Surface subsidence in southern Africa
Affaissements de surface en Afrique du sud

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SYNOPSIS: This paper discusses and examines the causes and distribution of large scale surface subsidence in southern Africa.

Severe subsidence problems are restricted to dolomitic rockmasses and shallow coal mining in incompetent sedimentary rockmasses.

The subsidence features associated with dolomitic rocks are sinkholes and dolines. The occurrence of these features is difficult to predict and, in the case of sinkholes, may result in loss of life. Development on these sites is preceded by detailed geotechnical investigations in which the risk of sinkholes and dolines occurring is assessed. On certain sites the risk can be reduced to acceptable limits by taking sensible precautionary measures. However, this risk can never be eliminated.

High extraction coal mining methods at shallow depth result in immediate subsidence which can be predicted within certain limits. However, not much has been published about the long term stability of such areas and research is being conducted in this regard. This will enable areas affected by total extraction to be restored to beneficial occupation as soon as possible after mining.

1 INTRODUCTION

Surface subsidence can cause widespread damage to infrastructure and can also reduce the development potential of an area.

In southern Africa surface subsidence is caused mainly by the following:

- Chemical solutioning of carbonate rocks and mechanical erosion of the derived permeable, compressible residuum. This leads to the formation of sinkholes and dolines. *

- Mine openings in which the support is either removed or collapses resulting in failure of the overlying rockmass and ultimately surface subsidence.

If there is a risk of sinkhole and doline development on a site this risk should be assessed at the outset of the project. The parameters which affect the risk should be listed, assessed, and the precautionary measures required to reduce the risk defined. If the risks or precautionary measures are unacceptable the project may be discontinued. Clearly it is necessary that this decision be made early in any project.

If mining is to take place in an area it is prudent to evaluate the nature and magnitude of possible subsidence. In this way the effect of subsidence on existing structures can be evaluated and the rehabilitation of the site on cessation of mining can be planned and the area restored to beneficial occupation.

In this paper the main causes of subsidence experienced in southern Africa are described and their mechanisms illustrated.

* See Appendix for definition of terms.

2 SUBSIDENCE DUE TO THE SOLUTIONING AND EROSION OF ROCKS

2.1 Statement of the problem in southern Africa

The problem is restricted to carbonate rocks (e.g. dolomite) susceptible to acidic attack by percolating groundwater in the phreatic zone. Subsequent internal erosion, or a lowering of the water table, can lead to the formation of sinkholes and dolines.

In particular the problem has been accentuated within those urban and mining areas where the water table has been artificially depressed or where there has been an unnatural and concentrated introduction of water into the residuum above the rockhead.

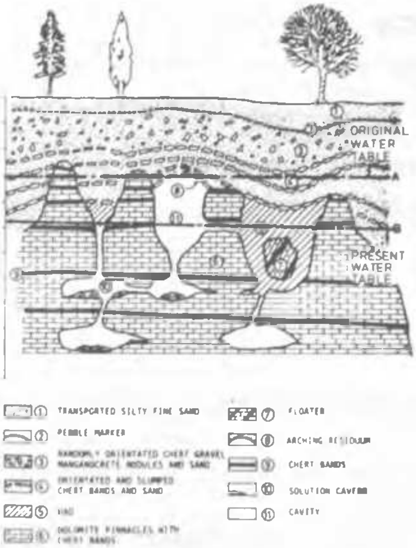
In those areas where artificial dewatering of the dolomite rockmass has occurred, thirty-eight people have lost their lives by being interred in sinkholes. Not so spectacular or catastrophic are large scale features caused by compaction subsidence which result in the differential depression of the surface over many hectares. These features (dolines) have resulted in extensive structural damage but not loss of life.

It has not been possible to ascertain the exact cost of damage and disruption caused by dolomitic subsidence but it runs into hundreds of millions of Dollars.

2.2 Development of the typical dolomite profile

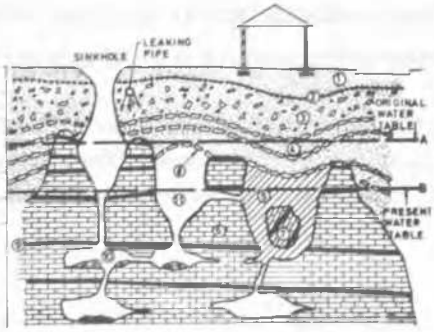
2.2.1 Solutioning

When fresh, the dolomite rock material has a high compressive strength and low porosity. It is, however, a calcium/magnesium carbonate and is therefore susceptible to attack by weak acidic solutions.



