# ZIRCON FROM NORTH BURGESS, ONTARIO

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Although no mineral has been longer the subject of exact studies than zircon, there is a notable lack in the literature of investigations of its various properties made upon material from any single locality. A large suite of specimens recently secured by the Harvard Mineralogical Museum seemed to offer unusual opportunity for such a series of studies and although not exhaustive, the following data have the merit of being secured from homogeneous material from a single deposit.

Mr. W. F. Ferrier, through whom the zircon was obtained for the Museum, has supplied data on its place and mode of occurrence secured from Mr. W. L. McLaren of Perth, Ontario, who collected the zircons when operating mica mines in 1904 and 1905. The locality is near Otty Lake in the township of North Burgess, Lanark Co., Ontario, about four miles directly south of Perth.

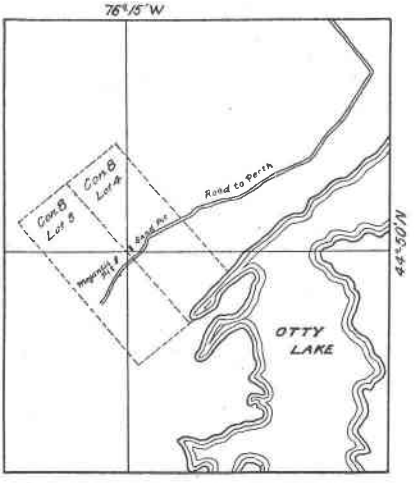



Fig. 1. Map of the locality in North Burgess, Ont., where zircon was found.

The detail map,[1] figure 1, shows the two pits from which the zircons came; they lie among scores of similar openings, originally

[1] Drawn from the map in an article by H. G. Vennor on Apatite Deposits of Lanark Co., in *Geol. Surv. Canada*, Rep. of Prog., **1873–74,** 128; and from notes by Mr. McLaren. The minerals of this region, except zircon, are also described in Mica, H. de Schmid, *Can. Dep. of Mines* No. **118,** 178, 1912.

developed about 1870 as apatite mines, later reworked in part as mica mines, and now all abandoned. Most of the crystals were taken from the pit located in Concession VIII, Lot 4, known as the Sand Pit. The one matrix specimen from here consists largely of serpentinized pyroxene with some granular calcite and fragmentary crystals of apatite. Several matrix specimens from the Megantic Pit show fresher rock with coarse cleavages of calcite, crystals of pyrite and phlogopite and areas of much fractured green apatite. The zircon in both groups of specimens is identical in color and properties. In the collections are a few matrix specimens of zircon from South Burgess which look much like these, but the zircon proved not to have the abnormality of angles which is peculiar to the North Burgess crystals.

CRYSTALLOGRAPHY. The zircon crystals from North Burgess are mostly loose but a few are still enclosed in their matrix. Few are now intact but the matrix specimens show that they were all originally complete individuals with double terminations. They range in size from a few millimeters in diameter to a length of 3 cm. and a cross section of $2\times1$ cm. The color is a deep red brown and when unflawed they are transparent and of gem quality. Unfortunately the crystals have been more or less fractured while imbedded and are very fragile, many of them falling to pieces when the matrix is disturbed. The smaller crystals are, however, sound and because of their brilliant faces particularly well suited for measurement.

The measurement and drawings of the crystals are the work of Dr. M. A. Peacock. All of them show the forms $m(110)$, $p(111)$, $u(331)$ and $x(311)$ but with the utmost variation in the development of the individual forms so that there is endless variety in the detailed habit. Figure 2 reproduces a crystal of average development showing the irregularity in size and shape of the faces of each form. The less common forms $\zeta(113)$ and $v(221)$ were seen only on the two crystals reproduced in figures 3 and 4, respectively. The form (113) was first recorded by Hidden[2] on a crystal from North Burgess, possibly from this identical pit, but was not figured. It has since been recorded only once from an Italian occurrence. $v(221)$ is also a rare form for zircon.

The first measurements made on these crystals revealed in the polar angles of all forms a definite and very consistent deviation

[2] *Am. J. Sc.*, **29**, 250, 1885.

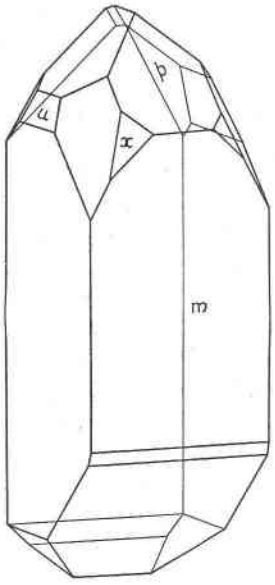
EXPLANATION OF PLATE XIII

Fig. 2. Zircon. Drawing of a crystal of average habit showing the forms $m(110)$, $p(111)$, $u(331)$, and $x(131)$.

