Dept. of Geology & Environmental Studies
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Schedule

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DO TRACE METAL CONCENTRATIONS IN ROCK VARNISH VARY WITH AGE?

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Rock varnish is a dark coating that is commonly developed on the surface of surficial boulders in many geomorphic settings including arid regions and accumulations of broken rock on steep slopes (scree) or at the base of cliffs (talus). The rock varnish of a scree located in the Blue Ridge northeast of Grottoes was investigated to see whether variations in trace metal content correlated with varying age of the geomorphic surface. Variations in degree of boulder weathering and the amount of lichen cover (Hupp, 1983) were used as indicators of scree surface stability and age. Most recent movement has occurred toward the central lower portion of the scree. Clear evidence of greater stability and longer exposure of the rocks to atmospheric weathering are apparent in the upper portion of the scree and toward the edges.

Rock samples were collected systematically along a line from the lower central portion of the scree to the upper and from a second line from one edge of the scree through the central portion to the other edge. A thin chip was cut from the upper surface of each sample and subjected to a two-step leaching process: 1) Hydroxylamine Hydrochloride to dissolve the manganese oxide portion of the coating; 2) 10% Hydrogen Peroxide in 0.1% Nitric acid to dissolve the lichen portion of the coating. Solutions were analyzed using standard atomic absorption methods and because metal concentrations are theoretically related to the scavenging properties of manganese oxide, results are presented as metal/manganese ratios.

Results indicate that while variations of Cu, Ni, and Zn in the coatings do occur, there is no systematic variation with age of the geomorphic surface. This is true for both the Hydroxylamine Hydrochloride and the Hydrogen Peroxide leaches.

STUDY OF THE LITHOLOGY AND SOURCE OF THE STONE WALL ALONG SUNKEN ROAD AT FREDERICKSBURG, VIRGINIA

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The stone wall along Sunken Road was an important feature at the Battle of Fredericksburg, during the Civil

War and is now a landmark of that site. The dominant rock type making up the stone wall is a coarse sandstone from the Aquia Formation. The Aquia sandstone consists of coarse quartz sand of various colors with a feldspar matrix. A few large quartz pebbles up to 2 inches in diameter are included. Other rocks found in the wall are composed of various igneous and metamorphic lithologies. The percentages of each rock type in the wall were determined by conducting linear traverses at set intervals along the wall. In addition to lithologic identifications, evidence of mechanical quarrying was noted on a small number of the rocks indicating that some of the rocks were mined from quarries in the area. Several abandoned quarries in the Aquia were identified within two miles of the stone wall. Wadel Roundness Values were used to rate the degree of roundness of the rocks in the wall and it was determined that the majority of the rocks in the wall are subrounded to subangular blocky in shape. In addition to shape, sizes of the rocks were also measured. The lithology, roundness, and size of the rocks in the stone wall are being statistically analyzed and the results used to determine if other rocks may have been brought in to rebuild sections of the wall at a later time.

DETERMINING THE ORIGIN OF SULFATE IN SELECTED WATERS OF SHENANDOAH VALLEY, VIRGINIA

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Sulfate is an ubiquitous constituent in most reservoirs of water on Earth. However, in the Shenandoah Valley waters with significant concentrations of sulfate are seemingly rare. Statistical analyses of previously published data indicate that a few springs and wells in the Valley have significantly higher concentrations of sulfate. In order to determine the origin of sulfate in these waters, samples were collected and analyzed for predominant chemical character and isotopes of sulfur. Sulfur isotopes can be used to discriminate between natural (e.g. pyrite, limestone, gypsum, organic matter) and anthropogenic sources of sulfur. The results of this study will provide previously unknown data about the origin of sulfate in waters of the Valley and how it relates to Valley geology and/or identify pollutants if present.

RECONSTRUCTION OF PALEO GROUNDWATER SYSTEMS IN THE MANISTIQUE EMBAYMENT, MICHIGAN

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Previous work has established the timing of Lake Michigan fluctuations over the last 4,700 calendar years BP (cal BP). However the influence that these fluctuation have had upon groundwater flow systems in areas influenced by changes in lake level remains unknown. It is the purpose of this project to investigate the potential controls on groundwater systems based upon changes in Lake Michigan lake-levels and geometry of the groundwater system through time.

