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Post-Variscan right-lateral wrench faulting in the Ardenne Allochthon and the Variscan Front (Belgium)

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ABSTRACT

New fault-slip data on post-Variscan strike-slip structures were collected in the Meuse valley between Liège and Huy, and in the area of Beauraing, Wellin and Han-sur-Lesse. These structures belong to two right-lateral wrench fault zones, developing in parallelism with the general Variscan trend: the "Nord-Artois" shear zone, which continues eastwards up to Liège in the North Variscan Front, and the Famenne zone in the Ardenne Allochthon. Paleostress inversion of fault-slip data gives a transpressional stress field with E-W to NW-SE directions of principal compression. Together with the Hunsrük-Taunus Border fault zone in western Germany, they may correspond to a Late Cretaceous - Paleogene intraplate compressional deformation, as a result of the Alpine collisional orogeny.

KEYWORDS

Alpine, Ardenne Allochthon, paleostress analysis, post-Hercynian, Variscan Front, wrench tectonics

Introduction

The presence of steep right-lateral strike-slip faults with thick mineralized fault breccia in the Liège coal basin have been recognized since the end of the last century by underground mining work (Fourmarier, 1907). They are cutting the weakly inclined thrust faults of the Variscan Front, and interrupting the coal seams. Four major faults of this type affect the Liège basin, all parallel to the general NE trend of the Variscan Front. They belong to a fan system which tends to narrow southwestwards, and merge together along the axis of the Meuse River valley (Humblet, 1941; Ancion, 1942; Fourmarier, 1954). This system develops between the Midi Fault to the south and the Bordière Fault to the north, in the North Variscan Front. Dextral displacement along one of these faults (St-Gilles) reaches 1400 m, with a reverse dip-slip component of 50 m (Walgraffe, 1942). This strike-slip fault system displaces the Midi Fault, and even affects the Cretaceous cover (Stievenard, 1949).
West of Belgium, in the north of France, Colbeaux (1974) evidenced a right-lateral displacement zone from Cap Gris-Nez to the vicinity of Namur ("zone de cisaillement nord-artois"). This zone is cutting and displacing the structures of the Variscan Front. The Mons Basin is situated along this shear zone, and its development appears to be syntectonic (Fourmarier, 1959), controlled by dextral movements during the Cretaceous-Paleocene (Vandycke *et al.*, 1992). In the region of Namur, the displacement might reach 6 km (Legrand, 1968).
In the Ardenne Allochthon itself, a broad zone of discontinuous dextral strike-slip movement has been recognized in the Famenne depression, between the High Ardenne and Condroz areas (Delvaux de Fenffe, 1985; 1990, Lemonne *et al.*, 1997). They occur as conjugate strike-slip faults with subhorizontal slickensides, minor thrusting and folding around subvertical axes. The amount of dextral displacement is estimated up to 1700 m, near Focant.

Paleostress tensor reconstruction

New fault-slip data were collected along the Meuse River valley at Engis and in the Famenne depression. Reduced paleostress tensors were determined according to standard procedures (Angelier, 1994; Dunne & Hancock, 1994), using the TENSOR program (Delvaux, 1993). Additional data were found in the detailed description of the Roptai faulted Ba-F-Pb deposit of Ave-et-Auffe (Lannoy, 1979). Paleostress tensors determined at the Flône quarry along the Meuse River (Sintubin & Muchez, 1995) were also used (Table 1).
In the Meuse River valley, between Huy and Liège, the Flône and Engis quarries are open in steeply inclined, WSW-ENE- to E-W-trending Carboniferous limestone in the Variscan Front, between the Midi and Bordière Faults.
At the Flône quarry Muchez & Sintubin (1997) report a Late Jurassic karstification period, followed by two successive dextral transpressional stages during the early Maastrichtian: the older, with a NW-SE horizontal principal compression (S_{Hmax}) and the younger, with a WNW-ESE S_{Hmax}. In the Engis quarry, well developed strike-slip faulting also follows an earlier karstification period. About 140 fault-slip data and joints were measured. The best expressed stage (75 data) corresponds to a strike-slip stress regime with WNW-ESE S_{Hmax} direction. The minor (and probably younger) stage is expressed by 25 faults, giving a pure compressional stress

Table 1. Reduced paleostress tensors from fault-slip data. n - fault data used in inversion; nt - data measured; σ1, σ2 and σ3 - plunge and azimuth of principal stress axes; R - stress ratio (σ2–σ3)/(σ1–σ3); a - mean slip deviation (°); Q - quality ranking (A: very good, B: good, C: medium, D: poor).

