COMPARATIVE GEOCHEMISTRY OF UNKNOWN BASALTS FROM PAULINA, OREGON TO DETERMINE MAP UNITS

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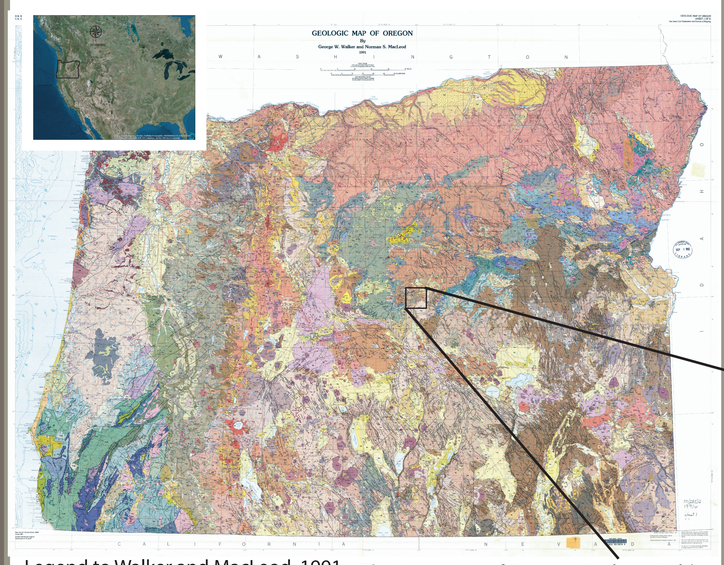
BACKGROUND

Abstract:
The Crooked River region near Paulina, Oregon has exposures of Oligocene to Miocene volcanic rocks. **The lowest exposed formation is the Clarno**. Above is the John Day formation, Mascall Formation, the Rattlesnake formation and Rattlesnake ash-flow tuff. **Atop these, are Columbia River Flood Basalts (CRBs) that erupted 18-8 Ma.** During the Neogene, these formations have undergone significant deformation including both broad scale folding and faulting. Recent geologic mapping has revealed a distortion of the volcanic package. **In some locations, it becomes difficult to be sure if basalt outcrops are of the lower Clarno Formation or the upper CRB Formation. This study aims to compare the geochemistry of the unknown basalts to compiled suites of basalts from known formations in order to determine the map unit.** Elemental abundances, of minor and major elements, were determined using X-ray Fluorescence Mass Spectrometry (XRF). A literature search was conducted to create a database of published Clarno and CRB geochemistry, much of which exists for the CRB group but relatively little data has been published on the Clarno. **Of the unknown basalts, we have determined that many are more geochemically similar to the CRBs, while some are similar to the Clarno. These results confirm the presence of large, inactive normal faults previously unrecognized.**



Legend to Walker and MacLeod, 1991 Geologic Map of Oregon

Ts **Tuffaceous sedimentary rocks and tuff (Pliocene and Miocene)**—Semiconsolidated to well-consolidated mostly lacustrine tuffaceous sandstone, siltstone, mudstone, concretionary claystone, pumicite, diatomite, air-fall and water-deposited vitric ash, palagonitic tuff and tuff breccia, and fluvial sandstone and conglomerate. Palagonitic tuff and breccia grade laterally into altered and unaltered basalt flows of unit Tob. In places includes layers of fluvial conglomerate and, in parts of the Deschutes-Umatilla Plateau, extensive deposits of fanglomerate composed mostly of Miocene basalt debris and silt. Also includes thin, welded and nonwelded ash-flow tuffs. Vertebrate and plant fossils indicate rocks of unit are mostly of Clarendonian and Hemphillian (late Miocene and Pliocene) age. Potassium-argon ages on interbedded basalt flows and ash-flow tuffs range from about 4 to 10 Ma. Includes the Drewsey Formation of Shotwell and others (1963); sedimentary parts of the Rattlesnake Formation of Brown and Thayer (1966)—an interstratified ash-flow tuff has been radiometrically dated by potassium-argon methods at about 6.6 Ma (see Fiebelkorn and others, 1983); Bully Creek Formation of Kittleman and others (1967); Dalles Formation of Newcomb (1966, 1969); Shutler Formation of Hodge (1932), McKay beds of Hogenson (1964) and Newcomb (1966) (see also Shotwell, 1956); Kern Basin Formation of Corcoran and others (1962); Rome beds of Baldwin (1976); parts of the (now obsolete) Danforth Formation of Piper and others (1939), Idaho Group of Malde and Powers (1962), Thousand Creek Beds of Merriam (1910); the Madras (or Deschutes) Formation, the "Sentustus formation" of Smith (1984), and the Yonna Formation (Newcomb, 1958)

