

# **26<sup>th</sup> Annual Five College Geology Undergraduate Student Symposium**



Wednesday April 20, 2005  
Red Barn, Hampshire College  
4:00pm

## **26<sup>th</sup> Annual Five College Geology Undergraduate Student Symposium**

**Elizabeth Thomas, Smith College**

Using Geochemical Evidence to Determine Provenance in a High Arctic Glacier-Fed Lake, Linné Valley, Svalbard, Norway

**David H. Forand, University of Massachusetts-Amherst**

Variations on a Theme: Modeled Slip Rates for the Chino Fault, Los Angeles Basin, California.

**Tamee Albrecht, Thomas Dedecko, Melissa King and James Kirwin, UMass**

A Tale of Two Earthquakes... the December 26, 2004 and March 28, 2005 earthquakes near Sumatra, Indonesia

**Lara Kapelanczyk, Smith College**

Petrological and geochemical analysis of a Tertiary volcanic sequence in Langadalsfjall, north-central Iceland

**Kristin Mayer, Smith College**

The Clay Mineralogy of Finger Lakes Vineyards

**Selby Cull, Hampshire College**

A Dynamic Digital Map of Mars

**Rachel E. Dunham, Department of Geology, Amherst College**

Temperature Dependence of Quartz and Feldspar Deformation Mechanisms in Two Contrasting Shear Zones: The Schlinig Fault, Eastern Alps, and the Tobacco Root Mountains, Montana

**Charlie T. Hoxie, Department of Geology, Amherst College**

Late Cambrian Arthropod Trackways in Subaerially Exposed Environments: Incentives to Simplify a Problematic Genus

**Naomi E. Kirk-Lawlor, Department of Geology, Amherst College**

Dating the Acadian Orogeny in Southwestern Massachusetts

**McFeely, M.B., Department of Geology, Amherst College**

CT-Scanning of Phosphatized Animal Embryos of the Neoproterozoic Doushantuo Formation: A Look Inside

**Jonathan Hayward, Michael Savarese, Philip Bienvenue, Sam Broder**

**University of Massachusetts-Amherst**

Leverett Pond GIS Project

# **Using Geochemical Evidence to Determine Provenance in a High Arctic Glacier-Fed Lake, Linné Valley, Svalbard, Norway**

Elizabeth Thomas

John Brady, Smith College, Faculty Advisor

Al Werner, Mt. Holyoke College and Steve Roof, Hampshire College, Project Advisors

The sediment provenance in Linnédalen was studied as part of a larger project to monitor and calibrate lamination stratigraphy in proglacial Linnévatnet. Linnédalen is located at 78°N on the island of Spitsbergen in Svalbard, Norway. Meltwater from Linnébreen, a glacier, carries fine-grained sediment 5 km downstream to the lake. Other transport processes include hillslope alluviation and sidevalley avalanche activity. Linnédalen lends itself to provenance studies because it contains three distinct rock types: the mountains to the east are composed of carbonate rocks, the valley floor, eroded by Linnébreen, is composed of sandstone with coal seams and the mountains to the west, eroded in the past by small cirque glaciers, are composed of low-grade metamorphic rocks (phyllites). A provenance study that provides information about the source areas of the sediment flux to the lake allows for reconstruction of glacial history in the valley.

The principal sediment source streams were identified on aerial photographs and during field surveys. Fine-grained sediment samples were collected from sand bars and in the lee of boulders in each streambed. Littoral sediment samples were gathered from 1-2m depth at 200m intervals along the south shoreline where the main inflow streams enter the lake. Lake basin sediment samples were recovered from three levels within short cores taken in the three different lake basins.

Samples were analyzed for major and trace element composition by X-Ray Fluorescence (XRF) and for organic carbon and carbonate content by loss on ignition (LOI). Unique geochemical fingerprints were identified for each source rock and then compared to inflow stream and lake basin sediment samples to identify the relative contributions of each primary bedrock source to the lake sediments.

