Phase 1 Palaeontological Impact Assessment of 54 Borrow Pits in the Oliver Tambo Municipal District, EC Province

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Executive Summary

- Anticipated development calls for the rehabilitation of gravel road infrastructure involving 54 roadside borrow pits in Oliver Tambo Municipal District in the Eastern Cape Province.
- The sedimentary geology largely constitutes Carboniferous Dwyka, Permian Ecca, and Triassic Beaufort Group strata.
- Fourteen borrow pits are exclusively doleritic and therefore not palaeontologically significant.
- One borrow pit (024 BP01) is located on Natal Group sediments which are not regarded as palaeontologically significant.
- The geology of the remaining pits consists of known fossil-bearing strata of Carboniferous, Permian and Triassic age, which are considered to be of low to moderate palaeontological significance.
- The borrow pit margins are covered by scattered superficial deposits of Quaternary age, including valley sediments and alluvium. No Quaternary vertebrate fossils were recorded in geologically recent alluvial valley-sediments recorded in the vicinity the borrow pits.
- There are **no major palaeontological grounds to suspend the use of the borrow pits** but given the nature of fossil distribution in Karoo sedimentary rocks, it is not possible to exactly predict the buried fossil content of an area other than in general terms unless fresh exposures indicate otherwise.
- No mitigation is required for borrow pits located within dolerite, Natal, Dwyka and Ecca Group strata.
- However, monitoring of fresh exposures and bedrock excavations into the moderately significant fossil-bearing strata of the Adelaide and Tarkastad Subgroups is advised (**Table 4**).

- Access by a palaeontologist should be facilitated at the appropriate stage during development in order to inspect fresh excavations.
- It is also advised that newly uncovered objects of palaeontological significance, found during the course of excavation activities, may require a Phase 2 rescue operation at the cost of the developer.

Contents

Glossary

Fossil: Mineralised bones of animals, shellfish, plants and marine animals. A trace fossil is the track or footprint of a fossil animal that is preserved in stone or consolidated sediment.

Heritage: That which is inherited and forms part of the National Estate (Historical places, objects, fossils as defined by the National Heritage Resources Act 25 of 1999.

Palaeontology: Study of any fossilized remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or trace.

Supergroup: A group of rock strata formed during a single, major and widespread episode of rock accumulation.

Introduction

A Phase 1 Palaeontological Impact Assessment was carried out along designated areas in the Oliver Tambo Municipal District with the aim to investigate the palaeontological significance of a 54 roadside borrow pit localities. The survey is required as a prerequisite for new development in terms of the National Environmental Management Act and is also called for in terms of the National Heritage Resources Act 25 of 1999.

Anticipated development calls for the utilization of the borrow pits to maintain and rehabilitate the gravel road infrastructure in the region. A site visit and assessment took place in September 2011.

The terms of reference

An assessment was carried out to evaluate the palaeontological potential within the footprint of each borrow pit.

The palaeontological assessment required:

- identification and recording of potential palaeontological heritage resources in the proposed areas of impact and;
- recommendation of mitigation measures to minimize potential impacts associated with the proposed development.

Description of the Affected Area

Details of area surveyed

The borrow pits are located on 1:50 000 topographic map sections 3128 and 3129 **(**indicated on portion of geological map in **Fig. 1). S**ite coordinates of each borrow pit are presented as reference points in **Table 1.** The study area is largely located along a coastal platform on mountainous and undulating terrain. It generally covers the area between Qumbu in the northwest, Flagstaff in the northeast, Port St. Johns in the southeast and Elliotdale in the southwest (**Appendix 1**).

Methodology

The palaeontological footprint is largely related to continuous sedimentary units that cover large geographical areas due to the lateral distribution and lithostratigraphy of the underlying Permian-Triassic rocks. A pedestrian survey was conducted in and around each of the 54 borrows pits. A Garmin Etrex Vista GPS hand model (set to the WGS 84 map datum) and a digital camera were used for recording purposes. Relevant geological and palaeontological information were assimilated for the report and integrated with data acquired during the on-site inspection.

Geological Background

The geology of the region has been described by Karpeta and Johnson (1979) and Johnston and Caston (1979). The area covered by the map in **Fig 1** is underlain by sedimentary strata belonging to the early Palaeozoic Natal Group and the late Palaeozoic – middle Mesozoic Karoo Sequence covering the period from the Ordovician to the Middle Jurassic (**Fig 2**). The Natal Group (***Dm***) comprises reddish-grey conglomerates, cross-bedded siliceous quartzose and feldspathic sandstone and mudstones. Although still vague, the age of the Natal Group is tentatively placed in the Ordovician epoch (Marshall 2006). However, a lack of diagnostic fossils and problems with direct correlation are compounding the problem.

The Late Carboniferous to Early Permian Dwyka Formation (***Pd***) unconformably overlies the Natal Group and is represented by a sequence of coarse but homogenous diamictites and subordinate mudstones and sandstones. Subsurface deposits in the region are represented by the Elandsvlei Formation (Visser *et al*. 1992). Thin lenses of finely laminated bluish-grey to

yellowish-grey shale are interbedded with the diamictites. Due to the distinctive lithological