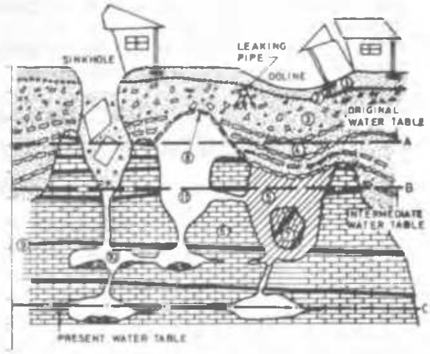
NOTES
1. NOTES 1 AND 2 AS FOR FIGURE 1(ii)
2. SITE IN EQUILIBRIUM WITH ENVIRONMENT WITH NO ACTIVE SINKHOLES.
3. SAND FILLED PALEO SINKHOLES AND DOLINES DO OCCUR.

FIGURE 1(i) UNDEVELOPED SITE WITH "STATIC" WATER TABLE CONDITIONS



NOTES
1. COVER OVER DOLOMITE MAY VARY FROM ZERO TO OVER 30m.
2. WATER TABLE LOWERED FROM A TO B OVER GEOLOGICAL TIME SCALE.
3. LIMITED SINKHOLE DEVELOPMENT DUE TO SUBSURFACE EROSION CAUSED BY CONCENTRATED ARTIFICIAL WATER INGRESS.

FIGURE 1 (ii) DEVELOPED SITE WITH "STATIC" WATER TABLE CONDITIONS



NOTES
1. COVER OVER DOLOMITE AS FOR FIGURE 1(ii)
2. WATER TABLE LOWERED FROM B TO C e.g. BY MINING.
3. RAPID LOWERING OF WATER TABLE AND SUBSURFACE EROSION DUE TO CONCENTRATED ARTIFICIAL WATER INGRESS.

FIGURE 1(iii) DEVELOPED SITE WITH RAPID LOWERING OF WATER TABLE

FIGURES 1 (i) TO 1 (iii) TYPICAL PROFILE ON DOLOMITE WITH DIFFERENT WATER TABLE CONDITIONS

In nature these solutions are represented by groundwater charged with carbon dioxide to form a weak carbonic acid. If solid (i.e. unjointed), the dolomite rockmass would resist such acid attack. However, as with most rockmasses, there is a well developed network of joints, faults, fractures, etc. resulting in a groundwater system that is hydraulically continuous. Movement of acidic groundwater within this system in the phreatic zone below the water table results in the widening of vertical joints (to form slots) and in the creation of near horizontal solution caverns in the zone immediately below the water table where acid attack is most severe.

2.2.2 Development of residuum

A fair percentage of the dolomite rock material comprises oxides of iron, aluminium and manganese. These oxides are resistant to acid attack and remain within the residuum after solutioning of the dolomite host rock. Of these, manganese oxide is the most important being represented by a highly erodible, low density, black sandy silt (wad).

Silica is also present as distinct hard rock bands of chert (SiO_2) which vary from millimetres to metres in thickness. The chert, being resistant to chemical attack, remains behind as large angular boulders and gravels along with the oxides, clays and sandy impurities which form the dolomite residuum (Figure 1).

2.2.3 The profile

In general, the typical profile shown in Figure 1 can be sub-divided into three basic units:

- A residuum of blocks of chert set in a matrix of oxides, clays and sands. In general the residuum is highly permeable and susceptible to internal erosion by percolating water. This erosion may result in the formation of cavities in the residuum above the water table.
- A semi-stable zone within the dolomite rockmass above and just below the water table characterised by solution widened slots, solution caverns and partially rubble filled or water filled cavities.
- A deeper stable zone within the dolomite rockmass where, although solutioning of joints has occurred, this has no real significance in the overall subsidence problem.

2.3 Mechanisms responsible for the formation of sinkholes and dolines

Of particular importance in the dolomite profile as described is:

- the occurrence of loose material (e.g. wad and sand) within the residuum. Erosion of this material leads to the rapid formation of cavities,
- the occurrence of chert blocks in the residuum. These blocks form semi-stable arches and allow cavities many metres in diameter to develop,
- the occurrence of large solution caverns in the zone immediately below the water table. Depression of the water table results in these caverns forming receptacles for the acceptance of the materials eroded downwards from the overlying residuum. Without these receptacles formation of cavities, and ultimately sinkholes, would be prevented.

