

Burrow casts from the *Lystrosaurus-Procolophon* Assemblage-zone, Karoo Sequence, South Africa

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Five types of burrow casts from the *Lystrosaurus-Procolophon* Assemblage-zone (Palingkloof Member and Katberg Formation, Triassic, Karoo sequence, South Africa) are associated with casts of desiccation cracks and red mudstone. Vertebrate remains of *Lystrosaurus* sp. and *Procolophon* sp. indicate that these animals probably made the burrows during the Triassic. It is possible that burrowing was an adaptive advantage during periods of severe and unfavourable climatic conditions. Similar burrow casts were found in the *Dicynodon-Therapsid* Assemblage-zone, suggesting a burrowing habit for fauna represented in this zone. In structure, the burrow casts resemble those of *Scoyenia*, *Thalassinoides*, *Histioderma*, *Gyrolithes* and *Planolites* reported from Germany, France, Asia, Ireland, Spain and the United States of America.

Key words: bioturbation, casts of burrows, *Gyrolithes*, Katberg, palaeoecology, palaeontology, Palingkloof, *Scoyenia*, sedimentology, trace fossils, Triassic.

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Introduction

Casts of large-scale (10-50 cm diameter) bioturbation structures have not been recorded from many biostratigraphic zones in the Karoo Sequence of South Africa (Voorhies 1975; Smith 1987); it is accepted that *Dicynodon* sp. and *Procolophon* sp. burrowed extensively (Smith 1987; Kitching *pers. comm.* 1990). Casts of burrows have been observed in the Karoo National Park. This paper reports interesting structures in the Triassic *Lystrosaurus-Procolophon* Assemblage-zone (= *Lystrosaurus-Thrinaxodon* Assemblage-zone (SACS 1980)) and speculates on their possible origin.

The structures are classified according to the descriptions of Häntzschel (1966) and the ecological system of Seilacher (1953, in Häntzschel 1966).

Geological Setting

The *Lystrosaurus-Procolophon* Assemblage-

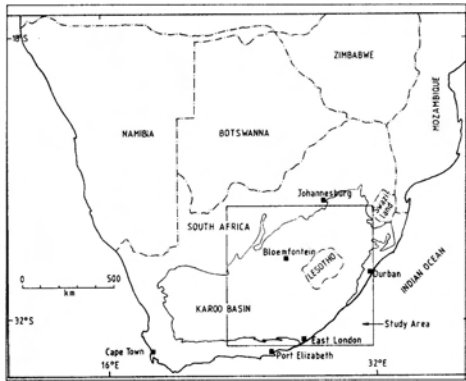
zone is associated with the Palingkloof Member of the Balfour Formation as well as with the Katberg Formation in the south-eastern part of the Karoo basin (Fig. 1) (Johnson 1976; Johnson & Keyser 1976).

Towards the northern part of the basin the zone is confined to the sediments underlying the Katberg Formation and its equivalent (Groenewald 1984, 1990) (Table 1).

The Palingkloof Member consists primarily of thinly interbedded sandstone and red mudstone, usually displaying casts of desiccation cracks; carbonate concretions are abundant. These sediments are interpreted as floodplain and lacustrine (playa) deposits.

The Katberg Formation consists mostly of interbedded thick beds of sandstone and thin mudstone layers (Dingle *et al.* 1983) except in the south-western part of the basin, where the mudstone/sandstone ratio is 43/57, and in the western part of the basin at Venterstad and Bethulie, where it consists of thinly laminated

Fig. 1. Study area. Casts of burrows are described from the upper part of the Karoo basin in South Africa.



sandstone and siltstone displaying numerous desiccation casts. The depositional environment of the formation is therefore subdivided into a south-eastern, south-western, western, eastern and north-eastern facies, the south-eastern, eastern and north-eastern facies being interpreted as braided stream deposits (Hiller & Stavakis 1979; Botha & Linström 1978; Groenewald 1984); the south-western facies as the product of low sinuosity

