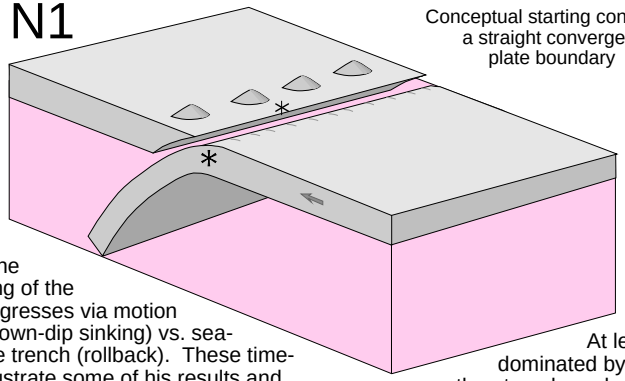
Slab width and styles of descent of lithospheric slabs

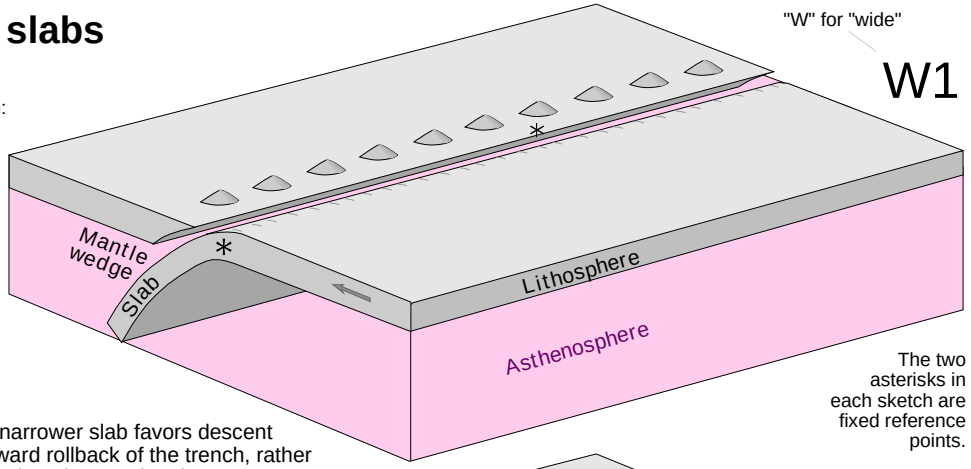
"N" for "narrow"

"W" for "wide"

Research by Prof. Wouter Schellart of Monash University in Australia has shown that width of a subducting slab of oceanic lithosphere has considerable influence on both the convexity of the resulting volcanic arc and on the extent to which sinking of the slab (subduction) progresses via motion parallel to the slab (down-dip sinking) vs. seaward migration of the trench (rollback). These time-series of sketches illustrate some of his results and suggest a causal explanation in terms of toroidal flow of asthenosphere around the edges of the slab, which is likewise a subject of Schellart's research. The principal concept presented here is that flow of asthenosphere around the edges of the slab is required for rollback, and that such flow can evacuate a large proportion of the asthenosphere behind a narrow slab but only a lesser proportion of the asthenosphere behind a wide slab.

