

**Duke's**  
**"Quick Qualitative Analysis"**  
**Third Edition – Revised**  
(Copyrighted 1957)

by **RAYMOND H. MAULSBY**

**VOLUME TWO - PARTS TWO AND THREE**  
**of Duke's**

**"Short Course in Prospecting and Mineral Identification"**  
**For Whom These Instructions Are Intended**

For Prospectors; Mine Owners; Mining Engineers; Geologists; Assayers; Mineral Collectors: Specimen Hunters - or the Amateur or Greenhorn who knows nothing about prospecting, minerals, rocks or ores at present but would like to learn some-thing thing about this interesting and profitable business-these instructions are for you.

**If Any of These 40 Elements Are Present You Can Find Them**

1. Aluminum	9. Cobalt	17. Iron	25. Palladium	33. Tellurium
2. Antimony	10. Columbium	18. Lead	26. Platinum	34. Thallium
3. Arsenic	11. Copper	19. Magnesium	27. Rhodium	35. Tin.
4. Bismuth	12. Didymium	20. Manganese	28. Ruthenium	36. Titanium
5. Cadmium	13. Fluorine	21. Mercury	29. Selenium	37. Tungsten
6. Carbon	14. Germanium	22. Molybdenum	30. Silver	38. Uranium
7. Chlorine	15. Gold	23. Nickel	31. Sulphur	39. Vanadium,
8. Chromium	16. Iridium	24. Osmium	32. Tantalum	40. Zinc

**These 40 Elements Cover Some 300 or More Commercial Ores I**  
**What To Assay For-What Do Your Rocks Contain?**

That is the purpose of Qualitative Analysis-to find out WHAT valuable element or elements to have it assayed for; this usually costs \$5 to \$15, and many times money spent only to find your rock contains nothing of value, and thus your money thrown away; you do not have it made - you may be passing up a fortune!

**Now a Complete Qualitative Analysis for Less Than 50 cents**

These instructions will teach you how to take any unknown rock or ore you may pick up in the hills or elsewhere, and make a complete qualitative analysis of the same in a few minutes' time, at a total cost of less than 50 cents per rock, and if any of the 40 elements above are in that rock or ore - you will find and identify them.

**Takes All the "Guess-work" Out of Mineral Identification**

Requires no higher education, previous experience or special ability, and no previous knowledge whatever of chemistry, minerals, rocks or ores, and no costly test equipment to buy, you can carry your complete "Field Test Kit" in a shoe box and thus make all tests right in the field, either on the rocks picked up in the hills, or in checking your mine or prospect hole, and thus, not only find all the values it may contain, but also the best place in which to do your digging! It is all so simple and easy we absolutely guarantee any average 14 year old boy can do it!

**Do Not Guess-Make a Test**

That hole or mine you are working on may contain other hidden values!  
Those rocks you are throwing away in the hills may contain a fortune!  
Now you can find and identify them; easy - simple - quick - accurate!

This Complete Two Volume Course Will Show You How!

**DUKE'S RESEARCH LABORATORY**

TRUTH OR CONSEQUENCES, NEW MEXICO

## PART T W O

### QUICK QUALITATIVE ANALYSIS and "METHOD OF PROCEDURE"

#### General Information

This, Part Two, contains our "Quick Qualitative Analysis" as the "Method of Procedure" given here is the one we always follow in testing out any unknown rock or ore. In this, the tests are all arranged in systematic order by which we identify the various elements AS WE COME TO THEM, and thus we no longer have to first identify each rock or ore in order to know what element or elements to test or have assayed for as was necessary by old method of identifying minerals by physical properties. By our system we pay no attention whatever to what any rock looks like - we simply proceed as follows.

**"Method of Procedure":** Simply take your rock or ore (any rock or ore regardless of what it may look like) and powder up a little of it as fine as possible; you then start right in at Test No, 1, then proceed to make each additional test just as given until you have completed your analysis for all the elements covered there,

**Results:** If any of the elements covered there are present in your rock or ore, you identify them AS YOU COME TO THEM, regardless of what your' rock or ore may look like.

**Example:** In Test 1 we identify the two elements, Vanadium and Manganese, and also catch the Sulphides and Carbonates. In Test 2 we catch Molybdenum-Lead and Molybdenum-Oxide. In Test 3 we catch Tellurium and `tungsten (any ores). In Test 4 we catch Tin (any ore). And so on until we have completed our analysis for all the elements covered **in** Part Two.

**First Procedure:** In this all tests are first made on the "crude ore", not concentrated, or we would wash out some of the lighter elements, such as the oxidized ores in **which** the elements do not occur in the metallic state in nature. Next to the "Method of Procedure" the two most valuable features of these tests are: The simplicity of explanation, and the condensed form in which the tests are written. So to keep the tests as condensed as possible, we will first give here all explanations, rather than at time of testing. Read this as well as all of Part One over carefully before starting in on the actual tests as given in the "Method of Procedure".

**1. Confirmatory Tests:** To Confirm means to verify or prove. In our method of procedure we will find many of the elements will give a reaction in more than one test, but in some plain-er than others. That is, while most tests in Part Two are positive, some are merely indicative, in which case, or any case where there is a doubt, we confirm by other tests and thus make sure before having quantitative assays made.

2. If you, do not get at least a slight reaction called for, there is nothing to confirm, so proceed with next test.

3. We will sometimes find that two or more elements will give the same reactions in some tests, but no two elements will give the same reaction in all tests, and thus their individual identification. Example: Columbium and Tungsten in Test 1.3 both give a blue color; in Test 3 Tungsten gives a blue color, but Columbium will, not, and thus identified. It is the same with all other elements under like conditions.

4. To identify Minerals: Example: In Test 13 the element Molybdenum will give a red or rose color with any ore. There are 3 main ores: Molybdenite (MoS); Wulfenite (MoPb); and Molybdate (MoO<sub>3</sub>). Test 9 gives a blue color for MoS, but not for MoPb or MoO<sub>3</sub>; Test 2 gives a blue for either MoPb or MoO<sub>3</sub> but not for MoS. If Molybdenum in Test 2 and Lead in Test 7 our ore is MoPb: but if no Lead in Test 7 then our ore is MoO<sub>3</sub>. Thus we identify our particular rock or ore.

5. If a color does not show up as listed it does not mean the element is not present; it may be too low-grade to show up in that particular test; the colors are given merely to show what they mean if they do show up in the tests.

6. In this work we are interested only in commercial minerals, or those in which one or more elements are present in paying quantities, not mere traces. While most elements will give a reaction on very low-grade ores, very few will show a mere trace, and thus save money on worthless assays. All the tests are positive if the elements are present in anything like commercial quantities.

7. **Quantitative:** Most of the tests are semi-quantitative; that is, poor, fair, or good. Example: In Test 3 for Tungsten: If whole solution turns blue quickly, high-grade ore. If the solution turns blue only after standing until cold or longer, fair grade ore. If just a slight blue ring on dish, and no blue solution, very low-grade ore. And so on with all the other elements. If, by using the same amount of material, and comparing with an ore of known percentage, a fairly accurate percentage of the unknown may be arrived at.

8. With but few exceptions, such as Cinnabar, it is a poor policy to "guess" what any metallic mineral might contain, then proceed to test it out for just that element alone by tests given in Part Three; in most cases these are intended for confirming the reactions found in Part Two. Remember many minerals may contain two or more valuable elements, and some a half dozen or more; make all tests just as given in Part Two. If a reaction in any one test, do not stop at that point - always complete your analysis. The object is to find ALL the valuable elements your rock or ore may contain, then have them assayed for quality or value.

DUKE'S  
QUICK QUALITATIVE ANALYSIS

THIRD EDITION - REVISED

# # #

"METHOD O F PROCEDURE"

**TEST No. 1:** For, Vanadium; Manganese; Sulphides; Carbonates. **1.** Use amount of powdered mineral equal to 3 grains of rice. **2.** Place above in clean porcelain evaporating dish. **3.** Add 3 or 4 drops of cold strong Hydrochloric Acid.

**RESULTS:**

**A:** If a Sulfide the odor of Sulphur, resembling rotten eggs may be detected. (We catch sulphides again later on).

**B:** If a Carbonate powder will effervesce (bubble or "fizz").

**NOTE:** Sulphides will also sometimes effervesce, but can be distinguished by the odor of sulphur as given above.

**C:** If Vanadium is present both powder and acid will turn red or brown quickly. If so, confirm by Test No, 60.

**D:** If Manganese (all black ores) solution will be a greenish-black. If so, confirm by Test No. 39, Part Three.

**NOTE:** If there is, or is not, a reaction above, use same dish and powdered mineral for next Test No. 2.

**TEST No. 2:** For, Molybdenum-Lead or Molybdenum-Oxide.

**1.** Use same dish and powdered mineral from Test No. 1 above. **2.** Add 1 cc or slightly more strong Hydrochloric Acid. **3.** boil over lamp flame; while boiling watch for a blue or green stain on dish; boil to dry if necessary. Remove dish from flame and let set for a few minutes to cool.

**RESULTS No. 1:** Blue stain on dish, hot or cold, is positive test for MoPb (Wulfenite) or MoO (Molybdate). A green stain in dish indicates one of the; above may be present. If so, confirm by Test 41 Part Three which will prove yes or no.

**RESULTS No. 2:** If no blue or green above test is complete as no MoPb or MoO present, so proceed with Test 3 below. But if blue or green see 4 previous page to find if MoPb or MoO.

**NOTE:** If there is, or is not, a reaction above, use same dish and powdered mineral for next Test No. 3 below.

# # #

**TEST No. 3:** For, Tellurium, or Tungsten; any and all ores.

**1.** Use same dish and powdered mineral from Test No. 2 above.

**2.** Add 2 cc Hydrochloric Acid; boil slightly over lamp flame.

**3.** Remove from flame and while hot add small piece tinfoil.

**RESULTS No. 1** for Tellurium: If much Tellurium is present solution will turn black; if but little Te. just a dark solution around tin. In either case confirm by Test 54.

**NOTE:** The above is dark solution - not coating on tin.

Now continue test for Tungsten, as follows:

**4.** Place dish back over lamp flame and boil until solution changes color; then a little longer. Do not boil to dry.

**RESULTS No. 2** for Tungsten: A blue solution is a positive test for tungsten; color may not show up until cold, depends on grade of ore; solution may first be red, but will turn blue on standing. See Test 58 Part Three. **NOTE:** MoO or MoPb may also give a red color, but will not turn blue on standing.

(3 - Part Two)

**TEST No. 4:** For Tin. Any Ore or Metal. Very Positive Test.

1. Place powdered mineral size 2 or 3 grains of rice in dish.
2. Add powdered zinc metal of about equal quantity.
3. Add 8 or 10 drops hydrochloric acid (this is Test Solution) 4. Place 2 or 3 drops of above Test Solution in another dish. 5. Add 1 or 2 drops of Cacothelin Solution.

