PALAEONTOLOGICAL IMPACT ASSESSMENT: DESKTOP STUDY

Proposed 100MW concentrating solar power (CSP) generation facility: Copperton, Northern Cape Province

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April 2010

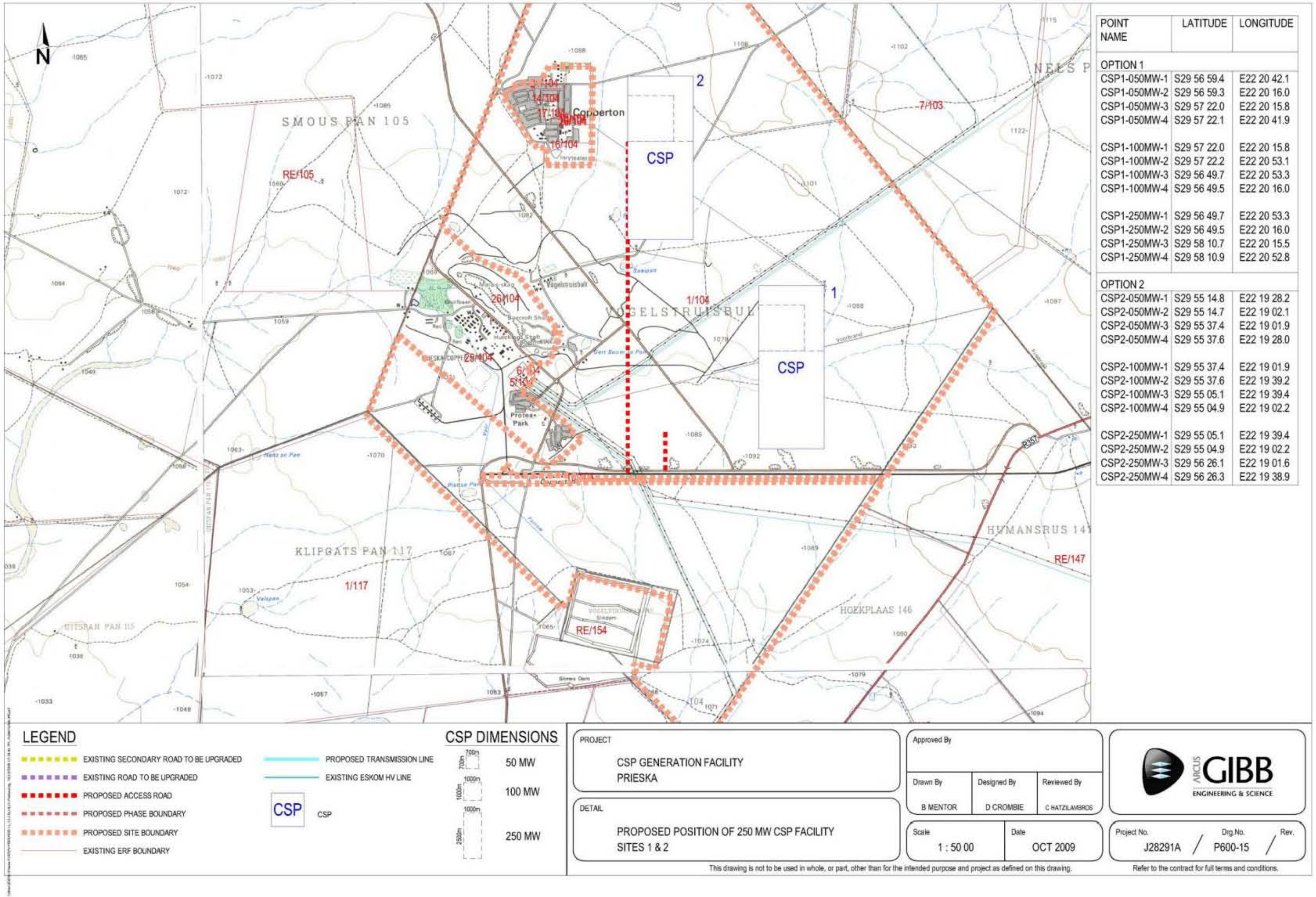
1. SUMMARY

The proposed new CSP power generation facility near Copperton, Northern Cape Province involves the construction of a 1100 x 1100m array close to the Cuprum Substation. Two alternative sites are being considered (CSP1, CSP2). The development footprint in both cases is underlain by thin aeolian sands of the Kalahari Group (Quaternary Gordonia Formation) and – at depth – by Late Palaeozoic, glacially-related rocks of the Dwyka Group (Mbizane Formation). Metamorphic rocks of the Mid Proterozoic (Late Precambrian) Vogelstruisbult Formation (Jacobsmyn Pan Group) and the Archaean (Early Precambrian) Spioenkop Formation (Marydale Group) also crop out in the area. The palaeontological sensitivity of these rock units ranges from zero to low, the development footprint is small, and extensive bedrock excavations are not envisaged. Therefore further palaeontological mitigation of this project is not considered necessary and there is no preference for either CSP site on palaeontological grounds. Should substantial fossil remains be exposed during construction, however, SAHRA should be notified by the ECO so that appropriate mitigation can be undertaken.

