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FLUORESCENT LIGHT MINERALOGY*

All of us are familiar with modern fluorescent lighting. We know that a tube of one of these modern lights which consumes 15 watts of electric energy is more efficient than an incandescent lamp which uses 100 watts; and we know that this tube is cold to the touch and not hot, as with the filament type bulb. But it is not generally realized that the new lights are a success, because of the fluorescence of certain minerals and chemicals under ultra-violet light.

The most common fluorescent lighting tube is essentially a glass cylinder, the inner walls of which are coated evenly with finely powdered minerals or chemicals. Tungsten filaments and mercury are put in the tube, and the tube unit exhausted of air, and then filled with inert gases such as neon or argon. A 300-volt potential or more across the tube's terminals is provided. All of these combined make the complete lamp.

When the current is turned on, the filaments or electrodes glow hot for awhile to ionize the mercury vapor. The vapor, when ionized, carries the current from electrode to electrode and emits ultra-violet light. Once ionization is complete the filaments cool. The ultra-violet light excites the chemical lining of the tube causing a fluorescence characteristic of the chemical used. By combining chemicals which give different fluorescent colors, a synthetic light which closely resembles daylight can be produced.

These new lamps produce a better light, more like daylight, at a cheaper cost than do incandescent lights.

Prospectors' lamps work on much the same principle as the household lighting units. The main differences are that the tube of the prospecting light is not coated, is made of quartz or special glass, and that, therefore, the ultra-violet radiations may be directed to a point some distance from their source. The rays are invisible, and hence are called "black light" by some people. The "black light" when turned upon a fluorescent mineral or compound excites the same kind of glow as that excited in the tube-coating of the lighting unit. Since prospectors' lights must be portable, they are operated by battery and have devices for converting the direct current to alternating current as well as stepping up the alternating current to higher voltages.

The three laboratories of the Department have recently obtained new "black light" lamps, mainly for detection of tungsten. The light is contained in a case about the size of a cigar box or smaller and is operated from a "hotshot" battery. The battery current is changed to alternating current by a vibrator and stepped up to a higher voltage by a transformer before entering the mercury vapor tube. The tube is of quartz, or special glass, since ordinary glass filters out the ultra-violet rays. All but the useful rays of light from the tube are held back by a colored filter. It is a simple device, but

*From a talk given September 1, 1942, over KUIN, Grants Pass, Oregon, by Ray C. Treasher.

it works wonders.

Scheelite, a tungsten mineral, fluoresces under ultra-violet light, and is now practically always prospected for with the aid of "black light". Scheelite ore is sometimes sorted under the lamp's rays in treatment plants. This tungsten mineral is ordinarily white to brown in color, but it fluoresces blue-white when pure, to golden yellow when impure. Molybdenum and copper are common impurities which lower the grade and sometimes make the rock worthless. Yellow fluorescing minerals should be checked by chemical analysis. If the mineral fluoresces green, red, or pink, it is not scheelite.

Hydrozincite, a hydrous zinc carbonate, fluoresces a soft blue. It is light in weight and soft, unlike scheelite in these characteristics. Black sand may contain grains of zircon which give an orange colored fluorescence.

Mercury vapor, even in extremely minute quantities, cuts out the "black light" so that when mercury is volatilized between the lamp and a fluorescent screen, the beam is cut off and cannot reach the screen. To perform this test, cautiously warm a small sample of mercury between the light window of the instrument and a screen painted with a fluorescent mineral such as willemite. A cloud appearing on the screen indicates mercury.

Tungsten miners use the ultra-violet lamp in distinguishing between ore and waste underground and thus avoid sending waste to the mill. Mill rock may be hand-sorted under the lamp, and tailings may be examined for unduly large losses. Efficiency of concentrating machinery may be checked and the flow sheet adjusted without waiting a day or more for assay returns. Old dumps from mines in which presence of tungsten has not been suspected might be profitably inspected with the aid of the lamp. These are only a few examples of the practical applications of the fluorescent light.

Agates, barite, calcite, fluorite, scheelite, uranium salts, and willemite are some of the many minerals which fluoresce. Calcite fluoresces red or orange, scheelite blue or white, willemite bright green, and so on; thus clues to a mineral's identity may be furnished by ultra-violet rays. Some easily acquired techniques may be necessary in order to make many of the tests, but there is nothing complicated about them.

Since different makes of lamps emit different wave lengths of light, it is important that the lamp chosen be one that gives suitable rays for the work to be done. Once the prospector has purchased his lamp he should experiment with it on various known specimens until he becomes thoroughly familiar with their characteristic fluorescence. Specimens should be examined wet and dry, in lumps and powdered, and from close and distant viewpoints. The angle of the ray incident to the specimen, the angle of observation, and the color of the visible light, some of which always gets through the filter, sometimes cause the variations of the fluorescent phenomenon.

