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COMPARISON OF FOLDS IN THE CHEVLIPONT AND ABBAYE DE VILLERS FORMATIONS, NEAR THE ABBEY OF VILLERS, THYLE VALLEY, BRABANT MASSIF

Ruth BECKERS

Geological Survey of Belgium, Jennerstraat 13, B-1000 Brussel and U. Ghent, Krijgslaan 281-S8, B-9000 Gent.

(2 figures)

ABSTRACT. In a detailed structural study in the Thyle valley folds were studied in the Chevlipont and Abbaye de Villers formations. On the basis of cleavage/fold relationships and other criteria, the presence is demonstrated of both slump folds and tectonic folds. Apparently, a spatial relationship exists between the tectonic folds and slump folds. On the basis of the orientations of the slump folds the probable palaeoslope is determined for both formations: north-dipping for the Chevlipont Formation, south-dipping for the Abbaye de Villers Formation. This may reflect a different basin geometry during deposition of these two formations. A structural cross-section is constructed on which a minimal thickness of 129.5 m is inferred for the Abbaye de Villers Formation. The cross-section also shows that the Abbaye de Villers Formation can be divided into a 119 m thick upper, southern part with thick, massive, S-dipping layers and a northern part of minimum 10.5 m thick, composed of thinner layers and containing numerous soft-sediment deformation features (slump folds and related features) as well as tectonic folds.

Keywords: Brabant Massif, Thyle valley, Chevlipont Formation, Abbaye de Villers Formation, tectonic folds, slump folds, palaeoslope, cross-section

1. Introduction

The study area is situated in the Thyle valley, one of the main outcrop areas of the Brabant Massif, representing the SE-part of the Anglo-Brabant fold belt. Pre-cleavage, syn-cleavage and post-cleavage deformation features were studied in two formations from a different palaeogeographical context: the Chevlipont Formation (the youngest formation of megasequence 1 of Verniers et al., 2002), with deposition in extensional basins when Avalonia was still attached to Gondwana and the Abbaye de Villers Formation (the oldest formation of megasequence 2 of Verniers et al., 2002), with thin sequences deposited in a shelf environment when Avalonia was already a separate continent, drifting to Baltica (Verniers *et al.*, 2002). Between both megasequences or between both formations an important hiatus of 8 to 15 Ma exists (Verniers *et al.*, 2001). The contact between both formations has never been observed As a consequence the exact thickness of both formations is not yet known.

2. Observations

Along a N-S-transect of 1200 meters twenty-four outcrops were studied: 3 in the Chevlipont Formation and 21 in the Abbaye de Villers Formation (Fig. 1). On the basis of the cleavage/fold relationships, we distinguished 3 types of folds: pre-cleavage, syn-cleavage and post-cleavage folds. Also other pre-cleavage, syn-cleavage and post-cleavage deformation features are observed. The syn-cleavage deformation features are mainly folds and most of them have a comparable fold shape with a gently dipping limb, a steeply dipping limb and a moderately N-dipping axial plane. They show a S-verging asymmetry. These folds are observed in the northern outcrops of the Abbaye de Villers Formation only and do not appear to be present in the southern outcrops, characterised by thick, more massive, S-dipping layers. The pre-cleavage deformation features are bedding truncations and folds. These occur in both formations. The pre-cleavage origin is inferred from the cleavage/fold relationships (non-axial planar penetrative cleavage and same sense of refraction in both limbs). For the Abbaye de Villers Formation it is remarkable that the syn-cleavage folds only occur where the pre-cleavage deformation features occur: in the northern outcrops.

Post-cleavage deformation features are rare; they include fault-related folds, faults, quartz veins and bedding truncations.

3. Discussion

The syn-cleavage folds, which are cogenetic with the (tectonic) cleavage, definitely have a tectonic origin and most likely formed during the Anglo-Brabant deformation phase, the only tectonic phase recognised thus far in the Brabant Massif (cf. Sintubin, 1999; Debacker, 2001; Verniers *et al.*, 2002). Two possibilities can be considered

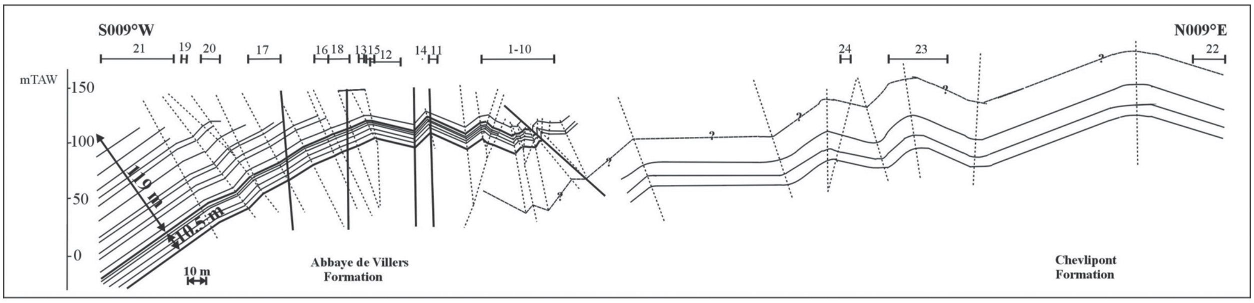

Figure 1. Cross-section of the whole study area.

