



THE ROLE OF GEOLOGICAL SURVEY IN MONITORING SEISMICITY IN MALAWI

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OUTLINE

- Introduction
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- Seismic Network in Malawi
- Seismicity of Malawi
- Devastating Earthquakes
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- Summary



INTRODUCTION

- Malawi is located on the western branch of the East African Rift System (EARS).
- It is a seismically active belt mostly characterized by shallow earthquakes

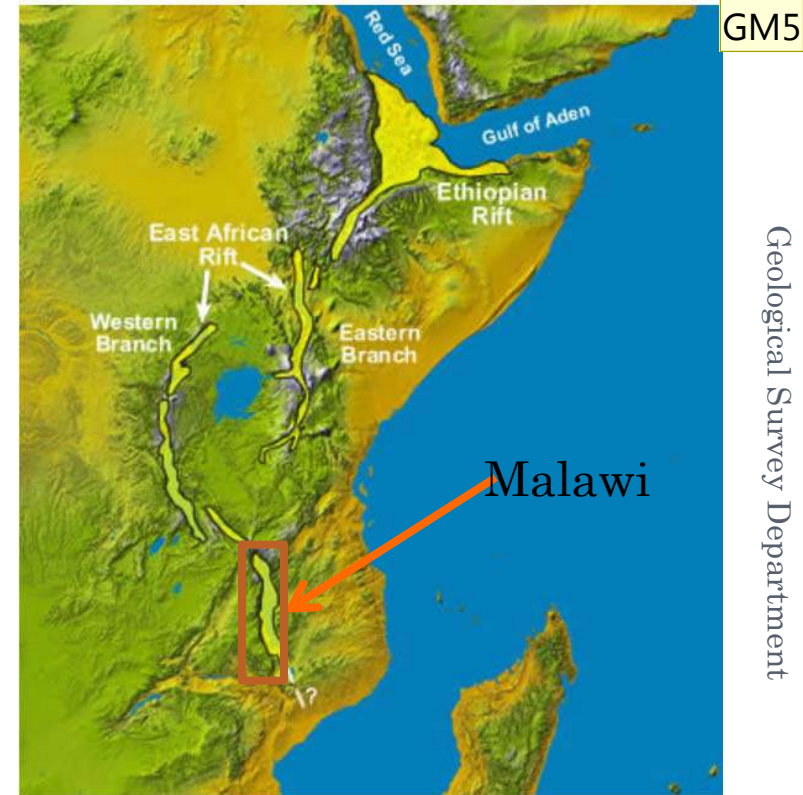


Figure 1: The East African Rift System



GEOLOGICAL AND TECTONIC SETTING

○ Underlain by crystalline Basement Complex rocks of Precambrian to Paleozoic age mostly gneisses and granulites.

