The Opportunities of Working in a Challenging Environment

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Abstract A few days after the American Geophysical Union announced that I am the recipient of the 2020 Africa Award for research excellence in Earth or Ocean Sciences, I received an email from Michael Wyssen, editor-in-chief of Perspectives of Earth and Space Scientists, to write a story about my scientific experiences. I was filled with emotions. I never thought of sharing my experience with other people (except to my wife and children and close friends). I hope my story will inspire mainly marginal students, who may think that society will exclude them owing to western credentials, and believe that they cannot achieve a spot in science because of their grades. I strongly believe that scientific excellence is achieved by hard work (mostly in a subject area that you like), and a little bit of good luck.

Plain Language Summary Hard work and a little bit of luck are important to secure a spot in academia. Most of the decisions in my professional life have been made by circumstances but I tried to make the best out of them.

1. Falling in Love With Physics (the Power of a Pat on the Shoulder)

I was born, raised, and I am still living in Addis Ababa, about 5 km from the city center. As the only child to my parents, I did not have as much fun as most children in my neighborhood. My mom was very protective and did not allow me to play outside. I stayed home during most of my childhood. I liked my life at school, except for the bullies. I was bullied during elementary school because of two main reasons - I was a good student and most of my friends were girls who were not intimidating.

I started spending a lot of time in the field, watching other children play football (called soccer in the United States). Eventually I became one of the top football players in the school (or among regular players in our dusty school football field) and was always the first one to be picked by the teams. As a consequence, the punches I received from the bullies diminished significantly. Looking back in time, I realize that my little brain had the ability to deal with difficult situations and used that to make positive impacts.

In my elementary school years, I did not show any sign of being attracted to any subject. During junior high school, we studied Science which included the subjects Biology, Chemistry, and Physics and it was not appealing to me. It is only in high school that we study those subjects separately. When I was in ninth grade during class exercise in Physics, which was about measurement units, I got all the questions right and the teacher was very happy and patted me on the shoulder (I was extremely happy because that was the best one could get from that teacher). Neither the teacher nor I expected that that small gesture would play the most monumental role in my academic life. I immediately fell in love with Physics. I almost stopped studying other subjects but Physics and Math.

After finishing high school, there were two important milestones in my life-to pass the Ethiopian School Leaving Certificate Examination, which was pretty hard at the time, and the other was to join Addis Ababa University. In Ethiopia, your grades play no role to which state university you are going to be assigned. As someone who was born, raised, and studied in Addis Ababa, the thought of moving to another city, especially the cities where good universities are located 500 km or even far from Addis Ababa, was unbearable. Luckily, all went well and I passed the exam and joined Addis Ababa University.
2. Undergraduate University Life

In 2001, I joined Addis Ababa University. After a year as a freshman taking all science courses, we selected the department we would like to join. The smart ones, those with a good GPA, are privileged and could join any department they like. Those who do not make high scores like me had no such luxury. I got Bs and Cs in many of the courses. Earth sciences (it was then called Geology and Geophysics) was my 9th choice from the list. So, one can imagine how bad my grades were. It should be clear that I am not a lazy person. I just do not like to read the subjects that I do not find interesting. Above all, I hate to study for exams because I am not able to give equal attention to all portions of the subject. I am easily carried away by the portion of the subject that I find interesting.

I was familiar with the subject of Geology from high school Geography and freshman Environmental Geology courses. To be honest, I did not like those topics and hence I was not excited about joining the department (why would I be when it was my ninth choice?). Anyway, I started attending the courses. We had two very good professors delivering the introductory course on Geology (the course was called General Geology). Among the list of reference books, there was a book called Physical Geology by Plummer and colleagues (Plummer et al., 1999) that I found extremely interesting. I spent most of my time reading this book and eventually developed a strong interest for seismology and plate tectonics. In 2001, an international team of scientists commenced a project called Ethiopia Afar Geoscientific Lithospheric Experiment (EAGLE) to understand rifting, magmatism and the evolution of the Main Ethiopian Rift. One of our General Geology course professors (Gezahegn Yirgu) was a co-organizer of this project and it was common to hear the aims of the EAGLE project during class time. I could not understand many of the scientific jargons but two things were clear to me - scientists are still trying to understand plate tectonics and Ethiopia is a perfect place (tectonic setting) to advance our understanding of the theory.

