of temporal-spatial volcanic center distributions in relationship to structural control. We also demonstrate an effective method for using ASTER data for geological mapping and other field studies in arid regions. ASTER has 14 bands, hence allowing for 364 red-green-blue (RGB) color combinations. Therefore, we apply a statistical approach including the Optimum Index Factor (OIF) to assist in selecting the most effective RGB color combinations for discriminating different geological materials. Small volume basaltic centers such as found in the Potrillo volcanic field do display a broad range of morphologic features, with several similar to those interpreted from the Mars Orbital Lander Altimeter (MOLA) topographic data: shields and flows (lava-tube and fissure-fed). A better understanding of Mars planetary volcanism through terrestrial analogs can be gained by integrating remote sensing, temporal, geochemical and geologic spatial information. Therefore, presented are preliminary observations of the Potrillo deposits for use as a terrestrial analog, with emphasis on phreatomagmatic centers (e.g. Kilbourne Hole and Malpais maar) in order to draw comparisons with martian landforms influenced by water (ice) during eruptions.

V51G-0363 0830h POSTER

The Volcanic Periodicity in Central and Southern Luzon, the Philippines: as Inferred from Tephra Study in the Ocean Core

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The completeness and continuous nature of marine sediment sequences makes marine tephrochronology an excellent geologic record of past volcanism from the general area. Total of 21 tephra layers in the giant piston core MD972142 raised from northern Palawan, South China Sea by the IMAGES 1997 cruise were identified for this purpose. The age constrains of tephra layers were based on the proxy of the previous reported foraminifer oxygen isotope stratigraphy. The tephrochronological results show two major periods of the tephra deposits in this area, 870 ka to 810 ka and 480 ka to present, respectively. It was notable that the volcanic activities between the above two periods existed an obvious about 330,000 yrs of apparent quiescence in this area. The fingerprints of mineral assemblages, chemical and isotopic compositions of glasses in tephra help to trace back to the potential on land sources. Seventeen layers of total 21 layers in the MD972142 in the younger deposit period dominantly consisted of the brown to light-brown sponge-type or pumice-type glass particles with some plagioclase, clinopyroxene and rare biotite. The SiO2 contents and 87Sr/86Sr values of glasses in these tephra layers revealed the range from 56 to 72 wt % and 0.7045 to 0.7053, respectively, those are indistinguishable with the previously reported characteristics of the volcanic rock from the Macolod Corridor segment (0.7043-0.7053). The rests of 4 tephra layers, three in the older deposit period and one at 83 ka, mostly constituted by white pumice, biotite and plagioclase. Characteristics of the calc-alkaline series of glasses, ranges from 73 to 79 wt % in SiO2 and 0.7039 to 0.7044 values in 87Sr/86Sr ratio, are well correlated to the reports from the Bataan Segment (0.7041-0.7045) in the central Luzon. The above results clearly illustrated that the volcanic activities in the Bataan segment with the more differentiation in the chemical compositions and less eruptive frequency was interrupted at around 800 ka, and after about 330,000 yrs of apparent quiescence, the volcanic activities in the Macolod Corridor segment dramatically increased the intensities and frequency from last 480 ka. It can be interpreted as corresponding with the changing stress field on the Philippine Fault in this area. In previous study, the tectonic setting of the Macolod Corridor segment has been considered as a pull-apart rifting zone or a shearing zone, mainly originated by the Philippine Fault. The volcanic activities in this region have been interpreted as related to the rifting environments. From above studies, in summery, overall fluctuations in the volcanic periodicity in central and southern Luzon should be correlated the variations in the regional tectonic (stress) regime field with time.

V51G-0364 0830h POSTER

Geology and stratigraphy of the Tacaná Volcanic Complex, Mexico-Guatemala

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The Tacaná Volcanic Complex (TVC) lies at the intersection of three important fault systems. The oldest is located west of the complex and consists of fractures and NE-SW faults affecting only granitic rocks of Paleozoic and Tertiary. The second fault system is aligned NE-SW, parallel to the TVC, while the youngest fault system is aligned N-S and crosscuts the other two fault systems. The TVC rises over a local basement of Paleozoic metamorphic rocks, early Miocene granodiorites and tonalities, and a late Tertiary volcanic sequence composed of welded green ignimbrites, and indurated block-and-ash flows (up to 100m thick). This latter volcanic sequence is likely associated with the nearby Tertiary-Quaternary caldera structures Pavincul and San Rafael. The TVC itself consists of four structures aligned in a NE-SW direction: Chichuj, Tacaná, San Antonio volcanoes , and Las Ardillas dome. At least three avalanche deposits have been found around the complex all of them covered by block-and-ash flow deposits of 38,000, 28,000 and 16,000 yr. B.P. The San Antonio volcano produced a Peléan-type eruption dated at 1,950 yr. B.P. that may represent the youngest eruption of the complex. However, the 1950, and 1986 phreatic explosions at Tacaná volcano attests to the potential hazard to the surrounding population of 250,000 people.

V51G-0365 0830h POSTER

Origin, Age, and Geochemistry of the Tuff of Saguache Creek, Southwestern Colorado

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A crystal-poor, rhyolitic, ash-flow tuff in the Eastern San Juan Volcanic Field currently known as the tuff of Saguache Creek (TSC) was reinterpreted by Simon and Wendlandt (1999) as not being distal Sapinero Mesa Tuff. Currently there is no source caldera established for this tuff thereby leaving uncertainties in the volcanic history. Regional mapping of the TSC has subsequently been completed to constrain a possible source caldera. Petrographic studies, and EPMA and LA-ICPMS analyses of the mineral assemblage have been performed to characterize further the tuff, enable correlation of mapped TSC, and constrain petrogenetic models. Petrographic and chemical identification of the TSC builds on characteristics set forth by Simon (2000). These characteristics include abundant feldspar clusters, alkali feldspar mantled plagioclase, no modal quartz, Fe-Ti oxides (often with apatites and zircons), and sparse biotite and pyroxene. Pyroxenes show curiously high MnO (avg 2.70 wt%) and Mg# (avg 79.2) and might be xenocrystic. In comparison, biotites have much lower MnO (avg 0.82 wt%). Average sanidine (Or50) and plagioclase (Ab71) compositions fall within the documented range (Simon, 2000) and show little trace element substitution including Eu <3 ppm and Ba <1200 ppm. Titanites are enriched in Ce (17,000-20,000 ppm) and Pr (2,200-2700 ppm). Apatites show similar enrichment in Ce (2200-7600 ppm) and Pr (330-350 ppm). Confirmed outcrops of TSC are best preserved just north of Trickle Mtn where it is approximately 30 m thick and overlain by a welded airfall ash deposit preliminarily dated at 29-30 Ma. Outcrop localities south of Colorado Highway 114 show thinning and are interpreted as erosional remnants plastered on older Conejos age volcanic deposits. Similarly, an andesitic topographic high just west of Trickle Mtn has TSC vitrophyre on the east-facing slope suggesting strong north-south channeling of the flow unit by paleo-topographic lows. Outcrop elevations also decrease from north to south supporting a possible source caldera to the north. This source could be explained by a distinct circular gravity low on the southeastern slope of the Continental Divide. The low is bordered to the north by a circular arrangement of peaks as well as debris breccias, andesitic flow breccias, and lahars.

