Taylor Note: Please list abstracts in program in the order presented. The numbers in the poster titles are intended, please retain in the final edited version.

EARTH SCIENCE

Session Chair: Steve Taylor
Session Title: Medical Geology: A Globally Emerging Discipline at the Crossroads of Earth Science and Public Health
Location: Werner University Center

Posters

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Steve Taylor *(faculty presenter)*

Title: 1. Session Overview: Effects of Geological Environments on Human Health

Abstract: This theme session involves presentation by 19 WOU Earth Science students enrolled in ES473 Environmental Geology, spring term 2010. The focus of the session is on the emerging specialty discipline of medical geology, the study of the effect of geological phenomena on animal and human health. Since 2001, this branch of geological science has experienced a renaissance and transformation from studies that were heretofore generically referred to as "environmental health". The geological community has rightfully staked a claim to its component of the public health field with representation of the discipline in international scientific societies (e.g. International Association of Medical Geologists, Geologic Society of America Health Division), the National Academies of Science (National Research Council, 2007, "Earth Materials and Health : Research Priorities for Earth Science and Public Health"), and prominent scientific publications (e.g. Oxford University Press, 2003, "Geology and Health: Closing the Gap"; Elsevier, 2005, "Essentials of Medical Geology").

The health effects of Earth materials and geological processes are well established. Recent newsworthy examples include the disease effects spawned in the aftermath of the January 2010 Haitian earthquake, arsenic toxicity associated with groundwater supplies in the vicinity of Roseburg, Oregon, and increased cancer rates in uranium-bearing terrains of the southwestern U.S. This theme session provides an overview of the science of medical geology and case study applications from around the world. The range of topics include: introduction to medical geology as a profession, health effects of Earth materials, medical impacts of water quality, biogeochemical interactions and nutrient anomalies, anthropogenic degradation of geological environments, application of geochemistry to environmental health issues, geospatial analysis as a tool in epidemiology, health hazards associated with volcanic eruptions, global dust flux and respiratory problems, impacts of radon-arsenic-selenium-mercury-iodine on physiological function, carcinogenic associations with coal and fibrous minerals, geological effects on animal health, and geophagy (human ingestion of soil materials as a dietary supplement).

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Kelsii Dana
Faculty sponsor: Steve Taylor

Title: 2. Medical Geology: Introduction and Overview of an Emerging Discipline

Abstract: Medical Geology is an ancient and re-emerging field of science that combines elements of earth science and public health. The focus of medical geology is to decipher the impacts of geologic phenomena and other environmental factors on human health and quality of life. Significant issues in medical geology today include toxic and deficient levels of essential and nonessential minerals, exposure to radioactive elements, industrial contribution to toxic exposures, dust, and geologic events such as volcanic eruptions. The goals of medical geology are to identify sources of health hazards in the geologic environment and prevent or diminish their ill affect on humans.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Angela Devenberg
Faculty sponsor: Steve Taylor

Title: 3. Medical Geology: Example Applications and Research Directives

Abstract: Medical geology can affect humans and animals directly and indirectly. Examples include release of elemental constituents into the environment from geology sources. Arsenic, Molybdenum and Radon are a few of the compounds that pose health risks. These elements are found in drinking water and soil. Some of the health risks associated with these elements includes skin disease, reproductive problems, and lung cancer. Other phenomena include natural hazards like earthquakes and volcanoes, which may cause catastrophic deaths or long-term chronic health conditions. Geologic health hazards, from gas clouds to lahars, may cause a wide variety of health problems ranging from asthma to death. This paper will examine the spectrum of applications in the emerging field of medical geology. Geologists play an important role by recognizing what actions need to be taken to reduce and prevent the risks associated with geologic health hazards. Through educational outreach programs, geologists work to increase public awareness of environmental health issues.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Jody Berg
Faculty sponsor: Steve Taylor

Title: 4. Earth Materials at the Foundation: Geological Factors that Effect Human Health

Abstract: The Earth's crust is comprised of rock material, which in turn is composed of inorganic silicate minerals. Rock material decomposes at the Earth's surface to form regolith via chemical and physical weathering. Regolith forms the basis of soil and the fundamental framework for life in the critical zone, at the interface of the hydrosphere, atmosphere, and geosphere. Soil forms via physical, chemical and biological transformations over time. As result of pedogenic process, elements are released into surface and groundwater, and subsequently become available as part of macro- and micro-nutrients in the food chain with plants at the foundation. Essential macro-elements derived from the lithologic environment include Ca, Mg, Na, Cl, K, P, and S. Lesser abundant, but still important nutrients include Mn, Fe, Co, Cu, Zn, and Se. Deficiencies and surpluses of nutrients in the food chain effect physiological function of both animals and humans. Thus an understanding of geological variables in terrestrial ecosystems is essential for regional public health studies. This paper examines the effects of Earth materials and related near-surface processes on human health.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Mac Marshall
Faculty sponsor: Steve Taylor

