ORAL PRESENTATION

Montane Pollen Indicates Character of Mid Cenozoic Uplands Across Sunda Shelf

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Many aspects of the Cenozoic palaeogeography of Sundaland remain poorly understood, especially with respect to the past distribution of uplands. Montane pollen is a common element of palynomorph assemblages across the region and provides an insight into the palaeoaltitude and palaeoclimate of lowlands and uplands from the Paleocene to the Pliocene.

Using a dataset derived from the palynological analysis of more than 250 petroleum exploration wells, maps have been constructed showing the occurrence through time of pollen of temperate or montane taxa across the region, including hickory (*Carya*), walnut (*Juglans*), alder (*Alnus*), wingnuts (*Pterocarya*), Pere David's pine (*Keteleeria*), hemlock (*Tsuga*) and spruce (*Picea*). These taxa are essentially restricted to temperate Asia today, although a few occur locally on mountains in northern Vietnam and Thailand, Myanmar and Laos.

Taking into account issues of pollen transportation and provenance, the former vegetation of uplands can be proposed in the areas of the submerged Sunda Shelf as well as for the Malay Peninsula, Indochina and Borneo, and from this, palaeoaltitudes over time can be suggested for each upland area based on the occurrence of pollen of temperate climate plants.

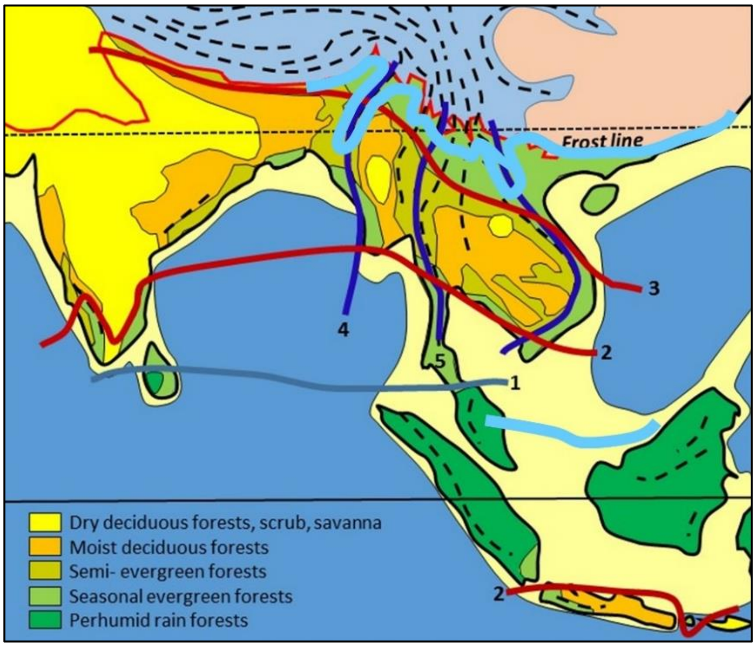

Figure 1. Present day vegetation belts in the South and Southeast Asian region (Ashton 2014, Morley in press), 1) Kangar-Pattani Line, marking the northern boundary of the perhumid tropics, 2) equatorward limit of seasonally dry climates, which control the distribution of semi-evergreen and deciduous forests and align with the Kra Isthmus; 3) northern limit of seasonally dry lowland climates. 4-6) N-S mountain ranges providing trackways for temperate plants to disperse equatorwards. Northern light blue line, southern limit of temperate deciduous trees, southern light blue line, southern limit of pollen of temperate trees in the Oligocene.

The distribution of Southeast Asian lowland vegetation is strongly controlled by latitude (Figure 1) with perhumid mixed Dipterocarp forests essentially occurring within 8° of the equator, and seasonally dry vegetation roughly from 12° to 20°N, then with seasonal evergreen forests occurring up to the frost line, which roughly coincides with the tropic of Cancer. The composition of montane vegetation on the other hand is controlled mainly by mean annual temperature, which changes with altitude, and seasonality (Fig 2). Pollen generated by lowland and montane vegetation is transported mostly by rivers and is widely preserved in marine sediments. A pollen assemblage from a marine deposit will probably contain pollen from lowland and montane vegetation occurring within an individual catchment, and once provenance is understood, the pollen record can be used to construct former lowland and montane vegetation on a regional scale. The former distribution of lowland vegetation based on fossil pollen will therefore provide an independent proxy for palaeolatitude, whereas pollen from montane plants provides a proxy for palaeoaltitude.

