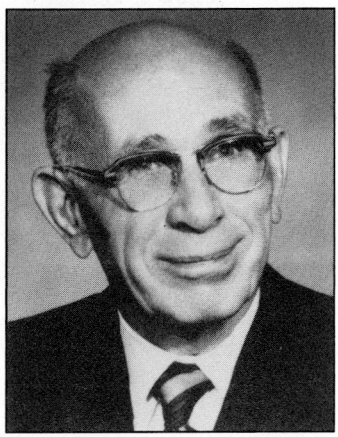
Memorial to Charles Vernon Theis 1900–1987

ROBERT R. WHITE
Albuquerque, New Mexico



C. V. Theis made great contributions to the study of ground water during his long career with the U.S. Geological Survey. His 1935 paper on the analysis of well data obtained under nonequilibrium conditions revolutionized the science of ground-water hydrology; the "Theis equation" has been widely used since that time. He was not a theoretician at heart; he was well-grounded in math, physics, geology, and engineering, but his research interests grew out of field experience and were directed toward the resolution of field problems. He was small, wiry, and intense; he was sometimes diffident but always candid; he was always willing to offer assistance to co-workers and students, but he could be critical of sloppy thinking. He had that wonderful combination of a brilliant mind and a great sense of humor.

Charles Vernon Theis was born on March 27, 1900, in Newport, Kentucky. He graduated from Newport High School at the age of 16, but not having enough money to attend college and not knowing what he wanted to study, he went to work as an office boy.

In the autumn of 1917, C. V. entered the civil engineering department at the University of Cincinnati, which offered a course of study involving co-op work. During his first year of work in the co-op program, he was a carpenter's assistant at the Englewood Dam site (north of Cincinnati on the Miami River); his last three years of co-op work were with the Bridge Section of the Kentucky Highway Department at Frankfort. In his third year at the University of Cincinnati, C. V. was elected to Tau Beta Pi, the honorary engineering society.

C. V. received his civil engineering degree in 1922. Soon after his graduation, he was offered an assistantship in the geology department at the University of Cincinnati. He thought that he would take this opportunity to learn enough geology to work with foundations or tunnels or some other aspect of engineering in which geology would be a help. His interest in geology, however, soon caused him to change the direction of his career.

In 1927, C. V. received a summer appointment with the U.S. Geological Survey to work with Arthur A. Baker near Moab, Utah. After he received his Ph.D. in June 1929 (the first doctorate in geology awarded by the University of Cincinnati), he began work for the Corps of Engineers as a junior geologist. He later applied for advancement to the level of assistant geologist (at $2,600 per year), and eventually he was offered a position at that level with the Ground Water Division of the U.S. Geological Survey. He began duty with the Survey on July 1, 1930, on a basis that he later described as "forever."

C. V.'s first assignment with the USGS was a ground-water study of 12 counties in south-central Tennessee. At the end of the 1930 field season, he went to Washington to work on his report. This project was not funded for 1931, so he was sent to eastern New Mexico to do a ground-water study in Roosevelt and Curry counties, with emphasis on the Portales area. He soon found that he very much liked working in New Mexico; in particular, he liked the dry climate.

C. V. did considerable field work from 1932 to 1934 on the High Plains of eastern New

Mexico and western Texas. When he tried to analyze aquifer tests, he found that the methods then available were very unsatisfactory. By early 1934, he was trying to develop a theoretical equation that could be used to ascertain aquifer characteristics with the nonequilibrium conditions that were observed during aquifer tests on the High Plains. He finally developed a clear conception of the physical process, but he had trouble deriving the necessary equations.

