The formation of slab tears and the evolution of arcs

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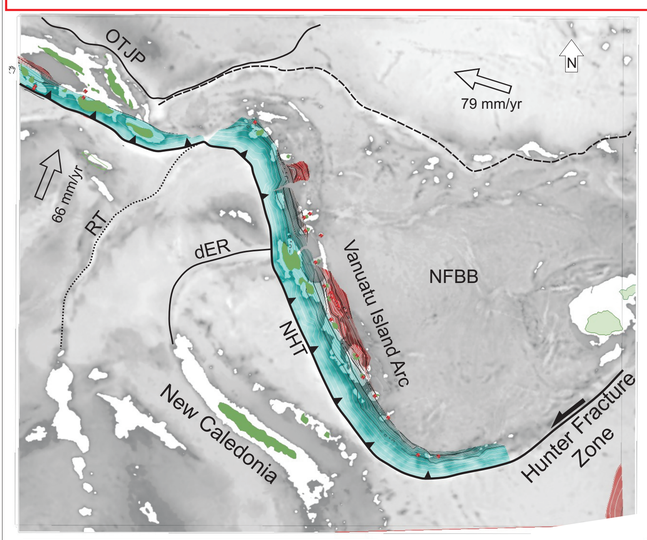
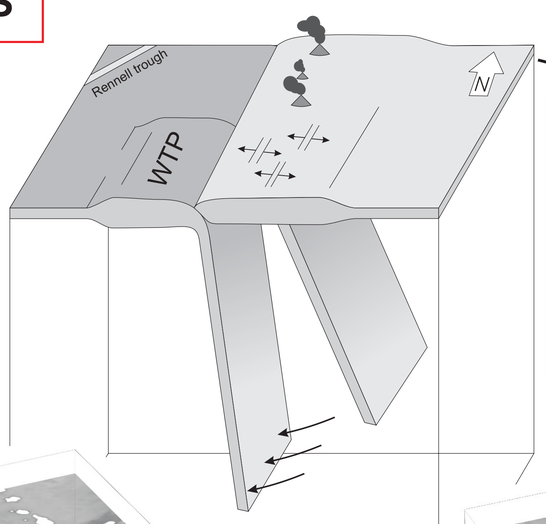
Tearing of subducting slabs occurs in response to variations in the geometry of the subduction trench combined with the affects of structures inherited by the oceanic crust. Such structures include bathymetric highs and oceanic fracture systems that start their life as transform faults at oceanic spreading centers. The south-west Pacific preserves several unique cases where slab tears have developed. The Australian plate subducts to the northeast beneath the overriding North Fiji Basin. As it subducted, the slab tore horizontally which in turn completely changed the dynamics of extension (rate and direction of opening) within the overriding plate (Richards et al., 2011). The rate of backarc basin opening slowed and the rate of arc volcanism and arc construction apparently increased. Accordingly, slab detachment significantly influenced the magmatic evolution of the arc. At the northern end of the New Hebrides arc, indentation of the subduction trench by the Rennell trough has resulted in the formation of a vertical tear. Another example of slab tearing is provided for the Marianas arc where indentation or pinning of the trench by the Caroline plate in the south and the Ogasawara Plateau in the north has resulted in differential retreat rates and the formation of two vertical growth tears in the subducted slab. The location of the tears are linked to variation in the geochemistry of the arc magmas. The influence of slab tearing on subduction volcanism may be overlooked if inaccurate slab models are used or slab geometries are overlooked.

