THE REPUBLIC OF THE PHILIPPINES

RECONNAISSANCE STUDY

ON

COAL RESERVES AND COAL FIRED THERMAL POWER PLANT DEVELOPMENT

IN

THE CEBU ISLAND

SEPTEMBER 1974

JAPAN

INTERNATIONAL

COOPERATION AGENCY

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PREFACE

The Government of Japan, in response to the request of the Government of the Republic of the Philippines, decided to make an investigation of coal reserve and coal fired thermal power plant development and entrusted the execution of it to the Overseas Technical Cooperation Agnecy (which was integrated into the Japan International Cooperation Agency on August 1st, 1974).

The Agency, being fully cognigant of the importance of the said survey in the light of the energy resources diversification and its effective utilization of the domestic resources in the country, organized a survey team headed by Mr. Shogoro Nagano (Regional Manager, Electric Power Development Co., Ltd) comprising six(6) members and sent it to the Republic of the Philippines on March 5th, 1974 to carry out the geological survey of the coal-fields spreading in Cebu Island as well as the preliminary survey on the power plant site.

After returning to Japan, on March 27th 1974, the team made an estimation of the amount of coal deposits and studied the feasibility of coal fired thermal power plant. Hereby presented is a report based upon the outcome of the survey performed. I believe that the report will serve to the benefits of the Republic of the Philippines.

Finally, I take this opportunity to express my heartfelt gratitude to the Government of the Republic of the Philippines and other authorities concerned for their kind cooperation and support extended to the survey team.

September 1974

Shinsaku Hogen
President
Japan International
Cooperation Agency

ELECTRIC POWER DEVELOPMENT COMPANY, LTD.
8-2, MARUNOUCHI, 1-CHOME, CHIYODA-KU, TOKYO, 100 JAPAN.

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Letter of Transmittal

September 1974

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency

Dear Sir:

Submitted herewith is the Reconnaissance Study Report on possibility of development of Coal Reserves and Coal Fired Thermal Power Plant in the Cebu Island, Republic of the Philippines, which the Survey Mission has worked out under cooperation of Electric Power Development Co., Ltd.; on the basis of its field survey conducted in March 1974 in accordance with the request of the Philippines Government and with the scope of assignments delegated by Overseas Technical Cooperation Agency (The Agency was integrated into the Japan International Cooperation Agency on August 1st, 1974).

The Survey Mission, organized by Overseas Technical Cooperation Agency and consisting of five experts from Electric Power Development Co., Ltd. (EPDC) and one expert from Ministry of International Trade and Industry, the Japanese Government, conducted field surveys at the coal fields and power plant sites in the Cebu Island for a period of 23 days from 5th to 27th on March, 1974.

In the Philippines and during the course of the field, the Survey Mission prepared a brief interim report on the coal reserves of the island, the economics of development of a coal fired thermal power plant and other several points in the utilization of coal in power generation. And the Mission submitted it to the Government of the Philippines before leaving the Philippines at the end of March 1974.

After returning to Japan, the Mission conducted studies to detail to expand and refine the said interim report to extensively to cover essential items including total coal reserves of the island, recoverable coal reserves, mining costs, quality of coal, long range power development planning, preliminary design for power plant, economic justifiability of developing a coal fired thermal power plant, necessity of importing coal from other places than Cebu and so forth. In relation to such items several factors were pointed out and made clear as regarding further studies before projected development is materialized.

The results of such detail studies were all incorporated into a draft report and explained to the organizations and responsible officials of the Philippines in late July 1974 and basically accepted by them. Thus, the Survey Mission is submitting its final report to you complete in all respects for forwarding to the Philippines Government.

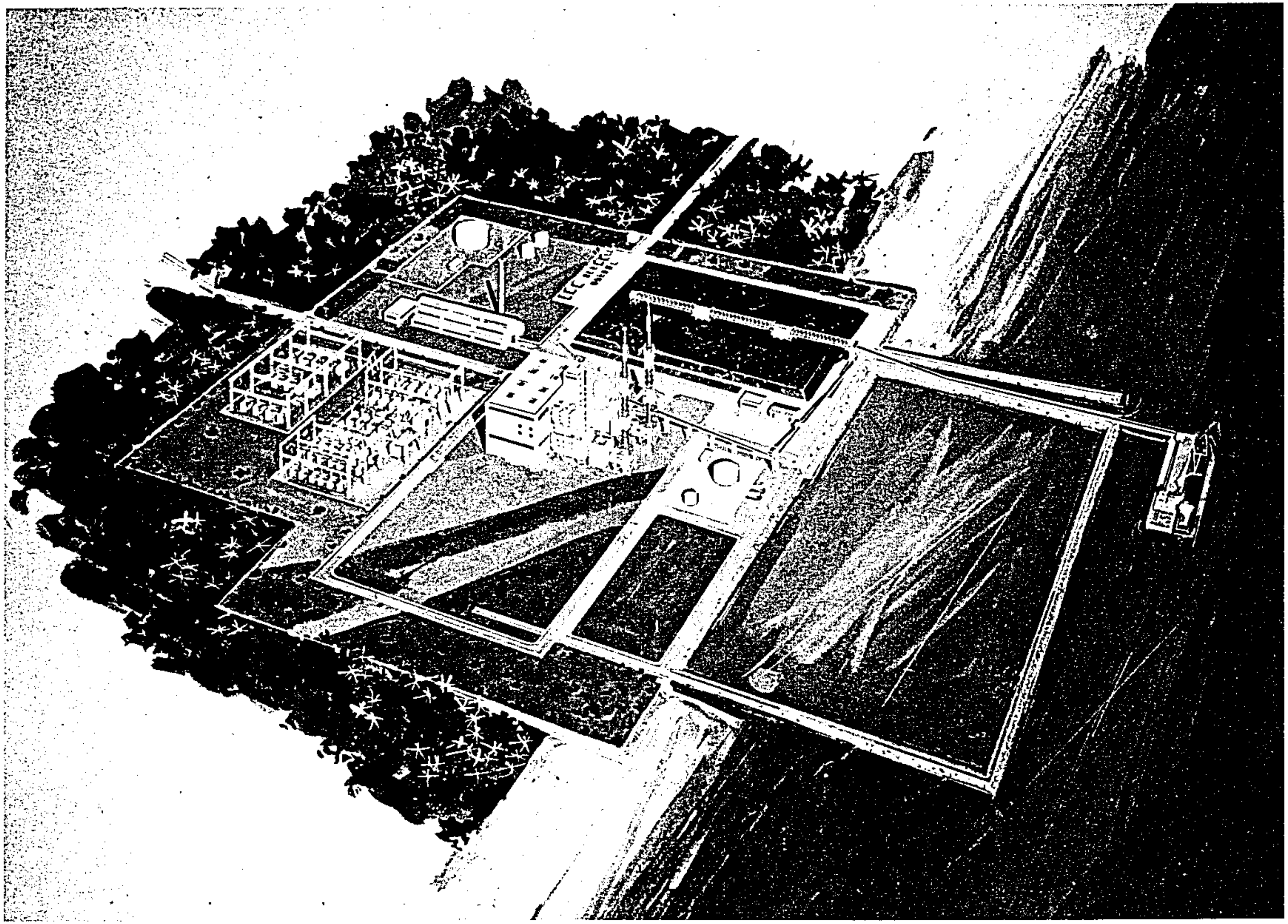
Since the advent of oil crisis in 1973, the question of effective utilization of domestic energy resources and diversification in energy resources has become the subject of keen interests common to almost all countries over the world, and the Philippines could not stand as an exception for such question. So, it seems that the development in Cebu of thermal power units in coal fired type will be very effective not only in meeting the increasing power demand in the island but also from view point of national interest of the Philippines in the prevalent energy situation. And we hope the present report will be of some use and help the Philippines Government to tuckle with development of energy supply sources in the Cebu Island in harmony with its social and economic framework.

In closing, I would like to request to your particular attention that the Survey Mission owes very much to the concerned officials of the Philippines Government including those of the National Power Corporation, the Bureau of Mines and the Presidental Economic Staff as well as member of the Japanese Embassy in Manila for their willing and unsparing cooperation to the Survey Mission during its assignment in the Philippines. The members of the Survey Mission shall be very pleased if you recognized it and deliver our heartful gratitude to them.

I would like to add that all members of the Survey Mission appreciate the assistance and help which the Survey Mission received from the responsible Ministries of Japan and your Japan International Cooperation Agency.

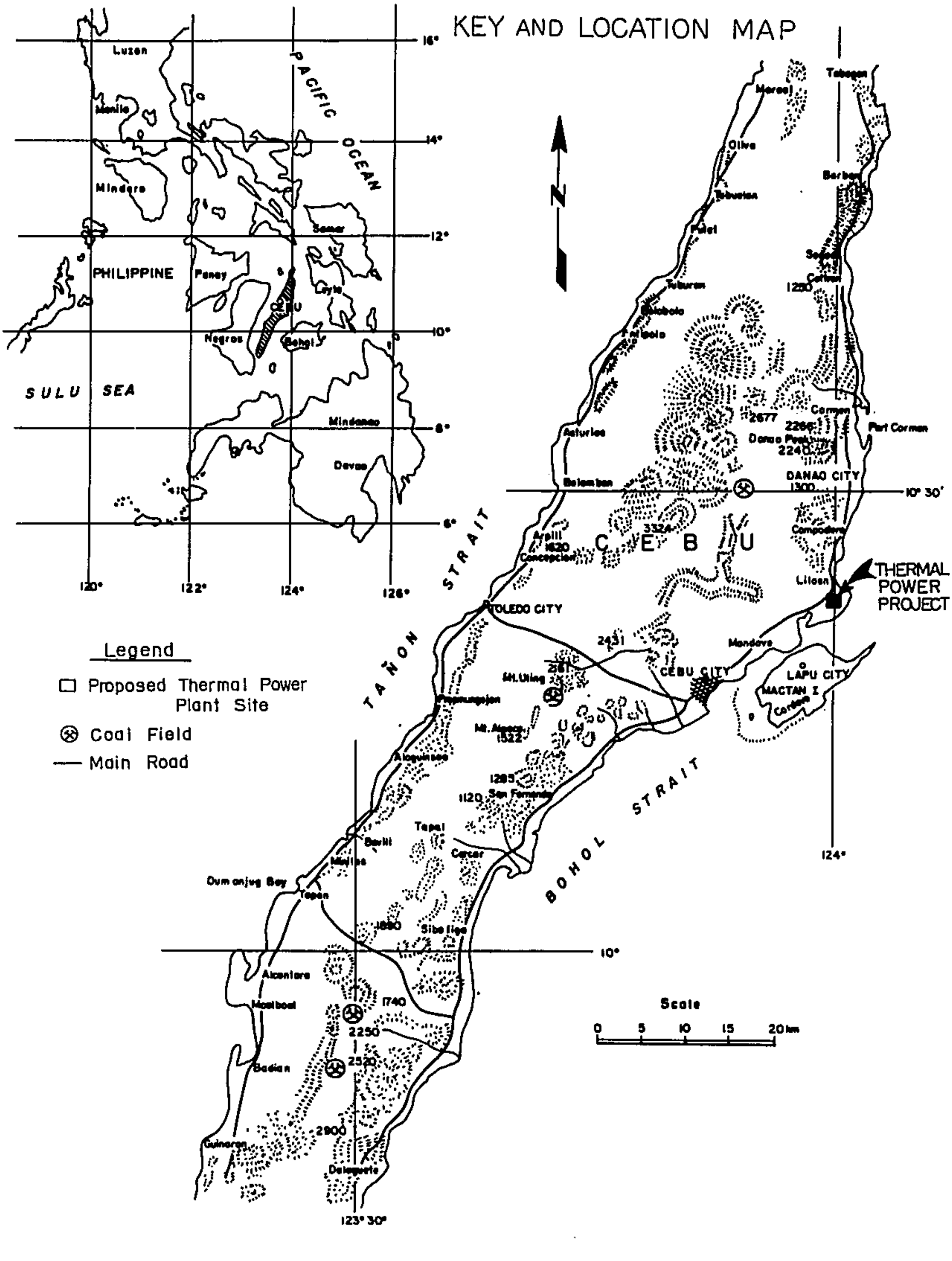
Yours respectfully,

Shogoro Nagao
Leader
Survey Mission for Coal Reserves
and Coal Fired Thermal Power
Plant Development in the Cebu Island



Artist's Imaginary View of Cebu Coal Fired Thermal Power Plant

KEY AND LOCATION MAP



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CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1-1. Objective of Studies

In response to the request of the Government of the Philippines, the present Survey Mission was dispatched to the Philippines by the Government of Japan to examine and study feasibility of developing a coal fired thermal power plant in the Cebu Island of the Visayas region.

The objective of the Mission covered the field investigation on the geological and topographical conditions of coal areas and power plant siting as well as studies, based on such investigations, of total coal reserves, recoverable coal amount, preliminary design of a coal fired thermal power plant and economic evaluation of the power plant. Included also in the objective was elucidation of work items which would require further examination before implementation of development of coal fired thermal power plant in the Cebu Island.

1-2. Background

(1) Along with several programs to consolidate the framework of social and economic development of the Philippines, the Government of the Philippines has been projecting to promote the program of intensifying capability of supplying electric power in the Visayas region. In the light of such projection and in response to the request of the Philippine Government, a Japanese Mission earlier undertook studies on the electric development of the Visayas region including the Cebu Island, and prepared and submitted to the Philippine Government a report for long range power development on the Visayas region.

(2) According to the report, the necessity was then recognized to provide two units of uni-oil fired thermal power facilities, 50 MW each, in succession to five units, 10 MW each, of generating facilities, which were proposed for earlier construction, in order to meet rapidly increasing demand for electricity in Cebu.

(3) On the other hand, the Philippine Government has been seeking the possibility of effective utilization of the domestic resources,

diversification of energy resources and promotion of regional development. Especially, the worldwide boast in the oil price triggered by the oil crisis of late 1973, the Philippines has come to note still more strongly the possible advantage of utilization of coal in power generation.

(4) On such ground, the Philippine Government took it of urgent necessity to make an investigation on coal reserves of the Cebu Island, and study on economical justifiability of using the coal in power generation, in order to sound out the possibility of design change for the proposed two units of 50 MW from uni-oil fired type to coal fired type. The Philippine Government accordingly requested the Japanese Government to provide technical cooperation in connection with such investigation and study.

(5) In response to the request, the Japanese Government organized and dispatched to the Philippines in March, 1974 the present Survey Mission consisting of six experts for field investigations at coal areas and power plant sites in the Cebu Island. The results of the field investigations and studies conducted in the Philippines were compiled in an interim report and submitted by the mission to the Government of the Philippines before the mission left the Philippines for home.

(6) After return to Japan, the Survey Mission made further studies to detail and worked out the final report on the basis of this detail studies and discussion with authorities concerned of the Philippines in July, 1974, which the mission had over its draft report.

1-3. Scope of Studies

The scope of studies which the mission conducted specifically includes the following items:

(1) Investigation of Geology

Geological structures in general of the Cebu Island and distribution of coal layers were elucidated by field survey and compilation of available geological data.

(2) Estimate of Total Reserves and Workable Reserves of Coal

Total amount of coal reserves and workable coal amount were estimated on the basis of the geological analysis made under Item (1) above and records of yield at present and in the past.

(3) Estimate of Mining Cost and Coal Price

From the geological structures and detail topographical conditions of coal districts, a development of coal mine was planned. And mining cost and coal price at the proposed power plant site were estimated based on investiments for the development of coal mine, the condition of worker, transportation cost and so on.

(4) Analysis of Quality of Coal

Quality of available coal was analysed by laboratory tests on coal pieces taken in the field survey.

(5) Formulation of Long Range Power Development Plan

Power demand was forecasted on long term basis by analysing statistical data on the electrical power systems, population and other economic indicators. Such a long range power development plan as will ensure the best economy on the whole power system was worked out with the long range power demand above and possible technical limitation on the various power plants eligible for development taken into account.

(6) Preliminary Design of the Coal Fired Thermal Power Plant

Preliminary design including construction schedule and estimate of construction costs was performed for two units of 50 MW coal fired generating facilities which were proposed for construction by 1979. The items of studies which should further be undertaken before the start of construction were also made clear.

(7) Economic Study on the Dual Fired Thermal Power Plant

Conditions to make a coal fired thermal power plant more advantageous economically than a uni-oil fired one were sought and established in terms of inter-relation between coal requirement and coal price. And economics of a dual fired thermal power plant was studied not only for the case of exclusive use of workable coal reserves in the Cebu Island, but also for the case of import of coal from outside of the Island.

(8) Recommendation on the Future Surveys and Studies

Several factors like necessity of coal field survey in the other island than Cebu and/or import of coal, which should be settled or studied before and implementation of the power plant development, were made clear and recommended.

1-4. Survey Mission

The mission consisted of the following six members from the Ministry of International Trade and Industry (MITI) and Electric Power Development Co., Ltd. (EPDC).

Chief :	SHOGORO NAGAO Foreign Activities Dept. EPDC	General
Member :	SHIGEICHI MOGI MITI, Japanese Government	Economist
	SHOHACHI UCHIDA Foreign Activities Dept. EPDC	Mining Engineer
	HISASHI YAYOSHI Foreign Activities Dept. EPDC	Geologist
	TATSURO HONDA Thermal Power Dept. EPDC	Electrical Engineer
	KAZUHIKO FURUKAWA Foreign Activities Dept. EPDC	Geologist

1-5. Period of Survey

The survey was conducted for a period of 23 days from 5th to 27th on March, 1974.

CHAPTER 2

SUMMARY

CHAPTER 2 SUMMARY

2-1 Coal Reserves

2-1-1 Coal Reserves and Estimation of Workable Reserves

According to several studies so far made by Mr. F. D. Spencer and other experts (1957) the total coal reserves of the entire Philippines is estimated to be 67 million metric tons. Of this amount, the coal reserves of measured and indicated areas with seam thickness of 75 cm or over which empirically are workable would be approximately 30 million metric tons. The recoverable reserves calculated in consideration of geological and workable factors amount to approximately 12 million metric tons.

Similarly, the total reserves of Cebu Island as a whole are approximately 23 million metric tons, of which the coal reserves of seam thickness of 75 cm or more in measured and indicated areas amount to 11 million metric tons, and likewise, the recoverable coal is 4 million metric tons.

However, it has been revealed by the present reconnaissance survey that the geological conditions of Cebu Island are such that the persistency of coal seams are poor, there are large numbers of folds and faults, the strata are generally steeply dipped and geological structure is complicated.

In Japan, the geologic age of successful coal fields mainly belongs to Paleogene (famous coal fields of Japan such as Miike, Sorachi, Yubari mines belong to the age), and only several fields of Neogen, which have geological similarity to the coal fields in question of the Philippines, have actually been explorated in northern Hokkaido such as Tempoku, Teshio and other few mines. These mines of Neogen age are of highly complicated geological structures characterized with small sedimentary basin, extreme variance in the thickness of coal seam, many folds and faults, and other drawbacks, and not suitable for modern mining in large scale. Such drawbacks were backgrounds of only few instances in Japan of exploration of Neogene fields though surveys and studies were so often tackled with.

In view of such experience with Japanese coal fields, it is though that development of a modernized mining in large scale cannot be anticipated. From the standpoint of workability based on geological data for the Argao-Dalaguete region, the total amount of workable reserves which can be developed by using systematic mining method instead of practiced Camote Mining method may be approximately 500,000 metric tons. This is only about 30% of the total measured and indicated recoverable coal reserves amounting to 1,730,000 metric tons of the Argao-Dalaguete region. If this ratio were to be applied to all of Cebu Island, the amount of workable coal reserves which could be developed systematically would be approximately 1.2 million metric tons. However, this estimated amount should be ascertained and confirmed through detailed surveys by means of surface exploration and drilling.

2-1-2 Possibility of Detailed Survey in Future

The results of the present reconnaissance survey suggest that some difficulties will likely be encountered in case a detailed survey is carried out on Cebu Island. That is, since the thickness of soil overburden is generally more than 3 m and there are limestone rolling boulders and talus from nearby mountains, it is thought that application of manual trenching would be difficult, and soil overburden should be removed by bulldozers. And further, it is presumable that efficiency of drilling will be low due to enforced oblique drilling and obstruction of limestone boulders.

As regards the feasibility of future exploration of the various areas, the present studies have come to a conclusion as follows;

On the Danao-Compostela area in the northern part detailed geological and topographical maps, old mine maps are not available and insufficient informations are available on the present situation of coal production. As the results of our reconnaissance survey, it is considered that the geological structure of the area is very complicated. In this connection, it will be necessary to go through the stages of a preliminary survey and then a detailed survey, which it is considered will require more than 2 years and considerable amount of expense, and involve many difficult factors to overcome. The difficulty on the surveying in this area can be surmised from the fact that in spite of the survey made by the team of Melandres and eleven others as one of the Coal Special Project, their report which was undergoing preparation in 1957 has never been published. In short, it does not seem well possible to carry out advanced studies of this area in the present stage.

In the central part of the island, there is only one workable seam in the Uling area, while in the Toledo area there are only one of two lenticular beds with about 1 m thick and thus both of these areas are scarcely worth exploring.

As regards the Argao-Dalaguete area in the southern part, geological data do exist (H. Barnes, 1956) and it will be possible to prepare a work plan for detailed survey. In this area, the districts of Bayabas-Balaas and Gransina-Mantalongon seem to have some potentiality for development. The field operations necessary for detailed study of these districts would require approximately 3 months for each one of the areas and it is estimated that the costs of field works including among others a minimum amount of exploratory drilling will be approximately 820, 000 Pesos for Bayabas-Balaas and 440, 000 Pesos for Gransia-Mantalongon. However, due to the complexity of the geologic structure, it may be assumed that a necessity will arise for surveys to be extended through additional exploratory drilling.

2-2 Coal Mine Development Plan and Cost Estimation

2-2-1 Preconditions

Since it is considered, as explained earlier in 2-1 of this report, that any single area of Cebu Island could never offer large coal deposits which can be systematically mined, it is difficult to estimate an average mining cost for Cebu Island as a whole. To get a reliable estimate of the mining costs, it is necessary to conduct detailed surveys of all district and make analyses of geological conditions and establish a mining plan. Until after such studies will have been completed the mining costs can not be estimated of the individual districts in question. In the present studies, for the purpose of the rule of thumb, the distribution of coal seams was surmised of Argao-Dalaguete area, of which the geologic structure is relatively well interpreted. Upon such estimated distribution of coal seams, the mining plan, equipment and mining costs of the field of this area were developed and calculated. Therefore, the development costs and other relevant costs described below cannot apply to all of the districts.

It was assumed that recoverable coal measures would be approximately 156,000 metric tons per mine section, and further that to develop this area two years would be taken. The area would be excavated by inclined shaft system, and the scale of coal production would be 200 metric tons per day and 60,000 metric tons per year. The number of personnel required for the mining was estimated to be 200 miners and a total of 240 men if indirectly engaged personnel are counted. The total productivity was taken to be 0.83 O.M.S. (output per man per shift).

2-2-2 Estimated Coal Price

The total estimated capital requirements will be 5.5 million dollars. The breakdown consists of 3.7 million dollars for the costs of mining equipment and 1.8 million dollars for indirect capital investment.

The estimated production cost is $36.50/MT including operational cost, housing allowances, administrative expenses, depreciation and interest.

If transportation cost from mine to power plant site, which would be $4.50/MT, is taken into account the cost of coal at the power plant site will be $41/MT. However, the cost estimate should naturally be reviewed and revised after detailed survey if the survey should find out the mining conditions disadvantageous than now anticipated. In the case of worse mining conditions, the cost of coal would naturally increase due to possible hike of equipment cost and lowering of productivity.

2-3 Coal Fired Thermal Power Plant

2-3-1 Power Plant Development Plan

This plan is a long-term power plant development scheme for satisfying the electric power demand until 1988 which is growing at a rate of 13.5% per year.

The power demand was estimated by the micro method compiling and analyzing the power demand on the electric power system of Cebu Island by use and by district, and the macro method analyzing the correlation between economic indexes and power demands of the various countries in the world, Republic of the Philippines and Cebu Island, respectively. This value is taken as being most probable. With consideration of future economic fluctuations, it was considered that it would be more plausible to assume demand growth in a band of a certain width rather than on a specific path. That is, it was assumed that demand will grow in a range of an upper limit of annual growth rate of 14.9% and a lower limit of 11.4%.

Due to this increase in power demand, the shortage in power supply capacity will be 11 MW by 1978, 92 MW by 1983, and 253 MW by 1988.

In order to cope with this shortage in supply capacity, three alternative long-term power development plans involving thermal power plants of 50 MW and 75 MW were considered for the choice of a plan with the optimum scale and timing for development. Hydroelectric power plants on Cebu Island are at the stage of desk studies with inadequate data, and could not be considered for the present development plans. As for determination of unit capacity of the thermal power plant, the entire power system capacity, scale merit, problematic points in manufacture of equipment, etc., were considered.

The optimum plan was selected by making economic comparisons of these three alternative development plans for their serviceable life. As a result, it was considered necessary that in the case of development of a thermal power plant on 50 MW unit basis the first 50 MW unit should be installed by 1979 and the second 50 MW unit in 1983, while in the case of 75 MW unit basis, the first 75 MW unit in 1985 and the second 75 MW unit in 1988 (see Fig. 4).

2-3-2 Economics of Dual Fired Thermal Power Plant

Since the advent of the oil crisis of 1973, utilization of domestic energy resources and diversification of energy resources have been reconsidered and the economic feasibility of a coal fired thermal power plant has been brought into focus. On the one hand, the construction schedule of a thermal power plant requires at least 4 years including preparation of specifications. Therefore, in order to start operation at the end of 1978, it will be necessary to make the definite plans at as early date as possible including selection of the kind of fuel. In view of this restraint on time-table and requirement on power plant planning, the possibility of development of a coal fired thermal power plant was examined particularly in regard to economics, as well as studies for the survey of the coal resources on Cebu Island.

Compared with a uni-oil fired thermal power plant which would be considered as an alternative supply capacity to a dual fired one, the construction cost for the dual fired plant would be approximately 20% higher. Therefore, in order for a dual fired plant to be more economical than the oil fired plant, a sufficient amount of coal must be secured at a price lower than petroleum to off-set this difference in construction cost. In this case, the smaller is the available quantity of coal, the lower should be the price of coal, to guarantee the economy of a dual fired plant. In other words, the lower is the dual firing ratio of a dual fired thermal power plant, or the shorter is the number of years of coal use, the price of coal used should be the cheaper.

The economic boundary of coal price which guarantees the economy of a dual fired plant in relation to the amount of used coal is graphically shown in Fig. 5. The construction cost of a dual fired thermal power plant, reflecting the recent worldwide inflationary trend, is 63.0 million dollars ($\$47.2 \times 10^6$ in foreign currency requirement and ₱104.3×10^6 in domestic currency requirement) which is 10.0 million dollars higher than a uni-oil fired thermal power plant. Even if the construction cost should rise due to some unforeseen reason, no significant change would be caused on the relation between used amount and price of coal (see Fig. 10-1).

