

sonite, remarked: "It occurs in seams in massive granular ore of the typical willemite-franklinite mixture; the seams are generally very thin with but a film of the mineral which is always associated with white barite and not uncommonly with plates of native copper." It will be noted that there is a very substantial similarity of association. It is not certain what mineral Wolff was referring to as "an earthy light pink manganese mineral," although this description is suggestive. On the whole, it appears that the association of barite, hodgkinsonite, and native copper at Franklin is normal. Other minerals, such as pyrochroite, axinite, and native lead, are also reported to occur with the three above.

Wolff⁴ noticed the altered character of the garnet gangue on one of his specimens, and believed that the deposition of the copper might have been related to this change. He also pointed out that the copper was always later than the associated minerals, basing his conclusion on the fact that the seams are always bounded by fracture and gliding planes. Palache and Schaller⁵ believed that the association and mode of occurrence of hodgkinsonite indicated a pneumatolytic origin for that mineral. This might also denote a pneumatolytic origin for the copper. In 1929, Palache⁶ stated again that all three minerals, barite, hodgkinsonite, and native copper, are pneumatolytic in origin. Irrespective of classification, this new occurrence of native copper with its associated minerals, is additional evidence of their constant genetic relationship.⁷

⁴ Wolff, J. E., *Op. cit.*, p. 431.

⁵ Palache, C., and Schaller, W. T., *Op. cit.*, p. 475.

⁶ Palache, C., Paragenetic classification of the minerals of Franklin, New Jersey: *Am. Min.*, vol. 14, no. 1, p. 11, 1929, and included table.

⁷ I wish to acknowledge the interest manifested by Dr. Paul F. Kerr, Professor of Mineralogy, and the aid extended by him in the preparation of this paper.

METHODS OF HANDLING AND DETERMINATION
OF DETRITAL GRAINS AND CRUSHED
ROCK FRAGMENTS

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I read with interest in your April issue Mr. F. C. Calkins' contribution on the handling of grains under the microscope. Perhaps the methods used in South Africa might also interest your readers.

In the Mineralogical Laboratory of the Geological Survey of the

Union of South Africa, where identifications and estimations are made for the public, chemical quantitative methods have been found far too time-absorbing and expensive for this type of work. They have therefore been superseded by quantitative mineralogical methods combined with spectroscopic and micro-chemical tests on the individual grains. As most of these methods involve the separation and estimation of comminuted material, the handling and determination of small grains under the microscope form a large part of the work and have received much attention. The accuracy of some of the methods I am still busy investigating, and the results I hope to publish soon. The following method of handling and cleaning grains has been in constant use for over seven years and has been found the most convenient when much of this work has to be done. The methods of determination, however, have been constantly revised, and the method described for determining the indices more accurately has only recently come into use. It was originally a suggestion of Dr. S. van der Lingen, then at the University of Cape Town.

For picking out *dry minerals in air* a bristle from an ordinary pig-hair-hand-broom is used. A glass tube is drawn out until the bristle will only just fit in it, and the bristle is fixed with sealing wax. It is essential that the bristle should be firm and pliable but not springy. This also applies to the wire used for picking grains out of liquids. The grains are apt to spring away when accidentally pressed or moved, if hard and springy wires and bristles are used instead of pliable ones. The material of the bristle must also be slightly but not very absorbent to water, as experience has shown that this produces the necessary thin film on the bristle instead of a drop at the end of it. The tapering part of the tube to the end of the bristle is 5–6 cms., and the straight part of the tube at least 9 cms. in length. This enables it to be used like a pencil, the hand resting on the stage of the microscope. A bristle between $\frac{1}{2}$ and $\frac{1}{4}$ mm. is used. This is wetted with distilled water and brought into contact with the isolated mineral (a mere touch being all that is necessary). A steady hand, after practice, can lift grains without isolation; in fact grains are now seldom isolated for picking out when dry. The very small amount of water used soon dries and the mineral falls off. It is therefore necessary to place the mineral on a slide as soon as possible. If it does not fall off at once, it is easily removed by drawing the bristle gently over the slide. To ensure

complete dryness the slide is usually waved in the flame of a spirit lamp, but the micro-burner used by M. N. Short has now been found better. If preferred, a drop of water can be placed on the slide and the point of the bristle dipped into this, when surface tension removes the grain as the bristle is withdrawn from the drop. The grain must then be carefully dried. Care should be taken that the bristle is never used in oil or liquid other than water.