**RESULTS:** A pale to dark-purple spot if tin is present; the darker the color the more tin. This is a very positive test, even for very small quantities of tin, and may be made semiquantitative by making test on spot paper as given below. NOTE: If no sign of purple color above, skip the following.

1. Place a piece of filter paper on clean piece of glass.
2. Place 1 drop of Test Solution above in center of paper.
3. Add 1 drop of Cacothelin Solution in center of paper.

**RESULTS:** A small pale-purple spot if very low grade ore. A large pale-purple spot, or a small dark-purple spot if fair grade ore. If high grade ore the spot will be dark-purple and at least size of a dime. By using same amount of powdered mineral and comparing with a sample of known percentage, a fairly accurate percentage of the unknown may be estimated.

\* \* \*

**TEST No. 5: NOTE:** This is a "master test" by which we catch from one solution below the following 11 elements: Sulphur; Copper; Nickel; Lead; Thallium; bismuth; Cobalt; Tellurium; Molybdenum-Sulfide; Arsenic; Silver. (In the order listed). NOTE: Results Nos. 1-2 and 3 below are not intended as positive tests, but are given to show what they indicate if present.

#### TO PREPARE TEST SOLUTION

1. Place 2 cc of strong nitric acid in a clean test tube.
  2. Add powdered mineral equal to about one large navy bean.
  3. Boil about 3 minutes; a little longer rather than less.
  4. Remove from flame and let set about 2 minutes or so.
- RESULTS No. 1: A spongy mass rising to top of the solution shows sulphides are present. confirm by Test No. 1.  
RESULTS No. 2: Green solution indicates copper or nickel or both. Confirm nickel by Test 6; copper by test 14.
5. Now add 3 cc pure water free of chlorine (see page 10 in Part. Three). Heat slowly and carefully just to boiling.

**RESULTS No. 3:** A rose-color indicates cobalt; see Test 8.

**NOTE:** We will call this Test Solution 5, for reference in making the following 9 tests from this one solution.

**TEST No. 6:** For Nickel (for any and all ores). Spot Test.

1. Place a piece of filter paper on a piece of clean glass. 2. Place 1 drop Dimethylglyoxime solution in center of paper. 3. Add 1 drop of Test Solution 5 above to center of damp spot. 4. Add 1 drop of strong ammonia to center of above spot.

**RESULTS:** A red or rose color, which will not fade, is a positive test for Nickel. (Iron will sometimes give a red or rose, but will fade out within a few minutes). The brighter the color the more nickel present. (see Test 42, Part Three).

**NOTE:** The color, especially for low grade nickel, can usually be brought out plainer if wait until the paper is dry and then add another drop of strong ammonia to center of paper.

**TEST No. 7:** Lead; Thallium; Bismuth; or Bismuth and Lead.

1. Place 2 drops of test solution 5 in an evaporating dish.
2. Add about 6 or 8 drops plain water to dilute solution.
3. Add few crystals Potassium Iodide (KI.); see FOOTNOTE.

#### R E S U L T S

**A:** For Lead or Thallium: If either present even in small quantities, there will be a yellow or brownish precipitate. Confirm Lead by Test 25. Confirm Thallium by Test 11-J.

**CAUTION:** Do not mistake a yellow solution for precipitate; if a precipitate it will settle out in bottom of the dish, which may be plainer seen after has set for a few minutes.

**B:** For Bismuth: If much bismuth solution will turn black.

**NOTE:** This is not a positive test for bismuth, but merely indicative, as too strong acid, or other impurities, will sometimes cause solution to turn black with potassium iodide. But if there is a black color, and to be sure and not over-look bismuth, confirm by Test 25, Part Three;-

**C:** For both Lead and bismuth: sometimes found in same ore. If much bismuth solution may first be black, but on setting for few minutes black color will leave in which the yellow or brown precipitate of lead may easily be seen in dish. Confirm either lead or bismuth by Test 25, Part Three.

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**TEST No. 8:** For, Cobalt (any and all ores).

1. Place 10 drops test solution 5 in clean evaporating dish.
2. Boil over lamp flame until dry; just a little longer.
3. Remove from, flame, while hot add 1 cc Hydrochloric Acid.

**RESULTS:** A green solution is a positive test for Cobalt, any and all ores; but may confirm by Test No. 16.

**NOTE:** Use same dish and acid for next Test No. 9.

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**TEST No. 9:** For, Tellurium; Molybdenum. Sulphide; Arsenic.

1. Use same dish and acid from previous Test No. 8.
2. Place over lamp flame and boil off 1/2 solution.
3. Remove from flame and immediately drop in small piece of pure tinfoil while hot; tip dish and slowly rotate once.

#### R E S U L T S

**A:** For Tellurium: If much Te. solution will turn black. if but little Te. a dark color around tin; watch closely!

**B:** For Molybdenum Sulphide: Blue stain on dish is positive test for MoS, needs no confirming. There will also be a red or rose-colored solution after dish has set for some time.

**C:** For Arsenic: A brown film or scales on dish or floating on solution indicates Arsenic. Confirm by Test No. 11-A.

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**TEST No. 10:** For, Silver, or Lead; or both if together.

1. Now take tube with remaining test solution 5.
2. Warm slightly; filter into clean test tube; let cool.
3. When solution cold add 1 or 2 drops Hydrochloric Acid.

**RESULTS:** A white "curdy" precipitate or mass, or a milky-white or opal-color, all indicate silver or lead or both; color depends upon amount of either or both present.

**NOTE:** To determine if silver or lead or both, see-pages 10 and 11 Part Three, and proceed as given there.

## TESTS MADE ON CHARCOAL

**TEST FOR:** As. Sb. Cd. Se. Os. Ge. S. Pb. Bi. Tl. Te. Sn. Zn.  
Al. Mg. Au. Ag. (Fe. Ni. Co.).

**TEST 11: CHARCOAL - NO FLUX.** (Tests made with blowpipe).

1. Use powdered mineral equal to 2 or 3 grains of rice.
2. Place on end of charcoal block (stick).
3. Heat steadily and for some time in the Oxidizing Flame.

**RESULTS:** See, "Reactions to watch for", as listed below.

4. If no results in above, heat in the Reducing Flame.
5. Now note if any reactions as listed below.

**NOTE:** For reactions of different elements see next page.

**TEST 12: CHARCOAL - WITH FLUX.** (Tests made with blowpipe).

1. Use powdered mineral equal to 2 or 3 grains of rice.
2. Mix with "Charcoal Flux" equal to a large navy bean.
3. Make into paste with drop of water; place on charcoal.
4. Fuse to liquid state with Reducing Flame, then, while hot, run knife blade under fusion, turn over, then fuse some more; a good fusion is quite necessary.

**RESULTS:** The same as in Test 11, and as listed below; some minerals which show little or no reaction without flux, may show a good reaction with flux; so both should be tried.

**NOTE:** For reaction of different elements see next page.

## REACTIONS TO WATCH FOR

(Both With and Without Flux)

**A: SUBLIMATE:** (Coating). If heavy or light; color; if near or distant from assay; color while hot; color when cold.

**B: VOLATILITY:** If easy, fairly easy, or non-volatile; first in Oxidizing Flame; then try Reducing Flame.

**C: FLAME COLORS:** Note if any change given off by the assay itself; or sublimate if touched with the Reducing Flame. **D:** Touch sublimate with R.F. (for instant only); note if a change in color, or colored flame; if so, what.

**E: ODORS:** Note if any; example: garlic-like odor indicates As. A radish-like odor indicates Selenium, etc.

**F: SMOKE OR FUMES:** Example: heavy white smoke indicates Sb. Fumes smart the eyes (good test) indicates Os. etc.

**G: ASSAY:** Note if any change in color or appearance; if so, what? Inspect hot; inspect cold.

**H: FUSIBILITY:** (No Flux): If easy, fairly easy, or hard to fuse, or infusible. Important in testing for Aluminum or Magnesium with Cobalt Nitrate; See Test 38 Part Three.

**I: GLOBULES:** Note if any small metallic beads; if so, their color, hot and cold.

**J: SECTILITY:** If globules are easy, fairly easy, or hard to cut with knife. (Such as Pb. Ag. Sn. Bi. etc.').

**K: MALLEABILITY:** If globules will flatten, or are brittle.

**L: MAGNETISM:** Test powder with magnet before heating; then after heating in R.F. Test mass after fusing with flux.

**NOTE: AFTER FUSING WITH FLUX, SAVE FUSION FOR TEST No. 13.**

## REACTIONS ON CHARCOAL

(With or Without Flux; try each; see previous page)

**NOTE:** First 7 elements are positive; need no confirming.

- A:** White light coat, distant assay. Very volatile. Garlic-like odor. (Odor is most positive test) - - - As.
- B:** White heavy coat, near assay, bluish out-border. Volatile. White smoke - continues after heating - - Sb.
- C:** Red or brown coat with bright blue border - - - Cd.
- D:** Steel-gray coating, red outer-border. Volatile. If coat touched with R.F. an azure-blue flame; a peculiar radish-like odor; odor is positive test - - Se.
- E:** Sharp bromine-like odor; fumes smart the eyes - - - Os.
- F:** First, pure white coat near assay, if more heat moves further out, assumes greenish to brownish or lemon color; if examined with lense coat presents a glazed or enamel-like surface. Small milk-white globules scattered on charcoal near the assay - - - Ge.
- G:** A very sharp pungent suffocating odor - - - S.

**NOTE:** Following are indicative; should be confirmed.

- H:** Yellow coating near assay; non-volatile. Small metallic beads on assay; malleable, easy cut - - - - - Pb.
- I:** Yellow coat near assay; non-volatile. May be small metallic beads on assay; harder to cut than lead - Bi.  
(Confirm either Lead or Bismuth by Test No. 25)
- J:** A slight white coat and an INTENSE green flame - - - Tl.  
(Confirm Thallium by Test No. 7)
- K:** Heavy white coat, blue out-border with yellowish cast, black band between; all burn off with bluish flame, which is also yielded by the assay itself - - Te.  
(Confirm Tellurium by Test No. 3; most positive)
- L:** Yellow hot, white cold coating; non-volatile, small metallic globules. If coating moistened with cobalt nitrate solution and assay strongly heated coating will become bluish-green when cold. - - - - - Sn.
- M:** Yellow hot, white cold with blue border. Non-volatile. No metallic globules. If coating moistened as above and reheated, coat becomes a bright green - - - - Zn.  
(Confirm Zinc by Test 60, Part Three)
- N:** No flux; infusible. If heated then assay moistened as in L. above and reheated, assay becomes green - - Al.
- O:** No flux; infusible. If heated then assay moistened as in L. above and reheated, assay becomes pink - - Mg.  
(Confirm Magnesium by Test No. 38, Part Three)
- P:** With flux: red metallic looking mass or specks - - Cu.  
(Confirm Copper by Test 14; most positive test)
- Q:** Yellow, soft, malleable globule, bead or button - - Au.  
(Confirm Gold by Test 34, Part Three)
- R:** White malleable globule, beads or button - - - - Ag.  
(Confirm Silver by Test 52, Part Three)
- S:** A magnetic residue after heating in R.F. and let cool indicates either Iron, Nickel, or Cobalt present.

