The Evolution of Seismic Monitoring at Utah FORGE

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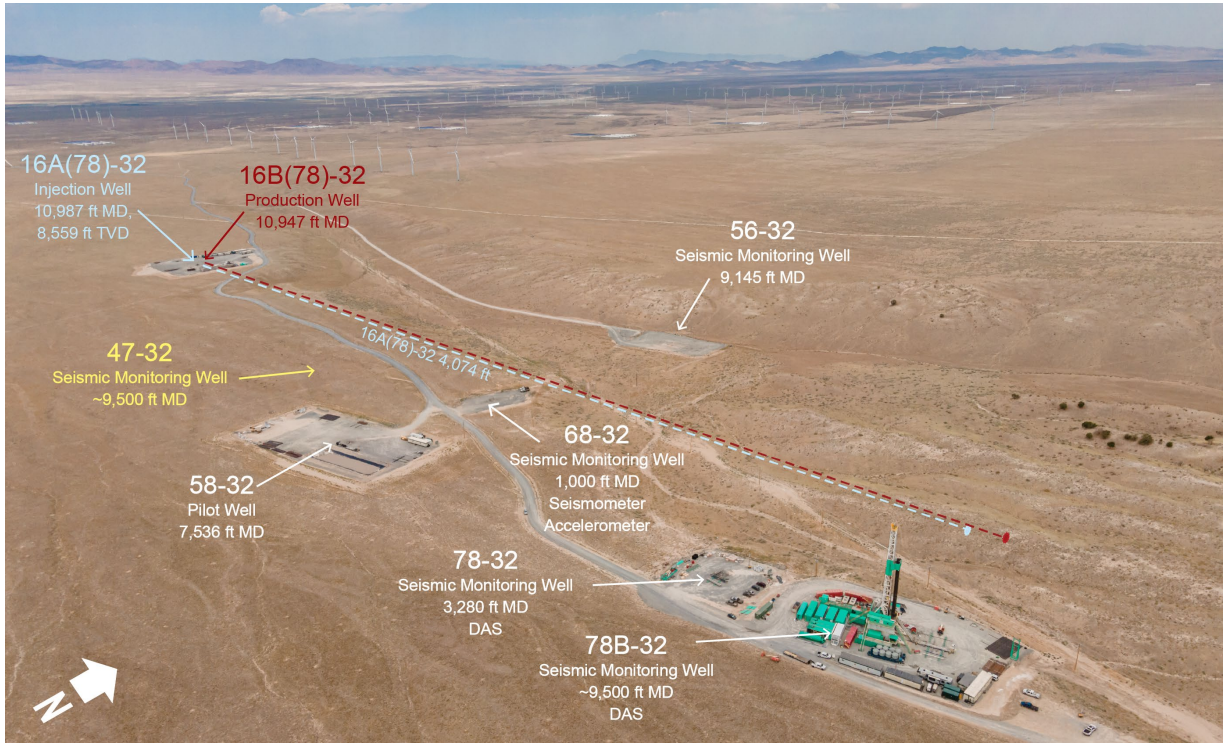
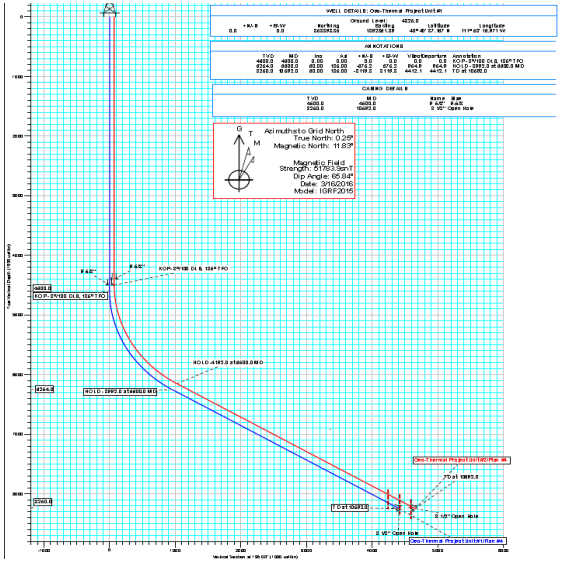
Field Scale Laboratory





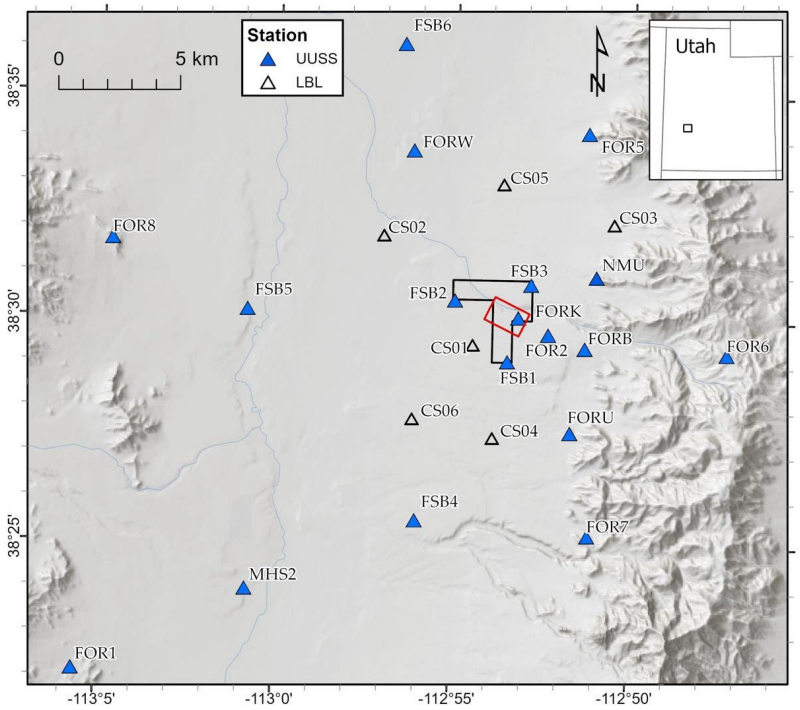
Connectivity – Conductivity – Conformance - Circulation

