Mantle Experiment). We use preferentially short propagation paths ($\Delta < 54^{\circ}$) to minimize off great circle path propagation, but increase the path length in areas of insufficient coverage. We resolve the subduction zones bounding the South Pacific to the east and west with a width compatible with the smoothing used in the tomographic inversion. The slow wave speed structure associated with the East Pacific Rise is offset to the west as has previously been noted in more detailed local studies. There seems to be no pervasive low wave speed feature in the upper mantle beneath the South Pacific. However, low wave speed structures extend from shallow depth to the transition zone beneath the Society hotspot, the Austral hotspot and Easter Island. The presence of similar structures beneath other Pacific hotspots is currently masked by lack of resolution.

V21F-04 1115h

The 'Plate-Like' Subsidence of the East Pacific Rise - South Pacific Superswell System

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The separation of small-scale features from the regional seafloor depth is an important problem in the geosciences, especially as it impacts our understanding of mid-plate topographic swells and subsidence away from mid-ocean ridges. In the south Pacific ocean, for example, the removal of these features from the bathymetry using modal techniques has revealed a large and unusually shallow region of the seafloor, which at ~3000 km wide and up to 1 km high has been dubbed a "Superswell". Modal analysis, however, does not completely isolate and remove small-scale features such as oceanic islands, seamounts, oceanic plateaus and localised hot-spot swells from the regional bathymetry. This is because these features are superimposed upon the unperturbed ridge-generated regional bathymetry, accordingly a technique is required that underlines topographic constructs rather than passing through them as is the tendency of any average (mean, median or mode). We have therefore developed an algorithm that reproducibly simulates manual interpretation (**MiMIC**), thereby removing the superimposed features and revealing larger scale trends. Application of **MiMIC** to grids of bathymetric data in the region 12-26°S, 200-243°E shows that seafloor of all ages (0.5-112Ma) deepens slowly (initially ~218 mMa$^{-1/2}$) and in essence monotonically from the East Pacific Rise (EPR). Although initially deep (-2712m) with respect to a standard plate model (-2500m, 125km, 1350°C), the low subsidence rate reduces the negative depth anomaly with time until it becomes a positive anomaly west of ~234°E (~20-25Ma) that increases to a maximum of 712±66m at 98Ma, not 1300m at ~65Ma as previously observed. Most significantly though, the Superswell appears to be part of a larger scale, monotonic and 'plate-like' subsidence trend that extends to the EPR, not an isolated shallowing that reverses subsidence and causes uplift between 40-80Ma. The continuous nature of the EPR-Superswell subsidence trend suggests to us a common causal mechanism that links processes acting at the Superswell with those at the EPR. Previous studies at the EPR show asymmetry in seafloor subsidence and other observables such as seismic velocity and electrical conductivity which have been interpreted in terms of an across-axis temperature gradient, possibly sustained by a flow of hotter material from the west. Thus, a lateral temperature gradient may exist across the entire EPR-Superswell system. We have tested this hypothesis using a model in which the isostatic and thermal effects of a lateral sub-lithospheric temperature gradient are allowed to perturb the subsidence of a standard plate. Our preferred model has a depth of isostatic compensation of 320km and a linear temperature gradient of only 0.014°C/km. Such a model better explains the regional seafloor depths of the EPR-Superswell system than published cooling plate models and is in accord with constraints from elastic thickness, heat flow, seismic tomographic and long-wavelength gravity anomalies.

