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Thrust kinematics, uplift and erosion in foreland fold-and-thrust belts: Comparative study of Canadian Rockies and the Saharan Atlas-North Algeria

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Foreland basins result from the flexure of the autochthonous continental lithosphere as a response to tectonic loading, usually characterised by a significant topography in the hinterland. The subsidence of these basins is generally fast, thus allowing the accumulation of thick synorogenic sediments derived from the erosion of both the hinterland and the craton, which induce also a synchronous maturation of the source rock.

We are interested here about the uplift and erosional history derived from kinematic and thermal modeling for two well known fold and thrust belt transects: the Canadian Rockies between Banff and Calgary and the Saharan Atlas - North Algeria profile crossing the Tell in the north to the Saharan Platform in the south.

The Alberta flexural basin was developed on the ancient North-American margin during Cretaceous times, as a result of coeval collisional in the hinterland, before being affected by tectonic contraction during the late-Cretaceous - Eocenes times. The lack of Tertiary deposits in the Alberta foothills is largely related to the thrust-related uplift and erosion. Apart of post Laramian extention and thermal doming, which account for anomalous topography both in the thrust belt and in the foreland, the postglacial isostasic readjustments helped also to resume recently uplift activity.

No matter the reason of past Eocene uplift, Up to 2,5 km of syntectonic sediments have been eroded in the foredeep since the end of the Cordilleran orogeny, against more than 3,5 km in the allochton.

In contrast, the subsidence and uplift histories of the Saharan Atlas in Algeria are rather complex, even if it remains largely un-known, because of early foreland inversion of Jurassic structures inherited from the Thetyan rifting episodes operating since the Eocene,. After a major Oligocene erosion episode, near the fore-bulge and along early inverted features of the foreland, the first transgressive and unconformable Neogene deposits had a limited extension, being restricted to a narrow flexural basin, located between the Saharan Atlas and the Tell. Uplift and erosion resumed in the Saharan Atlas during the Plio-Pleistocene, thus accounting for still active inversion processes in the foreland.

In this context of alternance of subsidence and uplift episodes, it is very important to reconstruct in detail the burial and thermal evolution of each potential source rocks identified in the basin, and which undoubtedly acquired their current maturity during various basin evolution episodes.

To quantify the amount of erosion, vertical uplift and history of the lithosphere flexure in both regions, we have developed an integrated approach using 1D backstripping, 2D kinematic, 2D thermal maturity simulations and gravity calibration at the lithospheric scale, in order to:

- Constrain the different sedimentary and topographic profiles through time, for the entire section (i.e. for the autochthon as well as for the foothills and the hinterland). This implies we must estimate the former thickness of eroded layers. For this purpose, we have used both the LOCACE software, which provides results based on geometrical considerations, and the GENEX decompaction software, which provides independent estimates and subsidence curves, based on 1D thermal modeling.

- Quantification of the same parameters and the erosion profiles on key portions of the transect, with the 2D Thrustpack-Foldis software. First, we have defined the initial architecture of sedimentary strata and thrust faults. We have used IFP's LOCACE software to restore the section in its pre-orogenic configuration (see fig.1: Restoration of the Algerian geologic cross section), starting from the present day architecture of the balanced cross-section. The majority of structural units has been restored by a flexural slip method with the LOCACE software. Then we had to specify the timing of each individual thrust fault motion in the 2D Thrustpack-Foldis software. The basic assumption made for managing thrust initiation during this study was a forward thrusting sequence that propagates from the hinterland toward the foreland. For each deformation stage (see fig.2: Structural scenariotested in THRUSTPACK - for the Canadian transect), the topography was reconstructed using the critical taper theory developed for inland and offshore accretionary wedges (cohesive Coulomb theory; Davis and al., 1983; Dahlen and Suppe, 1984). In this theory the mean topography or overall geometry of a tectonic wedge results from a constant balance between the amount of shortening, pore fluid pressure, mean dip of the basal decollement level and amount of erosion.

- Reconstruction of the petroleum systems history, by using the thermal and kinetic modules of the same THRUSTPACK software of basin modeling.

- These steps will be followed by the calibration of a thermo-mechanical model of flexure at the lithosphere scale, using topographic and gravimetric data, to taking also into account the vertical movements previously calibrated on available geological data.

