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The largest crystals

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Abstract

No upper limit on the size of crystals is to be expected, but the dimensions and occurrences of the largest known crystals in each of twenty-four categories (nine classes) of minerals are presented and discussed. The largest authenticated crystal of any type is a beryl from Malakialina, Malagasy Republic, being 18 m in length, 3.5 m in diameter, having a volume estimated at 143 m^3 and a mass approximately 380,000 kg.

Introduction

Palache (1923) wrote, "How large can crystals grow? What teacher of mineralogy but has been asked this question many times. He would probably reply that there is no limit but if he tried to tell of the biggest that had been found he would find it difficult to give an exact answer". Among the many improbable tales handed down from student to student is the story of a mysterious locality in the Urals where a quarry was made inside a single feldspar crystal. And yet there may be truth in this, for the undocumented report of such an orthoclase crystal can be traced to Lindgren (1933, p.754). Its size was given by Hurlbut (1968, p.14) thus ". . . in the Ural Mountains a quarry 30 × 30 feet of unknown depth was opened in a single feldspar crystal", and Kostov (1968, p.55) wrote "There are known, . . . orthoclase crystals 10 m × 10 m weighing up to 100 tons, . . ." Regrettably, like many giant crystals it was not accurately measured, so its true dimensions remain unknown.

More than half a century has passed since Palache (1923) published, in this journal, a list of the largest crystals known to him, and wrote "Will not every reader of this magazine supply such data as he possesses?" The plea must have been unheeded for an updated list did not appear, although Spencer (1928), Frondel (1935), and Jahns (1953) subsequently recorded additional data on large crystals of minerals which were of particular interest to them. A more recent appeal (Rickwood, 1976) for such data was also rewarded with little response. An extensive literature search, and a multitude of letters to mineralogists throughout the world, has, however, yielded much data which is presented here for it has never previously been brought together in a single compilation.

The Compilation

How best to present this data has been a problem for a list including every mineral species, such as Palache (1923) commenced to compile, would have been both cumbersome and extremely difficult to produce. Accordingly, this compilation gives (Table 1) the largest known crystals for each of the mineral classes in the classification used by Mason and Berry (1968, p.197). Each of the compositions named in their class titles has been separately listed and the most common minerals—silicates—have been considered by subclasses. In addition, some data for organic minerals are presented.

For each of the twenty-four mineral categories, there are listed in Table 1 the crystals which have the greatest length, the greatest volume, and the greatest mass. Sometimes a single crystal has all three records, but multiple entries for a category have often proved necessary to encompass these and establish the records in that sequence. Additional specimens are also listed whenever a larger crystal has been incompletely documented, or where doubt exists that it is a single crystal. All data are given in SI units with converted measurements being indicated by an asterisk and estimated or calculated parameters being enclosed by parentheses. Converted measurements have been rounded to the nearest cm (or two signifi-

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Table 1. The largest crystals of minerals

CLASS MINERAL, FORMULA & OCCURRENCE	DIMENSIONS (m) 1 x 2 x 3	VOLUME (m^3)	MASS (kg)	ASSUMED DENSITY (g/cm^3)	REFERENCES
1. NATIVE ELEMENTS					
a_1 Kamacite (α-iron alloy) Fe-Ni Gressk, Minsk Oblast, U.S.S.R.	0.92 x 0.54 x 0.23-0.13	(0.038)	303	(7.90)	FESENKOV (1958)
a_2 Gold Au Mother Lode, California, U.S.A.	*0.30 - -	-	-	(19.3)	SINKANKAS (1964,pp.278 280)
a_3 Sulphur S Perticara Mine, Urbino, Italy.	0.225 x 0.165 x 0.11	(<0.0025)	(<5.14)	(2.05)	de MICHELE (Pers. Comm.22.10.79) (Figure 1)
2. SULPHIDES & SULPHOSALTS					
(i)SULPHIDES & RELATED COMPOUNDS					
b_1 Stibnite Sb_2S_3 Yokohi Mines, Ichinokawa, Shikoku Island, Iyo Province, Japan.	0.60 x 0.05 x (0.05)	(0.0015)	(6.95)	(4.63)	WADA (1904,p.21). PALACHE (1923,p.362).
b_2 Stibnite Sb_2S_3 Ichinokawa, Iyo, Shikoku, Japan.	0.585 x 0.057 x 0.048	(0.0016)	(7.41)	(4.63)	HÄNISCH (Pers.Comm. 18.1.50)(Figure 2)
b_3 Galena PbS Great Laxey Mine, Isle of Man, U.K.	*0.25 x 0.25 x 0.25	(0.0156)	(118)	(7.58)	GREG & LETTSOM (1858, p.415). PALACHE (1923,p.362). (Figure 3)
(ii)SULPHOSALTS					
c_1 Tennantite $(Cu,Fe)_{12}As_4S_{13}$ Tsumeb, Namibia	0.30 - -	(0.00318)	(14.7)	(4.61)	PINCH & WILSON (1977,p.33)
c_2 Argyrodite Ag_8GeS_6 Bolivia	0.18 x 0.15 x 0.12	(0.00324)	(20.09)	(6.2)	GUILLEMIN(1964,p.1) (1972, p.115).
3. OXIDES AND HYDROXIDES					
(i) OXIDES					
d_1 Columbite $(Fe,Mn)(Nb,Ta)_2O_6$ Bob Ingersoll Mine, Dike No.1, Black Hills, S.Dakota, U.S.A.	*0.76 x 0.61 x <0.0064	(0.00297)	(15.4)	(5.2)	HANLEY (1953,p.77) PAGE (Pers.Comm. 6.6.80)
d_2 Corundum Al_2O_3 nr.Mica Siding, Transvaal, R.S.A.	0.65 x 0.40 (diam) -	(0.0356)	*152	(3.98)	HALL (1920,p.128, PLATE XXI) PALACHE(1923,p.363) (FIGURE 4.)

cant figures) and calculations of volume and mass have been based on the rounded figures, assuming simple geometrical shapes.

For each crystal, only the original reference is cited unless it is in a rather obscure publication, or a later paper includes additional data. Several measurements have been obtained from the book by Sinkankas (1964), but this author did not cite the data sources so this information could not be verified. Books by Guillemin (1964, 1972) are lists of se-

lected specimens contained in various museum collections and were most useful sources of information. However, occasional discrepancies in dimensions have been noticed between data given by Guillemin and that supplied by curators. In these instances the information provided by museum curators has been preferred. Note that Guillemin (1964) renumbered the pages for each museum so that it is necessary to know the location of the crystal before data can be retrieved.

The crystals recorded here merit inclusion by virture of their size and not their beauty. Indeed many of these large crystals have irregular form and little aesthetic appeal. Very large crystals can be difficult, if not impossible, to accurately measure unless they are completely mined out of their matrix. Seldom would a geologist be present throughout such an operation and so, of necessity, some dimensions may have been obtained from miners. It is also difficult to ascertain that these are single entities and not aggregates of smaller crystals. Hence, unless an author has specifically indicated that the material is a single crystal, there has been a conscious rejection of all data on "masses", "aggregates", "deposits", "shoots", "pods", *etc.*

Notes on entries in Table 1

Almost all of the entries in Table 1 require comment and to avoid an extensive list of footnotes these comments are included in the text. The alphabetic designation signifies the mineral category to which the comment relates, and the subscript numeral indicates the specific entry. Dimensions published in Imperial units have been converted to metric units and are given in parentheses in these notes.

a_1 This specimen is "... a monocrystal hexahedrite ..." being described as "an irregular bowl-shaped mass, with an overall length of 92 cm and a width of 54 cm; it attains a thickness of about 23 cm along the edges but is only 13 cm thick near the center". (Dr. B. Mason, Pers. Comm. 3.1.79).

The density of kamacite was found by Henderson and Parry (1954) to be 7.90±0.02 g/cm^3.

As this is extraterrestrial material, this entry is additional to those of terrestrial minerals.

a_2 Sinkankas (1964, p.280) mentioned "... octahedral plates to 12″ broad ..." (0.30 m) from an unspecified location in California, but the Curator, Mineral Museum, Division of Mines and Geology, State of California, U.S.A. cannot confirm this occurrence. (Mrs. E.M. Learned, Pers. Comm. 28.9.79).

Very large specimens of copper are recorded in the literature (Dana and Brush, 1872, p.15; Hurlbut, 1968, p.156; Murdoch, 1943; Palache *et al.*, 1944, p.101) as having been found in the Copper Range, Keweenaw Peninsula, Michigan, U.S.A. However, Mr. A.Y. Johnstone (Pers. Comm. 20.5.77) noted that these were almost certainly crystal aggregates and the largest of the rare single crystals from the area was only 4.4 × 3.2 × 3.2 cm.

a_3 This crystal (Fig. 1) is in the collection of the Museo Civico di Storia Naturale, Milan, Italy. A sketch supplied by Dr. V. de Michele (Pers. Comm. 22.10.79) gives the listed dimensions which are more accurate than those given by Guillemin (1964, p.1; 1972, p.5) and de Michele (1978, p.42). A small patch of calcite adheres to the sulphur so that the true weight is not known.

Other notable sulphur crystals are:

(i) one 18 cm long from Perticara, Urbino, Italy and kept in the Institute of Mineralogy, Milan, Italy; Guillemin (1964, p.1).

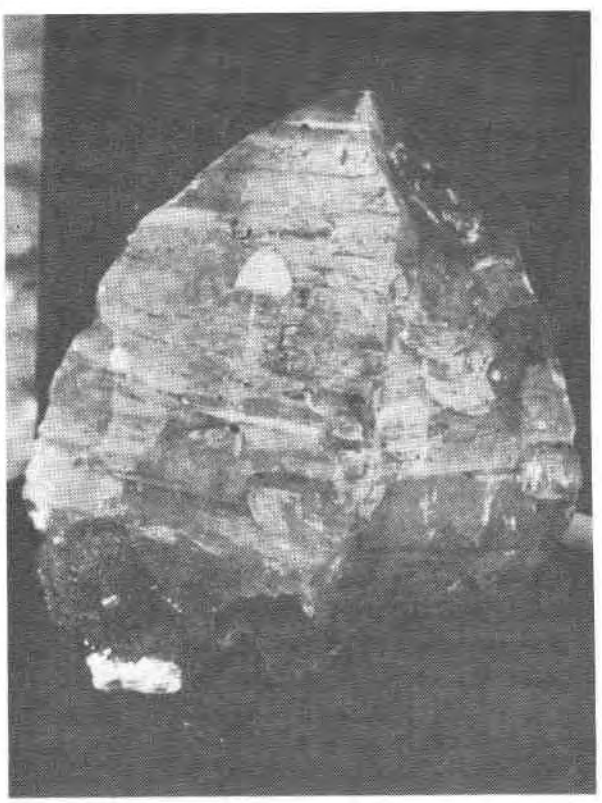

Fig. 1. The largest authenticated (terrestrial) *NATIVE ELEMENT* crystal by length, volume and mass. Sulphur, Perticara Mine, Urbino, Italy. This photograph has been supplied by, and is produced by permission of, Dr. V. de Michele, Museo Civico di Storia Naturale, Milan, Italy (Table 1-a_3).

(ii) ". . . presque parfaits de 15 à 20 cm . . ." from Kuibichev, U.S.S.R. which are in the Fersman Museum, Academy of Sciences, Moscow, U.S.S.R.; Guillemin (1972, p.98).

(iii) specimen 32156a in the American Museum of Natural History, New York, U.S.A. which is broken but still measures 14 × 13 × 8 cm and came from Cianciana, Sicily; Frondel (1935, p.473).

(iv) one 12.70 × 8.89 × 6.35 cm from Maybee Quarry, Monroe County, Michigan, U.S.A. and which is in the Cranbrook Institute of Science, Michigan, U.S.A.; Mr. A.Y. Johnstone (Pers. Comm. 20.5.77).

(v) "Groups de gros cristaux parfait de 10 à 15 cm" from Conil, Cadiz, Spain and kept in the Museum of Natural Sciences, Madrid, Spain; Guillemin (1964, p.1).

Graphite crystals 20 cm long have been reported from unspecified localities in Sri Lanka; Weinschenk (1900, p.292,297), Kostov (1968, p.105).

b_1 One 5 cm dimension is inferred. Note, Wada (1904, p.21) stated ". . . crystals more than 60 cm long were found". This specimen is in the Wada Collection, Central Research Laboratory, Mitsubishi Metal Mining Company, Yonu-Shi, Saitana Prefecture, Japan; it was found in Iyo Province which has since been renamed Ehime Prefecture; Namu (1970, p.152).

b_2 One of a group of crystals (Fig. 2) in the Mineralogisch-Petrographisches Institut, Universität Hamburg, Germany; Dr. M. Hänisch (Pers. Comm. 18.1.80). Guillemin (1972, p.5) reported that the length of the largest of these crystals was 65 cm, but the new measurements do not confirm that size. However, Dr. Hänisch reported that the group had twice been repaired and "may be, the length once was about 65 cm". The next largest crystal is 52 × 2.9 × 3.25 cm.