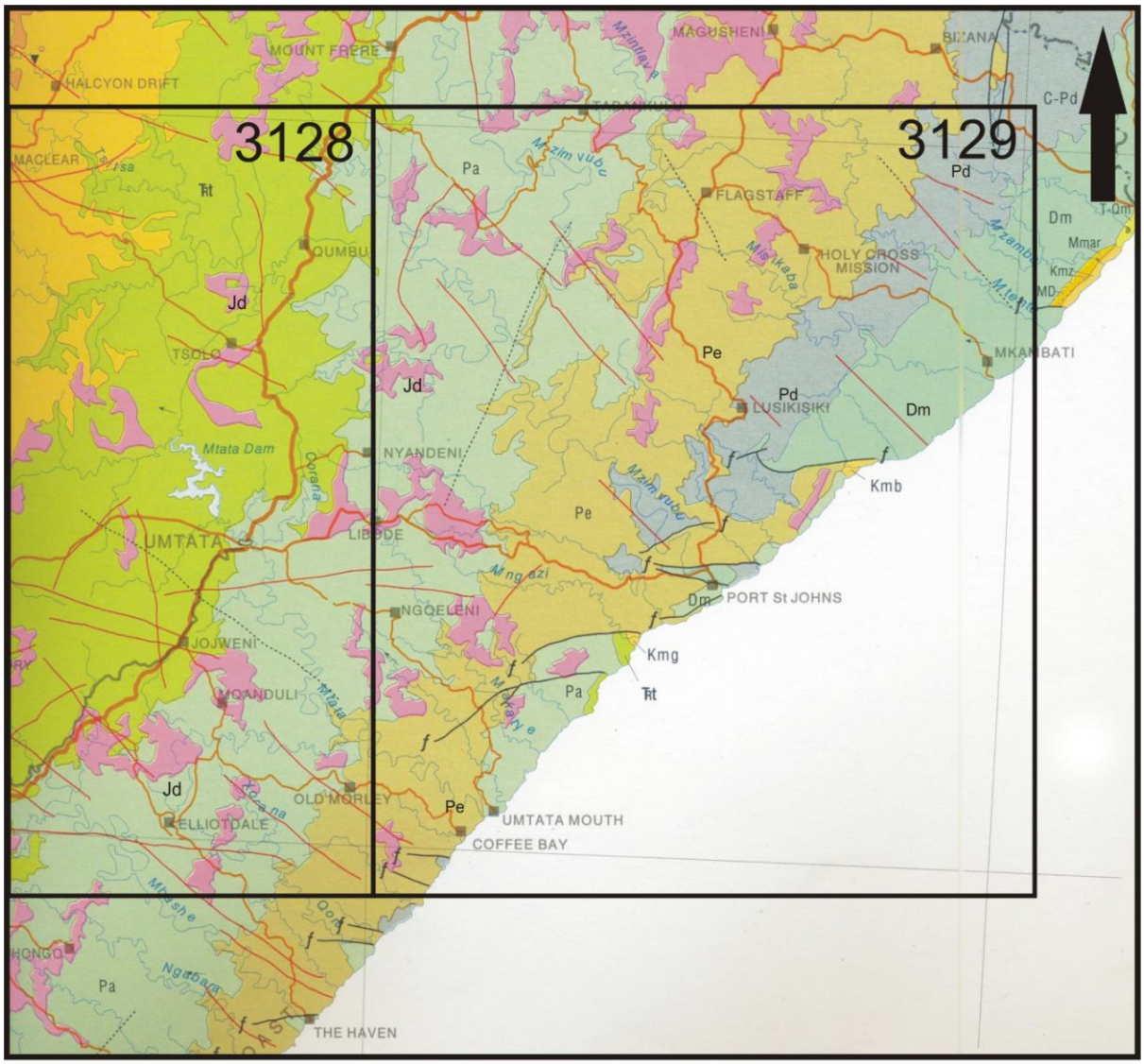

Figure 1. Portion of 1 to 1 000000 scale geological map of South Africa showing the bedrock geology in and around the study area. From oldest to youngest: Natal Group (*Dm / S?*), Dwyka Group, Elandsvlei Frm. (*Pd*) and Ecca Group (*Pe*); Beaufort Group, Adelaide (*Pa*) and Tarkastad (*Trt*) Subgroups; Dolerite intrusions (Jd) and Creataceous conglomerates (*Kmg, Kmb)*

features as well as the presence of glacial striations on the underlying bedrock the diamictites are considered to be glacial till with the shale shale and sandstone representing meltwater-lake deposits.

Conformably overlying the Dwyka tillites is a succession of shale and subordinate sandstone representing the Permian Ecca Group (***Pe***). In this region, along the eastern flank of the Karoo basin, the Ecca Group consists of undifferentiated mudrock. It has not been studied in detail because of poor exposures and repeated faulting. Carbonaceous shales, fine-grained

graywackes and alternating dark-grey shales are exposed near Coffee Bay while feldpathic greywacke occurs near the top of the Ecca west of Port St. Johns.

The Ecca Group grades upward into the Triassic Beaufort Group, which in the region is represented by the Adelaide and Tarkastad Subgroups. The Tarkastad Subgroup (***Trt***) is generally distinguished from the Adelaide Subgroup (***Pa***) by a distinct increase in the sandstone to mudstone ratio. From oldest to youngest, the Adelaide Subgroup west of 28°E is represented by the Koonaap, Middleton and Balfour Formations respectively, but they are difficult to separate due to poor exposures in the study area. Upward –fining cycles, lenticular sandstones and massive mudstones point to a fluviatile mode of deposition for the origin of the Adelaide Subgroup.

The Tarkastad Subgroup is made up of the lower arenaceous Katberg Formation (***Trk***) and the upper argillaceous Burgersdorp Formation (***Trb***). The Katberg Formation consist of reddish-grey medium-grained lithic sandstone and brownish-red and grey mudstones. The Burgersdorp Formation is mainly represented by grayish-red and greenish-grey mudstones with subordinate greenish-grey fine-grained lithic sandstone. Based on the characteristic presence of upward-fining cycles, lenticular sandstones, massive mudstones and non-marine vertebrate remains, the depositional history of the Tarkastad Subgroup is also interpreted as a fluviatile environment.

The sedimentary rocks were intruded by an interconnected network of dykes, sills and inclined sheets of resistant dolerite (***Jd***) during the Jurassic.

A small pocket of erosional remnants of Cretaceous strata are present at Mbotyi on the coast north of Port St. Johns and consists mainly of dolerite, shale and sandstone conglomerates (***Kmb***). The presence of dolerite clasts indicate a post-Jurassic age for the deposit. Another pocket of Cretacous sediments on the coast at the Mngazana River, south of Port St Johns, is primarily made up of a dolerite indurated shale, sandstone as well as basalt and agate pebble conglomerate (***Kmg***). Microfossils found in the sediments provide a lower Cretaceous age for the formation.

Alluvial valley-sediments adjoining main rivers and colluvial deposits make up the bulk of the superficial Quaternary deposits in the region.

