

Report for the International Association of Sedimentologists

Postgraduate student grant – 2nd session 2008

The migration of hydrocarbons along fault zones in unlithified sediments and its influence on sedimentary structures – study of a paleo-seep system (Eocene, Bulgaria)

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The IAS Postgraduate student grant was used to fund a field campaign (August 2008) to the Pobiti Kamani Lower Eocene seep area (Varna, NE Bulgaria) and allowed covering part of the subsequent costs of laboratory geochemical analyses. This work formed the base of a study that aims at understanding (1) the effect of shallow fault zones in poorly lithified sandy sediments on hydrocarbon-bearing fluid migration and (2) how this fluid migration affected the sedimentary sequence.

Actual studies of cold seep systems often focus on the nature of the pathways facilitating the rise of hydrocarbon-bearing fluids to the seafloor, whereby faults are repeatedly considered of large importance. However, the actual effect of shallow fault zones displacing unconsolidated sediments is still debated and their barrier versus conduit capacities may vary through time and space. Where these overpressured fluids reach the seafloor, they furthermore affect the sedimentary environment in terms of stability and early diagenetic processes near or at the seafloor. Detailed observations and the interpretation of spatial relationships at a wide range of horizontal and vertical scales require the study of outcropping paleo-seep systems in addition to the study of submarine seeps, which is both costly and time-consuming.

During the 10-day field study, two outcrops, i.e. the Beloslav quarry and the Beloslav N fault outcrop were studied in detail. At both sites an east-dipping, NNE- to NNW-trending normal fault separates Upper Cretaceous lithologies from the Lower Eocene Dikilitash Formation hosting methane seepage-related tubular sandstone concretions. At first, a sedimentary log was recorded at the first site with an overall dm-resolution. The homogeneous to parallel bedded unconsolidated coarse silts to sands are interlain by subhorizontal, bedding parallel cemented sandstone beds, which relate to storm deposits, hardground formation or cementation around bioclast pockets. These horizons could be traced over 100's of meters crossing several clusters of up to 10 m high tubular concretions. In a second step, the lateral differences in the occurrence and nature of sedimentary structures was documented along the 0.7 km fault-parallel lateral exposure. This clearly showed changes in thickness and cementation degree within a single sandstone bed with distance from the point of intersection with tubular concretions. Also, brecciation and sediment deformation structures like 'sand dikes' are restricted to locations in vicinity to tubular concretions and were not observed in reference sedimentary sections of the Dikilitash Formation. Preliminary petrographic observations and $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ data indicate that cementation started near or at the seafloor in the presence of marine pore waters, but became influenced by ^{13}C -depleted methane-bearing fluids prior to full lithification of the sandstone beds. Together these observations already demonstrated that, although partly lithified, laterally continuous sandstone beds could not prevent the rising methane-bearing fluids from reaching the seafloor and thereby created specific sediment deformation structures.

In addition, the fault zone architecture was mapped at the two study locations along sections approximately perpendicular to the fault strike. The collected kinematic data is compared with the results of former paleostress analyses and suggests that faulting and fault reactivation can most likely be related to the Lower – Middle Eocene Illirian Alpine tectonic phase, which affected both

the Balkan Mountains and its foreland where the study area is located. Different types of deformation structures (e.g. different sets of deformation bands, slip planes) and diagenetic phases were recognized and their relative ages were reconstructed based on cross-cutting relationships. Furthermore, two detailed schematic cross sections were recorded perpendicular to the fault strike, showing the lateral distribution of the different types of deformation structures and the variations in their characteristics and orientations. After mapping, representative samples of all structures within the fault core and from the fault damage zone at different distances from the major fault contact were collected (drilled core plugs and hammered rock samples). In addition to the field data, a petrographical-geochemical study of the deformation structures and diagenetic phases will allow evaluating the fault zone permeability with respect to methane-bearing fluids through time and with distance from the major fault plane.

The conducted research has been feasible thanks to the IAS Postgraduate student grant, which permitted to cover a major part of the expenses. A more detailed overview of the costs covered by the IAS grant is given below. The results of this work will be presented in part on the 27th IAS Meeting of Sedimentology (September 2009) and during the International Workshop 'Geological and bio(geo)chemical processes at cold seeps – Challenges in recent and ancient systems' (September 2009) which will be held in vicinity of the study area.

Field work	€	Comment
1. Transport and daily expenses	465.52	expproof1_Connections; expproof2_transport
2. Stay (youth hostel, 1 person)	110.00	Expproof3_accommodation
3. Equipment for hand drill device	105.58	Expproof4_Bestelling4500324488 (28jan. 1euro = 1.3260USD) cost of 1 drill bit
Laboratory analyses		
4. Carbon-oxygen stable isotope analyses (University of Erlangen, Germany)	180.00	Expproof5_Bestelling4500327501
5. EPMA analyses (UCL, Belgium)	138.90	Expproof6_Bestelling4500332198 55% of total cost
TOTAL	1000.00	