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Site M0098[1]

J.M. Webster, A.C. Ravelo, H.L.J. Grant, M. Rydzy, M. Stewart, N. Allison, R. Asami, B. Boston, J.C. Braga, L. Brenner, X. Chen, P. Chutcharavan, A. Dutton, T. Felis, N. Fukuyo, E. Gischler, S. Greve, A. Hagen, Y. Hamon, E. Hathorne, M. Humblet, S. Jorry, P. Khanna, E. Le Ber, H. McGregor, R. Mortlock, T. Nohl, D. Potts, A. Prohaska, N. Prouty, W. Renema, K.H. Rubin, H. Westphal, and Y. Yokoyama[2]

[1] Webster, J.M., Ravelo, A.C., Grant, H.L.J., Rydzy, M., Stewart, M., Allison, N., Asami, R., Boston, B., Braga, J.C., Brenner, L., Chen, X., Chutcharavan, P., Dutton, A., Felis, T., Fukuyo, N., Gischler, E., Greve, S., Hagen, A., Hamon, Y., Hathorne, E., Humblet, M., Jorry, S., Khanna, P., Le Ber, E., McGregor, H., Mortlock, R., Nohl, T., Potts, D., Prohaska, A., Prouty, N., Renema, W., Rubin, K.H., Westphal, H., and Yokoyama, Y., 2025. Site M0098. In Webster, J.M., Ravelo, A.C., Grant, H.L.J., and the Expedition 389 Scientists, Hawaiian Drowned Reefs. Proceedings of the International Ocean Discovery Program, 389: College Station, TX (International Ocean Discovery Program). https://doi.org/10.14379/iodp.proc.389.105.2025

[2] **Expedition 389 Scientists' affiliations.**

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1. Operations

The multipurpose vessel *MMA Valour* was used as the drilling platform throughout Expedition 389. At all sites, dynamic positioning was used to provide accurate positions throughout operations and water depth was established using a Sound Velocity Profiler (SVP) placed on the top of the PROD5 drilling system. For more detail on acquisition methods, see **Introduction** in the Expedition 389 methods chapter (Webster et al., 2025a).

Summary operational information for Hole M0098A is provided in Table **T1**. All times stated are in Hawaii Standard Time (HST).

1.1. Hole M0098A

The *MMA Valour* arrived at Site M0098 at 0030 h on 13 September 2023, and at 0220 h PROD5 was deployed at a water depth of 1100.1 m. Rotary coring and casing of Hole M0098A commenced at 0440 h and continued until 1358 h on 15 September, when drilling was halted at 19.10 meters below seafloor (mbsf) following an amber alert from the bridge. This was due to a fault in one of the ship's engines and subsequent difficulties with the vessel holding position in strong winds and currents. The captain of the *MMA Valour* requested that PROD5 be recovered to deck at 1415 h, and Hole M0098A was abandoned. Casing was removed, and PROD5 was recovered to deck at 1458 h. On-deck extraction of core barrels commenced, and at 1715 h, the vessel transited to Site M0097 and calmer weather closer to shore while the engine fault was repaired.

A total of 23 cores were recovered from Hole M0098A from 19.10 m of rotary coring, and the total recovered core length was 8.42 m (45.44% recovery).

Table T1. Hole summary, Site M0098. R = rotary coring mode, W = wash down mode. LAT = Lowest Astronomical Tide. **Download table in CSV format.**

Hole	Water depth (mbsf)	Date started (2023)	Date finished (2023)	Latitude	Longitude	Coring method	Total drilled depth (m)	Recovered length (m)	Core recovery (%)	Cores (*N*)	Notes
389-M0098A	1100.1	13 Sep	15 Sep	20.055425°	−156.189735°	R, W	19.10	8.42	45.44	23	LAT water depth: 1099.5 m. Washed 19.10–20.07 m. Vessel amber alert, drill was recovered.

