# Yukon-Tanana terrane: A partial acquittal

**Vicki L. Hansen** Department of Geological Sciences, Southern Methodist University, Dallas, Texas 75275

## ABSTRACT

**The Yukon-Tanana composite terrane, northern Canada and eastern Alaska, is divisible into two distinct terranes on the basis of metamorphic cooling ages and inferred structural level. The Nisling terrane records Early Cretaceous cooling ages, whereas the Teslin-Taylor Mountain terrane records pre-Late Jurassic cooling. The Nisling terrane, present at the lowest structural levels within the Yukon-Tanana terrane, represents North American continental-margin crust that was partly subducted beneath the accretionary prism of a southwest-dipping (present-day coordinates) early Mesozoic subduction complex, represented by the Teslin-Taylor Mountain and Slide Mountain terranes. The Nisling is exposed as a result of mid-Cretaceous crustal extension subsequent to Jurassic crustal thickening related to Teslin-Taylor Mountain-Slide Mountain emplacement. Although the Nisling and Teslin-Taylor Mountain terranes have many petrologic and tectonic differences, their mutual relations provide a unified view of early to middle Mesozoic tectonics of the western North American margin, a view that dispels the notion that large tracts of the northern Cordillera are "suspect."**

## INTRODUCTION

The Yukon-Tanana composite terrane, the largest "suspect" terrane of the northern North American Cordillera (Coney et al., 1980), is composed of dynamothermally metamorphosed sedimentary, volcanic, and plutonic rocks characterized by an L-S tectonite fabric. Questions about the Yukon-Tanana terrane have centered on the cause and age of dynamothermal metamorphism and the timing of terrane emplacement. Researchers in Alaska proposed that Yukon-Tanana deformation occurred during intrusion of Mississippian granitoids and/or during Cretaceous time (Dusel-Bacon and Aleinikoff, 1985; Aleinikoff et al., 1986). Some workers propose that tectonism in Yukon is pre-Late Triassic (Mortensen and Jilson, 1985), whereas others postulate that Yukon-Tanana tectonites represent the deep-seated part of a pre-Middle Jurassic subduction complex (Tempelman-Kluit, 1979; Erdmer, 1985; Hansen, 1988). In order to decipher overall Yukon-Tanana evolution one must consider tectonites in both Alaska and Yukon, and one must not operate under the assumption that Yukon-Tanana tectonic fabrics represent a single tectonic event. Previously defined Yukon-Tanana subterranes (Alaska) and assemblages (Yukon) can be correlated on the basis of lithology, isotopic character, and metamorphic grade, and can be grouped into two distinct terranes on the basis of metamorphic cooling ages and apparent structural level. I present a comprehensive tectonic model for the late Paleozoic to Mesozoic evolution, accretion, and subsequent deformation of these terranes, the Slide Mountain terrane, and adjacent North American strata. The model draws on structural, metamorphic, and thermochronologic studies in Yukon and Alaska; from it I conclude that a large part of the Yukon-Tanana terrane as previously defined is para-autochthonous with reference to North America, and hence should not be considered "suspect."

## TERRANES

### Yukon-Tanana, Nisling, and Teslin-Taylor Mountain Terranes

I propose that the Yukon-Tanana be divided into two distinct terranes, the Nisling and Teslin-Taylor Mountain (Fig. 1). Adoption of the Nisling and Teslin-Taylor Mountain nomenclature is suggested here first and foremost on the basis of metamorphic cooling ages and apparent structural position; however, it builds on previously defined Yukon-Tanana lithotectonic assemblages defined by lithology, protolith age, isotopic inheritance, and metamorphic grade. Nisling tectonites record Early Cretaceous cooling and are at apparently low structural levels within the Yukon-Tanana terrane; Teslin-Taylor Mountain tectonites yield pre-Late Jurassic metamorphic cooling ages and are in an upper structural position. These two terranes underwent different displacement paths as reflected in their cooling histories. I assign previously recognized Yukon-Tanana components in eastern Alaska and Yukon to either the Nisling or the Teslin-Taylor Mountain, and I use these new terrane definitions throughout my discussion.

In Alaska, the Yukon-Tanana has been divided into four subterranes, $Y_1$ to $Y_4$ (Churkin et al., 1982; Foster et al., 1987). $Y_1$ and $Y_2$ consist of quartzites, aluminous metasedimentary rocks, peraluminous orthogneiss, marble, and amphibolite, suggestive of continental derivation. In both $Y_1$ and $Y_2$, quartzites contain detrital zircons with Early Proterozoic inheritance (Aleinikoff et al., 1986) and orthogneisses yield 340-360 Ma U-Pb zircon ages with Proterozoic inheritance (Aleinikoff et al., 1986). $Y_1$ and $Y_2$ tectonites also, with few exceptions, yield Early Cretaceous metamorphic cooling ages (Wilson et al., 1985; Aleinikoff et al., 1986) and are assigned to the Nisling terrane. $Y_3$ and $Y_4$ consist of metasedimentary and metavolcanic rocks that record greenschist and albite-epidote amphibolite-grade metamorphism, respectively. Although $Y_3$ and $Y_4$ are juxtaposed along a 1-3-km-wide thrust zone (Foster et al., 1985), they appear to be structurally correlative (Hansen et al., unpub.). $Y_4$ tectonites record Late Triassic to Middle Jurassic cooling ages ($^{40}Ar/^{39}Ar$; Cushing, 1984; Hansen et al., 1988, and unpub. data), and Late Triassic-Early Jurassic intrusions postdate tectonite ductile deformation (e.g., Taylor Mountain batholith). No metamorphic cooling ages have been determined from $Y_3$ tectonites; however, their metamorphism must have been synchronous with, or predated, Middle Jurassic (Cushing, 1984) juxtaposition of $Y_4$ and $Y_3$ rocks. On this basis, $Y_3$ and $Y_4$ tectonites are assigned to the Teslin-Taylor Mountain terrane. Aleinikoff et al. (1987) distinguished two Yukon-Tanana subterranes on the basis of feldspar Pb isotopic compositions, termed Yukon-Tanana and Stikine, that are correlative with the Nisling and Teslin-Taylor Mountain respectively, as described here.

