

Geological Survey of Canada

RHENIUM AND OTHER PLATINUM-GROUP METALS IN PORPHYRY DEPOSITS

Commission géologique du Canada

W. David Sinclair, lan R. Jonasson, Rod V. Kirkham and Art E. Soregaroli



McMillan, 2005).



and other petroleum products. Rhenium is also used in tungsten-rhenium and molybdenum-rhenium alloys, which have a diversity of applications such as electrical contacts, flashbulbs, heating elements, thermocouples, vacuum tubes and x-ray tubes and targets. In recent years, the demand for rhenium has increased, in part due to supply disruptions, and prices have risen as high as US\$10,000 per kg. It is currently the sixth most expensive traded metal (Table 1).

Table 1. The ten most expensive traded metals (19 March 2009)

No.	Element	Price in \$/kg	Price in \$/oz
1	Rhodium	35,365	1,100
2	Platinum	35,043	1090
3	Gold	30,540	950
4	Iridium	12,380	385
5	Osmium	12,217	380
6	Rhenium	7,500	233
7	Ruthenium	6,400	199
8	Palladium	2,570	80
9	Germanium	920	29
10	Hafnium	800	25

Source: Lipmann Walton & Co. Ltd. (www.lipmann.co.uk)

Industrial Sources of Rhenium

magmatic-hydrothermal processes and in one notable and apparently unique be transported by low-temperature hydrothermal and diagenetic processes and concentrated in anoxic sediments such as highly carbonaceous black shales The average rhenium content of sediment-hosted copper deposits at Dzhezkazgan in Kazakhstan and in the Kupferschiefer of Poland and Germany ranges from 1 to 21 ppm and these deposits are currently the second most important source of rhenium. Rhenium is also recovered as a byproduct from in situ leaching of sandstone-hosted uranium deposits in Uzbekistan.

Samples and Analytical Methods

Samples for this study were collected from active mines as well as from mineral deposits and occurrences. From active mines, mill concentrates of molybdenite were obtained whenever possible. For other deposits and occurrences, including drill core, by hand picking coarse grains or by bench-scale floatation concentration. In the case of deposits for which molybdenite concentrates could panning were analyzed. Samples were analyzed for Re and Mo, and in many cases Au and other elements, by neutron activation. The reliability of neutron activation analysis for Re and Mo in particular has been affirmed by several different laboratories yielding results within ±10% on selected reference samples. localities, will be included in a GSC open file report to be released in 200 (Jonasson et al., in prep.). The results for BC and Yukon porphyry deposits are summarized here in Table 2

Geological Survey of Canada

rphyry Cu and Cu-Mo de	eposits	in the H	ighland V	alley dist	trict									
hlehem-Huestis	1	417				0.37			1.4	0.4	0.005	0.012	0.035	80
:hlehem-lona	1	1015			1	1.12			29.5	0.52	0.006	0.012	0.102	87
:hlehem-JA ¹	4	222	200	246					260	0.43	0.017	0.01	0.063	25
hmont - East Pit	1	530			1	0.5			123	0.25	0.024	0.004	0.212	10.4
hmont - West Pit	2	157	137	176	2	0.6	0.2	0.9	15	0.15	0.05	0.004	0.131	3
nex	1	345			1	0.4	0.1	1.1	460	0.404	0.014	0.006	0.081	29
ley	1	294			1	1.5			791	0.44	0.0067	0.006	0.033	66
rphyry Cu deposits														
tface	1	59			1	0.3			308	0.37	0.0072		0.007	51
raltar	4	443	238	750	2	2.7	0.5	4.84	935	0.29	0.006		0.044	48
anisle	4	526	522	528	4	0.8	0.6	1	171.2	0.43	0.005	0.13	0.044	86
ckleberry	2	253	247	258	2	0.4	0.37	0.5	73.4	0.49	0.014	0.04	0.059	35
and Copper	2	1784	1704	1863	2	1.5	1.0	1.9	600	0.338	0.0088	0.19	0.262	38
unt Washington	2	1066	608	1524	2	0.7	0.3	1.1	0.389	1.07				
	1	746			1	1.9			64	0.34	0.016		0.199	21
rphyry Cu-Mo deposits														
rg	4	152	67	215	4	1	0.5	1.8	238	0.39	0.031	0.06	0.079	12.6
enda	12	115	95	145	12	2.4	8.0	8.5	181.7	0.152	0.037	0.013	0.071	4.1
sh ²	2	92	54	129					36	0.28	0.021		0.032	13.3
sino ²	4	197	65	289					559	0.25	0.025		0.082	10
ggie	1	643			1	0.88			181.4	0.28	0.029		0.311	9.7
l Fort	1	159			1	16				0.21	0.024		0.064	8.8
naft Creek ³	1	590							1393	0.25	0.019	0.18	0.187	13.2
sap	1	130			1	0.5			1.5	0.155	0.045		0.098	3.4
iting Creek	4	92	13	172	4	0.4	0	0.96	123.5	0.062	0.025		0.038	2.5
rphyry Cu-Au deposits														
x West	1	3161			1	6			365	0.31	0.005	0.2	0.263	62
nson Slope	1	180			1	7.48			79	0.17	0.006	0.44	0.018	28
erbelle	1	1620			1	25			78.2	0.329	0.002	0.17	0.054	165
mess South ⁴	2	3858	3106	4609					213	0.22	0.008	0.65	0.514	28
chell (Sulphurets)	2	7590	7012	8170	2	13.1	10.9	15.4	734	0.18	0.005	0.69	0.633	36
seko (Empress)	1	154			1	0.1			10	0.61		0.79		
rphyry Mo deposits														
anac	4	12	8	22	4	0.4	0.19	0.54	143.7	0.001	0.059		0.012	0.02
iclimax (Crazy Fox)	4	54	9	96	3	0.4	0.07	1.02						
ss Mountain	7	80	49	157	4	0.3	0.11	0.68	63		0.074		0.099	
rmi	3	58	10	139	3	1.9	0.71	4.09	20.7		0.064		0.062	
ssiar Moly	2	9	3	14	1	0.7			12.2		0.026		0.004	
dako 1	12	35	15	67	12	0.44	0.11	1.75	600	0.002	0.07		0.041	0.03

