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Key Points:

- Forearc basin strata chronicle Talkeetna oceanic arc growth, collision, accretion to continental margin, and continental arc development
- Forearc basin unconformities plus hiatus in volcanic arc activity constrain the timing of Talkeetna arc accretion between circa 140 and 120 Ma
- Detrital zircon geochronology is a powerful tool to document collisional processes in forearc basins

Supporting Information:

- Supporting Information S1
- Data Set S1

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Detrital Zircon Record of a Mesozoic Collisional Forearc Basin in South Central Alaska: The Tectonic Transition From an Oceanic to Continental Arc

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Abstract The collision of oceanic arcs with continental margins is an important mechanism for the growth of continents. Ancient forearc basin strata in collisional orogens provide a record of the upper crustal response to this tectonic process. In south central Alaska, Mesozoic forearc basin strata are exposed in a complete crustal section. U-Pb detrital zircon geochronology from the forearc basin strata was analyzed within a ~107 Ma stratigraphic framework. The Jurassic strata contain unimodal detrital zircon populations that become progressively younger upsection and range from 175 to 151 Ma. These strata are derived from the active oceanic Talkeetna arc. The Cretaceous strata were deposited above multiple unconformities that collectively represent as much as ~30 Ma of nondeposition and/or erosion in the forearc basin. Erosion in the forearc basin and a general absence of detrital zircon ages between 140 and 120 Ma are interpreted as a hiatus of magmatism triggered by collision of the oceanic arc with the former continental margin. The Cretaceous strata have two main detrital zircon populations: a Cretaceous population ranging from 90 to 68 Ma that becomes progressively younger upsection and a Jurassic population with a broad range of peak ages from 194 to 144 Ma. The Cretaceous population marks the establishment of an active Cretaceous continental arc following the collisional event, and the older population reflects continued erosion of the remnant Jurassic oceanic arc plutons. Our results show that detrital zircon geochronology provides a powerful approach for delineating stages of forearc basin collision and the erosion of multiple magmatic arcs.

1. Introduction

The application of detrital zircon geochronology to sedimentary strata along the western margin of North America has resulted in a wealth of new insights on the tectonic development of this convergent margin (Brennan & Ridgway, 2015; Cassel et al., 2012; DeGraaff-Surpless et al., 2002; Dumitru et al., 2015, 2016; Gehrels et al., 1995; Gehrels & Pecha, 2014; Laskowski et al., 2013; Surpless et al., 2014; Yokelson et al., 2015, among others). Data from forearc basins are particularly insightful because these strata provide one of the most continuous and chronologically constrained records of the upper crustal response to subduction-related processes along convergent margins. The detrital zircon record of forearc basins, for example, has been shown to be a sensitive recorder of the adjacent magmatic arc and accretionary prism systems that characterize the upper plate of convergent margins (Hessler & Fildani, 2015; Jacobson et al., 2011; Surpless, 2015; Surpless et al., 2006, 2014; Wu et al., 2010).

In this study, we explore the provenance record of a Mesozoic forearc basin that formed as part of an oceanic arc and was subsequently accreted to the continental margin of western North America. We evaluate this record in terms of precollision, syncollision, and postcollision tectonic processes. We demonstrate that where oceanic forearc basins are preserved in ancient collisional orogens, their detrital zircon record can provide detailed information about the timing and stages of collisional processes. Our data show that the construction of the oceanic Talkeetna arc, the collision and accretion of this oceanic arc with the continental margin, and the establishment of new continental arc and forearc basin system are faithfully recorded in the Jurassic and Cretaceous forearc basin strata exposed in the Talkeetna Mountains and Matanuska Valley of south central Alaska.

The Jurassic igneous rocks of the Talkeetna arc represent one of the most complete, least deformed oceanic arc sections on Earth with exposures of the subarc mantle through subaerial volcanic rocks (Burns, 1985;

DeBari & Coleman, 1989). Similarly, the Jurassic-Cretaceous Chugach terrane is one of the largest exposed accretionary prisms on Earth (Plafker et al., 1994). Our analysis of the forearc basin strata integrates our findings with recent geochronologic and geochemical studies of both the Jurassic igneous rocks of the Talkeetna arc (Amato et al., 2007; Behn & Kelemen, 2006; Clift, Draut, et al., 2005; DeBari & Greene, 2011; Draut & Clift, 2006; Greene et al., 2006; Hacker et al., 2008, 2010; Mehl et al., 2003; Rioux et al., 2007, 2010) and the Mesozoic accretionary prism rocks of the Chugach terrane (Amato et al., 2013; Amato & Pavlis, 2010). The application of U-Pb detrital zircon geochronology to the Jurassic and Cretaceous forearc basin strata in the context of both the companion arc and accretionary prism rocks provides a powerful approach to chronicling arc erosion and collisional processes along this convergent margin. Understanding these processes is important because collision of oceanic arcs with continental margins is considered the dominant process of post-Archean continental growth (e.g., Brown, 2009; Clift et al., 2009; Draut & Clift, 2012, 2013; Hawkesworth & Kemp, 2006; Rudnick & Gao, 2003).

2. Geologic Setting

Jurassic igneous rocks representing the Talkeetna arc are exposed in a >1,000 km long belt in the upper plate of the southern Alaska convergent margin (Burns, 1985; DeBari & Coleman, 1989; Plafker et al., 1989). These rocks crop out over much of the Talkeetna Mountains and the Alaska Peninsula (Figure 1; Jpu and Jpl in Figure 2) (Rioux et al., 2007, 2010; Wilson et al., 2015). Middle and Upper Jurassic sedimentary strata (Js in Figure 2) were deposited chiefly in marine forearc basin environments associated with the Talkeetna arc (Caruthers & Smith, 2012; Imlay, 1981, 1984; LePain et al., 2013; Trop et al., 2005; Trop & Ridgway, 2007; Stanley et al., 2012; Wartes et al., 2012). Outboard of the arc and forearc basin rocks is an extensive belt of metasedimentary rocks of the Chugach terrane interpreted as accretionary prism deposits (Figures 1 and 2; Plafker et al., 1994).

The Talkeetna arc has been interpreted as an oceanic arc that formed above a north dipping subduction zone (present-day coordinates) (Clift, Draut, et al., 2005; DeBari & Sleep, 1991; Hacker et al., 2008). An oceanic arc interpretation is based on (1) isotopic data from middle/upper crustal intermediate and felsic plutons that show little or no involvement of continental crustal components (Amato et al., 2007; Rioux et al., 2007, 2010), (2) trace element data from volcanic strata diagnostic of ocean subduction petrogenesis (Clift, Draut, et al., 2005), and (3) marine depositional lithofacies associations from volcanoclastic strata, including debris aprons composed of turbidites and debris flow deposits (Draut & Clift, 2006). The interpretation of a north dipping subduction zone is based on (1) age-equivalent accretionary prism rocks exposed south of the Jurassic arc rocks (Amato et al., 2013; Plafker & Berg, 1994), (2) spatial isotopic trends in Jurassic volcanic strata of the arc (Clift, Draut, et al., 2005), and (3) northward younging of Jurassic plutons (Jpl versus Jpu in Figure 2) (Rioux et al., 2007). In contrast, Reed et al. (1983) infer a south dipping subduction zone during Early to Late Jurassic time based on whole-rock chemical differentiation trends in plutons exposed on the Alaska Peninsula.

Although positioned in an oceanic arc setting, several data sets indicate that the Talkeetna arc formed upon thickened crust with a protracted geologic history (i.e., analogous to the modern northern Aleutian arc on the Alaska Peninsula) as opposed to relatively thin, young oceanic crust (i.e., analogous to the modern Aleutian arc in the western Aleutian Islands or the Marianas arc). These data sets include zircon geochronology from Jurassic tuffs and pluton pendants that document minor Paleozoic and Precambrian inherited grains interpreted to indicate that the Jurassic arc developed upon or in proximity to continental crust (Amato et al., 2007; Pálffy et al., 1999; Rioux et al., 2007). In addition, a Quaternary volcano intruding the Jurassic arc rocks yields xenoliths with ~310 Ma and ~1865 Ma zircon crystallization ages, indicating that Paleozoic-Precambrian “basement” rocks may underlie the Jurassic arc (Bacon et al., 2012). Surface exposures of pre-Jurassic rocks underlying the Talkeetna arc are limited to sparse exposures of Paleozoic to early Mesozoic metamorphosed igneous and sedimentary rocks and Triassic limestone and greenstone, so little is known about the “basement” of the Jurassic arc. (Blodgett & Sralla, 2008; Labrado et al., 2015; Wilson et al., 2009).

