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Effect of Chemical Compositions on Electrical Properties of Low-Porosity Altered Granite in Dayingezhuang Gold Deposit, Shandong Province, NE China

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1 Introduction

Laboratory measurement of physical parameters of minerals and rocks is typically essential mean of geophysical prospecting, and also an effective way of exploring the structural and physicochemical properties of the deep Earth (Massonne H, 2013; LI J M, 2005). The diversity of factors affecting rocks electrical properties leads to the inconsistencies in field geophysical data and interior measured physical parameters, furthermore causes the non-uniqueness and uncertainties of exploration information interpretation in accuracy (He J S, 2006; Wang M Y, 2003; Fu L K., 1982; Zhang S Z, 1994), especially for electromagnetic prospecting on the metal deposit, of which altered wall rocks, stark contrasting in sandstone, are usually low porosity. For an understanding of dense granite electrical conductivity it is important to know to what extent effects, e.g. porosity, mineral and chemical composition, hold the dominant position of controlling the electrical properties of rocks. This information can only be obtained from the combined analysis of mineral and bulk rock chemistry, geophysical data (including electrical resistivity by direct-current) and density measurement. In this paper, such an approach is used to distinguish the difference between the effect of porosity and the key oxide content on the electrical conductivity of low-porosity rocks, with the progressively altered rocks from Dayingezhuang gold deposit from Zhaoping fault as example.

2 Geological Setting

Dayingezhuang gold deposit in Zhaoyuan Shandong Province, is one of the major altered rock-type gold enrichment areas in Jiaodong region. This gold deposit is

located in the eastern side of Yishu fracture, southeastern margin of Jiaoxibei uplift, south wing of Qixia multiple syncline, and in the middle part of Zhaoping fault. Stratas exposed in this area are mainly Archean Jiaodong Group metamorphic rocks and Quaternary humus and sandy clay. This gold deposit is mainly controlled by the Zhaoping fault, striking NE-NNE. The major magmatic rocks located in the footwall of this main fault in Dayingezhuang gold deposit, are Guojiadian K-feldspar granite, Linglong granite and Guojialing pluton. Most of the industrial ore bodies are different scales of wall rock alteration like silicification, sericitization, pyritization and K-feldspathization occur surrounding the veins. The major gold and ore production closely associated with pyritized phyllic alteration comes from the footwall of the Zhaoping fault.

3 Resistivity Measurement and Features

For accurately determining the physical parameters of the altered rocks, collected from a depth ranging between 380m and 616m underground, all samples were processed into the regular rectangular shape.

Resistivity was measured at DC at benchtop conditions using the 2-electrode method with the sample holder that is part of the Sample Core IP (Induced Polarization) System. The instrumental error for measured resistivities is $\pm 10\%$.

The test results showed that different types of altered granite held different electrical conductivity properties. All monzonitic granite, located in the footwall of the main fault, performed the high impedance, values of resistivity ranging between 2K $\Omega\cdot m$ and 11.2K $\Omega\cdot m$. The resistivity values of weathered granite were lower than the ones of fresh granite. Arranging the average resistivities of altered rocks in descending order is strong K-feldspar granite (10.67K $\Omega\cdot m$), sericitized granite (5.39K $\Omega\cdot m$), pyritized

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granite (2.96K $\Omega\cdot\text{m}$) and pyrite ore (41.26 $\Omega\cdot\text{m}$). Meanwhile structure constructors of pyrite, including disseminated and veinlet output, have an influence on the resistivity value as well, and the veined pyrite ore showed significantly low electrical resistivities.

4 Effect of Porosity on Electrical Conductivity of Dense Granite

It can be known from the sedimentary rock physics that the main factors affecting the electrical properties of sedimentary rocks are porosity and pore fluids. However the influence degree of porosity on resistivity of low-porosity dense granite is unclear. Porosity of rock samples was estimated from nuclear magnetic resonance system MiniMR-60 in Central South University non-destructively, rapidly and accurately, using the relaxation mechanism of ^1H nuclear with powerful gyromagnetic in the pore fluids.

The test data showed that total porosity of fine-grained granite veins was relatively high, ranging from 1.02% to 2.52%, and the porosity of small-size pores accounted over 70% of the total porosity. The T_2 frequency spectrum of K-feldspar granites were mainly well connected 3 peaks distribution, and the total porosity was 0.42%. T_2 frequency spectrum of pyritized granites, of which the porosity values of large-size being higher than the ones of other alteration-type granites, indicated that pyrite was mainly enriched along rock fractures equivalent with the previous microscopic observation results. However though the correlation analysis of resistivity and total porosity of vacuum water saturated granite rocks, it showed the feature of low correlation. It indicated that porosity had less impact on the electrical conductivity of low-porosity altered granite, but be associated with mineral components.

5 Relationship between Chemical Composition and Resistivity of Dense Granite

So far, the effect of chemical composition on the electrical conductivity had to be considered. Major element compositions were determined by XRF using a Rigaku Primus IIX in Central South University.

Though the whole rock chemistry, it was observed that

the content of any single one oxide had little relevance with resistivity of rock. However the value of the total amount of low-conductivity oxides divided by the total amount of high-conductivity oxides had a higher correlation with the resistivity, which was consistent with previous mantle minerals physics that there were some relevance between the minerals conductivity and their corresponding ratio of low conductivity oxide contents divided by high conductivity oxide contents.

In summary, it is different from the effect of pore fluid on electrical conductivity of extreme high-porosity sedimentary sandstone in petroleum exploration that the one of the main factors influencing the electrical conductivity of low-porosity dense altered granites should include the chemical composition of rock samples.

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