Mesozoic and Cenozoic tectonic growth of southern Alaska:
A sedimentary basin perspective

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ABSTRACT

Mesozoic and Cenozoic sedimentary strata exposed throughout southern Alaska contain a rich archive of information on the growth of collisional continental margins through the processes of terrane accretion, magmatism, accretionary prism development, and subduction of oceanic spreading ridges. Two major collisional events define the tectonic growth of southern Alaska: Mesozoic collision of the Wrangellia composite terrane and Cenozoic collision of the Yakutat terrane. The sedimentary record of these two collisional events can be summarized as follows. (1) Middle Jurassic volcaniclastic and sedimentary strata represent shallow-marine deposition in narrow subbasins adjacent to the volcanic edifice of the south-facing, intraoceanic Talkeetna arc. (2) Late Jurassic syndepositional regional shortening resulted in thick sections of conglomerate in proximal parts of both retroarc and forearc basins. In distal retroarc depocenters, fine-grained turbidite sedimentation commenced in a series of basins that presently extend for >2000 km along strike. This time interval also marked cessation of magmatism and rapid exhumation of the Talkeetna oceanic arc. We interpret these observations to reflect initial oblique collision, younging to the northwest, of the Wrangellia composite terrane with the continental margin of western North America. (3) During Early Cretaceous time, Jurassic retroarc basin strata were incorporated into an expanding north-verging thrust belt, and sediment was bypassed into more distal collisional retroarc basins located within the suture zone. Compositional data from these collisional basins show that the Wrangellia composite terrane was exhumed to deep stratigraphic levels. Detrital zircon ages from strata in these basins record some sediment derivation from source areas with North American continental margin affinity. Our data clearly show that the Wrangellia composite terrane and the former continental margin were in close proximity by this time. Accretion of this oceanic terrane and associated basinal deposits marked one of the largest additions of juvenile crust to western North America. The collision of the Wrangellia composite terrane also resulted in a change in subduction parameters that eventually prompted development of a new south-facing arc system, the Chisana arc. Construction of this arc was contemporaneous with renewed forearc basin subsidence and sedimentation. (4) Late Early Cretaceous to early Late Cretaceous time was characterized by regional deformation of retroarc collisional basin strata by south-verging thrust faults that are part of a regional thrust belt that

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INTRODUCTION

Mesozoic and Cenozoic strata exposed throughout southern Alaska provide a detailed record of collisional continental growth through terrane accretion, sedimentation, magmatism, and accretionary prism development. The tectonic growth of southern Alaska is defined by two main collisional events. The first event, Mesozoic collision of the Wrangellia composite terrane, resulted in one of the largest additions of juvenile crust to the North American Cordillera margin. The second event, Cenozoic collision of the Yakutat terrane, an excised continental fragment of western North America, has generated the largest coastal mountain range on Earth. This paper synthesizes recent advances in our understanding of Mesozoic and Cenozoic depositional and structural processes in relation to these two major collisional events.

Keywords: Alaska, tectonics, sedimentary basins, Mesozoic, Cenozoic.
Mesozoic and Cenozoic time (e.g., Jones et al., 1977; Coney et al., 1980; Nokleberg et al., 2001). Three composite terranes make up most of south-central Alaska. From north to south, these include the Yukon, Wrangellia, and Southern Margin composite terranes (Fig. 1D; Pfafker et al., 1994; Nokleberg et al., 1994, 2001). The Yukon composite terrane consists of ductilely deformed and structurally dismembered Proterozoic-Paleozoic metamorphic rocks (Yukon-Tanana terrane) and arc-related rocks (Stikine terrane). Metamorphic rocks of the Yukon-Tanana terrane crop out in a suspect position, faulted between autochthonous or slightly displaced North American crust and outboard allochthonous terranes (e.g., Mortensen, 1992; Foster et al., 1994; Nokleberg et al., 1994, 2001; Hansen and Dusel-Bacon, 1998; Dusel-Bacon et al., 2004). The Yukon-Tanana and Stikine terranes were probably attached to inboard terranes by Middle Jurassic time (Mihalynuk et al., 1994; Monger and Nokleberg, 1996; Gehrels, 2001).

The allochthonous Wrangellia composite terrane, one of the largest accreted terranes in the North American Cordillera, is juxtaposed against both the southern margin of the Yukon composite terrane and smaller continental terranes (Dillinger, Nixon-Fork) along a regional suture zone (Fig. 1D). This suture zone is commonly referred to as the Alaska Range suture zone (Ridgway et al., 2002) or as the megasuture zone (Jones et al., 1982) and is characterized by complexly deformed sedimentary, igneous, and metamorphic rocks attributable to Jurassic-Cretaceous collisional processes. The Denali fault bisects the suture zone (Fig. 1D) and has accommodated up to 400 km of Late Cretaceous-Cenozoic right-lateral displacement (Eisbacher, 1976; Nokleberg et al., 1985; Lowey, 1998). The Wrangellia composite terrane consists of three allochthonous terranes (Peninsular, Wrangellia, and Alexander terranes) that crop out discontinuously from western Alaska to southern British Columbia (Pfafker and Berg, 1994; Nokleberg et al., 2001). The Alexander and Wrangellia terranes were joined together by Middle Pennsylvanian time (Gardner et al., 1988). These terranes were positioned ~20–30° south of their present latitude during Late Triassic time before being translated northward to Alaska (Pfafker et al., 1989; Hillhouse and Coe, 1994; Stamatakos et al., 2001). The Early to Late Jurassic Talkeetna arc, which is part of the Peninsular terrane, was either constructed upon the previously combined Paleoich-Triassic crust of the Wrangellia-Alexander terrane, or it collided with the combined Wrangellia-Alexander terrane sometime during Permian to Late Jurassic time (Nokleberg et al., 2001; Trop et al., 2005a; Rioux et al., 2005; Clift et al., 2005b). Thus, two different tectonic

Figure 1. (continued on following page) (A, B) Index maps showing location of study area (black rectangle) in south-central Alaska within the context of Jurassic-Cretaceous (A) and latest Cretaceous-Cenozoic magmatic belts (B). Note inboard (northward) migration of magmatism from Early Jurassic through Late Cretaceous time prior to trenchward (southward) retreat. Adapted from Pfafker et al. (1994). (C) Explanation of map units shown in Figure 1D. (D) Generalized geologic map showing Mesozoic-Cenozoic sedimentary basins, terranes, faults, magmatic belts, and major structural elements of interior south-central Alaska. Abbreviation: LOF, Little Oshetna fault; MC, McCarthy; T, Totschunda. Thin black lines define 1:250,000 quadrangles. Adapted from Wilson et al. (1998) and Bradley et al. (2003).
models 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 et al., 2005b) and (2) Late Jurassic-Early Cretaceous juxtaposition of the combined Wrangellia, Alexander, and Peninsular terranes against the former continental margin (Ridgway et al., 2002; Trop et al., 2002, 2005a).

The Border Ranges fault juxtaposes the outboard (southern) margin of the Wrangellia composite terrane against the northern edge of the Southern Margin composite terrane, which includes the Mesozoic Chugach terrane and the Cenozoic Prince William and Yakutat terranes (Fig. 1D). Interpreted as a paleo-subduction-zone thrust, the Border Ranges fault accommodated northward underthrusting of oceanic crust beneath the Wrangellia composite terrane during Early Jurassic to Late Cretaceous time (e.g., Pavlis, 1982; Pavlis and Roeske, this volume). Latest Cretaceous-Tertiary reactivation of the fault accommodated up to hundreds of kilometers of right-lateral displacements along the fault (e.g., Little and Naeser, 1989; Little, 1990; Pavlis and Crouse, 1989; Smart et al., 1996; Roeske et al., 2003; Pavlis and Roeske, this volume).

The Chugach and Prince William terranes consist of metamorphic rocks, mélange, and offscraped oceanic sedimentary and volcanic rocks interpreted as the products of a long-lived subduction complex (Plafker et al., 1994). The age of strata, degree of structural deformation, and grade of metamorphism decrease systematically southward across the subduction complex, indicating protracted northward subduction (Plafker et al., 1994). The age of strata, degree of structural deformation, and grade of metamorphism decrease systematically southward across the subduction complex, indicating protracted northward subduction (Plafker et al., 1994). From north to south, the Chugach terrane includes (1) spatially limited blueschist belts with Late Triassic to Early Jurassic metamorphic ages (Sisson and Onstott, 1986; Roeske et al., 1989, 1992); (2) mélange (McHugh-Uyak Complex) with Triassic to Upper Cretaceous fossils (Plafker et al., 1994)—structural and geochronologic relations indicate that most of the mélange is younger than ca. 125 Ma (Pavlis et al., 1988; Barnett et al., 1994); and (3) the Valdez Group, a marine metasedimentary unit that bears latest Cretaceous
fossils and latest Cretaceous-Paleocene uplift ages (Plafker et al., 1994; Sample and Reid, 2003; Clendenen et al., 2003). Juxtaposed against the southernmost strata of the Valdez Group is the Prince William terrane, which consists of offscraped Paleocene-Eocene marine sedimentary and volcanic rocks (e.g., Ghost Rocks Formation, Orca Group, Sitikalidak Formation, and Resurrection Peninsula ophiolite; Plafker et al., 1994).

The southernmost part of the Southern Margin composite terrane is characterized by the ongoing collision of the Yakutat terrane (Fig. 1D). The allochthonous Yakutat terrane is faulted against the southern margin of the Chugach and Prince William terranes along the Chugach-Saint Elias and Fairweather faults (Fig. 1D). The Yakutat terrane, a sliver of the western North American continental margin, has been transported along the outboard margin of the Cordillera during the past 30 m.y. (e.g., Plafker et al., 1978; Bruns, 1983; Plafker, 1987; Plafker and Berg, 1994). The Yakutat terrane was located along the coast of southeastern Alaska and British Columbia (Plafker et al., 1994) or the Pacific Northwest (Bruns, 1983) when the transform fault boundary between the Pacific and North American plates moved inboard (ca. 30 Ma). Relocation of the transform boundary initiated northward tectonic transport of the Yakutat terrane and subsequent collision along the southeastern margin of Alaska (Bruhn et al., 2004; Pavlis et al., 2004). Several hundred kilometers of the northern margin of the terrane are inferred to have been subducted beneath North America and the northeastern end of the Aleutian subduction zone. Plafker et al. (1994) suggested that most of the subducted crust was “typical” oceanic lithosphere, but a more recent seismic study indicates that the subducted crust may have been an oceanic plateau (Ferris et al., 2003). In the tectonic model proposed by Plafker (1987), the Yakutat terrane has been tectonically transported ~600 km to its present position by dextral displacement along the Queen Charlotte-Fairweather transform fault system. Tectonic transport started at ca. 30 Ma, and continued from 30 to 25 Ma, prompting subductions of ~225 km of the Yakutat terrane beneath southern Alaska. The oldest lavas of the Wrangell volcanic field in eastern Alaska (Fig. 1D) record initiation of arc magmatism above the subduction zone at ca. 26 Ma (Richter et al., 1990). At ca. 10 Ma, the buoyant continental part of the Yakutat terrane entered the subduction zone and was partially subducted and underthrust beneath the North American continental margin (Plafker, 1987; Ridgway et al., 1996). At ca. 5 Ma, an increase in the angle and rate of plate convergence prompted more orthogonal convergence (Engebretson et al., 1985) and a corresponding increase in the rate of underthrusting of buoyant continental crust of the Yakutat terrane beneath the margin of southern Alaska. This underthrusting is partly responsible for regional uplift of the Saint Elias Mountains, Chugach Mountains, and adjacent parts of Canada and Alaska (e.g., Plafker et al., 1994; Jaeger et al., 2001; Bruhn et al., 2004; Pavlis et al., 2004). Presently, the Yakutat terrane is moving 45–50 mm/yr northwest with respect to interior Alaska (Sauber et al., 1997; Fletcher and Freymueller, 1999) while being internally deformed, partly subducted beneath, and partly accreted to the North American plate (Bruhn et al., 2004; Pavlis et al., 2004).

Magmatic Belts

The composite terranes of southern Alaska are intruded and overlain by plutonic and volcanic rocks attributable to collisional orogenesis, subduction of oceanic lithosphere, and slab-window magmatism (e.g., Plafker et al., 1989; Richter et al., 1990; Nokleberg et al., 1994; Hudson, 1994; Cole et al., 1999, 2006, this volume; Bradley et al., 2000, 2003; Kelemen et al., 2003; Clift et al., 2005a, 2005b). Linear belts of Jurassic, Cretaceous, and Neogene igneous rocks exhibit geochemical characteristics that suggest emplacement mainly within subduction-related arcs (Figs. 1A, 1B). Arc rocks are dominated by plutons interpreted as the deeper roots of subvolcanic intrusive masses, although thick extrusive successions are also preserved locally (e.g., Cretaceous Chisana Formation, Jurassic Talkeetna Formation, Miocene-Quaternary Wrangell Lava). Geochronologic data document progressive inboard (northward) migration of magmatism from Early Jurassic to Late Cretaceous time (Talkeetna, Chisana, and Kluane arcs on Figures 1A, 1B; Plafker et al., 1989), prior to trenchward (southward) retreat during Cenozoic plate reorganization (Neogene Alaska-Aleutian and Wrangell arcs; Plafker et al., 1989; Mollo-Stalcup, 1994; Preece and Harte, 2004). Most workers attribute Jurassic-Neogene arc magmatism to north-dipping subduction (using present-day coordinates) based on age-equivalent subduction complex strata exposed south of the arc rocks (e.g., Plafker et al., 1989; Plafker and Berg, 1994; Ridgway et al., 2002; Clift et al., 2005b). 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. However, definitive age-equivalent subduction complex strata are not recognized north of the Jurassic arc rocks (Nokleberg et al., 1994). Moreover, Jurassic volcanic rocks yield spatial isotopic trends that support north-dipping subduction (Clift et al., 2005a).