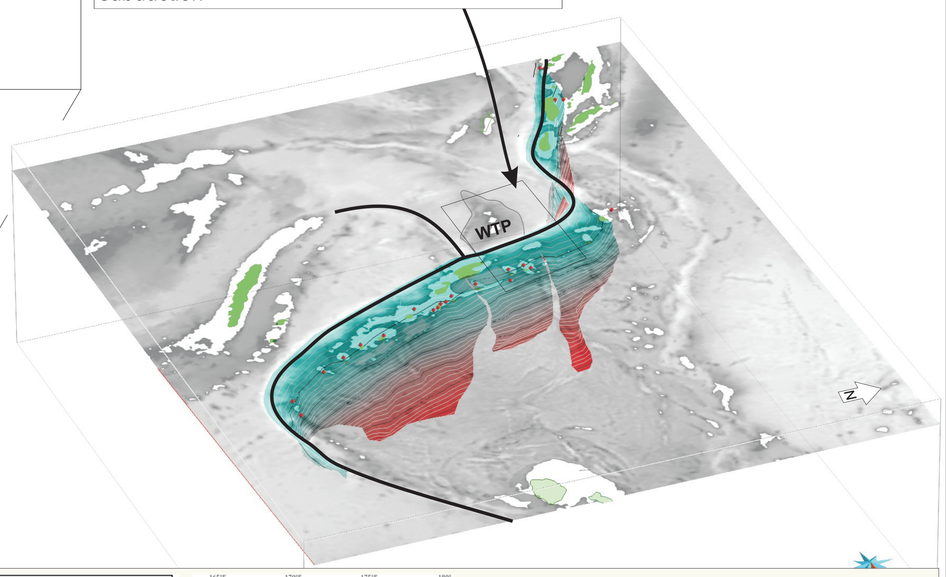
NEW HEBRIDES / VANUATU AND THE EASTERN SOLOMONS

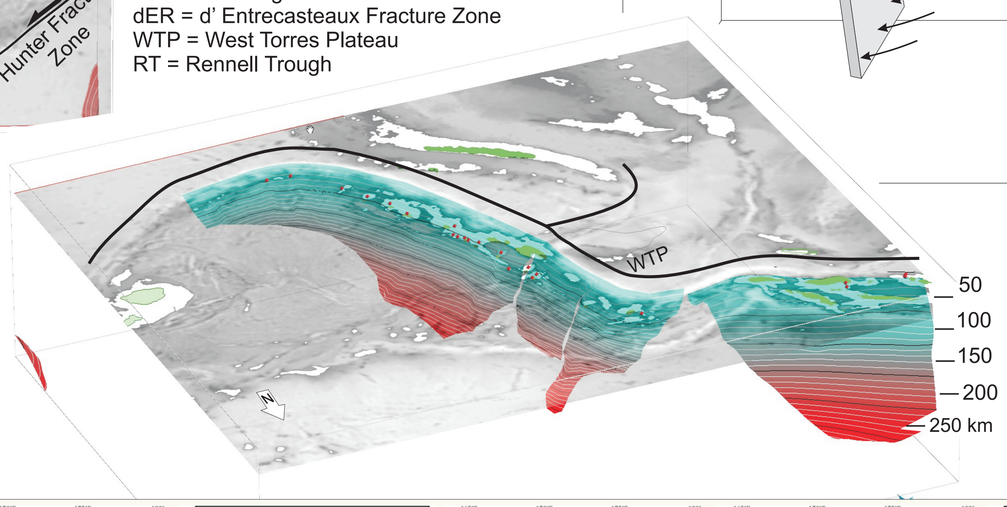


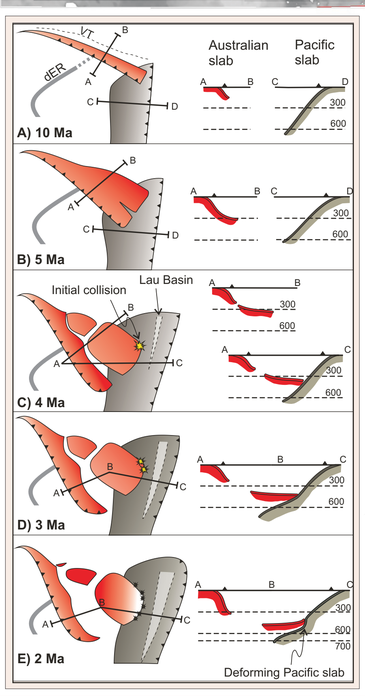
NHT = New Hebrides Trench
NFBB = North Fiji Backarc Basin
OTJP = Ontong Java Plateau
dER = d' Entrecasteaux Fracture Zone
WTP = West Torres Plateau
RT = Rennell Trough



