PALAEONTOLOGICAL STUDY OF

THE RYSTKUIL CHANNEL

Prepared by

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1. Introduction

Fossil discoveries from South Africa have greatly expanded knowledge of the development of life on Earth. In particular, the enormous palaeontological wealth of the Karoo Supergroup, covering a period of almost 100 million years from the Permian to the Jurassic, has enhanced understanding of the evolution of important tetrapod lineages, including mammals and dinosaurs (Rubidge, 1995b; Rubidge and Sidor, 2001; Yates and Kitching, 2003), and has made an invaluable contribution to studies of Permian and Triassic Gondwanan floras (Plumstead, 1972; Lacey et al., 1975; Anderson and Anderson, 1985; Bamford, 1999; Gastaldo et al., 2005). These fossils provide the best record of continental Permian to Jurassic faunal biodiversity. Recent research has demonstrated the importance of Karoo fossils for global stratigraphic correlation and for the conceptualization of basin development models (Catuneanu et al., 1998; Rubidge, 2005).

Three-fifths of the surface area of South Africa is covered by rocks of the Karoo basin, and because of the relatively high topography of South Africa coupled with the relatively arid environment this rock succession has yielded a rich fossil flora and tetrapod fauna and is internationally known as the best window to understand the life of vertebrates on earth from the Middle Permian to the Early Jurassic (Smith et al., 1998; Rubidge and Sidor, 2001; Hancox and Rubidge, 2001). Vertebrate groups represented by fossils recovered from the Karoo are: fish (Bender and Hancox, 2003), amphibians (Hancox et al., 2000; Damiani, 2003; Damiani and Rubidge, 2003); herbivorous reptiles of large size known as pareiasaurids (Lee 1997a, 1997b), many groups of 'mammal-like reptiles' or therapsids (Boonstra 1969; Rubidge and Hopson, 1990; Hancox and Rubidge, 1994, 2001; Rubidge, 1994; Rubidge and Kitching, 2003; Abdala, 2007), small

lizard-likes animals such as procolophonians and eosuchians (Cisneros, 2007), turtles (Gaffney and Kitching, 1994), dinosaurs (Yates and Kitching, 2003; Yates, 2005) and primitive mammals (Gow, 1986). Many of the fossils from this basin are key fossils that have helped to understand the origin and evolution of mammals, turtles and dinosaurs (Rubidge, 1995a; Smith et al., 1998; Rubidge and Sidor, 2001; Rubidge, 2005).

This wealth of tetrapod fossils from the rocks of the Beaufort Group has enabled the establishment of an 8-fold biostratigraphic scheme (Keyser and Smith, 1977/78; Kitching, 1977; Rubidge, 1995b). Although a lithostratigraphic scheme has also been developed for these fluvially deposited rocks, the fact that no long-ranging marker beds are present in the Group means that biostratigraphy remains the most reliable method for long distance stratigraphic correlation. This biostratigraphic scheme has also enhanced intercontinental correlation of Permian and Triassic terrestrial deposits (e.g. Lucas, 1998; Rubidge, 2005).

Uranium anomalies have been found in different regions of the south-western portion of the Karoo Basin, resulting from an active exploration programme developed in the 1960s and 70s (Cole, 1980; Cole and Wipplinger, 1991, Kitching and Rubidge, 1993). Renewed uranium prospecting in the Karoo has led to the identification of an area between the districts of Aberdeen, Beaufort West and Rietbron which is currently being targeted for mining activities.

The area being prospected in the southern Karoo is of particular paleontological interest for several reasons. Numerous authors have linked dated periods of compressional deformation in the Cape Fold Belt (Hälbich 1983, 1992; Hälbich et al., 1983; Gresse et al., 1992) to sedimentary responses in the Karoo Basin (Rust, 1959, 1962, 1975; Hiller and Stavrakis, 1984; Turner, 1986; Cole, 1992; Veevers et al., 1994;

Hancox and Rubidge, 1997; Catuneanu et al., 1998; Hancox, 1998). At present there is no consensus as to the cause-and-effect relationships, although most authors favour direct control in a unitary subsiding basin. One of the main problems hindering development of these models is a lack of good time resolution. In this regard fossils have proved useful, as enhanced understanding of the biostratigraphic distribution of plants and tetrapod faunas has led to improved time resolution of basinal depositional events for the subaerial continental deposits of the basin (Hancox and Rubidge, 1997, 2001). The rocks of the southern Beaufort Group host the oldest record of land living fossil tetrapods in the southern hemisphere (Rubidge 1995a, Rubidge 2005), and provide one of very few records of Middle Permian continental biodiversity but have received very little research attention since the seminal work of Boonstra (1969).

