intermountain Neogene depressions of the Western Carpathians. This assumption is confirmed by endemic fauna (Kosovia) found at several localities. The main reason of its isolation was the uplift of Žiar Mts. in the south, dated on the basis of FT apatite ages to 46±5 to 52±7 Ma, and an intense neovolcanic activity which products are preserved mainly in the southern part of the depression. The main phase of subsidence is represented by Martin Formation sediments which were deposited in a basin with the axis in NNE-SSW direction. The sediment input into the basin occurred from the west toward the east.

The compressional axis of the palaeostress field was during the Martin Formation deposition (?Late Sarmatian – Late Pannonian/Pliocene) oriented in the N–S to NE–SW direction. The main role during the depression tectonic evolution had dextral movement of two large blocks and activity marginal listric faults nearby the west margin during the whole Miocene. (Fig. 1). The generally NW–SE oriented extension also determined an origin of the antithetic faults nearby the eastern margin of the depression. The marginal fault activities resulted in origing of huge alluvial fans and rapid exhumation of the Malá Fatra Mts. Average rate of exhumation proved by FT apatite data is cca 0.72 mm/year. During the Pliocene the maximum deposition was concentrated in the southern part of the depression. In this part the clastic deposition continued to Pleistocene.

Preliminary Results of Analogue Modelling of the Palaeogene and Neogene Evolution of the Western Outer Carpathians (Poland)

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Scaled analogue experiments have been used to investigate the Palaeogene and Neogene evolution of the Western Outer Carpathians. The arcuate Outer Carpathian belt represents the external pile of nappes of the Pannonian-Carpathian-Dinaric system (PANCARDI). The Intra-Carpathian region is composed of two major blocks:

a) ALCAPA – the Eastern Alpine-Western Carpathian-Northern Pannonian, and
b) TISZA-DACIA – the Southern Pannonian-Eastern Carpathian one (Fodor et al. 1999).

The Polish Western Outer Carpathians, which compose the northernmost part of the Outer Carpathians, is a north-verging fold-and-thrust belt. The main structure of this belt was formed during the Palaeogene and Neogene, when the Outer Carpathians was an accretionary wedge. The belt is mainly composed of Lower Cretaceous to Lower Miocene flysch strata and comprises several nappes (Książkiewicz 1977). Two of these nappes, the Magura and Silesian nappes, extend along the entire belt. The other nappes are exposed mostly in the eastern part of the Polish Western Outer Carpathians. The orientations of map-scale fold axes of the Magura and Silesian nappes show curvilinear traces, changing their strike from the west to the east: from WSW-ENE, through W-E, to WNW-ESE (Książkiewicz 1977). The strata of the Magura nappe were counterclockwise rotated by about 60º, whereas those which fill the Carpathian Foredeep underwent 30–40º counterclockwise rotation (Márton and Tokarski 2000, Márton et al. 2004 and referenced therein).

The tectonic evolution of the Polish Western Outer Carpathians is characterized by the superposition of two shortening events:

a) NNW- (N), and
b) NE- (NNE) directed ones (Aleksandrowski 1989; Decker et al., 1997, 1999).

Folding and thrusting of the first event were of synsedimentary character. During the next, NE- (NNE) directed event, the NNW-directed thrust faults and related folds were overprinted and refolded.

The aim of this study is to find the procedure for the indentation modelling which would produce structures similar to the map-scale structures of the Western Outer Carpathians. The physical models were built using sandy silt as analogue material to represent the brittle upper crust. The modelling was carried out using a homogeneous single layer of the material. The progressive evolution of the models was photographically recorded.

The obtained reconstruction of tectonic evolution of the PANCARDI region suggests northward, and then eastward movement of the ALCAPA block (Aleksandrowski 1989), or counterclockwise rotation of the latter (Fodor et al. 1999). During laboratory modelling, different ways of displacement of the ALCAPA indenter were tested. The experimental procedure was differentiated both for the direction of the indenter movement, and the presence of its simultaneous counterclockwise rotation. Two shapes of the indenter were tested:

1. rectangular and
2. semi-triangular ones, simulating the northern, external shape of the ALCAPA block.