V51G-0366 0830h POSTER

40Ar/39Ar Geochronology of Hypabyssal Igneous Rocks in the Western Amazon Basin of Peru: a Record of Thermal History, Structure, and Alteration

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Hypabyssal dacites located in the western Amazon basin of Peru record the thermal, tectonic, and alteration history of the area. The dacites were emplaced into the foreland of the Andean fold and thrust belt, and are the only known intrusions along the deformation front in Peru. Deformation in the fold and thrust belt occurred approximately 16 Ma. Preliminary 40Ar/39Ar geochronology on three hornblende separates yields crystallization ages of 12 Ma, younger than the folding and faulting. The dacites are located within a domed area, which includes Cretaceous shales and sandstones of the Chonta and Vivian formations and Tertiary shales, sandstones and tuff of the Pozo, Yahuarango and Chambria formations. Petrographic evidence shows that the dacites are not deformed, but locally underwent quartz-sericite-pyrite alteration during later hydrothermal activity. Argon geochronology on hornblende and potassium feldspar will define cooling history and age of the intrusions. Argon geochronology on sericite will provide a minimum age of the hydrothermal alteration. Seismic data are being examined to determine if the rocks form a stock-like feature or a laccolith similar to that observed in the Henry Mountains, Utah, which represent analogous igneous rocks in a similar setting.

V51H MCC: Level 1 Friday 0830h

Geothermal and Low-Temperature Fluid-Rock Reactions Posters

Presiding: **I Chou,** U.S. Geological Survey

V51H-0367 0830h POSTER

Understanding the Chemical and Structural Dynamics of a Geothermal System Using Hyperspectral Imaging and Field Observations, Dixie Meadows, Nevada

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Dixie Valley hosts the largest geothermal plant in the state of Nevada. As part of an exploration program to evaluate other geothermal sites we mapped a 16 km swath of the eastern front of the Stillwater Range, including the Dixie Valley Fault system (Caskey et al. 1996) and Dixie Hot Springs. This visibly hydrothermally altered portion of the range front is located 25 km south of the existing plant and 10 km north of a major bend in the Dixie Valley Fault System. We used hyperspectral (HyMAP) data to locate outcrops of high temperature, hydrothermally altered minerals (including alunite, kaolinite, dickite, jarosite, and hematite). Several outcrops of these altered minerals exist in the mapped region, and one area of roughly 1

square kilometer shows abundant high temperature alteration. We also utilized an ASD field spectrometer to ground-truth our image interpretation and to map more subtle mineral distributions. These spectra support the locations of the mapped high temperature mineralization based on the hyperspectral data, and show that other high temperature minerals, such as vein chalcedony are present on scales below the spectral resolution of the HyMap data (3 m). At active fumaroles near the range front, acidic vapor-phase mineralization is occurring, and we measured ground temperatures of up to 94 °C. Approximately 1 km into the valley, at Dixie Valley Hot Springs, we measured alkaline liquid discharge to have a pH of 8.4 and a temperature of 75 °C. We also carried out structural analysis using a DEM, hyperspectral-based mineral mapping, and field observations. We find that this outcrop is bounded on all sides by a set of cross-cutting faults. We hypothesize that extension related to the release of the bend to the south has resulted in increased permeability, and as result, greater geothermal activity. Both the intense alteration in this area, including the presence of active fumeroles and hotsprings, and the high permeability introduced by cross-cutting faults support this hypothesis. We suggest that this region is a prime candidate for further geothermal exploration.

V51H-0368 0830h POSTER

A New Optical Cell for Spectroscopic Studies of Geofluids at Pressures up to 100 MPa

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Interpretation of Raman and fluorescence spectra of hydrocarbon fluid inclusions and spectroscopic observations of reactions in hydrocarbon-water systems require high quality reference spectra of individual gases, gas mixtures, and hydrocarbon-water systems. We constructed a new optical cell from a square flexible fused silica capillary tube (300 μm x 300 μm with 100 μm x 100 μm cavity) and a high-pressure valve that allows studies of fluids at room temperature and pressures up to 100 MPa. The cell has several advantages over existing ones, including the hydrothermal diamond-anvil cell, and they are: (1) ability to directly load sample fluids and monitor pressure during investigation; (2) no optical distortion; (3) small cell volume suitable for samples of limited supply (e.g., commercially available gas mixtures); (4) high pressures can be achieved; (5) a high-magnification, high-numerical-aperture objective lens (e.g., 100x) with a short working distance can be used due to the thin wall of the capillary tube, and (6) a heating-cooling stage can be added, allowing for investigations at temperatures other than room temperature, particularly suitable for studies of gas hydrates. Raman spectra have been collected from the cell for methane, ethane, propane, n-butane, and also for two gas mixtures containing up to 9 components as a function of pressure up to 41 MPa. The spectra document the shift in Raman bands with pressure as well as constrain the detection limits for various gas species in the mixtures. Preliminary experiments on the diffusion of methane in water were conducted by monitoring the concentration of dissolved methane in water, as a function of time and distance from the vapor-water boundary, immediately after the perturbation of an equilibrium state induced by a sudden change in methane pressure.

V51H-0369 0830h POSTER

Nano-scale solution-reprecipitation responsible for altered near-surface zones during feldspar dissolution

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The pH-dependency of the aqueous dissolution behavior of feldspar, the most abundant mineral in the Earth's crust, as well as many other aluminosilicate minerals, is generally modeled to invoke two distinct dissolution mechanisms: the formation of altered ('leached') near-surface layers at acid to neutral pH, and the absence of these layers at basic pH. Based on an approach combining transmission electron microscopy and spectroscopy methods with Å to nm spatial resolution, the interfacial region between altered and non-altered zones after dissolution at acid pH conditions is characterized by extremely sharp and spatially coincident changes in structure and chemistry. Based on these new data, we propose that near-surface altered zones in feldspars result from interfacial solution-reprecipitation, and not preferential leaching. Therefore, the intrinsic dissolution process is congruent, whereby the release of all elements to solution is governed by a single mechanism that is invariant with pH. These results call into question prevailing dissolution models for feldspars and related alumino-silicate minerals.

V51H-0370 0830h POSTER

Probing zeolite syntheses to determine natural occurances of zeolites

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In this study, zeolites were synthesized from different glasses to probe the occurrence of zeolites in nature. The experiments were carried out with synthetic glass systems of Na2O.Al2O3.nSiO2, CaO.Al2O3.nSiO2, xNa2O.(1-x)CaO.Al2O3.nSiO2 and xNa2O.(1-x)K2O.Al2O3.6SiO2 in alkaline solutions of NaOH, KOH, Na2CO3, NH4OH, NaOH (+) NaCl and NaOH (+) KOH at temperatures ranging from 110 to 210 and with autogeneous pressures in the autoclaves. Synthetic products were examined by an X-ray powder diffractometer, a scanning electron microscopy with an energy dispersive spectrometer, and an electron microprobe. The minerals synthesized included zeolites, i.e., thomsonite, gismondine, amicite, garronite, gobbinsite, analcime, phillipsite, merlinoite, chabazite and mordenite; artificial synthetic zeolites, and feldspars. Chemical analyses indicated that the composition of synthetic zeolites is profoundly influenced by the composition of the initial glasses, especially the SiO2/Al2O3 ratios and cations. On the other hand, the influence of Na+ and K+ have over the formation of zeolites in solution, other ions, such as CO32- were involved in the preventing of the formation of Ca-zeolites. Comparing the experimental results with natural occurrences suggests that thomsonite, gismondine and amicite are usually found in ultrabasic and basic rocks; garronite and gobbinsite in basic to intermediate rocks; analcime, phillipsite, and chabazite in basic to acid rocks; merlinoite in high-potassium rocks; and mordenite in acid rocks. In addition, Ca-zeolites including thomsonite, gismondine and garronite are favored in fresh water environments, and alkali zeolites including gobbinsite, phillipsite, and analcime are most abundant in saline lake and deep sea conditions.