The mineable and recoverable coal reserves of Cebu Island, as described in 2-1, are estimated to be not more than 1.2 million metric tons. This amount is only 14% of the total amount required for the operation of a dual fired thermal power plant for the serviceable life of 33 years.

The amount is also less than the total coal requirement to operate a dual fired plant at a dual firing ratio of 50% over a serviceable life of 20 years. To make the situation worse, while the coal price should be cheaper than \$6/MT, in case availability of coal is limited to 1.2 million tons, as described in 2-2, it is estimated that the actual production cost will be approximately \$41/MT. Therefore, in case a dual fired plant is to be operated on the coal from only with Cebu Island, it would be extremely uneconomical compared with a uni-oil fired thermal power plant. Even if the serviceable life of the thermal power plant would be taken as 20 years, the relation between the amount and price of coal shown in Fig. 5 will not sustain any significant change as seen in Table 10-1.

In effect, the amount of coal which could be produced on Cebu Island is extremely small for a thermal power plant of 50 MW. Consequently, it will be necessary to import coal from either domestic areas such as Mindanao and other islands or abroad.

For such case of import, if the oil price of \$90/kl and dual firing ratio of 100%, which means a total requirement of 8.7×10^6 MT over the serviceable life with annual consumption of 266×10^3 MT, be assumed and further if the coal price at the power plant site is \$50/MT or under, then a coal-fired thermal power plant will be economical. Further, in the case of coal price at \$40/MT, the merit of a dual fired plant over a uni-oil fired plant would accrue in an amount equivalent to 10.2 million dollars in term of total present value, even if coal is obtainable only in the amount just sufficient to feed a dual field plant for one half of the serviceable life.

If an annual amount of 80,000 metric tons of coal (corresponding to a dual firing ratio of 30%) is obtainable throughout the serviceable life, a dual fired plant could still roughly break even on the basis of comparison with a uni-oil fired plant.

As considered in the above paragraphs, if there is a good outlook for securing coal in the amounts and at the prices indicated in Fig. 5, a dual fired thermal power plant should be constructed instead of a uni-oil fired plant. The economic merit of a dual fired plant, which varies depending on the amount of used coal and its price, will range as shown on Fig. 10-2.

2-3-3 Preliminary Design of Thermal Power Plant

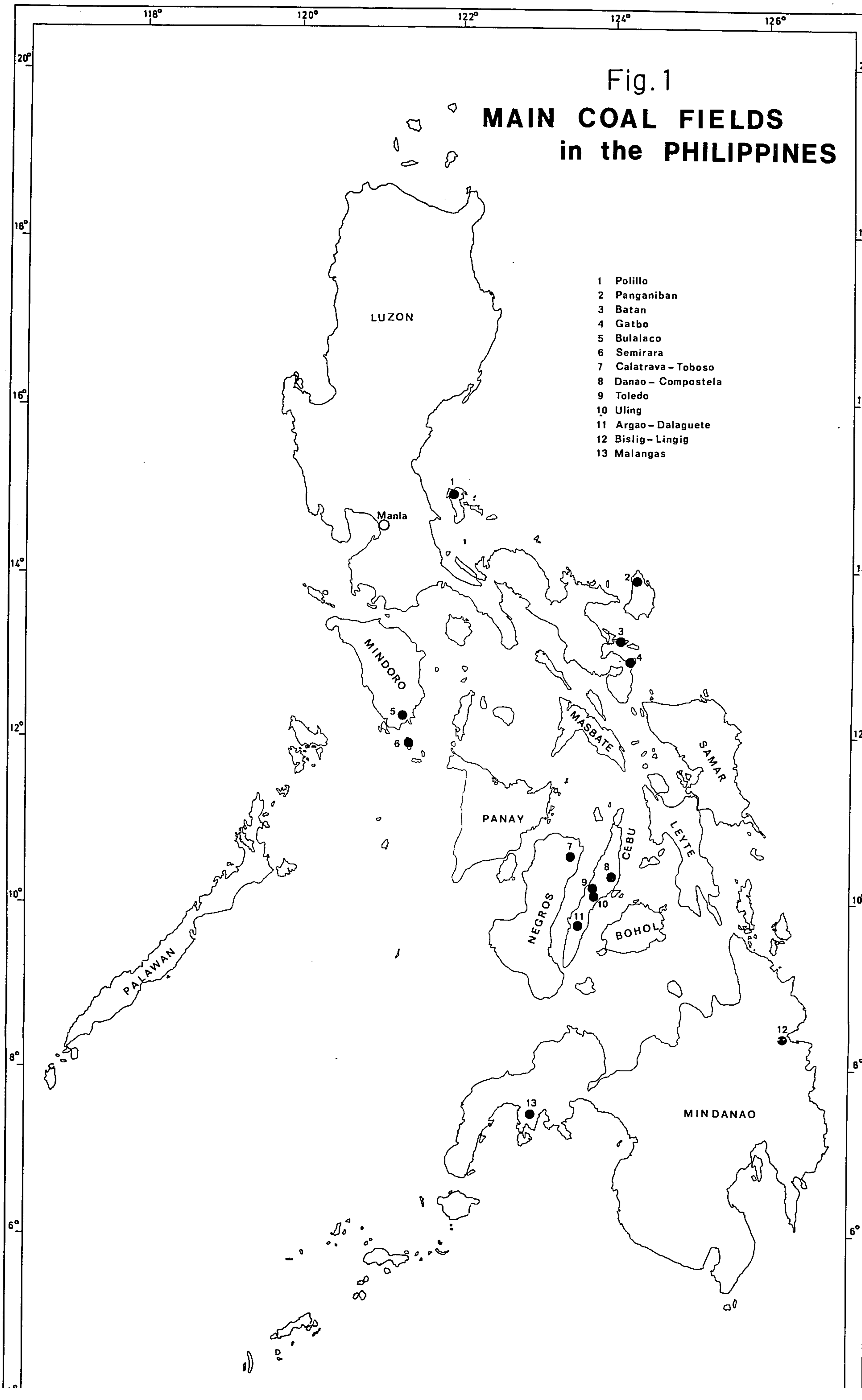
A preliminary design including layout of the power plant was carried out in view that construction of a thermal power plant is urgently needed to cope with the rapid increase of electric power demand and that the construction of a diesel power plant (10 MW x 5 units) is scheduled by NPC at the same site as the thermal power plant under the present study.

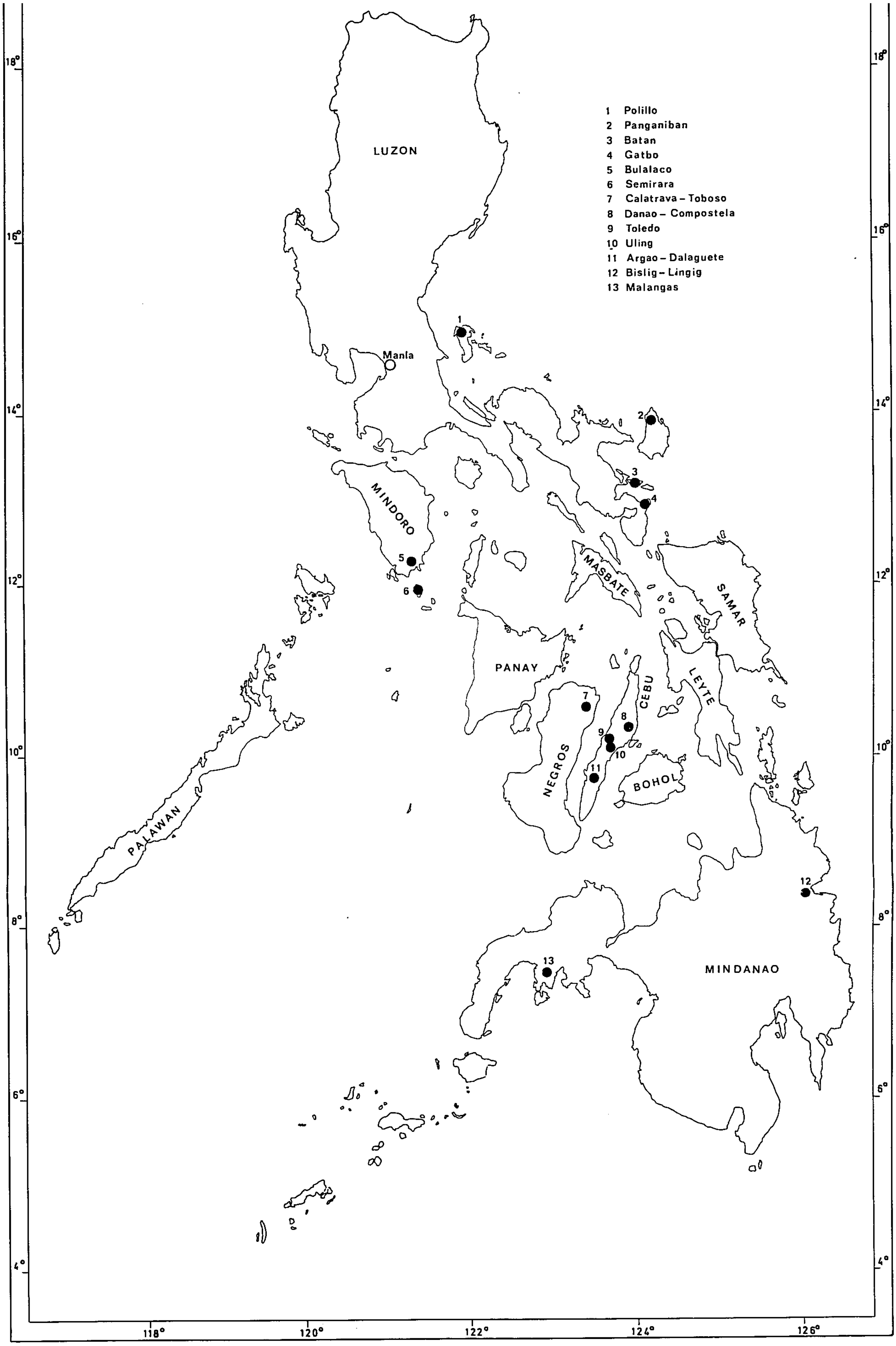
In designing a particular consideration was given to the point that the thermal power plant should be arranged so that it will easily allow addition of other units in the future for burning coal. The layout of building and equipment are shown on Fig. 11-3, 4.

The capacity of the ash disposal pond was designed to dispose ash waste from one unit of 50 MW for 10 years tentatively in order to reduce initial investment. The disposal area must be expanded in the future if other coal fired units are added. The layout of the switchyard was made simpler than in the NPC proposal in order to reduce construction cost, but this will not cause any problem in reliability.

As it is anticipated that about four years will be required from the start of preparation of specifications of the power plant through its start of commercial operation, if one unit of 50 MW is to start operation at the end of 1978, it will be necessary that the preparation of specification be started immediately upon completion of the feasibility study.

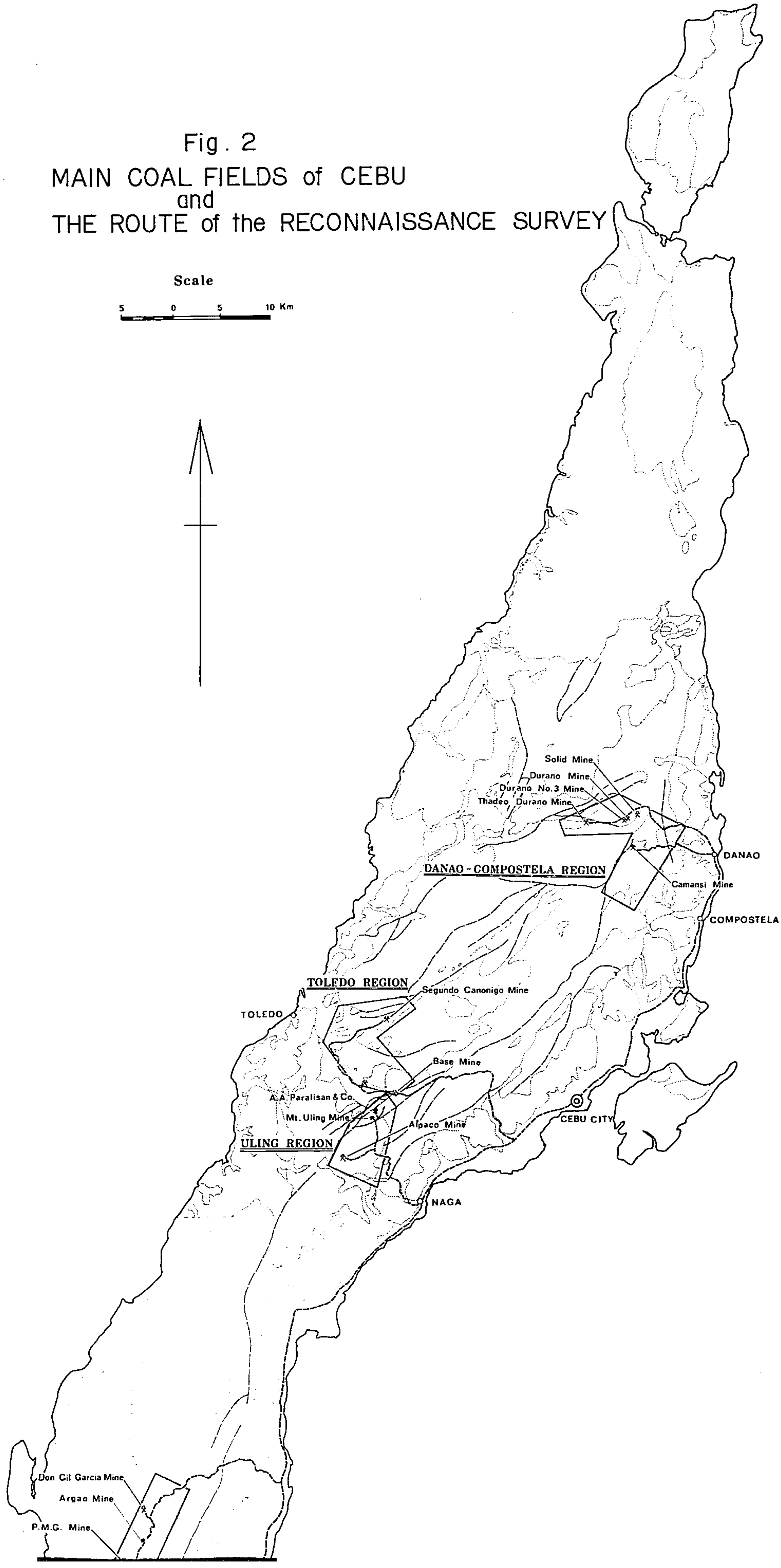
Fig. 1
MAIN COAL FIELDS in the PHILIPPINES





1 Polillo
2 Panganiban
3 Batan
4 Gatbo
5 Bulalaco
6 Semirara
7 Calatrava - Toboso
8 Danao - Compostela
9 Toledo
10 Uling
11 Argao - Dalaguete
12 Bislig - Lingig
13 Malangas
LUZON
Manla
MINDORO
SAMAR
LEYTE
MASBATE
PANAY
NEGROS
CEBU
BOHOL
MINDANAO
PALAWAN
18°
16°
14°
12°
10°
8°
6°
4°
118°
120°
122°
124°
126°

Fig. 2
MAIN COAL FIELDS of CEBU
and
THE ROUTE of the RECONNAISSANCE SURVEY



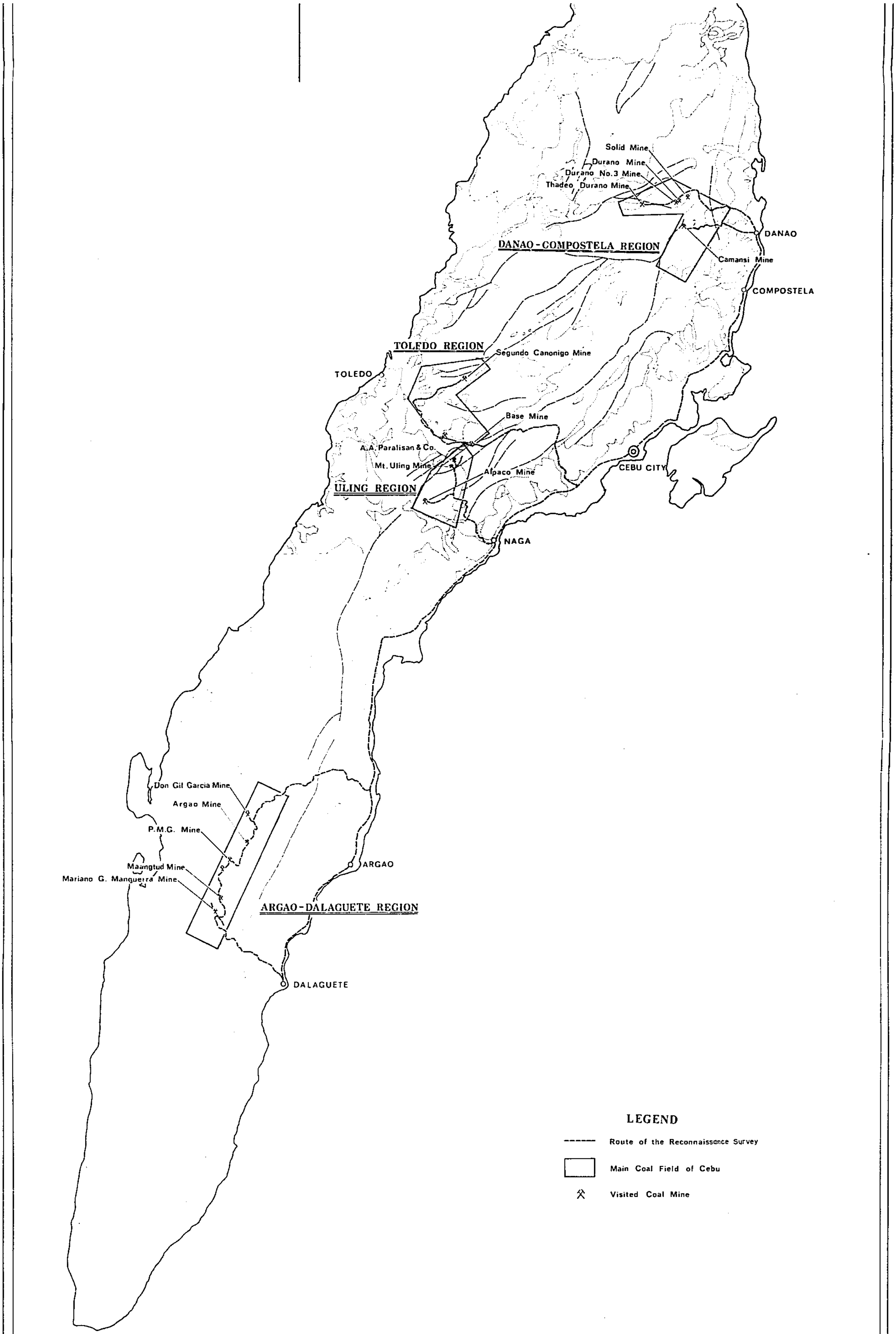
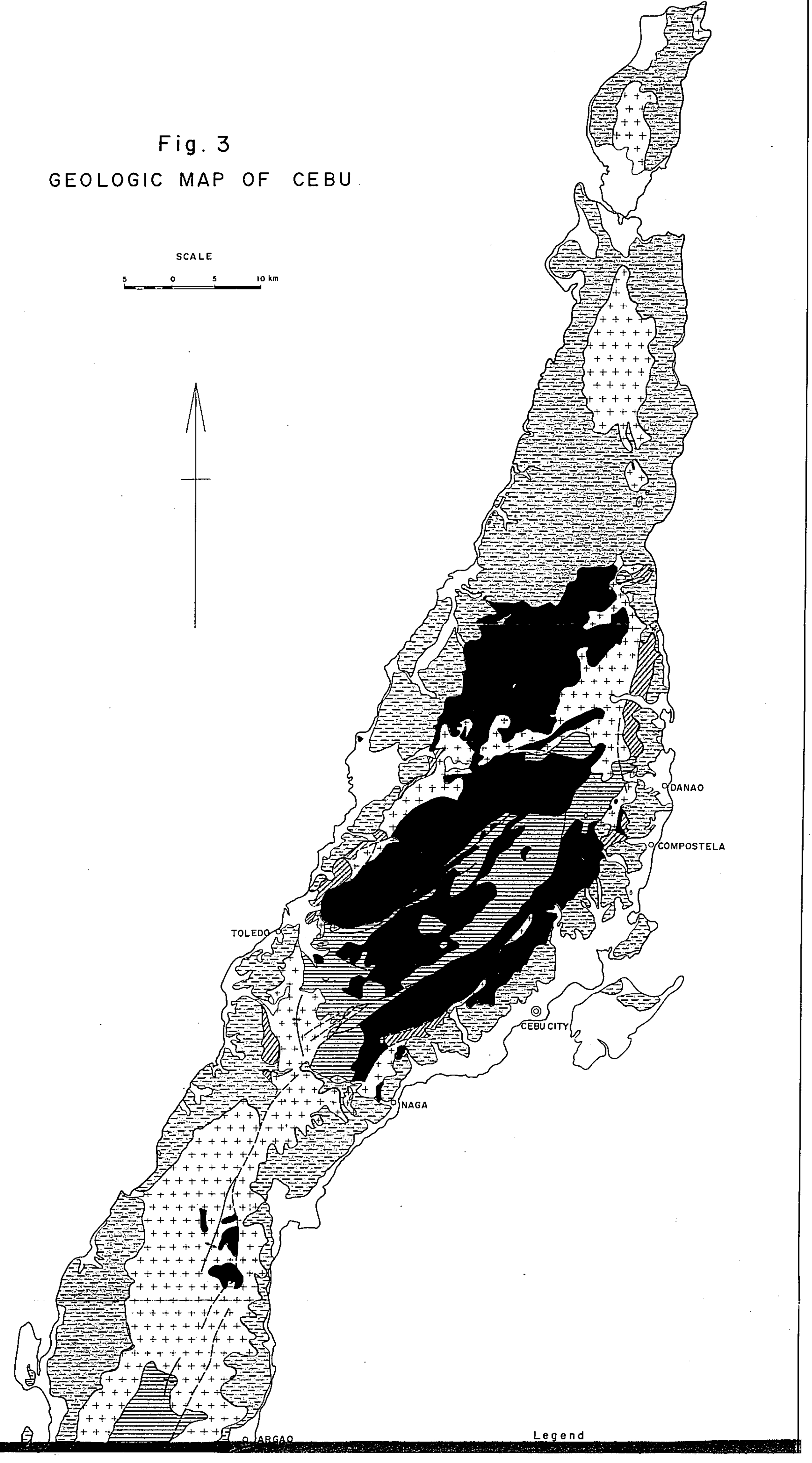
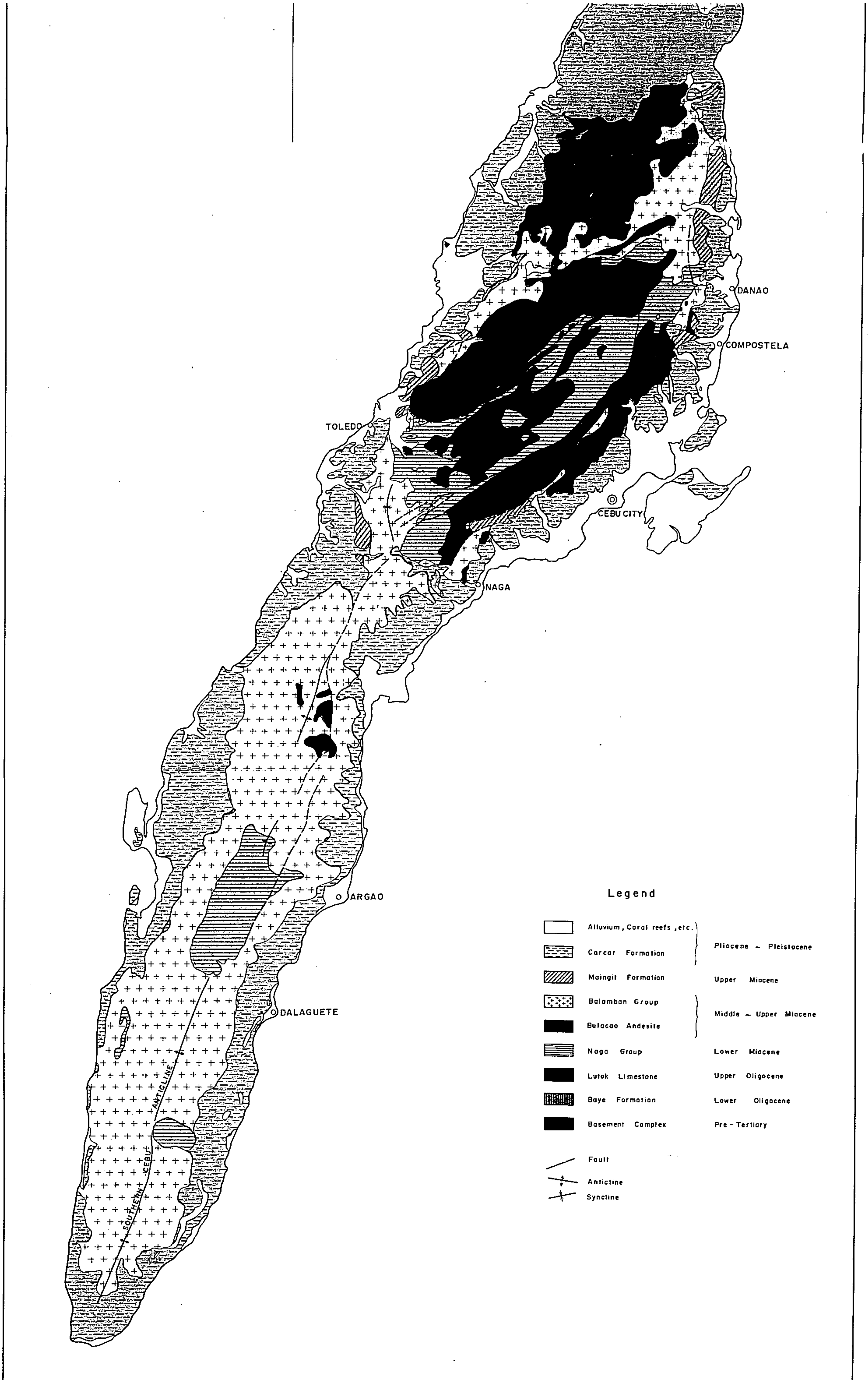

Solid Mine
Durano Mine
Durano No.3 Mine
Thadeo Durano Mine
DANAO
DANAO-COMPOSTELA REGION
Camansi Mine
COMPOSTELA
TOLEDO REGION
Segundo Canonigo Mine
TOLEDO
Base Mine
A.A. Paralisan & Co.
Mt. Uling Mine
Alpaco Mine
ULING REGION
CEBU CITY
NAGA
Don Gil Garcia Mine
Argao Mine
P.M.G. Mine
Maangtud Mine
Mariano G. Manguerra Mine
ARGAO
ARGAO-DALAGUETE REGION
DALAGUETE
LEGEND
Route of the Reconnaissance Survey
Main Coal Field of Cebu
Visited Coal Mine

Fig. 3

GEOLOGIC MAP OF CEBU





Modified from geologic Map compiled by Bureau of Mine, Philippines.

