Identifying low velocity salt stratifications using a new machine learning approach method over seismic attributes

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Abstract

Seismic images result from reflection information of rock interfaces. These reflections are functions of impedance differences between rocks. Regarding seismic studies, until the recent period, the initial models for the evaporite section in the Santos Basin considered almost constant the contents, mainly reflecting the halite properties. Halite, generally the most abundant mineral in the salt section has an average density of about 2.14 g/cm3 and a compressional velocity of about 4,500 m/s, but this approximation leads to errors in the depth migration process when salt is stratified, having other minerals. With the evolution of seismic migration algorithms and computational capacity, it was realized the need to model the salt section in a more complex way making it less homogeneous. The process of evaporates formation occurs in stages, according to specific evaporation rates, generating the observed layers, called stratifications. There are many types of evaporite minerals in the evaporitic section, the most commons: halite, anhydrite, gypsum, carnallite, tachyhydrite and sylvite. Well log analysis show that not all these minerals are seismically detectable by amplitude, due to its low thickness, below the seismic resolution. Thus, to facilitate the identification, ones grouped the evaporitic minerals into three main facies: halite, high-velocity-salts (anhydrite and gypsum) and low-velocity-salts (carnallite, tachyhydrite and sylvite). The last group has particular interest because of its high solubility that may cause circulation problems for drilling, sometimes leading to well abandonment. Because the low number of wells where low velocity salts appears, seismic attributes had to be used to help better representing the expected salt layers according to any well logs correspondence. In this work, we present a methodology for seismic facies identification enabling to insert the stratifications. It is based on the identification and separation of wavelets in cluster models of seismic already migrated using the wells drilled in the region as a reference, using this cluster models to compare the seismic trace, point-by-point generating new models that consider the salt stratifications. To achieve it, we used modern machine learning algorithms for clustering and dimensionality reduction, such as UMAP and a modified HDBSCAN. This combination, besides interpretation and calibration steps, produces better results than nowadays-conventional machine learning studies. The method proved to be quite versatile and useful in other depositional environments (siliciclastics or carbonatics).