UPDATE AND SENSITIVITY ANALYSIS OF "EXPORT OF COKING COAL FROM THE CHECUA-LENGUAZAQUE (COLOMBIA) COALFIELD"

by

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ABSTRACT

A re-evaluation of the Checua-Lenguazaque Coalfield was done. Financial analysis indicated that the plan proposed by the Economic Associates to mine the coalfield is not economically feasible, based on the assumption of a target rate of return of 15 percent and a pre-determined price of $20.50 per ton of coal. The re-evaluation indicated that with a price of $31.34 per ton, a 15 percent rate of return could be achieved.

The principal parameters influencing the development of the Checua-Lenguazaque Coalfield were studied. An alternative mining method to exploit this coalfield and possible alternatives of transport to carry coal from the mine site to the coast for exportation were considered.

The proposed mechanized mining system would provide lower costs. However, the low degree of mechanization and the lack of skilled labor in Colombia are the principal constraints for this method.

The unit train and slurry pipeline are the proposed alternative transport methods considered. The costs per ton-mile for these alternatives indicated a lower cost for the unit train than for the slurry pipeline. However, the

slurry pipeline would be more competitive if the output of coal increases.

The results of the market analysis indicated some possibilities for the development of Colombian coal resources based on the needs of the steel industry. A possible agreement between Colombia and Brazil indicates that a guaranteed market would be available close by.

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INTRODUCTION

The purpose of this study is to analyze the principal characteristics of the Checua-Lenguazaque Coalfield report such as mining, transportation, marketing, and coal prices in order to estimate acceptable lower costs and/or higher revenue that will permit achievement of a rate of return of 15 percent. This would be an acceptable rate in the Colombian context.

The present study is important because, according to estimates, the possible reserves of coal in Colombia are in the order of 4,600 million tons, with probable reserves of 520 million tons and proved reserves of 175 million tons. They represent approximately 60 percent of the total reserves in Latin America and should foster an important economic development of Colombia. Therefore, there is a need for further technical evaluations and feasibility studies to establish the potential development of these deposits.

The first part of this thesis consists of a review of an economic evaluation report on the Checua-Lenguazaque Coalfield, as completed in the early months of 1974 by a British consulting firm, Economic Associates Limited. This report concludes that the coalfield was not economic with a target rate of return of 15 percent. The Discounted Cash Flow Rate of Return, the Net Present Value, and the Payback Period are used as techniques to evaluate that report.

The second part of this thesis includes a proposed general mining plan with some investment estimates for different rates of production, costs, and prices that may be applied to Checua-Lenguazaque. Data gathered by the U.S. Bureau of Mines and the SME Mining Engineering Handbook are used for this analysis.

The third part of this thesis consists of an analysis of two proposed transport alternatives, pipeline and unit train. Those are compared to the normal railroad transportation which was the more economical transport alternative considered by the Economic Associates.

Cost data used in this study are adjusted for differences in time and location.

The last part of this thesis contains a market analysis for coal. Required prices for Checua-Lenguazaque coal to ensure an acceptable return are compared with international prices for coal of similar quality. It also establishes Colombian coal's possible markets, with special emphasis on the needs of the steel industry.

REVIEW OF THE ECONOMIC ASSOCIATES REPORT

The pre-feasibility study of export of coking coal from the Checua-Lenguazaque area of Colombia, South America, by the Economic Associates Limited, can be condensed as follows.

Location of the Coalfield

The field is located in the Department of Cundinamarca, about 25 miles to the north of Bogota; the main area of study is approximately 28 miles long and 5 to 8 miles wide. It covers an area of 224 sq. miles, stretching from Guacheta in the northwest to Nemocon in the southeast. The small towns of Ubate, Tausa, Cucunuba, Lenguazaque, and Guacheta are located within the coalfield. The region is shown in Fig. 1 below.

Geology

The coal deposits of the Checua-Lenguazaque are situated within the series of strata of the Guaduas Formation, which is basically of the Upper Cretaceous geological age. These strata outcrop along a series of hill ranges that project in a north-easterly direction above alluvial plains.

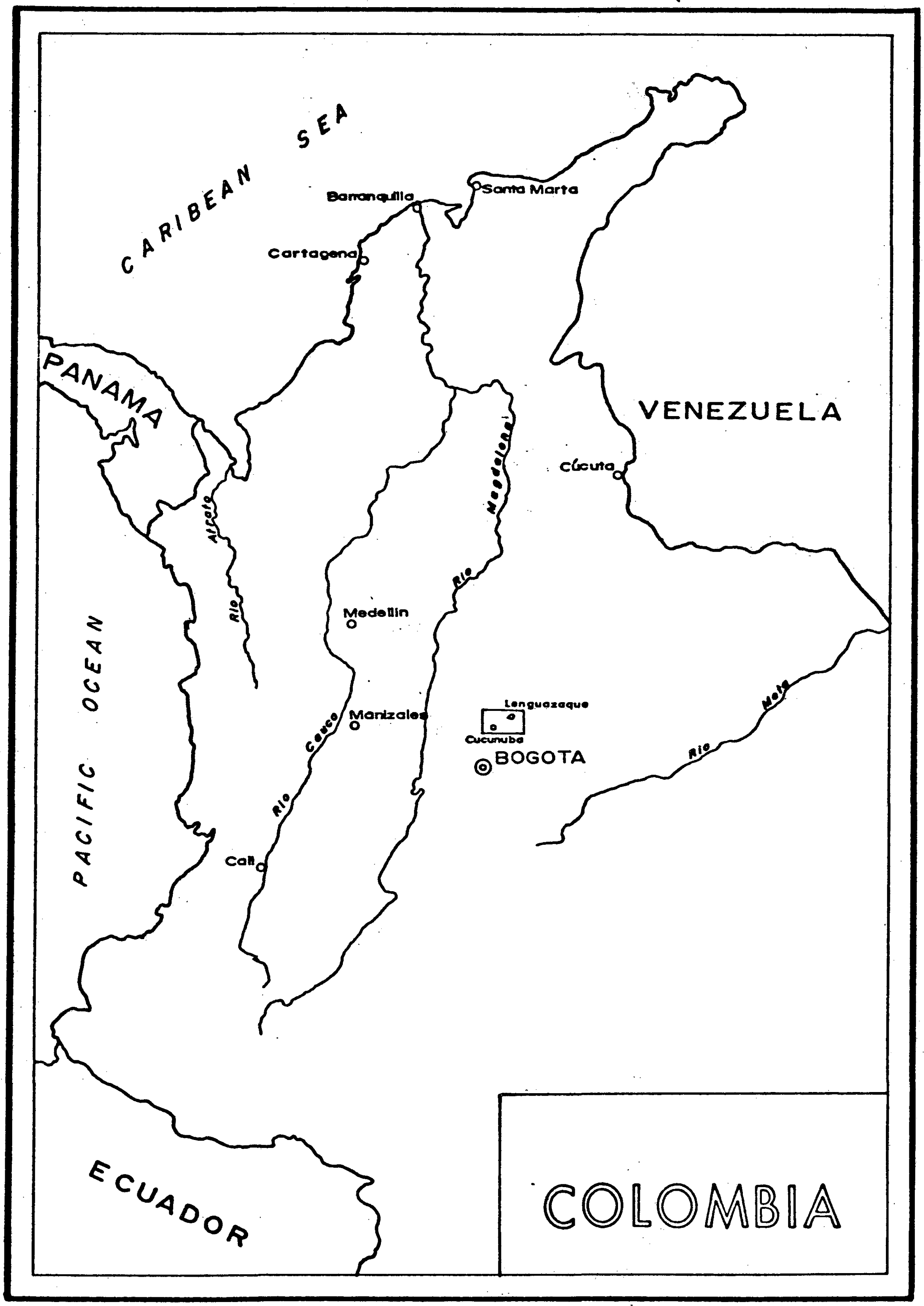

CARIBEAN SEA
Santa Marta
Barranquilla
Cartagena
PANAMA
VENEZUELA
Cúcuta
Rio Atrato
Rio Magdalena
Medellin
Lenguazaque
Manizales
Cucunuba
BOGOTA
Rio Cauca
Cali
PACIFIC OCEAN
Rio Meta
ECUADOR
COLOMBIA

Fig. 1

The plains are at a level of about 8,530 feet above sea level and the maximum altitude of the Guaduas Formation is about 11,155 feet.

The axial area of the syncline is obscured by thick Tertiary and alluvial deposits and the depth of these deposits remains unknown. The eastern limb of the syncline contains thin coal seams which are very steeply inclined and often overturned. The absence of persistent fossil horizons make seam correlation between adjacent areas very difficult.

Lithology

The Guaduas Formation, which contains the workable coal, has been sub-divided into five units (5):

(1) Unit TKG 1 is composed of about 328 feet to 492 feet of shales and siltstones.

(2) Unit TKG 2 is composed of sandstones, shales, mudstones, siltstones, and coal seams. In general, thickening has been observed to the north; the unit varies in thickness from some 394 to 984 feet.

(3) Unit TKG 3 is largely composed of siltstones, mudstones, thin ironstones, and coal seams. On the eastern flank of the syncline, the unit is almost entirely composed of sandstones. The thickness of the unit varies from about 2,297 feet in the south to 856 feet in the north.

(4) Unit TKG 4 - the sandstones are a series of lenses rather than distinct beds and are coarse to medium grained. The unit varies in thickness from 328 to 984 feet.

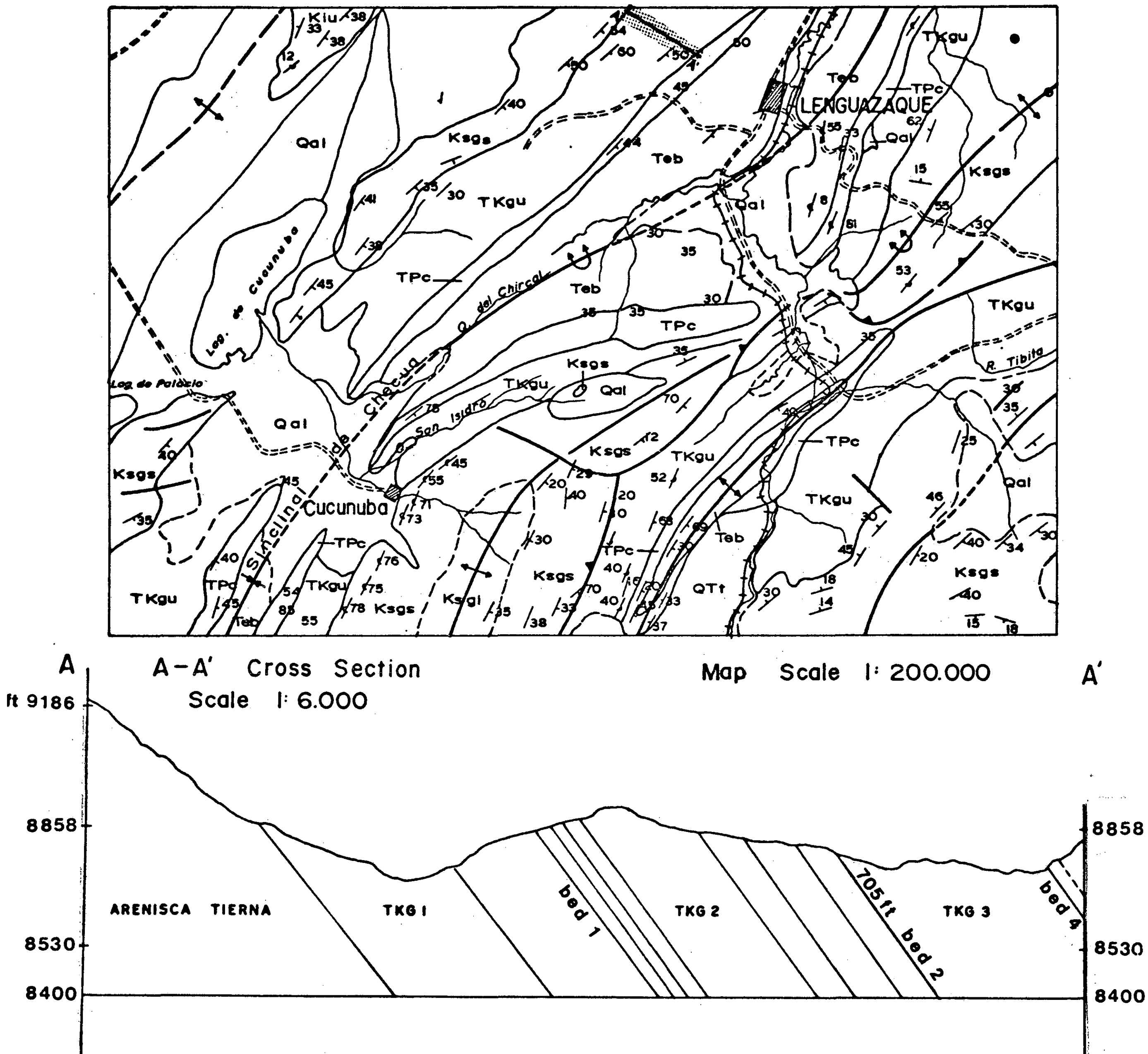
(5) Unit TKG 5 is the highest unit of the Guaduas Formation, which is essentially composed of red and blue siltstones (refer to map - Fig. 2).

