RESILIENCE OF ENDANGERED ACROPORA SP. CORALS IN BELIZE. WHY IS CORAL GARDENS REEF THRIVING?:
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TECTONIC EVOLUTION OF THE CHUGACH-PRINCE WILLIAM TERRANE, SOUTH CENTRAL ALASKA:
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EXPLORING THE PROTEROZOIC BIG SKY OROGENY IN SW MONTANA: METASUPRACRUSTAL ROCKS OF THE RUBY RANGE
Faculty: TEKLA HARMS, Amherst College, JULIE BALDWIN, University of Montana
Students: BRIANNA BERG, University of Montana, AMAR MUKUNDA, Amherst College, REBECCA BLAND, Mt. Holyoke College, JACOB HUGHES, Western Kentucky University, LUIS RODRIGUEZ, Universidad de Puerto Rico-Mayaguez, MARIAH ARMENTA, University of Arizona, CLEMENTINE HAMELIN, Smith College

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GEOMORPHOLOGIC AND PALEOENVIRONMENTAL CHANGE IN GLACIER NATIONAL PARK, MONTANA:
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ANTARCTIC Pliocene and Lower Pleistocene (Gelasian) PALEoclimate RECOncstructed FROM ocean DRILLING program Weddell Sea CoReS:
Faculty: SUZANNE O’CONNELL, Wesleyan University
Students: JAMES HALL, Wesleyan University, CASSANDRE STIRPE, Vassar College, HALI ENGLERT, Macalester College

HOLOCENE CLIMATIC CHANGE AND ACTIVe TECTONICS IN THE PerUVIAN ANDES:
Faculty: DON RODBELL & DAVID GILLIKIN, Union College
Students: NICHOLAS WEIDHAAS, Union College, ALIA PAYNE, Macalester College, JULIE DANIELS, Northern Illinois University

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Faculty: KIRSTEN NICOLAYSEN, Whitman College
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FIRE AND CATASTROPHIC FLOODING, FOURMILE CATCHMENT, FRONT RANGE, COLORADO:
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SOPHOMORE PROJECT: AQUATIC BIOGEOCHEMISTRY: TRACKING POLLUTION IN RIVER SYSTEMS
Faculty: ANOUK VERHEYDEN-GILLIKIN, Union College
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EXPLORING THE PRECAMBRIAN GEOLOGIC EVOLUTION OF THE RUBY RANGE IN SOUTHWEST MONTANA
TEKLA HARMS, Amherst College
JULIE BALDWIN, University of Montana

PETROLOGY, GEOCHEMISTRY, AND THERMOBAROMETRY OF AMPHIBOLITES IN THE RUBY RANGE, SOUTHWEST MONTANA
BRIANNA BERG, University of Montana
Research Advisor: Julie Baldwin

MONAZITE OCCURRENCE IN GARNET BEARING SCHIST AND GNEISS FROM THE RUBY RANGE, SOUTHWEST MONTANA
AMAR MUKUNDA, Amherst College
Research Advisor: Tekla Harms

CALCITE-GRAPHITE STABLE ISOTOPE THERMOMETRY IN MARBLES OF THE RUBY RANGE, SW MONTANA
REBECCA BLAND, Mount Holyoke College
Research Advisor: Steven R. Dunn

GEOTHERMOBAROMETRY AND PETROGRAPHIC INTERPRETATIONS OF CHRISTENSEN RANCH METAMORPHOSED BANDED IRON FORMATION FROM THE RUBY RANGE, MONTANA
JACOB HUGHES, Western Kentucky University
Research Advisor: Dr. Andrew Wulff

PETROGRAPHY AND MINERALOGY OF ULTRAMAFIC PODS IN THE RUBY RANGE WITH SPECIAL ATTENTION TO IDENTIFYING ACCESSORY MINERAL PHASES, INCLUDING ZIRCON
LUIS G. RODRIGUEZ, University of Puerto Rico-Mayaguez
AARON CAVOSIE, Curtin University Australia, University of Puerto Rico-Mayaguez