○ Affected by three mobile belts, Ubendian, Irumide and Mozambiquian

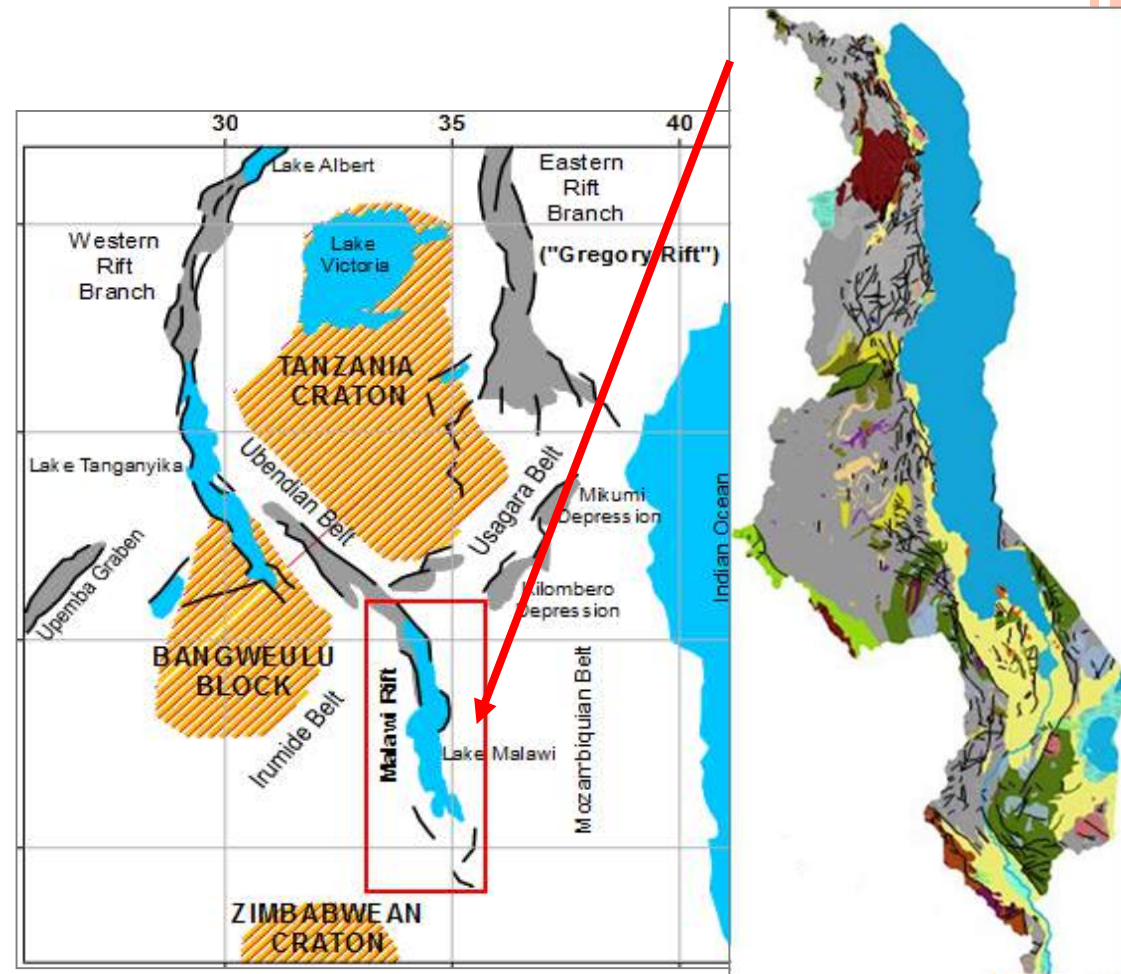
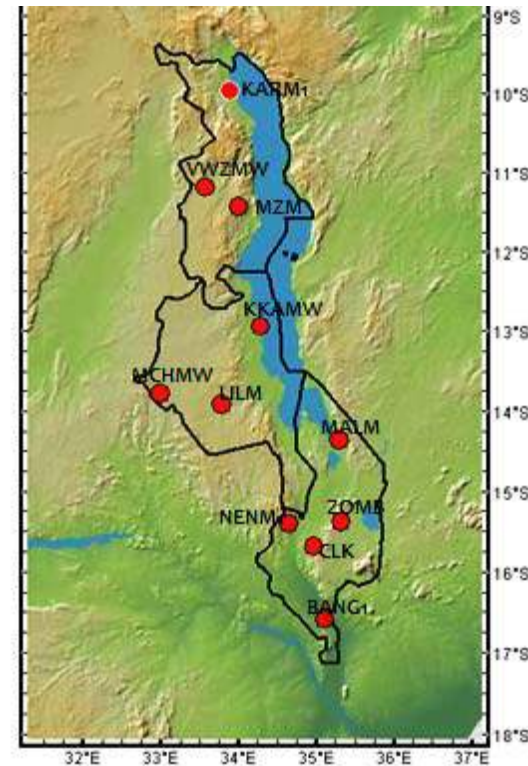


Figure 2: Geology and Tectonic setting of Malawi

SEISMIC NETWORK AND MONITORING

- Instrumental seismological observation in Malawi dates back to 1962
- Currently, Geological Survey Department operates 11 broadband seismic stations throughout the country.
- Four of GSDM stations are co-located with GPS stations in northern Malawi belonging to SEGMeNT Project led by Columbia University, USA.
- Two stations belong to AfricaArray Project (Pennsylvania State University, USA) in Zomba and Mzuzu, co-located with GPS and weather Stations.