**TEST No. 13-A:** For Cb., Ti. - any ore. (Also W. Mo. V. Co.).

**NOTE:** All these but Cb. and Ti. should have been found, if present, in previous tests, so main object here is to cover Cb. and Ti. However, reactions for others will also be given here to watch for. Some colors may occur quite soon, some only on standing until cold or longer - so watch both.

TO TEST: Use same fusion from Test 12, or make a new one.

1. Pulverize fusion from Test 12, or the new one.
2. Place in clean test tube with 2 cc Hydrochloric Acid.
3. Add a small piece of metallic tin. (Tinfoil best).
4. Boil until solution changes color; then a little longer.

**NOTE:** Add more tin if solution does not change color..

## R E S U L T S

**A:** Light-blue solution indicates Columbium; may not show up until cold or longer. Color brighter if let set few minutes then add powdered zinc metal equal to 2 grains rice.

**B:** Dark-blue solution indicates Tungsten. To determine if W. or Cb.: W. gives a blue solution in Test 3, Cb. will not.

**C:** A lavender solution indicates Ti. Confirm by Test 57.

**D:** A red or rose solution if Mo. present. Positive test.

**E:** A green solution indicates V. or Co. Confirm V. by tests 1-17 and 60. Confirm Co. by tests 5-8 and 17.

**NOTE:** In above, charcoal may remain in suspension and thus make colors hard to distinguish; if so, may proceed as in Test 13-B for Cb. and Ti. If no color above can skip 13-B.

**TEST 13-B:** Special test for Cb. and Ti. If in doubt above.

1. Place a piece of chinaware in adjustable holder.
2. Place on same powdered borax (or borax glass best) equal to about 1/2 size of common pea (more or less).
3. Add powdered mineral equal to about 2 grains of rice.
4. Add sodium hydroxide (pellet best) equal 1/2 size pea.
5. Fuse well with blowpipe, while hot turn over with knife blade and fuse again. A good fusion is necessary.
6. While hot remove fusion and crush in porcelain mortar.
7. Place in test tube with 2 cc strong Hydrochloric Acid.
8. Add 1 or 2 small pieces of metallic tin (tinfoil best).
9. Boil until solution changes color; then a little longer.

**RESULTS:** Same as in Test 13-A, but colors plainer seen.

Let set few minutes then add zinc powder size 2 grains rice.

**TEST No. 14:** For copper any ore; most positive test for Cu.

1. Place small piece scrap charcoal in adjustable holder.
2. Place an same small piece mineral size of match head.
3. Heat to redness in Oxidizing flame of blowpipe.
4. Add 1 drop Hydrochloric Acid; now reheat with blowpipe.

**RESULTS:** A blue or green flame if any copper present.

**TEST No. 15:** For Mercury (Hg). Method of Procedure.

**NOTE:** Cinnabar is only main ore; it is very characteristic color (usually vermilion-red or scarlet; very few rocks even resemble it. Should have known sample Cinnabar, then test for Hg. only when your rock resembles same, in which case see Test 40 Part Three, and proceed as given there.

## BORAX AND SALT OF PHOSPHOROUS BEADS

- General Information -

**BORAX BEADS:** Made on platinum wire, as follows:

1. Heat end of platinum wire in flame of the alcohol lamp.
2. While hot quickly touch to borax powder.
3. Reheat in lamp flame until fusion stops.
4. While hot touch again to borax, then reheat; repeat this until bead is about the size' of small grain of rice.
5. Now heat with blowpipe until bead clear and transparent.
6. While hot touch to few specks of roasted powdered mineral.
7. Heat for some time in the O.F. (Oxidizing Flame) of blow-pipe. Note the color, if any, while hot and when cold.
8. Now heat in R.F. (Reducing Flame); note color, hot, cold.
9. If no color, add few more specks of mineral; try again. Repeat this until bead is saturated (opaque).

**RESULTS:** If an appreciable amount of element is present a point will be reached where color will show up as listed on following page. **NOTE:** In making or heating bead, hold wire horizontal; to remove bead hold wire vertical, then heat.

**SALT OF PHOSPHOROUS BEADS:** These are made the same as Borax beads, except, Salt of Phosphorous is more liquid when hot, and thus harder to hold on the wire; beads must be built up slower, using less material at a time. In building up bead, hold higher above lamp flame, then gradually lower.

**AMOUNT OF MINERAL TO USE:** From a very few specks in most cases, up to the amount where the bead is saturated (opaque). This depends upon kind of mineral, quality and impurities. Generally speaking just a very few specks are sufficient.

**ROAST MINERALS FIRST:** All minerals should first be roasted on charcoal before making bead tests, otherwise beads may be dark or brown. **TO ROAST:** Place a little mineral on charcoal, heat to red in O.F. then in R.F. wind up by heating in the O.F. **CAUTION:** Note results, if any, for following reasons:

**RESULTS:** If any smoke or coating on charcoal in roasting, continue to heat in O.F. then in R.F. until all smoke and sublimate cease; otherwise volatile minerals will alloy with the platinum; this will not "salt" the wire, or cause any colors in future tests, but will make the wire brittle, and cause it to break off, and thus waste the valuable wire.

**CAUTION:** A clean wire must always be used, or may "salt" the wire from a previous test, that is providing a color was obtained in a previous test; if no color in previous test then need not be particular as no danger of "salting".

**TO TEST WIRE:** Make a bead in usual way (without using any mineral). Heat in O.F. then in R.F. Results: If no color shows up the wire is ok; but if color, then clean wire.

**TO CLEAN WIRE:** Boil in a little hydrochloric acid then wash well by shaking back and forth in clean water..

**NOTE:** For Bead Colors of the elements see following page.

## BEAD COLORS OF THE ELEMENTS

- With Borax and Salt of Phosphorous -

**ABBREVIATIONS:** Yel. means Yellow; Cls. means Colorless. O.F. is Oxidizing Flame; R.F. is Reducing Flame. (Blowpipe).

**NOTE:** All these elements but U. and Di. were covered in previous tests; but colors given here will help to confirm.

### TEST No. 16: BORAX BEAD COLORS

#### CHROMIUM - Cr.

O.F.: Yel. hot; green cold. R.F.: Green hot; green cold.  
Confirm by Test 27, as given in Part Three.

#### VANADIUM - V.

O.F. Yel. hot; green cold. R.F.: Green hot; green cold.  
Confirm by Test 60. (Any ore containing V. should also be assayed for Uranium as they many times occur in same ore).

#### URANIUM - U.

O.F.: Yel. hot; Ylsh-green cold. R.F.: Green hot; green cold.  
Confirm by Test 59; but above is always worthy of assay.

#### DIDYMIUM - Di.

NOTE: Is a mixture of Neodymium (Nd) and Praseodymium (Pr.).  
O.F.: Rose hot; rose cold. R.F.: Rose hot; rose cold. We have no confirmatory test for Di; usually none needed.

#### COBALT - Co.

O.F.: Blue hot; blue cold. R.F.: Blue hot; blue cold.  
This is very positive test; but may confirm by Test 8.

#### IRON - Fe.

O.F.: Yel. hot; Cls. cold. R.F.: Yel. hot; Cls. cold.  
NOTE: May be pale-green cold; see Test 36 in Part Three.

### TEST No. 17: SALT OF PHOSPHOROUS BEADS

NOTE: Borax beads are best for practice, but Salt of Phosphorous covers more elements more accurate; so best to use. Confirm same as Borax above, unless otherwise stated below.

#### CHROMIUM - Cr.

O.F.: Green hot; green cold. R.F.: Green hot; green cold.

#### VANADIUM - V.

O.F.: Yel. hot; yel. cold. R.F.: Green hot; green cold.  
NOTE: Yellow in O.F. when cold distinguishes V. from Cr.

#### URANIUM - U.

O.F.: Yel. hot; yel.-green cold. R.F.: Green hot; green cold.

#### MOLYBDENUM OXIDE - MOO.

O.F.: Yel. hot; Cls. cold. R.F.: Green hot; green cold.  
Confirm Molybdenum Oxide by Test No. 2; most positive test.

#### COLUMBIUM - Cb.

O.F.: Yel. hot; Cls. cold. R.F.: Brown hot; brown cold.  
Confirm by Test 13-ti; most positive test for Columbium.

#### DIDYMIUM - Di.

O.F.: Rose hot; rose cold. R.F.: Rose hot; rose cold.

#### COBALT Co.

O.F.: Blue hot; blue cold. R.F.: Blue hot; blue cold.

#### IRON - Fe.

O.F.: Yel. hot; Cls. cold. R.F.: Yel. hot; Cls. cold.  
NOTE: Iron with saturated bead may be pale-green cold.

**SECOND P R O C E D U R E TESTS MADE ON CONCENTRATES -  
General Information -**

1. After completing our Qualitative Analysis on the crude ore, as given in previous pages, we then proceed to concentrate our rock in a gold pan, then re-check for the heavier elements, such as gold, silver, lead, bismuth, nickel, tin, tungsten, uranium, tantalum, columbium, platinum minerals, etc., which due to their high value may be present in paying quantities, but did not catch in the first procedure on the crude ore due to small quantity material used in testing.

2. **Note:** If any sulphides or Tellurium found in the first procedure, roast ore thoroughly before panning.

3. To Roast Ore: Place crushed or powdered ore in a metal container, such as old frying-pan, pie tin or shovel, place over open flame, such as camp fire, stove with lid removed, or better in a blacksmith forge. Heat, and hold to a dull redness for 10 to 30 minutes, or until no more smoke or any sulphur fumes given off; keep stirring ore while roasting.

4. Another good method: For any and all rocks. Heat rock for some time, to red if possible, in camp fire, stove, or in blacksmith forge; then stand back in case rock explodes and toss in bucket of cold water. This will help free rock of sulphides and tellurium, also reduce certain elements to the metallic state, such as lead, bismuth, gold and silver tellurides, etc. Also make rock easier to pulverize later on,

5. To prepare ore for concentrating: Take a pound or more of your rock, crush in iron mortar or other means until all will pass through window screen, then place on a buck-board and with muller pulverize to flour fineness.

6. Buck-board: Any smooth flat piece of iron will do, such as old stove lid, but larger the iron, the quicker the work.

7. Muller: For rubbing or grinding ore on buck board. Any piece of smooth flat iron will do; the bottom plate of an old discarded electric flat-iron is ideal for this purpose.

