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Pre-, syn-, and postcollisional stratigraphic framework and provenance of Upper Triassic–Upper Cretaceous strata in the northwestern Talkeetna Mountains, Alaska

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ABSTRACT

Mesozoic strata of the northwestern Talkeetna Mountains are located in a regional suture zone between the allochthonous Wrangellia composite terrane and the former Mesozoic continental margin of North America (i.e., the Yukon-Tanana terrane). New geologic mapping, measured stratigraphic sections, and provenance data define a distinct three-part stratigraphy for these strata. The lowermost unit is greater than 290 m thick and consists of Upper Triassic–Lower Jurassic mafic lavas, fossiliferous limestone, and a volcaniclastic unit that we informally refer to as the Honolulu Pass formation. The uppermost 75 m of the Honolulu Pass formation represent a condensed stratigraphic interval that records limited sedimentation over a period of up to ca. 25 m.y. during Early Jurassic time. The contact between the Honolulu Pass formation and the overlying Upper Jurassic–Lower Cretaceous clastic marine strata of the Kahiltna assemblage represents a ca. 20 m.y. depositional hiatus that spans the Middle Jurassic and part of Late Jurassic time. The Kahiltna assemblage may be up to 3000 m thick and contains detrital zircons that have a robust U-Pb peak probability age of 119.2 Ma (i.e., minimum crystallization age/maximum depositional age). These data suggest that the upper age of the Kahiltna assemblage may be a minimum of 10–15 m.y. younger than the previously reported upper...
INTRODUCTION

Upper Triassic–Cretaceous sedimentary and volcanic strata are exposed between the allochthonous Wrangellia composite terrane and the former Mesozoic continental margin of western North America in a discontinuous belt that extends from southwestern Alaska to British Columbia (e.g., Berg et al., 1972; Rubin and Saleeby, 1991; McClelland et al., 1992; Cohen et al., 1995; Kapp and Gehrels, 1998; Kalbas et al., this volume). Some of the best exposures of these strata occur in south-central and southwestern Alaska, where the majority of the exposed Mesozoic stratigraphy consists of Upper Jurassic–Cretaceous clastic marine strata of the Kahiltna assemblage (Fig. 1A). The Kahiltna assemblage and equivalent strata in south-central Alaska occur in an elongate, southwest-trending outcrop belt that is bounded by the Wrangellia composite terrane and the Talkeetna fault to the south, and the Yukon-Tanana terrane and the Denali and Hines Creek faults to the north (Fig. 1A). This region has been referred to as the Alaska Range suture zone (Ridgway et al., 2002) or the megasuture zone (Jones et al., 1982). Previous studies have focused on the tectonic age of Valanginian. Sandstone composition (Q-43% F-30% L-27%—Lv-71% Lm-18% Ls-11%) and U-Pb detrital zircon ages suggest that the Kahiltna assemblage received igneous detritus mainly from the active Chisana arc, remnant Chitina and Talkeetna arcs, and Permian-Triassic plutons (Alexander terrane) of the Wrangellia composite terrane. Other sources of detritus for the Kahiltna assemblage were Upper Triassic–Lower Jurassic plutons of the Taylor Mountains batholith and Devonian–Mississippian plutons; both of these source areas are part of the Yukon-Tanana terrane. The Kahiltna assemblage is overlain by previously unrecognized nonmarine strata informally referred to here as the Caribou Pass formation. This unit is at least 250 m thick and has been tentatively assigned an Albian–Cenomanian-to-younger age based on limited palynomorphs and fossil leaves. Sandstone composition (Q-65% F-9% L-26%—Lv-28% Lm-52% Ls-20%) from this unit suggests a quartz-rich metamorphic source terrane that we interpret as having been the Yukon-Tanana terrane. Collectively, provenance data indicate that there was a fundamental shift from mainly arc-related sediment derivation from sources located south of the study area during Jurassic–Early Cretaceous (Aptian) time (Kahiltna assemblage) to mainly continental margin-derived sediment from sources located north and east of the study area by Albian–Cenomanian time (Caribou Pass formation). We interpret the three-part stratigraphy defined for the northwestern Talkeetna Mountains to represent pre-(the Honolulu Pass formation), syn-(the Kahiltna assemblage), and post- (the Caribou Pass formation) collision of the Wrangellia composite terrane with the Mesozoic continental margin. A similar Mesozoic stratigraphy appears to exist in other parts of south-central and southwestern Alaska along the suture zone based on previous regional mapping studies. New geologic mapping utilizing the three-part stratigraphy interprets the northwestern Talkeetna Mountains as consisting of two northwest-verging thrust sheets. Our structural interpretation is that of more localized thrust-fault imbrication of the three-part stratigraphy in contrast to previous interpretations of napp emplacement or terrane translation that require large-scale displacements.

Keywords: Talkeetna, Mesozoic, Stratigraphy, Wrangellia, Kahiltna.
STUDY AREA: Northwestern Talkeetna Mtns. - E. Fork Chulitna River area

- Strike-slip fault
- Fault (undifferentiated)

FAULT LEGEND

HCF - Hines Creek fault
DF - Denali fault
TF - Talkeetna fault
HCF - Border Ranges fault

LITHOLOGY LEGEND

- Cret.-Cenozoic (K-Cz and Qal) - sed. and volc. rock (undifferentiated) and alluvium
- Mesozoic-Cenozoic (Mz-Cz) - plutonic and volc. rocks (undifferentiated)
- Cretaceous (K) - nonmarine and marine sed. rocks – includes nonmarine strata of the Caribou Pass formation in study area and Kuskokwim Group to the southwest
- U Jurassic-Cretaceous (J-K) - marine sed. rocks – Kahiltna assemblage
- Triassic-L Jurassic (Tr-J) - volc. and sed. rocks – undifferentiated terranes exposed in the northwestern Talkeetna Mtns. (includes strata of the Honolulu Pass formation in the study area)
- Penn.-Triassic (Penn-Tr) - volc. and sed. rocks – Wrangellia terrane
- Triassic-Jurassic (Tr-J) - volc. and sed. rocks – Peninsular terrane
- Triassic-Jurassic (Tr-J) - sed. and volc. rocks – Chugach subduction complex
- Paleozoic (Pz) - sed. and metamorphic rocks – Yukon-Tanana terrane

STRUCTURE LEGEND

- Fossil leaf sample location
- U-Pb detrital zircon sample location
- Megafossil samp. loc. – Buchia fragments
- Megafossil samp. loc. – bivalve
- Megafossil samp. loc. – pectinatean or limoidean?
- Megafossil samp. loc. – bivalve
- Megafossil samp. loc. – brachiopod
- Megafossil samp. loc. – hydrozoan Heterastridium

STUDY AREA

- Stratigraphic horizon
- Isotopic horizon
- Fault
- Fault (undifferentiated)
- Fault (inferred)
- Thrust fault
- Uplifted beds
- Syncline
- Southern thrust fault

1. Cretaceous (K)
2. Upper Jurassic-Lower Cretaceous (J-K)
3. Upper Triassic-Lower Jurassic (Tr-J)
4. Lower Triassic (Tr-J)
5. Lower Jurassic (Tr-J)
6. Lower Cambrian (Cmb)

1. Fossil leaf sample location
2. U-Pb detrital zircon sample location
3. Megafossil samp. loc. – Buchia fragments
4. Megafossil samp. loc. – bivalve
5. Megafossil samp. loc. – pectinatean or limoidean?
6. Megafossil samp. loc. – bivalve
7. Megafossil samp. loc. – brachiopod
8. Megafossil samp. loc. – hydrozoan Heterastridium

- Strata of the Honolulu Pass formation (in the study area)
setting of the Upper Jurassic–Cretaceous Kahiltna assemblage in the suture zone (e.g., Pavlis, 1982; Coney and Jones, 1985; Jones et al., 1986; Wallace et al., 1989; Ridgway et al., 2002), however, no previous studies have developed a comprehensive stratigraphic framework for all of the Mesozoic strata in the suture zone.

The purpose of this study is to outline a three-part Upper Triassic–Cretaceous stratigraphy that is observed in the East Fork Chulitna River region of the northwestern Talkeetna Mountains (Fig. 1B). We present a newly defined stratigraphy for this region of the suture zone based on geologic mapping and measured stratigraphic sections. The study area is one of the few known locations in southern Alaska where Upper Triassic–Lower Jurassic strata are observed in stratigraphic contact with the Kahiltna assemblage and the first location in south-central Alaska where Cretaceous nonmarine strata have been documented overlying the Kahiltna assemblage. We also present new sandstone compositional data and U-Pb detrital zircon ages from the three-part stratigraphy that allow us to identify possible source terranes that contributed sediment to these units. The detrital zircon ages also allow us to evaluate the maximum depositional age for the Kahiltna assemblage, which prior to this study was based on limited marine macrofossil occurrences. In the final part of the paper, we discuss the regional extent of the new stratigraphic framework observed in the northwestern Talkeetna Mountains and discuss how it compares with stratigraphy in other parts of the suture zone throughout south-central and southwestern Alaska.

PREVIOUS WORK

The majority of prior investigations of Mesozoic stratigraphy in the northwestern Talkeetna Mountains have focused mainly on the significance of these strata within the context of accreted terranes and related overlap assemblages (e.g., Smith, 1927; Jones et al., 1980; Csejtey et al., 1992). Upper Triassic strata in the study area have been assigned an age of Norian based on the occurrences of the bivalve Monotis subcircularis and the hydrozoan Heterastridium. Initial documentation of the lithology and age of these strata have been summarized in Smith (1927), which presented locations and illustrations of Late Triassic fossils in an area located southwest of our study area. Subsequent studies in the northwestern Talkeetna Mountains have resulted in additional fossil localities and further lithologic description of Upper Triassic sedimentary and volcanic strata (fossil localities summarized by Jones et al., 1986, and Csejtey et al., 1992).

The Upper Jurassic–Lower Cretaceous Kahiltna assemblage has been described within the context of regional geologic mapping projects throughout south-central and southwestern Alaska (e.g., Csejtey et al., 1978, 1992; Reed and Nelson, 1980; Jones et al., 1982; Smith et al., 1988; Bundten et al., 1997), and has been interpreted to represent submarine fan strata that consist of sandstone, mudstone, and conglomerate with minor interbedded limestone (e.g., Wallace et al., 1989; Eastham et al., 2000; Ridgway et al., 2002). Previous work to determine the age of the Kahiltna assemblage throughout the northern part of the Talkeetna Mountains has been summarized by Csejtey et al. (1992). A Late Jurassic–Early Cretaceous (Kimmeridgian–Valanginian) age has been assigned to these strata based primarily on the limited occurrence of megafossils that include the bivalves Buchia sublaevis (Jones et al., 1980) and Buchia rugosa (Silberling et al., 1981a, 1981b; Smith et al., 1988). The nearest previously reported fossil occurrence to the study area is in a Buchia-bearing limestone of Valanginian age (e.g., Jones et al., 1980; Csejtey et al., 1992) that is located ~35 km to the east. Jones et al. (1980) reported the occurrence of a poorly preserved specimen of the Early Cretaceous bivalve Inoceramus northwest of the study area. Radiolaria have also been documented in the Kahiltna assemblage in the northwestern Talkeetna Mountains and suggest a Jurassic or Cretaceous age (Jones et al., 1983).

Upper Triassic strata together with the overlying Kahiltna assemblage have been referred to by previous investigators as the Susitna terrane (Jones et al., 1980, 1981; Silberling et al., 1981a, 1981b). The Susitna terrane has been interpreted as an allochthonous fault-bounded crustal block that may have undergone significant northward transport and tectonic juxtaposition to its present location (Jones et al., 1980, 1981; Silberling et al., 1981a, 1981b). Jones et al. (1980) noted the occurrence of Jurassic–Cretaceous strata both above and below the Upper Triassic strata and interpreted these relationships to represent either thrust sheets of Triassic strata over Jurassic–Cretaceous rocks or an isoclinally folded klippe within the Susitna terrane. Csejtey et al. (1992) proposed that Upper Triassic–Cretaceous strata are not part of a separate allochthonous terrane but, rather, represent a fault-bounded, overturned klippe containing Upper Triassic and older strata of Wrangellia that have been thrust to the north by a nappe-like structure that soles southward into the Talkeetna fault (located south of the study area—see Fig. 1A). A key component in the latter interpretation is that it requires both large-scale structural emplacement (>100 km) to account for the present position of Upper Triassic–Lower Cretaceous strata in this region and that all contacts between the Triassic strata and the overlying Kahiltna assemblage be fault contacts.

