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DETRITAL ZIRCON U/PB AGES OF THE PALEOCENE ORCA GROUP AND UPPER CRETACEOUS VALDEZ GROUP, RESURRECTION BAY, ALASKA

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INTRODUCTION

Resurrection Bay and Prince William Sound are located within the outermost units of the Chugach-Prince William (CPW) terrane, a Late Cretaceous to Eocene accretionary complex that spans nearly ~2200 km along the southern coast of Alaska (Plafker et al., 1994; Bradley and Miller, 2006). The CPW primarily consists of the very thickly bedded Maastrichtian Valdez Formation, and outboard Paleocene to Eocene Orca Group, separated by the Contact fault (Fig. 1). Both units are composed of deep-water turbidites (flysch), volcanic rocks, and slices of ophiolitic complexes. Paleocene to Eocene ridge subduction led to the emplacement of the 57 Ma Resurrection Peninsula and similarly aged Knight Island Ophiolite within the Orca Group turbidites (Tysdal et al., 1977; Nelson, 1989). The stratigraphic relationship/emplacement of the Resurrection Ophiolite within the adjacent Orca and Valdez groups is debated. There are three different interpretations for the relationship of the ophiolite and surrounding rocks: 1) the ophiolite is associated with the Valdez Group, suggesting a Cretaceous age for the ophiolite (Tysdal et al. 1977, and Tysdal and Case 1979);
2) the clastic cover of the western (upper) contact ophiolite is comformably overlying flysch (Humpy Cove Formation) in depositional contact with the 57 Ma ophiolite (Kusky and Young (1999); and 3) the ophiolite is a tectonic sliver of younger rocks (57 Ma) that were tectonically emplaced into the older Valdez Gorup (Bradley and Miller, 2006). Recent work shows that the maximum depositional age of the flysch interbedded with volcanic rocks at the stratigraphic top of the Resurrection Ophiolite is indeed Paleocene (Pettiette, 2013), but suggests that these rocks do not warrant the distinction of a new formation name and instead correlates the flysch that crops out along the eastern shore of Resurrection Bay to the Orca Group in Prince William Sound. Paleocene-Eocene ridge-trench interactions also led to the intrusion of the

