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MICRO-SEISMIC MONITORING OF SEISMOGENIC ZONES IN HUNGARY

CONTENTS

ABSTRACT

Hungary, or as geographically often referred the "*Pannonian Basin*" is situated in the territory between the Mediterranean area, which is seismically one of the active regions in the world, and the East European Platform which can be treated as nearly aseismic. In such seismically moderately active areas it really has been very challenging to find correlation between known tectonic structures and earthquakes just using historical and early instrumental data. The recent high quality earthquake observations and locations started in the last decade may gradually change this situation. Preliminary monitoring results show that recent small size earthquakes, in general, lie near to clusters of historical activity. However, clusters of stronger present day activity have been detected in the north-eastern part of the Transdanubian Mountain Range, close to the NE coast of lake Balaton and at the bend of the Danube above Budapest.

KEY WORDS: Earthquake, seismicity, Pannonian-Basin, Hungary

1. INTRODUCTION

The Pannonian Basin and surrounding orogens are located in the northern sector of the central Mediterranean region. The Pannonian Basin is bounded on the north to the east by the Carpathian mountain belt, on the south by the Dinarides mountain belt and on the west by the Eastern Alps. The area is tectonically rather complicated and has been studied intensively over the last twenty years. Development of the Carpathian mountain belt and the Pannonian Basin is attributed to collision between the Eurasian Plate and the African Plate between the Paleocene and Middle-Late Miocene (HORVÁTH, 1984; 1988; ROYDEN, 1988). Different authors basically agree that present-day deformation in the Pannonian Basin system is controlled by the northward movement and counter-clockwise rotation of the Adriatic microplate relative to Europe (BADA, 1999; BADA *et al.*, 1998; 1999; GERNER *et al.*, 1999).

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2. SEISMICITY

Although very strong (M>7) or catastrophic earthquakes are rare in the Pannonian region, there is a long history of earthquakes which have caused substantial damage. More than one and half millennium of historical and instrumental earthquake data, from 456 AD to 2002, indicates moderately active seismicity of the area. The epicentre distribution suggests that the most active parts of the area are the Carpathian and Dinaric tectonic belt and the Vrancea region in the Southeast Carpathians. Seismicity in the Pannonian Basin is more moderate compared to the peripherals, and the distribution of earthquake epicentres shows a rather scattered pattern. Moderate seismicity does not necessarily mean small size of earthquakes: reports of major earthquakes often refer to heavy building damage, liquefaction (e.g. 1763 Komárom earthquake, M 6.2; 1911 Kecskemét earthquake, M 5.6) and sometimes the possibility of surface fault rupture (e.g. 1834 Érmellék earthquake, M 6.2). These observations indicate that magnitude 6.0-6.5 earthquakes are not frequent but possible not only in the wider area of the Pannonian region but in the basin area as well.

The spatial distribution of the total seismic energy release (Fig. 1) shows that the most forceful deformation has been taking place in the Dinarides and the Vrancea zone. However, the deformation occurring in the Pannonian Basin has been considerably more intense than in the rest of the surrounding orogenic belts.

Distribution of focal depths indicates that shallow depth within the top 20 km of the earth's crust is almost exclusive in the whole region except the Vrancea zone in the Eastern Carpathians. In the Pannonian Basin area, the majority of events occur primarily between 6 and 15 km below ground level (TÓTH *et al.*, 2002).

Inferred from focal mechanism solutions, strike-slip and thrust faulting are almost exclusive in the Southern Alps and in the Dinarides, with the maximum horizontal stress directions being N-S and NNE-SSW. In the Eastern Alps and Western Carpathians focal mechanism solutions exhibit an exclusively strike-slip character; with NNW-SSE and N-S directions of the largest horizontal stresses most frequent. In the Pannonian Basin, thrust and strike-slip faulting seem to be dominant, with NNE-SSW and NE-SW directions of maximum horizontal stresses (TÓTH *et al.*, 1989)

