# The Engineering Geologist

THE GEOLOGICAL SOCIETY OF AMERICA

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

Volume 4, No. 2 May 1969


## Geological Engineer Plays Key Role in Power Industry


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*The following article by Dr. Lawrence P. Beer is condensed from his oral presentation at the 1968 National Meeting of Association of Engineering Geologists in Seattle, Washington.*

The Geological Engineer will continue to play an increasingly important role in the needs of the power industry. Whether on the staff of the utility or as a consultant to a utility, experience has shown that this environmental expert is necessary to aid the utility in its development of ever-expanding generating facilities. With the shift to nuclear power generation, his abilities become essential in the licensing of nuclear reactors. His duties involve studies of exploration for nuclear fuels, site selection, seismic criteria for plant design, ground-water hydraulics, decontamination studies, soil foundation evaluations, and general construction practices.

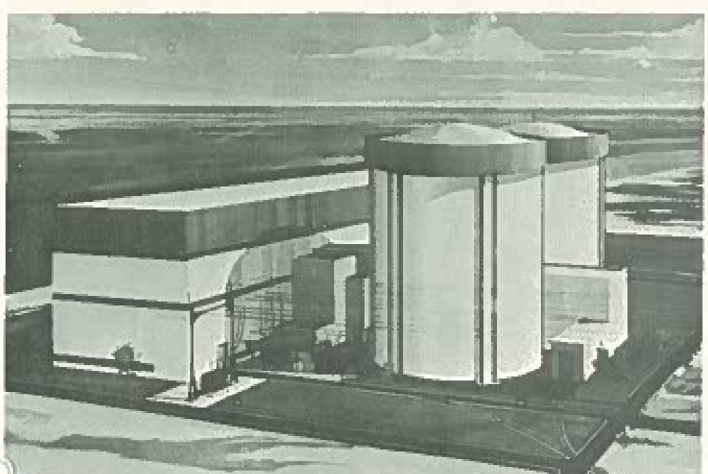

**Figure I. Commonwealth Edison's proposed Zion Nuclear Power Plant located along the southwest shore of Lake Michigan. This twin pressurized water reactor will generate 2200 megawatts of electricity with Unit 1 start-up scheduled for 1972.**

Each of these stages involves the geological engineer. In fact, he plays a key role in the initial review of possible sites. The prime consideration in deciding where to locate a reactor, other than the obvious one of planning it strategically in the transmission network, revolves around considerations of hydrology and geology. Hydrology is important in that nuclear reactors require condenser water flows of up to 1.5 million gallons per minute. Geology is important in that the seismic criteria for the design of Class I structures, such as the reactor containment, can be an expensive proposition. Locating in geologic areas that are seismically stable, as evidenced by an absence of fault zones and a history of infrequent seismic distrubances, will lessen the requirements of structural steel and concrete.

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## Message from the Chairman

In another portion of this Newsletter, you will find a list of officers, editors, committee chairmen, committee representatives, and liaison representatives. If any of you have ideas that might be helpful to any of these committees, officers, or representatives, I urge you to present your ideas and suggestions to them. I want you to note especially the new committee for the "Burwell Memorial Award." As most of you know "Ed" Burwell was one of the pioneers in Engineering Geology and was highly regarded by geologists, engineers, and others who worked with him or were familiar with his work. This award will honor the outstanding contributions that he made to the profession during his many years of engineering geology, nationally and internationally. The award will be made to the author or authors of a paper selected for its excellence and contribution to Engineering Geology. A certificate and cash award will be presented to the recipient at our annual Engineering Geology Division Luncheon. The selection committee for this year consists of Dr. S. S. Philbrick, Chairman, and Messrs. Cary, Dobrovolny, Hall, Irwin, and Supp. Because of the shortness of time, the committee must make a selection this year without the benefit of suggestions from the membership. For future years, however, I urge that you inform the selection committee of any Engineering Geology paper published within the past five-year period that you feel is worthy of consideration for the award.

*W. Harold Stuart*

# Geological Engineer...

*(Continued from Page 1)*

A prime example of the economic implications of seismic criteria involves Edison's latest nuclear power plant located at Zion, Illinois, and shown as an artist's conception in Fig. 1. These twin pressurized water reactors will have a generating capability of 2200 megawatts. Westinghouse will supply the nuclear steam supply system for this twin unit installation. In our initial presentations, we recommended structures capable of withstanding a maximum horizontal ground acceleration from a seismic shock of 0.12 g. After review by the Advisory Committee on Reactor Safeguards (ACRS) and their consultants, the United States Geological Survey and Coast and Geodetic Survey, a design based on 0.17 g was recommended.

**Soil Bearing Capacity Studied**

Studies of soil bearing capacity during the preconstruction and construction stages also involve the geological engineer; for it is he, working together with the structural engineer, who must decide the structural stability of the subsurface materials. It is he who must also decide how much unconsolidated material must be removed and, in zones where solution cavities or fracture zones are present, must decide on an adequate grouting design program that will result in sufficient foundation stability for the critical zones of the plant; *e.g.* reactor containment, turbine building, radwaste facilities.