Fig. 4 POWER PLANT DEVELOPMENT PROGRAM OF CEBU POWER GRID

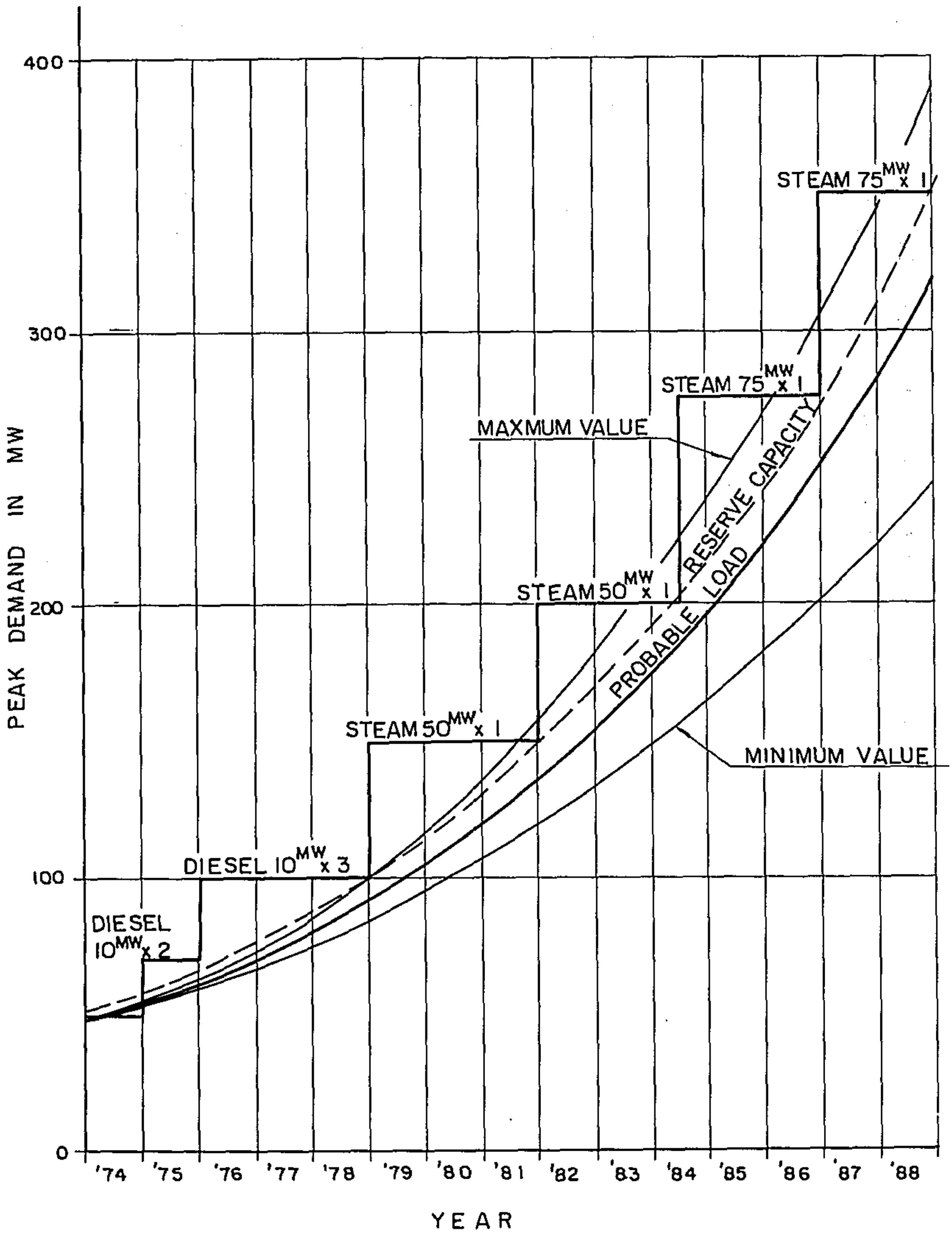
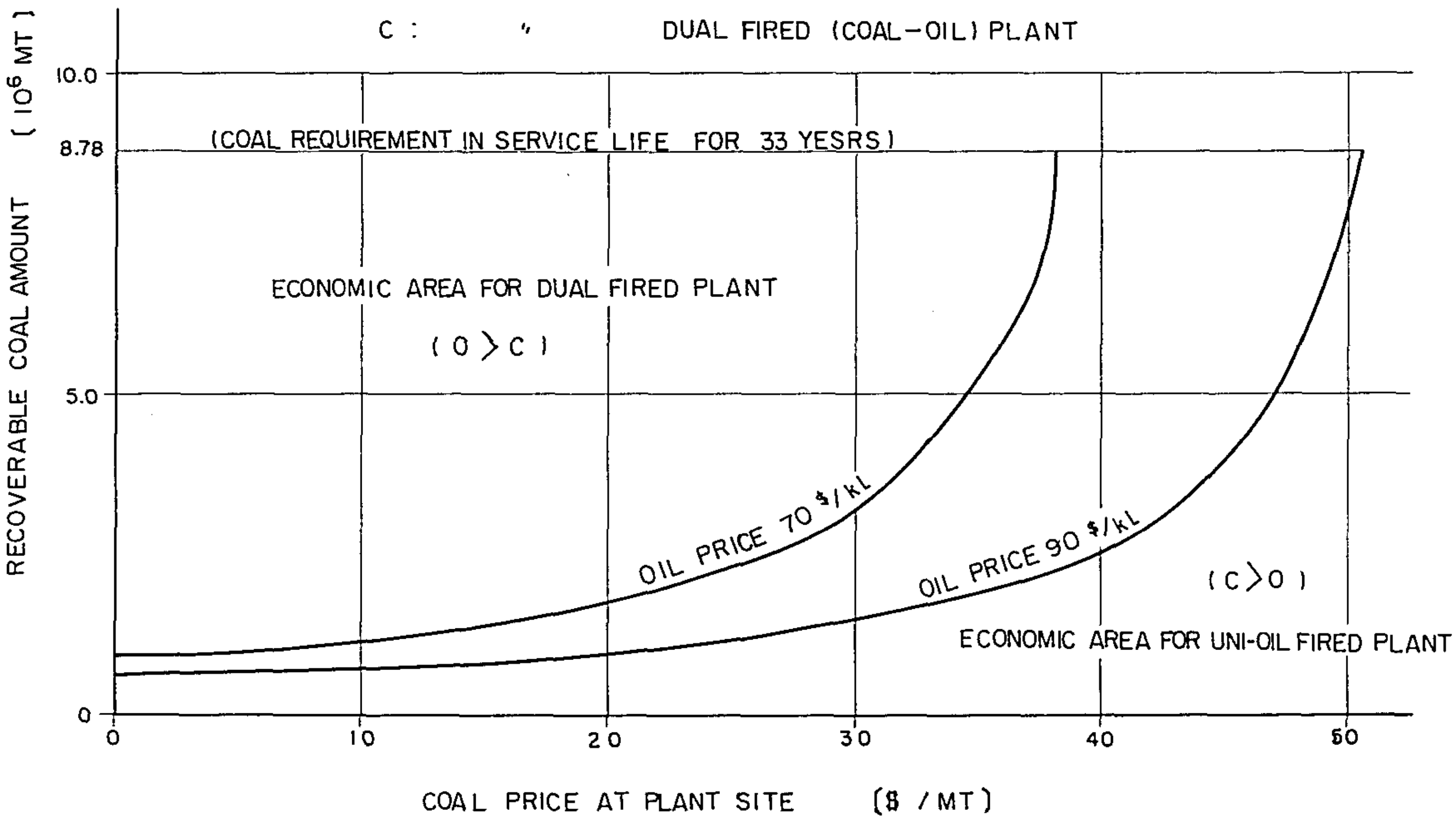


Fig. 5 . ECONOMIC BOUNDARY OF RECOVERABLE COAL AT PLANT SITE FOR THERMAL POWER PLANT $50^{MW} \times 2$

NOTE : O : ANNUAL COST OF UNI-OIL FIRED PLANT

C : 〃 DUAL FIRED (COAL-OIL) PLANT



CHAPTER 3

RECOMMENDATION

CHAPTER 3 RECOMMENDATION

(1) Judging from the results of present studies the coal reserves at Argao-Dalaguete might be developed, if operation be made systematically by employing sophisticated machines and equipment, in an estimated amount of 500,000 metric tons though geological and mining conditions will not be necessarily advantageous. Of this area, it is recommendable that a detail survey be made of the Bayabas-Balaas district which seemingly has a relatively high potentiality for development.

(2) Even if, however, the development of the coal reserves at Argao-Dalaguete is successfully promoted, the coal amount available from the reserves is too few to feed a dual fired thermal power plant of 50 MW. This means necessity of heavy dependence on oil which leads to extreme diseconomy. Accordingly, development of a dual fired thermal power plant would not be justifiable from economic point of view, if coal source is sought only from Cebu Island.

(3) However, if the matter is to be considered with more emphasis on a brooder national viewpoint, rather than on economic justifiability alone, of effective utilization of domestic energy resources, diversification of power resources and regional development, development of a dual fired thermal power plant may naturally be a subject of further study toward actualization. In this case, it is necessary to tackle with studies and investigation immediately of the coal fields in the other islands than Cebu such as Mindanao, and get detailed and reliable data on the available quantity and cost of coal in the various areas.

Besides, the study on the possibility of securing imported coal should also be taken up urgently, if diversification of energy sources is strongly aimed at.

In case studies and investigations recommended above be undertaken, this report could provide useful guidance in analysing economy of a dual fired thermal power plant from viewpoint of quantity-price relationship.

(4) To cope with the increase of demand for power, a thermal power plant of 50 MW should be completed by 1979. In view of this, selection of fuel for the thermal power plant should be finalized through the studies and investigations recommend in Item (3) above by around the end of the first half of the year 1975.

(5) In parallel with basic studies regarding coal, it will be necessary to start in 1974 arrangement and preparations necessary for implementation of the power plant construction including designing, preparation of specifications and monetary arrangement of required construction cost, etc.

Accordingly, it is further recommended that in order to ensure such time schedule of arrangement and preparations a preliminary investigation should be carried out immediately, regardless of the fuel type, including detail topographical surveying of the power plant site, preparation of a detailed topographical chart of the sea-bottom close to the power plant site, as well as measurements of sea conditions including wave heights and tide levels along the sea-shore around the Liloan district.

CHAPTER 4

OUTLINE OF COAL RESOURCES

CHAPTER 4. OUTLINE OF COAL RESOURCES

4-1 Coal in the Philippines

4-1-1 Coal Reserves

Although there are some published figures for coal reserves in the Philippines, the estimation of 67,078 thousand MT by Spencer and Vergara in 1957 is appeared to be generalized in the Philippines. (Special Project Series No. 20-coal)

However, these in-site reserves include the thin beds defined by minimum of 35 centimeters in thickness. Therefore, by means of picking up the figure of more than 75 centimeters thick, which are considered as workable, in measured area and adjacent indicated area with consideration of the actual mining, the reserves of 30,794 thousand MT are obtained. Then recoverable reserves are estimated as 11,663 thousand MT by multiplying geological factor and recoverable persentage to the above theoritical reserves. (Table 4-1)

Meanwhile, Roa has reported on the "Asia Mining" August, 1973 that the coal reserves of the Philippines are about 90,000 thousand MT. But this estimation is mostly based on the Spencer's remaining reserves and added only a few information. Of this figure, reserves of the Danao-Compostela region in Cebu are 11,979 thousand MT and also the figure of 13,671 thousand MT is given as Northern Camansi, but both figures are respectively remaining reserves and original one which are based on the Spencer's data. Northern Camansi is originally contained in the Danao-Compostela region. It would be, therefore, pointed out that the figure of 13,671 thousand MT is excessively summed up.

4-1-2 Coal Production

Total production of coal since 1842 in the Philippines is about 4 million tons as follows;

Coal Production in the Philippines

Year	Production in Metric Tons
1842 - 1906	30,000
1907 - 1912	95,869
1907 - 1916	No commercial production (roughly during the World War I)
1917 - 1940	780,215
1917 - 1941	150,000
1942 - 1945	(No report during the World War II)
1946 - 1972	2,958,531
Total as of Dec. 31, 1972	4,014,615

Annual production from 1920 to 1939 was 20,000 to 50,000 tons though it had some variation. In 1940 it was close to 100,000 tons and rose to 150,000 tons in 1941. After the World War II, the production was again increased and continued to a level of 120,000 to 160,000 tons. After that it has declined to 40,000 tons more or less.

The details are shown on Table 4-2.

Table 4-1 Estimation of Coal Reserves in the Philippines

More than 75 cm thick. Based on S. P. Series No. 20-coal. (In thousand metric tons)

Region	Measured reserves (a)	Mined or lost in mining (b)	Remaining reserves (c)=(a)-(b)	Indicated reserves (d)	Total reserves (e)=(c)+(d)	Recoverable reserves (f)	Remarks
Polillo	1,307	-	1,307	121	1,428	565	
Panganiban	68	-	68	244	312	112	
Hitoma-Manambrag	79	-	79	84	163	61	
Batan	5,848	725	5,123	1,235	6,358	2,481	*
Gatbo Peninsula	112	-	112	-	112	45	
Bulalacao	372	-	372	249	621	236	
Semirara	1,551	-	1,551	826	2,377	909	
Calatrava Toboso	331	-	331	189	520	198	
Malangas-Kabasalan	3,411	660	2,751	2,487	5,238	1,970	
Bislig-Lingig	1,553	-	1,553	625	2,178	840	*
Cebu Island							
Danao-Compostela	3,741	1,692	2,049	3,927	5,976	2,194	
Uling	774	-	774	-	774	310	
Toledo	38	9	29	-	29	12	
Argao-Dalaguete	1,932	295	1,637	3,071	4,708	1,730	
(Cebu Total)	(6,485)	(1,996)	(4,439)	(6,998)	(11,487)	(4,246)	
Grand-Totals	21,117	3,381	17,736	13,058	30,794	11,663	

Note: (1) The quantity of mined or lost in mining was assumed to have been extracted from the measured blocks.

(2) Recoverable riserves were estimated as 40% of the measured remaining reserves and as 35% of indicated one on the assumption of 80% and 70% geological safety factor and 50% recovery

(3) * marks have been estimated to minus 200 meters below assumed drainage level, and others are to minus 100 meters.

Table 4-2. Production of Coal in the Philippines from 1842 - 1972

Year	Production (in metric tons)	Year	Production (in metric tons)
1842 - 1906	30,000	1932	18,184
1907	4,123	1933	15,672
1908	10,035	1934	22,650
1909	30,336	1935	23,429
1910	28,655	1936	24,706
1911	20,000 1/	1937	21,691
1912	2,720	1938	40,522
1913	2/	1930	47,678
1914	2/	1940	96,072
1915	2/	1941	150,000
1916	2/	1942	-
1917	5,748	1943	-
1918	15,633	1944	-
1919	32,892	1945	-
1920	58,888	1946	48,427
1921	40,076	1947	73,732
1922	42,420	1948	87,748
1923	43,446	1949	123,336
1924	47,278	1950	158,822
1925	47,912	1951	150,691
1926	28,126	1952	139,440
1927	23,640	1953	154,905
1928	27,414	1954	119,627
1929	17,047	1955	130,243
1930	20,423	1956	151,708
1931	18,668	1957	191,151

1/ Estimated 2/ No commercial production - No available data

(Cont'd Table 4-2.)

Year	Production (in metric tons)
1958	107,780
1959	139,853
1960	147,857
1961	152,328
1962	162,978
1963	156,535
1964	114,936
1965	94,541
1966	75,324
1967	69,753
1968	32,150
1969	53,341
1970	42,401
1971	40,024
1972	38,900

(Data by Bureau of Mines in Manila)

4-1-3 Others

In 1951, coal mines consisted of four mines operated by CEPOC under the government and some 40 independent private operators. Total production in that year amounted to about 150,000 tons valued approximately ₱3.3 million. Daily production was therefore computed at an average of 500 tons. The only consumer of locally produced coal was CEPOC.

It was reported that as of April 30, 1953, CEPOC had a total investment of approximately ₱4 million on the four coal mines under its management located in Uling, Danao, Argao and Malangas.

Later because it was found by audit in the fiscal year 1957 - 58 that CEPOC spent more amount of ₱11 per ton on coal production than that obtainable from other suppliers, an auditor recommended to make a halt of coal mining operation by CEPOC.

It is said that CEPOC stopped the coal mining in Cebu in 1963 and at present the Malangas coal mine, Zamboanga is only being operated by its subsidiary company.

4-2 Coal Mining in Cebu

4-2-1 History

The first coal mining in the island of Cebu is recorded to have been worked in 1853 by the Spaniards in the Toledo region. In 1860 a 649 meters adit was driven at the foot of Mt. Uling and herein a thick coal bed was struck. A somewhat bigger scale of mining was undertaken in the Danao-Compostela region in the year 1890 and tram roads were constructed from the mine to the towns of Compostela and Danao in 1895.

These were used until the Spanish-American war in 1898 when all workings were abandoned.

In 1913 a systematic exploration program began in the Uling district. An adit was driven at a higher elevation than that driven in 1860 and at 121 meters reached coal seam. Mining work was commenced in 1914 and coal was produced from 1917 to 1925. In 1920, an adit of 471 meters long at the adjacent site of and at the same elevation as the previous adit in 1860 failed to reach coal seam. Meanwhile at Uling the Cebu Portland Cement Co. (CEPOC), a government firm began diamond drilling work in

1925 and actual mining was taken with a daily tonnage of 60 to 100 tons from 1938 to 1941 when work was interrupted by the war. Mining in the area was resumed in 1945 by CEPOC until 1952 when the mine area was given to a private party on a royalty basis.

The Camansi, Mabasa and Mantija areas of the Danao-Compostela region were worked by the Danao Mining Syndicate from 1917 to 1922 and the Mt. Licas area was exploited by the National Coal Co., a government subsidiary from 1918 to 1926. Some sporadic coal mining had been operated until the break of the war 1941. CEPOC started working in the Cajumay-jumayan area in the early part of 1946 and produced from 80 to 100 tons daily up to 1954

Later the property was taken over by private enterprise on royalty basis.

In the Argao-Dalaguete region, relatively little amount of coal was mined before World War II. After the war the first production started at the Gransina-Mantalongon area and later it was increased by adding the output from the Manlapay-Dumalan area. CEPOC subleased the Bayabas-Balaas area of the Garcia lease in 1951, and the production increased steadily and its operation was continued to 1963 when it was closed due to high cost.

Present coal mining in Cebu are mostly being done on contract basis by the residents in the locality where the coal areas are situated. Systematic mining is not practiced in the region, but "Camote mining" of individual outcrops as though digging sweet potatoes, is the standard procedure with using of simple hand tools. Most workings of more than 30 meters deep are abandoned.

<u>4-2-2 Coal Reserves in Cebu</u>

As mentioned before in-site reserves in the Philippines by Spencer and Vergara (1957) are 67,078 thousand MT. In this figure, the reserves of 22,998 thousand MT. of the Cebu island are included and are formed one third of all.

Measured and indicated reserves by them, of which the limit of estimated seams are defined by minimum of 75 centimeters in thickness, are shown on the lower part of Table 4-1 and total reserves are computed 11,487 thousand tons and recoverable one are calculated 4,246 thousand tons.

4-2-3 Production in Cebu

Coal production in Cebu from 1960 to 1973 is shown on Table 4-3, and the output in 1973 is about 40 thousand MT. Although there was a doubt a little bit about a few figures which exceed the annual production of whole the Philippines in Table 4-2, they were provided from different sources and it was not able to clarify.

Table 4-3 Coal Production in Cebu (1960 - 1973)

Metric Tons

Year	Danao-Compostela Region	Uling Region	Toledo Region	Argao-Dalaguete Region		Total
				Argao Area	Dalaguete Area	
1960	4,544	529	5.155	-	993	11,221
1961	6,278	1,355	19,979	783	1,133	29,528
1962	2,725	-	16,975	783	417	20,900
1963	277	277	12,565	-	-	13,119
1964	2,255	1,732	6,872	-	734	11,593
1965	1,426	978	3,885	3,277	386	9,952
1966	692	1,032	4,349	15,442	919	22,434
1967	17,864	-	-	-	-	17,864
1968	46,896	584	2,044	1,916	-	51,440
1969	17,828	-	-	-	-	17,828
1970	33,126	1,717	2,994	7,563	122	45,522
1971	13,923	669	399	6,302	4,443	25,736
1972	8,916	2,579	872	15,172	13,258	40,797
1973	19,314	3,216	4,353	5,817	8,198	40,898
Total	176,064	14,668	80,442	57,055	30,603	358,832

(Data by Bureau of Mines in Cebu.)

CHAPTER 5

RECONNAISSANCE SURVEY IN THE COAL REGION

CHAPTER 5 RECONNAISSANCE SURVEY IN THE COAL REGION

5-1 General Geology

The distributed rocks in the Cebu Island are predominated by sedimentary rock. Plate 2 is somewhat simplified from the geologic map of Cebu Island prepared by the Philippine Bureau of Mines. They are divided into 8 units. Of these, the seven younger units are known to be Oligocene to Pleistocene in age. The age of the Basement Complex is not known.

Alluvium	(Quaternary)
Carcar Formation	(Pliocene-Pleistocene)
Maingit Formation	(Upper Miocene)
Balamban Group	(Middle-Upper Miocene)
Bulacao Andesite	(Middle-Upper Miocene)
Naga Group	(Lower Miocene)
Lutok Limestone	(Upper Oligocene)
Baye Formation	(Lower? Oligocene)
Basement Complex	(Pre-Tertiary)

The Basement Complex widely exposes near the southern center of northern half in the Cebu Island. It consists mostly of metamorphic rocks with occasional igneous masses. The metamorphics frequently exhibit good bedding and usually dip steeply. The Pandan formation which is believed to be in Cretaceous age is not differentiated from the Basement Complex on Plate 2-1. It consists of regionally metamorphosed conglomerate, sandstone, shale and limestone with some interbedded basic lava flows. The metamorphism is of low grade.

Lutok Limestone and Baye Formation are thought to be in early and middle Oligocene and their exposure are confined in very small area.

Naga Group is important to contain the coal bearing formations and is described later in the explanation of each coal region.

Bulacao Andesite is mainly exposed in the vicinity of 5 kilometers to the north-west of Cebu City and of 10 kilometers to the west of Danao City. It is considered to be middle Miocene in age.

Balamban Group is one of the most widespread unit on the southern half of Cebu and consists mainly of porous, coralline limestone and marl.

Maingit Formation distributes near the Danao and Toledo towns, and is divisible into three lithologic members, a lower limestone, a middle conglomerate member and an upper sandstone and shale member.

Carcar Formation is one of the most widespread of all units on Cebu. It occupies the entire coastal area round the island and even crosses the island at two places near the north end. This is a porous, coralline limestone, massive or poorly bedded.

The general strike of Tertiary sediments is appeared to trend NS on the northern part, NE-SW in the central part and NNE-SSW at the southern portion of the island. These directions are mostly parallel to the present coastline. It is remarkable that the main anticlinal axis runs through to the NNE in the middle of the southern part of island.

5-2 Coal Area in Cebu and Source of Information

Coal is known to occur in four distinct regions on the island of Cebu, namely the Danao-Compostela, Uling, Toledo and Argao-Dalaguete regions, and the areal extent of these regions are respectively about 10x10. 8x5. 10x6 and 15x5 kilometers. These coal regions lie scattered in dissected hilly and central mountainous areas.

Various reports were collected and studied for this investigation. Geologic information and maps in this report are chiefly quoted from the below list, and the description is mainly referred to the coal bearing formation and not touched upon the limestone and fossil etc. The name of strata mentioned on the each coal area is shown on the stratigraphic correlation chart, Plate 2-2. Although there was a stratigraphic nomenclature by Melendres and others in 1957 in the Danao-Compostela region, it was unable to cite in this report, because their report had not been published.

1. F.D. Spencer et al., 1957

   Coal Resources of the Philippines.

2. H. Barnes et al., 1956

   Geology and Coal Resources of the Argao-Dalaguete region, Cebu.

3. H. Alberding, 1940

(1) Report on the coal resources of the Danao-Compostela district, Cebu.

(2) Report on the coal resources of the Uling district, Cebu.

(3) Report on the coal resources of the Toledo district, Cebu.

4. G. W. Corby et al, 1951

Geology and oil possibilities of the Philippines.

5-3. Geology in the Coal Area

5-3-1 Danao-Compostela Region

The Danao-Compostela coal region is located 5 to 10 kilometers to the west and north-west of the coastal municipalities of Compostela and Danao which are located 25 and 33 kilometers respectively to the north of Cebu City. It is mainly divided into three areas: the Mount Licos area in the south, the Camansi area 3.5 kilometers to the north-east of the Mt. Licos and the Cajumay-jimayan area 3.5 kilometers north of the Camansi area.

The region is in a mature state of topographic development. But there are a number of limestone peaks and the slope where limestone outcrops as on Mounts Mangilao, Lantauan and Licos are often vertical. The relief varies from 350 to 600 meters.

In this region the strata consists of Miocene clastic sediments, limestone beds and coal seams resting unconformably on top of a pre-Tertiary Basement Complex. The Miocene sediments have been divided into the following formations in ascending order: Cebu orbitoid limestone, Malubog formation, Mount Uling limestone, Toledo shales and Barili limestone. An unconformity exists at the base of the Mt. Uling limestone which is Middle Miocene and at the base of the Barili limestone, Upper Miocene in age.

The Cebu orbitoid limestone and Malubog formation are correspondable to the Naga Group which belong to Lower Miocene.

Another coal measures below the Cebu orbitoid limestone is discriminated by Melendres and others but their maps are not available.

The Malubog formation consists of shales, sandstones, some conglomerates and coal seams, and also containes the Binabac limestone between Mt. Licos and Camansi areas. In the Cajumay-jumayan area the formation is said at least 500 meters thick but the coal bearing part may be 300 meters or less in thickness.

The Toledo shales comprises the Danao coal measures which consist principally of dark grey and brown shales with three coal beds.