Other notable crystals of stibnite from this locality are:

(i) a 54 × 7 × 4 cm crystal, specimen 15426 in the Ecole National Superieure des Mines, Paris, France; Guillemin (1964, p.2; 1972, p.27).

(ii) a 42 × 4 × 4 cm crystal in the Museum of the Geological Survey, Pretoria, South Africa (Pers. Comm., The Director, 27.9.77).

(iii) a 40 × 3 cm crystal in the Wada Collection; Guillemin (1972, p.81).

(iv) a 40 cm crystal in the Faculté des Sciences, Paris, France; Guillemin (1964, p.4; 1972, p.43).

A cleavage fragment of orpiment (As_2S_3) from Yakutia, U.S.S.R. in the Fersman Museum, Academy of Sciences of the U.S.S.R., Moscow, U.S.S.R. is 35 × 15 cm; Guillemin (1964, p.2; 1972, p.94–95).

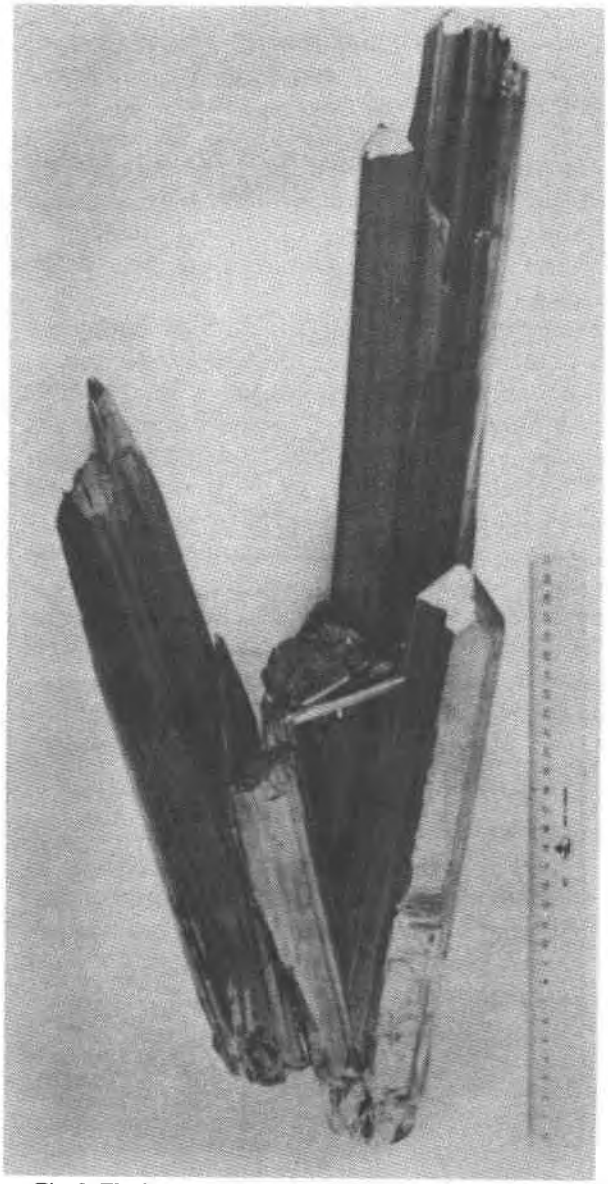

Fig. 2. The largest authenticated *SULPHIDE* crystal by length. Stibnite, Ichinokawa, Iyo, Shikoku, Japan. This photograph was supplied by, and is reproduced by permission of, Dr. M. Hänisch, Mineralogisch-Petrographisches Institut, Universität Hamburg, Germany (Table 1-b_2).

b_3 This specimen (BM 61213) is in the British Museum (Natural History), London. Figure 3.

The Fersman Museum, Academy of Sciences, Moscow, U.S.S.R., has a cube of pyrite 25 × 18 × 15 cm from Aktchitao, Kazakhstan, U.S.S.R. (Guillemin, 1964, p.4; 1972, p.98), and the Institute of Mineralogy, Heidelberg, Germany has a pyritohe-

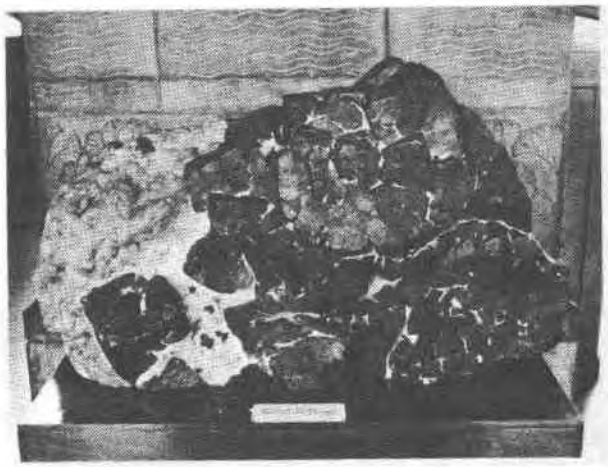

Fig. 3. The largest *SULPHIDE* crystal by volume and mass. Galena, Great Laxey Mine, Isle of Man, U.K.—(composite cubo-octahedra up to 25 cm, specimen BM 61213). Photograph reproduced by permission of the British Museum (Natural History), London (Table 1-b_3).

dron of pyrite 20 cm (in diameter?) from Rio Marina, Elba, Italy (Guillemin, 1964, p.1).

c_1 This was stated to be a set of "tetrahedral crystals up to 30 cm on an edge"—Pinch and Wilson (1977, p.33) and a perfectly symmetrical shape has been assumed. This is probably specimen 428 of the Kegel Collection which is now part of the Roebling Collection of the Smithsonian Institution; White (1977, p.51)—although the latter stated the size as 12″ × 12″ (30 × 30 cm) with a 6″ (15 cm) tetrahedron.

c_2 This is specimen C51 in the Cranfield Collection of the Smithsonian Institution, Washington, U.S.A. (Guillemin, 1972, p.115).

Other notable sulphosalt crystals are:

(i) Tetrahedrite ($Cu_{12}Sb_4S_{13}$) from a mine at Irazein, Ariège, France. A tetrahedral crystal with edges 15 cm in length and a mass of 2.6 kg is in the museum of the University of Paris (Sorbonne), Paris, France (Dr. P. Bariand, Pers. Comm. 28.11.80); it was photographically documented by Bariand and Bariand (1976, p.90–1).

(ii) Proustite (Ag_3AsS_3) from Schneeberg, German Democratic Republic. A specimen mined in 1936 is reputed (Dr. P. Bancroft, Pers. Comm. 17.7.79) to include a well terminated crystal 5 in. × 3 in. (12.7 × 7.62 cm); it is in The Bergakademie, Freiberg, German Democratic Republic. Guillemin (1964, p.4) reported that this academy had a proustite crystal, 8 cm × 3 cm, from Nieder Schlemma, Saxony, Germany.

In his book, Bancroft (1973, p.142) has a photograph of a proustite crystal from Chañarcillo, Atacama, Chile which is 8.3 × 6.4 cm (Pers. Comm. 17.7.79) and was the largest known proustite crystal when purchased by the British Museum (Natural History), London, England in 1900 (Specimen No. 84698). When recently measured (31.10.80) by Mr. P. Tandy and the author, its dimensions were 8.3 × 4.5 × 3.5 cm.

(iii) Bournonite ($PbCuSbS_3$), Vibora Mine, Machacamarca, Bolivia ". . . up to 10 cm in size."—Palache *et al.*, (1964, p.409). A larger crystal, 4.5 in. diameter and 1 in. thick (11.43 cm diameter × 2.54 cm thick) is part of a group from Liskeard, Cornwall, England, that comprises specimen 42222 in the British Museum (Natural History), London, England. (Dr. P. Bancroft, Pers. Comm. 17.7.79).

(iv) Enargite (Cu_3AsS_4), Tsumeb, Namibia, 8 × 3 cm,–Pinch and Wilson (1977, p.24), and ". . . large cleavages to 2″ × 3″ (7.6 × 5.1 cm) at La Paz, Bolivia"; Sinkankas (1964, p.318).

d_1 Hanley (1953) described the minerals at the Bob Ingersoll Mine, Keystone District, South Dakota, U.S.A. and stated (p.77) that in Dike No. 1 the wall zone of cleavelandite–quartz–muscovite pegmatite contains "Columbite, commonly in thin plates as much as 2.5 ft. long (0.76 m) and 2 ft. wide (0.61 m), . . ." In Dike No. 2 the quartz–albite pegmatite is coarser at the 4,950 ft. level than at the surface, ". . . , and columbite plates are as much as 2.5 ft. long (0.76 m) and 1.3 ft. wide (0.40 m) at this level." (p.79). Dr. L. R. Page (Pers. Comm. 6.6.80) described these as being ". . . very thin, as I remember, about one quarter of an inch or less." (≤0.0064 m).

d_2 The dimensions of this crystal (Fig. 4) were obtained by measurement of Hall's (1920) Plate XXI and are larger than values reported by Palache (1923, p.363) who gave 61 cm and 30 cm, the latter distance being clearly in error. The shape is roughly a cone on a hemispherical base and a volume calculated for this form is only in accord with the stated mass of 335 lbs. (152 kg) if the density is 4.27 g/cm^3. The crystal was found at Cleveland Rhone Tributes, a working on the left bank of Sudimani (or Sudimane) Spruit, south of Manuel's Kop (or Manual Beacon), 13.5 km NE of Mica Siding, about 25 km SW of Phalaborwa, Transvaal, Republic of South Africa. It is on display in the museum of the Geological Survey, Pretoria, South Africa. Note that Guillemin (1964, p.1) erroneously stated the mass to be 160 kg.

d_3 This was recorded by Jahns (1953, p.569) to be a crystal, however in the source reference Blake

(1884, p.341) clearly stated it to be a "mass" and Ziegler (1914, p.656) was in no doubt that this was an aggregate. Professor R. H. Jahns (Pers. Comm. 19.8.77) has written that he called it a crystal because of a description given to him by "... a reliable individual ..." who judged the continuity of rude cleavage surfaces to indicate that "the bulk of the mass however, evidently was a single poorly formed crystal". This crystal was "... sparsely studded with relatively small, roughly faced crystals in somewhat diverse orientation" and no doubt led to use of the terms mass and aggregate. Blake (1884, p.341) wrote "... weighing by calculation, taking the specific gravity at 6, not less than 2000 pounds (907 kg), or one ton". In fact, a density of 6.4 g/cm^3 is compatible with his measurements but as he also stated the material to be "nearly pure columbite" a density of 5.2 g/cm^3 is more appropriate, so yielding a weight of 825 kg.

A "piece" of tantalite, (Fe, Mn) $(Nb, Ta)_2O_6$, "... which weighed about five hundredweights" (254 kg) was found in a dyke at ML86 H.M., Wodinga, Pilbara, Western Australia; Maitland (1906, p.67).

e_1 "Aggregates of fibres reaching a length of 20 inches" (50.8 cm) were reported by Berman and West (1932, p.313) and substantiated by a photograph, but no cross section dimensions of individual crystals were given.

e_2 "The world's finest specimens came from Wood's and Low's chromite mines near the Pennsylvania–Maryland border, Lancaster County, Pennsylvania; crystals to 7″ (17.8 cm) across have been recorded as well as broad cleavages of snow-white color and fine pearly lustre over 8″ (20.3 cm) across. (Fig. 159)"; Sinkankas (1964, p.339). The specimen shown in Fig. 159 is stated to be 7½″ × 3¼″ (19.1 × 8.3 cm) and may be a single cleavage block.

e_3 This is the largest crystal for which full dimensions are available; it is in the American Museum of Natural History, New York, U.S.A.; Frondel (1935, p. 472).

This museum possesses two other noteable brucite specimens from this locality:

(i) " ... a cleavage surface with longest dimension = 19 cm. ."; Frondel (1935, p.472).

(ii) A block with crystals 10 × 8 cm; Guillemin (1964, p.3; 1972, p.103).

Sinkankas (1964, pp. 339–340) reported brucite occurring as "Fine white cleavage plates to 4" (10.2 cm) × 7″ (17.8 cm) in marble from Wakefield, ...".

f A spherical shape was assumed for calculation; Professor A. H. Jahns has stated (Pers. Comm. 25.4.77) that the specimen was accurately measured.

