V62B-1415 1330h POSTER

Petrologic Development of Wrangell Volcanic Field Basement Granitoids From White Mountain, Nabesna, Alaska

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The White Mountain granitoid suite represents an isolated window into Cretaceous age magma intruded into the Wrangellia terrane basement of this region. Locally the granitoids are unconformably overlain by ~ 2.5 Ma rocks of the Skookum Creek Volcanic Complex. Although the total area of exposed granitoid at White Mountain is relatively small (~ 1 km^2), significant complexities exist. Post dating the emplacement of the main granitoid bodies was a second episode marked by intrusion of intermediate composition dikes. Field evidence suggests that the granitoid was at least partially crystallized at this time. The main granitoid suite consists of six surficially isolated bodies all of which are calc-alkaline and metaluminous, ranging in composition from hornblende-biotite quartz diorite to biotite granodiorite. Two of the exposures, comprising ~ 20% of the total exposed granitoid, are enclave-bearing, with the hosts representing the most evolved material at White Mountain and the enclaves amongst the least evolved. The enclaves typically are <15 cm in size and circular to oval in shape, and are intermediate in composition (~ 54 wt.% SiO_2), with significant modal clinopyroxene, amphibole and interstitial oxide. Field, chemical, and petrographic evidence indicate that the enclaves do not represent xenoliths of wall rock. $^{40}Ar/^{39}Ar$ analyses were performed on one host and two nonenclave-bearing samples (1 biotite and 2 hornblende, respectively) providing cooling ages between 113.3±1.3 and 117.38±0.54 Ma.

The main granitoids range from 0.5 to 6 wt.% MgO with enclaves extending this to 9 wt.%. Most of the nonenclave-bearing granitoids fall between 4 and 5 wt.% MgO. When plotted vs. MgO, other major elements define linear trends with breaks in slope between 4 and 5 wt.% MgO. Within this same interval, Rb, Ba, Zr, and Zn exhibit a wide range in concentrations. Sub-samples from one granitoid exhibit textural and geochemical evidence for mixing at the low MgO end of the compositional spectrum. The enclaves are enriched in HREE and lack quenched margins, suggesting that they may represent cumulates from a now more evolved material. However, the enclaves contain the highest $^{143}Nd/^{144}Nd$ ratios measured in the granitoid suite. The above observations require processes including, but not limited to mixing/unmixing; processes such as crystallization in an open magmatic system.

V62B-1416 1330h POSTER

Geology and the origin of trachytes and pantellerites from the Eburru volcanic field, Kenya Rift

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The Eburru volcanic field is located in the Kenya Rift, where it is part of the very young axial volcanic activity. The Eburru field belongs to the complex of volcanoes – Menegai, Eburru, Olkaria, Longonot, and Suswa – that are centered on the Kenya Dome. All of these volcanoes are prime targets for geothermal energy, with Kenya's one geothermal plant at Olkaria.. Correlation with dated volcanism implies that the activity at Eburru is at most approximately 500,000 years. The surfaces preserved on the youngest flows suggest that they erupted within the last 1,000 years. Mapping indicates that the volcanic field is divided into an older western section, composed of pantellerites (Er1) and overlying, faulted trachytes (Et1), and a younger eastern section. The eastern section has a mapable ring structure, and is composed of trachytes (Et2) and pantellerites (Er2). Some of these flows may be contemporaneous, but the final phase of eruption is exclusively pantellerite. We have chemical data for all units except the older pantellerites. The data indicate that the trachytes and rhyolites are both pantelleritic in terms of their alumina and iron contents. This is in contradistinction to the rhyolites immediately adjacent at Olkaria, which are comenditic. Concentrations for all elements are highly elevated, except for Ba, Sr, K, P, and Ti that show deep negative anomalies. The relationship between the trachytes (Et2) and pantellerites (Er2) is one in which the pantellerites consistently have the highest concentrations in all elements, including those with negative anomalies. Correlation coefficients for pairs such as Zr and Rb support the field evidence for the western Et1 trachytes being a separate magmatic event from the Et2 and Er2 units of the eastern field. Sanidine is the principal phenocrystic phase in these rocks, and thus the elevated Sr and Ba in the pantellerites preclude simple crystal fractionation to derive pantellerite from trachyte. Bailey and Macdonald (1975, Min. Mag. 40, 405-414) reached the same conclusion and noted high correlation coefficients among F, Zr, and Rb on one hand and Cl, Nb, and Y as a second group. They argued that a halogen-bearing vapor is important to the genesis of the pantellerites. We have verified the same elemental correlations for our data set. Lowenstern (1994, Amer. Min. 79, 353-369) documented immiscible halide fluids in fluid inclusions from the type locality Pantelleria, Italy. This direct observation of halide lends credence to the importance of fluids in peralkaline rhyolites. We are currently examining fluid inclusions from the Eburru samples for similar evidence of a complex volatile phase.

