DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Coal exploration in Costa Rica: A project assessment

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Open-File Report 89-426

Report prepared jointly by the Refinadora Costarricense de Petroleo
and the U.S. Geological Survey under the auspices of the
U.S. Agency for International Development

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

1/ U.S. Geological Survey, Denver

1989

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ABSTRACT

Since the completion, in 1986, of the cooperative coal program between the U.S. Agency for International Development (USAID) and Refinadora Costarricense de Petroleo (RECOPE), exploration activities have decreased because of decreases in manpower and funding along with the decision to concentrate those resources in a small part of the Corina area of the Zent coal field, in order to create the information needed for recovery and utilization planning. All stages of exploration must be conducted, even if only at a low level of activity, or tomorrow's coal reserves will not be available for utilization.

Concentration of effort in the Zent coal field has resulted in the creation of the information necessary for planning recovery operations in a small part of the field. About 1 million tonnes of coal classified as minable is present in an area where the coal bed is about 2 m thick and has a maximum overburden of 50 m. Statistical appraisal of analyses of the coal bed, named El Indio, indicates an average moisture content of 41.36 percent, ash content of 12.58 percent, sulfur content of 0.98 percent, and an average heating value of 3,227 kcal/kg or 5,809 Btu/lb, all on the as-received basis. The average analysis equates to a moist, mineral matter-free Btu/lb of 6,707 which indicates that the coal has an apparent rank of lignite A and has medium ash and low sulfur contents. As such, because of the high moisture and resulting lower heat value, the coal is of lower quality than most coals in the USA but is comparable to or better than fuels used for generation of electricity or industrial process heat, or both, in some other countries of the world.

Almost 1,000 coal samples have been analyzed in the coal analytical laboratory that was established at RECOPE during the USAID/RECOPE cooperative program. A definitive evaluation and statistical analysis of the physical and chemical coal quality parameters determined by the laboratory, for samples from all coal areas of the country, is needed to allow informed planning for utilization. To date, only the samples from the Zent coal field have been studied in a detailed manner.

Even though much exploration remains to be done, advanced planning for initiation of utilization is urgently needed--now. The options for usage of coal as an alternative to other available fuels must be investigated. Pilot utilization studies are required and demonstration projects should follow shortly. Cooperation between all concerned Costa Rican agencies, organizations, and individuals, along with the available international assistance, could speed utilization of Costa Rica's coal.

INTRODUCTION

Background

In the spring of 1981, the Instituto Costarricense de Electricidad (ICE) requested technical assistance in aspects of coal resource assessment from the U.S. Agency for International Development (USAID). A visit during that year by U.S. Geological Survey (USGS) experts, under an interagency agreement with USAID, resulted in a summary of the available coal information and a proposed coal resource assessment plan (Landis and Miller, 1985). With some variations, that proposed plan has been followed by subsequent workers.

During the winter of 1982-1983, responsibility for investigation and development of the coal resources of Costa Rica was given to the Refinadora Costarricense de Petroleo S.A. (RECOPE). Technical assistance was requested of USAID by RECOPE and in January and February of 1983, a team composed of A.J. Sabadell of the Science and Technology-Energy group of USAID/Washington, D.P. Lijesen of Bechtel group, and E.R. Landis of USGS, along with counterpart Costa Ricans, drew up a work plan for coal resource development to be funded by USAID/Costa Rica. The work plan was signed in July 1983, and technical assistance in coal exploration was initiated under USAID Conventional Energy Technical Assistance Project 936-5724.

The cooperative program was completed in early 1986. The objectives of USAID in sponsoring the technical assistance project conducted cooperatively by USGS and RECOPE were achieved. Training and technology transfer in coal resource exploration and assessment had been effected and RECOPE has a group of professional and technical personnel trained and experienced in modern coal exploration (Landis, 1985). Since the end of the cooperative program, RECOPE has continued efforts in coal exploration and development.

Present Study

At the request of RECOPE and USAID/Costa Rica, the authors have reviewed the progress in coal exploration, development, and utilization planning done by RECOPE, since the end of the cooperative program that provided guidance, support, and training during the initial part of Costa Rican coal development efforts. The review process has provided a basis for identifying problems and assistance in providing suggestions for solutions or new directions of effort.

The activities at individual localities, areas, and coal fields are discussed in the section of this report entitled "Status of knowledge on coal occurrences." However, several major intimately related changes in the form, type, and quantity of coal-related activities have occurred since 1986; for example: 1) a shift in emphasis from the early stages of exploration in fairly large areas to concentration of effort into smaller and smaller areas; 2) a decrease in funding and manpower for geologic field work and drilling; 3) a large increase in emphasis on development work to allow estimation of more proven (measured) resources, so mine planning and utilization planning and testing can be conducted on a reliable basis; and 4) a concentration of effort into the strategically located Zent coal field near Limon.

Development and Utilization Planning

During the winter of 1984-1985, a demonstration and bulk sampling pit was opened by bulldozers in the Uatsi Project Area of the Baja Talamanca coal field. Politicians, public, and press were invited to observe that there was, indeed, coal of minable thickness that could be recovered in part by surface methods and that plans for further recovery and utilization should be made. A subsequent report on recovery and utilization possibilities was produced by Bechtel Group as the final part of the USAID-sponsored cooperative program. Since 1986, the re-alignments of program have caused exploration in the Uatsi Project Area to become inactive.

The concentration of available manpower and money in the Zent coal field, west of Limon and near the main east-west communication corridor of Costa Rica, has produced a fairly closely spaced net of data points in a small (less than one-half square kilometer) area. This data density allows reliable correlation of coal beds, definitive understanding of the structural relations, and placement of about 1 million tonnes of coal in a minable reserve category. Plans have been prepared for open-pit mining, estimates of cost have been made so that a price for deliverable coal can be set, an adequate field camp has been constructed for support of exploration and mining operations, and a coal preparation, storage, and handling area has been established and equipped.

Acknowledgments

The study reported herein could not have been conducted without the support of Heriberto Rodriguez (USAID/Costa Rica) and M.J. Bergin (USGS/Reston). The exploration personnel of RECOPE, under the leadership of Pedro S. Afonso L., were universally very helpful. RECOPE geologists, in particular, Oldemar Ramirez E., Kenneth Bolanos I., Luis Malavassi R., and Rogelio Samuels D. provided essential guidance and support. As usual, the authors' cooperative endeavors with RECOPE have been successful and pleasurable.

PREVIOUS EXPLORATION

When the USGS/RECOPE cooperative investigations began in 1983, little was known about the coal in Costa Rica (Landis and Miller, 1985). During the program, reconnaissance was undertaken in eight of the nine known and reported coal localities (fig. 1). In three of the eight localities, the Venado and Zent coal fields and the Uatsi Project Area of the Baja Talamanca coal field, more detailed investigations were initiated.

By the termination of the program in 1986, the Venado coal field had undergone Reconnaissance and Early Exploration Stage studies and Exploration Stage I investigations had been initiated (see appendix 1 for explanation of exploration stages). The Zent coal field was subdivided into three parts, and by the end of the program, reconnaissance had been completed or was in progress in all. In one part, the Corina area, Early Exploration Stage studies were completed and Exploration Stage I investigations were beginning. The Baja Talamanca coal field was subdivided into the Uatsi Project Area and an unnamed northern area; only reconnaissance was undertaken in the northern part. Reconnaissance and Early Exploration Stage studies had

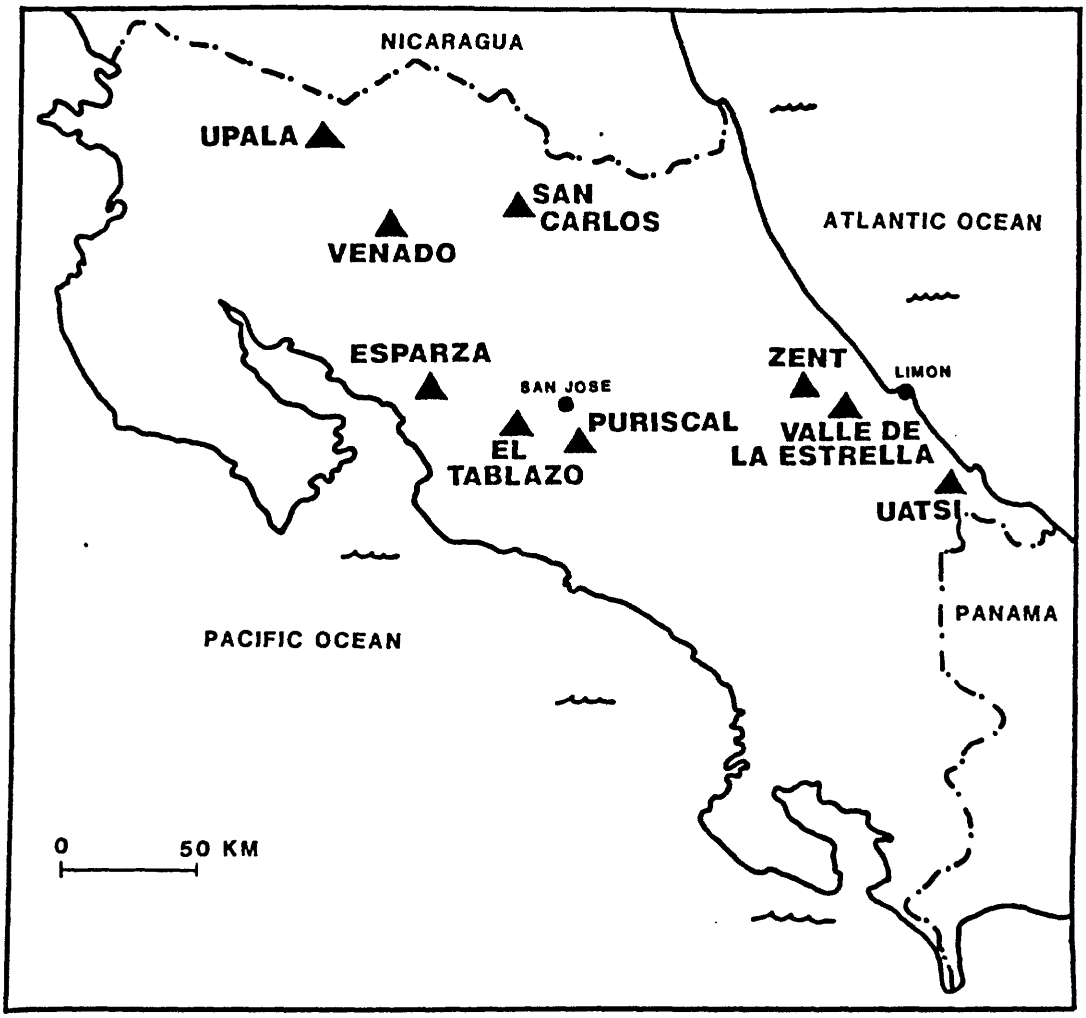

FIGURE 1 KNOWN COAL LOCATIONS IN COSTA RICA

already been completed in the Uatsi Project Area; therefore, Exploration Stage I studies were initiated there when the cooperative program began. This exploration stage was completed by the end of the program and Exploration Stage II had been started.

EXPLORATION 1986-1989

Since mid-1986, when the cooperative program between RECOPE and USGS was completed, RECOPE has continued coal exploration and development activities and initiated planning for coal recovery and utilization methods.

The facilities and the resulting systems have been tested. In 1988, about 700 tonnes of coal were recovered from the Zent open pit, moved to preparation facilities, and processed as shown in appendix 2, figure D. The resulting stockpile contained coal less than 1 in. (25 mm) in size and, as sampled by RECOPE, had, on the as-received basis, a moisture content of about 42 percent, ash content of less than 12 percent, sulfur content of 0.9 percent, and a heat value of 3,009 kcal/kg (5,416 Btu/lb). Consequently, the sample indicates a moist, mineral matter-free Btu of 6,206, a rank of lignite B (very near the artificial boundary between lignite B and lignite A), medium ash content, and a low sulfur content (Cubilla and Samuels, 1988).

The stockpiled coal was trucked to the cement factory near Cartago, which is operated by Industria Nacional de Cemento, S.A. (INCSA). There it was tested by INCSA for suitability and efficiency as a supplemental fuel. It was hoped that 20 or more percent of the bunker fuel oil could be replaced by coal during the test. In actuality, no more than about 11 percent of the primary fuel (fuel oil) was replaced (Avila and others, 1989). Several problems were encountered; for example, as a result of grinding and drying of the coal prior to its utilization, the moisture content was reduced to 2.24 percent from 41.39 percent, the ash content was increased from 21.73 to 43.69 percent by addition of cement dust, and the heat value was reduced from 5,090 kcal/kg to 2,646 kcal/kg. The problems were caused largely by procedures and equipment, and do not necessarily preclude the use of the coal in cement-making.

STATUS OF KNOWLEDGE ON COAL OCCURRENCES

Upala Occurrence

Coal (lignite) occurs near the town of Upala, along the Rio Zapote, in the northern part of Alajuela Province. Upala is about 8 km south-southwest of the Nicaraguan border, about 20 km south of Lake Nicaragua. A sample of the coal collected and analyzed in 1981 contained 60 percent ash and a heating value of 3,998 kcal/kg (7,196 Btu/lb), but no other data about the occurrence were reported (Landis and Miller, 1985). A subsequent visit by RECOPE geologists in 1985 confirmed the presence of coal in a bed 0.8 m thick but no additional samples from this bed were collected for analysis. Much of the area is covered by colluvium and landslide debris and no further information on the geologic factors was obtained. The reconnaissance confirmed presence of coal in the area but further reconnaissance is needed.

Rio San Carlos Occurrence

Coal is reportedly present along the Rio San Carlos, in the northeastern part of the Alajuela Province. A coal sample from one locality contained 11.4 percent ash and 0.45 percent sulfur and had a heating value of 6,167 kcal/kg (11,000 Btu/lb)(unpublished data in files of ICE). No other information is available.

In 1984, a RECOPE technician visited the assumed area of the reported coal locality and questioned inhabitants; no additional data were acquired and no further investigations have been made. A reconnaissance study is required.

Venado Occurrence

Coal has long been known near the settlement of Venado, on the northeast flank of the Cordillera de Guanacaste, about 20 km northeast of Arenal Lake (Landis and Miller, 1985). Reconnaissance investigations in the Venado area were conducted by RECOPE and USGS geologists during 1983. A preliminary geologic study of about 286 km^2 was completed and the presence of coal was confirmed. An area of about 160 km^2 was selected for additional exploration, including drilling of both small and large diameter (ca 75 mm) holes in an attempt to understand the geometry of the coal beds and the coal-bearing rock units. Several reports, some with contrasting interpretations of the geologic setting, have been produced. The coal of the Venado field is of lower apparent-rank than the coals of the Zent and Baja Talamanca coal fields and this fact has tended to reduce priority for further work near Venado (Landis, 1985).

Despite the apparent relatively low quality of the Venado coals, investigations should continue in the field as opportunities arise. Deeper drilling is needed to establish stratigraphic succession uninterrupted by the abundant landslide material. Geophysical studies extending information from drill holes will be required also in order to understand the stratigraphic and structural situation of the coal-bearing rocks and the coal beds in the field. The Venado coal field could be of importance in the energy future of Costa Rica, and efforts to interpret the geology and appraise the resource potential of the field should continue, even if at a low level of activity.