Raup and Sepkoski (1982) drew attention to the extinction events of the late Ordovician, Devonian, Permian, Triassic and Cretaceous as the five largest extinction events since the Cambrian explosion of life 540 million years ago. With the threat of the current "sixth extinction", global mass extinction events and their impact on the biota of the time are receiving increased attention. Because the Karoo Supergroup records two of these "Big Five" events (Smith, 1995; Smith and Ward, 2001; Hancox et al., 2002), it is an excellent place to study biological diversity patterns through time, and specifically the periods prior to a mass extinction event and the recovery after it. Apart from the end Permian and end Triassic extinctions a marked faunal change also occurs at the end of the Middle Permian. The results of this extinction have been well researched in the marine realm but not yet in the continental realm as there is a paucity of fossil-bearing terrestrially deposited rocks of this period. The only place where rocks are preserved which were deposited in the continental realm during the Middle-Late Permian transition

is in the Karoo of South Africa and fall within the *Tapinocephalus* Assemblage Zone (Rubidge, 1995b). These rocks could provide the key to understanding the floral and faunal changes that took place during the Permian, and may also provide important clues about the environmental changes that were occurring during this time. These are the rocks currently being targeted for uranium prospecting.

This report covers the potential impact of proposed mining on the palaeontological heritage of this area on the following farms: Oorlogspoort, Bok Vlei, Jury Fontain, Drie Bosch Kuil, De Pannen, Karee Poort, Klein Tavel Kop, Nieuw Jaars Fontein, Nieuw Jaars Fontein Ptn 1, Haane Kuil Prn 0, Haane Kuil Prn 7, Vlakplaats, Eerstewater Ptn 1, 3 and 4, Ryst Kuil, Kat Doorn Kuil and Kant Kraal (Figure 1). It was not possible to prospect the farm Klipstavels because the landowner would not give authorization.

2. Topography and Geological Information

Most of the areas under survey are topographically flat and covered by alluvium with the result that few fossil-bearing rock outcrops are present (Figure 2A). Good exposures are present only on the farms Oorlogspoort, Vogel Fontein, Farm 157 and Jury Fontain (Figure 2B). Small outcrops were observed in the farms Karree Poort, De Pannen, Klein Tavel Kop, Nieuw Jaars Fontein and Los Boomen and some good outcrops were also observed in Kant Kraal. The topography of the farm Klipstavels seems to suggest that there may be some good exposures, but proper searching of fossils was not possible.

Geological units of the outcrops in the area correspond to the Teekloof Formation, which is represented by three lithostratigraphic members: Poortjie,

Hoedemaker and Oukloof (Figure 2B). These members include fossil faunas of the *Pristerognathus*, *Tropidostoma* and *Cistecephalus* Assemblage Zones (Rubidge 1995b, Figures 3). On some farms situated in close proximity to the studied area (e.g., Diepleegate), rocks of the Abrahamskraal Formation are present which could potentially yield fossils of the *Tapinocephalus* Assemblage Zone.

3. Palaeontological Information

In the study area many fossil remains from the farm Oorlogspoort are housed at the collections of the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand and the Council for Geosciences, Pretoria. The majority of the fossils are dicynodonts (mostly *Diictodon*) and the levels with fossils are identified as *Tropidostoma* Assemblage Zone, which correspond to the Hoedemaker Member of the Teekloof Formation. This farm has better rock outcrops because of the higher topography. In addition to previously discovered fossils this survey also added several new fossil localities, and the fossils collected have been accessioned into the collections of the Bernard Price Institute for Palaeontological Research at the University of the Witwatersrand. It should be stressed that because of the total lack of outcrops in the study area, these are not outcrops which would normally have been prospected for fossils by palaeontologists.

