rock piles,tailings impoudments,underground workings, mine pits)can occur along numerous hydrological pathways including complex fracture controlled ground-water pathways. Since 1991, the United States Environmental Protection Agency, the Colorado Division of Minerals and Geology and the University of Colorado (INSTAAR)have been conducting applied hydrologic research at the Mary Murphy underground mine. The mine is in the Chalk Creek mining district which is located on the southwestern flanks of the Mount Princeton Batholith, a Tertiary age intrusive comprised primarily of quartz monzonite.The Mount Princeton batholith comprises a large portion of the southern part of the Collegiate Range west of Buena Vista in Chaffee County, CO. Chalk Creek and its 14 tributaries drain about 24,900 hectares of the eastern slopes of the Range including the mining district. Within the mining district, ground-water flow is controlled by the distribution, orientation and permeability of discontinuities within the bedrock. Important discontinuities include faults, joints and weathered zones. Local and intermediate flow systems are perturbed by extensive underground excavations associated with mining (adits, shafts, stopes, drifts, , etc.). During the past 12 years numerous hydrological investigations have been completed. The investigations have been focused on developing tools for characterizing ground-water flow and contaminant transport in the vicinity of hard-rock mines in fractured-rock settings. In addition, the results from these investigations have been used to develop a sound conceptual model of ground-water flow and transport of heavy metals from the mine workings to Chalk Creek. Ground-water tracing techniques (using organic, fluorescent dyes) have been successfully used to delineate ground-water flow paths. Surface-water tracing techniques have been used to acquire very accurate stream flow measuements and to identify ground-water inflow zones to streams. Stable (O18/D)and radioactive (tritium,sulphur 35) isotope anlysis of waters flowing into and out of underground workings have proved useful for conducting end member mixing analysis to determine which inflows and outflows are most significant with respect to metals loading. Hydrogeologic mapping, inverse geochemical modeling (using MINTEQAK code)and helium 3 analysis of ground water have also proven to useful tools. These tools, used in combination have provided multiple lines of evidence regarding the nature, timing and magnitude of ground-water inflow into underground mine workings and the distribution and types of hydrologic pathways that transport metals from the underground workings to Chalk Creek. This paper presents the results of some of the more important hydrologic investigations completed at the site and a conceptual model of ground-water flow in fractured rock settings that have been impacted by underground mining activites.

H42C MCC: Level 2 Thursday 1330h

Form, Process, and Climate in Landscape Evolution III Posters

Presiding: **K M Cuffey,** University of California, Berkeley**; M Strecker,** University of Potsdam

H42C-1084 1330h POSTER

Fluvial Responses to Holocene sea Level Variations Along the Macdonald River, New South Wales, Australia

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The Macdonald River drains the rugged eastern flanks of Australia's Great Dividing Range. It has a catchment area of 2000km^2, restricted alluvial lowlands confined by bedrock interfluves and flows into the Hawkesbury River, a larger estuarine valley. The Macdonald valley is presently tidal for 14km from the Hawkesbury. At about 8000 year before present (BP), rising sea level invaded the Macdonald Valley for at least 35km upstream of the Hawkesbury River. Rapid aggradation occurred between 8000 and 6000 years BP and a sand bed river was established in the Macdonald Valley, its mouth prograding rapidly towards the Hawkesbury. Little is known about the character of the sand bed river during the +2 meter sea level highstand occurring between 5000 and 4000 BP. However, from 3000 to 1500 BP when sea level was consistently at +1 to +1.5m, major floodplain and levee-like structures, now virtually inactive, were established. The bed is inferred to have been elevated above its present day level and consequently intersected mean sea level (MSL) downstream of its present location. This is consistent with reported sea levels at +1 to +2m above present levels for the New South Wales coast at this time. From 1500 years BP, local sea level fell rapidly to its present level. Aggradation of the levee crests ceased and sedimentation along the valley became restricted to aggradation of an inset floodplain, within the pre-1500 BP deposits. The channel contracted and the sandy river bed incised. An equivalent and synchronous change in sedimentation style is observed along the Tuross River 400km south of the Macdonald, lending support to sea level variations being the factor driving this change. By 1850 AD, the bed dipped below MSL about 10km upstream of its inferred position prior to 1500 years BP. A series of large floods between 1949 and 1955 eroded significant volumes of sandy sediment from the Holocene deposits. The channel bed widened from between 25 and 50m width to ∼100m along some 35km of river, mostly upstream of the tidal limit, and meanders were cut off. The bed aggraded by 3m and the point of intersection of the river bed with MSL shifted 7.6km down valley. The channel has contracted since these floods and is building a new floodplain below the post-1500 BP inset floodplain. The late Holocene fluvial history of the Macdonald River is one of rapid adjustment to falling base level. The formation of the major fluvial landforms of the valley coinciding with late Holocene sea level at +1 to +2m, followed by subsequent abandonment of this surface with associated bed incision and channel straightening, may be a common phenomenon along river systems of eastern Australia. If so it may explain the propensity for instability of rivers along the New South Wales coast.

