are typical for many field applications. The previous screening models lumped the entire NAPL source zone together without considering the spatial distribution of NAPL source zone concentrations. The new models will incorporate the fact that the NAPL mass in the upstream will dissolve first. It will create a dissolution zone and this zone will travel downstream at certain velocity. Based on this consideration, the NAPL zone concentration is dependent on not only the time but also the distance into the NAPL zone.

H21B-14 0830h POSTER

A Three-Dimensional Water Flow and Solute Transport Model in the Context of two Contrasting Boundary Conditions in Unsaturated Zone

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ABSTRACT A Three-Dimensional numerical model based on the Richards Equation and the Explicit Characteristic Galerkin Method for water flow and solute transport respectively was tested with potential seepage face and impermeable boundaries in the unsaturated zone. The test problem, envisaged as a representative section of a paddy field under irrigation for which the model will be used to predict water and solute movement during the growth period of rice and beyond, received solute with infiltrating water from the ground surface. The infiltration rate and solute concentration were kept constant as the soil moisture increased until the flow region became fully saturated, and then infiltrated water was allowed to recede through natural drainage. Usually, in order to save computation time, especially for three-dimensional cases, seepage face boundaries are undesirable while impermeable ones are sometimes hypothetical. The results indicate almost identical water flow and solute movement pattern prevailing during infiltration for both boundary conditions, but during drainage only seepage face boundaries seem to represent well the physical reality of ground water flow. Solute movement is significant during infiltration phase of simulation and confined to the saturated part. During drainage the movement is to the lesser extent and appears mainly near the boundaries in the unsaturated part. Generally, the model gives the expected trend for water flow and solute transport.

H21C CC: 220 C-E Tuesday 0830h

Tracers in Hydrology II Posters *(joint with B)*

Presiding: **B L McGlynn,** Montana State University**; M Weiler,** University of British Columbia

H21C-01 0830h POSTER

Hydrological implications of 234U/238U disequilibria observed along pressure dissolution discontinuities in deep Mesozoic limestone formations of the Eastern Paris basin

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Borehole core samples from the deep, low-permeability Mesozoic formations surrounding the target argilite layer of the Meuse/Haute-Marne experimental site of the French agency for nuclear waste management -ANDRA- were analyzed for their uranium isotopic abundance. This study attempts to decipher the history and the processes governing the mobility of uranium in such geological settings by means of precise measurements of the (234U/238U) activity ratio. Limestone zones characterized by pressure dissolution structures (stylolites or dissolution seams) display systematic (234U/238U) disequilibria: i) the material within the seams shows a deficit of 234U over 238U ((234U/238U) down to 0.80) and ii) the surrounding carbonate matrix is characterized by an activity ratio greater than unity (up to 1.05). These results highlight a discret, centimetric-scale uranium remobilization in the limestone formations along these subhorizontal seams during the last 1-2 Ma and, consequently, active water/rock interaction processes since fractionation of 234U vs 238U necessary involves exchanges at the water/rock interface and migration via interstitial fluid. The nature and the modalities of the driving processes responsible for these disequilibria are not unequivocal, but different scenarios can be put forward to explain the U-remobilization observed: 1) late epidiagenetic processes associated to the presence of pressure dissolution structures, or 2) preferential fluid circulation along the stylolitic pathway. The major consequences in terms of the conceptual modeling of the hydrology behavior of the formations and, obviously, on the site performance assessment, are discussed.