When I was a third year student, I had a very good Geophysics Professor (Abera Alemu), who helped me develop a very strong interest for the subject. I remember, one day he gave me an old Worden gravimeter so that I could measure the gravity field in the university campus and processed the raw gravity data manually. This inspired me greatly to pursue a career in Geophysics. In fact, I wanted to join the Geophysical Observatory, which was located in the Science campus. However, it was obvious that my grades were not at the level required to work in the university as a graduate assistant. So, in July 2005, I left the university with BSc degree and lot of uncertainties in what would lie ahead.

After spending a couple of months searching for jobs, I finally found a place at a company that specialized in foundation investigations for bridges, roads, and buildings. I was leading a drilling crew for foundation investigations in different parts of Ethiopia. Finally, 11 months after working for the company, in 2007, I joined the Geological Survey of Ethiopia, where I spent 4 years of my professional life.

3. Geological Survey of Ethiopia

At the Geological Survey of Ethiopia, I was assigned to a Czech-Ethiopia collaboration project studying the water resource management and environmental protections of the Jemma river basin, which is one of the major tributaries of the Abay (Nile) river. This project was my first encounter with foreign scientists and was also seminal in many ways. Our work was published in a book form with four accompanying maps, and I made my first study visit abroad to the Czech Republic for two and half weeks. In 2010, I led a similar project in the Ogaden Basin, in the southeastern part of Ethiopia, and published a book with two accompanying maps.

Two years after I graduated with bachelor's degree, I applied for an MSc study in hydrogeology at Addis Ababa University. A couple of days before the entrance examination, I received a call from the department that told me that my application documents were lost. I went to the head of the department, Balemwal Atnafu, and informed him of the situation. He advised me to join either paleontology or structural geology for the mere reason that these subjects did not attract sufficient number of students that year. Most students are interested to join applied geology streams such as hydrogeology and engineering geology. I started preparing myself for the structural geology entrance exam. A day or two before the exam, I received another call - again from the department. This time they found my application documents and invited me to sit for
the hydrogeology entrance exam. I declined the offer and joined structural geology as the only student for the stream in 2007.

4. Back to University

The excitement of being a student and a full time employee, simultaneously, did not last long. The fear of exams overshadowed everything else. My time was mainly consumed by studying the subjects that I liked the most and working for the Geological Survey. I earned a C+ in a course and the professor warned me to study very hard if I really wanted to remain a graduate student.

After finishing the first year of the MSc, I had to choose a thesis title. Tesfaye Kidane had proposed that I work on the tectonics of the northern Main Ethiopian Rift using paleomagnetic data, but I had already made up my mind to investigate the role of tectonics on groundwater flow in the Main Ethiopian Rift. One Saturday morning, I was reading a book by Robert Butler (1998) for the paleomagnetism course. I was so fascinated by the equations. I thought that I could realize my dream of becoming an expert in plate tectonics if I could specialize in paleomagnetism. I rushed into Tesfaye's office and told him that I wanted to do my thesis on paleomagnetism. He said OK with the “I already proposed you” look in his eyes. This led me to spend an exciting rest of my MSc study and beyond. Studying paleomagnetism also reunited me to mathematics, which is my passion. Unfortunately, in our undergraduate and postgraduate courses, we overlook the contribution of math in geosciences. So, it is clear that I have to refresh my memory on the subject. Nevertheless, the need for improving my computational skills was not clearly evident until I started my PhD study.

