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Epigenetic mineralization and areas favorable for uranium exploration in Tertiary continental sedimentary rock in south-central Alaska: A preliminary report

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One of the most important questions about the potential for epigenetic uranium deposits in the Tertiary sedimentary rocks of Alaska is whether or not geochemical conditions conducive to the epigenetic processes could have existed in the warm to cool-temperate moist climatic conditions that apparently were present during much of the Tertiary in south-central Alaska. Evidence bearing on this problem is meager, but uranium analyses of samples taken in this study suggest that low-level enrichment by uranium-bearing ground water has occurred.

Another important question is whether or not valid ranking of areas for uranium potential on the basis of average uranium content of host rocks can be made. This report offers no answer to this question, but consistent differences in uranium background in host rocks of different areas suggests that such a procedure is feasible.

Geological summary

Two of the areas investigated, the Kenai Peninsula and the northwest Cook Inlet area, are in the Cook Inlet basin and a third area, the Susitna Lowlands, is separated from the north end of the Cook Inlet basin by the Castle Mountain fault system. The Matanuska Valley extends northeastward from the northeast side of the Cook Inlet basin, and the Copper River basin extends eastward from the northeast end of the Matanuska Valley (fig. 1). The stratigraphic units studied and areas sampled are summarized in table 1.

The Cook Inlet basin is a structural fault-bounded basin in southern Alaska between the Alaska Range to the west and the Chugach 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. Cook Inlet basin contains a thickness of about 7,900 m of continental sedimentary rocks that compose the Tertiary Kenai Group and the West Foreland Formation. Calderwood and Fackler (1972) divided the Kenai Group, in ascending order, into the West Foreland Formation, Hemlock Conglomerate, Tyonek, Beluga, and Sterling Formations. Later Magoon, Adkison, and Egbert (1976) removed the West Foreland from the Kenai. The Sterling and Beluga Formations were sampled on the Kenai Peninsula, and the West Foreland, Tyonek, and Beluga Formations were sampled in the northwest Cook Inlet area for this report. Granitic rocks of the Alaska Range northwest of Cook

