

**A new case of reservoir triggered seismicity: the Laúca Reservoir in the Angolan Shield**

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# A New Case of Reservoir Triggered Seismicity: The Laúca Reservoir in the Angolan Shield



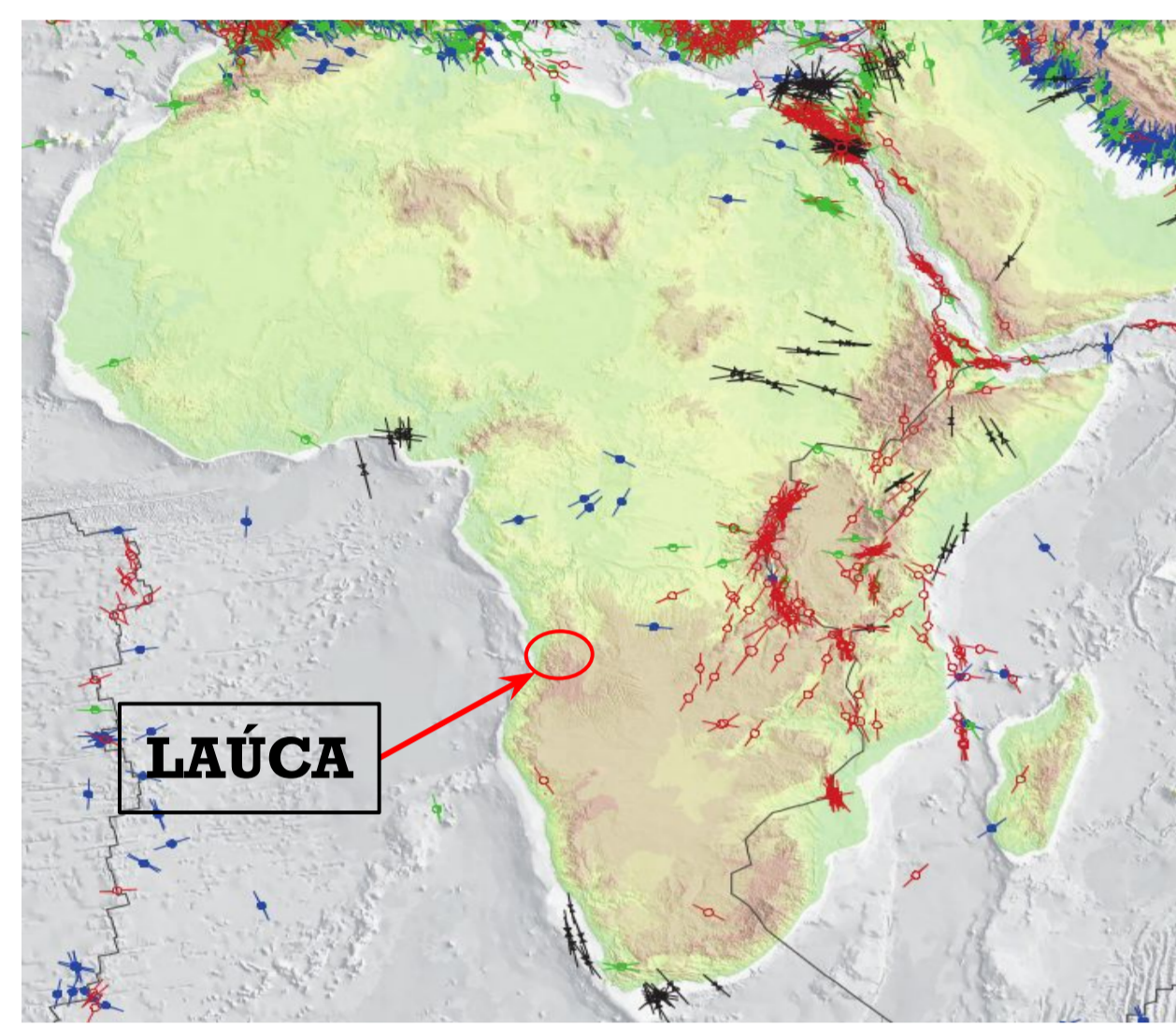
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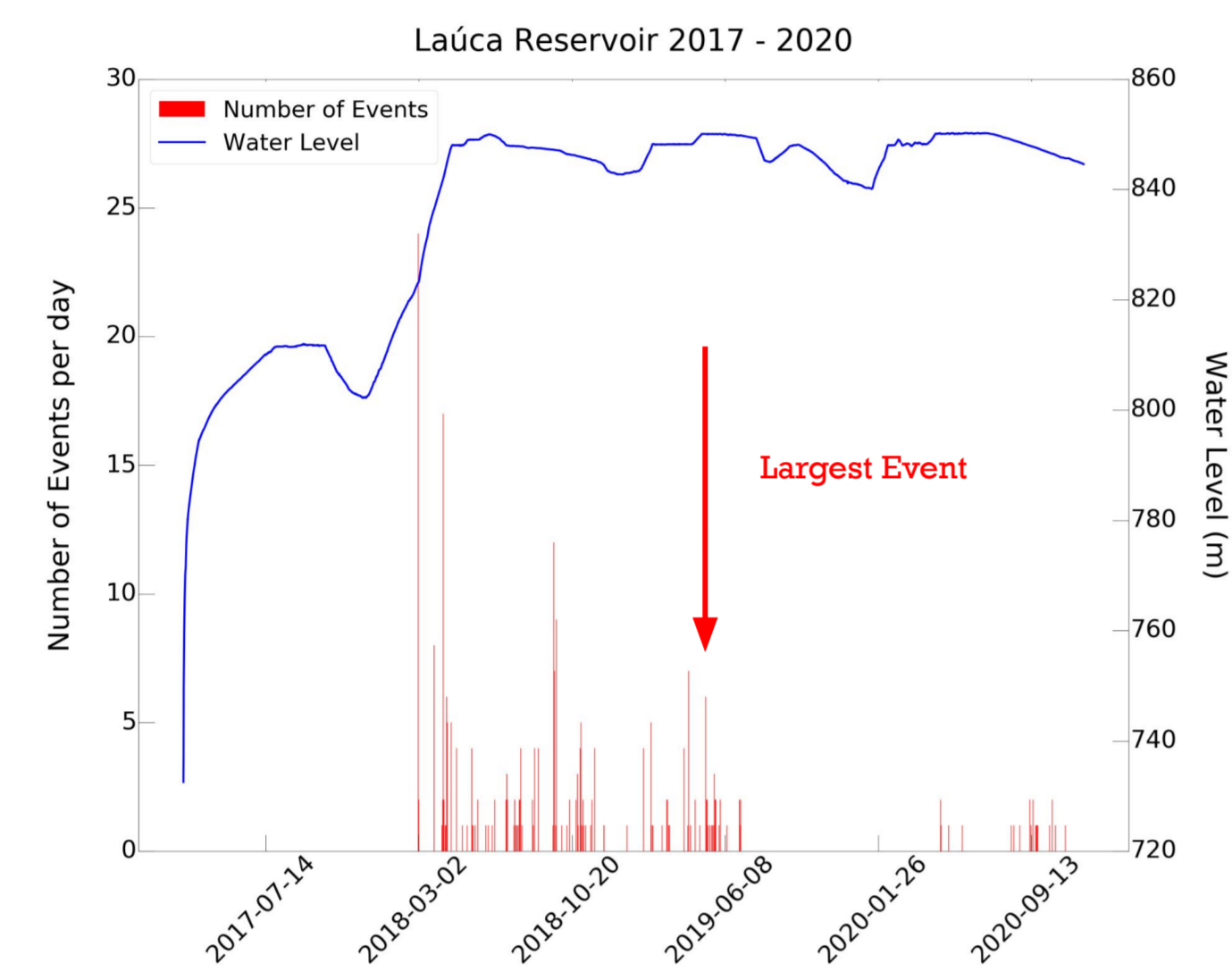


