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Two Different Representations of Moment Tensor and the Energetics of Shear Faulting

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The concept of moment tensor plays a key role in dealing with indigenous sources in the framework of linear elasticity. For the moment tensor, curiously, there are two different definitions, proposed by Gilbert [1971] and Backus & Mulcahy [1976]. In either definition, the moment tensor is represented by the volume integral of moment tensor density over the source region. So, the difference between these two definitions is due to difference in physical quantity chosen as the moment tensor density; Gilbert [1971] chose stress drop (difference between static stresses before and after the event), while Backus & Mulcahy [1976] chose stress glut (difference between elastic model stress and actual physical stress). As pointed out by Backus & Mulcahy [1976], the definition of moment tensor by Gilbert [1971] is certainly incorrect, but, if the volume integral of stress drop is carried out over the whole region, it will give the same tensor as in the case of Backus & Mulcahy [1976].

The Earth's crust is basically treated as a linear elastic body, but it includes a number of defects. The occurrence of inelastic deformation, such as brittle fracture and/or plastic flow, at the defects brings about elastic deformation in the surrounding regions. So, the actual constitutive equation, which relates actual physical stress with geometrically defined strain, is different from that of linear elasticity. Nevertheless, we aim to solve the equation of motion of the Earth's crust in the framework of linear elasticity. Then, in order to realize the actual deformation field, which is observable through seismological and geodetical measurements, we need to add some correction term (stress glut or stress drop) to the equation of motion in linear elasticity. Recently, through such theoretical consideration to the equation of motion in continuum mechanics, Matsu'ura et al. [2018 JpGU Meeting] obtained a fundamental equation; that is, the mathematical equivalence of the moment tensor of a seismic event and the volume integral of static stress changes due to the event over the whole region, which gives a theoretical basis of the CMT data inversion method to estimate the spatial pattern of tectonic stress orientation [Terakawa & Matsu'ura, 2008]. Furthermore, from this equivalence relation, we can derive a simple energy equation that relates the change in shear strain energy of the total system and the work done for shear faulting, which gives a theoretical background of the Wallace-Bott hypothesis: seismic slip occurs in the direction of the resolved shear traction [Wallace, 1951; Bott, 1959].