Reef depositional events along the Marquesas foreslopes (French Polynesia) since 26 ka

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Introduction

- Pattern of the reef growth during the last deglacial sea-level rise (i.e. the last 24,000 yr or 24 ka) is yet not well known.

- Study areas are rare in the world.

- Only sites in Barbados, Papua New Guinea, Vanuatu and Tahiti.

- But, in the Marquesas archipelago (French Polynesia.), occurrence of submarine platforms and terraces.

- Bathymetric surveys coupled with sedimentological and paleoecological analyses and radiometric dating of dredged rocks were performed to identify the periods of development.
# Occurrence of drowned reefs in the 3 Oceans

<table>
<thead>
<tr>
<th></th>
<th>Depths</th>
<th>Reference</th>
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<tbody>
<tr>
<td><strong>Pacific</strong></td>
<td></td>
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<tr>
<td>Australian Great Barrier Reef</td>
<td>45 to 150 m</td>
<td>Harris &amp; Davies, 1989, Beaman et al., 2008</td>
</tr>
<tr>
<td>Hawaii (O’ahu)</td>
<td>90 m</td>
<td>Fletcher &amp; Sherman, 1995, Webster et al., 2004</td>
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<tr>
<td>Hawaii (Au’au Channel)</td>
<td>10 to 30 m</td>
<td>Grigg et al., 2002</td>
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<tr>
<td>Marquesas</td>
<td>95 m</td>
<td>Rougerie et al., 1992</td>
</tr>
<tr>
<td><strong>Indian Ocean</strong></td>
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<tr>
<td>North-West &amp; West Malagassy</td>
<td>5 to 15 m</td>
<td>Battistini, 1972, Jouannic, 1972</td>
</tr>
<tr>
<td>South-West Malagassy</td>
<td>45 to 75 m</td>
<td>Jouannic, 1972</td>
</tr>
<tr>
<td>West India</td>
<td>85 to 136 m</td>
<td>Vora et al., 1996, Rao et al., 2003</td>
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<td><strong>Carribbean</strong></td>
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<tr>
<td>East Carribean (St-Croix)</td>
<td>10 to 15 m</td>
<td>Adey et al., 1977, Macintyre, 1988</td>
</tr>
<tr>
<td>Great Cayman</td>
<td>21 m</td>
<td>Blanchon et al., 2002</td>
</tr>
<tr>
<td>South-East Florida</td>
<td>15 to 30 m</td>
<td>Lighty et al., 1978, Macintyre, 1988</td>
</tr>
<tr>
<td>Sand key (Florida)</td>
<td>9 m</td>
<td>Toscano &amp; Lundberg, 1998</td>
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<tr>
<td>Carisfort Outlier Reef</td>
<td>7 m</td>
<td>Toscano &amp; Lundberg, 1998</td>
</tr>
<tr>
<td>West Barbados</td>
<td>70 to 80 m</td>
<td>Macintyre et al., 1991</td>
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</tbody>
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### 3 groups of depth

1. From 5 to 30 m
2. From 45 to 50 m
3. From 80 to 136 m

![Diagram showing three groups of depth](image)
Methodology

- Bathymetric survey (multibeam)
- Dredgings
- Sedimentological analyses
- Analysis of the fossil biological communities in order to define the reef biozonations by comparison with their modern counterparts
- Dating of the reef sequences (C14 and / or TIMS U/Th)
The Marquesas islands

Tectonically « stable » over the Late Quaternary
Two cruises performed in 1997 and 2002

R/V IRD « Alis »
Multibeam and dredgings

Identification of the drowned reefs

Coral samples recovered by dredging
Bathymetric map and dredgings performed at Nuku Hiva

Contour interval: 1 m

ReMarq cruise, Cabioch et al., 2002
Bathymetric map and dredgings performed at Hiva Oa

Contour interval : 1 m

ReMarq cruise, Cabioch et al., 2002
• Sedimentological analyses

• Paleoecological analyses
Characterization of reef facies by comparison with their modern counterparts: reef crest and upper reef slope facies

Facies 2, bindstone:
crusts of coralline algae:
(1) *Lithophyllum pustulatum* and
(2) *Hydrolithon onkodes* associated with
(3) gastropod vermetid

Typical association of the upper parts of the outer reef slope comprising crusts of coralline algae (1) *Lithophyllum pustulatum* and (2) *Hydrolithon onkodes*; (3) gastropod vermetid and (4) coral
Characterization of reef facies by comparison with their modern counterparts: forereef and/or backreef facies.

Facies 4a, floatstone rich in (1) *Halimeda* plates and (2) debris of coralline algae *Mesophyllum* sp.

