

# A Theory for Calculating Strains Caused by Dislocations in a Spherically Symmetric Earth &#8211; Theory for a Point Source

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Advancing in modern geodetic techniques makes it possible to detect co-seismic deformations, such as displacement, gravity change and strain. To properly applying the observed geophysical phenomena interpret or inverse the seismic parameters, a quasi-static dislocation theory is necessary. For a half-space earth model, many studies have been carried out by many scientists, among them are Steketee (1958), Maruyama (1964), Press (1965), Jovanovich et al. (1974a,b) and Okada (1985). They presented analytical expressions for calculating surface displacement, tilt, and strain due to various dislocations buried in the semi-infinite medium. Okubo (1991, 1992) proposed expressions in closed form to describe potential and gravity changes due to dislocations. Due to their mathematical simplicity, these dislocation theories have been widely applied up to the present day to study or inverse seismic faults. However, validity of these theories is strictly limited to a near field because Earth curvature and radial heterogeneity are ignored. Since modern geodesy can detect and observe far field crustal deformation, even a global so-seismic deformation, a dislocation theory for a more realistic earth model is demanded to interpret far field deformation.

Efforts to develop formations for such an earth model were advanced through numerous studies (Ben-Menahem and Sihn, 1968, 1970; Smylie and Mansinha, 1971). These studies revealed that earth curvature effects are negligible for shallow events, while vertical layering may have considerable effects on deformation fields. However, Sun and Okubo (2002) recent study comparing discrepancy between a half-space and a homogeneous sphere and between a homogeneous sphere and a stratified sphere indicates that both curvature and vertical layering have significant effects on co-seismic deformation. While stratified sphere models, such as the 1066A or PREM model, are the most realistic; they reflect both sphericity and stratified structure of the earth. For such an earth model, Rundle (1982) studied viscoelastic gravitational deformation by a rectangular thrust fault in a layered earth. Pollitz (1992) solved the problem of regional displacement and strain fields induced by dislocation in a viscoelastic, non-gravitational model. Sun and Okubo (1993, 1998) and Sun et al. (1996) presented theories to calculate co-seismic displacements and gravity changes in spherically symmetric earth models. Okubo (1993) proposed a reciprocity theorem for connecting solutions of dislocation and tidal, shear, and load deformations. Ma and Kuszniir (1994) modified elastic dislocation theory to derive subsurface displacements for faults in a three layer elastic gravitational medium. Piersanti et al. (1995, 1997) and Sabadini et al. (1995) studied displacement and rates induced by a dislocation in viscoelastic, stratified earth models. They produced surface displacement and velocity results in the near and far field for various viscosity profiles in the mantle.

However, calculating the co-seismic strain for a realistic earth model remains unsolved up to date. This research is to present a new theory for such a purpose. Assuming the seismic sources be located at the polar axis, corresponding expressions are derived, by introducing strain Green functions multiplying by an epicentral distances. A proper combination of these expressions can be used to calculate any co-seismic strain components caused an arbitrary seismic source at any geographical position in the earth. Numerical computations are performed for calculating strain components in the near field caused by four independent sources at a depth of 32 km inside the 1066A earth model. Results agree well with that calculated for a half-space earth model. It confirms the rightness of the theory presented in this research. This research is limited to an elastic earth model, but it can be extended easily to a viscoelastic one if necessary.