Morphometric assessment of uplifting coral reef sequences, Sumba Island, Indonesia

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1. Introduction

1. Sequences of paleoshorelines
   e.g. coral reef terraces (CRT), marine terraces, beach deposits

2. Incised by rivers
   Studied through morphometric indices
   e.g. drainage area, hypsometry, slope, ...

- Record successive highstands (eustasy) & emerged from tectonic (e.g. Lajoie, 1986)
- Staircase surfaces: isochrons, isohypsises
- Chronostratigraphy = uplift rates for upper & middle Pleistocene

Intent to fix 1 other parameter
Lithology → Reefal limestone (i.e. seq. of CRT)

1. Coral reef terraces: mapping & extension of previous work
2. Drainage: 8 morphometric indices: Area, relief, hypsometric integral, shape factor of catchments, residual relief, incision, $k_{sn}$ & SL index
   - 3 different scales: island, 15 catchment, coastal areas of similar uplift rates
Convergence of 3 main plates: Pacific, Indo-Australia & Eurasia

**Sumba Island**

Transition collision / subduction + well dated sequence CRT

Data from Hall (2002) & Pedoja et al. (2011)
**3. Setting**

**Sumba Isl.:** Ancient volcanic-arc uplifted + 2/3 of the coast = reefal limestone
3. Setting

Cape Laundi

6 main terraces up to 475 m, ESR + U/Th = chrono-morpho-stratigraphy
Key site for long record (1 Ma) of Pleistocene sea levels

ESR: 322 ±48, 327 ±49, 397 ±59 ka
U/Th: > 300 ka

Jouannic et al. 1988; Pirazzoli et al., 1991; Hantoro, 1992; Pirazzoli et al. 1993; Bard et al., 1996
4. Results: coral reef terraces analysis

1- Cartographic comparison:
Slope map vs prev. works (80% correlation)

2- Extension chrono-stratigraphy

3- Benchmark choice:
continuous = Terrace IIIb = MIS 11 (400 ka)

4- Coastal uplift rates

Nexer et al., in press

Legend:
- Red: MIS 5a-5e
- Yellow: IIa: MIS 7-9
- Pink: IIc: MIS 13
- Green: IIb: MIS 9
- Blue: IV: MIS 15-17
- Purple: V: MIS 19-23
- Violet: VI: MIS 25-29
- Our study (slope map, hillshade)
Excellent playground to investigate relationship between morphometric indices and slow to moderate coastal uplift rates.
4. Results: drainage

Island scale

- **Residual relief & incision**: Seq. Of CRT = Low incision

![Diagram of residual relief and incision](image)

![Map of island scale](image)

**Indian Ocean**

**Savu Sea**

- **Incision**
  - High: 478 m
  - Low: 0

Limite of coral reef terraces
4. Results: drainage

Island scale - Stream length indices: $k_{sn}$ & SL index

$S = k_s a^{-\theta}$

$k_{sn} = k_s a^{-\theta_{ref} - \theta}$

$S$: slope

$k_s$: slope index

$a$: area

$\Theta$: concavity

Cape Laundi

Long profile of streams 13, 14 & 15

Knickpoints when rivers cross paleo-seacliff
4. Results: drainage

Catchment scale

- Area, relief, hypsometric integral, shape factor of catchments, residual relief, incision, $k_{sn}$ & SL index.

High values on Cape Laundi
4. Results: drainage

"Zone of similar uplift rates" scale

12 zone of same range of uplift rates: same lithology + area larger than catchments
6. Discussion: correlations morphometric indices vs uplift rates

Catchment scale

Hypsometric integral, shape factor, SL & $k_{sn}$: tools to isolate high uplift rate zones (>0.3 mm/yr).

Mean relief, residual relief & incision: influenced by streams transient state $\rightarrow$ drainage young (<1 Ma?) + staircase morphology.
6. Discussion: correlations morphometric indices vs uplift rates

"Zone of similar uplift rates" scale

Residual relief & incision: poor correlation with uplift rate

Correlations are stronger when morphometric indices are extracted by range of uplift rates
6. Conclusions

- Knowledge of coastal tectonic of Sumba improved

- Variations morphometric indices function of uplift rates:
  Only incision & residual relief are not correlated to uplift rates because drainage network are not always in steady state

- “New tools” to discriminate rapidly uplifting areas:

  For Sumba Island when

  - HI > 0.55
  - Shape factor < 0.45
  - SL index > 150 m
  - $k_{sn} > 35$ m

  Uplift rates > 0.3 mm/yr

  [Nexer et al., in press (Geomorphology)]
Thanks for your attention