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Refined parameters for the 20 December 2020 earthquake in Gaborone

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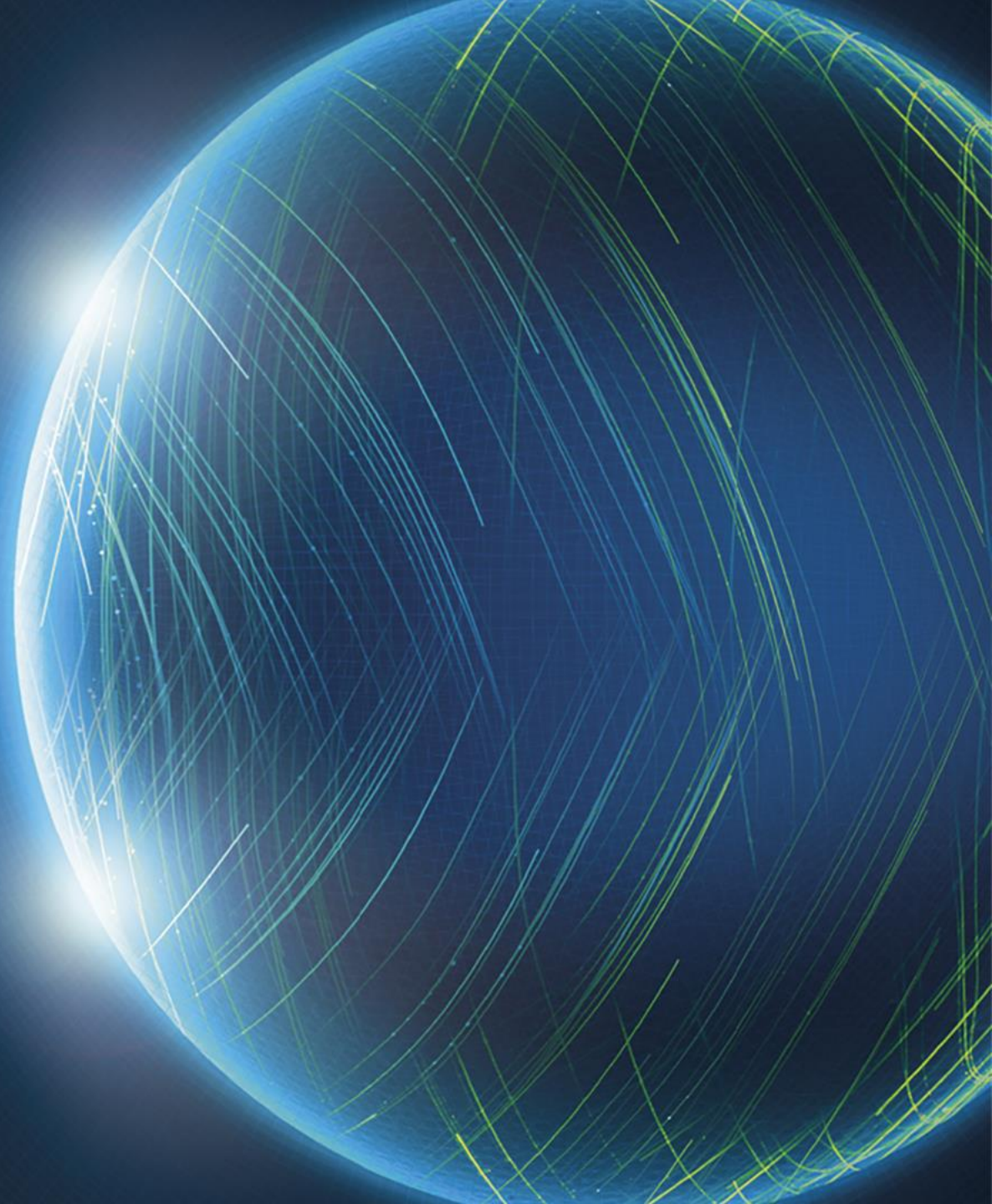
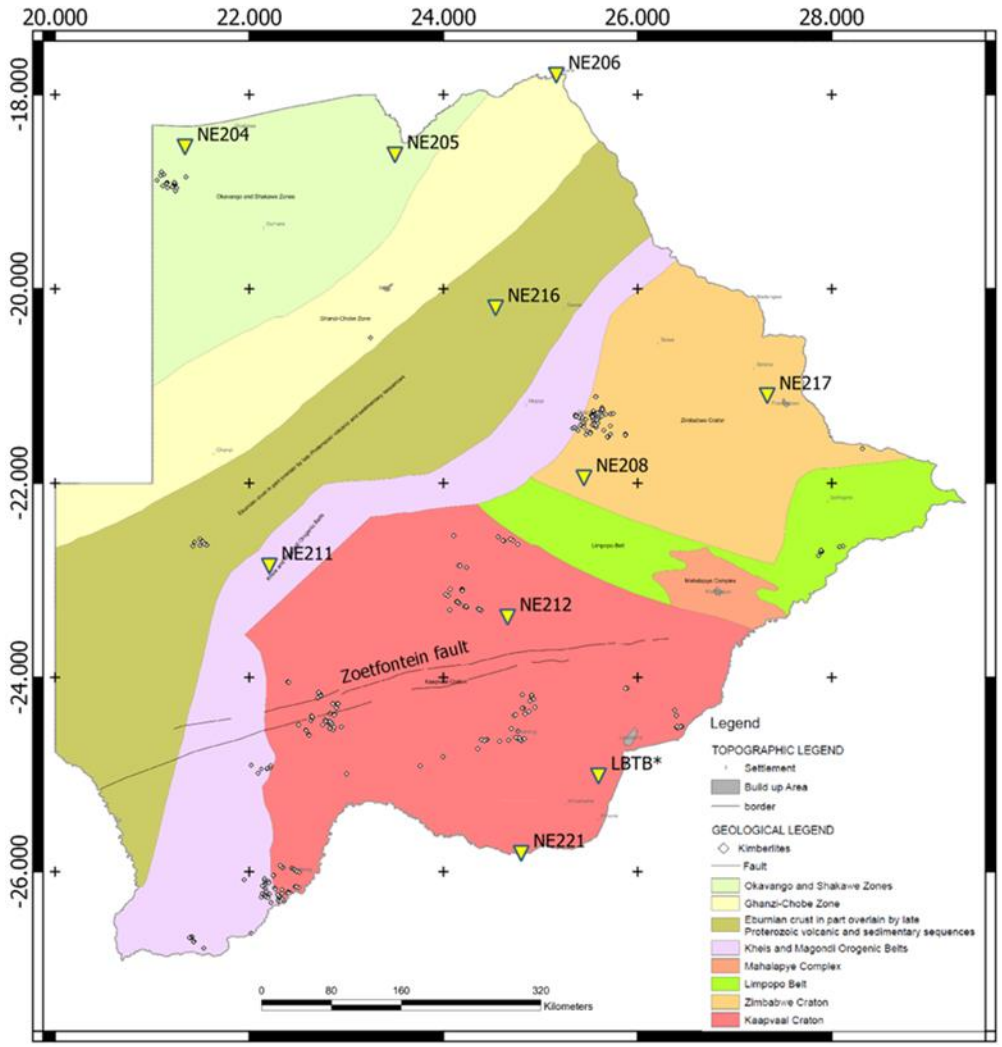