URL: http://www.earth.ox.ac.uk/~johnh/AGU2003.html

V21F-05 1130h

Reconstruction of Pacific-Nazca Plates, Nazca Ridge, and Easter Seamount Chain

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Relative plate motion history since 30 Ma between the Pacific and Nazca (Farallon) plates has been constrained by available seafloor magnetic anomaly data and a two-minute grid of predicted bathymetry. These data are used to create a new plate reconstruction based on finite and stage poles of rotation and radiometric ages along the Easter-Salas y Gomez-Nazca Ridge volcanic lineament. An iterative process of anomaly identifications, pole calculations and anomaly rotations was used to test for self-consistency in the interpretation. The new identified magnetic isochrons (10y, 7y, 6c, 5d, 5b, 5aa, 5o, 4a, and 3a) and the predicted tectonic history provide an improved understanding between chrons 7y (24.73 Ma) and 3 (4.18 Ma). However, the finite poles for 6c and 5d are poorly constrained. Eleven stage poles were calculated using the nine finite poles and two published instantaneous Euler vectors for the 1o and 2a isochrons. The stage poles indicate full-spreading rates increased from about 175 mm/yr to about 205 mm/yr after the break-up of the Farallon plate, and then have slowed to about 145 mm/yr. The tectonic reconstruction indicates two major southward propagating events, the first starting by 28 Ma and terminating by 18 Ma. The second starting in association with breakup of the Farallon plate around 24 Ma and terminating by about 11 Ma. Lithosphere was transferred from Nazca to Pacific during the first event and in the opposite sense during the second. Development of the Mendoza microplate east of the second propagator occurred at about 20 Ma and this dual spreading process appears to have lasted until about 15 Ma. Radiometric ages, geochemical data, relative and absolute motion models presented at the Nice AGU meeting by Duncan et al., Ray et al., Wilder et al., and Harada et al. indicate that since 30 Ma: 1) a hotspot located near Salas y Gomez Island does not require significant motion of the hotspot with respect to the Hawaiian hotspot; 2) that this hotspot has generated similar proportions of OIB vs. MORB endmember compositions in most samples collected east of Salas y Gomez; and 3) that the change of plate motion velocity was primarily accommodated by the combination of propagating rifts and microplate formation, including a rapid clockwise rotation of spreading direction and rapid increase in spreading rate, followed by a subsequent decline until present.

URL: http://imina.soest.hawaii.edu/wessel/drft06rr/

V21F-06 1145h

Revised Estimate of the Cenozoic Motion Between the Tristan da Cunha Hotspot and Pacific Hotspots

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We present a new method for objectively estimating the uncertainties of finite rotations of plates relative to hotspots. The input for our analysis are coeval dated locations along two or more ancient hotspot tracks, as well as the present locations of the hotspots. The output is a covariance matrix that can be used for testing hypotheses and for constructing confidence regions. Unlike prior methods, our method incorporates the uncertainties in all 3 degrees of freedom of a finite rotation. We apply our method to the Hawaiian and Louisville tracks on the Pacific plate and used the results to predict the track (and uncertainties) of the Tristan da Cunha hotspot on the Nubian plate. The Tristan da Cunha track provides a critical test for the fixed hotspot hypothesis because it has a fairly continuous track and has remained beneath the Nubian plate for the past 70 Myr and thus has not (in that time interval) greatly interacted with a mid-ocean ridge, which can severely complicate the track. In contrast to the results of prior studies, the predicted and observed Tristan da Cunha tracks have no significant differences for the past 48 Myr, which includes reconstructions for 11 Ma (chron 5), 20 Ma (chron 6), 33 Ma (chron 13), and 39 Ma (chron 18). For example, the predicted location of the Tristan hotspot at 48 Ma (chron 21) is about 100 km (± 250 km) from the nearest point on the Walvis Ridge, corresponding to motion between hotspots of 2 mm/yr ± 5 mm/yr. Numerical experiments indicate that the improvement to the fit to the fixed hotspot assumption for reconstructions over the past 48 Myr come from many sources including improvements to the geomagnetic reversal time scale, improvements in relative plate reconstructions, improvements in Pacific-hotspot rotation parameters, and improvements to age dates along the Hawaiian-Emperor chain. Unlike the reconstructions for the past 48 Myr, reconstructions for 56 Ma (chron 25) and 68 Ma (chron 31) have huge misfits between predicted and observed tracks. For example, the misfit between the predicted and observed point at 68 Ma (chron 31) is 1000 ± 250 km. A possible, but unlikely, explanation is that from 68 to 48 Ma, the Tristan da Cunha hotspot moved relative to the Pacific hotspots at a rate of 50 ± 12 mm/yr. An alternative explanation is that the misfit is largely accommodated by a "missing" plate boundary in the early Tertiary and Late Cretaceous global plate motion circuit, as is independently indicated by global paleomagnetic data [Acton & Gordon, 1994].

V21F-07 1205h

Revised Indo-Atlantic absolute plate rotations and their uncertainties based on moving hotspots

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Inconsistencies between the paleomagnetic and hotspot reference frames have been ascribed to the effects of hotspot motion and true polar wander (TPW). While revised models based on moving hotspots have been shown to improve a measure of fit; namely the difference between the predicted and observed hotspot tracks, the real uncertainties in such models can be quite large. We present a method for constraining the uncertainties in absolute plate motion models using a modified version of the Hellinger criterion. We use the dated tracks of four of the best studied hotspots in the Indo-Atlantic hemisphere; namely, Kerguelen, Reunion, Tristan de Cunha and the New England hotspots, together with their present positions to obtain finite rotations for the African plate. We also use models of hotspot motion to obtain analogous rotations for a moving hotspot' reference frame. The motion is consistent with available paleomagnetic constraints, and results in a significantly improved fit to the hotspot tracks. The uncertainty regions are less for the moving hotspot model due to the improved fit, and the covariance matrices obtained are equivalent to published relative plate rotation covariance matrices, and allow a combination of these uncertainties.

