TECHNICAL SESSION ABSTRACTS

Technical Session I – Volcanology and Geology

Chairs: Reuben Ganske, Dept. of Geosciences, Idaho State University
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Topography, Geochemistry and Volcanology of Eastern Snake River Plain Basaltic Shields Studied as Analogs to Mars Plains-style Volcanoes

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Morphologic analysis of small basaltic plains-style volcanoes on the eastern Snake River Plain (ESRP) reveals similarities to those on Mars in dimensions and vent spacing in volcanic fields. ESRP basalts erupted long after the passage of the Yellowstone hotspot, suggesting minimal or marginal involvement of an active mantle plume. Similarly, martian plains-style volcanic regions (Tempe Terra, Syria Planum, and near Pavonis Mons) are located near, but not within, larger plume-related magmatic provinces, suggesting near-plume or post-plume associations. Geochemistry and physical volcanology of the ESRP basalts, studied as planetary analogs to Mars, imply a system with variably evolved magma batches and possibly multiple magmatic sources. Chemical variability is extensive (MgO = ~11.2 - 4.6 wt. %; La = ~8 - 60 ppm) in over 500 analyses of samples representing ~40 individual eruptions. Results from magma evolution models suggest that sequences of sub-volcanic mafic intrusions fractionate to evolved compositions, which can be assimilated by subsequent, less-evolved melts. Olivine equilibrium temperatures determined for the high-MgO representatives are tightly constrained to temperatures above 1200^{o} C, and suggest final separation of magma from upper mantle or lower crust. Low-MgO samples represent lower temperature magmas that typically have the highest incompatible element abundances and coarse diktytaxitic textures composed of interlocking plagioclase crystals and large pore spaces. Oxygen fugacity measurements further suggest oxide equilibrium temperatures ranging ~750 - 1040^{o} C, reflecting protracted post-emplacement crystallization of cooling lava flows. These results support an extensive and diverse post-hotspot system of small mafic intrusions beneath the ESRP.

Keywords: volcanoes, basalt shields, plains-style

Basaltic Volcanism and Hydrogeology of the Eastern Snake River Plain, Idaho: What We Know, What We Don't Know, What We Need to Know, and Why

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After 160 years of sporadic study, the basaltic volcanism of the eastern Snake River Plain (ESRP), Idaho (northeast of 114^{o}W. Long.) is now reasonably well known and documented. Ninety-eight percent of the ESRP is underlain to a depth of at least 2 km by basaltic lava flows and the remainder consists of scattered rhyolitic domes, tuffs, and eruptive centers. Recent geologic mapping at 1:24,000-scale, in conjunction with 40Argon/39Argon dating and paleomagnetic studies, has yielded a detailed record of constant and widespread Holocene and Middle to Late Pleistocene basaltic volcanism. The main type of eruptions were fissure-controlled, shield-building eruptions that formed tube-fed pahoehoe lava fields covering 100-500 km^{2} and with volumes of 1-10 km^{3}; these eruptions lasted several months to several years. Shorter-duration, Holocene and Late Pleistocene, fissure-controlled eruptions produced smaller lava fields that are mostly obliterated by the longer-duration, larger-volume, pahoehoe lava fields. Eruptive fissures are typically aligned NW-SE and are related to NE-SW extension. Many of the fissure-dominated vents are concentrated in NW-trending volcanic rift zones that are parallel to and structurally associated with range-front faults along the margins of the ESRP. Most eruptions in the ESRP have been "single-shot", monogenetic eruptions. The main exceptions are: (1) the Craters of the Moon lava field, a composite lava field consisting of more than 60 individual flows erupted from a narrow (<5 km wide) zone of eruptive fissures and cinder-cone vents (the Great Rift volcanic rift zone) over a period of about 15 ka, and (2) the lava fields of the Spencer-High Point volcanic rift zone. There is paleomagnetic and dating evidence that segments of several ESRP volcanic rift zones as long as 60 km were in eruption at the same time. Holocene and latest Pleistocene basaltic volcanism is concentrated in and near the Craters of the Moon lava field and probably (no dating studies available) in the Spencer-High Point area. Because the most recent eruptions are so young and the repose intervals are so short, it is highly probable that the next volcanic event in the ESRP will occur at either of these two areas. Regional geologic mapping shows that the present courses of the Henrys Fork, South Fork, and upper Snake Rivers are largely controlled by the dis-

tribution of Middle and Late Pleistocene basaltic lava fields. Near-surface aquifers adjacent to these streams were formed by the interaction of volcanic and fluvial processes. Some major problems requiring further study of the basaltic volcanism and hydrogeology in the ESRP include the following: (1) Field mapping is needed in several areas of the northeastern ESRP to fill in important regional data gaps, such as in the Spencer-High Point and Island Park areas; (2) Major lava fields in the Idaho National Laboratory, Spencer-High Point, and Island Park areas remain undated; (3) Numerous shallow and deep coreholes are needed throughout the ESRP to improve our understanding of the 3-dimensional stratigraphy of lava-flow and fluvial units. (4) Computer-generated, 3-dimensional models of basalt-lava-flow and fluvial stratigraphy are needed to verify and improve groundwater-flow models, for watershed-management studies, and for volcanic-hazard analyses. Critical to these needs are geologic-framework studies, based on 1:100,000-scale geologic maps, which form the basic geologic/hydrologic data sets necessary for systematic watershed studies, groundwater-flow modeling, and land-use planning. Such maps also provide the basic data for volcanic-hazard analyses for INL, NPS and BLM lands, agricultural lands, and municipalities. These studies need the support of federal, state, and local agencies, but that support is currently unavailable.

Keywords: basaltic volcanism, hydrogeology

How Do Continental Flood Basalt Lava Flows Grow? The Importance of the Pahoehoe Inflation Mechanism

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I will examine the conditions required to explain the great length (up to 1000 km?) and the large volume (up to 10,000 km^3?) of continental flood basalt (CFB) lava flows on Earth. Two simple requirements for a long lava flow are 1) sufficient magma held in a chamber to supply a large volume of lava, and 2) an emplacement system that can transport the liquid lava from vent to flow front without the lava freezing. For the common lava composition in CFB provinces this is a cooling range of only 100 + 50 ^oC. During flow a combination of cooling and degassing promotes groundmass crystallization that is crucial in determining the resulting flow characteristics. An inventory of long lava flows shows them to be exclusively p'ahoehoe flow fields, or closely related varieties, in type. This is mandated by the fact that 'a'a flows are too thermally inefficient, losing ~ 2-5 ^oC per km in the feeder channels and rapidly developing groundmass crystals, to attain lengths much in excess of 100 km on Earth. Only the insulated flow model for p'ahoehoe flow fields where the dominant lava body is the inflated sheet lobe fits all the quantitative criteria required to explain the great extent of CFB flows: effusion rates are 1000s m^3/sec, lava travels from the vent to the flow front in days to weeks, heat losses are restricted to as little as 0.001-0.1 ^oC per km, and eruption durations are years to centuries. These values dictate that eruptive volumes must be 10s to 1000s of km^3, a condition met by lava flows in CFB provinces. Outstanding issues with the insulated flow model are: explaining the details of internal lava transport within active lava flow fields (no lava tubes!); exploring textural changes that occur during long-distance lava transport; deciphering what constitutes the products of one CFB eruption in the field; and, investigating the implications of such a model for the plumbing system of CFBs (magma chambers, feeder and vent systems).

Keywords: lava, pahoehoe, emplacement

Paleomagnetic Studies of the Basalt Lava Flows of the Eastern Snake River Plain

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Comprehensive geologic mapping of the eastern Snake River Plain (ESRP) is undergoing renewed interest at the present time, and field paleomagnetic studies have been utilized as part of this process. These studies extract the remanent magnetizations recorded in the basalt lava flows of the ESRP through field and laboratory processes, with flows recorded the same direction of magnetization if they are erupted at the same time. Our study of the Craters of the Moon Lava Field used such paleomagnetic data, along with chemistry and petrography, to group the lava flows into 8 major eruptive episodes over the past 15,000 years. The results clarified and strengthened our ability to group lava flows of the same age of the Field. We have expanded our field paleomagnetic studies to large parts of the entire ESRP, especially the area of the Great Rift National Monument and Preserve. While we have found that many shield volcanoes have remanent magnetic directions that are seemingly independent of others in their vicinity, we have also found examples of adjacent shields and vents sharing identical directions of magnetization. In particular, the Horse Butte-Bear Trap Cave and Wapi Park vents produce two large lava fields flowing 40km and 30km respectively to the west. These eruptions quickly emplaced 100's of sq. km.

of bare lava flows that were eolian mantled by the wind and revegetated as the climate allows. The non-linear time aspect of these big eruptions affects the assessment of volcanic hazards and biological reequilibration of the ESRP.

Keywords: paleomagnetism, volcanic hazard

Reconstructing a Breached Cinder Cone at Craters of the Moon National Monument: A Geographic Information Systems Approach

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North Crater is a breached basaltic cinder cone in the Pleistocene to Holocene Craters of the Moon lava field within Craters of the Moon National Monument and Preserve in the eastern Snake River Plain of southern Idaho. Three lava flows, the Highway, Devil's Orchard, and Serrate flows, erupted violently from vents within, or near, North Crater. These flows were viscous enough to break apart the cone and carry rafted blocks of the cone, like icebergs in ocean currents, as far as 13 km to the east and northeast. Rafted blocks were characterized in the field, and a geographic information systems (GIS) approach was utilized to extend the field observations, via domains, over the full extent of the flows to estimate the total volume of rafted blocks. The volume of cone material rafted from North Crater (46 x 106 m^3) far exceeds the volume that the breach in North Crater can contain (1.2 x 106 m^3). Adding the rafted material to the current North Crater (42 x 106 m^3) suggests paleo-North Crater may have been as large as 88 x 106 m^3. Based on height-diameter-volume relations of other cones in the volcanic field, documented by GIS analysis, paleo-North Crater would have been 50 m higher and 400 m wider than the modern cone. The North Crater area experienced a prolonged and complex eruptive history and it is possible that several smaller cones existed through time, each being built, partially or completely destroyed by block rafting events, and then rebuilt.

Keywords: rafted block, cinder cone, geographic information system

Contrasting Petrogenetic Evolution of Contemporaneous Quaternary Rhyolites of the Eastern Snake River Plain and Blackfoot Volcanic Fields, SE Idaho

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The ~1500 km^2 Blackfoot volcanic field (BVF) is a region of Quaternary bimodal basalt-rhyolite volcanism that has infilled parts of two northwest-trending late Cenozoic grabens, adjacent to the southern margin of the eastern Snake River Plain (ESRP). Diachronous clusters of compositionally and mineralogical similar high-silica, pl+sa+bt+hb-bearing (76.8% SiO^2) rhyolite domes occur in the northern and central parts of the field (1.5 Ma and 0.05 Ma, respectively). The BVF volcanic domes overlap broadly in age and in most compositional characteristics with Quaternary ESRP rhyolite domes. However the BVF domes are distinguished in some major- and trace-element concentrations (higher quantities of Cs, Rb, Th, U and lower quantities of FeO*, La, Zr, Ta and Hf), by more evolved initial Sr- and Nd-isotopic ratios (~0.7098 and eNd = -12 to -11, respectively), and by hydrous-mineral-bearing assemblages (sa > pl > bt, hb). Mineral thermobarometry and melt inclusion data indicates that BVF rhyolites equilibrated at P = ~350 MPa, T = 760^oC, and XH_2O ~ 4%. EC-RAF and MELTS modeling indicates that the rhyolites evolved primarily by fractional crystallization from a mafic parent, accompanied by ~20% assimilation of upper crust. Basaltic magmatic enclaves within the rhyolites suggest that the eruptions occurred in response to basalt magma injection. We propose that, like ESRP, genesis of BVF Quaternary rhyolites occurred primarily by polybaric fractionation of basaltic parental magmas - albeit with a higher fraction of assimilant owing to less refractory crustal country rocks. Magma mixing and assimilation appear to play recurring, but variable and subsidiary roles.