The final objective of this study is to establish a representative deformation scenario at a regional scale for both regions, in order to constrain in-depth the basement geometry, the Moho depth, as well as the attitude of the lithospheric flexure, and the controls applied by the deep lithosphere on surface processes such as deformation, erosion and thermicity.

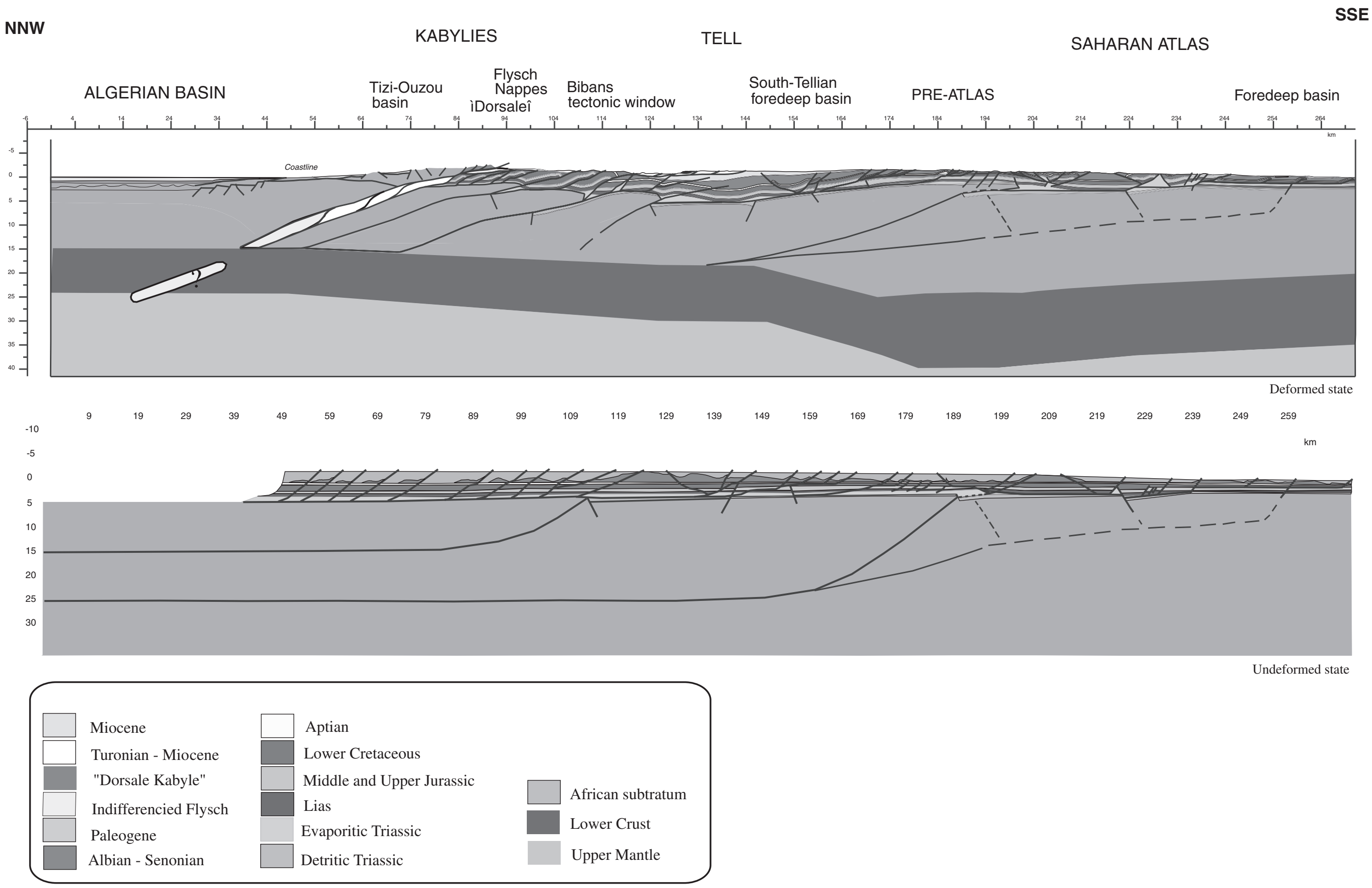

Fig. 1: Restoration of the Algerian Geologic Cross Section

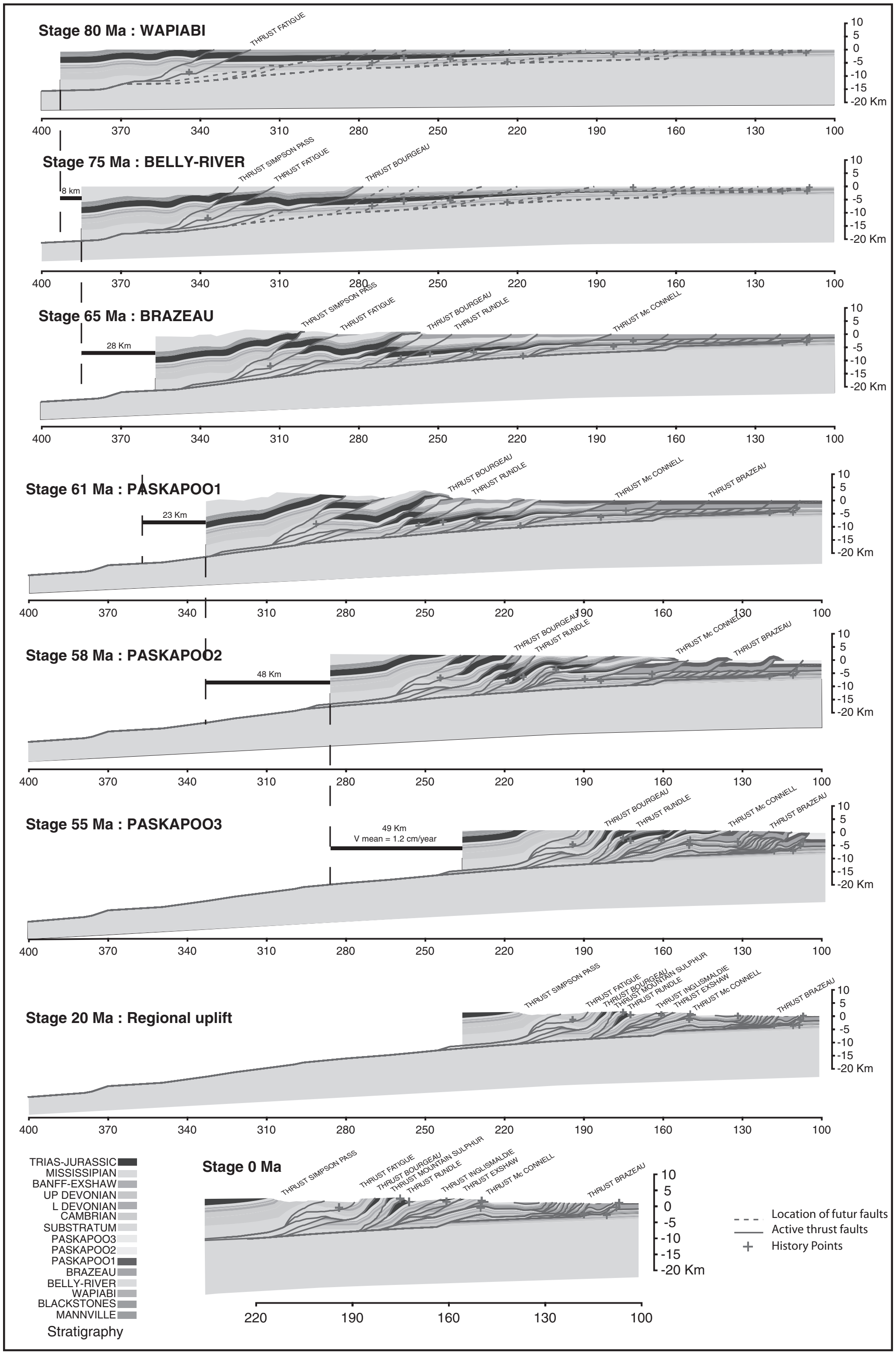

Fig. 2: Canadian structural scenario tested in THRUSTPACK