Energy Studies

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Newsletter of the Center for Energy Studies of The University of Texas at Austin

Energy Studies reports on activities of the Center for Energy Studies and other energy-related news from The University of Texas at Austin. Subscription is free upon request (six issues a year).

The Center for Energy Studies is a multidisciplinary research center, the central liaison for energy research, education, and public service at The University of Texas at Austin. Dr. Herbert H. Woodson is director.

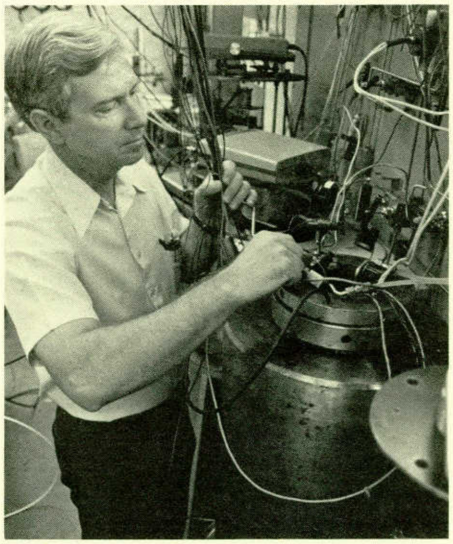
Editor: Jennifer Evans

Creep, Compressibility Differences Emerging in Geothermal Studies

Researchers studying subsurface geopressured formations have learned that these deep rocks behave in unexpected ways.

Not much information existed previously on geopressured rocks, said Dr. Ken Gray, who is director of the UT Center for Earth Sciences and Engineering. Differences in compressibility and creep (rock distortion) are emerging that will affect estimates of the commercial potential of future geothermal wells and perhaps other deep wells.

Dr. Gray's research is part of the overall geothermal research program of the UT Center for Energy Studies and Bureau of Economic Geology. Dr. William T. Thompson, UT associate professor of petroleum engineering, has carried out many of the creep studies. Two research engineers formerly with UT, Pushkar Jogi and Nobuo Morita, also contributed to the work.



Pressure vessels such as this one, being worked on by Charles Stephenson of the Center for Earth Sciences and Engineering, are used to test the properties of geothermal sandstone samples.

The geopressured-geothermal formations that lie along the curve of the US Gulf Coast may some day provide a new source of energy to the country.

Unusual formations. Geopressured formations lie at depths of 12,000 to 15,000 feet and below, deeper than most oil and gas wells. They are unusual in that they are trapped formations in which enormous pressure and heat have built up. They consist mainly of sandstone containing salty water, as well as certain amounts of methane gas, dissolved in the water.

Researchers generally assume that a commercially feasible geothermal reservoir is one that will achieve a production rate of about 40,000 barrels of water per day per well for something like 20 years, Dr. Gray said.

"To be able to predict the economic capacity of the reservoir, you must be able to describe the reservoir physically," he said. Reservoir engineers use measurements taken in the well and data from laboratory tests. From this information they build mathematical models of reservoir performance.

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This process is under way for the three geothermal test wells, Pleasant Bayou Nos. 1 and 2 in Texas and Amoco Fee No. 1 in Louisiana.

Dr. Gray said that the UT studies of rock behavior have turned up nonlinear variations in compressibility, creep, permeability, resistivity, and other factors related to flow rates and reservoir characterization.

"We haven't found a thing about a rock that is constant—not a thing," he said.

The main studies have dealt with compressibility and creep. In a typical lab test of compressibility, salt water and a sample of sandstone are placed in a pressure vessel that simulates geopressured conditions. When the rock has stabilized under the pressure, the fluid is removed systematically, and the changes in the compaction of the sample are measured precisely.

Testing creep. In a test of creep—how much a rock distorts when pressure is reduced—the sample is again put under pressure and allowed to stabilize. Then the pressure is reduced and changes in the rock are measured over time. Many rocks creep quite a lot in the first few hours and less and less as time goes by, but not all rocks follow this pattern.

For compressibility, reservoir engineers have often used a linear, i.e., one-to-one, relationship between pressure and compressibility: for each unit of pressure applied to a rock, the rock will compress one (tiny) unit of volume—no matter the depth, no matter the pressure already on the rock.

Dr. Gray said that geopressured rocks compress significantly less than was anticipated. The initial compressibility for a geopressured reservoir (before production starts) will be about 1 to 10 $\times$ 10^{-6} psi^{-1}, about one-tenth the values commonly assumed.

The studies also indicate that, while the compressibility will start high, it will decline during production to approximately one-third of the initial value. Permeability of the rock is also likely to decline over the lifetime of the well, to a final level of 30 to 50 percent of the original value.

The researchers are now doing rock compaction studies at elevated temperatures (385°F) to see how compressibility and other rock behavior are affected by geopressured temperature.

