

# A Sedimentological Analysis of the Tafagamanu Beach Sands of Savai'i

## Abstract

The results of sedimentological analyses of the Tafagamanu Beach Sands, on the island of Savai'i in Samoa are presented here. This poster explores the origins of these sands through the use of sedimentary petrologic and oceanographic analyses. The Tafagamanu Beach Sands are suspected to originate as lagoonal fill of mid-Holocene age which was subsequently remobilized. Preliminary analysis shows the sands are characterized as loose grains with an abundance of coral/shell fragments and coarse clastic materials. The relative abundance of coral fragments versus clastic inputs, and attempts to identify the source areas of the Tafagamanu Beach Sands will be discussed.



Figure 1. Geological Map of Savai'i Island with insets of Collection Sites (Kear, D. and Wood, B.L., 1959)

## Introduction & Background

The Tafagamanu Beach Sands, located at 13° 30' 00" S/172° 48' 00" W and 13° 25' 00" S/172° 21' 00" W (Figure 1) are respectively situated within the villages of Falealupo and Fagamalo on the Samoan island of Savai'i (Kear, D. and Wood, B.L., 1959). These calcareous accumulations overlay two separate yet distinct rock formations of volcanic origin with outcrops of the Puapua rock unit occurring in Falealupo and outcrops of the Mulifanua rock unit occurring in Fagamalo. As illustrated by Figure 2 Samoa's volcanic rock formations are named from oldest to youngest: Fagaloa, Salani, Mulifanua, Lefaga, Puapua and Aopo (Jopling, Tuapou Warren, 2014). The Puapua Volcanics of Falealupo Village are composed of picrite basalts, olivine basalts, and vitrophyric basalts (Kear, D. and Wood, B.L., 1959). Due to the presence of olivine phenocrysts and plagioclase laths it can be reasonably concluded that the picrite basalt of Falealupo most likely originated from alkali olivine basalt magmas.

According to Kear and Wood (1959) the olivine basalts of the Falealupo site contain large partially resorbed phenocrysts of olivine as well as labradorite, pyroxenes, ilmenite, and feldspar. The vitrophyric basalt of Falealupo is characterized by Kear and Wood (1959) as having a groundmass of 60 % basaltic glass in which is embedded phenocrysts of all of the minerals contained by the olivine basalts in this area with the exceptions of feldspar and ilmenite. Conversely, the composition of the Mulifanua Volcanics of Fagamalo Village is restricted to picrite basalts and olivine basalts (Kear, D. and Wood, B.L., 1959). Although devoid of plagioclase laths it is possible that the picrite basalt of Fagamalo could have also originated from alkali olivine basalt magmas due to the abundance of olivine phenocrysts and the copious amount of minute titan-augite crystals. Kear and Wood (1959) describe the picrite basalt of Fagamalo as having a groundmass composed of magnetite, ilmenite, apatite, intermittent olivine, and rare laths of labradorite. The groundmass of the olivine basalt of the Fagamalo site can be characterized by its abundance of titaniferous and diopside augite which can also be associated with the iron oxides ilmenite and magnetite (Kear, D. and Wood, B.L., 1959, p. 40). As illustrated by Figure 1 situated between both villages and the ocean are flat stretches of coral sand locally referred to as Tafagamanu Beach Sand.

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## Tafagamanu Sand

The origins of the Tafagamanu Beach Sands of Falealupo and Fagamalo are according to geologist Tuapou Warren Jopling inextricably linked to rising sea levels. He describes the origins of Tafagamanu Beach Sand as being precipitated by the drowning of old coral growth by the rapidly rising sea about 15,000 to 7,000 years ago (Jopling, Tuapou Warren, 2014, 2016). The weight of this 120 m rise in sea level Jopling (2014, 2016) explains depressed the thin Pacific Plate (composed of oceanic basalt) encompassing the islands into the Earth's mantle. Then plastic mantle material or magma collected beneath the islands resulting in uplift or as Jopling (2014, 2016) refers to it "hydroisostatic rebound" which is also referred to as isostatic rebound. The result of this rebounding process was a 2-3-meter uplift for Savai'i which could as stated by Jopling (2014) be attributed to the island's location above a shallow magma pool. The uplift of the Savai'i raised strips of coral sand along the shorelines of the island (Jopling, Tuapou Warren, 2016). Jopling (2016) also states that because this Tafagamanu Beach Sand is less than 6,000 years old it supports his assertion that uplift continued after the rapid sea level rise of 15000 to 7000 years ago. Currently the coral sand beaches of Savai'i have as per Jopling (2014, 2016) been constructed by the storm erosion of the Tafagamanu Sand, the addition of new sand by wave abrasion of the coral reef, and parrot fish grinding up coral in order to obtain algae and protein.

