DSPACE

https://dspace.org/

Cavern development in the Malmani Dolomite, Transvaal : the Wolkberg Cave.

Hawke, David Vivian

2015-01-26
http://hdl.handle.net/10539/16745

Downloaded from a DSpace repository. https://dspace.org/

water table during a period when that surface is uniform in elevation and flow for a considerable time, and the deposition of a clay fill during a period of reduced flow prior to drainage of the system by rejuvenation. Drainage of the system allows the deposition of speleothems to take place, and subsequently, degradation of the system by surface and underground erosion occurs.

Following an extensive study of cavern development in the Mendip Hills, two modes of speleogenesis in tilted limestones based on hydrological conditions were distinguished by Ford (1971). Under conditions of drainage in a down-dip direction where the water is forced to rise stratigraphically to reach the resurgence, the cave developed will be characterised by tubes oriented down dip and joint controlled chimneys linking adjacent tubes. If the drainage is to the strike, the cave developed will be quasi-horizontal and aligned along the strike, and such caves may approximate a true water table cave. Ford concluded that the type of cave formed depends on the structural characteristics of the rock, particularly on the frequency of joints and beds, and the number and type of their intersections, and thus on the hydraulic conductivity of the rock.

SPELEOGENESIS IN THE MALMANI DOLOMITE

The development of the Makapan caves has been attributed to the effects of corrosion along fracture zones which had been sealed previously by calcite (King, 1951). A number of caves

aligned with such sealed fractures were described by King (1951), who further noted that development was frequently aided by the breakdown of the cave roofs and walls.

It has been suggested that cavern development in the Malmani Dolomite is related to erosion cycles, and that the process should occur close to the top of the phreatic zone (Brink and Partridge, 1965). The sites of solution will be concentrated along joints and fracture planes, and, during an erosion cycle, the water table will be progressively lowered due to the enlargement of voids. Rejuvenation at the initiation of a new erosion cycle will result in the drainage of voids developed during the previous cycle and the initiation of new voids at a lower level. The deposition of speleothems will be initiated in the exposed caverns by the ingress of meteoric water which may further excavate fractures with some surface connection. Upon exposure of these fractures at the surface, detrital materials may migrate into the caverns, adding to the products of rock breakdown and collapse, particularly when collapse into pre-existing chambers produces subsidence caverns. The accumulation of internally and externally derived materials may be cemented into breccias. Any later development will be largely degradational due to reductions in the level of the land surface.

Studies of individual caves have indicated agreement with the postulate of phreatic cave development in the Transvaal. The

development of Echo Cave has been attributed to solution in the shallow phreatic zone by Marker and Brook (1970), who, furthermore, noted two major levels of development which they attribute to the influence of major bedding planes, whilst postulating that they may also be related to a two stage development caused by variations in the water table.

A detailed analysis of the Sterkfontein system, situated in steeply dipping strata, was conducted by Wilkinson (1973), who concluded that the cave had developed in a manner similar to that described by Ford (1971) under conditions of down dip drainage. Marker (1974) examined the caves of the Strydpoort Mountains and concluded that they are phreatic in origin, and, furthermore, that over a large area they occur at discrete levels which may be related to levels of the piezometric surface. This finding supports the conclusions of Marker and Moon (1969) that the caves of the North-Eastern Transvaal and of the Sterkfontein region show an association with previous water table levels. It should be noted, however, that Moon (1972) showed that this association does not hold on a local scale. Furthermore, such associations have rarely been indicated in the literature, and generally relate to caves developed under vadose conditions (Droppa, 1966).

The evidence from previous studies of caves developed in the Malmani Dolomite indicates that they are typically phreatic, that their general form may be predicted by theories developed in

relation to caves found in limestone regions, and that the model proposed by Brink and Partridge (1965) to account for both primary and later development may be inadequate. It is therefore necessary to assess the theories described in the preceding sections in relation to the evidence preserved in the Wolkberg Cave to further determine their validity in this context.