Esparza Occurrence

This coal locality, which is commonly called Esparta by local residents, was reportedly mined 40 or 50 years ago. Reconnaissance investigations of the area in 1983 established the presence of coal and evidence of mining activity as indicated by the inhabitants. In July 1989, RECOPE geologists were shown the supposed mine site by local people who related having worked at the mine as small children. Some ruins, such as possible loading chutes, remain but the actual mine site apparently has been covered by landslides.

Surface excavation, probably by bulldozer or similar machinery, is required before confirmation of the coal mine can be established and information can be obtained about coal-bed thickness, attitude, extent, and quality.

Puriscal Occurrence

Reconnaissance investigations of this reported locality (Landis and Miller, 1985) have recently been undertaken. Coal has been found and samples collected, but no analytical results are available yet. The coal is near the town of Santiago, about 40 km west of San Jose.

Further reconnaissance is needed because only the presence of coal has been validated and no information is available about geologic factors.

El Tablazo Occurrence

The El Tablazo coal occurrence is in the western part of the Central Valley, near the town of Orosi. During 1982 and 1983, F. Alvarado (oral commun., 1989) and Obando (1983) did some preliminary coal investigation work in the western part of the Central Valley (Obando, 1988).

The coal beds in this region are reported to be approximately 1 m thick. Twelve coal samples were analyzed following the American Society for Testing and Materials (ASTM) procedures. Seven of these samples had low sulfur contents (0.5 percent); the other five had higher contents (up to 3 percent). Organic contents as high as 69 percent in the samples might indicate a strong marine influence during Miocene time.

Work to date on the El Tablazo coal field indicates that continued reconnaissance should be done, contingent upon available funding and personnel. Its proximity to San Jose is an added major incentive.

Terraba Valley Reported Coal

Shortly after the coal exploration by RECOPE in the Uatsi area was publicized, the newspaper article elicited a response from an individual who resides in the Terraba Valley of western Costa Rica. The citizen reported that coal was present nearby. Rocks of Miocene age, which contain coal in other parts of Costa Rica, are reportedly present in the Terraba Valley area.

To date, no investigations have been made in the Terraba Valley because of manpower priorities for other areas, but reconnaissance should be conducted when possible.

Rio Pacuare Occurrence

Coal was found along the Rio Pacuare by personnel of ICE during investigations for possible dam sites during or prior to 1980. The area is east of the town of Siquirres, in Limon Province, and the coal is in the Gatun Formation that extends westward from the Zent coal field. O. Ramirez E. (oral commun., 1989) believes that the coal did not exceed 10-15 cm in thickness and that there was no indication of coal beds thick enough to be of present economic interest.

Even though the priority is low, this locality should eventually be investigated.

Zent Coal Field

(also see appendix 2)

The Zent coal field has been divided, for the purposes of exploration, into three areas: 1) Rio Peje to the east, 2) Corina, and 3) San Miguel to the west.

Rio Peje Area

The Rio Peje area was the first part of the Zent coal field to be explored; reconnaissance began in 1983 and continued until 1985. Access is difficult and the fording of rivers is required. The investigations did confirm that coal is present in the area, that folding and faulting are common, and that the coal beds seem to be thinner than in the Corina area. For these reasons, exploration in the Rio Peje area has been discontinued, though it is recognized that the area deserves a more comprehensive examination at some future time.

Corina Area

The Corina area was studied by reconnaissance in the fall of 1984. Beds of coal, as much as 2 m thick and with moderate inclinations, were found to be laterally extensive in the area. By the completion of the formal cooperative program, in mid-1986, the original Corina area of about 268 km^2 had been geologically mapped at a scale of 1:5,000, a total of nine exploratory holes had been drilled, and the drilling of 40 more shallow holes was planned. A progress report was prepared at the end of the cooperative project (Weaver and others, 1986).

Exploration by RECOPE has continued, but a decision was made to concentrate efforts in a small part of the area (less than 0.5 km^2) in order to provide enough data to estimate minable reserves and allow planning for open-pit recovery of a coal bed named El Indio. To date, 31 exploratory drill holes have been completed in the Corina area and most of the holes are in an area of about 40 hectares. The minable reserves of this small area are estimated to exceed 1 million tonnes under a thickness of 50 m or less of overburden (Cubilla and Samuels, 1988).

A bulk-sample was excavated by bulldozer in the area proposed for mining, and 700 tonnes of the coal were hauled by truck for stockpiling at a preparation station nearby. At the preparation station, the coal was placed by front-end loader on an inclined grate with a mesh size of 25 mm (about 1 in.) About 55 percent of the run-of-mine coal passed through the grate; the remainder entered a rotary-drum breaker that also had a 25-mm hole size. About 33 percent of the broken coal went through the grates of the drum breaker and the remainder, larger than 25 mm, was removed from the drum periodically. Initially, the oversized coal was returned to the inclined grate, but later in the test, the end of the drum was closed and no oversize was produced.

Analyses have been made to compare the run-of-mine coal, the coal that passed through the inclined grate, the coal that went through the rotary-drum breaker, the coal that was retained in the breaker during the early part of the test, and the final coal product (25 mm or less in size) that was stockpiled for transport to further testing sites. Tests have also been made to determine the breaking, washing, and drying characteristics of the Zent coal. A report on the analyses and other tests is being prepared (R. Iglesias and R. Samuels, RECOPE, oral commun., 1989).

San Miguel Area

The San Miguel area constitutes the western one-third of the Zent coal field. Only a few days of reconnaissance have been conducted in the area to date, but that amount of effort has shown that the El Indio coal bed, or zone, extends westward from the Corina area into the San Miguel area. More reconnaissance and exploration are required to demonstrate the existence of other correlatable coal beds or zones and to provide needed geologic background information.

Valle de La Estrella

The area between the Zent coal field and the Baja Talamanca coal field was investigated during several reconnaissance missions between 1985 and 1988. The presence of coal was verified in six sub-areas, but none of the outcropping coal beds exceeded 1 m in thickness. The stratigraphic and structural relationships of the geology appear complex, and the limiting boundary of the coal area remains undefined at this time (Alvarado, 1986).

Coal was penetrated in the Porvenir No. 1 oil and gas exploration test well that was drilled in the eastern part of the Valle de La Estrella area. Another oil and gas exploration hole, the San Clemente No. 1, a stratigraphic test, has recently been drilled in the area under a cooperative program between Petro-Canada Oil Company and RECOPE but no information is available about the coal-bearing sequence that might have been penetrated.

In an attempt to increase the amount of geologic mapping in the area, RECOPE supported thesis studies by six students earning licensio degrees at the Central American School of Geology in San Jose. Only one student reported finding coal outcrops that had not been reported previously. The mapping confirmed that the geology is both stratigraphically and structurally complex.

No further investigations are underway and none are planned. However, reconnaissance traverses should be made along any streams that have not been visited, and a few drill holes should be planned to provide basic stratigraphic information about the coal-bearing sequence. The records of the San Clemente No. 1 and the Porvenir No. 1 oil and gas tests should be studied from a coal perspective that might provide data for use in establishing suggested locations for coal exploratory drill holes. Coal and rock samples should be collected from any holes that might be drilled, and also, the holes should be geophysically logged as an aid to correlate stratigraphy in the area.

Baja Talamanca Coal Field

For exploration purposes, the Baja Talamanca coal field was defined by the Japan International Cooperation Agency (JICA)(1983) to include 140 km^2 in an area that extends northward from the Costa Rica-Panama boundary to about the latitude of the town of Cahuita on the Caribbean coast. Following initiation of the USAID/RECOPE cooperative coal program, the area was divided into the 34-km^2 Uatsi Project Area and an unnamed northern area.

Uatsi Project Area

The Uatsi Project Area in the southern part of the Baja Talamanca coal field was geologically mapped in 1982 during the cooperative program between JICA and ICE. The mapping program and the resulting report (JICA, 1983) provided the basic geologic information needed for planning the Exploration Stage I program that was initiated and completed during the RECOPE-USGS cooperative program.

During the Exploration Stage I phase, 17 exploratory holes were drilled in the 34-km^2 Uatsi Project Area. The drill-hole data were supplemented by surface trenching. Interpretation of the data resulted in an estimate of 17 million tons of coal resources in the Uatsi area. Of that amount, about 5 million metric tonnes could be recovered by surface-mining methods and additional coal could be mined by underground methods. Analyses of the coal samples, collected primarily from drill cores, indicate that the coal is lignite A to subbituminous C in apparent rank and has, on the average, 13.8 percent ash and 1.7 percent sulfur. This phase of investigation was completed by mid-1985 and a very comprehensive report was prepared by the RECOPE personnel (Bolanos and others, 1985). This long report was subsequently summarized and made generally available in order to publicize the successful results of the exploration and to attract interest and attention to the possibilities of utilization of the coal as an alternative energy source (Bolanos and others, 1985).

Following Exploration Stage I, the Bechtel Corporation, under contract to USAID, prepared an engineering study of possible mining methods and the prospects of utilizing the coal in a mine-mouth electricity-generating plant.

Exploration Stage II activities were planned to 1) enlarge the study area to permit evaluation of more coal resources in adjacent areas and 2) provide additional data for mine planning and environmental studies. However, the decision to concentrate exploration funds and manpower in the Zent coal field has effectively curtailed activities in the Uatsi Project Area since 1986. Even so, 13 additional exploratory holes were drilled at localities both within and adjacent to the Uatsi Project Area, and the estimated tonnage of coal resources has been increased from 17 million to 32 million (K. Bolanos, oral commun., 1989). As time permits, the report on the Uatsi Project Area (Bolanos and others, 1985) will be updated and supplemented by inclusion and integration of the data provided by the additional 13 exploratory drill holes.

More exploration is needed in the Baja Talamanca coal field area. Reconnaissance should be undertaken in those parts of the area not previously studied; for example, areas mostly north and west of the area mapped during the JICA/ICE program. Exploration studies, primarily by drilling, should be extended also to the north and west of the Uatsi Project Area that was the focus of the previous exploration completed in 1985. Such recommended drilling would expand the area confirmed to be underlain by coal and would increase the number of localities where coal quantity and quality data could be obtained.

At this time, the Uatsi Project Area is inactive and will probably remain so until recovery studies are completed and utilization decisions are made.

ANALYTICAL LABORATORY

Prior to the initiation of the USAID/RECOPE cooperative program on coal, analyses of coal samples had been done in several different laboratories in Costa Rica. In most cases, lack of equipment and experience combined to produce results of doubtful comparability and usability. As part of the cooperative program, a modern coal analytical laboratory capable of producing internationally comparable results was planned and a chemist from RECOPE was selected and trained for several months in the laboratories of Geochemical Testing, Inc., in the USA.

The coal analytical laboratory in RECOPE was functional and producing acceptable results under the guidance of the newly trained chemist before the cooperative program ended in 1986. The laboratory is presently located in RECOPE facilities in San Francisco, an eastern suburb of San Jose. Equipment that was on order at the conclusion of the cooperative program has subsequently been installed, the physical layout seems very adequate, the staff has been increased to four, and productivity has increased both in quantity and versatility. Appendix 3 is a general statement that lists the capabilities of the laboratory at this time. Presently, the laboratory can perform most of the analyses and tests required to support planning for utilization.

Productivity has steadily increased. In the first year of operation, 1985, a total of 90 coal samples were processed through the laboratory, most for only a minimal analytical and testing sequence because some equipment was not yet available. In 1986, 140 coal samples and 686 peat samples were analyzed. In 1987, a total of 451 samples of coal were analyzed and tested, but in 1988, a total of only 264 coal samples were received, probably reflecting a decrease in exploration and development drilling. However, the laboratory has continued to increase its productive capability and versatility with the addition of equipment and personnel, and more than 550 samples of various types of materials (for example, water samples for environmental control) were processed through the laboratory in 1988.

A total of about 945 coal samples have been analyzed and tested since the laboratory opened. The actual number of different analyses and tests performed on each sample has steadily increased over the years of operation as new equipment has become available. The earliest samples, such as those processed in 1985, could only be subjected to a few determinations in contrast to the large number and variety of determinations that may be conducted today.

When samples are submitted to the laboratory, the chemist-in-charge and the submitter generally confer about the information required by the submitter, and agreement is reached about the analytical sequence and the expected results of the analyses and the tests. Each sample has a number assigned to it and a very basic set of information is supplied by the submitter. Only the sample number and a point location according to Lambert Coordinates and the name of the appropriate topographic map (1:50,000) are required. No other geologic background information is required. When analysis is completed, a split of the sample is retained and the results of the analytical sequence are reported to the submitter who will presumably interpret and report on them in some appropriate manner.

CONCLUSIONS

1) RECOPE personnel have continued Reconnaissance and Early Exploration Stage investigations of coal in several areas since the cooperative program with the USGS ended, but these studies have been conducted largely in coincidental manner as opportunities arise.

2) Later stages of exploration, which are dependent mainly on widely spaced exploratory drilling, have ceased as emphasis has shifted to closely spaced drilling for coal-development data and mine-planning purposes. With the decision to concentrate manpower and money in the Corina area of the Zent coal field, exploration in other areas essentially has been suspended.

3) Those activities completed by RECOPE personnel to date have been well conducted, especially considering their lack of experience in most phases of coal-related work. The support complex created by RECOPE in the Zent coal field is simple but adequate. It will require additional and supplemental equipment as recovery operations proceed but has already demonstrated the ability to handle small quantities of coal. Plans have been adopted that will allow upgrading of this facility as required in the future.

4) The chemical analytical laboratory started by RECOPE with USAID assistance is almost certainly the only laboratory of its type in Central America. Both the productivity and range of analyses and tests that can be made on coal and peat have steadily increased, and RECOPE should be congratulated for establishing and maintaining this facility.

5) Additional coal-development and utilization tests must be planned and conducted. All technical options must be evaluated in relation to the quantity and quality of Costa Rica's coal resources.

SUGGESTIONS AND RECOMMENDATIONS

1) The early stages of exploration should be considered an inherent, integral part of the coal program of RECOPE. Although of relatively low priority in manpower and money, such exploration should be planned and completed on a regularly scheduled basis to help provide data necessary for resource decisions and policy-making. A minimum of one geologist plus support personnel should be engaged in the early stages of exploration as a continuing activity, and this number should be increased as manpower requirements allow.

Even though prioritizing needs is difficult, it appears now that the San Miguel area of the Zent coal field should be of prime priority, and then the Valle de La Estrella and extensions to the Uatsi Project Area, followed in turn by other areas identified as still requiring evaluation efforts.

2) Additional exploration, Exploration Stages I and II, are needed to increase resource and reserve base knowledge in areas where development, recovery, and utilization may be imminent; examples are the Corina area of the Zent coal field and the Uatsi Project Area of the Baja Talamanca coal field. In both cases, the required exploration would be lateral extensions of smaller

areas that comparatively have been well explored by drilling. These later exploration stages are dependent largely on exploratory drilling for required data and, consequently, may require considerable time. As possibilities for utilization of Costa Rica's coal increase, the priority for further exploration must rise.

Exploration must proceed concurrently with development, recovery, and utilization activities or the known coal resources of predictable quantity and quality will not yet be evaluated when required for utilization.

