

JILL ROBINSON HAIZLIP – GEOTHERMAL RESOURCE SPECIALIST

Geologica Inc., President and Principal Geochemist (based in San Francisco, California, USA)

Jill Haizlip has over 30 years of professional experience in the fields of geothermal resource exploration, assessment and development. She has applied expertise in aqueous geochemistry and geology on a variety of geothermal projects at all stages of development as well as water supply, environmental assessment, and surface and groundwater investigations. She is an expert in geothermal exploration, well testing, geothermal plant chemistry, water sampling, water quality data evaluation—particularly as it relates to establishing the hydrogeological and geochemical characteristics and relationships between geothermal fluids, surface manifestations and cold water systems and understanding the character of a geothermal system based on the chemistry of these components in the system. Ms. Haizlip has applied her experience working in numerous aspects of geothermal reservoir evaluation including well targeting, well testing, well test analysis and conceptual and numerical modeling leading to a successful record of quantitative resource assessment, resource development planning and reservoir management for sustainable geothermal fluid supplies. Her expertise in chemistry of geothermal fluids and natural waters has been applied frequently in the assessment of geothermal resources, geothermal development effects, and geothermal and hydrological issues such as: non-condensable gas loading, scaling and corrosion potential, air emissions, hydrogen sulfide abatement, steam treatment and other geochemical considerations of geothermal development.

Ms. Haizlip has managed numerous comprehensive geothermal resource exploration, assessment, and development planning projects, including resource capacity, production and injection plans. Working on many aspects of geothermal development from early exploration to operations and closure and from the wells through the plant, Ms. Haizlip brings a practical understanding of geothermal development to the team. In addition to this practical approach, because she has worked in operating fields for a geothermal developer as well as a consultant for private energy developers, financial institutions and governments around the world, she has also developed a multi-faceted and international perspective. She has been working on geothermal resource investigations and assessments in Turkey since 2004, primarily in the Menderes and Alasehir Grabens and Biga Peninsula, with other extensive involvement in geothermal systems in the US including in the Geysers, Nevada, and elsewhere in Western US and around the world in Africa, Indonesia, Pacific and Caribbean Islands, and Central and South America.

She received a B.Sc. from Middlebury College and a M.Sc. from Columbia University, both in Geology.

- 1. Date of birth: 22 April 1955**
- 2. Nationality:** United States
- 3. Civil status: US Citizen**
- 4. Education:**

<i>Institution</i>	Columbia University, NY
<i>Date:</i>	1980
<i>Degree(s) or Diploma(s) obtained:</i>	M.Sc. Geology

<i>Institution</i>	Middlebury College, VT
<i>Date:</i>	1976
<i>Degree(s) or Diploma(s) obtained:</i>	B.Sc. Geology (Cum Laude)

5. Language skills: (Mark 1 to 5 for competence, 5 being the highest)

<i>Language</i>	<i>Reading</i>	<i>Speaking</i>	<i>Writing</i>
English	5	5	5

6. Membership of professional bodies:

- Geothermal Resources Council, member since 1981;
- Journal Review Board-Geothermics since 2012;
- Technical Advisory Board for GeoTek Energy;
- Publications List attached.

7. Present position: Geologica Geothermal Group Inc., President and Principal Geologist/Geochemist

8. Years within the firm: 16 years

9. Key Project Experience:

Geothermal Geochemistry and Resource Evaluation for Domestic US Geothermal Projects

