THE GEOLOGICAL SOCIETY OF AMERICA

The Engineering Geologist

THE QUARTERLY NEWSLETTER OF THE ENGINEERING GEOLOGY DIVISION OF THE GEOLOGICAL SOCIETY OF AMERICA

Volume 4, No. 1 February 1969

Construction of Manicouagan 5 Raised Some Geological Problems

P. M. Crepeau

Manicouagan 5, about 350 miles northeast of Quebec, Canada, is the largest multiple arch dam in the world. Construction began in 1960, and the last concrete was placed in September 1968. At this time, the water level in the huge reservoir formed upstream of the structure was some 100 feet below full supply level. It is expected that the reservoir will be full after the spring runoff in 1972.

The dam, 4310 feet long at the crest and with a maximum height of 705 feet at the central arch, contains 2,940,000 cubic yards of concrete. The maximum design compressive stress in the concrete is 1400 p.s.i. The design is predicated on the elastic modulus of the bedrock foundations being of the same order of that of the concrete.

Studies and investigation to determine the properties of the bedrock foundations included surface mapping, seismic work, diamond core drilling, and both *in situ* and laboratory testing. Extensive use was made of downhole TV cameras in the examination of the walls of the boreholes.

The granitic gneisses that form the foundations are of Precambrian Age. These rocks are durable and competent but structural defects, such as faults and joints, gave rise to the problems encountered at the site.

On the right bank at Buttress 5, a near-horizontal, so-called rupture joint was found at a depth of 75 feet below the competent rock surface. This feature is probably the result of

(Continued on page 7)

View of the Bedrock excavation at buttress 5 showing the "rupture joint".

Manicouagan 5

Message From the Chairman

Involvement in EGD-GSA is a privilege and a duty. My current privilege and duty is to serve you during the next year as Chairman. Degree of involvement in EDG-GSA is a personal choice. We have almost 900 members; about 50 members are active on the Management Board, committees, liaison representatives, publications and programming. Some members may desire to become more involved; let me assure you, the opportunity is available. My goal for this term of office is to foster more member participation. I am certain that the Division will profit and that each member will derive satisfaction and benefits in proportion to his involvement.

You can become involved by furnishing short news articles for inclusion in the *Engineering Geologist*, attendance at our annual meetings, participation in Engineering Geology functions of section meetings, and by contributions to the Society *Bulletin*. The Editorial on page 3 of the October issue of *The Geologist* emphasized that short manuscripts suitable for publication as Notes and Discussions are particularly desired. With the availability of space in the *Bulletin* for technical Notes and Discussions with a minimum of review and editing and the use of the *Engineering Geologist* for Newsletter type articles we should materially improve our communication of Engineering Geology information.

I welcome any suggestions that you think will improve and benefit our Division.

Sincerely,
W. Harold Stuart

Atlantic-Pacific Interoceanic Canal Studies Status of Geological Investigations

John C. Bowman, Jr.

Engineering feasibility studies are progressing on the sea-level canal routes with all geological investigations scheduled for completion in 1969. These investigations were required to determine engineering feasibility, outline conventional and nuclear excavation design, and provide estimates of costs for each route. The locations of routes under study by the Canal Commission are shown on Figure 1. Nuclear excavation would be employed on Routes 8, 17, and 25. Because of proximity to populated areas and of relatively low elevations, Routes 10, 14, and part of Route 25 would be excavated by conventional means.

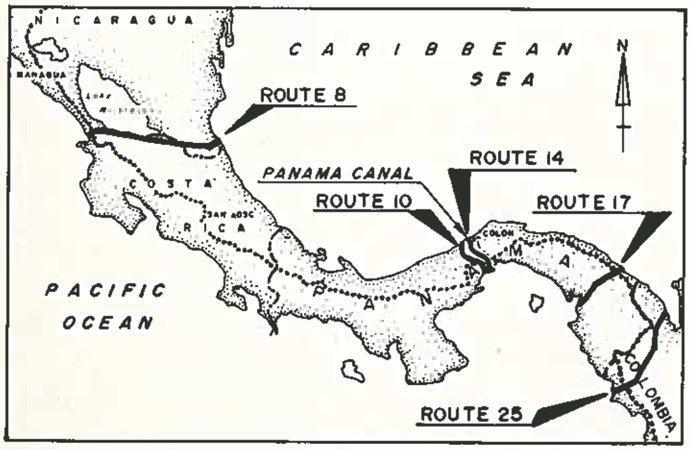

Fig. 1 Sea-level canal routes under study

The nuclear routes have unique requirements compared with conventional excavation design. Structural relationships and engineering properties of lithologic units are required for conventional excavation studies. In order to assess the cratering characteristics and to predict radiation products, however, information is also needed on the physical and chemical properties of the materials to depths of nuclear device emplacement. Regional geologic knowledge is also required to predict seismic effects produced by large scale nuclear excavation.

Surface and Subsurface Investigation

Methods of surface investigation have included topographic and geologic mapping, airborne magnetometer surveys, seismic refraction profiling, and gravity and magnetic surveys. Subsurface explorations included core borings, probings, test pits, borehole photography and downhole geophysical measurements, consisting of caliper, temperature, salinometer, electric, nuclear, density, and three-dimensional velocity logging. Laboratory investigations included paleontological identifications, petrographic analyses, strength testing of clay shales and rock, and high-pressure rock testing. Much of this work has been accomplished directly by the Corps of Engineers, for the Canal Commission; but some portions of the drilling, testing, and most of the geophysical studies have been done by contract.

