inclined slip planes (shear bands) that are kinematically associated with mode I fracture opening near the process zone. This creates space for continued liquid flow.

URL: http://www.ce.gatech.edu/~leonid/rockmechgroup/research.html

H51B-04 0845h

Seismic Monitoring of Mineral Precipitation in a Single Fracture

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Natural fractures and faults may be subjected to chemical dissolution and/or chemical precipitation of minerals that alter the fracture properties by changing the size and strength of the contact area and/or filling-in the void space. In this study, we used seismic measurements to monitor mineral deposition and its effect on hydraulic properties of single fractures. Hydraulic and seismic measurements were made prior to and after the deposition of $CaCO_3$ in initially water-saturated fractures in granitic samples (110 mm x 104 mm x 70 mm). The transmitted compressional waves were recorded in 1 mm increments within a 64 mm by 64 mm region of the sample to determine the spatial variation in fracture properties. Plane wave 1 MHz transducers were used to send and receive the signals. Four pairs of ports were distributed around the perimeter of the fracture to measure the variation in flow as a function of position. During mineral deposition, the flow rate at each port was monitored and the acoustic response was monitored at the center of the sample. Over a period of a month after mineral deposition, acoustic measurements were recorded over the two-dimensional region. Fluid flow measurements were repeated one month after chemical invasion. We observed that largest increases in seismic amplitudes after mineral precipitation occurred for fractures that were initially more compliant. The initial aperture of the fracture controls the amount and time-rate of mixing of the chemicals used to induce precipitation because mixing of the two chemical species is slower for smaller aperture fractures. The flow rate through the sample decreased by an order of magnitude and certain ports no longer supported flow, i.e., the flow paths to certain ports were blocked by mineral deposition. The most reliable seismic indicator that the fracture has been altered is the shift in the most probable frequency in the received signal. The most probable frequency shifted to higher frequency after chemical invasion indicating a stiffening of the contact regions of the fracture and possibly a reduction in fracture aperture through mineral deposition. The frequency shift may provide a seismic diagnostic method for remote assessment of alteration of a fracture by mineral deposition. Acknowledgments: The Authors acknowledge support of this research by the Geosciences Research Program, Office of Basic Energy Sciences, US Department of Energy. LJPN wishes to acknowledge Purdue University Faculty Scholar.

H51B-05 0900h

Dissolution of Limestone Fractures from Cooling Thermal Waters

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Most previous studies of dissolution growth in karst fractures have focused on meteoric systems. Calcite has a retrograde solubility with respect to temperature, therefore different behavior would be expected in hydrothermal systems. As deep geothermal waters rise through karst formations, they cool and maintain their dissolutional aggressiveness. We have developed several models to investigate the growth of calcite fractures in an effort to understand hypogene cave development. Our models include three-way coupling between flow, heat and mass transfer. We will present results of this work in one and two dimensional variable-aperture fractures and contrast meteoric and geothermal cases. Growth of meteoric systems is commonly measured in terms of the breakthrough time. As the overall fracture aperture and flow rate increase, calcite-unsaturated water occupies the entire fracture. The time when this first occurs is considered the breakthrough time. In meteoric systems breakthrough typically appears at the onset of turbulent flow. Results from our one dimensional simulations indicate breakthrough occurs earlier in hypogene systems than in meteoric systems. In hypogene systems a thermal gradient along the fracture length combined with retrograde solubility allows growth along the entire fracture. When the aperture increases over the length of the fracture, a rapid increase in flow rate occurs. As the flow rate increases there is a switch from conduction dominated heat transfer to convection dominated heat transfer which reduces calcite solubility in the fracture and slows growth.

H51B-06 0915h INVITED

Active Faulting and Regional Flow in the Corinth Rift

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The Corinth Rift, in western Greece, opens at the yearly rate of 1.5 cm/year with an uplift of its southern shore reaching locally 1 mm/year and elevations reaching 2500 m. The fault system on this southern shore involves a set of parallel fault segments with lengths reaching up to 40 to 50 km and offsets of the order of 1000 m. In the context of the European Corinth Rift Laboratory development, a 1000 m deep borehole has been drilled on the seashore, through the smaller Aegion fault, re-activated during a magnitude 6.2 earthquake, in 1995. The upper 490 m of the well intersects a series of quaternary conglomerates interbedded locally with horizons of calcilutite (calcite mud) which become predominant in the lower 250 m of this section. From 490 m to 690 m a strongly tectonized radiolarite series is encountered till the well penetrates a cretaceous series of fractured limestone, locally karstified. The 15 m thick fault zone, encountered between 750 m and 790 m, within the limestone, has been cored through its whole length and shows crystalline calcite grown in multidecimetric open cavities, within the fault breccia. A one-meter thick siliceous fault gouge made up from the radiolarite is intersected at 760 m. Laboratory permeability measurements yield 9 to 15 10^{-18} m^2 for the calcilutite and 0.9 to 2.0 10^{-18} m^2 , for the fault gouge. Production tests conducted during the drilling operation yield a hydraulic conductivity of 10^{-5} to 10^{-4} m/s for the upper conglomerates (200m depth) with no artesian flow. The limestone encountered just above the fault, below the radiolarite, is artesian with a 0.5 MPa overpressure and a flow rate equal to 0.7 m^3/h. Its hydraulic conductivity has been measured to be about 10^{-7} m/s. Below the fault, an artesian flow is produced through local karsts observed down to 960 m, with a total flow rate of about 50 m^3/h and a 1MPa overpressure, in no flow conditions. The downhole temperature is only 32° C, for an upper-hole temperature of 17°C. The fault is intersected some 250 m below the local sea-floor in the rift. Hence this active normal faults system acts as a strong hydraulic barrier, east-west oriented, while the mountainous terrain of the southern shore produces a natural hydrostatic load that induces downward flow down to depths, which remains to be ascertained. Geological observations, in the nearby Cyclades islands, some 300 km to the east, suggest meteoritic flow may reach the brittle-ductile transition.

URL: http://www.corinth-rift-lab.org

H51B-07 0930h

A Quantitative Assessment of the Influence of Structural Setting on Fault Hydraulic Property Distributions

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It is generally agreed that faults are an important control on groundwater flow, but relatively little work has been done to link structural setting with fault hydraulic properties at a level of detail appropriate for field-scale numerical modeling. The present study examines the influence of the structural setting on fault permeability by comparing spring temperature distributions from two geothermal areas in the Alvord Basin of southwest Oregon. Geothermal springs near the Borax Lake site occur along the trace of a normal fault, and appear to have developed a quasi-steady state spatial distribution. Geothermal vents in the Mickey Hot Springs area occur in a restricted zone between two fault splays; mean spring temperature at Mickey Hot Springs is significantly higher than at Borax Lake, and the center of spring activity shows evidence of migration with time. A geostatistical analysis of spring temperatures is used to quantify the differences in permeability distributions between the two sites, and illustrates the importance of including structural data in the development of realistic hydraulic property sets for numerical models of groundwater flow at fault-controlled sites.

URL: http://www.uidaho.edu/biogeochemistry

H51B-08 0945h

One Year of Massive Fluid Production Test in KTB Pilot Hole, Germany

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Germany's deep drilling program KTB in the years of the pre-surveys (1984 - 86), the active drilling phase (1987 - 94), and during operation of the deep crustal laboratory (1995 - 2000) has revealed a wealth of new geoscientific data. The full potential of the two KTB boreholes – the 4.0 km deep pilot hole (KTB-VB) and the 9.1 km deep main hole (KTB-HB), both in crystalline environment – has, however, not yet been exploited. A new series of in-situ experiments on the kilometer scale, addressing relevant open questions on hydrogeological, geochemical, rock mechanical, and other issues has started in 2002 under the new program 'ENERGY AND FLUID TRANSPORT IN CONTINENTAL FAULT SYSTEMS'. The activities are focused on large scale fluid production and injection tests in two major fault systems, at 4 km and 7.2 km depths. They are part of Germany's contribution to the International Continental Drilling Programme (ICDP). A massive fluid withdrawal test in the fault system at 4 km depth took place from June 2002 till June 2003. The average yield during the test was 50 l/min brine, with similar amount of gas, mainly N2; draw down was more than 600 m. In-situ permeability and fluid availability were found to be significantly larger than anticipated. We did not observe any significant changes in the concentrations of dissolved fluid constituents. Isotope ratios were constant throughout the production period. Rare earth element concentrations of the produced fluids were extremely low. A down-hole seismometer in the KTB-HB has detected a number of small seismic events near the active KTB-VB, presumably triggered by the hydraulic forcing. The second phase of this new series of KTB experiments is planned to start in April 2004 and will include a massive fluid injection test in the KTB-VB, lasting for again 12 months. Monitoring and analysis of induced microseismicity and the detectability of other geophysical observables will be key issues. International partners who are interested in the coming or future experiments are most welcome to participate.

URL: http://www.icdp-online.org/sites/ktb/index/index.html

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H51C MCC: Level 2 Friday 0830h

Water Quality of Hydrologic Systems Posters *(joint with B)*

Presiding: **M Gooseff,** Utah State University**; E W Boyer,** State University of New York

H51C-1044 0830h POSTER

When Good Tracers Go Bad: Tracer-dilution Sausage Recipes Revealed

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Theoretical development of the tracer-dilution technique for estimating streamflow is deceptively simple. Given a constant injection rate and concentration, streamflow is given by the simple ratio of injectate flux and observed tracer concentration. Practical application of the technique at the small-watershed scale is complicated by a number of factors, however, and streamflow estimates are often based on variations of the basic tracer-dilution formula. Case studies illustrate two non-ideal situations that can arise in the field: (1) the presence of losing reaches,and (2) failure to obtain a steady-state plateau. In the first case study, spatial tracer concentrations in the lower part of a study reach were nominally constant for more than 1500 meters. The spatially constant profile indicates that the 1500-meter subreach was either subject to a uniform flow field or a loss of flow. Conventional velocity-area discharge measurements coincident with the tracer experiment show a significant loss of flow within the subreach. Tracer-dilution estimates of streamflow were therefore adjusted to reflect the flow loss. An alternate form of the tracer-dilution equation was then used to estimate flows downstream of the losing subreach. In the second case study, the tracer concentrations did not reach a steady-state plateau during the injection period. Stream samples collected immediately before the end of the injection were used in conjunction with velocity-area discharge measurements to determine the flow field. Streamflow at approximately 1 kilometer downstream of the injection was first set equal to the velocity-area measurement. Using this streamflow estimate as a starting point, streamflow at the remaining downstream sites was estimated using an alternate form of the tracer-dilution equation and the site-to-site variations in tracer concentration. Streamflow estimates for sites upstream of 1 kilometer were obtained in a similar manner.

