PRELIMINARY INVESTIGATION OF ACID LEACHABLE TIN MINERALIZATION, WESTERN SEWARD PENINSULA, ALASKA

by Thomas C. Mowatt and Uldis Jansons, Alaska Field Operations Center, Juneau and Anchorage, Alaska

* Open File Report 32-85

UNITED STATES DEPARTMENT OF THE INTERIOR

Donald P. Hodel, Secretary

BUREAU OF MINES

Robert C. Horton

CONTENTS

ILLUSTRATIONS

TABLES

PRELIMINARY INVESTIGATION OF ACID LEACHABLE TIN MINERALIZATION, WESTERN SEWARD PENINSULA, ALASKA

By Thomas C. Mowatt[1] and Uldis Jansons[2]

ABSTRACT

Chemical and petrographic studies were carried out on selected tin-bearing rock samples of contact-metasomatic origin from the Cassiterite Creek and Brooks Mountain areas, Seward Peninsula, Alaska. The tin content of rocks ranged from 0.39 to 8.9 pct. Leaching with a 20 pct hydrochloric acid solution released from 19.3 to 67.9 pct of the tin. Cassiterite was not observed in the rock samples. These results are significant with regard to tin recovery and reserve delineation in these and similar occurrences. Part of this leachable tin may be associated with metasomatic borate minerals.

INTRODUCTION

In recent years increased attention has been given to the geological processes of contact-metamorphism and contact-metasomatism, in the context of the genesis, localization, and exploration for mineral deposits. Much of this stems from contributions by investigators in the U.S.S.R. (1, 2, 5, 6, 7, 10)[3]. This work has dealt with fundamental considerations of mineralogy, geochemistry, and petrology, as well as mineral resource delineation and utilization. Extensive and detailed field and laboratory study, combined with increased appreciation of theoretical aspects of geochemical relationships, have resulted in insights regarding contact metamorphic-metasomatic processes and resultant mineral assemblages ("skarns")(3).

[1] Supervisory Geologist, Alaska Field Operations Center, Juneau, Alaska.
[2] Supervisory Physical Scientist, Alaska Field Operations Center, Anchorage, Alaska.
[3] Underlined numbers in parentheses refer to items in the list of references at the end of this report.

The intrusive juxtaposition of leucocratic granitic rocks with dolomitic host rocks can be associated with development of contact-metasomatic rocks featuring significant concentrations of a suite of chemical elements including tin, boron, fluorine, beryllium, and iron, often with appreciable amounts of tungsten, and possibly some lead and zinc. The geochemical behavior of tin is apparently quite complex under these geologic (igneous/contact-metasomatic) conditions. The complexities involve distribution and redistribution of tin and other elements throughout the course of changing physico-chemical conditions. Textural and mineralogic complexities frequently make characterization of these associations difficult.

Of particular interest in the Alaskan localities are occurrences of various tin-bearing borate minerals and their alteration products. Frequently overlooked and/or misidentified in the field and laboratory, these minerals might well represent potential "unconventional" ores of tin. Some of these phases are somewhat soluble under moderate physico-chemical conditions and could represent an explanation of at least a portion of the enigmatic "missing tin", i.e. the difference in mass-balance values between bulk samples and processed concentrates, which has been a historic part of the tin mining activities in the Lost River area on the Seward Peninsula. A portion of the "bulk tin" values may be carried by these minerals, and may be lost in solution during ore processing.

Previous work on samples from the Seward Peninsula (5) has indicated the presence of several species of these tin-bearing minerals in the localities sampled, including appreciable amounts of nordenskioldine ($CaSn(BO_3)_2$), as well as hulsite-pageite (Mg-Fe borates) varieties containing up to 15 pct SnO_2. Thus, there is ample reason to evaluate the presence of and feasibility of recovering such potentially "readily-extractable" tin from these deposits.

ACKNOWLEDGMENTS

Field work and sampling was carried out in 1973 and 1979 jointly with S.M. Aleksandrov, Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow, U.S.S.R.

Some of the preliminary chemical analyses were performed in 1982 at the Bureau of Mines Reno Research Center (RRC), Reno, Nevada.