Overlying and locally interfingering with the subaerial volcanic rocks of the Talkeetna arc are Lower to Upper Jurassic siliciclastic strata that accumulated in mainly marine depositional environments and consist of first-cycle volcanic-plutonic detritus (Js in Figure 2; Tuxedni, Chinitna, and Naknek Formations in Figure 3) (Egbert & Magoon, 1986; Helmold et al., 2013; Imlay, 1981; LePain et al., 2013; Trop et al., 2005; Winkler, 1992). These

Figure 1. (a) Generalized tectonic and geologic map of south central Alaska showing the present distribution of accreted terranes, Jurassic-Cretaceous magmatic arc plutons, forearc basin strata, and accretionary prism deposits. This study emphasizes Jurassic-Cretaceous forearc basin strata (MB) exposed chiefly outboard (south) of Jurassic accreted oceanic arc rocks (purple) and Cretaceous continental arc rocks (pink). Correlative forearc strata occur along strike in the subsurface of the Cook Inlet basin and in outcrops on the Alaska Peninsula (PB) and the Wrangell Mountains basin (WB). The Cretaceous magmatic arc formed within a continental margin setting composed of the allochthonous Wrangellia composite terrane (WCT) and the para-autochthonous Paleozoic-Mesozoic metamorphic rocks of the Yukon composite terrane (YCT). Abbreviations not explained on map: A#, Anchorage; AV, Augustine volcano; BF, Bruin Bay fault; BRF, Border Ranges fault; and CF, Castle Mountain fault. Modified from Plafker et al. (1994), Moll-Stalcup (1994), and Wilson et al. (1998). (b) Cross section showing generalized crustal structure and tectonic elements of the southern Alaska convergent margin. See Figure 1a for line of section. Note active northward subduction, arc magmatism, and forearc-basin subsidence inboard of the Aleutian trench, analogous to the inferred tectonic framework of the Matanuska Valley-Talkeetna Mountains region during Jurassic-Cretaceous time. Abbreviations not explained in the figure: MC, McHugh Complex, pre-Maastrichtian part of accretionary prism and S.L., sea level. Adapted from Hudson and Magoon (2002).

strata are interpreted as forearc and intra-arc basin deposits based on their position outboard (south) or among Jurassic arc igneous rocks and inboard (north) of coeval accretionary prism metasedimentary rocks (LePain et al., 2013; Plafker & Berg, 1994; Trop et al., 2005; Trop & Ridgway, 2007).

Figure 2. Geologic map of the Matanuska Valley, southern Talkeetna Mountains, and northern Chugach Mountains. See Figure 1a for map location. Blue areas (Js) represent Jurassic sedimentary strata interpreted as forearc basin deposits linked with coeval arc plutons and volcanic rocks of the accreted oceanic Talkeetna arc to the north (light purple). Green areas (Km) represent Cretaceous sedimentary strata interpreted as forearc basin deposits linked with coeval continental arc plutons and volcanic rocks to the north (pink). Solid black circles show locations of detrital zircon geochronology samples discussed in text. Geology is adapted from Wilson et al. (1998).

The Talkeetna arc makes up much of the allochthonous peninsular terrane, which is part of the Wrangellia composite terrane. The composite terrane consists of three terranes (peninsular, Wrangellia, and Alexander terranes) that crop out discontinuously from western Alaska to southern British Columbia (Nokleberg et al., 2001; Plafker & Berg, 1994). The peninsular terrane is thought to have amalgamated with the Alexander and Wrangellia terranes prior to accretion to western North America (Beranek et al., 2014; Plafker & Berg, 1994; Rioux et al., 2007). Two different tectonic interpretations have been proposed to account for Mesozoic accretion of the Wrangellia composite terrane against inboard (northern) terranes based on studies from south central Alaska: (1) Late Jurassic collision of the Talkeetna arc (peninsular terrane) against the southern margin of the combined Wrangellia-Alexander terrane, followed by Early Cretaceous juxtaposition against the former continental margin (Clift, Pavlis, et al., 2005; Rioux et al., 2007); and (2) Late Jurassic-Early Cretaceous juxtaposition of the combined Wrangellia, Alexander, and peninsular terranes against the former continental margin (Hampton et al., 2010; Plafker & Berg, 1994; Ridgway et al., 2002; Trop et al., 2002, 2005). In

Figure 3. Stratigraphy of detrital zircon geochronology samples (DZ) collected from forearc basin strata in the southern Talkeetna Mountains and Matanuska Valley area. Horizontal black lines indicate the maximum depositional age of sampled beds based on DZ samples relative to biostratigraphic constraints (vertical black bars). Abbreviations: CBF: Caribou strand of Castle Mountain fault system, CMF: Castle Mountain strand of the Castle Mountain fault system, Kml: lower Matanuska Formation, and WCT: Wrangellia composite terrane. Refer to Bergquist (1961), Grantz (1960a, 1960b, 1961, 1964), Winkler (1992), Trop (2008), and Trop et al. (2005) for stratigraphic details.

both of these interpretations, initial collision and exhumation of the Talkeetna arc are marked in south central Alaska by (1) >400 m thick sections of boulder conglomerate of the Upper Jurassic Naknek Formation that contain igneous clasts with 159–151 Ma U-Pb ages (Trop et al., 2005). These clast ages overlap with the biostratigraphic depositional ages of the Naknek Formation, suggesting syndepositional exhumation of the Talkeetna arc; (2) the cessation of magmatism of the Talkeetna arc between 160 and 150 Ma (Clift, Pavlis, et al., 2005; Rioux et al., 2007, 2010); and (3) Jurassic plutonic rocks with more evolved initial isotopic ratios and the presence of xenocrystic zircons in the western Talkeetna Mountains (Rioux et al., 2007). Late Cretaceous-Paleocene plutons and volcanic rocks intrude and overlap both the Wrangellia composite terrane and inboard terranes of the Yukon composite terrane (Yukon-Tanana and Stikine terranes) in south central Alaska, recording postcollisional continental arc magmatism (Figure 1a) (Cole & Chung, 2013; Moll-Stalcup, 1994; Plafker & Berg, 1994).

Coeval postcollisional magmatic rocks are also exposed along strike in the Coast Mountains batholith of southeastern Alaska and coastal British Columbia (Gehrels et al., 2009). All these plutons are interpreted to have formed along a north dipping (present coordinates for Alaska) and east dipping (present coordinates for British Columbia) Late Cretaceous-Paleocene subduction zone based on age-equivalent accretionary prism metasedimentary rocks exposed outboard of the Cretaceous arc rocks (Amato et al., 2013; Haeussler et al., 2006; Plafker & Berg, 1994; Sample & Reid, 2003). The continental arc interpretation is also based on calc-alkaline geochemical compositions from plutons and volcanic rocks that crosscut regionally deformed parts of the accreted Wrangellia composite terrane (Cole et al., 2007; Cole & Chung, 2013; Moll-Stalcup, 1994).

Depositionally overlying Jurassic Talkeetna arc rocks and related marine sedimentary strata are Cretaceous siliciclastic strata that accumulated in mainly marine depositional environments (Km in Figure 2) (Grantz, 1960a, 1960b, 1964; Jones & Grantz, 1967; Trop, 2008). Multiple unconformities record erosion or nondeposition during Cretaceous sediment accumulation (Figure 3). The strata include sparse outcrops of Hauterivian-Barremian strata (Nelchina Limestone and unnamed strata) north of the Castle Mountain fault and more widespread outcrops of Albian-Maastrichtian strata on both sides of the fault (Matanuska Formation in Figure 3). The Cretaceous strata are interpreted as forearc basin deposits based on their position outboard (south) of the Cretaceous-Paleocene calc-alkaline plutons and inboard (north) of coeval accretionary prism strata (LePain et al., 2013; Plafker & Berg, 1994; Trop, 2008).

Two strike-slip faults, the Border Ranges and Castle Mountain fault systems shown in Figure 1, offset Talkeetna arc igneous rocks and associated forearc basin strata in the study area. The Border Ranges fault juxtaposes older and structurally lower Talkeetna arc igneous rocks (Jpl in Figure 2) against accretionary prism rocks of the Mesozoic Chugach terrane (Mzm and Kv in Figure 2). Interpreted as a paleosubduction zone thrust, the Border Ranges fault accommodated northward underthrusting of oceanic crust beneath the Wrangellia composite terrane during Early Jurassic-Late Cretaceous time (e.g., Pavlis, 1982). Latest Cretaceous-Paleogene reactivation of the fault accommodated up to hundreds of kilometers of right-lateral displacement along the fault (e.g., Pavlis & Roeske, 2007; Roeske et al., 2003). To the north, the Castle Mountain fault is an active fault with historical seismicity (Haeussler et al., 2002) and several tens of kilometers of Cenozoic dextral offset (Clardy, 1974; Detterman et al., 1976; Fuchs, 1980; Grantz, 1960a, 1960b; Trop et al., 2003). Trop et al. (2005) and Hackett (1976) interpreted up to 130 km of post-Jurassic dextral displacement based on correlation of potential offset geologic features across the Castle Mountain fault.

3. Methodology

Eight medium-grained sandstone samples were collected from stratigraphically contiguous Mesozoic forearc basin strata located in the Talkeetna Mountains and Matanuska Valley. Five samples were collected north of the Castle Mountain fault from the Talkeetna Formation (072310-TS7), Tuxedni Formation (072310-TS5), Naknek Formation (NAK-BC, 072310-TS6), and lower Matanuska Formation (072909CMK1) (Figures 2, 3, and S1 in the supporting information). Three additional samples were collected south of the Castle Mountain fault from the lower Matanuska Formation (072210KR-01) and the upper Matanuska Formation (GW1-DZ1 and 104-DZ1) (Figure 2). Figures 4 and S2 show typical exposures of the Jurassic and Cretaceous strata from which we sampled. All samples represent just one bed in their respective formations.

Figure 4. Representative photographs of Jurassic strata (Figures 4a–4d) exposed in the southern Talkeetna Mountains and Cretaceous sedimentary strata (Figures 4e–4g) exposed in the southern Talkeetna Mountains and Matanuska Valley. (a) Sedimentary strata of the Tuxedni, Chinitina?, and Naknek Formations overlying uppermost Talkeetna Formation volcanic rocks at Little Oshetna River. Figures 4b–4e are from this section. (b) Tuxedni Formation fluvial sandstone and conglomerate overlain by carbonaceous mudstone. Outcrop is ~18 m high. (c) Chinitina Formation marine mudstone and sandstone separated from Naknek Formation marine mudstone and sandstone by an unconformity (white triangles) with erosional relief. Outcrop is ~20 m high. (d) Naknek Formation marine sandstone turbidites separated by dark mudstone. (e) Lower Matanuska Formation fluvial sandstone and mudstone (Kbs) and shallow marine sandstone and mudstone (Km) unconformably overlain by dark marine mudstone (Ksc) of the upper Matanuska Formation, which is unconformably overlain by Eocene volcanic rocks (Tv). Outcrop is ~350 m high. (f) Lower Matanuska Formation thin-bedded sandstone turbidites and mudstone. Person with blue coat (lower center) for scale. (g) Upper Matanuska Formation thick-bedded sandstone turbidites separated by dark mudstone. Outcrop is ~18 m high.

