V41C MC: 304 Thursday 0830h

Geochemical and Isotopic Tracers of Earth Processes: Sedimentary Provenance Studies and Continental Tectonics (a session in honor of Gil Hanson) *(joint with H, T, GC, MR)*

Presiding: **C H Langmuir,** Lamont-Doherty; **K Mezger,** Universitaet Muenster

V41C-01 0830h

Conglomerate Provenance and Geochronology: Dating the Accretion of an Intra-Oceanic Arc, Bowers Terrane, Antarctica

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The Cambrian Bowers Terrane intra-oceanic volcanic arc, Antarctica, accreted to the Gondwanan continental margin sometime prior to deposition of poorly-dated passive margin quartz arenites. The Bowers Terrane currently lies adjacent to the Wilson Terrane which contains Cambrian Ross Orogen granitoid intrusions.

The Carryer conglomerate overlies the Bowers Terrane and is a red, polymict, mixed-bedload, braided river conglomerate. Felsic volcanic (2%), vein quartz (5%), schist, quartzite and granitoid (12%) clasts with I and S type compositions strongly indicate a mature continental arc source. High silica andesite (5%) and microgranodiorite clasts are of island arc affinity and are derived from the underlying Bowers arc. Trace amounts of red chert and mudstones may indicate an associated oceanic assemblage.

Isotopic provenance analysis of granitoid conglomerate clasts provides constraints on the timing and location of accretion given the paucity of fossils and discontinuous outcrop. SHRIMP U/Pb zircon ages from Carryer I-type clasts indicate crystallization ages of 504±4, 505±6, and 508±6 Ma with minor inheritance at 600, 791, 1042, 1087, and 2016 Ma. Ages from an S-type clast ranged from 483-2827 Ma. The Bowers Terrane mafic volcanic sequence contains an interbedded conglomerate with granitoid clasts. An I-type clast gave a crystallization age of 511±7 Ma with minor inheritance at 546 and 585 Ma. All crystallization ages are typical of the Ross Orogen; inheritance ages are typical Gondwana margin signatures.

Ross Orogen and Gondwana inheritance signatures suggest that accretion of the Bowers Terrane to the Gondwana continental margin occurred prior to the deposition of the Carryer Conglomerate with a possible source in the nearby Wilson Terrane. Granitoid clasts in the Bowers volcanic sequence indicate the approach prior to accretion. Red mudstone and chert clasts suggest an oceanic assemblage caught up in the suture zone. The timing of accretion, supported by possible correlation to conglomerates dated as early Upper Cambrian by trilobite fossils, is likely to be close to the upper Middle Cambrian age of the granitoid clasts.

V41C-02 0845h

Use of Ar-Ar ages of individual mica grains to determine the provenance of loess

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Ar-Ar ages for individual biotite and muscovite grains have been used to evaluate the provenance of loess in two sections on Long Island. Ages were determined on mica from Cretaceous sands, glacial outwash and loess from Caumsett State Park and from loess on the Stony Brook campus. Most of the muscovite ages in loess range between 250 to 375 Ma and are similar to those found for the muscovite in the glacial and Cretaceous sands. However, one muscovite age is 1000 Ma. Biotite was not found in the Cretaceous sands, but was found in the overlying glacial sands and gravels and loess at Caumsett State Park. The reason for this is probably that biotite cannot withstand the extensive weathering or recycling that the sand in the Cretaceous sediments had undergone prior to deposition. The biotite in the glacial sediments is probably more dominantly derived from freshly glacially scoured local basement rocks.

The ages for the biotite from the glacial sediments are mainly 250 to 400 Ma consistent with their derivation from the basement rocks underlying Long Island Sound or exposed in southern Connecticut. Ages for biotite from the loess range from 44 to 1287 Ma with the majority between 250 to 400 Ma. These mica ages suggest that the majority of the loess is of local origin and that the muscovite and biotite are derived mainly from sources similar to the underlying Cretaceous and glacial sediments. Some of the biotites have an ages of 700 to 900 Ma consistent with derivation from Grenville basement sources further to the west in the Hudson or New Jersey Highlands. The 44 Ma and 1287 Ma biotite ages may have a source much further to the west in the Rocky Mountains. These results suggest that Ar-Ar ages for individual mica grains may be a valuable tool for provenance analysis of loess. Biotite which is more likely to be a first cycle sedimentary mineral may have potential for evaluating more distant sources.