Routes 17 and 25 are in remote tropical jungles and pose severe logistical problems. Logistical support by helicopter as shown on Figure 2 greatly facilitated the study of these routes, especially the drilling operations.

Over 100 Borings Studied

Over 100 borings and probings have been drilled on all routes ranging from 123 to 1,445 feet in depth and totaling over 32,000 linear feet. Explorations scheduled on Route 10 will consist of approximately 50 borings totaling 20,000 linear feet of drilling. Wireline drilling equipment proved invaluable for the deeper holes, actually improving core recovery and reducing drilling time. The series of downhole geophysical measurements, logged mainly for nuclear excavation studies, have also proven useful for conventional engineering geology studies. "Troublesome-type" clay shales were encountered in the exploration of each route and present critical slope stability problems. The engineering behavior of these clay shales is being investigated by detailed laboratory analyses and empirical slope studies.

Geological investigations have been completed on Route 17 and are essentially complete on Routes 14 and 25. Exploration of Route 10 is scheduled early in 1969, and no field explorations are planned for Route 8. The completion of the exploration scheduled in 1969 will provide data necessary for feasibility and cost studies required for route evaluation.

Fig. 2 USAF Ch-3 helicopter lifting the drilling mast at a remote drilling site on Route 17.

THE ENGINEERING GEOLOGIST

Editor - Lloyd B. Underwood

Department of the Army, Missouri River Division

Corps of Engineers, P.O. Box 103, Downtown Station

Omaha, Nebraska 68101

Divisional Officers – 1968-1969

Chairman . . . . W. Harold Stuart - 430 N.W. Maywood Drive, Portland, Oregon 97210

Chairman-elect . . . . H. Garland Hershey - 330 Beldon Avenue, Iowa City, Iowa 52240

Secretary-Treasurer . . . . . . Richard E. Gray - 508 Lenox Avenue, Pittsburgh, Pennsylvania 15221

THE ENGINEERING GEOLOGIST is issued by THE GEOLOGICAL SOCIETY OF AMERICA, Engineering Geology Division, P.O. Box 1719 Boulder, Colorado 80302.

Joint Research Conducted on Behavior of Clay Shale Slopes

Robert W. Flemming

The U. S. Army Corps of Engineers Nuclear Cratering Group is sponsoring a joint research study on the behavior of clay shale slopes. Study participants, in addition to the Nuclear Cratering Group, are the Corps of Engineers Missouri River Division and the Waterways Experiment Station.

The purpose of the study is to assemble and analyze empirical data that are pertinent to the behavior of clay shale in high slopes. The results will help to develop better understanding of clay shale slope stability with particular emphasis on the long-term behavior of nuclear excavations in such rocks.

Upper Missouri River Valley To Be Area of Analysis

The study program consists primarily of a detailed field analysis of clay shale slopes along the upper Missouri River Valley, which have heights comparable to those anticipated for nuclear excavation applications and the identification and evaluation of the behavior of clay shale slopes at other selected areas in the U. S. and Canada. There are four separate phases in the investigation: (1) a detailed geologic field reconnaissance of selected slopes along the upper Missouri River Valley supplemented by a map and airphoto geomorphic study of a large number of individual slopes, (2) a subsurface investigation of selected clay shale slopes in the upper Missouri River Valley, (3) a comprehensive laboratory testing program of clay shale samples obtained during the subsurface investigation, and (4) an office study to collect and evaluate data on clay shale slopes in other selected areas.

Field Reconnaissance Completed

The geologic field reconnaissance has been completed. Slopes were mapped in the Colorado Group, Fort Union Group, Bearpaw Formation, Claggett Formation and Pierre Formation. Geologists from the Engineering Geology Branch of the U. S. Geological Survey, Denver, led an initial field trip to scout each geologic material and to assist in selection of particular slopes for mapping. One site each in the Bearpaw, Pierre, Claggett, Colorado and Fort Union clay shales will be explored in detail to develop the stratigraphic section and to obtain samples for testing (see Figure 1). Slope heights and lengths for these sites are shown in Table 1.

The five geologic units under investigation are thought to vary widely in physical properties even though all have been described as clay shales. The laboratory test program will determine index and strength properties of all the materials.

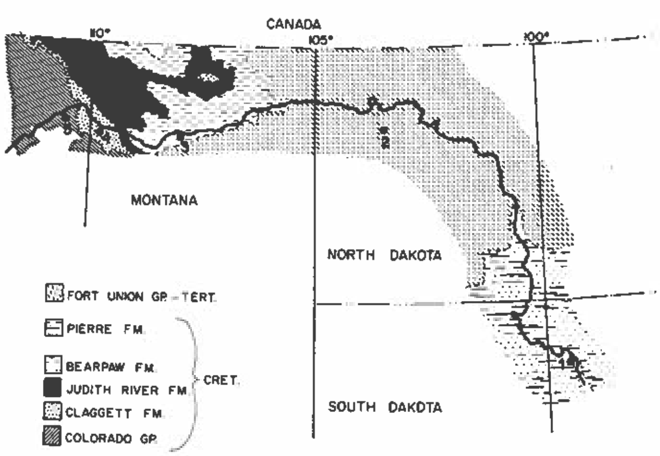

Fig. 1
Generalized geologic map showing sites for detailed investigation.

