Earthquake catalog from a year+ of seismic monitoring on Bioko Island, Equatorial Guinea

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Abstract

Equatorial Guinea's Bioko Island is located in the Atlantic Ocean off the west coast of Cameroon. It is a volcanic island and the first off-shore expression of the Cameroon Volcanic Line. It is home to three shield volcanoes: Pico de Basile, Pico Biao, and Gran Caldera de Luba. Eruptive history is only known for Pico de Basile which erupted within the past 100 years, and steam vents were observed as recently as 2012. There is no permanent seismic monitoring; the closest seismic stations are in Cameroon and have not reported data since 2015. In Nov. 2017 Drexel University researchers, supported by the Bioko Biodiversity Protection Program (BBPP) and the Universidad Nacional de Guinea Ecuatorial (UNGE), installed 4 broadband seismometers. Two more stations were installed in March of 2019. Due to the COVID-19 pandemic data from the two most recent stations has yet to be retrieved and analyzed. Local collaborators reported a station was vandalized. It is unknown at this time how much data was recorded by this station. Preliminary earthquake detection and location was completed using an automated STA/LTA algorithm. S wave arrivals were added manually. Initial locations use the global IASP91 model and events were relocated using a local model. Events cluster into two areas: those near Bioko Island and those near Cameroon. Between 12-Dec-2017 and 17-Feb-2018, 77 events were recorded. Local magnitudes range between 0.16 and 2.61. Of these events, 49 are located near Cameroon and 28 are near Bioko. Most of the depths are upper to mid-crust. Analysis of the entire data set yields 458 events with 367 near Bioko Island and 91 near Cameroon. The range in local magnitude is -0.28 – 3.86. Our preliminary results show seismicity associated with Bioko Island as well as Cameroon. Locations match well with events recorded by a regional network in Cameroon. Stations were serviced in Feb. and Nov. 2018 and March 2019. Failures have been due to water infiltration, vandalism, and heavy cloud cover. Enclosures were redesigned after the Feb. 2018 service. All stations were upgraded to the new design in Nov. 2018 and solar panels were upgraded (20 to 35 watt) in March 2019. The next anticipated service was to be completed in March 2020 but was canceled due to the COVID-19 pandemic. The next anticipated service will occur in March 2022 if travel restrictions allow.

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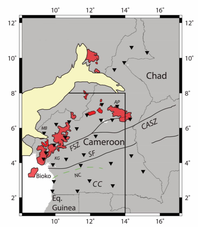
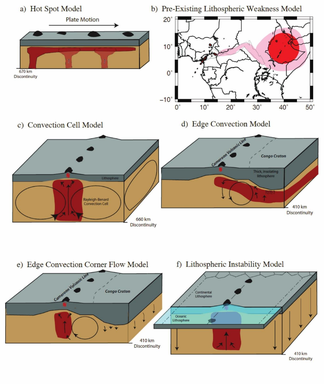
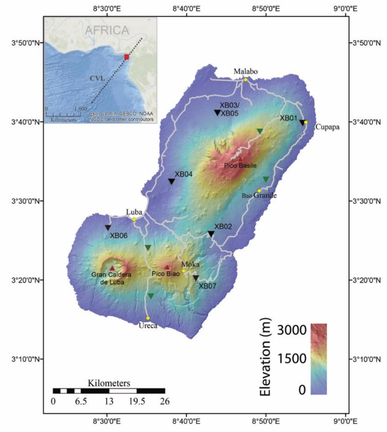
2. Background and Prior work



The CVL has been studied using the Cameroon Seismic Network (2005-2007). The top left figure (after Tokam et al., 2010) shows the network configuration and CVL magmatic bodies. Many models and hypotheses have been proposed to explain the CVL such as those summarized by Adams et al. (2015, bottom left). This work builds on the prior experiment and includes a newly installed network on Bioko Island (bottom right).





3. Challenges

Locally available materials. Finding plastic totes was surprisingly difficult. We finally settled with small plastic children's play boxes. The lids did latch, but there were no seals or gaskets to prevent water infiltration. Water was the primary problem. One station failed in January because the charge controller (housed in a pelican case) suffered water infiltration. Another station failed one week after the February service, also due to water infiltration.

