A survey of underground detection methods with a new proposal for urban underground detection

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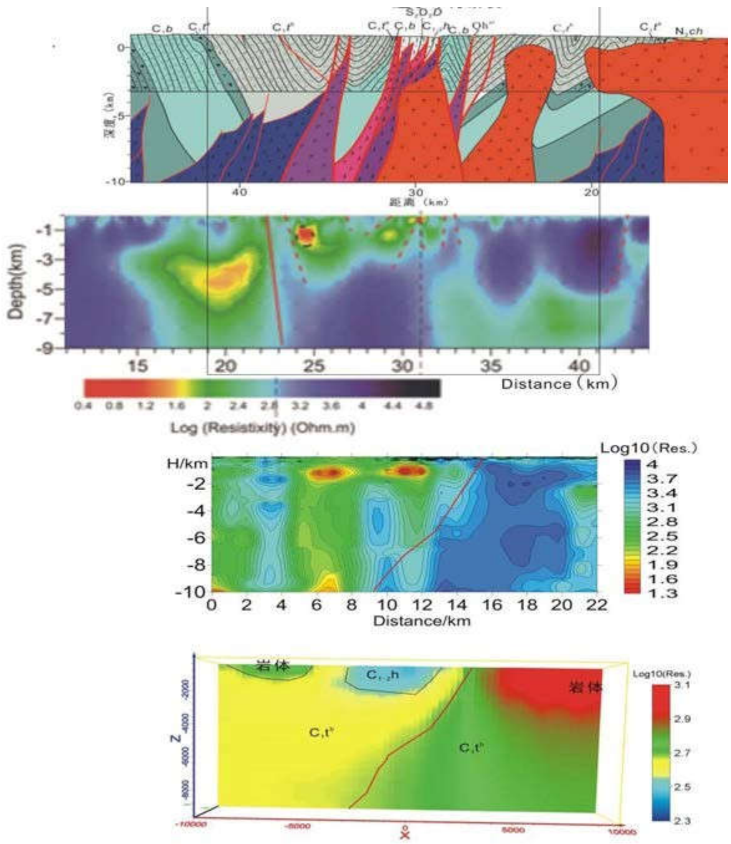
High-precision detection and comprehensive exploitation and utilization of urban underground space is essential to relieve the crises of urban population, environment and resources, and to realize sustainable urban development.

For underground space detection, the main geophysical methods can be divided into three categories, i.e., 1) dc resistivity theory-based methods, including the direct current method, the charging method, the induced polarization method and high density resistivity method; 2) elastic wave theory-based methods, including the shallow seismic reflection method and the Rayleigh wave method; 3) electromagnetic field theory-based method, including the controlled source electromagnetic method, the transient electromagnetic method and the ground penetrating radar (GPR) method. These methods have been extensively developed and are briefly reviewed in this paper with field application data presented for several typical methods. The application results from a high-depth electromagnetic detection method is shown in Figure 1.

In general, the detection depths of the existing technologies are small, and the detection precisions are poor. In addition, the detection of urban underground space is more difficult because of the existence of a variety of serious interferences in highly urbanized regions. How to obtain the accurate description about underground space in a severe condition and with no damage to the underground environment is an urgent problem. In this paper, a resistivity detection method based on a dense multi-frequency phase-controlled coil array is proposed, aiming to improve the detection depth and precision of urban underground space. The schematic diagram of the proposed method is shown in Figure 2. Simulations of the forward problem in the proposed method were carried out, and the preliminary results are shown in Figure 3.



Geological profile

Existing 2D reconstruction

Reconstructed 2D slice with field data

Reconstructed 3D image with field data

Figure 1. Field application results for underground detection by a high-depth electromagnetic detection method

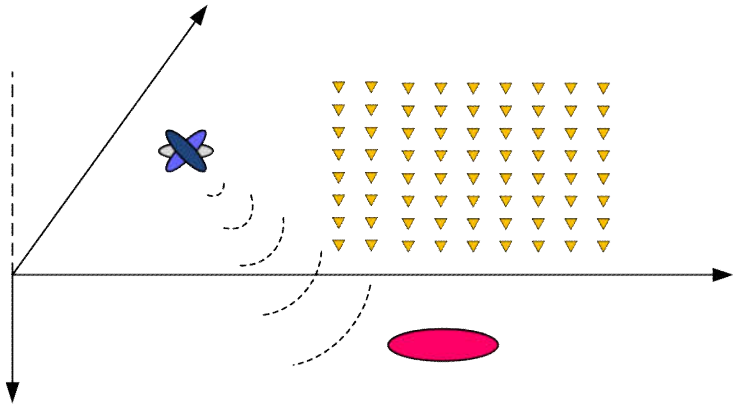


Figure 2. Schematic diagram of proposed method

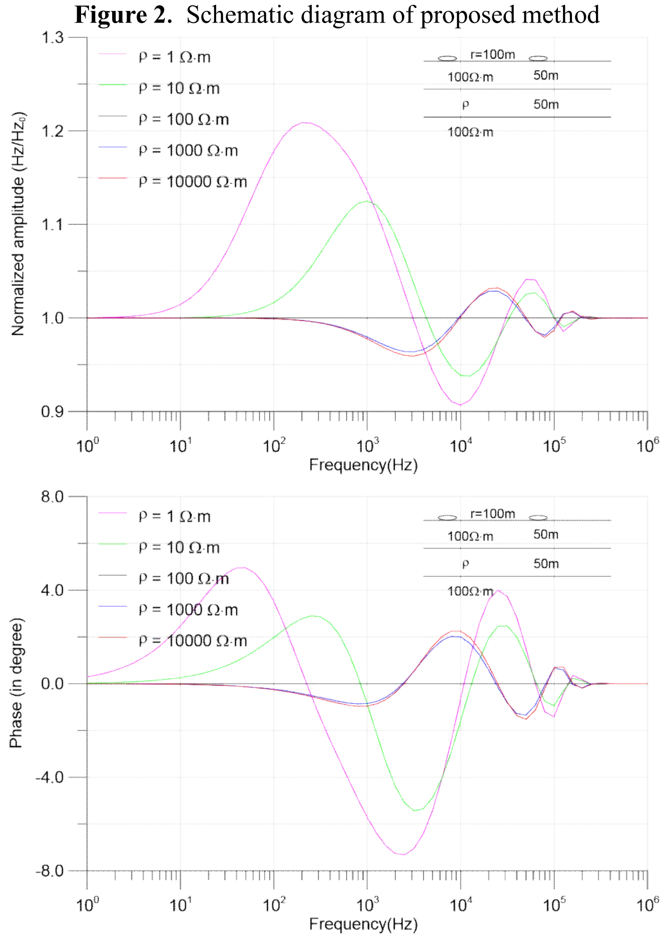


Figure 3. Preliminary simulation results