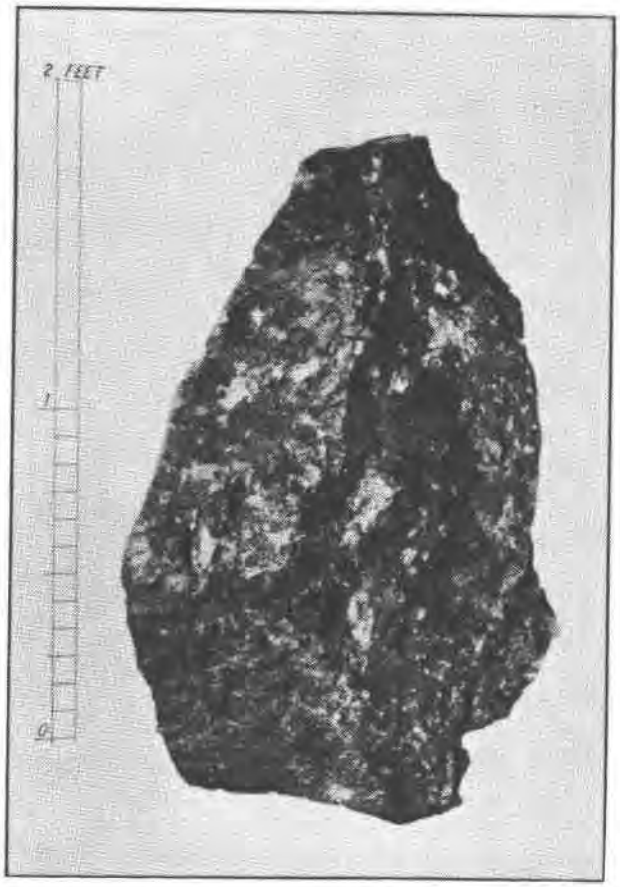

Fig. 4. The largest authenticated *OXIDE* crystal by length. Corundum, Cleveland Rhone Tributes, left bank Sudimani Spruit, Mica Siding, Transvaal, South Africa. This photograph has been copied from Plate XVI of the *Union of South Africa, Department of Mines and Industries Memoir*, 15, (1920) and is reproduced by permission of the Director, Geological Survey, South Africa (Table 1-d_2).

g The rhombohedral edges have been assumed equal on one face so that the volume is the product of each of the dimensions and $\sin^2 78.08°$. These three sets of measurements may relate to the same crystal and hence the data of Descloizeaux (1847, p.770) may have been misquoted. Indeed, Palache *et al.* (1951, p.155) and Bancroft (1973, p.128) reported the crystal to be 20 × 6.5 feet (6.10 × 1.98 m) and Palache (1923, p.363) previously indicated dimensions of 6 × 2 m to have been gained from an unstated account by Descloizeaux.

Some other large specimens of calcite are:

(i) Two very large crystals recorded by Kelley

Table 1. (continued)

CLASS	MINERAL, FORMULA & OCCURRENCE	DIMENSIONS (m) 1	x	2	x	3	VOLUME (m^3)	MASS (kg)	ASSUMED DENSITY (g/cm^3)	REFERENCES
d_3	Columbite $(Fe,Mn)(Nb,Ta)_2O_6$ Ingersoll No.1, Black Hills, S.Dakota, U.S.A.	*0.61		0.51		0.51	(0.159)	(827)	(5.2)	BLAKE (1884,p.341) JAHNS (1953,p.569).
(ii)	HYDROXIDES									
e_1	Ferroan-Brucite $(Mg,Fe)(OH)_2$ John-Manville Mine, Asbestos, Quebec,Canada.	*0.51		-		-	-	-	(2.40)	BERMAN & WEST (1932, p.313,Fig.1).
e_2	Brucite $Mg(OH)_2$ Wood's and Low's Mines, Lancaster County, Pennsylvania, U.S.A.	*>0.20		-		-	-	-	(2.40)	SINKANKAS (1964,p.339
e_3	Brucite $Mg(OH)_2$ Texas, Lancaster County, Pennsylvania,U.S.A.	0.14		0.08		0.01	(1.12×10^{-4})	(0.27)	(2.40)	FRONDEL (1935,p.472)
4.	HALIDES									
f	Fluorite CaF_2 A Dyke, Petaca District, New Mexico, U.S.A.	*2.13 (diam.)		-		-	(5.06)	(16,090)	(3.18)	JAHNS (1946,p.62; 1953, p.568).

(1940) from near the Harding Mine, Taos County, New Mexico. The larger crystal "... is estimated to have weighed at least thirty tons (33,069 kg) or possibly as much as forty tons (44,093 kg) before it was partially mined." (p. 365) and is shown in a photograph; Kelley (1940, Fig. 3, p.364).

(ii) A polysynthetic scalenohedron of calcite from Joplin, Missouri, U.S.A., with dimensions 1 m × 40 cm is in the American Museum of Natural History, New York, U.S.A. (specimen 32565); Guillemin (1972, p.103).

h_1 This is specimen BM66038 in the British Museum (Natural History), London, U.K. and is a bundle of subparallel fibrous crystals. The measurements were made by the author and Mr. P. Tandy (31.10.80).

h_2 This specimen is in the Musee de l'Afrique Centrale, Tervuren, Belgium; Dr. M. Deliens (Pers. Comm. 20.8.79). Guillemin (1964, p.1) reported that this museum had a larger crystal (1.5 cm long) from this occurrence; however, Dr. Deliens has indicated that during a recent re-examination of the entire collection it was found that the crystal was malachite and not gerhardtite.

There are few measurements of nitrate crystals recorded in the literature but Dietze (1891, p.446) and Osann (1894, p.584) did note that crystals of darapskite, $Na_3(NO_3)(SO_4) \cdot H_2O$ at Officino "Lautaro", Pampa del Toro, Chile had cross sectional areas up to 1 cm^2.

i As the habit is stated by Palache *et al.* (1951) to be nearly equant, the second and third dimensions have been assumed equal. Note that Schaller (1930, p.137) wrote that "some of the crystals are of immense size, the largest one seen measuring 8 feet (2.44 m) (*c* axis) by 3 feet" (0.91 m). This crystal was confirmed to exist by Dr. V. Morgan (Pers. Comm. 12.1.79) and is still *in situ* in old underground workings now closed by Federal mine regulations (Dr. J. Siefke, Pers. Comm. 22.4.80).

j_1 If linear dimensions are calculated on the basis of the axial ratios ~0.6331:1:0.6462, then the greatest length is 2.20 cm.

j_2 Specimen 86453 in the British Museum (Natural History), London, U.K. The crystals are "... as much as 6 mm across and are honey-yellow to reddish-brown in colour." "The crystals are very flat, and their contour is square with more or less rounded corners. They are formed of eight low pyramids, four above and four below, directly above one another in

Table 1. (continued)

CLASS MINERAL, FORMULA & OCCURRENCE	DIMENSIONS (m) 1 x 2 x 3	VOLUME (m^3)	MASS (kg)	ASSUMED DENSITY (g/cm^3)	REFERENCES
5. CARBONATES, NITRATES, BORATES IODATES					
(i) CARBONATES					
g Calcite $CaCO_3$ Helgustadir, Reydarfjördur, Iceland	7 7 2	(93.82)	(254,252)	(2.71)	KOSTOV (1968, p.536)
Calcite $CaCO_3$ Helgustadir, Reydarfjördur, Iceland	6 6 3	(103.39)	(280,187)	(2.71)	DESCLOIZEAUX (1947, p.770)
Calcite $CaCO_3$ Iceland	*5.49 5.49 2.74	(79.06)	(214,252)	(2.71)	DANA & BRUSH (1872, p.68)
(ii) NITRATES					
h_1 Soda nitre (nitratine) $NaNO_3$ Tarapaca, Chile.	0.174 - -	–	–	(2.25)	
h_2 Gerhardtite $Cu_2(NO_3)(OH)_3$ Likasi, Shaba, Zaire	0.003 0.0015 0.001	(4.5×10^{-9})	(1.53×10^{-5})	(3.40)	DELIENS (Pers.Comm. 20.8.79)
(iii) BORATES					
i Kernite $Na_2B_4O_7 \cdot 4H_2O$ Kramer, Kern County, California, U.S.A.	*2.44 0.91 (0.91)	(2.02)	(3,854)	1.908	SCHALLER (1930, pp.137, 147) PALACHE et al. (1951, p.336)

pairs. The pyramids are so much rounded that the shape of the crystals approximates to a very flat cone."; Smith and Prior (1911, p. 78–79). Mr. P. Tandy (Pers. Comm., 3.12.80, 13.2.81) stated that the largest crystal is a distorted, flattened bipyramid with a volume of 16 mm^3.

k Palache (1923, p.363) wrote "*Gypsum* Chile, Braden Mine. . 10 ft. × 3 in. (3 meters × 8 cm) Lindgren"; however, Lindgren (1933, p.685) stated "A crystal of gypsum 10 feet long and 2 feet in diameter was found in a cave. . .". A square cross section has been assumed with a diagonal length of 2 feet (0.61 m), hence side length is 17 inches (0.43 m).

Other noteable occurrences of gypsum are:

(i) Professor C. Frondel has written (Pers. Comm. 1978) that larger crystals probably occur in the Naica Mine, Mexico, but Foshag (1927, p.254) merely stated "many of them are four (1.22 m) and five feet (1.52 m) long and a few probably reach six feet". (1.83 m).

(ii) Talmage (1893, p.86) described a remarkable set of large selenite ($CaSO_4 \cdot 2H_2O$) crystals from a cave at South Wash, Fremont River canyon, Wayne County, southern Utah, thus. . "Cleaved slabs are obtainable six feet (1.83 m) in length, and two and a half feet (0.76 m) in breadth. One of the longest perfect prisms yet obtained extends fifty one inches, . . ." (1.30 m).

l_1 Reid (1925, p.12) wrote "The most important bodies, both as regards quantity and quality, occur at the Dundas Extended, West Comet, and Adelaide Mines where crystals of hyacinth red and deep scarlet colour, 10 to 12 centimetres long, with perfect terminations, are found. . .". Subsequently in mine descriptions the only mention of such crystals is under the heading of Adelaide Mine (". . . 3 to 6 inches (7.6–15.2 cm) in length. . ." p.79). A later publication (Tasmanian Dept. Mines, 1970, p.37), lists 10–12 cm crystal of crocoite only at the Dundas Extended and West Comet Mines.

l_2 This crystal is in the collection of Edward Swoboda, Los Angeles, California, U.S.A. The second dimension has been determined from the photograph published by Bancroft (1973, p.141) and the third dimension has been assumed. Sinkankas (1964, p.403) wrote "The largest single crystals, sometimes

Table 1. (continued)

CLASS	MINERAL, FORMULA & OCCURRENCE	DIMENSIONS (m) 1 x 2 x 3	VOLUME (m^3)	MASS (kg)	ASSUMED DENSITY (g/cm^3)	REFERENCES
(iv)	IODATES					
j_1	Lautarite $Ca(IO_3)_2$ Pampa del Pique III, or Pampa Grove, Chile	(0.016) (0.016) (0.016)	(4.36×10^{-6})	0.020	4.59	DIETZE (1891,p.448).
j_2	Schwartzembergite $Pb_5(IO_3)Cl_3O_3$ San Rafael Mine, Sierra Corda, Caraoles, Chile.	0.006 0.004 0.002	1.6×10^{-8}	(1.18×10^{-4})	7.39	SMITH & PRIOR (1911, p.78) TANDY (Pers. Comm. 3.12.80)
6.	SULPHATES, CHROMATES, MOLYBDATES, TUNGSTATES					
(i)	SULPHATES AND RELATED COMPOUNDS					
k	Gypsum $CaSO_4.2H_2O$ Braden Mine, Chile	*3.05 0.43 0.43	0.564	1,308	(2.32)	PALACHE (1923,p.363) LINDGREN (1930,p.685)
(ii)	CHROMATES					
l_1	Crocoite $PbCrO_4$ Adelaide Mine, Dundas, Tasmania, Australia.	*0.15 - -	-	-	(5.99)	REID (1925, p.79)

terminated, reached lengths of 3½″ (8.9 cm) and diameters of ⅜″ (0.95 cm).

Crocoite crystals from Beresovsk, Urals, U.S.S.R. measuring 8 to 10 cm long and 1 cm diameter are in the Natural History Museum, Vienna, Austria; Guillemin (1964, p.3).

m_1 Key (1977, p.50) wrote "These reached the astounding size of 2 feet (0.61 m) in diameter, but they were so thin and fragile that damage was severe: a sample from this occurrence is on display in the American Museum." Pinch and Wilson (1977, p.34) similarly described "... thin crystals up to 60 cm across intergrown with each other," as occurring at this locality. However, Sinkankas (1964, p.434) had previously claimed "and in magnificient reticulated clusters, probably the world's largest crystals, from Glove (Sunrise) Mine, Tyndall district, Santa Cruz County (Fig. 235). Some Glove crystals reach 4″ (10.2 cm) on edge and consist of exceedingly thin tablets of yellowish color, sometimes coated with descloizite." Wulfenite crystals, with 10 cm edges, from the Glove Mine, Amado, Arizona, U.S.A. comprise specimen 10,000 of the Roebling Collection in the Smithsonian Institution, Washington, D.C., U.S.A. (Guillemin, 1972, p.122).

Kostov (1968, p.487) cited a range of 6.5–7.0 g/cm^3 for the density of wulfenite, but although Mason and Berry (1968, p.378) gave the same range, they stated that the calculated value is 6.815 g/cm^3 and lower and higher densities occur due to substitution of Ca for Pb and W for Mo, respectively. This calculated value has been assumed here but note that Palache *et al.* (1951, p.1083) gave 6.88 g/cm^3 as the calculated value.

m_2 This (Fig. 5) is specimen #40351 in the National Museum of Natural Sciences, National Museums of Canada, Ottawa. The largest crystal is chipped and the dimensions reported here were supplied by Dr. J. D. Grice of that Museum and are more accurate than those given by Key (1977, p.50).