Name	Cover of Vegetation	Weathering Zone and Soil	Present Reef	Boulders on Uneven Land	Alterations to Cone Form	Surface Water	Olivine Nodules	Age
Aopo Volcanics	None or poor	None	None	Very common	None	None	Rare	Historical
Tafagamanu Sand								Post-Glacial + 5 ft sea level
Nu'utele Sand								Post-Glacial + 15 ft sea level
Lalomauga High-level Alluvium								Post-Mulifanua
Puapua Volcanics	Normal	Very thin	None	Very common	None	Virtually none	Rare	Middle to late Holocene
Lefaga Volcanics	Normal	Intermediate	Close inshore	Very common	Little	Virtually none	Rare	Early Holocene
Mulifanua Volcanics	Normal	Intermediate	Far offshore	Common, weathered, angular	Crater filling	Rare	Uncommon	Last Glaciation
Salani Volcanics	Normal	Thick (over 12" soil)	Far offshore	Very weathered rounded	Gorges cut in flanks	Sometimes	Present	? Penultimate Glaciation or Last Interglacial, to early Last Glaciation
Vini Tuff								Last Interglacial (about ± 30 ft sea level)
Fagaloa Volcanics	Can be poor (leaching)	Very thick	None or close inshore	Rare	Up to complete destruction, dykes exposed	Always	Common	Pre-Penultimate Glaciation - possibly late Pliocene

Figure 2. Western Samoan Rock Formations (Kear, D. and Wood, B.L., 1959, p. 18).

## Hypothesis

Since the island of Savai'i has previously been supposed to have "risen with rising sea levels" the Tafagamanu Beach Sands have long been assumed to be lagoonal fill of mid-Holocene age which underwent isostatic rebound, this report will investigate the possibility that the Tafagamanu Beach Sands could be a product of remobilization.

## Methods

- Performed Sieve Shaker Analysis to measure the grain sizes within both samples.
- Visually identified the overall mineral components of both samples using a Stereomicroscope.
- Differentiated the magnetic minerals Magnetite and Ilmenite using a hand magnet.
- Performed a dilute acid test (10% HCL) on the remaining sample materials to locate any noncarbonate constituents.

## Results & Conclusions

The Stereomicroscope and sieve analysis revealed that the Tafagamanu Sand from Falealupo was subangular to angular in terms of grain shape and poorly to moderately sorted. The overall composition of the Falealupo sample was 63.6 % Calcium Carbonate (CaCO<sub>3</sub>), 26.4 % Basalt, and 10% Iron Oxides (Fe<sub>3</sub>O<sub>4</sub> and FeTiO<sub>3</sub>).

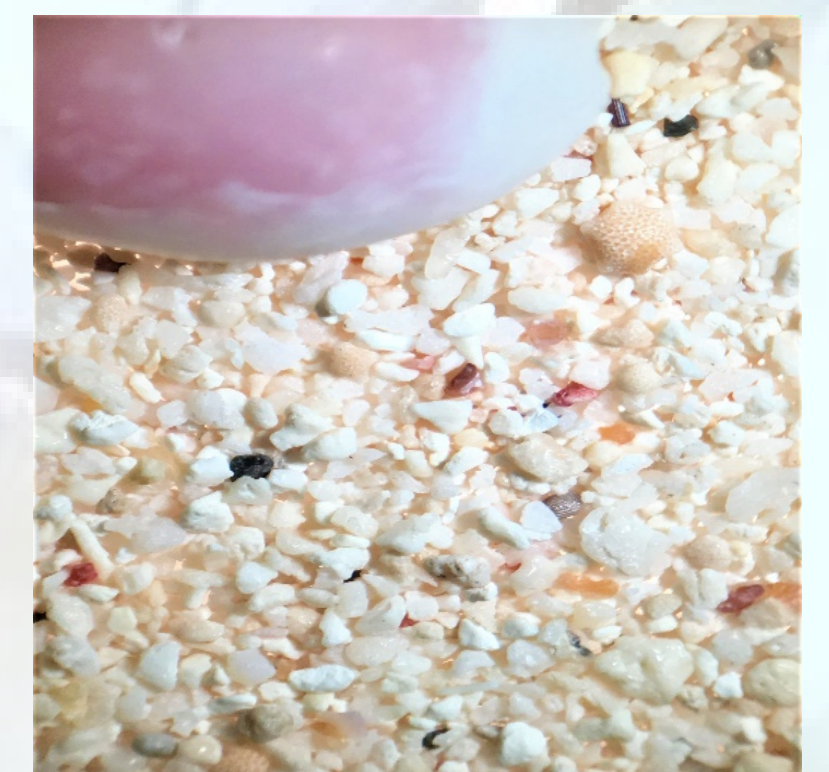
The Stereomicroscope and sieve analysis revealed that the Tafagamanu Sand from Fagamalo was sub-rounded to subangular in terms of grain shape and very poorly to poorly sorted. Coquina was only present in the Tafagamanu Sand from Fagamalo. Coarse Silt was only present in the Tafagamnu Sand from Fagamalo. Olivine was only present in the Tafagamanu Sand from Fagamalo.