H42C-1085 1330h POSTER

Heterogeneous Soil Morphology on the Taoyuan Terrace, Northwestern Taiwan

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In this study soil geomorphology is selected to work on the reciprocal relationship between the landscape evolution and soil genesis. Among geological studies on the Taoyuan area, it has remained a concern to apply lateritisation as an index on terrace correlation. To answer this question, the basic knowledge of laterite formation must be clearly understood. On the other hand, pedologists have long been interested in the genesis of laterite, especially those thick ones on the higher terraces. To give insights pedosequences must be built up to distinguish the influence of specific factor. Without assistance of geological data, this goal is hardly achieved. In spite of the obvious demand of interdisciplinary integration, it is short of dialogue between geology and pedology in Taiwan until the last decade when the first soil chronosequence was established in this area. However, the tacit assumption that soils on one geomorphic surface were homogeneous has never been carefully examined. A later study on soil toposequence in the coastal area of Taoyuan terraces soon discovered that soils on one surface were heterogeneous both morphologically and chemically. This finding was explained as the influence of the seasonal undulation of groundwater table. To understand whether the upland soils on geomorphic surfaces are also heterogeneously developed, the soil morphology on the Taoyuan Terrace is selected as target being carefully studied. The relationships among the soil morphology, the undulation of groundwater table (GWT), and the processes of soil formation are established by field investigation and previously reported datasets. Based on recompilation of the published soil maps, the soil series in study area can be divided into eight groups. To compare the soil morphology and assess the reliability of the soil maps, fifteen hand cores are drilled in the field. The datasets of engineering boreholes are also collected to assist the explanation on the spatial variation of soil morphology. We discovered that the soil morphology systematically changes from the terrace edge to the interior, showing a toposequence of red soil, orange soil, yellow soil, mottled soil, and gley soil. Based on the profile reconstructed by the engineering borehole data, the GWT is inconsistent with the subsurface lithology but controlled by the terrace geomorphology. Since soils on the terrace edge are usually developed in well-drained condition for lateritisation, we consequently suggest that they are the best prospective soils for terrace correlation.

H42C-1086 1330h POSTER

Cosmogenic ^{36}Cl dating of the all time limit of glaciation, Del Bonita upland Alberta/Montana border and insights into changing extents and ice-flow patterns in successive continental ice sheets

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The Del Bonita upland is a nearly horizontal, unglaciated interfluve along the Alberta, Canada/Montana, USA border (centered on 49°N and 113°W). It separates the basins of the Milk and St. Mary rivers. It is capped by the distinctive maroon Flaxville gravel of late Tertiary age. It is bordered to the west, north and east by a belt of moraine and glaciofluvial channels. The moraine represents the local limit of glaciation. It contains clasts derived from the Canadian Shield, Interior Plains and Rocky Mountains. Whether it is Late Wisconsinan in age or older has been disputed, with proponents on both sides of the international border arguing at various times for Wisconsinan and pre-Wisconsinan ages. Ages of emplacement were determined for eight large glacial erratics (2-30 m^3) using the cosmogenic ^{36}Cl exposure dating method. These included carbonate and quartzite erratics from the Rocky Mountains and plutonic and metamorphic erratics from the Canadian Shield. Erratics were situated between 112° 02' W to 112° 51' W and 49° 1'N to 49° 6'N. Zero erosion ages are, in increasing age (in years): 11,500±420,14,040±510, 15,500±630,19,600±780, 20,800±780, 21,050±670, 22,100±800, 30,300±1160. All, save the last age, indicate emplacement during the Late Wisconsinan Stage. The ca. 30 ka age was determined on one of the quartzite 'Foothills erratics'. It indicates some pre-exposure to cosmic radiation. That is consistent with the rockfall-on-mountain-glacier origin of the Foothills erratics. The mixture of Rocky Mountain and Canadian Shield erratics in this area is consistent with southeast flow of coalescent Laurentide Ice Sheet and Rocky Mountain piedmont glaciers along the eastern margin of the Rocky Mountain Foothills during the climax of the Late Wisconsinan Stage. The clearly Late Wisconsinan age of the erratics further supports the view that the Laurentide Ice Sheet of the LGM was the most extensive of all Pleistocene ice sheets in southwestern Alberta. Furthermore, when combined with the regional distribution of tills predating the Late Wisconsinan in southeastern Alberta, southwestern Saskatchewan and northern Montana, the southeastern flow pattern in the southwestern margin of the Laurentide Ice Sheet during LGM is shown to be unique: previous ice sheets had north to south or northeast to southwest flow patterns in the same region.

H42C-1087 1330h POSTER

Landscape Evolution and Carbon Accumulation: Uniformitarianism Revisited

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What is the role of hillslope transport in long-term carbon accumulation in soils? How do parent material, climate, and landform interact to produce the landscapes we observe today and to what extent can we use present day conditions to infer the dominant processes of the past? We use the CREEP [Rosenbloom, N.A. et al., 2001] process-response model to ask these questions, exploring the time-evolution of landscape form, soil distribution, and carbon accumulation in an undisturbed prairie site in western Iowa [Harden, J.W. et al., 2002]. The CREEP model simulates differential transport of soil particles, blanket deposition of atmospheric 10Be with eolian dust, and passive advection of soil carbon and 10Be, enabling the preferential enrichment and

burial of rapidly moving soil constituents. By comparing landscape-wide average accumulations of 10Be to borehole observations at three hillslope positions, we conclude that the distribution of clay-adsorbed 10Be cannot be explained by co-transport with clay particles alone. Rather, 10Be appears to behave as a more complex tracer than originally assumed, requiring an explicit, independent parameterization of wet deposition and transport. By comparison, model carbon accumulation strongly reflects patterns of clay redistribution indicating that in situ carbon turnover is faster than redistribution. Observed vertical distributions of soil properties, including 10Be, could only be explained by assuming variations in deposition and erosion rates, specifically periods of accumulation, followed by periods of transport. This effect might not be apparent if only landform shape, geometry, and soil depth were considered and vertical distributions of soil properties were not explicitly simulated. The current landscape reflects a history of strong shifts in erosion and accumulation rates that cannot be simulated using a uniform parameterization of long-term landscape-evolution processes.