Title: 5. Water Quality and Public Health

Abstract: Water is one of the most important resources on this planet, without it life wouldn't exist. The hydrosphere forms the foundation of the critical zone near the Earth's surface, in which biologic organisms flourish. The global demand for potable water is increasing while the availability and quality is decreasing. Hence, freshwater environments are of major importance to human health in both direct and indirect ways. This project examines geologic variables that influence water quality around the world, and its epidemiological effects.

A case study of groundwater quality from the Makutuapora in the Dodoma region of central Tanzania reveals a relationship between mineral-water interactions, water chemistry, bedrock geology, and microbiology. The natural geological and geochemical environment, in addition to providing beneficial elements that support plant growth, may also give rise to undesirable or toxic properties through deficiencies or anomalous excess.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Kailey Clarno
Faculty sponsor: Steve Taylor

Title: 6. Biogeochemical Cycling and Interactions: Implications for Human Health

Abstract: Before an element can be utilized by an organism, that organism must first be able to uptake it. Elements originating in geological materials are transported through soils and presented to plants in a convenient form for uptake. This project examines the pathways as nutrients are released from Earth materials and utilized by human organs.

Of the many elements on the periodic table, living organisms need about twenty of them. Eleven of these appear to be roughly constant and abundant in biological systems. Four elements (hydrogen, carbon, nitrogen, and oxygen) account for 96% of the total human body, as well as the bulk of living organisms and are termed “major elements”. The “minor elements” include sodium, magnesium, phosphorus, sulfur, chlorine, potassium, and calcium. The latter are termed electrolytes and comprise 3.78% of the human body mass. Lastly, there are eighteen essential trace elements. These nutrients are present in humans at levels that are orders of magnitude lower than found in the Earth’s crust. Metals comprise the bulk of essential trace elements available for uptake, but other important examples include selenium and iodine. Of the metals, iron is an element that is essential for many metabolic processes including oxygen transport, DNA synthesis, and electron transport. As such, this fundamental element is used as a case example to demonstrate the biogeochemical pathways starting in the soil and ending in human organs.

The impact that geology has on uptake of elements by humans and other organisms is dependent on a number biotic and abiotic variables. Understanding of the geological controls on nutrient uptake in plants and animals, including humans, is essential for deciphering public health consequences associated with deficiencies or toxicity.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Marc DesJardin
Faculty sponsor: Steve Taylor

Title: 7. Anthropogenic Factors and Human Health

Abstract: Anthropogenic releases of chemical contaminants into the geologic environment can cause significant health effects in humans and degrade ecosystems as a whole. The destruction of our natural resources for the expansion of urbanization and the pollution that urbanization creates could eventually be the fatal blow for mankind. Toxic releases have been associated with cardiovascular disease, malignant tumors, trauma and genetic anomalies. Polluting agents such as pesticides, heavy metals, petroleum compounds and industrial residues stimulate negative health feedbacks in the environment. Mankind is poisoning itself through environmental manipulation that leads to toxic releases that eventually work their way through the food chain back to mankind. This project examines the range of human-induced health risks including radiation, chemical releases, electromagnetic fields, soil contamination, agricultural degradation, and pollution.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Dan Dziekan
Faculty sponsor: Steve Taylor

Title: 8. Applied Geochemistry as a Tool in Medical Geology

Abstract: An increase of population and growth in economic development is causing adverse reactions with the surrounding environment of many areas. This population growth is responsible for changing the natural landscape and is also releasing a variety of pollutants. The combination of human-introduced chemicals, as well as those that occur geologically, have caused toxic elements to become more abundant and pose increased health risks. These pollutants can be studied using geochemical analysis of a given area, a combination of geological and chemical techniques applied in the context of public health.