When studying the formation of sinkholes and dolines in dolomite it is necessary to consider two situations viz:

- That in which the water table has been depressed naturally on a geological time scale i.e. is "static" with respect to current conditions.
- That in which there has been a rapid artificial lowering of the water table i.e. is "active" with respect to current conditions.

2.3.1 Dolomite within "static" water table

In most undisturbed dolomitic environments the water table is "static" in that lowering of the original water table (position A to position B, Figure 1(i)) takes place over millions of years. Slow solutioning and erosion occurs, and though some solution caverns may be above the water table, the area is generally in equilibrium with the environment and little or no subsidence occurs.

Should development take place in such an area, concentrated ingress of water into the profile could result causing erosion of the residuum from slots into those caverns above the water table. Cavities created by erosion in the residuum could then move upwards by progressive roof collapse eventually day-lighting as sinkholes as shown in Figure 1(ii). If the material forming the roof over a cavity is too weak to arch compaction subsidence results and dolines are formed.

2.3.2 Dolomite within "active" dewatering conditions

Assume an original water table at position B in Figure 1(iii). Most cavities and solution caverns are filled with water or residuum and are in equilibrium with the environment. Thus only minor erosion occurs within the residuum.

Should rapid dewatering take place and the water table is lowered to position C, the equilibrium is upset and subsurface erosion can occur. In addition rapid lowering of the water table within the residuum does not allow it to consolidate and thus increase in strength as would occur under undisturbed conditions. The residuum is thus more susceptible to erosion. Rapid dewatering empties large caverns providing receptacles for the eroded material and induces greater hydraulic gradients and thus internal erosion and the removal of residuum to these caverns. The nett result is the creation of large cavities within the residuum which generally, under the artificial conditions associated with dewatering, result in large sinkholes.

A doline develops where thick layers of compressible residuum, e.g. wad, are present below the original water table. Note that chert arches do not develop in the profile. This situation is shown in Figure 1(iii). The compressible residuum consolidates due to an increase in effective stress and this results in a slow subsidence at the surface leading to the development of a doline.

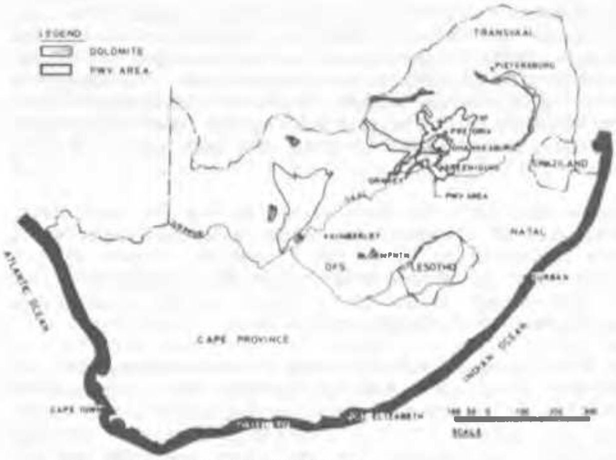


FIGURE 2 DISTRIBUTION OF DOLOMITE IN THE REPUBLIC OF SOUTH AFRICA From Brink (1979)

2.4 Distribution

The distribution of dolomite in South Africa is shown in Figure 2. This dolomite represents 98% of all soluble rocks and covers about 3% of the total area of the country (van Schalkwyk 1981).

In the Transvaal dolomite outcrops over an area of more than 15 000km^2. It is estimated that 14% of the industrialised PWV area is underlain by near-surface dolomite. It is in this area of ever-increasing residential, industrial and mining development where most problems have been experienced.

In certain areas dolomite is underlain by gold bearing reefs of Witwatersrand rocks (Figure 3). Here, dewatering during mining operations has resulted in some of the most severe subsidence problems.