The sandstone and carbonate source sediments are distinguishable based on silica, calcium, organic carbon and carbonate contents. The phyllite source sediments have high concentrations of most of the major and the trace elements. The sandstone and phyllite source rocks were the major sediment contributors to the 15m deep southern lake basins. The carbonate source rock is either dissolved into the water column or its geochemical fingerprint is overwhelmed by the other two source sediments. The 37m deep northern lake basin, distal to the main inflow streams, was dominated by a mix of material carried by currents within the lake and derived from marine terraces on the east and

west shores of the lake. The lake basin sediments have higher concentrations of aluminum and organic carbon and lower concentrations of silica and carbonate than the source sediments. Grain size fractionation and carbonate leaching seem to have significant influence on the lake sediment geochemistry. Sediment in the southern lake basins was found to increase in aluminum content and decrease in silica content from top to bottom in the cores. Inversely, the northern lake basin sediments decreased in aluminum content and increased in silica content from the top to the bottom of the core. These geochemical changes may be a result of varying source contributions.

This study provides a basis for future geochemical studies that more closely examine these compositional changes through time. Future provenance studies in Linnédalen should separate each sample by grain size and analyze each size fraction, since grain size differences can cause dramatic geochemical differences. Other methods that may be effective in determining provenance in Linnédalen include heavy mineral and clay mineral analysis. If the lake basin sediments are to be examined for geochemical fingerprints of source areas, it is imperative to determine the composition of the marine terrace sediment source. Examining the aqueous geochemistry of the inflow and outflow streams and of the lake would help to determine how and under what conditions carbonate leaching is affecting the lake water and sediment.



# **Variations on a Theme: Modeled Slip Rates for the Chino Fault, Los Angeles Basin, California.**

David H. Forand, University of Massachusetts-Amherst

The slip rates on the Chino fault in southern California have been subject to interpretation for quite some time. Seismic, paleosol, and field data does not correspond with each other. One way to constrain this spread in results is to model the slip of the Chino fault using 3d Move. Strike slip, dip slip and net slip will be validated based on the results of the models.

A three-dimensional model of the Los Angeles Basin has been previously constructed using published cross sections, surface trace maps, and products of the Southern California Earthquake Center (SCEC) Community Fault Model (CFM) working group. The model was then manipulated to fit the needs of this study. The Chino fault has two different geometries in the models used. In one model, the Chino fault intersects and extends through the Whittier fault. In the second, the upper of the Chino fault is truncated at the intersection points of the Whittier fault and does not extend below.

Two suites of models explore these two alternative Chino configurations. In one suite, all faults extend to the base of the seismogenic crust (15km). Another, modified by Scott Marshall, has all faults extending to the depth of the Moho (~30km).

Modeled results show that Chino has net slip between .78 and .98 mm/yr with dip slip between .72-.83 mm/yr and strike slip rates between .49-.73mm/yr. The modeled net slip rates of .7-1 mm/yr correlate well with geologic data. This strengthens the idea that the Chino fault has a net slip of about 1mm/yr.

Walls and Gath (2001) slip rates correlate the best with the modeled data, and show that the Chino fault has a larger rate of strike slip than dip slip. The Full Chino and Upper Chino 15km, as well as the Full Chino Moho model supports the best values of the strike slip, while retaining a net slope of about 1mm/yr.

## **A Tale of Two Earthquakes... the December 26, 2004 and March 28, 2005 earthquakes near Sumatra, Indonesia**

Poster by: Tamee Albrecht, Thomas Dedecko, Melissa King and James Kirwin, UMass

Indonesia lies in an area of active tectonics. Off the west coast of the island of Sumatra, the Indian and Australian plates are subducting under the Sunda plate and Burma microplate, forming the Sunda trench. These plates are moving at a rate of about 5-6cm/yr and subduct in an oblique sense to the N37W trending subduction zone. The plates move in a “stick-slip” fashion, building up stress and then slipping a few meters at once. The junction of the Eurasian and Sunda plates makes transmission of stress northward difficult because of the continent-continent boundary. Behind the trench (to the NE), strike-slip faults, thrust faults, east-west trending folds and fractures run up the island of Sumatra, parallel with the coast.

The M=9.3 earthquake on Dec 26, 2004 off the coast of northern Sumatra caused a northward rupture along the Sunda trench 1200 km in length with 15 m of displacement. The slip covered the entire length of the Burma microplate. The depth was 30 km. The rupture resulted in an average vertical displacement of about 1-3 m on the seafloor. It is believed that the motion or possible landslides caused the large tsunami, which affected many countries throughout the Indian Ocean. Aftershocks following the quakes were mainly confined to the Burma microplate, extending about 1000 km to north. It has been proposed that the Dec 26, 2004 earthquake was possibly triggered by the Dec 23, 2004 (M=8.1) earthquake also on the Australian plate.

