# Hydroacoustic observations of a seismic swarm near Melville Fracture Zone along the Southwest Indian Ridge in 2016-17

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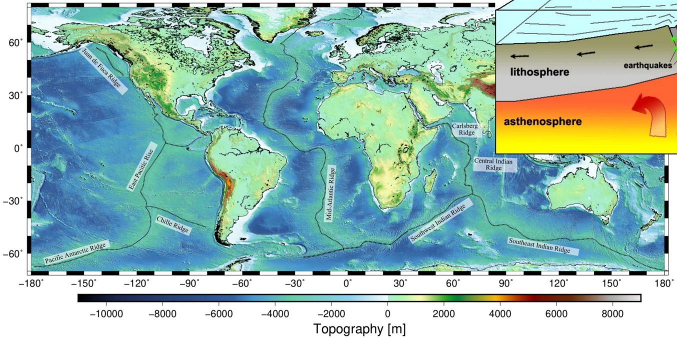
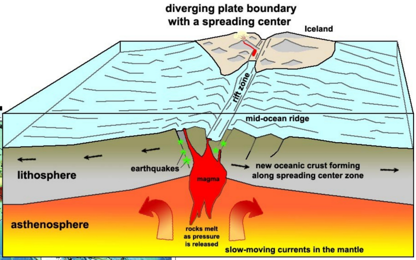
# Introduction: Mid-oceanic ridge

**Black line: Mid-oceanic ridge system**

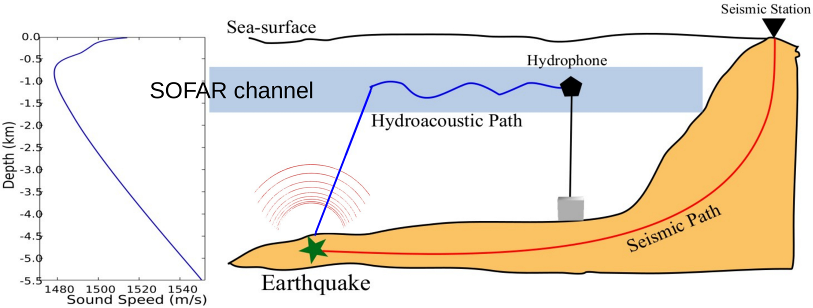



Source: gotbooks.miracosta

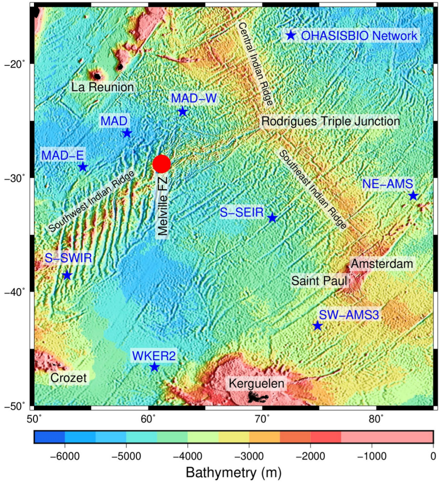
- MOR system is the longest chain of seafloor mountains along the divergent boundaries
- Seismic clusters along MOR are either magmatic or tectonic in origin
- They are associated with seafloor spreading

# Introduction: Hydroacoustic waves



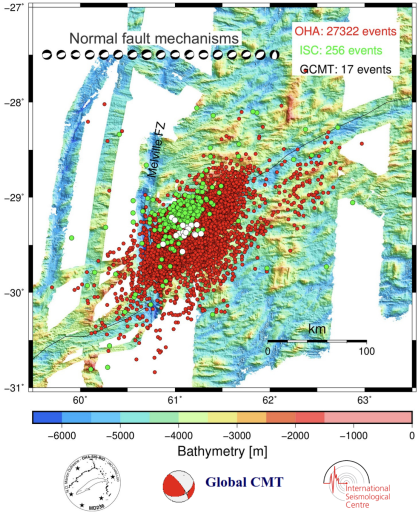

- MOR seismicity comprises small-magnitude earthquakes
  - Not reported in land-based catalogues due to remoteness and rapid wave attenuation
- Such events produce low-frequency hydroacoustic T-waves
  - By conversion of seismic waves to acoustic waves at sea-bottom
  - Travel through SOFAR channel over long distance with little attenuation

