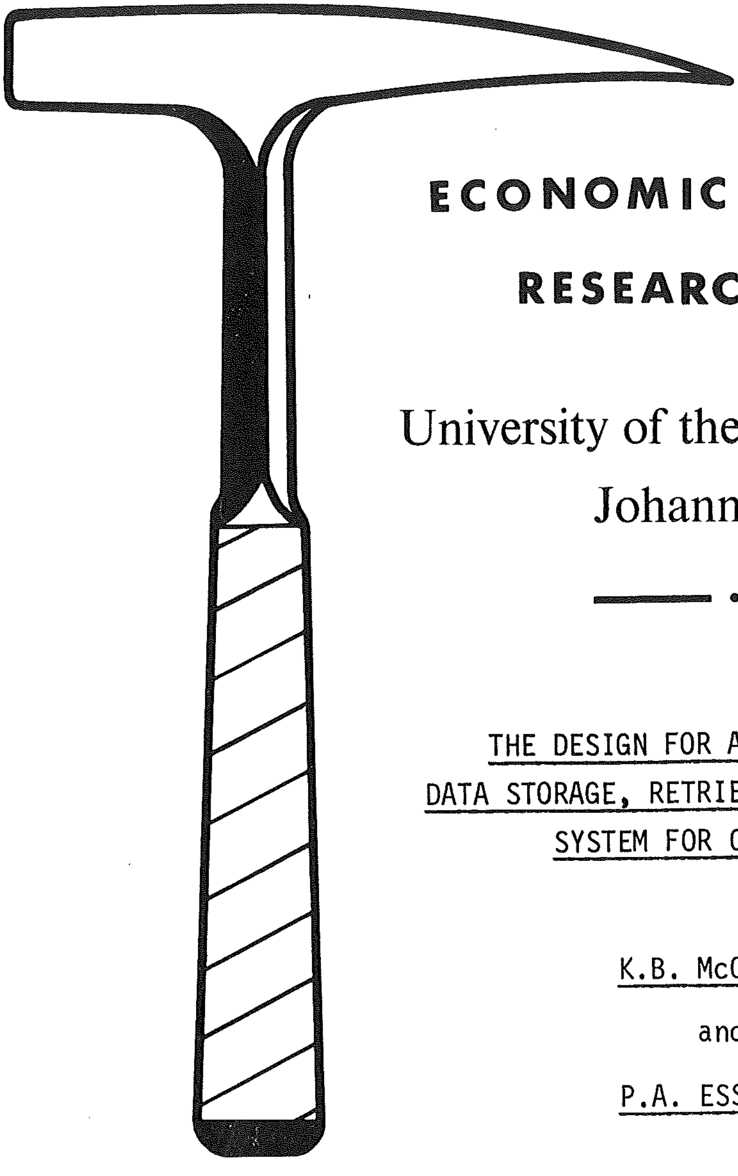


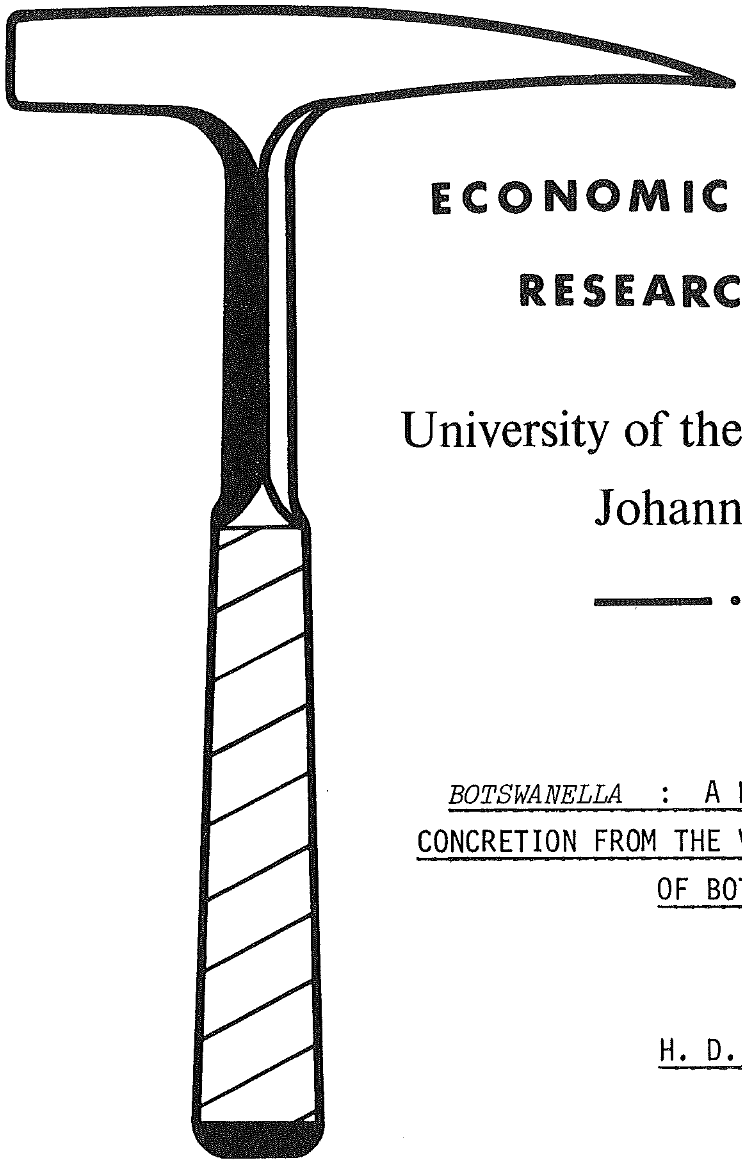
ECONOMIC GEOLOGY RESEARCH UNIT

University of the Witwatersrand
Johannesburg

THE DESIGN FOR A COMPUTER-BASED DATA STORAGE, RETRIEVAL, AND PROCESSING SYSTEM FOR COAL GEOLOGY

K.B. McQUILLIN
and
P.A. ESSELAAR

INFORMATION CIRCULAR No. 56



ECONOMIC GEOLOGY RESEARCH UNIT

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Johannesburg

BOTSWANELLA : A BACTERIA-PRODUCED CONCRETION FROM THE VENTERSDORP SEQUENCE OF BOTSWANA

H. D. PFLUG

INFORMATION CIRCULAR No. 57

UNIVERSITY OF THE WITWATERSRAND
JOHANNESBURG

THE DESIGN OF A COMPUTER-BASED DATA STORAGE, RETRIEVAL, AND PROCESSING SYSTEM FOR COAL GEOLOGY

by

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(Research Associate from the Anglo American Corporation of South Africa, Limited)

and

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ECONOMIC GEOLOGY RESEARCH UNIT