In Yukon, the Yukon-Tanana has been divided into four or more assemblages. The augen orthogneiss suite (Mortensen and Jilson, 1985), composed of Devonian-Mississippian peraluminous orthogneiss and upper greenschist to amphibolite facies metasedimentary rocks, is assigned to the Nisling. These rocks yield Late Jurassic to Early Cretaceous metamorphic cooling ages (Hansen et al., 1988, 1989, and unpub. data) and they consistently occur at the lowest structural levels (Mortensen, 1988b; Hansen, 1989b). The Nisutlin and Anvil allochthons (Tempelman-Kluit, 1979) consist of greenschist to albite-epidote amphibolite facies metasedimentary and metavolcanic tectonites, and rare eclogite and blueschist (Erdmer and Helmstaedt, 1983; Hansen, 1987); they record pre-Late Jurassic metamorphic cooling ages (Hansen et al., 1988, 1989, and unpub. data) and are assigned to the Teslin-Taylor Mountain terrane. The Sulphur Creek orthogneiss (263.8 ±3.8 Ma; U-Pb zircon, no inheritance) and the I-type Simpson plutonic suite (340-360 Ma; U-Pb zircon, no inheritance; equivalent to the Simpson allochthon of Tempelman-Kluit, 1979) (Mortensen, 1986, 1988b) are included with the Teslin-Taylor Mountain on the basis of their high structural position relative to other Yukon-Tanana tectonites (Mortensen, 1988b). Late Triassic-Early Jurassic granitoid rocks locally intrude Teslin-Taylor Mountain ductile tectonites in Yukon, as in Alaska (e.g., Klotassin batholith).

The Nisling terrane, characterized by Late Jurassic to Early Cretaceous metamorphic cooling ages, is composed of Devonian-Mississippian peraluminous orthogneiss and metasedimentary rocks that record Early Proterozoic U-Pb inheritance and Sm-Nd model ages consistent with North American cratonal basement values (Aleinikoff et al., 1981, 1986; Mortensen, 1988b; Mortensen and Jilson, 1985; Bennett and Hansen, 1988). In Yukon, Nisling rocks form the lowest exposed structural level; in Alaska, the structural level is unknown because of poor exposure (Foster et al., 1987). However, Cretaceous cooling ages, metamorphic grade, and contact relations with Teslin–Taylor Mountain rocks are consistent with a lower-plate Nisling position. The Teslin–Taylor Mountain, well-exposed within the Laberge–Quiet Lake area and in the Taylor Highway area (Fig. 1), includes mica quartzite, chlorite phyllite, amphibolite, metabasalt, metachert, and minor marble. These rocks record greenschist to moderately high *P/T* albite-epidote amphibolite facies metamorphism; blueschist and eclogite facies rocks are preserved locally (Erdmer and Helmstaedt, 1983; Brown and Forbes, 1986; Laird et al., 1985; Erdmer, 1987; Hansen, 1987). Teslin–Taylor Mountain rocks preserve an inverted metamorphic sequence from west to east in Yukon and from south to north in Alaska (Hansen, 1989a), and they record Late Triassic to Middle Jurassic cooling ages (Rb-Sr, K-Ar, and $^{40}$Ar/$^{39}$Ar; Cushing, 1984; Hansen et al., 1988, 1989, and unpub. data; Erdmer and Armstrong, 1989).

### Slide Mountain Terrane

The Slide Mountain terrane comprises a belt of klippen above North American Paleozoic miogeoclinal strata preserved along the length of the Canadian Cordillera (Fig. 1). The lithology, protolith ages, internal structure, timing of deformation, and tectonic setting of the Sylvester allochthon are representative of the Slide Mountain (Monger and Berg, 1987). Devonian to Late Triassic oceanic sedimentary and volcanic strata of the Sylvester are complexly interleaved in tectonic slices bounded by subhorizontal, layer-parallel younger-over-older faults that juxtapose unrelated rock types (Harms, 1986; Nelson and Bradford, 1987; Nelson et al., 1988). Faulting within the allochthon occurred synchronously with deposition, and predates, at least in part, post-Triassic to pre-mid-Cretaceous emplacement of the allochthon as the roof thrust to a foreland-style duplex within North American strata (Harms, 1986). The allochthon is composed of oceanic and arc components, and is divided into three lithologic and structural packages that increase in autochthonous character with decreasing structural level: (1) Pennsylvanian-Permian calc-alkalic to alkalic igneous rocks representative of an island arc; (2) Mississippian-Permian mid-ocean ridge basalt, and argillite and chert indicative of marginal basin sedimentation; and (3) marginal basin strata with shallow-water limestone and siliciclastic components indicative of a continental provenance (Nelson et al., 1988, 1989).