H42C-1088 1330h POSTER

The Effect of Wildfire on Rill Erosion

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Wildfire can alter hillslope hydrologic processes which in turn can alter the erosional processes. This becomes a problem if new, incisive erosion begins to operate in regions of the watershed that were previously only subject to diffusive erosion. Such erosional regimes, incisive versus diffusive, can be delineated by the relationships between slope and drainage area by assuming certain hydrologic conditions. The purpose of this study is to determine if rills, which commonly occur after wildfires, exist in regions of the watershed that are not typically subject to incisive erosion. This is accomplished by mapping the topographic position of new rills in two recently burned watersheds and determining if their origination points plot in modeled diffusive regions of a slope-area plot. Where the rills plot on the slope-area graph indicates the state of equilibrium for that hillslope. If the rills plot in areas dominated by erosion by overland flow, it indicates that there is a correlation between the erosional process and the erosional feature. If the rills plot in areas dominated by diffusive erosion, it indicates a state of disequilibrium between the erosional process and the erosional feature. The contributing area and slope of seven channel heads and forty-two rills in a burned watershed near Los Alamos New Mexico, and of three channel heads and twenty-one rills in a burned watershed near Bailey Colorado were plotted. Preliminary results show that the channel heads in both New Mexico and Colorado lie in the region predicted to dominated by overland flow. This result verifies the validity of the predictive nature of the slope-area plot. The rill data for both sites lies in the region predicted to be dominated by diffusive erosion. The occurrence of rills in this region indicates that wildfire is affecting the location of the rills by disrupting the hydrology of the hillslope.

H42C-1089 1330h POSTER

Arid Climate Landscape Evolution and the Pediment Problem

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Although widely disseminated throughout many different climatic environments, pediments, or gently sloping, laterally extensive surfaces characterized by a thin veneer of alluvium covering bedrock, are particularly well developed in granitic desert locales such as the Mojave and Colorado Deserts in southern California and the Sonoran Desert in western Arizona. These features form a transitional zone within the piedmont of many exposed batholithic mountainous bodies, separating a zone of bare bedrock erosion in the steep mountain mass from a depositional zone in the alluvial basin. Well developed pediments in granitic environments commonly contain bedrock outcroppings (tors or inselbergs) that may remain uncovered indefinitely and sharp slope discontinuities at the piedmont junction separating the pediment surface from the mountain mass. Pediments have been the focus of debate in geomorphic circles for over half a century. While some geomorphologists have proposed that pediments and their associated tor fields represent unearthed relict landforms, others propose unique modes of sediment transport that form and maintain the beveled form of pediment surfaces. We hypothesize that a simple relationship between bedrock weathering and alluvial thickness could explain this range of enigmatic features and phenomena, a relationship that Anderson (2002) incorporates in his proposed explanation for high alpine surfaces and tors. Field observations suggest that the transformation of bedrock to regolith is most rapid with a finite covering of regolith. This weathering rule, combined with a simple set of sediment transport rules provides a mechanism through which pediment surfaces are produced. We examine the development of pediment surfaces and associated features using a 3D numerical, distributed-parameter landscape evolution model incorporating the most pertinent landscape development processes acting in arid regions. Temporally and spatially variable rainfall (storm size, duration, and coverage), soil types, and rock types can be accommodated. A linear diffusive transport mechanism redistributes sediment downslope, parameterizing the aggregated effects of tree throw (*Yucca brevifolia*), rodent burrowing, rain splash, and soil creep. Sediment flux due to stream flow is nonlinear in water flux, and is modulated by storm averaged infiltration capacity, which is dependent on soil type, depth, and antecedent soil moisture conditions.

H42C-1090 1330h POSTER

Simulating Lanform Evolution on Mars

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Knowledge of the planet Mars largely derives from remote sensing. Although these data are of increasing resolution and spectral coverage, including global topography at about 1 km2 resolution, interpretations vary widely about past processes and environments. Most uncertain is the environment of early Mars, during the Noachian Period (4.5 to about 3.5 b.y.). Interpretations range from a relatively warm wet climate with lakes and precipitation runoff, to a cold, dry Mars with valley networks originating solely from hydrothermally-driven seepage. Geomorphic analysis has generally been based upon image interpretation and terrestrial analogs. Increasingly, however, quantitative process and landform modeling is being brought to bear, including simulation modeling of landform evolution. A simulation model incorporates geomorphic processes relevant to Mars. Impact cratering is simulated geometrically by randomly-located impacts drawn from a size-frequency distribution. Scaling of crater dimensions is based upon fresh martian crater morphology, and heuristic rules govern inheritance from the pre-existing topography. Simulated cratered landscapes serve as initial conditions for simulated eolian erosion and deposition, inundation by lava flows,and fluvial denudation. The heuristic eolian model assumes that the long-term rate of eolian deposition and erosion is a function of an “exposure index”, which is based upon the relative height of a location, such that valleys and crater floors are rapidly filled, level plains either receive no deposition or are slightly eroded, and crater rims and hill summits are eroded. Deposition on Mars is assumed to occur from saltation, deposition of dust from dust storms, and long-distance transport of crater ejecta and volcanic ash. The eolian model predicts that craters should infill at a nearly constant rate. Simulation of lava flow emplacement is also heuristic, based upon flow events of variable duration from specified source vents. The probability of a lava flow extending in a given direction is assumed greatest at the margins of recently active portions of the flow and is proportional to the local topographic gradient. Inundation of a cratered landscape is highly stochastic, with some craters surviving unscathed while neighbors are filled. Sumulation of fluvial erosion largely follows the landform evolution model of Howard [1994], with: 1) weathering rates a function of regolith thickness; 2) mass wasting involving both linear diffusional creep and accelerated motion as slopes approach a limiting angle; 3) detachment-limited fluvial erosion based upon shear stress, unit stream power, or bedload abrasion; and 4) sediment transport and deposition/erosion in alluvial channels, fans, deltas, and pediments. Fluvial erosion of cratered landscapes under assumed desert climate results in short valley systems with enclosed drainages in and between craters that resemble landscapes of the terrestrial Mojave and Basin and Range provinces. Drainage integration increases with time, but continued impact cratering disrupts fluvial networks. Model validation is limited by low resolution of images and topography, lack of stratigraphic information, absence of dating methods, and strong post-Noachian modification of landscapes by wind, mass-wasting, and “gardening” by small impacts. Nevertheless, the profiles of streams and fans are consistent with the gentle sections being sand or fine gravel, and steeper bedrock or boulder-floored sections. Simulated landscapes also compare favorably with the visual appearance of degraded Noachian cratered landscapes and with hypsometry and slope geometry statistics.