- Resource evaluation and reservoir management support using fluid chemistry and production and injection data, including tracking of injection fluids and changes in reservoir chemistry in the **Salton Sea Geothermal Resource** for CalEnergy Operating Corporation.
- Using fluid chemistry and production and injection data from steam and two-phase wells, evaluate reservoir conditions in support of resource management, including tracking of injection fluids, boiling and reservoir saturation in the **Coso Geothermal Resource** for Coso Operating Company/TerraGen and the U.S. Navy Geothermal Program Offices
- Resource evaluation of the decommissioned PG&E Unit 15 area at The Geysers, CA using geochemistry, mass flow, enthalpy and noncondensable gas projections, corrosion potential of steam supply for various development scenarios for Western GeoPower Inc.
- Reservoir evaluation for a 3 MW project, ongoing technical support for fluid chemistry and scaling issues, Paisley, Oregon for Surprise Valley Electric Company.
- Performed a state-wide survey of geothermal potential in **Arizona**. Collected geochemical samples, reviewed available data and provided a preliminary resource review of **Clifton Hot Springs, Arizona** for Arizona Public Service (APS)/Salt River Project; update in 2015 for APS.
- Performed a preliminary geothermal resource assessment of Allied Nevada Gold properties throughout **Nevada**. Supported Allied Nevada's geothermal leasing program. Performed geothermal exploration activities at an active gold mine in Nevada.
- Performed a data review and preliminary resource assessment of the Star Peak-Rye Patch-Humbolt House geothermal resource area **Humbolt County, Nevada** for Presco Energy.

- Evaluated geothermal resource assets of a 24 MW project in Nevada and a 20 MW project in Hawaii in support of financial valuation of geothermal investment for an equity investment companies.
- Performed a geochemical survey collecting fluid samples from hot springs and multiple lease areas in Salt Wells and Patua **Nevada**, analyzed analytical results for resource potential for geothermal power generation for Vulcan Power.
- Collected fluid and gas samples during flow tests of geothermal wells for evaluating geothermal contributions to fluid flow in **Newberry, Oregon**.
- Assessed, tested and developed mitigation of corrosion and scaling of surface geothermal fluid handling facilities including turbine corrosion, carbonate and silica scaling, and stress corrosion cracking related to impurities of natural geothermal fluids including volatile HCl in **The Geysers, CA**. Projects included identifying the source of corrosion, scaling potential, designing and testing solutions such as steam scrubbing, separator modifications, scale inhibitor injection and scale mitigation programs.
- Performed preliminary resource assessment for direct use geothermal development at two locations in **Cascade Valley, Idaho** including potential well locations as subcontractor to SPF Engineering.

Geothermal Geochemistry and Resource Evaluation for International Geothermal Projects

- Providing project management, resource evaluation and testing, well targeting and project oversight and procurement for an exploration drilling program in the Fiale Caldera, **Djibouti** (2015 to present) located in a challenging high-temperature high salinity volcanic environment.
- Providing resource assessment, exploration planning, power plant design criteria and well targeting for a geothermal development project in **Nevis, Caribbean Islands**.
- Lead Geochemist for the Suswa Geothermal Exploration and Well Targeting Project performed in **Kenya** cooperation with GDC and funded by ICEIDA-NDF. Geochemical investigations included sampling and analysis of surface manifestations and CO₂-flux and shallow temperature surveys. The exploration team presented the results in a Peer Review forum with the UN-funded ARGeo program in Tanzania and the first exploration wells in Suswa were targeted and drilling is planned for 2017.
- Managed and provided lead geochemistry for a geothermal resource assessment of a geothermal license area in **Western Turkey**, north of the Gedis Graben. Integrated the results of geophysical surveys to develop a conceptual model and locate geothermal test wells.
- Developed, managed and provided lead technical QA/QC and geochemistry for a multi-disciplinary multi-phase investigation of geothermal resource potential, Tutuila, **American Samoa** (2012 to 2016).
- Performed a preliminary resource assessment of 4 adjacent License areas on the southern edge of the **Biga Peninsula, Turkey** including an evaluation of geological, geophysical and geochemical surveys for ABK Enerji (2013-2014).
- Providing ongoing resource evaluation services to Zorlu Enerji for the 35 MW Alasehir Geothermal Power Project in **Manissa, Turkey** 75 MW Kizildere Geothermal Power Project in **Denizli, Turkey** (2009-present). Services provided include pre-feasibility resource assessment, well testing and well test analysis, reservoir conceptual and numerical modeling, project cost estimate, geothermal resource evaluation and development planning feasibility study.