2. INTRODUCTION & BRIEF

Mulilo Renewable Energy CSP Prieska (Pty) Ltd is proposing to develop a 100MW concentrating solar power generation facility near Copperton, an abandoned mining town in the Northern Cape Province. Two alternative sites of 1100m X 1100m on the farm Vogelstruisbult 104 are being considered, to the east (CSP2) and southeast (CSP1) of Copperton (Fig. 1). Larger arrays may be built on these sites in future. The sites are adjacent to the Cuprum Substation and near the Kronos Substation. Just over one kilometre of new gravel road will be required to provide access to the chosen site from a tar road to the south.

Both the proposed construction sites overlie potentially fossiliferous sands and bedrock of the Late Caenozoic Kalahari Group and the Palaeozoic Dwyka Group. A desktop palaeontological impact assessment for the project is therefore necessary in accordance with the requirements of the National Heritage Resources Act, 1999. This study has accordingly been commissioned by Mr Junaid Moosajee, Senior Environmental Consultant for DJ Environmental Consultants, Somerset West.



POINT NAME	LATITUDE	LONGITUDE
OPTION 1		
CSP1-050MW-1	S29 56 59.4	E22 20 42.1
CSP1-050MW-2	S29 56 59.3	E22 20 16.0
CSP1-050MW-3	S29 57 22.0	E22 20 15.8
CSP1-050MW-4	S29 57 22.1	E22 20 41.9
CSP1-100MW-1	S29 57 22.0	E22 20 15.8
CSP1-100MW-2	S29 57 22.2	E22 20 53.1
CSP1-100MW-3	S29 56 49.7	E22 20 53.3
CSP1-100MW-4	S29 56 49.5	E22 20 16.0
CSP1-250MW-1	S29 56 49.7	E22 20 53.3
CSP1-250MW-2	S29 56 49.5	E22 20 16.0
CSP1-250MW-3	S29 58 10.7	E22 20 15.5
CSP1-250MW-4	S29 58 10.9	E22 20 52.8
OPTION 2		
CSP2-050MW-1	S29 55 14.8	E22 19 28.2
CSP2-050MW-2	S29 55 14.7	E22 19 02.1
CSP2-050MW-3	S29 55 37.4	E22 19 01.9
CSP2-050MW-4	S29 55 37.6	E22 19 28.0
CSP2-100MW-1	S29 55 37.4	E22 19 01.9
CSP2-100MW-2	S29 55 37.6	E22 19 39.2
CSP2-100MW-3	S29 55 05.1	E22 19 39.4
CSP2-100MW-4	S29 55 04.9	E22 19 02.2
CSP2-250MW-1	S29 55 05.1	E22 19 39.4
CSP2-250MW-2	S29 55 04.9	E22 19 02.2
CSP2-250MW-3	S29 56 26.1	E22 19 01.6
CSP2-250MW-4	S29 56 26.3	E22 19 38.9

FIG. 1. Locality map showing alternative sites (CSP1, CSP2) for the proposed concentrated solar power generation facility near Copperton, Northern Cape (blue squares) (Map prepared by Arcus Gibb and provided by DJ Environmental Consultants).

3. GEOLOGICAL BACKGROUND

The geology of the study area around Copperton is shown on the 1: 250 000 geology map 2922 Prieska (Council for Geoscience, Pretoria; Fig. 2 herein). The explanation for the Prieska geological map has not yet been published; however, several of the rock units are treated in detail in the explanation for the Britstown sheet to the south (Prinsloo, 1989).

The site of the proposed photovoltaic power generation facility is underlain near-surface by unconsolidated aeolian (*i.e.* wind-blown) sands of the Quaternary **Gordonia Formation** (**Kalahari Group**) (Qg in Fig. 2) whose thickness in the study region is uncertain. The geology of the Late Cretaceous to Recent Kalahari Group is reviewed by Thomas (1981), Dingle *et al.* (1983), Thomas & Shaw 1991, Haddon (2000) and Partridge *et al.* (2006). The Gordonia dune sands are considered to range in age from the Late Pliocene / Early Pleistocene, dated in part from enclosed Middle to Late Stone Age stone tools (Dingle *et al*., 1983, p. 291). Note that the recent extension of the Pliocene - Pleistocene boundary from 1.8Ma back to 2.588 Ma would place the Gordonia Formation entirely within the Pleistocene Epoch.

A number of older Kalahari formations underlie the young wind-blown surface sands in the main Kalahari depository to the north of the study area (Fig. 3). However, at the latitude of Copperton (*c*. 30° S) Gordonia Formation sands less than 30m thick are likely to be the main or perhaps only Kalahari sediments present (*cf* isopach map of the Kalahari Group, fig. 6 *in* Partridge *et al*., 2006). These unconsolidated sands might be locally underlain by thin surface gravels equivalent to the Obobogorop Formation, formed from down-wasted (residual) or water-transported clasts weathered out of the Dwyka tillites, as well as by calcretes of Pleistocene age or younger (*cf* Mokalanen Formation, Fig. 3).