Close to the farmhouse on the farm Karree Poort (Figure 4) flat –topped hills of the Poortjie Member yielded remains of the dicynodont *Diictodon*, fossil wood and levels with fossil plants. On an isolated koppie positioned at the meeting point of the boundary fences of the farms De Pannen, Klein Tavel Kop, Nieuw Jaars Fontein and Los

Boomen, were found isolated fossil bones, in situ fossil wood and levels with fossilised plants. These plants are present in a pebble lag at the base of fluvial sandstone of the Poortjie Member.

On Nuwejaarskuil there are reasonable rock exposures close to the house below the dam wall, but despite intensive searching no fossil were recovered.

Despite the very flat topography of Nuwejaarsfontein it was possible to recognize fossil remains of a large vertebrate, probably a carnivorous therocephalian which was found in a positive weathering calcareous nodular horizon (Figure 5). On the neighbouring farm of Klein Tafel kop rock outcrops are even more sporadic and no fossil were recovered.

On the farms Haanekuil, Blydskap and Loodsplaas are low ridges of sandstone which have yielded fossil wood fragments, but these are relatively small and were mostly not *in situ*. No large well-preserved logs were found.

The topography on the neighbouring farm of Vlakplaats 350 is extremely flat and there are few outcrops as the rocks of this area have hardly any dip and are covered by thick alluvium. Rystkuil has a small hill at the farm boundary with Eerstewater and Klipstavels, but no fossils were found here.

On the farm Kat Doorn Kuil despite it having very flat topography we discovered two small dicynodont (*Diictodon*) skulls (Figure 6) which were associated with a brown calcareous nodular horizon.

Further to the south there are relatively good rock exposures on the farm Kant Kraal which delivered skulls of the dicynodonts *Robertia* and *Diictodon*. This farm appears to be stratigraphically slightly lower than those mentioned so far and is either

situated in the lowermost Pristerognathus Assemblage Zone, or the uppermost *Tapinocephalus* Assemblage Zone.

The farm Rooikop delivered no fossils, and although the farmer refused us access to look for fossils on the farm Klipstafels, from our drive onto the property we are able to ascertain that there was little possibility of finding fossils on the portion of the farm north of the homestead. On the small portion of the farm situated southwest of the homestead is slightly higher topography and there is a possibility of some outcrops in this area, but these are not of great importance for fossil prospecting.

The table below presents a summary of the fossils discovered on farms in the study area.

Farm	**Fossil type**	**Grid reference**
Kareeport	*Diictodon* skull	S 32° 27.661′/E 23° 21.113′
	Diictodon skull	S 32° 27.714′/E 23° 21.061′
	Wood	S 32° 27.667′/E 23° 21.118′
	Wood	S 32° 30.795′/E 23° 14.773′
	Plant fragments	S 32° 27.763′/E 23° 21.130′
Nuwejaarsfontein	Therocephalian postcranium	S 32° 33.033′/E 23° 13.637′
Haanekuil	Wood	S 32° 37.467′/E 23° 02.563′
Kat Doorn Kuil	*Diictodon* skull	S 32° 41.412′/E 22° 48.554′
	Diictodon skull	S 32° 41.451′/E 22° 48.563′
Kant Kraal	*Diictodon* skull (3)	S 32° 44.618′/E 22° 44.452′
	Robertia? skull	S 32° 44.599′/E 22° 45.080′

4. Concluding remarks

The only good outcrops which are likely to deliver large numbers of fossil are on the farms to the north of the study area close to the Oorlogspoort mountain. Over most of the study area the topography is very flat and the rocks of the Karoo Supergroup are covered by alluvium.

Our fossil prospecting for this study revealed the following biostratigraphic information: a) the base of the Oorlogspoort mountains situated to the north of the study area have yielded fossils of the *Pristerognathus* Assemblage Zone while the uppermost horizons of these mountains yielded fossils of the *Cistecephalus* Assemblage Zone; b) most of the study area seems to be in the *Pristerognathus* Assemblage Zone, except for Kantkraal which may be stratigraphically slightly lower, but this is not possible to say as no biostratigraphically diagnostic fossils were found here.

5. Recommendations

From a palaeontological perspective the study area would not normally be targeted by palaeontologists wishing to find large numbers of fossils as it is extremely flat and there are very few outcrops. For this reason the area is of importance as it covers the contact area between the southeastern and southwestern portions of the Beaufort Basin and covers the Willowmore palaeotopographic high. Because of poor outcrops both palaeontological and lithological data is poorly known and thus any additional information is of importance.