H42C-1091 1330h POSTER

Network Structure Control on Bed Material Grain Size Distribution

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The size distribution of the sediment load of a river is a function of the size distribution that enters the river, and the grain-size dependent effects of particle breakdown and net differential storage during downstream transport. In tectonically active mountains, where no net storage of sediment occurs, the average particle size of the sediment load crossing any reach must record the transformation of the input size distribution by the travel-distance dependent particle breakdown. Particles enter at different points along the river network and gather downstream. Hence, the network structure imparts load and travel distribution functions and therefore may strongly control sediment load size distribution. We explore these effects by using the width function (density function of travel distance to an outlet), a contributing area function (per unit reach of a given distance from the outlet (giving input rates)), an exponential decay function for gravel size with travel distance, and various input size distributions. In the simplest case of the input of a single grain size throughout the network, the contributing area and travel distribution functions cause entering particles to have a wide range of travel lengths to a given reach, and consequently a broad distribution of river load particle size is predicted. The lower the attrition rate, the narrower this distribution and more normal the size distribution function. High attrition rates produced grain size distributions skewed to smaller sizes. Grain size distribution passing a reach of the river, in the single grain size input case, is the direct reflection of the travel distribution function. The use of input functions that may typify natural size distributions results in size distributions that are predicted to be skewed towards smaller sizes. This simple modeling suggests that the size of the catchment, the network structure, and the form of the particle breakdown function may strongly dictate the grain sizes available for transport. In turn, this will influence the evolution of channel slope and characteristic bed morphology.

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H42C-1092 1330h POSTER

Predicting Channel Evolution and Sediment and Contaminant Transport Following the Cerro Grande Fire, New Mexico

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The May 2000 Cerro Grande Fire severely burned the headwaters of many of the canyon streams draining through the Los Alamos National Laboratory (LANL), Los Alamos County and Pueblos in Northern New Mexico. The fire increased observed flood magnitudes and hillslope erosion rates by one to two orders of magnitude above pre-fire conditions. A set of modeling activities was undertaken to predict the potential impacts of post-fire floods on channel and floodplain evolution, and sediment and contaminant transport in the steep streams draining the burn area. A contaminant transport model, Reach6, was developed and coupled to the HEC6T sediment transport model to predict redistribution and offsite transport of contaminated channel and floodplain sediments. Model predictions were tested against observed flood data. In particular, the HEC6T predictions were tested against high-resolution Airborne Laser Swath Mapping (ALSM) topographic data, collected before and after a 1440 cfs flash flood in a canyon contaminated with low levels of legacy Pu. The ALSM data showed the spatial distribution of channel and floodplain scour and deposition throughout the canyon. These data formed the backbone of our model testing process, along with observed sediment and Pu concentration data. Good correlation was found

between predicted and observed data for the 1440cfs event, and led to application of the HEC6T model in assessing the effectiveness of remediation and stabilization strategies for Pueblo Canyon. LANL LA-UR-03-6382.

H42C-1093 1330h POSTER

Modeling the stratigraphy and preservation potential of meandering stream deposits

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Both natural and human-induced modes of river and floodplain behavior have the potential to obscure, expose, or even destroy portions of the archaeological record. In valley systems with actively meandering channels much material can be lost to lateral bank erosion. Conversely, floodplain aggradation can bury and therefore obscure sites. In this study we aim to quantify the preservation potential of fluvial units containing archaeological sites as a function of the natural process of meandering, climate change and increased land-use during the Holocene. We used the CHILD simulation model of landscape evolution to explore alternative scenarios in which these three factors are both varied independently and combined. Boundary and initial conditions for the model scenarios are based on the Holocene evolution of the archaeologically-rich Upper Thames Valley, which is known to have witnessed variations in flood frequency, land-clearance, episodic alluviation and river entrenchment. The CHILD model is set up to combine four components that simulate the development of valley and floodplain system: hillslope and channel erosion, lateral stream meandering, overbank deposition, and the accumulation of a 3D stratigraphy. The landscape is represented by an adaptable triangular mesh of nodes, especially suited for simulating the gradual shifting of meander bends. The new stratigraphic layering routine recently added to the model in improves the resolution of the stratigraphic record accumulated by the model. Simulation results reveal systematic controls on preservation potential, and suggest potential sources of bias in the archaeological record.

URL: http://www.geog.ox.ac.uk/research/projects/evs/index.html

H42C-1094 1330h POSTER

Coupling catchment hydrology and landscape evolution: Interactive effects on hydrograph and basin shape

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The catchment hydrologic response to rainfall and the evolution of the river basin network and landscape morphology are closely linked phenomena, albeit active over different temporal scales. While the relation between hydrograph shape and catchment form has long been hypothesized, little is yet understood about the evolution of the basin hydrologic response with catchment age or geomorphic condition. Similarly, the long-term morphologic changes and feedbacks associated with a spatially-variable, evolving runoff response are still unknown. Understanding the complex interaction between basin hydrology and geomorphology was an important pursuit during Michael J. Kirkby's scientific career. In this study, we describe the interactive effects and feedbacks between the basin hydrograph (hydrologic response) and shape (geomorphic response) utilizing two state-of-the-art models: the Channel-Hillslope Integrated Landscape Development (CHILD) and the TIN-based Real-time Integrated Basin Simulator (tRIBS). We first illustrate the changes occurring in the basin hydrograph, variable source area and channel network as the catchment evolves. We then describe how the spatially-explicit hydrologic response from various mechanisms and its associated moisture field directly impacts the erosion and subsequently the basin shape. Quantitative comparisons are then made between a set of interactive and non-interactive simulations for idealized conditions. Our ultimate goal is to highlight the need for coupling distributed simulations of catchment hydrology and geomorphology for investigating the interaction between basin and hydrograph shape.