V62B-1417 1330h POSTER

Rift Volcanics or Rhyolitic Sills? The Jurassic-Cretaceous Rhyolitic Rocks of the Whetstone Mountains, Southeastern Arizona

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Previously mapped as both intrusive and extrusive, the rhyolitic bodies found within the Bisbee Group rift sedimentary rocks of the Whetstone Mountains were thought to represent the silicic end member of bimodal volcanism associated with extension of the Late Jurassic Mexican Borderland rift. However, preliminary investigations indicate that all the rhyolitic bodies are shallow intrusive sills and dikes that have intruded the Bisbee Group sediments parallel/sub-parallel to bedding. The age of the intrusions can be constrained by the age of the Bisbee Group rocks (Late Jurassic) and cross cutting relationships with a 74 Ma pluton, meaning the rhyolitic bodies may be tectonically related to either rifting or to early Laramide deformation.

The following lines of evidence suggest that these rhyolitic bodies are related to the extension of the Mexican Borderland Rift rather than Laramide deformation: 1.) The rhyolites found in the Whetstones are consistent with a high silica end member of bimodal volcanism associated with rifting, versus the intermediate composition magmas associated with Laramide deformation. 2.) Local deformation within the Whetstone Mountains has folded both Bisbee Group sedimentary rocks and the rhyolitic sills. One such fold has been truncated by the 74 Ma pluton restricting the age of the compressional structures to early Laramide and providing further evidence that the sills where emplaced and cooled long before folding occurred. 3.) The low abundance of hydrous minerals (<2% biotite), no vesiculation, no magma-water interaction at intrusion contacts, and general lack of volcanism indicate that these were dry silicic rift related magmas.

Columnar jointing, chilled margins, and aphanitic porphyritic textures point to emplacement of the magma at shallow depths. It is thought that the sedimentary rocks were dry at the time of magma emplacement due to lack of magma-water interaction. However, it is permissible that the magmas were emplaced only a few million years after sedimentary deposition suggesting that the magmas are Latest Jurassic to Early Cretaceous in age. If so, these rhyolites would extend the duration of rift magmatism within the Mexican Borderland Rift.

V62B-1418 1330h POSTER

Re-examining the Petrogenesis of the Tschicoma Dacite, Jemez Volcanic Field, NM: Geochemical and Geochronologic Evidence for Distinct Pulses of Volcanism

