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Part I: The Role of Alkaline Magmas in Continental Crust Formation
This is a continuation of work I've begun helping with this spring.

Subduction zones are zones where oceanic crust sinks into the mantle. When the oceanic crust sinks to sufficient depth, dehydration reactions release significant amounts of water. This upward water flux reduces the melting temperature of the overlying mantle. This results in partial melting of the mantle and magmatism. This magmatism, called arc magmatism, is generally hypothesized as the source for much of Earth's continental crust. However, there is significant disagreement over the specifics of this process, particularly in the lower crust.

There are four compositional categories of arc-related mantle-derived magmas. The role of the fractionation of the first three, high-Mg andesitic magmas, tholeiitic basaltic magmas, and calc-alkaline basaltic magmas in the generation of continental crust has been investigated. But, the role of the fourth category, alkaline basaltic magmas, in forming granitic crust in arcs has not been well studied. The alkali-rich chemical composition of the upper crust, however, suggests that alkaline basalts could be an important factor in the development of continental crust.

Claire Bucholz, a graduate student working with Prof. Oliver Jagoutz, has been studying an obducted lower crustal arc complex consisting of depleted mantle, alkali-rich cumulates, and alkali-rich granitoids in the Dariv Ophiolite of Mongolia. (As a magma cools or decompresses, depending on its composition, different minerals will crystallize at different temperatures or pressures. This can result in cumulates, an accumulation of minerals with similar crystallization conditions.) All lithologies are well-exposed and present an excellent opportunity to learn about the fractionation of alkaline magmas in the lower crust of arcs.

The Dariv Ophiolite is located in the Dariv Range which is part of the region-wide Altaid mountains. The Altaids are part of the Central Asian Orogenic Belt (CAOB), a subduction system that lasted for almost 700 My until about 250 Ma. In the CAOB, numerous arcs, ophiolites, and accretionary prisms that were accreted to the Siberian margin are preserved. The Dariv Range is wedged between a magmatic arc called the Lake Terrane and the Zahvan terrane, a proterozoic microcontinent. Besides the ophiolite, the range contains a zone of high temperature metamorphic rock and a zone of slightly metamorphosed sediments and igneous rocks.

This summer, from late June to mid August, I will be Claire's field assistant working in the Dariv Ophiolite. We will be performing lithological mapping of the region with the goal of creating a general geologic map of the ophiolite and related area. We will also be collecting samples for study upon return. X-ray fluorescence analyses will be performed in order to determine the proportions of various major elements in the rock. LA-ICP-MS, a mass-spectrometry technique that can detect trace elements in the rock, will also be used to determine precise chemistries. Oxygen isotope ratios and U-Pb geochronological dates will also be determined to help constraint the chemical and temporal development of the magmatism in the Dariv Range. This work will, hopefully, lead to a greater understanding of the basic crust formation processes on Earth

Part II: Faulting and Basin Formation in Mongolia

While in Mongolia, we also intend to spend a significant amount of time studying recent fault systems. Mongolia contains major thrust, normal and strike-slip faults throughout. These faults separate large mountain ranges from adjacent basins. The modern Altai and the Altai-Gobi (the location of the Dariv Ophiolite) are two of the major mountain ranges formed by these fault systems. The most recent phase of faulting began in the mid-late Cenozoic. Previous research has indicated that the faults are primarily transpressional, meaning that there is both a lateral slip component of motion and compressional thrusting component. The exact mechanisms through which this has formed the numerous basins and mountain ranges in Mongolia is poorly understood. We hope to shed some light on the problem.

The source of the stresses causing faulting in Mongolia is generally assigned to the collision of India with Eurasia. A classic paper by Tapponier and Molnar (1975) demonstrated that many of the macro-scale features of Central and Eastern Asia can be replicated by a rigid impactor (India) hitting a plasticine block (Eurasia). Whether this model of Asian tectonics explains all of the stresses (now and historically) involved in faulting is debatable. Extensional forces driven by slab-rollback of the East Asian Subduction Zone could also have significant effects on the interior of the continent. Through studying the faults in Mongolia, we may be able to move towards an answer.

Before going in the field this summer, we will be examining the literature on Mongolia's fault systems further so that we have a solid idea of what to expect and what needs to be studied. I will be performing broad-scale geologic mapping from satellite imagery. I will be identifying fault locations, examining stress directions, potentially identifying fault slip directions, and finding useful places to visit and study in detail while in Mongolia. While in the field, we will do a broad field overview of the areas that we determined were worth examining. We will perform lithologic mapping, examine sense of motion indicators and attempt to determine total displacement on the faults. In addition, we will take samples which can be dated to constrain the timing of motion along faults. We will also look at systems of multiple local faults and attempt to determine how, together, they are able to form the unique basins in Mongolia.

Part III: Why?

As an undergraduate studying geology, I find both of the problems we will be studying to be interesting. I also think the field work will be very educational – a great opportunity to learn from more experienced geologic field workers. The fault system project has only recently begun, making it a particularly fascinating opportunity to see the beginnings of a research project. Not to mention the fact that some of these faults have produced earthquake with magnitude 8 or higher! Finally, I hope to develop some of the work on recent fault systems into a senior thesis.