BLOWPIPE PETROGRAPHY*

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ABSTRACT

An attempt is made to elicit interest in the use of the blowpipe as an auxiliary tool in the petrographic identification of non-metallic minerals. The customary flame colorations, bead tests, and fusibility determinations become subordinate to the new role of the blowpipe: the production of characteristic microscopic textures and products. The procedure involved in this simple and inexpensive method is outlined. The various thermal effects which may be utilized are briefly discussed. Several examples illustrating the application of the technique in the distinction of easily-confused minerals are presented.

INTRODUCTION

The accurate identification of non-metallic minerals under the polarizing microscope is often attended with difficulties. Not infrequently, positive identification is impossible without resorting to one or more confirmatory tests involving features other than their recorded optical properties. The microscopic characteristics of minerals treated at temperatures sufficiently elevated to induce decomposition, inversion, etc., furnish potential criteria for their identification. Indeed, the ceramic petrographer must often rely solely upon such characteristics in his optical study of finished ceramic products. Rather by necessity than by choice, he attempts to interpret the secondary textures and reaction products developed during calcination, in order to arrive at the identity of the original mineral constituents. The mineralogist-petrographer may well profit from the experience of his ceramic colleague by supplementing recorded optical properties with data furnished by the heat-treated minerals. He will find that the petrographic examination of a mineral both before and after calcination is often more fruitful than study of the uncalcined mineral alone.

The study of the effect of heat treatment on the non-metallic minerals has by no means been neglected by mineralogists, particularly those with an interest in the industrial use of these minerals. Abundant data, including dehydration curves, differential thermal curves, and heat-induced changes in optical properties, are scattered through the mineralogical literature. The growing popularity of differential thermal methods in the qualitative and quantitative analysis of non-metallic mineral mixtures is well known. To the writer's knowledge, however, little diagnostic use has hitherto been made of the changes occasioned

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in the optical properties of such minerals by heat treatment. Yet many non-metallic minerals, when thermally treated (as for example in the blowpipe flame), will be found to yield microscopically recognizable textures and products. This technique, which for convenience is termed "blowpipe petrography," is believed to merit greater attention in general petrographic practice. It is the purpose of this paper to outline the simple procedure involved, to discuss some typical effects which will be found useful, and to present a number of examples of their application.

PROCEDURE

The technique herein referred to as "blowpipe petrography" is extremely simple. The only requirement in addition to the usual needs for petrographic study is a suitable means of heat-treating the specimens. A wide choice of methods is available for effecting calcination, choice being largely determined by the relative refractoriness of the material. A laboratory Bunsen burner has been found useful in some instances. The mineralogical blowpipe, which has all but disappeared from the modern mineralogical laboratory, is very satisfactory for many minerals. Much more convenient and versatile, however, is some such type as the National 3-A blowpipe,* equipped with tips for use with either gas and air, or gas and oxygen. Various other facilities may be utilized, such as laboratory furnaces, or production furnaces and kilns. These often permit fairly close control of temperature in a selected temperature range and over a prolonged period. The device described by Milton and Spicer (4), although never tested by the writer, would appear to offer a promising method for the rapid heat-treatment of small samples at a particular temperature.

As ordinarily practiced in the writer's laboratory, a very small sliver of the mineral being tested is held in the blowpipe flame by means of platinum-tipped forceps, much in the manner employed in standard blowpipe technique. In those cases in which the mineral is in the form of detrital grains or a fine-grained powder, the sample is wrapped in a small piece of platinum foil. For convenience the blowpipe is permanently mounted by clamps on a chemical burette-stand. In some instances in which fusion has occurred, it is desirable to quench the sample in water in order to preserve the glassy condition. In most cases, however, the sample is merely air-cooled by removal from the blowpipe flame. It is advisable to wear a pair of dark goggles during the blowpipe treatment. After calcination the mineral is powdered and examined according to regular powder-immersion procedure.

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* Manufactured by National Welding Equipment Company, San Francisco, California.

