

ALTERATION OF POLLUCITE IN SOME PEGMATITES OF SOUTHEASTERN MANITOBA*

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ABSTRACT

Clay pods from the Odd West (Bernic) and Buck Claim pegmatites in southeastern Manitoba have been identified as pseudomorphous after pollucite. The parent pegmatites belong to the pollucite-bearing group of the Bernic Lake-Rush Lake area, and the clay pods found in them are in near-core locations typical of pollucite occurrences. Braided micaceous veining preserved in the clay pseudomorphs closely resembles that of fresh pollucite from other localities. X-ray powder diffraction data corroborated by differential thermal analysis and partial chemical analyses show illite, kaolinite, quartz and smectite minerals as the main components of the pseudomorphs. The same assemblage replaces fresh pollucite in other pegmatites of the district. The character of the alteration process is not clear, although hydrothermal action seems more likely than supergene agents. Experimental study of the two possibilities is desirable as the chance of finding fresh pollucite in such pseudomorph-bearing pegmatites depends, among other factors, on the correct identification of the breakdown process.

SOMMAIRE

Les amas d'argile des pegmatites Odd West (Bernic) et Buck Claim, situées dans le Sud-Est du Manitoba, sont des pseudomorphoses de la pollucite. Ces pegmatites font partie du groupe de pegmatites de la région des lacs Bernic et Rush, qui contiennent de la pollucite saine. Les poches d'argile se trouvent près du centre des pegmatites, ce qui est typique de la pollucite. Des veinules micacées en tresses sont préservées dans les pseudomorphoses argileuses et ressemblent de très près aux veinules de la pollucite fraîche d'autres pegmatites. Par diffraction-X sur poudres, analyse thermique différentielle et analyse chimique partielle, on trouve que l'illite, la kaolinite, le quartz et les smectites sont les principaux minéraux des pseudomorphoses. Le même assemblage de minéraux remplace la pollucite saine dans d'autres pegmatites de la région. La nature du processus d'altération n'est pas évidente: elle semble plutôt hydrothermale que supergène. Une étude expérimentale des

deux possibilités serait souhaitable, car la probabilité d'une découverte de pollucite saine dans les pegmatites à pseudomorphoses argileuses dépend d'abord de notre connaissance du processus de déstabilisation.

(Traduit par la Rédaction)

INTRODUCTION

The pegmatite district of southeastern Manitoba gained world-wide recognition early this century for its size and its economic potential for lithium and beryllium (DeLury 1926; Derry 1931; Landes 1935; Fersman 1940; Schneiderhöhn 1961). More recently, several studies pointed out its unique reserves of cesium and tantalum (Černý & Turnock 1971; Solodov 1971; Gordiyenko 1974; Heinrich 1976).

The district harbors the world's largest known concentration of pollucite: the Tanco deposit at Bernic Lake contains 350,000 short tons averaging 23.3 wt.% Cs₂O (Černý & Simpson, in prep.). In addition, pollucite also occurs north of the Tanco pegmatite in the High Grade Dike at Maskwa Lake (Černý & Bristol 1972), and at Gullwing Lake, north of Dryden in adjacent northwestern Ontario (Mandarino & Harris 1965).

Pollucite-bearing pegmatites normally constitute a negligible fraction of all pegmatite bodies found within a pegmatite district, even where extreme enrichment in rare alkalis has occurred. Nevertheless, these three localities of pollucite in the western English River belt can hardly represent all occurrences in this area. The complex structure of the belt and widely scattered showings of highly fractionated pegmatite mineralization indicate that new findings of pollucite are possible (Černý & Trueman 1978).

One of the reasons for the restricted number of known pollucite occurrences in the area is the quartz-like appearance of this mineral and its common alteration. The difficulties encountered in field identification of fresh pollucite have been pointedly illustrated by the discovery of this mineral at Tanco (Frohberg 1967). The two pegmatite occurrences to be described in

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the present paper have been known and explored for several decades; however, their pollucite potential has passed unnoticed because of extensive alteration of this mineral.

LOCALITIES AND SAMPLES

The localities in which clay-rich nodules after pollucite were recognized are the Buck Claim and Odd West (Bernic) pegmatites, east of Bernic Lake, southeastern Manitoba (Fig. 1). For comparison, products of similar but incomplete alteration of pollucite were also studied from the Tanco and High Grade Dike pegmatites (Fig. 1), and from the Luolamäki pegmatite in Finland (Neuvonen & Vesasalo 1960). The specimens examined are described in Table 1.

