COMMUNICATIONS OF THE GEOLOGICAL SURVEY OF NAMIBIA

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MINISTRY OF MINES AND ENERGY

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Cover Image

Panoramic view of the northern flanks of the Ugab Valley, southwest of Outjo, Namibia, emphasising pipe outlets that drain the calcrete plateau above (Image Martin Pickford)

Editorial

This issue of the Communications of the Geological Survey of Namibia deals with a variety of geological topics ranging from geochemistry (radio-isotopic dating), geomorphology (aeolian processes along the coast, structure of the Klinghardt Mountains, piping processes), geology (onyx travertine deposits of the Sperrgebiet, Proterozoic geology of north-western Namibia) and palaeontology (enigmatic tiny early Miocene African carnivorans, Eocene adapoid primates).

In 2008, R. Miller published radio-isotopic age determinations of 45.67 +/- 0.1 and 46.52 +/- 0.1 Ma for unlocalised samples of phonolite from the Klinghardt Volcanic Suite, communicated to him by D. Phillips & J. Marsh. Up to now, these were the only dated samples from the main phonolite cluster of the Klinghardt Mountains, the other specimens being from Swartkop and cobbles from Gemsboktal Gravels at Black Crow and Granitbergfelder 15 (Pickford *et al*. 2013).

In this volume, J. Marsh and co-authors present basic data and age determinations of two samples from the Klinghardt volcanic cluster collected during surveys of the Klinghardt Mountains in 1974 and 1998. They thereby provide the raw data necessary for geologists to assess the reliability of age determinations published by Miller (2008) which have minor offsets from those published in this issue of the Communications. On the basis of the two dated samples J. Marsh and co-authors propose that the phonolites in the Klinghardt cluster were emplaced over a short span of time (several hundred kilo-years) at ca 46 Ma.

The contribution by J. Marsh and colleagues in this volume raises several questions concerning the succession of Tertiary geological events in the Sperrgebiet. If the age determination of 46 Ma for the Klinghardt Phonolites represents the age of emplacement, then the phonolites would predate the Black Crow (Middle Eocene, Ypresian/Lutetian, ca 45 Ma) and Eocliff (Late Eocene Bartonian or Priabonian ca 37 Ma) fossiliferous freshwater limestone occurrences, yet neither of these units, nor of the deposits underlying them, show the slightest hint of containing phonolite clasts. Likewise, the conglomerates immediately overlying these limestones (Blaubok Gravels, probably Oligocene-basal Miocene) contain no phonolite cobbles, but younger conglomerates (Gemsboktal Gravels) in the same areas contain abundant phonolite clasts (Sullivan & Clarke, 1962; Fowler, 1970; Pickford, 2015). The mismatch between the supposed age of phonolite emplacement (Lutetian) and the first presence of phonolite cobbles in the local sediment register (Oligo-Miocene) is probably over 20 million years, which seems excessive (Tables 1, 2) and requires further research to resolve.

The Eocliff Limestone is close to the Klinghardt phonolite cluster, the nearest outcrop of phonolite being a mere 600 metres from Eocliff and only 830 metres from Eoridge (Fig. 1) another limestone outcrop which yields Late Eocene mammal fossils, yet there are no signs of phonolite clasts beneath the limestones, within them or in the Blaubok Gravel overlying them. These outcrops are only 6-7 km from Pietab 2 and several other more significant bodies of phonolite in the region, and they lie close to or within the hydrographic networks that drain the country between the Klinghardt Mountains and the Atlantic coast to the west. Given the geomorphological setting of these limestones and gravels and their proximity to the phonolite outcrops, had phonolite outcrops been exposed at the surface, it is difficult to account for the absence of phonolite clasts within these middle to late Eocene and Oligo-Miocene deposits which are so close to the Klinghardt Mountains,. Yet, by the time that the Gemsboktal Gravels accumulated (Miocene) phonolite cobbles were ubiquitous and abundant throughout the drainages north, south and west of the Klinghardts.

This paradox requires attention. There are several possible explanations for such an offset. There is a possibility of incomplete outgassing of the dated phonolites at the time of emplacement, which might thereby have retained isotopic decay products resulting in spurious age determinations older than the eruption dates. As J. Marsh and colleagues point out in their paper, there is "*the difficulty of complete degassing of samples in vacuum furnaces*" and the lava was "*so viscous that flowage to form more typical lava sheets did not take place*." If degassing is difficult under laboratory vacuum conditions, then it is probably also difficult under natural conditions at atmospheric pressure or greater.

