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Lithium Anomaly Near Pringle, Southern Black Hills, South Dakota, Possibly Caused by Unexposed Rare-Mineral Pegmatite

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ABSTRACT

Six samples of biotite schist from a site near Pringle, South Dakota, contained from 140 to 750 parts per million lithium. These values are far greater than are found in mica schists in most of the rest of the southern Black Hills. The lithium may have emanated from concealed lithium pegmatite, and such pegmatite can be of interest as a possible source of rare minerals, especially tantalite and beryl. Whether making a full test of the anomaly will become economically judicious is much less clear.

INTRODUCTION

Analyses for lithium, rubidium, and cesium have been used in geochemical exploration for concealed lithium pegmatites (Trueman, 1978). The purpose was not so much to enlarge lithium reserves, which are abundant, as to find rare minerals, such as tantalite and beryl. Lithium pegmatites of the Black Hills, S. Dak., have been sources of both these minerals.

Between 1977 and 1980, the price of tantalite rose from about $20 to more than $100 per pound of contained Ta_2O_5. Interest in exploring for tantalite rose accordingly. In 1981 and 1982, a price retreat to $20–$25 dampened enthusiasm. Beryl in 1977 was about $40 per short ton unit (20 pounds of contained BeO) and in 1981 and 1982 it was $100–$130.

PRINGLE ANOMALY

The purpose of this report is to call attention to a lithium anomaly found near Pringle, S. Dak., during an investigation of the distribution of lithium in mica schists of the southern Black Hills (Norton, 1981). The principal locality is in biotite schist just east of Pringle (fig. 1) at the north end of the Shirttail Canyon road, just south of its intersection with U.S. Highway 385.

The six samples of schist from this site had a lithium content of 140 to 750 ppm (parts per million). Elsewhere over an area of about 800 km^2 (square kilometers) in the southern Black Hills, only 7 of 277 samples of mica schist had as much as 140 ppm, and the maximum among these was 350 ppm. The median of all samples was 52 ppm. Three other samples were collected from near Pringle, and these also had unusual amounts of lithium, at 97, 121, and 157 ppm. For this reason their positions are shown on figure 1. These samples are of mica schist of lower biotite content than at the Pringle locality.

The Pringle sampling site is near the south edge of the Precambrian core of the Black Hills. The site is east of a cluster of small pegmatites in a biotite-rich schist belonging to a narrow unit that trends 18 km due north to Custer (Redden and Norton, 1975, fig. 6). The unit has almost no outcrops over this entire distance. North of Custer, the biotite schist extends over broad areas and ultimately becomes a part of the biotite schist facies of the Oreville Formation (Ratté and Wayland, 1969).

Table 1 has data on the six samples of biotite schist from the Pringle locality. The schist consists mostly of biotite, quartz, and untwinned feldspar, but it also has conspicuous metacrysts of garnet and muscovite. Heavy-mineral separates obtained with bromoform had 620 ppm Li in sample 0–105 and 1,755 ppm Li in sample 0–106. The light frac-

