Cenozoic deformation and geomorphic evolution of the Sperrgebiet (Southern Namibia)

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Abstract: The Sperrgebiet is located along the coast of Namibia, bordered in the east by the Great Escarpment of the Southern African Plateau. The Cenozoic evolution of the coastal plain as a consequence of scarp retreat (backwearing) surrounding this plateau was hitherto poorly constrained because of the scarcity of well-dated marker horizons. However, Cenozoic terrigenous deposits and volcanics present in the Sperrgebiet constrain the timing of evolutionary events in the region during the Cenozoic. We combine an analysis of the geomorphic patterns, depositional environments and microtectonics to constrain this evolution and its driving processes. The outcome is that during the beginning of the Palaeocene a smooth scarp existed between an elevated plateau in the east and the coastal domain. The topography was affected by intense weathering that generated thick lateritic profiles that were etched after a change in climatic conditions followed by two deformational stages. The first stage corresponds to a low-scale bulging during the Oligocene and the second to a phase of brittle deformation with an initial WNW-ESE extension with rotated NE-SW extension. This small-scale brittle deformation is consistent with the greater deformation that affected the Southern African Plateau such as the Windhoek Graben and the graben of the Fish River. We propose that this deformation corresponds to changes in the relative contribution of horizontal and vertical stresses, which were induced by variations in the rates of ridge push.

Keywords: South African Plateau; scarp retreat; microtectonics; strike-slip; planation surfaces.

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Introduction

The southern African Plateau is a well-known geomorphic feature of the African plate delimited inland by the Great Escarpment. Over many decades, researchers have proposed diverse hypotheses concerning its origin (King 1963; Partridge & Maud 2000). Two opposing models have been advanced: an abnormal high-elevation plateau inherited since the Triassic (Doucouré & de Wit 2003; Dauteuil *et al.* 2013), or uplift during the Mesozoic and/or Cenozoic. The age of this uplift was actively debated : during the Mesozoic (Pysklwec & Mitrovica 1999; Van der Beek *et al.* 2002; Nyblade & Sleep 2003), in the late Cretaceous (Gallagher *et al.* 1998; Gallagher & Brown 1999; de Wit 2007; Tinker *et al.* 2008a; Tinker *et al.* 2008b), or during the late Cenozoic ~30 Ma (Burke 1996; Burke & Gunnell 2008); or ~3 Ma (Partridge & Maud 1987). These works did not investigate the evolution of the coastal domain formed by scarp retreat and did not discuss its geomorphology or deformation history. Two models of scarp retreat were advanced: i) downwasting in which the surface topography is lowered vertically from an initially high topography generating a concave palaeoplain, or ii) horizontal retreat (backwearing) from an initial steep scarp generated by major faults (Gallagher *et al.* 1998).

The initial stages of these models correspond roughly with an elevated inland. The main difference between them is the slope between the inland sector and the shoreline: smooth in the downwasting model and steep in the retreat model. The second difference is the age of the surface shaping the coastal domain: the age of the surface becomes younger landward in the retreat model and is more or less constant in the downwasting model. The third difference is the associated deformation. The retreat model predicts significant uplift decreasing landward, whereas under the downwasting model, uplift is low. Thus, an analysis combining tectonics, topography and sedimentary deposits provides essential constraints concerning the evolution of the coastal domain and as a consequence throws light on the evolution of the inland plateau.

The Sperrgebiet in Namibia (Fig. 1) is an appropriate place to study coastal plain dynamics because it is one of the few places around the Southern African Plateau which contains deposits and magmatic intrusions dating from this period. Therefore, we propose combining a microstructural analysis with a geomorphologic study of the northern part of the Sperrgebiet a hundred km south of Lüderitz in order to determine the deformation processes and to constrain the evolution of the coastal domain in relation with scarp retreat.

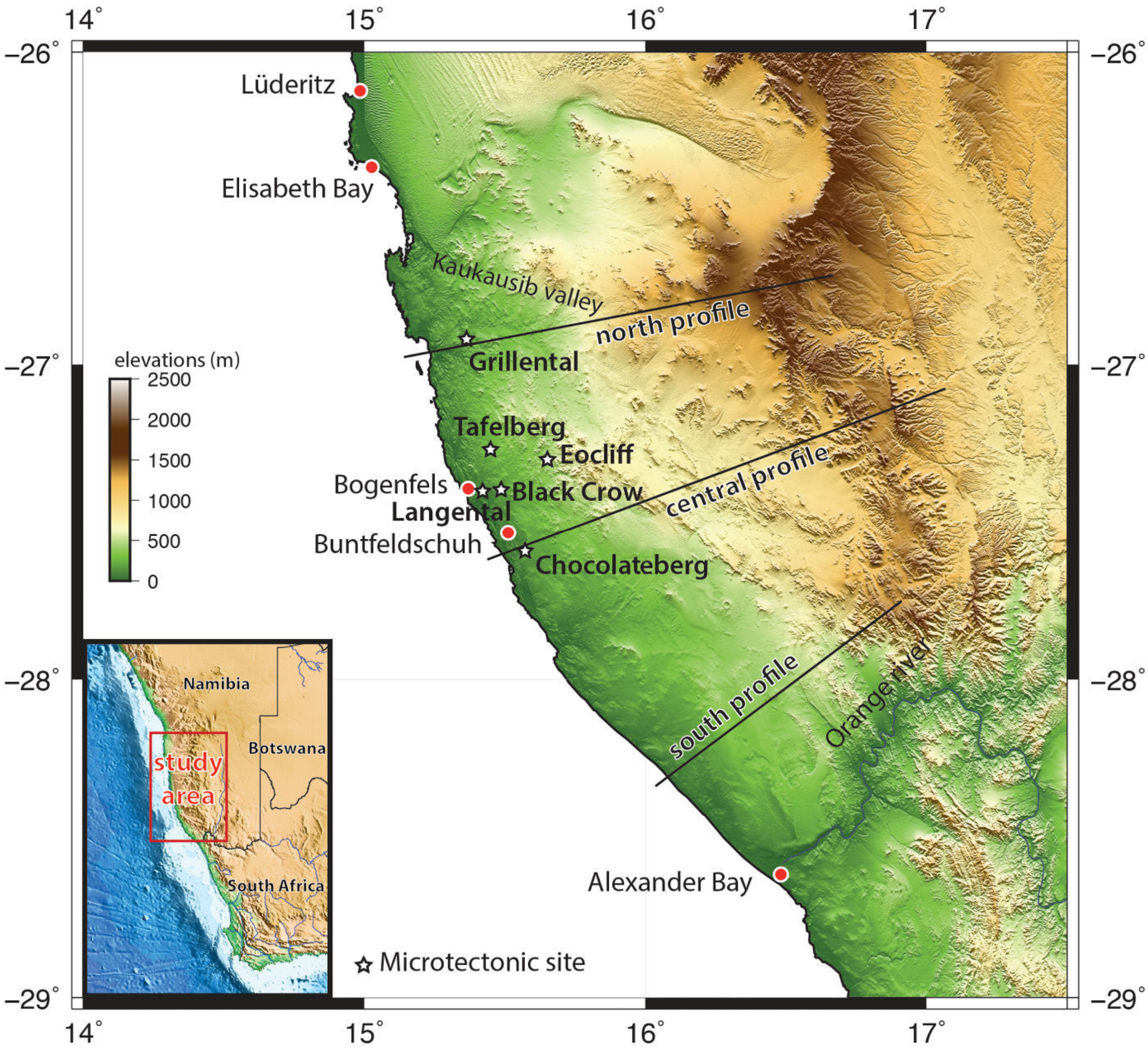

Figure 1. Topographic map of the study area beneath the South African Plateau. The insert displays the location of the study area, the black lines show the locations of the topographic profiles of Fig. 5 and the white stars the location of microtectonic sites.