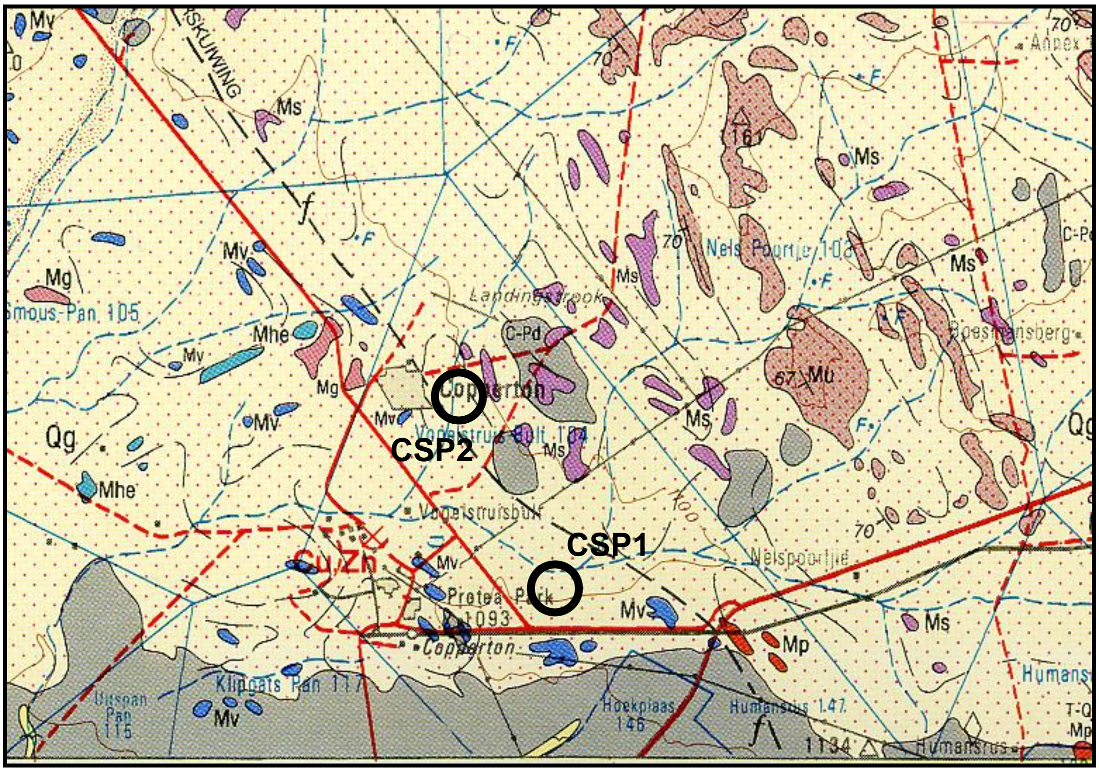


Fig. 2. Extract from 1: 250 000 geology map 2922 Prieska (Council for Geoscience, Pretoria) showing alternative locations of the proposed CSP generation facility (black circles). Purple (Ms) = Spioenkop Formation (Marydale Group) Dark blue (Mv) = Vogelstruisbult Formation (Jacobsmyn Pan Group) Grey (C-Pd) = Dwyka Group Pale yellow (Qg) = Gordonia Formation, Kalahari Group

