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Isochron/West, Bulletin of Isotopic Geochronology, v. 51, pp. 19-23

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POTASSIUM-ARGON AGE OF GRANITOID PLUTONIC ROCKS, SOUTHWEST YUKON TERRITORY, CANADA

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We report 29 new K-Ar age determinations for granitoid and metamorphic rocks bordering the Denali-Shakwak fault in southwestern Yukon Territory. Southwest of the fault, the data document protracted (270–140 Ma), episodic, intrusive activity for the Icefield Range Granites, followed by intrusion of the Kluane Range Diorites at 120 Ma and the Kluane Range Porphyry at 25 Ma. Our data from northeast of the fault substantiates that the Nisling Range Granodiorite was intruded at 100 Ma, and that the Ruby Range Granodiorite was intruded and cooled slowly between 67 and 55 Ma. Intrusion of the Nisling Range Alaskites coincided with the waning stages of intrusion of the Ruby Range Granodiorites at 55 Ma.

GEOLOGICAL SETTING

In the southwest Yukon (fig. 1), rocks of the Yukon Crystalline Terrane are juxtaposed across the northwest-trending Denali-Shakwak fault with a composite terrane comprising the Gravina-Nutzotin belt, the Taku-Skolai Terrane, and the Alexander Terrane. The Shakwak Trench which follows the trace of the fault is a major physiographic feature, separating the relatively subdued topography of the Ruby and Nisling Ranges to the northeast from the higher Kluane and Icefield Ranges of the St. Elias Mountains to the southwest. In the course of a reconnaissance study of the granitoid rocks of this area, samples were collected by D.C.W. and A.H.C. for K-Ar age determination from bodies intruding terranes on both sides of the fault and also from the Kluane Schist northeast of the fault. Way (1977) gives details of the sample locations, petrography and chemistry.

The Canadian Cordillera can be divided into five tectonostratigraphic subdivisions (Monger and others, 1972; Monger, 1984). Two of these, the Omineca Crystalline Belt and the Coast Plutonic Complex converge in the Yukon and are referred to as the Yukon Crystalline Terrane. The southwestern part of this terrane comprises a framework of Proterozoic to Paleozoic eugeosynclinal rock units metamorphosed to amphibolite facies (Muller, 1967; Tempelman-Kluit, 1976). Two of these units are exposed within the study area, the Biotite and Kluane Schists of Tempelman-Kluit (1976). Tempelman-Kluit assigned a Proterozoic age to the sedimentary protolith of the Biotite Schist and suggested that metamorphism occurred in the Early or Middle Triassic. The age of the Kluane Schists is not known with certainty but Eisbacher (1976) points out that they could be the metamorphosed equivalent of the Dezadeash Group and thus be as young as Late Jurassic to Early Cretaceous. Radiometric dates in this study suggest that they were metamorphosed in the early Tertiary, essentially coeval with intrusion of the Ruby Range Batholith.

In the northern portion of the study area, this terrane was intruded by the Nisling Range Granodiorite in the mid-Cretaceous and by the Nisling Range Alaskite in the Eocene (Tempelman-Kluit and Wanless, 1975; Le Couteur and Tempelman-Kluit, 1976). These intrusive phases are correlative with documented intrusive episodes in the Omineca Crystalline Belt. The Ruby Range Granodiorite which underlies much of the remainder of the study area northeast of the Denali-Shakwak fault is correlative with intrusives of the Coast Plutonic Complex and has yielded Paleogene K-Ar ages (Tempelman-Kluit and Wanless, 1975).

Southwest of the Denali-Shakwak fault several fault-bounded terranes are represented. The oldest rocks in the St. Elias Mountains are metasediments belonging to the Devonian Kaskawulsh Group (Muller, 1967). Overlying these with apparent conformity are greenstones and chlorite schists of the Greenschist Complex which may be Devonian to Mississippian age (Muller, 1967). Plutonic rocks (herein referred to as the Icefield Range Granites) have intrusive contacts only with rocks of the Kaskawulsh Group and Greenschist Complex. These are a part of the Alexander Terrane (Berg and others, 1972) and, together with the Icefield Range Granites, are restricted in outcrop to areas southwest of the Duke River thrust fault (fig. 1).

