Piezomagnetic signals in a borehole due to dislocation sources

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Geophysical observation using a borehole has some merits in seismology and volcanology: i.e. noise reduction and signal enhancement. However, when we are concerned with the potential-related quantities, i.e. gravity and magnetic filelds, we need special consideration, because we make measurements just within the source material of the potential field. In particular, when we observe the magnetic field inside a magnetized material, we should take into account the influence of magnetic poles around the cavity made for observation. This additional effect has a simple relationship to the displacement at the observation point in the case of piezomagnetic changes due to dislocation sources: It is given by the displacement itself multiplied by some material parameters (Sasai, 1983). That this effect enhances piezomagnetic signals was already confirmed for a vertical rectangular strike-slip fault (Sasai, 1994). We extend Sasai's (1994) formulation to every type of faulting, i.e. strike-slip, dip-slip and tensile movement across an inclined rectangular fault, which is also an extention of Utsugi et al.'s (2000) computer program.

First we obtain the elementary piezomagnetic potentials within a magnetized earth, which are potentials produced by six kinds of point dislocations. Such potentials outside the earth have been obtained by Sasai (1990). In this case, not only the effect of magnetic poles along the borehole but also the effect when we come across the earth's surface boundary should be taken into account. The latter term arises from a boundary condition that magnetic induction must be continuous and hence that the normal component of the magnetic field becomes discontinuous when we pass through the earth's surface. This discontinuity completely cancels the sudden appearance of the borehole effect, which makes the potential continuous across the earth's surface. The elementary potentials thus obtained are integrated over the dislocation surface, which gives the extended version of Utsugi et al.'s (2000) formula for an arbitrary fault.

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