## DEFORMATION

Several discrete deformational events are recognized in rocks previously defined as part of the Yukon-Tanana. Each of these spatially or temporally distinct ductile deformation events records part of the preaccretion, synaccretion, and postaccretion tectonic history of the Tesling–Taylor Mountain, Slide Mountain, and Nisling terranes and adjacent North American strata.

### Pre-Middle Jurassic Preaccretion(?) Deformation

Pre–Middle Jurassic dynamothermal metamorphism is best documented within the Teslin suture zone, the steeply dipping part of the

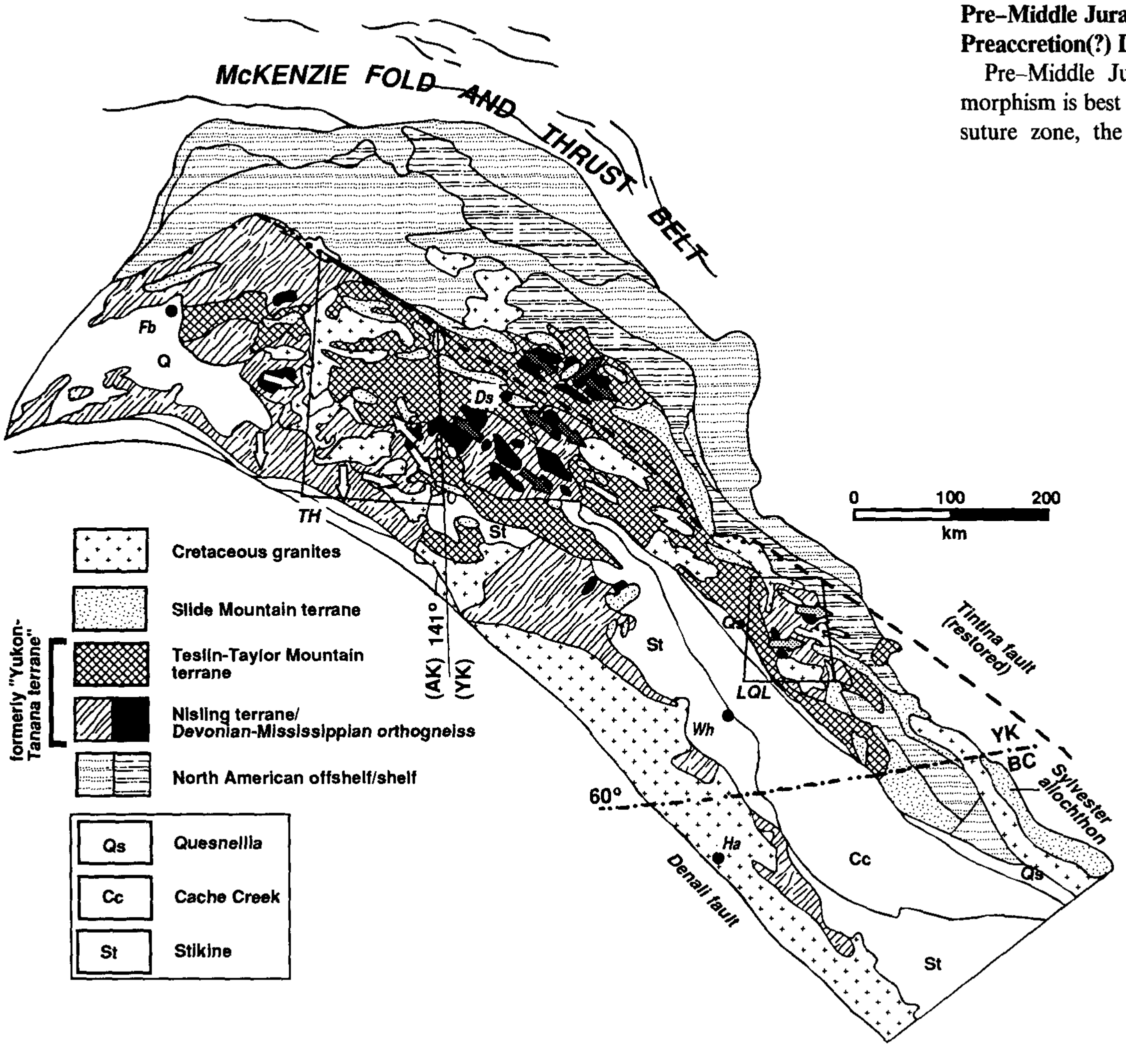

**Figure 1. Simplified terrane map of northern Canadian and Alaskan Cordillera with 450 km of dextral offset restored along Tintina fault (compiled from Foster et al., 1987; Hansen, 1987; Wheeler and McFeely, 1987). Towns (italics): Fb = Fairbanks; Ds = Dawson; Wh = Whitehorse; Ha = Haines. Boxes indicate Taylor Highway (TH) and Laberge-Quiet Lake (LQL) areas; Teslin suture zone is Laberge-Quiet Lake area. Arrows indicate displacement of upper-plate rocks relative to lower-plate rocks; white arrows = mid-Cretaceous displacement in Alaska; lightly stippled arrows = displacement of upper-plate rocks relative to Nisling terrane in central Yukon. Patterned arrows represent predicted displacement for upper-plate rocks relative to lower-plate Nisling rocks in west-central Yukon (see text).**

