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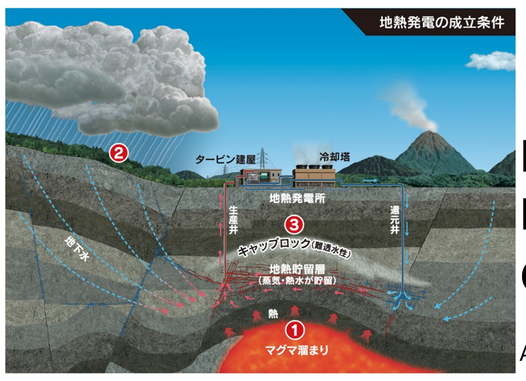
Understanding fluid flow behaviour in geothermal reservoirs through microseismic monitoring: Insights from a water recharge test

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INTRODUCTION



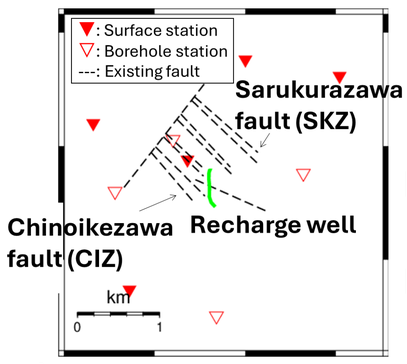
Yanaizu-Nishiyama Geothermal Plant
Rated Output
1995 : 65 MW
2017 : 30 MW
From the web-site of TOHOKU-EPCO



JOGMEC EGS Project
2015FY – 2023FY
Injecting river water into the reservoir to enhance steam volume in the reservoir
Continuous microseismic monitoring

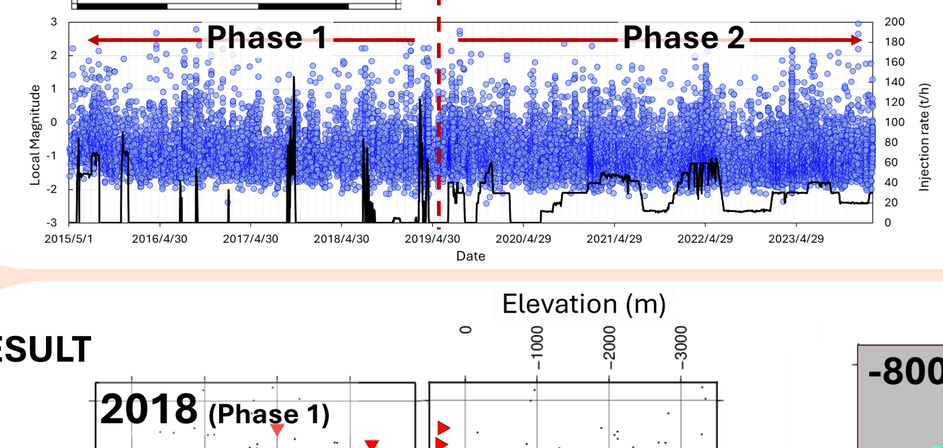
AfterJOGMEC (2020)

FIELD OVERVIEW



Reservoir original condition: Steam dominant

Phase 1: 5/2015～2019/4
174 k ton, < 2km depths
Phase 2: 7/2019～1/2024
1048 k ton, ~ 2km depths



METHOD

- Manual picking of P- and S-wave arrivals
- Double-difference (DD) hypocenter determination
- Event clustering
- DD based Travel-time and Attenuation tomography (tomoDD and DDQ)