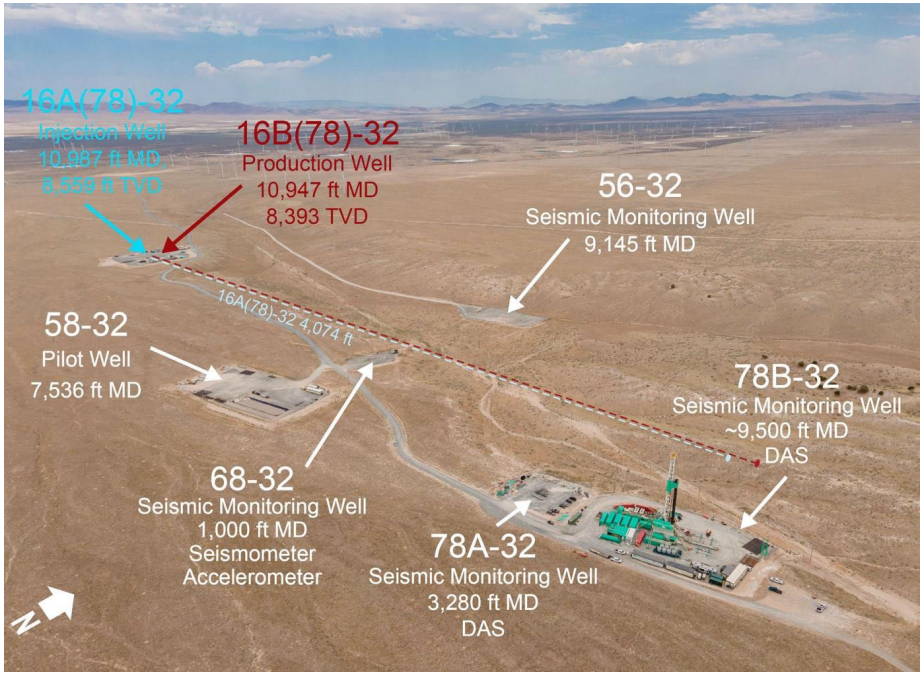
Operations Timeline

2019 April	58-32 Stimulation—can we create fractures? Can we detect stimulation microseismicity near and above the granite/basin-fill interface?
2021 January	Injection well 16A(78)-32 drilled
2022 April	16A stimulation—where do we drill production well
2023 June	Production well 16B(78)-32 drilled
2023 July	Circulation Test—are the injection and production wells connected?
2024 April	16A and 16B Stimulation—can we develop a commercial scale reservoir?
2024 August	Month long circulation Test—how much fluid can we recover?

Seismic Network

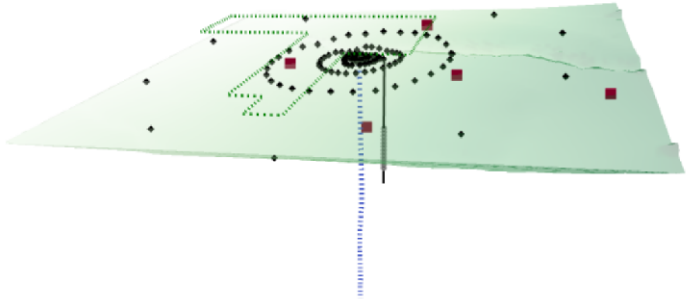
Pankow et al. 2025
Stanford Geothermal Workshop





Seismic Monitoring During Operations

April 2019



Instrumentation

■ UU ◆ Nodal geophones ● Downhole

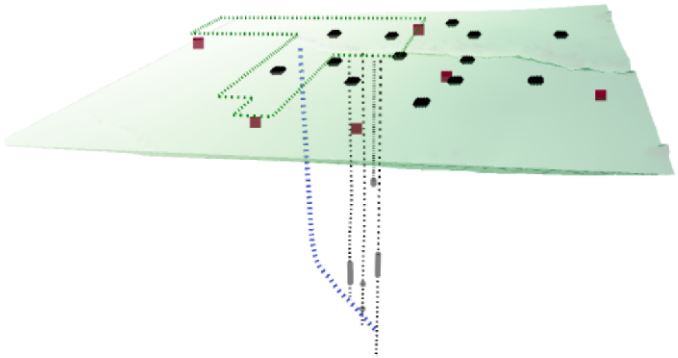
Wells

---(—) Injection (incl. fiber optics)

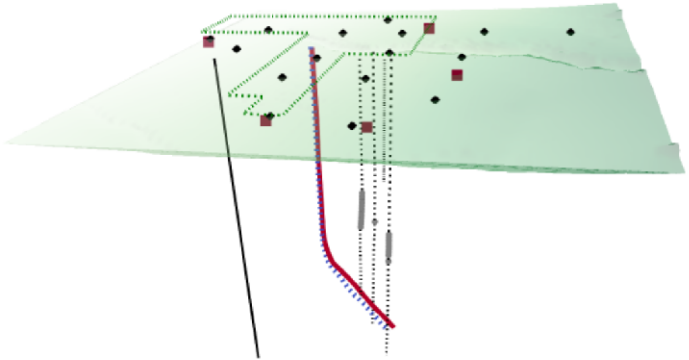
---(—) Production (incl. fiber optics)

