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GEOPHYSICAL AND PETROLOGIC STUDIES OF RADIOACTIVE CONTACT ZONES OF PYROXENITE DIKES IN NEPHELINE SYENITE OF THE EKIEK CREEK PLUTON, WESTERN ALASKA

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A ground geophysical, petrographic, and petrophysical study was made of a subsilicic composite pluton, the Ekiek Creek Complex of Miller (1972), in western Alaska to determine the sources of coincident total-count gamma-ray and aeromagnetic anomalies detected in aerial surveys. This pluton is related to a series of subsilicic intrusive stocks in western Alaska and the eastern Siberian peninsula (Miller, 1972), (fig. 1). Airborne radiometric studies of several of the stocks in Alaska indicate uranium mineralization, and ground surveys have shown low-grade uranium concentrations of as much as 92 ppm (Jones, 1976). Owing to the lack of outcrops, the morphology of these stocks must be delineated by geophysical methods.

The project included data collection in the 3x5 km study area, and petrographic and petrophysical analyses of representative samples. Field geophysics involved nine major east-west traverses, as well as a number of shorter crossing traverses, and totaled 35 line km of magnetic, VLF, and four-channel gamma-ray spectrometer measurements. Petrophysical work on the samples included measurements of remanent magnetism and magnetic susceptibility, density, and electrical resistivity. Detailed petrographic studies of representative samples also were made.

The Ekiek Creek pluton is a composite stock of Cretaceous age which intruded Lower Cretaceous silicic stocks and volcanic rocks. It includes two major silica-undersaturated rock types, fine-grained pyroxenite and medium-grained nepheline syenite. Field relationships between the two are anomalous. The pyroxenite occurs as broad tabular bodies in the syenite, but contact zones show veins of syenite through pyroxenite, and syenite along joints in pyroxenite, suggesting that the syenite intruded the pyroxenite. Extensive iron oxide alteration was noted along the contact zones, but no ore minerals were observed.

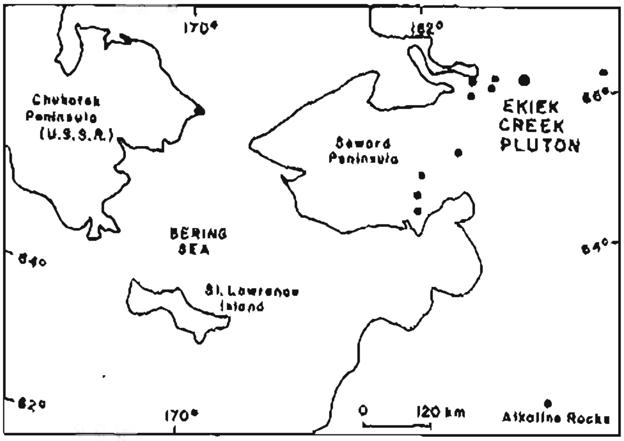

Figure 1

Petrographic studies of the samples collected in the field show a metamorphosed contact zone in addition to unaltered pyroxenite and nepheline syenite. The felsic rocks contain major orthoclase and nepheline, and varietal biotite, aegerine, and sphene. Melanite, a titanium-rich andradite garnet, occurs in variable amounts as deep-brown euhedral crystals of seemingly igneous origin. Zeolites, sericite, and cancrinite are common alteration products. The felsic rocks grade texturally from fine-grained hypidiomorphic-granular rocks to coarse porphyries containing orthoclase phenocrysts. The felsic rocks contain less than 15 percent mafic minerals, not including melanite, and orthoclase is much more common than nepheline.

The pyroxenites are fine to medium grained in thin section, and are composed of predominant aegerine-augite and biotite, and minor orthoclase, nepheline, sphene, and zeolites. Melanite, significantly, is absent. Flow textures are present in a few of the samples.

In contact zones poikiloblastic mafic minerals commonly contain inclusions of fine-grained melanite and orthoclase. The orthoclase and garnet become more common near the syenite, and euhedral garnets along the contact are poikiloblastic with inclusions of aegerine-augite. Microscopic contact relations between the pyroxenite and syenite show the syenite transecting preexisting flow structures in the pyroxenite.

