

Rare earth elements in Andaman Island surface seawater: Geochemical tracers for the monsoon

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The Asian summer monsoon affects the lives of billions of people. With the aim of identifying geochemical tracers for the monsoon related freshwater input from the major rivers draining into the Bay of Bengal and Andaman Sea we have taken surface seawater samples from various locations up and down the Andaman Islands during 2011. Importantly, in some locations samples have been taken in March, July and November, covering most of a seasonal cycle and different monsoon phases. Samples were collected from the side of small wooden boats or while swimming and were filtered within a few hours at 0.45 or 0.22 microns using the vacuum produced by a water jet or a hand operated peristaltic pump. Filtered and unfiltered samples were acidified to < pH 2 and analysed for Y and the REEs with an automated online preconcentration ICP-MS technique [1].

The local input of REEs from streams and sediment rich areas such as mangrove environments is clearly identified by middle REE enrichments in the shale normalised patterns of some samples. These middle REE bulges accompany large increases in dissolved REE concentrations at some locations, especially for the July samples obtained during the peak monsoon season with frequent storms. Y/Ho fractionation also occurs during the local input of dissolved REEs with affected samples having lower Y/Ho ratios. Conversely, some samples, in particular those taken after heavy rainfall in March, show strong REE scavenging accompanied by the preferential removal of dissolved light REEs and higher Y/Ho ratios.

The time series at a location away from local input sources shows remarkably similar REE patterns and concentrations in March and July. Then in October-November, following the peak in monsoon river discharge, the dissolved REE concentration increases by almost a factor of 2. The notable exception to this seasonal pattern is the Ce anomaly which is around 0.3 in March and November but 0.6 in July, implying less oxidative removal of Ce(IV) during the peak summer monsoon rains. With the exception of elevated dissolved Ce concentrations, the North Pacific Deep Water normalised REE patterns are similar to those reported for offshore samples from the Bay of Bengal and Andaman Sea [2]. These seawater normalised patterns are distinctive having a middle REE enriched arc with similar light and heavy REE values suggesting the input from large rivers in the region is traceable using seawater REE chemistry.

[1] Hathorne et al. (2012), Online preconcentration ICP-MS analysis of rare earth elements in seawater, *Geochem. Geophys. Geosyst.*, 13, Q01020, doi:10.1029/2011GC003907.

[2] Amakawa et al. (2000), *Geochim. Cosmochim. Acta* 64, 1715-1727.