Marine volcanics and sediments of the Permian Cache Creek Group (Muller, 1967) outcrop between the Duke River thrust fault and the Denali-Shakwak fault, where they form much of the Kluane Ranges. Eisbacher (1976) has reported Early Cretaceous K-Ar dates for ultramafic rocks that intrude these rocks. Volcanic and sedimentary rocks of the Mush Lake Group (Muller, 1967) disconformably overlie the Cache Creek rocks and outcrop extensively in the Kluane Ranges. The Cache Creek and Mush Lake Groups and associated ultramafics are part of the Taku-Skolai Terrane tectonic element (Berg and others, 1972). Mush Lake rocks are disconformably overlain by the Dezadeash Group, a thick assemblage of Upper Jurassic to Lower Cretaceous flysch sediments. Dezadeash sediments outcrop sparsely in the northwest Kluane Ranges but extensively in a fault-bounded area northeast of the Denali-Shakwak fault in the southern part of the study area, where they comprise part of another tectonic element known as the Gravina-Nutzotin Belt (Berg and others, 1972). Intruding these groups in the Kluane Ranges is a suite of diorites, the Kluane Range intrusions of Muller (1967), but herein referred to as the Kluane Range Diorite. These rocks are exposed only in the area between the Duke River fault and the Denali-Shakwak fault.

Unconformably overlying rocks of both the Alexander and the Taku-Skolai Terranes are sparse outcrops of Paleocene-to-Eocene continental, clastic sediments of the Amphitheatre Formation (Muller, 1967) and more extensive areas of younger sub-aerial Wrangell Lavas (Souther and Stanciu, 1975). Intrusive into these are small Miocene stocks (Christopher and others, 1972) which we refer to as the Kluane Lake Porphyry.

DISCUSSION

Samples from 28 locations were selected for K-Ar age determination. Standard isotope dilution/mass spectrometry of argon and flame photometric determination of potassium were used. Sample locations and K-Ar analytical data appear in table 1 and the dates are plotted on figure 1. Dates were calculated using the constants recommended

