FIRST RECORD OF THE SEISMITES IN PLIOCENE DEPOSITS FROM PRAHOVA VALLEY

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Abstract: In the lower Dacian deposits from Valea Rea point (Prahova county, south of Câmpina) two seismites zones (*sensu* Seilacher, 1969) have been recognized: segmented and rubble. The first zone is marked by the existence of fragmented thin layers and laminae, as well as by collaps structures or by remains of Skolithos type cylindrical, vertical galleries. The second zone is characterized by thin and discontinuous laminae, possible of *algal-mat* nature.

Key words: seismite, trace fossils, earthquake, sedimentary structures

INTRODUCTION

The term «*seismite*» was introduced in sedimentology by Seilacher (1969). With this term Seilacher nominated the genetic category of *fault-graded beds*, generated by discyclic events such as the seismic shocks. According to Seilacher (1969), a seismite includes the following zones, from the top to the base: a) the *liquefied zone* (soupy zone) with diffuse lamination; b) the *rubble zone* where compacted laminae are recognized, being largely fragmented and with diverse orientation; c) the *segmented zone*, with dominantly coherent lamination, broken by antithetic micro faults; d) *undisturbed sediment*, with primary lamination.

Recently Rodriguez Pascua *et al*. (2001) described nine types of seismites occurring in the proximal and distal lacustrine Miocene deposits in the Prebetic Spanish Zone (Table 1). The seismites formed in shallow water sediments were generated by liquefaction (sand dykes, pillow structures, intruded and fractured gravels). The deep lake deposits show varied structures (loop bedding, disturbed varved lamination, mixed layers and pseudonodules). Seismites indicate paleoearthquake magnitude intervals.

Sedimentary structures of the seismites type (= paleo-seismographs, *sensu* Seilacher, 1969) have been identified in metamorphosed Proterozoic formations (Mazumder *et al*., 2006), Tertiary (Rodriguez, Pascua *et al*., 2001) and Quaternary (Bowman *et al*., 2004) lacustrine deposits, as well as in pre-historic (Sukhija *et al*., 2002) and modern (Sukhija *et al*., 2003) sediments.

In Romania some sedimentologic features of the Kliwa sandstone formation (e.g. contorted sandstones with green pebbles etc.) mentioned by Dicea (1974) from Bucovina area, are assigned to the seismic activity at the end of the Oligocene time. Bleahu (1974) explains the discontinuity in the ice block from Scărişoara Cave (Bihor Mountains) as a consequence of the seismic activity. In the same cave three divergent stalagmites are explained by Bleahu (1974) as resulting from the action of seismic waves with different directions. Mârza and Selişcan (1987) report a similar phenomenon in the Valea Firii Cave (Someşul Cald basin).

CASE STUDY

The observations presented in this paper have been made at the point named Valea Rea near the locality Bobolia (Prahova county), located south of Câmpina, on the right bank of Prahova River. The deposits cropping out at this point have been accumulated in a Pliocene (lower Dacian age) deltaic environment.

In the lower Dacian deposits from the Valea Rea point one can recognize – *grosso modo* – two of the seismite zones (*sensu* Seilacher, 1969): segmented and rubble. The first zone, without micro faults, is marked by the existence of fragmented thin layers and laminae, as well as by collapsed structures

Table 1 Sketch of several seismite types in the Neogene lacustrine basins of the Prebetic Zone. Magnitudes at which the different seismites form (lower limit M > 5-5.5 for liquefaction). Seismites occurring in deep and shallow lake deposits are mentioned (1-9) in separate columns (simplified from Rodriguez Pascua *et al*., 2001)

Deep lake varved sediments	Magnitude	Shallow lake detrital sediments
	8	9
6		
	7	8
5		
	6	7
4		LIQUEFACTION
	5	
3		NO LIQUEFACTION
	4	
2		9 Intruded and fractured gravels 8 Pillow structures 7 Sand dykes
	Micro-seismicity	
1		6 Pseudonodules 5 Mixed layer with fluidization 4 Mushroom-like silts protruding into laminites
	Creep	3 Mixed layer without fluidization 2 Disturbed varved lamination 1 Loop bedding

(Plate I, Fig. 1) or by remains of *Skolithos* type cylindrical, vertical galleries. These galleries are transversally cut in different points (Plate I, Fig. 2), resulting segments with different orientations. Fragments of galleries probably of the same type, can be observed in the fine sand.