H42C-1095 1330h POSTER

Spatial organization of soil depths using a landform evolution model.

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The spatial and temporal changes and self-organization of soil depth are examined at both the hillslope and basin scale. In this study the evolution of soil depth is investigated by modeling the interaction between bedrock weathering and surface erosion within a landform evolution model. An enhanced version of the landform evolution model SIBERIA that simulates soil evolution on evolving landforms over geologic time is used in this study. The analysis is performed by modeling the physical processes of soil development such as erosion and weathering. A variety of bedrock weathering models are examined to assess the implications for soil evolution and self organization. For instance, one considers the feedback effects of soil moisture distribution on weathering rate. Previous research in hillslope hydrology has shown the important role of the bedrock surface, representing the effective hydrological impeding layer, in controlling the spatial dynamics of soil moisture. In this study two sets of simulations are compared using the soil wetness index computed using (1) the soil surface and (2) the bedrock elevations to explore the potential impact of the nonlinear feedback of soil moisture on soil organization. Preliminary comparison of the model results with field data is presented.

H42C-1096 1330h POSTER

Wildfire Disturbance and Sediment Transfers over Millennial Time Scales: A Numerical Modelling Study

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Wildfire may lead to accelerated soil erosion, debris flow and shallow landsliding activity in the years following disturbance. This study focuses on coastal drainage basins in British Columbia over millennial time scales, for which accelerated rates of shallow landsliding following wildfire may be of particular significance. An algorithm for wildfire occurrence, based on lake and sediment charcoal studies undertaken in coastal British Columbia and western Washington over millennial time scales (for example, Gavin et al., 2003), is incorporated into a numerical model of sediment routing over these same time scales. A stochastic rule set for wildfire frequency, based on a Weibull distribution of fire return intervals, assigns years of fire occurrence in the model. In terms of location, south-facing aspects are assigned a 25 times greater susceptibility to wildfire than north-facing aspects. As a first-order approximation, it is supposed that loss of tree root strength resulting from stand-replacing wildfires is comparable in its effects to clearcut logging. Therefore, documentation of increased shallow landslide activity associated with logging is used to adjust landsliding transport equations for the years following wildfire disturbance. Thereafter, landsliding rates are returned to pre-disturbance values. Fire return intervals, particularly those on north-facing aspects, can be relatively long in coastal British Columbia when compared to return intervals typically found in drier mountain ranges. This study investigates the degree to which wildfire disturbance affects sediment routing and delivery to channels over millennial time scales in coastal British Columbia. Sensitivity to model parameters is evaluated. Further investigations of wildfire effects on geomorphic process operation will lead to improved understanding of natural disturbance regimes to which ecosystems adjust over both the short and long term. Such information can be used to evaluate possible landscape and ecosystem responses to human disturbances, such as logging and prescribed burns. Reference: Gavin, D. Brubaker, L. and Lertzman, K. 2003. An 1800-year record of the spatial and temporal distribution of fire from the west coast of Vancouver Island, Canada. Canadian Journal of Forest Research 33, 573-586.

H42C-1097 1330h POSTER

How does the distribution of orographic precipitation guide exhumation patterns along the Southern Himalayan front, NW India?

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A strong climatic contrast exist across the Himalaya, whereas the Southern Himalayan Front (SHF) is affected by strong monsoonal precipitation, the internal region between the High Himalaya and the Indus-Tsangpo suture zone to the north is dry. When during the Indian summer monsoon the humid airflow has to cross the Himalaya, it is controlled and funneled by the topography. This result in asymmetric precipitation distribution concentrated in elevations of 2000 to 4000 m along the southern termination of the High Himalaya and provides a high seasonal fluvial runoff, which enables an effective sediment evacuation out of the range. The High Himalaya is actively deforming as indicated by young cooling ages, micro-seismicity, and geodetic data. In the area of the Sutlej River (NW-India) the deeper high-grade metamorphic rocks of High Himayalan and Lesser Himalayan Crystalline are being exhumed as an extruding wedge. Active deformation of the orogen coincides with high monsoonal precipitation, pronounced relief contrasts, steep river gradients and slope angles that predispose these rocks to effective mass removal. But how and if this inhomogeneous distribution of precipitation affects mountain building processes of the Himalayan range is still controversial. New young apatite fission track (AFT) (<1-5 Ma; 30 dates) and 40Ar/39Ar (20 dates) ages from the greater Sutlej area document rapid exhumation of high-grade metamorphic Lesser and Higher Himalayan Crystalline units. Two AFT sample transects are sampled in the range between 1.5 and 4.5 km in elevation along tributaries perpendicular to the Sutlej River. The AFT samples yield ages between <1-4 Ma and correlate with elevation. Compiled regional distribution of AFT ages document a ~50 km long sector where the Sutlej River is crossing the southern termination of the High Himalaya (main orographic barrier), and AFT samples provide young cooling ages of ~1 Ma. Assuming uniform long-term steady-state erosion and exhumation, the rocks were exhumed at a rate of ~1 mm/a during Plio-Pleistocene time. Samples collected near to the riverbanks of the Sutlej further upstream or downstream yield older cooling ages (>3 Ma). The sectors with high exhumation rates correlate with maxima in the distribution of monsoonal precipitation, where the orographic precipitation barrier results in >80% of the annual precipitation. These results suggest a strong interaction between rapid erosion, exhumation, and sediment evacuation concentrated in a ~50-km-wide sector of the Himalayan deformation belt. Thus, this sector may define an extruding wedge whose principal boundaries are defined by climatically controlled erosional processes.