TABLE 1. Analytical data for K-Ar dates

Sample number	Lat. N	Long. W	Rock type	Material analyzed	K %	^{40}Ar (rad.) × $10^{-6}cm^3STP/g$	Atm ^{40}Ar %	Date ± 2σ (Ma)
Icefield Range Granite (Alexander Terrane)								
W115	**60°18′**	137°38′	granodiorite	Hb	1.009	6.115	5.0	149.3 ± 4.4
W127	61°04′	139°17′	monzogranite	Hb	0.787	4.547	6.8	142.4 ± 4.4
				Hb	0.787	4.510	4.7	141.0 ± 4.4
W128	61°07′	139°34′	granodiorite	Bt	7.346	54.68	3.4	180.9 ± 5.4
W134	61°14′	140°03′	monzogranite	Bt	7.116	79.38	2.1	265.9 ± 10.6
W136	61°14′	140°03′	monzogranite	Hb	0.863	9.870	10.1	272.1 ± 8.2
Kluane Range Diorite (Gravina-Nutzotin Belt and Taku-Skolai Terrane)								
W144	61°21′	139°25′	diorite	Hb	0.389	1.970	28.3	114.4 ± 3.8
W167	61°44′	140°19′	granodiorite	Bt	6.214	30.97	9.1	123.7 ± 3.6
W169	61°56′	140°35′	granodiorite	Hb	0.620	3.030	20.6	121.3 ± 3.6
Kluane Range Porphyry (Gravina-Nutzotin Belt and Taku-Skolai Terrane)								
W145	61°22′	139°26′	latite porph.	Bt	7.400	7.802	16.0	26.9 ± 0.8
Nisling Range Granodiorite								
W1	61°53′	140°05′	granodiorite	Bt	7.179	29.21	12.1	101.6 ± 3.0
W2	61°59′	139°43′	monzogranite	Bt	5.777	23.91	10.3	103.3 ± 3.2
W24	61°50′	138°31′	monzogranite	Bt	7.440	20.38	10.8	69.0 ± 2.2
Ruby Range Granodiorite								
W7	61°46′	139°58′	granodiorite	Bt	7.697	17.03	16.6	56.0 ± 1.6
W13	61°37′	139°21′	monzogranite	Bt	7.112	15.60	25.5	55.5 ± 1.6
W18	61°41′	138°56′	monzogranite	Bt	7.403	16.34	14.5	55.8 ± 1.6
W32	61°36′	138°25′	granodiorite	Bt	6.323	15.77	11.5	63.0 ± 1.8
W48	61°31′	138°39′	qtz. diorite	Bt	7.572	16.69	23.2	55.7 ± 1.6
W54	61°23′	138°44′	qtz. diorite	Bt	7.489	16.44	23.4	55.5 ± 1.6
W61	60°49′	137°29′	granodiorite	Bt	6.997	13.96	19.7	50.6 ± 1.6
W77	60°35′	136°07′	monzonite	Bt	6.982	15.73	12.7	56.9 ± 1.8
W90	60°21′	136°21′	qtz. diorite	Bt	7.402	16.52	18.7	56.4 ± 1.8
W103	60°08′	136°07′	granodiorite	Bt	7.086	15.66	20.1	55.9 ± 1.6
W104	60°03′	136°53′	qtz. diorite	Bt	7.447	19.69	15.8	66.7 ± 2.0
Kluane Schist								
KLL-1-1	61°22′	138°40′	schist	Bt	7.060	15.30	7.8	54.8 ± 1.6
KLL-2-5	61°21′	138°43′	schist	WR	2.668	5.363	27.7	50.9 ± 1.6
KLL-2-1	61°10′	138°27′	schist	WR	2.149	3.596	23.7	42.5 ± 1.4
Nisling Range Alaskite								
W28	61°49′	138°33′	monzonite	Bt	6.162	13.82	14.4	56.7 ± 1.8
W36	61°28′	138°07′	monzonite	Bt	6.540	13.47	19.1	52.1 ± 1.6