Since glass will not transmit the "black light", glass containers are not suitable for holding solutions to be tested; quartz receptacles or cells with quartz windows are used. Two rocks appearing similar but of different composition can often be distinguished by the use of colored filters such as are used in photography. These filters allow only light of certain definite wave lengths to pass. Two ores that appear blue may differ in that one has red in its spectrum while the other has blue only. A red filter which passes only red light would make the wholly blue one appear black, whereas the other ore would show a bright red color due to the passing of those rays. All of this is getting a little involved and beyond the scope of ordinary fluorescent analysis, but it does suggest the infinite possibilities of the fluorescent technique to those who might want to delve deeper into the study. Those interested in a more detailed description of methods and apparatus are referred to "Fluorescent Light and its Applications" by Dake & DeMent.

Fluorescence phenomena are used in both qualitative and quantitative chemical analyses. Uranium, for instance, may be detected by mixing a very small amount of the powdered rock with sodium fluoride and fusing the mixture in a platinum loop over a Bunsen burner. The

resulting bead, when cooled, will fluoresce a brilliant yellow. In two minutes the test is completed, whereas, by other methods much time is consumed with less certain results. Vanadium, zinc, the rare earths, and other metals have been detected with ultra-violet light. Drugs, vitamins, and organic compounds have been assayed fluorophotometrically.

Now that we have discussed fluorescence and its wonderful properties, the question of the cost of the apparatus may be raised. The price ranges from a dollar or two up to hundreds for commercial machines. Devices vary in complexity from a soap box with a filter and a viewing window for use in the sunlight to complicated laboratory equipment that will determine certain compounds quantitatively. Prospectors will ordinarily be interested in the type of lamp owned by the Oregon Department of Geology and Mineral Industries and described earlier in this talk. Good tests may be made with a light-proof box with an ultra-violet filter over the specimen position and a peek-hole for the observer. Sunlight or photoflood bulbs serve as light sources. Cheap argon bulbs and "black light" bulbs are marketed commercially at a low price. Filtered iron-arc light is a very satisfactory source of ultra-violet. Any of these lights can be made or purchased for from two to ten dollars. The ionized gas type of instrument earlier described costs thirty-five dollars or more.

MINING LABOR ESSENTIAL TO THE WAR PROGRAM

In Occupational Bulletins No. 12 and No. 16 issued July 28 and August 27, 1942, General Lewis B. Hershey, Director of the Selective Service System, states that the War Manpower Commission has certified metallic and non-metallic mining activity together with the smelting, refining and rolling of metals as essential to war production.

The subject of these Occupational Bulletins cover the following essential activities:

Metal Mining: The mining of iron, copper, lead, zinc, aluminum, mercury, manganese, chromium, molybdenum, tungsten, vanadium and similar ores. Includes also removing overburden, sinking shafts, and other activities preparatory to metal-mining operations.

Non-Metallic Mining and Processing and Quarrying: The mining and processing of rock salt, phosphate rock, sulphur, potash, asbestos, graphite pyrites, graphite, borates and other salines, fluorspar, mica, talc, abrasive sands, and similar products. Excludes all mined or quarried nonmetallic materials used exclusively in construction.

Smelting, Refining, and Rolling of Metals: Primary and secondary smelting and refining, alloying, rolling, and drawing of iron, steel, copper, lead, zinc, magnesium, aluminum, brass, bronze, nickel, tin, cadmium, and any other metals used in the production of war materials.

Accompanying the bulletins are lists of "critical occupations" in the mineral industry. The lists include practically every job that has to do with production of essential minerals and metals.

In its bulletin service, the American Mining Congress makes the following comments on the Occupational Bulletins:

"It was obviously impossible to include in this list all the varied occupational titles in common use throughout the mining districts. However, a careful review of the list will show that the great majority of key mine and mill employees are covered directly or by direct association of job classifications. In certain instances, it will be necessary to point out to local draft boards the parallel between the degree of training, qualification or skill required for occupations not specifically listed and some of those included in the critical list. Please keep in mind that the Occupational Bulletin is not a direct order to draft officials, but is merely an official

guide, and any omission from the occupational list should not be considered ground for refusing deferment.

"The issuance of this Occupational Bulletin provides a means whereby the mining industry may protect its essential manpower insofar as military service is concerned. It is suggested that mining companies make a comprehensive survey of their key men who may be subject to the draft, and endeavor to see that the complete facts of each case are properly presented to the local draft board. Men in critical occupations should be made to realize that they are engaged in vital war service, and that their cooperation with management in all matters respecting their draft status is highly important."

As a corollary to the above the American Mining Congress reports that:

"Draft Director Hershey telegraphed State selective service directors this week and ordered that any worker who leaves his job in copper or other non-ferrous metal industries or the lumber industry be reclassified from 2-A or 2-B, into a class immediately available for military service.

"This action marks the first time such a step has been taken and may be the forerunner of further such orders. Hershey's telegrams backed up WMC's order to workers in 12 western states making a 'certificate of separation' issued by the U.S. Employment Service a requisite to the further employment of any man who has quit his job in a non-ferrous metal mine."