In December 1934, C. V. wrote to Clarence I. Lubin, an old friend at the University of Cincinnati, regarding the mathematics of the problem, stating in his letter, "The flow of ground water has many analogies to the flow of heat by conduction." On his way to Washington, D. C., in January 1935, C. V. stopped in Cincinnati to discuss his nonequilibrium work with Lubin. Within a day or two, Lubin had worked out the mathematics of the problem, based in great part on equations published in H. S. Carslaw's book, *Introduction to the Mathematical Theory of the Conduction of Heat in Solids* (1921). C. V. spent the spring of 1935 working on a paper that would relate the heat-flow equations to ground-water problems (Lubin declined to be coauthor, stating that his contribution to the work had been minor). In April, C. V. presented his findings at a conference of the American Geophysical Union, and they were published later that year in the *Transactions* of that organization.

C. V. published his work in *Economic Geology* in 1938 and in *Civil Engineering* in 1940. With publication in three prestigious journals in five years, C. V.'s ideas were given wide distribution, and the "Theis equation" was soon widely used in the analysis of aquifer characteristics. The publication of these papers revolutionized the science of ground-water hydrology.

C. V. was appointed district geologist of the Ground Water Branch in New Mexico in 1936. He continued his project work, particularly the Rio Grande Joint Investigation, which was an intensive study of the river done in cooperation with other agencies.

C. V. married Gladys Huling in October 1927. They had one child, Marilyn. Gladys was an artist who was listed in *Who's Who in American Art* from the 1930s through the 1950s. C. V. and Gladys developed an interest in Indian art and became friends with Maria Martinez, the famed potter of San Ildefonso Pueblo, New Mexico. They acquired several examples of Maria's work, and when Maria's husband, Julian, died in 1943, he was buried in C. V.'s tuxedo.

During World War II, C. V. spent much of his time in work related to the war effort. In February 1943, he went to Washington for five months to coordinate ground-water studies for the Military Geology Unit. From October 1943 until March 1944, he worked with the Corps of Engineers to develop water supplies for military bases along the Alaska Highway; he also turned his attention to permafrost problems. C. V. enjoyed saying that as a reward for spending one of the hottest summers on record in Washington, he was sent to Alaska for the winter.

Upon returning to New Mexico in the spring of 1944, C. V. resumed his duties as district geologist. For about three years, however, beginning in the middle of 1945, he also spent part of his time doing research on mine drainage and the relation of ground water to ore deposits in the Iron River area in Michigan. During the late 1940s, he also spent part of his time considering water-supply and radioactive-waste problems at the nuclear research facility at Los Alamos, New Mexico.

In January 1951, C. V. was asked to assume responsibility for coordinating all USGS work for the Atomic Energy Commission (AEC). He accepted the offer, but only on the condition that the work be done out of Albuquerque; he expressed opposition to moving to Washington under any conditions. His leadership of the work of the Survey on behalf of the AEC not only heightened his interest in problems of mass transport by ground water, but also led to his service on a committee established by the National Academy of Sciences–National Research Council at the request of the AEC to advise on research and development related to underground disposal of radioactive wastes. C. V. participated in the work of this committee from 1955 until the early 1970s.

In 1957, C. V. was reassigned to the Office of the Division Chief (although his duty station remained in Albuquerque), and was asked to do advanced research in hydrology. Much of his time was spent considering the hydrologic aspects of nuclear-energy research and development, but he also cooperated in the publication of several papers on new techniques in aquifer tests. His experiences at this time led him to comment that for the first half of his career he concentrated on the development and acceptance of the nonequilibrium flow concept, and for the last half he attempted to prevent the abuse of his brainchild.

From 1961 to 1964, C. V. took several months leave each year to teach graduate a course in ground-water hydrology at Columbia University in New York. During the mid-1960s, he was also a faculty associate in the geology department at the University of New Mexico, but this position did not include regular teaching duties.

In 1965, C. V. was asked to serve on a Committee on the Redefinition of Ground-Water Terms. This occupied his attention for some years and led to his work on a paper in which he attempted to clarify the definition of "aquifer" and introduced a new term, "hydropher," which he restricted to the saturated part of an aquifer. This paper was published posthumously in U.S. Geological Survey Water-Supply Paper 2415.