SOME TYPICAL THERMAL EFFECTS

A variety of thermal effects is encountered in the application of the blowpipe petrography technique. One such effect is complete fusion to a glass. This is akin to the well-known blowpipe fusibility test. But, whereas the latter test concerns itself merely with the relative tendency to fuse, blowpipe petrography involves the measurement of the refractive index of the glass, or the observation of the optical characteristics of the minerals which crystallize from the molten sample upon cooling. Another effect is that of incongruent melting in which the mineral partially melts with the liberation of another compound. A special case is that of liquid immiscibility, in which two liquid phases are formed. The phenomenon of polymorphic inversion is also very useful, in those instances in which re-inversion to the original form does not take place upon cooling. Some minerals which show little if any detectible cleavage can be induced to cleave by a sort of thermal shock treatment, thereby providing a lineation against which elongation and extinction can be measured. There are countless examples of hydrated minerals which may be reduced to the anhydrous oxides or silicates. Numerous carbonates may similarly be deprived of their volatiles to yield identifiable oxides. In the course of such dehydration or decarbonation, oriented or unoriented decomposition intergrowths are formed, which may prove to be quite diagnostic. The thermal behavior of some minerals may involve more than one of the above effects, as for example dehydration followed by polymorphic inversion. It is to be recommended, of course, that observations on relative fusibility, flame coloration, decrepitation, exfoliation, and other effects usually associated with standard use of the blowpipe, should also be made.

SOME TYPICAL APPLICATIONS

One promising application of blowpipe petrography is the routine determination of the plagioclase feldspars. The refractive index of the fused feldspar is merely checked against a curve plotted from the data of Larsen (3). This method, which is theoretically capable of twice the accuracy obtainable from the measurement of the indices of the crystalline feldspars, is briefly described elsewhere (1).

The striking similarity of bastnäsite and xenotime in optical properties and in mode of occurrence has recently been emphasized (2). The most convenient method for differentiating the two minerals is brief calcination in the Bunsen burner flame, followed by microscopic examination of the calcine.

A commercial product labelled "calcium aluminate" was found to be optically isotropic, with refractive index of about 1.60. It would be natural to assume that this was the isotropic form of $5CaO \cdot 3Al_2O_3$. However, calcination in the burner flame resulted in the evolution of water. It was, therefore, concluded that the material was $3CaO \cdot Al_2O_3 \cdot 6H_2O$. This was confirmed by a careful ignition test, which yielded almost exactly the weight loss to be expected.

An unlabelled mineral sample gave optical data suggestive of topaz. This identification appeared reasonable, as topaz samples were known to be at hand. Blowpipe calcination, rather than indicating a refractory mineral, resulted in ready fusion and a characteristic lithia flame. Accordingly, it was tentatively identified as amblygonite. Further check revealed that a sample of amblygonite had recently been received for test as a ceramic flux.

A sample of kyanite from Colorado had associated with it a brownish needle-like mineral, the optical properties of which suggested either anthophyllite or sillimanite. Both minerals are known to occur with kyanite, with sillimanite the more probable associate. Blowpipe calcination caused complete breakdown of the acicular structure, and the liberation of dark opaque magnetic grains. Such behavior is to be expected of anthophyllite but not of sillimanite.

A specimen of Arizona corundum "ore" showed areas of a gray vitreous mineral which, because of the closely packed sillimanite needles, strongly suggested cordierite. Optical properties were difficult to obtain, due to the inclusions, but the indices pointed to either orthoclase or cordierite. Sillimanite inclusions are cited by Winchell (5) as a criterion for distinguishing cordierite from feldspar. However, blowpipe treatment fused the matrix of the sillimanite needles to a viscous glass of about 1.49 index, thus indicating that the matrix must be feldspar rather than cordierite.