V41C-03 0900h

Trace Element and Nd-Isotopic Evolution of Eastern Laurentia in New England: Late Proterozoic to Middle Ordovician

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Sedimentary rocks deposited on the eastern margin of Laurentia from the late Cambrian to middle Ordovician display stratigraphic variations in trace element and Nd-isotopic characteristics. Samples from the early Paleozoic passive margin sequence display initial epsilon-Nd values ranging from -11.3 to -14.6, Th/Sc values ranging from 0.55 to 0.75 and Th/U values ranging from 5.43 to 7.47. These data are consistent with a provenance composed of a mixture of highly recycled and/or weathered Grenvillian sources with variable inputs from rift-related sources, both of which are derived solely from Laurentia. Middle Ordovician synorogenic shale and flysch deposits, generated during the Taconian Orogeny, display initial epsilon-Nd values ranging from -8.32 to -8.98, Th/Sc values ranging from 0.66 to 0.92 and Th/U values ranging from 3.87 to 4.23. These data are consistent with a provenance dominated by a younger Grenvillian component than that which contributed to passive margin deposits. Outlying Grenville basement massifs, re-exposed as a result of convergent Taconian tectonics, mixed with a lesser component of recycled passive margin sediment are suggested as likely sources. Combining these data with published Nd-isotope analyses for underlying late Proterozoic to early Cambrian rift stage sediments reveals a stratigraphic progression in the Nd-isotopic composition of these sediments analogous to that of correlative sequences from the northern and southern Appalachians and possibly the Ouachita Mountains. The implied correlation between these geographically disparate sequences suggests that sediments deposited on the eastern and southern margins of Laurentia shared a common provenance both before and after the onset of middle Ordovician Taconian orogenesis.

V41C-04 0915h INVITED

Nd Isotopic Provenance of Sedimentary Rocks Along Margins of North America: ten Years of Study

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Ten years of effort, principally employing Nd isotopes, have resulted in substantial advances in understanding of the movements of sedimentary material around North America from Cambrian to Cretaceous time. This synthesis has depended upon work of current and former students S. Samson, J. Gleason, N. Boghossian, C. Garzione, M. Roth, B. Canale and E. Rosenberg, as well as collaborators W. Dickinson and A. Embry, among others. Nd isotopes are particularly good at documenting movements of sedimentary material on the largest (continental) scale and over extended times. What has emerged is a picture of a largely exposed North America-Greenland craton from Neoproterozoic to Ordovician time, a partial to complete burial by detritus from Caledonian-Appalachian mountains starting in the Ordovician, a gradual exhumation during Late Paleozoic and Mesozoic time, followed by a partial burial with Cordilleran detritus during Late Jurassic to Tertiary time. One current question is the nature of the Mesozoic and Tertiary sedimentary material eroded from the North American Cordillera, and its relevance for Cordilleran orogenesis. Another current question is the extent to which Caledonian-Appalachian detritus covered the craton in Devonian-Carboniferous time, and the timing and manner of its removal during Mesozoic time. At first glance, available Nd isotopic data appear to suggest that the Canada-Greenland Shield was largely covered during most of Mesozoic time, a conclusion that would have profound effects on models of dynamic topography. However, this conclusion is also very dependent on the relationship between topography and erosion, because in certain situations a geographically-restricted cover sequence could dominate over low-relief cratonic terrain as a sediment source.