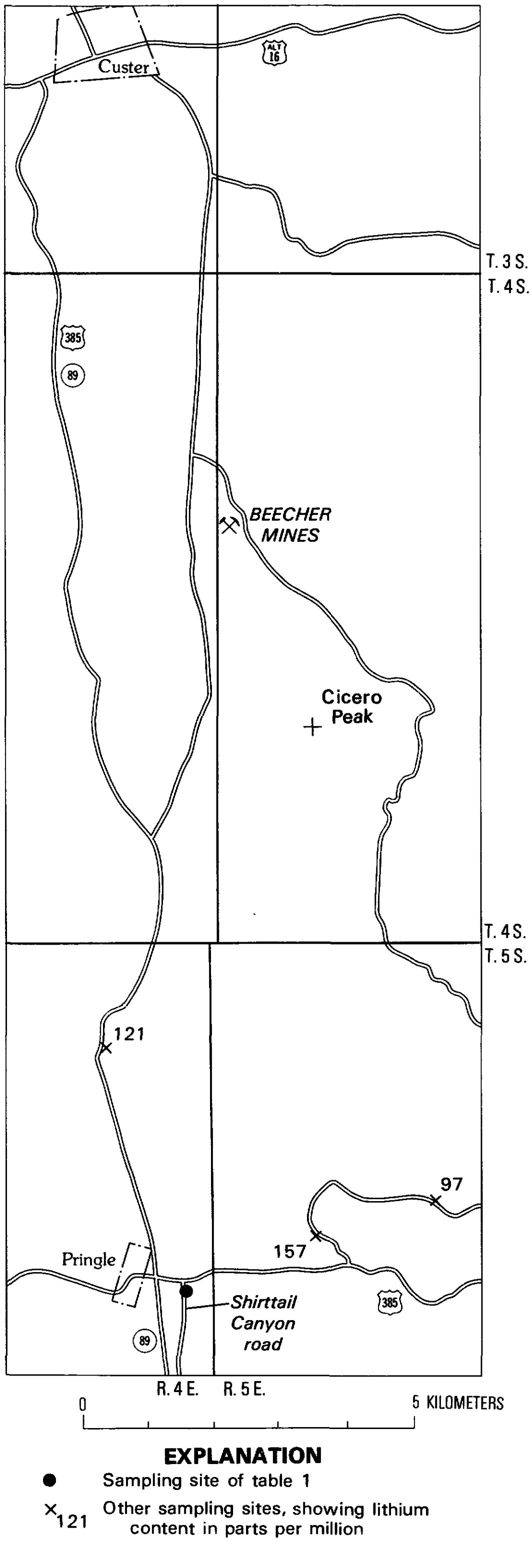

FIGURE 1. Map showing localities of lithium-rich samples and of the Beecher group of pegmatites, southern Black Hills, S. Dak.

tions had 76 and 150 ppm, respectively. The lithium thus seems to be concentrated in biotite.

Most of the samples were taken from near a northerly striking feldspar-quartz pegmatite about 2 m (meters) thick and 50 m long. Sample 0–109 is nearer another pegmatite, which is about 1 m east of the first one and is about 0.3 m thick and 6 m long. In all samples except 0–105, the lithium content seems strikingly related to proximity to these pegmatites. The pegmatites, however, are of quite ordinary appearance, and the one sample analyzed had only 19 ppm lithium. West of the two pegmatites at the sampling site are many other thin tabular pegmatites of northerly strike. They seem to be separate intrusions but could be offshoots from the top or bottom of a much larger pegmatite.

Although the Pringle analyses are clearly anomalous, a test of how they compare with schist enriched in Li by a known lithium pegmatite was made at the Mateen spodumene mine, 35 km north of Pringle at Hill City. The Mateen was chosen because the host rock is the same kind of biotite schist as at Pringle. The pegmatite has a steep eastward dip at the sampled locality, and according to Erickson and Steven (1953, pls. 26 and 27) the top of the intrusion was only about 15 m above the surface. Table 2 shows that the lithium contents are not much different, although perhaps a little lower, than at Pringle. Hence the Pringle anomaly seems likely to have been caused by lithium pegmatite not now exposed.

A harder question to answer is whether the suspected lithium pegmatite near Pringle is below the surface or has been eroded away from above the surface. A. A. Beus and his colleagues have examined this kind of problem, and translations of some of the pertinent material have been provided by D. L. Trueman and Petr Černý. Apparently the high lithium contents at Pringle are a favorable indication that a pegmatitic source lies beneath the locality. The Mateen analyses are in accord with this implication, for the samples came from near the top of the pegmatite. Semiquantitative analyses of Pringle samples 0–105 and 0–106 cast a little more light on the subject. These analyses indicate 50 and 10 ppm Be and 20 and 50 ppm Sn, respectively. Similar analyses of 98 biotite schist samples from elsewhere in the Black Hills show that one sample has 5 ppm Be and all others have less. In these same samples, Sn reached a maximum of 20 ppm, and that too was

Sample Number		Lithium, content[1] (ppm)	Location
Field	Laboratory		
0-105	D-187195	186	West of Shirttail Canyon road; 0.3 m east of 2-m-thick pegmatite.
0-106	D-187196	750	Do.
0-107	D-190406	520	Do.
0-108	D-190407	270	Middle of road; 3 m east of pegmatite.
0-109	D-190408	190	In road; north of sample 0-108 and 6 m east of 0.3-m-thick pegmatite.
0-110	D-190409	140	60 m south of other samples; no pegmatite exposed nearby.