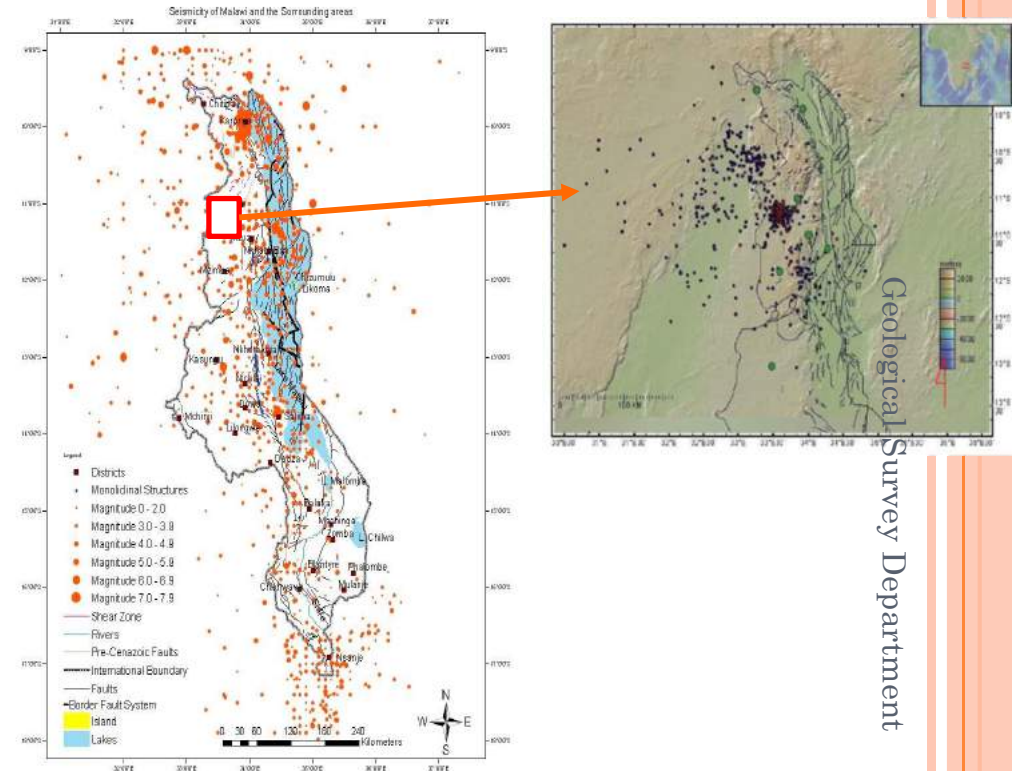
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Figure 4: Seismic Stations in Malawi



SEISMICITY IN MALAWI

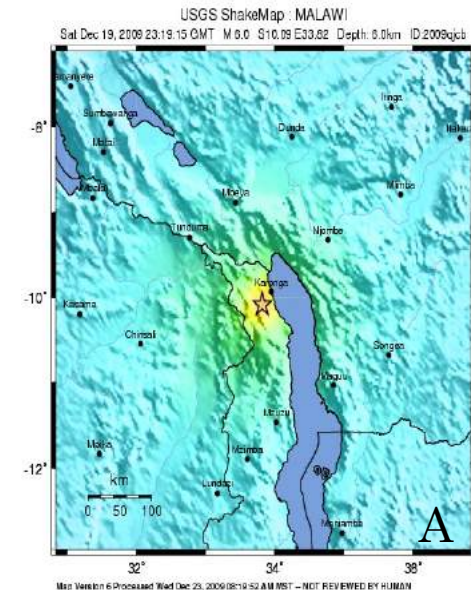
- Small-to-moderate earthquakes occur both from within the country and from neighbouring countries
- Spatial distribution
 - **North:** Highly active
 - **Centre:** Moderately active
 - **South:** Least active for most areas except Nsanje.
- Bulk of seismicity is noted south of Nsanje into Mozambique (Figure 5).
 - Due to reactivated Cenozoic faults



