Quantitative Estimation of Subseafloor Sulfide Deposit: Construction and Application of New Rock Physics Model of Complex Electrical Conductivity

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Quantitative estimation of target materials is one of the issues in the resources' exploration. The construction of a rock physics model appropriate for the target area and rock feature has been adaptable. For example, the electrical conductivity of rocks containing clay minerals have been formulated in the physical model, and fault structures have been evaluated using it. However, some target areas and materials remain difficult to interpret with existing technologies. Seafloor Massive Sulfide (SMS) deposit is one of such an objective.
Conductivity characteristics of SMS deposits are complicated to interpret because of two representative factors. One is the semi-conductive characteristic of specific sulfide minerals such as pyrite, chalcopyrite, and galena. The other is the large variation of conductivity of pore fluid due to the large variation of temperature and salinity. The solvable physics model that can explain both of their variation in one physical equation has not been constructed.
To solve this problem, we constructed a new rock physics model of multi-frequency complex electrical conductivity by integrating and modifying the preceding model, Pelton's equation and modified Archie's law. The equations have been applied to interpretations of complex resistivity of a sulfide mineral, and of the electrical conduction of a porous medium with pore fluid, respectively. Our model is represented by some other physical properties include pore fluid conductivity, and also by some parameters related to sulfide minerals such as pyrite, chalcopyrite, and galena.
We applied this model to the laboratory measurement data of rock samples obtained in Okinawa Trough, the seafloor hydrothermal area in Japan. As a result of the optimization of the parameters of our model, we succeeded in reproducing measurement complex electrical conductivity characteristics of rock samples. Through the optimization of model parameters, we obtained the regression equation between the components of metallic elements and one parameter of our model. Finally, our model and the regression equation were applied to the interpretation of geophysical exploration data in a seafloor hydrothermal area and contributed to proofing the existence of electrically conductive SMS ore body.
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