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Environmental planning for a new mine in a sensitive area*

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SYNOPSIS

Unbridled mining operations can have a serious negative impact on the surroundings. With the recent increased awareness of the need for environmental conservation and the resulting advances in environmental control, the mine planner has new tools at his disposal for the successful implementation of mining projects while avoiding negative environmental effects.

This paper discusses the environmental strategies adopted in the planning and commissioning of a trial underground coal mine. The minimization of negative environmental effects is demonstrated and, where applicable, environmental benefits are examined.

SAMEVATTING

Ondeurdagte mynbou-werksaamhede kan ernstige negatiewe gevolge vir die omgewing inhou. Met die toenemende bewaringsbewustheid en die gevolglike ontwikkeling in omgewingsbeheermaatreëls, het die mynbeplanner nou nuwe middele tot sy beskikking om mynbouprojekte te loods met die mins moontlike negatiewe invloed op die omgewing.

In hierdie referaat word die beplanning en inbedryfstelling van 'n proefmyn bespreek met spesifieke verwysing na die omgewingsstrategie wat gevolg is. Die minimisering van die negatiewe invloede op die omgewing word geïllustreer en waar van toepassing word die voordelige invloed op die omgewing ondersoek.

Introduction

South Africa's reserves of coking coal, which are limited in their extent, are regarded as a strategic mineral resource. When promising reserves were discovered in the vicinity of the Kruger National Park, Iscor Ltd commissioned an underground trial mine at Tshikondeni, adjacent to the Kruger National Park, in north-eastern Venda (Fig. 1). The decision to develop a full-scale mine will be made pending tests and evaluations of various mining methods in relation to the complex geological environment and possible developments in steel technology. The adverse publicity received by the Tshikondeni project is an indication of the sensitive nature of the area in question. The indigenous flora and fauna in the mining lease area have a certain uniqueness, and public awareness has been aroused over conservation issues.

From the outset, Iscor regarded it as essential that a comprehensive environmental-impact study should be undertaken and that rehabilitation guidelines should be formulated for the proposed mine. Consultants Plankonsult, were appointed to conduct this study in association with Steffen, Robertson & Kirsten. This paper is based on a report submitted by Plankonsult.

It was intended that the environmental-impact study would identify areas sensitive to mining operations so that the trial mine could be positioned and developed accordingly. The impact study comprised the following:

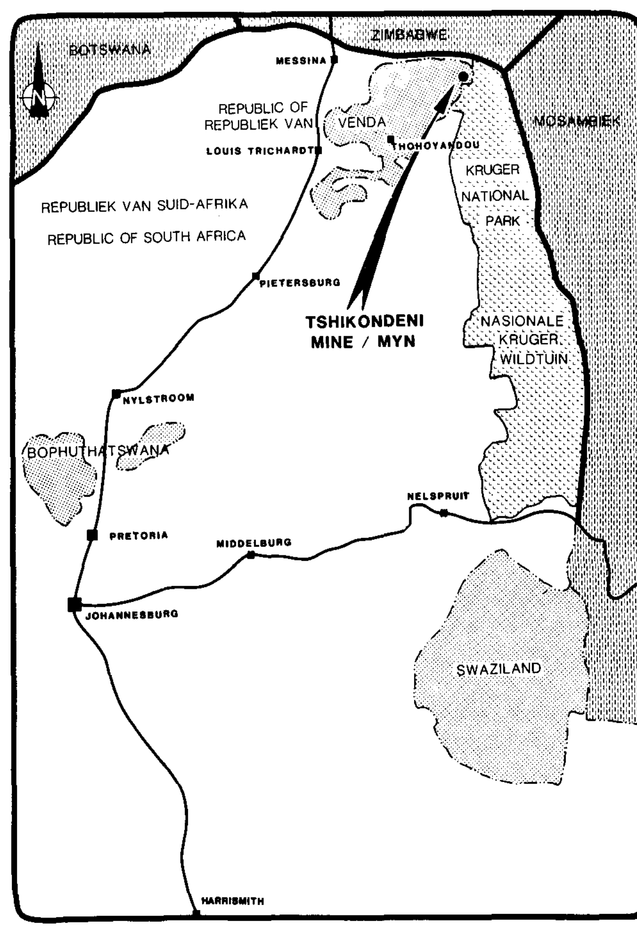

Fig. 1—Location of the Tshikondeni Mine

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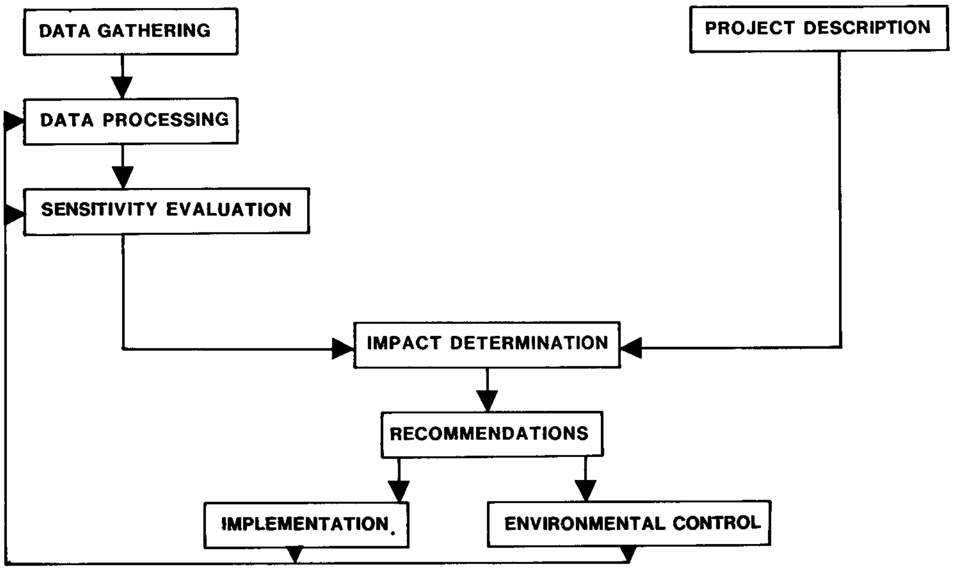