* * * * * * * * *

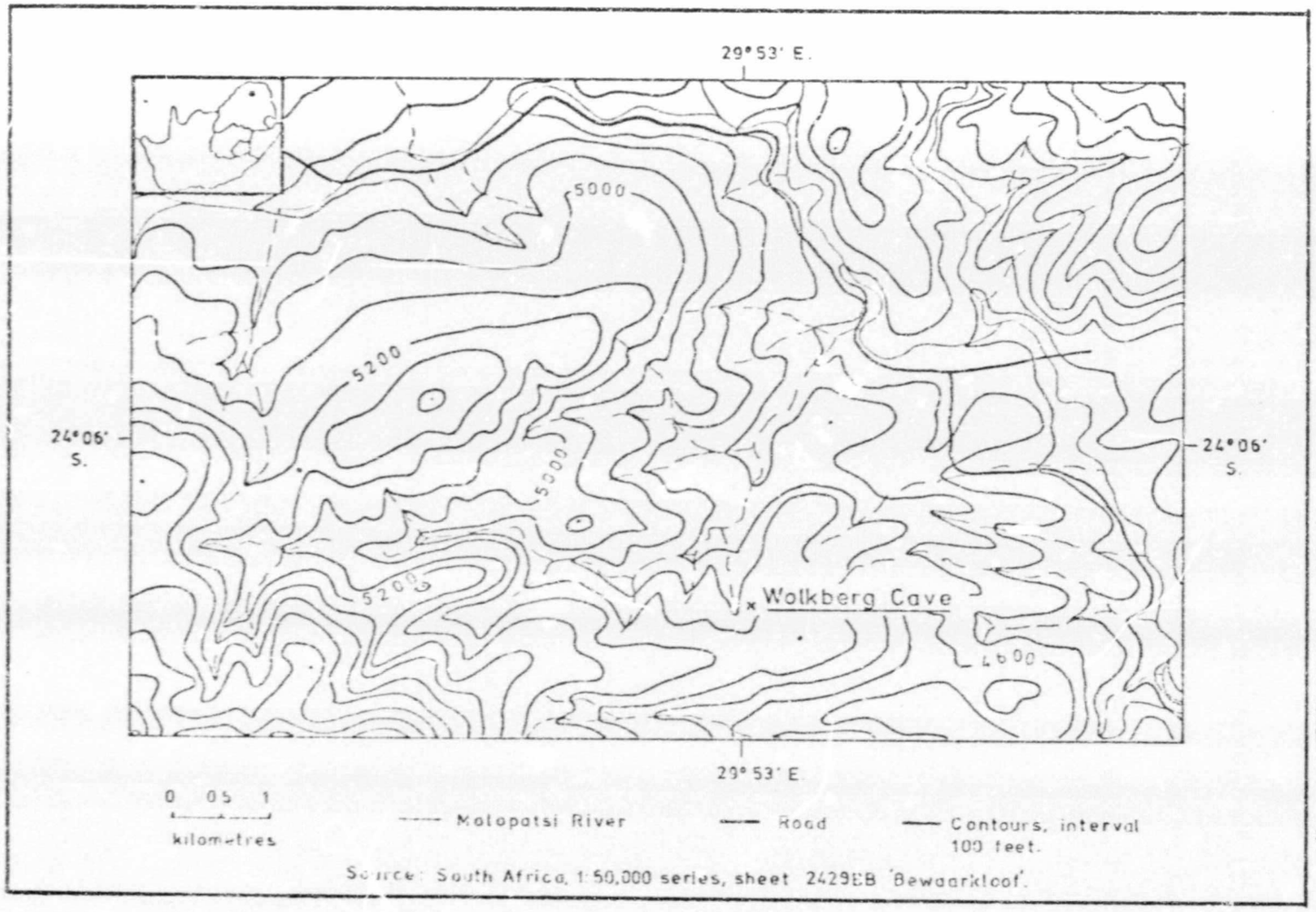


Figure 3.1: Topography in the vicinity of the Wolkberg Cave

CHAPTER THREE

THE PHYSICAL SETTING

SURFACE MORPHOLOGY

The Wolkberg Cave is situated in the catchment of the Molopatsi River (Fig.3.1), the topography of the area being dominated by valley-in-valley bevels. The dominant bevel, at an altitude of between 1500m and 1580m, is dissected by the incision of the Molopatsi River, the present valley floor occurring at an altitude of approximately 1425m. The river is currently incising into terrace and fan deposits, composed primarily of red earth and rounded dolomite and chert pebbles, and has exposed cemented stream bed deposits containing dolomite and chert pebbles in a matrix of earth and calcium carbonate cement. The general relief between valley floor and ridge tops is 200m, increasing to the south due to the exposure of a more resistant rock unit and the increasing depth of incision.

The detailed morphology of the area is controlled to a marked extent by structural features, particularly dykes and lineaments. The most prominent structural influences are reflected in the course of the Molopatsi and its major tributaries, but such control is also apparent in the minor valleys.

GEOLOGY

Stratigraphy

The Wolkberg Cave is developed within the Proterozoic Malmani Dolomite of the Transvaal Supergroup, which has been dated at approximately 2300 million years B.P. (Button, 1973). The Malmani Dolomite conformably overlies the Black Reef Quartzite, and grades upward into the upper member of the Supergroup, the Penge Banded Ironstone.

In hand specimen, the dolomite is typically crystalline and blue grey in colour, although it may assume a pink colouration close to fracture zones. The succession is comprised dominantly of carbonate rocks with interbedded cherts, and occasional intercalations of shale, particularly in the upper levels.