Yukon-Tanana as defined by Tempelman-Kluit (1979). Here Teslin–Taylor Mountain fabrics record penetrative dip-slip deformation ($D_1$) that progressively evolved into dextral translation along 1–3-km-wide shear zones ($D_2$) (Hansen, 1989b). The zone forms a regional inverted metamorphic sequence from albite-epidote amphibolite facies in the west to greenschist facies in the east. Both $D_1$ and $D_2$ tectonites display albite-epidote amphibolite facies assemblages, although phase compositions reveal significant *P-T* changes accompanied progressive change from regionally penetrative $D_1$ strain to localized $D_2$ ductile shear (Hansen, 1987). $D_1$ tectonites record *P-T* conditions of 12 ±4 kbar and 575–675 °C, whereas $D_2$ tectonites reequilibrated to 5 to 8 kbar and 425 to 550 °C. $D_1$ hornblende and white mica, and $D_2$ white mica yield $^{40}Ar/^{39}Ar$ plateau ages of ~194 Ma, indicating rapid cooling of $D_1$ and $D_2$ tectonites (Hansen et al., 1988, and unpub. data). Pre–Middle Jurassic ductile deformation also affects Teslin–Taylor Mountain rocks exposed in eastern Alaska along the Taylor Highway (Cushing, 1984); however, the low-angle orientation of tectonites along this transect makes structural and kinematic studies difficult. Hornblende and biotite pairs from two different tectonites yield $^{40}Ar/^{39}Ar$ plateau ages of 188–186 Ma and 187–185 Ma, respectively (Hansen et al., 1988), and provide a minimum age for ductile deformation. Teslin–Taylor Mountain cooling ages from Alaska and Yukon indicate fast cooling and uplift rates of ~5 mm/yr, assuming a 25 °C/km geotherm. Uplift rates are similiar to those determined for the Himalayan Pliocene uplift (Copeland et al., 1988) and are interpreted to result from postsubduction collision of Teslin–Taylor Mountain tectonites with North American continental crust.

### Late Jurassic to Mid-Cretaceous Synaccretion(?) Deformation

Pre–mid-Cretaceous imbrication of Paleozoic continental margin strata has long been recognized in Yukon (e.g., Tempelman-Kluit, 1977). However, until recently this deformation has only been described in upper-crustal rocks. Ductile roots of pre–mid-Cretaceous imbricate thrusts may be preserved within North American strata in the Laberge–Quiet Lake area (Hansen, 1989b; Spicuzza and Hansen, 1989). East of the Teslin suture zone, Devonian-Mississippian orthogneiss and metasedimentary rocks of the Nisling terrane record top-to-the-east shear (Fig. 1). Hornblende, white mica, and biotite separated from these tectonites yield Jurassic-Cretaceous $^{40}Ar/^{39}Ar$ cooling ages of about 150, 117, and 110 Ma, respectively, and place a minimum age on ductile deformation (Hansen et al., 1988, and unpub. data). These data indicate slow cooling at ~6 °C/m.y., which corresponds to uplift rates of ~0.24 mm/yr, assuming a 25 °C/km geotherm. These rocks were originally correlated with North American Paleozoic strata on the basis of lithology and field relations (Tempelman-Kluit, 1977); however, the presence of Devonian-Mississippian orthogneiss (Hansen et al., 1989) and mafic volcanic rocks differentiates these rocks from North American strata as defined by Mortensen and Jilson (1985). Therefore, either these Nisling rocks are not correlative with North America, or if they are correlative, then North American strata may host Devonian-Mississippian granitoid rocks. The latter interpretation is assumed in my model. In either case, this package of tectonites records discordant Jurassic-Cretaceous $^{40}Ar/^{39}Ar$ ages and therefore must have either been reheated or must not have cooled by pre–Late Jurassic time after Teslin–Taylor Mountain tectonites were uplifted. I interpret the age discordance to result from thermal reequilibration caused by tectonic burial of these rocks (Nisling) beneath eastward-transported Teslin–Taylor Mountain rocks in pre–Middle Jurassic time; the low-angle top-to-the-east shear zones represent roots of the thrusts that imbricate North American Paleozoic strata.

### Mid-Cretaceous Crustal Extension, Strike-Slip Translation, and Plutonism

In addition to differences in metamorphic cooling ages, Nisling rocks record higher metamorphic grade than adjacent, structurally higher Teslin–Taylor Mountain rocks as documented in the Dawson area (Mortensen, 1988a) and northeast of Fairbanks (Laird and Foster, 1986). Mid-Cretaceous crustal extension proposed for eastern Alaska (Pavlis et al., 1988; Duke et al., 1988; Hansen, 1989a) explains structural juxtaposition of lower-grade Teslin–Taylor Mountain rocks on higher-grade Nisling rocks, as well as the diachronous cooling ages. If 450 km of dextral offset is restored along the Tintina fault, the region of postulated mid-Cretaceous crustal extension is within the hinterland of the McKenzie fold and thrust belt. I propose that all Nisling tectonites in the hinterland are exposed because of mid-Cretaceous crustal extension, and that they represent metamorphosed North American strata structurally overridden by Teslin–Taylor Mountain and Slide Mountain rocks.