PRESENT INVESTIGATION

Tin-bearing minerals occur at several localities (Cassiterite Creek, Brooks Mountain, Tin Creek, Ear Mountain, Cape Mountain, Potato Mountain, and Black Mountain, figs. 1 and 2) in the western Seward Peninsula, Alaska. These field occurrences were sampled carefully, thoroughly, and in quantity. Sainsbury (8, 9) discussed the tin deposits of the western Seward Peninsula, including lode and placer occurrences, as well as geologic relationships. According to Sainsbury, the region is the only one in the United States in which deposits of economic grade and size exist. The Lost River Mine represents "by far the largest lode reserve of tin of comparable grade known in the United States. Continued exploration of deposits in the area, and exploration of deposits yet to be found ...may be expected to enhance the national importance of the tin area" (9). It should be noted that the Cassiterite Creek sampling area represents surface exposures of rhythmically-banded skarns located in carbonate rocks, in the vicinity of the subsurface Lost River Mine.

Petrographic, mineralogic, and geochemical studies led to the recognition and delineation of similarities and differences among these localities and analogous mineralization occurrences elsewhere worldwide.

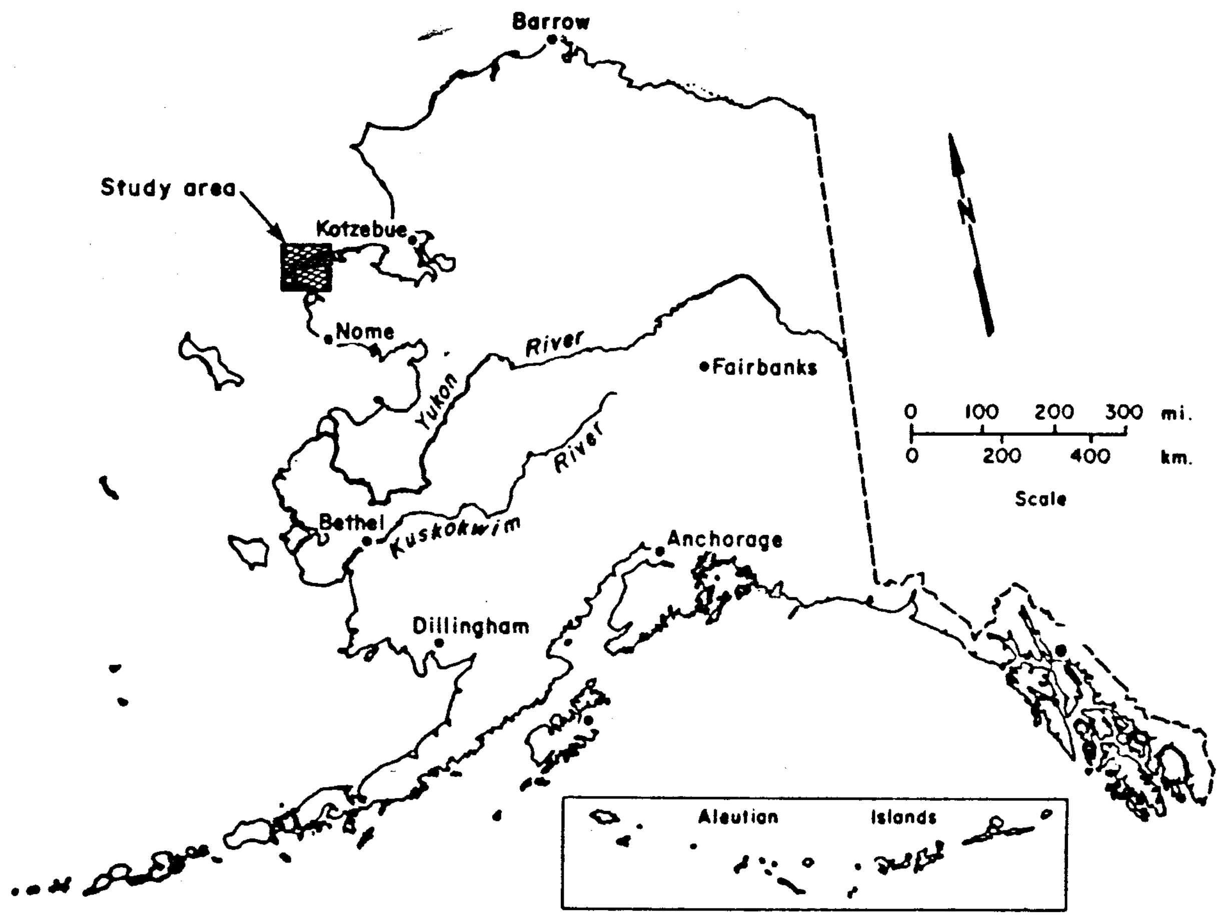

Figure 1: Location of study area, Seward Peninsula, Alaska

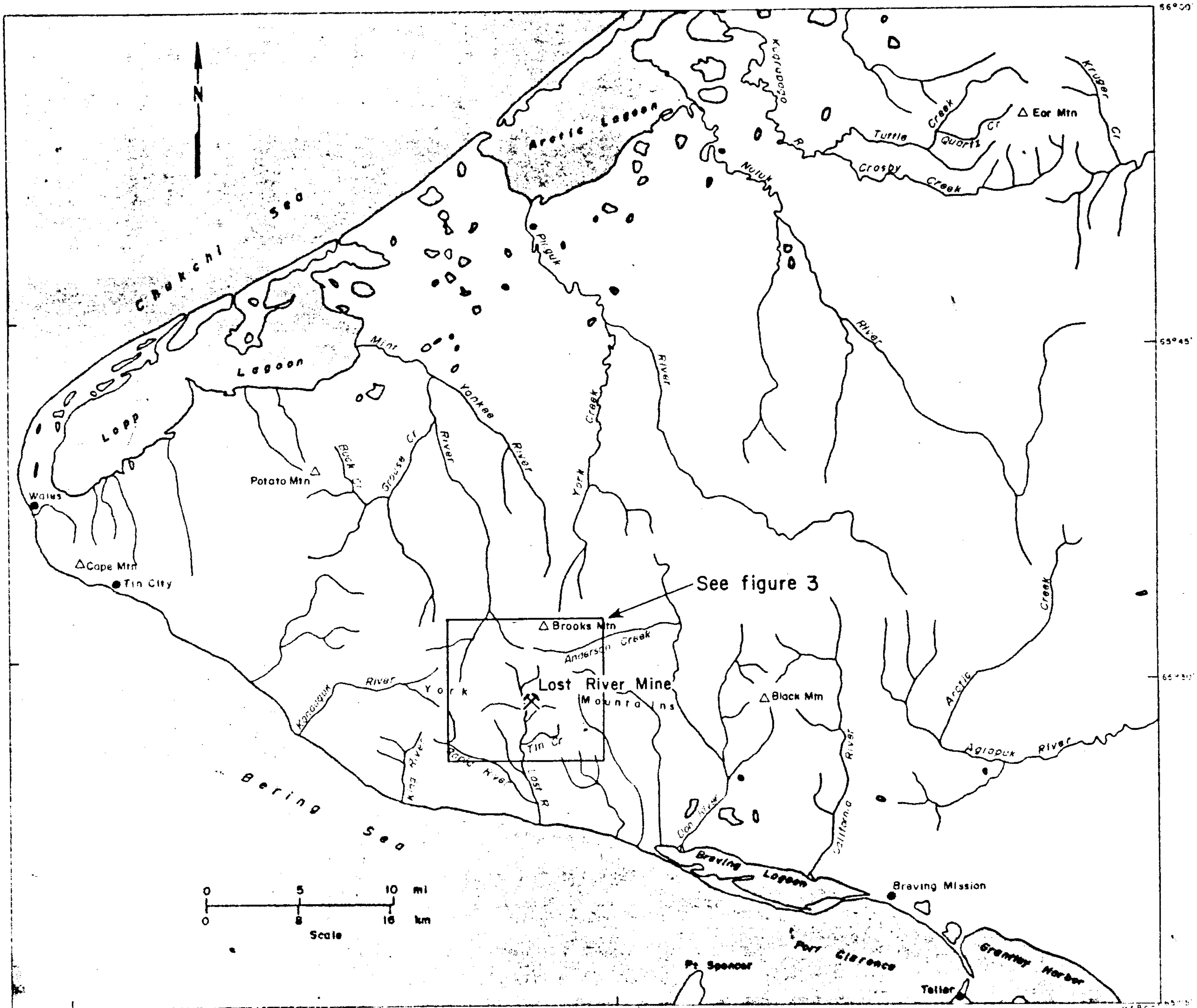

Figure 2: Map of the Seward Peninsula, Alaska, showing areas of sampling

SAMPLE SELECTION

On the basis of information from these studies, in order to investigate one deposit of each "tectonic type" as characterized by Aleksandrov (4, 5), samples from the Cassiterite Creek (fig. 3) and Brooks Mountain (fig. 3) areas were considered in the present work.

