

Gaudin has also reported that pyrite oxidizes xanthate ions. That the xanthate layer on pyrite is not stable has been shown by the author who determined the decrease in contact angle of pyrite conditioned in K-ethyl xanthate solution (25 mg./l.) and then transferred to distilled water. The results are shown in Fig. 2.

Recently, following the tracer technique, Gaudin (9) has reported that xanthate adsorption by pyrite is more in the presence of oxygen than in its absence. Moreover, with the increasing cyanide ion concentration there is a steady decrease in the adsorption density of xanthate.

Conclusion

On the surface of pyrite immersed under water ferrous ions are first formed owing to the oxidation by the dissolved air; these ions are then further oxidized to ferric ions. Ferric ions are capable of adsorption (binding) of xanthate ions, as the compound ferric xanthate is fairly insoluble. The surface layer of xanthate ions is not stable, however, as the ions are oxidized by the ferric ions. The presence of oxygen is desirable, therefore, when pyrite is to be floated. In actual flotation of pyrite, however, the destruction of the surface layer is prevented by coating the pyrite surface with copper by the addition of copper sulphate in the pulp. Now, if cyanide is added, cyanide ions will be

strongly adsorbed by ferrous ions and not by ferric ions, as ferrous cyanide is fairly insoluble, whereas ferric cyanide does not exist. The moment the ferric ions are reduced to ferrous state by the action of xanthate or other reducing ions which may be present in the pulp, therefore, the cyanides become very effective.

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Chemical Tests on Mineral Streaks

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The use of
"chemo-streak-tests"
as a rapid aid
in mineral
identification.

Abstract

It is stressed that although mineral streaks are very reactive the application of chemicals to such streaks in order to facilitate identification has been largely neglected in the past. The techniques employed by the writer in conducting "chemo-streak-tests," as they may be called, are described and the merits and demerits of the general analytical method are noted. Finally, practical details are given for identification of a number of ions.

Introduction

While the colour of a mineral streak on unglazed porcelain or similar material has long been used as a rapid and simple aid to mineral identification, comparatively little work has been carried out on the application of chemical tests to mineral streaks as a further aid. This is surprising, as the fresh streak is characterized by remarkable chemical reactivity.

Apparently the first to appreciate the potential value of the application of chemicals to mineral streaks as an aid to identification was Weyl (1942).¹ In a short note on the subject he states that the presence of "available" alumina in a rock can be indicated by making a streak on a vitrified unglazed floor-tile and immersing it in a 0.4% solution of morin in methanol for 2 min. followed by washing in water and examination under ultra-violet light. A positive streak fluoresces green. Weyl also suggests that the chemical "development" of colourless streaks has a wide field of application and observed, for example, that both lead and zinc ores can easily be recognized by a proper choice of chemicals.

Feigl (1947) makes a limited use of this analytical technique and notes that the presence of sulphide sulphur in minerals may be indicated by applying a drop of azide-iodine reagent (3 g. NaN_3 dissolved in 100 ml. of 0.1N iodine solution) to a streak. A stream of nitrogen bubbles will immediately arise from the sulphide (p. 464).

Somewhat akin to the work of Weyl and Feigl is that of Stevens and Carron (1948), who have evolved a simple field test for distinguishing minerals by abrasion pH. A soft non-absorbent mineral is scratched in a drop of water on a streak plate until a milky suspension is formed. A piece of pH indicator paper is dipped into the suspension, after which it is removed and the maximum deviation from neutrality is noted. Hard minerals are ground for a minute with a few drops of water in a mortar and the suspension so produced is applied to indicator papers. The major weakness of this method lies in the fact that the vast majority of similar minerals—for which a simple and rapid means of identification would be most welcome—have abrasion pH values which are, within the limits of the test, either very close or identical.

Because the present writer was long ago convinced that the application of chemicals to mineral streaks was an analytical method of considerable potential he has worked on the subject for a number of years and that which follows is a résumé of his studies.

Methods used in Making Chemo-Streak-Tests²

(a) Making the streak.

The method of making the streak depends

¹ A short list of references is given at the end of this article.

² For simplicity chemical tests on mineral streaks are termed "chemo-streak-tests" in this paper.

on the size of the specimen, large specimens being held in the hand and smaller ones in a pair of forceps. If the fragment is very small it is placed on a streak plate and broken down into a "streak" by rubbing it with a microscope slide or the blade of a knife. In all cases a fairly "heavy" streak is best.

(b) Streak "Plates" Used.

Most of the tests developed by the writer are made on a portion of vitrified unglazed tile about 2.25 sq. cm. in area. The test pieces are obtained by breaking down tiles about 10 cm. square which were kindly supplied by the Candy Tile Company, Newton Abbot, Devon. They have a surface hardness of a little over 6 on Moh's scale and are reasonably smooth, porous, and pale-cream in colour. From 40 to 50 suitable test pieces can be obtained from one tile and as a given piece is only used for one test there is no possibility of contamination from the products of previous examinations. The tiles are chemically stable, but most of them contain a little acid-soluble iron and some a little reactive aluminium. It is also to be noted that they can withstand a considerable amount of heat without cracking and can therefore, be used instead of charcoal blocks, plaster of paris, or fused silica plates for certain blow-pipe tests.