Cenozoic Geological Setting of Namibia

The Namibian basement is formed by accreted Proterozoic terranes. From the Carboniferous to Early Permian times, a widespread ice cap shaped the landforms, generating a surface that was subsequently buried (and thus preserved) by the Karoo sediments of which the source was the growth of a mountain belt, the Cape Fold Belt (Johnson *et al.* 1997). After deposition of the Karoo flood basalts which erupted during the Early Jurassic (Jourdan *et al.* 2004), continental break-up occurred on both sides of southern Africa. On the western side, the South Atlantic Ocean opened during the Early Cretaceous (Hauterivian (Moulin *et al.* 2010)). The rifting propagated from South to North until the Lower Cretaceous (Clemson *et al.* 1997) and was contemporaneous with the Etendeka-Parana magmatic event (Stollhofen *et al.* 1999; Jerram & Widdowson 2005). The main phase of the magmatic event occurred 132 myr ago and subsequent pulses occurred until 125 Ma. After continental break-up, the coastal domain underwent a long period of weathering and erosion that removed up to 5 km of cover in some places (Gallagher & Brown 1999; Brown *et al.* 1990; Raab *et al.* 2005; Dauteuil *et al.* 2013). The Late Mesozoic-Cenozoic history of the region is dominated by the climatic conditions that drove landscape evolution (Pickford *et al.* 2014). From the point of view of geomorphology, the most significant climatic event occurred during the Palaeocene corresponding to a hot and humid period that generated lateritic profiles up to 100 m thick which resulted in deep weathering of the basement. The climate then became drier (Pickford *et al.* 2014) and mechanical erosion became predominant, scouring the lateritic profile and leaving residual inselbergs. The result was a succession of stepped planation surfaces with high mantle etchplains and lower stripped etchplains and pediplains (Guillocheau *et al.* 2018).

Geological Setting of the Sperrgebiet

The Sperrgebiet is part of a vast arid domain largely covered by active dune fields of the Namib Desert (Fig. 2) (Pickford & Senut 1999, 2003, 2008). These dunes overlie a widespread planation surface that facetted the predominantly siliciclastic rocks of the Proterozoic Gariep Belt. This coastal domain is up to 150 km wide and is bounded in the east by the Great Escarpment (Fig. 1, 2). The coastal plain rises to 1300 m at the base of the scarp with a gentle slope (<9‰) (Fig. 1) (Pickford *et al*. 2008). Some residual hills in the coastal domain preserve elements of an old elevated topography. Lateritic profiles occur in a lot of these hills, and provide not only a time marker but also a geomorphic marker (Fig. 2, 3). Chocolatberg (Kakaoberg) is an example of a residual lateritic profile forming a hill 100 m high (Fig. 3). The flat summit is comprised of a ferricrust at least 15 m thick which overlies a yellow limonitic part approximately 50 m thick, which contains shark teeth in lenses of agates and sand. This layer unconformably overlies a nodular saprolite at least 15 m thick, the upper surface of which is marked by ophiomorph-like burrows. The saprolite crops out at the bottom of the hill as well as further afield, and we estimate its thickness to be at least 35 m. The age of the saprolitic profile is not precisely determined, but we can reasonably propose that it was generated during the major Eocene weathering phase (Guillocheau *et al.* 2018) on the grounds that it is unconformably overlain by Bartonian marine beds with shark teeth (Pickford 2015). The ferricrust at the top of Chocolatberg is considerably younger, formed during the Oligo-Miocene (Pickford 2016).

Cenozoic deposits of the Sperrgebiet (Fig. 2) were described in several works (Miller 2008; Pickford 2015; Pickford & Senut 1999, 2003, 2008; Corbett 2016) that summarized previous studies of the Cenozoic deposits in the Sperrgebiet and provided additional constraints with new ages (Pickford 2015). The synthetic chart (Fig. 4) summarises the depositional history. After a period of intense Palaeocene weathering, the first deposits are the fluvial Pomona Beds that include lateritic detrital elements. An Ypresian age was proposed for these deposits by Pickford (2015). They are followed by the marine Langental Beds (*Turritella* Beds: Bartonian) indicating a rise of the base level. This marine deposit is located in a narrow band ten kilometres wide. Then the base level fell and depositional conditions returned to fluvial environments in which the sediments of the Blaubok, Buntfeldschuh and Kakaoberg formations accumulated. These Rupelian to Aquitanian deposits occur in valleys up to 200 m wide and tens of metres deep. The Elisabeth Bay Formation, located on the coast, corresponds to sub-aerial floodplain deposits of Burdigalian age (Corbett 2016). The gravels of the Gemsboktal Formation cover an extensive zone in the upstream part of the coastal domain and are localised in valleys downstream. They were deposited during the Late Miocene. Notable is the intercalation of an aeolian unit in the Terrassenfeld Formation. The Plio-Pleistoene Fiskus Aeolianites complete the list of consolidated deposits in the Sperrgebiet.