It is reported by Spencer and Vergara, 1957 that according to Melendres and others' data, 1957, the different areas under the region contain seven to sixty-eight uncorrelated coal beds. It might be, however, that many very thin coal beds were accounted and also that some of which were duplicated beds. According to Alberding report, five to four seams have recognized in the Malubog formation and the thickness of the seams vary from 0.46 to 3.35 meters.

In the Danao coal measures three seams have been discriminated in the northeastern parts of the Cajumay-jumayan and Camansi areas. They are in ascending order E, F and G coal beds and average thickness of them in the west of Mt. Lantauan are 0.91, 1.22 and 3.05 meters respectively.

The principal folds of the region are two northeastward-plunging synclines with an anticline in between. The dip of the strata along the limbs of the folds average 30 to 40 degrees to the northwest and southeast. The principal fault of this district strikes NNE to SSW and passes to the east of Mounts Mangilao and Binaleu. Many faults were found in the Mt. Licos area during the coal mining operations by the National Coal Company.

5-3-2 Uling Region

The Uling region referred to by Alberding (1940) as the Uling coal district is located 12 kilometers northwest of Naga and is accessible from Naga by 17 kilometers road. The region is drained by thel Pandan River, which has a general southeasterly course, and its tributaries. The average relief of the region is from 300 to 400 meters but the dominant topographic feature in the northwestern region is a NE-SW trending limestone ridge where Mt. Uling is known as with a maximum elevation of 659 meters.

The region is underlain mostly by Tertiary sedimentary rocks which may have an approximate maximum thickness of about 1,370 meters and are divided into four formations. They were named by Alberding, in ascending order; Cebu coal measures, Cebu orbitoid limestone, Malubog formation and Mount Uling limestone. It is believed that the first three formations are Early Miocene and the last one is Middle Miocene in age and that the latter is unconformably underlain by the former. The Basement Complex unconformably underlie the Tertiary sediments. (Plate 5-1)

Coal seams are contained in the Cebu coal measures and the Malubog formation but the amount mined from the Cebu coal measures has been negligible because of the thin thickness and lenticularity of the seams, Cebu coal measures is only 50 meters thick and consists of sandstones, shales and coal seams. In the Malubog formation coal is not recognized in the basal Binabac shale. However, coal occurs interbedded with the Binabac limestone beds in the Uling mine, consist of limestone beds interbedded sandstones, shales and coal seams. Coal bearing parts have 150 to 300 meters in chickness. Nine coal beds occur in the Uling mine but only three of which had been exploited; coal Nos. 1 (lowest), 2, and No. 5. No. 5 coal bed is well known as the Dona Margarita seam and is the only seam of commercial importance in the Uling region with 2.91 meters (parting excluded) in average thickness. (Plates 5-2, 5-3.)

The Alpaco area of the Uling coal region is located about 4.5 kilometers to the southwest of the barrio of Uling. The coal seams are in the Alpaco silt member of the Malubog formation. A number of prospecting pits and tunnels have been excavated.

The strata of the region have been folded into a series of northeast striking anticlines and synclines. The average dip of the beds over most of the area covered by the Uling mine coal measures is 35 degrees to the north and northwest. The average dip of the Binabac limestone beds in the eastern part of the region is 40 degrees to the east and southeast, and west and northwest.

The major fault of this region is the Uling-Masaba fault which have a strike of northeast and dip steeply. It extends out of the regions to have a total length of approximately twenty kilometers and its throw may be 570 meters in the northeastern part decreasing to the west. It is a remarkable fact that numerous minor faults have been encountered in the Uling tunnel and mine workings.

5-3-3 Toledo Region

Toledo region which was described by Alberding (1940) lies between the municipality of Toledo and Cebu City. Most of the region is under the jurisdiction of Toledo and is divided into four areas; Malubog, Mabais, Masaba and Guila-Guila.

The topography of the region varies from a rugged, forest covered, limestone terrain; to gently-rolling, open, park-like country; to the broad alluviated valley of the westward-flowing Sapandaco River which drains most of the district. The Guila-Guila area is drained by the eastward-flowing Mananga River.

The strata of the region consist of Tertiary sandstones, conglomerates, shales, coal seams and limestone beds which attain a maximum thickness of 825 meters. Those are divided into five formations ranging in age from Lower to Middle Miocene and unconformably overlie a pre-Tertiary Basement Complex. These formations in ascending order are the Cebu coal measures, the Cebu orbitoid limestone, the Malubog formation, the Mount Uling limestone and the Toledo shales. It is believed to be an unconformity between the Malubog formation and the Mount Uling limestone.

It is observed that the coal seams only occur in the Cebu coal measures throughout this region and do not contain in any other formations.

The Cebu coal measures unconformably overlie the Basement Complex and attains a maximum thickness of 50 meters in this region. In the Malubog area the Malubog formation is well exposed and directly overlies the Basement Complex where the Cebu orbitoid limestone and Cebu coal measures pinch out and disappear. According to Alberding (1940), one or two highly-lenticular seams have been discriminated in each of the areas and many partings usually exist in the seams except in the Guila-Guila area. The seam is very impure and has many shale and sandstone partings.

The principal structure of the region is a large northeast to southwest trending anticline plunging towards the southwest with the Basement Complex exposed in its axial part. And the Tertiary sediments are flanked from the basement core on three sides. In the Malubog area, on the northwest flank of the anticline, the strata have been folded into a series of northeast-striking anticlines and synclines whose limbs dip from 14 to 71 degrees to the northeast and southwest. Elsewhere in the region the strata dip from 11 to 22 degrees generally in every direction except towards the north and northeast. The Uling-Masaba fault is the principal fault of the region and is described previous clause.

5-3-4 Argao-Dalaguete Region

The Argao-Dalaguete region is chiefly located in the municipalities of Argao and Dalaguete in the south-central of Cebu. Its central part is formed as an erosional window by a broad valley denudation through a younger thick limestone sequence with 600 meters relief in the older coal-bearing strata. West and southwest of the erosional window are the high points topographically where a number of peaks and ridges exceed 1,000 meters in altitude. Exitence of outcrops are confined to stream course and limestone cliffs.

Coal bearing strata expose in a long narrow window trending north or northeast toward with steeply dipping. The erosional window is framed by an overlying thick limestone beds of gently dipping.
A generalized section of formations in this region has been shown by Barnes and others 1956. In this report the correlation chart is included in Plate 2-2.

The important Tertiary sequence concerning coal bearing strata is called the Argao group which belongs to the lower Miocene in age and its subdivision is the Calagasan formation, the Butong limestone and the Linut-Od formation. They consist of conglomerate, sandstone and shale with interbedded limestone and coal. Both the Calagasan and Linut-Od, which is the lowest and highest formations, are coal bearing. Most of the coal and limestone lie near the middle of Argao sequence and the thickest coal beds occur just above or below the Butong limestone. The limestone is reported to vary the thickness laterally because of its lenticular or inconsistent bedding. Coal seams are generally lenticular also. Coal bearing parts are about 300 meters each in thickness.

This region has been divided into three areas and described as important coal areas, Bayabas-Balaas in the north, Manlapay-Dumalan in the middle and Gransina-Mantalongon in the south. Field work by Barnes and others which was done from September to December 1954 is based on outcrops, mine workings, trenching, hand-auger drilling and diamond drilling. Especially mine working are appeared to be successfully used to trace the continuity of coal beds. None reached a depth of more than 61.5 meters of the nine holes diamond-drilled because of troubles on encountering limestone boulders in the holes. Shallow hand-auger drilling, a total of about 155 holes were effective as exploration method.

a) Bayabas-Balaas area:-

From two to six coal beds ranging in thickness from 35 to 240 centimeters are included in the area.

b) Manlapay-Dumalan area:-

Three coal beds with thickness ranging from 35 to 400 centimeters are found in the Calagasan formation, and two or three seams with 180 centimeters thick are contained in the Linut-Od formation at Santiko, north of Manlapay.

c) Gransina-Mantalongon area:-

There are one to five beds of coal ranging from 35 to 223 centimeters thick in the Linut-Od formation.

There are two patterns of deformation for the structure of the Argao-Dalaguete region. The older Argao group shows north-south trending folds and east-west trending corss faults. Folding is relatively strong with vertical and overturned beds common. Many minor folds trend generally to the north and northwest. Beds generally dip steeply westward. The cross faults are dominant horizontal displacement than vertical one.

The younger Carcar and Balamban Group show tectonic feature having broad folds and faults with northeastward trend. Folding is relatively gentle and displacement by faulting is chiefly vertical. The Argao group is mostly exposed only where the limestone arch formed by the Carcar and Balamban sequence has been broken by erosion.

The Tacliad fault is the most remarkable fault in topographically lying eastern edge of the erosional window. The Basement Pandan formation of Cretaceous age in the upthrown is brought by this fault into contact with the Argao group in the downthrown western block. The Manlapay fault which lies near the middle of the erosional window with westward trending is the another major fault in this region. This fault is clearly indicated by the displacement of the Butong limestone.

There are several smaller faults and most of them are cross faults in the Argao group.

5-4 Present Status of Investigated Mines

5-4-1 Geological Situation

Outline of concerned geology for investigated mines as follows:

(1) Danao-Compostela region

Paved road with 8-10 meters in width has been extended from the Cebu city through Compostela (25 Km) to Danao (33 Km) and the gravel road with 6-4 meters wide has connected between the coal areas and the town of Danao or Compostela.

It takes two to three hours by vehicle to arrive this region from the Cebu City.

As it is necessary to pass through the river bed of Danao river about 5 kilometers in length to reach this area, the traffic becomes mostly impossible during rainy season.

Low hills which coal bearing formation distributes are among the rugged limestone mountains. In this region, lots of scattered old portal of shallow inclined shaft and vertical shaft were observed, and from this fact, it is not considered that coal seams are in good condition for mining and large scale production can be expected. In general, the covered soil on the surface is thick and the talus covers in surrounding area of the foot of limestone peaks. Therefore, geological survey will be too hard to be conducted in the region without drilling.

(a) Camansi Mine, Aznab Enterprises

One pit has been opened. Rock entry has been driven about 37 meters in length towards the drilling point. Slickensides, minor faults and drags of coal seam by fault are observed at the entry.

Judging from the distribution of the small old portals and the data of a few drillholes, three coal seams are workable in this area. These seams have about 1.5 meters in thickness at some few places but almost their thickness rapidly decreases and is less than 0.6 meters.

Although there are some places where the top soil is thin, it is generally over 3 meters in this area. Consequently, manual trenching for survey is not considered to be available.

(b) Solid Mine, Solid Mining Exploration Co.

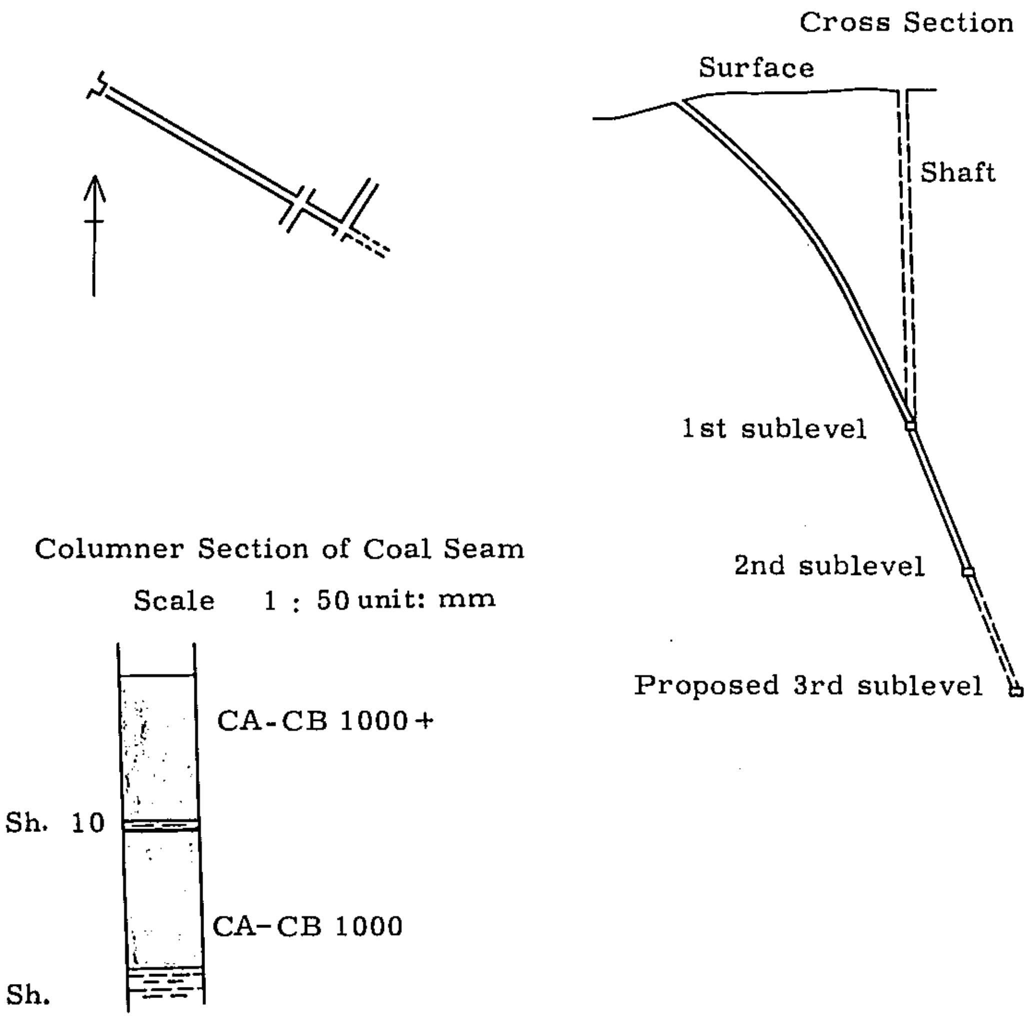
This coal mine is closely located at the west side of limestone cliff of Mt. Lantouan. The pit is opened on Oct., 1973, and the incline along seam which dips 35 to 70 degrees has been developed.

Coal seam is supposed to be about 3 meters in thickness but the roof and floor of seam is unable to find along the incline and at the working face. This seam has a brown shale parting with 1 cm thick which is used as the key of the underground excavation, and is presumably correlated to G seam named in this area. (Figure 5-1.)

At the part of northward of Mt. Lantouan, and northeast of the Solid mine, many small old shafts scatter there. It is said that the seam dip is nearly horizontal. Though the dip

Fig. 5-1 SOLID MINE

Scale 1 : 1000



of seam is quite different between Solid mine and this area, the coal seam is supposed to be same bed each other. Old shafts are filled with water up to near the mouth because of low land area.

(c) Durano Coal Mine

At the southwest of the Solid mine, and along the foot of limestone ridge, some old shafts and inclines which is about 10-20 meters in depth exist intermittently. Four pits are opened at present.

Strike of the coal seam is northeast to southwest and dip is 40-50 degrees towards southeast. This coal seam is supposed to continue to the seam in the Solid mine. It is interpreted by the distribution of old pits that at least three coal seams exist in this area.

This area is a low land and the pit mouths situate near the drainage level, so the mouths shall be easily flooded or broken down in rainy season. The top soil is generally 3-5 meters in thickness and limestone boulders on the surface increase as getting near the foot of limestone ridge.

(d) Thadeo Durano Mine

This mine is located near the top of the mountain which is approximately 2 Km southwest of Durano Coal Mine, and can be reached there passing through the road of area where Basement Complex distributes. Strike of the strata is approximately east to west and the dip is 40 degrees toward north, and coal bearing formation is covered by limestone.

There are one or two workable seams and its thickness is not clear. These coal beds contain many calcareous nodules. Some old, shallow inclines and shafts are scattering there. These coal beds are thought to be the same coal beds as correlated to the Cebu coal measure in the Toledo region.

(2) Uling region

It is 22 Km in distance along paved road of 6-10 m in width from Cebu to Naga, and is 17 Km long with gravel road of 8 m in width from Naga to Uling. It can be reached to Uling about 2 hours from the Cebu city. Gravel road to Alpaco area from the midway to Uling is very rough with 4-5 m in width passing the mountainous land, so the transportation may become impossible during rainy season.

There was a coking furnace factory which was ever operated by using the coal of Uling.

(a) A.A. Paralisan Co.

This is located near the eastern extremity of old Mt. Uling mine. It is preparing to mine the seam Nos. 5 and 6 in the vicinity of Drill No. 12 on Plate 5-2. Strike of the strata is N40°E and dip is 30 degrees toward northwest.

Coal bearing strata is covered by the boulders of limestone which fell down from Mt. Uling.

As shown on Plate 5-2 the outcrop line of seams are not so long and extension of the seams is restricted in some area, and many faults could be observed in the underground.

Therefore, even if a certain amount of the exploration by drilling and trenching are carried out, the acquisition of favourable results will be very difficult, because of complicated structures and small extension.

(b) Alpaco Mine.

The strike of seam is N70°W and the dip is 30° - 35° towards south.

The uppermost seam which is 1.8 m in thickness is now being extracted and the second seam, which is below 9 - 10 m and is 0.75 m thick, is also mined in small amount.

Surface well cultivated near this mine shows gentle relief and top soil may be over 3 meters in thickness.

Therefore, manual trenching method for the geological survey can not be adopted in the most area near this mine.

The coal seams distribute only 1 Km in width of both flank of a synclinal axis. The expansion of production scale may be supposed to be hard in this mine because of small extension of the coal seams.

(3) Toledo region

It takes two or three hours to get the region through Talisay from the Cebu City. Gravel road with 3-5 meters in width passes to coal areas from Talisay.

(a) Base Mine, Filipinas Carbon & Mining Corp.

Coal seam gently dips 5-6 degrees toward south but contains many shale patches. Two working faces are now operated in this mine. At the southwestern face, the coal seam is divided into two parts having 35 - 40 cm each in thickness by shale parting of 35 - 40 cm thick. At the northeast working face, many shale patches are also comprised in the seam like to another face though the seam is 75 cm in thickness, no parting.

It is observed that coal seam is lenticularly thinning out along bedding plane at some places in the underground. (Fig. 5-2)

Because the strata are gently dipping and are covered by limestone, coal survey might be mainly done by drilling.

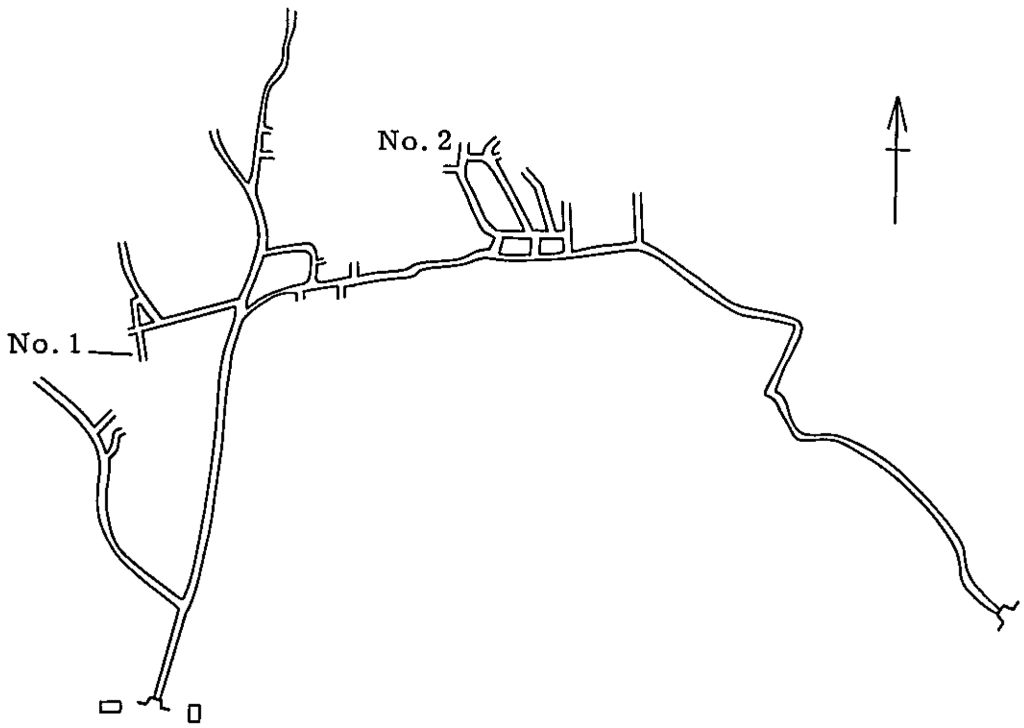
(b) Segundo Canonigo Mine

There are two coal seams. One incline shaft dipping 45 degrees has been driven 60 meters in length along upper seam, and the gateway along seam has been extended to the both side of which length is 15 meters.

Dip of seams are comparatively steep and seam thickness is not so thick, 1 meter more or less and also the lower bed has been already mined out. So more coal production in this mine can not be expected.

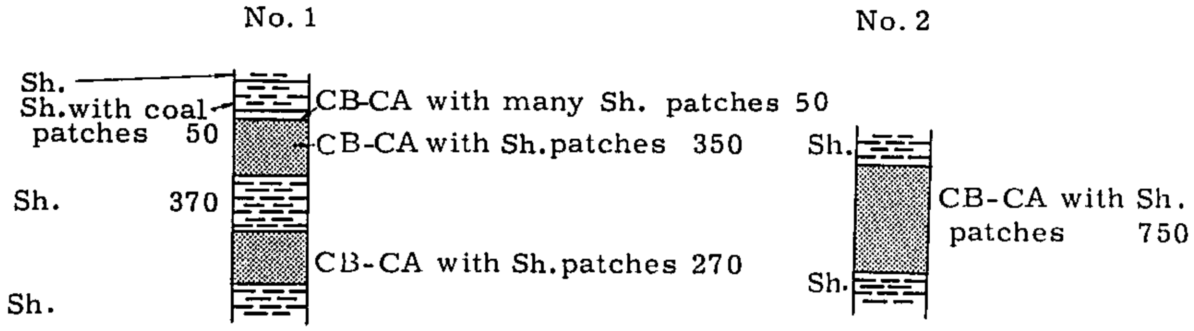
Fig. 5-2 BASE MINE

Scale 1 : 4000



Columner Sections of Coal Seam

Scale 1 : 50 unit: mm



(4) Argao-Dalaguete region

The towns of Argao and Dalaguete are situated in the southwest of 67 Km and 85 Km from the Cebu City, and it can be reached to the northern and middle areas through Taloot and to the southern area through Dalaguete taking 3 to 5 hours. All paved road runs from Cebu to Taloot but the south of Taloot is only paved a part. To reach Bayabas located northern edge, it is necessary to ascend the rough gravel road. The down road passing from Bayabas to Calagasan is 3 Km in distance and a half of its road is extremely rough, and the destruction by heavy rain in Nov., 1973 are still not recovered at two places on that road.

The gravel road passing from Dalaguete to the southern area of this region is being kept under a good condition. As the gravel road to reach Manlapay from Mangtud in the central area of the region runs at the mountain side, the traffic is held up by landslide sometimes.

There are a number of old pit mouths in this region besides the one plotted on the plates 6-3, 6-4 and 6-5, and many places are mined out to 30 meters in depth from surface. The old pit mouths are few in the vicinity of Manlapay.

In this region, the modes of occurrance on the seam is comparatively superior in the north, Bayabas-Balaas area, and the next is in the south, Gransina-Mantalongon area, and the most inferior is the central area, Manlapay-Dumalan.

(a) D.G.G. Mine (Don Gil Garcia Lease)

CEPOC had operated coal mine in this area. Only one pit is now opened and the remaining coal of the pit is mined by using picks and shovels.

The strike of seam is N40° W and its dip is 80 degrees towards east. A fault which has about 5 meters throw along seam entry is observed and also there is a fault on the top of seam at the working face.

There are some old horizontal entries, inclines and shafts shafts near this pit. Some of coal under drainage level might have been already mined out. (Figure 5-3.)

(b) Argao Mine, CEPOC (Not operating)

The Argao Mine at Calagasan which was operated by CEPOC from 1951 to 1963 was the biggest coal mine in Cebu. It is said that 300 men were working and production was 150 MT per day in this mine.

Although the configuration of the ground is slightly steep, it forms an advantage feature for mining of much coal where the cross-cut is driven at the low level from surface. Not only the portals of cross-cut but the portals of seam entry, incline and shaft are found in the mine area.

So that it is appeared to be mined out some of coal below drainage level.

Due to the very poor road condition, they say, it costed 20 pesos per ton for transportation.

Many boulders of limestone are scattered there, and top soil is generally over 3 meters in thickness, accordingly the applying of manual trenching may be difficult.

(c) M.G.M. Mine (Mariano G. Manguerra Carbon Mine).

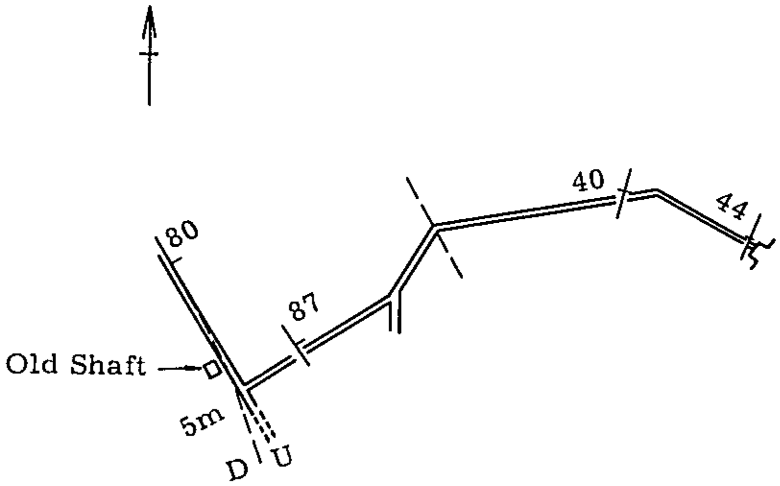
Coal lease is held by Mariano Cuenco Coal Mining, and M.G.M. commenced the work in Feb., 1974 as operator. Mine water of the old entry is discharging at present (72 cubic meters/shift/day)

Though the strata expose at some places along the creek, the distributed zone of coal bearing formation near this mine have a gentle topographic feature. So the trenching for coal survey is able to apply only a few places. (Figure 5-4.)

At Maangtud, two portals are now opened by M.G.M.

