Faith and Science Council Report:

Hawaii Field Work, August 1-11 – Rapid Geologic Rates and Isotope Ratios

14 October 2022

ABSTRACT

2022 August 1-11 – Five students and professors from the Loma Linda University Department of Earth and Biological Sciences (EBS) did geology field work on the big island of Hawaii. This report provides a sampling of pictures from the field work, maps of the sample collection locations, and spreadsheets of the data. Now we are curating the samples collected, selecting the ones for further study, cutting rocks for microscope thin sections, and sending some for geochemical analyses

2018 September – Several from EBS/GRI did a preliminary visit to the same island of Hawaii. This report includes an update on that field work with pictures of the fresh lava flows taken from a helicopter, a detailed analysis of thin sections, and a summary of the geochemistry done on others samples and on our 2018 samples.

The final section summarizes our science and religion goals and aims, especially in relation to Clyde Webster's Yellowstone/Hawaii research and to attendance at the July 2022 Goldschmidt geochemistry conference. This section references published material: in a book chapter about how we do research, in a poster for the General Conference session about our worldwide project, and in a *College and University Dialogue* article about how we share with the community.

2022 AUGUST

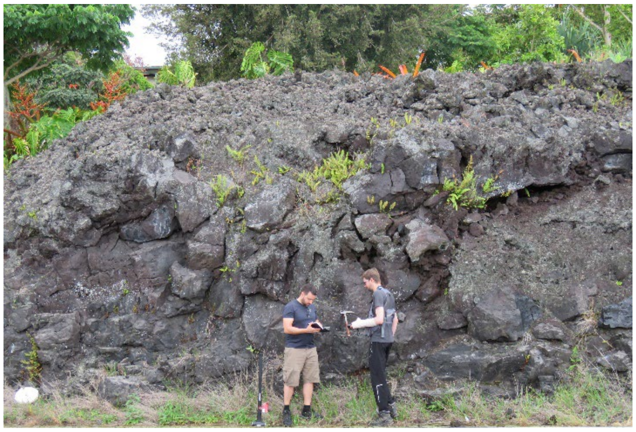
2022: Fieldwork

From August 1 to 11, Ana Martínez, Ben Clausen, Dan O'Hare, Alex Voos, and Roger Clawson did field work on the big island of Hawaii. Dr. Martínez is a geology professor in EBS and the lead investigator on this project. Clausen is a co-PI. Dan is an EBS student using this research in Hawaii as his PhD project. Alex is an EBS student during research on volcanics in Peru and using the Hawaii project to develop fieldwork skills. Roger is a retired dentist and currently an EBS student working in Bolivia with Raul Esperante. He owns a house near Kailua-Kona that he kindly let us use. For the last several days of our fieldwork, he joined us using his 4WD truck for some difficult sample collection sites.

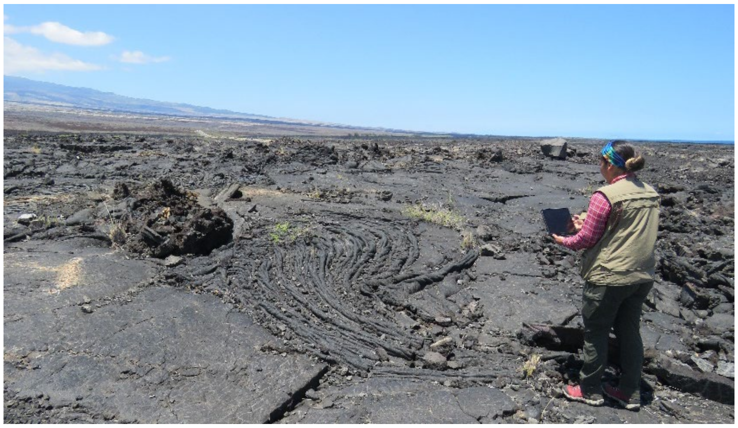
Clausen took more than a thousand field pictures. A couple dozen were posted to his Facebook page the beginning of August. Here are examples, with Dan, Ana, and Alex shown in the first picture:

Layered volcanic flows, southern most part of island.

Layered volcanic flows, Rainbow Falls near Hilo



Blocky volcanic flow, south of Kona.



Pahoehoe (ropey) lava, north of Kona.

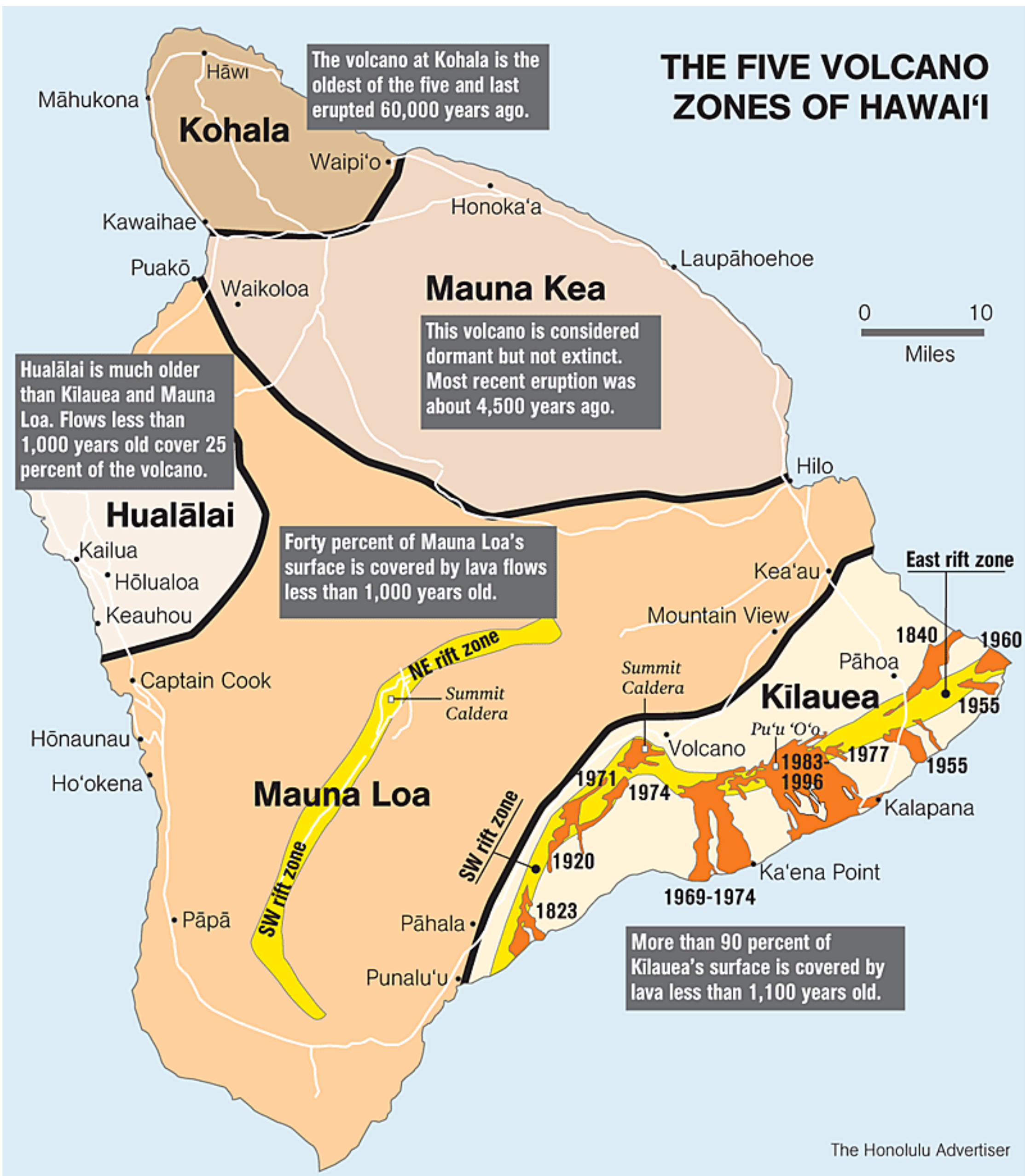
Lava flow with xenoliths from the mantle, east of Kona.

