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URANIUM- AND THORIUM-RICH VOLCANIC ROCKS OF THE SISCHU CREEK AREA, MEDFRA QUADRANGLE, ALASKA

By

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Introduction

Geologic studies in the Medfra quadrangle done in 1979 have shown the existence of strongly radioactive uranium- and thorium-rich rhyolitic volcanic rocks near Sischu Creek (fig. 1). Analytical data indicate above average back-ground amounts of uranium and thorium in these rocks and suggest the possibility of uranium enrichment. Volcanic rocks of similar composition and age are widespread in interior Alaska and may contain similar areas of uraniferous rocks.

Geologic setting

The uranium- and thorium-rich rhyolites are part of a narrow belt of siliceous volcanic rocks that extend northeast from the Sischu Mountains in the Medfra quadrangle to the southern Chitanatala Mountains in the Kantishna River quadrangle. This narrow belt of volcanic rocks is part of a discontinuous terrane of Late Cretaceous and early Tertiary volcanic and plutonic rocks that trends northeastward from the Yukon delta to the Arctic Circle near Bettles. The volcano-plutonic terrane consists of mafic and intermediate volcanic piles and volcano-plutonic complexes; silicic dikes, sills, domes, and flows; and numerous granitic stocks and plugs. K-Ar measurements on the volcanic and plutonic rocks from the Medfra, southern Ruby, and southwestern Kantishna River quadrangles give ages ranging from 60 to 70 m.y. (Silberman and others, 1979).

Within this broad volcano-plutonic terrane, the silicic volcanic rocks of the Sischu Mountains form a thick, broadly folded syncline that unconformably overlies a moderately to intensely deformed assemblage of Ordovician to Devonian carbonate rocks and Early Paleozoic phyllite and quartzite. Locally, thin, coal-bearing terrigenous beds of Late Cretaceous (Campanian -Maestrichtian) age conformably underlie the volcanic rocks. The area is also characterized by numerous northeast-trending major faults that locally bound the siliceous volcanic belt.

Although the unit is at least 500 m thick and laterally extensive, exposures of the volcanic rocks are poor. The area is heavily wooded, and exposures are confined to a few scattered patches of frost-riven rubble along the ridge tops and talus-covered cutbanks along the streams.

The volcanic rocks are chiefly weathered rhyolite and dacite flows and domes. Felsic tuff, andesite dikes, and basalt flows are also present in very minor amounts. Typical phenocrysts in the felsic rocks are quartz, plagioclase, sanidine, biotite, and magnetite. Sparse unpublished chemical data suggest that the rocks are potassic with K_2O ranging from 4.4 to 5.4 percent in the rhyolites and dacites and K_2O/Na_2O greater than 1 (1.2-1.6). However, the rocks are not peraluminous and appear to be high-K calc-alkalic rather than alkalic.

Uranium- and thorium-rich rocks

The strongly radioactive uranium- and thorium-rich rhyolites occur in two principal northeast-trending areas (Area 1, 2; fig. 1) near Sischu Creek in the north-central part of the belt of silicic volcanic rocks. Radioactivity over these two areas is high and ranges from 400 to 700 cps (counts per second) on a hand-held scintillometer. The areas underlain by strongly radioactive rhyolites are each about 4 mi long and 1-2 mi wide and separated by about 2 mi. A K-Ar age measurement on sanidine from a sanidine porphyry in Area 1 yielded an age of 66.3 ± 2.0 m.y. or Late Cretaceous (Table 1).

Petrography

The volcanic rocks of the easternmost occurrence (Area 1) consist of coarsely porphyritic sanidine rhyolite ranging in color from reddish orange to gray. Phenocrysts constitute about 40 percent of the rock and consist chiefly of oval-shaped sanidine crystals (about 80 percent of phenocrysts) as much as 2.5 cm long with lesser amounts of rounded and embayed quartz crystals and oval-shaped mafic pseudomorphs. These pseudomorphs, probably originally biotite, consist of quartzo-feldspathic anhedra (60 percent), opaque iron oxides (20 percent), and secondary biotite (20 percent). The quartz and mafic pseudomorphs range in size from 2 to 7 mm. The groundmass is composed of a mosaic of quartz and alkalic feldspar anhedra.

Zircon is a ubiquitous accessory and is particularly abundant in the mafic pseudomorphs. Fluorite, generally colorless to pale blue to pale violet, is a common accessory and occurs in clusters of several crystals. It is particularly common in the oval-shaped pseudomorphs but is also found in the groundmass and in fractures in phenocrysts.

The rocks from the western occurrence (Area 2) also are chiefly rhyolite and quartz porphyry but are much less porphyritic (14 percent phenocrysts) and finer grained. In contrast to Area 1, the phenocrysts are generally less than 10 mm across and are chiefly quartz (average 45 percent of phenocrysts), K-feldspar (average 29 percent), mafic pseudomorphs (average 17 percent), and plagioclase, which ranges from xero to 24 percent of the rock. Zircon and fluorite are common accessory minerals and have much the same character as in Area 1.