Eq. for the DD attenuation tomography

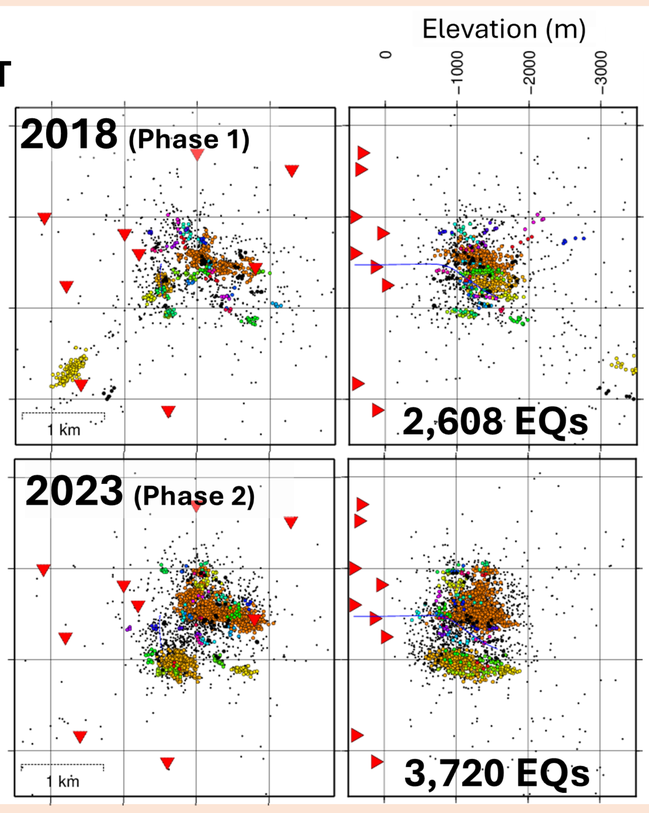
Event: *i*, *j*
Station: *k*
Amplitude spectrum
Zero-freq. spectral Lvl.
Corner freq.
decay factor

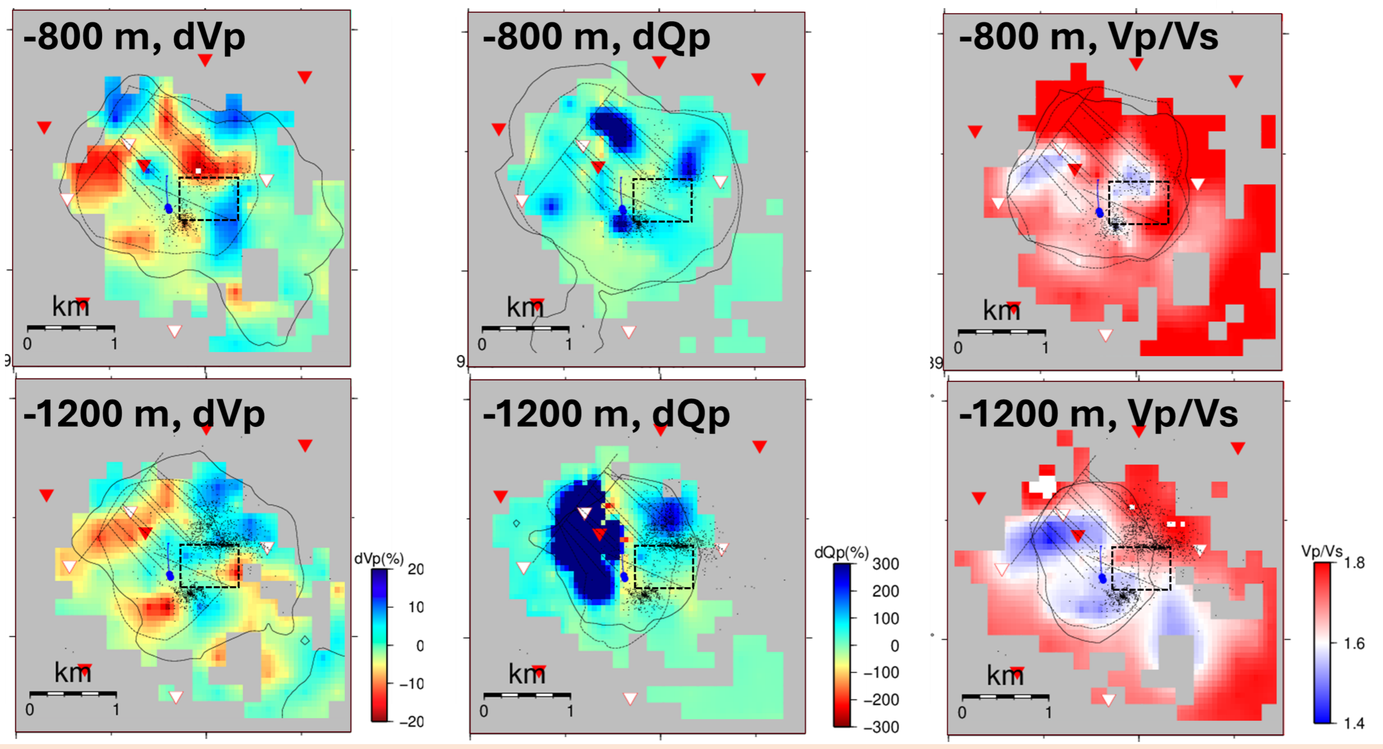
$$R_{A_k}(f) = \frac{A_k^i(f)}{A_k^j(f)} = \frac{\Omega_0^{ik}}{\Omega_0^{jk}} \frac{1+\left(f/f_c^j\right)^\gamma}{1+\left(f/f_c^i\right)^\gamma} e^{-\pi f\left(t_{ik}^* - t_{jk}^*\right)}$$