8. Panning: A 6 inch frying pan with handle cut off is a handy pan for lab, work. Fill an extra pan with water. Place powdered mineral in gold pan, fill with water, shake vigorously to settle heavy materials; now by lowering and raising pan in water, wash off lighter materials; stop and shake pan often; repeat this until only a spoonful or less remains.

9. Results: If any heavy concentrates in pan, especially if non-magnetic, as explained on following page, recheck for heavier elements as given in paragraph 1 above. Also check for gold and platinum minerals by tests 18-19-20-21.

## GOLD, AND THE PLATINUM GROUP MINERALS

### - General information -

**1. Gold:** The first thing to remember, and this will apply to old timers as well as greenhorns: While pure gold is always yellow it is seldom if ever found in the pure state in nature, but is always associated with other elements which may change its color; such as alloyed with silver or mercury, in which case it may have a bronzywhite color; or in chemical combination with tellurium, in which it will look silver-white or gray; or associated with iron oxides, in which it may be coated brown or red; or may be coated jet-black if found in manganese, and thus mistaken for black iron. So to make sure all concentrates should be checked for gold bar chemical tests.

**2. Platinum Minerals:** There are 6 minerals known as the Platinum Group: Platinum, Palladium, Iridium, Osmium, Rhodium and Ruthenium, listed in the order of their frequency of occurrence as well as uses. We seldom if ever find any one of these in the pure state in nature, but in practically all cases will find two or more alloyed together, and in some cases traces or more of all six.

This greatly simplifies our work in their identification, in the following manner: In practically every case each one will contain either Platinum or Palladium, or both. In Part Three we give tests for all 6 elements; while the tests for Iridium, Osmium, Ruthenium and Rhodium are all fairly accurate on the pure elements, they are not always accurate as found in nature due to impurities; but the tests for Platinum and Palladium are always accurate in all cases, regardless of impurities, with the following results.

We first test for Platinum and Palladium only: If both of these are absent in our concentrates, and while there are possible exceptions, we can usually quite safely assume that none of the other 4 are present. If we find either Platinum or Palladium, or both, we then have our ore or concentrates assayed for Iridium and Osmium as well as Platinum and Palladium. Rhodium and Ruthenium usually occur in small quantities and are obtained as a by-product in the refining of other platinum minerals, and are seldom if ever paid for.

The natural colors of Platinum and Palladium are silver-white or gray, but as found in nature, due to other impurities, they may tarnish black, resembling black iron, or may have a yellow or a bronzy cast resembling iron pyrites. For these reasons all heavy concentrates should always be tested for Pt. and Pd. regardless of color.

**3. Characteristics:** Gold, Platinum and Palladium are all quite soft and malleable; may be cut with a knife and will flatten without breaking. Iridium is also somewhat malleable, but harder. The only other soft malleable elements occurring in nature are native silver, bismuth and copper, all of which can be easily eliminated as follows: Silver, copper, and bismuth are all soluble in nitric acid; Gold and Platinum are not soluble in any single acid, but are both soluble in Aqua Regia, so if your material dissolves in nitric acid you can be sure it is not gold or platinum. Palladium is somewhat soluble in nitric acid, giving a wine-red solution, and completely soluble in aqua regia, and thus, gold, platinum and palladium can all 3 be detected if present in any aqua regia solution by the four simple tests 18-19-20 and 21 as given on the following page.

## TESTS FOR GOLD - PLATINUM - PALLADIUM

**TEST No. 18:** To prepare Test Solution for Au. Pt. Pd.

1. Pick out particles suspected of being Au. Pt. Pd. or use concentrates equal to about one navy bean or pea.
2. Place the above in a clean test tube.
3. Add 1 cc Nitric and 3 cc Hydrochloric Acid. (Aqua Regia).
4. Boil over lamp flame for at least 5 minutes or longer.

**RESULTS:** Gold, Platinum or Palladium, if present, are now in solution, from which we will make the following 3 tests.

**NOTE:** To become familiar with the various colors and other reactions in the following tests, one should first practice on known samples of gold, platinum and palladium.

# # #

**TEST No. 19:** For Gold - Au. Spot Test with Stannous Chloride.

1. Place a piece of filter paper on a clean piece of glass.
2. Place one drop of Test Solution 18 in center of paper.
3. Add one drop freshly prepared Stannous Chloride Solution.

(To prepare solution see article 6, page 23, Part One).

**RESULTS:** If gold is present there will be a purple or rose colored spot when paper is dry; color depending on amount of gold present; the darker the color the more Au. Color will show plainer, especially for low grade ores, if let paper dry then add another drop of stannous chloride solution.

# # #

**TEST No. 20:** For Platinum - Pt. With Potassium Iodide - KI.

1. Place about 20 drops Test Solution 18 in evaporating dish.
2. Boil over lamp flame until dry; then just a little longer.
3. Let dish set few minutes to cool so will not break dish.
4. Add 3 or 4 cc plain water; reheat just to boiling.
5. Filter solution into another clean evaporating dish.
6. Add potassium iodide equal to about one grain of rice.
7. Warm solution slightly over lamp flame; watch for color.

**RESULTS:** If Pt. is present the solution will turn a light or dark rose color, either at once or after set few minutes; the more Pt. present the quicker and darker the color.

**NOTE:** Sulphides or other impurities may sometimes give a red color which may be mistaken for a rose, in which case proceed as follows: boil off say one-half solution to hasten evaporation, then let dish set until dry, then add few drops plain water. **RESULTS:** If Pt. a bright rose color; if sulphides or other impurities solution will be colorless. This is the most positive test for Pt. If solution appears red, add a few cc's of plain water to better see rose color.

**TEST No. 21:** For Palladium - Pd. With Potassium Iodide.

**NOTE:** If in above test for Pt., and upon adding KI and warming (lines 6 and 7), if Pd. present the solution will turn dark colored or black, depending upon Pd. present; the more Pd. the darker the color. There will also be a black precipitate in bottom of dish, which upon adding an excess of KI will dissolve giving a wine-red color. However, the dark solution is the main test for Pd., otherwise a red color means nothing for reasons explained in Test 20 for Pt.

**PART T H R E E**  
\*  
**INDIVIDUAL AND CONFIRMATORY TESTS.**

**TEST No. 22**  
**ALUMINUM-Al.**

**NOTE:** Mineral should be light colored, or become so on ignition; **MUST BE INFUSIBLE**; test for fusibility first.

1. Place on charcoal small piece size of 2 grains of rice.
2. heat steadily in hottest part of the blowpipe flame.
3. Inspect with lens; note if fused even slightest on edge.  
**RESULTS:** If any sign of fusion, test will not apply, as any fusion will turn blue with Cobalt Nitrate solution.  
If no sign of fusion, proceed with test:
4. Replace piece of mineral on charcoal.
5. Apply 1 drop of Cobalt Nitrate solution to assay.
6. Heat in hottest part of blowpipe flame; note results.  
**RESULTS:** If assay turns blue indicates Al. but possibly Zinc; check Zn. If no Zn. it proves presence of Aluminum.  
If no blue by above test, proceed as follows:
7. Powder mineral; dampen with drop Cobalt Nitrate solution. 8. heat in hottest part of blowpipe flame. **RESULTS:** Same as results above.

# # #  
**TEST No. 23**  
**ANTIMONY-Sb.**

**TEST A:** Charcoal - No Flux. (See Test 11).

1. Place on charcoal small piece about size 2 grains rice.
2. Heat steadily in the Oxidizing Flame of blowpipe. **RESULTS:** Heavy white volatile sublimate near assay; white smoke; smoke may continue after heating ceased; smoke and sublimate is a positive test for Antimony.

**TEST B:** Charcoal - With Flux, (See Test 12).

1. Use powdered mineral equal to two grains of rice.
  2. Mix with "Charcoal Flux" equal to two navy beans.
  3. Heat and fuse in the Reducing Flame of the blowpipe.
- RESULTS:** Same as in Test A. (See Test 12 for reason why).

**TEST No. 24**  
**ARSENIC - As.**

**TEST A:** Charcoal - No Flux. (Some Arsenic minerals).

1. Use small piece of mineral size of 2 grains of rice.
2. Place on charcoal; heat in the Oxidizing Flame. **RESULTS:** Light white sublimate, some distance from assay; very volatile; GARLIC-LIKE ODOR; positive test.

**TEST B:** Charcoal - With Flux. (See Test 12).

1. Use powdered mineral equal to two grains of rice.
  2. Mix with "Charcoal Flux" equal to large navy bean.
  3. Dampen with water; place on charcoal block.
  4. Heat and fuse in the Reducing Flame; note results.
- RESULTS:** Same as in Test A. (See Test 12 for reason why).

**TEST No. 25**

**BISMUTH-Bi.**

**WITH BISMUTH FLUX:** Equal parts Potassium Iodide and Sulphur.

1. Place Bismuth Flux equal to about a large navy bean in a porcelain evaporating dish.
2. Add powdered mineral equal to about two grains of rice.
3. Dampen to thick paste with a drop of water and place on a charcoal block of gypsum tablet. (Gypsum tablet best for detecting small quantities of bismuth - easier to see).
4. Fuse thoroughly in the reducing flame of the blowpipe.

**RESULTS:** Yellow coating near assay, bright red border.

This is most accurate test for even small quantities of Bi.

**Note:** This is also a good test for Lead which gives a yellow coating near assay - no red border.

**TEST No. 26**

**CADMIUM-Cd.**

**TEST:** To detect 1 or less of Cadmium even with much Zinc.

(Cadmium is found associated with some zinc ores)

1. Use powdered mineral equal to about two grains of rice.
2. Mix with sodium carbonate equal to about one navy bean.
3. Make into thick paste with a drop of water.
4. Place on charcoal block and heat steadily in the reducing flame of the blowpipe.

**RESULTS:** Reddish-brown coating near the assay with a blue border; usually iridescent (peacock) if only a little of the sublimate forms. Sometimes seen best when cold.

**Note:** Zinc being less volatile the white coating of Zn. forms only after continued heating. Check Zinc by Test 61.

**TEST No. 27**

**CHROMIUM-Cr.**

**TEST A:** With Salt of Phosphorous Bead.

**Note:** For making bead tests see instructions in Part Two.

1. Oxidizing Flame: Dirty-green hot, emerald-green when cold.
2. Reducing Flame: Dirty-green hot, emerald-green when cold.

**TEST B:** Where iron etc., interferes with the above test.

1. Place Sodium Carbonate equal to one navy bean and same amount of Potassium Nitrate in an evaporating dish.
2. Add powdered mineral equal to about 2 grains of rice.
3. Mix above thoroughly and dampen with a drop of water.
4. Place on charcoal block and fuse thoroughly with blowpipe.  
**RESULTS:** Fusion usually yellow if much chromium present.
5. Place 3 cc of water in a test tube and heat to boiling.
6. Add powdered fusion to water and reheat to boiling.  
**RESULTS:** Chromium now in solution (usually yellow).
7. Filter solution into a clean test tube.
8. Add about 6 drops or so of Glacial Acetic Acid.
9. Add a few small crystals of Lead Acetate.