Sun availability. Surprisingly at the equator it can be difficult to get a full day of sun. Many days are quite hazy. It is also rather difficult on a tropical island to find clearings that offer good views of the sun. Vegetation grows quite fast and we provide a structure for vines to climb with our solar panels. Many clearings are also not appropriate for stations. For instance near the southern volcanoes, clearings tend to be lava flows.

Vandalism. We try to prevent vandalism by selecting sites less likely to be seen by passers-by. However we were apparently unsuccessful as station XB03 was vandalized about a week after servicing in February. The vandals stole the battery from the equipment enclosure. Luckily they pulled the cable from the battery and not from the Centaur, so our equipment seems to be in working order (further testing will determine if refurbishing is necessary). Solar panel theft in 2020 caused one of the newest stations to be retrieved after less than a year.

4. Station Design

November 2018 | March 2019 | November 2018 | March 2019

- Upgraded solar panels and mounts
- Solar panels mounted on adjustable arm
- Centaur, charge controller, and GPS mounted in a NEMA box enclosure mounted on pole beneath solar panel
- Battery buried in battery box to stabilize pole

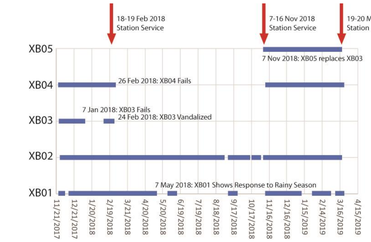
References

Adams, A. N., Wiens, D. A., Nyblade, A. A., Euler, G. G., Shore, P. J., & Tibi, R. (2015). Lithospheric instability and the source of the Cameroon Volcanic Line: Evidence from Rayleigh wave phase velocity tomography. Journal of Geophysical Research: Solid Earth, 120(3), 1708-1727, doi:10.1002/2014JB011580.

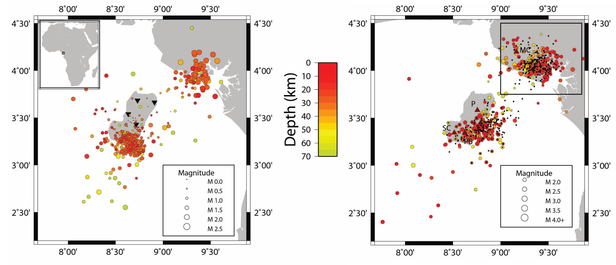
Tokam, A., Tabod, C., Nyblade, A., Julia, J., Wiens, D., and Pasyanos, M. (2010), Structure of the crust beneath Cameroon, West Africa, from the joint inversion of Rayleigh wave group velocities and receiver functions, Geophys. J. Int., 183(2), 1061-1076.

Wiens, D. and Nyblade, A. (2005), Broadband Seismic Investigation of the Cameroon Volcanic Line. International Federation of Digital Seismograph Networks. Other/Seismic Network, doi:10.7914/SN/XB_2005.

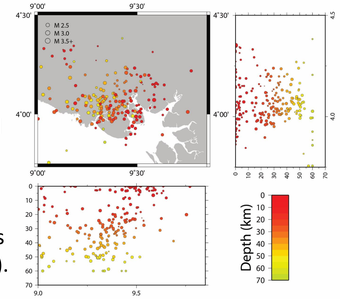
5. Data Retrieval



6. Results



Data retrieved in February 2018 (recorded beginning in late November 2017) indicate a level of seismicity comparable to that previously recorded by stations located in Cameroon. Data collected by both networks (Bioko network upper left, Cameroon Seismic Network upper right) shows that earthquakes are in a similar locations (typically in the Southeastern region). Left shows depth slices of figure indicated by box in upper right.



7. Conclusions and Future Work

- Earthquake patterns are consistent between data collected in 2005-2007 and 2017-present. These patterns are also consistent with reported event locations from the Mt. Cameroon Observatory network.
- More than 30 years of data (including anecdotal reports from Mt. Cameroon Observatory) show the same patterns.
- 458 events were located with the local Bioko network from 2017-2019.
- 367 near Bioko Island and 91 near Cameroon. The range in local magnitude is -0.28 – 3.86.
- 428 events were located with data collected by the Cameroon Seismic Experiment from 2005-2007.
- 190 events were located in Cameroon and 171 near Bioko. The range in local magnitude is 0.84-5.26.
- Future work includes returning to Bioko to collect data recorded since March 2019.
- Future analysis includes: tomography, receiver functions, and shear wave splitting.