INFORMATION CIRCULAR No. 56

August, 1970

THE DESIGN OF A COMPUTER-BASED DATA STORAGE, RETRIEVAL, AND PROCESSING SYSTEM FOR COAL GEOLOGY

ABSTRACT

The increasing volume of data produced by the Anglo American Corporation of South Africa, Limited, during the course of coal exploration prompted the development of a computer-based data processing system. The information to be stored by the system is punched on cards which are run through several edit programs designed to detect inconsistencies in the data. When the data sets are considered free of error, they are loaded into files kept on magnetic disk. There are four such files. The first contains stratigraphic information; the second, coal seam data; the third, chemical analyses of coal; and the fourth, analyses of partings between coal seams. Two programs have been written that process the disk data; the first lists stratigraphic information, while the second determines workable seam sections and the coal reserves based on these sections. The cost, as of May, 1970, of preparing and loading data on to disk in a form suitable for further processing is approximately R7.31 per borehole. Cost of processing the data on the computer is approximately one-eighth that of the cost of performing equivalent manual operations.

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THE DESIGN OF A COMPUTER-BASED DATA STORAGE, RETRIEVAL, AND PROCESSING SYSTEM FOR COAL GEOLOGY

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THE DESIGN OF A COMPUTER-BASED DATA STORAGE, RETRIEVAL, AND PROCESSING SYSTEM FOR COAL GEOLOGY

I. OBJECTIVES OF THE SYSTEM

Research into the design of a computer-based system for the storage, retrieval, and processing of geological information gathered during the course of exploration for, and evaluation of, coal deposits is being carried out at the request of the Geological Department of the Anglo American Corporation of South Africa, Limited. The senior author is a member of this department, and has been seconded to the Economic Geology Research Unit of the University of the Witwatersrand, Johannesburg, for the duration of the project.

Coal geology, in the context of the nature of the investigations carried out, might be defined as being the aspects of geology involved in selecting and prospecting an exploration area and in determining the grade and reserves of a coalfield or colliery possibly resulting from such exploration.

The pattern of the mining and utilization of coal in South Africa is changing (Shilling, 1969), the most important development in recent years being the growth in demand for energy. In 1965, the total generating capacity within the country was 6 100 megawatts. By the year 2000, Straszacker (1966) estimates that this could rise to 62 000 megawatts. Even taking into consideration the possible advent of nuclear power stations in South Africa, there ought to be room, by 1990, for another four coal-fired stations of 2 000 megawatts each, consuming a possible total of 24 million tons of coal a year (Shilling, 1969).

A. COAL GEOLOGY AND THE COMPUTER

A computer-orientated data storage and retrieval system is costly and time-consuming to establish. It is important, therefore, that one or more of the following three criteria be satisfied if a computer is to be used economically :

(i) There must be a large volume of data to be processed.

(ii) The processing must involve numerous mathematical manipulations.

(iii) The data sets are required to be retrieved and processed at frequent intervals.

These three requirements can be examined in the context of the projected demand for steam coal.

(a) Volume of Data

A 2 000 megawatt station burns approximately 6 million metric tons of coal a year, which, over a life span of 35 years, represents a coalfield containing *in situ* reserves of 400 million metric tons. To prove a coalfield of this extent requires the drilling of some 300 boreholes in a typical Sough African deposit. The seam intersections in these boreholes, on sampling and analysis, result in a mass of data describing approximately 2 400 samples and 5 000 analyses.

(b) Mathematical Manipulations

The calculation of the grade and reserves of a coalfield involves the compilation of structural plans, the evaluation of borehole seam sections, and the combination of these sections. An exercise of this nature would occupy a geologist for a number of months. A computer can perform the manipulations in a few hours, once the data have been stored in the system.

(c) Frequency of Retrieval

The above exercise produces one set of results based on the limits used. Should any of these limits, e.g. workable seam width or calorific value, be altered, the entire procedure must be repeated. A computer-based system can produce these alternative sets of results much more quickly and efficiently than any manual system of recalculation.

B. PURPOSE AND AIMS OF THE SYSTEM

The objectives of the system, bearing in mind the criteria discussed above, are to supply working programs designed to :

(i) store and retrieve coal borehole, or similar, data;

(ii) determine workable seam sections, and calculate the average grade of saleable coal contained in one, or several, reserve blocks in a coalfield;

(iii) calculate the tonnage of coal in a seam, together with the volumes of soil, subsoil, weathered rock and bedrock overlying the seam; and

(iv) utilize statistical techniques to improve the methods of calculating the grade and reserves of a coalfield - (in the past, these methods have not been widely employed because of the numerous mathematical manipulations involved).

II. DESIGN OF THE SYSTEM

The data storage and retrieval system is designed to accommodate data as presented in the coal borehole records of the Anglo American Corporation of South Africa, Limited. There are no major differences between the type of data recorded by this Group and that gathered by other coal-mining companies.

The programs are written in FORTRAN IV, and are designed to run under OS (full Operating System) on the IBM System 360/Model 50 computer of the University of the Witwatersrand.