The Buck Claim pegmatite, briefly described by Davies (1955) and currently under examination by P. G. Lenton, forms a subhorizontal sheet-like body in metabasalts at the eastern end of Bernic Lake. The pegmatite reaches about 12 m in true thickness and is almost completely hidden. In one locality opened by a trench-pit, the body displays an asymmetric zoning parallel to the outline of the pegmatite. The zonal sequence includes (a) albite and schorl along borders; (b) albite, muscovite, and verdelite in an upper wall-zone; (c) cleavelandite, microcline perthite, beryl, lithian muscovite, and amblygon-

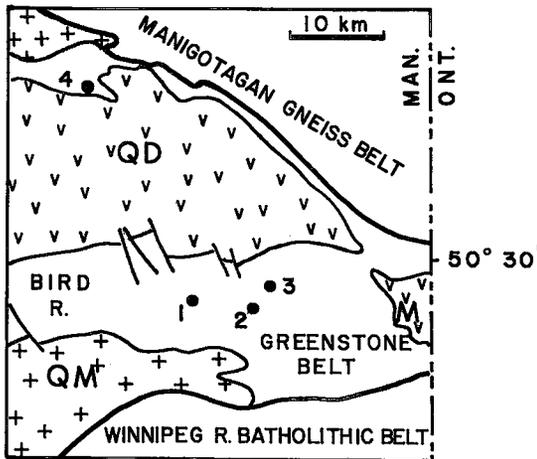


FIG. 1. Geographic and geological location of the Tanco (1), Buck Claim (2), Odd West (3), and High Grade Dike (4) pegmatites in the English River subprovince. The metavolcanic-metasedimentary Bird River greenstone belt hosting the pegmatites is penetrated by early quartz-dioritic diapirs (QD) and late quartz monzonite plutons (QM).

TABLE 1. LIST OF SAMPLES

<u>Buck Claim pegmatite, Bernic Lake:</u>	
BCNW-2B	apple-green to buff-colored clay from western and eastern wall
BCNW-109	greenish clay from western wall of the pit
BCNW-GC	apple-green to buff-colored clay from western wall of the pit
<u>Odd West pegmatite, north of Rush Lake:</u>	
OW-1-GC	hard dirty green clayish material with lepidolite veining
OW-2-WC	whitish fragile to soft clay with fragments of lepidolite veining
<u>Tanco pegmatite, Bernic Lake:</u>	
TAN-1-GC	green clay coating pollucite with veins of microcline
TAN-2	thick crust of dirty green to beige clay on pollucite
TAN-3-SC	light-green, finely black-spotted hard clay with microscopic relicts of pollucite
TAN-3-GC	pale-greenish clay along margins of the TAN-3-SC material
TAN-4	off-white soft clay
<u>High Grade Dike, Maskwa Lake area:</u>	
HGD-1-GC	greenish alteration of pollucite along veinlets of adularia
HGD-2A-GC	greenish clay nodules along adularia veinlets in pollucite
HGD-2B-WC	pale beige band occurring locally along the greenish clay/pollucite boundary in the preceding sample
<u>Luolamäki, Finland:</u>	
LUO-1	dark-green hard clay
LUO-2	light-green hard clay
LUO-3	off-white soft clay in eyelets among dark-green veinlets

ite in an intermediate zone, and (d) a zone of blocky microcline perthite with amblygonite-montebbrasite and spodumene + quartz pseudomorphs after petalite which surrounds (e) a quartz core containing blebs of triphylite.

Along the contact between the upper blocky zone and the quartz core four pods of apple-green clay are exposed in the walls of the pit. They occur adjacent to blocky amblygonite, microcline perthite, radial globules of cleavelandite and quartz, none of which show any signs of alteration. Occasionally a thin coating of microcrystalline quartz and greyish mica is observed.