Rhenium is one of the most widely dispersed elements in the earth's crust. Its abundance in most rocks is measured in parts per billion or less and minerals in which rhenium is a major constituent are rare. Rhenium is concentrated by occurrence at Kudriavy volcano in the Kuril arc, rhenium is actively deposited as Tessalina et al., 2008). Rhenium is similar geochemically to molybdenum and is levels in excess of 4% Re (e.g., Melfos et al., 2001). Molybdenites with the deposits, particularly porphyry copper deposits (e.g., Berzina et al., 2005), and

©Her Majesty the Queen in Right of Canada 200

Deposit Re ppm Au ppm n Ave Min Max n Ave Min Max Size (Mt)* Cu% Mo% Au g/t Re g/t** Cu/Mo

y Cu and Cu-Mo d	eposits	in the Hi	ghland V	alley dist	trict									_
m-Huestis	1	417	2006			0.37			1.4	0.4	0.005	0.012	0.035	80
m-lona	1	1015			1	1.12			29.5	0.52	0.006	0.012	0.102	87
m-JA ¹	4	222	200	246					260	0.43	0.017	0.01	0.063	25
t - East Pit	1	530			1	0.5			123	0.25	0.024	0.004	0.212	10.4
t - West Pit	2	157	137	176	2	0.6	0.2	0.9	15	0.15	0.05	0.004	0.131	3
	1	345			1	0.4	0.1	1.1	460	0.404	0.014	0.006	0.081	29
	1	294			1	1.5			791	0.44	0.0067	0.006	0.033	66
y Cu deposits														
	1	59			1	0.3			308	0.37	0.0072		0.007	51
	4	443	238	750	2	2.7	0.5	4.84	935	0.29	0.006		0.044	48
	4	526	522	528	4	0.8	0.6	1	171.2	0.43	0.005	0.13	0.044	86
erry	2	253	247	258	2	0.4	0.37	0.5	73.4	0.49	0.014	0.04	0.059	35
opper	2	1784	1704	1863	2	1.5	1.0	1.9	600	0.338	0.0088	0.19	0.262	38
ashington	2	1066	608	1524	2	0.7	0.3	1.1	0.389	1.07				
	1	746			1	1.9			64	0.34	0.016		0.199	21
y Cu-Mo deposits														
	4	152	67	215	4	1	0.5	1.8	238	0.39	0.031	0.06	0.079	12.6
	12	115	95	145	12	2.4	8.0	8.5	181.7	0.152	0.037	0.013	0.071	4.1
	2	92	54	129					36	0.28	0.021		0.032	13.3
	4	197	65	289					559	0.25	0.025		0.082	10
	1	643			1	0.88			181.4	0.28	0.029		0.311	9.7
	1	159			1	16				0.21	0.024		0.064	8.8
reek ³	1	590							1393	0.25	0.019	0.18	0.187	13.2
	1	130			1	0.5			1.5	0.155	0.045		0.098	3.4
Creek	4	92	13	172	4	0.4	0	0.96	123.5	0.062	0.025		0.038	2.5
y Cu-Au deposits														
st	1	3161			1	6			365	0.31	0.005	0.2	0.263	62
Slope	1	180			1	7.48			79	0.17	0.006	0.44	0.018	28
е	1	1620			1	25			78.2	0.329	0.002	0.17	0.054	165
South ⁴	2	3858	3106	4609					213	0.22	800.0	0.65	0.514	28
(Sulphurets)	2	7590	7012	8170	2	13.1	10.9	15.4	734	0.18	0.005	0.69	0.633	36
Empress)	1	154			1	0.1			10	0.61		0.79		
y Mo deposits														
	4	12	8	22	4	0.4	0.19	0.54	143.7	0.001	0.059		0.012	0.02
x (Crazy Fox)	4	54	9	96	3	0.4	0.07	1.02						
untain	7	80	49	157	4	0.3	0.11	0.68	63		0.074		0.099	
	3	58	10	139	3	1.9	0.71	4.09	20.7		0.064		0.062	
									1					

0.067 12.247 0.09 0.162 75.3 0.07 0.065 0.027 1.08 187 0.10 0.065

2 **61** 13 109 1 **0.15**

¹ Schindler, J.N., 1975, Rhenium and osmium in some Canadian ores by neutron activation analysis; unpub. Ph.D. thesis, McMaster University, Hamilton,

²Selby, D. and Creaser, R.A., 2001, Late and mid-Cretaceous mineralization in the northern Canadian Cordillera: constraints from Re-Os molybdenite dates