INVESTIGATING THE TIMING OF MELT-PRODUCING HIGH GRADE METAMORPHISM IN THE RUBY RANGE, SOUTHWESTERN MONTANA THROUGH ZIRCON U-Pb GEOCHRONOLOGY
MARIAH ARMENTA, University of Arizona
Research Advisor: George Gehrels

PETROGRAPHY, GEOTHERMOBAROMETRY, AND METAMORPHIC HISTORY OF METAPELITES FROM THE CENTRAL RUBY RANGE, SOUTHWEST MONTANA
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EXPLORING THE PRECAMBRIAN GEOLOGIC EVOLUTION OF THE RUBY RANGE IN SOUTHWEST MONTANA

TEKLA HARMS, Amherst College
JULIE BALDWIN, University of Montana

INTRODUCTION

Late Mesozoic to early Cenozoic Laramide block uplifts in southwestern Montana (Fig. 1), such as the Ruby Range, provide a window into the Precambrian basement of North America through which we can reconstruct the growth and stabilization of this continent, a process that occurred by the collision and amalgamation of smaller Archean cratons - including the Wyoming province - across Proterozoic orogenic belts.

Figure 1. Setting of the Ruby Range within southwestern Montana, the Wyoming province, and the Precambrian basement of North America. A. Basement map of North America showing Archean cratons (including the Wyoming province) in pink, intervening Paleoproterozoic orogenic belts in tan, and younger Meso- and Neoproterozoic orogenic belts in grey. Rimming Phanerozoic orogens are shown with thrust symbol. B. The ancient core of the Wyoming province (pink) and bounding collision belts affected by Paleoproterozoic orogeny (tan). Exposures of basement rocks in grey. C. Laramide ranges of southwest Montana with exposures of Precambrian basement rocks (grey). The boundary between the Montana Metasedimentary and Beartooth-Bighorn Magmatic suprovinces is shown, as is “Giletti’s Line”. Maps adapted from Hoffman (1988), Bleeker and Hall (2007), and Burger (2004).
The core of the Wyoming province, known as the Beartooth-Bighorn Magmatic subprovince (BBMS), mainly consists of intermediate-composition, metaplutonic rocks that bear zircons with 2.9 Ga and older ages (Foster et al., 2006). The Ruby Range and adjacent southwest Montana ranges are underlain by the Montana Metasedimentary subprovince (MMS), which flanks the BBMS and, like the BBMS, includes abundant quartzo-feldspathic gneisses that yield Archean zircons (Mueller et al., 2004; Mogk et al., 2004). The MMS, however, is distinguished by the presence of metasupracrustal suites with evidence for significant tectonic events at 2.45 Ga (variously called the Tendoy or Beaverhead orogeny) (Cheney et al., 2004; Baldwin et al., 2014; Jones, 2008) and/or at 1.79-1.72 Ga (called the Big Sky or Trans-Montana orogeny) (Brady et al., 2004; Cheney et al., 2004; Alcock and Muller, 2012; Roberts et al., 2002; Jones, 2008; Sims et al., 2004). The effects of the Big Sky orogeny are seen exclusively to the northwest of a thermoductonic boundary within the MMS, southeast of the Ruby Range, that has been called “Giletti’s Line” (Giletti, 1966; Brady et al., 2004; Foster et al., 2006).

The Ruby Range project investigates the timing, character, evolution, and tectonic setting of Proterozoic orogenic events that affected the MMS and bear on the incorporation of the Wyoming

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**Figure 2. Schematic geologic map and structural column of Precambrian rocks in the Ruby Range. Small inset map shows the general distribution of the three Precambrian suites that underlie the range. Geology taken from Ruppel and others (1993).**
province into the North American continent. Metasupracrustal rocks in the Ruby Range are well suited to analyses that establish the pressure, temperature, and time at which the deformation, metamorphism, and melt production associated with orogeny occurred and to constrain the original tectonic setting of the crustal blocks that came together during the collision.

