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New High Magnification Laboratory of the Mineral Industries School

By THOMAS F. BATES*

A new high magnification laboratory has been set up in the Division of Mineralogy of the School of Mineral Industries, intended to meet the needs of all workers in the School whose research requires the investigation of minute particles and structures. For this purpose the laboratory contains an R.C.A. electron microscrope and diffraction unit, a Bausch and Lomb metallographic camera, and in addition will have a large Bausch and Lomb photomicrographic camera as soon as the instrument can be completed and shipped from the factory.

These instruments make possible magnifications up to approximately 100,000 diameters. Inasmuch as the lower limit of magnification of the electron microscope overlaps the high magnification range of the light microscopes, any enlargement up to this figure is possible in the laboratory. Indeed, under critically controlled conditions the electron microscope is capable of still higher magnifications. In terms of particle size any microscopic object with a diameter larger than 30 angstrom units (0.000,000, 3cm.) can be studied and photographed. Since some of the macromolecules are larger than this, it can truly be said that the electron microscope has made visible a world of molecular dimensions. Nevertheless this powerful tool has by no means replaced the light microscope and both types are essential in a laboratory designed for high magnification work.

The electron microscope is pictured in Figure 1. Made by the Radio Corporation of America it is type EMB and possesses an electron diffraction unit which is incorporated in the column of the microscope. As is the case with all R.C.A. microscopes, the lenses are of the magnetic rather than the electrostatic type and the "illumination," focus, and magnification are controlled by varying the strength of the electromagnetic field in the lenses through which the electron beam must pass. Although higher magnifications are possible, most of the electron micrographs made in the laboratory are taken at magnifications of between five and fifteen thousand diameters. In fact because of the high resolving power of the microscope, a micrograph taken at a magnification of 15,000 diameters may be enlarged six or seven times photographically in order to attain a *useful* total magnification of 90,000 or 105,000 diameters. This is because a photographic film, due to the fine grain size in the emulsion, will record small details in the image that are invisible to the naked eye. Therefore enlargement from such a film will actually reveal more detail than is visible on the fluorescent screen of the microscope or in a contact print from the negative.

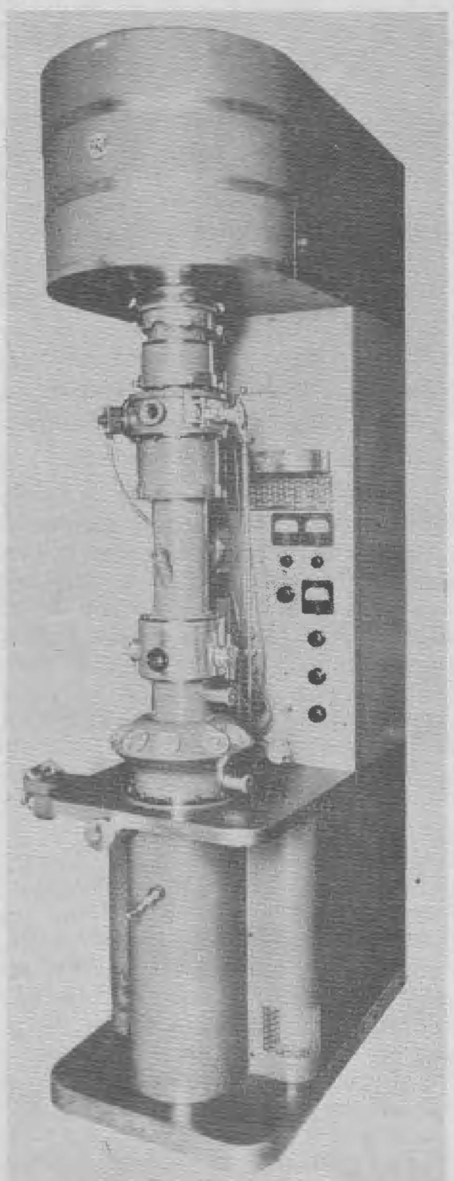

FIGURE 1

In recent years not only the scientist but the engineer and the layman have become increasingly aware of the importance of the fine structure of matter. It is realized more fully than ever before that the behavior of materials is dependent upon the physical and chemical nature and the arrangement of the minute particles of which larger, visible objects are composed.

In the mineral industries there are many applications for an instrument which will reveal the morphology and arrangement of tiny particles. The clay minerals which play such an important role in the field of ceramics are particularly suitable for study under the electron microscope because of their complexity and small grain size. The difficult problems pertaining to the particle size and the mineralogical nature of mine dust can best be solved by a combination of electron microscope and diffraction methods. In the short time of its existence the miscroscope has revealed diagnostic structures on metal surfaces and crystals never seen before. Smoke particles are easily mounted and observed at very high magnifications. In the last seven or eight years during which effective work with the electron microscope has been carried on, many valuable data have already been added to our knowledge. Indeed, when it is noted that the field of electron microscopy is less than fifteen years old it is evident that the science is growing by leaps and bounds.

