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Geology of the Golden Gate Highlands National Park

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The Golden Gate Highlands National Park is underlain by stratigraphic units belonging to the upper part of the Karoo Sequence. These units include part of the Beaufort Group and the Molteno, Elliot, Clarens and Drakensberg Formations. Dolerite dykes and sills are intruded into the succession while recent alluvium and scree cover the valley floors and mountain slopes. The Beaufort Group is represented by red mudstone and light brown fine-grained feldspathic sandstone of the Tarkastad Subgroup. The Molteno Formation consists of medium- to coarse-grained trough cross-bedded sandstone, while the Elliot Formation comprises a thick succession of red mudstone, siltstone and interlayered fine- to medium-grained, light yellow-brown sandstone. The most characteristic feature of the park is the yellowish sandstone cliffs of the Clarens Formation. Cave formation is caused by exudation, differential weathering due to different degrees of carbonate cementation and undercutting of the sandstone. The highest peaks are capped by numerous layers of amygdaloidal and massive varieties of basaltic lava of the Drakensberg Formation. A possible volcanic pipe occurs in the eastern part of the park. The Elliot and Clarens Formations are rich in vertebrate fossil remains, especially *Massospondylus* sp. Remains of *Notochampsa* sp., *Pachygenelus monus, Clarencea gracilis, Lanasaurus scalpridens* and a cluster of unidentified dinosaur eggs have also been found. The formations underlying the Golden Gate Highlands National Park were formed during the Late Triassic Epoch and the Jurassic Period (roughly 150 to 230 million years ago). The strata in the park show very little structural deformation and the only obvious structures are faults which are intruded by dolerite.

Key words: Karoo, Beaufort Group, Molteno Formation, Elliot Formation, vertebrate fossils, Clarens Formation, Drakensberg Formation.

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Introduction

The Golden Gate Highlands National Park (GGHNP) is situated in the north-eastern Orange Free State within the foothills of the Maluti Mountains. The name is derived from the distinctive yellowish sandstone cliffs (Clarens Formation) which characterise the area (Fig. 1).

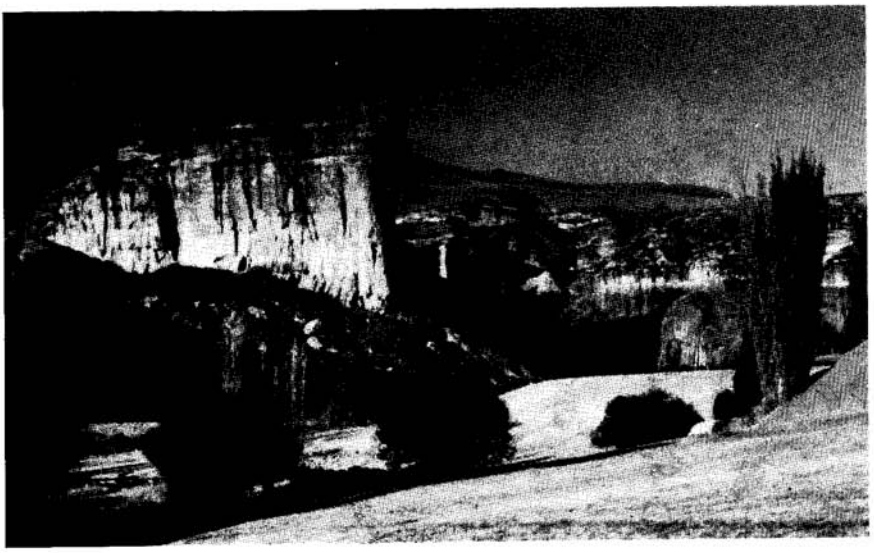


Fig. 1. Sandstone cliffs formed by the Clarens Formation.

At present the park covers an area of 6 241 hectares. The area mapped out for the present study includes the proposed extension of the park's boundaries. The park is situated approximately 360 km from Johannesburg and 56 km south-south-east of Bethlehem on the border between South Africa and Lesotho. Topographically the park lies between 1 892 m and 2 837 m above sea level and the area is very rugged. It is situated in the summer-rainfall region and the average rainfall is 764 mm per year of which the greater amount falls during November to April. The summers are mild while winters are usually very cold with occasional snow on the mountain peaks. Frost occurs during winter nights. The main vegetation is grass on the mountain slopes while the kloofs are normally overgrown by Ouhout trees *Leucosidea sericea* Eckl. & Zeyh.