In this same region of Alaska, Cretaceous plutons lack preferred shape orientation, whereas in the region between Quesnellia and the Tintina fault in Yukon, Cretaceous plutons form elongate northwest-trending bodies (Fig. 1). The shape of these plutons may reflect the crustal strain regime during emplacement. Dextral shear is broadly synchronous with Cretaceous plutonism in Yukon (Gabrielse, 1968; Gabrielse and Dodds, 1982) and reflects mid- to Late Cretaceous transcurrent strain in this part of the northern Cordillera (Gabrielse, 1985). Deformation related to transcurrent tectonism predominantly (or completely) postdates mid-Cretaceous crustal extension. Isotropic Cretaceous granitoids intrude both lower-plate Nisling rocks and upper-plate Teslin–Taylor Mountain rocks and Nisling tectonites yield mica cooling ages of ~110 Ma, whereas the granitoids generally yield ages of 100–70 Ma (Gabrielse, 1985; Wilson et al., 1985).

## TESTABLE MODEL OF NISLING–TESLIN–TAYLOR MOUNTAIN–SLIDE MOUNTAIN TERRANE EVOLUTION AND EMPLACEMENT

The spatially and regionally distinct ductile deformation events discussed above can be explained by a comprehensive tectonic model of oblique convergence; it builds on the model of Tempelman-Kluit (1979), yet has important differences. The model begins in Devonian-Mississippian time with emplacement of peraluminous granitoids into North American continental strata (Fig. 2A). U-Pb and Sm-Nd data reflect the continental crustal affinity of these rocks, and their significantly younger cooling histories are consistent with a lower-plate structural position. These data are best explained by a model in which Nisling rocks are parautochthonous with respect to North America. The origin of the granitic magmas is beyond the scope of this paper and lacks general consensus; magmatism may have resulted from subduction (Mortensen, 1988b; Rubin et al., 1989), crustal thickening, or extension (M. Churkin, personal commun.). Following, or perhaps related to, plutonism, a basin formed outboard of western North America (present-day coordinates) (Fig. 2B). This basin was built, at least in part, on oceanic crust locally preserved as ophiolitic assemblages within the Slide Mountain terrane. Neither the size of this basin nor the orientation of spreading centers is known. The basin may have been a large paleo–Pacific Ocean (Harms, 1986) or a narrow marginal basin, similar to that forming the Gulf of California. Ocean-type crust formation probably continued through Mississippian and Permian time, as suggested by exhalites of these ages within the Slide Mountain (Nelson and Bradford, 1987; Nelson et al., 1988).

In Permian time, southwest-dipping, right-oblique subduction outboard of western North America began to close the basin (Fig. 2C). A Permian (246 Ma) Rb-Sr cooling age on blueschist white mica (Erdmer and Armstrong, 1989)—interpreted to be from the Teslin–Taylor Mountain terrane—places a minimum age on subduction initiation. The Sulfur Creek orthogneiss near Dawson may represent plutonism resulting from this subduction. The basin closed during right-oblique subduction, as determined from pre–Middle Jurassic dextral shear zones ($D_2$) within the Teslin suture zone. The western overriding plate, composed of an arc(?) and accretionary complex, and represented at moderate crustal levels by Teslin–Taylor Mountain tectonites and at higher crustal levels by the Slide Mountain, incorporated progressively more autochthonous strata as the basin closed.

This terrane overrode North America earlier to the south along the Cordillera (Fig. 2D), consistent with right-oblique subduction and older cooling ages of the Teslin–Taylor Mountain terrane in Yukon relative to Alaska. Where along the Cordillera North American continental crust began to underthrust the Teslin–Taylor Mountain–Slide Mountain composite terrane is not known; however, initial crustal thickening related to terrane emplacement was probably not great in northern British Columbia and southern Yukon (Fig. 2E). With continued subduction, North American continental crust was underthrust farther beneath the accreting terrane; it shortened along intracontinental shear zones, and thickened as a result of imbrication and terrane obduction (Fig. 2F). Following emplacement of Teslin–Taylor Mountain–Slide Mountain terranes onto North American continental crust, subduction polarity changed to the east beneath North America (Fig. 2, G and H).