Fig. 2—Steps in the environmental impact study

(1) an assessment of the Tshikondeni project,
(2) an appraisal of the environment of the mining lease area,
(3) a determination of the interacting influences of the mine and its environment,
(4) proposals for the minimization of negative impacts.

Method of Approach

The approach adopted for the study of environmental impact is shown schematically in Fig. 2.

Initially, a precise description of the project was prepared, with emphasis on the physical aspects of the mine and the surface operations. Subsequently, an environmental appraisal was made, the approach being sufficiently comprehensive to accommodate all possible environmental impacts. Thus, the environment was assessed in terms of its physical, biological, and socio-economic aspects, and base-line data were collected and analysed to highlight the areas sensitive to development and any factors that might limit mine development.

Because the environment imposes certain limitations on mine planning, a logical approach to the problem involved a consideration of environmental influences on the mine, and of the influences of the mine on the environment. Proposals were then formulated to minimize negative impacts. In addition, environmental control measures and proposals for the monitoring of various environmental aspects were suggested, and the positive and negative impacts were examined.

Parameters of the Tshikondeni Mine

The surface layout of the trial mine is shown in Fig. 3, and the following are the planned parameters.

(a) Production	A production rate of 3 kt per week run-of-mine (coal) at a plant beneficiation yield of 50 per cent
(b) Workforce	Approximately 200 Venda residents and 20 administrative and management personnel
(c) Underground access	A winze served by an inclined surface excavation
(d) Coal beneficiation	A plant located directly south of the mine portal and fed with run-of-mine coal via a conveyor-belt system; a wet, closed-system plant was designed in order to prevent pollution by coal dust
(e) Plant waste disposal	A waste dump of 360 kt capacity
(f) Coal stockpiles	Two small stockpiles: a run-of-mine stockpile, and a stockpile of beneficiated coking coal of 6 kt and 1,7 kt maximum capacity respectively; the stockpiles are not covered since the wet-beneficiation process limits pollution by coal dust
(g) Offices and workshop	A small number of buildings to provide office and workshop space
(h) Housing	Approximately 20 houses and a single-quarters complex for the accommodation of key personnel
(i) Infrastructure	A new access road linking the mine to the existing Messina road, a landing strip 1,5 km long, on-site electricity generation, boreholes for water supply, and a telephone connection with Thohoyandou.

It was determined that an evaporation dam or treatment plant for the discharge of water containing unacceptable concentrations of contaminants would be required at a later date.

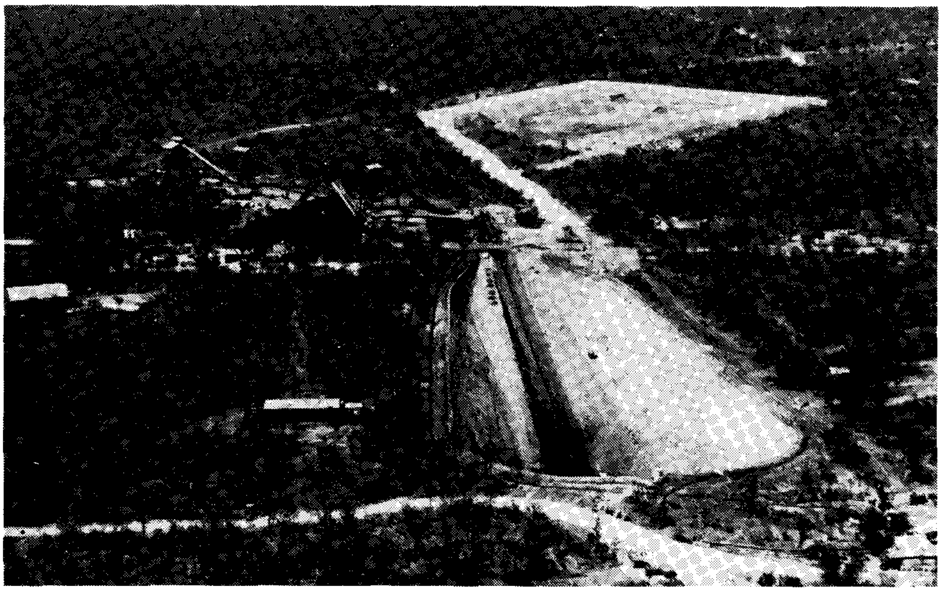

Fig. 3—The layout of the Tshikondeni Mine

The Physical Environment

Geology

The geology of the area (Fig. 4) is typified by a succession of mudstone, sandstone, siltstone, and shale horizons of Karoo sediment. The Karoo formations are overlain by a recent calcrete deposit with an interbedded alluvial boulder bed. The thickness of this calcrete cover ranges from 3 to 12 m.