Another important phase of the licensing and construction process lies in the field of ground-water hydraulics. In addition to the obvious ground-water evaluations involving the supply of water for both potable and nonpotable on-site uses, the dewatering of the construction area and the decontamination of ground-water systems in the case of an inadvertent radioactive liquid release, are two prime examples where the geological engineer fits into the picture.

Dewatering of large volumes of unconsolidated material can be a costly operation. At Edison's Quad-Cities Nuclear Power Plant, where Edison will generate 1600 megawatts of electricity from twin boiling water reactors, a well-point dewatering system was used (Fig. 2); however, because of the high permeability and transmissibility of the unconfined acquifer system coupled with considerable recharge from a general ground-water flow to the site as well as from the Mississippi River, considerable difficulty was encountered in dewatering. Adequate pumping and recovery tests would have defined the aquifer characteristics definitively, and aided in the determination of the well-point spacing and the sizing of pumps. Initial estimated costs were exceeded by more than 400 percent. Total cost of dewatering will exceed one million dollars.

Ground-water hydraulics played an important role in the safety evaluation of our Zion Station. Questions were asked by the Atomic Safety and Licensing Board regarding the potential contamination of adjacent wells and Lake Michigan by the accidental release of radioactive liquids either on the ground surface or below grade. Pumping tests and observations of wells in the area determined the direction and velocity of ground-water flow as well as the aquifer characteristics. On this basis we conclusively proved that because of the low