The overall composition of the Fagamalo sample was 59.2 % Calcium Carbonate (CaCO<sub>3</sub>), 16.8% Iron Oxides (Fe<sub>3</sub>O<sub>4</sub> and FeTiO<sub>3</sub>), 16.7 % Coarse Silt, 6.5 % Basalt, and 0.84 % Olivine (Mg<sub>2</sub>SiO<sub>4</sub> and Fe<sub>2</sub>SiO<sub>4</sub>).

Discovering the true origins of the Tafagamanu Beach Sands will require further study, but with current evidence as presented with this report, it seems plausible that the Tafagamanu Beach Sands of Falealupo and Fagamalo are products of isostatic rebound.

Sieve Analysis of Tafagamanu Beach Sand from Falealupo Village, Savai'i

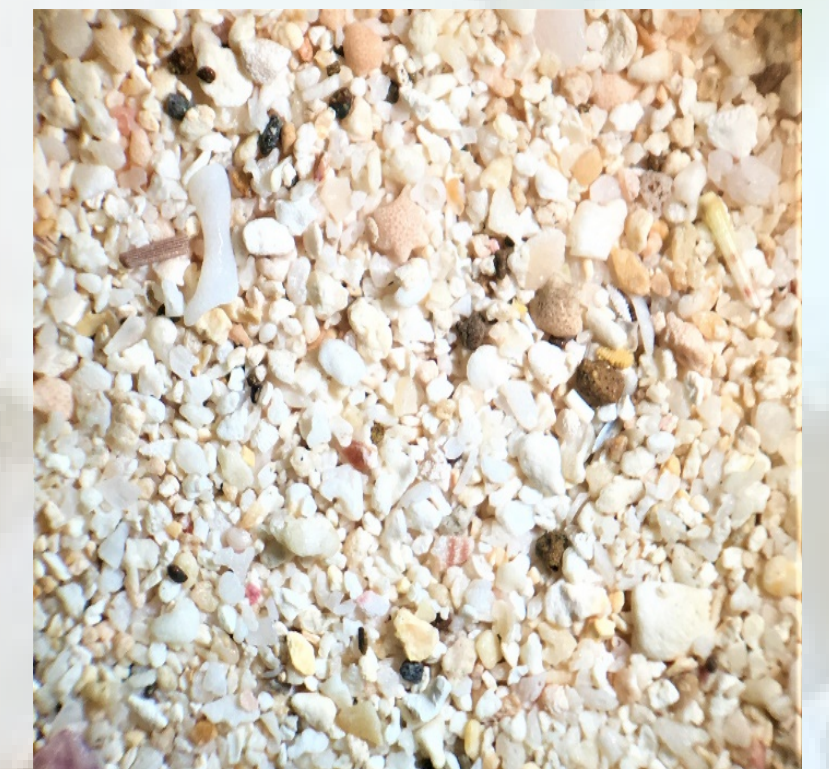
Mesh #	# 16	# 30	# 60	# 120	# 200	Bottom
Sieve Size	1.19 mm	0.59 mm	0.25 mm	0.125 mm	0.074 mm	< 0.074 mm
Mass of Sediment	1.36 g	14.69 g	23.52 g	0.41 g	0.02 g	0 g
Cumulative Mass	1.36 g	16.05 g	39.57 g	39.98 g	40 g	40 g
Percentage of Size Fraction	1.36 %	14.69 %	23.52 %	0.41 %	0.02 %	0 %
Cumulative Percentage of Mass	1.36 %	16.05 %	39.57 %	39.98 %	40 %	40 %