Wilson (1977, p.81) published a photograph of another large wulfenite crystal from Tsumeb, Namibia, and the part-owner has reported the dimensions to be 7.8–9.1 × 5.9–6.5 × 1.2–2.5 cm (Mrs. M. Zweibel, Pers. Comm., Feb. 79).

Large wulfenite crystals also occur at M'Fouati, Morocco and Guillemin (1972, p.21) noted that some 5–10 cm × 1 cm were in the École Nationale Superieure des Mines, Paris, France.

n_1 Frondel (1935, p.473) stated that this specimen is in the American Museum of Natural History, New York, U.S.A., but it has not proved possible to obtain additional data. Further, he wrote the name "Wada" after his entry relating to this crystal, but in

Table 1. (continued)

CLASS MINERAL, FORMULA & OCCURRENCE	DIMENSIONS (m) 1 x 2 x 3	VOLUME (m^3)	MASS (kg)	ASSUMED DENSITY (g/cm^3)	REFERENCES
l_2 Crocoite $PbCrO_4$ Adelaide Mine, Dundas, Tasmania, Australia.	0.11 0.011 (0.011)	(1.33×10^{-5})	(0.080)	(5.99)	BANCROFT (1973, p. 140, 141)
(iii) MOLYBDATES					
m_1 Wulfenite $PbMoO_4$ Tsumeb, Namibia	*0.61 (diam) - -	-	-	(6.815)	KEY (1977, p.50)
m_2 Wulfenite $PbMoO_4$ Tsumeb, Namibia	0.083 0.075 0.030	(1.87×10^{-4})	(1.27)	(6.815)	KEY (1977, p.50); GRICE (Pers.Comm. 30.1.79) (Figure 5)
(iv) TUNGSTATES					
n_1 Scheelite $CaWO_4$ Japan	0.33 - -	-	-	(6.10)	FRONDEL(1935, p.473)
n_2 Scheelite $CaWO_4$ Kramat Pulai, Perak, Malaysia	0.20 0.145 0.12	(9.60×10^{-4})	5.855	(6.10)	GUILLEMIN (1964, p.3) TANDY(Pers.Comm., 3.12.80)
n_3 Wolframite $(Fe,Mn)WO_4$ Good Luck Claim, Hill City, S.Dakota, U.S.A.	*0.20 - -	-	-	(7.31)	HESS (1909, p.152)

the book on the minerals of Japan by that renowned mineralogist (Wada 1904, p.72–76), the largest scheelite crystal is one of 9 cm (p.75) on a specimen from Sannotake, Buzen Pt, Japan. Sinkankas (1964, p.433) wrote: "A number of localities in Japan provide specimens, and from an unidentified source, an enormous crystal 13″ (33 cm) from tip to tip is recorded by the Japanese mineralogist Wada. Very large crystals also come from Korea, as at Taehwa, and rudely dipyramidal crystals to about 6″ (15.2 cm) length, have been recorded." Previously (p.431) Sinkankas had recorded wolframite crystals "to 5″ lengths" (13 cm) from Quartz Creek district, Gunnison County, Colorado, U.S.A. and the greater density (c 7.31 g/cm³) of this mineral would probably result in these crystals having the largest known mass for a molybdate. However, none of these claims can be considered to be adequately substantiated.

n_2 This scheelite crystal from Kramat Pulai, Malaya (Specimen BM1937, 98) was reported by Guillemin (1964, p.3) to be "octaedre de 20 cm". Inspection of the specimen (31.10.80) revealed that this dimension was approximately correct for the distance between the most remote apices of the square bipyramid. Subsequently, Mr. P. Tandy, British Museum (Natural History), U.K. has written (Pers. Comm., 3.12.80, 13.2.81) to report that the base edges are 12 cm long and the others are 14.5 cm. Thus the calculated volume is 1128.77 cm³ and for a density of 6.1

Fig. 5. The largest *MOLYBDATE* crystal by volume and mass. Wulfenite, Tsumeb, Namibia. This specimen is No NMNS#40351 in the National Museum of Natural Sciences, The National Museums of Canada and the photograph is reproduced by permission of Dr. J. D. Grice (Table 1-m_2).

g/cm³ the corresponding mass is 6685.50 g. However, the actual weight is 5855 g for some of the corners are missing. An encrustation of fluorite complicates matters but ignoring it, for its mass is unknown, yields a calculated volume of 959.84 cm³.

n_3 Hess (1909, p.152) described the wolframite to be mostly brilliant black and occasionally to have "the purplish rosiny appearance of hubnerite. Single cleavage blades reach perhaps 8 inches in length."

n_4 This is an elongate and truncated octahedron (Fig. 6), Specimen #97239 in the Geological Museum, Harvard University, Massachusetts, U.S.A. Professor C. Frondel (Pers. Comm. 23.1.79) reported its weight as 18¼ lbs. (8.28 kg) and this has been confirmed by Dr. C. A. Francis (Pers. Comm. 12.7.79) when the latter sent a sketch with edge lengths. Guillemin (1964, p.1) reported inaccurate dimensions of 20 × 10 cm.

o_1 Dr. J. J. Norton (Pers. Comm. 27.11.79) has written "The crystal was one that had been mostly mined, hence was not seen in its entirety, but enough of it remained to allow an estimate of its size." It was not photographed. The density of 3.00 g/cm³ has been derived from Kostov's (1968, p.450) values of 3.11 g/cm³ (amblygonite) and 2.98 g/cm³ (montebrasite) together with the stated composition Mo_{85} (Norton *et al.*, 1962, p.81).

Ziegler (1913, p.1056) described mineral occurrences at the Hugo Mine, Keystone, South Dakota, U.S.A. and wrote of amblygonite, $LiAlPO_4(F,OH)$: "The latter mineral occurs quite irregularly in nodules and pockets, sometimes of great size. Thus one shoot of practically solid amblygonite showed on the face of the open cut for a distance of 15 × 22 × 40 ft. (4.57 × 6.71 × 12.19 m). Masses 300 to 400 lb (136–181 kg) in weight are frequently found, ..." Nowhere did he imply that these were single crystals as Norton *et al.* (1962, p.77) have reported. However, Dr. Norton has written (Pers. Comm. 18.9.79) "So far as I can remember, all amblygonites I have seen were single crystals, whether small or large (I have seen probably a dozen of 5 tons (4,536 kg) or more). I am not aware that amblygonite ever forms large aggregates of small primary crystals in pegmatites. Certainly it does not at Hugo. But it is possible that large crystals have been found close enough to each other to be regarded by miners as a single body, and reported as such by them to a geologist, who is unlikely to be present long enough to see the whole situation as the amblygonite is uncovered during mining." Dr. L. R. Page (Pers. Comm., 6.6.80) has written, "The amblygonite masses of the Hugo, Bob Ingersoll, and Tinton deposits all have the appearance of uniform material and as I remember each individual mass had no obvious difference in cleavage in different parts of the body. We considered them crystals, but their rounded irregular outer shape caused us to call them masses. I saw similar masses of amblygonite at the Bikita mine in Southern Rhodesia in 1957 only my recollection is they were even larger in size and a few had shapes suggesting crystal faces."

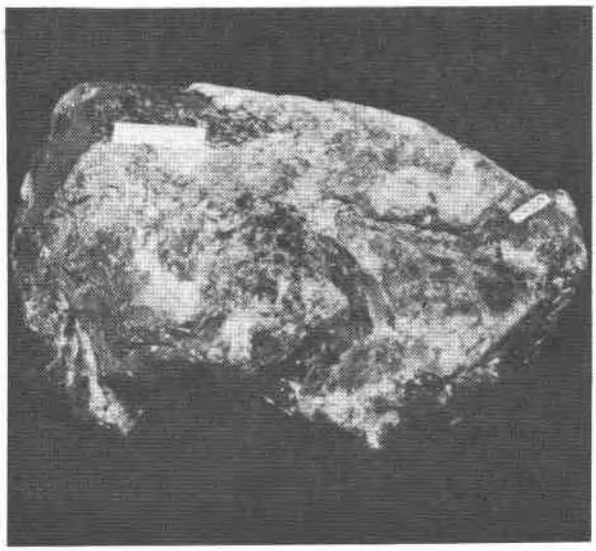

Fig. 6. The largest *TUNGSTATE* crystal by mass. Scheelite, Moctezuma, Sonora, Mexico. This photograph was supplied by, and is reproduced by permission of, Dr. C. A. Francis, Mineralogical Museum, Harvard University, Cambridge, Massachusetts, U.S.A. (Specimen #97239) (Table 1-n_4).

Accordingly, it is worth recording here some exceptionally large amblygonite occurrences:

(i) Dr. L. R. Page (Pers. Comm., 6.6.80) discussed amblygonite masses at Tinton, South Dakota, U.S.A. and wrote "However, the miners told of taking out a "continuous" mass for about 125 feet (38.1 m) on the SW side of the main pit. This is not shown in plate 40 of Prof. Paper 247 because those parts that remained are under an overhang. To the SE, however, on Section GG′ a 15-foot mass (4.57 m) is mapped—this I remember as one crystal, but rounded."

(ii) At the Peerless Mine, Keystone District, Black Hills, South Dakota, U.S.A., Hess (1925, p.289) reported an amblygonite mass 27 feet across (8.23 m) and other dimensions were said to be comparable but not fully exposed. Dr. J. J. Norton (Pers. Comm. 18.9.79) suggested calculating the volume of

Table 1. (continued)

CLASS	MINERAL, FORMULA & OCCURRENCES	DIMENSIONS (m) 1 x 2 x 3	VOLUME (m^3)	MASS (kg)	ASSUMED DENSITY (g/cm^3)	REFERENCES
n_4	Scheelite $CaWO_4$ Moctezuma, Sonora, Mexico	0.18 0.12 0.11	(0.00136)	*8.28	(6.10)	FRONDEL (Pers.Comm. 23.1.79) FRANCIS (Pers.Comm. 12.9.79)(Figure 6)
7.	PHOSPHATES, ARSENATES, VANADATES					
(i)	PHOSPHATES					
o_1	Amblygonite $LiAlPO_4(F,OH)$ Hugo Mine, Keystone, S.Dakota, U.S.A.	*7.62 2.44 1.83	(34.02)	(102,060)	(3.00)	NORTON, PAGE & BROBST (1962, p.81)
o_2	Triphyllite $Li(Fe,Mn)PO_4$ Palermo Pegmatite, New Hampshire,U.S.A.	*3.66 0.61 (0.61)	(1.36)	(4,868)	(3.58)	FRONDEL (Pers.Comm. 1978)
o_3	Triphyllite $Li(Fe,Mn)PO_4$ Palermo No. 1 Pegmatite, New Hampshire, U.S.A.	*2.44 1.83 1.22	(5.45)	(19,511)	(3.58)	MOORE (Pers.Comm. 15.1.79)
(ii)	ARSENATES					
p_1	Legrandite $Zn_3(AsO_4)_2,2\frac{1}{2}H_2O$ Ojuela Mine, Mexico.	*>0.15 - -	-		(4.01)	EMBREY (Pers.Comm. 9.1.79)

such by assuming an ellipsoidal shape; if the amblygonite is equidimensional then it would weigh about 875,000 kg.

(iii) At Beecher Lode, Custer District, Black Hills, South Dakota, U.S.A. "A 200-ton (181,000 kg) mass (of amblygonite) is said to have been removed from the north pit, . . ."; Joralemon (1953, p.70).

(iv) At Dike No. 1, Bob Ingersoll Mine, Keystone District, Black Hills, South Dakota, U.S.A.—"According to Mr. Johnson, one amblygonite mass had a surface length of about 30 ft., (9.14 m) an average width of about 4 ft., (1.22 m) and extended from the surface nearly to the adit level."—Hanley (1953, p.78). The third dimension could have been as much as 30 ft. (9.14 m), judging from section II′ on Plate 7, and hence the weight could have been about 160,000 kg.

o_2 Professor C. Frondel (Pers. Comm. 1978) stated that this crystal was only partially exposed when he saw it, so the third dimension has had to be assumed.

o_3 Professor P. B. Moore (Pers. Comm. 15.1.79) has written . . . "The Dan Patch pegmatite (Black Hills, South Dakota) had a triphylite crystal (or nodule) which I saw in 1968 and it was about 10 feet (3.05 m) across. At Palermo No. 1 pegmatite in New Hampshire recent (1975–1977) mining by the owners uncovered a triphylite with sarcopside exsolution lamellae and part of it was trenched out. When I last saw the remains the "crystal" was at least 8 feet wide (2.44 m), 6 feet deep (1.83 m) and 15 feet long (4.57 m), but it wasn't fully exposed. I took a crude measurement by footstep pacing. The only problem is that it could have been more than one single crystal but I have seen crude crystals of the same species measure 6′ × 8′ × 4′ (1.83 × 2.44 × 1.22 m)."

