

## SHORTER COMMUNICATIONS

### MOLYBDENITE POLYTYPES IN THE ROYAL ONTARIO MUSEUM

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When the paper first describing the  $3R$ -polytype of molybdenite appeared (Traill 1963), it seemed reasonable that a study of the collection of molybdenite specimens in the Royal Ontario Museum would produce additional localities for this polytype. Unfortunately this study could not be undertaken for several years owing to other commitments. Since Traill's original description of the  $3R$ -polytype from Yellowknife, N.W.T., Canada, four others have been described from:

Turtschi, Binnatal, Ct. Valais, Switzerland. (Graeser 1963).  
Minas da Panasqueira, Beira Baixa, Portugal. (Clark 1964).  
Inari, Lapland, Finland. (Vorma *et al.* 1966).  
Mont St. Hilaire, Quebec. (Chao *et al.* 1967).

The third paper involved the study of 170 specimens from various localities in Finland, and produced only one  $3R$ -polytype.  $x$ -ray powder patterns of the molybdenite specimens in our collections were prepared, and resulted in the discovery of nine additional localities for the  $3R$ -polytype:

Marble Bay Mine, Renfrew District, British Columbia, Canada;  
Pax International Mine, Powell Twp., Timiskaming Dist., Ontario, Canada;  
Harvey Hill Mine, Lot 17, R.XV, near Broughton, Megantic Co., Quebec, Canada;  
Ivigut, Greenland;  
Zovon, Euganei Mts., Italy;  
Mina La Verde, Neuva Italia, Michoacan, Mexico;  
Transvaal, Republic of South Africa;  
Deep Creek Mts., Utah, U.S.A.;  
Tacharwumchorr, Khibina Tundra, U.S.S.R.

Table 1 summarizes the results of this study.

Takeuchi & Nowacki (1963) derived, on theoretical grounds, four possible polytypes:  $2H_1$  (the regular hexagonal type),  $2H_2$ ,  $3R$  and  $2T$ . The present authors hoped that single crystal precession  $x$ -ray techniques would distinguish between these polytypes. It is possible to distinguish the hexagonal from the rhombohedral type by means of selected single crystal  $x$ -ray photographs, but it is much more practical to do this by  $x$ -ray powder techniques. The search for the  $2T$  and a means of differentiating between  $2H_1$  and  $2H_2$  met with no success.

Examination of our  $x$ -ray powder patterns revealed that the  $2H$ - and  $3R$ -polytypes may occur together, even in the small amount of material

TABLE 1. MOLYBDENITE POLYTYPES IN THE COLLECTIONS OF THE ROYAL ONTARIO MUSEUM, TORONTO, CANADA—A GEOGRAPHICAL LISTING

	Polytypes		R.O.M. Number
	2H	3R	
<b>AUSTRALIA</b>			
New South Wales			
Deepwater	x		M14115
			M9040
			M9060
Kingsgate, near Glen Innes, New England	x		M9061
			M14178
Northern Territory			
Port Darwin Mining District	x		M9521
Queensland			
Wolfram Camp	x		M26343
South Australia			
Yorkes Peninsula	x		M29198
Western Australia			
Mulgine	x		M23361
<b>CANADA</b>			
British Columbia			
Caribou District			
Boss Mountain Molybdenum Mine, Williams Lake	x		M22878
Cassiar District			
Alice Arm, Observatory Inlet	x		M9741
Coast District			
near Pacific	x		M9893
Fiddler Creek Showing, N. of Terrace	x		M28385
Bell Pitman Showing, N. of Usk	x		M28381
Kamloops District			
Tamarack Group, Ashcroft	x		E3634
Mara Showing, Shuswap	x		M28387
3 miles SW of Grand Prairie	x		E3626
Kootenay District			
Deer Park Showing, N of Castlegar	x		M28383
Giant Mine, Rossland	x		E2539
			M20711
Eastern Coxeey Claim, Rossland	x		M27084
Emerald Tungsten Mine, Salmo	x		M25964**
Erie Creek, Salmo District	x		M28384
Lost Creek, Salmo	x		M11369
Molly Mine, Salmo	x		2889
Renfrew District			
Marble Bay Mine		x	E3655
Similkameen District			
near Beaverdell	x		M28386
Stellar Mines, N. of Keremeos	x		M28382
British Columbia, Miscellaneous			
Bulkley Gate	x		M9763
Manitoba			
Falcon Lake District			
Empress Claim	x		M11178
East end of Falcon Lake	x		M11180
Smuggler Claim, Falcon Lake	x		M11181
Gull Claim, Falcon Lake	x		M11389
New Brunswick			
Burnt Hill Brook	x		E3672

TABLE 1 (Continued)

