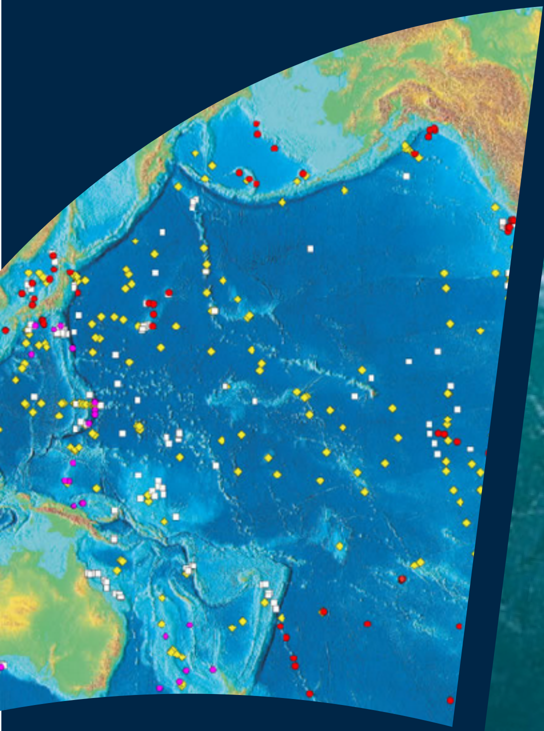
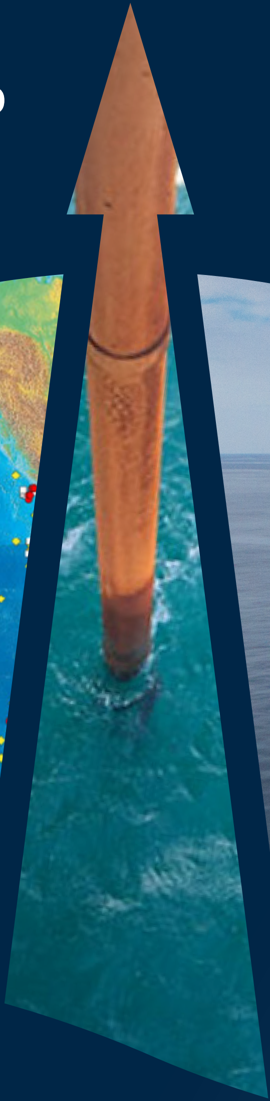
UK IODP INTERNATIONAL OCEAN DISCOVERY PROGRAM

Newsletter

2020 Issue 8
December





Contents

Cover image credits, clockwise from top: D. Smith & ECORD; IODP JRSO; IODP JRSO; L. Perez-Cruz & ECORD; IODP.

Opportunities & Events
December 2020

Opportunities

PhD Position at National Oceanography Centre Southampton
Explosive submarine eruption processes: pumice raft formation, dispersion and hazard
Supervisors: Dr Isobel Yeo, Prof. Bob Marsh, Dr Bramley Murton (all NOCS), Dr Iona McIntosh (JAMSTEC). Find out more

Events

UK IODP MSP Proposal Workshop, 9th to 11th February 2021, online.
Registration will open shortly
We will run a proposal-writing workshop to support scientists in developing IODP proposals for ECORD Mission Specific Platforms. This event is open to scientists based in the UK and internationally. **Deadline for Registration is 23:30 GMT on Sunday 10th January.** Find out more

Professor Paul F. Worthington: Commemorative Webinar, Thursday 10th and Friday 11th December 2020, online. Find out more and register to join

The Palaeontological Association's 64th Annual Meeting, 16th to 18th December 2020, Hosted online by the Oxford University Museum of Natural History, UK. Visit Website

Recent Publications & Media Highlights
December 2020

Recent Publications

Andrews, E., von Strandmann, P., Fantle, M.S., 2020. Exploring the importance of authigenic clay formation in the global Li cycle. Geochimica Et Cosmochimica Acta 289, 47-68.