The area in which the park is situated was previously mapped by Van Eeden (1937), Visser & Van Riet Lowe (1956) and Spies (1969). The most detailed mapping was done by Spies (1969). Detailed sedimentological studies on formations underlying the park were carried out by Beukes (1969), Robinson, Beer, Nutsch & Trumpelmann (1969), Turner (1975) and Erickson (1983). Fossil discoveries were described by Kitching (1979) and Kitching & Raath (1984).

The present study includes a detailed photogeological interpretation, the

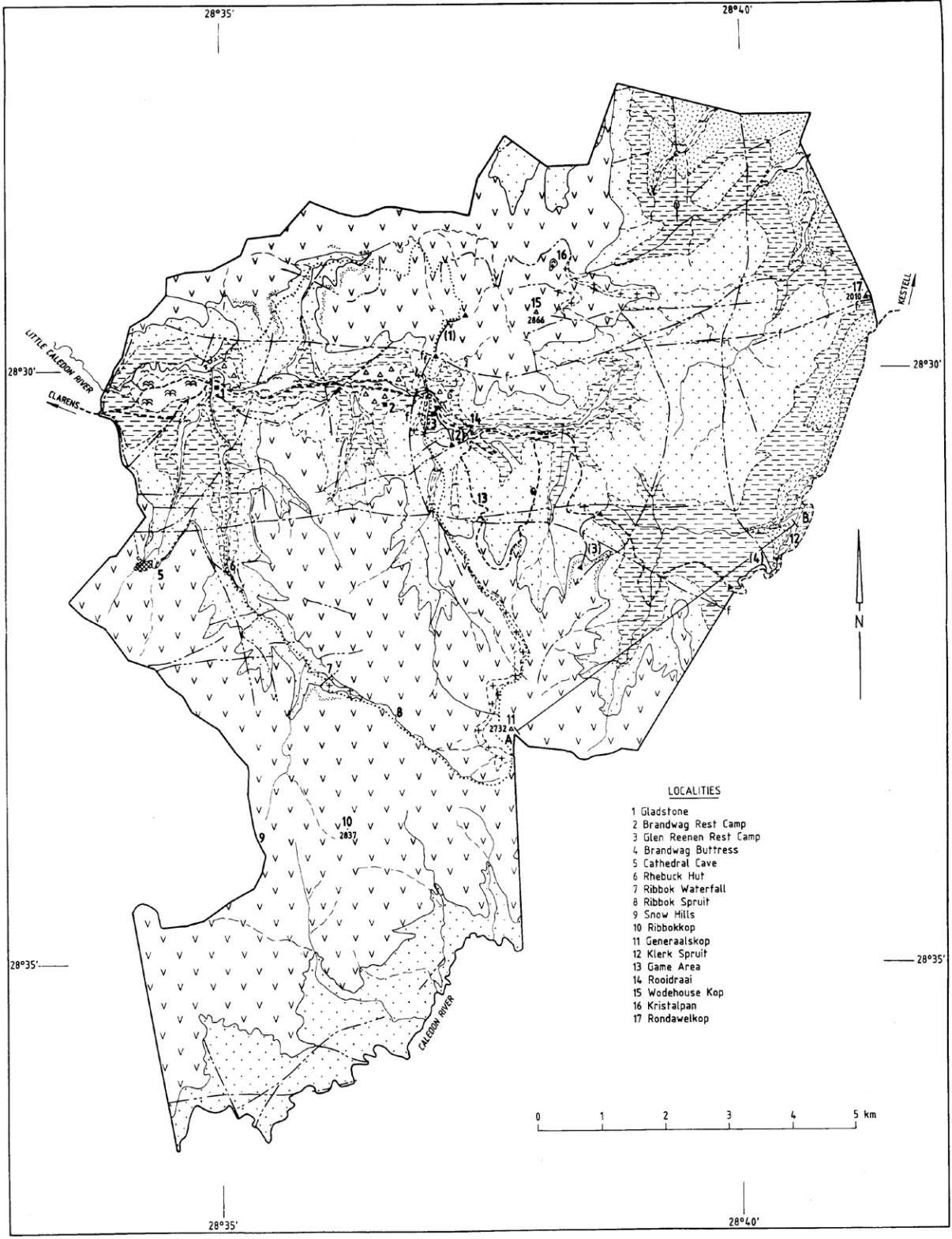


Fig. 2 GEOLOGICAL MAP OF THE GOLDEN GATE HIGHLANDS NATIONAL PARK

measurement of detailed stratigraphic sections and fieldwork to investigate areas where photogeological interpretations differed from existing maps. A geological map was drawn on a scale of 1:50 000 while a cross-section through a part of the park is indicated by the line A--B on the map (Figs. 2 and 3). The positions of all geographic features referred to in the text are indicated on Fig. 2.