While mining activities will be intrusive from an environmental perspective, excavations will enhance possibilities for finding new fossil evidence in this palaeontologically poorly-known part of the Karoo Basin. It is understood that most mining will be by underground rather than by opencast methods and it is thus unlikely that many fossils will be uncovered by mining activities. However because so little is known about the fossil of this area, it is essential that geologists from mining companies be shown by a palaeontologist how to recognise fossils and that they monitor excavation

activities for any possible fossil discoveries. These should then be reported to a recognised South African Palaeontological Research Centre, reported below, so that they can be excavated and stored for future research purposes.

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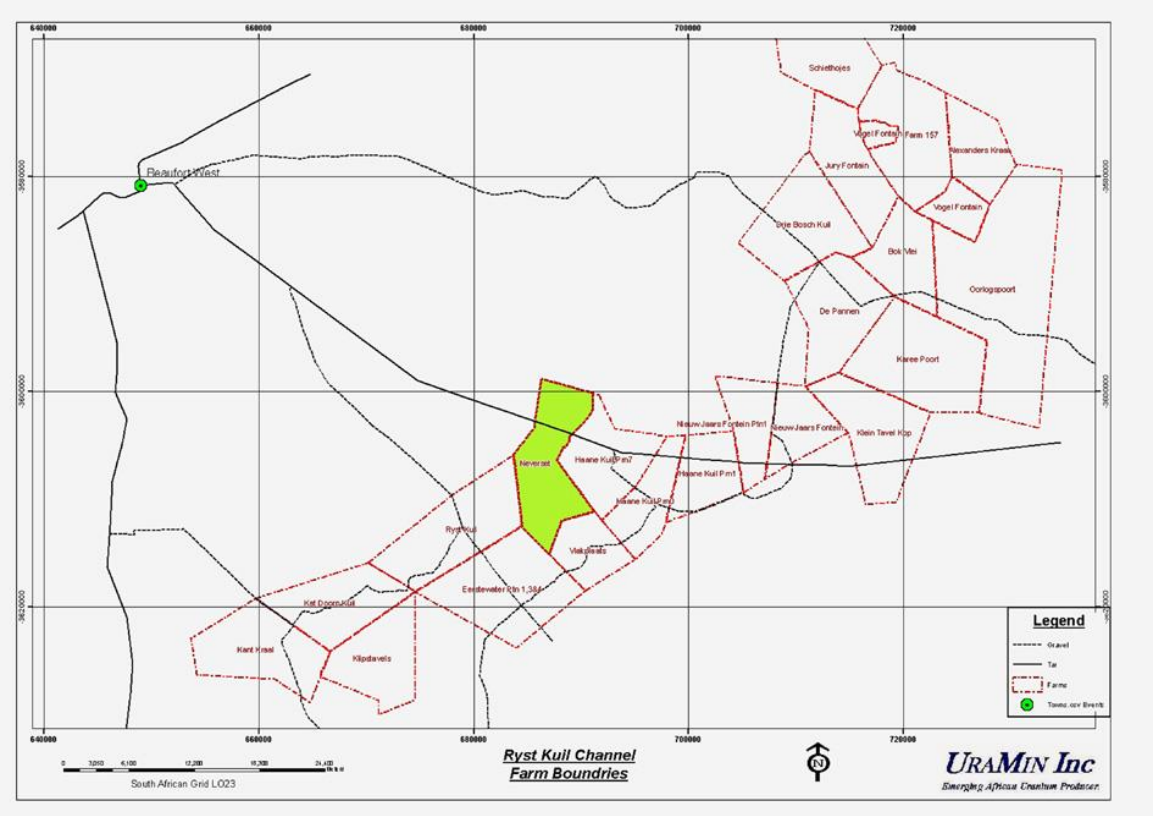
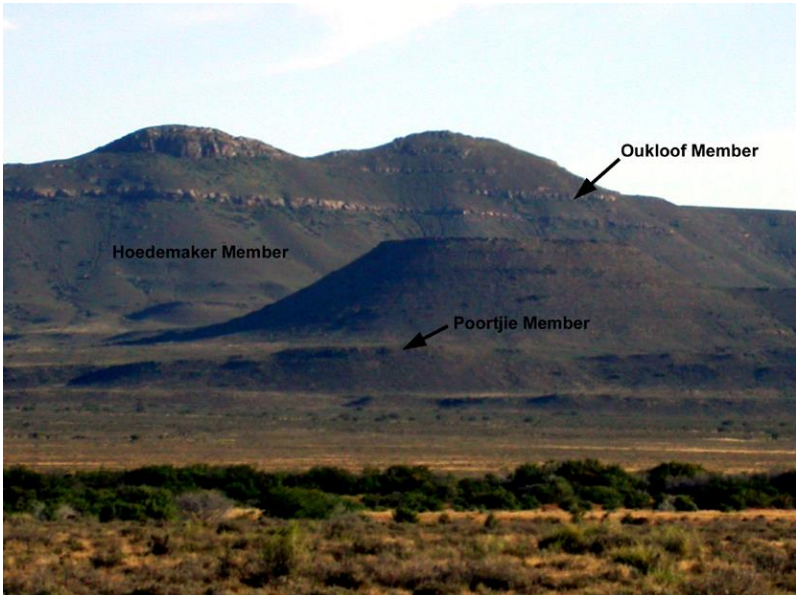


