FUTURE RESEARCH DIRECTIONS IN COAL GEOLOGY IN THE PROVINCE OF ALBERTA: A PLAN OF ACTION

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1. INTRODUCTION

A set of recommendations for future work in coal geology by the ARC included research in the areas of coal quality, regional coal evaluation and database management (Langenberg et al., 1986). Coal quality ranked as the most important area of research resulting in a decision to focus the 1986-1989 Alberta Geological Survey Coal Geology Program on coal quality studies.

Alberta has an enormous amount of mineable coal. In the Plains region alone, inferred resources of coal total more than 300 billion tonnes (Strobl et al., 1987.). The general consensus holds that there is enough coal to last well into the next century. For this reason emphasis is placed on studies addressing coal characterization (which includes improved utilization of coal, aspects of mine planning and coal quality) rather than on the delineation of new resources. These types of studies are in line with the Alberta Coal Research Strategic Plan (ENR, 1983), which plans to enhance the competitiveness of Alberta coals by improving the quality and developing new uses of the coals and with the position of the coal industry (Coal Association of Canada, 1985) which supports research on coal leading to increased coal utilization.

By taking a commanding role in coal and coal-related studies, Alberta will strengthen its marketing position and ensure proper management of the valuable coal resource. Future research proposed in this document is aimed towards immediate use by government planners and the coal industry and is designed to compliment work done by other research organizations.

In the following discussion, possible contributions by ARC's Coal Geology Group will be identified and ranked according to their priority.

2. BACKGROUND

PAST EFFORTS

Prior to 1986, the Coal Geology Group of the Alberta Geological Survey concentrated on regional studies of Upper Cretaceous and Tertiary coals in the plains region. The earliest programs were aimed mainly at assessing the size and nature of the coal resources. Location, depth and seam thicknesses were among the parameters considered first. As these studies progressed, other important aspects were included, such as controls on coal deposition by tectonic influences, relative subsidence rates, basin geometry, and variation in relative sea levels (McCabe et al., in prep., Richardson et al., in prep., Macdonald et al., in prep.). In addition, geological studies in the foothills showed that structural thickening results in mineable coal deposits (Langenberg, et al., 1987). It was recognized that understanding the regional depositional and structural setting is fundamental to predicting where the best coal deposits are and how the quality of the coal varies with location.

From relatively modest beginnings in which coal quality at various mines was catalogued (Stansfield and Lang, 1944; and Campbell,1964) to extensive drilling and sampling programs of shallow coals in the plains region (1974 and 1982), ARC played an important role in building a coal quality database. These data were used extensively by other government agencies and by private companies for exploration purposes and for assessing coal leases throughout the plains region. In addition to providing data on the coal deposits in the province, the Alberta Research Council also worked on characterization of the coal itself. Reports on coal quality by Nurkowski (1985) and Parkash (1985) are two recent examples of such work.

The study of coal quality in Alberta is still at an early stage as compared to what has been achieved in other jurisdictions. As the status report by Langenberg et al., (1986) points out, increased research on coal quality and its prediction is of the highest priority.

The present coal geology program of the Alberta Geological Survey is partly addressing this need.

PRESENT STATUS

Details of the present program are given in the status report and workplan by McCabe et al.,(1987), so only a brief overview is given here.

In the plains region, emphasis has been placed on quantifying the degree of variability and to develop an understanding of the factors that control coal quality in the Ardley (early Tertiary) and the Drumheller (Upper Cretaceous) coal zones. These are detailed studies in which analyses are available on a seam by seam basis. In addition, coal facies studies are underway to determine in-seam variations in coal quality.

In the foothills/mountains region, coal quality is being investigated on two scales. On a regional scale, statistical analysis is being performed on all publicly available coal quality data and a synthesis of coal rank variation is being prepared. On a more detailed scale, in a study of the Cadomin-Luscar coal field, a detailed assessment is being made of coal quality variations in a specific structurally deformed coal-bearing sequence. The effect of folding and faulting on local variation in coal quality (especially thickness, ash content and rank) is one of several aspects being investigated.

LEVEL OF KNOWLEDGE EXPECTED AT THE END OF THE PRESENT PROGRAM

By the end of the present program we expect to have gained a preliminary understanding of the geologic factors that control coal quality and to have developed predictive models for some of the observed variations in quality. The present program will solve some of the more pressing and immediate problems but preliminary results indicate that gaps in the database will severely limit our ability to draw general conclusions. The results will point out critical parameters and help us

focus future studies.

Although detailed coal quality studies are just in the beginning stages, many of the results will have direct application to industry and governments. Documentation of basic coal quality information (such as rank, sulphur, ash and moisture contents) of the economic coal zones in the foothills/mountains region is particularly needed. At present, coal quality data are only available at local minesites. In more general terms, we will also be able to put confidence limits on the prediction of coal quality. The development of predictive sedimentological and structural models and the understanding of the variability of certain coal quality parameters will enable us to improve sampling techniques and optimize drilling programs in selected areas. A sizeable contribution will be made to the development and maintenance of a coal quality database in which data are derived from a wide range of sources including the ERCB, GSC, private coal companies and the Alberta Research Council. It is these types of stepping stones that will put Alberta's coal resources in a favourable marketing position in the years to come.

