REVISED GEOLOGICAL MAP OF THE NELSON-RICMOND URBAN AREA

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Structural model of the evolution of the Waimea-Flaxmore Fault System in the Nelson area

Progressive deformation history of the Waimea-Flaxmore Fault System (W-FFS) has been tested through forward structural models (Ghisetti et al. 2020). Figure 1 shows snapshots of significant deformation stages of the model and the full animated reconstruction with details on the model construction is provided in the downloadable video. The model reconstructs accumulation of reverse slip on the Waimea and West Flaxmore faults, considered to be active with different slip rates since the mid Miocene and during sedimentation of the Tadmor Group. The Tahunanui Fault is depicted as a high-angle basement fault (sub-parallel to the major NE-SW faults of the W-FFS) that propagated upwards across the cover sequence post 10 Ma. Age of deposition, relative vertical thickness of the sedimentary succession and chronology of the unconformities are calibrated from surface geology. However, for a clearer depiction of the deformation induced by each fault, the horizontal distance between faults has been exaggerated (see approximate scale in Figure 1H).

The principal stages of the model are: (1) Initial configuration with an inherited set of late Early Cretaceous normal faults (proto Waimea and West Flaxmore faults) hosting the Bishopdale Conglomerate in their hanging wall, with waning of extensional activity after deposition of the Marsden Coal Measures at c. 35 Ma (Figure 1A). (2) Sedimentation of the marine units of the Jenkins Group from c. 34 to 20 Ma. The units are simply depicted with layer-cake configuration, with no deformation (Figure 1B). (3) Contractional inversion with accumulation of reverse slip on the Waimea and West Flaxmore faults in the time interval c. 19-10 Ma (Figures 1C-E), associated with uplift and development of an unconformity (mid Miocene hiatus). Fault propagation is modelled using trishear (Allmendinger 1998), with high progation to slip ratios (P/S) for the Waimea Fault (resulting in no significant folding in the footwall) and low P/S for the West Flaxmore Fault (with the development of the asymmetrical syncline in its footwall). (4) Upward propagation of the Tahunanui Fault during deposition of the Port Hills Gravel coeval with reactivation of the West Flaxmore and Waimea faults in the interval 10-3 Ma (Figure 1F-G), associated with uplift and truncation of the top of the gravels by an erosional unconformity. The resulting geometry (Figure 1G) is the gravel depocentre within the Port Hills Syncline and the tilted back-limb of gravels above the anticlinal hinge that exposes the Bishopdale Conglomerate in the hanging wall of the West Flaxmore Fault. (6) Late stage configuration at 1 Ma (Figure 1H), with all faults modelled as having accrued displacement after deposition of the Moutere Gravel.

Although the model is simplified, it reproduces many features of the cross sections, with, in particular, the decreasing structural elevation of the hanging wall panels of the Waimea, West Flaxmore and Tahunanui faults, the preserved wedge of Bishopdale Conglomerate in the hanging wall of the West Flaxmore Fault, the vertical to overturned SE limb of the Port Hills Syncline, and the growth accumulation of Port Hills Gravel in its core relative to the uplifted limb of Port Hills Gravel on the western flank of the Marsden Syncline.

The present-day structural setting can be replicated with a good fit by the forward structural model.