2. Lithostratigraphy

Hole M0098A was cored in the Kawaihae region, in the vicinity of Mahukona, at 1100.1 meters below sea level (mbsl). The hole's total depth is 19.22 mbsf, and based on the main lithologic changes, discontinuity surfaces, and/or changes in physical properties, it is possible to identify four main intervals (Figure **F1**):

- Interval 1 (0–0.35 mbsf) consists of coralgal boundstone and is bounded at its base by a major facies change.
- Interval 2 (0.35–1.97 mbsf) consists of a succession of unconsolidated sediments, coralgal boundstone, and grainstone and is bounded at its base by a major facies change.
- Interval 3 (1.97–11.04 mbsf) consists of coralgal boundstone and is bounded at its base by a facies change.
- Interval 4 (11.04–19.22 mbsf) consists of coralgal-microbial boundstone.

2.1. Hole M0098A

In Hole M0098A (Figure **F1**), fragmented to in situ coralgal boundstone was recovered from 0 to 0.35 mbsf. The boundstone contains a laminar coral (undetermined; Figure **F2**), several heavily bioeroded coral clasts (undetermined), and grainstone with gastropods (shells preserved),

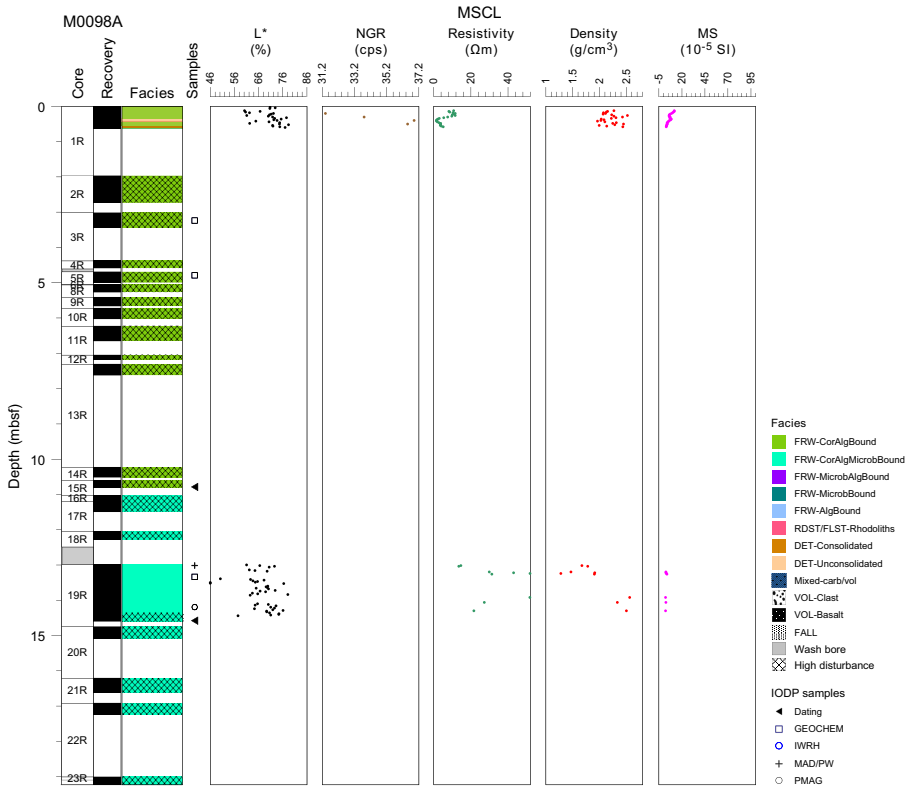

Figure F1. Lithostratigraphy and MSCL data, Hole M0098A. cps = counts per second, MS = magnetic susceptibility.

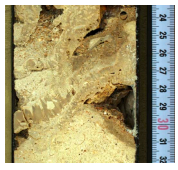

Figure F2. Lithologies, Hole M0098A. Coralgal boundstone with a laminar coral (1R-1, 23–32 cm).

