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Interactive comment on "On the Holocene Evolution of the Ayeyawady Megadelta" *by* Liviu Giosan et al.

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General comments:

First, to provide context: My personal knowledge of the region was restricted to the delta shelf and adjacent deep basin, during my field research on the Irrawaddy Delta in 1964 aboard USC&GS PIONEER during the International Indian Ocean Expedition, and on the global maiden voyage of OSS OCEANOGRAPHER in 1967. American visits to Burma were not encouraged by its government in the 1960's. The OCEANOGRAPHER was not allowed a courtesy port call to Rangoon because of rumors that the

ship was sent to map Martaban Canyon for use as a haven for nuclear-armed U.S. submarines to threaten the city. My 50-year desire to visit to the subaerial delta was never fulfilled, and so the opportunity to review this manuscript is a greatly appreciated and personally very educational, vicarious "bucket list" visit to Myanmar.

The paper is a valuable analysis of the evolution of the Ayeyarwady and deserves publication after major revision. It is too long, and in need of editorial polish; for example, some references give the publication year after the author name(s), others give the year at the very end. The text and figures also need to be better coordinated.

Specific comments, following the manuscript sequence:

Line 1 ff.: In the recent literature, the Irrawaddy has been variously renamed the Ayeyawady, as in this paper, but, more commonly, the Ayeyarwady, (e.g, cf. references in this paper: Brakenridge 2017; Damodararao 2016; Furuichi et al. 2009; Ramaswami et al. 2004; and Rao et al. 2005). Perhaps, to be internally consistent, can this paper use "Ayeyarwady, which is phonetically closer to "Irrawaddy" anyway?

80 Change "coagulate" to "congregate".

83 economic

93-9 Pyu, Bagan, and Ava historical periods are not defined and not well-known. Perhaps give the time spans of each in parentheses?

124-137 and Figure 1: A string of prominent Quaternary basaltic to basaltic-andesite volcanoes and associated volcanic plugs longitudinally bisects the Central Myanmar Basin, from Mt. Loimye at Lat. 26°N in the north to Mt. Popa at about Lat. 21°N. (see Lee et al., 2016, Late Cenozoic volcanism in central Myanmar: Geochemical characteristics and geodynamic significance, Lithos 245 p. 174-190). Popa rises more than 1.5 km above sea level and experienced Strombolian eruptions. At the very least, the volcanoes are tectonically significant enough to deserve inclusion in Figure 1, especially given that the figure shows the older volcanic rocks along the east of the CMB.

Might these younger volcanoes have sedimentologic and geochemical significance as well?

125 Oligocene/Early Miocene time

135 and Figures 1 and 5: The control of the Sagaing Fault on both tectonics and sedimentation requires that it be plotted more accurately, especially offshore. This is especially true in Figure 5. Figure 1 of Rao et al. (2005) plots the fault offshore, well to the west of where Figure 5 of Giosan et al. does, showing how strongly it divides sedimentation style. Plotted this way will give Figure 5 much more sense. (Lines 535-585 probably need to emphasize the role of the fault as well.)

162: "sync" is not a valid word. Instead of "in sync" say "synchronously"

200-203 "Despite the large fluvial sediment load of the combined Ayeyawady and Sittaung delivered annually (350–201 480 × 106 t), shoreline changes have been puzzlingly minor along the Ayeyawady delta coast since 1850 (Hedley et al., 2010)."

Perhaps the main reason is because most of the sediment, driven eastward into the Gulf of Mottama by the prevailing westerly currents during the southwest monsoon of maximum runoff and sediment discharge, does not stay there, but moves southward to depositional sites on the outer delta shelf, 60 to 100 km south of the Gulf of Mottama (Rodolfo, 1975). The role of contrasting tidal currents off the eastern and western delta, described in lines 559 ff. of Giosan et al. is very instructive.

Taking the opportunity to cite a researcher even older than I am: H. L. Chhibber (1934, The Geology of Burma. Macmillan, London, 538 pp) compared bathymetric charts of the Marine Survey of India compiled from 1854-1859 and 1903-1910 to calculate miles of seaward advance of the 3, 5, 10, and 20 fathom isobaths off the western lobe and in the Gulf of Martaban. (Table 2A of Rodolfo 1975 gives his data with their metric equivalents.) Off the western delta he reported about 4 km/100y with no consistent trend with depth. In contrast, rates of advance in the Gulf of Mottama increased steadily

with offshore distance and depth, from 8 km/100y for the 5-fathom (9.1 m) isobath to 56 km/100y for the 20 fathom (36.6 m) isobath. Unfortunately, he had no deeper data, for none were necessary for most marine traffic at the time.

