PROCEEDINGS, 50th Workshop on Geothermal Reservoir Engineering
Stanford University, Stanford, California, February 10-12, 2025
SGP-TR-229

Final Thoughts and Building on the Hawai'i Play Fairway Project

Nicole Lautze

1680 East-West Rd, POST 602, Honolulu, HI 96822

lautze@hawaii.edu

Keywords: Hawaiʻi, geothermal, Play Fairway, heat, drill

ABSTRACT

Still today very little is known about the extent of geothermal resources across the State of Hawai'i. The Department of Energy funded Hawai'i Play Fairway project took place from 2014-2020. It produced the State of Hawai'i's first quantitative geothermal resource probability model and first statewide geothermal resource assessment since the 1980s.

The project's field work culminated with slim-hole drilling of the deepest well off of Hawai'i Island on the caldera rim of Lāna'i volcano. At 1 kilometer depth, the temperature within the Lāna'i well exceeds those of some geothermal exploratory wells drilled within Kiauea's East Rift Zone (Hawai'i Island). The Play Fairway project incorporated the Lāna'i drilling data into a final resource probability model and produced a road map for future exploration activities.

After several years of advocacy with little to no funding, a $5 million state-funded project aims to drill a deep slim-hole in 2025. This paper will detail the final stages of the Hawai'i Play Fairway project and provide a status update on the current project. It will also discuss success with recent outreach activities and current discussions around refining Hawai'i's regulatory system to better facilitate characterization of the State's deep (greater than 1 kilometer) subsurface.

1. INTRODUCTION

The Hawaiʻi Play Fairway (PF) project, conducted between 2014 and 2022 and funded by the U.S. Department of Energy's Geothermal Technology Office (DOE-GTO), has provided the first comprehensive statewide geothermal resource assessment in Hawaiʻi in over three decades, and is the first to apply a mathematical approach to the consideration of resource probability. Phase 1 of our PF analyses introduced a universally-applicable Bayesian statistical methodology to integrate data relevant to Hawaiʻi's geothermal resources into a statewide resource probability map. This map was updated with new field and modeling data collected during Phases 2 and 3. To date the project results are summarized across five publications in the journal Geothermics (Lautze et al., 2017a, 2017b, 2020, 2024; Ito et al., 2017). Published here-in is our final evaluation of how best to apply the universal PF model derived in project Phase 1 to the specific case that is the current state of subsurface knowledge in Hawai'i. Whereas our previous assessments were based on computed probabilities of substantial Heat, Permeability, and Fluid for a geothermal resource, we now advocate using our final probability of heat alone, and our confidence in this probability, to drive the next phase of exploration.

2. FINAL PROBABILITY AND CONFIDENCE MAPS

Our published maps for each island in the State of Hawaiʻi from project Phase 1 show a) calculated probabilities of three attributes: Heat (Pr_H), Fluid (Pr_F), and Permeability (Pr_P)l b) the combined probability of a Resource (Pr_R), calculated as the product of the individual three probabilities; and c) our computed Confidence in Pr_R (Ito et al., 2017). Fig. 1 shows Phase 1 results for the Island of Oʻahu.

