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New analysis method of seismic geomagnetic disturbance vector using ground-based observation: a case study of the 2007 Peru earthquake

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Among many precursors related with geology, geophysics and geochemistry field, the geomagnetic field is one of the most sensitive factors of seismic activity. Current works basically analyzed scalar values of multiple components separately or the ratio of vertical component and horizontal component to extract electromagnetic radiation anomalies in different frequency range. However, the relationship of induced magnetic horizontal vector (IMHV) and earthquake light generated by pressure-simulated rock current (PSRC) was initially proved in M7.3 Fukushima earthquake of 16 March 2022. The geomagnetic anomalies obtained by current methods originate from alternating electromagnetic fields instead of rock current, which lack the investigation of the direction information of seismic geomagnetic disturbance vector.

By combining observational evidence from existing rock current experiments with the volumetric scaling effect, the intensity of current generated by the compressed crustal rock mass in seismogenic areas was estimated to be over 1 MA when the magnitude reaches 7 or above. Based on Biot-Savart's law, the magnetic field disturbance intensity generated by the rock current in three-dimensional space was simulated in this study. The simulation results indicate that magnetic field disturbances ranging from several nanotesla to tens of nanotesla can be generated at approximately 600 km from the rock current, which can be easily captured by the existing dense distribution of ground-based observatory networks (e.g., INTERMAGNET, MAGDAS).

This paper aims to propose an analysis method based on seismic geomagnetic disturbance vectors and validate it using the 2007 M7.3 Peru earthquake as a case study. In this method, two arbitrary geomagnetic stations around the seismogenic area are selected to obtain the magnetic variation of multiple geomagnetic component (e.g., declination horizontal, and vertical component), which are then synthesized into the disturbance vectors. Subsequently, the intersection line of the two vector planes of the magnetic field disturbances is determined based on the concept of forward intersection, allowing for an approximate estimation of the orientation of the rock current. Finally, the spatial relationship between multiple disturbance vectors and the rock current is assessed to determine if Biot-Savart's law is satisfied.

Taking the 2007 Peru earthquake as a research case, magnetic anomalies in both horizontal and vertical components were detected prior to the earthquake at two geomagnetic stations (i.e., the HUA station from INTERMAGNET and the ANC station from MAGDAS) located within 300 km from

the epicenter. The method proposed in this study was utilized to further analyze the data, revealing that the rock currents obtained from the disturbance vectors were distributed around the seismogenic area. Besides, the combination of geological data and the positive holes theory also provided confirmation of the presence of rock types capable of generating current carriers in the seismogenic area. The method proposed in this study, to a certain extent, can effectively verify the spatiotemporal correlation between geomagnetic anomalies and seismic activities, which enables the localization of stress-locked regions and can serve as an effective approach for detecting seismic magnetic anomalies and short-term earthquake forecasting.