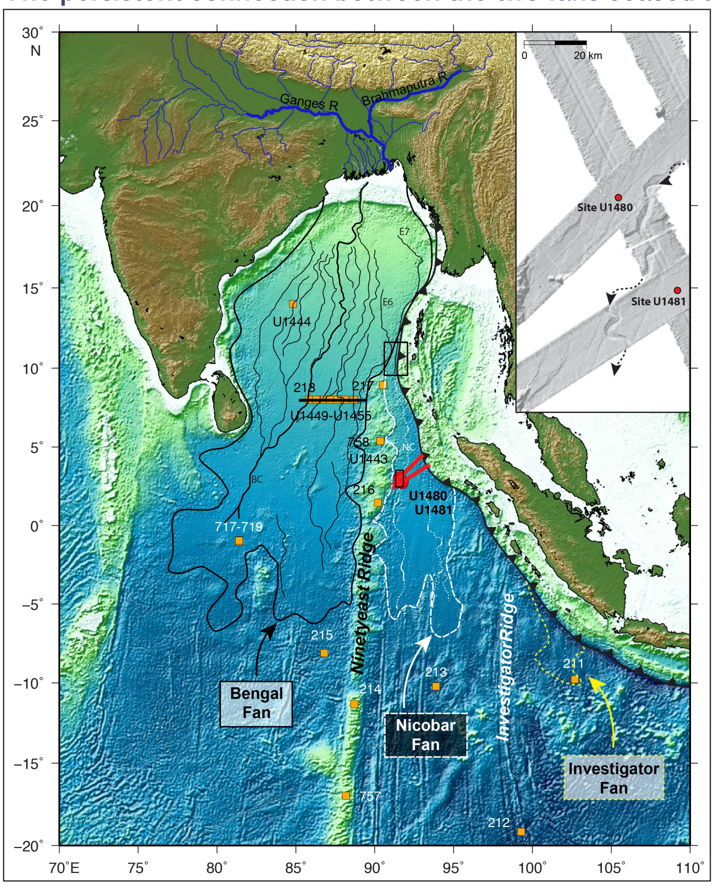
Detlef, H., Sosdian, S.M., Belt, S.T., Smik, L., Lear, C.H., Kender, S., Pearce, C., Hall, I.R., 2020. Late quaternary sea-ice and sedimentary redox conditions in the eastern Bering Sea - Implications for ventilation of the mid-depth North Pacific and an Atlantic-Pacific seesaw mechanism. Quaternary Science Reviews 248, 21.

Indian Ocean:
Deciphering relationships between the Nicobar and Bengal Submarine Fans

Integrated results of IODP Expedition 362 with older Deep Sea Drilling Project

Prof. Kevin T. Pickering*

The Nicobar Fan and Bengal submarine fans (Fig. 1) can be considered as the eastern and western parts, respectively, of the largest submarine-fan system in the world. Drill sites in the southern Bay of Bengal at 3°N 91°E (IODP 362) have sampled for the first time a complete section of the Nicobar Fan andbelow to the oceanic crust (McNeill et al. 2017a, b). The Nicobar Fan is a major sink for Himalaya derived material. This generally overlooked part of the Bengal–Nicobar Fan System has provided new insights into uplift and denudation rates of the Himalayas and Tibetan Plateau. Terrigenous sediment input began in the early Miocene at ~22.5 Ma as muds, overlain by very thin-bedded and thin-bedded muddy turbidites at ~19.5 Ma. From 9.5 Ma (Fig. 2), sand content and sediment supply sharply increase. The persistent connection between the two fans ceased at 0.28 Ma when the Nicobar Fan became inactive.



The research by Pickering (who was Lead Sedimentologist on the expedition) and colleagues presents integrated results of IODP Expedition 362 with older Deep Sea Drilling Project/Ocean Drilling Program/International Ocean Discovery Program sites that show that the Bengal–Nicobar Fan System experienced successive large scale avulsion processes that switched sediment supply between the Bengal Fan (middle Miocene and

Fig 1: Regional map of the Bengal Nicobar and Investigator fans, Indian Ocean. The map includes the deep-marine sedimentary system with fans separated by ridges, the Ganges–Brahmaputra River system, and relevant DSDP/ODP/IODP drill sites. Note the submarine channels that are recognised on the seafloor. Top right inset is a bathymetry map of the seafloor around IODP Expedition 362 sites, showing the presence of well-identified channel heading south. From Pickering et al. (2020a).