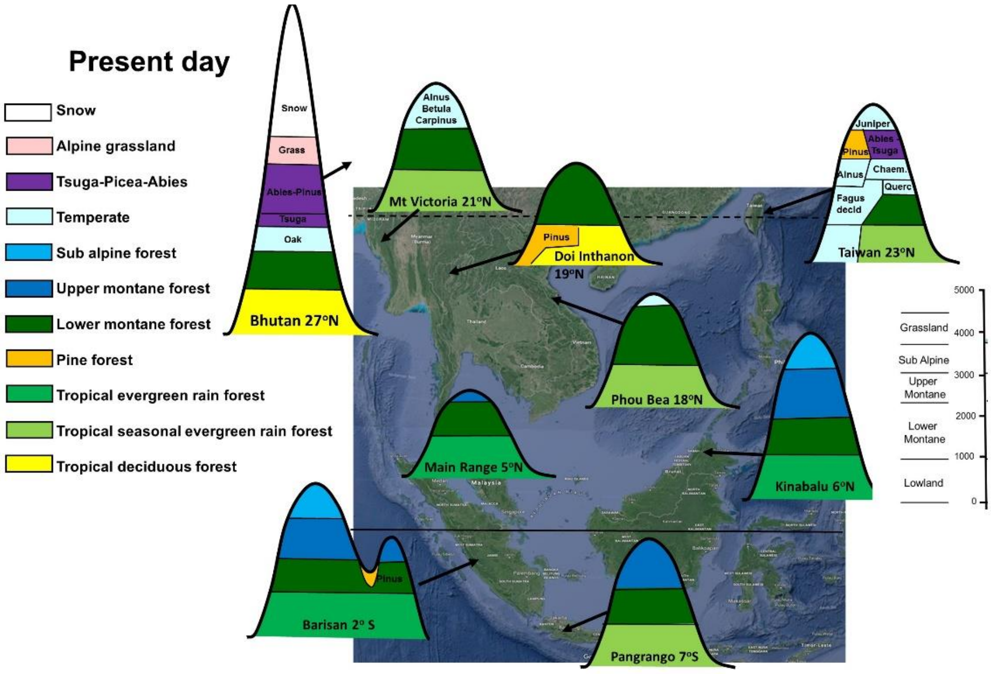

Figure 2. Present day mountain vegetation. In the perhumid tropics, montane vegetation consists of Lower Montane, Upper Montane and Sub-alpine formations. In the seasonal tropics, Upper Montane vegetation is missing and Lower Montane forests give way to temperate forests at 2000 m at 23°N and 2600 m at 18°N. There are no tall mountains between Mt Victoria in Myanmar and Kinabalu in Borneo.

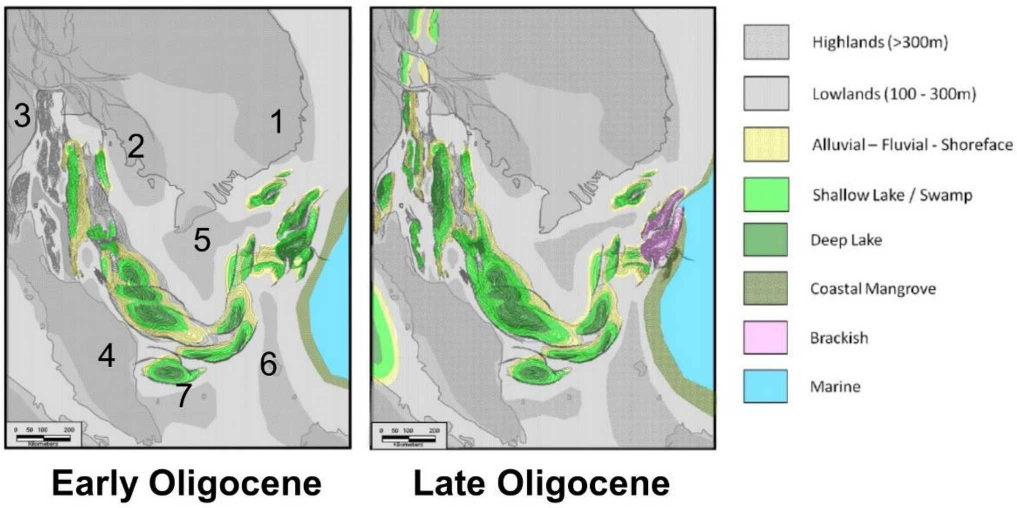

Figure 3. Areas which may include highlands during the Oligocene; 1, Ammanite Range in Vietnam; 2, Cardomoms in Cambodia; 3, Kra Isthmus; 4, Main Range, Malay Peninsula; 5, Con Son Swell; 6, Natuna Arch; 7, Singapore Rise.

In the Sunda region, areas which may have yielded uplands of sufficient altitude to support montane vegetation during the mid-Cenozoic are shown in Figure 3 (from Shoup et al 2012). As well as current upland areas such as the Ammanites, Cardomoms and Main Range, the Kra Isthmus, Con Son Swell and Natuna Arch were likely to have been of sufficient altitude during the Oligocene to bear a diverse montane palaeoflora.