Table 1
Correlation of the lithostratigraphy in the Karoo basin

South-eastern Karoo basin (SACS, 1980)					North-eastern Karoo basin (Groenewald, 1990)				
Sequence	Group	Subgroup	Formation	Member	Sequence	Group	Subgroup	Formation	Member
KAROO	BEAUFORT	Tarkastad	Molteno		KAROO	BEAUFORT	Tarkastad	Molteno	
			Burgersdorp					Driekoppen	
			Katberg					Verkykerskop	
		Adelaide	Balfour	Palingkloof			Normandien	Harrismith	
	Middleton			Schoondraai					
	Koonap			Rooinek					
					Frankfort				
	ECCA				ECCA				

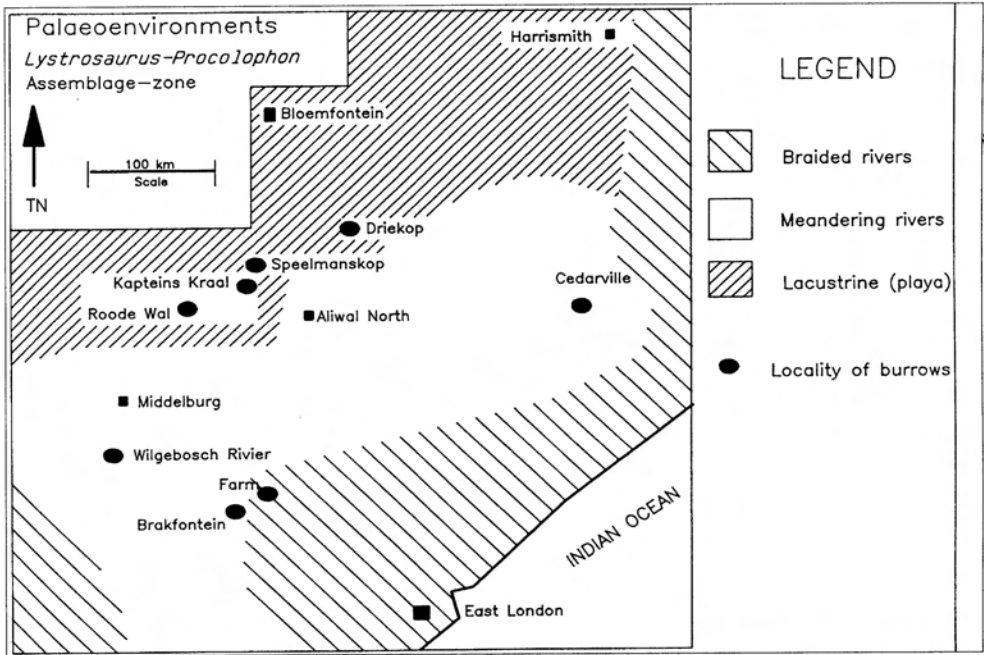


Fig. 2. Three major palaeoenvironments are identified in the *Lystroraurus-Procolophon* Assemblage-zone, casts of burrows occur at different localities, as indicated on the map.

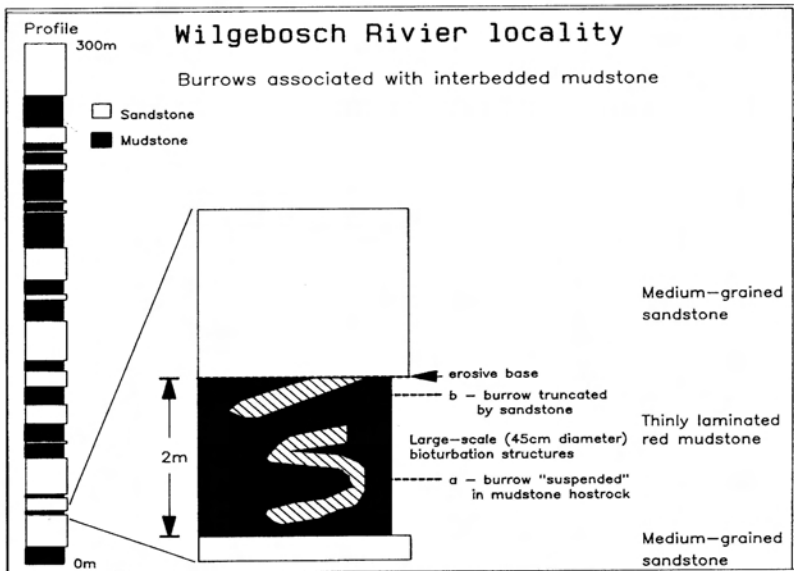


Fig. 3. Large-scale burrows (45 cm in diameter) occur in red mudstone of the Katberg Formation at Wilgebosch Rivier 241.

meandering rivers, whereas the western-central facies represents a dry, proximal lacustrine environment (Fig. 2).