	Polytypes		R.O.M. Number
	2H	3R	
Newfoundland and Labrador			
Fortune Bay, Newfoundland	x		M15109
Rencontre, Fortune Bay, Newfoundland	x		M15059
Labrador	x		M3793
Nova Scotia			
Cape Breton County, Gabarus Bay	x		E3669
Lunenburg County			
Larder Lake, New Ross	x		M9365
Ontario			
Frontenac County			
Kring's Farm, Lot 5, Miller Twp.	x		E3718
Plevna	x		M10006
Lot 2, Conc. 7, Olden Twp.	x		{ M25325**
			{ M25401**
Haliburton County			
Cardiff Twp.	x		M9467
Lot 8, Conc. 22, Cardiff Twp.	x		M20204
Cardiff Uranium Mine	x		M28682
Harcourt Twp.	x		E3619
Lot 3, Conc. I and II, Harcourt Twp.	x		M10020
Lot 3, Conc. 1, Harcourt Twp.	x		{ M20160
			{ M20209
Lot 7 or 8, Conc. II, Lutterworth Twp.	x		M10019
Lot 11, Conc. 15, Monmouth Twp.	x		M9885*
near Wilberforce	x		M9896
Hastings County			
Dyno Mine, Faraday Twp.	x		M29093
Faraday Mine, Bancroft, Faraday Twp.	x		{ M28675
			{ M28706
Lot 8, Conc. 5, Lake Twp.	x		M3785
Monteagle Twp.	x		M10017
Kenora District			
Echo Twp.	x		M21867
NW $\frac{1}{4}$ , S $\frac{1}{4}$ , Lot 8, Conc. 5, Pidgeon Property, Echo Twp.	x		M23988
NW $\frac{1}{4}$ , S $\frac{1}{4}$ , Lot 8, Conc. 5, Pidgeon Property, Echo Twp.	x		M23990
Lot 8, Conc. 5, Echo Twp.	x		M25366
Madsen Red Lake Mines Ltd., Red Lake	x		M22187
Lennox and Addington County			
Lot 5, Conc. 14, Sheffield Twp.	x		E3664
Nipissing District			
Gray's Siding, Timagami	x		E3627
Claim J S 82, near Net Lake Forest Reserve, Timagami	x		M20251
Parry Sound District			
NW of Parry Sound	x		M8533
Peterborough County			
Little Gold Lake, Anstruther Twp.	x		M29196
Rainy River District			
Bag Bay, Shoal Lake, Lake of the Woods	x		E3622*
Gull Lake, near Dryden	x		M9852
near Upper Manitou Lake	x		M9860
Rainy Lake	x		M20474

TABLE 1 (Continued)

	Polytypes		R.O.M. Number
	2H	3R	
Renfrew County			
"Renfrew County"	x		{ M3778
near Renfrew	x		{ M3784
Quilty Mine, Blythfield Twp.	x		{ M18627
Phoenix Mine, Bagot Twp.	x		{ M11726
Zenith Mine, Bagot Twp.	x		{ M19665*
Combermere	x		{ M29127
Craigmont	x		{ E1857
Spain Mine, Lot 31 and 32, Conc. V. Griffith Twp.	x		{ E1858
Lyndoch Twp.	x		{ E3615
Lots 5 and 6, Conc. 8, Lyndoch Twp.	x		{ M13902
Mount St. Patrick, Brougham Twp.	x		{ M10016
Lot 7, Conc. IX, Ross Twp.	x		{ M28997
Lot 22, R. II, Ross Twp.	x		{ E3630*
Lot 22, Conc. II, Ross Twp.	x		{ E3631
Sudbury District			
Bigwood Twp.	x		M28113
Thunder Bay District			
Dorothea Twp.	x		M28431
near Loon, McTavish Twp.	x		9688
Port Coldwell	x		M17448
Timiskaming District			
Pax International Mine, Powell Twp.	x	x	M26861
Victoria County			
Lot 5, Conc. XI, Webber Prospect, Coboconk	x		{ E3645
Lot 5, Conc. 11, Laxton Twp.	x		{ M20157
Lot 1, Conc. A., Somerville Twp.	x		{ M20193
Quebec			
Abitibi East County			
R. X, Lot 62, Malartic Twp.	x		M15748
Lacorne Twp.	x		M16463
R. I, Lot 1, Lacorne Twp.	x		M15749
Gatineau County			
Lot 69, Conc. 4, Egan Twp.	x		E3673
Masham Twp.	x		11749
Kensington Moly Mining Co., Maniwaki	x		M27844
Bear Lake, near Wakefield	x		M28902
Megantic County			
Harvey Hill Mine, Lot 17, R. XV, near Broughton	x	x	M3786
Pontiac County			
Aldfield Twp.	x		E1859
Lot 2, R. III, Aldfield Twp.	x		M3787
Aldfield Twp.	x		M13939
Height of Land Mine, Lake Keewagama	x		E3625
Squaw Lake	x		M10009
Chaput Mine, Breckenridge	x		M10007*
Lake Keewagama	x		M9528
"Pontiac County"	x		{ E3450
			{ M11333
			{ M17316

TABLE 1 (Continued)