In some chemo-streak-tests ground-glass ground-glass coated with a film of graphite, or aluminium-, tin- or zinc-sheet take the place of pieces of tile; examples of their use are noted later.

(c) Variations in Method.

Chiefly owing to the variations in method chemo-streak-tests may be divided into 11 groups, each of which is briefly discussed below.

Group I.—Tests depending on the mineral streak made on a portion of tile assuming a characteristic colour when drops of one or more reagents are applied to it.

This method of carrying out a chemical test upon a mineral is the quickest. It is generally applicable to a species of hardness less than 6, which produces a reasonably light-coloured streak which reacts readily in the cold with one or more liquid reagents with the production of a coloured precipitate which coats the mineral streak. It is a particularly useful aid to the identification of many minerals formed during the oxidation of ore deposits.

Group II.—*Tests depending on the solubility rate of a mineral streak on a portion of tile when treated with a given reagent.*

This technique was developed as the result of a search for a simple test for differentiating between massive bournonite, $4(\text{CuPbSbS}_3)$, and massive tetrahedrite, $8(\text{Cu}_3\text{SbS}_3)$. Tests on numerous specimens have indicated that differentiation can be made by applying a drop of concentrated nitric acid to a streak of the mineral made on a portion of tile. In every case the grey-black bournonite streak immediately disappeared, while the tetrahedrite streak was apparently unchanged.

This particular method has not been greatly developed because it has an inherent weakness; specimens of a given mineral species from different localities commonly exhibit considerable variations in the rates at which they are attacked by a given reagent. For this reason tests of the type under consideration may sometimes give misleading results.

Group III.—*Tests depending on streaking the mineral on a portion of tile to which a liquid reagent (or reagents) has previously been applied.*

This method has been developed in order to test certain minerals which are not sufficiently reactive to be tested by the application of reagents *directly* to their streaks. An increased time of attack under the most favourable conditions is obtained by streaking the mineral on a portion of tile which has been treated immediately previously with a suitable reagent. Thus while the application of a drop of concentrated HCl to a "cervantite," $\text{Sb}_2\text{O}_4(?)$, streak, followed by the application of a filter-paper damped with yellow ammonium sulphide, does not result in the streak assuming the orange of antimonious sulphide, a streak made by rubbing the mineral on a portion of tile just previously moistened with a drop of concentrated HCl invariably reacts positively.

The success of this technique is not only due to increased time of contact between mineral and attacking reagent but also to the fact that newly-developed corners and edges, which are highly reactive, are being continually developed in contact with the reagent. Furthermore, although the heat of friction which is generated is not great, locally the temperature may be greatly elevated and this may favourably influence the chemical reactions involved.

Group IV.—*Tests depending on the combined utilization of solid and liquid reagents on streaks made on portions of tile.*

Solid reagents are used in these tests to supply a high concentration of reagent and/or to prevent a very soluble reaction product from being rapidly and entirely lost by absorption into the tile. Thus the presence of bismuth in certain minerals—e.g., bismite, $4(\text{Bi}_2\text{O}_3)$, bismuthite, $2((\text{BiO})_2\text{CO}_3)$, and native bismuth—may be shown by applying to the streak a drop of 40% potassium iodide, followed by a drop of 1:7 HNO_3 , and then rubbing a small fragment of caesium chloride into the damp streak by means of a glass rod. The streak becomes a brilliant red.

Group V.—*Tests on which the mineral streak is made on a metal surface.*

This method has only a limited application, but is of value when detecting silver halides, mercury, tellurium, and vanadium. These tests are extremely rapid and simple and only when testing for tellurium and vanadium is it necessary to apply reagents to the streak. Thus the presence of dominant amounts of mercury in a mineral may be shown by streaking it on a sheet of aluminium when, after a short while, white "feathers" of aluminium oxide will be seen to be growing from the streak. Other tests of this type are described later.

Group VI.—*Tests on which the mineral streak is made on a ground glass surface.*

The test is conducted on a ground-glass surface either when the diagnostic reaction product is a coloured solution or when it is a gas. Thus the presence of sulphide ions in a mineral may be indicated by applying a drop of sodium azide-iodine reagent to a streak on ground glass, when bubbles of nitrogen are released.

Group VII.—*Tests depending on rapid fusion and rapid reduction techniques.*

The outstanding use of the rapid fusion technique is the identification of dominant amounts of manganese in minerals. To test for manganese a streak of the mineral is made on a portion of tile and covered with fresh sodium peroxide. A burning splint is held in contact with the peroxide until the vigorous action has ceased. Manganese is indicated by the fusion product being blue-green.

The following test for sulphates illustrates the use of the rapid reduction technique :—

A streak is made on a portion of tile covered with photographer's flash-powder. A comparatively small amount of finely-powdered potassium chlorate is placed on top of the flash-powder to aid ignition and the charge is ignited by touching it with a burning splint. This reaction reduces a sulphate to a sulphide and the latter may then be removed and tested by the sodium azide-iodine reagent noted earlier.