The Cassiterite Creek samples are representative of Aleksandrov's "long-lived crush (breccia) zone" type, while the Brooks Mountain samples are representative of the "monolithic skarn" type. These two types are distinctively different from one another texturally, mineralogically, and geochemically, due to dissimilarities in their petrogenesis and geochemical environments.

Fifteen samples from the Cassiterite Creek area were selected and analyzed in 1982. Ten contained tin concentrations of 1600 to 5100 ppm in the bulk rock materials (RRC analytical report, April 18, 1983). These are high tin values in rocks which apparently are essentially devoid of cassiterite.

Thirty-four additional specimens subsequently were chosen for examination in thin-section with a petrographic microscope. From this group of samples, ten were selected for petrographic and chemical analysis, as well as limited quantitative extraction study.

This work was carried out to determine the manner of occurrence of tin in six specimens from the Cassiterite Creek area (TM 83-10-26-1, 3, 22, 29; TM 73-45B, 48) and four specimens from the Brooks Mountain area (TM 73-98, 103, 126B, 128).

SAMPLE PREPARATION AND ANALYSIS

Samples were prepared for petrographic and chemical analysis as follows:

1. A piece was broken off, and a custom petrographic thin-section was prepared in a commercial laboratory. Thin-sections were examined in transmitted light with a petrographic microscope.