## INTRODUCTION

We present a new case of reservoir triggered seismicity in an intraplate environment, the Laúca reservoir in northwestern Angola. We study the local stress field using focal mechanisms. Over 270 events were recorded in the lake area between March/2018 and November/2020. The reservoir is monitored by stations LAUC and ZERO (90 events recorded at both stations). The maximum dam height is 156m and the reservoir volume is 5.482 km<sup>3</sup>. The largest earthquake detected had magnitude 3.0 ML.

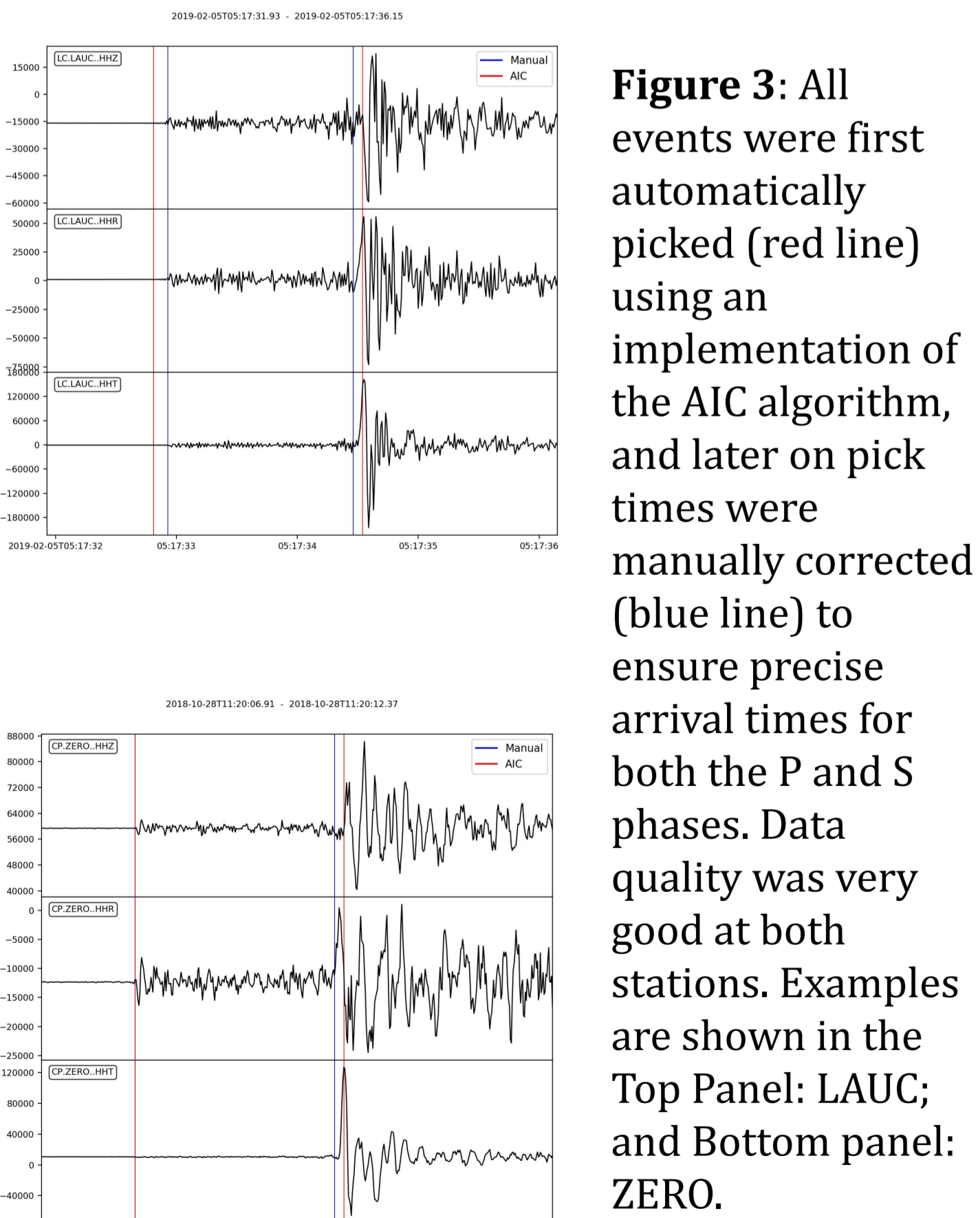


**Figure 1:** World Stress Map (WSM) as compiled by the Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences. Most focal mechanisms in the African Plate come from the East African Rift. Our work hopes to contribute to a better understanding of the regional stress field in Angola. (Source: Heidbach et al., 2016)