Bender, M.R., McCandlish, K., Gray, J. and Hyppa, R., 2007, Preliminary economic assessment on the development of the Schaft Creek Project located in ⁴ Duuring, P., Rowins, S.M., McKinley, B.S.M., Dickinson, J.M., Diakow, L.J., Kim, Y.-S. and Creaser, R.A., 2009, Magmatic and structural controls o porphyry-style Cu-Au-Mo mineralization at Kemess South, Toodoggone District of British Columbia, Canada; Mineralium Deposita, published online

Rhenium in Molybdenite from Porphyry Deposits

Porphyry W-Mo deposits

including relatively low values such as 180 ppm Re (Bronson Slope) and 154 2070 ppm Re in the Pebble West deposit in Alaska

Molvbdenites from porphyry Cu deposits have Re contents that range from 59 ppm (Catface) to more than 1500 ppm Re at Mount Washington and as high as produced about 27 t Re (Perelló et al., 1995). In foreign porphyry Cu deposits, ppm at Cerro Verde (Peru) and to more than 4000 ppm at Kounrad (Kazakhstan and Morenci (Arizona).

porphyry Cu and Cu-Au deposits. In BC and Yukon deposits, the range from is from 13 ppm Re (Whiting Creek) to 590 ppm Re in the Schaft Creek deposit. deposits range from 3 ppm Re (Dexing, China) up to 2000 ppm at Bingham (Kirki, Melitena and Maronia) have exceptionally high Re contents These are the highest recorded contents of Re in molybdenite and are atypical

0.06 0.061

42.9 0.12 0.130

163 0.031 0.011

Endako samples that contained 204 to 397 ppm Re. These appear to represent a including a run-of-the-mill concentrate, that ranged from 15 to 67 ppm Re and Tolmin, Washington). There appears to be no significant difference in the R poor deposits such as Endako (35 ppm Re), although molybdenite in one sample from the Quartz Hill deposit in Alaska contained 149 ppm Re. Mount Tolmin, with the highest Re-in-molybdenite content (182 ppm), also contains appreciable copper (0.09% Cu); Lasmanis and Utterback (1995) consider it to be a hybric deposit with characteristics of both Climax-type porphyry Mo deposits and

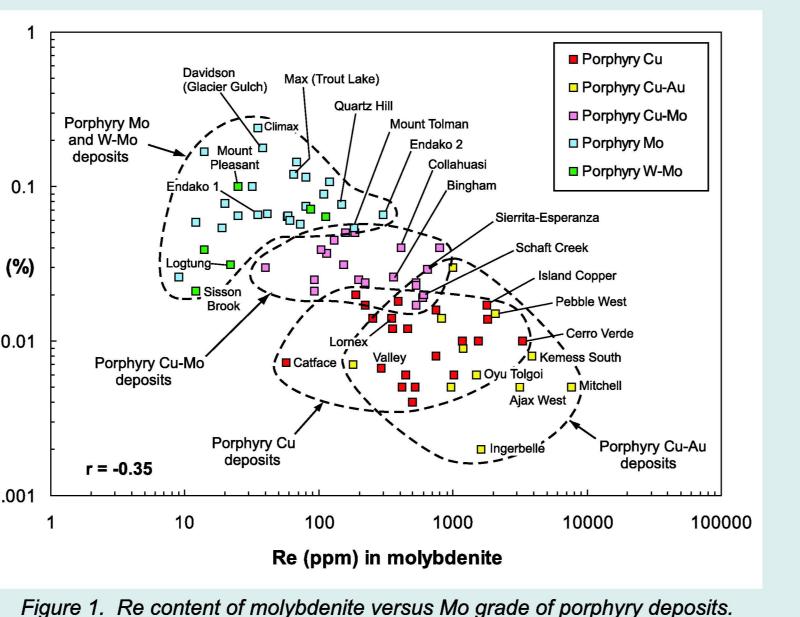
molybdenites from porphyry Mo deposits. For example, at Logtung (Yukon) the from 6 ppm Re (Sisson Brook, New Brunswick) to 190 ppm Re (Lake George, New Brunswick). Rhenium content in molybdenites from foreign porphyry W-Mo deposits ranges from 11 ppm Re (Mount Mulgine, Australia) to 115 ppm Re (Koktenkol, Kazakhstan).

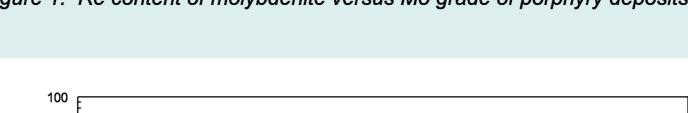
Variation in Re and Au Contents of Molybdenite

grade of the deposit decreases. The plot of Re content in molybdenite versus Cu/Mo content of the deposits (Fig. 2) shows a positive correlation of about the same magnitude. These plots show that the Re content of molvbdenite is highest in copper-rich porphyry deposits that have lowest