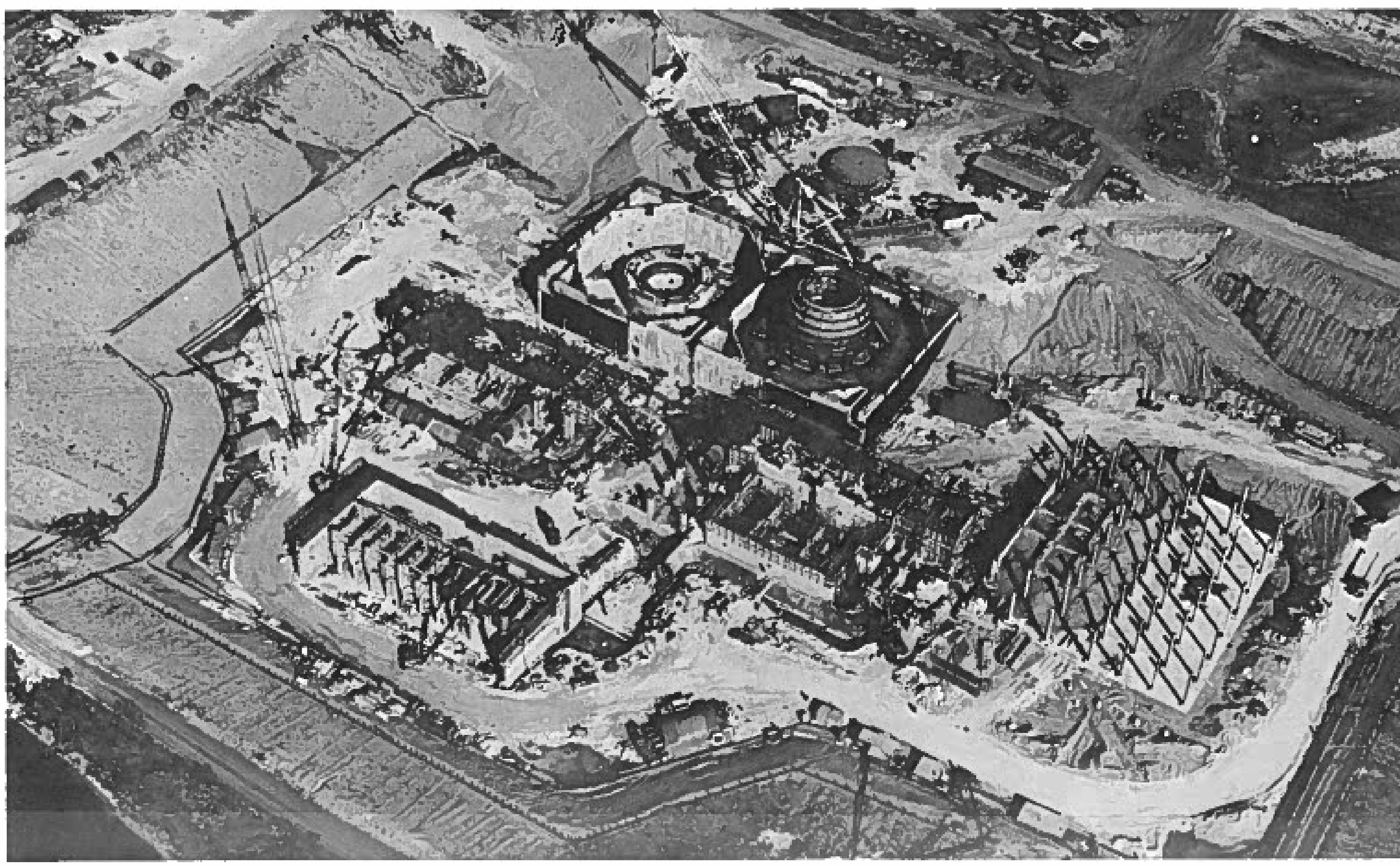

Figure 2. The dewatering system of well points encircling Commonwealth Edison's Quad-Cities Nuclear Power Plant. This twin boiling water reactor will generate 1600 megawatts of electricity with Unit 1 start-up scheduled for 1970. Site location is in Western Illinois along the Mississippi River, shown in the left foreground.

# Geological Engineer...

permeability and transmissibility of the sediments, regardless of location on-site of the accidental spill, a perimeter well-point system could be constructed to decontaminate the ground-water system by active withdrawal. A schematic diagram of the required well-point system that would be required to decontaminate radioactive liquid releases from three radwaste hold-up tanks, is shown in Figure 3. Calculations showed that 60 days would be required before releases traveled to a 30′ perimeter well-point header.

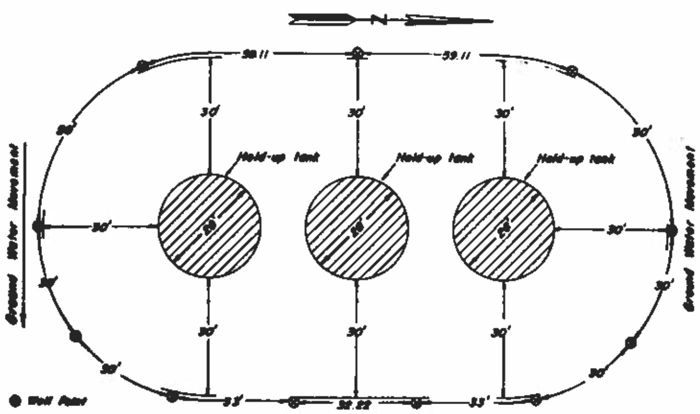


**Figure 3. Proposed well point dewatering system at Commonwealth Edison's Zion Nuclear Power Plant, in the case of an inadvertent accidental release of radioactive liquids. Shown are three 128,000 gallon hold-up tanks, used for the purpose of containing rad-waste liquids to ensure proper dilution before release to the condenser water flow into Lake Michigan.**

The geological engineer's participation in the everyday life of the utility company is important so that the utility can keep abreast of the increasing generation needs of an expanding population. Indeed, his expertise is essential in questions of nuclear fuel procurement, power plant siting, ground-water hydraulics, and general construction practices. For this reason, his future looks "rosy" and the power industry looks forward to his increased participation as power plant technology grows.

## News of the Profession

**Pennsylvania G. S. Organizes Environmental Geology Division**

**The Pennsylvania Geological Survey has organized an Environmental Geology Division which is headed by Alan R. Geyer. The Division presently has a staff of three.**

* * *

**Garald G. Parker Accepts Chief Hydrologist Position at Brooksville, Florida**

**Garald G. Parker, Principal Geologist and District Hydrologist, U. S. Geological Survey, Albany, New York, announced his retirement from the Survey on February 28 and his simultaneous acceptance of the position of Chief Hydrologist, Southwest Florida Water Management District, Brooksville, Florida 33512. Jerry is a past president of the American Water Resources Association, a newly appointed member of the National Resources Council – National Academy of Sciences, and is a charter member of A.I.P.G.**

# Robert H. Nesbitt Retires from U. S. Army Corps of Engineers

**Robert H. Nesbitt**

Robert H. Nesbitt, an internationally known engineering geologist employed by the U.S. Army Corps of Engineers, retired at the end of February after 35 years of Federal service. Mr. Nesbitt has been Chief of the Geology Branch in the Engineering Division of the Directorate of Civil Works, Office of the Chief of Engineers, and chief geologist for the U.S. Army Corps of Engineers for the past 12 years and assistant chief geologist for the preceding 9 years.

He started work for the U. S. Army Corps of Engineers on 5 February 1934, in the U. S. Engineer Office at Zanesville, Ohio, where he performed geologic explorations in connection with the design and construction of some of the early flood control dams built by the Corps of Engineers in Ohio. Since then, prior to his coming to the Office of Chief of Engineers, he also worked on flood control and navigation projects in Pittsburgh and Mobile Districts of the Corps of Engineers in Pittsburgh, Pennsylvania, and Mobile, Alabama, respectively, and in the Ohio River Division Office and Laboratory at Cincinnati, Ohio. He served as District Geologist in Mobile District and as Division Geologist in the Ohio River Division.