Green olivine phenocrysts, northern part of island.

2022: Schedule

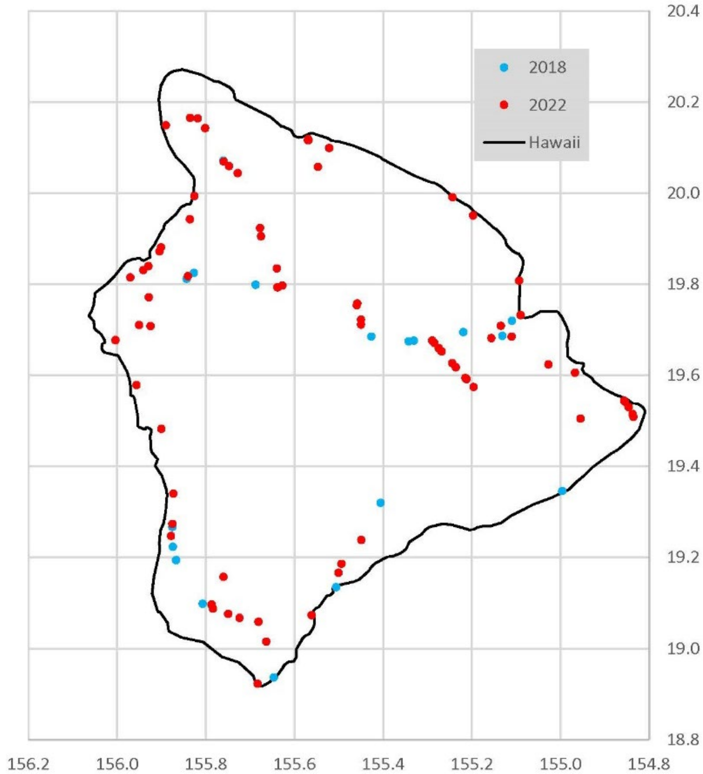
Samples were collected from the five volcanoes on the big island of Hawaii as follows:

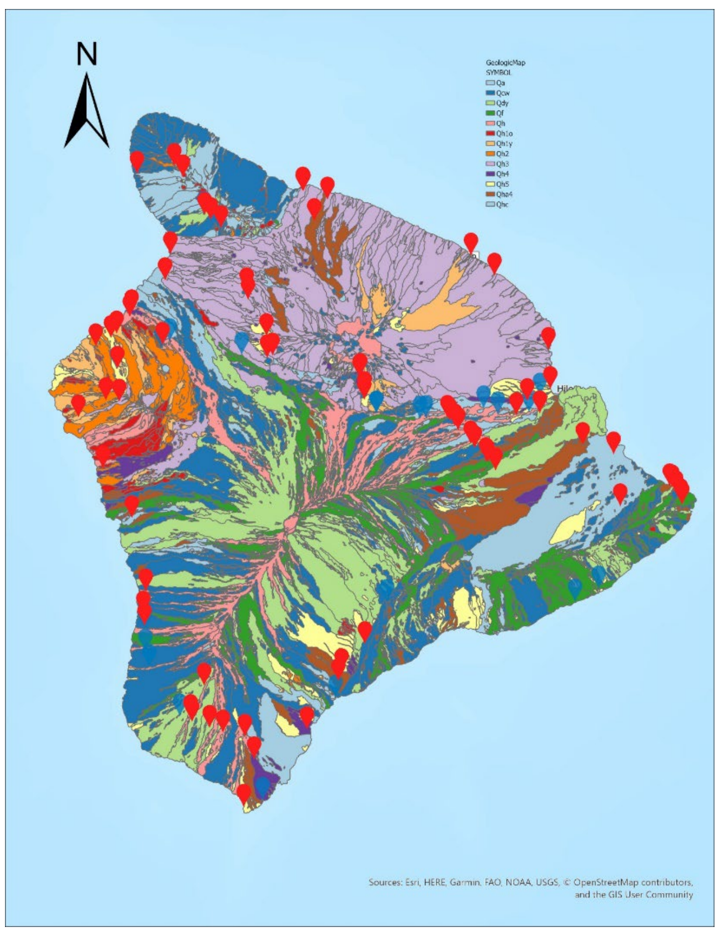
- Aug 1-3 – developing field strategy, Mauna Loa
- Aug 4 – Kilauea … still very active
- Aug 5 – Hualalei
- Aug 6 – Sabbath
- Aug 7 – Hilo area
- Aug 8 – Mauna Kea … with several telescopes at the top
- Aug 9 – Saddle Road between Mauna Kea and Mauna Loa
- Aug 10 – Kohala … extinct
- Aug 11 – preparing samples for transport, visiting Hawaii Volcanoes N.P.



The big island of Hawaii has five volcanoes from old to young: Kohala, Mauna Kea, Hualalai, Mauna Loa, and Kilauea.