V41C-05 0930h

Major Change in Hf Isotopic Composition of Deep-Ocean Sediments at About 120 Ma

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We report Hf isotopic compositions of sediments collected in the West Pacific in front of the Izu-Bonin arc during ODP Leg 185, Hole 1149. The drilled sedimentary pile is 408 m thick, covers a time range from Valanginien (about 133 Ma) to present-day and consists in a succession of biogenic cherts and siliceous and pelagic clays. All samples with ages up to 117Ma have positive and almost constant Epsilon Hf at about +6. At present only one chert sample from the lower part of the hole was analyzed. It has an age of 123Ma and a much lower Epsilon Hf at ?4. This shift in Hf isotopic composition is also seen in data reported by Pearce et al. (1999) for sediments from Site 801B located some 1800 km Southeast on the Pacific plate.

Hf isotopic studies of Fe-Mn and Mn crusts show that the present-day Pacific seawater has rather constant Epsilon Hf of +5 (Albarede et al., 1997, David et al., 2001). This is interpreted to represent the composition of ambient deep waters and to be little influenced by material of continental origin.

Since all samples from Hole 1149 with ages up to 117Ma have Hf isotopes similar to the value measured in present-day crusts, it appears that the source of Hf in the Pacific deep ocean remained similar over this time interval. However, a major shift occurred at 120 Ma; older sediments have Hf isotopes with a much stronger continental signature.

We suggest that a major change in the budget of Hf in seawater occurred at that time. The composition of seawater changed from continental dominated to mantle dominated. Processes that might explain such a drastic shift include: (1) the onset of massive volcanism on the Ontong-Java plateau and other Pacific plateaus at 120 Ma coupled with the enhanced activity of mid-ocean ridges wordwide. These processes are considered to be responsible for the major transgressions reported in the Cretaceous; (2) alternatively, drastic changes in ocean-water circulation could have the same effect, but this interpretation would still necessitate the existence of massive sediment discharge from the existing continents.

References: Albarede et al., GRL, 1997, 25, 3895-3898; Pearce et al., J of Petrol., 1999, 40, 1579-1611; David et al., Chem. Geol.., 2001, 178, 23-42.

V41C-06 0945h

Hf-Nd Isotopic and Trace-Element Geochemistry of Global Subducting Sediments

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Ferromanganese nodules, crusts, and associated metalliferous clays have long been known to have anomalously high Lu/Hf ratios and highly radiogenic Hf relative to Nd (Patchett et al., 1984; White et al., 1986). These oceanic sediments are some of the few terrestrial materials where Hf and Nd isotopes deviate from the crust-mantle array. This distinctive isotopic signature, therefore, has the potential to trace the fate of oceanic sediments through the subduction zone and into the mantle. It has recently been suggested, for example, that pelagic sediments can be detected in some Hawaiian basalts (Blichert-Toft et al., 1999) and in volcanic rocks from the Luzon arc (Marini et al., 2000) based on their Hf-Nd isotopic compositions. The weak link in this approach, however, is that we do not know, in any quantitative way, how widespread this anomalous signature is in oceanic sediments, what compositions are responsible for this signature, or how volumetrically important these compositions are in terms of the total sediment flux into subduction zones and the mantle. Most marine sediments analyzed thus far have been collected on or near the ocean floor and constitute an incomplete and unrepresentative inventory of the sediment column bound for the subduction zone. There is some reason to suspect that much of the sediment flux is not particularly anomalous, either in terms of Lu/Hf ratios or Hf and Nd isotopic compositions. The most dominant sediment types entering many subduction zones (terrigenous and other continentally derived sediments), have normal Lu/Hf ratios and Hf-Nd isotopic compositions that are indistinguishable from the crust-mantle array.

An examination is needed of the Hf-Nd isotopic composition of oceanic sediments, the major and trace-element geochemistry of global sediment flux, how such compositions may relate to Hf-Nd isotopic behavior, and potential Lu/Hf and Nd/Hf fractionation in subduction zones. In addition, the origin of the high Lu/Hf and anomalous radiogenic Hf isotopic character of pelagic sediments needs to be determined in order to understand the global sediment budget problem.