**RESULTS:** A yellow precipitate if much chromium present.

To confirm: Shake tube and filter; let paper dry, then test precipitate with Salt of Phosphorous Bead by Test A. above.

**TEST No. 28**  
**C O B A L T - Co.**

**TEST A:** Made with either Borax or Salt of Phosphorous beads.

1. Oxidizing Flame: Blue hot; blue cold.
2. Reducing Flame : Blue hot; blue cold.

**TEST B:** Quick test with Nitric and Hydrochloric Acids.

1. Place about 1 cc Nitric Acid in an evaporating dish.
2. Add powdered mineral equal to about 2 grains of rice.
3. Boil to dry over lamp flame; remove and let dish cool.
4. Add about 1 cc Hydrochloric Acid; warm dish slightly.

RESULTS: A green solution if Co. Confirm by Test A above.

**TEST No. 29**  
**COLUMBIUM-Cb.**

**TEST:** With Borax Fusion, hydrochloric Acid and Metallic Tin.

1. Place borax powder size 2 navy beans in evaporating dish.
2. Add finely powdered mineral equal to about 2 grains rice.
3. Dampen with water, place on charcoal block, or chinaware.
4. Fuse thoroughly in the Reducing Flame of the blowpipe.
5. Turn over and fuse again. A good fusion is necessary.
6. Crush fusion and grind to powder in a porcelain mortar.
7. Place in test tube with 3 cc strong Hydrochloric Acid.
8. Add a small piece of pure metallic tin. (Tinfoil best).
9. Boil until solution changes color; then a little longer.  
(Add extra tin if necessary to change color of solution).

**RESULTS:** A pale-blue solution if Columbium is present. Color may not show up until solution is cold or longer. The color may be brought out plainer if let dish set few minutes then add powdered metallic zinc equal to about 2 grains rice.

**NOTE:** Tungsten will give a dark-blue solution in this test. To determine if Cb. or W: Tungsten will give a blue color in Test 3, Columbium will not, and thus the; identification.

**TEST No. 30**  
**COPPER-Cu.**

**TEST A:** Made in test tube with Nitric Acid and Ammonia.

1. Place about 2 cc Strong Nitric Acid in a clean test tube.
2. Add powdered mineral equal to about 1/2 navy bean.
3. Boil over lamp flame for about a minute or two.

**RESULTS:** A green solution if Cu. (Sometimes if Nickel).

4. Add about 4 cc plain water; let set until cool.
5. Add 1 cc strong ammonia; filter into another test tube.

**RESULTS:** A blue solution indicates Copper (or Nickel). Check Nickel by Tests 5 and 6; check Cu. by Test-B below.

**TEST B:** Most positive test for small quantities of Copper. NOTE: Use small piece charcoal, not regular charcoal block; discard if reaction obtained; can use again if no reaction.

1. Use piece (not powdered mineral) 1/2 size pea, or less.
2. Place on charcoal, heat to redness in oxidizing flame.
3. Moisten mineral with 1 or 2 drops Hydrochloric Acid.
4. Reheat in either oxidizing or reducing flame of blowpipe.

**RESULTS:** A blue or green-colored flame if Copper present.

**TEST No. 31**

**DIDYMIUM - Di.**

**NOTE:** Didymium is a mixture of Neodymium and Praseodymium; also associated with Cerium and Lanthanum. All are valuable. TEST: Borax or Salt of Phosphorous Beads. (See instructions).

1. Oxidizing Flame: Rose while warm; rose when cold.
2. Reducing Flame: Rose while warm; rose when cold.

**TEST No. 32**

**FLUORINE - F.**

**NOTE:** Fluorine is not a metallic mineral; but Fluorspar-CaF<sub>2</sub> is not only an important, but also a very much needed mineral at the present time; so will be included in these tests. TEST: By the etching of glass. (With Sulphuric Acid).

1. Coat one side of a piece of glass with melted paraffin.
2. With a pointed stick make a number of scratches through the paraffin without scratching the glass.
3. Place some fine powdered mineral in an evaporating dish.
4. Add a little Sulphuric Acid and mix powder into a paste.
5. Add paste to scratches in paraffin; press lightly to make sure the paste reaches the glass.
6. Let set for an hour or longer.
7. Warm paraffin and remove from glass with a soft cloth.
8. Wash glass with warm water.

**RESULTS:** Hydrofluoric Acid produced by the fluorspar eats or etches the glass; inspect with a lens. A positive test.

**TEST No. 33**

**GERMANIUM - Ge.**

TEST: Charcoal - no flux. (See Test 11).

1. Use powdered mineral equal to two or three grains rice.
2. Place on charcoal; heat in Oxidizing Flame.

**RESULTS:** Germanium volatilizes; first it gives a pure white coating near the assay; on prolonged heating moves further out, and assumes a greenish or brownish, but mostly a lemon yellow color. When examined with a lens the coating has a glazed or enamel-like appearance. Small fused transparent globules may be seen scattered on charcoal near the assay.

**TEST No. 34**

**G O L D - Au.**

**TEST:** With Aqua Regia and Stannous Chloride. (Spot Test).

1. Place powdered ore or concentrates size of pea (or any particles suspected of being gold) in a test tube.
2. Add 1 cc Nitric and 3 cc Hydrochloric Acid (Aqua Regia).
3. Boil slowly about 5 minutes or longer over lamp flame.
4. Let set until fairly cool, or better until cold.
5. Place a piece of filter paper on a clean piece of glass.
6. Place one drop of above solution in center of paper.
7. Add one drop freshly prepared Stannous Chloride Solution.

**RESULTS:** A dark purple to a pale pink spot if gold present; the darker the color the more gold present. For testing Pt. from same solution see "Second Procedure" Part Two.

**TEST No. 35**  
**I R I D I U M-Ir.**

**NOTE:** Iridium is usually associated with Platinum. TEST:  
With Sodium Nitrate and Aqua Regia.

1. Pick out particles suspected of being Iridium.
  2. Place in an evaporating dish.
  3. Add Sodium Nitrate equal to three navy beans.
  4. Fuse thoroughly in dish over lamp flame.
  5. Add 4 cc of Aqua Regia. (1 Nitric: 3 Hydrochloric Acid,
- RESULTS:** Deep red or reddish-black solution if iridium.

**TEST No. 36**  
**IRON- Fe.**

**TEST A:** Magnetic properties.

1. Powder mineral real fine; test with a strong magnet:  
**RESULTS:** If magnet does not pick it up proceed as follows  
as most iron is not magnetic in its natural state.
2. Place powder on charcoal; heat thoroughly in R.F.  
**RESULTS:** Practically all iron ore will now become magnetic, and can  
be removed with a magnet.

**TEST B:** To remove Iron from acid solutions.

1. Use powdered mineral equal to one navy bean.
  2. Place in test tube with 6 cc dilute Nitric Acid. (2 cc  
**Nitric Acid:** 4 cc water).
  3. Boil for some considerable time; let set until cold.
  4. Add 2 cc more water.
  5. Add 2 cc Strong Ammonia.
- RESULTS:** Iron will be precipitated as a brown or red mass; this  
may be removed from solution by filtering.

**TEST No. 37**  
**L E A D - Pb.**

**TEST A:** On Charcoal - with "Charcoal Flux".

1. Use powdered mineral equal to two grains of rice.
  2. Mix with charcoal flux equal to two navy beans.
  3. make in paste with water; place on charcoal block.
  4. Fuse in the Reducing Flame of the blowpipe.
- RESULTS:** A yellow coating on charcoal near the assay; small  
globules of metallic lead; if globules are not visible in heating,  
crush and carefully wash off the residue, confirm by Test B. (As  
Bismuth will also give a similar reaction).

**TEST B:** A quick accurate test for Lead.

1. Use powdered mineral equal to two grains of rice.
  2. Place powdered mineral in an evaporating dish.
  3. Add 3 drops of strong Nitric Acid.
  4. Let set for about 5 minutes, or longer.
  5. Add 3 cc of cold water.
  6. Add a few small crystals of Potassium Iodide.
- RESULTS:** A dark yellow precipitate if much Lead. (Do not mistake a  
yellow solution for a precipitate). Try on Galena.
- NOTE:** If white curdy precipitate - test for Silver.

**TEST No. 38**  
**MAGNESIUM - Mg.**

**TEST A:** For most light-colored Mg. Minerals, if infusible.

1. Place piece of mineral size 2 grains rice on charcoal.
2. Heat in hottest part of blowpipe flame - try to fuse.
3. Examine carefully to see if slightest fusion, if so this test will not apply; if no fusion, proceed as follows.
4. Moisten mineral with drop of Cobalt Nitrate Solution.
5. Reheat in hottest part of blowpipe flame; note results.

**RESULTS:** A faint pink color if a magnesium mineral.

**TEST B:** For any Magnesium mineral, regardless of color.

1. Place 3 cc strong hydrochloric acid in a large test tube.
2. Add 2 drops nitric acid, and 6 cc of pure water.
3. Add powdered mineral equal to about one large navy bean.
4. Heat to boiling over lamp flame; let set until cold.
5. When cold add about 2 cc of strong ammonia.
6. Filter solution into another test tube (it. in solution).
7. Add Ammonium Carbonate equal to about two navy beans.
8. Filter into another test tube. (Magnesium in solution).
9. Add Sodium Phosphate powder or crystals size of 1/2 pea.

**RESULTS:** A white crystalline precipitate if Magnesium.

**TEST No. 39**  
**MANGANESE-Mn.**

**TEST A:** For all black or dark colored manganese ores.

1. Place powdered ore size 1 grain rice in evaporating dish.
2. Add one cc strong hydrochloric acid; heat to boiling.

**RESULTS:** A black to greenish-black solution if manganese.

**TEST B:** For any manganese ore regardless of color.

1. Place Sodium Carbonate size of pea in evaporating dish.
2. Add a few very small specks powdered mineral; very little.
3. Moisten to a thick paste with a drop of water.
4. Place on charcoal; heat in Oxidizing flame of blowpipe.

**RESULTS:** A blue or greenish blue bead if manganese.

**NOTE:** If bead turns black, try again, use less mineral.

**TEST No. 40**  
**MERCURY-Hg.**

**TEST:** By coating on Copper; most positive test for Mercury.

**NOTE:** The main ore of Mercury is Cinnabar (Mercury Sulphide). Color: Vermilion-red or scarlet. We test for mercury only when a rock contains or shows some shade of red.

1. Place powdered mineral size of pea in evaporating dish.
2. Add an equal amount of powdered Pyrolusite (! o).
3. Add one cc of strong Hydrochloric Acid.
4. Heat over lamp flame to boiling; add 2 cc of cold water.
5. Take a copper penny, place in another clean evaporating dish, add 6 drops of water add 6 drops Nitric Acid; when penny is clean remove and rinse well with clean water.
6. Now take the cleaned penny, hold upright with fingers and immerse the lower half in the solution being tested.