The chemicals found in the Earth have been directly linked to a multitude of health problems ranging in scale from allergies to cancer fatalities. Even minimal exposures over long periods of time can have adverse effects by allowing toxic elements, such as arsenic, to build up in the body. By taking the proper steps in monitoring geochemical parameters in the environment, it is possible to mitigate exposure and reduce health risks. This paper examines a variety of techniques that are used to determine the level of potentially dangerous chemicals occurring in the hydrosphere and geosphere. This work is placed in the context of case studies associated with agricultural and forestry practices.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
William Vreeland
Faculty sponsor: Steve Taylor

Title: 9. Geographic Information Systems and Geospatial Analysis: A 21st Century Tool for Epidemiology and Public Health Management

Abstract: Epidemiological studies involve analyzing public health factors in the context of time and space, with the goal of mitigating disease outbreaks. Emerging advances in computer processing power and cost are facilitating research into linkages between geospatially-distributed risk factors for illness and disease. Geographic Information Systems (GIS) provide a software technology that allows scientists to easily link public health databases to geospatial information and forms the cornerstone of epidemiology in the 21st century.

Improved resolution of datasets allows visual representation of complex, multilayered, logical, numerical, and statistical relationships between populations, risk factors, and known or hypothesized causal factors. Geospatial relationships combined with raw and processed data enable researchers to identify, mitigate, or prevent both epidemic and endemic disease fostered by vectors that have a geographic component. This developing technology comes with the cost of upgrading computer workstations and network bandwidth to accommodate the geometrically increasing size of the datasets, however the potential benefits to public health management are significant. This paper provides an overview of GIS applications in the public health sector, and presents case studies demonstrating the efficacy of the technology.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Alyssa Marquez
Faculty sponsor: Steve Taylor

Title: 10. Regional Medical Geology: Global Health Trends and Geographic Case Studies

Abstract: The field of medical geology studies the effects of geological materials on the health of both humans and animals. Plate tectonics, crustal lithology, and climate of any given region are spatially variable and have a direct influence on the input of elements into the soil, air, and water. Health issues associated with regional geologic variation have been observed all over the world. Tectonic and surface hazards (e.g. earthquakes, volcanic eruptions, floods, landslides, tsunamis) catastrophically impact social infrastructure, and in turn spawn a host of public health issues. Other examples include degraded water quality and anomalous concentrations of essential elements that also lead to adverse health effects. This paper provides a sampling of regional case studies in medical geology and demonstrates the geographic variability of health conditions associated therein.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Kevin Friscia
Faculty sponsor: Steve Taylor

Title: 11. Health Effects from Volcanic Eruptions

Abstract: Volcanic processes operated on Earth long before the onset of planetary life and biological evolution. Humans have long lived in the shadows of active volcanoes, with catastrophic deaths in proximal eruptive zones the most obvious hazard. Only in the past several decades have geoscientists begun monitoring the long term effects that volcanic emissions have on human health. Living near vents causes hazards associated with pyroclastic and lava flows, while farther away, fine atmospheric tephra pose other health problems. This study focuses on the long-term health effects from volcanic eruptions. Ejecta containing hot ash, gases and dust commonly result in inhalation, short-term respiratory stress, skin and ocular irritation. Inhalation of volcanic gases (e.g. SO_2, H_2S, SO_3, H_2SO_4) can lead to chronic respiratory disease and death. Understanding of the long- and short-term effects associated with volcanic eruptions is essential for developing public heath strategies and hazards mitigation plans in tectonically active regions. Both regional and global case studies are presented to demonstrate the relevance of medical geology with respect to applied practice.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Carlie Bulen
Faculty sponsor: Steve Taylor

Title: 12. The Effects of Global Dust Flux on Human Health

Abstract: One field of study in medical geology examines the effects of atmospheric dust on human health. These effects can have significant health consequences, but are not widely recognized in the literature. Dust inhalation and lung accumulation is known to cause long term chronic health conditions. Sources in the atmosphere include wind deflation, burning of vegetation, volcanic eruptions, and anthropogenic disturbance. Classic locations associated with dust-related lung complications include the great dry lands of the northern hemisphere, the U.S. Great Basin, and southern hemisphere arid regions of Australia, South America and southern Africa. These locations are notoriously associated with high rates of silicosis and asbestosis, and attendant lung disease. Factors that influence the severity of these conditions include duration of exposure, the size of particles inhaled, and the toxicity of minerals comprising the particles. One detrimental element found in dust particles that is linked to a significant number of these conditions is silica. Although dust-related lung disease is a significant problem in underdeveloped countries and desert regions, few public health actions are being implemented to mitigate harmful effects of dust inhalation. This paper presents an overview of the geological influences on global dust flux and case examples of chronic health effects associated with excessive inhalation.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Joni Osborn
Faculty sponsor: Steve Taylor

Title: 13. Radon: A Deadly Carcinogen in the Geologic Environment

Abstract: Radon is a naturally occurring noble gas that results from radioactive decay in uranium-bearing bedrock and regolith. Radon occurs in a variety of geologic settings around the world, including the United States. Bedrock sources most associated with radon include metamorphic rocks and granites, black shales, feldspathic glacial deposits, and uranium ores. Health hazards associated with this gas include lung and stomach cancers, caused primarily by inhalation or ingestion. Radon exposure increases chances of lung cancer deaths in smokers and miners who work in underground enclosures.