V41C-07 1020h

New Geochemical and Isotopic Evidence for Igneous Activity at the Triassic-Jurassic Boundary: the Effects of Volcanism in the Central Atlantic Magmatic Province

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Although the Triassic-Jurassic (T-J) boundary marks one of the big five extinction events of the Phanerozoic, the processes driving global change at that time remain obscure. The main contenders include substantial volcanic activity, large meteorite impacts, and major tectonic realignment. Recent results from high-precision Ar-Ar and U-Pb dating suggest that a major phase of volcanic activity, associated with the breakup of Pangea, started ∼200 Ma ago in the so-called Central Atlantic magmatic province (Marzoli et al., Science 284, p. 616, 1999). However, it is often hard to accurately assess the global impact of this volcanic activity because of the difficulties in correlating igneous ages with the changes in the sedimentary successions which in practice define the position of the T-J boundary, and because of the difficulties in estimating the volume and extent of volcanic activity.

In this study, we have adopted a new approach by determining the Mo, Re and platinum group element (PGE) abundances, and Os isotope compositions, of a suite of fully marine organic-rich mudrocks from three T-J boundary sections in the U.K. One of these sections (St. Audries Bay, Somerset) has been proposed as a candidate GSSP for the T-J boundary. The underlying rationale is that organic-rich mudrocks concentrate these elements from seawater, and reflect the particular geochemical and isotopic characteristics of seawater on a global scale at the time of mudrock deposition. Because the Re and PGE signatures of chondritic meteorites and terrestrial volcanism are distinctive, as are the signatures they impart to seawater, the patterns of these elements in well-preserved mudrock samples should help to define both the timing and nature of environmental change at the T-J boundary.

Our new results show that Os abundances in marine mudrocks increased more than five-fold in the latest Triassic; Re abundances started to rise at the same time and had increased by up to 2 orders of magnitude in the earliest Jurassic. At the same time, the $^{187}Os/^{188}Os$ ratio of seawater (as indicated by the $^{187}Os/^{188}Os_{(i)}$ ratio of the mudrocks) fell from a mean value of ∼0.55 in the late Triassic to ∼0.16 just before the T-J boundary. High levels of Re and unradiogenic Os characterise organic-rich mudrocks which were deposited during the ensuing 3-4 Ma of the earliest Jurassic (Cohen et al., EPSL 167, p.159, 1999). We attribute these substantial geochemical and isotopic changes in seawater to a sudden influx of large amounts of Re and unradiogenic Os derived from the hydrothermal alteration of volcanics erupted during the initial rifting of Pangea. These particular characteristics can not be readily attributed to the impact of a large chondritic or iron meteorite at that time. This assertion is further confirmed by preliminary Pt and Ir data, with Pt/Ir ratios indicative of crustal rather than meteoritic sources. Taken together, these results demonstrate that seawater Re-Os isotope characteristics and PGE abundance patterns can help to pinpoint and identify the timing of, and causes behind, episodes of major environmental change.

V41C-08 1035h

Ge/Si Ratios as a Tracer of Hydrothermal Activity in the Nepal Himalaya

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Advection of deep-seated crustal rocks, high internal heat production, and rapid erosion of the thrust wedge result in steep thermal gradients in the crystalline rocks of the Himalayan front. Meteoric water circulation within these rocks produces geothermal activity in the deeply-incised river valleys near the Main Central Thrust shear zone. The springs have measured temperatures up to 70°C and TDS up to 8000 mg/L and drive significant anomalies in river chemistry. We have carried out a detailed study of the role of hot springs in the Narayani River basin of central Nepal (area 35,000 km^2), the major drainage of the central Nepal Himalaya and a major tributary to the Ganges. In order to quantify the fluxes of heat and solutes from geothermal systems in the Narayani basin, the hydrothermal fluid flux must be estimated.

