To Jeff –
We're slow, but sure!
Marti

ARTICLES

Late Cretaceous through Cenozoic Strike-Slip Tectonics of Southwestern Alaska

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ABSTRACT

New geologic mapping and geochronology show that margin-parallel strike-slip faults on the western limb of the southern Alaska orocline have experienced multiple episodes of dextral motion since ~100 Ma. These faults are on the upper plate of a subduction zone ~350–450 km inboard of the paleotrench. In southwestern Alaska, dextral displacement is 134 km on the Denali fault, at least 88–94 km on the Iditarod–Nixon Fork fault, and perhaps tens of kilometers on the Dishna River fault. The strike-slip regime coincided with Late Cretaceous sedimentation and then folding in the Kuskokwim basin, and with episodes of magmatism and mineralization at ~70, ~60, and ~30 Ma. No single driving mechanism can explain all of the ~95 million-year history of strike-slip faulting. Since ~40 Ma, the observed dextral sense of strike slip has run contrary to the sense of subduction obliquity. This may be explained by northward motion of the Pacific Plate driving continental margin slivers into and/or around the oroclinal bend. From 44 to 66 Ma, oroclinal rotation, perhaps involving large-scale flexural slip, may have been accompanied by westward escape of crustal blocks along strike-slip faults. However, reconstructions of this period involve unproven assumptions about the identity of the subducting plate, the position of subducting ridges, and the exact timing of oroclinal bending, thus obscuring the driving mechanisms of strike slip. Prior to 66 Ma, oblique subduction is the most plausible driving mechanism for dextral strike slip. Cumulative displacement on all faults of the western limb of the orocline is at least 400 km, about half that on the eastern limb; this discrepancy might be explained by a combination of thrusting and unrecognized strike-slip faulting.

Introduction

Major strike-slip fault zones have long been recognized in western interior Alaska (Grantz 1966; figs. 1, 2). The Denali and Iditarod–Nixon Fork faults, in particular, are linear, through-going structures that have well-defined topographic expressions and are comparable in scale to the San Andreas and Alpine fault systems. They occur in the continental back-arc region of the present-day Aleutian subduction zone and strike roughly parallel to the curved continental margin. A number of studies have addressed the sense, timing, and amount of motion on the major margin-parallel strike-slip faults on the eastern limb of the southern Alaska orocline (e.g., Eisbacher 1976; Gabrielse 1985; Dover 1994; Lowey 1998) and in the hinge area of the orocline (Cole et al. 1999). Strike-slip faulting on the western limb has not been as thoroughly documented in the literature, and an up-to-date synthesis has been lacking. Approximately 88–94 km of dextral offset was documented for the Iditarod–Nixon Fork fault (Miller and Bundtzen 1988), and 145–153 km of dextral offset (revised herein to ~134 km) has been suggested for the Denali fault (Blodgett and Clough 1985). However, Csejtey et al. (1996) argued that Cenozoic dextral displacement across the Denali fault in the area of the Cantwell Basin (fig. 1) cannot exceed a few tens of kilometers, and Redfield and Fitzgerald (1993) suggested that, at least since the Miocene, the sense of motion in this area has been sinistral, not dex-

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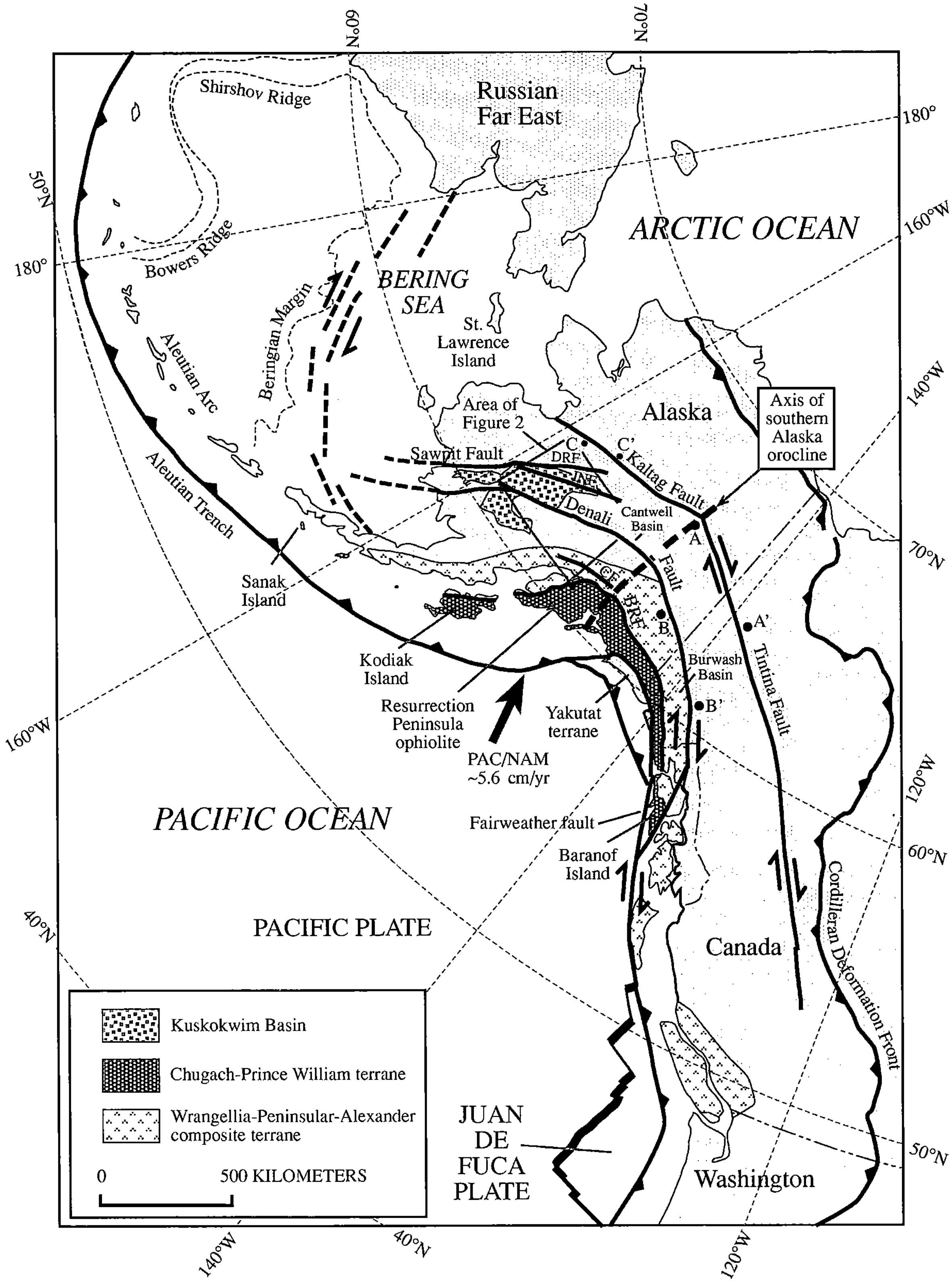