**RESULTS:** Metallic Mercury, if present, collects on copper giving it a silver-plated appearance. Very positive test.

**TEST No. 41**  
**MOLYBDENUM-Mo.**

**TEST:** For any and all Molybdenum Ores.

1. Place Charcoal Flux equal to about size of pea in dish.
2. Add powdered mineral equal to about two grains of rice.
3. Mix thoroughly and dampen to paste with drop of water.
4. Place on charcoal block, fuse thoroughly with blowpipe.
5. Remove fusion and crush to powder in a porcelain mortar.
6. Place 3 cc Strong Hydrochloric Acid in clean test tube.
7. Add powdered fusion (5 above) to the acid in test tube.
8. Add a small piece of metallic tin. (Tinfoil best).
9. Boil over lamp flame slowly until solution changes color; either colorless, red or rose. Let set until cold.

**RESULTS:** A red or rose color if molybdenum present. To determine type or ore, see article 4, page 2, Part One. NOTE: Titanium may give similar color; check Ti. Test 57.

**TEST No. 42**  
**NICKEL - Ni.**

**TEST A:** To prepare solution for test with Dimethylglyoxime.

1. Place 1 cc Nitric Acid in test tube, add 2 cc water.
2. Add powdered mineral equal to about one navy bean or pea.
3. boil over lamp flame about 3 minutes or more; let set for few minutes to settle. This is test solution for Tests below.

**TEST B:** Quick Spot Test; very positive for all nickel ores.

1. Place a piece of filter paper on a clean piece of glass.
2. Add 1 drop of Dimethylglyoxime solution to center paper.
3. Add 1 drop test solution (A. above) to center of paper.
4. Add 1 drop of Strong Ammonia to center of the paper.

**RESULTS:** A red or rose color which will not fade when paper is dry if nickel present. The color, especially for low grade ores, will show plainer if let paper dry, add 1 drop ammonia. NOTE: Some iron ores will also give a red or rose, but will fade out when paper is dry. See Test C. below.

**TEST C:** To remove iron from Test Solution.

1. Add 2 cc or more Strong Ammonia to Test Solution A.
2. Filter this solution into another clean test tube.

**RESULTS:** Nickel in solution; iron on paper, discard.

3. Add 6 drops Dimethylglyoxime to the filtered solution.

**RESULTS:** A rose-colored precipitate which will settle to bottom of tube after setting for some time; best over night. By using same amount of mineral of known percentage a fairly accurate percentage of the unknown may be estimated.

**TEST No. 43**

**OSMIUM- Os.**

**TEST:** On Charcoal - No Flux.

1. Place particles suspected of being osmium on charcoal,
2. Heat in the Oxidizing Flame of the blowpipe,

**RESULTS:** An exceedingly penetrating and disagreeable odor; fumes attack and smart the eyes much like peeling onions, if Osmium present. NOTE: Sulphide ores may give a similar odor. Check Sulphides by Test No. 1, Part Two.

**TEST No. 44**  
**PALLADIUM- Pd.**

**NOTE:** See "Second Procedure" Part Two regarding Palladium.

1. Place particle, or concentrates size of pea in test tube.
2. Add 1 cc Nitric and 3 cc hydrochloric Acid. (Aqua Regia).
3. Boil over lamp flame 5 minutes or more, then let settle.
4. Place about 25 drops solution in clean evaporating dish.
5. Boil over lamp flame to dry, then just a little longer.
6. Let dish cool, then add 3 cc water; reheat to boiling.
7. Filter solution into another clean evaporating dish.
8. Add Potassium Iodide equal to 1 grain rice, or smaller.

**RESULTS:** If Pd. present solution will turn black; also black precipitate which turns red on adding more potassium iodide.

**TEST No. 45**  
**PLATINUM-Pt.**

**NOTE:** See "Second Procedure" Part Two regarding Platinum.

1. Place particle, or concentrates size of pea in test tube.
2. Add 1 cc Nitric and 3 cc Hydrochloric Acid. (Aqua Regia).
3. Boil over lamp flame 5 minutes or more, then let settle.
4. Place about 25 drops solution in clean evaporating dish.
5. boil over lamp flame to dry, then just a little longer.
6. Let dish cool, then add 3 cc water; reheat to boiling.
7. Filter solution into another clean evaporating dish.
8. Add Potassium Iodide equal to about 1 grain rice, or less.

**RESULTS:** If Platinum present, a rose-colored solution, at once or after dish had set for 30 minutes or more.

**NOTE:** Sulphides may give red color; proceed as follows:

9. Let dish set until dry; add 2 or 3 drops of plain water.

**RESULTS:** A rose-color if Pt.; No red or rose if sulphides.

**TEST No. 46**  
**RHODIUM-Rh.**

**NOTE:** See "Second Procedure" Part Two regarding Pt. minerals.

1. Place Potassium Bisulphate size 2 peas in porcelain dish.
2. Add particles suspected of being rhodium to above dish.
3. Fuse in dish over lamp flame, let set until dish cool.
4. Add 4 cc Aqua Regia; boil 5 minutes or longer; let cool.
5. Filter solution into a clean test tube.
6. Add a few drops of Pure Grain Alcohol.

**RESULTS:** A black precipitate if Rhodium is present.

**TEST No. 47**  
**RUTHENIUM-Ru.**

**NOTE:** See "Second Procedure" Part Two regarding Pt. minerals.

1. Place Potassium Hydroxide equal to 2 peas, and same amount Potassium Chlorate in a clean evaporating dish.
2. Add particles of suspected Ruthenium to above dish.
3. Fuse in dish over lamp flame for some time; let cool.
4. Add 3 cc strong Hydrochloric Acid; boil 5 minutes or more.
5. Let set until cold, then filter into a clean test tube.

**RESULTS:** An orange-colored solution if Ru. is present

6. Gradually add a little Nitric Acid - a drop at a time.

**RESULTS:** A black precipitate if Ruthenium is present.

**TEST No. 48**

**SELENIUM- Se.**

**TEST A:** On charcoal: Odor; Sublimate; Flame Color.

1. Place a little mineral on a charcoal block.
2. Heat first in O.F: note results; then R.F: note results.

**RESULTS:**

- A:** ODOR: very curious odor resembling radishes, or decayed radishes; this odor is so pronounced that a very minute amount of Selenium may be detected.
- B:** SUBLIMATE: Brown smoke; a silvery coating some distance from the assay; may have brown or red border.
- C:** FLAME COLOR: If coating touched with Reducing Flame, the flame will have a beautiful azure-blue color.

**TEST B:** SPOT TEST: With Sodium Carbonate and Sodium Sulfide.

1. Use powdered mineral equal to two grains of rice.
2. Place in test tube with 8 drops of strong Nitric Acid.
3. Heat just to boiling.
4. Add 25 drops of a saturated solution of Sodium Carbonate.
5. boil slightly and filter. (Selenium is in the solution).
6. Place a piece of Spot Paper on a piece of glass.
7. Place 1 drop of above solution in center of spot paper.
8. Add 1 drop of a saturated solution of Sodium Sulfide.
9. Add 1 drop of strong Hydrochloric Acid. RESULTS: An orange to red spot if Selenium is present.

**TEST No. 49**

**S U L P H U R - S.**

**NOTE:** To find if a mineral is a Sulphide.

**TEST A:** On Charcoal - No Flux.

1. Place a little powdered mineral on a charcoal block.
2. Heat in O.F: note results; Heat in R.F: note results.

**RESULTS:** Odor if much sulphur; may be a blue flame.

**TEST B:** With Nitric or Hydrochloric Acid.

1. Place small amount of powdered mineral in a test tube.
2. Add a little Nitric or Hydrochloric Acid.

**RESULTS:** An odor somewhat resembling rotten eggs.

3. Boil for some time.

**RESULTS:** A yellow or black spongy mass rising to top of tube. indicates the mineral contains Sulphur.

**TEST C:** Darkens Silver after fusion with Sodium Carbonate.

1. Use powdered mineral equal to two grains of rice.
2. Mix with Sodium Carbonate equal to one navy bean,
3. Dampen with water; fuse on charcoal in Reducing Flame.

**RESULTS:** Note if an odor of Sulphur.

4. Crush melt; dampen with drop of water; place on a bright piece of silver; let set one-half hour or longer.

**RESULTS:** A black stain which will not wash off indicates S.

**NOTE:** A very positive test if no Te. or Se. is present.

Check Tellurium by Test 54. Selenium by Test 48.

**GENERAL INFORMATION ON TESTING SILVER: OR SILVER-LEAD ORES.**

1. Silver must be fairly high grade to get a reaction without first concentrating; the best method is to take 2 or 3 pounds, pulverize to fine powder, concentrate in a gold pan to a spoonful or two, then test the concentrates.
2. Silver and Lead are often associated together, both are soluble in dilute Nitric Acid, and both are precipitated by adding a Chloride, such as hydrochloric Acid, Salt, etc. The precipitate is then: Silver Chloride, or Lead Chloride.
3. Silver precipitates will turn dark on exposure to light; Lead precipitates will remain white; usually crystalline.
4. Silver Chloride precipitates are soluble in Ammonia, but are not soluble in hot water.
5. Lead Chloride precipitates are soluble in hot water, but are not soluble in Ammonia.
6. Silver Chloride precipitates, dissolved in ammonia, may be re-precipitates by adding a few drops of Nitric Acid.
7. Lead Chloride precipitates, dissolved in hot water, may be re-precipitated by adding a few drops of Sulphuric Acid.
8. Due to the above characteristics one may determine if the Chloride precipitate is Silver or Lead.
9. In testing Silver or Lead ores with dilute Nitric Acid, the diluting water must be free of Chlorine; all water to be used for this purpose should first be tested for Chlorine.

**TEST No. 50**

**TO TEST FOR CHLORINE IN WATER.**

1. Place 2 cc of water in a clean test tube.
  2. Add 8 or 10 drops of Pure Concentrated Nitric Acid.
  3. Heat to boiling; let set until cold.
  4. Add 1 or 2 drops of Silver Nitrate Solution.
- RESULTS:** A: A curdy, or milky color proves Chlorine present in the water, and cannot be used in Test A: in Test 52.  
B: If no Chlorine present, then water may be used in Test A. C. If Chlorine present, proceed with test C. Test 52.

**TEST No. 51**

**TO DETERMINE IF A MINERAL IS A CHLORIDE.**

1. Place powdered mineral size of a pea in a test tube.
  2. Add 2 cc of water known to be free of Chlorine.
  3. Add 6 drops of pure concentrated Nitric Acid.
  4. Boil slightly; let set until cold.
  5. When cold add a few drops of Silver Nitrate Solution.
- RESULTS:** A milky color, or curdy mass proves Cl. is present.

