From Student to Scientist:
Transitioning Introductory Geoscience Students into the Major using the Geology of Western North America

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Boise State University Overview

- Metropolitan university with >19,000 undergraduate students
- Average age of undergraduate students = 25
- 80% of students are from Idaho
- >70% of students work off campus
- 65% of students take > 12 credits per semester (full-time credit load)
- Most students underprepared in math

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Department of Geosciences

Offers B.S. degree in Geoscience with emphases in Geology, Hydrology, Geophysics, and Secondary Education

Approximately 180 undergraduate majors, most pursue the geology or hydrology emphasis

Majors are recruited from 100-level courses, transfer to the university, or enter as majors
Fall 2008 Curriculum Changes

Old Pathway:

- **GEOL 100**
  Fundamentals of Geology
  (GEOL 100 is recommended; however, you may substitute GEOL 101 if you receive a grade of B or higher)

- **GEOL 313**
  Geomorphology
  (Sp)

- **GEOL 380**
  Field Geology
  (Fa)

- **GEOL 221**
  Earth Materials
  (Fa)

- **MATH 147**
  Precalculus

- **CHEM 111/111L**
  Gen Chem I

(advised)
Problems with this Path

- Abrupt transition from 100 to 300-level courses
- Material in traditional Field Geology course was perceived as “out of context”
- Little introduction to geophysics or hydrology emphasis areas
New Pathway: Introduction of the “Sophomore Core”

- **GEOS 100**: Fundamentals of Geology
  - OR **GEOS 101**: Environmental Geology
  - Prereq GEOS 100 or 101 and coreq MATH 147

- **GEOS 212**: Water in the West
  - **GEOS 200**: Evolution of Western N. Am
  - **GEOPH 201**: Seeing the Unseen

- **GEOS 313**: Geomorphology
- **GEOS 314**: Structural Geology
- **GEOS 300**: Earth Materials

**MATH 147**: Precalculus

**CHEM 111/111L**: Gen Chem I

pre- or coreq
Advantages of the New Path

- Transition out of 100 level courses is eased (greater retention in major?)

- Field and lab methods are taught in context of geoscience subdisciplines (greater understanding?)

- Hydrology and geophysics can be taken before the junior or senior year (greater self-assessment of interests?)

- Greater emphasis on process of science and integration of different geoscience subdisciplines to address specific questions (better trained scientists?)

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GEOS 200 Evolution of Western North America

Learning objectives combine traditional field methods, Earth history, and critical thinking

• Develop an understanding of the principles and mechanics of the scientific method, as used by geoscientists to study geological phenomena.

• Develop skills in field observation, critical thinking, and geological inference, applied to geologic mapping.

• Apply concepts from geology, geochemistry and geophysics to understand the geologic, magmatic and tectonic evolution of western North America.

• Achieve a familiarity with sources of scientific information and be able to utilize scientific literature.
GEOS 200 Structure

- Two 1.25 hour classroom periods per week
  - 1/2 traditional lecture; 1/2 in-class exercises
  - first half of semester spent on disciplines applied to a science focus (SRP)
  - second half of semester spent on historical overview of WNA highlighting a dominant process in each time slice

- One 5 hour lab period per week
  - 2/3 in field; 1/3 on-campus
Integration of Disciplines

**Classroom**

- Sedimentology — outcrop scale description
- Stratigraphy — strat section description & correlation
- Magmatism — volcanic stratigraphy & petrography
- Structure — geologic maps and cross-sections
- Geochronology — laser ablation ICP-MS lab

**Field (& Laboratory)**
In the Classroom:
How Do Geoscientists Think?

GEOS 200: EVOLUTION OF WESTERN NORTH AMERICA

Process of Science Jigsaw Puzzle Activity

Purpose:
The purpose of this activity is to spur your thinking about the process of science. Specifically we will discuss:

* science as a community endeavor
* hypotheses
* data collection
* assumptions we make
* how we approach problems
* what happens when we get things wrong

You Will Turn In:
* Written (typed) answers to the questions listed below. Not in knowing what this activity made you think about. We
In the Classroom: Scientific Method Concept Map

http://serc.carleton.edu/introgeo/assessment/conceptmaps.html
In the Classroom:
Regional Focus... Snake River Plain
In the Classroom: Literature Reading & Discussion

