Revisiting Mountain Building in Taiwan

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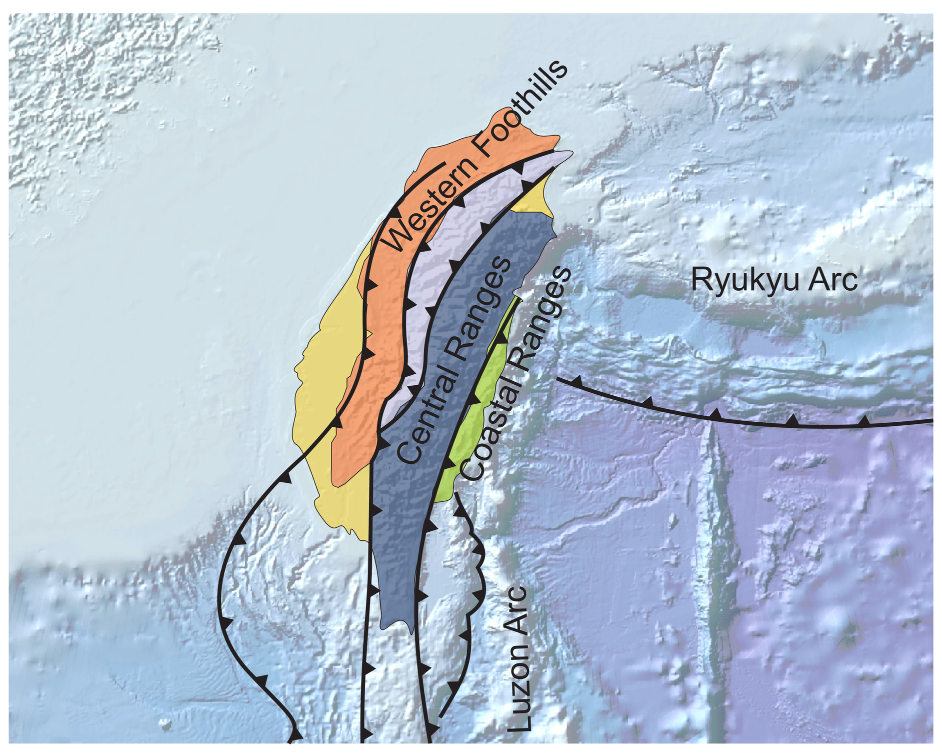
Why revisiting Taiwan?

The kinematics of an orogen, either due to collision of two continents or of a continent with an island arc, depends on various factors, including convergence rate, passive margin geometry, stratigraphy of incorporated sediments, and surface processes. Using multiple techniques, parts of these preconditions and history of deformation, exhumation, and foreland sedimentation may be recovered. However, in most cases the early orogenic stage is lost, limiting the possibility to investigate how kinematics and thermal structure evolved in the early collisional stage. In that regard, the Taiwan orogen clearly stands out, as, due to obliquity of the continental margin of China relative to the Manila subduction zone, its collision with the Luzon Arc is propagating southward.

