Seismic Quiescence Precursory to a Past and a Future Kurile Island Earthquake

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Abstract - A systematic search was made for seismicity rate changes in the segment of the Kurile island arc from 45°N to 53°N by studying the cumulative seismicity of shallow ($h \leq 100$ km) earthquakes within 11 overlapping volumes of radius 100 km for the time period 1960 through beginning of 1978. We found that in most parts of this island arc and most of the time the seismicity rate as obtained from the NOAA catalogue and not excluding any events is fairly constant except for increased seismicity in the mid 1960s in the southern portion due to the great 1963 mainshock there, and for seismicity quiescence during part of the time period studied within two well defined sections of the arc. The first of these is a volume of 100 km radius around a 1973 ($M_s = 7.3$) mainshock within which the seismicity rate was demonstrated at the 99% confidence level to have been lower by 50% during 2100 days (5.75 years) before this mainshock. The second volume of seismic quiescence coincides with the 400 km long north Kuriles gap. In this gap the seismicity rate is shown (at the 99% confidence level) to be lower by 50% from 1967 to present (1978), in comparison with the rate within the gap before 1967, as well as with the rate surrounding the gap. We propose that the anomalously low seismicity rate within the Kuriles gap is a precursor to a great earthquake, the occurrence time of which was estimated by the following preliminary relation between precursory quiescence time and source dimension $T = 190L^{0.345}$. We predict that an earthquake with source length of 200-400 km ($M > 8$) will occur along the north Kurile island arc between latitude 45.5°N and 49.2°N at a time between now and 1994.

Key words: Earthquake Prediction; Seismicity patterns; Tectonics of Kuriles.

Introduction

The seismicity in a given crustal or lithospheric volume is expected to be a function of the state of stress and the resistance to faulting in that volume. If the earthquake preparatory process involves changes of stress, or strength, the local seismicity may reflect these changes and provide information on the preparatory process.

Numerous authors have reported precursory seismicity patterns (e.g., Mogi, 1969; Nersesov et al., 1973; Kelleher and Savino, 1975; Ohtake et al., 1977; McNally, 1977; Qiu, 1978; Ishida and Kanamori, 1978; Khattri and Wyss, 1978; Wyss et al., 1978). The features of these patterns are either periods of relative quiescence, clustering of events in time and space, or a combination of the two. Similar
patterns are found by different authors, but sometimes one of the two types of deviations (clusters or quiescence) cannot be defined. In some cases this may be due to insufficient resolution of local seismicity, but it may also be that one or both types of anomalies do not occur before certain mainshocks. Patterns of seismicity migration may also hold clues useful for earthquake prediction (e.g., Mogi, 1967; Kelleher, 1970; Dewey, 1976; Kagan and Knopoff, 1975; Scholz, 1977).

The problem of identifying seismicity anomalies which are precursory to mainshocks is two-fold. First one has to detect a seismicity anomaly, then one has to show that the anomaly is precursory, i.e., somehow connected to the preparation process for a following mainshock.

Neglect of either one of these tasks can lead to incorrect precursor hypotheses. Quantitative measures need to be defined for the identification of seismicity anomalies, and the degree of significance of anomalies has to be estimated by statistical tests. To prove that a given seismicity anomaly was a precursor related to a following mainshock is difficult. At least one should attempt to make a plausibility argument which may be based on spatial and temporal correlation with the mainshock, its source area, and other precursory changes. A more convincing case might be made if one could show that the events of the anomalous seismicity period had different physical source parameters than background activity in the area.

The purpose of this paper is to examine systematically the seismicity of a segment of a plate boundary, the north Kurile island arc. Based on a detailed study of the M = 7.2 Hawaii earthquake of 1975 we hypothesize that large earthquakes may be preceded by seismic quiescence in most of the source volume with isolated areas of high seismicity indicating major asperities along the future rupture plane (Wyss et al., 1980). This model appears to be valid for the north Kurile area also, since the Mₚ = 7.2 Kurile earthquake of 1973 was preceded by seismic quiescence. Based on our hypothesis we are lead to predict a great earthquake in the Kurile island arc.

**Terminology**

With the recent increase in the number of seismicity studies it has become important to establish the implications of some frequently used terms. For that reason we give here the meanings which we attach to some words which play a key role in the discussion which follows. A *precursory phenomenon* is one which occurs before a mainshock and is a part of a physical preparation for the main rupture. It does not simply mean 'before' but it implies causal linkage to the mainshock. A *mainshock* designates a relatively large earthquake which was followed by aftershocks and whose possible precursors we are trying to detect. Its *source volume* is taken to be that outlined by the early aftershocks. A burst of seismic activity concentrated in space and time, but not including a clear mainshock, we will call a seismicity *cluster*. The word *foreshock* will be reserved for activity near the mainshock hypocenter which precedes