As a result of post-Karoo tensional tectonics, extensive faulting is in evidence, and many minor faults are expected within the mining lease area. The Karoo rocks have generally been preserved as long, narrow, more-or-less detached fault-bounded strips in which the strata dip northwards at between 3 and 18 degrees. Many dolerite dykes occur throughout the proposed mining area, most of which are strongly discordant with the sedimentary succession and vary in thickness from 0,5 to 10 m.

The coal-bearing succession, consisting of the Madzaringwe and Mikambeni Formations of the Ecca Group, is approximately 250 m thick, with a basal zone, 25 to 34 m thick, consisting of shale and interbedded coal. One seam in this zone, designated the lower seam, may have some economic value and is probably mineable.

An arenaceous unit 95 m thick, which contains minor coal seams, separates the lower seam from the main seam. The main seam varies between 3 and 4 m in thickness.

Widely separated coal bands occur between the main seam and the overlying Fripp sandstone. These bands are thin, some occasionally attaining a thickness of 60 cm. Their yield of coking coal is generally low, and they can therefore be regarded as of little economic value.

At the present time only the main seam is of importance to Iscor. The coal in this seam, which sub-outcrops within the mining lease area, has excellent coking properties.

Geomorphology

The present-day landscape has been moulded largely as a result of erosional forces, while faults and intrusions of competent dolerite dykes and sills have influenced the formation of hills and scarps. Accordingly, the topography is softly undulating with a few prominent ridges extending in an east–west direction. There are certain site conditions that limit mine development, including flood plains, steep slopes, and unstable landforms.

Climate

The mining lease area experiences very hot summers and mild winters, the summer temperatures often exceeding 40°C. A low rainfall, generally restricted to the summer months and averaging 375 mm a year, can be expected. The prevailing winds are easterly. (These figures are based on data from Messina meteorological station.)

Visual Aspects

The terrain is unspoilt and contains a variety of flora. The landscape is softly undulating, and there are few points from which the mining lease area can be overlooked. However, a number of hills lying alongside the border and within the Kruger National Park afford views over the proposed mine site (Fig. 5).

Hydrology

The surface hydrology is characterized by two large perennial rivers: the Mutale and the Luvuvhu Rivers. As both rivers flow from the mining lease area through the Kruger National Park, pollution of the surface water must be prevented at all costs.

Hydrogeology

The study area appears to be a ground-water recharge zone. The aquifer can be classified as heterogeneous where dykes and faults determine the ground-water flow. Faults and contact zones between dykes and country rock are highly permeable and may have adverse effects on underground operations. The present water table lies 20 to 44 m below the surface.

