PRELIMINARY Nd AND Sr ISOTOPIC ANALYSES FROM THE NISLING ASSEMBLAGE, NORTHERN STIKINE AND NORTHERN CACHE CREEK TERRANES, NORTHWESTERN BRITISH COLUMBIA AND ADJACENT YUKON (104M, N)

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INTRODUCTION

One of the fundamental tectonic problems in the western Canadian Cordillera is constraining the age of initial juxtaposition of the disparate terranes that underlie this region. Understanding of the temporal and spatial relationships between terranes is hindered by the unique stratigraphy of each terrane and by the fault-bounded nature of these fragments. To unravel relationships between terranes, one must examine the evolution of a terrane through time and look for changes that signal its proximity to another crustal fragment.

The use of radiogenic isotopes is one method by which we can examine changes in terrane stratigraphy through time. The Sm-Nd isotopic system is of particular value because most crustal rocks contain trace quantities of these elements, and samarium and neodymium are not significantly fractionated within the sedimentary system or during metamorphism (*e.g.* DePaolo, 1988). This latter quality allows analysis and direct comparison of values from all rock types that comprise a particular terrane, from sedimentary and volcanic rocks to plutons that intrude these fragments, as well as their metamorphosed equivalents. Although sometimes subject to disturbance, Rb-Sr isotopic analyses are valuable for comparison with existing data sets (*e.g.* Armstrong, 1988).

In this paper we report preliminary interpretations for data from 45 samples taken from the Nisling assemblage, northern Stikine Terrane and northern Cache Creek Terrane in northern British Columbia and adjacent Yukon. Full results of these analyses and precise sample locations will be published elsewhere (Jackson *et al.*, 1990b; in review; in preparation).

REGIONAL GEOLOGIC FRAMEWORK

Researchers have long recognized the oceanic Cache Creek Terrane as one of the most enigmatic terranes in the Cordillera, largely due to Permian Tethyan fauna that are distinct from coeval North American forms (*e.g.* Monger and Ross, 1971). The Quesnel and Stikine terranes border Cache Creek Terrane on the east and west respectively (Figure 1-16-1). The Quesnel and Stikine terranes are characterized by Upper Triassic strata characteristic of an intra-oceanic volcanic arc, including pyroxene-porphyritic basalt and related sedimentary rocks (Monger, 1977; Mortimer, 1986). The area west of the Stikine Terrane near Atlin, British Columbia, is underlain by the pericratonic basinal assemblage of metasedimentary and metavolcanic rocks termed the Nisling assemblage by Wheeler and McFeely (1987).

The initial juxtaposition of these terranes, with each other and with the North American margin, is generally accepted to have occurred in early Mesozoic time (Monger *et al.*, 1982), but the exact timing and method of this juxtaposition remains poorly constrained. Recent research has illustrated two additional reasons for examining the relations between these terranes:

(1) Workers have shown that metamorphic rocks in and west of the Coast Range batholith (Figure 1-16-1) have an ancient isotopic signature, both in neodymium isotopic studies (Samson, 1990) and detrital and inherited U-Pb zircon geochronology (Gehrels *et al.*, 1990a, b). These studies suggest that a significant component of Precambrian material has been recycled into these metamorphic rocks. Nisling rocks north and east of the Coast Range batholith also have this ancient crustal signature (Armstrong, 1988; Werner *in* Monger and Berg, 1987; Jackson *et al.*, 1990b). The Nisling assemblage has been correlated with the lower section of the Yukon-Tanana Terrane (Mortensen, in press) and the latter has in turn been correlated with portions of the North American miogeocline by isotopic and geochronologic studies (*e.g.* Bennett and Hansen, 1988). If the Nisling assemblage represents a part of the North American margin, a complex accretionary history is required to place the Stikine, Cache Creek and Quesnel terranes inboard of it.