Comprising a 1000-km-long outcrop belt from the eastern Copper River basin to the Alaska Peninsula, Lower to Upper Jurassic volcanic and plutonic rocks of the accreted oceanic Talkeetna arc young northward across the Peninsular terrane (Fig. 1A; Plafker et al., 1989; Nokleberg et al., 1994; Rioux et al., 2005). Upper Jurassic plutons also intrude the southern margin of Wrangellia from the eastern Copper River basin to southeastern Alaska (Chitina arc of Plafker et al., 1989), possibly representing an eastern extension of the Talkeetna arc (Trop et al., 2005a). The next major arc is represented by Lower Cretaceous volcanic and plutonic rocks that crop out along the inboard margin of the Wrangellia terrane for ~450 km from south-central to southeastern Alaska (Berg et al., 1972; Richter et al., 1975; Plafker et al., 1989; McClelland et al., 1992a). In south-central Alaska, igneous rocks associated with this arc are referred to as the Chisana arc (Fig. 1A), whereas correlative strata in southeastern Alaska are called the Gravina belt. No direct evidence suggests that Gravina-Chisana rocks depositionally overlap inboard terranes; the Denali fault juxtaposes these rocks against the Yukon-Tanana terrane. Upper Cretaceous-Paleocene plutonic and volcanic rocks (mainly 80–55 Ma) intrude both the Wrangellia and Yukon composite
tillines from western and central Alaska (Kuskokwim Mountains-Talkeetna Mountains belt of Moll-Stalcup, 1994) to eastern Alaska and British Columbia (Fig. 1B; Kluane arc of Plafker et al., 1989). Regional geologic data suggest that this arc formed after accretion of the Wrangellia composite terrane to inboard terranes (Plafker et al., 1989). Geochemical and lithologic characteristics of these rocks support emplacement within a continental-margin arc (Plafker et al., 1989; Moll-Stalcup, 1994).

Paleocene–Eocene volcanic rocks up to 3 km thick overlap the Wrangellia and Peninsular terranes from the southern Talkeetna Mountains to the central Alaska Range (Fig. 1D). Unlike Mesozoic igneous rocks of south-central Alaska, these strata crop out in a northwest-southeast-trending belt and yield geochemical signatures consistent with slab-window magmatism, probably in response to subduction of an oceanic spreading ridge (Cole and Stewart, 2005; Cole et al., 2006). Bisecting the outboard margin of the Wrangellia composite terrane, Miocene-Recent volcanic and plutonic rocks of the Aleutian-Wrangell arc (Fig. 1B) record subduction of the northern edge of the Pacific plate and the Yakutat terrane beneath the continental margin of southern Alaska (Richter et al., 1990; Moll-Stalcup, 1994; Preece and Hart, 2004).

EXHUMED AND ACTIVE SEDIMENTARY BASINS

In this section, we synthesize the characteristics of Mesozoic and Cenozoic sedimentary basinal strata of south-central Alaska. Figure 2 categorizes the basins in terms of their relationship to col-

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lision of the Wrangellia composite terrane and the Yakutat terrane and by their location in terms of being inboard (cratonward) or outboard (oceanward) with respect to the Wrangellia composite terrane. Refer to Figure 1D for the map location of basinal strata and Table 1 for details on formation names, ages, thicknesses, and lithologies. Space limitations prevent acknowledging all sources of data and interpretations. Cited references emphasize recent studies that contain more extensive bibliographies. Geologic time units are those of Palmer and Geissman (1999). Orientations of geologic and geographic features refer to present geographic coordinates.

**Inboard Margin Basins and Structures**

Mesozoic and Cenozoic sedimentary strata are discontinuously exposed along the inboard (northern) margin of the Wrangellia composite terrane in the Alaska Range, northern Talkeetna

**TABLE 1. SUMMARY OF MIDDLE JURASSIC-PLIOCENE SEDIMENTARY STRATA OF INTERIOR SOUTH-CENTRAL ALASKA**

<table>
<thead>
<tr>
<th>Basin/Formations</th>
<th>Age</th>
<th>Thickness</th>
<th>Common Lithologies</th>
<th>Depositional Environments</th>
<th>Inferred Basin Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cantwell Basin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Cantwell Fm.</td>
<td>Paleocene-Early Eocene</td>
<td>3000 m</td>
<td>Basalt, andesite, rhyolite, tuff, breccia</td>
<td>Subaerial volcanic eruptions</td>
<td>Successor/strike slip</td>
</tr>
<tr>
<td>Lower Cantwell Fm.</td>
<td>Campanian-Maastrichtian</td>
<td>4000 m</td>
<td>Conglomerate, sandstone, mudstone</td>
<td>Alluvial, fluvial, lacustrine</td>
<td>Thrust-top basin</td>
</tr>
<tr>
<td>Colorado Creek Basin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower member</td>
<td>Late Cretaceous</td>
<td>30 m</td>
<td>Sandstone, mudstone</td>
<td>Shallow marine shelf</td>
<td>Collisional basin*</td>
</tr>
<tr>
<td>Middle member</td>
<td>Early Oligocene</td>
<td>330 m</td>
<td>Conglomerate, sandstone, mudstone</td>
<td>Alluvial, fluvial, lacustrine</td>
<td>Continental strike slip</td>
</tr>
<tr>
<td>Upper member</td>
<td>Early Oligocene-Eocene (?)</td>
<td>55 m</td>
<td>Lava flows, tuff</td>
<td>Subaerial volcanic eruptions</td>
<td>Continental strike slip</td>
</tr>
<tr>
<td>Kahiltna Basin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kahiltna Assemblage</td>
<td>Valanginian-Cenomanian</td>
<td>&gt;3000 m</td>
<td>Mudstone, sandstone, limestone</td>
<td>Submarine fans</td>
<td>Remnant ocean basin</td>
</tr>
<tr>
<td>Caribou Pass Fm. (Talkeetna Mtns.)</td>
<td>Albian-Cenomanian</td>
<td>&gt;250 m</td>
<td>Sandstone, mudstone, conglomerate</td>
<td>Fluvial channels/floodplain</td>
<td>Collisional foreland*</td>
</tr>
<tr>
<td>Kahiltna Assemblage</td>
<td>Kimmeridgian-Albian</td>
<td>&gt;3000 m</td>
<td>Mudstone, sandstone, limestone</td>
<td>Submarine fans</td>
<td>Collisional foreland*</td>
</tr>
<tr>
<td>Nutzotin Basin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unnamed strata</td>
<td>Cretaceous(?)-Tertiary</td>
<td>90 m</td>
<td>Sandstone, conglomerate, tuff, coal</td>
<td>Sandy fluvial systems</td>
<td>Collisional foreland*</td>
</tr>
<tr>
<td>Chisana Fm.</td>
<td>Hauterivian-Aptian</td>
<td>3000 m</td>
<td>Lava flows, breccia, tuff</td>
<td>Subaerial volcanic eruptions</td>
<td>Collisional foreland*</td>
</tr>
<tr>
<td>Nutzotin Mtns. Seq.</td>
<td>Oxfordian-Valanginian</td>
<td>3000 m</td>
<td>Mudstone, sandstone, conglomerate</td>
<td>Submarine fans</td>
<td>Collisional foreland*</td>
</tr>
<tr>
<td>Tanana Basin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nenana Fm.</td>
<td>Pliocene</td>
<td>1040 m</td>
<td>Conglomerate, sandstone</td>
<td>Alluvial, braided fluvial</td>
<td>Retroarc foreland</td>
</tr>
<tr>
<td>Grubstake Fm.</td>
<td>Miocene</td>
<td>23-450 m</td>
<td>Laminated mudstone, sandstone</td>
<td>Lacustrine, fluvial</td>
<td>Retroarc foreland</td>
</tr>
<tr>
<td>Lignite Creek Fm.</td>
<td>Miocene</td>
<td>160 m</td>
<td>Conglomerate, sandstone, coal</td>
<td>Fluvial channels/floodplain</td>
<td>Retroarc foreland</td>
</tr>
<tr>
<td>Suntrana Fm.</td>
<td>Miocene</td>
<td>205 m</td>
<td>Sandstone, coal</td>
<td>Fluvial channels/floodplain</td>
<td>Retroarc foreland</td>
</tr>
<tr>
<td>Sanctuary Fm.</td>
<td>Miocene</td>
<td>30 m</td>
<td>Laminated mudstone</td>
<td>Lacustrine</td>
<td>Retroarc foreland</td>
</tr>
<tr>
<td>Healy Creek Fm.</td>
<td>Oligocene-Miocene</td>
<td>125 m</td>
<td>Sandstone, mudstone, coal</td>
<td>Fluvial channels/floodplain</td>
<td>Retroarc foreland</td>
</tr>
<tr>
<td>White Mountain Basin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unnamed strata</td>
<td>Late Oligocene</td>
<td>440 m</td>
<td>Conglomerate, sandstone, mudstone</td>
<td>Fluvial channels/floodplain</td>
<td>Continental strike slip</td>
</tr>
</tbody>
</table>

(continued)
### TABLE 1. SUMMARY OF MIDDLE JURASSIC-PLIOCENE SEDIMENTARY STRATA OF INTERIOR SOUTH-CENTRAL ALASKA (continued)

<table>
<thead>
<tr>
<th>Basin Position</th>
<th>Formation</th>
<th>Age</th>
<th>Thickness</th>
<th>Sediment Type</th>
<th>Environment/Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matanuska Valley-Talkeetna Mountains Basin</td>
<td>Tsadaka Fm.</td>
<td>Oligocene</td>
<td>200 m</td>
<td>Conglomerate, sandstone</td>
<td>Stream-dominated alluvial Remnant forearc</td>
</tr>
<tr>
<td></td>
<td>Wishbone Fm.</td>
<td>Eocene</td>
<td>1100 m</td>
<td>Conglomerate, sandstone, mudstone</td>
<td>Stream-dominated alluvial Remnant forearc</td>
</tr>
<tr>
<td></td>
<td>Arkose Ridge Fm.</td>
<td>Paleocene-Eocene</td>
<td>1600 m</td>
<td>Sandstone, mudstone, lava, tuff</td>
<td>Alluvial, fluvial, estuarine Remnant forearc</td>
</tr>
<tr>
<td></td>
<td>Chickaloon Fm.</td>
<td>Paleocene-Eocene</td>
<td>1500 m</td>
<td>Mudstone, sandstone, coal, tuff</td>
<td>Fluvial, lacustrine, estuarine Remnant forearc</td>
</tr>
<tr>
<td></td>
<td>Upper Matanuska Fm.</td>
<td>Campanian-Maastrichtian</td>
<td>2000 m</td>
<td>Sandstone, mudstone, conglomerate</td>
<td>Sandy submarine fans Forearc</td>
</tr>
<tr>
<td></td>
<td>Lower Matanuska Fm.</td>
<td>Albian-Santonian</td>
<td>500 m</td>
<td>Sandstone, mudstone, coal, tuff</td>
<td>Fluvial, shoreface, marine shelf Forearc</td>
</tr>
<tr>
<td></td>
<td>Nelchina Limestone</td>
<td>Valanginian-Barremian</td>
<td>200 m</td>
<td>Calcareous sandstone, mudstone</td>
<td>Calcareous marine shelf Forearc</td>
</tr>
<tr>
<td></td>
<td>Naknek Fm.</td>
<td>Oxfordian-Tithonian</td>
<td>700 m</td>
<td>Conglomerate, sandstone, mudstone</td>
<td>Marine fan-delta, slope, shelf</td>
</tr>
<tr>
<td></td>
<td>Chinitna Fm.</td>
<td>Bathonian-Callovian</td>
<td>300 m</td>
<td>Mudstone, sandstone, limestone</td>
<td>Marine shelf, slope Forearc</td>
</tr>
<tr>
<td></td>
<td>Tuxedni Fm.</td>
<td>Bajocian-Bathonian</td>
<td>150 m</td>
<td>Sandstone, mudstone, conglomerate</td>
<td>Shoreface, foreshore, shelf Forearc</td>
</tr>
</tbody>
</table>

| Wrangell Mountains Basin | Frederika Fm. | Middle to Late Miocene | 600 m | Sandstone, mudstone, tuff, cong. | Alluvial, fluvial, lacustrine Intra-arc |
|                         | MacColl Ridge Fm. | Campanian | 1150 m | Sandstone, cong., mudstone, tuff | Sandy submarine fans Forearc |
|                         | Chittu Fm. | Albian-Campanian | 1100 m | Mudstone, limestone, tuff | Submarine slope Forearc |
|                         | Schultzte Fm. | Albian-Cenomanian | 75 m | Siliceous mudstone, porcellanite | Marine shelf Forearc |
|                         | Moonshine Creek Fm. | Albian-Cenomanian | 1000 m | Sandstone, mudstone | Shoreface, foreshore, shelf Forearc |
|                         | Kennicott Fm. | Albain | 250 m | Sandstone, conglomerate, mudstone | Calcareous marine shelf Forearc |
|                         | Berg Ck./Kusk. Pass Fm. | Hauterivian-Barremian | 300 m | Calcareous sandstone, mudstone | Submarine slope/ fans Retroarc foreland |
|                         | Root Glacier Fm. | Oxfordian-Tithonian | 1100 m | Mudstone, sandstone, conglomerate | Fan-delta Retroarc foreland |
|                         | Kotsina Conglomerate | Kimmeridgian-Tithonian | 600 m | Conglomerate, sandstone | Submarine slope/ fans Retroarc foreland |
|                         | Nizina Mountain Fm. | Bathonian-Callovian | 250 m | Mudstone, sandstone, tuff | Marine shelf Backarc |

| Yakutat Basin | Yakataga Fm. | Miocene-Holocene | 5000 m | Sandstone, siltstone, diamicrite | Glacial marine Collisional foreland* |
|               | Poul Creek Fm. | Oligocene-lower Miocene | 2000 m | Sandstone, sandstone, tuff | Marine shelf Collisional foreland* |
|               | Kultheth, Stillwater, Token Fms. | Upper Paleocene Eocene | 3000 m | Sandstone, mudstone, coal | Fluvial-deltaic, shallow marine Continental margin |

*R: Regional arc magmatism partially overlapped with collisional orogenesis and deposition in these foreland basins

**W: Watana and MacCallum Creek basins are not listed due to paucity of stratigraphic/sedimentologic data

Key references for environmental and basin setting interpretations:
- Tanana - Wahrhaftig et al., 1969; Stevens, 1971; Butler and Triplehorn, 1976; Wolfe and Tanai, 1980; Selleck and Panuska, 1983; Stanley et al., 1991; Ager et al., 1994; Leopold and Liu, 1994; Ridgway et al., 1999a, 2002; Cantwell - Wolfe and Wahrhaftig, 1970; Gilbert et al., 1976; Ridgway et al., 1997; Cole et al., 1999; Kahitrus - Wallace et al., 1989; Csejtey et al., 1992; Eastham and Ridgway, 2002; O'Neill et al., 2003; Hampton et al., this volume; Kalsbe et al., this volume
- Nutzold - Berg et al., 1972; Richter, 1976; Manuszak and Ridgway, 1999; Manuszak et al., this volume; Colorado Creek - Csejtey et al., 1984, 1992; Trop et al., 2004; Matanuska Valley-Talkeetna Mountains - Clardy, 1974; Grantz, 1984; Little, 1988; Trop et al., 2003, 2005a, b; Trop, 2006
Mountains, and Mentasta-Nutzotin Mountains (Fig. 1D; Table 1). Strata crop out within a regional suture zone between accreted Mesozoic and older oceanic island-arc rocks of the Wrangellia composite terrane and Paleozoic and older continental margin rocks of the Yukon-Tanana terrane (e.g., Pavlis, 1982; Coney and Jones, 1985; Jones et al., 1982; Nokleberg et al., 1994; Wilson et al., 1998; Ridgway et al., 2002).

