Geomorphic Analysis of Mid-Cayman Rise's Mount Dent and Northeast Seamount

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BACKGROUND

The Mid-Cayman Spreading Center on the Mid-Cayman Rise, is approximately 107.4 km southwest of Grand Cayman Island. This area is ~15 million years old (Muller et al., 2008).The process that occurs here to accommodate plate separation is injection of magma into the gap that forms as the Caribbean and North American Plates pull apart (Cheadle and John, 2011). This mid-ocean ridge is spreading at a rate of 15-17mm/yr., which classifies the ridge as an ultra-slow spreading ridge (Mueller et al., 2008). What is known about these poorly understood ultra-slow spreading ridges is the associate formation of oceanic core complexes (OCC). OCCs have exposed, rock from the crust and mantle emergent at the ridge axis. OCCs reveal how the Earth's crust grows, providing greater insight into geophysical and geochemical processes that occur here and at other similar sites (Cheadle and John, 2011). Much of a seamount is made of basalt that plumed upward and cooled. However, during NOAA Ocean Exploration's ROV dive (EX1104-Dive06) peridotite (mantle) and gabbro (lower crust) rocks were found, indicating mantle exposure (NOAA EX1104, 2011). Hydrothermal vents were also found with abundant extremophile biota.

The main focus of this study is to compare the geomorphology of Mount Dent, a known OCC, with a seamount located ~51 km from Mount Dent on the opposite side of the ridge axis, referred to here as Northeast Seamount to possibly identify Northeast Seamount as an additional OCC. Comparisons use bathymetric surfaces, backscatter, and profiles of both sites.

(Below) a cross-section block diagram that illustrates key traits of Mount Dent as an Oceanic Core Complex (Image from Haughton et al., 2019)

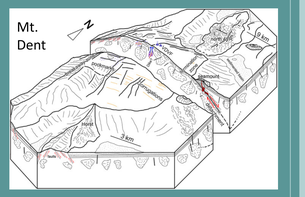
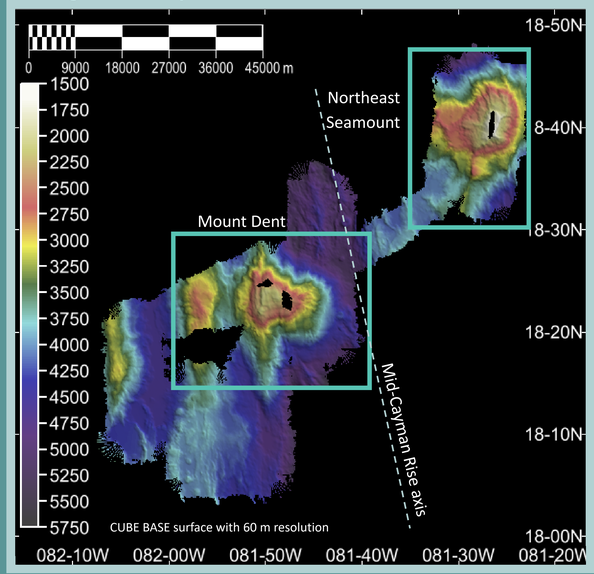