CADMIUM

Characteristics and Occurrence:

Cadmium is a soft malleable, ductile, bluish, silvery-white metal recovered as a by-product in zinc reduction plants. It is precipitated in the purification of zinc sulphate solutions prior to the electrodeposition of the zinc and the precipitate is later treated to recover the pure metal. Cadmium is also obtained from the "blue powder" or zinc dust from zinc distillation plants; from the flue dust from zinc blende roasting, from lithopone manufacture; and from lead smelting and refining mainly because of the presence of zinc with accompanying cadmium in the original ores treated.

Cadmium was discovered by Stromeyer in 1817 when he found that a specimen of yellow zinc oxide contained a new metal. He named it cadmium from cadmia, the name given to zinc ore by the ancients.

The atomic weight of cadmium is 112.41 (atomic weight of zinc is 65.38); melting point is 320.9° C. (zinc, 419.4° C); specific gravity is 8.65 (zinc, 7.14). The chemical symbol is Cd.

Cadmium is similar to zinc metallurgically, but there is enough difference in some characteristics so that the separation from zinc is not very difficult. Because of the greater volatility of cadmium, it may be separated from zinc by fractional distillation and subsequently refined. In electrolytic zinc plants, the cadmium together with other metallic impurities is precipitated from the zinc electrolyte by the addition of zinc dust. It is essential to precipitate the cadmium in order to make high-grade electrolytic zinc. In the manufacture of lithopone (white pigment consisting of a mixture of zinc sulphide and barium sulphate used in paints, varnish, lacquers, linoleum, rubber goods, etc.) it is equally necessary to precipitate the cadmium. The cadmium is eventually recovered from the precipitate and refined electrolytically.

The metal occurs in nature mainly combined with sulphur (CdS) as the mineral greenockite in association with zinc ores, although lead ores sometimes contain small amounts of cadmium. Greenockite is relatively soft with a hardness of 3 - 3.5 (hardness of zinc blende is 3.5 - 4); specific gravity is 4.9 - 5 (zinc blende, 3.9 - 4.1); color is yellow

Sherwin-Williams Co. Chicago, Ill., and
Coffeyville, Kansas
Sullivan Mining Co.. . . . Kellogg, Idaho
U. S. Smelting, Refining & Mining Co.. . . . Midvale, Utah

Uses:

The greatest use of cadmium is in electroplating. Over half of the metal produced in 1940 was used for this purpose. Next in importance is its use in bearing metals and in many alloys. About 12 percent of the 1940 production was used in pigments and chemicals.

Its corrosion resisting qualities have occasioned a large increase in the use of cadmium for electroplating iron and steel. The cadmium surface is about the same color as tin, and takes a high polish. It does not readily tarnish. Cadmium, containing a small percentage of silver, is used instead of nickel for plating steel and is said to give better protection than nickel. Cadmium-silver alloys are used in silver plating where as much as 25 percent of cadmium is sometimes used without affecting the appearance of the plate.

Cadmium bearings are used largely in high speed internal-combustion engines; therefore, the automobile industry is a large consumer of the metal. According to the Minerals Yearbook, Ford used nearly 890,000 pounds in the 1937 model year. It is said that cadmium-silver-copper alloys under severe engine tests have shown approximately three times the life of babbitt bearings.

Low-melting point alloys are obtained by combinations of cadmium, lead, tin, and bismuth; cadmium, tin, and bismuth; and cadmium, lead and tin. Melting points of these alloys vary between 140 degrees and 203 degrees Fahrenheit. They are used as soft solders for work with tin, lead, etc.; also in electric fuses, and as fusible plugs for automatic fire sprinklers. A cadmium-nickel storage battery is used in Europe for miners' lamps. A dental amalgam consists of 26 percent cadmium and 74 percent mercury. A Cliché metal for stereo-type plates consists of 22.5 percent cadmium, 27.5 tin, and 50 percent lead. Cadmium is used in the Weston cell for measuring electromotive force.

Chemical Salts:

Cadmium yellow is the name given cadmium sulphide prepared artificially. It is a bright lemon yellow from weakly acid solution and orange yellow from strongly acid solution. It is one of the most permanent pigments known.

Other commercial cadmium salts and their uses are cadmium acetate used in dentistry; cadmium chloride in dyeing and calico printing; cadmium nitrate in glass making and porcelain glazes; and cadmium halogen compounds in photography.

All cadmium salts ~~are~~ soluble in water and dilute acids are poisonous.

Cadmium as a Standard:

In spectroscopy the cadmium red line has been found to be the purest and most monochromatic of all spectrum lines. It has therefore been adopted as an international standard for all quantitative spectroscopic measurements. Many apparently single lines in a spectrum are in reality made up of a principal line together with lesser lines grouped closely on either side of it. Such complex lines would not be satisfactory as a standard. The cadmium red line has been determined as the most homogeneous line examined and in 1907 was adopted as the primary standard. Its wave length was designated as 6438.4696 Angstroms.

For defining and comparing a standard of length the best standard is a definite wave length of homogeneous light. Thus the standard meter is defined as a piece of metal whose length at 0 degrees C. equals 1,553,164 times the wave length of the red line of the spectrum of cadmium observed in dry air at 15 degrees C. of the normal hydrogen scale at a pressure of 760 mm. of mercury at 0 degrees C.

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