

Impermeable fault zone developed due to high-T brittle shear in in-situ oceanic crust, 30degreeN Mid-Atlantic Ridge

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The study of an in situ fault zone within Atlantis Massif oceanic core complex (Mid-Atlantic Ridge) provides clues into deformation mechanisms and their evolution in the oceanic crust. IODP EXP304/305 drilled a succession of gabbroic lithologies down to a final depth of 1415 meters below sea floor (mbsf), with very high recovery rates (~80%), up to 100%. We have identified an intra-crustal fault zone between 720 and 780 mbsf, in a section consisting of massive gabbro, olivine gabbro and oxide gabbro units, with minor diabase intrusions. Of particular interest is the section between 744 and 750 mbsf, which is portrayed by low recovery (17%). Electrical borehole wall images show a 1-m thick zone of east-dipping fractures within this interval that is otherwise dominated by N-S structures. Despite a high fracture density the section shows smooth walls with rare breakouts thus suggesting that the low recovery is due to a lithology change and not to well conditions. 'Ultracataclasite' and possibly incohesive 'fault gouge' formed in the upper amphibolite regime with mostly amphibole infill. Logging data suggest that the gabbroic rocks in this interval are rich in hydrous phases, corroborating increased amounts of amphibole found in the core. Equilibration temperature conditions of about 640 degree C were obtained for the plagioclase clasts and aluminous actinolite, assuming pressure of 200 MPa. Permeability experiments show that the permeability of the fault zone is in the range of 10^{-19} to 10^{-17} m². Although permeability appears to be higher within the fault zone in the section, overall permeability structure is yet as low as those in the lower crust. Consequently, since brittle failure occurred at high temperature condition, the fault zone has been subsequently completely sealed with hydrous minerals that are enough to prevent from further fluid circulation. Such completely sealed impermeable fault zone might be inactivated in the ocean floor, unless the hydrous minerals along the fault zone could be eventually involved in dehydration reaction, so that a new fault zone may occur in a wide range of tectonic environments from the ridge axis to the subduction zone in relation to its stress field.