Marisela A. Sánchez-Nagel, Ph D.

OilField Geomechanics LLC

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PRINCIPAL GEOMECHANICS SPECIALIST

More than 25+ years of experience in the Oil and Gas Industry

Principal Geomechanics Specialist, OilField Geomechanics LLC President and Owner. Marisela has been leader of integrated technology projects for assets, supervising and participating in multidisciplinary teams. Broad experience in geomechanical consulting and R&D projects in USA, Canada, Venezuela, Colombia, Brazil, Ecuador, México, North Sea and North and West Africa. She has worked as an engineer and consultant in many applications of geomechanics to the oil industry, including borehole stability, pore pressure prediction, in situ stress analysis, sand production prediction, compaction and subsidence, modeling of fractured reservoirs, hydraulic fracturing for unconventional plays and geomechanical characterization in the field and laboratory. She has been part of Steering committees of Joint Industry Projects with major operators in shale mechanics and borehole stability and is active in SPE workshops and conferences committees. She was selected as a Society of Petroleum Engineers-SPE-Distinguished lecturer for 2012-2013 and Director of the SPE Geomechanics Technical Section, 2017. She was awarded as a Distinguished Member of SPE in 2020. She has taught many training courses internal to companies, open courses and sponsored by SPE, SPWLA and ARMA.

Core Strengths:

- Building geomechanical models 1D and 3D from field and laboratory data, integrating geological, petrophysical, drilling, production and operational information for conventional and unconventional plays.
- Stress analysis during production , depletion and injection.
- Geomechanical analysis of borehole stability for drilling optimization in HPHT wells and UBD, geopressure analysis from seismic cubes and well data sanding analysis, compaction and subsidence. Fractured reservoir characterization. Laboratory and field geomechanical characterization and in-situ stress analysis.
- Hydraulic Fracturing modeling in unconventional plays.
- Opening market opportunities in the geomechanics business for oil and gas applications.
- Leading multidisciplinary technology projects.
- Geomechanics teaching and training experience.
- Witness expert for Geomechanics related projects.

EDUCATION

- **Mining Engineer,** Universidad Central de Venezuela, Venezuela (1984). Bs Thesis: Finite element modeling of a tunnel for Caracas Metro.
- **MSc Geotechnical Engineering,** Universidad Simón Bolívar, Venezuela (1990). MSc Thesis: Liquefaction potential analysis of sandy foundations of a Dyke in Lake Maracaibo.
- **PhD Geological Engineering, Geomechanics,** University of Oklahoma, USA (1997) PhD Thesis: "A Fully-coupled Two-Phase Flow and Rock Deformation Model for Reservoir Rocks".

INDUSTRY AND COMMITTEE ACTIVITIES

- SPE Distinguished Member, 2020
- SPE Geomechanics Technical Section – Director; 2017 – 2021
- SPE Distinguished Lecturer, 2012-2013; Organizing Committees, Discussion Leader, Session chair for ATW, Forums 2016, 2005, 2007, Invited lectures in SPE-GCS and SPWLA, 2015.
- Others: American Rock Mechanics Association, ARMA Organizing Committee 2011-2013; ARMA Leader 2011-2014; ARMA Organizing Committee 2015; Joint Industry Project in Shale Geomechanics SINTEF (2000 -2003); Joint Industry Project Hydraulic Fracturing and Geomechanics. The University of Oklahoma (1990-1995).

- Training Courses and Industry: Unconventionals – Noble, Diamondback Energy, Devon, YPF, PEMEX, Ecopetrol, ICP, PeruPetro, Pacific Rubiales, PDVSA, MTS, Petrobras, Whiting, Pioneer, Noble, Marathon, Weatherford, Schlumberger Mexico (2000 – 2015); Open Courses in Colombia, Mexico, USA; Workshops SPE HFTC Short Course on Geomechanics of Unconventionals (Jan 2016), AAPG, SPE URTEC 2014 and 2015. Graduate Courses at Universidad Surcolombiana, Neiva (2021), Colombia and Universidad del Zulia (2005), Maracaibo, Venezuela.