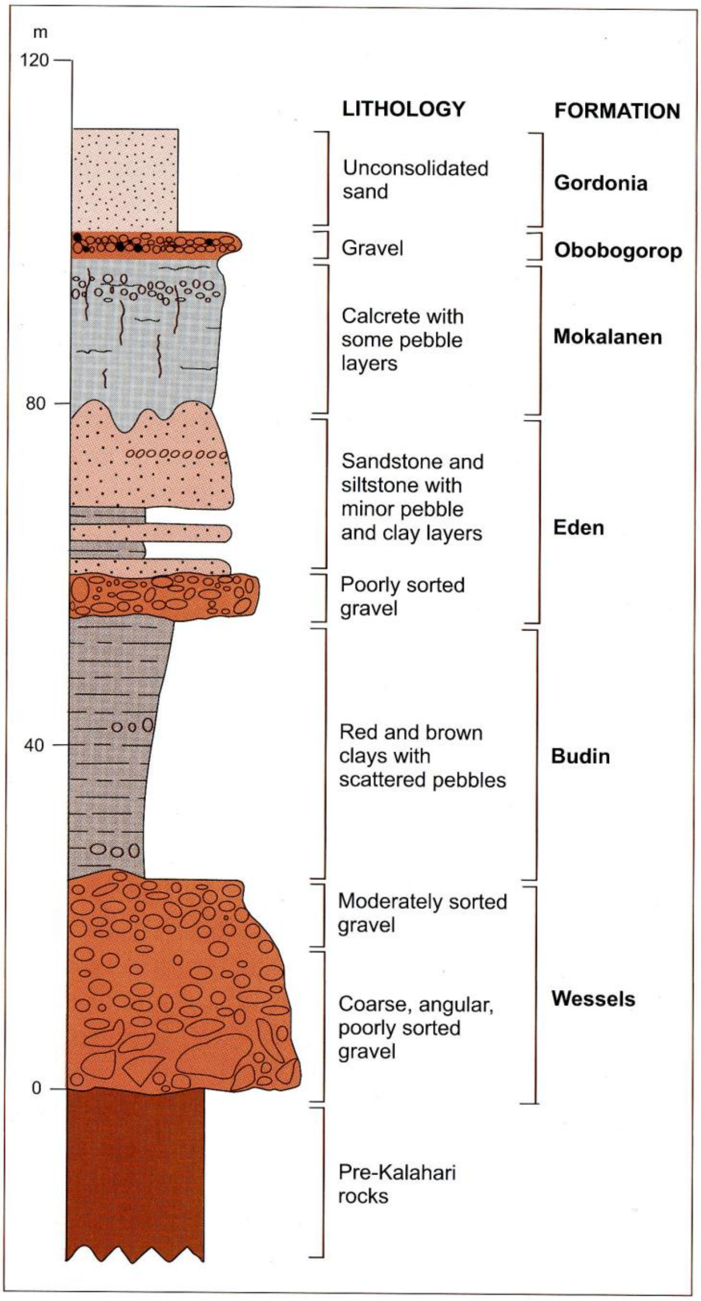


Fig. 3. Stratigraphy of the Kalahari Group (From Partridge *et al.,* 2006). Aeolian sands of the Gordonia Formation are represented in the study area.

Permocarboniferous glacial sediments of **Dwyka Group** (C-Pd) underlie the thin, superficial cover of Gordonia sands. Dwyka rocks may be intersected by deeper excavations during development. The geology of the Dwyka Group has been summarized by Visser (1989), Visser *et al.* (1990) and Johnson *et al.* (2006), among others.

The geology of the Dwyka Group along the north-western margin of the Main Karoo Basin in particular has been reviewed by Visser (1985). In Dwyka times the Prieska – Copperton area lay within a basement high region between the Sout River Valley in the west and the Prieska Basin in the east. This area is referred to as the Kaiing Hills or Kaiing Veld Region by Visser and is characterized by a relatively thin Dwyka succession (normally < 50m). This mainly comprises massive clast-rich diamictites and clast–poor argillaceous diamictites (“boulder shale”) overlain by a thin zone of laminated dropstone argillite with outsized clasts composed mainly of quartzite and gneiss (Visser 1985 and Figs. 4, 5 herein). Note the presence of an isolated peak (monadnock) of Proterozoic basement rocks to the southeast of Copperton shown in Fig. 5. Ice transport directions initially towards the south and later towards the southwest are reconstructed by Visser (1985, his fig. 17).

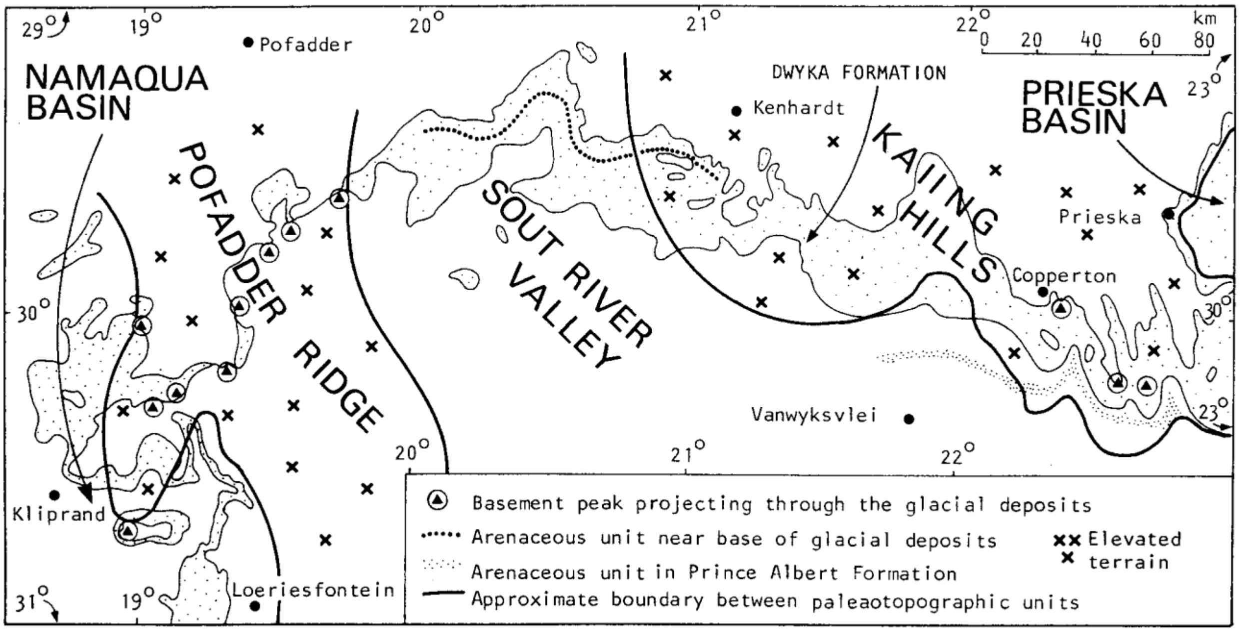


Fig. 4. Reconstruction of the topography along the northern margin of the Karoo Basin in Dwyka times showing location of the Prieska-Copperton area on a basement high (From Visser 1985).