In February 2009, I joined the team led by Julie Rowland and Tesfaye Kidane to Dabbahu Rift in northern Afar to conduct structural and paleomagnetic surveys. That was an amazing experience. While Tesfaye was drilling, my job was pumping the water and orienting samples. Although I was familiar with field work in a challenging environment, the field work in Afar was a whole new experience. Watching Tesfaye drilling under the Afar sun tirelessly, I was thinking this might be tough for a skinny boy like me. I thought the hard part of a paleomagnetic study was finished in the field. Little did I know that the most difficult part was the laboratory work. Back in the lab, Tesfaye showed me everything I needed to know to conduct the lab work. Our laboratory was equipped with basic facilities including the alternating and thermal demagnetizers, core cutting machine, and a JR-6 spinner magnetometer. I spent about 6 months in the lab to finish my thesis, which eventually led to the publication of my first peer-reviewed paper (Muluneh et al., 2013).

5. Life in Italy

I was highly encouraged by the results of my MSc thesis work. I started looking for a PhD scholarship. I wrote to scientists from around the world. Some were kind enough to reply with rejection letters. Some told me that applications are possible through the formal link between universities, but most ignored my letter. By mid-2010, Sapienza university of Rome announced a call for a PhD scholarship for foreign students. Among the calls, there were two positions in the departments of Astronomy, Physics, Chemistry, Mathematics, and Earth Sciences. I was third in the list of nine short listed candidates. After a couple of months, I received an email from the university registrar that the first on the list could not accept the offer and so they decided to give me the chance. A few days later, I got the acceptance letter written in Italian. I took the letter to Gezahegn Yirgu, who studied in Italy and speaks good Italian, who read the letter quickly and said “This is a very good scholarship. Make sure you work really hard.”

In October 2010, I traveled to Rome and started a PhD study at Sapienza University of Rome. The first couple of weeks were very tough on me. I had a very low self-esteem and it took me a while to learn the culture. Coming from a conservative family and culture, it was kind of expected. The other PhD students at the “Aula Dottorandi” noticed the situation I was enduring and invited me to join them for lunch. As time passed by, the lunches changed into dinner parties and occasional beers. I developed strong habits for rock and roll music (listening - not playing), photography, and hiking (It was a marvelous experience to hike Mt. Etna and visit Pompeii).

The best part of the PhD study was that the program was PhD by research and hence there were no exams. This made my study less stressful. My PhD was being supervised by Carlo Doglioni. I downloaded most of
his papers on global tectonics and started reading since the day I arrived at Rome. I was extremely fascinated by his works but did not know how I could relate my proposal on the kinematics of the Main Ethiopian Rift to the global tectonics model. He did not tell me either. He made no attempts to force me to follow his and his colleagues’ ideas on global tectonics or plate tectonics, in general. He just let me decide my path for myself. Basically, I had enough freedom to do what I wanted. I believe that helped me to become an independent researcher during and even after my PhD. During the first year of my PhD, Carlo introduced me to a very influential person on the kinematics and tectonics of the Ethiopian Rift, Giacomo Corti. I knew Giacomo even before I moved to Italy, but never met him in person. I used to make frequent visits to Florence to meet Giacomo and discuss the tectonics of the Ethiopian and Afar rifts. We became strong research collaborators and friends since then.

As part of the PhD course, I used to attend seminars and conferences at Roma Tre University. Once I attended a week long lecture by Thorsten Becker on geodynamics. I was intrigued by his and Claudio Facennia’s works that combined numerical and laboratory modeling of subduction zones. Maybe that was my first encounter with multi-disciplinary studies, but I immediately realized that collaboration with other scientists is very important, especially when the resources are limited. I started thinking of combining my skill sets with other disciplines to understand the rifting in Ethiopia. Our Tectonophyscis paper (Muluneh et al., 2014) was the first of such attempts.

While at Sapienza, Maurizio Battaglia used to deliver a course on Numerical Methods using MATLAB for PhD students. I had never used MATLAB or any other command-line interfaces before. It was very tough for me at the beginning. But eventually, I managed to understand the examples and started writing my own simple codes using MATLAB and Python. With the help of my co-advisor and endearing colleague, Marco Cuffaro, I started familiarizing myself with the quantitative part of plate tectonics using mathematical equations from the books by Cox and Hart (1986) and Stein and Wysession (2003). The equations in these books made the foundation for many of the papers I published, including my dissertation.

