USGS NSF GRIP, GSP Opportunity

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USGS Center:	Forest and Rangeland Ecosystem Science Center
Project Title:	Molybdenum dynamics in soil organic matter and implications for carbon storage
Summary:	Molybdenum - a metallic micronutrient with macroscopic impact – is an essential element that fuels biological nitrogen fixation, soil fertility and carbon storage on land. Recent studies suggest that organic matter regulates molybdenum dynamics in soil, and this project will use cutting-edge stable isotope methods to unravel how that occurs, and what it means for carbon storage on land.
Project Hypothesis or Objectives:	The trace element molybdenum (Mo) regulates biological nitrogen (N) fixation in many ecosystems, which in turn shapes soil fertility and carbon (C) sequestration in the terrestrial biosphere. Conversely, recent work by USGS and colleagues has identified soil C as a primary control of soil Mo pools across ecosystems worldwide, challenging long-standing ideas that mineralogy and redox regulate soil Mo biogeochemistry. Thus, an emerging frontier in advancing understanding of Mo biogeochemistry, and its interactions with C and N cycles, depends on resolving the mechanisms of Mo interaction with soil C. Recent improvements in the measurement of Mo stable isotopes, and in separating soil Mo fractions, are providing new insights into understanding of Mo geochemistry and biogeochemistry. This project will use these advances to pursue tractable questions of soil Mo bio/geochemistry, relying especially on unique capability for Mo stable isotope analysis in Corvallis, OR. These cutting-edge techniques will be applied across a well-constrained gradient of nearby forests that span a globally wide range of soil C, as part of ongoing research on coupled Mo-C-N cycles by USGS and colleagues. These forests provide an ideal natural laboratory for advancing fundamental understanding of coupled Mo-C-N biogeochemistry, because here: soil organic matter (C) varies widely across sites independent of other soil forming factors, soil C

storage regulates Mo accumulation and dominant soil Mo fractions, with patterns consistent across two geochemically distinct bedrock types (sedimentary and basalt), in forests where Mo demonstrably limits biological N fixation in actinorrhizal trees, lichens, and soil bacteria.

The proposed work will focus on laboratory measurements and experiments using soil collected from well-studied forest sites that span wide natural gradients in soil Mo-C-N. Specifically, the work will evaluate mechanisms of organic matter complexation of Mo, its relationship to soil pH and mineralogy, and their combined effect on soil Mo stable isotope fractionation. Answers to these tractable mechanistic questions will feed into larger questions of how ecosystems retain Mo, what controls Mo cycling and availability, and the relative supply of Mo to land ecosystems from bedrock vs. atmospheric sources. The project results have important implications for the sensitivity of Mo cycles to changing ecosystem C dynamics, and for the incorporation of Mo effects in coupled C-N-climate biogeochemical models.

Duration:	Up to 12 months
Internship Location:	Corvallis, OR
Field(s) of Study:	Chemistry, Geoscience
Applicable NSF Division:	EAR Earth Sciences, DEB Environmental Biology
Intern Type Preference:	NSF Graduate Research Fellow (GRF) via the Graduate Research Intern Program (GRIP)
Keywords:	biogeochemistry, molybdenum, carbon, nitrogen fixation, soil organic matter
Expected Outcome:	This research will answer emerging questions that are critical for understanding how Mo is retaining cycled in soil, with particular attention to interactions with C. These results will advance understanding of how couplings between Mo and C regulate biological N fixation, a major natural control on soil fertility and C storage in ecosystems worldwide. Given the importance of climate and land-use change for patterns of C sequestration, and for C in regulating Mo dynamics, this work will provide a foundation for understanding coupled Mo-C-N dynamics, and incorporating Mo effects in biogeochemical models. Results of this work also have important implications for understanding terrestrial controls on Mo retention and export, and thus the interpretation of Mo records in marine sediments. The project will benefit the intern by providing an opportunity to engage in collaborative, cutting-edge research into soil chemical dynamics, co-author a peer-reviewed journal article, and gain exposure to the scientific environment of the USGS.

Special skills/training Required:	A Bachelor's or Master's degree in chemistry, biogeochemistry, biology, Earth science, or related fields is a pre-requisite. Strong laboratory skills in wet chemistry are essential. Experience in soil science and appreciation of global C and N cycling are also desired.
Duties/Responsibilities:	The intern will work with a strong team of USGS and academic scientists to conduct laboratory experiments using fresh soil collected from nearby Pacific Northwest forests. These forests span a globally wide range of soil C and Mo, located in close proximity to the Corvallis, Oregon laboratory. The intern will participate in sample collection, will participate in the design of several short-term experiments to evaluate how soil organic matter influence Mo complexation and retention in simulated soil columns, will separate soil and aqueous Mo fractions, will prepare samples for sample isotope analyses, and will participate in analysis of samples via mass spectrometry. The intern will also be expected to take a lead role in preparing a manuscript for peer-reviewed publication based on the project findings, although this may not necessarily be completed during the duration of the internship.