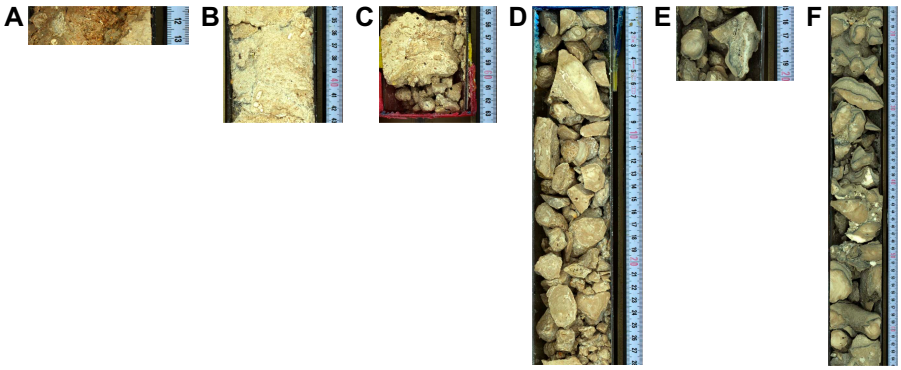

Figure F3. Lithologies, Hole M0098A. A. Bioclastic grainstone (1R-1, 12–13 cm). B. Unconsolidated sediments (1R-1, 34–43 cm). C. Grainstone (1R-1, 55–61 cm). D. Fragmented coralgal boundstone (3R-1, 0–28 cm). E. *Pavona*? (21R-1, 16–18 cm). F. Fragments of coralgal-microbialite boundstone (19R-1, 16–65 cm) composed mainly of branching *Porites*.

bivalves, and echinoid spines (Figure **F3A**). There are also a few infilled cavities and worm tubes within the boundstone. Unconsolidated sediments from 0.35 to 0.42 mbsf (Figure **F3B**) include bivalves, echinoid spines, and several other bioclasts. Coralgal boundstone from 0.42 to 0.55 mbsf has foliaceous and laminar corals, crustose coralline algae (CCA), and a few cavities filled with soft sediment. Grainstone from 0.55 to 0.63 mbsf (Figure **F3C**) consists of gastropods, worm tubes, *Halimeda* plates, echinoid spines, and coral fragments. No core was recovered from 0.63 to 1.97 mbsf. From 1.97 to 11.04 mbsf, coralgal boundstone (Figure **F3D**) has considerable drilling disturbance and abundant fragments of branching *Porites*, some of which are bored (e.g., *Gastrochaenolites*? at 10.33 mbsf) and encrusted with CCA. The boundstone also contains intervals of soft sediments, a crab claw (at 5.10 mbsf), and echinoid spines. Some coral branches show geopetal infills in borings, indicating that they are not in situ (e.g., 6.23–6.65 mbsf). Coralgal-microbial boundstone (disturbed by drilling operations) is present from 11.04 to 19.22 mbsf and has abundant fragments of branching *Porites* that are bored (*Entobia*?) along their margins (e.g., 11.05 mbsf) and encrusted with thin CCA and microbialite crusts. There are also a few small solitary corals at 13.40 mbsf, a *Pocillopora* clast at 14.05 mbsf, *Pavona* at 16.40 mbsf (Figure **F3E**), and echinoid spines (e.g., at 13.82 mbsf). Within the fragmented coralgal-microbial boundstone interval, an in situ nondisturbed coralgal-microbial boundstone (Figure **F3F**) from 12.98 to 14.35 mbsf consists predominantly of branching *Porites* (including *Porites compressa*?) with thin microbialite coatings and an important framework primary porosity.

3. Physical properties

Physical properties data for Site M0098 are shown in Table **T2** in the Site M0096 chapter (Webster et al., 2025b).

3.1. Hole M0098A

A total of 2.00 m of core was scanned with the multisensor core logger (MSCL), and because the core exhibited major drilling-induced disturbance, 35% of the acquired data passed QA/QC (see Table **T10** in the Expedition 389 methods chapter [Webster et al., 2025a]). Moisture and density (MAD) measurements were conducted on one discrete sample. The sampled plug was too friable to test for *P*-wave transmission. Digital linescans, color reflection data, and hyperspectral images were acquired for all core sections.