Fig. 3. Zircon. Drawing of an exceptional crystal showing the forms of figure 2 and in addition the uncommon pyramid $\zeta(113)$.

Fig. 4. Zircon. Drawing of a crystal of unusual habit showing the forms of figure 2 and in addition the rare pyramid $v(221)$.

Fig. 5. Curve plotted from TABLE I showing indices of refraction and dispersion of zircon from North Burgess. Before heating ————. After heating .....

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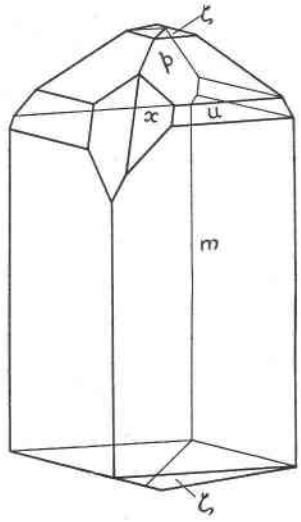


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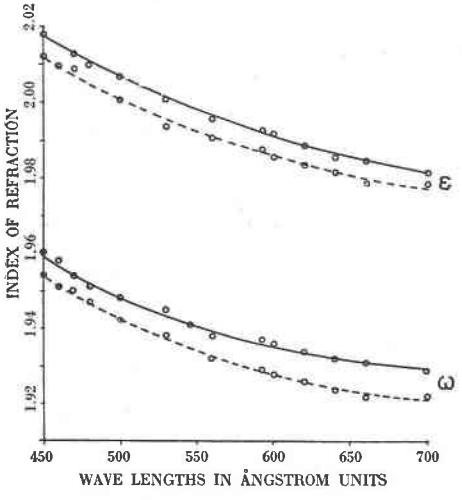


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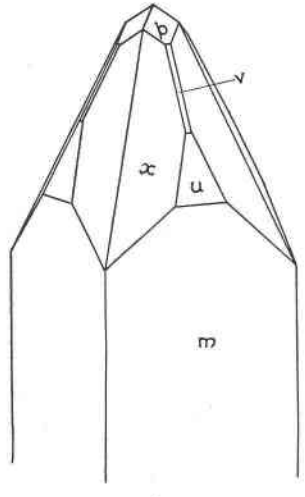


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PLATE XIII

from the accepted values for zircon. This deviation proved to be characteristic and constant within rather narrow limits and seemed sufficiently notable to be investigated in the hope of finding some explanation for it in the chemical nature of the zircon. The angles obtained are shown in the following table. Only measurements of the best quality are included, obtained in every case without the use of the magnifying ocular.

| Form | | Measured | | Deviations | | Calculated |
|---|---|---|---|---|---|---|
| | | $\phi$ | $\rho$ | $\phi$ | $\rho$ | $p_0$ |
| $p$(111) | Mean, 18 faces, 5 crystals | 45°00′ | 42°16′ | 1′ | +2 to −2′ | .6427 |
| | Winkeltabellen | 45 00 | 42 09 $\frac{2}{3}$ | | | |
| $u$(331) | Mean, 7 faces, 2 crystals | 45°00′ | 69 51 | 2 | +2 to −2 | .6424 |
| | Winkeltabellen | 45 00 | 69 47 $\frac{1}{3}$ | | | |
| $x$(311) | Mean, 24 faces, 5 crystals | 18 26 | 63 49 | 3 | +3 to −3 | .6431 |
| | Winkeltabellen | 18 26 | 63 43 | | | 3×.6432 |

Weighted average .6429
Winkeltabellen .6404

Poor readings were also obtained for the following:

| | | | Calculated |
|---|---|---|---|
| | | $\rho$ | $\rho$ |
| $\zeta$(113) | Mean 3 readings | 16°56′ | 16°52′ |
| $v$(221) | Mean 3 readings | 61 09 | 61 11$\frac{1}{2}$ |

The zircon crystals from North Burgess are completely decolored by heating to a dull red heat for not more than one minute. To test the effect of this heating upon the angles, a crystal was measured before and after heating. It was found that the faces suffered a slight decrease of brilliancy but still gave excellent readings.

| Before heating | After heating | Increase |
|---|---|---|
| $\rho$ | $\rho$ | |
| (111) 4 faces 42° 15′±1′ | 42° 16′±1′ | 1.0′ |
| (331) 4 faces 69 49.8±2 | 69 51 ±2 | 1.2 |
| (131) 8 faces 63 47.1±1 | 63 47.8±1 | 0.7 |

The permanent change of angular values is slight but definite and is consistent.

