PROCEEDINGS OF THE TWENTY-SEVENTH ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

April 2014
Mt. Holyoke College, South Hadley, MA

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ISSN# 1528-7491

The Consortium Colleges   The National Science Foundation   ExxonMobil Corporation

KECK GEOLOGY CONSORTIUM
PROCEEDINGS OF THE TWENTY-SEVENTH ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

ISSN# 1528-7491

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A GEOBIOLOGICAL APPROACH TO UNDERSTANDING DOLOMITE FORMATION AT DEEP SPRINGS LAKE, CA
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POTENTIAL EFFECTS OF WATER-LEVEL CHANGES ON ON ISLAND ECOSYSTEMS: A GIS SPATIOTEMPORAL ANALYSIS OF SHORELINE CONFIGURATION
Faculty**:** *KIM DIVER*, Wesleyan Univ.
Students: *RYAN EDGLEY*, California State Polytecnical University-Pomona, *EMILIE SINKLER*, Wesleyan University

PĀHOEHOE LAVA ON MARS AND THE EARTH: A COMPARATIVE STUDY OF INFLATED AND DISRUPTED FLOWS
Faculty: *ANDREW DE WET*, Franklin & Marshall College, *CHRIS HAMILTON*. Univ. Maryland, *JACOB BLEACHER*, NASA, GSFC, *BRENT GARRY*, NASA-GSFC
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THE GEOMORPHIC FOOTPRINT OF MEGATHRUST EARTHQUAKES: A FIELD INVESTIGATION OF CONVERGENT MARGIN MORPHOTECTONICS, NICOYA PENINSULA, COSTA RICA
Faculty*:* *JEFF MARSHALL*, Cal Poly Pomona, *TOM GARDNER*, Trinity University, *MARINO PROTTI, OVSICORI-UNA, SHAWN MORRISH*, Cal Poly Pomona
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Keck Geology Consortium: Projects 2013-2014
Short Contributions— Chugach Terrane, Alaska Project

STUDIES IN RESURRECTION BAY AND BARANOF ISLAND AIMED AT UNDERSTANDING THE TECTONIC EVOLUTION OF THE CHUGACH-PRINCE WILLIAM TERRANE, ALASKA
Faculty: JOHN I. GARVER, Union College
CAMERON DAVIDSON, Carleton College

DETRITAL ZIRCON U/PB AGES OF THE PALEOCENE ORCA GROUP AND UPPER CRETACEOUS VALDEZ GROUP, RESURRECTION BAY, ALASKA
BRIAN K. FRETT, Carleton College
Research Advisor: Cameron Davidson

EXHUMATION OF THE BARANOF SCHIST, ALASKA DETERMINED THROUGH DETRITAL ZIRCON FISSION TRACK DATING
KATE KAMINSKI, Union College
Research Advisor: John I. Garver

U/PB DATING OF DETRITAL ZIRCONS, BARANOF ISLAND, SE ALASKA
BRIANNA J. RICK, Carleton College
Research Advisor: Cameron Davidson, [John Garver, Union College]

THERMAL EVOLUTION OF THE SITKA GRAYWACKE, BARANOF ISLAND, ALASKA, REVEALED THROUGH ZIRCON FISSION TRACK DATING
MEGHAN PAIGE RIEHL, Union College
Research Advisor: John I. Garver

OXYGEN AND HAFNIUM ISOTOPE GEOCHEMISTRY OF ZIRCON, QUARTZ, AND GARNET FROM THE CRAWFISH INLET AND KRESTOF PLUTONS, BARANOF ISLAND, ALASKA
CLAUDIA I. ROIG, University of Puerto Rico, Mayagüez Campus
Research Advisor: Dr. Aaron J. Cavosie

PETROGRAPHY AND GEOCHEMISTRY OF THE CRAWFISH INLET AND KRESTOF ISLAND PLUTONS, BARANOF ISLAND, ALASKA
ADRIAN A. WACKETT, Trinity University
Research Advisor: Diane R. Smith