Casts from different localities

Sandstone and siltstone casts occur in several different localities in the outcrop area of the *Lystrosaurus-Procolophon* Assemblage-zone (Fig. 2).

On Farm 171 (26° 19' 42" E; 32° 07' 00" S), south of Tarkastad (Fig. 2), separate very straight casts less than 2 cm in diameter, filled with red calcareous mudstone cut thick (1 m to 2 m) sandstone layers at an angle of 30° (Fig. 4). The burrows resemble those of the genus *Scoyenia*, White, 1929 (Häntzschel 1966) described from localities in Germany, France and the United States of America. The total vertical extent of the structures was not

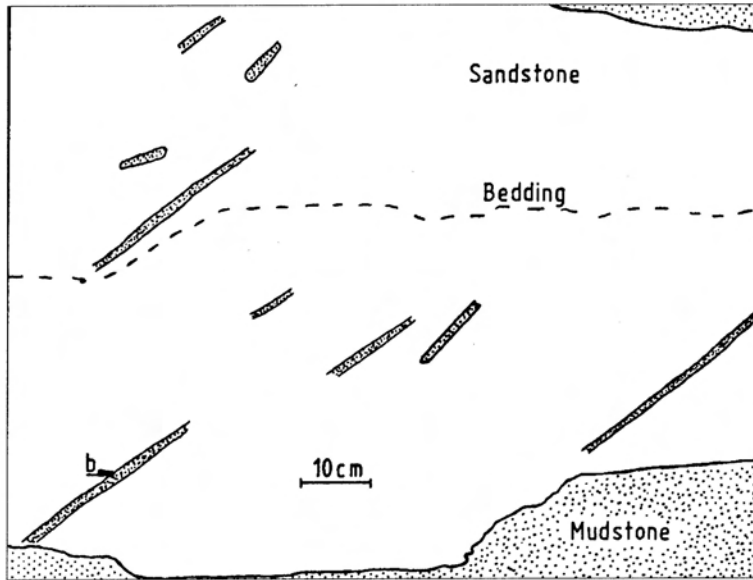


Fig. 4. At Farm 171, long, straight, calcareous, red mudstone burrows (b), resembling *Scoyenia*, cut at 30° through sandstone.

For the purpose of this paper the terms “small-scale” and “large-scale” refer to the section diameter of the casts; large-scale structures having a diameter greater than 10 cm, small-scale structures less than 10 cm.

Small-scale structures are associated with sandstone beds, most of the large-scale ones with red and olive-yellow mudstone and siltstone occurring at or close to the base of sandstone layers; others were found in mudstone host rock (Fig. 3).

determined. Fossilised remains in one of the burrows still need to be identified.

On Brakfontein 333 (26° 06' 42"E; 32°11'18" S) south-west of Tarkastad (Fig. 2), a single, complex siltstone-rich cast structure 5-10 cm in diameter is associated with red and maroon mudstone. The casts show a complex branching pattern (Fig. 5), comparable with *Thalassinoides* Ehrenberg, 1944 (Häntzschel 1966) reported from Europe and Asia, as well as recent mammalian prairie dog (*Cynomys* sp.) burrows (Voorhies 1975). Kitching (*pers.*

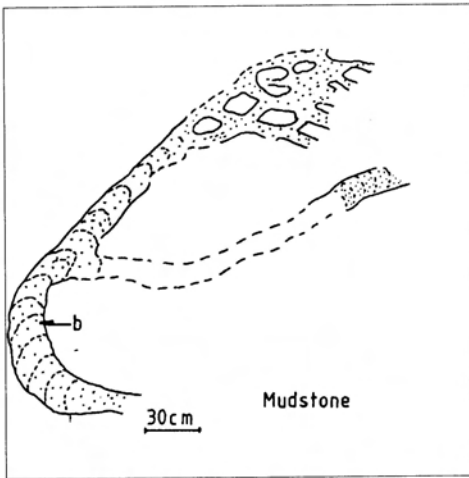


Fig. 5. A complex burrow system (b), resembling *Thalassinoides* occurs at Brakfontein 333.

comm. 1990) found *Procolophon* sp. remains in similar burrows.

