Geomorphology of the Late Palaeozoic glaciated landscape of Namibia

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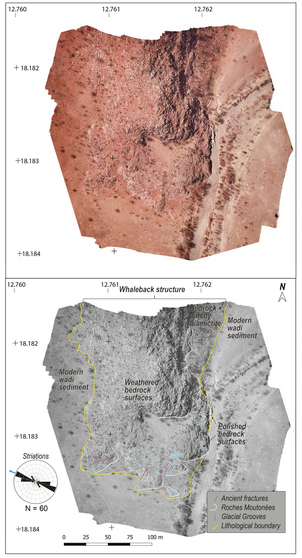
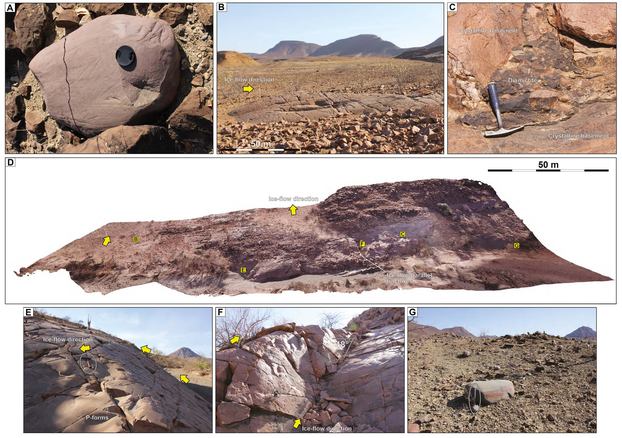


Okandjombo

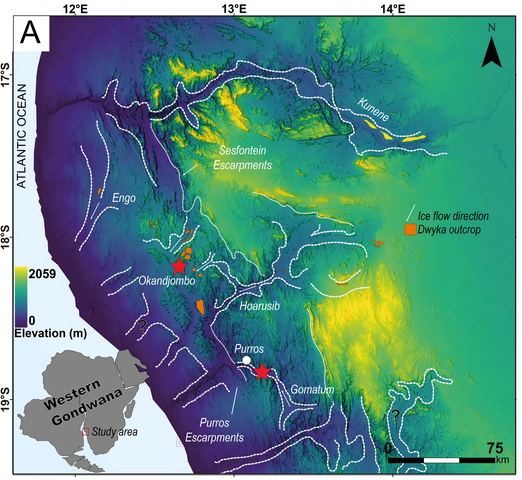
• Pristine subglacial landscape at the head of a paleo-fjord system

Left: Figure shows uninterpreted DEM-orthophoto composite on the left, and interpretation on the right. Note the wide areal extent of the whaleback structure on which the smaller scale subglacial bedforms (roches moutonnées, polished bedrock surfaces, glacial grooves / striations) are found. Letters A-D indicate the positions of features shown in Figure 4.

Below: Field evidence for subglacial processes at Okandjombo.
A: Striated boulder embedded into basal diamictite of the Dwyka Group. C: Well-developed roches moutonee with ice flow direction indicated. D: Close up of the basal diamictite plastered onto the bedrock. E: 3D model of the eastern side of the whaleback showing the steep inverse bedrock slope, interpreted ice flow, and the location of other features shown in the figure below. E: and F; Polished aspect of the bedrock with p-forms superimposed. G: Large striated boulder embedded in diamictite.