A. INPUT DATA

Figure 1 illustrates a geologist's log sheet indicating the data to be stored for a typical borehole. This sheet can be divided into three sections :

(i) borehole section (stratigraphic information);

(ii) section of coal seam; and

(iii) analysis of coal seam.

The input is stored in the system in four files, the first three of which correspond to the above three divisions :

(i) File 1 containing stratigraphic information;

(ii) File 2, a masterfile, containing coal seam data, together with a record of borehole/seam/sample numbers;

(iii) File 3 containing the coal seam analyses referred to by the borehole/seam/sample numbers in File 2; and

(iv) File 4 containing analyses of coal seam partings.

All relevant information describing the coal seams, samples, and analyses is stored. The geologist has a choice in the amount of stratigraphic data he can capture, in that a maximum of 15 horizons can be described for any particular area. In some instances, the stratigraphic data may be of relatively minor importance, and, therefore, the system has been designed so that File 1 is optional.

B. FLOWCHART OF THE SYSTEM

(a) General Description

The flowchart of the system is illustrated in Figure 2.

The ultimate aim of the system, from the user's point of view, is to provide accurate coal reserve information. However, before that can be accomplished, procedures must be developed to group and arrange the input (borehole) records in specific files on the computer, so as to facilitate the retrieval and processing of the data as the need arises. The data files can be stored on a variety of media, such as punched cards, paper tape, magnetic tape, or magnetic disk. The special characteristics of magnetic disks provide the most efficient solution to the problems encountered in the design of the present system.

The following general survey of the flowchart is followed by a more detailed description of its components. It must be remembered that this report does not pretend to serve as an exhaustive study of the system.

(i) The borehole information to be stored (Figure 1) is transferred on to specially prepared input forms.

(ii) These data are punched on cards.

(iii) The cards are run through several edit programs designed to detect obvious errors.

(iv) When the data files are error free, they are loaded on disk.

(v) The data are then in a form that can be processed by problem programs (calculation programs).

(vi) If the project is current, more borehole records can be added to the disk files.

(vii) The records can be updated at any stage, i.e. incorrect data can be altered, new analyses added, etc.

(viii) When an area is no longer current, its data files are written on to tape and the disk data sets are scratched.

(b) Input Forms and Punch Cards

The stratigraphic data, described in the left-hand section of the geologist's Borehole Log Sheet (Figure 1), are transferred on to two input forms. These are Form 1 (not illustrated), containing general descriptive information, such as borehole number and farm name, and Form 2, containing stratigraphic details (Figure 3). Data describing a maximum of 15 stratigraphic units can be stored, and the choice of units described can vary between areas. In any new area, the horizons to be used as input are selected and listed on the master copy of Form 2.

The data entered on Forms 1 and 2 are punched on two and four cards, respectively. These data, recorded for each borehole, constitute File 1, and may be omitted if not required.

The coal seam data, occupying the centre and right-hand sections of the log sheet, are transferred on to five types of input form. These consist of a borehole form for each borehole (Figure 4), a seam form for each seam, two types of sample form for each sample, and an analysis form (Figure 5) for each analysis. Each form is punched on one card. These data, recorded for each borehole, constitute Files 2 and 3.

File 4 is a small data set containing analyses of typical coal seam partings. It is not discussed at length in this report.

The forms are formatted for English units. The disk-loading program converts these units to metric, and all output from the system is in metric units.

The procedure followed in completing the input forms has not been described in detail in this report.

(c) Edit Programs

The punch cards are run through several edit programs designed to detect obvious errors. Thirteen checks are made of File 1, and 45 of Files 2 and 3. For example, the program tests whether the proximate analyses total 100 per cent; whether the total of the sample widths equals the seam width; whether the elevation data lie within acceptable limits; etc.

The accuracy of some parameters, such as depths and calorific values, can only be tested within acceptable limits. A calorific value of 9.98 lbs/lb incorrectly punched as 9.58 will not be detected. All inconsistencies, which might invalidate results, hopefully will be rejected, although errors which are noticed only when the data are on disk can be corrected by means of the update program.

(d) Disk Loading Program

The loading of File 1, containing the stratigraphic records, presents no problems, and is not described here. The loading of the coal seam data (Files 2 and 3) is more involved, and is discussed in greater detail.

The following considerations had to be taken into account in the design of the computer records :

(i) Individual analyses from a sample, within a seam, within a borehole, had to be readily identifiable on the storage medium.

(ii) Each borehole record is of different length. The first might intersect four seams, split into 20 samples and 50 proximate analyses, while a second might have one seam, 2 samples and 4 analyses.

(iii) The most convenient method of dealing with records of such variable length is to load them sequentially on to magnetic tape. Unfortunately, the geologist seldom processes boreholes sequentially. He might require, for example, the coal reserves using Boreholes 2, 56, 4, and 124. The tape unit reading device cannot move directly from records 2 to 56, and consequently wastes considerable time searching the intervening tape for the next required record number.

(iv) This problem can be overcome by loading the data sets on to magnetic disk. A disk file (Figure 6) is a device which resembles a gramophone record together with its playback mechanism. The disk platter is a circular sheet of metal 250 - 500 mm in diameter and 15 - 60 mm thick, coated on both sides with a magnetic material. The data are stored in grooves or tracks arranged in concentric circles. There may be 100 - 1000 tracks per surface. The advantage of a disk file is that the computer can skip from one record to another without having to read the intervening records. In the above borehole example, the read-write head on the disk (pick-up arm) would jump from record 2 to record 56. The address at which each record starts on the disk is known to the computer. A data set organized in this manner is called a direct-access data set.