Tests will be run on weathered and slumped material from near the surface and on intact material from depth.

Data analysis and interpretation will be performed by all participating agencies. An attempt will be made to relate the physical characteristics and geologic details to the configuration of each slope studied. Interpretations will be extended, insofar as possible, to develop better understanding of the stability of nuclear crater slopes in clay shale.

TABLE I

Geologic Unit	Location	Slope Height (Ft)	Horizontal Slope Length (Ft)
1. Pierre Formation	Chamberlain, S. D.	470	5451
2. Fort Union Group	Roosevelt Park, N. D. (North Unit)	595	4800
3. Bearpaw Formation	Robinson Bridge, Hwy. 191, Montana	676	3040
4. Claggett Formation	Mouth of Arrow Creek Montana	959	6250
5. Colorado Group	Fort Benton, Montana	312	442

WRITE FOR INFORMATION ABOUT ENVIRONMENTAL GEOLOGY REPORT

We recently received a letter requesting information relating to environmental geology from Professor Peter O. Coltman of the School of Architecture of the University of Texas, Austin, Texas, 78712. We suggest that you contact Professor Coltman directly if you have something to contribute to his forthcoming report. His letter follows:

Dear Sir:

The Kansas State Geological Survey is engaged through its Department of Environmental Geology in studies of the physical environment relative to geological conditions and geologic history. In order to do this effectively an actual area has been selected for study. It is 7-1/2 square miles in extent, west of the city of Lawrence and in the path of city expansion. Specialists in many fields have participated in the compilation of information on factors which influence the environment in some way or another. This study project has now reached a stage where mapping of existing features and conditions has been completed and criteria for the use of the land are being assessed.

I am writing to seek your assistance and guidance in setting effective land-use criteria which would be meaningful to members of your association in order that the forthcoming report can have as wide applicability as possible.

In particular, I am concerned with the future use of land relative to the following factors: topography, slope, depth to and variations of water table, depth and type of top soil and rippable material (or depth to rock). These items affect building location, building methods and building foundations given a choice of site and are the special factors affecting my own studies. Other factors recorded and being investigated by other people are these: geology, mineral resources, drainage basins, drainage networks, vegetation, soil types, physical properties of soils, land use past and present, aesthetic, historic and cultural elements. Climate has also been taken into account.

This is a difficult request to answer if you are not engaged in related work, but your special interest will help us to make the forthcoming publication of the report more useful to those engaged in your profession.

If you can provide references or have publications which refer to such land use criteria or if you are able to offer suggestions or advice related to this type of study, your help will of course be acknowledged. If you are unable to assist directly, but feel that someone you know could be of help, I would appreciate it if you would pass this letter on.

Yours truly and in appreciation,
Peter O. Coltman
Associate Professor of Architecture and Planning.

Rock Stress Measured in British Columbia

View of underground powerhouse (under construction) for the W.A.C. Bennett Dam.

Graham C. Morgan

Generation at the W.A.C. Bennett (formerly Portage Mountain) Dam on the Peace River in British Columbia officially commenced in September, 1968. The Gordon M. Shrum Generating Station will eventually house ten 227,000 kilowatt units. It is one of the world's largest underground powerhouses having a span of 67 feet, a height of 150 feet, and a length of 890 feet. The roof of the chamber lies 300 to 400 feet below ground level. Both the powerhouse and manifold chambers were excavated in Cretaceous sedimentary rocks, a near-horizontally bedded sequence of sandstone, shale and coal.

Prior to construction, an attempt was made to measure the rock stress conditions *in situ* using the drill-hole method developed by N. Hast in Sweden. The results indicated horizontal stresses appreciably in excess of the vertical stress which, in turn, was greater than the computed average overburden stress. The measurements were made from a 7-foot by 8-foot tunnel driven along the centreline of the future arch at the springline. Measurements were taken up to 40 feet away from the tunnel surface. The average vertical stress measured was 1000 p.s.i. with horizontal stresses ranging from 900 p.s.i. to 1900 p.s.i. By comparison, the vertical and horizontal stresses computed by conventional means from the thickness of overlying overburden was typically 500 p.s.i. and 125 p.s.i. Further evidence supporting this stress pattern was obtained from a photoelastic study of the relaxation of oriented samples of the rock.

Stress Relieving Slot Proves Successful

As a precautionary measure, after excavation of the roof and prior to the placement of the concrete arch, a stress-relieving slot was excavated along the centre of the chamber to a depth of 26 feet. The adjacent rock was then blasted into the slot to form a working surface of broken rock from which the arch was constructed. The chamber was successfully completed late in 1966 without any unusual experiences, and has performed normally since that time.