PRESENTATION OUTLINE

- Introduction
- Botswana Seismicity
- Gaborone Earthquake
- Data Analysis
- Results
- Conclusion
- Acknowledgements
- References

INTRODUCTION

INTRODUCTION



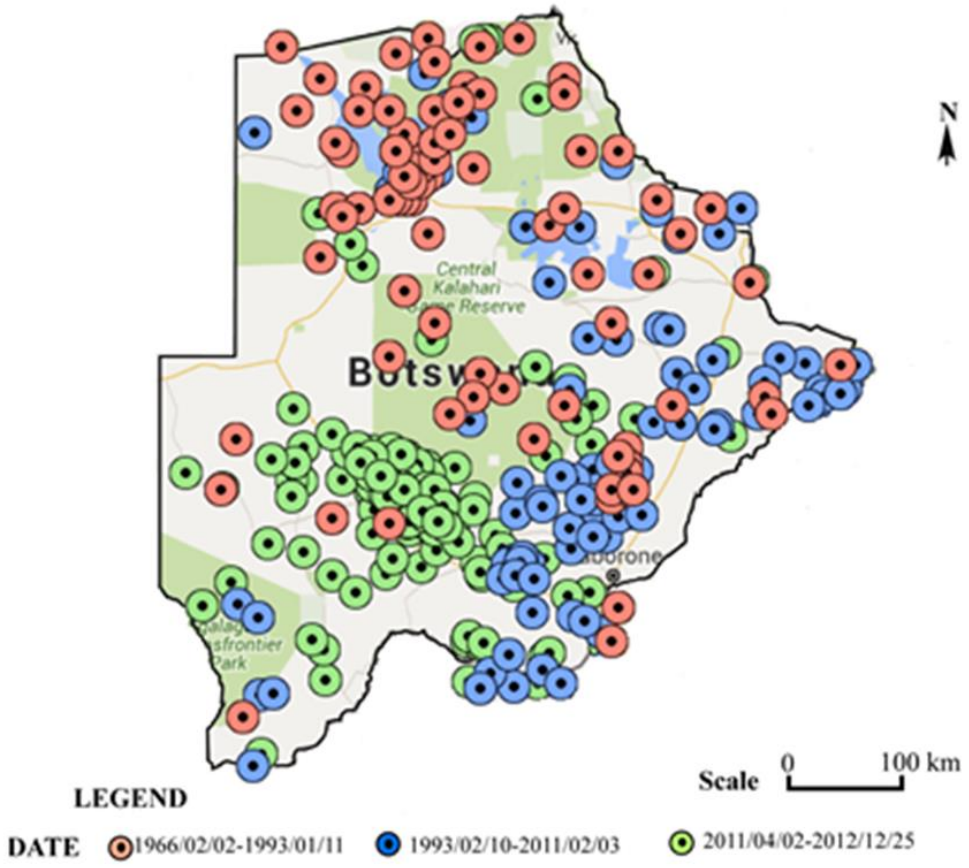
Botswana is predominantly covered by Kalahari sands.