At Wilgebosch Rivier 241 (25° 01' 42"E; 31° 46' 00" S), south of Middelburg (CP)

(Fig. 2), one large-scale sandstone-rich cast 45 cm in diameter cuts obliquely into mudstone hostrock (Fig. 6). Only 2,5 m of the structure is exposed but it seems to be helical in shape. Unidentified bone fragments are associated with it. Except for its large size it closely resembles *Gyrolithes* De Saporta, 1884 described from Europe or *Daimonelix* Barbour, 1892 (Häntzschel 1966) as reported by Smith (1987) from localities close to the Karoo National Park at Beaufort West, South Africa. The structures have a ramp angle of 10°-15° and a reference cylinder diameter of 250 cm (Fig. 7).

On Roode Wal 126 (25°31'42" E; 30°51' 30" S) and Keerom 55 (25° 37'12" E; 30° 49' 12" S), west of Venterstad (Fig. 2), clustered structures of mainly fine-grained sandstone less than 100 cm long and up to 50 cm in diameter, resembling *Histioderma* Kinahan, 1858 and *Cylindricum* Linck, 1949 (Häntzschel 1966) reported from Ireland and Europe, cut into light yellow-brown and olive siltstone (Fig. 8). The tops seem to be trun-

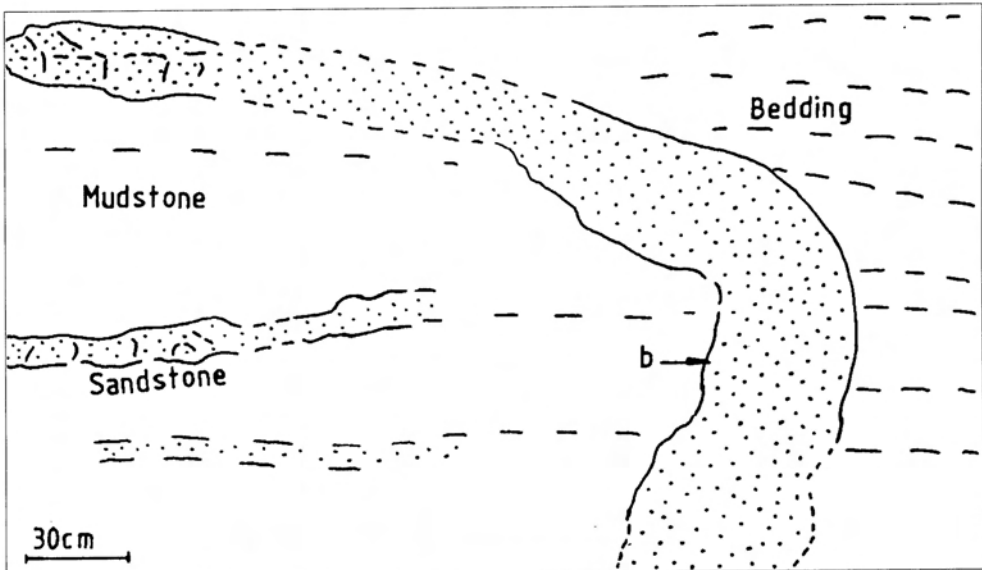


Fig. 6. A large-scale helical burrow cast (b), resembling *Gyrolithes* or *Daimonelix* cuts into mudstone host rock at Wilgebosch Rivier 241.

Fig. 7. Terminology used in describing helical and other burrow casts. Three elevations (A,B,C) and a perspective (D) are redrawn from Smith (1987, Fig. 7)

