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A New Method of Estimating Epicentral Distance and Magnitude for Early Earthquake Detection (1) Principle

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we present a new method of estimating an epicentral distance on the basis of slope of an initial part of P wave arrival. First, in order to express the difference in waveforms quantitatively, we introduced a simple function in the form of Bt exp(-At) and determined the unknown parameters A and B in terms of least square method by fitting this to observed seismic wave data. Then we found that logB is closely related to epicentral distance D. This relation seems to hold good independent of earthquake magnitudes. By using this relation we can roughly estimate an epicentral distance soon after P wave arrival. By using logB in place of D, we can estimate a magnitude easily from a formula similar to a conventional formula M= a logVmax + b logD + c.

1. Introduction

It is an important but quite difficult problem to estimate earthquake magnitude and epicentral distance within a few seconds from P wave arrival. The only method that has now been under practical use from the viewpoint of earthquake disaster prevention is the one based on the difference in predominant periods of waves which may vary with earthquake magnitudes. Here we present a new method of estimating an epicentral distance on the basis of slope of an initial part of P wave arrival. Then we can estimate a magnitude from maximum amplitudes within any given time interval by use of a formula analogous to a well-known conventional method.

2. Method

Seismic waves have a different waveform peculiar to each source condition specified by magnitude, epicentral distance and depth. Logarithmic expression of seismic waves is useful for understanding visually the difference in waveforms because we can easily recognize noise level, small amplitude initial P phase and predominant S phases together.

In order to express the difference in waveforms quantitatively, we introduced a simple function in the form of Bt exp(-At) and determined the unknown parameters A and B in terms of least square method by fitting this to observed seismic wave data. Parameter B indicates the average inclination of initial part of P phase and A is related to amplitude.

We find that near field small earthquakes and deep earthquakes are characterized by large values for A, indicating that amplitudes stand sharply and decay quickly soon after P arrival. The important features we find is that logB is closely related to epicentral distance D. This relation seems to hold good independent of earthquake magnitudes. By using this relation we can roughly estimate an epicentral distance soon after P wave arrival. Seismic data for 2 or 3 seconds seem to be sufficient for moderate and big earthquakes. However data of shorter intervals and high frequency sampling rate(e.g., 1000Hz or more) may be required for smaller earthquakes.

By using logB in place of D, we can estimate a magnitude easily from a formula similar to a conventional formula M= a logVmax + b logD + c. In our case, Vmax stands for maximum amplitudes within a given short interval from P arrival. Alternatively the parameter A can be used for logVmax. We expect that A is useful for discreminating small earthquakes and deep earthquakes from others.

Further investigation is required for the application of this method to actual data, the relation between an average slope B and an actual slope of initial P phase, relation between the range of M where B is independent of M, range of D and interval of analysis, and a physical background of the phenomenon.