3) Now that almost 1,000 Costa Rican coal samples have been tested and analyzed, a comprehensive evaluation should be made of the physical and chemical quality parameters reported in those analyses. Samples should be grouped according to all desirable, or required, categories and the data should be interpreted according to standardized internationally recognized methods of statistical analysis. The result will be vital to utilization planning. Inability to accurately predict the characteristics of a particular fuel has resulted in many engineering problems during coal utilization.

4) A comprehensive investigation of all options for utilization of Costa Rica's coal must be made. Identifications must include all possible applications of a new, for Costa Rica, alternative energy fuel and evaluations of both new, and older but improved, technologies. Pilot and demonstration tests using existing, modified, or new technical approaches and hardware are vitally needed as soon as possible. Cooperative programs of all types will almost certainly be needed among government, industry, academia, and financial institutions.

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APPENDIX 1

Terminology used in Respect to Coal Exploration

Coal Resources in Costa Rica

NOTE: For the purpose of this work plan document, the following terminology with respect to coal-exploration studies is used.

Reconnaissance Stage.--The objective of this stage is the establishment of the presence of coal in a geographical area and the gathering, compilation, and synthesis of enough information to allow reasonable inferences to be made about the location and general distribution of potential coal-bearing rocks and coal beds in the area.

Early Exploration Stage.--Once the presence of coal in an area has been established or reasonably inferred, a research stage is undertaken during which the pre-existing data base is collated and evaluated to determine the feasibility of the proceeding with the exploration using drill and geophysical survey techniques. The aim of this stage, therefore, is to make reliable assumptions as to the likely number of beds, depth, extent, quality, and commercial potential of coals within the study area. The existing information may be supplemented by carrying out geological mapping and stratigraphic studies to assist in the selection of drilling target based on geological criteria.

Exploration Stage I.--During this stage, the correlation and lateral continuity of the coal seams and strata are determined as well as the likely exploitation methods and utilization potential for various possible end uses. This is achieved by the drilling of a number of boreholes, mostly cored, on a widely spaced drill pattern. Surface geophysical techniques may also be employed to assist in defining the geological structure. Downhole geophysical logging techniques may also be employed. The stage is completed when resources can be estimated to indicated status.

Exploration Stage II.--In Stage I, the geological structure will have been delineated and beds correlated. Information obtained on the quality and quantity of resources, as well as possible mining and preparation methods, will have been, however, indicative only. In this next stage, the information must be raised to higher confidence levels to provide the basis for assessment of mining methods, costs, and potential market. The aim of this stage is, therefore, to make a confident assessment of coal resources and reserve base, coal quality mining conditions and (for potential surface mines) overburden quantities for preliminary mine and production planning, costing studies, and market survey. This is achieved by an increased density of drilling. The additional drilling will enable the estimation of resources to a largely measured status.

APPENDIX 2

Mine Development in the Zent Coal Field, Costa Rica

Mine Development of the Zent Coal Field in Costa Rica

(This section is an abbreviated version of the poster presentation of Rogelio Samuels, Gladys Cubilla, and Marco Rodriguez (RECOPE). The presentation was entitled "Mine Design of the Zent Coal Field, Costa Rica." The abstract can be found in appendix 5).

Introduction

The Zent coal field is located in the lower basin of the Chirripo and Barbilla Rivers. This coal field is situated near the main highway, 30 km before the port city of Limon (fig. A). The mining camp is located in Bristol, and the future exploitation and processing areas will be located close to or at Corina, 7 km west of the Saopin highway. A gravel road permits easy access to Bristol. Once inside the mining area, it is necessary to use a 4-wheel-drive vehicle throughout the year.

Geology

The coal-bearing sequence is part of the Rio Banano (Gatun) Formation. The rocks are mudstone, fine- to coarse-grained sandstone, some conglomerates, and coal. These sediments are interpreted to be of Upper Miocene age and were deposited in a prograding deltaic environment (RECOPE, 1989).

Zent Coal Field

The Zent coal field has been divided into three areas (fig. A):

San Miguel area - west
Corina area - central
Rio Peje area - east

The Corina area contains the site for an open-pit mine. The El Indio coal bed, with an average thickness of 2.2 m, as well as the Capa Segunda (0.70 m) were selected for the Zent open-pit mine in an area where the overburden is less than 50 m (fig. B). Thirty-one exploratory holes have been drilled in a 40 ha area (fig. C) and an area of calculated minable reserves has been delineated (fig. D).

A bulk-sample excavation was made by bulldozer in the area proposed for mining and 700 tonnes of coal were hauled by truck to a preparation station nearby. At the preparation station, the coal was dumped and placed by front loader on an inclined grate with hole spacing of about 1 in. About 55 percent of the run-of-mine coal went through the grate and the remainder of the coal entered a rotary-drum breaker that also had 1-in. hole size. About 33 percent of the coal was broken and went through the grates of the drum breaker and the remainder, larger than 1 in., was removed from the drum periodically. Initially, the larger than 1 in. was returned to the inclined grate, but later in the test, the end of the drum was closed and no oversize was produced. Figure E shows this process.

Resources

Recoverable resources from both the El Indio and Capa Segunda coal beds are 15 million metric tons in an area of 40 ha; 2 million metric tonnes are considered to be apt for open-pit mining methods (figs. F, G, H). The coal evaluated to date in the Zent coal field ranges in rank from lignite to subbituminous coal, with a calorific value of 3,200 kcal/kg "as-received" and of 5,200 kcal/kg on a dry basis (ASTM)(fig. H).

Mine Design

The mining design carried out for extraction of reserves associated with El Indio and Capa Segunda coal beds has required to take into consideration all the necessary parameters (figs. J, K, L). It is not a matter of geotechnically identifying fine to medium sandstones with high calcareous cement content, whose resistance favors large angles of talus slopes, but rather to evaluate the maximum angle which permits utilization of the complete sequence and interaction between the sandstone and loose sand.

The rock sequence is a homocline, inclined 15° NE. Two parallel normal faults, with north-south trends dipping 25° E., displace the sequence 20 and 40 m.

The heterogeneity of the sequence is not only reflected in the geotechnical aspects (fig. M), but also in that the hydrological evaluation becomes more complex. This takes into consideration the contrasting transmissibilities and permeabilities in the different lithologies or in the granulometric gradiations.

Geotechnical tests carried out at selected sites, convexivity tests, and the constant monitoring of wells and superficial waterways have shown talus slopes of 58° (fig. L) and confirmed that in spite of an average annual rainfall of 3,000 mm, water will not be a problem for the operation of the mine as long as collection pits are built along the periphery of the mine with appropriate drainage of the same and sedimentation lakes.

In regard to the treatment of the coal, experimental investigation has evaluated such aspects as breakup and washing and drying, in order to offer a product of the best possible quality at a reasonable cost. At this moment, the mine has a sieve and rotary breaker machine (fig. E). Even though this equipment is considered sufficient to meet the first years demand, this equipment is considered to be the first-stage models of the equipment necessary for operation on the large-scale projected (figs. N, O, P, Q). The design and construction of experimental models for the washing and drying of coal is presently in progress (RECOPE, 1989).

Mine Evaluation

The evaluation of the Zent Project has centered on two basic aspects. One is the advancement in the exploration of areas where the existence of coal outcrops is known. This is in order to be able to confront demands greater than those foreseen once the mineral is introduced as an energy resource of great importance to the country. The second is the evaluation of the El Indio stratum, the site at which systematic mining will hopefully begin soon.

The current stage now requires that a demonstration project be set up in order to test the Zent coal. The real life expectancy of the mine will reflect who will buy the coal, how it will be used, and what the rate of consumption will be. For this reason, the projected lifespan of the mine of 7 years seems unrealistic. Utilization tests must be made in order to accurately establish who and how much of the coal will be consumed. Only then will one be able to properly estimate the rate of consumption and the lifespan of the Zent coal mine.

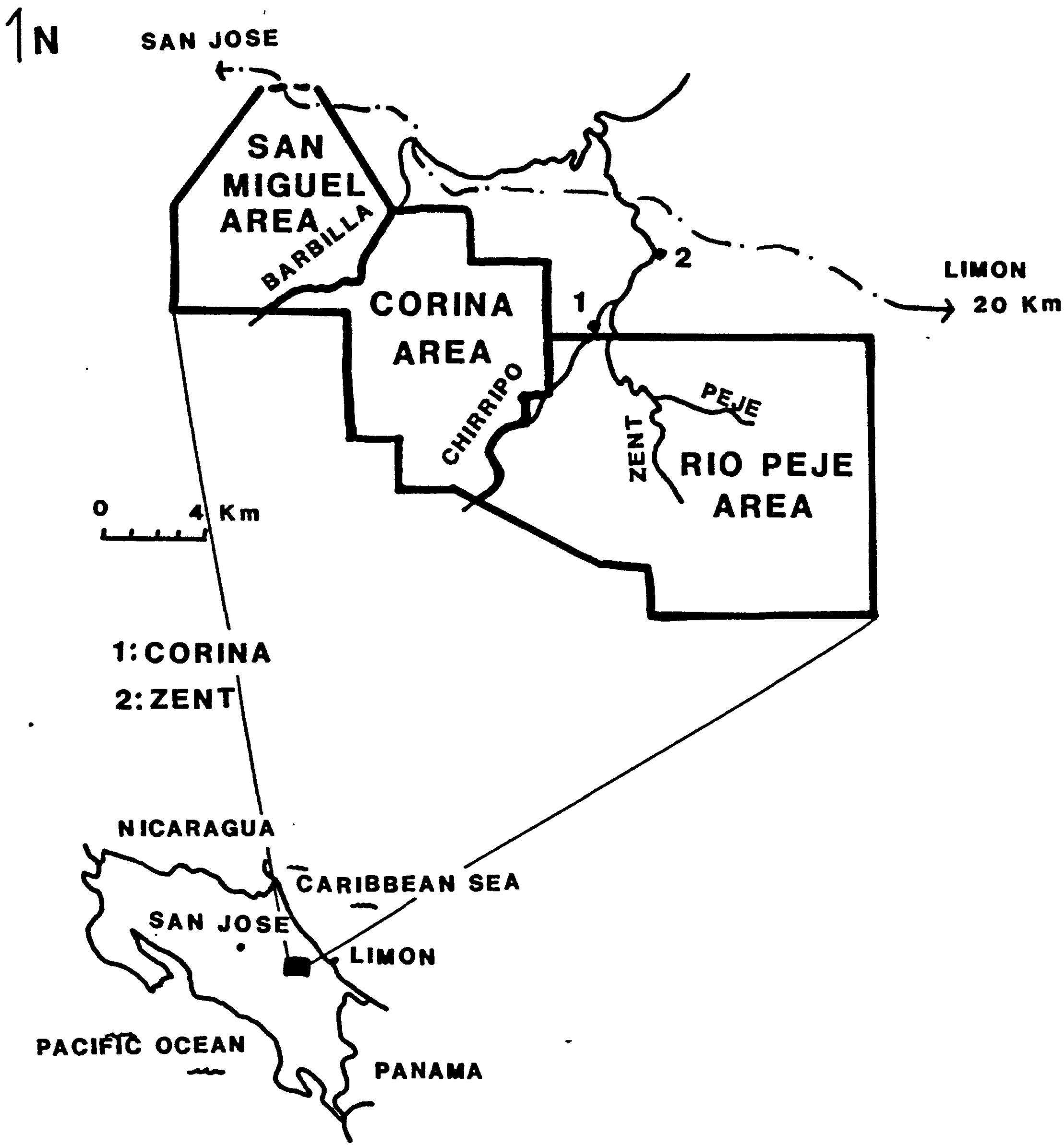

FIGURE A

LOCATION OF THE THREE COAL AREAS WITHIN THE ZENT COALFIELD

(RECOPE, 1989)

COLUMNA LITOLOGICA TIPICA

DEL AREA.