Funding Provided by:
Keck Geology Consortium Member Institutions
The National Science Foundation Grant NSF-REU 1062720
ExxonMobil Corporation

KECK Geology Consortium
Learning Science Through Research
Published by Keck Geology Consortium
Short Contributions
27th Annual Keck Symposium Volume
26 April, 2014
ISBN: 1528-7491

U/PB DATING OF DETRITAL ZIRCONS, BARANOF ISLAND, SE ALASKA

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Research Advisor: Cameron Davidson, [John Garver]

INTRODUCTION

The Chugach-Prince William Terrane (CPW) is a ~2200 km Mesozoic-Tertiary accretionary complex on the coast of southeastern Alaska, at the margin of the North American and Pacific plates (Cowan, 2003). This complex is one of the thickest accretionary complexes in the world, composed mainly of deep-water flysch, and is intruded by near-trench plutons of the 62-47 Ma Sanak-Baranof Belt (SBB) (Hudson et al., 1979; Bradley et al., 2003; Wackett et al., 2014). The location of the CPW during ridge interaction is under debate. The two main prevailing hypotheses for the location of the accretion of the Chugach-Prince William terrane include: 1) a northern (in-situ) option in which there are two TRT triple junctions producing plutons, one in Alaska and one along the Cascadia margin (Haeussler et al., 2003); or 2) a southern option, in which the CPW formed to the south and then was transported by large dextral coastal slip at least ~1100 km to the north (Cowan, 2003). These hypotheses require different source regions for the sediments deposited along the CPW.

The westernmost unit of the Chugach accretionary complex on southern Baranof Island is the Sitka Graywacke, and what has been assumed to be its metamorphic equivalent, the Baranof Schist (Loney et al., 1975). In this contribution, we present detrital zircon U/Pb ages from the Sitka Graywacke on Baranof Island. We show that the maximum depositional ages (MDA) generally young inboard to outboard, but that there are three age distinct belts of the Sitka Graywacke. We also show how these three belts of the Sitka Graywacke correlate to the McHugh, Valdez, and Orca Groups in Prince William Sound.

GEOLOGIC SETTING

Baranof Island

Southern Baranof Island, south of Sitka Alaska, is mainly underlain by the Sitka Graywacke, which was intruded by the Crawfish Inlet pluton around 50 Ma (Wackett et al., 2014). The Sitka Graywacke is composed of thickly bedded, steeply dipping turbidites, with poorly sorted fine- to coarse- grained sandstones. Loney et al. (1975) map the Sitka Graywacke as Late Jurassic to Early Cretaceous, based on fossils and correlation to other rocks on Chichagof Island. Haeussler et al. (2006) report maximum depositional ages (MDA) for the Sitka Graywacke ranging 72-75 Ma in the west and 97-105 Ma in the east, and therefore some of the Sitka must be Upper Cretaceous in age (Fig. 1). The Crawfish Inlet Pluton intrudes and separates the Sitka Graywacke near Sitka from the mapped metamorphic equivalent, referred to as the Baranof Schist, on southern Baranof Island surrounding Whale Bay (field study of this study). An important question has been how the Baranof Schist and the Sitka Graywacke correlate. The metamorphic facies of the Baranof Schist range from albite-epidote-horfels to amphibolite facies, a progressive low- to high- temperature medium-pressure metamorphism that must have been attained at 50 Ma when the pluton was intruded (Loney et al., 1975).

