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

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CARLY ROE, Lawrence University
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CARLY ROE, Lawrence University
Research Advisor: Marcia Bjornerud

INTRODUCTION

The Chugach-Prince William (CPW) terrane is an Upper Cretaceous to Eocene accretionary complex exposed for ~2200 km in southern Alaska, extending from Baranof Island in the east to Sanak Island in the west. One of the thickest subduction-related accretionary complexes in the world, the CPW terrane is composed of deep-water flysch and associated volcanic rocks and is intruded by near-trench plutons of the 62-50 Ma Sanak-Baranof belt. The location of the accretion of the CPW is a matter of debate. There are two prevailing hypotheses for the location of the CPW at the time of its intrusion by the Sanak-Baranof belt: either the CPW was formed in situ as the result of accretion related to the subduction of the now subducted Resurrection Plate (Hauessler et al., 2003); or the CPW formed further to the south and has since been translated northward, parallel to the coast (Cowan, 2003). These scenarios would result in distinctly different source regions for the sediment of the CPW flysch, therefore, an understanding of the provenance of the different units in the CPW can help to constrain the location of the CPW at the time of its accretion.

The Upper Cretaceous Shumagin Formation is found on Sanak and Shumagin Islands in the westernmost part of the CPW terrane. This study focused on determining the maximum depositional age and provenance of the Shumagin Formation based on mineralogy, detrital zircon U/Pb ages, and U/Pb dating of an interbedded tuff. U-Pb zircon data indicate that the maximum depositional age of the Sumagin Formation on Nagai Island is 73-77 Ma, and is consistent with the 73.7±1.2 Ma U/Pb date from an interbedded tuff.

Previous detrital zircon work of rocks in the area includes studies of the unit that lies directly inboard of the Shumagin Formation, the Kuskokwim Group—an Upper Cretaceous turbidite sequence (Miller et al., 2007)—as well as studies of correlative units in the CPW that occur along strike of the Shumagin Formation: the Orca Group of Prince William Sound (Hilbert-Wolf, 2012) and the Kodiak and Ghost Rocks Formations of Kodiak Island (Olivas, 2012).

GEOLOGIC SETTING

The Shumagin Formation

The Shumagin Formation has an estimated thickness of 3-4 km (Moore, 1975) and consists primarily of marine flysch intruded by granitic plutons. The flysch is composed of deformed, thin- to thick-bedded turbidites comprised of quartzofeldspathic to volcanic-lithic sandstone, siltstone, and mudstone. The turbidites represent deposition on a deep-marine submarine fan adjacent to an active volcanic arc. Individual turbidites are medium- to very thick-bedded with full Bouma sequences and contain sole marks, usually flutes and grooves. Paleocurrents are mainly to the southwest but flutes and grooves record transport to the SE in some beds. The presence of the age-diagnostic fossil Inoceramus kuroensis in several locations on Nagai Island constrains the age of the Shumagin Formation to Maastrichtian.

Deposition was followed by deformation, burial in the subduction wedge, and intrusion by the Sanak-