Tat **Silicic ash-flow tuff (lower Pliocene and upper Miocene)**—Ash-flow tuff and associated pumiceous air-fall tuff mostly of rhyolitic and rhyodacitic composition; includes minor tuffaceous sedimentary rocks. Grades laterally through less-densely welded tuff to nonwelded ash-flow tuff and interlayered tuffaceous sediments of unit Ts. Potassium-argon ages (Greene and others, 1972; Parker and Armstrong, 1972; Walker, 1979; McKee and others, 1976) on several different ash-flow tuffs included in unit range from about 4 to 10 Ma; although most ages are in the range of 6 to 9 Ma. Includes the Devine Canyon, Prater Creek, and Rattlesnake Ash-flow Tuffs (Walker, 1979); originally considered a part of the (now obsolete) Danforth Formation of Piper and others (1939), and the Rattlesnake Formation and the volcanic and fluvial deposits (undivided) and marginal facies of the Columbia River Group (undivided) of Brown and Thayer (1966). Also includes the welded soda-rhyolite tuff breccia of Dickinson and Vigrass (1965) in the Suplee-Izee area, the upper Miocene or lower Pliocene welded tuff of Prostka (1962; 1967) in the Baker area, "welded ash-flow tuff" of Swanson (1969a) and the Pliocene Poujet Tuff (Hampton, 1964) west of Fort Rock Valley, dated at about 4.5 Ma (McKee and others, 1976)

Tts **Tuffaceous sedimentary rocks, tuffs, pumicites, and silicic flows (Miocene)**—Moderately well indurated lacustrine and fluvial (flood-plain) deposits of tuff, pumicite, palagonite tuff, and lesser siltstone, arkosic sandstone, and pebble and cobble conglomerate. Locally contains some lignite beds. Former glass in silicic vitroclastic debris commonly crystallized and altered to secondary silica minerals, alkali feldspar, zeolites, and clay minerals. Contains some welded and nonwelded ash-flow tuffs, and minor rhyolite flows. Widespread and abundant vertebrate fossils and minor plant fossils indicate that most of unit is of middle Miocene (Barstovian) age, parts of unit between Goose Lake and Warner Valley may include rocks of early Miocene age. Locally interlayered with and locally overlies basalt and andesite flows of unit Tmb. Overlies and locally interfingers with Picture Gorge Basalt (Thayer and Brown, 1966) and with Miocene basalt south of Prineville. Includes Mascall Formation of Merriam (1901), Sucker (Succor) Creek Formation of Corcoran and others (1962) and Kittleman and others (1967), Drip Spring Formation of Kittleman and others (1965, 1967), Trout Creek Formation of Smith (1926), and "rocks of Miocene age" of Malde and Powers (1962) in the southern Owyhee Upland province. In southeast Oregon, some of these rocks represent caldera and moat-fill deposits

Tcp **Picture Gorge Basalt (middle and lower Miocene)**—Flows of aphyric and plagioclase porphyritic flood basalt. Potassium-argon ages mostly 15.0 to 16.4 Ma (Watkins and Baksi, 1974; Fiebelkorn and others, 1983)

Tsfj **John Day Formation of east-central Oregon (lower Miocene, Oligocene, and uppermost Eocene?)**