Fig. 5-3 DON GIL GARCIA MINE

Scale 1 : 1000



Columner Section of Coal Seam

Scale 1 : 50 unit: mm

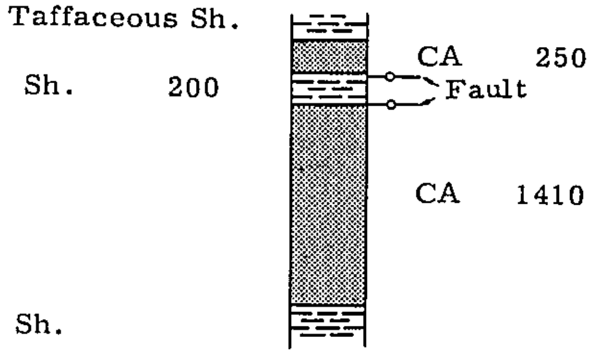
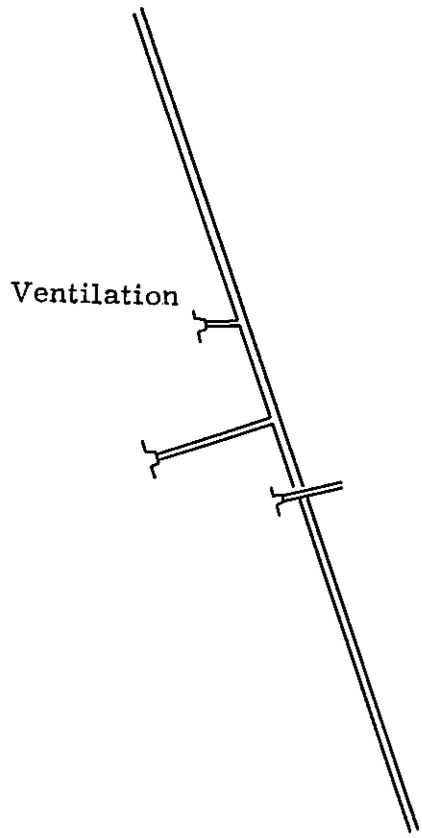


Fig. 5-4 M.G.M. MINE

Scale 1 : 1000



Columner Section of Coal Seam

Scale 1 : 50 unit: mm

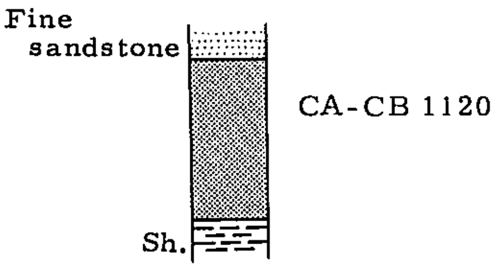
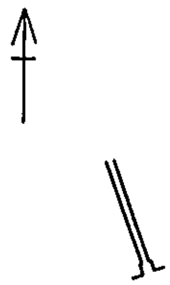
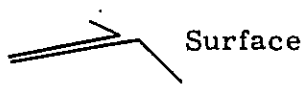


Fig. 5-5 P.M.G. MINE

Scale 1 : 1000

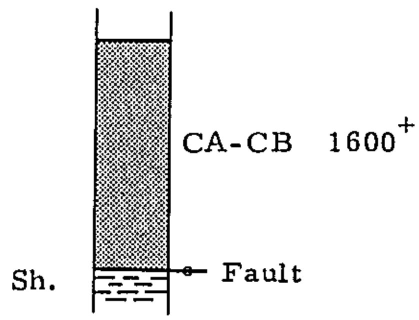


Cross Section



Columner Section of Coal Seam

Scale 1 : 50 unit: mm



(d) P.M.G. Mine

This mine is located at Manlapay and operated by a contractor. Three seams exist and their thickness are 2.0 m, 1.2 m and 0.9 m in descending order. The interval of them are 6 - 7 m each. Strike of the seams are trending east to west and the dip is approximately 30 degrees towards north. Only one entry has been opened and driven about 15 m in length.

The strata is disturbed by fault and a fault is also found at the bottom of the coal seam. (Figure 5-5.)

5-4-2 Present Trend of Coal Mining

Being pressed by oil price, coal industry has been declined steadily, because coal price was not competitive with oil. Therefore annual production was decreased to about 40,000 metric tons from about 160,000 metric tons in the last decade in the Philippines.

However, since a value of coal has been recognized again because of the recent energy crisis, the coal industry recovers consciousness, and they developing new pits or are re-opening old pits to mine the deep coal. On the other hand, there are some new mines which are being planned the systematic development for effective utilization of domestic energy and so forth.

About ten coal mines in four coal regions were investigated this time. These mines are small size which daily production at a mine is ranging 2 to 10 tons and numbers of the employees are 10 to 20.

The coal mining method is so-called Camote Mining. That is, the coal mining is carried out by a kind of room and pillar method from the outcrop or around site. When ventilation or haulage gets difficult, the portal is moved to the next location. Coal only near outcrop is mining in turn by such method.

Two methods are taken to open a portal. One of them is that a 30 to 40 meters long main level entry is driven from neighborhood of the outcrop at along a creek and is intersected the coal seams, then coal being upper and lower than the entry is excavated by development of entries along coal seam. Another method is that a 10 to 15 meters long rock slope is driven at an inclination of 45 to 60 degrees from the top of a small weathered hill and is intersected the coal seam, or a slope along coal seam is driven at steep inclination directly from the outcrop, then upper and lower coal seams are mined. In the latter case, portals are opened at intervals of 15 to 20 meters along the strike of stratum.

As for the mining method, in flat coal seams coal is excavated by driving the wide width of entries along the coal seam; and in steep coal seams upper and lower coal seam near main entry is mined by room and pillar method unsystematically.

In one of mines we investigated pneumatic coal-picks are used for coal winning, and in another mine jack-hammers and other machines at the rental base. In almost of the coal mines, coal winning is carried out by hand-picks.

Material of entry supporting is hemp palm or coconut tree, and the size of entry is 6' x 6'. Entries are supported by three-pieces tunnel set.

Main haulage system in a mine which coal seams are steep is a wooden skip driven by car engine and hoist, and that in another mine is a half size of drum drived by car engine and hoist. In the rest of the mines with steep seams, wooden skips, drums or backets are winded up with a rope by human power. Sluicing method is taken in a mine with flat seam. Underground haulage method in all the mines is carried out by wooden box or wheelbarrows pulled by human power.

Many mines are ventilated by natural ventilation system through a portal for return air provided at 15 meters away from that for haulage, it might be caused by their past bitter experiences. The natural ventilation, however, is not very effective, so that the movement of underground air is only originated by a drum winding for drainage.

Gas quantity is quite unknown. In all the mines we investigated, carbide lamps which are naked lights are used for underground lighting in stead of safety lamps.

As for drainage system, drainage with a drum is carried out just before the coal winning operation is begun. Quantity of water in the mines is judged to be much in general.

Coal from the mines to the consumer is all transported by means of 4 to 6 tons dump trucks. The routes are generally old and rough gravel roads, and some parts of their road are through the shallow along the river. Though transportation cost by truck depends upon the road condition, the cost in a certain mine in Danao Region is 5.3 Cent per ton-kilometer.

As for the skill of the laborers, there is no problem in their technical ability of supporting and so on, it possibly has come from the leading of veterans. We felt them have the moral of laborer.

The depth of coal seam which is mined out is not clear, because of no mine maps and data available, but according to the member of The Bureau of Mines, it is said that coal seam mined out to the depth of 30 meters below the drainage level.

Cost composition varies with the coal region and mining method. According to the coal mines we investigated, the mining by Camoto method is operated at a rate of one set of timbering per shift by three men. Accordingly, the timber price per set is ₱ 1.5, the labor wage is ₱ 8 per shift, three men work in a shift, and the total costs amount to 25.5 Pesos. As the output is 3.4 tons per one set of support, the direct cost comes to 7.5 Pesos per ton. On the other hand, subcontracters receive 15 Pesos per ton from the owner as a contract price by the coal. Needless say, the transportation cost and the mine openning cost are not included in this contract price.

Except this, according to the investigation at the mine under planning to re-develop the old pit to perform the mechanized mining, a standard of coal price per ton at mine for power station is ₱.75 at 10,000 BTU, namely 5,555 Kilocalorie per kilograme, and the cost is summed from the labor cost of 60%, the material cost of 20%, the power cost of 10%, and the expenses of 10%.

As for management organization of coal mine, the owner hire and ask to operate the mine to a subcontractor near the coal region, and its subcontracters are operating the mining works by a kind of a home industry as a superintendent with several to dozens of laborer employed. Besides, there are some mines under planning to systematically develop the deeper zone than the area which mined out by Camote Mining since energy crises. An example of personnel organization in a mine is as follows.

(1) Direct workers

No. 1 Mine	4 men	x 2 men	8
No. 2 Mine	4	x 2	8
No. 3 Mine	4	x 2	8
Old pit maintenance	2	x 2	4
Subtotal			28 men/day

(2) Indirect surface workers

Truck drivers	6
Bulldozer operator	1
Laborers subcontracted	14
Car driver	1
Service man	1
Mechanics	1
Road maintenance	2
Subtotal	26 men/day

(3) Supervisors

Accountants	7
Project engineer	1
Manager	1
Subtotal	9 men
Total	63 men

Remarks ..... A unit of coal mining operation

Coal hewer ....1 men underground

Pickmen, Transport men ....2 men underground

Hoist operator ....1 men surface

Total 4 men

In the case that the output is 50-60 ton/day, the productivity is estimated to be 0.8-1.0 ton/man/day.

Average productivity of the mines we investigated are 0.57 ton/man/day.

Main consumers of coal are:

the Visayan Electric Co. of Cebu City
Universal Cement in Danao City
the APO Cement Co. in Naga, Cebu
the Atlas Mining Co. in Toledo City

VECO is supplied coal mainly from Argao-Dalaguete Region, Universal Cement is supplied from Danao-Compostela Region, APO Cement is supplied from Toledo Region.

As for the other thing, see the Table 5-1 for reference.

5-5 The Results of Coal Analyses

All the samples are high volatile bituminous coal. As compared the analysis results with A.S.T.M., they belong to "High volatile B & C bituminous coal", and are low-carbonized coal with average reflection of 0.44-0.73.

Their ash contents are low, the value of 4.5-11.7%. However, their moisture contents are rather high, those of Base and D.G.G. Mine coal are 5-6%, and those of others are 10-18%.

As for softening temperature of ash, those of Base and M.G.M. Mine coal are more than 1,450°C, and those of solid and D.G.G. Mine coal are about 1,350°C. The latters are lower than the formers, but it is expected that the latter two coals can be used for common boiler as well as the former coals.

Alpaco and P.M.G. Mine coal are less than 1,350°C, so special consideration, such as blending with other high softening temperature coal, is possibly required for common boiler.

As for total sulphur, Base Mine coal is especially high with the value of 3.29%, and M.G.M. Mine coal is especially low with of 0.3%.

Other coals are within a range of 0.7-1.2%.

Percentage of nitrogen are 1.1-1.8, which is not so high compared with Japanese coal.

The F.S.I. and adhesiveness under high temperature are low, so it can be expected that there is no trouble from fusing and setting of coal while burning in stoker.

Concerning to ash composition, by the use of Storach's formular the following index can be obtained.

Sample Name	Storach Index
Solid Mine	2.87
Alpaco Mine	1.56
Base Mine	3.61
D.G.G. Mine	1.00
M.G.M. Mine	6.17
P.M.G. Mine	1.03

As these results show, the samples of M.G.M. Mine, Base Mine and Solid Mine indicate relatively high value of the Storach index and also have high ash-softening-temperature, i.e. 1,350°C or more. Generally speaking, therefore, these coals would have good nature for boiler availability. Although the ash-softening-temperature of D.G.G. Mine coal is relatively high, the lowest value of Storach index in this group is shown.

This would be recommendable that in order to use this coal for steam coal it might be necessary to blend with other high ash-softening-temperature coal as well as the coals of Alpaco Mine and P.M.G. Mine except for the use of slag-tap pulverized-fuel or cyclone furnaces.

Table 5-1 Main Coal Mines in Operation Which Were Investigated

Region	Danao-Compostella	Danao-Compostella	Uling	Toledo	Argao-Dalaguete	Argao-Dalaguete
Name of region	Danao	Danao	Naga	Toledo	Argao	Dalaguete
Name of coal mine	Camansi	Solid Coal Mine Solid Mining	Alpaco Mine No. 1 Bernardo-Ciriaco	Base Mine Base	Don Gill Garcia Don Gill Garcia	Mariano G. Manguerra Lower Garciana
Owner	Aznab	Quadalubic Oguias				
Operator	Contractor	Direct Management	Ierbio D. Rozario	Pilipinas Carbon	Dionisio Yabut	
Date of our visit	Mar, 12, 1974	Mar. 13, 1974	Mar. 14, 1974	Mar. 15, 1974	Mar. 16, 1974	Mar. 17, 1974
Start of production	Jan. 1974	Oct 1973	1953	Dec. 1973	1973	Feb. 1974
Production ton/day	Max. 9 t/d	20t/d (Target of Production; 100 t/d)	6 t/d	30 t/d	8 t/d	25 - 30 ton/shift
No. of shifts per day	3	3 shift/day x 30 days/ month	1 (10 hrs)	2	3	1 (12 hrs)
No. of underground workers	9	15 x 3 = 45	7	60	9	20
No. of surface workers	3	3 x 3 = 9	3	60	3	43
Total	12	54	10	120 (include, super-intendents)	12	63(include sub-controller)
Consumer	Cement		VECO	Atlas mine	VECO	VECO
Coal price ₱/ton	15	12 - 15(9,000 BUT)	80 (10,000 BTU)	75 (10,000 BTU)	75(10,000 BUT)	85(11,000 BTU)
Cost ₱/ton	(Labor cost: 1 ₱/hr. /man)	(Labor cost = 1 ₱/hr. /man)		90₱/t labour 60% material 20 % power 10 % expenses 10 % (administration)		
Coal seam						
Inclination	30°	55° - 60°	30°	5°	70° - 90°	70°
Thickness ft	3' 5' 8'	6'	4.5' - 7'	3.5'	6'	6'
Numbers	3	1	5	2	1	2
Unit cost of support	₱ 0.5/7'	₱ 1.5/14'	₱ 3.5/18'	₱ 5/8'	-	₱ 0.8/6'
Supporting	1/shift	-	-	-	-	-
Entry size	1.5 m x 1.5 m	1.5 m x 1.5 m	1.2 m x 1.2 m	3.5 ft x 4 ft	6 ft x 6 ft	6 ft x 6 ft
Distance from the portal	32 m (level)	200'(45° - 70°)	144'(vertical shaft)	700 m	48 m (level)	19 m (slope)
Haulage	Human power	90 HP car engine x wooden skip	Jeep engine, head frame	Sluicing	Wheelbarrow	Car engine
Ventilation	No facilities	Upcast shaft	Upcast shaft	Upcast shaft	No facilities	No facilities
Drainage	No facilities	Drainage with a drum through the shaft	0.3 m^3/m/min	Natural drainage	Much water	72 m^3/shift Drainage by drum through shaft in 10m
Transportation Method to the consumer	4 ton truck 11 Km to town	Truck	Truck cost: 15 ₱/t(35km)	Truck	Truck 5 Km to main road	Truck
Miscellaneous	Roof & floor are soft. Pit mouth is provided along a swamp. 5 Km transportation road is a shallow of a river. So, the transportation is impossible in rainy season.	For compressor, coal picks and 4 rock drills rental fee: 90 P/month Fuel: 70 1/24 hrs. Diesel oil: ₱ 0.8/1	Rental fee of a hoist: 90P/month 25 Km distance off Cebu-City	Coal pick mining in 3.5 m face. Underground layout is bad. Target of the production is 100 t/day. 25 Km distance off Cebu-City	Lump size 30 x 20 cm 35 x 20 cm 40 x 20 cm (Max.)	3 portals There are problems in the transportation and drainage. Also there is a worked out area

Table 5-2 Analytical Results of Coal by Regions and Areas

Apr. 27th 1974

Region	Mine	Sample	Proximate				Ultimate (Dry Ash Free)						Calorific Value K-Cal/Kg	Free Swell	Hardgrove Grindability	Rank	Fusion Temp of Ash (H= 1/2 W)	Total Sulphur
			Moist.	Vol. Matter	Fixed Carbon	Ash	Hydro-gen	Carbon	Nitro-gen	Oxigen	Sulphur	(Ash)						
Danao-Compostela	Solid	Face	16.6	43.8	31.0	8.6	5.4	74.4	1.6	17.6	1.0	-	5,410	0	66	High vol. C bit	1,350	1.00
Uling	Alpaco	R.O.M.	18.0	41.7	30.8	9.5	5.5	74.5	1.4	18.1	0.5	-	5,210	0	75	High vol. C bit	1,255	1.01
*Teledo (F. 1.3)	Base	Face	5.7	39.8	44.7	9.8	5.6	76.1	1.1	13.4	3.8	-	6,470	1 1/2	73	High vol. B bit	1,450	3.29
Argao-Dalaguete	D.G.G.	Face	5.4	43.3	46.8	4.5	5.8	79.0	1.6	12.6	1.0	-	7,040	1/2	67	High vol. B bit	1,335	1.13
Argao-Dalaguete	M.G.M.	Face	9.7	35.6	43.0	11.7	5.4	77.3	1.6	15.5	0.2	-	5,780	0	72	High vol. B bit	+1,450	0.31
Argao-Dalaguete	P.M.G.	Face	9.4	39.8	47.4	3.4	5.5	77.8	1.8	14.3	0.6	-	6,640	0	80	High vol. B bit	1,215	0.67

* Float 1.8 product was tested. Recovery = 72.5%

Table 5-3 Test Report

Date: Apr. 3 to May 1, 1974

Sample Number	Sample Name	Fusion Temperature° C		
		Initial Deform	Softening (H=1/2 W)	Fluid
142	Danago Compostela Solid Mine	1,310	1,350	1,370
143	Uling Alpaco Mine	1,235	1,255	1,285
146	Toledo Base Mine	1,430	1,450	+1,450
147	Arago-Dalaguete D.G.G. Mine	1,250	1,335	1,360
148	Aragao-Dalaguete M.G.M. Mine	+1,450	+1,450	+1,450
149	Aragao-Dalaguete P.M.G. Mine	1,190	1,215	1,280

Table 5-4 Test Report

Date: Apr. 3 to June 28, 1974

Sample Name	Mineral Analysis of Ash (%)										
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	P_2O_5	TiO_2	Total
Solid Mine	36.9	27.85	11.16	9.36	2.02	0.40	0.15	5.72	1.74	1.55	96.85
Alpaco Mine	28.5	18.08	12.42	13.80	3.63	2.85	0.50	16.00	Trace	0.85	96.63
Base Mine	48.4	24.81	16.61	2.92	0.77	0.45	1.10	1.00	Trace	2.22	98.28
D.G.G. Mine	20.0	20.82	15.46	21.87	4.31	0.45	0.15	11.25	0.79	0.95	96.95
M.G.M. Mine	77.8	3.58	5.91	5.83	1.45	0.12	0.10	3.80	Trace	0.22	98.81
P.M.G. Mine	34.3	8.32	28.38	9.59	3.47	0.15	0.25	12.52	Trace	0.52	97.50

PETROGRAPHIC ANALYSIS Table 5-5

Name of Coal Solid Mine

Date of Sampling MAR. 13, 1974
Date of Arrival APR. 3, 1974

Descriptor

		Petrographic Analysis	
Reactive Entities	Vitrinoid Types	1	
		2	
		3	5.8
		4	63.7
		5	2.9
		6	
		7	
		8	
		9	
		10	
		11	
		12	
		13	
		14	
		15	
		16	
		17	
		18	
		19	
		20	
		21	
		Vitrinoids	72.4
		1/3 S. Fus.	
		Resinoids	
		Exinoids	1.8
		Total Reactives	74.2
Inert Entities		Fusinoids	
		2/3 S. Fus.	
		Micrinoids	21.7*
		Min. Matter	4.1
		Total Inerts	25.8
		Mean Refl.	0.449
		Strength Index	2.14
		Comp. Balance Index	1.40
		Calculated Strength	0

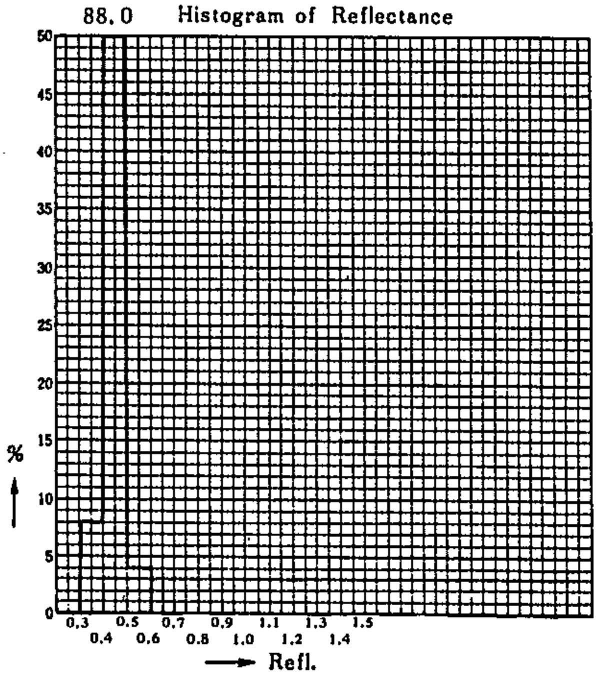
* Included weathered 14.9%

Aproximate Analysis		
Moisture	16.6	%
Volatile Matter	43.8	%
Fixed Carbon	31.0	%
Ash	8.6	%
Sulphur	1.0	%
F.S.I	0	
Cal	5410	Kcal/kg

Ultimate Analysis		
C	74.4	%
H	5.4	%
O	17.6	%
N	1.6	%
S	1.0	%

Gieseler Plastometer	
Maximum Fluidity	DDPM
Softening Temperature	℃
Maximum Fluid Temperature	℃
Solidification Temperature	℃
Range	℃

88.0 Histogram of Reflectance



PETROGRAPHIC ANALYSIS

Table 5-6

Name of coal Alpaco Mine

Date of Sampling MAR. 14, 1974
Date of Arrival APR. 3, 1974

Descriptor

		Petrographic Analysis	
Reactive Entities	Vitrinoid Types	1	
		2	
		3	7.9
		4	71.2
		5	
		6	
		7	
		8	
		9	
		10	
		11	
		12	
		13	
		14	
		15	
		16	
		17	
		18	
		19	
		20	
		21	
		Vitrinoids	79.1
		1/3 S. Fus.	
		Resinoids	
		Exinoids	4.2
		Total Reactives	83.3
Inert Entities		Fusinoids	
		2/3 S. Fus.	
		Micrinoids	12.1*
		Min. Matter	4.6
		Total Inerts	16.7
		Mean Refl.	0.429
		Strength Index	2.37
		Comp. Balance Index	0.81
		Calculated Strength	2

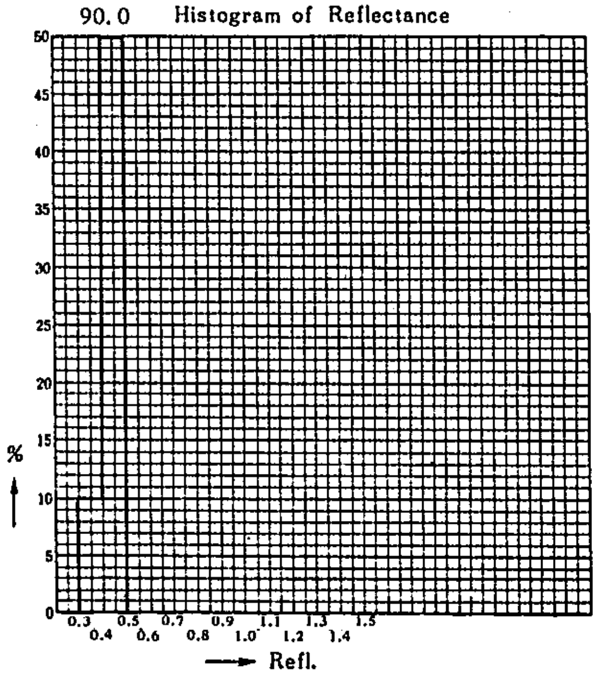
* Included weathered 5.1%

Aproximate Analysis		
Moisture	18.0	%
Volatile Matter	41.7	%
Fixed Carbon	30.8	%
Ash	9.5	%
Sulphur	1.0	%
F.S.I	0	
Cal	5210	Kcal/kg

Ultimate Analysis		
C	74.5	%
H	5.5	%
O	18.1	%
N	1.4	%
S	0.5	%

Gieseler Plastometer		
Maximum Fluidity		DDPM
Softening Temperature		℃
Maximum Fluid Temperature		℃
Solidification Temperature		℃
Range		℃

90.0 Histogram of Reflectance



PETROGRAPHIC ANALYSIS Table 5-7

Name of Coal Base Mine

Date of Sampling MAR. 15, 1974
Date of Arrival APR. 3, 1974

Descriptor

		Petrographic Analysis	
Reactive Entities	Vitrinoid Types	1	
		2	
		3	
		4	
		5	29.8
		6	56.0
		7	1.8
		8	
		9	
		10	
		11	
		12	
		13	
		14	
		15	
		16	
		17	
		18	
		19	
		20	
		21	
		Vitrinoids	87.6
		1/3 S. Fus.	
		Resinoids	
		Exinoids	3.0
		Total Reactives	90.6
Inert Entities		Fusinoids	
		2/3 S. Fus.	
		Micrinoids	4.7*
		Min. Matter	4.7
		Total Inerts	9.4
		Mean Refl.	0.608
		Strength Index	2.45
		Comp. Balance Index	0.35
		Calculated Strength	1.2

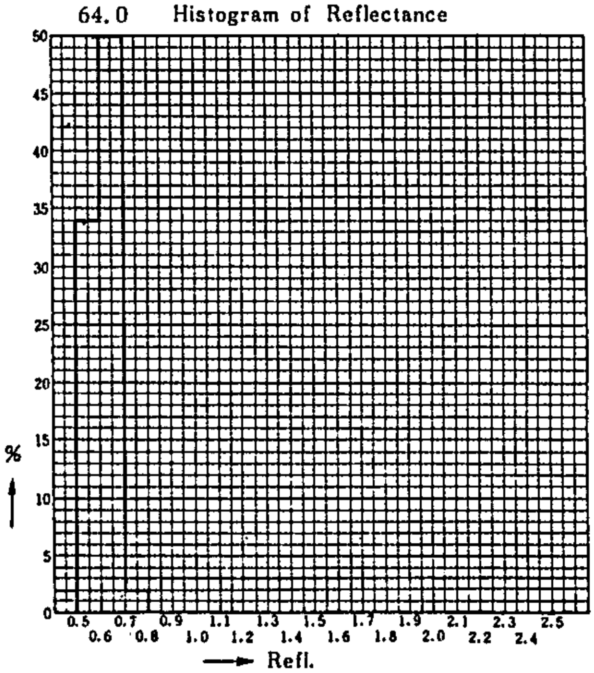
* Included weathered 1.0%

Aproximate Analysis		
Moisture	5.7	%
Volatile Matter	39.8	%
Fixed Carbon	44.7	%
Ash	9.8	%
Sulphur	3.3	%
F.S.I	1.5	
Cal	6470	Kcal/kg

