Blind Geothermal System Exploration in Active Volcanic Environments; Multi-phase Geophysical and Geochemical Surveys in Overt and Subtle Volcanic Systems, Hawai'i and Maui

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Innovative Exploration Technologies

This presentation does not contain any proprietary confidential, or otherwise restricted information.

Overview

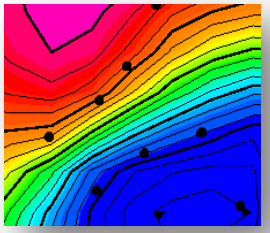
- Timeline
  - Project start date ***10/29/2009***
  - Project end date ***Q1 2012***
  - Percent complete **~10%**
- Budget
  - Total project funding **$10,486,559**
  - DOE share **$4,911,330**
  - Awardee share **$5,575,230**
  - FY10 funding **$598,269**
- Barriers
  - 'Blind' system
  - Culturally sensitive location
- Partners
  - Lawrence Berkeley National Lab
  - UC Santa Cruz

Relevance/Impact of Research

To fully realize the potential of geothermal in this century, we must pursue 'non-traditional' resource

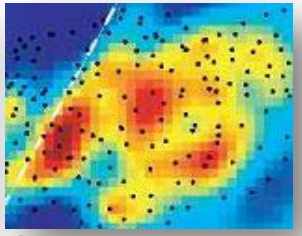
- This project targets a 'blind' volcanic system on the southwest flank of Maui, Hawai'i – unconventional due to volcanic dormancy and lack of surface thermal manifestation
- Assessing unconventional targets requires re-tooling the standard geothermal exploration kit and adding in new tools

We'll combine traditional and new technologies for a fresh look at a blind system

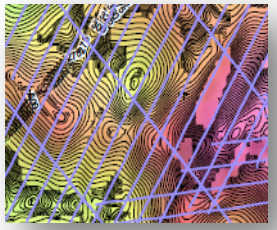


Gravity

CO_2 Flux

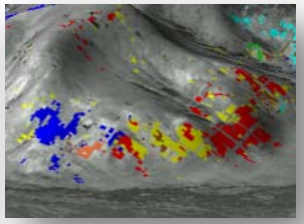


Soil Temp.



Aeromagnetics

Isotope Geochem



Hyperspectral

Objectives

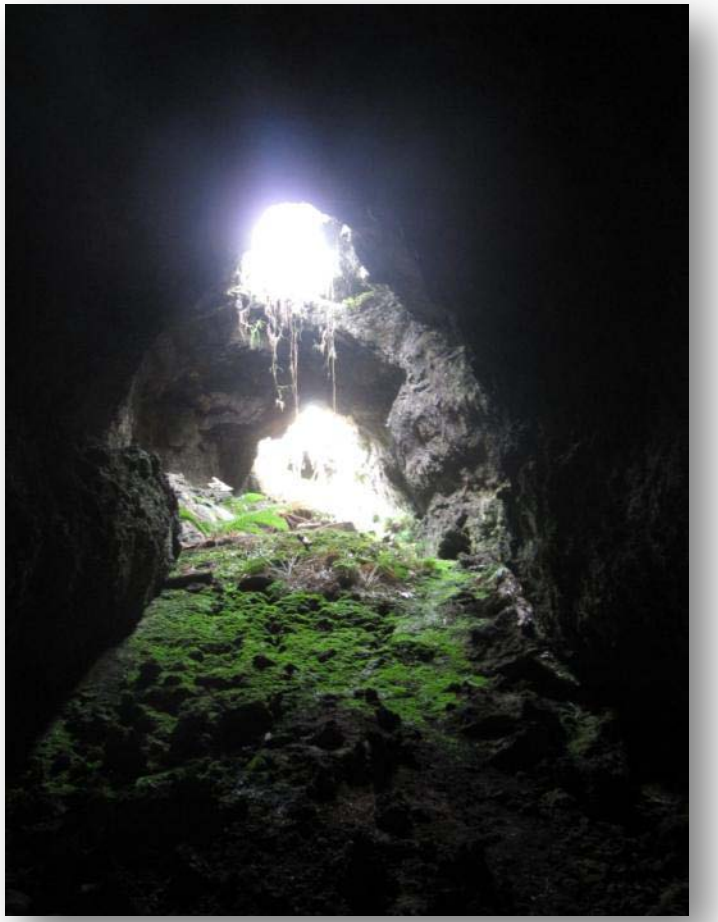
- We plan to use a combination of traditional geophysical and geochemical tools with exploration suites not typically used in geothermal exploration
  - These techniques will be assessed first at the Ormat-run Puna geothermal field – a 'known' system
  - The exploration suites will then be applied at Ulupalakua Ranch (a private lease on Maui); a site of similar, but older volcanism to Kilauea/Puna