A programme including a similar, though less extensive, series of stress measurements has also been recently completed for a future powerhouse at the Mica Damsite, on the Columbia River. There the powerhouse will be excavated out of gently dipping and locally folded granite gneisses and schists. The tests, conducted by Foundation Sciences Company of California, again indicated stresses appreciably higher than one would expect from consideration of the 700 to 800 feet of rock above the exploratory tunnel where the measurements were made. A maximum stress of the order of 1500 p.s.i. was measured away from the effect of the excavation.

The W.A.C. Bennett Dam and Powerhouse has been engineered by International Power and Engineering Consultants Limited (Vancouver). The engineers for the Mica Dam are CASECO Consultants Limited (Vancouver). The owner of both projects is the B. C. Hydro and Power Authority.

Members Attend Mexico City Meeting

Those members who attended the 81st annual meeting of the Geological Society of America in Mexico City, 11-13 November 1968, can testify that it was a huge success. Thomas F. Thompson, Chairman of the Program Committee and Frederick Mooser of Mexico who hosted the meeting of the Division on Engineering Geology are to be congratulated. Many excellent papers were presented at the technical sessions and the field trips guided by Mr. Mooser were especially informative.

NEW BOOKS AND LITERATURE IN ENGINEERING GEOLOGY

Raymond E. Whitla

MANGLA: Institution of Civil Engineers (London) Proceedings, vol. 38, Sess. 1967-68, pp. 338-575, Nov. 1967. This article is a report on the design and construction of Mangla Dam in West Pakistan. This structure was constructed across Jhelum River at Mangla and is a major component of the Indus Basin Project, which is the largest single water development project ever undertaken in the world. Mangla Dam itself is one of the world's largest earthfill dams from the standpoint of volume, having a volume of 83,000,000 cubic yards. It has a length of 10,300 feet and a maximum height above the core trench of 454 feet. Construction included five tunnels for development of power and of irrigation and a powerhouse. The report is presented in two parts, Part I titled "Engineering of Mangla," and Part II titled "Construction of Mangla." Engineering geologists should find much of interest in Part I of the report. Not only are the regional geologic setting, the details of site investigations, and the engineering properties of the bedrock covered, but also the influences of various geologic conditions on certain design features are described.

Glossop, R., THE RISE OF GEOTECHNOLOGY AND ITS INFLUENCE ON ENGINEERING PRACTICE: Geotechnique, vol. 18, no. 2, pp. 107-150, June 1968. This paper is the eighth Rankine Lecture of the British Geotechnical Society. It was given by Mr. Glossop at the Institution of Civil Engineers on February 14, 1968. In this paper Glossop suggests the term "Geotechnology" be used to cover the field of engineering geology and the related fields of soil mechanics and rock mechanics and discusses the development of geotechnology from the close of the 17th Century to the present time. His emphasis is on the field of soil mechanics. Glossop gives consideration to a number of engineering problems such as those associated with site exploration, the design of earth dams, the stability of natural slopes, excavations, roads, and geotechnical processes. In each case, the history of the problem is discussed, and the degree to which it has been influenced by soil mechanics is described and illustrated by means of case histories. In an appendix to the paper are five tables listing various exploration, sampling, and testing methods, the principles or techniques involved, and their applicability to civil engineering. A sixth table lists various laboratory tests and their applications. The reading of this paper is recommended to all persons in the field of geotechnology.

Underwood, Lloyd B., CLASSIFICATION AND IDENTIFICATION OF SHALES: American Society of Civil Engineers Proceedings, vol. 93, no. SM-6, Paper 5560, pp. 97-116, November 1967. This paper is concerned with developing an engineering classification of shales, and, after reviewing briefly the geological classification of shales and the characteristics on which that classification is based, it discusses the significant engineering properties and some of the *in-situ* behavior characteristics of shales in connection with the construction of civil engineering works. Although the author concludes that more research in laboratory and in field testing of shales is needed before a completely satisfactory engineering classification can be developed, he makes a significant contribution in his discussion of shale properties and *in-situ* behavior and in his table for evaluating the probable engineering behavior of shales on the basis of their physical properties.

Greensmith, J. T., and Tucker, E. V., FOULNESS, SOME GEOLOGICAL IMPLICATIONS: Civil Engineering and Public Works Review, vol. 63, no. 742, pp. 525, 527-529, May 1968. Few persons give thought prior to construction to the effects of man-made structures on the actions of nature. This article concerns a proposal to reclaim Foulness and Maplin Sands off Foulness Island near the mouth of the Thames River in Essex, England, as a site for London's third international airport and possible problems posed by construction of the facility at this location. Inevitably the reclamation of some 8,000 acres of intertidal zone will direct large volumes of seawater into adjacent estuaries, but the effect of this diversion can be only conjectured. This article discusses the geology of the Foulness area and some of the possible geologic problems in connection with the development of the airport facilities at this site.

Oriani, M., GROUTING ON THE SEA-BED AT DUNGENESS 'B' NUCLEAR POWER STATION IN KENT: Civil Engineering and Public Works Review, vol. 63, no. 742, pp. 539-540, May 1968. Problems of air losses during construction of a 2,700-foot-long water inlet tunnel at the Central Electricity Generating Board's new Dungeness 'B' Nuclear Power Station in Kent, England, were overcome by using special grouting techniques to waterproof the sea bed. Tunnelling was done in compressed air at a pressure of 39 pounds per square inch. During previous construction, the level of the sea floor had been raised in the area about the intake structure and along the line of the tunnel by dumping chalk, and heavy losses of air from the seaward end of the tunnel were expected because of the shallow cover of sand and the high permeability of the dumped chalk. The article describes the materials and the procedures used in grouting the chalk fill and the underlying sand in the sea bed to seal it against the loss of air during tunnel driving operation.