Keywords: bimodal volcanism, eastern Snake River Plain, geochemistry

Petrogenesis of Rhyolite and Cogenetic Mafic Magmatic Enclaves at East Butte Volcanic Dome, Eastern Snake River Plain, Idaho

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East Butte is one of four compositionally similar Quaternary high-silica rhyolite domes (HSR) on the eastern Snake River Plain (ESRP) segment of the Yellowstone hot spot track. It has geochemical and mineralogical features in common with 'A-

type granitic rocks', and may constitute an analog for magmatism leading to production of A-type magmas. The rhyolite contains an anhydrous phenocryst assemblage consisting of 10% crystals including: sanidine > quartz > ferroaugite, fayalite, Fe-Ti oxides, and accessory zircon, chevkinite and apatite. It also contains a distinctive assemblage of pl+cpx-phyric mafic magmatic enclaves - mostly COM-type basaltic trachyandesite (BTA), and minor amounts of mafic and felsic crustal xenoliths. Most BTA enclaves are vesicular, suggesting post-mixing degassing, and some contain cumulate-like plagioclase megacrysts and more mafic, OTB-like, magmatic(?) enclaves. BTA enclaves plot on fractional crystallization dominated curvilinear trends observed at other intermediate-composition volcanoes of the ESRP (e.g., Craters of the Moon and Cedar Butte). EMP analyses of HSR melt inclusions in pyroxene, olivine and quartz phenocrysts consistently yield low-totals (~93-98%), suggesting that the rhyolite magma contained ~2-5% H_2O prior to eruption. A hydrous phase of rhyolite evolution is further supported by the presence of pronounced granophyric textures in one of three texturally distinct populations of sanidine. Nd- and Sr-isotopic compositions of the rhyolite (0.512403 and 0.70795, respectively) are similar to coeval olivine tholeiite basalts, which limits an Archeon crustal component to less than a percent. Models suggest the evolution of East Butte rhyolite and BTA enclaves by extreme polybaric fractionation of a basaltic parental magma.

Keyword: East Butte

Whither the Big Lost River? Detrital Zircon Constraints on Neogene Drainage on the Snake River Plain

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Extensive sampling of fluvial and aeolian Miocene to Holocene sands for U-Pb detrital geochronology, using SHRIMP, constrains drainage history of the Snake River Plain. Distinctive provenance signatures are recognized for the Big and Little Lost Rivers, Birch Creek, Henry's and South Forks of the Snake River, and the Big and Little Wood Rivers on the north and east side of the Snake River Plain. The Big Lost Trough captured the Big Lost River by 2.2 Ma, and the Big Lost River has flowed into the Lost River Sinks since then. The presence of Eccene Challis magmatic grains in the Big Lost and Big Wood Rivers, and their absence in the Snake River requires that the northern drainages never crossed to the south side of the Snake River Plain east of Lake Minidoka and the Raft River (longitude 114 degrees west). The late Miocene and Pliocene Big Lost River may have flowed north of the incipient Craters of the Moon-Great Rift volcanic system, or may have passed through what is now the center of it. The tracking of detrital zircon provenance signatures has great utility in constraining the complex changes in eastern Idaho drainages during the development of the Middle Miocene to Holocene Snake River Plain-Yellowstone Hot Spot Track.

Keywords: Big Lost River, detrital zircon, neogene

The Influence of Eastern Snake River Plain Stratigraphic and Rift Architecture on Surface-Water and Groundwater Flow

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Eastern Snake River Plain (ESRP) basalts were erupted from low shield volcanoes, fissures and other vents mostly concentrated in volcanic rift zones usually perpendicular to the axis of the Plain. Active though currently-quiescent rifts are elevated with respect to surrounding volcanic tablelands and older inactive rifts. Topographic contrast and subsurface expression of active vs. inactive rifts influences the path of surface waters and groundwater out of neighboring Basin and Range valleys and across the Plain. Several hundred well logs from the Idaho National Laboratory and Idaho Department of Water Resources have been compiled to study the effect of ESRP stratigraphic and rift architecture on surface-water and groundwater flow. This research highlights previously-undiscovered features and illuminates other already-known or suspected features, including paleochannels of the Big Lost River that traveled southward. These channels may have crossed the area now occupied by the Arco and Great Rifts before these became topographic highs sometime after ~500 ka. Geochronological control of these events is poor. Before this, the Big Lost River was prevented from reaching the ancestral Snake River by the Axial Volcanic High, turning it west and possibly depositing its sediments in trapped basins evident in subsurface across Lincoln, Minidoka and Blaine Counties. This result is congruent with Snake and Big Lost River zircon dating results by P.K. Link and colleagues. Other results include mapping fluvial deposits in the Big Lost Trough and interpreting how the Arco and Great Rifts and other eruptive features influenced sedimentary deposits intercalated with ESRP basalts.

Inside the Great Rift – Deep Inside! A Caver's Perspective

Scott Earl, Director, Idaho Cave Survey, Idaho Falls, Idaho

Anyone who has tried to get a good look at the Great Rift in person can tell you that it is difficult to see very much of the rift due to limited access and really rough terrain. A few people have gone to the extreme effort required to visit the entire length of the rift, requiring backpacking trips of over 70 miles carrying everything needed with them. Additionally, a very few people have been privileged to visit the insides of the rift! Over the past 20 years, cavers associated with Idaho Cave Survey have conducted several almost expedition-type trips into the inner workings of the Great Rift. Caving at depths sometimes over 300 feet below the surface, often while hanging from ropes, they have documented many of the fantastic geological wonders inside the Great Rift. This PowerPoint presentation will display detailed maps and photographs of many of those wonders and describe scientific studies that have been carried out inside the rift, including recently discovered spectacular icefalls and pristine magma chambers that look as if the lava was there just days ago.

Keywords: caving, exploration

Technical Session IIa – Snake River Plain Geohydrology and Subsurface Science

Chairs: Catherine Helm-Clark and Thomas Wood, Idaho National Laboratory, Idaho Falls, Idaho

An Overview of the Idaho National Laboratory Site Wide Ground Water Model for Operable Unit 10-08 Remedial Investigation and Feasibility Study

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Erick Neher, CWI, Idaho Falls, Idaho

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The purpose of Waste Area Group (WAG) 10, Operable Unit (OU) 10-08, site wide ground water (SWGM) is to provide a comprehensive evaluation of environmental impacts from operations at the Idaho National Laboratory (INL) to the underlying Snake River Plain Aquifer. The SWGM is a schedule driven, product-oriented project supported by the Department of Energy and CH2M-WG to evaluate the cumulative impacts from residual plumes left by other WAGs. Risk will be evaluated during the OU 10-08 remedial investigation/feasibility study using the SWGM. The model will support environmental decisions and serve as a tool for managing, compiling, and synthesizing data. It is structured to integrate with and complement existing groundwater flow and contaminant transport models developed by others. The underlying strategy is a departure from the strategies for other models that have sought a single, unique solution to ground water flow and transport. The SWGM strategy recognizes the likelihood of varied interpretations arising from a relatively sparse data set for the complicated INL subsurface and the many programs utilizing the data for varied purposes. Flexibility in the modeling approach will allow evaluation and testing of competing interpretations and will help to define the bounds of flow and transport in the aquifer at the scale of the INL. The SWGM consists of two major components, the conceptual and numerical models. To ensure technical quality, enhance credibility and maintain consensus with the regulating government agencies, the SWGM is subject to an annual external peer review and Agency Modeling Summit Meeting.

Keywords: ground water model, Snake River Plain aquifer, INL

Overview of the Conceptual Model of Groundwater Flow within the Snake River Plain Aquifer at the INL Groundwater, Conceptual Model, Idaho National Laboratory

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Catherine Helm-Clark, Rob Podgorney, Mitchell Plummer, and Travis McLing, Idaho National Laboratory, Idaho Falls, Idaho

Mike Roddy, Idaho Completion Project. Idaho Falls, Idaho

The Snake River Plain aquifer, encompassing approximately 10,000 square miles of the eastern Snake River Plain in southeastern Idaho, is one of the most productive aquifers in North America. Volcanic features associated with this thick basaltic aquifer control groundwater flow and contaminant transport. The Idaho Completion Project at the Idaho National Laboratory (INL) is developing a numerical modeling tool to assess cumulative groundwater risk associated with past subsurface disposal of INL-derived radioactive and hazardous contaminants. This tool is based on the current conceptual model of flow through a 3,000 mile^2 subregion of the Snake River Plain aquifer beneath and surrounding the INL. The conceptual model incorporates our current understanding of geologic, hydrologic, and geochemical features to represent groundwater flow and contaminant transport within the aquifer. These features include the complex framework of thinly

layered basalt flows, structures associated with large-scale volcanic rift zones, inflows and outflows, and geochemical processes. Groundwater moves primarily through interflow rubble zones in an aquifer characterized by large horizontal and small vertical hydraulic conductivity. En echelon fractures and dikes associated with the Great Rift, oriented normal to the direction of regional groundwater flow downgradient from the INL, decrease hydraulic conductivity, as reflected in an abrupt increase in hydraulic gradient. Groundwater flowing through this complex system is derived from chemically different sources, including the Yellowstone highlands to the northeast, tributary drainage underflow to the northwest, and infiltration of streamflow and areal precipitation. Water chemistry differences and measured water levels are being used to evaluate this conceptual model.

The Stratigraphy of the Snake River Plain Aquifer from Mud Lake to the Great Rift of Idaho at Craters of the Moon

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The Snake River Plain Aquifer (SRPA) doesn't fit well into traditional conceptions of layered stratigraphy common to most aquifers, including those hosted in other basalt provinces. This is due to the unusual volcanism of Quaternary basalts on the Eastern Snake River Plain (ESRP). Thin flows are erupted onto the Plain from low-angle shield volcanoes and other vents. Flows rarely exceed 30 m in thickness and 50 km in lateral extent. These flows interfinger and pile on one another like a huge random stack of several hundred irregularly-shaped pancakes. Cutting through these basalts are volcanic rifts that can form zones of lowered hydraulic conductivity perpendicular to the general direction of SRPA flow. Based on recent research, the aquifer base is the boundary between fresh basalts above and altered basalts below where mineral growth closes off all porosity. Most groundwater flow in the aquifer is semi-confined to unconfined, moving through fractures and joints at the tops and bottoms of basalt flows. Sediments, which are interbedded or infiltrated into the basalts, commonly act to impede flow. The top of the aquifer doesn't follow any one flow, set of flows or geochronological horizon. The aquifer in the study area is recharged by underflow and surface flow out of the surrounding Basin and Range valleys: surface waters enter the aquifer through sinks of intermountain streams and underflow out of shallow basin-fill aquifers cascades into the SRPA across the abrupt transitions between the Basin and Range valleys and the basalts of the ESRP.