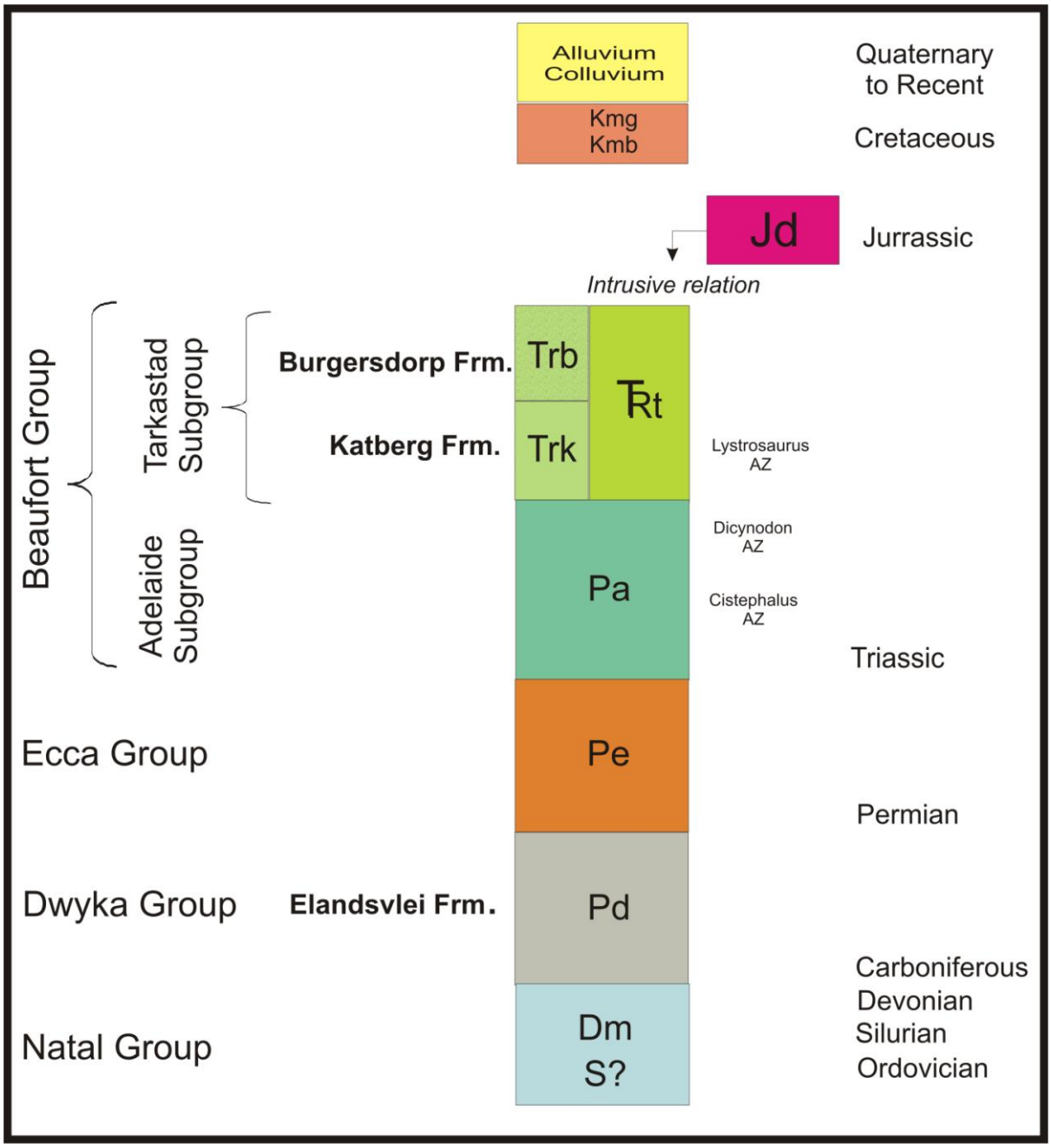

Figure 2. Schematic representation of the affected geology in the survey area.

Palaeontological Background

The potential fossil heritage within geological units affected by the proposed development is summarized in **Table 2**.

Natal Group

The Palaeozoic Natal Group probably represents a record of more than 130 million years from the Ordovician (~ 490 Ma) to the Devonian (~ 360 Ma). However, the tectonic overprint of the Cape Folding Event when lateral compression produced zones of intense folding, and the subsequent creation of the African Land Surface in the region, had a detrimental effect on the preservation of fossils. In addition, the removal of the upper portions of the Natal Group is considered to have been caused partially by subaerial erosion and partially by Dwyka glacial activity. Post-Cretaceous epeirogenic events caused further warping and periodic seaward tilting of the coastal belt.

Karoo Supergroup

As for the overlying Karoo Sequence, spores and acritarchs have been reported from intercalated mudrocks of the Elandsvlei Formation (Dwyka Group), but these are also badly damaged by heat and tectonism (Anderson and McLachlan 1976). Undiagnostic plant remains are rare while arthropod trackways and fish trails have been recorded on bedding planes near the base of the formation (Anderson 1981).

Vertebrate fossil remains from the upper part of the Ecca Group include the mesosaurid reptiles *Mesosaurus tenuidens* and *Stereosternum tumidum* (Oelofsen and Araujo 1987) as well as crustaceans (*Notocaris tapscotti*) and palaeoniscoid fish. Rare ichnofossils have been recorded in the central part of the Group. Plant and invertebrate fossils include wood and leaves (*Glossopteris*), sponge spicules and rare insect wings (McLachlan and Anderson 1977).

East of 24°E the uppermost part of the Middleton Formation and lowermost part of the Balfour Formation of the Adelaide Subgroup are assigned to the *Cistecephalus* Assemblage Zone (AZ). The fossil record of these biozones – including a wide variety of terrestrial tetrapods, plants, silicified wood and trace fossils, is summarized in Rubidge (1995) and MacRae (1999). This zone is characterized by the predominance of a number of dicynodont species including *Diictodon, Pristerodon, Cistecephalus, Aulacephalodon* and *Oudenodon*. Plant fossils include *Glossopteris* and *Schizoneura*. The vertebrate fauna are mostly preserved as dispersed isolated fossils in interchannel mudrocks.

Between 24°E and 25°E the upper Balfour Formation are mainly occupied by the *Dicynodon* AZ, but east of 25°E the *Dicynodon* AZ becomes indistinguishable from the underlying *Cistecephalus* AZ. The *Dicynodon* AZ is characterized by the presence of both therapsids

Dicynodon and *Theriognathus.* Therapsid fossils are normally well-preserved in mudrock horizons and are usually found as dispersed isolated specimens associated with an abundance of calcareous nodules. Fish fossils (*Atherstonia scutata*) and plant fossils such as *Dadoxylon* and *Glossopteris* also occur.

In the Tarkastad Subgroup the Katberg Formation strata (*Trk*) are assigned to the *Lystrosaurus* AZ, which overlies the *Dicynodon* AZ. Vertebrate fossils are primarily found in mudrock sequences between channel sandstones. The *Lystrosaurus* AZ is characterized by an abundance of *Lystrosaurus* in association with *Procolophon* and the absence of *Dicynodon lacerticeps*. Other common genera include *Moschorhinus, Proterosuchus* and *Lydekkerina.* Casts of large burrows have also been described from several localities within this biozone.

The Burgersdorp Formation strata (*Trb*) are assigned to the *Cynognathus* AZ, which overlies the *Lystrosaurus* AZ. The zone is characterized by the presence of *Cynognathus, Diadermodon* and *Kannemeyeria* and the absence of *Lystrosaurus*. Sediments assigned to this zone are well exposed in the Queenstown and Lady Frere districts and have been traced eastward as far as the Engcobo district. Rocks consist of blue-green, pale grayish green, dark red to very dark maroon mudstones that are in many instances more consolidated than those of the underlying *Lystrosaurus* AZ. Fossil-bearing lenticular sandstones with calcareous concretions are common. The fossil record of the *Cynognathus AZ* includes a variety of plants, trace fossils, amphibians, fish reptiles, synapsids, and occasional molluscs. Complete, articulated skeletons are rare, but well preserved therapsids occur in mudrock units as dispersed and isolated specimens. Fragmentary therapsid and amphibian fossils frequently occur in localized scatters or in conglomerates at the base of lenticular sandstones.

The dolerite dykes, sills and inclined sheets dolerite represents no palaeontological impact.

Cretaceous and Quaternary

No fossil have been reported from the Cretaceous Mbotyi conglomerates. The early Cretaceous Mgazana Formation on the other hand, includes a variety of plant fossils (*Cladophlebis, Onychiopsis* and *Nilsonia*) as well as gastropods (*Pseudomelania* and *Natica*), ammonites (*Bochianites* and *Rogersites*), bivalves (*Trigonia, Pecten, Corbula*) and microfossils.

Quaternary palaeontological sites are occasionally found in Pleistocene alluvial terraces and dongas along rivers and streams Quaternary alluvial deposits, especially near water courses and drainage lines, have the potential to yield microfossil and fossil vertebrate remains.