for the development of the pre-cleavage folds (cf. Debacker *et al*., 2001). They could have formed during an older, thus far unknown, tectonic phase. However, in the study area, as well as in the other outcrop areas (Sintubin, 1999; Debacker, 2001; Verniers *et al*., 2002), there is no evidence for more than one tectonic deformation phase. Another possibility is that they are formed by soft-sediment deformation. Evidence for slumping abounds in the study area. The pre-cleavage folds show the following characteristics of slump folds: isolated, intraformational position between non-folded beds, dispersed fold axis orientations (fig. 2), irregular fold shapes in comparison to the tectonic fold shapes, a spatial association with pre-cleavage bedding truncations. Furthermore, the pre-cleavage folds often occur in zones in which the sediments are disrupted (e.g. sand layers disintegrated into small sand lenses within clay matrix, abrupt terminations of individual layers, etc…) The post-cleavage folds appear to be associated with post-cleavage faults.

4. Conclusions

4.1. Tectonic folds

Perpendicular to the virtual intersection of the mean N-dipping cleavage and the mean S-dipping cleavage (09/101) a N11°E-oriented bulk shortening direction can be inferred (fig. 2). A comparison of the mean fold axis (01/096) and the intersection of the mean cleavage planes (09/101) suggests a 5° clockwise transection angle for the study area. However, both folds with a clockwise and folds with and anticlockwise transection occur, and a large range in transection angles exists (a clockwise transection angle from 1° to 20° and an anticlockwise transection angle from 15° to 31°). This may be related to the dispersed orientations of the tectonic fold axes. The latter could be explained by the presence of periclinal folds, observed in one of the studied outcrops and apparently quite common in the Brabant Massif (cf. Debacker, 2001). Moreover it is remarkable that the tectonic folds only occur where slump folds occur. On the basis of this we can suspect that, during tectonic deformation, the pre-cleavage deformation features (slump features) served as irregularities at which the tectonic folds initiated (cf. Price & Cosgrove, 1990). Hence, the variation of the tectonic fold axis orientation may be due to the variation in orientation and geometry of the slump features.

4.2. Slump folds

On the basis of the orientations of the slump folds the downslope direction of the probable palaeoslope could be determined for both formations: to the North (in the direction of 003°) for the Chevlipont Formation and to the South (in the direction of 178°) for the Abbaye de Villers Formation. These two different palaeoslopes possibly reflect a different basin geometry during megasequence 1 and megasequence 2 of Verniers *et al*. (2002).

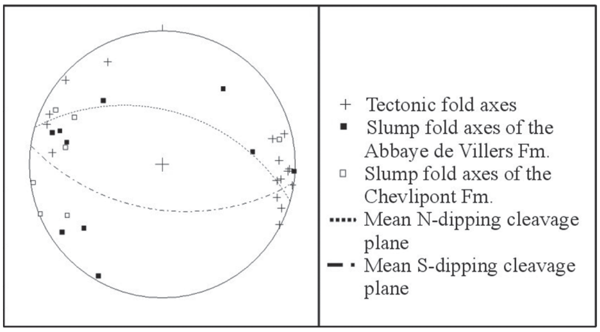

Figure 2. Stereoplot with tectonic fold axes, slump fold axes of the Abbaye de Villers and Chevlipont Formations, mean N-dipping cleavage plane and mean S-dipping cleavage plane.

4.3. Stratigraphic implications

On the basis of a structural cross-section (fig. 1) a minimal thickness of 129.5 m can be inferred for the Abbaye the Villers Formation. Because of the lack of outcrops the contact between the two formations could not be determined and as a consequence the exact thickness of the Abbaye the Villers Formation remains unknown. A borehole is required to solve this problem.

The structural cross-section shows that the Abbaye de Villers Formation can be divided into two parts: an upper, southern part of 119 m thick, consisting of rather sandy, massive, thick, S-dipping layers and a northern part of minimum 10.5 meters thick, consisting of thinner layers. Only in the northern part slump folds and numerous, tectonic folds occur.

Finally, this cross-section also shows that the oldest layers of the Abbaye de Villers Formation occur in outcrop 10, slightly to the south of the point where, because of the generally S-dipping layers, the oldest layers were expected. Acritarchs in these expected oldest layers indicate an upper Arenig or post-Arenig age (Vanguestaine *in* André *et al.*, 1991). The age remains to be determined of the oldest layers in outcrop 10.

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