- Provided multiple resource related services to Turcas Enerji related to the assessment and development planning of the Kuyucak geothermal project, **Aydin, Turkey** including: well test analysis, geochemical data interpretation from well tests, conceptual and numerical reservoir modeling for evaluating resource capacity and project financing, for current 16 MW development.
- Provided technical and engineering services to Maspo Enerji for the Manissa-Alasehir-Kavaklidere (MAK) Geothermal Project, **Manissa, Turkey** (2013-present). Services provided included geophysics, geochemical and geologic support for exploration of geothermal resources in the 126 km² MAK area, well siting and well test evaluation and analysis (Phase I, 2013). Recently updated resource capacity estimation, well-field planning and development of design criteria for an initial 10 MW geothermal power plant to be constructed beginning in late 2015. (Phase II, 2014-2015).
- Provided technical support for the well testing and well test analysis of the first well in a new geothermal resource area on the **Biga Peninsula, Turkey** for Transmark Renewables (Jan 2015-present).
- Currently working in the Bozkurt Mountains, south of the **Alasehir-Gediz Graben, Turkey** basin on a 23 MW geothermal development project providing technical support for resource assessment, well testing, conceptual modeling and well field development planning (December 2014 to present).
- Provided due diligence on the resource capacity to sustain existing development and potential for expanded development for a potential investor in Tuzla Geothermal Enerji's 7.5 MW Geothermal Power Project in **Cannakale, Turkey** (2012-2014).
- Provided technical and engineering services to BM Holding Geothermal Group for the assessment of geothermal resources in the Aegean region, **Turkey**, included geothermal resource assessment and preparation and implementing of step-by-step well testing plans including well test analysis, test oversight, wellfield development projections, drilling plans, scale mitigation, non-condensable gas loading, and environmental issues.
- Providing ongoing technical and engineering services to Gurmat Energy for the 45 MW Germencik Geothermal Power Project in **Aydin, Turkey**. Services provided include providing resource and geochemical data and interpretation from well testing for well-field and gathering system design, design and implementation of power plant gathering and injection system, separation station, and vent system, resource assessment, feasibility study and commissioning of multiple power plants.
- Providing ongoing technical and environmental support to the Geothermal Development Company (GDC) of **Kenya** for development of the Menengai Geothermal Prospect as part of a Consortium led by GreenMax Capital, funded by AfDB Bank (2014-present).
- Performed a resource sustainability assessment for due diligence of a 60 MW geothermal project in Nevada as due diligence for a potential buyout. The resource assessment included projecting mass flows, enthalpy for estimating make-up drilling and operations and maintenance issues related to scaling (2015 to present).
- Providing ongoing geothermal power plant technical and engineering services to Kalahari GeoEnergy in Lochnivar, Zambia. Providing exploration and drilling support services and have performed a preliminary geothermal resource assessment for the Lochnivar Geothermal Project in southern **Zambia** (2013-present).
- Performed a resource and environmental assessment proposed 64 MW development met the following IFC investment criteria: (i) successful development; (ii) sustainable operation; and (iii) low environmental and social impacts for Olkaria III geothermal prospect in **Kenya** (2002-2004). Subcontract to GPS.

- Provided geothermal resource and geochemical evaluation services to the Indonesian Petroleum Exploration Company (INPEX) for due diligence in the Sarulla Geothermal License Area in **North Sumatra, Indonesia** (2013 to present). Focus on potential development limitations related to acid fluids, gas, and silica mitigation using gas injection.
- Provided technical services to develop a framework and detailed outline of the criteria for a formal Environmental Impact Assessment (EIA) for Kenya's GDC for geothermal development of the Rift Zone of **Kenya**, partially funded by USTDA (2009). Subcontract to Power Engineers.