The rubble zone (Plate I, Fig. 2) is characterized by thin and discontinuous laminae, possibly of *algal-mat* nature, with quasi-parallel arrangement or layed out within concave spaces incised into the sandy sediment. Without offering the complete image of the seismite defined by Seilacher (1969, Plate I and Fig. 1), the above mentioned examples suggest the effects of a liquefaction process induced by seismic vibrations. This process produced the fragmentation of the laminae and of the biogeneous sedimentary structures consolidated during the early diagenesis phase.

DISCUSSION AND FINAL REMARKS

Deformed soft sediments believed to be seismites (globular, pseudoglobular, pillar, complex or chaotically folded structure types) have been described by Bowman *et al*. (2004) in the Quaternary lacustrine, fluvial and shoreline deposits from Kyrghyzstan. In the Issyk-Kul lake area from the Tien Shan mountains the authors used the following field criteria to point out the sedimentary deformations generated by paleo-seismic events: a) location in a seismically active area, b) sedimentary sequence made of loosely consolidated sediments, metastable sands and silts with low cohesion, c) similarity to experimental structures obtained through earthquake simulated shaking or reported as Seilacher's seismites, d) anticipation of trigger by gravity flow, e) sequence intercalated within non-deformed sedimentary sequence, f)

PLATE I

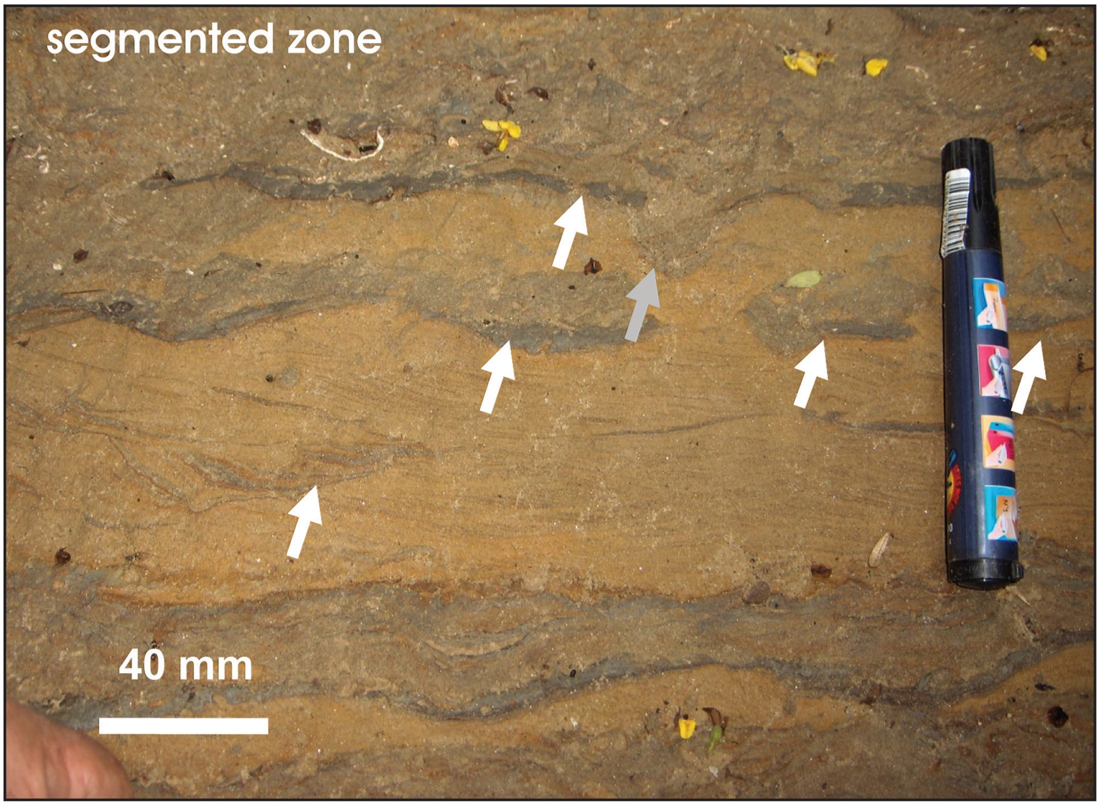

Fig. 1 Likely segmented zone with coherent older layers (white arrows) and collapse structure (grey arrow). Photo D. Jipa

