Excavation of Historic Cave, Progress Report 2001

A. Esterhuysen

1. Stability Assessment

Concern was expressed about the safety of the cave during the 2001 meeting of the Research Advisory Committee, and I was requested to carry out stability assessment. I consulted with two geologists Fred Calitz from GeoCon and John Cruise of John Cruise Mining in May 2001. The GeoCon report was only received in August 2001, while John Cruise responded immediately (copies of both responses are included). Under the advice of the two geologists, safe pathways were defined and the cave roof immediately over the excavation propped.

2. Excavations 2001

Three excavations were carried out over the course of the year, during July, October and December. Four members of the local communities were trained to sieve, sort, label and bag the artefacts. They were paid R45- per day and provided with lunch, as requested by the community. Further assistance was obtained from heritage and archaeology students, and archaeology colleagues from Cape Town and Wits.

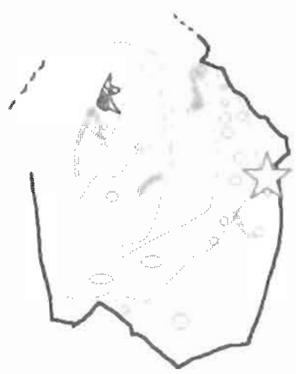

Fig. 1. Excavation Area

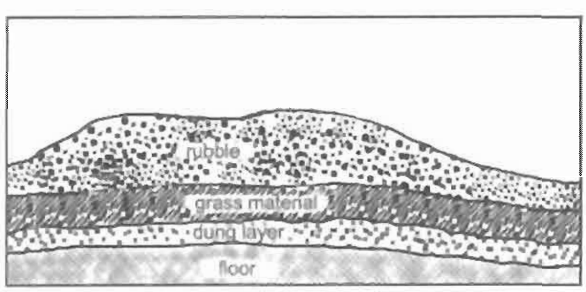

Fig. 2. Schematic of excavated layers

To date $12m^2$ have been excavated in the base of the eastern cavern (Fig.1). Essentially, three layers were removed (Fig. 2.). First, a layer of rubble comprised of roof spall (RBL); secondly, a layer rich in grass material (GM); and finally, a compressed layer of rodent droppings (RD). Underneath layer (RD) a moulded daga floor was exposed.

Analysis of the different layers provides an idea of the order and manner in which the deposit was built up. It appears that once human activity in the cave slowed down or ceased the rodents descended on mass, attracted by left over grain and rotting flesh. They deposited the layer of rodent droppings on top of the daga floor. A pole and daga wall that ran in front of M3/N3 may have been set alight as a thick layer of ash is mixed in with the rodent RD in M3/N3 (see Fig 3.). The rodents then began to build nests above the floor and ash. Most of the human remains were found in the grass nests of the rodents. The human remains are comprised mostly of mandibles, teeth, and a few long bones. At a later stage the sidewall collapsed into the rodent bedding, collapsed daga and the remains of burnt posts were located in M1/2 (see fig. 3). Finally, the roof collapsed.

All the layers were rich in artefacts. RBL as expected contained a mixture of old and more contemporary artefacts. For example, Early Iron Age pottery was found together with beads that date from the 50s and a coin from the 70s. One of the more interesting artefacts was a piece of newspaper that dates to between 1903 and 1913. It makes mention of mining activities on the reef, and documents the arrival of Cranberries in the Cape.

GM is by far the richest layer containing objects that appear to be more contemporary with the siege of 1854. Lead bullet, skeletal material, fragments of Dutch Bible, pottery, beads, pot holders, items of clothing etc. RD was fairly sterile apart from hair and insect pods that became trapped in it. These will be analysed.

Most of the objects lying immediately on the floor were plotted and once the floor was exposed it was mapped. Two activity areas are evident: first, an area of food storage and preparation (M/N/O2/1), and secondly, an area of ritual practice or storage of ritual objects (M/N3). This area may have been partially concealed by the fence/wall (collapsed ash).

The remains of a hanging basket, which was probably filled with sorghum/millet, provides evidence of a food storage area. Large amounts of grain were found all around the basket. A stone lid was found in N2 and may have covered the cavity in the floor in front of it. This has yet to be excavated (Fig. 4.).

A cooking pit was found in O2 and many grindstones; pottery and cooking utensils were spread around the floor. The area behind the floor and immediately in front of the cave wall functioned as a midden.

Piles of broken pottery and a number of broken cooking implements were found in this area. The loose soil in the back was also rich in millet sorghum, beans, aloe leaves and fruits seeds (mostly sour plum).

