Fossil overpressures compartments? A case study from the Eifel area and some general aspects *Vortrag*

Christoph Hilgers[1] Carsten Bücker[2]
Janos L. Urai[1]

Introduction

Fluid overpressures are well known from hydrocarbon exploration in many sedimentary basins. They can reach almost lithostatic values, and may cause the fracturing of rock. Fracturing allows the discharge of fluid overpressure, and fluid flows along a hydraulic gradient towards a low pressure reservoir. Different mechanisms may cause the precipitation from the fluid, such as a fluid pressure drop, a variation of temperature at the low pressure reservoir, or a different rock type inducing different Eh-pH conditions. Such precipitates in fractures are called veins, which often display paleo-fluid overpressures in rocks. In this study, we present some results from Devonian clastic sedimentary rocks of the Eifel area. Results are compared with other sedimentary basins to highlight some general aspects.

Geological setting

The lower Devonian rocks exposed along the shore of the Rursee water reservoir are Siegenian Upper Rurberger beds and Emsian Klerfer and Heimbacher beds to the NE. They are located on the SE-flank of the NE-plunging Variscan Venn-Anticlinorium. Both units expose shales, siltstones and sandstones deposited in the subsiding Devonian Eifel Basin.

Meso- and microstructural data

Two different vein sets are oriented subnormal (#1) and parallel (#2) to bedding, respectively. Both sets are filled with quartz. Vein set #1 is restricted to sandstone layers, and rarely continues into the enclosed shale beds. Their shape is sigmoidal on fold limbs, and their orientation in accordance with flexural slip along the bedding planes. The vein microstructure of #1 shows an elongate-blocky to fibrous microstructure. Fibrous grains continue across the vein (stretched crystals) and contain solid and fluid inclusions arranged parallel to the vein wall interface. Meso- and microstructural observations indicate vein formation prior or syn-folding, veins opened in incremental steps (crack-seal mechanism). Vein set #2 is located at the shale-sandstone interface and can be traced for several tens of metres. It generally truncates #1 and thus post-dates the bedding-normal veins. Locally, vein set #2 cuts trough the hanging-wall and is associated with small thrusts. The blocky quartz grains of vein set #2 extinct undulose and are recrystallised by grain boundary migration and subgrain rotation. The quartz grains of the host rock, however, are elongated (overgrowth, fringes and dissolution along the cleavage planes), but generally optically undeformed. This indicates that pressure solution was the dominant deformation mechanism in the host rock.

Modelling the subsidence of the upper Rurberg beds using published data of burial temperatures (vitrinite reflectance, illite crystallinity etc., e.g. von Winterfeld 1994) indicates rapid burial down to 7–8 km depth prior to the onset of Variscan compression and subsequent basin inversion. This accounts

---

[1] Geologie-Endogene Dynamik, RWTH-Aachen, Germany [2] Shell E&P, Houston, USA

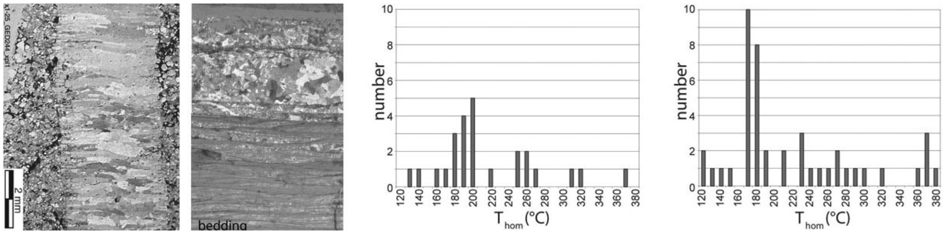

Figure 1: (a) The vein microstructure of #1 shows stretched crystals, which can laterally evolve towards an elongate-blocky microstructure grown syntaxially. b) Vein set #2 is blocky and was deformed plastically by dynamic recrystallisation. c, d) Fluid inclusion data show maximum temperatures of about 370°C for both vein sets #1 (c) and #2 (d).

for the up to approx. 6.5 km thick lower Devonian sedimentary pile deposited in the Eifel Basin, and fluid overpressure generation during subsidence and the onset of Variscan compression (Fig. 2).

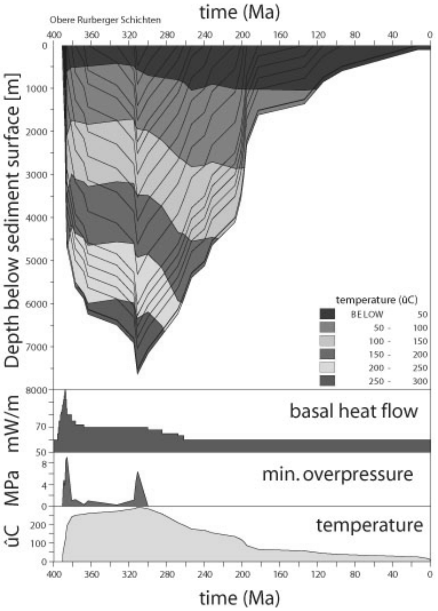

Figure 2: Subsidence curve of the Lower Devonian upper Rurberg beds.

Discussion and Conclusion

Field and microstructural observations of vein sets #1 and #2 are consistent with our modelled overpressure generation due to basin evolution (Fig. 2). Bedding normal veins #1 are restricted to the competent sandstone layers and formed in an already competent rock, as shown by transgranular fractures and the absence of compaction features associated with vein set #1. Repeated crack-seal increments and the variation of paleo-temperatures suggest that veins were subsequently opened and re-sealed during subsidence. Stretched crystals are oriented normal to the vein wall, indicating extension normal to bedding. Vein formation requires tensile fracturing of the sandstone with the maximum principal stress oriented normal to bedding, which is consistent with vein formation during subsidence at high fluid overpressures and low differential stress. Bedding-parallel vein set #2 truncates set #1 and cuts through the hanging wall associated with small thrusts. This indicates a reorientation of the principal stresses between #1 and #2. Vein set #2 is folded in accordance with the Variscan folds exposed on the shore, but parasitic folds of the veins are absent. This suggests that vein set #2 represents the first compressional event associated with Variscan deformation. The vein system of the Eifel Basin is consistent with results from other sedimentary basins, which may also include microstructural aspects.

References

von Winterfeld, C-H (1994) Variszische Deckentektonik und devonische Beckengeometrie der Nordeifel — Ein quantitatives Modell. PhD Thesis, RWTH Aachen, Aachen, 319 pp.