However, as is the case in any scientific method, there are definite limitations in the use of the electron microscope. From the standpoint of the scientist in the field of mineral industries two of these are most important. In the first place the sample can be observed only when it is in a vacuum,

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TRENDS and OBJECTIVES
By DEAN EDWARD STEIDLE

MINERAL FUELS AND SOUTH AMERICA

Lack of quality, reasonably accessible mineral fuels is a stumbling block in the industrialization of South America. Several countries have deposits of coal but little of the coal can be classified as chemical coal. There is no commercial natural gas. A few recent observations on oil in South America are worthy of note at this time.

Talara, Peru, is the oldest field and is still a large producer. Peru has great faith in a new field at Ganso Azul in the upper Amazon near the Brazilian border. Questions of nationalization are holding up development. Peru would like to pipeline the oil over the Andes to the Pacific Coast. Our Navy is interested. Brazil has hopes that upper Amazon oil will move down the Amazon, with a possible refinery at Manaos.

Venezuela is the second largest producer among the nations and depends largely on oil for revenue. Many Venezuelan oil men feel isolated from South America and have close affiliation with the American Petroleum Institute. Certain Colombian fields give promise but some of the concessions are hampered by new nationalization problems. Ecuador hoped to strike oil at Ancon on the coast north of Guayaquil, but thus far the field has given little promise. Local geologists figured on the same structure as at Talara. Priority drilling was carried on in this field during the war.

Bolivia has considerable oil compared to its needs but most of it finds its way to Argentina. No plans were made to pump the oil to La Paz and other cities high in the Andes. Talara oil moves to these cities by railroad. Argentina is pushing a pipeline into the field; Brazil, a railroad. Argentina produces oil in several fields but falls short of her needs. Extensive drilling is encouraged by the government. An American company is drilling on concessions in Paraguay but has not met with any success as of this date. Chile has brought in several producing wells on the Straits of Magellan but production data have not been made public.

Brazil is exploring in various regions, including the upper Amazon near the Bolivia-Peru border. Several producing wells have been brought in at Bahia, one recently producing 1500 barrels per day.

The South American Petroleum Institute has been organized with headquarters in Montevideo, Uruguay. Sections are reported in Brazil, Uruguay, Argentina, Peru, Bolivia, and Ecuador. The new Institute proposes to devote its interests to technical matters. The First Congress of the South American Petroleum Institute will be held at Lima, Peru, the first week in March 1947.

New High Magnification Laboratory of the Mineral Industries School

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thus making it relatively inaccessible. Secondly, 60KV electrons, such as are produced in most microscopes at present, are capable of penetrating only one micron of matter having a density of one (approximately that of organic matter). It is evident, therefor, that the preparation of specimens which will meet such conditions requires a great deal of time and study.

The problem of investigating the surface of a metal, for example, has occupied the attention of electron microscopists ever since the instrument became available. It has been in large part solved by the development of the "replica technique" whereby a thin film of plastic is poured over the metal surface, stripped off, and placed in the microscope for study. The irregularities in thickness of the film reflect the irregularities of the original surface and therefore reveal the structures upon it. The structures may be intensified on the replica by "shadowing" it with a dense element such as gold or chromium. This is accomplished by evaporating the gold from a tungsten filament "basket" in a vacuum so that the metal strikes the rough replica surface at a low angle giving rise to a shadowing effect which shows up particularly well in the electron micrograph. A "metal shadowing" unit has just been constructed in the high magnification laboratory and will make the replica work much more effective. Similarly, at first it would appear impossible to make sections of materials one micron or less in thickness. However, by placing a razor blade on the edge of an aluminum wheel four inches in diameter a high speed microtome has been made. Rotation of the wheel at 57,000 RPM produces a cutting speed of 1100 feet per second, which is sufficient to produce sections of the desired thickness of such things as tissues, rubber, lucite, nylon, and recently even certain metals such as copper.

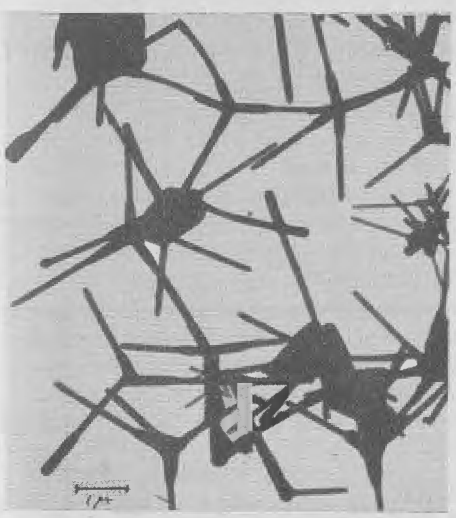
MICA PARTICLE

Nevertheless, despite such ingenious techniques, light microscopes are capable of accomplishing many things which the electron microscope cannot. In addition many problems do not require the unusually high magnifications of this instrument. For these and other reasons light microscopes are essential in a high magnification laboratory.