Fig. 4. Stone Lid in front of a possible pit

Fig 5. Back 'midden area'

The area N3 appears to have a more ritual association. A pot found in this area contained grey/blue pigment that had been mixed with a fatty substance. Iodine tests were carried out to test for the presence of fatty acids, and then to determine whether there was a predominance of saturated (animal) or unsaturated (plant) fatty acids. The mixture tested positive for saturated fatty acids. A few pieces of the grey/blue pigment found outside of the pot were used as a control. It is documented that fat was often used by the Langa Ndebele in protection 'muti'. A divining bone/dice, gourds filled with red and white pigment, as well as a cow horn with a thong looped through a small hole in the top, which would allow it to be hung, also speak of ritual activity. A bolus of half-burnt *Ficus* sp. was found lying in this area, and *Ficus* is also known for its ritual qualities.

3. Excavations 2002

This year the existing excavation will be extended to determine the extent and shape of the floor. Other floors will then be excavated, two on the terraced slope in the eastern cave and then hopefully another two in the northern cave. These will be excavated to provide a comparative base for the existing floor.

As these floors provide a benchmark from which to work backwards in time, they will then be broken and excavation will continue underneath them.

4. Community Meeting

A meeting was held with the Kekana on the 27th October 2001 in order to inform the elders about the excavation and findings. I was most concerned about the amount of human skeletal material that was being excavated, and repeated the requested that they permit me to hold them for research purposes until the excavation was complete. The complete collection human remains will then be returned for burial.

2.3 REAR SIDEWALLS

The following observations were made during a survey conducted on 21 May 2001:

- The rear sidewalls of the cave are composed of gently dipping sequences of highly fractured and partially shattered rock separated by more homogeneous and solid rock. As a consequence, a relatively solid slab of rock with widely spaced fractures and joints overhangs the principal area of research. This slab is only supported along the left and rear sidewalls of the cave.

- This slab is separated from the adjacent rock by prominent but narrow joints with relatively rough joint surfaces. The upper surface of the slab is defined by a narrow, horizontally orientated bedding plane that has been filled with a soil-like material.

- This slab exhibits very little lateral support, with the adjacent rock being highly fractured and shattered.

- The floor of the rear portion of the cave exhibits localised areas that are free of rock debris.

- Several large but localised pockets of very highly fractured and crumbly material overhang this area without significant support. These pockets are approximately 5 m^3 in volume, and thus weigh at least 10 tons. It must be noted that one of these pockets overhangs the entrance to the adjacent cave, severely limiting the use of this cave as a possible escape route in the event of cave collapse.

3 Conclusions

3.1 CAVE ENTRANCE

The arch of rock that forms the cave entrance is deemed to be ***highly unstable***. Collapse of the arch will mobilise a large volume of material that may ***seriously injure*** or ***kill*** persons working within the upper reaches of the cave or at the entrance.

In the light of the available and observed information, it is assumed that any of the following trigger mechanisms may lead to the collapse of the rock arch that overlies the cave entrance:

- Mining-induced seismic shocks on a regular basis (blasting, etc.)
- Reduction of the cohesion of the joint fill material, due to saturation after heavy precipitation events

The height of the arch above the unstable floor prevents it from being supported from beneath, except at prohibitive cost. The relatively thin layer of rock that occurs directly above the arch slab prevents the installation of a suitable rock anchoring system (i.e.: rock bolts, etc).

3.2 CENTRAL PORTION OF THE CAVE

The central portion of the cave is deemed to be ***moderately stable***. Collapse of portions of the roof along fractures may mobilise relatively small volume of material that may ***seriously injure*** persons working within the cave. The area exhibits a ***low risk*** of the collapse of larger portions of the roof that will mobilise a large volume of material that may ***seriously injure*** or ***kill*** persons working within the cave.

In the light of the available information, it is assumed that any of the following trigger mechanisms may lead to the collapse of the roof of the cave:

- Mining-induced seismic shocks on a regular basis (blasting, etc.)
- Reduction of the cohesion of the joint and fracture fill material, due to saturation after heavy precipitation events

The height of the roof above the unstable floor prevents it from being supported from beneath, except at prohibitive cost. The thickness of the layer of rock that occurs directly above the roof is currently unknown, but may be too thin to support the installation of a suitable rock anchoring system (i.e.: rock bolts, etc.).

