GEOLOGY OF THE ELKHORN MOUNTAINS, NORTHEASTERN OREGON

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GEOLOGIC SETTING

The Elkhorn Mountains of northeastern Oregon lie within the Blue Mountains geologic province which has a basement composed of accreted late Paleozoic to early Mesozoic island arc terranes intruded by Mesozoic plutons (Orr et al., 1992). The island arc rocks were deformed and subjected to low-grade regional metamorphism during accretion and were contact metamorphosed during emplacement of the plutons (Ave Lallement et al., 1980; Vallier and Brooks, 1995). The metamorphic and igneous basement rocks are overlain by a heterogeneous assemblage of Cenozoic volcanic and volcanogenic sedimentary rocks (Walker, 1990). The entire region was broadly uplifted during the Cenozoic along the Blue Mountains anticline.

During the late Cenozoic, parts of the Blue Mountains province, including the Elkhorn and Wallowa mountains, experienced more localized and dramatic uplift along high-angle range-front normal faults. These more elevated (8000+ ft.) parts of the Blue Mountains were extensively glaciated during the Pleistocene (Thurber and Carson, 1990).

PROJECT GOALS

The goals of the project were to study in detail various aspects of the geology of the Elkhorn Mountains while constructing a geologic map of the Crawfish Lake 7.5 min. quadrangle. The student projects were grouped into 4 sudivisions corresponding to the expertise of the faculty as follows: Bob Carson - glacial and Quaternary geology; Peter Crowley, metamorphic structure and petrology; Rick Hazlett, volcanology; Kevin Pogue, regional structure, stratigraphy, and tectonics.

FIELDWORK

The project began with 3 days of orientation and field trips to Hells Canyon led by Tracy Vallier and the project faculty. After moving into base camp at the Powder River Motel in North Powder, Oregon, a strategy was devised to complete the mapping of the quadrangle in the allotted time. The first two weeks were spent making traverses through the field area, identifying the various map units and ascertaining their field relationships. During this time the students became familiar with the geology of the area and the many problems to be addressed. The project faculty were assisted by Mark Ferns, co-author of several geologic maps of the Elkhorn Mountains (Brooks et al., 1982, Ferns et al., 1982) who conducted a very informative field trip. During the final two weeks of the project, the students continued mapping but also focused on their individual projects. Bedrock mapping of the quadrangle was completed (thanks to some long field days by team volcano) on the last day of the project. Mapping of surficial deposits was completed in the Fall during some "mop up" visits by Bob Carson and Emily Geraghty. The map is presently being compiled by Kevin Pogue prior to submission to the Oregon Department of Geology and Mineral Industries (DOGAMI) for publication.

STUDENT PROJECTS

Team Volcano - Rick Hazlett, team leader. The projects of team volcano involved mapping and interpreting the Oligocene-early Miocene geology of the Crawfish Lake Quadrangle. The area of Tertiary exposure occurs in the northwestern 8 square miles of the quadrangle, as well as in two southwestern outliers.

Carrie Brugger, with the assistance of her visiting advisor, Jeff Noblett, undertook an intensive sample collecting effort. She will analyze over two dozen samples of lava using the XRF at Colorado College and INAA facilities at Oregon State University to identify their geochemistry.

Kate Hofmann measured and described stratigraphic sections within the basal pyroclastic/epiclastic unit. Using these observations she will develop an interpretation for the origin of the individual lithologies and deduce the sequence of events responsible for the deposition of the unit as a whole.

Kyle McClure measured hundreds of joint plane orientations in the stacked andesite flows atop and around Chicken Hill to study the joint structure of these lavas, and ascertain the potential value of using some joint sets as bedding plane indicators. This risky practice, it was judged, might be worthwhile under certain circumstances. Just what these circumstances might be Kyle will describe.

John Bershaw focused on mapping and measuring columnar joint orientations in a spectacular andesitic erosional remnant in the low, rolling hills a few miles southeast of Chicken Hill. He is seeking to answer the question of whether this remnant represents part of an original intercanyon flow, or a plug. One great challenge to his fieldwork was the high magnetization of the outcrop area, which greatly reduced his ability to take accurate bearings. He devised a clever method of doing so, nonetheless, based upon setting up external survey lines around the site. He will describe this methodology in his final report.

Team Crud (glacial geology) - Bob Carson, team leader. The Quaternary geology/geomorphology students, led by Bob Carson of Whitman College, focused on the glaciation of the Elkhorn Mountains. Only three pieces of research on the glacial history of the Elkhorns were known, dissertations by Bentley (1974) and Bevis (1995) and a short paper by Thurber and Carson (1990). It was thought by DOGAMI that there was no evidence for pre-Pinedale glaciation.

