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The Sperrgebiet Domain, Aurus Mountains, SW Namibia: A ~2020–850 Ma window within the Pan-African Gariep Orogen

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ABSTRACT

The Aurus Mountains in SW Namibia form a tectonic inlier (Sperrgebiet Domain) within the Neoproterozoic Gariep belt. We document the geological history from field mapping, whole-rock geochemical, metamorphic and U-Pb zircon isotope data. The calc-alkaline granodioritic orthogneisses of the Wasserkuppe Suite, dated at ~2020 Ma, are the predominant, oldest rocks, which are interpreted to form part of a ~2 Ga "Sperrgebiet arc"; the tectono-magmatic equivalent of the ~250 km wide Richtersveld arc to the southeast, but ~100 Ma older. ~2 Ga detritus is common throughout the western Namaqua belt, but its source was hitherto unknown. The suite intruded synchronously with amphibolite facies metamorphism and deformation, considered an early phase of the Palaeoproterozoic Orange River Orogeny. The Wasserkuppe Suite is intruded by alkali granite and microgranodiorite dated at ~1885 Ma, interpreted as equivalents of the Vioolsdrif Suite (Richtersveld arc). The Sperrgebiet Domain is thus seen as an early phase of a process of Palaeoproterozoic island-arc development at the margins of the Archaean Kaapvaal Craton/Rehoboth Province. It was cannibalised by the later Richtersveld arc which dominated the palaeogeography of this part of southern Africa 100 m.y. later, and which forms the crustal infrastructure of much of Western Namaqualand.

The Palaeoproterozoic arc rocks are overlain by a clastic metasedimentary sequence; the Aurus Schist. Detrital zircon geochronology indicates that these rocks were predominantly derived from both arcs, with minor Archean and younger ~1800 Ma detritus, of unknown source(s). Bodies of latest Mesoproterozoic (~1000 Ma) Warmbad Granite and pegmatite are mapped throughout the area and represent the only Namaquan rocks definitively identified. Evidence for Namaquan metamorphic or tectonic imprints are lacking, apart from a garnet-clinopyroxene metabasic inclusion in a quartz-feldspar leucogneiss which gave a typical "Namaquan" P-T estimate of ~700–750 °C at 6–7 kbar. The leucogneisses, distributed throughout the area, were dated at ~840 Ma and are interpreted as metamorphosed felsic igneous rocks of the Richtersveld Suite, formed during early rifting of the proto-Gariep basin. The Sperrgebiet rocks are variably deformed by the Pan-African Gariep Orogeny that produced regionally-pervasive fabrics, predominantly partitioned into discrete high-strain shear zones in a NW-trending sinistral transpressive tectonic regime.

1. Introduction

The study area, within the Sperrgebiet National Park, lies in the former diamond-rich "Sperrgebiet" (*German: "Prohibited area"*) of southern Namibia. It extends from some 35 km NW of Rosh Pinah, approximately 70 km to the NW in an elongate, NW-SE trending conical-shaped sliver, covering just less than 1000 km^2, between 27.81°S/16.48°E in the SE and 27.36°S/15.98°E in the NW (Figs. 1 and 2). It includes the renowned Roter Kamm impact crater, an annular topographic feature some 2.5 km across with a rim rising ~200 m above the surrounding sandy plains. The rugged Aurus Mountain range and subsidiary ridges along with various isolated "satellite" outcrops culminates at 1084 m at Aurus peak. The main

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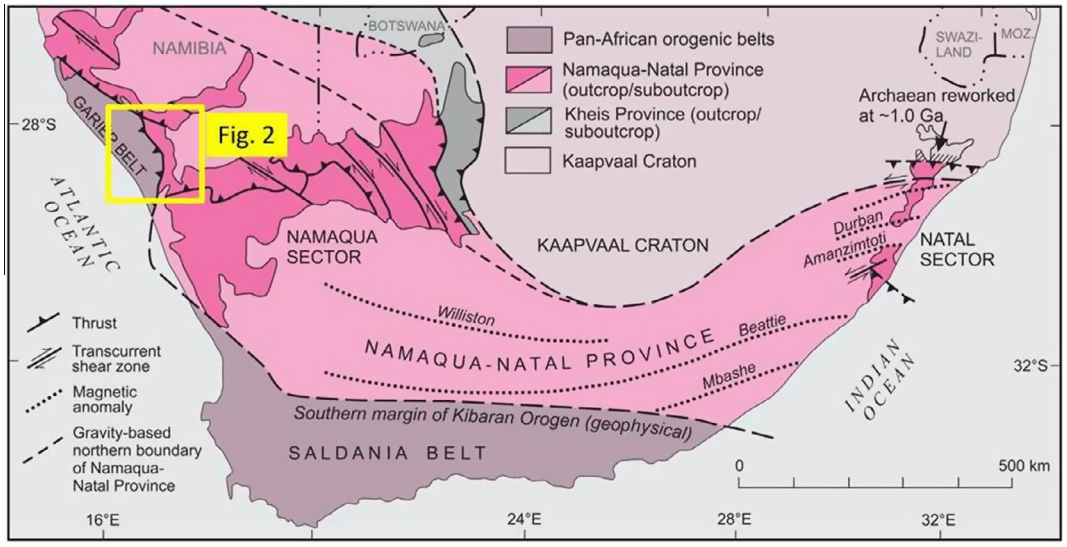

Fig. 1. The Namaqua-Natal Province (after Cornell et al., 2006), showing the location of the study area in the western Namaqua Sector.