Puna, Hawai'i

Ulupalakua, Maui

Relevance/Impact of Research

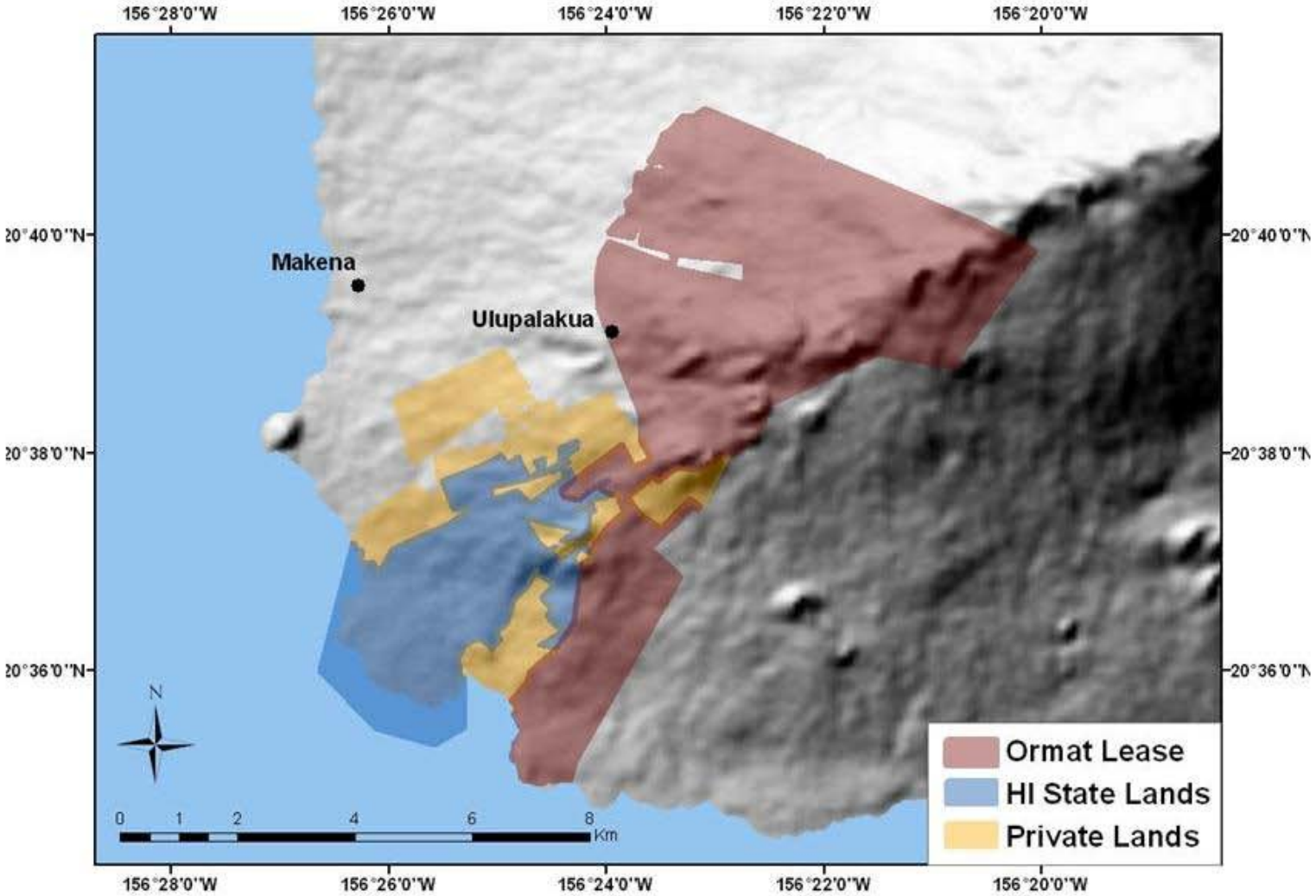
- Our research will
  - Provide a benchmark for exploration of other 'blind', dormant volcanic systems
  - Validate gravimetry and aeromagnetics for geothermal exploration in young, basaltic volcanic environments
  - Demonstrate use of CO_2, isotope analysis and hyperspectral imaging in young, hot-spot volcanic systems for geothermal exploration
  - Provide baseload energy for Maui island