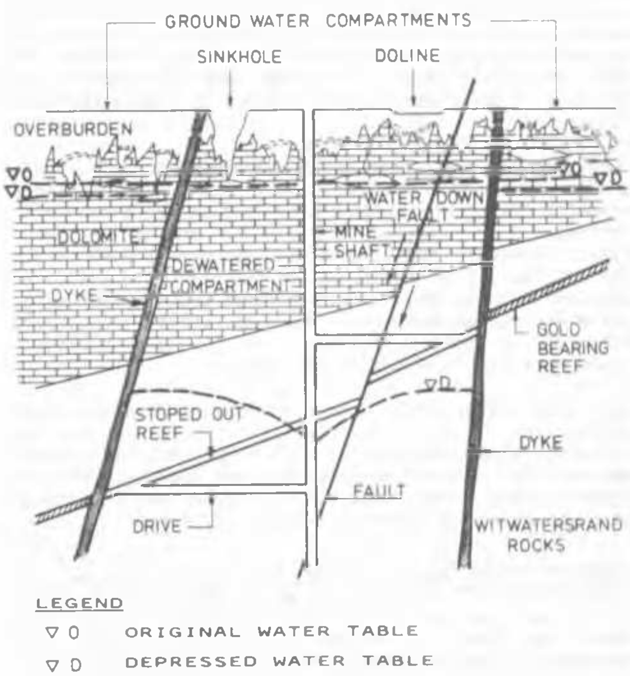


FIGURE 3 MINING OPERATION THROUGH DOLOMITE UNDERLAIN BY GOLD BEARING WITWATERSRAND ROCKS

Little or no development on dolomite has occurred elsewhere in the region. As these areas are ones in which the dolomite is in equilibrium with the environment (i.e. a "static" water table) less serious problems have been experienced with subsidence.

2.5 Case histories

Where areas of "static" water table are present, development on dolomite generally results in the formation of minor sinkholes and dolines which are almost always triggered by the concentrated artificial introduction of water into the profile. The damage is normally of limited extent (Figure 4). After backfilling the sinkhole or doline and sealing the immediate area to prevent further water ingress the problem is usually solved.

Damage has been far more severe on the Far West Rand, 60km west of Johannesburg, where dolomite compartments were dewatered by large scale pumping (Figure 3). A rapid lowering of the water table took place which led to wide-spread damage as a result of the accelerated development of sinkholes and dolines.

On 12th December 1962 the three storey crushing plant of the West Driefontein Mine disappeared into a steep-sided sinkhole 55m in diameter and 30m deep (Figure 5). There was no warning of the impending disaster and the structure and twenty-nine employees vanished without trace within minutes. In 1964 a family of five was swallowed by a sinkhole 60m in diameter and 30m deep at a neighbouring mining town. During 1963 a doline developed at Lupin Place in Carletonville. Twenty-two houses were affected by the subsidence which eventually reached a depth of 5m. Houses straddling the edge of the doline broke up, while those towards the centre settled uniformly and suffered little damage (Figure 6). As this subsidence took months to develop there was no loss of life. Due to problems with stormwater and services the houses were eventually evacuated and demolished.

These occurrences were without precedence in South Africa (Brink 1979 and Wolmarans 1984). As a direct result a number of research organisations were set up to determine the cause of the problem and to recommend safety measures. Jennings (1966) presented theories on the development of sinkholes and dolines. In addition he gave guidelines for the surveillance and protection of installations on dolomite. Jennings and his co-workers did much to restore confidence in the area and their guidelines have been widely followed.

Currently there are a number of publications outlining methods of investigation, classification and evaluation (Jennings 1966, Kleywegt 1981, Wagener 1982, Roux 1984) and methods of construction (Wagener and Day 1984 and Wagener 1985). Roux 1984, lists precautionary measures that should be implemented in dolomitic areas.

Although these guidelines are well proven there will always be a risk when developing on dolomite. However, this risk can be reduced to acceptable limits by developing those areas which are more stable and implementing the recommended precautionary measures.

FIG. 4: STATIC WATER TABLE - DAMAGE TO ROAD DUE TO COMPACTION SUBSIDENCE AT NEW DEVELOPMENT

FIG. 5: ACTIVE WATER TABLE - SINKHOLE WHICH ENGULFED THE WEST DRIEFONTEIN CRUSHER PLANT - 1962

FIG. 6: ACTIVE WATER TABLE - UNCRACKED HOUSE WITHIN DOLINE AT LUPIN PLACE CARLETONVILLE - 1963

3 SUBSIDENCE DUE TO MINING

3.1 Introduction

The exploitation of minerals in southern Africa forms a vital part in the region's economy. These minerals include gold, uranium, base metals and coal.

3.1.1 Gold and uranium

Currently, gold and its by-product, uranium, are mined at depths of more than 2 000m below surface in a highly competent quartzite rockmass. Mined out spans are usually limited to a fraction of the depth below surface. Surface subsidence is not a problem and is not usually monitored.

