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MANGANIAN ANDALUSITE FROM KIAWA MOUNTAIN, RIO ARRIBA COUNTY, NEW MEXICO*

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Abstract

Manganian, ferrian andalusite (viridine) occurs abundantly in kyanite-hematite quartzite of the Precambrian Kiawa Mountain formation at Kiawa Mountain, Rio Arriba County, New Mexico. Its extraordinary pleochroism (golden yellow to emerald green) results from the copresence of $Mn^{+3}(Mn_2O_3=4.5\%)$ and $Fe^{+3}(Fe_2O_3=3.0\%)$. The andalusite apparently formed essentially contemporaneously with the kyanite.

Introduction

In fall of 1952 the writers examined Precambrian rock exposures on the flanks of Kiawa Mountain about 8 airline miles northwest of Petaca, Rio Arriba County, New Mexico (Fig. 1), and discovered in the quartzite bands of a fine-grained bright green mineral which megascopically resembles epidote. Subsequently it was identified as the rare manganian variety of andalusite, usually referred to as viridine, which has been reported from only six other localities in the world.

The writers are indebted to R. W. Deane for separating a sample of the mineral. Professor R. M. Denning kindly checked the absorption spectrum of the mineral. Dr. M. Fleischer of the U. S. Geological Survey generously shared a specimen of viridine from Ultevis, Sweden, and also read the manuscript critically. Costs of thin and polished sections were paid for by the Department of Mineralogy, The University of Michigan. The study of the kyanite deposits of the Petaca district by Corey (1953) was supported by the New Mexico Bureau of Mines and Mineral Resources.

Mangan-andalusite was first found by De Gerr (1889) in the Vestanå district in south Sweden and was described subsequently by Bäckström (1896, 1897). Klemm (1911) found a similar mineral near Darmstadt in Hesse, Germany, and called it viridine. Wülfing (1917) decided viridine was an independent species and not a variety of andalusite. A mineral called gosseletite by Anten (1923) from Salm-Château, Belgium, was later identified as viridine by Corin (1933, 1934). Ödman (1947, 1950) found viridine relatively abundant in metasediments associated with manganese deposits in the Ultevis district, Jokkmokk, northern Sweden. Viridine that occurs at Timptonsk, Yakutia, A.S.S.R., has been

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FIG. 1. Index map of north-central New Mexico, showing location of Kiawa Mountain. One inch equals about 14 miles.

described by Serdyuchenko (1949) and by Shabynin (1950). An occurrence in Lume Valley in the Ruwenzori Massif, Belgian Congo, has been described briefly by Thonnart (1954).

GEOLOGY

The rock that contains the manganian andalusite is an aluminous quartzite, a variety of the rock originally called the Ortega quartzite, a Precambrian unit defined by Just (1937). Generally similar rocks extending south of Kiawa Mountain and underlying La Jarita Mesa were mapped by Just (1937) as the Petaca schist, a subordinate unit within the Ortega, consisting mainly of quartzite and muscovite-quartz schist. The area has been studied by Barker (1958), who was able to subdivide Just's units. The quartzite of Kiawa Mountain is called by Barker the upper quartzite member of the Kiawa Mountain formation, and is the youngest Precambrian metasedimentary unit in the area. Passing west-northwest through Kiawa Mountain is the axis of a major overturned syncline (Kiawa syncline). Foliation on the north side of the mountain strikes generally N. 65–80° W. with dips 70° SW. to vertical. Locally the quartzite banding is highly contorted. Small kyanite-bearing quartz veins are not uncommon on the east and northeast sides of the mountain.

PETROLOGY

The aluminous quartzite is well banded, generally gray-green to buff rock of uniformly fine grain. Variations in composition are marked, even within hand specimens (Fig. 2). Generally quartz or kyanite-quartz bands predominate and are thickest. These may or may not contain green andalusite. Gray quartzose bands commonly contain andalusite abundant enough to be conspicuous megascopically, whereas buff quartzose bands usually are andalusite-free. The gray color results from the presence of kyanite and some hematite. Thus layers of relatively pure quartz or of quartz and muscovite usually do not contain andalusite, whereas hematite-kyanite quartz bands commonly do. A few layers consist of quartz, andalusite, minor hematite, but no kyanite. Locally the gray quartzite contains ellipsoidal augen of white, coarser grained quartz representing deformed pebbles. In some specimens relict cross-bedding may be deciphered (Fig. 2).