The largest of these "Crystals" had a volume of 20.4 m^3 and a mass in excess of 73,000 kg, but as doubt was implied about it being a single crystal this specimen has been excluded from the tabulation.

Some other notably large phosphate crystals are:

(i) an apatite, $Ca_5(PO_4)_3(F,Cl,OH)$ found at the Aetna Mine, Quebec, Canada which was reported to be 7 ft × 4 ft diam. and to weigh 6 tons (2.13 m ×

Table 1. (continued)

CLASS	MINERAL, FORMULA & OCCURRENCE	DIMENSIONS (m) 1 x 2 x 3	VOLUME (m^3)	MASS (kg)	ASSUMED DENSITY (g/cm^3)	REFERENCES
p_2	Mimetite $Pb_5(AsO_4)_3Cl$ Tsumeb, Namibia.	0.06 (0.027) diam. -	(3.79×10^{-5})	(0.274)	(7.24)	WILSON (1977,p.62) (Figure 7)
iii)	VANADATES					
q_1	Vanadinite $Pb_5(VO_4)_3Cl$ Djebel Mahseur, near Oudjha, Morocco.	*0.127 - -	-	-	(6.88)	SINKANKAS (1964, p.423)
q_2	Vanadinite $Pb_5(VO_4)_3Cl$ Abenab, 28km N of Grootfontein, Namibia.	0.12 0.04 diam. -	(1.66×10^{-4})	(1.14)	(6.88)	GUILLEMIN (1964, p.1)
8.	SILICATES					
(i)	Nesosilicates					
r_1	Garnet $(Fe,Mg,Mn,Ca)_3$ $(Al,Fe)_2Si_3O_{12}$ Kristiansand, S.Norway	2.3 - -	10	(37,500)	(3.75)	BARTH (1930,p.128) BARTH (1962,p.300)

1.22 m diam., 5443 kg)—Anonymous (1889, p.6; 1890, p.159). If a hexagonal cross section is assumed, which would accord with the description that "It is perfectly formed." (Anonymous, 1889, p.6), then the calculated volume is 2.06 m^3 and the mass is 6548 kg for a density of 3.18 g/cm^3. The published estimated mass of 6 tons (assumed short tons and thus equal to 5443 kg; Anonymous, 1890, p.159) yields a density of 2.64 g/cm^3, which is too low.

(ii) amblygonite, $LiAlPO_4(F,OH)$, from North Morning Star Mine, San Domingo Wash, N.E. of Wickenburg, Arizona, U.S.A. The largest crystal was stated (Professor R. H. Jahns, Pers. Comm., 26.10.77) to have a "... maximum exposed dimension of five feet eight inches" (1.73 m). Note that previously Jahns (1952, p.40) described crystals up to six feet in diameter (1.83 m) but the source was unspecified and the largest crystal mentioned in the detailed mine descriptions was only five feet in diameter (1.52 m); Jahns (1952, p.81; 1953, p.569).

(iii) a vivianite, $Fe_3(PO_4)_2 \cdot 8H_2O$, crystal from Anloua, Cameroun which is 1.30 m long; Guillemin (1964, p.2; 1972, p.21). This specimen is in the École Nationale Superieure des Mines, Paris, France.

p_1 Dr. P. G. Embrey wrote (Pers. Comm., 1.1.79), "I have seen 4″ (10.2 cm) prisms, although we have none of this size, and I believe a specimen is known with 6″ (15.2 cm) prisms or perhaps longer".

Wilson (1978, p.35) wrote about a ... "remarkable single 8 inch (20 cm) spray of legrandite..." but no details are presently available.

Stellate sprays of erythrite, $Co_3(AsO_4)_2 \cdot 8H_2O$, with "acicular needles to 4″ ... (10.2 cm) were stated by Sinkankas (1964, p.409) to have been found in cavities in the Grube Rappold Mine, Schneeberg, Saxony, Germany.

p_2 This specimen is in the collection of Keith Proctor, Colorado Springs, U.S.A.: the photograph (Fig. 7) was previously published by Wilson (1977, p.62). The diameter between prism faces of this hexagonal crystal has been estimated from the photograph. A slightly smaller crystal (2 in. long × 1 in. diameter: 5.1 cm × 2.5 cm diam.) from this locality was mentioned by Key (1977, p.49).

An aggregate of novacekite, $Mg(UO_2 \cdot AsO_4)_2 \cdot 9H_2O$, crystals, measuring 6 cm in length is shown in a photograph by Bariand and Bariand (1976, p.120); the occurrence is at Brumado, Bahia State,

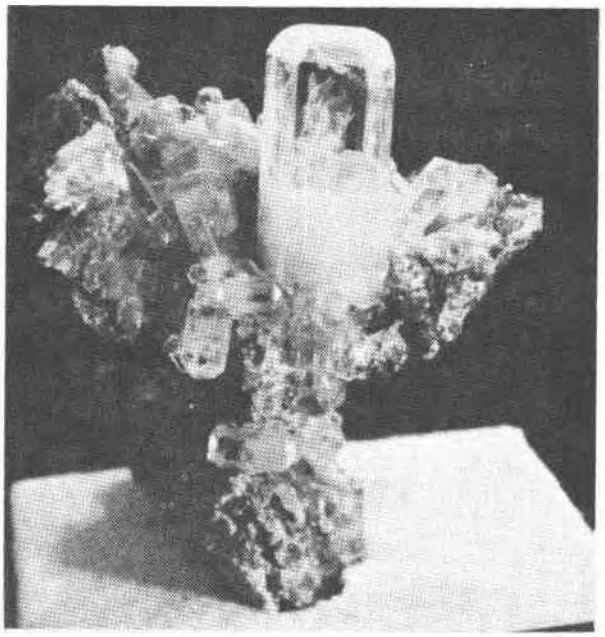

Fig. 7. The largest *ARSENATE* crystal by volume and mass that has been authenticated. Mimetite, Tsumeb, Namibia from the collection of Keith Proctor. The photograph is reproduced by permission of the photographer Dr. Wendell E. Wilson, Editor of *The Mineralogical Record* and was originally published on p. 62 of volume 8(3) of that journal (Table 1-p_2).

Brazil and the specimen is in the University of Paris (Sorbonne), Paris, France. Dr. Bariand (Pers. Comm., 28.11.80) has written that the largest crystal has a length of 5 cm.

q_1 Young (1976, p.243) recorded vanadinite crystals at Mibladen, Morocco thus, "I would say the largest crystals never exceed two inches (5.1 cm) . . . . that would be exceptional".

q_2 This is the largest crystal on specimen 4525 in the museum of the Geological Survey of South Africa, Pretoria, R.S.A. It was vanadinite but now is pseudomorphed by descloizite crystals, PbZn $(VO_4)(OH)$; Guillemin (1964, p.1). The smaller dimension has been assumed to be the diameter of a hexagonal cross section.

Dr. P. G. Embrey has written (Pers. Comm., 9.2.79) about a similar crystal from this locality which is specimen BM1933, 308 in the British Museum (Natural History), London, U.K. It is 8 × 4 cm, has a mass of 324 g, and before polishing was coated with descloizite.

r_1 This is an irregularly shaped shell of garnet around a block of limestone, and it may be a crystal aggregate. The density was calculated, not assumed, and is almost certainly smaller than the true value; the reported weight (37.5 tons) was taken to be in metric tonnes. A sketch accompanies both references and from it the maximum dimension of the garnet is measured as 2.3 m, a value incompatible with the stated volume estimate (10 m^3) even if the limestone is included.

r_2 Subsequently, Kolderup (1960, p.74) stated "Here a giant crystal, measuring 90 cm, was found" . . . , and Kostov (1968, p.318) recorded "In the western part of Norway garnet has been found as porphyroblasts with a diameter of 1 m in amphibolite". These accounts probably relate to the same specimen which is the very imperfect dodecahedral crystal, (Fig. 8) mentioned in Table 1, and which is kept at the Natural History Museum, Bergen, Norway. Note that the volume has been calculated from the reported mass and density.

r_3 Of necessity, a cubic shape was assumed but as this is most improbable for topaz the true mass and volume will be less than the calculated values.

A transparent perfect crystal of topaz from Minas Geraes, Brazil which weighs 300 kg and is 80 × 60 × 60 cm is in the American Museum of Natural History, New York, U.S.A.; Guillemin (1972, p.103).

r_4 The form was stated to be roughly spherical and the calculated mass of 1.70 short tons accords with the reported value of "over 1.5 tons". (Levin, 1950, p.546). The density is the mean of ten values for type XH garnets as given by Levin (1950, Table 1).

s This crystal is roughly circular in cross section and consists of a cylinder 49 cm × 37.8 cm diameter, between two truncated cones, 32 cm and 33 cm high with smallest diameters of 17.8 and 13.9 cm respectively (Fig. 9). All dimensions have been calculated and are based on the 40 cm rule included in the photograph taken by Staffan Waerndt. The volume has been calculated assuming the above idealized form. The calculated mass of 375 kg is slightly larger than the 300 kg estimated by Dr. B. Lindquist (Pers. Comm. 19.1.79) who reported that the "crystal is rather flattened so I prefer to estimate its weight by transforming it into a box shape, the edges being 55, 15, and 90 cm respectively. Assuming density 4.0 the mass should then be 297 kg, *i.e.*, around 300 kg." (13.2.79). The crystal is on display at the Naturhistoriska Riksmuseet, Stockholm, Sweden.

Other large sorosilicate crystals are:

(i) those recorded by Sinkankas (1964, p.521)

Table 1. (continued)

CLASS	MINERAL, FORMULA & OCCURRENCES	DIMENSIONS (m) 1 x 2 x 3	VOLUME (m^3)	MASS (kg)	ASSUMED DENSITY (g/cm^3)	REFERENCES
r_2	Garnet $(Fe,Mg,Mn,Ca)_3(Al,Fe)_2Si_3O_{12}$ Gjølanger, W. Norway	1 0.7 0.4	(0.176)	700	3.98	KOLDERUP and ROSENQVIST (1950); ROSENQVIST (1951) (Figure 8)
r_3	Topaz $Al_2SiO_4(F,OH)_2$ Ribaue-Alto Ligonha district, Mozambique	*0.91 (0.91) (0.91)	(0.754)	(2,677)	(3.55)	BANDY (1951, p.521); JAHNS (1953, p.569)
r_4	Garnet $(Fe,Mg,Mn,Ca)_3(Al,Fe)_2Si_3O_{12}$ Barton Deposit, Gore Mt., Adirondacks, U.S.A.	*0.91 (diam) - -	(0.395)	(1,544)	3.91	LEVIN (1950, pp.520, 524, 540)
(ii)	SOROSILICATES					
s	Orthite $(Ca,Ce)_2(Al,Fe)_3Si_3O_{12}(O,OH)$ Arendal, Norway	1.14 0.38 (diam) -	(0.0938)	(375)	(4.0)	LINDQVIST (Pers.Comm. 19.1.79) (Figure 9)

being slender blades of allanite, $(Ca,Ce,La,Na)_2(Al,Fe,Mn,Be,Mg)_3O(OH)(SiO_4)(Si_2O_7)$ which at the Rutherford Mines, Amelia, Amelia County, Virginia, U.S.A. attain 16 inches (40.6 cm) in length.

(ii) Sinkankas (*op.cit.*, p.520) also cited two occurrences of epidote, $Ca_2Al_2Fe\ Si_3O_{12}(OH)$, from which crystals 12 inches long (30 cm) have been obtained.

(iii) Bjørlykke (1935, p.255) in writing about orthite, $(Ca,Ce)_2(Al,Fe)_3Si_3O_{12}(O,OH)$ from Iveland, Setesdal, S. Norway, stated "It usually occurs in large ill-defined crystals up to a weight of 100 kgms and more ..." but no specific locality was given. However, in detailed descriptions of 108 pegmatite occurrences he nowhere mentioned these crystals but did write "The orthite was present in large ill-defined crystals"—Locality 58 Mølland 7 (p.231) and "Orthite was abundant in large ill-defined crystals."—Locality 99 Kåbuland 1 ("Amerika") (p.240).

t The reported mass (estimated as 250 tons) requires a density of only 1.75 g/cm^3 if metric units and a hexagonal cross section are assumed. The length and weight were confirmed by Dr. A. Gsell (Pers. Comm., 4.5.77) but he stated a slightly smaller diameter of 3 m which is consistent if he measured between hexagon edges and if the larger diameter was measured between corners. Jensen and Frigstad (1967, p.16) recorded the same length (18 m) and a diameter of 5 m, but the latter is probably erroneous in view of the similar estimates of the two local geologists who saw the crystal in 1964.

A tapered beryl crystal 33 feet long (10.06 m) and 6 feet (1.83 m) in diameter was recorded by Stevens (1972, p.50) as having been found in 1950 at the Bumpus Quarry, Albany, Oxford County, Maine, U.S.A.

