Geology differentiation: An integrative approach to imaging geology at depth

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Geophysics aims to image subsurface geological structure and identify different geologic units. Whereas the former has dominated the interpretation of most geophysical data, the latter has received much less attention. This disparity appears to have persisted despite many investigations that rely on the inference of geologic units from geophysical and geological observations. For example, mineral exploration inherently relies on the ability to identify different lithologic units or alteration types; and solid earth investigations may be interested in the distribution of materials of different origin and composition. In practice, such inferences are carried out routinely in a qualitative manner across a wide spectrum from exploration to geoscientific studies. Thus, it is meaningful to examine this aspect and to develop a system of quantitative approaches to identifying different geologic units, may they be lithology units, alteration types, or mineralized zones. The development of geophysical inversions in the last three decades makes such interpretation tools possible. We refer to this newly emerging direction as "geology differentiation" and the resultant representation of a geological model as quasi-geology model. Integrating multiple physical property models to differentiate and characterize geological units at depth and work with the derived quasi-geology model may lead to a step change in maximizing the value of geophysics in the investigation and exploration at depth.

In this paper, we provide an overview of the historical background of geology differentiation and the current development based on physical property inversions of multiple geophysical data sets. We present the latest advances in combining machine learning techniques with modern geophysical inversion methodology to achieve meaningful geology differentiation as a means to image and characterize the geology at large depth in the earth's crust.