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Response of Coal Rock Apparent Resistivity to Hydraulic Fracturing Process

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Abstract. In order to explore the comprehensive evaluation means of the extent of hydraulic fracturing region in coal seams, in this study, we analyzed the feasibility of detecting the response of coal rock direct current (DC) apparent resistivity to hydraulic-fracturing using Archie's theory and conducted experimental researches on the response of DC resistivity in the hydraulic fracturing process using small-scale coal rock samples. The experimental results showed that high-pressure water reduces the coal rock apparent resistivity by reducing the initial porosity of coalbeds and enlarging the water content in its flow-through region. The post-hydraulic fracturing apparent resistivity of coal rock samples was reduced by 2-3 fold compared with the pre-hydraulic fracturing apparent resistivity. The applied load indirectly affects apparent resistivity of coal rock samples by changing their porosity. Appearance of the low resistivity zone after hydraulic fracturing was accompanied by the formation of its surrounding stress concentration zone.

Keywords: Coal rock mass; Hydraulic fracturing; DC resistivity response; Apparent resistivity

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1. Introduction

In recent years, China's coal mines have introduced the hydraulic fracturing technique in oil and gas industry into coal mining for pressure relief and permeability improvement of difficult drainage coal seams. Experimental investigations (Huang *et al*. 2014, Lei and Wu 2014, Hou *et al*. 2013), numerical simulations (Yan *et al*. 2013, Zhou *et al*. 2013, Zhang *et al*. 2014) and field measurements (Li *et al*. 2013, Zhu *et al*. 2014) all have proven that hydraulic fracturing can effectively relieve gas pressure, increase gas permeability into coal seams, greatly improve gas drainage efficiency, and ultimately achieve both good gas drainage and outburst prevention.

The most key step in hydraulic fracturing technique applications is determination of the fractured zone. If it is determined reasonably, the engineering workload of gas drainage at the late stage at the mining site will be greatly reduced under without sacrificing the safe production of coal mining. Otherwise, the stress may inhomogeneously distributed on both sides of the single fractured crack or among the fractured cracks after coal rock fracturing, forming the stress concentration zone in the coal seams, evening inducing coal and gas outbursts. At present, the disturbance range of hydraulic fracturing is still determined using very traditional means, such as measuring the amount of drill cuttings, water content, gas drainage effect, etc (Chen 2012, Lin 2010). However, these parameters are only "point evaluation" of the potential regions impacted by hydraulic fracturing. In other words, these parameters are measured by extracting coal cores at fixed positions within the possible regions to assess whether hydraulic fracturing could affect the positions. Obviously, the method is no way to realize a comprehensive, continuous, spatiotemporal assessment of the coal rock structure within the regions. Thus, to some extent, it makes the late gas drainage construction blind, not only affecting the production safety but also greatly increasing the construction costs.

In recent years, many geoelectric techniques have been widely applied to the coal mine prospecting field (Van 2005, Wilkinson *et al*. 2005, Chambers *et al*. 2007, Karaoulis *et al*. 2014). Among them, the direct current resistivity method measures the potential of electrodes or potential difference between electrodes after supplying electricity into the measured coal rock region to inversely retrieve changes in coal rock apparent resistivity and further effectively determine the internal structure of coal seams. That is, the method diagnoses the geological anomaly area in coalbeds through testing changes in coal rock apparent resistivity (Loke *et al*. 2013, Liu 2014). Because apparent resistivity is highly sensitive to water, it is inevitable that in the hydraulic fracturing process, high pressure water flows along fractured cracks into coal rock mass, leading to changes in apparent resistivity in the coal-rock mass and its adjacent regions. In general, the region into which high pressure water permeates can be considered as the area effectively affected by hydraulic fracturing. Based on the above, we hypothesize that changes in apparent resistivity in the hydraulic fracturing process could be used to determine the areas impacted by hydraulic fracturing.

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