Ultimate Analysis		
C	76.1	%
H	5.6	%
O	13.4	%
N	1.1	%
S	3.8	%

Gieseler Plastometer	
Maximum Fluidity	DDPM
Softening Temperature	℃
Maximum Fluid Temperature	℃
Solidification Temperature	℃
Range	℃

64.0 Histogram of Reflectance



PETROGRAPHIC ANALYSIS

Table 5-8

Name of Coal D. G. G. Mine

Date of Sampling MAR. 16, 1974
Date of Arrival APR. 3, 1974

Descriptor

		Petrographic Analysis	
Reactive Entities	Vitrinoid Types	1	
		2	
		3	
		4	0.9
		5	24.8
		6	61.1
		7	1.8
		8	
		9	
		10	
		11	
		12	
		13	
		14	
		15	
		16	
		17	
		18	
		19	
		20	
		21	
		Vitrinoids	88.6
		1/3 S. Fus.	
		Resinoids	
		Exinoids	4.4
		Total Reactives	93.0
Inert Entities		Fusinoids	
		2/3 S. Fus.	
		Micrinoids	4.8*
		Min. Matter	2.2
		Total Inerts	7.0
		Mean Refl.	0.613
		Strength Index	2.39
		Comp. Balance Index	0.26
		Calculated Strength	0

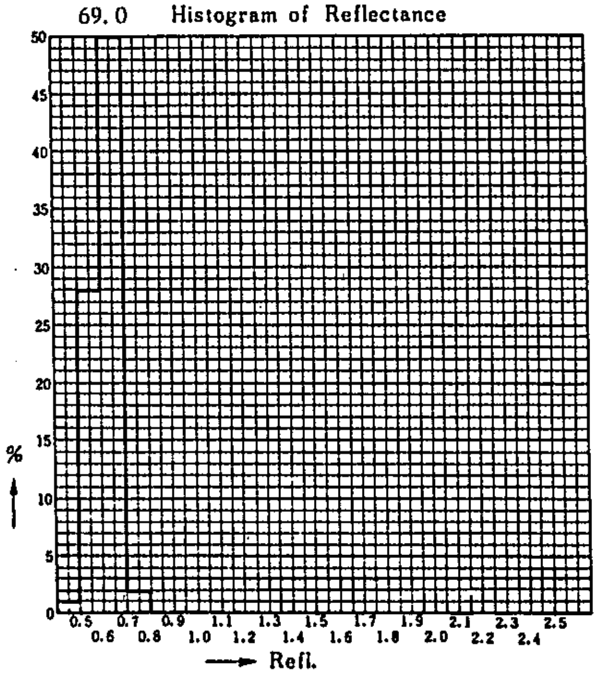
* Included weathered 3.1%

Aproximate Analysis		
Moisture	5.4	%
Volatile Matter	43.3	%
Fixed Carbon	46.8	%
Ash	4.5	%
Sulphur	1.1	%
F.S.I	0.5	
Cal	7040	Kcal/kg

Ultimate Analysis		
C	79.0	%
H	5.8	%
O	12.6	%
N	1.6	%
S	1.0	%

Gieseler Plastometer	
Maximum Fluidity	DDPM
Softening Temperature	℃
Maximum Fluid Temperature	℃
Solidification Temperature	℃
Rango	℃

69.0 Histogram of Reflectance



PETROGRAPHIC ANALYSIS Table 5-9

Name of Coal M. G. M. Mine

Date of Sampling MAR. 17, 1974
Date of Arrival APR. 3, 1974

Descriptor

		Petrographic Analysis	
Reactive Entities	Vitrinoid Types	1	
		2	
		3	
		4	1.4
		5	44.0
		6	26.6
		7	
		8	
		9	
		10	
		11	
		12	
		13	
		14	
		15	
		16	
		17	
		18	
		19	
		20	
		21	
		Vitrinoids	72.0
		1/3 S. Fus.	
		Resinoids	
		Exinoids	4.7
		Total Reactives	76.7
Inert Entities		Fusinoids	
		2/3 S. Fus.	
		Micrinoids	17.8*
		Min. Matter	5.5
		Total Inerts	23.3
		Mean Refl.	0.577
		Strength Index	2.45
		Comp. Balance Index	1.08
		Calculated Strength	3

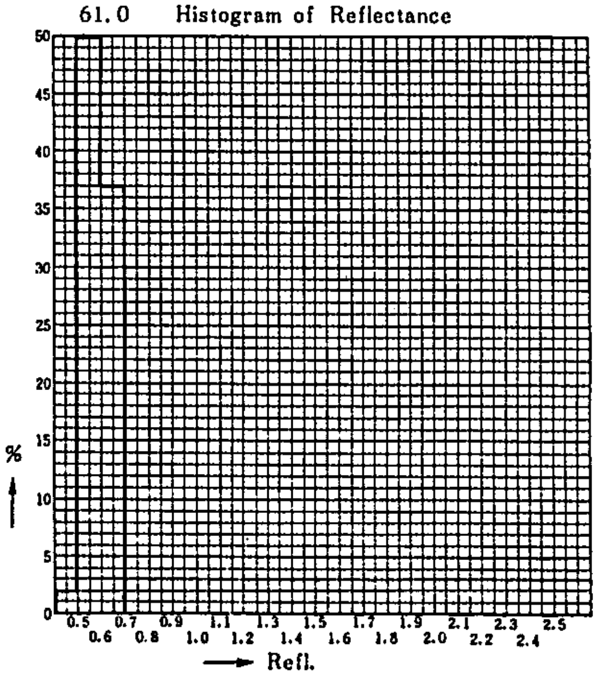
* Included weathered 16.3%

Aproximate Analysis		
Moisture	9.7	%
Volatile Matter	35.6	%
Fixed Carbon	43.0	%
Ash	11.7	%
Sulphur	0.3	%
F.S.I	0	
Cal	5780	Kcal/kg

Ultimate Analysis		
C	77.3	%
H	5.4	%
O	15.5	%
N	1.6	%
S	0.2	%

Gieseler Plastometer	
Maximum Fluidity	DDPM
Softening Temperature	℃
Maximum Fluid Temperature	℃
Solidification Temperature	℃
Range	℃

61.0 Histogram of Reflectance



PETROGRAPHIC ANALYSIS Table 5-10

Name of Coal P. M. G. Mine

Date of Sampling MAR. 18, 1974
Date of Arrival APR. 3, 1974

Descriptor

		Petrographic Analysis	
Reactive Entities	Vitrinoid Types	1	
		2	
		3	
		4	
		5	52.7
		6	39.8
		7	
		8	
		9	
		10	
		11	
		12	
		13	
		14	
		15	
		16	
		17	
		18	
		19	
		20	
		21	
		Vitrinoids	92.5
		1/3 S. Fus.	
		Resinoids	
		Exinoids	2.5
		Total Reactives	95.0
Inert Entities		Fusinoids	
		2/3 S. Fus.	
		Micrinoids	3.3*
		Min. Matter	1.7
		Total Inerts	5.0
		Mean Refl.	0.586
		Strength Index	2.32
		Comp. Balance Index	0.19
		Calculated Strength	0

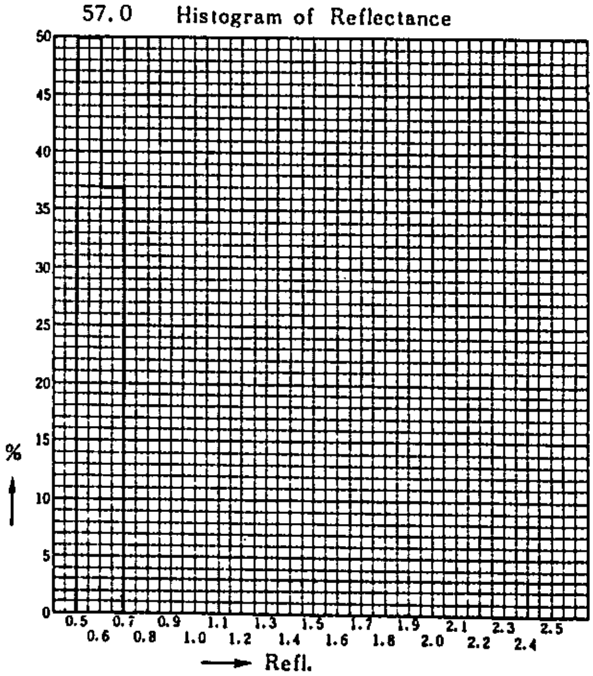
* Included weathered 0.8%

Aproximate Analysis		
Moisture	9.4	%
Volatile Matter	39.8	%
Fixed Carbon	47.4	%
Ash	3.4	%
Sulphur	0.7	%
F.S.I	0	
Cal	6640	Kcal/kg

Ultimate Analysis		
C	77.8	%
H	5.5	%
O	14.3	%
N	1.8	%
S	0.6	%

Gieseler Plastometer	
Maximum Fluidity	DDPM
Softening Temperature	℃
Maximum Fluid Temperature	℃
Solidification Temperature	℃
Range	℃

57.0 Histogram of Reflectance



CHAPTER 6

COAL MINE DEVELOPMENT PLAN AND IT'S COST ESTIMATION

CHAPTER 6. COAL MINE DEVELOPMENT PLAN AND IT'S COST ESTIMATION

6-1 Development Plan of Underground

6-1-1 Fundamental Matters of the Mine Development Planning

Mine development plan including estimation of capital expenditure and production cost should be made after the geological conditions are proven by means of exploration and geological investigation including drilling.

It was too difficult to make the development plan, because our investigation was in reconnaissance survey stage, so that this plan was made on the assumption as follows.

(1) There are four main coal regions in Cebu Island, but Argao-Dalaguete is only region where geological maps are available although those are not enough for development planning. Accordingly, the study was made for a field of the region, where coal seams are assumed to be comparatively continuous.

(2) As it is described in "Present Trend of Coal Mining", coal mining has been carried out in many places from old time by Camote Mining Method. As it was expected that upper and lower zone up to 30 m deep from drainage level might have been possibly mined by Camote Mining, these zones should be excluded from object of the systematic mining.

Besides, zone between -30m and -50m level should be remained as a safety pillar for water protection.

Consequently, coal seams up to 50 m deep from the drainage level are excluded from objective area of mining in this study.

(3) Judging from short continuation of the coal seams in strikeward of stratum, it is expected that their continuation in the direction of the dip is also short. Accordingly, it was planned that coal reserves between -50 m and -100 m level are to be mined on a basis of coal reserves estimation published by Bureau

of Mines of Philippine in 1957.

Conditions of coal seams deeper than -100 m level should be firmed by further detailed survey in the future. Main slopes are planned to be provided under and along the coal seams to be mined in order to be able to continue the operation even if large quantity of coal reserves are confirmed at the deeper zone.

(4) This development plan was made on premises that the length of coal seams in the direction of strike is 1,000 m, and average dip angle and average working thickness of the coal seams is 60° and 1.2 m respectively.

(5) Distance of surface road to be rehabilitated is assumed to be 5 Km.

(6) As for electric facility, a substation (1,000 KVA) and a power transmission line (15 Km) are planned.

(7) In estimation of costs, all the equipments and some parts of the supplies are regarded as the imported from Japan. After consideration of ocean freights from Japan to Manila City and from Manila City to Cebu City, cargo handling charge, overland freight in Cebu Island and other expenses, prices of the equipments are estimated 1.5 times as much as the prices in Japan.

(8) Working days are regarded as 300 days per annum.

(9) On the depreciation, expenditure for development of underground entries and indirect investment are depreciated by the unit of production method and other investments are depreciated by respective useful life established in Japan.

(10) Expenses for installation works of surface equipment are included in indirect investment.

6-1-2 Mine Opening Method

In this development study, objective coal reserves of mining are three coal seams, named A, B and C seam in Fig. 6-1, within the limit from -50 m level to -100 m level.

A main slope is driven in another coal seam as shown in Fig. 6-1, which seam is under and 70 m distant from C seam. Gradient of the main slope is 25°, the sectional area is 11.3 m^2 and the length is 300 m.

Crosscuts are driven from points of -50 mL and -100 mL on the main slopes, and they each intersect A seam after 110 m long crosscut driving.

After that, upper level for return air and filling material, and lower level for intake air and transportation are driven along the coal seam from the intersecting points. Sublevel is driven in the coal seam about 10 m above the lower level, and a working face is provided between the sublevel and the upper level, as shown in Fig. 6-1.

6-1-3 Production Scale

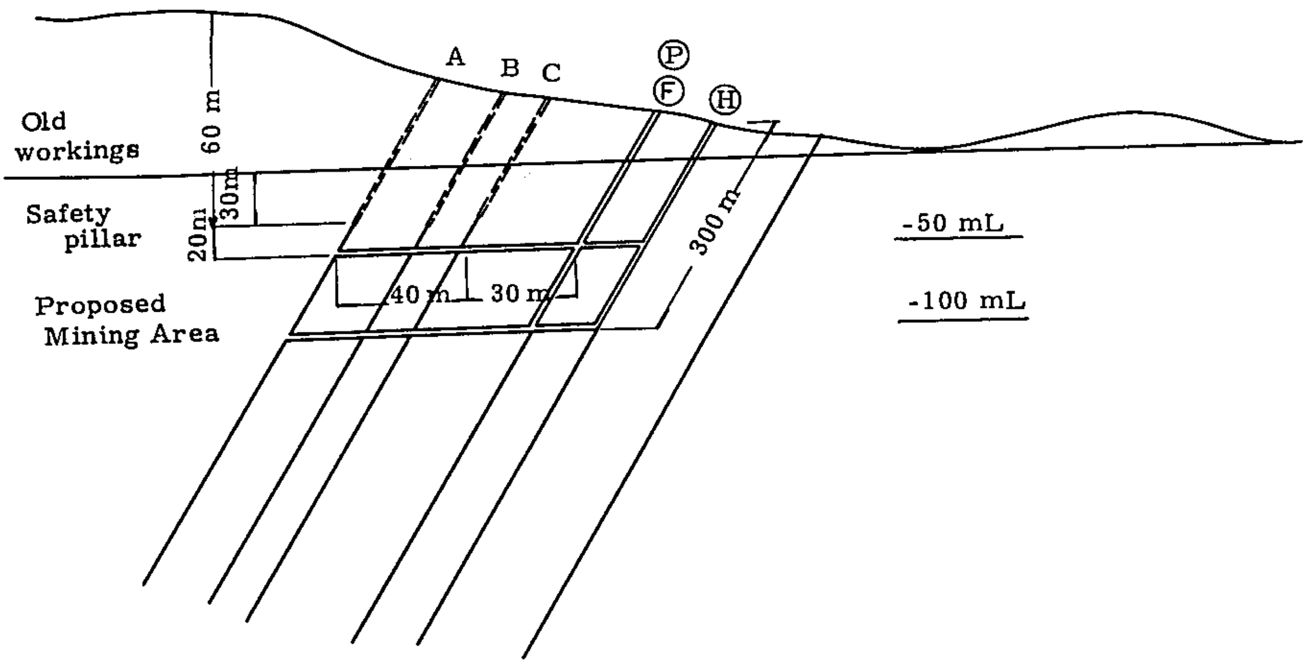
Recoverable coal reserves in proposed mining area become 47,000tons per seam in case of presumption in geological condition that length of the area in the direction of strike is 1,000 m, average working thickness of the coal seam is 1.2 m, length of the working face in the direction of true dip is 40 m, specific gravity of raw coal is 1.4 and mining recovery of coal reserves in the face is 70%. In case that three coal seams are mined, the recoverable coal reserves totals 156,000 tons including coal production from entry driving.

When development of new coal mine is planned, the mine life is usually expected about 15 years. If coal reserves here is mined for 15 years, output per day is only 30 ton. Meanwhile, because a 50,000 Kw thermal power plant is required at least 200 tons of coal per day when coal is used in the ratio of 50% out of fuel, many coal mines are necessary for the power plant. For this reason, production capacity of this mine was decided at 200tons per day. In this case, operation life of the proposed area is 2.6 years.

Because of steep seam, it is unable to work for many miners in a working face at a time, It is considered that max. number of workers in a face are 8 to 9 at the most, and the productivity may be about 10 to 11tons per man (for reference, the productivity in Mitsui-Ashibetsu,in

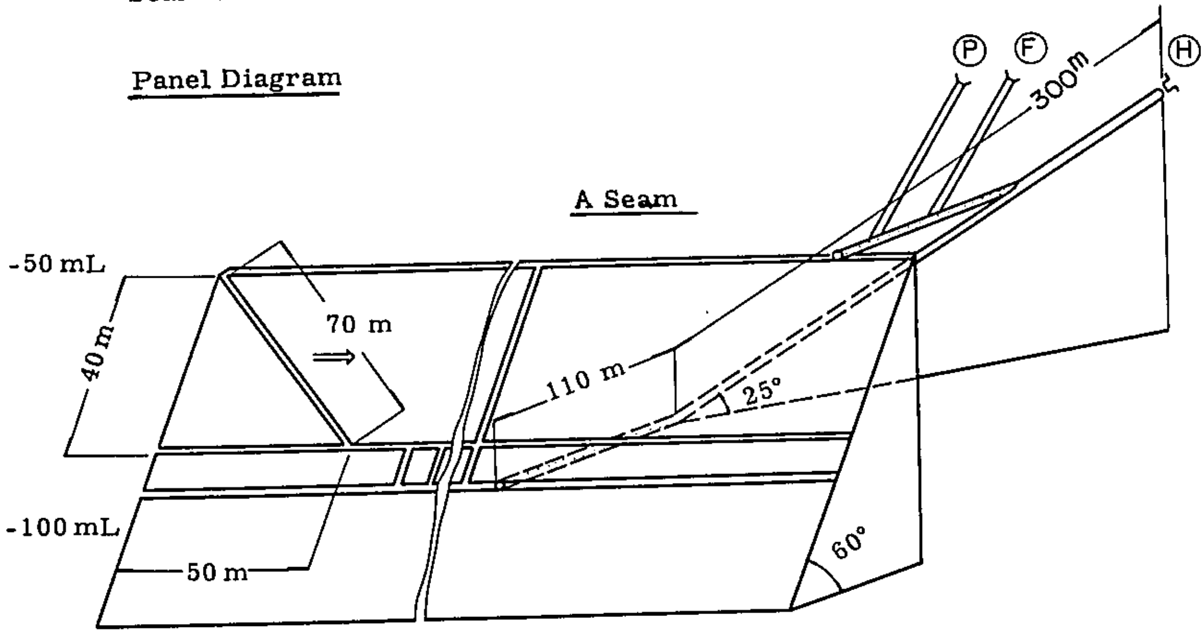
Japan is 16.5 ton per day). Accordingly, output per face is 180 tons per day in two shift works. Supposing that coal from the entry driving is 10% of total output, daily output is 200 tons, and annual production is 60,000 tons.

Fig. 6-1 SKELTON OF MINING STRUCTURE



Inclination 60°
Seam thickness 1.2m

Panel Diagram



6-1-4 Development Schedule

Table 6-1 Development Schedule

Periods	1st year	2nd year	3rd year	4th year	5th year
Exploration	——— 3 months				
Road reparing	——— 6 months				
Site	——— 6 months				
Underground development	———	———			
Production			200MT/d	200MT/d	200MT/d
Underground & Surface Equipment	———	———			

6-1-5 Underground Development Schedule

(1) Schedule

Table 6-2 Schedule

	1st year	2nd year
Winding house		
Main slope	300 m	
Main upcast slope	50 m	50 m
-50 mL crosscut	110 m	
-50 mL level entry		600 m
-100 mL crosscut	55	55
-100 mL level entry		500 m
Ventilation slope		50m
Working face and others		200
Slope for filling materilas		
Pump station & others		
Total	515 m	1, 535 m
Total production	75 MT	6, 010 MT

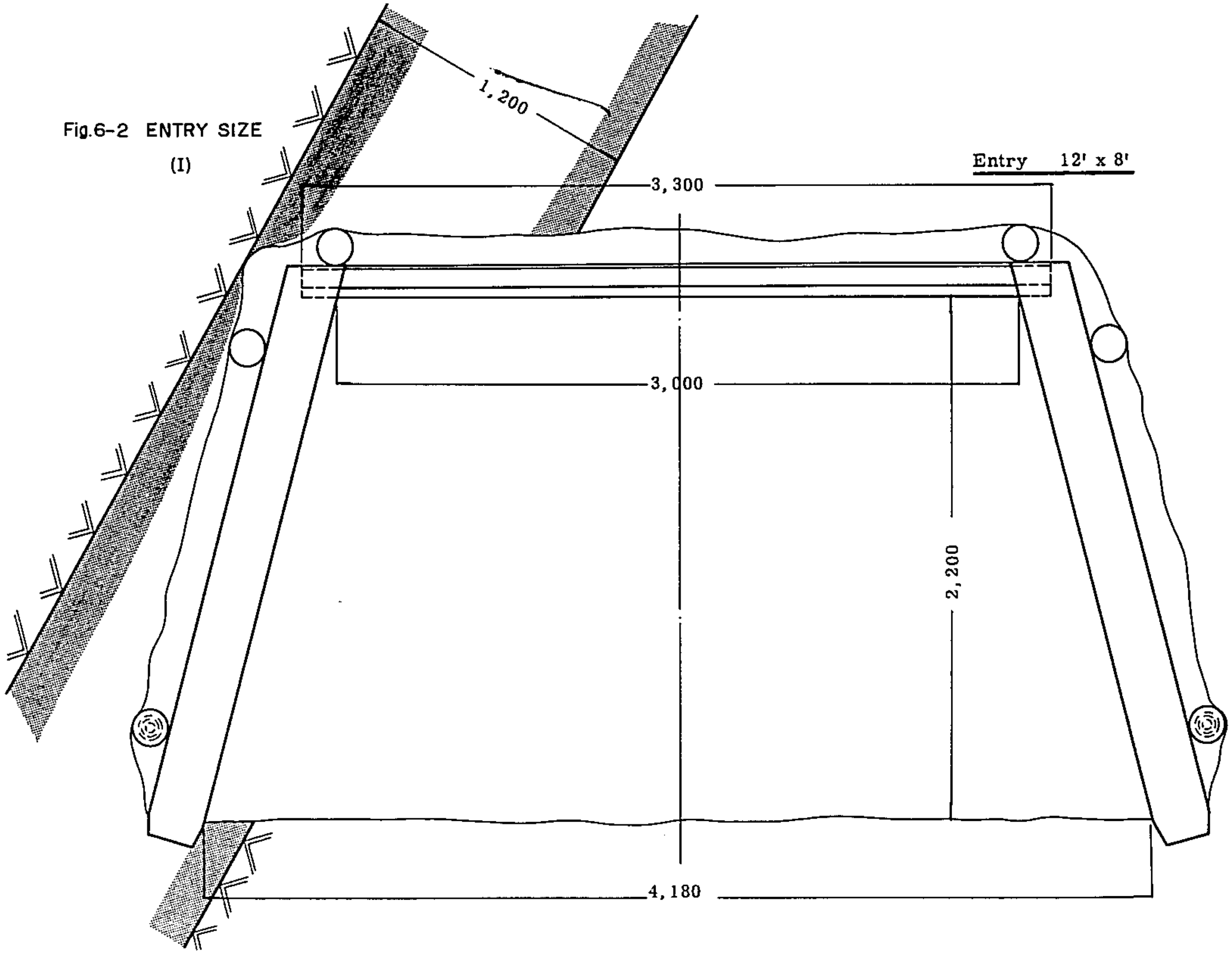
(2) Advancing Rate of Entry

Table 6-3 Advancing Rate of Entry

Name of Entry	Length (m)	Sectional Area (m^2)	Advance per day (m/day)	The day required (days)	The month required (months)	Production (MT)
Main slope	300	11.3	1.5	200	8.0	-
-50mL cross cut	110	7.8	2.0	55	2.2	-
-100mL cross cut	110	7.8	2.5	44	1.8	-
Main upcast slope	100	7.8	1.0	100	4.0	150
Ventilation slope	50	7.8	2.0	25	1.0	75
Material filling slope	80	7.8	2.0	40	1.6	-
-50mL level entry	(550 50	7.8 11.3	3.4 2.0	162 25	6.5 1.0	- 2,700
-100mL level entry	(450 50	7.8 11.3	3.4 2.0	132 25	5.3 1.0	- 2,250
Pocket & man way	30	5.0	4.0	8	0.4	135
Sub level	100	5.0	4.0	25	1.0	450
Face	70	5.0	4.0	18	0.7	325
Other entry (including Pump station)	(40)	(11.3)	(2.0)	(20)	(1.0)	
Total $11.3m^2$ 7.8 5.0		400 1,450 200				
Total		2,050				6,085

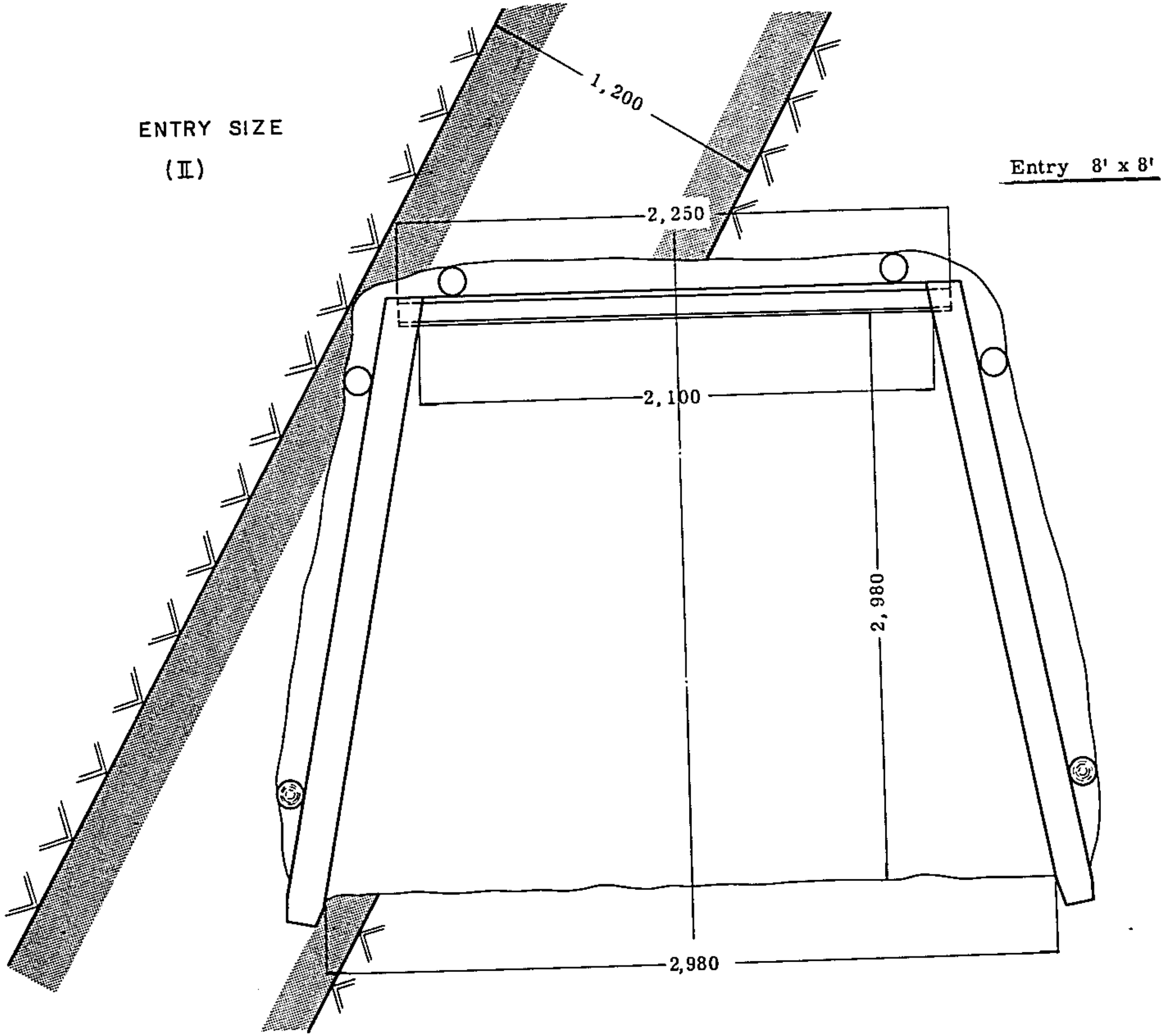
Fig.6-2 ENTRY SIZE

(I)