(v) The use of a magnetic disk, however, produces a further problem. In FORTRAN, a direct-access data set can contain only fixed-length records. This allows the computer to determine the address of the first character in each record. The borehole records differ widely in length, and, in order to conform to the specifications of direct-access data sets, they have to be made a fixed length, equal to the maximum expected record length. The average coal borehole record was found to contain data from 3 seams, 10 samples, and 15 analyses, although the number of analyses differs markedly, depending on the number of float fractions analysed for each sample. The concept was developed of a master record containing general descriptive data (borehole number, farm name, co-ordinates, etc.), together with seam and sample data, but excluding the analyses. This master record has a fixed length, and can accommodate a maximum of 6 sampled seams and 20 samples. Should a borehole contain only 2 seams and 10 samples, the section of the record dealing with the remaining 4 seams and 10 samples is left blank on the disk. In commercial operations, these blank spaces must be paid for, but the cost of disk storage is not excessive. The analyses form fixed-length records of their own, which are stored on a seperate disk file. If the first borehole loaded has 20 analyses, these are written as records 1 - 20 in the analysis file. The first analysis from the next borehole is loaded as record 21. There are, therefore, no blank spaces in this file. One problem remains, viz. to determine which analyses in this file belong to each borehole.

(vi) Each seam is given a unique number, e.g. the No. 4 Seam is given the number 4. The lowest sample in this seam is called 0401, the next highest, 0402, etc. Number 0205 is, therefore, the fifth sample in the No. 2 Seam. The borehole shown in Figure 1 has 2 seams and 7 samples. The second sample in the No. 4 Seam is called 0402. The section of the disk record occupied by this sample is illustrated in Figure 7. The last field of the sample section of the record (called ISAMAD) points to the address of the first analysis in the sample. Thus, the first analysis for sample 0402 is record number 119 on File 3. The last field on record 119 (called INDIC) points to the next analysis in the sample. Record 120, therefore, also belongs to sample 0402. The INDIC field on this record (120) contains a zero, indicating that there are no further analyses for this sample. The next sample is numbered 0403, and the address of its first analysis is 121. This system allows a variable number of fixed-length analyses to be written for each sample. An advantage of this method is that new analyses can be added to the borehole record at any time. Say, for example, a total of 657 analyses has been written on to File 3, and an additional analysis becomes available for sample 0402 (Figure 7). The update program merely changes the INDIC pointer on record 120 to 658 and the new analysis is written as record 658 on File 3. The INDIC pointer on this record is set to zero. A separate file is kept on disk containing the total number of boreholes and analyses written. This file is updated automatically by the system. When a new borehole is loaded, the computer program examines this file in order to determine the sequence number available for the next borehole and analysis. The organization of all the indicators involved in writing and arranging the records is handled by the program; all seam, sample, and analytical data are thus stored in a form readily accessible to the problem programs (calculation programs).

(e) *Updating of Records*

The records on disk can be updated in three ways :

(i) Any field which is found to be incorrect can be altered.

(ii) Combination samples can be added to the records. Quite frequently, two samples are combined and re-analyzed, e.g. samples 0401 and 0402 in Figure 1 might be combined to form a new sample called 0405. The update program automatically adds this sample, together with its analyses, to the loaded data sets.

(iii) New analyses can be added to the records. If more analyses become available subsequent to the loading of the records on disk, the update program will add these analyses to the existing data sets.

After updating, the record must be re-edited.

If, in the unlikely event of there being new seams or samples (other than combination samples), the entire borehole record must be repunched, edited, and reloaded.

(f) *Backup Procedures*

The contents of the disk are written on to magnetic tape at regular intervals, as a precaution in the event of disk data sets being inadvertently destroyed.

(g) *Archive Procedures*

When an area is no longer current, its data sets are written on to magnetic tape, and the disk is scratched. The reason for this procedure is that storage is cheaper on tape than on disk.

C. THE PROBLEM PROGRAMS

This report is intended to discuss the objectives and design of the system, but a brief description of the available and proposed problem programs is given in order to illustrate what can be accomplished by operating the system.

The following programs are available :

(i) STRAT : This program lists the most important stratigraphic information for requested units in File 1, e.g. No. 5 Seam : width, depth of base, elevation of base, and elevation of roof. These print-outs facilitate the compilation of structural maps.

(ii) CALC 1 : This program determines workable seam sections in requested boreholes, and calculates the coal reserves by combining these sections on a basis proportional to a given area of influence for each borehole. There are four variations to the program : (1) full seam - volume basis, raw or washed coal, (2) full seam - weighted basis, raw coal, (3) specified seam section - raw coal, and (4) specified seam section - washed coal. Once the borehole records are stored on the computer in a readily accessible format, hitherto impractical statistical methods can be utilized in providing a quicker and more accurate analysis of a coalfield.

III. COST OF THE SYSTEM

A. COST OF INSTALLATION

It has been stated that File 1, containing stratigraphic data, is independent of Files 2, 3, and 4. This enables the geologist to omit File 1 for a particular area, if it is not required, and for this reason the costs have been divided into categories based on the two sets of files. The following procedures and provisional costs are involved in installing the system; the costs are per 100 boreholes, each having an average of 2 seams, 8 samples, and 12 analyses :

(a) *Data Transfer*

The borehole information is transferred from the geologist's log sheets (source documents) on to specially prepared input forms. Approximately 36 of these forms are required per borehole (File 1-6; Files 2, 3, 4 = 30). It is estimated that a clerical assistant could complete 10 boreholes per day, although this figure depends on the type of source document from which the data have to be abstracted.

	File 1	Files 2, 3, 4
Data Transfer Cost :		
Assistant's time - 10 days at R10 per day	17.00	83.00
Supervision costs - one half-day per 100 boreholes at R32 per day	3.00	13.00
Sundry costs (input forms, etc.)	2.00	8.00
	R22.00	R104.00

Data Transfer Cost : R126.00

(b) *Card Punching*

Approximately 36 cards per borehole, i.e. one per input form, are required. The price listed is the average of two quotes obtained from card-punching firms.

	File 1	Files 2, 3, 4
Card Punching Cost :		
3600 cards at R42 per 100	25.00	126.00
Cost of correcting mistakes located by edit programs	2.00	7.00
	R27.00	R133.00

Card Punching Cost : R160.00

(c) *Editing and Loading Data*

The boreholes are edited and loaded in batches of twenty.