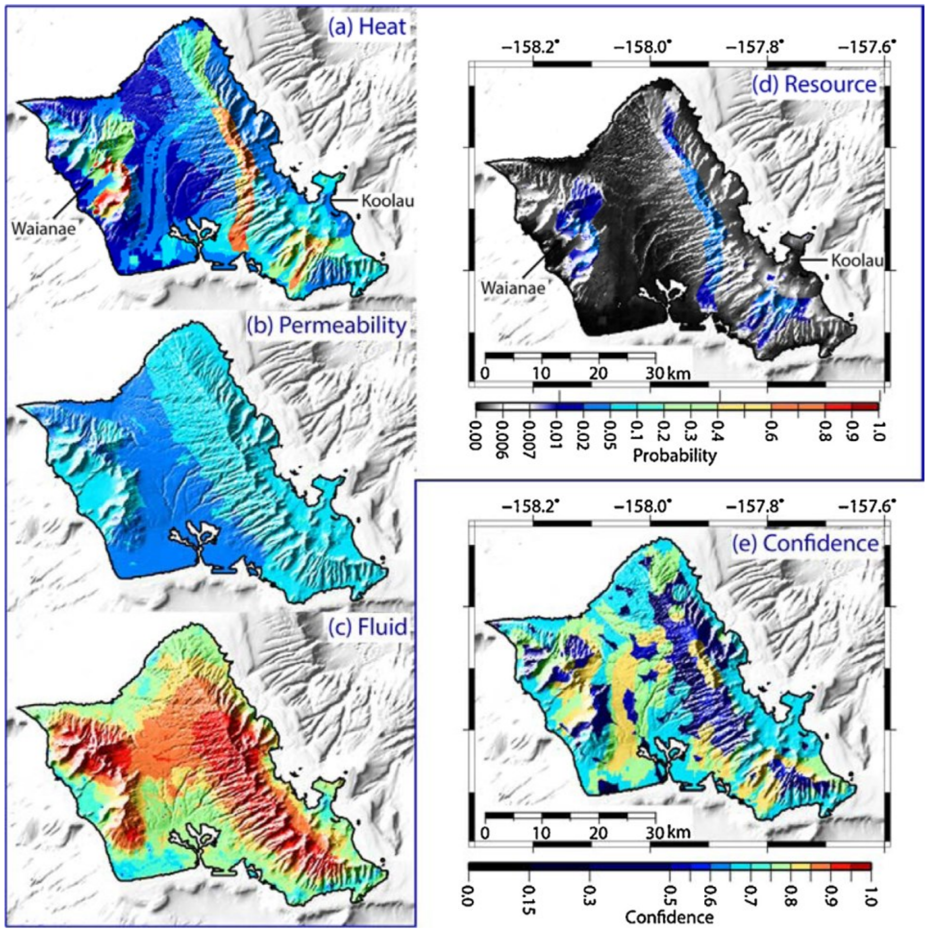

Figure 1: Phase 1 Probability and Confidence results for the Island of O‘ahu.

As is apparent in Fig. 1 and was is generally true statewide (Ito et al., 2017; Lautze et al., 2017b), the calculated Phase 1 resource probabilities (Pr_R) are low; our calculated Pr_R was less than 10% across most of the state, nowhere above 30% off of Hawai‘i Island, and only 45% at the state's only proven site, Puna Geothermal Venture (PGV).

2.1 Use Probability of Heat and not combined Resource Probability as a guide

We now conclude that our Phase 1 results were too conservative. Upon further consideration, we recognize that everywhere in Hawai‘i, Pr_F will be equal to 1 at resource depths below sea level (vast majority of the state). Also, we also recognize that owing to the paucity of deep (>1 km) drilling data across Hawai‘i, we have little data to constrain Pr_P at expected resource depths. Thus, until more data are acquired, we posit that statewide maps of Pr_H and Confidence in Pr_H guide exploration activities.

2.2. Remove groundwater data from PF model

Three issues concerning the use of groundwater data the Pr (H) were identified. These are: i) the absence of a positive thermal indicator in groundwater should not decrease the Pr_H because high rainfall rates can overwhelm even significant discharges from active hydrothermal systems; ii) large uncertainties in groundwater flow direction; and iii) our inability to unequivocally determine the ultimate source of the thermal anomalies where observed.

2.3. Include T/D data measured on Lānaʼi to refine heat loss with time function

A dearth of information is available to assess how Hawaiian shield volcanoes maintain (or lose) heat over time. Based on available data in Phase 1 of this project, we set a relatively rapid function for the heat loss with time since last eruption (Ito et al., 2017). Temperature measurements obtained via this project's Phase 3 drilling on Lānaʼi (Lautze et al., 2024) provided quantitative data resulting in a "reset" of this function to show more modest heat loss with time.