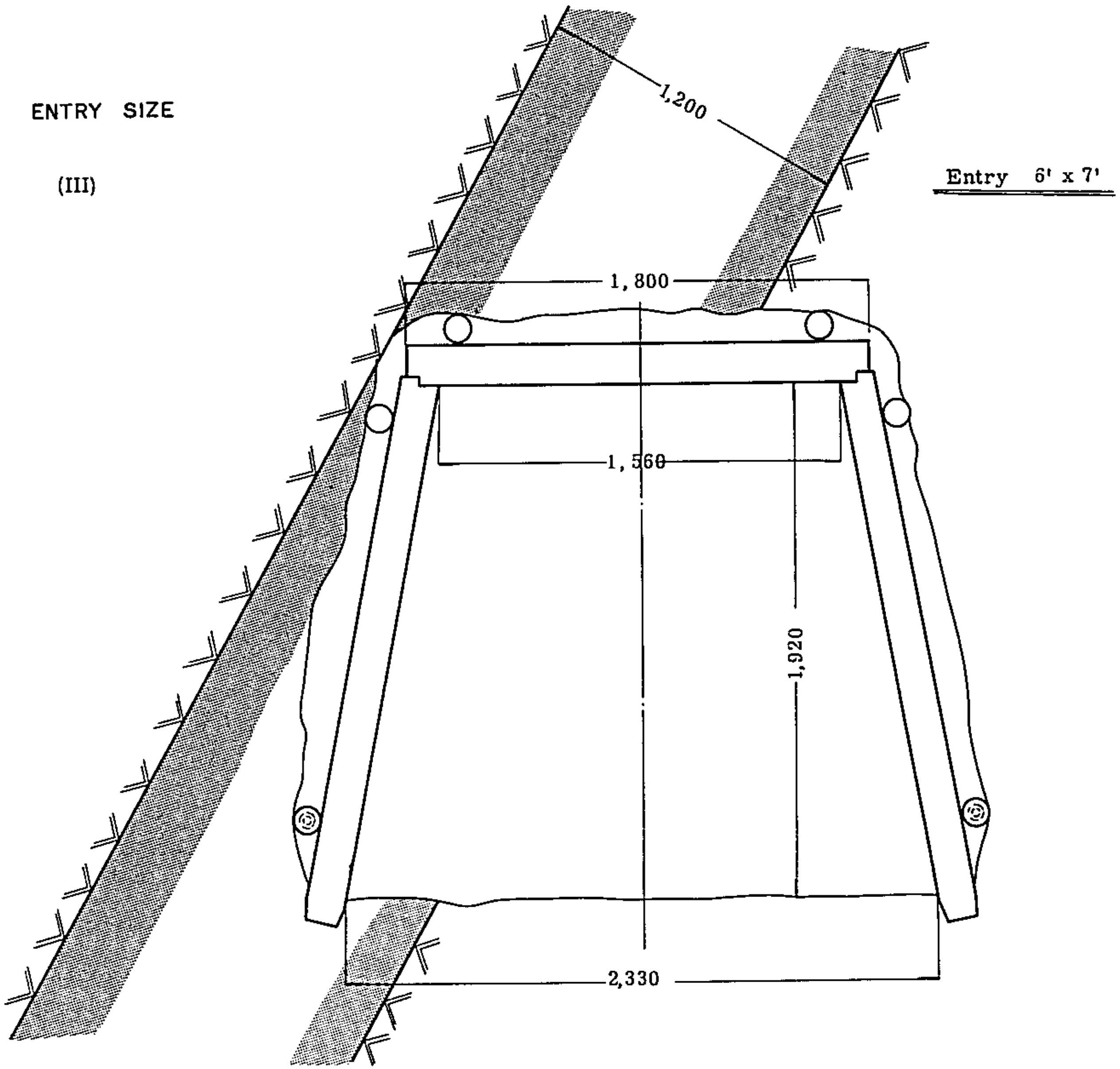
ENTRY SIZE (II)

Entry 8' x 8'



ENTRY SIZE

(III)



6-1-6 Coal Mining System

(1) Most suitable mining system

Qualitative comparison of various mining systems which are able to apply to steep coal seams and it's adaptability is shown in Table 6-4.

As a result of this comparison, longwall system with timber props and caving method and face along true dip and longwall system with diagonal face to dip are considered to be suitable for mining in this area.

Next, in comparison of two methods "longwall system with packing and diagonal face to dip" is easy and safe of the works. Moreover, judging from geological maps, the proposed mining area is expected to have many minor faults, and according to the rock test, strength of rock of the roof is low.

For these reasons, "longwall system with packing and diagonal face to dip" is considered to be most suitable for the proposed mining area.

Table 6-4 Qualitative Comparison of Various Mining System

	Limit of working thickness of coal seam	Adaptability for change of thickness of coal seam	Strength of roof required	Coal reserves enough for depreciation	Skill of workers
Hydraulic mining system	Over 3.5m X	Adaptable O	Strong X	Required X	Not required so much △
Longwall system with self-advancing supports	From 1.5m to 2.5 m X	Difficult to adapt X	Strong a little △	Required X	Required X
Longwall system with hydraulic steel props	ditto X	ditto X	ditto △	ditto X	ditto X
Longwall system with timber props, caving method and face along true dip	Over 0.75 m O	Adaptable O	ditto △	Not required O	Not required so much △
Longwall system with packing and diagonal face to dip	ditto O	ditto O	ditto △	ditto O	Not required O

Mark: O : Suitable △ : Suitable with proviso X : Unsuitable

Note: 1) Above marks are applied in the case of 1.2 m of average thickness of coal seam.

2) "face along true dip" means that face line is parallel to the dip of the coal seam. "diagonol face to dip" means that face line is at some angle of less than 90° with the dip.

(2) Hardness of the coal

A. Hardness testing results of coals by EGD-AN method, which samples were sent from the mines we investigated in Philippine, were as follows:

	h m/m	f4	FD
Solid Mine	84.5	1.22	18.9
Alpaco Mine No. 1	108.3	0.95	24.2
Alpaco Mine No. 4	103.5	1.00	23.0
Base Mine No. 1	95.5	1.07	21.5
Base Mine No. 2	116.5	0.88	26.1
D.G.G. Mine	104.7	0.98	24.5
M.G.M. Mine	107.0	0.96	24.0
P.M.G. Mine	96.5	1.07	21.5
Average		1.02	22.5

B. Friability

Following formula on the relation between friability (FD) and value of f4 by EGD-AN method was published by The Coal Mining Research Centre, Japan.

$$f4 \times FD = 23$$

The friability (FD) mentioned above was calculated with this formula and values of f4.

C. Selection of coal breaking system

Coal breaking system suitable by hardness of coal are as follows.

System	FD (Friability)	
Blasting	< 25	for semi-hard & hard coal seam
Coal cutter	15 - 45	for coal seam from semi-hard to semi-soft
Drum cutter	25 - 45	for medium & semi-soft coal
Coal pick	> 25	for coal seam from medium to soft
Coal plough	> 35	for soft coal seam

The values of FD of the samples gotten from the mines in Philippine are between 18.9 and 26.1, and 22.5 on the average.

Judging from these data, most suitable coal breaking method for these mines are thought to be mining by blasting.

D. Measuring by EGD-AN method

1) Five 75 gram samples are prepared, which consist of coal particles which size are 12 x 25 mm on average.

2) Each sample is put into a vessel, and is covered with a tube. A 2.4 Kg weight is dropped five times from a fixed height of 60 cm onto the sample.

3) After the above operation is carried out for each of five samples, all samples are put together and are classified with a seive with 0.5 mm opening. The undersize is put into a 23 mm cylindrical capacity meter, and its apparent volume is measured by inserting a small piston marked with mm-scale.

4) In order to eliminate the screening error by removing the individual difference on the volume of the undersize obtained, the screening is carried out for about a minute with a minute sandglass and by using a simple vibrator. Rough measuring method, which the undersize in a standard shieve is vibrated by hand for a minute, can be used for the treatment mentioned above.

5) Hardness index are given through a following experimental formula.

$$f = \frac{103}{l}$$

l (mm) = a length equivalent to the apparent volume shown on the scale of the capacity meter.

If the coal to be measured is very soft, a weight can be dropped only two or three times onto the sample.

When rock like the parting is measured, the number of times of the weight dropping can be increased up to ten times. In this case, a following formula must be used to get the hardness index.

$$f = \frac{20 \times n}{l}$$

n: number of times of the weight dropping

Note: The value of f is nearly equivalent to 1/100 to 1/150 of the compression strength (Kg/cm^2) of a 3 cm cube sample.

(3) Rock test

Although they are short in volume to judge the character of the roof, samples of rock of the roof, which were taken from the four mines in the coal areas we investigated, were tested at Tachikawa Laboratory of Sancoh Consultant Co., Ltd.

The test results are shown in Table 6-5, and the testing methods and our observations to the results are described as follows, with an additional remarks that the samples were sent in bad packing from the Philippines to Japan and their preserving conditions were imperfect.

A. Rock test method

Supersonic waves propagation velocity test ----- P-waves and S-waves at the natural state.

Uniaxial compression test ——> at the natural state

Apparent specific gravity test

Water absorption test

Effective porosity test

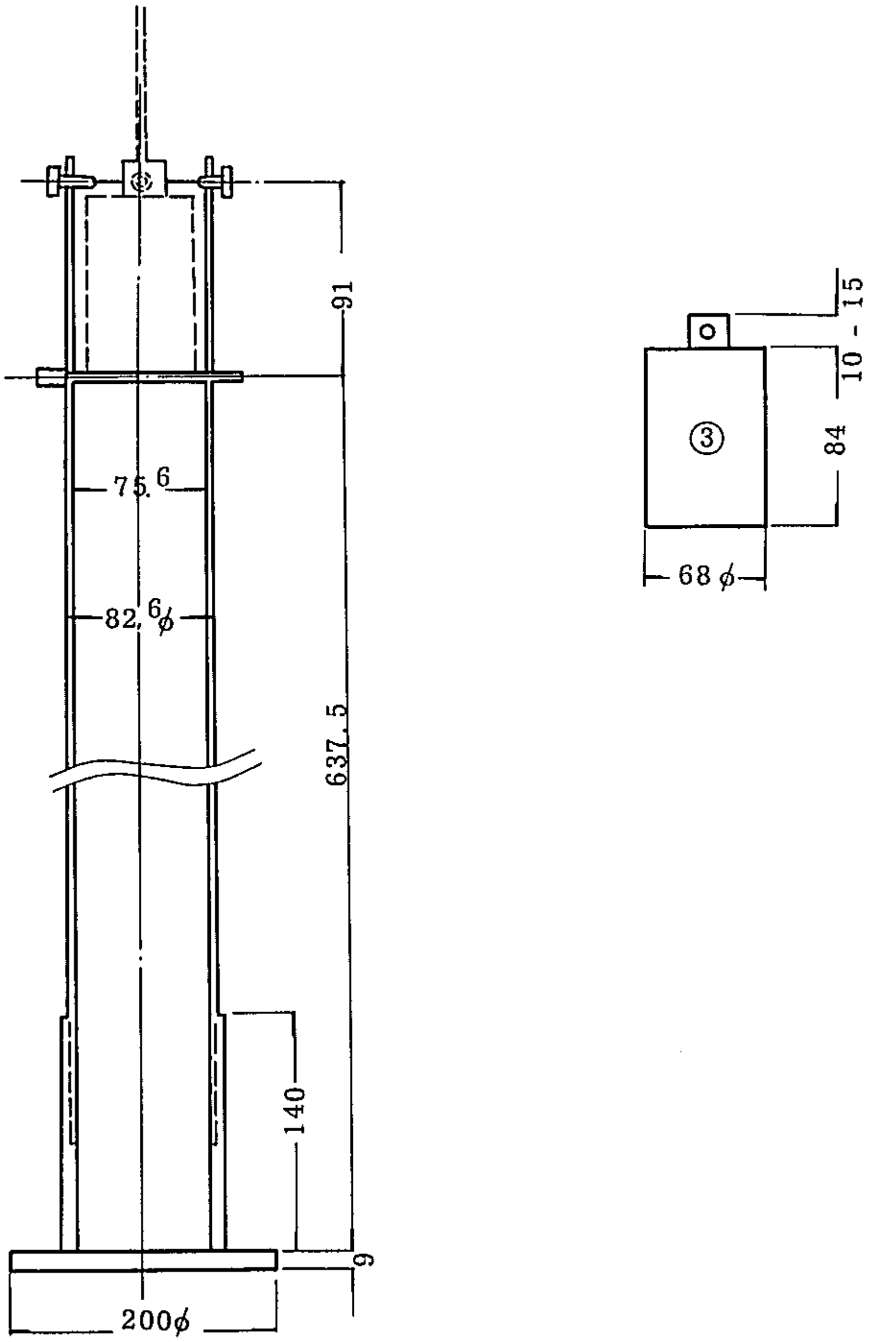
B. Name of the samples and kind of the rocks in massive sample

Alpaco mine	muddy shale	Uling Region
Camansi mine	very fine & fine sandstone	Danao Region
D.G.G. mine	shale	Argao Region
Base mine	carbonaceous shale	Toledo Region

C. Specimens for uniaxial compression test

In forming of the specimens for the uniaxial compression test, the specimen is formed out of a massive sample after scooping it out by a specimen scooping machine in order to make its height

Fig. 6-3 MEASURING APPARATUS OF INDEX BY EGD-AN METHOD



twice its diameter, $\phi 3.5$ to 5.0 cm.

A rock sample, however, which has many cracks'or is feared to be broken down for water, is unable to be scooped for a specimen, so that it has to be formed into a specimen of a shape of hexahedron. According to degree of cracks, sometimes there are rock samples which can not be formed even into the hexahedron.

As for the samples this time, those from D. G. G. mine could be formed into the hexahedron, but those from other mines could not be formed, because they were; for example,, those from Alpaco mine have not only many cracks to break down into fractions but also weakness to water. Those from Camansi mine are also weak to water, and those from Base mine came off into thin leaves.

According to the results of the test, uniaxial compression strength of the sample of D. G. G. mine was 95.5 Kg/cm^2, which is very low as the strength of rock. Table 6-5, 6-6 is shown for reference.

D. Supersonic waves propagation velosity test

Because specimen for this test is used the same one as specimen for uniaxial compression test, samples except of D. G. G. mine were formed into specimens by a special hand grinder.

As for the test results, P waves velosity of the sample of Base mine was specially low, and those of the other mines were between 2, 400 and 3, 200 m/sec. Besides, P-wave velosity of rock of Mitsui-Sunagawa mine in Japan is in the range of 3, 700 to 4, 300 m/sec, namely the velosity of rocks of Base mine are around 70% of that of Sunagawa mine. This fact means that the rock of Base mine has many cracks or its strength is low.

E. Physical property test

A sequence of the measurement is the weight measuring in the air, weight measuring in water after leaving the sample in the water for about four days, weight measuring of the sample which is in a state of wet saturation and weight measuring of it which is in a dry state after drying in a dryer for twenty-four hours at 110°C.

Because all the samples would be broken down in water, for an extreme case the rock of Alpaco mine was broken down about 20 min. after putting it into water, the measuring by paraffin method was conducted. In the process of the measuring, when the paraffin membrane was too thin, it often brew out from swelling of the sample for water and the sample was broken down.

F. Result

The rock of Alpaco mine have many cracks and is broken down into fraction after long exposure to the air, in the process of the tests. Moreover, it is sensitive to water and swells considerably when it contains water.

The rock of Camansi mine is sensitive also to water although the sensitivity is not so extreme as the rock of Alpaco mine.

The rocks of D.G.G. and Base mine swell little for water, but they are gradually broken down of themselves into thin leaves.

Judging from the test results like these, all the rocks have many cracks and their strength are low, so that there will be much possibility of creep, and maintenance of roadways will probably cause trouble. Especially it is expected that the driving and the maintenance of roadways around fault will meet with much difficulties.

Table 6-5 Summary of Rock Tests

Sample No.	Name of rock	Supersonic Wave Propagation Velocity (m/sec, natural dry)		Dynamic Poisson's Ratio	Apparent Specific Gravity			Water Absorption Ratio (%)	Effective Porosity (%)	Confined Compression Strength (Kg/cm^2)	Modulus of Dynamic Elasticity (Kg/cm^2)	Remarks
		P-wave	S-wave		natural	wet	dry					
Alpaco	Muddy shale	2,920	1,390	0.35	2.43	2.52	2.34	7.67	17.97		1.32×10^5	Broken down 20 min. after into water
Ca No.1	Very fine - fine grined sandstone	3,240	1,800	0.27	2.45	2.80	2.41	16.01	38.59		2.10×10^5	Broken down 20 min. after into water
D.G.G.	Shale	2,460	1,420	0.24	2.31	2.43	2.26	7.48	16.89	95.5	1.21×10^5	
Base	Carbonaceous Shale	1,600	890	0.27	2.22	2.31	2.16	7.16	15.45		4.64×10^4	Some part come off into thin leaves in water

Note:

1. As the sample of Alpaco was broken down to loss its original form 20 min after putting it into water, it was left in water for two hours under sealing on its surface with paraffin so as not to be broken down.

2. Ca No.1 was broken down in water at same time as Alpaco, but it could keep its original form for six hours in water under sealing with paraffin. It means that Ca No. 1 has larger absorption ratio than Alpaco.

3. As D.G.G. and Base came off into thin leaves because of the carbonaceous, they were left in water under sealing with paraffin for about one week in order to be completely saturated.

Table 6-6 Result of Rock Test

(Mitsui Sunagawa Mine)...for Reference

Depth	Name of rock	P-Wave m/sec.	S-Wave m/sec.	Specific Gravity	Uniaxial Compressive Strength kg/cm^2	Water Absorption Content %	Effective Porosity	Poisson's Ratio	Dynamic Young Modulus
-460 ML	nS	3,770	2,180	2.54	687	1.93	4.91	0.25	3.07×10^5
-560 ML	nS	4,020	2,270	2.55	868	2.13	5.35	0.27	3.37×10^5
-560 ML	nS	4,350	2,100	2.49	529	4.67	11.31	0.35	3.00×10^5

Remarks: Sampling place .... North Main Entry at Noborikawa Pit & South Main Entry at No. 1 Pit

Test Date .... November, 1970 at Tachikawa Laboratory

(4) Coal mining method

Coal mining is operated by the strikeward full packing long-wall mining system, as shown in Fig. 6-4.

Coal breaking is carried out by drilling and blasting. Coal broken by blasting runs down by gravity in iron troughs setted along the working face then the coal is carried to a pocket by 450 m/m conveyor which is installed on the sublevel, and is loaded at the lower level on mine car from the pocket.

The mining operation is two shifts of coal winning and one shift of packing per day.

Packing material is 50 to 60 m/m sized rock on the average which are excavated at surface, and it is stored in a pocket for packing material. Then the packing material is loaded on dumping car at the upper level, and is discharged into the trough mentioned above at the top of the working face. Goaf is filled in turn from the upper part with the packing material through the troughs. The trough is shown in Fig. 5.

After the packing operation, the coal winning operation is conducted.

The order of the operation mentioned above is repeated on turn.

Fig. 6-4 FULL PACKING LONGWALL MINING METHOD (DIAGONAL FACE TO DIP)

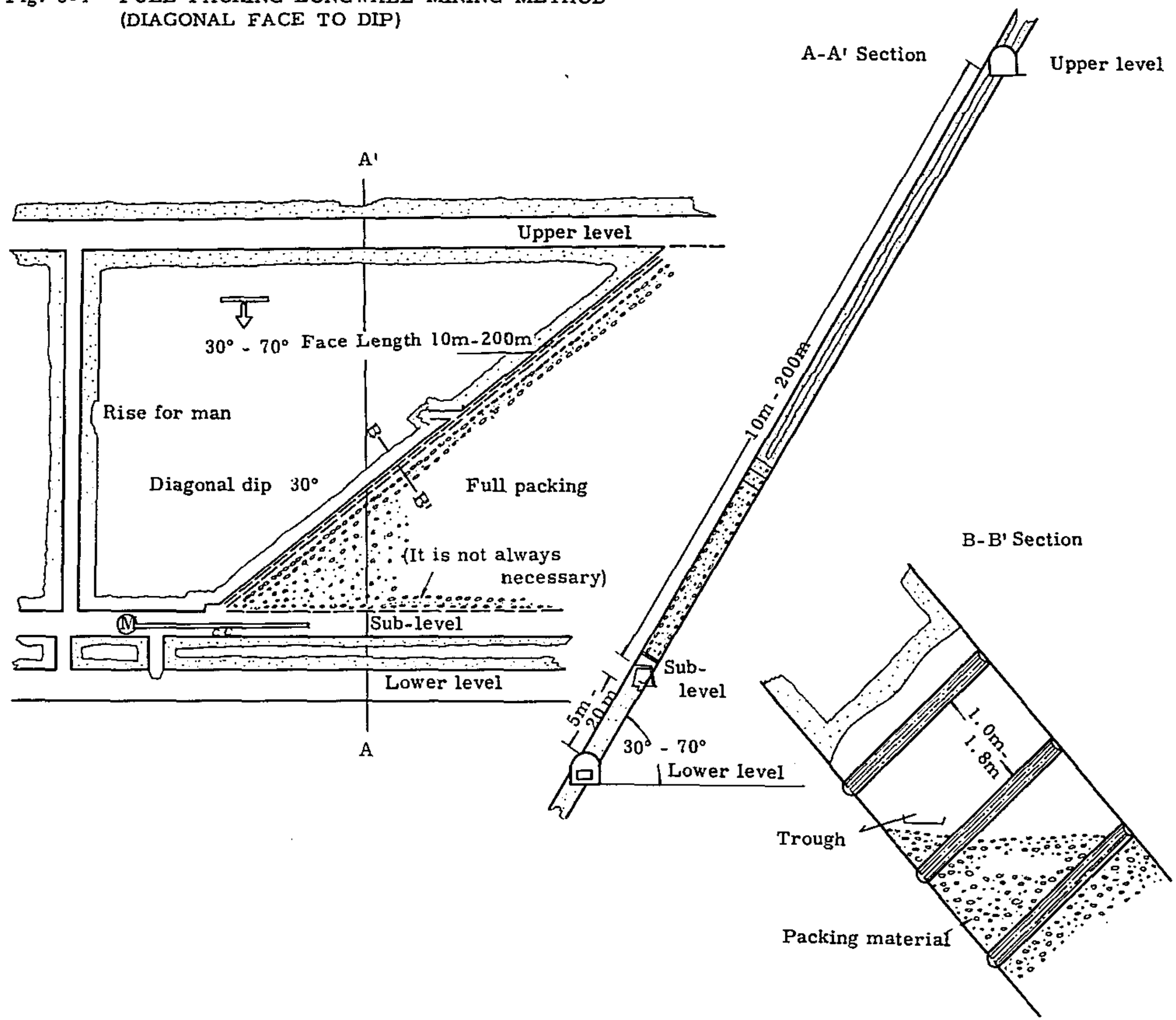
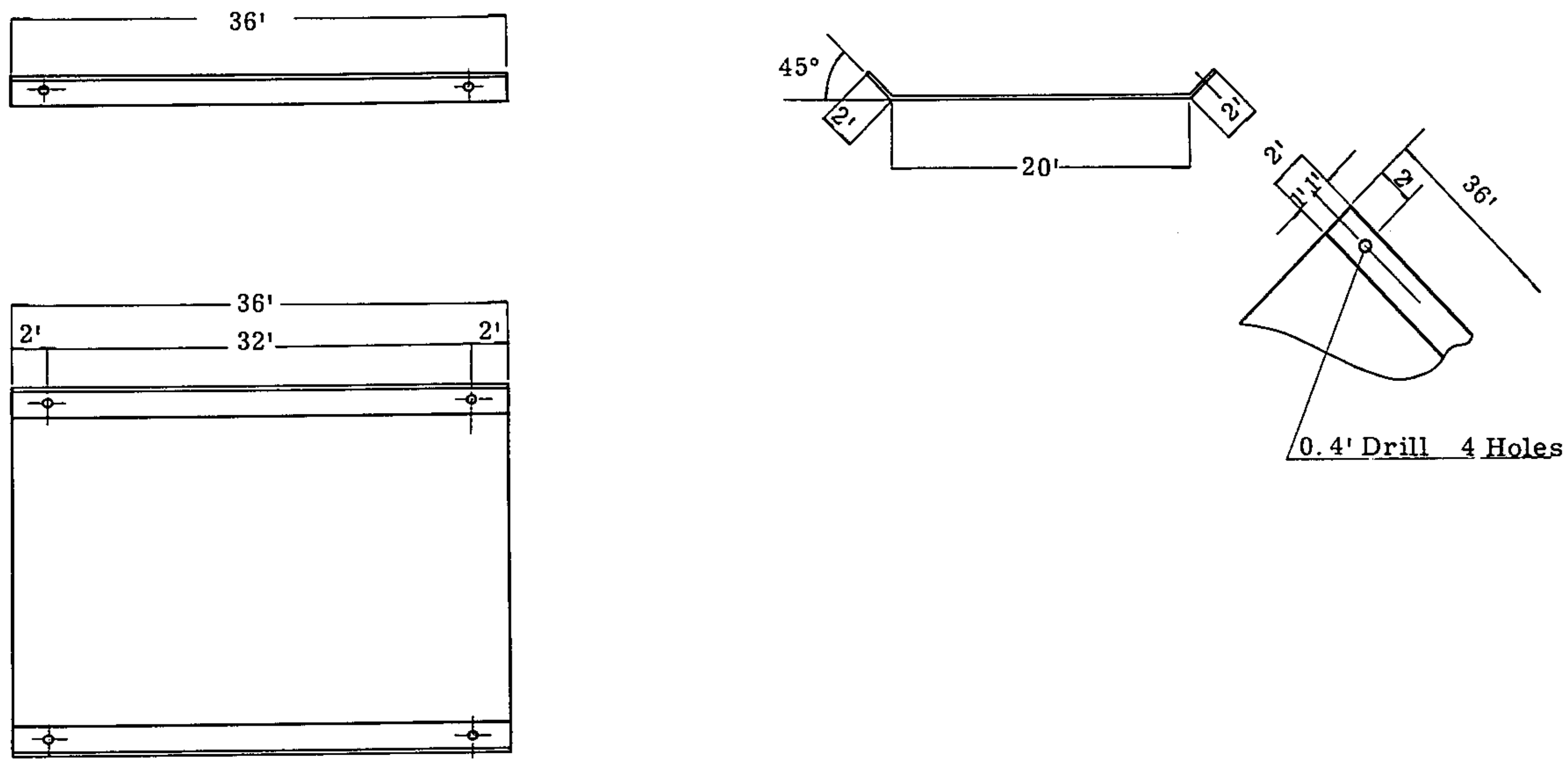


Fig. 6-5 TROUGH IN THE COAL FACE



6-1-7 Summary of Production

Summary of production is shown in Table 6-7.