# Experimental Setting



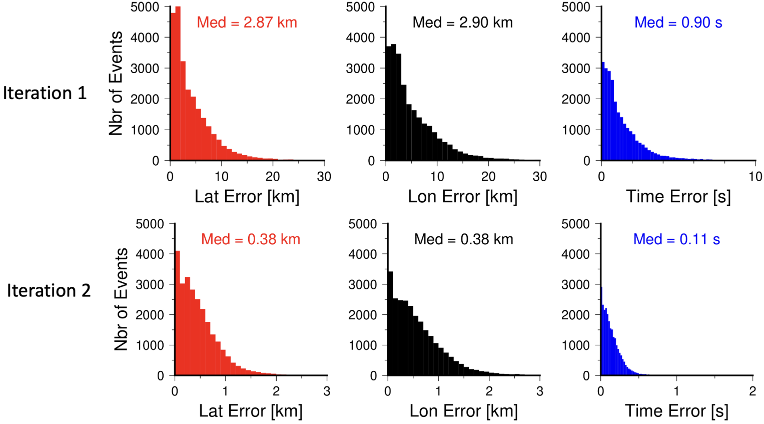

- Detected and analysed the hydroacoustic events on
  - **Southwest Indian Ridge** near *Melville FZ*
  - SWIR is ultraslow spreading ridge with spreading rate of 14 mm/a
- Examined hydroacoustic **T-waves** recorded by
  - Autonomous hydrophones of **OHASISBIO** (*Hydroacoustic Observatory of the Seismicity and Biodiversity in the Indian Ocean*)
  - Permanent stations of **CTBTO** (*Comprehensive Nuclear Test-Ban-Treaty Organization*)
- Build up catalogue of hydroacoustic events
  - With their **origin time, location** and **Source Level** (acoustic magnitude)
  - Based on **arrival-times of T-waves** on the hydrophones

# Results: Land-based vs Hydroacoustic events



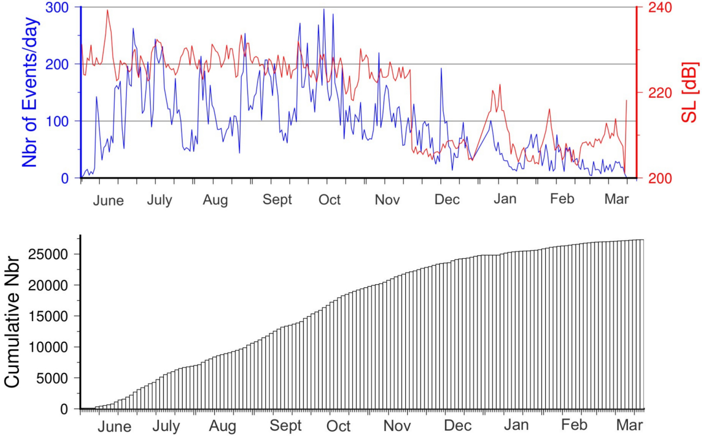

- **Dates Span**: 01 June 2016 to 26 March 2017
  - **291** Julian days
- International Seismological Centre (ISC) catalogue
  - **256 reported events**
  - Maximum $m_B = 5.5$ (16 Sept-18h38)
- Global Centroid Moment Tensor (GCMT) catalogue
  - **17 reported events**
  - Normal faulting mechanisms
  - Azimuths parallel to ridge axis
- Hydroacoustic catalogue
  - Used 3 to 9 hydrophones for detection
  - **27322 detected events**
  - ∼**107-fold** increase in event detection
  - ∼**94 events** per day (on average)

