Kinematic Indicators of Slip Sense Along Faults in Loess Deposits: a Case Study from Fossil Graben at Brzezie, Polish Carpathian Foredeep

Wojciech WŁODARSKI[1] and Marta RAUCH-WŁODARSKA[2]

[1] Institute of Geology, Adam Mickiewicz University, Maków Polnych 16, 61-686 Poznań, Poland
[2] Institute of Geological Sciences, Polish Academy of Sciences, Kraków Research Centre, Senacka 1, 31-002 Kraków, Poland

The meso and microscopic indicators of slip sense along faults in a poorly indurated sediments are the object of consideration here. The mesoscopic structural data and sediment samples for microscopic studies were obtained from the archaeological open site at Brzezie in the central part of the Polish Carpathian Foredeep. Here, the Pleistocene loess deposits and the Holocene pedogenic and deluvium layers are cut by numerous fractures. The fractures are often enriched by dark grey fine grained material which is macroscopically similar to the Eoholocene humic horizon of the pedogenic layer covering the loess deposits. The pattern of fractures arrangement is complex. There are major fractures and minor fractures. The major fractures run regularly at a distance of 2 metres at least and dip approximately 65–85 °. The minor fractures have shorter length and wide scale range of dipping. They often display an anastomosing pattern. It is difficult to recognise directly offsets and slip senses along the fractures due to the absent of internal layering within loess deposits. Only the stratigraphic marker that is represented by lower and upper surfaces of the Eoholocene humic horizon of the pedogenic layer show decimetric-scale vertical offsets along some of these fractures. The mesoscopic slickenlines scarcely present on the surfaces of the fractures. Based on these rare indicators we recognise a few normal or oblique-slip faults (Rauch-Włodarska et al. in prep). Some of these faults are master faults which bound the small fossil graben.

There are other mesoscopic kinematic indicators for slip sense determination of both the faults and some fractures with negligible offsets on a mesoscopic scale. The minor fractures which display a geometry of Riedel shears or C-S shears predominate. They are represented by synthetic R fractures, antithetic R' fractures, synthetic hybrid fractures and synthetic C or S fractures. These fractures do not constitute a composite planar fabric but occur as single structural elements connected with major fractures and faults. Some of the minor fractures join a tip points of two parallel major fractures and faults, forming isolating lenses which are typical of linking damage zones (Kim et al. 2004). The R' fractures often make an angle 60 ° with major fractures or faults. The absence of R fractures observed here shows that the synthetic slip could be accommodated by slip along major fractures or faults. The R fractures play an important role in asymmetric boudinaging of dark grey layers occurring in core of the major fractures and faults.

The microscopic appearances of analysed fractures and faults were analysed using the images obtained from the optical microscope and SEM (back-scattered electron imagery). They are composed of distributed subsidiary shear zones and fissures. The shear zones are defined by both the elongated domains of alignment clay platelets and the clay interweaving bunches. These "clay particles" display a C-S or Riedel shears geometry. The sigmoidal fractures observed within the shear zones are represented by two groups. The sigmoidal tension gashes are arranged 'en echelon'. The extensional steps bordered these gashes dip in the opposite direction to the C-S shears. The offsets between these steps range from 22 μm to 0.23 mm. The other group of sigmoidal fractures contain extensional forms which are similar in terms of shape and orientation to the C-S shears. The offsets between steps observed here are similar (micrometric-scale). We believe, that this group of sigmoidal fractures uncharacteristic of shear zones were produced by shrinkage of "clay particles" during dewatering of sediments. In some places the shear zones are accompanied by the microscopic drag folds composed of "clay particles". Here, the sigmoidal tension gashes occurring within the normal limb show flexural-slip between folding layers of the "clay particles". The other microscopic kinematic indicators as delta-clasts, microthrusts and minor asymmetric folds around silt-sized particles were rarely recorded within the shears zones and thus play a minor role in determination of the slip sense along analysed major fractures and faults.

The slip sense defined on the basis of both meso and microscopic kinematic indicators generally agree with one another. Moreover, in the case of faults, it is confirmed by mesoscopic offsets. The described examples of kinematic indicators show that loess deposits are worthy of greater interest of structural geologists, exactly in their neotectonic studies.

References

RAUCH-WŁODARSKA M., KALICKI T., WŁODARSKI W. and BUDEK A., (in prep). Young Quaternary fossil graben in the Vistulian loess at Brzezie near Cracow (Carpathian Foredeep, southern Poland). Studia Quaternaria.

KIM Y.S., PEACOCK D.C.P. and SANDERSON D.J., 2004. Fault damage zones. *Journal of Structural Geology*, 26:503-517.