(2) In central and northwestern British Columbia, the Upper Triassic Stuhini Group of the Stikine Terrane unconformably overlies the Paleozoic Stikine assemblage which comprises multiply deformed mafic and felsic volcanic rocks, related sedimentary rocks, chert and marble (Anderson, 1989). Both the Stuhini Group and Paleozoic Stikine assemblage in this region have juvenile neodymium and strontium isotopic signatures, indicating a lack of any significant quantity of recycled Precambrian material in this part of the Stikine Terrane (Samson *et al.*, 1989). In contrast, Stuhini Group and equivalent Lewes River Group rocks in extreme northwestern British Columbia and southern

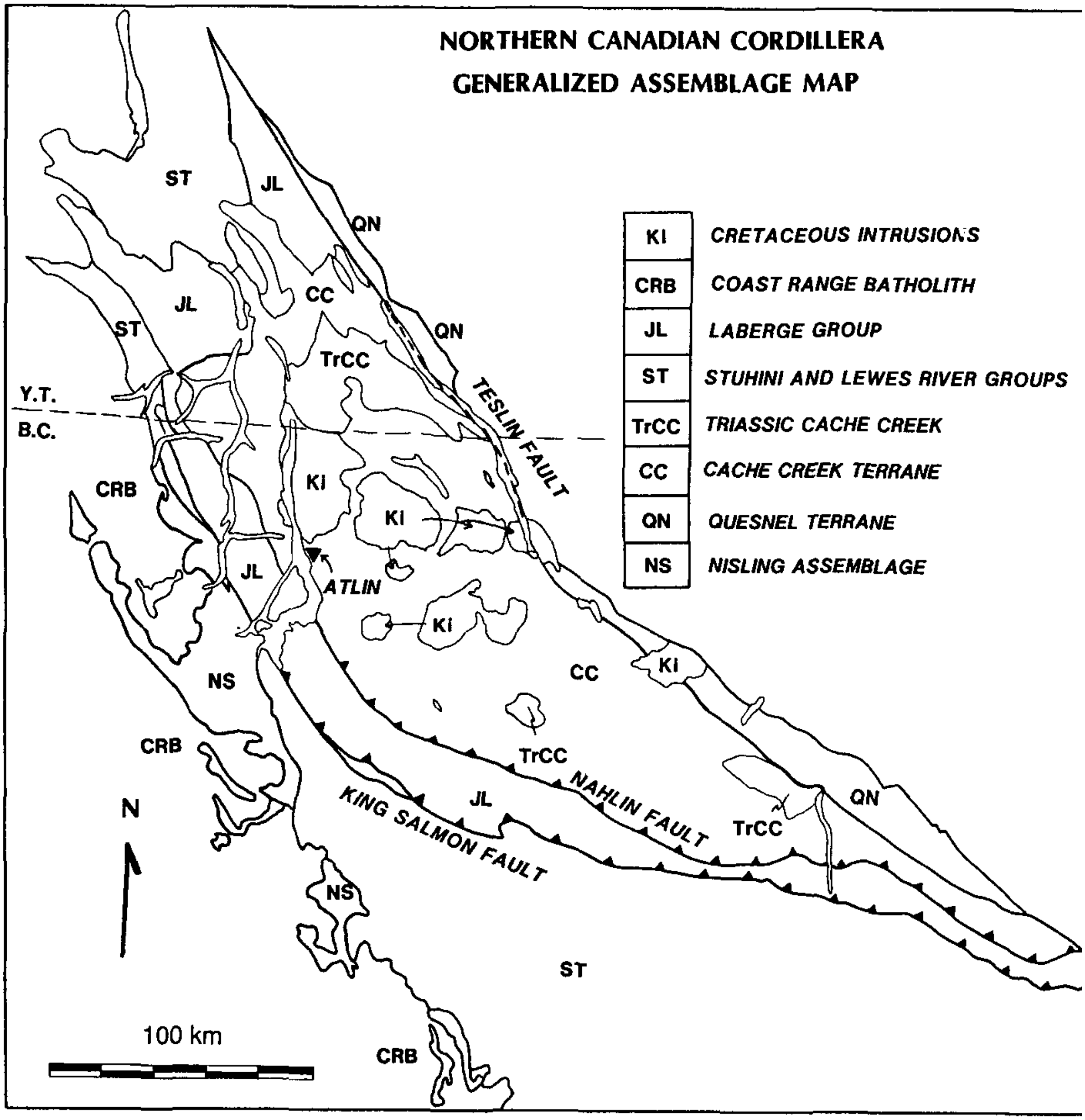

Figure 1-16-1. Generalized geology of the northern Canadian Cordillera (modified after Wheeler and McFeely, 1987).

Yukon have been interpreted to unconformably overlie the Nisling assemblage (Werner, 1978; Bultman, 1979; Mihalynuk and Rouse, 1988). Recent isotopic work shows that local clastic strata in the Stuhini Group of the northern Stikine Terrane contain a significant amount of ancient crustal material, seeming to confirm this interpretation (Jackson *et al.*, 1990b). This Nisling – northern Stikine Terrane link calls into question relations between the northern and southern parts of the Stikine Terrane and their along-strike continuity.

ISOTOPIC STUDIES

We have analyzed 43 samples for Sm-Nd isotopic composition and 19 samples for Rb-Sr isotopic composition. Neodymium data are summarized for this report by their depleted mantle model ages (DePaolo, 1981). For igneous rocks, the model age is a measure of the time at which the pluton or volcanic rock was removed from the mantle, plus any contamination from existing crustal material in the surrounding country rock which could have a very different model age. For sedimentary and metasedimentary rocks, the model age is a measure of the average age at which detritus that comprises these rocks was separated from the mantle. We use the depleted mantle form rather than the more traditional epsilon value because depositional ages or crystallization ages of many of the samples are poorly known.