V22A MCC: Level 1 Tuesday 1330h

Rift Zones on Volcanic Islands: Structure, Evolution, and Magmatic Processes II Posters *(joint with S, T)*

Presiding: **T R Walter,** Rosenstiel School of Marine and Atmospheric Science, University of Miami**; A KLGEL,** University of Bremen

V22A-0561 1330h POSTER

Subsidence of Askja Volcano, North Iceland: InSAR Observations and Different Modeling Approaches

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The Askja central volcano is located on the divergent plate boundary in North Iceland. The last major rifting episode happened in Askja in 1874-1876, but the most recent eruption in Askja occurred in 1961. Askja has been continuously deforming since crustal deformation measurements started in the area in 1966. GPS and optical leveling tilt measurements show subsidence of at least 75 cm from 1983 to 1998 at the volcano, without any eruptive activity. Interferometric analyses of Synthetic Aperture Radar images (InSAR), acquired by the ERS-1and ERS-2 satellites, have been conducted. The interferograms span the 1992-2000 period and cover a large area in central Iceland. A deformation signal around Askja, showing subsidence, is clearly evident in five different interferograms from two different Track/Frame pairs. The interferograms cover all of the Askja area and span different time periods. The observed deformation signal consists of a concentric fringe pattern, centered at the Askja caldera with a 20 km diameter, and slightly elongated in the north direction. The fringes are most closely spaced about 3 km from the center of deformation, suggesting that deformation gradients decrease near the center of Askja. Two approaches have been taken to model the InSAR data. Firstly, we assumed a Mogi model in an elastic half-space. A preliminary model indicates a 3 km source depth and a maximum vertical subsidence of 0.23 m, centered in the main caldera, from 1992 to 1998. An alternative approach is to use the finite element method in order to include topography. An axisymmetric model of a deflating spherical source has been constructed using the ANSYS software. Initially, a model that reproduces the Mogi source has been created, in order to compare analytical to finite element solutions. As agreement between the two sets of solutions was good, we have also constructed a model with a cone shape topographic relief, crudely approximating Askja. Results indicate that the maximum vertical displacement is not located above the center of the source, like in the half-space solutions, but on the sides of the volcano.

V22A-0562 1330h POSTER

Rubbly Pahoehoe Lavas: An Important Component of Icelandic Basaltic Lava Flows

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Eruptions at rift zones often produce basaltic lava flows. Structural and textural study of historic and prehistoric flows gives important clues about emplacement processes. The 1783-4 eruption of Laki produced 14.7 km^3 of lava from a fissure that opened along the Eastern Volcanic Zone of Iceland. The resulting 600 km^2 lava flow-field presents a wide range of surface morphologies that we explored to study emplacement mechanisms. We present results from preliminary field, macroscopic, and microscopic analysis. Field observations show that along a single flow surface morphologies change from (1) flat (with a coherent continuous, pahoehoe(phh)-like crust), to (2) slabby (with a disrupted surface made of phh-like slabs), to (3) rubbly (with a rough surface covered by loose vesicular blocks), and then to (4) folded rubbly (with ridges of rubble several meters high). Features characteristic of flow growth by inflation are abundant. The changes are unidirectional in the above order but the sequence can be repeated. This occurred if the fluid lava stored within the core of the flow broke through the front. Field relationships indicate that the majority of the flows were initially emplaced as small lobes of phh-type lava that gradually changed into slabby phh and then rubbly phh through progressive disruption, shearing and compression of the surface. During its entire advance, the lava flow never reached the point of incessant surface renewal with formation of aa-type clinker, neither did it extensively develop the smooth filamentous surface common in Hawaiian phh flows. Thus, Laki lavas are intermediate flows. Microtexture analysis of samples collected along single flows will tell us what caused this evolution, such as crystallinity due to degassing or viscosity change. This flow type has been recognized on Reykjanes Peninsula in young fissure-fed lava flow-fields and in the Columbia River Basalts and Kerguelen Plateau flows. It is therefore an important component of many lava flow-fields, being in some cases a more frequently occurring flow type than the phh and aa end-members.