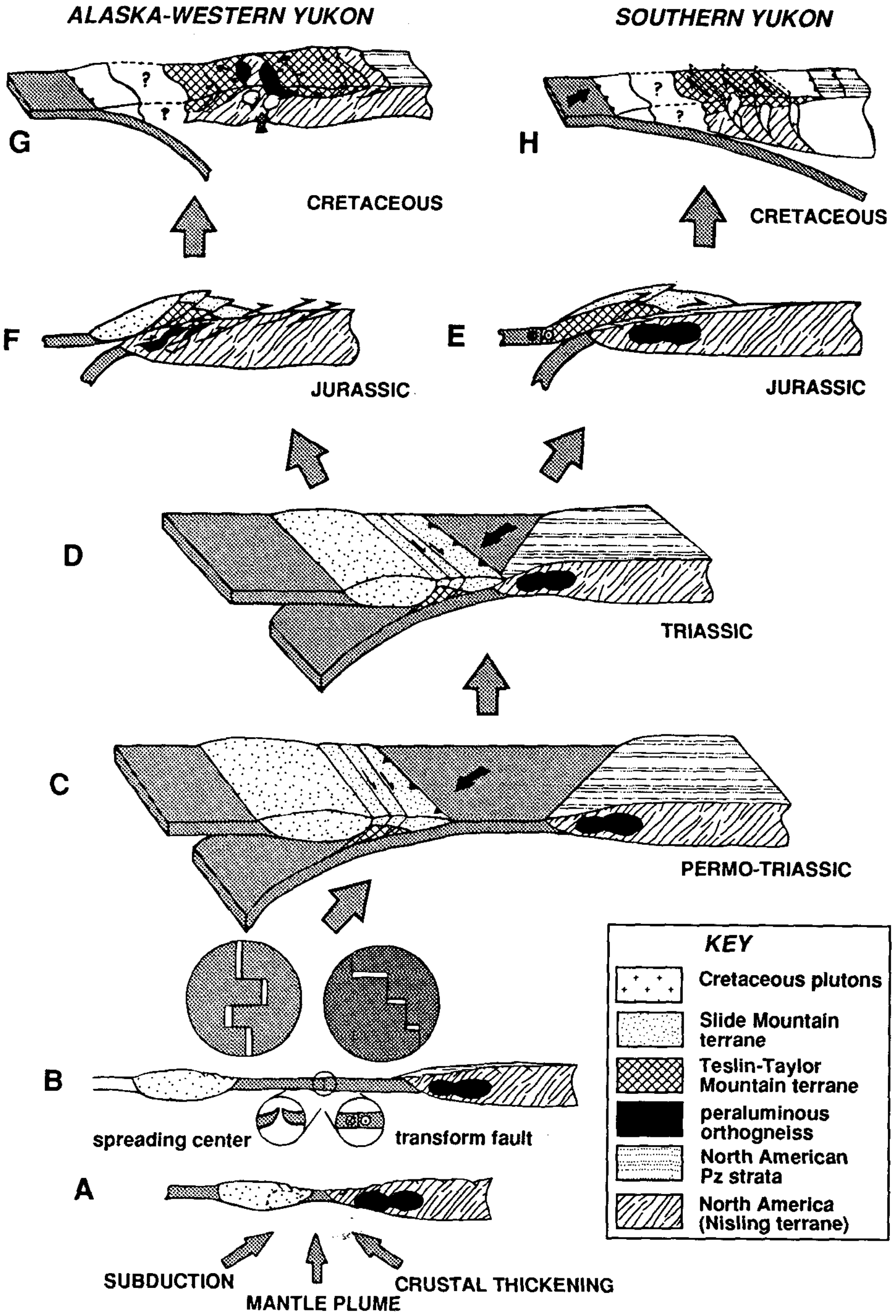

**Figure 2. Tectonic model for late Paleozoic to Mesozoic evolution of Teslin–Taylor Mountain, Slide Mountain, and Nisling terranes, and associated North American strata. Patterns as in Figure 1. In stages G and H, Teslin–Taylor Mountain and Slide Mountain terranes are shown as single unit for simplicity.**

Overthickened North American crust in western Yukon and eastern Alaska, the hinterland to the McKenzie fold and thrust belt, underwent gravitational collapse and resultant crustal extension (Fig. 2G) (e.g., Dewey, 1988; also see Pavlis, 1989). Mid-Cretaceous extension resulted in tectonic unroofing and exposure of previously underthrust North American strata. Regions that were not thickened to the point of tectonic instability, in northern British Columbia and southern Yukon, did not collapse (Fig. 2E). Right-oblique subduction beneath North America in Cretaceous time resulted in dextral translation of tectonic slivers of North American crust (including accreted Teslin–Taylor Mountain and Slide Mountain) along subduction-related margin-parallel shear zones (Fig. 2H) (e.g., Beck, 1986). Magma following margin-parallel crustal weaknesses in Yukon intruded as elongate northwest-trending bodies in Cretaceous time.

This model explains some of the data not adequately explained in previous models: (1) the continental character of the Nisling terrane, and U-Pb inheritance and Sm-Nd model ages consistent with North American values; (2) the low structural position of the Nisling terrane with respect to the Teslin–Taylor Mountain terrane; (3) Teslin–Taylor Mountain and Nisling diachronous cooling ages; (4) the location of Nisling rocks within the hinterland of the McKenzie fold and thrust belt; (5) the differences in metamorphic grade between the Nisling and Teslin–Taylor Mountain and the inverted metamorphic gradient within Teslin–Taylor Mountain rocks; and (6) the stacking order within the Slide Mountain Sylvester allochthon with increasing autochthonous character of the structurally lower, and eastward, packages.

The model proposes a coherent structural, thermal, and temporal evolution of each of the tectonic elements considered, and has important implications for the Paleozoic and Mesozoic tectonic evolution of the northern Cordillera. (1) Rocks of the Teslin–Taylor Mountain and the Slide Mountain terranes evolved offshore of North America in Paleozoic and early Mesozoic time, and they were deformed in pre–Early Jurassic time in a southwest-dipping, right-oblique subduction system. (2) Cooling ages from Teslin–Taylor Mountain tectonites provide the best estimate of the collision of these rocks with North American strata, although they may have been juxtaposed with adjacent strata in the mid-Cretaceous as a result of extension rather than contraction. (3) Nisling rocks are para-autochthonous North American strata exposed during mid-Cretaceous crustal extension. (4) Mid- to Late Cretaceous margin-parallel dextral translation displaced slivers of accreted terranes and the underlying North American rocks along high-angle, northwest-trending shear zones in central and southern Yukon. Thus, a significant component of the Yukon-Tanana (the Nisling) represents crustal material of North American affinity which was involved in collisional and translational convergent-margin tectonism. This paper underscores the danger in applying "suspect" status to Cordilleran terranes, and it affirms the importance of structural, metamorphic, and thermochronologic study of terranes and terrane boundaries.

