The life (and death?) of a mountain – the case of the Damara Belt

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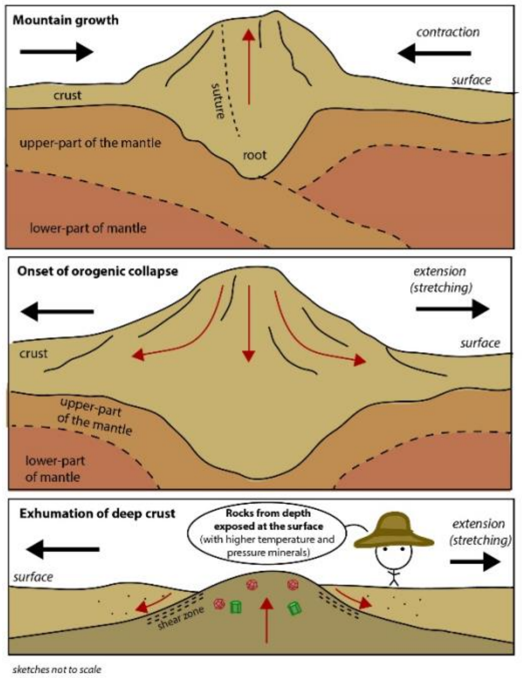
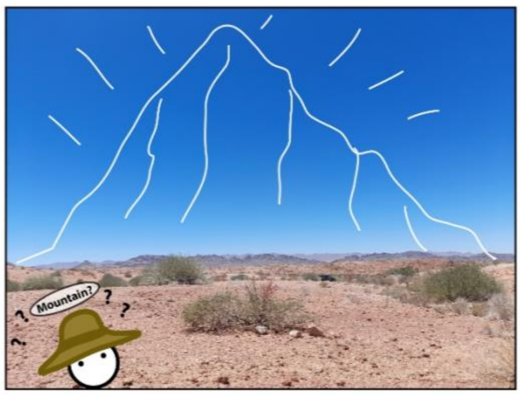
Mountains are big… I mean really big! Mountains play a key role on Earth, in defining geopolitical boundaries, controlling local climates, and even influencing species diversity. So how does a mountain just disappear? Well, like most things, mountains have a life cycle. A mountain can form when two tectonic plates collide, creating an area of extra thick crust as it grows (*orogenesis* – the growth of a mountain). Not only does the crust weld together in the mountain *suture zone* (the area where two continents met during a continent-continent collision) and create areas of extreme elevation, but a *mountain root* also develops deep into the crust (up to 80 km deep). A mountain is very heavy and can eventually collapse under its weight. This process is known as *orogenic* (mountain) *collapse*, and you can think about it a bit like a camembert cheese that spreads out when warm. As the mountain grows and the crust thickens, the rocks deep in the mountain root will start to warm up. The increasing temperature makes the rocks soft and weak, and with the added weight of the growing mountain, will eventually start to flow laterally outwards over tens of millions of years. This is one way that orogenic collapse can happen.

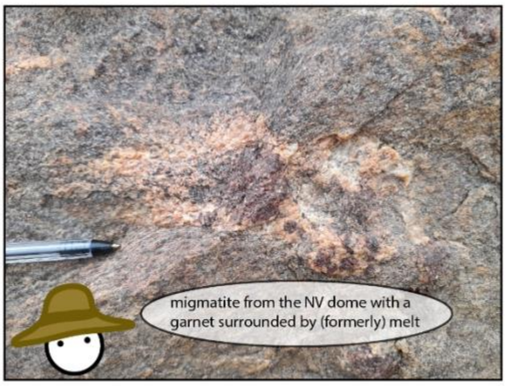


The outward flow of material forms areas in the mountain where the crust starts to stretch. Here certain geological structures can form, such as normal faults and shear zones. These structures, along with the thinning crust, cause rocks in the warmer, lower crust to rise towards the Earth's surface, a process known as *exhumation*. Orogenic collapse, along with erosion can cause a mountain, once towering over the landscape, to be nothing more than a flat plain, with only rocks that should be deeply buried now exposed on the surface right next to rocks from shallower crustal depths.



However, when studying these old mountain belts, we sometimes aren't sure if conditions were right for orogenic collapse to happen at all. The Damara Belt in Namibia is one of these ancient mountain belts and formed when three continents collided around 580 million years ago, during the build-up of the Gondwana supercontinent. While the geology of the Damara Belt tells the story of how the mountain belt grew, there is still some debate about whether it collapsed or not.

Supporters of orogenic collapse in the Damara Belt point to areas where rocks recording different pressure and temperature conditions (meaning rocks that were once at different crustal depths) occur next to each other, along with the presence of shear zones at the edges of these regions, as evidence of collapse. One such region is suggested to be near where the mountain root is now exposed at the surface, called the Central Zone of the Damara Belt. However, in the rocks of the Namibfontein-Vergenoeg (NV) dome found in the Central Zone, we see little evidence of the stretching that would have accompanied orogenic collapse. Rather, the rocks of the NV dome were folded at least three times. These rocks have been partially melted to form a special kind of rock called migmatite. We can use the suite of minerals within, and the chemical composition of the migmatite to show that the rocks were once very hot. We have calculated the temperature to once have been around ~755°C. Evidence from fieldwork tells us that these rocks were folded while they were partially molten. However, we do not see any large shear zones or other extensional structures (those caused by stretching) that would have brought rocks from deep in the crust towards the surface. It seems rather, that the NV dome rocks may have been exhumed during the folding episodes. Contraction linked to the growth stage of the mountain likely caused this multi-phase folding at the NV dome.



While the story of the NV dome is likely one of mountain growth, the NV dome represents only a small area (~20 km^2) of the Damara Belt, which is hundreds of kilometers in width and length. The unresolved reality of orogenic collapse in the Damara Belt is a line of research worth pursuing. As our database of pressure and temperature data, and the structural geology of the Damara rocks continue to grow, new patterns in the data emerge that may give us more clues as to whether or not the Damara Belt did in fact collapse. With new mapping, modelling, and laboratory techniques to analyze these rocks, the future for research in the Damara Belt is bright indeed!