Extension of the Yellowstone plateau, eastern Snake River Plain, and Owyhee plateau

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ABSTRACT
Formation of the late Cenozoic volcanic province comprising the Owyhee plateau, eastern Snake River Plain, and Yellowstone plateau has been accompanied by east-northeast-directed crustal extension. A new vector of 45° mm/yr, N56°E for the migration of silicic volcanism across the volcanic province is calculated. If migration of volcanism reflects west-southwest continental drift over a mantle plume, a zone of crustal extension must separate the volcanic province from the more slowly moving North American craton. Space-time relations of basin fill in the adjacent Basin and Range province provide evidence for a zone of extension, about 125 km wide, coincident with and east of coeval silicic volcanism. Since 16 Ma, the zone of extension has migrated along with silicic volcanism, maintaining its position between the province and the unextended craton.

INTRODUCTION
The Owyhee plateau, eastern Snake River Plain, and Yellowstone plateau form a linear, late Cenozoic volcanic province (Fig. 1) characterized by thick sequences of andesitic tuffs, intercalated alluvial and lacustrine sedimentary rocks, and overlying basalt (Leeman, 1982). Silicic eruptive centers become younger to the north, supporting the hypothesis of Morgan (19) that the trail of a mantle plume beneath North America terminated. If the volcanic province extends, the rate and path of migration of absolute plate vector for it during this time if migration were indicated by the independent measurements of the absolute plate vector. The two vectors are significantly different evidence that the volcanic province extension was coeval in the adjacent Basin and Range province model to estimate the amount of extension.

EVIDENCE FOR EXTENSION OF THE VOLCANIC PROVINCE Absolute Plate Vectors

Armstrong et al. (1975) derived the 35 mm/yr for the migration of volcanism estimating that volcanic centers and faces every 2 m.y. This was appropriate for the geologic small units at different times. Therefore, the path of migration calculated by methods the same as in the study by Kimball et al. (1975) and others. Third, the volcanic province of We believe that the emplacement of the first-arrive tuff at each eruptive center reflects the continental crust (Leeman, 1982). Our extension of the plate-related volcanic activity, so passage may reflect pre-plume crustal extension or emplacement of a mantle melt. For the reasons given above, a more rigorous analysis of volcanic centers can be obtained by eruptive centers along the volcanic province, whereas anhydrous hydrothermal fluids are erupted from the volcanoes in Table 1 (see footnote 1), and re-melted part of the volcanic province 1 relative to the underlying plume. The vector for the volcanic province extension, 45°, N56°E was derived using degree volcanic activity.

The California Arc: Thick Granitic Batholiths, Eclogitic Residues, Lithospheric-Scale Thrusting, and Magmatic Flare-Ups

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ABSTRACT
Recent geological and geophysical data show that a significant fraction of the crust (~33 km) in the central Sierra Nevada batholith is granitic, requiring that the batholith be underlain by a significant residual mass prior to Cenozoic extension. Although batholith residua are commonly thought to be granulites, xenolith data indicate that eclogite facies residues were an important part of the California arc at depth. The arc was continuously active for >140 m.y., yet most surface and/or shallow crustal magmatism took place via two short-lived episodes: one in the Late Jurassic (160–150 Ma), and a second, more voluminous one in the Late Cretaceous (100–85 Ma). These magmatic flare-ups cannot be explained solely by increases in convergence rates and magmatic additions from the mantle. Isotopic data on xenoliths and mid-crustal exposures suggest that North American lower crustal and lithospheric mantle was underthrusted beneath accreted rocks in the arc area. The Late Cretaceous flare-up is proposed to be the result of this major west-dipping-lithospheric scale thrusting, an event that preceded flare-up by ~15–25 m.y. I suggest that the central part of the arc shut off at ~80 Ma because the source became melt-drained and not be-cause of refrigeration from a shallowly subducted slab.