Button (1974) has subdivided the Malmani Dolomite into six conformable units on the basis of gross lithology (Fig.3.2). The lower unit, the Transition Zone, lies conformably on the Black Reef Quartzite, and may be readily identified by means of the abundance of quartzite and shale, the lack of interbedded chert, and the dark colour of the dolomite. The dolomite of this zone has a relatively high iron and manganese content, and displays a chocolate brown colouration on weathered surfaces. The Lower Chert - poor Zone conformably overlies the Transition Zone, being characterized by chocolate weathering dolomite and a paucity of

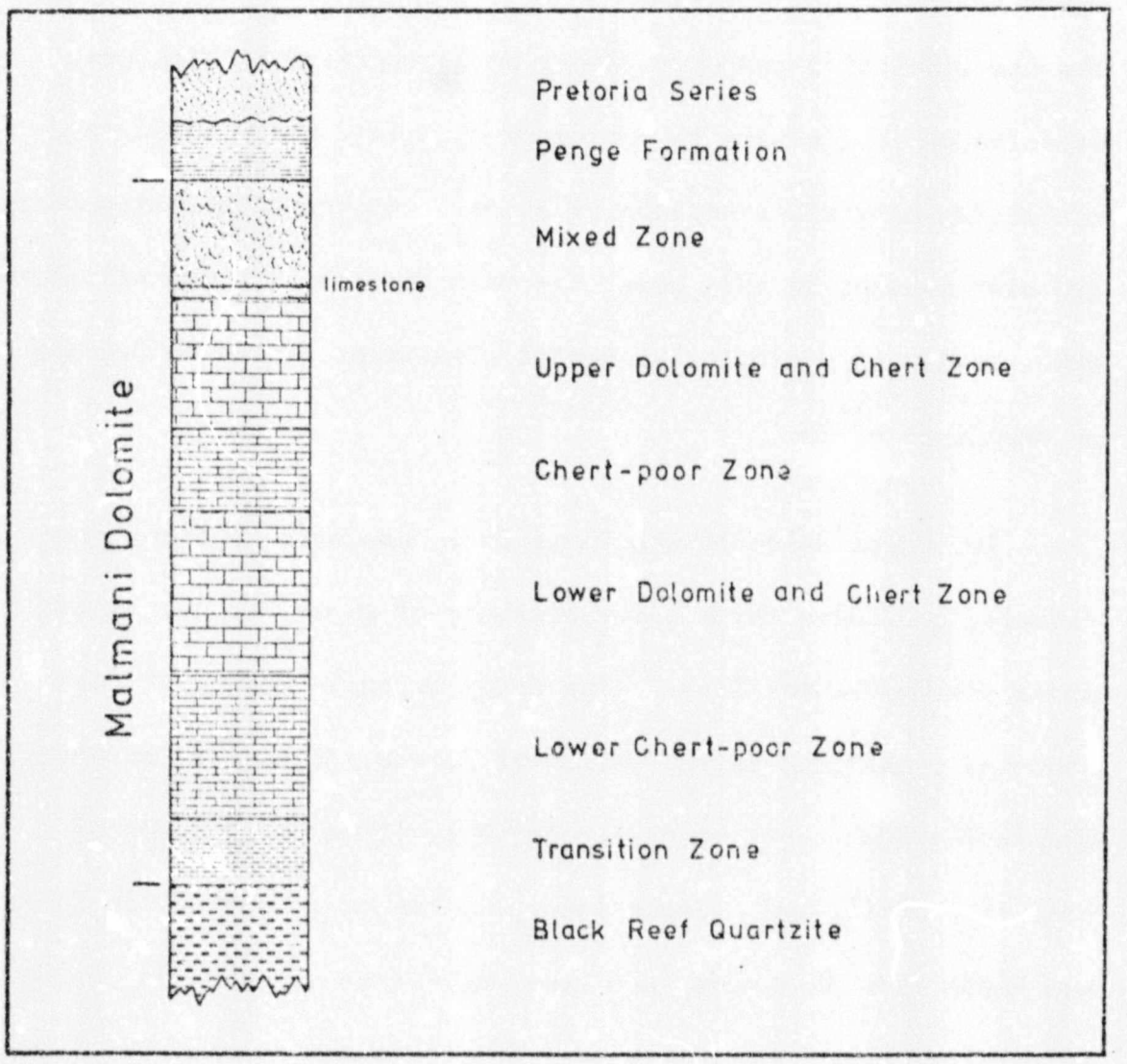


Figure 3.2: Stratigraphy of the Malmani Dolomite, North-Eastern Transvaal

chert. In addition, this zone exhibits algal laminations and domical stromatolites of up to 1m in diameter.

The Lower Chert-poor Zone is overlain by the Lower Dolomite and Chert Zone which consists of light grey dolomite interbedded with abundant chert, ranging from thin laminae to 2m thick beds. Beds of black mudstone and chert in shale breccia may be encountered within this zone, and occasional domical stromatolites of 100mm to

200mm in diameter may be observed. The Chert-poor Zone overlies the Lower Dolomite and Chert Zone, being typified by dark grey dolomite which weathers to a grey or chocolate brown colour and containing only minor amounts of chert. Stromatolitic structures are also present in this zone, the most diagnostic being elliptical domes having approximate horizontal dimensions of 10m by 3m, and an amplitude of 1m.

The Upper Dolomite and Chert Zone, composed of light grey dolomite and 100mm thick intercalations of chert, is developed above the Chert-poor Zone. The Upper Dolomite and Chert Zone contains a characteristic horizon of 'bread and butter' dolomite displaying 30mm chert bands separated by 150mm thick bands of dolomite. (Fig.3.3) Small laterally linked stromatolitic domes are known from this zone, and some very large domes of up to 10m in diameter have been observed. The uppermost zone of the Malmani Dolomite is the Mixed Zone, containing dolomite and chert alternations, significant amounts of limestone and banded ironstone, and a characteristic black carbonaceous mudstone marker indicating the base of the zone. Chert is generally subordinate in this zone, and is typified by its discontinuous distribution. Numerous limestone lenses are known, the most persistent having been traced for over 130km along strike, and being up to 100m in thickness.