Keywords: stratigraphy, eastern Snake River Plain, INL

Status of Drilling for 2005 for the INL WAG 10 Deep-Corehole Project

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Drilling and coring of two deep wells was initiated at the Idaho National Laboratory in 2005. These wells are intended to collect data to support the completion of the WAG 10 sitewide conceptual and numerical groundwater models. Multiple potential locations were identified prior to initiation of field activities. The locations were screened and ranked based upon the data they will provide in relation to data gaps associated with the sitewide model of groundwater flow and transport. Two well-construction sites were selected based on the screening process and both proposed to penetrate the full thickness of the aquifer. Corehole site MIDDLE-2050 is located between the Idaho Nuclear Technologies and Engineering Center (INTEC) and the Reactor Technologies Complex (RTC). The primary objective of this corehole is to provide stratigraphic information to evaluate apparent age-depth offsets in the subsurface between the two facilities. Corehole site MIDDLE-2051 is located northwest of the Radioactive Waste Management Complex (RWMC). The primary objective of this corehole is to identify and constrain contaminant pathways and potentially commingling contaminant plumes. Core collected from both coreholes through the active aquifer will provide valuable stratigraphic data. Completion of both wells with multilevel groundwater sampling systems will permit discrete sampling for water chemistry from multiple depths. Geophysical logs and samples for radiometric age dating, whole rock geochemical analysis, and paleomagnetic data are also being collected.

Keywords: coredrilling, Snake River Plain aquifer, INL

Determination of Large-Scale Effective Hydrostratigraphic Units in the Vicinity of the Idaho National Laboratory

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Conceptual and numerical models of groundwater flow and contaminant transport at the Idaho National Laboratory require identification of large-scale effective hydrostratigraphic units. Identification of these units is a challenging task because of the complex nature of the basaltic aquifer, which is comprised of a thick sequence of basalt flows derived from multiple vents over an extended period of time, as well as sedimentary interbeds that exhibit a high degree of spatial and vertical variability. The architecture of basalt flow sequences, presence of sediments, and local structural features exert significant control over groundwater flow. The strategy for definition of vertical and spatial distribution of large-scale effective hydrostratigraphic units for a sub-regional numerical model is being based upon a number of data types. The vertical layer discretization is based upon inflection points and the slope observed in temperature logs, geophysical logs, and core lithologic data collected throughout the active portion of the aquifer from numerous wells in and around the INL, with the aquifer domain is divided into layers defined qualitatively as either high or low flow. Aquifer properties are being assigned to each respective layer identified above using numerous aquifer pumping, slug, and straddle packer tests, with values distributed in light of such large-scale features as major rift zones, the Big Lost Trough, and ancestral lake beds and playas.

Keywords: hydrostratigraphic unit, Snake River Plain aquifer, INL

Interpretation of Water Level Data for the OU 10-08 Model Development

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Water levels within the Snake River Plain aquifer are one of the obvious targets for calibration of the OU 10-08 model of groundwater flow and contaminant transport at the Idaho National Laboratory. Collection of a self-consistent set of water levels over time is often problematic. Collection of field data has inherent problems that can affect interpretation if erroneous data are not screened out. A process for evaluating water level data and determining validity of the data has been developed for OU 10-08. This process involves analyzing time-series of water levels at locations for consistency, and considering data from nearby wells. We describe this process and specific applications where errant data were identified and removed. We also present examples where water-level data show some degree of inconsistency with the overall flow field but cannot be discarded based on this evaluation process.

Keywords: water levels, Snake River Plain aquifer, INL

Combined Use of Aquifer Temperature Distribution and Chemical/Isotopic Characteristics to Define Groundwater Flowpaths

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Researchers at the Idaho National Laboratory (INL) are utilizing non-anthropogenic groundwater parameters (i.e. temperature, chemistry, and isotopic composition) to develop a conceptual model of the Snake River Plain aquifer in the vicinity of the INL. These naturally occurring parameters provide valuable insight into the long-term structure and character of the aquifer. For example, temperature profiles in deep wells show inflection points from nearly isothermal (actively flowing groundwater) to steep regional geothermal gradients (stagnant groundwater flow). These temperature inflection points correspond to recognized digenesis of basalts in borehole cores. Secondary mineralization corresponds to the effective base of the productive aquifer. Based on temperature inflection points, aquifer thickness beneath the INL ranges from less than 100 m to about 400 m. The thickest portions of the aquifer are characterized by deep "channels" that apparently transmit relatively cold water rapidly downgradient. The warmest zones correspond to areas where the aquifer is very thin and/or where water chemistry and uranium and strontium isotope data suggest extensive groundwater residence time and input of geothermal constituents from depth. The combined use of aquifer temperature distribution and chemical/isotopic characteristics defines groundwater flowpaths at a level of detail not possible by other means. The intrusion of cool plumes of recharge water into warm aquifer zones, the aerially abrupt warming of cool recharge plumes, and the threading of cold recharge plumes through warm areas of the aquifer along the northwest margin of the Eastern Snake River Plain provide unique insights into groundwater flow.

Keywords: natural water/rock interactions, Snake River Plain aquifer, INL

Anthropogenic Contaminants as Groundwater Flow Tracers at the Idaho National Laboratory

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Although many facilities on the INL disposed similar contaminants to the subsurface, these sources are not identical and the differences can be used to "fingerprint" facility plumes. The use of multiple contaminants and ratios of contaminants can distinguish the specific source of contamination, map groundwater flow paths, evaluate the potential for upgradient influences, and evaluate the potential for contaminant plumes to overlap. A combination of anthropogenically introduced anionic and radiological constituents is used to evaluate contaminant sources and downgradient flow paths from individual facilities. The constituents utilized as groundwater flow tracers include chloride, sulfate, nitrate, iodine-129, chlorine-36, tritium, and Tc-99. The radiological constituents and chloride are very soluble and can be tracked over great distances. Although sulfate and nitrate concentrations are susceptible to redox changes, conditions in the aquifer are oxidizing and concentrations and isotope signatures should be relatively conservative in the Snake River Plain aquifer. Some anthropogenic constituents, such as iodine-129 and chlorine-36, can be used to determine groundwater flow paths and potential receptors in areas much further downgradient because samples can be analyzed using accelerator mass spectrometry methods to achieve ultra-low detection limits. These data are being used to refine groundwater flow paths, to support development of the groundwater flow model, and to assess wells that may potentially be impacted by contaminants from INL facilities.

Keywords: anthropogenic contaminants, Snake River Plain aquifer, INL

Flow Model Development for the Idaho National Laboratory Operable Unit 10-08 Sitewide Groundwater Model

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Mitchell A. Plummer and Swen O. Magnuson, Idaho National Laboratory, Idaho Falls, Idaho

A pilot point inverse modeling approach is being applied to facilitate model calibration for constructing the sitewide numerical groundwater flow and chemical transport models at the Idaho National Laboratory (INL). Aquifer hydraulic and transport properties are adjusted on the pre-selected pilot points and then interpolated to every grid cell within the model domain to minimize the difference between selected calibration targets. Higher spatial density of pilot points is applied close to individual facilities, areas of large head gradient, and areas where heterogeneity contrasts are expected to be large and to vary at different scales. The pilot point inverse modeling approach allows extraction of the maximum amount of information from available monitoring data, permitting the best possible representation of flow and transport at the INL. Comparisons are also made to alternative approaches including more traditional approaches of using predefined zones for hydraulic properties. Use of natural boundaries to define the simulation domain and the process for extending this flow model to three dimensions will also be discussed.

Keywords: groundwater model, Snake River Plain aquifer, INL

Technical Session IIb – Snake River Plain Geohydrology and Subsurface Science

Chairs: Catherine Helm-Clark and Thomas Wood, Idaho National Laboratory. Idaho Falls, Idaho

Modeling Heat Flow in the Snake River Plain Aquifer

Plummer Mitchell, Idaho National Laboratory, Idaho Falls, Idaho
Michael Rohe, CH2M-WG, Idaho Falls, Idaho
Swen O. Magnuson and Robert K. Podgorney, Idaho National Laboratory, Idaho Falls, Idaho
Mark Person, Indiana University, Bloomington, Indiana

Numerical modeling of groundwater flow and transport is one of the primary means of assessing the risk that buried wastes at the Idaho National Laboratory (INL) pose to the Snake River Plain aquifer (SRPA). To increase confidence in the sitewide groundwater model used for predicting contaminant transport at the INL, the CH2M-WG / INL modeling team is using groundwater temperature data as part of the model calibration process. Temperature measurements are valuable because the processes that control solute transport also control heat transport. Temperature measurements, however, are much less expensive than solute concentration measurements and complete vertical profiles of aquifer temperature are readily obtained from deep wells. Local thermal anomalies provide information about flow velocities, while temperature profiles provide information about mixing within the aquifer. The temperature distribution within the SRPA appears to be

largely a result of very slow geothermal heating of cold mountain-front recharge moving from the Yellowstone uplands through the aquifer toward Thousand Springs. Most deep wells are essentially isothermal within the active portion of the aquifer. This suggests that either there is strong vertical mixing within the aquifer or that horizontal transport velocities preclude significant heating except within localized zones of lower hydraulic conductivity. To use available temperature data to help constrain aquifer properties, we are developing a three-dimensional thermo-hydraulic model of the Snake River Plain aquifer. We present results of preliminary experiments conducted with that model, aimed at determining the primary processes that control characteristic temperature profiles and local thermal anomalies in the vicinity of the INL.

Keywords: heat flow, Snake River Plain aquifer, INL

Multi-objective and Multi-scale Modeling Approach for Idaho National Laboratory Operable Unit 10-08 Sitewide Groundwater Model

Swen Magnuson, Idaho National Laboratory, Idaho Falls, Idaho

Hai Huang and Mitchell A. Plummer, Idaho National Laboratory, Idaho Falls, Idaho

Michael Rohe, CH2M-WG, Idaho Falls, Idaho

The MODFLOW-2000 and MT3DMS simulators are being used to construct sitewide numerical groundwater flow and chemical transport models at the Idaho National Laboratory (INL). An integrated multi-objective and multi-scale modeling approach has been proposed to more accurately describe groundwater flow and chemical transport characteristics at various scales. Geochemical and natural isotope analyses will be used to identify general groundwater flow lines and to estimate travel times. Flow lines will also be inferred from a parallel geothermal modeling study. In addition to heads, inferred flow directions and travel times will be used to calibrate the flow model until general agreement between flow lines has been achieved. This multi-objective calibration approach will allow flow-model calibration not only to head data, as typically done in flow models, but also to general flow lines that honor both geochemical and geothermal characteristics. This modeling approach will build upon the information that exists both from studies that have been conducted at individual facilities and studies conducted at larger scales.

Keywords: groundwater model, Snake River Plain aquifer, INL

Response Surface Modeling Activities to Simulate Transport in the Snake River Plain Aquifer at the INL

Arthur Rood, Idaho National Laboratory, Idaho Falls, Idaho

A response surface modeling method has been developed to facilitate evaluation of remedial activities or additional anthropogenic sources for the OU 10-08 risk evaluation process. The response surface method uses a convolution integral approach to simulate transport in the Snake River Plain aquifer. In this method, unit source inputs from each identified source are integrated to estimate actual concentrations at predetermined aquifer receptor locations while mimicking simulated flow and transport conditions in two- or three-dimensional aquifer flow and transport simulations. The advantage of the response surface method is that it utilizes the detailed, comprehensive flow and transport simulation being developed for OU 10-08, but allows for a much more rapid evaluation where the only variable is the contaminant source loading to the aquifer. A brief overview of the methodology will be presented along with a proof-of-principle application mimicking groundwater flow and transport beneath the INL.