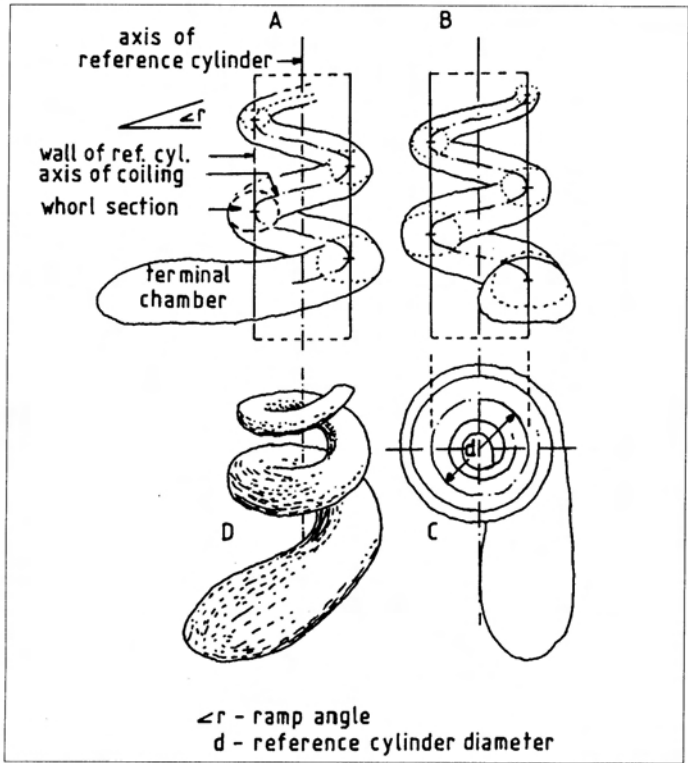
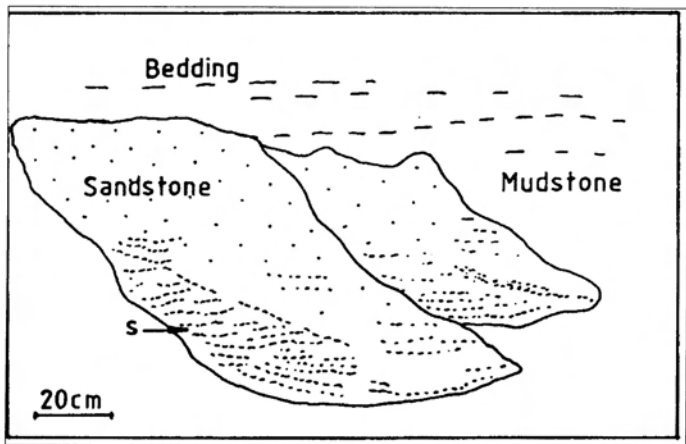


Fig 8. Two sandstone-rich, toe-shaped burrows, probably *Histioderma* or *Cylindricum*, cut into siltstone on Roode Wal 126. Striations (s) on the burrow walls resemble *Spongeliomorpha*.



cated at the sandstone/siltstone interface. The structures at Roode Wal display grooves similar to *Spongeliomorpha* De Saporta, 1887 (Häntzschel 1966) as described from North

America and Spain, on the outer perimeter. Casts in mudstone hostrock resemble *Cruziana* D'Orbigny, 1842 (Häntzschel 1966) trace fossils (Shone 1978). Fossilised bone material

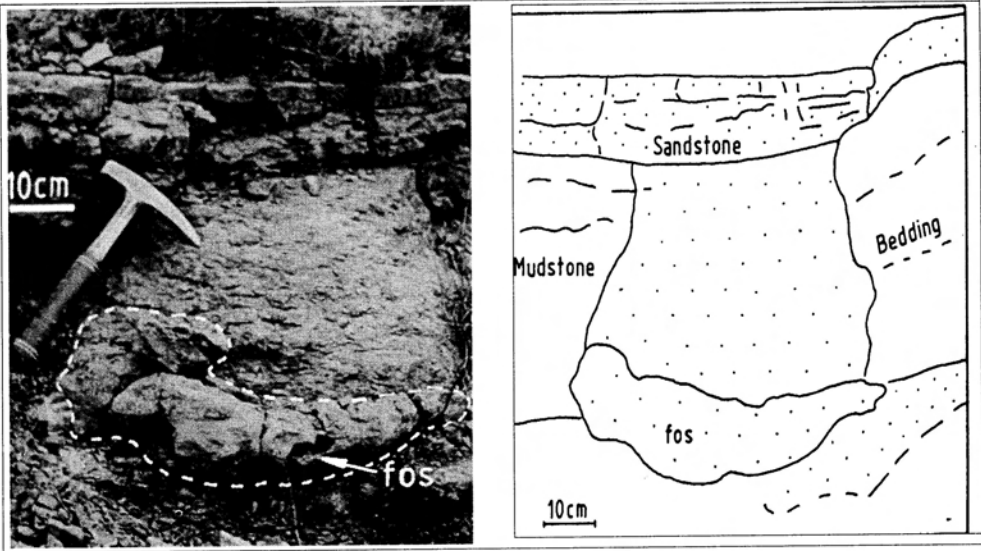


Fig. 9. Fossilised bone material (fos), associated with a toe-shaped burrow on Keerom 55, awaits identification.

in the structure at Keerom (Figure 9) awaits identification. Similar structures occur at Kapteinskraal 28 (26° 01' 54" E; 30° 23' 06" S), near Bethulie (Fig. 2).

