

**Phase 1 Palaeontological Impact Assessment for the
proposed Tetra 4 Cluster 1 Gas Production Project
near Virginia, Free State Province.**

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Summary

Tetra4 (formerly known as Molopo South Africa Exploration and Production) (Pty) Ltd) has lodged an application for Environmental Authorisation (EA) to the Petroleum Agency of South Africa to extend natural gas production operations within an existing Production Right covering 13671 ha in the Matjhabeng and Masilonyana Local Municipalities, near the town of Virginia Free State Province. Proposed well sites are underlain by palaeontologically significant Adelaide Subgroup rocks and well-developed superficial overburden (farmland) considered to be of very low palaeontological significance. The palaeontologically sensitive Adelaide Subgroup and underlying Ecca Group Volksrust Formation will be impacted by the exploration and well drilling process but given the average diameter of the proposed boreholes, impact on potential fossil material is considered moderate to low if it is assumed that fossil remains are not uniformly distributed in fossil-bearing rock units. For associated infrastructure, any excavation exceeding a depth of 1m into unweathered sedimentary bedrock will require monitoring by a palaeontologist during the construction phase of the well sites. All proposed pipeline route options are underlain by palaeontologically significant Adelaide Subgroup rocks and well-developed superficial overburden (farmland) considered to be of very low palaeontological significance. Two areas have been identified where a pipeline route will traverse potentially sensitive alluvial deposits ranging in thicknesses between 4 m and 15 m at the Bosluispruit and the Sand River . Any excavation exceeding a depth of 1m into these overbank deposits will require monitoring by a palaeontologist during the construction phase of the pipelines. Both site options for the Combined helium and CNG gas conditioning plant are underlain by palaeontologically significant Adelaide Subgroup rocks capped by well-developed superficial overburden considered to be of very low palaeontological significance. Any excavation exceeding a depth of 1m into unweathered sedimentary bedrock will require monitoring by a palaeontologist during the construction phase. The palaeontologist must apply for a valid permit from SAHRA for the collection / removal of fossils at each of the sites relevant to the project.

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Introduction

Tetra4 (formerly known as Molopo South Africa Exploration and Production) (Pty) Ltd) has lodged an application for Environmental Authorisation (EA) to the Petroleum Agency of South Africa to extend natural gas production operations within an existing Production Right covering 13671 ha in the Matjhabeng and Masilonyana Local Municipalities, near the town of Virginia Free State Province.

The proposed Cluster 1 gas field production method to be employed entails the following:

- Exploration drilling;
- Production well site connection made up of gas wells with well heads (13 existing and 6 new gas wells);
- Inline booster compressors (compressor at each well pipeline option) or reciprocating infield compressors (pipeline with centralised compressors pipeline option); and
- Combined helium and CNG gas conditioning plant.
- Pipeline routes including four new alternatives in addition to the originally proposed route

Legislation

The assessment 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 (NHRA) 25 of 1999. The region's unique and non-renewable palaeontological heritage sites are 'Generally' protected in terms of the National Heritage Resources Act (Act No 25 of 1999, section 35) and may not be disturbed at all without a permit from the relevant heritage resources authority. As many such heritage sites are threatened daily by development, both the environmental and heritage legislation require impact assessment reports that identify all heritage resources including palaeontological sites in the area to be developed, and that make recommendations for protection or mitigation of the impact of the sites.

The NHRA identifies what is defined as a heritage resource, the criteria for establishing its significance and lists specific activities for which a heritage specialist

study may be required. In this regard, categories of development listed in Section 38 (1) of the NHR Act are:

- The construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300m in length;
- The construction of a bridge or similar structure exceeding 50m in length;
- Any development or other activity which will change the character of the site
 - a) exceeding 5000 m² in extent; or
 - b) involving three or more existing erven or subdivisions thereof; or
 - c) involving three or more subdivisions thereof which have been consolidated within the past five years;
- The rezoning of a site exceeding 10 000 m²; or
- Any other category of development provided for in regulations by the South African Heritage Resources Agency (SAHRA).

Terms of Reference

- Identify and map possible heritage sites and occurrences using available resources.
- Determine and assess the potential impacts of the proposed development on potential heritage resources;
- Recommend mitigation measures to minimize potential impacts associated with the proposed development.

Methodology

The palaeontological significance of the affected area was evaluated on the basis of existing field data, database information and published literature. Relevant publications, aerial photographs (incl. Google Earth) and site records were consulted and integrated with data acquired during the on-site inspection. This was followed by a field assessment by means of a pedestrian survey. A Garmin Etrex Vista GPS hand model (set to the WGS 84 map datum) and a digital camera were used for recording purposes.