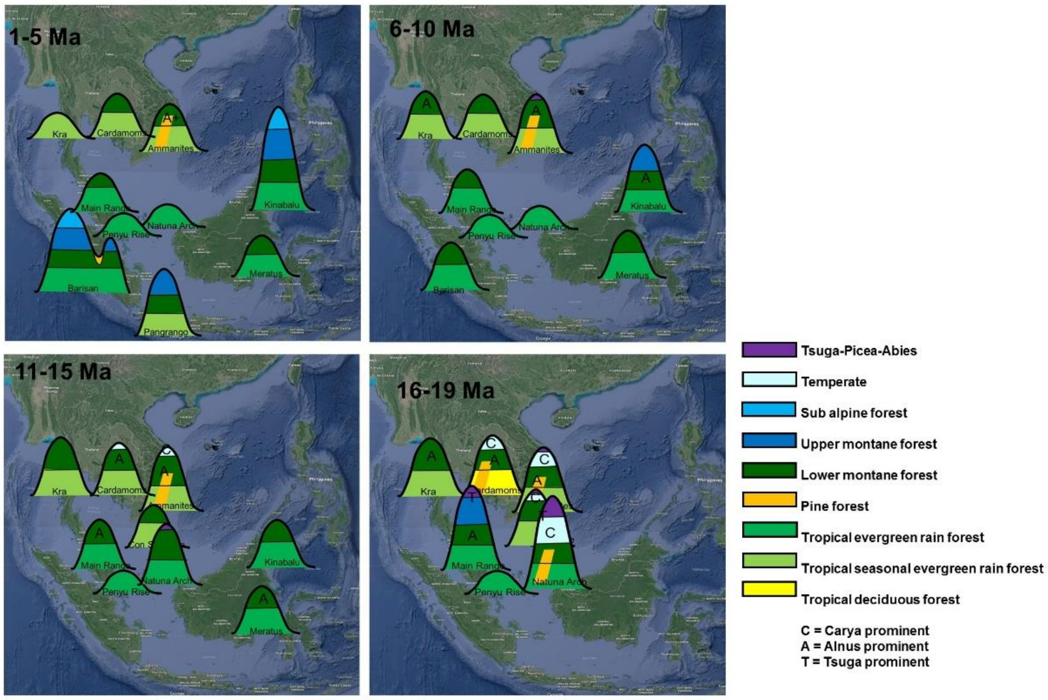

Figure 4a. Schematic altitudes of upland areas based on montane pollen occurrences, for time slices 1-5 Ma, 6-10 Ma, 11-15 Ma and 16 – 19 Ma

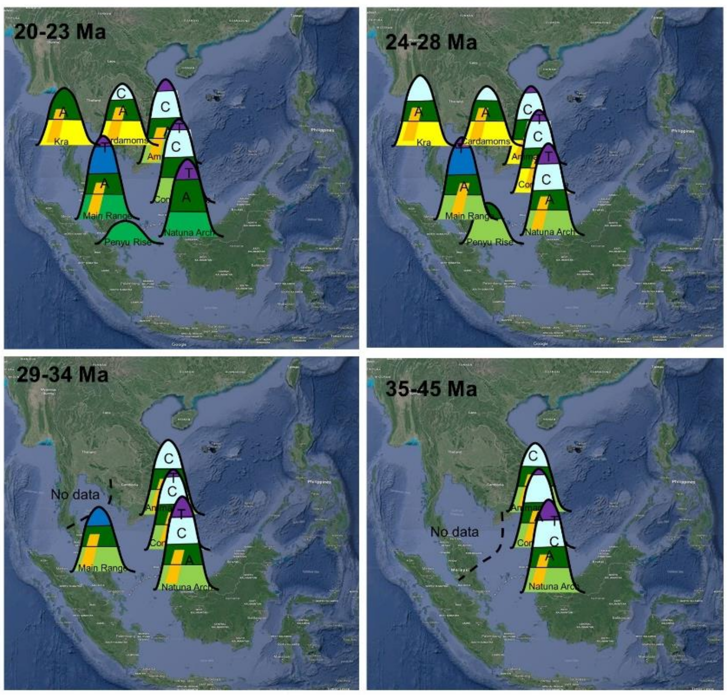

Figure 4b. Schematic altitudes of upland areas based on montane pollen occurrences, for time slices 20-23 Ma, 24-28 Ma, 29-34 Ma and 35-45 Ma

During the Late Eocene and Oligocene, the Natuna Arch, Con Son Swell and Ammanite Ranges were likely to have been of sufficient altitude to support temperate broadleaf and cool temperate conifer forests at their summits, with altitudes in the order of 2500m or more (Figure 4b). Highest altitudes were probably reached during the Late Oligocene. During the Miocene (Figure 4a), all of these areas variously eroded or subsided. Some further uplift may have occurred but the elevations of the Oligocene were not reached. The Late Miocene and Pliocene were characterised by uplift in Borneo, culminating in the Pliocene formation of Kinabalu (Cottam et al 2010, Merckx et al 2015), with the Barisan Range exhibiting uplift since the Late Miocene and the volcanoes of Java forming during the Pleistocene (Morley 2018).

The latitudinal distribution of vegetation over time is also discussed in relation to different plate tectonic models, with the transition from seasonal tropical to perhumid tropical climates initially taking place in southern Kalimantan and South Sumatra during the Late Oligocene and in the Natuna Arch and Malay Peninsula during the Early Miocene. The history of the regional shift from a seasonal tropical to a perhumid tropical climate during the Late Oligocene and Early Miocene is consistent with tectonic models that involve the clockwise rotation of Borneo into the equatorial zone, rather than models that keep Borneo in an equatorial position throughout the Cenozoic.

References

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