DEVASTATING EARTHQUAKES

- March 10, 1989, earthquake (M6.3) in Salima District along the Bilila-Mtakataka Fault.
 - Landslides were recorded in Dowa, Ntchisi and Kasungu districts.
 - 9 deaths recorded.
- December 19, 2009 earthquake (M6.0) in Karonga District, northern Malawi (Figure 5a-c)
 - Several earthquakes (45) between $4.5 < M < 5.9$ occurred between December 6 and 19, 2009.
 - ~2700 aftershocks
 - 2,752 houses affected
 - 4 deaths
 - 300 injuries

Figure 7: A) December 19, 2009 Earthquake in Karonga, northern Malawi, USGS B) Fault rupture for ~18Km.



Map Version 6 Processed Wed Dec 23, 2009 08:52 AM MST - NOT REVIEWED BY HUMAN

| PROCESSED | None | West. | Light | Moderate | Strong | Very strong | Severe | Violent | Extreme |
|------------------------|------|---------|---------|------------|--------|-------------|----------------|---------|------------|
| POTENTIAL DAMAGE | none | none | none | Very light | Light | Moderate | Moderate-Heavy | Heavy | Very Heavy |
| PEAK ACC (g) | <.17 | .17-1.4 | 1.4-2.9 | 2.9-9.2 | 9.2-18 | 18-34 | 34-85 | 85-124 | >124 |
| PEAK VELOCITY (cm/s) | <0.1 | 0.1-1.1 | 1.1-3.4 | 3.4-9.1 | 9.1-18 | 18-31 | 31-60 | 60-118 | >118 |
| INTRODUCTORY INTENSITY | I | II-III | IV | V | VI | VII | VIII | IX | X |





CASE STUDIES

EARTHQUAKE MONITORING: KARONGA SEQUENCE, 2009-10

- A sequence of earthquakes in Northern Malawi on the East African Rift
- Earthquakes were not on the border fault
- Occurred on multiple faults
- Some of the earthquakes occur within the graben