Group VIII.—*Tests depending on simple contact printing of streaks made on a portion of tile.*

This method of testing simply involves making a streak on a portion of tile and pressing the streak on a suitably impregnated piece of spot-reaction paper resting on a glass plate. Better contact is sometimes made by inserting a thin layer of plasticine between the paper and the plate. Depending on the test the reaction paper is impregnated with an attacking reagent, an attacking *plus* developing solution, or a developing solution. In all tests the streak is pressed on to the paper by means of the thumb and generally the pressure is maintained for 3 min. At the end of the contact period the tile is removed. If the paper has simply been impregnated with an attacking reagent a few drops of developer are added to it; if, on the other hand, a developing reagent was used initially a print of the streak will be seen on removing the tile.

The following points may be made with regard to the use of this method :—

(1) A test which depends on the production of a pale-coloured solution resulting from a reaction between a strongly-coloured solution and a mineral is best carried out by the contact print method. Thus the presence of fluoride ion in fluorite, $4(\text{CaF}_2)$, or cryolite, $2(\text{Na}_3\text{AlF}_6)$, is readily shown by printing the streak on paper impregnated with the pinkish-purple zirconium-alizarin reagent. If the paper is examined after being in contact with the streak for 3 min. a pale-yellow streak is seen. (The reagent is prepared by dissolving 0.05 g. of zirconium nitrate in 60 ml. of 1:5HCl and adding this to a solution of 0.05 g. of sodium alizarin sulphate in 50 ml. of water.)

(2) The cations in the majority of minerals with metallic lustre cannot be identified by applying the methods described earlier,

because many such minerals do not react readily with reagents in the cold and also because the dark colours of the streaks tend to obscure the colours of the reaction products. Many of these minerals can be conveniently tested by the contact printing method described above, utilizing developing and attacking reagents already developed by Hiller (1937), Gutzeit (1942), and Williams and Nakhla (1950-51). This method permits the use of stronger attacking reagents than could be tolerated when making a print on gelatin-coated paper. Furthermore, as there is no particular virtue in printing the exact shape of the streak, a developing reagent which results in the production of a coloured solution which diffuses rapidly is just as satisfactory as one which produces a precipitate.

(3) Certain tests for elements in minerals with a non-metallic lustre which require a prolonged period of attack are best made by the contact print method.

(4) Simple contact printing of streaks, besides being a useful method for identifying minerals, is also a simple and rapid way of determining to some extent the suitability of attacking and developing reagents for use in connection with the contact printing of minerals in polished sections.

(5) Finally, if a mineral streak is not readily soluble in cold reagents, a good print may often be made by applying the streak to a double thickness of spot-reaction paper impregnated with a suitable attacking reagent and resting on two thicknesses of asbestos paper which in turn rest on a heated metal block. Thus, using water as an attacking reagent and 0.2% sodium rhodizonate and 1:20 HCl as developing reagents, an intense red lead print was obtained from a streak of cotunnite, $4(\text{PbCl}_2)$, after an attack lasting only 5 seconds. Mineral streaks which readily give good prints with cold reagents produce very intense prints in a much shorter time when the heated metal block method is used.

Group IX.—*Tests depending on electro-graphic contact printing of streaks made on a ground-glass plate upon which a graphite "skin" has previously been superimposed.*

In these tests a graphite dynamo brush is rubbed on the ground surface of a microscope slide, or on a portion of the wall of a broken porcelain mortar until a highly polished area about 2 cm. $\times$ 1 cm. is developed. The mineral to be examined is

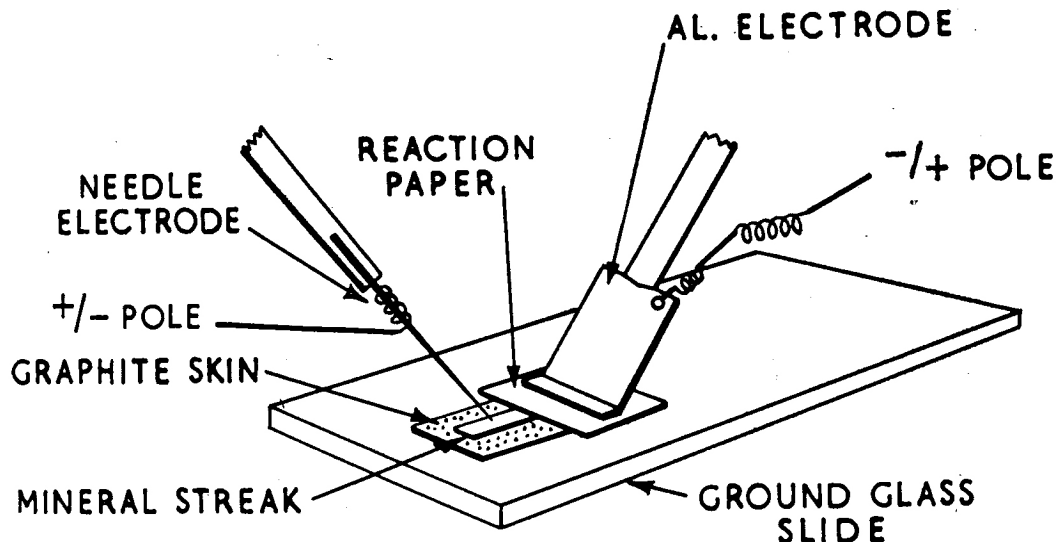


Fig. 1.—Apparatus for Taking Electrographic Contact Prints from Mineral Streaks.