Strontium data were obtained for igneous and metamorphic rocks in the study. Data for volcanic and plutonic rocks are reported by their initial $^{87}Sr/^{86}Sr$ values because the crystallization ages of samples collected are fairly well known. Metamorphic rocks, however, are reported by their measured $^{87}Sr/^{86}Sr$ value because neither depositional ages of their protoliths nor the age of metamorphism are known.

NISLING ASSEMBLAGE

The Nisling assemblage comprises metamorphic rocks interpreted as a pericratonic basinal assemblage (Wheeler and McFeely, 1987). Currie (1990) described these rocks in detail and broke out two subdivisions of metasedimentary rocks: the Florence Range suite, dominated by quartz-rich metaclastic strata and marble; and the Boundary Ranges suite, primarily composed of metavolcanic and related metasedimentary rocks. Relative ages of the two suites are unknown.

Neodymium isotopic data confirm that the rocks of the Florence Range suite contain a substantial amount of older Precambian material, with neodymium depleted mantle model ages ranging from 2700 Ma to 1600 Ma (Figure 1-16-2). Strontium data also show strongly evolved values, but these numbers are less meaningful due to severe disturbance during metamorphism (Jackson, unpublished data). Rocks of the Boundary Ranges suite, on the other hand, show younger average depleted mantle model ages between 1550 and 800 Ma and lower measured strontium ratios. This is consistent with, but does not require, the interpretation that Boundary Ranges rocks are younger than those of the Florence Range suite. Alternatively, these rocks may simply be derived from a more primitive source area.