STRATIGRAPHY

New geologic mapping and detailed measured stratigraphic sections exposed in the East Fork Chulitna River area of the northwestern Talkeetna Mountains reveal a distinct three-part stratigraphic framework for Mesozoic strata (Figs. 1, 2). This framework consists of a lower unit of Upper Triassic (Norian)–Lower Jurassic marine sedimentary and volcanic strata that we refer to here as the Honolulu Pass formation, a middle unit of Upper Jurassic–Lower Cretaceous (Kimmeridgian–Aptian) clastic marine sedimentary strata known as the Kahiltna assemblage, and an upper unit of Cretaceous (Albian/Cenomanian) to younger nonmarine strata rich in fossil debris. This upper unit has not been described in previous mapping studies of the northwestern Talkeetna Mountains; we informally refer to this unit as the Caribou Pass formation. Figure 2 gives an overview of the three-part stratigraphy for this region and summarizes the lithologies and age control (including new data from this study and previous studies).
Figure 2. Chronostratigraphic summary for Upper Triassic–Cretaceous strata of the northwestern Talkeetna Mountains showing new and previously reported age control (gray boxes in Age Data column denote extent of macrofossil age ranges, palynomorph ages, and U-Pb detrital zircon ages). Upper Triassic–Lower Cretaceous strata have been assigned ages based on occurrences of marine macrofossils (Smith, 1927; Jones et al., 1986; Csejtey et al., 1992), palynomorphs (this study), fossil leaves (this study), and maximum deposition ages determined from U-Pb detrital zircon ages (this study). Note that the uppermost 75 m of the Upper Triassic–Lower Jurassic Honolulu Pass formation is interpreted to consist of a condensed stratigraphic interval that represents limited sedimentation over a period of up to ca. 25 m.y. during Early Jurassic time. Also note the stratigraphic contact that represents a ca. 20 m.y. depositional hiatus between conformable strata of the Honolulu Pass formation and overlying Upper Jurassic–Lower Cretaceous Kahiltna assemblage. Prior to this study, the youngest age reported for the Kahiltna assemblage was Early Cretaceous (Valanginian); the new detrital zircon data indicate that the upper age extends at least to Aptian, suggesting that the Kahiltna assemblage is a minimum of 10–15 m.y. younger than previously reported. The Cretaceous to younger Caribou Pass formation has not been reported in previous studies. It is clear that these strata overlie the Kahiltna assemblage; however, the nature of this contact has yet to be determined (see text for additional discussion). Note thickness of stratigraphic units is not to scale. Time scale based on Gradstein et al. (2004).
Honolulu Pass Formation: Upper Triassic (Norian)–Lower Jurassic

Distribution and Measured-Section Locations

Upper Triassic (Norian) sedimentary and volcanic strata consist primarily of interbedded mafic lavas, siliceous volcaniclastic mudstone, fossiliferous limestone (Late Triassic fossils), siltstone, and mudstone, which are overlain by interbedded chert-rich sandstone and chert-pebble conglomerate, fossiliferous limestone (Early Jurassic fossils), siltstone, and mudstone (Figs. 3, 4, 5). These strata have been documented in four measured stratigraphic sections (Sections 2, 3, 5, and 6 in Fig. 5). Section 5 is the only measured section that documents the contact between the Honolulu Pass formation and the overlying Kahiltna assemblage (Fig. 5). Our most continuous measured section (290-m-thick Section 2 in Fig. 5) does not include the top of the Honolulu Pass formation; therefore, a minimum thickness for the Honolulu Pass formation is 290 m.

Lithologic description

Lavas. Pillow lavas crop out in continuous sections that are up to 175 m thick throughout the study area (Fig. 3A; Sections 2 and 3 in Fig. 5). Individual beds range from 0.3 to 40 m thick with average thicknesses between 3 and 10 m (Fig. 5). Pillow structures...
are well developed, easily distinguishable by their oblate geometry (up to 1 m in diameter) and smoothed surfaces (Fig. 3A), and occur interbedded with tabular beds of massive lava and fossiliferous calcareous mudstone (Section 2 in Fig. 5). Where pillow structures are absent, lavas occur as thin, tabular, massive sheets. Vesicles are common in both the massive sheets and in pillow lavas. The dominant constituent in lavas is a fine-grained plagioclase groundmass (predominantly microcrystalline with rare out-sized plagioclase laths and isolated occurrences of clinopyroxene; Fig. 3B). Measured sections and geologic mapping reveal a lateral transition from lavas in the northeastern part of the study area to more fine-grained siliceous volcaniclastic strata in the southwestern part of the study area (Sections 2 and 3 to Section 6 in Fig. 5).

**Siliceous volcaniclastic mudstone.** This unit consists of fine-grained, massive and bedded intervals of siliceous volcaniclastic mudstone strata that commonly exhibit a greenish white and orange banded tiger-stripe pattern on weathered surfaces (Fig. 3C). On fresh surfaces siliceous mudstone is dark gray to black and often exhibits a chert-like appearance. Locally, where this unit is more massive, it has the appearance in outcrop of a fine-grained volcanic tuff. Massive intervals are extremely indurated and exhibit conchoidal fracture on unweathered surfaces. Petrographic analysis reveals that parts of this unit consist of a fine-grained matrix composed of silt- and mud-size grains and possibly volcanic glass, all of which support isolated silt-sized grains of subrounded chert and quartz (Fig. 3D). Where bedding is evident, the unit is laminated, slightly less indurated, and has more of a silty appearance. Due to highly weathered exposures and little change in grain size, individual beds are difficult to distinguish but where observed range between 0.25 and 10 m thick. Mapping and measured sections suggest that the siliceous volcaniclastic unit is confined to the upper part of the Honolulu Pass formation and grades laterally along strike into massive and pillow lavas. These volcaniclastic strata and equivalent lavas are some of the most resistant lithologies in the study area and make up much of the more pronounced relief in the northwestern Talkeetna Mountains.

**Limestone.** Tabular beds of fossiliferous calcareous mudstone, which contain the bivalve Monotis subcircularis (Fig. 4A), are interbedded with massive lavas in the upper ~150 m of Section 2 (Fig. 5). Stratigraphically higher in the succession, limestone in the uppermost 75 m of the Honolulu Pass formation (Section 5 of Fig. 5) contains fossiliferous limestone (with the bivalve pectinacean or limoidean?) consisting primarily of grain-supported skeletal packstone and grainstone, matrix-supported skeletal wackestone, and carbonate mudstone interbedded with chert-rich sandstone and conglomerate (Figs. 3E, 4B, 5; carbonate classification combined from Dunham, 1962, and Folk, 1959). Individual carbonate beds range in thickness from 6 to 20 cm
Figure 4. Late Triassic–Early Jurassic age macrofossils documented from this study in the Honolulu Pass formation in the East Fork of the Chulitna River area. (A) Late Triassic (late Norian) age bivalve *Monotis (Pacimonotis) subcircularis* from the lower ~200 m of measured sections from the Honolulu Pass formation. Dashed box indicates location of enlarged photo and sketch. Ruler for scale. These types of fossils commonly occur in carbonate mudstone beds interbedded with lavas. The occurrence of *Monotis (Pacimonotis) subcircularis* has been documented in this region prior to our study (e.g., Smith, 1927; and fossil localities summarized by Jones et al., 1986, and Csejtey et al., 1992).

(B) Early Jurassic age bivalve pectinacean or limoidean (?) documented from the uppermost 75 m of the Honolulu Pass formation. Coin for scale. These types of fossils occur in carbonate mudstone beds interbedded with grain-supported skeletal packstone and grainstone, and matrix-supported skeletal wackestone. This is the first documented occurrence of Early Jurassic bivalve fossils in the northwestern Talkeetna Mountains.
Figure 5. Four measured stratigraphic sections of Upper Triassic–Lower Jurassic volcanic and marine sedimentary strata of the Honolulu Pass formation that document the occurrence of interbedded lava and limestone, siliceous volcaniclastic mudstone, and interbedded siltstone and mudstone. See Figure 1B for location of measured sections. Note the stratigraphic occurrence of fossils discussed in text and GPS coordinates for each fossil locality. GPS coordinates at the top of each measured section denote geographic location of base of sections. Note the occurrence of Late Triassic (late Norian) fossils in the lower ~200 m of Section 2. Section 5 documents the uppermost 75 m of the Honolulu Pass formation and the disconformable contact with the overlying Kahiltna assemblage. The upper 75 m of the formation in Section 5 consist of interbedded chert-rich sandstone, chert-pebble conglomerate, fossiliferous limestone (Early Jurassic fossils), mudstone, siltstone, and igneous sills (a detailed section of the top of the Honolulu Pass formation is shown to the right of Section 5). Note the location on measured sections of photomicrographs shown in Figures 3B, 3D, 3F, 3H. We interpret the uppermost 75 m of the Honolulu Pass formation as a condensed stratigraphic interval that represents up to ca. 25 m.y. of limited sedimentation (during Early Jurassic time) that was followed by a ca. 20 m.y. depositional hiatus (spanning the Middle and part of the Late Jurassic) prior to deposition of the Kahiltna assemblage.
(Fig. 3E). Wackestone and packstone typically form more indurated, resistant beds, whereas grainstone beds exhibit a distinct pockmarked weathering pattern in outcrop (Fig. 3E). Disarticulated fossil fragments are visible in packstone and grainstone beds and are typically <2 cm in length. Confident field identification of fossil fragments is difficult; however, most appear to be bivalve parts.

**Chert-rich sandstone and chert-pebble conglomerate.** Chert-rich sandstone and conglomerate occur in the upper 75 m of the Honolulu Pass formation (Section 5 in Fig. 5), where they are interbedded with fossiliferous limestone (Early Jurassic fossils), siltstone, mudstone, and igneous sills. Individual sandstone beds are <2 m thick and consist of medium- to coarse-grained sandstone (Fig. 3F) and are interbedded with beds of conglomerate containing granule- to pebble-size chert clasts (Fig. 3G). Chert-rich sandstone in the lower part of the 75-m interval (basal ~25 m) is fine- to medium-grained and poorly sorted with subrounded to angular chert grains and calcite grains (echinoderm fragments present locally) in calcite cement (Fig. 3F). Chert-rich sandstone and conglomerate in the overlying 50 m, in contrast, are well sorted with well-rounded grains and clasts. These units are primarily grain- and clast-supported, matrix-free, and absent of sedimentary structures. Petrographic analysis of medium-grained chert-rich sandstone reveals a near monolithic, grain-supported framework consisting dominantly of subrounded to rounded chert grains with very rare, isolated occurrences of calcite grains (Fig. 3H).

**Age Control**

The oldest strata of the Honolulu Pass formation exposed in the study area are assigned a Late Triassic (Norian) age based on the presence of the bivalve Monotis (Pacimonotis) subcircularis (Fig. 4A) and hydrozoan Heterastridium (e.g., Smith, 1927; and fossil localities summarized by Jones et al., 1986; Csejtey et al., 1992). Although occurrences of both Monotis and Heterastridium have been documented in previous studies from the northwestern Talkeetna Mountains, we present new fossil localities within the context of measured sections. Monotis is described as a thin-shelled, pecten-like bivalve thought to be a pseudoplanktonic and surface-dwelling organism (Silberling et al., 1997). Occurrences of Monotis (Pacimonotis) subcircularis in Alaska have been documented from the Wrangellia, Peninsular, Alexander, and Nixon Fork terranes in southern Alaska, as well as from the North Slope (Silberling et al., 1997). Heterastridium are planktonic and are recognized by their oblate-ellipsoid shape and internal radial, cellular structure. Both the bivalve Monotis (Pacimonotis) subcircularis and hydrozoan Heterastridium correlate with the upper Norian Cordilleranus Zone (Silberling et al., 1997); however, Heterastridium has been reported from older Norian strata from around the world.

Fossils that occur in limestone interbedded with chert-pebble conglomerate in the upper part of the Honolulu Pass formation in Section 5 (Fig. 5) have been tentatively identified as pectinacean or possibly limoidal (Fig. 4B) and are thought to be Early Jurassic in age. This is the first reported occurrence of Early Jurassic pectinacean or limoidal fossils in the northwestern Talkeetna Mountains. In summary, a Late Triassic–Early Jurassic age is interpreted for the Honolulu Pass formation based on the age range of all reported fossils.

