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3-D numerical modelling of the influence of reactivated pre-existing faults on the distribution of deformation: example of North-Western Ghana around 2.15-2.00 Ga

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High strain zones appear to play a significant role in feeding the upper crust with fluids and partially molten material from lower crust sources. The Bole-Bulenga terrain (North-Western Ghana) is located in between two subvertical shear zones, and mainly consists of high-grade orthogneisses, paragneisses and metabasites intruded by partially molten lower crustal material with monzogranites and orthogneisses (Eburnean orogeny, around 2.1 Ga). In order to understand the location of these high grade rocks at the edges and in between these two shear zones, a three dimensional numerical model was built to test the influence of different orientations of a system of branched strike-slip faults on visco-plastic deformation, under compressional and simple shear boundary conditions. Our models indicate domains of tensile vs. compressional strain as well as shear zones, and show that not only internal fault zones but also the host rock in between the faults behave relatively softer than external regions. Under both applied compressive and simple shear boundary conditions, these softened domains constitute preferential zones of tensile strain accommodation (dilation) in the upper crust, which may favor infilling by deeper partially molten rocks. Our modeled pre-existing faults zones are assumed to have formed during an early D1 stage of deformation, and they are shown to passively migrate and rotate together with the solid matrix under applied external boundary conditions (corresponding to a post D1 - early D2 phase of deformation). We suggest that in the Bole-Bulenga terrain, fluids or partially molten material stored in deeper crustal domains, preferentially intruded the upper crust within these highly (shear and tensile) strained domains, thanks to this D2 shearing deformation phase.

Building relief at the surface is primarily controlled by fault orientations, together with mechanical parameters and external boundary conditions. In particular, greatest magnitudes of relief are obtained when faults dip in parallel one with the other and when they are inclined at depth, as they thus facilitate stress rotation and material transfer from depth. The host rock density does not play a primary role in producing relief compared to variations in friction angle at the crustal scale (30km thick). Relief increases by 200 – 300 m when the host rock density is increased by 200 kg/m3 , whereas relief drops by about 1200 m when decreasing the host rock friction from φ = 20° to 10°.