Since there is a marked variation in lithological characteristics throughout the succession, the geochemical variation within the Malmani Dolomite will be examined.

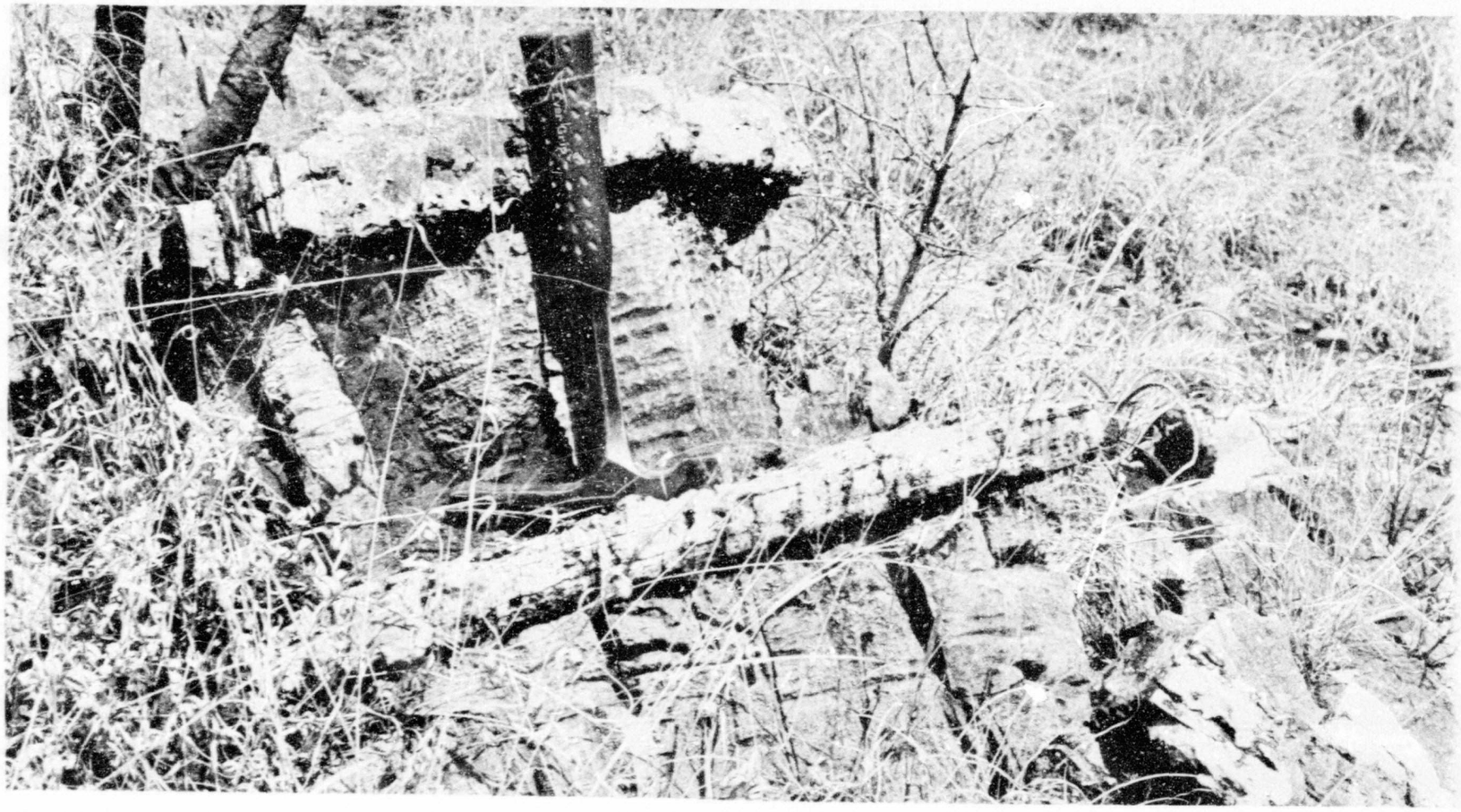


Figure 3.3: 'Bread and butter' dolomite near to the entrance of Wolkberg Cave

Geochemistry of the Dolomite

Eriksson (1971) and Button (1973) have conducted detailed chemical analyses on samples of the Malmani Dolomite which indicate that it is a true dolomite rather than a dolomitic limestone,[1] as had been previously proposed (Baring Horwood, 1910). Eriksson found that the variation in the CaO/MgO ratio of samples from the Potchefstroom region lies within the range 1,38 to 1,43, values which are comparable with that of true dolomite (1,39). Button's analysis of samples from the North-Eastern Transvaal confirmed these findings, and indicated that the dolomite becomes more calcic towards the top of the succession, CaO/MgO ratios rising from 1,3 at the base to 1,6 at the base of the mixed zone (Fig. 3.4a). The CaO/MgO ratio shows a marked increase at the position of the limestone bands of the Mixed Zone due to the increase in CaO (Fig.3.4b) and the corresponding decrease in MgO (Fig.3.4c).