---(—) Monitoring (incl fiber optics)

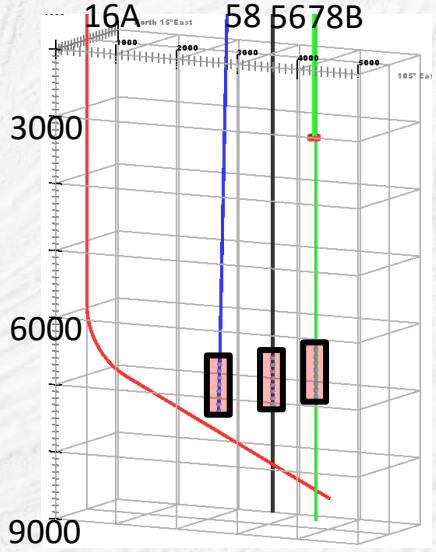
April 2022



April 2024

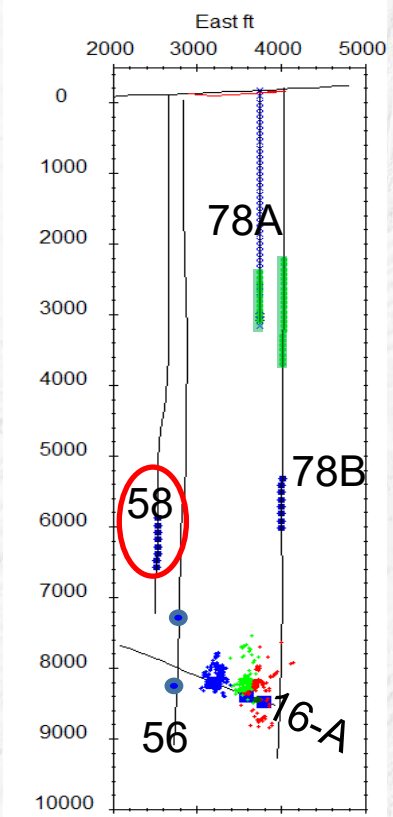


2022 Simulation – *Lesson 150º Max*

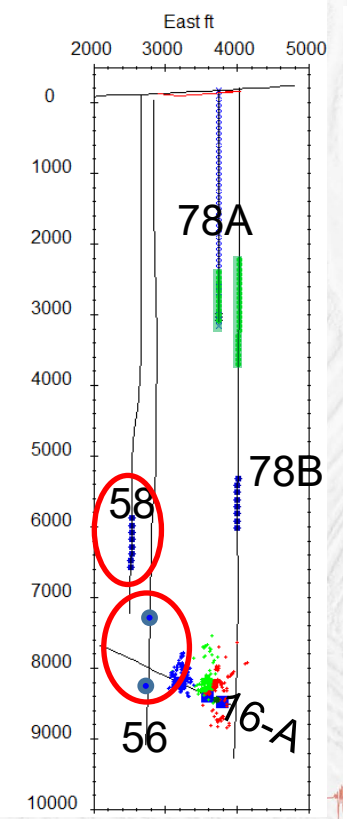


- Avalon's Geochain ASR 3C digital geophone strings deployed in three wells near reservoir depths--8 levels each, at 100 ft spacing
- Avalon's BOSS, 3 level, 3C fiber optic string and with wireline DAS
- Analog PSS sensors post-stimulation