then streaked on the graphite skin. A portion of spot-reaction paper impregnated with a suitable attacking reagent is then placed on the slide so as to cover about three-quarters of the streak. When printing cations a large aluminium cathode is pressed on to the paper about an eighth of an inch away from the exposed portion of the streak and an iron needle anode is brought into contact with the exposed portion of the streak at about the same distance from the paper (Fig. 1). The usual time of attack is about a minute, after which the circuit is broken and the paper removed. A drop or so of developing reagent is added to the paper and the colour of the print noted. In some cases the developing reagent can be conveniently added to the attacking reagent.

Portable dry batteries or accumulators with a variable resistance and a galvanometer included in the circuit are suitable sources of current in the field. In the laboratory it is more convenient to use a d.c. mains supply or rectified a.c. in conjunction with a variable resistance and milliammeter. Depending on the mineral the applied voltage usually varies from 4 to 30, while a current intensity between 20 and 40 milliamperes is normally satisfactory.

The methods of testing a considerable number of the more important minerals in polished sections by electrographic contact printing which have been advocated by Williams and Nakhla (1950–51) are generally

applicable, with little or no modification, to the streaks of these minerals.

The outstanding merit of this method is that it constitutes a simple and rapid means of identifying many conducting minerals (which as a group have a metallic lustre).

Group X.—*Chemo-streak-tests involving use of the blowpipe.*

Several simple tests can be made on mineral streaks with the aid of a blowpiped flame. While it is true that many of the tests carried out on a plaster tablet can be executed just as well on a portion of tile, the following tests indicate the lines along which blowpipe tests can be extended by employing tile.

(1) To differentiate between bismite, $4(\text{Bi}_2\text{O}_3)$, and "cervantite" (often regarded as Sb_2O_4), place a small quantity of "bismuth flux" on a portion of tile and rub the mineral in the powder in such a manner that some of it is entrapped between the mineral and the tile during the operation. Hold the tile with tweezers and touch the streak with the oxidizing flame. A bismuth streak immediately becomes crimson and an antimony streak orange.

(2) To differentiate between rhodochrosite $2(\text{MnCO}_3)$, and pink calcite, $2(\text{CaCO}_3)$ streak on a portion of tile and heat before the oxidizing flame. The rhodochrosite streak becomes dark-brown but that of calcite is little changed.

(3) To show the presence of tungsten in minerals with a non-metallic lustre place a few small crystals of ammonium hypophosphite on the streak and heat in the reducing flame of the blowpipe. While the streak—which may be pale-blue after the above treatment—is still warm add a few drops of water. The development of a marked deep-blue to purple halo is a certain indication of the presence of tungsten.

Advantages and Disadvantages of Chemo-Streak-Tests

The favourable characteristics of chemo-streak-tests are :—

(1) They often provide the most rapid means available for determining whether a given element (or radical) is present or absent in a mineral.

(2) Hand specimens, small fragments, and powders are all capable of being examined by chemo-streak-tests.

(3) The vast majority of minerals of economic importance of hardness not greater than about 6 on Moh's scale can be examined by one or more of the methods described.

(4) The tests often permit rapid differentiation between similar minerals.

(5) Valuable specimens may be tested without seriously damaging them and therefore chemo-streak-tests should be of use to museum workers.

(6) The techniques involved are usually of a simple nature and therefore easily mastered.

(7) The tests are very economical because the quantities of reagents used are very small and the apparatus required is not expensive.

(8) To carry out most of the tests described no external source of heat other than that of a match or a cigarette lighter is required—a distinct advantage when working in the field.

(9) Some of the methods employed are capable of supplying rapid information concerning the suitability of reagents for use in simple and electro-graphic contact printing from polished sections.

The disadvantages of chemo-streak-tests are :—

(1) They cannot be applied to minerals of hardness greater than about 6 on Moh's scale.

(2) They cannot be used for most of the economically important minerals which require fusion before chemical examination.

(3) No adequate chemo-streak-tests have yet been devised for certain elements which may occur as major constituents in sulphides,

arsenides, and closely related minerals; the most notable of these are tin, thallium, and germanium.

(4) Chemo-streak-tests are unsuitable for examining small quantities of material such as might reasonably be obtained by scratching the surface of a given mineral in a polished section with a needle. Such small quantities are best examined by micro-chemical, spectrographic, or X-ray methods.

Practical Details for the Detection of Specific Ions and the Differentiation of Certain Minerals

It must be stressed that the following is only a modest selection of the chemo-streak-tests known to the writer. It is hoped that those chosen will not only demonstrate the scope of the method and be of particular value to the prospector but will also encourage others to develop similar tests to facilitate the solution of their particular problems.

Almost without exception the following tests are new in that they have not before been carried out under the conditions described. Indeed, many of the tests would fail were it not for the enhanced reactivity which is characteristic of a mineral streak.