Water Quality and Chemical Analysis to Determine the Hydrology Affecting Springs within the Hagerman Fossil Beds National Monument

Brock Dille, Graduate Student, University of Idaho, Kimberly, Idaho

Neal Farmer, Natural Resource Specialist, National Park Service, Hagerman Fossil Beds NM/Minidoka Internment NM, Hagerman Idaho

Richard G. Allen, Research Professor, University of Idaho

Gary Johnson, Assistant Professor, University of Idaho

The Hagerman Fossil Beds National Monument (HAFO) is known internationally for its many paleontological fossil sites, which are threatened isolated landslides in the steep terrain of the monument along the Snake River. The first modern era landslide occurred about ten years after the formation of the Bell Rapids irrigation project in 1970, with a new landslide occurring somewhere in the monument approximately every two years. The Bell Rapids irrigation project pumped water from the Snake River to lands that are 200 m above the fossil beds. Drainage from canal systems and from irrigation water application have created springs and slope instabilities that have fostered the landslides. In 2005, the Bell Rapids project has sold their water to other uses and will no longer make diversions. Therefore, the monument area will once again

undergo a substantial hydrological change with the end of irrigation. With these changes, and the original changes in the 1970's, it has been important to understand the hydrologic processes affecting subsurface flows through monitoring the ground water levels, flows from surface springs, and the variation in water chemistry. The chemical composition of ground water is impacted by four different water sources: canal leakage, agricultural field seepage, regional ground water, and precipitation. Statistical comparisons have been made between chemical analyses on spring discharges, well contents and canal water to determine origins of water in various spring systems. These statistical analyses will be coupled with simple geochemical modeling to predict the different water sources.

Keywords: groundwater, landslides, springs

Using GIS to Estimate Recharge from Precipitation on Non-irrigated Arid Lands

Bryce Contor, Research Hydrologist, University of Idaho, Idaho Falls, Idaho

For a regional aquifer modeling project, University of Idaho used GIS to process a stepwise non-linear calculation to PRISM precipitation raster maps, in order to determine the amount, spatial distribution and temporal distribution of recharge that resulted from precipitation on non-irrigated arid lands. This is essentially a partition of precipitation to recharge and evapotranspiration. In a mountainous environment, stream runoff would be an additional partition that could be addressed. Knowledge of the partition of rainfall would also be useful in rangeland studies, for instance, to calculate the production of dry matter by arid-land vegetation. It would also be valuable in watershed studies to describe expected basin yield with different precipitation regimes. Different parameters were used for different general soil-type groups, representing differences in the ability of soil to retain precipitation as moisture stored in the root zone for later evapotranspiration. Theoretical calculations and calibration to recharge estimates by prior investigators show a large variation in the fraction of precipitation that becomes recharge, depending on soil characteristics. Application of the method to 22 years of data shows a large year-to-year variation in the fraction of precipitation that becomes recharge in wet and dry years. A weakness in the method is the lack of methodology to determine the parameters used. This weakness illustrates the need for further research.

Keywords: recharge, evapotranspiration, precipitation

Technical Session III – Resource Management and Environmental Education

Chairs: Mary Tess O'Sullivan, Lava Lake Foundation for Science and Conservation, Hailey, Idaho
Kimberly Truitt, Oregon State University, Dept. of Geosciences, Corvallis, Oregon

A Brief History of Science and Science-based Management at Craters of the Moon

John Apel, Resource Program Manager, National Park Service - Craters of the Moon, Arco, Idaho

The earliest record of science within what is now Craters of the Moon National Monument occurred in 1901. United States Geological Survey (USGS) geologist Israel Russell described the "Cinder Butte" area in detailed geologic terms for the first time. More than twenty years elapsed after Russell's account before additional accounts of the area were published. Robert Limbert, a self-taught naturalist and photographer, provided the earliest photographic record of the area's geologic features. Limbert also wrote extensively about his exploration of the area including an account published in National Geographic in 1924. At almost the same time that Limbert was roaming the lava fields another USGS geologist, Harold Sterns, was asked to investigate the area. These events led to the eventual designation of the original thirty-nine square mile Craters of the Moon National Monument in 1924. After this promising beginning, scientific study of the Craters of the Moon area remained very limited during the 1930s and 1940s. With a few notable exceptions most scientific literature of the area was published after 1960 and little or no research was initiated by the National Park Service before 1980. This paper will examine the history of scientific investigation of the Craters of the Moon area and how that knowledge has influenced the federal government's management of the area to the present day.

Keywords: history, science, management

Landscape Scale Conservation and Science-based Land Management in the Greater Great Rift region

Mary Tess O'Sullivan, Program Manager for Science and Conservation, Lava Lake Foundation for Science and Conservation, Hailey, Idaho

Michael S. Stevens, Chief Operating Officer, Lava Lake Land & Livestock, Hailey, Idaho

Alan R. Sands, Senior Ecologist, The Nature Conservancy, Boise, Idaho

Lava Lake Land and Livestock was organized in 1999 to (i) achieve landscape-scale conservation in the Pioneer and Boulder Mountains and in the Craters of the Moon area and (ii) establish an ecologically-sound and financially-viable business that supports our conservation activities. The Company's business is currently focused on all-natural and organic lamb production. Our grazing and conservation activities take place on 24,000 acres of private lands and 730,000 acres of lands administered by the Bureau of Land Management (BLM), the U.S. Forest Service (USFS), and the Idaho Department of Lands (IDL). We are pursuing our conservation mission by establishing a comprehensive scientific program, protecting private lands, restoring habitat for wildlife, managing livestock in ways that are compatible with habitat protection and are predator-friendly; participating in public lands management, and managing noxious weeds. Our science program includes ecological inventory and assessments, conservation planning, monitoring focusing on aspen, sagebrush steppe, and riparian ecosystem health, and research. A major thrust of the ecological surveys included mapping the vegetation of approximately 200,000 acres within our operating area. We are focusing our science and conservation efforts on: two wide ranging species — sage grouse and gray wolf; two endemic species — Wood River Sculpin and bugleg goldenweed; and the dominant habitat types of aspen, sagebrush steppe, riparian, and coniferous forest ecosystems. Our partners include the BLM, National Park Service, USFS, U.S. Fish and Wildlife Service, IDL, Idaho Fish and Game, Blaine County, Defenders of Wildlife, The Nature Conservancy, and the Nez Perce Tribe.

Keywords: biodiversity, conservation, restoration

Volcanology Interpretive Training Manual for Craters of the Moon National Monument

Kimberly Truitt, Graduate Student, Oregon State University, Dept. of Geosciences, Corvallis, Oregon

An illustrated volcanology training manual is being produced for Craters of the Moon National Monument (CRMO) in southeastern Idaho. The manual will encourage Interpretive Rangers, who may not have formal training in geology, to embrace geological concepts so that park visitors can appreciate their experience of a landscape developing through volcanic processes. My training as an Interpretive Ranger at CRMO and geology graduate student at Oregon State University (OSU) have allowed me to develop techniques to interpret geological concepts to the public that are pertinent to the park. CRMO's location among the lava flows of the Great Rift Zone make it a natural geology classroom that showcases some of the best examples of intracontinental basaltic volcanism in the United States. Pahoehoe and 'a'a lava flows, cinder and spatter cones, pressures ridges, lava bombs, eruptive and non-eruptive fissures, and volcanic craters are all easily accessible to park visitors via paved roads and hiking trails. Eruptive and non-eruptive fissures within the Designated Wilderness Area are given special focus in the manual to present the relationship of ongoing volcanic processes at CRMO to northeast-southwest extension in the Basin and Range Province.

Keywords: geology, volcanology, interpretation

Geologic Resource Inventory Monitoring of Sensitive Volcanic Features, Craters of the Moon National Monument and Preserve

Scott Hughes, Professor and Chair, Idaho State University, Dept. of Geosciences, Pocatello, Idaho

John Apel and Doug Owen, National Park Service, Craters of the Moon National Monument and Preserve, Arco, Idaho

Diana Boyack, Dept. of Geosciences, Idaho State University, Pocatello, Idaho

Protocols are being developed for field classification and formal documentation of sensitive geologic features within the recently expanded Craters of the Moon National Monument and Preserve. Sensitive geologic features are defined as those that must be preserved unimpaired for future generations to visit and observe. As of May 2005, twenty-seven categories of sensitive features related to volcanism (lava flow surfaces, squeeze-ups, tubes, channels, etc.) have been defined to survey and classify thousands of individual sites within park boundaries. Classification is based on the premise that selected volcanic features are visible at ground level, occur in sizes on the order of sub-meter to decameter scales, can be accessed by pedestrian or vehicular traffic, and are prone to human activity that could result in degradation or removal. Consideration is also given to features that may, over time, become naturally degraded by chemical or physical reactions related to atmospheric or surficial geologic processes, and to such reactions that may be enhanced by air and water pollution related directly or indirectly to human activities. Sources of primary information collected prior to current surveys

include old photographs, written reports, and formal publications. Information that includes digital imagery, feature descriptions, and GPS photopoint locations in selected project areas is necessary to enhance NPS and BLM efforts towards improved resource preservation. Archived data, compiled and managed in a GIS database, provide the basis for periodic revisits to sensitive features and the establishment of archival protocols in other NPS and BLM regions.

Keywords: geologic resource inventory

Creating Opportunities for Citizen Science and Education in the National Park Service Inventory and Monitoring Program

Tom Rodhouse, Ecologist, National Park Service, Upper Columbia Basin Network, Bend, Oregon

As part of its mission to develop and implement a long-term ecological monitoring program in the region, the National Park Service Upper Columbia Basin Network (UCBN) is pursuing opportunities to engage students and educators as participating "citizen scientists". Following model citizen science programs such as those developed by Cornell Lab of Ornithology and the National Park Service (NPS) Parks as Classrooms program, the UCBN has partnered with the Rocky Mountain Cooperative Ecosystem Studies Unit and the Oregon Museum of Science and Industry (OMSI) to sponsor science curriculum development and teacher trainings, and direct summer "tent and van based" research team programs for high school students. Recent programs have allowed students to conduct inventory and monitoring activities on bats and focal plant communities in Craters of the Moon National Monument and Preserve and other UCBN parks. These programs are unique in that students conduct start-to-finish projects, from formation of hypotheses and objectives to field data collection and data management to the reporting of results. These programs have clearly demonstrated that students can make an important scientific contribution to the NPS monitoring program and receive unique hands-on science education at the same time. Successful citizen science efforts depend on well-designed protocols and adequate training, as well as involvement from dedicated professional scientists to serve as mentors and program leaders. The UCBN looks forward to expanding its citizen science program in all of its Idaho parks.

Keywords: citizen science, science education, National Park Service

Native Waters

Ed Galindo, Research Scientist, University of Idaho, Pocatello, Idaho

This program model is taken from some research work I am currently doing with Native people in Montana, Utah, and Idaho. We are proposing teaching a class on this topic at the University of Idaho this fall with two main themes, one theme is water topics, and the second theme is education. Water connects all people together. Water is life; water is sacred for all things that live on this planet. We will be asking different tribal members to join us as we present scientific and cultural ways of knowing about water. Several important topics will be presented for consideration. For example, how water connects us, water stories, keepers of clean water, salmon, (stories of the finned ones), downstream destinations of water, honoring wetlands, and finally, understanding the common ground we all need, respect for clean water. The second theme, education, will be used to understand and integrate traditional ways of knowing and scientific ways of knowing. We know today that most water resource problems are multidimensional. Science alone cannot solve them. The solution of solving water problems is one of changing attitudes and actions. Traditional knowledge includes knowing a place. It covers knowledge of the environment. For example, snow, ice, weather resources, and the relationship between all these things. Traditional knowledge is a holistic way of looking at the world. An Elder told me " We are finally getting to the point again where we can put our ancient knowledge to use in the modern world, side by side with Western science". I feel this is an important story to tell. In summary, Native Waters is an educational program dedicated to increasing awareness and respect for water resources (example, Portneuf, Columbia, or Snake river system). This education and scientific initiative supports efforts of native and non-native community leaders, educators, elders, water managers, natural resource managers, and students to develop contemporary, scientifically accurate, and cultural sensitive water education resources, programs and networking opportunities. The bottom line is, we all need clean water to survive on this planet.