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Coupled sets of Sr and Nd isotopic, major and trace element, and $^{40}Ar/^{39}Ar$ age data were obtained for 22 of 24 of the mapped Tschicoma Formation dacite domes in the Jemez Volcanic Field (JVF), New Mexico. These data indicate that Tschicoma Formation dacite was erupted in two distinct pulses that underwent different petrologic evolutions. The first pulse was erupted ~7.4-7.2 Ma in the northwest portion of the JVF as a series of andesite and trachyandesite domes. Magmas erupted from these vents may be chemically related to one another by simple fractional crystallization models. Isotopic compositions vary from $^{87}Sr/^{86}Sr$ = 0.70493 to 0.70506 and ϵNd = -2.2 to -3.6 and suggest that minor lower crustal contamination occurred. The second eruptive interval occurred ~4-3 Ma. Activity was centered in the northeast portion of the JVF and was exclusively dacitic in composition. These magmas evolved by fractional crystallization and mixing with basaltic magmas. Modeling implies that fractionation of a small amount of observed phenocrysts was accompanied by significant amounts of basaltic contamination. The isotopic data range from $^{87}Sr/^{86}Sr$ = 0.70450 to 0.70433 and ϵNd = -3.3 to -2.0 and also demand addition of less evolved mafic magma. The data further suggest that a Lobato basalt sample collected in the vicinity of the dacite vents represents the mafic contaminant. This Lobato basalt was erupted coincident with the dacite eruptions and isotpically lies on-trend with the dacite mixing line. Previous K/Ar dates and geochemistry suggest a continuum of dacitic eruptions from 3.2 to 6.9 Ma, and did not resolve the two pulses of volcanism. Thus, mapped Tschicoma dacite actually represents two chronologically and chemically distinct magmatic events, separated by ~3 Ma. Previous work on the JVF suggests that the JVFs early evolution was dominated by an andesite shield while its later evolution was characterized by an initial period of dacitic volcanism accompanied by minor basaltic eruptions and culminated in the caldera-forming eruptions of the Bandelier tuff. This study suggests that a larger volume of dacite was erupted earlier in the JVFs evolution, while a smaller volume was erupted later than previous thought; an observation that could have implications for understanding the role tectonism played in the evolution of the JVF.

V62C MCC: 132 Saturday 1330h

The Big Score: Twenty Years of Research on the Pu'u 'O'o - Kupaianaha Eruption, Kilauea Volcano, Hawai'i I *(joint with S, T)*

Presiding: **J Kauahikaua,** U.S. Geological Survey**; M O Garcia,** University of Hawaii

V62C-01 1330h INVITED

The Pu'u 'O'o-Kupaianaha Eruption of Kilauea Volcano: The First 20 Years

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The Pu'u 'O'o-Kupaianaha eruption on Kilauea's east rift zone, which began January 3, 1983, is the volcano's longest rift-zone eruption during at least the past 600 years. The early years of the eruption were memorable for lava fountains as high as 460 m that erupted episodically from the Pu'u 'O'o vent. From June 1983 through June 1986, 44 episodes of fountaining fed channeled 'a'a flows and built a cinder-and-spatter cone 255-m high. For the past 16 years, however, the activity has been dominated by nearly continuous effusion, low eruption rates, and emplacement of tube-fed pahoehoe flows. The change in eruptive style began in July 1986, when the activity shifted 3 km downrift to a new vent, Kupaianaha, where overflows from a lava pond built a broad, low shield, 1 km in diameter and 56 m high. For much of the next 5.5 years, tubes delivered lava to the ocean, 12 km away. In February 1992, the Kupaianaha vent died, and the eruption returned to Pu'u 'O'o, where a series of flank vents on the southwest side of the cone has erupted nearly continuously for 11 years, again producing a shield and tube-fed pahoehoe flows to the coast. Since late 1986, lava has entered the ocean over 70 percent of the time. More than 210 hectares of new land have formed during this eruption, as lava deltas build seaward over steep, prograding submarine slopes of hyaloclastic debris and pillow lava.

The estimated long-term effusion rate of this eruption, averaged over its first 19 years, is approximately 0.12 km^3 per year (dense-rock equivalent). The total volume of lava produced, 2.1 km^3, accounts for over half the volume erupted by Kilauea in the last 160 years. The composite flow field covers 105 km^2 of the volcano's south flank and spans 14.5 km at the coastline, forming a lava plain 10-35 m thick.

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The Pu'u 'O'o-Kupaianaha eruption also ranks as Hawaiis most destructive of the past two centuries. Lava flows repeatedly invaded communities on Kilauea's southern coast, destroying 186 houses and prompting a federal disaster declaration in 1990. As the eruption approaches its 20^{th} anniversary, the State of Hawaii has shown renewed interest in seeking a politically and fiscally acceptable means to restrict development in areas with a high hazard of lava-flow inundation.