Hb = Hornblende; Bt = Biotite; WR = Whole-Rock

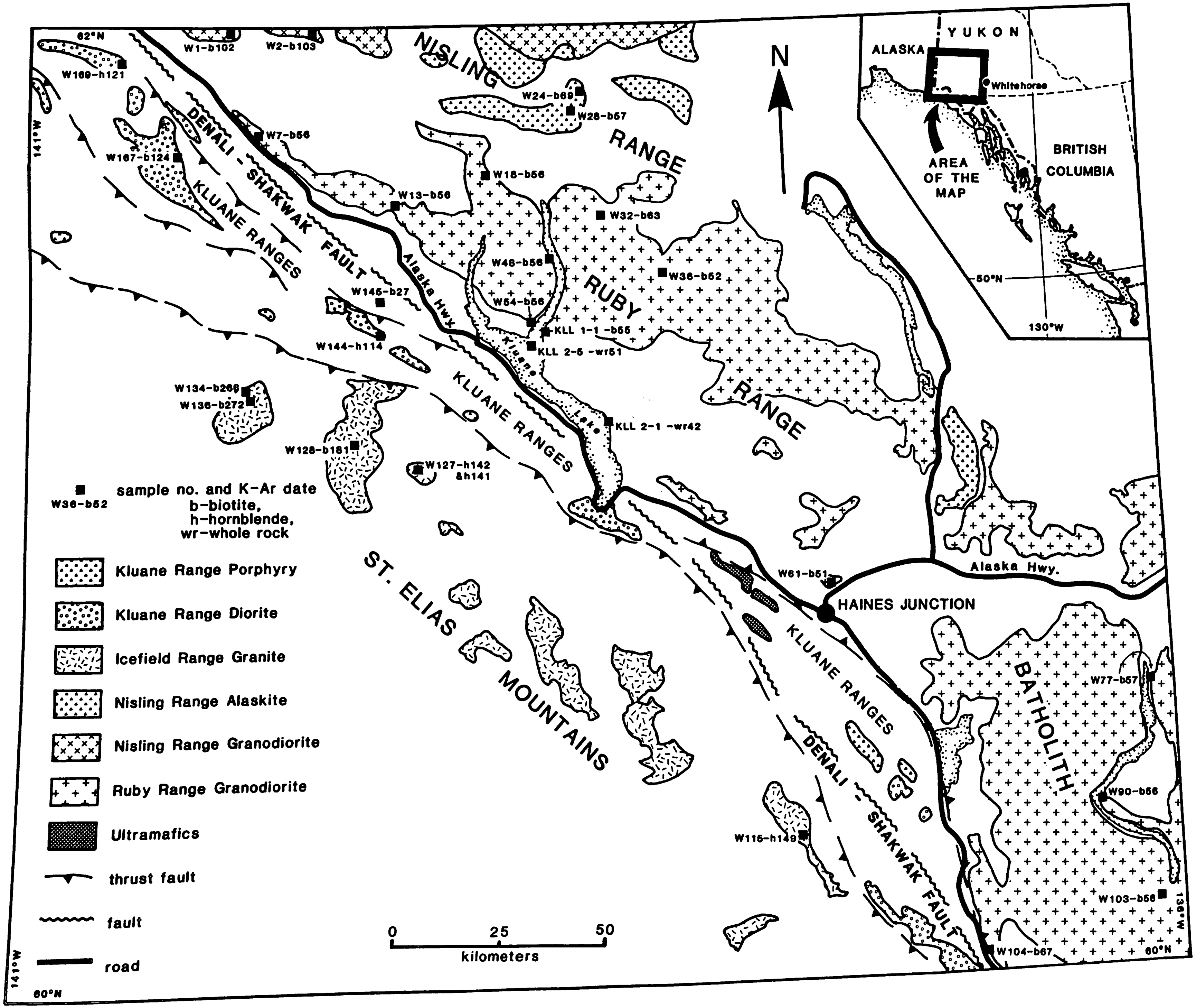

FIGURE 1. Map showing outline of plutons, sample locations and K-Ar dates, and major structural physiographic features.

by Steiger and Jager (1977) and, where necessary, dates referred to in the literature have been recalculated for these constants.

Region Southwest of the Denali-Shakwak Fault

Five samples from the **Icefield Range Granites** (Alexander Terrane) yield ages ranging from 142 to 272 Ma, which probably represent two plutonic eipsodes, one in the Early Permian, and the other spanning much of the Jurassic. The two oldest dates were obtained from the Steele Glacier stock. The agreement between hornblende and biotite dates suggest an Early Permian time of intrusion. The other three dates are from individual plutons and range from 142 to 181 Ma. The ages decrease regularly toward the northeast and possibly record a migration of plutonism across the Alexander Terrane. Richter and others (1975) have reported a comparable range and trend of dates in the Eastern Alaska Range.

Three samples from separate **Kluane Range Diorite** intrusions yield essentially concordant hornblende dates (117–119 Ma) reported by Christopher and others (1972) for one of the intrusions, and the biotite and hornblende dates (112–114 Ma) reported by Stevens and others (1982). Richter and others (1975) have dated four plutons in the Eastern Alaska Range which define a comparable period of intrusive activity from 120 to 108 Ma.

A sample from a **Kluane Range Porphyry** yields a biotite date of 26.9 Ma, coincident with biotite dates (26.5 to 27.2 Ma) reported by Christopher and others (1972) for several similar plugs, and casts doubt on the validity of whole-rock K-Ar dates (16.3, 13.6, 14.6 and 15.5 Ma) listed in preliminary form by Stevens and others (1982). However, a biotite date (20 Ma) that they record may indicate that a second period of intrusive activity occurred.