For reasons of economy the chemistry of the various reactions is not generally discussed and the formulae of the minerals have been omitted. Furthermore, whenever reactions are employed which are described by Feigl in "Spot Test" (1947) reference is made to this book rather than to the original literature.

Aluminium

Morin Test. (Feigl, F., 1947, pp. 142-143.)

Aluminium Minerals Tested: Bauxite, cryolite, enysite, lironite, potash alum, turquoise, wavelite and websterite.

Procedure and Results. The morin test, which is probably the best of the aluminium tests, depends on the fact that a saturated solution of morin in methanol reacts with aluminium in neutral, or in some slightly acid solutions, producing a salt which fluoresces green when examined under either long- or short-wave ultraviolet light.

When using the morin test it is necessary to vary the procedure, as indicated below, in order to obtain positive results. This, however, does not constitute a drawback; it is, on the contrary, an aid to the recognition of the mineral.

(a) Bauxite and Websterite.

Place a drop of morin on a portion of tile and streak the mineral in it. Examine under an ultraviolet light. The presence of aluminium in both minerals is indicated by the strong yellowish-green fluorescence of the streak. The addition of a

drop of 5N acetic acid intensifies the fluorescence, especially of the bauxite.

(b) *Enysite, Liroconite, Potash Alum, Turquoise, and Wavellite.*

Streak in morin solution as above, then place under ultraviolet light and add a drop of 5N acetic acid. A brilliant green fluorescent halo and/or streak indicates the presence of aluminium. The fluorescence may be transitory, as the fluorescent solution sinks into the tile.

Of the above minerals only wavellite, cryolite, and potash alum show any fluorescence before the addition of acid and this is slight.

A drop of water instead of a drop of acid increases the fluorescence due to potash alum, but the increase is by no means as marked as when acid is used.

(c) *Cryolite.*

Streak the mineral on a portion of tile and spot the streak with a drop of 5N H_2SO_4 . Immediately the acid has sunk into the tile add a drop of morin solution and examine under the ultra-violet lamp. The presence of Al is indicated by the streak fluorescing a brilliant green.

Other Notes.—(1) Be, Zn, Ga, and Sc form fluorescent compounds with morin, but of these only Zn interferes in the above tests. Thus, when a streak of smithsonite is subjected to the morin-acetic acid treatment and examined under ultra-violet light it displays a greenish fluorescence which is indistinguishable from that due to Al. However, the test described in the Zinc Section permits easy differentiation between Al and Zn minerals.

(2) It is always advisable to carry out an aluminium test on a portion of the tile used to supply fragments for the morin test as it may contain "reactive" aluminium. A small amount of reactive Al in the tile does not prevent it from being used, but when present a blank must be carried out with each test.

Antimony

(1) *Potassium Hydroxide Test.* (Short, M. N., 1940, p. 120.)

Antimony Minerals Tested: "Cervantite," jamesonite, kermesite, and stibnite.

Procedure and Results.—Streak the mineral on a portion of tile. Add a drop of 40% aqueous KOH. The kermesite and stibnite streaks immediately become orange-yellow, while the other streaks are unchanged.

Other Notes.—(1) This is one of several simple methods which are suitable for differentiating between stibnite and jamesonite. Another simple way of discriminating between these species is to apply a drop of conc. HNO_3 to the streak. The jamesonite streak disappears (or becomes white) whilst the stibnite streak is unchanged.

(2) The KOH test is also a rapid means of differentiating between kermesite and the not dissimilar chalcotrichite.

(2) *Yellow Ammonium Sulphide Test.*

Antimony Minerals Tested: Bindheimite, "cervantite," and valentinite.

Procedure and Results.—Place a drop of conc. HCl on a portion of tile and streak the mineral on the damp surface. Press the streak for about 5 seconds on to a piece of spot-reaction paper impregnated with yellow ammonium sulphide. Both the streaks and the prints of "cervantite" and valentinite turn

orange, while those of bindheimite become black. If the "cervantite" is admixed with limonite both the streak and the print will be dark grey to black initially, but after a few minutes they become orange.

Other Notes.—(1) The presence of Sb in bindheimite and related secondary products—such as, those resulting from oxidation of bournonite, which react to the above test giving a black streak—may indicated as follows:—

On the black streak place a drop of strong KI followed by a drop of 1:7 HNO_3 . The streak becomes partly yellow. Using a glass rod rub a small fragment of CsCl into the damp streak. The presence of Sb is indicated by the development of an orange to red colour which is enhanced by a further drop of KI. This KI-CsCl test may also be used to demonstrate the presence of Sb in fresh bournonite, jamesonite, stibnite, tetrahedrite, and valentinite. When certain bismuth minerals are similarly treated a rich-red colour appears.

Barium and Strontium

Sodium Rhodizonate Test. (Feigl, F., 1947, pp. 165–166.)

In the absence of secondary lead minerals this test may be used to show the presence of barium and/or strontium in carbonate—but not sulphate—minerals.

Procedure and Results.—To test for the presence of barium or strontium in carbonates streak the mineral on a portion of tile and add a drop of a 0.2% aqueous solution of sodium rhodizonate. The presence of Ba and/or Sr is indicated by the streak becoming reddish-brown. Add one or two drops of 1:20 HCl to the reddish-brown streak and if it becomes rose-red Ba (and possibly also Sr) is present. If it disappears only Sr is present.