Results

The baseline study involved a foot survey of the surroundings along each pit margin, and the exposures inside each pit. The burrow pits are easily accessible, being directly adjacent to the road. Except for 024 BP01, all the borrow pits are located on Karoo Supergroup rocks and or areas where Karoo Dolerite intrusions occur. Impact on potential palaeontological resources within the footprint is summarized in **Table 3**. No fossils or trace fossils were located near or in the vicinity of the burrow pits during the baseline survey. Unconsolidated Quaternary sediments overlying sedimentary rocks around the burrow pits are made up of thin deposits and are not fossilliferous.

Fourteen borrow pits are exclusively doleritic and therefore not palaeontologically significant (**Fig. 3**). One borrow pit (024 BP01) is located on Natal Group sediments which are not regarded as palaeontologically significant. The geology of the remaining pits consists of known fossil-bearing strata of Carboniferous, Permian and Triassic age, which are considered to be of low to moderate palaeontological significance (**Fig 4**).

The borrow pit margins are covered by scattered superficial deposits of Quaternary age, including valley sediments and alluvium. There is currently no record of Quaternary palaeontological exposures in the vicinity. No Quaternary vertebrate fossils were recorded in geologically recent alluvial valley-sediments recorded un the vicinity the borrow pits.

Impact Statement

There are **no major palaeontological grounds to suspend the use of the borrow pits** but given the nature of fossil distribution in Karoo sedimentary rocks, it is not possible to exactly predict the buried fossil content of an area other than in general terms unless fresh exposures indicate otherwise. Therefore, any developments that may destroy, or damage subsurface fossils are of conservation and research interest. Also, in most cases, sampling of fossils for the purpose of palaeontological mitigation cannot usually be conducted prior to the commencement of excavation activities.

Figure 3. Examples of dolerite exposures. Locality 025 BP 03 (above) and 019 BP 07 (below).

Recommendations

No mitigation is required for borrow pits located within dolerite, Natal, Dwyka and Ecca Group strata. However, monitoring of fresh exposures and bedrock excavations into the

moderately significant fossil-bearing strata of the Adelaide and Tarkastad Subgroups is advised (**Table 4**). Access by a palaeontologist should be facilitated at the appropriate stage during development in order to inspect fresh excavations. It is also advised that newly uncovered objects of palaeontological significance, found during the course of excavation activities, may require a Phase 2 rescue operation at the cost of the developer.

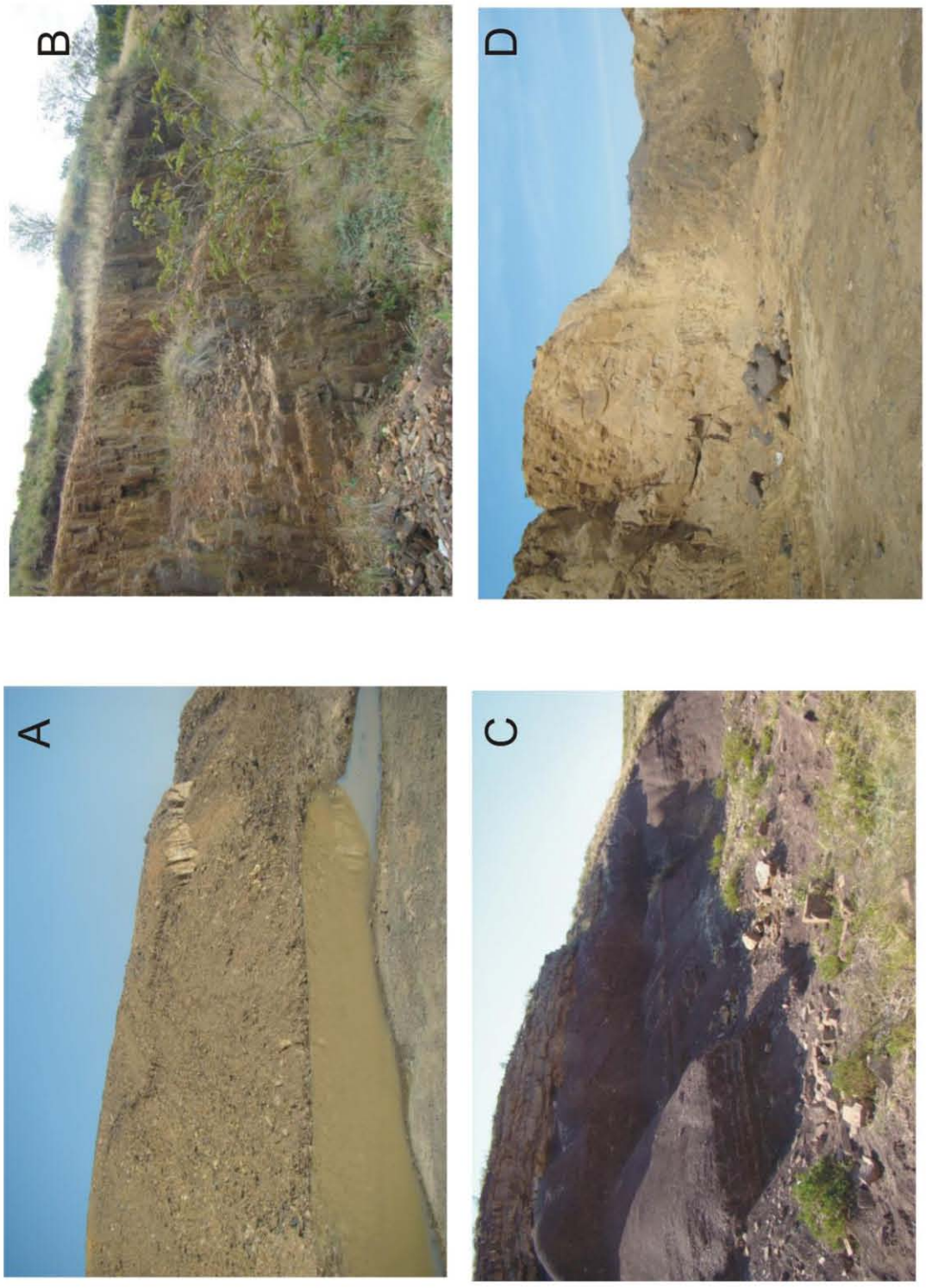

Figure 4. Examples of different types of Karoo Supergroup strata in the footprint. (A) Locality 151 BP 02, Elandsvlei Frm. (Dwyka Group) ; (B) Locality 191 BP 04, Ecca shales; (C) Locality 273 BP 02 Adelaide Subgroup mudrocks; (D) Locality 174 BP 02 Tarkastad Subgroup sandstones and mudrock.

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Table 1. General reference points of the borrow pits.