Although many of the contact relations between the two major rock types suggest that the syenite, as the younger rock, intruded the pyroxenite, the tabular pyroxenite in the syenite points to the pyroxenite being the youngest rock. The increasing predominance of garnet and orthoclase in the pyroxenite near the contact indicates an interaction between the two rock types. It does not seem likely that the syenite, with a relatively low solidus temperature, could ionically diffuse through the pyroxenite to produce the garnet and orthoclase. The reverse situation is more probable, with the pyroxenite assimilating the components of the syenite along the contact. The pyroxenite intruded the felsic crystalline mush, with some assimilation, and, owing to its higher solidus temperature, crystallized in the mush. Cooling produced shrinkage cracks into which the felsic mush was drawn, forming what now appear to be dikes of syenite in pyroxenite.

As of this writing, the ground magnetometer, VLF, and gamma-ray data await position-recovery, and, in the case of magnetic data, smoothing before they can be contoured. Samples collected at about 45 rubble-crop exposures yield a generalized geologic map. However, a much more detailed geological map should result when geophysical contour maps become available.

Figure 2 shows ground magnetic, VLF, and gamma-ray profiles collected on an east-west traverse across the

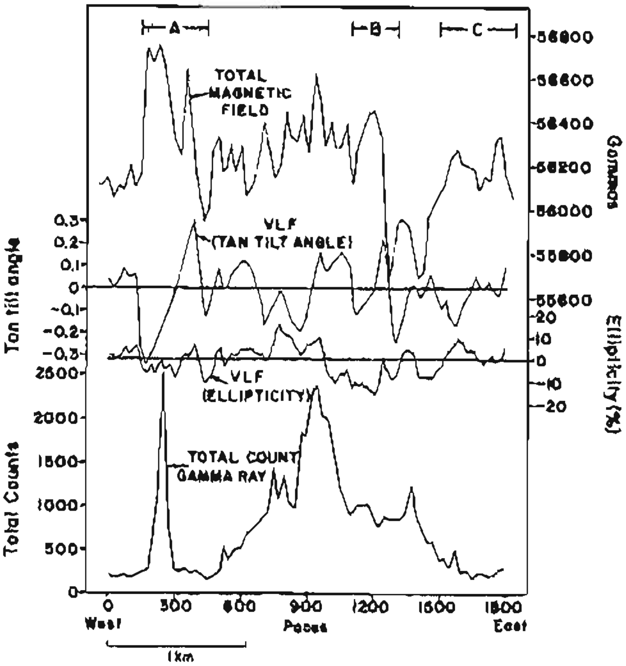

Figure 2

pluton. Magnetic highs labeled A and B coincide with zones of high conductivity, indicated by the "tangent tilt angle" VLF profile.

Magnetic and VLF anomalies A and B coincide with occurrences of pyroxenite. Anomaly B was traced in detail and found to be continuous for 500 m south and 1,600 m north of the east-west traverse. It is believed to mark a north-south-striking tabular body of pyroxenite at least 2,100 m long. Magnetic and VLF anomalies labeled A also occur on several east-west profiles, suggesting the presence of a second north-south tabular body, but the anomalies were not traced with the detail of anomaly B. Anomaly C did not show a clear VLF expression. Its appearance on several profiles suggests a possible third north-south-trending tabular body. Remanent magnetism and susceptibility measurements of samples show that the pyroxenite is more magnetic than the nepheline syenite.

The good correlation between the magnetic and VLF anomalies may occur because the ground is permanently frozen. Under ordinary temperature conditions VLF measurements are dominated by ionic conduction in water filled fractures. In frozen ground, however, ice-filled fractures would be non-conductive, and the VLF technique may be sensitive to changes in lithology.