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late Pleistocene) and the Nicobar Fan (late Miocene to early Pleistocene). A quantitative analysis of the submarine channels of the Nicobar Fan is also presented, including their stratigraphic frequency, showing that channel size/area and abundance peaked at ~2–3 Ma, but with a distinct low at 3–7 Ma: the intervening stratigraphic [sub]unit was a time of reduced sediment accumulation rates.

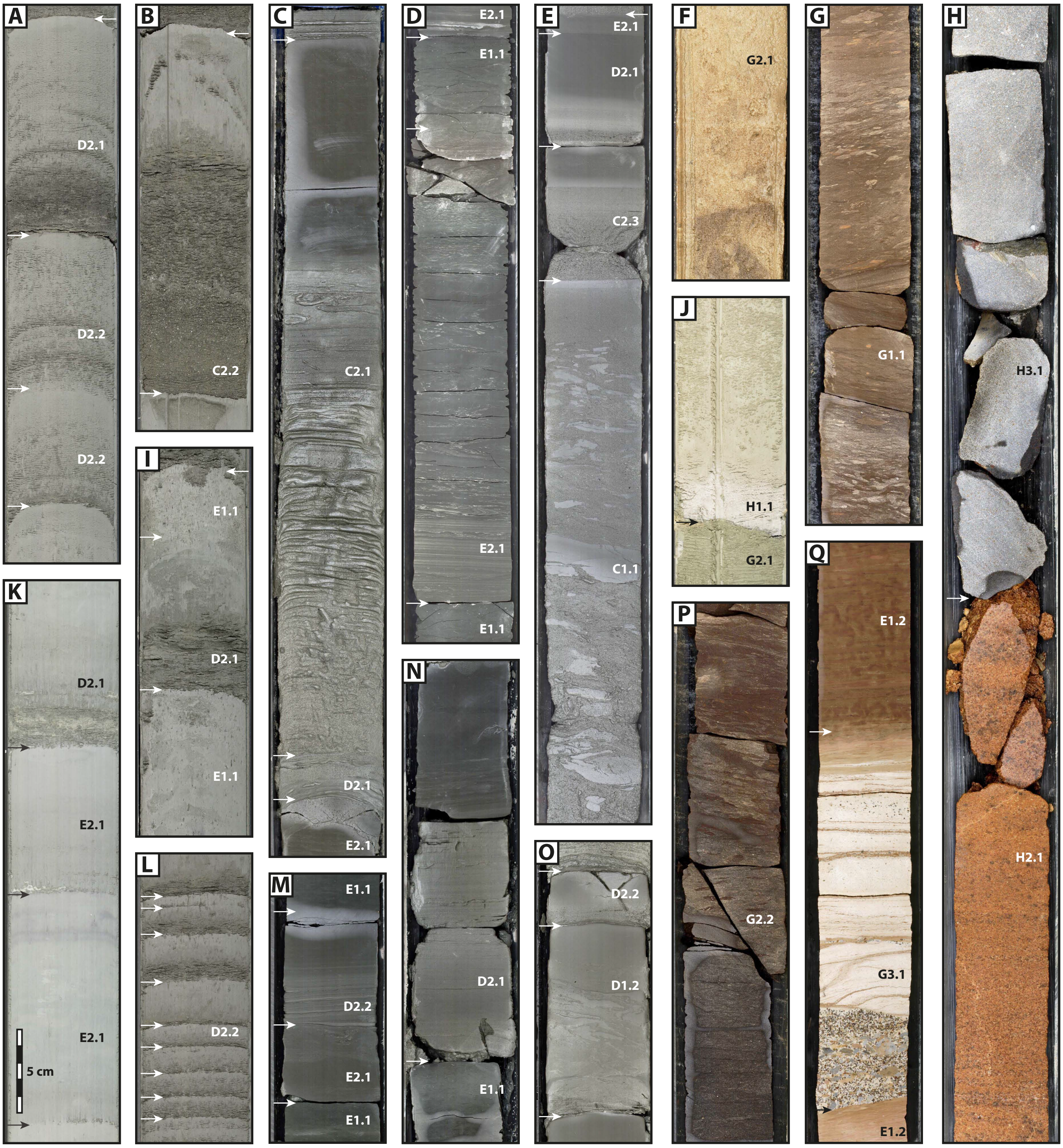

Fig. 2: Photographs of sediment facies (using the facies scheme in Pickering & Hiscott 2016) identified in Holes U1480 and U1481. All photographs are at the same vertical scale and horizontal scale. Arrows indicate the boundary between facies, and in the case of SGF deposits, the base of the bed. (A) Core U1480H-11H, section 2, 40–73 cm. (B) Core U1480H-2H, section 4, 53–78 cm. (C) Core U1480F-96X, section 2, 0–50 cm. (D) Core U1481A-30R, section 6, 42–82 cm. (E) Core U1481A-21R, section 1, 30–82 cm. (F) Core U1480E-1H, section 1, 16–42 cm. (G) U1480G-69R, section 7, 25–55 cm. (H) Core 1480G-62R, section 4, 85–118 cm. (I) Core U1480H-2H, section 5, 100–124 cm. (J) Core U1480H-2H, section 3, 64–79 cm. (K) Core U1480F-26F, section 1, 35–70 cm. (L) Core U1480E-11H, section 1, 30–60 cm. (M) Core U1480G-14R, section 3, 52–76 cm. (N) Core U1480G-54R, section 1, 40–70 cm. (O) Core U1480F-78X, section 1, 30–50 cm. (P) Core U1480G-69R, section 8, 10–35 cm. (Q) Core U1480G-61R, section 4, 24–57 cm. From Pickering et al. (2020a).