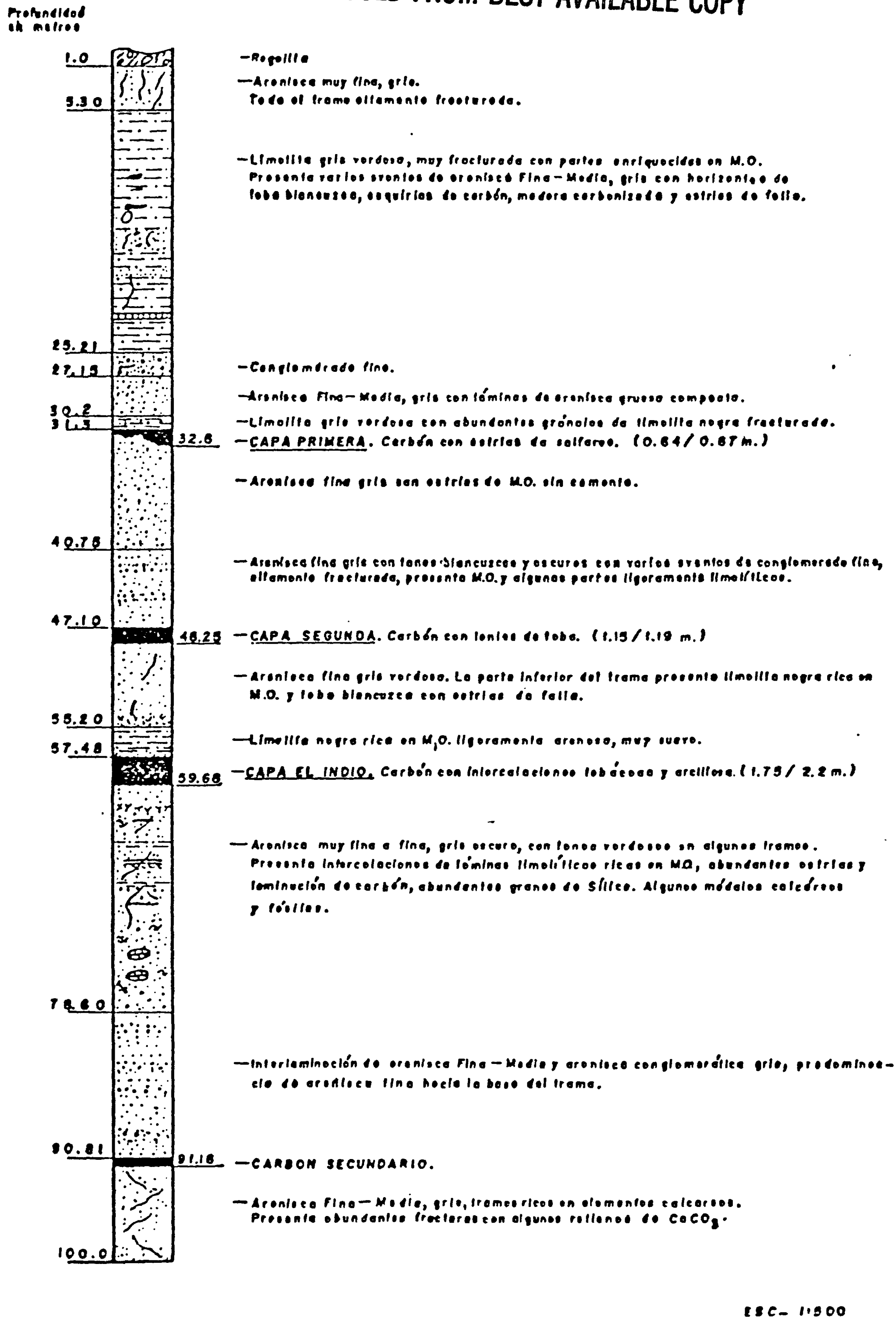

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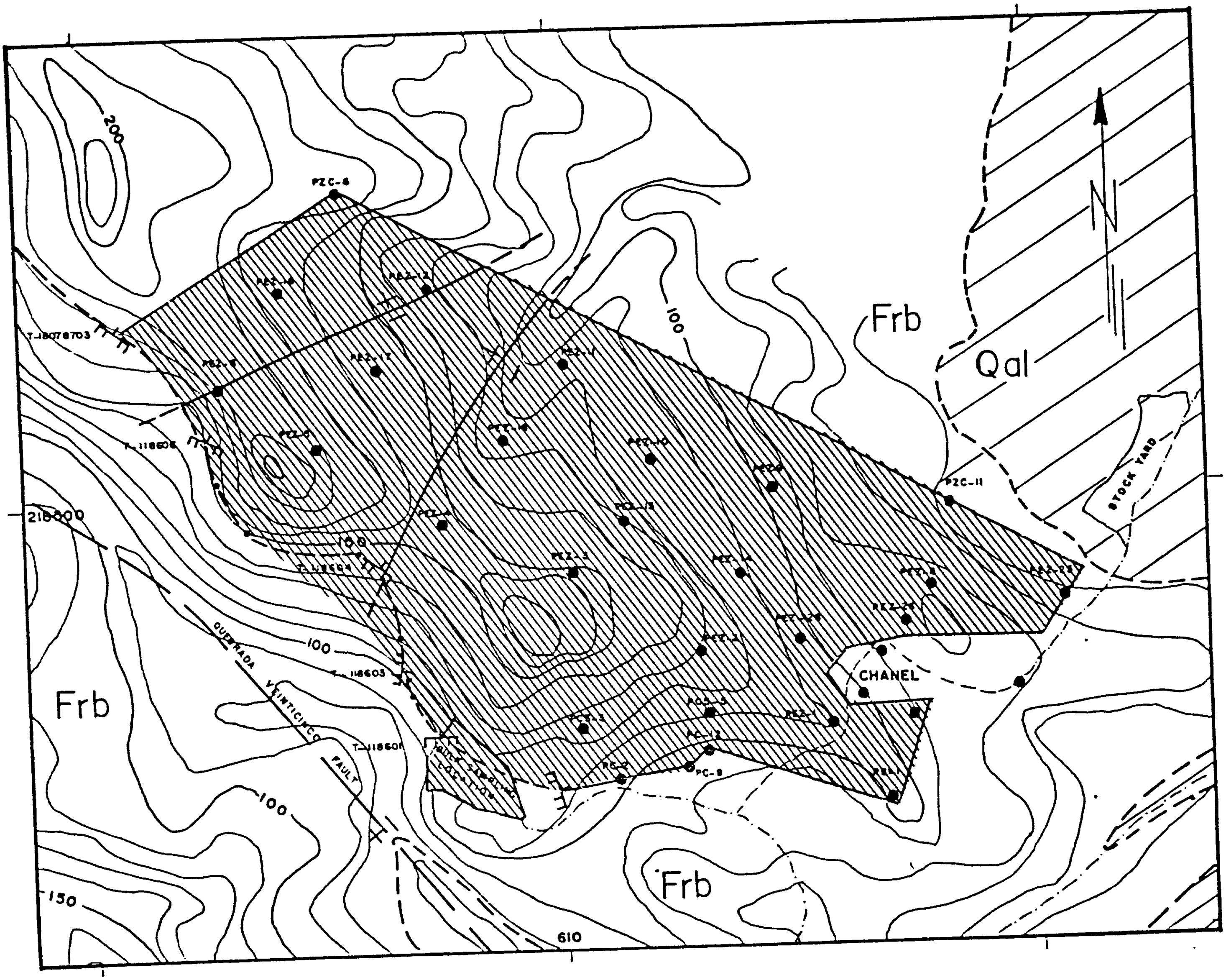
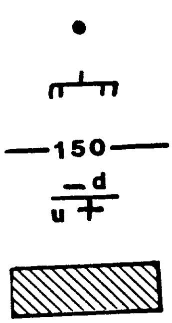
FIGURE B STRATIGRAPHIC COLUMN-CORINA AREA
(RECOPE, 1989)





DRILL HOLE

OUTCROP

CONTOUR IN METERS

FAULT

AREA OF FIG. D

FIGURE C DETAILED VIEW OF AREA TARGETED FOR MINING IN CORINA AREA (RECOPE, 1989)

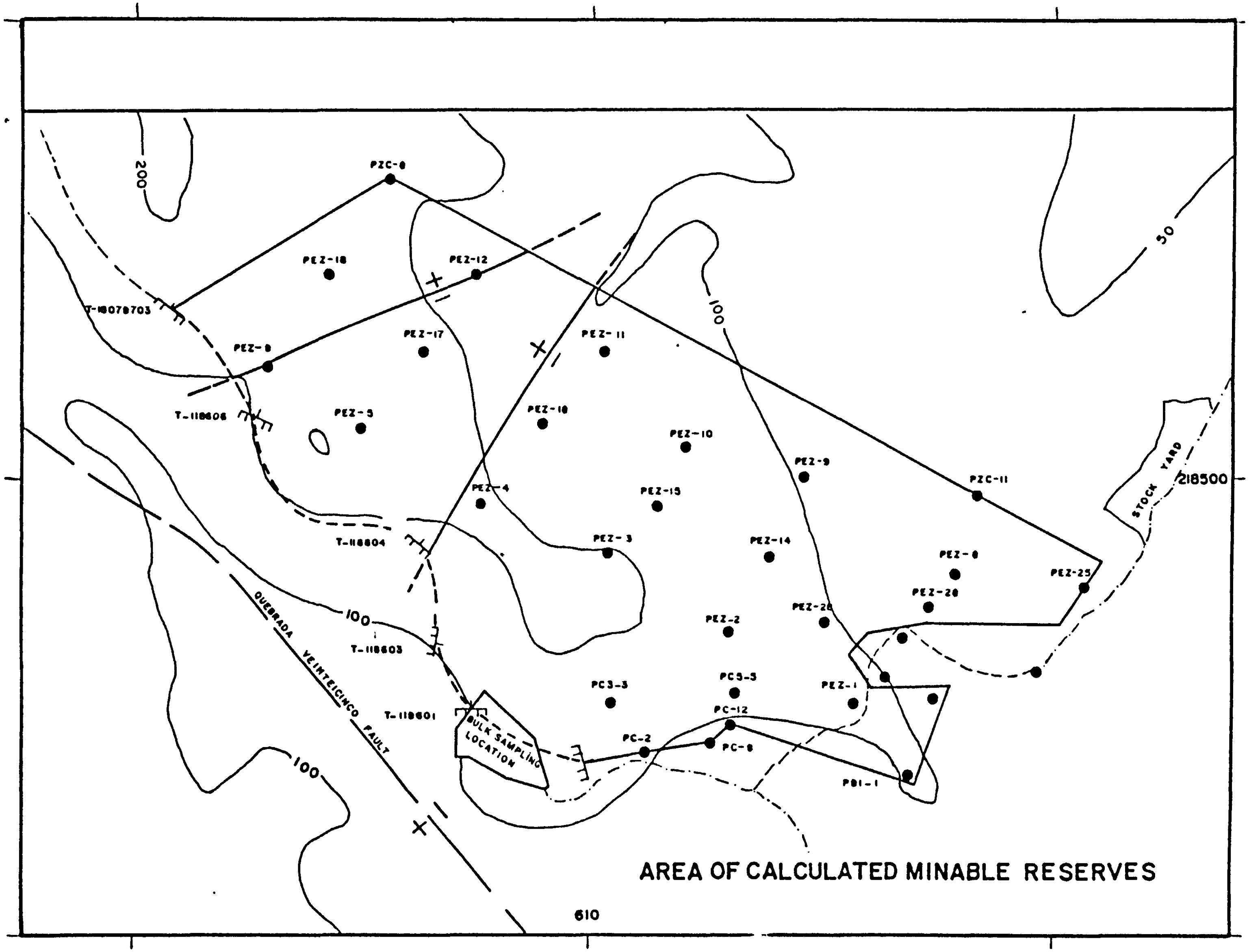
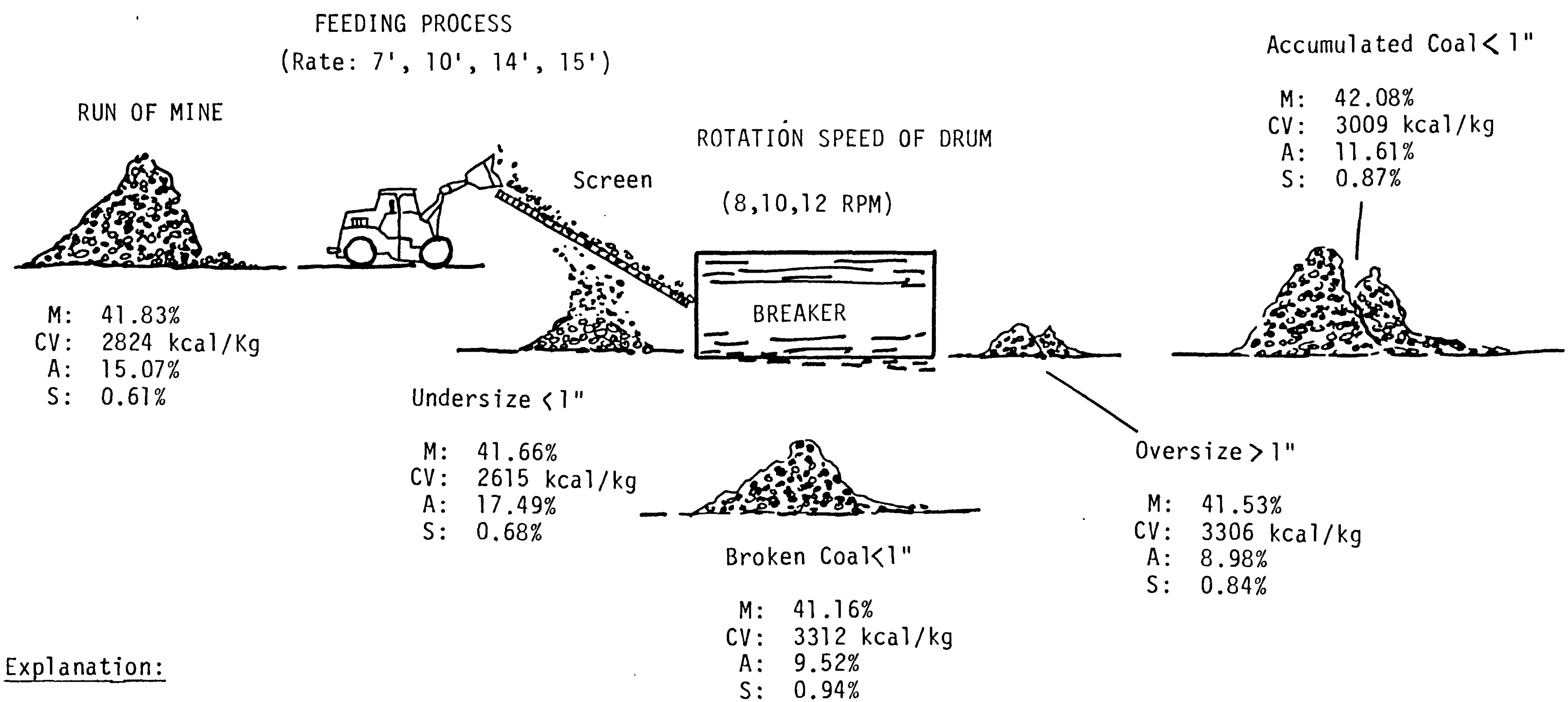


FIGURE D AREA OF CALCULATED MINABLE RESERVES WITHIN THE CORINA AREA (RECOPE, 1989)



Explanation:

M: Moisture Percent by Weight
CV: Calorific Potential (Moisture)
A: Ash Percent by Weight (Moisture)
S: Sulphur Percent by Weight (Moisture)

FIGURE E DIAGRAM SHOWING THE VARIOUS STAGES UNDERGONE BY COAL<1"

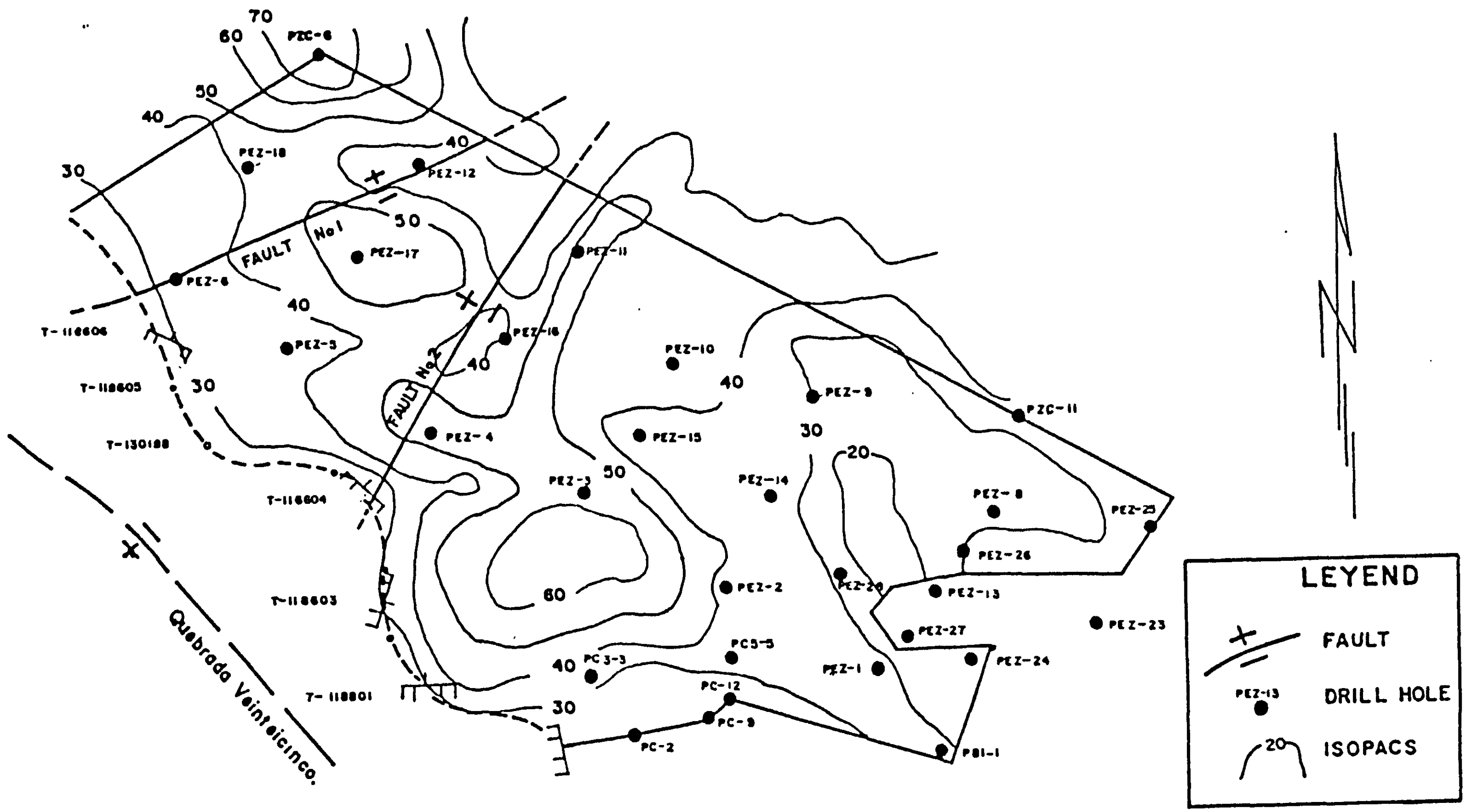


FIGURE F OVERBURDEN ISOPACHS (10 METER INTERVAL)
(RECOPE, 1989)