**Chief of Geology Branch**

As Chief of the Geology Branch in the Office of Chief of Engineers, Mr. Nesbitt has been chief technical advisor in the field of engineering geology on the design and the construction of all flood-control, navigation, and hydro-power structures of the Corps of Engineers as well as other projects and has been responsible for the planning and the over-all supervision of engineering geology and rock mechanics research in three of the Corps of Engineers' laboratories. Over 100 dams ranging from 50 to 450 feet in height had been constructed by the Corps of Engineers during this period of his professional career.

Mr. Nesbitt is the author of a number of professional papers related to engineering geology. He was instrumental in developing the Corps of Engineers NX Borehole Camera, an exploration device designed to photograph the walls of a 3-inch-diameter borehole, in the early 1950's, and his two papers describing that device and its operation have been widely distributed and read.

**Fellow of GSA and AAAS**

Mr. Nesbitt is a Fellow of the Geological Society of America and served as chairman of the Engineering Geology Division of that organization in 1961-62. He is also a Fellow of the American Association for the Advancement of Science and a member of the Association of Engineering Geologists, the American Geophysical Union, the United States Committee on Large Dams, and the Geological Society of Washington.

Mr. Nesbitt will engage in consulting work in the field of engineering geology.

## *Intersociety Committee on Rock Mechanics Announces International Roster for Symposium, 16 – 19 June*

The Intersociety Committee on Rock Mechanics has announced an international roster of speakers for the Eleventh Symposium on Rock Mechanics, to be held Monday through Thursday, 16-19 June, 1969, at the University of California, Berkeley.

A three-day technical program will emphasize the interdisciplinary character of the field. Monday's session, on geologic aspects of rock mechanics, will feature papers by experts from Britain, France, Germany, Czechoslovakia, Australia, and Canada as well as the United States. Simulation of rock behavior by theoretical and experimental means will be the subject of Tuesday's program. Wednesday's discussions will cover the role of fluids in rock mechanics and recent developments in rock mechanics.

The symposium will conclude Thursday with a day-long field trip to the site of Auburn Dam, near Sacramento, California. The investigations at this site have entailed the most comprehensive rock mechanics program ever conducted by the U. S. Bureau of Reclamation; construction is scheduled to start next year. The field trip will include a briefing by the USBR staff and an inspection of the underground test site and instrumentation.

Co-sponsoring the symposium with the Intersociety Committee are Continuing Education in Engineering and the College of Engineering, Berkeley. Copies of the program with registration forms and housing applications may be obtained by writing to Continuing Education in Engineering, University Extension, University of California, 2223 Fulton Street, Berkeley, California 94720, or by calling (415) 642-4151.

## Coming Events

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| May 15-17 | Third Annual Meeting of North-Central Section of GSA and Annual Meeting East-Central Section, NAGT, Ohio Union and Lae Bldg., Ohio State University, Columbus, Ohio |
| May 19-21 | International Symposium on the Determination of Stresses in Rock Masses, Lisbon, Portugal |
| June 2-6 & June 9-13 | Third Annual Short Course in Rock Mechanics, School of Mineral and Metallurgical Engineering, University of Minnesota, Minneapolis, Minnesota 55455 |
| June 16-18 | Eleventh Symposium on Rock Mechanics, Berkeley, California, 328 Hearst Mining Bldg., University of California at Berkeley, Berkeley, California 94720 |
| June 23-27 | Short Course in "Engineering in Appalachian Shales," Department of Engineering, West Virginia University, 371 Oakland Street, Morgantown, West Virginia 26506 |
| June 30 - July 2 | Fifth Rudolfs Research Conference, theme is "Origin, Distribution, Transport, and Fate of Organic Compounds in Aquatic Environments," College of Agriculture and Environmental Sciences, Rutgers, The State University, New Brunswick, New Jersey 08903 |

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# Seismic Map Shows Areas of U. S. Vulnerable to Earthquakes

*The following news release, dated 14 January 1969, by the Environmental Science Services Administration is considered to be of sufficient importance to the engineering geologist to be quoted in full in this issue.*

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The development of a seismic risk map, the first since 1952, showing the areas of the conterminous United States most vulnerable to earthquakes, was announced today.

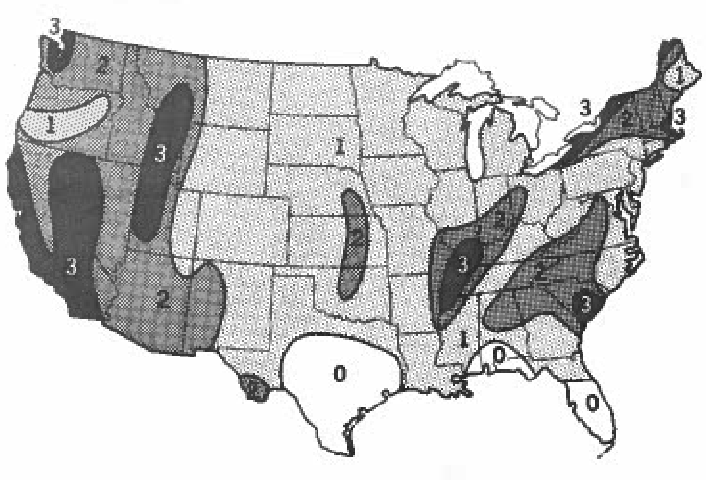
The map was developed by a group of research geophysicists headed by Dr. S. T. Algermissen of the Coast and Geodetic Survey, an agency of the Environmental Science Services Administration in the U.S. Department of Commerce.