V22A-0563 1330h POSTER

Marine Geophysical Investigations of Vestmannaeyjar and the Reykjanes Ridge, Iceland

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In July-August 2003 we conducted brief surveys of the Vestmannaeyjar area, south of Iceland, to try to determine whether or not the recent volcanic eruptions here result from nascent plate boundary processes. We used the SIO SUBSCAN chirp seismic system to collect seismic profiles and sidescan sonar swaths from the R/V Bjarni Saemundsson, and the EM300 system on the R/V Arni Fridriksson to acquire swath bathymetry and backscatter data. Vestmannaeyjar, including the recently active eruptive centers of Surtsey and Heimaey, may be forming at the tip of the reorganizing North America - Eurasia plate boundary system, where the seafloor spreading on Iceland appears to be shifting from the Western Volcanic Zone to the Eastern Volcanic Zone (EVZ). A linear chain of small islands and seafloor eruptions is consistent with Vestmannaeyjar being the southern extension of the EVZ. The seafloor volcanic pattern shows large spatial variability, with only a few indications of tectonic rift structures seen in either the seafloor or subsurface data. If this is the tip of a propagating rift, the rifting has not yet focussed the volcanic eruptions into a single coherent eruptive segment. Alternatively, these eruptions could result from plume flank volcanism, or some other process. In contrast to Vestmannaeyjar, a brief EM300 survey of the first Reykjanes Ridge segment offshore of the Reykjanes Peninsula shows that seafloor spreading here has been active long enough that the volcanism has coalesced into a focussed volcanic system. Few rift structures are visible here either, perhaps because shallow explosive eruptions tend to bury them. The approximately 20 degree change in azimuth between the en echelon volcanic system trends on the Reykjanes Peninsula and those observed on the Reykjanes Ridge occurs within this first offshore segment.

V22A-0564 1330h POSTER

Submarine Tuff Cones at the Depth of 75 m South of Iceland: Evidence for Lower Sea Level During the Pleistocene

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Vestmannaeyjar archipelago, off the south coast of Iceland, marks the southernmost tip of the Eastern Volcanic Zone (EVZ) cutting Iceland in half from south to north. The EVZ marks the plate boundary between the American and Eurasian plates. It is believed that the plate boundary was relocated some 3 Ma ago and since has been propagating towards the south. Volcanism in the area of Vestmannaeyjar has been active during the Holocene with two major eruptive episodes, the former starting some 7-6 Ka ago and the second starting 1963 AD with the last eruption dating back some 30 years on the island of Heimaey, the largest island within the archipelago. In July-August 2003 we conducted brief surveys of the Vestmannaeyjar area to try to determine whether or not the recent volcanic eruptions here result from nascent plate boundary processes. We used the SIO SUBSCAN chirp seismic system to collect seismic profiles and sidescan sonar swaths from the R/V Bjarni Saemundsson, and the EM300 system on the R/V Arni Fridriksson to collect swath bathymetry and backscatter data. The aim of this survey is to get a comprehensive look at the evolution of the volcanic history of the area. An area named "Stora Hraun" or Big Lava located just southeast of Surtsey Island revealed three major volcanic tuff cones at the depth of some 75 meters below sea level. The largest of these tuff cones has a diameter of 1 km while the two others range in diameter from 400 to 500 meters. Based on their low erosion state we estimate that palagonitisation took place before these craters were subject to erosion. Compared to the erosion state of the two parasitic cones formed in the Surtsey eruption 1963-1967, we suggest that the craters at Stora Hraun were fully palagonised at sub aerial conditions prior to being submerged. This suggests a substantially lower sea level during the Pleistocene.

V22A-0565 1330h POSTER

Internal structure and evolution of a North-Atlantic rift system: the Desertas rift zone, Madeira Archipelago

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The three Desertas Islands represent the top of a 60 km long submarine ridge southeast of Madeira. They dominantly consist of lava flows, cinder cones stacked one on another and steeply dipping, partly sheeted dike swarms and thus represent the deeply eroded interior of a well-developed volcanic rift zone. In order to reconstruct the evolution of the Desertas rift and to understand its volcanotectonic origin, we have undertaken detailed field studies of volcanic structures. It was found that the abundance of scoria cones, dikes and sills indicating proximity to eruptive centers increase along the rift towards south: The northern end is composed mainly of lava flows up to several meter thickness, whereas the central part shows an alternation of proximal pyroclastics and series of subhorizontal lava flows. The southern part is dominated by scoria and cinder cones and minor thin lava flows. Dikes, isolated or as swarms, were observed all along the islands' coasts. The most distinctive and most dense dike swarm, however, occurs in the southernmost region, and sills up to 30 m thickness are also more common in this area. We did not find any volcanological or petrological indication of a central caldera underlain by a shallow magma reservoir feeding the rift zone. Because of the distribution of volcanics and intrusive rocks, we propose that a major volcanic center was located at the southern end of the Desertas ridge, and that the rift zone successively developed towards Madeira. This model implies that the Desertas ridge represents a discrete volcanic system that became interconnected with Madeira by growth to the north-northeast. The evolution of the Desertas rift hence differs from that of caldera-centered, two-armed rift systems typical for Hawaiian volcanoes such as Kilauea. A conceivable explanation for the formation of the Desertas rift zone is a local gravitative stress field causing preferred extension in-between the two overlapping Madeira and Desertas edifices.

