Learning Science Through Research
Published by Keck Geology Consortium

Short Contriubtions
26th Annual Keck Symposium Volume
6 April, 2013
ISBN: 1528-7491

TECTONIC EVOLUTION OF THE CHUGACH-PRINCE WILLIAM TERRANE: SHUMAGIN ISLANDS AND KENAI PENINSULA, 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, 1998) that was intruded by near-trench plutons of the Sanak-Baranof belt (Hudson et al., 1979) 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 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 second year of a three-year 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 2012 our research group included five students from five different undergraduate institutions who spent four weeks in the field working on the Kenai Peninsula, Resurrection Bay near Seward, and the Shumagin Islands, near Sand Point, Alaska (Fig. 2).

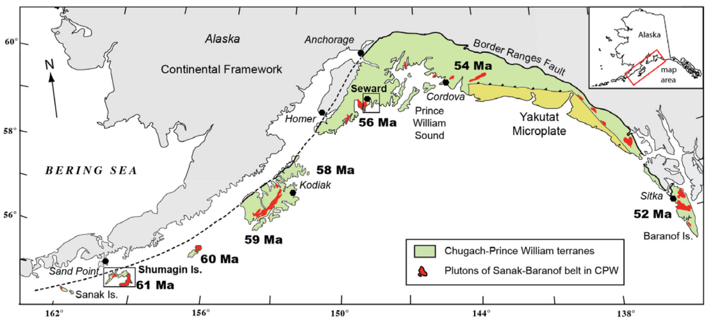

Figure 1. Extent of the Chugach-Prince William terrane in south central Alaska. 2012 field areas are indicated by black boxes. Pluton locations and dates are from Farris and Patterson (2009) and Bradley et al. (2003). Map modified from Pavlis and Roeske (2007).

PROJECT GOALS

The specific objectives for this project (summer 2012) were to: 1) determine the depositional setting and source for the Shumagin Formation exposed on Nagai Island in the Shumagin Archipelago near Sand Point, Alaska; 2) determine the crystallization age and geochemistry of the Shumagin Batholith complex, part of the Paleocene Sanak-Baranof belt of plutons; and 3) define the thermal history of the Shumagin Formation and batholith complex using zircon fission track dating. In addition to these objectives focused on the western exposures of the CPW in the Shumagin Islands, we were interested in: 4) determining the