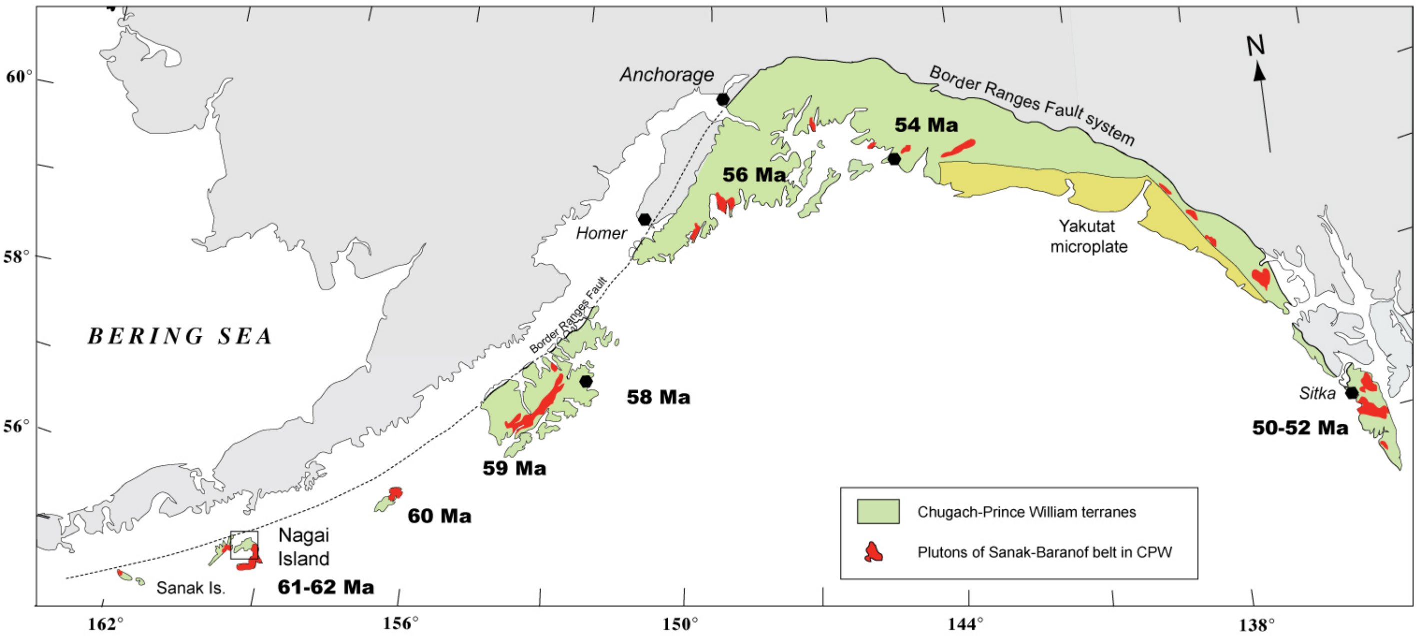


Figure 1. Location of Nagai Island and the Chugach-Prince William Terrane in southern Alaska. B) Geologic map of Nagai Island showing sample locations (modified from Moore, 1974).

Baranof Belt of plutons ~62 Ma which are interpreted as evidence of near trench plutonism related to the slab window of an adjacent TRT triple junction (Short, this volume).

Thin sections of samples from the full stratigraphic thickness of the Shumagin Formation were analyzed for sedimentary textures. Most grains consist of feldspar, quartz (both mono- and polycrystalline), and lithic fragments. Biotite, muscovite, chlorite and pyroxene are also present. Although most of the sheet silicates are detrital since these rocks are prehnite-pumpellyite grade, samples located close to the plutons contain metamorphic biotite. Samples range from poorly to well sorted; grain sizes typically range from about 0.025mm to 0.675 mm, but many samples contain lithic fragments as large as 1-3 mm in diameter. Grains are angular in most samples, indicating a nearby sediment source and relatively little physical abrasion. The feldspars range from quite fresh to heavily sericitized, but the alteration is clearly post-depostional.

As shown in Table 1, samples from the lower part of the formation, exposed on the northwest side of Nagai Island, contain less opaques (likely magnetite) and lithic fragments relative to quartz and feldspar and are generally better sorted than samples higher in the stratigraphic sequence in the southeast (Table 1). These former samples also yielded more detrital zircon grains. Samples from the southeast contain a wider range of grain sizes, tend to be less altered, and display greater mineral diversity than samples from the northwest.

Sample	Opaques (%)	Lithics (%)	Sorting
NI12-11	5	10	10
NI12-19	2	5	9
NI12-07	1	7	7
NI12-18	2	7	7
NI12-13	1	10	6
NI12-20	5	5	8
NI12-24	5	5	6
NI12-23	7	3	8
NI12-08	3	10	2
NI12-22	3	7	8
NI12-17	5	10	7
NI12-12	5	13	4
NI12-21	13	10	7
NI12-06	7	5	9
NI12-15	10	25	2
NI12-14	2	25	3

Table 1. Relative content of opaques and lithic fragments and a measure of sorting of a selection of samples from the Shumagin Formation. Values for the degree of sorting are assigned on a scale from 1-10, with 1 indicating a poorly sorted sample and 10 a well-sorted sample. Samples are arranged by location from furthest northwest at the top to furthest southeast at the bottom.