The map is a revision of one first issued in 1948, revised and reissued in 1951, and withdrawn from circulation in 1952 because "it was subject to misinterpretation and too general to satisfy the requirements of many users." However, the 1951 map is still part of the "Uniform Building Code" published by the International Conference of Building Officials in Pasadena, California.

**New Map Announced at Fourth World Conference**

Algermissen disclosed development of the new map today at the Fourth World Conference on Earthquake Engineering in Santiago, Chile. In addition to showing U. S. areas most vulnerable to earthquakes, the map also shows what types of damage could be expected in the various areas delineated on the map.

The map divides the conterminous United States into four zones: areas where there is thought to be no reasonable expectancy of earthquake damage; areas of expected minor damage; areas where moderate damage could be expected; and areas where major destructive earthquakes may occur.



**Seismic risk map for conterminous U. S., developed by ESSA/Coast and Geodetic Survey and issued in January 1969. Subject to revision as continuing research warrants, it is an updated edition of the map first published in 1948 and revised in 1951. The map divides the U. S. into four zones: Zone 0, areas with no reasonable expectancy of earthquake damage; Zone 1, expected minor damage; Zone 2, expected moderate damage; and Zone 3, where major destructive earthquakes may occur.**

The zones are based principally on the known distribution of damaging earthquakes, their intensities (observed effects of earthquakes), and geological considerations. The zones were delineated after a two-year study of 28,000 earthquakes in the conterminous United States, including 16,000 in California.

Algermissen emphasized that the map is subject to continual revision as new research developments occur. "Our objective has been to determine where earthquakes may be expected to occur in the reasonable future, their frequency, and the potential damage they will cause," said the ESSA scientist.

**Frequency of Damage Not Included**

The frequency with which damaging earthquakes may occur is not included on the map. The Risk Map shows only the nature of the earthquake risk over a very long time span. However, in a paper which accompanies the map presented at the Santiago conference, Algermissen has included tables which give a general idea of the frequency of damaging earthquakes across the United States. For example, portions of California and Missouri are both rated in Zone 3 on the map, but the probable frequency of occurrence of large, damaging earthquakes in certain parts of California is much greater than in Missouri.

"The continuing studies of earthquake risk by the Coast and Geodetic Survey," he continued, "will hopefully provide guidelines for building codes governing earthquake-resistant construction. Since earthquakes can neither be predicted at the present time nor prevented, the best deterrent against earthquake damage and resultant loss of life is earthquake-resistant construction."

**Purposes of Risk Prediction Stated**

Algermissen said general risk prediction has three main objectives: (1) providing information which may be used to reestablish, or update, design criteria for earthquake-resistive structures, such as buildings, dams and bridges, (2) providing information useful in planning land use on a very broad scale, (3) constructing a "seismotectonic" map. This involves establishing the variation of earthquake occurrences in the U. S., based on both historical accounts of earthquakes and earth movements that have left visible traces in the form of geologic faults and other topographic changes.

The ESSA seismologist said that if structures in a populated area survive a strong earthquake, there will probably be very little injury and loss of life. Therefore, he added, a major objective of earthquake investigations in this country is to design structures that will not sustain great damage during earthquakes.

**California Not Alone in Vulnerability**

California, well known for its earthquakes, is not alone in its vulnerability to earth tremors. Strong tremors may also occur in the St. Lawrence region which sustained major shocks in 1663 and in 1925; in Charleston, S. C., where a damaging shock in 1886 killed 60 people; and New Madrid, Mo., where great earthquakes occurred in December 1811 and January and February 1812.

# New Books and Literature in Engineering Geology

*Raymond E. Whitla*

**Stagg, K. G., and Zienkiewicz, O. C., Editors**, ROCK MECHANICS IN ENGINEERING PRACTICE, John Wiley & Sons, 605 Third Avenue, New York 10016, 442 p. 1968. Price $14.50. This book is a collective work of several authors in which each chapter is written by a person well-conversant with the particular field of activity covered by that chapter. The chapter headings and the basic contents were chosen by the editors with a view toward obtaining a comprehensive coverage of the subjects that the engineer dealing with design of structures on or within the rock mass will encounter. Chapter headings in the book can give an idea of the subject coverage. These headings are: Geological Considerations, Mechanical Properties of Rocks, Influence of Interstitial Water on the Behavior of Rock Masses, Brittle Failure of Rock, In Situ Tests on the Rock Mass, The Measurement of Strain and Stress in Rock Masses, Dynamic Behavior of Rock Masses, Continuum Mechanics as an Approach to Rock Mass Problems, The Mechanics of Discontinua or Clastic Mechanics in Rock Problems, Ultimate Behavior of Rock Structures, Model Simulation of Rock Mechanics Problems, and Methods of Improving the Properties of Rock Masses.