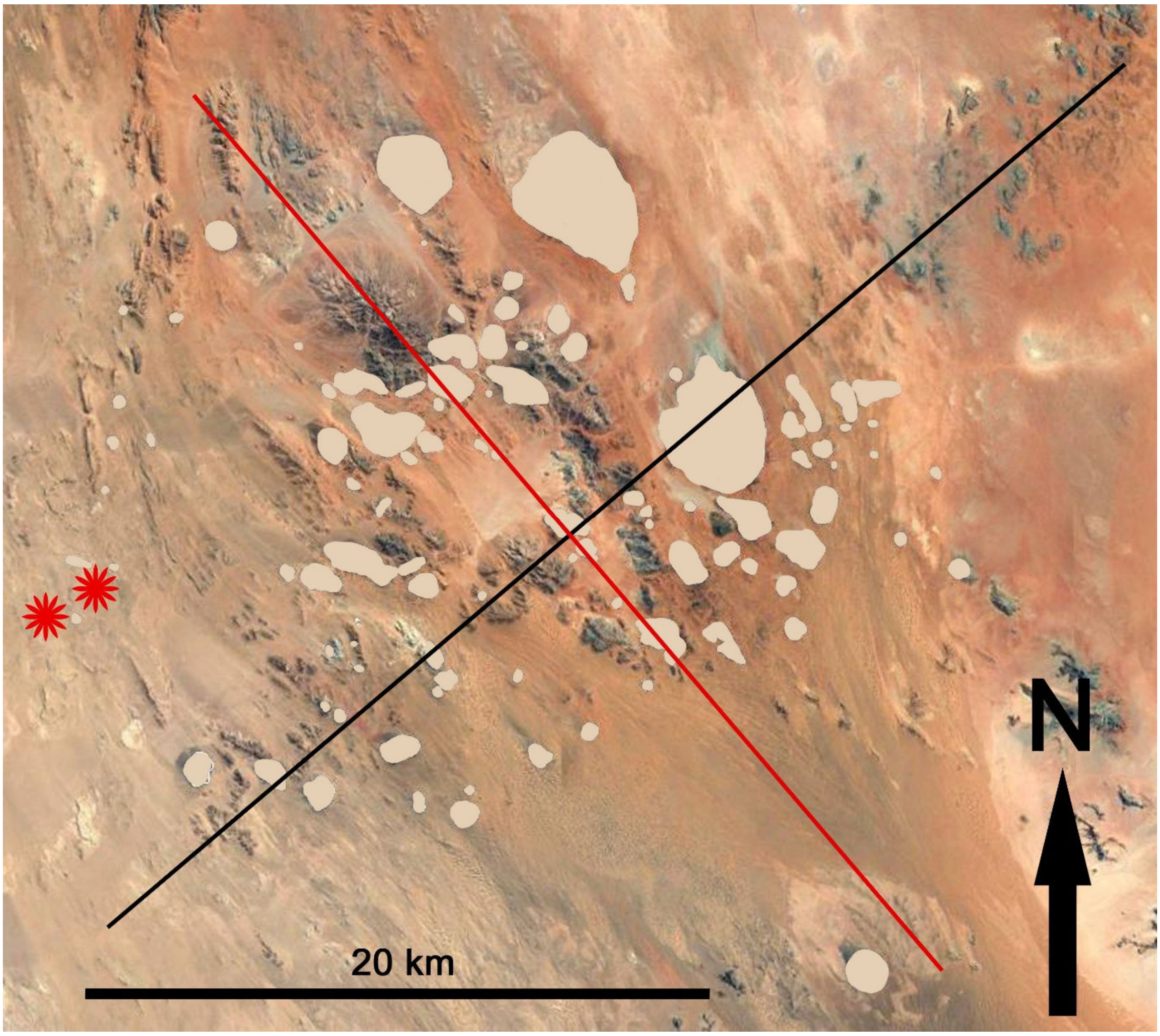

Figure 1. Satellite image of the Klinghardt Mountains with the outcrops of phonolite blanked out in order to highlight the underlying Basement structures. The highest relief in the mountains comprises PreCambrian quartzites (generally darker tones) overlain by well-bedded dolomites, the overall structure of the system resembling an asymmetrical doubly-plunging anticline with a long axis oriented northwest to southeast (red line) and a short axis oriented at right angles to the long axis (black line), the short axis lying in line with a broad ridge that is orthogonal to the general trend of the Great Escarpment (off the image to the right). The Basement rocks in this area lie at a generally higher altitude than the country rock northwest, west or southeast of the mountains. Note that the three largest outcrops of phonolite lie to the northeast of the dome-like central part of the basement structure, and the smaller outcrops generally occur to the west of the dome. Note also that some of the present-day drainage of the mountains is towards the east (i.e. towards the Great Escarpment) before diverting either northwestwards towards the Kaukausib drainage or southwards and then westwards towards the Atlantic Ocean. The red stars represent the Late Eocene (ca 37 Ma) fossiliferous freshwater limestone deposits at Eocliff and Eoridge which likely predate the eruption of the phonolites on the evidence that the sedimentary layers underlying them (Ystervark Carbonatites), within them (Eocliff Limestones) and immediately overlying them (Blaubok Gravels) contain no phonolite clasts, unlike the Gemsboktal Gravels in the same region (Miocene) which are replete with such cobbles (image modified from Google Earth).

Although several of the phonolite bodies lie on Tertiary deposits as has been pointed out by Fowler (1970) and J. Marsh and colleagues, it is possible that some of the phonolites did not reach the palaeo-landsurface when they were emplaced and that it took about 20 myr of erosion to unroof them, so that they could then contribute phonolite clasts to the various surface drainage networks. Such a scenario is possible because the Klinghardt Mountains were a positive relief feature in the region before the eruptions of the phonolites, as was recognised by Pickford *et al*. (2013) and they contributed immense quantities of basement-derived clasts into the Blaubok Gravels which crop out widely in the region west of the Klinghardt Mountains (Pickford, 2015).

Whether there was pre-volcanic doming of the region or not is debateable, but the mismatch between the proposed eruption date of 46 Ma as calculated from radio-isotopic data, and the first arrival of phonolite cobbles in fluvial deposits surrounding the positive relief of the Klinghardt Mountains is so lengthy that it demands an explanation, something that Marsh *et al*. (this volume) do not address in their contribution, although they do argue that that doming did not precede or accompany the volcanic activity in the region. Further study is required, as implied by J. Marsh and colleagues in their discussion of the geomorphology of the Klinghardt Mountains.