More detailed observations by Prinsloo (1989) on the Dwyka beds on the northern edge of the Britstown 1: 250 000 sheet are relevant to the Copperton area just to the north. Good surface outcrops of the Dwyka beds are rare here due to extensive cover by thin surface gravels. Massive tillites at the base of the Dwyka succession were deposited by dry-based ice sheets in deeper basement valleys. Later climatic amelioration led to melting, marine transgression and the retreat of the icesheets onto the continental highlands in the north. The valleys were then occupied by marine inlets within which drifting glaciers deposited dropstones onto the muddy sea bed (“boulder shales”). The upper Dwyka beds are typically heterolithic, with shales, siltstones and fine-grained sandstones of deltaic and / or turbiditic origin. These upper successions are typically upwards-coarsening and show extensive soft-sediment deformation (loading and slumping). Varved (rhythmically laminated) mudrocks with gritty to fine gravely dropstones indicate the onset of highly seasonal climates, with warmer intervals leading occasionally even to limestone precipitation.

According to maps in Visser *et al.* (1990) and Von Brunn and Visser (1999) the Dwyka rocks in the Prieska-Copperton area close to the northern edge of the Main Karoo Basin belong to the **Mbizane Formation**. This is equivalent to the Northern (valley and inlet) Facies of Visser *et al*. (1990). The Mbizane Formation, up to 190m thick, is recognized across the entire northern margin of the Main Karoo Basin where it may variously form the whole or (as here) only the *upper* part of the Dwyka succession. It is characterized by its extremely heterolithic nature, with marked vertical and horizontal facies variation (Von Brunn & Visser 1999). The proportion of diamictite and mudrock is often low, the former often confined to basement depressions. Orange-tinted sandstones (often structureless or displaying extensive soft-sediment deformation, amalgamation and mass flow processes) may dominate the succession. The Mbizane-type heterolithic successions characterize the thicker Dwyka of the ancient palaeovalleys cutting back into the northern basement rocks.

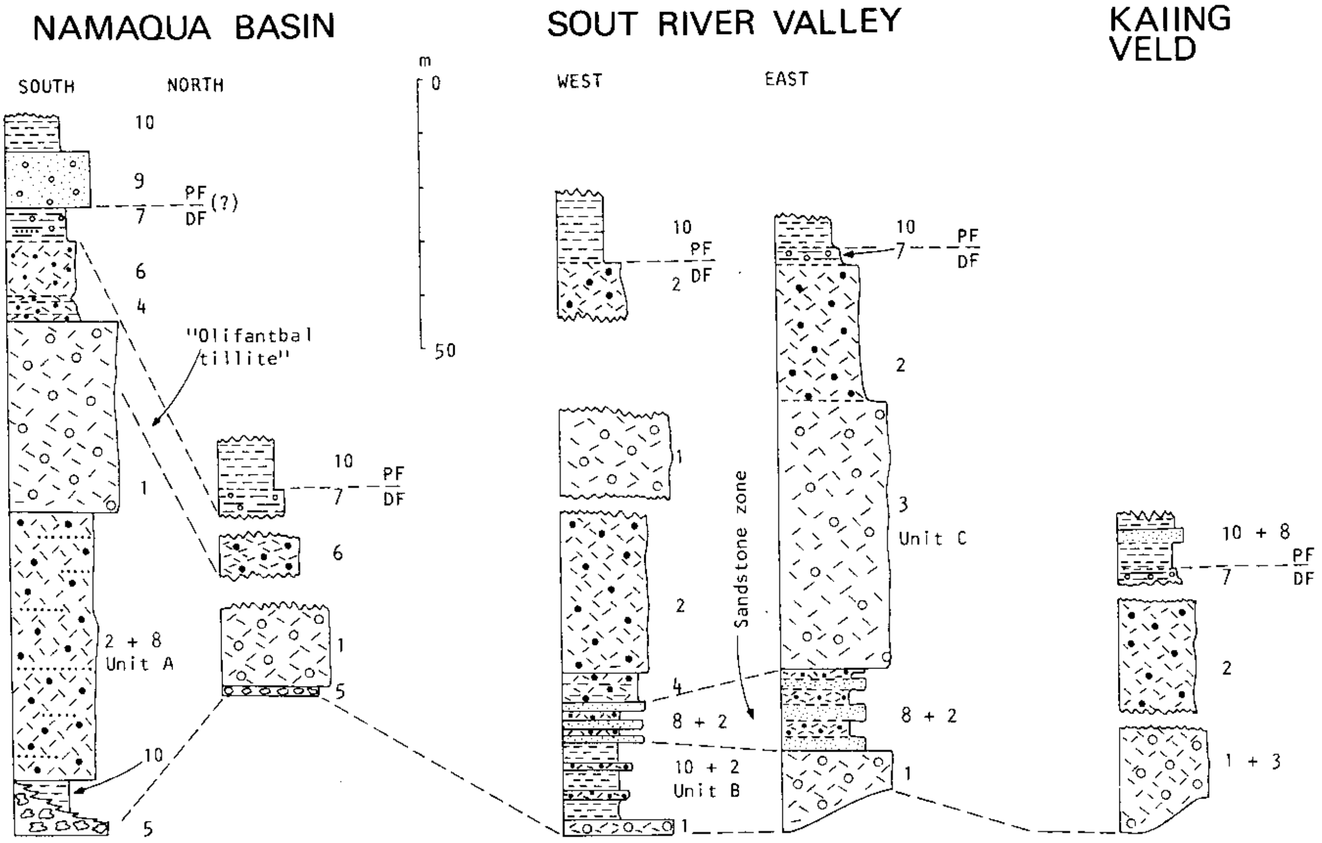


Figure 2

Regional stratigraphic sequences of the Dwyka Formation between Loeriesfontein and the Doringberg Range with the lithofacies indicated by numbers. 1. Massive clast-rich arenaceous diamictite. 2. Massive clast-poor argillaceous diamictite ("boulder shale"). 3. Massive diamictite (undifferentiated). 4. Bedded diamictite. 5. Brecciated basement rocks (local tillite). 6. Massive carbonate-rich diamictite ("olifantbal tillite"). 7. Dropstone argillite ("varved shale"). 8. Fine- to coarse-grained sandstone. 9. Pebbly sandstone. 10. Dark grey to black, micaceous shale and mudstone. Lithological units numbered A, B, and C will be referred to in the text. DF = Dwyka Formation, PF = Prince Albert Formation (see Fig. 1 for location of regions).