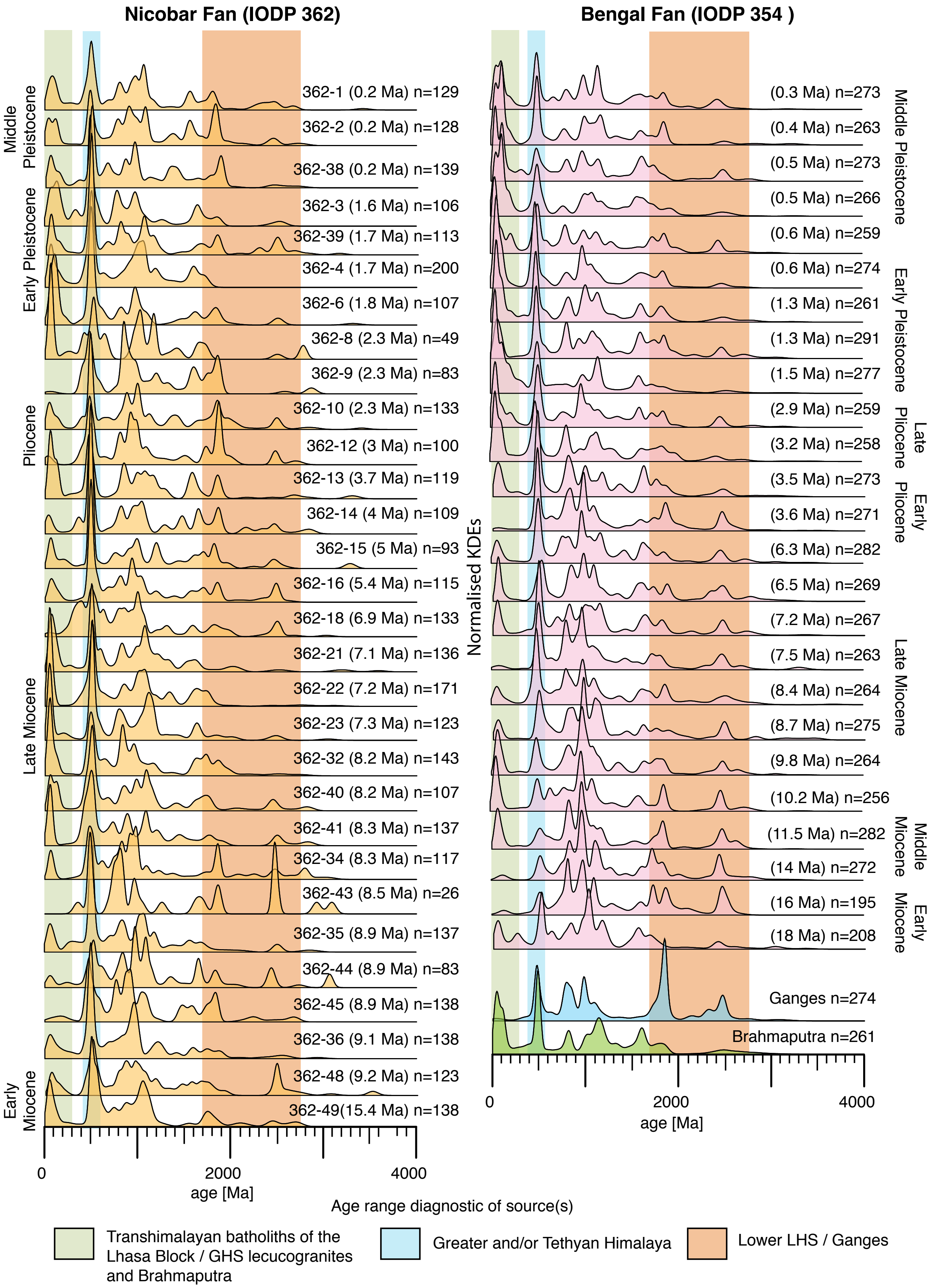

Fig. 3. Sample detrital zircon U–Pb age distributions plotted as adaptive kernel density estimates, comparing data from the Nicobar Fan study with Bengal Fan dataset and representative river sands from the Ganges and Brahmaputra rivers. From Pickering et al. (2020b).

Further research by Pickering and colleagues on samples of sandstones (Pickering et al. 2020b), and mudstones (Chen et al. 2020), showed that throughout their history both the Nicobar and Bengal fans were predominantly supplied by Himalaya-derived material (Fig. 3). A lack of volcanic material in the Nicobar Fan rules out sources from the Sumatra magmatic arc. Overall, the petrographic data shows a progressive decrease in sedimentary detritus and corresponding increase of higher-grade metamorphic detritus up-section. Changes in sediment provenance and exhumation rates in the Himalaya are seen to track changes in sediment accumulation rates. High sediment accumulation rates in the Bengal Fan occurred at 13.5–8.3 Ma, and in the Nicobar Fan from 9.5–5 Ma. Both fans show peak accumulation rates at 9.5–8.3 Ma (but with the Nicobar Fan being about twice as high), and both record a sharp drop from 5.5–5.2 Ma, that coincided with a change in river drainage associated with the Brahmaputra River diverting west of the uplifting Shillong Plateau. At 5 Ma, the Nicobar Fan was supplied by an eastern drainage route that finally closed at 2 Ma, when sediment accumulation rates in the Nicobar Fan significantly decreased. Sediment provenance record these changes in routing whereby Bengal Fan deposits include granitoid sources that are not seen in the Nicobar Fan, likely due to a more localised eastern drainage that included material from the Indo-Burman wedge. Prior to 3 Ma, source exhumation rates were rapid and constant and the short lag-time rules out significant intermediate storage and mixing. In terms of climate versus tectonic controls, tectonically driven changes in the river network have had most influence on fan sedimentation. Figure 4 summarises the depositional history of the Bengal and Nicobar submarine fans.