The Odd West (Bernic) pegmatite, briefly characterized by Černý & Harris (1973), constitutes a north-dipping tabular body exposed along a cliff of metagreywacke about 1 km north of the western end of Rush Lake. The pegmatite, partly opened by trenching, attains a thickness of about 4 m. Zoning is rather poorly developed and somewhat irregular. Medium-grained border and wall zones consist of albite, microcline perthite, quartz and schorl, and they contain patches of cassiterite-bearing "greisen" assemblages in

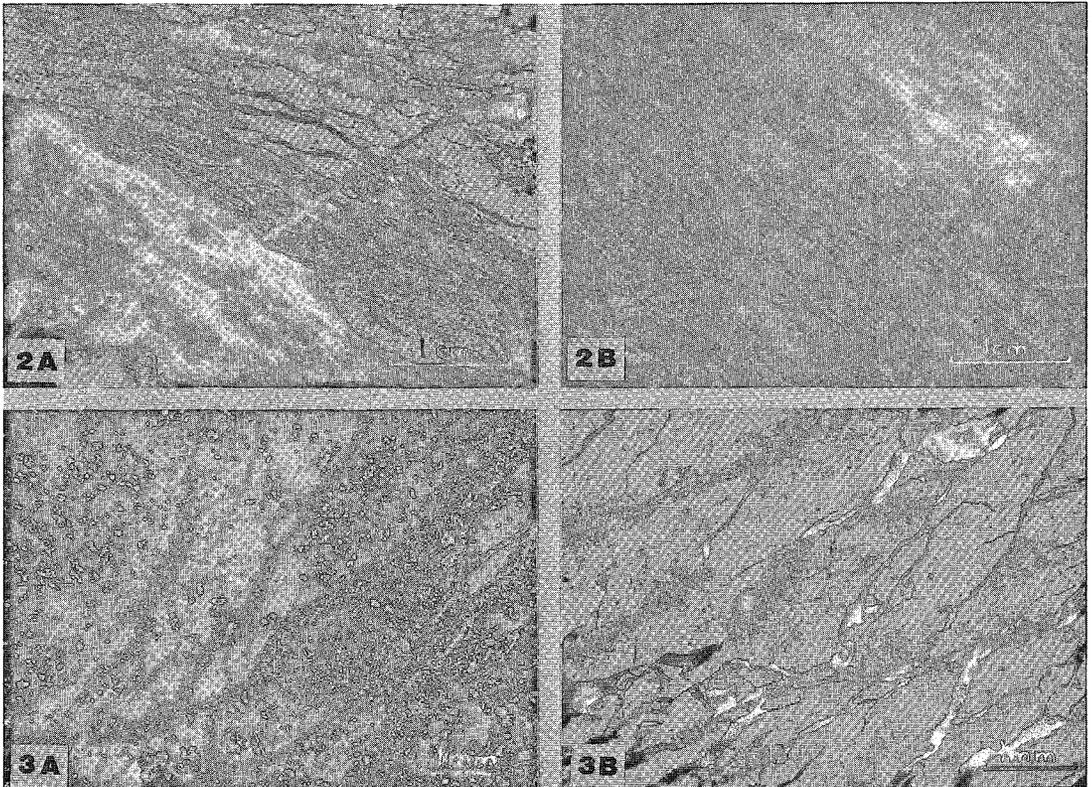


FIG. 2. Structure of altered and fresh pollucite in polished hand specimens. 2A: clay pseudomorph after pollucite (dark grey to white matrix), with braided and crosscutting veinlets of lepidolite (black), from the Odd West pegmatite; 2B: muscovite veinlets (white) in fresh pollucite (grey matrix) from the Tanco deposit. Note the close similarity of the veining patterns.

FIG. 3. Altered and fresh pollucite in thin sections. 3A: braided network of lepidolite veinlets in a mostly isotropic clay matrix from the Odd West pegmatite, between crossed polars; 3B: muscovite veinlets (dark grey to black) penetrating the Tanco pollucite (grey matrix). The structures of the veins and matrices closely resemble each other.

their hanging-wall segments. Large club-like microcline perthites surrounded by albite + quartz matrix form an upper intermediate zone; its lower counterpart is more blocky in texture and transitional into a core zone. This consists mainly of microcline perthite, cleavelandite, montebrasite, spodumene, muscovite and globular lepidolite. Although quartz is present in substantial quantities, it does not form a distinct zone in the present exposure.

In the central parts of the core zone, greenish-grey to buff-colored clay pods occur in direct contact with cleavelandite, montebrasite, platy muscovite overgrown by wrinkled lepidolite, and quartz. These latter minerals do not show any indication of alteration into, or veining by, the clayish material.