Lava Tube (900 yrs old)
Ulupalakua, Maui

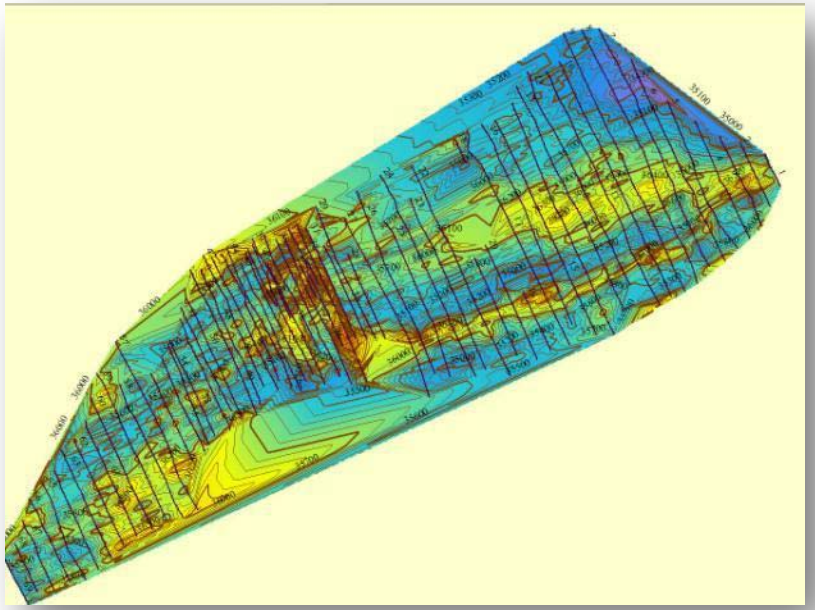
Study Area – Ulupalakua Ranch, Maui

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Scientific/Technical Approach

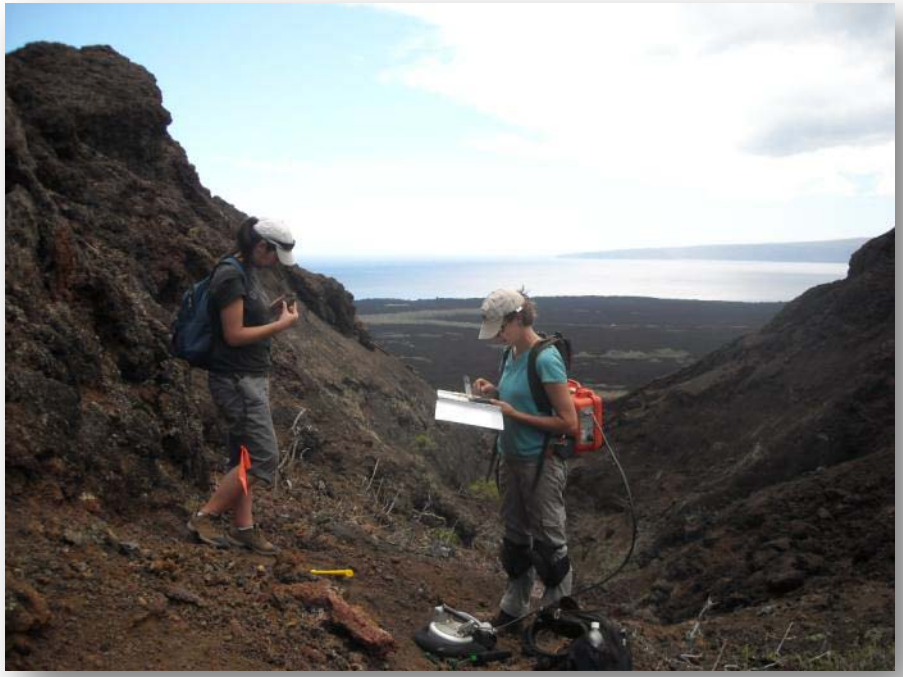
- Compile historical geophysical and geochemical information for the Puna geothermal field
  - Status: on-going
    - Old gravity and aeromag are being re-processed using modern algorithms and georeferenced to standard datums and projections
    - Geochemical data being compiled; many sources over three decades