Environmental Permitting and Regulatory Compliance for Geothermal Energy Projects in the Imperial Valley and California

- Provided technical support for modification to **Imperial County** APCD Authority to Construct/Permits to Operate resulting from proposed power plant modifications at the **Salton Sea, CA**
- Performed geochemical and hydrogeological data evaluation and reports for the Water Quality Control Board addressing the potential impacts of discharge from the holding ponds in several power plant locations in the **Salton Sea, Imperial County, CA**.
- Hydrological, geochemical and geological evaluation of existing conditions, potential impacts and possible mitigations of expanded geothermal development, **Long Valley-Casa Diablo, CA** BLM (Bishop Field Office)/US Forest Service (Mammoth District) (subcontractor to ESA) for environmental documentation and permitting.
- Provided Hydrologic, Geologic, GeoHazard and Geothermal Resource evaluation of baseline and potential impacts and mitigations for a Programmatic EIS for geothermal leasing in Rose Valley, **Inyo County, CA** for BLM (subcontractor to Power Engineers).
- As part of environmental mitigation and monitoring program for the 260 MW Coso Geothermal Field, physical and chemical aspects of the Coso surface manifestations which include **Coso Hot Springs, Inyo County, CA** fumaroles, steaming ground and mudpots have been monitored twice per year. Collate, assess and interpret the monitoring data and present results in annual reports for the Coso Hot Springs Monitoring Program (2000 to 2009) in compliance with MOA between local Indian tribal leaders and the U.S. Navy.
- Analyzed hydrological, hydrogeological, geological and geochemical environmental impacts of the water extraction and injection of 3000 gpm of water from Rose Valley into the **Coso Geothermal Field, Inyo County, California** on geothermal surface manifestations, and cold groundwater and surface waters. Participated in public meetings and appeal meetings in Inyo County regarding impacts to Coso Hot Springs and Rose Valley (subcontractor to MHA-RMT Environmental).
- Provided geological, geochemical, air quality, and geo-hazard analysis of existing conditions and potential impacts and proposed mitigations for NEPA and NEPA/CEQA documentation of multiple proposed geothermal developments in the Pacific Northwest including **Newberry, Oregon and Canby, California**.
- Performed gas loading, H₂S and other pollutant emission calculations based on historical and recent steam chemistry, mitigation and abatement methodologies and other technical support for the successful application for Conditional Use Permit for a 37 MW geothermal power plant in **Sonoma County, The Geysers, CA**. Recent data collection included sampling, analysis and quarterly reporting for APCD permit compliance, ATC/PTO Permit awarded in June 2009.

- Performed hydrological, geochemical and geological evaluation of existing conditions, potential impacts and possible mitigations of expanded geothermal development, **Long Valley, CA** for NEPA and CEQA documentation and compliance. Provided technical support at public meetings.
- Prepare Engineering Analysis, ATC/PTO for exploration and development wells and a geothermal power plant including detailed monitoring plans for compliance with air quality, construction and other environmental issues for the Air Pollution Control District at **Medicine Lake, Siskiyou County CA**. Provided technical support for defense of permit approvals and CEQA implementation during public appeal hearing process.
- Performed environmental site assessment (ESAs aka Phase I and Phase II Site Investigations), closure and remediation plans, and compliance audits of numerous geothermal power plants and wellfield operations for the purpose of assessing environmental liabilities and regulatory/permit compliance at numerous geothermal development facilities throughout **California and Nevada**.
- Provided technical input, hydrogeological analysis and project management for preparation of Environmental Assessment (EA) documents for NEPA compliance for several federally-funded small power generation projects using new technologies including a **Dixie Valley** “bottoming cycle” and **Steamboat Springs** alternative working fluid projects.

10. Professional Experience Record:

<i>Date: from (month/year) to (month/year)</i>	December 2014 – present* *in late December 2014, Geologica Inc. spun off its Geothermal Group as Geologica Geothermal Group, continuing with the same staff and project
<i>Location:</i>	United States-based with international travel
<i>Company:</i>	Geologica Geothermal Group, Inc. Reference: Mr. Brian Aubry Tel: 415.722-3629/e-mail: baubry@geologica.net
<i>Position:</i>	Principal Geochemist/President
<i>Description:</i>	<ul style="list-style-type: none"> • Provides geothermal resource evaluation, hydro-geochemical and environmental consulting services to the geothermal industry including developers, financial and governmental institutions throughout the world.