"spine" of the range forms a rocky escarpment ridge with a steep SW face.

The objective of the study was to produce the first geological map of the Aurus Mountains (at 1:50,000) scale and to ascertain the age and nature of the basement rocks, which have been assumed (e.g. Miller, 2008) to be a western segment of the Namaqua Sector (NS, or informally the Namaqua "belt") of the Namaqua-Natal Province (NNP). The survey was undertaken by the Council for Geoscience of South Africa on contract to the Geological Survey of Namibia. Fieldwork took place in July 2015, with data collection on toughbook computers with built-in GPS using the *BGS Sigma Mobile*© digital mapping system with ArcMap GIS software. Representative rock samples were analysed for petrography, whole-rock major and trace element geochemistry, U-Pb zircon dating by LA-ICPMS at Curtin University, Western Australia and metamorphic P-T determinations at the University of Cape Town, South Africa. The various preparation and analytical techniques are outlined in Appendix 1 (supplementary data). A geological map and sheet explanation is available in Thomas et al. (2016).

The geology of the area was unknown prior to this study. The 1:500,000 scale geological map of Becker and Schreiber (2000) shows the Sperrgebiet to be composed of "Mokolian" (1650–850 Ma) metasediments and metavolcanics of the NS. The only written reference to the rocks of the Aurus Mountains is of "granitic orthogneisses", assumed to be Namaquan (Mesoproterozoic; ~1.1 Ga) in age (Miller, 2008), who passed through the area *en route* to studying the Roter Kamm impact crater. The rocks were known to be a "tectonic inlier of crystalline basement", underlying the Neoproterozoic Gariep Supergroup, although this assumption was not based on geochronological data. In a schematic east-west cross-section across the Port Nolloth Zone of the Gariep belt Frimmel (2008) shows the area as an upfaulted basement block; the Aurus Horst. To the east, in the area of Namuskluft near Rosh Pinah, another extensive basement exposure is known to be Palaeo- to Mesoproterozoic in age (McMillan, 1968; Hoffmann et al., 2013; Gresse et al., 2016). The Roter Kamm crater, dated at 3.7 ± 0.3 Ma by Ar-Ar on melt glass (Hartung et al., 1991), has been well studied with the basement rocks of the rim described as biotite-bearing granitic gneisses of the "Namaqua Complex" (Miller, 2008).

The purpose of the this paper is to summarise the geology of this previously unsurveyed area and to present analytical data in order to place the Aurus Mountains in their geodynamic context within the Namaqua-Natal Province, one of the world's more important Mesoproterozoic mobile belts and a key component of the Kalahari Craton within the Rodinia assembly.

2. Regional geological setting

The Aurus Mountains form a basement window within the Neoproterozoic Gariep fold and thrust belt (Fig. 2). To the SE, in Namibia and adjacent South Africa, the geology of the lower Orange River region, east of the Gariep basal thrust, consists of rocks of the western Namaqua-Natal Province (NNP). The NNP is a major, roughly 400 km-wide, arcuate Mesoproterozoic (~1.2–0.95 Ma) polymetamorphic orogenic belt which extends for some 1500 km along the southern and south-western margins of the Archean Kaapvaal Craton from KwaZulu-Natal in SE South Africa to the Namibian coast near Lüderitz (Hartnady et al., 1985; Thomas et al., 1994). The western part of the belt, in which the Aurus Mountains lie, contains the oldest rocks (~1.9 Ga). By the end of the Mesoproterozoic the NNP and Kalahari Craton had stabilised to form the Kalahari Craton within Rodinia (e.g. Jacobs et al., 2008).

Initial extension and crustal thinning of the Rodinian lithosphere in the Early Neoproterozoic was accompanied by the intrusion of the Richtersveld Igneous Suite (~850–770 Ma) into the rocks of the NS. The suite comprises granite and quartz syenite plutons, felsic sub-volcanic plugs and their dacitic to rhyolitic volcanic equivalents (Allsopp et al., 1979; Frimmel et al., 2001). Continued extension led to the formation of a basin into which the lower Gariep Supergroup was deposited. The early coarse clastic rift sedimentation was accompanied by intrusion of the major N to NE-striking Gannakouriep mafic dyke swarm and minor coeval basaltic lavas at ~790 Ma (Reid et al., 1991; Ransome, 1992; Bartholomew, 2008). Progressive rift basin deepening resulted in marine incursion and the deposition of shelf carbonates and argillites and later turbidites and basaltic lavas of the Gariep Supergroup. Subsequent tectonic inversion during the assembly of Gondwana in the late Neoproterozoic (~550 Ma) resulted in the closure of the basin, continental collision between the Rio de la Plata and Kaapvaal Cratons and the development of the southeast-vergent Pan-African Gariep fold-and-thrust Belt (Frimmel, 2008). The NS rocks in the wide footwall to the Gariep