Initial Results of Risk-focused Monitoring for Ecological Receptors at the Idaho National Laboratory

Robin VanHorn, Staff Scientist, Idaho National Laboratory, Idaho Falls, Idaho

The Idaho National Laboratory (INL), a Department of Energy facility, is surrounded by 890 square miles of cool desert ecosystem characterized by shrub-steppe vegetative communities. INL an ecological treasure is possibly the largest intact expanse of sagebrush steppe habitat in the United States. This superfund site has nine "waste area groups" that have had past releases of multiple contaminants. Based on the requirements of the Comprehensive Environmental Response,

Compensation, and Liability Act (CERCLA), INL has systematically evaluated risk to ecological receptors located at each of nine waste area groups and across the entire facility. The Site-wide ecological risk assessment was a complex process that investigated combined risks to ecological receptors across the INL from all contaminated areas resulting in a "de minimus" impacts determination. However, limited data were collected supporting the ERA, and it could not be concluded with confidence that ecological receptors are adequately protected from past and current activities at the INL. Therefore, a five-year plan to collect data to address these uncertainties was initiated. The Long-term Ecological Monitoring (LTEM) plan sampling is directed at detecting contamination-related effects across a range of ecological organizational levels primarily to address this uncertainty. Yearly sampling for contaminant levels in biotic and abiotic media and effects characterization representing different levels of mechanistic understanding is performed. Links between elevated contaminant concentrations and effects are evaluated for correlations to allow selection of indicators for future trending and monitoring. This presentation will discuss the status of this effort and some of the preliminary results.

Keywords: ecological risk, ecological monitoring, sagebrush steppe

Employing Unmanned Aerial Vehicles for Monitoring Habitat and Species in Sagebrush-Steppe Ecosystems

Robert Breckenridge, Manager Ecological Sciences, Idaho National Laboratory/University of Idaho, Idaho Falls, Idaho

The Idaho National Laboratory (INL) is evaluating a novel approach for using Unmanned Aerial Vehicles (UAVs) as a quicker, safer and more cost effective method for monitoring biotic resources on Federal Lands. In this project, two types of UAV platforms, fixed wing and autocopter, are used to collect still frame and video imagery to assess vegetation composition in sagebrush-steppe ecosystems. This presentation will discuss the accuracy associated with using imagery collected from the UAVs to estimate total percent cover, identify different types of cover (shrub, forbs, grass and bare ground), and to locate sage grouse based on representative decoys. The field plots will be located on INL site west of Idaho Falls, in areas with varying amounts of cover. Two different image processing techniques, a point frame method and image processing software (for measuring total vegetative cover), will be performed on the imagery and evaluated. Results will be compared against standard ground based measurements to assess accuracy. Evaluation of vegetative cover is an important factor for maintaining the sustainability of many biotic resources. Improved methods for assessing vegetative cover that are accurate and cost-effective could revolutionize how biotic resources are monitored on western lands. Sagebrush area provide important habitat for a variety of species but also provide good areas for multiple uses. Improved methods are needed support the task of monitoring these habitats because there are not enough resources specialists or funds available for comprehensive ground surveys to be conducted on these lands.

Keywords: monitoring, sagebrush-steppe, ecosystem

Preliminary Assessment of Radioactive Fossils and Mineralization at Hagerman Fossil Beds National Monument

Neal Farmer, Physical Scientist, National Park Service, Hagerman, Idaho

Naturally occurring radioactivity has been identified at Hagerman Fossil Beds National Monument in both fossils and mineral deposits. Preliminary data indicates radioactive emission levels in some fossil specimens (cat.# 2004) at 10,000 disintegrations per minute (cpm) and 1.7 millirems per hour risk factor. Three Mile Island exposure risk is noted at about 3 millirems per hour (Murray, 2004). Oxidized mineral deposits have also exhibited above background levels at about 400 cpm. Background levels range from 20 to 50 cpm. Non-destructive analysis using X-ray fluorescence has shown the presence of Uranium 238, Iodine, and nearly all 'Lanthanide Series' or Rare Earth Elements (REE's) including Strontium and Yttrium. Several effects have resulted from the presence of radioactivity such as, handling and storage of radioactive specimens during preparation and emission of radon daughter products inside storage facilities. There have been benefits from the radioactive deposits such as using the presence, absence or level of radioactivity as a tracer to assist with mapping spatial distribution of geologic deposits and fossils on the Monument. This working knowledge was used for a recent discovery of a Mastodon fossil tusk in a landslide which was determined to be radioactive at 1,100 disintegrations per minute.

Keywords: fossil, radioactivity, geology

Abandoned Mine Safety Remediation: Closing the Holes while Preserving the Habitat

Christopher Ross, Abandoned Mine Program Lead, BLM Nevada State Office, Reno, Nevada

Nevada has an estimated 300,000 abandoned mine land (AML) features, of which about 50,000 represent significant risks to public safety. Almost every year there are injuries or deaths related to AML sites, from causes ranging from falls and collapses to drownings, asphyxiations, and motor vehicle accidents. A GIS project was developed to locate, analyze, and pri-

oritize hazards. A programmatic Environmental Assessment was developed to expedite NEPA compliance. Extensive clearances for land and mining claim status, bats and other wildlife, protected plants, and cultural resources are required prior to backfilling. Spreadsheets track clearances and resources. The State of Nevada AML program, which includes inventory and fencing by summer interns and volunteers from prospecting organizations and Eagle Scouts, as well as public education, is integral to the remediation process. An innovative cooperative effort to do clearances and actual dirtwork includes representatives from the Nevada Division of Minerals, the Nevada Mining Association, the Nevada Natural Heritage program, Nevada Department of Wildlife, Bat Conservation International, heavy equipment dealers, individual active mines, trucking companies, and others works closely with a minimum of formality to rapidly clear and close dangerous sites. The development of this team has made Nevada the national leader in mine hazard closures ñ over 80 backfills were done last year. Options for temporary and permanent mitigation, including gating, will be discussed. Obstacles and the means to overcome them will be presented, with specific lessons learned.

Keywords: AML, wildlife, NEPA

Cave Gates of Idaho

Jim Hathorn, Gem State Grotto

This presentation will introduce the audience to an overview of cave gates in the Craters of the Moon, Shoshone, and Gooding area. It will cover design and construction considerations, purposes of gates, and the role of volunteers in installation, maintenance and monitoring of existing gates. While most people would not think to protect caves with a gate, it is a misconception to think they are just another hole in the ground. Caves are a numerous and valuable resource within the Great Rift area. They contain interesting and unique biota, geological formations, and archaeological and paleontological deposits. While the rugged, sometimes foreboding, cave entrance may look like an intimidating place to visit, it is just the kind of place that some people like to enter and therein lies the problem. Sometimes cave use can lead to abuse. This presentation deals with how to mitigate the impact of unconcerned or unknowledgeable explorers. Since the first gate was installed in 1969 at Craters of the Moon, gating has been done on an as needed basis within the Great Rift. To date ten gates have been constructed using volunteer labor for design and construction. These gates protect valuable resources that are found within the caves. Maintenance and monitoring is done by a combination of volunteers and law enforcement. As gates have been installed abuse has diminished.

Technical Session IV – Archeology

Chairs: Kaylon McAlister, Museum of Natural and Cultural History, University of Oregon
Mark O'Brien, Idaho State University, Dept. of Anthropology

Archaeological Investigations at 10-BN-1066: A Late Prehistoric Water Catchment Site on the Lava's Edge, Craters of the Moon National Monument and Preserve

Mark O'Brien, Graduate Student, Idaho State University, Dept. of Anthropology, Pocatello, Idaho

In 2000, the Shoshone BLM received a report of a previously unrecorded, looted archaeological site in Laidlaw Park, Craters of the Moon National Monument and Preserve. Subsequent investigations by the BLM identified a lithic, groundstone, pottery, and bone scatter located along the edge of a 6,000 year old lava flow. The scatter was associated with four rock overhangs, and within the adjacent lava flow, a network of trails leading to a tool stone quarry, hunting blinds, and excavated water catchment basins. In June of 2004, a cultural resource management archaeology firm, under contract with the Shoshone BLM, partook in limited testing and restoration efforts at the site. An examination of the excavation report, as well as information gleaned from site visits by the author, has allowed for the interpretation of the site's age and function. The site appears to have been a seasonal short-term base camp at which game and plant processing and stone tool production and maintenance activities were conducted. The site was occupied by Shoshone peoples sometime after 700 years ago.

Keywords: archaeology, Craters of the Moon

Pictographs from the Lava Tube Caves in the Idaho Area of the Great Rift

Carolynne Merrell, Rock Art Specialist/Archaeologist, Moscow, Idaho

During the past 3 to 4 million years basalt lava flows across the Snake River Plain created long tubes through which lava

flowed. When the lava ceased, drainage occurred leaving underground channels. These tubes, with roofs that often collapsed, permitted access by people and animals. A number of these caves have pictographs along with other archaeological material. Pictographs include patterns of tally marks, shields, bison, bear, ungulates, anthropomorphs and abstract designs. While detailed interpretation is speculative for most of the pictographs, there are valued observations that can be made offering the potential to learn more about the people who used these caves and shelters in the past.

Keywords: pictographs, lava tube caves

Using Geospatial Data to Interpret the Holocene Archaeological Record on the Craters of the Moon National Monument and Preserve

Lael Suzann Henrikson, Research Archaeologist, Museum of Natural and Cultural History, University of Oregon, Eugene, Oregon

A geospatial analysis of archaeological data from the Craters of the Moon National Monument and Preserve suggests that Shoshone groups residing on the eastern Snake River Plain frequently relied on the widely scattered snow-melt ponds of the sagebrush steppe. While these ephemeral water sources were attractive locations for temporary encampments during the past 8000 years, the periphery of Holocene-aged lava flows were repeatedly used for lengthier stays in the high desert. The results of the geospatial analysis indicate that, rather than representing a harsh impediment to Shoshone groups traversing the eastern Snake River Plain on their seasonal round, the basalt flows created protective niches that consistently provided resources and shelter for thousands of years.

Keywords: Shoshone, archaeology, geospatial

Seeking the Source: Obsidian XRF Analysis of Projectile Points from the Craters of the Moon National Monument and Preserve

Kaylon McAlister, Research Assistant, Museum of Natural and Cultural History, University of Oregon, Eugene, Oregon
Lael Suzann Henrikson, Research Archaeologist, Museum of Natural and Cultural History, University of Oregon, Eugene, Oregon

Current archaeological research at the Craters of the Moon National Monument and Preserve indicates that eastern Snake River Plain basalt flows were utilized by Shoshone groups throughout the Holocene. In order to detect temporal variations in the Shoshone seasonal round and examine the spatial distribution of archaeological sites, an X-Ray Fluorescents source analysis of stone tools from the Preserve is underway. Preliminary results indicate that obsidian from local sources was generally favored for tool manufacture during the past 7500 years. However, at the onset of the Late Holocene around 3500 years ago, more distant sources of obsidian were utilized, suggesting that some Shoshone groups had either altered their seasonal round or expanded their trade networks. This hypothesis will be explored with additional XRF analyses of previously collected projectile points and specimens recovered from the 2005 field season.

