Geophysical Research Abstracts
Vol. 14, EGU2012-6947, 2012
EGU General Assembly 2012

The compositional and thermal structure of the lithosphere from thermodynamically-constrained multi-observable probabilistic inversion

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Our capacity to image and characterize the thermal and compositional structure of the lithospheric and sub-lithospheric upper mantle is a fundamental prerequisite for understanding the formation and evolution of the lithosphere, the interaction between the crust-mantle and lithosphere-asthenosphere systems, and the nature of the lithosphere-asthenosphere boundary (LAB). In this context, the conversion of geophysical observables (e.g. travel-time data, gravity anomalies, etc) into robust estimates of the true physical and chemical state of the Earth's interior plays a major role. Unfortunately, available methods/software used to make such conversions are not well suited to deal with one or more of the following problems:
1) Strong non-linearity of the system. Traditional linearized inversions do not generally provide reliable estimates.
2) The temperature effect on geophysical observables is much greater than the compositional effect, therefore the latter is much harder to isolate.
3) Non-uniqueness of the compositional field. Different compositions can fit equally well seismic and potential field observations.
4) Strong correlations between physical parameters and geophysical observables complicate the inversion procedure and their effects are poorly understood.
5) Trade-off between temperature and composition in wave speeds.
In this contribution we present a new full-3D multi-observable inversion method particularly designed to circumvent these problems. Some other key aspects of the method are: a) it combines multiple datasets (ambient noise tomography, receiver function analysis, body-wave tomography, magnetotelluric, geothermal, petrological, and gravity) in a single thermodynamic-geophysical framework, b) a general probabilistic (Bayesian) formulation is used to appraise the data, c) neither initial models nor well-defined a priori information is required, and d) it provides realistic uncertainty estimates. Both synthetic models and preliminary results for real-case examples will be used to discuss the benefits and limitations of this method.