The gamma-ray spectrometer traverses show zones of highest radioactivity along contacts between pyroxenite and nepheline syenite. Total counts measured over the contacts are 6 to 10 times those of the background over the muskeg, and 1.5 to 2.5 times those measured over the rubble-crops of the pluton as a whole. Iron-oxide staining, perhaps indicating hydrothermal alteration, is prominent along the contact zones. Detailed profiling by gamma-ray spectrometer shows that iron oxide-stained rocks are more radioactive than average, but the highest readings were obtained over a sharp, unoxidized contact of pyroxenite against nepheline syenite.

On a scale of kilometers, aeromagnetic highs of the Ekiek Creek pluton and of other alkalic plutons north of the Selawik Hills correlate with radioactivity anomalies. On a scale of 10 to 100 m, radioactivity anomalies correlate with contact zones between pyroxenite and nepheline syenite. The pyroxenite is distinguished by magnetic and VLF conductivity highs. Thus magnetic and electrical measurements, on either scale, may be tools for locating possible uranium mineralization.

Jones, B. K., 1976, Uranium and thorium in granitic and alkaline rocks in western Alaska: Master's thesis, University of Alaska, 123 p.

Miller, T. P., 1972, Potassium-rich alkaline intrusive rocks of western Alaska: Geol. Soc. America Bull., v. 83, p. 2111-2128.

URANIUM AND THORIUM DISTRIBUTION IN CONTINENTAL TERTIARY ROCKS OF THE COOK INLET BASIN AND SOME ADJACENT AREAS, ALASKA

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The distribution of uranium in potential host rocks may indicate whether the uranium was leached from potential source rocks and concentrated in the host rocks in the Cook Inlet area, including the Susitna lowlands and the lower end of the Matanuska valley. Suitable uranium source rocks in the form of granite and tuff are present in the surrounding area, and a large thickness of continental sedimentary rocks containing carbonaceous material is found in the basin. The important question is whether or not uranium has been leached from the potential source rocks and concentrated in the potential host rocks. One approach to this problem, although not a proven technique, is to determine the present

Table 1.--Sources of samples for uranium and thorium analysis

Stratigraphic unit	Area	Age	Rock description in area of sampling
Sterling Formation.	McNeil Canyon, Ninilchik beach and Southern Kenai Peninsula.	Pliocene-Miocene.	Sandstone, reddish-brown and gray; gray mudstone and shale; and coal. Fluvial sequence.
Beluga Formation.	Homer bluff, Southern Kenai Peninsula.	Miocene.	Sandstone, gray and reddish-brown, fine- to medium-grained, some calcitic cement; gray shale and mudstone, and coal. Fluvial sequence.
Tyonek Formation.	Capps Glacier and Chuitna River, 20-30 km northwest of Tyonek.	Miocene-Oligocene.	Sandstone, light-brown, fine- to coarse-grained, conglomeratic; gray mudstone and coal. Fluvial sequences.
West Foreland Formation.	Beluga River, 17 km north of Tyonek.	Eocene.	Siltstone and shale, gray, hard, micaceous.
Kenai Group undifferentiated.	Near Houston and Petersville.	Pliocene-Oligocene.	Sandstone, brownish-gray, fine-grained, hard and soft; and shale, gray, hard, micaceous.
Chickaloon Formation.	Premier coal mine, Glenn Highway, and Chickaloon River.	Paleocene.	Sandstone and conglomerate, gray and light-brown, soft and hard, arkosic: shale and mudstone, gray and brown; and coal.

distribution of uranium in the potential host rock to see if it has been mobilized by dissolution, transported, and redeposited. An advantage of this approach is that it provides background data that will aid in the recognition of areas affected by uranium mineralization.

A total of 57 samples of potential host rock were collected from various localities in the Cook Inlet area (table 1). Thorium and uranium were determined in these samples by the delayed-neutron method in the analytical laboratories of the U.S. Geological Survey at Lakewood, Colo. One measure of the precision of the data is the coefficient of variation for the counting statistics, which averaged 19 percent for thorium determinations and 4.5 percent for uranium determinations.

