HOW PHYSICAL PROPERTIES IDENTIFY STRUCTURE & COMPOSITION OF IGNEOUS BASEMENT ROCK

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Downhole well-logging data provide continuous information about the physical properties of the penetrated rocks – an important complement to drilling. DSDP/ODP holes afford an opportunity to compile data sets and compare log responses for different geologic settings. For example, logging data can be used to differentiate between igneous basement rocks, i.e., basalts and gabbros.

Igneous rocks in the ocean can be principally attributed to three geological settings. In Mid-Ocean Ridge (MOR) settings at divergent plate boundaries, new crust is built. The upper part of the crust consists primarily of basaltic lava flows and pillows, grading downwards into basaltic dikes. These are underlain by gabbros. In a subduction zone setting, where oceanic crust is mainly recycled, new crust may be formed in back-arc basins. Basalts from this setting typically contain many cavities formed by trapped air bubbles (high vesicularity). The third setting is that of Large Igneous Provinces (LIPs) where large amounts of basaltic magma were produced from the mantle in relatively short geological time periods and formed huge lava flows. A zone with varying degrees of vesicularity characterized these thick lava flows.

Analyses of the data sets compiled from the downhole log responses from DSDP/ODP drill holes have allowed the following observations. The highest density, velocity and electrical resistivity values are recorded from the massive lava flows and gabbros. The structurally homogenous character of the gabbros leads to the highest measured values in density and velocity. Rocks with more fracturing or cavities have lower densities and velocities. For example, fractures in pillow lava sections or vesicles in lava flows are filled with material, i.e. seawater or alteration minerals, that is lighter and electrically more conductive than basalt; thus, density and electrical resistivity decrease.

In-situ physical properties of oxide gabbros are controlled by the mineralogical composition of the rocks. The high amount of heavy and electrically conductive iron and titanium oxide minerals in the rocks causes the electrical resistivity to decrease and density to increase. In addition to physical distinctions, geochemical differences occur as well. Basalts and gabbros generally have low levels of radioactive elements such as potassium, thorium, and uranium. Slight increases in gamma-ray values are related to potassium enrichment due to seafloor alteration in MOR basalts or subaerial weathering in rocks from LIPs. Back-arc basalts are originally higher in potassium due to recycling and secondary alteration, thus showing high gamma-ray values.

Variations in fracturing and vesicularity are closely related to the origin of the rocks and variations in physical properties of the rocks may thus be used to differentiate between different structural types of basalts (Bartetzko et al., submitted). Hence, defining ranges of log responses for certain rock types helps to understand physical behavior of the basement and discovering density-velocity relations makes it invaluable for complementary research fields like seismic investigations. It is also fundamental for further drilling projects as core recovery is generally low in this environment. Classification of rock types and application of this knowledge improve log interpretation (e.g. Bartetzko et al., 2001).

References:

Bartetzko, A., Pezard, P., Goldberg, D., Sun, Y.-F., and Becker, K. (2001): Volcanic stratigraphy of DSDP/ODP Hole 395A: An interpretation using well-logging data. Mar. Geophys. Res. 22: 111-127.

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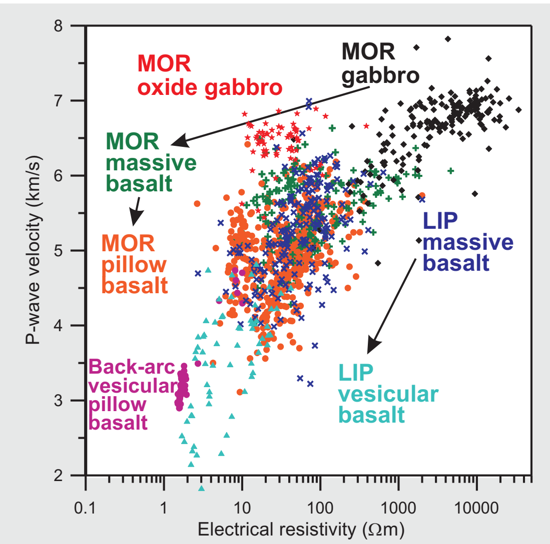

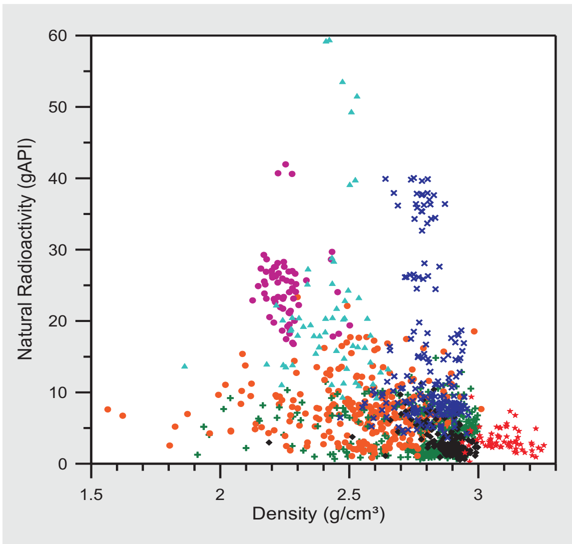

Different types of basaltic and gabbroic rocks show distinctive physical properties and can therefore be distinguished by downhole logs