The crystal reported by Waldschmidt (1920) as being the largest known of beryl came from the Bob Ingersoll mine, South Dakota, U.S.A., and had a diameter of 1.17 m (46 in.) and a known length of 1.12 m (44 in.).

u_1 Spencer (1928, p.259) recorded this crystal as being "47 feet in length with a cross section 3 to 5 feet, and from it 90 tons of material was quarried ...". These data are a curious admixture of those for several crystals described by Schaller (1916, p.138). The second dimension (80 cm) has been estimated from the photograph (Fig. 10) and a square cross section was assumed. This was the longest crystal discovered at this locality, but it was thinner than the subsequently mentioned specimen which yielded the greatest volume and mass.

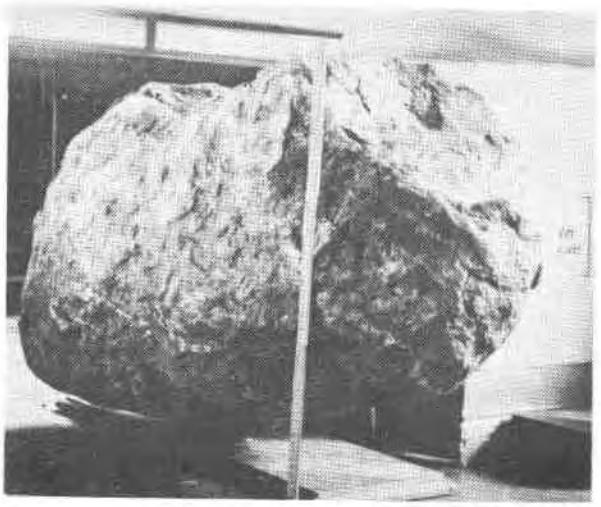

Fig. 8. The largest *NESOSILICATE* crystal by length, volume and mass that has been authenticated. Garnet, Selvik, north of Gjølanger Molle, Fjaler herred, Sogn of Fjordane fylke, Norway—(100 × 70 × 40 cm). Photograph provided by, and is reproduced by permission of, Professor B. A. Sturt, University of Bergen, Norway (Table 1-r_2).

Waldschmidt (1920, p.11) wrote "At the Etta Mine, . . . , spodumene crystals have been mined that were more than fifty feet (15.24 m) long and from four to six feet (1.22–1.83 m) in diameter." However, this claim seems doubtful.

u_2 Kostov (1968, p.340) recorded rounded metric measurements (13 m × 2 m × 1 m) and a mass of 65 tons (58,967 kg. if short tons) from which an improbable density of 2.27 g/cm^3 is derived. Ziegler (1913, p.1054; 1914, p.655) recorded a smaller crystal, 42 feet long and 5 ft. 4 in. maximum diameter (12.8 m × 1.63 m maximum diameter) which "would yield 90 tons (81,647 kg) of spodumene" (1914. p.655) but would necessitate an impossibly high density of 4.8 g/cm^3 if the "diameter" is the diagonal of a square cross section. The tabulated crystal was decayed and yielded only 37 tons (33.6 tonnes) of spodumene; Hess (1911, p.650).

v_1 Calculations have been based on an assumed hexagonal cross section. Palache (1923, p.363) estimated the total weight as ". . . not less than 90 tons" (81,647 kg) but this is far too low for the stated dimensions. He also attributed the data on this specimen to Ellsworth, but no mention of it can be found in the numerous publications of the latter (Mr. H. R. Steacy, Pers. Comm., 4.11.77, 20.1.78; Professor L. G. Berry, Pers. Comm., 3.2.78). de Schmid (1912, p.141), Spence (1929, p.69) and Hewitt (1968, p.29) recorded a phlogopite crystal from this mine with a stated diameter of "over 9 feet" (2.74 m).

v_2 Holland (1902, p.63) noted that this specimen was ". . . 10 feet across the basal planes and up to 15 feet across the folia."

Sinkankas (1964, p.482) wrote "The world's record (muscovite, $KAl_2(AlSi_3O_{10})(OH)_{2,}$) for size is held by a single crystal from the Inikurti Mine, Nellore, India which measured 15 feet (4.57 m) in length and 10 feet (3.05 m) in diameter and delivered a total of 85 tons (77,111 kg) of muscovite". A density of 2.79 g/cm^3 accords with this data, and is within the range given by Kostov (1968, p.361) *i.e.*, 2.76–3.0 g/cm^3 and indicates little substitution by iron. A hexagonal cross section, 10 feet between apices, has been assumed for calculation purposes.

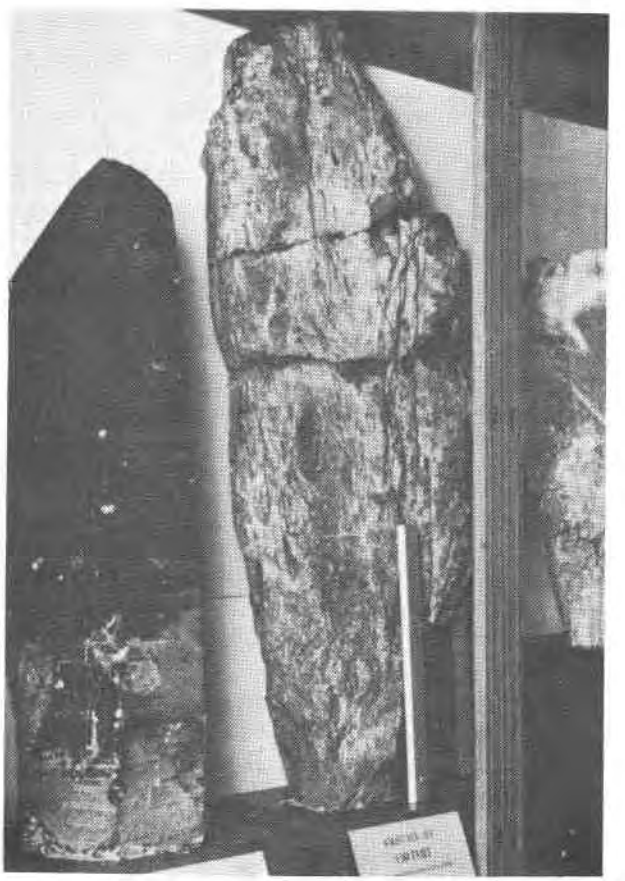

Fig. 9. The largest *SOROSILICATE* crystal by length, volume and mass. Orthite, Arendal, Norway. This crystal is in the collection of the Naturhistoriska Riksmuseet, Stockholm and the photograph by Staffan Waerndt is reproduced by permission: the ruler is 40 cm (Table 1-s).

Table 1. (continued)

CLASS MINERAL, FORMULA & OCCURRENCE	DIMENSIONS (m) 1 x 2 x 3	VOLUME (m^3)	MASS (kg)	ASSUMED DENSITY (g/cm^3)	REFERENCES
(iii) CYCLOSILICATES					
t Beryl $Be_3Al_2Si_6O_{18}$ Malakialina, Malagasy	18 3.5 (diam) -	(143.2)	(379,480)	(2.65)	MICHEL (Pers.Comm. 4.5.76)
(iv) INOSILICATES					
u_1 Spodumene $LiAlSi_2O_6$ Etta Mine, S.Dakota, U.S.A.	*14.33 0.80 (0.80)	(9.17)	(28,427)	(3.1)	SCHALLER (1916,p.138 , Plate VA) (Figure 10)
u_2 Spodumene $LiAlSi_2O_6$ Etta Mine, S.Dakota, U.S.A.	*12.80 1.83 0.91	(21.32)	(66,092)	(3.1)	HESS (1911, p.651)
(v) PHYLLOSILICATES					
v_1 Phlogopite $KMg_3[AlSi_3O_{10}](F,OH)_2$ Lacey Mine, Loughborough Township, Ontario, Canada.	*10.06 4.27 (diam.) -	(119.14)	(333,592)	(2.8)	PALACHE (1923, p.363)

v_3 Fersman (1931, p.119) stated that a biotite crystal, $K(Mg,Fe)_3(AlSi_3O_{10})(OH,F)_2$ with an area of 7 m^2 had been found in a feldspar mine at Evje, Norway and Barth, who worked on this area, mentioned 2–3 m flakes of both muscovite and biotite (1928, p.464) and specifically gave Rosas, Iveland as a location for 3 m long biotite flakes (1931, p.118).

v_4 Harding (1944, pp.34–35) wrote "One large mica crystal of phenomenal size, discovered by Justin Purdy and extracted by Purdy Mica Mines in 1943, was the source of spectacular sheets of clear muscovite with dimensions greater than 5 by 8 feet. One sheet from this huge crystal, one of the largest ever encountered in the history of Ontario mica-mining, was secured by the Royal Ontario Museum, Toronto". This, the largest authenticated phyllosilicate is shown in Figure 11; Harding (1944, p.34) published a photograph of a similar specimen which may have come from the same crystal.

w_1 Hanley *et al.* (1950, p.60) wrote "The mass of microcline exposed in the north face of the main open-cut is about 75 feet (22.86 m) wide and 40 feet (12.19 m) thick at the maximum and has an area of 2,337 square feet (217.11 m^2), yet individual cleavage planes extend unbroken across the entire mass, which is probably a single crystal". These dimensions correspond to the open cut area on Section CC′ of their Plate 7, but the entire area of microcline shown on that section has a maximum length of 118 feet (35.97 m), a width of 45 feet (13.72 m) and the surface area is 2912 sq. feet (270.5 m^2). Cross sections through the pegmatite are drawn at 35 foot (10.67 m) intervals and cross sectional areas of microcline age nil (EE′), 141.3 m^2 (DD′), 270.5 m^2 (CC′), 11.12 m^2 (BB′) and 20.15 m^2 (AA′). Thus continuity of microcline seems probable from 3 m south of EE′, as indicated on the plan, to somewhere south of AA′; a minimum distance of 138 feet (42.06 m). However, Dr. L. R. Page (Pers. Comm., 6.6.80) has stated that "This deposit had been mined for about 125 feet (38.10 m) at right angles to the cleavage. The miners claimed that the cleavage had remained the same throughout the pit length. I have always maintained that this was the largest crystal I'd ever seen". As the north face of the open cut is shown as being about 101 feet (30.78 m) north of AA′, the microcline is likely to have ex-

Table 1. (continued)

CLASS MINERAL, FORMULA & OCCURRENCES	DIMENSIONS (m) 1 x 2 x 3	VOLUME (m^3)	MASS (kg)	ASSUMED DENSITY (g/cm^3)	REFERENCES
V_2 Muscovite $KAl_2(AlSi_3O_{10})(OH)_2$ Inikurti Mine, Nellore, India.	*4.57 3.05 (diam.) -	(27.61)	77,111	(2.79)	HOLLAND (1902,p.63) SINKANKAS (1964, p.482)
V_3 Biotite $K(Mg,Fe)_3(AlSi_3O_{10})(OH,F)_2$ Rosaas, Iveland, Norway.	3 - -	-	-	(3.0)	BARTH (1931, p.118)
V_4 Muscovite $KAl_2(AlSi_3O_{10})(OH)_2$ Purdy Mica Mines, Ontario, Canada.	*>2.44 >1.52 -	-	-	(2.79)	HARDING (1944,p.34) (Figure 11)
(vi) TEKTOSILICATES					
W_1 Microcline $KAlSi_3O_8$ Devils Hole Beryl Mine Fremont County, Colorado, U.S.A.	*49.38 35.97 13.72	(6214.41)	(15,908,890)	(2.56)	HANLEY,HEINRICH & PAGE, (1950,p.60) PAGE (Pers.Comm., 6.6.80)
W_2 Perthite $(K,Na)AlSi_3O_8$ Hugo Mine, Keystone, S. Dakota, U.S.A.	*10.67 4.57 1.83	(89.23)	(230,213)	(2.58)	NORTON, PAGE & BROBST (1962, pp.64,65)
W_3 Feldspar ? Kure, S. of Mass, Norway	>10 - -	-	-	-	BRÖGGER (1890, p.231); BRÖGGER (1894, p. 67). KEMP (1924, p.706).

tended a further 24 feet (7.32 m) south of AA′. Hence, the probable maximum length of microcline is 138 + 24 = 162 feet (42.05 + 7.32 = 49.38 m); the maximum breadth and width have been taken as those shown on section CC′. It is much more difficult to estimate the original volume for the eastern portion of the microcline has been truncated by erosion and mining. Simple surface reconstruction, to allow for mining, increases the area of microcline from 20.15 m^2 to 67.3 m^2 on AA′ and from 11.12 m^2 to 167.7 m^2 on BB′; however, compensation for erosion is too subjective to be of value. Accordingly, using areas shown as the reconstructions on AA′ to DD′, and assuming zero area at the presumed termination points, the total volume has been calculated (using equations for a cone and its frustrum) to be 6214.41 m^3 (219,459.8 $ft.^3$) and the mass to be 15,908,890 kg(17,536.6 short tons).

This may have been the largest crystal ever discovered but it cannot be regarded as fully authenticated, particularly in respect to the microcline having been one single crystal throughout.