Road Nr	Borrow Pit	Latitude (I)	Longitude (I)
DR08290	290_BP01	31°43'39.6"" S	28°41'23.7"" E
DR08290	290_BP03	31°48'33.0"" S	28°40'09.5"" E
DR08308	308_BP01	31°43'16.0"" S	29°10'57.2"" E
DR08308	308_BP02	31°45'04.4"" S	29°12'09.8"" E
DR08308	308_BP05	31°48'52.6"" S	29°15'33.1"" E
DR08309	309_BP01	31°49'10.8"" S	29°15'40.5"" E
DR08313	313_BP01	31°43'48.0"" S	28°57'52.0"" E
DR08313	313_BP02	31°43'54.0"" S	28°57'44.0"" E
DR08313	313_BP04	31°51'18.0"" S	29°06'56.0"" E
DR18030	030_BP01	31°40'46.2"" S	29°02'13.3"" E
DR18030	030_BP02	31°40'46.8"" S	29°02'10.8"" E
DR18030	030_BP03	31°40'42.8"" S	29°02'03.1"" E
DR18030	030_BP04	31°42'29.3"" S	29°01'40.8"" E
DR18030	030_BP05	31°46'43.5"" S	29°09'33.4"" E
DR18030	030_BP06	31°48'02.2"" S	29°10'13.1"" E
DR18033	18033_BP01	31°51'50.3"" S	28°36'15.6"" E
DR18033	18033_BP02	31°58'39.2"" S	28°39'48.2"" E
DR18033	18033_BP08	32°11'56.1"" S	28°52'24.2"" E
DR08019	019_BP02	31°08'06.4"" S	29°26'08.7"" E
DR08019	019_BP03	31°08'04.7"" S	29°25'47.0"" E
DR08019	019_BP04	31°06'11.7"" S	29°23'50.0"" E
DR08019	019_BP05	31°06'22.4"" S	29°23'42.6"" E

DR08019	019_BP07	31°01'32.8"" S	29°19'26.7"" E
DR08024	024_BP01	31°20'30.7"" S	29°44'45.2"" E
DR08025	025_BP01	31°18'57.4"" S	29°33'49.9"" E
DR08025	025_BP02	31°14'51.5"" S	29°35'35.5"" E
DR08025	025_BP03	31°14'18.1"" S	29°35'43.3"" E
DR08025	025_BP04	31°12'31.1"" S	29°35'59.1"" E
DR08029	029_BP01	31°41'06.7"" S	29°22'55.2"" E
DR08033	033_BP02	31°44'57.9"" S	28°30'15.5"" E
DR08033	033_BP03	31°44'55.5"" S	28°29'59.2"" E
DR08033	033_BP04	31°42'25.8"" S	28°25'01.9"" E
DR08120	120_BP01	31°03'16.7"" S	29°45'24.6"" E
DR08120	120_BP02	31°10'12.9"" S	29°43'43.1"" E
DR08123	123_BP01	30°58'38.3"" S	29°40'23.4"" E
DR08124	124_BP01	30°57'36.5"" S	29°33'39.7"" E
DR08131	131_BP01	30°59'41.9"" S	28°44'06.3"" E
DR08151	151_BP01	31°27'06.5"" S	29°32'23.7"" E
DR08151	151_BP02	31°27'46.2"" S	29°33'28.7"" E
DR08151	151_BP03	31°29'56.9"" S	29°37'38.6"" E
DR08151	151_BP04	31°31'16.9"" S	29°39'45.9"" E
DR08153	153_BP02	31°17'16.9"" S	29°20'13.6"" E
DR08156	156_BP02	31°19'24.1"" S	29°23'06.4"" E
DR08157	157_BP01	31°25'08.7"" S	29°22'53.9"" E
DR08174	174_BP01	31°28'18.1"" S	28°53'04.3"" E
DR08174	174_BP02	31°28'14.6"" S	28°53'07.1"" E
DR08191	191_BP01	31°36'11.5"" S	29°26'18.4"" E

DR08191	191_BP04	31°32'51.0"" S	29°22'19.0"" E
DR08191	191_BP06	31°32'28.0"" S	29°21'00.0"" E
DR08212	212_BP01	31°32'37.5"" S	28°46'21.2"" E
DR08212	212_BP02	31°30'24.8"" S	28°45'29.7"" E
DR08212	212_BP03	31°28'10.3"" S	28°45'32.9"" E
DR08273	273_BP02	31°48'20.6"" S	28°17'58.6"" E
DR08275	275_BP02	31°47'55.6"" S	28°25'50.2"" E

Table 2. Potential fossil heritage within geological units affected by the proposed development.

Geological Unit		**Predominant rock types and Age**	**Previously recorded fossil heritage**
	Alluvium Colluvium	Late Cenozoic to Recent	Large mammal bones, horn cores and dentition, coprolites, pollen, phytoliths, terrestrial gastropods (Florisian LMA)
Beaufort Group	Tarkastad Subgroup Burgersdorp Frm. (*Trb*)	Fluvial and lacustrine mudstones and sandstones. Early Triassic	*Cistecephalus* Assemblage Zone
	Katberg Frm. (*Trk*)	Fluvial and lacustrine mudstones and sandstones. Early Triassic	*Lystrosaurus* Assemblage Zone
	Adelaide Subgroup Balfour Frm. (*Pa*)	Fluvial and lacustrine mudstones and sandstones. Late Permian	*Lystrosaurus* Assemblage Zone *Dicynodon* Assemblage Zone
Ecca Group (*Pe*)		Marine shales and sandstones; Permian	Mesosaurid reptiles, crustaceans, palaeoniscoid fish, rare ichnofossils plants, sponge spicules, insect wings
Dwyka Group	Elandsvlei Frm. (*Pd*)	Glacial tillites; diamictites; subordinate	Spores, acritarchs, arthropod trackways, plants

		mudstones and sandstones; Carboniferous	
Natal Group (S?)		Feldspathic sandstone and mudstone conglomerates; Ordovician / Silurian	Poor; no diagnostic fossils

Table 3. Assessment of impacts. Strata impacted by the development include the Natal Group (S?), Dwyka Group Elandsvlei Frm. (Pd), Ecca Group (Pe); Beaufort Group: Adelaide Subgroup (Pa) Tarkastad Subgroup (Trt), including the Katberg Frm. (Trk) and the Burgersdorp Frm. (Trb). Jurassic dolerites are designated (Jd).