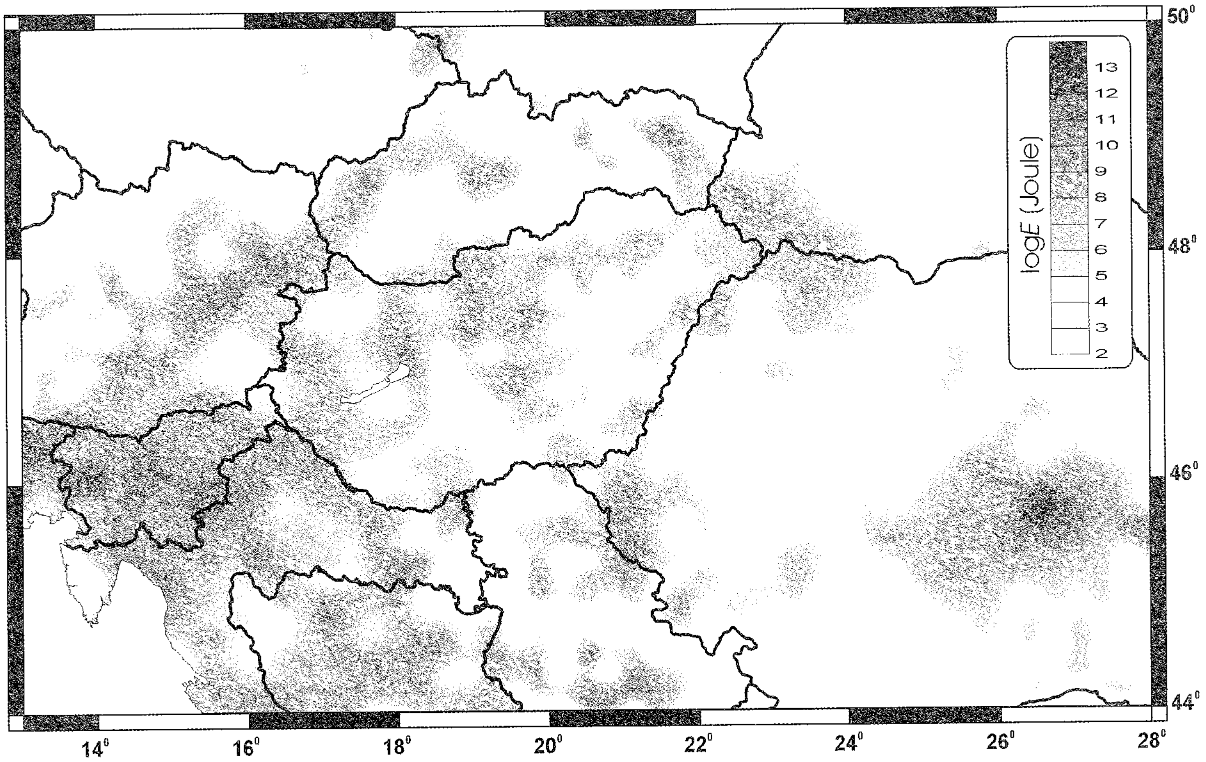

Fig. 1 - Spatial distribution of the total seismic energy release in the Pannonian Region. Most dynamic deformation has been taking place in the Dinarides and the Vrancea zone; but rather intense deformation has been taking place in the Pannonian Basin as well.

