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TWO DIMENSIONAL ELECTROSEISMIC MODELING

Patricia M. Gauzellino[1], **Juan E. Santos**[1,2,3] **and *Fabio I. Zyserman**[1,2]

[1]Facultad de Ciencias Astronómicas y Geofísicas, UNLP
Paseo del Bosque s/n, B1900FWA La Plata, Argentina.
gauze@fcaglp.unlp.edu.ar
(santos)
(zyserman)

[2] CONICET

[3]Department of Mathematics, Purdue University
150 N. University Street, West Lafayette, Indiana, 47907-2067,USA
santos@math.purdue.edu

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ABSTRACT

There is empiric evidence demonstrating that seismic waves propagating through near-surface layers of the Earth induce electromagnetic disturbances that can be measured at the surface (seismoelectric effect) [1,2]; and also recent tests suggest that the reciprocal process, *i.e.* surface measurable acoustic disturbances induced by electromagnetic fields (electroseismic effect), is also possible [3,4].
In order to explain these phenomena, Pride [5] suggested that they are generated by an electrokinetic coupling mechanism which can be shortly explained as follows [6,7]: Within a fluid saturated porous medium there exists a nanometer-scale separation of electric charge in which a bound charge existing on the surface of the solid matrix (normally of negative sign) is balanced by adsorbed positive ions of the surrounding fluid, setting an immobile layer. Further from the surface there exists a distribution of mobile counter ions, forming the so called diffuse layer. The effective thickness of this double layer is of about 10 nm. When an electric field is applied to this system, the ions in the diffuse layer move, dragging the pore fluid along with it because of the viscous traction. This is known as electro-osmosis and is responsible for the electroseismic phenomena. On the other hand, the reciprocal situation arises when an applied pressure gradient creates fluid flow and hence, an ionic convection current, which in turn produces an electric field. This is known as electrofiltration and is responsible for the so-called seismoelectric phenomena.
Pride [5] derived a set of equations controlling both electroseismic and seismoelectric effects in electrolyte-saturated porous media. In these equations the coupling mechanism acts through the (generally frequency dependent) electrokinetic coupling coefficient L. When this coefficient is set to zero, Pride's set of equations turns to the uncoupled Maxwell's and Biot's equations, describing the latter mechanical wave propagation in a fluid saturated porous medium [8,9].
There exist already some works implementing different numerical methods to solve the set of equations modeling both mentioned processes. The finite element procedures implemented in this work employ the nonconforming rectangular element defined in [10] to approximate the displacement vector in the solid phase, while the displacement in the fluid phase is approximated by using the vector part of the

Raviart-Thomas-Nedelec mixed finite element space of zero order, which is a conforming space.
A priori optimal error estimates for the discretization of Biot's equations of motion using this finite element spaces were derived in [11], and the corresponding dispersion analysis was presented in [12].
On the other hand, finite elements procedures to solve Maxwell's equations in 2D and 3D within the frame of magnetotelluric modeling were presented in [13,14].
Numerical experiments for two dimensional models of the subsurface and an infinite line source (for the TE mode) and an infinite solenoid (for the TM mode) are presented and analyzed.

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