U-PB GEOCHRONOLOGY

U/Pb detrital zircon ages were obtained from 10 samples collected along a transect roughly perpendicular to strike on Nagai Island (Fig. 2). Zircons were separated using standard rock pulverization and density separation techniques using heavy liquids. 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). Analysis of the collected U-Pb data was conducted using the Microsoft Excel program Age Pick provided by the LaserChron Center at the University of Arizona.

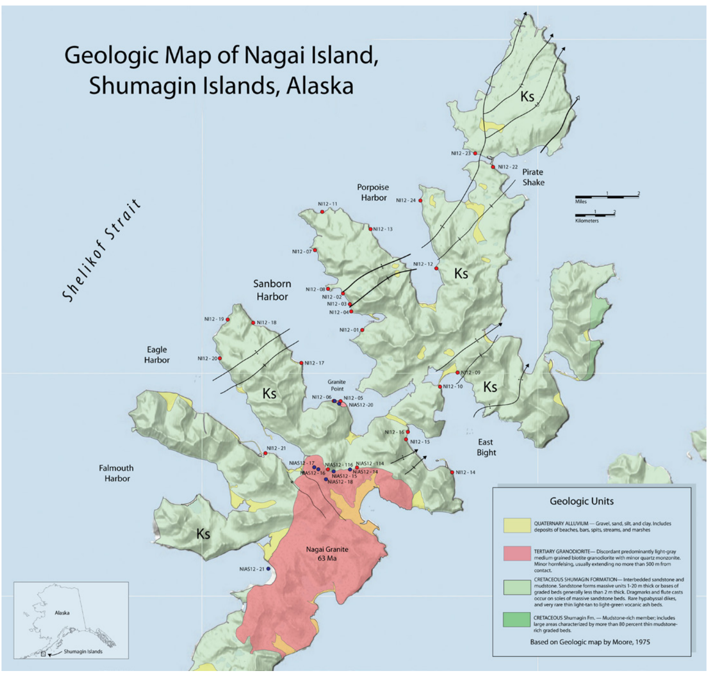


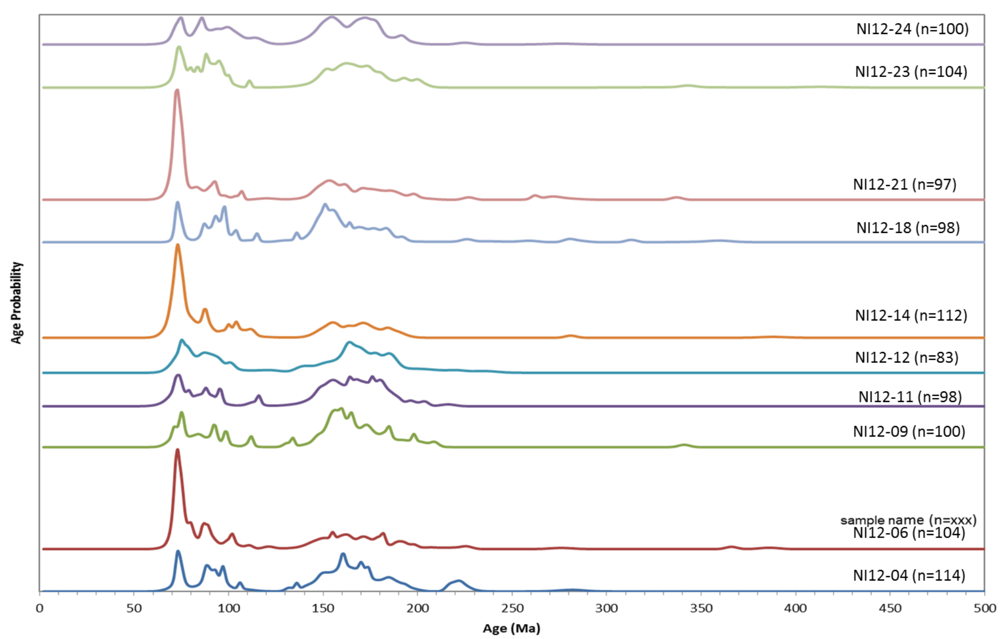
Figure 2. Geologic Map of Nagai Island showing sample location (modified from Moore, 1974).