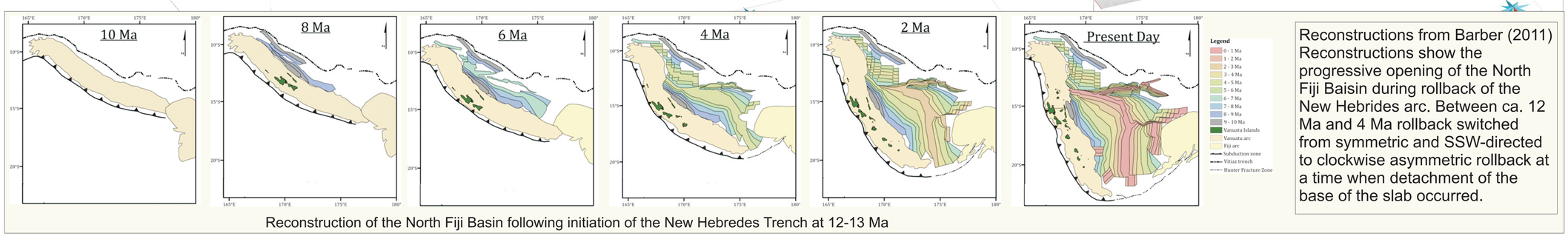
Arrival of the West Torres Plateau resulting in termination of plate subduction. A consequence of plateau arrival is the progressive steepening of the already subducted Australian slab. This progressive steepening of slab angle is coincident with extension in the upper plate. Both of these observations are counter intuitive to observations in other subduction systems (e.g. Chile, South America) where the arrival of bathymeytric highs has resulted in flat slab subduction







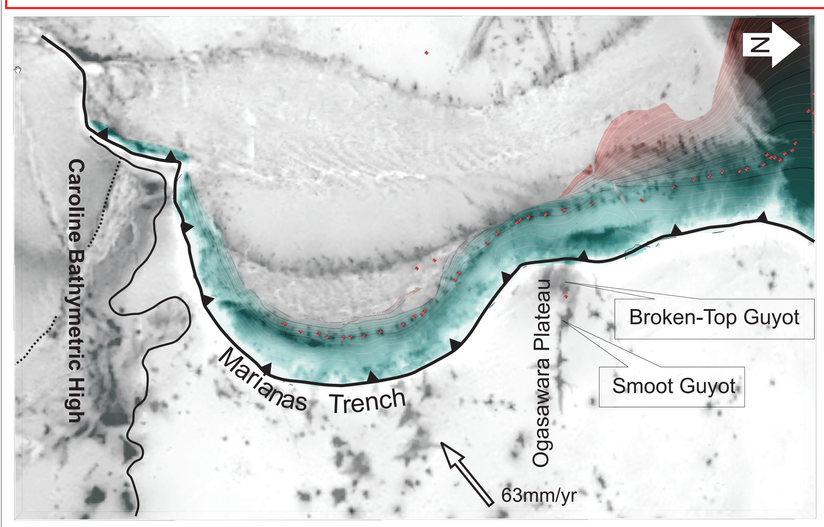
Cross section reconstructions from Richards et al., 2011



Reconstruction of the North Fiji Basin following initiation of the New Hebredes Trench at 12-13 Ma

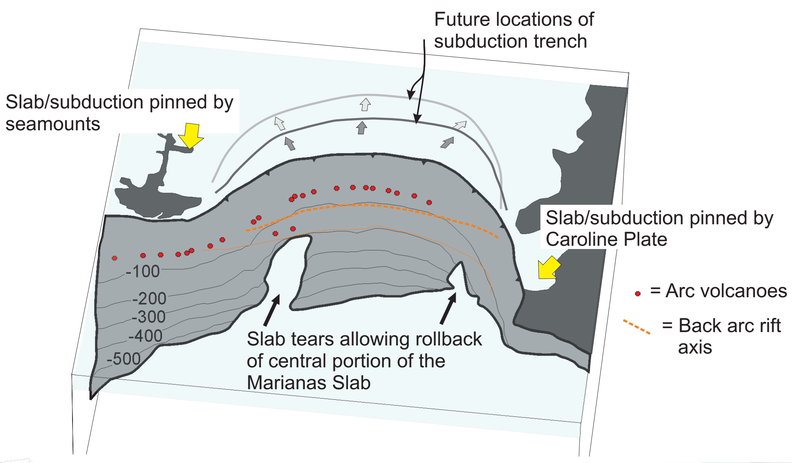
Reconstructions from Barber (2011) Reconstructions show the progressive opening of the North Fiji Baisin during rollback of the New Hebrides arc. Between ca. 12 Ma and 4 Ma rollback switched from symmetric and SSW-directed to clockwise asymmetric rollback at a time when detachment of the base of the slab occurred.