A major goal of the Quaternary team was to map the exact limit(s) of glaciation on the Crawfish Lake quadrangle and the nearby portions of adjacent 7.5' quadrangles. The three students took turns assisting Bob Carson in this effort. The following discoveries were made:

1. Most of the Crawfish Lake quad appears to be covered by Bull Lake, not Pinedale drift. Bull Lake drift is characterized by orange, grus-rich soils, rotten clasts at a depth of 1 to 2 meters, and, where present, basalt clasts with significant weathering rinds. Areas covered by Bull Lake ice have poorly preserved moraines and only low tors (nonglaciated areas have high tors where the bedrock is granite).

2. During Bull Lake time, the North Fork John Day ice extended west onto the Trout Meadows quadrangle, and dammed drainages to form glacial lakes at Crane Flats and along Trail Creek. The routes of both Trail and Crane Creeks were diverted.

3. Bull Lake ice extended north along the upper Grande Ronde River approximately 3 km onto the Limber Jim quadrangle.

4. Pinedale ice apparently moved only a few kilometers west from the Elkhorn crest, entering the Crawfish Lake quadrangle in the drainages of the Grande Ronde River, Crawfish Creek, the North Fork John Day River, and Baldy Creek. These short valley glaciers probably did not merge. Pinedale drift is characterized by grayish tan sandy soils with fresh clasts.

Eric Bilderback of Colorado College studied the evidence for ice originating in the Anthony Lakes cirque complex and advancing north and east down Anthony and Antone Creeks. The Anthony Creek valley glacier cut a "textbook" glacial trough; it was only slightly more extensive during the Bull Lake glaciation than it was during Pinedale time. Antone Creek ice deposited Bull Lake and Pinedale drifts which are well exposed on the road between North Powder and Anthony Lakes.

Whit Morriss of Washington and Lee University investigated the former glaciers which moved eastward from the north end of the Elkhorn crest. The valley glaciers along Dutch Flat Creek and the North Fork Powder River turned north as they crossed the range front. In contrast to the ice going west from the Elkhorn Crest, the valley glaciers which extended well east onto the Rock Creek quadrangle deposited large long terminal/lateral moraines, and the Bull Lake ice was only a little more extensive than the Pinedale ice.

Emily Geraghty of Whitman College synthesized existing knowledge of glaciation of the entire Elkhorn Range, and made a reconnaissance investigation of every valley. Large valley glaciers advanced east from the range crest along Rock, Pine, and Goodrich Creeks. An inactive talus-fed rock glacier lies on the north-facing side of the valley of Goodrich Creek. In the Mill and Marble Creek drainages, small glaciers extended eastward beyond the cirques. On the south side of the Elkhorn Range, a glacier complex originated in the area between Twin Peaks and Mount Ireland. The ice advanced toward but did not reach the Sumpter Valley. In most of the valleys, it was difficult to determine whether the age of drift is Bull Lake, Pinedale, or both.

Team Structure - Kevin Pogue, team leader. This team concentrated on the unconformity separating the basement rocks of the Baker terrane with the overlying volcanic units. The unconformity apparently has great relief and locally large gold-bearing river channels are preserved.

Kate Trafton is studying spectacular early Tertiary river channels exposed by hydraulic mining along the basement/cover unconformity. The channels expose boulder conglomerates with exotic lithologies that may represent the unroofing of the Idaho batholith. Kate's study will focus on identifying the provenance of the exotic lithologies and the tectonic implications.

Gabriel Cisneros is constructing structure contour maps on the basement/cover unconformity for the Crawfish Lake and adjacent quadrangles. He will analyze the resulting maps with regards to pre-Tertiary topography and post Cretaceous deformation.

Nate Gilbert is synthesizing the deformational history of the Crawfish Lake Quadrangle. He is analyzing structural data from all units and plans to describe the style and timing of major deformational events.

Team Metamorphic - Peter Crowley, team leader. Team metamorphic focused their studies on the rocks of the Baker terrane and on the intrusive contact of the Elkhorn Batholith. A contact metamorphic aureole is present in the Baker terrane for a distance that ranges from <0.5 kilometer to up to several kilometers from the margin of the Elkhorn batholith. These variations in the width of the aureole suggest that the orientation of the batholith contact varies from low-angle to near vertical. This interpretation is supported by map pattern of the contact. The region where there is a broad contact aureole, known locally as the Bellevue wedge is somewhat enigmatic. Baker terrane rocks from the Bellevue wedge contain outcrop scale structures and fabrics that indicate high temperature deformation. However, these structures and fabrics are cross-cut by the undeformed Elkhorn batholith, the presumed heat source for the high temperatures. Furthermore, no deformation of the age of the Elkhorn batholith is known regionally.

Sarah Newland is looking at the metamorphism of quartz-rich and gneissic rocks in the Bellevue wedge. Kristin Edgar is focusing on the metamorphism of the mafic rocks of the Baker terrane. Liz Godwin is examining the relationship between metamorphism and deformation to determine the approximate temperature of deformation of the Bellevue rocks.

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