When mining commenced several decades ago, extraction was much closer to surface. Subsidence due to collapse of workings gave rise to structural damage. Certain areas of the city of Johannesburg are now situated close to the shallow mining areas of bygone days and special construction precautions have had to be taken (Hammond and Plant 1986). General failure modes and development restrictions relating to shallow mined out areas are shown on Figure 7.

3.1.2 Base metals

Base metals are usually mined at shallow depth in competent igneous rockmasses by room and pillar methods. Apart from the elastic compression of the pillars, which is negligible, subsidence has only been known to occur as a result of block failure. Kotze 1986, described occurrences of subsidence at the Impala Platinum Mines where the failure of support pillars 160m underground resulted in sudden subsidences of 200mm to 300mm.

3.1.3 Coal

Coal is mined at depths of 60m to 200m below surface in a horizontally bedded sedimentary sequence comprising both sandy (sandstone) and muddy rocks (siltstones and mudstones). Intrusive dolerite dykes and sills are present. The mining environment, even though weak by South African standards, is strong when compared to conditions in Europe and Britain. In South Africa more than 70% of the overburden has uniaxial compressive strength in excess of 50MPa.

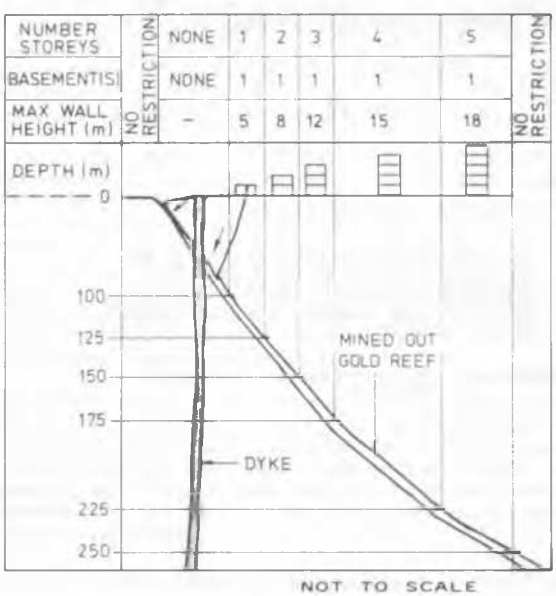


FIGURE 7 BLOCK FAILURE AND BUILDING RESTRICTIONS OVER OUTCROP WORKINGS

Coal mining methods range from bord and pillar (Figure 8) to the increasingly popular high extraction mining methods such as mechanised long walling and pillar extraction (Figures 9, 10 and 11). Where high extraction methods are employed surface subsidence invariably results as the roof is allowed to collapse in those areas where extraction has been completed. In general, long walling subsidence is of a more predictable and smoother nature than that caused by the other mining methods where coal pillars or panels may be left behind. It is usually also of greater magnitude.

3.2 The subsidence process

3.2.1 Deep level, competent environment

This environment is typical within the gold mining industry and subsidence is caused by elastic deflection of the overburden. Elastic modelling assuming a homogeneous, isotropic medium has indicated that the deformations responsible for damage on surface, namely induced strain and tilt, are very small. Several residential areas undermined by deep level gold mining, have suffered no adverse effects, damage due to seismicity excluded.

3.2.2 Shallow, competent environment

Those areas of shallow gold and base metal mining are representative of this environment. The main mechanism in shallow gold mining environments leading to subsidence would appear to be block caving geometrically bounded by geological discontinuities (Figure 7). The amount of subsidence is difficult to predict but would appear to be in the region of 10% to 20% of the mining height. As noted failures of base metal openings are rare and apparently due to pillar failure.

3.2.3 Shallow, incompetent environment

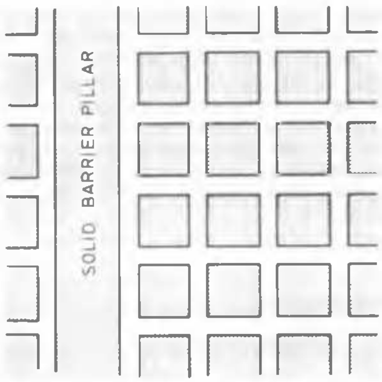
This is restricted largely to coal extraction. Where the mining method is bord and pillar, subsidence is limited to the compression of the pillars. This is generally less than a few millimetres. Should the pillars fail further subsidence results. The bulking phenomenon, explained in the next paragraph, is absent in this case.