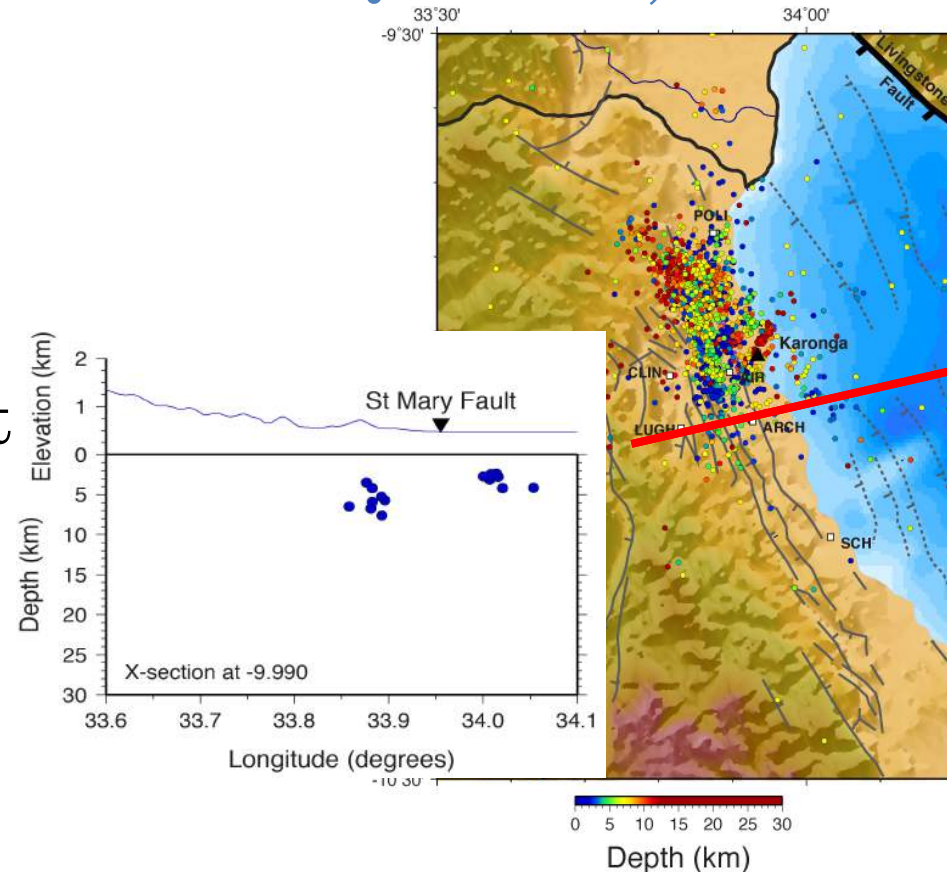


Figure 8: Karonga earthquake sequence, 2009-2010. Faults after Mortimer et al., 2007 and Biggs et al., 2010. Bathymetry from Lyons et al., in press

ACTIVE FAULT MAPPING: SEGMENT PROJECT

- 55 onshore seismic stations
- MT data collection finished in October 2014
- 5 years of GPS data acquired so far
- Dating and analysis of samples from Rungwe volcanic province underway.
- Broadband OBS deployed in lake from March 2015 to November 2015
- Active source imaging experiment in March-April 2015