Site	n	nt	σ1	σ2	σ3	R	α	Q
Meuse valley								
Flône, older (Sintubin & Muchez, 1995)	10	23	13/315	77/128	02/225	0.44		C
Flône, younger (Sintubin & Muchez, 1995)	13	23	08/292	65/105	23/025	0.50		C
Engis quarry, main stage	75	115	20/303	66/086	13/208	0.47	10.2	A
Engis quarry, minor (Younger?) stage	25	115	10/096	06/187	78/309	0.59	8.0	B
Engis quarry, latest movement	17	33	74/245	16/077	03/346	0.61	11.4	B
Famenne								
Froidlieu abandoned quarry	16	21	12/274	64/042	19/179	0.16	6.6	A
Fonds des Vaux quarry, Wellin	31	37	09/079	57/335	32/175	0.22	10.1	A
Roptai, Ave-et-Auffe, normal faulting	13	23	78/326	00/237	12/146	0.15	1.1	D
Roptai, Ave-et-Auffe, strike-slip faulting	10	23	01/315	85/223	05/045	0.53	5.7	B

tensor with E-W S_{Hmax} direction. A last reactivation stage corresponds to NS extension (17 faults).

The detailed structure of the Famenne depression, in the Ardenne Allochthon between Beauraing and Rochefort, is described in Delvaux de Fenffe (1985; 1990). A series of structures related to dextral movement along this zone affect the folded structure and partly reactivate the late-Variscan normal faults. Fault-slip data were measured in the Froidlieu abondoned quarry and the "Fond des Vaux" quarry in Wellin. In addition, the fault structure of the "Roptai" Ba-F-Pb deposit of Ave-et-Auffe (Lannoy, 1979) has also been interpreted in a kinematic way.

The reduced paleostress tensors obtained correspond to a transpressional regime with almost E-W S_{Hmax} in both the Froidlieu and Fond des Vaux quarries. In Ave-et-Auffe, a pure strike-slip regime with NW-SE S_{Hmax} was obtained for the conjugate strike-slip fault system. The Ba-F-Pb mineralization occured contemporaneously with the activity of both fault systems (Lannoy, 1979).

Discussion

Our results show that the "Nord-Artois" shear zone, which extends eastwards, at least up to Liège, and has to be redefined as the "Nord Artois-Liège" shear zone. Together with the Famenne zone, they form right-lateral wrench fault zones of discontinuous strike-slip faulting. They have much similarities with the NE-trending Hunsrük-Taunus fault zone in western Germany, between the Upper and Lower Rhine Grabens (Anderle, 1987). Along the latter, Permian lava were displaced by 5 to 8 km by a right-lateral movement, probably in the Early Tertiary, but before the Middle Oligocene (Schwab, 1987).

The paleostress tensors obtained here are strike-slip to transpressional, with S_{Hmax} oriented WNW-ESE to almost E-W. This type of stress field does not correlate well with the paleostress field of the European Platform determined by Bergerat (1987) for the Oligocene-Miocene period. They are only compatible with the most recent stress field, that was established by the end of the Miocene. However, the stress tensor obtained are compatible with the Early Maastrichtian paleostress stage studied by Vandycke *et al.* (1991) in the Cretaceous of the Mons Basin. This stage is associated with pull-apart basin formation, with well expressed synsedimentary faults in the "la Malogne" quarry, consistent with the right-lateral movement along the "Nord-Artois" shear zone. This stage is the only strike-slip one, in a dominantly extensional context of basin formation during the Late Cretaceous - Paleocene in the Mons area (Vandycke *et al.*, 1991).

Conclusion

Three major dextral wrench fault zones affect the North-Variscan front and the Rhenish massif in Belgium and adjacent areas: the "Nord-Artois" shear zone, which extends eastwards up to Liège, the Famenne and Hunsrük-Taunus shear zones. They all reactivate pre- to Late-Variscan weakness zones. They are probably related to the Late Cretaceous-Cenozoic intraplate compressional deformation that affected the Alpine foreland as the result of the Alpine collisional orogeny (*e.g.* Ziegler, 1987). They are related to a strike-slip to transpressional stress field with E-W to WNW-ESE S_{Hmax}, acting broadly during the Maastrichtian-Paleocene period.