For *minerals in a liquid* a similar tube is used with a fine pliable wire instead of a bristle, e.g., copper wire from ordinary electric flex. When the grains are in water the wire is coated with vaseline; for their removal in other liquids a greasy or gummy substance insoluble in the liquid must be used. The wire is stuck about half an inch into a pot of vaseline and wiped by gently drawing over the inside of the pot until no vaseline is visible to the naked eye; the object being to get as thin a film of vaseline as possible on the wire. If a wire of about $\frac{1}{4}$ mm. diameter is used the wiping is seldom necessary, but the top must be examined to see that a blob of vaseline is not sticking to it (as sometimes does occur). It is then very gently pressed on the grain. The wire with the adhering grain is dipped into a drop of benzol on a slide. Benzol is used rather than xylol because it is cheaper and evaporates quicker. The only difference is that xylol dissolves the vaseline rather more rapidly. For other greasy substances suitable solvents must be used. When the grain has fallen from the end of the wire it is rolled over a few times and pushed forwards or dragged to another part of the slide, before the benzol has evaporated, far enough away that the new drop of benzol, with which it is washed, cannot run into the old position. This procedure is repeated and the mineral then removed to a clean slide by the dry method. Two washings have been found to be quite sufficient to clean most grains. If one has not a steady hand, it is advisable to use the method of cleaning described for immersion liquids. A small cover is then placed on the drop of benzol after the grain has fallen from the wire and the procedure described in the next paragraph carried out. Grains of .05 to .5 mm. have been successfully handled in this way. This work is usually done on a dissecting stage under a binocular, but is also used with little loss of rapidity under a microscope.

For testing indices by immersion methods small glasses are cut with a sharp diamond from ordinary square cover-glasses. These are about 3 mm. square. They are rather troublesome to cut, but

it is well worth the trouble as they make the manipulation of individual grains much easier than large glasses. They can be made to serve almost indefinitely if they are scratched into spirits in a wide-necked bottle, after use. They can then be cleaned with $\text{H}_2\text{SO}_4\text{-K}_2\text{Cr}_2\text{O}_7$ mixture, after pouring off the spirits, washed without handling in an evaporating dish, and dried by spreading on blotting paper. When these covers are used the area to be searched is small and the mineral is easily found. Less immersion liquid is used and cleansing of the grain is facilitated. The cover glass is touched with the immersion liquid and then placed on top of the mineral with a pair of forceps. To remove the liquid the cover-glass is tilted (i.e., merely pressed down on one side) and a clean piece of thin blotting or other absorbent paper placed in contact with the lower edge. The paper must have sharply cut edges and must not be torn. All but a minute fraction of the immersion liquid is rapidly absorbed when these small glasses are used. Benzol or some other quickly-evaporating solvent for the immersion liquid is then run under the cover-glass by means of a capillary tube. This is repeated three times, each drop of benzol being completely absorbed by blotting paper. Two washings usually suffice, but three will be better. This operation must be carried out on a flat surface and not in the hand as the cover-glass and mineral are liable to slip off the slide. The slide is then carefully held above the flame of a burner (Short's micro-burner has proved very much better) for a second, and any trace of liquid driven off. The slide cools in a few seconds and is ready for the next immersion liquid to be used.

When accurate indices are required the following method is used with the ordinary set of index liquids, from which mixtures are gradually being eliminated. A suitable grain is selected, if a Universal Stage is not available. When the oriented grain is found in polarized light to have an index just higher or lower than the liquid, a monochromater is substituted for the white-light used and the wave length varied until no bright line is seen on altering the focus of the microscope. The grain is washed, the next liquid, either higher or lower, substituted and the determination repeated. Indices are thus obtained in red and green or blue light. These are plotted on a graph and the index of the mineral in sodium light obtained by assuming that the index of the mineral varies in a straight line. The indices of the liquids are obtained by reading them from a

graph giving the index-wave-length curves of all the liquids in the set (their variation with temperature also being known). Where great accuracy is necessary or where the data for the liquid used are not known, a drop is placed in a prism and the index determined with the same wave-length of light and at the same temperature by the method of minimum deviation. With mixtures of liquids, where differential evaporation may occur, this index determination should always be made. We have found, however, that when correct containers are used for the liquids, this determination is only necessary about once a year.