**Kahiltna Basin**

In south-central Alaska, the Kahiltna assemblage is exposed in a 100-km-wide and >300-km-long outcrop belt in the Alaska Range, and a 60-km-wide and 150-km-long outcrop belt in the northern Talkeetna Mountains (Fig. 1D; Eastham and Ridgway, 2002; Ridgway et al., 2002). Broad Pass, a major topographic lineament, separates the two Kahiltna outcrop belts. In the northern Talkeetna Mountains, the Kahiltna assemblage disconformably overlies Upper Triassic marine volcanic and sedimentary strata (Honolulu Pass Formation of Hampton et al., this volume). The Kahiltna assemblage in this area contains Kimmeridgian-Valanginian marine megafossils, but detrital zircon ages indicate that deposition extended at least into Albian time (Table 1; Hampton et al., 2005, this volume). In the northeasternmost Talkeetna Mountains, the Kahiltna assemblage is locally metamorphosed to kyanite-garnet schist and gneiss (Maclaren Glacier metamorphic belt; Nokleberg et al., 1985; Davidson et al., 1992). Albian-Cenomanian nonmarine sedimentary strata informally referred to as the Caribou Pass Formation overlie the Kahiltna assemblage in the northwestern Talkeetna Mountains (Hampton et al., 2003, this volume).

The Kahiltna assemblage in the Alaska Range is juxtaposed against the Yukon-Tanana terrane along the Denali and Hines Creek faults (Fig. 1D). The lower contact of the Kahiltna assemblage in the central Alaska Range has not been observed by the authors or by previous mapping studies. To the southwest in the western Alaska Range, however, the Kahiltna assemblage disconformably overlies Upper Triassic marine volcanic and volcaniclastic strata (Kalbas et al., this volume). Submarine-fan strata >5.5 km thick characterize the Kahiltna assemblage in the Alaska Range (Fig. 2; Eastham and Ridgway, 2002; Kalbas et al., 2003, this volume). The Kahiltna assemblage in the Alaska Range contains Valanginian-Cenomanian fossils. South of the Denali fault in the central Alaska Range, unnamed Santonian-Campanian marginal-marine strata and Oligocene nonmarine strata overlie the Kahiltna assemblage above an angular unconformity (Trop et al., 2004). North of the Denali fault, the Kahiltna assemblage is overlain by Campanian-Maastrichtian nonmarine and marginal-marine strata (lower Cantwell Formation; Figures 1D, 2; Ridgway et al., 1997).

**Nutzotin Basin**

Exhumed strata of the Nutzotin basin crop out in a 15- to 35-km-wide and 250-km-long belt in the Nutzotin and Mentasta Mountains of east-central Alaska (Fig. 1D; Richter, 1976; MacKevett, 1978). The basin fill consists of three stratigraphic units: a 3-km-thick Upper Jurassic-Lower Cretaceous sedimentary succession dominated by submarine-fan strata (Nutzotin Mountains sequence), a 3-km-thick Lower Cretaceous volcanic succession (Chisana Formation), and ~90 m of unnamed Paleogene (?) nonmarine sedimentary and volcaniclastic strata (Fig. 2; Table 1; Berg et al., 1972; Richter, 1976; Manuszak and Ridgway, 1999; Manuszak et al., this volume). South of the Totschunda fault, lowestmost strata of the Nutzotin Mountains sequence disconformably overlie Upper Triassic strata of the Wrangellia terrane. Throughout most of the outcrop belt, however, a north-dipping décollement or the Totschunda fault juxtaposes the Nutzotin Mountain sequence against the Wrangellia terrane (Manuszak, 2000; Manuszak et al., this volume). The Denali fault juxtaposes the Nutzotin Mountains sequence against metamorphic rocks of the Yukon-Tanana terrane along the northern boundary of the outcrop belt (Fig. 1D). Estimates of up to 400 km of Late Cretaceous-Cenozoic right-lateral displacement along the Denali fault are based partly on the interpretation that the Nutzotin Mountains sequence is laterally offset from the Dezadeash Formation, which is exposed in the Yukon Territory on the opposite (north) side of the fault (Eisbacher, 1976; Nokleberg et al., 1985; Lowey, 1998).

**Cantwell Basin**

The Cantwell basin is defined by the 45-km-wide and 135-km-long outcrop belt of the Cantwell Formation in the central Alaska Range (Fig. 1D). Two distinct lithologic units make up the Cantwell Formation, a >3-km-thick Upper Cretaceous (Campanian-Maastrichtian) sedimentary unit (lower Cantwell Formation; Figure 2; Ridgway et al., 1997) and a >3-km-thick Paleocene-Eocene volcanic unit (upper Cantwell Formation; Figures 2; Cole et al., 1999). Locally, an angular unconformity separates the sedimentary and volcanic units records a 10–20 m.y. hiatus (Cole et al., 1999). Nonmarine to marginal-marine strata of the lower Cantwell Formation disconformably overlie marine strata of the Kahiltna assemblages along a regional angular unconformity. The southern structural limit of the basin is defined by a series of south-dipping thrust faults that are truncated by the east-west-trending Denali fault (Ridgway et al., 1997). Northern basin margin strata of the Cantwell basin are juxtaposed against Paleozoic metamorphic rocks of the Yukon-Tanana terrane along the Hines Creek fault (Fig. 1D; Trop and Ridgway, 1997).

**Tanana Basin**

The Holocene Tanana basin, a 22,000 km² alluvial and swampy lowland, is located north of the Alaska Range and south of the Yukon-Tanana uplands (Fig. 1D). Large braided-stream systems flow transverse to the Alaska Range (Kantishna, Nenana, and Delta rivers) and merge into an axial drainage (Tanana River) oriented subparallel to the Alaska Range (Fig. 1D; Lesh, 2002; Lesh and Ridgway, this volume). Deposits of the Tanana basin include alluvial, fluvial, and lacustrine strata with a cumulative thickness >1.6 km (Usibelli Group, Nenana Gravel, and Quaternary surficial deposits; Figure 2; Table 1). The Usibelli Group and Nenana
Gravel crop out in a ~225-km-long and 30- to 50-km-wide outcrop belt in the northern foothills of the Alaska Range; correlative strata occupy the subsurface of the basin based on exploratory drillholes (Nenana #1 and Totek Hills #1 on Fig. 1D) and geophysical surveys (Stanley et al., 1990a; Ridgway et al., 2002, this volume). The Usibelli Group is >800 m thick and consists of five sedimentary formations with Late Eocene to Late Miocene age ranges, although the bulk of the strata are Miocene age (Fig. 2; Wolfe and Tanai, 1980; Leopold and Liu, 1994). North of the Hines Creek fault, an angular unconformity separates the Usibelli Group from underlying metamorphic rocks of the Yukon-Tanana terrane. South of the fault, spatially limited outcrops of the Usibelli Group overlie the Cantwell Formation along an angular unconformity (Csejtey et al., 1992; Thoms, 2000). Pliocene conglomerate up to 1200 m thick (Nenana Gravel) and Quaternary proglacial deposits overlie the Usibelli Group (Ridgway et al., 2002, this volume).

Northway Basin
The Holocene Northway basin is a fluvial and swampy lowland area of ~3000 km² located between the Wrangell-St. Elias Range to the south and the Yukon-Tanana uplands to the north (Fig. 1D). Proglacial braided rivers flow transverse to the Wrangell-St. Elias and Nutzotin-Mentasta ranges (Chisana and Nabesna rivers on Fig. 1D) and merge into an axial fluvial system (Tanana River on Fig. 1D) that drains the basin. Pleistocene-Holocene strata were deposited in alluvial, fluvial, eolian, and lacustrine environments (Richter, 1976). Basinal strata are less than 1000 m thick, overlie metamorphic rocks of the Yukon-Tanana terrane, and are juxtaposed against strata of the Nutzotin basin by the Denali fault (Fig. 1D; Richter, 1976; Kirschner, 1994).

Outboard Margin Basins
Jurassic-Miocene sedimentary basin strata are exposed along the outboard (southern) margin of the Wrangellia composite terrane in the Wrangell Mountains and in the Matanuska Valley-southern Talkeetna Mountains area (Fig. 1D). Correlative strata are preserved in the subsurface of the Holocene Susitna and Copper River basins (Fig. 1D) based on exploratory drillholes and gravity surveys. Cenozoic sedimentary basin strata are also exposed on the Yakutat terrane in the Robinson Mountains (Fig. 1D).

Matanuska Valley–Talkeetna Mountains Basin
The Matanuska Valley–Talkeetna Mountains basin consists of an ~90-km-long and 20- to 70-km-wide belt of Mesozoic-Cenozoic sedimentary strata that crop out in the Matanuska Valley, southern Talkeetna Mountains, and northern Chugach Mountains (Fig. 1D). Middle Jurassic-Upper Cretaceous marine strata >3800 m thick and Paleocene-Oligocene nonmarine strata >2900 m thick unconformably overlie Lower to Middle Jurassic igneous rocks of the accreted Talkeetna oceanic arc (Table 1; Grantz, 1964; Clardy, 1974; Fuchs, 1980; Little, 1988; Flores and Strickler, 1993; Trop and Ridgway, 1999; Trop et al., 2003, 2005a, 2005b; Trop and Plawman, 2006). The Border Ranges fault places southern basin margin strata in the hanging wall against the Chugach subduction complex in the footwall (Fig. 1D). Northernmost strata of this basin are juxtaposed against Jurassic arc plutons along the Little Oshetna fault (LOF on Figure 1D; Trop et al., 2005a). The Castle Mountain fault system bisects the basin (Fig. 1D).

Wrangell Mountains Basin
Strata of the Wrangell Mountains basin crop out in a ~55-km-wide and ~120-km-long belt in the Wrangell-Saint Elias Mountains and Chitina Valley (Fig. 1D). Basinal strata include >4500 m of Middle Jurassic-Upper Cretaceous marine sedimentary strata and >600 m of Miocene nonmarine sedimentary and volcanic strata (Fig. 2; MacKevett, 1978; Trop et al., 1999, 2002; Tidmore et al., 2005). These strata unconformably overlie the Wrangellia and Alexander terranes; they crop out north of Upper Jurassic arc rocks (Talkeetna-Chitina arc) and south of Lower to Upper Cretaceous arc rocks (Figs. 1A, 1D; Chisana and Klune arcs). Southern basin margin strata are faulted against the Chugach subduction complex along the Border Ranges fault (Fig. 1D). North of the Border Ranges fault, south-dipping thrust faults (Chitina thrust belt) juxtapose Jurassic arc rocks and the Wrangellia terrane against Jurassic sedimentary strata. Regional folds and the Totschunda fault separate northern basin margin strata of the Wrangell Mountains basin from the Nutzotin basin to the north. Strata of the Nutzotin and Wrangell Mountains basins record different depositional histories in separate depocenters (Trop et al., 2002; Manuszak et al., this volume).

Susitna Basin
The Holocene Susitna basin is a fluvial and swampy lowland of ~13,000 km² located between the Alaska Range on the north and west, the Talkeetna Mountains on the east, and Cook Inlet basin on the south (Fig. 1D). Modern glacially influenced fluvial systems (e.g., Susitna, Kahlitna, and Yentna rivers) flow southward from the Alaska Range and merge into a major trunk system (Susitna River) that drains into the upper Cook Inlet estuary. Considered a northern extension of Cook Inlet basin, the Susitna basin is bisected by the Castle Mountain fault (Haeussler, 1998; Haeussler et al., 2002). Exploratory drillholes and gravity surveys penetrate >4 km of Paleocene-Miocene conglomerate, carbonaceous sandstone, mudstone, and coal deposited in fluvial-lacustrine environments (e.g., Hackett, 1977; Merritt, 1986; Meyer et al., 1996; Meyer and Boggess, 2003b). Quaternary deposits up to 180 m thick record deposition in fluvial and glacial environments influenced by at least five Pleistocene glacial episodes (Karlstrom, 1964). Tertiary strata unconformably overlie a 4- to 6-km-thick succession of Mesozoic-Paleozoic sedimentary strata (Hackett, 1977).

Copper River Basin
The Holocene Copper River basin is a 4500 km² fluvial-lacustrine lowland that separates the Matanuska Valley-Talkeetna
Mountains and Wrangell Mountains basins (Fig. 1D). Eleven exploratory drillholes encountered up to 580 m of Tertiary strata and up to 1715 m of Upper Jurassic-Upper Cretaceous strata (Alaska Geological Society, 1970a, 1970b; Wilson et al., 1998). Maximum thicknesses of 1200 m and 7000 m are inferred for the Tertiary and Jurassic-Cretaceous sequences, respectively, based on seismic profiles (Fuis and Plafker, 1989), aeromagnetic data (Case et al., 1986; Meyer and Saltus, 1995), and gravity profiles (Andreasen et al., 1964; Barnes et al., 1994; Meyer and Bogess, 2003a).

**Yakutat Basin**

Sedimentary strata of the Yakutat basin depositionally overlie the Yakutat terrane and crop out in an ~50-km-wide and ~190-km-long belt in the Robinson Mountains along the southeastern coastline of Alaska (Figs. 1D, 2; Miller, 1961, 1971; Plafker, 1967, 1987; Winkler and Plafker, 1993). Cenozoic strata of the Yakutat basin include: (1) the Upper Paleocene-Eocene nonmarine to shallow-marine coal-bearing Kulthieth Formation and lateral submarine-slope facies equivalents (Stillwater and Tokun Formations) that locally exceed 3 km in thickness, (2) Oligocene-Lower Miocene marine and tuffaceous strata of the Poul Creek Formation (~2 km thick), and (3) Middle Miocene-Holocene glacial marine strata of the Yakataga Formation (up to ~5-km thick; Fig. 2; Table 1). These strata have been incorporated into a south-verging, thin-skinned fold-and-thrust belt attributable to underthrusting of the Yakutat terrane beneath the southern Alaska margin along the Chugach-Saint Elias fault (Fig. 1D; Bruhn et al., 2004).