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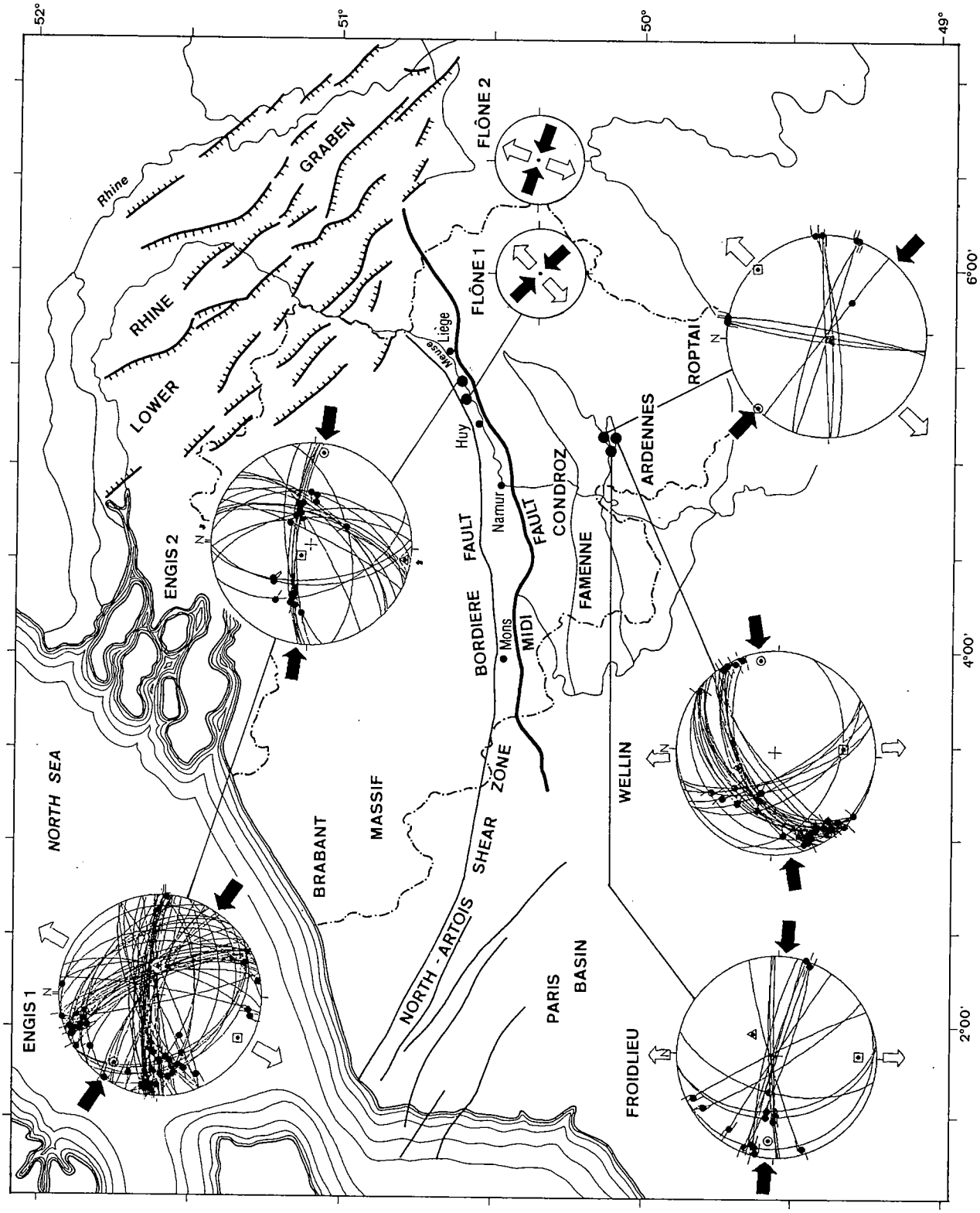

Fig. 1. Structural map of Belgium and adjacent regions, with major post-Variscan structures, location of observation sites and related paleostress tensors. Lower-hemisphere Schmidt projections for new data presented in this study. Paleostress symbols only for the data of Sintubin & Muchez (1997).

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