# Results: Improvements in errors



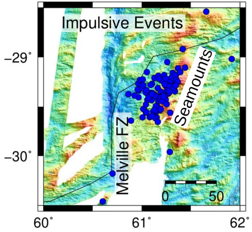

- In iteration 1, build a catalogue of detections with their origin time, location, Source Level and associated errors
- In iteration 2, re-analyse the primary catalogue to improve the errors in location by ∼8-fold
- Errors in latitude/longitude are improved to ∼**400 m** compared with ∼**20 km** in land-based catalogues

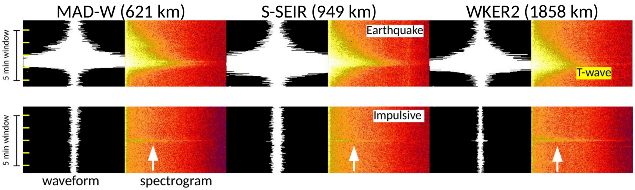
# Results: Source Level of events




- **Source Level** and **number of events per day** show a sudden drop in seismic activity after 16 November 2016
- Despite of several periods of high activity ($>$ 150 events per day), **cumulative number** of events increases gradually
- Absence of clear mainshock-aftershock sequence (strong events do not govern the seismic rate)

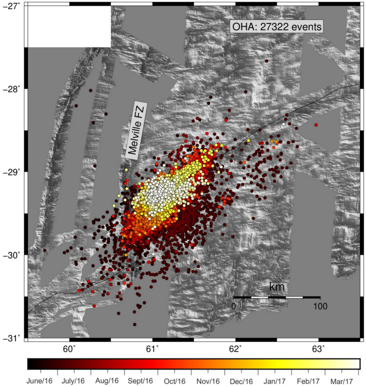
# Results: Impulsive events



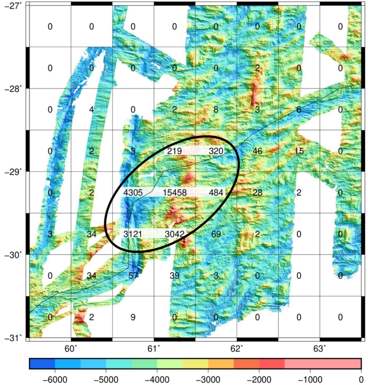




- Occurrence of many **impulsive events** (118 in total)
  - **Short duration** (∼10 s) compared with earthquake events (∼200 s)
  - **Highly energetic**, since detectable 2000 km away (WKER2 site)
- Characteristics
  - Located on the **slopes of seamount** near ridge axis
  - **H-waves** like, with high energy released directly in water column
  - Interpreted as **thermal explosions** due to direct magma supply on the seafloor, as observed in sub-marine volcanic contexts [*Wilcock et al. 2016 (Sci.); Bazin et al. 2022 (C. R. Geosci.)*]

# Results: Spatio-Temporal distribution




Temporal pattern of seismicity




Event count per half degree grid

- Activity initiated near **Melville FZ** and **spread in N-E direction**; parallel to SWIR axis
- Then, mostly **concentrated near a seamount chain**, east of Melville FZ
- Clustering of events near these seamounts, next to ridge axis, interpreted as **magmatic intrusions**, followed by local **stress readjustments**

# Summary

- 61°E SWIR swarm comprises **27322 events over 291 days** (94 events per day)
- Hydroacoustic network recorded ∼**100 times more events** than land-based seismological networks
- Acoustic triangulation over 2 iterations shrunk the uncertainties **to 400 m in location and 0.1 s in origin time**
- **Magmatic origin** inferred from :
  - **Absence of mainshock-aftershock** sequences (typical of tectonic events)
  - Characteristic **spatio-temporal distribution** of magmatic intrusions
  - **Impulsive events** focused on the slopes of local seamounts, likely related to active lava flows on the seafloor

**THANK YOU**