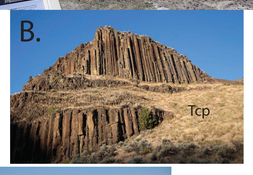
Tca **Clastic rocks and andesite flows (lower Oligocene?, Eocene, and Paleocene?)**—Mostly andesitic lava flows, domes, breccia, and small intrusive masses and lesser basaltic to rhyolitic rocks; interlayered saprolite, bedded volcaniclastic and epiclastic mudstone, claystone, siltstone, sandstone, conglomerate, and mudflow (lahar) deposits. Mostly consists of Clarno Formation of central Oregon and unnamed rocks of Basin and Range Province in south-central Oregon. Fossil plants and vertebrates in these rocks are Eocene in age. Andesite and basalt lava flows are typically slightly altered; most glass is devitrified and altered to clay minerals, zeolites, and secondary feldspar. Reliable K-Ar ages of rocks from unit range from about 54 Ma to about 37 Ma (Evernden and James, 1964; Fiebelkorn and others, 1983). A number of K-Ar ages on rocks shown on source maps as part of the Clarno Formation are in the range of about 36 to 19 Ma (Fiebelkorn and others, 1983). Although these rocks are lithologically similar to, but generally less altered than, rocks of the Clarno Formation, they are cowal with the John Day Formation. Most of these enigmatic rocks of Oligocene and early Miocene age are included in unit Tas. At base of unit in Blue Mountains Province, locally includes quartzose and feldspathic sandstone, siltstone, and shale largely of granitic or metamorphic provenance, fossil plants in these sedimentary rocks indicate an early Eocene or Paleocene age

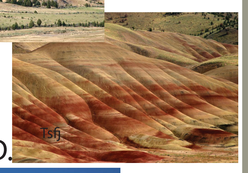
Ks **Sedimentary rocks (Cretaceous)**—Marine graywacke, subgraywacke, conglomerate, and shale. Pebbles and cobbles in conglomerate are well-rounded volcanic and metavolcanic rocks, low-grade metasedimentary rocks, quartzite, chert, and minor silicic and intermediate plutonic rocks. Shales are gray to black and are fissile to blocky. Sandstones commonly display graded bedding; conglomerate beds are commonly thick and poorly bedded. Shales, near Mitchell, have yielded latest Early Cretaceous (Albian) fossils; some earliest Late Cretaceous (Cenomanian) fossils occur in beds southeast of Mitchell (D.L. Jones, oral commun., 1972). Includes Hudspeth and Gable Creek Formations of Wilkinson and Oles (1968), Bernard Formation of Dickinson and Vigrass (1965), and Cretaceous sedimentary rocks of Brown and Thayer (1966)

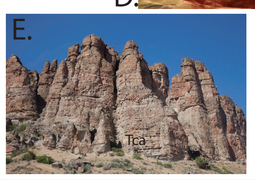
The University of Oregon Geology Field Camp has been working in this area over the last three summers in one week intervals. The aim of the course is to teach field mapping techniques, but there is also a driving research goal: to investigate the Quaternary active faults.

Several previously unidentified faults have been identified, some of which have geomorphically young scarps.

In this project, we are investigating one of these faults by using geochemistry to determine if assumed map units are correct.



