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Thermal cracking and the deep hydration of oceanic lithosphere

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The mechanical properties of oceanic lithosphere is investigated using the numerical modeling of viscoelastic fracture mechanics. The development of thermal stress in cooling lithosphere is controlled by complex interaction among viscoelastic relaxation, thermal cracking, and chemical reaction such as serpentinization. The temporal evolution of viscoelastic fracture system, in the presence of lithospheric strress (which tends to heal cracks), has been scarcely explored in the past. Most of previous studies on thermal stress in oceanic lithosphere are limited to elastic analysis with various kinds of approximation, most notably "blocking temperature" and "free-moving boundaries". On the basis of physically more realistic viscoelastic analysis (with proper rheology for dry oceanic lithosphere), the validity of those approximations can be closely examined. Preliminary results indicate that, just by simple surface cooling, considerable thermal stress can be accumulated down to the depth of about 50km, making the upper half of mature oceanic lithosphere prone to brittle fracture. Possible consequences of this ambient stress state, including pervasive thermal cracking, chemical alteration of shallow upper mantle, and resulting mechanical weakening of oceanic plate, will be presented.