At the normal retirement age of 65, C. V. received an appointment as a Division scientist and was asked to do "whatever research you consider to be most important in fulfilling the Division's current and long-range objectives." Five years later, in 1970, he officially retired, but he kept going to the office every day to work on things that attracted his attention. During the early 1970s, he spent considerable time on the problem of aquifer anisotropy. He lectured on this subject and prepared a manuscript, "A Primer on Anisotropy." which was first published in USGS Water-Supply Paper 2415.

By the mid-1980s, C. V. had begun to decrease his work schedule, but only within the last six months of his life did illness prevent him from going to his office. Even then he continued to devote his diminishing energies to his chosen field of science, using a tape recorder to dictate comments on various research interests only a few weeks before his death. He died on July 31, 1987.

C. V. made enormously important contributions to the field of hydrology early in his career and continued to make significant contributions throughout the rest of his life. The number of honors bestowed on him by scientific colleagues and by scientific and professional organizations attests as much to his qualities as a human being as to his scientific accomplishments. Various symposia have been dedicated to him, including the annual symposium of the American Institute of Hydrology. He received the Horton Medal from the American Geophysical Union, and the American Institute of Hydrology established, and presents annually, the C. V. Theis Award for outstanding contributions in ground-water hydrology.

SELECTED BIBLIOGRAPHY OF C. V. THEIS

Compiled by Alfred Clebsch

1927 Structural geological map of Henderson County, Kentucky: Kentucky Geological Survey, Series 6, scale 1:63,360.

1928 The filled valleys of western Kentucky [abs.]: Ohio Academy of Science Proceedings, v. 8, pt. 4, p. 178–179.

1931 Some recent studies in evaporation: American Geophysical Union Transactions, 12th Annual Meeting, p. 220–224.

1932 Equation for lines of flow in vicinity of discharging artesian well: American Geophysical Union Transactions, 13th Annual Meeting, June 1932, p. 317–320.

1934 Progress report on the ground-water supply of the Portales Valley, [Curry and Roosevelt

Counties] New Mexico State Engineer: 11th Biennial Report, 1932–1934, p. 87–108.
1935 The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: American Geophysical Union Transactions, 16th Annual Meeting, v. 16, pt. 2, p. 519–524. [Also published in American Water Resources Association Bulletin, v. 1, no. 3, p. 10–15, 1965; *in* Freeze, R. A., and Back, William, eds., Physical hydrogeology: Stroudsburg, Pennsylvania, Hutchinson Ross Publishing Co., Benchmark Papers in Geology 72: p. 141–146, 1983; *in* Moore, J. E., Zaporozec, A. A., Csallany, S. C., and Varney, T. C., Recent advances in ground-water hydrology: Minneapolis, Minnesota, American Institute of Hydrology, p. xiii–xvii, 1989].
1936 Ground water in south-central Tennessee: U. S. Geological Survey Water-Supply Paper 677, 182 p., 7 pl.
—— Possible effects of ground water on the Ogallala formation of Llano Estacado [abs.]: Washington Academy of Science Journal, v. 26, no. 9, p. 390–392.
1937 Amount of ground-water recharge in the southern High Plains: American Geophysical Union Transactions, 18th Annual Meeting, v. 18, pt. 2, p. 564–568.
1938 The significance and nature of the cone of depression in ground-water bodies: Economic Geology, v. 33, no. 8, p. 889–902.
1939 Earth tides expressed in fluctuations of the water level in artesian wells in New Mexico [preprint]: International Union of Geodesy and Geophysics, Washington Assembly, 11 p.
1940 The source of water derived from wells—essential factors controlling the response of an aquifer to development: Civil Engineering, v. 10, no. 5, p. 277–280.
1941 The effect of a well on the flow of a nearby stream: Eos (Transactions, American Geophysical Union), v. 22, pt. 3, p. 734–738.
1942 (and Morgan, A. M., Hale, W. E., and Loeltz, O. J.) Ground-water hydrology of areas in the Pecos Valley, New Mexico, in Part II, Reports of the United States Geological Survey, Section 2, Geology and ground water, *in* Pecos River Joint Investigation, reports of the participating agencies: Washington, D. C., National Resources Planning Board, p. 38–75.
1944 Thermal processes related to the formation of permafrost: U.S. Geological Survey Open-File Report, 36 p., 1 fig.
1948 (with Stuart, W. T., and Stanley, G. M.) Ground-water problems of the Iron River District [Michigan]: Michigan Geological Survey Technical Report 2, 59 p.
1954 (and Brown, R. H., and Meyer, R. R.) Estimating the transmissibility of aquifers from the specific capacity of wells, *in* Bentall, Ray, compiler, Methods of determining permeability, transmissibility and drawdown: U.S. Geological Survey Water-Supply Paper 1536-I, p. 331–340.
1956 Problems of ground disposal of nuclear wastes, *in* Peaceful uses of atomic energy—Volume 9, Reactor technology and chemical processing: Internation Conference on Peaceful Uses of Atomic Energy, Geneva [United Nations], June 1955, p. 679–683.
1959 The disposal of low and intermediate level radioactive wastes to the ground, *in* Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, on industrial radioactive waste disposal, January 28–30 and February 2–3, 1959, Volume 2: U. S. Congress, 86th, 1st session, p. 1116–1123.
1962 Notes on dispersion in fluid flow by geologic features, *in* Morgan, J. M., Jamison, D. K., and Stevenson, J. D., compilers and editors, Ground disposal of radioactive wastes, 2nd Conference Proceedings, held at Atomic Energy of Canada Limited, Chalk River, Ontario, Canada, September 26–29, 1961: U.S. Atomic Energy Commission, TID 7628, p. 166–178.
1963 Hydrologic phenomena affecting the use of tracers in timing ground-water flow, *in* Symposium on application of radioisotopes in hydrology, Tokyo, March 4–8, 1963,