The angles calculated from the new element for these crystals are as follows:

| | Calculated | | Observed | Winkeltabellen |
|---|---|---|---|---|
| | $\phi$ | $\rho$ | $\rho$ | $\rho$ |
| (111) | 45°00′ | 42°16½′ | 42°16′ | 42°09⅔′ |
| (331) | 45 00 | 69 52 | 69 51 | 69 47⅓ |
| (131) | 18 26 | 63 48½ | 63 49 | 63 43 |

(111) $pp'$56° 48′30″ (Kupffer) 56°40′26″ Calculated

Thus the $\rho$ angles of the three forms are from 5 to 6 minutes larger than the accepted values. That this variation is exceptional is shown by a careful examination of the observations recorded in Hintze. Calculating $\rho$ from the observed angles where necessary and including all values apparently based on crystals of good quality we find the following:

| Observer | Locality | Form | Angle | Element | $HfO_2$ |
|---|---|---|---|---|---|
| | | | $\rho$ | $p_0$ | % |
| Kupffer, Kokscharoff | Ilmen Mts. | (111) | 42°09′ | .6404 | 1.1 |
| Dauber | Ceylon | (111) | 42 10 | .6404 | ... |
| Dauber | Pfitschthal | (111) | 42 09 | .6404 | ... |
| Dauber | Fredrikvarn | (111) | 42 09 | .6404 | 1.0 |
| Vom Rath | Laach | (111) | 42 10 | .6404 | ... |
| Negri | Loredo | (111) | 42 10 | .6405 | 0.9 |
| Artini | Novale | (111) | 42 10 | .6406 | 0.7 |
| Lacroix | Espailly | (111) | 42 10 | .6406 | 0.7 |
| Grattarola | Ceylon | (111) | 42 10 | .6407 | ... |

One of the crystals from South Burgess mentioned above was measured and gave results which are fairly consistent and very close to normal values.

| | | $\rho$ |
|---|---|---|
| (111) | 4 faces | 42°11′ ± 2′ |
| (331) | 3 faces | 69 45 ± 3′ |
| (131) | 5 faces | 63 41 ± 6′ |

These angles vary not more than 2′ from normal angles.

Optical Characters. A prism was cut from one of the clearest crystals, the refracting edge being parallel to the $c$-axis, and the refracting angle, $\alpha$, 20°31′. The measurements made upon this prism by Mr. Berman before and after heating are shown in the following table and in the plot, Plate XIII, figure 5. It is clear that the effect of heating which renders the substance colorless

is to lower the indices of refraction without, however, producing significant effect on the dispersion or birefringence. It is uniaxial both before and after heating.

TABLE I. INDICES OF REFRACTION OF ZIRCON FROM NORTH BURGESS

| Wave length | Before heating | | | After Heating | | |
|---|---|---|---|---|---|---|
| Ångstrom units | $\alpha = 20°31'$ | | Birefringence | $\alpha = 20°35'$ | | Birefringence |
| | $\omega$ | $\epsilon$ | | $\omega$ | $\epsilon$ | |
| 450 | 1.959 | 2.016 | .057 | 1.953 | 2.011 | .058 |
| 460 | 1.957 | 2.011 | .054 | 1.950 | 2.008 | .058 |
| 470 | 1.953 | 2.010 | .058 | 1.949 | 2.007 | .058 |
| 480 | 1.950 | 2.008 | .058 | 1.946 | 2.003 | .057 |
| 500 | 1.947 | 2.005 | .059 | 1.941 | 1.999 | .058 |
| 530 | 1.944 | 1.999 | .055 | 1.937 | 1.992 | .055 |
| 546 | 1.940 | 1.997 | .057 | | | |
| 560 | 1.937 | 1.994 | .057 | 1.931 | 1.989 | .058 |
| 589 | 1.936 | 1.991 | .055 | 1.928 | 1.986 | .058 |
| 600 | 1.935 | 1.990 | .055 | 1.927 | 1.984 | .057 |
| 620 | 1.933 | 1.987 | .054 | 1.925 | 1.982 | .057 |
| 640 | 1.931 | 1.984 | .053 | 1.923 | 1.980 | .057 |
| 660 | 1.930 | 1.983 | .053 | 1.921 | 1.977 | .056 |
| 700 | 1.928 | 1.980 | .052 | 1.921 | 1.977 | .056 |

SPECIFIC GRAVITY. The specific gravity of the analyzed sample of North Burgess zircon (about 8 grams) was determined by Mr. Berman as 4.657 at 27°, and by Dr. Ellsworth as 4.659 at about 20°. A small portion of the same material after heating to dull redness had specific gravity 4.667 at 27°.