The variation in Fe (Fig.3.4d) and Mn (Fig.3.4e) through the succession has been noted to be closely linked with the occurrence of chocolate weathering dolomite (Button, 1974), the chocolate colour of the weathered surfaces being due to the oxidation of Fe and Mn. Button also discussed the irregular distribution of SiO_2 (Fig.3.4f), and concluded that as the increases in SiO_2

---

1. The form of the dolomite molecule influences the effect of solution since a true dolomite, having the form $Ca.Mg.(CO_3)_2$, is less soluble than a dolomitic limestone which has the form $CaCO_3.MgCO_3$.

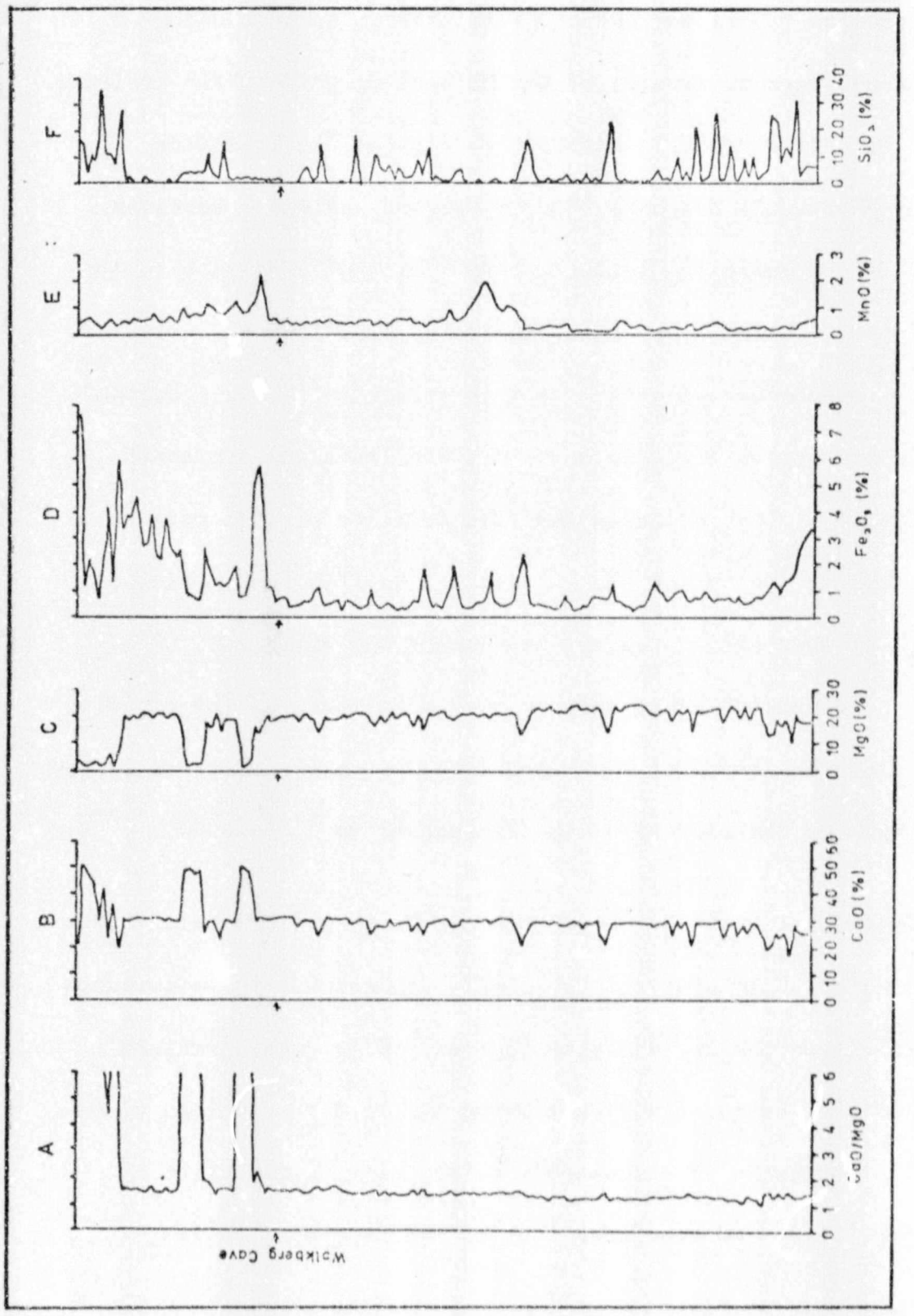


Figure 3.4: Variation of chemical parameters within the Malmani Dolomite (after Button, 1973): (a) CaO/MgO ratio; (b) CaO; (c) MgO; (d) Fe_2O_3; (e) MnO; (f) SiO_2.

content were linked with an increase of the CaO/MgO ratio, the development of chert was due to the replacement of carbonates with silica, MgO rather than CaO being replaced preferentially.