2022: Collection locations





Samples collected from all five volcanoes: 26 samples (blue) in 2018 and 87 (red) in 2022

2022: Sample and data curation

We now have more than one hundred samples from Hawaii with a weight of more than 200 pounds. These have been curated with the following information:

- Date/time – for labeling purposes and to correlate with pictures taken in the field
- Label – by year, month, day, stop#
- Location – latitude/longitude of the sample site taken with a Garmin GPS, as well as milepost and nearby geography
- Pictures – of the field outcrop, as well as of the rock sample when preparing for transport
- Weight – to help in determining sample size available for different analyses
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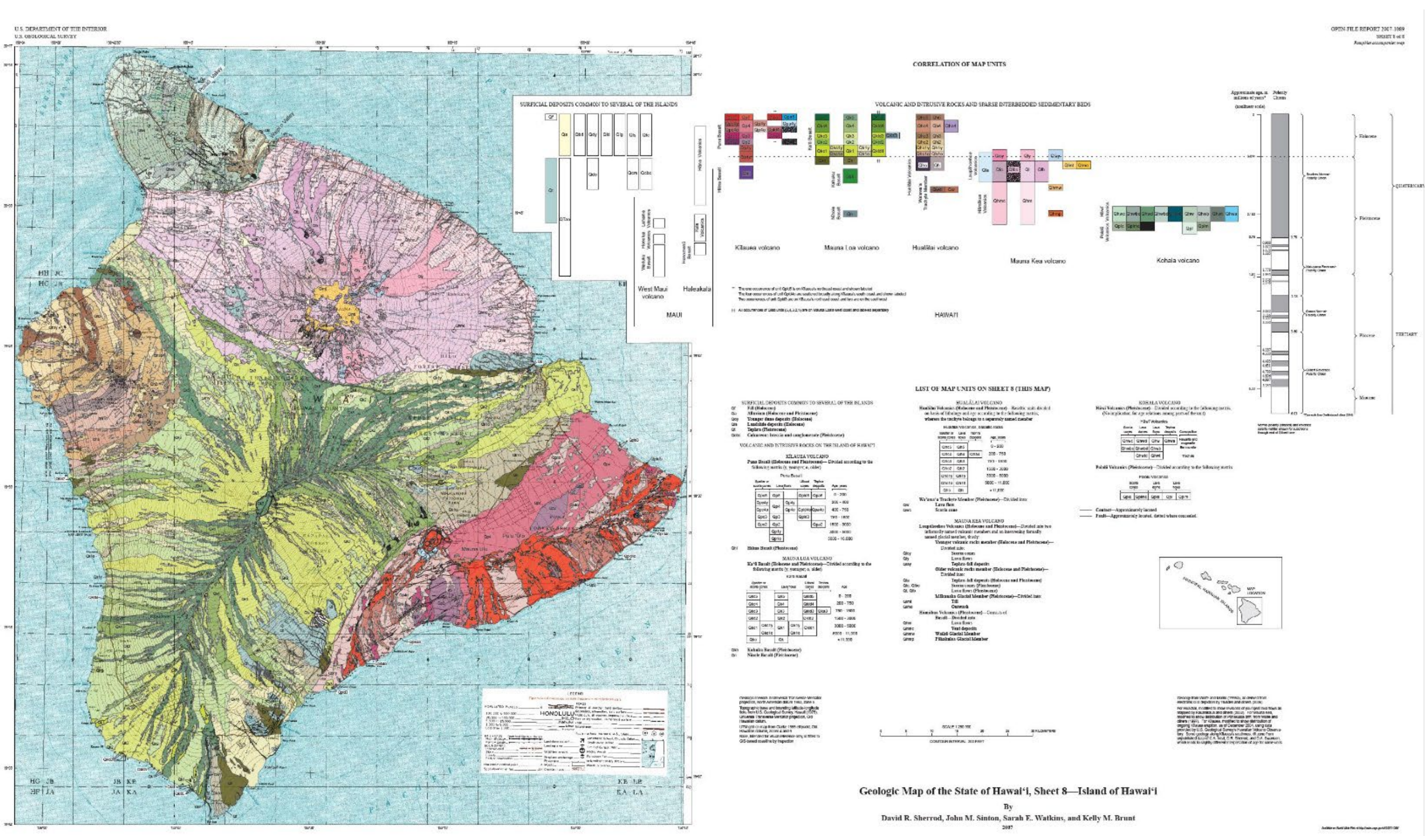
- Rock unit/type – by observation and from the geologic map and the literature (later from geochemistry)
- Outcrop type – e.g., lava flow, ash fall, aa/pahoehoe, cinders, xenoliths, …
- Description – including: vesicle size, color, weathering (amount and type), structure/fabric, magnetic susceptibility, local vegetation
- Minerals – type (olivine, plagioclase, pyroxene), size, abundance (using a chart)
- Age – historic flows have a known age; older flows have an estimated age

This data is shown in the attached Excel spreadsheet. It is being incorporated into ArcGIS for map display, along with data from the literature as available in GEOROC. A sample collected from Diamond Head on the island of Oahu in July is also included.



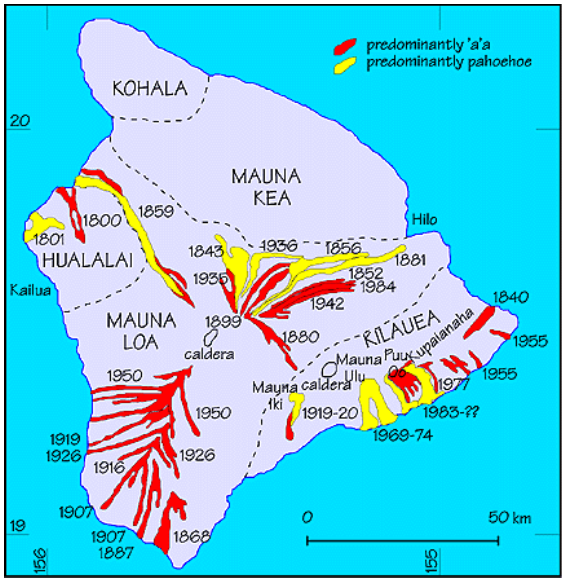
Official geologic map of the island, showing the many individual lava flows from each volcano.

2022: Geochemical analysis of samples

At the July Goldschmidt geochemistry conference in Honolulu, Dominique Weis asked William White what needs to be done next in understanding mantle plumes, especially in Hawaii. He said we need all the different possible analysis done on the same rock for many samples. This may be a way we can benefit the scientific community with new and carefully collected data.