Major geological features in Botswana:

- Okavango & Shakawe zones
- Ghanzi-Chobe zone
- Kheis-Magondi orogenic belt
- Zimbabwe craton
- Limpopo belt
- Kaapvaal craton
- Mahalapye complex
- Zoetfontein fault

Map modified after Carney et al. (1994).

SEISMICITY



Source: Nthaba et al. (2018)

Seismicity of Botswana:

- The adjacent figure shows seismicity from 1966-2012.
- Historically seismicity has been in the Okavango & Shakawe zones (shown by the cluster of red events).
- Seismicity is dominated by events of low to moderate magnitudes.

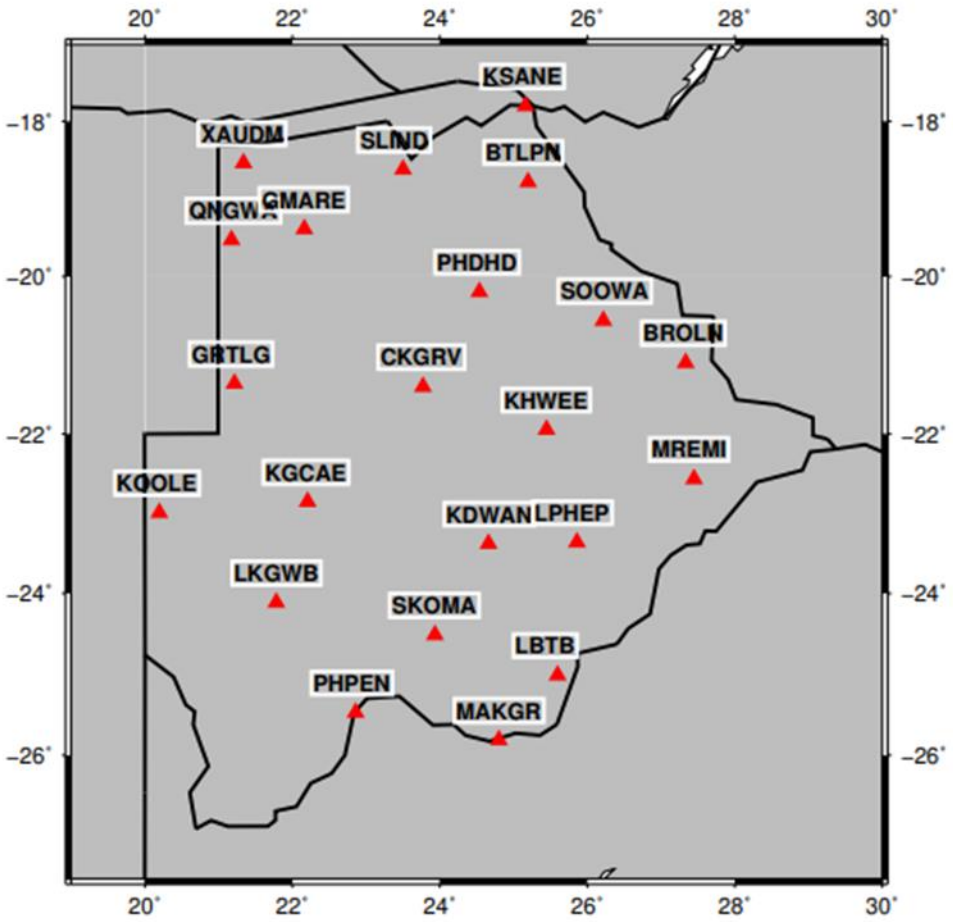
GABORONE EARTHQUAKE

- This event occurred at midday on Sunday 20 December 2020, and was widely felt across Gaborone and the surrounding villages.
- According to Kwadiba et al. (2020), the perceived ground shaking ranged from weak to strong shaking.
- They estimated that the Modified Mercalli Intensity (MMI) scale values were in the range II-V.