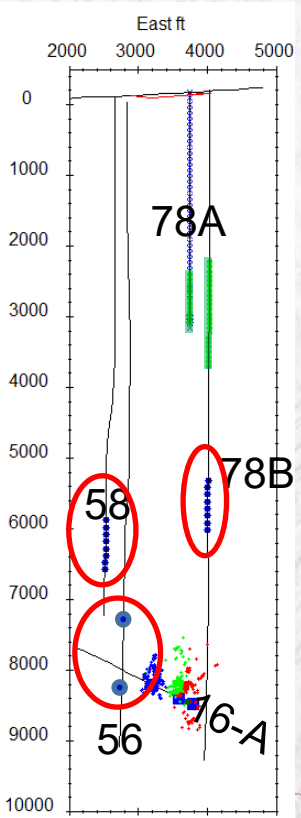
Stage 1

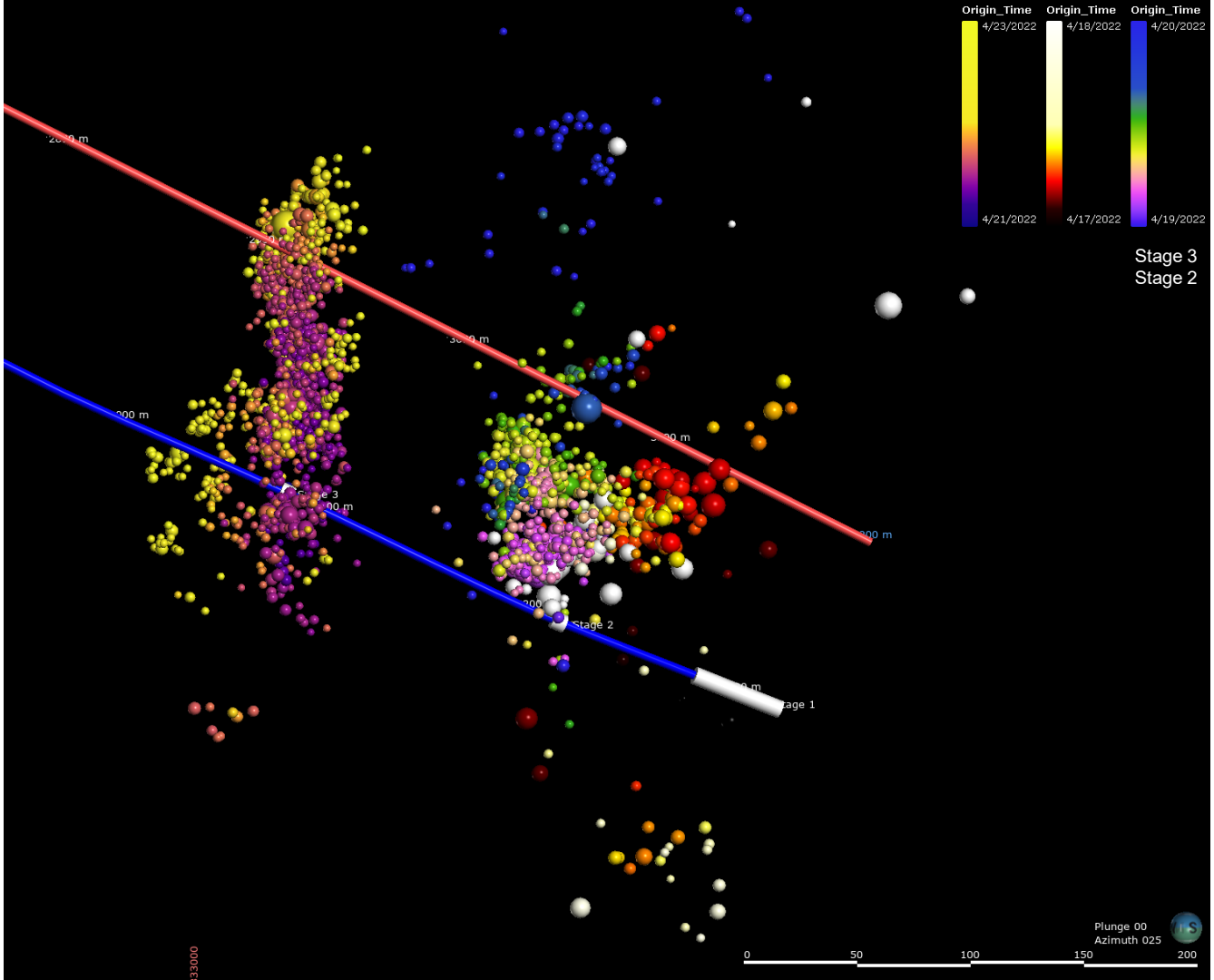


Stage 2



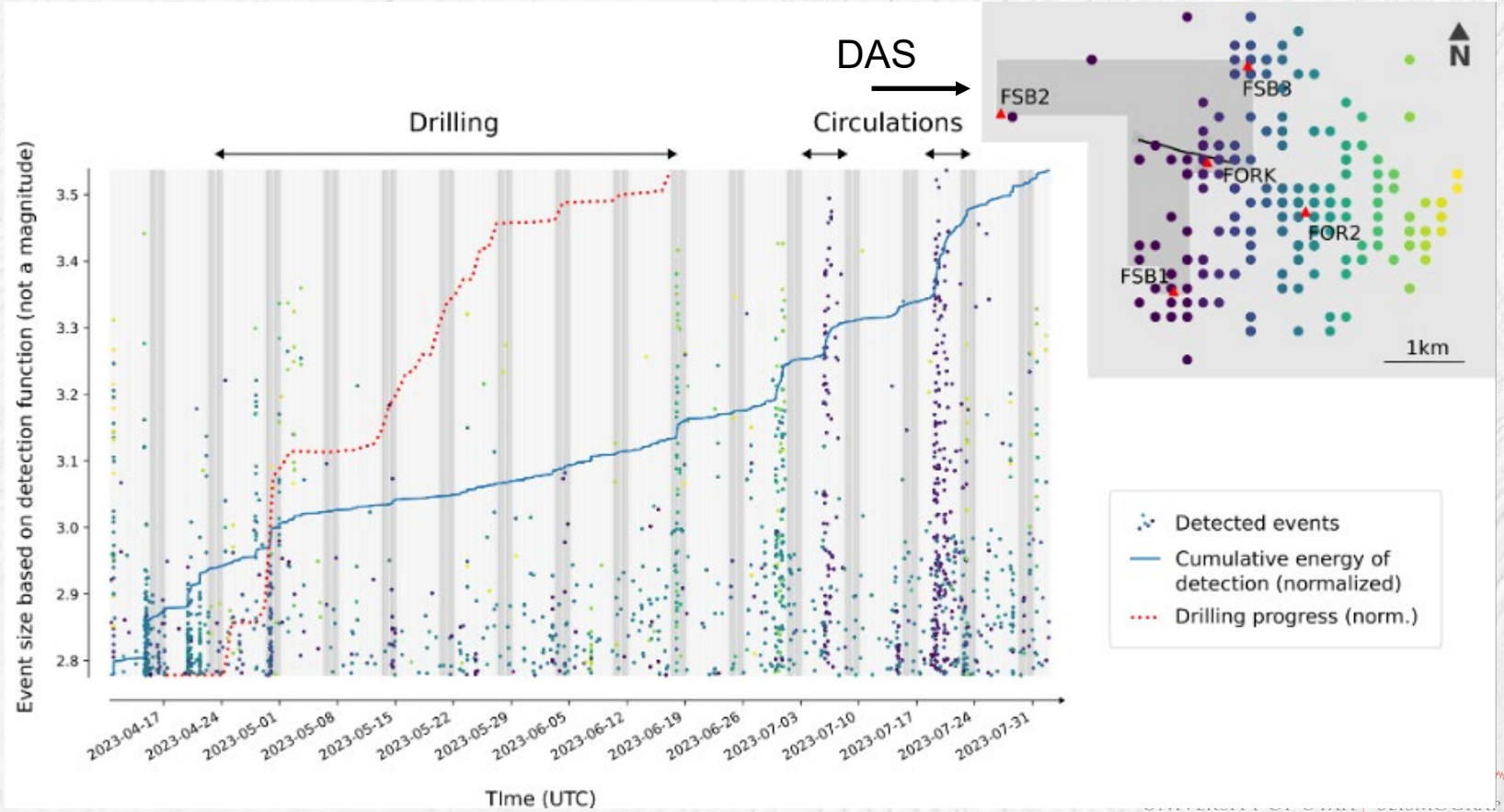
Stage 3



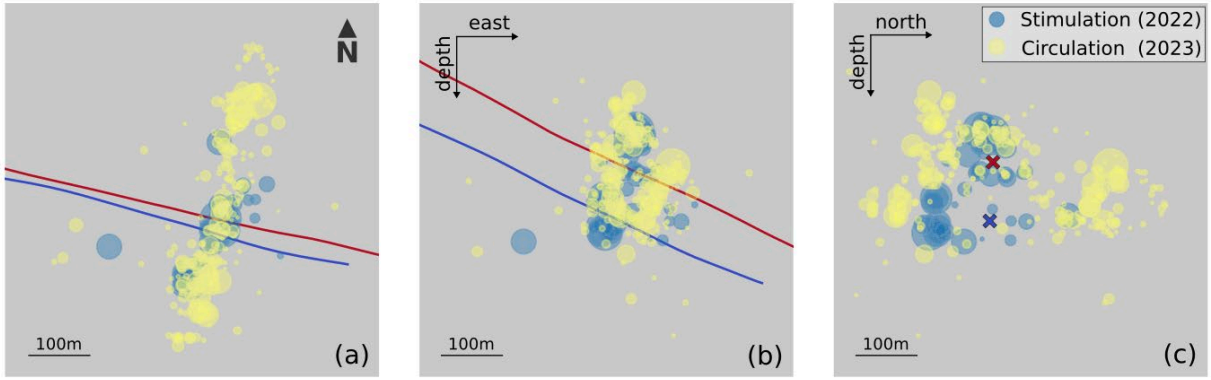

Origin_Time
4/23/2022
4/21/2022
Origin_Time
4/18/2022
4/17/2022
Origin_Time
4/20/2022