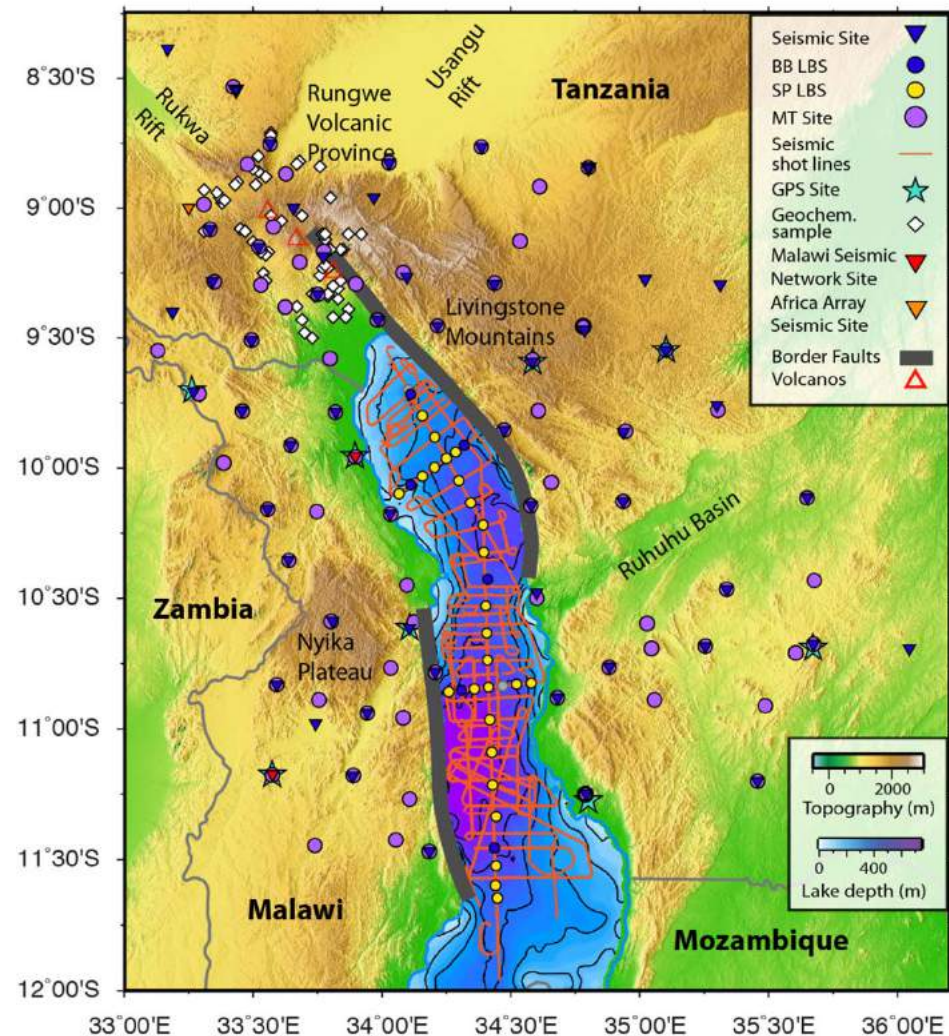


Figure 9: Fault imaging in Lake Malawi, 2015. Shillington et al., SRL, 2016

- Intrabasin faults with significant cumulative offset
- Active faults seen offsets on new and megadrought horizons

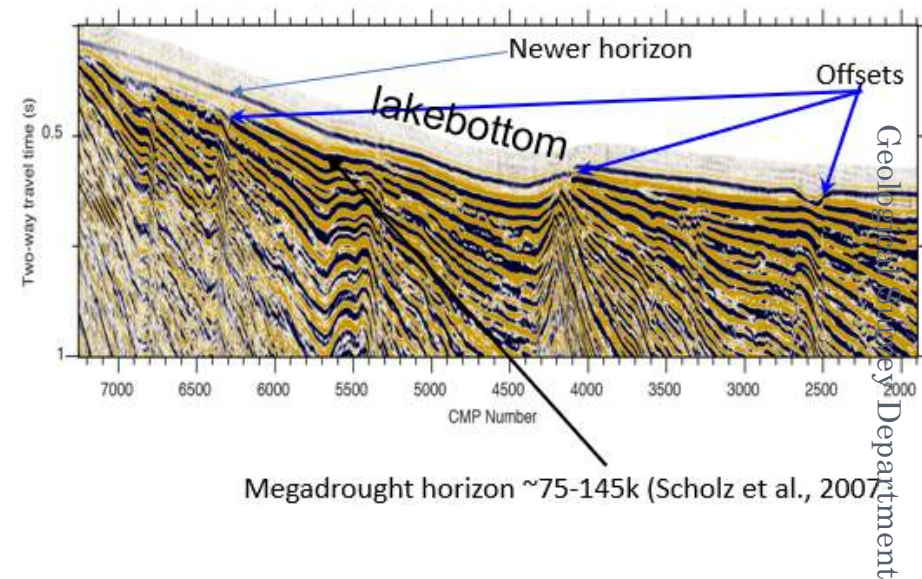
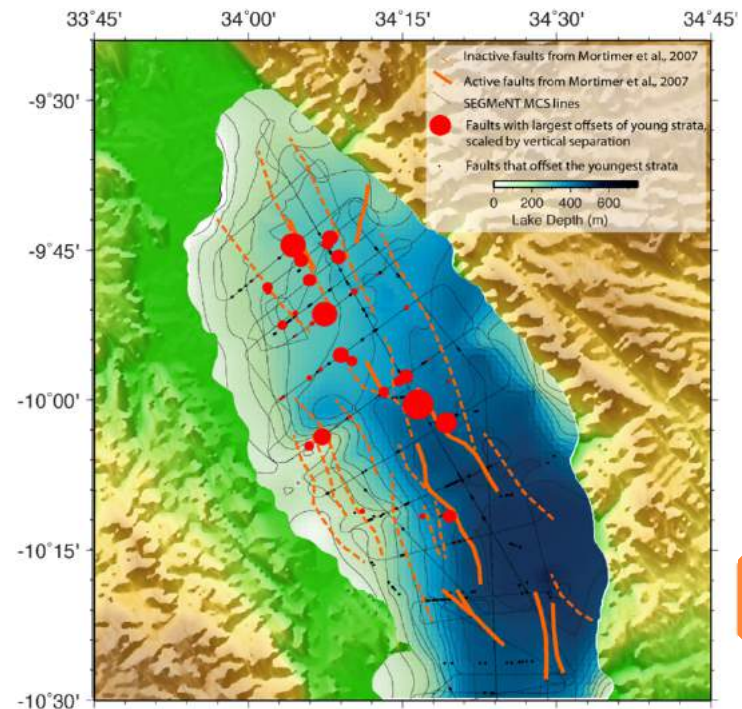
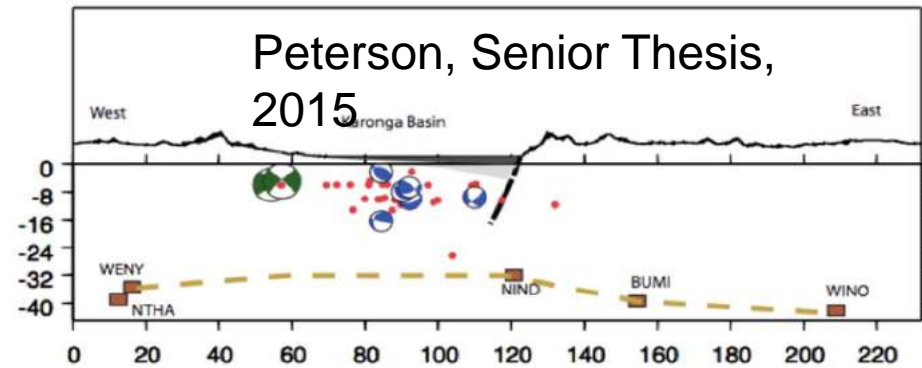


