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THERM-MECHANICAL COUPLING FOR SALT DOMES FORMATION

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It is well known in the oil industry the importance of large deformations suffered by the rocksalt since such deformations are responsible for the whole structure of the basins. In addition, they are the major obstacle to be overcome by the engineers during the drilling process. Therefore, the study and the numerical simulation of the mechanical aspects of the salt migration are essential in understanding this phenomenon.

In the literature ([3], [4], [9]) this problem has often been treated as Rayleigh-Taylor instability in viscous fluids. In recent articles ([1], [6], [7]) a numerical method called Successive Linear Approximation (SLA) was proposed, which allows, in a unified manner, the simulation of the motion of salt and the sediment layers as viscoelastic solids ([6]). This method, similar to the well-known problem of small deformation superposed on finite deformation in the literature ([2]), is nothing but a Lagrangian formulation of mechanical problems in relative motion description and it is called the relative Lagrangian formulation, in contrast to the widely used (total or updated) Lagrangian and Eulerian formulations ([5], [11]).

However, temperature effects may also be important for the formation of salt domes. In [10] this influence was studied, in which the body is regarded as a thermo-viscoelastic solid and a one way coupling between the thermal and the mechanical problems, the latter being solved using the SLA method.

Based on [10], this work proposes to study the influence of temperature on the formation

of the salt dome and the influence of the salt migration on the temperature. To this end, it is now considered a coupled system between the thermal and the mechanical problems, characterizing the mutual influence between the geomechanical and thermal properties.

It will be presented some numerical results illustrating the effect of temperature on the formation of salt dome, as well as the efficiency of the SLA method for simulating large deformations of sediment and salt layers.

REFERENCES

[1] R. A. Cipolatti, I-S Liu, M. A. Rincon. Mathematical analysis of sucessive linear approximation for Mooney-Rivlin material model in finite elasticity. *Journal of Applied Analysis and Computation*, Vol. **2**, n. 4, 363-379, 2012.

[2] A. E. Green, R. S. Rivlin, R. T. Shield. General theory of small elastic deformations superposed on finite deformations. *Pro. Roy. Soc. London, Ser. A*, Vol **211**, 128–154, 1952.

[3] A. T Ismail-Zadeh, H. E. Huppert, J. R. Lister. Gravitational and buckling instabilities of rheologically layered structure: implications for salt diapirism. *Geophys. J. Int.*, Vol **148**, 288–302, 2002.

[4] P. E. van Keken, C. J. Spiers, A. P. van den Berg, E. J. Muyzert. The effective viscosity of rocksalt: implementation of steady-state creep laws in numerical models of salt diapirism. *Tectonophysics*, Vol **225**, 457–476, 1993.

[5] I-S Liu. *Continuum Mechanics*. Springer: Berlin Heidelberg, 2002.

[6] I-S Liu, R. A. Cipolatti, M. A. Rincon. Successive linear approximation for finite elasticity. *Computational & Applied Mathematics*, Vol. **29**, n. 3, 465–478, 2010.

[7] I-S Liu. Successive linear approximation for boundary value problems of nonlinear elasticity in relative-descriptional formulation. *International Journal of Engineering Science*, Vol **49**, n 7, 635–645, 2011.

[8] I-S Liu, R. A. Cipolatti, M.A. Rincon, L. A. Palermo. Successive linear approximation for large deformations - Instability of salt migration. *Journal of Elasticity*, published online, 2013.

[9] P. Massimi, A. Quarteroni, F. E. Saleri, G. Scrofani. Modeling of Salt Tectonics. *Comput. Methods Appl. Mech. Eng.*, Vol **197**, 281–293, 2007.

[10] M. G. Teixeira, I-S Liu, M. A. Rincon, R. A. Cipolatti. The influence of temperature on the formation of salt domes. *Annals of the XXXIV Ibero-Latin American Congress on Computational Methods in Engineering*, 2013.

[11] C. Truesdell, W. Noll. *The Non-Linear Field Theories of Mechanics*, 3rd edition. Springer: Berlin, 2004.