URL: http://co.water.usgs.gov/toxics

H51C-1045 0830h POSTER

Rapid In-Situ Measurement of Gamma Activity in Soil for Environmental Assessment

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In-situ measurements of gamma radiation in soil are used as a rapid, low-cost, non-intrusive alternative to conventional sampling and analysis methods in the preliminary assessment of environmental impacts to watersheds at the Savannah River Site (SRS). The method resolves the ambient gamma-radiation field near ground surface into background and residual components and provides radionuclide-specific soil activity determination. The efficacy of the method has been evaluated and compares favorably with conventional gamma-PHA soil analyses and aerial survey data. The method has garnered regulatory approval and is being successfully deployed to evaluate the impact of Cs-137 contamination from CERCLA sites.

H51C-1046 0830h POSTER

A Movable Combined Water Treatment Facility for Rainwater Harvesting

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Alarming water shortage and increased water scarcity world wide has led to increased interests in alternative water sources. Rainwater harvesting is one of them which is getting more and more attention. There is a huge potential for generalization and extension of rainwater harvesting system as an alternative water supply. This is especially important for arid and semi-arid regions where the water shortage blocks further social, economical development. Earlier laboratory experiments and field study showed that harvested rainwater requires treatments of different degrees in order to meet the WHO drinking water standards. The main focus of this study is to ascertain the quality of stored rainwater for drinking purposes with emphasis on water disinfection and pollutants removal. A movable, low-cost, fully functional small scale treatment facility is proposed and tested under simulated field condition. A number of actual and potential hazardous pollutants were identified in the collected water samples together with laboratory test. The corresponding water purification procedure and fresh-keeping methods are discussed. The final proposal of this movable facility needs to be further examined to achieve optimal combined treatment efficiency.

H51C-1047 0830h POSTER

Tracking River Recharge in the Central Valley of California Using Chemical and Isotopic Tracers

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Recharge to alluvial aquifers along the major rivers of the Central Valley of California is influenced by human activity in adjacent urban areas and groundwater basins. Intense pumping of Central Valley aquifers may induce recharge, while slurry walls, emplaced for flood control in densely populated areas, are intended to protect levees by preventing shallow recharge. These large rivers carry distinct chemical and isotopic signatures that allow recent recharge to be traced in adjacent wells. In particular, stable isotopes of oxygen delineate areas where river water, carrying a depleted isotopic signature from Sierra Nevada precipitation (-11 to -15 per mil), is recharging groundwater aquifers where local precipitation is significantly heavier (-7 per mil). Trace anthropogenic compounds present in river water, such as MtBE (from precipitation and recreational boating on watershed reservoirs), are also useful for identifying areas where river water has recently infiltrated. Analysis of groundwater age, using the tritium-helium method allows estimation of the time since recharge, and evaluation of the effect of human activity on the natural groundwater recharge and flow patterns. Results from a detailed study along the American River in Sacramento, where a slurry wall is in place, show areas of recent recharge, as evidenced by relatively high MtBE concentrations (matching river concentrations) and young groundwater ages in shallow wells. In other wells, older ages and very low MtBE concentrations delineate areas where active recharge is not taking place. These results are interpreted in the context of basin-wide analyses for the Sacramento urban area, where most groundwater sampled from municipal wells is devoid of tritium, and therefore recharged more than about 50 years ago. These data are collected for the Ambient Groundwater Monitoring and Assessment (GAMA) program, sponsored by the CA State Water Resources Control Board. Oxygen isotopes indicate that American River water has recharged a large portion of this basin, with wells showing decreasing fractions of isotopically depleted water moving away from the river to the north. A similar pattern is observed in other areas of intense pumping in groundwater basins along the major rivers in the Central Valley. This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.

H51C-1048 0830h POSTER

Rare Earth Element Concentrations and Fractionation Patterns Along Groundwater Flow Paths in Two Different Aquifer Types (i.e., Sand vs. Carbonate)

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Groundwater samples were collected in two different types of aquifer (i.e., Carrizo Sand Aquifer, Texas and Upper Floridan carbonate Aquifer, west-central Florida) to study the concentrations, fractionation, and speciation of rare earth elements (REE) along groundwater flow paths in each aquifer. Major solutes and dissolved organic carbon (DOC) were also measured in these groundwaters. The Carrizo Sand aquifer was sampled in October 2002 and June 2003, whereas, to date, we have only sampled the Floridan once (i.e., June 2003). The data reveal no significant seasonal differences in major solute and REE concentrations for the Carrizo. In Carrizo sand aquifer, groundwaters from relatively shallow wells (i.e., less than 167 m) in the recharge zone are chiefly Ca-Na-HCO3-Cl type waters. With flow down-gradient the groundwaters shift composition to the Na-HCO3 waters. pH and alkalinity initially decrease with flow away from the recharge zone before increasing again down-gradient. DOC is generally low (0.65 mg/L) along the flow path. REE concentrations are highest in groundwaters from the recharge zone (Nd 40.5 pmol/kg), and decrease substantially with flow down-gradient reaching relatively low and stable values (Nd 4.1-8.6 pmol/kg) roughly 10 km from the recharge zone. Generally, Carrizo groundwaters exhibit HREE-enriched shale-normalized patterns. The HREE enrichments are especially strong for waters from the recharge zone [(Yb/Nd)SN =1.7-5.6], whereas down-gradient (deep) groundwaters have flatter patterns [(Yb/Nd)SN =0.7-2.5]. All groundwaters have slightly positive Eu anomalies (Eu/Eu* 0.09-0.14) and negative Ce anomalies (Ce/Ce* -0.85 - -0.07). In the Upper Floridan Aquifer, Ca, Mg, SO4, and Cl concentrations generally increase along groundwater flow path, whereas pH and alkalinity generally decrease. DOC is higher (0.64 - 2.29 mg/L) than in the Carrizo and initially increases along the flow path and then decreases down-gradient. LREE (Nd) concentrations generally increase along groundwater flow path, however, MREE (Gd) exhibit little change and HREE (Yb) concentrations tend to decreases along the flow path. Floridan groundwaters have HREE enriched shale-normalized patterns, although (Yb/Nd)SN values decrease along groundwater flow path. Thus, REE patterns of Floridan groundwaters tend to flatten with flow down-gradient. All groundwaters show positive Eu anomalies (0.06 - 0.17) and negative Ce anomalies (-0.12 - -0.63).

H51C-1049 0830h POSTER

Elevated Uranium in Aquifers of the Jacobsville Sandstone

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The EPA has announced a new standard for uranium in drinking water of 30 parts per billion (ppb). This maximum contaminant level (MCL) takes effect for community water supplies December 2003. The EPA's ruling has heightened awareness among residential well owners that uranium in drinking water may increase the risk of kidney disease and cancer and has created a need for a quantified, scientific understanding of the occurrence and distribution of uranium isotopes in aquifers. The authors are investigating the occurrence of elevated uranium in northern Michigan aquifers of the Middle Proterozoic Jacobsville sandstone, a red to mottled sequence of sandstones, conglomerates, siltstones and shales deposited as basin fill in the 1.1 Ga Midcontinent rift. Approximately 25% of 300 well water samples tested for isotopic uranium have concentrations above the MCL. Elevated uranium occurrences are distributed throughout the Jacobsville sandstone aquifers stretching across Michigan's Upper Peninsula. However, there is significant variation in well water uranium concentrations (from 0.01 to 190 ppb) and neighboring wells do not necessarily have similar concentrations. The authors are investigating hydrogeologic controls on ground water uranium concentrations in the Jacobsville sandstone, e.g. variations in lithology, mineralogy, groundwater residence time and geochemistry. Approximately 2000' of Jacobsville core from the Amoco St. Amour well was examined in conjunction with the spectral gamma ray log run in the borehole. Spikes in equivalent uranium (eU) concentration from the log are frequently associated with clay and heavy mineral layers in the sandstone core. The lithology and mineralogy of these layers will be determined by analysis of thin sections and x-ray diffraction. A portable spectrometer, model GRS-2000/BL, will be used on the sandstone cliffs along Lake Superior to characterize depositional and lithologic facies of the Jacobsville sandstone in terms of concentrations and ratios of eU, eTh and K. Equipped with borehole accessories, the spectrometer will be used to log residential drinking wells to determine a relationship between the uranium concentration of well water and the eU concentration in the sandstone. Tritium/helium-3 dating will be used to determine whether ground water uranium concentrations increase with residence time. PHREEQCI will be used to model dominate aqueous species of uranium and saturation indices of uranium minerals.

H51C-1050 0830h POSTER

Uranium Transport in Subsurface Materials: An Experimental Analysis of the Effects of pH and Inorganic Carbonate Concentration

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Uranium is a long-lived radionuclide, and has been found in high concentrations in various groundwater

systems leading to human health concerns. Uranium in the (VI) valence state forms many mobile hydroxide and carbonate complexes. Immobilization of uranium by reduction to U(IV), either by direct biological enzymatic processes or by the production of a reducing "biobarrier", has been proposed as one possible mechanism for remediating uranium contamination. In this preliminary work, we have examined U(VI) transport and sorption in natural sediments (on iron oxide mineral phases) under various inorganic carbon and pH conditions. To determine the dependence of U(VI) transport on these variables, a series of six experiments were conducted in a closed one-dimensional column system utilizing three pH (high, neutral, and low) and two carbonate concentrations (high and low). Pulses of U(VI) were introduced into the column at a fixed pore velocitiy, and samples were collected using an auto sampler to develop breakthrough curves. Effective transport and kinetic sorption parameters were determined by inverse fitting the data using the code CXTFIT. Speciation of uranium for each experiment was determined utilizing the code MINEQL+. The dependence of U(VI) adsorption on pH and carbonate concentration have been quantified under conditions of flow and transport, and it appears that at groundwater-relevant pore water velocities, an equilibrium model may not accurately describe the sorption process.

