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A combined X-ray micro-tomography & SEM investigation of stylolite interfaces: implications for localised pressure solution.

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We present the first results of an extensive X-ray micro-tomography analysis of stylolite interfaces in fine grained calcite limestones. Traditionally, stylolites are examined in 2D cross-sections in the outcrop or thin-section, or their topography is investigated by laser profilometry of mechanically opened interfaces, essentially gaining 1D or 2D information. The tomography data of stylolite interfaces presented here give full 3D insight. This allows to investigate the relationship of the interpenetrating surfaces, which are separated by a residual layer (i.e. the residual of the dissolved material) and thus the aperture scaling of stylolite interfaces. In contrast to the current state of the research, our micro-tomography data, in combination with SEM analysis, demonstrates that the aperture (i.e. the residual clay layer) can vary up to two orders of magnitude along individual stylolite interfaces. We found that the changes in aperture can be related to (I) the distribution of heterogeneities in the host-rock, e.g. clay particles and quartz grains and (II) relatively large asperities along the interface which reveal a reduction in the aperture below the resolution of the tomography data in the peak area.

The influence of heterogeneities on the aperture can easily be explained by differences in the relative dissolution rate. The punctual reduction of the aperture in the vicinity of relatively large stylolite peaks is more difficult to explain, neither with conventional pictures of localised pressure solution surfaces, nor with local variation in the distribution of the residuum. We hypothesise that a certain fraction of the asperities form a load bearing framework where the two opposing calcite interfaces touch each other. The lack of clays in the vicinity of these asperities might significantly reduce the rate of pressure solution. Due to compatibility reasons this scenario suggests that the overall rate of pressure solution is dominated by these load bearing contact points. Our findings have important consequences for fluid flow along stylolite interfaces and shed new light on localised pressure solution surfaces.