Shale transformations and physical properties—Implications for seismic expression of mobile shales

Soto, J.I., Hudec, M.R., Mondol, N.H. and Heidari, M., 2021. Shale transformations and physical properties—Implications for seismic expression of mobile shales. *Earth-Science Reviews*, 220, p.103746.

Presenter: Hassan Aleem
Advisor: Prof. Maryline Le Beon
Date: 2022/05/13

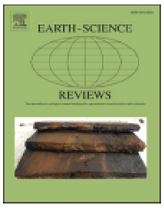
Abstract

Mobile shales are fine-grained sedimentary rocks associated with a very high fluid pressure. There are two end members of mobile shales: mud volcano and intrusive ductile flowing mobile shales. They have been investigated on many continental margins and deep sedimentary basins. Because of no direct access to intrusive mobile shales, it is foremost to understand their expression on seismic images. The seismic properties of mobile shales are influenced by the fluid content and the fluid overpressure which are not easy to predict. Mostly, the seismic images acquired are not very clear due to their low seismic-impedance contrast with many sedimentary rocks, spatial variation of their seismic properties, and their complex geometries. To solve this problem, the physical properties of the shales were reviewed, combining the data from in-situ measurements of density and sonic during velocities with experimental data and analysis results. The authors reported that the water expelled to the pore system smectite-illite transition and methane generated during oil cracking reduce the reflectivity of shales. Different amounts of these fluids were modeled to establish a further reduction in reflectivity of mobile shales. Furthermore, theoretical results were compared for mobile shale contacts with the sea bed, sandstone, and normally compacted shale using examples from mud volcanoes and many complex shale diapirs. We found that the mobile shale underlying normal shale gives a negative reflection. Mobile shale rich in fluids like methane and water produces negative reflections. Sandstone underlain by mobile shale gives slightly positive reflections. Mobile shales in direct contact with seabed will give positive reflections which can be explained by the formation of authigenic carbonates when methane in the mobile shales reacts with seawater. For a better understanding of the mobile shales, the authors suggested advanced seismic processing and detailed analysis of basin burial and thermal histories.

Contents lists available at ScienceDirect

Earth-Science Reviews

journal homepage: www.elsevier.com/locate/earscirev



Shale transformations and physical properties—Implications for seismic expression of mobile shales

Juan I. Soto[a,*,1], Michael R. Hudec[a], Nazmul H. Mondol[b,c], Mahdi Heidari[a]

[a] *Bureau of Economic Geology, Jackson School of Geosciences, The University of Texas at Austin, University Station, Box X, Austin, Texas 78713-8924, USA*
[b] *Department of Geosciences, University of Oslo, 0316 Oslo, Norway*
[c] *Norwegian Geotechnical Institute, 0855 Oslo, Norway*

ARTICLE INFO

Keywords:
Shale tectonics
Mobile shales
Clay transformations
Hydrocarbons
Seismic interpretation
Shale diapirs

ABSTRACT

Seismic interpretation of mobile shales is challenging, mostly because of their unclear seismic expression. Imaging of mobile shales is difficult because of their low seismic-impedance contrast with many sedimentary rocks, spatial variation of their seismic properties, complex geometries of mobile-shales structures, and their complex internal structures. Furthermore, their seismic properties depend strongly on both overpressure and fluid content, which are difficult to predict.

To unravel this problem, we reviewed the physical properties of shales, merging data from in situ determinations of density and sonic velocities with experimental data and modeling results. We analyzed how diagenetic transformations during shale burial modify their physical properties and seismic characteristics. We reviewed conditions for smectite-illite transformation and gas generation (mostly methane) by oil cracking to evaluate how thermal gradient, shale composition, and hydrocarbon content modify the densities, sonic velocities, and seismic expressions of mobile shales. We then incorporated the amount and type of fluids released in shales during diagenesis into a study of seismic reflectivity of mobile shales.

Results derived theoretically for various types of mobile-shale contacts are compared with high-quality seismic examples, including mud volcanoes and a variety of complex shale diapirs. Observed reflectivity and seismic fabrics are discussed to infer clay composition, fluid content and type, and temperature.