H51C-1051 0830h POSTER

A Mathematical Formulation for the Effects of Nonlinear Chemical Reactions upon Taylor Dispersive Phenomena

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In 1953, G.I. Taylor published his landmark paper concerning the transport of a contaminant dissolved in a fluid flowing through a pipe of narrow diameter. He demonstrated that an interaction between the transverse variations in the fluid's velocity field and the transverse diffusion of the solute yielded an effective downstream mixing mechanism for the transverse average of the solute. This mechanism has since been dubbed "Taylor Dispersion." Since his original publication, many related studies have surfaced. These include generalizations of channel geometry, generalizations of the velocity field (including turbulent field), applications to sedimentation problems, etc. However, much less attention has been given to the effects of nonlinear chemical reactions upon a *system* of solutes undergoing Taylor Dispersion. We present a rigorous mathematical model for the evolution of the transverse averages of reacting solutes that travel within a fluid flowing down a pipe of arbitrary cross-section. The technique for deriving this model is a generalization of a multiple scales perturbation approach described by P.C. Fife for linear (reactionless) problems. The key outcome is that while one still finds an effective mechanism for downstream mixing, but also there is also a effective mechanism for nonlinear advection.

H51C-1052 0830h POSTER

The Association of Cryptosporidium parvum With Suspended Sediments: Implications for Transport in Surface Waters

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Understanding the transport and fate of microorganisms in surface waters is of vital concern in protecting the integrity and safety of municipal water supply systems. The human pathogen Cryptosporidium parvum is a particular public health interest, as it is ubiquitous in the surface waters of the United States, it can persist for long periods in the environment, and it is difficult to disinfect in water treatment plants. Due to its small size (5 um), low specific gravity (1.05 g/cm3), and negative surface charge, C. parvum oocysts are generally considered to move through watersheds from their source to drinking water reservoirs with little attenuation. However, the transport of the oocysts in surface waters may be mediated by interactions with suspended sediments. Batch experiments were conducted to determine the extent of C. parvum oocyst attachment to several inorganic and organic sediments under varying water chemical conditions, and settling column experiments were performed to demonstrate how these associations influence the effective settling velocity of C. parvum oocysts. Results from these experiments showed that C. parvum oocysts do associate with inorganic and organic sediments and often settle at the rate of the suspended sediment. The size and surface charge of the host suspended sediment influenced the extent of oocyst attachment as oocysts preferentially associated with particles greater than 3 um, and fewer oocysts associated with particles having a highly negative surface charge. Background water chemical conditions including ionic strength, ion composition, and pH did not have a significant effect on oocyst attachment to suspended sediments.

H51C-1053 0830h POSTER

The Effect of Citric Acid on the Oxidation of Organic Contaminants by Fenton's Reagent

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Combined with acids and iron catalysts, hydrogen peroxide (H_2O_2) as Fenton's reagent is proven to be effective in oxidizing halogenated volatile organic compounds (VOCs). The Fenton's reagent, traditionally used for waste water treatment technique, has been applied to the remediation of contaminated soil systems and numerous investigators have found intrinsic iron salts are effective source of iron catalyst for the reaction. Citric acid, which is naturally occurring nutrients to microorganisms and less destructive to soil chemical properties, is selected for an acidifying agent to create acidic soil condition. However, citric acid has been considered as a reaction inhibitant because it sequesters ferric iron from Fenton's catalytic cycle by forming strong chelates with iron. This paper presents the feasibility of using citric acid as an acidifying agent of soil matrix for the Fenton-like oxidation.
Series of batch tests were performed to test disappearance of VOCs in various aqueous systems with two acidifying agents (citric acid or sulfuric acid) and three iron sources (iron sulfate, water soluble soil iron, or soil matrix). Batch results show that soluble iron is essential for near complete disappearance of VOCs and that citric acid performs similarly to sulfuric acid at low H_2O_2 dosage (< 1 wt%). The test soil provided water-soluble soil iron but also contained scavengers of the oxidizing agents, resulting in limited removals of VOCs. Column tests confirmed the results of the batch tests, suggesting citric acid is also as effective as sulfuric acid in providing acidic environment for the Fenton-like oxidation.
The batch experiments also reveal that higher doses of H_2O_2 lower the degree of VOC removals in citric acid systems. Potential explanations for this declining include that excessive presence of H_2O_2 expedites the oxidation of ferrous to ferric iron, which then forms a strong complex with citrate, leading to the sequestration of the iron from the Fenton's reaction cycle. Consequently, additional supply of ferrous iron would be required for continuing oxidation of VOCs, as well as slow injection of H_2O_2. Detailed mechanistic study would be needed for factual understanding.

H51C-1054 0830h POSTER

Long-Term Monitoring of Post-Aquifer Flushing With Cyclodextrin

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Cyclodextrins are benign sugar solutions that have been shown at numerous DoD sites to be effective in removing many different types of organic compounds from aquifers through flushing. Cyclodextrins enhance the solubility of many organic contaminants because the interior cavity of the toroidal shaped molecule has favorable conditions for inclusion of low-polarity compounds. They are also effective for aquifer flushing because the outside of the molecule is highly polar resulting in a high aqueous solubility. Their feasibility as a remedial alternative for many sites is dependent on whether unrecovered cyclodextrin mass left in the aquifer after active remediation leads to adverse results. The potential adverse results could include enhanced potential for spreading of hydrophobic contaminant and complications resulting from biodegradation of large quantities of cyclodextrin altering geochemical conditions. In the summer of 2002, a pilot test was performed at a military base in the Norfolk area of Virginia. Through funding by the Environmental Security Technology Certification Program within the DoD, hydroxyl-propyl-beta-cyclodextrin (HPCD) flushing was evaluated as a remedial technique for a chlorinated solvent contaminated aquifer. At the hazardous waste site there is a trichloroethylene (TCE) and sewage contaminated surficial sand aquifer. During the four months of field activities, tens of thousands of gallons of 20 percent wt./vol. HPCD solution were flushed through the aquifer. During and for 1.5 years after the cessation of flushing activities, the concentration of HPCD, TCE, dissolved oxygen (DO), nitrate, sulfate, and iron were monitored within the aquifer by sampling from the high density of monitoring wells at the site. The results of long-term monitoring have found that HPCD concentration continues to linger above 0.5 percent wt./vol. at the site. But, TCE levels have rebounded only slightly from post-flushing levels. Background dissolved oxygen is low at the site approximately 0.4 mg/L, but we found that the rates of DO depletion during flushing activities increased with exposure of the aquifer to HPCD solutions. Currently, we are examining the potential for HPCD to enhance the mobility of TCE by determining whether the ability of HPCD to enhance the solubility of low-polarity compounds is reduced over the time the HPCD solution resides in the aquifer.

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H51C-1055 0830h POSTER

Implications of a Multi-well Tracer Test in the Transport of Pathogens at a Riverbank Filtration Experiment Site.

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This study tracks the transport of bromide and microspheres mimicking pathogens in an arid environment. The study site uses the Rio Grande that experiences significant annual fluctuations in both water quantity and quality. The pumping well is 17 m from the stream bank and the water table was 2 m below the stream surface. The aquifer is medium and fine-grained sand comprising two flow units. Observation wells are screened over 1 or 1.5 m intervals. The average hydraulic conductivity was about 2 x 10-3 m/s based on a test analysis, however, the responses indicated that sediment heterogeneities affected the hydraulic behavior. A 427 hour tracer test using bromide and fluorescent microspheres provides initial results that are relevant to the transport of pathogens through the subsurface under riverbank filtration conditions. Bromide was injected into an observation well at the channel margin. Differently colored fluorescent microspheres (0.25nm, 1?m, 6?m and 10?m) were injected into the stream bottom and into two observation wells. Conclusions from the tracer test are: 1) Both bromide and microspheres continued to be observed throughout the 18 days of the experiment. 2) The bromide recovery in the pumping well and in the deeper observation wells showed early and late peaks with a long tails indicating that the geological medium at the field site behaves like a double-porosity medium allowing the tracer to

move relatively quickly through the higher conductivity units while being significantly retarded in the low hydraulic conductivity units. 3) Some wells showed consistently higher concentrations of bromide. 4) The 1? micospheres were abundant in the observation wells and allowed tracing of flowpaths. These showed multiple peaks similar to the bromide results. This indicates highly preferential transport paths in the sediment. 5) Microspheres from the three injection sites had distinctly different transport paths and rates. 6) Both bromide and microspheres appeared in the stream soon after injection, moving apparently against an 2-m head difference. 7) The 6 ? and 10 ? microspheres were observed in low concentrations and were episodically detected in the stream and in two widely spaced observation wells. The significance of these results is that: 1) Inorganic microspheres may mimic the episodic occurrence of microorganisms in wells. 2) Even in this relatively homogeneous aquifer, preferential transport within the aquifer results in highly divergent transport paths and rates. Microspheres from one of the injection sites traveled essentially perpendicular to the expected transport direction. 3) Even small variations in the sand grain size can effectively compartmentalize the aquifer. The next steps of this project will include field studies to observe the migration and persistence of selected organisms (E.coli, enterococci, coliphages, cysts, oocysts and enteroviruses) in the pumping well and observation wells under different pumping rates. Continued combined chemical sampling along with the microbial sampling will document the whether changes in water chemistry alter the behavior of the organisms.

URL: http://www.geo.utep.edu/pub/langford/RioBosque

H51C-1056 0830h POSTER

Behavior of Rare Earth Elements in Fractured Aquifers

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An understanding of the geochemistry of potential host rocks is very important in the site evaluation for construction of an underground geologic repository for radioactive waste. Because of similar valence and ionic radii and high similarity in electronic structure with trivalent actinides (such as Am^{3+} and Cm^{3+}), the rare earth elements (REEs) have been used to predict the behavior of actinide-series elements in solution. For Am and Cm, which occur only in the trivalent states in most waste-disposal repository environments, the analogy with the REEs is particularly relevant. Krauskopf calculated the retardation factors for radionuclides in various rock materials based on some compiled data. But, in general, because the transuranic actinides do not occur naturally in appreciable quantities, their behaviors in repository environments cannot be predicted from evidence of their movement in geologic environments (mainly in groundwater) over geologic timespans. Predictions about long-term future behavior of transuranic actinides have therefore been made by extrapolation from short-term observations of their chemical properties in laboratory experiments or in field tests, but such extrapolation is fraught with uncertainty. In order to verify the behavior of Eu in various geological environments, we estimated the abundance of rare earth elements in three gneiss bodies originated from different geological environments and volcanic tuff. We also carried out some leaching experiment of fracture-filling calcite precipitated due to changes of geochemical environment in paleo-groundwater. Of the three gneisses, two gneisses are granitic-granodioritic origin and the other is tonalitic-trondjemitic origin. As a result, we could observe that Eu had a close relationship with fracture-filling calcite precipitation due to water-rock interaction. Our results show that Eu is the most variable element of REEs for the hydrogeological environment such as change of oxidation-reduction and petrography. The similarity in physical and chemical properties between REEs and actinides shows well in the cohesive energy diagram against the REEs and actinides. In addition, the ionic radii of Eu^{2+}, Eu^{3+}, Am^{2+} and Am^{3+} at CN= 8 and 9 are summarized. They have very similar ionic radii in di- and trivalent ionic state. This suggests that they may be very similar behavior in geological states. In conclusion, the fracture-filling calcite and REE is a good tool in understanding the changes of geochemical environments in paleo-groundwater as well as an analogue for actinide elements.