Figure 1. Map of Alaska, the northeastern Pacific, and parts of Canada and the Russian Far East showing key features mentioned in text. Geologic offsets *A* and *A′* (Tintina fault), *B* and *B′* (Denali fault), and *C* and *C′* (Kaltag fault) are indicated. *BRF*, Border Ranges fault; *CF*, Castle Mountain fault. Strike-slip faults of Beringian margin after Worrall (1991).

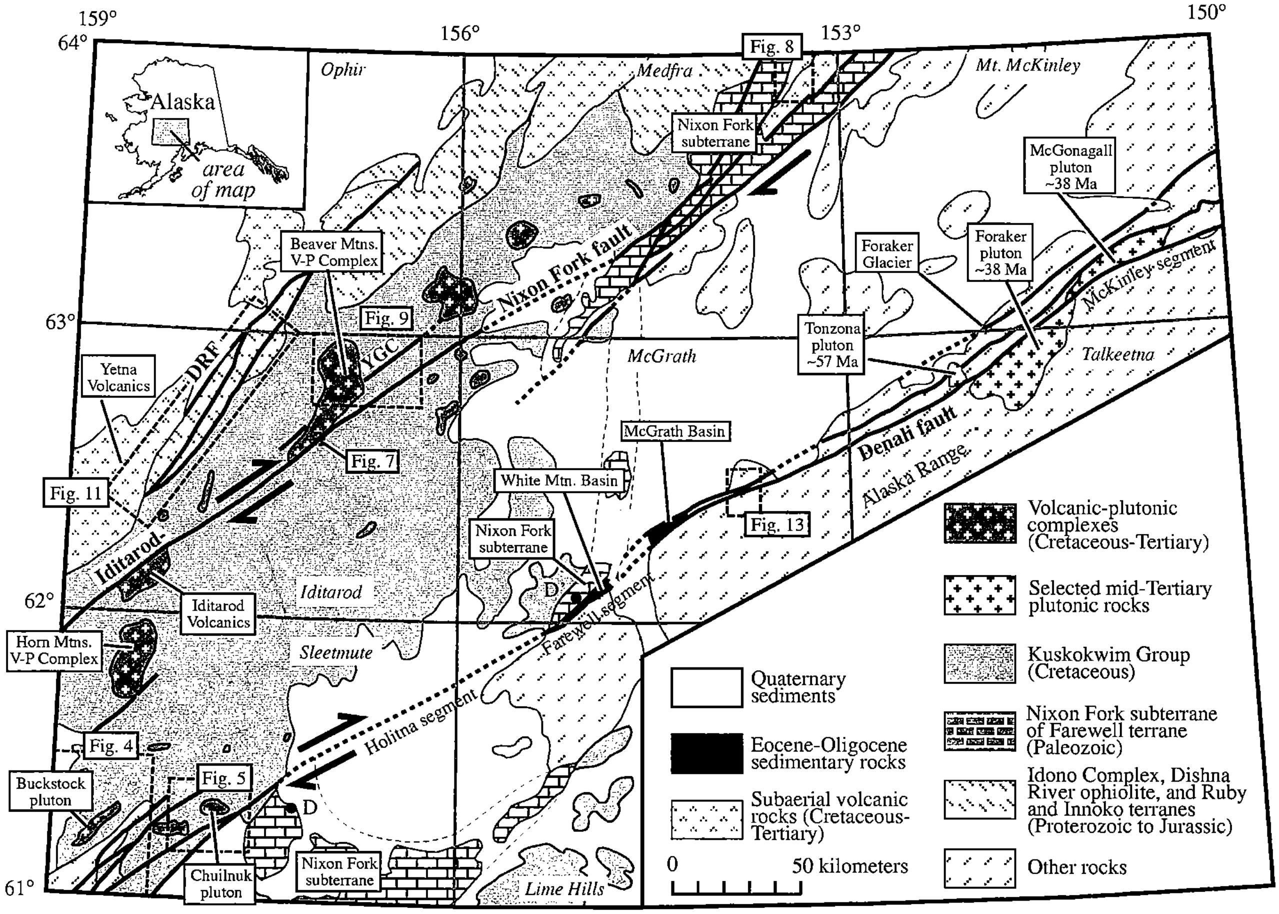

Figure 2. Generalized geologic map of part of southwestern Alaska emphasizing strike-slip faults and key features that bear on their interpretation. *YGC*, Yankee-Ganes Creek fault; *DRF*, Dishna River fault. Area of the Kuskokwim basin is delineated by the Kuskokwim Group. *D* and *D'* mark offset Silurian reefs (R. Blodgett, written communication, 1999).

tral. In light of these controversies, the main purpose of this article is to document the sense, timing, and amount of motion on these margin-parallel strike-slip faults—potentially valuable geologic constraints that might be brought to bear on plate reconstructions in the Pacific and on the history of terrane transport. The history of strike-slip faulting is also important for economic geology reasons: a number of gold and mercury deposits are spatially associated with the major strike-slip faults (fig. 3), one major gold trend is offset 90 km across the Iditarod–Nixon Fork fault, and, as we suggest here, mineralization during three time intervals (~70, ~60, and ~30 Ma) was coeval with strike-slip movements.

Our conclusions are regional in scope, but the data we describe in detail are based primarily on new mapping in the Iditarod, McGrath, and Sleetmute 1 : 250,000-scale quadrangles (fig. 2), performed by the U.S. Geological Survey and the Alaska Division of Geological and Geophysical Surveys (see, e.g., Miller and Bundtzen 1994; Decker et al. 1995; Bundtzen et al. 1997, 1999; and U.S. Geological Survey unpublished mapping).