**Interpretation of Depositional Environments**

**Arc-related volcanism.** The lavas of the Honolulu Pass formation are interpreted to have formed in a marine setting based on the presence of pillow structures and interbedded limestone containing marine fossils. Volcanic activity was characterized by coeval subaqueous lava flows and volcaniclastic sediment gravity flows. The small lobate geometry of individual pillows and the tabular bed geometries are characteristic of more low-viscosity basaltic and andesitic lava flows rather than high-viscosity rhyolitic lava flows. The occurrence of vesicles throughout the lavas suggests the presence of trapped gas and volatiles and implies rapid cooling rather than slower cooling conditions where gas and volatiles have a chance to escape the flow. Fossiliferous carbonate mudstone containing Monotis subcircularis and Heterastridium were likely deposited during times of subdued volcanic activity or interruptive periods.

Siliceous volcaniclastic mudstone strata are interpreted as the products of sediment gravity-flow processes related to pyroclastic flows (ash-flow tuffs). Deposition was subaqueous; however, pyroclastic flows may have originated from either subaqueous eruptions or subaerial eruptions and subsequent pyroclastic flow into water. Deposition by pyroclastic flows, when analyzed as density-stratified turbidity currents, can result in a wide variety of sedimentary facies due primarily to variations in flow density (Valentine, 1987) and may account for the variety of sedimentary and volcanic lithologies observed in this unit. Bedding and crude laminations are the result of relatively less dense pyroclastic flows, whereas massive, structureless units are the result of high-density turbidity currents. Massive units may also have been the result of pyroclastic ash fall rather than ash flow, in which case volcaniclastic detritus was deposited by suspension fallout rather than turbidity currents. We tentatively interpret volcanic and volcaniclastic strata of the Honolulu Pass formation as a product of arc volcanism; however, detailed geochemical analyses of both the lavas and volcaniclastic units are needed for a more rigorous interpretation.

**Arc-carbonate platform.** Carbonate strata of the Honolulu Pass formation are interpreted to have been deposited in low- to high-energy environments associated with an immature and poorly developed carbonate platform/ramp. Classification of high-energy carbonate ramp environments includes a shallow inner-ramp environment characterized by constant wave agitation and a mid-ramp environment characterized by frequent storm reworking. Lower-energy ramp environments occur farther offshore and include an outer-ramp environment characterized by infrequent sediment reworking and a basinal environment that is characterized by little to no sediment reworking (e.g., Burchette and Wright, 1992). We suggest that limestone beds at the top of the Honolulu Pass formation contain the bivalves pectinacean or limoidal
were likely deposited in high-energy inner- and mid-ramp shoreface environments. The skeletal packstone and grainstone were likely the result of disarticulation of marine shells during high-energy wave action. Additional support for this interpretation includes occurrences of bivalves found near the top of the formation that are considered to be shallower-water assemblages compared to the bivalve Monotis found in limestone lower in the section (e.g., Silberling et al., 1997).

The concentration of chert-pebble conglomerate and fossiliferous chert-rich sandstone in the upper part of the Honolulu Pass formation is also likely the result of similar high-energy processes active within an inner ramp environment. These strata likely represent erosion and reworking of the arc and carbonate platform/ramp. The upsection transition from angular/subrounded grains to well-rounded chert grains in sandstone in the uppermost part of the Honolulu Pass formation suggests an environment characterized by high-energy wave action that resulted in long-term reworking of siliceous volcaniclastic detritus.

The uppermost 75 m of the Honolulu Pass formation are interpreted as a condensed stratigraphic interval that represents a period of limited sedimentation during Early Jurassic time (Fig. 2). We interpret the concentration of well-rounded chert clasts in conglomerate, chert-rich sandstone, and carbonate grainstone to represent erosion and reworking of arc and carbonate platform strata/sediments in a high-energy inner-ramp environment. The duration of time represented by this condensed interval is unclear, but the documentation of Early Jurassic fossils at the base (Section 5 of Fig. 5) suggests that it could potentially record up to ca. 25 m.y. of Early Jurassic time. The top of this condensed interval defines the depositional contact between the Honolulu Pass formation and the overlying Kahiltna assemblage (Section 5 of Fig. 5). The youngest age-diagnostic fossil in the Honolulu Pass formation is Early Jurassic (199.6–175.6 Ma), whereas the oldest age-diagnostic fossil in the Kahiltna assemblage is Late Jurassic (Kimmeridgian, 155.7–150.8 Ma; discussed in more detail in the following section). A disconformity representing a minimum of ca. 20 m.y. between Middle and part of Late Jurassic time, therefore, exists at the contact between the Honolulu Pass formation and Kahiltna assemblage. We interpret this ca. 20 m.y. hiatus in deposition as a product of subsidence or drowning of the previously active volcanic arc/carbonate platform that is represented by the Honolulu Pass formation. Similar modern examples of subsidence of inactive volcanic arc/carbonate platforms have been well documented from the Bismarck arc in the Huon Gulf, Papua New Guinea (Galewsky et al., 1996) and the Hawaiian islands (Moore and Fornari, 1984).

Kahiltna Assemblage: Upper Jurassic–Lower Cretaceous (Kimmeridgian–Aptian)

Distribution and Measured-Section Locations

The Kahiltna assemblage disconformably overlies the Honolulu Pass formation in the study area and is made up primarily of tabular beds of sandstone, siltstone, and mudstone (Figs. 6, 7). This unit is estimated to be up to 3000 m thick in parts of south-central Alaska, but a single continuous section has not been documented in our study area. Our Section 5 covers the lower ~575 m of the unit that directly overlie the Honolulu Pass formation (Fig. 7), and we also measured several sections from higher in the Kahiltna assemblage (Sections 2, 4, and 6 of Fig. 7). Our measured sections show that the Kahiltna assemblage coarsens upward from predominantly mudstone near the base to more sandstone-rich upsection (Fig. 7).

Lithologic Description

Sandstone, siltstone, and mudstone (subordinate conglomerate). The Kahiltna assemblage is characterized by dark- to light-gray siltstone, fine- to medium-grained sandstone, and subordinate mudstone (Figs. 6A, 6B, 7). The lower part of the Kahiltna assemblage is defined predominantly by interbedded laminated to massive mudstone and siltstone where individual beds are typically ~0.2 m thick (Section 5 in Fig. 7). Individual beds fine upward from siltstone to mudstone. The sandstone beds that form the upper part of the Kahiltna assemblage (Sections 2, 4, and 6 in Fig. 7) are typically 0.1–1 m thick (Figs. 6A, 6B). Isolated sandstone beds up to 3 m thick occur in the upper part of the Kahiltna assemblage. Sandstone units are tabular with no evidence of basal erosional scour (Figs. 6A, 6B). Individual sandstone units have sharp basal contacts and transitional upper contacts that commonly grade into siltstone. Sedimentary structures in the sandstone consist primarily of horizontal stratification and ripple cross-stratification (Fig. 6C). A typical vertical distribution of facies within an individual sandstone unit consists of massive sandstone that grades upward into horizontally stratified sandstone with ripple cross-stratified sandstone and siltstone at the top of the bed (Fig. 7). Sandstone units are either directly overlain by mudstone or, in some cases, by siltstone that grades upward into mudstone. Climbing-ripple structures (Fig. 6C) and distorted, convolute bedding are common in individual sandstone units. Load structures have been observed at the base of individual beds. Rare tabular beds of conglomerate (up to 1 m thick) are matrix-supported with clast sizes typically <2 cm in diameter. Individual conglomerate clasts are subrounded to well rounded and consist primarily of gray chert, dark gray siltstone, and quartz.

Age Control

The Kahiltna assemblage in the northwestern Talkeetna Mountains has been assigned an age of Late Jurassic (Kimmeridgian) to Early Cretaceous (Valanginian) based on previous studies that have documented the occurrence of the bivalve Buchia sublaevis and Buchia rugosa (Jones et al., 1980; Silberling et al., 1981a; Smith et al., 1988). This biostratigraphic age assignment suggests that the Kahiltna assemblage was deposited between 155 and 137 Ma. It is important to note that fossil control is limited for the Kahiltna assemblage in the northwestern Talkeetna Mountains (fewer than five fossil localities). In a later section, we present new U-Pb detrital zircon ages for the Kahiltna assemblage from sandstone samples collected within the context of each of
our measured sections (Fig. 7). The youngest detrital zircon ages fall between 130 and 115 Ma and indicate that the upper age of the Kahiltna assemblage in the East Fork Chulitna River area is at least as young as latest Early Cretaceous (Aptian). Our detrital zircon data imply that the Kahiltna assemblage is, at a minimum, 10–15 m.y. younger than the previously reported Valanginian age. We present a detailed summary of the U-Pb detrital zircon age distribution for the Kahiltna assemblage and review possible source areas for these grains in a later part of this paper.

**Interpretation of Depositional Environments**

**Submarine fan system.** The Kahiltna assemblage exposed in the East Fork Chulitna River area is interpreted to represent deposition by a combination of low- to high-density flow events associated with sediment gravity flows in submarine fan environments. The occurrence of both laminated mudstone and siltstone and horizontally stratified sandstone together with massive sandstone and ripple cross-stratified sandstone suggests sediment distribution was influenced by both laminar and turbulent flow. Tabular beds marked...

Figure 6. Photographs of the Upper Jurassic–Lower Cretaceous (Kimmeridgian–Aptian) Kahiltna assemblage in the study area. (A) Tabular beds of sandstone, siltstone, and mudstone that characterize this unit. White arrow points to person for scale. Bedding dips steeply to the right. (B) The lower part of the Kahiltna assemblage consists mainly of fine-grained sandstone and siltstone in tabular beds that are typically between 0.1 and 1 m thick. Hammer (white arrow) for scale. (C) Common sedimentary structures in the Kahiltna assemblage include climbing-ripple stratification and convolute bedding. Black camera lens cap (lower left) for scale.

Figure 7. Four measured stratigraphic sections of the Kahiltna assemblage. See Figure 1B for location of measured sections. GPS coordinates denote geographic location of base of measured sections. Detailed stratigraphy from Sections 4 and 5 shows vertical distribution of sandstone facies. The lower ~575 m of the Kahiltna assemblage is documented in Section 5, and individual beds show a common distribution of facies that includes horizontally stratified and ripple cross-stratified sandstone along with interspersed convolute beds. Soft-sediment deformation and climbing-ripple stratification are more common in the upper part of the Kahiltna assemblage. Section 4 shows how much thicker (up to 3 m thick in places) and more coarse-grained individual sandstone units become upsection in the Kahiltna assemblage; compare fine-grained strata of Section 5 to Sections 2, 4, 6. Section 4 shows a vertical section consisting predominantly of massive sandstone (Sm), and horizontally stratified and ripple cross-stratified sandstone interbedded with subordinate siltstone. Note the location of U-Pb detrital zircon samples that are discussed in the text (ages reported represent minimum crystallization ages/maximum depositional ages).
Kahiltna assemblage (base)

Disconformity

Honolulu Pass formation (top)

Condensed stratigraphic interval (upper 75 m)

Represents up to ca. 25 m.y. during Early Jurassic time

Contact represents up to ca. 20 m.y. during Middle and early Late Jurassic

Underlain by interbedded basalt, limestone (late Norian), and siliceous volcaniclastic strata

Refer to Fig. 5 for detailed stratigraphy

Stratigraphic location of U-Pb detrital zircon sample (age denotes maximum depositional age)

Sm = Massive sandstone

- Ripple-cross stratification (Sr)
- Horizontal stratification (Sh)
- Soft-sediment deformation

Sm = Massive sandstone

Section 2
E. Fork Chulitna River
N63°10.181' W149°13.678'

Section 4
Three Cirque Basin
N63°12.274' W149°07.712'

Section 5
Honolulu Pass
N63°06.250' W149°20.367'

Section 6
Antimony Mine
N63°06.468' W149°23.045'

Contact represents up to ca. 20 m.y. during Middle and early Late Jurassic

Underlain by interbedded basalt, limestone (late Norian), and siliceous volcaniclastic strata

Refer to Fig. 5 for detailed stratigraphy

Stratigraphic location of U-Pb detrital zircon sample (age denotes maximum depositional age)
The minimum thickness for this unit is limited occurrences of clast-supported conglomerate (Figs. 8, 9). Sandstone and fossil leaf-bearing siltstone and black mudstone with area consists primarily of interbedded fine- to medium-grained to Younger) Caribou Pass Formation: Cretaceous (Albian/Campanian (Eastham and Ridgway, 2002; Ridgway et al., 2002). Bidites that make up the base of the Kahiltna assemblage. Our of submarine fan systems successively prograded over older, and siltstone near the base (Section 5 in Fig. 7) suggests an overall stages of individual flow events (e.g., Ghiraudo, 1992). Convolute bedding is the result of postdepositional reorganization through dewatering and likely occurred in strata associated with high sus- pended sediment load during original deposition.

