



## Spatial and temporal distribution of seismicity before the Umbria-Marche September 26, 1997 earthquakes

R. Di Giovambattista<sup>1</sup> & Yu S. Tyupkin<sup>2</sup>

<sup>1</sup>Istituto Nazionale di Geofisica, Roma, Italy; <sup>2</sup>Geophysical Center of the Joint Institute of the Physics of the Earth, RAS, Moscow, Russia

Received 18 March 1999; accepted in revised form 12 May 2000

*Key words:* foreshock, precursory seismic activity, seismic quiescence, seismicity patterns, time-to-failure model, weak seismicity

### Abstract

Spatial and temporal distribution of seismicity occurring prior to the Umbria-Marche earthquake of September 26, 1997, are studied. By applying the RTL prognostic parameter, a quiescence stage followed by a period of foreshock activation is observed before the event. The main shock occurred soon after the recovery of the RTL parameter to its normal background level. An investigation of the clustering process is performed on the earthquakes with  $M \geq 3.5$ , occurred since 1989 in the area of the epicenter of the September 26, 1997 event. In comparison to the average background of the previous period, the increase of the area of rupture activated during the twelve months leading up to the Umbria-Marche concentrates in the vicinity of the main shock. Some results of application of the time-to-failure model to seismicity before the Umbria-Marche main shock, are also discussed.

### Introduction

Research has shown that anomaly fluctuations of weak seismicity, electrical and magnetic properties of rocks, deformation of crust, level of underground water and its chemical composition etc., can all be observed before the occurrence of a large earthquake. Nevertheless, attempts to predict large earthquakes on the basis of these anomalies are generally unsuccessful due to the many different factors that influence the manifestation of each particular irregularity. In our opinion, the absence of a deep insight into the process of earthquake preparation inhibits the development of a reliable forecast method. We believe that a systematic study of the behavioral peculiarities of possible precursors to a large earthquake and the application of these precursors to the parameter of future earthquakes, may help to provide a solution to the problem of earthquake prediction.

To date, seismic precursors are the most extensively studied. Scientific literature provides in depth discussion on the many features of weak seismicity before a large earthquake such as; seismic quiescence

(Mogi, 1979; Wyss and Habermann, 1988); foreshock activation (Ma Zonglin et al., 1989; Prozorov and Schreider 1990, for example); and clustering (Caputo et al., 1977; Sobolev and Zavyalov, 1981). In this paper we examine the peculiarities of weak seismicity which were observed before two severe earthquakes ( $ML = 5.6$  and  $ML = 5.8$ ) that occurred within a nine hour interval on September 26, 1997, near the border of the provinces of Umbria and Marche (Central Italy). The earthquakes were a part of a sequence which started with a  $ML = 4.5$  foreshock on September 3 and continued until October with strong aftershock activity. The last damaging event of this sequence ( $ML = 5.5$ ) occurred on October 14, 1997. We would like to stress that we do not discuss the problem of prediction of this series in the paper. We only hope that presented analysis may be useful in solution of this problem in the future.

The analysis is principally based on data from the Istituto Nazionale di Geofisica (ING) earthquake catalogue for 1986–1998 (Barba et al., 1995). The level of completeness of the catalogue for Central Italy is  $M_{\min} = 2.3$  and weaker earthquakes are not involved