In 2013, at the final year of my PhD study at Rome, I received a travel grant from the American Geophysical Union (AGU) to attend the fall meeting in San Francisco. I was extremely fascinated by the quality of the presentations at the meeting. I spent only a few minutes near my poster because I was attending other people’s work. I also made one or two attempts to form contacts with scientists for a potential postdoc position, but that did not work. To be frank, I was not very much interested in postdoc at the time. I wanted to return back to Ethiopia to be with my son and my wife who was pregnant with our second son.

6. Back to Addis Ababa University—This Time for a Different Cause

I returned back to Ethiopia, a month after I finished my PhD study, with high hopes of finding an academic position at Addis Ababa University, School of Earth Sciences. Although I received good recommendations and support from some of the faculty members, the bureaucracy was so painful. I waited for about 10 grueling months with no salary. During those periods, I received several job offers from other universities and industries, but did not want to take them. Finally, in January 2015, with the help of really good people (Teskaye Kidane and Seifu Kebede), I secured a permanent position at the School of Earth Sciences. Along came another problem. My study focuses on a multi-disciplinary approach, which is not quite common in the school. For geophysicists, it was not mathematical enough, for geologists it was not field based.

I began my tenure with giving common courses to Geology students and some specialized courses to Geophysics students. At this time, Tesfaye Kidane was leading the GeoPower Africa project and involved me as a project structural geologist in 2016. The main topic of this project was collecting information on geothermal sites all over the country and producing a national database with the ultimate goal of locating potential sites for direct use. Through this project, we collected several data from the literature and the field. Our project directly contributed to the success of the Geothermal Village concept by Jacques Varet in the northern Afar. The project funded several young, highly motivated Ethiopian scientists, whose works were published in peer-reviewed journals (Darge et al., 2019; Nugsse et al., 2018). I was in charge of this project, after Tesfaye moved to South Africa, until its completion in 2017.
One of my research targets was to understand frictional strength of earthquake generating faults in the Ethiopian Rift. To this end, I inverted earthquake focal mechanisms from the Keir et al. (2006) catalog and estimated shear strength and friction coefficients. I discussed the findings with Tesfaye Kidane and Giacomo Corti. Both were very interested and Giacomo introduced me to Derek Keir, who worked a lot on the Ethiopian and Afar rifts and the four of us wrote our 2018 paper together (Muluneh et al., 2018). In the work, we showed that magma input plays a significant role on the strength of the faults in the rift. Our study confutes some geodynamic models, which assume that large faults accumulate large strain and hence the friction coefficient is significantly reduced. We observe no such behavior in the Ethiopian Rift. This might suggest that the common approach in numerical modeling should be challenged and models should consider magma input in controlling the frictional parameters of faults.

7. Challenges and Opportunities of Being a Scientist

I like Science very much. As the only child who grew up in a conservative family, I used to stay at home for most of my childhood, which taught me to be patient. Together with the right skill sets, I believed that was the sufficient qualification to pursue a career in academia. Everyday I challenge myself to become a better person, a better scientist. However, the main challenge for me (and scientists in Africa in general) was that only limited resources were available for research. To make the situation even worse, those limited resources are allotted for studies conducted to directly solve societal problems. To sidestep this problem, I started using methods that require more computer time than field work. Fortunately, many scientists (earthquake seismologists and GPS experts) have collected ample data from the Ethiopian and Afar rifts and most of which are available as either supporting material or included in repositories. These data can be interpreted/discussed in terms of tectonics.

I am fortunate enough to collaborate with an international team of scientists. In 2018, Giacomo Corti introduced me to Sascha Brune, who was very much interested in the modeling of lithospheric extension. His paper on rift propagation and linkage in the southern Ethiopia (Brune et al., 2017) had already caught my attention. Together with Sascha, I applied for the TWAS-DFG cooperation visit. I won the fellowship and went to GFZ German Research Center for 3 months during winter 2019. My stay in Germany was fascinating. Sascha introduced me to the amazing world of numerical geodynamic modeling and parallel computation. I had never used a parallel computational facility before. It is interesting that I still use the facility at GFZ while I am in Ethiopia using a remote license.