V51H-0371 0830h POSTER

Effects of Kaolinitization on the K-Ar Sytematics in Weathered Muscovite From the Cretaceous and Tertiary Kaolin Deposits of Georgia

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Detrital muscovite in the Cretaceous and Tertiary kaolin deposits of central Georgia has been studied to determine K-Ar and $^{40}Ar/^{39}Ar$ apparent age values and examine the effect of weathering and kaolinitization on the K-Ar radiometric clock. K-Ar dates of muscovite separates range from 166 ± 4 Ma to 374 ± 8 Ma. Both the muscovite dates and K_2O contents increase with increasing stratigraphic age. $^{40}Ar/^{39}Ar$ spot analysis of a single large grain from the base of the Tertiary deposits reveals an apparent-age profile through the grain from the margin to the center. The oldest date, from near the center of the grain is 292 ± 13 Ma; the youngest, from nearest the edge of the grain is 223 ± 10 Ma. K-Ar analyses also reveal that all of the muscovite is significantly depleted in K, which has been removed during intense weathering in the sedimentary weathering environment. Hand sample and petrographic analyses show unremarkable detrital muscovite grains exhibiting no obvious signs of kaolinitization. All the grains are delaminated to very thin sheets and the edges of all grains are rounded. All samples analyzed appear to be muscovite. Electron microprobe analysis reveals that the Tertiary muscovites tend to have lower K_2O contents at their weathered margins than elsewhere. The altered zones are approximately 10-15 μm wide in grains with diameters ranging from 150 to 300 μm. Some larger grains (300-600 μm diameter) show random patterns of K-depletion, possibly related to the presence of fractures or other imperfections. These K-depleted zones imply the presence of a non-muscovite weathering product mineral. X-ray diffraction analysis of random powder mounts confirms electron-microprobe implications of the presence of a secondary weathering product. All samples analyzed are shown to contain both muscovite and kaolinite. The peak intensities of kaolinite relative to muscovite in the samples increase with decreasing grain size. Furthermore, the deepest and most weathered samples analyzed show the greatest relative kaolinite peak intensities; whereas, the most shallow, least weathered samples have the lowest. X-ray diffraction analysis of a single large grain also shows the presence of kaolinite, though with a much lower relative intensity. Powdered samples of 150-300 μm sized separates from the same sample have significantly greater kaolinite peak intensities. The general agreement of the measured K-Ar dates from these separates (282 ± 6 Ma) and the $^{40}Ar/^{39}Ar$ spot dates (223 ± 10 to 292 ± 13 Ma) from the same large grain and the variability of $^{40}Ar/^{39}Ar$ spot dates across the grain indicate that Ar is lost preferentially over K, and not simply due to edge diffusion as would be expected.

V51H-0372 0830h POSTER

Hydrothermal Petroleum in Active Continental Rift: Lake Chapala, Western Mexico, Initial Results.

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Lake Chapala in western Mexico is located partially in the Citala Rift, which belongs to the well-known neotectonic Jalisco continental triple junction. The region is characterized by active volcanism (Ceboruco, Volcan de Fuego), tectonic (1995 earthquake, M=8, 40-50 mm to SW) and hydrothermal (San Juan Cosala & Villa Corona spas and La Calera sinter deposit) activities. Hydrothermal petroleum has been described in active continental rift (East African Rift) and marine spreading zones (Guaymas Basin, Gulf of California). In 1868 the Mexican local press reported that manifestations of bitumen were appearing in front of the Columba Cap on the mid south shore of Lake Chapala. This bitumen is linked to the lake bottom and when the water level decreases sufficiently it is possible to access these tar bodies as islands. Because of these manifestations the Mexican oil company (PEMEX) drilled an exploration well (2,348m) at Tizapan El Alto without success. Hydrothermal activity is evident in the tar island zone as three in-shore thermal springs (26.8 m depth, 48.5°C, pH 7.8 and oriented N-S). The preliminary analyses by GC-MS of the tar from these islands indicate hydrothermal petroleum derived from lake sedimentary organic matter, generated at low temperatures (150°-200°C). The tars contain no n-alkanes, no PAH or other aromatics, but a major UCM of branched and cyclic hydrocarbons and mature biomarkers derived from lacustrine biota. The biomarkers consist of mainly 17α(H),21β(H)-hopanes ranging from C_{27} to C_{34} (no C_{28}), gammacerane, tricyclic terpanes (C_{20}-C_{26}), carotane and its cracking products, and drimanes (C_{14}-C_{16}). The biomarker composition indicates an organic matter source from bacteria and algae, typical of lacustrine ecosystems. ^{14}C dating of samples from two tar islands yielded ages exceeding 40 kyrs, i.e., old carbon from hydrothermal/tectonic remobilization of bitumen from deeper horizons to the surface. The occurrence of hydrothermal petroleum in continental rift systems is now well known and should be included as a target in exploration for future energy resources in such regions.

V51H-0373 0830h POSTER

Clay Mineralogy of the Meade Peak Member of the Phosphoria Shale Formation, Idaho

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Characterization of clay mineralogy and age of illitic clay in samples from the Meade Peak Phosphatic Shale Member of the Phosphoria Shale Formation located in the Western Phosphate Field, SE Idaho, USA, are presented. Illite is the predominant clay mineral within these samples, with smectite, apatite, and 1:1 clays also found. A subset of the samples are further analyzed for illite-smectite (I-S) relationships. These samples were fractionated to $<2\mu$m size. The half-height of the illite 001 peak range from 0.36^o to 0.61^o 2Θ. Srodon intensity ratios are in the range of 1.02 to 1.33. This results in XRD scattering domain size, N, of approximately 15 with 1-2 percent of swelling layers for I-S. The illite 002/smectite 003 reflection peaks of the EG-solvated patterns are approximately 5 Åfor all samples and size fractions. This indicates that illite/smectite is composed of >90% illite. For the majority of the size fractions, a reflection peak around 8^o 2Θ is present, indicating that the clays exhibit mostly R3 ordering. In three samples, the K-Ar dates of the $<0.25\mu$m size fractions are 209-252 Ma, the 0.25-1μm size fractions are 281-290 Ma, and the 1-2μm size fractions are 246-290 Ma. The decrease in K-Ar dates with decreased size fraction is consistent with an interpretation that the clay fraction is a mixture of detrital and diagenetic illite. A third generation of illite is seen in one sample of the Phosphoria as thin seam of small (1 mm) illite crystal rosettes.

V51H-0374 0830h POSTER

Mineral Dissolution Rates as a Function of Distance From Equilibrium

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The attempt to quantify silicate mineral dissolution kinetics close(r) to equilibrium faces a major problem: the rates are often very slow and hard, if not impossible, to measure. Therefore, only a handful of data sets are available. At the same time, our fundamental theoretical knowledge of the dependence of dissolution rate on the saturation state of the solution is limited. Some experimental studies with fine-grained mineral powders seem to indicate that the dissolution rate as a function of distance from equilibrium may be an s-shaped curve with a slow rate and almost linear dependence close to equilibrium. The results of the powder experiments seem to indicate that the rate will increase sharply when etch pits begin to open. Far away from equilibrium, the rate becomes independent of distance from equilibrium (dissolution plateau). Our experimental approach uses vertical scanning interferometry for direct observations of single-crystal albite cleavage surfaces and a hydrothermal reaction vessel with flow-through capabilities. Experiments were designed to confirm whether there is a continuous function of ΔG that describes the dependence of the dissolution rate on equilibrium, or if the change in reaction mechanism when pits begin to open causes a bifurcation in the reaction pathway. The latter result would mean that the dissolution rate switches from slow (close to equilibrium without pits) to fast (further from equilibrium with pits). In this case, there would be a different function of ΔG for each mechanism and no continuous one. Such a situation would have wide implications for modeling dissolution reaction kinetics. It would put in jeopardy any attempt to extrapolate experimental results obtained far from equilibrium to conditions close to equilibrium.