3. POSSIBLE AREAS OF COOPERATION BETWEEN AGENCIES

Joint research is possible in many aspects of coal geology including coal quality, stratigraphy and correlation, structural mapping, sedimentology, coal databases, geophysics and new technologies. A summary of the most important areas is given in Langenberg et al., (1986). Some selected examples are given below. Data sharing and the development of a central database deserves attention. Large amounts of data have been collected by agencies such as the Alberta Research Council, Geologic Survey of Canada, Energy Resources Conservation Board and private coal mining companies. Combining these data would result in a rich database from which various studies, including coal quality, could be launched. A cooperative venture using geographic information systems (GIS) for resource management, mine planning and related studies is another possibility. A relatively small GIS effort by ARC has already attracted industry interest and will undoubtedly form a basis for joint efforts in the near future. Through cooperation in areas such as coal petrography and geologic studies between ARC and the Geologic Survey of Canada, scientific efforts will be optimized.

4. FUTURE DIRECTIONS

ARC should play a leading role in four major research areas. For each of these a series of projects are outlined in which the Council has the in-house expertise and the facilities to begin work immediately. They are: coal quality, geological studies, new technologies and management of the resulting coal databases. A ranking and a brief description of some recommended projects in each research area are provided. Together, they lead to the long term objective of characterizing Alberta's coal resources (figure 1).

COAL QUALITY

The area of coal quality research is divided into three major project groupings: coal quality/resource data collection in the foothills and mountains; coal quality/resource data collection in the plains; and statistical analysis of new data (see figure 2). Most segments of these project groupings are expected to take between 5 and 20 years to complete.

Coal quality studies in the foothills and mountains - Studies of the foothills and mountains have a high priority because of the limited data that are currently available. Coal quality studies go hand in hand with geologic studies. Study areas of immediate interest include Copton Creek, Coleman-Blairmore, Coalspur, the area between Hinton and Grande Cache and the area between Cadomin and Nordegg.

Coal quality studies in the plains - Near surface and more deeply buried coal deposits in the plains are an ongoing concern. In areas presently mined, a high priority is given to detailed coal quality studies to solve specific mining problems such as the variation in sulphur and sodium. In promising new areas such as Wapiti and Cold Lake, regional assessments of the coal resources and coal quality will be needed.

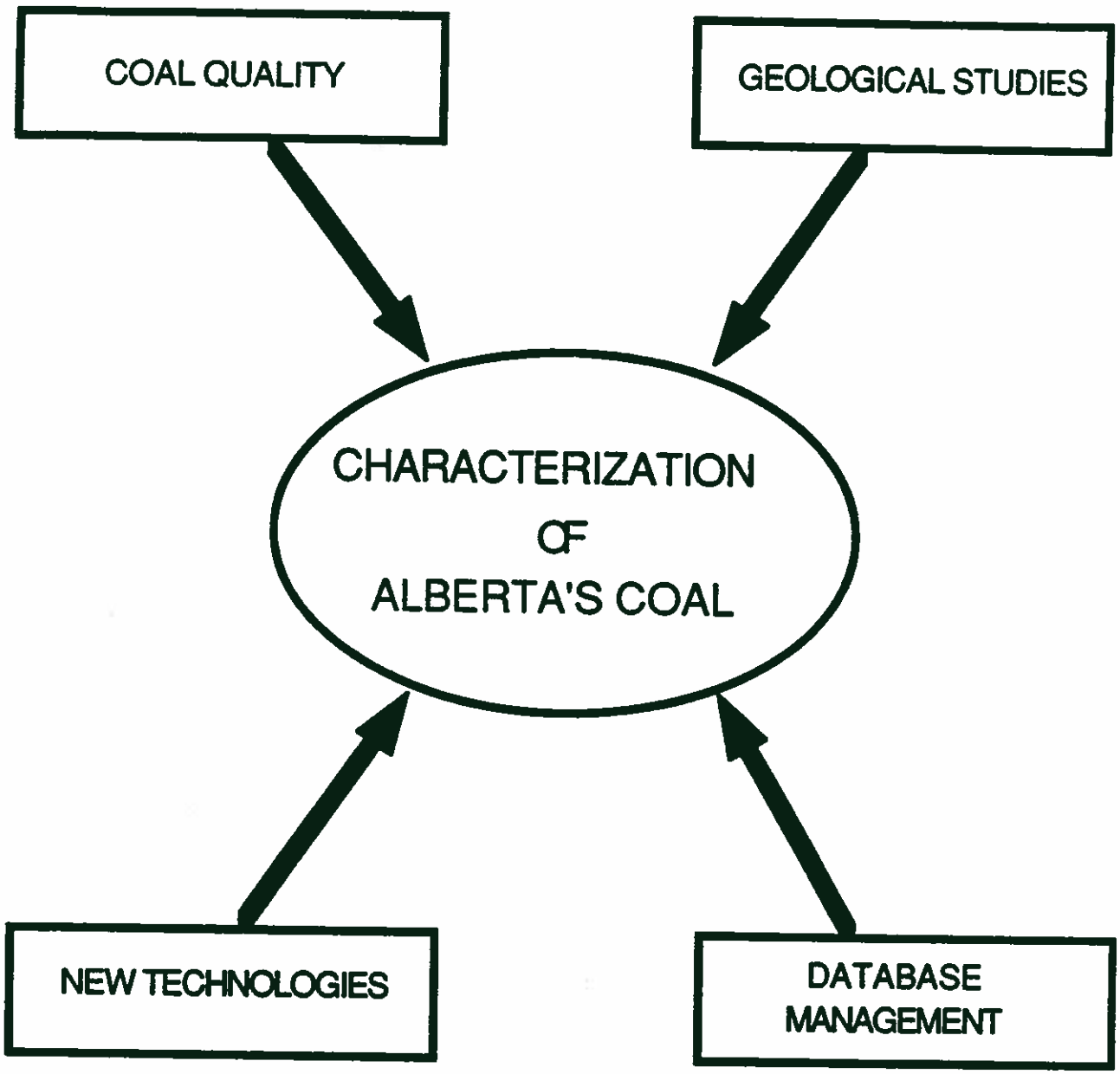
COAL QUALITY
GEOLOGICAL STUDIES
CHARACTERIZATION
OF
ALBERTA'S COAL
NEW TECHNOLOGIES
DATABASE
MANAGEMENT

