专题:深地地球物理技术

直流电阻率法与深部地下空间开发利用

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摘要:直流电阻率方法原理简单、抗干扰能力强,物性方程满足泊松方程,因此,对低阻、高阻体均具有明显的物理响应,且其分辨率不受电磁波“频率”影响,适合于深部空间开发利用大尺度工程探测和小尺度原位测试。

大尺度工程应用:地下空间的开发利用安全首当其中,和煤炭开采有相似地方,查明目标地质体构造是保证安全的前提。其中主要包括两部分初始掘进超前探测和巷道行程后的地下空间的利用。在掘进巷道内铺设电极,激发全电场数据,利用全空间三维反演技术探测掘进面前方的地质情况;地下巷道行成后,利用巷道空间,环绕工作面铺设电极,利用全电场数据,给工作利用三维反演技术对工作面内部地质情况进行探查。

小尺度岩石样本测定和原位测试:深部地下空间(大于1500米)岩石电性物理特征研究是进行电磁法探测基础,而目前电磁法研究主要聚焦在大尺度问题,主要利用其低频成分。利用低频电磁信号成分研究小尺度岩石样本不可行。直流电阻率方法,其物性方程满足泊松方程,不受大小尺度大小的现在,其分辨率主要决定于剖分网格的大小,可对岩石小样把进行测试,利用三维反演技术可对其内部构造进行刻画。原位测试指在深部地层岩石的原始部位或者模拟相似环境中进行,因此要高精密的仪器设备支持深部空间环境,与电磁法电磁场相比,直流电场稳定,更适宜用于原位测试。

关键词:直流电阻率方法;深部空间与利用;小尺度原位测试;大尺度工程应用

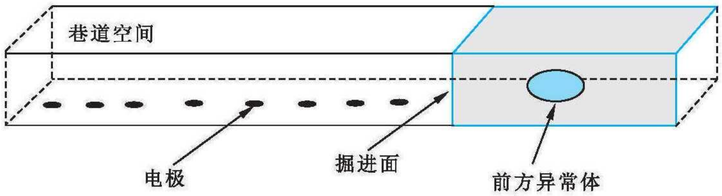

图1 地下空间超前探测观测系统示意图

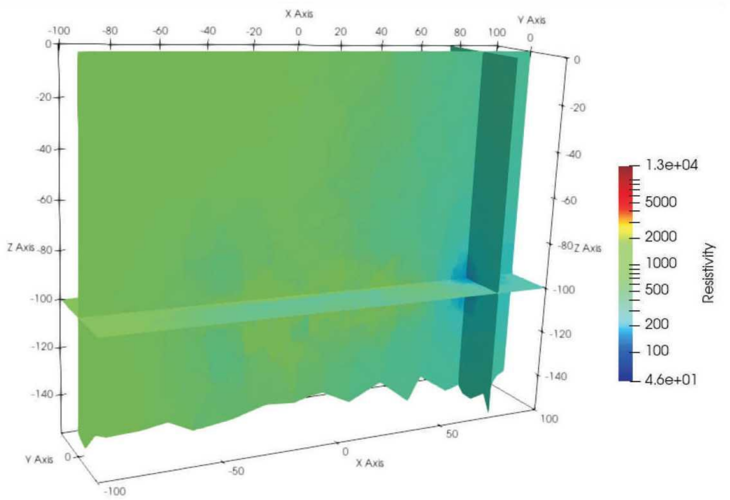

图2 地下空间电阻率法超前探测反演结果

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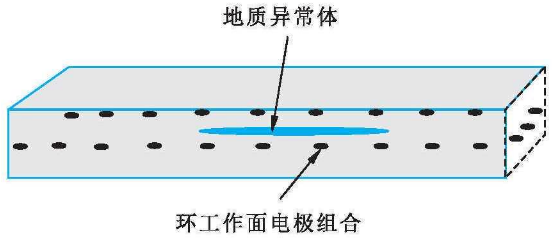