Chemistry

A single chemical analysis (table 2) of the sanidine-rich porphyritic rhyolite confirms the silicic nature of the rock with a SiO_2 content of 73 wt. percent (water-free); the rock is potassic with more than 5 percent K_2O and a K_2O/Na_2O ratio of 1.3.

Uranium and thorium analyses have been obtained on samples from both areas of radioactive rhyolite (table 3) and indicate above average amounts of U and Th. Area 1 has an average uranium content of 38 ppm with a range of 24 to 70 ppm; thorium averages 118 ppm with a range of 108 to 127 ppm. Area 2 has an average uranium content of 19 ppm with a range of 16 to 25 ppm and an average thorium content of 71 ppm with a range of 69 to 74 ppm. Although igneous rocks of this composition (>70 percent SiO_2) are generally expected to contain about 4 ppm uranium and 18 ppm thorium according to Rodgers and Adams (1964), Nishimori and others (1977) state that uranium contents of 10 to 20 ppm are common in rhyolites. In any case, the uranium content of the rhyolites from both areas is anomalously high.

The Th/U ratio can be an important parameter in interpreting the behavior of these elements during magmatic and subsequent alteration processes because of mutual differences in mobility and oxidation potential between the two elements. A Th/U ratio of 3.5 to 4 is considered typical for igneous rocks, and rocks from Areas 1 and 2 generally fall near this average; however, sample 79AMm9D (Area 1) and, to a lesser extent, 79AMm13 (Area 2) have lower Th/U ratios indicating enrichment of uranium with respect to thorium and suggesting that uranium, at least locally, has been mobile in this particular geologic setting.

Discussion

The high background contents of uranium and thorium in the sanidine porphyry, quartz porphyry, and other rhyolites of the Sischu Creek area suggest that these rocks as a group are enriched in U and Th as compared to rocks of similar composition elsewhere. The enrichment of uranium relative to thorium in at least some of the analyzed samples suggests that uranium during late magmatic stages or in later alteration phases may have been mobilized and reconcentrated, perhaps in concentrations of economic interest such as vein deposits. The presence of hematite staining and, less commonly, purple fluorite in these rocks is also an indication of uranium mineralization, on the basis of similar occurrences in interior Alaska (Miller, 1977) and elsewhere (Rich and others, 1977). Although further detailed studies will be necessary to evaluate these areas adequately, the association of strongly radioactive rhyolite, high uranium and thorium contents, variable Th/U ratios, hematite, and fluorite suggests the Sischu Creek area has a high potential for uranium deposits.

The occurrence of two these relatively large areas, underlain by uraniferous rhyolite suggests that similar occurrences may be present elsewhere in the Late Cretaceous to early Tertiary volcano-plutonic terrane of interior Alaska.

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Table 1. K-Ar measurement [1] on sanidine from porphyritic rhyolite, Sischu Creek area

Field no.	Percent K_2O	Ar^{40} rad (modes/gm)	Ar^{40} rad / Ar^{40} total	Apparent age (millions of years)
78APa36A	7.65 7.64	7.34×10^{-10}	0.82	66.3 ±2.0

[1] Ages were calculated using the following constants:

K^{40} decay constants: $\lambda\varepsilon + \lambda\varepsilon' = 0.581 \times 10^{-10}$ year^{-1}

$\lambda\beta = 4.963 \times 10^{-10}$ year^{-1}

Abundance ratio: $K^{40}/K = 1.167 \times 10^{-4}$ atom percent

Potassium analyses and age calculations: M. Taylor, B. Lai

Argon analyses and age calculation: M. L. Silberman, L. B. Gray

Table 2. Chemical analysis (weight percent) and CIPW norm of sanidine rhyolite porphyry (sample no. 78APA36) from Sischu Creek area