H51C-1057 0830h POSTER

Filtration of Pathogenic Parasites Using Surfactant-Modified Zeolites

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Migration of pathogenic microorganisms, specifically Cryptosporidium parvum and Giardia lamblia, in groundwater due to sewage effluent and mismanaged wastewater has become an increased concern for human health in many regions. Cryptosporididosis and Giardiasis produces moderate to severe intestinal illness for many weeks and is a serious threat for immunodeficient persons. Previous studies by Schulze-Makuch et al. (2002) indicated that surfactant-modified zeolites (SMZ) removed all of the bacteria and most viruses in laboratory experiments. This study focuses on the efficiency of the SMZ to prevent migration of the protozoan spores in groundwater. Adsorption of the spores involves interactions between the surface properties of the spores and the SMZ. The efficiency of removal is tested simulating natural conditions. Laboratory experiments are conducted in a plexiglass model aquifer and pathogen removal is measured by taking water samples from strategically placed piezometers in the model. Since C. parvum and G. lamblia are hazardous to humans and move primarily in spore state through groundwater, polystyrene microspheres of similar sizes and Bacillus subtilis, a sporulating bacterium, are used as analogues for the protozoa. Preliminary results show a significant decrease in concentration of the B. subtilis spores down-gradient of the barrier.

H51C-1058 0830h POSTER

Ecological Indicators in Diversified Forested Watersheds: Relationships Between Watershed Characteristics and Stream Water Quality in Fort Benning, GA

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Stream water quality depends on many factors including land use, climate, and soil conditions. As such, water quality may be used as an indicator of upslope watershed condition. However, limited studies have been conducted to identify potential indicators. An ongoing investigation in diversified forested watersheds at Fort Benning, GA examines these relationships with the objective of identifying surface water chemical signatures that may be used as ecological indicators. This study analyzes two years of water quality data collected in 7 watersheds that are characterized by very low nutrient concentrations, particularly nitrogen and phosphorus. Relationships between water quality parameters (e.g., pH, specific conductivity, temperature, total Kjeldahl nitrogen, total phosphorus, total organic carbon, total suspended solids, chloride, and sulfate) and watershed characteristics (e.g., area, stream density, road density, average elevation and slope, disturbance level, and land use) are explored using both statistical and spatial analysis techniques. Preliminary data analyses show negative correlation of pH and TP mean concentrations with average slope and forest area and positive correlation with military land use percentage and road and stream lengths. Wetland area had little impact on the pH, TKN, TOC, and TSS concentrations. However, mean chloride concentration show a significant correlation with wetland area. Chloride, TP, and TSS exhibit poor correlation with military land use.

H51C-1059 0830h POSTER

Impact of Land-use and Climate on the Transport of TOC and Nutrients from Three Small Drainage Basins in North Europe

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In this research we studied to what extent the concentrations and loads of carbon, nitrogen and phosphorus may vary seasonally and annually in three forested upstream rivers with slightly different land-use practices in the surrounding drainage area. The three drainage basins belong to the drainage area of Lake Pääjärvi with a total area of 223 km^2. The data set consists of continuous discharge measurements in all rivers since early 1970s, and chemical analyses based on weekly sampling (or during a few winters biweekly or once a month) since autumn 1994. In the rivers the concentration of TOC, N and P varied seasonally up to 5-10 -fold, and their annual loads up to 4 fold. Within such a small geographical area the rivers behaved in a very coherent way both in terms of hydrology and nutrient concentrations. The results strongly support the hypothesis that besides land-use, climate is the key driving force which regulates not only short-term variability in nutrient concentrations and loads in boreal rivers, but very much also the annual loads of the nutrients. As a consequence of warmer winter conditions nutrient transportation to downstream lakes and seas from boreal drainage basins may substantially increase.

H51C-1060 0830h POSTER

A New Paradigm of Modeling Two-Dimensional Overland Watershed Water Quality

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This paper presents the development of sediment and reactive chemical transport under non-isotherm condition in two-dimensional overland watershed system. Through decomposition of reaction network via Gauss-Jordan column reduction, (a) redundant fast reactions and irrelevant kinetic reactions are removed from the system; (b) fast reactions and slow reactions can be decoupled; (c) species reaction equations are transformed into two sets: equilibrium species mass action equations and kinetic-variable reaction equations. This enable our model to include as many types of reactions as possible, choose kinetic-variables instead of chemical species as primary dependent variables, and simplify the reaction terms in transport equations. In our model two options are provided to solve the advection-dispersion transport equation: Lagrangian-Eulerian approach, and Finite Element Method in Conservative Form, and three options to deal with the reaction term: Fully-implicit, Predictor-corrector, and Operator-splitting methods. The production-consumption rate of chemical species is determined by reaction-based formulations. One example problem is employed to demonstrate the design capability of the model and the robustness of the numerical simulations.

H51C-1061 0830h POSTER

Widespread PCE Contamination: Characterization and Source Investigation to Protect Municipal Wells

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Fifteen years of groundwater quality monitoring of municipal wells in Reno, Nevada have shown increasing levels of PCE (tetrachloroethylene) beyond the U.S. EPA MCL of 5 ug/L. Eleven of the 28 municipal wells have detectable levels of PCE, with five of those wells requiring wellhead treatment. The Central Truckee Meadows Remediation District (CTMRD) was created to provide wellhead treatment of PCE, and evaluate, characterize, and remediate (if possible) the PCE-contaminated groundwater. The CTMRD's first tasks of wellhead treatment, plume characterization, remediation plan development, and source zone identification has been completed. The CTMRD recently completed investigations into the presence of PCE in sanitary sewer systems and their potential as pathways for contaminant migration throughout the Reno/Sparks metropolitan area. The first phase of the sewer investigation considered the possibility that PCE resides in the sanitary sewer system and that it may be actively

discharged to the sewer system as well. Results of this investigation revealed that nine sub-regions contained maximum PCE concentrations of that exceeded 100 ug/L, 20 times the U.S. EPA MCL of 5 ug/L. Eight of these nine subregions were located downgradient from active dry-cleaning facilities. One of the sampling locations had a maximum PCE concentration greater than 36,000 ug/L over a 24-hour period. The second phase of the sewer investigation explored for the sanitary sewer system to allow PCE to act as a conduit for contaminant migration. A phased approach was employed to investigate the sewer line leakage and resultant soil and groundwater impact. The investigation found that groundwater beneath most of the targeted sewer line reaches was contaminated. In particular, PCE was detected in 88% of all passive soil gas samples, 71% of all active soil gas samples, 23% of all soil samples, and 73% of all groundwater samples.

H51C-1062 0830h POSTER

Annual CO_2 Riverine Evasion From New Zealand

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Riverine dissolved organic carbon (DOC) export represents one fraction of the total carbon flux from the terrestrial environment to the coastal seas. Throughout transport, chemical and biological oxidation mechanisms remove DOC from the water column, producing CO_2 and other photochemical byproducts. The primary aim of this study was to estimate the annual CO_2 riverine evasion from New Zealand´s stream network using a combination of empirical measurements throughout the island nation, combined with diel experiments within a single basin and re-aeration estimates. From headwater streams to large rivers, surface-water CO_2 concentrations were supersaturated indicating that the river network releases CO_2 to the atmosphere. Diel measurements in subsurface porewaters showed that CO_2 concentrations were greater than surface-water concentrations due to both microbial DOC oxidation in the hyporheic zone and groundwater input of supersaturated CO_2 water. As expected, CO_2 concentrations are also a function of photosynthetic processes within the water column that consume CO_2 during daylight hours. Using our measurements and extrapolating to the national scale through a stream-order analysis, the annual CO_2 evasion estimates indicate that up to 30% of the riverine DOC export is consumed before reaching the sea.

H51C-1063 0830h POSTER

Analysis of Biogeochemistry of Acid-Mine Drainage at Rowe, Massachusetts

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Acid waters rich in iron and sulfate can support a wide variety of microorganisms that catalyze the oxidation-reduction reactions of these bioactive elements, exemplified by acid-mine drainage (AMD). In order to study the biogeochemistry of natural attenuation a field site has been established at Davis Mine, an abandoned pyrite mine in rural Rowe Massachusetts. This site is of particular interest because of the apparent dynamic equilibrium that has restricted the extent of the AMD in this area since the mine was closed nearly 100 years ago. Initial evidence suggests that sulfate reduction is occurring at the fringes of the site. Multi-level monitoring wells and surface water sampling points have been installed. Soil samples collected from the drilled wells are being used to provide inoculums for cultivating bacteria and identifying DNA. Preliminary data indicate a restricted lens of impacted groundwater that moves rapidly through the mine tailings and shallow bedrock fractures, but is contained by ambient groundwater from uncontaminated recharge areas. Sulfate reduction has been documented at the margins of the acid-generating area, and this has been reproduced in laboratory experiments. Current research is now examining the processes of Fe(III) and SO4 reduction and the roles of acidophilic and acid-tolerant anaerobic microorganisms. K12 teachers are part of the research teams and the effects of research experiences on their higher-level understanding of science are being evaluated.