V22A-0566 1330h POSTER

Discovery of a Young Submarine Rift Zone Near Madeira Island: the Leading Edge of the Madeira Hotspot Track?

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During RV "METEOR" cruise M51/1 in 2001, a hitherto unknown submarine ridge off Madeira island was discovered, hydroacoustically mapped and sampled. Funchal ridge (working name) extends from near the capital Funchal over 50 km to the south and rises up to 600 m over the surrounding seafloor. At least 20

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volcanic cones have been identified along the ridge, including a volcanic field at its southern end. Funchal ridge represents a classic rift zone and shows some similarities to the ridge forming the Desertas islands further northeast. Many of the alkalic basalts dredged are remarkably fresh and are highly vesicular despite sampling depths of up to 3600 m. We thus propose that Funchal ridge is the locus of most recent volcanic activity of Madeira Archipelago, marking the present location of the hotspot. This interpretation is in agreement with the concentration of small earthquakes around the ridge and with the occurrence of stratigraphically young cinder cones in prolongation of the ridge near the city of Funchal. The volcanic field at the southern end of the ridge where activity is concentrated may thus represent the early shield stage of a future island. Preliminary Sr, Nd and Pb isotope data support this interpretation since samples from Funchal ridge overlap with those from the isotopically enriched Madeira shield stage but differ from the less radiogenic post-erosional stage presently occurring on Madeira. According to our model, Funchal ridge could become the fourth large volcano of the Archipelago following Porto Santo (14.3 - 11.1 Ma subaerial age range), Madeira (4.6 Ma to <10 ka), and the Desertas islands (3.6 - <3.2 Ma). The reason for formation of a long ridge instead of a circular seamount at this early stage may be the overlap of the new edifice with Madeira's lower slope. Gravitative stresses of such a geometry, combined with gravitative spreading of Madeira, can qualitatively explain the observed relations as we have modelled by analogue experiments.

V22A-0567 1330h POSTER

A Geochemical Study of Magmatic Processes and Evolution along the Submarine Southwest Rift zone of Mauna Loa Volcano, Hawaii

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Mauna Loa's southwest rift zone (SWR) extends for 102 km from its summit caldera, at an elevation of 4,170 m above sea level, to submarine depths of over 4,500 m. About 65% of the rift zone is subaerial and 35% submarine. Recent sampling with the Jason II submersible of the 'mile-high' (1800 m) Ka Lae submarine landslide scarp and the deepest section of the rift zone, in conjunction with previous submersible and dredge-haul collecting, provides petrological and geochemical understanding of rift zone processes, as well as a record of Mauna Loa's eruptive history extending back about 400 ka. The major and trace element trends of the submarine lavas are remarkably similar to those of historical and young prehistoric lavas (<31 ka) erupted along the subaerial SWR. We take this to imply that magma-forming processes have remained relatively constant over much of the volcano's recorded eruptive history. However, the distribution of samples along these trends has varied, and is correlated with elevation. There are very few picrites (>12% MgO) among the subaerial lavas, and compositions tend to cluster around 6.8-8.0% MgO. In contrast, picritic lavas are extremely abundant in the submarine samples, increasing in frequency with depth, especially below 1200 m. These observations support earlier interpretations that the submarine lavas are derived directly from deeper levels in the magma column, and that magmas from a shallow, steady-state, magma reservoir are of uncommon at these depths. Isotopic ratios of Pb and Sr in the submarine lavas, in conjunction with Nb/Y and Zr/Nb ratios, extend from values that are identical with subaerial historical Mauna Loa lavas to lavas with markedly lower 87Sr/86Sr and higher 206Pb/204Pb isotopic ratios. As yet, we see no correlation with depth or age, but the implications are that, in the past, the plume source of Mauna Loa magmas was more variable than in the last 31 ka, and contained a greater proportion of the Kea component. *Team members also include: H. Guillou, CEA/CNRS, France; M. Kurz and D. Fornari, WHOI; M. Norman and V. Bennett, ANU, Australia; S. Schilling, USGS; M. Chapman, Morehead State University; D. Wanless and K. Kolysko, University of Hawaii.

