A Characteristic Change in Fractal Dimension Prior to the 2003 Tokachi-oki Earthquake and its Tectonic Significance

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Generally, the form of hypocenter distribution has a fractal structure. Therefore, hypocenters are distributed heterogeneously. The degree of heterogeneity of fractal hypocenter distribution can be expressed in a fractal dimension D. When seismic activity in a part of an analysis area became active or quiescent, the degree of this heterogeneity will change. Therefore, it is expected that the D of hypocenter spatial distribution plays an indicator of the seismic activation or quiescence.Now, it is often reported that unusual variation of hypocenter distribution, such as the seismic activation or quiescence, appears before a large earthquake occurrence. Then, D may change prior to a large earthquake occurrence. Actually, it was reported that the phenomena which resembled such D changes had appeared before some other large earthquakes, for example the 1995 Hyogoken-Nanbu Earthquake and the 2000 Tottoriken-Seibu Earthquake, etc.

It is expected the 2003 Tokachi-Oki Earthquake had the D variation same as these preseismic changes, because this was one of the largest earthquake in recent Japan. In this study, the author investigated whether there was a D change to precede this earthquake occurrence.

In this study, Japan Meteorological Agency Earthquake Catalog was used. The D value of hypocenter distribution was calculated by the correlation integral method. In order to examine the temporal variations in D, the running time-window method was used. Each time-window is composed of 100 or 300 consecutive earthquakes. The windows are advanced by 10 events between each calculation.

The D value had changed within the range of nearly 1.5 before 1998. D began to decrease in 1998, and became the minimum in the middle of 2002. After that, the value of D had been very small, for about one year before the main shock occurrence. But, the unusual variation in number of earthquakes was not found.

These D changes may be precursors of these large earthquakes. Now, the D which is estimated by correlation integral method is sensitive to spatial concentration of hypocenters. If most of earthquakes are in hypocenter clusters, the D will decrease effectively. It is considered that such a situation is caused by seismic activation and quiescence. First, as its cause, the hypocenter cluster is formed by swarm earthquake or aftershock activity which has the small activity area. In this case, it seems that seismic activity become active. Second, when a seismic gap is formed by seismic quiescence, such situation may be realized. In this case, it is expected that the earthquakes are isolated and compose clusters, because a seismic gap cuts the spatial connection of hypocenters. In conclusion, both of seismic activation and quiescence are effective for D decrease. In case of the 2003 Tokachi-Oki Earthquake, the hypocenter clusters appeared with D decrease simultaneously, but the number of earthquakes did not change especially. As this reason, it is proposed that the number of earthquake was offset because the seismic activity became quiet except cluster parts. However, D may decrease effectively in such situation. Consequently, it is thought that the drastic D decrease was led by these effects.