Structure

The Malmani Dolomite in the North Eastern Transvaal has undergone regional tectonism, resulting in the development of an east-northeast to west-southwest trending fold belt, and the emplacement of dolerite dykes. The structure in the vicinity of the Wolkberg Cave is dominated by a series of anticlines and synclines (Fig.3.5), and the cave is located on the southern limb of an anticline, the rock dipping at 30° to the south. Structural features, particularly dykes and lineaments, are frequent, and may be seen to have influenced the development of the landscape, as is evidenced by the linearity of valleys and stream courses. An analysis of these features from aerial photographs of the region[1] indicates that the major lineaments have an azimuth[2] between 300° and 310° and between 330° and 340° (Fig.3.6a). The dolomite is well jointed, and an analysis based on the length and orientation of joints in the vicinity of the cave entrance indicates that the major joint sets have azimuths lying between 300° and 310°, and between 010° and 020° (Fig.3.6b).

* * * * * * * * * *

---

1. Government Survey, Pretoria, Run 651, Photographs 2659, 2660, 2661.
2. All Azimuths cited in this dissertation relate to True North

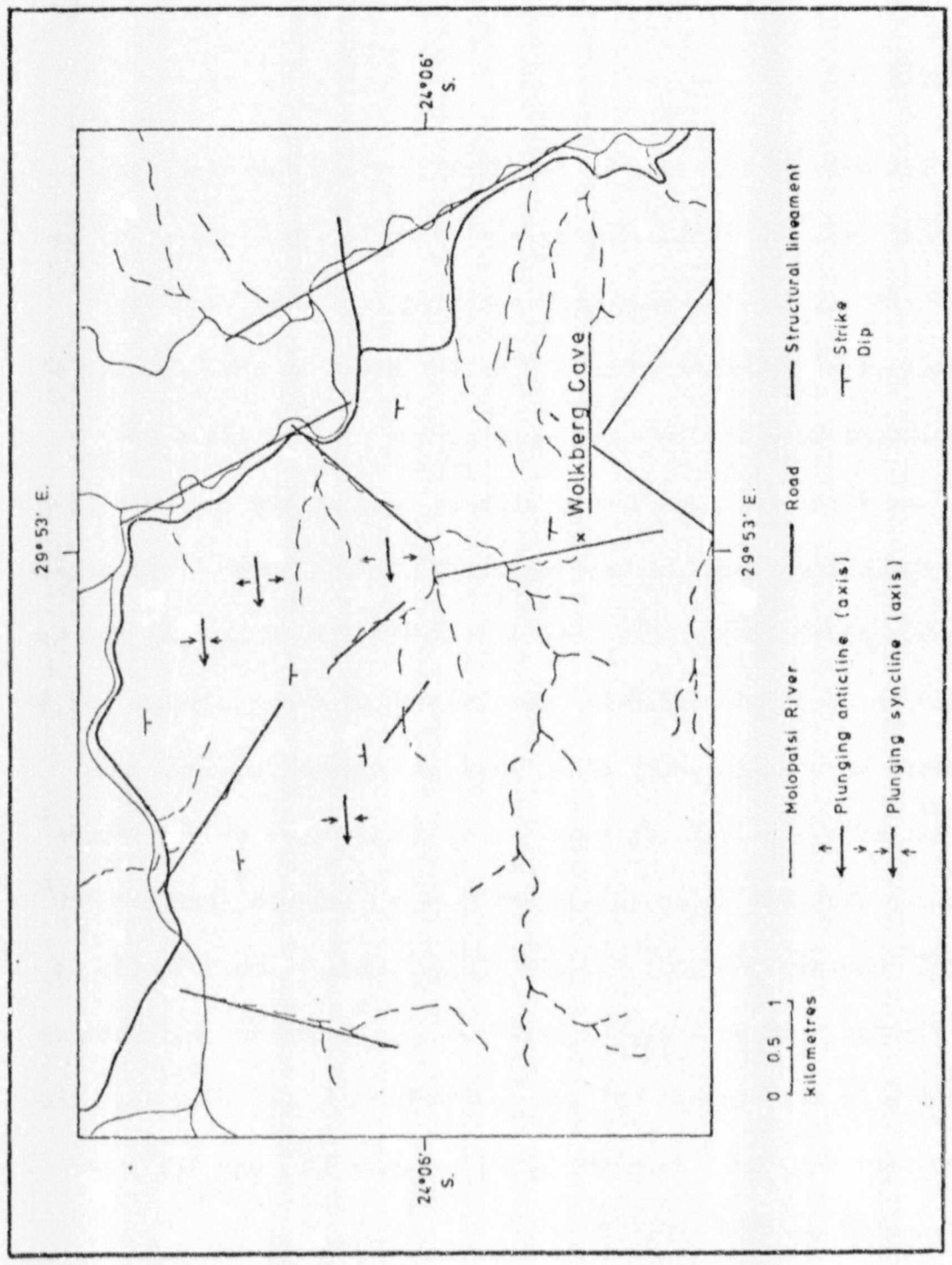


Figure 3.5: Geological structure in the vicinity of the Wolkberg Cave.