V51H-0375 0830h POSTER

Groundwater Paleohydrology Using Microsample Sr Isotopic Data

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Physical microsampling of silicate alteration phases produced during past episodes of groundwater flow, combined with Sr isotopic data, can be used to determine the age of the alteration phases and to define paleogroundwater flow paths. For example, we have obtained microsamples of secondary adularia present in the K-metasomatized, mid-Tertiary Lemitar Tuff in southern New Mexico. The microsamples (25 micrograms) yield a Rb-Sr "errochron" (MSWD 29) of 6.3 Ma, and an 87Sr/86Sr (6 Ma)=0.7206. The adularia isotopic compositions are considerably higher than those determined for igneous plagioclase and sanidine phenocrysts in the same tuff (0.710), or for the tuff matrix, and indicate that the radiogenic Sr incorporated into the adularia was introduced to the tuff during alteration. Na-Ca sulfates present in playa deposits in the Tertiary Popotosa Formation have Sr isotopic compositions similar to the unaltered tuffs, and not the adularia, and suggest that the fluids responsible for the K-metasomatism of the Lemitar Tuff were not down-flowing saline fluids originating from playa lakes in the Popotosa Basin. Instead, we argue that the fluids were generated during topographically driven flow of meteoric waters through high 87Sr/86Sr Precambrian basement-cored horsts generated during early Basin and Range extension in this area. These data illustrate the utility of such Sr isotopic information in investigations of paleogroundwater flow and we are currently extending the technique to study the origin of the multiple low-T groundwater flow events recorded in the various secondary silicate, sulfate, and carbonate phases present in the Late Paleozoic Fountain Formation in northern Colorado.

V51H-0376 0830h POSTER

Geochemical Investigation of Chemical Weathering in Taiwan: River water chemistry and Sr Isotopes

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Taiwan is an active tectonic island and has the highest physical denudation rate in the world. In this study, we investigate the state of chemical weathering in various river systems distributed all around the island. More than 200 water samples were collected from eight major rivers and their tributaries, including Choshui, Kaopin, Erhjen, Wu, Houlung, Hsiukuluan and Pachang. Among them, the Erhjen was visited nine times at 19 stations in two consecutive years for a detailed study of impacts due to seasonal variation. These water samples were centrifuged and analyzed for major ions (i.e., Na, K, Mg, Ca, Cl, bicarbonate and sulfate) and trace elements (Li, B, Si, Rb, Sr, Ba, and REE), as well as Sr, Pb and U isotopes. Applying factor analysis method, the most dominant factors controlling the chemical compositions are: (1) sea-salt contribution and tidal effect; (2) degree of water-ambient rock interaction; and (3) anthropogenic pollutant. Other effects including regional and seasonal variability are also detected. For instance, Sr isotopes indicate significant seasonal variation in river waters possibly reflecting source changes in ambient soils due to monsoon rain in summer. The Sr concentration and Sr isotope plot show interesting mixing among four sources. The near estuary stations display strong seawater isotopic signature. Stations at mid-stream were influenced by chemical erosion of bed-rock or ambient soils. The upstream samples were affected largely by the characteristics of tributary waters. Uranium isotopes vary largely in the Taiwanese river samples, a range of 1.14 to 2.5, possibly due to alpha recoils.

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Geochemistry and Stable Isotopes of Tacana Volcano-Hydrothermal System, Mexico-Guatemala

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Tacana volcano (4100 m.s.n.m.), situated on the border between Chiapas (Mexico) and Guatemala is considered an active volcano. In May 1986, after a minor phreatic explosion, a fumarole field was formed at an altitude between 3200 and 3600 m.a.s.l. Around the volcano, at altitudes between 1500 and 2000 m.a.s.l., exist several thermal springs, with temperatures up to 63 degrees C. Incomplete chemical composition of the Agua Caliente thermal waters in the period 1986-1993 were presented by Medina (1986), De la Cruz-Reyna et al. (1989) and Armienta and De la Cruz-Reyna (1995), a chemical analysis of fumarole gases were published by Martini et al. (1986). This study presents the first series of isotope data of water and gases: hydrogen, oxygen, carbon and helium. Data on gas and water chemistry of several thermal spring waters and gases are presented in more detail than ever. Hydrogen and oxygen isotopes of Tacana thermal spring waters show that meteoric water is the main contribution for the thermal waters. Cation geothermometry of the spring waters confirm these meteoric contribution, as all waters are immature in a dynamic system of water-rock interaction with a constant infiltration of fresh meteoric waters (precipitation of 6000 mm per year). The relatively high bicarbonate (up to 1100 ppm) and sulphate (up to 1200 ppm) concentrations in the thermal waters suggest an important degassing up to 2500 m below the volcano summit, which indicates the presence of a extended and complex volcano-hydrothermal system. Helium isotopes of free and dissolved gases confirm the existence of a magmatic contribution, so as for fumarole gases (6.6 R/R_a) as for gases sampled at the thermal springs (5.7-6.2 R/R_a for free gases and between 0.50 and 5.55 R/R_a for dissolved gases). These values are typical for gases liberated at volcanoes in clasic volcanic arcs. The lower values for the dissolved He is probably due to an interaction with the granitic basement, which can be found at hights upto 2000 m.a.s.l. Carbon isotopes of CO_2 from fumarole gases confirm the magmatic contribution for the Tacana volcano-hydrothermal system (-3.56 per mil vs PDB), as well as the total dissolved carbon with $\delta^{13}C$ values between -1.40 and -3 per mil vs PDB. The bicarbonate and sulphate concentrations in the thermal spring waters correspond with those measured in the Agua Caliente spring up to December 1993, more than seven years after the phreatic explosion, which might suggest there weren't any drastic changes in the volcanic activity for the last ten years. These first data on isotopes and complete chemistry of thermal springs -many of them sampled for the first time- give a general characterization of the fluids, while next series of data might give a description of the changes in the Tacana volcano-hydrothermal system and related volcanic activity.

V51H-0378 0830h POSTER

Geochemical and Paleomagnetic Implications of Iron-Sulfide Formation in Clayey Sediments from the Upper Pliocene Valle Ricca Section, Italy

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Clayey upper Pliocene sediments from the Valle Ricca section (Rome, Italy) exhibit intriguing intergrowth features among pyrite, pyrrhotite, and greigite, which have implications for variations in sediment diagenesis and paleomagnetism. SEM data indicate that pyrite occurs as octahedral crystals (sub- to several microns in size) that form framboids or irregular aggregates locally surrounding greigite and other pyrite framboids. Individual euhedral crystals and framboids or aggregates of pyrite are present in the matrix, occasionally enclosed within foraminiferal skeletons. Greigite typically occurs as grains less than 0.5 micron in size. The greigite forms framboids several microns in size or small irregular aggregates that occupy space between pyrite crystals or as framboids within pyrite aggregates, or as dispersed grains or aggregates intermixed with randomly-oriented subhedral pyrrhotite crystals forming nodules several mm in size. Pyrrhotite occurs with 3 types of microstructure: (1) banded aggregates up to several hundred microns thick, consisting of sub-parallel to parallel platy crystals of hexagonal shape up to 30 microns wide and 5 microns thick, associated with and locally enclosing pyrite and greigite framboids; (2) aggregates of randomly-oriented platy crystals forming massive pyrrhotite-greigite nodules, with pyrrhotite enriched in border areas, and (3) small clusters of platy crystals, up to several tens of microns in size occurring in matrix or within phyllosilicate {001} cleavages. The complex growth features of iron-sulfide minerals collectively suggest authigenic neoformation following the sequence of pyrite, greigite, and pyrrhotite, implying a change from early moderate Eh and high total dissolved S to highly reducing and relatively low dissolved S environments during diagenesis. The petrographic evidence for post-depositional formation of greigite is supportive of previously identified low-temperature normal polarity that is opposite to that recorded by detrital magnetite.

