Geophysical Research Abstracts
Vol. 19, EGU2017-9919, 2017
EGU General Assembly 2017

What is the role of structural inheritance on present-day deformation in intraplate domains?

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Intraplate earthquakes with magnitudes up to 7 are rare and unexpected. The associated seismic hazard is therefore significant. The mechanisms involved in intra-continental deformation are poorly known at present and still discussed. One of the reasons is that the intraplate strain rates are low compared to those in plate-boundary regions: $\sim 10^{-11}$ to 10^{-8} versus 10^{-7} yr^{-1} or more, i.e. at the precision limit of geodetic data. Calais et al. (2015) propose a new paradigm to explain those earthquakes: faults are preloaded by inherited stress with no present accumulation and the threshold is reached because of transient phenomenon.

Observations suggest that intraplate deformation is related to the reactivation of crustal and lithospheric paleo-structures. The objective of our study is to understand the role of these weakened areas, more particularly their impact on strain localizations and rates.

In this study, we combine GPS observations and numerical modelling to analyze the role of inherited weakening on present day strain rates in intraplate domains, with specific observations along the St. Lawrence Valley of eastern Canada. We put a special emphasis on determining as precisely as possible the GPS velocities and strain rates. Preliminary strain rates estimations in the weakened St Lawrence valley reach about 10^{-9} yr^{-1}, one order of magnitude higher than the background intraplate domain. Our new numerical (finite-element) models investigate the steady-state deformation of the lithosphere, integrating structural inheritance using a weakening coefficient based on the study of Gueydan and al. (2014). This innovative model allows us to study crustal strain rates mainly as a function of lithospheric rheology, geometry and location of the weakening area (crust and mantle). Preliminary results show that modelled strain rates in weakened area are one order of magnitude lower than those observed by GPS. This difference is likely due to the fact that our GPS observations are associated with postglacial rebound. Thus, this transient process must be integrated in our models.

Our research will also focus on intraplate areas in general. Expected modelling results should find the same strain rates than those typically observed in stable continental domain and therefore highlighting the mechanisms at the origin of the intraplate deformation.