Meanwhile, I won the newly established Canon-foundation Japan Africa Exchange program. I already developed a very good research collaboration with scientists from Kyoto University through Tesfaye Kidane (Ryokie Yoshimura, Naoto Ishikawa, Jim Mori and many others). So, when I went to Kyoto, Disaster Prevention and Research Institute in summer 2019 and winter 2020 for two months each, it felt like home. The time I spent in Japan was one of my happiest moments. I used to work in the office until 2 a.m. and managed to write a significant portion of our recently published paper (Muluneh et al., 2021) and a proposal, which just got accepted for funding by the Alexander von Humboldt Foundation Georg Forster fellowship for experienced researchers.

At the end of 2019, Addis Ababa University circulated a call to apply for Africa-Oxford collaborative research at University of Oxford, with a deadline fast approaching. I sent an email to Derek Keir to introduce me to Mike Kendall, who had just moved from Bristol to Oxford. Derek sent an email to Mike and Tamsin Mather. Mike was in Antarctica for field work. Tamsin replied immediately and told me to meet David Pyle, who had just arrived at Addis Ababa for field work in the rift. David and I met in my office and discussed my proposal. He liked it. This proposal is now funded by the University of Oxford and the research will be conducted at Richard Katz’s geodynamic modeling laboratory.

Every time I travel abroad, either for conference or as a visiting scholar, I try hard to make the best out of them since these opportunities do not come easily. For example, a discussion with Cindy Ebinger in autumn 2016, during my visit to University of Rochester, about the use of Kostrov summation in strain rate analysis led to the publication of our 2017 paper (Muluneh et al., 2017). Attending the 2019 European Geoscience Union meeting at Vienna, Austria, resulted in the paper co-authored by scientists from seven countries in four continents (Muluneh et al., 2020). My efforts in publishing papers and grant applications are greatly
supported by the really smart and kind scientists including Tesfaye Kidane, Giacomo Corti, Derek Keir, Sascha Brune and many others. I am privileged to have them in my circle and, in fact, I promised myself to be kind and supportive to others who need my help in their scientific endeavors. Together with young and highly motivated scientists and faculty members at the School of Earth Sciences (Binyam Hailu and Behailu Berhanu), we are working on forming a multidisciplinary team involving remote sensing and GIS, hydrogeology, and tectonics. We believe that there are lots of unanswered questions that we can tackle by working together from different perspectives.

One of the proudest moments in my academic life was that I was invited to attend the young leader forum in 2019 by Science and Technology for Society held in Kyoto, Japan. I had the privilege and honor to sit with Nobel Laureates and great scholars to discuss the role science played and should play to solve societal problems (Figure 1).

In November 2020, AGU announced that I am the recipient of the 2020 Africa Award for Research Excellence in Earth or Ocean Sciences. The award letter by Robin Bell, the president of AGU, says, “This award is in recognition for completing significant work that shows the focus and promise of making outstanding contributions to research in Earth or Ocean sciences by an early career scientists from African continent.” I particularly liked this sentence because it emphasizes that I still have a lot to do. I like science and I want to stay in business as long as I can and make a significant impact on both academia and society. I consider myself lucky to contribute a small part in the quest for a better understanding of the geodynamics and the resources of the East African Rift.

8. Recommendations

I conclude this article by making a few suggestions, based on personal experiences, to early career scientists and graduate students on how to avoid pitfalls in order to remain as scientists. In a continent where basic science is sometimes considered as a luxury, scientists working in those fields have few opportunities. I benefited a lot from the research grants from funding agencies that target African scientists. The grants from those funding agencies are doing me and other junior researchers a great favor. Furthermore, the research visits organized as part of these fellowships are like windows that we can use to escape from intense course teachings at our home institutions and help us focus more on research. I strongly suggest to my colleagues to target those funding schemes for both long and short term fellowship opportunities. The other important approach to remain as a scientist in Africa is to make strong collaboration with foreign and local scientists, which is crucial in increasing knowledge and skill transfer.