	File 1	Files 2, 3, 4
Editing and Loading Cost :		
Editing	18.00	138.00
Loading	11.00	118.00
	R29.00	R256.00

Editing and Loading Cost : R285.00

(d) *Summary of Installation Costs*

The total installation costs, per 100 boreholes, can be represented as follows :

	File 1	Files 2, 3, 4	Total
Data Transfer	22.00	104.00	126.00
Card Punching	27.00	133.00	160.00
Editing and Loading	29.00	256.00	285.00
Total Cost	R78.00	493.00	571.00

The cost of preparing data for an area where more detailed sampling and analytical information is available (say, 12 samples and 25 analyses per borehole) would probably be of the order of R731 per 100 boreholes, represented as follows :

Data Transfer	226.00
Card Punching	220.00
Editing and Loading	285.00
	R731.00

B. STORAGE AND MAINTENANCE COSTS

The monthly charge for storing 1000 borehole records on disk at the University's Computer Centre would be approximately R7.50.

The cost of copying data sets, from an area no longer current, on to tape, would be of the order of R15 per area.

C. COST OF OPERATING THE SYSTEM

As previously noted, there are two problem programs available at present.

The STRAT program processes File 1. The costs are for processing 100 boreholes in ten different ways. An example of two of these alternatives is :

(i) No. 5 Seam - print-out for each borehole, showing borehole number, width, depth of base, elevation of base, elevation of roof.

(ii) Parting between No. 4 and No. 2 Seams - print-out for each borehole, showing borehole number, depth of base of top horizon, depth of top of bottom horizon, parting width.

Processing Cost : R15.00

The CALC 1 program operates on data Files 2, 3, and 4. The costs are for processing 100 boreholes in four different ways, e.g. calculating and listing four alternative workable sections for each borehole, and calculating and listing the coal reserves based on these four sections.

Processing Cost : R175.00

A geologist, taking 50 days for the above tasks, would cost R1600. Operation costs should vary only slightly for different areas.

IV. SUMMARY

For a computer to be used economically, one or more of the following conditions must be present :

(i) There must be a large volume of data to be processed.

(ii) The processing must involve numerous mathematical manipulations.

(iii) The data must be retrieved or processed at frequent intervals.

A mining company actively prospecting a large coalfield or operating a network of collieries could probably satisfy these criteria and use an electronic data processing system with great advantage.

The main objective of the system described is to provide computer programs intended to supply coal reserve information. It has been designed to accommodate the coal borehole records of the Anglo American Corporation of South Africa, Limited, but should be adaptable to the records produced by other coal-mining companies.

The data to be stored in the system are transferred on to specially prepared input forms. These data are punched on cards which are run through several edit programs designed to detect obvious errors. When the data sets are error free, they are loaded on to a magnetic disk.

The records are stored in four files on disk. The first file contains stratigraphic information; the second, coal seam data; the third, analytic data; and the fourth, analyses of coal seam partings.

These records can be updated by altering fields, adding combination samples, or inserting additional analyses into existing samples.

The contents of the disk are written on to magnetic tape at regular intervals, as a precaution against the disk data sets being inadvertently destroyed. When an area is no longer current, the data sets are copied on to tape, and the disk is scratched.

To date, two programs have been written to process the data stored on the system. They are STRAT, which lists the most important stratigraphic information from requested boreholes, and CALC 1 which determines workable borehole seam sections, and calculates coal reserves by combining these sections on a basis proportional to the area of influence of each borehole.

The total cost of preparing and loading the data on to disk in a form suitable for further processing is estimated at approximately R7.31 per borehole. This cost is based on boreholes having 12 samples and 25 analyses each, and is made up as follows (per 100 boreholes) :

1.	Transfer of data on to input forms	R226
2.	Card punching	220
3.	Editing and loading data	285
		R731

The cost of processing <u>100 boreholes</u> using the programs STRAT and CALC 1, i.e. producing a list of information on 10 stratigraphic units, and calculating and listing four alternative workable sections in each borehole, together with the reserves based on these four alternatives, is estimated at approximately R190. A geologist, taking 50 days for the same task, would cost R1600.

* *

List of References

1. Shilling, J.W., 1969, "Facing the Challenge of Change" : Optima, Vol. 19, p. 104-112.
2. Straszacker, R.L., 1966, "The Future of Electric Power as Seen by Escom" : EASA, May-June, p. 36-74.

Acknowledgements

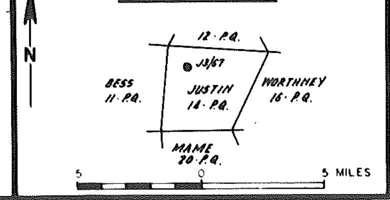
The Anglo American Corporation of South Africa, Limited, is thanked for permitting this report to be made public. The diagrams were drawn by Mr. G. Martens of the Corporation. Thanks are also due to Mr. I. Kong of the Computer Centre of the University of the Witwatersrand for assistance with programming problems.

* *

ANGLO AMERICAN CORPORATION OF S.A. LTD.
GEOLOGICAL DEPARTMENT

CONSULTING GEOLOGIST

LOCALITY PLAN



XXXX BLOCK

FARM :- JUSTIN 14 - P.Q.

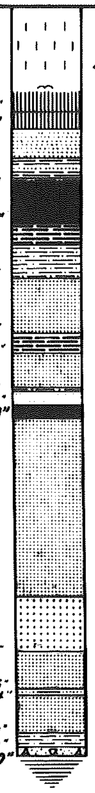
DISTRICT :- SPRINGS.

BOREHOLE Nº J 3/67.

SAMPLED BY R.H. GILLIGAN. DATE 6 · 6 · 67.
LOGGED BY R.H. GILLIGAN. DATE 7 · 6 · 67.
F/S ANALYSIS BY T.C.O.A. DATE 27 · 6 · 67.
COAL ANALYSIS BY T.C.O.A. DATE 27 · 6 · 67.