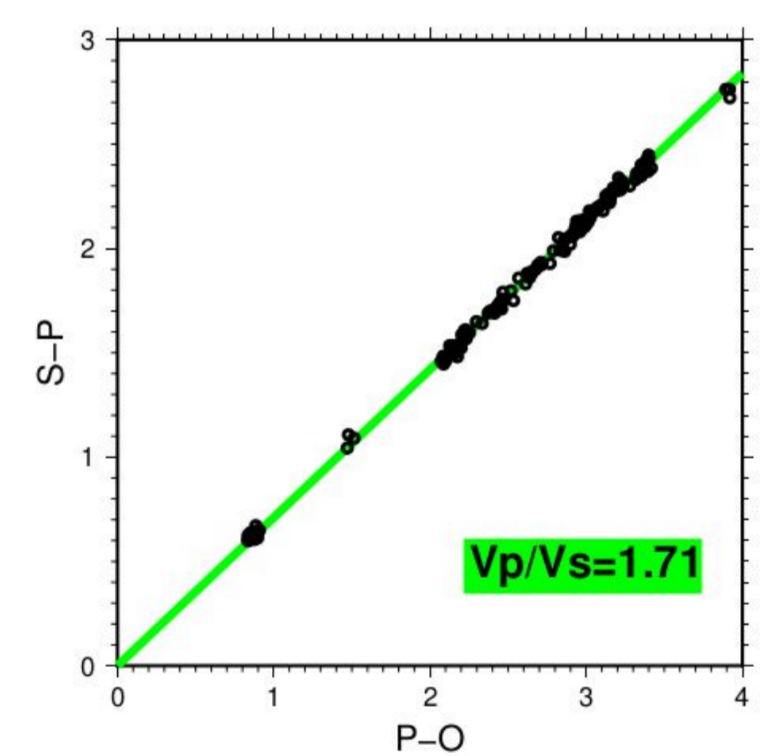


**Figure 2:** Daily event frequency compared to water level variations since impoundment. Seismicity was first observed after the water level rose to approximately 86.8 m. Out of the >270 events detected, 90 were registered at both stations (ZERO and LAUC). The red arrow indicates the day on which the largest event occurred, in 2019-10-05 10:00:09 (UTC).