PROFESSIONAL EXPERIENCE

University of North Dakota Dec 2021– Present
ADJUNCT PROFESSOR

OilField Geomechanics LLC. April 2014– Present

PRINCIPAL GEOMECHANICS SPECIALIST & PRESIDENT

Founded Oilfield Geomechanics LLC. Working on engineering projects, consultant in general geomechanics, including borehole stability, pore pressure prediction, in situ stresses determination, stress analyses with depletion and injection, sand production prediction, modeling of fractured reservoirs and geomechanical characterization in the field and laboratory. Teaching courses in geomechanics fundamentals and oilfield applications. Geomechanics analysis for HPHT ultra-deep wells in the GoM shelf for McMoran. Borehole stability analysis for wells in unconventional shale reservoirs for PEMEX. 1D Geomechanical models in Vaca Muerta, Argentina for YPF, 3D geomechanical models and pore pressure prediction from seismic for Pluspetrol (Vaca Muerta Argentina) and PEMEX (Chicontepec, Tsimin). Drilling Optimization for Ku-Maloob-Zaap Fields (Mexico). Borehole stability Analysis for Teotleco, Ku-Maloob-Zaap Unconventional geomechanical analysis, hydraulic fracturing optimization and training for Pemex, Whiting, Pioneer, Devon. Cap rock integrity for Kosmos in Ghana. Instructor for geomechanics training courses for AAPG at URTEC and SPE HFTC and open courses in Houston. Witness Expert for Geomechanics related projects.

Itasca Houston, Inc. March 2007– April 2014

PRINCIPAL GEOMECHANICS SPECIALIST/GENERAL MANAGER

Responsible for opening and managing Itasca Houston, the oil and gas office for Itasca International. Responsible for sales/marketing and building a worldwide clientele for the office and defining product/services/development strategies. Team leader and engineer for integrated projects with reservoir engineering, completion and geoscience companies and other Itasca companies. Provided integrated solutions to clients in conventional and unconventional geomechanics projects for companies like YPF, ConocoPhillips, BP, PEMEX. Development of engineering projects on borehole stability in deep wells and 1-D and 3D stress analysis and geomechanical models in North and South America, Canada and North Africa. Instructor for geomechanics training courses for Pemex, Ecopetrol and YPF.

GeoMechanics International, Inc. 2005 – March, 2007

SENIOR GEOMECHANICS SPECIALIST

Responsible for leading and performing more than 30 projects in borehole stability, fault leakage potential, pore pressure prediction, fractured reservoir characterization for clients in Venezuela, México, Ecuador, Colombia and Brazil and USA; has taught company courses in borehole stability, related software products and reservoir geomechanics. Support in sales and marketing in North and South America.

Global GeoSoluciones Consultores C.A. 2003-2005

PRESIDENT AND FOUNDER. PROJECT LEADER.

President of Global Geo Soluciones, a company that provided consulting services and training in petroleum geomechanics. In charge of project development in borehole stability, in situ stress analysis, geopressure analysis, compaction and subsidence projects. Company closed in March 2005.

Responsible for the sales of the company and expanding a client portfolio consisting the following companies: Teikoku Oil Venezuela, Baker Venezuela, CGG Mexico and France, Rashpetco in Egypt, Schlumberger-Mexico, Geoprocesados-Paradigm Mexico, Repsol-Bolivia, ICP Ecopetrol Colombia, Petrolera Ameriven (Joint Venture between PDVSA, ConocoPhillips and Chevron Texaco), Venezuela. Leader and participant of a project for Petrolera Ameriven consisting in the determination of subsidence potential for environmental impact in Orinoco Oil Belt. Worked as geomechanics engineer in a project for Schlumberger/Mexico in Geomechanical analysis of drilling experience for 6 wells in Tabasco. Leader and geopressure analyst of a 3D pore pressure study as a subcontractor for Companhie General de Geophisique (CGG), for RASHPETCO, a Joint Venture Egyptian-British Company. Was responsible for analyzing logs, drilling data for 24 wells in a field in the Nile Delta and develop a geopressure cube from a seismic velocity cube for the field. Developed a study for a

geopressure cube for CGG as a pore pressure analyst in Macuspana Basin, for PEMEX. Pore Pressure analysis of an exploratory well (Mercurio-1) in Lamprea Asset for CGG (PEMEX).