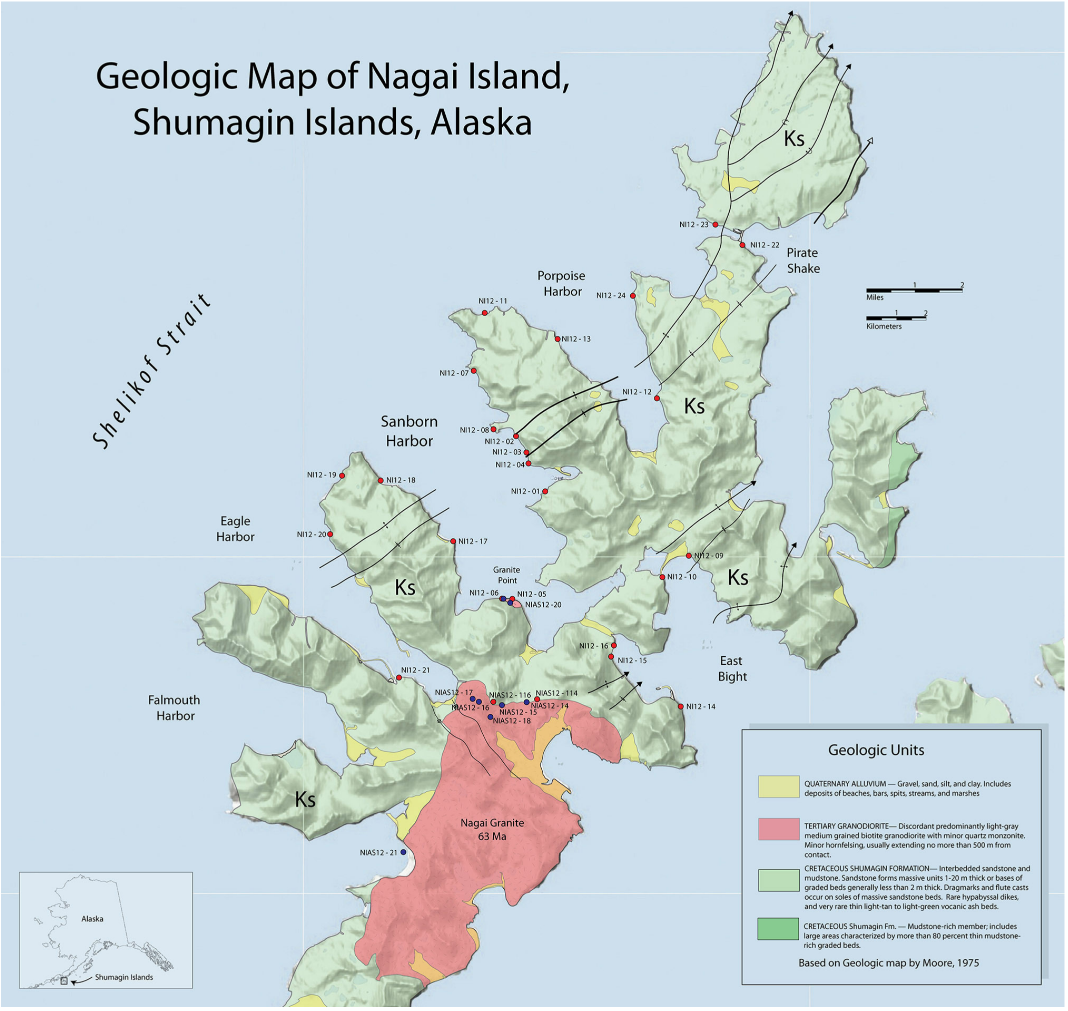

Figure 2. Geologic map of the Shumagin Islands, Alaska. Sample locations shown as red dots (Shumagin Formation), and blue dots (Nagai pluton). Map modified from Moore (1974).

origin and depositional age of CPW flysch exposed stratigraphically above the Resurrection Ophiolite near Seward; and finally, 5) measure the Hf isotope composition of detrital zircon from across the CPW to help define provenance. We complement much of these efforts with ongoing studies of zircon crystallinity using Raman spectroscopy.

RESEARCH

Age, Provenance, and Thermal History of the Shumagin Formation

Carly Roe (Lawrence University) measured 1053 detrital zircon U/Pb dates from ten samples of volcanic-lithic and arkosic sandstones from the Shumagin Formation on Nagai Island. She shows that the maximum depositional ages from Nagai Island are closely clustered and range from 73-77 Ma confirming a Late Cretaceous age for the Shumagin Formation. She also obtained a U/Pb zircon crystallization age of 73.7 ± 1.2 Ma from an interbedded tuff further confirming the Late Cretaceous age of these rocks. The major age populations from the Shumagin Formation do not appear to correlate with units of similar age immediately inboard of the Shumagin Islands (Kuskokwim Group). However, they do compare well with correlative units along strike including the Kodiak and Ghost Rocks Formations on Kodiak Island, Valdez and Orca Groups in Prince William Sound, and the Yakutat Formation near Yakutat, Alaska.

Alex Short (University of Minnesota-Morris) collected 12 samples from the Shumagin Batholith for major and trace element geochemistry and used U/Pb zircon dating from two samples to determine a crystallization age for the batholith. He obtained concordant crystallization ages of 61.7 ± 0.7 Ma and 62.6 ± 0.7 Ma, and both samples showed some inheritance. The geochemistry of the batholith is distinctly peraluminous with most of the samples containing magmatic muscovite, and one sample contains a large (~ 1 cm) xenocryst of cordierite. Alex uses these data and field relationships to suggest that the Shumagin

Batholith formed from basaltic underplating and partial melting of the CPW accretionary complex.