3.3 REAR SIDEWALLS

The rear sidewalls of the cave are deemed to be ***moderately unstable***. Collapse of portions of the sidewalls along fractures may mobilise relatively small volume of material that may ***seriously injure*** persons working within the cave. This area exhibits a ***moderate risk*** of the collapse of larger portions of the rear sidewalls that will mobilise a large volume of material that may ***seriously injure*** or ***kill*** persons working within this area. However, the localised pockets of fractured and crumbly material exhibits a ***high risk*** of collapse that will mobilise a relatively large volume of material that may ***seriously injure*** or ***kill*** persons working within this area.

In the light of the available information, it is assumed that any of the following trigger mechanisms may lead to the collapse of the rear sidewalls of the cave:

- Mining-induced seismic shocks on a regular basis (blasting, etc.)
- Reduction of the cohesion of the joint fill material, due to saturation after heavy precipitation events
- Gravity

The height of the rock slabs above the relatively stable floor allows the installation of a suitable rock support system (i.e.: telescoping rods, scaffolding, etc.).

The height of the pockets of fractured and crumbly rock above the cave floor, as well as the poor stability of this material, prevent it from being supported from beneath.

4 Recommendations

4.1 SHORT TERM UTILISATION

The following monitoring actions are recommended for implementation during the conducting of short-term **RESEARCH** within the cave:

- The rock slabs overhanging the area of principal research should be ***supported*** by means of telescoping rods or the installation of scaffolding.
- It is also recommended that a ***net*** with a high tensile strength be installed vertically in front of the scaffolding to dissipate the momentum of the relatively small rock fragments, thus reducing the risk of rock fragments penetrating into the research area.
- ***Constant vigilance*** is required to spot areas where collapse may potentially occur.

4.2 MEDIUM- AND LONG-TERM UTILISATION

The long-term utilisation of the cave for research and/or tourism purposes can be ensured by either the installation of suitable, aesthetically acceptable, ***long-term support structures***, or the implementation of a ***stability monitoring system***.

4.2.1 Long-term support structures

- It is recommended that ***nets*** with a high tensile strength be installed in relatively homogeneous and solid rock from the rear sidewalls directly behind the dome of the cave roof towards the cave entrance to dissipate the momentum of the relatively small rock fragments, thus reducing the risk of rock fragments penetrating into the research area in the lower reaches of the cave.
- Suitable measures should be taken to support or strengthen the cave entrance arch.

4.2.2 Monitoring

- Strain gauges should be installed over the most prominent zones of weakness in locations to be determined on site. These gauges should give ***audible warning*** in the event of any movement along this joint.
- ***The cave should be evacuated without delay at the sounding of this alarm, even if there are no other signs of collapse (i.e.: sifting rock powder or the falling of small fragments).***
- The sounding of the alarm should be reported to GeoCon as soon as possible to allow the re-evaluation of the stability of the arch. ***No persons should be allowed into the cave until this assessment has been conducted.***
- The area in question should be ***photographed*** after each alarm for future reference, and the date and time noted in a long-term databank. The gauges should be reset if the imminent collapse is not anticipated.

4.3 DETAILED INFORMATION ON RECOMMENDED SUPPORT ACTIONS

4.3.1 Long-term support structures

The placement of nets within the cave may reduce the risk of serious injuries or loss of life to a significant degree, but will have a significant impact on the visual aesthetics of the cave for tourism purposes.

No recommendations on the specific method for the support or strengthening of the cave entrance arch are included in this report., due to budgetary constraints and the complexity of the problem.

Cost estimations with regard to long-term support structures will have to be obtained during consultation with specialists, if required.

4.3.2 Strain gauges

Discussions with Mr. Brian Jones of the firm Brain Jones Associates has led to the design of a simple, but elegant, strain gauge monitoring system for implementation at the Makapans Historical Cave.

It is recommended that a total of three strain gauges be installed initially, at the following locations:

Gauge 1	*Cave entrance arch*
Gauge 2	*Joint along cave roof*
Gauge 3	*Joint at rear sidewall*

Deformation of a piezo-crystal mounted inside the gauges will generate an electrical current that will be transmitted to a single control unit, mounted in a lockable steel box placed directly outside the cave entrance, by means of brown-coloured wires (to lower its visual impact).

The control unit will be battery-powered, as solar panels are deemed to be too expensive, and are prone to vandalism and theft. Care must, however, be taken that worn batteries are replaced timeously.

The control unit will record movement in any or all of the gauges, and will signal an audible warning by means of an amplifier and siren. The control unit will also be able to display the strength of the current being generated by a specific gauge to facilitate the evaluation of the magnitude of movement at that location.