As part of an ongoing effort to investigate the use of germanium-silicon systematics, we measured Ge/Si ratios in main stem, tributary and hot spring waters of the Narayani basin. While Ge/Si ratios in tributaries are similar to non-polluted world rivers (<1.5 μmol/mol), Ge/Si values in the main streams range from 2 to 13 μmol/mol, some of the highest values reported. Thermal waters yield Ge/Si ratios from 6 to 1000 μmol/mol; comparable to or higher than ocean floor hot springs (<25 μmol/mol) and thermal waters from Iceland (9 to 150 μmol/mol). The high Ge/Si ratios in the hot springs may reflect Rayleigh fractionation as low Ge/Si quartz is precipitated. The wide disparity in stream vs. hydrothermal values makes Ge/Si a valuable tool for quantifying hydrothermal fluid flux by mass balance.

We can use a hydrothermal fluid flux estimate derived from the chemical mass balance to estimate convective heat loss in the Narayani basin. Preliminary estimates in the Marsyandi River yield a thermal power output rate of 200 MW, comparable with geothermal fields in the Taupo Volcanic Zone and when distributed over the spring affected area, yield a hydrothermal heat flow (160 mW/m^2) comparable to continental heat flow and hydrothermal heat loss in the geothermal belt across Tibet. Fluxes of solutes and heat carried by Himalayan hot springs appear to be significant for Himalayan river chemistry and for thermal models of the Himalayan orogen.

V41C-09 1050h

The Influence of Sediment Flux from Nanga Parbat in Interpreting Regional Erosion Patterns from the Indus Fan

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The Indus is the only major river in the western Himalaya and its sedimentary flux into the Indus Fan might be expected to contain an erosional record of the growth of high topography since India-Asia collision. Interpretation of regional seismic profiles across the shelf and continental slope suggests sedimentation rates peaking in the Middle Miocene (11-16 Ma), then falling to the present day. This variability does not correlate with apparent monsoon intensification at 8.5 Ma or with Late Miocene to Recent exhumation in the Nanga Parbat-Haramosh Massif (NPHM). There is however a first order correlation between sedimentation and rapid exhumation of the Karakoram Batholith and start of motion on the Karakoram Fault. However, in order to understand the meaning of ancient periods of rapid sedimentation on the fan we must first understand the influence that very rapidly uplifting crystalline massifs have on the flux of sediment to the modern Indus River. The NPHM located in the western syntaxis of the Himalaya is one of the most rapidly exhuming massifs known globally and potentially major source of sediment. Comparison of the trace element chemistry of single amphibole grains from Indus River sands located up and downstream of NPHM demonstrates that erosion from this region is not a major contributor of these minerals to the river bedload. Although bulk sediment ϵ_{Nd} falls in the Indus between the Indus Suture in Ladakh and the Arabian Sea because of mixing with India Plate sources, values downstream of NPHM suggests that this body contributes only 13% of the sediment reaching the foreland and 6-10% of that reaching the Arabian Sea. Consequently, Nd isotopic analysis confirms that the NPHM is a not a dominant sediment source to the Indus Fan. Single grain, ion microprobe Pb isotope analyses of K-feldspars from the Indus Fan and river confirm the Karakoram and suture zone arc batholiths as the dominant modern sediment sources, with much less flux from Indian Plate sources. NPHM is particularly radiogenic, and its erosional products are readily picked out. The Southern Karakoram Metamorphic Belt, also a region of very rapid modern exhumation, is revealed as the major modern sediment source. Data from the Indus Fan confirm that this is not dominated by erosion of NPHM or similar massifs, but instead provides a more regional image of erosion within its drainage basin, reflecting both surface area and instantaneous tectonic uplift rates of source regions at the time of erosion.

V41C-10 1105h

Late Miocene to Quaternary Transition in Magmatism and Tectonics, Sierra Nevada Basin and Range Boundary, Northern California-Western Nevada