The coal sequences of TKG 2 and TKG 3 appear to be normal coal measures of the facies type. Some structural restriction in deposition might be indicated by apparent breaks in the lateral continuity of the coal horizons in the Lenguazaque and Cucunuba River valleys.

Structure

The Checua-Lenguazaque Syncline is an asymetric structure trending for some 40 miles in a north-easterly direction from Zipaquira to the north-east of Guacheta. Between Zipaquira and Cucunuba several minor folds of similar trend are developed within the central part of the syncline. The dip of the measures on the western limb varies from 20 to 65 degrees. Steeper dips prevail on the eastern side, with frequent overturning.

More than 120 mines operate in the western limb, the most likely area for increased coal exploitation. The average thickness of the seams is estimated at 3.94 feet.



QUATERNARY		TERTIARY		CRETACEOUS	
Qal	Alluvium	Teb	Bogotá Fm.	Ksgs	Upper Guadalupe Fm.
		TPc	Arenisca del Cacho	Ksgi	Lower Guadalupe Fm.
		TKgu	Guaduas Fm.	Kiu	Une Fm.

Fig. 2 GEOLOGICAL MAP AND CROSS SECTION CHECUA-LENGUAZAQUE AREA

Quality

The coal within the area is medium to low volatile, medium ash, and low sulphur content. The coal appears to have a "free swelling index" varying between 3.5 and 9.0, with an average of about 7.0.

There appears to be an increase in the volatile content of the coals sampled from north to south. The coals with the lowest volatile percentage appear to be those from the mines in the Frio River Syncline area and the area to the north of the Lenguazaque River.

Reserves

The assumptions used by Economic Associates Limited in making the preliminary estimates are as follows:

Only the reserves above the level of the valleys near Cucunuba and Lenguazaque are mineable at this time.

Only the seams with a thickness greater than 1.97 feet are likely to prove economically exploitable. Although mining of seams less than 1.97 feet thick is possible, it is likely to be impractical on a large scale within the geological environment of the Checua-Lenguazaque Coalfield.

Only seams which are a sufficient stratagraphical distance from adjacent workable seams have been included.

At this time, December of 1975, about 30 percent of the total proved reserves are being mined.

Because of lack of information on the persistence of the coal seams in thickness, quality, dip, roof and floor strata, it is considered that only 60 percent of the remaining in-situ reserves could be extracted. For the purposes of this study, a 58 percent level of extraction will be used as a maximum.

The maximum depth of economic mining below the surface is about 1,476 feet.

Based on the above criteria, the proved recoverable reserves for Checua-Lenguazaque were estimated in 1974 to be 62.1 million short tons.

The coalfield may prove to have larger quantities of workable reserves. Therefore, to complete any study in the detail required for the planning of a large mine in this area, it is necessary to carry out some core drilling from the surface. Equipment capable of drilling at least 1,969 feet is necessary, and in order to explore the area within a reasonable time, it would appear that at least three rigs are required. A full program of work to keep the rigs in continuous operation should be prepared.

Production Estimated

The Economic Associates report estimated initial production of coal in 1983 with 200,000 tons, 500,000 tons for 1984, and building up to a maximum of 810,000 tons per year in 1985.

Project Life Period

The total life of the project is 33 years, begining in 1974 and ending in 2007. The economic life of the mine is 25 years, starting in 1983, based on present reserves estimates.

Proposed Mining Systems

Short-Wall - Tunnels or entries are driven up in coal, approximately 39 to 49 feet apart between the upper and lower horizons and the coal mined between them by retreating downwards toward the lower horizon. Coal would be mined by pneumatic picks.

Long-Wall - After some experience is gained on the short-wall system, it is recommended that face lengths of about 164 feet should initially be used, with the use of pneumatic picks for loading the coal onto a face chain conveyor. The coal would then be loaded onto a belt conveyor and thereafter into mine cars for transportation to the surface.

After some experience of the above method, the Economic Associates determined that a mechanized system such as a "shearer loader" might be technically feasible.

The Transport Alternatives

The analysis of transport modes concentrated on two major alternatives, both by way of a port on the Caribbean Coast.

Single Mode - Rail transport from the mine site to a suitable seaport near the present port of Santa Marta.

Split Mode - Rail transport from the mine site to a suitable port site on the Magdalena River; then, transport to a suitable seaport site near the ports of Barranquilla or Cartegena.

In the single mode, Economics Associates considered two alternative railways between the mine site and the possible port near Santa Marta, at Bahia Concha and near Gaira. The first was the existing route via Bogota. The other required the construction of a new link between Saboya and Carare.

The route to the Pacific Coast (Buenaventura) was also considered. At Buenaventura the possible port sites are very restricted because of the sedimentation problems in the access channel.

The engineering analysis and estimates of economic costs indicated that the optimum transportation mode would be by rail to a port site near Santa Marta (Bahia Concha). Although the transport through Gaira would be the cheapest overall by a small margin, the route to Bahia Concha is preferred on engineering and maritime grounds, as it would provide a better port site.

Figure 3 shows the general plan proposed by the Economics Associates, with the final f.o.b. cost for each alternative.

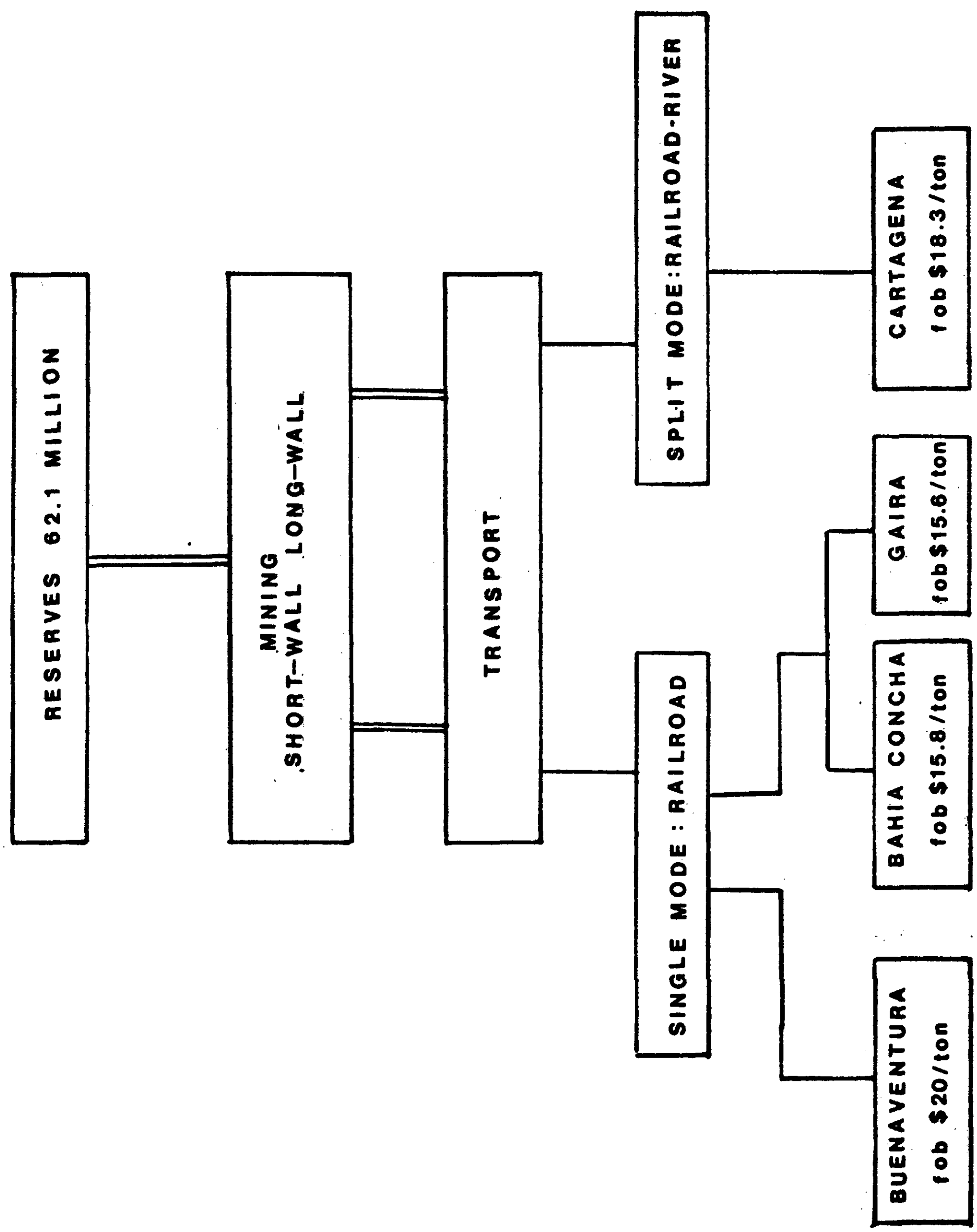


Fig. 3 MAJOR ALTERNATIVES

ECONOMIC ASSOCIATES

<u>General Conclusion</u>

At the pre-feasibility stage, the primary conclusion reached by Economic Associates is that the development of coal for export from the Checua-Lenguazaque Coalfield would not be viable at f.o.b. price of $20.50 per ton of coal, taking as a base a minimum rate of return of 15 percent. The annual rate of return at a price of $20.50 per ton is only about 6.9 percent.

ECONOMIC ANALYSIS OF THE ECONOMIC ASSOCIATES REPORT - ACTUAL DATA, 1974

Several methods of evaluation are available for the economic analysis of this kind of project. Each has peculiar weaknesses, and to limit the analysis to a single technique could result in an erroneous conclusion.

The DCF 1 is a computer program available at the CSM Mineral Economics Library, which evaluates the discounted cash flow rate of return (DCFROR) for each set of cash flows or project cost data, the net present value (NPV) given a minimum (acceptable) rate of return, and the payback period (PB).

This program was used for this analysis. No modifications are necessary for Colombian taxes, because cash flows are complete before using the program. Appendix I shows the schematic model of cash flow computations.

One of the most important concepts in investment appraisals is the net cash flow (NCF), which is the excess of inflows of funds over outlays.

The term cash flows, as used here, is defined as the net profit after taxes, plus depreciation, depletion, and other non-cash expenses; thus, cash flow represents the total amount of money generated by the project and available for other uses.

The Discounted Cash Flow Rate of Return (DCFROR), as defined by Stermole (23), is:

> "The rate of return that makes the present worth of cash flow for an investment (including after-tax salvage value) equal to the present worth of all after tax investments."

The Net Present Value (NPV) method is the most common evaluation technique in use. For the analysis, a predetermined interest rate is required, which represents the firm's cost of capital. Expected net cash flows throughout the life of the project, either positive or negative, are discounted or compounded to a given time period, and summed up. A positive net present value indicates a favorable venture.

The Payback Period (PB) method establishes the length of time the project will have been in operation to return in cash the amount of money invested. This method utilizes cash flow, but not any interest compounding or discounting; in other words, it does not take into account the time value of money.

<u>Computation of DCFROR, NPV, and PB</u>

To calculate the discounted cash flow rate of return (DCFROR), the net present value (NPV), and the payback (PB), the first thing that must be done is to compute after-tax cash flow for each year of the evaluation.

The preproduction investment (negative cash flows) is shown in Table 1.

Table 2 shows the cash flow calculation for 810,000 tons per year of coal.

Program Results

The Discounted Cash Flow Rate of Return for this project is

5.82 Percent

The Net Present Value is -$15,709,074 (using a minimum rate of return of 15 percent).

The Payback Period for this project is

21.16 Years

Comparison of the Results

Now one can compare the general conclusion for the Checua-Lenguazaque Coalfield.

For Economic Associates: 6.9% rate of return

For the author of this thesis: 5.82% rate of return

The difference of the results may be the methods chosen for the evaluation. The rate of return method (ROR) used by the Economic Associates is the percent return on unamortized investment each year, on a before-tax basis. On an after-tax

TABLE 1

SCHEDULE OF PRE-PRODUCTION EXPENDITURES AND WORKING CAPITAL REQUIREMENTS

ECONOMIC ASSOCIATES REPORT - 1974

ITEM	YEARS - (thousands of dollars)										
	1974	75	76	77	78	79	80	81	82	83	84
Mine Development	160	580	260		416.24	1841.18	1841.18	2861.48	4712.18	638.00	319.00
Housing-Urban Facilities					360.00	680.00	960.00	1840.00	1840.00	1120.00	698.26
Railway Capital Cost					840.00	880.00	2620.00	6280.00	14160.00	7856.88	
Capital Port Facilities							641.80	2897.00	6946.00	1437.00	
Equipment										4293.68	6540.00
Working Capital										2000.00	2000.00
Total	$160	580	260		1616.24	3401.18	6062.98	13873.98	27658.18	17345.56	9557.26

TABLE 2

CASH FLOW CALCULATIONS

(thous. dollars)

	200,000 tpy 1983	500,000 tpy 1984	810,000 tpy 1985-2007
Sales	4100.00	10250.00	16605.00
- Operating Cost	3333.00	5853.00	8457.00
Gross Profit	767.00	4397.00	8148.00
- Deprec/Amortiz.	752.54	752.54	3227.00
Net taxable Income before depletion	14.46	3644.46	4921.00
- % Depletion (10% sales)	410.00	1025.00	1660.50
Taxable Income	- 395.54	2619.46	3260.50
- Tax 40%	-0-	1047.78	1304.20
Net Profit	- 395.54	1571.68	1956.30
+ Depreciation	752.54	752.54	3227.00
+ Depletion	410.00	1025.00	1660.50
Cash Flow	767.00	3349.22	6843.80

Economic Life: 25 years
Price/Ton: $20.50
Salvage Value: $2,750,000
Working Capital return $4,000,000 at end of the 25 years.

basis, this project's ROR is the rate yielded by the method chosen by this author.