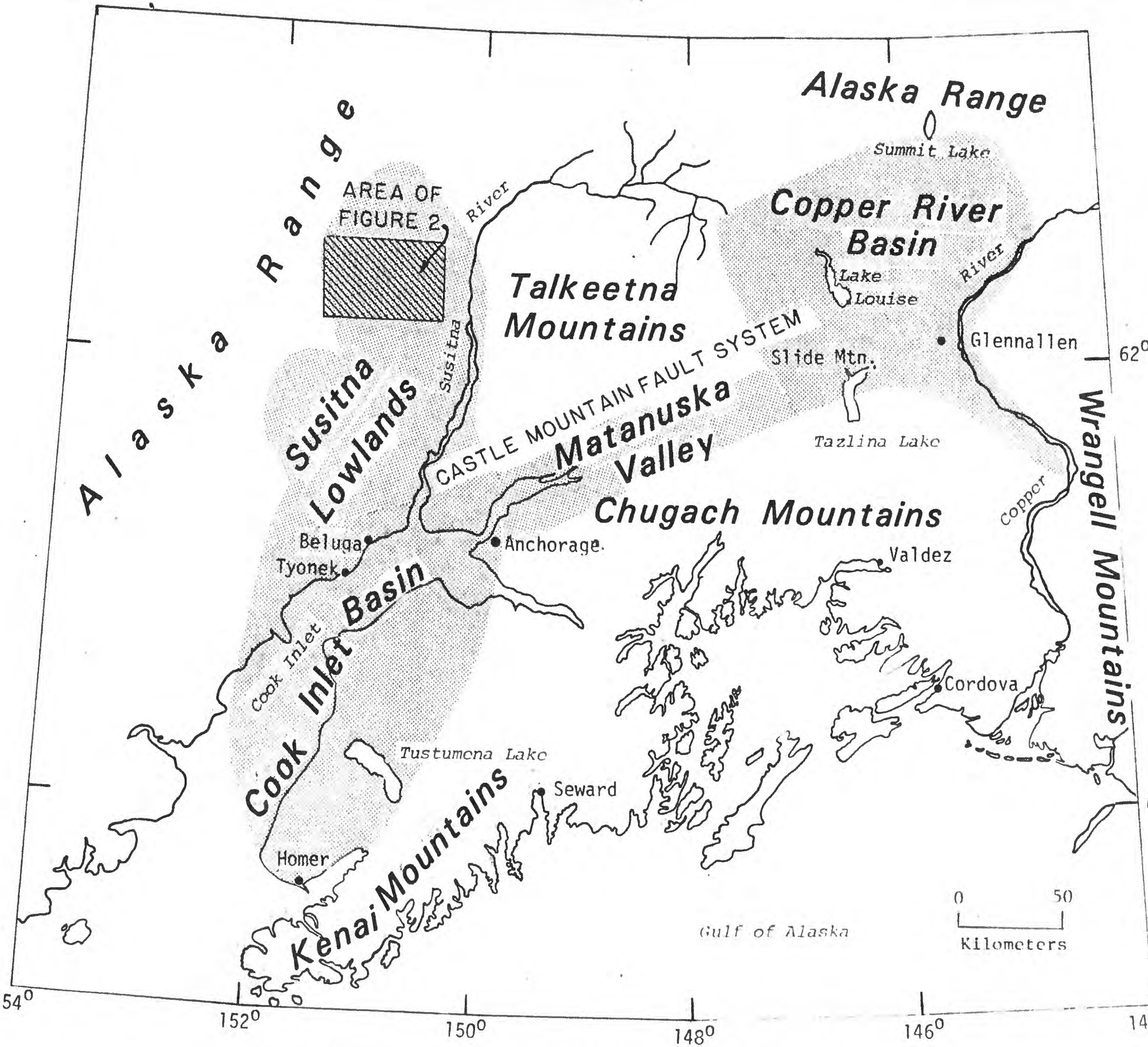


Figure 1.--Tertiary depositional basins (stippled areas) of south-central Alaska. Diagonally-ruled area is that of fig. 2.

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

Area	Stratigraphic units	Age	Rock description	Depositional environment
Susitna Lowlands Peters Hills Fairview Mountain	Kenai Group	Late Oligocene, Miocene and Pliocene	Conglomerate and sandstone, light-brown and gray; mudstone, gray, carbonaceous; and coal.	Alluvial fan; mud flow and fluvial: proximal and distal-braided channels and flood plain.
Northwest Cook Inlet Chuitna and Beluga Rivers Coal Creek	West Foreland, Beluga, and Tyonek Formations	Eocene to Pliocene	Conglomerate and sandstone, light-brown and gray; mudstone, gray, carbonaceous; and thick seams of coal.	Alluvial fan; mud flow and fluvial: proximal and distal-braided channels and flood plain.
Matanuska Valley Premier Coal Mine Blenn Highway Chickaloon River	Chickaloon Formation	Paleocene	Conglomerate and sandstone, light-brown and gray, hard; shale and mudstone, gray and brown; and coal.	Fluvial: channel and flood plain.
Kenai Peninsula Homer Bluff McNeil Creek Ninilchik Beach	Sterling and Beluga Formations	Miocene to Pliocene	Sandstone, reddish-brown gray; mudstone and shale, gray; and coal.	Fluvial: distal-braided and meandering channels and flood plain.
Copper River Basin Slide Mountain McCallum Creek	Lower Tertiary rocks, undifferentiated, and Gakona Formation	Eocene(?)	Conglomerate and sandstone, gray and light-brown; mudstone, gray, carbonaceous; and small amounts of coal.	Alluvial fan: mudflow and fluvial, channel and flood plain.

Inlet and volcanic rock along the northwest margin of the basin might have served as uranium source rocks. The largely metamorphic rocks of the Kenai and Chugach Mountains are a less likely source for uranium.

The Susitna Lowlands is a depositional basin 130 by 100 km on the upthrown side of the Castle Mountain fault system. The sedimentary units from the Cook Inlet basin extend northward into the Susitna Lowlands where they are much thinner, perhaps no more than 600 m thick. The Kenai Group is undifferentiated in this area. The Fairview Mountain and Peters Hills areas were sampled for this report. Granitic rocks in the Alaska Range to the west and the Talkeetna Mountains to the east could provide a source for uranium for the Susitna Lowlands.

The Copper River basin is an inland depositional basin surrounded on nearly all sides by mountain ranges: the Alaska Range to the north, the Talkeetna Mountains to the west, the Chugach Mountains to the south, and the Wrangell Mountains to the east. The basin contains a thickness of more than 2,500 m of sedimentary rock, but most of it is older than Tertiary (Eakins, 1975). For this study, samples were collected at two widely separated areas. One area, near Slide Mountain on the west side of the basin, contains lower Tertiary rock; and the other area, near Summit Lake north of the basin as outlined by Eakins (1975), contains the middle or late Oligocene Gakona Formation (Andreasen and others, 1964; Mendenhall, 1905). Most of the basin is covered with glacial sediment and exposures are scarce.