Other Notes: The streaks of all white—or near white—lead minerals of the oxidation zone become reddish when subject to the above test, but differentiation between similar Pb and Ba minerals can be made by applying the potassium iodide test which is described in the Lead Section.

Bismuth

Cinchonine-Potassium Iodide Test (Feigl, F., 1947, pp. 59–60.)

Bismuth Minerals Tested: Aikinite, bismite, bismuthinite, bismutite, cosalite, and native bismuth.

Procedure and Results.—Streak the mineral on a portion of tile and press the streak on to a piece of spot-reaction paper damped with a drop of 1:1 HNO_3 . After 2 min. develop the print by the addition of a drop of cinchonine-iodide reagent. The presence of Bi in all the above species is indicated by the production of an orange print which is quite distinct despite the fact that it is associated with free iodine.

Cinchonine-Iodide Reagent.—Dissolve 1 g. of cinchonine by warming in a 100 ml. of water containing a little HNO_3 . After cooling add 2 g. of KI.

Other Notes.—The presence of Bi in bismite and bismutite is even more simply indicated by applying first a drop of 1:10 HCl to the streak and then a of cinchonine-iodide reagent, when an intense orange colour develops.

Calcium

While no chemo-streak-tests have been developed for establishing the presence of Ca in minerals the

following enable rapid differentiation to be made between certain similar calcium-bearing species.

To Differentiate between Calcite and Aragonite.

Streak the mineral on a piece of tile and add a drop of strong freshly-prepared ferrous ammonium sulphate solution. An aragonite streak immediately becomes dull green, while a calcite streak slowly becomes brown. After 10 minutes the calcite streak is a strong rust-brown, while the aragonite streak is still dull green, although sometimes a few small brown areas may also be seen.

To Differentiate between Calcite and Dolomite or Magnesite.

(a) Test for Mg by the titan yellow reaction noted in the magnesium section.

(b) Place a drop of phenolphthalein on a ground-glass slide and streak the mineral on it. If the mineral is magnesite or dolomite the solution becomes red, while if it is calcite it remains colourless.

Chromium (as Chromate)

Diphenylcarbazide Test. (Feigl, F., 1947, p. 305.)

Chromium Mineral Tested: Crocoite.

Procedure and Results.—Streak the mineral on a portion of tile and add a drop of conc. H_2SO_4 to it. When the acid has sunk into the tile add a drop of a 1.0% alcoholic solution of diphenylcarbazide. The crocoite streak becomes reddish-purple.

Other Notes.—Wulfenite, descloizite, and vanadinite—i.e., molybdates and vanadates—react similarly, but the dense orange appearance of the untreated crocoite streak serves to distinguish it from these.

Cobalt

Ammonium Thiocyanate-Acetone Test. (Feigl, F., 1947, pp. 112–113.)

Cobalt Minerals Tested: Asbolite, bieberite, erythrite, and sphaerocobaltite.

Procedure and Results.—Print the streak by pressing it for 2 min. on spot-reaction paper damped with 1 : 7 HNO_3 thiocyanate. Co is indicated in all the above species by the development of a blue print which may take about 30 seconds to reach its maximum intensity and which persists for only a few minutes.

Copper

The vast majority of copper minerals developed in the zone of oxidation react positively to the three following tests:—

(1) *Sodium Xanthate Test.*

Procedure and Results.—Streak on a portion of the tile and add a drop of 10% sodium xanthate solution. Cu is indicated by the streak immediately becoming yellow.

(2) *Rubeanic Acid Test.* (Feigl, F., 1947, pp. 70–72.)

Procedure and Results.—Streak on a portion of tile and add a drop of a 1% alcoholic solution of rubeanic acid followed by a drop of 0.880 ammonia. Cu is indicated by the streak becoming olive-green to greenish-black.

Other Notes.—Under the conditions of the test the streaks of certain secondary Co and Ni minerals become brown and pale-blue respectively.

(3) *Potassium Ferrocyanide Test.*

Procedure and Results.—To a streak on a portion of tile add a drop of a 5% solution of potassium ferrocyanide followed by a drop of 5N HCl. Cu is indicated by the streak becoming reddish-brown.

Other Notes.—The development of a blue colour, due to the presence of “reactive” iron in the tile or in the mineral under test does not—in the writer’s experience—obscure the brown colour of the copper compound. However, it is important to note that U and Mo also form brown ferrocyanides.

Silver Nitrate Test

This test enables differentiation to be made between cuprite and similar red minerals and between chalcocite and similar grey minerals.

Minerals Tested: Bornite, bournonite, chalcocite, chalcopyrite, cinnabar, cuprite, hematite, jamesonite, kermesite, marcasite, native copper, niccolite, pyrite, stannite, stibnite, and tetrahedrite. (Red species are in italics.)

Procedure and Results.—Add a drop of 0.1 N silver nitrate to a streak of the mineral on a piece of tile.

(i) *Native Copper.*—The streak becomes black immediately and particles of silver are apparent under the magnifying glass.

(ii) *Cuprite.*—The streak becomes brownish-black and some silver is to be seen.