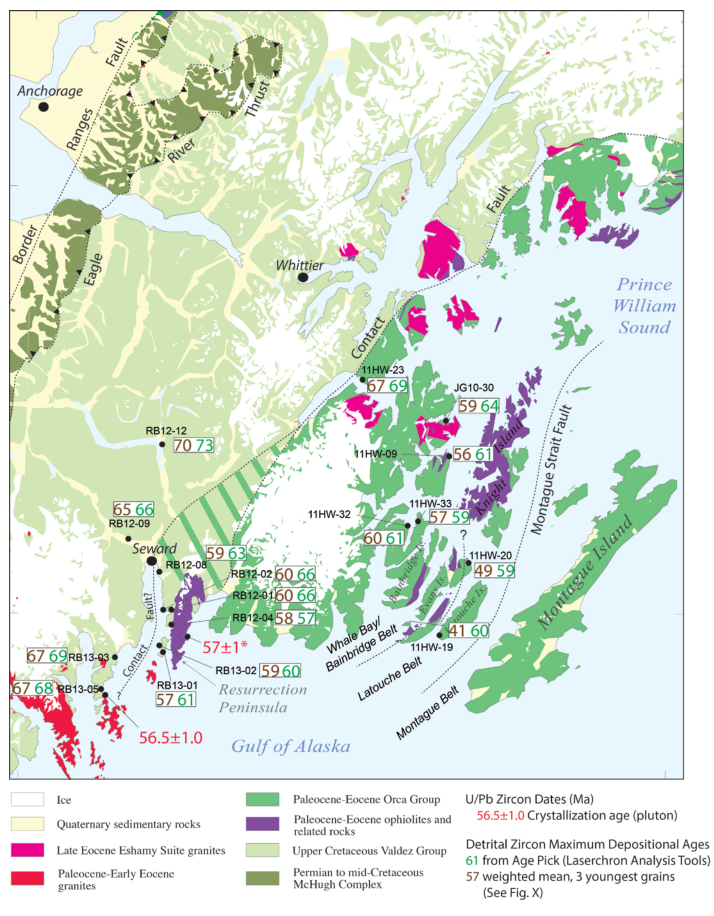


*Figure 1. Geologic map and sample locations from the Chugach-Prince William Terrane in western Prince William Sound, Alaska. Modified from Bradley (2006) and Kveton (1989). U/Pb zircon crystallization ages of plutons shown in red, and maximum depositional ages from detrital zircon samples also shown (see key). *from Bradley and Miller, 2006.*

Sanak-Baranof belt (SBB) of near-trench plutons with crystallization ages that young from west to east (61-47 Ma) from Sanak Island to Baranof Island (Nelson et al., 1989; Kusky and Young, 1999).

In this contribution, I use U/Pb dating of detrital zircon to show that the ophiolite and adjacent clastic strata along the eastern shore of Resurrection Bay and all of Fox Island are in fact part of the Paleocene Orca Group, and that these rocks appear to correlate with the Whale Bay Belt in Prince William Sound. The clastic rocks on the Aialik Peninsula, along the western shore of Resurrection Bay, have Maastrichtian maximum depositional ages that characteristic of the Valdez Formation. These correlations suggest that the Contact fault is coincident with Resurrection Bay, and probably comes onshore near Seward. In addition, a new 56.5 ± 1.0 Ma U/Pb zircon crystallization age for the Aialik Pluton indicates that intrusion was nearly contemporaneous with the formation of the 57 Ma Resurrection Ophiolite.

GEOLOGIC SETTING

The Cretaceous Valdez Group and Paleocene Orca Group are the two most outboard units of the CPW. These units are similar in lithology as both are composed of predominately thin- to thick-bedded turbidites consisting of sandstone, siltstone, mudstone, and slices of oceanic volcanic rocks (Plafker et al., 1994). Both the Orca Group and Valdez Group have been subjected to folding, deformation, and intrusion of plutons that resulted in metamorphic grade mainly from prehnite-pumpellyite to upper-greenschist facies, with local development of amphibolite (Dumoulin, 1989). Emplaced within the Orca Group, during the Tertiary, are the petrographically and chemically similar Resurrection and Knight Island Ophiolites (Kusky and Young, 1999; Lytwyn et al., 1997). Both ophiolites are composed of ultramafic rock, gabbro, sheeted dikes, and pillow basalts. Paleocene to Eocene granitoid plutons of the Sanak-Baranof Belt intrude the outermost units of the CPW and range in composition from biotite hornblende tonalite to muscovite leucogranite; some plutons contain xenocrysts of cordierite, sillimanite, and/or kyanite (Ferris, 2010; Short, 2013; Wackett et al., 2014). At the southernmost part of the Aialik Peninsula (in Resurrection Bay), the Aialik Pluton is mapped as intruding the Valdez Group. This pluton is a medium- to coarse-grained granodiorite that has a 56.5±1.0 Ma date of crystallization (Fig. 2). This new age of crystallization is very similar to the 57 Ma age of the Resurrection Ophiolite, and indicates