The upward-coarsening trend from predominantly mudstone and siltstone upsection near the base (Section 5 in Fig. 7) to increased sand- stone upsection (Sections 2, 4, 6 in Fig. 7) suggests an overall progradational package where younger and more proximal parts of submarine fan systems successively prograded over older, more distal, finer-grained submarine fan deposits or slope turbidites that make up the base of the Kahiltna assemblage. Our descriptions of the upper and lower portions of the Kahiltna assemblage are consistent with previous interpretations of this unit as representing submarine fan deposition (Csejtey et al., 1992; Eastham and Ridgway, 2002; Ridgway et al., 2002).

**Caribou Pass Formation: Cretaceous (Albian/Campanian to Younger)**

The uppermost unit of the three-part stratigraphy in the study area consists primarily of interbedded fine- to medium-grained sandstone and fossil leaf-bearing siltstone and black mudstone with limited occurrences of clast-supported conglomerate (Figs. 8, 9). The minimum thickness for this unit is ~250 m, documented from a measured section from the northeastern part of the study area (Section 1 in Fig. 9). Overall, the Caribou Pass formation represents the most coarse-grained strata observed in the study area.

**Lithologic Description**

**Sandstone, siltstone, and mudstone (subordinate conglomerate).** Sandstone units of the Caribou Pass formation have lenticular geometries and are characterized by erosional scour contacts and mudstone rip-up clasts near their base. Individual sandstone bodies consist of vertically stacked beds that are typically between 0.2 and 1 m thick (Figs. 8A, 9) and are up to 3 m thick in places. Low-angle, sloped surfaces are common at the base of some sandstone beds and are referred to in our descriptions as lateral accretion surfaces (Figs. 8A, 8A’, and 9). A common vertical distribution of sedimentary structures in sandstone beds includes basal planar cross-stratification overlain by trough cross-stratification and capped by horizontal stratification or ripple cross-stratification (Figs. 8B, 9). Distorted, convolute bedding was documented locally throughout this unit (Fig. 9). Conglomerate beds are typically <0.5 m thick and are well sorted, sandy, and often appear massive (Figs. 8C). Clasts range in size from 0.5 to 1.5 cm and consist mainly of rounded black and gray chert and quartz clasts. Minor subrounded, elongate clasts of siltstone and mudstone also occur.

Siltstone and mudstone form successions up to 10 m thick in the Caribou Pass formation (Fig. 9). Individual beds are typically <1 m thick, tabular, and consist of laminated mudstone and mas- sive to laminated siltstone. The basal part of these finer-grained beds is characterized by a sharp contact with underlying sand- stone units. Upper contacts are often scoured by overlying sand- stone units. Fossil leaves ranging from 4 to 10 cm in length occur primarily within very fine-grained sandstone, massive siltstone, and laminated mudstone (Figs. 8D, 8D’). The best-preserved fos- sil leaves occur in siltstone and represent leaf mats containing numerous overlapping leaf traces. Individual fossil leaves appear to have a graphite-like carbon film, and their host siltstone or mudstone commonly gives off a phyllitic sheen. Fossil ferns or possibly conifer foliage also occurs locally on bedding planes within finely laminated mudstone. Elongated wood fragments (up to 15 cm long) and individual seeds or pods (<4 cm in diameter) occur sporadically throughout mudstone, siltstone, and sandstone in this unit.

**Age Control**

A total of ten samples were collected from the Caribou Pass formation for palynomorph analysis. Recovery from three of these samples, representing one sample location, yielded occurrences of Polyiculingulatisporites reduncus (gymnosperm pollen) and Cica- tricosisporites cf. venustus (Pteridophytic spores), both of which indicate that this unit could be as old as Cretaceous (Albian–Cenomanian; Ravn, 1995). Figure 10 provides a list of palynomor- isms found from this unit. The upper age limit of these strata is unknown but is loosely constrained to Cenomanian or younger based on the occurrence of leaf fossils. The possible occurrence of several planatoid leaf fossils may suggest an uppermost Early Cretaceous to Late Cretaceous age (Albian–Cenomanian), but the leaves could also be as young as Paleocene age (Scott Wing, 2006, personal commun.). We tentatively suggest that the Caribou Pass formation is Albian/Cenomanian to younger based on the age range of palynomorphs and the occurrence of fossil leaves.

**Interpretation of Depositional Environments**

**Fluvial system.** The Caribou Pass formation is interpreted to be the result of traction transport in confined fluvial channels and of laminar flow in overbank floodplain regions. The presence of lenticular sandstone units, lateral accretion surfaces, planar cross- stratification, and trough cross-stratification is indicative of sig- nificant sediment migration by lateral and downstream bars within fluvial channels (Miall, 1978, 1985). Basal erosional scour surfaces and rip-up clasts suggest that channel flow velocities were sufficient to scour and erode underlying units. Convolute bedding may have resulted from dewatering of beds after periods of deposition in bedload conditions in channels. Deposition of con- glomerate suggests sedimentation during periods of upper flow regime conditions. Tabular, laminated beds of mudstone and silt- stone are interpreted to represent unconfined sedimentation in overbank floodplain regions. The preservation of fossil leaves in these strata suggest that floodplain regions were stable and defined by periods of nondeposition at least long enough to pro- mote the development of vegetation.
Figure 8. Photographs of the Cretaceous (Albian/Cenomanian) to younger nonmarine Caribou Pass formation. (A) Lateral accretion surfaces in sandstone. Hammer (white arrow) for scale. (A’) Identical photo, but with bold white lines illustrating low-angle lateral accretion surfaces (thin white lines represent base and top of low-angle bedsets). Note how bed thicknesses pinch out laterally in these units (from left to right side of photo). Hammer (white arrow) for scale. (B) Planar cross-stratified sandstone (Sp) overlain by low-angle trough cross-stratified sandstone (St) and capped by horizontally stratified sandstone (Sh). Black camera lens cap (white arrow) for scale. (C) Rounded- to well-rounded, moderate- to well-sorted, clast-supported conglomerate (Gm) with sandstone interbeds (Sm). Bedding dips gently to the right side of the photo. Ruler is 15 cm long for scale. Individual clasts range from 0.5 to 1.5 cm in a typical conglomerate. (D) Fossil leaf imprints on the top of a siltstone bed. White arrow shows coin for scale. (D’) Identical photo, but with white lines outlining fossil leaf margins.
STRATIGRAPHIC AND STRUCTURAL RELATIONSHIPS

Our geologic mapping and measured stratigraphic sections document several geologic relationships that have not been reported by previous studies. In this section, we describe two key stratigraphic contacts and present a revised structural interpretation for the northwestern Talkeetna Mountains.

Stratigraphic Configuration

Contact 1: Top of the Honolulu Pass Formation—Base of the Kahltna Assemblage

Our stratigraphic data document a disconformable depositional contact between the top of the Honolulu Pass formation and the base of the Kahltna assemblage (Section 5 in Figs. 5, 7). New mapping from our study suggests that both units are part of a continuous stratigraphic package that has been incorporated into two northwest-verging thrust sheets (Figs. 11A, 11B, 12A). At a distance, this relationship is recognized by a change from gray to yellow, massive resistant units of the Honolulu Pass formation (labeled Tr–J on Fig. 11C) to less-resistant dark black units of the overlying Kahltna assemblage (labeled J–K on Fig. 11C). The contact between the two units is located at the top of an ~75-m-thick interval of interbedded siltstone, mudstone, chert-rich sandstone, chert-pebble conglomerate, fossiliferous limestone (Early Jurassic age fossils), and igneous sills that define the top of the Honolulu Pass formation (Figs. 5, 11D). This interval is overlain by mudstone of the Kahltna assemblage (J–K; Section 5 in Fig. 5, Figs. 11C, 11D). We found no evidence of a structural break across this contact.
Figure 10. Age range of Albian–Cenomanian palynomorphs of the Caribou Pass formation. A maximum age of Albian is assigned to this unit based on palynomorph assemblages. Geologic time scale from Albian to Cenomanian (112 Ma to 93.5 Ma) is based on Gradstein et al. (2004).

Figure 11. (continued on the next page) Photographs of geologic relationships mapped in the East Fork Chulitna River area of the northwestern Talkeetna Mountains. White dip-direction indicators show orientation of beds in each photo. (A) Regional view from the northeasternmost part of the field area looking southwestward across the East Fork of the Chulitna River (valley in midground) at the deformed three-part stratigraphic succession. A southeast-dipping thrust fault (dashed line) carries Upper Triassic–Lower Jurassic Honolulu Pass formation (Tr–J), and Upper Jurassic–Lower Cretaceous strata of the Kahiltna assemblage (J–K) in the hanging wall and juxtaposes them against Kahiltna assemblage in the footwall (northern thrust fault of Fig. 1B). Note that Cretaceous to younger strata of the Caribou Pass formation (K) overlie the Kahiltna assemblage in the footwall (right part of photo). The Caribou Pass formation (K) has been deformed into a northeast-trending syncline in the right half of the photo. The broken thin white lines in the center of the photo mark a series of sills that define the boundary between the Kahiltna assemblage and the Caribou Pass formation. A close-up photo of this relationship is shown in Figure 11E. (B) Two north-verging thrust sheets in the field area (northern and southern thrust faults of Fig. 1B). View to the south-southwest. Note that the Honolulu Pass formation (Tr–J) has a deposition contact with the overlying Kahiltna assemblage (J–K) in both thrust sheets. Dashed white lines show location of the two thrust faults and arrows show direction of hanging wall displacement. Note that tectonic transport is to the northwest. White circle in lower left part of the photo outlines two tents for scale. (C) Depositional contact between the top of the Honolulu Pass formation (Tr–J) and overlying Kahiltna assemblage (J–K) that can be recognized by a break in color between the gray and yellow resistant layers of the Honolulu Pass formation (lower part of photo) and dark gray to black, less resistant strata of the Kahiltna assemblage. Dashed white line indicates approximate location of the contact. Exposure is ~500 m from base to top of photo. (D) Photo showing the depositional contact between the Honolulu Pass formation (Tr–J) and Kahiltna assemblage (J–K). Fossiliferous limestone of the Honolulu Pass formation (Tr–J) is exposed in the rightmost portion of the photo, and bedding is dipping to the left. The base of the Kahiltna assemblage (J–K) is exposed in the left part of photo. A 75-m-thick succession of interbedded chert-pebble conglomerate, fossiliferous limestone (Early Jurassic age fossils), siltstone, mudstone, and igneous sills makes up the top of the Honolulu Pass formation and represents up to ca. 25 m.y. of limited sedimentation during the Early Jurassic. The top of the Honolulu Pass formation is defined by a disconformable contact that represents ca. 20 m.y. of nondeposition during Middle and part of Late Jurassic time. There is no change in bedding orientation across the contact and no evidence for a structural break. (E) An angular unconformity or fault contact observed along the southeastern limb of the syncline between the Caribou Pass formation (K; upper part of photo) and the Kahiltna assemblage (J–K; lower part of photo). Note that the contact between these units is marked by a poorly exposed zone >200 m thick that contains a series of igneous dikes and sills. Dashed white lines mark locations of the more obvious sills. The nature of this contact is poorly understood and will require additional mapping. View is to the northeast. See Figure 12A for location of this photo in the context of structural location.
Figure 11. (continued)

**Contact 2: Top of the Kahiltna Assemblage—Base of the Caribou Pass Formation**

The contact between the Kahiltna assemblage and the Caribou Pass formation is best exposed along the northeast trending syncline located north of the East Fork of the Chulitna River (Fig. 12A). Along the southeastern margin of the syncline, the contact is defined by a diffuse >200-m-thick zone of igneous sills and dikes (Fig. 11E). Directly under this poorly exposed zone, beds of the Kahiltna assemblage (J–K on Figs. 11E, 12) are vertical to overturned, whereas, above the diffuse zone, beds of the Caribou Pass formation dip gently to the northwest (K on Figs. 11E, 12A). This contact is exposed ~1 km from a fault that is mapped in the Kahiltna assemblage (Fig. 12A). It is not clear whether the abrupt change in bedding across the diffuse zone represents an angular unconformity between the Kahiltna assemblage and the Caribou Pass formation or if it is a fault contact. Along the northwestern margin of the syncline, the contact appears to be depositional with both the Kahiltna assemblage and the Caribou Pass formation dipping to the southeast (Fig. 12A). Studies are ongoing to further understand the nature of the contact between the Kahiltna assemblage and the Caribou Pass formation in the northwestern Talkeetna Mountains (Altekruse et al., 2006).