On March 28, 2005, a second large earthquake occurred about 150 km southeast of the Dec 26 quake. This quake was a M=8.7, and occurred at a depth of about 30 km. The quake caused a rupture along the Sunda trench, propagating both north and south along the fault. This earthquake did not cause a major tsunami.

Tsunamis can be caused by submarine earthquakes and/or landslides. Factors affecting the mechanics of tsunamis include earthquake magnitude, coastline geometry, continental shelf width and wavelength. No warning systems for tsunamis exist in the Indian Ocean due to the rarity of tsunamis there. The last major tsunami occurred in 1883, after the Krakatoa eruption.

Historical seismicity of the Sunda trench includes more than five major earthquakes (M>7.0), but no clear pattern of location or propagation. It is likely that the rupture on December 26, 2004 redistributed stresses on the fault, contributing to the March 28 rupture.

# Petrological and geochemical analysis of a Tertiary volcanic sequence in Langadalsfjall, north-central Iceland

Lara Kapelanczyk, Smith College; Faculty Advisor: Dr. Mark Brandriss

**Abstract:** This project examines a sequence of Tertiary volcanic rocks from the Langidalsfjall mountain range in the Skagi Peninsula of north-central Iceland, formed at about 7-8 Ma. This sequence is composed of basaltic flows, andesitic flows, and rhyolitic rocks (a flow and a dike). The main unit of interest is a 30-40 m thick plagioclase-phyric andesite flow. This flow contains calcium-rich (up to  $An_{88}$ ) plagioclase phenocrysts up to 2 cm in size, constituting 10-20% of the rock in a groundmass of intermingled lighter and darker material (mm-dm scale) (Fig. 1). Petrological and geochemical evidence, such as disequilibrium between phenocrysts and groundmass, resorbed and sieved phenocrysts, and contrasting mineral assemblages in the light and dark groundmass zones suggest that this unit was formed by the mixing of mafic and felsic magmas. Harker major element diagrams, however, do not support simple end-member mixing of two magmas. Instead mixing requires that plagioclase phenocrysts be added as a third independent mixing component, resulting in a reasonable mixing model in which the plagioclase-phyric andesite consists of 65% rhyolite, 24% basalt, and 11% plagioclase phenocrysts. REE and other trace element data are consistent with this mixing model.

To explain the compositional variation within the basalts, Pearce element ratio diagrams were made which supported fractional crystallization of olivine, plagioclase, and augite (all found as phenocryst phases). Fe-Ti oxides are also found as phenocryst phases in small amounts and are supported by Harker and Fenner diagrams.

The rhyolites are hypothesized to have formed by partial melting of crustal material rather than by fractional crystallization. This hypothesis is based on phenocryst assemblages that include olivine and clinopyroxene, phases not normally found in rhyolites, but sometimes present in superheated felsic magmas formed by crustal melting.

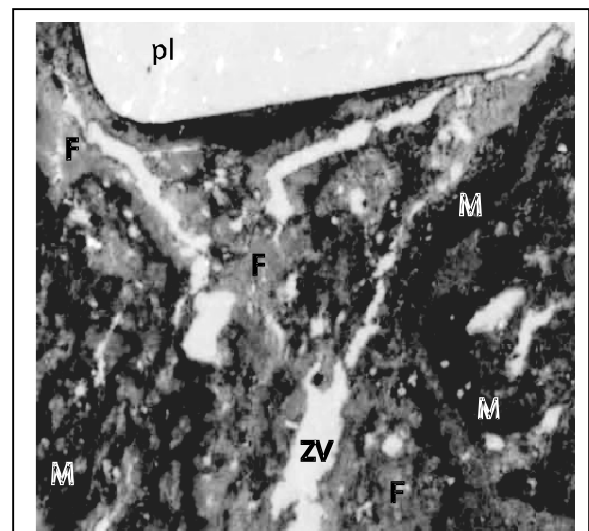


Fig. 1. A photograph of a thin section of the plagioclase-phyric andesite displaying its characteristic intermingling of mafic (M) and felsic (F) groundmass. Also present are a portion of a plagioclase phenocryst (pl) and part of a zeolite vein (ZV). The length of the crystal in this photo (from left to right) is about 4 mm.