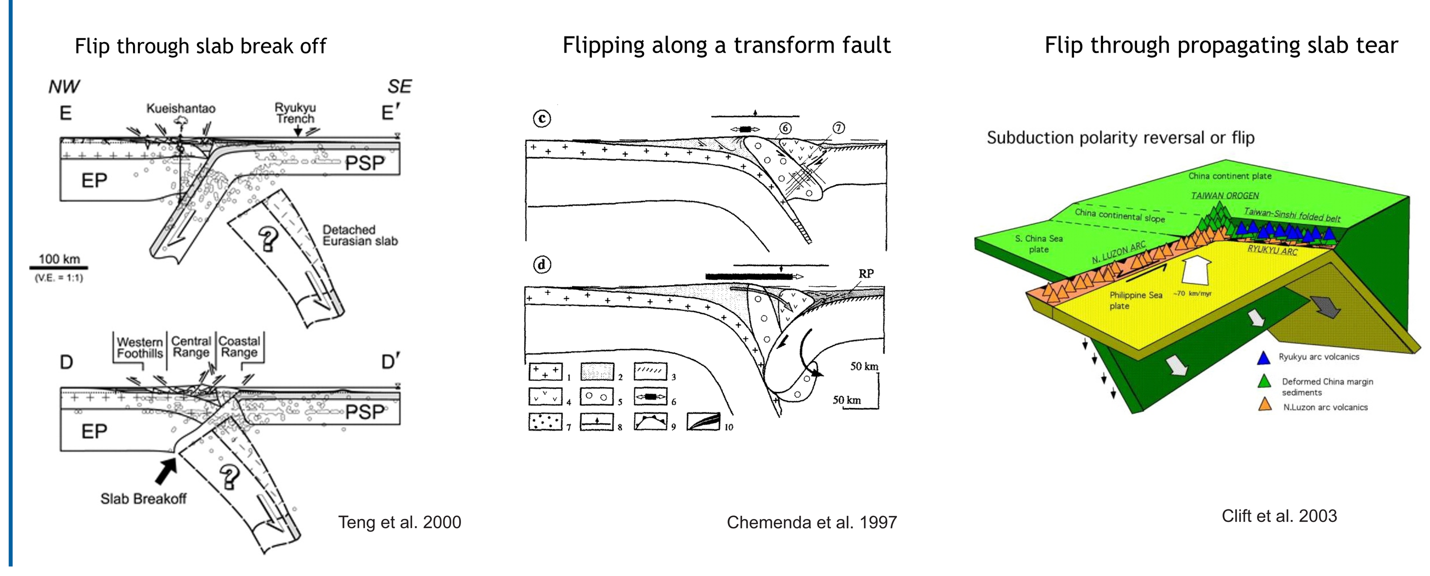
However, despite the vast amount of geological and geophysical data, different models of mountain building in Taiwan exist, which we will address in the following. Resolving these issues is of major importance, as Taiwan is often used as case example for other mountain belts.

Tectonic setting of Taiwan, and major units discussed. A key area are the southern Central Ranges, as they show the transition from subduction to collision



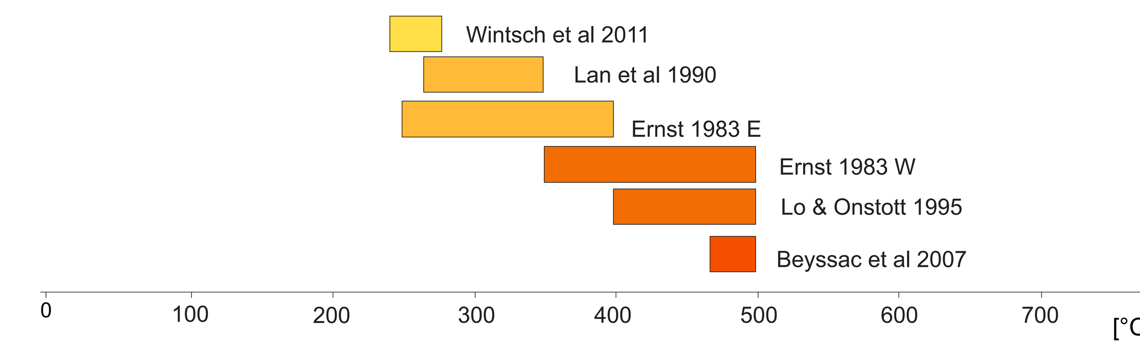
Issue 1: Does subduction polarity currently flip?

Taiwan is THE example for a progressively flipping subduction zone and is used for many other orogens as case study. Several different models have been proposed. However, maybe this progressive flip does not occur.