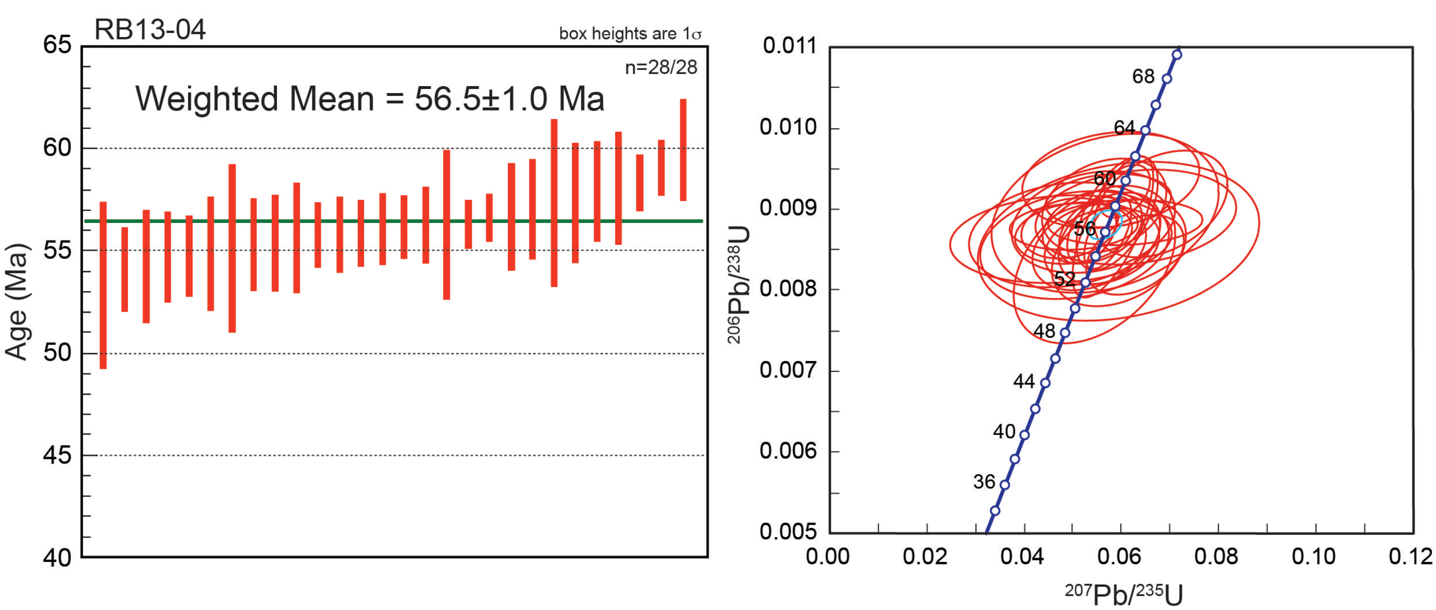


Figure 2. U/Pb zircon weighted mean and concordia diagram from the Aialik Pluton, Resurrection Bay, Alaska. Weighted mean and concordia diagrams calculated using Isoplot (Ludwig, 2003). We interpret the weighted mean age as the crystallization age of the pluton.

contemporaneous intrusion of the pluton during the formation of the Resurrection Ophiolite.

METHODS

For this study we determined 459 new U/Pb dates on detrital zircon from a total of five samples collected from the flysch of the CPW on either side of Ressurection Bay, and from near Exit Glacier (Fig.1). Three samples (RB13-03, RB13-04 and RB13-05) came from the Valdez Formation; RB13-05 was collected from the Aialik Pluton. Two samples (RB13-01 and RB13-02) were collected from the western part of Fox Island. Isolation of zircon crystals was executed by standard zircon separation techniques. In this study, ~100 zircons from each sample were randomly selected and dated to distinguish major age components and prominent grain-age populations. In addition 16 targeted Precambrian zircons were handpicked and individually dated. U/Pb dates were collected using LA-MC-ICPMS at the Arizona LaserChron Center (Gehrels et al., 2008). Two different methods were used for calculating maximum depositional ages (MDA): 1) Age pick: age of the youngest coherent peak with at least three grains, and 2) weighted mean of the youngest 3 and 10 grains. A Kolmogorov-Smirnoff (K-S) test was conducted on the samples to determine if there is a statistically significant difference between the zircon age distributions. For this, if the P-value is greater than 0.05 than there is a certain confidence level that the distributions are the same.