Table 1
Previous and New Maximum Age Constraints on Forearc Basin Strata

Formation	Previous chronologic constraints		Maximum depositional age (this study)		
	Biostratigraphic control	Igneous clast age (Ma)	Sample	Method 1 (Ma) unmixing algorithm	Method 2 (Ma) youngest grain
Upper Matanuska Formation	Campanian-Maastrichtian	79–77	GW1-DZ1	68	64.9 ± 0.8
			104-DZ1	76	68.2 ± 1.6
Lower Matanuska Formation	Albian-Coniacian	NA	072210KR-01	90	79.2 ± 5.0
			072909CMK1	122	118 ± 9.4
Naknek Formation	Oxfordian-Tithonian	167–156	NAK-BC, 071210-TS6	151	146.6 ± 7.0
Tuxedni Formation	Bajocian-Bathonian	NA	072310-TS5	167	156.1 ± 7.9
Talkeetna Formation	Pliensbachian-late Toarcian	NA	072310-TS7	175	168.6 ± 9.0

Note. References for biostratigraphic constraints and igneous clast ages are provided in the text. NA, not applicable.

Detrital zircon grains were analyzed using the laser ablation inductively coupled plasma–mass spectrometer at the Arizona LaserChron Center following the methods of Gehrels et al. (2006, 2008). Laser ablation of a 30–35 μm spot created an ablation pit approximately 15 μm deep. Composite Pb correction addresses uncertainties recorded in Stacey and Kramers (1975) of 1.0 for $^{206}\text{Pb}/^{204}\text{Pb}$ and 0.3 for $^{207}\text{Pb}/^{204}\text{Pb}$. The $^{206}\text{Pb}/^{238}\text{U}$ ages were used for grains <1.0 Ga, whereas the $^{206}\text{Pb}/^{207}\text{Pb}$ age was deemed more accurate for grains >1.0 Ga. Approximately 100 grains were analyzed for each sample, and the results are plotted in a probability density diagram using the Isoplot program designed by Ludwig (2003). Peak ages generated using the Age-Pick program illustrate populations of three or more overlapping grains within 2σ error.

4. Results

4.1. General Distribution of Detrital Zircon Ages

The results of the detrital zircon U–Pb analyses are summarized in stratigraphic order on Table 1 and Figure 5 using the geologic time scale from Walker et al. (2012); all geochronologic data are available in supporting information Table S1. The Jurassic strata contain unimodal populations of Jurassic grains that become progressively younger upsection and range from 175 to 151 Ma (Figure 5). Compared to Cretaceous detrital zircons, the Jurassic detrital zircons yielded larger errors, which correlate with low uranium concentrations (Figures 7 and 8). Low uranium concentration is discussed specifically in section 6.1. The Cretaceous strata, in contrast, exhibit similar Jurassic detrital zircon populations as documented in the Jurassic forearc strata but with a broader range of peak ages that extend from 195 to 144 Ma (Figures 5 and 6). The unimodal Cretaceous detrital zircon populations become progressively younger upsection and range from 122 to 68 Ma (Figure 5). Although both the Jurassic and Cretaceous strata record predominantly Mesozoic signatures, the Cretaceous samples have slightly more Paleozoic and Precambrian detrital zircon grains. The U–Pb ages of the Cretaceous forearc strata have a distribution of 93.0% Mesozoic, 3.3% Paleozoic, and 3.6% Precambrian detrital zircon grains, whereas the Jurassic strata contain a more concentrated age distribution of 98.3% Mesozoic, 0.7% Paleozoic, and 0.7% Precambrian grains. Note that 98.9% of detrital zircons from both Jurassic and Cretaceous strata have U/Th ratios below 10 (supporting information Figure S3), an indicator of igneous provenance (e.g., Gehrels, 2011).

4.2. Jurassic Strata

4.2.1. Uppermost Talkeetna Formation

The lowest stratigraphic unit in this study is the Lower Jurassic Talkeetna Formation (Figures 3 and 4a). Sample 072310-TS7 from the uppermost Talkeetna Formation shows a graphical unimodal peak at 175 Ma (Figure 5) with the youngest single grain at 168.6 ± 9.0 Ma (Table 1). Grain ages in this sample span ~34 Ma with the exception of one Silurian grain (Figure 5).

4.2.2. Tuxedni Formation

Stratigraphically above the Talkeetna Formation is the Middle Jurassic Tuxedni Formation (Figures 3 and 4b). Sample 072310-TS5 has a single numerical age peak of 167 Ma (Figure 5) and a youngest single grain age of 156.1 ± 7.9 Ma (Table 1). The ages in this sample are constrained mostly in a span of ~42 Ma with the exception of two Triassic grains (Figure 5).

Figure 5. Age-distribution diagrams for detrital zircon grains from Mesozoic forearc basin strata in stratigraphic upsection order. A detrital zircon probability plot for each sample is imposed on histogram of age distribution. Sample locations and stratigraphic positions can be found in Figures 2 and 3; detailed geologic maps of sampled areas can be found in supporting information Figure S1. Histogram plots 0–3250 Ma have 20 Ma bin widths. Inset histograms ranging from 0 to 550 Ma have 5 Ma bin widths. Age peaks shown in italics are calculated from three or more grains that overlap within 2σ error.

4.2.3. Naknek Formation

The Upper Jurassic Naknek Formation is the youngest Jurassic strata analyzed (Figures 3, 4c, and 4d). Similar results from separate analyses of sample NAK-BC and sample 072310-TS6 were combined in the graphical and numerical analysis of this unit. The Naknek Formation exhibits a unimodal signature with a single age peak at 151 Ma (Figure 5). The youngest single grain age is 146.6 ± 7.0 Ma (Table 1). The spread of ages for

Figure 6. Composite normalized probability plots for all samples in the Matanuska Valley forearc basin (this study) and the Chugach accretionary prism (Amato et al., 2013). (a) Jurassic strata include the Talkeetna, Tuxedni, and Naknek formations from the forearc basin and the Potter Creek Assemblage from the accretionary prism. (b) Middle Cretaceous strata include the Lower Matanuska Formation from the forearc basin and the McHugh Creek Assemblage from the accretionary prism. (c) Late Cretaceous strata include the Lower Matanuska Formation from the forearc basin and the Valdez Group from the accretionary prism.

the Naknek Formation spans ~49 Ma (Figure 5) with the exception of one Triassic grain and one Precambrian grain.

4.3. Cretaceous Strata

4.3.1. Lower Matanuska Formation

Two samples from the lower Matanuska Formation were analyzed (Figures 3, 4e, and 4f). The unimodal signature exhibited in Jurassic forearc strata changes upsection to a multimodal signature with a wider distribution of detrital zircon grains in the Cretaceous samples (Figure 6). Sample 072909CMK1 contains two numerical age peaks of 122 Ma and 164 Ma (Figure 5) with a youngest single grain of 118.0 ± 9.4 Ma (Table 1). The spread of ages in this sample is ~93 Ma with the exception of one Devonian grain.

Sample 072210KR-01 has a broader age distribution of both individual grains and peak ages (Figure 5). Five Mesozoic peak ages for this sample include three Cretaceous peak ages, 90 Ma, 95 Ma, and 144 Ma, and two Jurassic peak ages, 181 Ma and 191 Ma (Figure 5). One Paleozoic peak age occurs at 356 Ma. The youngest single grain is 79.2 ± 5.9 Ma (Table 1). These six different age peaks highlight the broad distribution of grains that spans ~279 Ma (Figure 5) in the Mesozoic and Paleozoic with the exception of three Precambrian grains.

4.3.2. Upper Matanuska Formation

Two samples from the upper Matanuska Formation were analyzed (Figures 3 and 4g). Sample 104-DZ1 in the upper Matanuska Formation contains 11 age peaks. Mesozoic grains dominate these peak age populations with five Cretaceous peak ages (76 Ma, 80 Ma, 85 Ma, 133 Ma, and 144 Ma) and five Jurassic peak ages (161 Ma, 169 Ma, 174 Ma, 178 Ma, and 195 Ma; Figure 5). One Paleozoic peak age occurs at 375 Ma. The detrital ages in this sample span ~316 Ma (Figure 5) with the exception of four Precambrian grains. The youngest single grain is 68.2 ± 1.6 Ma (Table 1). Sample GW1-DZ1 from the upper Matanuska Formation contains a similar range of data as sample 104-DZ1 but has only four age peaks. The youngest peak age is 68 Ma with a population of eight grains. The remaining peak ages occur at 74 Ma, 79 Ma, and 171 Ma (Figure 5). The youngest single grain is 64.9 ± 0.8 Ma (Table 1). The ages span ~272 Ma with the exception of five Precambrian grains (Figure 5).

