Dickite from the Witwatersrand gold mines.

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THE occurrence of dickite in the gold-bearing rocks of the Witwatersrand system was first reported by Mr. H. C. M. Whiteside.[1] In addition, among the many mineral samples given to me by students of the Witwatersrand Technical College, Johannesburg, were several dickite specimens from mines all along the Witwatersrand area. Dickite may therefore be regarded as fairly widespread in the rocks of at least the Main-Bird series, although not in large quantity.

The only occurrence of which a detailed record is available is that from the Daggafontein mine. Little is known of the other samples except from the immediate mineral associations. It is, however, clear that all the occurrences are of hydrothermal origin.

Although the various specimens do not differ greatly in any particular property, it is considered best to describe the associations and macroscopic features of each specimen separately.

Daggafontein mine.—The dickite, which is in rounded lumps, was embedded in a greenish-grey clay; this material was composed of quartz crystals and a chloritic mineral none of which is available for detailed study. The dickite lumps are irregularly streaked with grey chlorite in which are embedded small pyrrhotine crystals and small kidney-shaped and rounded particles of a lustrous black organic material. No positive identification was given for this substance by Whiteside, who suggested it resembled grahamite on the grounds of specific gravity. Careful determinations on a sample in my possession gave a specific gravity of 1·27. This is probably slightly high owing to a small amount of complex impurity which is left as an ash after ignition. In the absence of any detailed analysis its true nature remains for the present unknown. The other minerals present have been described by Whiteside previously, but mention must be made of a few small cubes of silvery gersdorffite, which is possibly the mineral originally described as galena.

[1] H. C. M. Whiteside, 1941. An unusual suite of minerals from a vug in a quartz vein in the Kimberley series, Daggafontein mines, Ltd. Trans. Geol. Soc. South Africa, 1942, vol. 44 (for 1941), pp. 121–126. [M.A. 9–65.]

Rand Leases.—Two specimens from different parts of this mine show the same mineral associations. The dickite as received was adhering to aggregates of small quartz crystals growing from the walls of quartz vugs. None of the quartz crystals was quite like those from Daggafontein; most of them were terminated at one end only. There were, however, several crystals absolutely water-white and doubly terminated. An interesting feature is the inclusion of irregular vein-like growths of a lustrious black organic material in some of these crystals.

With the dickite are minute crystals of pyrite as cubes, pyrrhotine as books of hexagonal plates, and chalcopyrite as slender and flat crystals. Much sooty-like 'carbon' is scattered among the dickite aggregates.

Langlaagte Estates.—This sample consisted of two small pieces of quartz vug wall with dickite and sulphide crystals similar to those from Rand Leases.

Consolidated Main Reef mine.—The specimen of dickite from this mine has a more interesting appearance than those from the other mines. Dickite is present as a thick layer of drab green colour moulded on the conglomerate reef itself as well as on to imperfectly formed quartz crystals and nodular pyrite.

Crystallographic and optical properties.

Little can be added from the detailed study of all the Witwatersrand specimens to the data already on record for dickite. In the classic work so carefully carried out by Dick[1] and the subsequent investigation by Ross and Kerr[2] the mineral has been described most thoroughly.

Under the microscope the various samples show practically perfect crystals of a fascinating beauty. Forms and habits identical with those drawn by Dick of the Anglesey material are seen. The dominant crystal faces are the basal pinakoid (001) and the prism (110). The clinopinakoid (010) is present on the larger crystals (fig. 1 *c*), but it is poorly developed and almost entirely absent on the smaller crystals. This is particularly so of those from the Daggafontein mine (fig. 1 *b*). The orthopinakoid (100) is poorly developed on relatively few crystals. The pyramids (111) and (*hkl*) are recognizable, the former considerably more frequently. The presence of the dome (0*kl*) is doubtful.

[1] A. B. Dick, On kaolinite. Min. Mag., 1888, vol. 8, pp. 15–27. Supplementary notes on the mineral kaolinite. Ibid., 1908, vol. 15, pp. 124–127.

[2] C. S. Ross and P. F. Kerr. The kaolin minerals. Prof. Paper U.S. Geol. Surv., 1931, no. 165-E, pp. 151–176. [M.A. 5–359.]

Some of the optical properties determined in sodium-light are tabulated below. In addition, the trace of *c* (001) on *b* (010) was measured as 22 to 23°. For comparative purposes the properties of a specimen of dickite separated from a clay from the Middelburg district, Transvaal, are added.[1]

	α.	β.	γ.	Extinction on *b* (010).	2Vγ
1	1·561	1·564	1·567	14°	69°
2	1·560	1·564	1·567	16°	69°
3	1·561	1·563	1·568	15°	67°
4	1·560	1·563	1·567	16 to 17°	66 to 68°

1. Dickite, Daggafontein mine; 2, Rand Leases; 3. Rand Leases; 4. Middelburg district, Transvaal. (Refractive indices all ±0·001.)

Chemical Composition.

A chemical analysis was made previously of a 'green dickite' from the Consolidated Main Reef mine and more recently the specimen from the Daggafontein mine was analysed.