3.1.1. Density and porosity

Data from density and porosity measurements are presented in Figures **F1** and **F4**. MSCL bulk density values range 1.28–2.56 g/cm^3. One discrete sample (389-M0098A-19R-1, 4–7 cm) was analyzed for MAD, giving a bulk density of 2.31 g/cm^3, a porosity of 26.7%, and a grain density of 2.781 g/cm^3.

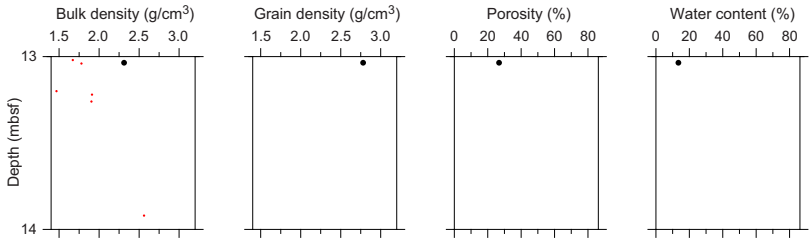

Figure F4. Physical properties, Hole M0098A. Black = discrete samples, red = MSCL.

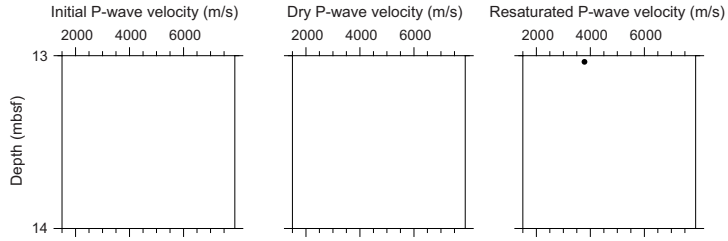

Figure F5. Initial, dry, and resaturated *P*-wave velocities measured on the discrete sample, Hole M0098A. *P*-wave velocities were not obtained off shore or for the dry sample (see text).

3.1.2. *P*-wave velocity

MSCL *P*-wave velocity measurements for Hole M0098A yielded no data. No *P*-wave velocity value was obtained for the dry discrete sample because the sample was too friable to test. A *P*-wave velocity of 3789 m/s was obtained for the resaturated sample (Figure **F5**).

3.1.3. Thermal conductivity

Because of the presence of drilling-induced disturbance, large voids, and uneven surfaces, thermal conductivity measurements were not performed on cores from Hole M0098A.

3.1.4. Magnetic susceptibility

MSCL magnetic susceptibility data range -0.61×10^{-5} to 8.88×10^{-5} SI (Figure **F1**). However, most magnetic susceptibility values average around 2.86×10^{-5} SI. Hole M0098A shows a trend of decreasing values from 0 to 0.6 mbsf (8.9×10^{-5} to 0.1×10^{-5} SI). Between 13.00 and 14.30 mbsf, values range -0.6×10^{-5} to 0.9×10^{-5} SI.

3.1.5. Electrical resistivity

MSCL noncontact resistivity ranges 1.46–51.80 Ωm (Figure **F1**).

3.1.6. Natural gamma radiation

MSCL natural gamma radiation (NGR) measurements range 31–37 counts/s and show no apparent trend downhole (Figure **F1**).

3.1.7. Digital linescans, color reflectance, and hyperspectral imaging

All Hole M0098A cores were digitally linescanned, measured for color reflectance (where appropriate), and imaged with the hyperspectral scanner (see HYPERSPECTRAL in **Supplementary material**). Color reflectance L* values vary between 30.32% and 78.33%, a* varies between –0.63 and 7.61, b* varies between 8.78 and 26.23, and a*/b* varies between –0.06 and 0.29 (Figure **F1**).

4. Geochemistry

4.1. Interstitial water

No interstitial water samples were collected from Site M0098.

4.2. Surface seawater

One surface seawater sample was collected from Site M0098 (Hole M0098A) using an improvised sampling device deployed from the side of the vessel (see Figure **F22** in the Expedition 389 methods chapter [Webster et al., 2025a]). The salinity, pH, alkalinity, and concentrations of ammonium were analyzed off shore, and major cations and anions were measured during the Onshore Science Party (OSP). The pH, alkalinity, ammonium, and major element chemistry measured for this sample are consistent with the other surface seawater samples taken during Expedition 389 and align with the expected values for conservative elements in seawater. Salinity is slightly higher than for the other samples (36 psu) (see Tables **T15** and **T17** in the Expedition 389 methods chapter [Webster et al., 2025a]).

