Abdullah Ibrahim - Project Profile

Unravelling the nature and origin of the active tectonic pulses in the failed Suez rift, Egypt

2023 AGeS-Grad awardee

Lab: *Luminescence Dating Research Laboratory, Baylor University, Texas*

Lab Mentors: *Prof. Steven Forman, Liliana Marin*

What scientific question(s) does your research address and what motivates this work?

My research tackled several key questions concerning the nature and origin of active tectonic signals in the Suez Rift, Egypt. Although often cited as a classic example of a failed rift, the Suez Rift continues to exhibit tectonic activity, as indicated by seismological records and GNSS measurements. However, the origin of this activity remains poorly understood. Two competing hypotheses have been proposed: (1) fault reactivation driven by far-field stresses from the distant Dead Sea Transform, and (2) continued extensional strain within the Rift at lower rates. This debate raises several critical questions: (1) What is the origin and nature of tectonic pulses in the Rift? (2) What are the timescales and rates of deformation along active faults? (3) Has extension in the rift persisted to the present day? (4) If the rift is still active, is it slowly dying through decreasing strain rates, or maintaining stable, low rates? To address these questions, my research focused on the Ataqa Fault Block, a major structural feature at the northern tip of the Rift, where previous studies revealed a recent tectonic activity. We employed a multidisciplinary approach, integrating InSAR analysis, seismological records, structural and tectono-geomorphic analyses, and optically stimulated luminescence (OSL) dating.

What chronometric tool did you employ and why?

During my project, I applied optically stimulated luminescence (OSL) dating techniques on both quartz and feldspar to estimate the ages of several alluvial terraces and fans that are either dissected by or deposited along major faults in the Suez Rift, Egypt. The aim was to establish a temporal framework for neotectonic activity in the Rift, a region previously lacking absolute age constraints and has been the subject of longstanding debate regarding the nature, origin, and spatial and temporal scales of its tectonic signals. Earlier studies assigned very old ages (early Pleistocene or Pliocene) to the alluvial sediments and consequently inferred that tectonic activity had ceased during those periods. However, these conclusions were based solely on relative stratigraphy, without solid absolute age control, highlighting the need for more robust chronological constraints. Guided by our hypothesis that the Suez Rift remains tectonically active, albeit at lower strain rates, and our understanding of Quaternary paleoclimatic cycles in NE Africa, we proposed that these sediments should range in age from the Late Pleistocene to the Holocene, consistent with a model of continued extension in the Suez Rift.