Regional Geology

This article focuses on the Kuskokwim Mountains region of southwestern interior Alaska, a largely unglaciated area, characterized by rolling hills as high as 900 m that separate wide, sediment-filled valleys. Bedrock is poorly exposed due to extensive vegetation, local loess cover, and the antiquity of the landscape. The dominant bedrock unit is the Upper Cretaceous Kuskokwim Group (Cady et al. 1955) that is largely composed of turbiditic sand-

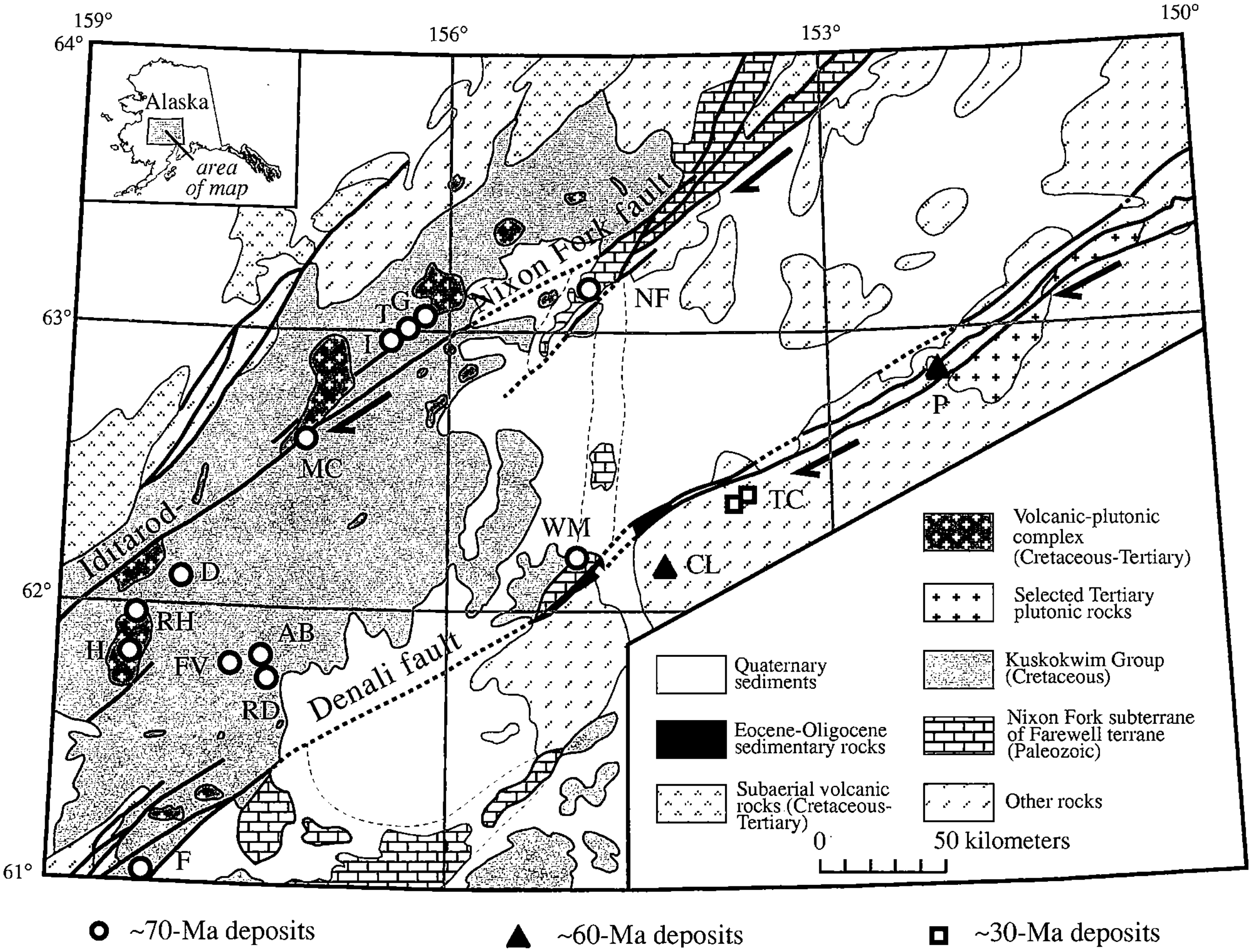

Figure 3. Same area as figure 2 showing key mineral deposits that have some bearing on the Late Cretaceous to Tertiary tectonic history. Symbols correspond to ages as shown. Abbreviations for deposits are as follows: *AB,* Alice and Bessie; *CL,* Chip Loy; *D,* Donlin Creek; *F,* Fortyseven Creek; *FV,* Fairview; *G,* Goss Gulch; *H,* Horn Mountains; *I,* Independence; *MC,* Moore Creek; *NF,* Nixon Fork; *P,* Purkeypile; *RD,* Red Devil; *RH,* Rhyolite; *T,* Telephone Hill; *WM,* White Mountain.

stone and shale (fig. 2). This basin-fill sequence overlies a number of older basement terranes of varied origin that were amalgamated by mid-Cretaceous time (Decker et al. 1994; Patton et al. 1994). The waning stages of Kuskokwim Group deposition were accompanied by regional volcanism and intrusion (Miller and Bundtzen 1994). A number of volcanic-plutonic complexes of Late Cretaceous and early Tertiary age partly intrude and partly overlie the Kuskokwim Group; approximately coeval felsic and intermediate dikes also cut the sedimentary rocks. In the eastern part of figure 2, two younger units bear on the displacement history of the Denali fault: mid-Tertiary plutons of the Alaska Range and Eocene to Oligocene nonmarine sedimentary rocks of the McGrath and White Mountain basins.

Pre-Mid-Cretaceous Rocks. Older bedrock of the Kuskokwim region includes Proterozoic to Lower Cretaceous units of various types. West of the Kuskokwim basin, the oldest rocks are assigned to the Early Proterozoic Idono Complex (Miller et al. 1991) and the Late(?) Proterozoic to Paleozoic Ruby terrane (Jones et al. 1987; Patton et al. 1994). The fault-bounded Idono Complex consists of amphibolite-grade granitic to dioritic orthogneiss, amphibolite, and metasedimentary rocks. Rocks of the Ruby terrane in the area of interest are also fault bounded and consist of greenschist facies meta-igneous and metasedimentary rocks (Chapman et al. 1985; Miller and Bundtzen 1994). Paleozoic-Mesozoic oceanic crust and subduction zone assemblages also crop out on the west side of the Kuskokwim basin (fig. 2). These include slivers of dismembered Jurassic ophiolite (Dishna River mafic-ultramafic rocks of Miller [1990]) and volcanic and sedimentary rocks of the Mississippian to Triassic Innoko terrane (of Jones et al. [1987]).