Borrow Pit	**Rock type**	**Potential impact / significance**	**Irreplaceable loss of palaeontological resources?**	**Mitigation required and measures**
290_BP01	*Jd*	none	no	no
290_BP03	*Jd*	none	no	no
308_BP01	*Pe*	low	no	no
308_BP02	*Pe*	low	no	no
308_BP05	*Jd*	none	no	no
309_BP01	*Pa*	moderate	no	monitoring of fresh exposures and bedrock excavations
313_BP01	*Jd, Pa*	low	no	no
313_BP02	*Jd*	none	no	no
313_BP04	*Pe*	low	no	no
030_BP01	*Pa*	moderate	no	monitoring of fresh exposures and bedrock excavations
030_BP02	*Pa*	moderate	no	monitoring of fresh exposures and bedrock excavations

030_BP03	*Pa*	moderate	no	monitoring of fresh exposures and bedrock excavations
030_BP04	*Pa*	moderate	no	monitoring of fresh exposures and bedrock excavations
030_BP05	*Pe*	low	no	no
030_BP06	*Pe*	low	no	no
18033_BP01	*Jd, Trk*	low	no	no
18033_BP02	*Pa*	moderate	no	monitoring of fresh exposures and bedrock excavations
18033_BP08	*Pa*	moderate	no	monitoring of fresh exposures and bedrock excavations
019_BP02	*Pe*	low	no	no
019_BP03	*Pe*	low	no	no
019_BP04	*Jd*	none	no	no
019_BP05	*Jd, Pe*	low	no	no
019_BP07	*Jd*	none	no	no
024_BP01	*S?*	low	no	no
025_BP01	*Pe*	low	no	no
025_BP02	*Pe*	low	no	no
025_BP03	*Jd*	none	no	no

025_BP04	*Pe*	low	no	no
029_BP01	*Pa, Trk*	moderate	no	monitoring of fresh exposures and bedrock excavations
033_BP02	*undiff. Trt*	moderate	no	monitoring of fresh exposures and bedrock excavations
033_BP03	*undiff. Trt*	moderate	no	monitoring of fresh exposures and bedrock excavations
033_BP04	*Jd*	none	no	no
120_BP01	*undiff. Trt*	moderate	no	monitoring of fresh exposures and bedrock excavations
120_BP02	*Pe*	low	no	no
123_BP01	*Pe*	low	no	no
124_BP01	*Pe*	low	no	no
131_BP01	*Jd, undiff.Trt*	low	no	monitoring of fresh exposures and bedrock excavations
151_BP01	*Jd*	none	no	no
151_BP02	*Pd*	low	no	no
151_BP03	*Jd, Pd*	low	no	no

151_BP04	*Pe*	low	no	no
153_BP02	*Pa*	moderate	no	monitoring of fresh exposures and bedrock excavations
156_BP02	*Pa*	moderate	no	monitoring of fresh exposures and bedrock excavations
157_BP01	*Pe*	low	no	no
174_BP01	*Trk*	moderate	no	monitoring of fresh exposures and bedrock excavations
174_BP02	*Jd, Trk*	low	no	no
191_BP01	*Jd*	none	no	no
191_BP04	*Pe*	low	no	no
191_BP06	*Jd*	none	no	no
212_BP01	*Jd*	none	no	no
212_BP02	*Jd*	none	no	no
212_BP03	*Jd*	none	no	no
273_BP02	*Trk*	moderate	no	monitoring of fresh exposures and bedrock excavations
275_BP02	*Trk*	moderate	no	monitoring of fresh exposures and bedrock

				excavations

Table 4. Borrow Pits recommended for ongoing palaeontological monitoring.

Borrow Pit	Rock type
309_BP01	Pa
030_BP01	Pa
030_BP02	Pa
030_BP03	Pa
030_BP04	Pa
18033_BP02	Pa
18033_BP08	Pa
029_BP01	Pa, Trk
033_BP02	undiff. Trt
033_BP03	undiff. Trt
120_BP01	undiff. Trt
153_BP02	Pa
156_BP02	Pa
174_BP01	Trk
273_BP02	Trk
275_BP02	Trk

Appendix 1: Geological map localities of borrow pits

Plate 1. Portion of the 250 000 scale geological map 3128 Umtata showing locality of Borrow Pits surveyed in the Umtata region.

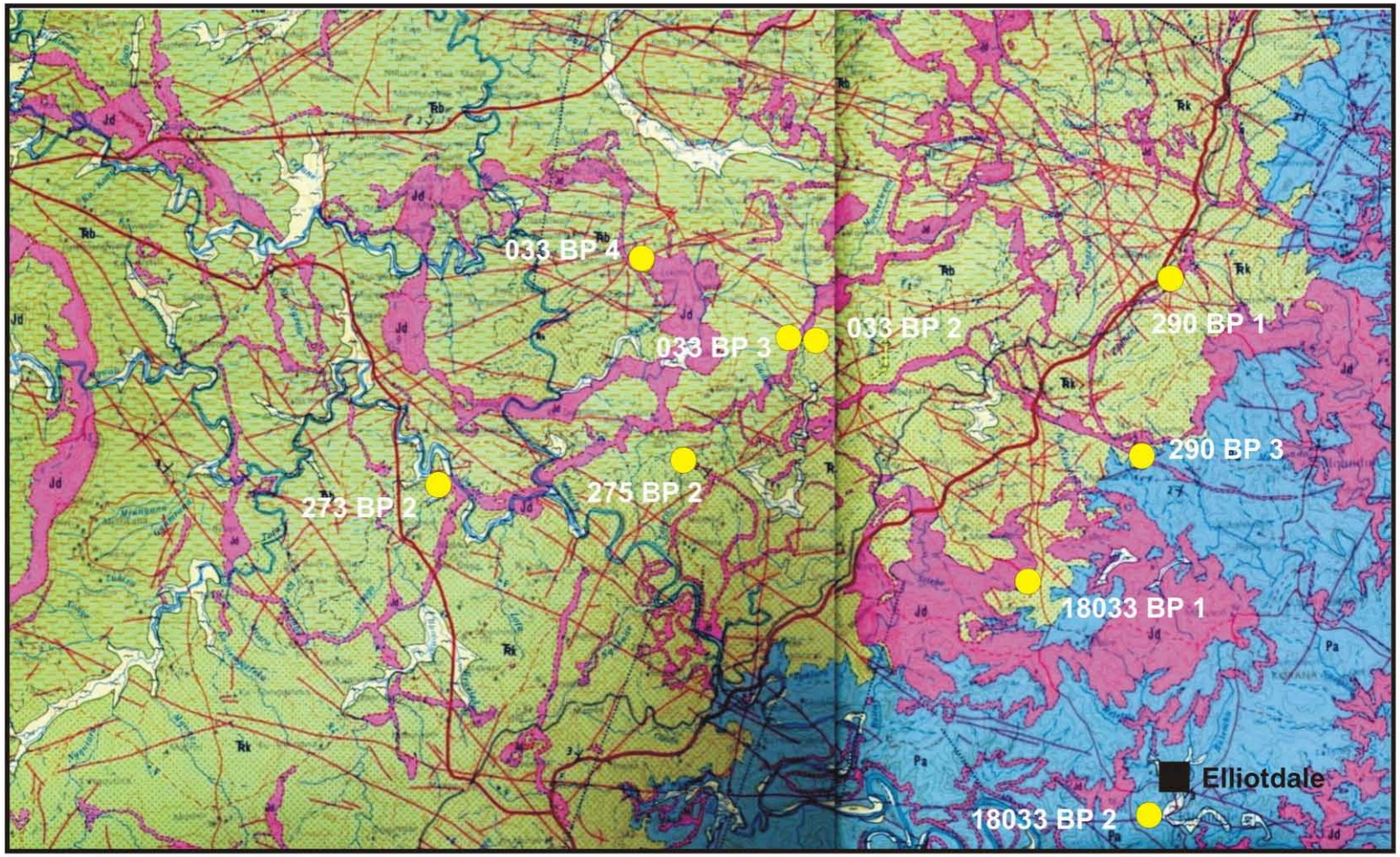

Plate 2. Portion of the 250 000 scale geological map 3128 Umtata showing the locality of Borrow Pits surveyed around Elliotdale.