<i>Date: from (month/year) to (month/year)</i>	April/1999 – late 2014** **in late December 2014, Geologica Inc. spun off its Geothermal Group as Geologica Geothermal Group, continuing with the same staff and project
<i>Location:</i>	United States-based with international travel
<i>Company:</i>	Geologica, Inc. Reference: Mr. Brian Aubry Tel: 415.597.7883/e-mail: baubry@geologica.net
<i>Position:</i>	Senior Geochemist/Principal

<i>Description:</i>	<ul style="list-style-type: none"> Provides geothermal resource evaluation, hydro-geochemical and environmental consulting services to geothermal, industrial and governmental clients throughout the world.
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<i>Date: from (month/year) to (month/year)</i>	November/1990 – April/1999
<i>Location:</i>	United States-based with international travel
<i>Company:</i>	Dames & Moore. Reference: David Klimberg Tel: 510.595-1421/email: dklimberg@geologica.net
<i>Position:</i>	Senior Geochemist
<i>Description:</i>	<ul style="list-style-type: none"> Provided geothermal resource, environmental and hydro-geochemical consulting services to geothermal, industrial and governmental clients throughout the world.

<i>Date: from (month/year) to (month/year)</i>	June/1990 – April/1990
<i>Location:</i>	United States
<i>Company:</i>	Independent Geochemical Consultant Reference: Mr. Robert E. Tucker Tel: 720-635-7811/e-mail: Robert.tucker@powersolutions.com
<i>Position:</i>	Consultant
<i>Description:</i>	<ul style="list-style-type: none"> Provided consulting services to various clients for geothermal resource assessment and project development, environmental compliance and for solving and implementing solutions to geochemical problems in geothermal operations and development.

<i>Date: from (month/year) to (month/year)</i>	January/1981 – June/1990
<i>Location:</i>	United States
<i>Company:</i>	Geothermal Resources International, Inc. Reference: Dr. Jim Combs Tel: 775-843-8394/e-mail: jimjeany@ix.netcom.com
<i>Position:</i>	Senior Geochemist
<i>Description:</i>	<ul style="list-style-type: none"> Responsible for all geochemical projects and personnel. Managed projects and programs including: supervising up to 6 people; writing reports and proposals for internal, partnership, bank and government funding; planning and budgeting of projects and programs up to several hundred thousand dollars; and interacting with the scientific community.

11. Others:

12. Publications:

J. R. Haizlip, 2016, "Application of geochemistry to resource assessment and geothermal development projects" pp. 77-106 in Geothermal Power Generation Developments and Innovation, edited by Ronald DiPippo, Elsevier-Woodhead Publishing, 787 p.

F. TUT HAKLIDIR, Raziye SENGUN, J. R. HAZLIP, 2015, "The Geochemistry of the Deep Reservoir Wells in Kizildere Geothermal Field (Turkey)," World Geothermal Congress, 10-24 April 2015, Melbourne, Australia

S. K. GARG, J. R. HAZLIP, K. K. BLOOMFIELD, A. KINDAP, F.S.T. HAKLIDIR, and A.GUNEY, 2015, "A Numerical Model of the Kizildere Geothermal Field, Turkey," World Geothermal Congress, 10-24 April 2015, Melbourne, Australia

J. R. Haizlip, Agun Guney, Fusun S.Tut-Halkidir, and Sabodh K. Garg, 2013, "Comparison of Reservoir Conditions in High Noncondensable Gas Geothermal Systems", PROCEEDINGS, Thirty-Eighth Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, February 11-12, 2013, SGP-TR-198.

J. R. Haizlip, Agun Guney, Fusun S.Tut-Halkidir, and Sabodh K. Garg, 2012, "The Impact of High Noncondensable Gas On Well Performance Kizildere Geothermal Reservoir, Turkey" PROCEEDINGS, Thirty-Seventh Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 30 - February 1, 2012SGP-TR-194.

J. R. Haizlip and Fusun S. Tut-Halkidir, 2011, "High Noncondensable Gas Liquid Dominated Geothermal Reservoir Kizildere, Turkey" Geothermal Resources Council Transactions, Vol. 35.

Brophy, P. and J. R. Haizlip, 2003, "Geothermal Exploration of La Soufriere Volcano, St Vincent, West Indies", Geothermal Resources Council, Transactions, Vol. 27.