Figure 1. Study Area and Site Locations

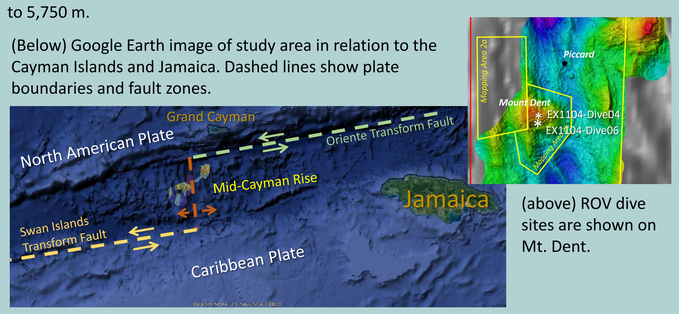


ROV *Little Hercules*

NOAA Ship *Okeanos Explorer*

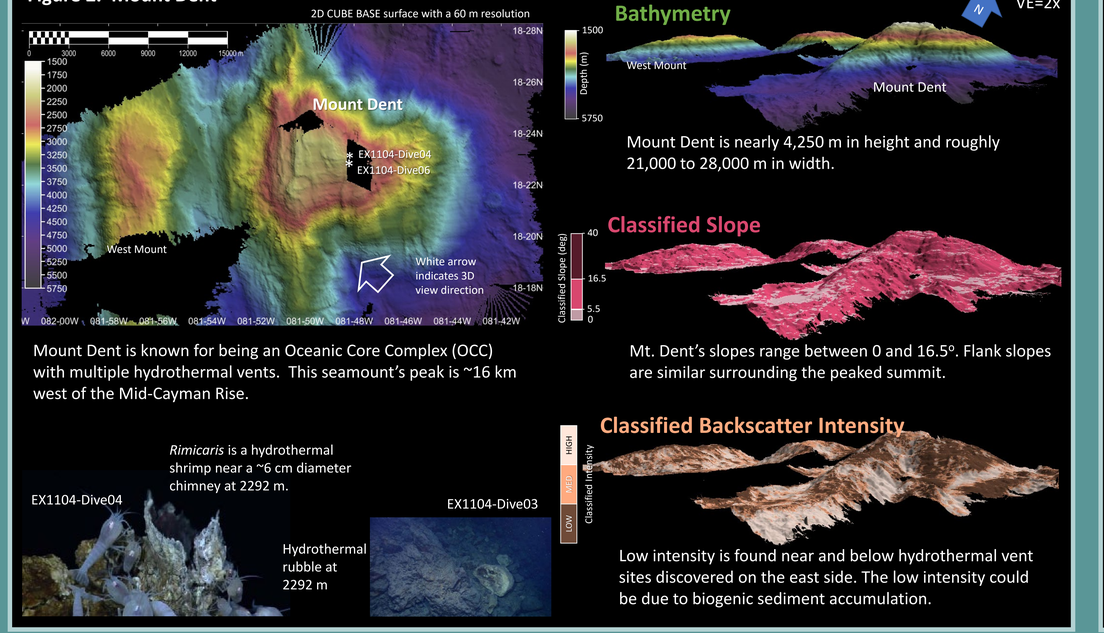
The study area lies within the Cayman Trough and includes the Mid-Cayman Rise, a spreading ridge. Two site locations are separated by the rise, each of which has a prominent seamount. The "Northeast Seamount" has not been explored, however during the NOAA 2011 expedition Mount Dent was explored using numerous ROV dives. The study area varies in depth from 1,500 to 5,750 m.

(Below) Google Earth image of study area in relation to the Cayman Islands and Jamaica. Dashed lines show plate boundaries and fault zones.



(above) ROV dive sites are shown on Mt. Dent.

Figure 2. Mount Dent



Mount Dent is known for being an Oceanic Core Complex (OCC) with multiple hydrothermal vents. This seamount's peak is ~16 km west of the Mid-Cayman Rise.

Mount Dent is nearly 4,250 m in height and roughly 21,000 to 28,000 m in width.

Mt. Dent's slopes range between 0 and 16.5°. Flank slopes are similar surrounding the peaked summit.

Rimicaris is a hydrothermal shrimp near a ~6 cm diameter chimney at 2292 m.

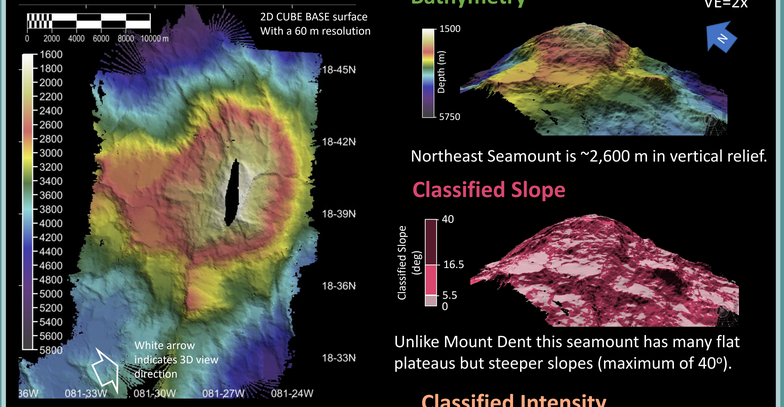
EX1104-Dive04

Hydrothermal rubble at 2292 m

EX1104-Dive03

Low intensity is found near and below hydrothermal vent sites discovered on the east side. The low intensity could be due to biogenic sediment accumulation.

Figure 3. Northeast Seamount



Northeast Seamount is ~45 km northeast of the Mid-Cayman Rise and is ~40 km south of the Oriente Transform Fault (Fig. 1). Northeast Seamount is more elliptical than Mount Dent.

Northeast Seamount is ~2,600 m in vertical relief.