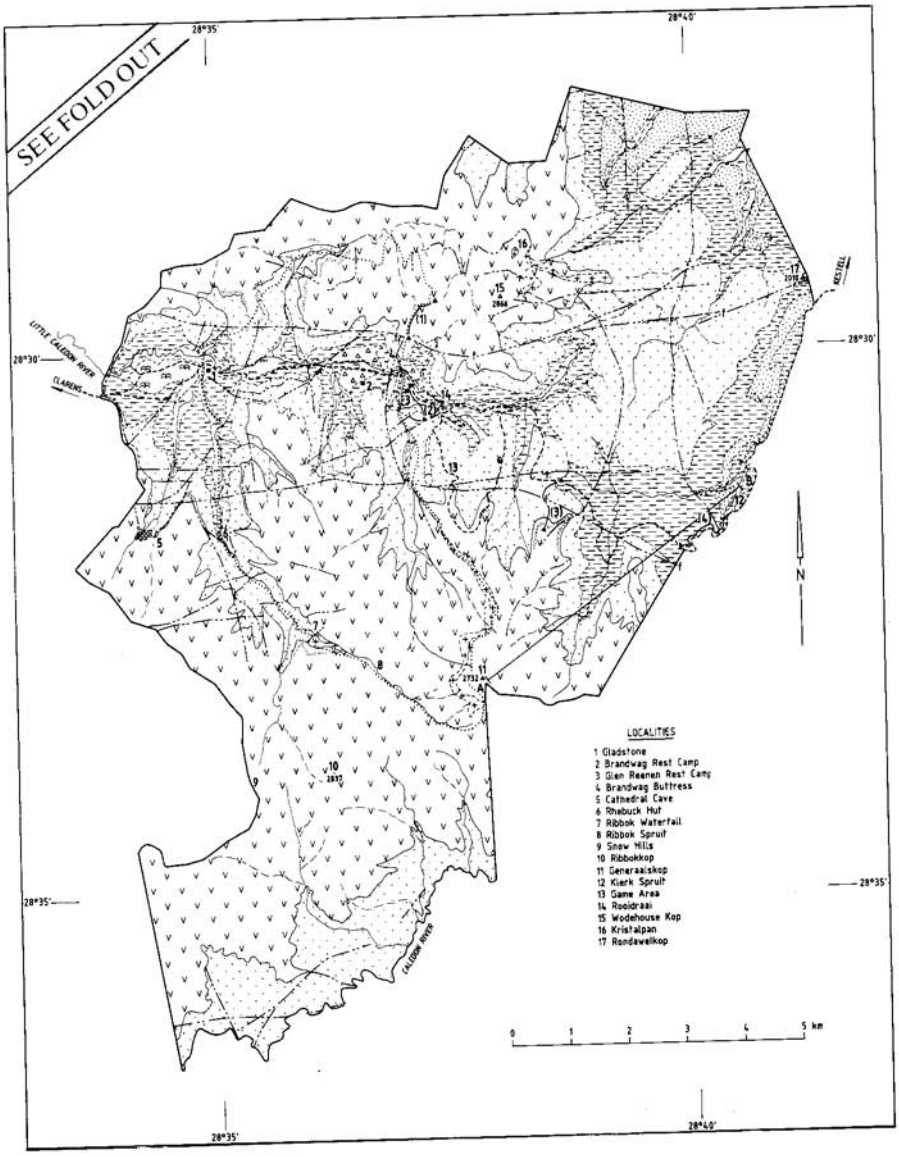


Fig. 2. Geological map of the Golden Gate Highlands National Park.