Radon hazard mapping helps locate risk areas and guides public health protection. Global hot spots for radon exposure include the Sierra Nevada-Rocky-Appalachian mountain regions of the U.S., glacial terrains of the upper Midwest, Great Britain, Norway, and the Czech Republic. This paper provides an overview of the geochemistry behind radon occurrence and presents examples of mitigation projects from around the world.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Riccilee Keller
Faculty sponsor: Steve Taylor

Title: 14. The Problem with Geogenic Arsenic and Global Health Effects

Abstract: The 20th most abundant element found in the Earth is Arsenic (As). This element naturally occurs as As (III) and As (V). These two oxidation states determine toxicity levels and control its fate and transport into the human body, via geologic processes. Sources of arsenic exposure include contaminated ground water, coal, geothermal springs, volcanic sediments, and anthropogenically-related releases. Arsenite (H_3AsO_3) is the dominant species of As (III) in solution and is strongly absorbed onto iron oxides and other soil constituents (e.g. clay). Arsenate (H_3AsO_4) is the most common form of As (V) and highest absorption rates occur when pH falls between 4 and 7. As is highly mobile in the hydrosphere and poses a widespread public health concern.

Exposure to Arsenic can come from both natural and anthropogenic activities. The most common toxic pathway is via groundwater, where the most acute cases are associated with Asian countries. West Bengal and Bangladesh, in particular, suffer from rampant arsenic poisoning, often interpreted as the result of agricultural irrigation. In heaviest impacted areas, concentration levels range up to 500 ppb (parts per billion), whereas background levels usually average between 3 and 20 ppb. China's Guizhou Province suffers from As poisoning via lithologic pathways, thought to be intensified by use of domestic coal fuel associated with concentrations up to 3500 ppb. Long term exposure to As, whether air born, in food supplies, or drinking water, may result in cardiovascular disease, neurological disorders, skin depigmentation, rhagades, hyperkeratosis and Bowen's Disease (squamous cell carcinoma). This paper examines the global impact of environmental arsenic and its range of human health effects.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Von Blanchard
Faculty sponsor: Steve Taylor

Title: 15. Arsenic Occurrence and Health Risks in Aquifer Systems of Western Oregon

Abstract: Arsenic concentrations in groundwater of western Oregon commonly exceeds the maximum concentration limits (MCL) specified by the U.S. Environmental Protection Agency. Arsenic varies spatially according to
composition of bedrock aquifer materials and temporally with seasonal changes in climate-driven recharge. Select aquifer systems in Lane and Linn Counties, the Tualatin basin, and the Sutherlin area are associated with anomalous arsenic concentrations in groundwater. Arsenic toxicity and long term health effects pose a risk to rural water users and well owners in these areas. This paper examines the geochemical conditions associated with arsenic distribution in western Oregon and considers mitigation strategies with respect to public health practice.

11:30 a.m. – 1:30 p.m., WUC Pacific Room

Caitlin Morris

Faculty sponsor: Steve Taylor

Title: 16. Geochemical Controls on Selenium Occurrence in the Environment: Dietary Balancing Between Deficiency and Toxicity

Abstract: Recent advances in medical geology have improved scientific understanding of the role of selenium (Se) as an essential trace element in human health. Even though selenium is an essential element, it has one of the narrowest concentration ranges between physiological deficiency and toxicity, either of which is potentially detrimental to bodily function. Se deficiency is directly correlated with Keshan Disease (KD), a heart ailment mainly affecting women and children, and Kashin-Beck Disease (KBD), which leads to deformity of the feet and hands. The effects of Se toxicity are less dramatic than those associated with deficiency, but just as efficient in causing health-related discomfort. This project examines the role of selenium geochemistry in human health, and provides case examples of public health issues from around the world.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Trista Ten Clay
Faculty sponsor: Steve Taylor

Title: 17. Geologic Occurrence of Mercury and Iodine: Health Concerns in the 21st Century

