

Name: Dr. Sabodh K. Garg

Position: Vice President, Reservoir Engineering

*Technical Expertise: Geothermal Reservoir Engineering
Geothermal Resource Evaluation
Computer-Based Modeling
Well Test Analysis*

E-mail: SGarg@geologica.net

Mobile: +1-858-205-5108

EXPERIENCE SUMMARY

Dr. Sabodh K. Garg joined Geologica in January 2019. Prior to that, he was a Project Manager with Leidos, Inc. and predecessor companies from 1969 to 2018 (SAIC, Maxwell Technologies, S-Cubed). He has been an active participant in geothermal R&D since the mid-1970's and specializes in geothermal reservoir engineering, geophysical survey interpretation, resource assessment, and development planning. He has carried out technical studies in geothermal reservoir mechanics, pressure transient analysis, multi-phase non-isothermal flow, rock mechanics, and the behavior of geopressed reservoirs. He was principal investigator on a multi-year U.S. Department of Energy (DOE)-funded project to evaluate the utility of exploration surveys to characterize geothermal reservoirs: results show that a suite of carefully designed electrical surveys can often be used to infer subsurface conditions in a geothermal reservoir. For the past several years he has been engaged in providing advisory consulting services for purposes of geothermal resource assessment and capacity estimation for various project developers and financial investors. He has been a member of the Board of Editors of *Geothermics* (the industry technical journal) since 1998 and served as the journal's Editor-in-Chief from 2008 to 2010. Between 1990 and 1993, he was a member of the Board of Editors of *Energy Sources*. From 2005 to 2008, he was a member of the OCRWM OST&I Natural Barriers Thrust Area Project Review Panel. Between 1990 and 1993 he served on the U.S. National Academy of Sciences panel on Coupled Processes at the Yucca Mountain Nuclear Waste Repository. He also served on DOE review panels for the Baca Geothermal Reservoir project (1980-1981) and the Hot Dry Rock project (1986). He is a member of the American Geophysical Union, Society of Petroleum Engineers, and the Geothermal Resources Council (GRC).

EXPERTISE

Geothermal Well Test Planning and Analysis
Data Synthesis and Conceptual Modeling
Natural State Modeling, History-match, and Forecast
Geothermal Reservoir Assessment
Rock Mechanics
Natural Gas Hydrates

EDUCATION

Ph.D. in Engineering Science & Mechanics 1965, University of Florida, Gainesville, FL.
M.S.E. in Engineering Mechanics 1962, University of Florida, Gainesville, FL.
B.A. (Hons.) in English and Mathematics 1960, Panjab University, India

AWARDS

GRC Special Achievement Award (2001)
GRC Joseph W. Aidlin Award (2003)
GRC Hank Ramey Reservoir Engineering Award (2017)

PUBLICATIONS

Dr. Garg is the author of over 150 technical papers, one book (Analysis of Structural Composite Materials, Marcel Dekker, New York, 1973), and one patent. List is available upon request.

REPRESENTATIVE PROJECT EXPERIENCE**DOMESTIC U.S. CLIENTS****U.S. Department of Energy**

Period of Performance: 2014-Present

Place of Performance: U.S.A.

Project Description: Under a co-operative agreement with the U.S. Department of Energy (DOE), Utah State University is carrying out a research program to identify promising geothermal prospects in the Snake River Plain (SRP) volcanic province. The goals of this Phase 1 study are to: (1) adapt the methodology of *Play Fairway Analysis* for geothermal exploration, creating a formal basis for its application to geothermal systems, (2) assemble relevant data for the Snake River Plain volcanic province from publicly available and private sources, and (3) build a geothermal play fairway model for the Snake River Plain that will allow the delineation of the most promising plays, using software tools that are standard in the petroleum industry.

U.S. Department of Energy

Period of Performance: 2014-2018

Place of Performance: U.S.A.

Project Description: Geothermal energy production by water circulation in natural and/or man-made fracture systems is referred to as enhanced or engineered geothermal systems (EGS). The permeable zones of an EGS must be created by stimulation, a process which involves fracture initiation and/or activation of discontinuities such as joints by pore pressure and stress



perturbations. The stimulation of a rock mass is often accompanied by multiple microseismic events (micro-earthquakes, or MEQs) which are responsible for detectable acoustic emissions (AE). To study this process on laboratory scale, we (University of Oklahoma and Leidos Inc.) performed reservoir stimulation using 13x13x13 inch pre-heated cubical rock samples under representative *in-situ* stress regimes. The data collected were then analyzed to develop a better understanding of the fractures and the induced fracture permeability and fluid/heat flow.