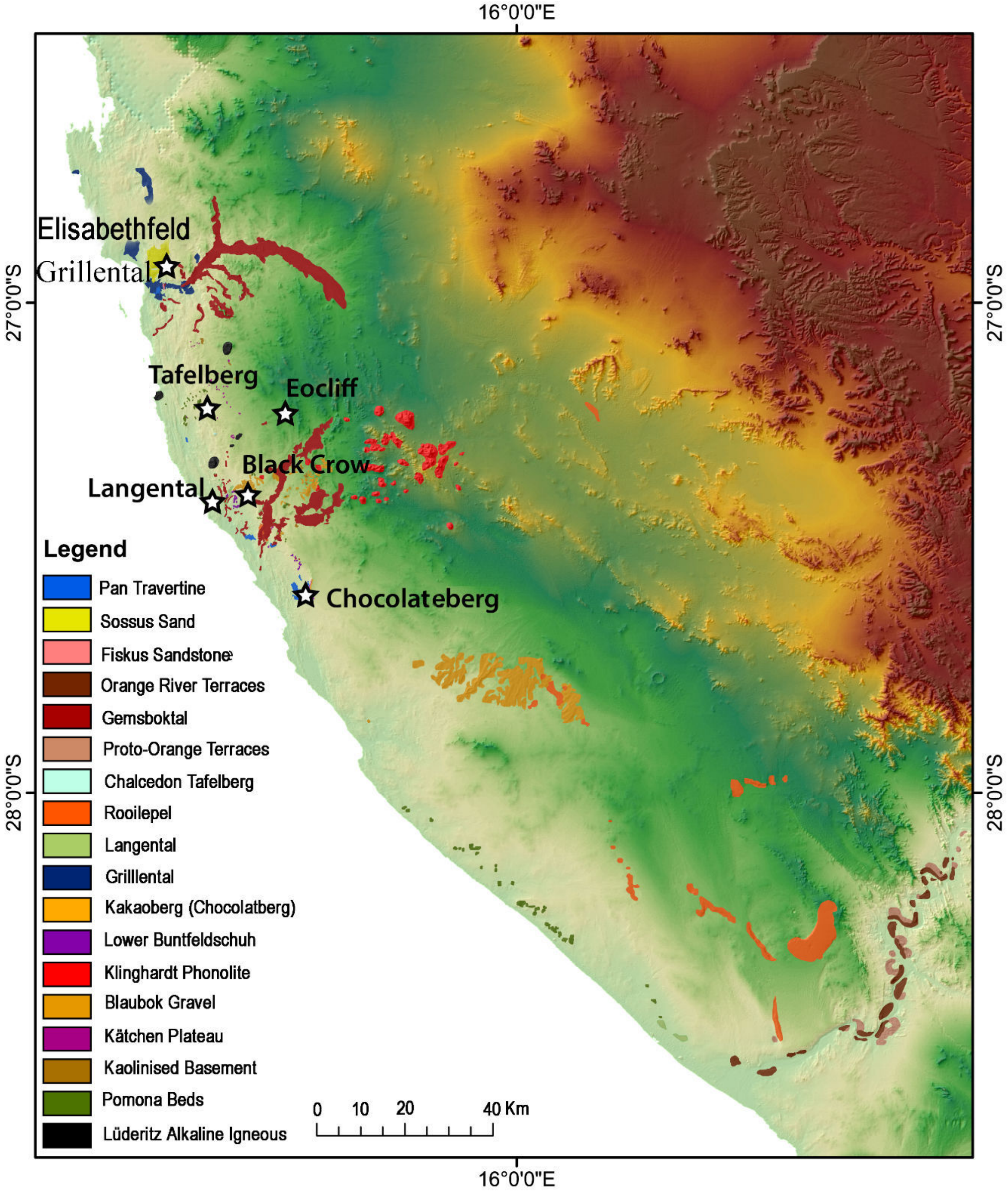

Figure 2. Compilation map of the Cenozoic deposits in the Sperrgebiet from Jacob *et al.* 2006; Miller 2008; Pickford 2015.

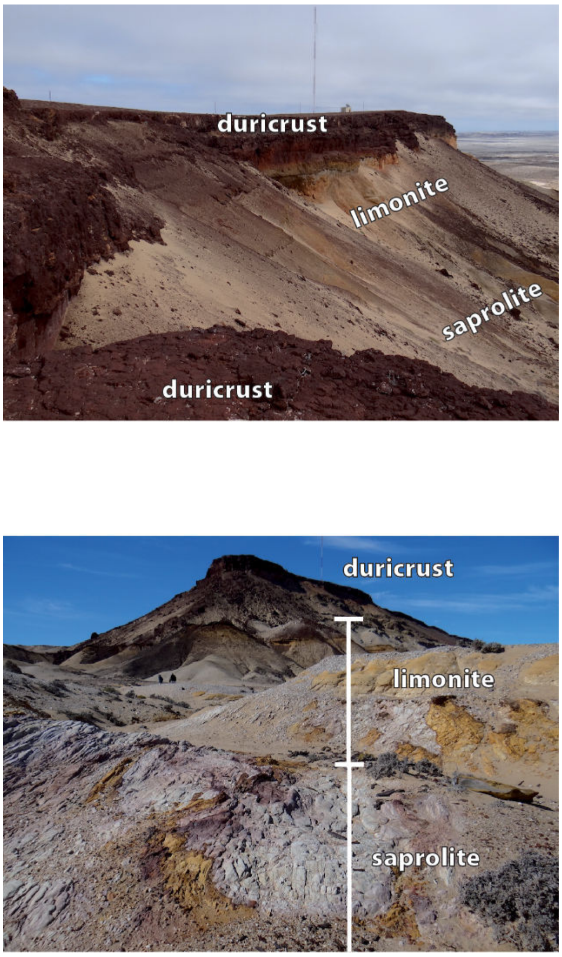

Figure 3. Images of Chocolatberg (Kakaoberg) capped by a residual lateritic profile. The upper photograph shows the duricrust and the lower photograph the upper part of the underlying lateritic profile.

During the Cenozoic, magmatic complexes intruded the basement rocks of the Sperrgebiet. Three main events occurred: the Teufelskuppe and Kaukausib carbonatites (Verwoerd 1993; Miller 2008; Pickford 2015), the Klinghardt phonolitic complex and the Schwarzerberg nephelinites (Fig. 2). The carbonatites of Teufelskuppe and Kaukausib correspond to volcanic cone sheets with necks filled with breccias. These intrusions are not directly dated, but they are assumed to be contemporaneous with the Dicker Willem intrusion aged 49.1 Ma (Reid *et al.* 1990). The Klinghardt volcanic complex comprises several units (plugs, breccia pipes, extrusive bodies and phonolite dykes) which were emplaced over a roughly circular area with a radius of 15 km (Fig. 2). Pyroclastic phonolite is associated with breccias and effusive rocks with kimberlitic affinities (Winter & Rikhotso 1998). Some carbonatite pipes occur on the western side of the phonolite complex. Fossils from limestones associated with the carbonatite ashes indicate an age of Ypresian/Lutetian for the Black Crow occurrence (Pickford 2015) and a Bartonian age for the Eocliff and Eoridge occurrences, in line with the age estimate proposed by Reid *et al*. (1990).

Landscape Patterns

The Sperrgebiet landscape consists of three domains clearly illustrated in the topographic profiles (Fig. 5) and in the slope map (Fig. 6). From the shoreline to the South African Plateau, we can distinguish: 1) a coastal domain extending 40 km inland with a gentle slope and an elevation up to 600 m, 2) an intermediate domain with higher regular slopes, low topographic roughness and a more horizontal segment close to the scarp, and 3) the South African Plateau with high elevations, greater than 1000 m and high topographic roughness. The slope map (Fig. 6) displays well these three domains especially the main scarp that is far from the shoreline in the north (130 km) and close to the coast in the south (25 km). The main scarp is the watershed between the drainage networks which flow inland and those that flow seawards. Relief in the intermediate domain is dominated by very flat and smooth wide plains surrounding residual hills and inselbergs. The latter belong to old weathering profiles eroded after a change in climatic conditions and/or a fall in the base level. These open plains trend NW-SE roughly following the structural pattern of the Gariep Orogeny. The coastal domain is covered by dunes which obscure details of the underlying relief. Several residual hills emerge from flat areas. At least three valleys which reach the sea traverse the basement oblique to the structural pattern that trends NNS-SSE to NW-SE. They are partially filled with Miocene to Recent terrigenous deposits. The upstream ends of these valleys occur at the boundary between the intermediate and coastal domains.