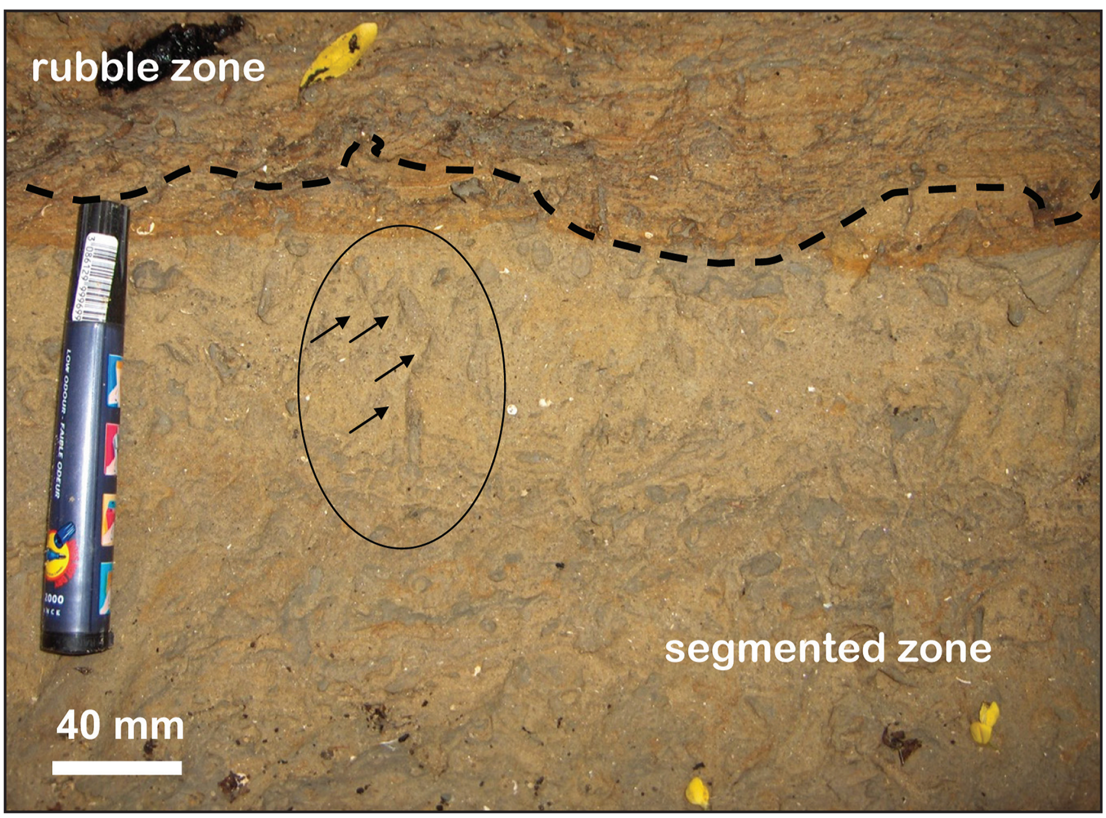

Fig. 2 Rubble with varying orientation fragments of the original sediment (top), and segmented zones (down) with Skolithos-like broke vertical burrows (arrows). Photo D. Jipa

lateral continuity and regional frequency, g) cyclic repetitions of deformed structures.

The seismically active zones offer multiple examples of strong earthquakes recorded in the lacustrine sedimentary sequences and in travertine accumulations. Becker *et al*. (2005) point out a veritable seismicity geological archive in the Pleistocen-Holocen time interval, expresses as activities of the Basle-Reinach active faults, rockfall deposits, slope instabilities, and others. In this way it was possible to supplement the earthquakes catalogue with 13 seismic events of magnitude M”6, which have been active 15000 years ago.

In Spain the deformation of the upper Pleistocene – Holocene travertine accumulation marks the paleo-seismic activity of the active fault Alhama de Murcia from the Betic Cordilliera (Martinez-Diaz & Hernandez-Enrile, 2001).

The seismites identification and location in the Mio-Pliocene or older sedimentary succession represents a research field which has to be intensified. The results of this investigation cold be used to unravel the paleoseismic evolution of the Carpathian Bend area, a very active geodynamic zone.

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