RESULTS

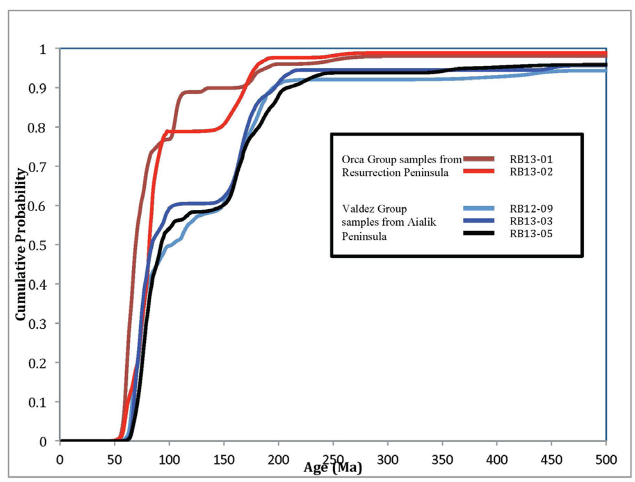
Samples from Resurrection Bay dated in this study (RB12-09, RB13-01, 02, 03, and 05) yielded maximum depositional ages ranging from 57-67 Ma. The youngest population of grains from the Aialik Peninsula samples (RB13-03 and RB13-05) yield peak ages of 68 and 69 Ma, respectively, with other prominent peaks in the Early Cretaceous, and a larger peak in the Jurassic-Triassic. The weighted average of the three youngest grains of each sample yielded an MDA of 67 Ma. The youngest population of grains from the two samples from Fox Island (RB13-01 and RB13-02) yield peak ages of 60 and 61 Ma, with other prominent peaks in both the Late Cretaceous and Jurassic. The weighted mean of the three youngest grains of these samples give MDAs of 57 and 59 Ma, respectively. Sample RB12-09, collected north of Seward near Exit glacier, and has a youngest population of grains at 66 Ma, with other prominent peaks in the Early Cretaceous and Jurassic-Triassic. The weighted average of the three youngest grains yielded a MDA of 65 Ma.

DISCUSSION

Maximum Depositional Age

The Maastrichtian MDAs of the strata from the Aialik Peninsula are consistent with both the current mapping of the CPW, and to ages previously determined in the outboard Valdez by Pettiette (2012) at Resurrection Bay, Hilbert-Wolf (2013) at Prince-William Sound and by Kochelek et al. (2011) ~50 km south of Anchorage; with a range of 65-70 Ma. RB12-09 has an MDA that is younger than the other Valdez samples, however, a Kolmogorov-Smirnoff (K-S) test and Cumulative Probability Plot (CDF) indicate that this sample correlates to the Valdez Group with 95% confidence

A.



B.

K-S P-values using error in the CDF

	RB13-02	RB13-01	RB12-09	RB13-03	RB13-05
RB13-02		0.000	0.002	**0.058**	0.008
RB13-01	0.000		0.000	0.000	0.000
RB12-09	0.002	0.000		**0.810**	**0.803**
RB13-03	**0.058**	0.000	**0.810**		**0.605**
RB13-05	0.008	0.000	**0.803**	**0.605**	

Figure 3. A) Cumulative frequency plot comparing samples from the Resurrection Peninsula (Orca flysch) and Aialik Peninsula (Valdez Formation); includes samples from Pettiette (2013). B) Kolmogorov-Smirnoff (K-S) results of the same samples shown in (A). Highlighted boxes within the matrix indicate a P-value > 0.05.

(Fig. 3). Based on MDAs, sample 11-HW-23 (67 Ma) from Prince William Sound must be included within the Valdez Group, which facilitates revision of the Contact fault at this location.

The samples collected from Fox Island have nearly identical MDAs to samples (RB12-01, 02, 04, and 08) previously evaluated at Resurrection Bay by Pettiette (2012); including a sample interbedded with pillow basalt of the 57 Ma Resurrection Ophiolite. This further confirms the stratigraphic continuity of the Resurrection Ophiolite and overlying fysch at the Resurrection Peninsula. The Paleocene (57-60 Ma) ages from this flysch in Resurrection Bay are significantly different than the Cretaceous (66-71 Ma) samples collected on the Aialik Peninsula and Exit Glacier, thus verifying the Resurrection Ophiolite, and clastic strata, as definitively part of the Orca Group, and ultimately settling the controversy surrounding the age of the strata associated with the ophiolite.