Hydrogeochemistry

The presence of a deep regional ground-water supply

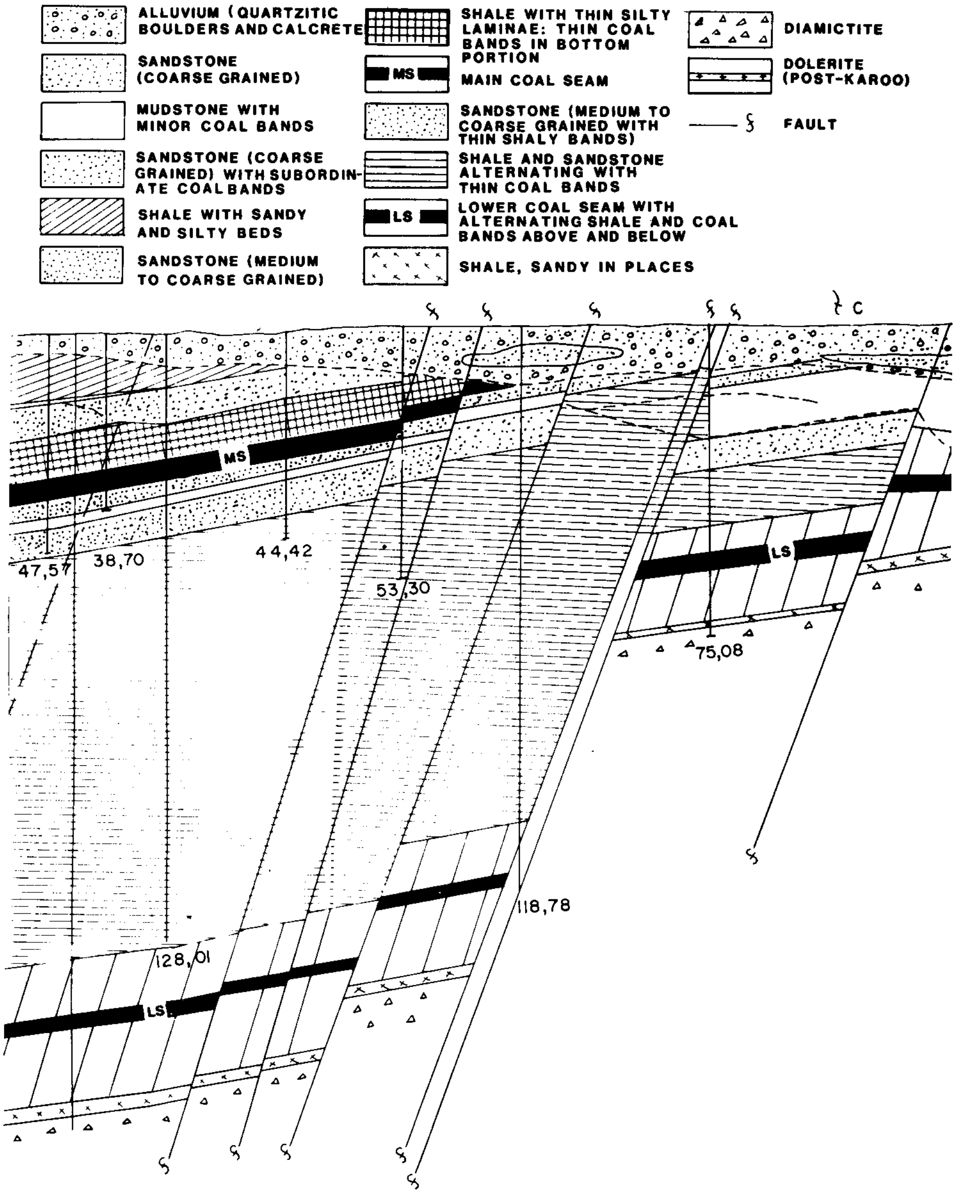

Fig. 4—The geology of the mining area

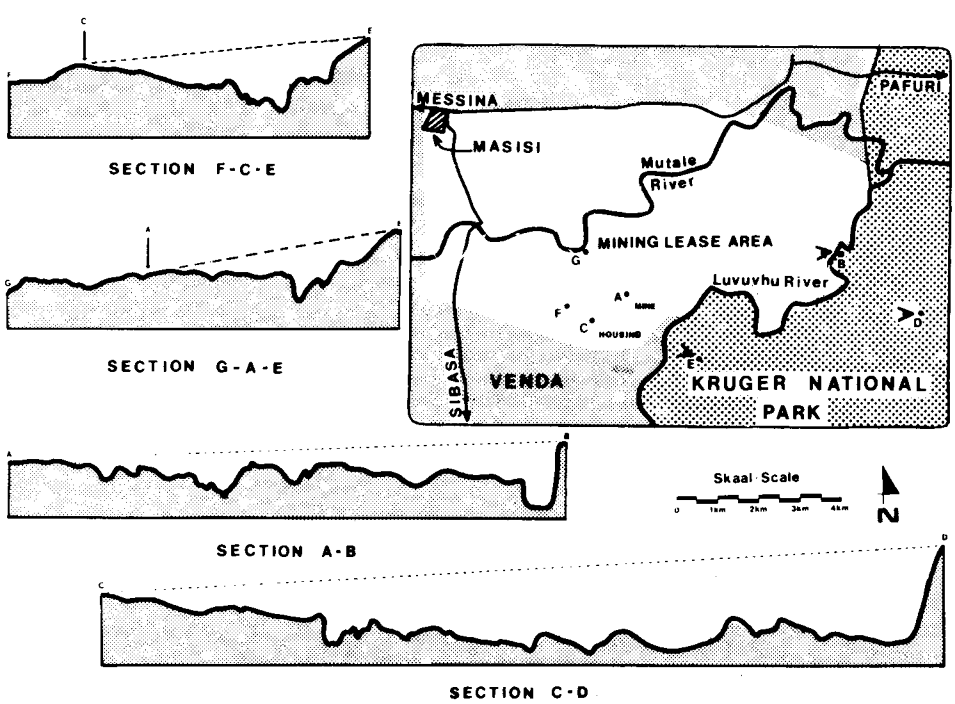

Fig. 5—The visual sensitivity of the Tshikondeni Mine (B, D E being viewpoints in the Kruger National Park)

is indicated, but there are significant local variations in the characteristics of the ground water.

Most of the boreholes sampled do not meet the criteria for domestic water supply, and the water most suitable for domestic use occurs in the north of the mining lease area.

In terms of irrigation uses, most samples display chloride and sulphate contents that are well in excess of the recommended maximum allowable limits. This is particularly true of samples from boreholes located directly north of the entrance winze. The high sodium content of most ground waters in the mine area could cause damage to the soil structure if used for irrigation purposes. The iron and chloride concentrations of a few boreholes exceed the recommended limits for the watering of livestock, but these excesses are generally not significant and the watering of livestock from groundwater sources is considered to be feasible.

In the area immediately north of the entrance winze, most samples of ground water have excessively high concentrations of total dissolved solids (TDS). If they are to be discharged as effluent into the Mutale River, these waters would require prior treatment.

Only the concentrations of chloride and iron are excessive in terms of the recommended limits for aquatic life. However, their dilution with river flow would be sufficient in most cases except during periods of low flow. The aeration of iron-rich waters would induce the precipitation of iron and so reduce the amount of iron held in solution.

Soils

The mining lease area is covered predominantly by sandy soils, but shallow, stony soils are found on the higher-lying areas and clayey soils occur in the valleys. Generally, the soils are suitable as foundation material and growth media, while only soils having limited erosion potential should be used for the covering of waste dumps.