[1]Analyses by atomic absorption. Analysts: Carol Gent and Violet Merritt.

in only one sample. The Be and Sn contents tend to support the view that the source is at depth. No other data at hand are suitable for further appraisal of the problem. Because the tests are far less than rigorous, one can conclude only that the cause of the anomaly is somewhat more likely to be below than above the present surface. Geologic mapping and structural analysis of the cluster of pegmatites west of the sampling site might show whether some or all these pegmatites are likely to be at the top or bottom of a large pegmatite that could have caused the anomaly.

THE BEECHER GROUP OF PEGMATITES

The best means of judging the possible nature of lithium pegmatites that might be found near Pringle is to examine the geology of some known lithium pegmatites of the southern Black Hills. Most of these are far to the north near the edge of the pegmatite region. The only significant exception is the three lithium pegmatites of the Beecher group, which are 11 km north of Pringle and are in much the same geologic environment as at Pringle (Redden and Norton, 1975, fig. 6; Norton, 1975, fig. 21). These pegmatites are so large and exceptional among Black Hills pegmatites that it would be rash to assume that Pringle has equal deposits. Nevertheless, the Beecher lithium pegmatites are much nearer Pringle than any others and have the most relevance in predicting the outlook for exploration.

Two of the pegmatites, the Beecher Lode and Beecher No. 2, have been described by Joralemon (1953a, b). The third pegmatite, called Beecher No. 3-Black Diamond, has been described in detail by Redden (1959, 1963).

The Beecher Lode is 265 m long and as much as 25 m thick. Information is meager about how deep it goes and about its structure at depth. The exposed part of the pegmatite consists mainly of feldspathic outer zones and a quartz-spodumene

TABLE 2. *Lithium content of biotite schist samples from near the Mateen pegmatite, Hill City, S. Dak.*[1]

Sample Number		Lithium content[1] (ppm)	Distance from contacts of pegmatite
Field	Laboratory		
MAT-3	D-223184	138	At east contact.
MAT-4	D-223185	242	1.2 m from east contact.
MAT-5	D-223186	325	23 m from east contact.
MAT-1	D-223182	158	At west contact.
MAT-2	D-223183	420	1.2 m from west contact.

[1]Collected from between sections BB′ and CC′ of Erickson and Steven (1953, p. 126). Analyses by atomic absorption. Analyst: G. Angsten.

inner zone. The Beecher Lode became prominent as a source of amblygonite early in the century when amblygonite was the favored source of lithium. Its production of about 1,800 metric tons is more than one-fifth of the total Black Hills output of amblygonite. Beryl production exceeds 100 tons, but the beryl is iron stained and anhedral, and hence difficult to cob to an acceptable degree of purity. George Bland (oral commun., Aug. 31, 1981) estimated the tantalite-columbite production to be at least 55 metric tons, which would be probably at least one-half of the total Black Hills production. The minable concentrations of amblygonite, tantalite-columbite, and much of the beryl were found in the outer part of the quartz-spodumene zone.

The Beecher No. 2 pegmatite is exposed for a length of 350 m and has an average thickness of 60 m. The vertical dimension is unknown. The body is a multiple intrusion consisting of three coalescing pegmatites, each of which has a core of albite-quartz-spodumene pegmatite and outer zones of quartz-albite-muscovite and albite-quartz pegmatite. The pegmatite was mined for spodumene by the Lithium Corporation of America during the 1950's. Although the pegmatite has been rather extensively opened up, no rare minerals of commercial value have ever been reported.

At the Beecher No. 3-Black Diamond deposit, the original top of the pegmatite was probably nowhere more than about 10 m above the present surface. Outcrops are rather sparse and mine workings are small. Hence, exploring this deposit is much like exploring a concealed pegmatite. It was tested in a diamond-drilling program by the Lithium Corporation of America, and the results were described by Redden (1963).