PDVSA – Intevep, Los Teques – Edo. Miranda. Venezuela. 1987-1997; 2000-2002

GEOMECHANICS ENGINEER AND PROJECT LEADER

Leader of the Geomechanics Group at PDVSA-Intevep and member of steering committee of the PDVSA Knowledge Community. Leader of an integrated project for technology support to the Ceuta-Tomoporo asset (leading a group of specialists in geosciences, drilling, production, surface facilities and environmental). Leader of a drilling optimization project in the well construction department (supervising groups for UBD, zonal isolation for HPHT wells, risk analysis applied to drilling operations and ERD). Member of steering committee for the Joint Industry Project for drilling fluid-shale interaction modeling and laboratory studies (SINTEF) and industry projects with CSIRO. Borehole stability for under balance drilling projects. Pore Pressure/FG Prediction and borehole stability in HPHT exploration wells and offshore wells. In situ stress studies. Experience in the use of geomechanical reservoir (FLAC3D) and well simulators (Pbore 3D). This experience is gathered in 45 internal technical reports. Has taught courses in Geomechanics for professionals in the oil Industry at PDVSA-Cied, Pemex, Universidad Sur Colombiana, graduate courses at Zulia University in Venezuela and courses on Performance, Completions and Stimulation of Horizontal wells. Supervised 5 Master theses in the area of Petroleum Geomechanics.

Selected Projects and Achievements:

- Leader of an integrated project to determine economical technology opportunities for Ceuta Tomoporo in Eastern Venezuela.
- Leader of a project to determine opportunities in the use data, information and knowledge to optimize drilling and completion on a corporate level in PDVSA.
- Integrated a multidisciplinary team for Underbalance drilling design and monitoring in Gas fields and depleted reservoirs.
- Pore pressure prediction for exploratory fields in Eastern Venezuela. Responsible for projects and training drilling engineers in geopressure analysis in PDVSA.
- Leader of the shale stability program at Intevep, integrating fluid, geomechanics and drilling mechanics specialists for projects in deep, extended reach wells in Western Venezuela. Included, laboratory, field and modeling of coupled processes.
- Borehole stability and In situ stress studies for High angle wells. Spreading state of the art in the company operations, integrating geomechanics to drilling design.
- Sand production studies for HPHT fields. Modeling and field studies of sanding in North Monagas using Sand3D model.

VVA Consultores. Caracas. Venezuela. 1997-2000

GEOMECHANICS ENGINEER

Selected Projects and Accomplishments:

- Developed a borehole stability study for a well in Hudson field, North Sea, for Innovative Engineering Systems, Inc., Aberdeen.
- Geomechanical applications to operations optimization in Apure, south of Venezuela. Evaluated efficiency of drilling and completion operations in Guafita field. Modeling of horizontal well stability with elastoplastic analysis.
- For North Barinas, fractured reservoirs: Analysis of fracture trends from image logs and its relation to structural and in situ stress field. Design and evaluation and feasibility of hydraulic fracturing operations.
- Geomechanics application in a highly compartmentalized field. Geopressure analysis and shale stability. 3D geological modeling of in-situ stresses in Barúa-Motatán field.
- Analysis of mechanical and thermal properties of unconsolidated sands and its applications to heavy Oil SAGD project.
- Geomechanical modeling of naturally fractured reservoir in-Mara Oeste using FLAC 3D.
- Study for the diagnostics and managing sand production in a deep, high temperature field in North Monagas

SELECTED PUBLICATIONS

Nagel, N.B., D. Gokaraju, A. Mitra, and M. Sanchez-Nagel, 2017, "Consideration of Stress Shadows in Stacked Plays", Paper ARMA 17-884 presented at 51st US Rock Mechanics/Geomechanics Symposium, San Francisco, CA, USA, 25-28 June.

Sanchez-Nagel,M., N.B. Nagel, A.A. Rodriguez, and N. Nieto, 2017, "Evaluating Stresses Along Horizontal Wells in Unconventional Plays", SPE Paper 184875 presented at the SPE Hydraulic Fracturing Technology Conference, The

Woodlands, Texas, USA, 24-28 January.

Nagel, N.B. and Sanchez-Nagel M., 2015, “On the Importance and Impact of Key Geomechanical Parameters in Unconventional Play Developments”, ARMA paper number 15-514 presented at the 49th US Rock Mechanics /Geomechanics Symposium held in san Francisco June, 2015.