CO-ORDINATES Y -53,608.
X +5,402,786.
SURFACE ELEVATION -891' below datum.
DRILLER THERON.
DATE COMMENCED 31 · 5 · 67.
DATE COMPLETED 6 · 6 · 67.
DIAM. OF CORE Nx.
CASING LEFT IN HOLE Nil.

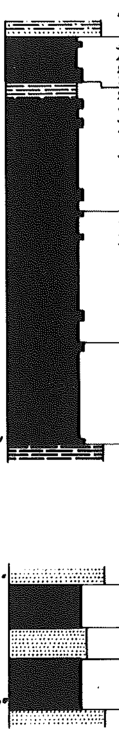
BOREHOLE SECTION



ELEV.	DEPTH	WIDTH	RECORD OF STRATA
	±45'0"	45'0"	Nil recovery. **SOIL. OVERBURDEN. CLAY.**
	52'0"	7'0"	**CLAY. MICACEOUS.**
	64'0"	12'0"	Nº 4 Sandstone.
	73'1"	9'1"	Nº 4 Roof beds.
	74'7"	1'6"	Sandy shales.
	91'11"	17'4"	**COAL ZONE ~ Nº 4 SEAM.**
	100'8"	8'9"	Carbonaceous shale.
	115'3"	14'7"	Sandy brown shales.
	138'8"	23'5"	Laminated sandstone.
	147'7"	8'11"	Carbonaceous shales.
	161'8"	14'1"	Finely laminated sandstone.
	163'9"	2'1"	Sandy shales.
	169'4"	5'7"	Medium-grained sandstone.
	174'8"	5'4"	**COAL ~ Nº 2 SEAM.**
	251'9"	77'1"	Sub. 2 Sandstone.
	273'8"	21'11"	Coarse grit
	289'6"	15'10"	Mainly ill-sorted sandstone.
	292'4"	2'10"	Carbonaceous sandstone.
	308'8"	16'4"	Dirty sandstone, some pebbles.
	314'2"	5'6"	Sandy shales.
	317'0"	2'10"	**TILLITE**, fine pebbles, closely packed.

WEATHERED TO 63'0".

SECTION OF COAL SEAM



ELEVATION	DEPTH	DESCRIPTION	%CORE RECOV.	SAMPLE WIDTH	SAMPLE Nº	COMPUTER SAMPLE NUMBER
		Nº 4 SEAM.				
	74'7"	ROOF :- Easily parted **SANDY SHALES** with sand stringers Note. Only 22' of consolidated rock above seam.			J3.	
		3" MIXED COAL. 4" DULL HEAVY INFERIOR COAL WITH SAND LENSES. 9" DULL LUSTROUS COAL. 7" MIXED COAL.		23"	67/4/4.	0404
		9" COALY SHALES WITH COAL STREAKS · SOME BROWN LUSTROUS SUBSTANCE IN LENSES. 5" DULL INFERIOR COAL. 5" BRIGHT COAL. 4" DULL BANDED COAL. 32" DULL LUSTROUS COAL. 6" BRIGHT COAL. 6" DULL INFERIOR COAL.		67"	67/4/3.	0403
		2" SANDY COAL. 9" DULL LUSTROUS COAL. 3" BRIGHT COAL. 36" DULL LUSTROUS BANDED COAL. 5" BRIGHT COAL. 11" DULL INFERIOR COAL.	98%	66"	67/4/2.	0402
		5" ZONE OF DULL COAL WITH BROWN SPORES. 45" DULL LUSTROUS COAL WITH PYRITES. 2" MIXED COAL.		52"	67/4/1.	0401
	91'11"	FLOOR :- **BLACK CARBONACEOUS SHALES** with coal streaks · very fissile.				
		Nº 2 SEAM.				
	169'4"	ROOF :- Medium-grained **SANDSTONE**.				
		22" MIXED COAL WITH 2 ½" BANDS OF SANDSTONE BLEBS IN COAL.		22"	67/2/2.	0203
		16" MAINLY LAMINATED FINE-MEDIUM-GRAINED, WHITE-GREY SANDSTONE.	98%	16"	N.S.	0202
		26" MAINLY INFERIOR DULL COAL.		26"	67/2/1.	0201
	174'8"	FLOOR :- Coarse **SANDSTONE**.				

ANALYSIS OF COAL SEAM

COMPUTER SAMPLE NUMBER	FRACTION S.G	FRACTION Yield %	FRACTION Cum. Yield %	MOISTURE % Fraction	MOISTURE % Cumul.	ASH % Fraction	ASH % Cumul	VOLATILE % Fraction	VOLATILE % Cumu	FIXED CARBON % Fraction	FIXED CARBON % Cumul	CALORIFIC VALUE LB./LB. Fraction	CALORIFIC VALUE LB./LB. Cumul	W.D SWELLING Nº	S %	A.F.T. °C Def	A.F.T. °C Hem.	A.F.T. °C Flow
	Sample Nº J3/67/4/4. Width 23".																	
0404	**F1·60**	77·0	**77·0**	5·2	**5·2**	15·0	**15·0**	27·8	**27·8**	52·0	**52·0**	11·28	**11·28**					
	S1·60	23·0	**100·0**	4·2	**5·0**	46·9	**22·3**	15·6	**25·0**	33·3	**47·7**	6·40	**10·16**					
	Sample Nº J3/67/4/3. Width 67".																	
0403	**F1·60**	44·4	**44·4**	6·5	**6·5**	17·7	**17·7**	24·1	**24·1**	51·7	**51·7**	10·48	**10·48**					
	S1·60	55·6	**100·0**	4·6	**5·5**	47·2	**34·1**	15·7	**19·4**	32·5	**41·0**	6·03	**8·01**					
	RAW					35·6						7·88						
	Sample Nº J3/67/4/2. Width 66".																	
0402	**F1·60**	67·8	**67·8**	5·7	**5·7**	17·0	**17·0**	26·1	**26·1**	51·2	**51·2**	10·71	**10·71**					
	S1·60	32·2	**100·0**	4·2	**5·2**	37·2	**23·5**	18·1	**23·5**	40·5	**47·8**	7·55	**9·69**					
	RAW					23·5						9·68						
	Sample Nº J3/67/4/1. Width 52".																	
0401	**F1·60**	84·3	**84·3**	6·5	**6·5**	16·4	**16·4**	24·8	**24·8**	52·3	**52·3**	10·56	**10·56**					
	S1·60	15·7	**100·0**	4·2	**6·1**	34·7	**19·3**	23·2	**24·6**	37·9	**50·0**	7·88	**10·14**					
	RAW					21·1						9·94						
	Sample Nº J3/67/2/2. Width 22".																	
0203	**F1·60**	85·9	**85·9**	5·2	**5·2**	15·0	**15·0**	27·7	**27·7**	52·1	**52·1**	11·39	**11·39**					
	S1·60	14·1	**100·0**	3·5	**5·0**	43·6	**19·0**	20·3	**26·7**	32·6	**49·3**	6·01	**10·74**					
0202																		
	Sample Nº J3/67/2/1. Width 26".																	
0201	**F1·60**	62·0	**62·0**	5·1	**5·1**	15·2	**15·2**	27·0	**27·0**	52·7	**52·7**	11·26	**11·26**					
	S1·60	38·0	**100·0**	3·5	**4·5**	43·6	**26·0**	20·3	**24·4**	32·6	**45·1**	6·01	**9·57**					