Subsidence is another concern in the decision to drill and produce a geopressured well.

"If the surface were to subside one inch out in a cow pasture, that wouldn't matter," Dr. Gray said, but if a manmade facility such as a refinery were nearby, one inch of subsidence would cause problems.

Removing tons of salt water from beneath the ground will result in creep and may result in subsidence. Some of the subsidence effect can be offset if the water is reinjected as planned into a shallower, more porous formation.

Creep and subsidence. The creep tests done so far have given unexpected results.

"We knew it would creep—we were astounded at how much," Dr. Gray said. The creep will help sustain the pressure, but overall will have a negative effect on flow because it will decrease the permeability and porosity of the rock. It probably will cause long-term subsidence also.

"We may produce the reservoir for 50 years. It may subside for 200. The truth is, we don't know yet how long or how much it will subside."

More creep studies are needed to follow up on the few that have been done, he said. "Until creep behavior can be predicted over hours, weeks, and months, predictions 50 years and beyond are subject to substantial error."

At present all three geothermal test wells are shut in, with full testing yet to be completed. Congress and the Department of Energy will decide in the next few months whether to do so.

CES Publications

Geopressured Geothermal Bibliography, Second Edition, Vol. 1, Citation Abstracts, Vol. 2, Geopressure Thesaurus

by Kamy Sepehrnoori, Frances Carter, Robert Schneider, Steve Street, and Kira McGill, Vol. 1, 761 pages, Vol. 2, 204 pages.

A computerized data base, the *Geopressured Geothermal Bibliography* is primarily a literature search tool for geopressured-geothermal researchers. About 300 citations have been added in the second edition of the bibliography, bringing the total to more than 1,100.

The bibliography's citations describe journal articles, research reports, conference proceedings, and other publications related to geopressured energy resources. The years covered are 1963 to 1981. Most of the citations contain an abstract, or summary, of the publication cited, and other information, such as how to obtain it.

Quick and accurate searches of the bibliography are made possible by six indices and a thesaurus, which is a list of 3,800 key terms. Each citation is coded for appropriate key terms, and a user can search the data base by means of the key term system.

The development of the *Geopressured Geothermal Bibliography* was funded by the US DOE Division of Energy Technology.

An unbound, computer printout version ($20) is available from the Center for Energy Studies. Bound paper versions (Vol. 1, $54; Vol. 2, $18) and microfiche versions ($4 per volume) are available from NTIS as described in the accompanying box.

Publications List Available

A list of Center for Energy Studies publications can be obtained by writing Publications, Center for Energy Studies, ENS 143, The University of Texas at Austin, Austin, Texas 78712. Many of these publications are available free from the center (in single copies only). Most out-of-print reports can be ordered from the National Technical Information Service, P. O. Box 1552, Springfield, Virginia 22151 (202/487-4600).

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CES Update

Office of Director

Dr. Herbert H. Woodson, director of the Center for Energy Studies, has been selected to receive the **1984 Nikola Tesla Award** from the Institute of Electrical and Electronics Engineers (IEEE).

The award and a $1,000 cash prize will be presented to Dr. Woodson at the winter meeting of the IEEE Power Engineering Society in Dallas February 1.

Dr. Woodson was cited for his "contributions to power generation technology, particularly in superconducting generators and magnetohydrodynamic generators."

A specialist in power systems and electromechanics, Dr. Woodson has written numerous articles and two textbooks on these subjects and holds four related patents. At The University of Texas, he is director of the Center for Energy Studies, director ad interim of the Center for Fusion Engineering, associate director of the Center for Electromechanics, and a professor of electrical engineering. He holds the Ernest H. Cockrell Chair in Engineering.

Dr. Woodson is a member of the National Academy of Engineering and has received other awards, including the Outstanding Power Engineering Educator Award from the Edison Electric Institute and the Joe J. King Professional Engineering Achievement Award from The University of Texas.

The Tesla Award is named after the Yugoslav-American inventor Nikola Tesla, who originated the induction motor and the multiphase alternating current system for electricity that is the standard today.

Nuclear Studies

Nuclear Studies Division researchers have identified and tested a substance that allows **traces of heavy elements in water to be more accurately measured.**

In the project, researchers experimented with trace amounts of uranium, thorium, copper, vanadium, molybdenum, zinc, selenium, arsenic, and lead.

Dr. Dale Klein, head of the division and of the UT Nuclear Engineering Teaching Laboratory, said that the substance is a synthetic organic compound. It can be used in environmental monitoring of water, in exploring for uranium deposits, and in checking human urine for radioactive trace elements.

The compound is called APDC, which stands for ammonium 1-pyrrolidine-dithiocarbonate.

Dr. Klein said that the technique for using APDC is simple and appears easy to adapt from the laboratory to the field.