The pegmatite is 540 m long at the surface and probably longer in the subsurface. The thickness is highly variable, but the average is about 25 m. Drilling has shown that the pegmatite extends to a depth of at least 60 m. Calculations from Redden's cross sections show that it is likely to contain as much as 3,000,000 metric tons of rock, which is extremely large for a Black Hills zoned pegmatite. Redden (1959, 1963) separated the pegmatite into five zones containing differing quantities of feldspars, quartz, and muscovite, and a sixth zone, apparently small, of quartz-perthite-albite-spodumene pegmatite. The only production has been 342 tons of beryl, which was in a small and structurally unusual part of an outer zone. Tantalite-columbite has not been found, but the pegmatite has not been explored enough to show that it does not contain tantalum ore.

These three pegmatites are large. Two of them have been important mines for lithium minerals, and the third contains lithium minerals. A lithium anomaly almost certainly exists in the nearby schists, although no tests to prove this have been attempted. One of the pegmatites has produced only spodumene, and has little or no promise for other minerals. Two pegmatites have been significant sources of beryl. One of these also has had a sizable output of tantalite-columbite, and the other may contain undiscovered deposits. The concentrations of beryl and tantalite-columbite, however, constitute only small parts of this group of pegmatites.

MINING AND EXPLORATION FOR LITHIUM MINERALS, BERYL, AND TANTALITE-COLUMBITE IN THE BLACK HILLS

None of the known rare-mineral pegmatites in the Black Hills was found by geochemical exploration, nor has there been much effort to find them by this means. The reason for the slightness of the effort may be that the nature of Black Hills pegmatites makes exploration for concealed deposits economically unattractive. Finding a few samples of lithium-rich schist is only a minor preliminary step in finding, developing, and mining a pegmatite. The lithium-rich schist near Pringle is so remote from the known lithium pegmatite localities of the Black Hills that it normally would not be sampled in geochemical prospecting for rare-mineral pegmatites. Perspective for gauging the advisability of investigating the Pringle anomaly can be obtained by examining a few aspects of the mining and geology of Black Hills pegmatites.

Most of the lithium production has been from mining operations in which lithium minerals were the main product. Beryl and tantalite-columbite have had a status better described as that of a byproduct or coproduct. Concentrations of these minerals have, of course, been found in natural outcrops and then mined out. Several such discoveries were an accidental result of prospecting for other minerals. Most concentrations, however, especially of beryl, have been exposed during mining for other products. They were mined when found, or in some instances left untouched until a price increase caused them to be mined.

Although Black Hills pegmatites were the dominant source of the world's lithium in the first half of the century, subsequent expansion of the lithium market caused the industry to turn away from the small deposits of the Black Hills and to obtain its supplies from much larger deposits elsewhere in the world. Lithium mining in the Black Hills virtually halted in 1960. There is no imminent likelihood that lithium mining in the region will return to its previous level.

Total beryl production of the Black Hills probably now slightly exceeds 5,000 metric tons. Perhaps somewhat more than half of this came from a dozen pegmatite mines. Many of these were feldspar quarries in which most of the beryl would have been unobtainable if the feldspar-rich parts of the pegmatite had not been removed. At the Peerless pegmatite, which has the largest production, the beryl was a byproduct of mining for scrap mica from a narrow outer zone. A similar zone contained the beryl mined at the Beecher No. 3. The beryl-rich rock was discovered in an old prospect pit, and beryl was the only mineral mined; mining was discontinued partly for lack of coproducts to help finance further operation. At the Bob Ingersoll Mine, where two pegmatites have yielded about as much beryl as the Peerless, the main incentive for mining was lithium minerals. In the light of these experiences with the mining of beryl from outcropping pegmatites, little weight should be placed on the potential for finding minable beryl deposits in an unexposed pegmatite.

With tantalite-columbite, experience is smaller and what experience there is has lost much of its relevance as a result of price changes. Until the late 1970's, prices were too low and the availability of buyers for tantalite-columbite was too erratic to encourage prospecting and mining in the Black Hills. Recorded production was 85 metric tons through 1973 (Norton, 1975), and unrecorded production plus recent output may have brought the total to more than 100 metric tons. Most of this production came from two deposits. According to George Bland (oral commun., Aug. 31, 1981), the Beecher Lode has supplied at least 55 metric tons, a substantial share of which appears not to have been included in published statistics. Personal records of A. I. Johnson (oral commun., Sept. 17, 1981) show the production at Tinton in the northern Black Hills to be 30 metric tons from the Giant-Volney pegmatite and adjacent placer ground. Less than 10 other pegmatites in the Black Hills could have produced more than 1 metric ton each. The overall contribution of all other pegmatites is at best a few metric tons. The Black Hills has about 40 sizable pegmatite mines and many smaller mines and prospects. Finding only two significant tantalite deposits hardly encourages hope that additional discoveries can be made easily. At the Beecher Lode most of the tantalite was made accessible by mining for other minerals. The tantalite at Tinton was mined as the main product, although it probably was originally discovered as a result of prospecting for tin.