FIGURE 1

Statistical analysis - Statistics play an important role in the formulation of predictive models that relate coal quality to independent variables such as depositional environment and structural deformation. A wide range of statistical techniques will be used depending on the purpose of each study. Much attention will be given to the quantification of variability and the setting of confidence levels.

A brief description of some recommended substudies, each requiring 5 years or less to complete, is given below. These substudies will either form segments of the overall research effort or be derived from the wealth of data resulting from this effort. The ultimate goal of all coal quality studies is to develop sedimentologic, structural, and statistical models characterizing and predicting coal quality in Alberta (see figure 2).

Sodium in coal - Sodium in thermal coals often causes severe slagging and costly boiler problems. In metallurgical coals, excessive sodium can alter the coking properties of the coal. The prediction of the distribution of sodium content is, therefore, an important problem to be addressed in the near future and is given a high priority.

Sulphur in coal - The sulphur content of most Alberta thermal coals is comparatively low. However, strict SO_2 emission standards must be adhered to. Alberta's utility companies are very concerned and currently monitor the sulphur content of the raw coal and the SO_2 stack emissions. In addition, relatively high concentrations of sulphur affect the coking properties of metallurgical coals for the export market. It is essential that studies be undertaken to document the forms of sulphur, and the distribution and prediction of total sulphur. This problem is given a high priority.

Ash in coal - The ash content of Alberta's coal varies laterally and vertically within seams and between different coal zones. It is important to quantify the variation in ash and to develop predictive models. Current studies address this problem for selected areas but considerably more work is needed. Ash in coal is given a high priority.