V62C-02 1350h INVITED

Insights from deformation during the Pu'u O'o eruption of Kilauea volcano

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The Pu'u O'o eruptive period has been one of relatively stability, characterized by quasi steady deformation punctuated by discrete events and transients. During this time the south flank of Kilauea displaced SSE at up to 8 cm/yr, while sites N of the East Rift Zone (ERZ) were stable. Velocities decreased to the east and west of the central south flank such that the distal ends of both rift zones were stable, while the ERZ extended significantly. This deformation is believed to be driven by slip on a decollement at the interface between the sea floor and the volcanic pile, combined with dilation of the ERZ at depths of 3 to 9 km. GPS data shows that the south flank of Mauna Loa also undergoes SSE directed motion. Since 1983 Kilaueas caldera has subsided over 2 m, due to a combination of deflation of a shallow magma reservoir and rifting. The shallow reservoir, however, supplied only a small fraction of the magma to the eruption. Tilt signals indicated that the dike that initiated the Pu'u Oo eruption propagated at rate of 0.5 km/hr, consistent with the seismic swarm. Smaller intrusions and eruptions have occurred since 1983. Given that Pu'u O'o presents an open conduit to the surface, it is unlikely that magma pressures could build up to the level necessary to initiate dike propagation. Furthermore, these intrusions were not preceded by summit inflation. We believe that these intrusions are "passive", occurring because the ERZ is extended by south flank slip, causing the ERZ to fail in extension. Deformation during the 1997 ERZ intrusion/eruption was particularly well recorded by continuous GPS. The data show that dike propagation began 8 hours prior to the eruption, coincident with an increase in tremor. The inferred flux of melt into the growing dike indicates that the pressure at the dike inlet decreased as source reservoirs were depleted and/or as fluid flow into the dike failed to keep up with dike growth. The depth to the bottom of the dike is well constrained at 2-3 km, consistent with the inferred transition to steady rift opening at depth.

The stability of Kilaueas north flank has been explained by the "buttressing effect" of Mauna Loa. The finding that the south flank of Mauna Loa exhibits SSE motions suggests a more general explanation is required. Other unexplained observations include the fact that the flank fails in large (M7) earthquakes but also slips steadily. Aftershocks following the M 7.2 1975 earthquake were largely restricted to the narrow band between the rift and the Pali, yet we know from the tsunami that slip occurred offshore. We propose that the mechanical properties of the decollement change as they are buried beneath the volcano. At its seaward end, the fault zone contains fluid saturated abyssal and volcaniclastic sediments, and is unlikely to experience stick-slip. As these sediments are buried beneath the volcano they are subject to elevated pressures and temperatures eventually becoming lithified and exhibiting velocity weakening and stick-slip. At greater temperatures near the volcanic axis the interface becomes steady-state velocity strengthening. Finally, north of Mauna Loa the fault zone pore-pressures may be sufficiently reduced, by a combination of fluid diffusion and metamorphic reactions, that the near horizontal interface can no longer slide under the ambient stresses. While, at this point qualitative, this model explains the asymmetry in the observed deformation, the distribution of seismicity, and presence of both stable and unstable sliding on the decollement.

V62C-03 1410h INVITED

Emplacement of Hawaiian Lava Flows - the Perspective From Twenty Years of Observations at Kilauea Volcano

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The past two decades at Kilauea Volcano have been a time of nearly continuous lava flow activity that has provided enormous scope for observing the ways in which basaltic lava flows advance, evolve, and develop feeder systems (channels and tube) and flow fields. Technological advances have allowed direct measurements of the physical conditions of lava flow emplacement (lava flux, velocity, tube development, etc.). Concurrent studies of lava samples document changes in flow composition, crystallinity and vesicularity, that reflect the physical state of the lava under different transport and emplacement conditions. Finally, analog studies of solidifying flows and fluid suspensions permit parameterization of flow and cooling characteristics in simple systems that provide important underpinnings to physical interpretations of active flow processes.