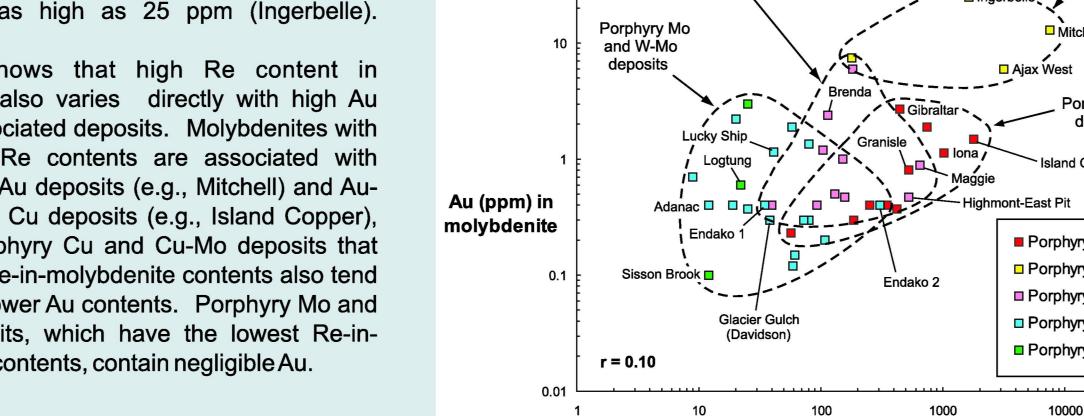
In addition to concentrating Re, molybdenite in porphyry deposits also concentrates Au to a degree that reflects the gold content of the deposit. Figure 3 shows that molybdenites from porphyry Mo and W-Mo deposits, which have low contents of Re, generally have low Au contents of less than 1 ppm Au, although they range up to 4 ppm Au (e.g., Storie Moly). Molybdenites from porphyry Cu-Au deposits and Au-rich porphyry Cu deposits have Au contents that range from 1.9 ppm (Island Copper) to as high as 25 ppm (Ingerbelle).

Figure 4 shows that high Re content molybdenite also varies directly with high Au grade in associated deposits. Molybdenites with the highest Re contents are associated with porphyry Cu-Au deposits (e.g., Mitchell) and Auwhereas porphyry Cu and Cu-Mo deposits that have lower Re-in-molybdenite contents also tend to have the lower Au contents. Porphyry Mo and W-Mo deposits, which have the lowest Re-inmolybdenite contents, contain negligible Au.

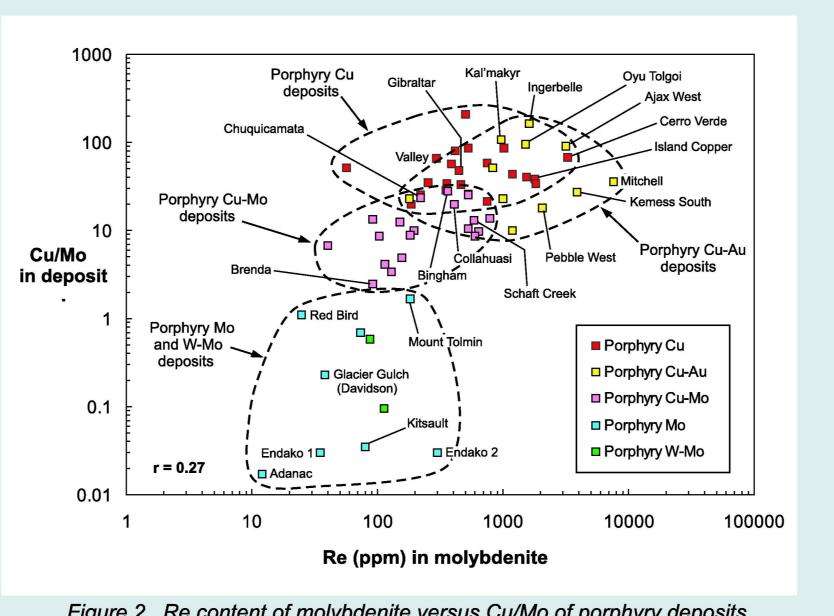


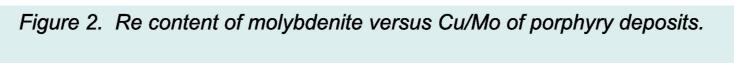


Porphyry Cu-Mo deposits



Re (ppm) in molybdenite Figure 3. Re content of molybdenite versus Au content of molybdenite in





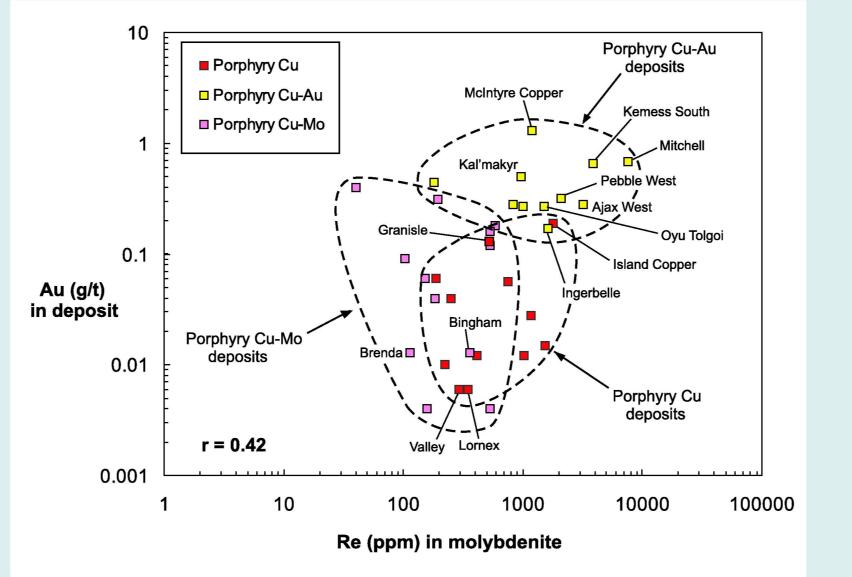


Figure 4. Re content of molybdenite versus Au grade of porphyry deposits.