(iii) *Chalcocite.*—The streak rapidly becomes grey and metallic on account of a heavy precipitation of silver.

(iv) *Bornite.*—Reacts as chalcocite but the change is less rapid.

(v) *All other Minerals Noted above.*—No obvious change.

Iron

Potassium Ferrocyanide Test.

Practically all iron-rich minerals developed in the zone of oxidation react positively to this test. Hematite and certain limonites are notable exceptions.

Procedure and Results.—Streak on a portion of tile and add a drop of 5% potassium ferrocyanide followed by a drop of conc. HCl. Fe is indicated by the development of an intense blue streak (and halo).

Other Notes. (1) A “blank” streak (made, for example, with a fragment of glass) often reacts positively, but the colour is very pale when compared with that due to most iron-rich “reactive” minerals and so it does not normally cause confusion.

(2) The presence of Fe in the more inert minerals—such as, hematite and wolframite—may usually be indicated as follows:—Streak the mineral on a piece of a broken porcelain mortar. Cover the streak with a little sodium peroxide and fuse by applying a burning splint to it. Add a few drops of conc. HCl to the product and then a drop or so of ferrocyanide. An intense blue colour indicates Fe.

Lead

(1) *Potassium Iodide Test.*

All lead minerals developed in the zone of oxidation which have been examined react positively to this test.

Procedure and Results.—Add a drop of freshly-prepared strong KI solution to the streak on a piece of tile and when the solution has largely sunk into the tile add a drop of 1 : 7 HNO_3 . Pb is usually indicated by the streak becoming an intense yellow. However, the wulfenite streak changes from yellow to green and after c. 10 minutes it becomes blue. The red minium streak alters to dark brown and the brown plattnerite streak darkens appreciably.

(2) *Sodium Rhodizonate Test.*—See Barium and Strontium Section.

Magnesium

Titan Yellow Test. (Kolthoff, I. M., 1927, p. 254.)

Magnesium Minerals Tested: Bloodite, brucite, carnallite, dolomite, hydromagnesite, magnesite, periclase, polyhalite, and steatite.

Procedure and Results.—Streak the mineral on a portion of tile and add a drop of 0.1% Titan Yellow followed by a drop of 5N NaOH. The presence of Mg is indicated by the streak becoming pink to vermilion. All the above species react positively although some varieties of steatite may not.

Other Notes.—In the presence of Ba and Ca ions the reaction is intensified, but Sn, As, Bi, Mn, and Al interfere.

Molybdenum and Molybdates

Potassium Ethyl Xanthate Test.

Molybdenum Minerals Tested: Molybdic ochre and wulfenite.

Procedure and Results.—Streak on a portion of tile, then place a small crystal of potassium ethyl xanthate on the streak and add a drop of 5N acetic acid. The presence of Mo in the above species is indicated by the development of a reddish-purple colour.

Other Notes.—The presence of Mo in molybdenite may be shown by covering a streak of the mineral on a piece of tile with sodium peroxide and applying a burning splint. The molybdate thus produced may be confirmed by applying the xanthate test.

Nickel

Dimethylglyoxime Test. (Feigl, F., 1947, pp. 114–117.)

Nickel Minerals Tested: Annabergite, bunsenite, garnierite, morenosite, and zaraitite.

Procedure and Results.—To the streak on a portion of tile add a drop of 0.880 ammonia and then a drop of a 1.0% alcoholic solution of dimethylglyoxime. Ni is indicated by the streak becoming rose-red. All the above species react positively.

Silver

(1) *Dimethylglyoxime Test.* (Feigl, F., 1947, pp. 302–303.)—All silver halides react positively to this test.

Procedure and Results.—Streak the mineral on a portion of tile and add a drop of the reagent. Silver halide is indicated by the streak becoming red immediately.

Reagent.—Immediately before the test prepare the reagent by mixing equal volumes of $K_2Ni(CN)_4$, 1.0% alcoholic dimethylglyoxime, and 0.880 ammonia. The $K_2Ni(CN)_4$ is prepared by boiling KCN solution with such an amount of freshly precipitated $Ni(CN)_2$ that only a portion of the latter dissolves.

(2) *Iron Plate Test for Silver Halides.*

Procedure and Results.—Rub the mineral on an iron plate. A silver halide is indicated by the fact that the portion of mineral which was in contact with the plate is silvered and usually a silvery streak is also apparent on the plate.

Tellurium

Tin-Sulphuric Acid Test.

Tellurium Minerals Tested: Calaverite, nagyagite, native tellurium, petzite, and sylvanite.

Procedure and Results.—Streak the mineral on a piece of sheet tin (or the lid of a tobacco tin). Add

a drop of conc. H_2SO_4 and warm with a match or a cigarette lighter. Te in the above species is indicated by the development of a reddish-purple colour.

Tungsten

Zinc-HCl Test.—All tungsten-rich minerals, excepting members of the ferberite-wolframite-hübnerite series, react positively to this test.

Procedure and Results.—Cover the streak on a portion of tile with zinc powder. Add a few drops of conc. HCl and then wash off the remaining zinc immediately. W is indicated by the streak becoming a strong blue.

Other Notes. (1) Molybdic ochre and wulfenite may yield a slightly blue streak under these conditions.