Figure 10: Seismic reflection data used to map out faults that offset the seafloor and the 'megadrought' horizon (*Chindandali P, 2016. Internship at Lamont, USA*)



CONT'D..

- These results show very few events associated with the border faults.
- Most seismicity appears to occur at depths between ~5-15 km beneath the basin on intra-basin faults



MACROSEISMIC STUDY IN NSANJE

- Following the March 8, 2018 earthquakes near Nsanje
 - M5.5 and M5.0 Earthquakes near Malawi-Mozambique border
 - 16-29Km SE of Nsanje
 - Other notable aftershocks
 - ❖ M4.9: March 17, 2018
 - ❖ M4.0: April 6, 2018
 - Depth 16- 21Km



Figure 12: Red dot represents epicentre of Mw5.5 earthquake in Mozambique

- Macroseismic survey carried out
- Intensity values decrease from MMI=V to IV at 0-40Km
- MMI=III to II at 40-150Km
- Areas within 26-35Km from epicentre experienced strong shaking and damage (cracks) to property
- Located in sediments



Figure 13: Damage due to earthquakes

OUTREACH ACTIVITIES: EARTHQUAKE DRILLS

- **DROP! COVER! HOLD ON!**
- The discipline of dealing with how to avoid earthquake injuries, damage & deaths.
 - Intended to equip people with skills on what to do during and after an earthquake occurrence.
- By planning and practicing earthquake drills, people can learn to react correctly when the shaking begins.



Figure 14: Mwanza Secondary School Students practising Earthquake Drills in 2012.

SUMMARY/CONCLUSION

- The Geological Survey is Mandated to acquire archive and disseminate geoscientific data which includes earth occurrence and assessment results.
- Tectonic set up for Malawi favour earthquakes concentrates along the rift structures.
- Northern Malawi is highly active followed by the centre
- Seismicity in the south is sparsely distributed before it picks up in Nsanje and Mozambique areas.
- Recent events in Karonga areas in northern Malawi, bring insights into how vulnerable the communities are with regard to poor buildings
- Need for earthquake resilient structure and outreach campaigns

Thanks for your Attention

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