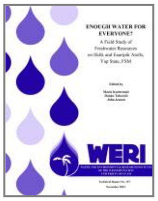

Citation for this document:

Miklavič, B. (2015) **Ifalik, Eauripik, and Sorol Atoll - Storm Frequency and Severity and Atoll Island Morphology.** In: Kottermair, M., Taboroši, D., and Jenson, J. W. (Eds.), *Enough Water for Everyone? A Field Study of Freshwater Resources on Ifalik and Eauripik Atolls, Yap State, FSM.* WERI Technical Report 157. Water and Environmental Research Institute of the Western Pacific, University of Guam, Mangilao, Guam.

IFALIK, EAURIPIK, AND SOROL ATOLL

Storm Frequency and Severity and Atoll Island Morphology 2015

by Blaž Miklavič

The reef and island morphology of all the visited islands was observed in the context of formational and depositional environment in order to roughly estimate the islands' storm frequency and severity, both crucial for island and population storm vulnerability assessment. Atoll orientation was not considered in the analysis.

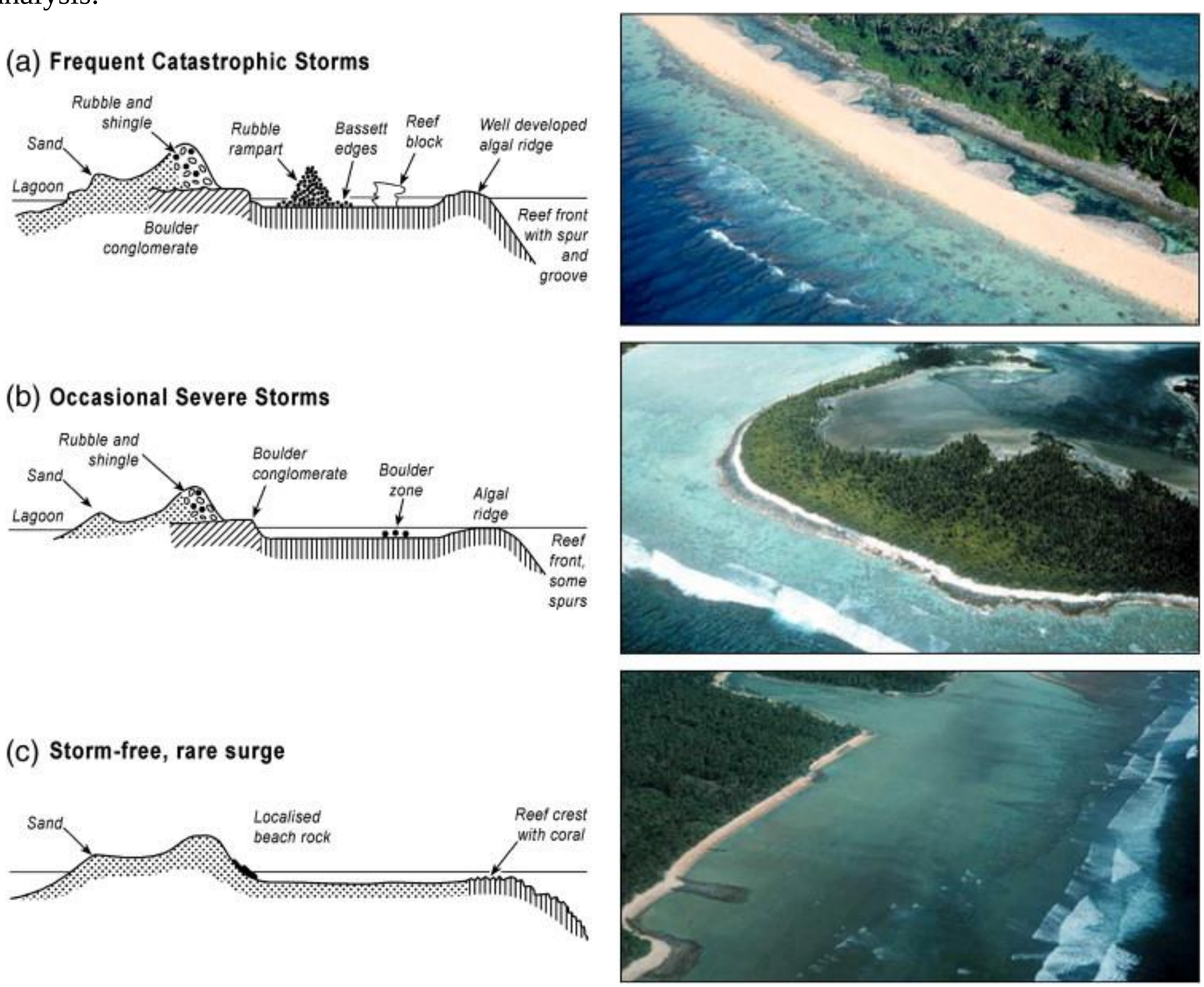

Figure 1: Characteristic morphology of atoll islands and their respective reefs formed under different frequency and severity of storms. The morphology of Eauripik and Sorol islands indicates that these two atolls formed in a relatively calm areas, with Eauripik being in a perhaps more stormy environment. (Figure from Woodroffe, 2008).