Abstract: The emerging field of medical geology provides a unique perspective to the many health effects caused by iodine and mercury in the natural environment. Iodine in small quantities is an important element that helps the body retain and use water, making it vital to human and animal health. Overexposure and underexposure of iodine may cause very serious and sometimes deadly effects. In contrast, mercury is a toxic metal that is tolerable to physiological function in small amounts; but the process of bioaccumulation and incremental increases in the food chain creates a threat of overexposure. Case studies are examined to understand the geologic controls on the mercury and iodine occurrence. Examples include a goitre occurrence in Sri Lanka, excessive iodine accumulation in southeast Asia, mercury toxicity in the gold fields of Kenya, and bioaccumulation potential in regional food supplies.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Kacey McCallister
Faculty sponsor: Steve Taylor

Title: 18. Impacts of Mineral Resource Extraction: The Effects of Coal and Asbestos Residues on Human Health

Abstract: Coal and fibrous minerals have many adverse health effects in those individuals that encounter them through mining, industrial processing, or domestic use. Certain coals that are found in China are used to dry crops such as corn and peppers, and in cooking. Unfortunately the coal that is available in that region contains high amounts of arsenic and fluoride. Exposure leads to many health issues such as decay of the teeth, bowed and crippled limbs, and scaly skin. Another mineral resource with direct and harmful side effects is asbestos. Asbestos minerals tend towards a fibrous habit that is very dangerous to the body because of their ability to enter into the lungs and alter cell function. Those afflicted with respiratory illnesses slowly find it harder to breath because of tissue hardening over time. This paper examines the effects of mineral resource extraction and the effects residual environmental release on human health.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Rachel Johnson
Faculty sponsor: Steve Taylor

Title: 19. Bedrock Composition, Soil Chemistry and Animal Health: Global Case Studies in Applied Medical Geology

Abstract: This paper examines relationships between regional bedrock geology, soil composition, and plant nutrient quality. Animals are affected by changes in bedrock composition and attendant soil mineralogy. Mineral deficiencies and poisonings occur due to geochemical anomalies in a given region. Mineral imbalances can also cause diseases as the excessive uptake of one element blocks absorption of other necessary nutrients. Changes in soil moisture, organic matter content, clay content, pH levels, cation exchange capacity affect bulk soil chemistry and hence plant nutrient uptake. Plants in turn absorb these elements and sicken foraging animals if they do not contain the proper mineral balance. Deficiencies are further exacerbated by droughts, excessive snowfall, and temperature extremes that restrict animal diets to less efficient food sources.

Case studies are presented to illustrate bedrock-plant nutrient associations. Farmers have experienced ruminants succumbing to molybdenosis and copper deficiency. Molybdenum creates an endocrine imbalance leading to weight loss, lethargy, emaciation, and behavioral disturbances. Wild herbivores are most affected by excessive or deficient mineral quantities in plants. For example, Swedish moose commonly develop type-2 diabetes due to chronic molybdenosis and elevated glucose levels. In Africa, animal migration patterns follow the availability of plants that contain essential trace elements that are endemic to a particular geologic terrain.

11:30 a.m. – 1:30 p.m., WUC Pacific Room
Lindsey Robinson
Faculty sponsor: Steve Taylor

Title: 20. Geophagy: The Effects of Soil Ingestion on Human Diet and Health

Abstract: Geophagy is the ingestion of soil, either involuntarily or deliberately. Foods can be contaminated, dust may be inhaled, or it can be a part of a person's everyday diet. Deliberate geophagy has been in existence since before the evolution of *Homo sapiens*, however it was first recorded in the 1st century A.D. when *terra sigillata* was used for medicinal purposes. This composite substance was made from a soil that comes from the Greek island of Lemnos, mixed with goat's blood and dried into a nickel-sized tablet. These tablets were used for many medicinal purposes and was listed in medical journals up through 1848. In the "New World" many natives practiced geophagy, though most only used it in times of great famine or for suicide. Geophagy in the U.S. today, though not widely admitted for obvious reasons, can be attributed to the practices of the slaves brought over from Africa in the early years of our nation's history.

Some reasons for modern day geophagy include: food or a food detoxifier, treatment of psychological disorders, use as a pharmaceutical, cultural tradition, or as a form of suicide. Claimed benefits of geophagy include relief of pregnancy symptoms or use as a mineral supplement. Side effects include elemental deficiencies, toxicities, and anxillary ingestion of soil-borne pathogens. This paper examines the history and practice of geophagy in medical applications.