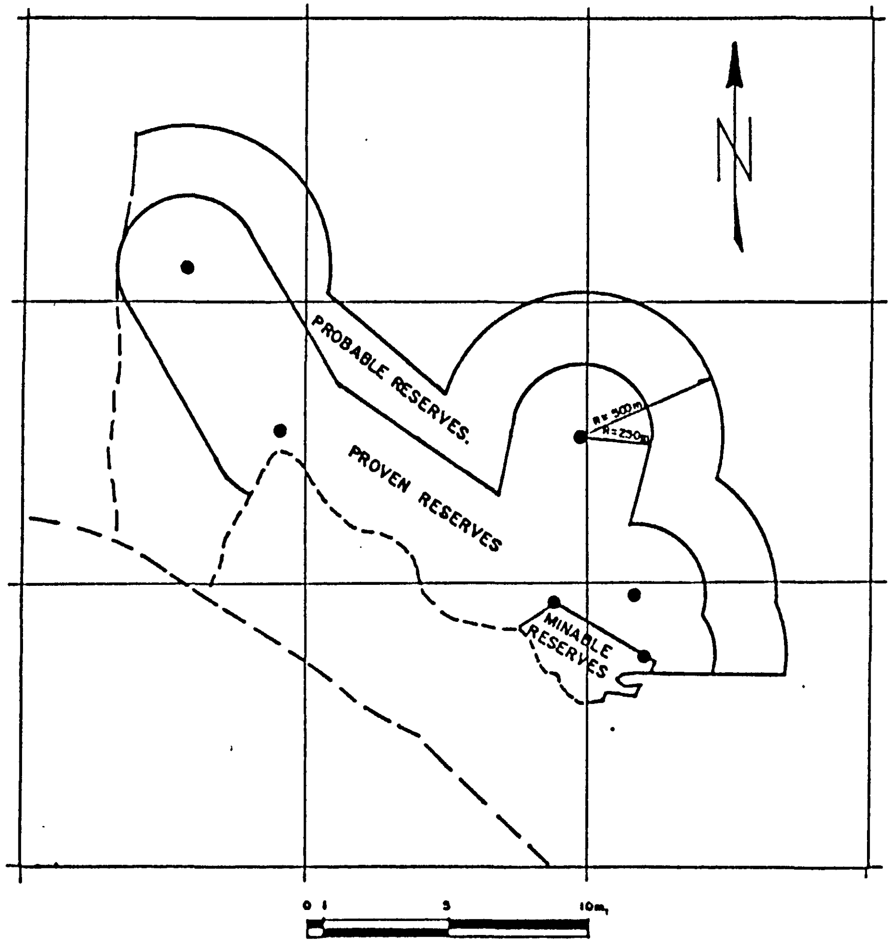


FIGURE G CHART OF RESERVES
(Cubilla and Samuels, 1989)

CHART OF RESERVES		
TOTAL RESERVES	14.98X10^6	METRIC TONS
PROVEN RESERVES	4.59X10^6	METRIC TONS
PROBABLE RESERVES	9.37X10^6	METRIC TONS
MINEABLE RESERVES OPEN-PIT MINE (FIRST PHASE)	1.02X10^6	METRIC TONS

FIGURE H CHART OF RESERVES IN METRIC TONNES

(Cubilla and Samuels, 1989)

CHARACTERISTIC	ARITHMETIC MEAN	STANDARD DEVIATION	MAXIMUM	MINIMUM
Air Dry Loss (% weight)	28.07	5.51	40.52	9.85
Sulphur (% weight)	0.98	0.42	2.15	0.44
Fixed Carbon (% weight)	19.24	3.54	27.74	11.48
Ash (% weight)	12.15	3.18	20.50	6.03
Total Moisture (% weight)	41.36	3.71	49.91	28.61
Volatile Matter (% weight)	27.24	3.23	37.19	18.71
Calorific Value (kcal/kg)	3158	284	4173	2291

(Cubilla and Samuels, 1989)

FIGURE I ANALYSIS OF COAL QUALITY

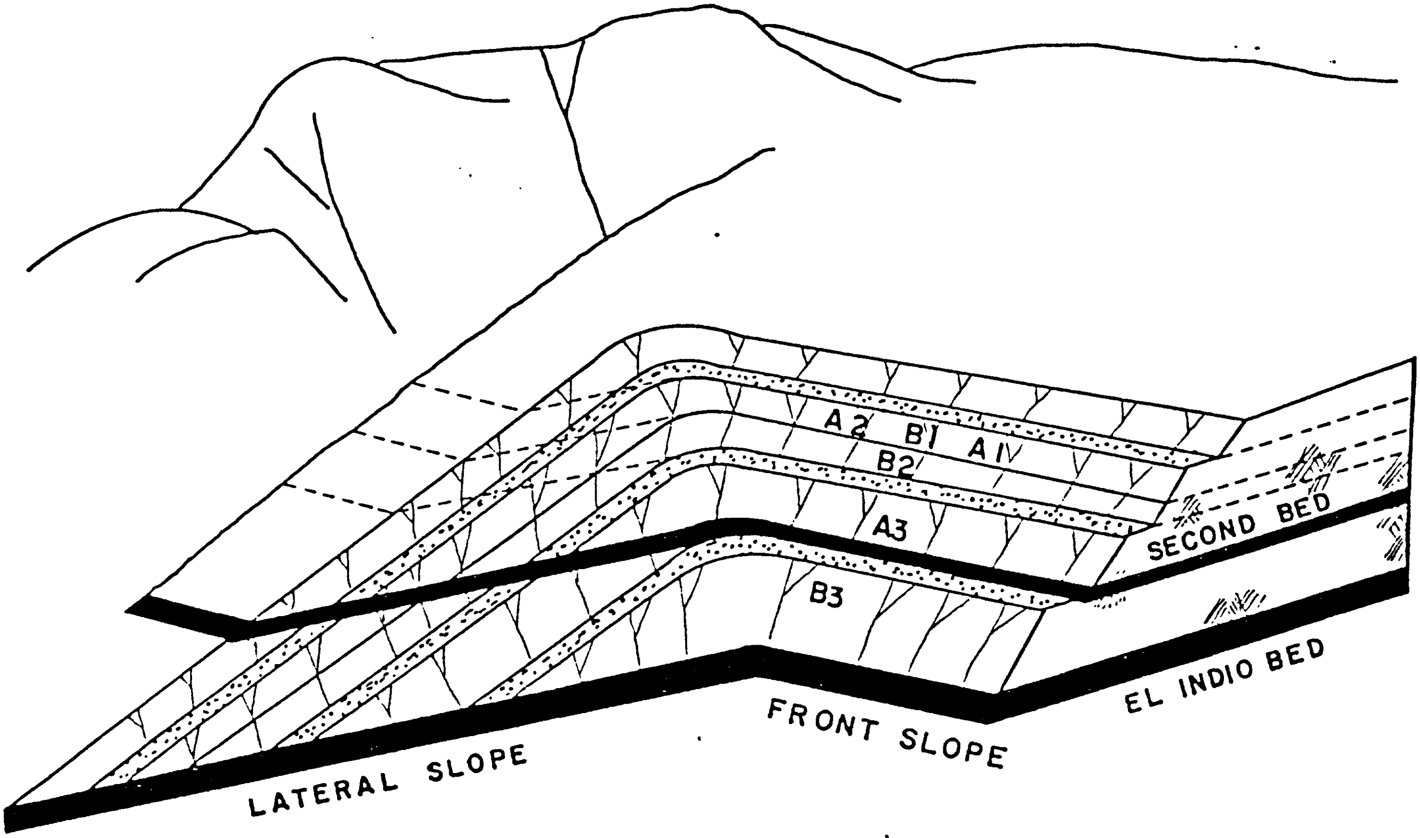
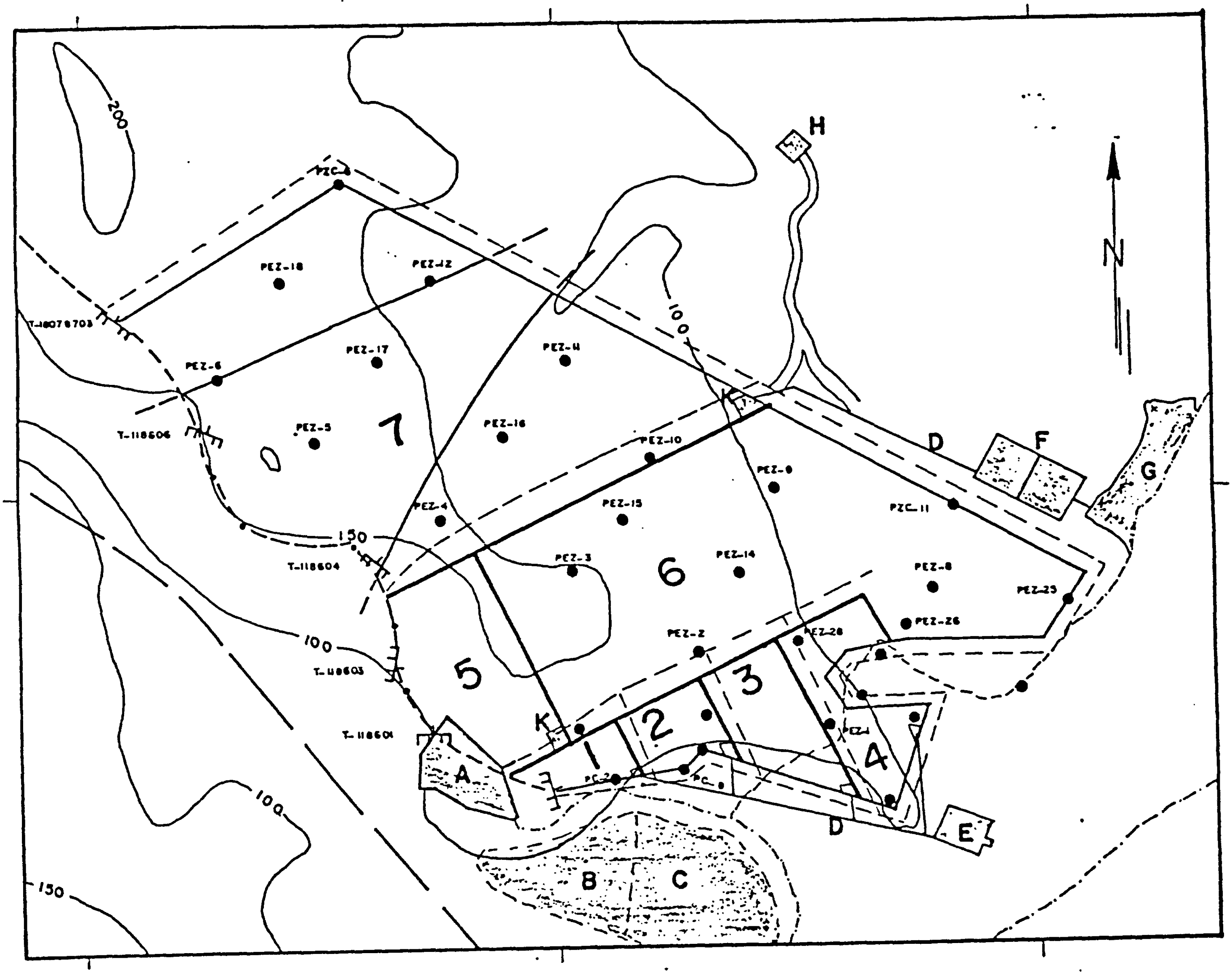


FIGURE J SCHEMATIC REPRESENTATION OF PROPOSED SLOPE AT THE ZENT MINE
(Cubilla and Samuels, 1989)



A — BULK SAMPLING LOCATION.

B — HUMIC SOIL DUMP.

C — OVERBURDEN DUMP (TWO FIRST YEARS)

D — MINE WATER DRAINAGE CHANNEL

E–F — WATER TREATMENT POND.

G — STOCK YARD.

H — EXPLOSIVE STORAGE.

FIGURE K
LAYOUT FOR THE ZENT MINE
(Cubilla and Samuels, 1989)