Some Black Hills zoned pegmatites are large by most standards, but none of those so far found are more than a tiny fraction of the size of the Tanco pegmatite, Bernic Lake, Manitoba, where the success at mining tantalum minerals has stimulated interest in exploration elsewhere. The Hugo is the largest highly differentiated pegmatite in the Black Hills for which nearly complete data about its size are available. It originally had about 1,570,000 metric tons of rock (Norton and others, 1962, table 19). Tanco, according to calculations from an isopach map by Crouse and others (1979, fig. 3), has somewhat more than 50,000,000 tons. Reserves of tantalum ore when mining began in 1969 were 1,700,000 metric tons containing 0.23 percent Ta_2O_5 (Howe, 1968, p. 44). At the end of 1979, higher prices had dropped the minable grade to 0.137 percent (Jones, 1980, p. 267), and the size of the bodies of ore, mined and not yet mined, became perhaps 3,000,000 metric tons, or only about 6 percent of the entire pegmatite. Ore bodies occupying a similar share of a typical Black Hills pegmatite would be extremely small and difficult to find. Tantalite-columbite does, however, tend to be most abundant in the inner units of zoned pegmatites, and exploration can be focused on those units. Tantalite-bearing units can be zones or parts of zones, but they also can be replacement bodies, as at Tinton (Page and others, 1953, p. 204–205) and at the Tanco deposit (Crouse and others, 1979). Many replacement bodies are irregular and much more erratic than zones, and hence are more difficult to explore. At Tanco the tantalum ore was discovered not by exploration for tantalum, but as an unforeseen result of years of exploring for lithium minerals. The recognition of the existence of tantalum ore bodies came from reexamining core from 75 drill holes (Howe, 1968, p. 39).

In the Black Hills the first result of the increase in the price of tantalite was to draw attention to old mine dumps. Black Hills pegmatite mines, in the course of producing somewhat more than 2,000,000 metric tons of various commercial minerals, have accumulated at least 3,000,000 metric tons of waste rock now in numerous dumps. Some of the dumps have enough tantalite to have become economically attractive at the high prices of 1981, but their merits may not be apparent except from tests of bulk samples (R. L. Cullum, oral commun., Aug. 31, 1981). Renewed mining of pegmatites known to contain tantalite was modest. Searching for concealed pegmatites took a distant third place. If high prices return, some deposits other than the Beecher Lode and Giant-Volney may be found to have enough tantalite to become economically important, even if too low grade to have been of interest or perhaps even to have been noticed previously.

One of the remarkable advantages of the Tanco deposit is the high ratio of Ta to Nb in its several tantalum minerals (Grice and others, 1972). In the Black Hills the content of Ta is generally much lower and Nb correspondingly higher. Furthermore, tantalite-columbite in a single pegmatite may range from tantalum-rich to niobium-rich. In 10 specimens from the Etta Mine, Keystone, S. Dak., Headden (1891, p. 95) found a continuity of compositions from 18.20 percent Ta_2O_5 and 64.09 percent[1] Nb_2O_5 at one extreme to 53.28 percent Ta_2O_5 and 29.78 percent Nb_2O_5 at the other. Figure 2 shows the wide distribution of Ta and Nb in these specimens, but does so in atomic percent to show how well these old analyses conform to the tantalite-columbite formula, (Fe,Mn) $O\cdot(Ta,Nb)_2O_5$. Page and others (1953, p. 58) suggested that such differences are attributable to an increase in the Ta-Nb ratio toward the centers of pegmatites, and Grice and others (1972, p. 640) found such a trend in the Tanco pegmatite. The range in the Ta-Nb ratio was not commercially troublesome in the Black Hills during the last few years; nearly all shipments and all concentrates from test mill runs had far more than the acceptable minimum of 30 percent Ta_2O_5 (R. L. Cullum and George Bland, oral communs., Aug. 31, 1981). Experience in new deposits would not necessarily be the same.