The model, most closely resembling the Western Outer Carpathians, was produced by analogue modelling using a semi-triangular indenter which was counterclockwise rotated by about 56º and simultaneously moved in the NNE direction (in the present-day geographic coordinates). The results of experiments resemble well the map-scale pattern of faults and folds in the Polish Western Outer Carpathians. They could also explain the superposition of two heteroaxial shortening events identified there, as well as the counterclockwise rotation of rocks detected by palaeomagnetic investigations in the Western Outer Carpathians and their foredeep.

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Pattern of the Mesoscopic Thrust Faults in the Central Part of the Silesian Nappe (Polish Western Outer Carpathians)

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Polish Western Outer Carpathians is a north-verging fold-and--thrust belt. The belt is mainly composed of Lower Cretaceous to Lower Miocene flysch sediments (Książkiewicz1977). The Outer Carpathians comprise several nappes. One of those nappes, the Silesian nappe, extends along the whole belt. The study area is located in the central part of this nappe, between the Dunajec and Wisłoka River.

In the traditional point of view the rocks of the Polish Outer Carpathians are folded during single regional episode (Książkiewicz 1977). In the two of the biggest nappes of the Carpathians, Magura and Silesian nappes the map-scale fold axes are oriented parallel to the frontal thrust of individual nappe. The fold axes vary their orientation along the orogen (from west to east): from WSW-ENE, through W-E to NW-SE (Książkiewicz 1977).

The tectonic evolution of the Polish Western Outer Carpathians is characterized by the superposition of two shortening events: a) NNW-(N), and b) NE-(NNE) directed ones (Aleksandrowski 1989, Decker et al. 1997, 1999). Folding and thrusting of the first event were of synsedimentary character. During the next, NE-(NNE) directed event, the NNW-directed thrust faults and related folds were overprinted and refolded.

The rocks of the studied area are cut by numerous map-scale faults mostly thrust and strike-slip faults. The thrust faults are oriented NW-SE and NE-SW but usually their orientation varying between ENE-WSW and WNW-ESE. The thrust faults are characterized by lateral termination, to westward mostly in the strike-slip faults. In the studied area occur mostly inclined folds. Axes of the map-scale folds are oriented NW-SE and roughly W-E, rarely SW-NE. The main map-scale anticlines are cut by thrust faults.

The studied mesoscopic thrust faults were divided into two groups formed in:

1. horizontal strata and
2. tilted strata.

Numerous thrust faults of (1) group were tilted, together with the host strata during folding. Such faults were backtilted at the beginning of the structural analysis.

There are two dominant strike orientations of the mesoscopic thrust faults WSW-ENE and ESE-WNW. The orientation of the fault strike of (1) group varies from ESE-WNW through W-E to WSW-ENE but the latter is the most common. However, the thrust faults of (2) group are characterized by more stable orientation of strike, which is ESE-WNW. According to crosscutting relationship older thrust faults are commonly these faults striking WSW-ENE and younger are these faults striking ESE-WNW. The reconstructed orientation of the horizontal compression is NNW-SSE for the older thrust faults and NNE-SSW for the younger ones. Locally, however, in the eastern part of the map-scale folds have been observed different relationship. The thrust faults caused by NE-SW–directed compression were cut by the thrust faults caused by NNE-SSE – directed compression.

The dominant age relationship of the thrust faults could be caused by clockwise rotation of the horizontal compression. Numerous thrust faults of (1) group vary in strike orientation with the host strata, this fact may suggest that the rotation of the horizontal compression took place locally before folding.

There is also second explanation of such thrust faulting: the NNE-oriented, stable horizontal compression and counterclockwise or locally (in the eastern part of map-scale folds) clockwise