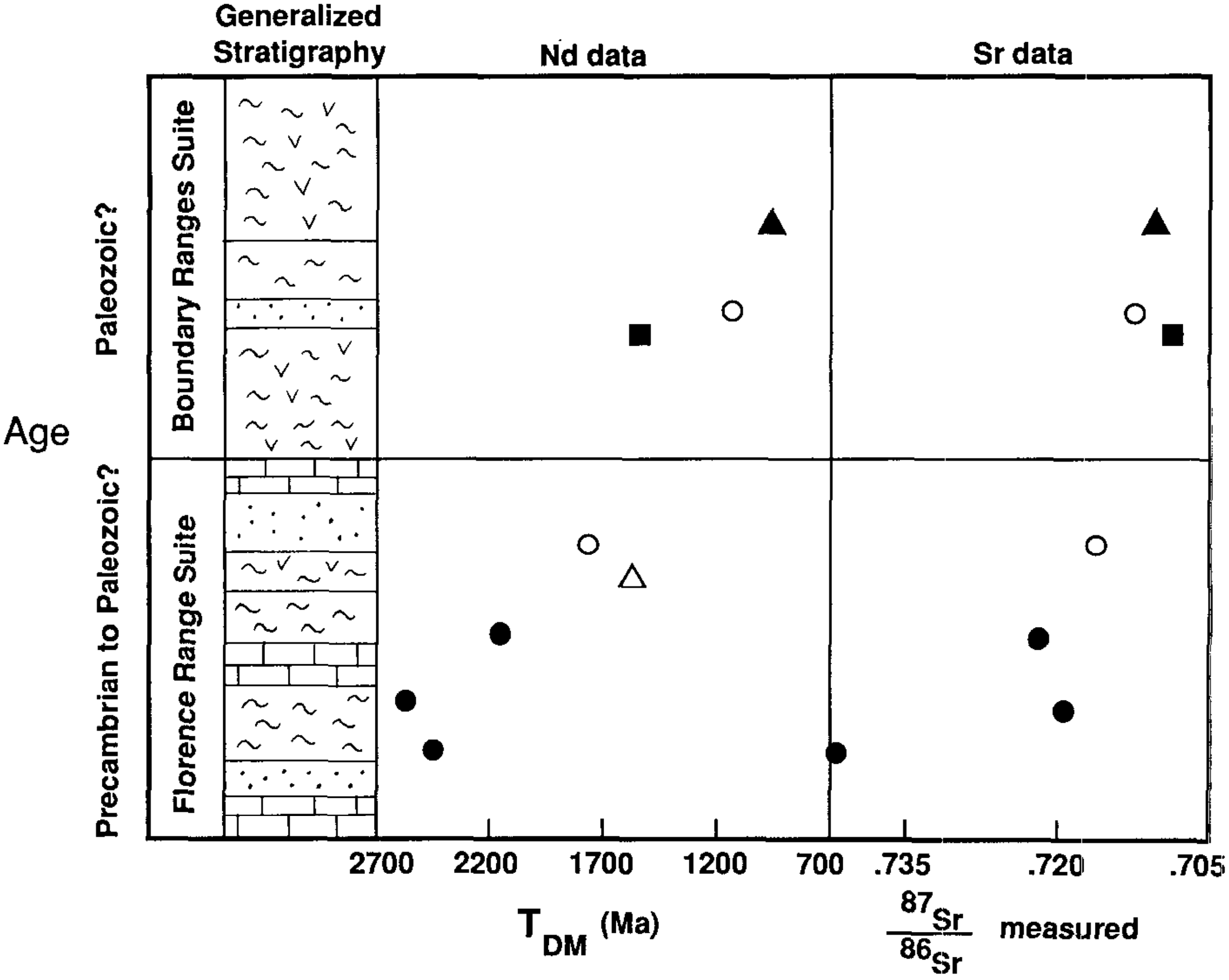

Figure 1-16-2. Nd and Sr isotopic data from the Nisling assemblage. Black circles are carbonaceous schist, open circles are quartzite, black squares are chlorite-actinolite schist, black triangles are quartz-chlorite schist and open triangles are a chlorite schist clast within Stuhini conglomerate.