Parker, Dana C., REMOTE SENSING OF SOILS AND ROCK: Materials Research and Standards, vol. 8, no. 2, pp. 22-30, February 1968. This article discusses the uses of various airborne sensors in engineering surveys of soils and rocks. The sensors include cameras, infrared and passive microwave mappers, radar, spectrometers, laser, radiofrequency, and induction devices. Their applications include identifying and delimiting soil and rock units and locating soil and rock materials suitable for engineering purposes. The data obtained by these devices also provide information about surface and subsurface conditions that affect ease of excavation, slope stability, and suitability for subgrade, foundation, or fill materials. The paper points out that many potentially valuable sensors are not being exploited or considered because of the cost of converting developments in sensor technology and data interpretation into routine engineering practice. Although sensor technology imposes limits, capability could be advanced by developing techniques to interpret data accurately and routinely in terms of engineering parameters.

Lundgren, Raymond, Sturges, F. C., and Cluff, L. S., BOREHOLE CAMERAS: Materials Research and Standards, vol. 8, no. 8, pp. 17-22, August 1968. The authors discuss various general types of borehole cameras that have been developed to obtain information from boreholes not obtainable from recovered cores for one reason or another. In their discussion, borehole cameras are categorized into three types: cameras that obtain an image of the borehole on film, television cameras, and periscopes. Most of the discussion deals with borehole cameras that record an image on film. The authors mention some of the general considerations in the design of borehole cameras and discuss the applications and the uses of borehole cameras and some of their limitations. The last section of the article deals with the probable direction of expansion in the use of borehole cameras and possible improvements. The article omits any mention of persons or organizations who have been instrumental in the development of borehole cameras. The NX borehole camera illustrated in the article was developed by the U. S. Army Corps of Engineers, and the borehole camera views from a drill hole into an abandoned mine were taken with a camera invented by one of the authors.

Bellier, Jean, THE MALPASSET DAM FAILURE: Travaux, vol. 50, no. 389, pp. 363-383, July 1967. Translated from French in U.S. Bureau of Reclamation Translation 742, pp. 67, January 1968. This report summarizes the research by a group of engineers executing the final instructions of Andre Coyne to find the causes of this dramatic dam failure. Malpasset Dam failed December 2, 1959. It was the first total failure in the history of arch dams. Examination of the ruins indicated that the arch itself was not to be blamed either in principle or in execution. Failure occurred in the foundation of the entire left abutment. Motivating agent in the failure was pore water pressure in the rock. The pore pressure condition would not have triggered the failure if three conditions at the site had not existed: (1) nature of the rock, which would ordinarily be satisfactory, (2) geometry of the structure of the rock mass foundation, particularly the foliation, and (3) a fault downstream from the dam. The report discusses the geology of the site and describes the dam before, during, and after the failure. This report should be of particular interest to all engineering geologists and engineers concerned with design and construction of dams.

Warner, Don L., DEEP WELL DISPOSAL OF INDUSTRIAL WASTES: Federal Water Pollution Control Administration, Publication WP-20-10, pp. 45, November 1967. Available from Superintendent of Documents, Washington, D. C. 20402. The use of deep wells for disposal of some concentrated, relatively untreatable liquid wastes has increased in recent years, and it is expected that this method will be applied widely in the future as water pollution control is emphasized. This publication lists 110 industrial waste injection wells and some of their characteristics. The data listed include: operator of well, well location, date of initiation of operation, total well depth, depth of injection horizon, geologic formations used for injection, chemical and physical character of waste, injection rate, injection pressure (well head), and source of information. Thirty-one references are listed.

EARTH RESISTIVITY MANUAL, Soiltest, Inc., 2205 Lee Street, Evanston, Illinois 60202, pp. 52, 1968. This is a manual prepared by Soiltest, Inc., on the use of electrical resistivity for subsurface explorations in connection with civil engineering and water-supply projects, materials prospecting, archeological investigations, and other uses. It is intended principally as a source of information for the occasional user of electrical resistivity methods rather than for the professional geophysicist. The manual explores the capabilities and the limitations of the electrical resistivity method. It discusses resistivity theory, the field use of electrical resistivity units, interpretation methods, and applications of electrical resistivity methods. A list of 36 references concerning electrical resistivity methods is given in the final section.

Terzaghi, Karl, and Peck, Ralph B., SOIL MECHANICS IN ENGINEERING PRACTICE (2nd Edition), John Wiley & Sons, Inc., 605 Third Avenue, New York, N. Y. 10016, pp. 729 1967. Price $14.95. This revised edition is an updated version of the original work published in 1948 and contains substantial changes and additions to that earlier edition.

