Distribution and origin of thrust patterns in the Ruhr Coal District, north Variscan margin, Germany

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The more than 5000 m thick Upper Carboniferous strata of the Ruhr Coal District represent the folded and thrust foredeep at the northern margin of the Variscan orogen. The shortening deduced from the fold geometry reaches locally about 50 %. Fold wavelengths and amplitudes range up to kilometre scale. Major structures may be followed along strike for more than 100 km. The throw on thrusts normally ranges from a few metres to some hundreds of metres. Exceptionally it exceeds a kilometre on thrusts which may be followed for tens of kilometres along strike. The sequence of formation of thrusts and folds, possible reasons for interferences between these structural elements as well as the general position of the Ruhr Coal District as a whole within the structural framework of the Variscan orogen is a subject of debate already for a long time. A systematic investigation of the regional distribution of thrust patterns followed by a comparison with the regional trend of shortening and analysis of the relations to major folds have been used as a new approach to find further arguments.

In the Ruhr Coal District the degree of Variscan shortening gradually decreases towards the NW, i.e., the external side of the Variscan orogen. This gradient could be explained by a corresponding general decrease in the Variscan strain towards the north in an autochthonous foreland or could be related to southward increasing shortening above a flat-lying buried thrust of regional extension with a tip line north of the Ruhr Coal District. In order to evaluate these two hypotheses the thrusts observed in the Upper Carboniferous strata of the Ruhr Coal District have been classified into thrust patterns taking into account, e.g., the number of cooperating faults, angles between faults, characteristic combinations, orientation, inclination with respect to bedding, sense of displacement, curvature, and vertical extension. Compared to the shortening by folding their distribution in more than 90 published cross sections displays some trends. In areas with less than 10 % shortening long straight thrusts directed towards the north prevail. Between 10 and 20 % shortening these thrusts can have as well a listric form. Imbrications directed towards the south, crocodile, pop-up and triangle structures occur throughout the folds as additional thrust patterns in areas shortened by more than 10 %. Folded thrusts are restricted to areas where the shortening exceeds 20 %, preferably 30 %. Other thrust patterns show a strong preference for certain positions in folds, indicating a formation as secondary structures governed by local influences induced by the folding. This is especially illustrated by the occurence of short south directed thrusts in the northern and north directed thrusts in the southern limbs of anticlines.

The two end members imaginable for the structural style of the foreland deformation in the Ruhr Coal District should lead to specific changes in the development and distribution of the thrust patterns. In an autochthonous foreland-orogen transition the regional distribution of the thrusts should be related to the folds and show as well patterns specific for the different limbs. Above a buried detachment at least some thrusts should be expected which are essentially independent of the folding and support the overall orogenic transport directed towards the external parts. Thus, the observations provide further arguments in favour of the interpretation of the Ruhr Coal District as part of an autochthonous foreland.