	1.	2.	3.	(Atoms on basis 9(O,OH))	
SiO_2	41·90	45·49	45·58	1·97	
TiO_2	trace	none	—		
Al_2O_3	33·12	40·91	40·99	2·07	
Fe_2O_3	0·93	—	—		
FeO	10·28	0·17	—		Si,Al 2·00
MnO	0·23	n.f.	—		Al 2·04
MgO	0·03	trace	—		(OH) 3·97
CaO	0·12	none	—		
H_2O^+	13·24	13·92	13·94	3·97	
H_2O^-	none	0·01	—		
Cr_2O_3	n.f.	trace	—		
	99·85	100·50	100·51		

1. Green dickite, Consoliated Main Reef mine. (Frankel, 1944.)
2. White dickite, Daggafontein mine.
3. Analysis 2, recalculated after removal of moisture and iron.

Dr. B. Wasserstein of the Union Geological Survey very kindly made a qualitative spectrographic analysis of the Daggafontein dickite and reported as follows. (The digits are rough arbitrary determinations of visual intensity of certain sensitive lines.) Pb 2, Fe 7, Cr 9, V 5, Ni 1, Mg 1, Ga 1. Absent—Mn, K, Li, Na, Rb, Ca, Ti, Sr, Ba, Sn, Co. Mo, Yt, &c.

Under the microscope the 'green dickite' is seen to be composed of perfect crystals of colourless dickite (fig. 1 *a*) surrounded by a green

[1] Determinations made on a sample kindly supplied by Dr. V. L. Bosazza some years back.

mineral of low birefringence with a mean refractive index of roughly 1·625. This green mineral makes up approximately 15 per cent. of the sample. A computation of its composition obtained by subtracting the theoretical composition of dickite from the analysis suggests a chloritic mineral rather than a variety of nontronite, which was a tentative suggestion made earlier.[1]

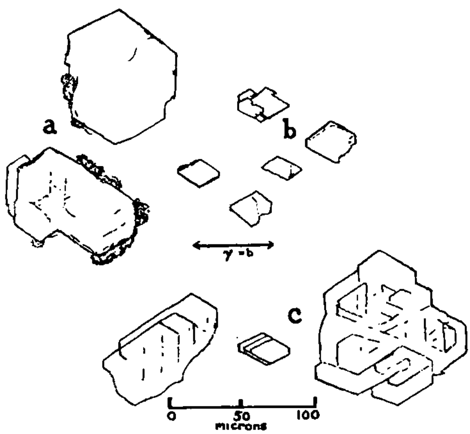

FIG. 1. Camera lucida drawings of dickite crystals.

a. Shows an association of colourless dickite partly surrounded by an irregular growth of a green chloritic mineral. Consolidated Main Reef mine.

b. Characteristic habit of the smaller crystals from the Daggafontein mine.

c. Crystals from Langlaagte Estates.

The ferrous oxide reported in the Daggafontein analysis is due to the presence of a minute amount of extremely fine pyrrhotine. The ferrous oxide was removed from the analysis and the recalculated values gave the formula of this dickite as $(Si,Al)_{2\cdot00}(Al)_{2\cdot04}(OH)_{3\cdot97}(O)_{5\cdot03}$ which may be compared with the theoretical figures of $Si_2Al_2(OH)_4O_5$.

Physical Properties.

Pressure on crystals between glass slide and cover-slip has revealed no direction of cleavage other than that of the perfect basal cleavage. The specific gravity of the Daggafontein material was found by suspension in a heavy liquid to be 2·61 to 2·62. In the hand-specimens the colour varies from dead white (Daggafontein) to a pale silvery-

[1] J. J. Frankel, On silicates and dusts from the Witwatersrand gold mines. Journ. Chem. Metall. Mining Soc. South Africa, 1944, vol. 44, pp. 169–177. [M.A. 9–103.]

grey (Rand Leases). The green colour of the Consolidated Main Reef specimen is of course due to the admixture of the unidentified green mineral. Under the microscope all the crystals are colourless and perfectly transparent.

The following table gives the crystal-sizes in microns (average of the maximum and minimum directions across the basal pinakoid).

	Large.	Small.	Average.
1	40	6	15μ
2	80	10	60
3	80	30	60
4	100	20	40
5	150	60	80
6	100	30	60

1, Daggafontein mine; 2, Rand Leases mine; 3, Rand Leases mine; 4, Langlaagte Estates; 5, Consoliated Main Reef mine; 6, Middelburg district, Transvaal.

Most of the samples are made up of individual crystals in parallel orientation with the basal pinakoid as contact face; and, as noted by Ross and Kerr, rotation of one crystal with reference to the other when basal pinakoid is the contact face is often observed. Single crystals are fairly abundant.

Staining tests with organic dyes gave the characteristic poor adsorption and no development of artificial pleochroism. Occasional shreds of kaolinite present in the specimens stand out sharply by contrast because of their reaction to the dyes.

X-ray powder photographs taken of several of the specimens show all the dickite lines clearly, including those of high order.

In all the examples from the Witwatersrand the mineral associations show that the dickite is of hydrothermal origin. It is anticipated that many more occurrences of dickite will be discovered in the course of mining.