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During the late Miocene and early Pliocene, the Ancestral Cascades Arc (ARC) in northern CA and western NV shut off as the Mendocino triple junction migrated northward. At the same time, Basin and Range extension migrated westward into the Sierra Nevada block, with major episodes at 12 and 3 Ma. These tectonic events are reflected in a complex transition in magmatic composition and style. We are using geochemical, isotopic, and 40Ar/39Ar data to evaluate magma petrogenesis, the timing of volcanism, and the relationship between volcanism and tectonism in this poorly understood region of Mio-Pliocene arc volcanism. The ARC erupted highly porphyritic, pyroxene- or hornblende-plagioclase andesites to dacites, termed the Kate Peak Formation, from numerous stratovolcano complexes over basement rocks of the Sierra Nevada Batholith. Our new and published dating indicate activity from ∼16 to 4 Ma. Immediately west of Reno, sequences dominated by poorly-phyric, olivine- and pyroxene-basaltic andesite, commonly termed Lousetown Formation, began to erupt as early as 10 Ma and continued to ∼1 Ma. Early episodes, at 10.3 and 4 Ma, were contemporaneous with continued arc magmatism. Further, post-arc mafic volcanism continued in the area north of Lake Tahoe between 2.9 and 1.2 Ma. Although the change from hydrous intermediate rocks to ∼ anhydrous mafic rocks suggests a fundamental change in magmatic sources and tectonic setting, the mafic rocks have normalized incompatible element patterns and radiogenic isotope compositions that include a strong subduction component that is virtually indistinguishable from that in ARC intermediate lavas. Thus mafic and intermediate magmas, including post-arc magmas, share a common, fluid-modified, mantle wedge source. Additionally, the timing of mafic magmatism coincides only imprecisely with extension. No mafic magmas erupted before the beginning of extension at any location, but the earliest activity followed extension by ∼2Ma. Also, the apparent cessation of arc magmatism at 4 Ma preceded the major extensional event in the region at 3 Ma. Periods of extension appear to allow more primitive magmas to rise to the surface without being assimilated into the magmatic plumbing system of a stratovolcano complex. Ongoing Ar-Ar and geochemical analyses of mafic rocks will allow us to define stratigraphic and petrogenetic relationships between mafic units and provide snapshots of the mantle wedge over a 10 Ma period.

V

V41C-11 1120h

Tertiary Chemical Structure of the Afar Plume: Evidence From Primitive Mafic Lavas From Turkana, N. Kenya

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The East African Rift System is an ideal location for investigating the link between tectonism and magmatism during rift evolution. Geochemical studies in this region provide insight into plume-driven rift processes, including documenting the chemical structure of the sub-lithospheric mantle. The structure and chemistry of the Oligocene Afar plume were categorized by Pik et al. (1999) and Marty et al. (1996) in Ethiopian flood basalts of the northern rift. Plume influences have also been noted in Quaternary samples of the Afar/Red Sea region (Barrat et al. 1993) as well as at Turkana, N. Kenya (Furman et al., 2001).

We use new data on primitive (6-28 wt. % MgO) mafic lavas of Tertiary age from Turkana to investigate possible temporal and spatial evolution of the sub-lithospheric source region(s) beneath the East African Rift. Preliminary data suggest a plume influence in the source region for Tertiary Turkana mafic lavas. For example, most primitive lavas have La/Nb greater than 0.6 and Ba/Nb values between 3 and 20. Furthermore, Zr/Nb ratios from the Turkana suite demonstrate that incompatible trace element signatures in this area are spatially controlled; Zr/Nb values in central Turkana mafic lavas (about 5.5) are significantly higher than those observed 40 km to the south (around 2.5). La/Nb ratios also show spatial control, with values in the north ranging from 0.75-0.85 and those in the south ranging 0.45-0.7. These data imply consistent, latitudinal spatial heterogeneity in the Turkana source area.

U/Th ratios of the Turkana Tertiary suite overlap mafic Turkana Quaternary samples, suggesting a common, sub-lithospheric source component. Geochemical differences between Turkana and Ethiopian HT2 flood basalts (Pik et al. 1999) in the Tertiary may reflect the chemical structure of the Afar plume, or may imply a more complex scenario of melt segregation and transport within the lithosphere. The geochemical and isotopic data from Turkana basalts are thus an important part of a comprehensive interpretation of the dynamic East African Rift System and will enable us to constrain temporal and spatial chemical structures of the Afar plume.