On quite a distinct subject, I. Corbett extends his previous publications on the superficial geology of the Sperrgebiet (Corbett, 2016) with detailed descriptions and analyses of currently active aeolian geomorphological processes in the coastal belt of Namibia as a background to understanding the development of diamond placers and deflation concentrations, among other aspects of the area's regional geology. It is clear that aeolian processes played a preponderant role in shaping the geomorphology of the coastal strip during which diamondiferous marine and coastal placers were deposited, deflated, transported and reburied, depending on the local geomorphological setting.

The role of piping (underground erosion) in the African fossil record is investigated by M. Pickford (this volume). The geomorphological processes involved are generally well-understood and, the realisation that in Spain, some fossil occurrences were due to piping activities has resulted in the solution of several enigmatic biostratigraphic problems. The same seems to apply to certain localities in Africa, including Namibia.

M. Pickford describes some of the onyx travertine occurrences in the Kaukausib and Tsirub drainages in the Northern Sperrgebiet. Previously confused with calcretes, these deposits attest to a more humid, cooler palaeoclimatic phase during the Pliocene than exists today.

Classic mapping and stratigraphy has been carried out by P. Hoffman and colleagues in southern Kunene (north-western Namibia) on the Proterozoic succession that is exceptionally well-exposed in the region. Their report is a preliminary lead-in to a monographic treatment to be published next year.

J. Morales and M. Pickford analyse the fossil record of a minute hypercarnivorous mammalian family found in early Miocene deposits in Namibia, Kenya and Uganda. The two known taxa are as small as the smallest extant carnivore, *Mustela nivalis*. Debate about the affinities of these carnivores, Prionogalidae, has been active, but new fossils found in Uganda and Namibia reduce the quantity of hypotheses and indicate affinities with Creodonta, an extinct order of carnivorans.

To complete the issue, M. Godinot and colleagues describe a new genus of adapoid primate from the Middle Eocene Black Crow Limestone. Interestingly, this species has affinities with taxa from similar aged deposits in Switzerland and China.

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Martin PICKFORD, Editor

Table 1:- Stratigraphic relationships in the Klinghardt Mountains and vicinity presented by Sullivan & Clarke (1962) and Fowler (1970).