Additionally, Paleozoic and Precambrian zircon grains were preferentially selected for dating by targeting grains with characteristics of older zircon grains, specifically roundness and a pink color. Non-euhedral grains are thought to have undergone significant transport and recycling, and a pink to purple color reflects metamictization from radiation damage. These older zircons potentially have distinctive age signatures indicative of their provenance.

RESULTS

All samples yielded maximum depositional ages that are tightly clustered in the Upper Cretaceous. The youngest zircons from each sample yield ages ranging from 70.2-72.8 Ma and the maximum depositional ages for each sample range from 73-77 Ma. Also, a U-Pb zircon date of 73.7 ± 1.2 Ma was determined for an interbedded tuff (NI12-02) in the middle part of the section which further constrains the age of the Shumagin Formation to Upper Cretaceous and indicates that the maximum depositional ages calculated by AgePick (Laserchron in house Excel program) are close to the depositional ages of these rocks.

Figure 3. U/Pb detrital zircon age probability curves for ten sandstones from the Shumigan Formation, Nagai Island, Alaska. All samples exhibit main age populations at 71-78 Ma, 85-100 Ma, and 146-186 Ma.



Normalized age probability curves of the detrital zircon ages yield three main age populations in the Phanerozoic: 71-78 Ma, 85-100 Ma, and 146-186 Ma (Fig. 3). The ten Shumagin Formation samples (n=1053) yielded only 17 Precambrian grains, ranging in age from 1445-2760 Ma, and of those 17, 13 fell within the 1750-2000 Ma range.

DISCUSSION

The maximum depositional ages of all the samples from Nagai Island are tightly clustered between 73 and 77 Ma, and a 73.4 ± 1.2 Ma interbedded tuff confirms the Upper Cretaceous age of these rocks. The fact that the age of this tuff is so close to the youngest detrital zircon ages indicates that the Shumagin Formation represents the deposition of a massive volume of sediment in a volcanically active area in a relatively short period of time. This is also supported by textural evidence from thin sections of the samples. Mineral grains are very angular and any alteration was most certainly post-depositional which indicates the sediment was immature and close to its source. Based on the changing abundance of lithic fragments, magnetite and zircon, the volcanic contribution to the sediment supply appears to increase up-section.

There are three main age populations in the detrital zircon U-Pb data consistent across all ten samples. The youngest population from 71-78 Ma was likely coming from an active volcanic arc. The 85-100 Ma population is from a slightly older volcanic arc and the 146-186 Ma population represents a Mesozoic arc basement terrane.

The Kuskokwim Group is found directly inboard from the Shumagin Formation and has the same to slightly older depositional age as the Shumagin Formation. Therefore, it would likely have captured zircons from the same source area as the Shumagin Formation if the CPW was adjacent to this part of Alaska in the late Cretaceous. However, the age distributions of detrital zircons from Kuskokwim Group have peaks at ~93 Ma, ~185 Ma, ~350Ma, and ~525 Ma (Miller et al., 2007) and are distinctly different from those of the Shumagin Formation. It is clear that the Kuskokwim Group and the Shumagin Formation did not share the same source. The primary modes are different, and the Kuskokwim has a large fraction of Paleozoic grains with modes at 350 and 525 Ma, which are not present in the Shumagin Formation.