The researchers studied concentrations of 0.2 to 200 parts per billion of the elements studied. These are significant levels but extremely dilute, Dr. Klein said, "pushing the limits of detection." In fact, the levels were so low that natural background radiation interfered, and a lead shield was constructed.

Previous work carried out by Mr. Andre H. Pradzynski, a radiochemist formerly in the Nuclear Engineering Teaching Laboratory, first indicated that APDC was effective in precipitating (removing) heavy elements for the purpose of analysis by X-ray fluorescence spectroscopy.

The most recent APDC project, supported by the Center for Energy Studies and carried out in the lab, was the thesis project of mechanical engineering graduate student Mohammed Ally, supervised by Dr. Klein. This research demonstrated that APDC also performs well with another leading form of trace element analysis, instrumental neutron activation analysis.

In the laboratory tests APDC, combined with a zirconium carrier, was found to be effective as a reagent for precipitating these heavy elements from water. Precipitation is important because it gathers and concentrates the otherwise extremely dilute contaminants. The more effective the precipitate, the more accurate the final measurement, Dr. Klein said.

Other concentration methods—such as evaporation, filtration, or solvent extraction—are not sensitive enough.

In each test, measured amounts of all the contaminants were added to a container of pure, deionized water. The pH of the solution was adjusted, the precipitating material stirred in, and the mixture left to settle. The solution was filtered. The thin layer of residue left on the filter was air dried and then analyzed by one of the two measurement techniques. The final measurement was compared with the original concentration to determine its accuracy.

APDC extracted each of the nine heavy elements, leaving less than 1/10 of a part per million of each. Five other organic reagents studied performed much less effectively. Their detection limits were found to be in the parts per million range.

Conservation and Solar Energy

Dr. Bruce Hunn, head of the Conservation and Solar Energy Division, will give a CES Energy Briefing at 4 p.m., December 7, in Welch 2.312. The topic will be **"Passive/Hybrid Solar Heating, Cooling, and Lighting of Buildings: Designing with the Climate."** The public is invited to attend.

Separations Research Program

A formal **research participation agreement** for the Separations Research Program was approved September 23 by the UT Austin administration.

Dr. Jimmy L. Humphrey, program manager, said the agreement has been mailed to companies that have expressed interest in sponsoring the new program.

The aim of the Separations Research Program is to carry out research on separations processes of

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interest to industry. The program will start in January. The first meeting of sponsors and researchers will occur February 9–10.

The research participation agreement outlines the relationship between the university and the sponsoring company. On patents and inventions, it states that sponsors shall be granted a worldwide, royalty-free, nonexclusive license to make, sell, or use inventions, software, and other items developed in the program during their participation period.

Dr. Humphrey said that any company seeking information about the Separations Research Program may contact him (512/471-4946; Center for Energy Studies, ENS 143, The University of Texas at Austin, Austin, Texas 78712).

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Two Separations Research Program researchers have won awards from the American Chemical Society.

Dr. Allen J. Bard, the Norman Hackerman Professor of Chemistry at UT, is the 1984 winner of the ACS Award in Analytical Chemistry.

Dr. Donald R. Paul, the T. Brockett Hudson Professor and chairman of chemical engineering at UT, was honored with the Award in Applied Polymer Science.

The awards will be presented in April in St. Louis at the society's 187th annual meeting.

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A visiting scholar from Germany, **Dr. Heinz Finken,** has joined the Separations Research Program. He will be with the program for a year, doing fundamental research in gas separations by membranes.

UT Austin Energy

Center for Electromechanics Wins IR 100 Award for Homopolar Generator

The compact pulsed homopolar generator, a new technology developed out of the fusion energy research program at The University of Texas at Austin, has been selected as one of the 100 most significant technological advances of the year by *Industrial Research & Development* magazine.

The award winners were announced at a banquet September 22 at the Chicago Museum of Science and Industry. Among the other organizations with winning products are Dow Chemical Company, Fermilab, the National Aeronautics and Space Administration, Rockwell International, and Westinghouse Electric Corporation.

UT Austin's compact pulsed homopolar generator is a new technology capable of supplying pulsed power at very high levels—hundreds of megawatts for a second or less, depending on the application.

It was developed by engineers at the UT Center for Electromechanics. Technical director of CEM is William Weldon. The Center for Electromechanics is a part of the UT Bureau of Engineering Research.

In April 1983, the UT System Board of Regents agreed to license the homopolar generator to OIME Inc., of Odessa, Texas.

Because the compact pulsed homopolar generator produces very high current, pulsed electrical discharges, it has applications for any repetitive process that requires substantial bursts of energy. It might be used in areas such as the railroad, automotive, steel, electric power plant, and pipeline industries.

"The homopolar generator has the potential for making a number of industrial processes less expensive," said Mr. Weldon.