**Sellers, J. B.**, ROCK MECHANICS INSTRUMENTATION IN TUNNELS: Water Power, vol. 20, no. 7, p. 272-276, July 1968. Rock mechanics instrumentation in connection with the design and the construction of tunnels is accomplished to provide basic data for the tunnel design and data for control of the safety and the economy of the tunnel supports during excavation. Required information for design in addition to the usual geologic data are (1) the stress conditions inherent in the rock mass, (2) the modulus of deformation of the rock mass (3) the strength of the rock mass, and (4) the strength of the planes of weakness. This article reviews the various types of instruments and techniques used to obtain such information, and those used for monitoring changes in rock pressure and rock movement during and after tunnel excavation and construction. Some of the instruments and techniques discussed are gauges and overcoring devices and their use in obtaining information on residual or inherent stress in the rock, jacking tests and equipment and the use of dilatometers for determining moduli of deformation, and the use of torsional shear apparatus for determining the strength of planes of weakness.

Knill, John L., GEOTECHNICAL SIGNIFICANCE OF SOME GLACIALLY INDUCED ROCK DISCONTINUITIES: Bulletin of the Association of Engineering Geologists, vol. 5, no. 1, p. 49-62, Spring 1968. This paper is concerned with certain discontinuities encountered in the rock of several construction sites in the United Kingdom that appear to have been the result of deep-seated glacial shearing. The discontinuities for the most part are in the upper 50 ft of rock although some were encountered at depths as much as 100 ft. They have a planar or a curvi-planar form, are oriented approximately parallel to the existing ground surface, and are filled with silt or clayey material. The paper discusses the origin of these features and the technical problems posed by them in the construction of engineering structures.

BUILDING CALIFORNIA'S CASTAIC DAM, Western Construction, vol. 43, no. 11, p. 38, 43, 46-47, November 1968. Castaic Dam will be the southerly terminus of the West Branch of the California Aqueduct and will operate on a pumped storage basis. It will be a zoned earth embankment structure 5,200 ft long having a height of 335 ft above streambed. This article describes some of the construction problems facing the contractor that are related to the site geology and how they are being handled. One such problem has to do with the bedrock foundation material. This is a tough siltstone in place before it is uncovered, but it slacks rapidly on exposure and breaks up into a relatively unstable particulate material. Another problem has to do with filling and sealing numerous inoperative oil wells in the area. The article also contains a sketch showing the zoning arrangement in the embankment and describes the material requirements for each zone as well as other construction features.

**Howell, Frank T., and Todd, J. Geoffrey**, GEOLOGICAL INVESTIGATIONS FOR THE MANCHESTER RAPID TRANSIT STUDY: Civil Engineering and Public Works Review, vol. 63, no. 747, p. 1123, 1125-26, October 1968. This is a report describing the geological investigations that were made during preliminary studies for a rapid transit system for Manchester, England. The studies were made for a north-south route some 16 miles long including a 1.5 mile section through the center of the city that was decided would need to be underground. Geologic information obtained early in the studies was from records of borings, excavations and foundation work, geological and mining surveys, and local memoirs. Field and laboratory investigations were carried out later to prove the geological environment in more detail for the underground section of the route. The greater part of the report describes the nature of these later investigations. The report points out that the geological investigations were part of preliminary studies and that the program was not designed to take the place of more detailed investigations for later planning and design.

MOLE SETS FAST PACE IN NEVADA ROCK: Western Construction, vol. 43, no. 12, p. 38-39, 52, December 1968. This article describes the rotary mining machine and the excavation operations being employed in excavating the River Mountains Tunnel in southern Nevada. This tunnel is the key structure in the Southern Nevada Water Project, a U. S. Bureau of Reclamation Project to supply supplemental water from Lake Mead to Las Vegas, Henderson, Boulder City, Nellis Air Force Base, and other southern Nevada areas. The tunnel when completed will have a lined diameter of 10 feet and a length of nearly 20,000 feet. Rock through which the tunnel is being cut is described as a heterogeneous mixture of rhyolite, decite, tuff, and other igneous rocks of varying hardness.

**Norman, N. E.**, BIG-HOLE DRILLING IS COMING OF AGE UNDERGROUND: Mining Engineering, vol. 20, no. 6, p. 41-46, June 1968. Considerable attention has been given in recent years to rapid excavation methods and equipment, particularly with regard to underground operations. This article examines the use of big-hole drilling machines in the three main areas of big-hole drilling; that is, in the excavation of shafts, in tunnel excavation, and in raise boring. It discusses the advantages and the disadvantages connected with use of the drilling machines in each of these areas and some of the improvements presently needed to bring about their greater use. The article gives the names of some of the manufacturers of these machines, especially those that have been used in tunnelling work, and the names of some of the companies that have made use of them in mining operation.