Where high extraction methods are used the roof is allowed to collapse as shown on Figure 12. Due to bulking, a stage will be reached when the available space is filled by rubble. Further subsidence occurs when the rockmass above the rubble deflects and fails and forms large blocks. These blocks rest on the rubble and compress it further. This process proceeds upwards resulting in surface subsidence.

As coal mining is currently the largest cause of subsidence problems the following section is devoted to this mining method.

3.3 Types of subsidence caused by coal mining

Two broad classes, planned and unplanned subsidence, can be distinguished. Unplanned subsidence is the result of unplanned pillar failure, whilst planned subsidence is the direct consequence of high extraction mining methods



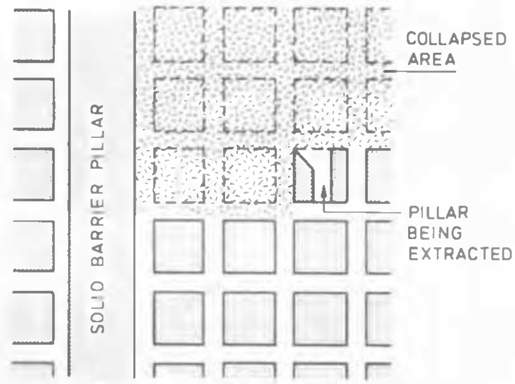
NOTES

1) DRAWING NOT TO SCALE.

2) THE PILLAR DIMENSIONS ARE DESIGNED TO CORRESPOND TO A SAFETY FACTOR (USUALLY 1,6) AT THE SPECIFIC DEPTH BELOW SURFACE.

3) ROADS ARE USUALLY 5m TO 6m WIDE.

FIGURE 8 BORD AND PILLAR MINING

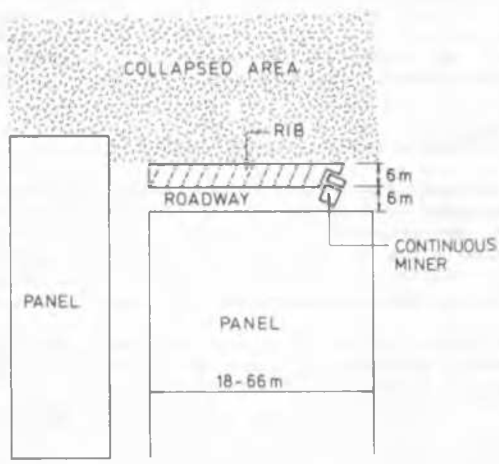


NOTES

1. DRAWING NOT TO SCALE.

2) PILLARS ARE INDIVIDUALLY EXTRACTED BY A CONTINUOUS MINER. ON EXTRACTION THE ROOF COLLAPSES. REMNANTS ARE SOMETIMES LEFT BEHIND DUE TO ADVERSE ROOF CONDITIONS DURING CUTTING.

FIGURE 9 PLAN VIEW OF PILLAR EXTRACTION

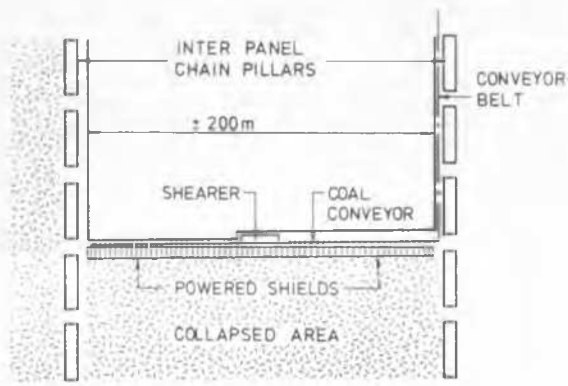


NOTES

1) DRAWING NOT TO SCALE.

2) RIBS, 6m WIDE, ARE FORMED BY MINING A 6m WIDE ROADWAY INTO THE SOLID BLOCK OF COAL, AND ARE IMMEDIATELY EXTRACTED IN SLICES. THIS IS BUT ONE OF SEVERAL VARIATIONS. THE ROOF IS ALLOWED TO COLLAPSE WHERE THE RIBS HAVE BEEN EXTRACTED.