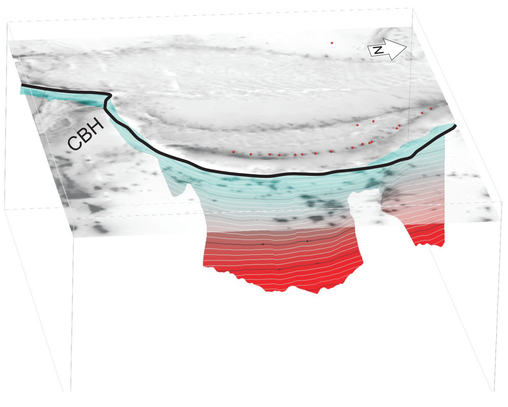
SLAB TEARING AND ROLLBACK OF THE MARIANAS SLAB

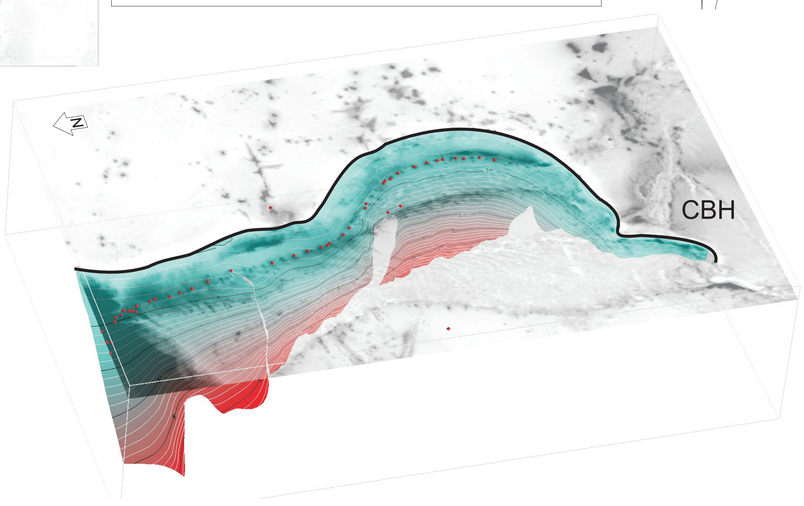


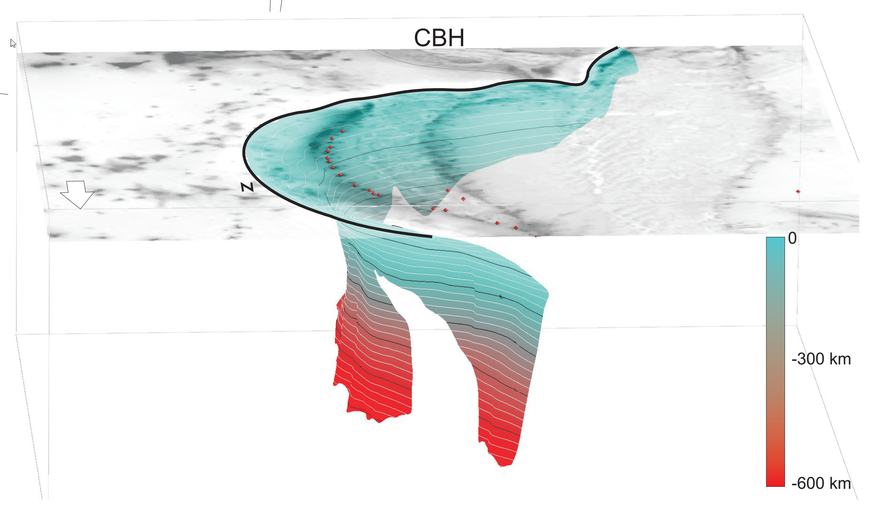
- Marianas arc volcanoes

Two vertical tears are forming in the subducting Pacific plate beneath the Marianas. The two tears are interpreted here as forming in response to pinning of the subduction zone at the Caroline plate in the south and the Ogasawara Palteau in the north. The steep dip of the subducting slab is, in effect, pulling the central part of the Marianas trench and underlying slab eastwards toward the Pacific ocean. The resulting geometry of the slab is influencing both the rate of backarc opening but also the geochemistry and location of arc volcanics. 3D models of the slab hav enabled a better understanding of the link between slab structure and tectonomagmatic evolution of the overriding plate.

