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Calcareous foraminifera from tropical north Queensland, Australia: Their usefulness as proxy sea-level indicators in the absence of fossil agglutinated foraminifera

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Using foraminifera as sea-level indicators rests on the assumption that their distribution is related to sea level in a quantifiable manner and by establishing this vertical relationship with a specified tide level, former positions of relative sea-level may be determined. In temperate areas agglutinated upper intertidal foraminifera are well preserved in fossil sediments. Therefore relatively precise quantitative sea-level reconstructions are possible using modern training sets which cover short elevation gradients excluding calcareous assemblages from low intertidal and subtidal environments (*e.g.* Gehrels, 2000. *The Holocene*, 10(3): 367-376; Gehrels *et al.*, 2005. *Quaternary Science Reviews*, 24: 2083-2100; Horton & Edwards, 2005. *The Holocene*, 15(2): 216-228). However sediment cores taken from Cleveland Bay in north Queensland, Australia to quantitatively reconstruct mid/late Holocene sea-level changes contain calcareous foraminifera in minerogenic horizons but no foraminifera in organic horizons (Woodroffe *et al.*, 2005. *Journal of Foraminiferal Research*, 35(3): 259-270). The reason for this is unknown, but may be due to a series of interrelated factors including burrowing by fiddler crabs and molluscs, increased air and water temperature, biological turnover and predation in tropical intertidal environments.

Calcareous foraminiferal assemblages are assumed to be poor proxy indicators for Holocene sea-level reconstructions, largely because tidal current and wave transport of tests occurring in unvegetated intertidal and shallow subtidal environments gives each assemblage broader elevational zonation than in vegetated upper intertidal environments (Hayward *et al.*, 2004. *Holocene*, 14(2): 218-232), and foraminifera respond to other environmental variables

such as availability of light, nutrient status and temperature (Sen Gupta, 1999).
In: *Modern Foraminifera*. Kluwer, Dordrecht: 140-159).

I collected modern foraminiferal samples and environmental information from equally spaced elevation intervals between Mean Tide Level (MTL) and 5.3 m below Lowest Astronomical Tide level (LAT) in Cleveland Bay, north Queensland, Australia to investigate the usefulness of calcareous assemblages from low intertidal/shallow subtidal environments as fossil sea-level indicators. Although the dominant calcareous species (including *Ammonia aoteana*, *Pararotalia venusta* and *Parrellina hispidula*) are present to some degree in all samples, foraminiferal assemblages from MTL to 5.3 m below LAT show good vertical zonation, with elevation explaining 17 % of variance in foraminiferal assemblages. This compares poorly to the influence of elevation on agglutinated foraminifera on U.K. salt marshes, but elevation is still an important environmental variable governing foraminiferal distributions.

A transfer function developed solely using calcareous foraminifera from MTL to 5.3 m below LAT has good predictive ability, with an r^2 of 0.96 and RMSEP of 0.43 m. The error term is large compared to studies using agglutinated foraminifera and a short environmental gradient (*e.g.* Gehrels *et al.*, 2005), but the error term compares favourably to the errors associated with other indicators such as coral, mangrove sediments and fossil oyster beds, also used as paleo sea-level indicators along this coastline.