Re-processed TMI (archival USGS data) - Puna, Hawai'i

Scientific/Technical Approach

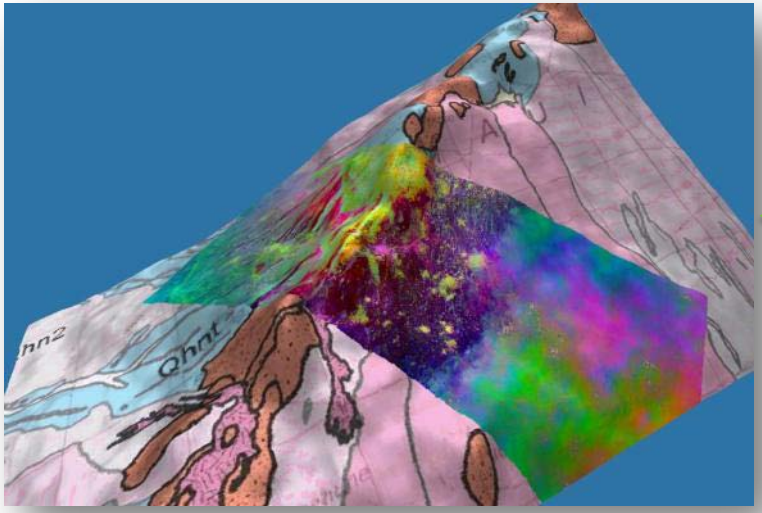
- Conduct initial reconnaissance of Puna and Maui for potential CO2 degassing (in preparation for full gridded survey)
  - Status: completed
    - Flux measurements were taken over three days within and directly adjacent to the Puna field during outage
    - Sites of recent volcanism along the HSWRZ were sampled over three days on Maui



CO2 Flux measurements
Kuala O Lapa, Maui – April 2010

Scientific/Technical Approach

- Hyperspectral imagery analysis for biological and geological anomalies related to potential degassing or other geothermal signatures
  - Status: In-progress.
    - Initial analysis for vegetation stress caused by potential degassing was completed. Anomalies could not be confirmed as CO2-induced; may be due to other factors (eg. Moisture, parasites, etc.)
    - Geological mapping on-going; alteration so-far is minimal