V51H-0379 0830h POSTER

Noble Gas Tracing of Subsurface CO2 Origin and the Role of Groundwater as a CO2 Sink

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The source, generation, migration and accumulation of CO2 gas associated either alone or with hydrocarbons are unclear and therefore hard to predict. So far, noble gases provide one of the best tools to resolve this question, because they are conservative within the subsurface system. The atmosphere-derived noble gases dissolved in groundwater do not react with the rock system, while noble gases produced in the rock phase by radioactive decay or input from magmatic source are isotopically distinct and can be resolved from the dissolved air-derived noble gases. 10 samples were taken from a CO2-rich natural gas reservoir in Jackson Dome, Mississippi, USA to investigate its origin and extent of interaction with the groundwater system. The area lies within the Mississippi Interior Salt Basin. It is bounded on the north by the Pickens-Gilbertown fault system, the updip limit of the Jurassic Louann Salt unit, and on the south by basement highs of the Wiggins, South Mississippi, and Lasalle uplifts. We present compositional, stable isotope and noble gas results of Jackson Dome samples. Gas composition is 98.75-99.38% CO2, with small amounts of methane and nitrogen. CO2 content increases linearly with the decrease of CH4. d13C(CO2) in all samples ranges between -3.55 and -2.57 per mil, increasing with the increase of the CO2 content. Atmosphere-derived He contributions are negligible in all cases. 3He/4He ratios are between 4.27 and 5.01Ra, indicating a strong mantle signature. Crustal 4He in these samples therefore accounts for between 7.0% and 20.8%, the remainder being magmatic in origin. 40Ar/36Ar ratios are all above air ratio, ranging between 4071 and 6420. Air corrected 40Ar* vary between 92.7 and 95.4%, to give 4He/40Ar* ratios of between 1.26 and 2.52. This range is comparable with values estimated for the upper mantle. CO2/3He values are between 1.09E+9 and 4.62E+9, and also fall in the mantle range, indicating that the CO2 gas in Jackson Dome is also predominantly mantle in origin. 20Ne is dominantly sourced from the groundwater. A strong anti-correlation between 20Ne and CO2/3He, is indicative that groundwater plays the principle control in changing the CO2/3He ratio. Because 3He is conservative, this is probably by CO2 loss into the water phase and seems to account for the 75% reduction from initial CO2/3He

V51H-0380 0830h POSTER

Reactivity and Speciation of Heavy Metals With Nanoparticulate Goethite

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Of the many nanoscale mineral phases present in the environment, iron (oxy)hydroxides are among the most common and most reactive in terms of metal contaminant uptake. However, the effects of particle size on metal sorption to phases such as goethite (α-FeOOH), particularly in the nanoscale range, have not yet been well characterized. To study the effects of particle size on metal uptake, a series of goethite batches was synthesized using a microwave synthesis technique followed by aging in suspension at 90°C. This method resulted in batches of goethite with discrete particle sizes ranging from 10-80 nm in effective diameter. Each batch was characterized by BET surface area analysis, laser light scattering, transmission electron microscopy (TEM), X-ray diffraction (XRD), and small angle X-ray scattering (SAXS). Goethite nanoparticle growth by this procedure occurs in two distinct stages: 1) rapid growth from 10-60 nm over the first 4 days followed by 2) slower growth from 60-80 nm over the next 28 days. This may represent a progression from aggregation-based growth to ripening-based growth, as suggested by TEM analysis. Goethite batches of 10, 25, and 75 nm in effective diameter were selected for use in batch uptake experiments featuring As(V), Cu(II), Hg(II), and Zn(II), metal(loid) contaminants frequently associated with acid mine drainage systems. Sorption products were analyzed with X-ray absorption fine structure (XAFS) spectroscopy to investigate potential changes in the mode of metal uptake as a function of particle size. While the speciation of the contaminants on the 10- and 25-nm goethites were effectively identical, subtle differences in both second-neighbor distances and coordination numbers indicate changes in the mode of uptake on the 75-nm sized particles (as well as on "bulk" 200-nm sized particles generated using a more traditional synthesis method). Such differences may be due to changing proportions of binding sites (e.g. edges, corners) and particle morphology evolution from oblong (10-nm particles) to more tabular/acicular (75-nm particles) as particle size increases.

V51H-0381 0830h POSTER

Remagnetization and Clay diagenesis in Jurassic Sediments of Skye, Scotland

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The thrust of this study is to test the hypothesized connection between magnetite authigenesis and diagenetic reactions forming illite, an idea based on the results of paleomagnetic, rock magnetic, geochemical, and petrographic/SEM studies on Jurassic sedimentary rocks of Skye, Scotland. The Jurassic rocks in southern Skye contain a dual polarity magnetization residing in magnetite that is interpreted as a chemical remanent magnetization (CRM) and has directions similar to those of early Tertiary igneous rocks on Skye. The presence-absence test and the timing of acquisition for this CRM suggest that magnetite authigenesis is related to the smectite-to-illite conversion, and that clay diagenesis is a viable remagnetization mechanism. The clay fractions consist of illite-smectite (I-S), kaolinite, and trace amounts of chlorite. The I-S exhibits Kalkberg order (IISI) and typically contains $\sim$ 85% to 90% illite layers based on the positions of the 001 reflection. The $2M_1$, 1M and $1M_d$ illite polytypes are present in variable proportions depending on size fraction. The K-Ar dates of I-S in the finest fraction range from 100 to 131 Ma while the K-Ar dates of I-S of the coarse fractions range from 160-210 Ma. In all cases, the dates of the finest I-S are much greater than the Tertiary CRM ages recorded in these rocks (65 Ma). The K-Ar dates decrease with decrease in particle size. At first approximation, the decrease is thought to reflect smaller amounts of detrital illite in the finer fractions. The youngest K-Ar dates of I-S are significantly greater than the CRM age recorded in these sediments. The most likely explanation of the discordance between K-Ar dates and CRM is that the finest fractions contain small amounts of detrital illite.

V51H-0382 0830h POSTER

Copper Solubility and Speciation in Mineral-Buffered Fluids at Crust to Upper Mantle Conditions

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Fluid inclusions, synthesised in a piston-cylinder apparatus, were used to trap representative high *P-T* fluid samples under mineral-buffered conditions in the systems Cu_2O-MgO-SiO_2-HCl-H_2O and Cu-K_2O-Al_2O_3-SiO_2-Fe_3O_4-Fe_2O_3-HCl-H_2O at up to 850°C and 1.7 GPa, and as a function of salinity to 11 mol/kg Cl. Copper solubility and speciation were obtained by analysing individual fluid inclusions by excimer laser ablation inductively coupled mass spectrometry (LA-ICP-MS), proton induced X-ray emission (PIXE) and Cu K-edge X-ray absorption near edge structure (XANES) spectroscopy. Quenched capsule fluids were also analysed. At 710°C copper-cuprite-talc-quartz solubility in aqueous fluid containing 1 mol/kg Cl increases with *P* to at least 1.7 GPa. Conspicuously, with increasing *P* ($> \sim$ 0.5 GPa) talc solubility increases and molal Cu concentrations exceed those of Cl. Isothermal Cu solubility appears to mimic the solubility isopleths in the SiO_2-H_2O system. Solubility trends suggest that the stability field of copper(I) hydroxide complexes (e.g. $Cu(OH)_{aq}$) expands to higher salinities such that H_2O may become an effective ligand at high-*P*. At constant *P* (e.g. 0.35 GPa) solubility decreases with increasing *T* (i.e. $>$ 525°C). High-T Cu K-edge XANES spectra of single homogenised synthetic fluid inclusions indicate that highly coordinated chlorocopper(I) complexes (e.g. Cu:Cl, 1:3 to 4) predominate at high salinity, whereas lower-order linear Cu-Cl coordination predominates at lower salinities, in fluids buffered by quartz-talc-copper-cuprite. This is consistent with the interpretation of the solubility data. At equivalent salinity, *T* and *P* conditions, spectra for fluids buffered by native copper-orthoclase-sillimanite-quartz-magnetite-hematite show no evidence for higher-order chlorocopper(I) complexes. Preliminary extended X-ray absorption fine structure data for these latter inclusions indicate that $[CuCl_2]^-$ predominates. The stability of higher-order complexes is strongly coupled to HCl concentrations, which at constant *P* and *T* is determined by both the specific mineral assemblage and total salinity. This is the first spectroscopic evidence for highly coordinated chlorocopper(I) complexes in supercritical fluids. Furthermore, the speciation dependence on the buffering mineral assemblage has not been recognized previously. Similarly, this is the first experimental confirmation that copper concentrations in mineral-buffered fluids can be extremely high, e.g. $\sim$ 10 wt%, substantiating inferences based on natural fluid inclusions associated with porphyry copper ore deposits.