Microscopically the rock can be seen to consist of the following main constituents in their approximate order of abundance, although from band to band the percentages vary greatly: quartz, kyanite, green andalusite, muscovite, and specular hematite. Rutile is locally abundant; other accessories are zircon, apatite, hematite, and ilmenite.

Quartz grains are usually very uniform in size, especially within individual bands, averaging between 0.3 to 0.6 mm. in diameter, but in some hematite-rich bands the grains may be considerably smaller, down to 0.1 mm. in average diameter. The grains tend to be slightly elongate,

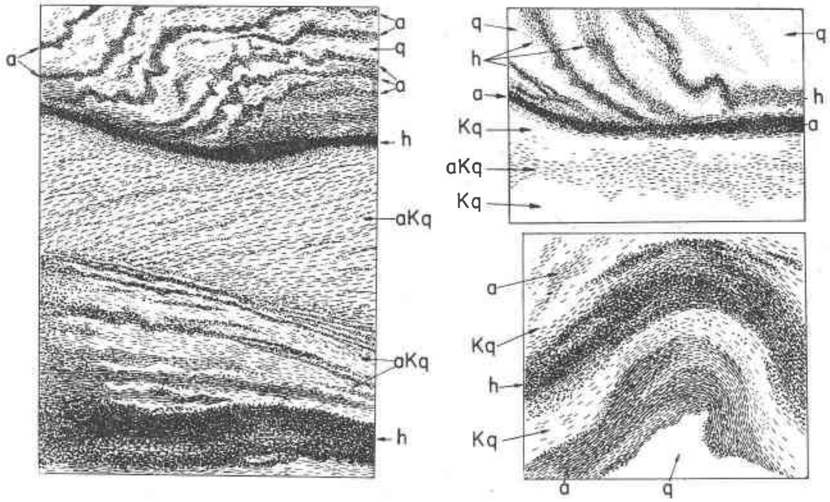

FIG. 2. Mineralogical banding in kyanite-andalusite quartzite, Kiawa Mountain, New Mexico (×0.6). q = quartz, h = hematite, a = andalusite, K = kyanite.

with patterns varying from nearly mosaic to somewhat interlocking. Kyanite is in blades with irregular terminations or in anhedra; inclusions of hematite are common. The blades are poorly oriented.

Andalusite usually forms anhedra or spongy clusters of anhedra peppered with minute inclusions of hematite, rutile and quartz; kyanite is rarely included. In one quartz-muscovite band andalusite appears as minute slender elongated inclusion-free prisms, enclosed in quartz grains, euhedral, and in parallel orientation.

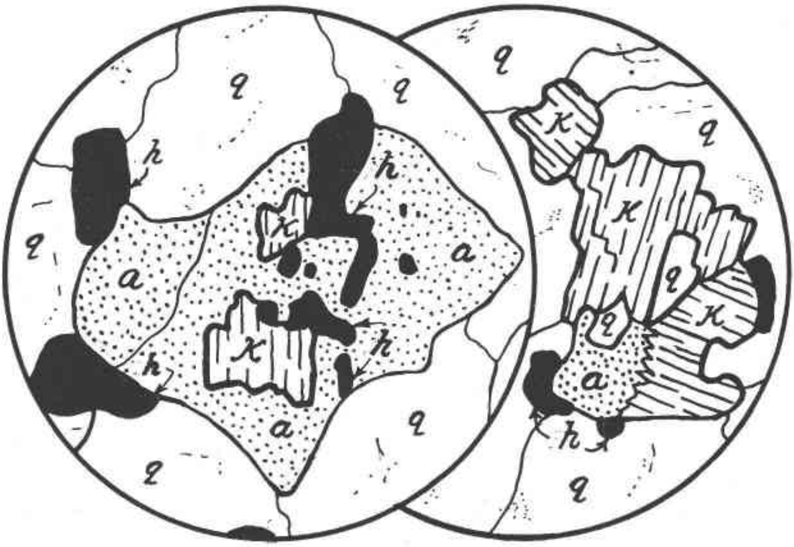

FIG. 3. Andalusite (a)-kyanite (k) intergrowths drawn for thin sections of quartzite, Kiawa Mountain, New Mexico (×80). q=quartz, h=hematite.