RUBY RANGE GEOLOGY

Precambrian rocks of the Ruby Range are metamorphic rocks in which compositional layering and fabric are concordantly north-northeast striking and west-northwest dipping, consequently rocks on the east side of the range are structurally lowest (Fig. 2). Sillimanite occurs in rocks of appropriate aluminous composition across the range, establishing a lower limit on temperatures and pressures of metamorphism at all structural levels. Lenses and pods of leucocratic neosome, interpreted as partial melt, are also present (Fig. 3).

Figure 3. Some very large garnets grow in neosomal lenses and layers in the metamorphic rocks of the Ruby Range. Shown here is a biotite-garnet-sillimanite gneiss within the Dillon Gneiss suite. Pencil at top of outcrop for scale.

Basement rocks of the Ruby Range have been divided into three suites (Fig. 2) (James, 1990; Heinrich and Rabbitt, 1960).

The “Pre-Cherry Creek suite” is the structurally lowest. It consists of minor quartzite, pelitic gneiss and amphibolite whose metasupracrustal origins are clear, interlayered with more abundant biotite gneiss and quartzofeldspathic gneiss whose protoliths are less uniquely determinable. Marble is notably absent.

The “Christensen Ranch suite” is structurally highest, occurring continuously along the west flank of the range. It is a diverse suite of interlayered metasupracrustal rock types including thick layers of marble and calcsilicate, with quartzite, pelitic schist, amphibolite, orthoamphibole schist, banded iron formation and discontinuous pods of ultramafic rock.

The “Dillon Gneiss” is poorly characterized but is known to include abundant biotite gneiss, quartzofeldspathic gneiss, and metagranite, with layers of marble and amphibolite locally. Whether the quartzofeldspathic gneiss and biotite gneiss have an igneous or sedimentary origin has not been determined (see the discussion in James, 1990). Contacts with the Pre-Cherry Creek suite below and with the Christensen Ranch suite above are poorly identified and may be gradational or intrusive - making the age of this suite relative to the adjacent suites undetermined.

PROJECT GOALS

The research goal of the Ruby Range project is to characterize the protoliths, the grade and timing of metamorphism, and the intensity and nature of tectonism in Precambrian metasupracrustal rocks of the Range, and to integrate these findings into our developing understanding of the growth and stabilization of the North American continent. Work focuses on rocks exposed along an across-strike transect of the north-central Ruby Range afforded by the Stone Creek-Cottonwood Creek roads, which connect across the summit of the range (Fig. 2).
Individual projects undertaken are:

**MARIAH ARMENTA**, University of Arizona: Constraining the time of partial melt-producing reactions and the intrusive age of mylonitic leucogneiss in all three suites in the Ruby Range through U-Pb zircon geochronology.

**BRIANNA BERG**, University of Montana: Comparative petrography, petrology, geochemistry and thermobarometry of garnet amphibolites that occur in all three suites of Ruby Range rocks.

**REBECCA BLAND**, Mt. Holyoke College: Determining the temperatures and fluid phases active during metamorphism of graphite-calcite marbles and calc-silicate marbles in the Christensen Ranch and Dillon Gneiss suites by stable isotope analysis.

**CLEMENTINE HAMELIN**, Smith College: Petrography, petrology, and thermobarometry of pelitic schist in the Christensen Ranch suite.

**JACOB HUGHES**, Western Kentucky University: Petrology and mineral chemistry of banded iron formation in the Christensen Ranch suite.

**AMAR MUKUNDA**, Amherst College: Constraining the age of metamorphic reactions in garnet-bearing rocks through monazite geochronology.

**LUIS RODRIGUEZ**, University of Puerto Rico, Mayaguez: Petrography and mineralogy of ultramafic pods in the Christensen Ranch and Dillon Gneiss suites with special attention to identifying accessory mineral phases, including zircon.

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