GABORONE EARTHQUAKE

- Eye-witnesses who were at the Gaborone dam, reported that water in the dam was behaving as if it was ‘boiling’.
- However, the level of water in the dam was not affected.
- The event did not result in any deaths, casualty or damage to property.

GABORONE EARTHQUAKE



- Local stations that recorded the event are part of the Botswana Seismic Network (BSN).

- 8 BSN stations
- 1 IMS station (LBTB)

GABORONE EARTHQUAKE

Table 1: Gaborone earthquake station coordinates

Station Code	Latitude (Degrees)	Longitude (Degrees)
LPHEP	-23.3630	25.8596
MAKGR	-25.8119	24.8009
KDWAN	-23.3804	24.6608
PHPEN	-25.4755	22.8573
BROLN	-21.0997	27.3342
LKGWB	-24.1135	21.7823
KGCAE	-22.8538	22.2068
KOOLE	-22.9931	20.1956
LBTB	-25.0151	25.5967
BOSA	-28.6140	25.2554
MATP	-20.4258	28.4994
SUR	-32.3797	20.8117
TSUM	-19.2022	17.5838

13 Stations were used:

- 8 BSN stations
- 1 IMS station (LBTB)
  &
- 4 IMS stations (Regional)

DATA ANALYSIS

- The waveforms of the Gaborone event were analysed using Geotool software from the CTBTO.

- To obtain the following parameters:

  - Origin time
  - Epicentre
  - Focal depth
  - Magnitude

DATA ANALYSIS

- The waveforms used in the analysis were from 13 broadband stations.
- The nearest station to the event had an epicentral distance of 0.43^{o}.
- Only unfiltered components with clear phases were used.
  - 13 P phases from vertical components.
  - 4 S phases from horizontal components.

DATA ANALYSIS

Table 2: 1-D Velocity Model (Modified after Wright et al., 2003).

Layer	Depth (km)	Vp (km/s)	Vs (km/s)
0	0.000	5.780	3.300
1	15.000	6.800	3.580
2	20.000	7.100	4.099
3	34.000	7.789	4.516
4	77.000	8.100	4.676

DATA ANALYSIS

- This was followed by an analysis using the Regional Seismic Travel Time model (RSTT) (e.g. Myers et al., 2011; Myers et al., 2017; Bondar, 2018).

- To obtain the following parameters:

  - Origin time
  - Epicentre
  - Focal depth

DATA ANALYSIS

- RSTT was developed in the USA at the Lawrence Livermore, Los Alamos, & Sandia National Laboratories to:
  - Improve the accuracy of regional seismic travel time and event location (Myers et al., 2017).
- RSTT computes the travel time using vertical cross section of 3D model between source & receiver.

DATA ANALYSIS

- RSTT model uses nodes closest to the station location.
- Hence, the travel time calculation for a given ray can use several model nodes.
- For local distances, a 1D model at the station is used to compute the travel-time.

DATA ANALYSIS

- The 1D model is a linear interpolation of layer depths & layer velocities from the nearest model nodes.
- RSTT requires initial hypocentre information in the form of a bulletin.
- Hence, parameters of the Gaborone event from Geotool, were used as the initial hypocentre information with RSTT.

RESULTS

Geotool results for the Gaborone event:

- Epicentre location was at 24.701 ^{o}S and 25.930 ^{o}E.
- Origin time was 10:44:46.6 (UTC) or 12:46:46.6 (local time) and uncertainty of +/- 1.98 s.
- Body magnitude (mb) = 4.2 +/- 0.2.
- Local magnitude (ml) = 3.6 +/- 0.5.
- Depth = 11.3 km.

