Surface wave analysis of Botswana using two-station and ambient noise methods

Introduction

NARS-Botswana is a temporary seismological network of 21 seismometers that is currently installed in Botswana. Its main aim is to explore the subsurface structure and the geodynamical framework of one of the least studied areas in Africa and the world. In this study we use surface wave analysis to obtain insight into the tectonic framework of the study area. Here we present preliminary results for data from 13 NARS-Botswana stations and an additional GSMN station (LTBT). Fig. 1 shows the stations used here (NARS) in yellow color while we are still waiting for data from (NARS-W) stations in grey color.

The area is characterized by complex tectonics between the Kaapvaal Craton in the south-east and the Congo Craton in the north-west. It includes mobile fold belts of Palaeo-Proterozoic, Palaeo-Mesoproterozoic and Neo-Proterozoic age, with ophiolites and main faults trending northeast-southwest, and a supposed buried ancient craton called (Maltahohe) in the south-western part (Begg et al., 2009).

Two-station analysis

Interstation phase velocities were obtained from the cross-correlations of the vertical component records of earthquakes within 7 degrees from the interstation azimuth and epicentral distances from 5 to 120 degrees. The data were corrected for instrument response and decimated to 1 Hz. After visual inspection of the cross-correlations, the phase velocities were determined by frequency-time analysis (FTAN; Bensen et al., 2001). It is based on minimizing a penalty function based on data mismatch, model smoothness, and perturbation from a reference model. Here we show our first results for a 9 x 9 grid with a smoothing distance of 111 km with a weight threshold of 20.

Rayleigh wave dispersion curves for periods of 3 to 40 seconds were extracted for 3 months of noise data between March and June 2014 using the methodology by Poli et al., (2013).

- 4-hour time windows.
- Exclude windows that contain amplitudes larger than 10 times the standard deviation of the window data.
- Instrument correction.
- Decimation to 1 Hz.
- Spectral whitening.
- Cross-correlation.

We then applied FTAN with a signal to noise ratio (SNR) threshold of 20.

Ambient noise analysis

We inverted the dispersion curves into phase velocity maps for periods 3-40 seconds using the method of Barmin et al. (2001). It is based on minimizing a penalty function based on data misfit, model smoothness, and perturbation from a reference model. Here we show our first results for a 9 x 9 grid with a smoothing distance of 111 km with a weight threshold of 20.

In general, the phase velocities showed agreement with the tectonic features:
- 5-15 sec maps: The most obvious feature is the low-velocity area of the Nosop basin in the southwest. Also, the high-velocity areas of Kaapvaal and Zimbabwe cratons can be identified. Moreover, a low-velocity feature can be recognized from the Damara belt (Okavango rift system) towards the Passarge basin and Okwa block.
- 15-30 sec maps: The obvious features are the high-velocity area of the Kaapvaal Craton and the low-velocity area under the Passarge basin and Okwa block. This low-velocity anomaly can be related to the development of the incipient Okavango rift zone. Moreover, a high-velocity feature starts to develop under the Nosop basin. This can be either extension of the Kaapvaal Craton or a buried ancient craton (Maltahohe) as suggested by Begg et al., (2009).

Conclusions

- The estimated phase velocity maps showed a good agreement with the tectonic provinces in the study area.
- A low-velocity anomaly has been found underneath Damara belt, Passarge basin, and Okwa block, which may be related to the development of the incipient Okavango rift system.
- High-velocities have been detected at periods 20-30 sec in the south-west underneath the Nosop Basin which can be related to a buried craton.

Future work: By next year, more data will be available to improve the data coverage and the quality of the measurements of the two-station (period 15-100 sec) and noise (period 5-30 sec) analyses. The phase velocity maps will then be inverted for a 3D tomographic shear-wave velocity model to image the subsurface structure of the study area.

References


For more information

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