**Previous Structural Interpretation**

Previous studies have suggested that the Upper Triassic–Cretaceous strata in the northwestern Talkeetna Mountains represent an allochthonous, fault-bounded, crustal block that may...
This study

<table>
<thead>
<tr>
<th>Quaternary (Qal) – Alluvium</th>
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<tr>
<td>Tertiary (T) – volc. rocks (basalt)</td>
</tr>
<tr>
<td>-Paleocene-Oligocene</td>
</tr>
<tr>
<td>Cretaceous-Tertiary, (K-T) – plut. rocks (granite)</td>
</tr>
<tr>
<td>-Paleocene-Oligocene</td>
</tr>
</tbody>
</table>

**FIGURE KEY**

- **Quaternary (Qal)** – Alluvium
- **Tertiary (T)** – volc. rocks (basalt)
  -Paleocene-Oligocene
- **Cretaceous-Tertiary, (K-T)** – plut. rocks (granite)
  -Paleocene-Oligocene

- **Fault**
  -thrust
  -inferred
  -undifferentiated
- **Thrust fault**
  (overturned/observed)
- **Syndcline**
  (overturned/inferred)
- **Anticline**
  (overturned/observed)
- **Bedding**
  OT
  Bedding (overturned)
- **Thrust fault**
have undergone significant displacement and deformation during northward transport and juxtaposition along the continental margin of North America (Susitna terrane of Jones et al., 1980, 1981; Silverling et al., 1981a, 1981b). Other mapping studies have interpreted the Honolulu Pass formation and the Kahiltna assemblage as part of a series of overturned, structurally emplaced, rootless nappes that ultimately restore back to Wrangellia and the Talkeetna fault to the south (Figs. 1A, 12B; e.g., Csejtey et al., 1992). This interpretation requires that part of the stratigraphy in the study area be overturned and that every contact between the Honolulu Pass formation and the Kahiltna assemblage be a fault (Fig. 12B). More recent studies of deformation fabrics and facies distribution along the Talkeetna fault have suggested that the fault may not represent a large-scale structure or terrane boundary (O’Neill et al., 2003).

Revised Structural Interpretation

Figure 12 provides a comparison of previous mapping in the northwestern Talkeetna Mountains with our new mapping data. We observe that the majority of the Honolulu Pass formation and Kahiltna assemblage consist of upright, tilted strata that dip southeastward. Typical southeast-dipping beds of the Honolulu Pass formation (Tr–J) and Kahiltna assemblage (J–K) are shown in Figure 11A. Both units are part of a continuous stratigraphic package that has been incorporated into two northwest-verging thrust sheets (Figs. 11B, 12A). These thrust sheets locally place the Honolulu Pass formation over the Kahiltna assemblage in the footwalls (Figs. 11A, 12B). The Kahiltna assemblage (J–K) has a disconformable contact with the underlying Honolulu Pass formation (Tr–J) in the hanging walls of the thrust sheets (Figs. 11B, 12A). The Caribou Pass formation occurs in the northeastern part of the study area, where it has been documented in a northeast-southwest trending syncline (K on Figs. 11A, 12A). In summary, our revised structural interpretation is that of more localized thrust-fault imbrication of the Honolulu Pass formation and Kahiltna assemblage in contrast to previous interpretations of nappe emplacement or large-scale terrane translation.

PROVENANCE

Compositional Data

Compositional trends were determined for sandstone samples collected within the context of measured stratigraphic sections from the Kahiltna assemblage and the overlying Caribou Pass formation. Standard petrographic thin sections for each sample were cut and stained for plagioclase and potassium feldspar. A total of 44 thin sections were analyzed using a modified Gazzi-Dickinson method of point counting (Dickinson, 1970; Ingersoll et al., 1984). Modal composition was determined by the identification of at least 400 framework grains in each thin section. Point-count parameters are shown in Table 1; raw point–count data are available in GSA Data Repository, Appendix 1, and recalculated data are available in Table 2. Recalculated data are based on procedures defined by Ingersoll et al. (1984) and Dickinson (1985).

Kahiltna Assemblage

The modal composition of the Kahiltna assemblage is characterized by predominantly quartz and roughly equal amounts of feldspar and lithic grains (Q-43% F-30% L-27%). Quartz grains consist of monocrystalline quartz (Qm), polycrystalline quartz (Qp), and chert (C; Figs. 13A–13D) with polycrystalline quartz being the most common constituent. The feldspar population in these sandstones is dominated by plagioclase grains (P; Qm-37% P-61% K-2%; Fig. 13D). Lithic grains consist largely of volcanic types (Lv; Figs. 13B, 13C) with metamorphic (Lm) and sedimentary types (Ls) being less common (Lv-71% Lm-18% Ls-11%). Common textures observed in lithic volcanic grains include pilitaxitic microlitic (Fig. 13B), lawthwork (Figs. 13B, 13C), vitric, and felsic. Lithic metamorphic grains are mainly micaceous schist and fine-grained pelitic schist. Sedimentary lithic grains (Ls) consist primarily of siltstone and mudstone.

Caribou Pass Formation

The Caribou Pass formation is made up predominantly of quartz grains (largely polycrystalline) with subordinate lithic fragments and feldspar grains (Q-65% F-9% L-26%; Figs. 13E–13H).

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TABLE 1. SUMMARY OF PARAMETERS FOR SANDSTONE POINT COUNTS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz (Q)</td>
<td>Qm + Qp + chert</td>
</tr>
<tr>
<td>Feldspar (F)</td>
<td>P + K</td>
</tr>
<tr>
<td>Lithic fragments (L)</td>
<td>Ls + Lm + Lv</td>
</tr>
<tr>
<td>Lithic sedimentary (Ls)</td>
<td>Argillite (Lsa) + Mudstone (Lsd) + Sandstone (Lss) + Limestone (Lsl)</td>
</tr>
<tr>
<td>Lithic metamorphic (Lm)</td>
<td>Phyllite (Lmph) + Shist (Lmsh) + Gneiss (Lmgm) + Metamachert (Lmc) + Metavolcanic (Lmv)</td>
</tr>
<tr>
<td>Lithic volcanic (Lv)</td>
<td>Lm + Ls + Qp + chert</td>
</tr>
<tr>
<td>Lvm</td>
<td>Lv + metavolcanic</td>
</tr>
<tr>
<td>Lsm</td>
<td>Ls + metasedimentary</td>
</tr>
</tbody>
</table>

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4GSA Data Repository Item 2007111, Appendices 1 and 2, is available on request from Documents Secretary, GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA, editing@geosociety.org, or at www.geosociety.org/pubs/ft2007.htm.
# Table 2. Recalculated Modal Point–Count Data for Sandstone Samples of the Kahiltna Assemblage and Caribou Pass Formation

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Q-F-L %</th>
<th>Qm-F-Lt %</th>
<th>Qm-P-K %</th>
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Note: Q-F-L, Qm-F-Lt, Qm-P-K, Qp-Lvm-Lsm, Lv-Lm-Ls represent the percentages of different mineral types in the sandstone samples.
Polycrystalline quartz (Qp; Figs. 13E, 13F, 13G), lithic metamorphic grains (Lm) of pelitic schist, and mica schist are common (Fig. 13G), with quartzite (Fig. 13H) being a lesser constituent. Plagioclase feldspar (P) is more common than potassium feldspar (Qm-65% P-34% K-1%), and metamorphic types (Lm) are the most common lithic grain (Lv-25% Lm-51% Ls-24%). Lithic volcanic (Lv) grains commonly exhibit felsitic textures in addition to microlithic and fathework textures (Fig. 13F, 13H). Sedimentary grains (Ls) consist primarily of siltstone and sandstone and make up nearly a quarter of the total lithic fragments.

Summary: Compositional Trends and Potential Sources

Our compositional data from the Kahiltna assemblage and Caribou Pass formation document some significant differences between the two units (Fig. 14). There is a noticeable difference, for example, in the relative abundance of quartz and feldspar between the units (Kahiltna assemblage: Q-43% F-30% L-27%; Caribou Pass formation: Q-65% F-9% L-26%). The Kahiltna assemblage also contains a relative abundance of lithic volcanic grains compared to the Caribou Pass formation (Fig. 14). The Caribou Pass formation, in contrast, is enriched in polycrystalline quartz and lithic metamorphic and sedimentary grains relative to the Kahiltna assemblage (Fig. 14). These compositional differences suggest sediment derivation from distinct source terranes for each unit. The composition of the Kahiltna assemblage requires it to have been derived from a source rich in volcanic rocks. The composition of the Caribou Pass formation, in contrast, requires derivation from a source terrane consisting of quartz-rich metamorphic and sedimentary rocks. Comparing our compositional data with the provenance fields of Dickinson et al. (1983), the Kahiltna assemblage plots with sandstones derived from arc sources (transitional to dissected) with minor contributions from recycled orogen sources, whereas the Caribou Pass formation plots with sandstones derived primarily from recycled orogen sources (Figs. 14A, 14B).

The Kahiltna assemblage and Caribou Pass formation in the study area are located in the Mesozoic suture zone between oceanic rocks of the Wrangellia composite terrane and metamorphosed continental-margin rocks of the Yukon-Tanana terrane (Fig. 1A; e.g., Ridgway et al., 2002). Our compositional data suggest that both of these terranes provided detritus for Mesozoic sandstones currently exposed in the northwestern Talkeetna Mountains. volcanic detritus was likely derived from more arc-rich parts of the Wrangellia composite terrane (Wrangellia and Peninsular terranes) during the Late Jurassic–Early Cretaceous (Kimmeridgian–Aptian) deposition of the Kahiltna assemblage. We do not rule out the possibility that Paleozoic arc rocks of the Yukon-Tanana terrane contributed some detritus during this time. In fact, our detrital zircon data discussed in the next section suggest that the Yukon-Tanana terrane contributed sediment during deposition of the Kahiltna assemblage. By the end of Early Cretaceous time (Albian/Cenomanian), however, quartz-rich meta-morphic rocks of the Yukon-Tanana terrane supplied the bulk of the sediment during deposition of the Caribou Pass formation. In summary, the sandstone compositional data indicate that there was a fundamental shift from arc-derived sediment from sources located south of the study area to continental margin-derived sediment from sources located north and east of the study area during Albian time.

U-Pb Detrital Zircon Analysis

Methodology

Zircons were collected from four sandstone samples of the Kahiltna assemblage in the northwestern Talkeetna Mountains. (See Fig. 1B for geographic location of the samples and Fig. 7 for stratigraphic location of samples within the context of our measured sections.) These samples were analyzed with a Micromass Isoprobe multicollector Inductively Coupled Plasma Mass Spectrometer (ICPMS) equipped with nine Faraday collectors, an axial Daly detector, and four ion-counting channels. The Isoprobe is equipped with a New Wave DUV 193 laser ablation system with an emission wavelength of 193 nm. The analyses were conducted on 35–50 micron spots with an output energy of ~40 mJ and a repetition rate of 8 Hz. Each analysis consisted of one 20-second integration on the backgrounds (on peaks with no laser firing) and twenty 1-second integrations on peaks with the laser firing. The depth of each ablation pit is ~20 microns. The collector configuration allows simultaneous measurement of 206Pb in a secondary electron multiplier, whereas 206Pb, 207Pb, 208Pb, 232Th, and 238U are measured with Faraday detectors. All analyses were conducted in static mode.