Another sample, the exact source of which in North Burgess is unknown, gave somewhat different values.

Specific gravity before heating 4.646
Specific gravity after heating 4.659

The increase in the two samples is of the same order.

CHEMICAL COMPOSITION. A sample of about 9 grams of the zircon was prepared by Mr. Berman. For this purpose a matrix specimen, probably from the Megantic Pit, was used, one of the crystals being measured to be sure that it had the characteristic large angles of the North Burgess material. The hand-picked fragments were found to have slight films of calcite, formed on some of the cracks in the otherwise glassy zircon; it was therefore treated with dilute HCl until effervescence ceased. Under the microscope no impurity could be discovered in the sample. The analysis was made by the junior author. The sample was crushed

on a hard steel plate, not ground, treated with HCl to remove particles of steel and sifted through silk. Solution was effected by 4 or 5 fusions alternating with alkali carbonate and bisulphate. The sample showed negligible radioactivity so that U and Th could not be determined by analytical methods. The procedure was such that Ti, Ta, Cb, Be, Mn and Sn should have been detected if present. Particular pains were taken to obtain the whole of the silica. Zirconia was precipitated by cupferron after removing Fe, Al, rare earths and alkaline earths.

ANALYSIS OF ZIRCON BY H. V. ELLSWORTH[3]

| | Percentages | Mol. ratios |
|---|---|---|
| $SiO_2$ | 32.51 | .539 |
| $ZrO_2$ | 67.02 | .544 |
| CaO | 0.22 | .004 |
| MgO | 0.01 | ..... |
| Rare earths | 0.04 | ..... |
| $Fe_2O_3$ | 0.08 | .0005 |
| $Al_2O_3$, etc. | 0.21 | .002 |
| Ignition | 0.03 | |
| | 100.12 | |

The part played in the composition of zircon by the minor constituents shown above is unknown; in any case their amount is so small that their effect is almost negligible. If silica and zirconia alone be considered, the molecular ratios show a slight deficiency of silica. This might be regarded as due to the presence of hafnium oxide in the zirconia. If 1 per cent. of $HfO_2$ were considered to be present the one to one ratio of bases to silica would be exact.

| | Percentages | Mol. wt. | Mol. ratios |
|---|---|---|---|
| $SiO_2$ | 32.51 | 60.06 | .541 |
| $ZrO_2$ | 65.52 | 123. | .537 } .541 |
| $HfO_2$ | 1. | 210.6 | .004 } |

It is known from the researches of Hevesy and others that some hafnium is always present in zircon. On page 388 above, in the last column of the table of previous observations made on zircon there are given the amounts of hafnium oxide determined in

[3] Published by permission of the Director of the Geological Survey of Canada.

samples of zircon from several well known localities.[4] In unaltered zircon (with measurable crystals) the amount seems not to exceed 1 per cent.

To test the hypothesis that hafnium oxide was present, the zirconia precipitate was examined in Professor Duane's laboratory at Harvard, for its Roentgen absorption spectrum. The result of this examination was negative as to the presence of hafnium. It is hoped, however, to have a more extensive examination of the mineral made for hafnium in the laboratory of Professor von Hevesy.

SUMMARY. Zircon crystals from North Burgess, Ontario, are characterized by unusual brilliancy; by extraordinary constancy of angles, corresponding faces on any one crystal never varying in position by more than one minute; by larger angles than hitherto recorded for the species, the polar angles of all forms being from five to six minutes larger than the accepted values; these angles lead to an axial ratio of $a:c=1:.6429$. The angles are increased by about one minute after heating to redness, a temperature which changes the red color to pure white. It is uniaxial, with the refractive indices of "normal zircon" and the indices are slightly lower after heating. The specific gravity, 4.646–4.658 is increased by heating to 4.659–4.667. Analysis shows it to be very pure zirconium silicate with an inconsiderable content of hafnium. The abnormal angles cannot therefore be assigned to the presence of the latter element and are unexplained.

[4] von Hevesy, G. Recherches sur les Propriétés du Hafnium *Kgl. Danske Vid. Selsk. Med.*, **VI**, 7, 25, 1925.

von Hevesy, G. DAS ELEMENT HAFNIUM, *Berlin*, 38, **1927.**