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TECTONIC EVOLUTION OF THE PRINCE WILLIAM TERRANE IN RESURRECTION BAY AND EASTERN PRINCE WILLIAM SOUND, ALASKA

CAMERON DAVIDSON, Carleton College
JOHN I. GARVER, Union College

INTRODUCTION

An outstanding question in the assembly of the North American Cordillera is the accretion and subsequent translation history of the Campanian to Eocene Chugach-Prince William terrane (CPW) that extends for ~2200 kilometers along southern Alaskan margin (Fig. 1). The CPW is a thick accretionary complex primarily composed of deep-water turbidites with abundant quartzofeldspathic and volcanic-lithic sandstones and basaltic rocks (Plafker et al., 1994) that was intruded by near-trench plutons of the Sanak-Baranof belt (Hudson et al., 1979; Bradley et al., 2000) inferred to be related to the subduction of the Kula-Farallon or Kula-Resurrection plate ridge (Bradley et al., 2003; Haeussler et al., 2003; Cowan, 2003). There are two prevailing, but mutually exclusive hypotheses for the position of formation of the CPW along the Cordilleran margin: 1) The CPW formed more or less in place and ridge subduction progressed from west to east along the southern Alaskan margin during subduction of the Resurrection plate (Haeussler et al., 2003); or 2) the CPW formed far to the south and was intruded by near-trench plutons at 48-49°N during coastwise translation of the CPW (Cowan, 2003). The possible formation of the CPW far to the south and subsequent translation along the continental margin in the Paleocene and Eocene may be a defining event in Cordilleran tectonics and makes testable predictions for the provenance and thermal evolution of these rocks.

This contribution summarizes our findings from the fourth year of a Keck Geology Consortium and NSF-supported project to understand the tectonic and thermal evolution of the Chugach-Prince William Terrane in southern Alaska. In summer 2014 our research team included six students from four different undergraduate institutions who spent four weeks in the field working in Resurrection Bay out of Seward, and in eastern Prince William Sound out of Cordova (Fig. 2).

Figure 1. Extent of the Chugach-Prince William terrane in south central Alaska. 2014 field areas are indicated by boxes. Pluton locations and dates are from Farris and Patterson (2009) and Bradley et al. (2003). Map modified from Pavlis and Roeske (2007).
PROJECT GOALS

The specific objectives for 2014-15 include: 1) determine the provenance, maximum depositional ages, and thermal history of the flysch of the Orca Group in eastern Prince William Sound; 2) sample and measure the whole-rock geochemistry of interbedded pillow basalts and associated volcanic rocks of the Orca Group around Cordova and compare with similar rocks of the Knight Island ophiolite and Chenega Island volcanics in western Prince William Sound; 3) determine the crystallization age, geochemistry, and zircon Hf-isotope systematics of the Sheep Bay and McKinley Peak plutons, part of the Paleocene Sanak-Baranof belt of plutons near Cordova; and 4) obtain detrital zircon U-Pb dates from previously collected samples from the Tofino basin (Garver and Brandon, 1994) and underlying Blue Mountain unit of the Crescent Formation located in the Olympic Mountains of Washington. In addition, we complement much of these efforts with ongoing studies of crystallinity in Precambrian zircon using Raman spectroscopy.

Figure 2. Geologic map of Resurrection Bay and Prince William Sound, Alaska. Sample locations shown as black dots; boxes show the maximum depositional age determined from the youngest three zircon grains (brown) and youngest coherent population (green) using AgePick (Excel macro provided by G. Gehrels, University of Arizona). Samples along Turnagain Arm (AnJ) and near Whittier (KeD) are from Amato et al. (2013). Map modified from Bradley and Miller (2006).
RESEARCH

Age, Provenance, and Thermal History of the Orca Group in Eastern Prince William Sound

Bill Grimm (Carleton College) measured 1931 detrital zircon U-Pb dates from eight samples of volcanic-lithic and arkosic sandstones collected from the Orca Group near Cordova, Alaska. Combined with previously collected U-Pb data from the Orca Group near Cordova and one sample from the Valdez Group northeast of Valdez, Alaska (unpublished data) he was able to show that the maximum depositional ages from these rocks range from 62-51 Ma (Fig. 2). This is a remarkable result because it encompasses a large area of rock (>11,000 km$^2$) with over 70 km of structural thickness that must have been eroded, deposited and accreted to the North American margin in ~10 Ma. This result also suggests at least some of the rock mapped as the Valdez Group, including the type area of Port Valdez, in eastern Prince William Sound is Paleocene and not Maastrichtian in age. This study also shows that the grain-age distributions in this area are nearly identical to those in western Prince William Sound (Hilbert-Wolf, 2012), suggesting that the source area for these rocks is the Coast Plutonic Complex in southeast Alaska and British Columbia.