**TECTONIC AND PALEOGEOGRAPHIC MODEL FOR BASIN DEVELOPMENT AND CONTINENTAL GROWTH**

This section summarizes our interpretation of the tectonic and paleogeographic development of southern Alaska, emphasizing the evolution of sedimentary basins and related syndepositional structures. Our interpretations build upon previous tectonic models (e.g., Plafker and Berg, 1994; Nokleberg et al., 2001) by incorporating the results of recent detailed investigations of sedimentary basins, syndepositional structures, and magmatic belts. Schematic paleogeographic reconstructions and cross sections summarizing key aspects of Mesozoic and Cenozoic tectonics and basin development are shown in Figures 3 and 4, respectively. These new figures emphasize our preferred tectonic interpretations based on the presently available geologic information; alternative interpretations are discussed within the text. Higher-resolution stratigraphic, geochronologic, and structural investigations are needed to develop more detailed palinspastic reconstructions. Some geologic events span the time range shown on specific maps and/or cross sections; that is, there is a continuum in some cases between distinct stages shown on Figures 3 and 4 and those discussed in the text. The time scale and absolute ages are from Palmer and Geissman (1999).

### Middle Jurassic (Bajocian-Callovian; 176–159 Ma):
**Intraoceanic Arc Construction and Sedimentation**

Middle Jurassic sedimentary strata accumulated in shallow-marine depocenters that fringed a south-facing oceanic island-arc (Talkeetna arc; Figs. 3A, 4A). An oceanic subduction setting is based on detailed geochemical and stratigraphic investigations of Jurassic arc-related igneous rocks (e.g., Burns, 1985; Plafker et al., 1989; DeBari and Coleman, 1989; DeBari and Sleep, 1991; Kelemen et al., 2003; Clift et al., 2005a, 2005b; Draut and Clift, 2006). North-dipping subduction is also indicated by the location of Jurassic arc rocks inboard (north) of age-equivalent (but poorly dated) north-dipping subduction complex strata (McHugh Complex on Figs. 3A, 4A; Plafker et al., 1994); moreover, geochemical data from arc rocks (Talkeetna Formation) also indicate northward reduction in subduction influences (Clift et al., 2005a).

In the Matanuska Valley-Talkeetna Mountains basin, Middle Jurassic sedimentary strata (Tuxedni and Chininita Formations) were deposited in a forearc setting (MB on Figs. 3A, 4A), outboard (south) of Middle to Upper Jurassic arc plutons and inboard (north) of the subduction complex and remnant Lower Jurassic arc plutons (Nokleberg et al., 1994; Trop et al., 2005a). In the southern Wrangell Mountains, the Middle Jurassic Nizina Mountain Formation records deposition in a backarc position, inboard (north) of Upper Jurassic arc plutons (WB on Figs. 3A, 4A; Chitina arc of Plafker et al., 1989; Roeske et al., 1989, 2003). Age-correlative strata were not deposited or are not preserved along the inboard (northern) margin of the Wrangellia composite terrane (Figs. 2, 3A, 4A).

In general, forearc and retroarc Middle Jurassic sedimentary strata exposed in the southern Talkeetna Mountains and Wrangell Mountains, respectively, were deposited in relatively low-gradient marine shelf environments based on sedimentological and paleontological data (Imlay and Detterman, 1973; Detterman et al., 1996; Kelemen et al., 1995; Clift et al., 2005b). Measured stratigraphic sections document mainly mudstone and sandstone along with sparse tuff, and conglomerate. Sandstone and conglomerate compositional data demonstrate that these strata contain mainly volcanic and minor plutonic lithic detritus, consistent with erosion of a partially dissected magmatic arc (Fig. 5A). Volcaniclastic sandstone from the southern Talkeetna Mountains yields zircons with exclusively Early to Middle Jurassic isotopic ages (Amato et al., this volume, chapter 11), overlapping isotopic ages of nearby Talkeetna arc rocks (Rioux et al., 2005). Sparse tuff interbedded throughout the section records intermittent volcaniclastic eruptions (Fig. 6A). The dominance of juvenile igneous detritus, localization of sediment accumulation within the Jurassic arc platform, and presence of primary volcanic strata are all consistent with Middle Jurassic sedimentation being related to erosion of adjacent oceanic arc rocks prior to collision with inboard terranes (Trop et al., 2002, 2005a; Clift et al., 2005b).

Middle Jurassic sedimentation in the Matanuska Valley-Talkeetna Mountains basin is also interesting because it is linked with a shift in the locus of arc magmatism. Arc plutons exposed
Figure 3. (continued on following pages)
Sketch maps showing the inferred paleogeographic evolution of the Wrangellia composite terrane and associated tectonic elements. See Figure 4 for companion paleotectonic cross sections. See Table 2 for explanation of abbreviations and patterns. Paleolatitudes are not shown due to uncertainty in the paleoposition of the Wrangellia composite terrane with respect to North America (see Cowan et al., 1997, for review). Current distance between the towns of Anchorage (#A) and McCarthy is ~390 km. See text for discussion.
Figure 3 (continued)

F 61-33 Ma
Late Paleocene-Eocene

Late Paleocene subduction complex (Valdez Group)

Magmatism (60-55 Ma; CB; 60-50 Ma; JV) within remnant collisional basins along suture zone attributable to remnant mantle wedge from earlier arc magmatism.

30°-60° rotation of southwestern Alaska

30°-60° rotation of southwestern Alaska

Arc magmatism (TK) until ca. 56 Ma.

Alluvial-fluvial-lacustrine deposition in southwestward-tilted, two-sided forearc basin (CIB). Detritus derived from former continental margin and uplifted marine collisional basin deposits (UKB).

Diachronous near-trench plutonism within subduction complex during northeastward subduction of spreading ridge oriented obliquely to trench.

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Alluvial-fluvial-lacustrine deposition (Healy Ck. Fm.) in Tanana foreland basin (TB), inboard of Denali fault (DF) and uplifted collisional basins (UCB, UKB).

Regional extensional dextral shortening along Denali fault (DF) prompts alluvial-fluvial-lacustrine deposition in narrow fault-bound basins (CCB, MCB).

Dextral transpressive shortening along Denali fault (DF) prompts uplift of Mesozoic collisional basins (UCB, UKB, UNB). Area of high seismicity and large earthquakes.

Continental arc magmatism in Aleutian-Alaska arc (43-30 Ma) and alluvial-lacustrine deposition (Hemlock Conglomerate, Tyonek Fm.) in Cook Inlet forearc basin. Continental arc magmatism in Alaskan arc (43-30 Ma).


Alluvial-fluvial-lacustrine deposition in remnant forearc basin (MB) coeval with oblique right-lateral displacement on Castle Mtn. fault (CMF).

Possible subsidence and nonmarine deposition in Copper River basin.

Uplifted Mesozoic subduction complex (CT). Possible subsidence and nonmarine deposition in Copper River basin.

Regional extensional dextral shortening along Denali fault (DF) prompts alluvial-fluvial-lacustrine deposition in narrow fault-bound basins (CCB, MCB).

Continental arc magmatism in Alaskan arc (43-30 Ma) and alluvial-lacustrine deposition (Hemlock Conglomerate, Tyonek Fm.) in Cook Inlet forearc basin. Continental arc magmatism in Alaskan arc (43-30 Ma).


Alluvial-fluvial-lacustrine deposition in remnant forearc basin (MB) coeval with oblique right-lateral displacement on Castle Mtn. fault (CMF).

Possible subsidence and nonmarine deposition in Copper River basin.

Uplifted Mesozoic subduction complex (CT). Possible subsidence and nonmarine deposition in Copper River basin.

Regional extensional dextral shortening along Denali fault (DF) prompts alluvial-fluvial-lacustrine deposition in narrow fault-bound basins (CCB, MCB).

Continental arc magmatism in Alaskan arc (43-30 Ma) and alluvial-lacustrine deposition (Hemlock Conglomerate, Tyonek Fm.) in Cook Inlet forearc basin. Continental arc magmatism in Alaskan arc (43-30 Ma).

immediately north of the Border Ranges fault yield Early Jurassic crystallization ages (ca. 201–181 Ma), whereas plutons exposed to the north in the Talkeetna Mountains yield Middle to Late Jurassic crystallization ages (ca. 177–156 Ma; Figures 1A, 3A, 4A; Clift et al., 2005b; Rioux et al., 2005). The northward shift in magmatism was coeval with the onset of Middle Jurassic sedimentation based on the oldest age-diagnostic fossils from the Tuxedni Formation (Fig. 2; Bajocian; ca. 177 Ma; Imlay, 1982, 1984). Middle Jurassic forearc basin strata unconformably onlapped marine volcanic strata of the remnant Lower Jurassic arc platform. Middle Jurassic northward migration of arc magmatism and deposition is attributable to shallowing of the subducting slab (e.g., Plafker et al., 1989) and/or tectonic removal of Lower Jurassic forearc strata by subduction erosion (Clift et al., 2005b).

Subduction shallowing and tectonic erosion may also account for the apparent absence of Jurassic forearc basin strata in the southern Wrangell Mountains region, where Upper Jurassic plutons are juxtaposed directly against the subduction complex (Fig. 1D). Inferred Lower to Middle Jurassic arc plutons and associated forearc basin strata in the Wrangell Mountains region are interpreted to have been tectonically removed via exhumation, strike-slip truncation, and/or subduction erosion (Figs. 3A, 3B; Pavlis et al., 1988; Plafker et al., 1989; Roeske et al., 1989, 1992; Trop et al., 2005a; Clift et al., 2005b).

Late Jurassic (Oxfordian-Tithonian; 159–144 Ma): Collisional Orogenesis and Oceanic Arc Exhumation

Regional basin development and coarse-grained sedimentation throughout southern Alaska commenced during Late Jurassic (Oxfordian-Kimmeridgian) time in response to shortening, uplift, and erosion of multiple structural levels of the Wrangellia composite terrane (Manuszak and Ridgway, 1999; Trop et al., 2002, 2005a; Eastham and Ridgway, 2002; Hampton et al., 2003, this volume; Manuszak et al., this volume). Early to Late Jurassic oceanic-arc magmatism ceased during latest Jurassic time, concurrent with crustal-scale shortening, exhumation, and coarse-grained sedimentation (Clift et al., 2005b; Amato et al., this volume, chapter 11; Figs. 3B, 4B). In the Wrangell Mountains, the Upper Jurassic Kotsina Conglomerate and Upper Root Glacier Formation record development of a thrust belt and narrow retroarc foreland basin inboard (north) of Jurassic arc plutons (Chitina thrust belt/CTB on Figures 3B, 4B). Conglomerate locally covers south-dipping faults within the thrust belt, recording Late...
Jurassic syndepositional thrusting (Figs. 6B, 7A; Trop et al., 2002). Deposition occurred on fan-deltas (Kotsina Conglomerate) that merged northward into submarine fans (Upper Root Glacier Formation). Compositional and detrital geochronologic data document exhumation of Upper Jurassic plutons and multiple structural levels of the Wrangellia terrane (Fig. 6C). Late Jurassic retroarc thrusting and synorogenic sedimentation along the Chitina thrust belt was coeval with regional downflexure and foreland basin development ~60–100 km inboard of Jurassic arc plutons in the Kahlitna and Nutzotin basins (KB, NB on Figure 3B; Manuszak, 2000; Manuszak et al., this volume; Eastham, 2002; Eastham and Ridgway, 2002; Hampton et al., 2003, this volume). Sedimentologic data indicate sediment flux away from the Wrangellia composite terrane. Paleocurrent and lithologic data document northward–to northwestward-directed sediment gravity flows on submarine fans in the Kahlitna basin of the northern Talkeetna Mountains (KB on Fig. 3B) and northward–to eastward-directed sediment gravity flows on submarine fans in the Nutzotin basin (NB on Fig. 3B). Paleocurrent, detrital geochronologic, and paleoslope data from correlative strata in the Yukon Territory (Dezadeash Formation) also indicate sediment flux away from the Wrangellia composite terrane (DB on Fig. 3B; Eisbacher, 1976; Lowey, 2006).

Rapid exhumation and coarse-grained sedimentation also characterized the outboard margin of the Wrangellia composite terrane during Late Jurassic time (Figs. 3B, 4B). In the Matanuska
Mesozoic and Cenozoic tectonic growth of southern Alaska

Valley-Talkeetna Mountains basin, coarse-grained successions from 800 to 3000 m thick were deposited in a forearc basin setting (Nuknek Formation; MB on Figure 3B), judging from their location between Middle to Upper Jurassic arc plutons to the north and Chugach subduction complex deposits to the south. Sedimentologic, compositional, and geochronologic data from the Upper Jurassic forearc strata indicate rapid exhumation of Middle to Upper Jurassic felsic plutons of the remnant Talkeetna arc (Fig. 5A; Detterman et al., 1996; Trop et al., 2005a; Clift et al., 2005a). Marine sediment gravity flows transported sediment southward on unstable, trenchward-dipping fan deltas (Figs. 6D, 7B). Exhumation and sedimentation may have been influenced by syndepositional displacement on arcward-dipping reverse faults, including the Bruin Bay and Little Oshetna faults (BLF on Figures 3B, 4B).

