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Petrophysical characterization of magmatic rocks from geophysical logs of the Serra Geral group in wells of the Paraná region.

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Introduction

The capacity of volcanic rock lithologies for CO₂ storage has driven interest in this study within industry and academia in recent years (Millett et al., 2024; Zou, 2013). Several studies with different approaches have been proposed (petrophysical, geochemical, geophysical, etc.); however, the petrophysical properties of volcanic rocks are not yet fully understood. Nevertheless, understanding the petrophysical properties (porosity and permeability) of such rocks is essential (Luo et al., 2005; Sruoga, Rubinstein, 2007; Farooqui et al., 2009; Jin; Pan; Qiao, 2013). The main difficulties in analyzing these characteristics lie in the variability of lithofacies with complex permo-porous systems (Sruoga and Rubinstein, 2007) and access to the study of volcanic sections at depth. Therefore, it becomes necessary to identify and associate the lithotypes with variations in petrophysical properties. The objective of this work is the quantification of petrophysical parameters by the analysis of geophysical well logs from the basaltic rocks of the Serra Geral Group within the Paraná Igneous Province. The Paraná-Etendeka Magmatic Province, located in the upper part of the Paraná Basin, represents one of the largest continental flood basalt provinces in the world (Almeida; Carneiro; Bartorelli, 2012). Within this province, in Brazil, lies the Serra Geral Group (SGG), whose flows are mainly composed of basic volcanic and intrusive rocks and exhibit a maximum thickness of 1700 meters (Melfi, Piccirillo, and Nardy, 1988). The volcanic rocks of the SGG overlie the eolian sandstones of the Botucatu Formation (White, 1908) or directly overlie metamorphic rocks of the Precambrian basement (Almeida; Carneiro; Bartorelli, 2012). The Serra Geral Group has been stratigraphically divided into four formations, from base to top: Formation Torres (FT), Vale do Sol (FVS), Palmas (FP), and Esmeralda (FE). The FT consists of basalts and basaltic andesites in the form of compound pahoehoe flows. Subsequently, rubbly pahoehoe-type lavas composed of basaltic andesites were deposited, corresponding to the FVS. Successively, acid volcanics of the FP are grouped and the top of this sequence, the FE outcrops, consisting of simple and compound pahoehoe-type basalts (Rossetti et al., 2018).

Method

This research will qualitatively correlate the patterns of petrophysical data with the different lithotypes present. For this study, 44 wells available in the local literature, located in the Paraná region and covering various formations, were used. For petrophysical characterization, the analysis of the following geophysical well logs was employed: resistivity, sonic, neutron porosity, bulk density and gamma ray, as well as empirical equations relating the information contained in the logs to porosity and permeability in basalts. The data were processed, interpreted, and plotted using specialized software, such as EPerform.

Results and Conclusions

The results obtained in this study allowed for the identification of characteristic patterns of the petrophysical properties of the igneous rocks. Furthermore, the results made it possible to establish links between the lithotypes and the permo-porous patterns. Finally, this methodology, which utilizes basic geophysical well logs, provides valuable subsurface insights into the permo-porous system in volcanic lithotypes. Therefore, the use of well log data proves to be an important tool for the subsurface study of these rocks.