I F A L I K   A T O L L

The morphology of the entire Ifalik Island was thoroughly researched. On the ocean side of the island a prominent, high storm berm consisting of boulders, rubble and shingle almost continuously along the beach (Figure 2). This berm was also measured to be the highest area of the island by previous researchers (Tracey et al., 1961). Below the berm there are extensive beachrock outcrops (Figure 3). Especially near the northern-most tip of the island conglomerate occurs consisting of cobbles typically 20-30 cm in diameter and coral heads of various sizes in non-growth position (Figure 3). At least part of these outcrops is also considered to be beachrock due to the dip angle typical for beaches (*ca*. 20-30°). In contrast to Sorol atoll, no beachrock was found on the lagoon side of the island.

The central and lagoon side of the island composed of sand and sandy gravel, observed also in some of the trash and well pits. The occurrence of these sediments is in agreement with the geologic map published by Tracey *et al*. (1961).

The reef flat extending along the ocean side of the island is 80 to 100 m wide (determined using Google Earth) and visually narrower than the analogous reef flat observe on Sorol Atoll, although now scaled satellite image for Sorol was available to confirm the observation. A rather small algal ridge was observed at the outer edge of the reef. Near the former channel between Ifalik and Fallap an unusual linear carbonate wall-shaped formation was observed.

Concluding remarks

The occurrence of a high storm berm consisting also of boulders, and conglomerate and beachrock outcrops containing large cobble together with the reef morphology indicate that the island has been formed under **occasional severe storm conditions** (Figure 1).

Figure 2: The prominent storm berm extending along the ocean side (east) coast of the island. The berm consists of cobbles, shingle, and boulders. On the picture is covered with vegetation. The red arrow marks the top of the berm. Along the shoreline a patchy beachrock can be seen. Ifalik.

Figure 3: Beachrock conglomerates along the northern ocean side of the island. Note the cobble-sized clasts of the conglomerate. The red arrow points to one of the beachrock bands, while the yellow arrow indicates the point where beachorck disappears under the storm berm. Ifalik.

Potential Paleokarst?

The satellite image of the Ifalik Lagoon shows submerged karst forms such as dolines or cockpit karst (Figure 4). Similar imagery in Nagura Bay (Ishigaki Island, Japan) shows similar patterns, and a bathymetric survey indicated that it is most probably submerged karst overgrown by reef organisms (Kan *et al*., 2015). Both locations, Ifalik Lagoon and Nagura Bay would have an expected high sedimentation rate that would arguably completely cover and mask the pre-existing relief. Considering the discoveries in Nagura Bay it can be thus justifiably suspected that a karst relief forms the foundations of the Ifalik lagoon. However, reef growth simulations, based on observations in the so-called cellular reefs (look alike submerged karst) of Western Australia's Houtman Abrolhos Islands show that such morphology can be self-generated by reef building organisms regardless of the substrate (Figure 5, Blakeway & Hamblin, 2015).

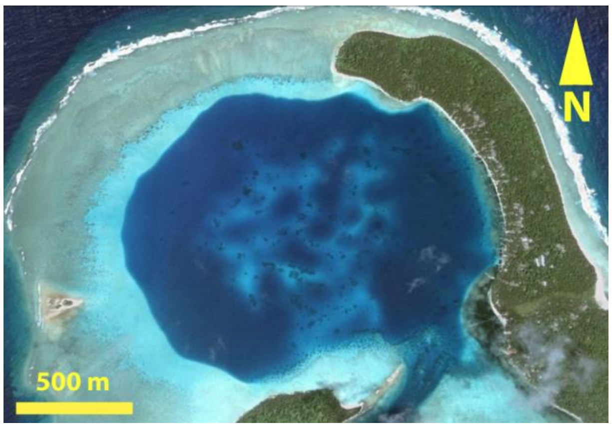

Figure 4: The bottom of the lagoon reminds of karst landscape (dolines, or cockpit karst). Source: Google Earth.