## REFERENCES CITED

Aleinikoff, J., Dusel-Bacon, C., Foster, H.L., and Futa, K., 1981, Proterozoic zircon from augen gneiss, Yukon-Tanana upland, east-central Alaska: Geology, v. 9, p. 469–473.

Aleinikoff, J., Dusel-Bacon, C., and Foster, H.L., 1986, Geochronology of augen gneiss and related rocks, Yukon-Tanana terrane, east-central Alaska: Geological Society of America Bulletin, v. 97, p. 626–637.

Aleinikoff, J., Dusel-Bacon, C., Foster, H.L., and Nokleberg, W.J., 1987, Lead isotopic fingerprinting of tectono-stratigraphic terranes, east-central Alaska: Canadian Journal of Earth Sciences, v. 24, p. 2089–2098.

Beck, M.E., Jr., 1986, Model for late Mesozoic–early Tertiary tectonics of coastal California and western Mexico and speculations on the origin of the San Andreas fault: Tectonics, v. 5, p. 49–64.

Bennett, V.C., and Hansen, V.L., 1988, Neodymium isotopic similarities between the Yukon-Tanana terrane, Yukon Territory and continental North America: Geological Society of America Abstracts with Programs, v. 20, p. A111.

Brown, E.H, and Forbes, R.B., 1986, Phase petrology of eclogitic rocks in the Fairbanks District, Alaska, *in* Evans, B.W., and Brown, E.H., eds., Blueschists and eclogites: Geological Society of America Memoir 164, p. 155–168.

Churkin, M., Jr., Foster, H.L., Chapman, R.M., and Weber, F.R., 1982, Terranes and suture zones in east-central Alaska: Journal of Geophysical Research, v. 87, p. 3718–3730.

Coney, P.J., Jones, D.L., and Monger, J.W.H., 1980, Cordilleran suspect terranes: Nature, v. 188, p. 329–333.

Copeland, P., Hodges, K.V., Harrison, T.M., LeFort, P., and Pecher, A., 1988, Rapid Pliocene uplift associated with the Main Boundary thrust, central Nepal: Geological Society of America Abstracts with Programs, v. 20, p. A321.

Cushing, G.W., 1984, The tectonic evolution of the eastern Yukon Tanana upland, Alaska [M.S. thesis]: Albany, State University of New York, 255 p.

Dewey, J.F., 1988, Extensional collapse of orogens: Tectonics, v. 7, p. 1123–1140.

Duke, N.A., Nauman, C.R., and Newkirk, S.R., 1988, Evidence for Late Cretaceous extensional uplift of the Yukon-Tanana crystalline terrane, Eastern Alaska Range: Geological Society of America Abstracts with Programs, v. 20, p. A113.

Dusel-Bacon, C., and Aleinikoff, J., 1985, Petrology and tectonic significance of augen gneiss from a belt of Mississippian granitoids in the Yukon-Tanana terrane, east-central Alaska: Geological Society of America Bulletin, v. 96, p. 411–425.

Erdmer, P., 1985, An examination of the cataclastic fabrics and structures of parts of Nisutlin, Anvil, and Simpson allochthons, central Yukon: Test of the arc-continent collision model: Journal of Structural Geology, v. 7, p. 57–72.

——1987, Blueschist and eclogite in mylonitic allochthons, Ross River and Watson Lake areas, southeastern Yukon: Canadian Journal of Earth Sciences, v. 24, p. 1439–1449.

Erdmer, P., and Armstrong, R.L., 1989, Permo-Triassic isotopic dates for blueschist, Ross River area, Yukon, *in* Yukon geology, Volume 3: Yukon, Indian and Northern Affairs Canada, Exploration and Geological Services Division.

Erdmer, P., and Helmstaedt, H., 1983, Eclogite from central Yukon: A record of subduction at the western margin of ancient North America: Canadian Journal of Earth Sciences, v. 20, p. 1389–1408.

Foster, H.L., Cushing, G.W., and Keith, T.E.C., 1985, Early Mesozoic tectonic history of the Boundary Area, east-central Alaska: Geophysical Research Letters, v. 12, p. 553–556.

Foster, H.L., Keith, T.E.C., and Menzie, W.D., 1987, Geology of east-central Alaska: U.S. Geological Survey Open-File Report 87-188, 59 p.

Gabrielse, H., 1968, Geology of the Jennings River map-area, British Columbia (104-O): Geological Survey of Canada Paper 68-55, 37 p.

——1985, Major dextral transcurrent displacements along the Northern Rocky Mountain Trench and related lineaments in north-central British Columbia: Geological Society of America Bulletin, v. 96, p. 1–14.

Gabrielse, H., and Dodds, C.J., 1982, Faulting and plutonism in northwestern Cry Lake and adjacent map areas, British Columbia, *in* Current research: Geological Survey of Canada Paper 82-1A, p. 321–323.

Hansen, V.L., 1987, Structural, metamorphic, and geochronologic evolution of the Teslin suture zone, Yukon: Evidence for Mesozoic oblique convergence outboard of the northern Canadian Cordillera [Ph.D. thesis]: Los Angeles, University of California, 221 p.

——1988, A model for terrane accretion: Yukon-Tanana and Slide Mountain terranes, northwest North America: Tectonics, v. 7, p. 1167–1177.

——1989a, Mesozoic evolution of the Yukon-Tanana terrane: Geological Society of America Abstracts with Programs, v. 21, no. 5, p. 90.