LETTERS ONLY INDICATE BOUNDARIES OF BLOCKS

EXPLOTATION SLOPE (58°)
SECURITY FACTOR: I

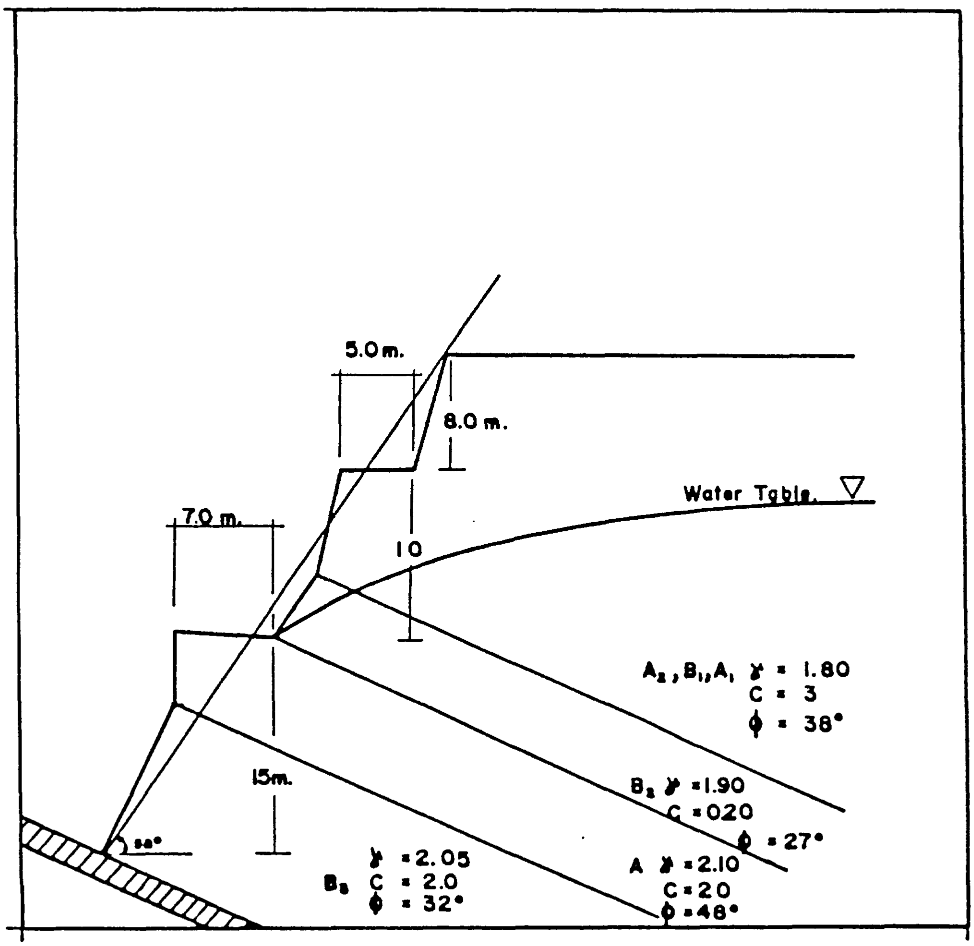
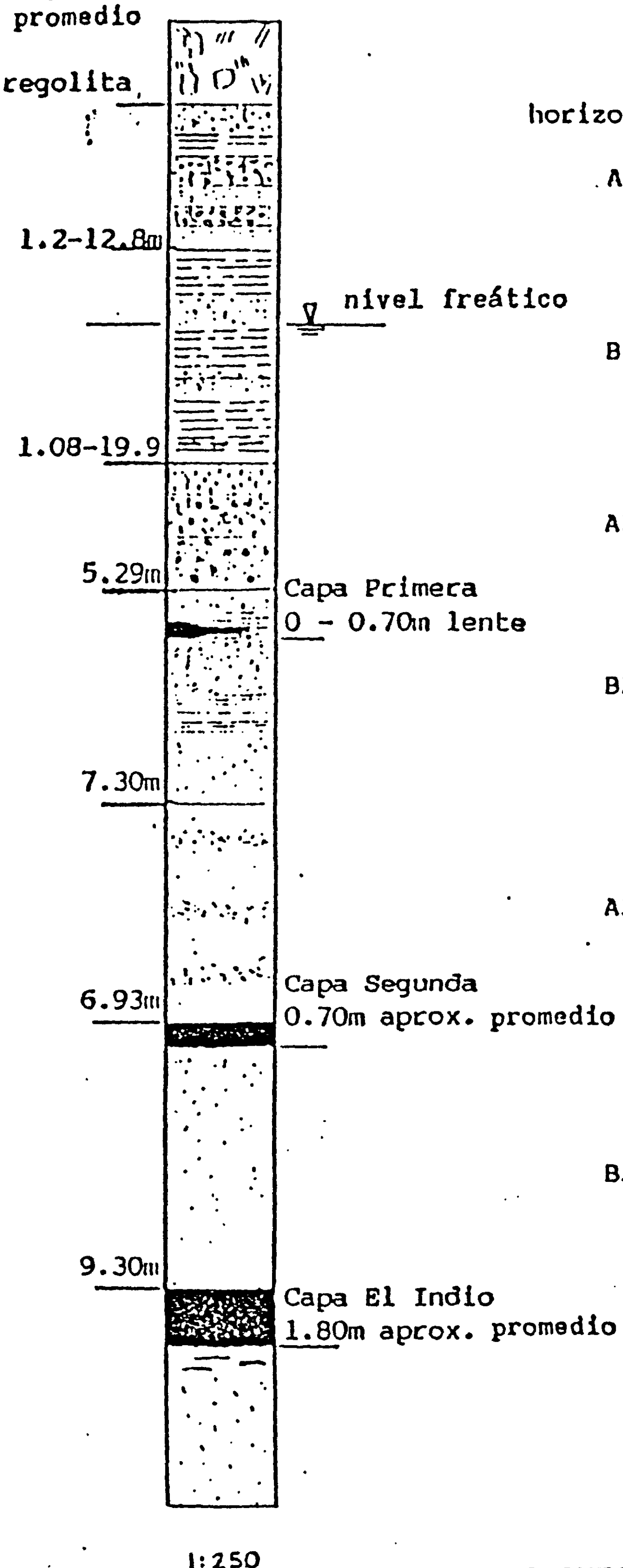


FIGURE L DIAGRAM OF SLOPE AT PROPOSED ZENT MINE

COLUMNA GEOTECNICA TIPICA



horizonte	densidad (ton/m3)	C (kg/cm2)	ϕ
A1	1.8 a 2.1	5 a 15	50
B1	1.7 a 1.8	0 a 1	27-30
A2	1.5 a 1.8	2 a 5	40-45
B2	1.5 a 1.7	0 a 2	20-30
A3	1.9 a 2.1	5 a 15	44-48
B3	1.9 a 2.05	0 a 1.5	32-35

C: cohesión del horizonte

Ø: ángulo de fricción interna (º)

La densidad es saturada.

THE GEOMECHANICAL CHARACTERISTICS OF THESE MATERIALS ARE CLASSOFIED AS SOFT ROCKS ACCORDING TO THE INTERNATIONAL SOCIETY OF ROCKS MECHANICS.

FIGURE M STRATIGRAPHIC COLUMN EMPHASIZING ROCK MECHANICS
(Cubilla and Samuels, 1989)

HORIZONS	RIPPABLE VOLUME (M3)	EXPLOSIVE MATERIALS NEEDED (M3)	SUB-TOTAL
A1	0.53X10 6	0.35X10 6	0.88X10 6
A2	1.12X10 6	0.12X10 6	1.24X10 6
A3	1.19X10 6	1.15X10 6	2.34X10 6
B1	1.27X10 6	---	1.27X10 6
B2	2.69X10 6	---	2.69X10 6
B3	3.20X10 6	---	3.20X10 6
SOIL	1.79X10 6	---	1.79X10 6
TOTAL	11.79X10 6	1.63X10 6	13.41X10 6

Figure N. Comparison of rippable material with required explosives (Cubilla and Samuels, 1988).

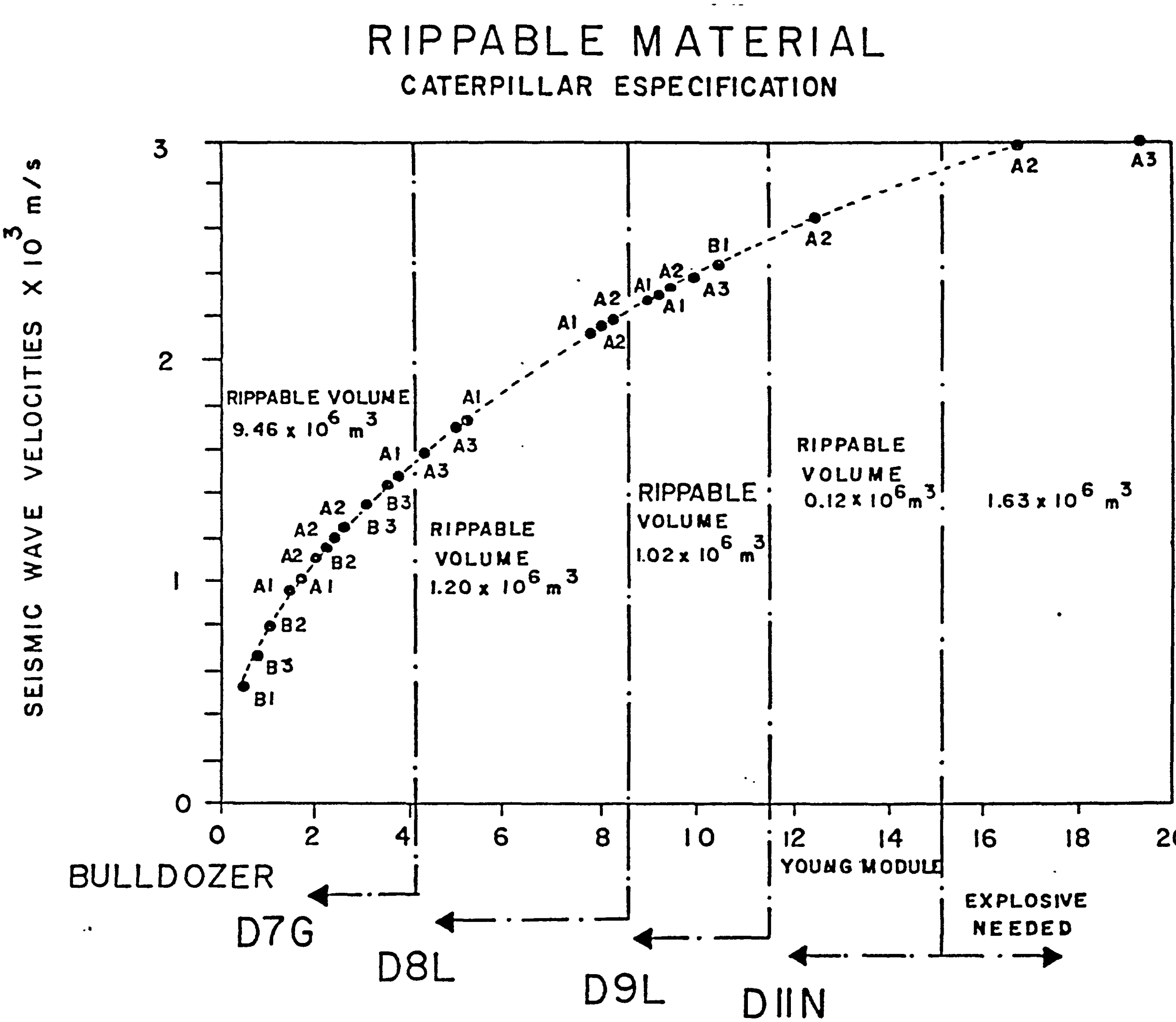


FIGURE O RIPPABLE MATERIAL vs REQUIRED EQUIPMENT
(Cubilla and Samuels, 1989)

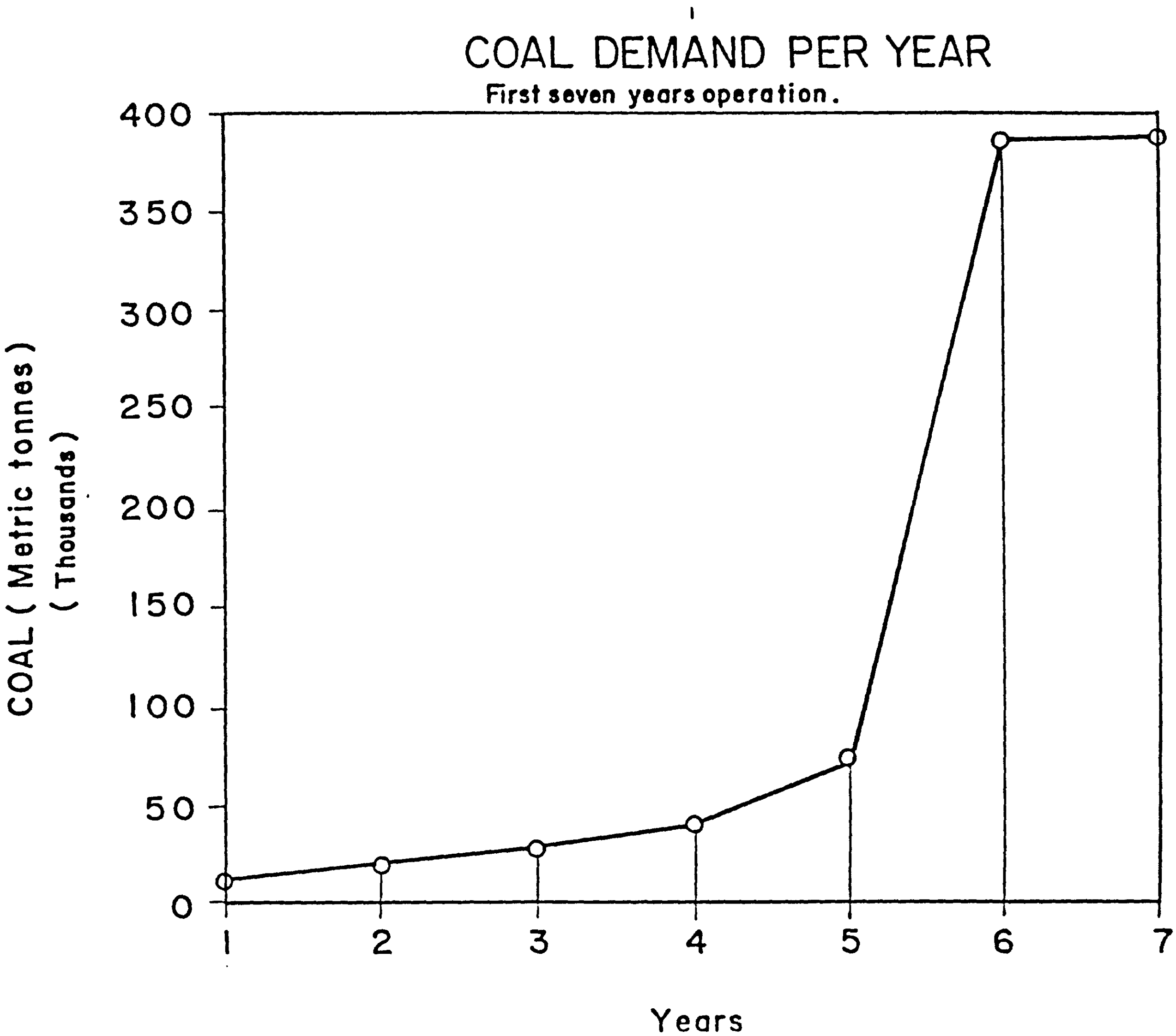


FIGURE P COAL DEMAND PER YEAR
(Cubilla and Samuels, 1989)

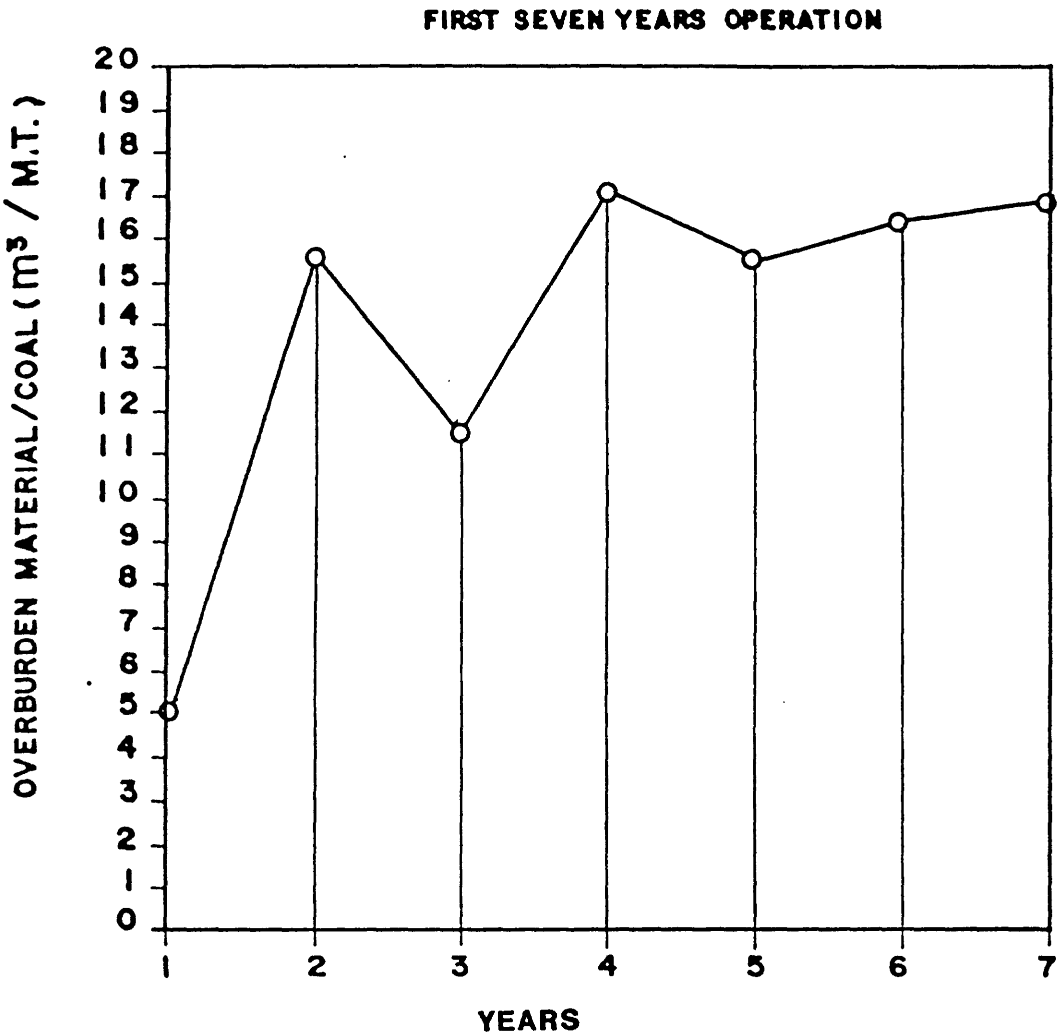


FIGURE Q OBERBURDEN/COAL RATIO PER YEARS
(Cubilla and Samuels, 1989)

APPENDIX 3

Analytical Laboratory Capabilities (RECOPE)

REFINADORA COSTARRICENSE DE PETROLEO GERENCIA DE PRODUCCION PRIMARIA
LABORATORIO GEOQUIMICO
GENERAL INFORMATION

By

Lourdes Quesada[1]

Geochemical Testing Lab. of RECOPE, S.A. is part of Gerencia de Produccion Primaria, RECOPE, S.A. Its activities are as follows:

- Coal geochemical analysis.
- Peat analysis.
- Inorganic and organic sediments analysis.
- Several chemical analysis using the latest spectroscopy technology.
- Complete water analysis for environmental control in mining process.
- Other geochemical analysis.