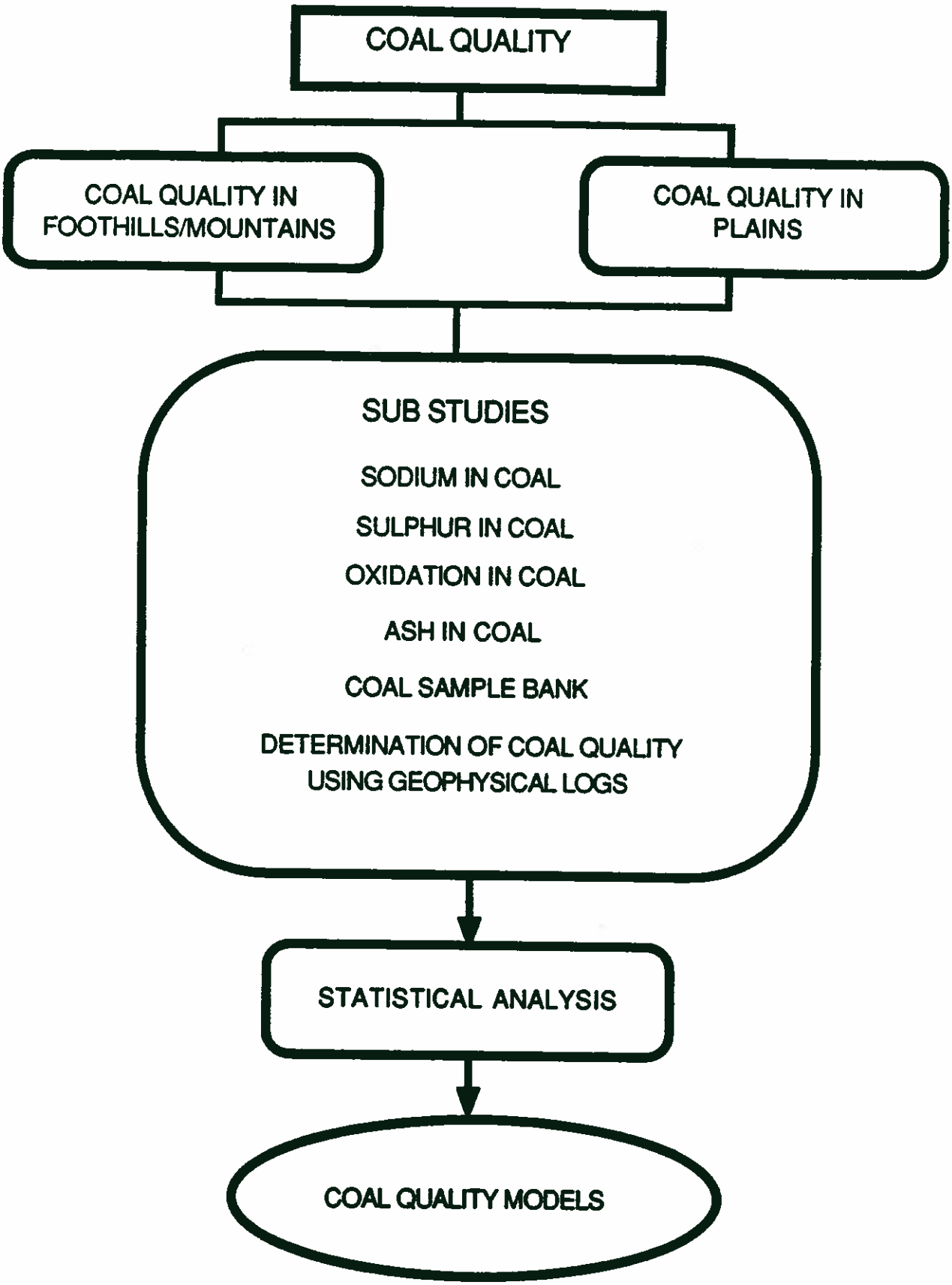
COAL QUALITY
COAL QUALITY IN FOOTHILLS/MOUNTAINS
COAL QUALITY IN PLAINS
SUB STUDIES
SODIUM IN COAL
SULPHUR IN COAL
OXIDATION IN COAL
ASH IN COAL
COAL SAMPLE BANK
DETERMINATION OF COAL QUALITY USING GEOPHYSICAL LOGS
STATISTICAL ANALYSIS
COAL QUALITY MODELS

FIGURE 2

Coal sample bank - A sample bank provides a supply of samples on which a variety of geochemical and geological studies within the province can be based. In addition, numerous requests are received for samples from potential clients outside of the province. A sample bank will also provide standards for calibration of measurement techniques. This project is given a high priority.

Determination of coal quality using geophysical logs - Although more than 40 000 coal exploration holes have been drilled in Alberta, only about 10 percent have coal quality data associated with them. Some of the more important coal quality parameters such as ash, moisture and carbon content can be measured directly from geophysical well logs. Determination of coal quality parameters from well logs is desirable for the understanding of coal quality in the vast regions of Alberta lacking this information. This project is given a high priority.

Oxidation in coal - It is widely known that coals exposed to the atmosphere oxidize and their quality degrades. For this reason large amounts of coal located along subcrop boundaries are not mined. Studies on the detection and measurement of oxidized coal in samples and the effects of oxidation on coal utilization are considered to have a lower priority at present, but will be increasingly important over the long term.

GEOLOGICAL STUDIES

This area is divided into two major project groupings: detailed geologic mapping and regional geologic mapping. These efforts tie in closely to coal quality research. The projects are expected to take between 5 and 20 years to complete. Figure 3 shows the relationship of these project groupings to the ultimate goal of geologic modelling.

Detailed geologic studies - Detailed studies of selected areas are very much required in the foothills/mountains and the plains. Drilling programs are recommended in order to obtain optimal results. Detailed structural and correlation studies for the foothills/mountains include Copton Creek and Coleman-Blairmore. These areas have been of interest to industry for some time, yet very little is known about the geology or quality of the coals. Detailed studies proposed for the plains include the Wapiti and Cold Lake areas. Reconnaissance mapping indicates that substantial amounts of near-surface coal are contained in the Wapiti area, but to date, only limited data are available on the resources and coal quality of these coals. Detailed studies of the Cold Lake area are being considered as a source of energy for recovery of heavy oils and bitumen.

Regional geologic studies - Regional studies are recommended for areas with limited geologic and structural mapping and/or limited coal quality information. In the foothills/mountains, suggested areas for study include Coalspur, and the areas between Hinton and Grande Cache and between Cadomin and Nordegg. In the plains, regional studies of rank variation and the methane resources of deeply buried coals are recommended. The Peace River Arch and selected portions of the Deep Basin are attractive areas for further study. In these areas, limited data are available on the thermal maturation of potential hydrocarbon-bearing strata and on potentially economic sources of methane contained in the coals.