Basement rocks on the east side of the Kuskokwim basin consist of parts of the Nixon Fork, Dillinger, and Mystic subterranes. Depositional relationships between the three suggest that they are facies of a single terrane, referred to as the "Farewell terrane" by Decker et al. (1994). The Nixon Fork subterrane, which is a platformal carbonate succession of Late Proterozoic to Devonian age, provides the best evidence for offset across the Denali fault in the study area; accordingly, the Nixon Fork subterrane is indicated in figure 2 by a special pattern, whereas the rest of the Farewell terrane is included with "other rocks."

Kuskokwim Basin Fill. Upper Cretaceous sedimentary and minor volcanic rocks of the Kuskokwim Group depositionally overlie structural slivers of the pre-Cretaceous bedrock units (fig. 2). The Kuskokwim Group was deposited primarily by turbidity currents into an elongate, probably strike-slip basin beginning in Late Cretaceous time (Miller and Bundtzen 1992, 1994). Cady et al. (1955) estimated a minimum thickness of 7.5 km. The basinal sequence is successively overlapped by shoreline facies, suggesting that shallow-water strata were deposited when the sedimentation rate exceeded the subsidence rate. Fossils from the Kuskokwim Group are mainly Turonian but range in age from Cenomanian to Campanian or Maastrichtian. The youngest fossils are poorly diagnostic spores. Better control is provided by tuff, interbedded with shoreline facies rocks near the top of the Kuskokwim Group, that has yielded a 77-Ma K/Ar age on biotite (Miller and Bundtzen 1994). For the purposes of this article, we will take this as the approximate upper age limit of the Kuskokwim Group, which accordingly would have an age range from about 95 to 77 Ma.

Late Cretaceous and Tertiary Igneous Rocks. In the Kuskokwim region, Late Cretaceous and Tertiary igneous rocks are of four main types: (1) volcanic-plutonic complexes; (2) subaerial volcanic fields; (3) felsic to intermediate dikes, sills, and stocks; and (4) volumetrically minor altered intermediate to mafic dikes (Miller and Bundtzen 1994; Bundtzen and Miller 1997). Only the first two types are of sufficient aerial extent to show on figure 2. The volcanic-plutonic complexes are important to the strike-slip history because they provide evidence for timing and amount of movement.

Calc-alkaline volcanic-plutonic complexes of Late Cretaceous and early Tertiary age intrude and locally overlie strata of the Kuskokwim Group (Bundtzen et al. 1988; Miller and Bundtzen 1994). About 20 of these complexes, which range from as small as 8 km^2 to as large as 650 km^2, crop out in a broad, 450-km-long, northeast-trending belt (Miller et al. 1989; Moll-Stalcup 1994; Bundtzen and Miller 1997). The majority of the volcanic-plutonic complexes lie in the focus area of this report (fig. 2); three additional complexes are located to the southwest. These complexes generally consist of intermediate to mafic, and locally rhyolitic, tuffs and flows and comagmatic monzonite to quartz monzonite composite plutons. Hornfels aureoles, as wide as 2 km, surround most of the larger plutons and developed in both the clastic sedimentary and overlying volcanic rocks. Conventional K/Ar and a limited number of $^{40}Ar/^{39}Ar$ ages of volcanic rocks range from about 76 to 63 Ma (Moll et al. 1981; Miller and Bundtzen 1994; Decker et al. 1995; Bundtzen et al. 1999). The comagmatic plutons yield ages ranging from about 71 to 67 Ma, although some younger ages (to 60 Ma) have been reported (Moll et al. 1981; Miller and Bundtzen 1994; Decker et al. 1995; Bundtzen et al. 1999). There is no significant time break between deposition of the uppermost Kuskokwim Group (Campanian) and initial volcanism associated with the volcanic-plutonic complexes. Indeed, the volcanic rocks are locally conformable and disconformable with the Kuskokwim Group (Miller and Bundtzen 1994).

Volcanic rocks of similar Late Cretaceous and early Tertiary age, but which do not have associated comagmatic plutons, form locally extensive fields in the Kuskokwim region. These volcanic sequences are largely andesitic in composition but commonly have dacite, rhyolite, and minor basalt. Subaerial volcanic flows, tuffs, and locally domes compose the fields, which individually cover areas as large as 5000 km^2. Conventional K/Ar ages range from about 71 to 54 Ma, and, like the volcanic-plutonic complexes, major- and trace-element geochemistry indicates broad calc-alkaline trends.

Hypabyssal felsic to intermediate dikes, sills, and stocks of Late Cretaceous and early Tertiary age crop out discontinuously across the Kuskokwim region. Although of similar age, they are probably not directly related to the volcanic-plutonic complexes. The hypabyssal rocks are characterized by a distinctly peraluminous chemistry and commonly contain garnet phenocrysts, suggesting they represent melted continental crust (Miller and

Bundtzen 1994). These porphyritic intrusive rocks are spatially related to gold-bearing veins and to placer gold occurrences, making them an important exploration target. K/Ar ages for the hypabyssal rocks appear to be bimodal, centering around 70 and 65 Ma (Miller and Bundtzen 1994).

Intermediate to mafic dikes comprise a volumetrically minor, fourth type of Late Cretaceous and early Tertiary igneous rock of the Kuskokwim region. The dikes are generally less than 3 m wide and are ubiquitously altered to an assemblage of chlorite, calcite, and silica, a fact that has led to their moniker, "silica-carbonate dikes" (Cady et al. 1955). These dikes are generally not related to any obvious parent bodies. A number of mercury prospects are spatially associated with the dikes; this association is not considered genetic but rather structural in nature in that both the dikes and mineralized fluids followed the same structural conduits, and (or) the dikes provided a favorable structural competency contrast for dilation.