Muscovite plates and sheaves, usually along quartz grain contacts, are commonly in subparallel arrangement. Secondary finer-grained muscovite, partly stained by secondary hematite, may replace kyanite preferentially to andalusite.

In iron-rich bands hematite and rutile are closely intergrown. Some rutile is zoned, with red cores and golden yellow margins. Zircon is anhedral to euhedral, with some euhedra showing either concentric zoning (variation in birefringence) or crystallographically oriented opaque inclusions (as in chiastolite).

Generally andalusite and kyanite show no significant textural relationships with respect to each other, but in a very few grains clusters it appears that one may have replaced the other (Fig. 3), but the relations are far from clear. In rare examples subhedral kyanite laths lie decussate across the fabric of an aggregate of andalusite anhedra. Textures indicate that the two species formed throughout essentially the same time period, but that some kyanite may have continued to form after all the andalusite had crystallized. This conclusion is substantiated by the presence of kyanite in veins cutting these rocks.

The kyanite veins of Kiawa Mountain transect the foliation of quartzite that generally may be poor in kyanite and may contain little or no andalusite. These veins, up to about a foot thick and a few feet long, are tabular, lensoid, or sinuous. They contain quartz, with kyanite locally very abundant (10–55%), and small amounts of hematite and secondary pale green muscovite. In kyanite-rich parts the kyanite forms buff to silvery gray blades generally no more than $\frac{3}{4}$ inch long (max. about 2 inches), usually tending to be oriented normal to the sharply defined vein walls or in semi-rosettes or subradial clusters.

TABLE 1. OPTICAL PROPERTIES OF MANGANIAN ANDALUSITE FROM KIAWA MOUNTAINS (A) COMPARED WITH THOSE OF VIRIDINE FROM ULTEVIS, SWEDEN (B) (DATA FROM ÖDMAN, 1950), AND WITH THOSE OF ORDINARY ANDALUSITE (C)

		A	B	C
Pleochroism	α	emerald green	yellowish green	pink
	β	yellow green	emerald green	colorless, pale yellow
	γ	golden yellow	golden yellow	colorless, pale yellow
Indices of refraction			(Na)	
	α	1.649	1.658	1.629–1.640
	β	1.654	1.662	1.633–1.644
	γ	1.662	1.670	1.639–1.647
2V		65–70°	72°	80–85°
Sign		(+)	(+)	(−)
Dispersion		$r<v$, very strong	$r<v$	$r<v$

MANGANIAN ANDALUSITE

The andalusite is an intensely and beautifully pleochroic mineral (Table 1). The colors are somewhat variable from grain to grain, and the intensity of the pleochroism varies even in single grains. This is similar to variations noted by Ödman (1950). It is also in conformity with color variations in ordinary andalusite in which single grains may be uniformly pinkish, or zoned pink-colorless, or contain irregularly distributed patches of color. Other optical properties are listed in Table 1. The interference colors in some orientations are markedly anomalous.

The identification of the mineral as a variety of andalusite is confirmed on the basis of the *x*-ray powder pattern (Table 2).

The preparation of a pure sample for analysis proved exceedingly difficult owing to the very fine inclusions of hematite and to the closely associated kyanite. Separation of a heavy mineral fraction in bromoform was followed by repeated fractionation by means of a Frantz isodynamic separator. Eventually a product was obtained which was estimated microscopically to contain about 6% of species other than andalusite, the chief contaminant being kyanite (about 5%), the rest (about 1%) chiefly hematite and quartz, with a trace of rutile.