URL: http://www.umass.edu/biocomplexity/

H51C-1064 0830h POSTER

Developing Water Quality Management Strategies At Different Watershed Scales Using System Dynamics Simulation

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System Dynamics simulation is used for developing models to understand the fate and transport of pathogens at different watershed scales. The models are developed using an object-oriented modeling environment to simulate and analyze water quality management strategies for pathogen impaired streams. The main objective of this work is to evaluate the relative contributions of pathogen loads from each watershed to facilitate the budget allocations that have to be made in each watershed and also to understand the fate and transport of pathogens in impaired streams of each watershed. The models can be used to generate several management scenarios and evaluate several adaptive management alternatives that are designed to reduce further impairment. An object-oriented simulation environment, conceived on the principles of system dynamics (SD) is used for the development of the model. Two important generic building blocks, stocks and flows that are part of the simulation environment are used to model various elements that govern the water bodies and pollutant loadings. The modeling process consists of developing, stock-flow diagrams and finally carrying out computer simulations using difference equations to integrate stocks and flows. The model structure and behavior of the system is validated using dimensionality, replication and sensitivity tests; and calibration along with validation is carried out using appropriate model performance measures. Case study application of this concept is illustrated by developing simulation models for pathogen impaired streams in the three watersheds, North Fork, Upper Cumberland and Big Sandy in southeastern region of Kentucky, USA. Straight pipes and failing septic systems have been identified to be the major sources of pathogen impairment in these watersheds and therefore are key factors influencing management alternatives. Preliminary results suggest that the fate and transport process of pathogens in a river system and at a larger watershed scale can be simulated using simple object-oriented simulation models under data-sparse conditions. The model helps the user to separate policy questions from the data and provides the facility to generate "what-if" scenarios while keeping the modeling process transparent.

H51C-1065 0830h POSTER

Modeling phosphorus transport in surface flow under non-equilibrium conditions

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Phase of chemicals - gaseous, dissolved or immobilized - may affect its transport in surface flow. Highly soluble chemicals are primarily transported in dissolved form while relatively less soluble chemicals are transported as being attached to sediment. Therefore, in modeling the movement in surface flow of the less soluble chemicals, it is important to consider sediment dynamics. Also adsorption kinetics between the less soluble chemicals and sediment should be considered in cases where dissolved chemicals are a major concern even though their concentration in the flow is relatively low. Chemicals such as phosphorus and ammonium reportedly take days to reach an equilibrium state, while some heavy metals and pesticides take minutes or hours. Thus, most chemical transport models, which have been developed based on equilibrium state assumption, may not be appropriate for predicting less soluble chemicals. In this study, dynamical modeling is attempted for phosphorus and sediment transport in overland flow and channel flow considering the interactions of phosphorus with suspended sediment and land surface or channel bed. Two models are developed in slightly different forms for the transport in each of overland flow and channel flow. The models consist of the kinematic wave equation for flow rate and the continuity equations for sediment, dissolved phosphorus and adsorbed phosphorus, and equations for land surface or channel bed. The effects of sediment dispersion as well as dissolved phosphorus dispersion are included for channel flow while they are ignored for overland flow. The model is applied to data from field experiments where sediment concentration, dissolved phosphorus concentration, and adsorbed phosphorus amount were measured at the outlet of the channel in small time intervals.

H51C-1066 0830h POSTER

Effect of Suburban Development and Landscape Position on Water Quality in Three Small Watersheds Within the Croton System, New York.

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Internal hydrological processes in suburban watersheds and their effects on water quality warrant investigation. Instrument clusters (throughfall collectors, suction lysimeters, monitoring wells, and shallow and deep piezometers) were installed at several locations within three small (50 - 70 ha) watersheds (one forested, two with different degrees of suburban development) in the Croton Watershed, southeastern New York. Biweekly and storm samples were analyzed for base cations, selected anions, and DOC over a one-year period. The topographic index (TI) quantified landscape position; flowpath analyses determined degree of development at each cluster, using % impervious cover as the metric. Water quality degradation was observed in sites with medium and high TI values; no such effect was observed along the ridges, i.e., low TI values. At medium TI values, areas with more than 5% impervious had degraded water quality. At high TI values, the water chemistry degradation appeared at 10% or greater impervious surface

H51C-1067 0830h POSTER

The Geochemical Behavior and Transport Characteristics of Xenoestrogens

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Xenoestrogens are estrogenic active synthetic chemicals that mimic the actions of female sex hormones. Xenoestrogens can be produced synthetically and naturally, and exposure can occur from a variety of sources-food additives, plastics, pesticides, or pharmaceuticals. These environmental chemicals are also known as endocrine disruptors because exposure to low doses (ng/L) have been linked to adverse effects in the reproductive and developmental stages in aquatic species (i.e. reproductive anomalies, feminization, infertility, alterations in growth during life cycles, and changes in community structures). Determining the exposure risks of these toxicological compounds, however, requires a better understanding of the geochemical behavior and transport of synthetic estrogens it is discharged to. Estrogen and its metabolites are also useful tracers because of their specific medical usage (sources from birth control pills, estrogen replacement therapy, and livestock farming), slow degradation before excretion, and unique physiochemical properties (low volatility, hydrophobicity, and high Kow). Estradiol concentrations analyzed by an enzyme-linked immunoassay (ELISA) show that <2-55 ng/L are discharged to Walnut Creek, a stream that also connects to the Colorado River(TX). The bioavailability of these compounds is affected by sorption processes, where xenoestrogens become associated with solid phases. A series of batch sorption experiments using sediment collected from Walnut Creek downstream of an Austin waste water treatment plant and synthetic estrogen

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standards (Simga@ Estrone, 17B-Estradiol, and Estriol), examined the distribution of estrogen between solid and aqueous phases. Analysis of the concentrations sorbed to sediment result in Freundlich sorption isotherms using HPLC/UV techniques (High Performance Liquid Chromatography with UV detectors- 220 and 280nm). Sorption occurs rapidly with 98% of 17B-Estradiol sorbed within 30 minutes (Estriol=80%, Estrone=95%), which is compared to photolysis degradation rates under UV and a broader spectrum sun lamp. Ultraviolet/Visible (UV/VIS) spectroscopy of the estrogen standards with dilute fulvic acid may indicate complexing with organic material. The hydrophobic nature of estrogen molecules due to a phenolic group seem to play a large role in the sorption rate. This sorption may alter direct photolysis decay rates, thereby acting as both a sunscreen' and a carrier by increasing the exposure distance and bioavailability of xenoestrogens in the aquatic environment.

H51C-1068 0830h POSTER

Temperature Patterns and Cooling Through a Short Step-Pool Reach in a Headwater Stream, Dry Creek, Idaho

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Stream temperature is a controlling variable of stream ecology and can be influenced by hyporheic exchange. The extent of the role hyporheic exchange plays in small streams is not well understood because few studies have been able to close the energy balance for the study reaches. The objectives of this study are to quantify energy exchange associated with hyporheic flow and bed conduction, to balance a heat budget by including all major fluxes of heat energy through the reach and to compare resulting temperature predictions with measured values in a small a riffle-step pool sequence. The study is being conducted in the Dry Creek Experimental Watershed near Boise, Idaho. The stream flows through an upland desert steppe environment, but is heavily shaded by growth directly adjacent to the stream. During the field campaign the stream maintained a typical flow of 0.01m3/s and was steadily losing flow to the subsurface, with some flow returning through hyporheic exchange. Loss of flow to groundwater was assumed to be negligible for this short reach. Stream temperatures cooled as much as 0.7°C through the short, 5m, study reach. Net radiation is the dominant inflow of energy to the reach, with evaporation, hyporheic exchange and bed conduction combining to result in a net cooling.

H51C-1069 0830h POSTER

Source Water Assessment for the Las Vegas Valley Surface Waters

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The 1996 amendment to the Safe Drinking Water Act of 1974 created the Source Water Assessment Program (SWAP) with an objective to evaluate potential sources of contamination to drinking water intakes. The development of a Source Water Assessment Plan for Las Vegas Valley surface water runoff into Lake Mead is important since it will guide future work on source water protection of the main source of water. The first step was the identification of the watershed boundary and source water protection area. Two protection zones were delineated. Zone A extends 500 ft around water bodies, and Zone B extends 3000 ft from the boundaries of Zone A. These Zones extend upstream to the limits of dry weather flows in the storm channels within the Las Vegas Valley. After the protection areas were identified, the potential sources of contamination in the protection area were inventoried. Field work was conducted to identify possible sources of contamination. A GIS coverage obtained from local data sources was used to identify the septic tank locations. Finally, the National Pollutant Discharge Elimination System (NPDES) Permits were obtained from the State of Nevada, and included in the inventory. After the inventory was completed, a level of risk was assigned to each potential contaminating activity (PCA). The contaminants of concern were grouped into five categories: volatile organic compounds (VOCs), synthetic organic compounds (SOCs), inorganic compounds (IOCs), microbiological, and radionuclides. The vulnerability of the water intake to each of the PCAs was assigned based on these five categories, and also on three other factors: the physical barrier effectiveness, the risk potential, and the time of travel. The vulnerability analysis shows that the PCAs with the highest vulnerability rating include septic systems, golf courses/parks, storm channels, gas stations, auto repair shops, construction, and the wastewater treatment plant discharges. Based on the current water quality data (prior to treatment), the proximity of Las Vegas Wash to the intake, and the results of the vulnerability analysis of potential contaminating activities, it is determined that the drinking water intake is at a Moderate level of risk for VOC, SOC, and microbiological contaminants. The drinking water intake is at a High level of risk for IOC contaminants. Vulnerability to radiological contamination is Moderate. Source water protection in the Las Vegas Valley is strongly encouraged because of the documented influence of the Las Vegas Wash on the quality of the water at the intake.