Porphyry Cu deposits

Analyses of Pt and Pd in molybdenite and in copper concentrates

Figure 5 shows that molybdenites from porphyry deposits can concentrate platinum-group metals, with Pt+Pd content ranging as high as 1214 ppb (Island Copper). However, no obvious correlation exists between Re content and Pt+Pd content (r=0.05) Molybdenites from most porphyry Mo and Cu-Mo deposits have Pt+Pd contents that range from 24 to 200 ppb, except for molybdenite from the Boss Mountain porphyry Mo deposit, which contains 849 ppb Pt+Pd. Molybdenites from porphyry Cu and Cu-Au deposits have Pt+Pd contents similar to those from porphyry Mo and Cu-Mo deposits, with the exception of molybdenite from Island Copper (1214 ppb), Kadjaran (748 ppb) and Aksug (681).

molybdenite. However, they also demonstrate that platinum-gro

Spatial and Temporal Variations in Re Distribution

Temporal variations in Re distribution may also present. For example, in the Kitsault porphyry Mo deposit, molybdenites from four successive mineralizat stages increased in Re content from 36 to 129 ppm (Giles and Schilling, 1972). At the Endako porphyry Mo deposit, Selby and Creaser (2001) recognized two periods of molybdenum mineralization, the first characterized by a Re content of 20.0 ppm, and the second by molybdenites containing 6.5 to 38.4 ppm Re. mineralization at Endako and are similar in Re content to the majority of our samples from Endako that averaged 35 ppm Re (Endako 1 in Table 2). Three 397 ppm) suggest that a third stage of mineralization may be present.

Highland Valley district, British Columbia

different deposits in the Highland Valley district in south-central British Columbia. In the Highland Valley district, porphyry Cu and Cu-Mo deposits are related to the border of the batholith inward (Fig. 7). Mineralization episodes in the batholith are associated with subvolcanic breccias and porphyry dike swarms and appear which is associated with a large porphyry dike and minor breccia, and the Lornex deposit, which is associated with an aplitic stock that intruded near the contact of has a relatively low Re content (294 ppm), despite the fact that the deposit has a the Bethlehem and Guichon phases, is ambiguous but considered to be slightly relatively high Cu/Mo value (74.6). deeper than that of the Highmont deposit (McMillan, 2005).

1200 □ Porphyry Cu-Au

Highland Valley Phase TRIASSIC COUNTRY ROCK Nicola Group (1015) ppm Re in molybdenite

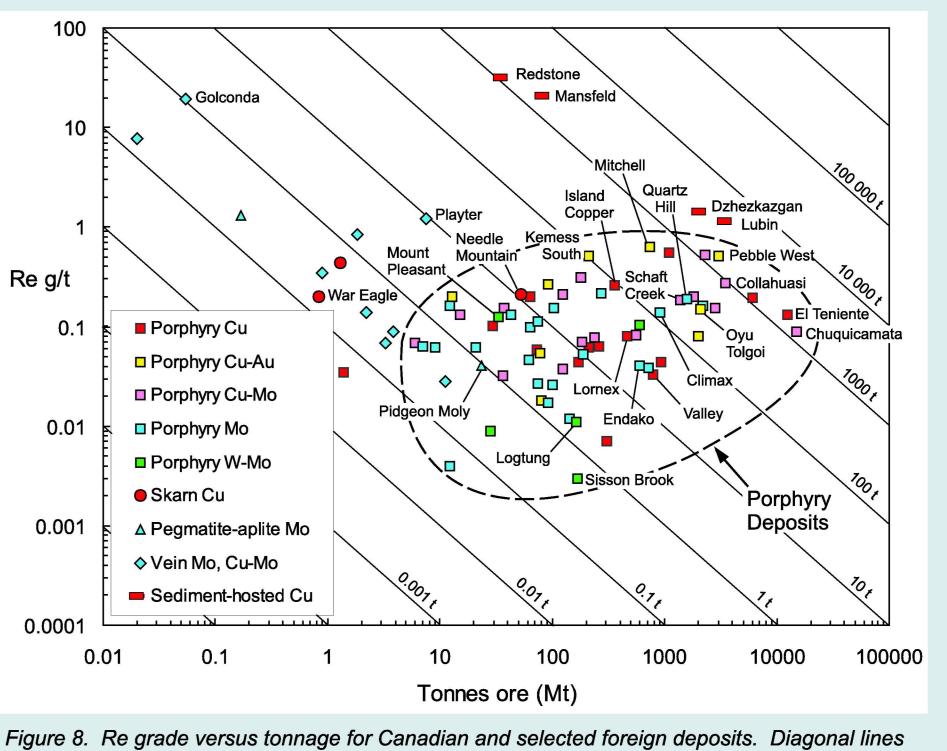
to 1015 ppm Re, typical of most porphyry Cu and Cu-Mo deposits (Table 2), and nolybdenite content (Fig. 7). Deposits related to the Bethsaida phase have lower Cu/Mo values and their molybdenites generally have lower Re contents in the range from 157 ppm to 530 ppm Re.