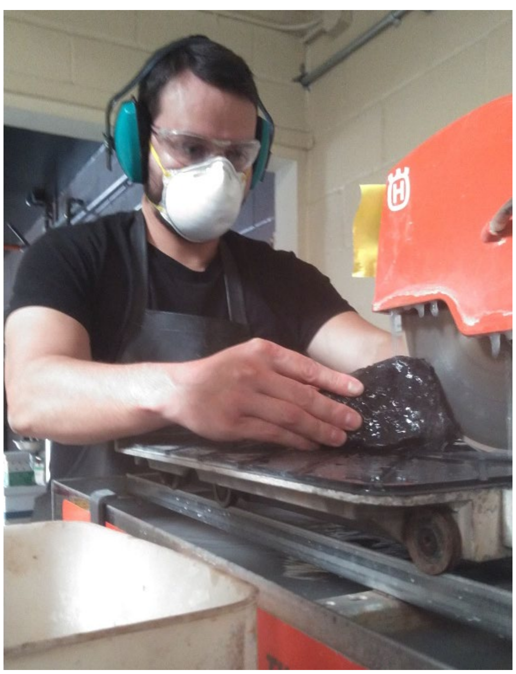
Here are some of the analyses that we will be doing:

- Major elements – The major oxides are: silica SiO_2, alumina Al_2O_3, "rust" Fe_2O_3, magnesia MgO, lime CaO, soda Na_2O, potash K_2O, and titania TiO_2. We have done these analyses on our 2018 Hawaii samples and will do it for most of our 2022 samples.
- Trace elements – For our purposes, some of the more important trace elements are strontium Sr, rubidium Rb, barium Ba, zirconium Zr, hafnium Hf, uranium U, thorium Th, niobium Nb, tantalum Ta, lead Pb, nickel Ni, cobalt Co, scandium Sc, the rare earth elements, and yttrium Y. The Sr/Y ratio can be an indicator of the source depth for the magma. Zirconium is the element of importance in the mineral zircon and can be substituted by uranium or thorium. Rubidium and barium are incompatible elements that preferentially move into liquid magma in contrast to nickel, cobalt, and scandium which preferentially stay in the solid.
    - We have done trace element analyses on our 2018 samples and will do it for most of our 2022 samples. Apparently, a lot of trace element data is missing for past geochemical sampling.
    - The cost for doing a full set of major and trace elements is about $75/sample.
- Radiogenic isotopes, standard – The mostly commonly measured radiogenic isotopes are strontium, neodymium, and lead. These come from the decay of rubidium, samarium, and uranium/thorium respectively. These are important for radiometric age dating, but also in determining the source of the magma. Different magma reservoirs have different isotope ratios, e.g., between the Earth's crust and mantle.
    - Our interest is in determining whether these isotope ratios can come from recycling and mixing of magmas from different crust and mantle reservoirs, rather than from long ages of radioactive decay.
    - The cost for doing a Sr/Nd/Pb isotope analysis can easily be $1000/sample; however, we are usually able to get it done for half that much at University of Arizona.
    - For the Hawaii samples, Dominique Weis has a special way of measuring lead isotopes in her laboratory, in order to determine the original ratios in the magma chamber unaltered by later contamination.
- Radiogenic isotopes, other – Hafnium Hf, osmium Os, and helium He are other radiogenic isotopes that are sometimes measured to aid in determining magma reservoir source. We have done a number of Hf analyses on our zircon grains in the past, and would like to try some of these analyses on our new samples from Hawaii. Any isotope analysis is expensive, however.
- Stable isotopes – The most commonly measured stable isotopes are oxygen, sulfur, and carbon. The relative abundance of isotopes for an element is difficult to change. Magmatic processes generally have little effect, so radioactive decay seems to be the primary method in the Earth's interior. However, at the Earth's surface the isotope ratios can be changed by processes such as evaporation for oxygen and hydrogen and life's metabolic processes for carbon. If these isotope ratios are not primordial, they may come from subducted crust recycled into the mantle.
- Ages – We are interested in getting radiometric ages on some of our Hawaii samples, especially historical lava flows for which we already know the age. If we can find zircons in any of our mafic basalts, we could get uranium-lead ages; however, it would be easier to find zircons in our more felsic samples such as trachyte and benmoreite. It also might be possible to get potassium-argon ages on minerals such as hornblende and sanidine.



Specific ages are known for the historic lava flows on the big island of Hawaii. We have samples of most of these flows and can do radiometric dating on them.

<u>2022: Rock sample preparation</u>



Dan O'Hare cutting one of his Hawaii basalt rock samples.

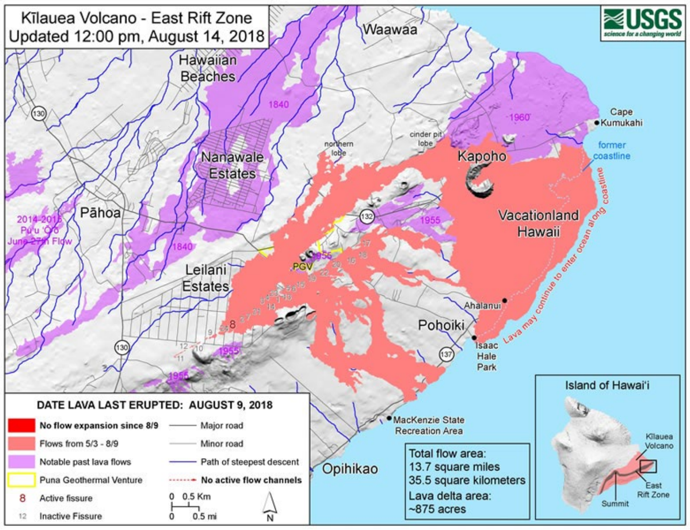
Dan and others preparing microscope thin sections of their rock samples.

2018 SEPTEMBER

2018: Fieldwork

During our September 2018 visit to Hawaii, we flew over the fresh lava flows in a helicopter. I recently labeled these pictures and posted a few to Facebook. Here are several examples:

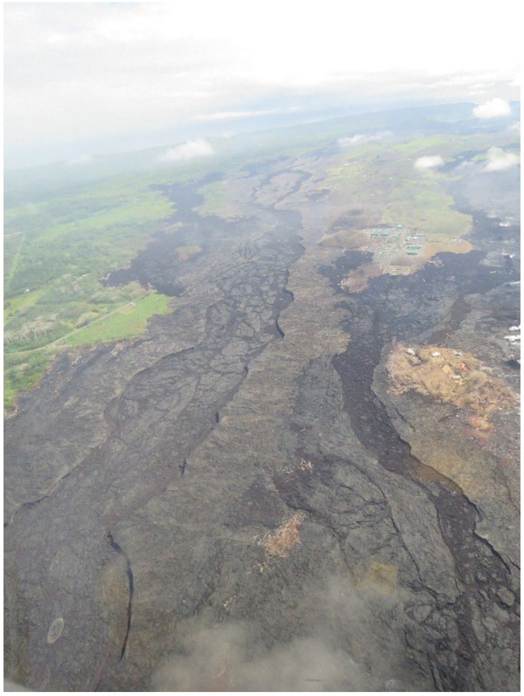
Dr. Martinez exiting after the helicopter flight.