Keywords: XRF, Craters of the Moon, archaeology

Traditional Cultural Practices of the Shoshone-Bannock in the Great Rift Region

Lisa Cresswell, Archaeologist, Bureaqu of Land Management, Shoshone, Idaho
Christopher Loether, Idaho State University, Dept. of Anthropology, Pocatello, Idaho
Drusilla Gould, Idaho State University, Dept. of Anthropology, Pocatello, Idaho

Shoshone-Bannock Tribal members have used the natural resources of the Great Rift region for thousands of years. In addition to the archaeological evidence present, Shoshone-Bannock oral tradition also documents the use of this region. Resources of importance include native plants, animals and even the lava rock itself. This paper presents a preliminary look at the traditional cultural uses of these resources and suggests appropriate protection measures for resources at risk.

Keywords: Shoshone-Bannock tribes, oral tradition, native plants

Geophysical Investigations of Archaeological Resources in Southern Idaho

Brenda Ringe Pace, Registered Professional Archaeologist, Idaho National Laboratory, Idaho Falls, Idaho
Gail Heath and Clark Scott, Geophysicist, Idaho National Laboratory, Idaho Falls, Idaho
Carlan McDaniel, Student, Idaho State University / Idaho National Laboratory, Idaho Falls, Idaho

At the Idaho National Laboratory and other locations across southern Idaho, geophysical tools are being used to discover, map, and evaluate archaeological sites. A variety of settings are being explored to expand the library of geophysical signatures relevant to archaeology in the region. Current targets of interest include: prehistoric archaeological features in open areas

as well as lava tube caves, historical structures and activity areas, and emigrant travel paths. We draw from a comprehensive, state of the art geophysical instrumentation pool to support this work. Equipment and facilities include ground penetrating radar, electromagnetic and magnetic sensors, multiple resistivity instruments, advanced positioning instrumentation, state of the art processing and data analysis software, and laboratory facilities for controlled experiments.

Keywords: archaeology, geophysics

Prehistoric use of Lava Tube Caves in the Cerro Grande Lava Flow: The Eastern Snake River Plain, Idaho

Julie-anna Rodman, Graduate Student, University of Idaho, Moscow, Idaho

The Cerro Grande lava flow, near Big Southern Butte, on the eastern Snake River Plain contains a number of unique lava tube caves. The caves contain evidence of prehistoric human use including hunting, food processing and storage, lithic tool manufacture, and hide preparation. The caves contained in the Cerro Grande flow include Raptor Cave, Roadside Cave, Bat Snack Cave, Coyote Lair, Corroded Abode, Swiss Cheese Cave, Hikers Oasis, Powerline Cave, Bobcat Cave, and Condor Cave. Archaeological excavations have been conducted in Bobcat Cave, Raptor Cave, and Roadside Cave. Bobcat Cave was excavated in 1987 and 1989 by Idaho State University and BLM archaeologists. Bobcat Cave contains extensive rock art and excavations in the lower cold chamber produced evidence of food storage and possible water collection activities. Raptor and Roadside caves were being damaged by pothunters and in 2003 and 2004 University of Idaho and BLM archaeologists conducted excavations to determine the extend of the damage and rehabilitate the caves. Raptor cave contains significant rock art including images of bison and shield bearing warriors. The cave also contains year round ice and may have provided water in the high desert. Roadside Cave contained extensive lithic and ceramic artifacts. This paper presents the results of these excavations and a discussion of the surrounding unexcavated caves.

Keywords: archaeology, caves, Cerro Grande lava flow

Technical Session V – Animal Ecology

Chairs: Monte Sanford, University of Nevada, Dept. of Ecology, Evolution and Conservation Biology
Brad Lowe, Idaho State University, Dept. of Biological Sciences

Juniper and Sagebrush Dependent Wildlife Species in South Central Idaho

Peggy Bartels, Wildlife Biologist, University of Oregon/Butler University, Burley, Idaho

Pygmy rabbits (*Brachylagus idahoensis*), cliff chipmunks (*Neotamias dorsalis*), greater sage grouse (*Centrocercus urophasianus),* ferruginous hawks (*Buteo regalis*), and burrowing owls (*Athene cunicularia*) are key shrub steppe species in south central Idaho. Each of these species represents a spectrum of the shrub steppe ecosystem niches from grasslands to juniper forests. Recent presence and absence inventories of pygmy rabbits in south central Idaho demonstrate an 80% loss of their 1980 distribution and range in south central Idaho. Cliff chipmunks have experienced a range expansion in south central Idaho. Based on the past 25 years of lek attendance surveys, 30% of the leks have become inactive in south central Idaho (no activity during that past five years). However, in some sub-basins up to 75% of the leks have become inactive. Approximately one percent of the world's breeding population of ferruginous hawks nest in south central Idaho. This species has experienced a 3% decline in fledgling success during the past five years, but this decline is not significantly different from the past 35 years of data. Nest occupancy and nest success have not significantly declined during the past 35 years.

Keywords: shrub steppe

Burrowing Owls of the Great Rift and Adjacent Snake River Plain: A Growing Conservation Concern

Miriam Austin, Field Biologist, Twin Falls, Idaho

Once widely known from grasslands and deserts, the Western Burrowing Owl (*Athene cunicularia*) is no longer a familiar sight. Increasing urbanization and agricultural conversion of open lands occurring from Canada to Mexico, destruction of burrowing mammals, widespread use of pesticides, loss of suitable nest sites, fatal collisions with vehicles, and diseases like West Nile Virus are all factors related to alarming declines of this small owl in western North America. Populations known for the Great Rift and adjacent Snake River Plain are no exception, with demonstrable declines in recent years. As a PhD candidate in Ecology (Atlantic International University), I have just completed the third year of a four-year study of Burrowing Owl populations and their relationship to soils and plant community values within the Great Rift and adja-

cent Snake River Plain. My presentation focuses on study results to date, and illustrates the value of the Great Rift and similar shrub steppe habitats to native western wildlife.

Keywords: habitat, burrow, fledgling

Patterns of Pocket Gopher Mound Production in Response to Shrub Removal, Nitrogen Addition, and Drought in Sagebrush Steppe

Richard Inouye, Professor of Ecology, Idaho State University, Dept. of Biological Sciences, Pocatello, Idaho

I monitored pocket gopher (*Thomomys talpoides*) mound production for more than 5 years on sagebrush steppe plots that received one of three experimental treatments (control, annual nitrogen addition, shrub removal). Significantly more mounds were produced on shrub removal plots, which had significantly greater cover and biomass of herbaceous vegetation than either control or nitrogen addition plots. There was not a significant increase in mound production in response to nitrogen addition. Neither plant species richness nor diversity was greater in areas associated with mounds. No mounds were produced on any of the plots from July 2000 to October 2004, a period during which annual precipitation was less than 75% of average. During that period soil moisture was markedly lower than in preceding years. Decreased primary production, as a result of reduced precipitation, and increased energetic costs of burrowing through dry tightly bound soils probably both contributed to the absence of mound production. New mounds appeared on one plot in November 2004 and on a second plot in April 2005, following a year with close to average annual precipitation.

Keyword: gopher mound, disturbance, drought

Diversity, Abundance, and Seasonal Phenology of Arthropods on Big Sagebrush

Monte Sanford, University of Nevada, Dept. of Ecology, Evolution and Conservation Biology, Reno, Nevada
Nancy Huntly, Professor of Ecology, Idaho State University, Dept. of Biological Sciences, Pocatello, Idaho

The sagebrush biotype is the largest in the western United States. Sagebrush areas within the Great Basin comprise over 2.06 x 105 km^2 alone, while the sagebrush steppe on the Columbia and Snake River Plateaus comprise 4.48 x 105 km^2 of land surface. This vast sagebrush community is thought to harbor equally vast and diverse arthropod communities that remain largely unexplored. Our objective was to examine the diversity, abundance, and seasonal phenology of arthropod taxa on Big Sagebrush (*Artemisia tridentata*). We sampled free-living arthropods on a stratified random sample of 50 sagebrush plants at the Barton Road Ecological Research Area in late May, late June, and late August, resulting in a sample of almost 4,000 individuals. Over 230 species and morphospecies were identified. Species richness and abundance declined from May to August, and abundance of most taxa similarly decreased over the summer, but a few taxa, including *Acari* (mites), were notably more abundant in August. Fluid-feeders were the most diverse and abundant feeding type during all months and comprised 57% to 79% of species. Other functional groups shifted in abundance and diversity across months. We also sampled gall-forming insects, which included 4713 individuals of 12 species of the gall fly, *Rhopalomyia*. These were primarily (97%) of the species *Rhopalomyia ampullaria*, and abundance of galls increased from young to old-aged plants. Overall, *A. tridentata* were host to a high diversity of arthropods, some of which have the potential to cause or mitigate high damage to their host plant.

Keywords: arthropods, herbivory, big sagebrush

The Big Sagebrush *(Artemisia tridentata):* Home of a Rich Arthropod Fauna

José Ramirez, Graduate Research Assistant, Idaho State University, Dept. of Biological Sciences, Pocatello, Idaho
Nancy Huntly, Dept. of Biological Sciences, Idaho State University, Pocatello, Idaho

The big sagebrush *(Artemisia tridentata)* is one of most dominant shrubs of the sage-steppe ecosystem and supports a rich microfauna of associated species. Arthropods of many taxonomic groups and feeding guilds make use of the vast resources offered by A. tridentata, forming intricate food webs, which remain largely unexplored. Even seemingly abnormal structures such as galls form unique microhabitats that themselves support surprisingly diverse food webs, including phytophages, parasitoids, and inquilines. Here, we present a brief overview of the arthropod diversity and food webs that are found on A. tridentata at Craters of the Moon National Monument and Preserve.

Keywords: arthropods, food webs, sagebrush

The Diversity, Abundance, and Trophic Structure of Arthropods on Sagebrush *(Artemisia tridentata tridentata)* at Craters of the Moon National Monument and a Nearby Agricultural Region

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Nancy Huntly, Michael Kreuzer, Jr., Monte P. Sanford, and Nicole Talaro, Idaho State University, Pocatello, Idaho

We assessed the arthropod food webs associated with big sagebrush *(Artemisia tridentata)* in two landscapes of the Snake River Plain that can be regarded as having fragments of once more-continuous sage steppe: kipukas within ancient lava flows at Craters of the Moon National Monument, and patches of sage-steppe that have been left within lands more recently converted to agriculture. Our sample included over 10,000 individuals, from over 200 morphospecies. The structure and species composition of the arthropod community of big sagebrush differed markedly between kipukas and agricultural areas. Species composition and overall abundance of several groups differed markedly between kipukas and sage patches within agriculture, including spiders, flies, beetles, and lepidopteran. Galling insects were far more abundant on sage within agricultural regions, but more species were present on kipukas. Several predator groups were disproportionately abundant, relative to their prey, in agricultural areas as compared with kipukas, suggesting that predators might more strongly limit groups lower in the food chains in sage patches within agriculture than on the kipukas. The overall community of arthropods on kipukas appeared to be more strongly affected by habitat size and isolation than was that of sage patches within agriculture.