H51C-1070 0830h POSTER

Use of the Water, Energy, and Biogeochemical Model (WEBMOD) to Simulate Water Quality at Five U.S. Geological Survey Research Watersheds

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The Water, Energy, and Biogeochemical Model (WEBMOD) was developed as an aid to compare and contrast basic hydrologic and biogeochemical processes active in the diverse hydroclimatic regions represented by the five U.S. Geological Survey (USGS) Water, Energy, and Biogeochemical Budget (WEBB) sites: Loch Vale, Colorado; Trout Lake, Wisconsin; Sleepers River, Vermont; Panola Mountain, Georgia; and Luquillo Experimental Forest, Puerto Rico. WEBMOD simulates solute concentrations for vegetation canopy, snow pack, impermeable ground, leaf litter, unsaturated and saturated soil zones, riparian zones and streams using selected process modules coupled within the USGS Modular Modeling System (MMS). Source codes for the MMS hydrologic modules include the USGS Precipitation Runoff Modeling System, the National Weather Service Hydro-17 snow model, and TOPMODEL. The hydrologic modules distribute precipitation and temperature to predict evapotranspiration, snow accumulation, snow melt, and streamflow. Streamflow generation mechanisms include infiltration excess, saturated overland flow, preferential lateral flow, and base flow. Input precipitation chemistry, and fluxes and residence times predicted by the hydrologic modules are input into the geochemical module where solute concentrations are computed for a series of discrete well-mixed reservoirs using calls to the geochemical engine PHREEQC. WEBMOD was used to better understand variations in water quality observed at the WEBB sites from October 1991 through September 1997. Initial calibrations were completed by fitting the simulated hydrographs with those measured at the watershed outlets. Model performance was then refined by comparing the predicted export of conservative chemical tracers such as chloride, with those measured at the watershed outlets. The model succeeded in duplicating the temporal variability of net exports of major ions from the watersheds.

H51C-1071 0830h POSTER

Modeling Streambed Heating in Shallow Streams

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The Oregon Department of Environmental Quality is moving forward to develop TMDLs to address water quality concerns and threatened and endangered species habitat requirements in water bodies throughout Oregon. Approximately 940 water body segments are listed as water quality limited for stream temperature. CE-QUAL-W2 Version 3 is a two-dimensional water quality and hydrodynamic model capable of modeling watersheds with interconnected rivers, reservoirs and estuaries and accounts for the impact of riparian vegetative and topographic shading on stream temperature. One important aspect of modeling stream temperature is how to model the short-wave solar radiation that penetrates the water surface and impacts the channel bed or substrate, which can significantly affect temperature predictions under low-flow stream conditions. Algorithms were added to CE-QULA-W2 incorporating dynamic vegetative and topographic stream-side shading and dynamic three-dimensional streambed heating. The Bull Run River-Reservoir system is a 264 km2 watershed located 41.8 km east of downtown Portland serves as the city's primary drinking water source. The watershed consists of two reservoirs, Bull Run Lake and river sections above and below the reservoirs. Fieldwork was conducted in the Bull Run River during the summer of 2002 to monitor streambed temperatures, meteorological conditions, and stream temperatures.

H51C-1072 0830h POSTER

Transport of Iodine Species in the Terrestrial Environment

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The fate and transport of iodine in the environment is of interest because of the large production and release of ^{129}I from anthropogenic sources. ^{129}I has a long half-life (1.57 x 10^7 years) and exhibits complex geochemical behavior. The main source of ^{129}I in the environment is from nuclear fuel reprocessing facilities; about 2,600 kg from facilities in England and France. During 1944-1972, the Hanford Site in Washington state released about 260 kg ^{129}I. Iodine has a unique and complex chemistry in the environment, and its fate and transport in aqueous environments is dictated by its chemical speciation. In reducing environments, aqueous iodine usually occurs as the highly mobile iodide anion (I^-). Under more oxidizing conditions, iodine may be present as the more reactive iodate anion (IO_3^-), which could lead to retarded transport through interaction with clays and organic matter. Co-existing iodine species (I^-, IO_3^-, I_2, and organoiodine compounds), in different proportions, has been reported in various terrestrial environments. However, there are conflicting reports regarding the environmental behavior of the different types of inorganic iodine and few publications on organic iodine compounds. This work examines the sorption and transport behavior of both inorganic and organic iodine species in geological samples from several complexes of the U.S. Department of Energy, where transport of radionuclides, including ^{129}I, may occur. Experiments on soils and sediments from the Savannah River Site in South Carolina, Oak Ridge Site in Tennessee, Hanford Site in Washington, Livermore Site 300 in California, and a surface soil from Santa Fe in New Mexico near Los Alamos were carried out. Samples from Savannah River Site and Livermore Site 300 are available from different depths. In addition, a surface soil of Wisconsin with a high amount of organic matter is utilized. This wide variety of sample types provides opportunities to examine the influence of organic matter, clay mineralogy, soil pH, and texture on the environmental behavior of iodine. The effects of initial concentration and competitive sorption on iodine transport are also investigated.

H51C-1073 0830h POSTER

Groundwater Flow Patterns and Chemical Evolution in the Yucca Mountain Area as Inferred from Groundwater Geochemical and Isotopic Data

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Groundwater flow patterns and chemical evolution in the Yucca Mountain area were inferred using groundwater geochemical and isotopic data taken from several databases available for the region. The interpreted flow patterns are based on areal distributions and cross-correlations of relatively nonreactive chemical (Cl and SO_4) and isotopic ($\delta^{18}O$, $\delta^{2}H$, $\delta^{34}S$) species, as well as on inverse groundwater mixing and water/rock reaction models simulated with the USGS geochemical code PHREEQC that considered the evolution of reactive species. The use of multiple chemical and isotopic species within a general modeling framework that considers both mixing and water/rock interactions provides a better understanding of groundwater compositional variations for the Yucca Mountain area than has previously been available. The PHREEQC groundwater mixing and reaction models were also used to understand carbon isotope evolution along the flow paths and provide more confidence in calculations of groundwater velocities using groundwater carbon-14 activities.

H51C-1074 0830h POSTER

Factors Affecting the Reactivity, Efficiency, and Lifetime of Iron Nanoparticles for In Situ Degradation of TCE

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Over the past decade, laboratory and field studies have demonstrated that Fe^0 can rapidly transform dissolved chlorinated organic solvents into non-toxic compounds. Using nanoscale Fe^0 (~100nm particles) offers a host of novel in situ subsurface remediation options because particles can be delivered into the small pores of porous media where residual contamination resides. Using Fe^0 nanoparticles for in situ groundwater remediation is a recent nanotechnology application and little is known about the optimal properties for these particles. The objective of this research is to determine the factors controlling reactivity, lifetime, and efficiency of Fe^0 nanoparticles so more reactive and efficient Fe^0 nanoparticles can be developed. The physical and chemical properties of two types of Fe^0 nanoparticles; Fe^0 (AR-2, Toda America, Inc.) and Boron-doped Fe^0 particles synthesized by $NaBH_4$ reduction of Fe^{2+}(aq) (Fe^0/B) were determined before and after reaction with TCE in water using TEM, HRTEM, magnetometry, BET N_2 adsorption, electron diffraction, and ICP-AES. The TCE transformation rate and efficiency (% of total Fe oxidized used to dechlorinate TCE) afforded by each type of particle were measured. Under identical reaction conditions, Fe^0 nanoparticles (k_{obs}=0.013 $Lg^{-1}d^{-1}$) are 2 orders of magnitude less reactive than boron-doped (Fe0/B) particles (k_{obs}=1.3 $Lg^{-1}d^{-1}$). The oxidized surface of Fe^0 nanoparticles prevents them from corroding and limits the rate of TCE dechlorination. The presence of boron appears to mitigate this effect. Although the Fe^0/B particles are highly reactive, HRTEM shows a clear core-shell composition of these particles before reaction. Dissolution of the boron-containing oxide layer formed on the Fe^0/B particles may be responsible for their higher reactivity. TEM indicates the presence of acicular 200nm by 15nm a-Fe_2O_3 particles in Fe^0/B particles that have been fully reacted with TCE in water, suggesting that the Fe-oxides formed away from the Fe^0/B particle surface. The efficiency of completely reacted Fe^0/B particles was relatively low at 10%. This indicates a trade-off between reaction rate and efficiency, and suggests that optimal Fe^0-based nanoparticles may not necessarily be those that afford the fastest dechlorination rates.

H51C-1075 0830h POSTER

Effects of a Controlled Water Release on Water Quality in the Mokelumne River, California

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Managed water releases from reservoirs (i.e., controlled flood events) help to restore impounded rivers to more "natural" ecological conditions. Periodic high discharge can remove fine sediments and algae from spawning gravels, mobilize gravel bars, and clear brush encroaching from the stream banks. The effects of a managed release event on water quality were investigated on the lower Mokelumne River in the western Sierra Nevada, central California. The managed release was characterized by an increase in flow over a three-day period (from 440 cfs to 2000 cfs) and then a gradual decrease to pre-flood conditions over the next nine days. In the two years preceding the controlled release, flows in the lower Mokelumne averaged 288 cfs and did not exceed 520 cfs. Four automatic pump samplers were placed along a 55 km stretch of the Mokelumne River below Camanche Dam: 0.7, 16.4, 37.4, 54.4 km below the dam. One sampling site was immediately below Lake Lodi, a small reservoir 36 km downstream of the dam. Water was collected over the 12 day release and was analyzed for total suspended solids (TSS), total nitrogen, ammonium (NH4-N), nitrate (NO3-N), total phosphorus, soluble reactive ortho-phosphate (PO4-P), DOC, chlorophyll, and selected pathogens. The chemograph of the rising limb exhibited spikes in TSS (<1.0 to 41 mg/L), total N (0.08 to 0.73 ppm), NH4-N +NO3-N (0.015 to 0.1 ppm), total P (0.02 to 0.13 ppm), PO4-P (<0.003 to 0.017 ppm), DOC (0.5 to 2.48 ppm), chlorophyll (0.7 to 6.4 ppb), fecal coliform (0-4326 cfu/100mL), and E. coli (0-2866 cfu/100mL). Due to the attenuation of the flood wave as it moved downstream similar trends with respect the upper site were observed at the lower sites but with less pronounced concentration spikes. Fluxes of TSS, total P and total N released over the 0.7 to 16.4 km reach were 300, 0.33 and 3.5 Mg, respectively. Lake Lodi acted as a sink for TSS, total N and total P retaining about 100 Mg of sediment, 0.2 Mg total P and 8.8 Mg of total N. The reservoir acted as a source of dissolved nutrients (NO3-N, NH4-N, and PO4-P). Unlike in rainfall generated storms, fluxes of each constituent were mobilized from the channel alone, with little terrestrial influence. This distinction creates an opportunity for differentiation between channel derived fluxes and landscape derived fluxes.