Stratigraphy	**Sedimentary and Metamorphic Succession**	**Igneous Succession**
Recent	(Deflation deposits, Windblown (sand (and (talus (loams and muds	
Tertiary-Recent	(Calcrete partly or wholly (silicified (Younger Phonolite-bearing (Gravels	
Eocene	(Older, partly Residual Gravels (pan deposits	Phonolite porphyries, lava and Tuffs
End-Cretaceous	(Chalcedonic Limestones	Breccia pipes of Kimberlitic affinities
Cretaceous ?	(Residual marls and clays (Absent) (Pomona Series – Friable schists (shales, calcareous sandstones, con- (glomerate and quartzites. (Intense silicification and ferrugi- (nation of the early Cretaceous Land (surface	
Pre-Cretaceous	(Dolomite Formation) ? Nama System (Quartzite Formation) ? Nama System (Numees Formation (Metamorphic Series	

Table 2:- Revised Tertiary stratigraphy and age estimates by Pickford (2015) and Pickford *et al*. (2013). Note the anomalous position of the Klinghardt Phonolites if their eruption age is 46 Ma (red).

Pickford, 2015; Pickford et al. 2013	**Sedimentary Succession (as above)** ***(Revised nomenclature, stratigraphy, radio-isotopic age determinations and fossils)***	**Igneous Succession**
Pleistocene and Recent	Deflation deposits, Windblown sand and talus, loams and muds (*Struthio camelus, Hodotermes*)	
Miocene and Pliocene	Calcrete partly or wholly silicified (*Namib I and Namib II Calc-crusts - Struthio daberasensis, Trigonephrus*) (*Early Miocene fluvio-palustral deposits : mammals*) Younger Phonolite-bearing Gravels (*Gemsboktal Formation*)	
Oligo-Miocene	Ferruginisation (*Oligo-Miocene*) Older, partly Residual Gravels (*Blaubok Formation - Wood*)	Phonolite porphyries, lava and Tuffs (**46 Ma**)
Late Eocene (Bartonian/Priabonian) *Middle Eocene (Lutetian)*	Intense silicification Chalcedonic Limestones (*Bartonian-Priabonian*) (*Eocliff, Eoridge, Silica North, Silica South, mammals* ***ca 37 Ma*** *Eisenkieselklippenbacke, Chalcedon Tafelberg, Steffenkop plants, gastropods)* *(Lutetian : Black Crow, mammals gastropods* ***ca 45 Ma****)*	Breccia pipes of Kimberlitic affinities (*Ystervark Carbonatite*)
Early Eocene	Friable schists, shales, calcareous sandstones, conglomerate and quartzites *(Bo Alterite*)	

COMMUNICATIONS OF THE GEOLOGICAL SURVEY OF NAMIBIA

Communications first appeared in 1985 with the aim to disseminate information about research and mapping projects carried out by Geological Survey staff, as well as by visiting scientists, on an annual basis. Although for a number of years this goal has not been met, it is planned with this issue to return to its original objective. If warranted by the number of contributions, bi-annual publication will be considered. Communications is published in digital format and available on the Geological Survey's website (http://www.mme.gov.na/publications/?designation=gsn); printed copies (volumes 1 to 13) and copies on CD (volumes 14 to 18) can be purchased at the Geological Survey's sales office at 6 Aviation Road, Windhoek.

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1. Manuscripts must be written in English.

2. A short abstract of less than 200 words must accompany research papers and reports.

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4. Contributions have to be submitted in digital format. The preferred format for text is Microsoft Word, for figures jpg or tiff.

5. Papers will be reviewed by external and/or internal referees; reports will be reviewed by internal referees. Manuscripts submitted by students should be critically reviewed by their supervisors before submission. It is the responsibility of the supervisor to ensure that a high standard is maintained.

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2. The format and sequence of headings are as follows:

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- Free-standing italics (centred)
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If further subdivision is needed, numerals or letters (lower case) should be used.

3. An alphabetical list of all references must follow the text, with a format as follows:

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Blignault, H.J. 1977. *Structural-metamorphic imprint on part of the Namaqua Mobile Belt in South-West Africa*. Ph.D. thesis (unpubl.), Univ. Cape Town, 197 pp.

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3. Figure captions must be provided as a separate list.

4. Headings of tables and appendices should appear above the table.

5. All illustrations or photographs are termed figures, and are referred to as Fig. or Figs in the text.