Table 2. *X*-Ray Powder Diffraction Data for Manganian Andalusite from Kiawa Mountain (A) and for Andalusite from White Mountain, California (B) (ASTM card II-446)

A		B		A		B	
d	*I*	*d*	*I*	*d*	*I*	*d*	*I*
5.52	9	5.58	7	1.75	3	1.74	2
4.56	10	4.52	10				
3.92	7	3.92	6			1.65	1n
3.52	7	3.49	5	1.59	4	1.59	3
		3.33	4	1.54	4	1.53	4
2.77	9	2.75	9	1.51	1		
2.47	7	2.47	6	1.49	7		
2.38	4	2.35	2	1.48	3	1.47	10
2.35	4					1.42	$\frac{1}{2}$n
2.27	8	2.26	9	1.39	6	1.38	5
2.17	8	2.17	10			1.34	1
1.97	2	1.97	1	1.29	3		
1.95	1			1.28	3	1.28	5n
1.89	2			1.24	5	1.24	5
1.85	2	1.83	2	1.21	1	1.21	2
1.80	3			1.19	1		
1.79	3	1.79	2	1.18	1	1.18	2

This fraction was analyzed by *x*-ray fluorescence (A, Table 3). The magnetic fraction, consisting chiefly of hematite with some rutile, traces of zircon, and appreciable manganian andalusite in grains that are characterized by abundant hematite inclusions, also was analyzed in similar manner (B, Table 3).

All of the Mn probably may be assigned to andalusite, but a small amount of the Fe belongs to included hematite and a very little of the Ti

TABLE 3. ANALYSIS OF MANGANIAN ANDALUSITE CONCENTRATE (A) AND OF MAGNETIC CONCENTRATE (B), KIAWA MOUNTAIN, NEW MEXICO. BY *X*-RAY FLUORESCENCE

	A	*B*
Mn	3.9%	1.3%
Fe	2.7	60.0
Ti	0.8	1.8
Zn	0.02	—
Zr	0.2	0.09
Cu	0.04	
Ni	0.02	
Sr	0.03	
Nb	0.01	
Y	0.02	
Cr	abs.	
V	abs.	

to included rutile. A comparison of the composition of the Kiawa andalusite with those of other green andalusites is presented in Table 4.

DISCUSSION OF COLOR

Many andalusites show faint pleochroism of the type pink to green, and in relatively thick grains the color change may be marked.

The color of the Kiawa andalusite heated in air at 1100° C. for three hours showed no change in hue or intensity upon cooling. Probably both Fe^3 and Mn^3 contribute to the unusual pleochroism of the mineral. Macdonald and Merriam (1938) have described andalusite from Fresno County, California, which in hand specimen varies in color from pale pink to dark reddish violet. The pleochroisms and compositions of their two extreme varieties are:

	Lightest	*Darkest*
α	Nearly colorless	Deep pink
$\beta=\gamma$	Both colorless to very pale	Oil green
Fe_2O_3	0.51%	2.44
FeO	0.60	0.42

TABLE 4. Mn, Fe AND Ti CONTENT OF GREEN ANDALUSITES

	Kiawa Mtn.	Ultevis	Vestanå	Darmstadt
Mn_2O_3	5.6	3.63	6.91	4.77
Fe_2O_3	3.0*	3.4	—	4.16
TiO_2	1.2**	0.07	—	1.04

* Corrected for included hematite.

** Corrected for included rutile.

Both were shown to contain no Ti or Mn spectrographically. Thus it appears that, if Mn is absent, the intensity of the absorption for the α direction increases with increasing Fe^3. With large amounts of Mn present the α direction displays green tints. The absorption spectrum of viridine (Corin, 1934) shows two bands: one between 496–505 mμ at the border between blue and green, the other at 550 mμ at the border between green and yellow. The Kiawa viridine shows an absorption band at 555 ± 5 mμ, but the sensitivity of the apparatus was too low to detect the absorption band in the red. Absorption curves for manganic acetate solutions in phosphoric acid (Kolbe, 1935) show peaks from 520–500 mμ. Some other Mn^3 compounds also are green, *e.g.* $Mn_2(SO_4)_3$, $MnCl_3$, and $MnPO_4 \cdot H_2O$. According to Weyl (1951), Mn^{+3} in silicate glasses shows a strong absorption band with a maximum between 470 and 520 mμ.