V22A-0568 1330h POSTER

Numerous Submarine Radial Vents Revealed on Mauna Loa Volcano

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Among Hawaiian shield volcanoes, Mauna Loa is distinct in having vents outside of its summit and rift zones. These radial vents are located on its northern and western flanks and account for approximately 10% of historic eruptions outside the summit region. Thirty-three subaerial and one submarine vent (active in 1877) were known prior to our work. During a recent Jason2 expedition to the volcano's western flank, nine new submarine radial vents were discovered. Eighty-five samples were collected from these and the 1877 radial vent. Bathymetry and side-scan imagery were acquired using an EM300 multibeam echo sounder. The high resolution data (vertical resolution of approximately 4 m and horizontal resolution of 25 m) allowed us to create the first detailed geologic map of Mauna Loa's western submarine flank. The map was compiled using video and still photography from the Jason2 ROV and geochemical analysis of the samples. The geochemistry includes microprobe glass and XRF whole rock major and trace element data. Eight of the submarine radial vents sampled erupted tholeiitic lavas that are geochemically similar to historical subaerial eruptions on Mauna Loa. However, in contrast to all previously collected Mauna Loa lavas, two of the young vents erupted alkalic basalts. These lavas may have been derived from Mauna Loa, as they have somewhat higher FeO and TiO2 values at a given MgO content than alkalic lavas from neighboring Hualalai volcano, whose vents are located only on rifts 16 km away. Alkalic lavas are indicative of the postshield stage of volcanism and may signal the impending demise of Mauna Loa volcano.

V22A-0569 1330h POSTER

Crustal deformation in East Rift Zone of Kilauea volcano derived from JERS-1/InSAR

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SAR interferometry was applied to Kilauea volcano to investigate volcanic activity mechanism from detailed crustal deformation field. SAR data used in this study were acquired at 20 Oct. 1992 and 1 Mar. 1993 (reoccurrence time is 132 days) by L-band SAR (wavelength: 23.5cm) installed in JERS-1 satellite. The summit caldera and East Rift Zone are included in the scene area. In this analysis, SRTM DEM (http://seamless.usgs.gov) was used to remove topographic and orbital effects. High coherence is obtained in whole land area, and the phase difference was very flat in most area except Kilauea volcanic zone, indicating that the accurate interferogram is obtained. Around Pu fu fO fo, which was continuously extruding lava in the observation period, the crustal deformation with subsidence sense is obtained. It is suggested that this deformation was caused by the deflation of magma source associated with extrusion of lava. In the south of Makaopuhi crater, the fringes with concentric shape are obtained. The phase difference at the center of fringes is consistent with -33.7 cm of displacement in line-of-sight (LOS) component (plus value indicates that the slant range extended), also in the north of crater, the displacement of 8.0 cm in LOS component is obtained. Epicenter distribution around Makaopuhi crater shows that earthquake swarm occurred at 3 Feb. 1993, and its location just falls within the area between north and south fringes. Therefore, this deformation had to be caused by dyke-intrusion under the Makaopuhi crater. We attempted to construct dyke-intrusion model with the tensile fault of elastic half space dislocation model. The estimated dyke has about 2 x 2 km size, 73° dip angle and 1.2m opening. The simulated interferogram from this model well explained the observed one, but the fringes showing the crustal deformation with subsidence sense remained along East Rift Zone. Such subsidence along East Rift Zone was also derived from 5-year GPS-campaign observation [Owen et al., 2000], and therefore we think that this fringe shows the actual crustal deformation. However subsidence rate obtained from SAR interferometry is large relative to GPS derived one. Hence the subsidence in this period might be larger due to dyke-intrusion event.

V22A-0570 1330h POSTER

3D Modeling of the Dike Intrusions at Piton de la Fournaise Using Radar Interferometry Between 1998 and 2000

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Piton de la Fournaise volcano (Réunion Island) has been experiencing frequent eruptions since March 1998 after more than five years of rest. The displacements associated to the five eruptions, from March 1998 to June 2000, have been recorded by the RADARSAT-1 satellite. A total of 18 ascending and descending interferograms were computed from the images recorded in fine mode. They show that the March 1998 and February 2000 eruptions caused asymmetric displacements with the eastern side of the eruptive fissures moving seaward by up to 50 cm and negligeable displacements west of the fissures. These eruptions occured north of the central craters. On the other hand, the September 1999 and June 2000 eruptions which occured south of the central craters showed symmetric displacement patterns. The displacements were modeled using a three-dimensional boundary element method that takes the topography into account. With this method, pressure sources (magma chambers, fractures) and shear faults of any shapes can also be taken into account. Acceptable models of the dike geometry and the pressure parameters (over pressure and pressure gradient) for the five eruptions were found using a neighbourhood algorithm (Sambridge, 1999). Preliminary results show a dike location consistent with the center of inflation determined using clinometric data.