References cited: Barrat et al. 1993, GCA, 57, 2291-2302 Furman et al. 2001, EPSL, submitted Marty et al. 1996, EPSL, 144, 223-237 Pik et al. 1999, GCA, 63, 2263-2279.

V42A MC: Hall D Thursday 1330h

Conduit Processes During Explosive Basaltic Eruptions I *(joint with P, S, T)*

Presiding: **J Sable,** SOEST

V42A-0983 1330h POSTER

Consequences of Dynamic Limits to Eruption Speeds Orthogonal to the Direction of Flow in Basaltic Volcanic Eruptions

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In sustained explosive volcanic eruptions, the vertical velocity of gas and entrained pyroclasts may exceed Mach 1 relative to the speed of sound in the erupting fluid. This commonly occurs when the vent geometry allows the fluid to be pressure-balanced with the atmosphere, and many eruptions have been shown to have had sustained eruption velocities of up to at least Mach 4. This includes some basaltic eruptions, such as the plinian phases of eruptions at Tarawera.

The dynamics of the transition from sub-sonic to supersonic flow place lower and upper limits on the lateral spreading rate of a subsurface supersonic gas-pyroclast mixture. If the volcanic fluid is in contact with the conduit walls, the gradient of the walls must be greater than a lower limit controlled by both the speed of sound in the erupting gas-pyroclast mixture and the wall friction factor: the walls must form a de Lavalle nozzle. The upper limit to the spreading rate of the mixture is equal to the inverse of the speed of sound of the erupting fluid. For eruptions that are supersonic at the vent, this can significantly affect near-vent conditions, resulting in significantly over-pressured (choked) eruptions in circumstances where pressure-balanced eruptions might be expected.

This helps to explain discrepancies between observed and modelled vent radii in many volcanic eruptions. Application of the constraint also helps with problems in model continuity between sub-surface volcanic dynamics and eruption plume dynamics, as the same constraint applies to volcanic jets above the surface.

V42A-0984 1330h POSTER

Nucleation Rates of Bubbles in Magmas

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The formation of gas bubbles in magmas drives explosive volcanic eruptions. Bubbles form in response to gas supersaturation by first nucleating and then growing. Studies of bubble nucleation in magmas have focused on whether it is homogenous or heterogeneous. Homogenous nucleation involves random clustering of gas molecules in a melt into stable entities, whereas heterogeneous nucleation involves clustering on pre-existing surfaces. For either mechanism, however, little work has focused on the nucleation rate. Therefore, here we investigate experimentally these rates in magmas.

Experiments were performed on natural rhyolitic glasses. These were hydrated at high temperatures and pressures, and then isothermally decompressed rapidly to lower pressures, where they were held for varying lengths of time before quenching. Specially designed pressure vessels enable quenching within a couple of seconds. Quenched samples were analyzed for the sizes and number densities of bubbles that nucleated as a result of the lower pressure. Control experiments were run to ensure that no small bubbles nucleated before decompression. Bubble size distributions allow us to determine the variation in nucleation rate with time, and estimate the size distribution of nucleated bubbles.

Initial experiments were run at 800^{o} C and various hydration pressures. Pressure drops were such that the same percent supersaturation was achieved. Results show that the rate of bubble nucleation is insensitive to water content in the range of 4-6 wt.%. Nucleation was heterogeneous, with bubbles nucleating on Fe-Ti oxide microlites. Almost all bubbles nucleated within 45 seconds, although a few nucleated up to 120 seconds. The peak nucleation rate occurred between 10 to 15 seconds, and was 2.5-3.5x10^{6} cm^{-3} s^{-1}. Even in the shortest runs, all bubbles are 0.5 m or larger, suggesting that the critical size water bubbles is about that size. These results indicate that bubble nucleation is very fast, and can be considered instantaneous compared to growth rates. Further work will explore nucleation rates as a function of supersaturation pressures.