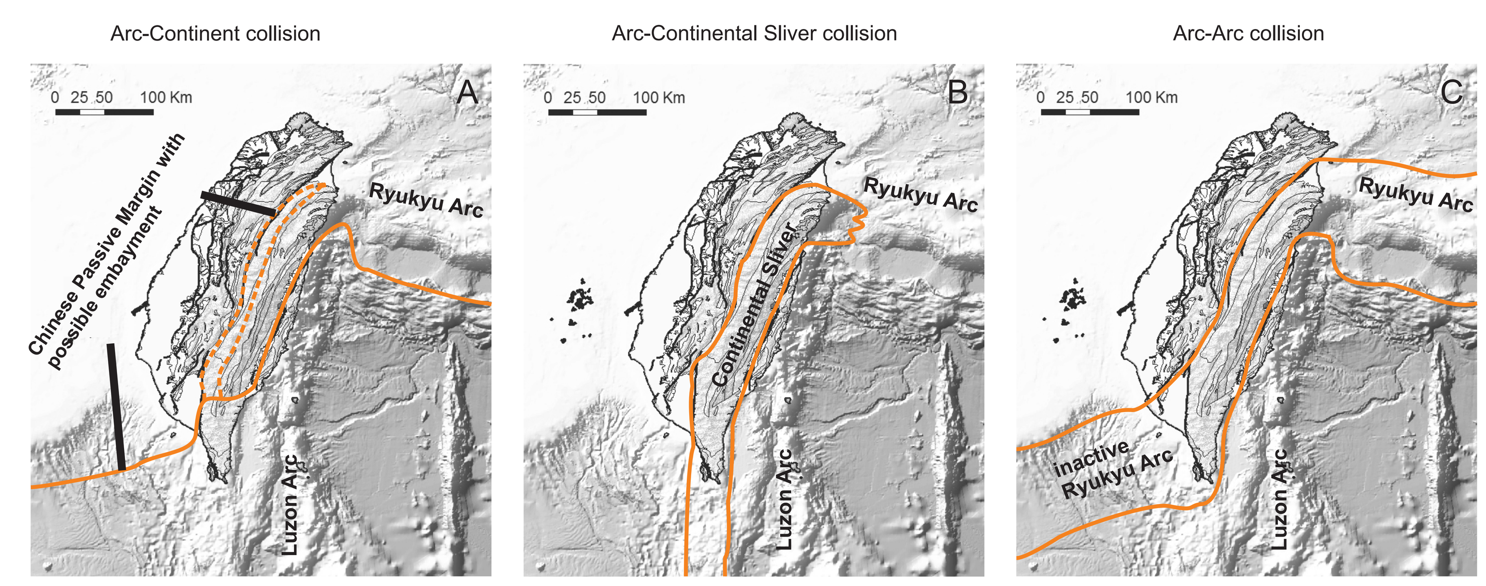
Issue 2: When did Taiwan reach peak metamorphic conditions, and how high is this peak?

Compilation of temperature estimates for the Cenozoic orogeny in Taiwan, showing the wide range of proposed conditions. Likewise, the timing and magnitude of peak-pressure conditions is not well known. P-T paths have been established, which favor **either peak pressure** conditions related to **mid-Jurassic** subduction and **peak temperatures** related to intrusion of granitic bodies during the **Late Cretaceous**, **OR Late Cenozoic maximum P-T conditions**.