V22A-0571 1330h POSTER

Spreading of Somma-Vesuvio Volcanic Complex: is the Hazard for Plinian Eruptions being reduced?

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Contrary to what is the common knowledge, a detailed structural study of active faulting and rifting of the summit area of Somma-Vesuvio volcanic complex, combined with INSAR, levelling data and seismic profiling at sea suggests that the present-day long-term dynamic behaviour of the complex and of its summit caldera is characterized by volcanic spreading. The structural evolution is controlled by a number of asymmetric, intersecting leaf-grabens. The boundary faults of these grabens intersect at different angles the Somma caldera walls generating a set of wedge-horsts. While normal faulting characterizes the Somma caldera walls, the lavas of the past 150 years, infilling the caldera, have been rifted all around the southern, eastern and northern base of Vesuvio's cone, which, in turn, is being displaced seaward. Associated to the subsidence and extension of the summit area, relative uplift occurs along the coast; in addition, deformation of recent sediments 6-18 km offshore also indicate compression and uplift, which appears to be unrelated to regional tectonics. A preliminary evaluation indicates that rifting of the lavas is in the order of 1-2 mm/a with a southwestward average direction of displacement. Based on these data, we suggest that a wide sector of Somma-Vesuvio is spreading on its plastic sedimentary substratum, which have been identified by drilling. Volcanic spreading appears to have controlled the magmatic evolution and the energy decrease of major historic explosive eruptions since 79 AD. If our interpretation is correct, major plinian eruptions should not occur in the near future. On the other hand, rifting around the caldera suggests that volcanic activity could soon be renewed.

V22A-0572 1330h POSTER

Gravitational and magma forced spreading of Mount Etna volcano revealed by InSAR data

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Mount Etna volcano underwent a cycle of activity over the past ten years from a large flank eruption ending in March 1993, to quiescence, followed by resumed summit activity in August 1995 and recent large flank eruptions in 2001 and 2002-2003. Observations from differential interferometric synthetic aperture radar reveal patterns of surface deformation that result from the changing magma and structural dynamics of the volcano. Here we compute a time series of ground deformation from more than 100 radar interferograms to reveal Mount Etna's time varying surface deformation from 1992 to 2001. We find that during this time interval it experienced magmatic inflation and radial spreading to the West, South, and East. Steady motion between the West-South flanks and between the East-North flanks during this time interval suggests they are related to gravitational spreading of the volcanic edifice. In particular, we find spreading across conjugate, arcuate crossing faults that fit laboratory models of volcano spreading. In contrast, time series analysis shows that southeastern basal anticline growth is not constant, but initiated with the end of magma recharge in 1995, thus showing a direct link between deep-seated magma intrusions and edifice spreading. We will present both results of the time series analysis as well as examples from numerous interferograms. Together these observations support a more complex mode of radial gravitational collapse underlain by deeper magma driven basal spreading.

V22A-0573 1330h POSTER

Large scale ground deformation of Etna observed by GPS between 1994 and 1999

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Using the GAMIT software, we processed 33 GPS campaigns carried out at Etna from 1994 to 1999. The temporal evolution at twenty-two points observed three times or more is analyzed. Our solution confirms, improves and extends the one previously published by Bonforte and Puglisi (2003), estimated for the period 1994-1996 processing their data with the Trimble GPSurvey 2.3 software. The times series at almost all points show no temporal change of the deformation pattern during the five years period. This suggests that at large scale the volcano evolved in a steady manner during this interval, although this was not the case for the eruptive activity registered at the summit, which varied from calm to episodically explosive during the same period. The deformation field is interpreted as the sum of a global inflation of the volcano and an eastward motion of its eastern flank. This measured eastward motion reaches 40 mm/yr along the Ionian coast, on the eastern and south-eastern flanks of the volcano, and is still 9 mm/yr on the southernmost border, in Catania. Previously published InSAR data covering the same time interval quantitatively agree with our GPS results. Moreover they allow to accurately assess the location of the active structures that decouple the mobile flank from the stable part of the volcano. To the South those are mainly the Nicolosi - Tremestieri fault and the Gravina fault and to the North the Pernicana fault. The GPS results show that the relative motion has the same direction of those three structures, highlighting that they are affected by pure shear strain, without almost any component of compression or extension. Our GPS solutions are not accurate enough to estimate vertical velocities, which in any case do not show evident trends, as horizontal components do, and are very little in magnitude.