**TEST No. 52**  
**S I L V E R - Ag.**

**TEST A:** In dilute nitric Acid; precipitated by a Chloride.

1. Use powdered mineral (or concentrates) size navy bean.
2. Place in test tube with 1 cc Nitric Acid: 2 cc water.  
(Water must be free of Chlorine - see Test 50)
3. Boil for some considerable time to dissolve the silver.
4. Filter; let set until cold.
5. Divide the filtered solution in two test tubes.
6. TUBE #1: Add few drops of Hydrochloric Acid (or salt).

**RESULTS:**

- A:** A white precipitate if Silver (or Lead).
  - B:** A milky or opal color if very low grade.
  - C:** A thick curdy mass if high grade.
  - D:** If Ag. will -turn dark if exposed to light some time.
  - E:** If Lead the precipitate will remain white.
7. To- further confirm Pb, or Ag. proceed as follows:
  8. Let set until all precipitate has settled to bottom.
  9. Pour off as much liquid as possible without disturbing the precipitate in bottom of tube.
  10. Ad" 2 cc of water and heat to boiling.

**RESULTS:**

- A:** If Lead Chloride the precipitate will dissolve.
  - B:** If Silver Chloride the precipitate will not dissolve.
  - C:** If does not dissolve, confirm Silver as follows:
11. Pour off water without disturbing precipitate.
  12. Add 1 cc strong Ammonia. Shake tube slightly. RESULTS: If Silver, precipitate will now dissolve.
  13. Add 2 cc of water.
  14. Add 2 drops of Nitric Acid.
- RESULTS:** The Silver will be re-precipitated.

TEST TUBE #2: Use this in making Test B.

**TEST B:** SPOT TEST: Using test solution in Tube #2 above.

1. Place a piece of Spot Paper on a piece of glass.  
(Squares of common filter paper used for this purpose).
2. To spot paper add 1 drop of test solution (Tube #2).
3. Add 1 drop of hydrochloric Acid (or salt water).
4. Add 1 more drop of test solution.

**RESULTS:** If Ag, spot will turn dark after setting awhile.

TEST C: If no water free of Chlorine for diluting Acid.

1. Use powdered mineral (or concentrates) size navy bean.
2. Place in test tube with 2 cc strong Nitric Acid.
3. Boil for some, considerable time to dissolve the silver.
4. In another test tube place 2 cc of Chlorine water.
5. Filter the nitric acid solution containing the silver into the second tube containing the Chlorine water.

**RESULTS:** The same as in Test A; a white precipitate if Ag. (or Pb.). Proceed as in last half of Test A, to determine if Silver or Lead; however, the fact that Silver precipitates will turn dark on exposure to light is usually sufficient.

**TEST No. 54**  
**TELLURIUM-Te.**

**NOTE:** Tellurium is the only element in which gold is found in chemical combination in nature, in which case an ore may be rich in gold, yet none visible, either in the rock or in the concentrates in a gold pan. Also found in silver and in bismuth ores. Any ore containing Tellurium should always be tested for all 3 elements. See "Second Procedure" Part Two.

**TEST A:** In evaporating dish with Hydrochloric Acid and Tin.  
1. Place powdered mineral size 1/2 pea in evaporating dish.  
2. Add 2 cc strong Hydrochloric Acid.  
3. Boil for about a minute or so over the lamp flame.  
4. Add a small piece of metallic tin (tinfoil best).

**RESULTS:** If tellurium is present the solution will turn dark or black, depending on the amount of tellurium present; the darker the color the more tellurium.

**NOTE:** Remember to watch for dark solution, not merely dark coating on tin.

**TEST B:** In evaporating dish with concentrated Sulphuric Acid.

1. Place powdered mineral equal to 2 grains rice in dish.  
2. Add about 2 or 3 drops of concentrated Sulphuric Acid.  
3. Heat over lamp flame until white fumes start to appear.  
4. Remove from flame and rotate dish to spread the acid.

**RESULTS:** A bright red color if Te. present, either while hot or upon cooling. Very positive test. If but little Te. just small red specks; disappear on cooling; watch closely.

**TEST No. 55**  
**T H A L L I U M-Tl.**

**NOTE:** There are but two known ores of Thallium: CROOKESITE, containing Tl, Se, Cu, Ag. Color, lead-gray; hardness 2.5 to 3 (very soft). Specific Gravity, 6.9 (extra heavy). LORANDITE, containing Tl, As, and S. Color, carmine-red; hardness, 2 to 2.5 (soft). Specific Gravity, 5.5 (heavy). **NOTE:** The average iron ore is usually less than 5.

**TEST A:** (h Charcoal - No Flux.

1. Use powdered mineral equal to two grains of rice.  
2. Place powdered mineral on one end of a charcoal block. 3. Heat in the Reducing Flame of the blowpipe. **RESULTS:** A slight white coating; an INTENSE GREEN FLAME. **NOTE:** Tellurium and some copper ores will also give a green flame; check Te. by Tests 54-A and b; check Cu. by Test 30-A.

**TEST B:** Q Charcoal - with bismuth Flux.

**BISMUTH FLUX:** Equal parts of Potassium Iodide and Sulphur.

1. Use powdered mineral equal to two grains of rice.  
2. Mix with Bismuth Flux equal to a large navy bean.  
3. Dampen with drop of water and place on charcoal block.  
4. Heat in the Oxidizing Flame of the blowpipe.

**RESULTS:** A yellow-green coating; an intense green flame.

**NOTE:** Lead Iodide similar - but no green flame.

**TEST No. 54**  
**TELLURIUM-Te.**

**NOTE:** Tellurium is the only element in which gold is found in chemical combination in nature, in which case an ore may be rich in gold, yet none visible, either in the rock or in the concentrates in a gold pan. Also found in silver and in bismuth ores. Any ore containing Tellurium should always be tested for all 3 elements. See "Second Procedure" Part Two.

**TEST A:** In evaporating dish with Hydrochloric Acid and Tin.

1. Place powdered mineral size 1/2 pea in evaporating dish.
2. Add 2 cc strong Hydrochloric Acid.
3. Boil for about a minute or so over the lamp flame.
4. Add a small piece of metallic tin (tin foil best).

**RESULTS:** If tellurium is present the solution will turn dark or black, depending on the amount of tellurium present; the darker the color the more tellurium.

**NOTE:** Remember to watch for dark solution, not merely dark coating on tin.

**TEST B:** In evaporating dish with concentrated Sulphuric Acid.

1. Place powdered mineral equal to 2 grains rice in dish.
2. Add about 2 or 3 drops of concentrated Sulphuric Acid.
3. Heat over lamp flame until white fumes start to appear.
4. Remove from flame and rotate dish to spread the acid.

**RESULTS:** A bright red color if Te. present, either while hot or upon cooling. Very positive test. If but little Te. just small red specks; disappear on cooling; watch closely.

**TEST No. 55**  
**T H A L L I U M-Tl.**

**NOTE:** There are but two known ores of Thallium:

CROOKESITE, containing Tl, Se, Cu, Ag. Color, lead-gray; hardness 2.5 to 3 (very soft). Specific Gravity, 6.9 (extra heavy). LORANDITE, containing Tl, As, and S. Color, carmine-red; hardness, 2 to 2.5 (soft). Specific Gravity, 5.5 (heavy). **NOTE:** The average iron ore is usually less than 5.

**TEST A:** (h Charcoal - No Flux.

1. Use powdered mineral equal to two grains of rice.
2. Place powdered mineral on one end of a charcoal block.
3. Heat in the Reducing Flame of the blowpipe. **RESULTS:** A slight white coating; an INTENSE GREEN FLAME. **NOTE:** Tellurium and some copper ores will also give a green flame; check Te. by Tests 54-A and b; check Cu. by Test 30-A.

**TEST B:** Q Charcoal - with bismuth Flux.

**BISMUTH FLUX:** Equal parts of Potassium Iodide and Sulphur.

1. Use powdered mineral equal to two grains of rice.
2. Mix with Bismuth Flux equal to a large navy bean.
3. Dampen with drop of water and place on charcoal block.
4. Heat in the Oxidizing Flame of the blowpipe.

**RESULTS:** A yellow-green coating; an intense green flame.

**NOTE:** Lead Iodide similar - but no green flame.

## TEST No. 56

### T I N - Sn.

Tin is never found in the metallic state in nature, but is obtained by smelting certain ores in which the tin occurs as oxides or sulphides. While there are several ores in which tin may occur in commercial quantities, Cassiterite (SnO) is the most important. It is usually black or red, much resembling common iron ores, but may be white, yellow or green, in which it may be mistaken for common rock. It may be found in placer form, in which it usually occurs in fairly pure nodules or nuggets, or in lode form in small veins or specks in the rock. Usually found in some form of granite, rhyolite or pegmatite. Specific Gravity around 7 when pure, and may contain up to 76 per cent Tin dioxide (SnO<sub>2</sub>). Tin, if present in any rock, even in small quantities, will be detected by the following tests,

**TEST A:** Most positive test for all tin ores. Test made in evaporating dish with Cacothelin and Metallic Zinc.

1. Place powdered ore size 2 grains rice in evaporating dish.
2. Add same amount of powdered zinc; shake dish to mix.
3. Add 8 or 10 drops hydrochloric acid (this is Test Solution).
4. Place 2 or 3 drops of above Test Solution in another dish.
5. Add 1 or 2 drops of Cacothelin solution.

**RESULTS:** A purple or lavender colored solution if tin is present; exact color hard to describe but very characteristic and easily remembered if once seen, and for this purpose one should first practice on a known sample of tin ore.

**NOTE:** This test may be made semi-quantitative, to the extent of telling if ore is poor, fair, or good by Test B below. However, Test B would not be made unless at least a slight tin reaction is obtained in Test A above, as some other elements may give a somewhat similar reaction, thus deceiving.

\*

**TEST B:** Spot Test. A semi-quantitative test for Tin ores.

1. Place a piece of filter paper on a clean piece of glass.
2. Add 1 drop of Cacothelin solution to center of paper.
3. Add 1 drop of Test Solution from dish prepared for-Test A.

**RESULTS:** A purple or lavender colored spot if Sn. present. The brighter the color and more surface covered the more Sn.; from a very small dim spot for a trace of very low grade ore, up to a bright spot at least the size of a dime for high grade or commercial tin ores. By using the same amount of material and comparing with a sample of known percentage a fairly accurate percentage of the unknown may be estimated.

**TEST C** By coating of metallic tin on cassiterite nodules.

1. Place nodule or tin ore at least size of pea in test tube.
2. Add an equal amount of powdered zinc or zinc metal.
3. Add, very slowly, about 2 cc of strong hydrochloric acid.
4. Let set few minutes, remove nodule and rinse with water.

**RESULTS:** The nodule will have a silver white coating of metallic tin; will become brighter if rubbed with soft cloth. **NOTE:** This test is not as accurate as Test A, but can be made if you do not have Cacothelin; always make Test A if possible.