Locality data

Site Information

1: 250 000 scale geological map 2826 Winburg

The study area referred to as Cluster 1 is located approximately 20 km south west of the town of Virginia, within the Matjhabeng and Masilonyana Local Municipalities, in the Free State Province (**Fig. 1**). The footprint is approximately 13 671 ha in extent and covers 58 farms.

Background

According to the SAHRIS palaeo-sensitivity map the study area is located within an area considered to be of high to moderate palaeontological sensitivity. The geology underlying the footprint area is underlain by Karoo Supergroup rocks (see 1: 250 000 geological map 2826 Winburg, Council for Geoscience, Pretoria, **Fig. 2**) (Nolte 1995). These sedimentary rocks form the base on which younger, superficial deposits of late Cenozoic age (*Qs*) has been deposited (**Fig. 2**). Dykes and sills of resistant Jurassic dolerites (*Jd*) largely determine landscape topography as indicated by the distinctive koppies and flat-topped inselbergs in the region.

From oldest to youngest, the deposits of the Karoo Supergroup in the region are assigned to Upper Ecca and Lower Beaufort Group rocks, respectively represented by the Middle Permian Volksrust Formation (*Pvo*) and the overlying Late Permian Adelaide Subgroup (*Pa*). The predominantly argillaceous Volksrust Formation consists of a monotonous sequence of grey marine shales with thin, bioturbated, siltstone and sandstone lenses, exposed towards the northwest of the study area. It represents a transgressive sequence consisting largely of mud deposited from suspension when large, swampy deltas were formed after Gondwana started to drift from the Antarctic region and rivers flowing into the inland Karoo Sea, deposited huge amounts of sediment along its shorelines consisting of alternating sandstone and mudstone layers. It consists of a monotonous sequence of grey shale and fossils are significant, but rarely recorded. Fossils include rare temnospondyl amphibian remains, invertebrates, minor coals with plant remains, petrified wood, and low-diversity marine to non-marine trace fossil assemblages.

The Volksrust Formation interfingers with an overlying sequence of Adelaide Subgroup sandstone and mudrock towards the east of the study area. The Adelaide Subgroup contains some of the richest Permo-Triassic tetrapod fauna from Pangaea/Gondwana and provides key evidence for evolution of mammalian characteristics among therapsids. The rocks in this outcrop area are assigned to one of eight different biostratigraphic units or assemblage zones (Rubidge 1995), namely the *Dicynodon* Assemblage Zone, recently revised (Kitching 1995; Van der Walt *et al.* 2010; Viglietti *et al.* 2016). The sediments assigned to this AZ are associated with stream deposits consisting of floodplain mudstones and subordinate, lenticular channel sandstones (McCarthy and Rubidge, 2005; Johnson *et al.*, 2006). The biozone is characterized by the presence of a distinctive and fairly common dicynodont genus. Dicynodonts are well-known herbivorous therapsids from the Karoo Basin with at least 35 dicynodont genera recorded in the Beaufort Group. Therapsids from this biozone occur generally well-preserved in mudrock horizons and are usually found as dispersed and isolated specimens associated with an abundance of calcareous nodules. Other vertebrate fossils include fish, amphibians and amniotes. Molluscs, insects, plant (*Dadoxylon*, *Glossopteris*) and trace fossils (arthropod trails, worm burrows) also occur.

Another palaeontologically significant sequence in the region is represented by late Cenozoic (Plio-Pleistocene) floodplain deposits (overbank sediments) associated with the Sand, Doring Vals and Vet River systems as well as pan sites, which contain localized but abundant mammal vertebrate fossil localities. The discovery of *in situ* proboscidian fossil material, consisting of a lower molar, the proximal half of an ulna and a large part of a tusk from fine to pebbly channel-fill sediments 40 meters above the current riverbed of the Sand River near Virginia, has highlighted the potential antiquity of the floodplain deposits flanking the river (**Fig. 3 no. 1**). Originally described as *Archidiskodon scotti* (Meiring 1955) the proboscidean fossil material was subsequently assigned to the Pliocene species *Mammuthus subplanifrons* (Coppens *et al.* 1978). Subsequent investigations at the site yielded a diverse fauna that include fish, amphibians, reptiles, birds and an array of proboscideans, perissodactyls and artiodactyls (De Ruiter 2010; pers. obs.) (**Fig. 3 no. 2**). Pliocene fossil occurrences have also been identified in terrace gravels above the Vet River southwest of Welkom (pers. obs.) (**Fig. 3 no. 3**). More recent exploratory surveys along the Doring, Sand, Vals and Vet Rivers indicate moderately fossiliferous overbank sediments and

