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Sedimentary record of Tropical Cyclone Pam from Vanuatu: implications for long-term event records in the tropical South Pacific

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Vanuatu has a history of tropical cyclones impacting its coastlines, including Tropical Cyclone (TC) Pam, a rare Category 5 event that made landfall in March 2015. Reliable records of tropical cyclones impacting Vanuatu are limited to the last several decades, with only fragmentary evidence of events extending as far back as the 1890's. Geological investigations are a means for expanding the short historical record of tropical cyclones by hundreds to thousands of years, permitting the study of even the rare, but intense events. However, geological records of past tropical cyclones are limited in their ability to quantify the intensity of past events. Modern analogues of landfalling tropical cyclones present an opportunity to characterize overwash sediments deposited by a storm of known intensity. In this study, we document the sedimentological and micropaleontological characteristics of sediments deposited by TC Pam in order to assess sediment provenance associated with a landfalling Category 5 storm.

Within three months of TC Pam making landfall on Vanuatu we surveyed high-water marks associated with the storm surge and documented the foraminiferal assemblages and grain size distributions contained within the overwash sediments from Manuro (mixed-carbonate site on Efate Island) and Port Resolution Bay (volcaniclastic site on Tanna Island). The combined use of foraminiferal taxonomy and taphonomy (surface condition of foraminifera) was most useful in distinguishing the TC Pam sediments from the underlying layer. TC Pam sediments were characterized by an influx of calcareous marine foraminifera that were dominantly unaltered relative to those that were abraded and fragmented. Similar to studies that use mollusk taphonomy to identify overwash deposits, we found that TC Pam sediments were associated with an influx of angular fragments that were broken during transport by the storm surge. A statistical comparison of foraminifera from six modern environments on Efate Island (open bay, forereef, reef crest, reef flat, mangrove, and beach) with TC Pam sediments revealed a shallow nearshore to supratidal (reef crest to beach) source, spanning depths ranging from 1.3 to -4.9 m above MSL. On Efate Island, the TC Pam sediments consisted of a medium-grained (1.20Φ), moderately well-sorted (0.55Φ), mixed-carbonate sand. At this location, the sand extended 130 m inland, where it abruptly transitioned to a pumice layer that extended 400 m inland. In contrast, TC Pam deposited a medium-grained (1.81Φ), moderately well-sorted volcanic sand at Port Resolution Bay, where the sand extended up to 320 m inland. We used a combination of measured flow heights obtained at the Port Resolution Bay site and laboratory derived grain size settling velocities to calculate the distance of sediment transport caused by TC Pam's storm surge. Based on the distribution of settling velocities from our samples, transport distances for material deposited in the trench suggests a source for the overwash sand ranging from the supratidal berm to 290 m seaward in the nearshore at Port Resolution Bay.