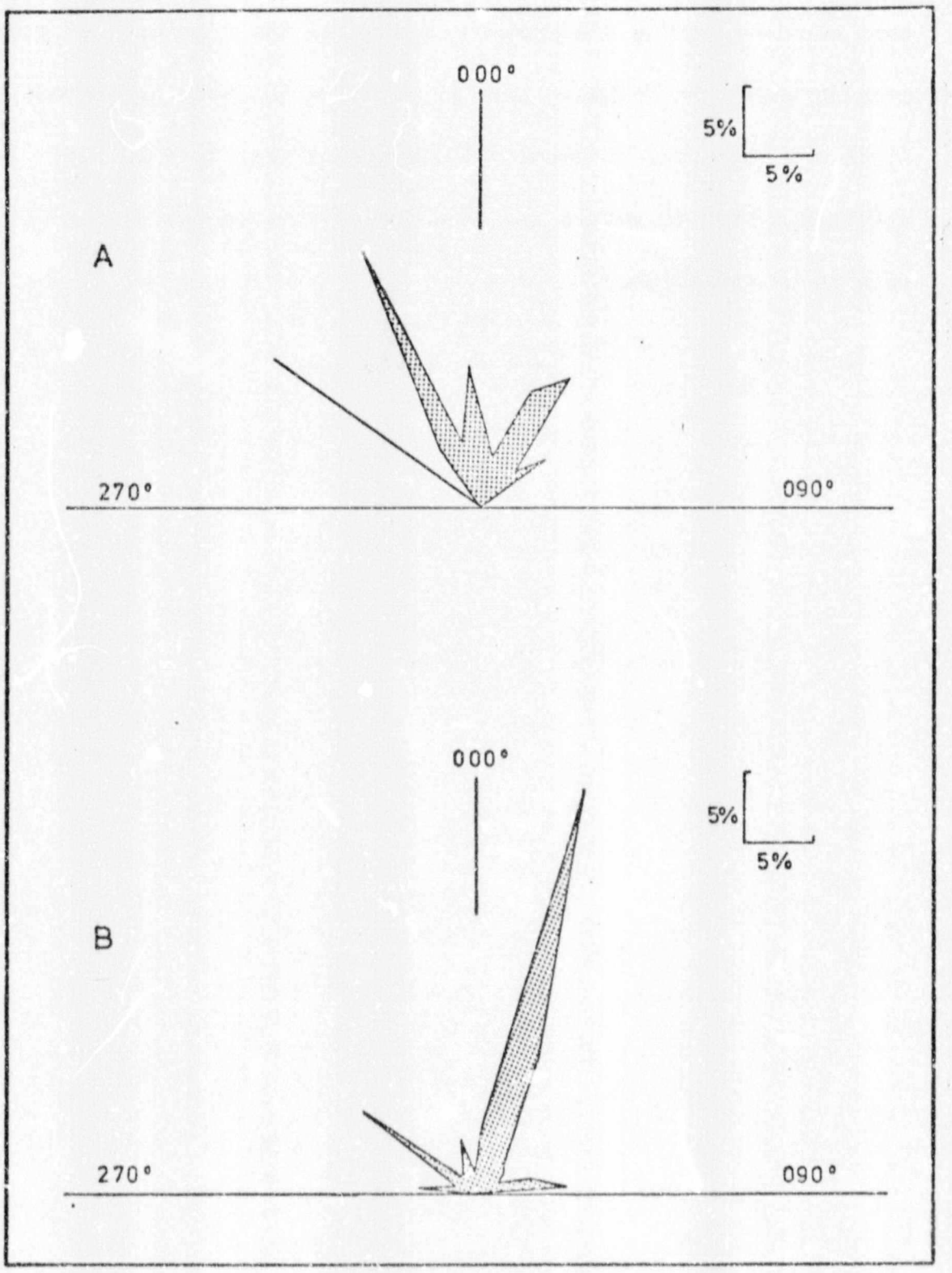


Figure 3.6: Orientations of :

(a) structural lineaments,
(b) joint sets.

In the preceding sections, the available literature has been examined, and a description of the relevant features of the area in which the Wolkberg Cave is situated has been presented. It is now necessary to examine the evidence preserved in the Wolkberg system to enable the sequence of development of that cave to be established.

