The summary of RIKEN-IFREQ and the future direction of earthquake prediction research by using EM methods.

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RIKEN-IFREQ (International Frontier Research Group for Earthquakes) was successfully terminated in March 2003. During IFREQ period and afterwards, seismo-electromagnetic research has made notable progress. A nationwide forum called SEMS (Seismic Electric Magnetic Signals) has been formed to promote mutual communication and collaboration and IFREQ has been playing a central role in its activity. Almost explosive rise of seismo-EM is not limited in Japan. Internationally too, the research has made rapid progress. To name a few, China, France, Greece, Italy, Mexico, Russia, Taiwan and USA are especially active in this field. In France, a satellite called DEMETER is planned to be launched in 2004 for global seismo-EM monitoring. Recognizing this trend, International Union of Geodesy and Geophysics (IUGG) established an Inter-association Working Group on Electro Magnetic Study on Earthquakes and Volcanoes (EMSEV) in 2002.

For future direction, we still need continued efforts to collect and accumulate more data since EQ phenomena are so diverse. In doing so, it will be needed to seek continuously the better way through positive feed back with laboratory and field experiments, theory, and modeling. The simultaneous observation by methods which deal with different frequency phenomena will be essential for making the results more convincing. Another essential point will be to integrate seismo-EM findings with those of other equally rapidly advancing disciplines, notably seismology, geodesy, hydrology and geochemistry. Only through this approach, seismo-EM will be able to contribute to the understanding of physics of seismicity as a critical phenomenon and gain full credibility from the wide geoscience community and society at large.

Some important specific future tasks and problems are:

1) Measurements at sea-floor near subducting plate boundaries, namely deep ocean trenches, where giant EQs occur. Because sea-floor measurements have advantages of closeness to the focal areas and much less natural and manmade noise.

2) One of the most outstanding basic questions to solve is the mechanism of the proposed Lithosphere-Atmosphere-Ionosphere (LAI) Coupling as the cause of the transmission anomaly of EM waves. We have to confirm the pre-seismic ionospheric electron density variation by direct sounding from the ground and/or by cooperation with the French seismo-EM monitoring satellite DEMETER.

3) Physics of DC to ULF/ELF signal generation/transmission now appears more or less tractable, but emergence of VLF to VHF emission from focal zone through conducting earth remains a puzzling question. It seems to require sources close to observation sites and solving these problems will contribute to understand the EQ preparation process.

4) Role of water in the seismogenic process is also an important issue and EM investigation may be particularly useful in detecting the movement of water in the earth.