W_2 As the composition of this perthite is Ab_{27} (Norton *et al.*, 1962, p.65) the density is approximately 2.58 g/cm^3 (Kostov, 1968, Fig. 386). This crystal was carefully measured by Drs. J. J. Norton and L. R. Page for it occurred on a corner of a quarry wall and all three dimensions could be determined. Dr. Norton wrote (Pers. Comm. 18.9.79) that prior to measurement "... a sizeable part of this crystal had already been removed by mining ...". Subsequently, it was completely mined out and it was never photographed.

Norton *et al.* (1962, p.64,65) described perthite, $(K,Na)AlSi_3O_8$, in Zone 3a of the Hugo Pegmatite, Keystone, South Dakota, U.S.A. thus: "Largest crystal observed was 35 by 15 by 6 foot (10.67 × 4.57 × 1.83 m), but much larger crystals were exposed in the early years of mining (G. M. Schwartz, oral communication, 1948)." "The largest crystal observed contained an estimated 250 tons of perthite." (226,796 kg).

Dr. Norton wrote (Pers. Comm. 18.9.79) that G. M. Schwartz, an eminent geologist, had said to

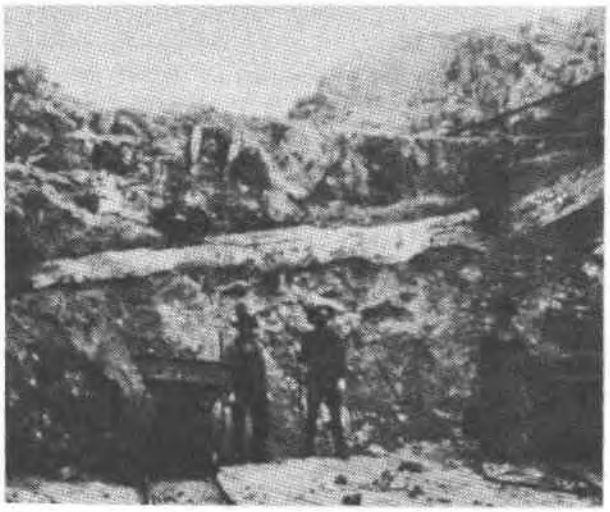

Fig. 10. The largest *INOSILICATE* crystal by length Spodumene, Etta Mine, South Dakota, U.S.A.—(14.3 m long). Photograph copied from Plate *VA, U.S. Geological Survey Bulletin 610,* (1916) and reproduced by permission of the Director, U.S. Geological Survey (Table 1-u_1).

Fig. 11. The largest authenticated *PHYLLOSILICATE* crystal by length. Purdy Mica Mines. Ontario, Canada. This cleavage flake is in the Royal Ontario Museum, Toronto, Canada and the photograph has been supplied by, and is reproduced by permission of, Dr. J. A. Mandarino (Table 1-v_4).

him "... that he had in the 1920's seen the cleavage of a single perthite crystal over the whole face then being mined. This crystal would have been several times as large as the one I reported."

The Bikita and Nolan Mines, Zimbabwe, are cut into a pegmatite body which "... contains some of the largest crystals I have ever seen—perthite crystals more than 40 feet (12.19 m) long"; Dr. L. R. Page (Pers. Comm., 6.6.80). Surprisingly, however, Wilson and Martin (1964) do not mention these.

w_3 These reports have been kept because the above perthite is a mineral intergrowth and could be disputed as a single crystal.

w_4 The reported weight is assumed to have been in long tons. Hurlbut (1968, p.14) recorded the dimensions as 30 × 30 feet (9.14 × 9.14 m).

w_5 Fersman (1931, p.119) recorded a 100 tonne microcline, $KAlSi_3O_8$, crystal from Norway which was 10 m long, Barth (1928, p.404) mentioned microcline crystals between 5 and 10 m in length as occurring in dykes in Iveland, Norway, and Barth (1947, p.53) (1960, p.40) also described pegmatites cutting amphibolite at Evje, Norway as being "... very coarse-grained, feldspar and quartz, SiO_2, crystals attaining 8 metres in length". These are all general statements which cannot be found in detailed descriptions of the feldspar mines of this area as given by Andersen (1931), Barth (1931, 1947, 1960) and Bjørlykke (1935). Both Barth (1931, p.114) and Bjørlykke (1935, p.217–219) recorded microcline crystals with faces up to 6 m in length, and weighing more than 100 tons, at Tveit, Norway and specifically at Tveit—3, one of six pegmatites in the area. Barth (1928, p.419) also recorded 6 m long microcline crystals at Rudjord in Lyngdal, Norway.

Other notable tektosilicate crystals are:

(i) The largest quartz (SiO_2) crystal which has been substantiated was found at Manchõ Felipe, near Itaporé, Goiaz, Brazil (Frondel, 1962, p.244) and was 20 feet long (6.10 m), 5 feet (1.52 m) across a prism face and was estimated to have weighed over 44 tons (39,916 kg.). If the crystal was regular in shape, and lacked pyramid faces, then the volume would have been 36.78 m^3 and the mass 97,479 kg; the weight estimate is less than half of this calculated value and must be questionable. Campbell (1946, p.797) described quartz "Crystals up to 6 m long with

Table 1. (continued)

CLASS	MINERAL, FORMULA & OCCURRENCES	DIMENSIONS (m) 1 x 2 x 3	VOLUME (m^3)	MASS (kg)	ASSUMED DENSITY (g/cm^3)	REFERENCES
	Microcline $KAlSi_3O_8$	(4.27) (4.27) (4.27)	(78.13)	>200,000	(2.56)	BJØRLYKKE (1935, pp.213, 240)
	Frikstad 9 ("Steli") Pegmatite, Iveland, Setesdal, S.Norway					
w_4	Orthoclase $KAlSi_3O_8$	10 10 (≤0.40)	(≤39.69)	*101,605	(2.56)	LINDGREN (1933, p.754); KOSTOV (1968, p. 55)
	Urals, U.S.S.R.					
w_5	Perthitic Microcline $(K,Na)AlSi_3O_8$	*9.14 3.66 2.13	(71.25)	(185,250)	(2.6)	HESS (1933, p.455)
	Tveit, Iveland district, N. of Kristiansand, Norway					
9.	ORGANIC MINERALS					
x_1	Whewellite $CaC_2O_4 \cdot H_2O$	0.055 0.055 0.015	(c.1.3x10^{-5})	(c.0.030)	(2.23)	GUILLEMIN (1965, pp.1,2); HOFMANN (Pers.Comm. 5.3.80) (Figure 11)
	Zwickau, Saxony, Germany					
x_2	Whewellite $CaC_2O_4 \cdot H_2O$	0.054 0.039 0.0085	(7.4x10^{-6})	0.0165	(2.23)	SVENEK (Pers.Comm. 4.9.79)
	Pchery, Theodor Mine, Kladno District, Czechoslovakia					

Footnotes:
* Imperial measurements have been converted to metric. N.B. 1000 kg = 1 tonne = 1.102313 short tons = 0.984206 long tons.
( ) Calculated or estimated value.
Unless otherwise stated, the densities have been estimated from values given by KOSTOV(1968).

the prism face 1.5 m wide were seen," some of which were shown in the photographs that accompanied his paper.

(ii) Dr. D. D. Hogarth (Pers.Comm. 25.1.78) observed a scapolite ($(Na,Ca)_4[Al,Si)Si_2O_8](Cl,CO_3)$) crystal, now concealed beneath the Gatineau Parkway, at Pinks Lake, Gatineau Park, Canada which he conservatively estimated to be at least 15 feet by 2.5 feet (4.57 × 0.76 m).

x_1 This is specimen 27153 in the Bergakademie, Freiberg, D.D.R., which is a twinned crystal that weighs 100 g with the matrix. Dr. F. Höfmann (Pers. Comm. 5.3.80) reported the thickness to be 30 mm, so for a single crystal this has been halved. The mass has been estimated assuming that the matrix weighs roughly a third of the total; the volume corresponds to the estimated mass. This crystal is shown in Fig. 12. The density was obtained from Palache *et al.* (1951, p.1100) who noted "Among the natural occurrences may be mentioned Burgk near Dresden, Saxony, where crystals up to several inches in size occur with calcite in the footwall of a coal seam."

x_2 This twinned crystal was obtained from coal deposits 25 km west of Prague, and is specimen 6185 in the Prirodovedecke Muzeum, Prague, Czechoslovakia. The twin was reported by Dr. J. Svenek (Pers. Comm. 4.9.79) to weigh 33 g; this and the smallest dimension have been halved to estimate the size of a single crystal.

Discussion

It may be seen from Table 1 that the largest authenticated crystal whether considered by length, volume, or mass is the beryl (18 m, 143 m^3, and 379,480 kg respectively) from Malakialina, Malagasy Republic. However, the mysterious orthoclase crystal found in the Urals, U.S.S.R. (Lindgren, 1933, p.754) could have been the biggest by volume and mass for the calculated depth of only 40 cm seems improbable in conjunction with two other dimensions each of ten meters. A depth of only 1.44 m would yield the greatest volume and 1.49 m would yield the greatest mass as well; both values would be plausible. The microcline deposit in Colorado, U.S.A. may well have con-

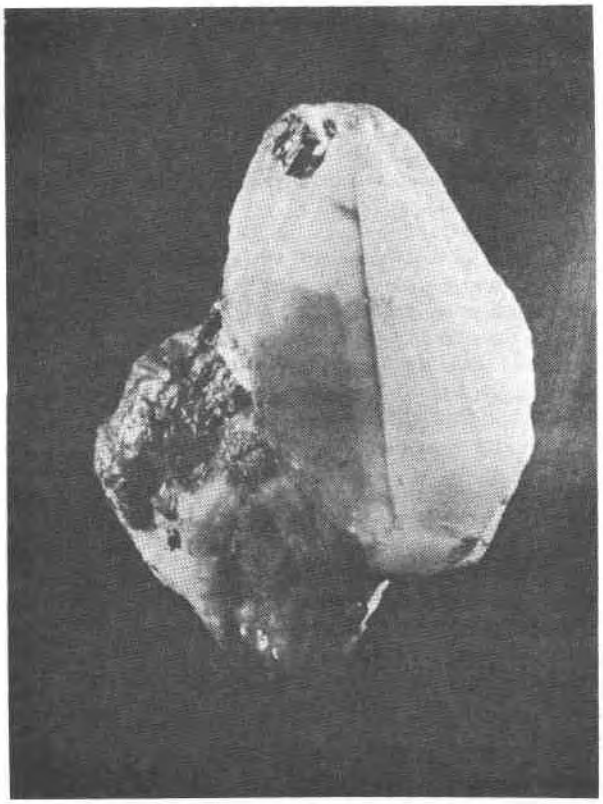

Fig. 12. The largest *ORGANIC* crystal by length, volume and mass. Whewellite, Zwickau, Saxony, Germany. This is specimen 27153 in the Bergakademie, Freiberg, D.D.R. and the photograph is reproduced by permission of Dr. F. Höfmann (Table 1-x_1).

tained the largest crystal ever discovered but there is insufficient evidence to support that claim. The volume and mass of the main microcline body so far exceed corresponding parameters for any other crystals (× 43.5 and × 41.9 respectively over the beryl from Malagasy) that the parameters given in Table 1 must be regarded with scepticism.

Of the 60 crystals listed in Table 1, 20 are known to be in museum collections (sulphur, stibnite (2), galena, argyrodite, corundum, brucite, soda-nitre, gerhardtite, schwartzembergite, wulfenite, scheelite (3), vanadinite, garnet, orthite, muscovite, whewellite (2)), 3 (crocoite, legrandite and mimetite) are in private collections and 1 (kernite) is still *in situ*. Three others, kamacite, tennantite, and wulfenite may be in museums but there is some uncertainty. The ferroan-brucite (e_1) is likely to be in a museum, probably in the U.S.A.

An attempt has been made to obtain photographic proof of the data in Table 1 from museum curators and mineralogists. Included in this paper are photographs of 12 of these crystals (sulphur, stibnite, galena, corundum, wulfenite, scheelite, mimetite, garnet, orthite, spodumene, muscovite and whewellite). Photographic evidence has been published for two additional crystals from this list, ferroan-brucite (Berman and West, 1932, Fig. 1) and crocoite (Bancroft, 1973, p.141) and sketches of a garnet (Barth, 1930, p.128; 1962, p.300) and whewellite (Guillemin, 1964, p.22) have been printed. The largest crystal of which photographic evidence exists is the 14.3 m (47 foot) long spodumene (Fig. 9) from the Etta Mine, South Dakota, U.S.A.

In 1928, Spencer cogently discussed the problems and philosophy of museums in regard to large crystals. However, it is unfortunate that not even photographs exist of most of these unique specimens.

Acknowledgments

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References

Anderson, O., (1931) Feltspat II. Forekomster I Fylkene Buskerud og Telemark, I Flere Herreder I Aust-Agder og I Hidra I Vest-Agder. Norges Geologiske Undersokelse, 128 B, 1–109.

Anonymous (1889) Canadian Mining Review, 8, (11), 6. (not sighted; extract by Dr. D. D. Hogarth—25-1-78).