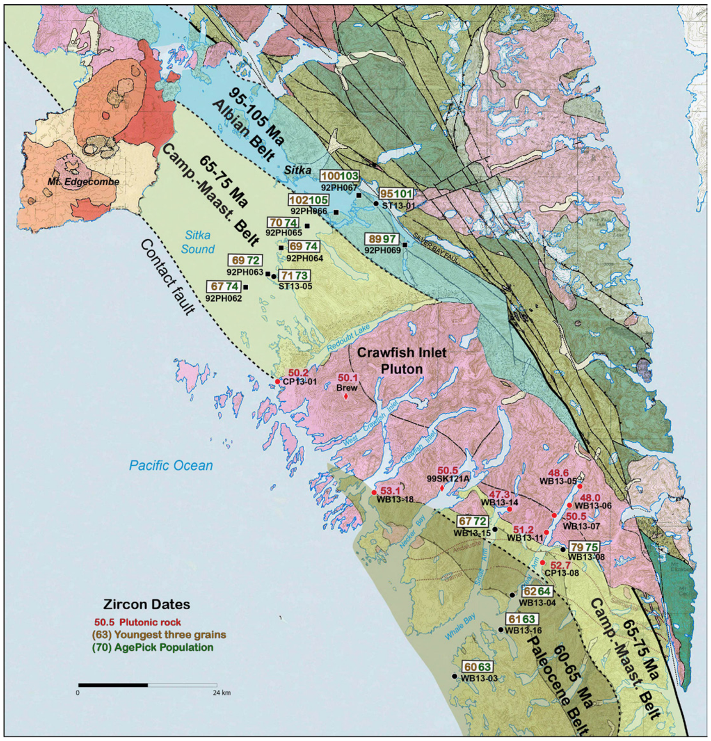

Figure 1. Geologic map and sample locations of Baranof Island in Southeast Alaska (modified from Karl et al., in review). Maximum depositional age (MDA) determined from detrital zircons is given in brown and green (see key), and U/Pb zircon crystallization ages are shown in red (Haeussler et al., 2006; Roig, this volume; this study). Three proposed packages of rocks on Baranof Island are also shown: the 60-65 Ma Paleocene belt (brown), the 65-75 Ma Campanian-Maastrichtian belt (green), and the 95-105 Ma Albian belt (blue). These three belts appear to correlate with the Whale Bay Belt of the Orca group, Valdez, and McHugh Formations (respectively) in Prince William Sound.

U/PB GEOCHRONOLOGY

Previous detrital zircon studies have been conducted along strike on the CPW, including the Shumagin Islands (Roe, 2013), Kodiak Island (Olivas, 2012), Kenai Peninsula (Amato and Pavlis, 2010) and Prince William Sound (Hilbert-Wolf, 2012), as well as the Yakutat microplate (Roberts, 2013), which can be used to compare units across the CPW. Prior U/Pb detrital ages for the Sitka Graywacke near Sitka were collected by Heaussler et al. (2006). Crawfish Inlet pluton crystallization ages are reported by Roig and Wackett (this volume).

METHODS

U/Pb detrital zircon ages were obtained from five samples collected along a SW-NE transect in Whale Bay (~52 km south of Sitka), and from two samples in the Sitka Sound (Fig. 1). Zircons were separated using standard rock pulverization, magnetic separation, and density separation techniques using heavy liquids. Approximately one hundred zircons from each sample were randomly selected and individually dated using LA-MC-ICPMS at the Arizona Laserchron Center (Gehrels et al., 2008); some samples have more than one hundred analyses because they were augmented by the targeting of Precambrian grains. Precambrian grains were selected based on roundness and a pink color with the assumption that round grains have experienced significant transport and perhaps recycling, and a pink to purple color reflects accumulated radiation damage (Garver and Kamp, 2002). Analysis of the collected U/Pb data was conducted using IsoPlot (Ludwig, 2003) and Age Pick, an Excel macro provided by the LaserChron Center at the University of Arizona.

The maximum depositional age (MDA) for a sample is calculated in two ways in this study. The MDA calculated using AgePick comes from the probability distribution function of the youngest coherent population of three or more zircons. For samples with a large population of young zircons, the total number of zircons contributing to the MDA can exceed 1/3 of the sample. An alternative method calculates the MDA from the weighted mean of the three youngest zircon grains in a sample. For most samples, the difference in MDA calculated by these two methods is 1-3 Ma.