H51C-1076 0830h POSTER

Possible Processes For Acidity And Metal Contaminant Attenuation In A Polluted Estuarine Aquifer

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Geochemical data obtained from an estuarine sandy aquifer situated below an old industrial landfill (Ayrshire, Scotland) indicated that acidic groundwater (pH <2) exists 100 meters from the estuary bank. Associated with this acidic plume, elevated concentrations of dissolved heavy metals (Al, Zn, Cu, Cr, Cd) were observed. Water table monitoring and chemical data showed that the groundwater is intruded by estuarine water and is tidally influenced. While geochemical processes associated with acidic plumes and related metal contamination have been widely studied in inland aquifer systems, they have received much less attention in near shore aquifers. Rarely have processes taking place in tidally influenced acidic aquifers been investigated in detail in the field. The aim of the study was to identify the key processes controlling the migration of the acidic plume and reactive transport of contaminants on the path from the aquifer to the estuary. More specifically, the research work has focused on the role played by estuarine water intrusion on the geochemical processes occurring in the aquifer. Through integration of intense geophysical, hydrogeological and hydrogeochemical Investigations, a comprehensive field-monitoring program and laboratory experiments have been carried out. Data obtained were analysed using a geochemical modelling code, PHREEQC-2. In parallel, a model for multi-components reactive transport with density dependent flow was developed and applied to the site. Results from the field, laboratory, and modelling work indicated that oxidation of sulphurous waste located in the landfill at the pollution source is the origin of the groundwater acidity. The low pH plume and associated contaminants are slowly migrating towards the estuary. Retardation of the plume and pH buffering processes are clearly occurring in the aquifer. Ion exchange, precipitation, buffering mineral dissolution, and tidal forcing on the advective-dispersive transport were identified as the main factors influencing contaminant migration and behaviour in the aquifer.

H51C-1077 0830h POSTER

Modeling the Relative Contributions of Sediments and Urban Runoff-Borne Particles to PCB (Polychlorinated Biphenyl) Levels in the Water and Foodchain of an Urbanized Waterway (Columbia Slough, Portland, OR, USA)

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The Columbia Slough is an urbanized waterway in Portland, OR, USA that provides important habitat for a wide range of species and recreational opportunities for humans. Of special concern in the Slough is the potential for human ingestion of fish containing elevated levels of persistent chlorinated compounds, particularly PCBs. Fish tissue analyses and exposure studies suggest the human population ingesting Slough fish may face a relatively high (>1:10 000) risk of an excess lifetime cancer fatality. Since only a few localized sources of PCB to the water way have been identified, attention has focused on two sources. The sediments are contaminated with PCB at relatively low levels (<30 ug/kg) but sediment inputs may be enhanced by a significant throughput of groundwater. The second potential source is urban runoff containing particles with PCB from historical low-level soil contamination or ongoing atmospheric inputs. We used a combination of field data and dynamic computer modeling to compare the relative contributions of PCB desorption from sediments (as enhanced by advective groundwater motion) and contaminated particulate matter from runoff. Most of the PCB in the trophic levels of the food chain studied can be attributed to input from legacy contamination in the sediments. However, urban runoff does present the potential for inducing a small long-term risk to fish-consumers.

H51C-1078 0830h POSTER

Stream Water Quality Modeling in the Great Smoky Mountains National Park

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The purpose of this study was to examine water quality in the acid-impacted Great Smoky Mountains National Park (GRSM). Water samples have been collected roughly quarterly at ninety sampling sites throughout the Park from October, 1993 to November, 2002.. These samples were analyzed for pH, acid neutralizing capacity (ANC), conductivity, major cations, and major anions. The trout fisheries of the GRSM are considered some of the best in the eastern United

States. However, fisheries biologists at the GRSM believe that some of the streams that once supported trout populations twenty or thirty years ago, no longer do. This study outlines and quantifies surface water quality conditions that might be harmful to trout populations through a literature review. This study identifies 71 sites (79 percent of total sampling sites) that currently have a median pH of greater than 6.0, above which, is unlikely to be harmful to trout species unless a high runoff of acid, Al-rich water creates a mixing zone where Al(OH)3 precipitates. The precipitate can accumulate on the gills and impede normal diffusion of O2, CO2, and nutrients. There are 17 sites (18 percent) that have median pH values in the 5.0 to 6.0 range. This range of pH values is likely to be harmful to trout species when aluminum concentrations exceed about 0.2 mg/l. The lower end of this range is probably harmful to the eggs and fry of trout and also to non-acclimated trout especially when calcium, sodium, and chloride concentrations are low. Only two sampling sites have median pH values in the 4.5 to 5.0 range. This pH range is likely harmful to eggs, fry and adult trout, particularly in the soft water conditions prevalent in the GRSM. The mechanisms adversely affecting trout in these ranges are ionoregulatory dysfunction, respiratory stress, and circulatory stress. Currently, there are no sampling sites with median pH values less than 4.5, although pH values could be lowered by more than one pH unit during high-flow episodic events depending on the ANC in the stream. Stepwise multiple linear regression was used to model pH, ANC, nitrate and sulfate. This study incorporates basin characteristics, time, acid deposition data, USGS stream flow data as surrogate hydrologic data, and precipitation data, e.g., inches of rain on preceding days, to determine whether these variables are associated with water quality. Acid deposition data came from biweekly wet only and throughfall monitoring at the Noland Divide, which is a high elevation acid deposition monitoring site within the Park. Precipitation data is collected at five National Weather Service monitoring sites within the Park. Each of the above variables were found to be statistically significant ($p<0.05$) influencing factors to water quality, particularly pH. Water quality conditions were adversely (decreasing pH and ANC and increasing sulfate and nitrate) affected by increased stream flows, acid deposition and precipitation. Models for pH and ANC produced R-square values around 0.71 and 0.86, respectively. Nitrate and sulfate modeling produced R-square values around 0.30. This study also analyzes temporal trends in pH. Modeling reveals statistically significant decreasing trends in pH with time. If conditions remain the same and past trends continue, models suggest that 30.0 percent of the sampling sites will reach pH values less than 6.0 in less than 10 years, 63.3 percent of the sites will reach pH values less than 6.0 in less than 25 years, and 96.7 percent of the sites will reach pH values less than 6.0 in less than 50 years. The models used to predict future pH values explain around 70 percent of the variability in the data.

H51C-1079 0830h POSTER

Assessment of Extent to Which Intensively-Studied Lakes are Representative of the Adirondack Mountain Region, New York

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This recently-initiated research represents a multidisciplinary and multi-institutional effort to extrapolate research, monitoring, and modeling results, including physical, chemical, and biological findings, from intensively-studied lakes to the regional population of acid-sensitive Adirondack lakes. Extrapolation will be based on the statistical frame of EPA's Environmental Monitoring and Assessment Program (EMAP) and intensively-studied sites were drawn from RPI's Adirondack Effects Assessment Program (AEAP) and EPA's Adirondack Long-term Monitoring Project (ALTM). A total of 68 watersheds will be included in this effort, which has involved field sampling during summer, 2003 to develop a statistically-representative soils database and will involve model projections using the MAGIC and PnET-BGC models to classify lakes according to their sensitivity to change in S and/or N deposition. The results of this research will allow fuller utilization of data from on-going chemical and biological monitoring and process-level studies by providing a mechanism for regionalization of findings and developing/refining relationships among watershed characteristics, chemical change, and biological responses to changing levels of acid deposition. This project is important for the management of the ecosystems in New York that are most responsive to changes in acid deposition. Results of this project will determine the portions of the Adirondack region where acidified lakes will recover, and by how much, in response to varying levels of future deposition. It will also identify portions of the region and types of watersheds in which recovery is unlikely. It will provide critical information for determining which areas require the most intensive research or remediation efforts.

H51C-1080 0830h POSTER

Water Quality Monitoring in the Great Smoky Mountains National Park: Present and Future

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The streams of the Great Smoky Mountains National Park (GRSM) are all headwater streams. Five of these streams are designated Outstanding National Resource Waters (ONRW). But these and other streams are threatened with impairment by the highest acid deposition rate received by any park. Acid deposition is already suspected of causing trout loss in multiple stream reaches. This paper discusses the current GRSM water quality monitoring program and future changes. The major GRSM water quality issues include: 1) How healthy' are the streams for aquatic life? 2) Is water quality getting better or worse? 3) Why is the stream quality as it is and why do several trends exist? To answer these questions, several water quality monitoring efforts are ongoing: 1) Quarterly grab samples are collected from 90 sites and analyzed for major ions, pH, acid neutralizing capacity (ANC), conductivity, and aluminum. 2) A high altitude site in the Noland Divide watershed records flow, pH, conductivity, and temperature every 15 minutes on two small streams. Biweekly stream, open sit precipitation, and throughfall samples are analyzed for the same analytes as above. 3) Special projects have monitored water quality in adjacent streams during road reconstruction projects. The objectives of the Noland Divide site include providing data on acid deposition flux and trends in the Park as well as flow and chemistry data on the two streams to monitor trends. The objectives of the stream survey of 90 sites include identifying long term trends in water quality, assessing the health of streams, assisting Park management decisions, e.g., viable streams for brook trout restoration, and understanding drivers of water quality in the Park (geology, vegetation, acid deposition, precipitation, logging history, elevation, watershed geometry, stream size, etc.). Analyses of the data and literature have led to several conclusions: 1) pH is decreasing over time at lower elevations 2) Streams have very little capacity to resist acidification, and severe drops in pH during storms can be expected. 3) 80 percent of the GRSM waters are OK for trout during baseline flow conditions. 4) Watershed with higher elevations and steeper slopes have lower pH probably due to shallower soils. 5) Watersheds with higher limestone have higher ANC and thus are less sensitive to acid deposition A monitoring limitation is that few storm event samples are taken. pH regularly dropped to less than 5.0 during the few storm events studied. To collect more storm event data, sondes, precipitation gauges, and auto-samplers are being installed in a watershed. Also, a new ICP spectrometer will allow a more metals to be analyzed. Recently, the stream sampling network was analyzed to identify redundancies in water quality and basin characteristics between sites. Based on multivariate analyses and a simulated annealing optimization approach, about 40 sites will be dropped and four sites added. Also, sampling frequency will increase to six times per year to allow faster trend identification.