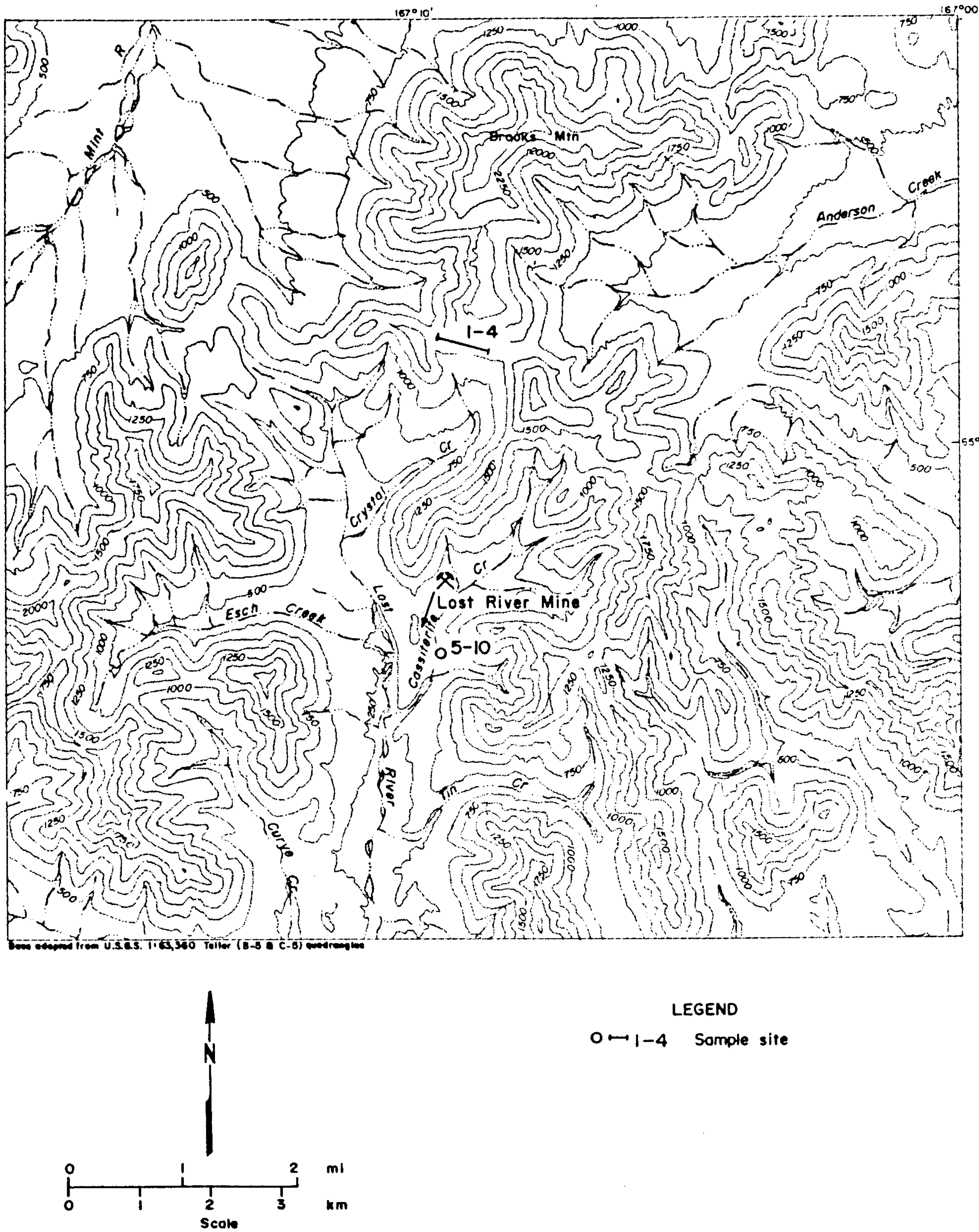

Figure 3: Brooks Mountain and Cassiterite Creek sampling sites, Seward Peninsula, Alaska

2. A second piece was retained as a reserve specimen, when feasible.

3. The remainder of the specimen was crushed and pulverized to a minus 100 mesh pulp, in stainless steel equipment.

4. The pulp was homogenized by repeated splitting and recombining.

5. A portion of this pulp was analyzed for tin in a commercial laboratory using atomic absorption spectrometry.

6. An aliquot, weighed portion of the pulp was stirred into a known volume of 20 pct hydrochloric acid (HCl) solution at ambient laboratory temperature, left for twenty-four hours, restirred, the remnant solid material separated from the supernatant solution by centrifugation and decantation. The extracted solution was analyzed for tin by a commercial laboratory, using atomic absorption spectrometry.

ANALYTICAL RESULTS

Petrographic analyses yielded less than definitive characterizations of mineral phases present in the samples examined in the present study due to limitations imposed by the very fine grain size of some of the minerals, and the intimate intergrowth of the minerals, as well as the lack of sufficiently characteristic optical properties to permit clear-cut definition among certain minerals, particularly the borates. Thus, some of the mineralogic identifications reported are tentative, and are so indicated, (?), in table 1. Tin-bearing borate minerals have been reported from the Cassiterite Creek (eg. nordenskioldine) and Brooks Mountain (eg. hulsite/pageite, nordenskioldine) localities by Aleksandrov (4, 5) on the basis of detailed studies.

While the presence and nature of metasomatic tin-bearing minerals remain to be defined, the concentrations and mode(s) of occurrence of tin can be addressed in a preliminary fashion by means of chemical analyses. Leachability tests for tin were carried out using a 20 pct HCl solution. The results of this work are presented in table 2.

The tin content of the bulk rock samples ranged from 0.39 to 0.63 pct at Cassiterite Creek and from 3.0 to 8.9 pct from Brooks Mountain.

The amount of tin extracted from the samples ranged from 19.3 to 67.9 pct which indicates a component of tin which is "readily-extractable" under the experimental conditions of the present study.

Table 1. - Petrographic descriptions of tin-bearing samples from Cassiterite Creek and Brooks Mountain, Seward Peninsula, Alaska--Continued

Sample Number	Description
	Brooks Mountain Samples (Localities 1-4, fig.3)
TM 73-98	Massive skarn-greisen. Mineral assemblage features quartz, tourmaline, nordenskioldine (?), trace cassiterite.
TM 73-103	Massive skarn assemblage, featuring ludwigite-vonsenite (?) hulsite-pageite (?), garnet, magnetite (?), clinopyroxene, minor nordenskioldine (?).
TM 73-126B	Similar to TM 73-103, above, with minor idocrase (?), phlogopite-biotite (with chlorite), dolomite (?).
TM 73-128	Similar to TM 73-98, above.

