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SENSITIVITY ANALYSIS OF STRESS STATES INDUCED BY SALT STRUCTURE

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The main oil and gas reserves around the world are found in regions containing evaporitic rocks that owing to their low porosity and low permeability properties provide favorable conditions for hydrocarbon trapping, increasing the probability of success in oil and gas exploration.

Recently, a light crude oil reserve has been discovered below a salt layer of 2000m thickness in Santos Basin, Brazil. Due to the creep behaviour of the salt rock, many operational problems while drilling in salt zones have been reported, such as loss of circulation, stuck pipe and casing collapse, leading to well abandon in extreme cases.

In the early 90's, the Multimechanism-Deformation model (Dislocation Glide, Dislocation Climb and Undefined Mechanism) started being used to represent the behaviour of evaporitic rocks [1][2]. In this model, according to temperature conditions and deviatoric stress range, the corresponding mechanism is activated. The salt rock exhibits time-dependent strain behavior when submitted to deviatoric stresses. Because of that, the vertical and horizontal stresses adjacent to salt bodies are highly perturbed. Therefore, a more accurate estimate of the stress state in salt zones is required for a more rigorous planning of well paths and location, enabling better drilling strategies.

The main objective of the present work is to carry out sensitivity analyses of several parameters that influence the stress state in the vicinity of salt domes. Some of these parameters are: far-field stress state (k0), type of salt rock, water column height, depth of the salt body and geothermal gradient. In addition, some geometrical parameters, such as height and extension of the salt body, are very important in this study.

This work presents a geomechanical simulation methodology to evaluate the influence of these parameters on the stress state induced by salt structures. The creep behaviour of salt bodies is studied using the Finite Element Method. Numerical analyses are performed

considering plane strain state of stresses. A geomechanical model based on two-dimensional parameterized templates allows fast modelling and contributes to a viable sensitivity analysis. The templates are implemented in the Sigma2D [5] system, which was developed at Tecgraf/PUC-Rio Institute in partnership with PETROBRAS and is used in the pre-processing and post-processing of finite element models.

The numerical simulation of the creep behaviour of the salt body is carried out with the finite element system ANVEC [6]. This system uses the Newton-Raphson Method for the solution of the incremental equilibrium considering the nonlinear creep behaviour of the salt rock and plastic deformation of the surrounding rock structure. The initial stress state is calculated considering the geostatic equilibrium condition at rest.

The creep behaviour of the salt body follows the constitutive equation based on the Multimechanism-Deformation model. As suggested in other works [4], a 2-million-year simulation period is used so that the stress redistribution reaches the steady state condition.

The FE results for the states of stress and strain and the plastification index in the vicinity of the salt body, along with those for the displacement field of the surrounding formation, are used to evaluate the influence of the above mentioned parameters. Here is a salt dome with a typical geometry known as salt pillow [3] adopted in the sensitivity analysis.

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