Keywords: arthropods, diversity, sagebrush

Linking Landscape Disturbance to Population Level Variation in Western Rattlesnake Life Histories

Christopher L. Jenkins, PhD Candidate, Idaho State University

The synergistic effects of livestock grazing, invasive plants, and fires are altering the sagebrush steppe ecosystems of southern Idaho. This phenomenon is having a negative impact on a number of wildlife species that inhabit these systems. Our preliminary results from a 14-year mark recapture data set of two western rattlesnake populations shows that there is significant geographic variation in life histories among populations. The goal of this study is to determine if difference in the level of disturbance between two rattlesnake populations (one with low life history values and one with high life history values) cause differences in the prey availability resulting in the observed life history differences. We used radio telemetry to follow 30 snakes during the 2003-2004 active seasons and measured a suite of habitat characteristics and trapped small mammals at each snake location and a series of random locations. We found that small mammal biomass is associated with habitat characteristics typical of undisturbed sagebrush steppe including increases in shrub height and biological crust cover and decreases in grass cover. We also found that snakes were captured in areas with higher small mammal biomass relative to random locations. In addition, habitats were more disturbed and small mammal biomass was lower in the areas inhabited by the rattlesnake population with 'low' life history values. Our results suggest that widespread disturbance is having a negative impact on rattlesnake life histories through a series of trophic interactions. Suggestions for conserving remaining undisturbed areas and restoring disturbed areas are discussed.

Keywords: disturbance, wildlife ecology, conservation biology

Greater Sage-Grouse Use of Threetip Sagebrush Communities in Idaho's Great Rift Region

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David J. Delehanty, Idaho State University, Dept. of Biological Sciences, Pocatello, Idaho

In 1996, several fires burned large stands of sagebrush (*Artemesia* spp.) in the Great Rift area south and west of Craters of the Moon National Monument, Idaho. Following the fires, the U.S. Bureau of Land Management seeded many of the burned areas with native grasses and shrubs including sagebrush. Greater sage-grouse (*Centrocercus urophasianus*) are viewed as an umbrella species and the presence of breeding sage-grouse suggests that other sagebrush obligate species are also able to use restored sites. We are measuring greater sage-grouse use of seeded areas. Of particular interest is sage-grouse use of threetip sagebrush (*Artemisia tripartita*) communities because threetip sagebrush can be an early and abundant colonizing sagebrush species following fire in the Great Rift region. We monitored 42 radio-marked sage grouse (24 females and 18 males) in Great Rift burn areas from March-August 2005. Sage-grouse nest success was low, but sage-grouse did nest successfully under threetip sagebrush, basin big sagebrush (*Artemisia tridentata tridentata*), and rabbitbrush (*Chrysothamnus* spp.). Sage-grouse use of burned areas and threetip sagebrush communities will be reported. Knowing how sage-grouse use recovering sagebrush communities, including threetip sagebrush, especially in the presence of other sagebrush species, will provide valuable insight into how sage-grouse and other sagebrush obligate species respond to fire and fire restoration efforts.

Keywords: sage-grouse, threetip, fire

Technical Session VI – Plant and Ecosystems Ecology
Chairs: Heather Bechtold, Cameron Pedersen

Sagebrush Steppe Vegetation Recovery Following a Wildland Fire on the Upper Snake River Plain

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Amy D. Forman, Plant Ecologist, and Jackie R. Hafla, Natural Resources Scientist, S.M. Stoller Corp., Idaho Falls, Idaho
Mike Pellant, Great Basin Restoration Initiative Coordinator, Bureau of Land Management, Boise, Idaho
Robert D. Jones, Interagency Liason, Department of Energy - Idaho Operations Office, Idaho Falls, Idaho
Alan Sands, Southern Idaho Stewardship Ecologist, The Nature Conservancy, Boise, Idaho
Gregory J. White, Ecologist, Idaho National Laboratory, Idaho Falls, Idaho

The Tin Cup Fire Recovery Project was started in 2002 to study successional trajectories of good to excellent condition Wyoming big sagebrush/bluebunch wheatgrass communities recovering from a July 2000 fire and to address the efficiency of seeding the burned area with big sagebrush. We measured plant cover on ten exclosed plots in the burned area in 2002, 2003 and 2004. Mean total cover was 11.7, 13.6 and 20.1 percent in 2002, 2003 and 2004 respectively. Native perennial grass cover increased from 1.5 percent in 2002 to 2.3 percent in 2003 and remained unchanged through 2004. Percent cover of native perennial forbs remained relatively stable with a high of 4.1 in 2003 and a low of 3.6 in 2004. Cover by introduced species (primarily annual forbs) was 0.6, 0.3 and 1.9 percent in 2002, 2003 and 2004 respectively. Cover by native annual and biennial forbs was 0.6, 0.0 and 3.2 percent in 2002, 2003 and 2004 respectively. The increase in cover by annual and biennial species in 2004 may have been the result of higher precipitation in May and June of 2004 compared to 2002 and 2003. Approximately 4,700 ha of the burned area were aerially seeded with Wyoming big sagebrush in February of 2001. Surveys were conducted on six 1.0-km long belt transects. In 2002 and 2003, we surveyed six transects in the area planted. The surveys in 2002 found no seedlings attributable to the 2001 planting. In 2003, only 5 seedlings were found on transects in the planted area.

Keywords: fire ecology, *Artemisia tridentata*, Idaho National Laboratory

Relationships of Fire, Soil, Water, and Invasive Forbs in Sagebrush Steppe

Matthew Germino, Assistant Professor, Idaho State University, Idaho State University, Pocatello, Idaho
Jonathan Horton, University of North Carolina, Asheville, North Carolina

Sagebrush steppe communities appear unusually vulnerable to invasions by exotic herbs that can have considerable impacts on ecosystem structure and function. Understanding factors contributing to exotic plant invasions will help land managers target causes and not just symptoms of plant invasions, such as with herbicide use. Invasions by exotic forbs, such as leafy spurge (*Euphorbia esula*) and spotted knapweed (*Centaurea maculosa*), are common in sagebrush steppe following disturbances such as fire, but can also persist well past colonization phases of succession. We hypothesized that fire increases deep soil water by selectively removing deep-rooted woody plants, and that increases in the availability of deep soil water selectively favors exotic forbs over native herbs. We measured soil water contents, depth of water uptake, water status, and photosynthetic carbon uptake in knapweed, spurge, and native plants. Soil water increased substantially below about 0.4 m depth in burned compared to control plots, due largely to removal of deep-rooted sagebrush. Carbon uptake was ~50% greater in knapweed than grasses, due apparently to water uptake from deeper soils and correspondingly greater water status in knapweed. Spurge had no greater photosynthesis or water status than native plants, but, like sagebrush, acquired water from deeper than native herbs. We tentatively conclude that greater availabilities of deep soil water lead to greater carbon uptake in *C. maculosa* compared to native herbs, whereas *E. esula* might experience less carbon uptake and water status than native herbs without access to elevated levels of water in soils beneath rooting zones of native herbs.

Keywords: fire, invasive plants, plant ecology

Distribution of Soil Nutrients Following Shrub Removal and Nitrogen Addition in Sagebrush Steppe

Heather Bechtold, Graduate Student, Idaho State University, Dept. of Biological Sciences, Pocatello, Idaho
Richard Inouye, Assistant Chair, Biological Sciences Graduate Programs, and Professor, Idaho State University, Pocatello, Idaho

We examined plant available soil nitrogen, total soil nitrogen, and soil carbon under and away from shrub canopies in undisturbed areas, where shrubs were removed, and in areas that have received annual additions of nitrogen, to improve our

understanding of the effects of perturbation on nutrient distribution. Understanding the persistence or depletion of resource patches (resource islands) following shrub loss and after nitrogen addition may allow land mangers to better predict ecosystem response to anthropogenic disturbance. We found higher concentrations of carbon and nitrogen under shrub canopies compared to open areas between shrub canopies. Seven years after shrubs were removed there were still higher concentrations of nutrients where shrub canopies had been, compared to open areas between shrub canopies. There was a 24.7% increase in total soil carbon on shrub removals compared to controls, possibly due to an increase in litter inputs from herbaceous plants. There was no change in total N or C on plots that had N added when compared to control plots. This suggests N is not stored in soil organic matter and may be used or taken up by plants. Plant available N was higher below shrub canopies than in open interspaces throughout the 21 months of monitoring, however, there was one sample period during which there was more inorganic N in open areas. There were large fluctuations of plant available N between years, and throughout each year. Such variation could be linked to water availability; we found that high available N correlates with high rainfall events. Soil moisture was slightly lower below canopy than in open interspace areas.

Keywords: sagebrush, nitrogen, removal

Patterns of Diversity at Multiple Scales in a Fragmented Sagebrush-steppe Landscape

Cameron Pedersen, Ph.D. Candidate, Idaho State University, Pocatello, Idaho
Nancy J. Huntly, Professor, Idaho State University, Pocatello, Idaho

Fragmented landscapes can exhibit different patterns of diversity than continuous landscapes. We measured components of diversity of plant cover in a system of kipukas, patches of shrub-steppe habitat surrounded by lava flows at Craters of the Moon National Monument. For each of 19 kipukas, we measured relative abundance of plant cover along 4 25m transects using a 36-point 1x0.5m point-frame. For each of three spatial scales (transect, kipuka, region), we calculated alpha diversity using the Shannon-Wiener index, and beta diversity using the Sorenson index. We also calculated total species richness for an additional 30 kipukas. There was a positive relationship between alpha and beta diversity at both the kipuka and regional scale. Kipuka and regional diversity were positively correlated with area. We found no relationship between alpha diversity in kipukas and soil texture, though there was a slight negative relationship between alpha diversity and elevation. Our results differ from other studies that have shown that landscape fragmentation can lead to decreased alpha diversity relative to beta diversity. Rather, both alpha and beta diversity appear to increase with habitat availability in sagebrush-steppe.

Keywords: sage-steppe, diversity

The Flora of Kipukas of Craters of the Moon National Monument and Preserve

Nancy Huntly, Professor of Ecology, Idaho State University, Dept. of Biological Sciences, Pocatello, Idaho
Cameron Pedersen, Dept. of Biological Sciences, Idaho State University, Pocatello, Idaho

We studied the flora of kipukas of Craters of the Moon National Monument and Preserve, sampling kipukas that represented the range of sizes and distances from nearby extensive sage tracts and were dispersed over the geographic extent of the Monument during the summers of 2004 and 2005. We found relatively few non-native plant species, and most were not common. However, cheat grass *(Bromus tectorum),* was frequently present on kipukas and was found on most kipukas except in the northern part of the Monument where it was less frequent and less abundant. Patterns of distribution and abundance of species of interest will be discussed.

Keywords: flora, kipukas, species of interest

Distribution of Cesium in Soils and Plants of the Eastern Snake River Plain

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Richard Inouye, Professor, Dept. of Biological Sciences, Idaho State University, Pocatello, Idaho
Terence McGonigle, Assistant Professor, Department of Botany, Brandon University, Brandon, Manitoba, Canada

Stable cesium (Cs) concentrations were determined for 28 soil and 330 distilled water-rinsed plant samples collected from 27 sites located across the eastern Snake River Plain and adjoining areas. Soils were analyzed for pH, grain size distribution, percent carbon, cation exchange capacity, percent exchangeable potassium, sodium, calcium, and magnesium, and mineralogy of the clay-size fraction. Soil Cs concentrations ranged from 2030 to 6290 ppb (ng Cs • g dried soil^{-1}). Approximately 98% of the total variation in soil Cs concentration was explained by cation exchange capacity and abundances of the minerals smectite, mica-illite, vermiculite, quartz, and potassium feldspar. Plant samples consisted of above ground tissues. Values for plant Cs ranged from 0 to 364.72 ppb (ng Cs • g dried plant tissue^{-1}) and for transfer factors

from 0 to 8.66 x 10^{-2}. Transfer factors were calculated for all plant samples by dividing the plant Cs concentration by the soil Cs concentration. Titianium (Ti) concentrations were determined for plant samples and were used as an indicator of soil contamination because Ti is prevalent in soil and not taken up by plants. Values for Ti concentration ranged from 0 to 223.66 ppm (µg Ti • g dried plant $tissue^{-1}$). For the 18 most frequent species, average plant Cs concentration was strongly correlated (r^2 = 0.9456) with average plant Ti concentration suggesting that most of the Cs associated with plants is related to soil contamination rather than uptake and that rinsing with distilled water was not completely effective in removing soil contamination.

