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Observation of Earth’s magnetic field in search for earthquake precursors

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The changes in the magnetic field associated with the variations in the stress field were first observed by Stacey (1963) and Nagata (1969). Tectonomagnetism involves the variation of the magnetic field associated with the occurrence of the seismic events (Parkinson, 1983; Edwin et al., 1983). Reikitaki (1976) and Melon et al. (1998) studied the geomagnetic effect of earthquakes. A comparison of geomagnetic and seismic data shows the relation between these two quantities is quite evident. (Liu et al., 2006; ; Hayakawa et al., 2007; Ghamry et al., 2013).

In this study, the data are driven from the INTERMAGNET website. Some additional required data such as geomagnetic storm indices are extracted from Solar-Geophysical Data section of National Centers for Environmental Information and Space Weather Archive websites. According to Dobrovolski's relation $P=10^{0.43M}$ (Dobrovolski et al. 1979), it is expected that the precursory phenomena will be observed within a radius up to1000 km from the earthquake for a 7 magnitude earthquake (Fig. 1). Among the various magnetic components, the X or horizontal components are usually more suitable for the proposed processing method (Fig. 2).

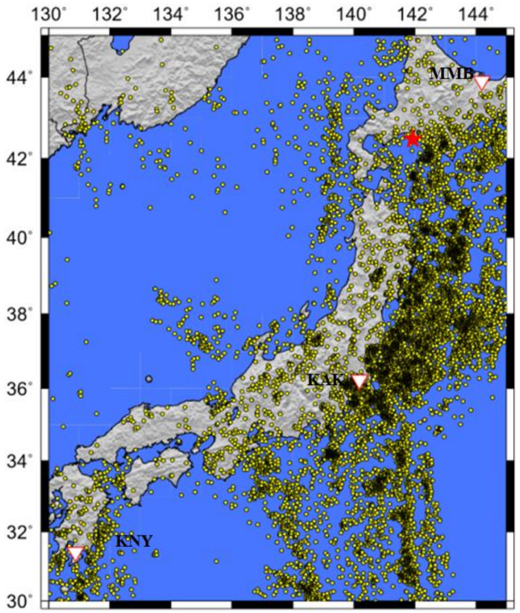

Fig 1. The epicenter of the 6.6 magnitude earthquake on 09/05/2018 in Japan (red star), the location of the investigated stations (white triangle)

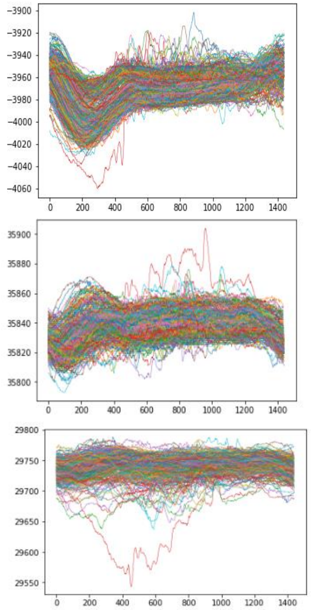

Fig 2. The characteristic curve in a one-year period for X, Y and Z components of the .magnetic field.

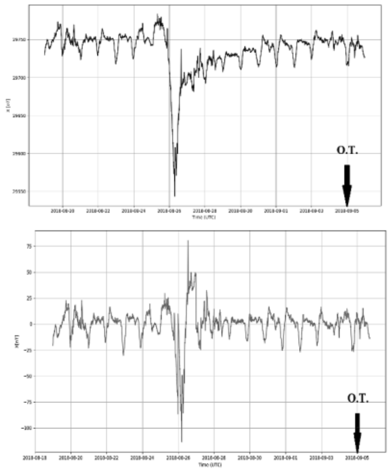

Fig 3. The raw (upper) and the processed data (lower) within a week before and after the origin time of the Earthquake for one of the stations (Y component)

The characteristic curve method is proposed here to reduce the effect of factors affecting the Earth's magnetic field at the magnetic stations' location. After identifying the station's geomagnetic nature, or in other words, the repetitive effect of daily variations observed at the station, the relevant effect is reduced from the data. These anomalies are then compared with the region's seismic activities by examining the anomalies which are more apparent after the above steps. Indeed, we separate the noise from the desired signal and finally the observed anomaly is more distinct. This way the usability of the data as an earthquake precursor is enhanced.

To display the geomagnetic data under discussion, one must first correct the values which are not correctly recorded, by replacing them with the previous or an average value. After selecting the appropriate time interval using the available data from each station, the repeated plot of the observed values over 24 hours interval shows the station's geomagnetic nature in question. This plot shows the characteristic curve.

Thus each ground station has a characteristic curve for each magnetic field component, which estimates the expected values of these components within the desired time range. By subtracting these values from the geomagnetic record, it is possible to obtain purer anomalies and correlate them with the seismic activity. After getting the characteristic curve and subtracting it from the record to reduce the effect of the daily variations, the anomalies observed before the earthquakes are more intense (Fig. 3). Based on the obtained results, anomalies in the magnetic field can be considered as earthquake predictions.

As shown in Fig. 4, the information collected from the magnetic storm showed that there was also a magnetic storm on the date (26/08/2018) when the anomaly in the Earth's magnetic field was reported. Therefore, due to the coincidence between the magnetic storm and the magnetic anomaly, these anomalies cannot be directly related to the earthquake with high certainty. Likewise, it cannot be assumed that the observed anomaly has no connection with the intended earthquake. As mentioned in the introduction, there are many cases of observing geomagnetic precursors before earthquakes, all of which were not affected by the magnetic storm. Apart from the nature and mechanism of the geomagnetic precursor generation, the dependence of the magnetic storm and the anomalies observed in this field is also a phenomenon that can be discussed and needs to be investigated. Therefore, commenting on the existence or non-existence of indicators in the investigated earthquake requires more data and detailed studies.

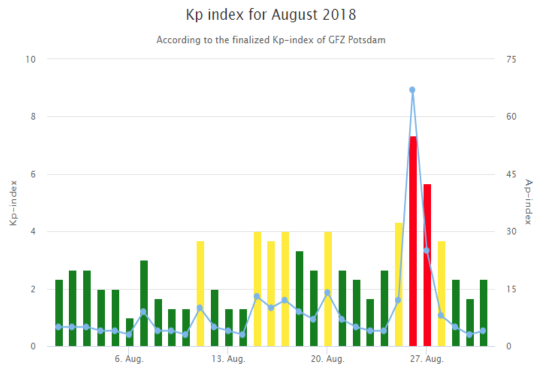

Fig. 4.Reported magnetic storm (from spaceweatherlive.com)