Note :- Input data in bold lettering.

Figure 1. Borehole log showing input data.

CALCULATIONS CHECKED BY S.J. LOG CHECKED BY S.J. LOG DRAWN BY C.G.

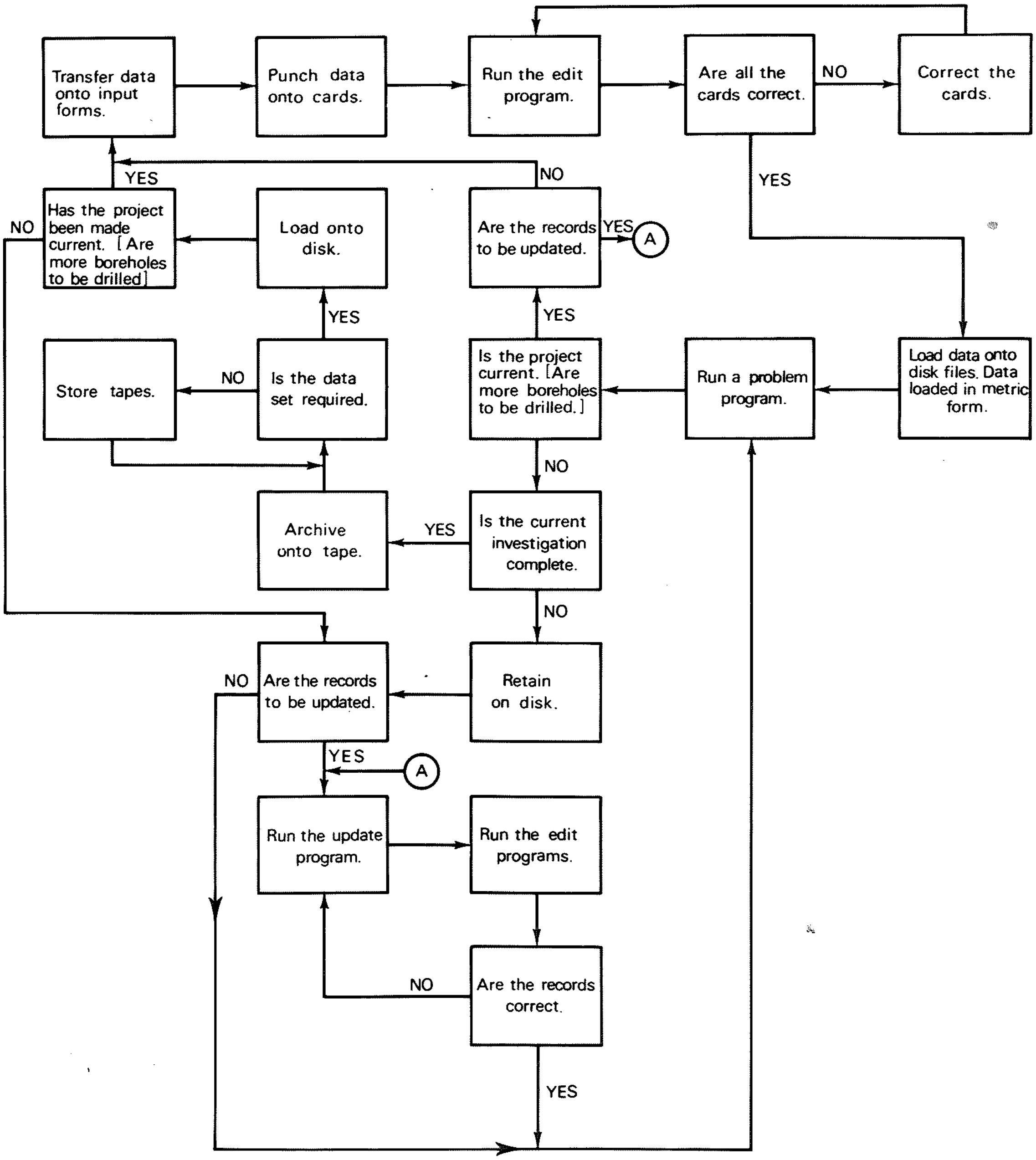


Figure 2. THE SYSTEM FLOWCHART

FIGURE 3

STRATIGRAPHIC DATA FORM 2

All entries are right justified unless indicated by an →

CODE	DESCRIPTION	CARD NO	WIDTH		DESCRIPTIVE CODE	ABSENT CODE	DEPTH OF BASE	
			Feet	Inches			Feet	Inches
0 1	SOIL AND OVERBURDEN	CARD 3	1	5	→ 6	8	9	14
0 2	WEATHERED ZONE		15	19	→ 20	22	23	28
0 3	NUMBER 5 SEAM		29	33	→ 34	36	37	42
0 4	NUMBER 4 SEAM		43	47	→ 48	50	51	56
0 5	NUMBER 2 SEAM		57	61	→ 62	64	65	70
0 6	DWYKA SERIES	CARD 4	1	5	→ 6	8	9	14
0 7	PRE KARROO		15	19	→ 20	22	23	28
0 8			29	33	→ 34	36	37	42
0 9			43	47	→ 48	50	51	56
1 0			57	61	→ 62	64	65	70
1 1		CARD 5	1	5	→ 6	8	9	14
1 2			15	19	→ 20	22	23	28
1 3	SOIL OVERBURDEN WITH DOLERITE BOULDERS		29	33	→ 34	36	37	42
1 4	DOLERITE TOPMOST		43	47	→ 48	50	51	56
1 5	DOLERITE BOTTOM MOST.		57	61	→ 62	64	65	70
	END OF HOLE DEPTH	CARD 6	1	6				
	NUMBER OF DOLERITES OTHER THAN THOSE DESCRIBED ABOVE		7					
	PRE KARROO ROCK TYPE	→						

FIGURE 4

All entries are right justified unless indicated by an →

COAL SEAM DATA BOREHOLE CARD

COMPUTER BH. NUMBER ↓ 1 4

A.A.C BH NUMBER ↓ 5 14

FARM NAME '5 34

FARM CODE 35 37

Y–COORDINATE 38 . 47

X–COORDINATE 48 . 58

ELEVATION :

ABOVE SEA LEVEL 59 . 66
OR
BELOW DATUM 67 . 74