Spectral analysis for vegetation anomalies

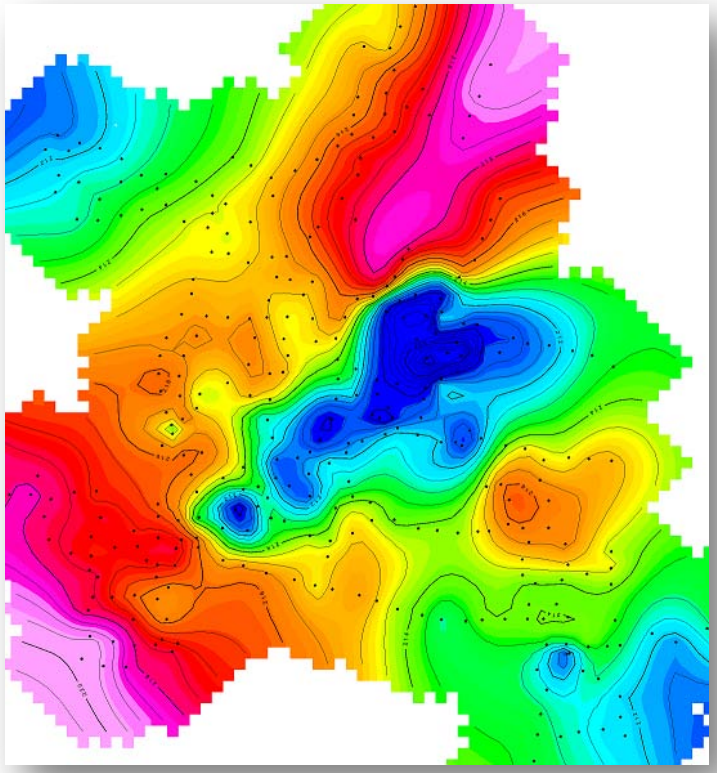
-HSWRZ, Maui

Dead/stressed vegetation

Makua Pu'u, Maui – April 2010

Scientific/Technical Approach

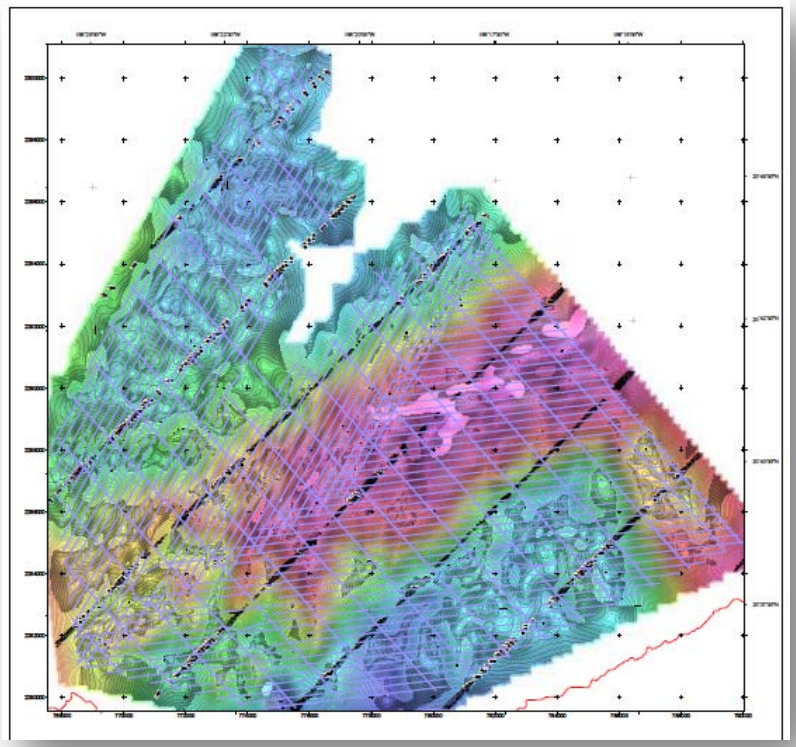
- Acquire ground-based gravity of Ulupalakua Ranch and surrounding land on Maui (~400 stations at 400 m spacing)
  - Status: 80% complete as of 3 May 2010



Preliminary Bouger gravity (CBA@ 2.35 gm/cc). Terrain corrections range from 16m to 10km (no bathymetry, curvature, near-zone, etc. corrections yet)

Scientific/Technical Approach

- Acquire aeromagnetics of Ulupalakua Ranch and surrounding land on Maui (~1500 line kilometers @ 400 m spacing)
  - Status: Complete – post-processing underway



Preliminary RTP magnetic survey (box-grid flight lines in light purple); unleveled in regions of high gradient - 50m grid interval

Scientific/Technical Approach

- Creation of database and 3-D structural model of the Ulupalakua project using newly acquired geophysics and ground mapping results
  - Status: In-progress.
    - Final delivery of Maui geophysical surveys expected in early June.
    - Re-processed Puna geophysics expected mid-June.
    - Currently testing new software suites to improve our modeling capability.
- Collection of full CO_2 flux grids and isotope geochemistry over the Puna and Ulupalakua projects as queued by the geophysical models
  - Status: Not yet begun
    - Planned for mid to late July

Milestones – Go/No-Go Decisions

- Milestones FY2010
  - Project began 10/29/2010
  - Contract signed 4/5/2010

- Go/No-Go *Phase 1*
  - Though Maui is a site of recent volcanism, there is no surface thermal manifestation and the existence of an active, convecting hydrothermal system on Maui is presently unknown
    - Lack of faulting, fracturing and/or intrusions revealed by geophysics and field mapping coupled with no/poor geochemical results will result in a No-Go decision
    - Lack of an encouraging geochemical signature will not preclude Phase 2 drilling

Project Management/Coordination

- Project Management
  - Martini (co-PI) is managing and overseeing all phases of database creation, geophysical acquisition, hyperspectral analysis, project logistics and budgeting
  - Lewicki (co-PI) is coordinating the geochemical surveys (CO2 flux and isotope)
- Schedule
  - Phase 1 completion ***(Q4/2010)***
  - Phase 2/3 completion – Permitting and drilling ***(Q4/2011)***
- NGDS integration
  - Our database (that will include geophysical surveys and geochemical measurements) will be provided to the NGDS in whatever requested format is decided upon

Southwest Rift Zone
Makua Pu'u, Maui – April 2010

Future Directions

- We're looking towards development of our structural model to queue geochemistry this summer 2010
  - *We expect to site drill targets in Q4/2010*

- Community outreach continues
  - *Renewable energy has a lot of support in Maui (~9% of their load is wind)*
  - *Our private lease with Ulupalakua Ranch remains solid and adjacent landowners are supportive*
  - *Traditional resources have been identified and the Native Hawaiian community remains supportive*
  - *The Natural Area Reserve System has been engaged and has also been supportive to our exploration*

Summary

- Key geophysical surveys are complete or near completion on Maui
- Historical databases for Puna are in-progress
- The second half of Phase 1 (geochemistry) will begin in July 2010
- A Go/No-Go decision will be made in Q4 – 2010 with regards to drilling