Denny, Charles S., Warren, Charles R., Dow, Donald H., and Dale, William J., A DESCRIPTIVE CATALOG OF SELECTED AERIAL PHOTOGRAPHS OF GEOLOGIC FEATURES IN THE UNITED STATES: U. S. Geological Survey Professional Paper 590, pp. 79, 1969. Price $2.25. Available from the Supt. of Documents, Washington, D.C. 20402. This publication lists special sets of aerial photographs that have been selected and assembled by the U. S. Geological Survey to illustrate numerous types of geologic features in the United States and that are available for purchase from that agency. A total of 857 aerial photographs have been grouped into 317 sets, each consisting of from 1 to 6 contact prints. The catalog describes the features illustrated and, besides the 79 pages of text, contains 53 pages showing one reduced representative photograph from each set. It also contains instructions for ordering the photographs.

Erickson, Herbert B., STRENGTHENING ROCK BY INJECTION OF CHEMICAL GROUT: American Society of Civil Engineer's Proceedings, vol. 94, SM-1, paper 5744, pp. 159-173, Jan. 1968. This report discusses the strengthening of fractured rock by use of polyester and epoxy resins and is based on the experience at the NORAD Underground Combat Operation Center near Colorado Springs, Colorado. Rock strengthening at the NORAD project by use of epoxy resin was accomplished more economically than could have been done with the other methods of strengthening that were considered without delaying the construction schedule. The epoxy resin used provided greater strength and had better penetration characteristics than could have been obtained with portland cement grout. The equipment and the procedures used for injecting the resin grouts also are described.

Karol, Reuben H., CHEMICAL GROUTING TECHNOLOGY: American Soc. of Civil Engineers Proceedings, vol. 94, SM-1, paper 5748, pp. 175-204, Jan. 1968. This paper presents some fundamentals of chemical grouting technology that have been developed in the laboratory with experiments involving the injection of a chemical grout (AM-9) in granular materials. It discusses the effects of ground-water flow on the shape and the location of the grouted mass, the effects of stratified materials and the techniques for obtaining uniform or near-uniform penetration in stratified materials, and techniques for developing a relatively impermeable barrier, or curtain, in a predetermined location. The last section of the report discusses two field grouting operations where the procedures developed in the laboratory were applied.

Sheeler, J. B., SUMMARIZATION AND COMPARISON OF ENGINEERING PROPERTIES OF LOESS IN THE UNITED STATES: Highway Research Record no. 212, pp. 1-9, 1968. Large deposits of loess occur in many parts of the United States, but published values of the engineering properties of loess are relatively scarce. The author of this paper has gathered data to indicate similarities and to compare the properties of loess from one area to another. In this paper, the term loess means an aeolian material that was deposited thousands of years ago and has remained in place since the time of deposition. The paper discusses the identification of loess and such engineering properties as mechanical analysis, specific gravity, Atterberg limits, permeability, density, shear strength, consolidation, bearing capacity, natural moisture content, and erosion. The ranges in values of the engineering properties of loess in Iowa, Nebraska, Tennessee, Mississippi, Illinois, Alaska, Washington, and Colorado, as taken from literature sources, are summarized in a table.

Turnbull, W. J., CONSTRUCTION PROBLEMS EXPERIENCED WITH LOESS SOILS: Highway Research Record no. 212, pp. 10-27, 1968. This paper is based on the author's personal experience and study of loess from two areas, Mississippi and Nebraska. The author's principal background of experience in construction work with loess soil was gained on the Central Nebraska Public Power and Irrigation District project from 1934 to 1941. The paper discusses briefly the differences in origin and in characteristics of the loess from Nebraska and from Mississippi and describes the internal structure and the stratification of loess and slope face problem of cuts in loess. The last two-thirds of the paper is given to problems with loess on the Central Nebraska Project.

Schlicker, Herbert G., and Deacon, Robert J., ENGINEERING GEOLOGY OF THE TUALATIN VALLEY REGION, OREGON: Oregon Department of Geology and Mineral Industries Bulletin 60, pp. 103, 1967. This report was prepared to bring together information on the geologic and the hydrologic factors pertinent to the urban development of the Tualatin Valley region of Oregon. It is the first report of a long-range program by the Oregon Department of Geology and Mineral Industries for detailed study and mapping of the geology of urban areas in Willamette Valley. The area of the report is the northern part of Willamette Valley in northwest Oregon. The eastern margin of the area is part of metropolitan Portland. The report describes the regional geology and then discusses the engineering characteristics of the various soil and rock units, the geologic hazards, construction materials, ground-water resources, and pollution problems that are applicable to engineering problems. Accompanying the report in a separate envelope are four plates consisting of a geologic map, a sheet of geologic cross sections, a geologic hazards map, and a map showing depth of the Columbia River basalt under the region. The report was prepared to be an aid to engineers and planners working in the Tualatin Valley region but not intended to be a substitute for a site investigation. This bulletin is a good example of what can be done by state geologic surveys or similar organizations to lay the foundation for safe and effective development of urban land.

THE QUEER KOYNA EARTHQUAKE: Science and Technology, no. 78, pp. 66-69, June 1968. In December 1967, an area of India that normally is free of seismic disturbance was devastated by an earthquake having a magnitude of 7.5 on the Richter scale. Over 200 persons were killed and about 3,000 were injured. Nearly 1,000 villages were destroyed. In spite of the heavy shocks, Koyna Dam was virtually undamaged except for cracks at a few places. Soli Ghaswala, Bombay science writer and consulting engineer, describes this geological accident, its probable causes, and the lessons that it has taught.