	Polytypes		R.O.M. Number
	2H	3R	
Rouville County			
Desourdy's Quarry, St. Hilaire	x	x	M27804
			M28754
		x	M28755
			M28756
Anglo American Mine, Pressiac	x		M29045
Saguenay County			
Romaine, Lower St. Lawrence	x		E3675
Quetachoo-Manicouagan Bay	x		E3683
CHINA			
Shih-ping-Chuan, Tsingten, Chekiang	x		M28828
CZECHOSLOVAKIA			
Krupka, NW Bohemia	x		M23443
Stachlovice, near Vidnava, Silesia	x		M24455
GERMANY			
Altenberg, Saxony	x		M3789
GREENLAND			
Iviglut		x	{ 11757
			M20659
GUYANA			
Watt Mine	x		M24781
ITALY			
Zovon, Euganei Mtns.	x	x	M16794
JAPAN			
Hirase, Shirakawa Village, Ono Gun, Gifu Pref.	x		M23779
Iwagori, Idzuma Province	x		M3797
MALAGASY REPUBLIC			
"Malagasy Republic"	x		M12813
MEXICO			
Mina La Verde, Nueva Italia, Michoacan near Nacozari, Sonora	x	x	M28417
			M26293***
NORWAY			
"Norway"	x		M3796
Iveland	x		M22041****
Engeland Mine, Øvrebø, Vennessla	x		{ M28816
Knaben Mine	x		M28817
			M29195
REPUBLIC OF SOUTH AFRICA			
Rooiberg District, Transvaal	x		M28073
Transvaal (probably Rustenburg)	x	x	M27771
RHODESIA			
Felabusi, Insiza District	x		M13235
SOUTH WEST AFRICA			
"South West Africa"	x		E3256
Otjimboyo, NE of Karibib	x		M13485
SWEDEN			
Uddgruvan Mine, Dalarna	x		M24705
Baggetorp, Ostergotland	x		M24702
UNITED STATES OF AMERICA			
Arizona			
"Arizona"	x		M18844
Mohave County	x		M14896*

TABLE 1 (*Concluded*)

	Polytypes		R.O.M. Number
	2H	3R	
California			
Black Mtn., Sierra Nevada Mtns. near Randsburg	x		E3809**
Garnet Hill, Calaveras County	x		M28578
Colorado			
Climax Mine, Climax, Lake County	x		{ M25239 M28940
Phillipson Level, Climax Mine, Climax, Lake Co.	x		M28753
Maine			
Brunswick	x		{ M3794 M7336
Montana			
Butte	x		M27805
Anaconda Copper Mining Co., Nettie Mine, Butte	x		8536
New Hampshire			
Westmoreland	x		{ M3791 M3792
New Jersey			
Phillipsburg	x		M28752
Pennsylvania			
Frankford Creek Quarries	x		{ M3788 M3790
Utah			
Deep Creek Mts.	x	x	M28853
Little Cottonwood Canyon, Salt Lake Co.	x		M28354
Washington			
Okanagan County	x		E3781
U.S.S.R.			
Tacharwumchorr, Khibina Tundra	x	x	M17165

\*Specimen registered as molybdate + molybdenite.

\*\*Specimen registered as powellite + molybdenite.

\*\*\*Specimen registered as scheelite + molybdenite.

\*\*\*\*Specimen registered as thortveitite + molybdenite.

required for such a pattern. Intensity differences occur between the 3R lines and the 2H lines. Thus the amounts of the polytypes present vary within a single specimen and also from specimen to specimen from the same locality. Because of this intimate mixture of polytypes, it is difficult to derive any genetic implications from these studies.

Because it is impossible to distinguish molybdenite from tungstenite by x-ray diffraction (Gait & Mandarino 1970), it is intended that all specimens reported here will be analyzed for tungsten and molybdenum.

The authors would like to acknowledge the long hours spent by Mrs. Ruth Gallant in preparing the x-ray powder patterns used for this study. Some of the later patterns were produced by Mr. Alberto Hurtado and Mr. Joel Grice. The latter also assisted one of us (RIG) in the single crystal study which was supported partly by a grant (to RIG) from the Department of University Affairs of the Province of Ontario.

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## POLYTYPES OF TUNGSTENITE

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Tungstenite (WS<sub>2</sub>) is isotypic with molybdenite and, to date, only two localities are known. X-ray powder data for material from the Emma Mine, Salt Lake County, Utah, are given by R. B. Ferguson in Berry & Thompson (1962), and for material from Crevola d'Ossola, Italy, by Graeser (1963).

Table 1 lists the pertinent portions of the x-ray powder diffraction data of molybdenite-2H, molybdenite-3R, and tungstenite (all from Graeser, 1963); tungstenite (Berry & Thompson, 1962); and tungstenite-3R (calculated). It is quite clear that the Italian tungstenite described by Graeser is the 2H-polytype. Although the Utah tungstenite was indexed as a 2H-polytype in Berry & Thompson (1962), the existence of the two broad bands indexed as *d*(103) and *d*(105) led Graeser to speculate on the possibility that the Utah tungstenite might be, in fact, the 3R-polytype. Through the kind cooperation of Professor R. B. Ferguson, the