RESULTS

All samples collected on Baranof Island contain some or all peaks in the Paleocene-Late Cretaceous, Jurassic or Triassic, and Devonian. Paleocene populations are found in WB13-03, -16, and -04 (farthest outboard samples; Fig. 1). These samples also have a significant Early Jurassic to Late Triassic peak and a Devonian population. Late Cretaceous peaks are found in WB13-15, WB-08, ST13-05, and ST13-01, with Middle to Late Jurassic populations. Devonian grains are not found in these samples. Paleozoic to Precambrian grain populations were detected in five of the seven samples. Precambrian grains (n = 93 for all of Baranof Island; WB13-03, -16, -04, -15, ST13-

05) had a noticeable 1800-2000 Ma population. The two oldest samples (WB13-08, ST13-01) yielded no Precambrian grains.

The three youngest zircons analyzed from WB13-08 (farthest inboard in Whale Bay; Fig. 1) yield a maximum depositional age (MDA) of 79 Ma. The MDA for WB13-15, -04, -16, and -03 (inboard to outboard) are 67, 62, 61, and 60 Ma respectively (Fig. 1). The three youngest zircons analyzed from ST13-01 yield an MDA of 100 Ma, and the three youngest grains from ST13-05 yield an MDA of 71 Ma.

DISCUSSION

The three main age populations in the U/Pb detrital zircon data vary slightly across all seven samples collected on southern Baranof Island. These peaks include the Paleocene-Late Cretaceous, Jurassic to Triassic, and the Devonian. The presence of these three major zircon populations supports previous studies that suggest these sediments are derived from an active Late Cretaceous to Paleocene arc situated on a metaplutonic Jurassic basement. The smaller yet significant contribution from an older Devonian arc in the younger and most outboard samples also suggests Devonian source rocks during the Paleocene.

Precambrian grains analyzed from Baranof Island (n = 93) have the highest concentration around 1800-2000 Ma. No Precambrian grains occur in the farthest inboard samples (ST13-01, WB13-08), even when samples were high-graded (picked). The presence of grains 1800-2000 Ma are consistent with the Paleoproterozoic and Archean modes found in correlative units along strike in the CPW. These populations suggest a Northern Laurentian signal (Fig. 2).

Maximum depositional ages analyzed in this study range from 97 Ma inboard (ST13-01) to 60 Ma outboard (WB13-03). From inboard to outboard,

