

## APPENDIX 2

### CHARACTERISTICS OF COMMON ORE MINERALS

**TABLE A2.1 The Common Ore Minerals in Order of Increasing Minimum Reflectance (in Air) at 546 nm**

Mineral	R%	Mineral	R%
<i>Reflectance Between 1 and 10%</i>			
Graphite	6.2–26.4	Chalcophanite	9.1–27.0
Covellite	6.6–23.7	Scheelite	9.8–10.2
Coffinite	7.9– 8.0		
<i>Reflectance Between 10 and 20%</i>			
Graphite	6.2–26.4	Psilomelane	~15–30
Covellite	6.6–23.7	Wolframite group	15.2–16.3
Chalcophanite	9.1–27.0	Columbite-tantalite	15.3–17.4
Scheelite	9.8–10.1	Ulvöspinel	15.5
Valleriite	10.3–20.5	Goethite	15.5–17.5
Cassiterite	10.7–12.2	Hausmannite	16.3–20.2
Zincite	11.1–11.3	Ilmenite	16.4–19.2
Lepidocrocite	11.6–18.4	Sphalerite	16.6
Chromite	13.5	Braunite	18.9–19.9
Uraninite	13.6	Molybdenite	19.5–38.5
Manganite	14.1–20.5	Magnetite	19.9
Brannerite	15.0–15.1		
<i>Reflectance Between 20 and 30%</i>			
Graphite	6.2–26.4	Alabandite	22.8
Covellite	6.6–23.7	Orpiment	23.0–27.5

**TABLE A2.1 (Continued)**

Mineral	R%	Mineral	R%
<i>Reflectance Between 20 and 30% (Continued)</i>			
Chalcophanite	9.1–27.0	Famatinite	24 –27.4
Valleriite	10.3–20.5	Enargite	24.2–25.2
Manganite	14.1–20.5	Proustite	24.2–27.7
Psilomelane	~15–30	Maghemite	24.4
Mackinawite	16.2–40.4	Cinnabar	24.7–29.7
Hausmannite	16.3–20.2	Stannite	26.0–27.3
Delafossite	18.4–22.1	Hematite	26.4–29.9
Molybdenite	19.5–38.5	Cuprite	26.6
Rutile	19.7–23.1	Stromeyerite	26.6–30.9
Tenorite	20.4–27.5	Mawsonite	26.9–29.7
Jacobsite	21.1	Idaite	27 –33.6
Bornite	21.7	Stephanite	28.1–30.4
Digenite	21.9	Pyrrargyrite	28.5–30.3
Realgar	22.1	Pyrolusite	29.0–40.0
Bixbyite	22.2	Freibergite	33.0
<i>Reflectance Between 30 and 40%</i>			
Mackinawite	16.2–40.4	Stibnite	31.1–48.1
Molybdenite	19.5–38.5	Miargyrite	31.6–34.5
Stephanite	28.1–30.4	Tetrahedrite	32.5
Pyrrargyrite	28.5–30.3	Chalcocite	33.2–33.4
Pyrolusite	29.0–40.0	Cubanite	35.4–39.4
Pearcite	29.1–32.2	Pyrrhotite	36.3–43.4
Tennantite	30.1	Jamesonite	36.4–44.2
Berthierite	30.3–42.3	Bismuthinite	37.1–49.0
Polybasite	30.7–32.5	Boulangerite	37.4–41.8
Nickeloan pyrite "bravoite"	~31–54	Chalcostibite	37.8–43.7
Acanthite	31.0	Breithauptite	37.8–48.0
<i>Reflectance Between 40 and 50%</i>			
Mackinawite	16.2–40.4	Carrollite	42.9
Pyrolusite	29.0–40.0	Galena	42.9
Berthierite	30.3–42.3	Chalcopyrite	44.6–45.0
Bravoite	~31–54	Kobellite	44.8–47.2
Stibnite	31.1–48.1	Violarite	45.3
Pyrrhotite	36.3–43.4	Nickeline	46.1–51.4
Jamesonite	36.4–44.2	Pentlandite	46.5
Bismuthinite	37.1–49.0	Siegenite	46.7
Boulangerite	37.4–41.8	Ullmannite	47.3
Chalcostibite	37.8–43.7	Maucherite	48.4–49.6
Breithauptite	37.8–48.0	Marcasite	49.1–56.2
Cosalite	41.4–45.7	Linnaeite	49.5

**TABLE A2.1 (Continued)**

Mineral	R%	Mineral	R%
<i>Reflectance Between 50 and 60%</i>			
Nickeloan pyrite "bravoite"	~31-54	Sylvanite	52.5-63.0
Nickeline	46.1-51.4	Löllingite	53.4-55.5
Marcasite	49.1-56.2	Safflorite	54.1-54.6
Glaucodot	50.0-50.6	Gersdorffite	54.7
Millerite	50.2-56.6	Tetradymite	54.8-60.5
Cobaltite	50.6	Skutterudite	55.2
Arsenic	51.7-55.7	Rammelsbergite	56.8-60.9
Pyrite	51.7	Iron	58.1
Arsenopyrite	51.8-52.2	Pararammelsbergite	58.9-59.7
		Bismuth	59.8-67.2
<i>Reflectance Over 60%</i>			
Sylvanite	52.5-63.0	Platinum	69.7
Tetradymite	54.8-60.5	Allargentum	~70
Rammelsbergite	56.8-60.0	Antimony	74.4-77.9
Bismuth	59.8-67.2	Gold	77.0
Dyscrasite	60.1-62.8	Silver	93.3
Copper	64.6		

**TABLE A2.2 Examples of Common Ore Minerals Arranged in Order of Increasing Minimum Vickers Microhardness (at 100g Load)**