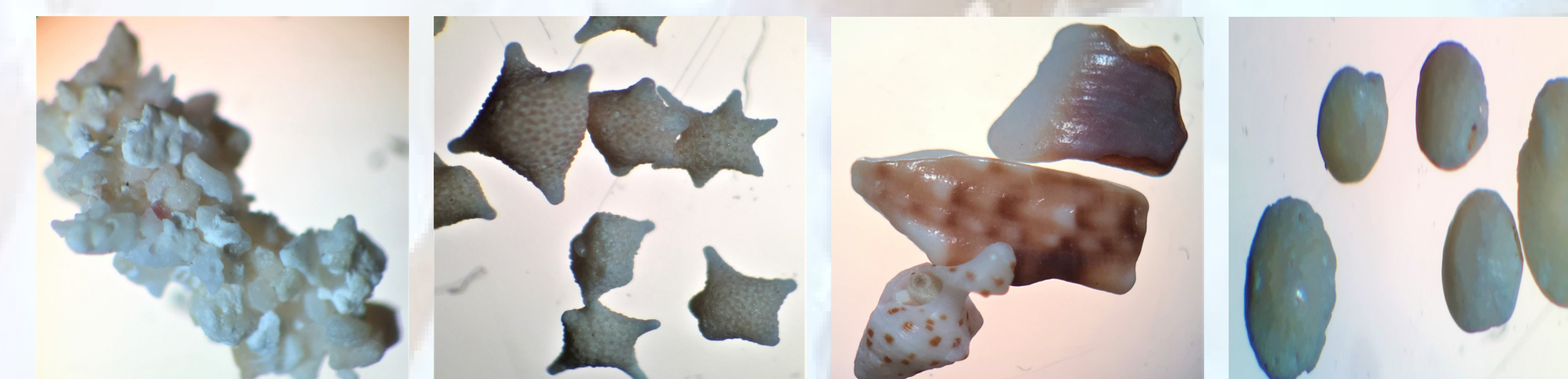
Figures 3 and 4. Falealupo Dry Sieve Analysis Results and Degree of Sorting/Grain Shape.

Sieve Analysis of Tafagamanu Beach Sand from Fagamalo Village, Savai'i

Mesh #	# 16	# 30	# 60	# 120	# 200	Bottom
Sieve Size	1.19 mm	0.59 mm	0.25 mm	0.125 mm	0.074 mm	< 0.074 mm
Mass of Sediment	0.37 g	4.33 g	27.57 g	7.62 g	0.06 g	0.89 g
Cumulative Mass	0.37 g	4.7 g	32.27 g	39.89 g	39.95 g	40 g
Percentage of Size Fraction	0.37 %	4.33 %	27.57 %	7.62 %	0.06 %	0.05 %
Cumulative Percentage of Mass	0.37 %	4.7 %	32.27 %	39.89 %	39.95 %	40 %

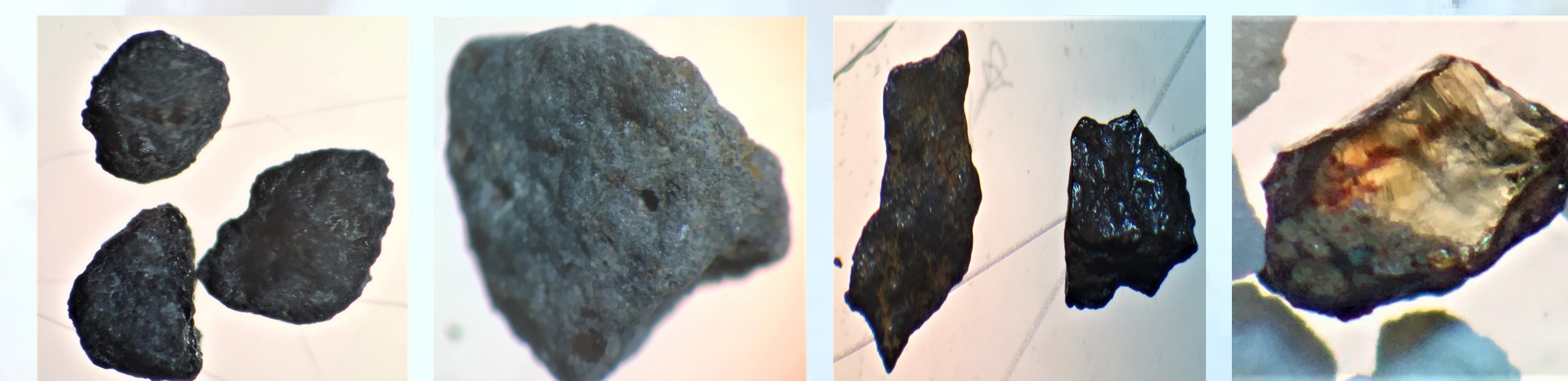


Figures 5 and 6. Fagamalo Dry Sieve Analysis Results and Degree of Sorting/Grain Shape.



(Above) Figures 7-10 (From Left to Right). Coquina (Fagamalo 1.19mm), Foramins (Fagamalo 0.59mm), Shell Fragments (Falealupo 1.19mm), and Ooids (Fagamalo 0.59mm).

(Below) Figures 11- 14 (From Left to Right). Basalt (Falealupo 0.59mm), Ilmenite (Fagamalo 1.19mm), Magnetite (Falealupo 0.59mm), and Olivine (Fagamalo 0.25 mm).



## References

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