Key to all aspects of lava flow emplacement are the combined effects of flow advance rate, cooling and the rheological changes that lava undergoes during solidification. When flow advance is sufficiently slow, local shear at flow margins is not sufficient to prevent crust formation and the flow surface quickly solidifies to smooth pahoehoe. Flow is transported through internal lava tubes and flow fields grow by inflation or surface breakouts. Lava flowing beneath a crust remains hot and fluid and may thermally erode its base. In Hawaii, the length of tube-fed pahoehoe flows is commonly limited only by a flow reaching the ocean. When flow advance is sufficiently rapid, flows are transported through open channels with lateral shear zones at the flow margin that remain free of crust. Initial rates of flow advance are controlled primarily by the eruptive flux and at high flux rates flows may advance quickly for several kilometers. Cooling from the crust-free surface is radiative and rapid, as is the resulting crystallization of the interior lava. The addition of crystals, and accompanying loss of bubbles, causes an increase in viscosity and eventually the onset of non-Newtonian flow behavior and the formation of transitional and aa flow surfaces upon cooling. While aa flow advance is often continuous, aa flows may also stall and inflate. During the past decade, aa flows have formed under conditions of temporarily high flux, when surface breakouts traverse steep slopes, or near the eruptive vent when the flux is unsteady.

Although our knowledge of Hawaiian lava flows has improved substantially over the past two decades, we still lack predictive models that truly link macroscopic features of flow advance to microscopic changes in the physical state of the lava. Comparisons of analog and numerical models to existing data sets are limited by the relatively small dynamic range of activity exhibited by Kilauea over the past decade. Improved linkage of observations over different scales requires quantitative field observations that span a broader range of scale than supplied by the current eruption, a limitation that may be overcome by well designed field campaigns for the next eruption of Mauna Loa volcano.

V62C-04 1430h INVITED

The Pu'u 'O'o Eruption: Space-Borne Remote Sensing of the Evolving Lava Flow Field

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Volcanic eruptions provide excellent targets for remote sensing platforms designed to monitor surface change. The Pu'u 'O'o eruption has been ongoing during a remarkable period of technological advance in satellite instruments developed by NASA, ESA, and NASDA. Here, we divide instruments into three groups based on their spatial/temporal resolution and spectral data collection capabilities. Group 1 includes the Landsat family of satellites that have been providing multi-spectral (visible-IR) images at 30 m spatial resolution once every 16 days since the launch of Landsat 1 in 1972. Since 1991, we have used Landsats 4, 5, and 7 and the ASTER instrument to map the active lava flow field during the various phases of the Pu'u 'O'o eruption and to calculate effusion rates over the entire flow field. Maps of radiative energy have been created that highlight actively expanding versus cooling lava flow pads. The Earth Observing-1 satellite, launched in November, 2000, carries the hyperspectral Hyperion instrument that has 30 m per pixel spatial resolution. Offering 220 spectral bands at 0.4 - 2.5 microns, Hyperion data are used to calculate multiple radiative thermal components from lava surfaces at different temperatures and thus provides better estimates of effusion rates. Group 2 includes NOAA's GOES and NASA's MODIS series instruments that offer higher temporal resolution data (images every 15 minutes - 1 day) for hazard monitoring, but lower spatial resolution data (0.25 -4 km/pixel). We have used GOES data to track the start and stop times of eruptions. We have used MODIS data to provide detailed daily flow maps of the eruptions. MODIS and MISR data can also be used to track the downwind dispersal of the volcanic aerosol plume. The GOES and MODIS data streams are also used in near-real-time operational hazard monitoring web-based information systems. Group 3 includes imaging radar systems (JERS-1, SIR-C, ERS and RADARSAT) that use interferometry to investigate the growth of new lava flows or identify surface deformation due to the sub-surface intrusion of dikes along the segment of the East Rift Zone extending up to the summit.