H42C-1098 1330h POSTER

Modeling the Erosion Process in Beaded Streams in a Semi-arid Bajada, Southern New Mexico

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A channel network in Southern New Mexico falls in one of the three categories: splay, bead, and braid. A splay simply refers to diverging channels. A bead refers to channel reaches in which flow first diverges to form an area of multiple flow paths and then converges to form a single channel. A braid is intermediate between a splay and a bead. Recent studies have demonstrated that beads, which widely exist in the semi-arid environment of Southern New Mexico, serve as sinks to attract

more water, nutrients, and sediment than other areas. Thus beads provide a physical base for ecological remediation means to reverse the desertification process. However, the mechanisms for the formation of a bead and geomorphologic factors controlling the properties of a bead are still poorly understood. Given the difficulties of physically tracking and quantitatively estimating the development of a bead in the field, a computer simulation is adopted to model the erosion process that leads to the beaded streams. The modeling is based on a FORTRAN algorithm in which the bajada surface is represented by a matrix of square cells. On each cell, both sediment transport and continuity equations, which are sufficient to describe the erosion process, are applied to determine whether the cell is degraded (erosion), aggraded (deposition), or graded (equilibrium). With a rule of determining the distribution of flow rate from a cell to its downstream neighbors, channels are automatically formed by the erosion processes. The simulation indicates (1) that a bead is formed with the combination of three factors: uneven distribution of flow rate, infiltration, and the degree of distribution, (2) that a bead, once formed, is stable, (3) that the size and shape of a bead are controlled by the discharge-infiltration ratio.

H42C-1099 1330h POSTER

Threshold conditions for channel initiation based on hydro-geomorphic observation in the eastern Ashio Mountains, Japan

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Threshold conditions for channel initiation in a humid forested mountain in the eastern Ashio Mountains, Japan, were examined from the monitored data of hydro-geomorphic processes coupled with the concept of channel initiation model. The study area is underlain by Triassic bedded chert, and has an annual rainfall of 1476 mm. Field investigation at 22 channel heads showed an inverse correlation between A (source area m^2) and S (local channel gradient below a channel head): A = 768 S$^{-2.5}$ (r^2 = 0.56). Observation of discharge at 12 springs revealed scattered area-discharge relations at the base-flow regimes, but a better area-discharge correlation ($p < 0.001$, $r^2 = 0.79$) was observed at the recession stage of the largest storm flow. Stream discharge and rainfall were automatically monitored at two channel-head basins (C1 and C3U) during summer to autumn rainy season (June to October) for 3 years (2000-2002). Relation among peak discharge Q_p, source area A, and rainfall properties can be empirically expressed by a linear function here: $Q_p = k_p r_e A$, where, k_p is dimensionless coefficient on runoff peak generation, r_e is effective rainfall rate for runoff peak generation. Maximum 4-hour rainfall (R_4) is suitable for the effective rainfall rate. Based on the regression analysis ($p < 0.001$, $r^2 = 0.85$), rainfall-runoff relationship is expressed as $Q_p/A = 68.66 \times 10^{-6}$ (R_4 - 0.014) m s^{-1}. Bed-load discharge was also observed at the channel-head sites (C1 and C3U) for 3 years (2000-2002). The result indicates that once the peak-stream discharge exceeds a critical value, bed-load discharge abruptly increases. Estimated critical discharge Q_{cr} is 0.035 m^3 s^{-1} at C1, and is 0.007 m^3 s^{-1} at C3U. The critical discharge can be approximately expressed by a power function of $Q_{cr} = \gamma / S^2$, where $\gamma = 6.4 \times 10^{-3}$ m^3 s^{-1}. Considering the condition of $Q_p = Q_{cr}$, the threshold condition for bed-load transport is $AS^2 = \gamma / k_p r_e = 93.4/(R_4 - 0.014)$ m^2. Comparing the observed channel-head location with the threshold condition, R_4 = 120 mm (0.12 m), which corresponds to the estimated return period of 20 years, is the most suitable rainfall condition for channel initiation. The channel head, which may be initiated by a rare intensive storm with quite long return period (>> 20 years), cannot be maintained probably by the sediment supply from slopes.

H42C-1100 1330h POSTER

Drainage Development in a Submarine Setting, Offshore Eastern Taiwan

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The connectivity between the submarine and subaerial environments is intrinsic to landscape development in an emerging mountain belt. We present initial results from a study of onshore and offshore topography in Taiwan. Taiwan forms a linear mountain belt propagating from the north-east to south-west. The offshore bathymetry to the south-east is progressively uplifted and exposed subaerially, providing a template on which onshore topography develops. In turn the drainage network onshore transports material to the ocean controlling the distribution of sediment offshore and the position of river-fed submarine canyons. We have implemented a number of common geomorphic tools to compare onshore and offshore channel networks in eastern Taiwan. Onshore channels show typical concave profiles with many tributaries merging smoothly into the main channel. Local channel slope decreases systematically with increasing drainage area and there is a clear distinction between hillslope and channel processes at ~1 km^2 upstream area. The slope frequency statistics peak at ~30°, probably related to the threshold for slope failure. The main offshore channels are steeper implying the submarine slope has a steeper taper than the subaerial part of the mountain belt. The longitudinal profiles have large knickpoints suggesting less efficient cutting or more active faults offshore. The tributary catchments have constant slope with increasing upslope area and abruptly join the main channel. This constant slope, ~20°, is considerably lower than onshore, possibly due to increased pore pressures, and suggests landslides dominate at smaller drainage areas. Despite similar slope area statistics at drainage areas greater than ~1 km^2 our observations imply fundamental differences between the erosional processes in the submarine and subaerial domains.

