Student mini-projects for Badlands project

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Introduction

This is a large collaborative project looking at the orientations, geometries and geochemistry of chalcedony veins and clastic dikes along with the mineralogy and geochemistry of the enclosing Tertiary strata. The larger question is as to their genesis, specifically as to the role that structural diagenesis played. The larger project can be broken down into well defined mini-projects for students to work on, and it is worthwhile to think about how this collaborative effort is organized. In the field, we will be flexible with teams of students collecting data, each team consisting of 2-3 people. Sometimes we may all work on one project, and at other times the teams may work apart. It is useful to think of this data as communal, and so it is important to have high quality data that can be easily shared. Each student team will select or be assigned a specific mini-project from the field excursion list, and will be responsible for writing up the report for that project. The data and samples collected will then be further analyzed during the fall and spring semesters. This may be by the same team that did the field work (optimal) or by other students coming into the project (still can work well). At least some of these mini-project should turn into independent studies, senior theses, and/or professional presentations. It will be useful to read the grant proposal and other support materials before reading the mini-projects described below.

Brief descriptions of mini-projects

Vertical clay sample suite through a stratiform chalcedony horizon:

This will be a bread and butter mini-project, and would be a repeat of Jami Shuler's thesis which produced some very interesting initial results, but at other localities. The fundamental question would be – what vertical variation in clay and silica mineralogy exists above, below and within a chalcedony horizon and why? A different mineralogy associated with the chalcedony vein horizons should give insight into the diagenetic changes that may be driving vein formation. A team could measure a detailed stratigraphic column, take samples, prepare the samples and analyze the results, comparing against previous work including Jami's thesis.

Comparison of major and trace element characteristics of veins versus their country rock.

A basic premise is that diagenesis produced the silica and other material that migrated and precipitated into the veins. You can think of it as sediment juices get lightly cooked ouf of the rock. Looking at the chemistry of the veins versus should provide insight. If the juices are locally derived it may be an approximately closed system. Does the chemistry reflect this? Do we see depletion in the surrounding sediment of more mobile trace elements, with their concentration in the veins? Does the nature of any trace element enrichment indicate anything about the nature of the fluids (e.g. fresh vs. saline). Or are there ‘exotic’ components that came from elsewhere? The idea sample suite would have 4 populations: vein samples, altered material adjacent to the vein, adjacent but unaltered country rock, country rock without stratiform veins present. Potentially a detailed sampling traverse could look for a vein perpendicular gradient as a second phase of this study. This could easily be done this summer and fall (2009). Good sample sites exist both in the National Badlands Park and at Toadstool.

Vein growth history patterns:

This would be a more challenging project (but quite interesting), probably one that someone who has taken structure should undertake. The first step would be a detailed map of veins in a large enough area. A rope grid could be helpful, with gps coordinates of the corners and compass bearings of the 4 sides. Other possibility is to do a close range (2 m) photomosaic using a step ladder rig, where the camera axis is vertical, and a regular grid is established. Then, using curvature geometries timing relationships are generated. A ‘long horn’ structure for example would suggest the perpendicular vein already existed and had altered the stress field. A vein that curves towards perpendicular with another vein, would have formed later. Do certain directions tend to form first? Are smaller veins typically later (as is the case with mudcracks), and as would be expected with syneresis (as earlier cracks have relieved some of the stress). The fundamental question would be can we constrain how these networks grew?

Random versus non-random scale breaks of fracture patterns.

This will be another bread and butter mini-project that can be done by different teams at different localities. Previous student work has established that on a smaller scale the vein pattern is organized, but on a larger pattern it is not. Some vein patches show this, while others do not. These projects could look at new areas, and also look at dikes and see if a similar pattern exists (but on a larger scale) to build our understanding and a regional database. A whole series of related questions about the size and shape of non-random sub areas exist. Students would take GPS and orientation measurements on several hundred veins from an area.

Clay signatures inside and outside a clastic dike.

A comparison of clays inside versus outside the clastic dikes should provide insight. If the dike preceded a diagenetic change then clays inside and outside the dike should show similar changes. Ome might also look for a corresponding vertical zonation inside and outside the dike, given that diagenetic changes are burial depth dependent. If, the clays inside and outside the dikes are quite different then the story is more complex (and interesting). For example, fluid migration along the dike could cause a distinctive diagenetic mineralogy to be formed in the dike. There is significant interest in clastic dikes as fluid flow conduits. The basic idea is that comparing clay signatures from within the dike to those in the surrounding strata at the same level should provide information. This would make a very nicely defined mini-project. A team could work on collecting a suite of dike/wallrock samples, along with a careful description of the dike. Some dikes have wall rock alteration zones, which could also be sampled.

Thin section study of clastic dikes.

This work would be focused on exploring what information exists in a microscopic view (thin section) of the clastic dike fill. The clastic dikes have all sorts of complexities going on within them, including flow textures and periods of multiple injection. Chalcedony veins and material can be a part of the dikes, clearly indicating that some type of connection existed. Microscopic textural information can often give important clues as tto timing and as to process. This mini-project will nicely complement the work on the mini-project of looking at the geochemistry of the clastic dikes and their wall rock. What are the silica phases and how do they compare to those in nearby chalcedony veins would be a primary question? The hybrid dike-veins would be especially good to focus on. This might be appropriate for a more advanced student. In addition, one could look for evidence of timing of other diagenetic changes. The same samples that are collected for geochemical work could also be used for thin section analysis. There is also a long standing debate as to the origin of clastic dikes that this work may speak to.

Thin section study of Toadstool fault rocks

The question here would be - how do the microscopic textures and mineralogy in the faults compare with those in the veins. If similar this would support the idea of a hydrologic connection between the chalcedony veins and faults during diagenesis. Timing relationships can be established. This mini-project could build on Mike Riggle's thesis (which focused on the veins). At Toadstool one good sample locality would be the fault that exhibits vertical zonation with apparent ascent of chalcedony producing fluids along the fault. The idea would be to collect a sample suite from the different levels. This could be coupled with a trace element look.

Scaling relationships between length and width of veins

Who would think that crack growth can be so complicated? Two different models for crack development are that new growth only comes as a process tip zone migrates (all the action is at the tip), while an alternate is that the whole length of the crack is active so that it continuously gets wider as it gets longer. In the second case the variation in crack width should be along the crack's length, while in the first it is only at a process zone. Detailed measurements of width along crack length, with a concentration on tips and tip geometry could answer this. Internal banding geometries may also provide insight. Some initial work has been done, but not with enough data to really get results. One problem to consider is the effect of level of exposure (the 3-d geometry), and horizontal growth versus vertical growth. It is clear that in some cases horizontal growth dominates.

Other possibilities for mini-projects exist and will likely arise as we discover more.