

Crystal Data: Tetragonal. *Point Group:* $4/m\ 2/m\ 2/m$. Crystals typically acute dipyramidal {011}, often highly modified; obtuse pyramidal or tabular on {001}; less commonly prismatic on [001], with {110}, {010}, to 3.75 cm. *Twinning:* Rare, on {112}.

Physical Properties: *Cleavage:* Perfect on {001} and {011}. *Fracture:* Subconchoidal. *Tenacity:* Brittle. Hardness = 5.5–6 VHN = 616–698 (100 g load). D(meas.) = 3.79–3.97 D(calc.) = [3.89]

Optical Properties: Transparent when light colored, to nearly opaque when deeply colored. Pyramidal crystals may appear opaque because of total reflection. *Color:* Brown, pale yellow or reddish brown, indigo, black; pale green, pale lilac, gray, rarely nearly colorless; brown, yellow-brown, pale green, blue in transmitted light. *Streak:* White to pale yellow. *Luster:* Adamantine to splendent, metallic.

Optical Class: Uniaxial (–); anomalously biaxial in deeply colored crystals. *Pleochroism:* Weak; stronger in deeply colored crystals. *Absorption:* Commonly $E > O$; may be $O < E$. $\omega = 2.5612$ $\epsilon = 2.4880$ $2V(\text{meas.}) = \text{Small}$.

R_1 – R_2 : (400) 23.7–23.8, (420) 22.4–22.5, (440) 21.7–21.6, (460) 21.1–21.0, (480) 20.7–20.4, (500) 20.2–20.0, (520) 19.9–19.6, (540) 19.6–19.3, (560) 19.4–19.0, (580) 19.2–18.8, (600) 19.0–18.5, (620) 18.8–18.4, (640) 18.7–18.2, (660) 18.6–18.1, (680) 18.5–18.0, (700) 18.4–17.8

Cell Data: *Space Group:* $I4_1/amd$ (synthetic). $a = 3.7845$ $c = 9.5143$ $Z = 4$

X-ray Powder Pattern: Synthetic.

3.52 (100), 1.892 (35), 2.378 (20), 1.6999 (20), 1.6665 (20), 1.4808 (14), 2.431 (10)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
TiO ₂	98.98	98.36	Al ₂ O ₃	0.15		CaO	0.15	
SnO ₂		0.20	Fe ₂ O ₃	0.10	1.11	LOI	0.77	
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						Total	100.15	99.67

(1) Rio Cipo, Minas Gerais, Brazil. (2) Brazil.

Polymorphism & Series: Trimorphous with brookite and rutile.

Occurrence: Usually secondary, derived from other titanium-bearing minerals. In Alpine veins, derived from the enclosing gneisses or schists by hydrothermal solutions. In igneous and metamorphic rocks; in pegmatites; from a carbonatite. A common detrital mineral.

Association: Brookite, rutile, titanite, ilmenite, titanian magnetite, hematite, quartz.

Distribution: A very wide-spread mineral; only a few occurrences can be noted. In Alpine veins at many localities throughout the Swiss, French, and Italian and Tirolian Alps: large crystals from Binn, Valais, and at Cavradi, Tavetsch, Graubünden, Switzerland. From LaGrave, Hautes-Alpes, and Bourg d'Oisans, Isère, France. In Norway, at Kragerø; fine crystals from Hardangervidda, Ullensvang; Slidre, Valdres; and Gudbrandsdalen. From the Khodrovoy Mountains, Sakha, Russia. In the Virtuous Lady mine, Devonshire, England. At Fron Oleu, near Tremadog, Gwynned, Wales. In several carbonatite deposits, aggregating 500 million tons, in Minas Gerais and Pará, Brazil. In the USA, at many localities in Burke Co., North Carolina; Buckingham Co., Virginia; from Quincy, Norfolk Co., Massachusetts; at Placerville, Eldorado Co., California. In Canada, at Sherbrooke Township, Nova Scotia, and in Henvey Township, Ontario.

Name: From the Greek meaning *extension*, for the greater length of the usual pyramid compared with other tetragonal minerals.

Type Material: Natural History Museum, Paris, France.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 583–588. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 40–43. (3) Howard, C.J., T.M. Sabine, and F. Dickson (1992) Structural and thermal parameters for rutile and anatase. Acta Cryst., 47, 462–468. (4) (1969) NBS Mono. 25, 7, 82.

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