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Formation of Quartz-Carbonate Veins: Evidence From Experimental Supercritical Carbon Dioxide-Brine-Rock System

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Quartz-carbonate veins are common in a variety of moderate temperature hydrothermal systems and ore deposits. Associated fluid inclusions have a wide range

of compositions, including liquid carbon dioxide fillings. Examination of chemical and physical conditions which result precipitation of quartz and carbonate in veins raises several key questions about multiphase fluid processes and reaction rates. We have been experimentally investigating physical-chemical reaction processes of mixed brine-carbon dioxide fluids for the shallow crust. Synthetic arkose (microcline + oligoclase + quartz + biotite) plus argillaceous shale were reacted with 5.5 molal NaCl brine. The system was held at 200 C and 200 bars for 32 days to approach steady state, then injected with carbon dioxide and allowed to react for an additional 45 days. In a parallel experiment, the system was allowed to react for 77 days without injection of carbon dioxide. Trace ions initially absent from NaCl brine appeared in solution at mM (K, Ca, and silica) to uM (Mg, Al, Fe and Mn) quantities, reflecting reaction of brine with rock. Without carbon dioxide injection, the silica concentration (2.4 mM) was stable below calculated quartz solubility (3.9 mM). Injection of carbon dioxide resulted in decreased pH and increased silica concentration to a level near calculated chalcedony solubility (5.4 mM). Dissolution of silicate minerals is apparently coupled to the acidity, and concomitant inhibition of the precipitation of quartz (and other silicates). A significant increase in concentration of trace metals is consistent with in-situ pH decrease and increased carbon dioxide dissolved in brine. Multiphase fluid reaction relationships between supercritical carbon dioxide and brine-rock systems allow formation of carbonate vein precipitates in substantial quantities. Brine and continued rock reactions provide a substantial reservoir for Ca, Mg and Fe components. A separate carbon dioxide liquid allows precipitation from relatively small volumes of total fluid, with coupled increases in pH and mineral stability. The doubling of silica concentration in the experimental system containing acidic brine and supercritical carbon dioxide indicates that precipitation of silica can occur in parallel to carbonate minerals when pH increases. Emplacement of silica super-saturated brine into a rock-dominated reaction system buffered to more neutral pH conditions may enhance precipitation of quartz, chalcedony, or amorphous silica as veins or cements, depending on the permeability structure of the host rock. Phase separation or loss of carbon dioxide with decreasing pressure can substantially shift pH upwards, with potential for creating massive vein or scale formation.

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Simultaneous Thermal Analysis Techniques for Determining the Energetics of Water in Mineral Hydrates

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Hydrate minerals (those containing molecular water; e.g., expandable clays, zeolites, hydrated salts) are important phases in surficial and near-surface Earth systems. These phases can undergo reversible dehydration and dehydration as temperature, pressure, and water fugacity vary, which can have a profound effect on the rheological, hydrological, thermal, and geochemical behavior of the crust. In addition, prediction of the water content of hydrate minerals is essential for assessing their stability. While thermodynamic models necessary for predicting hydration state are well established, experimental data based on equilibrium observations and calorimetry are often insufficient and too inconsistent for accurate depiction of hydration state. This uncertainty largely arises from inadequate knowledge of the heat capacities of these minerals as a function of temperature and hydration state and imprecise knowledge of the actual hydration states of samples during experiments. Simultaneous thermal analysis (STA) combining differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) can overcome many of these difficulties by allowing direct observation of hydration state during calorimetric experiments, thereby eliminating ambiguities in sample composition. Samples can be prepared in virtually any relevant hydration state within an STA apparatus, and subsequently used in calorimetric experiments. Although the precision of heat capacity measurements by DSC is lower than other common methods, direct monitoring of hydration state during experiments permits evaluation and elimination of excess heat of dehydration effects. Isothermal gas immersion measurements of the heat of hydration by DSC can also be directly monitored to assess the initial and final states of the sample, and permit partial molar heats of hydration to be determined over a wide range of hydration state from one experiment. Coupled application of heat capacity and immersion heat measurements by this method are demonstrated on the rock-forming zeolite natrolite. Comparison of the results of the present study with previous calorimetric and equilibrium observations of natrolite dehydration illustrate the critical importance of reliable heat capacity measurements and the experimental efficiency of present technique.

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The Influence of $ZnBr_2$ and $ZnCl_2$ Liquid in Rock-Eval Pyrolysis of Separated Macerals

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This study examined the influence of density liquid in Rock-Eval pyrolysis results of separated macerals. Zinc bromide and zinc chloride were chosen as density liquids for separating macerals. The samples are mid-Miocene high volatile bituminous coals which are from lower member of Shitih Formation in Taiwan. Samples were all crushed to pass #20 sieve and soaked in five different densities (from 1.0 to 1.5 g/cm3) of both zinc bromide and zinc chloride density liquids. After soaking for 2 hrs, the samples were divided into two parts. One was dried directly, and another part was dried after thorough washing by distilled water, until the specific gravity of filtrate water is come to 1.000. It revealed that pyrolytic parameters could be resumed back to their original values after washing. Rock-Eval pyrolysis was performed for all samples afterwards, with heating rate 25°C/min from 250 to 550°C. We found that T_{max} decrease with specific gravity of soaking density liquid in soaked samples. As the trend of T_{max}, S_2 has similar effect in soaked samples. It might has two reasons: 1) the density liquids made the pyrolytic reaction speed up faster. Hydrocarbons can be cracked early, and the peak of S_2 advanced earlier in time. Thus when the peak showed early, the temperature of the peak was lower. 2) Zinc bromide and zinc chloride both melted at temperature over 400°C. The liquid wrapped up the coal particles like walls and the hydrocarbon can not been completely cracked out. When S_2 decrease, the peak of S_2 appears early, and T_{max} becomes lower, too. In Rock-Eval pyrolysis, zinc bromide and zinc chloride will melt before peak S_2 sine their melt points were lower than 400°C. The melting materials will wrap up samples and hinder hydrocarbon to crack. It has to be noticed that T_{max} and S_2 may reduce with liquid gravity in using both two materials as density liquid. The effect of these density liquids can be removed by wash, although washing may still result in the decrease of S_1. Chemical compounds with low melting point were expected to wrap the coal particles and causing T_{max} to be advanced, and S_2 to be decreased. This influence is more conspicuous when higher density liquid is prepared for maceral separation.