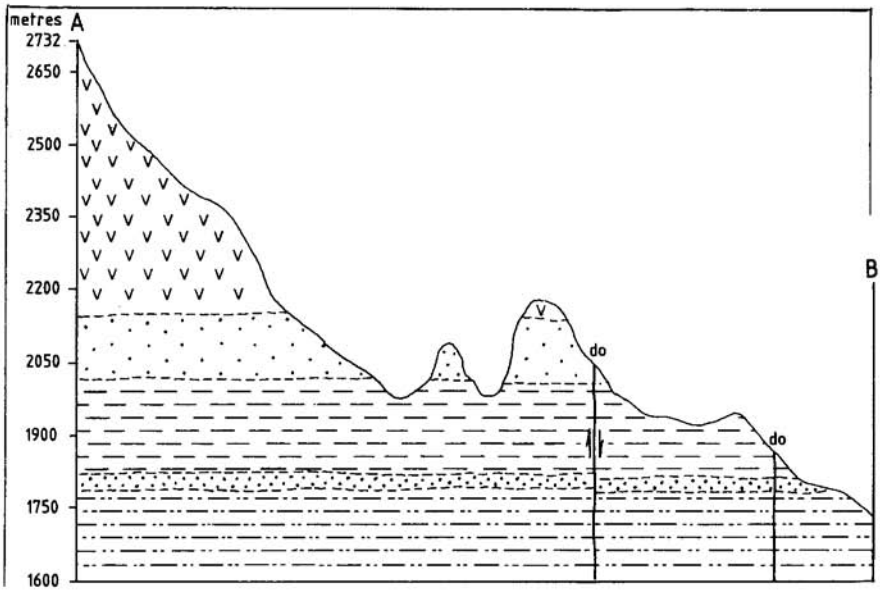
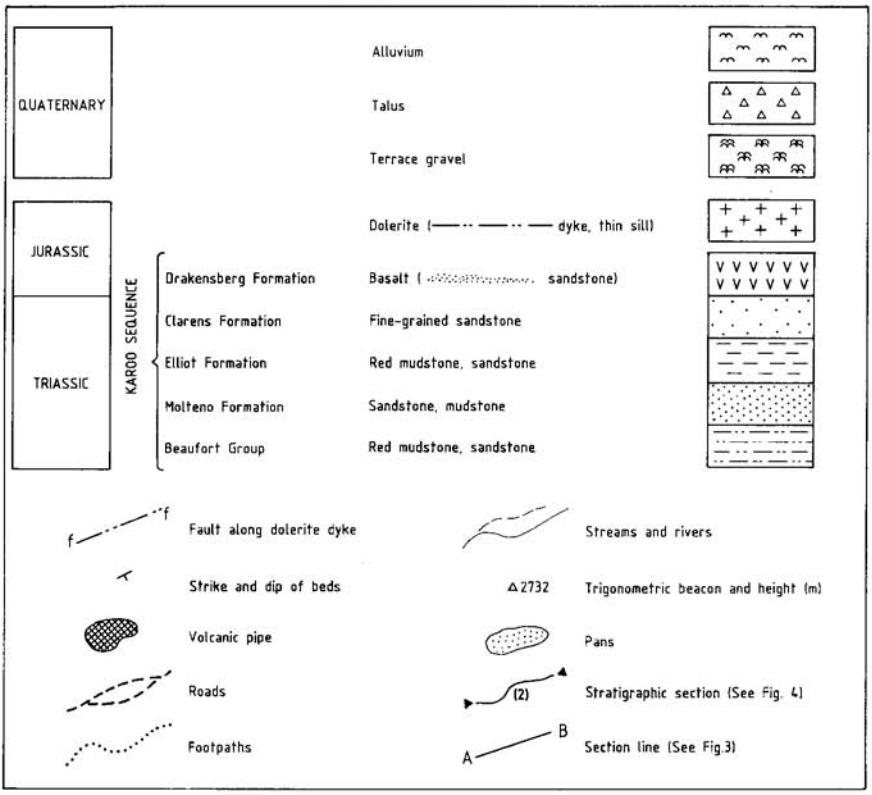


Fig. 3. Cross-section A-B through part of the Golden Gate Highlands National Park.

LEGEND FOR FIGS. 2 AND 3



Geological Description

1. Regional Geological Setting

The park is underlain by rock formations representing the upper part of the Karoo Sequence in South Africa. The Karoo Sequence underlies the greater part of South Africa south of the Vaal River and is subdivided as shown in Table 1. Names that were used in the past for some of the units are also given.