Unlike Mount Dent this seamount has many flat plateaus but steeper slopes (maximum of 40°).

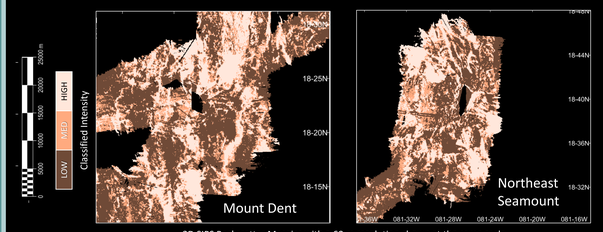
Plateaus show high intensity while sloping areas show a low intensity, suggesting exposed rock on the plateaus and sediments on the slopes.

METHODS

- Raw multibeam sonar data collected by NOAA Ship *Okeanos Explorer* using a Kongsberg EM302 Multibeam echosounder.
- Raw sonar data were processed using CARIS HIPS and SIPS 11.4.
- Images and data collected using 60 m resolution 2D and 3D surfaces detail the bathymetry and slope.
- A 60 m resolution 2D and 3D classified backscatter intensity was used to study and compare intensity values.
- Seafloor images and dive logs of ROV *Little Hercules* EX1104 DIVE01-DIVE12 were used to ground-truth sonar data.

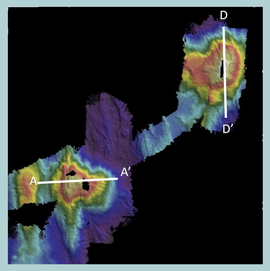
Figure 4. Comparative of Backscatter Intensity

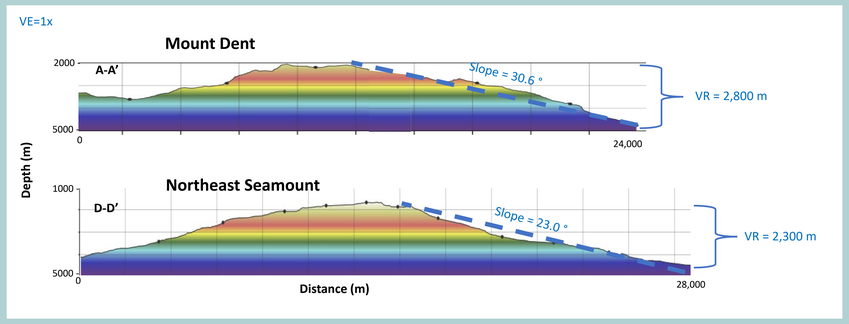
The rock composition at Northeast Seamount is not known, as there are no substrate images. Basalt is likely a main component given how seamounts form from basalt eruptions at axial rifts. Similar patterns of backscatter intensity suggests the two seamounts could have similar substrate, where high intensity may indicate peridotite and gabbro found near the top of Mount Dent (EX1104-Dive06). Areas with low intensity suggest substrate with biogenic sediment accumulation.



2D SIPS Backscatter Mosaics with a 60 m resolution shown at the same scale.

Figure 5. Comparative Profiles





Profiles of each seamount are shown at the same scale, with no vertical exaggeration. The vertical relief (VR) and flank slope of the seamounts are very similar. Though Classified Slopes of the seamounts show Northeast Seamount as having steeper slopes, the greatest overall slope is close to that of Mt. Dent (Fig. 2&3). Given these similarities, Northeast Seamount appears to have the capacity to have formations like those found on Mt. Dent i.e. hydrothermal vents or exposed mantle.

DISCUSSION and CONCLUSIONS

The observed similarities between Mt. Dent, a known OCC, and Northeast Seamount support the hypothesis that Northeast Seamount is also an OCC. Northeast Seamount is steeper than Mt. Dent, but the two seamounts are similar in size and shape. Backscatter intensity shows a similar pattern and distribution of high intensity, so the seamounts may have similar substrate, potentially composed of upper mantle peridotite and gabbro, as well as low intensity biogenic sedimentation. The Northeast Seamount is on the other side of the ridge axis almost parallel to Mt. Dent. A ridge axis can often have the same feature on both sides due to symmetrical formation during divergence. Further research, exploration and ROV dives at the Northeast Seamount would verify its occurrence as an OCC and identify areas of hydrothermal venting. Having more sites to study would be beneficial to improve our limited understanding of OCCs. The strong association of OCCs with hydrothermal vents also makes them of interest to biochemical and geochemical research.

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