Region Northwest of the Denali-Shakwak Fault

Three samples from the **Nisling Range Granodiorite** yield biotite ages of 102, 103 and 69 Ma. The two mid-Cretaceous dates are taken to represent times of crystallization. Sample W24 (69 Ma) was taken from a small, sparsely mineralized stock that has been invaded by two sets of quartz veins, which probably are associated with intrusion of the Eocene Nisling Range Alaskites. We suggest that this sample was partially degassed during this event. Ample evidence exists for a mid-Cretaceous intrusive event in the region. Tempelman-Kluit and Wanless (1975) report two pairs of coexisting biotites and hornblendes that yield dates of 87.3–94.0 Ma and 96.7–97.1 Ma. Similarly, Richter and others (1975) report biotite and hornblende K-Ar dates ranging from 91 to 96 Ma for similar intrusives in the Eastern Alaska Range.

Eleven samples from the **Ruby Range Granodiorite** yield biotite dates that range from 50.6 to 66.7 Ma, with eight falling in a narrow interval between 55.5 and 56.9 Ma. These dates are consistent with K-Ar age determinations (Tempelman-Kluit and Wanless, 1975) for three biotite-hornblende pairs ranging from 50.2 to 69.9 Ma; with two biotite dates (Christopher and others, 1972) of 52.8 and 55.5 Ma; and a single biotite date of 54.1 Ma (Stevens and others, 1982). Furthermore, the range in K-Ar dates is similar to the range in Rb-Sr dates of Le Couteur and Tempelman-Kluit (1976) who report mineral isochrons yielding dates of 53 and 67 Ma. Geological Survey of Canada K-Ar dates for the Ruby Range Granodiorite determined prior to 1965 (Tempelman-Kluit and Wanless, 1975) are considered to be suspect. The available geochronological and geological data (Way, 1977) are consistent with mesozonal emplacement of the batholith at 67 Ma followed by protracted cooling over the next 15 Ma. We see little evidence to support a Triassic age (Tempelman-Kluit, 1976) for the batholith with the Tertiary K-Ar and Rb-Sr dates having resulted from overprinting associated with the volumetrically minor intrusions of the Nisling Range Alaskite.

Three samples from the **Kluane Schist** were dated. A biotite (54.8 Ma) is concordant with most of the dates from the nearby Ruby Range Batholith; whole-rocks yield somewhat younger dates (50.9 and 42.5 Ma). Mica dates (54.7 and 52.8 Ma) for the schists have also been reported by Stevens and others (1982). The inherent unreliability of whole-rock dates and the excellent agreement among the mica date, suggest that the rocks were metamorphosed coevally with intrusion of the Ruby Range Granite.

Samples from the **Nisling Range Alaskite** (52.1 and 56.7 Ma) agree with biotite dates (53.0–57.1 Ma) reported by Tempelman-Kluit and Wanless (1975). These dates coincide closely with the younger dates for the Ruby Range Batholith even though contact relationships clearly show the Alaskite suite to be younger (Tempelman-Kluit, 1976). The Alaskite suite is chemically, mineralogically, and petrologically distinct from the Ruby Range Batholith (Way, 1977) and thus is the youngest plutonic suite in the study area northeast of the Denali-Shakwak fault.

CONCLUSIONS

Primarily on the basis of their K-Ar geochronology, we believe that granitic rocks bordering the Denali-Shakwak fault in southwestern Yukon were emplaced during several discrete intrusive episodes.

Southwest of the Denali-Shakwak fault, the Icefield Range Granites intruded the Alexander Terrane in two phases, the first at 270 Ma and the second between 150 and 180 Ma. The Taku-Skolai Terrane was intruded by Kluane Range Diorites between 125 and 115 Ma ago, and by the Kluane Range Porphyry 25 Ma ago.

Northeast of the Denali-Shakwak fault three intrusive episodes are recognized. The Yukon Crystalline Terrane was intruded by the Nisling Range Granodiorite at 100 Ma and by the Nisling Range Alaskite at 55 Ma. The Ruby Range Granite, the northernmost manifestation of the Coast Crystalline Complex, was emplaced between 65 and 55 Ma ago.

ACKNOWLEDGEMENTS

Field, logistical, and financial support for this project was generously provided by the Department of Indian and Northern Affairs. The analytical work was supported by research grants from the Natural Sciences and Engineering Council of Canada.

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