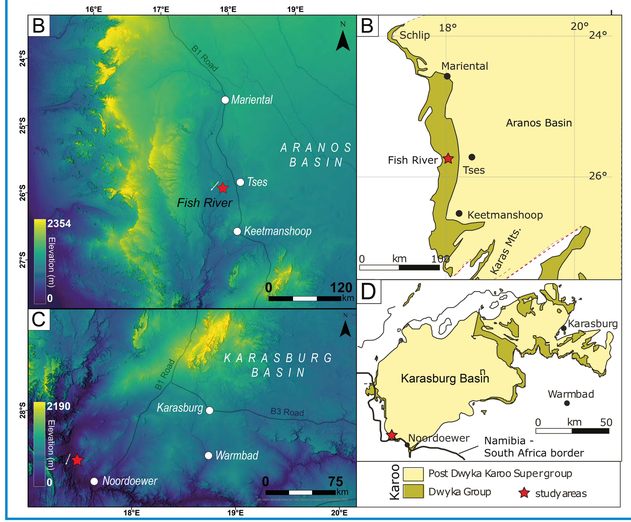


Fjords ✓



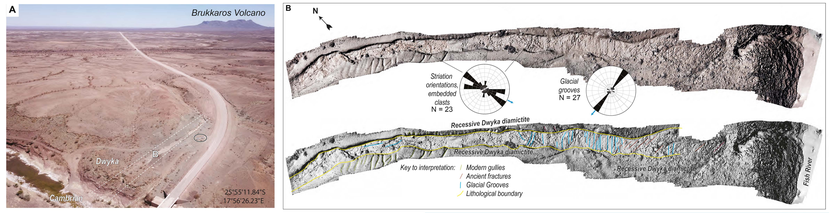
Southern Namibia

Fjords ✗



Fish River

• Subglacial grooves mapped with aerial photogrammetry

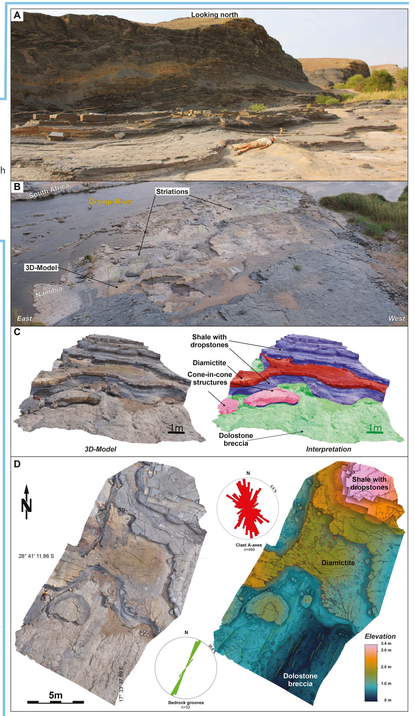


Above: A: Aerial view of the zone covered by detailed UAV imagery. B: Composite orthophoto-DEM image revealing the presence of bedrock grooves, interpreted as representing potential subglacial grooves. These structures are overlain by the basal Dwyka diamictite. Bedrock fractures, which are interpreted to be unrelated to the subglacial grooves, are shown in red. Note the contrasting and apparently conflicting directional data represented by the two rose diagrams: the orientation of striations measured from clast surfaces is almost orthogonal to the orientation of the interpreted glacial grooves.

Noordoewer

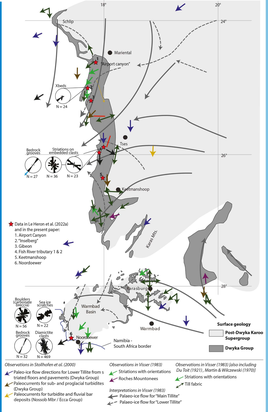
• Subglacial grooves examined at ground level

Right: The basal Dwyka palaeotopography at Nordoewer along the Orange River at the border with South Africa. A: General photograph showing the nature of the outcrop and the presence of low amplitude fold-like structures. B: Map view photomosaic constructed from ground-level photogrammetry. Note that the fold-like structures are onlapped by overlying dropstone-bearing shales and are thus interpreted to have formed during prior to deposition of the latter deposits. We interpret them as potential subglacial grooves.



Ice flow summary

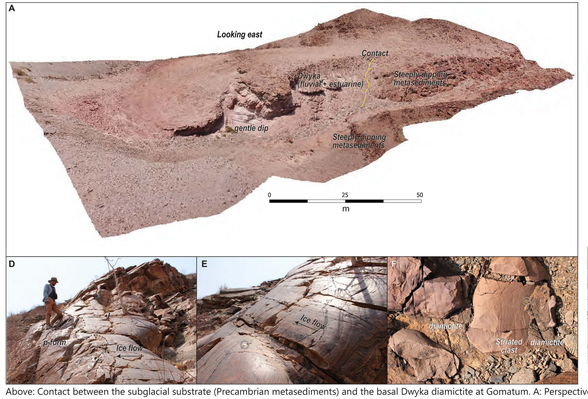
• Complex picture in southern Namibia!

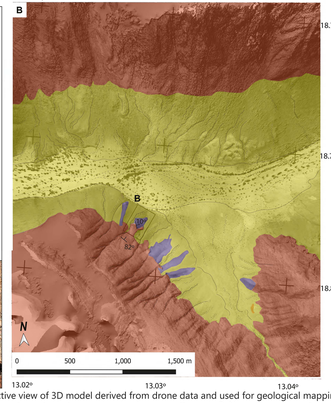


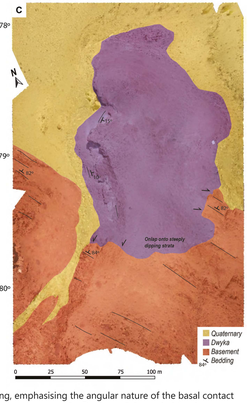
Above: Compilation of datasets and ice flow interpretation directions in southern Namibia from the literature, including recent work (Le Heron et al., 2022a), the new data herein (Noordoewer and Fish River), and literature data from Du toit (1921), Martin and Wilczewski (1979), Visser (1983) and Stollhofen et al. (2000).

Gomatum

• Insight into geometry of a palaeo-fjord and its infill







Above: Contact between the subglacial substrate (Precambrian metasediments) and the basal Dwyka diamictite at Gomatum. A: Perspective view of 3D model derived from drone data and used for geological mapping, emphasising the angular nature of the basal contact representing the palaeo-fjord margin. B: Small scale geological map, produced using a hybrid DEM-Orthophoto as a base map. C: Large scale geological map, zooming into a small area in B. Note the stratigraphic contact between the Dwyka and the underlying basement. D: Detail of the sub-Dwyka polished surface at the western end of the Gomatum palaeovalley, revealing a p-form with interpreted ice flow direction also shown. E: Detail of the stoss slope of the p-form, with a coin circled for scale, revealing a glacial polish on the striated surfaces. F: Relationship between a striated siltstone clast and its host diamictite directly above the surface shown in D and E.