The alteration of pollucite from Tanco and from the High Grade Dike is similar in character. The clayey material is restricted to the immediate vicinity of K-feldspar veinlets which penetrate the outer parts of the pollucite bodies. The only difference is in the type of feldspar: at Tanco, apple-green clay selvages develop along veinlets of nonperthitic, twinned, near-maximum microcline whereas the greenish-grey clay at the other locality follows adularia of a high-sanidine type.

At Luolamäki in Finland, pollucite and petalite are surrounded by a zone of greenish montmorillonite, kaolinite and chlorite; quartz is also abundant in the alteration products after petalite (Neuvonen & Vesasalo 1960). In the present study, chlorite could not be confirmed.

TEXTURAL RELATIONSHIPS

Examination of subconchoidal fracture surfaces and sections of the Buck Claim clay does not reveal any regular textural features. The clayish aggregates are randomly veined by microcrystalline quartz and mica, and dotted by irregularly dispersed tiny cavities. Inclusions of fine granular quartz and albite tend to accumulate in marginal parts of the pods; they probably represent contamination from the quarrying operations.

The Odd West pods show a characteristic veining pattern. A polygonal to braided network of lepidolite veinlets penetrates all the clayey aggregates. The lepidolite commonly spreads out from its adjacent fine-flaked patches, but it may be confined to the veinlets. Such veining is remarkably similar to the micaceous network typical of Tanco pollucite, both in hand specimen and thin section (Figs. 2, 3).

CHEMICAL COMPOSITION

Partial chemical analyses of several samples of hand-picked clays were performed using atomic absorption spectroscopy, and the results are given in Table 2. Two of five alkalis and alkaline earth elements are present in each sample in quantities larger than 1 wt.%. K_2O is high in all samples; MgO and CaO are enriched in three specimens but Cs_2O , Li_2O , and Na_2O are mostly subordinate and Rb_2O is low in all samples. The complex cationic composition of the clay aggregates and the high totals of the seven oxides suggest polyminerale composition. The high K_2O may indicate a micaceous mineral, and high totals of CaO , MgO , and Na_2O could be attributed to a smectite phase.

TABLE 2. CHEMICAL ANALYSES

Sample #	Li_2O	Na_2O	K_2O	Rb_2O	Cs_2O	MgO	CaO
BCNW-28-GC	0.11	0.05	4.64	0.08	0.05	3.72	0.13
OW-1-GC	1.29*	0.09	3.36	0.30	0.24	0.19	3.45
OW-2-WC	0.36	0.47	3.46	0.16	0.07	1.32	1.45
TAN-1-GC	0.09	1.92	4.94	0.18	5.00**	1.76	4.95

Analysts: R.M. Hill and R. Chapman, Dept. Earth Sciences, Univ. of Manitoba

* XRD patterns do not reveal any lepidolite admixture; Li_2O should be present in the illite or montmorillonite phase.

** The analyzed sample contains XRD-detectable pollucite but substantial part of the Cs_2O percentage should be in the clay materials; 5 wt.% of Cs_2O found in pollucite would represent a 15 wt.% admixture of this mineral, which is much more than indicated by X-ray diffraction intensities.

X-RAY POWDER DIFFRACTION

The initial study of typical fragments of untreated clay aggregates revealed substantial quartz in all specimens; pollucite was identified in samples TAN-1, TAN-3-SC, and in all HGD specimens. The micaceous and clay-mineral fractions were subsequently prepared by sedimentation from aqueous suspension, which eliminated most of the quartz and all of the XRD-detectable pollucite and thereby reduced interference with mica and clay-mineral reflections to negligible levels. Oriented glass-like mounts of the purified layer-silicate mixtures were prepared by settling from suspensions; they were X-rayed in natural state and after saturation with ethylene glycol. Heated samples were pulverized and sprinkled on glass slides covered with double-sided tape.