Shoreline geometry and paleo lake-levels for Lake Michigan have been incorporated into a mathematical model to reconstruct the groundwater flow system in the Manistique and Thompson embayments in the upper peninsula of Michigan. For this project eleven "snapshots" in time have been reconstructed to show the impact that groundwater focusing by embayment shape, the values of vertical and horizontal conductivity, and the altitudes of Lake Michigan lake-levels have in determining fluctuations in the local groundwater flow system for the past 4,700 cal BP. This knowledge will help us understand how and when certain changes in plant diversity and type (observed in the paleobotanical record) have occurred in response

to changes in the local groundwater flow system. Additionally, this study will start to help us predict the impact that future changes in Lake Michigan lake levels will have on groundwater flow systems.

SOIL PEDOGENESIS OF DEBRIS FANS, GRAVES MILL, VA

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Debris-flow fan deposits in the upper Rapidan River Basin record a long and complex history of activity. During a storm on June 27, 1995, 30.5 inches of rain in 16 hours initiated approximately 1000 slope failures, and incised stream channels and debris fans. The Generals debris fan complex, located 1 km west of Graves Mill in the Blue Ridge physiographic province, was partially impacted by the deluge, and the scouring from the floodwaters exposed prehistoric fluvial and mass movement deposits. This event has allowed the study of soil pedogenesis and geomorphic activity of prehistoric debris flow fans. Cosmogenic 10Be dating and soil chronosequence studies reveal a minimum of five distinct ages of debris fans, spanning from approximately 500,000 YBP to present. The oldest debris fan exhibits two distinct debris flows. The upper unit has a 1.0 m argillic horizon, a 2.5 YR Munsell color, and a clay content of 72%. The lower unit has an argillic horizon that exceeds 0.8 m, a 10R Munsell color, and a clay content of 40%. In contrast, the youngest fan surface lacks significant soil pedogenesis, shows Munsell colors of 10YR, and a clay content of only 3%. XRD analyses of the soil profiles reveal a range of clay mineralogy that includes Kaolinite, Illite, Chlorite, and Vermiculite. Additional research of the debris fan should help further elucidate the landscape evolution of this region.

USING HYDROCHEMICAL DATA AND ENVIRONMENTAL ISOTOPES TO ASSESS MIXING OF WATERS IN A PRAIRIE WETLAND: COWBANE NATURE AREA PRESERVE, STUARTS DRAFT, VIRGINIA

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The Cowbane Nature Area Preserve in Stuarts Draft, Virginia is a prairie wetland with a unique interaction between its surface waters and groundwater. The wetland consists of an upper perched aquifer, a lower groundwater fed spring, a groundwater fed stream that defines the southern extent of the nature preserve, and an area downstream of the spring that appears to be mixing with the upper perched aquifer. To asses the extent of interaction between these chemically distinct waters within the nature preserve the hydrochemical parameters of pH, temperature, specific conductance, and the major ions Ca^{2+}, K^{+}, Na^{+}, Mg^{2+}, Cl^{-}, $SO_4^{=}$, HCO_3^{-}, NO_3^{-}, along with isotopes of hydrogen and oxygen where analyzed. These data show that the upper site contains chemically immature water, which is most likely ponded rainwater while the spring and stream waters are originating from a deeper source causing the water to be more chemically mature.

To assess the degree of mixing occurring between the spring and the upper perched aquifer, a binary mixing model was developed to predict the changes in chemistry for different volumes of water mixed. This model was field tested by analyzing waters along the mixing path.

It is hoped that the results of the mixing model will assist in an effort to establish a zone of the nature preserve where *Buckbean* (Menyanthes trifoliata) can be reintroduced. *Buckbean* is a very rare plant in Virginia's prairie wetlands and needs highly calcareous waters to succeed.

THE KARST DEVELOPMENT OF THE UNION AND HURRICANE RIDGE CAVE SYSTEMS, DICKSON SPRING DRAINAGE BASIN, MONROE COUNTY, WEST VIRGINIA

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The Dickson Spring drainage basin of northern Monroe County, West Virginia, is a well-developed karst basin that encompasses an area of approximately 25 mi2. Until recently, little has been known about subsurface flow routes of waters within the Dickson drainage basin, other than their eventual emergence at the Dickson Spring. However, two recent cave discoveries have revealed significant portions of this complex karst drainage system. These are the Hurricane Ridge and Union Cave systems, which currently comprise more than five miles of known cave passage, and new passages are progressively being surveyed and explored. Union Cave has been positively dye-traced to the Dickson Spring, 6.5 miles to the north.

Mapping of cave passages within Union cave reveals that many of the active tributaries, as well as abandoned paleo-passages, flow (or once flowed) southward, whereas the active main river passage flows almost due north to the Dickson Spring. These two cave systems lie near the southern boundary of the Dickson drainage basin, south of which waters drain southward to Indian Creek. The research assesses the possible roles of headward erosion and stream piracy of the Dickson drainage basin in capturing waters that once drained to the south.