Agharazi, A., Lee, BT., Nagel, N.B., Zhang, F., and Sanchez-Nagel, M., 2013 “Tip-Effect Microseismicity – Numerically Evaluating the Geomechanical Causes for Focal Mechanisms and Microseismicity Magnitude at the Tip of a Propagating Hydraulic Fracture”, SPE Paper 167129 presented at the SPE Unconventional Resources Conference-Canada, Calgary, Alberta, 5-7 November.

Zhang, F., Nagel, N.B., Sanchez-Nagel, M., Lee, BT., Agharazi, A., 2013, “The Critical Role of In-Situ Pressure on Natural Fracture Shear and Hydraulic Fracturing-Induced Microseismicity Generation”, SPE Paper 167130 presented at the SPE Unconventional Resources Conference-Canada, Calgary, Alberta, 5-7 November.

Zhang, F., Nagel, N.B., Sanchez-Nagel, M., Lee, BT., Agharazi, A., 2013, “The Critical Role of In-Situ Pressure on Natural Fracture Shear and Hydraulic Fracturing-Induced Microseismicity Generation”, SPE Paper 167130 presented at the SPE Unconventional Resources Conference-Canada, Calgary, Alberta, 5-7 November.

Nagel, N.B., Zhang, F., Sanchez-Nagel, M., Lee, BT., Agharazi A., 2013, “Stress Shadow Evaluations for Completion Design in Unconventional Plays”, SPE Paper 167128 presented at the SPE Unconventional Resources Conference-Canada, Calgary, Alberta, 5-7 November.

Nagel, N.B., F. Zhang, M. Sanchez-Nagel and B. Lee, 2013, "Evaluation of Stress Changes Due to Multi-Stage Hydraulic Fracturing - Consideration of Field Results", presented at Rock Mechanics for Resources, Energy and Environment, Eurock13, the ISRM International Symposium, Wroclaw, Poland, 21-26 September.

Rios, A.M., G. Gutierrez, N.B. Nagel, F. Zhang, M. Sanchez-Nagel and B. Lee, 2013, "Stress Shadow Evaluations for Chicontepec - Evaluating New Completion Options", Paper ARMA 13-200 presented at 47th US Rock Mechanics/Geomechanics Symposium, San Francisco, CA, USA, 23-26 June.

Zhang, F., N.B. Nagel, B. Lee and M. Sanchez-Nagel, 2013, "The Influence of Fracture Network Connectivity on Hydraulic Fracture Effectiveness and Microseismcity Generation", Paper ARMA 13-199 presented at 47th US Rock Mechanics/Geomechanics Symposium, San Francisco, CA, USA, 23-26 June.

Zhang, F., N.B. Nagel, X. Garcia, B. Lee and M. Sanchez-Nagel, 2013, "Fracture Network Connectivity - A Key To Hydraulic Fracturing Effectiveness and Microseismcity Generation", presented at ISRM International Conference for Effective and Sustainable Hydraulic Fracturing, Brisbane, Australia, 20-22 May.

Nagel, N.B., F. Zhang, M. Sanchez-Nagel, X. Garcia, and B. Lee, 2013, "Quantitative Evaluation of Completion Techniques on Influencing Shale Fracture Complexity", presented at ISRM International Conference for Effective and Sustainable Hydraulic Fracturing, Brisbane, Australia, 20-22 May.

Savitski, A. A., M. Lin, A. Riahi, B. Damjanac and N.B. Nagel, 2013, "Explicit Modeling of Hydraulic Fracture Propagation in Fractured Shales," in International Petroleum Technology Conference, Beijing, China.

Nagel, N.B., M. Sanchez-Nagel, F. Zhang, X. Garcia, and B. Lee, 2013, “Coupled Numerical Evaluations of the Geomechanical Interactions Between a Hydrualic Fracture Stimulation and a Natural Fracture System in Shale Formations”, Rock Mechanics and Rock Engineering, DOI 10.1007/s00603-013-0391-x

Nagel, N.B., Sanchez-Nagel, M.A., and Lee, B., “Gas Shale Hydraulic Fracturing: A Numerical Evaluation of the Effect of Geomechanical Parameters”, SPE Paper #152192-PP presented at the SPE Hydraulic Fracturing Technology Conference, The Woodlands, USA, February 6-8, 2012.