H42C-1101 1330h POSTER

Impacts of Groundwater Dynamics on Landscape Evolution

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Many numerical models have been developed recently to describe the evolution of landscapes under tectonic, hillslope, and fluvial processes. In most of these models, hydrological processes such as precipitation, infiltration, and groundwater flow are greatly simplified or neglected to facilitate efficient computation. These hydrologic processes ultimately determine the movement and distribution of water, which control soil erosion and sediment transport. Groundwater is one of the most important hydrologic components because it influences soil moisture conditions and the partitioning of precipitation between surface runoff and infiltration. In addition, when groundwater returns to the land surface, it can produce saturated seepage faces, which are often associated with amphitheatre-like channel sources. Groundwater has been considered in several recent landscape evolution models by introducing an effective precipitation rate that equals the difference between the precipitation rate and an infiltration rate. In these models, the infiltrating water is simply removed from the simulation, so groundwater discharge is not possible. This paper presents a new method to consider groundwater in models of landscape evolution. The two-dimensional Dupuit equation is used to describe the groundwater flow in a homogeneous isotropic unconfined aquifer. The aquifer can represent the regolith and the impervious layer under the aquifer can be an irregular bedrock surface. The groundwater table is tracked by simulating this equation, and the locations and amounts of groundwater discharge are calculated through a comparison of the groundwater table and the land surface. The results from this model are compared with those from traditional models. Under certain circumstances, groundwater has an important impact on the slope-area relationship and other measures of basin morphology.

H42C-1102 1330h POSTER

Coupled Environmental Processes: Implications for Landscape Development in the northern Mojave Desert

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Hypotheses were developed that several environmental processes in the near-surface biosphere are intimately linked or "coupled" and can lead to the development of highly stable landscapes in arid climates. Evaluation of these hypotheses can be used to design vegetated, evapotranspiration (ET) covers that could be long-term stable components of waste disposal sites, and to understand how disturbed land (from development or military activities) can be restored or rehabilitated. To define these links quantitatively through time, field and laboratory studies were conducted on changes in soil structure, soil hydraulic properties, vegetation establishment and diversity, and bioturbation processes at a series of four analog sites (30, 2000-3000, 7500-12,500, and 125,000 years in age) on the Nevada Test Site, Nevada, USA. Tests included soil textural and structural determination; soil hydraulic property measurements in sub-canopy and plant interspaces; and vegetation, faunal and geomorphic surveys. Result

H42C-1103 1330h POSTER

Digital elevation models and the characterisation of catchments over different grid scales

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Well known geomorphological descriptors and statistics are examined for their ability to differentiate between catchments with spatially varying geology, size and shape. The effect of digital elevation model grid resolution on these statistics is also examined. Results demonstrate that catchment descriptors such as the area-slope relationship, cumulative area distribution and hypsometric curve can differentiate between catchments with different geology and resultant morphology, but catchment network statistics are insensitive to differences in geology. Examination of the effects of digital elevation model grid scale demonstrates that while considerable catchment information can be gained at digital elevation grids greater than 10m by 10m, considerable hillslope and hydrological detail can be lost. Consequently, caution is needed when deciding on an appropriate grid resolution as well as the interpretation and analysis of catchment properties at grid scales greater than that for optimal hillslope and area aggregation definition.

H42C-1104 1330h POSTER

Climatic influences on Holocene variations in soil erosion rates on a small hill in the Mojave Desert

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A study of a small hill in NE Mojave Desert in eastern California was conducted to determine the effect of climate on variations in soil erosion rates in the Holocene. Field surveys and sampling obtained information on topography, geomorpohology, soil and vegetation conditions, seismic refraction, sediment deposition, and hillslope processes. The hill topography at the end of the Holocene was reconstructed, and the evolution from the end of the Holocene to the present was deduced. Holocene transport rates were estimated. Packrat midden studies by other investigators imply that the NE Mojave Desert experienced enhanced monsoonal precipitation in the early Holocene, presumably

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accentuating soil loss. Water erosion on one slope of the hill was simulated using WEPP (Water Erosion Prediction Project) using 4 kyr and 6 kyr of precipitation input compatible with an appropriate monsoonal climate and the present climate, respectively. The WEPP-predicted soil losses for the chosen slope were compatible with inferred soil losses. Identification of two time periods within the Holocene with distince erosion characteristics may provide new insight into the current state of Mojave Desert landform evolution.

H42D MCC: Level 2 Thursday 1330h

Linking Lateral Hydrologic and Geomorphic Processes to Space-time Scaling Behavior in the Near-Surface Environment Posters *(joint with NG)*

Presiding: **T R Green,** USDA Agricultural Research Service**; J A Ramirez,** Colorado State University

H42D-1105 1330h INVITED POSTER

Coupled surface-subsurface response to rainfall: Runoff nonlinearity and scale-dependence in a topographically complex catchment

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Storm hydrograph peak and timing are controlled by the interaction of rainfall characteristics, such as storm intensity and duration, with the antecedent wetness in a topographically complex catchment. This study investigates the transient runoff response to storm events of varying properties using a physically-based, distributed model of the coupled surface-subsurface system which incorporates the observed spatial variability in topography, soils and vegetation. We demonstrate the significant control that differential runoff partitioning (infiltration-excess runoff, saturation-excess runoff, perched return flow and subsurface stormflow) has on the nonlinearity in the rainfall-runoff transformation and its scale-dependence over multiple internal basins. Antecedent wetness conditions imposed through a distributed water table position are also varied to illustrate its important effect on runoff generation. Differences in rainfall partitioning into surface and subsurface flows explain the nonlinearities in the hydrograph characteristics over a range of basin scales. In particular, storm events excite specific components of the surface-subsurface model leading to variable flood responses over the complex terrain. An analysis of the spatial organization of runoff production also illustrates that multiple runoff mechanisms have specific catchment niches and can occur simultaneously within the basin. In addition, catchment scale plays an important role in the spatial-temporal distribution of individual runoff mechanism as topographic complexity is varied.