The presence of Mn^{+3} in many other silicate species produces a pink coloration, e.g. in pink muscovite and lepidolite (Heinrich and Levinson, 1953) and in piedmontite, thulite, and kunzite (Claffy, 1953).

The viridine from Yakutia is reported by Serdyuchenko (1949) as containing 10.91% MnO, 6.60% Fe_2O_3, and 0.35 TiO_2, and by Shabynin (1948) as containing 7.66% Mn (or 9.89% MnO) and 9.60% Fe_2O_3. It is not known whether the two analyses were made on the same sample, but, if this was the case, the discrepancies are disturbing. If the two analyses represent viridine from different parts of the same deposit, then the differences are less significant. However, both investigators argue that the Mn is present as Mn^{+2}. Serdyuchenko (1949) claims that the color is related only to the Fe^{+3} content because spectrophotometric analysis shows only the absorption characteristics of Fe^{+3} silicates and, since the coloring power of Mn^{+3} generally and by far exceeds that of Fe^{+3} (according to Serdyuchenko), the Mn must be present as Mn^{+2}. These data are inconsistent. First, in silicates the coloring power of Fe^{+3} is usually considerably greater than that of Mn^{+3} (e.g. Heinrich and Levinson, 1953). Second, the andalusite structure is incapable of containing Mn^{+2} in any appreciable amounts; Mn^{+3} and Fe^{+3} may proxy for Al but Mn^{+2} is unlikely both because of differences in ionic size and because of difficulties in compensating for valence differences. Third, the analysis by Serdyuchenko (1949) also shows $CaO+1.61\%$ and $H_2O=1.31\%$, further attesting to the inhomogeneity of the analyzed andalusite.

ISOMORPHISM IN Al_2SiO_5 MINERALS

The three Al_2SiO_5 minerals, andalusite, kyanite, and sillimanite, can be cited as examples of species whose compositions are unusually constant, for silicates. There appears to be essentially no subsitution of Al or other elements for Si in the tetrahedral positions. In sillimanite only very small amounts of Fe^3 have been reported. The kyanite structure appears to be capable of permitting slightly more varied substitutions, with Fe^3, Ti, and even Cr (Ozerov and Bykhover, 1936) reported. Jakob (1937, 1940, 1941) has reported that Na, K, and H_2O may participate as minor constituents in kyanite. Inasmuch as muscovite is commonly intergrown with kyanite or replaces it and since no mention is made of checks on the purity of his analyzed material, Jakob's claim cannot be regarded as verified. Furthermore, new analyses by Henriques (1957) show that Na_2O+K_2O does not exceed 0.06% in pure kyanite. Of the three, andalusite shows by far the greatest variation in properties—indices, 2V, sign, color, and specific gravity, and analyses show that at

TABLE 5. COMPARISON OF THE PARAGENESIS AND ORIGIN OF MANGANIAN ANDALUSITE

Locality	Host Rock	Associated Minerals	Parent Material	Origin
Vestana district, south Sweden (Bäckström, 1896, 1897; Wülfing, 1917)	Quartzose mica schist	Quartz, muscovite. Acc. zircon, garnet	Manganiferous argillaceous sandstone	Low- to medium-grade regional metamorphism
Darmstadt, Hesse, Germany (Klemm, 1911; Wülfing, 1917)	Schistose quartz-rich hornfels	Quartz; psilomelane, piedmontite, muscovite, biotite; acc. apatite, rutile, garnet, hematite		Low-grade contact metamorphism
Salm-Château, Belgium (Anten, 1923; Corin, 1933, 1934)	Manganiferous phyllites	Quartz, hematite, spessartite, ottrelite		Low-grade regional metamorphism
Ultevis, Jokkmokk, Sweden (Ödman, 1947, 1950)	Quartzite, feldspathic quartzite (leptite)	Quartz, microcline, sodic plagioclase, hematite, muscovite, apatite, epidote, tourmaline, zircon, piedmontite, scheelite	Manganiferous argillaceous and feldspathic sandstones and mixed impure clastic and tuffaceous sediments	Low-grade regional metamorphism
	Pegmatitic veinlets cutting leptite	Quartz, microcline, orthopyroxene?, Mn-garnet		
Timptonsk, South Yakutia, A.S.S.R. (Serdyuchenko, 1949; Shabynin, 1950)	Quartzite	Quartz, biotite, feldspar, sillimanite, almandite, rutile, apatite, graphite, magne tite, hematite, chlorite		Medium- to high-grade(?) regional metamorphism associated with sillimanite-cordierite gneisses and magnetite schists
Lume Valley, Ruwenzori Massif, Belgian Congo (Thonnart, 1954)	Quartzite	Quartz, piedmontite, sericite		
Kiawa Mtn., N.M.	Aluminous quartzite	Quartz, kyanite, muscovite, hematite; rutile, zircon	Mn- and Fe-bearing kaolinitic sandstone	Medium-grade regional metamorphism