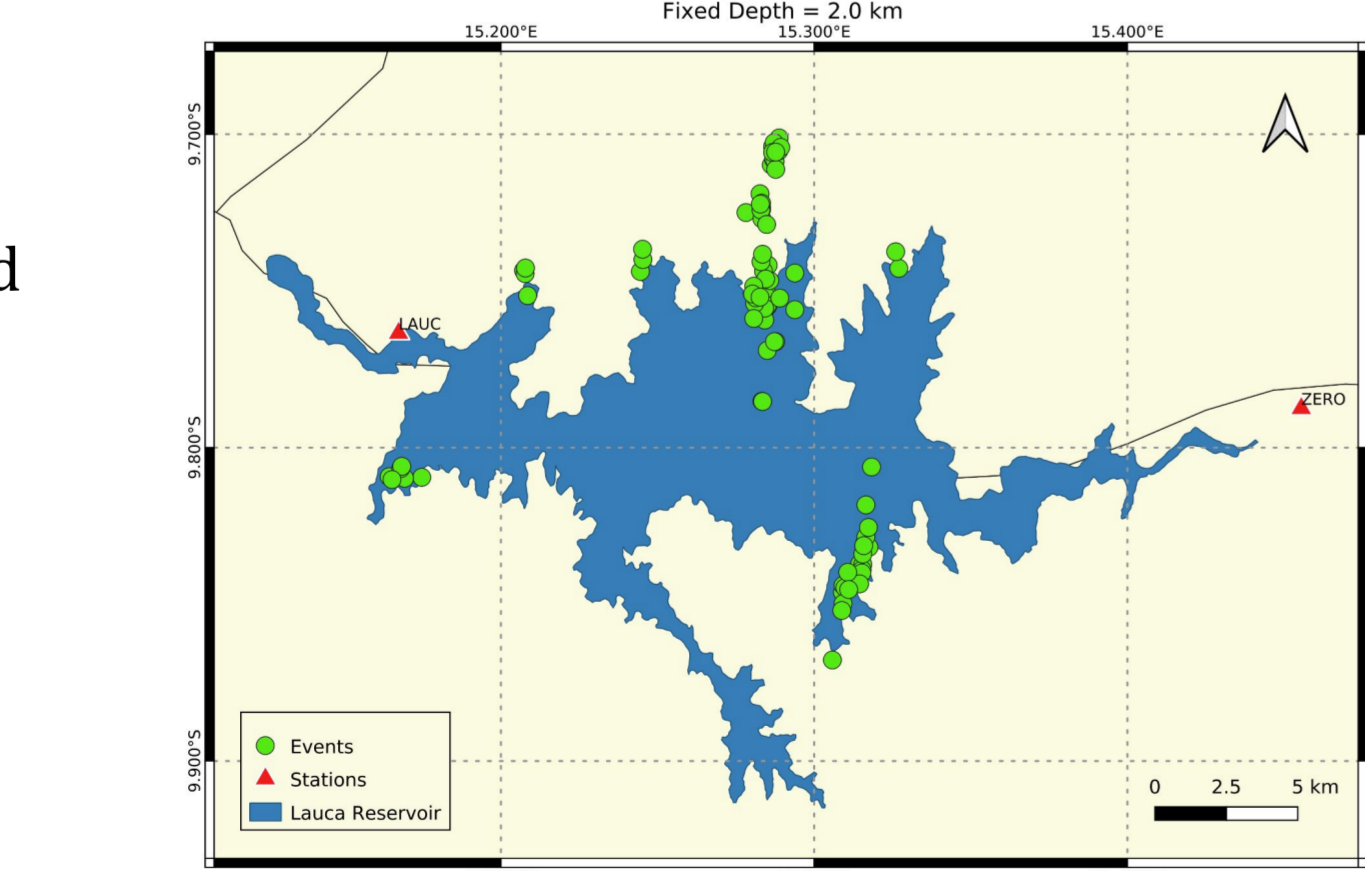
## EPICENTER DETERMINATION



**Figure 3:** All events were first automatically picked (red line) using an implementation of the AIC algorithm, and later on pick times were manually corrected (blue line) to ensure precise arrival times for both the P and S phases. Data quality was very good at both stations. Examples are shown in the Top Panel: LAUC; and Bottom panel: ZERO.