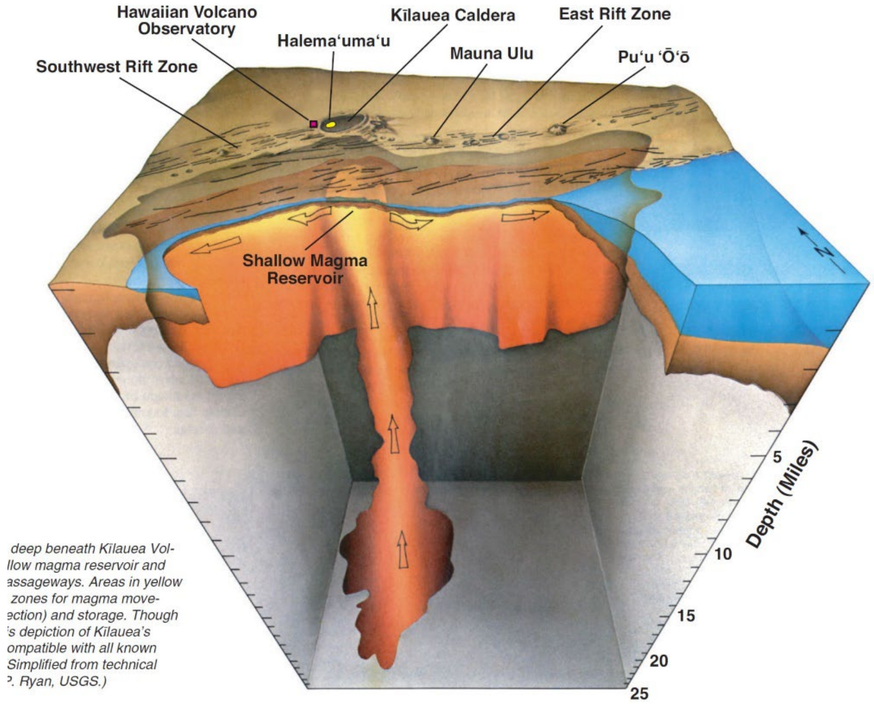
The 2018 flows are shown in pink

The lava flow shown as furthest south on the map.

The lava flow shown as furthest west on the map, with the line of smoke located on the East Rift Zone (see figure, p.3)



Lava flow extending northeast from the previous figure.



Cross section of the inferred magma chamber under the East Rift Zone. See p.3 for the map view.

<u>2018: Microscope thin sections</u>

Earlier this year, Dan O'Hare prepared microscope thin sections of samples collected during our visit to Hawaii in September 2018. The 46p 38MB report is available upon request. Here is the report index and one of the figures.

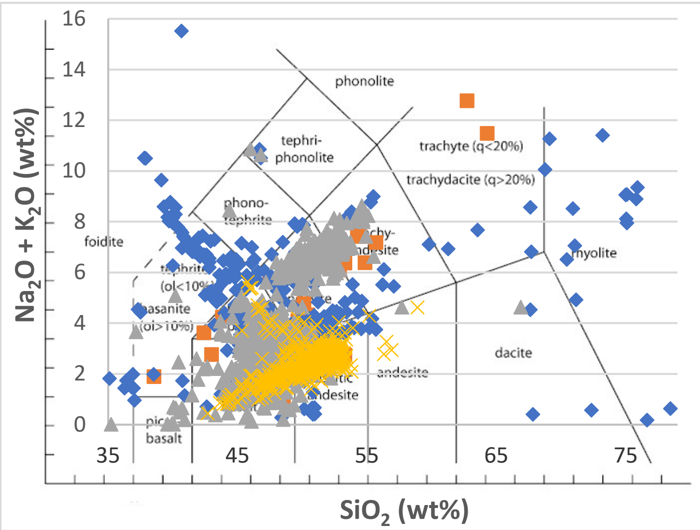
Index:

- p. 1- 2 – background and location, with map
- p. 2- 4 – mineral point counting for five samples, plotted on a basalt ternary diagram
- p. 5-10 – sample 18901A; Rainbow Falls / 10,500 B.P. flow … aphanitic basalt, with vesicles, some with olivine
- p.11-17 – sample 18902B: Saddle Rd / 1855-1856 flow … aphanitic and vesicular basalt, with olivine
- p.17-23 – sample 18902Jb: xenoliths / 1800-1801 flow … basalt containing peridotite xenolith
- p.24-31 – sample 18902Jc: xenoliths / 1800-1801 flow … xenolith with crystals (see figure below)
- p.31-37 – sample 18902K: Kailua-Kona / 1859 flow … basalt containing plagioclase and olivine
- p.37-38 – interpretation
- p.39-45 – point counting data for thin sections

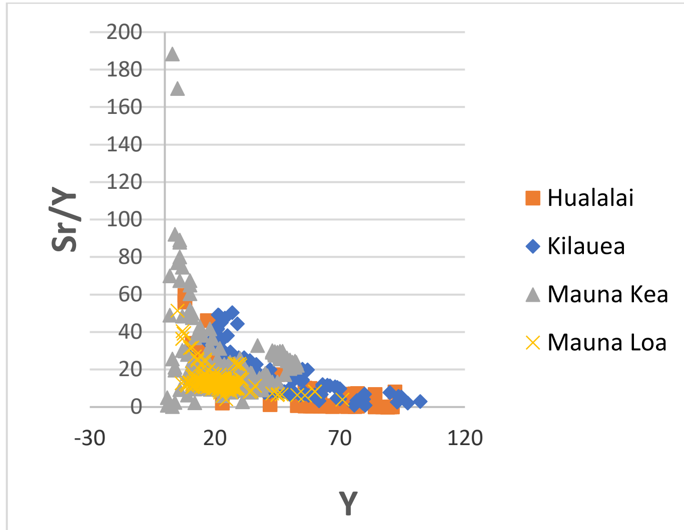
18902Jc – Microscope thin section taken in crossed polarized light. Olivine is the pink and green in the center of the pictures. The many plagioclase mineral crystals show twinning lineations. The scale bar is 1mm.

2018: Others geochemistry

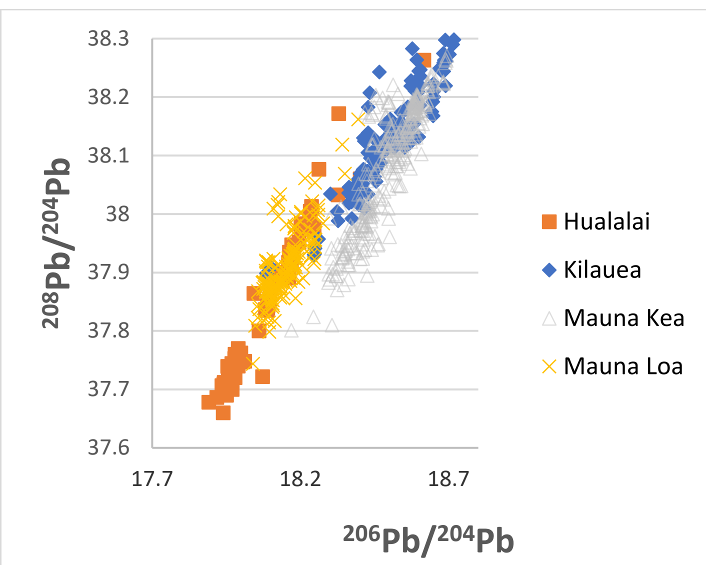
OTHERS DATA --- Earlier this year, Dan O'Hare prepared a 24p 4MB report on the past published geochemistry data for the big island of Hawaii. It was based on 13,000 samples from all the Hawaiian islands as archived in the GEOROC online database and initially developed by Jamey Cooper into a 50MB Excel file. The full report is available upon request. Here are several of Dan's most important plots:



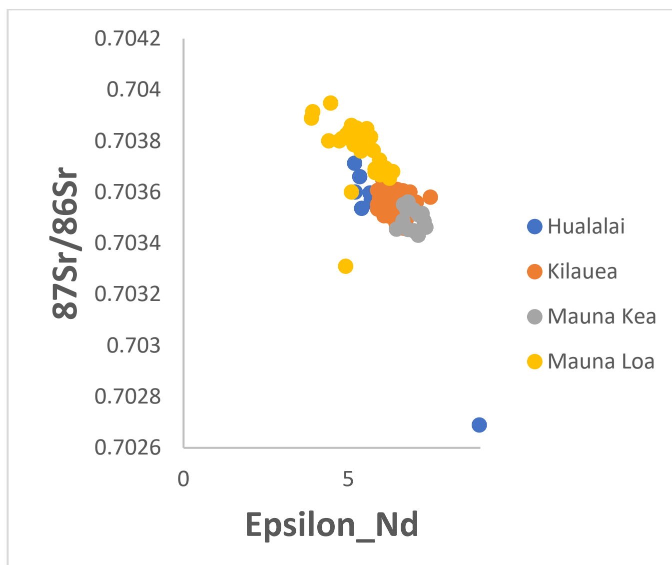
The volcanoes have different amounts of alkali elements sodium (Na) and potassium (K). These are water soluble and may indicate differing amounts of water in the magma.



The volcanoes have different strontium/yttrium (Sr/Y) trace element ratios. These are interpreted to relate to depth of magma source, with Mauna Kea from the deepest source.

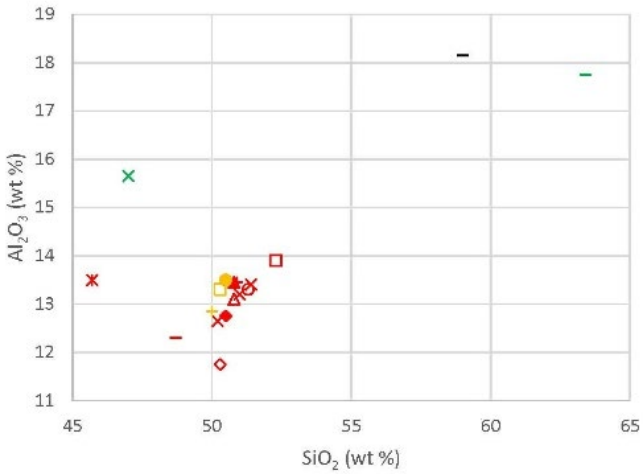


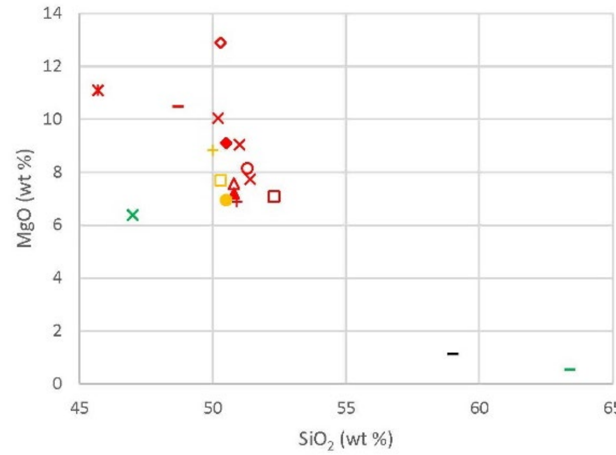
The volcanoes have different lead (Pb) isotope ratios, indicating different magma reservoir sources. These isotopes often come from the decay of uranium and thorium. We wonder whether the ratios are due to source instead of time.



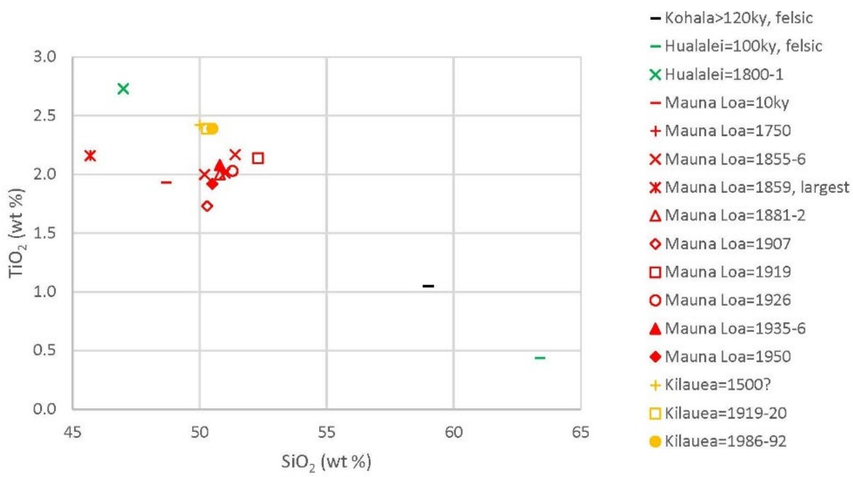
The volcanoes have different strontium (Sr) and neodymium (Nd) isotope ratios, indicating different magma reservoir sources. These isotopes often come from the decay of rubidium and samarium respectively. Higher Sr indicates a more evolved magma.