NUMBER OF SAMPLED SEAMS IN BOREHOLE (maximum of 6) 75

NUMBER OF SAMPLES IN BOREHOLE (maximum of 20) 76 77

NUMBER OF ANALYSES IN BOREHOLE 78 80

FIGURE 5

All entries are right justified unless indicated by an →

COAL SEAM DATA – ANALYSIS CARD

COMPUTER SEAM NUMBER ☐☐ 1 2

COMPUTER SAMPLE NO. ☐☐ 3 4

SIZE FRACTION ☐ 1 5 6

QUANTITY (%) 1 0 0 • 0 7 11

Record the cumulative values for the following proximate analysis: –

S G ☐☐☐ 12 14

YIELD ☐☐☐ • ☐ 15 19

H20 ☐☐☐ • ☐ 20 24

ASH ☐☐☐ • ☐ 25 29

VOL ☐☐☐ • ☐ 30 34

F C ☐☐☐ • ☐ 35 39

C V ☐☐☐☐☐ • ☐☐ 40 47

C V CODE ☐ 48 1 = lbs lb, 2 = B T U's

HAS THE C V BEEN DETERMINED ☐ 49 1 = yes . 2 = no

S W NO. ☐ • ☐ 50 52

HAS THE S W. NO. BEEN DETERMINED ☐ 53 1 = yes, 2 = no

SULPHUR ☐☐ • ☐☐ 54 58

PHOSPHOROUS ☐ • ☐☐☐ 59 63

ASH FUSION TEMPERATURES:

DEF. ☐☐☐☐ 64 67

HEM. ☐☐☐☐ 68 71

FLOW ☐☐☐☐ 72 75

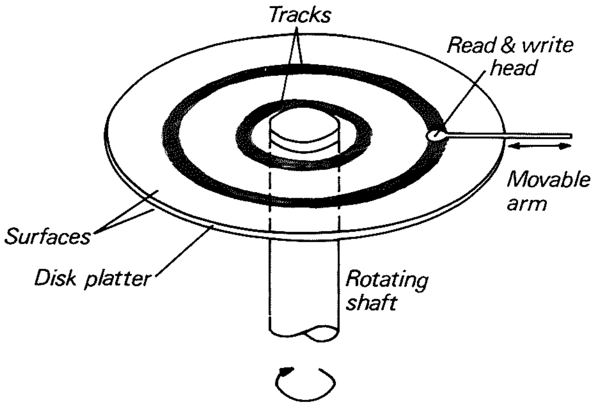
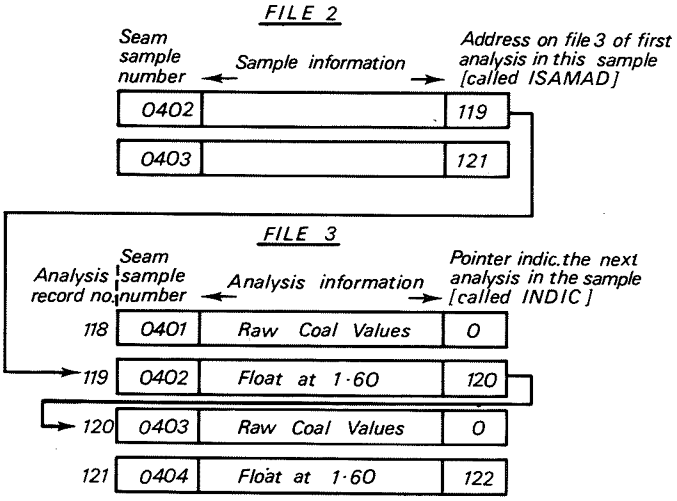


Figure 6. Disk



FILE 2

Seam sample number	Sample information	Address on file 3 of first analysis in this sample [called ISAMAD]
0402		119
0403		121

FILE 3

Analysis record no.	Seam sample number	Analysis information	Pointer indic. the next analysis in the sample [called INDIC]
118	0401	Raw Coal Values	0
119	0402	Float at 1·60	120
120	0403	Raw Coal Values	0
121	0404	Float at 1·60	122

A section of files 2 and 3 as stored on disk for the borehole record illustrated in Figure 1.

Figure 7