The detrital zircon data from the Shumagin Formation were also compared with those from correlative rock units along strike: the Kodiak and Ghost Rocks Formations from Kodiak Island (Olivas, 2012), the Orca Group from Prince William Sound (Hilbert-Wolf, 2012), and one sample from the Yakutat Group. As shown in Figure 4, the detrital zircon age populations of the Shumagin Formation closely resemble those of the other units, with the possible exception of the Yakutat Group. This implies that the four units share similar source terranes although fewer Precambrian grains (17 out of 1053) were recovered from the Shumagin Formation than from those correlative units (Roberts, this volume). The 17 Precambrian ages are consistent, however, with the Paleoproterozoic and Archean modes found in all of the correlative units farther east. The paucity of Precambrian grains in the Shumagin Formation may reflect along-strike variations in the meta-plutonic basement of the late Cretaceous arc source region.

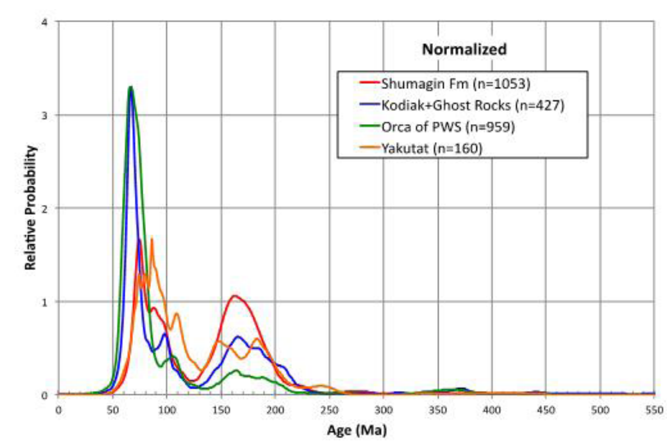


Figure 4. Comparison of the U/Pb detrital zircon age populations of the Shumagin Formation (Nagai Island), the Kodiak and Ghost Rocks Formations (Kodiak Island), older part of the Orca Group (Prince William Sound), and the Yakutat Group

CONCLUSIONS

Detrital zircon data from Nagai Island in the Shumagin archipelago confirm that the Shumagin Formation is Upper Cretaceous. Detrital zircon U-Pb analysis of ten samples of volcanic-lithic and arkosic sandstone from Nagai Island yield tightly clustered maximum depositional ages ranging from 73-77 Ma. The U-Pb zircon age of an interbedded tuff yields an age of 73.7 ± 1.2 Ma, further confirming the Upper Cretaceous age of the Shumagin Formation and suggests that the ages of the youngest detrital zircons in most of the samples are close to the depositional age of these rocks. Petrographic evidence—angular mineral grains and abundant feldspar and lithic fragments—indicates short-distance transport and immature sediment. The Shumagin Formation therefore represents the rapid deposition of a massive amount of sediment over a relatively short period of time. The volcanic contribution to the sediment supply also appears to increase up-section based on the increasing abundance of lithic fragment and magnetite.

Collectively, samples from the Shumagin Formation have three main populations of zircon ages, with modes at 74, 89, and 161 Ma. Variations between samples lie mainly in the relative number of grains making up these populations. Only 17 out of 1053 grains analyzed are Precambrian. These range from 1445 – 2760 Ma, with all but four falling between 1750 and 2000 Ma.

A comparison of detrital zircon populations between the directly inboard Kuskokwim Group and Shumagin Formation indicates that they did not share the same source terrane. Neither Mesozoic nor Paleozoic zircon age modes from the Kuskokwim Group match well with those in the Shumagin Formation. The Shumagin Formation zircon populations do however coincide closely with those of correlative rock units found along strike in Prince William Sound, Kodiak Island, and Yakutat, indicating that they shared a common source with the Shumagin Formation. This source region likely consisted of an active late Cretaceous arc built on a mostly Mesozoic age meta-plutonic basement. The Precambrian ages in the Shumagin Formation are consistent with the Paleoproterozoic and Archean modes found in these correlative units. The paucity of Precambrian grains in the Shumagin Formation may indicate along strike variations in the meta-plutonic basement of the late Cretaceous arc source region.

Based on its U-Pb age spectra and its resemblance to correlative units along strike, we conclude that detrital zircon from the Shumagin Formation were partially derived from exhumed rocks of the Coast Mountains Batholith. Hf isotope data also point to the Coast Mountains Batholith as a possible source (Roberts, this volume).

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