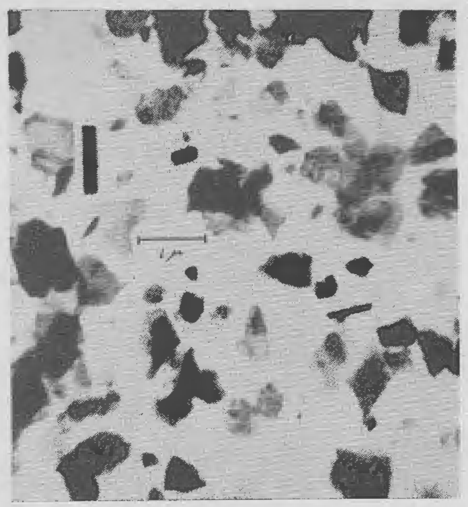
The research metallographic equipment is mounted on a horizontal bench and consists of a permanently aligned camera, microscope assembly, and tungsten arc lamp. The microscope is capable of useful magnifications of 800 diameters, and together with the camera, effective total enlargement of 2000 diameters can be obtained. Since this type of microscope utilizes light that is reflected from the surface of the specimen it is one of the most effective tools for the study of metals. Studies of the morphology of individual grains and their structural arrangement are of importance in the solution of metallurgical problems which involve the identification of metals, the effect of impurities on structure and therefore on the physical properties and behavior of the substance, the cause of porosity, and many others. Structures containing extremely minute detail are first photographed at high magnification on this instrument and then studied, in the form of replicas, at various magnifications in the electron microscope.

The research photomicographic apparatus is similar to the metallographic equipment except that transmitted rather than reflected light is used. Useful magnifications up to 2000 diameters are possible and the instrument is used to study materials which are capable of transmitting light. This includes a large proportion of the common minerals, ceramic compounds, and glass and makes the instrument of value in all phases of work in the mineral industries. Since the sample is easily accessible and its effect on the light beam may be studied with various accessories, a great deal more information on its optical nature may be obtained from the light microscope than from the electron microscope. The latter supplements rather than supplants the instruments which use light rather than electrons.

In the short time since its installation the laboratory has already made some important contributions in the field of mineral industries. Studies of clay minerals in the electron microscope have been particularly important. It has been found for example that the micaceous mineral known as illite which is found in many sediments occurs in large, well crystallized plates in the slate from northeastern Pennsylvania; while in a typical shale the individual shreds are



ZINC OXIDE



ILLITE FROM SLATE

difficult to resolve even under magnification up to 100,000 diameters. It is believed that the growth of the larger flakes is a direct result of metamorphism, and if so, a more detailed study will probably shed considerable light on the nature of metamorphic processes. Effective studies of the nature of clay minerals in oil bearing sands have been made in the laboratory, and certain transition products in metals have been investigated by using collodion replica techniques.

Future plans for the laboratory include a complete microscopic investigation of all the clay minerals at every available magnification. Stereoscopic electron microscope methods coupled with metal shadowing techniques will be used to study in detail the shapes of particles which, up until a few years ago, were never seen before. The new metal shadowing unit will also be used to bring out the minute details on the surfaces of crystals in order to give information which may be of value in learning more of the nature of crystal growth. Similar techniques will be used to make the investigation of metal surfaces at high magnifications more effective. Metallurgical problems such as the cause of fracture in steels, the nature of temper brittleness in alloy steels, and the mechanism of the yield point and strain-aging will be attacked by these methods.

Bates Heads High Magnification Laboratory

Dr. Thomas F. Bates is Assistant Professor of Mineralogy and is in charge of the high magnification laboratory in the School of Mineral Industries.

Dr. Bates was graduated from Denison University in 1939 with a Bachelor of Arts degree in Geology. From Columbia University he received the Master of Arts degree in Geology in 1940 and the degree of Doctor of Philosophy in 1944. He was the Nathaniel Lord Britton Scholar in Geology at Columbia in 1940-41 and a University Fellow in 1941-42. He came to The Pennsylvania State College in 1942 to instruct and do research in Mineralogy. He is a member of the Mineralogical Society of America, the Crystallographic Society, and the Electron Microscope Society of America.