4/19/2022
Stage 3
Stage 2
Stage 2
Stage 1
Plunge 00
Azimuth 025
0
50
100
150
200

X-section

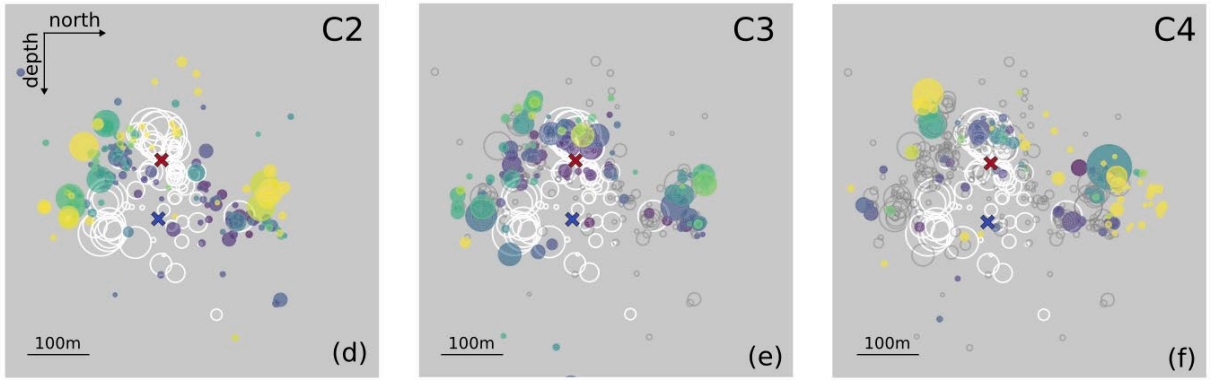
2023 Circulation–Implemented *qseek*



(a-c) Relative relocations (stimulation + circulation)



(d-f) Spatiotemporal event migration (circulation)