图 3　地下空间环工作面探测意图

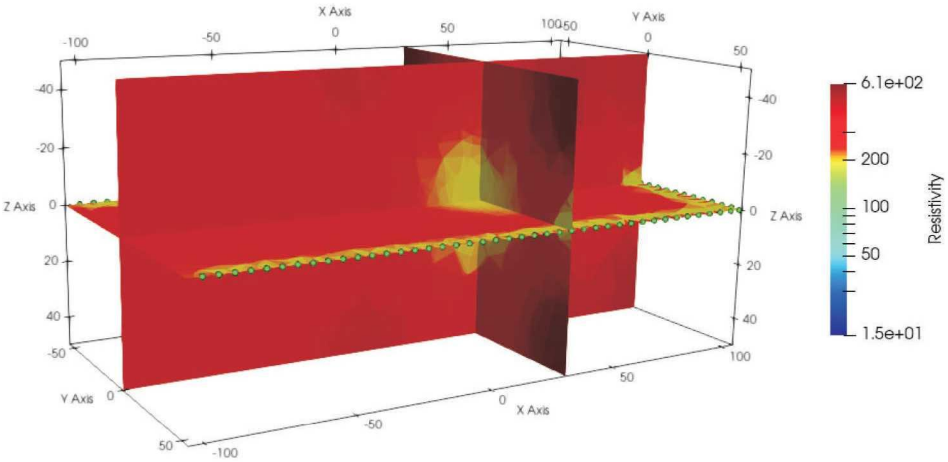

图 4　地下空间环工作面探测反演结果

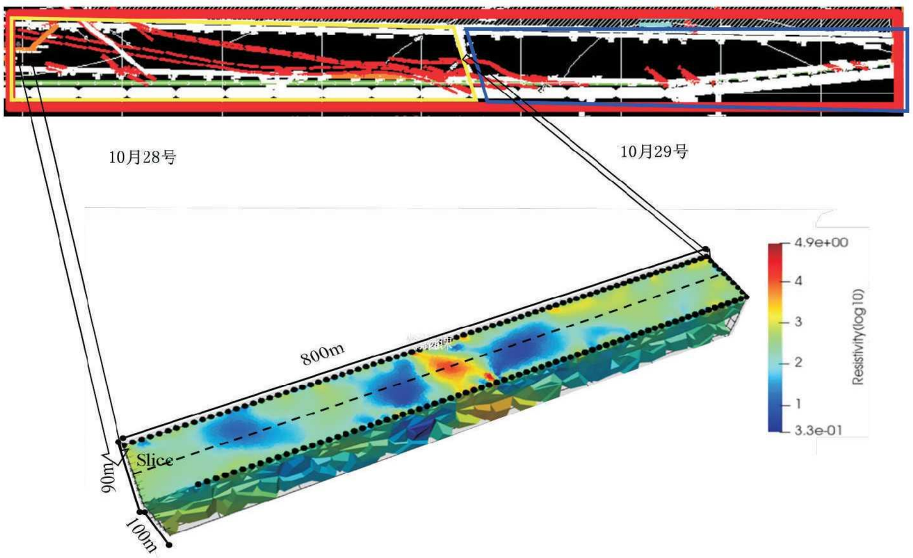

图 5　地下空间工程探测结果

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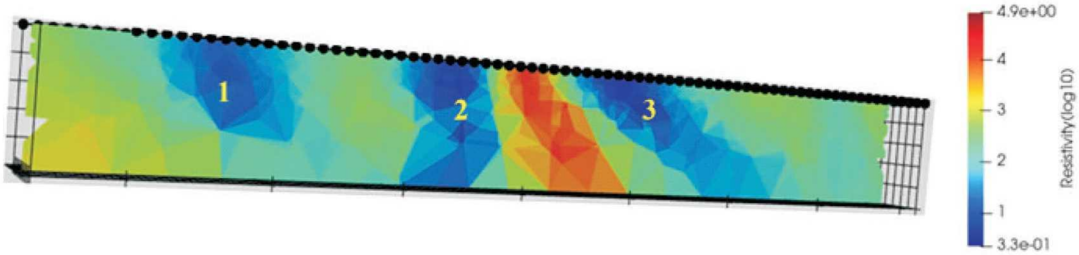