least as much as about 10% $Fe_2O_3+Mn_2O_3+TiO_2$ may be present. Andalusite has the lowest specific gravity of the three Al_2SiO_5 minerals, and it is expectable that its structure would be the one most able to tolerate the presence in modest amounts of ions other than Al, Si, and O.

Origin

The parageneses of the recorded occurrences of manganian andalusite are summarized in Table 5. The chief and striking difference between the paragenesis of the Kiawa Mountain andalusite and those of the other manganian andalusites is the copresence of abundant kyanite at Kiawa Mountain. Textural relations indicate that here these two minerals were formed essentially together. The rocks of the Petaca area were metaphosed under regional metamorphic conditions whose intensities reached those of the kyanite-staurolite subfacies of the amphibolite facies. From mineral assemblages in rocks elsewhere in the area the rocks achieved equilibrium. Normally under these conditions andalusite, if it were formed earlier at lower temperatures, would not persist. Usually where two or more modifications of Al_2SiO_5 occur together it can be seen that inversions have taken place (see, for example, Hietanen, 1956). Since the composition of the Kiawa andalusite is distinctly modified from that of ordinary andalusite, it is probable that its stability field has been extended over that suggested by Clark et al. (1957), probably toward higher temperatures and pressures, and may overlap the kyanite field. Possibly the formation of the manganian andalusite within the environment normal to kyanite was governed by the availability of trivalent manganese and structurally tolerable ferric iron, and when the supply of manganese was exhausted the kyanite modification remained as the sole stable aluminous phase. Where manganese was not present in the aluminous rocks and the iron remained largely unoxidized, staurolite instead of andalusite was developed along with kyanite. The staurolite rocks contain magnetite instead of hematite.

References

Anten, J. (1923). Le Salmien métamorphic du Sud du Massif Stavelot: *Mém. Acad. Roy. Belgique, Cl. Ser.* **II, 5,** fasc. 3.

Bäckström, H. (1896). Manganandalusit från Vestanå: *Geol. För. Förh.* **18,** 386–389.

——— (1897). Vestanåfältet. En petrogenetisk studie: *Sveriges. Geol. Unders.*, Ser. **C,** No. 168.

Barker, F. (1958). Precambrian and Tertiary geology of Las Tablas Quadrangle, New Mexico: *New Mex. Bur. Mines Min. Res. Bull.* **45.**

Claffy, E. W. (1953). Composition, tenebrescence and luminescence of spodumene minerals: *Am. Mineral.* **38,** 919–31.

Clark, S. P., Sr., E. C. Robertson, and F. Birch (1957). Experimental determination of kyanite-sillimanite equilibrium relations at high temperatures and pressures: *Am. Jour. Sci.* **255,** 628–640.

Corey, A. F. (1953). Kyanite deposits of the Petaca district, Rio Arriba County, New Mexico: *Univ. Michigan Ph.D. Thesis*, 141 pp.

Corin, F. (1933). Identité probable de la gosseletite et de la viridine (mangandalousite). Occurrence de la viridine à Salm-Château: *Ann. Soc. Géol. Belgique* **77,** B 152–157.

