Electromagnetic responses of ore bodies: finite-difference time-domain modelling of time-domain electromagnetic geophysical data

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Time-domain electromagnetic (TDEM) geophysical methods are used extensively to identify and constrain zones of anomalously high conductivity in the subsurface, which in turn can correspond to mineral deposits. A multitude of TDEM systems have been developed. They primarily differ in the geometry of the transmitter and receiver and in the transmitted waveform, which are designed to optimize a system for particular kinds of targets. Forward modelling and inversion for an electromagnetic problem is complicated. The range of geometries that can be handled analytically is limited, and computationally inexpensive numerical methods are also limited to relatively simple geometries, such as plates, rectangular prisms, spheres, and cylinders. In addition to a complex geometry, a body can have a non-uniform conductivity structure with vertical and lateral variations, as is the case for volcanogenic massive sulfide (VMS) deposits. We propose to use the finite-difference time-domain (FDTD) method to model TDEM responses of conductors with realistic geometries and physical properties. There are several advantages to using FDTD for modelling TDEM data. First, as FDTD is a time-domain numerical method, the time series is obtained directly, with no need to compute responses at several frequencies followed by an inverse Fourier transform to extract the time series. Secondly, the FDTD method uses rectangular cells to discretize a three-dimensional geometrical domain; this approach can easily handle arbitrary inhomogeneous conductivity distributions. Unlike in a finite-element scheme, discretizing the geometry is simple in terms of both the algorithm and computational resources required. Also, FDTD can easily be parallelized, which we implement using a powerful desktop graphics processing unit (GPU). The merits of the FDTD method will be examined in two ways: (1) a comparison of the FDTD results to existing approaches; and (2), examples will be presented of realistic ore bodies whose electromagnetic response can only be modelled with a general-purpose scheme such as FDTD.