Elaine Young (Ohio Wesleyan University) analyzed 13 samples from the basaltic volcanic rocks and pillow basalts interbedded with the flysch of the Orca Group. Using major and trace element geochemistry, she shows that most of these volcanic rocks have MORB signatures, with some samples having a subduction related component. Based on the distribution of rare earth elements, she shows that there are three related, but distinct sources for the basaltic magmas and that most of the samples from eastern Prince William Sound (PWS) appear to correlate with the Knight Island ophiolite and Chenega volcanics in western PWS (Miner, 2012). She compares these results with previously published data from similar age volcanic rocks from the Yakutat (Alaska) and Crescent (Washington) terranes to the east and south and suggests that the basalts are all derived from distinct but related source regions supporting that these rocks my have once been contiguous.

Rainer Lempert (Amherst College) focused on the petrogenesis and crystallization ages of the Sheep Bay and McKinley Peak plutons, part of the Sanak-Baranof belt of plutons that intrude the Chugach-Prince William terrane. Mafic enclaves and host granites are predominantly metaluminous in the Sheep Bay pluton and those from the McKinley Peak are peraluminous suggesting slightly different source regions for the granites. The Sheep Bay pluton intrudes Orca Group rocks with a maximum depositional age of 57 Ma (Grimm, this volume) and U-Pb zircon crystallization ages of 54.8 ± 0.7 Ma and 54.5 ± 1.7 Ma for the Sheep Bay and McKinley Peak plutons, respectively, show that the Orca Group sedimentary rocks were deposited, buried and intruded by these plutons in a relatively short period of time. Zircon in the Sheep Bay pluton has more evolved Hf-isotope ratios than the McKinley Peak pluton supporting previous studies (Barker et al. 1992) that the two plutons were derived from geochemically and isotopically distinct source regions.

Eileen Alejos (Union College) applied detrital zircon fission track (ZFT) dating to sandstones from across the Rude River Fault on Hinchinbrook Island (Fig. 2). She shows that these rocks have been partially reset during regional low-grade metamorphism as evidenced by multimodal grain age populations, the youngest of which is less than depositional age. Most of the samples have a youngest reset population (>10% of grains) with a peak between 25-35 Ma. This important thermal event occurs everywhere in the CPW east of the Kenai Peninsula (Enkelmann et al., 2008, Izykowski et al., 2011; Carlson, 2012; Kaminski, 2014), and might be related to the arrival and initial subduction of the Yakutat block (Enkelmann et al., 2008) or strike slip motion along the Alaskan margin (Kaminski, 2014).

Provenance of the Tofino Basin, Olympic Peninsula, Washington

Rudy Molinek (Carleton College) builds on the work of Garver and Brandon (1994) and completes the first detailed study of detrital zircon U-Pb ages from the Eocene to Oligocene Tofino basin and underlying Blue Mountain unit of the Crescent Formation that crops
out along the northern coast of the Olympic Peninsula in Washington. He shows that the Blue Mountain unit, that interfingers with the base of the Crescent basalts, might be as young as 48 Ma. If this holds up, it implies that >16 km of the Crescent basalts were extruded in < 1 Ma (cf. Wells et al., 2014). U-Pb zircon ages from the Tofino basin support the conclusions of Garver and Brandon (1994) that these rocks were largely derived from the Coast Plutonic Complex. However, the grain-age populations are distinctly different than those from age-correlative parts of the Orca Group in Prince William Sound, suggesting that these sedimentary basins did not share the same drainage basin.

Zircon Crystallinity

Kaitlyn Suarez (Union College) conducted laboratory and natural annealing experiments to help understand the role of U content, time, and temperature on the crystallinity of zircon using Raman spectroscopy. Laboratory experiments were conducted on fragments of the 564 Ma Sri Lanka zircon standard with a nominal U content of 518 ppm over a temperature range of 400°C to 1000°C. She shows that the most dramatic change in the Raman spectra occurs between 400°C and 800°C. Her natural experiment used Precambrian zircons collected and dated by Rick (2013) from regionally metamorphosed rocks of the Sitka greywacke on Baranof Island, Alaska. These rocks record a steep metamorphic field gradient from prehnite-pumpellyte facies rocks to biotite-andalusite zone rocks of the amphibolite facies near the Crawfish Inlet pluton. Her results show a distinct Raman shift indicating increasing crystallinity of zircon near the pluton. This work holds great promise as another powerful tool to help constrain zircon provenance in detrital studies.

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