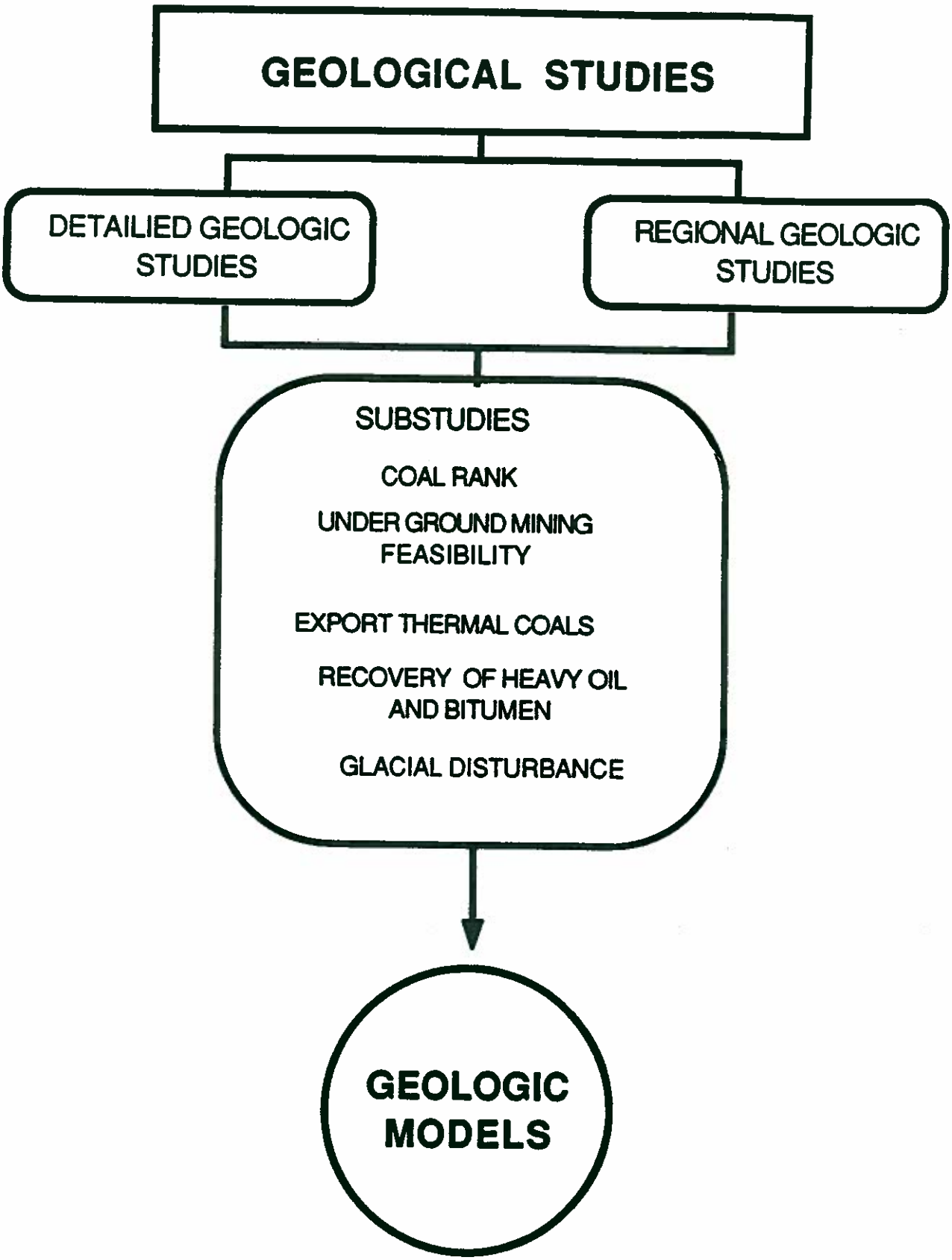
GEOLOGICAL STUDIES
DETAILIED GEOLOGIC STUDIES
REGIONAL GEOLOGIC STUDIES
SUBSTUDIES
COAL RANK
UNDER GROUND MINING FEASIBILITY
EXPORT THERMAL COALS
RECOVERY OF HEAVY OIL AND BITUMEN
GLACIAL DISTURBANCE
GEOLOGIC MODELS

FIGURE 3

An outline of some recommended substudies is given below. The duration of these substudies depends on the size of areas selected and the level of detail required. Most substudies have a 5 to 10 year duration.

Export thermal coals - Alberta coals are an attractive source of energy for eastern Canada because of their relatively low sulphur content. Increased use of high quality thermal coals from Alberta will significantly reduce a growing acid rain problem. Defining deposits of coal which can compete for this market should be given high priority.