Acoustics

Measurements on site have indicated that the existing environmental noise level is 32 dB(A). The South African Bureau of Standards Code of Practice SABS 0103–1970 recommends that the noise level in this area should not exceed 35 dB(A).

The Biological Environment

The areas of important wildlife and plant communities are shown in Fig. 6.

Flora

Eleven different plant communities exist within the mining lease area. Of these, forests of *Androstachys johnsonii* (Lebombo ironwood) are particularly worthy of note. Not only do they provide a unique habitat for fauna, but they are completely different in composition from other plant communities in the Bushveld.

Fauna

Several varieties of game, birds, fish, reptiles, and amphibians are encountered in the mining lease area, which is attributed to the diversity of habitats available and the perennial water supply of the Mutale and Luvuvhu Rivers. Several endangered species are present, including the suni, leopard, osprey, and Nile crocodile. As Fig. 6 clearly shows, the mine will not disturb wildlife habitats and plant communities.

The Socio-economic Environment

North-eastern Venda has a relatively small population, and little development has occurred. The mining lease area is of considerable archaeological importance since it contains examples of the first contacts between Black populations and European traders, various Black race groups migrated south through the study area, and the mining lease area is largely undisturbed by recent human activities, which enhances the opportunities for archaeological research.

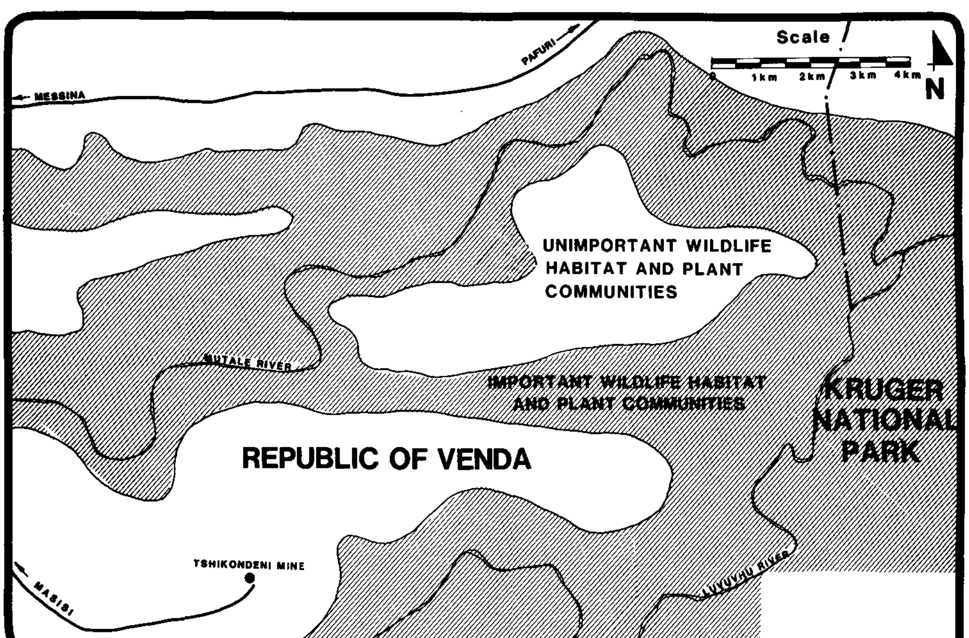

Fig. 6—Areas of wildlife habitats and plant communities

Adverse Environmental Influences on Mine Planning

Ground Water

The possible sudden inflow of large quantities of ground water into underground excavations is a crucial consideration. It has been estimated that a flow of 2000 m^3 per day could arise from the intersection of a linear structure. The provision of dewatering boreholes spaced at 100 to 500 m intervals (depending on geological conditions) and pumping 5000 m^3 per day would alleviate this potential problem.

Visual Sensitivity

Large parts of the mining lease area are visible from within the Kruger National Park. The following strategies were adopted with the intention of minimizing the visual disturbance.

(1) The beneficiation plant has been painted a dull blue-grey so that it will blend with the background hills.
(2) The waste dump has been located so that it is obscured from view within the park.
(3) Dark tiles have been used for domestic roofing.
(4) To retain cover, the removal of trees has been minimized.
(5) The regulations in regard to the importation of non-indigenous plants to the area and the maintenance of existing flora have been enforced.

Water Quality

Water analyses have shown that the direct discharge of ground water from certain boreholes into surface streams is not acceptable. Alternatives are currently under investigation. It is envisaged that either an evaporation dam or a water-treatment plant will be used to conform to State requirements in regard to the discharge of ground water into existing streams.

Climate

Extremely high temperatures and humidities are experienced throughout spring, summer, and autumn. Air-conditioning has been installed in the offices and houses and, wherever possible, tree cover has been retained and supplemented to assist in moderating the harsh climate.

Beneficial Environmental Influences on Mine Planning

Natural Screening

The mining lease area is covered with dense arboreal vegetation, with the result that most mining operations and installations are effectively camouflaged. The consultants' recommendations were implemented, with the result that as little plant cover as possible was removed during the construction phase.

Labour Supply

Ample mine labour is available throughout Venda, and no problems were encountered in the local recruitment of the 200 workers employed at the trial mine.

Labour Accommodation

The proximity of the Venda settlements from which the mine's workforce was obtained has enabled the commuting of mine workers on a daily basis between their homes and the mine. This situation is advantageous and in contrast to the general practice of the mining industry in Southern Africa. This has also meant a reduction in the accommodation required on the mine premises.