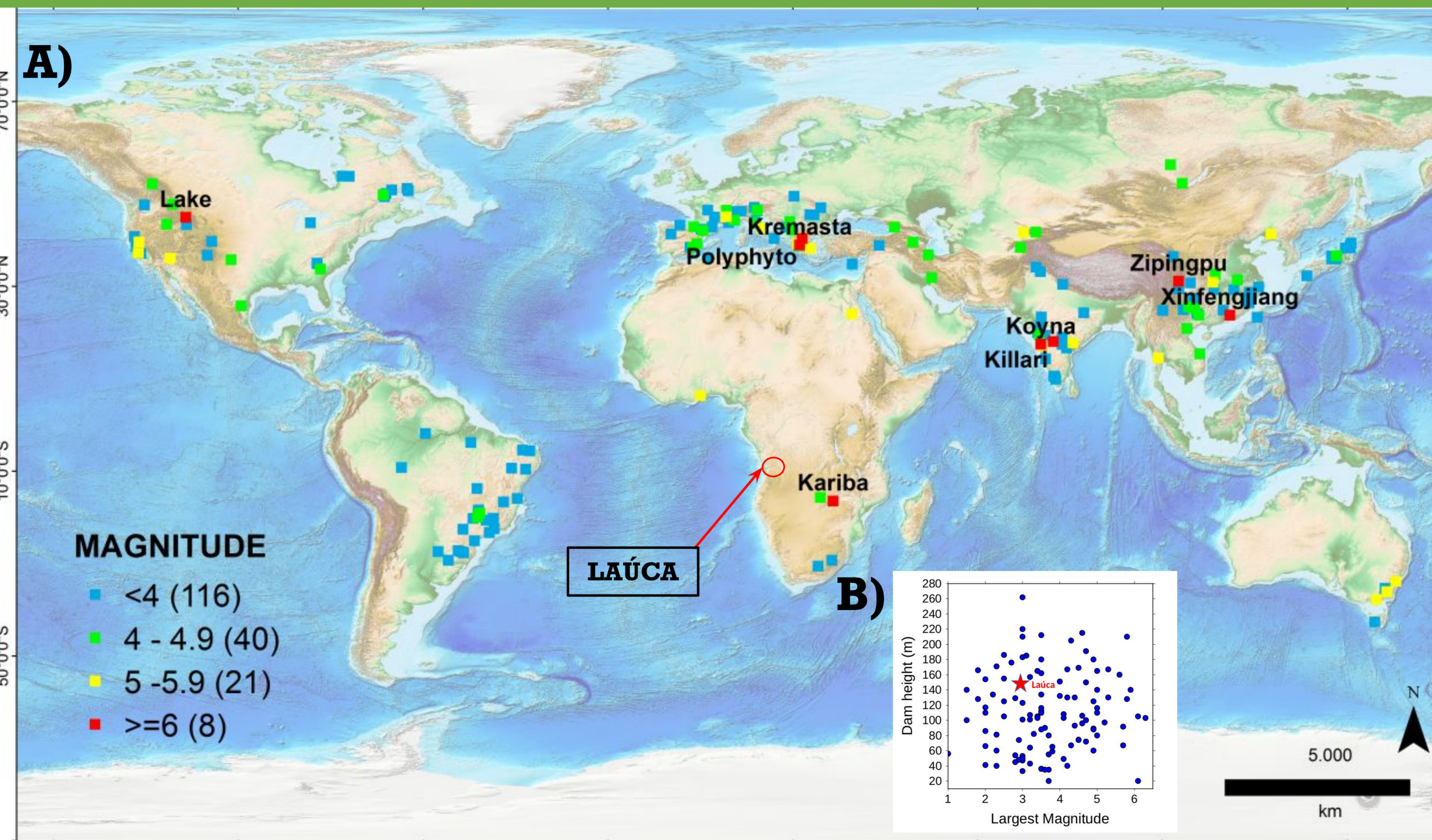


**Figure 4:** Composite Wadati diagram for the 90 events recorded at both stations, yielding  $V_p/V_s = 1.710 \pm 0.003$  km/s. The result is compatible with the local geology, made up mostly of igneous (granitic) rocks covered by a thin sedimentary layer.



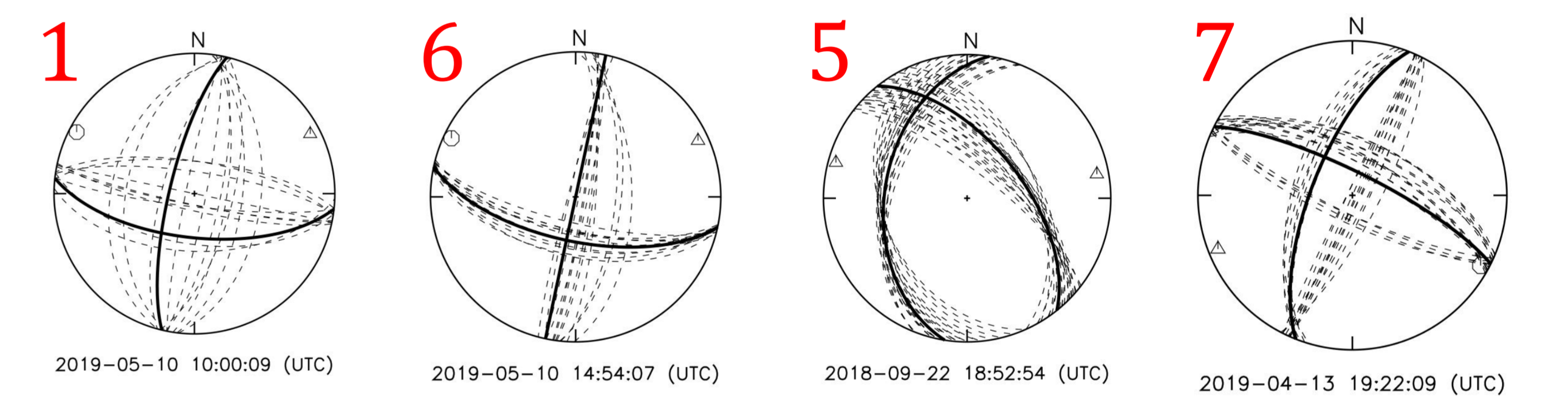
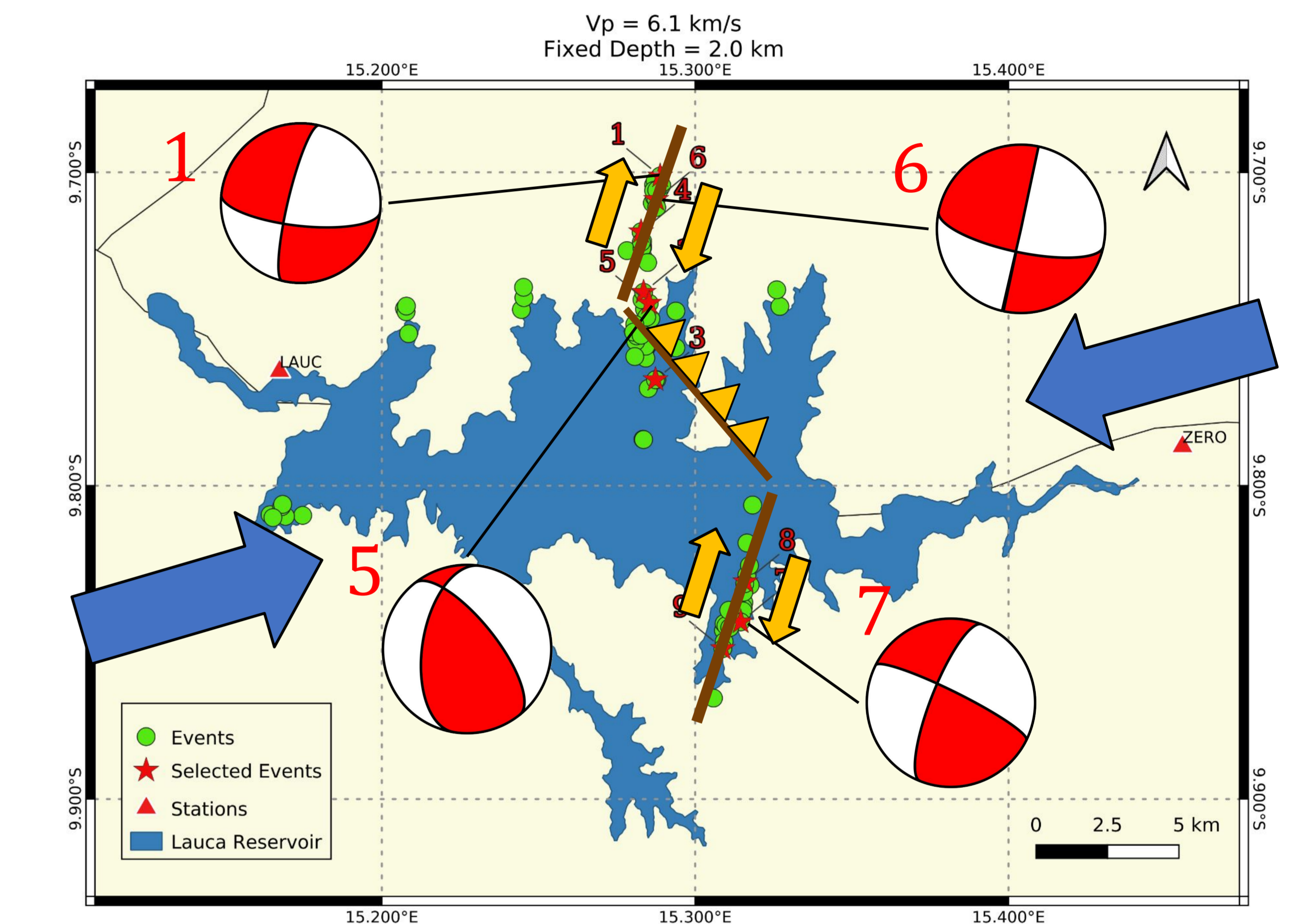
**Figure 5:** Epicentral locations using the best solution half space model obtained from minimization of traveltime residuals, and a  $V_p/V_s$  ratio of  $1.710 \pm 0.003$  km/s. Only events detected at both stations are shown. The best velocity model yields  $V_p = 6.1$  km/s. Depth is poorly constrained, and was fixed at 2.0 km. Back-Azimuths measured at both stations were used to constrain the epicenters.