Specializing in the application of X-ray diffraction, electron diffraction, and electron microscopy to mineralogical problems, he has been particularly interested in using these and other techniques in detailed investigations of the clay minerals. Since coming to the School of Mineral Industries he has built up a large collection of

THOMAS F. BATES

x-ray diffraction photographs of the crystalline materials which are likely to be encountered in the research being carried on within the School.

Mining Extension Supervisors Collaborate on Institute Paper

D. C. Jones, Supervisor of Mining Extension, and J. W. Hunt, Assistant Supervisor of Mining Extension, collaborated recently on the presentation of a paper before the Coal Mining Institute of America in its 60th Annual Meeting in Pittsburgh on December 5 and 6, 1946. The paper "The Development of Future Miners Through High School Training Programs" was prepared by Mr. Jones, but since he was unable to be present at the meeting was read by Mr. Hunt. The paper traced the recent development of vocational mining programs in high schools in this country, and also treated the types of programs being

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RICHARD D. SNOUFFER

MINING DIVISION CHIEF

Richard D. Snouffer was appointed Chief of the Division of Mining on January 1, 1946.

Mr. Snouffer received his Bachelor of Engineering in Mining from The Ohio State University in 1936 and his Master of Science degree in 1937 from the same institution. He is a member of Tau Beta Pi, national engineering honorary, a junior member of the American Institute of Mining and Metallurgical Engineers, and holds membership in the American Association of University Professors.

He has had coal mining experience in this country and Europe. His work in this country has varied from corps work in Ohio and West Virginia to research and engineering design in the Western Pennsylvania field. His employment with the Pittsburgh Coal Company, before entering the service, was as director of Training.

In August 1944 he was among a small group of officers called to Washington by the Army to be prepared to rehabilitate and supervise operations of the coal mines in Western Europe as they would be recovered by the Allied Forces. Within a few weeks, he was assigned to the operation of mines in Northern France and later took an active part in the direction of production and coal distribution in the Netherlands. After June 1945 Mr. Snouffer was the senior U. S. Army officer on the technical staff (composed of English, French, Russian and U. S. military personnel) for the Fuel Committee of the Allied Control Authority for Germany, a post he held until his return to the States for release from active duty.

He is the current chairman of the Committee on Bituminous Mining Methods for the Coal Division of the American Institute of Mining and Metallurgical Engineers.

GEOGRAPHY

Mr. William A. Bryan, recently appointed instructor in the Division of Geography, came to Penn State from Northwestern University. At Northwestern Mr. Bryan was an instructor in geography, teaching in the School of Liberal Arts and also teaching the Naval V-12 and ROTC units. Prior to his appointment at Northwestern he had been an instructor at Syracuse University where he had charge of instruction in the Army Air Corps program and taught in the Army Engineers, and Area and Language Programs. He served as an instructor at Great Lakes Naval Training Center, and was a supervisor in the Chicago Branch of the Army Map Service. Mr. Bryan is also geographic consultant to Britannica Junior. His academic work includes an AB from Princeton in 1940, an MS from Northwestern in 1942, and work towards his PhD. His major interest lies in the field of physical geography, stressing medical climatology and land use problems.

Two members of the Division of Geography published papers in the October issue of the Economic Geography Magazine. Mrs. Phyllis Griess' article is on, "Colombia's Petroleum Resources" and E. Willard Miller's article is on, "The Mineral Resources of Indo-China."

WILLIAM A. BRYAN

Dr. Miller has been appointed the book review editor of the Producers' Monthly Magazine. This petroleum magazine is devoted to the secondary recovery program throughout the United States.

Mining Extension Supervisors Collaborate on Institute Paper

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offered, the registrations by schools and states, and some of the difficulties that were being experienced in organizing the programs. Considerable interest in the paper was displayed at the meeting, especially by public school administrators from Pennsylvania and adjoining states who attended for the express purpose of discussing this work and acquainting the mining industry with its problems. The Institute appointed a committee to inquire into the work and see what could be done to foster interest in its development. Newspaper coverage of the paper following the meeting and still later unsolicited comments by mail indicates the interest that has developed in this phase of secondary school education.

Old Timers Club Establishes Mining Scholarships

At a meeting recently held in Pittsburgh, the Old Timers Club, an organization of the older mining engineers and executives in the coal industry, organized an affiliated organization called the Old Timers Club, Incorporated, which is to administer contributions of the members, which are to be used for the purpose of setting up coal mining engineering scholarships throughout the Country.

The Old Timers Club continues as a social organization, with Neil E. Salsich as president and George H. Deike, a graduate of the College in Mining Engineering in 1903 and also a College trustee, as secretary-treasurer Mr. Deike is secretary of the Old Timers Club, Inc.