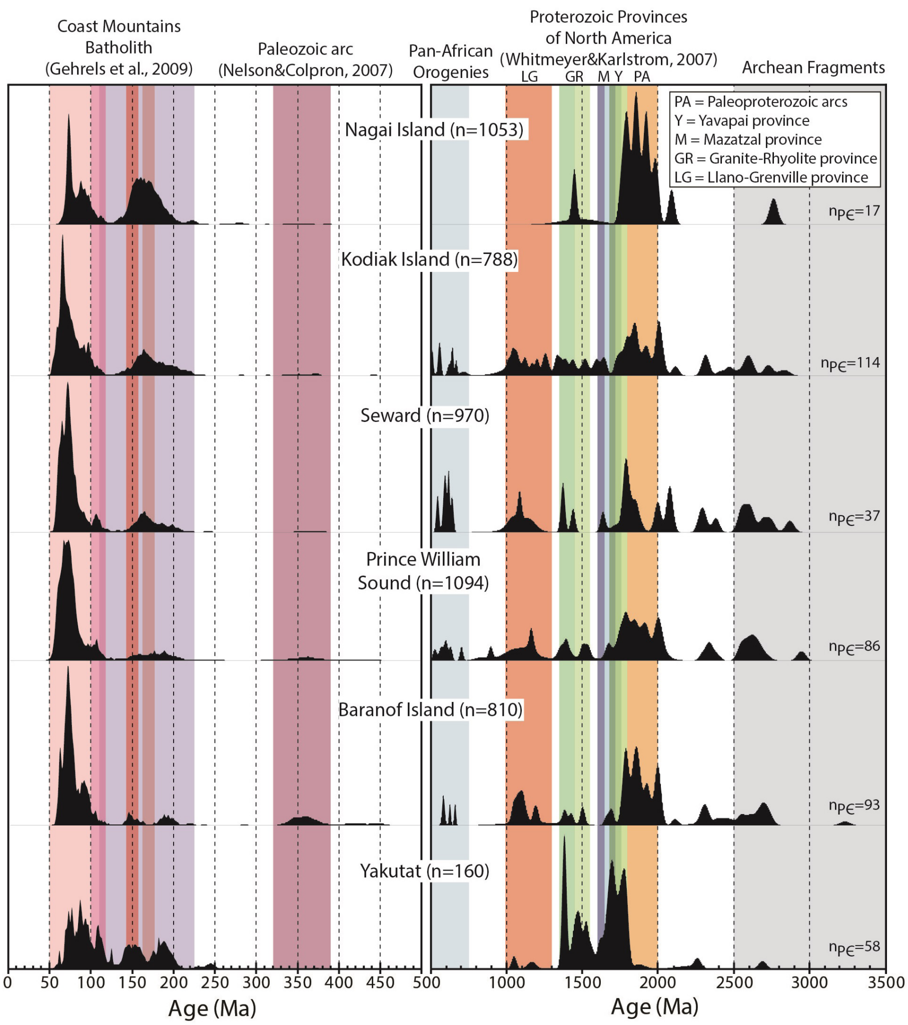

Figure 2. Comparison of detrital zircon U/Pb age normalized probability distributions from the flysch of the Chugach Prince William Terrane, Alaska. Note there is a scale change in the abscissa and ordinate for the Precambrian. Baranof Island includes data from Haeussler et al. (2006). The similarities between Nagai Island, Kodiak Island, Prince William Sound, and Baranof Island suggest similar provenance. The absence of Northern Laurentian Paleoproterozoic arc zircons, and dominance of Southern Laurentian Yavapai-Mazatzal and Granite-Rhyolite grains in the Yakutat sample supports the restoration of the Yakutat microplate to south of Baranof Island, and suggests that the entire Chugach-Prince William terrane was located closer to Southern Laurentia in the Late Cretaceous.

MDAs from the weighted mean of three youngest zircons are as follows: 95, 79, 72, 71, 62, 61, and 60 Ma (Fig. 1). U/Pb detrital zircon results from Haeussler et al. (2004) show a similar younging pattern in Sitka Sound, ranging from 100 Ma inboard (92PH067) to 67 Ma outboard (92PH062) (Fig. 1). Haeussler et al. (2003) recognize two belts in Sitka Sound, a western Campanian-Maastrichtian belt and an eastern Albian Belt, separated by a ~30 Ma gap (in MDA) and inferred thrust fault.

The distribution of maximum depositional ages from this study demonstrates that a third younger belt, likely Paleocene, occurs in Whale Bay. The three packages of rock young inboard to outboard: A) an inboard Albian belt deposited 105-95 Ma; B) an intermediate Campanian-Maastrichtian Belt deposited 75-65 Ma; C) an outboard Paleocene belt deposited 65-60 Ma (Fig. 1). While these belts are mainly determined by age, all samples in the Albian belt yielded no Precambrian zircons. WB13-08 is mapped in the Campanian-Maastrichtian belt, but the lack of Precambrian grains suggests it should be included in the Albian belt. The near continuous deposition from 100 Ma to 60 Ma reflects typical deposition within an accretionary complex.