* * * * * * * * *

PART TWO: THE WOLKBERG CAVE

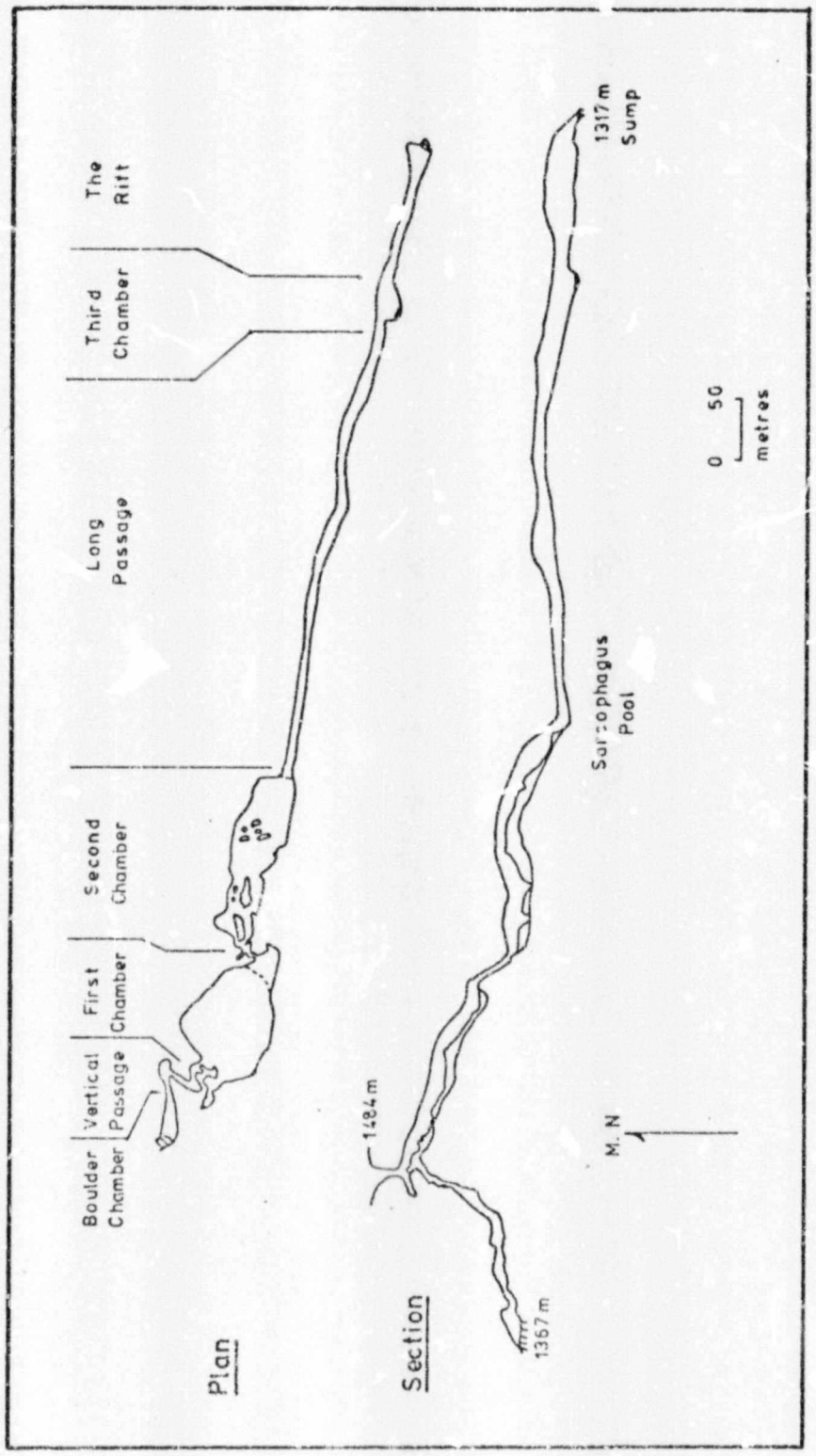


Figure 4.1: The Wolkberg Cave (after S.Afr. Spel. Ass., 1969).

CHAPTER FOUR

FORM AND FEATURES OF THE WOLKBERG CAVE

MORPHOLOGY

The Wolkberg Cave is a linear cave approximately 1000m in length, having an azimuth of 300° to 302°, and it may conveniently be divided into seven component sections on the basis of morphology (Fig.4.1, Table 4.1). The most striking feature of the system is the lack of side passages The First and Second Chambers have previously been thought to be offset and two separate chambers (Marker, 1974), but a detailed survey of the tube connecting these two caverns indicates that the Second Chamber is a continuation of the First (Fig.4.2). This conclusion is supported by the nature of the floor and ceiling in the vicinity of the tube, since both slope at a similar gradient in the same direction in both chambers, rather than in opposite directions as would be expected were they two separate chambers. In long profile, the system may best be described as sub-horizontal, although bedrock floor is never exposed due to the amount of fill material present, and the ceiling height varies due to the influence of collapse domes.

A further feature of interest is the variation in width of the First, Second and Third Chambers, and the minor variation in the width of the Long Passage and The Rift in relation to the general outline of the Long Passage. Examination of the areas

Author Hawke David Vivian
Name of thesis Cavern development in the Malmani Dolomite, Transvaal. 1975

PUBLISHER:
University of the Witwatersrand, Johannesburg
©2013

LEGAL NOTICES:

Copyright Notice: All materials on the University of the Witwatersrand, Johannesburg Library website are protected by South African copyright law and may not be distributed, transmitted, displayed, or otherwise published in any format, without the prior written permission of the copyright owner.

Disclaimer and Terms of Use: Provided that you maintain all copyright and other notices contained therein, you may download material (one machine readable copy and one print copy per page) for your personal and/or educational non-commercial use only.

The University of the Witwatersrand, Johannesburg, is not responsible for any errors or omissions and excludes any and all liability for any errors in or omissions from the information on the Library website.