erosional gullies that frequently contain fossil remains of a variety of Quaternary-aged mammals (Brink et al. 1999; De Ruiter et al. 2011; pers. obs.) (**Fig. 3 nos. 4 – 10**) Ancient pan sites in the region, such as the one near Whites have equally produced abundant Quaternary-aged mammal fossil remains (pers. obs.) (**Fig. 3 no. 11**).

Field Assessment

The 13 existing and 6 new well sites are underlain by Adelaide Subgroup rocks capped by well-developed superficial overburden (wind-blown sand, residual soils) that are currently being used for agricultural purposes (**Fig. 4**). All the pipeline route options and associated infrastructure are underlain by Adelaide Subgroup rocks that are capped by well-developed superficial sediments made up of wind-blown sand and residual soils as well as late Quaternary alluvial floodplain deposits associated with the Sand and Doring Rivers. Both site options for the Combined helium and CNG gas conditioning plant are underlain by Adelaide Subgroup rocks, capped by well-developed superficial overburden.

Impact Statement and Recommendation

Some of the most significant fossil-bearing rocks in the study are associated with Permian deposits of the Karoo Supergroup, in this case represented by the Ecca Group Volksrust Formation and the lower Adelaide Subgroup of the Beaufort Group. These deposits are allocated a moderate to very high palaeontological significance respectively and represent one of the richest assemblages of vertebrate, invertebrate and plant fossils in the world. Other palaeontologically significant sediments include late Quaternary floodplain deposits associated with the Sand and Doring Rivers.

The well sites are underlain by palaeontologically significant Adelaide Subgroup rocks and well-developed superficial overburden (farmland) considered to be of very low palaeontological significance. The palaeontologically sensitive Adelaide Subgroup and underlying Ecca Group Volksrust Formation will be impacted by the exploration and well drilling process but given the average diameter of the proposed boreholes, impact on potential fossil material is considered moderate to low if it is assumed that fossil remains are not uniformly distributed in fossil-bearing rock units. For associated infrastructure, any excavation exceeding a depth of 1m into unweathered sedimentary bedrock will require monitoring by a palaeontologist during the construction phase of the well sites. The palaeontologist must apply for a valid permit

from SAHRA for the collection / removal of fossils at each of the sites relevant to the project.

All the pipeline route options are underlain by palaeontologically significant Adelaide Subgroup rocks and well-developed superficial overburden (farmland) considered to be of very low palaeontological significance. Areas associated with late Quaternary alluvial deposits (erosional gullies flanking river crossings) were investigated but no aboveground evidence of Quaternary fossil remains were found. Two areas have been identified where a pipeline route will traverse potentially sensitive alluvial deposits ranging in thicknesses between 4 m and 15 m at the Bosluispruit (GPS coordinates 28°11'4.46"S 26°43'54.24"E) (**Fig. 5 & 6**) and the Sand River (GPS coordinates 28°7'4.33"S 26°43'9.88"E) (**Fig. 7-9**). Any excavation exceeding a depth of 1m into these overbank deposits will require monitoring by a palaeontologist during the construction phase of the pipelines. The palaeontologist must apply for a valid permit from SAHRA for the collection / removal of fossils at each of the sites relevant to the project.

Both site options for the Combined helium and CNG gas conditioning plant are underlain by palaeontologically significant Adelaide Subgroup rocks capped by well-developed superficial overburden considered to be of very low palaeontological significance. Any excavation exceeding a depth of 1m into unweathered sedimentary bedrock will require monitoring by a palaeontologist during the construction phase. The palaeontologist must apply for a valid permit from SAHRA for the collection / removal of fossils at each of the sites relevant to the project.

As for the author's personal view with regards to the potential impact of drilling on groundwater aquifers, the following recommendations are offered for consideration:

- It is necessary to provide a clear explanation of the drilling procedures and the methods that will be used to prevent hydrocarbons and associated gas from the Ecca and Beaufort Groups from entering these linear aquifers and polluting them or to avoid the creation of conduits through which deep-seated groundwater could migrate to shallow aquifers. The information must be disseminated to the South African heritage community as well as to all affected communities going forward in reviewing the EIA process.
- The applicant should appoint a suitably qualified groundwater specialist to establish beforehand that groundwater aquifers will not be negatively affected before the construction phase of the project commences.