**TEST No. 57**  
**TITANIUM-Ti.**

**NOTES:**

1. There is a little Titanium found in a great many minerals but only a few in which it is found in commercial amounts.
2. ORES: Rutile, Ilmenite, Titanite, are the most important; one should have a specimen of each of these for comparison; if an unknown ore resembles one of these, and shows a good reaction in Test A, then it may pay to have it assayed for Titanium; especially if there is a fairly large deposit.
3. Hydrogen Peroxide loses its strength and becomes stale if exposed to air for some time; bottle should always be kept tightly closed when not in use.

**TEST A:** For all Commercial Ores.

1. Place sodium carbonate equal to about large navy bean, or size of pea, in an evaporating dish.
2. Add potassium nitrate about 1/2 amount of above.
3. Add powdered mineral size 2 grains rice; mix all well.
4. Dampen with drop water; place on charcoal or chinaware.
5. Fuse thoroughly in Reducing Flame of the blowpipe.  
(When fusion stops, turn over and fuse some more).
6. Crush and powder fusion in a porcelain mortar.
7. Place in test tube with 3 cc Strong Hydrochloric Acid.
8. Add 2 or 3 small pieces of pure test tin.
9. Boil until solution becomes colorless (or lavender).

**RESULTS:**

**A:** A lavender colored solution if Ti; darker the color the more Ti. (Color seen best when solution cold).

**B:** If Molybdenum, a somewhat similar color, but more of a red or rose; further tests will determine.

10. When cold add an equal amount of cold water.
11. Add 5 or 6 drops of fresh Hydrogen Peroxide.

**RESULTS:**

- A:** If much Titanium a bright red band on top of solution.  
**B:** A green band will appear under the red band.  
**C:** After setting for some time, green band will widen and settle, and change to a yellowish or amber color.  
**D:** If Molybdenum (either MoS or MoPb) there will be no red or green band, but a colorless band, which will gradually settle until all the solution becomes colorless.

**TEST B:** To detect small amount of Ti. in other minerals.

1. Proceed as in Test A: from 1 to 6 (Note\*).
2. Now place 1 cc of water in a test tube.
3. Add 1 cc of strong Sulphuric Acid.
4. Add powdered fused mineral; boil until clear.
5. Add 2 cc more water.
6. Let set until solution is cold.
7. Add 4 or 5 drops of fresh Hydrogen Peroxide.

**RESULTS:** A yellow or orange colored ring on top of solution; the darker the color the more Titanium is present.

**TEST No. 58**  
**T U N G S T E N- W.**

**General Information**

There are 4 main ores of Tungsten: Wolframite, Ferberite and Hubnerite, each containing up to 75 per cent tungsten trioxide, and Scheelite containing up to 80 per cent tungsten trioxide. The first 3 are all dark colored ores, much resembling common black iron ores. Scheelite is usually white or yellow, much resembling common quartz, barite or calcite, or may be green if associated with copper ores. All may be quickly and accurately identified as tungsten ores by the one test given below.

**TEST:** In evaporating dish with hydrochloric acid and tin.

1. Place powdered ore size 2 grains rice in evaporating dish.
2. Add about 2 cc of strong hydrochloric acid.
3. Add a small piece of pure metallic tin (tin foil best).
4. Boil over lamp flame until solution changes color, then a little longer, but do not boil to dry. (See Note 1 below).

**RESULTS**

**A:** A blue stain on dish and blue solution if W. is present.

**NOTE:** This test is semi-quantitative, indicating if ore is good, fair or poor, by the following reactions.

**B:** If good ore the solution will turn dark blue while boiling.

**C:** If fair ore there will be a blue stain on the dish and the solution will turn blue after setting for a few minutes.

**D:** A small blue ring or specks on dish, but the solution will not turn blue after setting, very poor or low grade ore.

**E:** Some tungsten, especially the black ores, due to iron and other impurities, the solution may first be red, but will gradually turn blue after setting for some time. In this case the ore may be high grade even tho the solution does not turn blue until after setting for some time.

**F:** Some Molybdenum ores, such as MoO or MoPb may also give a blue or greenish-blue ring or specks on dish, but in this case the solution will turn red or rose instead of blue after setting a short time, thus distinguishing from W.

**G:** If the solution turns black on adding tin and heating, it indicates Tellurium is present. Confirm by Test ho. 54.

**NOTES**

1. When any powdered mineral containing much iron is added to hydrochloric acid, the solution will usually turn yellow, brown or red, but upon boiling with metallic tin the solution will always turn colorless before the blue of tungsten shows up; so always boil until solution turns clear, then a little longer in making all tests. In some cases it may be necessary to add more acid and tin to bring about the color change.

2. Testing samples: Pure tungsten ores are seldom found in commercial quantities, but usually occur as large or small particles in other rocks containing less than 10% tungsten; 2% tungsten ore is considered good if found in large quantities. For these reasons one should always powder up several small rocks, or pick out the black or brown particles suspected of being black tungsten ores, or light colored particles suspected of being Scheelite for testing purposes.

**TEST No. 59**  
**U R A N I U M- U.**

**The "Key" To Prospecting For Uranium Ores**

In this work we are interested only in commercial Uranium Ores - those which may be mined for their uranium contents. Uranium may be found in some 150 or more different rocks, but only a half dozen or so which have any commercial value as uranium ores. These may be black, red, brown, green, etc., but in practically every case will show some form of yellow - which is the "Key" to hunting uranium. This may be the natural color of the rock itself, as with Carnotite, but usually occurs as a soft yellow coating, much resembling common sulphur, either on the surface or in cracks or seams when the rock is freshly broken, and may be in large spots or in small specks, so watch closely. While you may find many yellow rocks which do not contain uranium, you will seldom ever find a commercial uranium ore without some yellow as explained above, and thus furnish a valuable "clue" as to what rocks to pick up and test for uranium.

**NOTE:** This coating is sometimes very soft and easily removed, and for this reason may not show up on the surface of rocks exposed to the weather.

**TEST A:** With Salt of Phosphorous Bead. (See Page 9 part Two).

1. In Oxidizing Flame: Yellow hot; yellowish-green cold.
2. in Reducing Flame : Green hot; green cold.

**NOTE:** The following elements may sometimes give a similar color.

**A:** Chromium: Confirm by Test No. 27.

**B:** Molybdenum: Confirm by Test No. 41.

**C:** Vanadium: Confirm by Test No. 60. **NOTE:** U. is often present in V. ores, so if V. present always also assay for uranium.

**D:** Iron: can usually be eliminated from powdered minerals with a Magnet for Test A, but not necessary for Test b below.

**E:** Confirm Uranium by Test B. below - most positive test.

**TEST B:** With Aqua Regia, Ammonium Carbonate, Potassium Ferrocyanide. **NOTE:** First prepare the last two solutions above, as follows:

**A:** Place ammonium carbonate size of pea in test tube and add 2 cc plain water; shake to dissolve; let set until needed below.

**B:** Place potassium ferrocyanide size 1/2 pea in test tube and add 1 cc water; shake to dissolve; let set until needed below.

1. Place 10 drops of strong nitric acid in clean evaporating dish.
2. Add 30 drops of strong hydrochloric acid (this is Aqua Regia).
3. Add powdered mineral equal to about 3 grains of rice.
4. boil over lamp flame until perfectly dry; remove, let cool.
5. Add the 2 cc of ammonium carbonate; reheat just to boiling.
6. Filter into another evaporating dish (uranium in solution).  
**NOTE:** If filter paper is over 2", fold and trim off the top with scissors, or it will absorb too much of the solution.
7. Add 2 drops hydrochloric acid (this is Test Solution).
8. Place 2 drops of Test Solution in another clean evaporating dish.
9. Add 1 or 2 drops of potassium ferrocyanide solution.

**RESULTS:** A pink, brown, or dark red solution if uranium present.

**NOTE:** This test is semi-quantitative to extent of telling if our ore is poor, fair, or good: A faint pink solution if very low grade; a brown solution if fair grade; a red solution if high grade.

**TEST No, 60**

**VANADIUM-V.**

**TEST A:** With Salt of Phosphorous Bead. See Test No. 17.

**NOTE:** Some other elements such as chromium, molybdenum, iron, and uranium may give similar beads; confirm V. by tests below,

**TEST B:** A quick test for most all Vanadium Ores.

1. Place powdered mineral size 2 or 3 grains of rice in dish.

2. Add 4 or 5 drops of strong (not dilute) hydrochloric acid.

**RESULTS:** If V. a red or brown solution; will turn green if let set for few minutes. Confirm V. as follows.

3. Add 1 or 2 drops cold water; red-brown color will leave.

4. Add 1 or 2 drops fresh hydrogen peroxide; red color will reappear, but lighter than first. Confirm by Test C below.

**TEST C:** Test for all Vanadium Ores, especially for low grade.

1. Place in dish sodium carbonate equal to 1 navy bean, and potassium nitrate equal to 1/2 navy bean; mix thoroughly.

2. Add powdered mineral size 2 grains rice; mix thoroughly.

3. Dampen with drop of water; place on charcoal block; fuse well with blowpipe; remove and powder fusion.

4. Place 2 cc water in a test tube; add powdered fusion and heat to boiling. Vanadium, if present, now in solution.

5. Filter solution into a clean test tube.

6. Add 4 or 5 drops of strong hydrochloric acid,

7. Let set until solution is cold. (The colder the better).

8. When cold, add 2 or 3 drops of fresh hydrogen peroxide.

**RESULTS:** A bright red solution, or a red band at top of the solution if vanadium is present. A very positive test.

**TEST No. 61**

**ZINC -Zn.**

**TEST A:** On Charcoal - With Flux. See Page 6 Part Two.

1. Place Charcoal Flux equal to 1 large navy bean in dish.

2. Add powdered mineral equal to 2 grains rice; mix well.

3. Make paste with drop of water; place on charcoal block.

4. Fuse thoroughly in the Reducing Flame with the blowpipe.

**RESULTS:** White coating near assay; narrow blue border.

5. Place 1 drop cobalt nitrate solution on white coating.

6. Reheat assay steadily in rather broad Reducing Flame.

**RESULTS:** Bluish-green coating if Zn; seen best when cold.

**NOTE:** Tin somewhat similar. Confirm Zinc by Test B below.

**TEST B:** In test tube with Ammonia and Sodium Sulfide.

1. Place 1 cc strong hydrochloric acid in a clean test tube.

2. Add 1 drop of strong nitric acid..

3. Add powdered mineral equal to 2 or 3 grains of rice.

4. Heat slowly just to boiling; let set for a few minutes.

5. Add 2 cc cold water; let set until solution cold.

6. Add 2 cc strong ammonia. (Be sure solution is cold).

7. Filter into another test tube. (Zinc is now in solution).

8. Add 2 or 3 drops of sodium sulfide solution.

**RESULTS:** Throws down white curdy precipitate if zinc present.