Facies 4b, floatstone rich in debris of *Halimeda*.
Distribution of reef facies depending on the irradiance (depth) and the high-water energy degrees

- 4a & 4b
- 4a
- 3
- 2b
- 2a
- 1

- Inner reef flat
- Reef flat
- Reef crest
- Upper outer reef slope
- Lower outer reef slope

Water depth (m):
- 1: coral framestone
- 2a: wackestone or floatstone rich in corals
- 2b: boundstone or floatstone rich in coralline algae
- 2c: floatstone with various skeletal and algal debris
- 3: bindstone (encrusting coralline algae)
- 4: floatstone or rudstone rich in Halimeda
  - 4a: intact plates of Halimeda
  - 4b: debris of Halimeda

Present mean sea-level
Deepening-upward, biolithological sequences at Hiva Hoa island

A: sample HO DR13 bis(1): the reef rock (Facies 2 and 3), made up of corals (CO), coralline algae (CA), is overcapped by a deep-water deposit (Facies 5), composed of various bioclastic debris and microbialite crusts (MI).

B: sample HO DR4bis (5): the reef rock (Facies 2 and 3), made up of corals (CO), coralline algae (CA) and encrusting foraminifera (FE), is overcapped by a deep-water deposit (Facies 5), composed of various bioclastic debris including benthic and planktonic foraminifers (De), Halimeda segments (H) and phosphatic-metallic crusts (PH/M).
• Morphological features

• Bathymetric range of the reef generations (RG) *sensu* Montaggioni, 2005
EIAO
Three-dimensional reconstruction of the foreslopes and cross-section from 130 to 60 m
HIVA OA

Three-dimensional reconstruction of the foreslopes and cross-section from 140 to 68 m
NUKU-HIVA
Three-dimensional reconstruction of the foreslopes and cross-section from 150 to 50 m

* Dates published in Paterné et al. (2004) from corals collected during the cruise "Musrorstom 9"
Distribution of the 4 Reef Generations

- **RG 0**: between 125 and 115 m, from 26 to 19 ka
- **RG I**: between 110 and 95 m, from 18 to 15 ka
- **RG II**: between 76 and 58 m, from 14 to 11.5 ka
- **RG III**: at around 50 to 60 m, dated at around 9 ka

- **Younger Dryas**
- **MWP - 1B**
- **MWP - 1A**
- **Terminal LGM**

**Ages (ka)**
(1 ka = 1,000 years)
Comparison in the Pacific
(work in progress, Cabioch et al.)

<table>
<thead>
<tr>
<th>Region</th>
<th>Source(s)</th>
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<tbody>
<tr>
<td>Tahiti</td>
<td>Montaggioni et al., 1997, Cabioch et al., 1999</td>
</tr>
<tr>
<td>Vanuatu</td>
<td>Urelepa island, Cabioch et al., 2003</td>
</tr>
<tr>
<td>Australia</td>
<td>Beaman et al., 2008</td>
</tr>
<tr>
<td>Marquesas</td>
<td>Cabioch et al., 2008</td>
</tr>
</tbody>
</table>

**Diagram:***
- **Modern reefs**
- **"catch-up"**
- **Reef?**
- **RG III (9 ka)**
- **RG II (12 ka)**
- **RG I (15 ka)**
- **RG 0 (26 ka)**

**Key:**
- Black: Drowning
- Red: "catch-up" reef mode
- Yellow: Sand
- Blue: "keep-up" reef mode
- White: Pleistocene reef

**Graph:**
- Relatif sea-level (m)
- MWP - 1B
- MWP - 1A
- Terminal LGM
- LGM
- Ages (ka) (1 ka = 1,000 years)
Conclusion

• Several reef generations (RG) *sensu* Montaggioni, 2005, ranging from 26 to 9 ka were identified
  – (1) RG 0 between 125 and 115 m dated from 26 to 19 ka
  – (2) RG 1 between 110 and 95 m, from 18 to 15 ka
  – (3) RG 3 between 76 and 58 m, from 14 to 11.5 ka
  – (4) RG 4 at around 50 to 60 m dated at around 9 ka

• The biofacies of these RG were defined
  – RG 1, 2 and 3 are characterized by biofacies typical of coral reefs *sensu stricto*
  – RG 4 appears to be similar to modern coral banks characterising the modern reef environments in the Marquesas

• Causes of the drowning (*work in progress*)
  – The development of these reef formations has probably been disrupted by rapid sea level rise due to ice melting pulses
  – and / or alternatively by other yet unidentified causes

References