4.4. Interpretation of Maximum Depositional Ages

The age range of the Jurassic-Cretaceous forearc basin strata examined in this study was previously based mainly on biostratigraphic studies (Table 1) (Detterman & Westermann, 1992; Grantz, 1964; Imlay & Detterman, 1973; Imlay, 1981, 1984; Jones, 1963; Jones & Grantz, 1967; Pálffy et al., 1999; Trop et al., 2005; Trop, 2008). The sampled strata yield abundant age-diagnostic fossils, mainly ammonites, bivalves, foraminifera, and radiolaria. A handful of U-Pb zircon ages from igneous clasts in conglomerate of the Naknek Formation and the upper Matanuska Formation add robust constraints for discrete stratigraphic intervals (Table 1) (Trop, 2008; Trop et al., 2005). The >600 new detrital zircon ages reported here provide an opportunity to reexamine the interpreted depositional age of each formation.

This study uses two measures of maximum depositional age for detrital zircon analyses first introduced by Dickinson and Gehrels (2009): (1) the youngest numerical age peak of at least a three grain cluster with overlapping ages of 2σ error and a mean square weighted distribution (MSWD) ≤ 1 and (2) the age of the youngest single grain within a sample with 1σ error less than 10 Ma. The former measure provides a conservative estimate of maximum depositional age that incorporates both analytical and systematic error (Dickinson & Gehrels, 2009). The utility of this estimate is maximized in samples characterized by multiple age peaks and a large distribution of grain ages. The second measure, though less conservative, provides a higher-resolution maximum depositional age for the concentrated unimodal data sets examined in this study and can be used if the age is reproducible (Dickinson & Gehrels, 2009). Because the errors of individual grains in some of our samples are high, we rely on the more conservative measure of maximum depositional age that uses multiple grain ages. Peak ages in this study use between 7 and 30 grains to produce a maximum depositional age (Figure 7). Maximum depositional ages using both methods are summarized in Table 1. Although we rely predominantly on the first method, both measures of maximum depositional age result in adjustments to the previously defined biostratigraphic ranges. These adjustments are presented in Figure 7 and detailed in the following text.

4.4.1. Uppermost Talkeetna Formation

A single sample from the uppermost Talkeetna Formation, 072310-TS7, introduces new constraints on the maximum depositional age of this unit. The first measure of maximum depositional age produces a single numerical peak age at ~175 Ma (Figures 5 and 7). The second method of maximum depositional age, the youngest single grain age, yields an age of 168.6 ± 9.0 Ma (Table 1). Given that 48 grains in a sample of 83 grains are younger than the unimodal peak age, a younger maximum depositional age is likely (Figures 5 and 7). Biostratigraphic data and geochronologic ages from the Talkeetna Formation west of our study area indicate a depositional age between the Sinemurian to late Toarcian (199–176 Ma) (Figure 7) (Caruthers & Smith, 2012; Pálffy et al., 1999). The ~175 Ma peak in our sample suggests a slightly younger maximum depositional age, and the youngest single grain suggests that the maximum depositional age could be 6.9 Ma younger than the age peak determination (Figure 7). Our new data are consistent with previously reported detrital zircon ages from sandstone overlying the Talkeetna Formation that indicate a maximum depositional age of ~167 Ma (Amato et al., 2007).

4.4.2. Tuxedni Formation

Biostratigraphic age ranges established for the Tuxedni Formation are between the Bajocian and the Bathonian (170–166 Ma) (Figure 7) (Imlay & Detterman, 1973; LePain et al., 2011). The ~167 Ma age peak for sample 072310-TS5 lies within the biostratigraphic range established for this unit. The measured age of

Figure 7. Detrital zircon ages (individual datapoints) and errors (vertical black lines) that are part of the youngest peak age population of three or more grains with overlapping 2σ error are shown in the center column of Figure 7. Solid horizontal lines represent maximum depositional ages calculated using Method 1 (see text for description; colors specify individual samples). Dashed horizontal lines indicate previous maximum depositional ages constrained by zircon geochronology on conglomerate clasts (Trop, 2008; Trop et al., 2005). To the left we show the Jurassic and Cretaceous Formation ages based on biostratigraphic data (Bergquist, 1961; Imlay & Detterman, 1973; Grantz, 1960a, 1960b, 1964; Trop, 2008; Trop et al., 2005; Winkler, 1992). Using the new maximum depositional ages (in the middle column) we adjust the chronologic constraints on the stratigraphy. These new formation age determinations are shown in the column to the right.

156.1 ± 7.9 Ma for the youngest single grain, however, may indicate a younger maximum depositional age. The abundance of grains younger than the peak age, 42 grains in sample of 87 grains, supports this possibility (Figure 5).

4.4.3. Naknek Formation

The biostratigraphic age range established for the Naknek Formation places it from early Oxfordian to early Tithonian time (161–148 Ma) (Figure 7) (Imlay & Detterman, 1973; Trop et al., 2005). This age range is consistent with 167–156 Ma U-Pb ages of igneous conglomerate clasts in the formation (Trop et al., 2005). The age peak of ~151 Ma for samples NAK-BC and 072310-TS6 from the upper and middle parts of the Naknek Formation, respectively, lie in the younger part of the biostratigraphic age range. A bulk of grain ages, however, are younger than the ~151 Ma age peak (59 of 127 grains). The youngest single grain is 146.6 ± 7.0 Ma. While the age peak falls within the youngest end of the range established by biostratigraphy, the number of grains younger than 151 Ma supports a younger maximum depositional age suggesting that much of the middle to upper part of the Naknek Formation may be Tithonian in age.

4.4.4. Lower Matanuska Formation

The biostratigraphic age range for the lower Matanuska Formation extends between the Albian and Santonian (113–84 Ma; Figure 7) (Jones & Grantz, 1967). The youngest single grain for sample 072909CMK1 is 118.0 ± 9.4 Ma, part of only a three-grain population that lies below the youngest age peak of ~122 Ma (Table 1). Both the youngest peak age and the youngest single grain age are older than the biostratigraphic constraints (Figure 7). Given the abundant, well-preserved fossils from the same locality as this sample (Jones & Grantz, 1967), an Albian depositional age is likely. The second and stratigraphically higher sample from the lower Matanuska Formation, 072210KR-01, exhibits a much younger peak age of ~90 Ma (Figure 7). At 79.2 ± 5.9 Ma the youngest single grain for this sample falls within the established biostratigraphic age range (Table 1).

4.4.5. Upper Matanuska Formation

The biostratigraphic age range for the upper Matanuska Formation is Campanian to Maastrichtian (84–66 Ma; Figure 7) (Grantz, 1964; Jones, 1963). This age range is consistent with the youngest population of igneous clasts from conglomerate (79–77 Ma) and detrital zircons from sandstone (77–71 Ma) previously reported from this formation (Table 1; Trop, 2008). The youngest age peak in sample 104-DZ1, 76 Ma, is populated

by 18 grains that constitute 18% of this sample (Figure 5). Both the youngest age peak and the youngest single grain age, 68.2 ± 1.6 Ma, support the established maximum depositional age (Table 1). Sample GW1-DZ1 is also from the upper Matanuska Formation and has a similar age. The youngest peak age of ~ 68 Ma is populated by eight grains with the youngest single grain of 64.9 ± 0.8 Ma overlapping within error the upper limit of the established depositional age (Figure 7 and Table 1). In summary, the detrital zircon maximum depositional ages are broadly consistent with previous biostratigraphic age assignments for the forearc basin stratigraphy suggesting that detrital zircon data provide accurate proxies for depositional ages in this setting but with the added advantage of higher precision. Still, it is important to note that the true depositional age is younger than or equal to the maximum depositional age interpreted from detrital zircon geochronology (e.g., Dickinson & Gehrels, 2009). Based on the detrital zircon maximum depositional ages from this study, sedimentation in the southern Alaska Mesozoic forearc basin spanned from ~ 175 to 68 Ma.

5. Provenance

5.1. Potential Sources of Sediment North of the Basin

5.1.1. Primary Sources

North of the study area, primary sources of sediment include the Jurassic plutonic and volcanic rocks that represent the Talkeetna oceanic arc (e.g., DeBari & Greene, 2011). These rocks crop out extensively in the southern Talkeetna Mountains (shown as purple in Figure 1; shown as Jpu and Jpl in Figure 2) and are considered to be part of the peninsular terrane (Jones & Silberling, 1979; Plafker et al., 1989; Reed & Lanphere, 1974). U-Pb zircon ages from these potential sources of sediment range in age from 190 to 153 Ma with the highest volume of plutonic rocks with ages between 177 and 153 Ma (Rioux et al., 2007).

More distal potential sources include Upper Jurassic-Lower Cretaceous plutons of the Chitina arc located south of the Wrangell Mountains and Middle Cretaceous plutons of the Chisana arc, located north of the Wrangell Mountains. Direct measurement of the Chitina arc plutons yield 153–150 Ma U-Pb zircon ages; however, U-Pb zircon ages of modern river sands draining the Chitina Valley batholith range between 156 and 130 Ma (E. M. Day et al., 2016; Plafker et al., 1989; MacKevett, 1978; Roeske et al., 1992, 2003; Trop et al., 2016; Winkler et al., 1980). Contemporaneous arc-related plutons from the Saint Elias plutonic suite to the southeast (present coordinates) contain U-Pb ages on zircon between 155 and 147 Ma (Beranek et al., 2017). Chisana arc plutons and volcanic rocks yield circa 126–105 Ma radiometric ages (Graham et al., 2016; Richter et al., 1975; Snyder & Hart, 2007).

Northwest of the Jurassic igneous rocks are Cretaceous plutons that crop out throughout much of southern Alaska in the Wrangellia and Yukon composite terranes (Figure 1; Chisana arc and Kluane arc of Plafker & Berg, 1994) (Brennan & Ridgway, 2015; Moll-Stalcup, 1994; Wallace & Engebretson, 1984). In the southern Talkeetna Mountains, Upper Cretaceous diorite and granite plutons have 79–67 Ma U-Pb ages (Kg in Figure 2) (Bleick et al., 2012; Davidson & McPhillips, 2007; Donaghy, 2012; Harlan & Vielreicher, 2003).