3. HEAT MAP

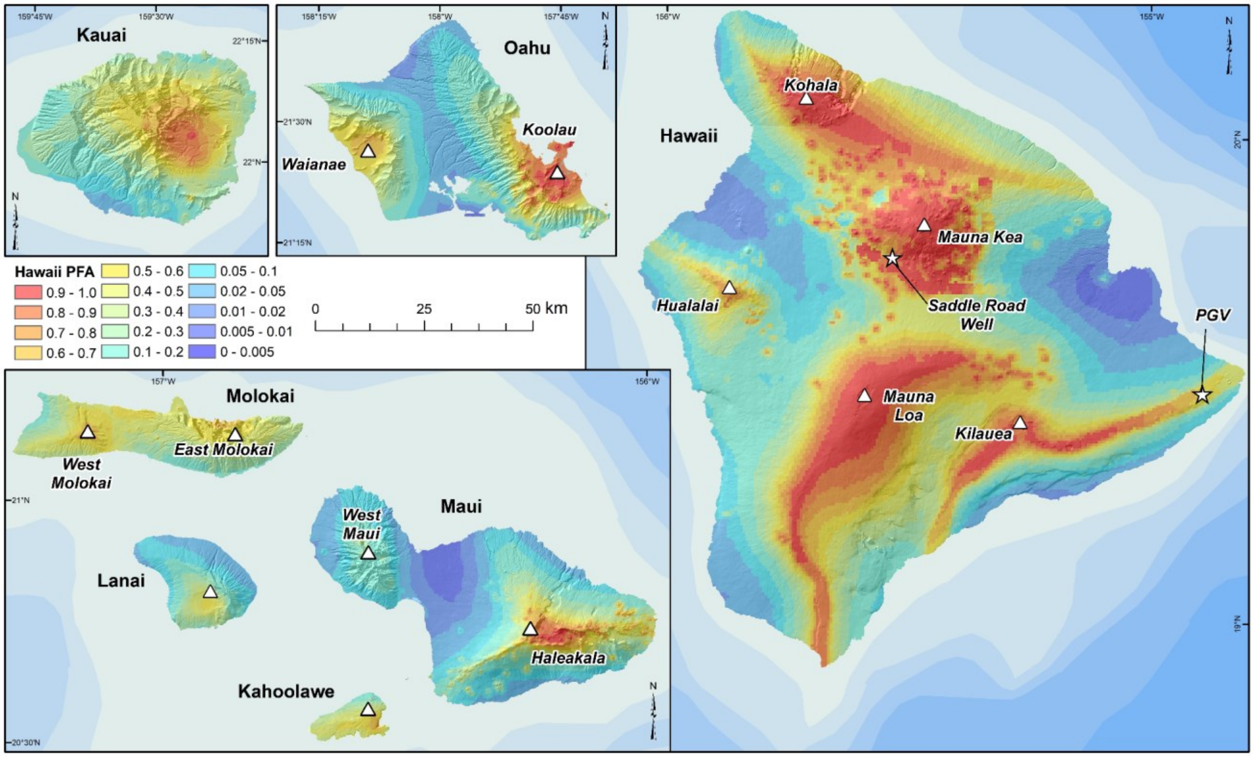

Figure 2: Probability of subsurface Heat across the State of Hawai'i as calculated according to the Hawai'i Play Fairway method

4. UPDATES

In this author's opinion, there are 3 primary outstanding issues that present obstacles to further development of geothermal across the State of Hawai'i currently. These are: lack of basic data, lack of understanding, current regulations. It will be important to move forward with tackling all three, and movements are in place to do so.

5. CONCLUSIONS

This paper presents a final statewide map of the probability of a geothermal heat across the State of Hawai'i (Pr_H). In contrast to our prior maps of Pr_R, which were based on the products of the computed probabilities of substantial Heat, Fluid, and Permeability,

$$Pr_R(x) = Pr_H(x)Pr_F(x)Pr_P(x) \tag{1}$$

where Pr_R, Pr_H, Pr_F, Pr_P, x, are probability of a geothermal resource, heat, fluid, permeability, and location on a map, respectively. We now suggest using Pr(H,x) and its confidence to guide future exploration activities. The probability of fluid is essentially approximated as being equal to one because extensive evidence indicates that fluid is pervasive in the Hawaiian crust below sea level, which coincides with the expected subsurface depths of Hawai'i's geothermal resources where production is viable. The lack of ability to assess Probability of permeability Pr_P should motivate further deep (1-3km) exploratory drilling across the State of Hawai'i.

REFERENCES

Ito, G., Frazer, N., Lautze, N.C., Thomas, D.M., Hinz, N., Waller, D., Whittier, R., Wallin, E., 2017. Play Fairway Analysis of Geothermal Resources across the State of Hawai'i: 2. Resource Probability Mapping. Geothermics, 70, 393–405. https://doi.org/10.1016/j.geothermics.2016.11.004

Lautze, N.C., Ito, G., Thomas, D.M., Frazer, N., Martel, S., Hinz, N., Tachera, D., Hill, G., Pierce, H., Wannamaker, P., Martin, T., 2020. Play Fairway Analysis of geothermal resources across the State of Hawai'i: 4. Updates with new groundwater chemistry, subsurface stress analysis, and focused geophysical surveys, Geothermics 86. https://doi.org/10.1016/j.geothermics.2019.101798.

Lautze, N.C., Thomas, D.M., Haskins, E., 2024. Play Fairway Analysis of Geothermal Resources across the State of Hawai'i: 5. Slim hole drilling on Lāna'i Island. Geothermics 124. https://doi.org/10.1016/j.geothermics.2024.103147.

Lautze, N.C., Thomas, D.M., Hinz, N., Ito, G., Frazer, N., Waller, D., 2017. Play Fairway Analysis of Geothermal Resources across the State of Hawai'i: 1. Geological, geophysical, and geochemical datasets. Geothermics 70, 376–392. https://doi.org/10.1016/j.geothermics.2017.02.001.

Lautze, N.C., Thomas, D.M., Waller, D., Hinz, N., Frazer, N., Ito, G., 2017. Play Fairway Analysis of Geothermal Resources across the State of Hawai'i: 3. Use of Development Viability as one criteria to prioritize future exploration activities. Geothermics 70, 406–413. https://doi.org/10.1016/j.geothermics.2017.07.005.