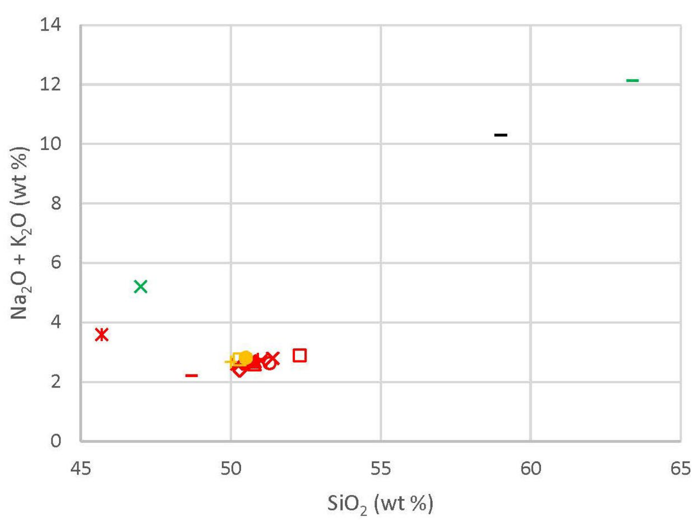
2018: Our geochemistry

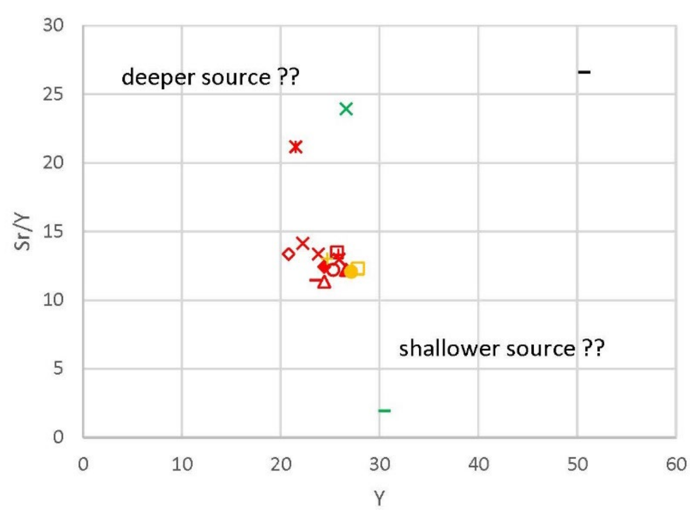




To be compared with Webster's figures on the next page.



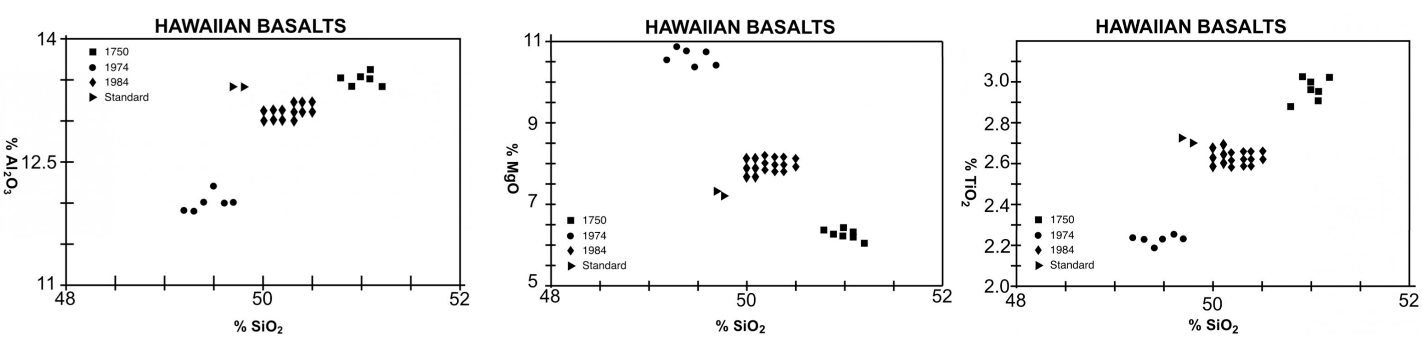




To be compared with others geochemistry on the previous page.

Comments about the geochemistry variation for the different volcanoes and lava flows shown on the previous page.

- Purpose – To display how the geochemistry changes with time, as we study rates of geological processes
- Ordering – The data points are listed in order from oldest to youngest volcanoes and then from oldest to youngest flows for each volcano. From the map on p.3.
    - Kohala > 60 k.y.
    - Mauna Kea > 4.5 k.y. … but we don't yet have any geochemistry
    - Hualalei < 1000 yrs for 25%
    - Mauna Loa < 1000 yrs for 40%
    - Kilauea < 1000 yrs for 90%
- Kohala & Hualalei felsic – The oldest volcanic rocks we analyzed are dated at 100 k.y. or older and are felsic, i.e., high in silica (SiO_2). They are also highly alkaline (sodium Na and potassium K), but low in magnesium (Mg) and titanium (Ti), as expected.
- Hualalei – The old (100ky) and the young (1800) rocks for the Hualalei volcano have very different geochemistry. The old is felsic and therefore plots by itself. The young also plots by itself. It is mafic with low silica (SiO_2), and high TiO_2 as expected, but the low Na and K and high Mg are not as extreme as might be expected, and the Al is unique.
- Mauna Loa – The Mauna Loa geochemistry has less variation than the older volcanoes, although the 1859 flow sample has an especially low silica content. This particular flow traveled 25 miles in 300 days. Our sample was collected near the distal end of the flow. To travel that distance the lava no doubt needed low viscosity, which is most likely for a sample with low silica content.
- Kilauea – The three Kilauea samples show variation in geochemistry with age. This differentiation to more felsic (higher Si, Al, Na, K and lower Mg) is expected over time.
- Clyde Webster – Our Al, Mg, and Ti plots are similar to Clyde Webster's shown below, although we are not exactly certain where he collected his samples. He saw a variation in geochemistry with age, as we have.
- Sr/Y – The final plot shows the ratio between strontium and yttrium elements. This ratio is often taken to correlate with the depth of the magma source. If that is the case, the oldest Kohala volcano has magma coming from the deepest source, which may be a unique magma reservoir. However, this pattern doesn't follow for the next oldest Hualalei volcano which appears to have magma coming from both a shallow and a deep source. The longest Mauna Loa 1859 flow also appears to come from a deeper source which would be expected to have a lower SiO_2 content.



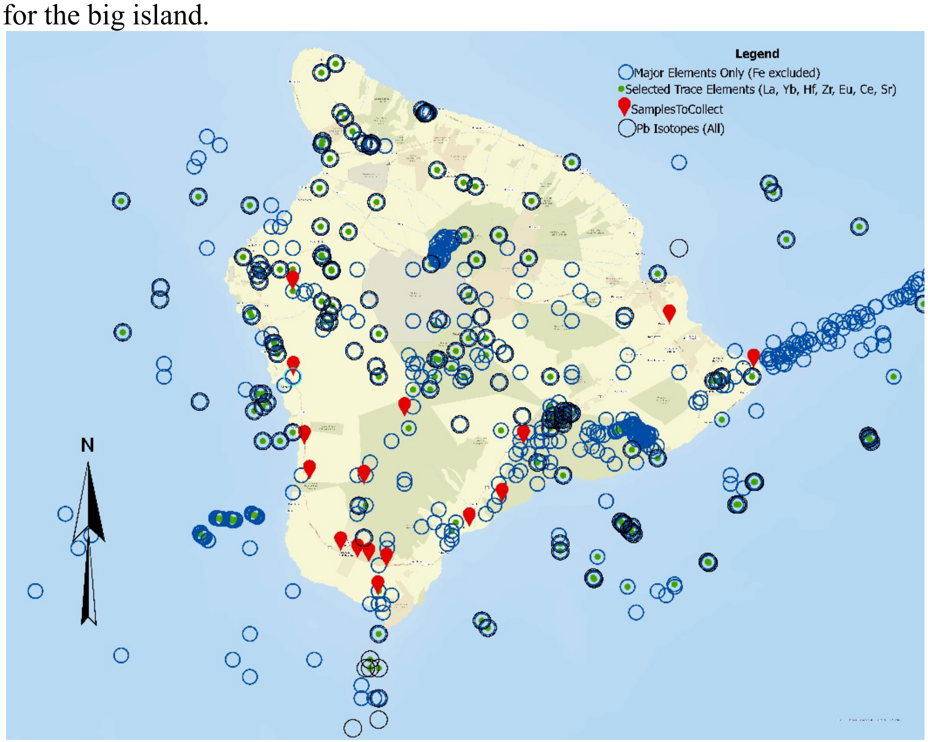
Some of the major element analysis that Clyde Webster did on his Hawaii samples in the 1990s to compare with volcanic analyses in Yellowstone. See his Figure 5 in *Origins*, n.65, p.62-74 (2018) --- https://www.grisda.org/origins-65062