Geochemical Testing Lab. of RECOPE, S.A. is considered one of the best of Latinamerica and its personnel has been trained in U.S.A.

Lab equipment and its applications:

A--Elemental analyzer for C, H, and N.
Kind of sample: solids and heavy liquids.

B--Sulphur analyzer.
Kind of sample: solids and heavy liquids.

C--Atomic absorption spectroscopy for minerals.
Kind of sample: solids and heavy liquids.

D--Ion analyzer for hydrogen, cyanide, fluoride, etc.
Kind of sample: solids and heavy liquids.

E--Ovens and muffle furnace for proximate analysis and others.
Kind of sample: solids and heavy liquids.

F--Modern sample preparation equipment.
Kind of sample: solids and heavy liquids.

G--Analytical balances for weight measurements for analysis.
Kind of sample: solids and heavy liquids.

H--Calorimetric system for coal testing.
Kind of sample: solids and heavy liquids.

I--Soxlet instrumentation for extraction.
Kind of sample: solids and heavy liquids.

J--Volumetric equipment for water analysis.
Kind of sample: liquids.

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[1]Recope, Division de Recursos Carboniferos, San Jose, Costa Rica.

APPENDIX 4

Current Organization Chart of RECOPE

pg 42 follows

APPENDIX 5

Abstracts from the Coal and Peat Poster Presentations and Technical Sessions of the Circum-Pacific Meeting
(San Jose, Costa Rica, March 9-10, 1989)

ORAL PRESENTATIONS

GEOLOGIC SETTINGS OF PEAT DEPOSITS IN CENTRAL AMERICA AND THE CARIBBEAN REGION

By

Arthur D. Cohen[1], Oldemar Ramirez[2], Luis Obando[2], Luis Malavassi[2], and Arturo Ramirez[3]

Peat deposits are found extensively throughout Central America and the Caribbean region, with large deposits having been reported in Jamaica, Costa Rica, and Panama and smaller ones in the Dominican Republic, Puerto Rico, Belize, Honduras, Cuba, Nicaragua, and Guatemala. It is likely that many others will be discovered as more exploration takes place. This exploration could be greatly aided by an understanding of the geologic conditions under which these deposits are formed.

All of the deposits investigated to date can be grouped into three geomorphic types: (1) back-barrier (shoreline-related); (2) river flood plain; or (3) high altitude mountaintop. Some examples of these types are (1) the Changuinola deposit of Panama and the Moin deposit of Costa Rica (back-barrier); (2) the Black River Morasse deposit of Jamaica and Rio Medio Queso deposit of Costa Rica (flood plain); and (3) the Talamanca Mountain deposits of Costa Rica (mountaintop).

Factors that control the locations of these deposits include rainfall, temperature, subpeat and surrounding sediment or rock type, hydrologic conditions, and tectonic factors (such as faulting). The composition of the peats formed in these settings is controlled not only by the above factors but also by water chemistry and nearness to sources of detrital mineral contaminants (such as volcanos, rivers, marine water).

Peat deposits (once formed) are often detectable from aerial photographs by the pattern of their surface vegetation and by the color or the pattern of the streams that pass through them or drain them. These surface expressions can also provide clues to the thickness of the deposit and its probable composition.

Thus, study of the geologic settings of known peat deposits has proven valuable both in finding new deposits and in evaluating their commercial potential.

[1]Department of Geological Sciences, University of South Carolina, Columbia, SC 29208.
[2]Refinadora Costarricense de Petroleo (Costa Rica).
[3]Instituto de Recursos Hidraulicos y Electrificacion (Panama).

GEOLOGIC SETTING OF COAL DEPOSITS IN THE CENTRAL AMERICAN-CARIBBEAN REGION

By

E.R. Landis[1], J.N. Weaver[1], M.D. Carter[1], and G.H. Wood, Jr.[1]

Except in Colombia and Venezuela, the coal-resource potential of the Central American-Caribbean Region has been largely ignored. However, coal is known or has been reported to be present in 13 other countries of the region.

Although coals of the region occur in fluviatile and marginal-marine rocks ranging in age from Triassic/Jurassic to Tertiary, nearly all the known and reported occurrences are in strata of Paleocene to Miocene age. Deposited mostly in relatively small basins, the coal-bearing units have subsequently been vigorously folded, faulted, and eroded. Evaluation of the coal-resource potential of the region is difficult because of the structural complexity of the coal-bearing regions and because of the lack of detailed information about the coals and the stratigraphic sequences that contain them.

Because of the relative youth of the coal-bearing strata, the coals tend to be of low rank and are suitable for both thermal purposes and conversion processes. Locally, heating by intrusive bodies and burial under thick sequences of sedimentary and volcanic rocks have raised the rank to within the range of coking coals. Ash and sulfur contents range from low to very high, and information about other coal-quality factors, such as ash-fusion temperatures, is generally unavailable.

Many of the nations of the Central American-Caribbean Region possess coals that might constitute usable alternative energy sources. However, much exploration and related research are needed before the coal-resource potential of the region can be realistically evaluated.

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[1]U.S. Geological Survey.

OPPORTUNITIES TO COLLABORATIVELY ADVANCE UTILIZATION OF CLEAN COAL TECHNOLOGIES

By

Denise Swink[1]

The U.S. Department of Energy (DOE) has a major program to participate with the U.S. private sector in research, development, and demonstration activities related to increased utilization of clean coal technologies. These technologies range from pre-combustion fuel cleaning/refining to combustion and/or conversion with improved environmental and efficiency performance to post-combustion flue gas cleanup. DOE actively pursues opportunities to collaborate in advancing utilization of these clean coal technologies worldwide, and promotes bilateral agreements for technical exchange as well as research, development, and demonstration collaborative efforts.

With respect to the Central American-Caribbean Region, close geographic proximity between countries in this Region and the U.S. allows facile opportunities for exposure to U.S. clean coal technology project sites and responsible host site representatives and technology venders and the performance of U.S. coals at these sites. While it is understood that some of the Central American-Caribbean Region countries have priorities to develop their own indigenous coal resources, initial use of U.S. coals proven in U.S. clean coal technologies at sites in these countries could smooth the transition to coal use and extend the domestic reserves. For low quality indigenous coal reserves, blending with high quality U.S. coals may be an attractive option. The coal reserves in the U.S. are vast and can be relied upon as a long-term, secure, reliable fuel supply. DOE looks forward to exploring opportunities with countries of the Central American-Caribbean Region to advance utilization of clean coal technologies.

In addition, the U.S. DOE has collaborative research and development efforts with countries close to the Central American-Caribbean Region (such as Venezuela) in extraction of oil and gas and related geosciences. Similar efforts could be pursued with countries of the Central American-Caribbean Region.

[1]Director, Office of Planning and Environment
Office of Fossil Energy (FE-4)
U.S. Department of Energy
Washington, D.C. 20585

EXPLOITATION, DEVELOPMENT, AND UTILIZATION OF COAL IN COSTA RICA

By

Oldemar Ramirez E.[1], Kenneth Bolanos I.[1], and Luis Malavassi R.[1]

Due to the strong dependency of Costa Rica on imported traditional hydrocarbons, coal is presented as a concrete alternative of energy substitution.

Accordingly, the Government decided, since 1982, to initiate a methodologic evaluation process of the potential national coal that could produce short-term benefits to the country. Considering this, RECOPE was in charge of the Investigation and Development National Program for the Costarrican Coals.

To date, it has found eight localities with coal potential, three of them being where the exploration has been concentrated: Venado, Uatsi, and Zent. The calculated coal potential of these three areas is 50 million metric tons, and there is a lot to be evaluated. From the geochemistry characterization point of view, the ranks vary between lignite and subbituminous coals.

Actually, the mining design is completed for the Zent area, goaling to supply during this year, the coal demand to users in the cement factories sector.

Additionally to this segment of consumption, the necessary studies are being conducted for a mine-mouth thermoelectrical plant, as the demand analysis for the general industry and residential sectors. More options of substitution had been considered in the short term, in a way that these resources generate a lot of benefits to the Costarrican socio-economic activity.

[1]Recope, Division de Recursos Carboniferos, Apto. 4351-1000, San Jose, Costa Rica.

CARBONIFEROUS STRUCTURES IN THE CESAR RIVER VALLEY, COLOMBIA

By

Hernan Gomez Mejia[1]

A feasibility study for a 500 MW coal-fired powerplant led to investigation of the coal resources of the Cesar Valley. Regional and detailed geologic studies, interpretation of seismic reflection profiles, and exploratory drilling performed during and prior to the project indicate the presence of seven carboniferous structures in the area.

The coal is in the Upper Cuervos Formation of Paleocene Age, which is about 400 m thick. The Cuervos is overlain in an angular unconformable relationship by sandstone and conglomerate of the Cuesta Formation. The Cuesta is overlain by alluvial deposits of variable thickness and composition.

Seismic reflection profiles were used in conjunction with stratigraphic data from drilling in the Boqueron Syncline to locate sites for exploratory drilling in the La Loma and Descanso Synclines. Four drill holes, which ranged in depth from 137 to 255 m, each penetrated from 1 to 13 coal beds.

The exploratory drill program and seismic data provided enough information to allow estimation of demonstrated reserves in excess of 800 million tons of surface-minable coal in four different deposits in the Cesar River area.

[1]Instituto Geografico, Bogota, Colombia.

ECONOMICS OF SELECTED ENERGY APPLICATIONS OF PEAT IN PANAMA AND COSTA RICA

By

Gary Thayer[1], Oldemar Ramirez[2], and Arturo Ramirez[3]

Studies were performed to determine the economic competitiveness of peat in Costa Rica and Panama. The cases examined were: electrical production in Panama and industrial boilers and cement plants in Costa Rica. Based on estimates of peat mining costs and the end-use costs we calculated, for each application, the price of coal and oil at which the levelized life cycle cost of energy using peat was the same as that when coal or oil was used. We found that a peat-fueled powerplant in Panama would be economic if the price of fuel oil was above $0.10 per liter and the cost of coal was above $40.00 per metric ton delivered. Peat was competitive with oil in small boilers (5,000 kg steam per hour) when fuel oil was above $0.08 per liter. If fixed grate boilers were used to burn peat, peat would be competitive with fuel oil when fuel oil was greater than $0.05 per liter and coal when it was above $30.00 per metric ton delivered. For larger boilers (34,000 kg steam per hour), peat was competitive when fuel oil was priced above $0.105 per liter and coal was above $43.00 per metric ton delivered. Peat would be competitive in a cement plant when fuel oil prices are above $0.08 per liter and coal prices are above $40.00 per metric ton delivered.

---

[1]Los Alamos National Laboratory, Los Alamos, New Mexico.
[2]Refinadora Costarricense de Petroleo.
[3]San Jose, Costa Rica.

PEAT DEPOSITS OF COSTA RICA

By

Luis G. Obando[1], Luis R. Malavassi[1], and Rodrigo A. Estrada[1]

The peat deposits of Costa Rica are best found in the alluvial plain of the Atlantic coast (Back-arc basin) and along the mountain systems (Intra-arc basin).

The peat swamps along the Atlantic coastal plain display a morphology analogous to the "barrier beaches" or in irregular shapes which are "drowned" when lateral to meander belts.

Peat thicknesses, locally are relatively continuous from 0.5 to 14 m with values varying between 2,000 and 4,500 kcal/kg (dry basis) and lower in sulfur and relatively higher in ash.

The Yolillo (Raphia) palm fragments are the main plant component of the Atlantic coastal peat deposits. The inorganic components preceeded the emplacement of the magmatic arc to the south which acted as the source for the volcanic sediments.

Peats along the intra-arc basin (Talamanca Range) are found in the higher valley elevations. These types of peat deposits have not been well studied and have irregular cross-sections. Cold climate, the high precipitation, poor drainage and lack of inorganic matter and produce a low sulfur and ash peat which have relatively high calorific value (4277 kcal/kg).

In this environment, the vegetation is tropical cloud forest with extensive open areas containing herbaceous vegetation such as sedges, grasses, fern peat moss (Sphagnum), and heaths.

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[1]Recope, Division de Recursos Carboniferos, Apto. 4351-1000, San Jose, Costa Rica.

MINING DESIGN OF THE ZENT COAL PROJECT IN COSTA RICA

By

Rogelio Samuels[1], Gladys Cubilla[1], and Marcos E. Rodriguez[1]

The Zent coal field is located in the southeastern part of Costa Rica, in the Atlantic water shed in the Limon Province. It covers 268 Km^2 and it is divided into three subareas: San Miguel, Rio Peje, and Corina.

Investigations were concentrated in the Corina Subarea where two main coal beds were evaluated "El Indio" coal bed with an average thickness of 1.8 m and the "Second" coal bed with an average thickness of 0.70 m, separated stratigraphically by 10 m.

A total of 14 88 x 10^6 M.T. have been evaluated in an area of 5.8 Km^2 from which 4.59 x 10^6 M.T. are proven reserves and 9.36 x 10^2 M.T. probable reserves. 1.025 x 10^6 M.T. of this coal are planned to be developed by open pit methods, in an area of 0.4 Km^2 with a maximum overburden thickness of 50 m.