**Marshall, J. K., Saravanapavan, A., and Spiegel, Z.,** OPERATION OF A RECHARGE BOREHOLE: The Institution of Civil Engineers Proceedings, vol. 41, p. 447-473, November 1968. To the uninitiated, the construction and operation of a recharge well for recharging a ground-water aquifer would appear to be a simple, straightforward matter. This usually is not the case. The paper presented here describes experiences of the Birmingham Racecourse Company at Birmingham, England, with the operation of a deep borehole into a sandstone aquifer that was recharged in winter with water supplied by the City of Birmingham and used in summer as a source of water for irrigation at the racecourse. The license for operating the borehole limited the amount of water that could be taken from it to the volume of water that had been recharged previously into it, but, in spite of the small quantity needed for irrigation, difficulty was experienced in recharging this amount. The paper covers the use made of the borehole over 2½ years, records the recharge performance obtained, and describes the experiments that were made during that period to discover the causes of failure and of methods of improvement in recharge performance.

**Prokopovich, N. P., and Hebert, D. J.,** LAND SUBSIDENCE ALONG THE DELTA-MENDOTA CANAL, CALIFORNIA: Journal American Waterworks Association, vol. 60, no. 8, p. 915-920, August 1968. The Delta-Mendota Canal extends from near the town of Tracy to near Mendota in the San Joaquin Valley of California. Ground-water pumping for irrigation prior to the start of major water deliveries from the canal in 1953 resulted in decline of piezometric levels along the downstream 40 miles of the canal of 90 to 200 feet. The existence of land subsidence in the vicinity of the canal, though, was not recognized during pre-construction and construction surveys. Discrepancies between old and new benchmark elevations and topographic maps were thought to be changes caused by earthquakes. By the time that elevation changes were recognized as being due to land subsidence, the canal had been constructed. No allowances for future subsidence, thus, were included in the design. This article discusses land subsidence along the lower reaches of the Delta-Mendota Canal that has taken place since it was constructed and some of the effects of subsidence on the canal. It also presents a formula for estimating the ultimate future amounts of subsidence along the canal.

**Hoover, D. B., and Dietrich, J. A.,** SEISMIC ACTIVITY DURING THE 1968 TEST PUMPING AT THE ROCKY MOUNTAIN ARSENAL DISPOSAL WELL: U. S. Geological Survey Circular 613, p. 35, 1969. Available from the U. S. Geological Survey, Washington, D. C. 20242. Free. In September and October 1968, the U. S. Army Corps of Engineers made a pumping test of the Rocky Mountain Arsenal Disposal Well near Denver, Colorado. This well had been used to inject about 165 million gallons of waste fluid into Precambrian basement rock 12,000 ft below the surface of the Denver basin. Injection was discontinued in 1966 because of an apparent correlation between injection operations and seismic activity in the area. During the 1968 pumping tests at the disposal well, the U. S. Geological Survey was responsible for monitoring seismic activity in the area of the arsenal and making chemical analyses of the fluids removed. This circular gives the criteria that were established to suspend pumping if anomalous seismic activity occurred during the pumping and describes the monitoring system and operations and the results of the test. During the periods of pumping, seismic activity remained within acceptable limits, and, in the 2½-month period after the start of the test, a larger percent of the earth tremors occurred at the arsenal than in the previous 8-month period. The temperature in the cooled zone at the bottom of the well 2 weeks after pumping stopped was 12 degrees warmer than it was in January 1968. Preliminary chemical analyses of the fluids pumped from the well indicate that very little mixing of the injected waste fluid with connate water had occurred. The circular contains tables listing the hypocenters of tremors in the vicinity of the arsenal during 1967 and 1968 and listing tremors at the arsenal from September 1 to November 15, 1968. The circular uses the term "earthquake" throughout, but, of the 210 events listed as occurring between September 1 and November 15, 1968, only 17 events had Richter magnitudes greater than 1 and only 3 events had Richter magnitudes of 2 or greater. Magnitudes of most of the tremors, or quakes, were less than 1.

**Reese, Lymon C., and Matlock, Hudson,** STRUCTURAL DAMAGE FROM TSUNAMI AT HILO, HAWAII: American Society of Civil Engineers Proceedings, vol. 94, no. HY 4, p. 961-982, July 1968. The catastrophic earthquake that shook Chile late in May of 1960 triggered a series of seismic sea waves that traversed the Pacific and struck the Hawaiian Islands as a destructive tsunami at approximately 1:00 a.m. on the morning of May 23. This tsunami caused extensive damage to the central business district of Hilo, Hawaii. This article describes the tsunami waves, the water heights, the damage that was done, and the conditions that affected the degree of damage. It also presents analyses of selected damage cases. At the end of article is a summary and an evaluation.