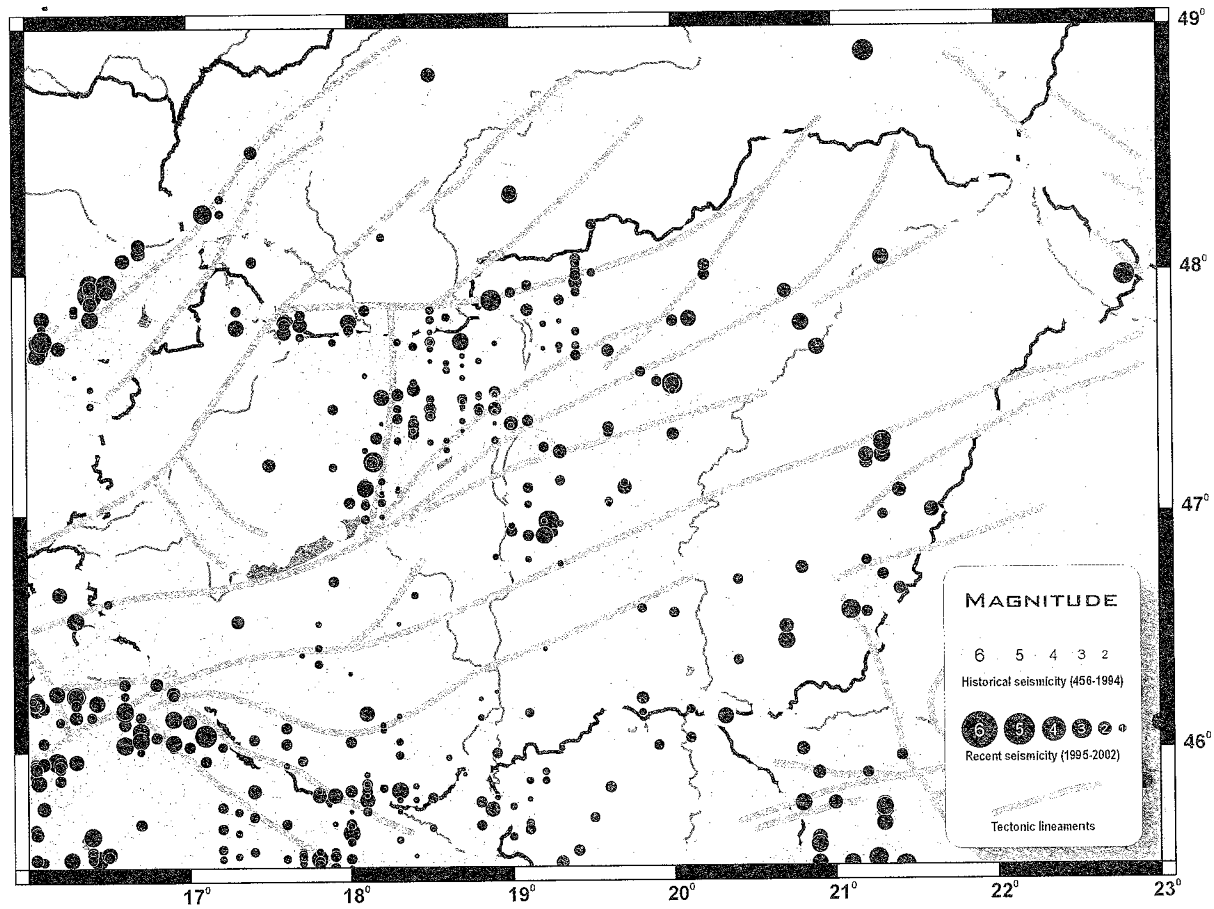

Fig. 2 - Historical (456 A.D.–1994) and recent (1995-2002) seismicity in and around Hungary (45.5-49.0N; 16.0-23.0E). Grey circles show historical earthquakes mostly based on macroseismic effects while solid black dots indicate latest epicentres located since high sensitivity digital networks came into operation. Heavy grey lines show tectonic lineaments as defined by F. Horváth and G. Bada (personal communication).

3. CORRELATION BETWEEN OUTCROPPING FAULTS AND EARTHQUAKES

Up to recently, it has been really very difficult to find correlation between outcropping tectonic structures and earthquakes using only historical and early instrumental data due to epicenter uncertainty of historical earthquakes in one hand, and the lack of detailed knowledge of faults on the other. To close this knowledge gap, a network of high quality digital seismographs was installed in 1995 capable of locating earthquakes as small as magnitude M_L 2.0 in most part of the country. The developing database of these well located earthquakes (Tóth *et al.*, 2003) may gradually change this situation and can help to resolve tectonic frameworks in the Pannonian Basin.

Preliminary results show (Fig. 2) that the recent earthquakes, in general, lie near to clusters of historical activity. Just a minority of events are exceptions, in that they appear to be unassociated with historical activity. However, clusters of stronger present day activity have been detected in the north-eastern part of the Transdanubian Mountain Range, close to the NE coast of lake Balaton and at the bend of the Danube above Budapest.

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