Major Strike-Slip Faults and Their Displacement Histories

The three most significant fault systems in the area of this study—the Denali, Iditarod–Nixon Fork, and Dishna River systems—are discussed below. Between these major faults lie a number of lesser faults that roughly parallel the main structures. These are not discussed in detail, but are shown on regional quadrangle maps (e.g., Patton et al. 1980; Miller et al. 1989; Miller and Bundtzen 1994).

Denali Fault. The Denali fault system is one of the most important strike-slip faults in the North American Cordillera (fig. 1). It is composed of numerous subsidiary strands along its approximately 2000-km length in Alaska and Canada. In eastern Alaska and Yukon, Eisbacher (1976) estimated at least 300 km of dextral offset based on a correlation between the Nutzotin Mountains flysch sequence in Alaska and the Dezadeash flysch sequence in Yukon. Lowey (1998) refined this estimate by suggesting a matchup between distinctive boulder conglomerate units in these two areas, indicating 370 km since mid-Cretaceous time (fig. 1, *B* and *B'*).

In the area of our study (fig. 2), the Denali fault has somewhat less displacement. Along the Farewell segment (fig. 2), it cuts and offsets both the Kuskokwim Group and the Farewell terrane. A Late Silurian to Early Devonian algal reef within the Nixon Fork subterrane (of the Farewell terrane) provides the best measure of displacement in this area. Blodgett and Clough (1985) originally proposed that the reefs are offset by 145–153 km, but map relations suggest that 134 km is a better estimate. This new estimate was obtained by projecting along strike from the two reef tracts to the fault and measuring the offset (*D–D'* in fig. 2). Even without this distinctive reef facies, the map offset between the Kuskokwim and Farewell contact is approximately the same. Displacement must postdate deposition of the Cenomanian to Campanian Kuskokwim Group strata, which are cut by the fault. Following is a discussion of specific evidence for fault movement progressing from youngest to oldest.

Quaternary offsets have so far been recognized only in the eastern part of figure 2. Large glaciers flowing north from the Alaska Range (e.g., Foraker Glacier, fig. 2) have been deflected 5–7 km in a dextral sense (Grantz 1966). These glaciers could not have existed before the rise of the modern Alaska Range, an event dated at 5.6 Ma by apatite fission track (Redfield and Fitzgerald 1993). Redfield and Fitzgerald explained the observed dextral offsets as the consequence of clockwise block rotations between unspecified strands in a sinistral fault system. We disagree with this interpretation because it can only work if the blocks somehow rotate faster than the master faults are displacing them.

The White Mountain and McGrath basins (fig. 2) are exposed between strands of the Denali fault along the north flank of the western Alaska Range. These basins correspond to part of a much broader lowland area referred to as the "Minchumina basin" by Kirschner (1994). They are filled with Tertiary nonmarine sandstone, conglomerate, and minor coal (Dickey 1984; Bundtzen et al. 1997; Ridgway et al. 2000). The location of the basins within the fault system and the fact that basinal sediments lie at lower elevations than the surrounding basement rocks that provided the sediment source together suggest syntectonic deposition. Spores suggest a late Oligocene to possibly earliest Miocene age for the White Mountain basin (Ridgway et al. 2000). McGrath basin strata have yielded pollen of Eocene to Oligocene age but are intruded by a 45.5-Ma dike, which restricts the age to Early or Middle Eocene (Bundtzen et al. 1997). Neither the sense nor amount of fault displacement along this portion of the Denali fault system is known during this interval.

Along the McKinley segment in the central Alaska Range (fig. 2), truncated plutons on opposite sides of the fault provide good evidence for dextral movement of about 38 km since their 38-Ma emplacement (Reed and Lanphere 1974). The Foraker pluton, south of the fault, and the McGonagall pluton, north of the fault, are strikingly similar in