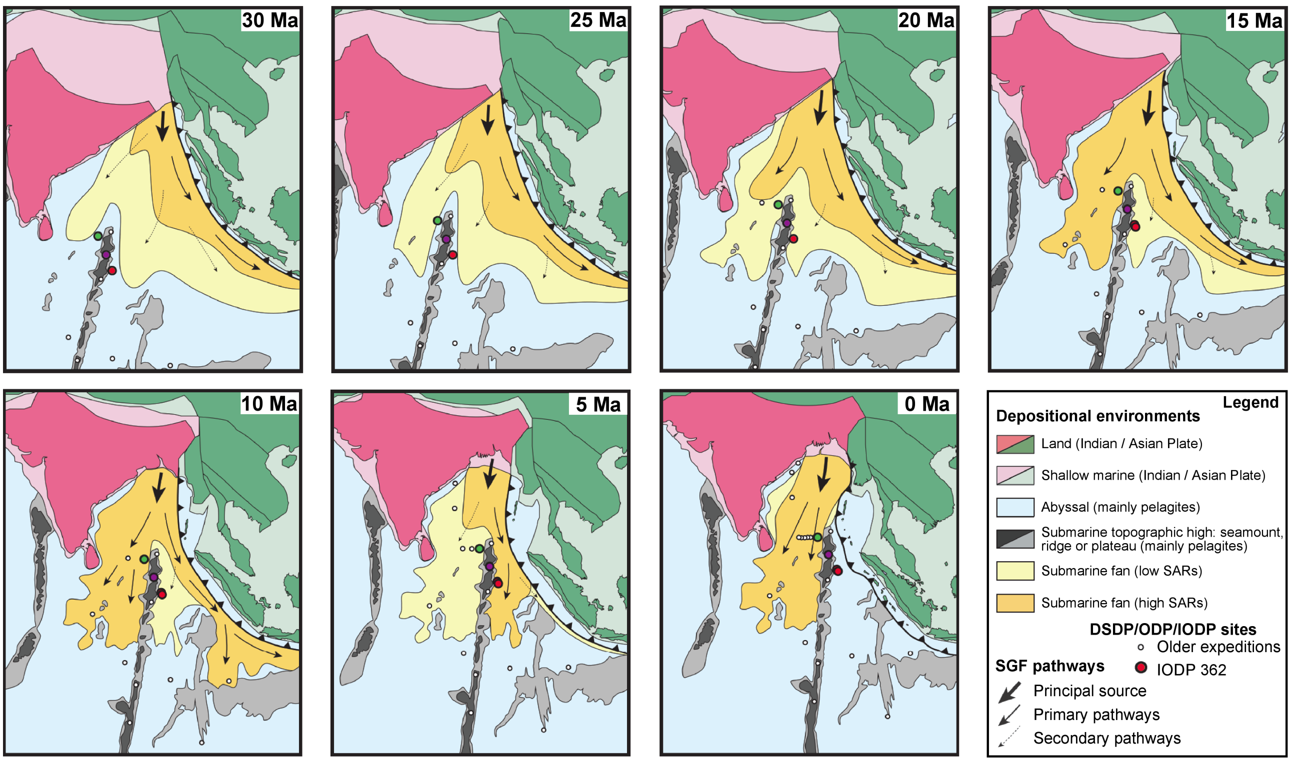

Fig. 4: Palaeogeographic reconstructions of the Bengal–Nicobar Fan System (BNFS). Core data from DSDP/ODP/IODP sites (white dots; red dots = IODP Expedition 362 sites). Sediment mass accumulation rates (MAR) were calculated for Sites U1451 (green dot), U1453 (purple dot) and U1480-1481: the white dots are other drill DSDP/ODP/IODP sites. The postulated earliest submarine-fan deposits are shown as routing along the eastern side of the Indian Ocean, as axial sediment gravity flows (SGFs) along the Sunda subduction zone trench until it was overfilled to construct the Bengal Fan. The latest Eocene and early Oligocene Andaman Flysch, now as accreted and uplifted sedimentary rocks forming part of the Andaman Islands, is the oldest interpreted trench deposits (~30 Ma map). Also, note the much increased coarser-grained terrigenous sediment supply to the Bengal Fan between 13.5–8.5 Ma (but beginning at ~27 Ma), switching to the Nicobar Fan after ~9.5–9.0 Ma, and then back to the Bengal Fan after ~2 Ma. From Pickering et al. (2020a).