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Figures

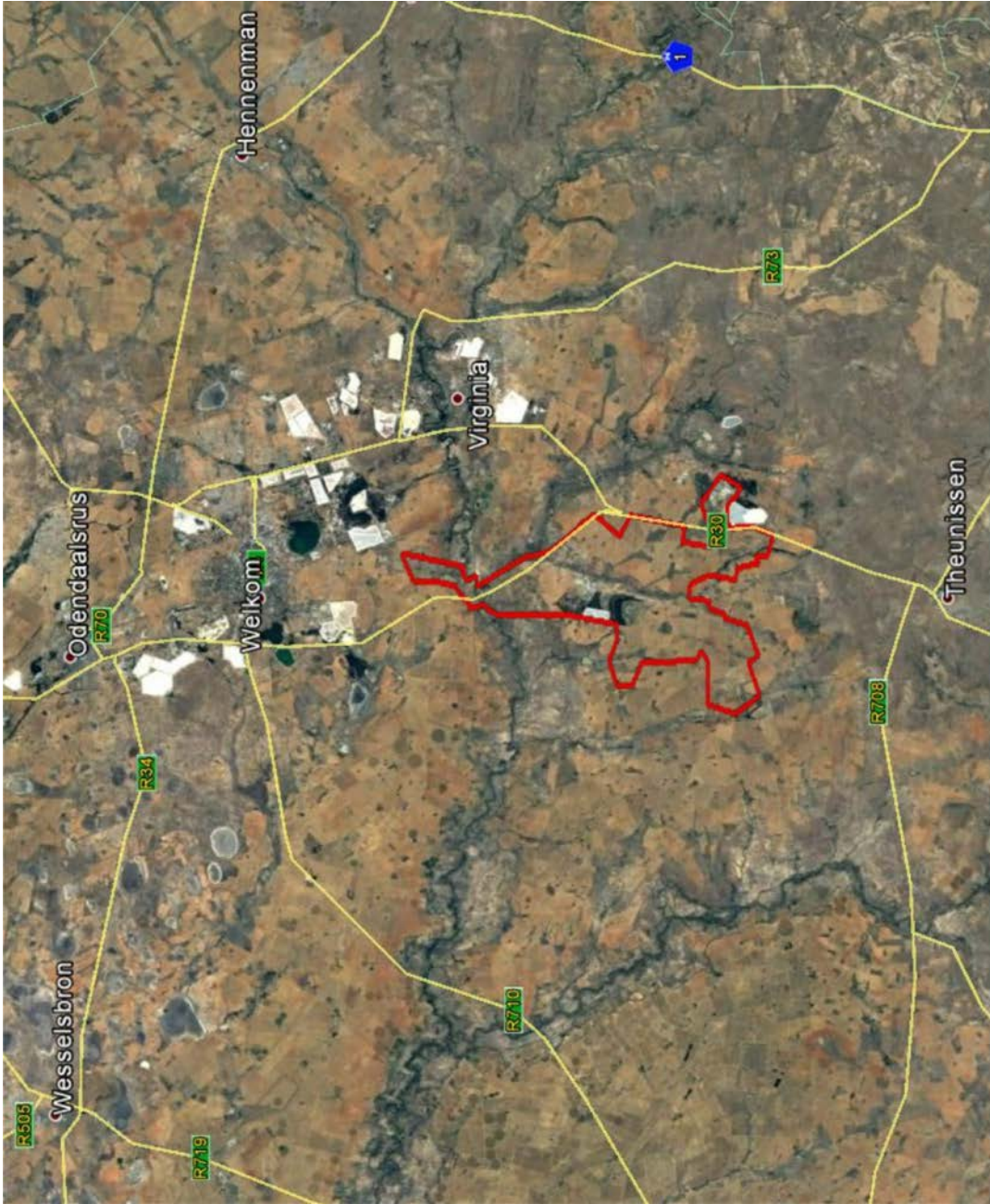


Figure 1. Aerial view of the Cluster 1 study area in relation to the location of Virginia.

