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Interlayer fissures in TEM images of naturally deformed biotite grains: artifacts or natural defects?

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Micas are believed to be incredibly important minerals with regard to strain localization in the Earth's crust owing to their common role as the weakest phase in crustal lithologies. Dislocation climb, and by extension dislocation creep, is inhibited in micas by the lack of easy slip systems outside of the basal plane. Basal dislocation glide alone is unable to satisfy von Mises criterion and facilitate shape change in grains, therefore other deformation mechanisms must be active. The transmission electron microscope (TEM) provides an invaluable tool for the study of mica deformation mechanisms at the nano-scale. We show TEM images of biotite mica from naturally deformed orthogneiss mylonites that display abundant elongate fissures parallel to the basal plane. The origin of these features is unknown but they may represent the expression of a new type of defect described in layered solids known as ripplocations. The features we observe partially resemble nano-scale basal cleavage except for the fact that the cavitation is highly localised, with lattice fringes bending back into place and returning to a regular spacing at either end of the cavity. The fissures regularly occur in apparently ordered, en-echelon sequences which produce roughly diamond shaped arrays visible throughout biotite grains. Somewhat similar features have been described in previous TEM studies of phyllosilicates and attributed to damage due to prolonged exposure to the electron beam. However the extent and ordered nature of the structures that we observe has not been previously reported and may hint at a natural origin. We present details of a preliminary investigation into these delaminations with the aim of determining whether they are artefacts, caused by electron beam damage or sample preparation, or indeed natural deformation nano-structures. If these delaminations are the TEM expression of ripplocations, then these new defects could be the missing agents that enable crystal-plastic deformation of phyllosilicates and which may therefore accommodate significant amounts of strain within mica-bearing crustal shear zones.