Wakabayashi, Jiro, WATER JETS EXCAVATE NARROW FAULT SEAMS THAT ARE CONCERNED AND PRESTRESSED WITH ROCK LAYERS TO STABILIZE DAM ABUTMENTS. Construction Methods and Equipment, vol. 50, no. 9, pp. 90-95, September 1968. This article describes a procedure being used to strengthen and to reinforce the rock in the abutments for the concrete arch Nagawado Dam in Japan. Highpowered water jets are used to wash clayey sandy gouge and fractured rock from fault zones in the abutment rock, and the voids then are filled with concrete. The faults are nearly vertical and in general parallel the river. Following the replacement of the fault zone material with concrete, the abutments are reinforced with steel prestressing rods installed in 6-inch-diameter holes that are drilled nearly horizontally into the abutment rock normal to the fault zones. The prestressing rods range in length from 160 to 260 feet.

Wiss, John F., EFFECTS OF BLASTING VIBRATIONS ON BUILDINGS AND PEOPLE: Civil Engineering, vol. 38, no. 7, pp. 46-48, July 1968. Sooner or later most engineering geologists come up against the problem of the effects of blasting on nearby structures. In this article, the author presents some guides to be used in the control of blasting operations where blasting is performed without benefit of seismographic tests to establish the limits for the operation. These guides are based on the scaled distance concept, which is the measure of the vibration potential; the peak particle velocity, which determines the damage potential; and the frequency of vibration, which relates to the human evaluation of vibration. At the end of the article, the author gives four recommendations to provide information that could be helpful in the event of litigation.

Langefors, U., and Kihlstüm, B., THE MODERN TECHNIQUE OF ROCK BLASTING (2nd edition), John Wiley & Sons, Inc., 605 Third Ave., New York, N. Y. 10016, pp. 405 1967. Price $17.50. This is a revised edition of the original work published in 1963. The aim of the book is to provide an introduction to the technology of rock blasting as it has been built up in mining and civil engineering in the post-war years through research, theoretical investigations, field tests, and full-scale application. Some of the chapter headings are "The Mechanics of Breakage," "Calculation of the Charge," "Loading of Drill Holes," "Bench Blasting with Ammonium Nitrate Explosives," "Short Delay Blasting," "Tunnel Blasting," "Ground Vibrations," "Smooth Blasting and Presplitting," and "Underwater Blasting and Blasting through Overburden." All persons concerned with rock blasting should have this book.

Shreve, Ronald L., THE BLACKHAWK LANDSLIDE 1968. viii + 47 pages. 3 plates (6 photographs, color map in back pocket). 7 figures. 3 tables. Paperbound. Geol. Soc. America, Special Paper 108. Price $3.75 The prehistoric Blackhawk Landslide in southern California promises to become the classic example of a massive avalanche, believed to have traveled on a layer of compressed air. The hypothesis of air-layer lubrication readily accounts for the low friction, very high speed, and nonflowing motion of numerous huge landslides; it also explains many otherwise puzzling features of their form and structure. CONTENTS: Abstract. Introduction. Geology. Blackhawk area. Older rocks. Younger rocks. Faults and folds. Geologic history. Mechanics. Blackhawk landslide. Modern counterparts. Air-layer lubrication. Conclusion. References Cited.

COMING EVENTS OF INTEREST TO THE ENGINEERING GEOLOGIST

January 20-24 – Fourth Conference on Drilling and Rock Mechanics, Austin, Texas, Society of Petroleum Engineers and Texas University.

February 2-7 – ASTM Winter Meeting, Denver: Rock Mechanics – A one-day session on "Determination of the In-Situ Modulus of Deformation of Rock" will be given on February 6, 1969. The session is sponsored by Committee D-18 on Soil and Rock for Engineering Purposes. Ten papers will be presented describing new techniques for measuring the in-situ testing for design of dams, underground power plants, bridges, and high-rise buildings. The session will close with a Panel Discussion directed at the question, Should In-Situ Tests for Determining the Modulus of Deformation of Rocks Be Standardized?

March 6-7 – A Research Seminar will be held at the University of Alberta, Edmonton. The theme of this Seminar will be "The Geological Engineering Aspects of Landslides." The Seminar will consist of four sessions; the topic for each session is, very broadly, as follows:

Session 1	Thursday Morning	Causes
Session 2	Thursday Afternoon	Prediction
Session 3	Friday Morning	Analyses
Session 4	Friday Afternoon	Control

Particular emphasis will be placed on the research aspects of the topics to be discussed. No formal proceedings will be forthcoming.

Contributions for presentation or discussion are solicited but should be short due to time limitations. Deadline for submissions was 4 January 1969.

April 9, 10, 11 – Seventh Annual Engineering Geology and Soils Engineering Symposium, University of Idaho, Moscow, Idaho 83843.

Manicouagan 5 . . .

(Continued from page 1)

post-glacial decompression. Detailed investigation was carried out, and the decision was taken to found this buttress on the continuously competent rock below the level of this joint.