Mike Deluca (Union College) uses detrital zircon fission track (ZFT) dating of samples from the Shumagin Formation and shows that these rocks have a complex cooling history with samples near the plutons yielding: 1) thermally reset cooling ages of 44-53 Ma; 2) samples with partially reset ages that have a wide range of cooling ages, but with a young population at 45-58 Ma; and 3) not thermally reset samples with a wide range of cooling ages that reflect the cooling ages of the original source regions. He double dated (ZFT and U/Pb) one sample from the thermally reset group and one sample from the partially reset group and shows that zircons with high effective U concentrations are more likely to be reset that grains with low effective U concentrations. From these data, Deluca suggests that the Shumagin Formation was buried to depths at or near the lower bound of the zircon partial annealing zone, was intruded and heated locally by the Shumagin batholith at ~62 Ma, and after intrusion, the rocks remained at depth and cooled slowly into the Eocene (c. 50 Ma) before passing to higher crustal levels.

Age of Clastic Cover to the Resurrection Peninsula Ophiolite

Rose Pettiette (Washington and Lee) takes on a controversy over the age and stratigraphic relationship of clastic strata that structurally overlies the Resurrection Ophiolite near Seward, Alaska. The 57 Ma Resurrection Ophiolite is mapped by some workers as a thrust slice into Upper Cretaceous Valdez Group flysch (e.g. Bradley and Miller, 2006); however, Kusky and Young (1999) suggest that the clastic rocks overlying the ophiolite are in depositional contact and therefore younger than, or coeval with, the crystallization age of the ophiolite. Pettiette reports new detrital zircon U/Pb dates from four samples (n=404) from Thumb Cove, Humpy Cove, and Nash Road, across the bay from Seward. One sample (RB12-04), collected at the end of Humpy Cove, is from a thin-bedded, medium-grained sandstone interbedded with (and cross-cut by) basaltic rocks of the Resurrection Ophiolite. The maximum depositional age of RB12-04 is 57 Ma given by a robust mode formed from the youngest four zircons. Pettiette also shows that the clastic strata in Resurrection Bay are nearly identical in zircon grain age distribution to the Paleocene part of the Orca Group 70-80 km to the NE in Prince William Sound. This tie of the Resurrection Ophiolite to the flysch of the Prince William terrane is significant because it removes the stratigraphic uncertainty of paleomagnetic data obtained from the Resurrection Peninsula ophiolite that indicate a paleolatitude 13 ± 9° south of the present location to near present day northern Washington (Bol et al., 1992).

Hafnium Isotope Composition of Zircon from the Chugach-Prince William Terrane

Nick Roberts (Carleton College) presents several hundred integrated U/Pb ages and Hf isotope compositions from four widely separated locations along the arcuate belt of the CPW to reveal a range of source regions with dramatically different zircon crystallization and mantle separation ages. Zircons from the Shumagin Formation yield positive εHf (t) values consistent with partial melting of a relatively juvenile source region. This is in contrast to similar-aged zircons from the other three sampling areas (from west to east), Kodiak Island, Prince William Sound, and Yakutat, where εHf (t) values range from +11.9 to -26.5 suggesting that Phanerozoic zircons from these areas crystalized from melts derived from a heterogeneous source region that included juvenile and Precambrian crust. Taken together, the integrated U/Pb and Hf isotope data show that the origin and provenance of detrital zircons from the CPW varies systematically along strike. Phanerozoic U/Pb ages have a strong Coast Mountains batholith signature with more juvenile crust in the magmatic source region in the Shumagin Formation, compared to tectonostratigraphically equivalent rocks in Kodiak, PWS, and Yakutat.