U.S. Department of Energy

Period of Performance: 2010 – 2013

Place of Performance: USA

Project Description: The principal objective of this project was to develop an advanced simulator for (1) predicting the response of an EGS reservoir to hydraulic stimulation, and for (2) modeling the behavior of the reservoir to long-term injection and production operations. Secondary objectives included the development of interpretation techniques for characterizing fractures based on tracer test data, and various surface and downhole measurements.

Idaho National Laboratory (U.S. Department of Energy)

Period of Performance: 2004 – 2007

Place of Performance: USA

Project Description: The utility of electrical surveys for geothermal reservoir characterization was tested using existing reservoir and exploration data sets from the Beowawe geothermal field, located in north-central Nevada. A geothermal reservoir simulator was used to model the quasi-steady natural state, and the DC, MT and SP response corresponding to available survey data. The results support the view that a suite carefully designed of electrical surveys (DC, MT, and SP) may be employed to infer subsurface geothermal reservoir characteristics.

Gradient Resources Inc. (Previously Vulcan Power Company)

Period of Performance: November 2008 – 2014

Place of Performance: Nevada

Project Description: Gradient performed a program of geothermal resource exploration at the Salt Wells and Patua geothermal prospects in Nevada that has included geological and geophysical surveys, exploration well drilling and well testing. As Gradient's Independent Engineer, LEIDOS was responsible for advising Gradient on well testing, and for preparing Resource Reports for review by Gradient's Board of Directors and investors.

Merrill Lynch Commodities, Inc.

Denham Capital Management LP

Period of Performance: 2007 – 2008

Place of Performance: Nevada, Oregon, California

Project Description: Assisted Merrill Lynch and Denham in performing due diligence prior to their equity investments in Vulcan Power Company. LEIDOS reviewed geothermal resource data and reports provided by Vulcan and those available in the public domain.



INTERNATIONAL CLIENTS:**Güris, Turkey**

Period of Performance: 2016 – 2018

Place of Performance: Turkey

Project Description: Güris A.Ş. (Güris) is developing the Germencik geothermal license area that is located near Germencik, Aydın, Turkey. Güris has developed several power plants, binary and flash systems, with a total capacity of 162.5MWe. Our team (Geologia Geothermal Group and Leidos) provided engineering and consultancy service for numerical reservoir modeling of the Germencik Geothermal Reservoir.

ENAL, Mexico

Period of Performance: 2013-2015

Place of Performance: Mexico

Project Description: ENAL is developing the San Pedro Geothermal field. Leidos performed a Geothermal Resource Assessment including evaluation of geothermal reservoir characteristics and capacity required to supply geofluid to Phase I 30 MWe project. Activities included analyses of field data, development of conceptual and 3 D numerical models, and training of ENAL staff in reservoir engineering and simulation

J-Power, Japan

Period of Performance: January 2009 – December 2009

Place of Performance: Japan

Project Description: J-Power and Mitsubishi Materials Corporation have formed a joint venture to develop the Wasabizawa-Akinomiya geothermal field, Japan. Reviewed the existing dataset (geological, geochemical and geophysical surveys, exploration well drilling and testing), and developed conceptual and detailed numerical models of the geothermal field. The numerical model has been used to forecast the electrical generation capacity of the geothermal field.

Zorlu, Turkey

Period of Performance: January 2009 – 2015

Place of Performance: Turkey

Project Description: Zorlu has redeveloped of the Kizildere geothermal field, Turkey. Leidos as part of a multi-organization team (Power Engineers, Veizades Associates, Geologica, Cumming Geoscience, Apex, Leidos) was tasked by Zorlu to prepare a comprehensive report (including reservoir modeling, surface facilities, and power plant design) for the development of the Kizildere field.

Contact Energy, New Zealand

Period of Performance: 2007 – 2010

Place of Performance: New Zealand

Project Description: Contact Energy is considering additional development of the Wairakei-Tauhara geothermal field. Leidos performed Peer Reviews of the resource data and reports provided by Contact, and provided an independent opinion on the adequacy of the geothermal resource to provide hot fluid for the new power plants.



Mighty River Power, New Zealand

Period of Performance: 2006 – 2009

Place of Performance: New Zealand

Project Description: Leidos was retained to perform Peer Reviews of the resource data and reports for several projects. In each case, Leidos provided an independent opinion on the adequacy of the geothermal resource to supply the power plant.