According to Stermole (23), the DCFROR is the number one economic evaluation decision method used by more than 90 percent of chemical, petroleum, mineral, and electronic product oriented companies that use a formal economic evaluation procedure to evaluate the real economic potential of investment.

Regardless of the method, this project is not economic under the actual conditions, using a target rate of return of 15 percent and a price of $20.50 per ton of coal.

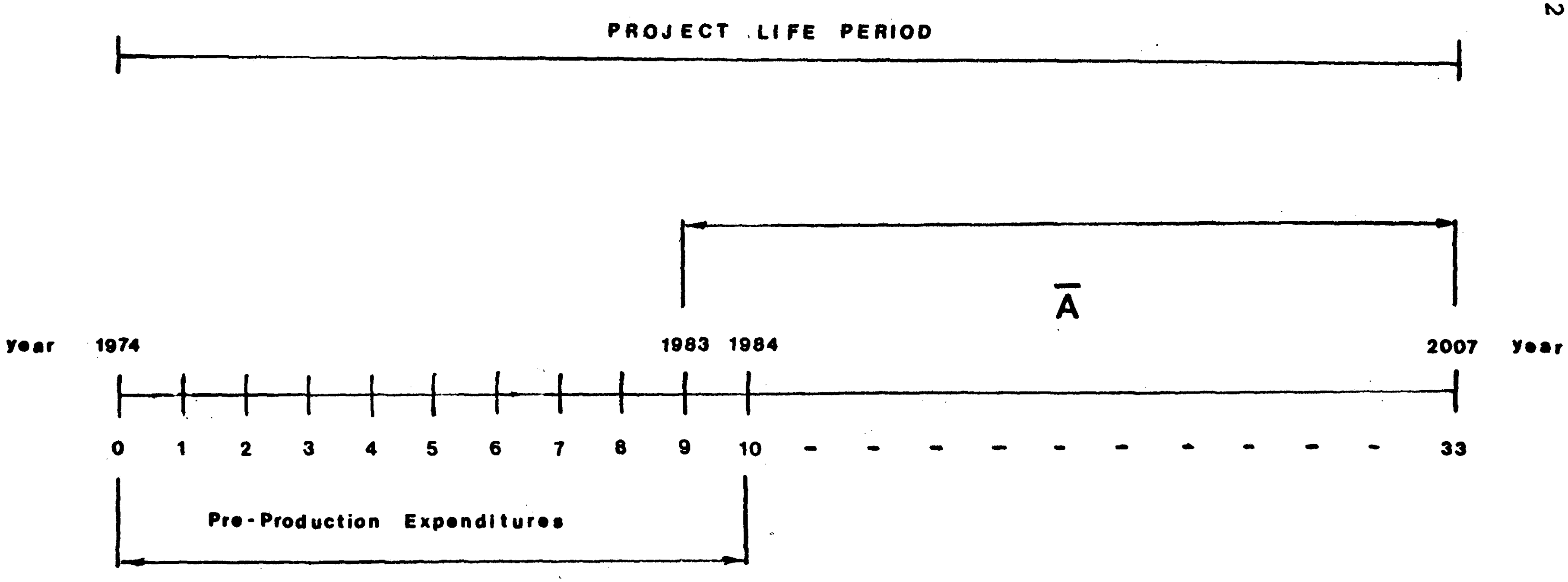
Price Calculation

A price for the coal which will achieve a rate of return for this project of at least 15 percent is calculated below.

The computation is based on the pre-production investment data listed in Table 1, the time diagram shown in Fig. 4, and the major breakdown of cost model for the Economic Associates report, Figure 5.

The Net Present Value Equation is used,

$$-160 -58\ (P/F_{15.1}) -260\ (P/F_{15.2}) -1616.2\ (P/F_{15.4}) -3401.2\ (P/F_{15.5}) -6063\ (P/F_{15.6}) -13874\ (P/F_{15.7}) -27658.2\ (P/F_{15.8}) -17345\ (P/F_{15.9}) -9557\ (P/F_{15.10}) + 6750\ (P/F_{15.33}) + \bar{A}\ (P/A_{15.25})\ (P/F_{15.8}) = NPV$$



$\overline{A}$ IS THE FUNDS FLOWS; THE SINGLE TOTAL AMOUNT OF FUNDS FLOWING CONTINUOUSLY DURING A PERIOD, IN A UNIFORM SERIES OF n EQUAL PAYMENTS.

Fig. 4 TIME DIAGRAM

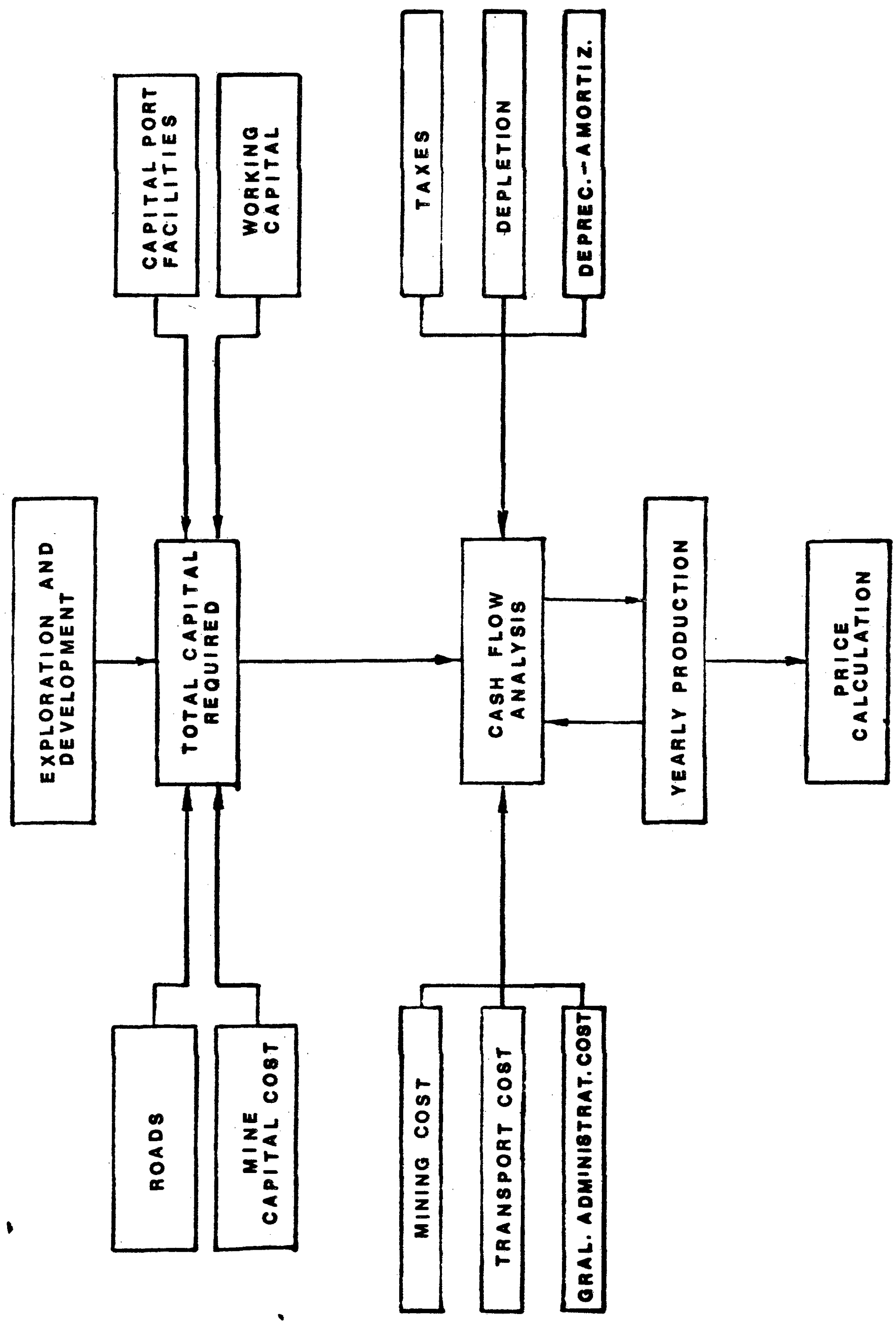


Fig. 5 MAJOR BREAKDOWN OF COST MODEL

(All the coefficients in thousand dollars.)

Where:

$P/F_{i,n}$ is the factor called the "single payment present worth factor" used to calculate a present single sum, P, that is equivalent to a future single sum, F (23).

$P/A_{i,n}$ is the factor called the "uniform series present worth factor" used to calculate the present sum, P, that is equivalent to a uniform series of equal end of period payments, A (23).

$\overline{A}$ is the funds flow.

Computation gives:

$$26411.59 = 81 + 2.113\ \overline{A}$$

$$\overline{A} = \$12,451,240$$

Now, using the next equation from Appendix I, the annual sales is calculated:

$$\text{Sales} = \frac{1}{.64}\ [\text{cash flow} + 0.6\ (\text{Op. Cost}) - 0.4\ \text{Dep. \& Amortiz.})]$$

$$\text{Sales} = \frac{1}{.64}\ [12,451,240 + 0.6\ (8457) - 0.4\ (3227)]$$

$$= 25,382,250.$$

With an annual production of 810,000 tons of coal, the price that permits a 15 percent DCFROR will be:

$$\text{Price} = \frac{25,382,250}{810,000} = \$31.24/\text{ton}$$

ECONOMIC ANALYSIS OF THE ECONOMIC ASSOCIATES REPORT - UPDATED 1975

The same methods used in the earlier study will be applied again to evaluate the updated conditions. It is important to note that costs are changing rapidly with the current inflation. The effects of inflation on the feasibility of a project depend on the magnitude of the rate and its duration. In a high rate of inflation the role of time adjustment is even more important as the effects of increases in capital cost and production cost become more significant and decisive to the feasibility of the project.

For Colombian conditions, where the rate of inflation has shown tremendous fluctuations in the last years, inflation creates problems in project evaluations. However, it is necessary to apply some criteria in order to update all the available data.

For mine development and working capital a 10 percent increase is estimated for the period of 1974 to 1975.

For the rest of the capital investment (except machinery and equipment) a 15 percent increase is estimated.

For machinery and equipment, the price index published by Coal Age and other magazines is applied, assuming that they will be bought from the USA.

The cost of production is increased by 15 percent over 1974 costs to compensate for inflation.

For the coal price, a 30 percent increase is estimated.

In addition, Table 3 gives a similar schedule of expenditures but for a five-year exploration and development interval instead of the ten-year interval suggested by Economic Associates report. Such redistribution of expenditures and activities is used in the analysis to determine the effect on profitability of more efficient pre-production scheduling. A cash flow, Table 4, for an annual production of 810,000 tons follows.

Finally, a sensitivity analysis is done, to determine the impact on profitability of major parameters, which are critical to the results.

TABLE 3

REDISTRIBUTED EXPENDITURES UP-DATED

(thousand dollars)

ITEM	YEARS				
	1	2	3	4	5
Mine Development	1558	2025	2025	3148	6236
Housing-Urban Facilities	2300	2116	2116	1288	803
Railway Capital Cost	1978	3013	7222	15364	7573
Capital Port Facilities		738	3326	7988	1653
Equipment				5152	7848
Working Capital				2200	2200
Total	$ 5836	7892	14689	35140	26313

TABLE 4

CASH FLOW CALCULATION

810,000 TPY OF COAL

	(thousand dollars)
Sales	$21627
- Operating Cost	9726
Gross Profit	11901
- Deprec. & Amortiz.	2643
Net Taxable Income before Depletion	9258
- Depletion (10% sales)	2163
Taxable Income	7095
- Tax 40%	2838
Net Profit	4257
+ Deprec. & Amortiz.	2643
+ Depletion	2163
Cash Flow	9063

Economic Life = 25 years
Price/Ton = $26.70
Salvage Value = $3,300,000
Working Capital Return $4,400,000 at end of 25 years.

PROGRAM RESULTS

The Discounted Cash Flow Rate of Return for this project is

* * * 7.76 * * * percent

The Net Present Value is $ -28,325,606 (using a minimum ROR of 15%).