A white fibrous mineral submitted by a prospector in the belief that it was sillimanite yielded optical properties coinciding with either an iron-free anthophyllite or xonotlite. Because of some attached serpentinous material and the comparative rarity of xonotlite, the mineral was tentatively identified as anthophyllite. However, a blowpipe test led to the production of pseudowollastonite, indicating that the original mineral was xonotlite.

A pitchy, black mineral from Ontario was labelled allanite, but correlation with allanite on the basis of optical properties was uncertain. The birefringence and indices were much lower than one would expect for a cerian epidote, and it was not possible to establish the optical character. Heating to a dull red heat strengthened the pleochroism, notably increased the indices and birefringence, and permitted determination of the biaxial negative character and large optic axial angle.

Among the fibrous and acicular minerals frequently forwarded to the Champion laboratories by prospectors in the belief that they are sillimanite, are wollastonite and tremolite. An excellent confirmatory test for wollastonite is the development of the mosaic texture of pseudowollastonite upon blowpipe calcination. Tremolite, too, gives a diagnostic texture upon such treatment. This texture consists of parallel needles of what is apparently a clinoenstatite-diopside solid solution with interstitial siliceous material, the needles showing inclined extinction up to about 32°.

Certain minerals which in crushed fragments display irregular grains, with no clue, in the form of visible cleavage traces, of crystallographic directions, can be induced to reveal lineation features upon ordinary blowpipe treatment. Thus, beryl grains develop almost parallel lines of bubbles, against which extinction is parallel and elongation positive. Andalusite, too, develops roughly parallel cracks, or zones of incipient mullitization, against which extinction is parallel and elongation negative. Cordierite likewise develops numerous close-set continuous or discontinuous cleavage traces against which extinction is parallel and elongation negative. More intense heat-treatment of andalusite and cordierite cause their decomposition to mullite and siliceous glass.

A soft, white massive sample exhibited indices of refraction between 1.52 and 1.53. These properties suggested gypsum, but because of the microcrystalline nature of the mosaic aggregate texture, additional optical properties were unobtainable. Blowpipe calcination yielded large equidimensional grains of high birefringence and indices between 1.57 and 1.61. Since these latter characteristics agree with anhydrite, the blowpipe test may be considered as confirmation of the tentative identification of the original material as gypsum.

The above enumeration includes by no means all of the instances in which the blowpipe petrography technique has been successfully applied. Other cases which might be briefly cited are: the distinction of sillimanite and mullite by reason of the tendency of sillimanite to form mullite above 1600° C.; the differentiation of monticellite and forsterite by virtue of the formation of periclase by the former; the confirmation of sapphirine by its development of spinel crystals; verification of gamma dicalcium silicate, of tricalcium silicate and certain of the hydrated calcium silicate minerals through their conversion to larnite; identification of diaspore, beta-alumina and alunite through their formation of corundum; the unmistakable criterion of andalusite in its well-known parallel mullite-cristobalite aggregates; the distinction between pyrope and spinel by means of the decomposition of the garnet as contrasted with the stability of spinel; the formation of periclase as a clue to the identity of brucite, hydromagnesite, magnesite, and dolomite; the complete decomposition of jadeite to yield albite and nepheline between 800° and 1000° C.; the decomposition of phenacite into its constituent oxides above 1600° C.; the characteristic melting of danburite to form two immiscible liquids; the restoration of the normal optical properties of a number of metamict minerals.

CONCLUSION

It has been the purpose of this paper to try to interest the student and the practicing petrographer in the potentialities of the blowpipe petrography technique. To that end, it did not appear needful to present an exhaustive list of all of its possible applications. Nevertheless, the writer is currently compiling the widely scattered data on the thermal behavior of the non-metallic minerals, with the view to their more convenient use as diagnostic criteria. Although no systematic scheme has been devised, as in the case of standard optical properties, such is neither necessary nor, perhaps, desirable. At best, the blowpipe petrography technique is to be looked upon as a confirmatory step, subordinate and supplementary to the standard petrographic procedure. That it has distinct possibilities in this direction should be apparent from the selected examples discussed above.

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