Correction for common Pb was done by measuring 206Pb/204Pb, with the composition of common Pb from Stacey and Kramers (1975) and uncertainties of 1.0 for 206Pb/204Pb and 0.3 for 207Pb/206Pb. Fractionation of 206Pb/238U and 206Pb/207Pb during ablation was monitored by analyzing fragments of a large concordant zircon crystal that has a known isotope dissolution-thermal ionization mass spectrometry (ID-TIMS) age of 564 ± 4 Ma (2-sigma; George Gehrels, 2006, personal commun.). Typically this reference zircon was analyzed once for every four unknowns. The uncertainty arising from this calibration correction, combined with the uncertainty from decay constants and common Pb composition, contributes ~1% systematic error to the 206Pb/238U and 206Pb/207Pb ages (2-sigma level). The preferred ages are based on 206Pb/238U ratios for <1.0 Ga grains and on 206Pb/207Pb for >1.0 Ga grains. A summary of measured isotopic ratios and ages is reported in GSA Data Repository, Appendix 2 (see footnote 1). For each sample, the analyses are shown on a Pb/U concordia diagram (Fig. 15A) and on an age probability plot (Fig. 16; using plotting program of Ludwig, 2003). The latter is generated by summing the individual probability distributions for all grains in a sample. Also shown is a plot of U/Tl versus age (Fig. 15B). Uranium and thorium concentrations are calibrated by analysis of NBS SRM 610 trace element glass.
Figure 13. Photomicrographs of the Kahiltna assemblage and overlying Caribou Pass formation (note scale bar in the lower right corner of each photo). Kahiltna assemblage. (A) Monocrystalline quartz (Qm) and plagioclase (P) together with lithic volcanic grains are the main constituents of the Kahiltna assemblage. (B) Grains of monocrystalline quartz (Qm), lithic volcanics (Lv), plagioclase (P), and chert (C) with subordinate polycrystalline quartz (Qp). (C) Outsized lithic volcanic grain (Lv) surrounded by monocrystalline quartz (Qm), polycrystalline quartz (Qp), plagioclase (P), and chert (C). (D) Plagioclase (P), chert (C), monocrystalline quartz (Qm), and polycrystalline quartz (Qp) are common in sandstone of the Kahiltna assemblage. Caribou Pass formation. (E) Polycrystalline quartz (Qp) is one of the primary constituents of the Caribou Pass formation. (F) Polycrystalline quartz (Qp), lithic volcanic grain (Lv), monocrystalline quartz (Qm), and chert (C). (G) An elongate quartz-rich lithic metamorphic grain (Lm), polycrystalline quartz (Qp), chert (C), and monocrystalline quartz (Qm). (H) Lithic metamorphic grains (Lm) of quartzite (larger Lm grain) and schist (smaller Lm grain), lithic volcanic grain (Lv), monocrystalline quartz (Qm), chert (C), and plagioclase (P).
Paleozoic age grains occur within a window of 380–300 Ma with one sample having a few additional occurrences between 300 and 280 Ma and 420–380 Ma (sample TCB-205 on Fig. 16). The majority of Precambrian age grains fall between 1.9 and 1.6 Ga (~56% of total Pc grains) and 3.0–2.0 Ga (~28% of total Pc grains) with the remainder of isolated grains near 1.4 Ga (5% of total Pc grains) and around 620 Ma (11% of total Pc grains).

**U-Pb Maximum Depositional Ages**

The youngest and oldest concordant ages from these samples are 106 ± 7 Ma and 2695 ± 12 Ma, respectively. Because the youngest age may have experienced Pb loss, a more reliable minimum crystallization age (maximum depositional age) is determined from the youngest cluster of three or more overlapping and concordant analyses. The most likely ages of these clusters can be determined from peaks in the age probability plots (Fig. 16) or from the TuffZirc program of Ludwig (2003). For each sample these analyses yield maximum depositional ages as follows: sample EFC-071102–04 peak age = 117.6 Ma, and TuffZirc age = 116.1 +2.8/−2.7 Ma; sample HPC-072802–02 peak age = 124.3 Ma, and TuffZirc age = 124.1 +5.0/−4.4 Ma; sample TCB-205 peak age = 126.7 Ma, and TuffZirc age = 125.4 +4.8/−4.9 Ma; sample AC-072002-01 peak age = 124.5 Ma, and TuffZirc age = 127.0 +3.3/−7.6 Ma (all uncertainties are at 2-sigma and include all random and systematic errors). If the youngest 83 analyses from these samples are grouped together, the peak in age probability occurs at 119.2 Ma and TuffZirc identifies 48 analyses that cluster at 118.3/1.4 Ma. All of these ages are within the Aptian according to the time scale of Gradstein et al. (2004). It is important to note that there are a number of individual grains that are as young as Albian. The revised Aptian age presented here for the Kahiltna assemblage in the northwestern Talkeetna Mountains is determined from peak ages and considered to be a robust maximum depositional age.

Previous studies have cited the age of the Kahiltna assemblage in this area as Upper Jurassic–Lower Cretaceous (Kimmeridgian–Valanginian) based on Buchia macrofossils (Jones et al., 1980; Silberling et al., 1981; Smith et al., 1988). We suggest that the upper age of the Kahiltna assemblage may be at least 10–15 m.y. younger than previously reported based on maximum depositional ages from the detrital zircon data. The new age range for the Kahiltna assemblage employing both biostratigraphy and detrital zircon age data is Kimmeridgian–Aptian.

**Provenance of Detrital Zircons**

Matching U-Pb ages of detrital zircons from the Kahiltna assemblage with U-Pb ages of possible source terranes provides a powerful provenance tool. The low ratios of uranium-thorium recorded from detrital zircon grains within the Kahiltna assemblage (values <8; Fig. 15B) suggest that these grains were derived from igneous rather than metamorphic source areas. Figure 17 provides a general summary of possible igneous source areas located north and south of the study area.
Figure 15. (A) U-Pb concordia diagrams of single detrital zircon grains from four samples of sandstone from the Kahiltna assemblage. Enlargements on right of each plot show data for grains <542 Ma. Concordia plots were produced using the programs of Ludwig (1991a, 1991b). All errors are shown at the 95% confidence level. Sample number and number of grains counted (n) are shown in box in the upper left corner of each plot. See Figure 7 for stratigraphic position of samples within our measured sections. (B) Plot of U/Th versus age for all samples (dashed line represents U/Th value of 5). Note that <1.5% of total samples have U/Th values >5.
It is important to note that Cretaceous–Tertiary dextral displacement (up to 400 km) along the Denali fault is thought to have been largely responsible for much of the geology observed in southern Alaska and western Canada (e.g., Eisbacher 1976; Nokleberg et al., 1985; Plafker and Berg, 1994; Cole et al., 1999; Trop et al., 2004; Trop and Ridgway, this volume). Given the tectonic complexity of the North American Cordillera since the middle of the Mesozoic, an investigation into potential source areas for detrital zircon grains should ideally involve a comprehensive examination of the entire Cordillera. Such an approach is beyond the scope of this study given the limited number of samples. We do, however, provide a general summary of potential igneous sources in southern Alaska and the adjacent Yukon Territory.

**Potential sources south of study area.** Some of the more widespread potential Mesozoic igneous source areas located south of the study area include (1) Upper Triassic–Jurassic rocks of the Peninsular terrane (including the Talkeetna arc) and partially coeval Jurassic granitoid rocks of the Chitina arc in the Wrangell Mountains (Fig. 17), and (2) Cretaceous granitoid rocks of the Chisana arc in the Wrangellia terrane (Fig. 17). Igneous activity associated with the Chisana arc ranges from ca. 140–125 Ma; however, new $^{40}$Ar/$^{39}$Ar ages from volcanic rocks (113 ± 1.3 Ma and 116 ± 1.3 Ma) and cooling ages from granitoid rocks (113 ± 1.3 Ma and 117 ± 0.54 Ma) suggest that the arc was active at least until Late Cretaceous time (Short et al., 2005; Snyder and Hart, 2005, this volume).

Granitoid rocks associated with the Peninsular terrane (Talkeetna arc and equivalent rocks) are exposed north of the Border Ranges fault and south of the Kukllna assemblage in south-central and southwestern Alaska (Fig. 17). The oldest ages reported for
Figure 17. A simplified geologic map of southern Alaska and adjacent Yukon Territory that shows the distribution of the Kahiltna assemblage (J–K), as well as potential igneous source areas that may have provided sediment to the Kahiltna assemblage. Potential source areas include plutonic rocks of the Wrangellia composite terrane located south and east of the outcrop belt of the Kahiltna assemblage and the Yukon-Tanana terrane located to the north and northeast of the outcrop belt. Specific ages of arc/plutonic rocks that have some overlap with the ages of detrital zircons grains from the Kahiltna assemblage are shown in the legend. See text for additional discussion.
the Talkeetna arc are between 201 and 198 Ma (Päily et al., 1999; Rioux et al., 2005; Amato et al., this volume, chapter 11). Mesozoic magmatism associated with the Talkeetna arc is thought to have taken place from 201–153 Ma with punctuated episodes of plutonism between 201 and 181 Ma and between 177 and 153 Ma (Onstott et al., 1989; Rioux et al., 2002, 2003). Ultramafic rocks, informally referred to as the Border Ranges ultramafic–mafic complex (Burns, 1985) are thought to be slightly older to contemporaneous with intermediate plutons and have been proposed to represent the deepest part of the Talkeetna arc (Fig. 17; Burns, 1985). It should be noted, that although generally thought to be contemporaneous with the Talkeetna arc, a diorite crystallization age as old as 217 ± 10 Ma has been reported from the Border Ranges mafic-ultramafic complex (Roeske et al., 1989). Upper Jurassic plutonic and metaplutonic rocks of the Chitina arc are exposed southeast of the study area in the Wrangell Mountains and in the Yukon Territory (Fig. 17) and represent igneous activity from ca. 175–135 Ma (Pfläger et al., 1989; Nokleberg et al., 1994; Roeske et al., 2003). The Chitina arc intruded the Wrangellia terrane and was partially coeval with the Talkeetna arc of the Peninsular terrane (Fig. 17; Troup et al., 2005).

Although the Kahltna assemblage contains Triassic (majority between ca. 240–200 Ma) and mid-Paleozoic (majority between ca. 380 and 300 Ma) age detrital zircons (Fig. 16) there are few known source areas south of the study area that would contribute grains of these ages. It should be noted that Paleozoic igneous rocks associated with the Skolai arc are rare but do occur south of the study area in parts of the Wrangellia and the Alexander terranes in southeastern Alaska (Fig. 17). The range of ages for these rocks is around 320–285 Ma with the majority of ages around 310 Ma (Nokleberg et al., 1986; Aleinikoff et al., 1986; Gardner et al., 1988; Beard and Barker, 1989; Pfläger et al., 1989); these ages are slightly younger than the Devonian–Mississippian detrital peaks observed in the Kahltna assemblage (Fig. 18). The Alexander terrane in southeastern Alaska contains Permian–Triassic (ca. 280–220 Ma) and Ordovician–Silurian (480–410 Ma) plutonic suites (Gehrels and Saleeby, 1987; Gehrels, 1990) that are likely sources for Triassic grains older than ca. 215 Ma, as well as the Permian zircons documented in the Kahltna assemblage.

**Potential sources north and east of the study area.** Some of the oldest Mesozoic plutonic rocks in Alaska are found north of the Denali fault and consist of Upper Triassic to Lower Jurassic plutons that make up the Taylor Mountains batholith of the Yukon-Tanana terrane (Fig. 17). A host of studies have presented U-Pb, ⁴⁰Ar/³⁹Ar, and K-Ar ages from Upper Triassic–Lower Jurassic plutons from this region that fall between 215 and 175 Ma (e.g., Aleinikoff et al., 1981; Cushing, 1984; Wilson et al., 1985; Foster et al., 1994; Dusel-Bacon et al., 2002). Younger plutons, Lower to Upper Cretaceous age, have been reported from segments of the Yukon-Tanana terrane with ages ranging from 110–85 Ma (Foster et al., 1994). These plutons were not a major source but likely contributed some of the youngest grains reported from the Kahltna assemblage.

Devonian and Mississippian age plutonic rocks from segments of the Yukon-Tanana terrane (Fig. 17) consist of augen gneiss, dioritic orthogneiss, and granitic orthogneiss, all of which have originated from plutonic protoliths that were part of a middle Paleozoic continental magmatic arc (Dusel-Bacon and Aleinikoff, 1985). U-Pb zircon SHRIMP ages, U-Pb concordia ages, and Rb-Sr whole-rock isochron ages from these Paleozoic plutonic rocks have an age range between ca. 380 and 330 Ma (Mortensen, 1983; Aleinikoff et al., 1986; Dusel-Bacon and Aleinikoff, 1985; Dusel-Bacon et al., 2001; Day et al., 2003).