4.3. Bulk sediment

A total of three bulk sediment samples were taken from Site M0098 (Hole M0098A) (Figure **F1**) and analyzed for mineralogy, elemental composition, and carbon content (Table **T2**). These samples were derived from coralgal boundstone and coralgal-microbialite boundstone facies (see Figure **F10** in the Expedition 389 methods chapter [Webster et al., 2025a]).

4.4. Mineralogy

Mineral abundances for Hole M0098A are shown in Table **T2**. Bulk geochemistry samples from Hole M0098A are dominated by carbonate minerals, which make up 100% of the mineral abundance. The two uppermost samples were taken from the coralgal boundstone, and the lower sample comes from the coralgal-microbialite boundstone. However, all samples are rich in aragonite (82%–43%) followed by high Mg-calcite (55%–4%), whereas calcite abundance is low (0%–4%). Sample 389-M0098A-5R-1, 10–12 cm (4.82 mbsf), also contains 13% of manganocalcite, kutnohorite, or rhodocrosite.

4.5. Elemental abundances

The solid-phase elements including Ca, Mg, Sr, Ni, and Rb are briefly described below for Hole M0098A. Al, Br, Fe, K, Mn, Si, S, Ti, Zr, Cr, Cu, V, and Zn are listed in Table **T3**.

Solid-phase Ca content is high in all three samples, ranging 348,645–364,976 mg/kg. Magnesium content is variable and ranges 15,753–33,273 mg/kg. All three samples have a high Sr content (3,225–6,002 mg/kg), and Ni is present, ranging 15–25 mg/kg. All other elements are minor and/or below the detection limit.

4.6. Carbon content

The results for total organic carbon (TOC), total carbon (TC), and total inorganic carbon (TIC) are presented in Table **T4**. TC content ranges 11.80%–11.90%, TOC content ranges 0.13%–0.23%, and TIC content ranges 11.57%–11.75%. All three samples show similar amounts of TC; however, Sample 389-M0098A-3R-1, 22–31 cm (3.24 mbsf), shows almost double the amount of TOC than the other two samples and therefore slightly less TIC.

Table T2. Mineral abundances, Site M0098. **Download table in CSV format.**

Table T3. Bulk elemental compositions, Hole M0098A. **Download table in CSV format.**

Table T4. TOC, TC, and TIC, Hole M0098A. **Download table in CSV format.**

Table T5. Magnetic susceptibility and NRM, Hole M0098A. **Download table in CSV format.**

Core, section, interval (cm)	Sample type	Depth (mbsf)	Magnetic susceptibility (m^3/kg)	Initial NRM Intensity (A/m)
389-M0098A-19R-1, 122–127	Coral	14.23	-1.02×10^{-8}	5.18×10^{-5}

5. Paleomagnetism

One paleomagnetism sample was obtained from Hole M0098A. The low-field and mass-specific magnetic susceptibility (χ) measurement and initial natural remanent magnetization (NRM) were determined for this sample. NRM was also measured following stepwise alternating field demagnetization up to 20 mT. For further details, see **Paleomagnetism** in the Expedition 389 methods chapter (Webster et al., 2025a). Paleomagnetism data for Site M0098 is shown in Table **T5**.

5.1. Hole M0098A

One carbonate sample was taken at 14.23 mbsf in Hole M0098A (Sample 19R-1, 122–127 cm). The χ value of the sample is -1.02×10^{-8} m^3/kg, and the initial NRM intensity is 5.18×10^{-5} A/m.

6. Geochronology

A total of two U-Th dates were measured on samples from Hole M0098A, neither of which were rejected (see Tables **T21** and **T22** in the Expedition 389 methods chapter [Webster et al., 2025a]). These dates range ~410–421 ky BP, consistent with the estimated age of the H8 terrace (Ludwig et al., 1991; Webster et al., 2009).

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