V62C-05 1445h INVITED

Regional Seismographic Network Applications at Kilauea Volcano, Hawai`i

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A principal monitoring focus of the U. S. Geological Survey's Hawaiian Volcano Observatory (HVO) seismographic network is Kilauea Volcano and its continuing Pu`u `O`o-Kupaianaha east rift zone eruption. We are in the process of implementing procedures to enhance our basic earthquake cataloging capabilities beyond routine hypocentral estimation. Precise relative earthquake relocation techniques have previously been directed at specific targets on Kilauea and have afforded new mechanical insights into rift zone processes. We have since undertaken broader, more comprehensive earthquake relocations which now span over 10 years of the Hawai`i earthquake record. Correlating earthquake groups, or multiplets, are identifiable and, depending on relative distances between sources and stations, provide detailed images of the seismogenic structures beneath Kilauea. At HVO, we are now experimenting with an automated, near-real-time, precise earthquake relative relocation procedure, implemented as an Earthworm module.

We are also using the HVO earthquake catalogs to infer regional Coulomb stress changes. Again, this approach has been applied to targets and time periods of specific interest at Kilauea, including the 1977-1983 inter-eruptive period in Kilauea's east rift zone. Compared with mechanical models derived from available geodetic data, it appears that seismicity rates can be used as stress indicators, and we are now calculating Coulomb stress changes over time using the entire seismicity catalog. We expect these stress estimates to complement geodetic techniques in volcano and earthquake monitoring.

V62C-06 1500h INVITED

Twenty Years of Continuous gas Release at Kilauea: Effusive Lessons in a Volatile Time

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The observatory worker who has lived a quarter of a century with Hawaiian lavas frothing in action, cannot fail to realize that gas chemistry is the heart of the volcano magma problem. T.A. Jaggar, 1940

Kilauea's Pu'u 'O'o-Kupaianaha eruption has presented workers with a nearly ideal setting to develop and test models of how this volcano and others like it work, from the viewpoint of magma transport, gas release, and eruption dynamics. Gas sampling studies, and in-situ and remote emission measurements can be conducted more easily at Kilauea than at other volcanoes because of its approachable nature and because of advances in instrumentation and analytical techniques.

Analyses of gases from the eruption and from early in the last century have, with studies of volatiles trapped in submarine lavas, been used to conceptualize a degassing model for Kilauea concordant with contemporaneous geologic and geophysical evidence delineating the volcano's internal structure. More recent studies have revealed a greater CO_2 emission rate than previously thought. The revised estimates have been used to infer changes in magma supply rate. Meanwhile, SO_2 emission rates and our improved knowledge of residual volatiles are being used in parallel with geophysical methods, to monitor the eruption rate.

Continuous monitoring studies using on-site species-selective sensors are a rapidly evolving part of the gas studies effort for the eruption.

The Pu'u 'O'o-Kupaianaha eruption has also provided an opportunity to study hazards associated with long-term environmental effects of volcanic emissions. Beginning in mid-1986, when activity changed from episodic fountaining to continuous effusion, volcanic air pollution, known locally as vog, became an unfortunate part of everyday life for Hawai'i residents and visitors. Since then, Kilauea has on average released about 1,600 tonnes of SO_2 per day, roughly 6,000 times the daily amount judged by the EPA to classify an emitter as a major industrial source. The emissions are converted by oxygen, moisture and sunlight to a mixture of gases and sub-micron acidic particles capable of being drawn and retained deep in the lung.

When the northeasterly trade winds, which prevail more than 75% of the year, are disrupted, emissions build up in east, rather than west Hawai'i. The acidic nature of vog causes unquantified respiratory effects, rapidly corrodes metal objects, damages crops, degrades domestic water quality and has been linked to decreased rainfall in downwind areas on the island of Hawai'i. Unlike the *mostly episodic* nature of earthquakes and lava flows that have become the signature of hazards during the eruption, volcanic air pollution has been *a nearly continuous* albeit low-level hazard since 1986. Depending upon wind direction, some portion of the island and its 150,000 residents are affected. During trade wind disruptions, Oahu, 300 km northwest, is impacted as well.

Vog buildup in east Hawai'i degrades air quality for residents and also for some of Hawai'i National Park's 2.3 million annual visitors. The emissions have taken at least one life directly, and asthma deaths island-wide, probably caused in part by Kilauea's large SO_2 emissions, exceeded predictions by 300 percent after the eruption became continuous. Health care professionals, scientists and educators are currently working with the community to define vog's health effects. While this hazard evaluation proceeds, the USGS, in collaboration with the National Park Service, has developed a real-time system to inform and advise park visitors and employees when vog levels, as approximated by ambient SO_2 concentration, exceeds preset levels.