FIGURE 10 PLAN VIEW OF RIB PILLAR EXTRACTION

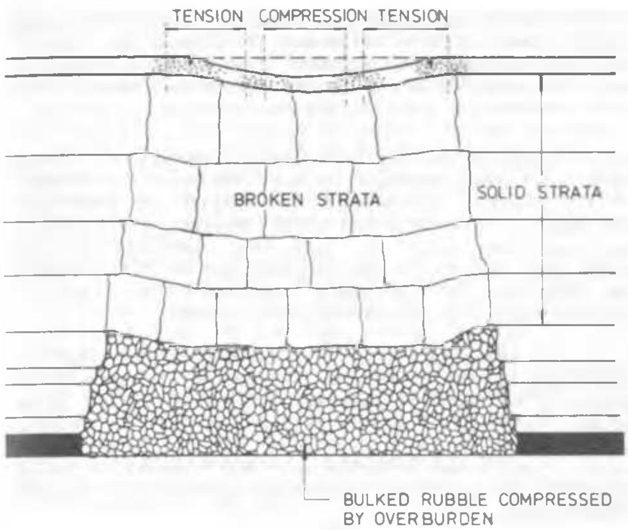


NOTES

1. DRAWING NOT TO SCALE.

2. THE SHEARER CUTS THE COAL AS IT MOVES FROM RIGHT TO LEFT AFTER WHICH THE SHIELDS WILL ADVANCE TO THE FACE. THE ROOF BEHIND THE SHIELDS IS ALLOWED TO COLLAPSE.

FIGURE 11 PLAN VIEW OF LONGWALL MINING



NOTES

1) DRAWING NOT TO SCALE.

2) THE SKETCH ILLUSTRATES THE MECHANISM OF COMPRESSION OF THE RUBBLE WHICH HAD PREVIOUSLY UNDERGONE VOLUMETRIC EXPANSION.

FIGURE 12 CROSS SECTION THROUGH FULLY SUBSIDED AREA

3.3.1 Unplanned subsidence

Pillar failure is a rare occurrence and is largely confined to areas that were mined before the safety factor method of mining was introduced (Salamon 1967).

The Coalbrook disaster of 1960, in which four hundred and thirty-seven men lost their lives, is probably the best known example. In this particular instance, the undermined area was overlain by a dolerite sill. The geological structure was complicated by the presence of dykes and open joints associated with steep dip of the coal seam (Bryan et al 1964). It appears that the triggering mechanism was down dip displacement of the overburden strata on a steeply dipping coal seam which increased pillar loading and caused their collapse.

Other mechanisms causing pillar failure occur. Currently workings are failing near the town of Witbank in the eastern Transvaal where shallow workings flooded at the turn of the century have now been dewatered. The subsequent introduction of oxygen has resulted in the coal pillars igniting causing a severe underground fire. An abundance of cracks through to surface has so far frustated efforts to seal and contain the fire. This large scale buring of pillars has resulted in collapse of workings and significant subsidence.

Recently mined areas in the Vaal River Basin, 80km south of the city of Johannesburg, have also been subjected to pillar failure. The area is characterised by a very weak roof. Investigations have shown that pillar failure is preceded by roof failure resulting in higher and therefore weaker pillars which then fail and cause roof collapse and subsidence.

McCourt et al 1986, conducted an analysis of 17 cases of subsidence caused by collapsed bord and pillar workings. They showed that vertical subsidence, expressed as a percentage of the equivalent mining height, exceeded that caused by total extraction mining (the equivalent mining height is a direct function of the percentage coal recovered.) The authors concluded that this was due to the fact that extensive bulking and caving of the overlying strata does not take place over collapsed bord and pillar workings.

3.3.2 Planned subsidence

Planned subsidence results from high extraction coal mining. Two classes, full subsidence and arrested subsidence, can be defined. Definition is based on the occurrence, geometry and properties of dolerite sills in the overburden.

(a) Full subsidence

The term "full subsidence" refers to the case where dolerite is either absent or where the mining geometry was such that sills fail totally.

The magnitude of full subsidence is generally half the extracted height. The subsidence trough is normally contained well within the perimeter of the underground panel. This is a marked departure from experience in countries such as the United Kingdom.

These phenomena are probably partially due to the strong nature of the roof rockmass. The compressibility of the rubble material is lower than that found in areas where higher subsidence occurs. The fact that the subsidence is confined is probably due to cantilevering of the overburden rockmass.

A deviation from the South African norm was recorded where double seam extraction was done at the Sigma Colliery in the Vaal River Basin. In this case, the vertical subsidence was 2,6m or 87% of the extracted height of 3m. Vertical subsidence, tilt and the extent of the subsided area corresponded extremely well with the commonly observed British case (van der Merwe 1987). This phenomenon is probably due to primary mining "breaking" the overlying strata and reducing it's strength to the extent where the behaviour of the strata was similar to that of weaker rock types.