X-ray powder diffraction data indicate the presence of kaolinite ($d = 7.1$ and 3.6\AA), an illite-type mica (non-swelling 10\AA , decreasing to 9.6 after heating to 500°C ; Brown 1961, p. 224), and smectite minerals (Fig. 4). These smectites consist of montmorillonite *sensu stricto* (its $14\text{-}15\text{\AA}$ peak shifts to $17\text{-}18\text{\AA}$ with ethylene glycol, and to 9.6\AA after heating to 500°C) mixed with more complex types: the 19 and 24\AA peaks which disappear after glycolation suggest montmorillonite-kaolinite and montmorillonite-illite mixed-layer sequences, and the 12\AA reflection may belong to Na-montmorillonite (Brown 1961; Thorez 1975). The $14\text{-}15\text{\AA}$ reflections that do not change after glycolation may represent either chlorite or, more likely, a non-swelling smectite component.

These principal components are detectable in all examined samples but their proportions are highly variable, and they differ even in fragments from a single hand-specimen. Thus the intensities of characteristic reflections shown in Fig. 4 cannot be taken as representative of average compositions.

DIFFERENTIAL THERMAL ANALYSIS

The differential thermal records do not contribute to the positive identification of individual mineral phases because of overlap of most of the major thermal reactions of the three layer-silicates identified by X-rays (Grim 1947; Mackenzie 1957; Brown 1961). However, at least the thermal studies do not contradict the X-ray diffraction results; they do not reveal additional mineral phases.

Selected thermal records (Fig. 5) obtained on the DTA-13M apparatus (R. L. Stone Co.)

show any alteration which could possibly have released some of their Cs into late solutions.

(6) Of all possible Cs-bearing phases, pollucite seems to be the only one capable of yielding clayey residua with up to 0.24 wt.% Cs_2O . This concentration equals the maximum contents encountered in fresh K-feldspars or muscovites. The alteration of these minerals should result in at least partial dispersion of their Cs content. Further, the internal structure of the clay pods suggests a physically isotropic primary phase; ghost cleavages should be discernible in pseudomorphs after feldspar or mica.

(7) The alteration completely digested the primary mineral at the Buck Claim and Odd West localities but left the adjacent quartz, albite, K-feldspar, and amblygonite intact. Such a selective breakdown at low temperatures is characteristic of pollucite. The only other mineral known to succumb to this type of alteration is petalite (Neuvonen & Vesasalo 1960); however, clay pseudomorphs after petalite display prominent parting inherited from the cleavage of the original mineral.

With pollucite convincingly established as the primary mineral of the clay nodules, the physicochemical character of its breakdown remains to be established. The identity of the alteration products in four Manitoba pegmatites located in different country rocks, surface relief, and drainage conditions suggests that the decomposition was hydrothermal, and probably occurred in the last stages of the pegmatite evolution. This contention is supported by the association of illite-montmorillonite with cesium analcime, adularia, albite, calcite, cookeite, carbonate-apatite and other minerals of a typical hydrothermal alteration assemblage found in the Tanco pegmatite (Černý 1972). Hydrothermal leaching and transport of Cs^+ is particularly promoted in Na^+ and (HCO_3^-) -bearing solutions (Pentcheva 1971), and these components are typically enriched in late pegmatite solutions (e.g., Beus 1960). The near-identical mineralogy of pollucite alteration at Luolamäki, considered hydrothermal by Neuvonen & Vesasalo (1960), is another supporting factor.

However, the hydrothermal character of the pollucite alteration just described cannot be accepted without reservations. W. L. Roberts (pers. comm. 1977) has observed pollucite from the Tin Mountain pegmatite, South Dakota, transforming to montmorillonite after 6 months of exposure to surface conditions. Other pollucites also are sensitive to atmospheric agents (Vlasov 1966). Unfortunately, experimental work on hydrothermal and supergene breakdown of pollucite seems to be non-existent.

CONCLUSIONS

This study shows that clayey pseudomorphs after pollucite can be correctly recognized even in the absence of pollucite relics. Location in the pegmatite body, structure and mineralogy of the alteration products, and residual Cs contents in the clay assemblage permit the identification, particularly if a comparison is possible with incomplete pollucite breakdown in con-sanguineous pegmatites.

The chance of survival of pollucite in pseudomorph-bearing pegmatite bodies is rather unpredictable, and probably depends on the type of the alteration. If of supergene nature, geomorphic and drainage conditions combined with soil type and vegetation cover should be correlated. If of hydrothermal character, and this is likely the case, the extent and intensity of low-temperature hydrothermal processes are impossible to assess without detailed exploration of the parent pegmatite. In any case, the need to investigate the stability and breakdown products of pollucite in experimental systems is clearly indicated.

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