All the rocks sampled for this report are of continental origin. They consist almost entirely of conglomerate, sandstone, mudstone, and coal. The conglomerate units generally have a sandy, silty, and clayey matrix and were largely deposited near their source in mudflows and proximal braided-stream systems on alluvial fans. The sandstone, mudstone, and coal were commonly deposited in fining-upward sequences that represent distal-braided and meandering-stream systems on flood plains. The sandstone and conglomerate units were deposited in channels, and the mudstone and coal units in interchannel lacustrine and paludal areas.

The conglomerate and sandstone units consist predominantly of quartz, plagioclase, and smaller amounts of orthoclase; they are arkosic. The mudstone and claystone units contain large amounts of the clay minerals illite and chlorite. Siderite and other carbonate concretions are common in most of the units. Much of the sandstone and conglomerate is oxidized at the surface, judging from the oxidation state of iron minerals present. Mineralogic and petrologic studies are not yet complete.

The distribution of uranium and thorium is summarized in table 2. In all of the areas sampled, both uranium and thorium are more abundant in the finer-grained rock, mudstone, siltstone, and claystone than in the coarser-grained rock, sandstone, and conglomerate. The coarser rock averaged 2.1 ppm uranium and the finer sediments averaged 3.4 ppm uranium. The amount of thorium is also greater in the fine-grained rock, where it averages 5.8 ppm. The coarse-grained rocks average 3.8 ppm thorium. The

Table 2.--Average uranium and thorium contents of upper Tertiary continental sedimentary rocks in south-central Alaska.

Area	Number of samples	Thorium (ppm)	Uranium (ppm)	Th/U (ppm)
Sandstone and conglomerate				
Susitna Lowlands	11	4.29	2.48	1.93
Northwest Cook Inlet	18	3.54	2.37	1.50
Matanuska Valley	9	5.05	2.44	2.05
Kenai Peninsula	23	3.97	1.84	2.18
Cooper River basin	7	2.41	1.23	1.90
Claystone, siltstone, and mudstone				
Susitna Lowlands	18	7.22	5.12	1.6
Northwest Cook Inlet	22	6.10	3.56	1.69
Matanuska Valley	4	8.58	3.21	2.63
Kenai Peninsula	19	5.81	2.77	2.21
Copper River basin	15	2.98	1.84	1.61
All sedimentary rocks				
Susitna Lowlands	29	6.11	4.11	17.2
Northwest Cook Inlet	40	4.95	3.03	1.61
Matanuska Valley	13	6.13	2.68	2.23
Kenai Peninsula	42	4.80	2.23	2.19
Copper River basin	22	2.80	1.65	1.70

thorium-to-uranium ratio is very nearly the same for both groups of rock: 1.9 for the coarse group and 1.8 for the fine group. Samples from the Susitna Lowlands have the highest uranium values for both the fine- and coarse-grained sediments. Northwest Cook Inlet is second highest for fine-grained rocks, and Matanuska Valley is second highest for coarse-grained rocks. Copper River basin is lowest in both categories and Kenai Peninsula is second from lowest in both categories.

Epigenetic mineralization

For the first time, evidence has been produced to show that epigenetic uranium mineralization has occurred in the Tertiary sedimentary rocks in Alaska. Two mudstone samples, both related to an oxidized facies in fluvial sedimentary rocks in the Susitna Lowlands, contained an average of 12 ppm uranium (figs. 2 and 3). Although this amount is far from economically recoverable, it is more than four times the average for south-central Alaska. Both samples were related to oxidized facies, as indicated by the oxidation state of iron, in outcrops along stream banks in the continentally deposited sedimentary rock. Sample S-1 (fig. 2) was collected from a very carbonaceous thin mudstone layer in a thick sequence of brown conglomerate. It contained 11 ppm uranium. The other sample, S-2 (fig. 2), which contained 13 ppm uranium, was collected from a thick sandstone bed along Peters Creek. This sample consisted mostly of siderite and came from a reddish-brown rind that separated an area of gray reduced sandstone from the enclosing light-brown oxidized sandstone. The sample suggests

