Interaction of forearc basin stratigraphy with growth of accretionary wedge: Insights from numerical simulations

*Atsushi Noda[1]

1. National Institute of Advanced Industrial Science and Technology

Forearc basins are important elements along subduction zones; their deposits and structures recorded various events in history at a high resolution. However, forearc basins have received relatively less attention than the deformation front, because their formations depend on complex interactions among uplift/subsidence of backstop, growth/shrink of accretionary wedge, subducting oceanic slab, and covering sediments. It is often difficult to evaluate influence of each factor. In accretion-dominated margins, forearc basins commonly develop on or beside accretionary wedges, indicating growth patterns of the wedge may be primary controllers of the basin formations. Because material fluxes between the boundary of overriding and subducting plates highly influence the wedge growth patterns, They must be also important for development of forearc basins. The aim of this study is to understand formation of forearc basin stratigraphy in terms of sediment fluxes in subduction zones. I performed numerical simulations to reproduce forearc basins formed between growing accretionary wedges and continental backstops. The simulations assumed that sediments filling forearc basin (Q_{inFAB}) were determined by balance among sediment supply to the basin (Q_{s}), trench fill sediments (Q_{inT}), and subducting sediments from the trench into subduction channel (Q_{outT}). The sediment fluxes of Q_{s}, Q_{inT}, and Q_{outT} were independently fluctuated, and sediments accreted to the wedge (Q_{inAC}) was Q_{s} - Q_{inFAB} + Q_{inT} - Q_{outT}. Two models of constant and dynamic taper angles of the wedges were tested. In the dynamic taper model, the taper angle (θ) relied on pore pressure ratios of the wedge interior and the basal detachment, which were functions of Q_{inAC} and Q_{outT}, respectively.

The constant taper models showed positive relationships between Q_{inFAB} with Q_{total} (= Q_{s} + Q_{inT} $-Q_{\mathrm{outT}}$) or Q_{inAC}. Underfilled basin could exist only when Q_{s} was smaller than depositional area produced by the wedge growth. At a time of transition from underfill to overfill, trajectories of Q_{inFAB} and Q_{inAC} broke and then returned to the equilibriums with some fluctuations. The dynamic taper models also showed linear relationships between Q_{inFAB} and Q_{total}, although Q_{inAC} and Q_{inFAB} relationships were much more scattered than the constant taper models. A prominent feature of the dynamic taper model was a negative relationship between time-averaged differences of Q_{inAC} and Q_{inFAB}, when θ was increasing or decreasing. The sediment input rates to the basins (Q_{inFAB}) decreased, even though those to the wedge (Q_{inAC}) increased with reducing θ. Similar negative relationships could be observed during increase of θ. These results suggest that growing wedge with changing the taper angle significantly affects the basin stratigraphy. Two end members of the wedge-growth patterns can be considered; (1) progradation by frontal accretion with decreasing θ and (2) vertical growth by basal accretion or thickening by splay faults with increasing θ. For the former type (1), most of Q_{inT} are consumed for progradation of the wedge to approach the reduced θ, resulting in slower sedimentation rate and then occurrence of a condensed section or an unconformity, even though sufficient Q_{s} is supplied to the basin. The latter type (2) yields more space for sedimentation landward side of the wedge due to uplift of the outer arc high, which leads to faster sedimentation rate or occurrence of an underfilled basin, depending on Q_{s}.

Keywords: forearc basin, accretionary wedge, sediment flux, subduction zone

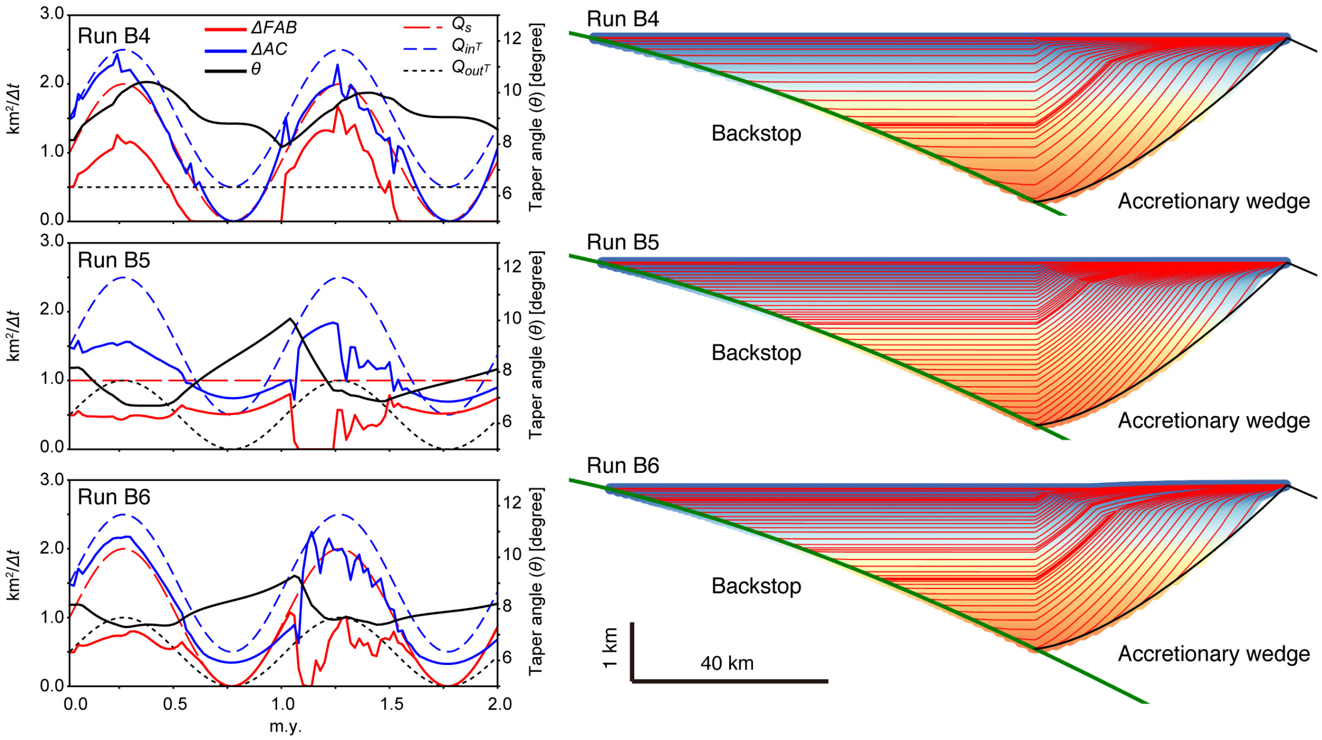

Fig. 1: Selective examples from the dynamic taper models. (Left) Diagrams for initial parameters of Q_s, $Q_{in\mathrm{T}}$, and $Q_{out\mathrm{T}}$ (see the text for notations), taper angles (θ), and increased areas of forearc basin (ΔFAB) and accretionary wedge (ΔAC) at each time step. (Right) Resultant stratigraphy of forearc basins.