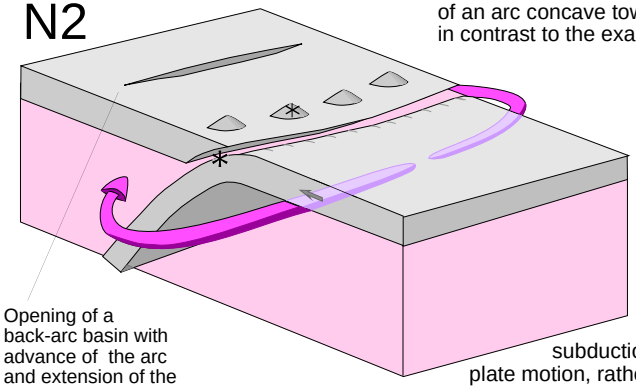


Conceptual starting condition: a straight convergent plate boundary

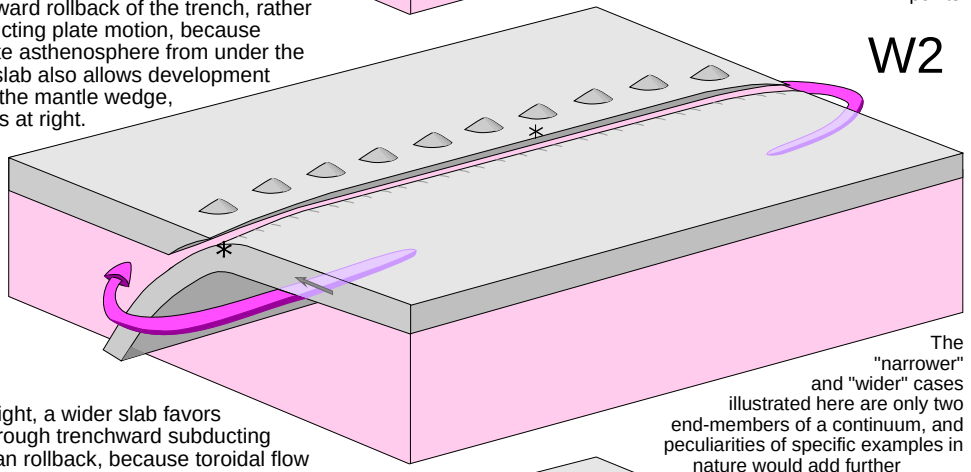


The two asterisks in each sketch are fixed reference points.

At left, a narrower slab favors descent dominated by seaward rollback of the trench, rather than trenchward subducting plate motion, because toroidal flow can evacuate asthenosphere from under the narrow slab. A narrower slab also allows development of an arc concave toward the mantle wedge, in contrast to the examples at right.

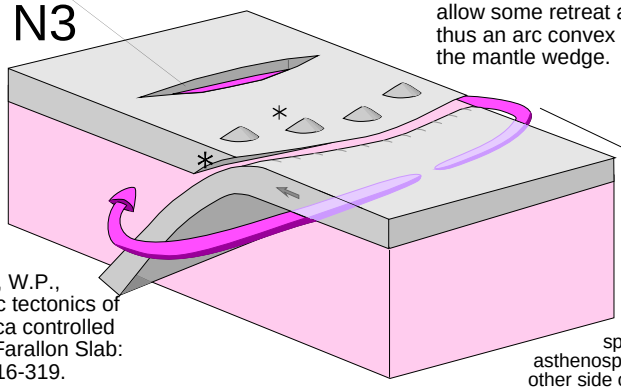


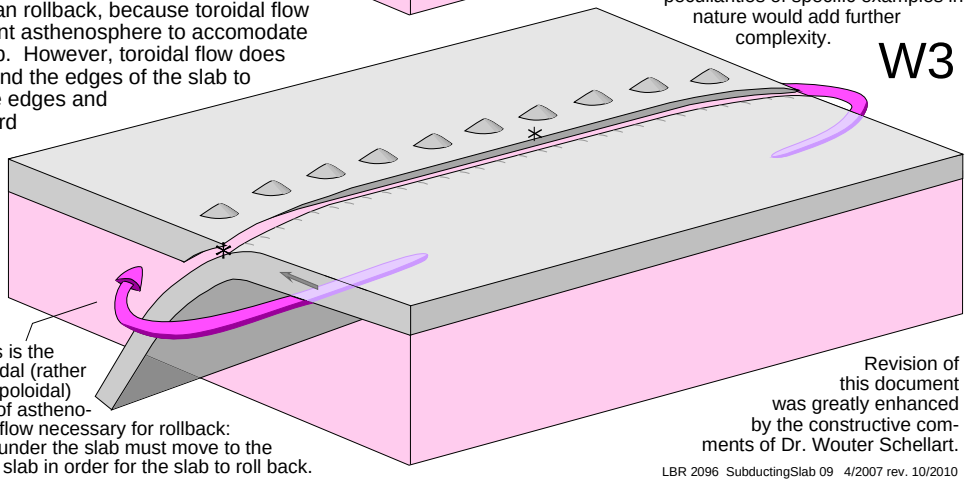
Opening of a back-arc basin with advance of the arc and extension of the back-arc region



The "narrower" and "wider" cases illustrated here are only two end-members of a continuum, and peculiarities of specific examples in nature would add further complexity.

At right, a wider slab favors subduction through trenchward subducting plate motion, rather than rollback, because toroidal flow cannot evacuate sufficient asthenosphere to accomodate rollback of the entire slab. However, toroidal flow does allow sufficient flow around the edges of the slab to allow some retreat at the edges and thus an arc convex toward the mantle wedge.





This is the toroidal (rather than poloidal) flow of asthenosphere flow necessary for rollback: asthenosphere under the slab must move to the other side of the slab in order for the slab to roll back.

Sources include Schellart, W.P., et al., 2007, Evolution and diversity of subduction zones controlled by slab width: *Nature,* v. 446, p. 308-311; Schellart, W.P., et al., 2010, Cenozoic tectonics of western North America controlled by evolving width of Farallon Slab: *Science,* v. 329, p. 316-319.

Revision of this document was greatly enhanced by the constructive comments of Dr. Wouter Schellart.