Two general tectonic models have been proposed to account for regionally extensive Late Jurassic shortening, exhumation, and sedimentation in south-central Alaska: (1) collision of the combined Wrangellia, Alexander, and Peninsular terranes with inboard terranes (i.e., Yukon-Tanana and Stikine; Nokleberg et al., 2001; Ridgway et al., 2002; Trop et al., 2002, 2005a) and (2) collision of the Talkeetna arc (Peninsular terrane) with the previously combined Wrangellia and Alexander terranes, prior to Cretaceous collision against inboard terranes (Clift et al., 2005a, 2005b). A potential weak point in the latter model is that the Peninsular and Wrangellia terranes appear to have a shared history prior to the proposed collision event. For example, cross-cutting intrusions demonstrate amalgamation of the Wrangellia and Alexander terranes by Middle Pennsylvanian time (Gardner et al., 1988), and overlap assemblages link the Peninsular and Wrangellia terranes by Late Jurassic time (Plafker et al., 1989; Trop et al., 2005a). In addition, the Wrangellia and Peninsular terranes apparently contain lithologically similar Permian-Triassic strata, indicating a potentially longer shared
**A**

Upper Jurassic Naknek Fm.  n=1,339

- **G**: metabasalt
- **L**: limestone
- **C**: chert
- **Q**: quartz
- **P**: granite/diorite
- **O**: other
- **V**: fine-grained volcanic

LA-ICPS-MS zircon ages (n=71)
Northern Talkeetna Mountains
Youngest detrital zircons = 74-75 Ma

**B**

Upper Nutzotin Mtns. Sequence
(Lower Cretaceous; n=102)

- **G**: metabasalt
- **L**: limestone
- **C**: chert
- **Q**: quartz
- **P**: granite/diorite
- **O**: other
- **V**: fine-grained volcanic

SHRIMP-RG zircon ages (n=81)
Matanuska Valley
Matanuska Formation (sandstone)
Maastrichtian fossils and zircons
Youngest detrital zircon = 72-71 Ma

**C**

Kahiltna Assemblage
410 m above base
n=142

- **L**: limestone
- **V**: volcanic
- **A**: argillite
- **C**: chert
- **S**: siltstone

**D**

LA-ICPS-MS zircon ages (n=71)
Northern Talkeetna Mountains
Youngest detrital zircons = 74-75 Ma

**E**

Cantwell Fm. Northern basin margin

- **Q**: quartz
- **C**: chert
- **N**: Nenana Gravel

**F**

Percent (%)

- **G**: metabasalt
- **L**: limestone
- **C**: chert
- **Q**: quartz
- **P**: granite/diorite
- **O**: other
- **V**: fine-grained volcanic
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history between the two terranes (Plafker et al., 1989; Nokleberg et al., 1994). A potential weak point of the first model is that detritus with unequivocal affinity with inboard terranes has not been documented in the Upper Jurassic stratigraphy of sedimentary basins exposed along the inboard margin of the Wrangellia composite terrane (i.e., Kahlitna, Nutzotin, and Dezadeash basins). If the Wrangellia composite terrane did not interact with inboard terranes until Cretaceous time, Upper Jurassic basinal deposits within the suture zone should lack abundant metamorphic detritus as well as >900 Ma detrital zircon grains, features diagnostic of sediment contribution from inboard terranes (i.e., Yukon-Tanana terrane). These types of provenance indicators are common in Lower Cretaceous strata of the Gravina and Kahlitna basins (Kapp and Gehrels, 1998; Kaltbas et al., this volume; Hampton et al., 2005, this volume). Unfortunately, detrital zircon analyses have yet not been reported from Upper Jurassic strata of the inboard basins. In either tectonic model, collision of the Wrangellia composite terrane was likely time-transgressive, starting in southeastern Alaska and progressing northward to south-central Alaska (Pavlis, 1982; McClelland et al., 1992a; Ridgway et al., 2002; Trop et al., 2005a). Whereas initial collision of the south-central Alaska segment of the composite terrane took place sometime during Late Jurassic-Cretaceous time, geologic relations in southeastern Alaska and western Canada indicate close proximity of the composite terrane with the outboard margin of the Yukon-Tanana and Stikine terranes by Middle Jurassic time (e.g., McClelland and Gehrels, 1990; McClelland et al., 1991; van der Heyden, 1992, Kapp and Gehrels, 1998; Saleeby, 2000; Gehrels, 2001).

Early Cretaceous (Berriasian-Aptian; 144–112 Ma): Diachronous Suturing and Collisional Basin Development

Lower Cretaceous strata on both the inboard and outboard margins of the Wrangellia composite terrane continued regional shortening, cessation of arc magmatism, and erosion/recycling of older marine basinal strata (Fig. 3C; Ridgway et al., 2002; Trop et al., 2002, 2005a; Clift et al., 2005b). Outboard of Middle to Upper Jurassic plutons in the Talkeetna Mountains, for example, a regional disconformity separates the Naknek Formation from the overlying Nelschina Limestone and unnamed strata (Fig. 2). This forearc basin unconformity marks subaerial uplift and partial erosion of Jurassic marine forearc basin strata. Inboard of Jurassic plutons in the Wrangell Mountains, northward propagation of shortening in the Chitina thrust belt prompted subaerial uplift and erosion of proximal retroarc Jurassic strata (Figs. 3C, 4C, 8D; Trop et al., 2002). Shortening and uplift within the Chitina thrust belt was coeval with continued subsidence and submarine-fan deposition along the inboard margin of the terrane in the Kahlitna and Nutzotin basins (Figs. 6E and 6F). Upsection variations in clast composition in these basins record progressive unroofing of sedimentary and volcanic rocks of the Wrangellia composite terrane (Figs. 5B and 5C; Manuszak and Ridgway, 1999; Eastham and Ridgway, 2002; O’Neill et al., 2003; Ridgway et al., 2002). Detrital zircons from Lower Cretaceous sandstone of the Nutzotin basin yield Late Jurassic isotopic ages (Manuszak, 2000; Manuszak et al., this volume) that are consistent with ages reported from plutons to the south that had been incorporated into the Chitina thrust belt (Chitina segment of Talkeetna-Chitina arc; Plafker et al., 1989; Roeseke et al., 1992, 2003). Similarly, Kahlitna assemblage sandstone exposed in the northern Talkeetna Mountains yields Middle to Late Jurassic detrital zircons that match zircon ages from plutons exposed south of the basin (Talkeetna segment of the Talkeetna-Chitina arc; Hampton et al., 2005, this volume; Rioux et al., 2005). We attribute regional shortening, subaerial uplift of Jurassic marine depocenters, exhumation of Jurassic plutons, and voluminous clastic sedimentation in the Nutzotin and Kahlitna basins as the product of collision of the Wrangellia composite terrane with inboard terranes. Alternatively, collisional orogenesis and sedimentation have been interpreted to reflect accretion of the Peninsular terrane with the previously combined Wrangellia and Alexander terranes, as discussed in the previous section. We, in contrast, interpret the >2000-km-long belt of siliciclastic detritus represented by the Kahlitna, Nutzotin, and Gravina basins, as well as the detrital zircons with “continental margin” ages in these strata, as more indicative of a regional collisional event along the former continental margin rather than a localized collision between terranes.

During late Early Cretaceous time, magmatism was reestablished ~30–50 km northward of remnant Jurassic arc plutons...
Figure 6. (A) Tuffs in the Middle Jurassic Nizina Mountain Formation of the Wrangell Mountains basin. White arrows point to thin-bedded tuffs that are interbedded with fine-grained sandstone and bioturbated mudstone. These strata were deposited in a retroarc basin inboard of Jurassic arc plutons. Person lower left for scale. (B) Upper Jurassic syndepositional thrust of the Chitina thrust belt (black barbed line) with Triassic Nizina Lime-
stone (Trn) in the hanging wall and Upper Jurassic Kotsina Conglomerate (Jk) in the footwall. Locally, the Kotsina Conglomerate covers similar
thrust faults in the China thrust belt (See Figure 7A). Black circle and arrow point to person for scale. Tadpole symbols indicate bedding orientation.  
(C) Kotsina Conglomerate in the Wrangell Mountains retroarc basin indicates exhumation of multiple stratigraphic levels of the Wrangellia terrane
coeval with displacement along the Chitina thrust belt. Clast types: L = limestone, G = granite, M = metabasalt (greenstone). Hammer for scale.  
(D) Upper Jurassic coarse-grained strata (Naknek Formation) of the Matanuska Valley-Talkeetna Mountains basin. These strata record exhumation
of the Talkeetna arc and deposition of marine sediment gravity flows in proximal forearc depositional environments. (E) Lower Cretaceous sand-
stone and mudstone of the Kahiltna assemblage in the western Alaska Range near the Farewell Lake area. These strata contain detrital zircons that
have ages indicating derivation from continental margin strata of the Yukon-Tanana terrane as well as from remnant arc rocks of the Wrangellia com-
posite terrane. Tadpole symbols show dip of bedding. (F) Close-up of the Kahiltna assemblage of the Kahiltna basin exposed in the northwestern
Talkeetna Mountains. Alternating beds of sandstone (lighter color) and mudstone (darker color) are interpreted as submarine-fan strata. Hammer for
scale (white box).
(Figs. 3C, 4C). Northward migration of magmatism is consistent with shallowing of the subducting slab (Plafker et al., 1989) and/or tectonic erosion/removal of forearc crust. In south-central Alaska, construction of the Chisana arc is recorded in the Nutzotin basin by an upsection transition from marine sedimentary strata (Nutzotin Mountains sequence) to ca. 130–113 Ma marine volcanic strata of the Chisana Formation (Figs. 1A, 2, 8A; Berg et al., 1972; Short et al., 2005); coeval felsic plutons crop out in the eastern Alaska Range and Nutzotin Mountains (e.g., Richter, 1976). Chisana Formation lavas and spatially associated granitic intrusions exhibit geochemical traits, particularly initial Nd and Sr isotopic compositions, consistent with a subduction petrogenesis in which recycling of continental crust was minimal (Barker, 1988; Snyder and Hart, 2002, 2005, this volume; Short et al., 2005). Instead, source materials responsible for the production of magmas are limited to the depleted mantle wedge above the subducting plate (Snyder and Hart, 2005, this volume; Trop et al., 2005b). Sandstone detrital modes are attributable to Late Jurassic-Early Cretaceous deformation (Trop et al., 2002, 2005a). Conglomerate along the southern margin of the Chitina Valley contains diagnostic red chert and black argillite clasts that are consistent with local subaerial uplift and erosion of the Chugach accretionary prism by this time range locally. Renewed volcanism and marine deposition documented in south-central Alaska may have been equivalent to the post-collisional, transtensional setting inferred for age-equivalent basinal strata in southeastern Alaska (e.g., Gehrels and Saleeby, 1985; McClelland et al., 1992a; Monger et al., 1994).

Late Early Cretaceous sedimentation and arc magmatism overlapped with accretion of the McHugh Complex mélangé in the Chugach subduction complex and emplacement of 125–115 Ma near-trench intrusive rocks along the Border Ranges fault (e.g., Pavlis et al., 1988; Barnett et al., 1994; Bradley et al., 2000). These rocks are currently located >100 km trenchward (southward) of the contemporaneous subduction-related arc rocks (Chisana arc). Emplacement of this near-trench intrusive suite was synchronous with southward thrusting of the Wrangellia composite terrane against the subduction complex along the Border Ranges fault (Pavlis et al., 1988). Previous workers attribute near-trench magmatism to shallow melting of metamorphic rocks along the juvenile subduction zone or slab-window magmatism associated with subduction of an oceanic spreading ridge (Barnett et al., 1994). We suggest that the regional unconformity spanning ca. 130–115 Ma in forearc basal strata from the Matanuska Valley to the Wrangell Mountains may record subduction of this oceanic spreading ridge. Stratigraphically, this unconformity is defined by late Early Albian and younger marine sedimentary strata (Kennicott and Matanuska Formations on Fig. 2) that unconformably overlie Berriasian marine sedimentary strata (Kuskalana Pass and Nelchina Formations). We interpret this unconformity as potentially recording uplift of the forearc region concurrent with the thrusting and near-trench magmatism along the Border Ranges fault. Subduction of progressively more buoyant, topographically higher lithosphere (the spreading ridge) followed by less buoyant, topographically lower lithosphere could have prompted initial uplift of the forearc basin floor (Aptian to Early Albian unconformity) followed by extension, subsidence, and renewed marine sedimentation (Kennicott and lower Matanuska Formations; Fig. 2).

Early Cretaceous to Late Cretaceous (Albian-Santonian; 112–83 Ma): Diachronous Subaerial Uplift of Suture Zone

Continued Late Cretaceous oblique suturing of the Wrangellia composite terrane to the continental margin prompted diachronous shortening and subaerial uplift of marine foreland basins positioned along the inboard margin of the composite terrane. In the eastern Alaska Range, marine strata of the Nutzotin basin were deformed by southwest-verging folds and thrust faults that sole into a basin-wide décollement (Figs. 3D, 4D, 9A; Manuszak, 2000; Manuszak et al., this volume). These deformed strata are intruded by undeformed plutons with 117–105 Ma K-Ar ages (e.g., Richter, 1976; Manuszak et al., this volume). Concurrently, retrograde metamorphism and development of a regional anticlinorium occurred along the southern margin of the Yukon-Tanana from ca. 115–106 Ma (Fig. 4D; Nokleberg et al., 1992; Ridgway et al., 2002). South- to southwest-verging asymmetric folds within the metamorphic zone indicate southward thrusting (Nokleberg et al., 1992), consistent with the structural vergence in strata of the nearby Nutzotin basin (Figs. 4D, 9A).

Coeval with shortening and uplift of the Nutzotin basin, marine sedimentation continued to the northwest in the Kahltna basin through Late Albian-Cenomanian time (Fig. 3D; Csejtey et al., 1982; Hampton et al., 2003, this volume; Kalbas et al., 2003, this volume). Albian-Cenomanian sedimentation in the Kahltna basin was characterized by sediment input from both metamorphic rocks of the former continental margin and oceanic rocks of...
Figure 7. Cross sections showing key structural relations from sedimentary basins along the outboard margin of the Wrangellia composite terrane. See Figure 1D for locations of cross sections. (A) Structural cross section through part of the Chitina thrust belt in the Wrangell Mountains. Upper Jurassic Kotsina Conglomerate (Jk) is exposed in the footwall of thrust faults and locally covers thrust faults (inset), indicating syntectonic displacement (from Trop et al., 2002). WT—Wrangellia terrane. (B) Geologic cross section showing faulted northern margin of the Matanuska Valley-southern Talkeetna Mountains basin. Northwest-dipping Little Oshetna fault juxtaposes Jurassic arc-related igneous rocks (PT) against conglomerate of the Upper Jurassic Naknek Formation (Jn) and underlying Middle Jurassic Chinuita Formation (Jc). Proximal conglomerate consists of volcanic and plutonic clasts with isotopic ages that match the age of igneous rocks exposed north of the fault. Proximal fan-delta conglomerate merges southward into distal prodelta sandstone and mudstone (from Trop et al., 2005a). (C) Cross section showing angular unconformity between the Lower Cretaceous Kennicott Formation (black bed) and folded Upper Triassic-Lower Jurassic strata of the Wrangell Mountains basin and Wrangellia terrane (WT). Note relative southward thickening of the Kennicott (black bed) and Chititu (Ks) Formations across southward-dipping normal faults (from Trop et al., 2002). (D) Cross section through the Castle Mountain fault along the northern part of the Matanuska Valley-Talkeetna Mountains basin. Note that immediately south of the Castle Mountain fault, attitudes of beds decrease progressively upsection (from $-80^\circ$ to $10^\circ$), and a distinct angular unconformity separates the Eocene Wishbone Formation (Tw) from overlying Tertiary volcanic strata (Tv; from Trop et al., 2003).
the Wrangellia composite terrane (Eastham, 2002; Hampton et al., 2005, this volume; Kalbas et al., 2003, this volume). Evidence of sediment contribution from the Wrangellia composite terrane comes from detrital zircon peaks in sandstone of the Kahiltna assemblage in the Alaska Range that are consistent with age data from magmatic belts exposed south of the Kahiltna basin, including the Cretaceous Chisana arc (Snyder and Hart, 2002, this volume; Short et al., 2005), Jurassic Talkeetna arc (Rioux et al., 2005), and Upper Triassic igneous rocks (Nikolai Greenstone; Nokleberg et al., 1994). All of these igneous successions are part of the Wrangellia composite terrane. Evidence for sediment contribution from the former continental margin includes detrital zircon grains >900 Ma in sandstone of the Kahiltna assemblage that are interpreted as reflecting erosion of Precambrian-Paleozoic source terranes (e.g., Yukon-Tanana, Dillinger, and Pingston terranes), which are spatially limited to regions north of the Kahiltna basin. In addition, limestone clasts in conglomerate of the Kahiltna assemblage contain Paleozoic conodonts that are correlative with conodont assemblages from inboard terranes with continental affinities (Ridgway et al., 2002). Limited paleocurrent indicators and facies transitions from strata of the Kahiltna basin exposed in the Alaska Range are consistent with axial (southwestward-directed) sediment transport coeval with oblique closure of the basin and development of topographic relief along the suture zone between the Yukon-Tanana and Wrangellia composite terranes (Fig. 3D; Eastham, 2002; Eastham and Ridgway, 2002; Ridgway et al., 2002; Kalbas et al., 2003, this volume).