V62D MCC: 132 Saturday 1530h

Hawaiian Volcanism *(joint with T)*

Presiding: **K H Rubin,** University of Hawaii

V62D-01 1530h

Magnetotelluric Investigations of the Kilauea Volcano, Hawaii

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A collaborative effort between Lawrence Berkeley National Laboratory, Sandia National Laboratories, Electromagnetic Instruments and the USGS Hawaiian Volcano Observatory has undertaken a three-dimensional (3D) magnetotelluric (MT) study of the Kilauea volcano in Hawaii. The survey objectives are 1): to produce a high quality 3D MT data set over the central caldera and the eastern and southwestern rift zones, 2) to use this data set to drive the continued development of new 3D MT inversion algorithms and 3) to integrate existing gravity, seismic and electrical data with the new MT data to provide an improved understanding of the internal structure of the volcano. Data acquired over the currently active eastern rift zone are compared to that from the now dormant southwest rift zone. The first phase of data collection acquired 6 sites in February 2002 with a second phase acquiring 30 sites in August 2002. The survey was designed to make use of multiple remote reference sites and multi-station robust processing techniques with as many as eight acquisition systems operating simultaneously. Excellent quality data was obtained even in the harshest conditions, such as those encountered on the fresh lava flows of the eastern rift zone, where electrical contact resistances were extremely high.

Most sites, which required helicopter access, were recorded with only electric (E) fields to reduce weight and setup time. Certain helicopter sites had magnetic (H) data and were processed with and without local H data demonstrating the validity of using remote H fields with local E fields for impedance calculations. 3-D inversion of the data assuming the data to be local impedance is compared to 3D inversion that explicitly models the locations of the measured E and H fields. Selected two-dimensional (2D) lines of sites are inverted with 2D algorithms and compared to previously obtained electrical structure from transient EM soundings.

Early one-dimensional inversion of a site located near the caldera shows a conductor at 5km depth, which is consistent with the depth to magma as shown by seismic monitoring experiments. In addition, a shallower conductor at about 1km depth is indicated and is being investigated as a possible indicator of shallow magma. The site near the caldera was occupied in February and again in August 2002, giving a time-lapse view of the resistivity structure. Three dimensional modeling of the entire island of Hawaii shows that the costal effects of the sea-land interface on the MT data is greatly reduced compared to the effects observed at continental boundaries where the interface is more 2D in nature.

V62D-02 1545h

Submarine geology of South Kona landslide complex: investigation using ROV Kaiko

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KR01-12 cruise of Japan Marine Science and Technology Center using ROV KAIKO and its mother ship R/V KAIREI were carried out around Hawaii islands in the early fall of 2001. During this cruise, two dives of ROV KAIKO were made on western submarine flank of the island of Hawaii: South Kona landslide complex (K210:proximal part of the south Kona landslide, K211: distal block of the landslide). One single channel seismic reflection line was collected from vicinity of the above dive sites. These areas have never been systematically studied using submersible due to the bad sea state and /or the depth of outcrops. Valuable information about the submarine geology and in situ rock samples from western franks of the island of Hawaii were obtained.

K211 site is one of the distal landslide block and can be divided into 3 geological units from bottom to top: picritic sheet lava and hyaloclastite, volcaniclastic deposit with picritic breccia, muddy breccia with highly vesiculated ol basalt. On the other hand, rocks recovered from K210 are composed mainly of aa clinker and aa lava which are highly vesiculated and reddish in color. The rocks from K210 is similar to the upper part of K211 in their bulk rock chemistry. Based on the geological and bulk rock chemistry, rocks recovered from both sites should be erupted subaerially. It suggests that these landslide blocks were composed subaerial portion of the paleo-Mauna Loa volcano.