The Cook Inlet basin is a structural fault-bounded basin in southern Alaska between the Alaska Range to the west and the Chugach Mountains and Kenai Mountains to the east. It is about 300 km long and 100 km wide. More than half of the area is submerged in Cook Inlet, which opens into the Gulf of Alaska to the southeast and the Shelikof Strait to the southwest. The Cook Inlet basin contains about 7,925 m of continental sedimentary rocks that compose the Tertiary Kenai Group and West Foreland Formation. Calderwood and Fackler (1972) have divided the Kenai Group, in ascending order, into the West Foreland Formation, Hemlock Conglomerate, Tyonek, Beluga, and Sterling Formations (table 1). Later Magoon, Adkison, and Egbert (1976) removed the West Foreland from the Kenai; and their usage will be followed in this report. The Susitna lowlands, which are separated from the Cook Inlet basin by the Castle Mountain fault, may be a northern extension of the basin.

The Matanuska valley is a fault-bounded basin between the Talkeetna Mountains to the north and the Chugach Mountains to the south. The valley, which connects to the Cook Inlet basin along its northeast margin, contains about 2,135 m of Tertiary continental sedimentary rocks. These rocks are divided into three formations, in ascending order, the Chickaloon, Wishbone, and Tsadaka (table 1; Magoon and others, 1976).

The thorium and uranium contents found in continental sedimentary rocks in the Cook Inlet area are remarkably uniform (table 2). The uranium content averaged about 2.4 ppm and the range was from about 0.5 to 4.3 ppm. The thorium:uranium ratio averaged about 2.3, low compared to the general terrestrial ratio of 3-4, and low compared to many oxidized nonmarine sedimentary rocks that characteristically have ratios of more than 7 (Adams and Weaver, 1958). Shale, siltstone, and mudstone samples contain about 1 ppm more uranium than sandstone samples. This difference may have resulted from slightly more leaching of uranium from porous sandstone or adsorption by the clay, but it could also have resulted from depositional segregation of heavy uranium-bearing minerals into placer deposits. Reddish-brown sandstone, which presumably was subjected to oxidation, has nearly the same uranium content as gray sandstone, indicating that the oxidation was insufficient to leach uranium from the sandstone.

Table 2.--Distribution of uranium and thorium in continental Tertiary rocks of the Cook Inlet basin, Susitna basin, and the southern part of the Matanuska Valley as shown by average values and ratios.

[Numbers in parentheses are number of samples averaged.]

	Thorium (ppm)	Uranium (ppm)	Uranium: thorium ratio
All samples	5.59 (57)	2.38 (66)	2.30 (57)
Sterling Formation	5.27 (15)	2.13 (21)	2.19 (15)
Beluga Formation	5.22 (20)	2.24 (22)	2.38 (20)
Tyonek Formation	6.14 (2)	4.00 (2)	1.51 (2)
West Foreland Formation	8.95 (2)	2.97 (2)	3.01 (2)
Kenai Group undifferentiated	4.69 (4)	1.97 (4)	2.37 (4)
Chickaloon Formation	6.68 (7)	2.85 (7)	2.22 (7)
Reddish-brown sandstone	4.16 (17)	2.01 (17)	2.12 (17)
Gray sandstone	4.34 (18)	1.99 (18)	2.18 (18)
Mudstone, siltstone, and shale	6.84 (21)	2.88 (21)	2.42 (21)

The low uniform uranium content and the low thorium:uranium ratio found in Tertiary sedimentary rocks of the Cook Inlet area may indicate that geochemical conditions have not been favorable for the formation of epigenetic uranium deposits in these rocks, but it is important to note that the samples collected and analyzed for this report may not adequately represent the large amount of potential host rocks. Not known yet, for instance, are the geochemical conditions that existed in the subsurface, especially around petroleum accumulations. Hayes, Harms, and Wilson (1976) reported rocks in the Sterling Formation that contain montmorillonite and some from which volcanic glass has been dissolved. None of these samples were evaluated in this report.

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