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Rare Earth Element Geochemistry of Atacama Desert Soils

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The Atacama Desert of northern Chile is one of driest deserts in the world, with a hyper-arid climate that arguably has persisted since the Miocene. Soils in the driest parts of the Atacama record the effects of long-term hyperaridity, retaining atmospherically-derived elements in quantities rarely seen on Earth. Recent work has demonstrated that the hyper-arid environment allows Atacama soils to accumulate large amounts of sulfate (e.g., anhydrite, gypsum), nitrate ($NaNO_3$), and chloride (halite) that result in radical volumetric expansion of the soil. Possible salt sources include eolian redistribution from Atacama playas and/or marine aerosols. The objective of this work is to examine the rare earth element (REE) geochemistry of Atacama soils in order to understand how these trace elements chemically behave as soil water decreases to nearly zero. Two soils developed on fluvial landforms were examined along a south to north transect (Copiapo to Yungay) that coincides with decreasing moisture levels ($\sim$15mm to $\sim$2 mm yr^{-1}, south to north). Both soils have likely been undergoing soil formation since the Plio-Pleistocene. REE mass balance determinations were conducted on both soils through a comparison to that of the granitic alluvium from which they formed. An apparent net loss of REE relative to the granitic alluvium (10 to 30% Yungay; 15 to 65% Copiapo) has been calculated for these soils. The apparent loss of REE in both soils suggests that REE have been removed by some process or they have been have been diluted by dust and aerosols that have lower REE levels. Atmospheric deposition of marine and non-marine salts is the likely cause for the net loss of REE in the most arid soil, while weathering and leaching losses are a likely cause in the more humid endmember. Salts of marine origin are known to have low REE levels. Chondrite-normalized REE diagrams of the soils and parent materials are examined to determine if variations in local parent materials are evident. Europium anomalies, La/Yb, Gb/Yb, and Sm/Nd ratios are also presented to assess variations between soil horizons and parent materials.

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Oxidative promoted dissolution of chromite by manganese dioxide and concurrent production of chromate

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Chromium release and oxidation from chromite is a potential environmental hazard in sediments and soils and a pathway for soil development (weathering of primary minerals) related to ultramafic rocks and their metamorphic derivatives (serpentinites). Birnessite is a common pedologic mineral in these sediments and soils capable of oxidizing aqueous Cr(III). In this study, the interaction between chromite and birnessite is investigated, with an interest in the potential generation of Cr(VI). Specifically, the effects of chromite suspension density, birnessite suspension density, and pH at a temperature of 25 C in relation to the reaction kinetics were examined. The rate of Cr(VI) in solution increases with increasing chromite suspension densities and decreasing pH, but is independent of birnessite suspension densities at values greater than 20 m^2 L^{-1}. The overall rate expression of Cr released and oxidized in solution from chromite can be expressed as $d[Cr(VI)]/dt = k' \text{ Chromite}^{0.69}$ where k' is 0.0016 pH^2 – 0.025pH + 0.097 uM L m^2 L^{-1}, Chromite is the chromite suspension density in m^2 L^{-1}, birnessite suspension densities are greater than 20 m^2 L^{-1} and pH values are between 3 to 8. Experiments involving serpentine soils containing chromite and birnessite produce Cr(VI) rates consistent with those predicted by the overall rate expression with Cr(VI) rates ranging from 9E-4 to 4.4E-3 uM h^{-1}. Additionally, these experiments demonstrate that serpentine soils are a source of non-anthropogenic Cr(VI).

V51H-0388 0830h POSTER

Framboidal Vaterite and its Transformation to Calcite

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Vaterite, the most soluble of the three anhydrous calcium carbonate polymorphs, is observed to form in laboratory experiments performed at high degrees of supersaturation. Under standard condition it rapidly transforms into calcite and (or) aragonite. Experimental studies on vaterite are generally based on bubbling carbon dioxide through a calcium carbonate solution. The morphology of the crystals formed is often described to be “of some spherical shape”, with a typical diameter of about 5m. A detailed investigation of the morphology by means of a high resolution scanning electron microscope (SFEG-SEM) revealed that these spheres in turn are build up of smaller spherical particles with diameters typically 100 nm. Here we propose the following mechanism for the formation of these “framboidal” structures. Nucleation of the first particles occurs on the carbon dioxide to solution interface of the bubble. The fast growth of the individual crystals leads to a depletion in solution around the crystal, which stops crystal growth at a size of about 100 nm. The collapsing gas bubble concentrates the particles within its former volume. Additional evidence for such a mechanism comes from the observation that terminating the experiment after formation of the first particles does not result in any “framboidal” aggregates. Using CO2 bubbling sometimes results in a vaterite powder containing additional calcite. A pure vaterite powder and a powder containing calcite were compared to show different transformation pathways. The morphology of the solids is identical, i.e. the calcite present is not

visible under the SFEG-SEM. Calcite formation is observed immediately after a pure vaterite is added to water. Synchronous nucleation at many different sites was observed. The observation that crystal growth was not effected by changes in stirring speed confirms that diffusion did not limit crystal growth. On the hand the powder initially already containing calcite transforms by growth of a few bigger sized crystals. The impact of differences in stirring speed on the transformation rate can be explained by diffusion limited growth of a restricted number of bigger crystals, i.e. less nucleation sites available. Due to Oswald Ripening smaller crystals will eventually disappear and the final morphology of both solids will look similar. However, the different kinetics be explained only by following the change in morphology during the complete transformation process. All evidence of different transformation pathways gets lost as the morphology of the solids before and after transformation is nearly identical.

V51H-0389 0830h POSTER

Source Signature of Sr Isotopes in Fluids Emitting From Mud volcanoes in Taiwan

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Located at the boundary between the Philippine Sea Plate and the Asia Continental Plate, abundance of mud volcanoes were erupted on land in Taiwan. According to their occurrences and associated tectonic settings, these mud volcanoes were classified into four groupies. The group (I) mud volcanoes are located in the western coastal plane, whereas group (II) and (III) are situated near the Kutinkung anticline axis and the Chishan fault respectively. The group (IV) mud volcanoes are discovered at the Coastal Range. Although there are numerous studies focused on morphology, possible fluid migration paths and sources are poorly understood. We have collected and analyzed major ions and Sr isotopic ratios in fluids separated from various mud volcanoes in Taiwan. Chemical contents of these fluids were measured by IC and the emitted gasses were analyzed by GC. The Sr concentrations in these fluids were determined using AA and the isotopic compositions were analyzed by TIMS. The dominated ions in fluids are Na and Cl which account for 98% of dissolved materials. All fluids show similar Na/Cl ratios(0.7-0.8), slightly higher than seawater but each group has unique Sr isotopic signature. Waters expelled from group I mud volcanoes featured with low salinity and high Sr isotopic ratios ranged from 0.71150 to 0.71175. Groups II and III were outcroped in the Kutinkung formation but show distinctive chemical compositions. Group II fluids have four times Cl concentrations(358-522mM) compared with those of group III(85-162mM). The latter fluids appear to be more radiogenic(0.71012- 0.71075) indicating possible influence due to water-rock interactions. Low $^{87}Sr/^{86}Sr$(0.70692-0.70939) is typical characteristic of mud volcano fluids in group IV where large Mg and K depletion were discovered, suggesting effects due to sediment diagenetic processes. The chemical compositions of mud volcano associated gasses show similar distribution pattern. The major gas constituents in mud volcano zones II and III are methane(>80%), air(1-10%) and carbon dioxide(1-5%). Gases collected from zone IV display significantly higher air content(5-20%) with low carbon dioxide(<0.2%). These results are useful for gaining a better understanding of mud volcano fluid sources.

