

3D joint inversion of MT and seismic with hybrid structural and petrophysical couplings

H. Song^{1,2}, P. Yu³, D. Diba⁴, Y. Usui⁵, M. Uyeshima⁶

¹State Key Laboratory of Marine Geology, Tongji University, 1831736@tongji.edu.cn

²Earthquake Research Institute, the University of Tokyo, songhan@g.ecc.u-tokyo.ac.jp

³State Key Laboratory of Marine Geology, Tongji University, yupeng@tongji.edu.cn

⁴Earthquake Research Institute, the University of Tokyo, dieno@eri.u-tokyo.ac.jp

⁵Earthquake Research Institute, the University of Tokyo, yusui@eri.u-tokyo.ac.jp

⁶Earthquake Research Institute, the University of Tokyo, uyeshima@eri.u-tokyo.ac.jp

SUMMARY

Joint inversion that utilizes multiple geophysical datasets is a practical way to produce models with reduced uncertainty and improved resolution. One of the keys to unlocking the advantages of joint inversion lies in a reasonable coupling mechanism. Currently, mainstream couplings fall into two categories: petrophysical and structural. The former assumes that there exists a relationship between different physical parameters and correlates them via a theoretical, empirical, or statistical relationship; the latter enforces the models of different physical properties to have similar spatial structures. Most joint inversion studies focus on utilizing either petrophysical or structural couplings in a study area. However, in situations where prior petrophysical relationships exist, relying solely on structural coupling is insufficient to enforce relationships between different geophysical parameters. Meanwhile, petrophysical coupling usually heavily depends on the accuracy of empirical relationships, and using only petrophysical coupling in the whole model space can lead to biased results caused by inaccurate relationships. Therefore, to comprehensively leverage multi-geophysical, petrophysical, and geological information, we propose a 3D joint inversion framework that incorporates both structural and petrophysical couplings. Different from the parameter selection scheme for purely smoothness regularization that is designed mainly to stabilize the inversion process, the relative weighting of structural coupling is specified based on the linearized model uncertainty analysis, and the relative weighting for petrophysical coupling is based on the reliability of a prior relationship. This framework provides a chance to use hybrid petrophysical and structural couplings simultaneously, which is important in the case of complex geology.

Keywords: Joint inversion, MT, seismic, structural coupling, petrophysical coupling