Extension of Contact Fault

The detrital zircon ages from flysch of eastern Resurrection Bay are identical to the similarly aged Orca Group rocks in Prince William Sound (Hilbert-Wolf, 2010). Figure 4 is a normalized probability plot of the Orca at Resurrection Bay (RB12-01, 02, 04, 08, RB13-01, and 02) and the Orca from the Whale Bay Belt of Prince William Sound (JG10-30, 11HW-09,

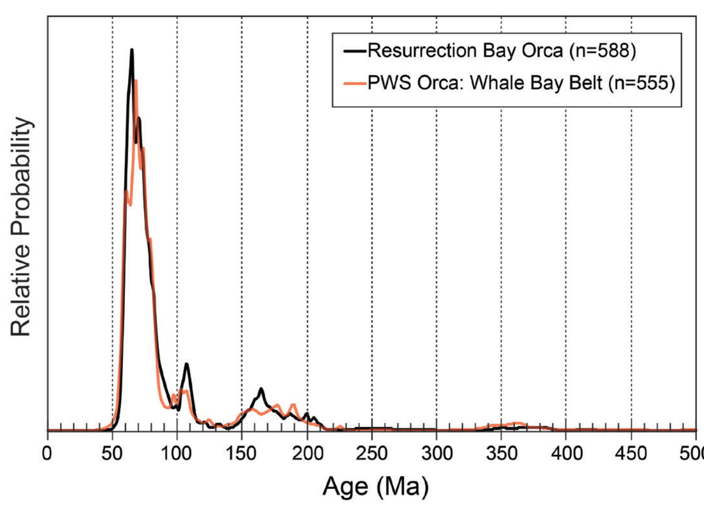


Figure 4. Comparison of detrital zircon U/Pb age normalized probability distributions for the 60-65 Ma Whale Bay Belt of the Orca Group in Prince William Sound (from Hilbert-Wolf, 2011), and the Paleocene samples of the Orca Group in Resurrection Bay (Pettiette, 2013; this study).

23, 32, and 33). Both locations have major age peaks representing an active Cretaceous arc and a major, yet less prominent, peak in the Jurassic representing the Jurasic-Triassic meta-plutonic basement. The similar MDAs suggest inclusion of Resurrection Bay within the Whale Bay Belt, and the subsequent extension of the Contact fault that separates the Valdez from the Orca in Prince-William Sound to come ashore near Seward. Sample RB12-08 was collected north of the proposed ophiolite-Valdez thrust fault; however, its 59 Ma Paleocene age (MDA) indicates that these rocks too are part of the Orca Group. The age of RB12-08 is significantly different than RB12-09 collected north of Seward, indicating the presence of a terrane boundary (Contact fault) that runs between the two collection sites; possibly through Seward.

Kusky (2004) proposed that the upper bounding, strongly foliated Fox Island shear zone resulted in the emplacement of the Resurrection Ophiolite, marking the contact between the Valdez and Orca. These new detrital zircon data would indicate that this interpretation is incorrect. His interpretation suggests that the rocks to the west of the shear zone are Cretaceous in age. However, RB13-02 was collected within strongly foliated turbidites west of the fault, and had Paleocene MDA of 59 Ma. Thus this result combined with the strong foliation shows that the Island is apart of a shear zone internal to the Paleocene package: the Contact fault needs to be mapped closer to the Cretaceous Aialik Peninsula (see “Contact fault” Fig.1).

Resurrection Ophiolite and Aialik Pluton

The U/Pb date from the Aialik Pluton of 56.5±1.0 Ma shows that it was intruded into the Valdez Formation and crystallized contemporaneously with the formation of the 57 Ma Resurrection Ophiolite. This finding suggests that: 1) ophiolite formation, imbrication, and pluton intrusion occurred in less than 1 Myr; or 2) ophiolite formation and pluton intrusion occurred at different margins of the crust and were since juxtaposed along unidentified structures. The new location of the Contact fault combined with the intrusion of the Aialik Pluton within the Cretaceous Valdez, indicates that the second option is possible. This means that at Resurrection Bay the interaction with a subducting spreading ridge led to the contemporaneous emplacement of the ophiolite and intrusion of the Aialik Pluton.

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