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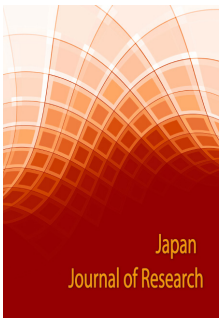
Short Communication



Earthquake Prediction: Recent Development and Problems

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We started to study earthquake prediction from 1978 to develop ocean bottom seismometer and seismic activity, and worked in many fields of projects, construction of the first GPS observation network, MT survey, electromagnetic observation using the borehole antenna at seven sites. We spend lots of time in electromagnetic observation to find anomalous phenomena. There is one of electromagnetic sensors using higher resolving power at the site near the fracture zone of the Tohoku Earthquake 2011. The clear amorous phenomena are detected from 9 days before occurrence of the event. We get very clear phenomena and published the results in several journals [1].

However, we cannot find sponsors to construct the large network of the system as a social implementation. Meanwhile we find a big company interested to develop earthquake prediction method in 2018. We discussed several weeks with them which kinds of method should be used. As matter of fact, we must select seismic or GPS network both of which cover whole Japan having about 1,000 observation sites compared with situation of only 7 borehole sensors.

We found the foreshock as precursor is not limited to the real earthquake but the slow-slips are observed by using low frequency tremor [2], and found important messages "short term prediction will be possible if it can be detected by geophysical means " in Scholz [3], and in Ohnaka and Matsu'ura [4].

So that we tried to find those phenomena using continuous data of the High-net several months, and at last find 4 kinds of tremors and two small micro-earthquakes (HFTs). The score parameter is defined to show the degree of activity of the events in the focal area and reference area of four sample earthquakes. The score is introduced to count number of sites where the activity exceeds each local threshold value.

Three standing out peaks are found before one of major earthquakes and be assumed to be precursors in nucleation process. But those peaks must be distinguished from many of peaks of any other stage. We checked these peaks using two key parameters, peak strength (number of score) and time rate of them (acceleration) referring Voight [5] and Scholz [3].

Three kinds of dominant precursors, initial, intermediate, and immediate, are shown to occur in order and at 6.4 weeks ±1.2 for initial precursor, at 4.6 weeks ±0.4 for intermediate precursor, and at 0.5 weeks ±0.3 weeks for immediate precursor, respectively [6,7].

There are several problems to be solved before social implementation of such system. At first, much more samples of major earthquake should be analysed to find have enough robust threshold. We used the observation sites based on the epicenter of sample earthquake and evaluation area using official reports, which cannot be used for real-time operation. The rule of distinguishing was deduced from analyses of three sample major earthquakes. We should find robust characteristics as far as possible. For example, the initial precursor is enough robust to be distinguished, and the immediate precursor is distinguished by the same threshold at least for the cases of the four sample major earthquakes.

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