Distal potential eastern sources include Devonian, Mississippian, and Pennsylvanian intrusions and volcanic rocks that crop out in the Wrangellia composite terrane in eastern Alaska and Yukon Territory (Beard & Barker, 1989; Israel et al., 2014). Distal northern/northeastern sediment sources may include Middle Devonian to Lower Mississippian and Upper Triassic to Middle Jurassic plutons of the Yukon composite terrane (YCT in Figure 1) exposed north of the Denali fault in south central Alaska and Yukon Territory (Figure 1). These plutonic rocks have U-Pb zircon and Rb-Sr whole-rock ages between 373–333 Ma and 220–168 Ma (Aleinikoff et al., 1986; Colpron et al., 2015; Dusel-Bacon et al., 2006, 2013, 2004; Dusel-Bacon & Aleinikoff, 1996; Dusel-Bacon & Williams, 2009; Johnston et al., 1996; Mortensen, 1983, 1990).

Even more distant, potential primary sources crop out in the Coast Mountains batholith in southeastern Alaska and western British Columbia, where plutons within the Alexander and Wrangellia terranes yield mainly ~ 177 –162 Ma, ~ 157 –142 Ma, and ~ 118 –100 Ma U-Pb zircon ages (Gehrels et al., 2009). Farther inboard, plutons emplaced into the Stikine and Yukon-Tanana terranes yield chiefly ~ 180 –110 Ma and ~ 100 –50 Ma U-Pb zircon ages (Gehrels et al., 2009). These potential distant sources were positioned closer to the sampled forearc basin during Jurassic-Cretaceous deposition given that several hundred kilometers of Cretaceous-Cenozoic dextral displacement occurred along the eastern part of the Denali fault system during Cretaceous-Cenozoic time (e.g., Eisbacher, 1976; Lowey, 1998; Nokleberg et al., 1985).

5.1.2. Secondary Sources

In the northern Talkeetna Mountains and southern Alaska Range, Upper Jurassic to Upper Cretaceous strata known as the Kahiltina assemblage are widely exposed (Csejtey et al., 1992; Ridgway et al., 2002; Hampton et al., 2007). A provenance study of the Kahiltina strata documented 74% Mesozoic detrital zircon grains with large populations around 123 Ma, 156 Ma, and 201 Ma (Hampton et al., 2010). Paleozoic detrital zircons in the Kahiltina strata are concentrated between 380 and 300 Ma and make up 11% of the grains measured. Precambrian grains comprise 15% of the Kahiltina strata with most detrital zircons in the 2.1–1.7 Ga and 2.8–2.3 Ga age ranges. A more distal potential secondary source of sediment is Proterozoic (?)–Paleozoic metasedimentary rocks of the Yukon composite terrane located north of the Alaska Range (Figure 1). U–Pb ages from metamorphic basement rocks in Alaska, Yukon Territory, and British Columbia range chiefly between 2000 and 1700 Ma and between 3000 and 2200 Ma (Dusel-Bacon & Williams, 2009; Gehrels et al., 1995; Gehrels & Kapp, 1998; Gehrels & Ross, 1998; Pecha et al., 2016; Piercey & Colpron, 2009). These metamorphic rocks also include Middle to Upper Devonian and Middle to Upper Permian magmatic intrusions (Mortensen, 1992; Nelson et al., 2006).

5.2. Potential Sources of Sediment South of the Basin

5.2.1. Primary Sources

South of the Matanuska Valley, plutons exposed in the Chugach Mountains just north of the Border Ranges fault form a southern, older segment of the Jurassic Talkeetna arc (DeBari & Coleman, 1989). The U–Pb zircon ages of these plutons range from 202 to 181 Ma (Jpl in Figure 2) (Rioux et al., 2007). More spatially limited and sparsely dated Cretaceous intrusions located just north of the Border Ranges fault (Ki in Figure 2) yield one U–Pb age of 121 Ma (Labrado et al., 2015). More recent, unpublished data from these rocks identify a distinct concentration of U–Pb ages between 125 and 121 Ma (T. Pavlis, personal communication, 2017).

5.2.2. Secondary Sources

South of the Border Ranges fault, Mesozoic accretionary prism rocks that define the Chugach Terrane (Figure 1) consist of three primary members: the Upper Jurassic–Lower Cretaceous Potter Creek assemblage (Mzm in Figure 2), the mid-Cretaceous McHugh Creek assemblage (Mzm in Figure 2), and the Upper Cretaceous Valdez Group (Kv on Figure 2) based on the classification of Amato et al. (2013). These metasedimentary units extend throughout the southern margin of Alaska and are potential sources of recycled zircons for the Mesozoic forearc basin strata in the study area. The Potter Creek assemblage has U–Pb detrital zircon ages ranging mainly from 204 to 144 Ma. The McHugh Creek assemblage has U–Pb detrital zircon ages ranging mainly from 113 to 86 Ma. The Valdez Group contains a broader distribution of Mesozoic U–Pb ages with major detrital zircon populations from 105 to 60 Ma and 200 to 125 Ma (Amato et al., 2013; Kochelek et al., 2011). It is also possible that Mesozoic forearc basin strata were sourced from erosion and reworking of Jurassic–Cretaceous sedimentary strata from the local forearc basin.

5.3. Provenance Interpretation

The detrital zircon signatures recorded in Mesozoic forearc basin strata of south central Alaska chronicle changes in sources of sediment, sediment transport pathways, and timing of deposition in the forearc basin. In our study over 72% of the grains from Jurassic forearc strata have U–Pb ages of 201–153 Ma that match ages from the nearby plutons of the Talkeetna arc. Over 95% of the analyzed zircons with U–Pb ages between 201 and 153 Ma have uranium concentrations lower than 250 ppm (Figure 8a). Previous studies have interpreted these igneous rocks as representing an oceanic arc (Clift, Draut, et al., 2005; Rioux et al., 2007). The detrital record of this oceanic arc in the forearc basin strata is recorded in a series of unimodal peaks that young progressively upsection (Figure 9). The upsection trend of progressively younger unimodal peak ages in the Jurassic strata suggests that zircon-bearing igneous rocks were rapidly exposed to erosion with short lag times between erosion in the arc and deposition in the forearc basin. Progressive unroofing of the oceanic arc is consistent with compositional data dominated by volcanic–plutonic clasts in sandstone and conglomerate, including upsection increases in plutonic detritus in the study area (Trop et al., 2005) and along strike in the Cook Inlet basin (Helmold et al., 2013; LePain et al., 2013).

The Talkeetna arc includes plutons located north of the forearc basin in the Talkeetna Mountains (192–153 Ma) and plutons located south of the forearc basin in the Chugach Mountains (202–181 Ma) (Rioux et al., 2007). Although the timing of magmatism overlaps in the two suites of plutons, 66% of the detrital zircons from the Jurassic forearc basin strata have ages that match only pluton ages of the northern

Figure 8. Plot of uranium concentration versus U-Pb age for detrital zircon grains from (a) Jurassic strata and (b) Cretaceous strata. Samples derived from Matanuska Valley forearc basin strata are indicated by black diamonds; samples derived from accretionary prism strata are denoted by gray circles. Note that grains from Jurassic strata with Jurassic ages interpreted to be derived from an oceanic volcanic arc (i.e., the Talkeetna arc) have very low uranium concentrations. In contrast, detrital zircons from Cretaceous strata with Cretaceous ages interpreted to be derived from a continental arc system have a wide range of uranium concentrations. In Cretaceous strata, zircons with Jurassic ages and low uranium concentrations are likely recycled from exposed Jurassic strata or eroded from Jurassic volcanic-plutonic rocks.

Talkeetna arc (i.e., 181–153 Ma), 6% of analyzed detrital zircons have ages that overlap with both northern and southern plutons (192–181 Ma), and 0% of detrital zircons match pluton ages of only the southern Talkeetna arc (202–192 Ma). These results suggest that the majority of sediment contributed from the Talkeetna arc was sourced from the northern plutons, and this sediment was subsequently transported southward (present coordinates) prior to deposition in the Jurassic forearc basin, consistent with southward fining of lithofacies and south directed paleocurrent data in the study area (Trop et al., 2005) and along strike in the Cook Inlet forearc basin (LePain et al., 2013).

Of the remainder of the detrital zircon grains analyzed from Jurassic forearc basin strata, 26% of the grains have 153–131 Ma ages. No primary igneous sources of corresponding age have been documented in the

Figure 9. (a) Probability density curves of detrital zircon populations showing the changing erosional signature of the Matanuska Valley forearc basin following Early Cretaceous collision. See text for additional discussion. (b) Plot showing the age span of detritus eroded into the forearc basin. Note that the youngest age of the detritus reflects the most recently active part of the arc system and that these populations young progressively upsection. For Jurassic strata, there is also a relative younging of the oldest sediment eroded from the arc. This suggests that with time, older parts of the oceanic arc were either mostly eroded or no longer supplied sediment to the forearc basin. In the case of the Cretaceous continental arc/forearc basin system, a number of sources supplied sediment to the basin reflecting multiple source rocks in the upper plate of the Cretaceous convergent margin. The youngest modal peak in the Cretaceous samples reflects the progressive growth of the continental arc system. A dashed line indicates that no detrital zircons with ages corresponding to that time interval are present in the sample.

