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RESULTS OF ULF MAGNETIC FIELD MEASUREMENTS NEAR THE EPICENTERS OF THE SPITAK (M_S = 6.9) AND LOMA PRIETA (M_S = 7.1) EARTHQUAKES: COMPARATIVE ANALYSIS

O. A. Molchanov[1], Yu. A. Kopytenko[2], P. M. Voronov[2], E. A. Kopytenko[2]
T. G. Matiashvili[3], A. C. Fraser-Smith[4], A. Bernardi[5]

Abstract. The characteristics of the ULF magnetic field emissions measured at two magnetic observatories in the Republic of Georgia prior to and after the M_S = 6.9 earthquake that occurred near Spitak, Armenia, on December 7, 1988, are compared with the apparently similar emissions associated with the M_S = 7.1 earthquake that occurred near Loma Prieta, California, on October 17, 1989. The main features of the Spitak measurements, according to observations made at the Dusheti station (128 km to the Spitak epicenter), as compared with the Loma Prieta measurements, which were made at Corralitos, California (7 km to the Loma Prieta epicenter), are the following: (1) The intensity of ULF background activity started growing 3 to 5 days before the Spitak earthquake, whereas the corresponding increase in activity began 12 days before the Loma Prieta earthquake; (2) a substantial ULF emission burst was recorded at Dusheti starting 4 hours prior to the main shock; a similar large burst of ULF activity commenced 3 hours before the Loma Prieta event, and continued until the occurrence of the main shock; (3) ULF activity remained high for about two weeks after the Spitak earthquake, and for several months after the Loma Prieta earthquake; (4) ULF noise bursts were observed 1 to 6 hours before powerful aftershocks at Spitak during the period of enhanced activity, but there was no conclusive link between the ULF noise at Corralitos and the aftershocks. A major difference in the ULF activity preceding the two earthquakes is a difference in amplitude (0.2 nT at Spitak and 5 nT at Loma Prieta), but this is easily explained as being caused by the different distances of the observation stations from the epicenters.

Introduction

The nature of short-term precursors of earthquakes and their possible use in earthquake prediction have been widely discussed in recent years. A variety of short-term precursors have been proposed, including water level variations in wells, radon content variations in underground water and gases, the anomalous behavior of animals, atmospheric lights, and variations in atmospheric electric fields and electrotelluric fields [*Rikitake*, 1976; *Varotsos and Alexopoulos*, 1987; *Ralchovsky and Komarov*, 1988].

[1]Institute of Physics of the Earth, Russian Academy of Sciences.
[2]St. Petersburg Department, Institute of Earth Magnetism, Ionosphere and Wave Propagation, Russian Academy of Sciences.
[3]Institute of Geophysics, Georgian Academy of Sciences.
[4]STAR Laboratory, Stanford University.
[5]Teknekron Communications Systems.

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Electromagnetic precursors to earthquakes form a special class. Historically they had been studied in the comparatively high-frequency ELF/VLF range (100 Hz to 32 kHz), using both ground-based [*Gokhberg et al.*, 1982] and spaceborne observations [*Larkina et al.*, 1989; *Parrot and Mogilevski*, 1989], as well as in the lower-frequency range ($f < 10^{-3}$ Hz) of long-term geomagnetic field variations [*Johnston and Mueller*, 1987].

It has recently been found that the upper part of the ULF frequency range (0.01–10 Hz), in which Pc 1– 4 geomagnetic pulsations characteristically occur, may contain earthquake precursor signals [*Fraser-Smith et al.*, 1990a, b; *Bernardi et al.*, 1991; *Kopytenko et al.*, 1990]. Recognizing that a common drawback of the various proposed short-term precursors of earthquakes is their lack of reliability, and that the characteristics the same type of precursor often differ in descriptions given by different authors, we here compare the ULF signals recorded independently at Corralitos, California, in association with the M_S = 7.1 Loma Prieta earthquake [*Fraser-Smith et al.*, 1990a, b; *Bernardi et al.*, 1991], and at two observation sites in the Republic of Georgia in association with the similarly-sized (M_S = 6.9) earthquake near Spitak, Armenia [*Kopytenko et al.*, 1990].

Experimental Results

On December 7, 1988, at 0741 UT a strong earthquake (M_S = 6.9) occurred near the town of Spitak in Armenia; its epicenter was located at 41.00° N, 44.20° E, or roughly 19 km to the NW of Spitak. At the time of this earthquake, ULF magnetic field measurements were being made at the Dusheti observatory in the Republic of Georgia (geographic coordinates: 42.10° N, 44.68° E; geomagnetic coordinates: ϕ = 35.7°, λ = 116.1°, L = 1.5) and the measurements analyzed for this communication are primarily those from Dusheti for the interval November 14, 1988 to March 5, 1989. Also included are some supplemental measurements taken at the Vardziya observatory (41.38° N, 43.32° E) during the February–April, 1989, decrease of aftershock activity. The Vardziya station was also located in the Republic of Georgia, at a distance of roughly 138 km southwest of Dusheti. The distances of the two observatories from the Spitak earthquake epicenter zone are ~ 129 km NNE for Dusheti and ~ 85 km NW for Vardziya. A map showing the relative locations of the observation sites, the town of Spitak, and the epicentral region is given in Figure 1.

The ULF magnetic field measurements were made with three-axis high-sensitivity magnetometers of magnetostatic type with photoelectric conversion and deep negative magnetic field feedback. The main performance characteristics of these magnetometers, including the frequency ranges of their HF and LF filters, are listed in Table 1. A pen recorder was used for the measurements and their time resolution depended on the recorder speed and varied within ~ 0.2 to 2 s.