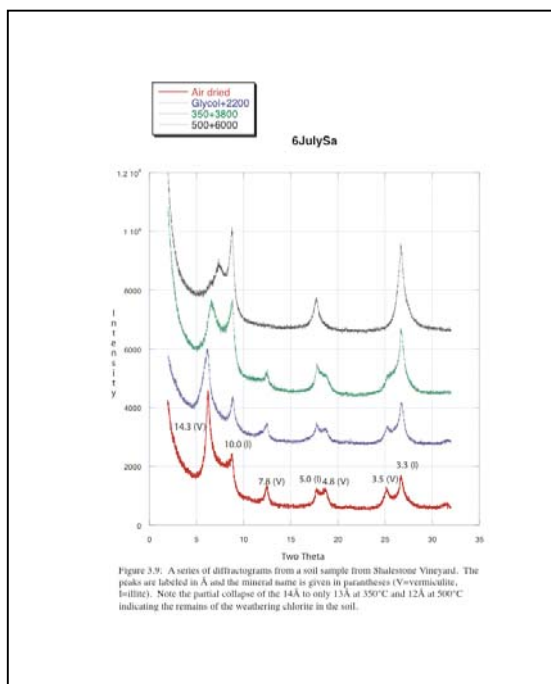
# The Clay Mineralogy of Finger Lakes Vineyards

Kristin Mayer, Smith College; Advisor Bob Newton, Smith College

*Terroir* is a French word that links the production of fine wines to geology that influences the development of the grape. Soil is a key element in *terroir*, and the clay mineralogy of the soil can influence the availability of important nutrients such as potassium for the grapes to absorb. This study examined the origins of the clay minerals in the soils of five Finger Lakes vineyards and determined the influence these minerals have on the nutrient availability for the grape vines.

Clay minerals were identified by X-ray diffraction of oriented samples of less than 1-micron interval. The clay minerals in the bedrock were determined to be chlorite and illite formed by the burial diagenesis of smectite after deposition of the sediment 400 million years ago. The bedrock is the source material for glacial sediments, primarily till, deposited during the Pleistocene glaciations, which ended 14,000 years ago. Post-glacial weathering of the glacial sediments is characterized by the alteration of chlorite to vermiculite. The soil clay mineralogy is composed of vermiculite from the weathered chlorite and illite from the bedrock. The figure below, a diffractogram from a sample in Shalestone Vineyard, is typical of the soil samples in all the vineyards.

The presence of vermiculite is important, as it has the highest cation exchange capacity of any clay mineral. Measured Cation Exchange Capacities in these soils ranged from 120 to 420 meq/100g.



Base saturation is nearly 100%. These exchangeable bases provide plants with essential nutrients such as calcium and magnesium through equilibrium reactions in soil solutions. Exchangeable potassium is low due to the tendency of vermiculite to sequester this cation. Potassium is a critical nutrient for the grape. The presence of high charge vermiculite in the soil inhibits potassium mobility. Potassium in soil solutions can be taken up by the vermiculite thus depriving the grape of this essential nutrient. This can lead to chlorosis and development problems in the grapes. A suggested solution for this problem is to add excessive amounts of potassium to the soil, as much of it will be absorbed by the vermiculite in the soil.

Clay mineralogy is an important aspect of *terroir* as it influences the availability of key nutrients such as potassium for the grape vine, and the presence of vermiculite in the soil may limit the availability of potassium for the grape vine.