——— (1934). Spectre d'absorption de la viridine: *Bull. Soc. Belge Géol.* **44,** 313–315.

De Geer, G. (1889). Beskrivning till Kartbladet "Bäckaslog": *Sver. Geol. Unders. Ser. Aa* No. **103**.

Heinrich, E. Wm., and A. F. Corey (1952). Kyanite deposits near Petaca, New Mexico (abs.): *Am. Inst. Min. Eng. Program, Ind. Min. Divis. Ann. Meet. 1952*, p. 3.

———, and A. A. Levinson (1953). Studies in the mica group; mineralogy of the rose muscovites: *Am. Mineral.* **38,** 25–49.

Henriques, Åke (1957). The alkali content of kyanite. *Ark. Mineral. Geol.* **2(12),** 271–274.

Hietanen, A. (1956). Kyanite, andalusite, and sillimanite in the schist in Boehls Butte-quadrangle, Idaho: *Am. Mineral.* **41,** 1–27.

Jakob, J. (1937). Ueber den Alkaligehalt der Disthene: *Schweiz. Min. Petro. Mitt.* **17,** 214–219.

——— (1940). Über den Chemismus des Andalusits: *Schweiz. Min. Petro. Mitt.* **20,** 8–10.

——— (1941). Chemische und strukturelle Untersuchungen am Disthen: *Schweiz. Min. Petro. Mitt.* **21,** 131–135.

Jahns, R. H. (1946). Mica deposits of the Petaca district, Rio Arriba County, New Mexico: *New Mex. Bur. Mines Mineral Res. Bull.* **25.**

Just, E. (1937). Geology and economic features of the pegmatites of Taos and Rio Arriba counties, New Mexico: *New Mex. Bur. Mines Mineral Res. Bull.* **13.**

Klemm, G. (1911). Über Viridin, eine Abart des Andalusits: *Not.-Bl. Ver. Erdkunde Darmstadt,* **32.**

Kolbe, E. (1935). Über die Färbung von Mineralien durch Mangan, Chrom und Eisen: *Neues Jahrb. Min. BeB.* **69(A),** 183–254.

Macdonald, G. A., and R. Merriam (1938). Andalusite in pegmatite from Fresno County, California: *Am. Mineral.* **23,** 588–594.

Northrop, S. A. (1942). Minerals of New Mexico: *Univ. New Mex. Bull., Geol. Ser.,* **6,** No. 10.

Ödman, O. H. (1947). Manganese mineralization in the Ultevis district, Jokkmokk, North Sweden. Part I: Geology: *Sveriges Geol. Unders.* **41,** No. 6.

——— (1950). Manganese mineralization in the Ultevis district, Jokkmokk, North Sweden. Part 2: Mineralogical Notes: *Sveriges Geol. Unders. Årsbok* **44,** No. 2.

Ozerov, K. N., and N. A. Bykhover (1936). Corundum and kyanite deposits of the Verkhne-Timpton district of the Yakutian A.S.S.R.: *Trans. Centr. Geol. Prosp. Inst. U.S.S.R.* **82,** 106 pp.

Serdyuchenko, D. P. (1949). O sostave i khimicheskoi constitutsii margantsovistykh andaluzitov: Vsesoyuz. Miner. Obshch., Zap. (*Mem. Soc. Russe Mineral.*) **78**(2), 133–135 (*Chem. Abs.* **43,** 6119, 1949).

Shabynin, L. I. (1948). Viridin iz Yakutii: Vsesoyuz. Miner. Obshch., Zap. (*Mem. Soc. Russe Mineral.*) **77**(3), 203–214 (*Chem. Abs.* **44,** 7721, 1950).

Thonnart, Pierre (1954). Découverte de manganandalousite dans le massif du Ruwenzori, au Congo Belge. *Compt. Rendu* **238,** 1140–1141.

Weyl, W. (1951). Coloured glasses: *Soc. Glass Tech. Publ., Sheffield, England.*

Wülfing, E. A. (1917). Der Viridine und seine Beziehung zum Andalusit: *Sitzb. Heidel. Akad. Wiss, Math.-naturw. Kl., Abt. A.*

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