Recent IODP publications by author

Chen, W.-H., Yan, Y., Clift, P.D., Carter, A., Huang, C.-Y., Pickering, K.T., Chemale Jr., F., Shan, Y. & Zhang, X. 2020. Drainage evolution and exhumation history of the eastern Himalaya: Insights from the Nicobar Fan, northeastern Indian Ocean. Earth and Planetary Science Letters, 548, https://-doi.org/10.1016/j.epsl.2020.116472.

McNeill, L.C., Dugan, B., Backman, J., Pickering, K.T., Pouderoux, H.F.A., Henstock, T.J., Petronotis, K.E., Carter, A., Chemale Jr.F., Milliken, K.L., Kutterolf, S., Mukoyoshi, H., Chen, W., Kachovich, S., Mitchison, F.L., Bourlange, S., Colson, T.A., Frederik, M.C.G., Guèrin, G., Hamahashi, M., House, B.M., Hüpers, A., Jeppson, T.N., Kenigsberg, A.R., Kuranaga, M., Nair, N., Owari, S., Shan, Y., Song, I., Torres, M.E., Vannucchi, P., Vrolijk, P.J., Yang, T., Zhao, X. & Thomas, E. 2017a. Understanding Himalayan Erosion and the Significance of the Nicobar Fan. Earth and Planetary Science Letters, 475, 134–142. doi.org/10.1016/j.epsl.2017.07.019.

McNeill, L.C., Dugan, B., Petronotis, K., and Expedition 362 Scientists 2017b. Sumatra Subduction Zone, Proceedings of the International Ocean Discovery Program, 362, College Station, TX, USA, https://-doi.org/10.14379/iodp.proc.362.2017.

Pickering, K.T., Pouderoux, H., McNeill, L.C., Backman, J., Chemale, F., Kutterolf, S., Milliken, K., Mukoyoshi, H., Henstock, T.J., Stevens, D.E., Parnell, C. & Dugan, B. 2020a. Sedimentology, stratigraphy and architecture of the Nicobar Fan (Bengal–Nicobar Fan System), Indian Ocean: Results from International Ocean Discovery Program Expedition 362. Sedimentology, 67(5), 2248–2281. doi: 10.1111/sed.12701.

Pickering, K.T., Carter, A., Andò, S., Garzanti, E., Limonta, M., Vezzoli, G. & Milliken, K. 2020b. Deciphering relationships between the Nicobar and Bengal Submarine Fans, Indian Ocean. Earth and Planetary Science Letters, 544. doi.org/10.1016/j.epsl.2020.116329.

UK shipboard scientists on IODP Expedition 362 were Lisa McNeill (Co-Chief Scientist), Tim Henstock (Geophysics), Freya Mitchison (Micropalaeontology), and Kevin Pickering (Lead sedimentology).

In Memoriam
Professor Paul F. Worthington

Earlier this summer the world of ocean drilling lost a great supporter and innovator when Paul Worthington sadly passed away. Paul was an industry petrophysicist, with academic credentials, who was greatly instrumental in bringing downhole logging into ocean drilling on a routine basis, as DSDP developed into ODP. From 1986–1992 he served as Chair of the Downhole Measurements Panel (ODP) and for 10 years was co-editor of Petroleum Geoscience. Amongst many publications, in 1988 he co-authored a paper on Scientific applications of downhole measurements in the ocean basins, and in 1989 co-organised a workshop on ODP Log Data Quality Control.

Paul's background was a degree in physics and maths, an MSc in geophysics, and a PhD characterising the petrophysics of Britain's second most important aquifer, the Sherwood sandstone. He started his technical career in the water industry, before moving into the oil industry with BP in 1980, where some years later he became Head of Formation Evaluation at the BP Research Centre in Sunbury-on-Thames, England. Here, crucially, he promoted the study of both the theoretical side of petrophysics and the use of core data to condition the interpretations obtained from well log data. This interest in integrated studies for reservoir evaluation and in assimilating data from different measurement scales was ideally suited to becoming involved in ocean drilling.