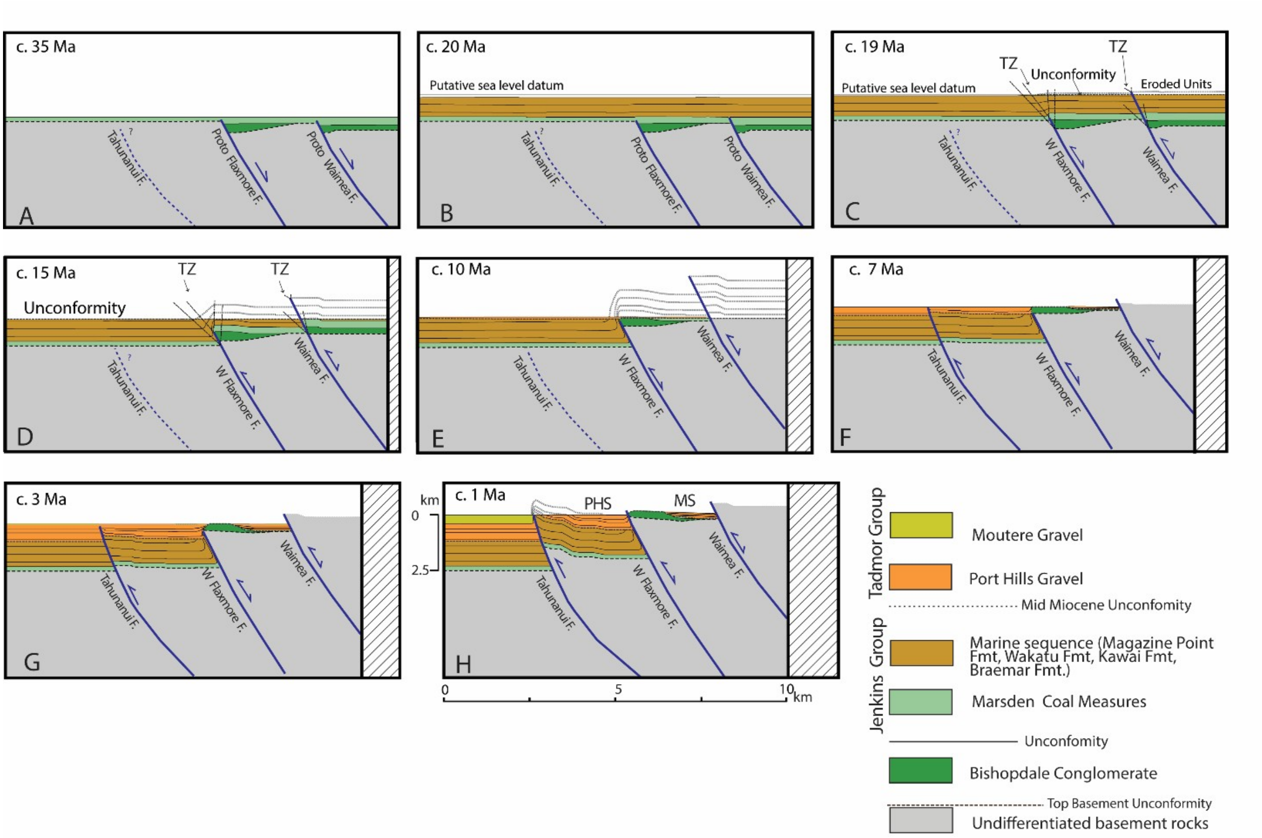

Figure 1 Significant stages of progressive deformation extracted from the forward model (see video ofthe animated forward model and its description).

Video of the structural evolution of the Waimea-Flaxmore Fault System in the Nelson area

The video shows the animated forward model that reconstructs the evolution of the Waimea, West Flaxmore and Tahunanui faults in the Nelson-Richmond urban area. The animation is redrawn from the model prepared using StructureSolver 3.2. The software allows for interactive adjustment of geometric model parameters (fault shape and dip, amount of slip, shear angle at fault bend). Models incorporate syn-tectonic erosional unconformities and folding of growth sequences during trishear fault-propagation folding, with control over trishear angle, position of the initial and final fault tip, propagation-to-slip ratio (P/S). The kinematic evolution can be modified during the model run in to define the combination of structural parameters that produce the best fit to the present-day configuration (cf. Eichelberger et al. 2015; 2018).

The reconstruction has been elaborated by F. Ghisetti and is included as a Supplemental File for the paper published by Ghisetti et al. (2020).

References

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