The study also examines the evolution of the Hurricane Ridge and Union Cave systems, with emphasis on their hydrology, and structural and lithological controls on passage development and passage orientation. This aspect of the study is accomplished through the ongoing surveying and mapping of cave passages and subsurface geology. The results of this study should help elucidate the subsurface hydrology of this region.

THE INFLUENCE OF WATER AVAILABILITY ON PLANT RECOVERY RATES AT THE KINSEY RUN DEBRIS FAN; SHENANDOAH NATIONAL PARK, VIRGINIA

Stephen H. Reynolds, L. Scott Eaton, Department of Geology & Environmental Science

A major storm event on June 27, 1995 impacted western Madison and Greene Counties, Virginia, where approximately 30.5 inches of rain fell in 16 hours. The deluge triggered numerous debris flows that impacted a small tributary of the upper Rapidan River basin, Kinsey Run, located in the Shenandoah National Park. One flow traveled for over 2 miles, had a peak estimated velocity of 50 mph, and leveled all vegetation in its path. Today, vegetation is in the process of re-establishing itself at varied rates throughout the fan. Recovery rates were analyzed at six 100 m^2 land plots throughout disturbed area, in addition to a control plot of equal area unaffected by the debris flow. Plant biomass and biodiversity were quantified and compared to the factors of: site position in the fan, grain size and sorting of the soil, topographic elevation, and depth to water table. Preliminary results suggest that recovery rates are greatest in soils that contain high clay-to-sand ratios, typical of minimally disturbed fan surfaces, and in areas of high water availability.

COMPUTER MODELING OF CONTIGUITY AMONG GROWING CRYSTALS IN MAGMA

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The contiguity of a crystal in magma influences physical properties such as effective magma viscosity, strength, and mobility. An understanding of the effect of contiguity is crucial to the study of volcanism and the movement of magma through the Earth's crust. One measure of the degree of contiguity of crystals in a melt is the average count of the number of neighboring crystals that touch each crystal. A computer-modeling program developed with the assistance of students at James Madison University simulates the simultaneous growth of crystals in a magma chamber. Program constants are set before each trial run and include crystal population density, constant growth rates, and crystal shapes and chamber volume. Nucleation sites and crystal orientation are random. Results of three simulations of cubic crystals illustrate minimal deviation when plotted as average contiguity versus percent crystallization, a relationship that appears to be first order. At 100% crystallization the contiguity index is 21. Analysis of data from current trials of tetragonal plates shows a higher maximum contiguity index as well as slightly higher deviation among trials. Further research will include trials of tetragonal needles and various common crystal habits.

A GIS CONSTRUCTION OF A GEOLOGIC MAP OF THE GEORGE WASHINGTON NATIONAL FOREST

Mark Villa, W.C. Sherwood, Department of Geology & Environmental Science

The purpose of this project was to compile a geologic map of the George Washington National Forest in a GIS environment. Quadrangle maps of 1:100,000 scale and state geologic maps of 1:250,000 scale were digitized in Abicas, a GIS program for personal computers by Innovative Technologies of America, Inc.. Lithological formations were attributed to areas created using the digitized maps. Area files were converted to shape files for use in ArcExplorer and ArcInfo. There was extensive edge matching required at this stage to form a complete map of the National Forest from individual shape files of quadrangles. At the same time that the bedrock geology was being compiled in the GIS format, a database containing acid resistivity linked to lithology was created in spreadsheet form. This data can be imported into ArcInfo and added as an attribute to formations. The GIS environment offers the ability to attach numerous other attributes to formations and overlay multiple layers containing any mappable features.

TIDAL INFLUENCE ON THE HYDROCHEMISTRY OF A FRESHWATER TIDAL CREEK; MOUNT CREEK, VIRGINIA

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The Mount Creek waterway, on the Rappahanock River approximately 50 miles inland of the Chesapeake Bay in Virginia's Coastal Plain, experiences fluctuations in water level due to tidal influences. Water chemistry in waterways such as Mount Creek can be impacted by a number of factors such as farming, residential development, and changes due to fluctuating salinity derived from the tides themselves.

Variations in the concentrations of Ca^{2+}, K^{+}, Na^{+}, Mg^{2+}, Cl^{-}, $SO_4^{=}$, and, NO_3^{-}, have been monitored in relationship to tidal variation. It is anticipated that the results of this study can be used as a baseline assessment of the relative impacts that changes in natural salinity and/or anthropogenically derived constituents have on the Mount Creek waterway.