Those involved in the early days of downhole measurements in ODP have fond memories of Paul's involvement.

Roger Anderson, the first Director of the ODP Logging Program, states that "without Paul, wireline logging would never have made it into ODP. Logging schools in each of the global member countries was completely Paul's idea! He was wonderful to work with!"

Dave Goldberg commented: "Very, very sad news. I have many memories of my own in working with him, both early on while I was finishing my PhD and later as Director of the ODP logging program, and then from many, many conference meetings. I recall Paul as a "tour-de-force" in regard to advancing downhole measurements for scientific drilling. Paul was generous with his time whenever and wherever it was requested, flying over from the UK to uncountable ODP meetings and conferences. From his industry experience, he was especially adamant that clear and accurate correlation of downhole logs with similar measurements made on core samples would convince the scientific community of the vast benefits of logging. He was correct. Logging became more commonplace in the ODP, and new oceanographic discoveries (and sea-going experts) related to core-log integration and stratigraphic correlation were hatched. It's hard to underestimate the positive impact this had on scientific research - from paleoclimate studies to methane hydrates to stratigraphic imaging - which has continued to propagate through today in the current International Ocean Discovery Program."

Dan Moos remembers his first encounter with Paul at a DMP (or maybe the Tech Panel?) meeting back in the day (1986 maybe?). "I was the L-DGO lithosphere panel liaison. Regardless of which it was, they both were always active and lively with many smart vocal people contributing - and at that meeting I watched Paul masterfully encouraging contributions from quieter members and orchestrating positive outcomes that reflected what was said by each. It wasn't till I had gotten to know him better that I realized that he also had well-considered opinions with which those outcomes were well aligned. A master lesson in "leading from behind" that I have never forgotten! The community is a bit smaller for his passing..."

Keir Becker said "My most enduring memory of Paul was how skillful he was at chairing international panel meetings: I don't think he failed to end any meeting later than 5 minutes past the time he had predicted when he convened the meeting, and he always composed complete and concise minutes on his flight home, and distributed them right away." (Reader, please take note.)

My own memories of Paul are of his role in promoting downhole measurements in ocean drilling, largely in collaboration with Roger Anderson who was instrumental in bringing downhole measurements in as a major part of ocean drilling in the 1980s. Paul seemed to be everywhere, at every meeting, and later was even closely involved in the deep drilling project in Germany (KTB). My involvement with ocean drilling started in 1986, firstly at Nottingham and then at Leicester University, and Paul was always a great supporter as we established ocean drilling petrophysics within UK academia, and developed collaborative links with industry.

Separate to Paul's involvement in ocean drilling, he was devoted to the pursuit of excellence and to sharing his knowledge for the benefit of all. Although Paul worked primarily in industry, he published over 100 peer-reviewed papers in the fields of engineering geoscience and petroleum unitization and coedited four books on core and log analysis. He has been described within petrophysical circles as "one of the giants of the discipline" and one of its "most referenced authors". Paul was the recipient of numerous industry awards including the Society of Petrophysicists & Well Log Analysts' top honour, the Gold Medal for Technical Achievement (2012), as well as the Medal of Honour for Career Service (2006), the Distinguished Technical Achievement Award (2004), and the Distinguished Service Award (1996). He was also the recipient of the Distinguished Service Award of the Society of Core Analysts.

Paul was a major player in petrophysics and highly regarded. Many of his papers are considered seminal and are essential references in any relevant research. But in addition to this, perhaps one of Paul's major legacies, is how he could write excellent review papers, condensing a large number of technical and complex petrophysical publications down into a logical and coherent summary that really helped our understanding of petrophysics. I think this contribution is easily underestimated in its importance and this should be corrected. He leaves a legacy of these publications that will be read for many years to come and provide an excellent starting point for further discussion of petrophysics.

Mike Lovell, University of Leicester

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