the Bethsaida phase exhibit lower Re-in-molybdenite values that decrease with increasing depth of the deposit, from Highmont (530 ppm Re) to Valley (294 ppm deposit, which formed at the deepest level and latest in the crystallization history

Grade-Tonnage Characteristics of Re in Porphyry Deposits

the Re in a deposit is taken up by molybdenite, the less molybdenite in a deposit, the higher its Re content, and vice versa.

approximately 27 t was recovered. Large porphyry Mo deposits contain comparable Endako deposit prior to mining was on the order of 25 t Re, although no production of



Acknowledgements

Samples for this study were contributed

numerous colleagues, including Wes Johnson,

Andre Panteleyev, Nick Carter, Bruce

personnel and many others. Samples were

also obtained from archival collections of the

National Mineral Collection of Canada.

Samples were prepared by Patrice Lavergne of

the GSC, who devised and carried out floatation

procedures for molybdenite and other sulphide

concentrates on several hundred bulk samples.

Neutron activation analyses for Re, Mo, Cu and

Au were performed by Novatrack Analysts

Limited, UBC Campus; Chemex Laboratories

Ltd., Mississauga, ON; and Becquere

Laboratories, Mississauga, ON. Analyses for

Pt, Pd and Au were carried out by Conrad

Gregoire, GSC and by Neutron Activation

graciously provided unpublished Re data or

Services Ltd., Toronto, ON. Holly St

rhenium content of other sulfides is typically on the order of parts pe billion or less. Rhenium grades calculated for BC-Yukon porphyry deposits are included in Table 2 and rhenium grades versus tonnages o these and other Canadian deposits, and selected foreign deposits, are

References

Brenan, J.M., 2008, The platinum-group elements: "Admirably adapted for science and industry": Elements, v. 4 Economou-Eliopoulos, M., 2005, Ch.10., Platinum group element potential of porphyry deposits: in Mungall, J.E., ed., Exploration for Deposits of Platinum Group Elements: Mineralogical Association of Canada, Short Course Faramazyan, A.S., Kalinin, S.K. and Terekhovich, S.L., 1970, Geochemistry of Pt group elements in the ores of Cu-Mo deposits of Armenia: Doklady Earth Science Sections, v. 190, Issues 1-6, p. 220-221. Giles, D.L. and Schilling, J.H., 1972, Variation in rhenium content of molybdenite: Report of the 24th Session, International Geological Congress, vol. 24, no. 10, p. 145-152. Jonasson, I.R., Sinclair, W.D., Kirkham, R.V. and Soregaroli, A.E., Rhenium distribution in Canadian mineral deposits: Geological Survey of Canada, Open File Report (in prep.). Korobeinikov, A.F., Grabezhev, A.I. and Moloshag, V.P., 2002, The behaviour of Pt, Pd, Au during the formation

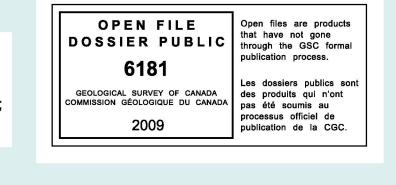
Berzina, A.N., Sotnikov, V.I., Economou-Eliopoulos, M., and Eliopoulos, D.G., 2005, Distribution of rhenium in molybdenite from porphyry Cu-Mo and Mo-Cu deposits of Russia (Siberia) and Mongolia: Ore Geology Reviews,

AcMillan, W.J., 2005, Porphyry Cu-Mo deposits of the Highland Valley District, Guichon Creek Batholith, British Lasmanis, R. and Utterback, W.C., 1995, The Mount Tolman porphyry molybdenum-copper deposit, Ferry

Canadian Institute of Mining, Metallurgy and Petroleum, Special Volume 46, p. 718-731. Melfos, V., Voudouris, P., Arikas, K., and Vavelidis, M., 2001, Rhenium-rich molybdenites in Thracian porphyry Cu±Mo occurrences, NE Greece: Bulletin of the Geological Society of Greece, v. 34, p. 1015-1022 (in Greek

Perelló, J.A., Fleming, J.A., O'Kane, K.P., Burt, P.D., Clarke, G.A., Himes, M.D., and Reeves, A.T., 1995, orphyry copper-gold-molybdenum deposits in the Island Copper cluster, northern Vancouver Island, British Columbia, in Schroeter, T.G., ed., Porphyry Deposits of the Northwestern Cordillera of North America, Canadian nstitute of Mining, Metallurgy and Petroleum, Special Volume 46, p. 214-238. Selby, D. and Creaser, R.A., 2001, Re-Os geochronology and systematics in molybdenite from the Endako porphyry molybdenum deposit, British Columbia, Canada; Economic Geology, v. 96, p. 197-204. Sotnikov, V.I., Berzina, A.N., Economou-Eliopoulos, M. and Eliopoulos, D.G., 2001, Pd, Pt and Au distribution in

corphyry Cu + Mo deposits of Russia and Mongolia: Ore Geology Reviews, v. 18, p. 95-111. arkian, M. and Koopmann, G., 1995, Platinum group minerals in the Santo Tomas II (Philex) porphyry Cu-Au leposit, Luzon Island, Philippines: Mineral.Deposita, v. 30, p. 39-47. essalina, S.G., Yudovskaya, M.A., Chaplygin, I.V., Birck, J.-L. and Capmas, F., 2008, Sources of unique rhenium enrichment in fumaroles and sulphides at Kudryavy volcano: Geochemica et Cosmochimica Acta, v. 72,