H42D-1106 1330h INVITED POSTER

Nonlinearity as a linkage between lateral hydrologic and geomorphic processes and emergent space-time scaling behavior

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The causal relationships between near-surface hydrologic/geomorphic/meteorologic processes operating over a wide range of space and time scales are poorly known. While nonlinear complexities have been explored theoretically in hydrology, concrete examples of process nonlinear complexity has yet to be well defined. In geomprhology, a recent paper by Phillip (2003 Progress in Physical Geography, 27: 1-23) has clearly defined known field observable nonlinearies: storage effects, saturation and depletion, self-reinforcing positive feedbacks, self limitation, competitive relationships, multiple modes of adjustment, self organization and hysteresis. This poster follows from Phillip by presenting an equivalent set of archetypal nonlinearities observed in hillslope hydrology. This synthesis is based on examples from our research sites in New Zealand, Japan, North America and Europe. We argue that this identification of the underlying causes of seemingly "random" behavior (where every hillslope and small catchment appears unique!), may be an important step to predictability, particularly in ungauged settings. A nonlinearity-based approach to hillslope hydrology-geomorphic coupling may be a useful framework to sort through the morass of process complexity revealed in the past decades. The poster makes a case for urging experimentalists in the coming years to return to the myriad of hillslopes and catchments where we have worked and perform intercomparison and classification of these nonlinear first order controls. They may well be a pathway to understanding emergent behavior and space-time scaling behavior.

H42D-1107 1330h INVITED POSTER

Hydraulic Property Upscaling in heterogeneous Soils

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We discuss two themes for upscaling of soil hydraulic properties in both steady state and transient flows in heterogeneous soils: (1) hydraulic parameter averaging schemes in describing the ensemble behavior of heterogeneous formations and, (2) the effective hydraulic parameters obtained by conceptualizing the heterogeneous soil formation as an equivalent homogeneous medium that will approximately discharge same flux as the ensemble flux of the heterogeneous formations. For the steady state flows, we compare the averaging schemes and the ensemble behavior of the heterogeneous soils and address their effectiveness and uncertainties. We also investigate the impact of parameter correlation, boundary condition (surface pressure head) and elevation above water table on the effective hydraulic parameters. For the transient flows, we investigate the effective soil scaling factor for infiltration under relatively wet conditions in terms of the optimal effective powers for the input parameter fields. The derived optimal effective powers for the random parameters define an optimal averaging scheme for the random fields. Specifically, we discuss the effects of microtopography (as reflected in surface ponding depth), and hydraulic parameter correlation on the ensemble behavior as well as on the optimal effective powers. Variability of the Miller-Miller scaling factor has the most significant effect on the ensemble flux behavior. The correlation among the Miller-Miller scaling factor, the saturated water content and the surface ponding surface increases the effects of soil heterogeneity. However, the ensemble flux behavior can be more precisely mimicked through the idea of optimal effective powers when the random fields are better correlated.

H42D-1108 1330h POSTER

EFFECTIVE SOIL HYDRAULIC PARAMETERS IN HETEROGENEOUS SOILS

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The effective soil hydraulic parameters of the areally heterogeneous soil formation are derived by conceptualizing the heterogeneous soil formation as an equivalent homogeneous medium and assuming that the equivalent homogeneous soil will approximately discharge same total amount of flux and produce same average pressure head profile in the formation. As compared to previous effective hydraulic property studies, a specific feature of this study is that the derived effective hydraulic parameters are mean-gradient-dependent (i.e., vary across depth). Three widely used hydraulic conductivity models were employed in this study, i.e., the Gardner model, the Brooks and Corey model and the van Genuchten model. We examined the impact of parameter correlation, boundary condition (surface pressure head) and elevation above the water table on the effective saturated hydraulic conductivity and shape parameter. The correlation between the saturated hydraulic conductivity Ks and the shape parameter α increases the effective saturated hydraulic conductivity, while it does not affect the effective α. The effective α is usually smaller than the mean value of α, while the effective Ks can be smaller or larger than the mean value depending on no correlation or full correlation between Ks and Á fields, respectively. An important observation of this study is that the Gardner and the van Genuchten functions resulted in effective parameters, whereas it is difficult to define effective parameters for the Brooks Corey model since this model uses a piecewise-continuous profile for hydraulic conductivity.

H42D-1109 1330h POSTER

On The Soil Moisture Dynamics: Does Simplification Alter Soil Moisture Prediction?

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The soil moisture dynamics of water controlled ecosystems are governed by complex interactions between vegetation, soils and climate. Recent research has achieved significant results in the description of such dynamics through the development of a steady state probability density function (pdf) of the soil moisture [Rodriguez-Iturbe et al., 1999 and Laio et al., 2001]. The assumptions of this model are necessarily oriented to simplify the mathematical form of the soil loss function and the rainfall process. In order to asses the effect of these simplifying assumptions, we incorporated alternative representations of leakage, infiltration, and rainfall into the existing model introduced by Rodriguez-Iturbe et al. [1999]. The mean and variance of the soil moisture pdf obtained using numerical simulation of four different schemes are compared across a range of climate, soil, and vegetation combinations. The analysis finds that the previous model agrees well with the alternative representations for many cases, but that significant differences can occur. Results are considered to be of interest for both ecohydrological studies and hydrological analysis.

H42D-1110 1330h POSTER

Small-Scale Land Surface Variability Effects on Hillslope-Scale Hortonian Runoff Generation

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Factors that control infiltration, and therefore runoff generation, are known to vary at sub-hillslope scales. Spatially variable runoff generation leads to the potential for interactive infiltration. These small-scale dynamic interactions can exert a strong control over hillslope-scale response timing and magnitude. Questions remain regarding the nature of small-scale interactions: What is the aggregated effect of increasing variability? How do correlation length scale and structure govern interactive infiltration? How do these factors interact with macro and microtopography? These and other questions can be addressed using direct numerical simulation of the small-scale hydrodynamic processes, using a computational mesh small enough to explicitly resolve landscape spatial variability. For such simulations, random landscape property fields that comprise synthetic hillslopes with specific characteristics (e.g., mean, coefficient of variation, correlation length scale and structure of saturated hydraulic conductivity) are generated. Results of simulations performed on a range of synthetic hillslopes are presented in this poster.

H42D-1111 1330h POSTER

A Physical, Mechanistic and Fully Coupled Hillslope Hydrology Model

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