Insert Selby Cull's abstract (PDF format) here

# **TEMPERATURE DEPENDENCE OF QUARTZ AND FELDSPAR DEFORMATION MECHANISMS IN TWO CONTRASTING SHEAR ZONES: THE SCHLINIG FAULT, EASTERN ALPS, AND THE TOBACCO ROOT MOUNTAINS, MONTANA**

**Rachel E. Dunham, Department of Geology, Amherst College, Amherst, MA 01002  
redunham@amherst.edu**

Electron backscatter diffraction (EBSD) analysis of quartz and feldspar in deformed rocks has yielded lattice patterns that can be used to correlate deformation mechanism to temperature for quartz and feldspar deformation. Samples studied are quartzofeldspathic mylonites from the Schlinig fault in the eastern Alps and quartzites and quartzofeldspathic gneisses from the Tobacco Root Mountains, Montana. Together these localities record intense non-coaxial deformation under metamorphic conditions ranging from greenschist to granulite facies. The Schlinig fault is a Cretaceous thrust fault that records a metamorphic gradient from greenschist to upper amphibolite facies across the length of the fault (Schmid and Haas, 1989). Along part of its trace it was subsequently reactivated as a normal fault (Froitzheim et al., 1997). The Precambrian rocks in the Tobacco Root Mountains have undergone substantial simple shear at the thermal peak of an upper amphibolite to granulite facies ( $>700^{\circ}\text{C}$ ,  $\sim 1$  GPa) metamorphic event ca. 1.78-1.72 Ga (Cheney et al., 2004a). Quartz and feldspar grains in all samples record substantial shear deformation at the microscopic level in quartz ribbons, serrate grain boundaries, pressure shadows, and subgrain and deformation bands. Presence of these different deformation textures reflect variations in material behavior, and as temperature increases a transition is seen between deformation mechanisms, including bulging recrystallization, subgrain rotation, and grain boundary migration (Stipp et al., 2002). The thermal activation of slip systems in both quartz and feldspar grains is examined in order to understand these mechanism transitions.

# **LATE CAMBRIAN ARTHROPOD TRACKWAYS IN SUBAERIALY EXPOSED ENVIRONMENTS: INCENTIVES TO SIMPLIFY A PROBLEMATIC GENUS**

**Charlie T. Hoxie, Department of Geology, Amherst College, Amherst, MA 01002  
cthoxie@amherst.edu**

In this study, fossilized arthropod trackways were studied in the hopes of gaining more information regarding the terrestrialization of Earth by animals. Trace fossils of the ichnogenus *Protichnites* from the Upper Cambrian of Wisconsin were analyzed in detail in the field, and the discovery of several trackways in marginal marine and subaerially exposed environments reinforces the importance of further investigations both in the locality studied and of other possible *Protichnites*-bearing strata around the world, especially from this interval in geologic time.

The specimens from Wisconsin were compared to other examples found during field work in New York and Canada, as well as findings reported in the geologic literature and plaster casts of the type specimens. It was found that since its inception, the term *Protichnites* has caused a great deal of confusion in arthropod trackway nomenclature, as some specimens that should have been called *Protichnites* have been given other names, and more often, specimens are called *Protichnites* that really should have been named otherwise. It is suggested that more effort be put into describing and documenting the occurrences of *Protichnites* and similar ichnofossils, so that the ichnological community may have a clearer understanding of what are necessary and sufficient characteristics for inclusion in this ichnogenus.

# DATING THE ACADIAN OROGENY IN SOUTHWESTERN MASSACHUSETTS

**Naomi E. Kirk-Lawlor, Department of Geology, Amherst College, Amherst, MA 01002**  
**nekirk@amherst.edu**

Fifty-three in situ Th-Pb ion microprobe spot ages were obtained on monazite grains from thirteen muscovite schist samples using the UCLA Ion Microprobe. The dated monazites in these Paleozoic meta-sedimentary rocks occur as inclusions in staurolite and garnet and within the muscovite-biotite matrix. These pelite samples have mineral fabrics consistent with a complex clockwise Barrovian –T evolution.

The monazite grains are age zoned with individual grains ranging in age by as much as 49Ma (discounting outlying ages). The samples are from an east west transect along US Route 20 in southwestern Massachusetts that extends from the Mesozoic Connecticut Valley boarder fault on the east to the Berkshire Massif on the west. Four samples are from the pre-Silurian Rowe, Moretown and Cobble Mountain formations, which may have been effected by the Taconian metamorphism, and nine are from the Siluro-Devonian Waits River and Goshen Formations. The majority of the monazite ages range from  $364 \pm 2.51$  to  $376 \pm 2.48$  in the Rowe, Moretown and Cobble Mountain formations and from  $363 \pm 2.52$  to  $389 \pm 2.53$  in the Waits River and Goshen Formations. The samples yielded only Acadian ages. Muscovite from the nine Siluro-Devonian samples were previously dated by  $^{40}\text{Ar}/^{39}\text{Ar}$  and yielded ages that range from  $332 \pm 3$  to  $356 \pm 5$  Ma (Blanchard et al., 1995; Henderson et al., 1996). Preliminary geothermobarometry based on garnet-biotite and plagioclase, garnet aluminosilicate quartz from Henderson (1996) show increasing metamorphic pressures from 0.6 GPa in the east to 1.1 Gpa in the west.