Table 1

Summary of stratigraphic units

	PRESENT TERMINOLOGY (SACS, 1980)			PREVIOUS TERMINOLOGY				
Period	SEQUENCE	GROUP	Formation	SYSTEM	SERIES	Stage	Lithology	Origin
Jurassic	KAROO		Drakensberg	KAROO	STORMBERG	Drakensberg	Basalt	Volcanic
Triassic			Clarens			Cave Sandstone	Sandstone	Aeolian
			Elliot			Red Beds	Mudstone, Siltstone	Fluvial
			Molteno			Molteno	Sandstone, Mudstone	Fluvial
		BEAUFORT			BEAUFORT		Mudstone, Sandstone	Fluvial

The Karoo rocks are intruded by dolerite dykes and sills. A few volcanic pipes are found in the vicinity of the park and were described by Spies (1969) while one new discovery of a possible volcanic pipe situated within the park was made during the present investigation. All the valleys in the park are filled with thick deposits of Quaternary alluvium and scree.

Formations outcropping in the region covered by the Golden Gate Highlands National Park include the upper part of the Beaufort Group and the Molteno, Elliot, Clarens and Drakensberg Formations.

2. Beaufort Group

Exposures of strata representing the Beaufort Group are confined to a very small portion of the park (next to the road to Kestell on the eastern boundary of the park). The outcrop is poor but at the drift over Klerkspruit a very prominent outcrop of fine- to medium-grained feldspathic sandstone is responsible for a small waterfall. This sandstone, which contains large cross-beds and a few calcareous concretions, is at least 24 m thick (Fig. 4 Klerkspruit section).

The sandstone is overlain by red to purple mudstone, approximately 24 m thick (Fig. 4 Klerkspruit section). The mudstone is rich in calcareous concretions. The upper boundary of the Beaufort Group is taken at the sharp contact between the red mudstone and the overlying very coarse- to coarse-grained sandstone of the Molteno Formation.

The presence of fining-upward cycles of sedimentation, trough cross-bedding and channels in the sandstone, clay-pellet conglomerate, as well as the red colour of the sediments indicate that the upper part of the Beaufort Group probably represents fluvial deposits. Deposition appears to have taken place under arid oxidising conditions, which gave rise to the red colour of the sediments, while the abundance of mudstone in the formation points to high-sinuosity rivers flanked by extensive flood plains. The sandstones represent channel deposits. The formation was deposited during the Late Triassic Epoch (*i.e.* about 195-210 million years ago – Van Eysinga, 1975).

3. Molteno Formation

The Molteno Formation consists mainly of medium- to coarse-grained slightly feldspathic sandstone and crops out in the eastern and north-eastern part of the park. The best outcrops are at the drift over Klerkspruit on the road to Kestell (Fig. 2 and Fig. 4, Klerkspruit section). The sand grains are angular to subrounded while secondary quartz overgrowth is responsible for the glistening appearance of the sandstone. Trough cross-bedding and horizontal lamination are the main sedimentary structures. Small-pebble conglomerates are occasionally developed at the base of individual beds.

The lower boundary of the formation is taken at the sharp erosional contact between the underlying red and purple mudstone of the Beaufort Group and the coarse-grained sandstone. The upper boundary is not well exposed and is taken at the point where a sharp break in topography occurs and the sandstone is overlain by red and purple mudstones which are mainly soil-covered.

A thickness of 23 m measured for the formation (Fig. 4, Klerkspruit section) agrees well with values given by Robinson *et al.* (1969) who obtained a thickness of 20 m-30 m for the formation in the vicinity of the park. Turner (1975) did a detailed study of the Molteno Formation and mentions the same thickness. Erickson (1983), on the other hand, seems to have described a sequence of fine-grained sandstone lying within the Elliot Formation (Fig. 4, Klerkspruit section) as belonging to the Molteno Formation.

Trough cross-bedding is common in the Molteno Formation (Fig. 5) and the main direction of transport measured in the park was towards the south-west, which is unusual for the Molteno Formation. Turner (1975) obtained similar directions for this part of the basin. Elsewhere the main palaeocurrents in the Molteno Formation were directed towards the north and north-east (Turner 1975; Erickson 1983, 1984).

