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Basalts of Serra Geral Formation: the main “villain” in seismic imaging of the Paraná Basin?

Isaack Esdras Encarnação (Eneva), Sergio Luciano Freire (CPGeo), Carlos Siedschlag (Eneva), Diogo Michelon (Eneva SA), Eduardo Lopes de Faria (Eneva), Roberto Ribeiro (Eneva), João Luiz Caldeira (Eneva), Frederico Miranda (Eneva)

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Introduction

The lava flows of Serra Geral Formation have historically been regarded as the main challenge to effective seismic imaging of Paraná Basin. This perception stems from their considerable thickness – reaching up to 1.700 meters - which introduces significant velocity variations and attenuates seismic energy transmission. After a prolonged period of limited exploratory activity, a new seismic acquisition initiative has been launched in the state of Mato Grosso do Sul by a joint venture between Eneva S.A. and Brava Energia.

The Paraná Basin, an intracratonic Paleozoic basin, is characterized by extensive diabase intrusions and a thick Jurassic-Cretaceous basalt cover, both products of the Parana-Etendeka magmatism. These magmatic features contribute to pronounced velocity variations that make seismic processing challenging. However, a detailed analysis has prompted a reevaluation of the assumption that basalts are the dominant cause of seismic energy attenuation. This study explores alternative factors that may influence seismic imaging quality.

Method and/or Theory

This study aims to identify the causes of imaging quality variation in parts of the acquired seismic lines by modeling the Low Velocity Layer (LVL) using first-arrival seismic waves to estimate its velocity and thickness. This methodology also forms the basis for statics correction applied in the subsequent seismic processing workflow. The hypothesis is that LVL thickness affects energy transmission and signal-to-noise ratio, impacting imaging quality.

Explosive-source seismic acquisition is a standard method in land exploration. Effective parameterization ensures cost-efficiency, practicality, and imaging quality. A major challenge in land seismic acquisition is the near-surface low-velocity layer (LVL), which absorbs seismic energy and exhibits rapid velocity variations (340–2,000 m/s in the Paraná Basin), reducing wave frequency and signal-to-noise ratio. The intensity and dispersive nature of ground-roll vary significantly according to the geological and topographic features of the area. In addition, the thickness of the weathering layer directly influences this phenomenon: the thicker the layer, the more intense and dispersive the ground-roll wave trains tend to be, leading to greater attenuation of useful energy and, consequently, a reduction in the energy available for seismic reflections. Deeper holes could help mitigate these effects, but such an approach may bring significant operational constraints and may pose additional challenges related to land access and permitting on a region with intensive agricultural activity.

Results and Conclusions

Based on the results obtained we can establish a direct relationship between surface elevation and LVL thickness, particularly in the uppermost layer, where velocities range from 340 m/s to 1.000 m/s. Among the many still-unknown factors directly affecting seismic imaging in the basin, our observations suggest that the presence of a cap of igneous rocks does not necessarily indicate poor seismic imaging quality. Instead, increased LVL thickness – often associated with higher altimetry – emerges as more significant contributor to reduced seismic imaging quality. These insights challenge the prevailing notion that Serra Geral volcanic cover is the principal factor degrading seismic imaging in Paraná Basin.