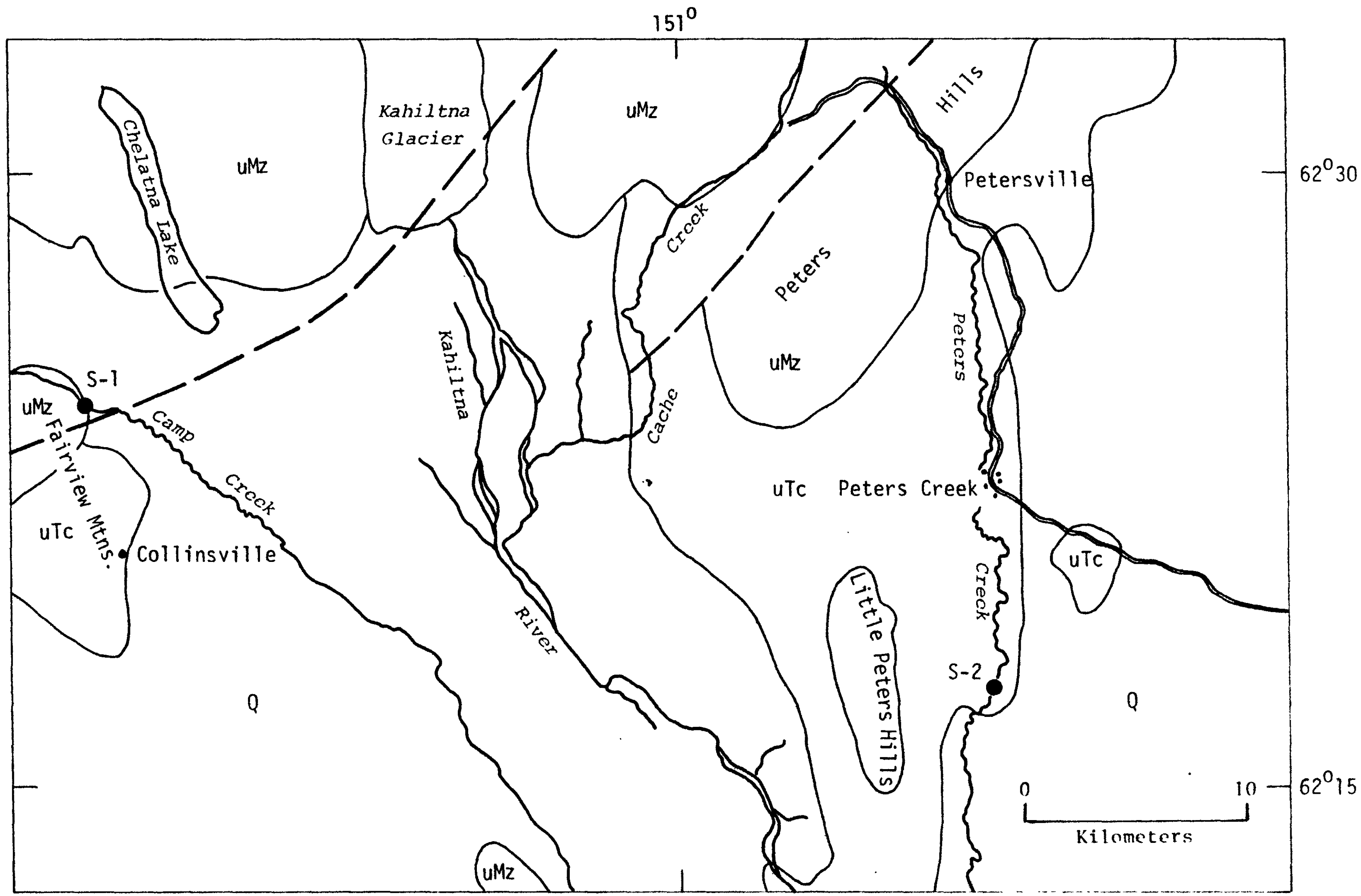
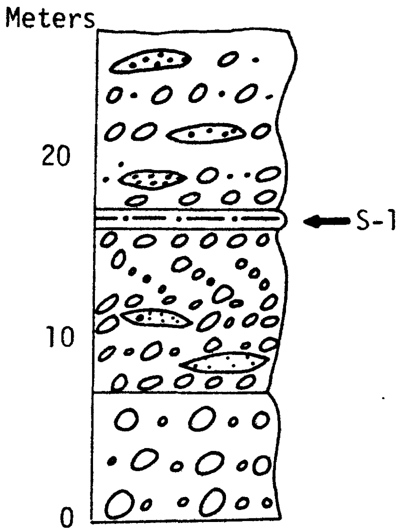


Figure 2. Geology of part of sample area: uTc, upper Tertiary continental deposits; uMz, Jurassic and Cretaceous metamorphic rock; and Q, Quaternary deposits. Geology is from Beikman (1974). Sample locations S-1 and S-2 are shown by round symbol.