Although Precambrian age detrital zircons make up a small percentage of the grain population in the Kahltna assemblage (~5%), it is important to consider possible source areas because their occurrence suggests that this region was in proximity to the continental margin and receiving detritus from North America during Cretaceous time. Precambrian basement provinces in western North America consist of the Canadian Shield (>2.5 Ga) and surrounding cratonic rocks in western Canada that include ages from 2.4–2.0 Ga and from 2.0–1.8 Ga. In the western U.S., the primary Precambrian source areas include rocks of Grenville age (1.2–1.0 Ga) and Yavapai-Mazatzal age (1.87–1.67 Ga). Age ranges for Precambrian basement are summarized from Hoffman (1989), Ross (1991), and Reed (1993). Sedimentary rocks of the Belt-Purcell and Windermere Supergroup in western Alberta, Montana, and Idaho are a potential source of recycled detrital zircons and contain a range of Precambrian age detritus from the western United States and western Canada (Ross et al., 1992). Occurrences of Precambrian grains ranging from 3.0–1.0 Ga have also been reported from the Alexander terrane (Gehrels et al., 1996).

**Interpretation of U-Pb Detrital Zircon Data**

Figure 18 outlines our interpretation for the provenance of Mesozoic and Paleozoic detrital zircons documented in the Kahltna assemblage of the northwestern Talkeetna Mountains. Mesozoic detrital zircon grains make up ~84% of the total grains from the Kahltna assemblage. Approximately 19% of the detrital zircon grains from the Kahltna assemblages have Mesozoic ages younger than 140 Ma (Fig. 18). Of these grains, ages that fall between 140 and 115 Ma (~15% of total grains) were most likely derived from granitoid rocks of the Chisana arc of Wrangellia located southeast of the study area (Fig. 17). The remaining ~4% of Mesozoic grains are younger than 115 Ma and were likely derived from Cretaceous plutons of the Yukon-Tanana terrane located northeast of the study area.

The bulk of the Mesozoic detrital zircons have age ranges between 215 and 135 Ma (~55% of total grains; Fig. 18). We interpret these grains to have been derived in part from the Talkeetna-Chitina arc (south of the study area) and the Taylor Mountains batholith (northeast of the study area). It is important to note the overlap in ages between the Chitina arc (175–135 Ma) and Talkeetna arc (201–153 Ma), as well as the Talkeetna arc and the Taylor Mountains batholith (215–175 Ma). Based on these overlapping ages, Mesozoic grains with ages between 153 and 135 Ma (~2% of total grains) were likely derived solely from plutons of
Figure 18. Age probability histogram plots showing the distribution of Mesozoic and Paleozoic detrital zircons ages from four sandstone samples of the Kahiltna assemblage. Black histograms are in 5 m.y. intervals. The age range for Mesozoic and Paleozoic potential source areas from the Wrangellia composite terrane and Yukon-Tanana terrane are shown to compare age distribution of detrital grains with known ages of plutonic arc suites adjacent to the study area. See Figure 17 for geographic locations of potential source areas. The main sources of detritus during deposition of the Kahiltna assemblage appear to be the Chisana arc, Talkeetna-Chitina arcs, and Permian–Triassic plutons (Alexander terrane) of the Wrangellia composite terrane and the Taylor Mountains batholith of the Yukon-Tanana terrane. Devonian–Mississippian age zircon grains of the Kahiltna assemblage were also likely derived from the Yukon-Tanana terrane. The youngest and oldest zircon grains were likely derived from the Yukon-Tanana terrane and Alexander Terrane, respectively. See text for additional discussion.
the Chitina arc. Detrital zircons with age ranges between 201 and 153 Ma (~37% of total grains) are interpreted to represent derivation from a combination of the Chitina and Talkeetna arcs as well as the Taylor Mountains batholith. Mesozoic ages between 215 and 201 Ma (~16% of total grains) were likely derived solely from the Taylor Mountains batholith of the Yukon-Tanana terrane. The remainder of Mesozoic detrital zircon grains documented in the Kahltna assemblage that are older than 215 Ma (~10% of total grains) were most likely derived from younger parts of Permian–Triassic plutons of the Alexander terrane (Fig. 18).

Paleozoic age detrital zircon grains make up ~11% of the total grains from the Kahltna assemblage and are interpreted to have been derived from source areas related to the Skolai arc (320–285 Ma); undifferentiated augen gneiss, dioritic orthogneiss, and granitic orthogneiss from segments of the Yukon-Tanana terrane (380–330 Ma); and a possible contribution from Ordovician–Silurian plutonic rocks of the Alexander terrane (480–410 Ma; Figs. 17, 18). Of these potential sources, ~14% of Paleozoic age detrital zircon grains from the Kahltna assemblage (<2% of total grains) fall within the range of the Skolai arc and ~55% (~6% of total grains) are within the range of igneous sources of the Yukon-Tanana terrane. Approximately 10% are split between age ranges for Permian–Triassic plutons (5%) and Ordovician–Silurian plutons (5%) of the Alexander terrane (Fig. 18). The remaining ~21% of Paleozoic age detrital zircon grains are between 330 and 320 Ma (~12%) and between 410 and 380 Ma (~9%). These age ranges fall between the oldest ages of the Skolai arc and the youngest ages of Mississippian plutonic rocks of the Yukon-Tanana terrane and between the oldest ages of Devonian plutonic rocks of the Yukon-Tanana terrane and the youngest ages of Silurian plutonic rocks of the Alexander terrane, respectively (Fig. 18).

Precambrian grains make up ~5% of the total zircon population from the Kahltna assemblage. Up to ~56% of Precambrian detrital zircon grains have ages between 1.9 and 1.6 Ga and ~28% are between 3.0 and 2.0 Ga (Fig. 15). The remainder of ages for the Precambrian grains are isolated near 1.4 Ga (~5% of total Pc grains) and ca. 620 Ma (11% of total Pc grains). Ages >2.0 Ga and between 1.9 and 1.6 Ga were likely derived from northern locations within the North American Cordillera (north of latitude 40°N) that include the Canadian Shield and recycled detrital zircons from the Windermere Supergroup and Belt-Purcell Group (e.g., Gehrels et al., 1995; Mahoney et al., 1999). Younger Precambrian detrital zircons likely originated south of latitude 40°N and may have come to their present location by multiple recycling events throughout the evolution of the Cordillera (e.g., Ross et al., 1992; Gehrels et al., 1995). Precambrian grains ranging from 3.0 to 1.0 Ga have also been reported from the Alexander terrane (Gehrels et al., 1996). Due to the small number of Precambrian grains in the Kahltna assemblage, we do not use the occurrence of Precambrian detrital grains to infer amount of translation or transport along the western North American continental margin; rather, we use these occurrences to strengthen our contention that the Kahltna basin was receiving detritus from continental-margin sources during Early Cretaceous time.

In summary, our U-Pb detrital zircon data suggest that the Upper Jurassic–Lower Cretaceous Kahltna assemblage in the study area was receiving sediment from both arc-related rocks of the Wrangellia composite terrane to the south and continental-margin rocks of the Yukon-Tanana terrane to the northeast. The bulk of the zircon ages can be attributed to the Wrangellia composite terrane, but there is a clear signal of sediment contribution from continental margin sources (minimum of ~26% of total grains).

DISCUSSION

Regional Stratigraphic Correlation Along the Suture Zone

Upper Triassic–Cretaceous strata located between the Wrangellia composite terrane and the Mesozoic continental margin of North America are exposed in an elongate, southwest-trending belt that has been studied mainly in the context of regional mapping projects (Fig. 19). Figure 20 presents a summary of our tentative stratigraphic correlations of Upper Triassic–Cretaceous strata along the suture zone. In the following text, we briefly discuss these potential stratigraphic relationships. Our regional stratigraphic summary does not necessarily imply that all Mesozoic strata were deposited in the same basin; however, it does point to some common stratigraphic elements in all the basinal settings.

Lake Clark Region

The Mesozoic stratigraphy in this region of southwestern Alaska (location 1 on Figures 19, 20) is defined by a succession that consists of the Upper Triassic–Lower Jurassic (?) Chilikadrotna greenstone sequence, the Upper Jurassic–Lower Cretaceous Koksetna River sequence, and the Upper Cretaceous Kuskokwim Group (Eakins et al., 1978; Hanks et al., 1985; Wallace et al., 1989; Elder and Box, 1992). The Chilikadrotna greenstone sequence and the Koksetna River sequence have been collectively referred to as the southern Kahiltna terrane by Wallace et al. (1989). The main part of the Chilikadrotna greenstone sequence consists of Upper Triassic (Norian) interbedded massive lavas (locally pillow lavas), limestone, and chert. Conodonts from the limestone units have been assigned a Late Triassic (Norian) age (Wallace et al., 1989). The top of the Chilikadrotna greenstone sequence is defined by andesite flows, tuffs, and tuff breccia. No bounding ages have been recorded from the top or bottom of the sequence; thus, the upper and lower age extent remains unknown. Further study is necessary to determine if the stratigraphy at the top of the Chilikadrotna greenstone sequence represents a condensed stratigraphic section similar to that described for the Honolulu Pass formation (Fig. 20). The Chilikadrotna greenstone has been tentatively correlated with the Peninsular terrane based on stratigraphic similarities (Wallace et al., 1989; Nokleberg et al., 1994).

The Chilikadrotna greenstone sequence is overlain by the Upper Jurassic–Lower Cretaceous (Kimmeridgian–Valanginian) Koksetna River sequence (Fig. 20; Bundtzen et al., 1979; Wallace...
et al., 1989). This unit consists of a volcanic lithic-rich marine succession of interbedded mudstone, siltstone, fine-grained sandstone, and minor conglomerate. These strata have been interpreted as the product of submarine fan deposition (Wallace et al., 1989). Limited sandstone compositional data from the Koksetna River sequence indicate a predominantly arc provenance (Wallace et al., 1989); no U-Pb detrital zircon data are available from these strata. Age control for the Koksetna River sequence is based on the occurrence of Upper Jurassic—Lower Cretaceous bivalves that include Buchia mosquensis and Buchia sublaevi (Eakins et al., 1978; Wallace et al., 1989). Given a Late Triassic (Norian) age for the Chilikadotna greenstone sequence and the Upper Jurassic—Cretaceous (Kimmeridgian—Valanginian) age for the Koksetna River sequence, there may be an extended period of nondeposition represented in the stratigraphy between these two sequences during Early—Middle Jurassic time (Fig. 20).

Overlying the Koksetna River sequence are Upper Cretaceous strata of the Kuskokwim Group. The contact between these two units has not been documented in this region and may be either a fault or stratigraphic contact. The Kuskokwim Group in the Lake Clark region is thought to be Late Cretaceous (Cenomanian—Turonian) based on the occurrence of the bivalve Inoceramus (Elder and Box, 1992). The Kuskokwim Group is interpreted to have been deposited in a shallow marine and deltaic depositional environment (Elder and Box, 1992; Miller et al., 2002).

**Tatina River Area**

In the western Alaska Range, a similar stratigraphy has been described for the Upper Triassic—Lower Jurassic Tatina River volcanic unit, which is disconformably overlain by the Lower Cretaceous Kahltna assemblage (location 2 on Figs. 19, 20; Kalbas et al., this volume). The Tatina River volcanic unit disconformably overlies Devonian—Permian strata; all these units are considered to be part of the Mystic subterrane (Fig. 20; Bundtzen et al., 1997). The base of the Tatina River volcanic unit consists of interbedded pillow lavas, mudstone, chert, and volcaniclastic strata that contain the Triassic bivalve Monotis subcircularis. The upper part of the Tatina River volcanic unit consists of interbedded volcaniclastic sandstone, shale, and chert-pebble conglomerate and is thought to be Early Jurassic (Sinemurian) in age based on the occurrence of ammonites and pelecypods (Reed and Nelson, 1980; Bundtzen et al., 1997). Early Jurassic strata in this area are
Figure 20. Stratigraphic regional correlation diagram of Upper Triassic–Cretaceous strata throughout south-central and southwestern Alaska along the inboard margin of the Wrangellia composite terrane. Composite stratigraphic sections were constructed from references cited in figure; thickness of stratigraphic units is not to scale. Note that most elements of the three-part stratigraphy documented in the northwestern Talkeetna Mountains are present in each of the composite sections. See text for more discussion. Upper Triassic–Jurassic Chulitna stratigraphy summarized from Jones et al. (1982), Csejtey et al. (1992), and Clautice et al. (2001).
very similar to volcanic, volcanioclastic, and chert-rich sandstone and conglomerate described from the Early Jurassic condensed interval of the Honolulu Pass formation in the northwestern Talkeetna Mountains (Fig. 20). A disconformable contact exists between the Tatina River volcanic unit and the overlying Lower Cretaceous Kahiltna assemblage. This contact may represent a period of little to no deposition during part of Early, Middle, and Late Jurassic time (Fig. 20; Kalbas et al., this volume).