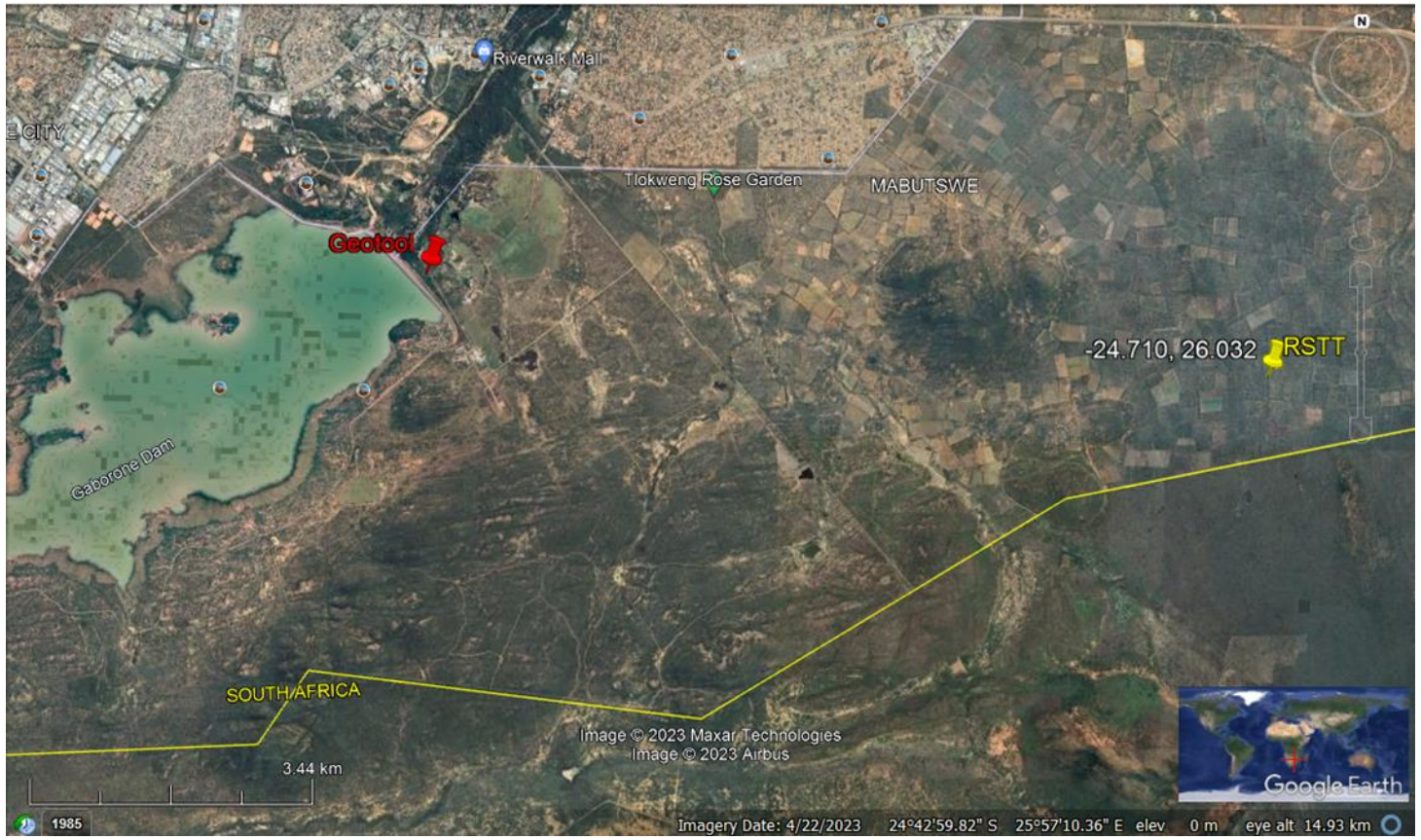
RESULTS

RSTT results for the Gaborone event:

- Epicentre location was at 24.710 ^{o}S and 26.032 ^{o}E.
- Origin time was 10:44:46.787 (UTC) or

  12:44:46.787 (local time) & uncertainty of +/- 1.5 s.
- Depth = 10.6 km.

CONCLUSION



Epicentre locations of the Gaborone earthquake from Geotool (red) and RSTT (yellow).

CONCLUSION

- Gaborone earthquake occurred in the upper crust.
    - Since the crustal thickness closest to this event is from SA62 at 40.5 km from Kgaswane et al. (2009).
    - They used data from the Kaapvaal craton project.
- A seismic station is needed in Gaborone city.
- IMS data & IDC products are useful in civil and scientific applications.
- RSTT results agree with those from Geotool for this event.

CONCLUSION

- Both software packages were provided by CTBTO.
- IMS section for data.
- BGI as custodian of Botswana data.
- The RSTT team for the software, & Dr. Stephen Myers for the installation of the software during one of the CTBTO workshops.
- University of Botswana, Faculty of Science, Physics Department.

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THANK YOU!!