The Payback Period is 13.92 years.

In conclusion, it is clear that the proposed plan by Economic Associates to develop the Checua-Lenguazaque Coalfield is not economic under the actual and updated conditions considered in this study.

In view of the potential impact of developing this coalfield on the Colombian economy, it is important to seek alternate means for the design and the operations of the mine, in order to reduce costs and ensure its economic feasibility.

SENSITIVITY ANALYSIS - SINGLE PARAMETER VARIANCE

CAPITAL INVESTMENT		OPERATING COST	
Variance	DCFROR	Variance	DCFROR
%	%	%	%
-20	10.13	-10	8.44
-10	8.81	0	7.76
0	7.76	+10	7.18

INCOME TAX RATE		PRICE	
Variance	DCFROR	Variance	DCFROR
%	%	%	%
-10	8.58	-10	6.27
0	7.76	0	7.76
+10	7.07	+10	9.27

The DCFROR sensitivity to changes in different parameters can be comparatively seen through the relevant results as follows: A decrease of 10 percent in capital investment produced a DCFROR change from 7.76 to 8.81 percent (+1.05 percent); an income tax rate decrease from 40 to 30 percent produces a DCFROR change from 7.76 to 8.58 percent (+0.82 percent): a price increase of 10 percent produced a DCFROR change from 7.76 to 9.27 percent (+1.51 percent); and a decrease of 10 percent in the operating costs produces a change from 7.76 to 8.44 percent (+0.68 percent) in the DCFROR. It can be deduced from the above results that the DCFROR is more sensitive to changes in the capital investment and in the price. Therefore, future technological advances toward less expensive processes, as well as future increases in coal prices in the international market, will surely make this project more attractive and therefore feasible.

The next section describes a proposed alternative mining method that may be applied to the Chequa Lenguazaque Coalfield. The data were gathered from the Bureau of Mines and Mining Engineering Handbook. They are adjusted to account for differences in time and location.

ALTERNATIVE MINING METHOD

In order to choose any particular mining method, it is necessary to consider several factors, such as the depth of the coal seam, the type of rock in the overburden, the characteristics of the coal seam, and the nature of floor and roof of the coal seam.

The system selected must provide a good degree of safety, lowest extraction cost per ton, maximum production per man-shift, and maximum percentage of recovery.

In the case of the Checua-Lenguazaque Coalfield, due to the lack of information, it is assumed that the deposit could be exploited using the general mining plan described on the next pages, with data adapted from similar projects by the U.S. Bureau of Mines and the Mining Engineering Handbook. There is no attempt to give precise results; the objective is to give a general view over the whole scheme, to indicate future possibilities and some ways in which these developments may perhaps influence future approaches toward the full development of the coalfield of Checua-Lenguazaque.

General Mining Plan

It is assumed that the mine would be operated 220 days per year, 3 shifts per day, and would have 20-year life of continuous mining and that conventional equipment would be used to develop the field.

The system at present requires that a continuous pillar be formed, usually 150 feet in width, by driving entries, perhaps two or three each side of the pillar, with the length of the pillar frequently between 1500 feet and 3000 feet. The pillar is then extracted by taking a series of open-ended lifts with a continuous miner. The roof of these lifts is maintained by self-advancing roof supports.

The normal depth of each lift is about 10 feet, and the supports are moved two or more times to cover the roof so exposed.

Each loading unit consists of a continuous miner-loading machine, two shuttle cars, and a roof bolter.

Coal is transported to the surface by belt conveyors; main heading conveyors are about 40 inches wide.

Reasons for this Method

The desirability of using the same coal-mining machine for driving the development entries and for extracting pillars is all important. It saves capital, extra training of all personnel, and allows for continuity of production. The continuous miner can go immediately into the next development as soon as one panel is extracted.

In addition, this system offers good recovery, with reduced roof support costs.

Capital Investment and Operating Costs

Capital investment and operating costs are estimated for annual production rates of 1.0 million, 2.043 million, and 3.2 million tons. They are shown in Table 5 and Table 6, respectively.

It is important to note that the selected rates of production are merely arbitrary for the purpose of this evaluation.

Price Calculation

Using the Discounted Cash Flow analysis with the selected rate of productions, a price calculation is made for each alternative, at 15 percent rate of return and 20 year life.

In each case, the distribution of the capital investment, estimated over the 20-year life time, is based on the requirement for replacing worn-out machinery and equipment after their useful life and their remaining salvage values at the termination of mining activities.

TABLE 5

ESTIMATED CAPITAL INVESTMENTS SUMMARY

UNDERGROUND COAL MINE

	1 million TPY	2.043 million TPY	3.2 million TPY
	(thousands of dollars)		
Total Direct Cost	$ 9175.80	14437.40	20462.90
Freight on Equipment (50% of equipment cost)	4516.65	6731.20	10088.30
Indirect Cost	183.50	288.70	409.30
Total Direct Plus Indirect	13875.95	21457.30	30960.50
Contingency (15% direct plus indirect)	2081.39	3218.60	4644.08
Engineering (2% direct plus indirect)	277.52	429.15	619.21
Overhead - Administration (5% direct plus indirect)	693.80	1072.87	1548.03
Fee (2% direct plus indirect)	277.52	429.15	619.21
Total Plant Cost	17206.18	26607.07	38391.03
Interest during construction (10%)	1720.62	2660.71	3839.10
Working Capital	2000.00	3192.85	4223.00
Total Capital Requirements	$ 20962.80	32460.63	46453.13
Cost Per Ton (annual capacity)	$ 20.96	15.89	14.52

Source: Bureau of Mines, I.C. 8682, 1975.
Mining Engineering Handbook, Vol. 1, 1973.

TABLE 6

ESTIMATED ANNUAL OPERATING COSTS*

UNDERGROUND COAL MINE

	1 Million TPY Annual Cost (thousand $)	1 Million TPY Cost Per Ton	2.043 Million TPY Annual Cost (thousand $)	2.043 Million TPY Cost Per Ton	3.2 Million TPY Annual Cost (thousand $)	3.2 Million TPY Cost Per Ton
Direct Cost**						
Labor	313.22	0.31	575.60	0.28	873.92	0.27
Supervision	334.85	0.33	434.04	0.21	548.49	0.17
Operating Supplies	2440.32	2.44	4664.58	2.28	7010.52	2.19
Power	105.35	0.11	167.43	0.08	268.16	0.08
Others (40% of above)	3026.32	3.03	2249.85	1.10	3438.04	1.09
Indirect Cost						
15% Labor/Sup/Suppl.	438.15	0.43	818.58	0.40	1266.29	0.40
Fixed Cost						
Depreciation	1828.17	1.83	2284.00	1.11	4081.20	1.28
Others (2% Plant Cost)	532.14	0.53	532.14	0.26	767.82	0.24
Annual Operating Cost	9018.52	9.01	11726.22	5.74	18309.44	5.72

*Source: Bureau of Mines Information Circular 8682, 1975. Mining Engineering Handbook.

**Costs are modified from Bureau of Mines, I.C. 8682, 1975, and the Mining Engineering Handbook, Vol. 1, 1973, to apply to the Chequa Lenguazaque Coalfield.

Discounted cash flow - 1.0 million tpy

15 percent - 20 years

From Appendix II, the annual cash flow is calculated.

$$\text{Annual cash flow} = \frac{23,668,150}{6,259^{*}}$$

$$= \$3,781,420$$

Using the equation established in Appendix I, the annual sales and the price per ton of coal is calculated for output of 1 million tons per year.

$$\text{Price} = \frac{\text{Annual Sales}}{\text{Annual production}} = \frac{13,220,790}{1,000,000}$$

$$= \$13.22/\text{ton}^{**}$$

Discounted cash flow - 2.043 million tpy

15 percent - 20 years

From Appendix II it is possible to calculate the annual cash flow

$$\text{Annual cash flow} = \frac{39,542,020}{6.259^{*}}$$

$$= \$6,317,626$$

Using again the equation from Appendix I, the annual sales and the price per ton of coal is calculated for output of 2.043 million tons per year.

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* Uniform series Present Worth Factor.
** F.O.B. price at the mine.

$$\text{Price} = \frac{\text{Annual Sales}}{\text{Annual production}} = \frac{19,437,130}{2,043,000}$$

$$= \$9.51/\text{ton}^{*}$$

<u>Discounted cash flow - 3.2 million tpy</u>

15 percent - 20 years

From Appendix II, the annual cash flow is calculated.

$$\text{Annual cash flow} = \frac{55,119,710}{6.259^{**}}$$

$$= \$8,806.470$$

From Appendix I, the annual sales and the price per ton of coal is calculated.

$$\text{Price} = \frac{\text{Annual Sales}}{\text{Annual production}} = \frac{28,372,260}{3,200,000}$$

$$= \$8.86/\text{ton}^{*}$$

---

* F.O.B. price at the mine.
** Uniform Series Present Worth Factor.

Inferences from Study of Alternative Mining System

The mechanized proposed mining system would provide lower costs for the Checua-Lenguazaque Coalfield.

However, it is important to recognize some constraints in developing this system for the general mining conditions in Colombia.

1) A low degree of mechanization is a principal characteristic of the present Colombian mining industry. The most mechanized operations employ chain and belt conveyors, diesel and trolley locomotives, and similar mechanized equipment. Present medium and small-sized operations have a very low degree of mechanization and they work with primitive tools: hand picks for mining, human beings and wheelbarrows for underground transport, and candles for lighting.

2) At present, the safety of mining operations is low. The Government still does not have any legislation of mining safety.

3) A high percentage of illiteracy is the common denominator among the mining workmen. The consequence is low skill among the mining people, including foremen and supervisory personnel.

4) A high percentage of geologists and mining engineers are working in other activities and are not available to supervise a mechanized operation.

In short, a new approach to mining systems would require a complete revision of the present extraction system.

ALTERNATIVES OF TRANSPORT

In this section, the cost of transportation of coal by slurry pipeline is presented and compared to a second alternative mode of transportation - the unit train.

It is not necessary, in doing an economic evaluation, to go deeply into the technical considerations. A rapid appraisal of the technology is sufficient for the purpose of this study.

Slurry Pipeline

Technology of slurry pipelines to carry coal and other solids has reached a maturity, based on 1.7 billion annual ton-miles of experience. The capacity of this system has increased almost five times in the last five years; this trend is expected to continue at an accelerated rate.

The energy required to transport solids by pipeline compares well with that required by other means of transportation. Actually, large slurry pipelines require less energy than rail or barge.

One important characteristic of the slurry pipeline is its relatively low exposure to escalation of costs, due primarily to the high capital intensity of these systems.

The list of commercially operating systems in Table 7 below is becoming quite lengthy. Most of the expansion in slurry pipeline volume is due to large coal pipeline systems, since coal is a source of energy rather than a raw material, and it must be transported to the vicinity of use in one form or another.

The overall volume of coal movement and the volume of usage at selected sites particularly encourage the use of slurry pipelines.

Commercial Slurries

The solid's specific gravity and the slurry concentration are basic factors in the selection of the maximum pipe size.

The physical properties of some commercially transported minerals are listed below.

Material	Specific Gravity	Maximum Particle Size	Concentr. of Solids by Weight %	Pipeline Design Velocity fps
Coal	1.4	8 mesh	45-55	5.0
Limestone	2.7	48 mesh	60-65	3.5
Copper	4.3	65 mesh	60-65	5.0
Magnetite	4.9	100 mesh	60-65	6.0

At their operating velocity, these slurries are as nearly homogeneous as is likely to be found. The slurries are nonabrasive at design velocities and noncorrosive.

TABLE 7

SELECTED COMMERCIAL SLURRY PIPELINES

LOCATION	MATERIAL	LENGTH miles	DIAMET. in.	CAPAC. M tpy
Ohio, U.S.	Coal	108	10	1.3
Arizona, U.S	Coal	273	18	4.8
USSR	Coal	38	12	1.8
France	Coal	5.5	15	1.5
Poland	Coal	126	10	-
Utah, U.S.	Gilsonite	72	6	0.4
Colombia, S.A.	Limestone	9	5-6	0.4
Trinidad	Limestone	6	8	0.6
England	Limestone	57	10	1.7
California, U.S.	Limestone	17	7	2.0
Georgia, U.S.	Kaolin	16	8	0.6
Tasmania, Australia	Iron Concent.	53	9	2.3
Waipipi, N. Zealand	Magnetite	4	8	1.0
Bougainville	Copper Concent.	17	6	1.0
Turkey	Pyrite	38	5	1.0
West Irian	Copper Concent.	70	4.5	0.3
South Africa	Gold Tailings	22	6&9	1.1
Japan	Copper Tailings	40	8	1.0
Under Construction				
Las Truchas, Mex.	Iron Concent.	25	10	1.5
Pena Colorado, Mex.	Iron Concent.	30	8	2.5
Planned				
U.S.	Coal	1040	38	25.0
U.S.	Coal	600	28	12.5
Canada	Sulphur/Hydroc.	800	12	
Africa	Iron Concent.	165	16	4.0
Australia	Phosphate	180	16-22	-
Argentina, S.A.	Iron Concent.	20	8	2.0
India	Iron Concent.	36	20-22	10.0
Brazil, S.A.	Bauxite	200	-	6.0
Brazil, S.A.	Iron Concent.	300	-	-
Africa	Bauxite	90	-	1.0

Source: J.M. Link, Some Economic Aspects of Mineral Slurry Pipelines, Dec. 1974

Another important property of most slurries is that they are restartable; that is, when the pipeline shuts down and the slurry settles, it settles in such a way that the system can be restarted.