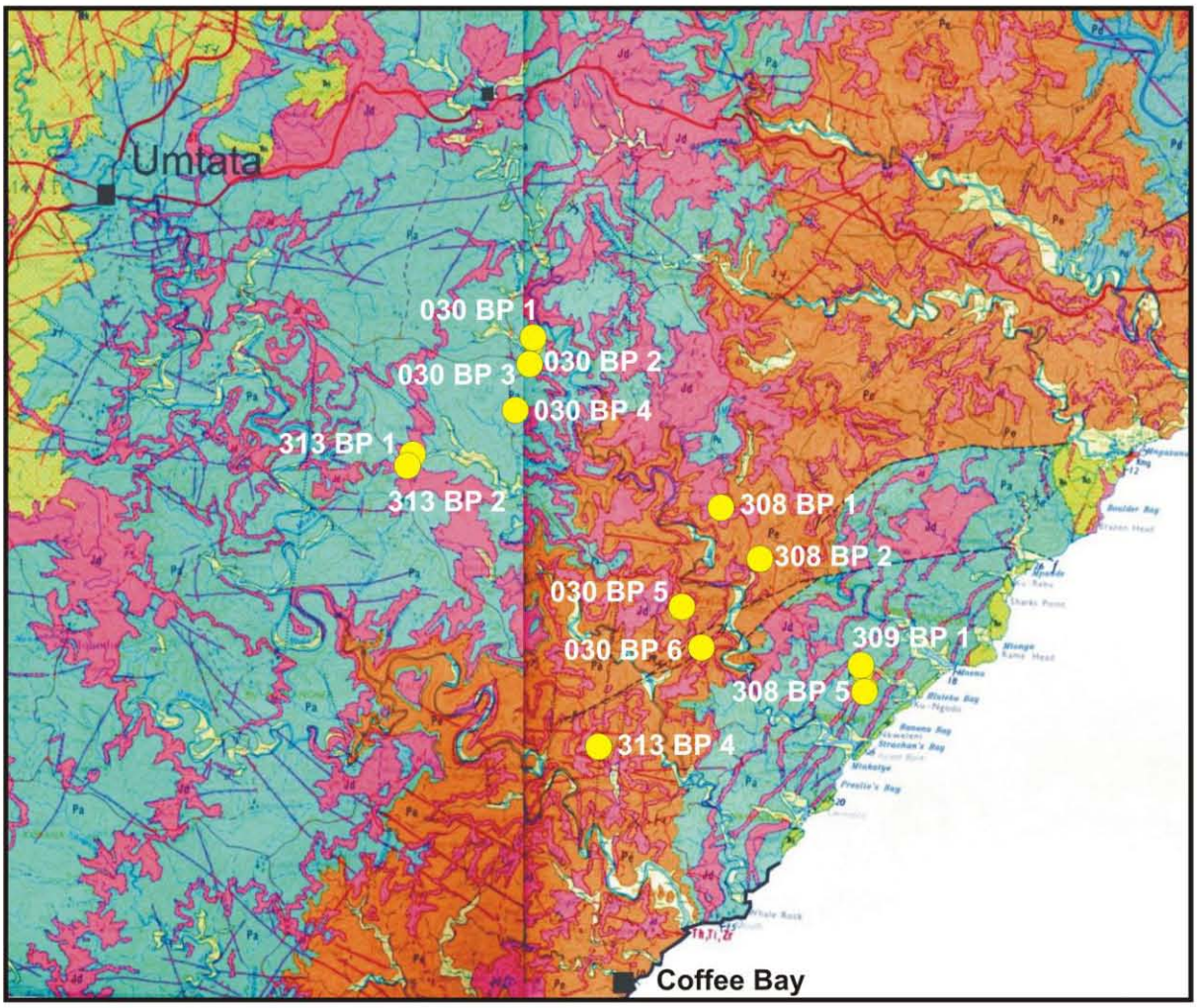

Plate 3. Portion of the 250 000 scale geological map 3128 Umtata showing the locality of Borrow Pits surveyed around Coffee Bay.