V42A-0985 1330h POSTER

On the Fragmentation Front in Conduit

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Vesiculation and fragmentation of magma in the conduit are the most fundamental processes to characterize explosive eruption. The interval from the vesiculation front to the fragmentation front critically controls the size distribution of pyroclasts and hence the style of eruption. The vesiculation process has been extensively investigated through experimental and model-simulational approaches. As for the fragmentation process, on the other hand, its physical basis is still not well-understood. In the above context, the movement of the fragmentation front is an important subject to be clarified. In this poster, we present a simple model which demonstrates how the fragmentation front is formed and how it moves. The model assumes mixture of gsolidh particles and ggash particles, each having contrasting values of density and compressibility. The initial state is compressed state of all particles. After removing externally-constrained pressure, particles begin to move driven by the forces due to the compression and mutual collision, exchanging the momentum between ggash and gsolidh particles. 2D numerical integration on this particles system clearly shows formation of quasi-shock front, which, we consider, corresponds to the fragmentation front. Non-linearity of the compressibility of ggash phase and cross-over of the continuous phase(pressure-sustaining phase) actually control the formation of the fragmentation front. Its propagation velocity is characterized by considering effective gHugonioth of this system.

V42A-0986 1330h POSTER

Numerical modelling of 2D solid/fluid interactions in explosive volcanic regimes using finite volumes: magma and multiphase flow dynamics induced by seismic elastic waves.

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In many volcanoes like the Popocatepetl, it is not well known if seismicity induces explosive eruptions, or inversely if the dynamics induces seismicity, or how both mechanisms trigger each other. In order to understand this mechanisms we numerically simulate, at greater scales than in laboratory, the behaviour of highly viscous magmas submitted to an incoming PSV wave involving high stresses. For that purpose we use a finite volume scheme of second order with a semi implicit algorithm in time for the fluid and a classical velocity/stress formulation at the second order to describe the elastic waves. The magma is considered as compressible and consists in a high viscous fluid and volatile gases. The gas fractions are computed following a power state law of the pressure. The disturbance of the fluid by the wave causes the pressure to increase and the gas to exsolve. The magma is then submitted to a convection behaviour and can arise through the conduit till reaching a certain depth which defines the location of fragmentation of the mixture. These simulations allow us to conclude that, depending on the magnitude of the wave, a viscous compressible fluid like a magma can be highly disturbed and differ strongly then from the quasistatic and acoustic behaviour classically taken into account in classical modelling of waves travelling through acoustic fluid/elastic solid structures. Depending on the Reynolds number, from laminar to turbulent, the fluid can not any longer be assumed incompressible, irrotational and non viscous. Inversely, when the magma has reached the fragmentation depth in the conduit, the fluid becomes multiphasic with specific exit velocities, pressures, temperatures, particle fractions. It is modelled with one particle phase and one gas phase interacting with drag forces and heat exchange terms. With a similar algorithm as described before, we show that the flow can be expelled at shock speeds and produce travelling elastic waves in the ground through the conduit walls. We show the pattern of the recorded waves at the free surface and their associated spectra.

V42A-0987 1330h POSTER

Sound Propagation in an inhomogeneous two-phase system: the influence of the gas bubble concentration on the sound source model.

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Volcanic explosions produce pressure perturbations in the atmosphere (infrasound) which are not contaminated by path effects as for the seismic wavefield and contain useful and direct informations on the source dynamics. Recently, many dynamical models of the explosive process are based on the analysis of the acoustic field. We have analyzed the acoustic wave field in terms of elastic wave propagation in a two-phase medium where the viscosity and compressibility are spatially inhomogeneous. At low pressure (<10 MPa) the magma can not be considered as an homogeneous medium, but has to be treated as a mixture of fluid magma and gas bubbles. Gas bubble nucleation starts when the pressure of the system drops below the supersaturation level (a few hundreds of meters for H2O in basaltic magmas) and increases towards the surface, reaching its maximum value at the magma-air interface. Such a variation is non-linear with depth and is particularly strong at shallow depth. With the decrease of depth the density of the mixture and the sound velocity drop drastically while the shear viscosity of the mixture increases. We calculated the propagation of an elastic wavefield generated by an explosive source embedded in the magma column as function of the void fraction