The control unit will be fitted with a red LED that will indicate that an alarm has been given. Resetting the alarm will cause a green LED to glow. This system will indicate the sounding of an alarm during periods where no personnel are within the cave (i.e.: at night or over weekends), ***in which case no person should be allowed to enter the cave until a stability evaluation has been conducted.***

An estimation of the costs with regard to the supply and installation of three strain gauges and the control unit is included as Appendix A. A total cost of **R 38 000**, including cabling and installation, is envisaged for the basic gauge system. Optionally real-time radio-based telemetry and a solar power unit can be installed to provide a quicker response time.

4.3.3 Monitoring

It is envisaged that a GeoCon official will generally be able to respond to such an alarm ***within 60 minutes***, depending on other project commitments

These inspections will initially be conducted at a time/cost basis until a longer-term trend can be distinguished, after which a monitoring fee can be determined for a specific monitoring period. This will facilitate the calibration of the monitoring programme with regard to the weekly mine-induced seismic shocks that may regularly sound one or all of the alarms. It is envisaged that the costs with regard to these inspections will be in the order of ***R 1 000*** *(excluding VAT)*.

GeoCon undertakes to design and maintain the stability database on an ongoing basis, if required by the University. Costs in this regard are included in the above-mentioned monitoring fees.

Details of skulls removed by W. L. Distant

1299[1]. A metopic cranium.

C. 515, L. 184, B. 129, Bi. 701, H. 133, Hi. 723, BN. 105, BA. 105, Ai. 1000, Nh. 47, Nw. 25, Ni. 532, Ow. 37, Oh. 34, Oi. 919, Ca. 1445.

1299[2]. A cranium.

C. 510, L. 185, B. 128, Bi. 692, BN. 98, BA. 100, Ai. 1020, Nh. 55, Nw. 28, Ni. 509, Ow. 36, Oh. 39, Oi. 1083, Ca. 1350.

1299[3]. A cranium.

C. 501, L. 182, B. 124, Bi. 681, H. 129, Hi. 709, BN. 96, BA. 95, Ai. 990, Nh. 43, Nw. 26, Ni. 605, Ow. 37, Oh. 32, Oi. 865, Ca. 1275.

1299[4]. A cranium (14).

C. 492, L. 178, B. 128, Bi. 719, H. 128, Hi. 719, BN. 95, BA. 94, Ai. 989, Nh. 38, Nw. 22, Ni. 579, Ow. 38, Oh. 30, Oi. 789, Ca. 1305.

1299[5]. A cranium (13).

C. 500, L. 181, B. 131, Bi. 724, H. 128, Hi. 707, BN. 90, BA. 91, Ai. 1011, Nh. 45, Nw. 22, Ni. 489, Ow. 34, Oh. 31, Oi. 912, Ca. 1530.

1299[6]. A cranium (12).

C. 485, L. 175, B. 127, Bi. 726, H. 126, Hi. 720, BN. 92, BA. 97, Ai. 1054, Nh. 36, Nw. 22, Ni. 611, Ow. 36, Oh. 30, Oi. 833, Ca. 1340.

The above six crania are from the Makapan's cave, and probably belong to the Makapan Tribe, Waterbery District, Transvaal.

Presented by W. L. Distant, Esq., 1892.

1300. The articulated skeleton of an adult male Bushman. O. C. 5357.

Most of the teeth have been lost during life; and the calvarial sutures are partly united.

Height 4 feet 4·5 inches = 1333.

Clavicle 131; humerus, *r.* 255, *l.* 250; radius, *r.* 208, *l.* 207; femur, *r.* 356, *l.* 363; tibia, *r.* 299, *l.* 302.

Cranium: C. 500, L. 175, B. 134, Bi. 766, H. 128, Hi. 731, BN. 91, Nh. 46, Nw. 29, Ni. 630, Ow. 38, Oh. 29, Oi. 763, Ca. 1260.

Presented by Henry Bickersteth, Esq., Surgeon to the Somerset Hospital, Capetown, 1849.

1 Introduction

1.1 TERMS OF REFERENCE

Southern Africa GeoConsultants (PTY) Ltd, known as GeoCon, was appointed by the School of Geography, Archaeology and Environmental Studies of the University of the Witwatersrand to evaluate the stability of the Historical Cave at the Makapans Gat Cave Complex located on the farm Makapansgat 39-KS near Potgietersurs in the Northern Province (Figure 1).