Figure 1. Map showing the farms included in the present palaeontological report.

A



B

Figure 2. Topography of the area. **A**. Flat topography in the farm Rystkuil, typical of the majority of the prospected area. **B**. Fossiliferous outcrops exposed to the north of the studied area. Geological units are indicated.

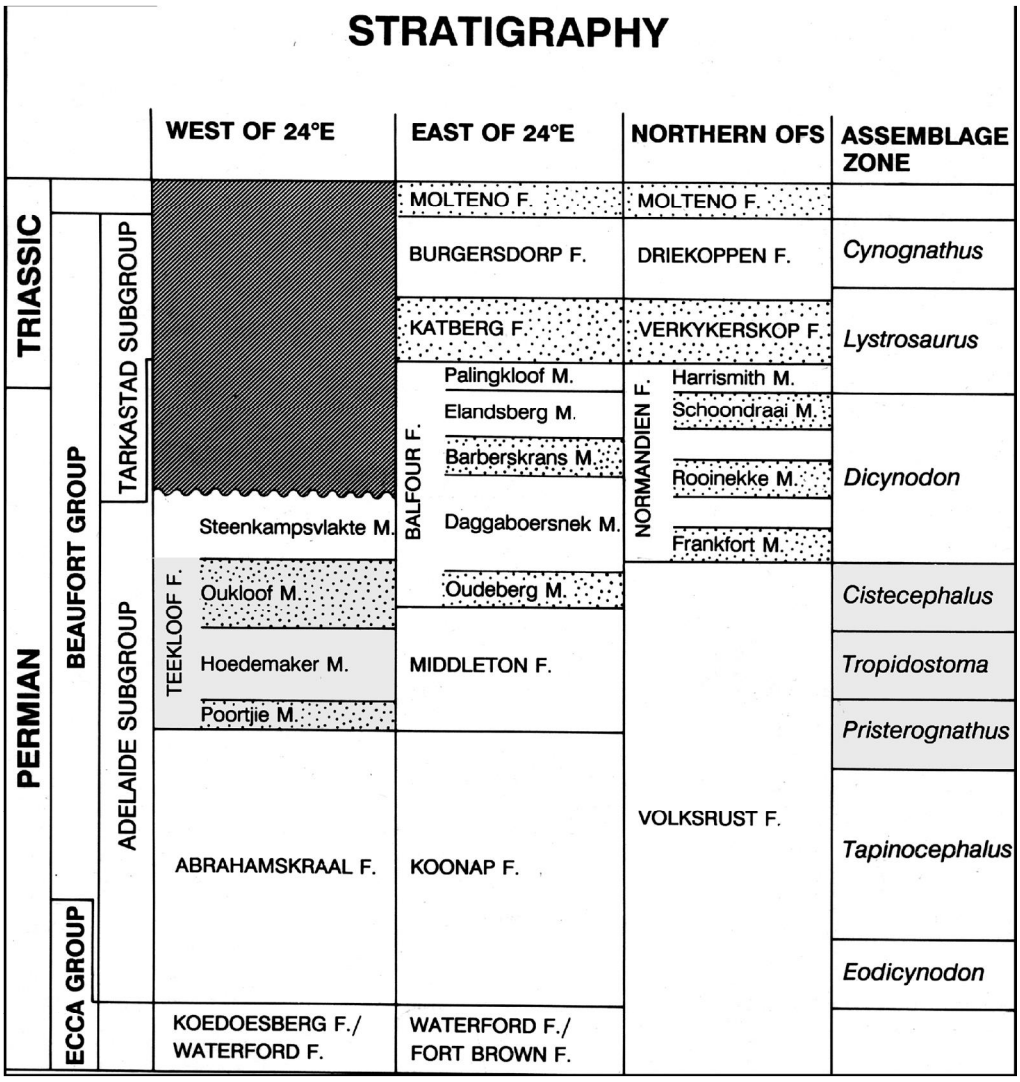


Figure 3. Litho- and biostratigraphy of the Beaufort Group in the Karoo Basin. Highlighted in light grey are the geological units and assemblage zones recognized in the Rystkuil area. From Rubidge (1995b).

A

B

C