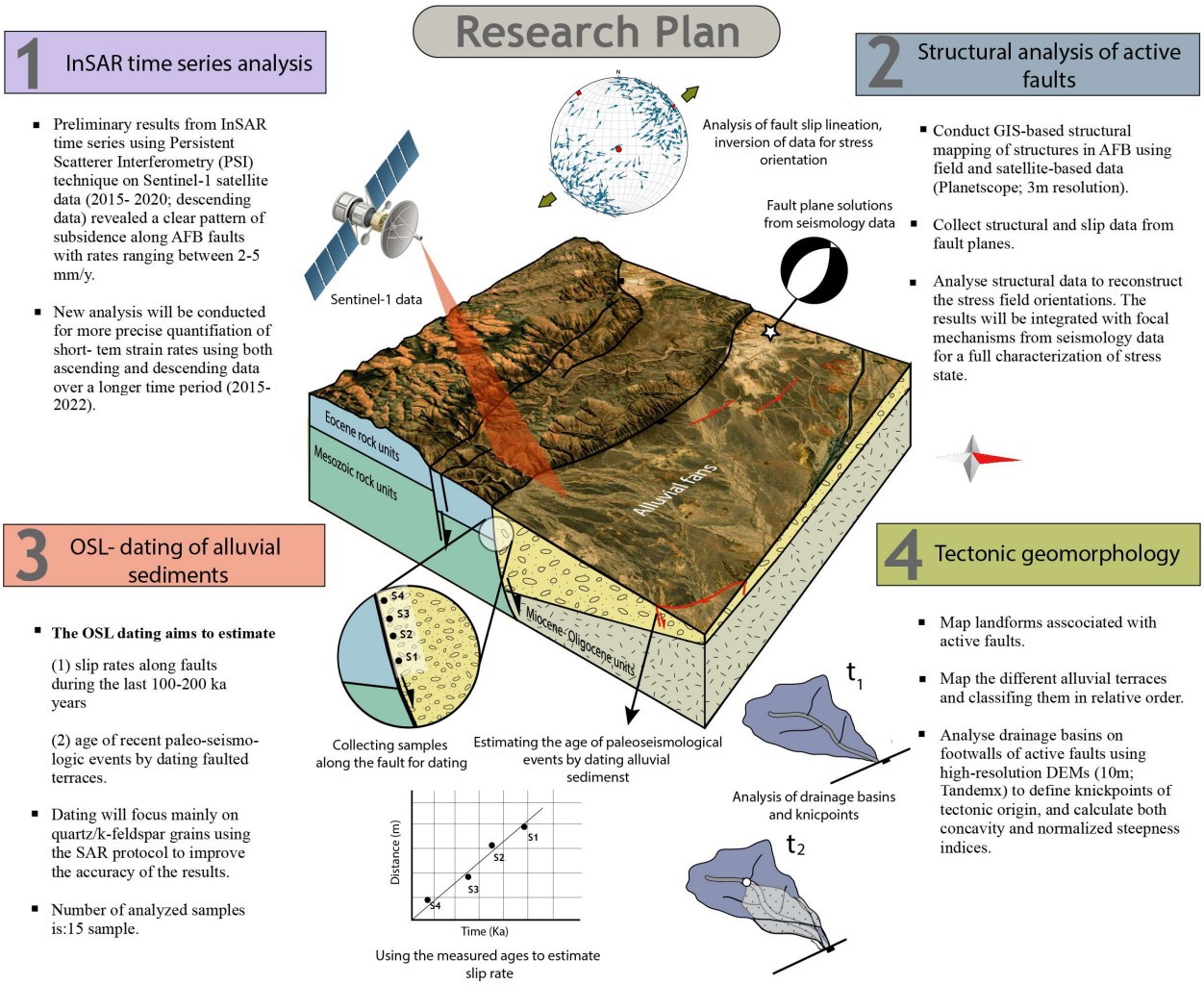

Figure 1 Research plan of the research project illustrating the different tools used through the study to unveil the nature, origin and temporal framework of tectonic signals in the Suez Rift, Egypt.

What were some of the key takeaways of your research?

- Age constraints from OSL dating of alluvial sediments reveal very recent tectonic activity, with samples ranging from the Late Pleistocene (>170–12 ka) to the Holocene (1.6–9.5 ka), confirming our initial hypothesis that the alluvial sediments along the Rift are Late Pleistocene to Holocene in age.
- Integration of structural and geomorphic data provided robust estimates of slip rates along several active faults, ranging from approximately 0.14 to 0.3 mm/yr, and an average extension rate of about 0.35 mm/yr—values consistent with independent estimates from GNSS measurements and InSAR analysis.
- The newly established temporal framework for fault activity, combined with kinematics from structural and seismological evidence, supports the persistence of extension in the Suez Rift to the present day and challenges the traditional failed rift model. Our results demonstrate that the Suez Rift has remained tectonically

active, undergoing slow-rate oblique extension since the establishment of the Dead Sea Transform and its isolation from the Red Sea system.

What new experiences, opportunities, and collaborations did you gain as an AGeS-Grad awardee?

Receiving the AGeS-Grad award significantly expanded my technical expertise in geochronology and broadened my professional network. Through the award, I gained hands-on experience with OSL dating techniques at the Luminescence Dating Research Laboratory, Baylor University, working closely with Prof. Forman and Liliana. This opportunity enhanced my background in OSL geochronology and exposed me to new best practices in data analysis interpretation. The award also advanced our collaboration with Dr. Forman, leading to a successful NASA Earth Surface and Interior (ESI) Program proposal, which secured funding in 2024. This new project allows for more extensive research across the Suez Rift, beyond the scope of the original AGeS-2023 proposal. Working with Dr. Forman, whose expertise spans OSL dating, paleoclimatology, and sedimentology, significantly improved my understanding of the alluvial depositional systems and the factors influencing the sediment architecture and ages. Our work also generated a new research idea using chemical analyses and dating results to trace sediment sources along the rift, offering insights into the interplay of tectonics, paleoclimate, and sedimentation. Overall, the AGeS-Grad experience was pivotal in strengthening my research skills, expanding interdisciplinary collaboration, and preparing me for future work.

What is one piece of advice you have for future AGeS-Grad award applicants or awardees?

I advise future applicants to fully take advantage of the opportunities the AGeS-Grad program offers by building strong collaborations with host researchers and expanding their skills in geochronological methods, data analysis, and interpretation, key steps that can greatly enhance the quality of their research outcomes. I also recommend careful planning and open communication with the hosting lab mentors before the visit to develop a clear and focused plan for their visit that will maximize the success and impact of their time in the lab.

Figure 2 Abdullah Ibrahim during collecting samples for OSL dating from the alluvial sediments, Suez Rift, Egypt

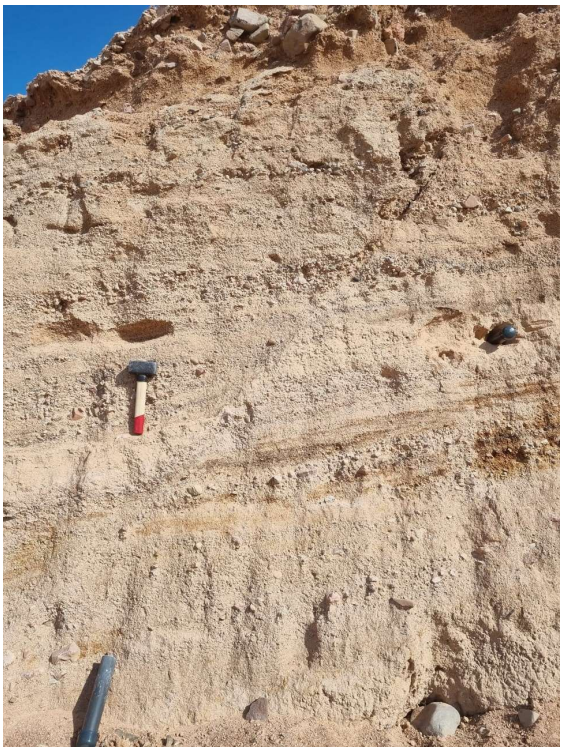

Figure 3 Alluvial sediments of late Pleistocene age in the Suez Rift, dissected by a small normal fault. Note the location of the OSL-sample tube in the right side.