QUANTITATIVE INTERPRETATION OF GEOLOGICAL DATA

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ABSTRACT : A numerical models is a tool that helps us interpret geological observations by integrating the effects of a range of physical processes at play in the Earth's interior or along its surface to predict the response of an often complex and interconnected system to a given perturbation. For example, geomorphologists are interested in the effect of the Quaternary glaciations on the evolution of relief in alpine regions. To estimate relief evolution, we measure the cooling age of rocks exhumed at the surface of the Earth and try to estimate how the evolution of this surface in the recent past may have influenced the spatial distribution of ages. To extract information about relief history from the distribution of cooling ages at the surface, we need to compute the evolution of the temperature within the crust and how it is affected by both the rapid exhumation of rocks and the changing geometry of the Earth's upper surface. This can only be done using a sophisticated 3D numerical model. However, these so-called "forward" models can only predict the effect of a given tectono-morphic scenario on the age distribution. The inverse problem of inferring the most probable scenario from the observed age-distribution is a more difficult goal to achieve, although it is what motivates the observation in the first place. I will present, through a series of examples, how complex numerical models are now used to extract constraints on Earth system behavior by Bayesian inversion of geological observations. In particular, I will show how thermochronological data has been used to constrain the tectono-morphic evolution of the French Alps and the Southern Alps of New Zealand, and show how those two small orogens have responded differently to the recent glaciations. I will also show how geological observations - and in particular, sedimentary data - can be used to infer something about the current large-scale flow in the Earth's mantle and its past evolution.