V62D-03 1600h

Evolution of the Hawaiian Plume: Evidence from Submarine Haleakala Volcano (Hana Ridge), Hawaii

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Hana Ridge is the submarine portion of the east rift zone of Haleakala Volcano, Hawaii. At 140 km long, Hana Ridge is the longest submarine rift zone in the Hawaiian Island chain and has developed a complex morphology compared to other Hawaiian rift zones, such as Puna Ridge. The main ridge comprises two or three subparallel or subjacent ridges with distinct morphological expressions related to sequential accretionary stages of the shield-building phase of Haleakala volcano. In order to investigate the geochemical evolution of Haleakala shield-building, we sampled several sections of Hana Ridge on six dives with ROV Kaiko and Shinkai 6500 submersible, both operated by JAMSTEC, in 2001 and 2002.

We report new geochemical data for basalt samples from these six dives on Hana Ridge. All the recovered rocks are primitive tholeiites and picrites and more than half of them, those obtained in the deeper portions of the ridge, are picrites. Major and trace elements of the submarine Hana ridge rocks are similar to modern Kilauea and unlike Honomanu series lavas. Our results indicate that the mantle plume source for the Haleakala shield has changed over time from Kilauea-like compositions (high La/Sm, low Zr/Nb) in the submarine lavas to Mauna Loa-like compositions (lower La/Sm, higher Zr/Nb) in the subaerial Honomanu shield lavas. Moreover, the submarine stages show a gradual, but irregular, trend from higher to lower La/Sm with decreasing water depth (inferred to be decreasing age). We infer that Haleakala volcano originally had typical Hawaiian tholeiite magma compositions whose source material was similar to present-day Kilauea volcano and that the magma source became more Mauna Loa-like during growth of Haleakala volcano.

V62D-04 1615h

Understanding the Thermal and Rheological Evolution of Deep Submarine Lava Flows in the North Arch Volcanic Field

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The North Hawaiian Arch Volcanic Field is a 24,000 km^2 region of relatively young submarine volcanic landforms located 100-390 km north of Oahu and Kauai, centered on the flexural arch created by the Hawaiian Islands. In HAWAII-MR1 acoustic imagery, individual lava flows are resolvable due to the large backscatter contrast between the young lavas and the pelagic sediments they overlie. In the southern portion of the volcanic field is a well-surveyed flow that provides an excellent location to apply a numerical model to investigate thermal and rheological evolution during flow emplacement. This flow was emplaced on slopes that average 0.35° in MR1 bathymetry and is typically less than 1 km wide, yet attains a length of approximately 45 km from an inferred fissure source.

FLOWGO, a thermo-rheological model used to determine how far lava will flow in a channel in the subaerial regime, has been modified for the submarine environment, allowing measured lava flow parameters to help constrain the model for submarine applications. Adaptations for the submarine environment include recognizing that the dominant heat-loss mechanism switched from radiative in the subaerial environment to convective in the deep submarine environment, where we calculate the convective heat transfer coefficient appropriate to the seafloor. By fitting the model output to measured flow dimensions, we find that the only way to obtain the observed length is for the flow to have had extremely effective thermal insulation. If the layer of insulation moved with the flow, the insulation was most likely a cool, thick crust insulating a molten core or a tube roof if the crust was stationary. The model also indicates flow emplacement may have been associated with effusion rates of 10^3 m^3 s^{-1}.

Several model input variables, such as vesicularity, crystallinity and slope, were obtained from flow samples obtained during submersible dives and from sidescan and bathymetry from sonar surveys. Repeated model runs were performed to determine the sensitivity of the model to all input parameters. The results show that reasonable variation in factors other than crust cover and temperature have very little impact in our results.

V62D-05 1630h

Relatively Recent Volcanism on Oahu, Hawaii: New U-series and Paleomagnetic Age Constraints on the Hanauma Bay Eruption

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The Koko Rift Zone (KRZ), eastern Oahu, is generally regarded as among the youngest volcanic features on the island. Previous workers have suggested that the 9 or 10 vents of this rift erupted near-simultaneously. However, K-Ar data in the literature (32-39 ka vs 320 ka) provide only general guidance on the youthfulness of these eruptions. We present new age constraints

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