Equipment

Using steel pipeline with welded joints allows the use of cross-country construction techniques with their inherent economic advantages associated with production-line techniques.

Positive displacement pumps are selected in the majority of cases, because of their higher pressures and higher operating efficiency as compared to centrifugal pumps. Commercially available pumps for slurry pipelines range up to about 1750 hp, with annual capacities of two to three million tons per pump.

The other major component of a slurry pipeline system is the storage tank. In the Black Mesa system in the USA, tanks of 6 million-gallons operating capacity were installed at the Mohave generating station, with a 500 hp agitator (16).

The System

One important factor in sizing a pipeline system is the annual operating factor. Basically, slurry pipelines can be designed to operate constantly, or 24 hours a day, 365 days a year. Since spare pumps are provided in pumping stations, the instances of unplanned system outage are limited to instances of power failures. System availability of 95 percent per annum is commonly used for design.

Spacing of pump stations depends on terrain, economic balance between pump stations, high design pressures, and line size. Generally, stations are spaced at 60 to 90 mile intervals. As the pipeline diameter gets smaller, say below 10 in., the station spacing will be shorter, due to the high friction losses in small diameter pipe.

To date, water has usually been used to transport commercial solids in slurries; special cases have used other vehicles such as oil.

Preparation of coal slurry is done to meet the transportation requirements. The dewatering process brings the coal nearly back to its original state of dryness for use in the power plant. Work expended in grinding coal for transportation is a savings for the firing process. The coal must be ground to pass 48 mesh before entering the pulverized-coal-fired boiler.

Coal application provides an opportunity for the slurry to be designed for the system, taking into consideration the slurry preparation, transportation, dewatering, and utilization process.

<u>Characteristics of the Proposed Pipeline for Colombia</u>

This section describes the principal characteristics for the proposed pipeline to carry coal from the site of the mine. Checua-Lenguazaque, to the coast. No effort has been made to accurately compute capital or operating costs.

<u>Diameter of the Pipe</u>. Given the annual throughput requirement in tons per year, it is possible to estimate the pipe diameter. Here, a design velocity of 5.5 feet per second is used, which is consistent with the commercial experience for coal in the U.S. A 95 percent availability is also assumed.

Assuming an annual production of 1.0 million tons of coal, the diameter of pipe will be about 10 in. (2).

The pipe wall thickness will be 0.438 in.

<u>Route Survey</u>. Segment Lenguazaque-Carare-Gamarra

Rolling terrain - The longitudal measure should be increased by fifty percent, between Lenguazaque-Carare, to compensate for the uneven terrain.

Estimated length - 274 miles

A maintenance access or service road, should be cleared the complete length of the line, approximately 249 miles.

Segment Gamarra - Fundacion

Level land - The length is the same as in the topography maps

Length - 164 miles

Should be able to save on the cost of the maintenance road by following the railroad line when possible.

Segment Fundacion - Bahia Concha

Flat land - The length is the same as in the topography maps.

Length - 52 miles

Here also, by following the railroad line much can be saved on the cost of the maintenance road.

Total length estimated: 490 miles.

Explanations for Route Selection

1) It is important to avoid the marshlands because of the difficulty in construction of the line and the clearing of the service road.

2) In the Fundacion-Bahia Concha segment, by following the Cienega-Santa Marta route, a spur of the Sierra Nevada can be avoided (the last section of the line crosses some mountainous terrain).

3) If the costs of water-transport are, as they seem to be, comparatively less than the construction and maintenance of the line--the alternative of building the line to Gamarra only and then, continuation by the Magdalena

River to Barranquilla, should be studied in the future.

The service or maintenance road corresponds to a fourth class road, a road-bed of gravel without pavement, complying with the minimum standards for roads; its object is to have access to the pipeline for whatever maintenance or repair work.

Figure 6 shows the profile of proposed route for the slurry pipeline and Figure 7 indicates its location in Colombia.

Economic Evaluation

The following simplified economic analysis is provided to gain an idea of capital operating and ton-mile costs for the slurry pipeline from the site of the mine (Checua-Lenguazaque) to the coast (Bahia Concha) for exportation of coal. The capital estimates are based on current "rule of thumb" estimating factors and no effort has been made to accurately compute capital or operating costs.

In addition, costs estimates have been developed using published data from previous studies of slurry pipelines in the U.S.

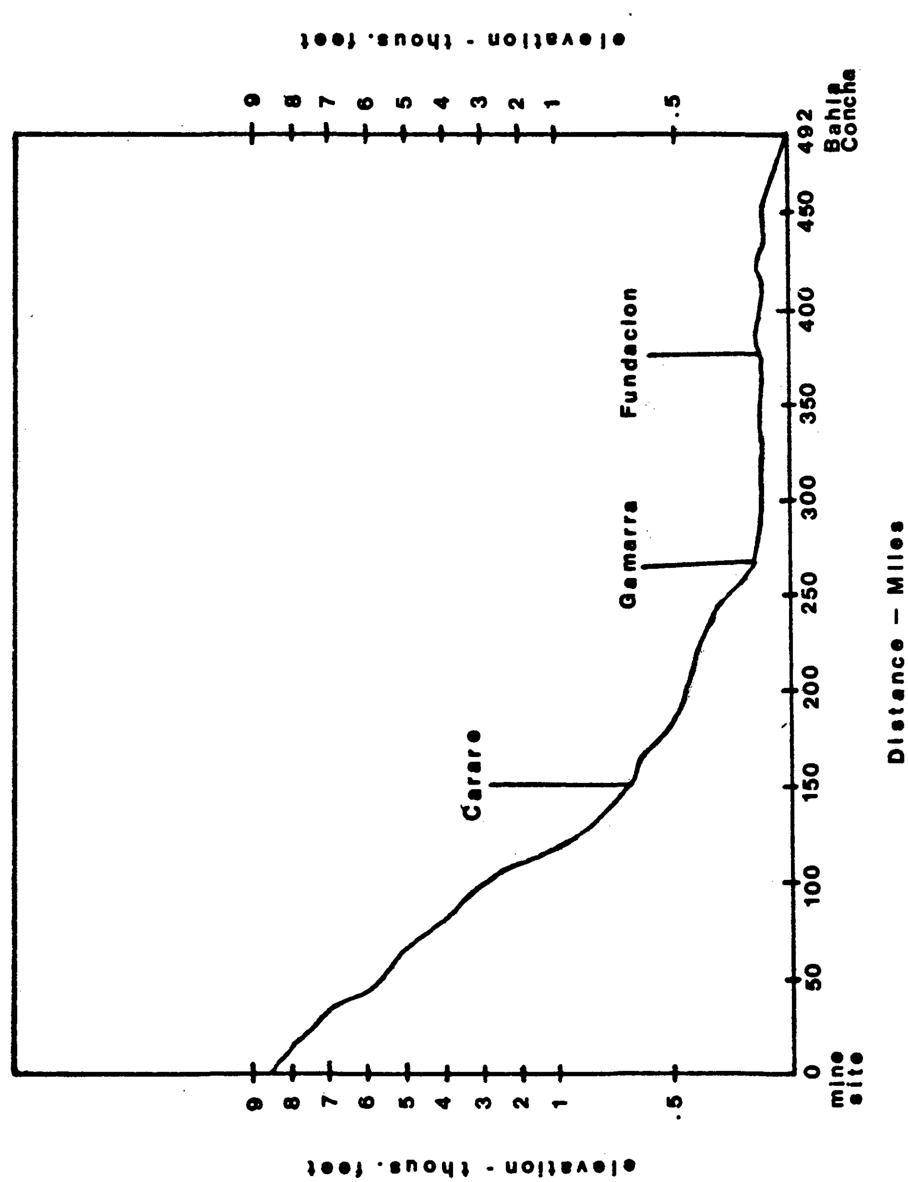

Fig. 6 PROFILE OF PROPOSED ROUTE FOR PIPELINE - COLOMBIA

(NO SCALE)

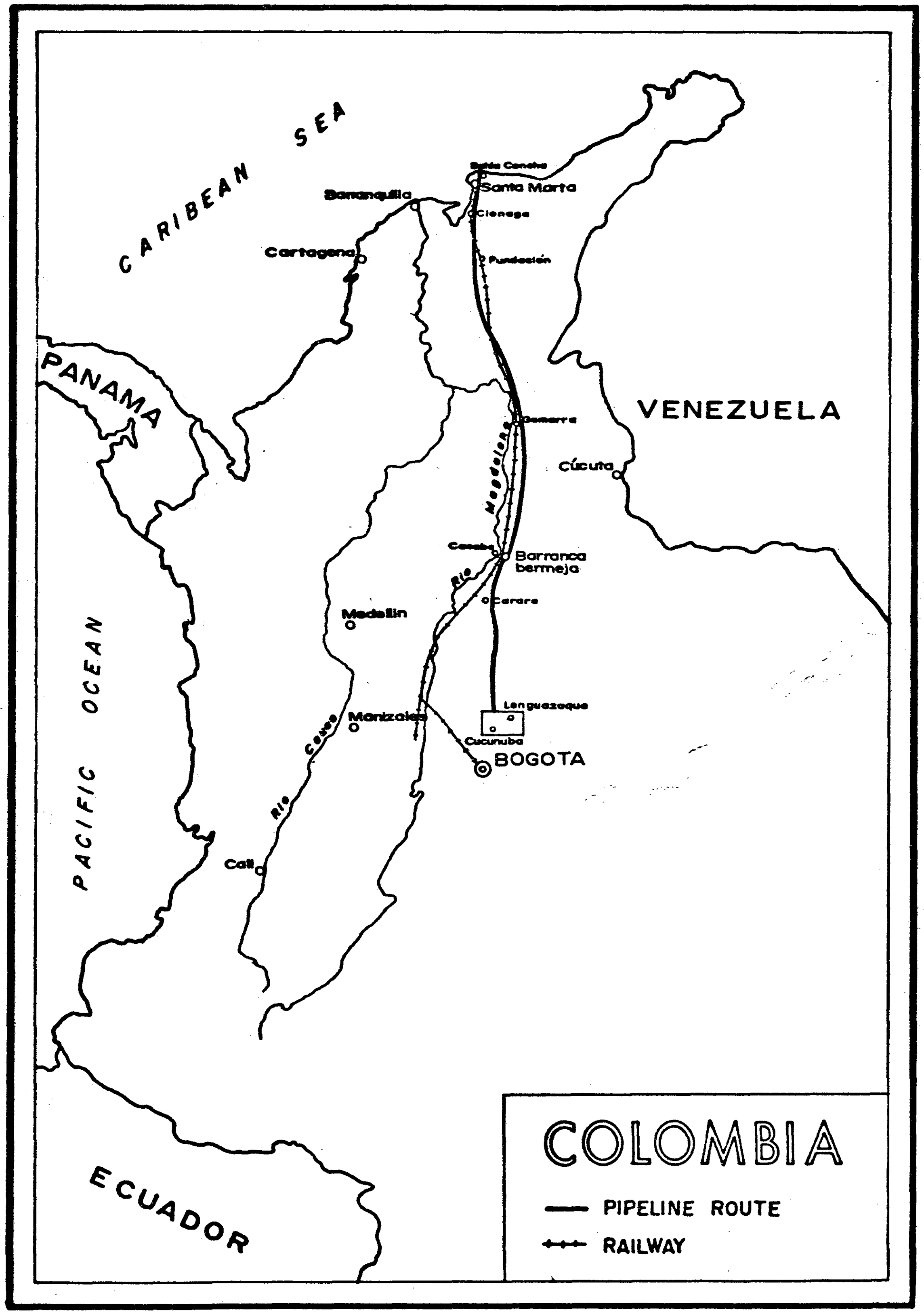

Fig. 7 PROPOSED PIPELINE ROUTE

Coal from the mine would be received at a processing facility where it would be pulverized and mixed with water. Slurry preparation in its simplest form consists of reducing solids to a size suitable for pumping, mixing them with a fluid, water generally, and then introducing the slurry into the pipeline system. Coal is reduced by crushing and further size reduction is accomplished in rod mills. To reduce 1 million tpy or 115 tons per hour of medium hard bituminous coal, a 36 in. by 54 in. roll crusher with a 150 hp motor would be required.

The second reduction might be a 60 in., two-row, cage mill with a 250 hp motor.

Rod milling the coal to one hundred percent passing 65 mesh would require a 13 by 18 foot rod mill with a 1,500 hp motor.

Slurry from the rod mill would be stored in agitated holdings tanks; two tanks with necessary pumps, piping, and instruments would be used.

The cost estimate for the slurry preparation facility is shown in Table 8.