Talkeetna Mountains. These ages do overlap with detrital zircon populations in the accretionary prism, but the forearc basin samples lack the broad spectrum of ages documented in detrital zircon populations making up most of the accretionary prism (Amato et al., 2013). It is more likely that strata in the forearc basin and the accretionary prism share a provenance source than that the accretionary prism served as a source for strata in the forearc basin. Instead, detrital zircons between 153 and 131 Ma support an igneous source of sediment (Figure S3), possibly derived from undated plutons associated with northern Talkeetna arc magmatism. This interpretation could extend Talkeetna arc magmatism into Early Cretaceous time, but more geologic mapping and geochronology are needed to properly address this hypothesis. Alternatively, 153–131 Ma detrital zircons may reflect contributions from more distant sources located >150 km along strike to the east in the Wrangell Mountains, where the Chitina Valley batholith yields 153–150 Ma U-Pb zircon ages (Plafker et al., 1989; Roeske et al., 2003) and adjacent modern rivers in this area yield detrital zircons with 155–130 Ma U-Pb ages (E. M. Day et al., 2016; Trop et al., 2016). An even more distant potential source is the Saint Elias plutonic suite, which yields U-Pb zircon ages between 155 and 147 Ma (Beranek et al., 2017). The general lack of Paleozoic and Precambrian detrital zircons of Laurentian affinity in the Jurassic strata is consistent with an oceanic setting for the Talkeetna arc that had little or no sediment connection to the former continental margin of North America. These results are consistent with

isotopic and geochemical data from the plutonic and volcanic rocks of the Talkeetna arc that indicate little or no continental crustal input (Amato et al., 2007; Clift, Draut, et al., 2005; Rioux et al., 2007).

Cretaceous strata of the forearc basin in south central Alaska were deposited across multiple unconformities that represent as much as 30 Ma of nondeposition and/or erosion (Figure 3) (Finzel & Ridgway, 2017; Grantz, 1960a, 1960b; Imlay, 1981; Imlay & Detterman, 1973). Strata overlying one of the unconformities, the lower Matanuska Formation, document the introduction of multiple sediment sources during Cretaceous deposition in the forearc basin (Figure 5). In contrast to the Jurassic strata, detrital zircon samples analyzed from both the lower and upper Matanuska Formation have only 36% of grains with U-Pb ages that match the 202–153 Ma pluton ages from the Jurassic Talkeetna arc (Figure 5) and only 54% of all zircons grains in Cretaceous strata have uranium concentrations lower than 250 ppm (Figure 8b). Composite data from the Cretaceous samples show a broad range of Jurassic peak ages ranging from 194 to 144 Ma (Figure 5b). The peak ages of Jurassic zircons within individual Cretaceous samples also lack the progressively younger upward stratigraphic trend evident in the Jurassic strata of the forearc basin (Figure 5). This change from mainly a unimodal Jurassic detrital zircon population to a Jurassic detrital zircon population with multiple peak ages is interpreted to reflect (1) coeval exhumation and erosion of several different Jurassic plutons with different ages during the development of the regional unconformity; in this interpretation, the cessation of widespread active magmatism in the Talkeetna arc ended mainly after deposition of the Naknek Formation and/or (2) this phenomenon may also reflect the exhumation and reworking of previously deposited Jurassic strata such as the Talkeetna, Tuxedni, and Naknek Formations during Cretaceous deposition in the forearc basin.

Like the detrital zircons in the Jurassic strata, most Jurassic zircons in the Cretaceous forearc basin strata, 29%, are coeval with magmatism in the northern Talkeetna arc from 181 to 153 Ma, 5% of the grains overlap with plutons from both the northern and southern Talkeetna arcs (192–181 Ma). Just 3% match the age of the 202–192 Ma plutons of the southern Talkeetna arc. While the northern Talkeetna arc contributed most detritus to the forearc basin, detrital zircon ages from the Cretaceous strata indicate that at least a small portion of the grains are potentially derived from the southern Talkeetna arc exposed in the Chugach Mountains. If correct, this might indicate that the accretionary prism that defined the southern margin of the Cretaceous forearc basin had significant enough relief to contribute some sediment to the forearc basin by this time.

Similar to the Jurassic forearc basin strata, the Cretaceous strata document a continuous range of ages younger than 153 Ma possibly associated with undated plutonism in the northern Talkeetna arc. For example, an additional 7% of the zircon grains in these samples have ages between 153 and 140 Ma. A second, more distributed population includes ages between 140 and 100 Ma. This age range accounts for 6% of the detrital zircons from Cretaceous strata examined in this study (Figure 6). Subordinate Lower Cretaceous detrital zircon grains in sandstone overlap the age range of 140–115 Ma plutons and volcanic rocks, known as the Chisana arc, northeast of the Wrangell Mountains (Figure 1) (Graham et al., 2016; Richter et al., 1975; Short et al., 2005; Snyder & Hart, 2007). Cretaceous sedimentary strata exposed in the northern Talkeetna Mountains (Kahiltna assemblage) also contain abundant 130–115 Ma detrital zircons that are interpreted as recording erosion of the Chisana arc (Hampton et al., 2007; Kalbas et al., 2007). Lower Cretaceous detrital zircons may have also been sourced from spatially and temporally limited 125–121 Ma intrusions that crop out in the northern Chugach Mountains along the Border Ranges fault zone (Ki in Figure 2) (Amato et al., 2013; Labrado et al., 2015; T. Pavlis, personal communication, 2017).

In the Cretaceous forearc basin strata, 42% of the grains fall in the window of Cretaceous arc magmatism between 100 and 60 Ma. Igneous rocks of this age are common in southern Alaska and throughout the northern Cordillera, (pink in Figure 2), and this age distribution captures the beginning of the Late Cretaceous magmatic pulse documented in widespread plutons throughout southern Alaska (Moll-Stalcup, 1994; Wilson et al., 2015). This source is located mainly inboard of the Jurassic plutons of the Talkeetna arc, but locally, these Cretaceous plutons were intruded into and adjacent to the Jurassic plutons (Figures 1 and 2). Regionally, the Cretaceous igneous belt intrudes and stitches both the accreted oceanic terranes and the older continental margin rocks and is interpreted as a continental magmatic arc (e.g., Moll-Stalcup, 1994; Plafker & Berg, 1994). Much like the Jurassic strata, age peaks and youngest single grains of detrital zircons in the Cretaceous strata (Table 1) reflect syndepositional arc magmatism, including a shift upsection to progressively younger ages in response to erosion of an active arc (Figure 9). In our interpretation, detrital zircon

samples from the Cretaceous forearc basin strata reflect the demise and erosion of the remnant oceanic Jurassic Talkeetna arc and the establishment of a new, mainly Late Cretaceous continental arc (Figure 9). The new Cretaceous arc was widespread and supplied large amounts of sediment to the forearc basin between 100 and 68 Ma (upper three samples in Figure 5). Coeval arc plutons were unroofed relatively quickly, judging by the presence of abundant 76–68 Ma detrital zircons in sandstone and 79–77 Ma granitic clasts in conglomerate, together with Maastrichtian (71–65 Ma) fossils (Trop, 2008). The paucity of metasedimentary clasts diagnostic of accretionary prism sources in the sampled strata together with south directed lithofacies trends and paleocurrent trends supports erosion mainly of northern, igneous sediment sources during Cretaceous forearc basin deposition (Trop, 2008).

Paleozoic grains account for 3% of the detrital zircons analyzed in the Cretaceous forearc basin strata and broadly match published ages of Mississippian and Devonian plutons from the Yukon composite terrane north of the Denali fault in Alaska (Dusel-Bacon et al., 2004, 2006, 2013; Dusel-Bacon & Williams, 2009; W. C. Day et al., 2003). If correct, however, Yukon composite terrane sources presently exposed along strike in Canada likely would have provided this sediment given that several hundred kilometers of dextral displacement occurred along the Denali fault since Late Cretaceous time (Benowitz et al., 2012; Eisbacher, 1976; Lowey, 1998; Mortensen, 1992; Nelson et al., 2006; Nokleberg et al., 1985; Roeske et al., 2012).

In summary, the detrital zircon record of the Cretaceous forearc basin strata indicates two dominant sources of sediment. These include two primary igneous sources located north of the basin, the plutons of the inactive/remnant Talkeetna arc and the active Late Cretaceous arc currently exposed in the Talkeetna Mountains and Alaska Range (Figure 1). These two sources of sediment provided 78% of the detrital zircons documented in the Cretaceous strata. Minor contributors of sediment from the north may include the Mississippian and Devonian plutons of the Yukon composite terrane and/or recycled sediment from the Kahiltna strata. From the south, Lower Jurassic plutons from the Chugach Mountains appear to have provided minor amounts of sediment to the forearc basin, but little evidence exists to suggest that the accretionary complex served as a dominant sediment source.

6. Discussion

6.1. Uranium Concentration

Although average uranium concentrations in zircon range from 100 to 1,000 ppm (Garver & Kamp, 2002), most detrital zircons derived from the Jurassic arc have uranium concentrations between 50 and 250 ppm with an average of ~145 ppm (Figure 8a). By contrast, the uranium concentration of Cretaceous detrital zircons follows more closely the natural range of uranium in zircon with an average uranium concentration of ~593 ppm (Figure 8b).