Strata of the Kahiltna basin were shortened, subaerially exposed, and possibly partially underthrust beneath the Yukon-Tanana terrane during Cenomanian-Campanian time. In the northern Talkeetna Mountains, Albian-Cenomanian nonmarine strata overlie marine strata of the Kahiltna assemblage (Caribou Pass formation on Figures 2, 8C; Hampton et al., this volume). Farther north, Coniacian-Campanian marginal-marine strata (lower member of Colorado Creek basin on Fig. 2) overlie deformed marine strata of the Kahiltna assemblage along a prominent angular unconformity (Fig. 8B, 9D; Trop et al., 2004). North of the Denali fault, nonmarine strata of the Campanian-Maastrichtian lower Cantwell Formation overlie folded marine strata of the Kahiltna assemblage along an angular unconformity (Ridgway et al., 1997).

Regional late Early to early Late Cretaceous shortening and subaerial uplift of the Kahiltna and Nutzotin basins of south-central Alaska may be part of a regional thrust belt that extends southeastward to the state of Washington (e.g., Rubin et al., 1990; Manuszak et al., this volume). This thrust belt is defined by a series of inboard- (northward- and eastward-) dipping thrust faults that juxtapose Upper Jurassic-Upper Cretaceous marine basinal strata above the Wrangellia composite terrane. In south-central Alaska for example, marine strata of the Gravina belt were imbricated and underthrust to relatively deep crustal levels (~25–30 km) beneath the Yukon-Tanana terrane, starting at ca. 113–98 Ma and ending ca. 90 Ma (McClelland et al., 1992b; Haeussler, 1992). Similarly, interpretations of seismic refraction and magnetotelluric data across the central Alaska Range suggest that the Kahiltna assemblage and Wrangellia terrane have been underthrust beneath the Yukon-Tanana terrane (Stanley et al., 1990b; Beaudoin et al., 1992).

Regional deformation of sedimentary basins along the inboard margin of the Wrangellia composite terrane was coeval with renewed sediment accumulation in outboard basins (WB, MB on Figure 3D; KF, MCF, SF, CF on Figure 4D). Apparently, southward thrusting and uplift along the suture zone of the Wrangellia composite terrane enhanced subsidence and southward sediment delivery to forearc depocenters. In the Wrangell Mountains basin, sandy shoreface and inner shelf environments (northernmost exposures of the Kennicott and Moonshine Creek Formations) merged southward with muddy outer shelf environments (Fig. 7C; Schultz Formation and southern exposures of the Moonshine Creek Formation) and submarine slope environments that were influenced by normal faults (Chititu Formation; Trop et al., 2002). In the Matanuska Valley Talkeetna Mountains basin, strata of the lower Matanuska Formation record deposition in swampy fluvial, shoreface, shelf, and slope depositional environments (Fig. 3D, 8E; Grantz and Jones, 1960, 1967; Trop and Plawman, 2006).

Late Cretaceous (Campanian-Maastrichtian; 83–68 Ma): Post-collisional Suturing and Continental-Margin Arc Construction

Latest Cretaceous basinal strata provide a regional sedimentary record of Cretaceous continental-margin arc construction related to northward subduction of oceanic crust beneath southern Alaska (Figs. 3E, 4E). Coalescing 80–60 Ma plutons and subordinate volcanic rocks occupy an outcrop belt up to 150 km wide and >3000 km long, comprising the Alaska Range-Talkeetna Mountain magmatic belt in south-central Alaska, Kluane arc in eastern Alaska-Yukon Territory, and Coast arc in western Canada (Fig. 1B; Wallace and Engebretson, 1984; Pflaeker et al., 1989; Moll-Stalcup, 1994; Nokleberg et al., 2001). Latest Cretaceous Continental-Margin arc rocks stitch accreted oceanic terranes (Wrangellia composite terrane) and the former continental margin (Yukon composite terrane). Geochemical compositions from the Upper Cretaceous igneous rocks are typical of continental-margin arc rocks (Moll-Stalcup, 1994). Construction of the continental-margin arc was contemporaneous with rapid expansion of the Chugach accretionary prism in response to accretion of extensive submarine slope/fan deposits via north-directed subduction beneath the continental margin (Valdez Group on Figures 1D, 4E; Pflaeker et al., 1994). Stratigraphic data indicate that the main phase of accretionary prism growth took place during Early Maastrichtian time, probably over a time interval of less than four million years (Sample and Reid, 2003). Petrographic and geochemical data from Late Cretaceous accretionary prism strata, including Nd isotopic compositions, indicate that they were derived from a recycled oceanic component of Proterozoic rocks, as well as continental-margin volcanic arc sources (Sample and Reid, 2003).

Forearc depocenters, positioned between the accretionary prism to the south and continental-margin arc to the north, were characterized by submarine sediment-gravity flows and mass-slides in the Matanuska Valley (upper Matanuska Formation on Figures 2,
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8F) and Wrangell Mountains (MacColl Ridge Formation on Figures 2, 8G). Isotopic ages from interbedded tuff and detrital zircon ages from sandstone demonstrate that forearc basin detritus was derived from the coeval continental-margin arc and remnant accreted arcs. Synvolcanic detritus is evidenced by numerous thin- to thickbedded tuffs, sandstone with embayed quartz, feldspar laths, and volcanic lithic grains, and detrital zircon grains that overlap in age with source terranes exposed inboard of the basin, including coeval and remnant arc rocks (Fig. 5D; Trop et al., 1999, 2005b; Trop and Plawman, 2006). Conglomerate compositional data and Jurassic-Early Cretaceous detrital zircons indicate contribution from remnant magmatic belts as well (Talkeetna-Chitina, Chisana arcs; Fig. 5D). Subsidegence of the forearc region into deeper-water settings may reflect flexural subsidence of the forearc under the growing load of the Chugach accretionary prism, which expanded markedly during latest Cretaceous time (Plafker et al., 1994); isostatic subsidence under the growing sediment load, which added >4 km to the bathymetry of Late Cretaceous time; and thermochronometric data. Although the forearc region history is presently hampered by a lack of reliable constraints on key parameters known to influence forearc basin subsidence, including changes in thickness of the subduction complex, changes in the thermal regime of the arc region, and variations in the buoyancy of the subducting oceanic slab (Dickinson, 1995).

Within and inboard of the Alaska Range-Talkeetna Mountains segment of the latest Cretaceous continental-margin arc, the suture zone between the Wrangellia composite terrane and inboard terranes was characterized by deformation and exhumation of marine basinal strata and deposition of coarse-grained nonmarine strata (Pass Creek strata). Deformation of marine strata culminated with metamorphism within the Maclaren Glacier metamorphic belt and Valdez Creek shear zone (VCS on Figures 3E, 4E, 9B; Csejty et al., 1982; Nokleberg et al., 1985; Davidson et al., 1992; Ridgway et al., 2002). A >1000-m-thick succession of conglomerate and sandstone exposed within the Valdez Creek shear zone records erosion of coeval, continental arc rocks, as well as remnant oceanic arc source terranes based on detrital zircon geochronology (Fig. 5D) and conglomerate compositional data; subordinate detritus was derived from the former continental margin (e.g., Yukon-Tanana terrane; Hampton et al., 2005; Trop et al., 2005b). However, direct age data are presently lacking from these sedimentary strata; a Campanian or younger depositional age is inferred based on the age of the youngest detrital zircon cluster (ca. 80–75 Ma).

Inboard of the locus of arc magmatism, northward thrusting of the Kahltna assemblage and Wrangellia composite terrane against the Yukon-Tanana terrane prompted development of the Cantwell thrust-top basin. Campanian-Maastrichtian strata up to 4000 m thick (lower Cantwell Formation on Fig. 2) were deposited unconformably above deformed marine strata of the Kahltna assemblage. Sedimentological, paleocurrent, and compositional data document a two-sided basin characterized by alluvial, fluvial, lacustrine, and minor marginal-marine deposystems (Fig. 8H; Wolfe and Wahrhaftig, 1970; Ridgway et al., 1997; Trop and Ridgway, 1997). Along the southern margin of the Cantwell basin, river growth synclines indicate synepepositional displacement on southward-dipping thrust faults (Fig. 9C). Conglomerate data from southern basin margin strata document erosion of oceanic source terranes exposed within south-dipping thrust sheets in the suture zone, including recycled marine strata of the Kahltna basin and Triassic volcanic rocks (Fig. 5E; Trop and Ridgway, 1997). Along the northern basin margin, synepepositional displacement along the Hines Creek fault prompted erosion of quartz-rich metamorphic source terranes within the Yukon-Tanana terrane (Fig. 5E). The dominance of nonmarine strata and evidence for detritus eroded from both oceanic and continental margin sources indicate that deposition of the lower Cantwell Formation was coeval with regional subaerial uplift of the suture zone between the Yukon and Wrangellia composite terranes (Ridgway et al., 2002).

Late Maastrichtian-Early Eocene (68–61 Ma): Continental Margin Uplift and Regional Unconformity Development

Sedimentary basins on both the inboard and outboard margins of the Wrangellia composite terrane were subaerially uplifted, shortened, and partially eroded during Late Maastrichtian...
Figure 9. (continued on the following page) Cross sections showing key structural relations from sedimentary basins along the inboard margin of the Wrangellia composite terrane. See Figure 1D for locations. (A) Cross section showing structural relationships between the Nutzotin Mountains sequence (KJn), the Wrangellia terrane (WT), and the Yukon composite terrane (YT). Note that the Nutzotin Mountains sequence has been thrust over the Wrangellia terrane along the north-dipping Lost Creek décollement. Geochronologic ages are not available from plutons shown on cross section (Kp), including the Buck Creek, Lost Creek, and Devil’s Mountain plutons. These plutons are interpreted to be equivalent to a suite of nearby plutons that yield 117–105 Ma K-Ar ages. Qs = Quaternary surficial deposits. Bedding attitudes (tadpole symbols) are from Manuszak (2000), Richter et al. (1975) and Richter (1976). The Totschunda and Denali faults are interpreted to have accommodated oblique displacement: A = block moving away from viewer, T = block moving toward the viewer (from Manuszak et al., this volume. (B) Cross section showing Valdez Creek shear zone in the northeastern corner of the Kahiltna basin. In this area, metamorphosed strata of the Kahiltna basin are part of the Maclaren Glacier metamorphic belt. Solid lines are bedding, and dashed lines are the orientation of axial-planar cleavage. Note that kyanite schist in the hanging wall of the Valdez Creek shear zone is juxtaposed against relatively undeformed Kahiltna assemblage in the footwall. Abbreviations: Grt = garnet-in isograd, Stl ± Ky = staurolite-kyanite-in isograd, KJk = Kahiltna assemblage, WCT = Wrangellia composite terrane (from Ridgway et al., 2002). (C) Cross section along southern margin of the Cantwell basin showing bedding orientation and location of intraformational unconformities in the lower Cantwell Formation (Kcs). Cross section represents line interpretation of a photomosaic that was used during field mapping. Wavy black lines indicate intraformational unconformities, and tadpole symbols represent dip of bedding. Note northward decrease in dip away from thrust-fault that forms the southern boundary of the Cantwell basin. Also, note change in dip across intraformational unconformities (wavy lines) that are interpreted as a product of progressive tilting of strata by syndepositional thrust-fault displacement. Adapted from Ridgway et al. (1997).
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Figure 9 (continued). (D) Simplified structural cross section through the Colorado Creek and Cantwell basins adjacent to the Denali fault in the central Alaska Range. Note unconformity between the Kahiltna assemblage (KJk) and overlying strata in both the Colorado Creek and Cantwell basins. Abbreviations: Kcs = Cretaceous lower Cantwell Formation; Tcv = Paleocene upper Cantwell Formation; A = block moving away from viewer; T = block moving toward the viewer (modified from Trop et al., 2004).

to Early Paleocene time. Along the outboard margin, an unconformity records deformation and subaerial uplift of marine sedimentary strata deposited on the forearc side of the Late Cretaceous-Paleocene magmatic arc (Fig. 2). In the Matanuska Valley-Talkeetna Mountains basin, Campanian-Maastrichtian marine sediment-gravity-flow deposits (upper Matanuska Formation) were subaerially exposed prior to onlap by Paleocene-Eocene fluviol-estuarine strata (Chickaloon and Arkose Ridge Formations; Winkler, 1992; Little and Naeser, 1989; Trop et al., 2003). The timing of unconformity development is constrained by ammonite fossils and detrital zircon ages from the upper Matanuska Formation (ca. 72–71 Ma; Trop et al., 2005b) in combination with plant fossils and isotopic ages from felsic tuffs in the Chickaloon and Arkose Ridge Formations (ca. 59 Ma; Triplehorn et al., 1984; D. Bradley, unpublished data) from the overlying Chickaloon and Arkose Ridge formations. Along strike, in the Wrangell Mountains, Campanian submarine-fan deposits were subaerially uplifted prior to intrusion of Miocene igneous stocks and nonmarine deposition of the Miocene Frederika Formation (Fig. 2). The timing of unconformity development in this area is constrained by 79–78 Ma isotopic ages from tuff of the MacColl Ridge Formation (Trop et al., 1999) and 11–10 Ma isotopic ages from volcanic strata in the Frederika Formation (Denton and Armstrong, 1969; Tidmore et al., 2005).