From the slurry preparation facility, the slurry moves to the pump station where it is started through the pipeline.

The 115 tons per hour of coal would yield about 1,600 gallons per minute of 50 weight percent coal slurry, that could be pumped through a 10 in. pipe with a velocity of 5

TABLE 8

COST ESTIMATE FOR SLURRY PREPARATION FACILITY*

	Total Cost	Cost/ton
Primary crusher	$ 221,135	$ .22
Secondary crusher	221,135	.22
Rod mill	1,438,353	1.44
Tanks, pumps, instru. and assoc. piping	354,056	.35
Total	$2,234,679	$ 2.23

*Costs are updated using Marshall and Stevens Index.

Source: J. M.,Link Some Economic Aspects of Mineral Slurry Pipelining, 1974.

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feet per second. Friction losses would be about 29 psi per mile. Assuming a maximum pump pressure of 1,600 psi and no topographic effects, pump stations would be about 56 miles apart.

The capital cost for pumping stations installed with accessories has been developed with the next equation (17).

$$\text{Cost/HP} = 5536.4 - 12.8674\ (HP) + .01411\ (HP^2) - .7223 \times 10^{-5}\ (HP^3) + .1402 \times 10^{-8}\ (HP^4)$$

Table 9 shows the results for pumping station facilities.

TABLE 9

COST ESTIMATE FOR PUMP STATION*

	Cost	Cost/ton
8, 750 hp pumps, installed plus accesories	$7,314,780	$7.31

* Costs are updated, using Marshall and Stevens Index.

Source: J.M. Link, How to Build Pipeline Transport for Industrial Minerals, 1972.

The cost in dollars per mile for steel pipe, its installation, and right of way, will be calculated using the following formula (17):

$$\text{Cost/mile} = 314239 - 67266.41\,(D) + 5543.78\,(D^2) - 160.46\,(D^3) + 1.64065\,(D^4)$$

where

D = pipe diameter in inches.

The cost estimate for pipeline is given in Table 10.

TABLE 10

PIPELINE COST ESTIMATE *

	Cost	Cost/ton
Pipeline including installation and ROW	$27,293,316	$27.29

*Costs are updated, using Marshall and Stevens Index

Source: J.M. Link, Some Economic Aspects of Mineral Slurry Pipelining, 1974.

Slurry from the line discharges into agitated storage tanks prior to dewatering. From those tanks, it moves to a series of centrifuges where coal and water are separated. Centrifuges capable of dewatering 30 tons per hour of coal would be installed; eight of these would be required to dewater 115 tons of coal per hour, or 1 million tons per year.

Table 11 shows the cost estimates for dewatering facilities.

TABLE 11

COST ESTIMATES FOR DEWATERING FACILITIES*

	Cost	Cost/ton
Centrifuges	$2,655,422	$2.66
Tanks and piping	354,056	.35
Total	$3,009,478	$3,01

* Costs are updated, using Marshall and Stevens Index.

Source: J.M. Link, Some Economic Aspects of Mineral Slurry Pipelining, 1974.

Table 12 gives the capital investment summary.

TABLE 12

TOTAL CAPITAL INVESTMENT, SLURRY PIPELINE *

	Cost	Cost/ton
Slurry preparation	$ 2,234,679	$ 2.23
Pump station	7,314,780	7.31
Pipeline	27,293,316	27.29
Dewatering	3,009,478	3.01
Total	$39,852,253	$39.85

*Costs are updated, using Marshall and Stevens Index.

Source: J.M. Link, Some Economic Aspects of Mineral Slurry Pipelining, 1974.

Operating costs for the system would consist of labor, supervision, electricity, and supplies.

Electricity is assumed to be available at a cost of \$0.0065 per kw-hr in Colombia. About 6,000 hp would be required for the entire facility. The annual electrical power cost is computed in dollars per year, using the following formula (17).

$$PY = .7456 \times (365) \times (24) \times (.95) \times (ELECT) \times (THP)$$

where

ELEC = electricity rate

THP = total operating horse-power

and PY = annual electrical power cost.

Other annual operating costs are computed at the indicated percentage of the total capital investment.

Supervision .3%

Operating labor .9%

Insurance and taxes 1.58%

Maintenance cost for materials and supplies will be estimated at 2 percent of the original capital investment, and will include an allowance for rotating the pipe every third year.

Annual operating costs appear in Table 13.

TABLE 13

ANNUAL OPERATING COSTS ESTIMATED

	Cost	Cost/ton
Annual investment cost	$7,440,009	$7.44
Taxes and insurance	629,666	.63
Power cost	242,023	.24
Supervision and overhead	119,557	.12
Labor	46,627	.05
Maintenance and supplies	91,660	.09
Total	$8,569,542	$8.57

In order to arrive at the annual capital costs, a straight line depreciation is used. No distinction is made between equity and debt, and no salvage value at the end of the project is assumed. In addition, an increase of 50 percent on the annual investment cost is assumed for Colombia, taking in consideration the effect of transportation and ocean transport cost for machinery and equipment.

According to Table 13, the total transportation cost of this sytem is $8.57/ton, or $0.0174/ton-mile, at an annual capacity of 1.0 million tons of coal. This figure will be used later to determine the total f.o.b. cost per ton at the coast and the price for coal, considering the slurry pipeline alternative of transport.

Unit Train

The continued loss of the railroad's share in shipments of utility coal in recent years--as the result of dumped residual fuel oil, interruptible gas, and coal slurry pipelines plus the threat of extra high-voltage transmission of mine-mouth generated energy--made it necessary for the railroads to take prompt action to maintain and try to increase their participation in the energy transportation market. These efforts culminated in the development of the integral train (unit-train) concept.

According to United States Railroad Tariff Definition, a Unit Train is

> "a solid train of conventional size and equipment operating on regulary scheduled cycle movement, with dedicated private cards and assigned locomotives, between a single origin and a single destination" (15).

Unit-Train Economics

The economics of the train load shipments required elimination of waste, minimization of capital investment by high utilization of equipment, and more efficient application of manpower, obviously economizing comes from full and rapid use of cars. While a substantial reduction accrues from better car utilization, this savings is but part of the improvement.

The minimum practical shipment level in a unit train is about 4,000 tons per week or 180,000 tons per year. A lower tonnage will hardly justify the capital expenditures necessary to furnish facilities to load 4,000 tons within 24 hours. The maximum practical production is about 28,000 tons per day or 7 million tons per year. This would require two 7,000 ton trains to be loaded on each of two shifts, which is possible with a 3-hour loading cycle.

In general, the savings possible through the use of unit-train transportation are dependent upon such factors as annual volume, loading and unloading time, and distance traveled.

Storage Facilities

The storage facilities may take the form of open storage piles or enclosed bins and silos. In the case of coal, the type of storage will be dependent of the following factors (15):

If storage is desired for train-load surge and emergency storage, a large capacity open stockpile would probable be desirable.

If coal is thermally dried to a low moisture content, it will not be desirable to use open storage. In addition, if it is necessary to market a low moisture coal, a closed storage bin or silo is indicated.

If dust control is critical, a closed bin or silo would be more desirable.

If the weather is such that coal would tend to freeze in storage or in cars, then a closed bin or silo would be better.

Loading

Loading facilities range from the very simple to the very complex. A single and low cost loading arrangement is a system that has a rated loading capacity of 2,400 tph. A 60-inch reclaim belt from a tunnel under a conical stockpile discharges 2,400 tph into an 85-ton hopper. The hopper is equipped with a pneumatic gate with a 48-inch opening. Below the gate is a 48-inch square choke-loading chute which is mounted on rollers and can be moved to the side in order to allow passage of locomotives. When the coal level in the car rises to the mouth of the chute, the coal flow is choked off until the car is moved ahead. As the car is moved ahead, coal begins to flow again to load the next car. The blade is closed until the next empty car is in position under the chute. The empty cars are pushed through by a locomotive at about 17 to 20 feet per minute and the entire train of 7,500 tons is loaded in about three hours.

Unloading

On the receiving end, coke works and docks are the best candidates for early installation of rapid unloading.

Projects currently being studied are designed for capacities of about 3,000 tph. There are two major systems: one is the rotary dump which will handle gondolas or hoppers, and the other is the track pit which requires hopper cars. Rotary dumps are more expensive to build than pits, but the gondola car is cheaper than the hopper car with automatic quick-opening doors.

Case Studies

Table 14 shows a summary comparison of some unit-train operations, prepared by the U.S. Bureau of Mines. However, new ideas and techniques are bringing many changes that probably do not appear in this table.

A combination of large storage capacity and rapid loading was utilized at each installation. Open and enclosed storage facilities were used. The predominant ground storage was in conical piles. Coal preparation consisted only of crushing and screening run-of-mine coal for some, while at others, coal was cleaned to reduce the impurities. The average of the one-way haulage distance was 292 miles. The size and number of the locomotives varied with the size of the shipment and with track grades, and also with curves encountered. Minimum shipment per unit train was about 7,000 tons and maximum was 12,600 tons. The cars were loaded at rates of 2,400 to 4,000 tph, at speeds of 20 to 30 fpm.

TABLE 14

SUMMARY OF CASE STUDIES- U.S. BUREAU OF MINES 1970
UNIT TRAIN

INFORMATION	INLAND STEEL MINE	VALLEY CAMP #3 MINE	LANCASHIRE #20 MINE	ORIENT #5 MINE	MATTHEWS MINE	BELL&ZOLLER #9 MINE	TRENTON CHANNEL
Reserves ....years	40	50	25	20	20	27	40
Type of storage	3 silos	1 silo	ground	ground	ground	ground	ground
Capacity of storage ..tons	42,000	11,000	36,000	30,000	40,000	60,000	55,000
Shape of storage	silo	silo	conical	conical	conical	kidney	conical
Ventilation of storage	fan	fan	fan	fan	natural	fan	natural
Coal preparation	clean	clean	clean	raw	clean	raw	raw
Haulage distance ..miles	279	450	180	130	457	-	317
Cars per train	125	105	105	70	96	72	82
Type of cars	hopper	hopper	hopper	hopper	gondola	hopper	gondola
Capacity of cars ..tons	100	50-84	100	100	110	100	100
Minimum tons per shipment	12,500	7,000	10,500	7,000	10,000	7,500	8 200
Minimum tons per year	1,500,000		1,800,000	1 000000	1500 000	1,750,000	1,800,000
Rate of car movement..fph	4 000	2,500	3,200	2,400	3,000	3,300	3,000
Cost per ton (haulage tariff rate) ..$	1.50	3.53	1.50	1.00	1.75	-	1.66
Cost per ton-mile (haulage) ..$	.0054	.0078	.0083	.0077	.0038	-	.0052
Percent of production shipped by Unit Train	100	65	100	57	100	100	55

Source : U.S.Bureau of Mines, I.C. 8444, Unit train transportation of coal, 1970 the cost per ton-mile ranged from $0.0038 to $0.0083 (1970).

Based on Interstate Commerce Commission data, Table 15 gives more recent information (1974-1975) for unit train coal rates in the U.S.

Figure 8 illustrates the relationship between rail-mile and cost/ton-mile for unit trains in the U.S.

Estimated Coal Rates for Colombia - Unit Train

Data from Figure 8 are used to develop Table 16, which shows the estimated costs for Unit Train in Colombia. In addition, a location factor of 1.5 is applied to those data, because of ocean freight and importation costs.

TABLE 16

ESTIMATED COAL RATES UNIT TRAIN-COLOMBIA

Miles	Cost-ton	Cost/ton-mile
100	$22.14	$.045
150	14.76	.030
200	12.94	.0263
300	9.54	.0195
400	8.71	.0177
500	7.38	.0151
600	6.49	.0132

Comparison of the Results

Table 17 gives the alternatives of transportation costs at Bahia Concha, the best port site, according to Economic Associates. Those costs are then compared with the best

TABLE 15

UNIT TRAIN COAL RATES - USA

Origen	Destination	Miles	Ton/yr Thous.	Cost/t. $	Cost/t-m. $
Belle Ayr, Woy.	Pueblo, Co.	600	1670	3.36	.0056
Dana, Woy.	Sarg. Bluff, Iow.	741	1100	3.41	.0046
Colstrip, Mont.	Cohasset, Min.	834	1750	3.67	.0044
Kvekn, Mont.	St. Paul, Min.	826	400	5.62	.0068
Colstrip, Mont.	Minneapolis, Min.	809	700	5.58	.0069
Colstrip, Mont.	Columbia, Wisc.	1016	2000	5.28	.0052
Decker, Mont.	Plaines, Ill.	1250	2000	10.00	.0080
Dana, Woy.	Wakegan, Ill.	1185	2100	6.99	.0059
Kuehn, Mont.	Sommer, Ill.	-	1800	-	.0124

Source : Interstate Commerce Commission, U.S.A., 1975.