The future of our continent depends on the young generation of scientists we are training. The most seasoned African scientists and university professors have to evaluate their contribution to academia and society based on the quality of their graduate and postgraduate students. They have a moral obligation to provide support wherever needed. Our universities should also boost the career of junior scientists by allocating specific research (start-up) grants at the beginning of their tenure. Our graduate students should believe that it is not always true that you have to be at the top of your class to achieve a spot in academia. My personal story highlighted that hard work and a little bit of luck are also equally important.

References

Brune, S., Corti, G., & Ranalli, G. (2017). Controls of inherited lithospheric heterogeneity on rift linkage: Numerical and analogue models of interaction between the Kenyan and Ethiopian rifts across the Turkana depression. Tectonics, 36, 1767–1786. https://doi.org/10.1002/2017TC004739

Butler, R. (1998). Paleomagnetism: Magnetic domains to geologic terranes (Electronic edition). Cox, A., & Hart, R. (1986). Plate Tectonics- how it works (1st ed.). Blackwell Scientific Publications.
Darge, Y., Hailu, B., Muluneh, A., & Kidane, T. (2019). Detection of geothermal anomalies using Landsat 8 TIRS data in Tulu Moye geothermal prospect, Main Ethiopian Rift. *International Journal of Applied Earth Observation and Geoinformation, 74*, 16–26. https://doi.org/10.1016/j.jag.2018.08.027

Keir, D., Ebinger, C., Stuart, G., Daly, E., & Ayele, A. (2006). Strain accommodation by magmatism and faulting as rifting proceeds to breakup: Seismicity of the northern Ethiopian Rift. *Journal of Geophysical Research, 111*, B05314. https://doi.org/10.1029/2005jb003748

Muluneh, A., Brune, S., Illsley-Kemp, F., Corti, G., Keir, D., Glerum, A., et al. (2020). Mechanism for deep crustal seismicity: Insight from modeling of deformation processes at the Main Ethiopian Rift. *Geochemistry, Geophysics, Geosystems, 21*, e2020GC008935. https://doi.org/10.1029/2020GC008935

Muluneh, A., Cuffaro, M., & Doglioni, C. (2014). Left-lateral transtension along the Ethiopian Rift and constrains on the mantle-reference plate motions. *Tectonophysics, 632*, 21–31. https://doi.org/10.1016/j.tecto.2014.05.036

Muluneh, A., Cuffaro, M., & Kidane, T. (2017). Along-strike variation in deformation style inferred from kinematic reconstruction and strain rate analysis: A case study of the Ethiopian Rift. *Physics of the Earth and Planetary Interiors, 270*, 176–182. https://doi.org/10.1016/j.tecto.2014.05.036

Muluneh, A., Keir, D., & Corti, G. (2021). Thermo-rheological properties of the Ethiopian lithosphere and evidence for transient fluid induced lower crustal seismicity beneath the Ethiopian rift. *Frontiers in Earth Science, 9*, 610165. https://doi.org/10.3389/feart.2021.610165

Muluneh, A., Kidane, T., Corti, G., & Keir, D. (2018). Constraints on fault and crustal strength of the Main Ethiopian Rift from formal inversion of earthquake focal mechanism data. *Tectonophysics, 731–732*, 172–180. https://doi.org/10.1016/j.tecto.2018.03.010

Muluneh, A., Kidane, T., Rowland, J., & Bachtadse, V. (2013). Counterclockwise block rotation linked to southward propagation and overlap of sub-areal Red Sea Rift segments, Afar Depression: Insights from paleomagnetism. *Tectonophysics, 593*, 111–120. https://doi.org/10.1016/j.tecto.2013.02.030

Nugsse, K., Muluneh, A., & Kidane, T. (2018). Paleomagnetic evidence for counterclockwise rotation of the Dofan magmatic segment, Main Ethiopian Rift. *Tectonophysics, 731–732*, 85–94. https://doi.org/10.1016/j.tecto.2018.03.013

Plummer, C., McGeary, D., & Carlson, D. (1999). *Physical geology* (8th ed.). William C Brown Publishing.

Stein, S., & Wysession, M. (2003). *An introduction to seismology, earthquakes and Earth structure*. Blackwell Publishing.