Along the inboard margin of the Wrangellia composite terrane, strata of the Kahiltna and Cantwell basins were deformed and uplifted by north-dipping thrusts and associated folds within the Alaska Range suture zone (Ridgway et al., 2002; Hampton et al., this volume). Campanian-Maastrichtian sedimentary strata of the Cantwell basin were folded and partly eroded prior to the onset of volcanism at ca. 59 Ma (upper Cantwell Formation; Cole et al., 1999). Approximately, 100 km south of the Cantwell basin, metamorphosed rocks of the Valdez Creek shear zone and Mc-Claren Glacier metamorphic belt cooled through the biotite closure temperature by ca. 62 Ma (Ridgway et al., 2002). Regional shortening and exhumation were contemporaneous with rapid accretion and cooling of metamorphic and plutonic rocks within the Chugach accretionary prism (Clendenen et al., 2003).

From a regional perspective, Late Maastrichtian-Early Paleocene deformation of the continental margin of south-central Alaska was contemporaneous with crustal shortening and rapid uplift throughout southeastern Alaska and western Canada (Wood et al., 1991; McClelland et al., 1992a; McClelland and Mattei, 2000; Haeussler et al., 2003). Widespread deformation is attributable to rapid low-angle subduction of oceanic crust and associated dextral transpression of the previously amalgamated Wrangellia and Yukon composite terranes along orogen-parallel, strike-slip faults (Plafker and Berg, 1994; Smart et al., 1996; Roeske et al., 2003). This model is consistent with published plate motion reconstructions that infer oblique subduction along the northeast Pacific margin from ca. 85 to 50 Ma (Engebretson et al., 1985; Stock and Molnar, 1988; Haeussler et al., 2003). Uplift in south-central Alaska may have been a consequence of subduction of increasingly younger, more buoyant oceanic crust associated with ridge subduction. Geologic evidence documents west-to-east subduction of an oceanic spreading ridge oriented subparallel to the margin from 61 to 50 Ma (Fig. 3F; Bradley et al., 2000, 2003; Haeussler et al., 2000, 2003; Sisson et al., 2003; Cole et al., 2006). Buoyancy considerations (Cloos, 1993) suggest that subduction of <10 Ma oceanic crust inboard of the approaching spreading ridge (Fig. 4E) would have prompted higher shear stresses between the subducting crust and overriding plate (i.e., stronger coupling) and may have been manifested by uplift and erosion throughout the continental margin.

Late Paleocene-Early Eocene (61–49 Ma): Oceanic Spreading Ridge Subduction

Regional continental-margin arc magmatism ceased in south-central Alaska during Late Paleocene time (Fig. 1B). Sedimentation was limited to remnant forearc depocenters exposed in the Matanuska Valley and southern Talkeetna Mountains (MB on Fig. 3F). Upper Paleocene-Eocene nonmarine sedimentary strata (Chickaloon, Arkose Ridge, and Wishbone Formations on Figures 2, 3F, 4F, 10A, 10B) were deposited across Upper Cretaceous and older deep-marine strata. Gravelly alluvial-fluvial deposystems prograded from both the northern and southern
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basin margins across swampy basin-axis fluvial environments (Fig. 3F; Clardy, 1974; Little, 1988; Trop et al., 2003). Along the southern basin margin, alluvial-fluvial strata record erosion of metatransvolcanic and metasedimentary source terranes of the adja-

cent Chugach accretionary prism (Fig. 10C), coeval with displacement along the Border Ranges fault (Little and Naeser, 1989; Little, 1990). Along the northern basin margin, alluvial-fluvial strata record erosion of dissected Jurassic-Cretaceous magmatic arcs and coeval Paleocene-Eocene igneous rocks synchronous with dextral-oblique displacement along the Castle Mountain fault system (Fig. 7D; Flores and Stricker, 1993; Trop et al., 2003).

Paleocene-Eocene sedimentary strata were deposited during complex convergent margin tectonism, including oblique sub-

duction of oceanic crust and a spreading ridge (Haeussler et al., 2003), right-lateral displacements on orogen-parallel, strike-slip faults (Smart et al., 1996; Cole et al., 1999; Roeske et al., 2003), and oroclinal bending of western and interior southern Alaska (Coe et al., 1985). During Paleogene-Neogene time, arc magmatism shifted southward to form the Aleutian and Wrangell arc systems, possibly in response to break-off or roll-back of the subducting slab following terminal suturing of the Wrangellia composite terrane (Pfaffker and Berg, 1994; Cole and Stewart, 2005; Cole et al., 2006). During this reorganization, west-to-east subduction of an oceanic spreading center influenced a >2000-

km-long segment of the margin from south-central Alaska to western Canada (Haeussler et al., 2003). Effects of ridge subduction within the accretionary prism include near-trench magmatism (Bradley et al., 2000); high-temperature, low-pressure metamorphism (Sisson et al., 1989, 2003); generation of lode-gold de-

posits (Haeussler et al., 1995), and ophiolite accretion (Kusky and Young, 1999).

Less well understood are potential geologic effects of ridge subduction inboard of the near-trench intrusive belt. Distinct episodes of uplift, coarse-grained nonmarine sedimentation, and magmatism took place inboard of the subduction complex during near-trench magmatism, indicating potential links with ridge subduction processes (e.g., Bradley et al., 2003). In the Matan-

uska Valley, subduction of progressively more buoyant, topographically higher lithosphere (juvenile oceanic crust and the spreading ridge) followed by less buoyant, topographically lower lithosphere (progressively older crust) may have prompted sub-
aerial exposure of the formerly marine forearc basin, followed by Eocene coarse-grained nonmarine sedimentation (e.g., Wish-

bone Formation on Fig. 2; Trop et al., 2003). Eocene volcanic and intrusive rocks interfere with and intrude Eocene sedimentary rocks in the Talkeetna Mountains (CTV, CV on Fig. 3F) and the Matanuska Valley (MB on Fig. 3F). Geochemical compositions from the igneous rocks indicate derivation of magmas from a de-

pleted magma source, consistent with an upper-mantle slab win-
dow associated with subduction of a spreading ridge (Silberman and Grantz, 1984; Amos and Cole, 2003; Cole et al., 2006). Further inboard, coeval volcanic rocks exposed in the northern Tal-

keetna Mountains (JV on Figure 3F; Cole and Stewart, 2005; Cole et al., this volume) and the central Alaska Range (CB on Figure 3F; upper Cantwell Formation; Cole et al., 1999) yield geochemical compositions that reflect derivation from a more en-

riched mantle source, likely the remnant mantle wedge from Late Cretaceous-Paleocene continental-margin arc magmatism (Cole et al., 1999; Cole et al., this volume).

Late Eocene-Late Oligocene (49–26 Ma): Dextral Transpression and Strike-Slip Basin Development

Transpressional tectonics, dextral displacement along orogen-

parallel faults, and localized nonmarine sedimentation character-

ized south-central Alaska during Late Eocene-Late Oligocene time (Figs. 3G, 4G). An angular unconformity separating the Paleocene-

Eocene Wishbone Formation and Oligocene Tsadaka Formation (Fig. 2) records deformation along the outboard margin of the Wrangellia composite terrane during this interval. Limited sedi-

mentologic data from the Tsadaka Formation document deposition

Figure 10. (A) Photograph of coarse-grained alluvial-fan strata (Wishbone Formation, Tw) and overlying volcanic strata (Tv) that were deposited along the northern margin of the Matanuska Valley–Talkeetna Mountains basin during Eocene time. Compositional and detrital geochronologic data indicate that detritus was derived from remnant to coeval magmatic belts along the northern basin margin. Exposure is ~200 m thick. (B) Carbona-

ceous fluvial and overbank strata (Chickaloon Formation) that were deposited along the axis of the Matanuska Valley-Talkeetna Mountains basin during Paleocene-Eocene time. Person circled in lower right for scale. (C) Paleocene-Eocene conglomerate deposited along the southern margin of the Matanuska Valley-Talkeetna Mountains basin contains abundant red chert (R), vein quartz (Q), and black argillite (A) derived from the Chugach accretionary prism. (D) Interbedded conglomerate and coal (dark units, white arrows) of the Amphitheater Formation (TA) in the Eocene-Oligocene Burwash basin. This strike-slip basin formed along the Duke River fault, an eastern segment of the Denali fault system. The fault is located at the base of the snow-covered mountains in the background. Tent (black arrow) for scale in lower right of photo. (E) Yakataga Formation of the Robin-

son Mountains, which was deposited during Miocene-Recent collision of the Yakutat terrane along the southern continental margin of Alaska. Resis-
tant bed in midground (white arrows mark the base) is a lenticular bed of glacial diamicite (Tyd) that is interbedded with marine mudstone (Tym). Two people circled (lower left) for scale. (F) Photograph of Miocene sedimentary strata of the Frederika Formation (FT) and lava flows of the Wrangell Lava (Tw), which were deposited in an intra-arc basin within the Wrangell continental arc. Note boulders >2 m long (white arrows). Exposure is ~180 m thick. (G) Photograph of interbeded coal and coarse-grained sandstone in the Miocene Usibelli Group in the Tanana foreland basin. Coal beds up to 20 m thick are present in this basin. Spruce forest at bottom of photo for scale. (H) Conglomerate of the Piocone Nenana Gravel in the Tanana foreland basin. Diagnostic conglomerate clasts (C) and paleocurrent data indicate exhumation and recycling of latest Cretaceous nonmarine strata (lower Cantwell Formation) exposed in thrust sheets to the south in the Alaska Range. Hammer for scale.
of boulder-rich conglomerate on south-sloping humid alluvial fans in the Matanuska Valley (Fig. 3G; Clardy, 1974; Trop et al., 2003). Compositional and paleocurrent data from these strata indicate erosion of dissected Jurassic-Paleocene felsic plutons exposed in the southern Talkeetna Mountains, including the remnant Talkeetna oceanic arc and the Alaska Range-Talkeetna Mountains magmatic belt. Syndepositional dextral-oblique displacement along the Castle Mountain fault probably contributed to erosion of these igneous source terranes (Figs. 3G, 4G; Fuchs, 1980; Trop et al., 2003).

Oligocene synorogenic sedimentation in the Matanuska Valley-Talkeetna Mountains was coeval with formation of small fault-bound basins along the Denali fault system within the previously formed suture zone between the Wrangellia composite terrane and inboard terranes (Figs. 1D; 3G). In western Canada, Upper Eocene-Oligocene alluvial-fluvial strata up to 750 m thick are interpreted as the product of right-lateral displacement on the eastern Denali fault along the Duke River and Dalton segments of the Denali fault system (Fig. 10D; Bates Lake, Burwash, Sheep Creek, and Three Guardsmen basins; Ridgway et al., 1992; Cole and Ridgway, 1993); most strike-slip displacement took place between 40 and 30 Ma (Ridgway et al., 1995, 1996). In the central Alaska Range, Lower Oligocene alluvial-fluvial strata >700 m thick (Tcb on Fig. 8B) are linked with right-lateral displacement along the McKinley segment of the Denali fault (middle member of Colorado Creek basin on Figure 2, Table 1; CCB on Figures 3G, 9D; Trop et al., 2004) and along the Talkeetna fault (WCB on Figure 3G; Hardy, 1986). In western Alaska, Upper Oligocene strata >440 m thick record alluvial-fluvial deposition along the Farewell segment of the Denali fault in the White Mountain basin (WMB on Figure 3G; Ridgway et al., 1999b); other Eocene-Oligocene nonmarine sedimentary successions exposed along the Farewell segment of the Denali fault system (Talkeetna and McGrath basins; Reed and Nelson, 1980; Dickey, 1984) may also reflect right-lateral displacement, but structural controls on sedimentation are unclear in these basins given the available published information. Collectively, these nonmarine basal strata record Late Eocene to Late Oligocene right-lateral displacement and synorogenic sedimentation along much of the 2,100 km length of the Denali fault system from western Canada to southwestern Alaska.

This distinct episode of right-lateral, strike-slip tectonism prompted lateral shuffling along the suture zone, including tectonic escape (extrusion) of accreted terranes, basin margins, and magmatic belts along the Denali, Nixon Fork, and Kaltag faults in western Alaska (Scholl et al., 1992a, 1992b). Matching inferred source lithologies north of the Denali fault with conglomerate clast types south of the fault (Trop et al., 2004) and offset Eocene igneous belts (Reed and Lanphere, 1974; Cole, 1999) indicates ~30–40 km of post-Eocene, right-lateral displacement along the central Denali fault, part of up to 400 km of Late Cretaceous–Cenozoic right-lateral displacement along the eastern and central segments of the Denali fault system (e.g., Eissbacher 1976; Nokleberg et al., 1985; Lowey, 1998).

**Latest Oligocene-Recent (26–0 Ma): Yakutat Collision and Regional Transpression**

A second major phase of terrane collision and basin development characterized the southern margin of Alaska during latest Oligocene to Holocene time (Figs. 3H, 4H). Sedimentary basins record deformation, magmatism, and exhumation associated with oblique collision of the allochthonous Yakutat terrane. The stratigraphic record of this Neogene collisional event is well exposed in outcrops in the Robinson Mountains of the Yakutat basin, in the Wrangell Mountains, and the Tanana basin north of the central Alaska Range (Fig. 1D). Subsurface deposits in the Copper River, Northway, Susitna, and Cook Inlet basins also record latest Oligocene-Recent sedimentation. The outboard sedimentary record of Neogene collision of the Yakutat terrane is recorded in the Middle Miocene-Holocene glacial-marine strata of the Yakataga Formation exposed in the Robinson Mountains (Figs. 3H, 10E). This formation is ~5 km thick and contains abundant evidence of syndepositional deformation, such as growth structures and progressive unconformities (Plafker 1967, 1987; Miller, 1971). Ongoing collision of the Yakutat terrane has prompted incorporation of the Yakataga Formation into an oceanward-verging fold-and-thrust belt (Figs. 3H, 4H; Bruhn et al., 2004; Pavlis et al., 2004). Collision of the Yakutat terrane in this part of the Gulf of Alaska has produced the largest concentration of peaks higher than 4300 m on the North American continent, including the second highest peak in North America (Mt. Logan). Sediment flux from this mountainous coastal setting via glaciers and proglacial streams has produced thick packages of sediment in offshore basins with some of the highest sediment accumulation rates on Earth (e.g., Hallet et al., 1996; Merrand and Hallet, 1996; Meigs and Sauber, 2000; Jaeger et al., 2001; Sheaf et al., 2003).