To our knowledge, no previous studies have used relative uranium concentrations to differentiate between populations of detrital zircons but our results highlight the potential for further investigation of this relationship. In our study, four Jurassic samples from the Talkeetna, Tuxedni, and Naknek Formations contain notably homogeneous detrital zircon age distributions (circa 190–140 Ma) interpreted as being derived from oceanic arc rocks. The zircons from these samples also all have uranium concentrations that are below ~200 ppm. The four Cretaceous samples examined in this study from the lower and upper Matanuska Formation, in contrast, contain a much broader distribution of detrital zircon ages as well as a consistently broad distribution of uranium concentrations (Figure 8b). It is possible to identify zircons in the Cretaceous Matanuska Formation that were recycled from either synorogenic Jurassic arc strata (such as the Talkeetna, Tuxedni, or Naknek Formations) or remnant arc plutons by identifying grains with both low (50–250 ppm) uranium concentrations and Jurassic U-Pb ages (Figure 8). This relationship is also observed in the zircons from strata in the Chugach accretionary prism analyzed by Amato et al. (2013). The mainly Jurassic Potter Creek Assemblage, interpreted to be derived primarily from the Jurassic arc (Amato et al., 2013), has relatively lower uranium concentrations (average ~187 ppm) than Cretaceous zircons from the McHugh Creek Assemblage (Figure 8).

For the purposes of our analysis, the distinct differences in uranium concentrations between two different age groups of zircons suggest different petrogenetic processes for Jurassic oceanic arc rocks that supplied zircons to the forearc basin and accretionary prism relative to the Late Cretaceous continental arc rocks

that supplied zircons to the forearc basin and accretionary prism (e.g., Grimes et al., 2015). In a practical sense, low uranium concentrations inhibit the precision of measured U-Pb ages, and low uranium concentration grains produced measurements with higher error as shown in Figure 7 and in Table S1.

6.2. Implications for Jurassic-Cretaceous Forearc and Accretionary Prism Tectonics

The well-exposed Mesozoic forearc basin strata in south central Alaska crop out adjacent to igneous rocks of the Talkeetna arc that have been described as a complete crustal section of oceanic arc lithosphere (DeBari & Coleman, 1989; Clift, Draut, et al., 2005; Greene et al., 2006; Rioux et al., 2007). While the igneous rocks of the oceanic arc crust have been studied in considerable detail (Burns, 1985; Draut et al., 2009; DeBari & Greene, 2011; Hacker et al., 2008; Rioux et al., 2007), parallel studies of the forearc basin strata are generally lacking (LePain et al., 2013; Trop et al., 2005). Our U-Pb detrital zircon data indicate that the Jurassic forearc basin strata were derived almost exclusively from the adjacent active magmatic arc. The dominance of arc-derived sediment in the Jurassic forearc strata and the absence of any other sources of sediment are consistent with the Talkeetna arc developing as an oceanic arc isolated from inboard continental sources of sediment (Figures 9 and 10a). From a regional perspective, the Jurassic oceanic forearc basin strata are equivalent to Jurassic-Lower Cretaceous metasedimentary and metavolcanic rocks of the Potter Creek assemblage, part of the accretionary prism represented by the Chugach terrane (Figure 10; Amato et al., 2013). This part of the accretionary prism has been described as a mesomélange with U-Pb detrital zircon ages ranging from 180 to 146 Ma (Figure 6a; Amato et al., 2013). Like the sampled forearc basin strata, these detrital ages indicate erosion of a Middle-Late Jurassic oceanic arc, most likely the Talkeetna arc, with little sediment contribution from inboard continental terranes. The dominant population of detrital zircons documented in both the Jurassic forearc basin strata and time-equivalent accretionary prism strata (Figure 6a) indicates a direct sediment connection from the active Talkeetna arc to the forearc basin and into the subduction trench (Figures 10a and 10b; also see Amato et al., 2013, their Figure 11b). The Jurassic accretionary prism rocks form limited, discontinuous exposures throughout the currently exposed accretionary prism (Figure 1b); their limited distribution suggests that they may represent a period of subduction erosion (Amato et al., 2013; Clift, Draut, et al., 2005; Roeske et al., 1989). Subduction zones characterized by tectonic erosion are common in oceanic arcs (Clift & Vannucchi, 2004; von Huene & Scholl, 1991) and are consistent with our interpretation that the Jurassic forearc strata were deposited within an oceanic arc.

Latest Jurassic to Early Cretaceous time in the forearc basin of south central Alaska is marked by multiple unconformities that record as much as 30 Ma of nondeposition and/or erosion (Figures 9 and 10c). A general absence of 140–120 Ma detrital zircon ages in the forearc basin strata coincides with the interpreted timing of diachronous collision of the Talkeetna arc with inboard terranes during Late Jurassic–early Late Cretaceous time (Amato et al., 2013; Clift, Draut, et al., 2005; Hampton et al., 2007; Ridgway et al., 2002; Trop et al., 2005) and a lull in magmatism throughout the northern Cordillera (Armstrong, 1988; Gehrels et al., 2009). The correlative gap of detrital zircon ages in the southern Alaska forearc basin may signal a hiatus of both subduction of “normal” oceanic crust and related upper-plate magmatism triggered by collision of the Talkeetna arc. Other interpretations of the causes of erosion in the forearc basin may include (1) Early Cretaceous subduction of an oceanic spreading ridge from ~125 to 105 Ma and related emplacement of ~125–121 Ma forearc intrusions (e.g., Amato et al., 2013; Pavlis et al., 1988; Trop & Ridgway, 2007) and (2) an Early Cretaceous interval of sinistral displacement that has been proposed for the along-strike Cordilleran arc-forearc basin system in British Columbia (Gehrels et al., 2009; Monger et al., 1994; Yokelson et al., 2015). The end of Aptian-Albian forearc basin erosion was marked by deposition of the McHugh Creek assemblage in the accretionary prism and the Albian-Santonian lower Matanuska Formation in the forearc basin (Figure 3). The 110–90 Ma distinct population of detrital zircons documented in the McHugh Creek assemblage is not as pronounced in the forearc basin strata (Figure 6b) and suggests to us that during this interval most arc-derived sediment bypassed the forearc basin and accumulated in trench-slope basins or the trench.

Note in our interpretation that the collision of the Wrangellia composite terrane with the former continental margin resulted in underthrusting of oceanic crust beneath the continental margin (Figure 10c). We envision this collisional configuration to be similar to modern tectonic settings such as the Ontong Java plateau in Australia and the Yakutat terrane in southern Alaska. In both these setting subduction/collision of thickened oceanic crust has resulted in widespread deformation and exhumation of both the upper and lower plates

Figure 10. Schematic cross sections showing interpreted tectonic development of the southern Alaska convergent margin during Mesozoic-Cenozoic time. Pink text highlights dynamics of the magmatic arc and adjacent forearc basin system, the focus of this study. See text for discussion and references. It is important to note that major strike-slip faults were transporting rocks in and out of the plane of the generalized cross section at various stages of tectonic development. Simplified from Trop and Ridgway (2007).

(Enkelmann et al., 2015; Finzel et al., 2011; Knesel et al., 2008; Mann & Taira, 2004; Pavlis et al., 2012). In the context of this interpretation, uplift of the forearc basin during collision of the Talkeetna arc was coeval with the regional shortening of retroarc basins (KB in Figure 10c). Regional shortening of forearc and retroarc basins may be related to crustal thickening in the deeper levels of the collisional zone. Rioux et al. (2007), for example, interpreted northernmost Jurassic plutonic rocks with more evolved initial isotopic ratios and the presence of xenocrystic zircons as potentially reflecting the initial collisional process.

It is also possible that during collision ultramafic cumulates of the Talkeetna arc may have been removed by crustal foundering (delamination). This suggestion is based on modeling by Kelemen et al. (2003), Greene et al. (2006), and Behn and Kelemen (2006) that requires a significant section of the cumulate pyroxenites to have been physically removed from the base of the Talkeetna arc. The timing of delamination of the dense ultramafic cumulates is unclear, but that this process may have occurred during regional crustal thickening

may be a plausible interpretation from our perspective. If so, regional uplift/unconformity development in the forearc basin and exhumation/cooling of the Talkeetna arc may also be partly a response to isostatic rebound related to gravitational foundering of the deep roots of Talkeetna arc (in a broad sense of DeCelles et al., 2009; DeCelles & Graham, 2015). The thermal history of the Talkeetna arc is spatially variable but in our study area of the eastern Talkeetna Mountains cooling occurred from 149 to 143 Ma based on $^{40}\text{Ar}/^{39}\text{Ar}$ mica ages and from 130 to 119 Ma based on limited (U-Th)/He ages on zircon and apatite (Hacker et al., 2011). These cooling ages are consistent with our interpreted syncollisional stage (164–113 Ma in Figure 4) and suggest a possible link between delamination of the roots of the Talkeetna arc and surface responses in the forearc basin that warrants additional future study.

Stratigraphically above the Middle Cretaceous unconformities in our study area, the broader age distribution of detrital zircon samples from the Cretaceous forearc basin reflects continued erosion of the remnant oceanic Jurassic Talkeetna arc coeval with erosion of a newly constructed Late Cretaceous continental arc (Figures 9 and 10d). Like the sampled forearc basin strata, detrital zircons from Upper Cretaceous strata of the accretionary prism consist of mostly Late Cretaceous ages and subordinate Jurassic ages, reflecting erosion of both coeval continental margin arc and remnant arc rocks (Figure 6c; Amato et al., 2013). The accretionary prism associated with the Late Cretaceous continental arc formed one of the largest known accretionary prisms on Earth (i.e., the Chugach terrane in Figure 1; Valdez Group in Figures 6 and 10d). Construction of the Cretaceous continental arc along the northern Cordilleran convergent margin provided enormous volumes of sediment to the subduction zone ($\sim 3\text{--}6 \times 10^6 \text{ km}^3$) that was subsequently offscraped and accreted to the accretionary prism (Amato et al., 2013; Hudson & Magoon, 2002; Plafker et al., 1994; Sample & Reid, 2003). This supply of sediment changed the margin from a margin dominated by subduction erosion during Jurassic time to a predominantly accretionary margin during Cretaceous time (e.g., Amato et al., 2013; Clift, Pavlis, et al., 2005). This change in mode of subduction is predicted by the models of Draut and Clift (2013) that suggest significant growth of continental margins by accretionary prism processes following oceanic arc collision. Along these lines, it is interesting that in direct contrast to the Middle Cretaceous detrital zircon record (Figure 6b), the youngest major detrital zircon age peaks in the Upper Cretaceous strata are more pronounced in the forearc basin than in the accretionary prism (Figure 6c). This reversal may be a product of the bathymetric growth of the accretionary prisms after Middle Cretaceous collision that resulted in a sediment barrier between the accretionary prism and forearc basin. This configuration may have resulted in more of the sediment deposited locally within the forearc basin and a less direct sediment pathway to the subduction trench.