On the same farm, a cluster of large-scale structures resembling *Scoyenia*, are well exposed, virtually straight, 220-330 cm long and up to 60 cm wide (Fig. 10). Grooves, similar to large *Spongeliomorpha* occur on the outer surface; a small "hump" (10 cm across) is present on the underside.

One of the structures at this locality is more complex: a steep incline at the upper end, an enlargement in the turn, and a slight upward bend towards the lower end (Fig. 11).

A smaller structure (20 cm in diameter), with strong indications of open helical coiling as in *Gyrolithes*, occurs at the same place. It has well-defined *Spongeliomorpha* grooves on the outer surface. Positive identification of the associated fossil remains has not been possible, but either *Lystrosaurus* sp. or *Dicy-*

nodon lacerticeps may be present (James Kitching pers. comm. 1990).

At Speelmanskop (26° 07' 00" E; 30° 19' 30" S), close to Bethulie (Fig. 2), small-scale structures are associated with *Dicynodon lacerticeps* remains.

Large-scale structures, badly weathered and difficult to recognise, occur on the farm Driekop 508 (26° 49' 42" E; 29° 54' 36" S), Wepener area (Fig. 2), in the *Lystrosaurus - Procolophon* Assemblage-zone. Large casts of desiccation cracks are common.

Small-scale structures which resemble invertebrate *Planolites* Nicholson, 1873 burrows (Häntzschel 1966) as reported from Germany, occur at many other localities in the *Lystrosaurus-Procolophon* Assemblage-zone.

At Cedarville (29° 01' 00" E; 30° 25' 00" S) in the eastern Karoo basin (Fig. 2), similar structures occur in mudstone of the Katberg



Fig. 10. Large-scale structures (b), resembling *Scoyenia* burrows, occur on Kapteins Kraal 28. Two structures intersect (I) at 90°.

Formation. Small-scale structures contain fossilised material, some of which is being prepared for identification. Large-scale structures apparently do not contain any bone material. Extensive weathering has hampered the search for well preserved body fossils.

Classification

Five types of burrow casts can be identified in the *Lystrosaurus-Procolophon* Assemblage-zone (Table 2). All the structures fall within the *traces endogène* group of Lesserti-

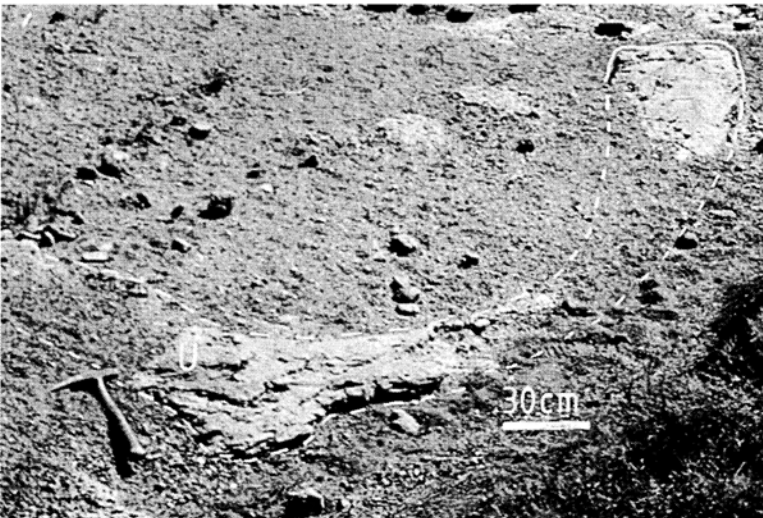


Figure 11. A more complex structure at Kapteins Kraal 28, outlined on the photograph, has some helical characteristics and is enlarged at the upper end (U).