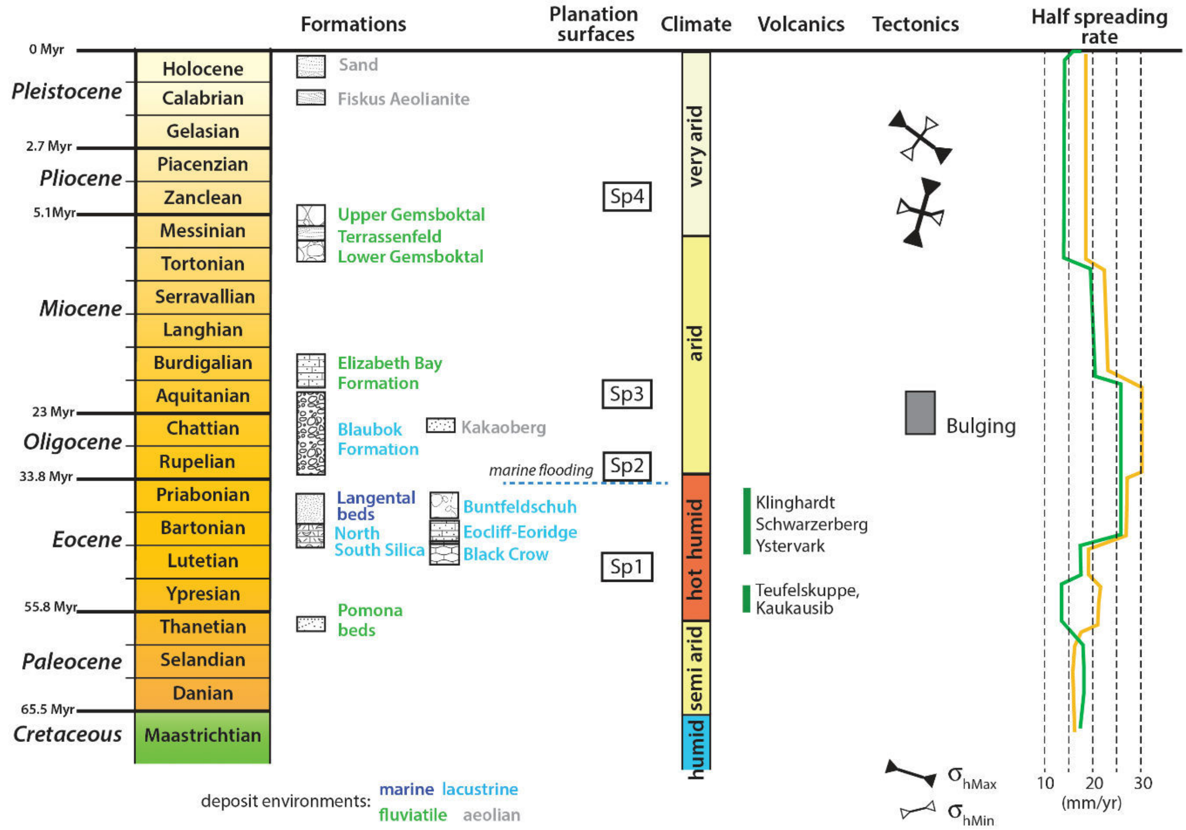

Figure 4. Chart summarising Late Cretaceous and Cenozoic stratigraphic, geomorphic and tectonic events in the Sperrgebiet.

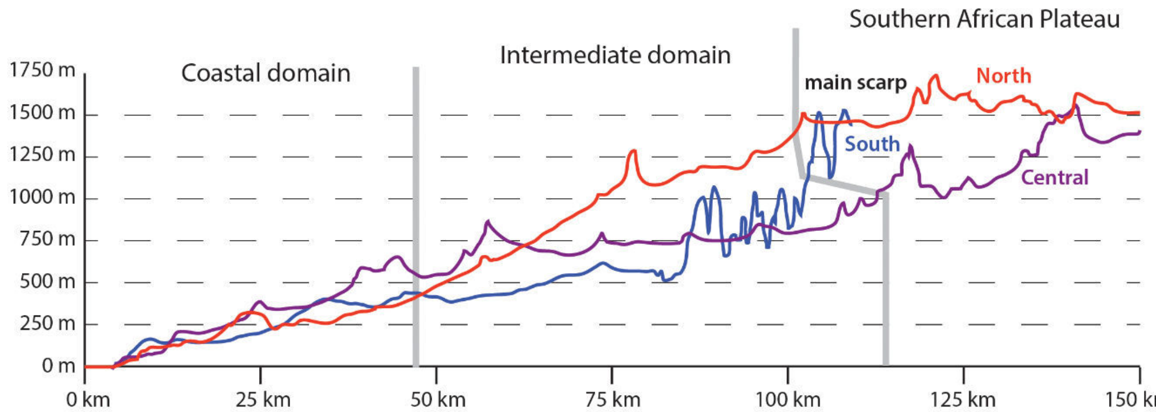

Figure 5. Topographic profiles in the northern, central and southern Sperrgebiet. See map in Fig. 1 in which the black lines localise the profiles.

In terms of planation, four surfaces have been mapped in the Sperrgebiet: two are located on the South African Plateau, one shapes the intermediate domain, and the last is the coastal domain. We labelled them especially for this work: the map (Fig. 7) provides the correspondences between this study and the work of Picart *et al*. (submitted), which described in detail the planation surfaces for the entire Namibian Plateau and coastal plain. The surfaces shaping the plateau (Sp1 and Sp2) correspond to an etchplain and to a mantle etchplain, i.e. lateritic surface. Surfaces Sp1 and Sp2 in the south can be extrapolated toward the shoreline from several residual hills topped by duricrust (Fig. 3). The summits of these residual hills are lower than the mantle etchplain located on the plateau. Thus, the surface Sp1 interpolated toward the shoreline has a continuous curved surface, without disruption. The two surfaces shaping the coastal plain correspond to an etchplain for surface Sp3 and to a peneplain for the lowest surface Sp4. The boundary between them accords with the boundary between the coastal and intermediate domains highlighted in the slope map and corresponds to a change in mean slopes: the mean slopes of Sp3 being lower than the mean slopes of Sp4. Surface Sp4 is locally incised by valleys, which are filled with sediments.

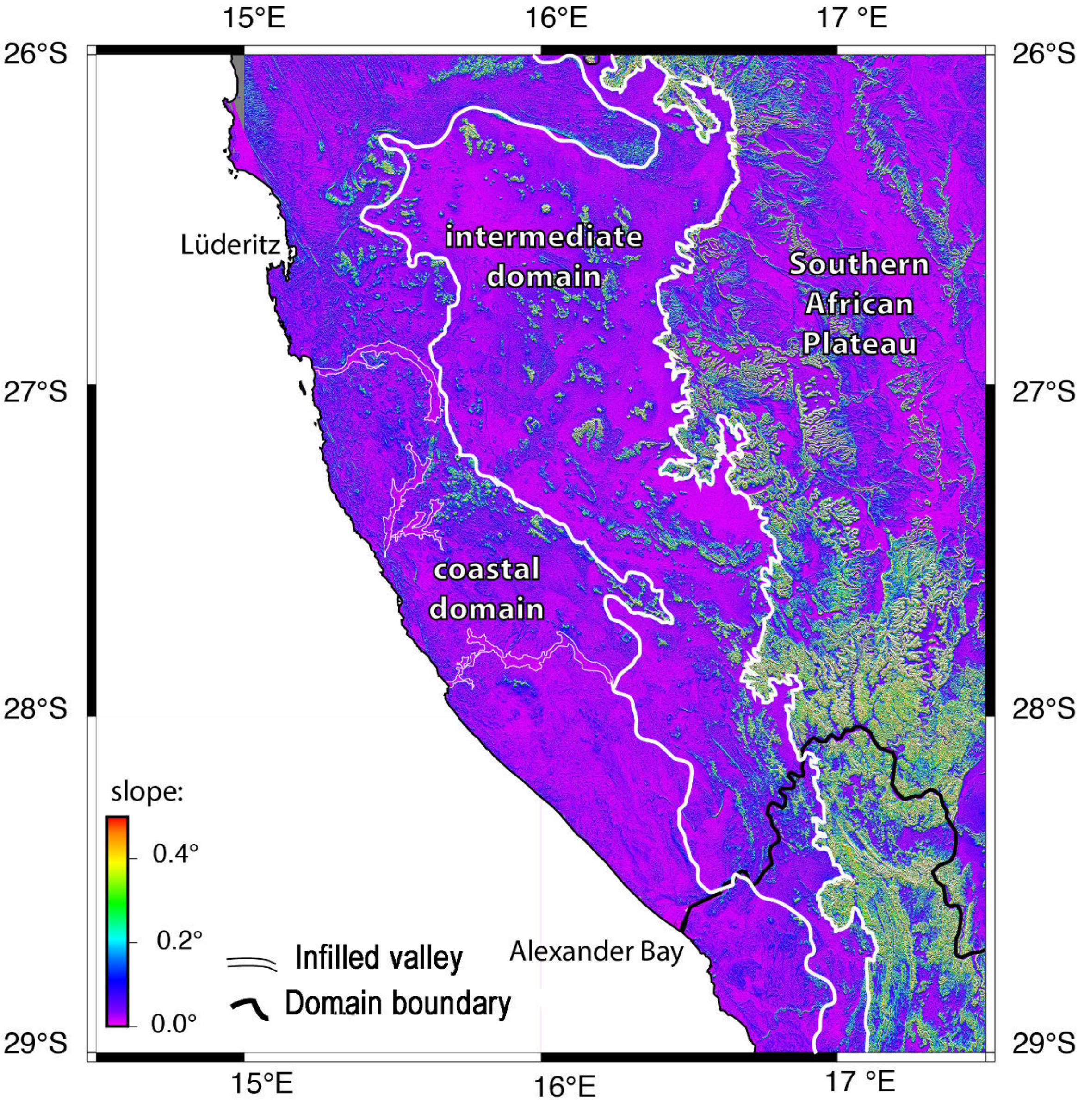

Figure 6. Slope map of the elevation with white lines delimiting the three main domains.