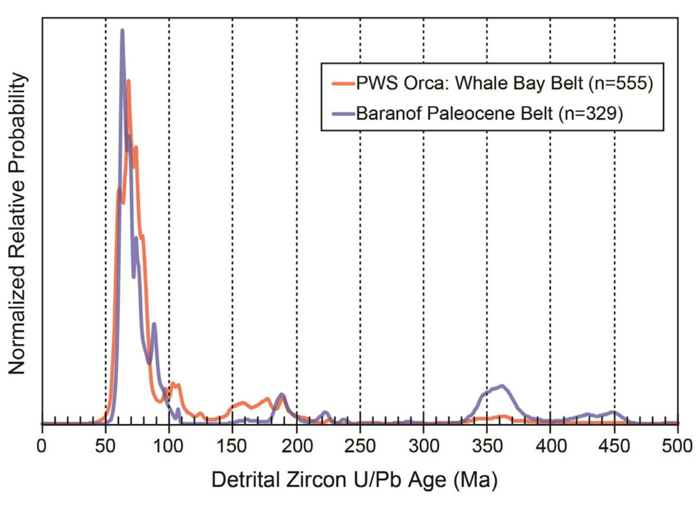

Figure 3. Comparison of detrital zircon U/Pb age normalized probability distributions for the 60-65 Ma Paleocene belt of the Sitka Graywacke and the Whale Bay Belt of the Orca Group in Prince William Sound (Hilbert-Wolf, 2011; this study).

The three belts on Baranof Island can be correlated to belts in Prince William Sound where the CPW is well studied. Figure 3 shows correlation in zircon distribution between the Whale Bay belt of the Orca Group (69-60 Ma; Hilbert-Wolf, 2012) and the Baranof Paleocene belt (65-60 Ma; this study). While further research is needed, U/Pb detrital zircons suggest the following correlations: McHugh Group (91-84 Ma; Amato and Palvis, 2010) to the Albian Belt (95-105 Ma; this study) and the Valdez Group (82-69 Ma; Kochelek, 2011 and Bradley, 2009) to the Campanian-Maastrichtian Belt (65-75 Ma; this study). Hauessler et al. (2003) also recognize correlation between the Albian belt and the McHugh Complex, as well as the Campanian-Maastrichtian belt and the Valdez Group.

The U/Pb data presented in this study supports the correlation of along-strike units of the CPW. As shown in Figure 2, composite detrital zircon signals for the Shumigan Islands, Kodiak Island, Prince William Sound, and Baranof Island closely resemble one another, implying a similar source terrane. All areas excluding the Yakutat Microplate contain Phanerozoic peaks in the Paleocene-Late Cretaceous and Jurassic, with a significant Precambrian signal 1800-2000 Ma, suggesting a Northern Laurentian signature. The Yakutat Microplate has a Precambrian signal that matches with a Southern Laurentian signature, supporting the restoration of the Yakutat Microplate south of Baranof Island.

CONCLUSIONS

New U/Pb data from detrital zircons from southern Baranof Island contribute to the overall understanding of the correlations across the Chugach-Prince William terrane and its depositional history. This study has three main findings: 1) The Sitka Graywacke and metamorphic equivalent are packaged into three groups younging inboard to outboard: A) an inboard Albian belt deposited 95-105 Ma; B) an intermediate Campanian-Maastrichtian Belt deposited 65-75 Ma; C) an outboard Paleocene belt deposited 60-65 Ma. 2) The youngest and most outboard Paleocene belt (60-65 Ma) on Baranof Island correlates to the Whale Bay belt of the Orca Group in Prince William Sound. 3) Precambrian grains suggest a Northern Laurentian signal for the CPW extending to Baranof Island, supporting the restoration of the Yakutat Microplate, with a Southern Laurentian signal, south of Baranof Island.

ACKNOWLEDGMENTS

I would like to thank Dr. Cameron Davidson for all his support, patience, and insightful discussions throughout the duration of this project. The success of this project has also been greatly influenced by support from Dr. John Garver. I would like to recognize and thank our field team: Brian Frett, Adrian Wackett, Meghan Riehl, Kate Kamanski, and Claudia Roig. This research was made possible by grants from the Keck Geology Consortium and the National Science Foundation (EAR 1116536 to Cameron Davidson, EAR 1116554 to John Garver, and EAR-1062720 to Keck/Varga). Sample collection was permitted through the Tongass National Forest. This study is a part of the Keck Geology Consortium project: Tectonic evolution of the Chugach-Prince William terrane, south-central Alaska. U/Pb zircon analyses were conducted at the University of Arizona LaserChron center supported by National Science Foundation EAR-1032156; Mark Pecha and Intan Yokelson are thanked for their help with data reduction and quality control.

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