At Arch 2-3, the second from the right abutment, a large mass of rock had to be removed to develop foundations of the required competency. The mass of rock was bounded by three interacting faults or main joints along which movement had occurred. The rock within these boundaries was cut by shear zones containing clay gouge. The V-shaped excavation was carried down to a depth in excess of 100 feet to remove all the fractured and sheared rock, thereby eliminating the danger of localized compression or the development of uplift pressure.

An inclined grout curtain was established at the heel of the dam, and blanket grouting was carried out throughout its base area. The foundation drainage system consists of holes immediately downstream of the grout curtain plus rows of holes extending to the toes of the arches. Galleries were constructed in the dam for the drilling of these holes and to permit observation of water levels or flows from the holes.

Because of climatic conditions at the site, where the temperature can drop below minus 50°F, the drainage system was designed so that all possibility of the freezing of the drainage system was eliminated.

NEWS OF THE PROFESSION

Appointment Announcement

Dr. Jack R. Van Lopik, Technical Director of Geosciences Operations at Texas Instruments Incorporated, has been named Director of Sea Grant Development at Louisiana State University. To facilitate conduct of associated instructional and research programs, he will also serve as professor and chairman of the Department of Marine Sciences and Associate Director, Coastal Studies Institute.

Biographies of the Newly Elected Officers For The Engineering Geology Division of the Geological Society of America, 1968-1969

Chairman, **W. Harold Stuart**, graduate of Ohio State University 1933 with major in Geology. Thirty-four years with Corps of Engineers in Engineering Geology. Chief, Geology, Soils and Materials Branch, North Pacific Division, Corps of Engineers.

Chairman-elect, **H. Garland Hershey**, was born in Quarryville, Pennsylvania, received his Ph.D. from Johns Hopkins in 1936 and since then has been with the Iowa Geological Survey, as State Geologist since 1947. A past Councilor of the GSA (1955-58), past Councilor of the Division (1961 and 62), and present Secretary of the EGD. He is Chairman of the Iowa Natural Resources Council, governor's alternate on the Missouri Basin Inter-Agency Committee, Vice-Chairman U. S. National Committee, International Hydrological Decade.

Secretary-Treasurer, **Richard E. Gray** is a graduate of Carnegie Institute of Technology and a principal of General Analytics, Inc., Consulting Engineers, Pittsburgh, Pennsylvania. He is a member of the ASCE-GSA Joint Committee on Engineering Geology, a member of ASTM's Committee D-18 on Soil and Rock for Engineering Purposes, and Chairman of the American Institute of Professional Geologists' Committee on Geologic Hazards for the Northeastern United States.

Program Chairman, **Gordon Prescott**, Office, Chief of Engineers, Washington, D.C. is the Program Chairman for the Engineering Geology Division's annual (1969) meeting in Atlantic City, New Jersey.

Promotions and Awards

Bruce Hall, lunar geologist, was promoted to Chief Scientist of the Extraterrestrial Research Agency of the Office, Chief of Engineers. Mr. Hall also received the 1968 Army Research and Development Achievement Award for his work in developing lunar surface sampling techniques and equipment.

Alice Allen was promoted to Chief Space Scientist in the same agency and received a sustained superior performance award in July 1968.

Newsletter Reporters

In order to obtain as complete a news coverage as possible of items of interest to engineering geologists, it is planned to have contact men as reporters for the Newsletter from various geographical regions throughout the Americas.

Thanks to Don MacDonald, our past chairman, our Canadian friends have their country well covered by the following 4 reporters:

Mr. Graham C. Morgan
2770 Wembley Drive
North Vancouver, British Columbia
(Graham Morgan is a geologist with the British Columbia Hydro and Power Authority, Vancouver)

Dr. J. S. Scott
2373 Clare Crescent
Niagara Falls, Ontario
(John Scott is a geologist with H. G. Acres & Company Limited, Niagara Falls)

Mr. I. D. MacKenzie
The Shawinigan Engineering Company Limited
P. O. Box 3010 - Station B
Montreal, Quebec
(Don MacKenzie is a geologist with Shawinigan)

Mr. Don H. Pollock
401 Motherwell Building
Regina, Saskatchewan
(Don Pollock is Chief, Geology and Air Surveys Division of the Prairie Farm Rehabilitation Administration)

Don MacKenzie and John Scott are both in the consulting field, and **Graham Morgan** is with a public organization that is currently doing a large amount of very interesting work in British Columbia. Don MacKenzie, being in Montreal, [illegible] quick access to the Hydro Quebec work and, in general, all work in Eastern Canada, whereas John Scott has good connections with the several departments in Ottawa and with the groundwater field in many parts of the country. Moreover, he has access to any work that Acres is involved in anywhere in Canada and abroad. **Don Pollock** has agreed to take on the reporting job for Alberta, Saskatchewan and Manitoba where the Prairie Farm Rehabilitation Administration has many engineering projects under investigation.

Harold Stuart, our new chairman, has promised to furnish names of reporters for the United States, Mexico and South America to be announced in the March 1969 issue of the Newsletter.

THE GEOLOGICAL SOCIETY OF AMERICA
P. O. Box 1719, Boulder, Colorado 80302

Non Profit Organization
U. S. POSTAGE
PAID
DENVER, COLORADO
PERMIT NO. 1349

THIRD CLASS