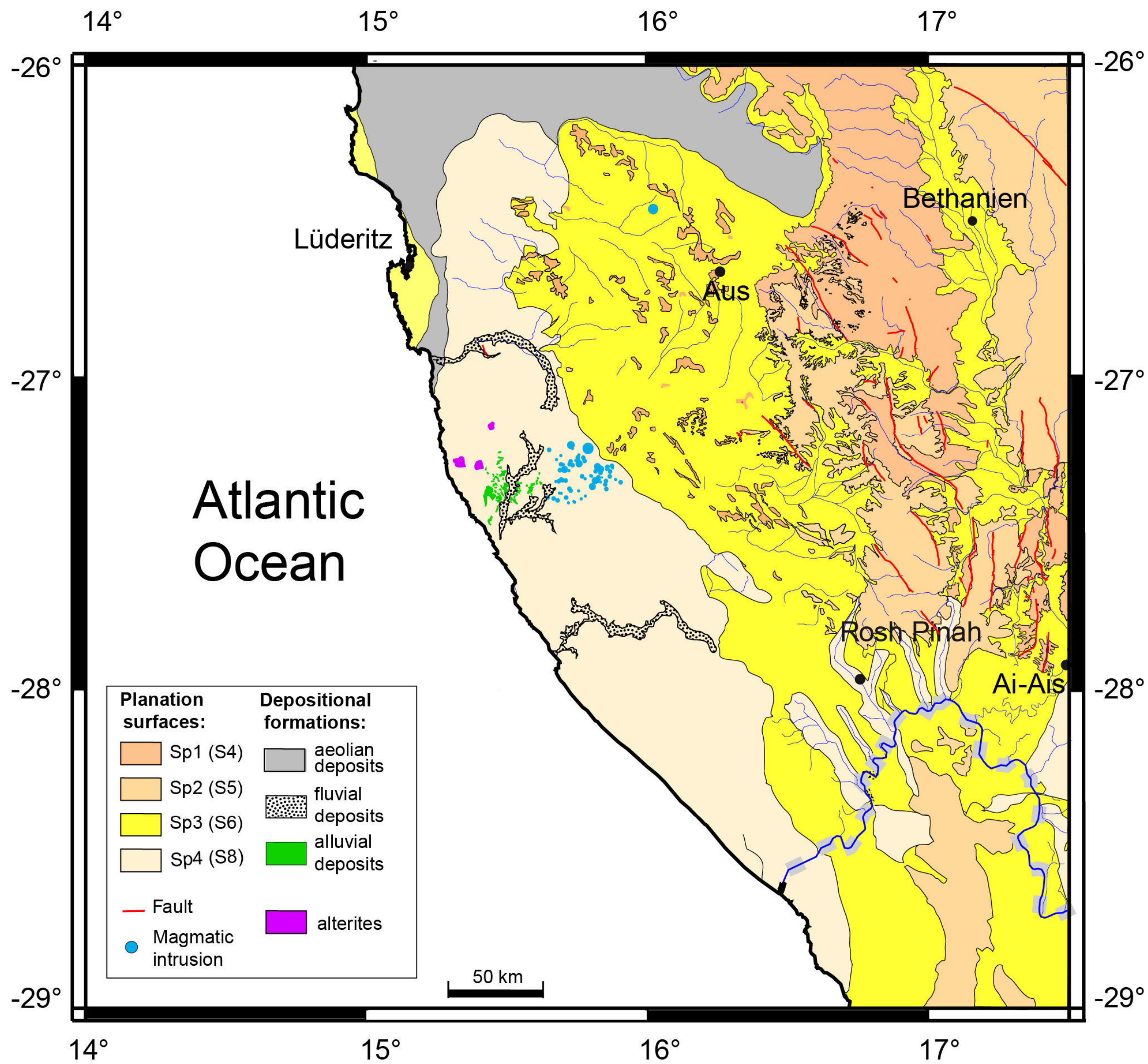

Figure 7. Map of four planation surfaces shaping the relief of the Sperrgebiet. The surface labels are defined in this study, the labels in brackets correspond to the names in Picart *et al*. (submitted).

Microtectonics

Data and Processing

Microstructural data were collected during a field trip in 2014. 19 stations corresponding to various formations were measured. Table 1 lists the locations, formations and ages of the different stations. We only measured joints with crystallization (Fig. 9) in order to avoid thermal joints generated by high temperature variations under desert conditions. Thermal joints are roughly perpendicular to the main wind direction and have a shell-like (exfoliation) surface. Four sites show joints with shear displacements (shear joints) and some striated planes (Fig. 9, 10). The joint measurements were processed with Stereonet software (Cardozo & Allmendinger 2013) to produce stereonet and azimuthal rose diagrams (Fig. 10). Faultkin software (Allmendinger *et al.* 2011) was used to plot striated planes and shear joints and to estimate stress orientation from these planes (Fig. 10). We compared the stress directions obtained from the striated planes and the shear joints so as to interpret the simple joints by assuming that they are perpendicular to Ò$_3$ and parallel to Ò$_1$.

Table 1. Table of microstructural sites with lithologies and probable ages from Pickford (2015). See Fig. 11 for locations of sites.

Site	Location name	Co-ordinates	Lithology	Age
site14-1	Grillental	-26.972938N 15.326657E	Sandstone	Oligo-Miocene
site14-2	Grillental	-26.968758N 15.325173E	Sandstone	Oligo-Miocene
site14-3	Grillental	-26.96884N 15.32498E	Sandstone	Oligo-Miocene
site15-1	Kakaoberg	-27.5896183N 15.5724733E	Duricrust	Oligo-Miocene
site15-2	Kakaoberg	-27.5874733N 15.56871833E	Shales	Priabonia
site15-3	Kakaoberg	-27.5885783N 15.5709383E	Aeolian sandstone	Oligocene
site15-4	Langental	-27.39558N 15.40804E	Conglomerate	Priabonian
site15-5	Langental	-27.39558N 15.40804E	Green to grey shales	Priabonian
site16-1	Chalcedon Tafelberg	-27.2680583N 15.3817133E	Shales	Lutetian
site16-2	Chalcedon Tafelberg	-27.267761667N 15.384068333E	Shales	Lutetian
site16-3	Tafelberg	-27.26093N 15.37964E	Lateritic colluvium	Lutetian
site16-4	Tafelberg	-27.26093N 15.37964E	Lateritic colluvium	Lutetian
site17-1	Eocliff	-27.3498216667N 15.5961183333E	Limestone	Bartonian
site17-2	Eoridge	-27.342293N 15.582204E	Limestone	Bartonian
site18-1	Black Crow	-27.37778N 15.46278E	Namib I Calc-crust	Middle Miocene
site18-2	Black Crow	-27.377870N 15.46290167E	Limestone	Ypresian/Lutetian
site18-3	Black Crow	-27.377870N 15.46290167E	Slate limestone	Ypresian/Lutetian
site18-4	Black Crow	-27.377870N 15.46290167E	Limestone	Ypresian/Lutetian
site18-5	Black Crow	-27.377870N 15.46290167E	Limestone	Ypresian/Lutetian