**Galley, John E., Editor,** SUBSURFACE DISPOSAL IN GEOLOGIC BASINS – A STUDY OF RESERVOIR STRATA: The American Association of Petroleum Geologists, P. O. Box 979, Tulsa, Oklahoma 74101, 253 p. 1968. Price $12.50. I have not seen this book but the following is quoted from a notice of its publication appearing in the Oil and Gas Journal for November 25, 1968: "The publication of this book by AAPG is a direct outgrowth of a request in 1958 by an agency of the U. S. Atomic Energy Commission for help in certain geologic studies. Request was for the studies of geologic basins in which safe underground disposal of radio-active waste might be attempted on an experimental basis. Emphasis in this collection of papers is on the subsurface disposal of industrial wastes in general."

**Voloshin, V., Nixon, D. D., and Timberlake, L. L.,** ORIENTED CORE: A NEW TECHNIQUE IN ENGINEERING GEOLOGY: Bulletin of the Association of Engineering Geologists, vol. 5, no. 1, p. 37-48, Spring 1968. This paper deals with the use of a modification of the Christensen-Hügel Orienting Core Barrel by geologists for the State of California Department of Water Resources in core drilling operations at two projects on the West Branch of the California Aqueduct, the Oso Pumping Plant and the Pyramid Power Plant. The paper describes the orienting core barrel, its operations, and its application at the two projects in determining the geologic structure and the dip and the strike of beds. Knowledge of the geologic structure and of the dip and the strike of the bedrock strata was extremely important at both of these projects in designing excavations for slope stability.

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## William I. Gardner Retired 28 February

Dr. William I. Gardner

Dr. William I. Gardner, a consultant to 11 nations on 3 continents during a 35-year engineering career, retired 28 February, as Chief of the Division of Engineering Geology at the Bureau of Reclamation's Denver Engineering and Research Center. He joined the Bureau in 1936, and has been chief of his division since 1963.

During his Federal Government service, he supervised construction geology work on a dozen Bureau of Reclamation dams, including Friant, Shasta, and Keswick, as part of the Central Valley Project in California.

Each year since 1965, Dr. Gardner has performed special geologic planning functions for the massive Pa Mong Project on the Mekong River in Thailand and Laos. A multiple-purpose project that will dwarf the Columbia Basin Project in the United States, Pa Mong will provide hydroelectric power, make possible irrigation development, and produce flood control benefits for parts of four countries in Southeast Asia.

Dr. Gardner also has participated in geological work for water development studies in the Philippines, on the Blue Nile Basin in Ethiopia, in Korea, and in Nigeria.

As a consultant for United States engineering firms, he worked on projects in Venezuela, India, Taiwan, Iran, Peru, and Iraq.

Dr. Gardner was geologist on California's Central Valley Project from 1936 until 1942, when he became Regional Geologist for the Bureau of Reclamation's Region 2 Office. That region includes most of California and parts of Oregon and Nevada.

He is a member of numerous professional societies and organizations, and is a founder of the Association of Engineering Geologists. He is Associate Editor of the Geological Society of America; a member of the House of Society Representatives for the American Geological Institute; a member of the International Commission on Large Dams, and of the International Commission for Irrigation and Drainage.

He also is a member of the United States National Committee for Rock Mechanics, of the National Research Council, the National Academy of Sciences, and of the Ad Hoc Advisory Committee to the Secretary of Interior on Geological-Seismological Factors at Nuclear Reactor Sites.

A registered Professional Engineer in the State of Colorado, Dr. Gardner is a member of Sigma Xi, and of Sigma Gamma Epsilon.

His Bureau of Reclamation career includes geologic supervision during the construction of Shasta, Keswick, Friant, Trinity, Whiskeytown, Lewistown, San Luis, Monticello, Spring Creek, Vaquero, Cachuma, and Casitas Dams, all in California.

As head of the Division of Engineering Geology, Dr. Gardner was responsible for geological matters in the investigation, design, and construction of all major Bureau of Reclamation structures and projects.

**Two GSA Publications in Engineering Geology Now Available**

Reviews in Engineering Geology, Volume II is the second in a series of volumes prepared by the Division on Engineering Geology, Geological Society of America, designed to summarize the states of knowledge on various aspects of the application of geology to engineering problems. Through an unfortunate series of delays, publication of the book was delayed several years beyond the completion of the contained papers. The geologic principles are still sound, however, and are certain to be useful to the practicing engineering geologist. Nine papers review the following subjects: foundations for heavy structures; geology and pedology in highway soil engineering; clay as a canal sealeant; portland cement and concrete; pozzolan; geocryology and engineering; land subsidence due to withdrawal of fluids; land subsidence due to the application of water; and geologic settings of subsidence.

Case Histories #7, is the seventh volume in the Case History series of the Division on Engineering Geology of the Geological Society of America, initiated in 1957. Each succeeding volume has enjoyed increasing acceptance as an aid in the teaching and practice of engineering geology. Volume 7 deals with the legal aspects of geology in engineering practice. Of the ten papers, one presents general advice to the engineering geologist who may be called on to act as an expert witness. The others summarize actual court cases where geology has played a significant part in litigation.

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