1.2 SCOPE OF THE WORK

The investigation comprised the following actions:

- A desk study, during which all available information on the cave was studied
- A cave stability survey, during which the cave was divided into stability zones based on visual inspection
- Data evaluation
- Liaison with tunnel and cave support specialists
- Report compilation

2 Results

2.1 CAVE ENTRANCE

The following observations were made during a survey conducted on 21 May 2001:

- The Makapans Historical Cave entrance is formed by a highly fractured and partially shattered rock arch, and is overhung by rock slabs at least 20 m^3 in volume (i.e.: in the order of 40 tons in weight).
- The largest of these slabs is separated from the adjacent rock by prominent but narrow joints with relatively rough joint surfaces. The upper surface of the slab is defined by a narrow, horizontally orientated bedding plane that has been filled with a soil-like material.
- This slab exhibits very little lateral support, with the adjacent rock being highly fractured and shattered.
- A relatively thin sequence of nearly horizontally layered rock overlies the slab.
- The arch is located approximately 20 m above a steeply dipping, rubble-strewn floor, where some sites of historical and archaeological value are located. This area also forms the main entrance route to the lower reaches of the cave.

2.2 CENTRAL PORTION OF THE CAVE

The following observations were made during a survey conducted on 21 May 2001:

- The cave roof is formed by moderately fractured and partially shattered rock with a nearly horizontal bedding structure. These fractures are generally narrow and have been cemented by calcium deposits. Small speleothemes can be observed along these fractures.
- The roof generally exhibits an onion-skin layering composed of relatively homogeneous dolomite slabs up to 2 m thick separated by narrow, horizontal bedding planes. Some of these layers have collapsed in the past, but the roof generally exhibits a smooth surface reflecting the base of one of these layers.
- The rock mass adjacent to the fractures is generally highly fractured and shattered, and has been broken into relatively small fragments (i.e.: approximately 1 m^3 in volume, weighing approximately 2 tons). These fragments exhibit very little lateral support.
- The roof is extensively coated with soot presumed to be from camping fires of Makapan community *circa* 1854. No evidence of more recent collapse (i.e.: portions of the roof where no soot stains occur within an otherwise stained area) was observed in this area.
- The roof is located between 20 and 30 m above a steeply dipping and rubble-strewn floor where several sites of historical and archaeological value are located. The main access route to the lower reaches of the cave leads through this area.

In the western cave, the roof is not as arched as the eastern cave and is held up by the thickness of the rock beam to the next parting plane and the tightness of that plane.

OPINION

It is my professional opinion that:-

1. The western cave is safe for intermittent through travelling.
2. The eastern cave is also safe for through travelling.
3. At the area indicated for excavation in the eastern cave i.e. against the sidewall, the area is safe for extended periods of working.
4. The least safe area is the entrance to the eastern cave under the brow. Recent cracking and minor falls were observed.

RECOMMENDATION

1. Both western and eastern caves can be used as is for access to and from the excavation site. However, it would be prudent to prohibit tourists from entering.
2. As an additional safety precaution, timber props should be erected at the excavation site to provide support for the immediate roof and to provide psychological comfort to those people working there for extended periods of time.
3. The viewing platform at the entrance of eastern cave should be moved back so that it is not under the brow of the entrance. It can be raised a metre or two to obtain a better view of the inside of the cave.

J.A. CRUISE PR. ENG.

Project report: 2001/06/05/KARST

Stability assessment:

Makapans Historical Cave located on the farm Makapansgat 39-KS near Potgietersrus in the Northern Province

July 2001

Author:

F. Calitz

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2 June 2001

The Director
BPI Institute of Palaeontological Research Unit
University of the Witwatersrand
1 Jan Smuts Avenue
Braamfontein

Attention: Professor Bruce Rubidge

Dear Bruce

MAKAPANSGAT HISTORIC CAVE – SAFETY

I visited the Historic Cave at Makapansgat with Amanda Esterhuysen on Saturday 2 June 2001 with a view to determining the relative safety of persons working inside the cave from falls of rock from the roof.

We entered the western cave, proceeded to the eastern cave, inspected the proposed excavation site and exited through the eastern cave entrance.

In determining the possibility of collapse of the roof, cognisance is taken of the physical nature of the cave, which includes faults, parting planes, joints, rock types, gouge filling and the geometry of the cave. In addition, observations were taken of dynamic occurrences such as recent rockfalls, ingress of flowing groundwater and human disturbances such as mining or blasting.

GENERAL OBSERVATIONS

The caves appear to have been open for some time and there does not appear to have been a major rockfall in the past few years. The eastern cave has arched and although major faults and bedding planes are evident as are isolated pockets of soft gouge fill, the geometry of the roof structure as an arch is a more stable structure than would be a flat roof over that large a span. There does not appear to be seepage of groundwater, which could weaken the joints, nor is there evidence of recent mining.

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FIG.3.
H = human remains