Recreation Potential

Where a mine is located in a remote area, recreational facilities are of importance. The inherent beauty of the region and the native flora and fauna in themselves provide excellent recreational facilities, and add to the quality of life at the mine.

Potential Negative Effects of the Mine

Spontaneous Combustion of Waste Dumps

Visual defacement through smoke, and air pollution via the emission of noxious gases, occurs with spontaneous combustion of coal waste dumps.

Air pollution is effected by several gases, the most important being carbon monoxide, carbon dioxide, and sulphur dioxide. Other sulphurous gases, for example hydrogen sulphide, can be expected as a result of incomplete combustion. The pollution problem is emphasized when the climate is dominated by the inversions that are characteristic of winter conditions.

Spontaneous combustion of the Tshikondeni waste dump is prevented by the implementation of the following strategies:

(a) the waste-dump site was prepared by the removal of all organic material to a depth of 500 mm,
(b) the material extracted from the mine access excavation was used, for the construction of retaining walls to accommodate the future dump, was compacted to prevent oxygen flow into the dump, and will ultimately be used to cover the waste dump,
(c) waste is placed in layers not exceeding 400 mm in thickness and compacted with vibration rollers,
(d) the waste dump has been designed to encourage weathering of the coal waste through exposure to the atmosphere,
(e) internal temperatures and gas concentrations are monitored with thermocouples and gas-sampling probes, and
(f) thermographic (infrared) photogrammetry is conducted on a quarterly basis to determine temperature variations in the waste dump.

Ground-water Pollution

Water pollution as a result of seepage and run-off from the waste dump is a problem. Seepage, both during the dump's use and after its rehabilitation, is minimized by the compaction process employed to prevent spontaneous combustion. The pollution of fines by run-off stormwater during the dump's active phase is alleviated by the fact that the gradients of the dump slopes do not exceed 1:4, which limits erosional forces, and by the provision of settling paddocks. The nature of the dump covering material and revegetation will prevent the pollution of run-off water after rehabilitation.

Tailings are treated at the beneficiation plant, where a closed-circuit water system and two belt filters are in operation. This obviates the necessity for a slimes dam since tailings are dewatered at the plant and solids accompany other waste to the waste dump.

In the avoidance of slimes dams, a potential source of pollution has been overcome.

Visual Defacement

Visual defacement of the environment is an inherent factor of any mining operation. However, as a result of topographical screening and the dense vegetation, the Tshikondeni Mine is generally visible only at close quarters. So that the waste dump will not protrude above the horizon line, it has been located in a valley due west of the mine.

The beneficiation plant and housing area are visible from within the Kruger National Park, but the problem is limited to the extent that all the structures fall below the horizon line.

The necessity of extensive overhead lines for power distribution has been significantly reduced by the use of on-site diesel-powered generators. However, the construction of a 2 km overhead line between the mine and the housing area was unavoidable. This line has been located along the existing road reserve and, in conjunction with natural screening, the visual disturbance has been limited.

Surface Disruption

The mining lease area comprises approximately 15 000 ha, and planning permission for the surface development of 200 ha has been obtained. To date, 80 ha have been selectively cleared for mine installations. The mining lease area remains the responsibility of the State of Venda.

Extensive exploration work has occurred throughout the area. This has entailed bush clearance along cut lines and access roads. The cut lines, though visible from the air, do not mar the natural appearance of the area, since they are unobtrusive and well-disguised by dense vegetation. As cut lines and access roads become redundant, they will be subject to the on-going rehabilitation programme.

New Road Development

Few new roads were required for the trial mine. After consultation with design engineers, the new access road was located so as to be invisible from most vantage points. During the construction of the access road (under the auspices of the State of Venda), an excessive road reserve was cleared of natural vegetation, resulting in adverse environmental impacts. Recommendations for the revegetation of the road reserve have been presented to the State of Venda.

Acoustic Disturbance

The possible acoustic disturbance was assessed from a determination of the noise made by machinery similar to that to be utilized at Tshikondeni. The assessment indicated that the recommended level of 35 dB(A) would generally not be exceeded. However, isolated high spots within the Kruger National Park may under certain climatic conditions experience noise levels in excess of the present environmental level.

To ensure minimal disturbance, low-noise ventilation fans have been installed.

Lowering of the Water Table

Before any mining activities started, the water table in the vicinity of the trial mine varied between 20 and 44 m below the surface. As previously determined, extensive dewatering could be a prerequisite to safe and successful underground operations.

According to Van Wyk, ground water that is at a depth of more than 20 m is not utilized by the flora of the mining lease area. Accordingly, dewatering is unlikely to have any negative impact on the vegetation.

Potential Positive Effects of the Mine

The Stimulation of Further Development

According to Stols, it seems likely that the State of Venda will allocate the town of Masisi (Fig. 7) as a concentration point for economic activities and development. Should the Tshikondeni trial mine be upgraded to full scale, the mine employees would be housed at Masisi, thus facilitating the development of the town.

A portion of the mining lease area has been declared a game and nature reserve. Further development of the reserve could be expected to stimulate the tourist industry in Venda.