H21C-02 0830h POSTER

The Effect of Transient Flow on Contaminant Dispersion in Porous Media

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Our ability to predict solute transport in groundwater is limited by our imperfect understanding of the physical processes governing the spreading of underground contaminant plumes beneath the surface. Inaccurate prediction of solute migration can in turn result in unreliable risk analyses, or higher costs for groundwater decontamination. It is generally accepted that spatial variations in the hydraulic conductivity of porous materials largely contributes to the spreading of solutes dissolved in groundwater. Unsteady hydraulic gradients can also enhance this dispersion by imposing an additional source of variability on the flow field. Most field and numerical studies assume steady state groundwater flow, despite compelling field evidence suggesting that flow transience may be ubiquitous. This study characterizes the effects of transient groundwater flow on contaminant migration in both homogeneous and heterogeneous porous media. The macroscopic dispersion of miscible solutes subjected to unsteady flow fields is assessed quantitatively through a series of laboratory experiments and numerical simulations. An innovative laboratory model is introduced, which consists of a two-dimensional flow cell and coupled hydraulic control system that allow the construction of spatially homogeneous or heterogeneous porous media of prescribed statistical properties, and to impose deterministic flow transients on the system. A monitoring procedure combining image processing with spatial moment analysis is used to characterize with great spatial and temporal resolution the evolution of contaminant plumes, as measured from sequences of digital images acquired during the course of laboratory experiments. Results suggest that the influence of flow transience on solute dispersion compares well with results reported in the literature, based on theoretical or numerical investigations. Changes in the mean flow direction significantly increase transverse dispersion in proportion to the rotation angle; conversely, longitudinal dispersivity decreases in response to variations in the flow direction, but to a lesser extent. Reversing hydraulic gradients can cause a reduction in the plume extents, or plume "shrinking". Although both the spatial and temporal variability enhance solute spreading, heterogeneity of the porous medium can mask the temporal variations in the flow field. The increased complexity introduced by the spatial and temporal variability can lead to inconsistencies between experimental and numerical models.

H21C-03 0830h POSTER

Determination of groundwater recharge rate using multiple tracers

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Ground water rate is a critical hydrological parameter for understanding groundwater contamination and for groundwater assessment and management. The objective of this study is to determine groundwater recharge rate and transport mechanisms in the unsaturated zone using long-term natural and applied tracers in a semiarid region, Saskatchewan, Canada. Tritium, applied Cl, natural NO3, and SO4 in soil profile were analyzed. From the peak locations of these tracers, ground water recharge rate was determined from the profile distribution of these tracers. Uncertainty associated with these recharge rate estimated was also analyzed.

H21C-04 0830h POSTER

Temporal And Spatial Aspects Of River-Groundwater Exchange In The Regulated Rhone River (Switzerland) Using Chemical And Physical Tracers

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Over the last two centuries most river systems in Central Europe have been regulated to improve flood protection. Large hydropower schemes were developed in the Swiss-Alps, which strongly modified the hydrological cycle. As a consequence of increasing number of flood events, the upgrading and renewal of flood protection dikes in the lowlands is often combined with river restoration projects today. Because this often involves removing or dislocating dikes, the planning and design of such projects under consideration of both flood protection and hydropower schemes should be based on a detailed knowledge of river-groundwater interactions. We test and apply a combination of different chemical and physical tracer methods to qualitatively and quantitatively approach these interactions in the channalised Rhone river reach upstreams of lake Geneva (Switzerland). With these tools we address a series of questions like: 1)Can the seasonality of delta-18O in precipitation be used to distinguish between the hydrological cycles above and below the catchment basin of the hydropower plants? 2)Can we quantify the water exchange between the river and the groundwater in the alluvial aquifer? 18O and sulphate as a tracer: Due to the geological situation -high altitude differences and the presence of gypsum in the Penninic nappes on the south side of the valley, 18O and sulphate concentrations prove to be the most effective parameters to study water exchange. Monitoring stable isotopes in precipitation of different altitudes shows more depleted signatures in winter than in summer. However, this pattern is reversed in the receiving river of the valley ground. The delta-18O winter values in the river (-13.3 to -14.2 permil) are more positive than in summer (-15.2 to -14.4 permil), with variations in delta-18O up to 0.8 permil. This means that the seasonality in the river water (more negative values in summer than in winter) is reversed in comparison to the seasonality in precipitation. Sulphate river concentrations in winter are significantly higher than in summer and scatter largely because of strong influence of the daily runoff fluctuations caused by hydropower production. Temperature and hydraulic pressure as a tracer: The flood protection dike on both sides of the Rhone forms a clear interface between the groundwater and the river itself. In order to evaluate the effects of hydropeaking across the dam, water level and temperature were determined in groundwater wells in different distances from the river. The water level of the Rhone reflects the cycles of hydropeaking. From Monday through Friday, the water level fluctuates daily by approximately one meter. The same behaviour is observed in wells on either side of the dam but the amplitude is attenuated. When the turbines are switched off on Friday evening, the groundwater level stabilises at a lower level, as does the water level of the Rhone. When monitoring the temperature variations in the groundwater, some wells within the dike structure show a regular pattern corresponding to the hydropeaks in the river. Daily temperature fluctuations are 0.1-0.2 degree Celsius. Weekends show a temperature rise by as much as 0.4 degree Celsius. Cross correlating the long-term databases of the pressure and temperature signals provides information about clogging of the river border and allows partial quantification of water exchange between the river and the groundwater.