INTRODUCTION
The California arc formed as a product of the prolonged subduction of oceanic plate beneath the southwestern edge of the North America plate (Dickinson, 1981). The arc was active between 220
In the Field: Geology is Local!
In the Field: Scaffolding of Skills and Scales

Outcrop

Section

Map

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In the Field: Field Observation & Note-taking

10/5/10 Discovery Park Military Reserve

LOCATION: Drive up Hill 21, just before Discovery Park at the base of Lucky Peak Dam. On the north side of the road is large roadcut outcrop & sedimentary structures.

PURPOSE: Sketch & describe outcrop. Dean & Warren, in field notebook, take slips & dip at 3-4 locations to determine paleocurrent direction. Attempt to determine which strat column outcrop fits into & give reasons.

General description of outcrop:
- Roadcut exposing intermingled layers of sedimentary structures varying from fine grained, well sorted cross stratified units to pebbly/robbly sized matrix supported conglomerate
- Entire outcrop is not well cemented and is slope forming, no reactivation within the roadcut, but has overlying thin horizon of immature soil. Base of outcrop is slope forming colluvium. Composition of the sediments is primarily quartz, mica, feldspar.
In the Field:
First Geologic Maps
Does the New Track Work?

- Track student progress before/after 2008 in terms of:
  - **Engagement** in the geosciences = student enrollment in geoscience courses after GEOS 100 or 101
  - **Retention** in the geosciences = continued enrollment in geosciences courses after the first non-100-level geoscience course
  - **Graduation** in the geosciences = award of B.S. degree
Retention and Graduation Study

Looked at individual transcripts for students enrolled in Earth materials, geomorphology, field geology, or the sophomore core classes from 2003 - 2012

- n=113 students in “old curriculum”
- n=152 students in “new curriculum”

Study does not consider:
- students who may have exited the major before reaching sophomore-level courses
- changes to other university programming that may affect retention and graduation

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Student Engagement after First 200-level Course

“Old Curriculum” 2003-2008

- 43% no more geoscience courses
- 57% take additional geoscience courses

n = 113

“New Curriculum” 2008-2012

- 24% no more geoscience courses
- 76% take additional geoscience courses

n = 152

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Where are Students Now?

n = 113

- 37% Left University
- 34% Geoscience Graduates
- 4% Other Graduates
- 23% Geo Pipeline

n = 152

- 29% Left University
- 29% Geoscience Graduates
- 11% Other Pipeline
- 13% Other Graduates
- 3% Geo Pipeline

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FTFT Graduation Rate (%) in Geoscience with Projected Pipeline Graduation

University FTFT Graduation Rates:
- 4 year = 11%
- 6 year = 30%

Old Curriculum
n = 42
17%
New Curriculum
n = 45
16% 33%
Pipeline
n = 45
20% 49%

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Graduation Rates from Geoscience Sophomore Standing

<table>
<thead>
<tr>
<th>Curriculum Type</th>
<th>5 year graduation rate</th>
<th>3 year graduation rate</th>
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<tbody>
<tr>
<td>Old Curriculum</td>
<td>32%</td>
<td>20%</td>
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<tr>
<td>n = 113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Curriculum</td>
<td>44%</td>
<td>28%</td>
</tr>
<tr>
<td>n = 152</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipeline</td>
<td>56%</td>
<td>30%</td>
</tr>
<tr>
<td>n = 152</td>
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</tbody>
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## Summary Comparison

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<tbody>
<tr>
<td>Students take geo courses after first non-100 course</td>
<td>57%</td>
<td>76%</td>
</tr>
<tr>
<td>6-year graduation rate for FTFT students</td>
<td>17%</td>
<td>49%</td>
</tr>
<tr>
<td>5-year graduation rate for all students in population from sophomore geoscience standing</td>
<td>32%</td>
<td>56%</td>
</tr>
</tbody>
</table>

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Conclusions I

Changes to curriculum correspond with increased student retention and graduation in the geosciences.

Strategies for improved student success:

- Provide curriculum that promotes identification and self-assessment of geoscience interests
- Provide curriculum that bridges lower and upper division course work and develops scientific skills and habits
Conclusions II

- The sophomore core promotes the transition from a passive student to an active scientist engaged in hypothesis formulation, careful observation, and inference.

- Subsequent upper division courses report benefits of early practice in field note-taking, spatial perception and location, use of field (compass) and laboratory (microscope) tools.

- High-performing sophomores are poised to immediately engage with faculty research programs.