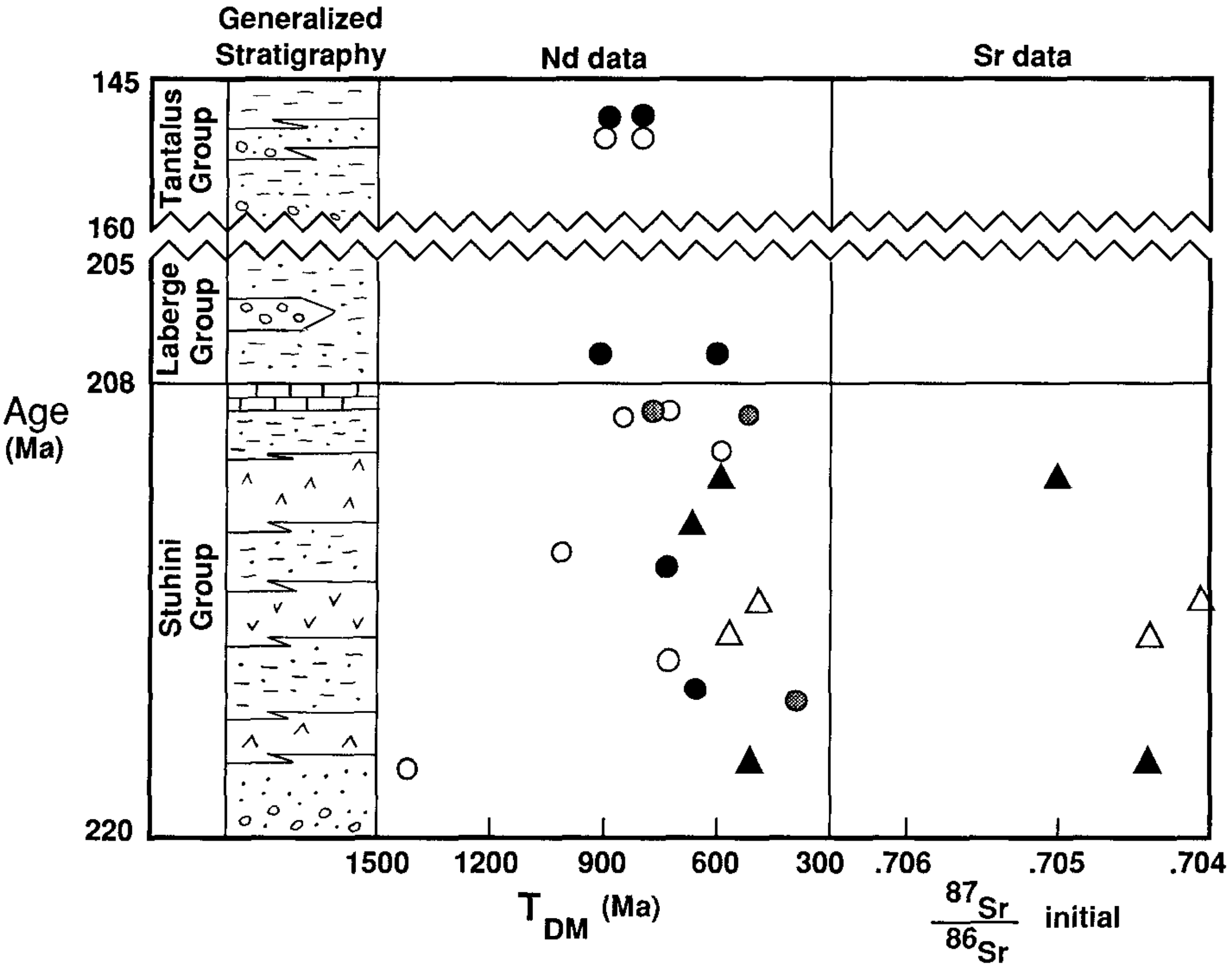

Figure 1-16-3. Nd and Sr isotopic data from the northern Stikine Terrane. Black circles are argillite and shale, shaded circles are siltstone, open circles are sandstone, black triangles are mafic volcanic rock and open triangles are felsic volcanic rock.