[1]Published as 54.09, but internal evidence proves this to be a misprint.

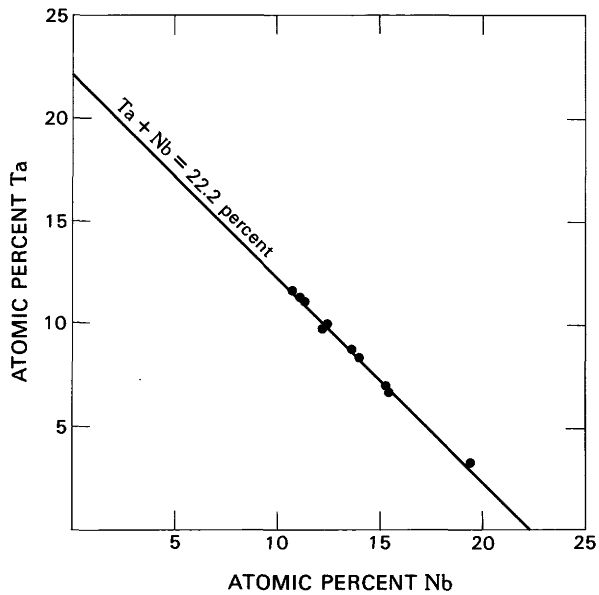

FIGURE 2. Tantalum (Ta) and niobium (Nb) contents of 10 specimens of tantalite-columbite from the Etta pegmatite, Keystone, S. Dak. Calculated from analyses by Headden (1891, p. 95). The line for Ta + Nb=22.2 percent shows the contents in the formula for tantalite-columbite.

George Bland has commented (oral commun., Aug. 31, 1981) that columbite seems generally to have more iron-oxide alteration than tantalite and probably has a higher Fe-Mn ratio. This observation led to plotting the Etta analyses on figure 3, which shows high Ta to be accompanied by high Mn and high Nb to go with high Fe. Černý and

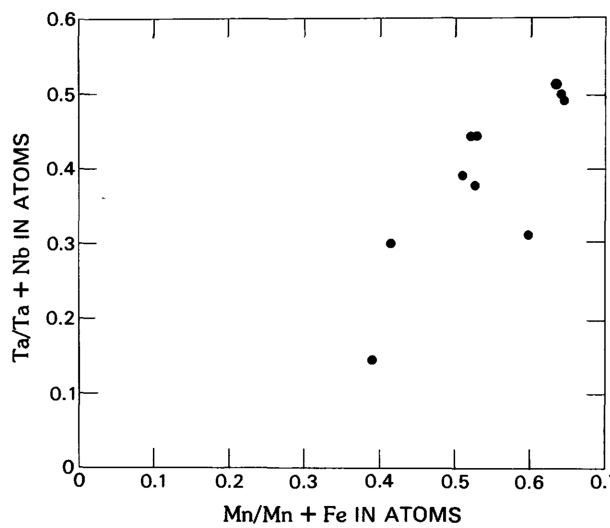

FIGURE 3. Graph showing the relationship between Ta/ Ta + Nb and Mn/Mn + Fe in the samples of figure 2.

others (1981, fig. 104) show a similar trend in Manitoba. The relationship seems to have no commercial importance and no obvious geologic explanation. The subject is brought up here only because it may interest others.

SUMMARY

Mica schist samples from near Pringle, South Dakota, are anomalously rich in lithium. This anomaly suggests the possibility that one or more lithium pegmatites lies beneath the surface. Interest in finding another lithium pegmatite in the Black Hills has long been negligible, but interest in finding tantalum minerals and beryl, which are associated with lithium deposits, has been much greater. Hidden lithium pegmatites have few attractions as potential sources of tantalum or beryl that are not also possessed by outcropping lithium pegmatites.

The primary purpose of this report is to announce the existence of the Pringle lithium analyses. The nearest known lithium pegmatites are 11 km away in the Beecher group, which has three large deposits. These deposits suggest the nature of what could be found at Pringle. They and other Black Hills pegmatites also illuminate the difficulties of finding a rare mineral concentration even after a lithium pegmatite has been discovered.

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