图 6　地下空间工程探测结果

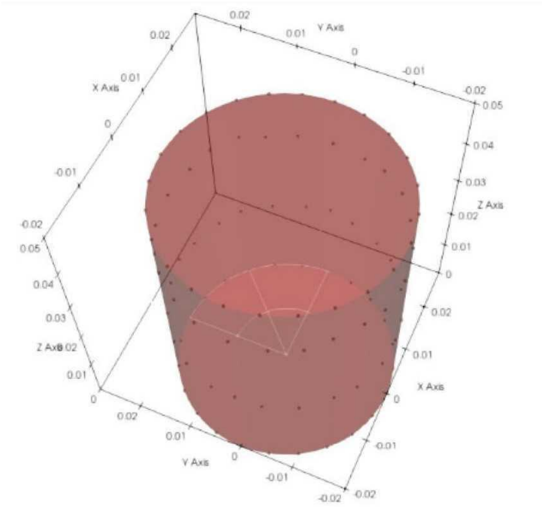

图 7　岩石样本测量反演示意图

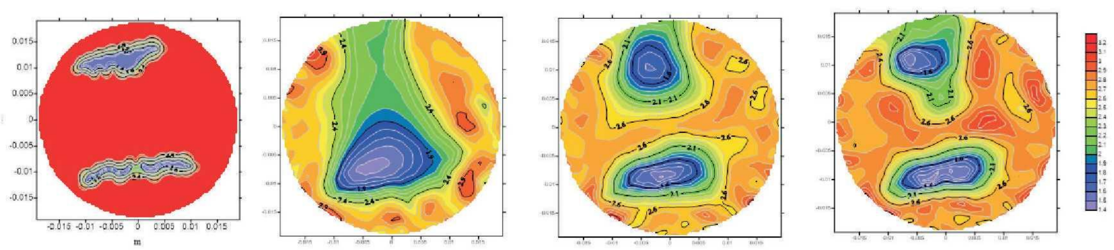

图 8　岩石样本测试反演结果示意图

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DC Resistivity Method Application in Deep Underground Space Development and Utilization

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Abstract: DC resistivity method has simple principle and strong anti-interference ability, besides its the physical property equation satisfies the Poisson equation. Therefore, it has clear physical response to both low and high resistance bodies. Furthermore, its resolution is not affected by the "frequency" of electromagnetic waves. For this reason, not only it is suitable for large-scale engineering detection of deep space development but also can be used for small-scale rock sample measurement.

Applications in large-scale engineering: The safety of underground space development and utilization is the first issue, which is similar to that of coal mining. Identifying the structure of target geological body is the premise of ensuring safety. It mainly includes two parts: the advance detection of initial tunneling and the utilization of underground space after roadway travel. Electrodes are laid in the tunneling roadway to stimulate the full electric field data, and the full space three-dimensional inversion technology is used to detect the geological conditions in front of the tunneling. After the underground roadway is formed, the electrode is laid around the working face by using the roadway space, and the three-dimensional inversion technology is used to explore the internal geological conditions of the working face by using the full electric field data.

Determination of small-scale rock samples and in-situ measurement: The study of the electrical physical characteristics of rocks in deep underground space (greater than 1500 meters) is the basis for electromagnetic detection, and the current electromagnetic research mainly focuses on the large-scale problems, mainly using the low-frequency components. It is not feasible to study small-scale rock samples by using low-frequency electromagnetic signal components. The DC resistivity method, whose physical property equation satisfies the Poisson equation, is not limited by the size of the scale, and its resolution is mainly determined by the size of the grid, which can be used to test the rock sample and characterize its internal structure by using three-dimensional inversion technology. In-situ measurement is mainly carried out in the original parts of deep formation rocks or in the simulated similar environment, so it is necessary to support the deep space environment with high-precision instruments and equipment. Compared with electromagnetic field, the direct current electric field is more stable and more suitable for in-situ measurement.

Keyword: DC resistivity method; Deep space and utilization; Small-scale in-situ measurement; Large-scale engineering applications

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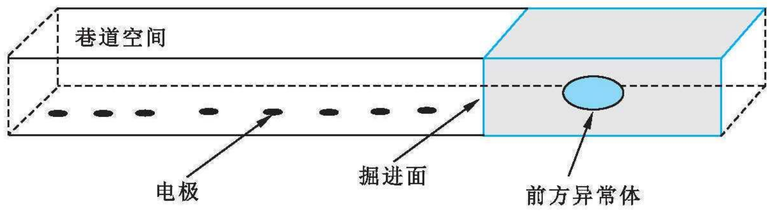

