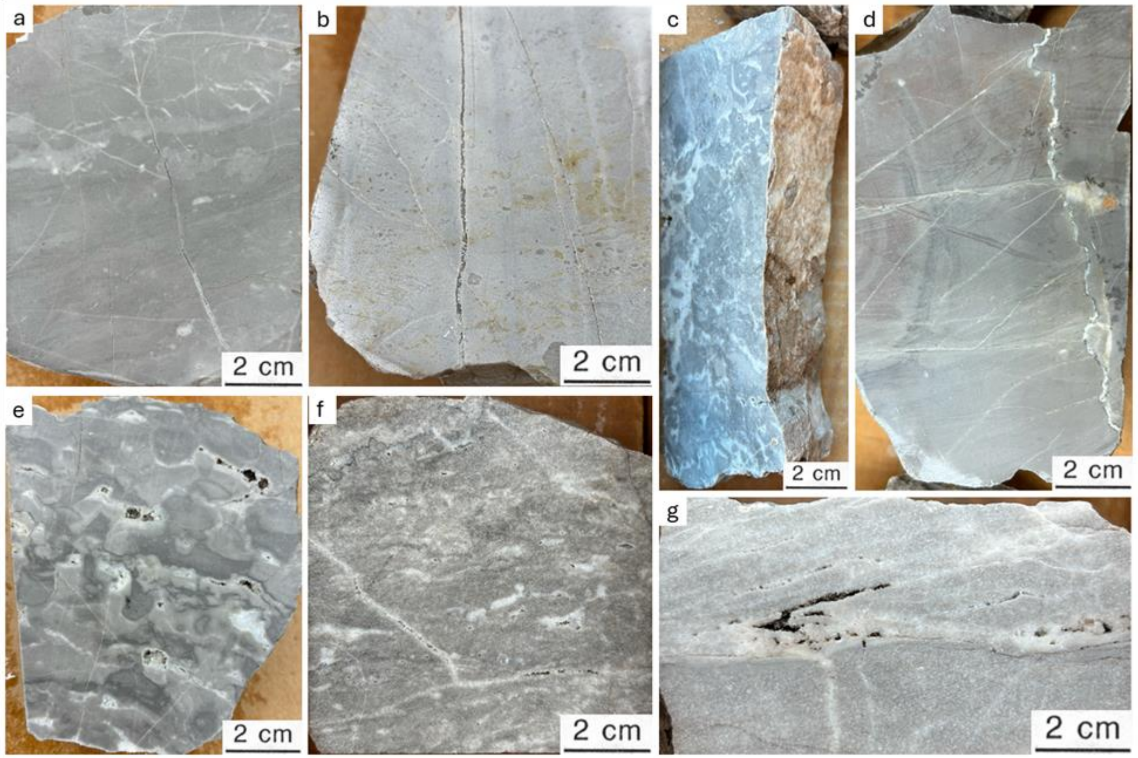




Fracture characteristics from core



Examples of Ellenburger paleokarst breccias, Gulf Mitchell Bros. State No. 1, Presidio County, west Texas. (Bhattacharya et al., 2024)



Core photograph of tectonic fracture porosity and porosity in microbialites (Bhattacharya et al., 2024)

Subsurface parameters for techno-economics

Based on regional geothermal assessment (spatially varying rock properties)

Age	Major rock type	Avg. Fm. top	Min. Fm. top	Max. Fm. top	Avg. thickness	Min. thickness	Max. thickness	Avg. porosity	Thermal conductivity	Avg. density
Units		ft	ft	ft	ft	ft	ft	p.u.	W/mK	g/cc
Tertiary	Basalt	30	0	60	4499	2571	4746	6	3.63	2.76
Mesozoic-Paleozoic	Carbonate	4091	2601	4779	4895	4393	14906	9	3	2.6
Precambrian	Granite	8585	7999	19685	n/a	n/a	n/a	n/a	3.3	2.75

Yellow indicates high uncertainties in values.

- Thermal conductivity from petrophysics (mineralogy, porosity, and fluid) AND formation analogs
- All other subsurface information from well logs, cross-sections, and maps
- Border and interior region rock properties are DIFFERENT! Development strategies should consider it.

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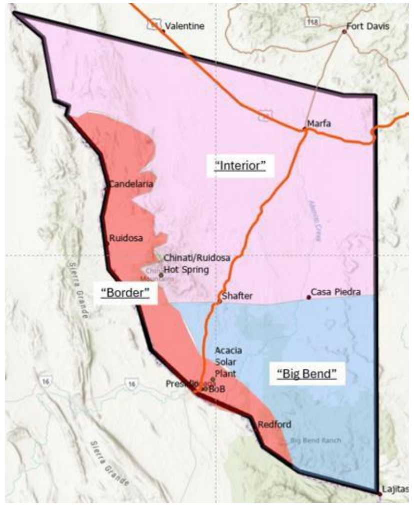
Techno-economics of geothermal power generation and direct use



Study area

Power generation using EGS and closed-loop (AGS) geothermal system

Scenario	Style	Region	Zone	Electricity (MW)	LCOE (cents/kWh)	NPV (M$)	IRR (%)	VIR=PI=PIR	Temperature (degC)	CAPEX (M$)	OPEX (M$)
1	EGS (250)	Border	Basement	20.83	3.71	316.75	40.98	6.55	241.7	57.08	3.2
2	EGS (200)	Border	Basement	12.25	4.61	173.43	33.92	5.34	196.7	39.98	2.43
3	AGS (200)	Border	Basement	5.54	13.53	7.32	7.07	1.1	173	71.24	2.3
4	AGS (175)	Interior	Basement	5.46	15.28	-6.35	5.6	0.92	172	80.78	2.48

Direct use

Scenario	Type of Direct Use	NPV (M$)	IRR (%)	VIR=PI=PIR	Payback (years)	Lifetime (years)	Depth (km)	Temperature (degC)	Heat (MW)	CAPEX (M$)	OPEX (M$)
5	Agri-processing	558.61	147.29	24,97	1.69	30	4.7	238.4	37.45	23.3	1.56
6	Greenhouses	32.9	29.89	4.68	4.54	30	3.1	100.2	2.8	8.93	0.42
7	Geothermally driven Direct Air Capture of CO2	29.42	13.81	1.74	8.05	20	7	222	4.82	39.82	2.27
8	Absorption Chiller	241.05	90.3	11.71	2.13	20	6	209	27.31	22.51	1.26

Summary

- Trans-Pecos region in Texas has substantial, undeveloped geothermal resources
- The location qualifies for substantial government incentives
- These resources could prove economically viable to develop in a wide range of scenarios for electricity production, and for industrial/agricultural and heating/cooling use

Thank You & Contacts

WHAT STARTS HERE CHANGES THE WORLD

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