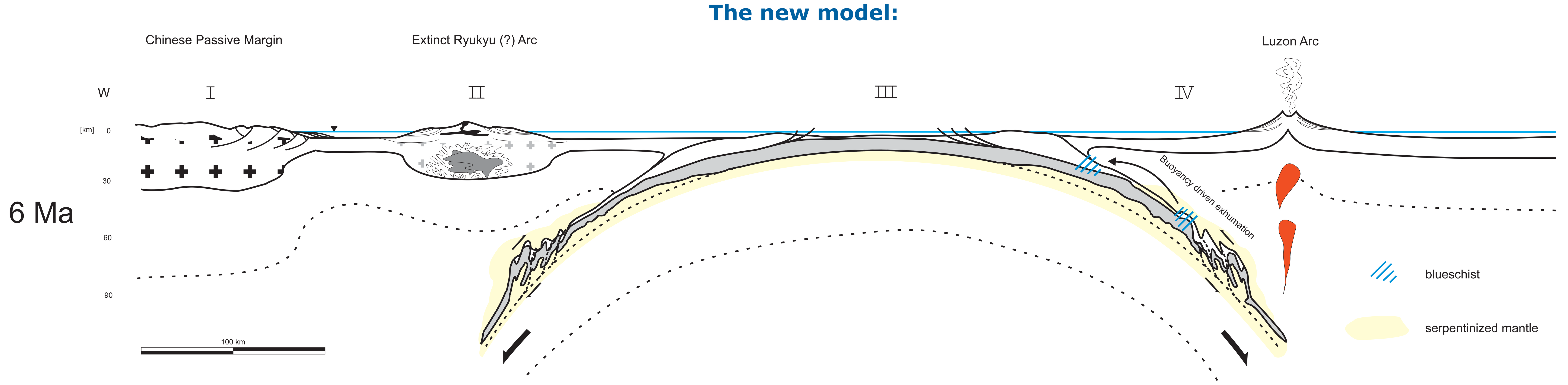


Issue 3: What is actually colliding in Taiwan?

Contrasting models of the pre-collisional architecture of Taiwan. A: **Arc-Continent collision**. The Luzon Arc collides with the Chinese passive margin. B: **Arc-Continental Sliver- Continent collision**. A sliver of continental crust, which forms the modern Central Ranges, existed between the Luzon Arc and the Chinese continental margin. C: **Arc-Arc collision**. The Luzon Arc collided with the prolongation of the Ryukyu Arc. Key area to distinguish between these models is the Hengchun Peninsula and SE Taiwan. An alternative model explaining the thick crust beneath the Hengchun Peninsula is southward extrusion of the Central Ranges.



The new model:



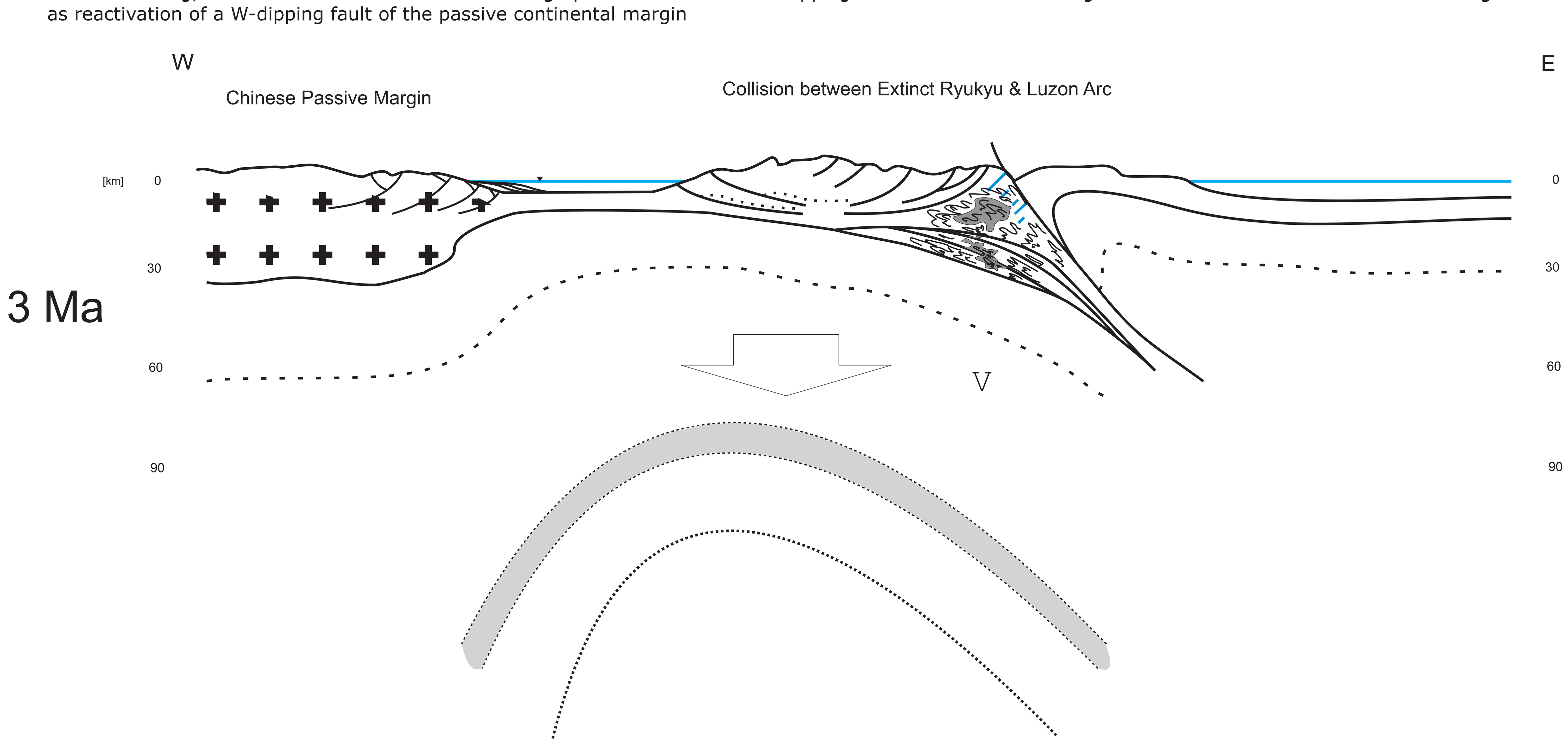
I: The Chinese passive margin is separated from the extinct Ryukyu Arc by **oceanic (or highly stretched continental) crust**. Note the landward dipping normal faults, as observed in seismic sections