Proceedings: Vienna, International Atomic Energy Agency, p. 193–206.

—— Chart for the computation of drawdown in the vicinity of a discharging well, *in* Bentall, Ray, compiler, Shortcuts and special problems in aquifer tests: U.S. Geological Survey Water-Supply Paper 1545-C, p. C10–C15.

—— Drawdowns caused by a well discharging under equilibrium conditions from an aquifer bounded by a finite straight-line source, *in* Bentall, Ray, compiler, Shortcuts and special problems in aquifer tests: U.S. Geological Survey Water-Supply Paper 1545-C, p. C101–C105.

—— (with Conover, C. S., and Griggs, R. L.) Geology and hydrology of Valle Grande and Valle Toledo, Sandoval County, New Mexico: U.S. Geological Survey Water-Supply Paper 1619-Y, 37 p.

1965 Ground water in southwestern region, *in* Galley, J. E., ed., Fluids in subsurface environments—A symposium: American Association of Petroleum Geologists Memoir 4, p. 327–341.

1967 Aquifers and models, *in* Symposium on Ground-Water Hydrology, San Francisco, Calif., 1967, Proceedings: American Water Resources Association Proceedings Series, no. 4, p. 138–148.

1971 Preliminary consideration of movement of ground water from infiltration areas on the Llano Estacado, Texas and New Mexico: U.S. Geological Survey Professional Paper 750-B, p. B236–B243.

1972 (with Lohman, S. W., and others) Definitions of selected ground-water terms—Revisions and conceptual refinements: U.S. Geological Survey Water-Supply Paper 1988, 21 p.

1994 A primer on anisotropy, *in* Clebsch, Alfred, editor, Selected contributions to ground-water hydrology by C. V. Theis, and a review of his life and work: U.S. Geological Survey Water-Supply Paper 2415, p. 5–24.

—— Aquifers, ground-water bodies, and hydrophers, *in* Clebsch, Alfred, editor, Selected contributions to ground-water hydrology by C. V. Theis, and a review of his life and work: U.S. Geological Survey Water-Supply Paper 2415, p. 33–37.

The Geological Society of America
3300 Penrose Place • P.O. Box 9140 • Boulder, Colorado 80301

Printed in U.S.A. on Recycled Paper 12/94