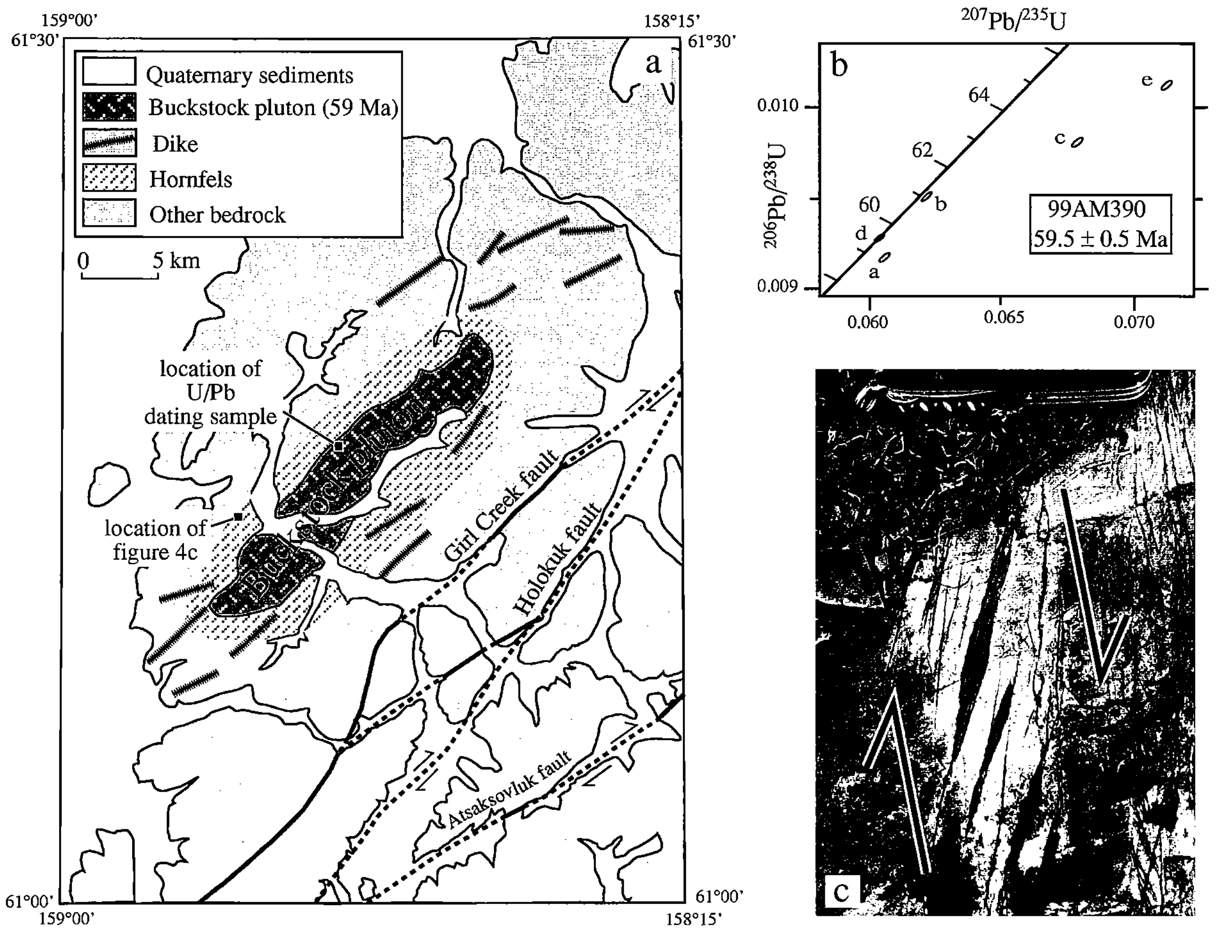

Figure 4. *a*, Geologic map of the Buckstock pluton and surrounding areas. *b*, U/Pb concordia diagram. *c*, Outcrop photograph of contact-metamorphosed Kuskokwim Group in the aureole of the Buckstock pluton, showing pervasive tourmaline- and chlorite-filled fractures, which formed during pluton emplacement in a northeast-striking subvertical zone of dextral shear.

megascopic appearance, mineralogy (both are hornblende-biotite granodiorite), geochemistry, and K/Ar age. Moreover, the matchup across the fault is unique, as there are no other plutons of the same age that have been thusly truncated.

In the same region, the Tonzona pluton provides evidence for an earlier episode of motion along a more northerly strand of the Denali fault system. This pluton consists of biotite-muscovite granite (Reed and Nelson 1980); a biotite separate yielded a K/Ar age of 57.4 Ma (Lanphere and Reed 1985), that is, latest Paleocene. Reed and Nelson's (1980) mapping implies to us that the pluton intruded across the linear trace of a high-angle fault, thus sealing this older splay of the Denali fault system. Nonmarine sandstone, conglomerate, and minor tuff are preserved in a down-dropped block along this fault. Plant fossils of probable Paleocene age (Reed and Nelson 1980) indicate that these sedimentary rocks cannot be significantly older than the Tonzona pluton; the tight time constraints are best met if sedimentation and faulting were synchronous.

Evidence for a dextral sense of motion during this same time comes from a newly discovered pluton in the western part of the Sleetmute quadrangle, 350 km to the southwest (fig. 2). The Buckstock pluton, composed of biotite-hornblende granodiorite, is an elongate, 5 × 24-km body, the long axis of which trends northeast, parallel to the regional strike-slip faults (fig. 4*a*). A zircon separate yielded a concordant U/Pb age of 59.5 ± 0.5 Ma (fig. 4*b*; table 1). In the contact aureole northwest of the pluton, abundant northeast-striking subvertical en-echelon tension gashes cut hornfels and indicate a dextral shear component (fig. 4*c*). The fractures are

Table 1. U/Pb Data and Isotopic Ages for Buckstock Pluton (Sample 99AM390A)

Fraction/size (μm)[a]	Wt (mg)	Concentration U	Concentration Pb*	Isotopic composition[b] $^{206}Pb/^{204}Pb$	$^{206}Pb/^{207}Pb$	$^{206}Pb/^{208}Pb$	Apparent ages (Ma)[c] $^{206}Pb^*/^{238}U$	$^{207}Pb^*/^{235}U$	$^{207}Pb^*/^{206}Pb^*$	Th-corrected ages (Ma)[d] $^{206}Pb^*/^{238}U$	$^{207}Pb^*/^{206}Pb^*$
a. 30-63	.1	1421	12.3	7290 ± 11	20.004	16.690	58.7	59.7 ± .2	98	58.8 ± .1	95 ± 4
b. 63-80A	.1	665	6.0	4320 ± 6	19.652	15.589	60.9	61.2 ± .2	74	61.0 ± .1	71 ± 4
c. 80-100A	.2	511	4.7	6444 ± 8	19.028	16.906	62.8	66.7 ± .2	208	62.9 ± .1	205 ± 3
d. 100-350A	.1	758	6.6	7436 ± 11	20.299	19.621	59.5	59.6 ± .2	64	59.6 ± .1	60 ± 4
e. 100-350A	.1	517	5.0	5594 ± 8	18.612	16.448	64.8	69.9 ± .2	246	64.9 ± .1	243 ± 3

Note. Pb* is radiogenic Pb.
[a] The letters "a," "b," etc. designate conventional multigrain fractions; "A" designates fractions abraded to 30%–60% of original mass. Zircon fractions are nonmagnetic on Frantz magnetic separator at 1.8 amps, 15° forward slope, and side slope of 1°.
[b] Reported ratios corrected for fractionation (0.125% ± 0.038%/AMU) and spike Pb. Ratios used in age calculation were adjusted for 2 pg of blank Pb with isotopic composition of $^{206}Pb/^{204}Pb = 18.6$, $^{207}Pb/^{204}Pb = 15.5$, and $^{208}Pb/^{204}Pb = 38.4$, 2 pg of blank U, 0.25% ± 0.049%/AMU fractionation for UO_2, and initial common Pb with isotopic composition approximated from Stacey and Kramers (1975) with an assigned uncertainty of 0.1 to initial $^{207}Pb/^{204}Pb$ ratio.
[c] Uncertainties reported as 2σ. Error assignment for individual analyses follows Mattinson (1987) and is consistent with Ludwig (1991). An uncertainty of 0.2% is assigned to the $^{206}Pb/^{238}U$ ratio based on our estimated reproducibility unless this value is exceeded by analytical uncertainties. Calculated uncertainty in the $^{207}Pb/^{206}Pb$ ratio incorporates uncertainty due to measured $^{204}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$ ratios, initial $^{207}Pb/^{204}Pb$ ratio, and composition and amount of blank. Linear regression of discordant data utilized by Ludwig (1992). Decay constants used: $^{238}U = 1.5513 \times 10^{-10}$, $^{235}U = 9.8485 \times 10^{-10}$, $^{238}U/^{235}U = 137.88$.
[d] A 75% ± 25% efficiency in ^{230}Th exclusion during zircon crystallization is assumed, and $^{207}Pb/^{206}Pb$ and $^{206}Pb/^{238}U$ ratios have been adjusted accordingly. Age assignments presented are derived from the Th-corrected ratios.

filled with chlorite and tourmaline, suggesting they are synplutonic. The Buckstock pluton lies just north of several mapped splays of the Denali fault system (fig. 4*a*) and may have intruded along an unmapped splay. Regardless of whether it was intruded along a fault, it provides evidence for northeast-striking dextral shear at 59.5 Ma.