——1989b, Structural and kinematic evolution of the Teslin suture zone, Yukon: Record of an ancient transpressional margin: Journal of Structural Geology, v. 11, p. 717–733.

Hansen, V.L., Heilzer, M.T., and Harrison, T.M., 1988, Mesozoic thermal evolution of the Yukon-Tanana terrane, Yukon and Alaska: New evidence from $^{40}Ar/^{39}Ar$ data: Geological Society of America Abstracts with Programs, v. 20, p. A111–A112.

Hansen, V.L., Armstrong, R.L., and Mortensen, J.K., 1989, Pre-Jurassic dutile deformation and synchronous metamorphism of the Yukon-Tanana terrane: Geochronologic constraints from the Teslin suture zone, Yukon: Canadian Journal of Earth Sciences, v. 26.

Harms, T.A., 1986, Structural and tectonic analysis of the Sylvester allochthon, northern British Columbia: Implications for paleogeography and accretion [Ph.D. thesis]: Tucson, University of Arizona, 80 p.

Laird, J., and Foster, H.L., 1986, Petrologic evidence for a terrane boundary in south-central Circle quadrangle, Alaska: Geophysical Research Letters, v. 13, p. 1035–1038.

Laird, J., Foster, H.L., and Weber, F.R., 1985, Amphibolite eclogite in the Circle quadrangle, Yukon-Tanana upland, Alaska: U.S. Geological Survey Circular 969, p. 57–60.

Monger, J.W.H., and Berg, H.C., 1987, Lithotectonic terrane map of western Canada and southeastern Alaska: U.S. Geological Survey Miscellaneous Field Investigations Map MF-1874-B, scale 1:2,500,000.

Mortensen, J.K., 1986, U-Pb ages for granitic orthogneiss from western Yukon Territory: Selwyn Gneiss and Fiftymile Batholith revisited: Geological Survey of Canada Paper 86-1B, p. 141–146.

——1988a, Geology of the southwestern Dawson map area, Yukon Territory: Geological Survey of Canada Paper 88-1E, p. 73–78.

——1988b, Significance of episodic magmatism in Yukon-Tanana Terrane, Yukon and Alaska: Geological Society of America Abstracts with Programs, v. 20, p. A111.

Mortensen, J.K., and Jilson, G.A., 1985, Evolution of the Yukon-Tanana terrane: Evidence from southeastern Yukon Territory: Geology, v. 13, p. 806–810

Nelson, J., and Bradford, J., 1987, Geology of the area around the Midway deposit, northern British Columbia (104O/16): British Columbia Ministry of Energy, Mines and Petroleum Resources Paper 1987-1, p. 181–192.

Nelson, J., Bradford, J.A., Green, K.C., and Marsden, H., 1988, Geology and patterns of mineralization, Blue Dome map area, Cassiar district (104P/12): British Columbia Ministry of Energy, Mines and Petroleum Resources Paper 1988-1, p. 233–243.

Nelson, J.L., Bradford, J.A., Ferri, F., and Schiarizza, P., 1989, Marginal basin and island arc elements in the Slide Mountain terrane: Evidence for early North American affinities: Geological Society of America Abstracts with Programs, v. 21, no. 5, p. 121.

Pavlis, T.L., 1989, Middle Cretaceous orogenesis in the northern Cordillera: A Mediterranean analog of collision-related tectonics: Geology, v. 17, p. 947–950.

Pavlis, T.L., Sisson, V.B., Nokleberg, W.J., Plafker, G., and Foster, H., 1988, Evidence for Cretaceous extension in the Yukon Crystalline terrane, east-central Alaska: Eos (Transactions, American Geophysical Union), v. 69, p. 1543.

Rubin, C.M., Smith, G., and Miller, M.M., 1989, The geologic evolution and tectonic setting of mid-Paleozoic arc basement in the North American Cordillera: Geological Society of America Abstracts with Programs, v. 21, no. 5, p. 137.

Spicuzza, M.J., and Hansen, V.L., 1989, Constraints on Mesozoic evolution of south-central Yukon: Structural and metamorphic data from the Late Cretaceous Nisutlin batholith and host rocks: Geological Society of America Abstracts with Programs, v. 21, no. 5, p. 147.

Tempelman-Kluit, D.J., 1977, Quiet Lake (105F) and Finlayson Lake (105G) map area, Yukon: Geological Survey of Canada Open File 486, scale 1:250,000.

——1979, Transported cataclasite, ophiolite and granodiorite in Yukon: Evidence of arc-continent collision: Geological Survey of Canada Paper 79-14, 27 p.

Wheeler, J.O., and McFeely, P., 1987, Tectonic assemblage map of the Canadian Cordillera and adjacent parts of the United States of America (revised edition): Geological Survey of Canada Open File 1565, scale 1:2,000,000.

Wilson, F.H., Smith, J.G., and Shew, N., 1985, Review of radiometric data from the Yukon Crystalline Terrane, Alaska and Yukon Territory: Canadian Journal of Earth Sciences, v. 22, p. 525–537.

## ACKNOWLEDGMENTS

Supported by National Science Foundation Grant EAR-8715911. C. Dusel-Bacon, J. W. Goodge, and T. L. Pavlis provided careful, thoughtful, and critical reviews.

Manuscript received June 19, 1989
Revised manuscript received October 19, 1989
Manuscript accepted November 2, 1989