Keywords: cesium, titanium, plants

Technical Session VII – History and Cultural Arts

Chairs: Julie Braun, Lennie Ramacher

The First Hundred Years (1830-1930) of Historical Comments Regarding and Geologic Studies of Basaltic Volcanism of the Eastern Snake River Plain, Idaho: the Contributions of Benjamin L. E. Bonneville, John C. Fremont, Ferdinand V. Hayden, Israel C. Russell, and Harold T. Stearns

Mel Kuntz, Research Geologist Emeritus, U.S. Geological Survey, Denver, Colorado

Bonneville described the Craters of the Moon area (1832 or 1833): "An area of about 60 miles in diameter, where nothing meets the eye but a desolate and awful waste, where no grass grows nor water runs, and where nothing is seen but lava." Fremont's journal (1845) notes that the eastern Snake River Plain (ESRP) was "covered as far as the eye can see with artemisia, the dark and ugly appearance of this plain obtained for it the name of the Sage Desert." He said, "The banks (of the Snake River) consist of fine vesicular trap rock, intermediate portions being compact and crystalline. The high banks of scoriated volcanic rock form a chasm rent through the country." Thomas Fitzpatrick, a guide for Fremont, described the ESRP as "so broken up and rent into chasms as to be impracticable for a man even on foot." Hayden (1871) commented "We come to the southern border of the great basaltic overflow in the valley of the Port Neuf and Snake River, for I am now convinced that this comparatively modern eruption of igneous material covered an immense area of country, and might be called the basin of a wide, extended lake of igneous material, of which the Snake River basin was the center." Hayden recognized Menan Buttes as "extinct craters" and recognized how rivers such as Camas, Medicine Lodge, Godins (Little Lost) "disappear into the plains and find their way, from 10 to 30 miles, to Snake River, underneath this basaltic floor." Frank Bradley, of the 1872 Hayden Survey, recognized that flows in Portneuf Valley had vents near Soda Springs. Bradley said of Menan Buttes "I am strongly impressed with the belief that the eruption and deposition were subaqueous and took place when this whole plain was covered by the waters of a lake." Russell conducted fieldwork in 1900 and 1901 to determine how "geological conditions favored artesian wells in the broad lava-floored plains bordering the Snake River". Significant conclusions he reached were: East and Big Buttes are "extinct rhyolites volcanoes;" basalt lava flows cover >20,000 mi^2 and are >700 feet thick in southern Idaho; fissure eruptions are the main source of basalt flows, as postulated in 1879 by Geikie; that ESRP volcanoes are either of cone-type or low, flat-topped cones with broad bases; and recognition of pahoehoe and 'a'a flows, lava tubes, tuff cones, bombs, pressure ridges, and the significance of pillow basalts. Stearns began fieldwork in the Mud Lake area in 1921, at age 21, just weeks after graduating from Wesleyan University. His Plate 3 of USGS WSP 818 is the first detailed geologic map of the ESRP, covering an area from Terreton to Island Park, Idaho. Stearns described and mapped various volcanic features, vents, and flows in the area north and east of Mud Lake, determined that the flows were more than 1,000 feet thick and, because of their permeability, constituted the main aquifers in the area. Stearns is best known for his studies of the Craters of the Moon lava field; his fieldwork was conducted in 1922 and 1926. A report he prepared in 1922 for the NPS was instrumental in establishment of the Craters of the Moon National Monument in 1924. It is important to note that the volcanological knowledge he used in his studies in Idaho before 1924 was self-taught. He witnessed the 1924 eruption of Kilauea volcano, Hawaii, and, later that year, visited volcanoes in Japan, Indonesia, and Italy. Thus, his later studies of volcanic terranes in Idaho were influenced by these studies of active volcanoes.

Keywords: history, basaltic volcanism, H. T. Stearns

The First Exploration of the Great Rift and Craters of the Moon

Clark Heglar, Lead Interpreter/Historian, Celebration Park, Melba, Idaho

Robert "Two Gun" Limbert was the first to completely explore the Great Rift and what would become the Craters of the Moon National Monument. In a landscape described by early emigrants on the Goodale Cutoff of the Oregon Trail as "Devils Vomit" he traversed the 80 miles of the Great Rift between Minidoka and Arco in May of 1920. In 17 days of exploration, documentation and photography he showed and explained the uniqueness and beauty of the area. Many think that his photographs and descriptions of his exploration published in the National Geographic single handedly led to the creation of Craters of the Moon National Monument. Clark Heglar created his historical portrayal as Limbert at the request of Dave Clark, Craters of the Moon National Monument's Chief Interpreter, to help promote the 75th anniversary of the Park in 1999. Heglar will portray Limbert, and in character present special information and photographs of the pioneering trip in a program created exclusively for the symposium.

Keywords: Craters of the Moon, exploration, photography

National Geographic and Craters of the Moon

Clark Heglar, Lead Interpreter/Historian, Celebration Park, Melba, Idaho

Robert "Two Gun Bob" Limbert will talk about the article and show photographs he created for the March 1924 National Geographic during his first exploration of The Great Rift and what would become Craters of the Moon National Monument. Clark Heglar created his portrayal of Limbert at the request of Dave Clark, Chief Interpreter at Craters of the Moon to help promote and celebrate the 75th anniversary of the Monument. Heglar in his role as Limbert will talk about the explorations and the documentation of what Limbert saw and wrote about for the magazine. His article was held up for thirty months while scientists, geologist and journalists verified his observations. Because of the great acclaim after the article was published the area was made a National Monument, Idaho's first by President Calvin Coolidge. Special information created exclusive for the symposium will be presented.

Keywords: National Geographic, photography, exploration

Among the Craters of the Moon, The Life of Idaho Explorer Robert W. Limbert

Steve Wursta, Documentary Film Maker/Photographer, Arctic Circle Productions, Bend, Oregon

With the recent discovery of thousands of pages of manuscripts and hand written documents, the details of Robert W. Limbert's discoveries in Craters of the Moon come to life. The new details immerged through 8-months of research on Limbert's life for a 1-hour documentary film. We now know that Limbert was a trained surveyor for the Union Pacific railroad and assisted in a number of important archeological digs in Nebraska. Limbert's discoveries along the Great Rift were the results of methodical research and preparation but also in his fascination with grizzly bears, including the 1915 government report of a dwarf grizzly bear killed on the lavas north of Minidoka. Although removed from all published accounts, Limbert recorded his triangulated positions throughout his journeys in the lavas. Limbert even calculated magnetic declination via the Polar Star for accuracy. We now know that Limbert concern for the environment and the preservation of artifacts were instilled at a very early age and appear in his original drafts of his work. Editors removed many of his concerns and calls to action before publication. The narratives of his multiple journeys in the 1920's paint a fascinating picture of the animal life and the state of artifacts from nomadic peoples who crossed the Great Rift over the millennia.

Keywords: history, Limbert, Craters of the Moon

Photography: "Art" Becoming a Baseline for Scientific Inquiry

Clark Heglar, Lead Interpreter/Historian, Celebration Park, Melba, Idaho

Robert "Two Gun" Limbert never went exploring wild Idaho without a gun or camera. His resulting photography is manifold over the years. In our times his photographs have uses that even he could not imagine. In his time the photographs were used to illustrate and document his explorations, his work, and his life. Many of the photographs were of such quality and beauty that Ansel Adams spoke highly of his work and its influence to the members of the f-64 group that was setting the standards of scenic "art" photography at the time. His photographs created excitement and interest in an area largely ignored. Limbert's photos of what became Craters of the Moon National Monument were published in the National Geographic and drew national acclaim, and proved that his descriptions of the area, the geology, flora and fauna were accurate. The resulting body of work that survived shows how Idaho looked 80 years ago and his "art" has allowed diverse groups, such as the BLM, the U. S. Forest Service, Idaho Conservation League and other environmental interest groups to document the changes in bio-diversity, geology, historical sites and artifacts that have taken place in Idaho in the last

80 years. If it wasn't for his "art" of photography we would not be able to compare the changes that have taken place. Heglar will be talking about and showing these contributions of "art" that have impacted the science of today.

Keywords: photography, art, historical

Craters of the Moon Photographic Project

Tim Frazier, Professor, Idaho State University, Idaho Falls, Idaho

Craters of the Moon Photographic Project created a concise, accurate and detailed photographic survey of Craters of the Moon National Monument and Preserve. A wide variety of photographic methods were employed including conventional film based imaging as well as the latest digital techniques. The organization of this yearlong effort was modeled on the photographic surveys of the post-American Civil War period, in particular, the Hayden Geological Survey of what is now Yellowstone National Park. Prior to the Craters of the Moon Photographic Project, no systematic photographic documentation of that National Monument existed. Also, the recent acquisition of 700,000 additional acres has made Craters of the Moon one of the 20 largest national monuments in the United States. None of this new addition has been photographed and portions are unexplored. This project has produced a visual library of the current state of this national monument and portfolios of scientific and aesthetic images. This presentation will outline the project, showcase the images and relate this effort to the historic surveys of the 19th century American west. The interrelationship of science and art in providing an overview of Craters of the Moon is stressed throughout this presentation.

Keywords: photographic survey, scientific photos, aesthetic photos

Passing Impressions: Human Encounters with a Desolate Landscape

Lennie Ramacher, Park Guide, Craters of the Moon National Monument, Arco, Idaho

Human history at Craters of the Moon National Monument and Preserve is dictated by the environment. Stretching from the base of the Pioneer Mountains southward to the Snake River, volcanic eruptions along the Great Rift over the last 15,000 years spilled basalt over more than 700 square miles. The rugged lava formations and arid high desert climate of the Snake River Plain combine to make the Craters of the Moon region nearly impassable to human travelers, let alone inhabitable. A scarcity of basic resources – food, shelter, and a reliable supply of surface water – is directly responsible for sporadic visitation by humans. The historical record at Craters of the Moon is one of groups and individuals – Native Americans, Oregon Trail emigrants, and explorers – coping with the harsh environment while passing through the area. The landscape continues to resist development so that today's visits remain brief, like those of our forebears.

The Idaho National Laboratory: An Historic World War II Trash Trove

Julie Braun, Team Lead/Architectural Historian, Cultural Resource Management Office, Idaho National Laboratory, Idaho Falls, Idaho

Historians and archaeologists love trash, the older the better. Sometimes these researchers find their passion in unexpected places. In this presentation, the treasures found in a large historic dump that lies relatively untouched in the middle of the Idaho National Laboratory (INL) will be described. The U.S. military used the central portion of the INL as one of only six naval proving grounds during World War II. They dumped trash in dry irrigation canals during and after their wartime activities and shortly before the federal government designated this arid and desolate place as the nation's nuclear reactor testing station in 1949. When read critically and combined with memories and photographs, the 60-year old trash provides a glimpse into 1940s' culture and the everyday lives of ordinary people who lived and worked during this time on Idaho's desert. Thanks to priceless stories, hours of research, and the ability to read the language of historic artifacts, the dump was turned from just another trash heap into a treasure trove of 1940s memorabilia. Such studies of American material culture serve to fire our imaginations, enrich our understanding of past practices, and humanize history. Historical archaeology provides opportunities to integrate inanimate objects with animated narrative and, the more recent the artifacts, the more human the stories they can tell.

Keywords: Idaho, archaeology, history