These monazite ages from southwestern Massachusetts are consistent with ages reported in similar rocks in southern Vermont. Monazite ages differ from muscovite cooling ages by as little as 12 Ma. The resulting cooling rate of ca. 20 degrees C/m.y. may be accommodated by erosion but the E-W pressure gradient requires some 15km of differential exhumation at 350Ma along some as yet undetermined structure.

# CT-SCANNING OF PHOSPHATIZED ANIMAL EMBRYOS OF THE NEOPROTEROZOIC DOUSHANTUO FORMATION: A LOOK INSIDE

McFeely, M.B., Department of Geology, Amherst College, Amherst, MA 01002  
mbmcfeely@amherst.edu

Embryos in the fossil record are especially rare, as are unambiguous examples of Precambrian metazoan life. The animal embryos of the Neoproterozoic Doushantuo Formation of Weng'an, China are phosphatized, allowing for preservation of cellular and possible subcellular tissues, and may hold important clues about some of the earliest multicellular organisms. Forty-six animal embryos extracted from the unit were analyzed using microfocus X-radiographic computed tomography (microCT), which allowed for close study of the  $\sim 500\text{ }\mu\text{m}$  diameter samples. To aid data collection, three-dimensional isosurface models of embryos, cells, and subcellular structures were constructed from microCT images and analyzed.

By collectively studying embryos of each morphospecies in the sample population, distinctive characteristics of the embryos were revealed, and data such as embryo and cellular volume, embryo surface area to volume ratios, embryo and cell shape, cell distribution within the embryo, and angles of cell cleavage could be interpreted in terms of embryological and developmental attributes. Patterns found in embryo topology provide a basis for proposing a relatively complete ontogenetic sequence.

Subcellular structures, possibly representing nuclei or spindle poles, exist in several of the samples. To test the hypothesis that these structures represent embryological features, their presence, shape, volume, location, and distribution within certain cells was examined. Embryos representing the four to sixteen cell ontogenetic stages were emphasized in this analysis.

Although the embryos represent many ontogenetic stages, from single- to many-celled varieties, it is unclear what taxonomic diversity is represented among the embryo population. Highly morphologically differentiated cells observed in *Caveasphaera costata* suggest that these animal embryos are from a different taxon than *Parapandorina raphospissa*, meaning that there are at least two embryonic metazoan taxa represented in the Doushantuo Formation.

**Jonathan Hayward: Imaging team**  
**Michael Savarese: Independent Study**  
**Philip Bienvenue: Imaging Team**  
**Sam Broder: Imaging Team**  
**University of Massachusetts Amherst**  
**Geosciences Department**  
**GEO 594A Introduction to GIS**  
**April 19, 2005**

Introduction to GIS 594A, under the instruction of Sean Fitzgerald was assigned the Leverett Pond area as a study site. The criteria gathered and analyzed for the class project was split into three even groups. These groups are Geomorphology, Imaging, Environmental and Built Environment. Each group obtained and manipulated data based on their respective group for a comprehensive analysis of Leverett Pond and the surrounding watershed. This comprehensive study had yielded new geographies for the entire area, which are useful for many practical and spatial uses. Such features as elevation, geology, land use, and 3D models were extrapolated from the class data to form a database of accessible information on the pond. This poster serves as a visual compilation of the class work as a whole to show the relationships between the study criteria as well as the formation of a well-rounded and detailed study. Data gathered from MassGIS and the Geosciences Department was used with ESRI GIS software to assemble the Leverett Pond project. This project involved lab time and field work with such tools as GPS units and ArcMap. This project also serves as the base of education in the introductory class.