Coal quality analysis shows 3,200 kcal/kg as average heating value ("as received" America Standards for Testing and Materials, ASTM), 12 percent ash content, 1 percent sulfur, and 41 percent moisture. Therefore, it is classified as lignite to subbituminous.

Overburden rock materials are estimated for 13.4 x 10^6 m^3 and have been subdivided in 6 different geotechnical intervals, but all of them are classified as weak rocks (International Society of Rock Mechanics). *0 percent of the volume is rippable. With this in mind, the permissible maximum angle for the mine slope is 58° with a security factor of 1.

Boundaries of the exploitation blocks were delimited according to the annual projected demand. Seven blocks designed according with a demand of 499,458,000 M.T. projected next seven years (Demand Scenary No. 2).

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[1]Recope, Division de Recursos Carboniferos, Apto. 4351-1000, San Jose, Costa Rica.

COAL RESOURCES OF THE BAJA TALAMANCA AREA OF COSTA RICA

By

Geologo Kenneth Bolanos I.[1], Ingeniero Manuel Salas P.[1]

A total of 17 million metric tons (MT) of subbituminous C and B coal, have been evaluated to present in the three subareas of the southern part of Baja Talamanca Coal Field (Uatsi Project), which 8.6 million are classified as proved reserves (measured).

-2.6 million MT, with a thickness of 1.5 m, in the V-9 coal seam of the northern subarea of the Carbon Volio River basin. Around 2.0 million of these tons are classified as proved reserves, in the area of 3.75 Km^2.

The coal-bearing sequence is folded in an asymmetric anticline that imply an underground mining for this coal bed.

-3.1 million MT, with an average thickness of 0.95 m, in the V-7 of the eastern subarea of the Carbon Volio River basin, in an area of 3.3 Km^2.

Approximately 1.9 million of the total estimated are proved reserves. The coal-bearing member is dipping with angles from 10 to 20 degrees gently folded. Underground mining is needed to recover most of these resources.

-11.3 million MT are estimated to date in the V-1 and V-9Nueva coal seams, in the western subarea of the Carbon Volio River basin. The inferior bed (V-1), with a thickness of 0.95 m, has 5.1 million MT, which 1.8 are proved reserves. The superior bed, separated 140 m stratigraphically, has 6.2 million MT with an average thickness of 1.5 m. Around 2.9 million MT are proved.

The V-1 seam will have to be developed by underground methods.

The V-9Nueva has an overburden relation in meters of 20:1 or less, in an area of 0.4 Km^2, coal that is going to be developed by open pit methods.

According with the method used, proved reserves are in a radius of 0.25 Km from known points as outcrops or boreholes.

Most of the total reserves evaluated are in a radius of 0.5 Km from known points of observation. A total of 37 measured outcrops and 17 boreholes were used to derive this resource evaluation.

In addition to the beds evaluated there are others for which extension and other characteristics have not been determined, as well as there are other areas where exist coal and we know very little about them.

More efforts are needed to evaluate completely the coal resources, and establish the real potential of Baja Talamanca, before any exploitation.

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[1]Recope, Division de Recursos Carboniferos, Apto. 4351-1000, San Jose, Costa Rica.

Conclusions

1. The general stratigraphic column of the area describes from small grain sizes in the base (Uscari Formation) of deeper marine environment to the medium grain sizes of Gatun Formation and then coarse continental sediments at the top (Suretka Formation).

   This "coarsening up" general sequence is due to the uplifting of the Talamanca Range

2. Gatun Format (Rio Banano) was deposited in a transitional environment: shallow marine (200 m) to continental deposits.

3. Coal was deposited in small basins, involved in multiple transgressive and regressive sequences in the uplifting process of the Talamanca Range.

4. The measured maximum thickness is 2.1 m on the V-9 coal seam, but the correlation of these beds is 2.3 km as a maximum, because of the complex geological structures.

5. Coal quality: coal found in the Baja Talamanca Coal Field is classified as subbituminous C and B, with some bituminous and lignite small sectors.

6. Most of the reserves evaluated are considered to be mined by underground methods (90 percent).

   V-9Nueva Coal Seam has an area of 0.4 km^2 where the coal is consider to be mined by surface methods, due to overburden thicknesses less than 50 m.

7. Resource evaluation of Uatsi Project area is estimated as follows:

	PROVED	PROBABLE	POSSIBLE	TOTAL
COAL SEAM		(million metric tons)		
V-1	1.8	1.1	2.2	5.1
V-7	1.9	1.2	---	3.1
V-9	1.9	0.7	---	2.6
V-9Nueva	2.9	1.2	2.1	6.2
TOTAL	8.5	4.2	4.3	17.0

APPLICATION OF COAL TO THE CEMENT INDUSTRY OF COSTA RICA

By

Geol. Fernando Alvarado[1], Ing. Rafael Yglesias[1], Econ. Luis C. Solera[1]

The cement industry is one of the most important industries in Costa Rica. It represents 0.37 percent of the gross internal product.

In actuality the country is using about 60 percent of its production capacity of Portland Cement in the following manner:

1. Industria Nacional de Cemento, S.A. (INCSA) began operations in 1964, and now has an operation capacity of 1800 metric tonnes per day.

2. Cementos del Valle, S.A. (CEMVASA) was in operation between 1978 and 1983 and it had a production capacity of 400 metric tonnes per day.

3. Cementos del Pacifico, S.A. (CEMPASA) has been in operation since 1980 and has an operational capacity of 1250 metric tonnes per day.

The growth of the demand of cement has risen about 10 percent per year between 1964 and 1978. However, it decreased to 3 percent from 1978 to 1983. Since 1983 to until now, it has been growing and is almost up to 5 percent annually. Due to the economic stability of the country and the "Plan de Vivlenda" (Building Houses Plan) which had increased construction.

Energy represents more than 50 percent of the variable cost in the production of cement. About 75 percent of the total consumption of energy is bunker-C (fuel oil). Forty-seven percent of the total consumption of bunker in the country is used in cement production.

Due to the last increments in price of bunker-C, the cement industries have found it to be in their best interest to change to more economical energy sources. Therefore, they are now substituting partially the bunker-C for other fuels. It is estimated that the costs of total transformation would be about $14 million U.S.

As a result of this new policy, INCSA has made substitution improvements in bunker fuel C by using solid fuels like mineral coal, African palm shells, corn cobs and imported coke.

The results of coal substitution have been rather satisfactory. At the present moment, 13 percent of the total energy process has been changed to coal.

Further expectations are to increase the substitution to at least 20 percent without having large changes in the production process.

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[1]Recope, Division de Recursos Carboniferos, Apto. 4351-1000, San Jose, Costa Rica.

The importance of transformation in the cement industry is based on the assured supply of fuels of local sources at a stable price. These prices would not be influenced by international market. Also, they are important in the development of this new sector of production, the increment of sources of employment, savings accounts and national aggregate value.

POSTER PRESENTATIONS

REFINADORA COSTARRICENSE DE PETROLEO GERENCIA DE PRODUCCION PRIMARIA LABORATORIO GEOQUIMICO

By

Lourdes Quesada

General Information

Geochemical Testing Lab. of RECOPE, S.A. is part of Gerencia de Produccion Primaria, RECOPE, S.A. Its activities are as follows:

- coal geochemical analysis
- peat analysis
- inorganic and organic sediments analysis
- several chemical analysis using the lastest spectroscopy technology
- complete water analysis for environmental control in mining process
- other geochemical analysis

Geochemcial Testing Lab. of RECOPE S.A. is considered one of the best of Latin America and its personnel has been trained in the U.S.A.

Lab Equipment and its Applications

A. Elemental analyzer for C, H, and N
Kind of sample: solids and heavy liquids

B. Sulfur analyzer
Kind of samples: solids and heavy liquids

C. Atomic absorption spectroscopy for minerals
Kind of sample: solids and heavy liquids

D. Ion analyzer for hydrogen, cyanide, fluoride, etc.
Kind of sample: solids and heavy liquids

E. Ovens and muffle furnace for proximate analysis and others
Kind of sample: solids and heavy liquid

F. Modern sample preparation equipment
Kind of sample: solids and heavy liquids

G. Analytical balances for weight measurements for analysis
Kind of sample: solids and heavy liquids

H. Calorimetric system for coal testing
Kind of sample: solids and heavy liquids

I. Soxlet instrumentation for extraction
Kind of sample: solids and heavy liquids

J. Volumetric equipment for water analysis
Kind of sample: liquids

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[1]Recope, Division de Recursos Carboniferos, San Jose, Costa Rica.

COAL RESOURCES IN THE CENTRAL AMERICAN-CARIBBEAN REGION

By

J.N. Weaver[1], E.R. Landis[1], M.D. Carter[2], and G.H. Wood, Jr.[2]

Total coal resource estimates for the Central American countries of El Salvador, Honduras, Nicaragua, Costa Rica, and Panama are 1,000 million short tons; for the northern Caribbean countries of Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico, and Anguilla, 160 million short tons; and for the northern South American countries of Colombia, Venezuela, and Trinidad, 18,000 million short tons. Total resource estimates include identified/hypothetical and speculative coal resources. These estimates are based on an extensive literature search which includes reports of isolated occurrences that are difficult to evaluate as well as detailed evaluations of known coal fields. The literature search found more than 90 references to coal for Central America, more than 35 references for the northern Caribbean, and more than 75 for northern South America.

For Central America, 350 million short tons is classified as identified/hypothetical coal-in-place; and 650 million short tons is speculative coal-in-place resources. For the northern Caribbean countries, all of the 160 million short tons is identified/hypothetical coal-in-place resources. In the northern part of South America, 11,000 million short tons is identified/hypothetical coal-in-place and 123,000 is speculative coal-in-place resources. All coals reported are of Tertiary age except for ten occurrences of Jurassic/Triassic age in Guatemala. Coals classed as lignite are reported to being present in Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Panama, Venezuela, Colombia, Trinidad, Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico, and Anguilla. Coals classed as bituminous are reported to be present in Colombia, Venezuela, Guatemala, and Costa Rica. Subbituminous coals are reported in Honduras, Costa Rica, and Colombia.

The reported estimates are conservative, and represent a very preliminary evaluation of the coal resources in the Central American-Caribbean Region. They are intended to stimulate and guide the research efforts needed to increase our understanding of this potentially important energy source.

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[1]U.S. Geological Survey, Federal Center, MS 972, Denver, CO 80225
[2]U.S. Geological Survey, National Center, MS 956, Reston, VA 22092

APPENDIX 6

Recommendation from the Coal and Peat Working Group
(Circum-Pacific Meeting)

This is the suggested introduction to the coal and peat section of the Proceedings volume for the Circum Pacific council meeting, which was held in San Jose, Costa Rica (March 6-10, 1989).

The Working Group on coal and peat discussed many of the same problems and concepts that were identified by other working groups, especially those on petroleum and mineral resources. Particularly, the panel strongly agreed that a vastly increased amount of basic geologic and related engineering studies are needed before we can properly evaluate the fuel and mineral resource potential of the Central American-Caribbean Region. The working group agreed that a great potential for coal and peat does exist within the region and emphasized that a greater effort should be made in geologic and economic assessments of solid fuels. Successful coal and peat programs are currently underway in Costa Rica, Colombia, and Venezuela.

From the perspective of solid fuels, a study of the sedimentary basins, large and small, is vital to improved understanding of the resource potential of the region. The sedimentary basins and their fringes are the habitat of fuels and related mineral resources, such as phosphate, and the geologic factors that control occurrence and the resource quality factors that decide recoverability and utilization are poorly understood in most of the basinal areas of the Central American-Caribbean Region.

The panel recognized three facets of the basic and applied information problems:

1) existing relevant information should be gathered, integrated, and summarized for regional use;

2) identified data needs should be satisfied by basic and applied research; and

3) a mechanism or organization for transfer and dissemination of information among individuals and groups with responsibilities in solid fuels should be created.

The subject of educational opportunities was discussed and general support for an increase in scholarships, etc., was recognized. However, the panel specifically recognized a lack of opportunity to study solid fuels at both the undergraduate and graduate levels in local regional facilities. They strongly encouraged establishment of study courses in solid fuels at facilities such as the Central American School of Geology in San Jose, Costa Rica.

APPENDIX 7

Trip Report

Control Number (See Approved DI-1175)

FOREIGN TRAVEL TRIP REPORT

(To be submitted within 10 working days after trip completed)

Name of Traveler/Division	Dates of Travel	Countries Visited
EDWIN R. LANDIS / Geologic	Feb 26 - Mar 21	Costa Rica

Names of Others Accompanying Traveler and Affiliation	Key Counterpart Personnel and Affiliation
Jean N. Weaver - Geologic Div., Branch of Coal Geology, USGS	Heriberto Rodrigues - USAID/Costa Rica Oldemar Ramirez - RECOPE

Purpose of Trip or Title and Sponsor of Meeting Attended

Review of coal development program activities since end of cooperative USGS/RECOPE program that was partially sponsored by USAID. Attend Circum-Pacific Symposium on Energy and Mineral Resources of CA-CR.

Summary of Trip Discussions and Activities

Report prepared describing progress of coal exploration and development program conducted by RECOPE.

Suggestion and recommendations regarding present and future program needs are important part of report.

Benefits to USGS/DOI Mission or Foreign Policy Objectives

RECOPE ready to utilize coal as alternative fuel. USAID, DOE and USGS may be asked for assistance in exploration, development and utilization planning.

Problems Encountered, Actions Taken (If Any), Responsible Personnel

Report tendered to USAID/Costa Rica before departure

Conclusions and Recommendations

Costa Rica important as model for alternative fuels strategy in developing nations.

Distribution: Original + 2 copies to AD/EG (MS 106); 1 Copy to OIG (MS 517); Division Copies

Control Number (See Approved DI-1175)

600

FOREIGN TRA[illegible] TRIP REPORT

(To be submitted within 10 working days after trip completed)

Name of Traveler/Division

Jean N. Weaver/Geologic

Dates of Travel

2/26/89-3/21/89

Countries Visited

Costa Rica

Names of Others Accompanying Traveler and Affiliation

Edwin R. Landis - Geologic Division
Branch of Coal Geology, USGS

Key Counterpart Personnel and Affiliation

Heriberto Rodriguez, USAID/Costa Rica

Oldemar Ramirez - RECOPE
Kenneth Bolanos - RECOPE

Purpose of Trip or Title and Sponsor of Meeting Attended

1) Present an invited poster at Circum - Pacific Symposium on Energy and Mineral Resources of CA - CR.
2) Update the status of an ongoing cooperative program between USGS/AID and RECOPE

Summary of Trip Discussions and Activities

Reviewed the current status on the RECOPE coal exploration and development programs - presented a first draft to USAID Mission in Costa Rica with suggestions and recommendations about programs future needs.

Benefits to USGS/DOI Mission or Foreign Policy Objectives

RECOPE is ready to utilize coal as an alternative fued. USAID, DOE & USGS may be asked for assistance in exploration, development and utilization planning.

Problems Encountered, Actions Taken (If Any), Responsible Personnel

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Conclusions and Recommendations

Utilization tests need to be planned and conducted for Costa Rican coal. This is an important step to properly evaluating this alternative fuel option.

Distribution: Original + 2 copies to AD/EG (MS 106); 1 Copy to OIG (MS 517); Division Copies

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[illegible] 3/31/89