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Along strike variations in the width of the seismogenic zone of the Lesser Antilles subduction predicted by thermal modeling

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The Lesser Antilles subduction zone has produced no recent strong thrust earthquakes, making it difficult to quantify the seismic hazard from such events. The Lesser Antilles arc has a slow convergence rate (2cm/yr) overall and a very wide accretionary wedge (200-300 km) at its southern end. To investigate the effect of the accretionary wedge on seismogenesis, numerical models of forearc thermal structure were constructed along six transects perpendicular to the arc in order to determine the thermally predicted width of the seismogenic zone. The geometry of each section is constrained by published seismic profiles and crustal models derived from gravity and seismic data and by earthquake hypocenters at depth. A major constraint on the deep part of the model is that mantle temperature beneath the volcanic arc should achieve a temperature of 1100°C to generate partial melt. Predicted surface heat flow is compared to the available heat flow observations. Thermal modeling results indicate a systematic southward increase in the width of the seismogenic zone, more than doubling in width from north to south and corresponding to a dramatic southward increase in forearc width (trench - arc distance). The minimum width of the seismogenic zone (distance between the intersections of the subduction interface with the 150°C and 350°C isotherms) increases from about 80 km, north of 16°N, to 230 km, at 13°N. The maximum width (between the 100°C and 450°C isotherms) ranges from about 150 km in the north to up to 320 km in the south. This large variation in the width of the seismogenic zone is a consequence of the increasing width of the accretionary wedge to the south, caused by the increased thickness of sediment on the downgoing plate. In the northern portion of the arc, there is good agreement between the thermally predicted seismogenic limits and the distribution of recorded thrust earthquakes. To the south of Martinique (14.5°N) there is an absence of thrust earthquakes, making it difficult to test the predictions of the thermal model. Possible scenarios for earthquakes are discussed for different portions of the mega-thrust fault plane. Magnitude 8 events seem possible in the northern Lesser Antilles arc. If the southern portion of the mega-thrust fault plane is also locked and accumulating elastic strain, then for a longer segment length (500 km along-strike), a magnitude 8-9 event cannot be excluded.