Table 2. - Tin leachability of Cassiterite Creek and Brooks Mountain samples, Seward Peninsula, Alaska

Sample	Original solid (g. Sn/10 g. spl)	HCl (20 pct solution) (extract g. Sn)	Sn extracted (pct)
Cassiterite Creek Samples (Localities 5-10, fig. 3)			
TM 83-10-26- 1..	0.039	0.018	46.2
- 3..	0.046	0.021	45.7
-22..	0.028	0.019	67.9
-29..	0.063	0.013	20.6
TM 73-45B.......	0.057	0.011	19.3
-48	0.060	0.019	31.7
Brooks Mountain Samples (Localities 1-4, fig. 3)			
TM 73- 98.......	0.893	0.547	61.3
103	0.301	0.082	27.2
126B	0.632	0.159	25.2
128	0.705	0.403	57.2

CONCLUSIONS

Acid extractable tin is present in selected samples from the Cassiterite Creek and Brooks Mountain areas of the Seward Peninsula, Alaska. The manner in which this tin occurs in these samples is problematic, but the indicated presence of various borate minerals, including ludwigite-vonsenite, hulsite-pageite, and possibly nordenskioldine could well explain the "extractable" tin. These minerals are known to contain appreciable proportions of tin within their crystal structures.

Also, it is possible that some or all of this "readily-extractable" tin might be present in other modes of occurrence, such as hydrous-hydrated minerals (e.g. schoenfleissite, $MgSn(OH)_6$), various iron-bearing minerals in which Sn^{+4} may be isomorphous with Fe^{+3}, and/or as any extremely fine-grained tin-bearing mineral(s) resulting from comminution/pulverizing due to tectonic shearing stress.

The choice of 20 pct HCl as the leaching agent represented a compromise first test, and additional studies are needed. Such studies should include a series of sequential leaching experiments and be monitored carefully in terms of analyses of solids and leach solutions for a spectrum of relevant elements, as well as by means of x-ray diffraction analyses of solid materials before and after each experimental step.

REFERENCES

1. Aleksandrov, S.M., V.L. Barsukov, and V.V. Scherbina. Geochimiya endogennogo bora (Geochemistry of Endogene Boron). "Nauka", Moscow, 1968.

2. Aleksandrov, S.M., and N.N. Pertsev. Korrelyatsiya sostavov magnezial'no-zhelezistykh boratov i assotisiiruyushchikh s nimi mineralov v magnezial'nukh skarnakn (Correlation Between Ferromagnesian Borates and the Minerals Associated with them in Magnesian Skarns). Geokhimiya, No. 11, 1968.

3. Aleksandrov, S.M., 1973-1984, Personal communications.

4. Aleksandrov, S.M. Geokhimicheskiye osobennosti obrazovaniya boroolovyannoy mineralizatisii v magnezial'skarnakh Vostochnoy Chukotki (The Geochemistry of Formation of Boron-Tin Mineralization in the Magnesian Skarns of Eastern Chukotka). Geokhimiya, No. 5, 1974.

5. Aleksandrov, S.M. Geokhimicheskiye osobennosti obrazovaniya boroolobyannykh rud na mestorozhdeniyakh Alyaski, SSha (The Geochemistry of Formation of Boron-Tin Ores in Alaskan Deposits, U.S.A.). Geokhimiya, No. 4, 1975.

6. Aleksandrov, S.M. Osobennosti proyavleniya stadii kislotnogo vyshchelachivaniya na mestorozhdeniyakh bora i olova magnesial'no-Skarnovoy formatsii (Characteristics of the Stage of Acid Leaching at Boron and Tin Deposits in Magnesian Skarns). Geokhimiya, No. 3, 1975.

7. Korzhinskiy, D.S. Ocherk metasomaticheskikh protesessov. V kn.: Osnovnyye problemy v uchenii o magmatogennykh rudnykh mestotozhdeniyakh (An Essay on Metasomatic Processes, Principal Problems in the Science of Ore Deposits in the Science of Ore Deposits of Magmatic Origin. IZd. Akad. Nauk USSR, Moscow, 1955.

8. Sainsbury, C.L., 1968. Tin and Beryllium Deposits of the Central York Mountains, Western Seward Peninsula, Alaska. Ore Deposits of the United States, 1933-1967, the American Institute of Mining, Metallurgical, and Petroleum Engineers, New York, 1962 pp. 1555-1572.

9. Sainsbury, C.L. Geology and Ore Deposits of the Central York Mountains, Western Seward Peninsula, Alaska. U.S. Geol. Surv. Bull. 1287, 1969, 101 pp.

10. Smirnov, V.I. Geology of Mineral Deposits, MIR Publishers, Moscow, U.S.S.R., 1976, 520 pp.