Mineral	VHN	Mineral	VHN
<i>VHN from 1 to 100</i>			
Molybdenite	8-100	Jamesonite	66-86
Graphite	12-16	Proustite	70-105
Bismuth	16-18	Arsenic	72-173
Orpiment	22-58	Cosalite	74-161
Acanthite	23-26	Mackinawite	~74-181
Tetradymite	25-76	Copper	79-99
Stphanite	26-124	Cinnabar	82-156
Stromeyerite	30-32	Chalcocite	84-87
Stibnite	42-153	Digenite	86-106
Realgar	47-60		(001 section)
Antimony	50-69	Bornite	87-100
Gold	53-58	Miargyrite	88-130
Galena	59-65	Boulangerite	92-125
Silver	60-65		

**TABLE A2.2 (Continued)**

Mineral	VHN	Mineral	VHN
<i>VHN from 101 to 200</i>			
Stephanite	26-124	Sphalerite	138-160
Stibnite	42-153	Stannite	140-326
Proustite	70-105	Pyrolusite	146-243
Arsenic	72-173	Dyscrasite	153-179
Cosalite	74-161	Sylvanite	154-172
Mackinawite	~74-181	Mawsonite	166-210
Cinnabar	82-156	Berthierite	168-228
Digenite	86-106	Idaite	176-260
Miargyrite	88-130	Pearcite	180-192
Boulangerite	92-125	Chalcocopyrite	181-203
Kobellite	100-117	Chalcopyhanite	188-253
Pyrrargyrite	107-144	Tenorite	190-300
Iron	110-117	Millerite	192-376
Bismuthinite	110-136	Cuprite	193-207
Covellite	128-138		
<i>VHN from 201 to 300</i>			
Stannite	140-326	Coffinite	230-302
Pyrolusite	146-243	Pyrrhotite	230-409
Mawsonite	166-210	Alabandite	240-251
Berthierite	168-228	Columbite-tantalite	240-1,021
Idaite	176-260	Violarite	241-373
Chalcocopyrite	181-203	Cubanite	247-287
Chalcopyhanite	188-253	Freibergite	263-340
Tenorite	190-300	Pentlandite	268-285
Millerite	192-376	Chalcostibite	283-309
Cuprite	193-207	Enargite	285-327
Psilomelane	203-813	Tennantite	294-380
Zincite	205-221	Platinum	297-339
Famatinite	205-397		
<i>VHN from 301 to 400</i>			
Stannite	140-326	Chalcostibite	283-309
Millerite	192-376	Enargite	285-327
Psilomelane	203-813	Tennantite	294-380
Famatinite	205-397	Platinum	297-339
Coffinite	230-302	Tetrahedrite	312-351
Pyrrhotite	230-409	Wolframite group	319-390
Columbite-tantalite	240-1,021	Niccolite	363-372
Violarite	241-373	Scheelite	383-464
Freibergite	263-340		

**TABLE A2.2 (Continued)**

Mineral	VHN	Mineral	VHN
<i>VHN from 401 to 500</i>			
Psilomelane	203-813	Delafossite	412-488
Pyrrhotite	230-409	Breithauptite	412-584
Columbite-tantalite	240-1,021	Hausmannite	437-572
Scheelite	383-464	Linnaeite	450-613
Lepidocrocite	402 (av.)	Uraninite	499-548
Maghemite	412 (av.)		
<i>VHN from 501 to 600</i>			
Psilomelane	203-813	Siegenite	503-525
Columbite-tantalite	240-1,021	Carrollite	507-586
Breithauptite	412-584	Ilmenite	566-698
Hausmannite	437-572	Ullmannite	592-627
Linnaeite	450-613	Rammelsbergite	630-758
Uraninite	499-548		
<i>VHN from 601 to 700</i>			
Psilomelane	203-813	Manganite	630-743
Columbite-tantalite	240-1,021	Rammelsbergite	630-758
Linnaeite	450-613	Goethite	667 (av.)
Ilmenite	566-698	Nickeloan pyrite	668-1,535
Ullmannite	592-627	("bravoite")	
Skutterudite	606-824	Pararammelsbergite	681-830
Maucherite	623-724	Brannerite	690 (av.)
<i>VHN from 701 to 800</i>			
Psilomelane	203-813	Nickeloan pyrite	668-1,535
Columbite-tantalite	240-1,021	("bravoite")	
Skutterudite	606-824	Pararammelsbergite	681-830
Maucherite	623-724	Arsenopyrite	715-1,354
Manganite	630-743	Jacobsite	720-813
Rammelsbergite	630-758	Safflorite	792-882
<i>VHN from 801 to 900</i>			
Psilomelane	203-813	Pararammelsbergite	681-830
Columbite-tantalite	240-1,021	Arsenopyrite	715-1,354
Skutterudite	606-824	Safflorite	792-882
Rammelsbergite	630-758	Gersdorffite	844-935
Nickeloan pyrite	668-1,535	Löllingite	859-920
("bravoite")		Rutile	894-974

**TABLE A2.2 (Continued)**

Mineral	VHN	Mineral	VHN
<i>VHN from 901 to 1,000</i>			
Columbite-tantalite	240-1,021	Bixbyite	946-1,402
Nickeloan pyrite ("bravoite")	668-1,535	Hematite	1,000-1,100
Arsenopyrite	715-1,534	Glaucodot	1,097-1,115
Gersdorffite	844-935	Cassiterite	1,168-1,332
Rutile	894-974	Chromite	1,278-1,456
Braunite	920-1,196	Marcasite	1,288-1,681
Cobaltite	935-1,131	Pyrite	1,505-1,620