ACKNOWLEDGMENTS

This research was made possible by grants from the Keck Geology Consortium and the National Science Foundation (NSF EAR 1116554 to Garver; EAR 1116536 to Davidson, and EAR-1062720 to Keck/Varga). We are indebted to Mark Pecha, Nicky Giesler , and George Gehrels at the Arizona LaserChron Center and their strong support for undergraduate research. We have had fruitful planning discussions for field logistics and we have enjoyed a lively scientific discourse with Peter Haeussler, Darrel Cowan, Phil Armstrong, Steve Nelson, Dwight Bradley, Sue Karl, Marti Miller, Kevin Kveton, Terry Pavlis, and Casey Moore. Donny Eubank, captain of the Cub Point, expertly supported us in the field. We appreciate the thoughtful guidance and mentoring of Jeff Rahl (Washington and Lee), James Cotter (University of Minnesota-Morris) and Marcia Bjornerud (Lawrence University).

REFERENCES

Bol, A.J., Coe, R.S., Grommé, C.S., Hillhouse, J.W., 1992. Paleomagnetism of the Resurrection Peninsula, Alaska: Implications for the tectonics of southern Alaska and the Kula-Farallon ridge, J. Geophys. Res. v. 97, p. 17213-17232.

Bradley, D.C., Kusky, T.M., Haeussler, P.J., Goldfarb, R.J., Miller, M.L., Dumoulin, J.A., Nelson, S.W. & Karl, S.M. 2003, Geologic signature of early Tertiary ridge subduction in Alaska; Geology of a transpressional orogen developed during ridge-trench interaction along the North Pacific margin, Special Paper - Geological Society of America, vol. 371, pp. 19-49.

Bradley, D.C., and Miller, M.L., 2006, Field guide to south-central Alaska's accretionary complex, Anchorage to Seward: Anchorage, Alaska Geological Society, 32 p.

Cowan, D.S., 2003, Revisiting the Baranof-Leech River hypothesis for early Tertiary coastwise transport of the Chugach-Prince William terrane. Earth and Planetary Science Letters, v. 213, 463-475.

Farris, D.W. and Paterson, S.R., 2009, Subduction of a segmented ridge along a curved continental margin: Variations between the western and eastern Sanak-Baranof belt, southern Alaska, Tectonophysics, 464, p. 137-163.

Haeussler, P.J., Bradley, D.C., Wells, R.E. & Miller, M.L. 2003, Life and death of the Resurrection Plate; evidence for its existence and subduction in the northeastern Pacific in Paleocene-Eocene time, Geological Society of America Bulletin, vol. 115, no. 7, pp. 867-880.

Hudson, T., Plafker, G., and Peterman, Z.E., 1979, Paleogene anatexis along the Gulf of Alaska margin: Geology, v. 7, p. 573-577.

Kusky, T.M., and Young, C.P., 1999, Emplacement of the Resurrection Peninsula ophiolite in the southern Alaska forearc during a ridge-trench encounter: Journal of Geophysical Research, v. 104, no. B12, p. 29,025-29,054.

Moore, J. C., 1974, Geologic and structural map of the Shumagin Islands: U.S. Geol. Survey Misc. Investigations Series Map I-815.

Pavlis, T.L., and Roeske, S.M., 2007, The Border Ranges Fault System, southern Alaska, in Ridgway, K.D., Trop, J.M., Glen, J.M.G., and O'Neill, J.M., eds., Tectonic Growth of a Collisional Continental Margin: Crustal Evolution of Southern Alaska: Geol. Soc. of Am. Sp. Pap. 431, p. 95–128.

Plafker, G., Moore, J.C. & Winkler, G.R. 1994, Geology of the Southern Alaska margin in The geology of Alaska, eds. G. Plafker & H.C. Berg, Geological Society of America, Boulder, CO, United States (USA), United States (USA).