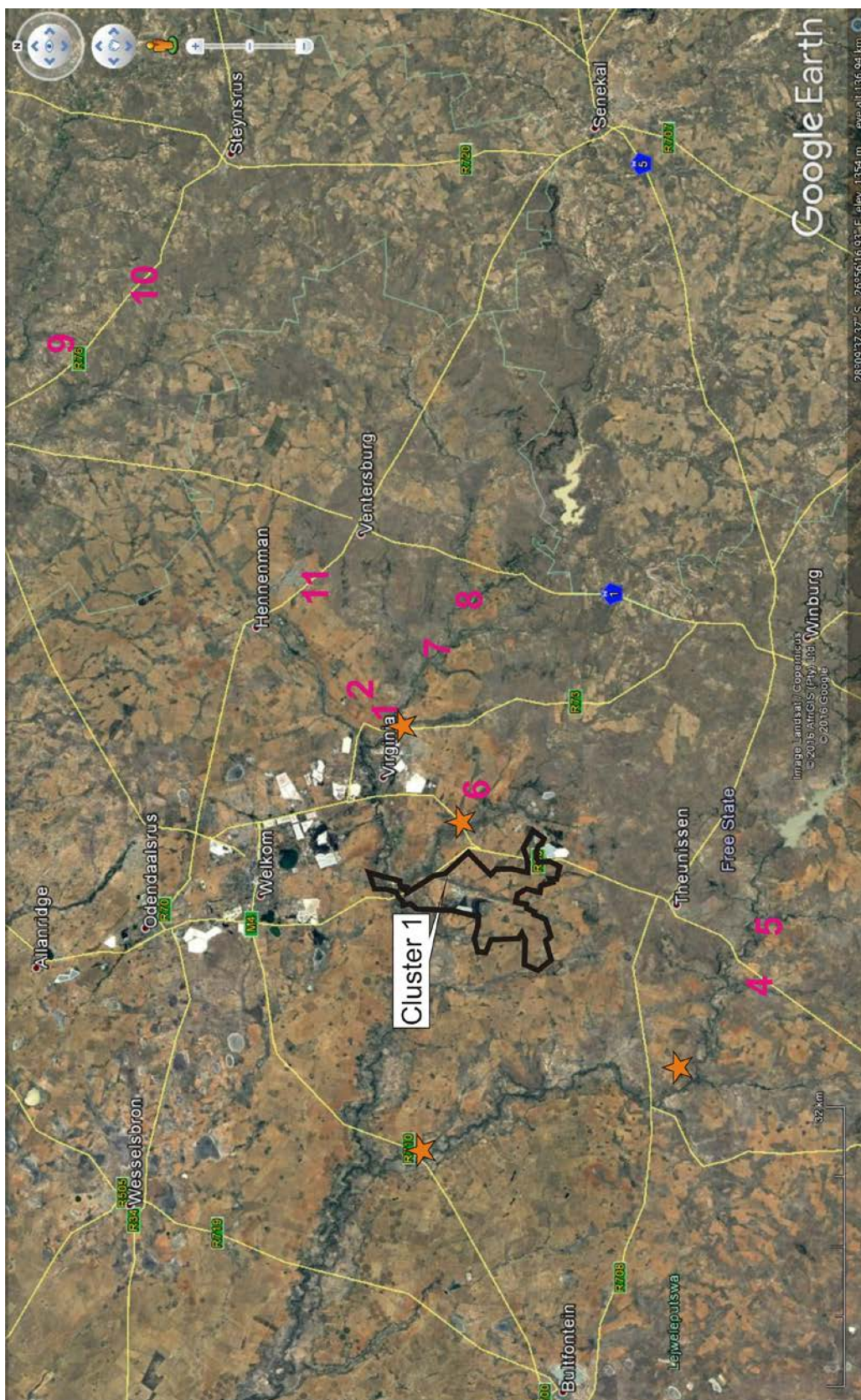


Figure 3. General map of late Cenozoic palaeontological localities in the region. Highly sensitive alluvial (floodplain) sediments and associated overbank deposits are indicated by stars.



Figure 4. The well sites are primarily located on farmland are currently being used for agricultural purposes.



Figure 5. General view of the palaeontologically sensitive overbank sediments of the Bosluisspruit at GPS coordinates 28° 11'4.46"S 26°43'54.24"E.



Figure 6. Aerial view of the potential fossil locality on the Bosluisspruit.



Figure 7. General view of the palaeontologically sensitive overbank sediments underlying the pipeline route across the Sand River (southern bank), looking east towards the Doring River confluence.



Figure 8. Well-developed floodplain deposits, looking south towards the Sand River (northern bank, top). Palaeontologically sensitive alluvium exposed by erosional gullies (dongas) along the northern bank, immediately east of the proposed pipeline route across the river.



Figure 9. Aerial view of the potential fossil locality on the Sand River.