I also compared the 1854-1859 survey with the bathymetry measured by the PIONEER and the survey ship USN SERRANO from 1960 to 1964, and by the OCEANOGRAPHER in 1967. Again, starting 60 to 140 km off the Gulf of Mottama coast, isobaths advanced increasingly more rapidly seaward, from 24 km/100y closer to shore to as fast as 56 km/100y offshore. The corresponding net shoaling in that zone ranges seaward from 5 to 60 m during the century between data sets.

South of this zone of depositional shoaling, the Mottama Depression is an area of more than 11, 000 km2 of essentially no accumulation, incised with a dendritic complex of shallow, poorly defined channels that lead to the Martaban Canyon. Its impressive 100-km length, average 0°45' gradient, 6-km width and 600 m of relief testify to the major, long-term role of the canyon, and the channels that feed sediment into it, in funneling great quantities of Ayeyarwaddy sediment to the deep Andaman Basin floor. Given its importance, it merits greater mention, and inclusion in Figs. 4 and 5.

Line 248ff: A discussion of human impacts on the delta that exacerbate flooding needs to include the impact of land subsidence due to excessive groundwater withdrawal. See Syvitski et al. (including Giosan), 2009, Sinking deltas due to human activities: https://www.nature.com/articles/ngeo629. This article reports that the Ayeryawady is aggrading 1.4 mm/y, much slower than relative sea level rise of 3.4-6 mm/y. The problem is especially serious in many coastal East Asian metropolitan areas. Many of them are experiencing centimeters per year of subsidence, resulting in worsening floods and tidal encroachment (see Rodolfo and Siringan, 1996, https://www.researchgate.net/publication/ 7264797flooding from subsidence is ignored_around northern Manila B, Philippines). These include Tokyo and Osaka in Japan, 14 of China's 36 coastal and deltaic cities, six of which are sinking at rates of 4 cm/y or more; Taipei, Taiwan; Hanoi, Vietnam; Manila, Philippines; Bankok, Thailand; and Jakarta, Indonesia. Yangon, with its rapidly growing population (5.21 million in 2014) is apparently no exception. In “Sinking Yangon: Detection of subsidence caused by groundwater extraction using SAR interferometry and PSI time-series analysis for Sentinel-1 data” Van der Horst (2017)(https://www.myanmarwaterportal.com/repository/281- sinking-yangon.html), reports that about 2 million of the metropolitan population get their water from household wells; additional, undetermined quantities are withdrawn by industry; and initial SAR results indicate parts of the city are subsiding more than 9 cm/y. Excessive pumpage and the resulting subsidence surely are not limited to Yangon. Given the monsoonal seasonality of rainfall, does not agri- and aquaculture on the delta rely substantially on groundwater during the dry season as well? That certainly is the case on Pampanga Delta north of Manila in the Philippines, which shares Myanmar's monsoonal seasonal rainfall.

Lines 295 ff: For better reference, IR1 and IR2 should be plotted on Figure 2 (d), and the caption for Figure 3 should refer to that.

358 ff: Plate 1, the outsized bathymetric chart for Rodolfo 1969a pocketed in the back cover of its issue, included data gathered by OSS OCEANOGRAPHER, which used satellite navigation otherwise restricted to the U.S. military. Those data were used to control the tracks of the PIONEER; USN SERRANO was probably equipped with satellite navigation as well. The bathymetry of the shelf and adjacent sea floor was reasonably accurate.

592 One “be” too many.

659 ff (References): Perhaps one co-author should systematically go through each, check punctuations, and rigorously follow all the journal's References format: author surname [comma] author initials [for each author] colon Title [first letter capitalized] [comma] Journal title [comma] volume number [comma] first page [comma] last page [comma] url if provided [comma] year [period]. The journal copy editors will be

pleased…

Minor edits: 694: …Prades, L.: Design… 702: Description 728: Blount, C. D., 733: Garzanti, E., Wang… 760 (Myanmar). 789: Ramaswamy, V., and Rao, P. S. The Myanmar 798: Turney, C. S. M., 809: Rodolfo, K. S., 1975: [by date, this should be the third Rodolfo reference, not the first, and the year should end the citation] 812: Rodolfo, K .S., 1969a: Bathymetry [move date to end of citation] 816: Scher, H. D. and Delaney, M. L. Breaking the glass ceiling 817: paleoceanography. Chemical Geology 820: Shi, W. and Wang, M.: 828: paleoceanography. Chemical 832: Nakamura, T.,

Figure 4. The precision and accuracy of the DEM-derived bathymetry are not impressive. Also: why are the horizontal and vertical scales of Profile 3 different from those of the other profiles, and why is it presented to the left of Profile 4?

Figure 5. Top panel: The two-head red arrow is not explained in the figure caption, or in the text. Middle panel: It is interesting that the orange hydrologic “shear front” is so similarly positioned with the offshore Sagaing Fault as plotted by Rao et al. (2005).

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