The Molteno Formation is interpreted as a braided river deposit since it mainly consists of thick beds of cross-bedded sandstone with very little interlayered mudstone in the upward-fining cycles. In some areas a conglomerate is developed at the base of the thick sandstone beds, indicating channel-lag or braid-bar deposits (Turner 1984).

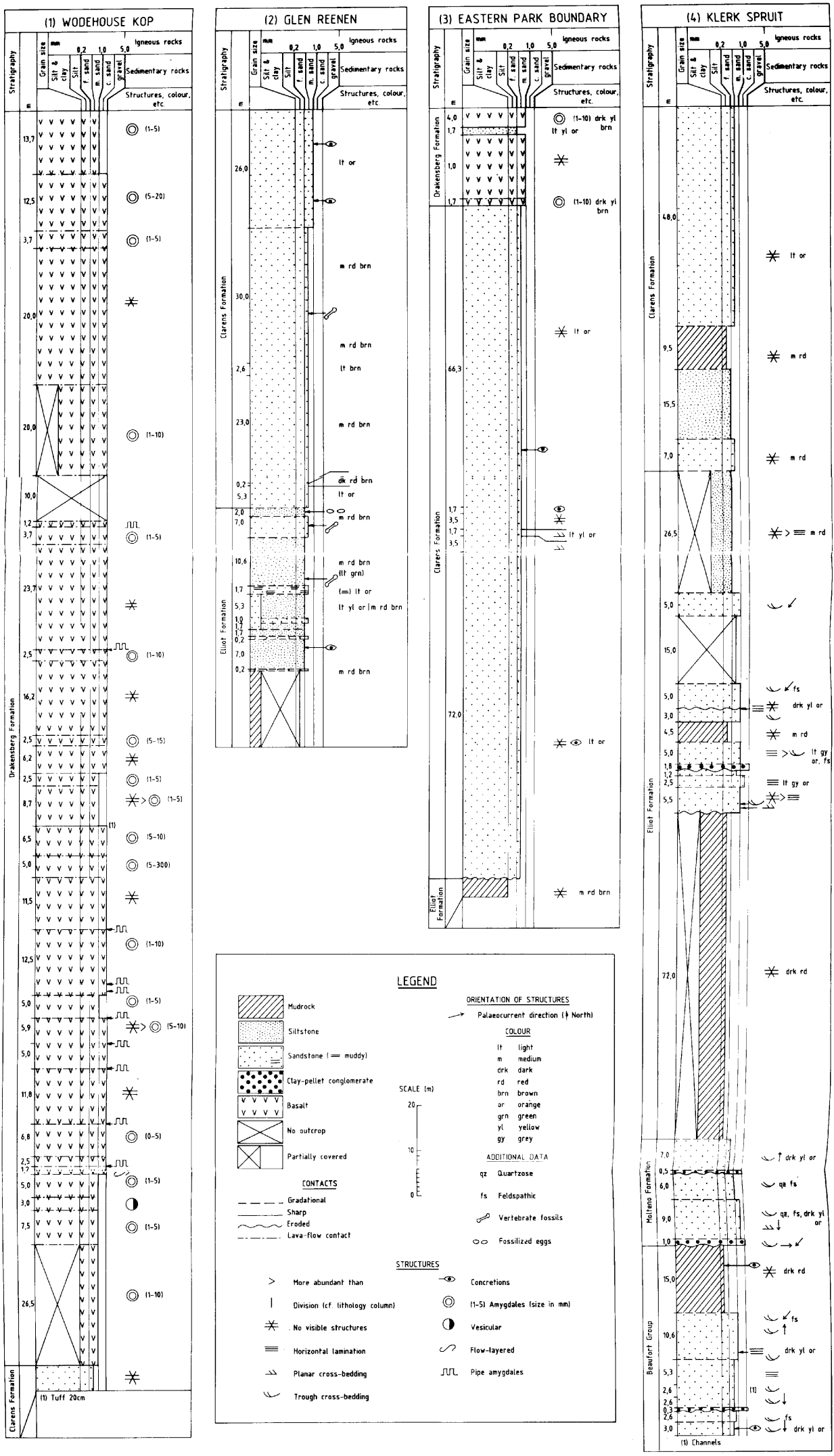


Fig. 4. Columnar sections of formations in the Golden Gate National Park