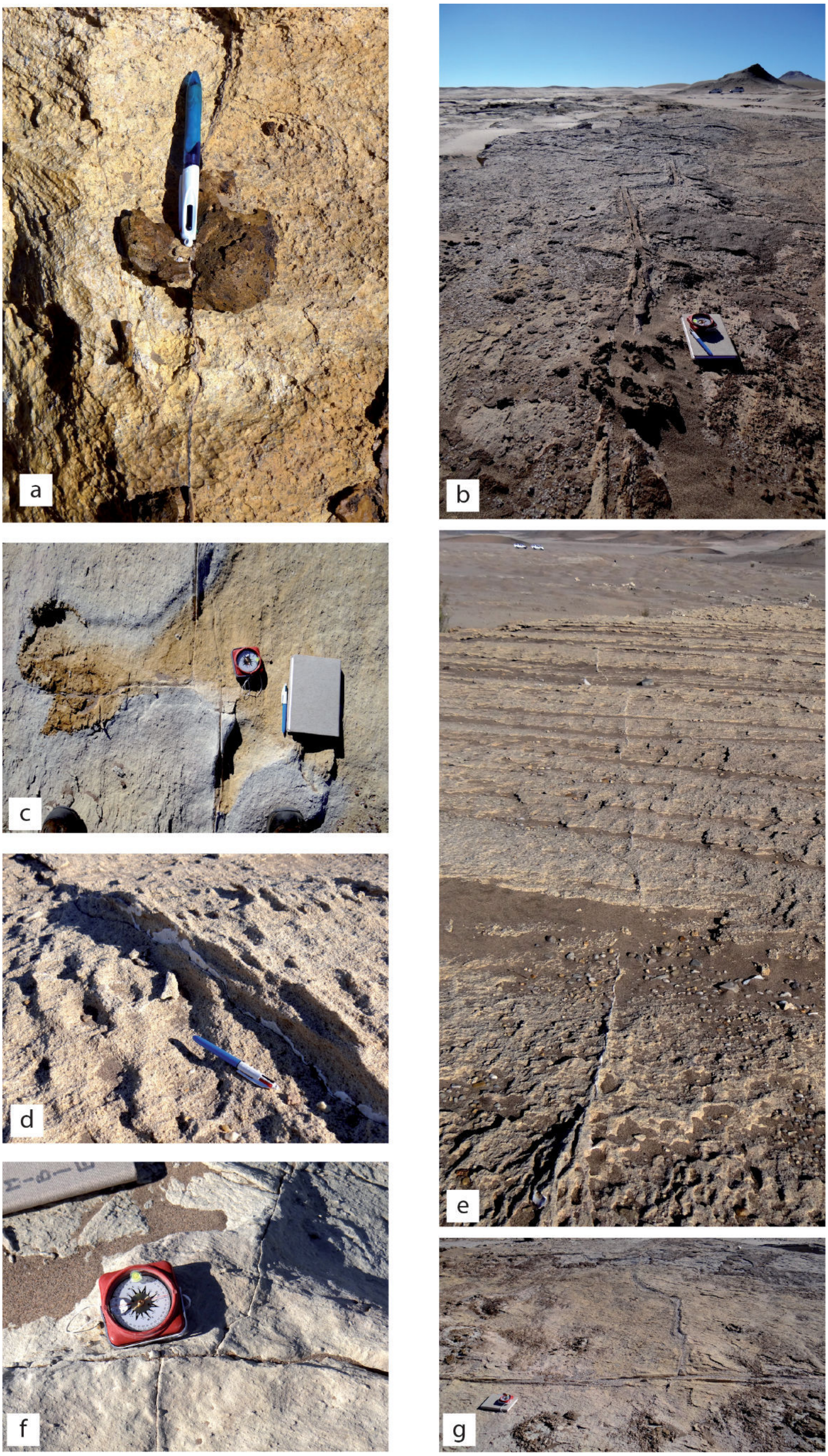

Figure 8. Pictures of microtectonic features: joints and striated planes.

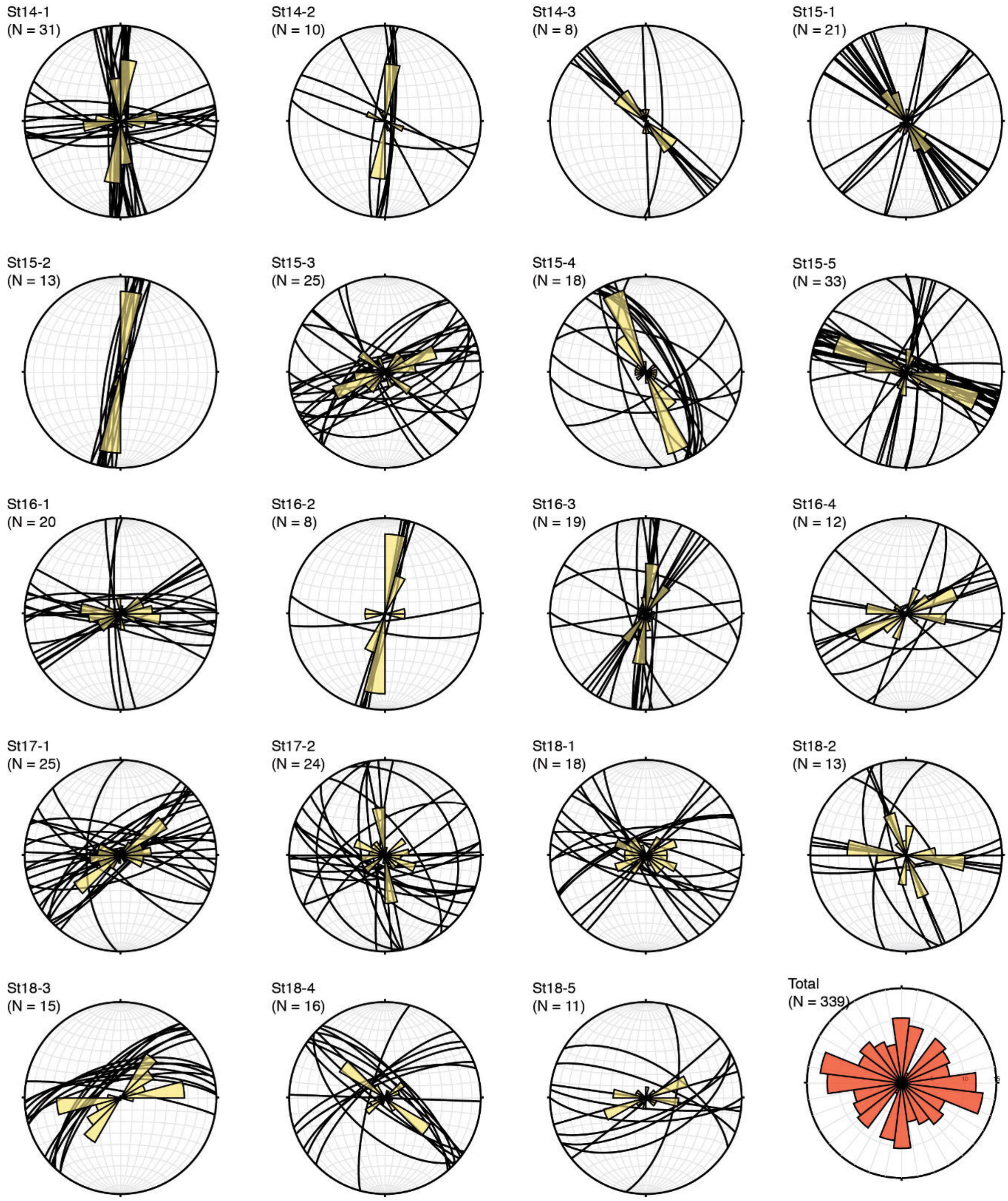

Figure 9. Stereonet plots of the joints and associated rose diagram for the 19 studied sites. The lower right plot (in red) displays the azimuth distribution of all the measurements. The site locations are provided in Fig. 1 (white stars) and Fig. 11 and in Table 1.