V22A-0574 1330h POSTER

Rapid opening of the Asal rift in Afar observed with radar interferometry

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Located at the western end of the Aden ridge, the Asal rift is the first emerged section of the ridge propagating into Afar and the locus of intense volcanic and seismic activity. We use radar interferometry data acquired by the Canadian satellite Radarsat between 1997 and 2003 from both ascending and descending passes to measure the surface deformation in a 100 km wide region centered on the rift. The turbulent atmosphere in this sub-tropical region produces a phase delay error in the data exceeding the tectonic signal we seek. To estimate the deformation rates from the series of interferograms, we solve a least-square problem and derive the vertical and rift-perpendicular, horizontal components of the surface velocity from the series of ascending and descending line of sight observations by the radar. The resulting 2-component surface velocity map of the rift area shows the following features: A 40 km wide zone centered on the rift is inflating at a rate of 7 mm/yr. The 8 km-wide central rift subsides at a rate of 2mm/yr with respect to the shoulders of the rifts. The horizontal velocity indicates extension across the central rift at a rate of up to 20 mm/yr, gradually decreasing in the far field, the maxima of the horizontal velocity being located on both side of the rift, 12 km from its axis. This local opening rate exceeds the 13 mm/yr far-field plate motion between the Arabia and Nubia plates, suggesting that magmatic activity is currently controlling the opening of the Asal rift. Preliminary models shows that a 4 km deep dyke system expanding both laterally and upward accounts for the observed velocity field across the Asal rift.

V22A-0575 1330h POSTER

General Expressions of Internal Displacement and Stress Fields due to a Moment Tensor in an Elastic-Viscoelastic Layered Half-Space

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We succeeded in deriving general expressions of internal deformation fields due to a moment tensor in a gravitational two-layered elastic-viscoelastic half-space. In general, any indigenous source can be expressed in a form of moment tensor, and a moment tensor can be uniquely decomposed into three different types of sources corresponding to isotropic explosion, crack opening, and shear faulting. Among these three different types of sources, the expressions for shear faulting have been already obtained, but not for isotropic explosion and crack opening. To derive the expressions, we begin with the classical expressions of static displacement fields due to a moment tensor in an infinite elastic medium in Cartesian coordinates. Applying Hankel transformation to the expressions in Cartesian coordinates, we obtained the expressions in cylindrical coordinates. These expressions correspond to the special solution originated from a force term of the equilibrium equation of an infinite elastic medium. In order to obtain the general solution, the homogeneous solution for a two layered half-space must be added to the special solution. With a generalized propagator matrix method, we obtain the general expressions of internal deformation fields due to a moment tensor in a two-layered elastic half-space. The general expressions of internal deformation fields due to a moment tensor in an elastic-viscoelastic layered half-space can be obtained applying the correspondence principle in linear viscoelasticity to the elastic solution. In this presentation, as examples of numerical computation, we show the internal velocity fields caused by steady plate divergence at mid-ocean ridge. We also show the change in internal stress fields associated with magmatic intrusion.

V22A-0576 1330h POSTER

Dike Models of Tiltmeter Data From the 1984 Rifting Event at Krafla, Iceland: Testing for a Vertical Component to the Propagation Direction

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The September 4th 1984 Krafla fissure eruption occurred in northern Iceland at the end of the 1975-1984 rifting episode. The surface deformation resulting from the propagation of the feeder dike was monitored by three continuously recording tiltmeters located around the southern end of the 8.5 km long fissure, within the Krafla caldera. The tiltmeter time series (east and north components) were compared to models of dike propagation and magma chamber deflation by computing model-predicted tilt from both a growing dislocation and a deflating Mogi source in an elastic halfspace. End-member models (vertical vs. lateral propagation) favored vertical dike propagation, indicating that there was an important vertical component to the propagation direction. However, dike propagation models that combined lateral and vertical dike propagation indicated that, below 1 km, the continuous tiltmeter network was inadequate for determining the depth at which the dike initiated vertical propagation. We also found that the fit to the continuous tiltmeter time series was improved by adjusting some of the dike and magma chamber model parameters. These parameters had been estimated based on EDM, leveling, and optical tilt data that spanned different time periods. We ran inversions of EDM, leveling, and optical leveling tilt data with the continuous tilt data to provide a realistic model for the dike and magma chamber parameters. Results from this study can improve our understanding of the magma transport mechanisms at Krafla and similar volcanic systems such as mid-ocean ridges.

V22B MCC: Level 1 Tuesday 1330h

Many Facets of Garnet: Recorders of Crust and Mantle Dynamics III Posters *(joint with T)*

Presiding: **D L Whitney,** University of Minnesota**; M Pertermann,** Swiss Federal Institute of Technology Zurich

V

V22B-0577 1330h POSTER

Garnet Solid Solutions: Microscopic-Macroscopic Strain and Implications for Thermodynamic Mixing and Trace Element Substitution Behavior

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