Haizlip, J.R., A.H. Truesdell, K. Bloomfield, and A.J. Driscoll, 1995, "Changes in Plant Inlet Gas Chemistry with Reservoir Condition, Location, and Time Over 15 Years of Production at The Geysers, CA, U.S.A.," Proceedings of the World Geothermal Congress, 1995, Volume 3, pp. 1939-1944.

Osborn, W. L., P. Hirtz, and J. R. Haizlip, 1990, "Scale Inhibitor Testing at East Mesa," Geothermal Resources Council, Transactions, Vol. 14.

Meeker, K. A., and J. R. Haizlip, 1990, "Factors controlling pH and Optimum Corrosion Mitigation in Chloride-Bearing Geothermal Steam at The Geysers," Geothermal Resources Council Transactions, Vol. 14.

D'Amore, F., A. H. Truesdell, and J. R. Haizlip, 1990, "Production of HC1 by Mineral Reactions in High Temperature Geothermal Systems," Proceedings, 15th Workshop on Geothermal Reservoir Engineering, Stanford, California, January 23-25, 1990.

Haizlip, J. R. and A. H. Truesdell, 1992, "Noncondensable Gas and Chloride Are Correlated in Steam at The Geysers," Monographs on The Geysers Geothermal Field, Geothermal Resources Council, Special Report No. 17, pp. 139-144.

McCartney, R. A., and J. R. Haizlip, 1989, "Anomalous Behavior of Hydrogen Steam from Vapor-Dominated Geothermal Systems," Proceedings, 14th Workshop on Geothermal Reservoir Engineering, Stanford, California, January 24-26, 1989.

Truesdell, A. H., F. D'Amore, J. R. Haizlip, 1989, "The Rise and Fall of Chloride in Larderello Steam," Proceedings, 14th Workshop on Geothermal Reservoir Engineering, Stanford, California, January 24-26, 1989.

McCartney, R. A., and J. R. Haizlip, 1989, "Boiling processes in vapor-dominated geothermal systems: Evidence from The Geysers Geothermal Field," Proceedings, 6th International Symposium on Water-Rock Interaction, Malvern U.K., August 3-9, 1989, pp. 469-473.

Truesdell, A. H., J. R. Haizlip, H. Armannsson, and F. D'Amore, 1989, "Origin and Transport of Chloride in Superheated Geothermal Steam," *Geothermics*, Vol. 18, No. 1/2, pp. 295-304.

Haizlip, J. R. and A. H. Truesdell, 1988, "Hydrogen Chloride in Superheated Steam and Chloride in Deep Brine at The Geysers Geothermal Field, California," *Proceedings, 13th Workshop on Geothermal Reservoir Engineering*, Stanford, California, January 19-21, 1988.

Walters, M. A., J. N. Sternfeld, J. R. Haizlip, and A. F. Drenick, 1988, "A Vapor-Dominated Reservoir Exceeding 600°F at The Geysers, Sonoma County, California," *Proceedings, 13th Workshop on Geothermal Reservoir Engineering*, Stanford, California, January 19-21, 1988.

Truesdell, A.H., J. R. Haizlip, W. T. Box, and F. D'Amore, 1987, "Fieldwide Chemical and Isotopic Gradients in Steam from The Geysers," *Proceedings, 12th Workshop on Geothermal Reservoir Engineering*, Stanford, California, January 20-22, 1987.

Shigeno, H., M. L. Stallard, A. H. Truesdell, and J. R. Haizlip, 1987, "13C/12C and D/H Ratios of CO₂, CH₄ and H₂ in The Geysers Geothermal Reservoir and their Implications," *abs. EOS*, Vol. 68, No. 44.

Truesdell, A. H., J. R. Haizlip, and W. T. Box, 1986, "A Geochemical Overview of The Geysers (California) Geothermal Reservoir," *Transactions, 4th Circum-Pacific Energy and Mineral Resources Conference*, August 17-22, 1986, pp. 487-499.

Haizlip, J. R., 1985, "Stable Isotopic Composition of Steam from Wells in the Northwest Geysers, Sonoma County, California," *Geothermal Resources Council Transactions*, Vol. 9, pt. 1, pp. 311-316.

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