H51C-1081 0830h POSTER

Trends in Hydrophobic Organic Contaminants in Lake Sediments Across the United States, 1970 to Present

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U.S. environmental policy shifted greatly toward water-quality protection beginning about 1970. Conversely, changing demographics and large increases in vehicle use have occurred that could adversely effect water quality. To assess resulting changes in the quality of streams and lakes across the United States, the U.S. Geological Survey collected and analyzed sediment cores from 42 lakes (34 reservoirs and 8 natural lakes). Land use in sampled watersheds ranged from undeveloped (nine sites), to moderate urban (16 sites), to dense urban (17 sites with more than 60 percent urban). Cores were analyzed for polycyclic aromatic hydrocarbons (PAHs) and chlorinated hydrocarbons (organochlorine pesticides and polychlorinated biphenyls) and contaminant trends were tested statistically. Significant trends among the chlorinated hydrocarbons were mostly downward, and significant trends among the PAHs were mostly upward. One-half the 42 lakes, for example, had downward trends in DDE and no lake had an upward trend, whereas 22 lakes had upward trends in benzo(a)pyrene while only three were downward. Most of the downward trends in PAHs were at reference sites and no downward trends in total PAH occurred at dense urban sites. Concentrations varied greatly with intensity of urbanization. Median total PAH at the tops of cores was about 25 times greater among the dense urban sites than the reference sites. Compared to sediment quality guidelines, chlordane was the compound that most often exceeded the probable effect concentration, often by an order of magnitude at dense urban sites. These results suggest that improvements brought about by regulation of chlorinated hydrocarbons since the 1970s are being offset by increases in PAHs in response to urbanization.

H51C-1082 0830h POSTER

Reconstructing U.S. National Trends in Metals from Reservoir and Lake Sediments, 1970 to Present

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Legislation, regulation, and changing demographics and industrial practices in the United States during the past three decades likely have had an effect on the amount of metals delivered to the environment. To determine whether the combined contribution has resulted in overall increases or decreases in metal concentrations in the environment, the U.S. Geological Survey collected sediment cores from 42 reservoirs and lakes across the country, covering a land-use gradient from undeveloped (reference) to fully urbanized. The cores were subsampled on small intervals and analyzed for a suite of major and trace elements; trends in seven metals (Cd, Cr, Cu, Hg, Ni, Pb, and Zn) from 1970 to present are discussed here. When all lakes were considered together, statistically significantly downward trends outnumbered statistically significantly upward trends for all metals except Zn. This was most pronounced for Cr and Pb, for which downward trends outnumbered upward trends by 11 to 1. When lakes were

classified by land use (reference, light urban, and dense urban) and the three groups tested separately, the results were similar. The number of lakes for which the probable effect concentration was exceeded varied by metal, from just 2 percent of lakes for Cd to 42 percent of lakes for Pb. Concentrations of individual metals increased greatly with urban land use and most often exceeded the probable effect concentration at dense urban sites. These results indicate that overall contamination of United States streams and lakes by metals is decreasing, but even so, current concentrations continue to be at levels that could pose a threat to aquatic biota.

H51C-1083 0830h POSTER

Calcium Carbonate Effects On U(VI) Sorption To Soils

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Uranium contamination of the subsurface resulting from past radioactive waste disposal and storage practices represents a serious environmental contamination problem at a number of sites. Under oxidizing geochemical conditions, sorption is one of the primarily controlling factors on U(VI) mobility in subsurface. In many soil systems, calcium carbonate represents an important mineral phase which likely affects U(VI) sorption behavior. To quantify this influence, sorption of U(VI) to soils in the presence of naturally occurring calcium carbonate was investigated by conducting batch experiments in which either U(VI) concentration or solution pH was varied. Two soils containing different calcite concentrations were selected, one from Oak Ridge, Tennessee, and another from Altamont Pass, California. The results show that the presence of calcium carbonate in soils strongly affects U(VI) sorption. Higher concentrations of soil calcium carbonate lead to a pronounced suppression of the pH-dependent sorption curve in neutral pH range, because of the formation of a very stable neutral complex of calcium uranyl carbonate (Ca2UO2(CO3)3) in solution. A surface complexation model considering both strong and weak sites for ferrihydrite and ionizable hydroxyl sites for clay minerals was compared with experimental results, and U(VI) binding parameters were reasonably estimated. Fair agreement was found between the model predictions and sorption data, which span a wide range of U(VI) concentrations and pH. The results also show that selection of appropriate solution-to-solid ratios is important when measuring distribution coefficients in calcareous soils because the impact of calcium carbonate on U(VI) sorption in natural systems can be artificially diminished by dilution.

H51C-1084 0830h POSTER

Cs-137 Distribution and Retention in Savannah, Georgia (USA) Estuarine, Marsh and Riverine Environments

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The Savannah River drainage basin spans parts of North Carolina, South Carolina and Georgia (USA). For those radionuclides that are not permanently sequestered at their introduction sites, the aquatic system often becomes the major mechanism by which the radionuclides are transported. Riverine, marsh and estuarine sediments were examined in order to identify processes affecting the distribution of Cs-137 and excess Pb-210 in the Savannah area. Results indicate that Cs-137 activities range from below detection limits to 3.42 dpm/g. Radiogeochemistry patterns suggest that in the marsh, steady-state particle mixing and burial processes primarily controls downcore particulate Cs-137 distribution, whereas in the local riverine and estuarine environments, non-steady state processes govern post-depositional Cs-137 distribution. In addition to physical processes, clay mineralogy and grain-size differences may also influence the Cs-137 retention ability of the Savannah area aquatic sediments. This research is apart of a larger on-going investigation of Savannah area aquatic radiogeochemistry.

H51C-1085 0830h POSTER

Water Quality Assessment: Statistical Versus Classification Approach

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Water quality assessment requires the acquisition and analysis of data. An efficient assessment involves the use of statistics and other methods such as data classifications. Statistical techniques range from developing plots of data to iterative model building and parameter estimation. Water quality assessment based on data classifications such as water quality indices has some limitations. Water quality indices formulas are not used as absolute measures of the degree of pollution or the actual water quality in a stream. These formulas result in inherent loss of information. However, in statistical approaches, comparisons and analysis of data demonstrate complications that arise if the assessment results obtained from one data set are used to compare with the results from a different data set, unless all data sets are evaluated together simultaneously and have the same types of data. Thus, a statistical approach to evaluate the water quality is less applicable than the water quality index classification approach, which is considered as more objective and repeatable. Because of the requirements from some international or regional directives on critical issues related to water pollution, most countries need to report the status of their water quality based on a classification scheme. Although different countries are applying different classification schemes and the assessment approach in the index classification schemes differs greatly, they can be combined together into a single assessment technique that can be represented as index class value. In this study, a comparison between the classification and statistical approaches will be given through sufficient case studies to judge which method is better to understand and design systems for environmental protection.

H51C-1086 0830h POSTER

Modeling linkages between groundwater, surface water and perhiphyton-driven oxygen dynamics in the lower Truckee River, Nevada

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Long-term water quality monitoring in the lower Truckee River, Nevada (U.S.) reveals increases in several constituents [e.g., total dissolved solids (TDS) and nitrogen (N)] not easily explained by simple solute and hydrologic budgets of surface inputs (i.e., suburban runoff; agricultural surface return flow; etc). Regional and sub-regional hydrologic investigations focusing on groundwater indicate that much of the solute increase is attributable to subsurface non-point source (NPS) returns driven by a complex combination of agricultural activities (e.g., flood irrigation of field crops) juxtaposed upon naturally occurring regional groundwater flow. A two-year monitoring program focusing on periphyton within the same river reach further reveals local maxima in biomass corresponding to gaining river reaches. A long-term dynamic surface water quality model provides the unifying element for these data, and helps support earlier theses suggesting a link between NPS groundwater returns, nutrient enrichment and periphyton-driven oxygen dynamics in the lower river.

H51D MCC: Level 2 Friday 0830h

Hillslope and Basin Geomorphology Posters

Presiding: **E B Safran,** Lewis and Clark College**; E Wohl,** Colorado State University

H51D-1087 0830h POSTER

Constraining Passive Margin Escarpment Evolution by Low-Temperature Thermochronology

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Passive margin escarpments are major geomorphic features that separate low-relief, high elevation plateaux from near sea-level coastal plains. Their initial development is often linked to a base level drop associated with the episode of continental rifting that leads to the opening of an adjacent oceanic basin. How they migrate from their original coastal position to their present-day location sometimes several hundred kilometers inland, remains a matter of debate. Do escarpments retreat while maintaining their shape, or do they evolve from their original position to the location of a pre-existing inland divide by downwearing of the continental plateau. Recent thermo-chronological studies across the Great Escarpment of Southeastern Australia and the escarpment flanking the southern margins of the African continent have provided some constraints on the rate and nature of escarpment migration. Here, we use a complex three-dimensional thermal model of the crust coupled to a surface processes model to demonstrate under which circumstances thermochronological data can be used to provide meaningful information on the evolution of the escarpment. Furthermore, we define specific sampling strategies to optimize the information that can be extracted from thermochronological datasets on the rate of escarpment migration, the nature of its retreat as well as the value of poorly constrained parameters such as the local geothermal gradient and the flexural thickness of the lithosphere. In this context, we re-analyze published datasets on the Great Escarpment of Southeastern Australia and demonstrate that they contain incomplete information on the evolution of the escarpment. We define new potential targets that might provide more constraining information.

H51D-1088 0830h POSTER

Transverse drainage development along a tectonically active transform plate boundary (San Lorenzo River and Pancho Rico Creek, Monterey County, California)

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Transverse drainage is often assumed to form as a result of either antecedence or superposition. Drainage-basin geomorphology in the Diablo Range of central California suggests that Pancho Rico Creek established transverse drainage as result of headward erosion, and drainage diversion caused by a landslide. Stream piracy may have also played a significant role. Mesoscale stream catchments within the Diablo Range of central California are elongate parallel to the NW trending San Andreas Fault zone (SAFZ). Principal streams draining these catchments ultimately flow to the west and form transverse drainages across the western ridges of the Diablo Range. Examples include the San Lorenzo River (SLR), which flows into the Salinas Valley at King City, and Pancho Rico Creek (PRC), which flows into the Salinas Valley at San Ardo. Incision patterns, fluvial stratigraphy, wind gaps, and beheaded, SW-flowing piedmont streams suggest that southeastward expansion of the SLR catchment occurred via headward erosion parallel to the SAFZ. Expansion occurred at the expense of SW-flowing piedmont streams, which were separated from the upland parts of their catchment by