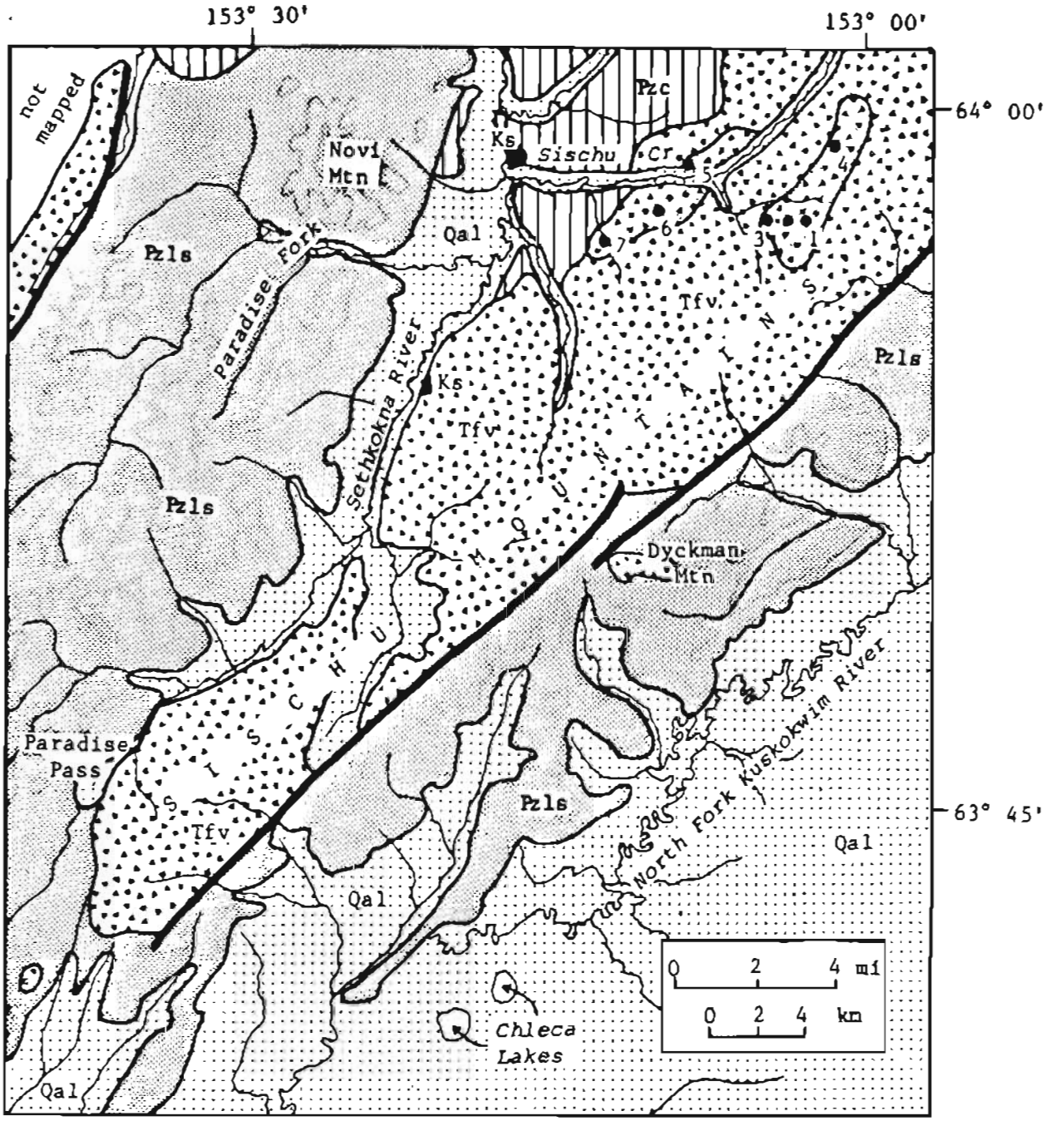
Chemical analysis		CIPW norm	
SiO_2	72.17	Q	26.9
Al_2O_3	14.60	C	.99
Fe_2O_3	1.49	Or	31.4
FeO	.06	Ab	34.4
MgO	.08	An	3.4
CaO	.79	En	.20
Na_2O	4.05	Hm	1.5
K_2O	5.29	Il	.12
TiO_2	.13	Ru	.07
P_2O_5	.03	Ap	.07
MnO	.00	Cc	.14
H_2O^+	.31		
H_2O^-	.47		
CO_2	.06		
Total	99.53		
SiO_2 (H_2O free)	73.12		

Table 3. Delayed neutron analysis of uranium and thorium content in parts per million (ppm) of volcanic rocks from Sischu Creek area

Map No.	Sample No.	U (ppm)	CV[1]	TH (ppm)	CV[1]	Th/U	Lithology
				Area 1			
1	79AMm9A	29.4	1	127	3	4.31	Hematite-stained sanidine porphyry
1	79AMm9B	35.8	1	108	4	3.01	Sanidine porphyry
2	79AMm9C	28.0	1	125	3	4.47	Sanidine porphyry
3	79AMm9D	70.3	1	114	5	1.62	Sanidine porphyry
4	79AMm14	24.1	1	117	3	4.85	Fe-stained sanidine porphyry
				Area 2			
5	79AMm15	16.5	2	70.4	3	4.27	Fe-stained quartz porphyry
6	79AMm13	25.4	1	68.9	4	2.72	Fe-stained quartz porphyry
7	79AMm12A	16.4	2	73.8	3	4.5	Slightly porphyritic fine-grained rhyolite

Analysts: H. T. Millard, Jr., R. B. Vaughn; S. W. Lasater, B. A. Keaton

[1] CV = Coefficient of variation = one standard deviation, based on counting statistics expressed as percent of concentration.



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QUATERNARY
- Qal — Surficial deposits

TERTIARY
- Tfv — Tertiary felsic volcanic rocks. Chiefly rhyolite and dacite domes and flows. (Shaded area within unit indicates uranium-rich rocks.)

CRETACEOUS
- Ks — Cretaceous conglomerate, sandstone and lignite. Contains Campanian-Maestrichtian pollen.

PALEOZOIC
- Pzls — Paleozoic limestone (Ordovician to Devonian).
- Pzc — Lower Paleozoic phyllite and quartzite.

$\bullet_3$ Sample locality referred to in table 3.

Figure 1. Generalized geologic map of the Sischu Creek area, Medfra Quadrangle, Alaska.