Nagel, N.B., Damjanac, B., Garcia, X., and Sanchez-Nagel, M.A., “Discrete Element Hydraulic Fracture Modeling - Evaluating Changes in Natural Fracture Aperture and Transmissivity”, CSUG/SPE Paper #148957-PP presented at the Canadian Unconventional Resources Conference, Calagary, Alberta, Canada, November 15-17, 2011.

Nagel, N.B. and Sanchez-Nagel, M.A., “Stress Shadowing and Microseismic Events: A Numerical Evaluation”, SPE Paper #147363-PP presented at the SPE Annual Technical Conference and Exhibition, Denver, CO, USA, October 30-November 2, 2011.

Pettitt, W., M. Pierce, B. Damjanac, J. Hazzard, L. Lorig, C. Fairhurst, I. Gil, M. Sanchez, N. Nagel, J. Reyes-Montes, and R. Paul Young, 2011, Fracture Network Engineering for Hydraulic Fracturing, The Leading Edge, In Print.

Neal Nagel, Ivan Gil, and Marisela Sanchez-Nagel, SPE, Itasca Houston, Inc., Branko Damjanac (2011) Simulating Hydraulic Fracturing in Real Fractured Rocks - Overcoming the Limits of Pseudo3D Models. SPE Hydraulic Fracturing Technology Conference, *24-26* January, The Woodlands, Texas.

Damjanac, B, Gil I, Pierce, M Sanchez, M., and Mc Lennan, J (2010). A new approach to hydraulic fracturing modeling in naturally fractured reservoirs. Proc., paper ARMA 10-40044th - U.S. Rock Mechanics Symposium and 5th U.S.-Canada Rock Mechanics Symposium, June 27 - 30, Salt Lake City, Utah.

Adachi, J T., T. Hartman, L. Lomas, R. Plumb, I Gil, M Sanchez and R Taghavi (2008). Automatic grid generation, property rezoning and Geomechanical Analysis of Petrel-Eclipse petroleum reservoir data with FLAC3. 1st International FLAC/DEM Symposium, Minneapolis, August – Paper No. 02-01

Jean Claude Roegiers, University of Oklahoma, Marisela Sánchez, Andrés R. Vásquez H., V.V.A. Consultores C.A. José A. González, Manuel Ramones, Arturo Sulbarán, W. Poquioma (2000). Application of Geomechanics to solve sand production and Borehole Stability problems in the Area 2 Sur-Ceuta field, Lake Maracaibo, Venezuela. Oil & Gas Exe Vol. 3, No. 2.

Sánchez D, M, Vásquez A., Van Alstine, D. Butterworth, J. García J., Carmona R., Poquioma W., Ramones M. (1999). Application of Geomechanics to the development of a naturally fractured carbonate reservoir in Mara Oeste field, Venezuela**.** SPE 54008, LACPEC, Caracas.

Vásquez, A.R., Sánchez, M.S., McLennan, J.D., Guo, Q., Portillo, F., Poquioma, W., Blundun, M. and Mendoza, H.: "Mechanical and Thermal Properties of Unconsolidated Sands and its Application to the Heavy Oil SAGD Project the Tia Juana Field, Venezuela," *paper SPE 54009* presented at the 1999 SPE Latin American and Caribbean Petroleum Engineering Conference, Caracas, Venezuela, April 21-23.

Vásquez A., Sánchez M., Yánez R., Poquioma W., Rampazzo M., El Chirity K. (1999). The diagnosis, Well Damage Evaluation and critical drawdown calculations of Sand production problems in the Ceuta Field, Lake Maracaibo, Venezuela. SPE 54011, LACPEC, Caracas, 1999.

Sánchez, M., Cabrera J.R., Coll. C. (1996). Geomechanical Design of a Horizontal well in Maracaibo Lake: Real-drilling time application" SPE 37088. International Conference and Exhibition on Horizontal Well Technology, Canada.

Sánchez, M., Lin D., Roegiers, J.-C (1993). Chebyshev Spectral Collocation Method for Leakoff in Hydraulic Fractures" International Conference for Computer Methods and Advances in Geomechanics. Morgantown, West Virginia.

Sánchez, M., Natera, J. and Abreu, R (1990). Compressibility of rocks from El Furrial. III South American Conference in Rock Mechanics.

Rajani, B., Sanchez, M. (1989). Regional Characterization of Geomechanical Properties of Unconsolidated Sands of the Heavy Oil Belt, Venezuela. V UNITAR Conference, Canada.