Field relations in the Chuilnuk Mountains (fig. 5) show that some dextral movement took place in Late Cretaceous time. In the aureole of the 68-Ma Chuilnuk pluton (Decker et al. 1995), hornfels metasedimentary rocks of the Kuskokwim Group are folded about closely spaced, upright, north-trending axes; the pluton truncated the folds, indicating that folding predated pluton emplacement. In nearby areas, the Kuskokwim Group has yielded bivalves as young as late Coniacian or early Santonian (Box and Elder 1992); hence, the folding postdates the 87–85-Ma deposition but predates pluton emplacement at 68 Ma. Folds of this orientation are consistent with dextral shear, and their occurrence within only 10 km of the Denali fault suggests a genetic relation. The amount of offset during this episode is unknown.

To summarize, the Denali fault in the area of figure 2 has a total dextral displacement of 134 km, during various episodes and on various strands, since mid-Cretaceous time (fig. 6). Specifically, (1) deflected glaciers in the Alaska Range show 5–7 km of dextral displacement since 5.6 Ma; (2) some movement is inferred for late Oligocene to possibly earliest Miocene time (~22–28 Ma) during subsidence of the White Mountain basin; (3) offset plutons in the Alaska Range show 38 km dextral displacement since 38 Ma; (4) some movement is inferred for Early to Middle Eocene time (~46–55 Ma) during subsidence of the McGrath basin; (5) one strand was crosscut by the Tonzona pluton at 57 Ma and has not moved since; (6) the 59.5-Ma Buckstock pluton was emplaced in a northeast-trending dextral shear regime near the northern edge of the Denali fault system; and (7) dextral motion is inferred in the Chuilnuk Mountains between about 85 and 68 Ma.

The 2000-km-long Denali fault shows different amounts of offset, but similar times of motion, on its eastern and western limbs. The total displacement on the Denali fault in the area of figure 2 is less than half of the displacement on the opposite limb of the orocline. This discrepancy might be explained by some combination of thrusting on faults in the Alaska Range and strike slip on minor or unrecognized faults throughout the region. However, evidence for the age of displacement is consistent on both limbs. Richter and Matson (1971) recognized Holocene and Quaternary offsets across the Denali fault in eastern Alaska, comparable to item 1 above. Ridgway et al. (1995) presented evidence that the Oligocene-Eocene Burwash Basin of the Yukon Territory (fig. 1) was deposited during an episode of dextral displacement, consistent with items 2 and 3 above. A Paleocene (~59 Ma) episode of dextral motion (comparable to items 4 and 5 above) has not been explicitly recognized east of the area of figure 2 but is permitted by evidence from the hinge area of the orocline. Volcanic rocks

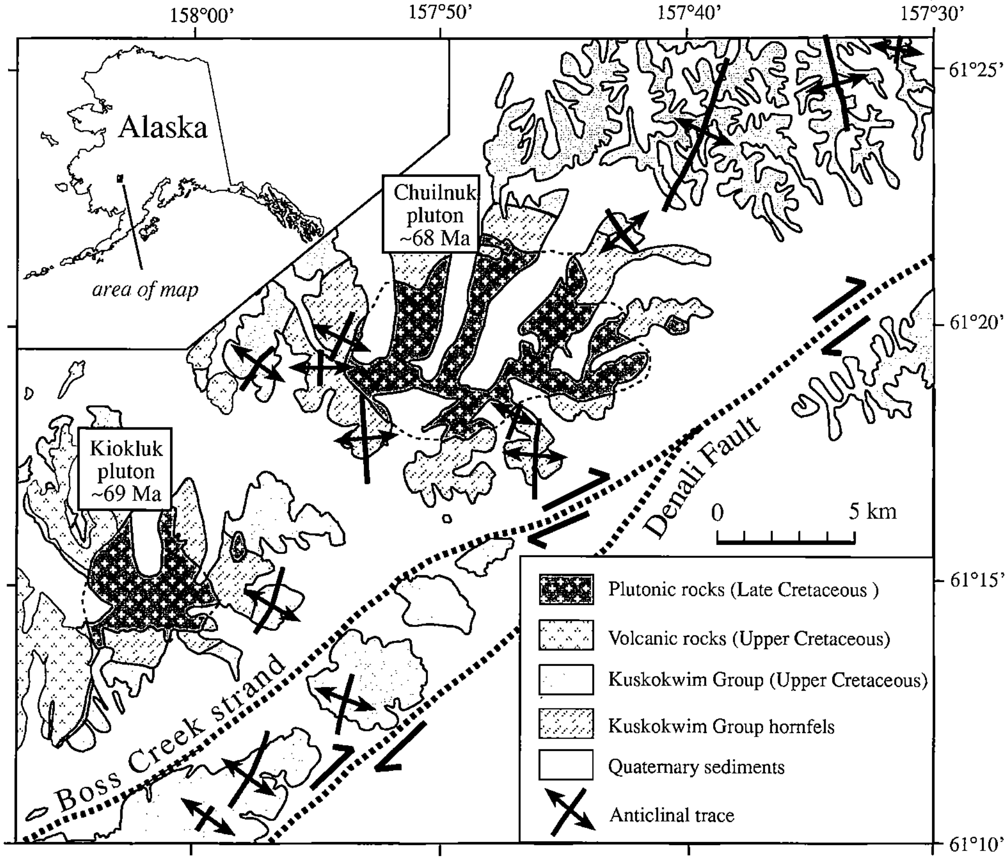

Figure 5. Geologic map of the Chuilnuk and Kiokluk Mountains area near the Denali fault. North-trending folds in the contact aureole of the Chuilnuk pluton suggest pre–68 Ma dextral motion on the nearby Denali fault system. Adapted from Decker et al. (1995).

in the Cantwell Basin (fig. 1) were erupted from 59.8 ± 0.2 to 55.5 ± 0.2 Ma (Cole et al. 1999), 10–20 m.yr. after a Late Cretaceous episode of north-south shortening (Ridgway et al. 1997). These volcanic rocks were deformed in a dextral shear regime sometime between the earliest Eocene and early Miocene (Cole et al. 1999). We speculate that Cantwell volcanism may itself have coincided with an episode of strike-slip displacement. Our 85–68-Ma episode of strike-slip motion in southwestern Alaska (item 6 above) has not been recognized as such on the eastern limb of the orocline.