Rhenium and the platinum-group elements have many properties in Table 3. Pt and Pd contents of molybdenite and Cu concentrates from Canadian and foreign porphyry deposits common, in particular a strong affinity for metallic or sulphide

Variation in Re and Platinum-Group Metal Contents of Porphyry Deposits

phases, and they are grouped together with gold as the highly siderophile elements (Brenan, 2008). It should not be surprising therefore, that porphyry deposits with high contents of rhenium might also be enriched in platinum-group metals.

from Canadian deposits are presented in Table 3, along with comparable analyses from foreign deposits reported in the literature. These data have been used to calculate minimum Pt and Pd contents in ore. Variations between Re and Pt+Pd in molybdenite and between Re in molybdenite and Pt+Pd in ore are shown in Figures 5 and 6

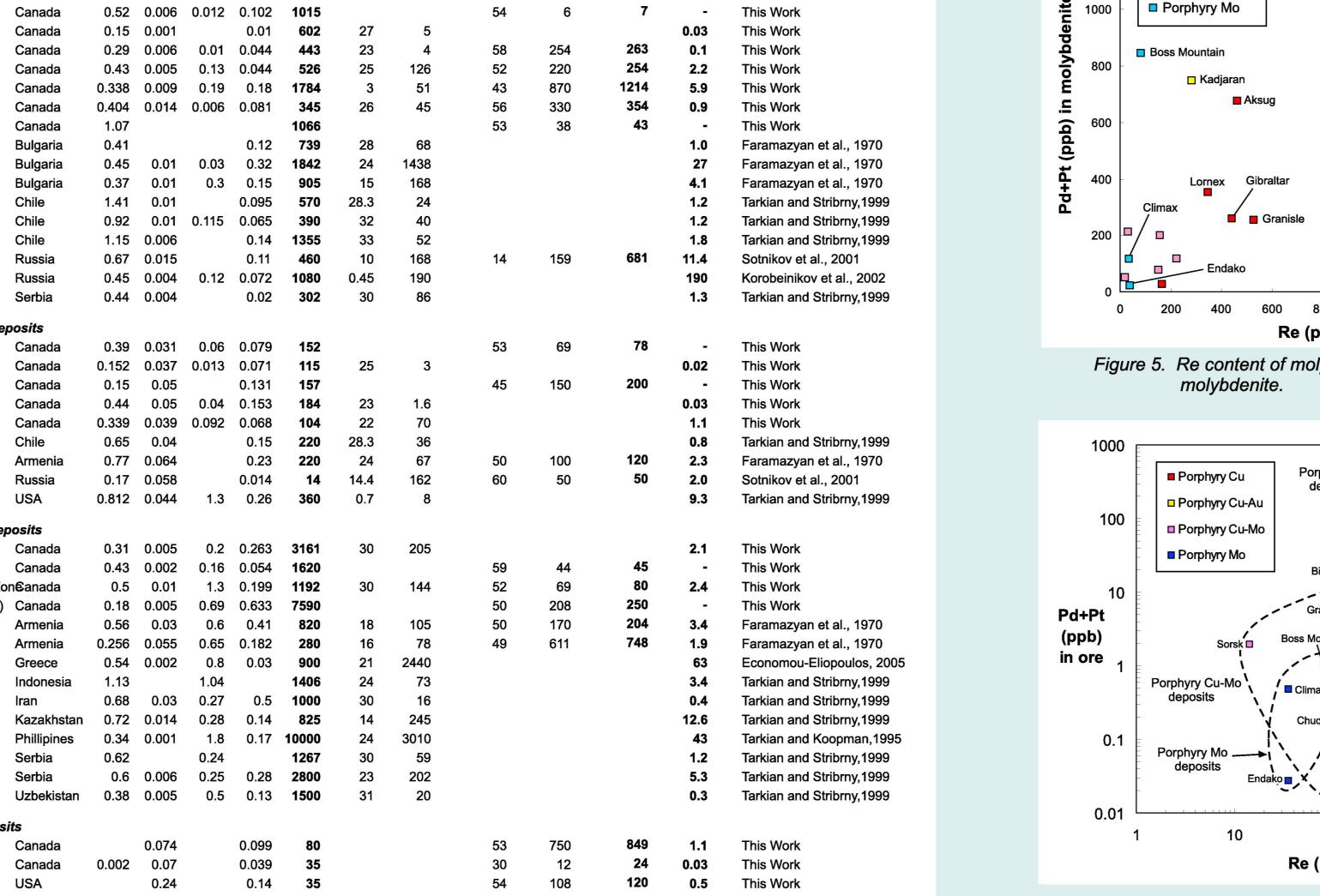
Much better correlation exists between Re content of molybdenite and overall Pt+Pd grade of the deposit (r=0.20). Figure 6 shows that porphyry Mo and Cu-Mo deposits have lower Pt+Pd contents, ranging from 0.03 ppb (Endako) to 2.3 ppb (Dastakert), whereas porphyry Cu and Cu-Au deposits have Pt+Pd contents that range from 0.03 ppb (Don Rouyn) to as high as 190 ppb (Tominskoe). Figures 5 and 6 reflect the fact that platinum-group metals are sequestered primarily in copper sulphides, rather than in metals, like Au, are concentrated in porphyry deposits along with Re and that high contents of Re in molybdenite can be an indicator of