When the optical properties of the grain have been ascertained, it is usually cleaned and tested microchemically for the main constituents of the mineral as indicated by the optical properties, after opening the mineral, if necessary, by the method used by P. C. Putnam, E. J. Roberts and D. H. Selchow (Contributions to Determinative Mineralogy, Part I, *American Journal of Science*, February 1928); or if enough of the grains can be found and picked out of the mass with certainty, 20–50 grains are selected, taken up in chemically pure sulphur, and tested spectroscopically.

For the general inspection of a sample nitrobenzol in a small shallow watch-glass, or uncovered on a slide, is used to cover grains instead of water, as this causes quartz and the feldspars to be practically invisible, and easily identified. As balsam and vaseline are slowly soluble in this liquid, seccotine is used to pick the grains out. Seccotine is very useful for this purpose. It is readily but slowly soluble in distilled water, and the grains are easily cleaned. The grain is therefore washed in water twice and finally in alcohol to hasten the drying. Seccotine can also be used with bromnaphthalene and methylene iodide and their mixtures. The pin of the tube is just covered with seccotine and the wire drawn over it. Nitrobenzol is a liquid strongly to be recommended to those working with crushed-rock grains or residues. Its index is near the higher index of quartz and its dispersion gives most quartz-grains red and blue borders under the microscope. It is also very useful for plagioclase feldspars—separating those commonly found in syenitic and granitic rocks from those found in basic and dioritic rocks. The nitrobenzol used has an index of 1.552 at 20°C. in sodium light.

Thus: a grain of feldspar showing any index > the liquid no matter what its orientation cannot have An < ± 30.

If the indices of all grains of the plagioclase are $>$ the liquid it is hardly likely to be $< \text{An} \pm 44$.

If the indices of all grains of the plagioclase are $<$ the liquid it is hardly likely to be $> \text{An} \pm 30$.

If one index is greater and one less than the liquid then it is between $\text{An} \pm 30$ and $\text{An} \pm 44$.

Therefore mere inspection of a crushed sample, in this medium, generally serves to identify an igneous rock or at least place it in its correct group. When more careful work is necessary the relative proportions of the constituent minerals are roughly estimated by areal or linear measurements. Grains of minerals other than quartz and feldspars are then selected from the sample and identified. From the properties and proportions of the minerals the rough composition of the rock is readily obtained. So far those results that have been checked against actual chemical analyses of the rock have shown good agreement. The crushed fragments are obtained by breaking pieces from different parts of the handspecimen, and crushed by sharp blows of a pair of two-inch-square hardened-steel plates.

An ordinary student's zoological set is very useful for accessory apparatus in this work. The scalpel is used for picking up samples of the crushed grains. The seeker is used for isolating grains by pushing them apart, and is also magnetized; the lancet is used for breaking off pieces of a mineral on the handspecimen; the forceps for handling cover-glasses, and the scissors for cutting the absorbent paper.

NEW PUBLICATIONS

KURSUS DER KRISTALLOMETRIE, VICTOR GOLDSCHMIDT; HANS HIMMEL AND KARL MÜLLER. Gebrüder Borntraeger, Berlin, 1934, viii+167 pages, 183 text figures. 11.50 RM. bound.

Victor Goldschmidt, in his last years, gave considerable thought to the publication of a textbook describing the principles and methods of crystal measurement, projection, drawing, and calculation which he had developed.¹ The present volume is a laboratory manual, and follows closely the course² as given at Hauptstrasse Nr. 48.

Prefaced by 14 precepts (Arbeitsregeln), the introduction discusses the gnomonic, stereographic, and orthographic projections of crystals, and crystal measurement by means of the "Penfield" contact goniometer, and the Goldschmidt two-circle

¹ *Am. Mineral.* vol. 19, pp. 106-111, 1934. The Goldschmidt Two-circle Method; *Am. Mineral.*, 1921.

² Victor Goldschmidt Institut für Kristallforschung, Heidelberg.