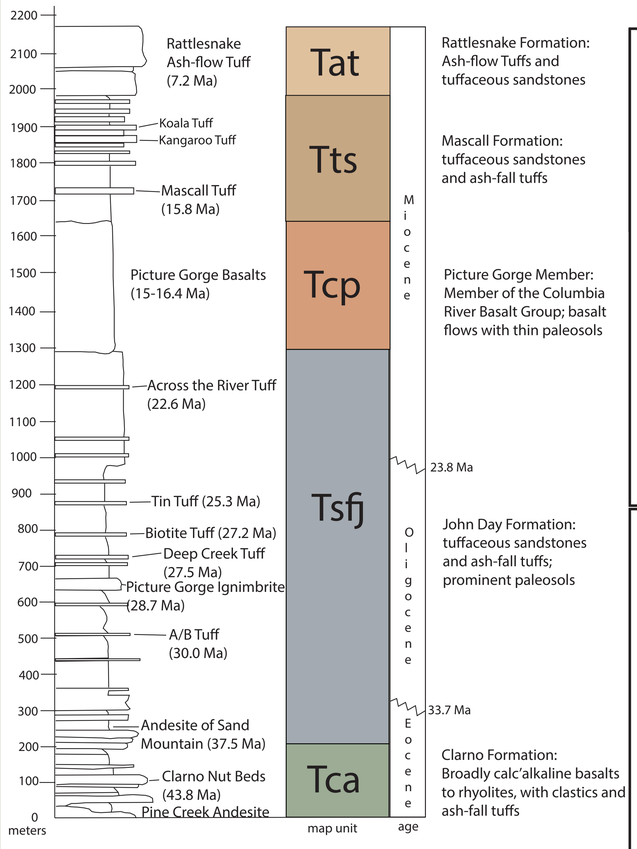


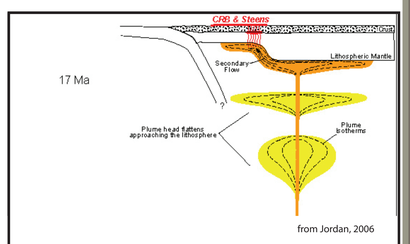


Photos A-E show the beauty of this section of rock. In addition to the beauty, this section provides an amazing fossil record of Eocene-Miocene North American climate, flora, and fauna. E) Landslide deposits of the Clarno Formaion. D) Big Basin member of the John Day formation, also known as the Painted Hills. The red paleosols represent a tropical climate. C) Turtle Cover member of the John Day formation overlain by the Picture Gorge Basalts. The green paleosols represent a drier climate and soils supporting open oak woodlands. B) A spectacular exposure of columnar jointing withing the Picture Goreg Basalt flows. A) The light colored Mascall Formation paleosols represent grasslands, which are overlain by Rattlesnake Ash-flow Tuff composing the flat horizon.

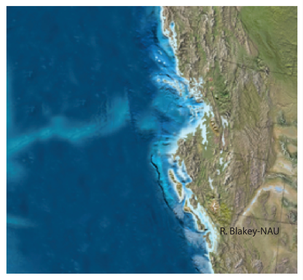
Photos by Marli Miller University of Oregon

HYPOTHESES

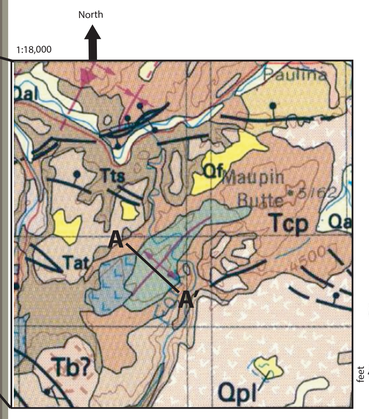




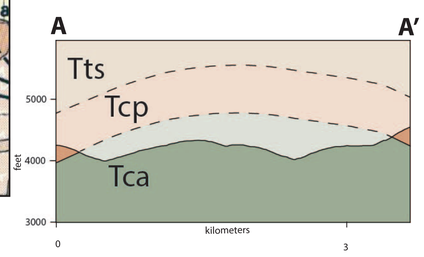
The Picture Gorge Basalts are a member of the much larger Columbia River Basalt Group that covers much of eastern Washington and Oregon. This Large Igneous Province (LIP) marks the initiation of hotspot volcanism related to the Yellowstone Hostspot. Though the individual groups of CRBs vary, the plume-related basalts are **tholeiitic** in composition.

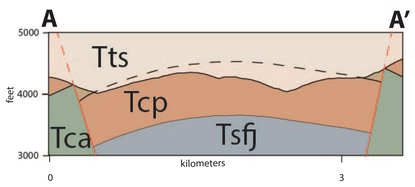


The volcanics of Clarno Formation are broadly **calc-alkaline**. These volcanics represent a change in the subducting Farallon plate after the Siletzia Terrane was accreted. A new subuction zone formed to the west of Siletzia, the abondoned slab delaminated and created back-arc volcanism (Clarno Formation).



TEST:
Geochemical Analysis using X-Ray Mass Spectrometry to determine if basalts are calc-alkaline or tholeiitic



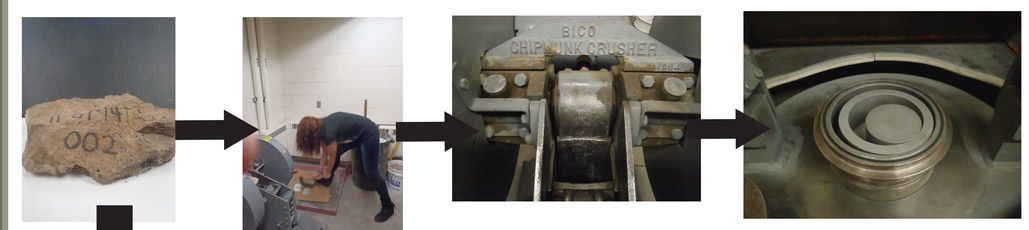


HYPOTHESES:

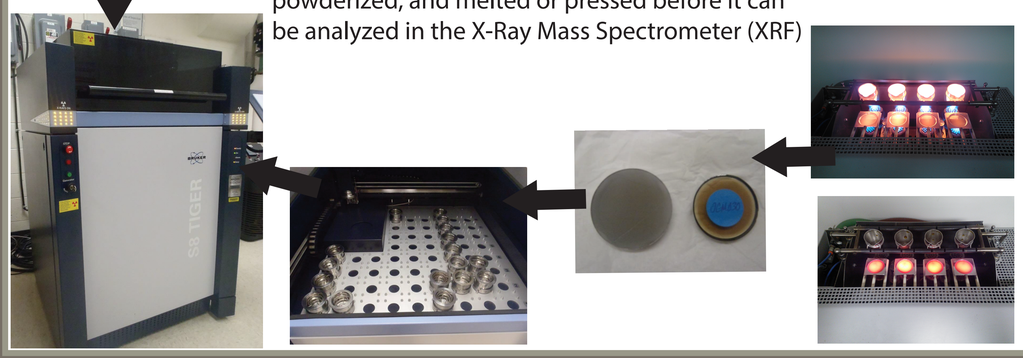
1. The currently mapped doubly plunging fold requires Picture Gorge Basalts to be directly on top of Clarno, which makes up the core of the fold.

2. Field investigation suggests the Picture Gorge Basalts are faulted, making a graben in the center.

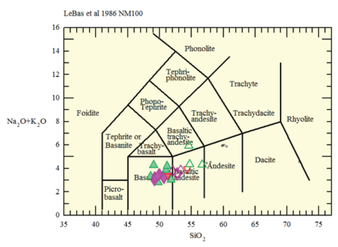
SAMPLE PROCESSING

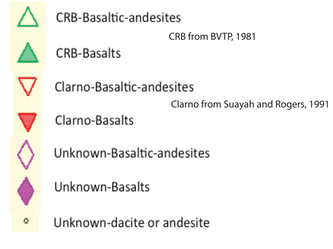


The raw rock sample must be smashed, crushed, powderized, and melted or pressed before it can be analyzed in the X-Ray Mass Spectrometer (XRF)

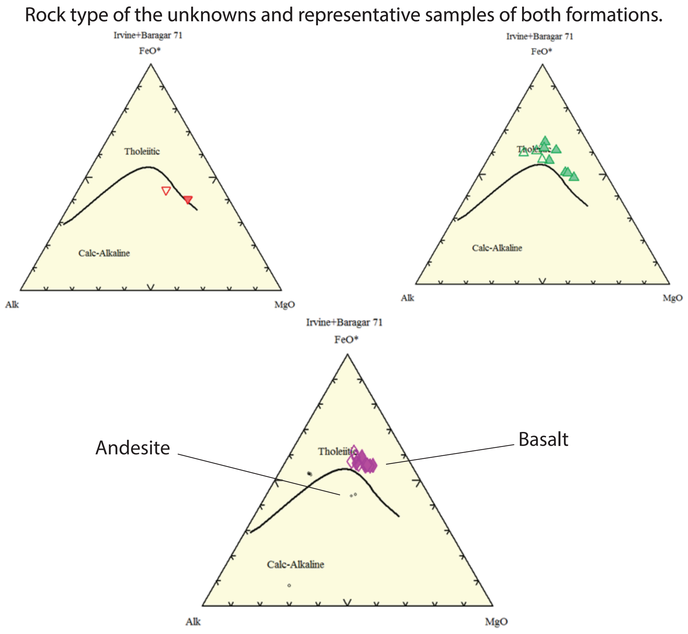


CONCLUSIONS





Rock type of the unknowns and representative samples of both formations.



A-F-M diagrams showing the basalt classification of each group of basalt.

1) All CRB samples plot in tholeiitic field.
2) Clarno Basaltic-andesites plot as calc-alkaline, while basalts plot as high-MgO tholeiites.
3) All unknowns plot in the tholeiitic field (none with high MgO).

The geochemical results suggest all of the unknown basalts are Picture Gorge Basalts, which supports hypothesis 2.

FUTURE WORK

UO Field Camp will continue to work in this area.

The Clarno Volcanics are understudied, mostly limited by mapping. A future study will focus on the distribution of rock types within the Clarno basin.

Becuase of the superb rock processing and geochemical analysis equipment at UWEC, the institutions will continue to collaborate on this project, potentially including UWEC students in mapping.

ACKNOWLEDGEMENTS

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