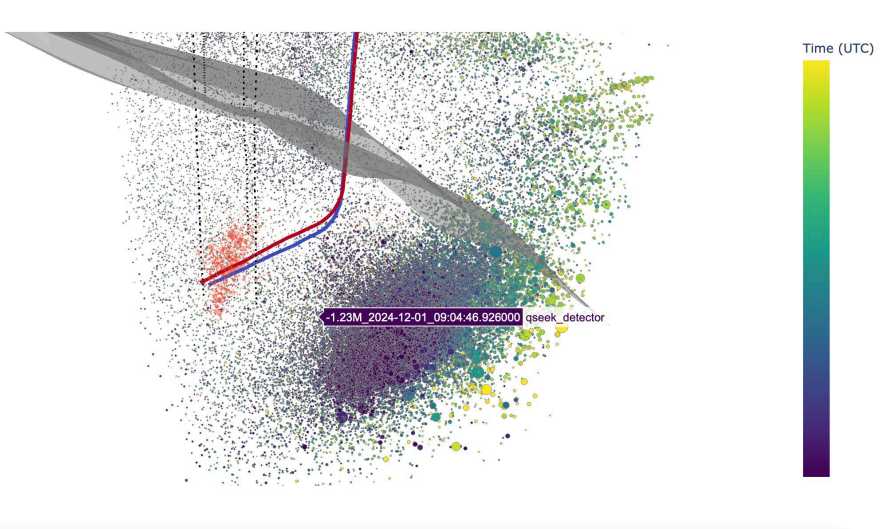


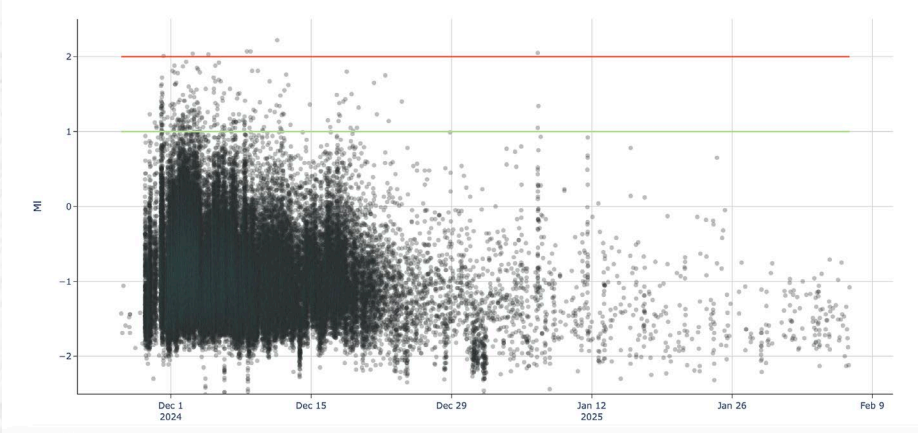
Niemz et al. (2024, Geothermics)

Detection and location algorithm, Qseek:
Isken et al. (2025, Seismica)