Table 2
Classification of burrow-casts after Häntzschel (1966) and Seilacher (1953)

Generic type	Description	Ecological Class
Häntzschel (1966)		Seilacher (1953)
1a. <i>Scoyenia</i> (small-scale)	Single burrow less than 3 cm in diameter; up to 3 m long; straight; ramp angle 20-30°; excavated into sandstone; filled with calcareous siltstone; contains unidentified fossilised bone fragments.	Domichnia, (dwelling burrow) Fodinichnia, (feeding burrow)
1b. <i>Scoyenia</i> (large-scale)	Single burrow 20- 45 cm in diameter; 3 m long; ramp angle 0-10°; sandstone fill in mudstone host rock; grooves and ridges well defined on sides; burrows overlie each other at 90°; chambers present; burrows associated with casts of desiccation cracks; fossil remains of <i>Lystrosaurus</i> sp. and <i>Dicynodon lacerticeps</i> .	Domichnia (dwelling burrow)
2. <i>Gyrolithes</i> and <i>Daimonelix</i>	Single burrow; helical; loosely coiled; whorl section 20-45 cm in diameter; ramp angle 10-15°; reference cylinder diameter 250 cm; axis of reference cylinder vertical; sandstone fill in mudstone host rock; grooves and ridges on sides; unidentified vertebrate fossil remains, possibly <i>Lystrosaurus</i> sp.	Domichnia (dwelling burrow)
3. <i>Histioderma</i>	Single burrow; 20-50 cm in diameter; up to 100 cm long; lobate; ramp angle 40°; starts at upper sandstone-mudstone interface; sandstone fill in mudstone host rock, grooves and ridges on sides; terminal chamber contains large vertebrate fossil, possibly <i>Lystrosaurus</i> sp.	Domichnia (dwelling burrows) Fodinichnia(feeding burrows)
4. <i>Thalassinoides</i>	Single complex burrow; 3-15 cm in diameter; forms complex net-like pattern of interconnected tunnels up to 2 m ² ; burrow filled with sandy siltstone; contains fossilised <i>Procolophon</i> sp. remains.	Domichnia (dwelling burrows) Fodinichnia (feeding burrows)
5a. <i>Planolites</i> , 5b. <i>Scolithos</i> , 5c. <i>Scoyenia</i>	Single or clustered burrows; 0,5-2 cm in diameter; 5-70 cm long; excavated obliquely into mudstone host rock.	Domichnia (dwelling burrows) Fodinichnia (feeding burrows)

seur (1955, in Häntzschel 1966). Generic classification is based on Häntzschel (1966), with ecological groupings according to Seilacher (1953, in Häntzschel 1966).

Discussion

The cast structures in the *Lystrosaurus-Procolophon* Assemblage-zone resemble those from the *Pristerognathus-Diictodon* Assemblage-zone (Smith 1987). Kitching (*pers. comm.* 1990) has recognised similar structures associated with *Procolophon* sp. Shone (1978) described similar trace-fossils from Burgersdorp, and Hayes-e-Silva (1988) reported *Scoyenia*-type structures from an area south of Queenstown.

The association of fossilised material with the structures; prominent grooves on their walls; well defined ridges on the base; and the helical character of some structures suggest that they are casts of burrows and therefore *lebensspuren* (Häntzschel 1966). The association with *Lystrosaurus* sp., *Procolophon* sp. and *Dicynodon lacerticeps* strongly suggests that these animals were burrowers.

It is possible that such animals made burrows to escape from severe environmental conditions on distal floodplains and lacustrine (playa) environments. The structures are invariably associated with casts of desiccation cracks in red or maroon mudstone, or with fine-grained, thinly bedded sandstone.

Conclusion

The casts in the *Lystrosaurus-Procolophon* Assemblage-zone represent several different kinds of burrows. Some of the animals were burrowers, either to escape intolerable climatic conditions, or as part of their social behaviour. *Procolophon* sp. is known to be a burrower. The size of the fossilised bones in some of the larger burrows suggests that *Lystrosaurus* sp. and even *Dicynodon lacerticeps*, from the underlying *Dicynodon-Therionathus* Assemblage-zone, were also burrowers. Careful observation in the Mountain Zebra National Park should therefore reveal casts of burrows similar to those described above.

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