V51I MCC: Level 1 Friday 0830h

Intrusions and Ore Deposits Posters

Presiding: **A E Boudreau,** Duke University**; J S Miller,** San Jose State University

V51I-0390 0830h POSTER

Vapor Separation and Migration in a Solidifying and Compacting Crystal Pile

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The effect of vapor separation and migration in a crystal pile undergoing simultaneous crystallization and compaction has been investigated using a modified version of the IRIDIUM program. This program incorporates a simplified version of the MELTS program of Ghiorso and others coupled with compaction-driven thermal and mass transfer based on the works of Mckenzie and Shirley. The program also allows for trace-element modeling. The program has been modified to allow the independent upward migration of a separate vapor phase. It also now incorporates a COHS gas phase and sulfide phases. The solidification of a crystal + liquid assemblage that is loosing heat out the bottom results in the eventual separation of a volatile-rich fluid or vapor. The vapor separated from cooler parts of the crystal pile migrates upward to hotter assemblages and redissolves in the interstitial liquid that has not reached vapor saturation. This influx of volatiles results in a remelting of the solids, producing a liquid-rich zone within the crystal pile. This liquid-rich zone migrates upward with time, and mimics a zone-refining metallurgical process. If the remelting zone approaches the top of the crystal pile, the effect is a relatively sharp transition from liquid-rich to liquid-poor assemblages. After the zone has passed any given horizon, major mineral compositions are relatively unaffected (e.g., there is no readily apparent change in mg# or mineral porportions). However, vapor-soluble elements are moved upward over time. In the case of sulfur, this can result in the upward migration of a sulfide-saturation zone with time. The remelting of pre-existing solids may lead to zones of instability within the crystal pile. Examples of slumping, shearing and layer disruption from the Stillwater Complex are shown that may have been caused by such a process.

V51I-0391 0830h POSTER

Tungsten Mineralization Associated With Granitoid Rocks in Southwest of Arak, Iran

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The NezamAbad-Malmir intrusion is located 45 km southwest of Shazand, Arak. It is trending southeast-northwest and is a part of the Sanandaj-Sirjan zone of the metamorphic belt of Iran. The intrusion is composed of some huge composite bodies with an area of 180-200 km^2. It is related to Alpine orogeny and intrudes metasediments of upper Triassic-Jurassic. The latter rocks consist of phyllites, micaschists, quartzites, metamorphosed cherty limestones and metamorphic acidic and basic tuffs. Two types of tungsten mineralization accompany the NezamAbad-Malmir intrusion: 1. Stratabound type, 2. Quartz-tourmaline vein type. Stratabound type is seen at Bamsar. In this area, six ore-bearing horizons have been identified. Country rocks are mainly calcareous schists in which ore minerals occur in laminas and layers. Ore paragenesis includes scheelite, chalcopyrite, arsenopyrite, sphalerite, pyrite, cassiterite, chalcocite and covellite. Vein type mineralization is hosted by tonalite-quartzdiorite intrusions at Revesht, NezamAbad and Fizaneh that are located 3, 7 & 8 km away from Bamsar. Ore paragenesis in these mineralized tourmaline and quartz veins consists of euhedral to anhedral scheelite and chalcopyrite. The NezamAbad-Malmir intrusion shows a range in composition from tonalite to alkali-granite. These plutons are texturally medium-grained granular but include some porphyritic textures. In thin section, the granophyre and myrmekite are observed. Pegmatite-aplite veins and dykes are fairly abundant. XRF analyses for 2 aplites (near tungsten mineralization) and a pegmatite sample show 3, 8 and 23 ppm tungsten, respectively. The tungsten content of the intrusion samples range from 15 to 45 ppm. The rock sample with the highest tungsten content (45 ppm), is a tonalite situated near the contact with metasediments. It is suggested that at Revesht, NezamAbad and Fizaneh, the NezamAbad-Malmir intrusion provided the tungsten deposited in quartz-tourmaline veins. The Bamsar occurrence is however, sedimentary-diagenetic in origin, subsequent concentration happening through Late Kimmerian regional metamorphism and deformation.

V51I-0392 0830h POSTER

Absence of Cryptic Zonation in Modally zoned Granitic Pegmatites: Petrogenetic Implications

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The Evje-Iveland and the Froland granitic pegmatite fields in South Norway share many similarities and are nearly indistinguishable in terms of their mineralogy, radiogenic isotope signature and accessory mineral assemblage. Both fields comprise REE-Nb-Ta type pegmatites with overlapping Mesoproterozoic ages close to 900 Ma and low 87Sr/86Sr ratios of only 0.7062-0.7064. However, a recent study of the REE distribution in K-feldspar (Larsen, 2002, The Canadian Mineralogist, 40, 137-151) unequivocally demonstrates that the parent melts forming the two pegmatite fields were derived from different source regions. The trace and major element distribution in feldspar follows well defined igneous trajectories during igneous evolution of the granitic melts from typical K/Rb ratios in perthite of 360 in the most primitive pegmatites to 100 at the most evolved localities. Altogether the pegmatites in both fields feature a well-defined igneous evolution from primitive to progressively more evolved compositions. The individual pegmatites are modally zoned from the margin towards the interior. The wall zone is dominated by plagioclase and perthite, accessory biotite and muscovite, and quartz. The intermediate zone (IZ) comprises metre size crystals of biotite, perthite, plagioclase, quartz and minor muscovite. The core-zone (CZ) features rafts of perthite and minor plagioclase in large masses of quartz. Given this well-defined modal zonation and the regional igneous evolution, it would be expected that the major minerals feature a cryptic zonation from relatively primitive compositions in wall zone to more evolved compositions in the core-zone. However, sampling and analysis of perthite from IZ to CZ from 20 pegmatites failed to confirm the presence of a cryptic zonation when comparing the major and minor element compositions. Key element ratios including the K/Rb, Sr/Rb, Eu/Rb and the LREE/HREE ratios that all are supposed to decrease from IZ to CZ mostly remained unchanged or were increasing. Similar to perthite, the trace element distribution in quartz change systematically from primitive to progressively more evolved pegmatites throughout the pegmatite fields. However, the analysis of trace elements in quartz from 120 localities also failed to document systematic changes in key trace element ratios (e.g. the Ti/Ge ratio) from the margin towards the interior of individual pegmatites. The absence of a cryptic zonation of major minerals from contact to core in the otherwise modally zoned granitic pegmatites is a challenge to normal petrogenetic models. Some possible models that will be discussed at the AGU 2003 Fall Meeting are: A) The modally distinctive zones of the granitic pegmatites solidify simultaneously in compositionally distinctive domains that may be maintained by double diffusive convection cells. B) Following a recent proposal by M. Taylor, the hydrous pegmatite melts transform into gels upon emplacement or during crystallization. Gels facilitate the evolution of large modally distinctive domains that crystallize simultaneously (Taylor M., 18th IMA Meet. 2002, Prog. Abstr. P. 260).

V51I-0393 0830h POSTER

Preliminary Experimental Results on Phase Relations in the PbS-$AgSbS_2$-$AgBiS_2$ Ternary

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The presence of significant solid-solution of silver sulfosalts in galena in the PbS (galena)-$AgSbS_2$(miargyrite)-$AgBiS_2$ (matildite) ternary system suggests that ore in many important silver deposits may have been formed by retrograde unmixing of higher-temperature silver-bearing galena solid solution. We present results of evacuated silica capsule experiments designed to constrain the extent of Ag solid solution in galena and other important phase relations in this system over a range of temperatures relevant to ore formation. Experimentally-based phase diagrams in the $AgSbS_2$-PbS, $AgSbS_2$-$AgBiS_2$, and $AgBiS_2$-PbS binaries indicate complete solid solution above 420°C. If these phase diagrams are correct and the topological features can be extended into the supersystem, they would imply that the galena structure (Fm-3m) extends across most or all of the ternary at high temperatures. Below 420°C, a miscibility gap is observed on the $AgSbS_2$-PbS binary, approximately midway between the freieslebenite ($PbAgSbS_3$) and galena compositions. New experimental data indicate that this miscibility gap on the $AgSbS_2$-PbS binary extends well into the ternary. This miscibility gap appears to close at $X_{PbS} > 0.60$ and $X_{AgBiS2} > 0.12$ at about 350°C, and $X_{PbS} > 0.65$ and X_{AgBiS2}

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