Recovery of heavy oil and bitumen - Coal is an attractive source of energy for steam generation in the thermal recovery of heavy oil and bitumen, and for generating electricity to drive refineries. Companies operating in the Lloydminster and Cold Lake areas have investigated this idea, but because the geology of nearby coal deposits is not well understood, progress has been slow. This project is given a high priority.

Glacial disturbance - Research into highwall stability, undertaken by the ARC, has played an important role in mine planning at the Highvale and Paintearth minesites. There is a growing concern about glacially thrusted terrain and its relationship to near-surface coal resources. As new surface mines are opened and as presently operating mines expand, this type of research will be particularly useful. This project is given a high priority.

Coal rank - The rank of coal at surface in the Alberta plains is well documented, but very limited data are available at depth. Samples from coal zones intersected in oil and gas wells can be obtained quickly and economically. Using vitrinite reflectance as a tool, we will determine the variation of rank with depth. Results of this study can also be used to measure the thermal maturity of potential hydrocarbon-bearing sediments basinwide. Similarly, the potential of methane generation from coal zones throughout the basin can be evaluated. A lower priority is given to this project because coal quality of near-surface coals is

considered more important at this time.

Underground mining feasibility studies - Underground mining in the plains region will become attractive when the best near-surface deposits become depleted. There is good reason to believe that underground mines will be economic in the foreseeable future. Projects falling in this field are given a lower priority because only shallow coals are presently being mined.

DATABASE MANAGEMENT

Information obtained through current and future coal geology studies must be stored and maintained in a central database. Data stored in this manner can be easily accessed by the ARC and other research organizations for expanded or completely new studies. The ARC is currently developing a central database, which integrates data produced by the Coal Geology Group and by the Energy Resources Conservation Board (ERCB). Since the Alberta Geological Survey has the computer facilities and the expertise, it should be a key player in designing and maintaining future expanded databases.

Recommended sources of data for the central database are shown in figure 4. A brief description of each source is given below. A more complete explanation of database management is available in McCabe et al. (1987).

Alberta Research Council - The Council has information on coal resources and coal quality. Coal quality information from previous programs contains proximate and ultimate analyses of coal at relatively shallow depths, along subcrop boundaries and at various minesites throughout the province. Coal resource information is available for coals ranging from the near-surface to depths of about 400 m. The current program will generate considerably more information on coal quality for both the foothills/mountains and the plains region.

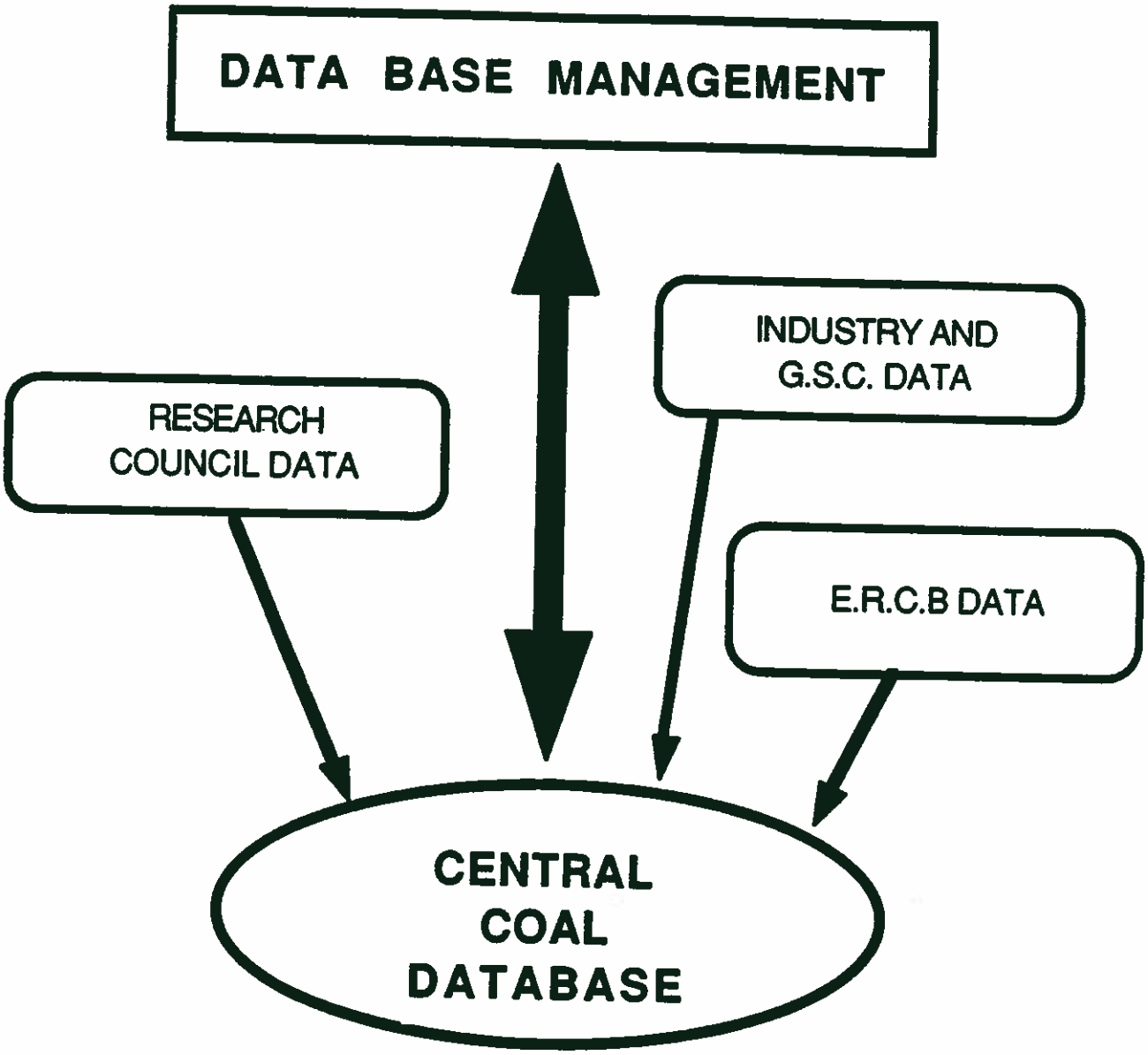
DATA BASE MANAGEMENT
INDUSTRY AND G.S.C. DATA
RESEARCH COUNCIL DATA
E.R.C.B DATA
CENTRAL COAL DATABASE