GOALS

From Goldschmidt geochemistry conference

A report was sent to the Faith and Science Council on August 19 about the geochemistry conference I attended in Honolulu in July. The report highlighted our research goals in Hawaii as follows:

- For Science – We need to figure out how best to assist the scientific community in studying the Hawaiian hot spot.
    - One way to know that is by studying the presentations at the Goldschmidt conference (esp, Harpp, White, Weis). An Excel file sent with the August 19 report lists some of the most pertinent posters and talks. A number of important ones were downloaded:
        - Posters – These were downloaded from the website as pdf files, or in a few cases a picture was taken of the poster.
        - Talks – Felipe Pichinual, a geology student coming to us from Chile, has kindly download most of the MP4 videos of the oral presentations.
    - We have started assisting the scientific community by collecting samples to fill gaps in the data already available for the big island.



Map showing location (in blue/black) of samples collected by others for geochemical analysis.
We used that information to determine sites (in red) to collect additional samples for trace element and isotope analysis.

- For Origins – The August 19 report suggests many possible projects related to origins issues and rates for geologic processes. The Excel file sent then emphasizes the Goldschmidt presentations of interest to the origins discussion:
    - catastrophic volcanism, determining rates of volcanic processes, searching for interpretations of radiogenic isotopes ratios other than long time, and trying new methods for large data analysis important for a world-wide flood.
    - rapid magmatic processes – Volcano research finds timescales of years or months or days for geochemistry variation, magma reactions, storage, and ascent. Our research is asking whether rapid volcanic magmatic processes can be extrapolated to rapid plutonic ('granitic') magmatic processes that are usually inferred to take much longer times. The difference between plutonic and volcanic rates is discussed in a recent article from *Nature* --- https://www.sciencedaily.com/releases/2022/08/220803112555.htm
- We look forward to providing new geology insights, being part of the Hawaii geology community, and making new friends. We want to find new data and interpretations about rapid geologic processes.

From a recent paper

- Catastrophic growth of totally molten magma chambers in months to years / 23 September 2022 / Catherine Annen, et al. / *Science Advances*, v.8, n.38 … DOI: 10.1126/sciadv.abq0394
  - https://www.science.org/doi/full/10.1126/sciadv.abq0394
  - The lead author is Catherine Annen. She attended a Hutton granite conference near Cape Town in 2007 that I also attended. We both went on a post-conference field trip to visit the early Precambrian Barberton granite-greenstone belt east of Johannesburg. During the field trip we had a chance to visit.
- Creation-Evolution Headlines
  - https://crev.info/2022/09/magma-dogma/
  - David Coppedge recently summarized Annen's article – "Major Rethink of Magma Dogma" / September 26
  - How fast does it take to fill a big magma chamber? Millions of years? No. Just a few months, actually.
- Comment – This may be a useful observation about very rapid magmatic processes, but caution is necessary in claiming too much for it. More research needs to be done. Our work in Hawaii will hopeful be part of that necessary research.

Current top priority

How does the geochemistry change in space and time (especially how fast does it change)? Can most of the change be attributed to variation in space, rather than time. … From large- to small-scale, this could be

  - trends – difference between Kea and Loa trends for all of the islands, apparently due to plume heterogeneity
  - islands – moving from older to younger islands
  - volcanoes – the difference between the five volcanoes on the big island of Hawaii
  - stages –for each volcano: submarine pre-shield, shield (submarine, explosive, subaerial), post-shield, erosional, rejuvenated, coral atoll, guyot
    - for a simplified summary --- https://en.wikipedia.org/wiki/Evolution_of_Hawaiian_volcanoes
  - flows – short time-scale variation within each stage
    - e.g., the changes in geochemistry of Mauna Loa flows over the past 400 years
  - distance – sampling a flow proximal to distal from the volcanic vent might sample geochemical variation bottom to top of a zoned magma chamber
  - minerals – how geochemistry changes from core to rim of a single mineral
    - this would indicate how the geochemistry of the magma chamber changed with time as the mineral crystallized at a specific location

PHILOSOPHY

Our philosophical approach is summarized in:

- a book chapter
  - "Respecting God's Word, God's World, and People in God's Image" – IN: *Design and Catastrophe: 51 Scientists Explore the Evidence in Nature*, L. James Gibson, Ronny Nalin, and Humberto M. Rasi, eds. (Berrien Springs, MI: Andrews University Press, 2021), p.180-183.
- a poster for the 2022 General Conference session
  - "Geology research motivated by the Genesis record"
  - http://bclausen.net/GCposter/
- a journal article
  - "What Adventists Have to Share with the Scientific Community" – *College and University Dialogue*, v.30, n.3, p.10-14 (2018)
  - https://dialogue.adventist.org/3065/what-adventists-have-to-share-with-the-scientific-community
  -
  - "Only if Christians can be trusted in areas scientists know, will they be trusted in areas scientists don't know."

APPENDICES

Several extended reports that are summarized here are available upon request:

- Old geochemistry (available) – Jamey Cooper prepared a 52MB Excel data file listing some 13,000 samples from all of the Hawaiian Islands. This originally came from GEOROC, an online geochemistry data base
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- 2018 samples, thin section (available) – Dan O'Hare prepared a 46p 38MB report, winter quarter 2022
- 2018 samples, geochemistry (available) – Dan O'Hare prepared a 24p 4MB report, winter quarter 2022
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- 2022 geochemistry conference (sent Aug 19) – an Excel listing of presentations at the July 2022 Goldschmidt geochemistry conference that are especially pertinent to origins issues
- 2022 collected samples (attached) – a detailed listing of sample collected on the big island of Hawaii in August 2022