6.3. Implications for Accretion of the Wrangellia Composite Terrane

There is widespread agreement that a regional Middle Cretaceous contractional orogen developed along the suture zone between the Wrangellia composite terrane and inboard terranes, resulting in closure of marine basins that formerly separated the composite terrane from inboard terranes (e.g., Gehrels et al., 2009; Rubin et al., 1990; Trop & Ridgway, 2007). The nature, extent, and tectonic setting of the marine basins, however, remain controversial (Monger, 2014, provides a very useful overview of this issue). Studies in south central and southwestern Alaska, for example, interpret that these basins were associated with diachronous south-to-north closure of an open ocean basin system (Hampton et al., 2010; Kalbas et al., 2007). In these interpretations, the Gravina-Nutzotin-Kahiltna basin system along the inboard margin of the composite terrane (KB in Figure 10) formed synchronously with collision and was closed diachronously, consistent with the northward younging of strata within these basins (Kalbas et al., 2007; Pavlis, 1982; Wallace et al., 1989). In a similar line of reasoning, the diachronous forearc basin unconformities that occur in Middle to Upper Jurassic strata in the Queen Charlotte basin, Lower Cretaceous strata in south central Alaska, and in Upper Cretaceous strata in the Alaska Peninsula forearc basin also appear to indicate a south-to-north sequential collision (Finzel & Ridgway, 2017; Trop et al., 2002). Following south-to-north closure along the suture zone, the strata representing these ocean basins are interpreted to have been further disrupted by younger strike-slip displacement.

In contrast to the studies from south central and southwestern Alaska, geologic studies in southeastern Alaska, southwest Yukon, and coastal British Columbia have led other workers to suggest that Jurassic deformation represents accretion of the Wrangellia composite terrane against North America followed shortly thereafter by backarc opening and sinistral transtensional tectonics to form the Gravina-Nutzotin-Kahiltna basin system (Gehrels et al., 2009, 2017; McClelland et al., 1992; McClelland & Mattinson, 2000; Monger, 2014;

van der Heyden, 1992; Yokelson et al., 2015). In these interpretations, mid-Cretaceous shortening represents closure of a series of backarc basins (i.e., the Gravina-Nutzotin-Kahiltina basins). Distinguishing between backarc basin closure and open-ocean basin collision is a challenging problem in tectonic studies given that reconstructing the original extent of a now dismembered marine basin is difficult and that subsequent plutonism, deformation, and metamorphism obscure the history of the suture zone. In some ways, oblique south-to-north accretion of the Wrangellia composite terrane to the continental margin can accommodate many aspects of both interpretations; the southern part of the terrane may have accreted by Jurassic time, while the northern part of the terrane was still an oceanic arc system separated from the continental margin by an ocean basin. From this perspective, the modern Aleutian arc may be a useful modern analogue to consider for the Jurassic-Cretaceous configuration of the Wrangellia composite terrane. Along the Alaska Peninsula the present-day Aleutian arc is a continental arc built upon accreted terranes, but westward it transitions into an oceanic arc across the Aleutian Islands. Active collision of the Banda arc near Timor provides another analog for oblique collision and along-strike variations in tectonic processes. There, northeastern arc volcanoes and adjacent depocenters remain oceanic, while the southwestern segment of the arc actively collides with the northern edge of the Indo-Australian Plate, resulting in subaerial uplift of marine continental margin depocenters and contamination of oceanic volcanoes by continental crust (e.g., Harris, 2011).

Our new detrital zircon data, integrated with previous detrital zircon ages from Jurassic-Cretaceous forearc strata (Trop, 2008; Trop et al., 2005) and detrital zircon ages from Jurassic-Cretaceous accretionary prism strata (Amato et al., 2010, 2013), provide additional information for evaluating the accretionary history of the composite terrane. Collectively, the forearc and accretionary prism data sets reflect more complex detrital spectra through time, in response to erosion of progressively younger arc rocks coeval with continued erosion of remnant arc rocks (Figure 6). We interpret the presence of unconformities in the forearc basin strata together with a distinct change in forearc provenance from Jurassic oceanic arc to both Jurassic oceanic and Cretaceous continental arc sources as reflecting Late Jurassic-Early Cretaceous collision of the present-day, south central Alaska segment of the Wrangellia composite terrane (Figure 9). However, it is important to note that the detrital geochronologic data sets do not provide unequivocal evidence of sediment derived from inboard continental terranes. Sparse Paleozoic-Precambrian zircons in Upper Cretaceous forearc and accretionary prism strata may reflect minor contributions from inboard terranes that formed the former continental margin, but recent studies also show some evidence for Paleozoic-Precambrian sources in the Wrangellia composite terrane, including rocks potentially underlying the Talkeetna arc (e.g., Amato et al., 2007; Bacon et al., 2012; Rioux et al., 2007). In our interpretation, we infer that the topography of remnant oceanic arcs and deformed ocean basin strata within the suture zone (represented by area between LCF and UK in Figure 10d) prevented transport of significant continental detritus to the forearc region for an extended period of time during and following collision. Instead, continental-derived sediments were initially transported by orogen-parallel axial deposystems within the suture zone (e.g., Kalbas et al., 2007). Detrital geochronologic data indicate that even during Paleogene time, forearc depocenters were dominated by sediment derived from local magmatic arcs and recycled accretionary prism deposits (Kortyna et al., 2014). Not until well after terminal suturing of the Wrangellia composite terrane to the former continental margin did forearc depocenters start to receive significant continental detritus from inboard terranes. Published studies, for example, show that by Miocene-Pliocene time, interior rivers traversed dissected topography of the Wrangellia composite terrane and delivered abundant sediment eroded from source terranes inboard of the Wrangellia composite terrane, including the Yukon composite terrane (e.g., Bristol et al., 2017; Finzel et al., 2016, 2015).

6.4. Implications for Collisional Forearc Basin Systems

The southern Alaska convergent margin is the type example of the growth of continents by Mesozoic and Cenozoic collisional and accretionary processes (Coney et al., 1980; Jones et al., 1977; Plafker, 1987; Plafker & Berg, 1994). Within the trinity of the magmatic arc-forearc basin-accretionary prism elements that characterize the upper plate of convergent margins, forearc basins have the highest potential of providing a high-resolution record of collisional processes because they are the main areas of sediment accumulation and preservation (Dickinson, 1995). In this study, we utilize the detrital zircon record of Jurassic and Cretaceous forearc basin strata to provide insights on the growth of an oceanic arc and forearc basin

system, the collision and accretion of this arc to the continental margin, and the subsequent establishment of a new continental arc and forearc basin system.

Previous studies utilizing forearc basin strata to evaluate collisional processes are mainly limited to exhumed forearc basins preserved along the Transhimalayan arc-forearc accretionary prism system in northwestern India, Pakistan, and southern Tibet (Dürr, 1996; Draut & Clift, 2012; Einsele et al., 1994; Garzanti & Van Haver, 1988; Petterson, 2010; Orme et al., 2015, and references therein). These studies show that this forearc basin system contains a record of the transition from a continental arc located along the Asian continental margin and/or Lhasa terrane to subsequent collision with India. The forearc basin record of this collision is recorded by a regional unconformity (Ding et al., 2005) and/or uplift and erosion of the forearc basin strata (Orme et al., 2015). In the case of the Transhimalayan system, there is not a reestablishment of a new arc, probably due to the scale of it being a continent-to-continent collision compared to an oceanic arc-to-continent collision as in the case of the Mesozoic of the southern Alaska convergent margin.

Results of our study from southern Alaska along with the findings from the Transhimalayan forearc basin strata (Aitchison et al., 2011; Orme et al., 2015; Wu et al., 2010) indicate that detrital zircon geochronology of forearc basin strata may be an important tool for delineating timing of collisional events along convergent margins. In forearc basins, magmatism in the adjacent arc is often fairly continuous over geologic time scales (Dickinson, 1995), as demonstrated in our study by the progressively younger maximum depositional ages in each stratigraphically younger sample deposited in both the Jurassic oceanic forearc basin and the Cretaceous continental forearc basin of south central Alaska (Figure 9). Equally as important in our interpretation is the marked absence of detrital zircons with ages in the range from circa 140 to 120 Ma that we interpret along with other geologic data as marking the timing of collision of the Talkeetna arc and a hiatus in magmatism.

In general, the proximity of a high-relief igneous source of sediment (e.g., the volcanic arc) to a depositional sink (e.g., the forearc basin) should produce a relatively brief lag time between the magmatic crystallization age of zircons and deposition in the basin over geologic time scales. The combination of well-dated volcano-plutonic belts and U-Pb detrital geochronology of forearc basin and accretionary prism strata in orogens is a powerful approach because the igneous rocks provide the link to melting in the deeper levels of the upper plate, the forearc basin strata record the upper crustal and surface response to these processes in the upper plate, and the accretionary prism strata provide the connection to subduction zone processes of the lower plate.

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