Fig. 5. Stratigraphic logs through the Dwyka Group along the northern margin of the Main Karoo Basin. The short Kaaing Veld log on the RHS, dominated by diamictite facies, is most relevant to the Copperton area (From Visser 1985).

Several small inliers of ancient Precambrian basement rocks emerge through the cover of Kalahari sands in the Copperton area. Those to the southwest of the NW-SE fault line running past Copperton, close to site CSP1, are assigned to the **Vogelstruisbult Formation** of the **Jacobsmyn Pan Group** (Mv in Fig. 2). This group of basement rocks mainly consists of high grade metamorphic rocks (banded pelitic gneiss, migmatites) that are unfossiliferous (Slabbert *et al.*, 1999, Cornell *et al.*, 2006). They are of undetermined Mokolian age, *i.e.* mid-Proterozoic (between 1000 to 2050 Ma = million years old). An isolated remnant of Mokolian basement rocks was protected from pre-Dwyka erosion to the southeast of Copperton (Fig. 4). Basement rocks to the northeast of the fault line, close to site CSP2, are assigned to the much older **Spioenkop Formation** of the **Marydale Group** (Ms in Fig. 2). They consist mainly of metamorphosed sediments (quartzites, schists) with some metamorphosed igneous rocks as well (*e.g.* amphibolites). They form part of a 2-8km thick Archaean (Early Precambrian) greenstone belt (ancient oceanic crust) along the southwest margin of the ancient Kaapvaal continent and are over 2500 million years old (Potgieter & Botha 1982, Brandl *et al.*, 2006).

4. PALAEONTOLOGICAL HERITAGE

The fossil heritage recorded within each of the three rock units occurring within the study area is outlined here in order of decreasing geological age.

4.1. Fossils in the Marydale and Jacobsmyn Pan Groups

Although they may originally have contained microfossils (*e.g.* ancient bacteria) all these ancient basement rocks have been too intensely metamorphosed to contain fossils.

4.2. Fossils in the Dwyka Group

The generally poor fossil record of the Dwyka Group (McLachlan & Anderson 1973, Anderson & McLachlan 1976, Visser 1989, Visser *et al*., 1990, Visser 2003, Almond & Pether 2008) is hardly surprising given the glacial climates that prevailed during much of the Late Carboniferous to Permian Periods in southern Africa. However, most Dwyka sediments were deposited during periods of glacial retreat associated with climatic amelioration. Sparse, low diversity fossil biotas from the Mbizane Formation in particular mainly consist of arthropod trackways associated with dropstone laminites and sporadic vascular plant remains, while palynomorphs (organic-walled microfossils) are also likely to be present within finer-grained mudrock facies. Glacial diamictites (tillites or “boulder mudstones”) are normally unfossiliferous but do occasionally contain fragmentary transported plant material as well as palynomorphs in the fine-grained matrix. There are interesting records of limestone glacial erratics from tillites along the southern margins of the Great Karoo (Elandsvlei Formation) that contain Cambrian eodiscid trilobites as well as archaeocyathid sponges. Such derived fossils provide important data for reconstructing the movement of Gondwana ice sheets (Cooper & Oosthuizen 1974, Stone & Thompson 2005).

A limited range of marine fossils are associated with the later phases of several of the four main Dwyka deglaciation cycles (DSI to DSIV), especially in the Kalahari Basin of southern Namibia but also in some cases within the Main Karoo Basin in South Africa (Oelofsen 1986, Visser 1989, 1997, Visser *et al*. 1997, Bangert *et al*. 1999, Stollhofen *et al*. 2000, Almond 2008). These deglaciation sequences are estimated to have lasted five to seven million years on average (Bangert *et al*. 1999). A range of stenohaline (*i.e.* exclusively salt water) invertebrate fossils indicates that fully marine salinities prevailed at the end of each sequence, at least in the western outcrop area (Namibia, Northern Cape). These invertebrates include echinoderms (starfish, crinoids, echinoids), cephalopods (nautiloids, goniatites), articulate brachiopods, bryozoans, foraminiferans, and conulariids, among others. Primitive bony fish (palaeoniscoids), spiral “coprolites” attributable to sharks or eurypterids, as well as wood and trace fossils are also recorded from mudrock facies at the tops of DSII (Ganikobis Shale Member), DS III (Hardap Member) and DSIV (Nossob Shale Member, as well as base of the Prince Albert Formation (Ecca Group) in southern Namibia and, in the last case at least, in the Northern Cape near Douglas (McLachlan and Anderson 1973, Veevers *et al*. 1994, Grill 1997, Bangert *et al*. 1999, Pickford & Senut 2002, Evans 2005). The Ganikobis (DSII) fauna has been radiometrically dated to *c*. 300 Ma, or end-Carboniferous (Gzhelian), while the Hardap fauna (DSIII) is correlated with the *Eurydesma* transgression of earliest Permian age (Asselian) that can be widely picked up across Gondwana (Dickens 1961, 1984, Bangert *et al*. 1999, Stollhofen *et al*. 2000). The distinctive thick-shelled bivalve *Eurydesma*, well known from the Dwyka of southern Namibia, has not yet been recorded from the main Karoo Basin, however (McLachlan and Anderson 1973). The upper part of DSIV, just above the Dwyka / Ecca boundary in the western Karoo Basin (*i.e.* situated within the basal Prince Albert Formation), has been radiometrically dated to 290-288 Ma (Stollhofen *et al*. 2000).