II: The extinct Ryukyu Arc. Gray patches are **granitic intrusions** c. 90 Ma. They contact-metamorphose carbonates & clastic sediments, which later form the **marbles & meta-sediments of the Taroko Gorge**. It is unclear whether there are also fragments of continental crust at the base of the arc.

III: The South China Sea, or remnants of old Pacific crust. The s**ubduction zone is dipping westward** underneath the extinct Ryukyu Arc. In the East, the Luzon Arc developed at c. 15 Ma.

IV: The Luzon Arc. During subduction of the oceanic fragment, **sediments & oceanic crust are reaching blueschist metamorphic conditions** (we depict the conditions determined by Beyssac et al. 2008). The blueschists rise rapidly (buoyancy driven) to the base of the accretionary wedge, where they come to rest. Pathways are created due to fluid migration, c.f. Angiboust et al. 2012

V: Initial collision. The Luzon Arc collides with the extinct Ryukyu Arc, forming a backstop. The light **material of the Ryukyu Arc is underplated**. This leads to over-steepening of the wedge, and consequent **extension** in the upper part (c.f. Platt 1986). The blueschists are thrust to higher parts within the wedge. This wedge forms the Proto-Central Ranges. The remnants of the closed ocean **break off** & sink into the mantle. Eastward subduction continues thereafter. Using present day convergence rates c. 90 mm/yr, the present day slab would be 270 km long, which is consistent with recent tomographic results. The west-dipping normal faults in the wedge will be reactivated as thrust faults during final collision. We interpret the Lishan Fault as such a **reactivated normal fault**. Alternatively, it may be interpreted as reactivation of a W-dipping fault of the passive continental margin



Consequences and implications

- Subduction polarity does not flip progressively from N to S
- Oceanic crust may exist between the Extinct Ryukyu Arc and the passive Chinese Margin
- Exhumation of blueschist in the Luzon forearc relates to underplating of the Extinct Ryukyu Arc and extension of the over-steepened wedge
- The Central Ranges are the deformed prolongation of the Ryukyu Arc (or an even older arc)