Figure 4. Farm Karreepoort. A. General view of the outcrop, near the farm house. Arrow indicates the Poortjie sandstones (B) where fossils plants are present. C Detail of a slab with a fossil plant.

A

B

Figure 5. Farm Nuwejaarsfontein. A. Calcareous nodular horizon. B. Fossil remains of a big carnivorous tetrapod recovered from a nodule.

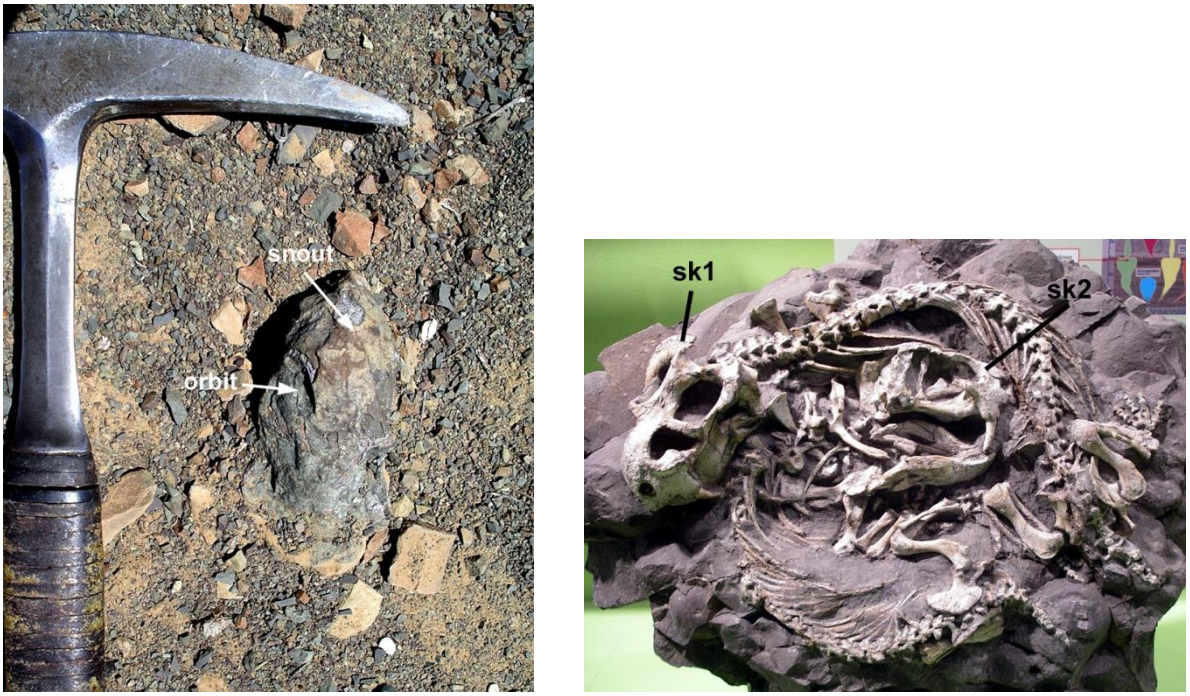


Figure 6. Dicynodon *Diictodon*. A. One of the skulls found in the farm Kat Doorn Kuil during the current survey. B. Skull and skeleton of two completely prepared specimens in the collection of the Iziko South African Museum. Skulls of the two specimens are indicated