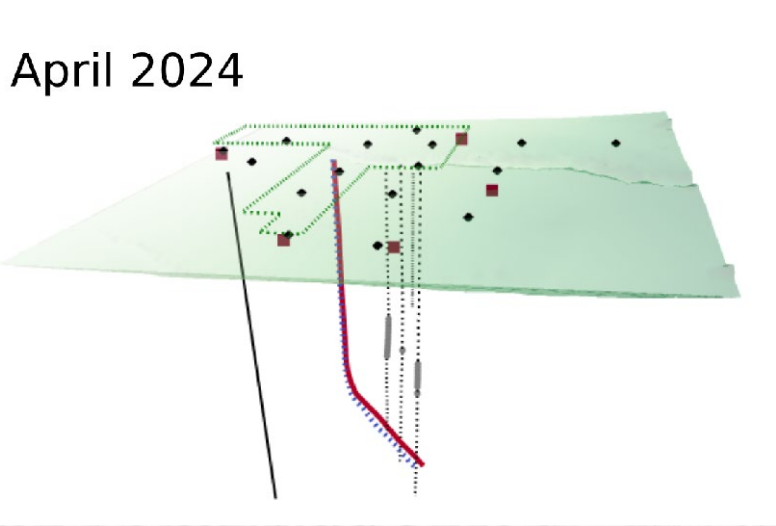
VERSITY OF UTAH | SEISMOGRAPH STATIONS

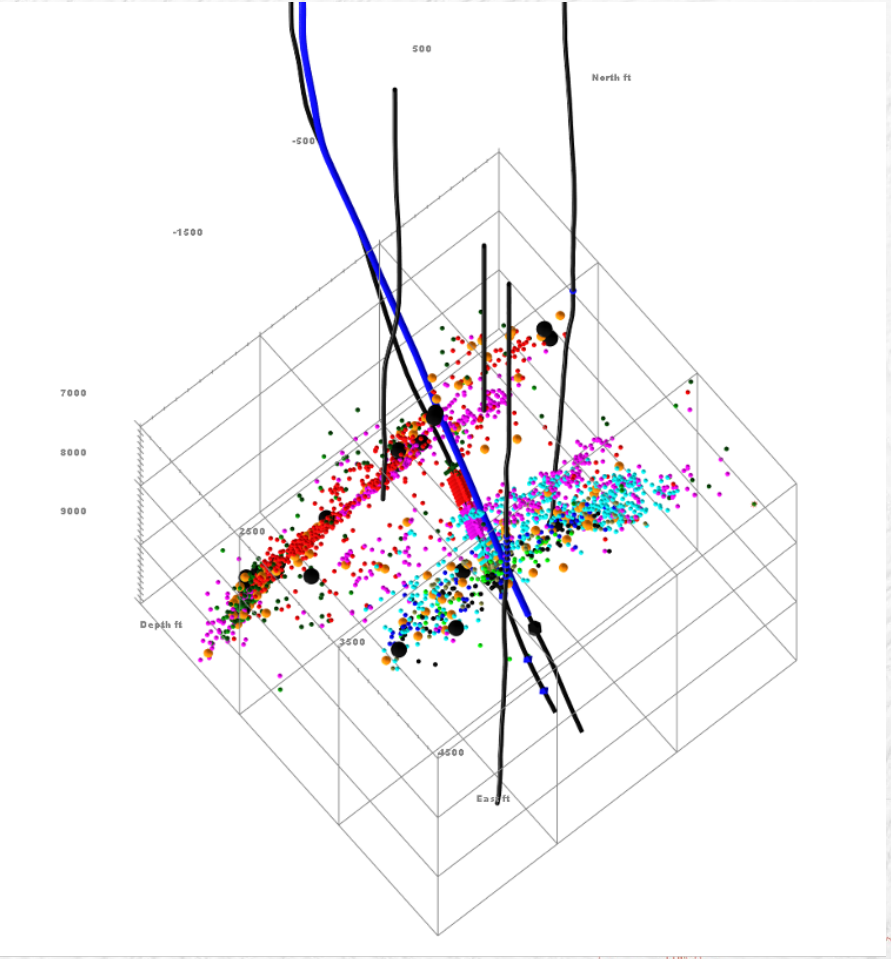
Real-time Monitoring with *Qseek*





2024 Simulation



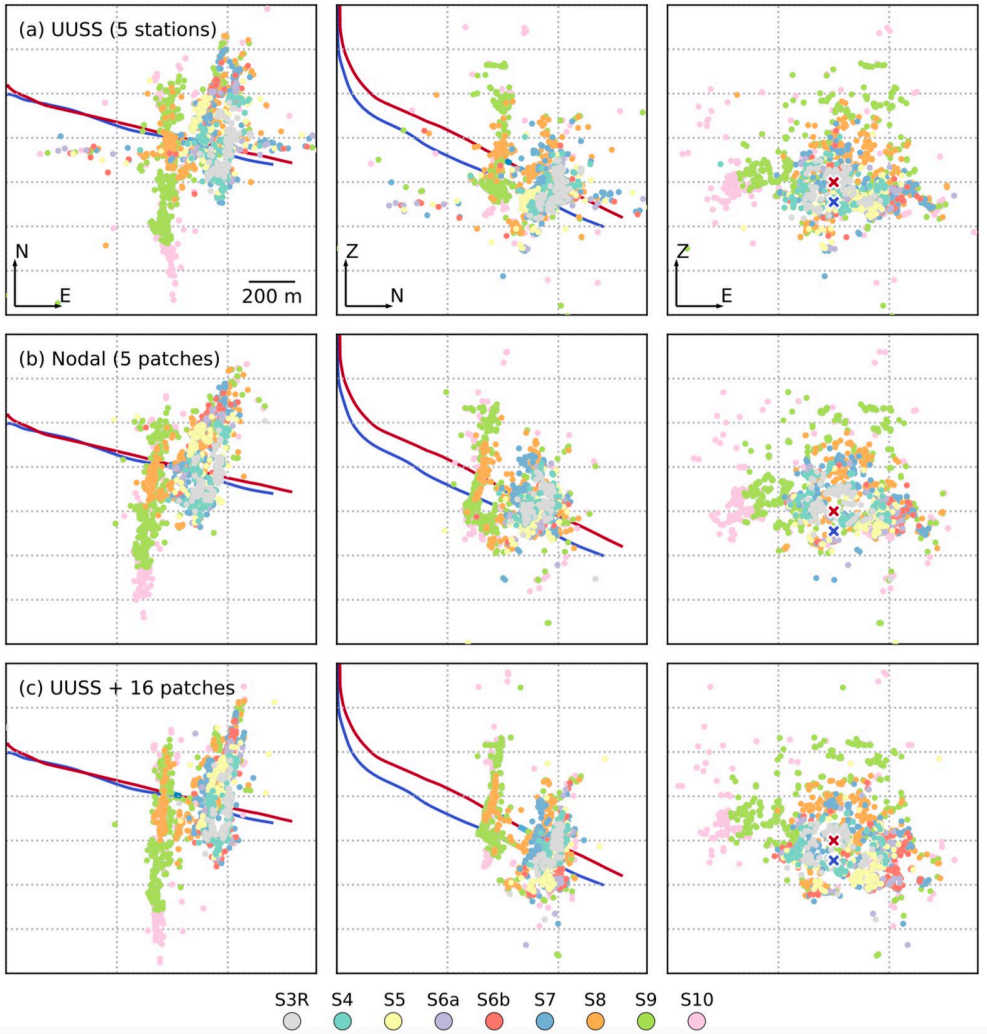


See Dyer talk at 5:30

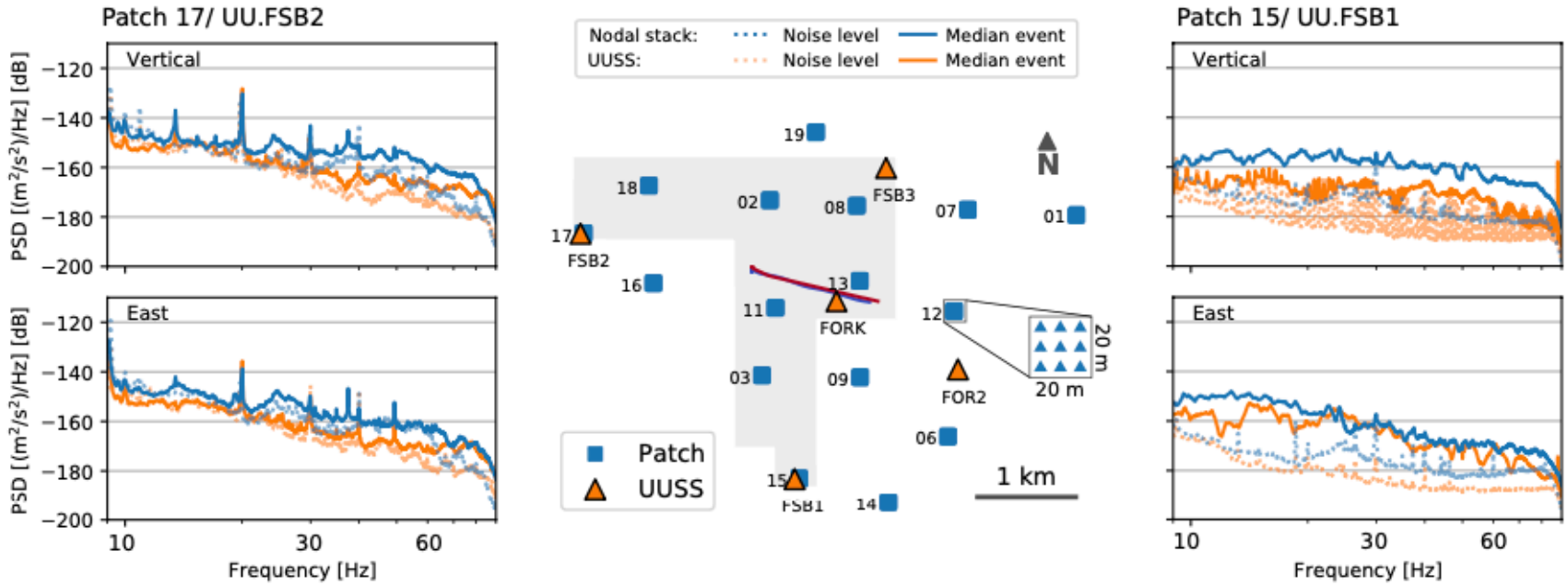
Enhanced Processing with Local (near-) surface network