Iditarod–Nixon Fork Fault. The Iditarod–Nixon Fork fault is one of the most significant strike-slip faults in Alaska (Grantz 1966; fig. 1). It can be traced from just west of the Sleetmute quadrangle to the Mount McKinley quadrangle, a distance of about 450 km (fig. 2). The northeastern part of the fault consists of several strands that cut the Farewell terrane (Patton et al. 1980; Dumoulin et al. 1999). The southwestern portion of the fault cuts the Kuskokwim Group, and in this sector there is a single, dominant strand. In the Iditarod quadrangle, a subparallel fault (Yankee-Ganes Creek) has a slightly older history and is also discussed in this section. The Iditarod–Nixon Fork fault cannot yet be traced with confidence very far beyond the limits of figure 2. Offset exceeds 88–94 km by an unknown amount. Specific evidence for fault movement will be discussed progressing from youngest to oldest.

Evidence bearing on the Neogene displacement history of the Iditarod–Nixon Fork fault system comes from two locations. In the central part of the fault system near Moore Creek (fig. 2), crosscutting relationships and modern placer deposit geomorphology suggest that gold-bearing drainages have been successively offset right laterally from their lode source (fig. 7). Two ancestral drainages of the gold-bearing Moore Creek monzonite are subparallel to, and lie southwest of, the modern drainage.

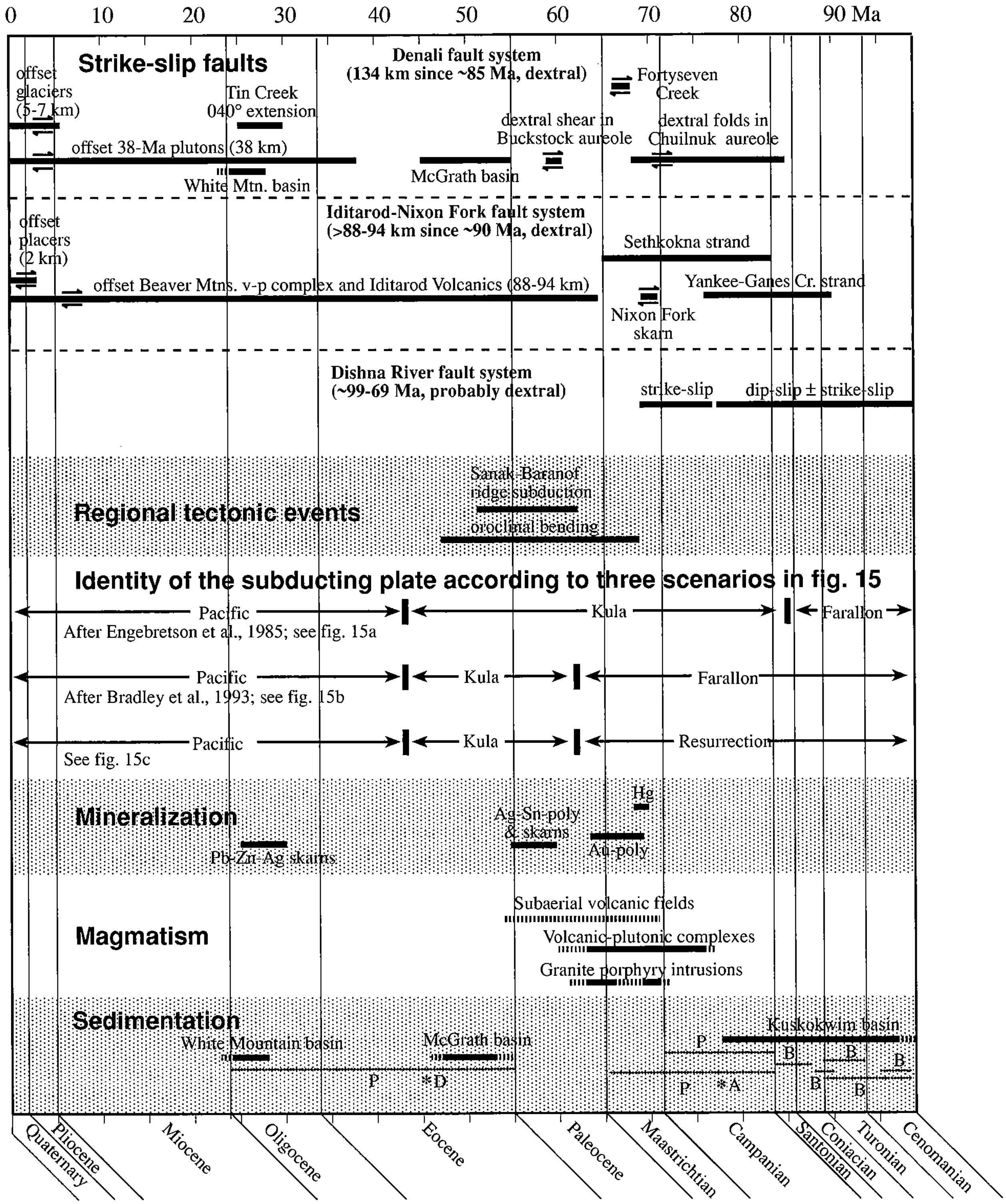

Figure 6. Time lines comparing ages of strike-slip motion, sedimentation, mineralization, and magmatism. Numerical calibration of the time scale is from Berggren et al. (1995) and Gradstein et al. (1994). Abbreviations are as follows for stratigraphic age controls: *P*, palynological age range; *B*, bivalve age range; **A*, isotopically dated ash layer; **D*, isotopically dated crosscutting dike.