Most of the above observations are relevant to long walling. Other high extraction methods, such as pillar extraction, have been seen to exhibit slightly different effects. In pillar extraction, coal remnants sometimes have to be left behind due to adverse roof conditions. Though subsidence does occur, large remnants may result in a noticeably uneven subsidence trough. As it is virtually impossible to predict the locality of such remnants the precise characteristics of a subsidence trough caused by pillar extraction is very difficult to forecast.

(b) Arrested subsidence

Arrested subsidence takes place when high extraction mining occurs below a partially failed dolerite sill. The amount of observed subsidence is appreciably less than that which would have occurred in strata where the sill is absent. The failure of the sill is governed by the mine geometry relative to the geometry and strength of the sill.

If the mining span is less than the span resulting in dolerite failure, the amount of vertical subsidence is usually of the order of 20% of the mining height.

In view of the limited time over which coal mining subsidence has been actively studied in South Africa, not much is known of the long term stability of areas subjected to arrested subsidence. Van der Merwe 1984, describes a case at Coalbrook Collieries where a second phase of subsidence occurred after a period of a few years. However, even this subsidence did not bring the total amount near the calculated magnitude of full subsidence.

3.4 Comparison of surface subsidence resulting from various mining methods

In Table 1 the surface subsidence expected from various mining methods is given. A mining depth of 120m below surface has been assumed, with a 3m mining height and 200m panel span.

TABLE 1 - COMPARISON OF LIKELY SUBSIDENCES CAUSED BY VARIOUS COAL MINING CONDITIONS

MINING METHOD	VERTICAL SUBSIDENCE (mm)	INDUCED TILT (mm/m)
Stable bord and pillar, safety factor 1,6	2	-
Failed bord and pillar, safety factor 1,6	750	5
Long wall, unfailed dolerite, primary subsidence	300	4
Long wall, unfailed dolerite, secondary subsidence	750	5
Long wall, failed dolerite	1 500	37
Long wall, double seam, failed dolerite	2 600	55
British coal mine, long wall, no backfill	2 700	58

4 DISCUSSION

This paper examines the two common mechanisms for subsidence as experienced in the southern African context.

It is evident that these mechanisms and their resultant effects are widely different thus:

- the subsidence resulting from the erosion within the residuum of a dolomite profile is unpredictable, often catastrophic, and uncontrollable to a large degree,

- whilst that resulting from shallow mining in incompetent rockmasses is predictable (in the case of total extraction), safe and can be controlled and planned within certain limits.

In the case of dolomitic subsidence it is possible using various investigative techniques to assess the risk of sinkhole and doline development and to reduce this risk by taking sensible precautionary measures. However, this risk can never be reduced to zero.

With respect to shallow coal mining, increasingly large areas are being affected by total extraction methods. It is possible to predict the amount of immediate settlement within certain limits. However, not much has been published about the long term stability of such areas and research is being conducted in this regard. The magnitude of secondary subsidence in areas of arrested subsidence is difficult to assess.

At present development on shallow undermined areas is restricted mainly to farming. However, it may soon be necessary to develop townships and industries on these areas. Further research is required so that the extent, magnitude and rate of subsidence can be calculated to enable those areas affected by total extraction to be restored to beneficial occupation as soon as possible after mining.

5 APPENDIX

5.1 Description of Terms

Solution cavern - a large void within the "solid" dolomite formed by the solution of carbonates as a result of chemical weathering processes and leaching by mildly acidic ground water.

Cavity - a void within the unconsolidated overburden caused by erosion of this material into underlying solution caverns.

Sinkhole - a cylindrical and steep-sided hole in the ground which occurs suddenly, due to collapse of surface material into a cavity, sometimes with catastrophic consequences.

Doline (or compaction subsidence) - a subsidence of the ground surface which occurs slowly. It may be circular, oval or linear in plan. The final depth may be the same as that of a sinkhole but dolines are generally not as steep-sided. Damage to structures can be substantial but there is no danger to life.

Slots or grikes - solution widened joints in dolomite.

Overburden - the transported material and weathered residuum which overlies the "solid" dolomite.

Residuum - that portion of the dolomite which remains behind when part of the rock has been removed by chemical weathering processes and leaching. It comprises chert gravel, sand, wad and small quantities of clay. The residuum is usually mixed with transported material which filters from above.

Wad (or manganiferous earth) - a black residuum, consisting of manganese and iron oxides, with a low density and high void ratio.

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