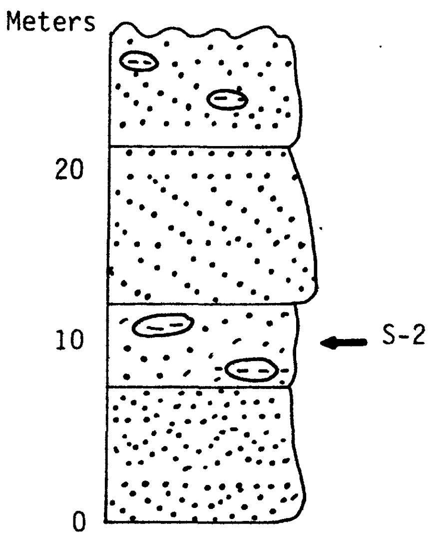
Conglomerate, light-green to gray pebbles; size ranges from 1 to 10 cm; horizontal beds 1-2 m thick, containing 5- to 10-cm-thick sandstone lenses.

Claystone and coal, dark-gray with brown streaks to yellowish-orange at top; contains 11 ppm uranium.

Conglomerate, light-gray, interbedded with 2- to 10-cm-thick sandstone lenses; reddish-brown sandstone matrix; low-angle foreset beds and abundant dark-gray pebbles.

Conglomerate, light-grayish-brown streaked with dark-reddish-brown; no bedding visible.

Section S-1 Along Camp Creek northwest of Fairview Mountain (fig. 2).



Sandstone, light-brown, soft, fine-grained, well-sorted, crossbedded; sets as much as 1 m thick; contorted bedding; contains clay clasts.

Sandstone, light-brown, soft; crossbed sets as much as 1 m thick; irregularly horizontal beds between crossbeds.

Sandstone, light-grayish-brown, fine-grained; massive bedding; contains clay clasts and siderite rind around dark-gray sandstone area about 2 m wide; siderite contains 13 ppm uranium.

Sandstone, light-gray to reddish-brown, partly oxidized, fine-grained, well-sorted; trough crossbeds and contorted beds; contains partly ripped up clay bed.

Section S-2 Along Peters Creek east of Little Peters Hills (fig. 2).

Figure 3.-- Sections of Kenai Group undifferentiated in the Susitna Lowlands showing sample positions.

that uranium was precipitated from oxidizing ground water where it came in contact with the reducing environment. Siderite probably was deposited from the same water, which brought carbonate ions from the oxidizing environment into contact with ferrous iron from the reducing environment. These observations should be confirmed by more examples.

Leaching of uranium from potential host rocks does not seem to be taking place in the present cool moist climate of southern Alaska. Analyses of weathered granite near Big Delta and of soil profile near Homer give no evidence of uranium leaching (Dickinson, unpublished data, 1978). Furthermore, no epigenetic uranium deposits are known anywhere north of 50 degrees north latitude.

The answer to the question of whether or not uranium has been leached and epigenetically enriched in the Tertiary sedimentary rocks sufficiently for economic recovery in Alaska has not been answered. The solution of this problem must await more information.

Favorability for uranium exploration

The five areas discussed in this report (table 1) are ranked according to favorability for uranium exploration as follows: first, Susitna Lowlands; second, northwest Cook Inlet; third, Matanuska Valley; fourth, Kenai Peninsula; and fifth, Copper River basin. The Susitna Lowlands are ranked most favorable because they have the highest average uranium content and because low-level secondary enrichment has occurred there. Northwest Cook

Inlet is second and Matanuska Valley is third on the basis of average uranium content. The Kenai Peninsula is fourth because of its low average uranium content and because most of the sediments in this area were derived from the east from the Kenai Mountains, which lack large areas of granitic or volcanic rock that might have provided a source for uranium. Copper River basin is ranked least favorable because it has the lowest uranium content. This assessment of the Copper River basin agrees with that of Forbes, Carden, and Zdepski (1977), who deleted the Copper River basin from possible uranium provinces on the basis of their field and laboratory analyses of low-level airborne radiometric anomalies.

Methods

Sections were measured, described, and sampled where exposures were sufficiently thick and well exposed. About 1700 m were described and measured in the northwest Cook Inlet area, 1600 m in the Susitna Lowlands, 1050 m on the Kenai Peninsula and 950 in the Copper River basin. About one sample was collected for every 40 m measured; no sections were measured in the Matanuska Valley, but 22 samples were taken there. Uranium and thorium were determined in the laboratories of the U.S. Geological Survey in Denver, Colorado using the neutron-activation technique.

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