Low diversity ichnoassemblages dominated by non-marine arthropod trackways are widely associated with cold water periglacial mudrocks, including dropstone laminites, within the Mbizane Formation in the Main Karoo Basin (Von Brunn & Visser, 1999, Savage 1970, 1971, Anderson 1974, 1975, 1976, 1981, Almond 2008, 2009). They are assigned to the non-marine / lacustrine *Mermia* ichnofacies that has been extensively recorded from post-glacial epicontinental seas and large lakes of Permian age across southern Gondwana (Buatois & Mangano 1995, 2004). These Dwyka ichnoassemblages include the arthropod trackways *Maculichna*, *Umfolozia* and *Isopodichnus*, the possible crustacean resting trace *Gluckstadtella*, sinuous fish-fin traces (*Undichna*) as well as various unnamed horizontal burrows. The association of these interglacial or post-glacial ichnoassemblages with rhythmites (interpreted as varvites generated by seasonal ice melt), the absence of stenohaline marine invertebrate remains, and their low diversity suggest a restricted, fresh- or brackish water environment. Herbert and Compton (2007) also inferred a freshwater depositional environment for the Dwyka / Ecca contact beds in the SW Cape based on geochemical analyses of calcareous and phosphatic diagenetic nodules within the upper Elandsvlei and Prince Albert Formations respectively. Well-developed U-shaped burrows of the ichnogenus *Rhizocorallium* are recorded from sandstones interbedded with varved mudrocks within the upper Dwyka Group (Mbizane facies) on the Britstown sheet (Prinsloo 1989; Fig. 6 herein). Similar *Rhizocorallium* traces also described from the Dwyka Group of Namibia (*e.g.*the Hardap Shale Member, Miller 2008). References to occurrences of the complex helical spreiten burrow *Zoophycos* in the Dwyka of the Britstown sheet and elsewhere (*e.g.* Prinsloo 1989) are probably in error, since in Palaeozoic times this was predominantly a shallow marine to estuarine ichnogenus (Seilacher 2007).

Scattered records of fossil vascular plants within the Dwyka Group of the Main Karoo Basin record the early phase of the colonisation of SW Gondwana by members of the *Glossopteris* Flora in the Late Carboniferous (Plumstead 1969, Anderson & McLachlan 1976, Anderson & Anderson 1985 and earlier refs. therein). These records include fragmentary carbonized stems and leaves of the seed ferns *Glossopteris* / *Gamgamopteris* and several gymnospermous genera (*e.g. Noeggerathiopsis, Ginkgophyllum*) that are even found within glacial tillites. More "primitive" plant taxa include lycopods (club mosses) and true mosses such as *Dwykea*. It should be noted that the depositional setting (*e.g.* fluvial *versus* glacial) and stratigraphic position of some of these records are contested (cf Anderson & McLachlan 1976). Petrified woods with well-developed seasonal growth rings are recorded from the upper Dwyka Group (Mbizane Formation) of the northern Karoo Basin (*e.g.* Prinsloo 1989) as well as from the latest Carboniferous of southern Namibia. The more abundant Namibian material (*e.g.Megaporoxylon*) has recently received systematic attention (Bangert & Bamford 2001, Bamford 2000, 2004) and is clearly gymnospermous (pycnoxylic, *i.e.* dense woods with narrow rays) but most cannot be assigned to any particular gymnosperm order.

Borehole cores through Dwyka mudrocks have yielded moderately diverse palynomorph assemblages (organic-walled spores, acanthomorph acritarchs) as well as plant cuticles. These mudrocks are interbedded with diamictites in the southern Karoo as well as within Dwyka valley infills along the northern margin of the Main Karoo Basin (McLachlan & Anderson 1973, Anderson 1977, Stapleton 1977, Visser 1989, Anderson & Anderson 1985). Thirty one Dwyka palynomorph species are mentioned by the last authors, for example. Anderson's (1977) Late Carboniferous to Early Permian Biozone 1 based on Dwyka palynomorph assemblages is characterized by abundant *Microbaculispora*, monosaccate pollens (*e.g. Vestigisporites*) and nontaeniate bisaccate pollens (*e.g. Pityosporites*) (Stephenson 2008). Prinsloo (1989) mentions stromatolitic limestone lenses within the uppermost Dwyka Group in the Britstown sheet area. These may be comparable to interglacial microbial mats and mounds described from the Ganikobis Shale Member (DSII) of southern Namibia by Grill (1997) and Bangert *et al.* (2000).