Niemz et al. (2025) SRL

Detection and location algorithm, Qseek: Isken et al. (2025)



Temporary Nodal Arrays



Niemz et al. (2025) SRL

See Niemz talk tomorrow at 11:15—full moment tensors

Evolution of the Network

Real-Time Monitoring

All processing integrated into RSN →

→ RSN configured for TLS thresholds

→ Advanced processing for reservoir monitoring (no deep boreholes)

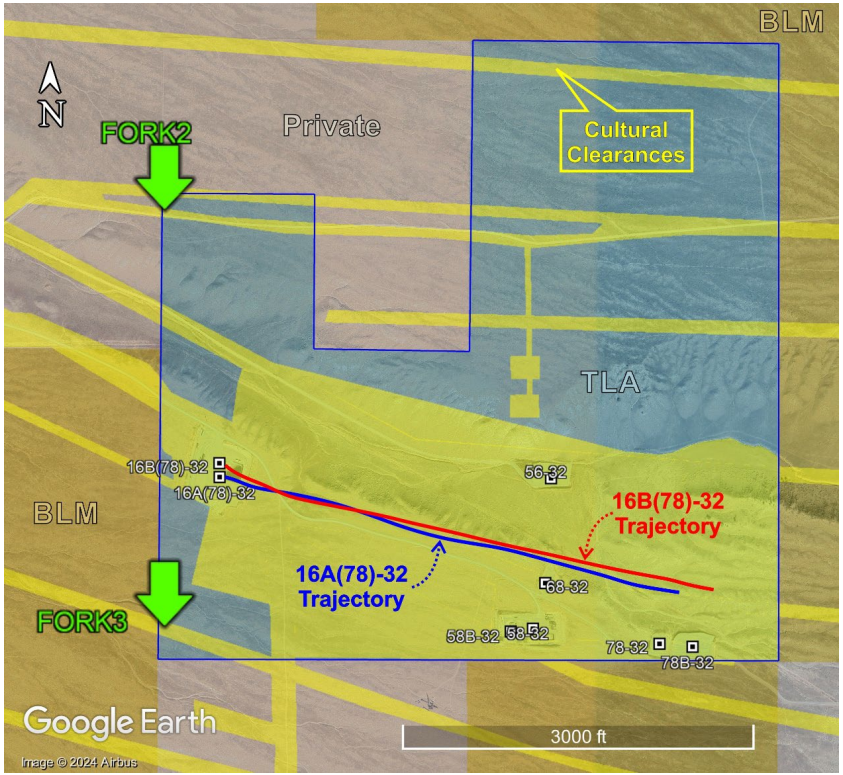
Deep Borehole Monitoring During Operations

Multiple deep boreholes instrumented with geophones → Combination of geophones and DAS

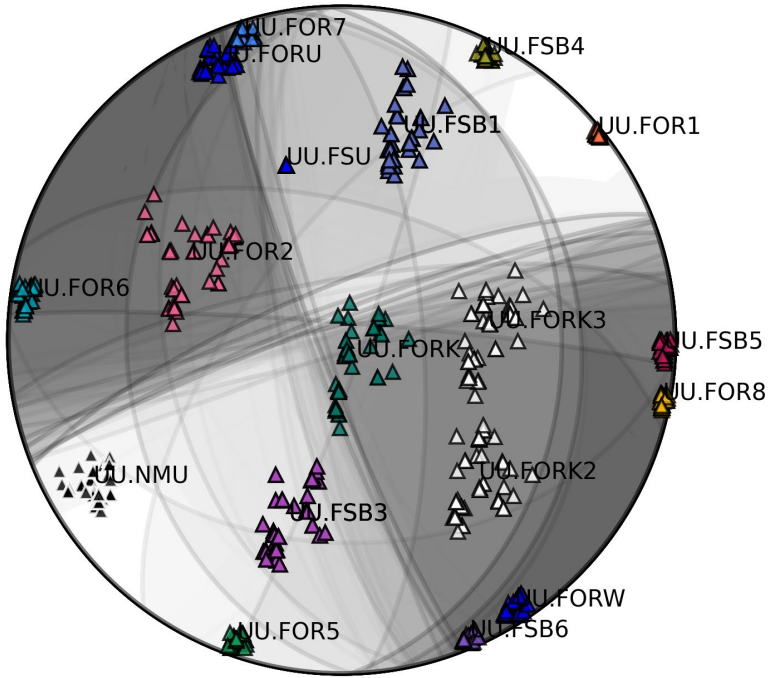
Nodal Geophone Deployments

Single sensors in rectangular or circular arrays → Multi-sensors in patch geometry

Next



1D vel. model - rays (pyrocko.cake)



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THANK YOU!