Brittle Structures of the Sperrgebiet

The striated planes and the shear joints in the Sperrgebiet are mainly vertical to sub-vertical (>70°) and trend N080° to N180°. The plunge of the striations along planes is very often horizontal but some striations plunge at up to 50°. The displacements are generally tens of cm and can reach 40 cm. The structural analysis shows that they are organized into two brittle phases (Fig. 10). The first is a pure strike-slip displacement with the maximum stress Ò$_1$ trending NW-SE and the minimum stress Ò$_3$ oriented SW-NE. It corresponds to a left-lateral strike-slip along a N170° mean fault plane. The second is a transtensional displacement with the maximum stress Ò$_1$ trending N025° and plunging at 30°, and the minimum stress Ò$_3$ trending N115° and plunging at 30°. The displacement has a left-lateral component along the mean fault plane trending N068°.

The joints are generally vertical to sub-vertical (dip > 60°) and cluster into two main sets: one trending at N010° and the second trending at N100°. Secondary sets are oriented at N135° and N045°. The N100° trending joints are compatible with the left-lateral strike-slip regime and the N010° with the left-lateral transtension. The other joints are not organised and seem to be associated with widespread diffuse deformation including local deformation or rotated stresses. Fig. 10 summarises the two main tectonic regimes with associated features and the direction of Ò$_3$ at each site.

All the sites studied display the two main tectonic regimes, indicating that they have a regional distribution. Several relative chronological criteria indicate that the left-lateral transtension happened later than the left-lateral strike-slip. These two regimes affected the Oligo-Miocene deposits of the Blaubock Formation. Thus, we propose they occurred later than the middle Miocene.

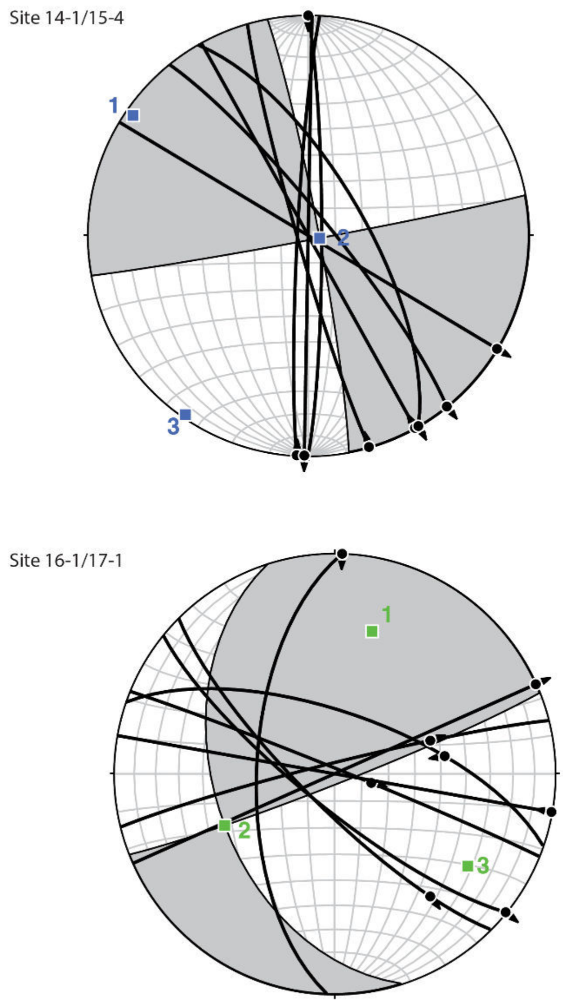

Figure 10. Stereonets of the striated planes and shear joints. Locations are given in Fig. 11 and Table 1.

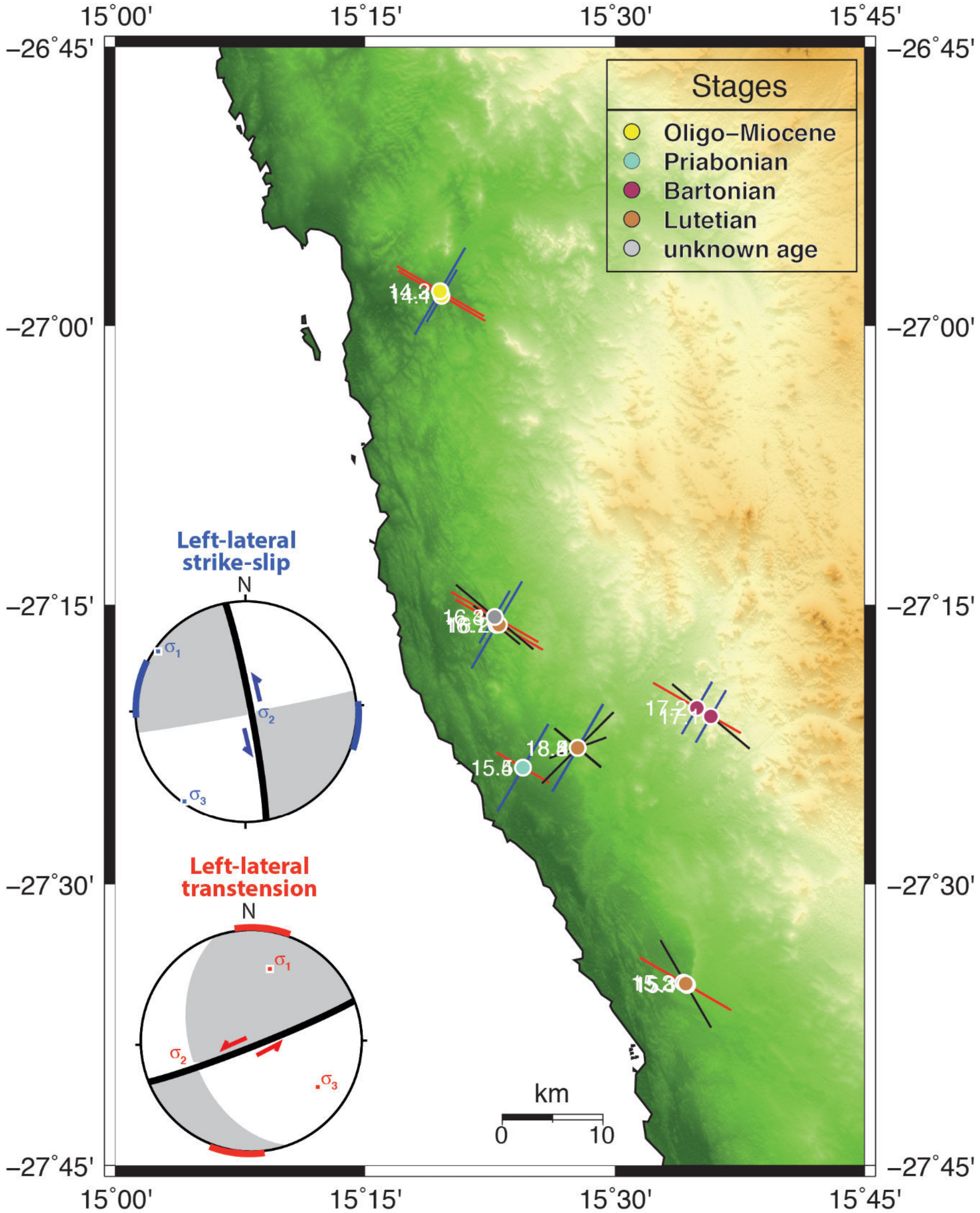

Figure 11. Synthesis of microtectonic results. The stereonets at lower left summarise the two main tectonic regimes (left-lateral strike-slip and left-lateral transtension) with stresses and associated tectonic features. The red, blue and black lines depict the average trend of the Ò3, at each site (blue for left-lateral strike-slip, red for left-lateral transtension, black for undetermined). The colours of the dots located on the sites correspond to their ages.

