Channel Networks

Channel networks (CNs) can be found all over our planet and are a major route for water flow. We know astonishingly little about how these structures form for how important they are for shaping the landscape and moving resources. It is accepted that erosion is a major driving force for the formation of these vein-like structures, but the factors that shape the symmetry in CNs has remained elusive. Dr. X generates computational models of the development of these networks so that they can be used to understand the role CNs play in shaping the geometry of a landscape. Past methods were unable to distinguish between random and natural networks, so they were practically useless. Dr. X used a new method called a Landscape Evolution Model (LEM) that takes conservation of mass into account (which is an important feature for calculating the effects of erosion) to develop a model that can distinguish between random and natural CNs. He used this model to identify constraints that shape a CN. Dr. X found that channel concavity and elevation change are two key factors in shaping CNs and are critical criteria to include when generating mathematical models of them. This new model improves the field's understanding of what features have the most influence over CN formation. He has taken this research and obtained a patent for software that can automatically detect and take measurements of CNs.

Thermochronometry and Mountain Belt Evolution

Dr. X is interested in the dynamics of the surface of the earth. Specifically, she studies how the earth's plates move over time using mapping and dating techniques, and how this movement, in combination with erosion and other environmental factors, can sculpt mountain ranges. Dr. X's work takes her to Asia and North and South America, where she performs ground-surveys to generate detailed maps of the earth's surface. There, she collects sediment samples that are analyzed back in her lab. These data are used to track the changes of mountain ranges over time as well as to identify regions that are likely to be vulnerable or resistant to earthquakes. The recent advent of "thermochronometry,' a process that uses radiometric dating of multiple minerals to calculate the cooling of a rock over time, has made tracing the history of plate movements more accurate. Thermochronometry generates a thermal history of a rock that can be used in conjunction with older techniques, like mathematically computing plate movement trajectories, to develop accurate models of the dynamics of the earth's surface. In addition to thermochronometry, Dr. X draws cross-section maps, which are descriptions of rock layers presented as a vertical slice through the surface. Cross-sections are generated by applying a set of modeling rules to data collected from surface-exposed rock. Researchers work to make these cross-sections as accurate as possible and use them to track changes over time.

Geochemistry

Dr. X is interested in how environments change over long periods of time. His research program marries the development of new research methods with the application of those methods to study the planet. His lab focuses on detecting chemical changes in a range of environments to understand how the earth has altered over time and what the impact of human activity has been. To obtain this kind of information, his laboratory studies the "rock record," collecting core samples from the bottoms of lakes all over the world including locations in East Africa, Canada, Peru, and Mexico. He analyzes the organic material in these core samples, searching for "biomarkers" that describe the environment during different time periods. These biomarkers can be any molecule that remains stable over time and contains information about the organism that generated it. Biomarkers can provide a great deal of insight into the composition of an ecosystem at a given time, including biodiversity, temperature, waterfall, and human habitation. Dr. X is specifically interested in temperature and water levels, and the interpretation of this data with regard to climate change.

In a recent study, Dr. X's group and collaborators made headlines as they presented data from a lake that had never been studied before and challenged the current views about the climate of East Africa. The lake they studied, Lake Malawi, was previously inaccessible as no tools were able to drill core samples at the required depth. Dr. X's collaborators designed a barge with a modified piece of an oil-rig that allowed them to obtain a core sample that was almost 380m long from a depth of 590m underwater. Dr. X's laboratory specializes in core sample analysis, and used a protocol called TEX_{86} to evaluate the temperature of the Lake Malawi region over the past 1.3 million years. The TEX_{86} method uses mass-spec analysis to evaluate the lipid content of the cell membranes of *Thaumarchaeota*, a marine archaea species that are found all over the world. The lipid composition in these membranes changes with temperature and can provide a historical record of climate. Dr. X's lab had previously published the first study that took TEX_{86}, a method only used for analysis of oceans, and successfully evaluated core samples from lakes. In addition to TEX_{86} analysis, Dr. X looked at fossil leaf waxes, which give insight into the foliage growing in an area and provide additional insight into the climate that supported their growth. The analysis from this study showed that contrary to prior thought, the climate surrounding Lake Malawi is getting wetter, and undergoes cycles of wet and dry climate conditions every 100,000 years. Dr. X continues to evaluate samples from Lake Malawi to understand what other factors are contributing to the unexpected changes in wetness.