Increased Income

The majority of the residents in north-eastern Venda survive on a subsistence economy. The average monthly income of a Tshikondeni mine worker is approximately R200. With an average family unit of 6 persons, 1200 people will benefit directly from this income. A multiplier effect in the economy can be expected with increased spending on commodities and services.

Increased State Revenue

The State of Venda receives levies on all the coal extracted by Iscor. As a result, increased capital becomes available for the provision of community services, roads, water schemes, and other infrastructure.

Environmental Education

Iscor is enforcing a strict policy of environmental conservation at Tshikondeni. Emphasis is placed on the disposal of domestic waste, the prohibition of the destruction of game and flora, and the use of indigenous plants for all revegetation programmes.

The State of Venda is accountable for the conservation of the environment and the education of the Venda people in this respect. The problems of particular concern are the denudation of indigenous flora through the uncontrolled gathering of firewood, and the indiscriminate hunting of game.

Rehabilitation

Cut-lines and access roads are subject to rehabilitation as soon as they become expendable. Compacted soil is ripped and natural revegetation actively encouraged.

The final rehabilitation programme (Fig. 8) for the mine will involve the removal of all surface structures, with the possible exception of housing, which may be used as accommodation facilities for the Venda game reserve; the recontouring of excavations for the mine access, the entrance being modified to render it safe to both the inhabitants and the game of the area; and the rehabilitation of the waste dump, which was designed with a slope of 1:5 to ensure that, in conjunction with recontouring, its final shape will be compatible with the surrounding topography; material from the previously constructed re-

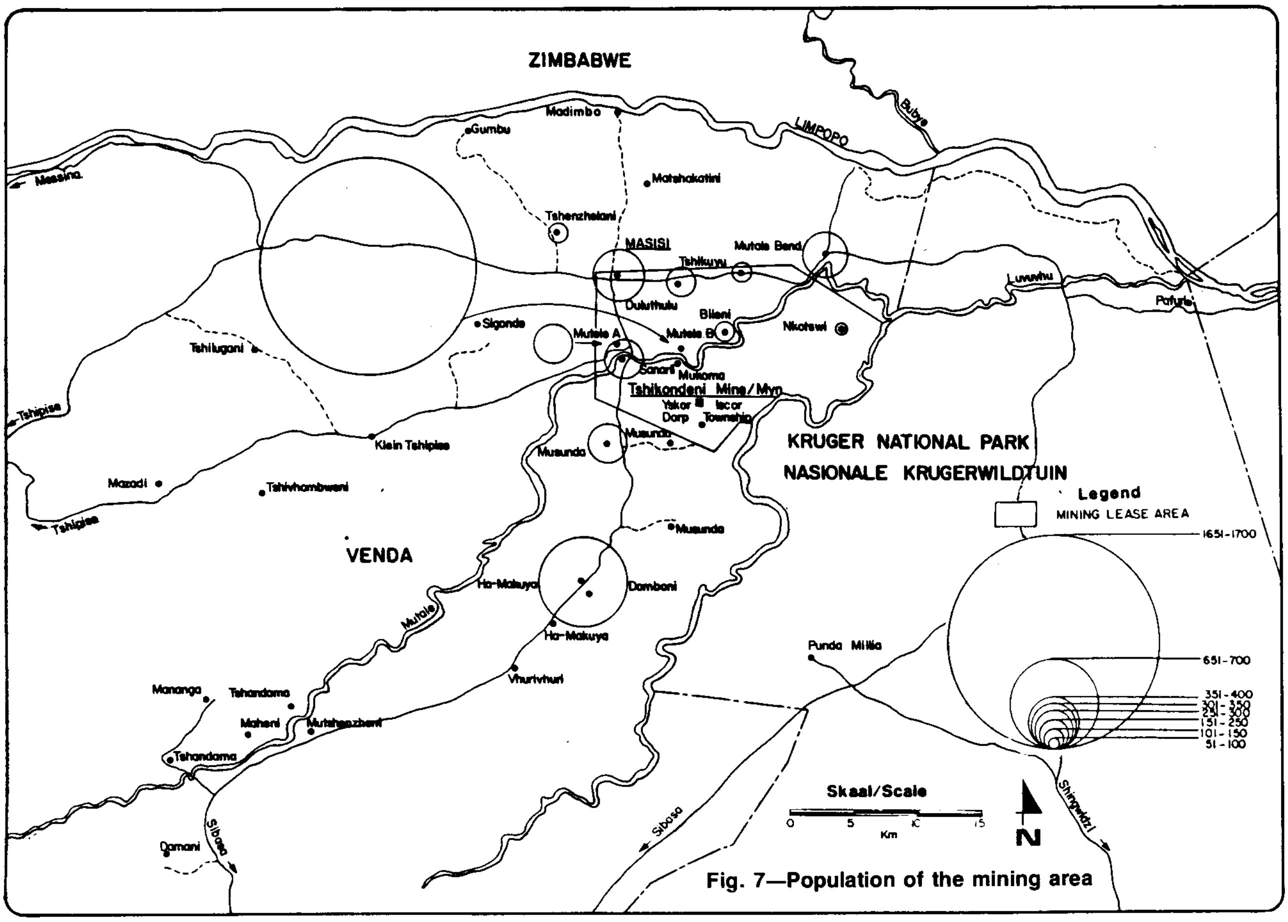

Fig. 7—Population of the mining area

taining walls of the dump will be used to cover the coal waste, and revegetation will be encouraged by the addition of previously stockpiled topsoil.