(2) A useful alternative way of conducting the above test is to place a drop of conc. HCl on the surface of the mineral and then rub the latter with a zinc rod.

Uranium

Potassium Ferrocyanide Test.—In the absence of copper and molybdenum this test may be used to confirm the presence of uranium in most, if not all, uranium species developed in the oxidation zone.

Procedure and Results.—Streak on a portion of tile and add a drop of 1.0% potassium ferrocyanide followed by a drop of 5N HCl. In the absence of Cu and Mo uranium is indicated by the streak becoming brown.

Vanadium

Potassium Ferrocyanide Test. (Heinrich, C. F. J., 1949, pp. 160–161.)

Vanadium Minerals Tested: Calcio-volborthite, descloizite, turanite, and vanadinite.

Procedure and Results.—Streak on a portion of zinc sheet and add a drop of 5N HCl. After about 10 seconds add a drop of 1.0% potassium ferrocyanide and warm by applying a match to the under-surface of the sheet. The presence of V in all the above species is indicated by the zinc ferrocyanide precipitate becoming pale-pink to rose-red.

Zinc

Ferricyanide—Oxalic Acid—Diethylaniline Test. (Feigl, F., 1947, pp. 137–139.)

Zinc Minerals Tested: Goslarite, hemimorphite, hopeite, sphalerite, tarbuttite, hydrozincite, parahopeite, smithsonite, and willemite.

Procedure and Results.—Streak on a portion of tile and add a drop of the reagent. Zn is indicated by the streak becoming orange, vermilion, or deep-red. With the exception of sphalerite all the minerals noted above react positively.

Reagent.—Immediately before the test mix equal volumes of 3% potassium ferricyanide with a 0.5% solution of diethylaniline in 3% oxalic acid.

Other Notes. (1) Probably this test is capable of identifying Zn in any zinc mineral developed in the zone of oxidation provided that it does not contain appreciable quantities of ions that form coloured insoluble ferrocyanides.

(2) The test is of the utmost value in differentiating rapidly between white (or near-white) secondary zinc minerals and other white minerals with which they are commonly associated.

Acknowledgments

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Large Walking Dragline Gets to Work

A machine recently
put into service
in this country
is described

What is described as the world's largest walking dragline, weighing 1,675 tons and equipped with a 282-ft. long tubular steel jib, has just begun work at an open-cast ironstone quarry near Stamford, operated by the Ore Mining Branch of the United Steel Companies, Ltd. The machine, which cost £800,000, is employed to strip the overburden from the ironstone, which is subsequently

loaded by excavators and transported 75 miles by rail to the ironworks of Appleby-Frodingham Steel Company in Scunthorpe. Taking 30-ton bites at the overburden, the W1400, as it is called, is expected to uncover 20,000 tons of ironstone each week initially. The actual rate of stripping ironstone is, however, dependent on the thickness of the overburden, which at the Exton Park open-

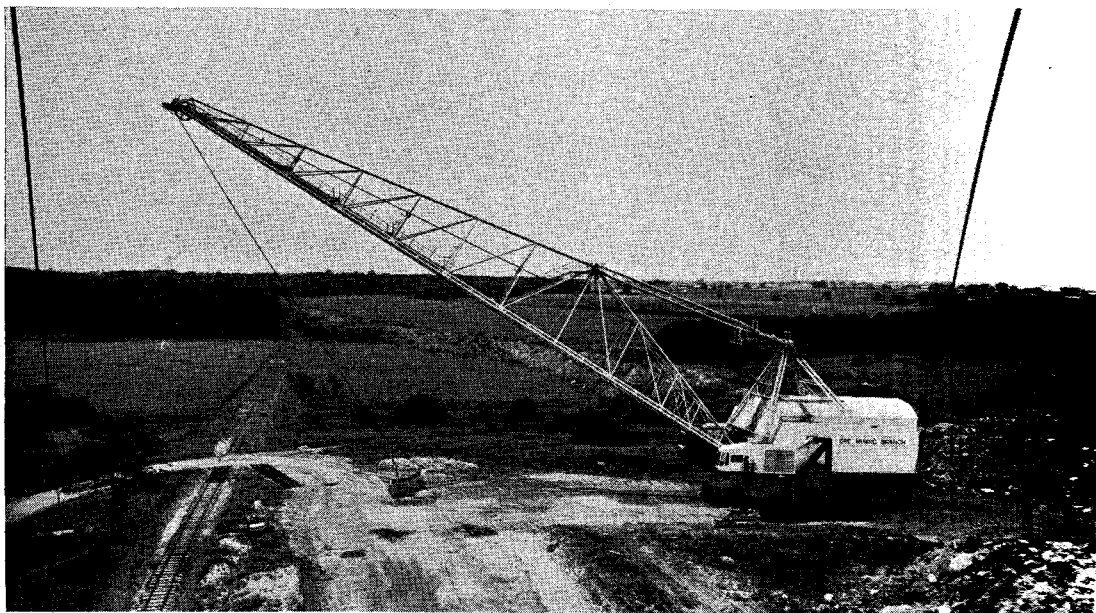


Fig. 1.—W1400 Walking Dragline.