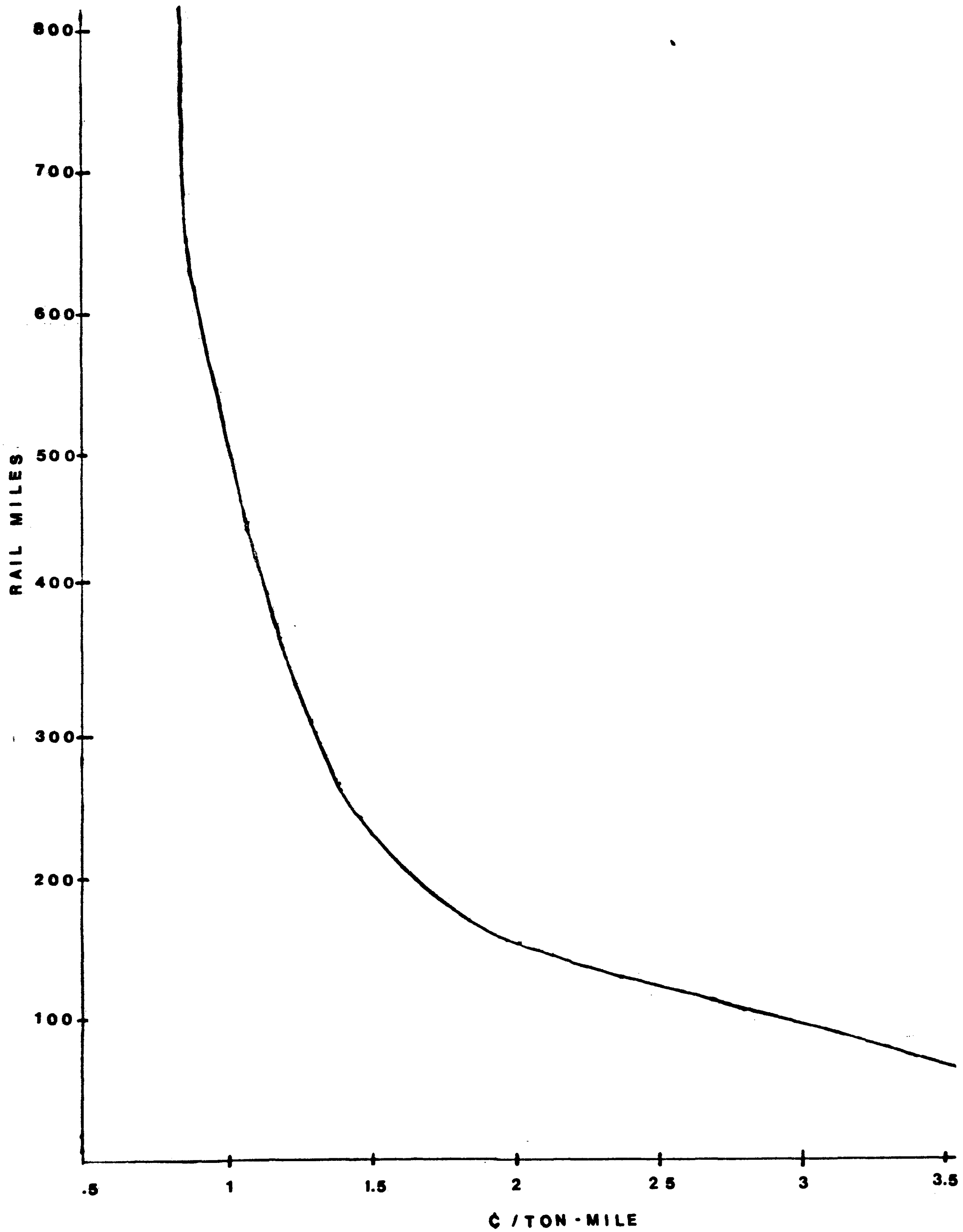

Fig. 8 U.S UNIT TRAIN RATES

transport alternative suggested in the current report.

As shown in Table 17, transport by normal train would be the cheapest by a small margin over unit train and pipeline.

TABLE 17

COST COMPARISON FOR TRANSPORTATION ALTERNATIVES AT BAHIA CONCHA PORT SITE

	Cost/ton	Cost/ton-mile
Pipeline	$8.57	$.0174
Unit Train	7.38	.0132
Normal Train*	7.08	.0144

*Cost is updated from Economic Associates.

However, coal slurry pipelines are superior to the rail transportation in most of the areas where it is possible to compare them. This does not lead to the conclusion that pipelines should replace all rail coal shipping, since pipelines are only adaptable to situations where there are large, stable volumes of coal to be delivered over fixed routes. Rail transportation will remain vital for hauling the majority of the coal tonnage.

Total F.O.B. Costs at Bahia Concha

Now, Table 18 shows the summary of the overall cost calculations.

TABLE 18

TOTAL COSTS AT BAHIA CONCHA - 1 MILLION TPY

	Train Cost/t*	Pipeline Cost/t	Unit Train Cost/t
Operating cost	$ 9.66	$ 9.00	$ 9.00
Capital charge	0.62	0.77	0.77
Transportation	7.08	8.57	7.38
Total	$17.36	$18.34	$17.15

*Cost is updated from Economic Associates Report.

It can be seen from the figures quoted in the previous table that the transport by normal train would be the cheapest overall by a small margin over the unit train.

The most profound aspect of the pipeline from an economic stand-point is its low escalation rate.

Railroads costs for unit train coal hauls are lower than pipeline costs up to about 800 miles. From there on, the pipeline offers significant savings with increasing capacity.

Price Calculation for the Alternatives

With the same procedure used in the page 31, Table 19 illustrates the price required to obtain a 15 percent rate of return for the proposed transportation alternatives, and the alternative mining method.

TABLE 19

SELLING PRICE PER TON

Mining and Pipeline	$21.95
Mining and Unit Train	$20.84

Sensitivity Analysis for Prices

It is believed that no one part of the project is likely to be subject to an error in cost estimates of more than 20 percent in either direction, and certain parts are believed to be much more accurate than that, provided the assumptions underlying the estimates are accepted. Tables 18 and 19 show the sensitivity of prices to variations in operating, capital, and transportation costs of 10 percent and 20 percent in either direction, for each transport alternative.

TABLE 20

SENSITIVITY TO VARIATION IN PIPELINE COSTS

	Operating	Capital	Transport	Price/T.
Basic	$9.00	$0.77	$8.57	$21.95
1) Variation in Operating Costs				
+10%	9.90	0.77	8.57	22.80
+20%	10.80	0.77	8.57	23.64
-10%	8.10	0.77	8.57	21.11
-20%	7.20	0.77	8.57	20.27
2) Variation in Capital Costs				
+10%	9.00	0.85	8.57	22.03
+20%	9.00	0.92	8.57	22.10
-10%	9.00	0.69	8.57	21.88
-20%	9.00	0.62	8.57	21.82
3) Variations in Transport Costs				
+10%	9.00	0.77	9.43	22.76
+20%	9.00	0.77	10.28	23.56
-10%	9.00	0.77	7.71	21.15
-20%	9.00	0.77	6.86	20.35

TABLE 21

SENSITIVITY TO VARIATION IN UNIT TRAIN COSTS

	Operating	Capital	Transport	Price/T.
Basic	$9.00	$0.77	$7.38	$20.84
1) Variations in Operating Costs				
+10%	9.90	0.77	7.38	21.68
+20%	10.80	0.77	7.38	22.53
-10%	8.10	0.77	7.38	20.00
-20%	7.20	0.77	7.38	19.15
2) Variations in Capital Costs				
+10%	9.00	0.85	7.38	20.92
+20%	9.00	0.92	7.38	20.98
-10%	9.00	0.69	7.38	20.77
-20%	9.00	0.62	7.38	20.07
3) Variation in Transport Costs				
+10%	9.00	0.85	8.12	21.53
+20%	9.00	0.85	8.86	22.23
-10%	9.00	0.85	6.64	20.15
-20%	9.00	0.85	5.90	19.45

MARKETING

The economic trends of various countries and the current problems in the world energy market, make it difficult to give a good estimate of future demand and price for coal.

While most countries will continue to expand their steel production in the long run, major questions still remain to be resolved, and some of these expansion plans may not be carried out, reducing the growth rate in the coking coal market.

In general, world steel production has increased steadily in the last 25 years, but production in the U.S. and Western Europe has not increased as rapidly as in Japan.

The international market for coking coal is likely to become increasingly regionalized because of petroleum product prices and their consequent effect on ocean transport costs. Therefore, the major Latin American steel producer, Brazil, would be the most likely market for Colombian coal.

In 1973, the Brazilian Government negotiated with the Colombian Government for the possible purchase of coking coal but the price that such coal could command in 1985 was difficult to estimate.

The Nature of Coking Coal

According to Economic Associates, the coking coal can be classified as "that which is suitable for producing coke for smelting iron ore in blast furnaces or for use in the foundry and other industries."

Not all bituminous coals become coke when they are heated to a temperature at which most of the volatile matter is driven off.

Because of the complex blending problem involved in the production of blast furnace coke, the principal international trade is in coking coal and not in blast furnace coke; the market for blast furnace coke is very small.

The reduction of iron-ore in blast furnaces to produce pig-iron creates the demand for metallurgical or blast furnace grade coking coal. As a general average, 1.6 tons of coal are needed to produce one ton of coke.

The quantity of coke required by a blast furnace to produce one ton of pig-iron is more variable; in current practice coke consumption may range from 0.45 to 0.75 tons per ton of pig-iron.

Crude steel is produced by the conversion of a mixture of pig-iron and steel scrap. Therefore, the ratio of pig-iron production tc crude steel output also varies from 0.60 to 1.0.

World Trade in Coking Coal

The major importers of coking coal are Western European countries and Japan. In 1971, out of a total of approximately 69 million tons of coking coal imported by the iron and steel industries of Western Europe and Japan, about 67 percent was accounted for by Japan.

Between 1960 and 1973, Japanese coking coal imports increased at an average rate of 15.8 percent a year. The remarkable expansion in Japan coking coal imports is directly related to the equally rapid expansion of its steel industry, which has grown from a production of 23.2 million tons in 1960 to 117.2 million tons in 1974. The major suppliers were the United States, Australia, and Canada.

In Latin America, Brazil is the most important market, and more than 70 percent of its coking coal requirements are imported, principally from the United States, Australia, and Poland. The most important factor in the Brazilian situation is the lack of substantial domestic coking coal reserves. As a result, coking coal imports are expected to rise considerably with the growth of the steel industry.

In Argentina, imports of coal by the iron and steel industry are less than half those of Brazil: in 1970-838,627 tons were imported, and in 1971-717,284 tons.

Venezuela and Mexico are also possible outlets for Colombian coal; most of their imports requirements are supplied by the United States.

The Demand for Coking Coal in the World

The demand for coking coal is based on the requirements of the iron and steel industries. Therefore, it is reasonable to correlate future demand for coking coal with estimates of future levels of steel and iron production and consumption.

According to the United Nations Economic Commission for Europe, it was predicted in 1973 that world requirements of coking coal would increase by 33 percent between 1970 and 1985, from 451 million to 600 million tons, based on the projected level of pig-iron output. Table 33 shows these estimates.

TABLE 22

COKING COAL REQUIRED FOR PIG-IRON PRODUCTION (MILL. TON)

	1970	1980	1985
World Pig-Iron production	427	684	812
Coke requirements of Iron and Steel Industry*	287	347	377
Coking coal requirements*	451	545	600

* Excludes North Korea and China

The Iron and Steel Institute has made a projection of world steel consumption with periods of five years, as shown in Table 23. Between 1970 and 1985, it is expected that world steel consumption will increase by an average of 4.5 percent a year; consumption in Japan is projected to grow

TABLE 23

WORLD STEEL CONSUMPTION - PROJECTION (MILL. TONS)

	1970	1975	1980	1985
North America				
Canada	11.1	13.5	16.5	20.0
USA	126.5	152.5	170.0	190.0
Western Europe	158.0	179.4	220.5	266.8
Eastern Europe	151.8	201.2	258.0	306.2
Latin America	18.3	25.1	35.3	48.1
Asia				
Japan	70.6	91.3	112.5	133.8
Other	36.5	59.9	89.7	130.1
Africa and Middle East	14.1	18.2	24.8	34.2
Oceania	7.5	9.7	12.2	15.3
Total	594.4	751.0	939.2	1,144.3

Source: American Iron and Steel Institute, 1974. Annual Statistics Report.

a rate of 4.5 percent, in Western Europe at 3.5 percent, and in Latin America at 6.7 percent.

Thus, in 1975 the coking coal requirement for Japan was expected to be about 58 million tons, in 1980-72 million tons and 1985-85 million tons. In Western Europe, the coking coal requirements were estimated to be 110 million tons in 1975, 120 million tons in 1980, and 145 million in 1985.

The Latin American market is the most likely outlet for Colombian coking coal, because Colombia has the geographical advantage of being one of the closest sources of supply; most important is the Brazilian market, as referred to earlier.

Forecasting Latin American Steel Production

An attempt to forecast the Latin American production of steel is done, using regression analysis to fit a linear trend to the production data by the method of least squares. The data from 1970 to 1974 are taken from the American Iron and Steel Institute, 1974, and the results are shown in Table 24. The coking coal requirement is also incorporated in this table.