dt*

- Higher quality dt* can be acquired from spectral ratio inversions
- Uncertainties along the common ray path can be canceled out

RESULT

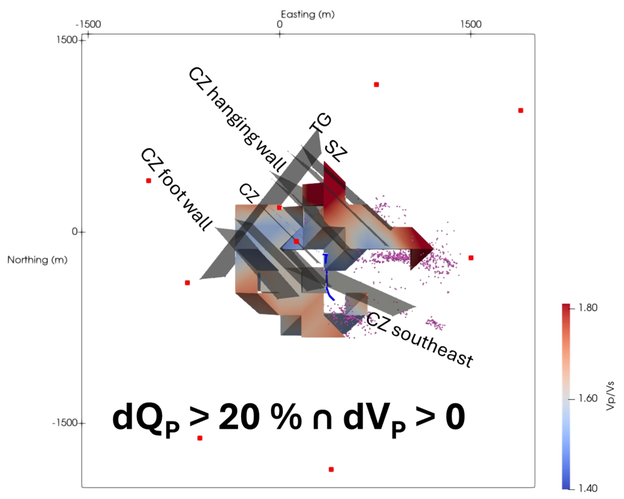




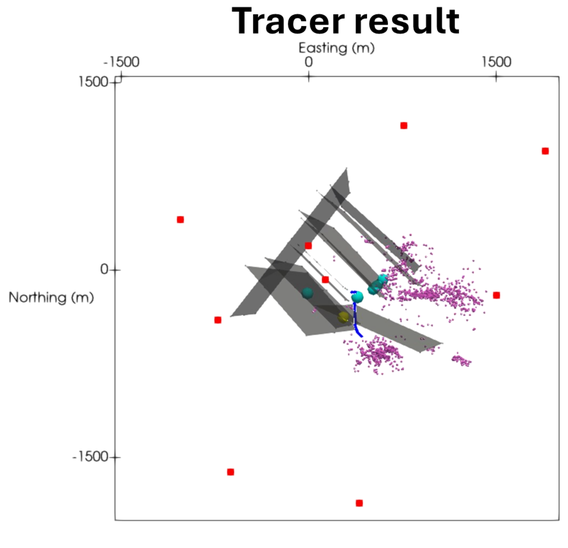
INTERPRETATION

	Saturation increase (partial saturation)	Saturation increase (full saturation)	Pore-pressure increase	Rock damage	Gas dominant	Liquid dominant
dV_P	Decrease	Increase	Decrease	Decrease	-	-
dQ_P	Decrease	**Significant increase**	Decease	Decrease	-	-
V_P/V_S	-	-	-	-	Low	High

Possible macroscopic flow paths

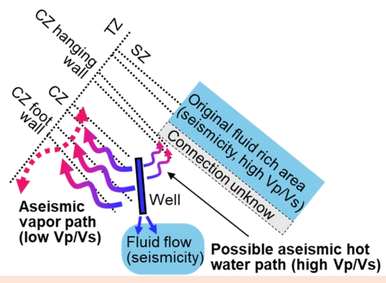


Tracer result



SUMMARY

- Microseismic monitoring and time-lapse seismic tomography were applied to monitor fluid flow during long-term water injection.
- Attenuation (QP) changes revealed macroscopic fluid flow even in aseismic areas.
- Combined VP, QP, and VP/VS analyses could identify liquid- and vapor-dominated zones.
- Tracer tests confirmed flow paths along the CZ fault, validating the tomographic results.



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