Fig.1 Schematic diagram of the observation system for advanced detection of underground space

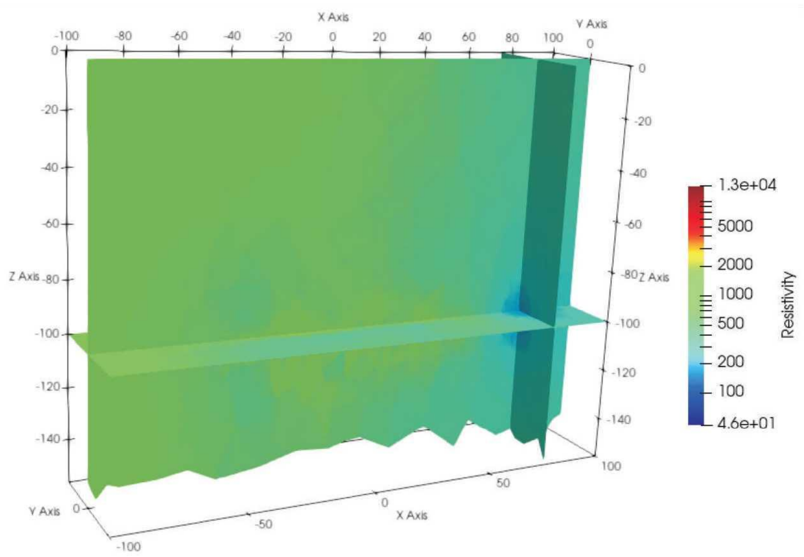

Fig.2 Advanced detection and inversion results of underground space resistivity method

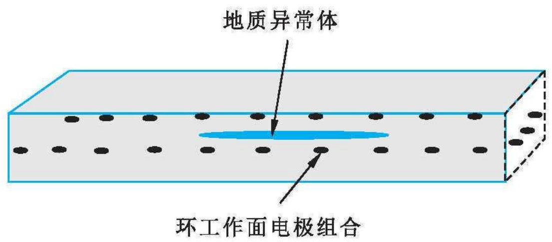

Fig.3 Detection intent of underground space ring working face

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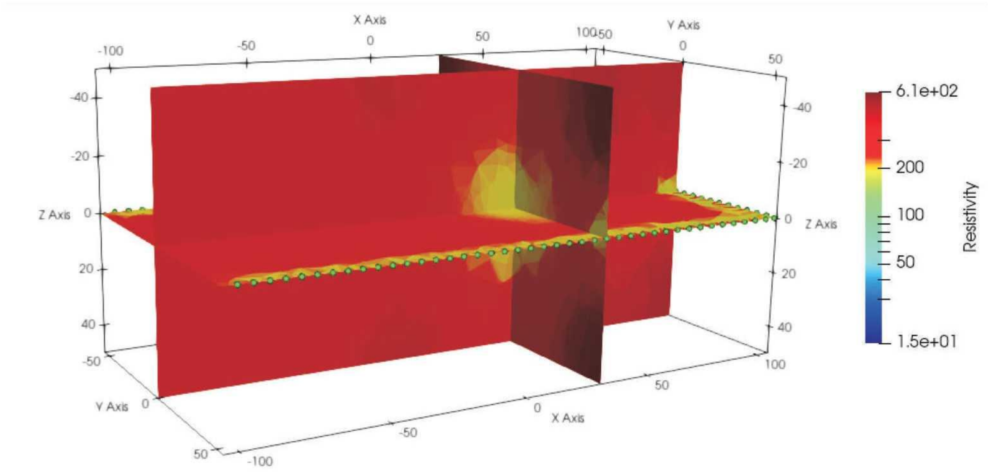