FIGURE 4

Energy Resources Conservation Board - The Energy Resources Conservation Board (ERCB) has available all non-confidential data submitted by coal companies in the province. These data are usually derived from exploration and development drillholes. The ERCB data are available for the entire province and are updated regularly.

Industry Data - Abundant coal quality data and coal resource data are available from around and within minesites. In the plains region especially, these data are from closely spaced drillholes. The Geologic Survey of Canada (GSC) also operates a coal resource database. It incorporates information from coal development drilling within established coalfields. Stratigraphic information on the coal is included in it, which is an advantage.

NEW TECHNOLOGIES

Technological advances over the last decade, especially in the area of computing, have resulted in remarkable changes in the study of coal geology. Some examples of new research fields created by these advances include Geographic Information Systems (GIS) and expert systems (a type of artificial intelligence). The relationship of these projects to the long term goal is illustrated in figure 5.

Geographic Information Systems - Geographic information systems (GIS) are a breakthrough in information technology. They allow the combination of traditional databases with spatially oriented information to form one relational database. Information in a GIS database can be manipulated, updated and retrieved in the form of maps, graphs and tables. The flexibility of GIS allows, for example, to combine locational information with stored relational data such as coal quality, hydrogeology, land management and satellite photography. The real power of GIS lies in its flexibility and its ability to manipulate and directly compare information from several sources.

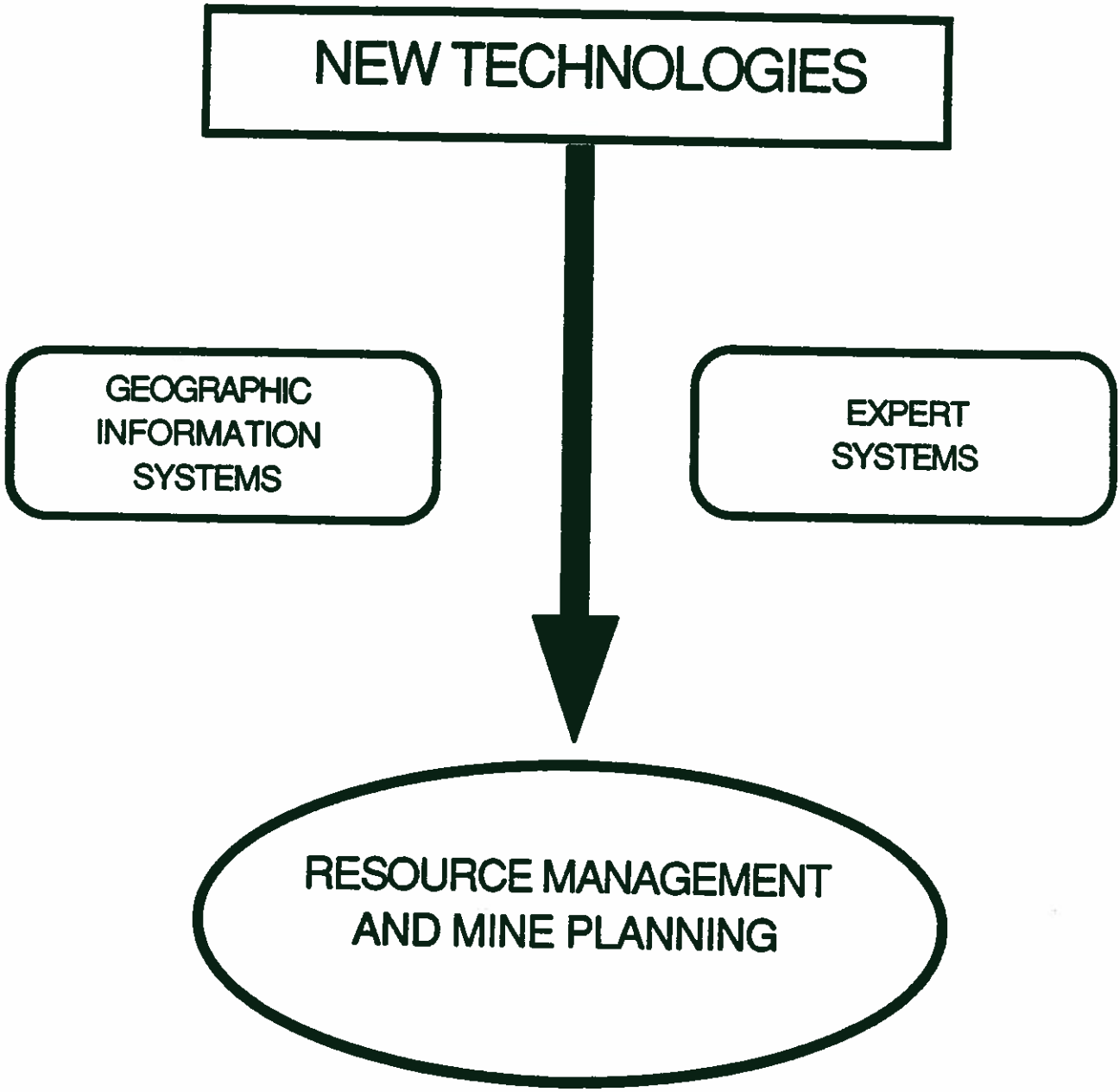
NEW TECHNOLOGIES
GEOGRAPHIC INFORMATION SYSTEMS
EXPERT SYSTEMS
RESOURCE MANAGEMENT AND MINE PLANNING

