Preface

The present special issue is a collection of papers presented at a Symposium of the IUGG2003, Sapporo, Japan, entitled "Hagiwara Symposium on Monitoring and Modeling of Earthquake and Volcanic Processes for Prediction". Takahiro Hagiwara symbolizes an era of the earthquake prediction research in which monitoring was emphasized and a variety of monitoring data have been accumulated throughout the world with the ever increasing quantity and improving quality. We now find, however, a growing recognition among earthquake scientists, especially in Japan, that modeling is as important as monitoring for a healthy development of earthquake prediction research as a branch of Physical Science. The papers in this issue review the progress made in the earthquake prediction research in the past and address the promising directions in the future.

The first paper in the Research News section in this issue is about Takahiro Hagiwara and his contribution to the earthquake prediction research by Ohtake. The past accomplishment in the earthquake prediction research in Japan since the blue print of 1962 is well demonstrated by papers by Okada *et al.* and Sagiya on the current seismic and geodetic network, respectively. They are followed by a broader perspective of the past, present and future earthquake prediction research in Japan by Hirata, who recognizes that we are in a transient period from the empirical approach of the Hagiwara era to the more physically based one in which monitoring observations will be coupled closely with modeling of the earthquake process.

The earthquake prediction research, however, is different from the traditional science in the following two important aspects. First, unlike the traditional science in which causal relations are sought under conditions controlled or restricted as much as possible, the prediction science must deal with the diverse nature as it is. Thus we need to consider, simultaneously, many models that can be constrained by the monitored data to cope with the complex course of nature. The other aspect is the direct impact of the outcome of research on human society. The scientific community must give a consensus message to the public for an effective communication. It is not a simple problem to reconcile the need for multiple models to deal with nature and the need for a single voice to deal with society. The paper by Mogi in this issue, which may not be a scientific paper in the traditional sense, is important to expose serious problems in implementing scientific information into public policy.

The original research papers of the present issue are concerned with the future of the earthquake prediction research. It is convenient to start with Aki's paper in which precursory signals originating in the brittle part of the lithosphere was distinguished from those in the ductile part. The former is dominated by the self-similarly scaled phenomena without any unique scale length which cannot be explained by a simple physical model, but sometimes allow us a useful empirical prediction. The latter shows a clear departure from the self-similarity suggesting the possibility of simple modeling, but appears to behave erratic for predicting individual earthquakes. This recognition of distinct difference between two types of precursory phenomena came from an on-site prediction research on the eruption of an active volcano, Piton de la Fournaise, but seems to apply to earthquakes also.

Papers by Shebalin *et al.*, Wyss and Clippard, Imoto, Evison and Rhoades, and Rundle *et al.* are all concerned with the signals from the brittle part, and their empirical or statistical approaches are inevitable. The success of the advance short-term prediction of the recent M8.0 Tokachi-oki, Japan, earthquake by Shebalin *et al.*, and the lack of imminent foreshock as reported by Imoto and the absence of short-term precursor in crustal deformation reported by GPS monitoring (Sagiya) before the occurrence of this earthquake underline the complex non-linear dynamics operating in the brittle part of the lithosphere.

In papers by Ohnaka, Yoshida *et al.*, Matsuzawa *et al.*, Kawasaki, Jin *et al.*, Iio *et al.*, and Ishibashi, we see the emergence of deterministic physical modeling of the earthquake process that deviates from the self-similar scaling relation and concerned with the interaction between brittle fracture and ductile/inelastic deformation. As mentioned earlier, we need many such models that can be constrained by the monitored observations in order to cope with the complex nature.

Another idea introduced in Aki's paper about the fundamental similarity between the earthquake and volcano prediction research may open some productive interaction between the two research communities so far worked separately. For example, the most important factor in the long-term predictability of the eruption of Piton de la Fournaise came from the recognition of a phenomenon similar to "the Odawara earthquake" of Ishibashi.

Finally, we thank the following colleagues for their contribution in reviewing manuscripts for the special issue: R. E. Abercrombie, P. Bernard, S. Das, R. Dmowska, W. L. Ellsworth, F. Evison, S. A. Fedotov, Y. Fujinawa, E. I. Gordeev, A. Hasegawa, M. Hashimoto, M. Imoto, M. Ishida, T. Kato, V. I. Keilis-Borok, C.-Y. King, C. Kisslinger, R. I. Madariaga, R. S. Matsu'ura, T. Matsuzawa, J.-B. Minster, K. Mogi, Y. Ogata, Y. Okada, D. A. Rhoades, J. R. Rice, H. Sato, J. Schmittbuhl, T. Seno, D. Simpson, W. Thatcher, H. Utada, S. Uyeda, S. N. Ward, M. Wyss, S. Yoshida, I. Zaliapin, M. L. Zoback.

Guest Editors: Keiiti Aki
Anshu Jin
Eiichi Fukuyama