Fig.4　Detection and inversion results of underground space annular working face

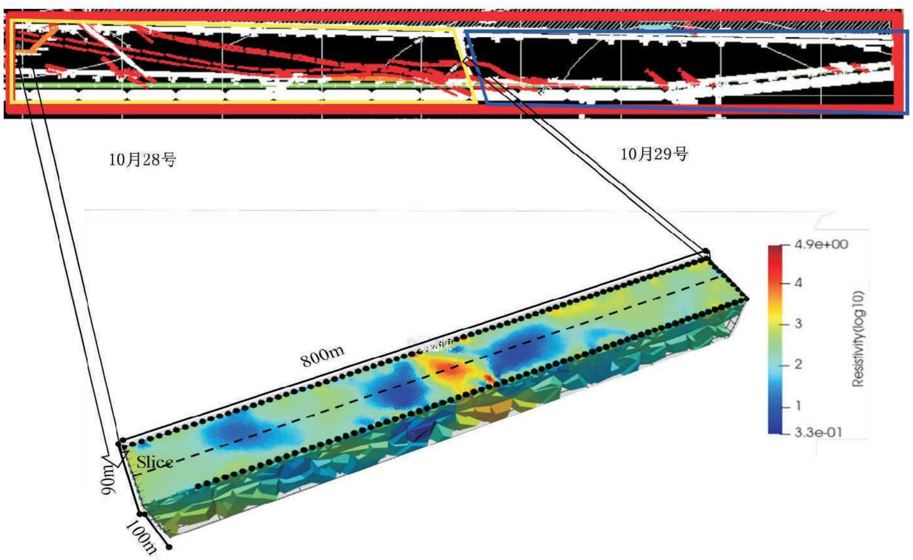

Fig.5　Detection results of underground space engineering

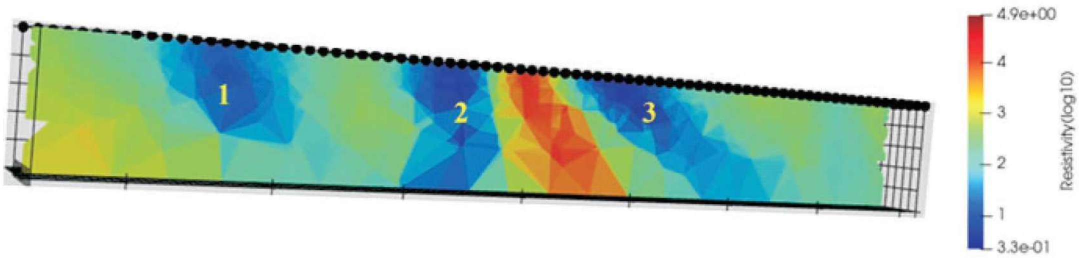

Fig.6　Slice of detection results

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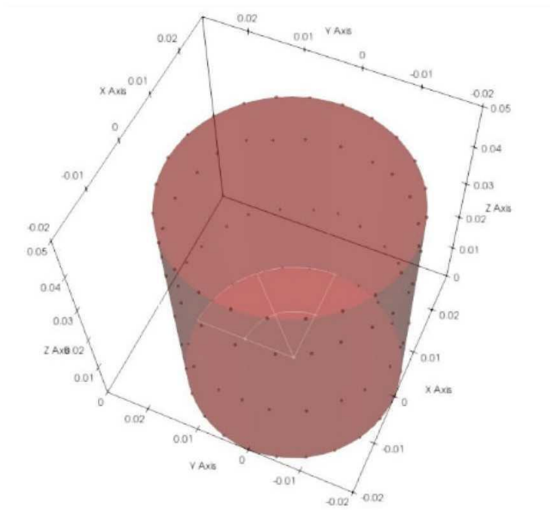
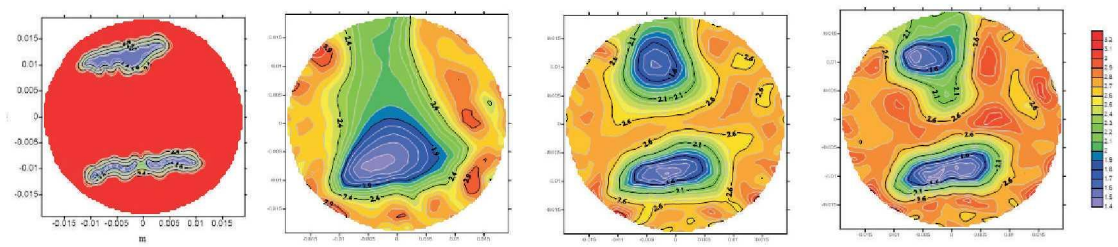


Fig.7 Schematic diagram of rock sample measurement and inversion



rock sample model; inversion result of 78 data points; 140 data points; 216 data points

Fig.8 Schematic diagram of rock sample measurement and inversion results

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