FIGURE 5

Expert Systems - Expert systems are defined as man-machine systems with a specialized problem solving expertise. Relating specialist knowledge of a particular field, the computer can isolate critical elements of a problem, apply written rules and definitions, and detect incomplete data or errors in data. An expert system is more than a simple database in that the computer can provide solutions to problems based on amassed human knowledge and experience. Specialist knowledge can be divided into two domains, public and private. The public domain commonly consists of written rules, facts and definitions. The private domain contains what is commonly referred to as "experience", a set of empirical formulas allowing the user to make educated guesses and to deal with errors. Several expert systems are currently in use. Some examples are MYCIN for medical diagnosis, DENDRAI for solving problems related to molecular structures and MUPROSPECTOR for mineral and oil exploration.

An outline of some recommended substudies is given below. Duration of these substudies varies from 5 to 10 man years. This is by no means a complete listing, but rather a set of examples.

Remote sensing in GIS - Remote sensing (or satellite imagery) has remarkable capabilities. With a resolution of about 50 metres, it now offers a powerful tool for analyzing surface features. Incorporation of these data into a geographic information system, would play an important role in mine planning and resource feasibility studies. Because of accelerated interest in GIS and the use of remote sensing, this project is given a high priority.

GIS for mine planning - A flexible and powerful mine planning and modelling system can be developed using a GIS. Important aspects include its ability to integrate subsurface data with surface attributes and the integration of cross-sections. The capabilities of TRIPOD should be built into this GIS. A low cost GIS of this type is of immediate interest to industry so this project has a high priority.

GIS processing of geologic maps - A geologic map can be regarded as a display of spatial data with several layers of information. Geologic units, structural data, locations of roads and rivers, and point information such as locations of drill holes and settlements are commonly given in these maps. If such data are stored in a GIS, changes to separate layers can be done independently without affecting other layers. Maps with updated information or maps made to order with specialized information can be easily produced. Promotion of GIS for processing of geologic maps is given a high priority.

Expert system for the Tripod structural software - Tripod is a structural geology software program developed by the University of Alberta, with some assistance from the Alberta Research Council. Tripod's primary function is the processing of geologic information and the production of various displays of deformed strata. The down-plunge projection feature has helped predict the locations of economic coal deposits which are now being mined. If the expertise of Tripod's developers could be included with the software in the form of an expert system, Tripod's uses would be greatly expanded. As an aside, it is interesting to note that the use of Tripod is not restricted to coal exploration. It can also be applied to the exploration for oil and gas. This project is given a lower priority.

APPENDIX 1.

INITIAL PRIORIZATION AND LISTING OF FUTURE RESEARCH PROJECTS

1. Coal Quality
   - A. Coal quality studies of the foothills and mountains.
   - b. Coal quality studies of the plains.

2. New Technologies
   - a. Geographic Information Systems.
   - b. Expert systems

3. Geological Studies
   - a. Detailed geological studies.
   - b. Regional geological studies.

4. Database Management

PRIORIZATION SCHEME

FIRST SUBDIVISION

HIGHEST 1. ----> 4. MEDIUM

SECOND SUBDIVISION

HIGHEST A. ----> B. LOWEST