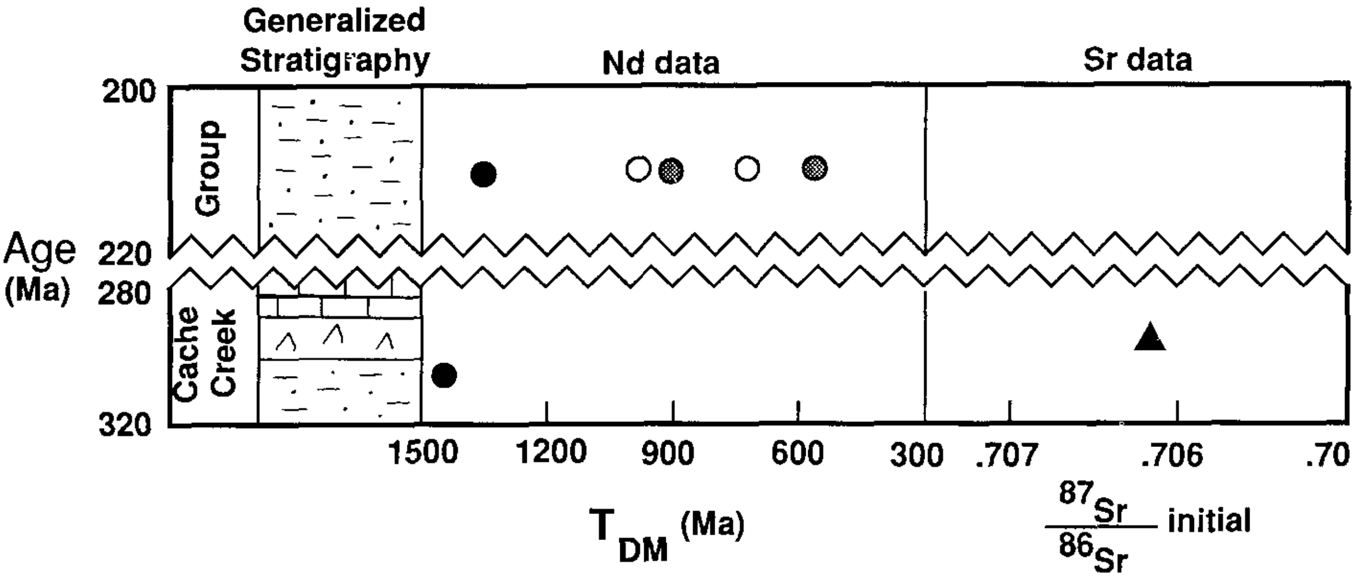

Figure 1-16-4. Nd and Sr isotopic data from the northern Cache Creek Terrane. Symbols are the same as in Figure 1-16-3.

NORTHERN STIKINE TERRANE

Samples analyzed from the northern Stikine Terrane include sedimentary and volcanic rocks from the Upper Triassic Stuhini and age-equivalent Lewes River goups, and clastic rocks from the Lower to Middle Jurassic Laberge Group and the Upper Jurassic to Lower Cretaceous Tantalus Group (Figure 1-16-3; for stratigraphic descriptions *see* Mihalynuk and Mountjoy, 1990; Hart and Radloff, 1990). In general, the Stuhini rocks have a primitive isotopic signature quite similar to rocks in the southern sections of Stikinia (*cf.* Samson *et al.*, 1990). With younger depositional ages, however, the neodymium data show a slight trend toward older depleted mantle model ages. Two Stuhini Group sandstone samples in the northern Stikine Terrane, however, are a marked exception to this pattern with model ages of 1410 and 1010 Ma (Figure 1-16-3). The most likely source for the old detritus in this arkose is the adjacent Nisling assemblage which is interpreted to have been linked with northern Stikine Terrane by Late Triassic time (Werner, 1978; Bultman, 1979; Jackson *et al.*, 1990b).