Monitoring of Environmental Quality

Various aspects of the environment will be monitored to ensure sound mining operations, as well as protection of the environment. These include monitoring of surface-water quality, ground-water levels, ground-water quality, acoustics, and economic progress in the area.

Conclusions

An environmental impact study of this nature must precede the finalization of mine planning so that the strategies adopted can be formulated according to environmental constraints. Some might consider that such a study places an unnecessary burden on management, but this was not Iscor's experience, since the Tshikondeni impact study proved to be a useful tool in the achievement of a comprehensive, realistic plan.

When regarded as a percentage of the total expenditure on the project, the costs of the Tshikondeni impact study were minimal but, viewed in isolation, the initial costs were significant. This may deter other mining companies from undertaking such studies. At Tshikondeni, the identification of numerous positive and negative impacts led to effective measures to ensure that environmentally detrimental influences were minimized, and will continue to be minimized. As a result of these measures, it is expected that future expenditure, especially in regard to environmental rehabilitation, will be significantly less than it would otherwise have been.

It is concluded that development and environmental aspects can be collated, not only for short-term economic benefits to the local population, but also for the maintenance of the surrounding natural area for posterity. It therefore follows that man and nature can co-exist in productive harmony to satisfy the social, economic, and other expectations of the present and future population.

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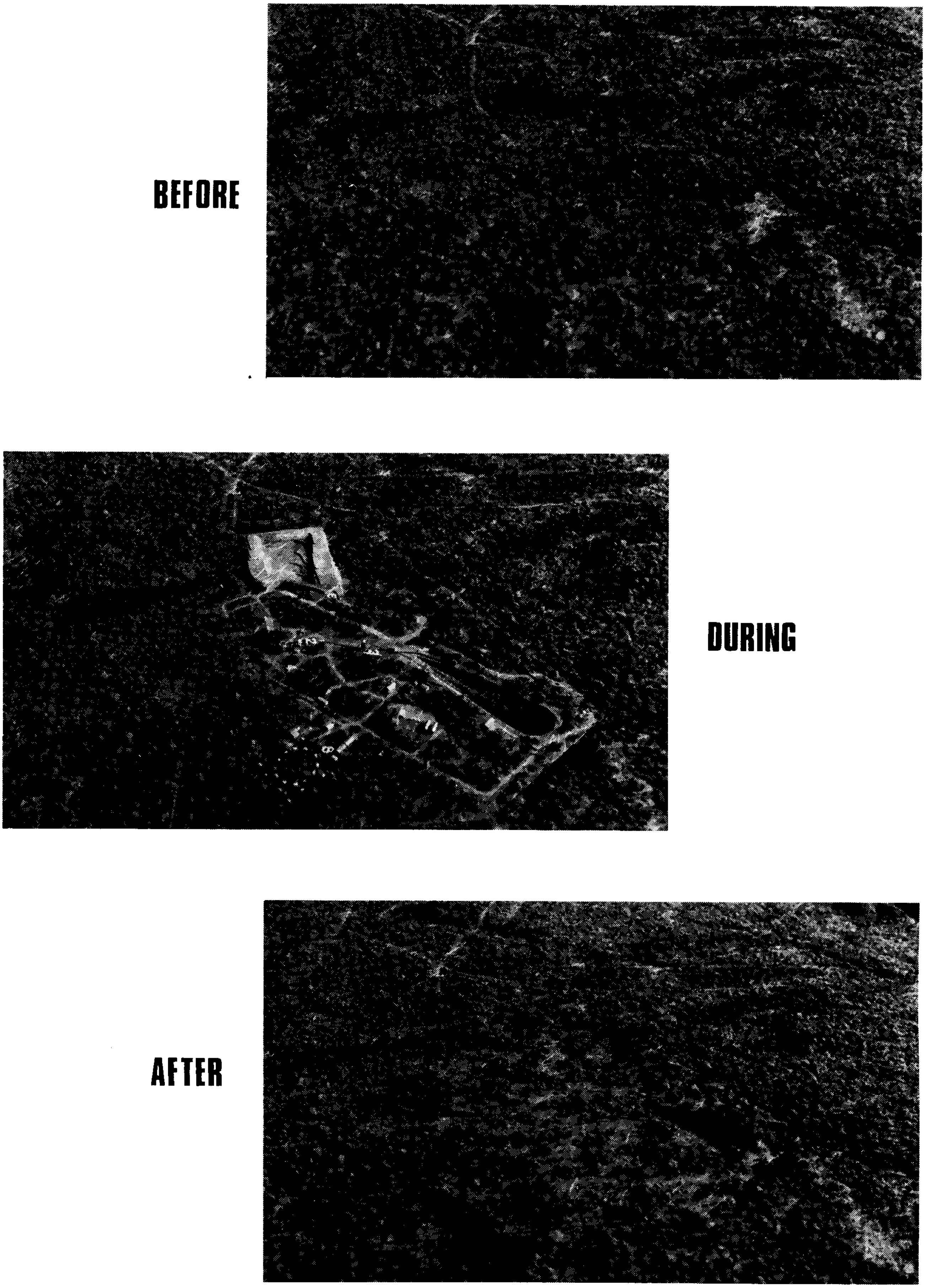

Fig. 8—The effect of the rehabilitation programme