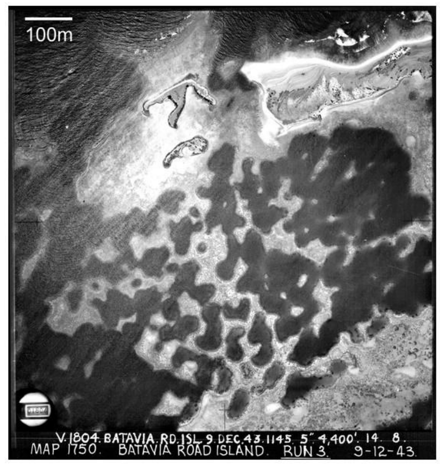

Figure 5: Cellular reefs in the Pelsaert Group lagoon, Houtman Abrolhos Islands, Western Australia. Source: Blakeway & Hamblin, 2015

E A U R I P I K A T O L L

Eauripik and Siteng Islands were examined. Both of the islands are located at the tip of the lagoon where the atoll forms a peninsular shape. Hence, the islands are virtually almost completely surrounded by a reef flat facing the open ocean. The southern side of the islands is closer to the open ocean and the reef is 400 to 500 m wide. The edge of the southern reef flat was carefully examined by swimming over it during low tide and no coral-algal ridge was observed. Individual coral cobbles but no boulders were observed on the reef flat.

Eauripik Island is entirely composed of sand. Siteng Island, on the other hand, has a distinct conglomerate basement cropping out around the whole island and covered by sand deposits (Figures 17 to 20 in Chapter Conglomerate and sea-level notch in the Evidence of Sea Level Change Report). The conglomerate consists of horizontally layered gravel-sized bioclasts. No distinct storm berm was observed on either of the two islands and no cobble-size deposits were observed (individual cobbles can be found).

Concluding remarks

The absence of a distinct storm berm and substantial deposits with cobble-sized clasts, or boulders, and the reef morphology indicate that Eauripik Atoll formed **storm free environment with rare surge** (Figure 1**)**. Considering the occurrence of the conglomerates and analogy with other reported islands, occasional more sever storms events are not excluded.

S O R O L A T O L L

Bigeliwol and Birara islands are mostly composed of sand and only in minor proportions shingle on the outer reef side of the island. The reef flat of the atoll is wide (no scaled image of the island was available to check the actual width), and no algal ridge was observed during low tide. Bigelimol and Sorol islands have more pronounced rubble outcrops. Bigelimol has a rubble ground in the central part of the island (Figure 6) while the reef side was not researched. Sorol Island also has rubble deposits on the open reef side but this side of the island was also not carefully researched due to time constraints (nightfall). All island have beachrock outcrops on the lagoon side of the atoll. No high and distinct storm berm or conglomerate basement has been observed on any of the islands (Figure 7). All the islands appear to be very low. A thin soil cover was expected on the Bigelimol Island due to its size and relatively diverse and thick tree vegetation. However, no soil cover was observed. On the rubbly ground there were, however, many tree trunks lying perpendicularly to the coastline (Figure 6).

Birara had relatively small palm trees (Figure 7), Bigeliwol and Bigelimol slightly higher. Very high, however, were palm trees on Sorol island. The age of each island was not researched.

Figure 6: The ground of the interiof or the Bigelimol Island is covered with coral cobbles but no soil is visible on the surface. The tree trunks on the ground tend to be aligned perpednicularly to the coast line. Sorol.

Figure 7: The ocean side of the Birara Island. From the top of sandy scarp seen on the picture the terrain gently pends towards the lagoon side. Compare with the ocean side of Ifalik island on Figure 1. No beach rock was observed on the ocean side of the island. Sorol.

Concluding remarks
The absence of significant coarse-grain deposits (rubble to boulder size), lack of a pronounced high storm berm and conglomerate outcrops, and the occurrence of a wide reef flat on the ocean side with no algal ridge, suggest that the atoll formed in a **storm free environment with rare surge** (Figure 1**)**. The tree trunks on Bigelimol (Figure 6) are probably aligned by waves swashing over the island during high surge. Such high surge would also remove any fine sediment such as soil possibly accumulating on the island's inner part.

The geologic evidence of relative calmness of the area is also supported by the very high palm trees on Sorol Island, which is probably also the most permanent and oldest of all the islands. The small palms observed on the other islands could be related to the age of the respective island and also its size that could limit the nutrient supply. Further, even a relatively low surge can wash away the accumulating organic top layer from such small islands.

Puzzling remains the occurrence of the beachrock which, against expectations, is commonly found on the lagoon side of the islands.

Literature

Blakeway D, Hamblin M.G., 2015. Self-generated morphology in lagoon reefs. PeerJ 3:e935 https://dx.doi.org/10.7717/peerj.935

Kan, H., Urata, K., Nagao, M., Hori, N.,Fujita, K.,Yokoyama, Y., Nakashima, Y., Ohashi, T., Goto, K., Suzuki, A., 2015. Submerged karst landforms observed by multibeam bathymetric survey in Nagura Bay, Ishigaki Island, southwestern Japan, Geomorphology, 229/15, p. 112-124.

Tracey, J.I., Abbott, D.P., Arnow, T., 1961. Natural history of Ifaluk Atoll: Physical environment. Bernice P. Bishop Musem Bulletin 222, 77 p. Honolulu, HI.

Woodroffe, C.D., 2008. Reef-island topography and the vulnerability of atolls to sea-level rise, Global and Planetary Change, 62/1–2, p. 77-96.