NORTHERN CACHE CREEK TERRANE

A sample of late Paleozoic (Pennsylvanian to Permian?) argillite has a model age of 1450 Ma which indicates a significant component of Precambrian detritus (Figure 1-16-4). This reflects either: pelagic deposition in an open ocean basin where clastic strata have been derived from the continents surrounding it (Ben Othman *et al.*, 1989; Jackson *et al.*, 1990a); or deposition near a continent or continental fragment composed of rocks with Precambrian model ages. The Upper Triassic argillite carries this same ancient crustal signature, reflecting a similar depositional setting. Interbedded Late Triassic, coarse clastic strata, however, have younger model ages. This suggests input of detritus from a source of juvenile crustal material in the Late Triassic, periodically interrupting the pelagic deposition of chert and argillite. This juvenile source is most likely one of the flanking volcanic-arc terranes (Samson *et al.*, 1989; Jackson *et al.*, 1990b).

An upper Paleozoic metabasalt has an initial $^{87}Sr/^{86}Sr$ ratio of 0.7064. This slightly evolved signature is most likely due to alteration during greenschist-facies metamorphism. Analyses of 14 additional Cache Creek samples, currently in progress, will add details to these preliminary interpretations.

PLUTONIC ROCKS

Felsic plutonic rocks that intrude the Nisling assemblage, northern Stikine and northern Cache Creek terranes show

