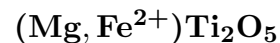


**Armalcolite**

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**Crystal Data:** Orthorhombic. *Point Group:*  $2/m\ 2/m\ 2/m$ . As subhedral to anhedral grains, to 300  $\mu\text{m}$ .**Physical Properties:** Hardness = [ $< 5$ ] (less than ilmenite).  $D(\text{meas.}) = 4.94$   
 $D(\text{calc.}) = 4.64$ **Optical Properties:** Opaque. *Color:* Gray to tan in reflected light. *Luster:* Metallic.  
*Optical Class:* Biaxial. *Pleochroism:* Observed. *Anisotropism:* Strong; pale gray to dark bluish-gray.  
 $R_1$ – $R_2$ : (450) 14.1–15.2, (470) 14.0–15.0, (500) 13.8–14.7, (520) 13.7–14.5, (546) 13.4–14.4, (586) 13.3–14.3, (620) 13.2–14.2, (640) 13.0–14.1**Cell Data:** *Space Group:*  $Bbmm$ .  $a = 9.743(30)$   $b = 10.023(20)$   $c = 3.738(30)$   $Z = 2$ **X-ray Powder Pattern:** Tranquillity Base, Moon.  
3.468 (100), 1.958 (80), 2.763 (25), 2.454 (25), 2.235 (15), 2.199 (15), 2.414 (10)

Chemistry:	(1)		(2)	
	(1)	(2)	(1)	(2)
TiO <sub>2</sub>	72.0	76.2	FeO	14.7
Al <sub>2</sub> O <sub>3</sub>	1.48	1.65	MnO	0.07
V <sub>2</sub> O <sub>5</sub>	0.07		MgO	8.7
Cr <sub>2</sub> O <sub>3</sub>	1.94	0.34	CaO	0.32
			Total	99.28
				99.2

(1) Tranquillity Base, Moon; by electron microprobe, total Fe as FeO; corresponds to  $(\text{Mg}_{0.46}\text{Fe}_{0.44}^{2+}\text{Al}_{0.06}\text{Cr}_{0.06}\text{Ca}_{0.01})_{\Sigma=1.03}\text{Ti}_{1.92}\text{O}_5$ . (2) Disko Island, Greenland; by electron microprobe, total Fe as FeO; corresponds to  $(\text{Mg}_{0.49}\text{Fe}_{0.32}^{2+}\text{Al}_{0.07}\text{Mn}_{0.02}\text{Cr}_{0.01})_{\Sigma=0.91}\text{Ti}_{2.02}\text{O}_5$ .**Occurrence:** Formed typically at low pressures and high temperatures; in Ti-rich basalts and microbreccias of lunar samples; in salic volcanics; rarely in granite pegmatite; in ultramafic rocks, lamproites, kimberlites; in terrestrial impact craters; in inclusions in a carbonaceous chondrite.**Association:** Ilmenite, Fe–Ti oxides, iron, graphite (Disko Island, Greenland); phlogopite, analcime, diopside (Smoky Butte, Montana, USA); rutile, ilmenite (Kimberley, South Africa).**Distribution:** From Mare Tranquillitatis at Tranquillity Base; the Taurus-Littrow site; and the Descartes site, Moon. In the Knippa quarry, near Uvalde, Uvalde Co., Texas, and at Smoky Butte, near Jordan, Garfield Co., Montana, USA. From the El Toro cinder cone, near San Luis Potosí, Mexico. In the Nördlinger Reis crater, Bavaria, Germany. From Jumilla, Murcia Province, and Cancarix, Albacete Province, Spain. On Disko Island, Greenland. From the Jagersfontein, Bultfontein, and Dutoitspan diamond mines, Kimberley, Transvaal, South Africa. In the Mwenezi area, Zimbabwe. From several undefined localities in Russia, and elsewhere.**Name:** An acronym derived from the last names of Neil Alden ARMstrong (1930–), Edwin Eugene ALdrin (1930–), and Michael COLLins (1930–), the Apollo XI astronauts who collected the type samples.**Type Material:** Lunar Science Institute, Houston, Texas, USA.**References:** (1) Anderson, A.T., T.E. Bunch, E.N. Cameron, S.E. Haggerty, F.R. Boyd, L.W. Finger, O.B. James, K. Keil, M. Prinz, P. Ramdohr, and A. El Goresy (1970) Armalcolite: a new mineral from the Apollo 11 samples. *Geochim. Cosmochim. Acta*, 34, Supp. 1, 55–63. (2) (1970) *Amer. Mineral.*, 55, 2136 (abs. ref. 1). (3) Pedersen, A.K. (1981) Armalcolite-bearing Fe–Ti oxide assemblages in graphite-equilibrated salic volcanic rocks with native iron from Disko, central west Greenland. *Contr. Mineral. Petrol.*, 77, 307–324. (4) Bowles, J.F.W. (1988) Definition and range of composition of naturally occurring minerals with the pseudobrookite structure. *Amer. Mineral.*, 73, 1377–1383. (5) Hayob, J.L. and E.J. Essene (1995) Armalcolite in crustal paragneiss xenoliths, central Mexico. *Amer. Mineral.*, 80, 810–822.

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