The faulting regime at Laúca reservoir is transpressive. The maximum horizontal stress ( $SH_{Max}$ ) orientation in the lake area is SW-NE.



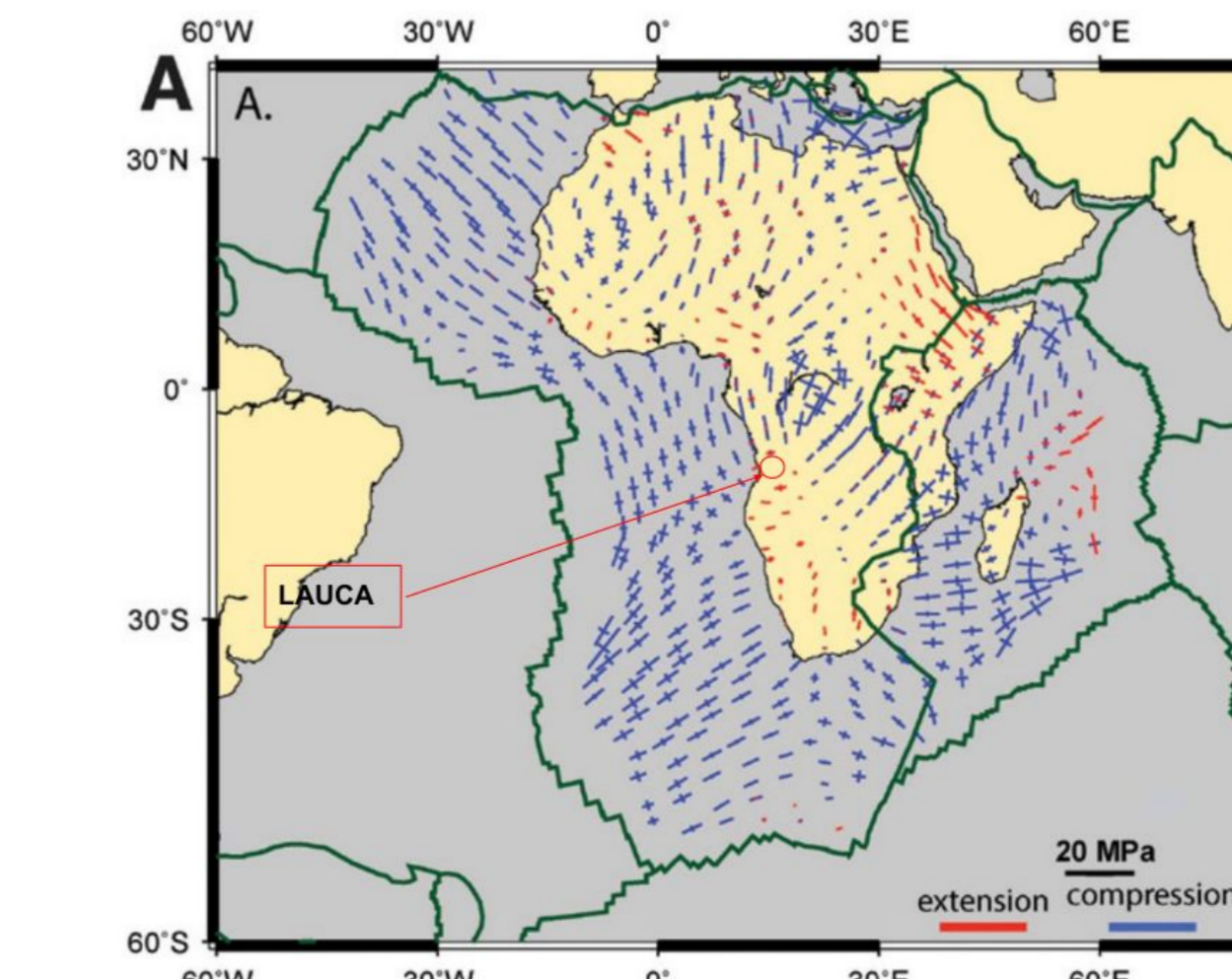
**Figure 6:** A) World map of events triggered by reservoirs (Sayão et al., 2020). The location of Laúca reservoir is shown in red. It is a new case of reservoir triggered seismicity in a region of Africa that up until now had seen none. B) Plot showing the largest magnitude recorded vs dam height for RTS cases worldwide. The largest magnitude at Laúca reservoir was 3.0 ML in 2019-05-10 10:00:09 (UTC) and is highlighted as a red star in the plot.

## FOCAL MECHANISMS



**Figure 7: Top)** Map showing focal mechanisms for 4 selected events at Laúca reservoir, determined with the program FOCMEC. Both P and SH polarities were used in determining the solutions, as well as P/SV and P/SH ratios at both stations. No polarity errors were allowed, and a  $\log_{10}(A) = 0.3$  error was allowed for all amplitude ratios. The beach balls shown are the solutions with the smallest RMS. **Bottom)** FOCMEC solutions showing all nodal planes matching the error criteria for the amplitude ratios for each one of the selected events. The solution with the smallest RMS is shown in a dark solid line, and the dashed lines are the other acceptable solutions. The P axes in all solutions are oriented in the SW-NE direction. The yellow arrows indicate possible transpressional motion under a SW-NE  $SH_{max}$  orientation.

## DISCUSSION



**Figure 8:** The predicted stress field at the Laúca reservoir area derived from elastic finite element analysis suggests extensional tectonics with  $SH_{max}$  pointing in the WSW-ESE direction (Source: Rezene Mahatsente, David Coblenz, 2015). Our work suggests compressive tectonics with  $SH_{max}$  pointing in the SW-NE direction and a strike-slip/reverse faulting regime, similar to what is seen further to the East in the Congo Craton.

### References:

Heidbach, O., M. Rajabi, K. Reiter, M.O. Ziegler, and the WSM Team (2016): World Stress Map Database Release 2016. GFZ Data Services, doi:10.5880/WSM.2016.001  
 Rezene Mahatsente, David Coblenz; Ridge-push force and the state of stress in the Nubia-Somalia plate system. Lithosphere 2015; 7 (5): 503-510.  
 Sayão, Eveline, et al. "Spatial database and website for reservoir-triggered seismicity in Brazil." Natural Hazards and Earth System Sciences 20.7 (2020): 2001-2019.

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