Anonymous (1890) The Canadian phosphate industry. Canadian Mining Review, 9, (11), 158–160.

Bancroft, P. (1973) The World's finest minerals and crystals. Thomas and Hudson, London.

Bandy, M. L. (1951) The Ribaue–Alto Ligonha pegmatite district, Portuguese East Africa. Rocks and Minerals, 26, 512–521.

Bariand, P. and Bariand, N. (1976) Marvellous world of minerals. Trans. D. Macrae. Abbey Library, London.

Barth, T. (1928) Zur Genese der Pegmatite im Urgebirge. 1. Die Geologie und Petrographie der granitischen Pegmatite im Südlichsten Norwegen. Neues Jahrbuch fur Mineralogie, Geologie und Palaeontologie, 50, 385–432.

Barth, T. (1930) Zur Genesis der Pegmatite im Urgebirge. 11. Ein syntektischer Gesteinskomplex aus dem Südlichsten Norwegen. Chemie der Erde, 4, 95–136.

Barth, T. F. W. (1931) Feltspat III, Forekomster I Iveland og Vegusdal I Aust-Agder og I Flere Herreder I Vest-Agder. Norges Geologiske Undersokelse, 128B, 111–151.

Barth, T. F. W. (1947) The nickeliferous Iveland-Evje amphibolite and its relation. Norges Geologiske Undersokelse, 168a.

Barth, T. F. W. (1960) Telemark-Rogaland region. 34-48 in Holtedahl, O. (Ed.). Geology of Norway. Norges Geologiske Undersokelse, 208.

Barth, T. F. W. (1962) Theoretical Petrology. John Wiley and Sons, Inc., New York.

Berman, H. and West, C. D. (1932) Fibrous brucite from Quebec. American Mineralogist, 17, 313–316.

Bjørlykke, H. (1935) The mineral paragenesis and classification of the granite pegmatites of Iveland, Setesdal, Southern Norway. Norsk Geologisk Tidskrift, 14, 211–311.

Blake, W. P. (1884) Columbite in the Black Hills of Dakota. American Journal Science Ser. 3., 28, 340–341.

Brögger, W. C. (1890) Die Mineralien der Syenitpegmatitgänge der Sudnorwegischen Augit und Nephelinsyenite. Zeitschrift fur Krystallographie und Mineralogie, 16, 215–235.

Brögger, W. C. (1894) On the formation of pegmatite veins. Translated Evans, N. N. Canadian Record of Science, 6, 34–46, 61–71.

Campbell, D. F. (1946) Quartz crystal deposits in the State of Goiaz, Brazil. Economic Geology, 41, 773–799.

Dana, J. D. and Brush, G. J. (1872) A System of Mineralogy. Descriptive Mineralogy. Fifth Edition. John Wiley and Sons, New York.

Descloizeaux, M. (1847) Note sur le gisement du spath d'Islande. Bulletin de la Societe géologique de France, 2nd Series, 4, 768–772.

Dietze, A. (1891) Einige neue chilenische Mineralien Zeitschrift fur Kristallographie und Mineralogie, 19, 445–451.

Fersman, A. E. (1931) Les Pegmatites. Leur importance scientifique et pratique. 3 vols. Academie des Sciences de L'U.R.S.S. Leningrad 1931.

Fesenkov, V. G. (1958) Progress in meteoritics (in Russian) · Meteoritika, 16, 5–10. [not sighted; data from this publication was supplied by Dr. B. Mason—Feb. 1979].

Foshag, W. F. (1927) The selenite caves of Naica, Mexico. American Mineralogist, 12, 252–256.

Frondel, C. (1935) The size of crystals. American Mineralogist, 20, 469–473.

Frondel, C. (1962) The system of mineralogy of J. D. Dana and E. S. Dana, Yale University, 1837–1892. 7th Edition. Vol. 3, Silica Minerals. John Wiley and Sons Inc., New York.

Gregg, R. P. and Lettsom, W. G. (1858) Manual of the mineralogy of Great Britain and Ireland. John van Voorst, London.

Guillemin, C. (1964) En visitant les grandes collections minéralogiques mondiales. Bureau de recherches géologiques et minières, Paris. (Pagination recommences with each museum entry).

Guillemin, C. (1972) En visitant les grandes collections minéralogiques mondiales. Bureau de recherches géologiques et minières, Paris.

Hall, R. L. (1920) Corundum in the Northern and Eastern Transvaal. Union of South Africa, Department of Mines and Industries, Memoir, 15.

Hanley, J. B. (1953) Bob Ingersoll Mine (Keystone District). U.S. Geological Survey, Professional Paper, 247, 75–83.

Hanley, J. B., Heinrich, E. W. and Page, L. R. (1950) Pegmatite investigations in Colorado, Wyoming and Utah 1942–1944. U.S. Geological Survey Professional Paper, 227.

Harding, W. D. (1944) The geology of the Mattawan–Olrig Area. Ontario Department of Mines, 53, 1–47.

Henderson, E. P. and Perry, S. H. (1954) A discussion of the densities of iron meteorites. Geochimica et Cosmochimica Acta, 6, 221–240.

Hess, F. L. (1909) Rare metals. Tin, tungsten, and tantalum deposits of South Dakota. U.S. Geological Survey, Bulletin, 380, 131–163.

Hess, F. L. (1911) Lithium. In Mineral Resources of the United States, calendar year 1909, pt. 2. U.S. Geological Survey, 649–653.

Hess, F. L. (1925) The natural history of the pegmatites. Engineering and Mining Journal-Press, 120, 289–298.

Hess, F. L. (1933) Pegmatites. Economic Geology, 28, 447–461.

Hewitt, D. F. (1968) Phlogopite mica in Ontario. Ontario Department of Mines, Mineral Resources Circular, 8.

Holland, T. H. (1902) The mica deposits of India. Memoir of the Geological Survey of India, 34. (Part 2).

Hurlbut, C. S. (1968) Minerals and Man. Random House, New York.

Jahns, R. H. (1946) Mica deposits of the Petaca District, Rio Arriba County, New Mexico. New Mexico Bureau of Mines and Mineral Resources, Bulletin, 25.

Jahns, R. H. (1952) Pegmatite deposits of the White Picacho District, Maricopa and Yavapai Counties, Arizona. Arizona Bureau of Mines Bulletin, 162.

Jahns, R. H. (1953) The genesis of pegmatites. 1. Occurrence and origin of giant crystals. American Mineralogist, 38, 563–598.

Jensen, B. and Frigstad, O. F. (1967) Large beryl crystals. Internal Notes, Geologisk Museum, Oslo, 7th. Dec., 16.

Joralemon, P. (1953) Beecher Lode (Custer District). U.S. Geological Survey, Professional Paper, 247, 65–71.

Kelley, V. C. (1940) Iceland Spar in New Mexico. American Mineralogist, 25, 357–367.

Kemp, J. (1924) The pegmatites. Economic Geology, 19, 697–723.

Key, C. L. (1977). The best of Tsumeb. Mineralogical Record, 8,(3), 48–50.

Kolderup, N. H. (1960). Origin of Norwegian eclogites in gneisses. Norsk Geologisk Tidskrift, 40, 73–76.

Kolderup, N. H. and Rosenqvist, I. T. (1950). Giant garnet crystals from Gjølanger, Western Norway. Univ. Bergen Årbok, 6, 3–10.

Kostov, I. (1968). Mineralogy. Translated by P. G. Embrey and J. Phemister. Oliver and Boyd, Edinburgh.

Levin, S. B. (1950). Genesis of some Adirondack garnet deposits. Bulletin of the Geological Society of America, 61, 519–565.

Lindgren, W. (1933). Mineral deposits. 4th. Edition. McGraw-Hill Book Co. Inc., New York.

Maitland, A. G. (1906). Third report on the geological features

and mineral resources of the Pilbara goldfield. Western Australia Geological Survey Bulletin, 23.

Mason, B. and Berry, L. G. (1968). Elements of Mineralogy. W. H. Freeman and Company, New York.

de Michelle, V. (1978). Le collezioni mineralogiche del Museo Civico di Storia Naturale di Milano attraverso 140 anni di Storia. Atti della Societa Italiana di Scienze Naturale del Museo civico di Storia Naturale di Milano, 119, 3–58.

Murdoch, A. (1943) Boom Copper. (Reprinted 1964). The McMillan Co., New York. (Not seen: extract supplied by Mr. A. Y. Johnstone, 20.5.77).

Namu, M. (1970) Introduction to Japanese Minerals, edited by Editorial Committee for "Introduction to Japanese Minerals" Organizing Committee, IMA -IAGOD Meeting '70. Geological Survey of Japan.

Norton, J. J., Page, L. R. and Brobst, D. A. (1962) Geology of the Hugo Pegmatite, Keystone, South Dakota. U.S. Geological Survey Professional Paper, 297-B, 49–127.

Osann, A. (1894) Krystallographische Untersuchung einiger neuer chilenischer Mineralien. Zeitschrift fur Kristallographie und Mineralogie, 23, 584–589.

Palache, C. (1923) The largest crystal. American Mineralogist, 17, 362–363.

Palache, C., Berman, H., and Frondel, C. (1944) The system of mineralogy of J. D. Dana and E. S. Dana, Yale University 1837–1892. 7th Edition. Vol. 1. Elements, Sulfides, Sulfoxides and Oxides. John Wiley & Sons, Inc. New York.

Palache, C., Berman, H., and Frondel, C. (1951) The system of mineralogy of J. D. Dana and E. S. Dana, Yale University 1837–1892. 7th Edition. Vol. 2. Halides, Nitrates, Borates, Carbonates, Sulfates, Phosphates, Arsenates, Tungstates, Molybdates etc. John Wiley and Sons, Inc., New York.

Pinch, W. W. and Wilson, W. E. (1977) Tsumeb minerals: a descriptive list. Mineralogical Record, 8(3), 17–37.

Reid, A. M. (1925) The Dundas Mineral Field. Tasmania Department of Mines, Geological Survey Bulletin, 36.

Reuning, E. (1925) Die Natasmine in Südwest-Afrika, eine pegmatitisch-pneumatolytisch-hydrothermale Übergangslagerstätte mit Scheelit, Molybdänglanz, Kupfererzen und Gold. Neues Jahrbuch fur Mineralogie, 52, 192–264.

Rickwood, P. C. (1976) As big as a rock. Geotimes, April, 15.

Rosenqvist, J. T. (1951) Kjempegranaten fra Gjølanger. Bergen tidende, 15th Dec.

Schaller, W. T. (1916) Gigantic crystals of spodumene. U.S. Geological Survey Bulletin, 610, 138.

Schaller, W. T. (1930) Borate minerals from the Kramer District, Mohave Desert, California. U.S. Geological Survey, Professional Paper, 158-1, 137–170.

de Schmid, H. S. (1912) Mica, its occurrence, exploitation, and uses. Canada Department of Mines Publication, 118.

Sinkankas, J. (1964) Mineralogy for amateurs. D. Van Nostrand Company, Inc., Princeton, New Jersey, U.S.A.

Smith, G. F. and Prior, G. T. (1911) On schwartzembergite. Mineralogical Magazine 16, 77–83.

Spence, H. S. (1929) Mica. Canada Department of Mines Publication, 701.

Spencer, L. J. (1928) Large specimens of spar from the Snailbeach Mine, Shropshire. Natural History Magazine, 1(7), 258–265.

Stevens, J. P. (1972) Gems and minerals of Oxford County (Maine). 216pp. Privately published. Perham's Maine Mineral Store, West Paris, Maine.

Talmage, J. E. (1893) A remarkable occurrence of selenite. Science, 21, 85–86.

Tasmania Department of Mines (1970) Catalogue of the minerals of Tasmania. Tasmania Department of Mines, Geological Survey Record, 9.

Wada, T. (1904) Minerals of Japan. Translated by T. Ogawa, Tokyo.

Waldschmidt, W. A. (1920) The largest known beryl crystal. Pahasapa Quarterly (Black Hills Engineer), 9, 11–16.

Weinschenk, E. (1900) Zur Kenntniss der Graphitlagerstätten. III. Die Graphitlagerstätten der Insel Ceylon. Bayerischen Akademie der Wissenschaft, 21(2), 281–334.

White, J. W. (1977) Tsumeb. Kegel Collection. Mineralogical Record, 8(3), 51–53.

Wilson, J. F. and Martin, H. J. (1964) The geology of the country around Fort Victoria and the Bikita Tinfield. Abhandlungen der Southern Rhodesia Geological Survey Bulletin, 58.

Wilson, W. (1977) Folio:Tsumeb! Mineralogical Record, 8(3), 55–85.

Wilson, W. E. (1978) What's new in minerals. Mineralogical Record, 10(1), 31–35.

Yount, V. (1976) M. R. Interview. Mineralogical Record, 7(5), 241–247.

Ziegler, V. (1913) The lithia deposits of the Black Hills. Engineering and Mining Journal, 96, 1053–1056.

Ziegler, V. (1914) The mineral resources of the Harney Peak pegmatites. Mining and Scientific Press, 108, 604–608, 654–656.

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