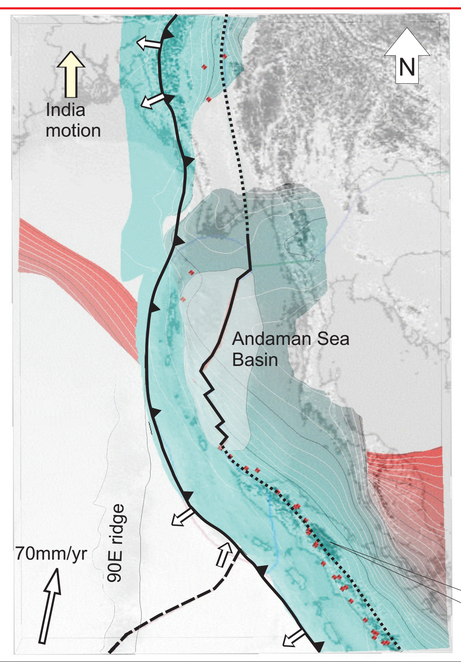


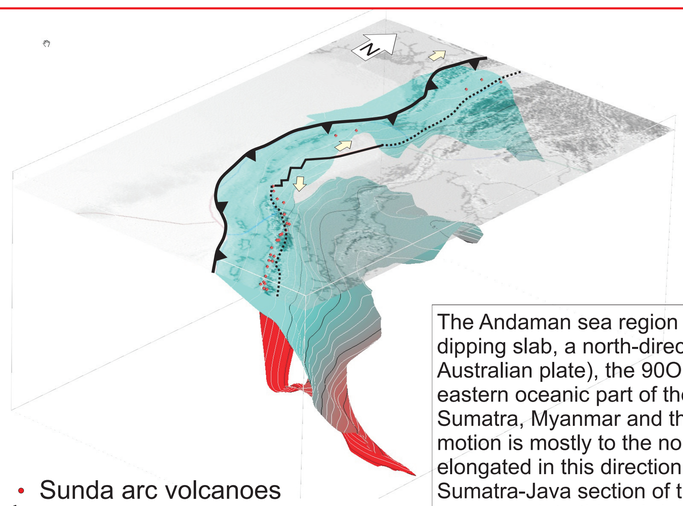






SUBDUCTION SEGMENTATION, SLAB TEARING IN THE ANDAM SEA REGION

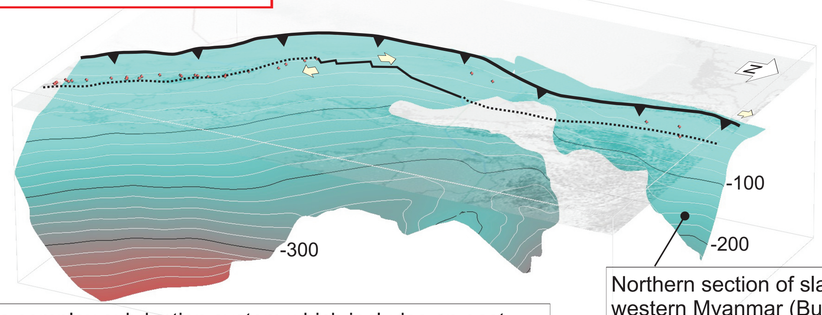




- Sunda arc volcanoes

Paleo Indo-Australian plate boundary

Sumatra



The Andaman sea region is a complex subduction system which includes an east-dipping slab, a north-directed continental and oceanic late system (the Indo-Australian plate), the 90OE volcanic ridge and the Andaman extension basin. The eastern oceanic part of the Indo-Australian plate is subducting to the east beneath Sumatra, Myanmar and the Andaman Islands (see figs above), however, the plate motion is mostly to the north. Accordingly, the subduction zone is being stretched and elongated in this direction but also to the south as SE-directed rollback of the Sumatra-Java section of the slab retreats toward the Indian Ocean. In order to accommodate this subduction zone elongation and the change in trench geometry, the subducted portion of the slab is tearing both vertically and horizontally beneath the Andaman Islands and the Andaman Sea. The Andaman Sea rift is forming in response to the variation in plate motion between the southern and northern parts of the Sumatra-Myanmar trench. The development of the slab teaaccomodates this variation in motion.

Northern section of slab beneath western Myanmar (Burma) is retreading to the west as the slab continues to subduct beneath the overriding plate. The slab is coupled to the Indian plate and is also moving northwards thereby contributing to the progresive opening of the Andaman Sea and accentuation of the sub-horizontal slab tear in the Indo-Australian-Andaman slab.