International Price for Coking Coal

As mentioned earlier, it is very difficult to estimate the likely fluctuations in the international price for coking coal. In general, the prices are negotiated between producers

TABLE 24

FORECAST OF CRUDE STEEL PRODUCTION - LATIN AMERICA

	Actual (thousand tons)					Forecast (thous. tons)	
	1970	1971	1972	1973	1974	1980	1985
Argentina	2,010	2,108	2,321	2,431	2,608	3,511	4,270
Brazil	5,942	6,669	7,240	7,882	8,347	12,034	15,046
Chile	653	728	705	605	721	693	699
Colombia	341	358	397	399	358	431	468
Cuba	60	60	55	243	265	611	908
Mexico	4,278	4,212	4,810	5,247	5,655	7,872	9,766
Peru	104	158	212	392	535	1,157	1,750
Venezuela	1,021	1,019	1,242	1,172	1,150	1,450	1,655
Others	99	103	99	23	31	-	-
Total	14,508	15,415	17,081	18,394	19,670	27,759	34,517
Estimated coking coal requirements (thous. tons)						18,348	22,859

Source: For 1970-1974, American Iron and Steel Institute, 1974, Annual Statistics Report.

and consumers. Japanese coal supplies are purchased on the basis of long term contracts, principally with the United States, Australia, and Canada. Essentially, the prices are governed by coal quality.

In 1971, Japan imported coking coal under long-term contracts with prices varying from $12.85 to $18.80 per ton.

At the end of 1973, the price paid for coking coal under long term contract for Hampton Roads--the main exporting port of the U.S.--ranged from $17.50 to $23.50 per ton f.o.b.

Table 25 shows the production of U.S. bituminous and lignite and prices fo coking coal in the last years.

TABLE 25

U.S. BITUMINOUS COAL AND LIGNITE

	1971	1972	1973	1974*
Production, thou. short tons	$ 552,192	$ 595,386	$ 591,738	$ 601,000
Value, thous.	3,904,562	4,561,983	5,049,612	9,015,000
Price, average per net ton: Cost of coking coal at merchant coke ovens	$15.26	$17.67	$19.77	$36.50

*Preliminary

Source: Bureau of the Census, U.S. Department of Commerce, 1975.

The recent disturbances in the energy market, the increase in petroleum prices, and its consequent effect on ocean freight, are all expected fo raise the international prices for coking coal. The f.o.b. price may be expected to increase substantially in the next few years. But, the same short term movements, coupled with the general rise in prices, will also lead to increases in the cost of mining in the developed countries. Thus, in such a highly mobile situation, it is difficult to predict prices for coking coal.

In the view of the preceding arguments it is felt that if Colombia could produce for an f.o.b. price range of $19.45 to $23.64 per ton, given by the Sensitivity Analysis, it would be competitive internationally and there should be a ready market for its exports.

SUMMARY AND CONCLUSIONS

The objectives of this study were as follows:

1) To analyze the Checua-Lenguazaque coalfield report, as compiled by the Economic Associates Limited, under actual (1974) and updated circumstances. In both cases, a target rate of return of 15 percent was used. In summary the results were:

a) Economic Associates Data (1974 costs) - Author's analysis

Discounted Cash Flow Rate of Return (DCFROR): 5.82%

Net Presnet Value -$15,709,074

Payback period: 21 years

A pre-determined price of $20.50/ton of coal was used for this analysis.

Using the same data, the Economic Associates estimated a rate of return of 6.9 percent. This figure is higher than the 5.82 percent rate computed by the author, because it was computed on a before-tax basis (ROR method) rather than after-tax basis (DCFROR method). The author feels that the before-tax basis would be the proper approach in order to evaluate the real economic potential of investment.

With a price of $31.34/ton, a 15 percent rate of return is achieved.

b) <u>Economic Associates Data - Author's Analysis (1975 costs)</u>

Discounted Cash Flow Rate of Return (DCFROR): 7.67%

Net Present Value -$28,459,344

Payback period: 14 years

A price of $26.65/ton of coal was used

With a price of $39.48/ton of coal, a 15 percent rate of return is achieved.

It is clear that the proposed plan by Economic Associates to develop the Checua-Lenguazaque coalfield is not economic under the actual or updated conditions. New investigations are of great importance to determine the effects of changed economic conditions or alternative mining systems.

2) An alternative mining method was proposed to exploit the coalfield. Capital and operating costs and prices were calculated at different rates of production, with the following results:

<u>At 1.0 million tpy of coal</u>

Capital estimate $20,962,800

Production cost $9.01/ton

The cash flow model suggest a free on board (f.o.b.) price at the mine of $13.22/ton, for a 15 percent rate of return.

<u>At 2.043 million tpy of coal</u>

Capital estimate $32,460,630

Production cost $5.74/ton

A free on board (f.o.b.) price at the mine of $9.51/ton is required for a 15 percent rate of return.

<u>At 3.2 million tpy of coal</u>

Capital estimate $46,453,130

Production cost $5.72/ton

A free on board (f.o.b.) price at the mine of $8.86/ton is suggested by the Cash Flow, for a 15 percent rate of return.

The proposed mining method should be applied only if the Colombian Government guarantees a higher degree of mechanization and sufficient skilled labor among the mining workmen.

The selection of foreign firms for negotiation of joint ventures is an important factor for success in the mineral industry. They must have a broad experience from mining activities through preparation to marketing.

3) Two alternative transport systems were proposed to carry coal from the mine site to the coast for export--pipeline and unit train.

Estimated cost/ton-mile for each of the systems:

Pipeline $0.0174

Unit train $0.0132

The Economic Associates report estimated a cost per ton of $17.32 (or $0.6144/ton-mile, updated) for conventional train, which was their most economic transport alternative.

Due to its capital intensive character, a pipeline is much less subject to escalating costs than a railroad. It will probably assume a greater role in the future than other transportation systems in Colombia.

4) A market analysis for coal was presented, considering mainly the requirement of coking coal in the steel industry.

If Colombia could produce coking coal for a price between \$19.45 to \$23.64 f.o.b. port, it would be competitive internationally and it could find a ready market for its coking coal exports.

A possible agreement between Colombia and Brazil indicates that a guaranteed market would be available close by.

A major upward revision in coal prices is a requisite to profitable production, however.

The lack of geological information is the principal constraint for development of the Checua-Lenguazaque coalfield; therefore, further explorations are recommended.

The labor force will have to be trained to perform the task in a mechanized mine. Also the high level of wages will increase the standard of living and this will be reflected in a general growth of the economy of the region.

Finally, the present legal and financial structure of Colombian coal mining is not adequate for development of this important potential resource. Therefore, in order to gain maximum benefits from existing coal deposits, the most advisable approach by the Colombian government is to undertake as soon as possible, a series of legislative and fiscal measures to encourage personnel training and exploration research. Such an approach would greatly assist development of Colombian coal resources.

APPENDIX I

SCHEMATIC MODEL OF CASH FLOW COMPUTATIONS *

		Conventional symbols
	Sales	a
Less	Operating cost	b
Less	Deprec. & Amortiz.	c
Less	Depletion (10% sales)	d
Equal	Income Before Tax	e
Less	Income Tax (40%)	f
Equal	Net Profit	g
Plus	Deprec. & Amortiz.	c
Plus	Depletion	d
Equal	Cash Flow	h

The next set of equations can be established to determine the total annual sales.

$$.6(a-b-c-d) + (c+d) = h$$

$$.1\ (a) = d$$

$$.6\ (a-b-c -.1a)+(c +.1a) = h$$

$$1\ /.64\ [h +.6(b) -.4(c)] = a$$

* Net operating cash flow
Investments, capitalized or expensed, are substracted from the net operating cash flow.

APPENDIX II

SUMMARY OF DISCOUNTED CASH FLOW - 1.0 MILLION TPY *

Year	Capital investment (thous.$)	Cash flow (thous.$)	Present worth factor - 15%	Present worth Capital invest. 15% (thous. $)	Present worth cash flow-15% (thous.$)
0	$ 20,962.80	$-20,962.80	1.0000	$ 20,962.80	$ -20,962.80
1		3,781.42	.8696		3,288.32
2		3,781.42	.7561		2,859.13
3		3,781.42	.6575		2,486.28
4		3,781.42	.5718		2,162.22
5	446.00	3,335.42	.4972	221.75	1,658.37
6		3,781.42	.4323		1,634.71
7		3,781.42	.3759		1,421.44
8		3,781.42	.3269		1,236.15
9		3,781.42	.2843		1,075.06
10	12,358.50	-8,577.08	.2472	3,055.00	-2,120.25
11		3,781.42	.2149		812.63
12		3,781.42	.1869		706.75
13		3,781.42	.1625		614.48
14		3,781.42	.1413		534.31
15	446.00	3,335.42	.1229	54.81	409.92
16		3,781.42	.1069		404.23
17		3,781.42	.0929		351.29
18		3,781.42	.0808		305.54
19		3,781.42	.0703		265.83
20	-10,265.80	14,047.20	.0611	-626.21	858.28
				$ 23,668.15	$ 1.89

* Modified from Bureau of Mines, I.C. 8682, 1975

APPENDIX II Continued

SUMMARY OF DISCOUNTED CASH FLOW- 2.043 TPY*

Year	Capital investment (thous.$)	Cash flow (thous.$)	Present worth factor- 15%	Present worth Capital invest. -15%(thous. $)	Present worth cash flow -15% (thous.$)
-1	$ 12,984.25	$-12,984.25	1.1500	$ 14,931.89	$ -14,931.89
0	19,475.38	-19,475.38	1.0000	19,475.38	-19,475.38
1		6,317.63	.8696		5,493.81
2		6,317.63	.7561		4,776.76
3		6,317.63	.6575		4,153.84
4		6,317.63	.5718		3,612.42
5	456.00	5,861.63	.4972	226.72	2,914.40
6		6,317.63	.4323		2,731.11
7		6,317.63	.3759		2,374.80
8		6,317.63	.3269		2,065.23
9		6,317.63	.2843		1,796.10
10	20,020.50	-13,702.87	.2472	4,949.07	-3,387.35
11		6,317.63	.2149		1,357.66
12		6,317.63	.1869		1,180.77
13		6,317.63	.1625		1,026.61
14		6,317,63	.1413		892.68
15	456.00	5,861.63	.1229	56.04	720.39
16		6,317.63	.1069		675.35
17		6,317.63	.0929		586.91
18		6,317.63	.0808		510.46
19		6,317.63	.0703		444.13
20	-1,607.94	7,925.57	.0611	-98.08	484.25
				$ 39,542.02	$ 3.06

* Modified from Bureau of Mines, I.C. 8682, 1975

APPENDIX II Continued

SUMMARY OF DISCOUNTED CASH FLOW - 3.2 TPY *

Year	Capital investment (thous.$)	Cash flow (thous.$)	Present worth factor - 15%	Present worth capital invest. -15% (thous.$)	Present worth cash flow-15% (thous.$)
-1	$ 18,591.25	$-18,591.25	1.1500	$ 21,379.94	$-21,379.94
0	27,871.88	-27,871.88	1.0000	27,871.88	-27,871.88
1		8,806.47	.8696		7,658.11
2		8,806.47	.7561		6,658.57
3		8,806.47	.6575		5,790.25
4		8,806.47	.5718		5,035.54
5	659.25	8,147.22	.4972	327.78	4,050.80
6		8,806.47	.4323		3,807.04
7		8,806.47	.3759		3,310.35
8		8,806.47	.3269		2,878.84
9		8,806.47	.2843		2,503.70
10	28,688.25	-19,881.78	.2472	7,091.74	-4,914.78
11		8,806.47	.2149		1,892.51
12		8,806.47	.1869		1,645.93
13		8,806.47	.1625		1,431.05
14		8,806.47	.1413		1,244.35
15	659.25	8,147.22	.1229	81.02	1,001.29
16		8,806.47	.1069		941.41
17		8,806.47	.0929		818.12
18		8,806.47	.0808		711.56
19		8,806.47	.0703		619.10
20	-26,720.96	35,527.43	.0611	-1,632.65	2,170.73
				$ 55,119.71	$ 2.65

* Modified from Bureau of Mines, I.C. 8682, 1975

APPENDIX III

COAL AND COKE PRODUCTION OF COLOMBIA
(thousand short tons)

Year	Coal*	Coke
1967	3417	480
1968	3417	480
1969	3656	513
1970	3660	549
1971	2856	390
1972	3600	510

* Includes Bituminous Coal and Anthracite

Source: U.S. Bureau of Mines, Mineral Yearbook, 1973

Boletin Mensual de Estadistica, No. 241,
Departamento Nacional de Estadistica (DANE)
1971.

APPENDIX IV

COLOMBIA- COAL AND COKE EXPORTS *

Year	Quantity (Short tons)	Col $ 000	US $ 000
1968	2,808	749.7	46.9
1969	3,676	1,178.8	67.8
1970	8,816	3,191.7	174.1
1971	12,100	6,704.0	330.9
1972	36,251	16,308.0	742.9

* Coal, coke and briquettes.

Source : Anuarios de Comercio Exterior, DANE, 1973

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