In the Wrangell Mountains of east-central Alaska, thick sections of interbedded volcanic and sedimentary strata record construction of a continental-margin arc that formed in response to oblique collision and subduction of the Yakutat terrane beneath the continental margin (Richter et al., 1990; Preece and Hart, 2004; Tidmore et al., 2005). Magma genesis commenced in western Canada and eastern Alaska ca. 26 Ma, coeval with northward translation of the Yakutat terrane along the Queen Charlotte fault. Magmatism migrated northwestward during Miocene-Holocene time, progressively shutting down along the southeastern part of the arc in Canada as continental crust of the Yakutat terrane started to collide with the continental margin from 16 to 10 Ma (Richter et al., 1990; Ridgway et al., 1996). Oligocene-Miocene volcanic strata located in the Canadian part of the volcanic field have geochemical signatures consistent with magma genesis along leaky transform faults (Skulski et al., 1991). Miocene-Holocene volcanic strata in the Alaska part of the field, in contrast, have geochemical traits attributable to northward subduction of Pacific plate oceanic crust and the Yakutat terrane along the leading edge of the Yakutat terrane (Richter et al., 1990; Skulski et al., 1991; Preece and Hart,
environments in the wedge-top depozone of the foreland-basin system. Pliocene strata that were deposited in alluvial-fan and braided river environments of the foredeep depozone, the Usibelli Group, consists of 800 m of mainly Miocene strata that were deposited in basin-axis meandering fluvial channels, swampy floodplains, and lacustrine environments. Sandstone and conglomerate compositional data document erosion of coeval eruptive centers, Jurassic-Cretaceous marine basinal strata, and accreted Triassic oceanic rocks. Lavas of the Frederika Formation exhibit geochemical characteristics that are typical of subduction-related arc volcanic suites and are indistinguishable from those observed for a subset of <5 Ma western Wrangell arc lavas interpreted to have been emplaced in an intra-arc extensional setting. Arc magmatism has been relatively dormant over the past 200,000 years, and the underlying Wadati-Benioff zone presently exhibits weak seismicity, attributes that may reflect accommodation of Yakutat terrane plate motion along active strike-slip faults (e.g., Fairweather and Totschunda faults; Richter et al., 1990).

To the west, Pliocene-Recent transgression along the Castle Mountain-Bruin Bay fault system partitioned the outboard margin of the Wrangellia composite terrane into localized uplifts and fault-bound nonmarine depocenters (Fig. 3H; Detterman et al., 1974; Fuchs, 1980; Bruhn and Pavlis, 1981; Lahr, et al., 1986; Haeussler et al., 2000, 2002). Deformation of remnant forearc-basin deposits continues to the present. The Castle Mountain fault, which truncates strata of the forearc basin, has a historical record of two right-lateral earthquakes, and paleoseismologic studies have interpreted four major earthquakes during the past 2700 years (Detterman et al., 1974; Lahr et al., 1986; Haeussler et al., 2002).

The Neogene Tanana basin contains the inboard sedimentary record of the collision of the Yakutat terrane. Strata in this foreland basin are 2–3 km thick and have been deformed and exhumed in thrust faults that form the foothills along the north side of the Alaska Range (Figs. 3H, 1H; Ridgway et al., 2002, this volume). The lower part of the sedimentary package, the Usibelli Group, consists of 800 m of mainly Miocene strata that were deposited in fluvial, lacustrine, and peat-bog environments of the foredeep depozone of the foreland-basin system (Table 1; Fig. 10G). Compositional data, as well as recycled Upper Cretaceous palynomorphs, indicate that the Miocene foreland-basin system was supplied with increasing amounts of sediment from lithologies currently exposed in thrust sheets located south of the basin (Fig. 5F; Ridgway et al., 1999a, this volume). The upper part of the sedimentary package, the Nenana Gravel, consists of 1200 m of mainly Pliocene strata that were deposited in alluvial-fan and braidedplain environments in the wedge-top depozone of the foreland-basin system (Thoms, 2000; Ridgway et al., this volume). Compositional data from conglomerate and sandstone (Figs. 5F, 10H), as well as isotopic dating of detrital feldspar grains in sandstone and granitic clasts in conglomerate, indicate that lithologies exposed in the central Alaska Range provided most of the detritus to the Pliocene foreland-basin system. The age distribution of detrital feldspar grains of the Nenana Gravel records progressive northward exhumation of plutons located south of the Pliocene Tanana basin.

The modern deposystems of the Tanana basin have been re-organized by extensive Pleistocene glaciation and ongoing deformation. Rivers in the active wedge-top depozone are presently incised through deformed strata of the Nenana Gravel and are transporting detritus eroded from the core of the central Alaska Range northward into the active foredeep depozone of the Tanana foreland-basin system. We attribute Neogene contractual deformation, uplift, and related flexural subsidence of the Tanana basin to regional transpressive shortening along the central Denali fault in response to oblique subduction of the Pacific plate, as well as underthrusting of the Yakutat terrane (e.g., Plafker et al., 1994; Pavlis et al., 2004). Active deformation within the transpressive zone includes folding and thrust-fault deformation of proximal foreland basin strata (Lesh et al., 2001; Lesh, 2002; Ridgway et al., 2002, this volume; Bemis, 2004; Bemis and Wallace, 2004; Lesh and Ridgway, this volume) and recent large-magnitude earthquakes along the Denali fault (Mw 6.7 and Mw 7.9 in 2002; Eberhart-Phillips et al., 2003). GPS data indicate ~8–9 mm/year of dextral-oblique slip on the active Denali fault, with some slip likely on parallel strands north of the main fault trace (Fletcher, 2002).

**SUMMARY: SEDIMENTARY RECORD OF COLLISIONAL TECTONICS**

The sedimentary basin record of south-central Alaska contributes to our growing understanding of the complex processes associated with crustal growth and recycling within the North American Cordillera. The tectonic growth of southern Alaska is defined by Mesozoic collision of the Wrangellia composite terrane and Cenozoic collision of the Yakutat terrane. The sedimentary basinal record of these two collisional events is summarized as follows.

1. **Middle Jurassic marine volcaniclastic sandstone, mudstone, chert, and tuff were deposited in narrow forearc and backarc basins positioned south and north, respectively, of the volcanic edifice of the Talkeetna-Chuitina arc (Figs. 3A, 4A).** This south-facing oceanic arc system was probably located at substantially lower paleolatitudes during deposition of these strata.

2. **Late Jurassic syndepositional regional shortening and coarse-grained sedimentation mark a change in the tectonic configuration of the northwestern Cordillera. Over 700 m of coarse-grained, clastic detritus was deposited in a forearc basin (Matanuska Valley-Southern Talkeetna Mountains) coeval with**
final phases of oceanic-arc magmatism. In proximal retroarc basins (Wrangell Mountains), ~600 m of synformal deposition conglomerate was deposited in the footwall of the south-dipping Chitina thrust belt (Figs. 3B, 4B). In more distal retroarc depocenters, fine-grained turbidite sedimentation was initiated in a series of collisional foreland basins that presently extend for ~2000 km from British Columbia to southwestern Alaska (Kahiltna, Nutzotin, Dezadeash, and Gravina basins). This time interval also marked the demise of Talkeetna-Chitina arc magmatism. The cessation of magmatism, exhumation of the Talkeetna-Chitina arc, and introduction of coarse-grained clastic detritus to both retroarc and forearc basins may reflect either initial accretion of the previously combined Wrangellia and Peninsular terranes to the continental margin of western North America or amalgamation of the Peninsular and Wrangellia terranes prior to collision with the former continental margin. We prefer the former interpretation. Oblique collision of the Wrangellia composite terrane, younging to the northwest, is inferred based on the diachronous ages of Jurassic-Cretaceous deformation, uplift, and sedimentation along the continental margin from British Columbia to southwestern Alaska.

(3) During earliest Cretaceous time, Jurassic retroarc basin deposits in the Wrangell Mountains basin were incorporated into an expanding, north-verging thrust belt associated with continued collision of the Wrangellia composite terrane (Figs. 3C, 4C). This regional deformation is marked by an angular unconformity across which sediment was bypassed into collisional foreland basins (Kahiltna and Nutzotin basins) along the inboard margin of the composite terrane. This tectonic configuration led to exhumation and partial erosion of the Wrangell Mountains forearc basin and the Wrangellia composite terrane, and produced distinct upward-coarsening megasequences in collisional foreland basins (Kahiltna and Nutzotin basins). The first sediment with unequivocal North American continental margin affinity was deposited in these basins during Early Cretaceous time. The Early Cretaceous (Valanginian-Aptian) southern margin of Alaska was reconfigured through development of the Chisana arc. Construction of this arc marked the resumption of subsidence and deposition of clastic sediments in forearc basins. Forearc deposition was influenced by a series of south-dipping, syndepositional normal faults.

(4) Late Early Cretaceous to early Late Cretaceous time was characterized by regional deformation of retroarc basins by south-verging thrusts that are part of a regional thrust belt that extends for ~2000 km from south-central Alaska to southern British Columbia (Figs. 3D, 4D). This thrust belt merged along strike into a collisional basin that is recorded by strata of the Kahiltna assemblage in south-central and southwestern Alaska.

(5) The Late Cretaceous tectonic setting of southern Alaska was marked by folding, metamorphism, and exhumation of retroarc basinal strata in a broad continental suture zone between oceanic rocks of the Wrangellia composite terrane and the quartz-rich metamorphic rocks of the former continental margin (Figs. 3E, 4E). Subsequently, a latest Cretaceous-Paleocene continental arc (Kluane arc) intruded and stitched the remnant oceanic arcs, deformed retroarc basin strata, and the former continental margin. Locally, Latest Cretaceous post-collisional retroarc basin strata (Pass Creek strata, lower Cantwell Formation) unconformably overlie deformed older syncollisional retroarc strata (Kahiltna assemblage) and record sediment input from both coeval and remnant arc assemblages to the south of the suture zone, as well as from the former continental margin to the north. Northward convergence and arc emplacement prompted development of a retroarc thrust belt that produced thrust-top basins, such as the Cantwell basin of the central Alaska Range. These nonmarine to marginal-marine deposits reflect subaerial exposure of the suture zone contemporaneous with persistent marine sedimentation in outboard forearc depocenters. Forearc depocenters subsided into deep-water settings and were characterized by detritus derived from remnant and coeval magmatic arcs.

(6) Paleocene-Neogene nonmarine forearc, intra-arc, and retroarc foreland basin strata contain the record of post-collisional processes related to the Wrangellia composite terrane and document erosion of the now amalgamated continental arc rocks, remnant accreted oceanic arcs, and subaerially exposed segments of the subduction complex (Figs. 3F–3H, 4F–4H). Growth of the southern Alaska continental margin during Paleocene-Early Eocene time is defined by emplacement of the McKinley plutons, mainly nonmarine deposition in forearc and retroarc regions, and continued expansion of the accretionary prism. Accretionary prism and forearc basin deposits record coarse-grained deposition, near-trench magmatism, and high-temperature metamorphism linked to subduction of an oceanic spreading ridge from 60 to 50 Ma.

(7) Middle Eocene-Oligocene time was characterized by regional transpressive deformation along regional strike-slip faults (Figs. 3G, 4G). The sedimentary record of this deformation is contained in localized strike-slip basin deposits exposed along several segments of the Denali and Talkeetna faults during this interval. Transpressive deformation throughout interior south-central Alaska resulted in a regional uplift that provided abundant sediment for the actively subsiding Cook Inlet forearc basin.

(8) A second major phase of terrane collision and basin development characterized the southern margin of Alaska during latest Oligocene-Holocene time (Figs. 3H, 4H). Northward translation and collision of the Yakutat terrane resulted in the growth of the largest coastal mountain range on Earth (St. Elias Mountains), construction of a new continental arc (Wrangell-St. Elias Mountains), deformation of remnant forearc basin strata in the Wrangell and Talkeetna Mountains, and renewed uplift of the Alaska Range. The sedimentary record of this collision is contained in the Tanana retroarc foreland basin north of the Alaska Range, intra-arc basins in the Wrangell Mountains, and in collisional foreland basins on the Yakutat terrane and offshore Gulf of Alaska. This phase of collision continues to the present as evidenced by seismicity, geodetic data, and some of the highest sediment accumulation rates on Earth.
ACKNOWLEDGMENTS

Our studies in southern Alaska would not have been possible without the original geologic mapping by Bela Csejtey, Arthur Grantz, Davey Jones, Ed MacKevett, Warren Nokleberg, George Pfafker, Don Richter, Clyde Wahrhaftig, and Gary Winkler, among many others. We thank the U.S. Geological Survey, Wrangell-St. Elias National Park, Denali National Park, and the Bureau of Land Management for supporting our research. Assistance from National Park geologists Phil Brease and Danny Rosenkrans has been especially important. Primary funding was provided by the National Science Foundation, Donors of the Petroleum Research Fund administered by the American Chemical Society, Anschutz Corporation, Forest Oil Corporation, and the U.S. Geological Survey. Additional support was provided by the Geological Society of America, American Association of Petroleum Geologists, Sigma Xi, Purdue Research Foundation, and Bucknell Program for Undergraduate Research. This synthesis includes important contributions from many collaborators, including geochronology (George Gehrels, Paul Layer, Matt Rioux, Terry Spell), palynology (Rob Ravn, Art Sweet, James White), paleontology (Robert Blodgett, Jim Haggart, Anita Harris, Mike Mickey, Scott Wing), igneous petrology and geochemistry (Ron Cole, Bill Hart, Darin Snyder, Tom Skulski), metamorphic petrology (Cam Davidson, Sarah Roeske), structural geology (Mike O’Neill, Terry Pavlis), and paleomagnetic analysis (John Stamatakos). We thank current and former students at Purdue University (Kevin Eastham, Brian Hampton, Jay Kalbas, Paul Landis, Mark Lesh, and Jeff Manuszak) and Bucknell University (Ryan Delaney, Aubri Jensen, Emily Short, Darren Szuch, Clay Slaughter, Rob Tidmore, and John Wittmer) for their many contributions. KDR also thanks Dwight, Lauren, Alice, and Dan Bradley for their generous hospitality in letting the Purdue basin analysis group use their home as a base camp.

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MANUSCRIPT ACCEPTED BY THE SOCIETY 31 JANUARY 2007