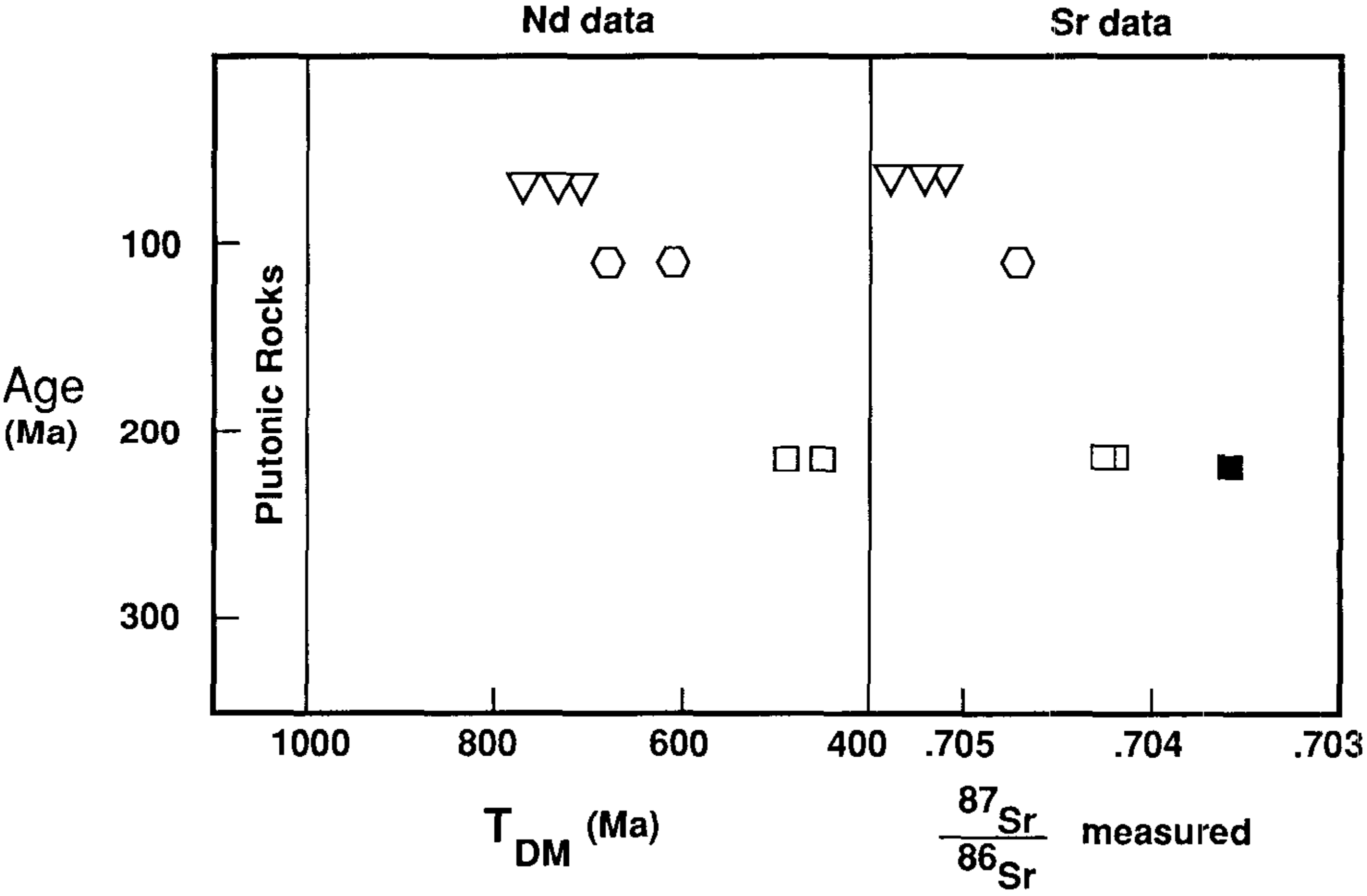

Figure 1-16-5. Nd and Sr isotopic data from plutons. Open triangles are felsic plutons that intrude the Nisling assemblage, open hexagons are felsic plutons that intrude the Cache Creek Group, open squares are felsic plutons that intrude the Stikine Terrane and the black square is a gabbro that intrudes Stikinia.

distinct differences in their neodymium and strontium isotopic signatures. The oldest model ages, ranging from 710 to 770 Ma, are found in Cretaceous granodiorite and tonalite plutons that intrude Nisling assemblage rocks southwest of Atlin. (Figures 1-16-1; 1-16-5). Northern Cache Creek granodiorite shows intermediate model ages of 610 to 680 Ma. Northern Stikine granodiorite samples have young model ages of 450 to 490 Ma. Initial strontium data mimic the neodymium model age trends. Two possible controls on these isotopic ratios are as follows. First, wallrock contamination may affect the model ages of these plutons. Nisling assemblage rocks have the oldest neodymium model ages, whereas those of Stikinia are the youngest. Strata in the Cache Creek Terrane are intermediate with old model ages for argillite and young model ages for interbedded siltstone and sandstone. Second, the data show an increase in model age with decreasing crystallization age (Figure 1-16-5). This may be a function of plutons intruding a crustal section that has become progressively thickened through Jurassic and Cretaceous structural shortening (Monger, 1977; Monger *et al.*, 1982; Bloodgood and Bellefontaine, 1990).

TECTONIC SIGNIFICANCE

Examination of the neodymium and strontium isotopic signatures of three terranes in the northern Canadian Cordillera can help place constraints on the timing of juxtaposition of these fragments. Local layers of Late Triassic sandstone in the northern Stikine Terrane contain a significant component of older crustal material (Figure 1-16-3) which provides a link between northern Stikine Terrane and the Nisling assemblage at this time (Jackson *et al.*, 1990b).

In the northern Cache Creek Terrane, sandstone beds with isotopic ratios indicative of juvenile crust are interstratified with argillite carrying an ancient crustal signature. Two possible models can account for this pattern. In one model, the argillite could reflect pelagic deposition in an ocean basin as described above, whereas sandstone beds would demonstrate increasing proximity to a source of juvenile detritus, most likely from the Stikine Terrane or the Quesnel Terrane. Alternatively, the ancient component of detritus in Cache Creek argillite could signal proximity to either the Nisling assemblage or the North American continental margin, with sandstone beds representing periodic input from a nearby source of juvenile material (Quesnel Terrane or Stikine Terrane). Further isotopic and petrographic analyses will aid in discriminating between these models.

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