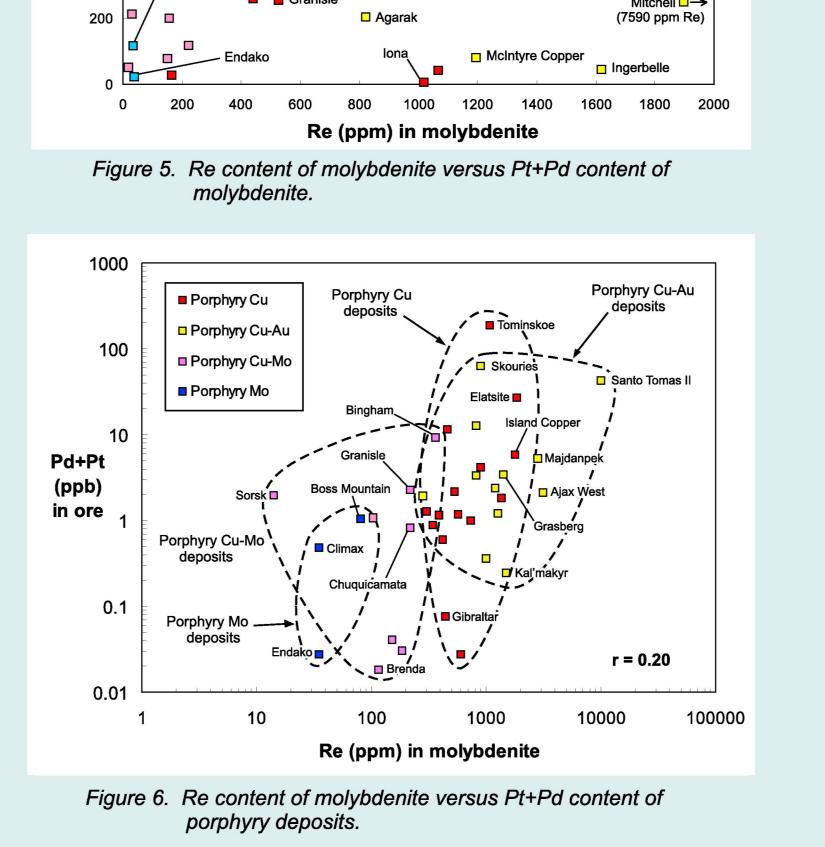
0.6 This Work **1.0** Faramazyan et al., 1970 27 Faramazyan et al., 1970 **4.1** Faramazyan et al., 1970 1.2 Tarkian and Stribrny, 1999 1.2 Tarkian and Stribrny, 1999 1.8 Tarkian and Stribrny, 1999 **681 11.4** Sotnikov et al., 2001 190 Korobeinikov et al., 2002 1.3 Tarkian and Stribrny, 1999 0.02 This Work 0.03 This Work 1.1 This Work **0.8** Tarkian and Stribrny, 1999 **120 2.3** Faramazyan et al., 1970 0.014 **14** 14.4 162 60 50 **50 2.0** Sotnikov et al., 2001 2.1 This Work 63 Economou-Eliopoulos, 200 3.4 Tarkian and Stribrny,1999 **0.4** Tarkian and Stribrny, 1999 12.6 Tarkian and Stribrny,1999 43 Tarkian and Koopman, 1995 1.2 Tarkian and Stribrny,1999 Majdanpek Serbia 0.6 0.006 0.25 0.28 **2800** 23 202 **5.3** Tarkian and Stribrny,1999 Kal'makyr (Almalyk) Uzbekistan 0.38 0.005 0.5 0.13 **1500** 31 20

*Pt+Pd content of molybdenite concentrate normalized to 60% Mo (stoichiometric Mo content of molybdenite

Re-moly Cu concentrate Mo concentrate Pd+Pt in Pd+Pt in

ppm % Cu Pd+Pt ppb % Mo Pd+Pt ppb moly ppb* ore ppb





Rhenium in Other Types of Deposits

of rhenium after porphyry deposits. The rhenium content of deposits such as Dzhezkazkan (Kazakhstan) and in the Kupferschiefer of Poland and Germany ranges from 1 to 21 ppm Re. The Re appears to be concentrated in sulphide- and organic-rich sections that also carry elevated levels of platinum group metals. Our analyses of samples from Redstone (NWT) and other sediment-hosted copper deposits and occurrences in Canada indicate that comparable levels of Re are present and suggest that Re should not be overlooked as a potential byproduct.

Other types of deposits Mo-bearing deposits that also contain rhenium include skarns, vein and pegmatite-aplite deposits. The Re content of molybdenite from skarn deposits ranges as high as 521 ppm Re in the War Eagle deposit in the Whitehorse Copper Belt and 759 ppm Re in the Mountain skarn Cu deposit of Gaspé Copper contains 353 to 371 ppm

Rhenium content of molybdenites from vein deposits is generally less than 300 ppm Re. Two notable exceptions are the Golconda Cu-Mo vein in British Columbia, which has Re contents in molybdenite that range from 1095 to 1335 ppm Re, and the Playter Mo vein in Ontario, which has molybdenite containing 200 to more than 900 ppm Re

Sinclair, W.D., Jonasson, I.R., Kirkham, R.V., and Soregaroli, A.E.