Cenozoic Evolution of the Sperrgebiet Domain

The presence of lateritic profiles is used as a geomorphic marker defining the relief at the beginning of the Cenozoic. The lateritic profiles forming hills at low elevations (<100 m) on the coastal plain and at high elevation (1100 m) on the plateau provide evidence concerning the topography at the beginning of the Tertiary. Two hypotheses have been advanced: 1) an inherited relief with high elevations in the plateau sloping gradually to low elevations on the coastal plain, or 2) a late vertical offset of the lateritic surface generated by faults or by regional bending. Several previous works (Partridge & Maud 1987; Brown *et al.* 2014; Burke & Gunnell 2008; Tinker 2005) proposed that a major uplift (hundreds of metres) occurred during the Turonian, i.e. before the main weathering episode. Dauteuil *et al*. (2013) and Picart *et al*. (submitted) in contrast, suggested smaller uplifts (< 100 m) during the Cenozoic that cannot account for the differences in elevation between the coastline and the plateau. Therefore, the topography of the basement which was weathered during the Palaeocene had a bent shape of medium wavelength acquired either during the Turonian uplift or even earlier during rifting. The slope of the topography emphasised the development of thick lateritic profiles because water could circulate at a greater depth and could drain away before becoming chemically saturated.

Subsequently, the coastal domain was eroded after a change in climatic conditions that resulted in a more arid climate and after regional bulging (Picart *et al*. submitted) that increased the slopes. The new climatic conditions accelerated mechanical erosion, which affected the lateritic profiles, with erosion constrained by the NW-SE structural pattern of the Konkiep Basement. Thus, etchplains and pedivalleys were generated parallel to the structural pattern of the basement. Erosion, transportation and deposition by flash floods resulted in the deposition of the Blaubock conglomerate over a wide area (Fig. 5).

Finally, the zone close to the shoreline was reactivated because of variations in sea level (Dauteuil *et al.* 2015). Regression of the sea increased planation and incision due to the fall in base level while transgression of the sea resulted in the backfilling of the previously incised valleys, such as the valley of Kaukausib in which the Gemsboktal Formation was deposited. During this period, the two widespread brittle deformations affected the study area.

The organization of the planation surfaces in the coastal domain with the older one located close to the scarp and the younger, slightly stepped one close to the shoreline is consistent with a regressive erosion phase (downwasting model) that generated the coastal plain. Significant uplift is not compatible with the very low elevations of the remaining laterites. If they were significantly uplifted, one would need to invoke the generation of the laterites several hundred metres below sea level, which is not possible.

Consequences of Cenozoic Deformation on the South African Plateau

We provide new constraints to the Cenozoic deformation of the South African Plateau by highlighting two late brittle deformations that occurred later than the middle Miocene. Previous studies described diverse deformations that affected the South African Plateau. Picart *et al*. (submitted) proposed a huge bulging roughly parallel to the coast during the late Eocene-lower Oligocene.

Several previous studies described faulting that affected the South African Plateau during the Cenozoic. Three sets of faults were described: N-S, NE-SW and NW-SE. The most obvious set corresponds to N-S faults forming graben such as the Windhoek Graben, and between Ai-Ais and Hobas (Picart *et al*. submitted) and the lower Fish River Canyon (Mvondo *et al.* 2011). These normal faults produced large vertical displacements: tens of metres and have an age estimated to be younger than Eocene (Mvondo *et al.* 2011). The second set of faults trends NW-SE is largely present in the south, between Ai-Ais and Rosh Pinah (Picart *et al*. submitted). A few scattered faults are located in the north, such the Hebron Fault close to Sesriem Canyon for which a Pleistocene age is estimated (White *et al.* 2009), and between Maltahöhe and Bethanien (Picart *et al*. submitted). The third set, which trends NE-SW, is located in the south-east between Keetmanshoop and Grünau, and in the central part of the plateau forming the Okavango Graben (Kinabo *et al.* 2007; Pastier *et al.* 2017).

The NE-SW extension is compatible with the left-lateral strike-slip deformation observed in the Sperrgebiet. The NW-SE extension is compatible with the left-lateral transtensional phase highlighted in this study. The E-W extension is not well recorded by microtectonic structures. However, many N-S joints were observed and were interpreted to belong to the left-lateral transtension episode. Thus, we suggest that the E-W extension also affected the coastal band but with lower intensity than in the other places. It should also be noted that the main N-S regional faults are systematically located to the east of the NW-SE faults. Thus, we propose that the E-W extension generating N-S faults and the NE-SW extensions generating NW-SE faults correspond to a rotation ranging from E-W inland to NE-SW along the coast. This rotation was accompanied by a shift in the maximum stresses from vertical to horizontal with a decrease of stress magnitude. These changes could be a consequence of scarp retreat which resulted in erosion removing large volumes of superficial rocks, thereby decreasing the vertical forces.

Thus, this study reveals some variations in the maximal horizontal stress resulting in changes of the cinematic conditions occurring at the margin of the South African Plateau.

Analysis of the spreading rate of the South Atlantic Ocean indicates that there was a decrease in rate of 50% at the end of the Miocene (Müller *et al.* 2008). This decrease of ridge push relaxed the horizontal stress affecting the continent, emphasizing the vertical stress (due to gravity) relative to the horizontal stress (due to ridge push). Note that the opposite evolution occurred during the Oligo-Miocene when an increase in spreading rate, and thus of ridge push, generated bulging, i.e. compression inland (Picart *et al*. submitted). Such a process of inland deformation induced by variations in oceanic ridge push (Leroy *et al.* 2004; Leroy 2004; Husson *et al.* 2015) was described in several contexts such as in the northern Atlantic margin (Le Breton *et al.* 2012) or around the African plate (Gaina *et al.* 2013).

Conclusions

The study of microtectonics combined with geomorphic and stratigraphic analyses throws light on the tectono-geomorphic evolution of the coastal domain of the Sperrgebiet, Namibia. This evolution was driven by three processes acting at different times. Deformation acted in two ways: bulging during the Oligocene and two brittle deformations during the Late Miocene to Early Pleistocene. Climatic conditions controlled mechanical erosion versus weathering. A hot and humid climate at the beginning of the Palaeocene resulted in the development of thick lateritic profiles that were etched after a change in climate from humid to arid. The last factor involved was variation in sea level that either increased planation and erosion (during regressive episodes) or infilled the valleys (during transgressions). The genesis of the coastal domain corresponds to the regression model with the mean elevation of the topography decreasing vertically through time. No strong deformation induced by an uplift was observed. The brittle deformation deduced from microtectonic features is compatible with widespread deformation that affected the South African Plateau. It corresponds to NW-SE and to E-W extension that generated N-S graben, for example. We propose that this deformation was induced by variations in rates of ridge push. Therefore, the South African Plateau was not as tectonically stable as has commonly been inferred and it reacted to the dynamic activity occurring in the surrounding oceans.

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