The Kahiltna assemblage in this region consists of interbedded mudstone, siltstone, and sandstone with minor conglomerate and is interpreted to have been deposited in submarine fan environments. These strata are Lower Cretaceous (Valanginian–Albian) age based on both the occurrence of the bivalve Inoceramus (Fig. 20; Reed and Nelson 1980; Bundtzen et al., 1997) and maximum depositional age from detrital zircons (Kalbas et al., this volume). Sandstone compositional data from the Kahiltna assemblage in this area indicate predominantly arc provenance; limited U-Pb detrital zircon data indicate a mixture of arc sources from the Wrangellia composite terrane and continental margin sources of the Yukon-Tanana terrane (Kalbas et al., this volume). Shallow marine and/or nonmarine strata overlying the submarine fan strata of the Kahiltna assemblage have not been reported from this area (Fig. 20).

**Colorado Creek/Chulitna Region**

Triassic stratigraphy in the south-central Alaska Range (Figs. 19, 20) is well exposed in the Chulitna terrane of Jones et al. (1980) and consists of Paleozoic limestone and fine-grained turbidite strata, and Upper Triassic pillow lava, fossiliferous limestone, volcanioclastic strata, and a quartz-rich redbed unit (Jones et al., 1982; Csejtey et al., 1992; Clautice et al., 2001). A Norian age has been assigned to Upper Triassic strata based on the occurrence of the bivalve Monotis and hydrozoan Heterastridium (Blodgett and Clautice, 2000; Clautice et al., 2001). Upper Triassic strata are overlain by a succession of Lower Jurassic sandstone, limestone, and argillite that is thought to be as young as Early Jurassic (Sinemurian) in age based on the occurrence of ammonites (Blodgett and Clautice, 2000; Clautice et al., 2001). These strata are partially age equivalent to the Early Jurassic condensed stratigraphic interval described from previously discussed locations in the suture zone. Some workers have suggested that the Upper Triassic pillow lava and limestone stratigraphy of the Chulitna terrane is time-equivalent and bears some lithologic similarity to that of the Honolulu Pass formation in the northwestern Talkeetna Mountains and to the Wrangellia stratigraphy exposed south of the Talkeetna fault (Fig. 1A; Jones et al., 1982; Csejtey et al., 1992; Clautice et al., 2001).

A poorly defined unit consisting primarily of argillite and cherty argillite with minor cherty tuff and basaltic tuff is thought to overlie Early Jurassic strata and may be as young as Middle–Late Jurassic (Callovian–Tithonian) age based on radiolarian biostratigraphy (Blodgett and Clautice, 2000; Clautice et al., 2001). The relationship of this unit with the overlying Lower Cretaceous Kahiltna assemblage is unclear; however, if it represents the base of the Kahiltna, a disconformity representing part of Early Jurassic and Middle Jurassic time may exist between this unit and the underlying Upper Triassic–Lower Jurassic (Norian–Sinemurian) strata (Fig. 20).

The Kahiltna assemblage in this area is Lower Cretaceous (Valanginian–Cenomanian) and consists of submarine fan deposits of interbedded sandstone, siltstone, and conglomerate with minor limestone (Eastham, 2002; Eastham and Ridgway, 2002). The age of the Kahiltna assemblage in this area is based on the Early Cretaceous bivalves Inoceramus and Buchia and Late Cretaceous ammonites (Jones et al., 1980; Jones et al., 1983). Sandstone compositional data from the Kahiltna assemblage in the central Alaska Range have a mixed arc and recycled orogen signature (Eastham et al., 2000). Conodonts from limestone clasts in conglomerate of the Kahiltna assemblage indicate derivation from Paleozoic continental margin strata (Ridgway et al., 2002). U-Pb detrital zircon data from the Kahiltna assemblage in this area show a clear mixture of sediment derivation from the Wrangellia composite terrane and continental margin strata (Hampton et al., 2005). Overlying the Kahiltna assemblage with an angular unconformity is a thin succession (~20 m thick) of Upper Cretaceous (Coniacian–early Campanian) strata that contain marginal marine dinoflagellate taxa (Trop et al., 2004). These strata consist of interbedded sandstone and mudstone that conformably underlie lower Oligocene nonmarine conglomeratic strata (Trop et al., 2004).

**Correlation Summary**

Regional stratigraphic correlation of Upper Triassic–Cretaceous strata throughout the Alaska Range suture zone in southwestern and south-central Alaska demonstrates several common stratigraphic elements. The first common element is Upper Triassic–Lower Jurassic volcanic and carbonate strata that appear to have comparable lithologies with similar fossil occurrences (Fig. 20). With the exception of the Upper Triassic siliciclastic redbed unit of the Chulitna terrane, Upper Triassic–Lower Jurassic strata throughout the suture zone share closest commonalities with volcanic and sedimentary rocks described for the Wrangellia and Peninsular terranes. Within the context of the tectonic evolution of the suture zone, we tentatively interpret the Upper Triassic–Lower Jurassic strata of the Lake Clark region and Tatina River area as representing precollisional deposition on an arc margin and related carbonate platform/ramp as described for the Honolulu Pass formation of the northwestern Talkeetna Mountains. Much more work is needed to determine the nature of the units that underlie the Upper Triassic strata throughout the suture zone in order to test our preliminary correlation.

A second common element documented in our regional correlation is a hiatus in the stratigraphic record that may represent a condensed stratigraphic interval and/or disconformity that occurred throughout part of Early, Middle, and Late Jurassic time. This is best documented by what we interpret as a condensed 75-m-thick stratigraphic interval representing up to ~25 m.y. of limited sedimentation during Early Jurassic time and a ~20 m.y. disconformity.
that lasted throughout Middle and part of Late Jurassic time in the northwestern Talkeetna Mountains. The importance of this condensed stratigraphy and overlying unconformity throughout the suture zone is currently not well understood. Within the context of the development of the suture zone this event may record thermal subsidence or drowning of an inactive volcanic arc/carbonate platform. A second hypothesis is that this event is the product of tectonic subsidence due to loading of the arc margin by some unknown (at present) tectonic feature.

A third common element in our regional stratigraphic correlation is that the Late Jurassic (Kimmeridgian) marks the initiation of submarine fan deposition throughout the suture zone (Fig. 20). In the northwestern Talkeetna Mountains, this stratigraphic package coarsens upward and deposition continued through at least Aptian time, but locally in other parts of the suture zone submarine fan deposition extended into Cenomanian time (Fig. 20). In the context of the tectonic evolution of the suture zone, we interpret the thick Upper Jurassic–Lower Cretaceous submarine fan strata to represent the syncollisional sedimentary record associated with collision of the Wrangellia composite terrane with inboard terranes of the continental margin. Our provenance data from the Kahiltna assemblage in the study area clearly show that sediment deposited in the Kahiltna basin was being derived from both the Wrangellia composite terrane and the Mesozoic continental margin.

A fourth common element in the regional stratigraphic correlation is the transition from Upper Jurassic–Lower Cretaceous deep marine, submarine fan strata to overlying Lower Cretaceous and younger shallow marine to nonmarine strata (Fig. 20). Cretaceous strata in the northwestern Talkeetna Mountains, the newly discovered Caribou Pass formation, are nonmarine and were derived from exhumed continental margin strata of the Yukon–Tanana terrane based on our compositional data. In the central Alaska Range (Colorado Creek/Chulitna area), partially equivalent marginal marine strata overlie the submarine strata of the Kahiltna assemblage with an angular unconformity. Potentially, coeval shallow marine and minor nonmarine strata of the Kuskokwim Group depositionally overlie the Kahiltna assemblage in southwestern Alaska (Fig. 20). Although additional study is needed to determine the nature of the contact between Upper Cretaceous and underlying strata throughout the suture zone, the presence of nonmarine to shallow marine strata and isolated angular relationships suggests that Upper Cretaceous strata represent the transition from a pre- to postcollisional stage of suture zone development. Collectively, our correlation suggests a southwestward nonmarine to marine transition in interpreted postcollisional strata.

In summary, the three-part stratigraphy established by our study of Mesozoic strata in the northwestern Talkeetna Mountains appears to be correlative to similar strata along strike in the suture zone. Regional correlation between four areas over a distance of $\sim 375$ km in a structurally complex suture zone is overly optimistic at best, but we feel that the stratigraphic similarities exhibited throughout this region are strong enough to warrant additional detailed stratigraphic studies that have the potential to help delineate the tectonic development of southern Alaska and contribute to a better understanding of the general stratigraphic record of collisional continental margins.

CONCLUSIONS

1. Newly defined stratigraphy for Mesozoic strata exposed in the northwestern Talkeetna Mountains consists of three parts: the Upper Triassic–Lower Jurassic Honolulu Pass formation, which represents volcanic arc/carbonate ramp depositional environments; the Upper Jurassic–Lower Cretaceous Kahiltna assemblage, which represents submarine fan deposition in a marine basin; and the Lower Cretaceous to younger Caribou Pass formation, which represents nonmarine sedimentation. We interpret this three-part stratigraphy to represent the pre-, syn-, and postcollisional stages between the Wrangellia composite terrane and the Mesozoic continental margin based on geologic mapping, measured stratigraphic sections, and provenance data.

2. Detailed geologic mapping of the study area utilizing the three-part stratigraphy shows that it consists of two north-west-verging thrust sheets. Our new structural interpretation is that of more localized thrust-fault imbrication of the three-part stratigraphy in contrast to previous interpretations of nappe emplacement or terrane translation that require large-scale displacements.

3. Peak U-Pb detrital zircon ages from the Kahiltna assemblage show that deposition continued at least through Early Cretaceous (Aptian) time. This new finding extends the age range of the Kahiltna assemblage exposed in the northwestern Talkeetna Mountains by a minimum of 10–15 m.y.

4. The provenance of the Kahiltna assemblage in the study area indicates that much of the detritus was derived from active and remnants of the Caribou Pass formation, and nonmarine strata of the Yukon–Tanana terrane based on our compositional data. In the central Alaska Range (Colorado Creek/Chulitna area), partially equivalent marginal marine strata overlie the submarine strata of the Kahiltna assemblage with an angular unconformity. Potentially, shallow marine and minor nonmarine strata of the Kuskokwim Group depositionally overlie the Kahiltna assemblage in southwestern Alaska (Fig. 20). Although additional study is needed to determine the nature of the contact between Upper Cretaceous and underlying strata throughout the suture zone, the presence of nonmarine to shallow marine strata and isolated angular relationships suggests that Upper Cretaceous strata represent the transition from a pre- to postcollisional stage of suture zone development. Collectively, our correlation suggests a southwestward nonmarine to marine transition in interpreted postcollisional strata.

In summary, the three-part stratigraphy established by our study of Mesozoic strata in the northwestern Talkeetna Mountains appears to be correlative to similar strata along strike in the suture zone. Regional correlation between four areas over a distance of $\sim 375$ km in a structurally complex suture zone is overly optimistic at best, but we feel that the stratigraphic similarities exhibited throughout this region are strong enough to warrant additional detailed stratigraphic studies that have the potential to help delineate the tectonic development of southern Alaska and contribute to a better understanding of the general stratigraphic record of collisional continental margins.

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5. The stratigraphy that we have defined for the northwestern Talkeetna Mountains appears to be correlative to stratigraphy throughout the suture zone in parts of south-central and southwestern Alaska. Common stratigraphic elements include: an Upper Triassic–Lower Jurassic volcanic base-
Upper Cretaceous shallow marine and nonmarine strata that were mainly derived from continental margin sources.

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REFERENCES CITED


transpressional tectonics along the central Denali fault system: Canadian
Trop, J.M., Szuch, D.A., Rioux, M., and Blodgett, R.B., 2005, Sedimentology and
provenance of the Upper Jurassic Naknek Formation, Talkeetna Mountains,
Alaska: Bearings on the accretionary tectonic history of the Wrangellia com-
doi: 10.1130/B25575.1

Wallace, W.K., Hanks, C.L., and Rogers, J.F., 1989, The southern Kahiltna ter-
rane: Implications for the tectonic evolution of southwestern Alaska: Geo-
ological Society of America Bulletin, v. 101, no. 11, p. 1389–1407, doi:
the Yukon crystalline terrane, Alaska and Yukon Territory: Canadian Jour-
nal of Earth Sciences, v. 22, no. 4, p. 525–537.

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