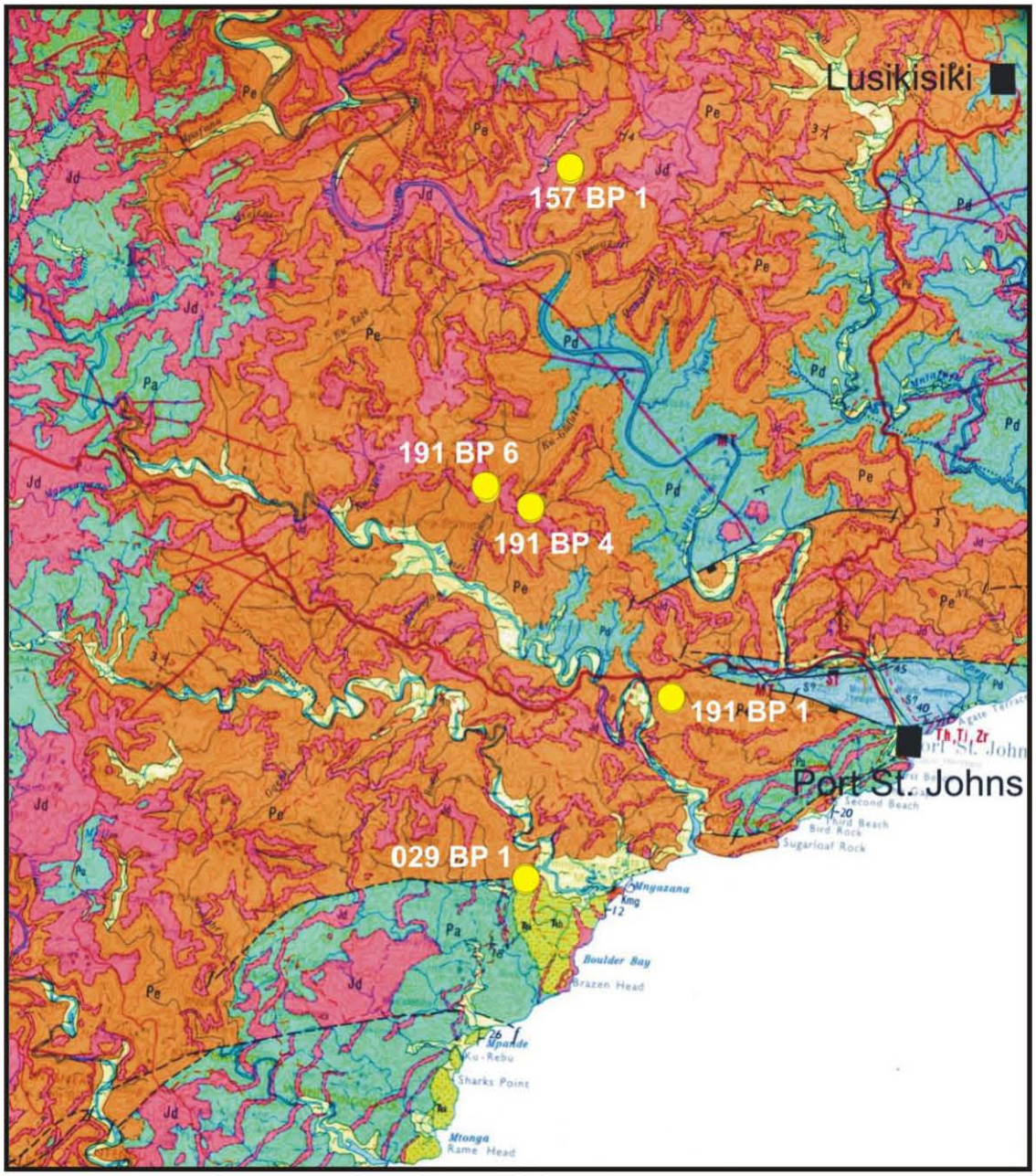

Plate 4. Portion of the 250 000 scale geological map 3128 Umtata showing the locality of Borrow Pits surveyed around Port St. Johns.

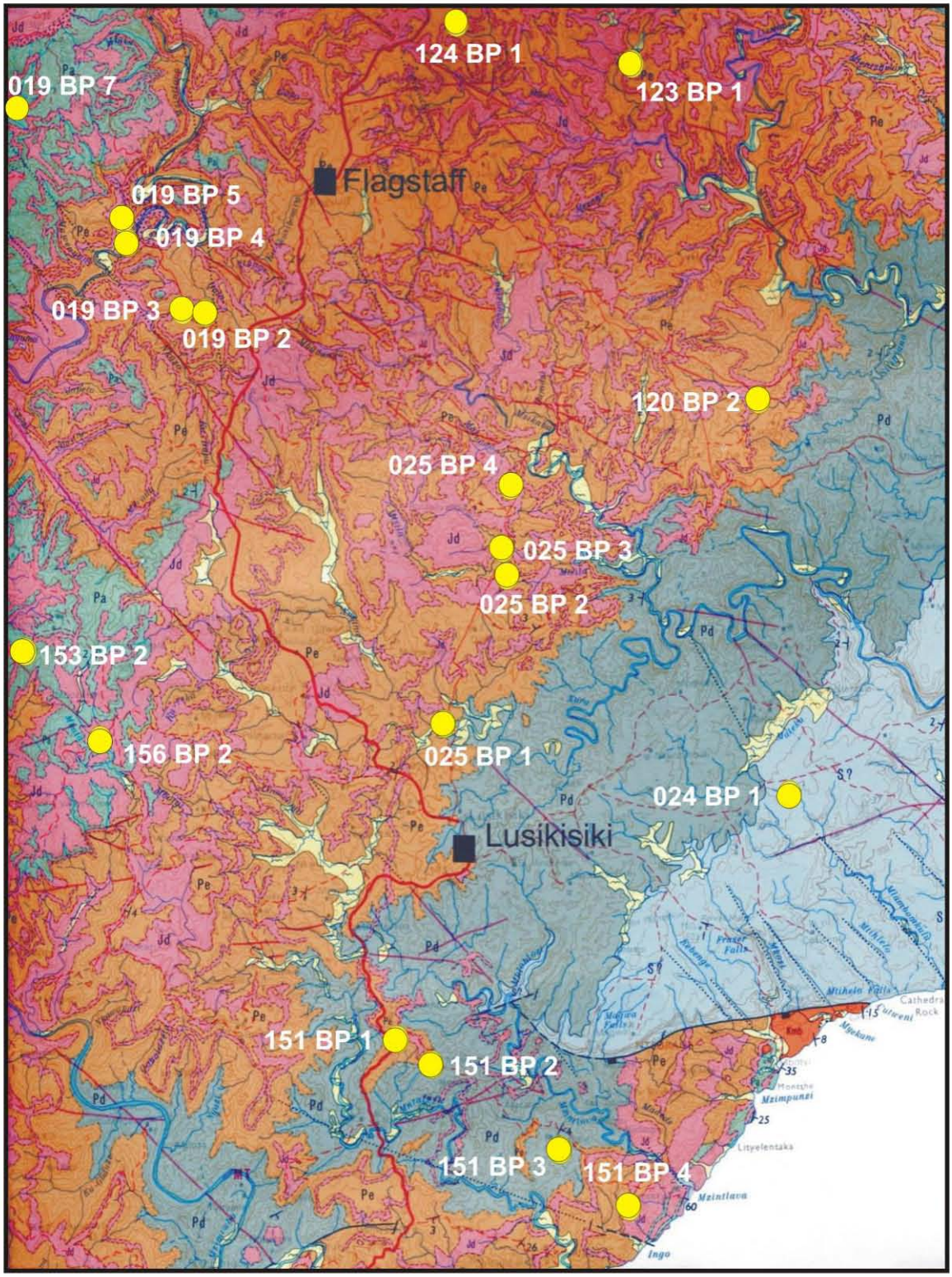

Plate 5. Portion of the 250 000 scale geological map 3128 Umtata showing the locality of Borrow Pits surveyed around Lusikisiki and Flafstaff.

Appendix 2. Photographic record of Borrow Pits

DR 08019

019_BP02	Pe	
019_BP03	Pe	
019_BP04	Jd	
019_BP05	Jd, Pe	
019_BP07	Jd	

DR 08024 - 25

024_BP01	S?	
025_BP01	Pe	
025_BP02	Pe	
025_BP03	Jd	
025_BP04	Pe	

DR 08029
DR 18030

029_BP01	Pa, Trk	
030_BP01	Pa	
030_BP02	Pa	
030_BP03	Pa	
030_BP04	Pa	
030_BP05	Pe	
030_BP06	Pe	

DR 08033

033_BP02	undiff. Trt
033_BP03	undiff. Trt
033_BP04	Jd

DR 08120 - 31

120_BP01	undiff. Trt
120_BP02	Pe
123_BP01	Pe
124_BP01	Pe
131_BP01	Jd, undiff.Trt

DR 08151

151_BP01	Jd	
151_BP02	Pd	
151_BP03	Jd, Pd	
151_BP04	Pe	

DR 08153 - 157

153_BP02	Pa
156_BP02	Pa
157_BP01	Pe

DR 08174

174_BP01	Trk
174_BP02	Jd, Trk

DR 08191

191_BP01	Jd	
191_BP04	Pe	
191_BP06	Jd	

DR 08212

212_BP01	Jd
212_BP02	Jd
212_BP03	Jd

DR 08273 - 275

273_BP02	Trk	
275_BP02	Trk	

DR 08290

290_BP01	Jd	
290_BP03	Jd	

DR 08308 - 309

308_BP01	Pe	
308_BP02	Pe	
308_BP05	Jd	
309_BP01	Pa	

DR 08313

313_BP01	Jd, Pa
313_BP02	Jd
313_BP04	Pe

DR 18033

18033_BP01	Jd, Trk
18033_BP02	Pa
18033_BP08	Pa