Although a wide range of fossils are now known from the Dwyka Group, most sediments assigned to this succession are unfossiliferous (with the possible exception of microfossils). The overall palaeontological sensitivity of the Dwyka Group is therefore rated as low (Almond & Pether 2008). Any interglacial mudrocks and heterolithic successions (*i.e.* interbedded sandstones and mudrocks) are worth investigating for fossils, however. Since the Prieska-Copperton area lay on a basement high in Dwyka times (Fig. 4), interglacial mudrocks are unlikely to be well represented here. Late-glacial or post-glacial mudrocks, such as those containing a fairly rich shelly fossil record at Douglas in the Northern Cape (McLachlan & Anderson 1973) have been lost to erosion in the Prieska region.

Fig. 6. Large U-burrows of the ichnogenus *Rhizocorallium* in ripple-marked sandstones of the upper Dwyka Group, Britstown sheet area (From Prinsloo, 1989).

4.3. Fossils in the Kalahari Group

The fossil record of the Kalahari Group is generally sparse and low in diversity. The Gordonia Formation dune sands were mainly active during cold, drier intervals of the Pleistocene Epoch that were inimical to most forms of life, apart from hardy, desert-adapted species. Porous dune sands are not generally conducive to fossil preservation. However, mummification of soft tissues may play a role here and migrating lime-rich groundwaters derived from the underlying Dwyka Group may lead to the rapid calcretisation of organic structures such as burrows and root casts. Occasional terrestrial fossil remains that might be expected within this unit include calcretized rhizoliths (root casts) and termitaria (*e..g Hodotermes*, the harvester termite), ostrich egg shells (*Struthio*) and shells of land snails (*e.g. Trigonephrus*) (Almond 2008, Almond & Pether 2008). Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*) and snails, ostracods (seed shrimps), charophytes (stonework algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) are associated with local watercourses and pans. Microfossils such as diatoms may be blown by wind into nearby dune sands (Du Toit 1954, Dingle *et al*., 1983). These Kalahari fossils (or subfossils) can be expected to occur sporadically but widely, and the overall palaeontological sensitivity of the Gordonia Formation is therefore considered to be low (*ibid*.). Underlying calcretes might also contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings) may be expected occasionally expected within Kalahari Group sediments. However, no fossil records of Pleistocene mammals are listed in the study region in the review by Klein (1984).

5. CONCLUSIONS & RECOMMENDATIONS

Palaeontological mitigation generally concerns the construction phase rather than the operational phase of a development, unless this development involves ongoing excavation of bedrock (*e.g.* mining). The inferred palaeontological sensitivity of fossil heritage within each of the four rock units represented in the study area near Copperton is summarized in Table 1 below (*cf* also Almond & Pether 2008). Given the zero to low palaeontological sensitivity of rocks in the region, the small footprint of the development and the shallow excavations envisaged, no further palaeontolgical mitigation is recommended for this development. There is no preference on palaeontological grounds for one CSP site over another. Should substantial fossil remains be exposed during construction, however, the ECO should alert SAHRA so that appropriate action (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist.

6. ACKNOWLEDGEMENTS

Mr Junaid Moosajee, Senior Environmental Consultant for DJ Environmental Consultants, Somerset West, is thanked for commissioning this study and for kindly providing all the necessary background information.

TABLE 1: FOSSIL HERITAGE IN THE COPPERTON AREA				
GEOLOGICAL UNIT	**ROCK TYPES & AGE**	**FOSSIL HERITAGE**	**PALAEONTOLOGICAL SENSITIVITY**	**RECOMMENDED MITIGATION**
Gordonia Formation **KALAHARI GROUP**	**mainly aeolian sands *plus* minor fluvial gravels, freshwater pan deposits** **PLEISTOCENE**	**calcretised rhizoliths & termitaria, ostrich egg shells, land snail shells, rare mammalian and reptile(*e.g.* tortoise) bones, teeth** **freshwater units associated with diatoms, molluscs, stromatolites *etc***	**LOW**	**none recommended** **any substantial fossil finds to be reported by ECO to SAHRA**
Mbizane Formation **DWYKA GROUP**	**tillites, interglacial mudrocks, deltaic & turbiditic sandstones, minor thin limestones** **LATE CARBONIFEROUS – EARLY PERMIAN**	**sparse petrified wood & other plant remains, palynomorphs, trace fossils (*e.g.* arthropod trackways, fish trails, U-burrows)** **possible stromatolites in limestones**	**LOW**	**none recommended** **any substantial fossil finds to be reported by ECO to SAHRA**
Vogelstruisbult Formation **JACOBSMYN PAN GROUP**	**high grade metamorphic rocks (*e.g.* banded gneisses, migmatites)** **MID PROTEROZOIC = LATE PRECAMBRIAN**	**none**	**ZERO**	**none recommended**
Spioenkop Formation **MARYDALE GROUP**	**metamorphic rocks (*e.g.* quartzites, schists, amphibolites)** **ARCHEAN = EARLY PRECAMBRIAN**	**none**	**ZERO**	**none recommended**

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Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape under the aegis of his Cape Town-based company *Natura Viva* cc. He is a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHAP (Association of Professional Heritage Assessment Practitioners – Western Cape).