Table 6-7 Summary of Production

Item				Remarks
Output	Raw coal	ton/day	225	Coal is expected to mix with packing material and waste from diving.
		ton/year	67,500	
	Clean coal	ton/day	200	
		ton/year	60,000	Operated days: 300 days/year
Personnel	Underground men		143	Excluded foreman and administrator.
	Surface men		60	
	Total		203	
Productivity tons/man clean coal			0.99	Total 0.83 t/man/shift (including other people)
Yield		%	89	
Length of driving required	Total	m/day	1,800	30m/1,000 ton coal
		m/day	6	
	Level	m/day	2.4	40%
	Sub-level	m/day	3.6	60%
Driving efficiency	Level	m/day	3.4	0.3m/man x 15men/day x 75%
	Sub-level	m/day	4.0	0.36m/man x 15men/day x 75%
Number of driving team	Level		0.7	
	Sub-level		0.9	
Coal output in driving	Level	ton/day	8.5	
	Sub-level	ton/day	12.5	
	Total	ton/day	21.0	
Coal output in mining face	No. of mining shift/day		2	
	No. of packing shift/day		1	
	Productivity t/man/shift		11.2	
	No. of workers/shift		8	
	Output/day		179	
Filling material		m^3/day	110	Size: max 100 m/m mean 50 - 60 m/m
Calory of clean coal		BTU	10,000-12,000	

6-2 Production Equipment

6-2-1 Summary of Production Equipment

Table 6-8 Summary of Production Equipment

Equipment and Machine	No. of Unit	Remarks
Drill		
for coal mining	6	
for driving	6	included in driving cost
for spare	4	including one for road
Total	16	repair & stand-by
Coal pick	6	including the stand-by
Air compressor	200 HP x 2	air quantity required $22m^3/min$
Winding machine		
Main winder	300 HP x 1	
Sub-winder	75 Kw x 1	
Hoist for mining	10 HP x 2	including the stand-by
Hoist for driving	15 HP x 3	including the stand-by
Hoist for others	5 HP x 1	on the surface
Ventilating fan		
Main fan	37Kw x 81mm x $1,100m^3/min$ x 1	on the surface
Local fan	3.5 Kw x 5	including the stand-by
Loader		
Loader for driving	RS-55 x 1	air-powered
Locomotive		
Diesel loco.	4 ton x 2	one each for the surface and the underground
Double chain conveyor		
for coal mining	22 Kw x 3	
for driving	22 Kw x 1	
Drainage pump		
Main pump	2 m^3/min x 130m x 100 HP x 1	for the underground
Small pump	10 HP x 2	for driving and others
Small pump	2 HP x 1	for the surface
for water service	30 Kw x 2	on the surface

Equipment and Machine	No. of Unit	Remarks
Mine car		
Mine car for mining and driving	1 m^3 x 100	including dumping car rotation ratio 3 stand-by 15%
Mine car for packing Material	1 m^3 x 50	ditto
Supply car	10	
Other machinery for excavating the packing material		on the surface
Dump truck	6 ton x 3	including the stand-by with ripper
Bulldozer	21 ton x 1	
Loader	2.1 m^3 x 1	
For supply of the packing material		
Bulldozer	11 ton x 1	
Tractor-shovel	150 HP x 1	

6-2-2 Haulage System

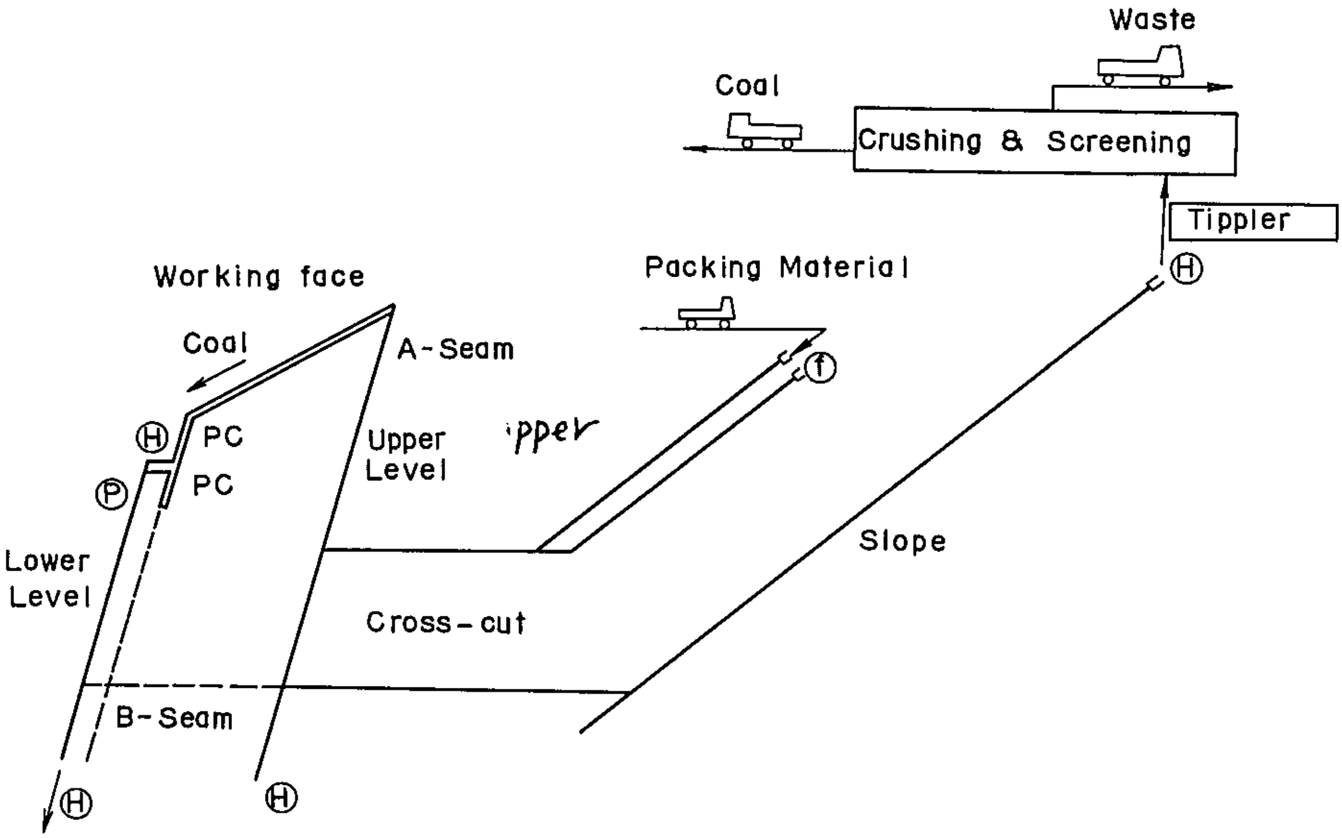
(1) Flow sheet of coal haulage system

Underground	working face	running down by gravity in troughs
	↓	
	sublevel	22 Kw double chain conveyor
	↓	
	lower level	diesel locomotive, mine car
	↓	
	cross-cut	ditto
	↓	
	slope	300 HP winding machine
	↓	
Surface	coal dressing	screen, breaker and others
	↓	
	coal storage	
	↓	
	transportation	truck

(2) Supplies are carried into underground workings from surface with mine cars or supply cars.

Men go to the working places on foot.

(3) Haulage System



Ⓟ	Pocket
P.C.	Armourd Conveyor
Ⓗ	Hoist
D.L.	Diesel Locomotive

(4) Winding Capacity of the Main Slope

A 300 Horse Power winding machine is to be prepared for the main slope.

A. Premises for the calculation

Diameter of rope	30 mm
Weight of rope	3.33 Kg/m
Winding speed	180 m/min.
Quantity to be hauled	250 MT/day
Haulage distance	350 m
Average inclination of the slope	25 degrees
Actual working hours per day	10 hours
Dead weight of a mine car	650 Kg
Carrying capacity of a mine car	1,000 Kg
Coefficient of friction of mine car	0.015
Coefficient of friction of rope	0.1

B. Number of mine cars to be hauled at a time

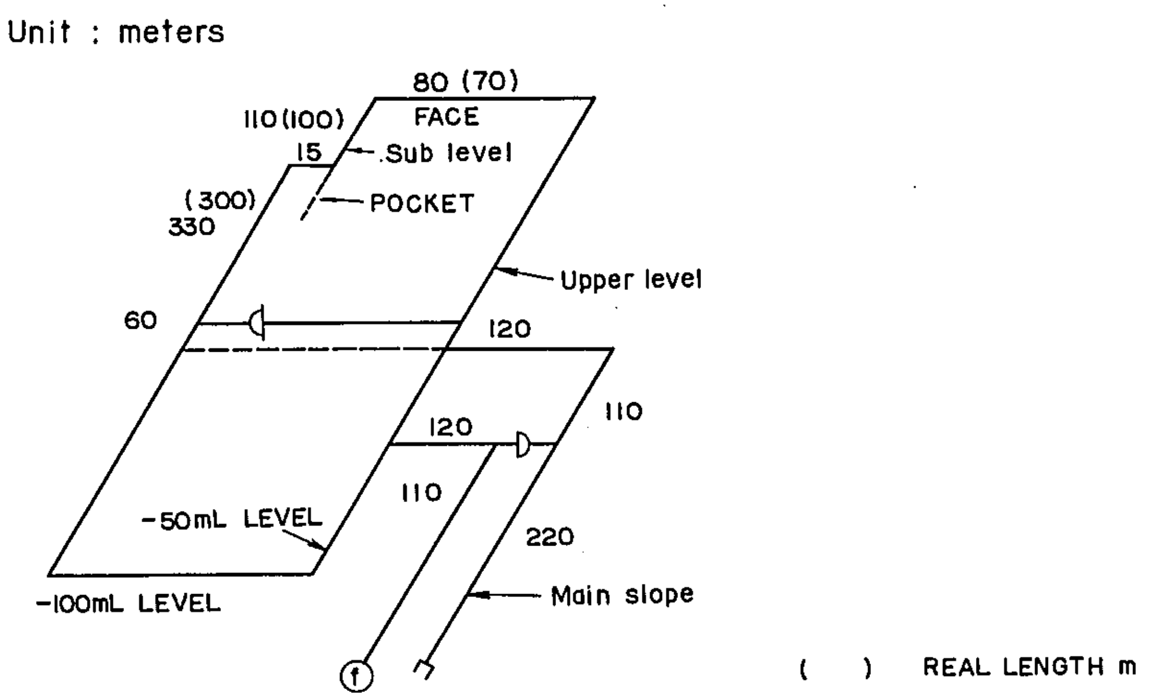
Time required for a haulage	2 min.
Time required for acceleration & retardation	30 x 2 sec.
Time for the train operation at the portal and the turn-out.	10 min.
Time required for a round trip	15 min.
Number of trips per day	40
Quantity required to be hauled at a time	6 tons
Number of mine cars required to be hauled at a time in a train	6 cars
Ditto including a spare car	7 cars

C. Horse power of motor required

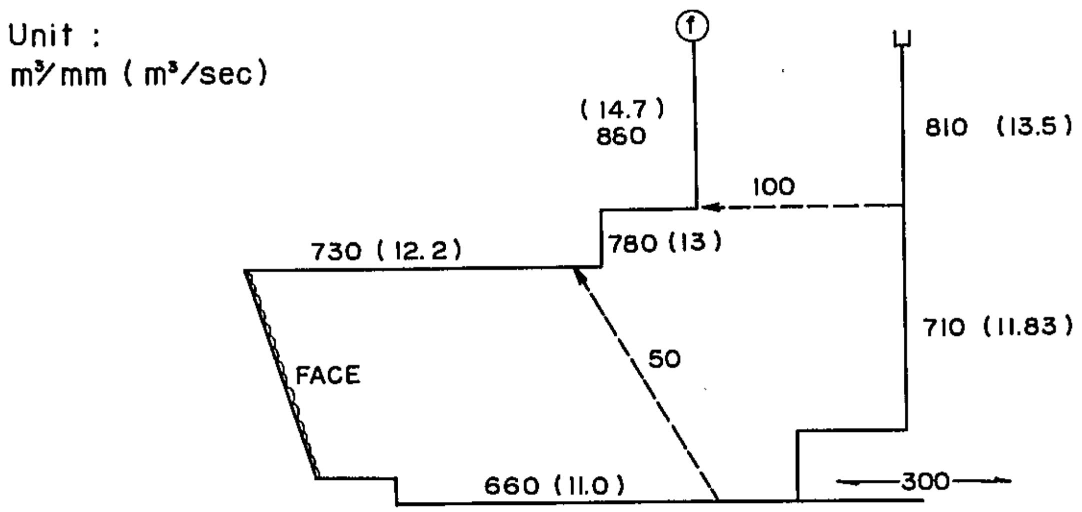
Pull	5,636 Kg.
Horse Power	300 HP

6-2-3 Ventilation System

(1) Ventilation Map



(2) Air Quantity Map



(3) Ventilation resistance of roadway

Dimension of roadway	Sectional area for ventilation	Rubbing surface per 1 m of roadway	Coefficient of friction	R=100 cm
12 ft x 8 ft	7.73 m	11.38 m	0.002	0.00493
8 x 8	5.24	9.28	0.002	0.01290
6 x 7	3.46	7.55	0.002	0.03645

(4) Length of roadway which was used in the calculation is real length x 110%.

(5) Air quantity obtained from the calculation

Working face : $1.5 m^3/min/ton \times 180 \div 75\% = 360 m^3/min$

Heading : $150 m^3/min \times 2$ places $= 300 m^3/min$

Others : $150 m^3/min$

Total : $810 m^3/min$ ($13.5 m^3/sec.$)

(6) Depression

$$13.5 \times 0.00493 \times 2.2 + 11.83 \times (0.0129 \times 1.1 + 0.0129 \times 1.2 + 0.00493 \times 0.6) + 11.0 \times (0.0129 \times 3.8 + 0.03645 \times 1.12 + 0.03645 \times 0.8 + 0.0129 \times 5.5) + 13.0 \times 0.0129 \times 2.3 + 13.5 \times 0.0129 \times 1.1 \times 1.2 = 45 \text{ mm}$$

(7) Power required

$$\frac{845}{60} \times 45 \times \frac{1}{75} \times \frac{1}{0.6} = 14.1 \text{ HP}$$

(8) Ventilation plan

Fan capacity which is required for mining operation in the upper area is calculated to be enough for 14.1 HP. But quantity of gas emission is unable to be pre-expected at present stage and also there is a possibility to develop the deeper mining area under -100 mL by the result of further survey.

Therefore, a 30 kw x 81 mm x 1,100 $m^3/min.$ turbo blower is designed for main ventilater in order to cover this unknown factors.

6-2-4 Drainage System

(1) Amount of water in the mine

A. Estimation from the rainfall

Area of land surface which affects the mining is about 2.6 Km^2. Average amount of rainfall per annum is 86.46 inch namely 2.196 mm.

If it is presumed that one-third of total water from the rainfall sink into the ground, amount of water in mine is:

$$2.6 \times 2.196 \times 10^6 \div (365 \times 24 \times 60) \times \frac{1}{3} = 3.62\ m^3/min.$$

B. Estimation from the mining operation

If it is presumed that the rate of percolation into the mine is 3.5%, amount of water in mine is:

$$15,600\ m^2 \times 1,000\ m \times 0.035 = 546,000\ m^3$$

$$546,000\ m^3 \div 2\ year \div 525,600\ min/year = 0.52\ m^3/min$$

(2) Estimation of amount of mine water

It is not reasonable to estimate that all of the one-third of water from the rainfall meet with in the underground workings through the mining of the upper parts of the mine. Beside, it can not be estimated only by means of the rate of percolation into the mine. Accordingly, other factors must be taken into consideration.

In this plan, amount of water in the mine is expected to be 1.0 m^3/min, which is two times as much as that estimated from the mining operation described at B. after consideration of mining influence. Moreover, concerning ourselves about rainy seasons, amount of water to be pumped out from the mine is estimated at 2.0 m^3/min. in this plan.

(3) Horse power of pump

$$HP = \frac{1,000 \times 2 \times 156}{75 \times 0.7 \times 60} = 100\ HP$$

Vertical delivery head : 130 m

Efficiency of pump and it's motor : 70%

6-3 Surface Facilities

6-3-1 Summary of Surface Facilities

Layout of surface facilities is roughly planned according to the geographical conditions, and it is to be finally decided after detailed investigation.

Surface facilities required for the development are shown in Table 6-9.

Table 6-9 Surface Facilities

Facility	Item	No. of Unit	Remarks
Ventilation	Main fan	1	37 Kw
	Housing and foundation	20 m^2	
Compressed air	Compressor	200 HP x 2	
	Pipe 6"	1,000 m	
	Housing and foundation	60 m^2	Wooden-made
Electricity	1 set		As stated in 6-3-2 including communication system
Safety lamp	Safety lamp		As stated in 6-3-2
	Housing	30 m^2	made of concrete
Substation	1 set		As stated in 6-3-2
	Housing	100 m^2	made of concrete
Coal preparation			As stated in 6-3-3
Water service	30 Kw pump x 2 & others		
Packing material and waste dumping	Truck 6 ton	3	For transportation
	Bulldozer 21 ton	1	For packing material excavation
	Bulldozer 11 ton	1	For other purpose
	Loader 2.1 m	1	For waste loading
	Tractor-shovel	1	For waste dumping
	Hoist 5 HP	1	For waste dumping
	Pump 2 HP	1	For waste dumping
	Pocket and others		For packing material
Miscellaneous	Wash house	330 m^2	Wooden-made
	Machine store	150 m^2	Wooden-made
	Material store	150 m^2	
	Oil store	15 m^2	Made of concrete
	Garage	30 m^2	Wooden-made
	Mine office	270 m^2	Wooden-made
	The fitting of the office		Air cooler 5.5Kwx4
	Power magazine	10 m^2	Made of reinforced concrete
	Timber stock yard station	15 m^2	Wooden-made
	Machine shop	200 m^2	Steel frame building
	Fittings for machine shop		As stated in 6-11
	Saw mill	40 m^2	Wooden-made
	Road rehabilitation	5 Km	
	Land preparation	80,000 m^2	
	Car	3	

6-3-2 Electric Facilities

(1) Outline

A. Electrical machinery and apparatus to be used on the ground are those for general use, but all of those for underground use are explosion-proof pressure type established for coal mine. Flame-proofed cable and dry type electric machinery and apparatus, which are not used flamable oils inside, are to be used below ground in order to keep the mine safe.

B. Voltage for the underground equipment is 3, 300 volt for 75 Kw motor of pump, and is 440 volt for the others.

Accordingly, a 3, 300 volt current is transmitted into the mine through the cable, and is transformed into a 440 volt current by a three-phase 150 KVA transformer room.

C. Voltage for the surface equipment is 3, 300 volt for a 225 Kw winding machine and for two 150 Kw air compressors, and is 440 V for the others.

D. Specifications of the electric equipment are mentioned in (2)

E. The mine receives electric power at 6, 600 volt, and a substation is provided at a receiving point of power transmission line in the site. Main transformer is three-phase, 1, 000 KVA, 6, 600 V/3, 300 V in the specification.

F. Construction cost for 15 Km of a 6, 600 V power transmission line up to the receiving point is estimated in this study.

G. Facilities for 204 safety lumps, 30 gas inspectors and a telephone system for surface and underground including a private telephone exchange station with 30 circuits are planned in this study.

(2) Details of the electrical equipment

A-1 For motor

Underground electrical equipment for motor and accessories listed below are required.

Works	Equipment	Capacity	In operation	Accessories required
Coal Winning	Hoist	7.5Kw x 2	7.5Kw x 1	Cab-tyre cable 2C x 3.5sq. x 400 m; Cab-tyre cable 4C x 8 sq. x 400 m; Reversible motor starter (50A type) x 2 Push button x 10 Air-break switch(50A type) x 2 Bell-transformer x 2 Bell x 2
	Conveyor	22Kw x 3	22Kw x 2	Cab-tyre cable 4C x 14sq. x 600 m; Magnet switch (100A type) x 3 Air-break switch (100A type) x 3 Cab-tyre cable 4C x 3.5sq. x 600 m; Push button switch x 6
Entry driving	Local fan	3.5Kw x 5	3.5Kw x 3	Combination startor (35A type) x 5 Cab-tyre cable 4C x 8 sq. x 600 m
	Hoist	11.25Kw x 3	11.25Kw x 2	Cab-tyre cable 2C x 3.5 sq. x 600 m Cab-tyre cable 4C x 8 sq. x 600 m Reversible motor startor (100A) x 3 Bell-transformer x 3 Air-break switch (100A) x 3 Bell x 3 Push button switch x 15
Haulage	Winding machine for slope	225Kw x 1	225Kw x 1	Drive-control devices x 1 set Push button switch x 5 Signal cable 4C x 3.5 sq. x 250 m

(Cont'd) (2) Details of the electrical equipment; A-1 For motor

Works	Equipment	Capacity	In operation	Accessories required
Drainage	Pump	75 Kw x 1	75 Kw x 1	High-pressure airbreak switch x 1 Automatic operation system x 1 set Cable and others
	Pump	7.5 Kw x 2	7.5 Kw x 1	Combination startor (35A x 1 Automatic operation system x 1 set
Total		447.25Kw	392 Kw	

A transformer room is provided in the mine, which transform a 3,300 V current into 440 V for these equipment.

Capacity of a transformer in the room is three phase 150 KVA.

A-2 Surface electrical equipment for motor

Works	Machine	Capacity	In Operation	Accessories
Transpor-tation	Conveyor	22Kw x 1	22Kw x 1	Cab-tyre cable 4C x 14Sq x 100m Cab-tyre cable 2Cx3. 5Sq x 100m Magnetic switch (100A Type) x 1 Air-break switch(100A)x1
Ventilation	Fan	37Kw x 1	37Kw x 1	Bridged polyethylene cable 3C x 22 Sq. x 100m Drive control system 1 set
Compressor	Compres-sor	150Kw x 2	150Kw x 2	Bridged polyethylene cable 3C x 22 Sq x 100m High pressure magnetic switch (100A) x 2 High pressure air-break switch (100A) x 2
Coal preparation		Total 25Kw	25 Kw	Bridged polyethlene cable 3C x 14 Sq x 200 m Polyvinyl cab-tyre cable 4C x 3. 5 Sq x 200 m Operation control system x 1 set
Water service	Pump	30Kw x 2	30Kw x 2	Bridged polyethlene cable 3C x 14 Sq x 200 m Operation control system x 1 set
Others	Pump & Others	12. 75Kw x 1	12. 75Kw x 1	Bridged polyethylene cable 3C x 14 Sq x 100 m Drive control system x 1 set
Surface	Air conditioner	5. 5Kw x 4	5. 5Kw x 2	Vinyl armed cable 4C x 5. 5 Sq x 200 m
Repair shop		Total 45 Kw	45 Kw	Bridged polyethylene cable 3C x 14 Sq x 100 m Switch for driving 1 set
Total		523. 75 Kw	512. 75 Kw	

B. Lighting

B-1 Underground lighting

i) Lamps with simple guard are set up at intervals of 10 m on the main slope, of 200 m long.

20 lamps total 2 Kw

ii) Ten 100 Watt lamps with simple guard are set up in the pump station.

total 1 Kw

Underground total 3 Kw

B-2 Surface lighting

i)	Pit mouth	300 Kw floodlight	4	1.2 Kw
ii)	Material yard	ditto	4	1.2 Kw
iii)	Waste dumping site	ditto	4	1.2 Kw
iv)	Packing material excavating site	ditto	4	1.2 Kw
v)	Outdoor light	ditto	2	0.6 Kw
vi)	Outdoor light	100 W lamp with bracket	20	2.0 Kw
			Surface total	7.4 Kw

B-3 Interior lighting

Building	Average intensity of illumination (lx)	Sort of light source	Floor space (m)	Power required (W/m^2)	No. of lights to be set up	Power consumption (Kw)
Office & lodgings	500	Fluorescent lamp	615	20	40W x 308(F)	12. 32
Compressor room	200	Fluorescent lamp	60	8	40W x 12 (Fl)	0. 48
Warehouse	30	Fluorescent lamp Incandescent lamp	300	5	40W x 18 (Fl) 100W x 18 (Il)	2. 52
Repair shop	200	Fluorescent lamp	240	8	40W x 48 (Fl)	1. 92
Powder magazine	30	Fluorescent lamp	55	5	40W x 7 (Fl)	0. 28
Winding room	100	ditto	100	5	40W x 13 (Fl)	0. 52
Fan room	100	ditto	20	5	40W x 3 (Fl)	0. 12
Preparation plant	100	ditto	100	5	40W x 13 (Fl)	0. 52
Lamp room	200	ditto	30	8	40W x 6 (Fl)	0. 24
Substation	200	ditto	50	8	40W x 10 (Fl)	0. 4
Total					40W x 438 (Fl) 100W x 18 (I l)	19. 32

B-4 Capacity of transformers and wiring for lighting

Exclusive transformers are provided for underground lighting and for lighting of the winding machine room respectively.

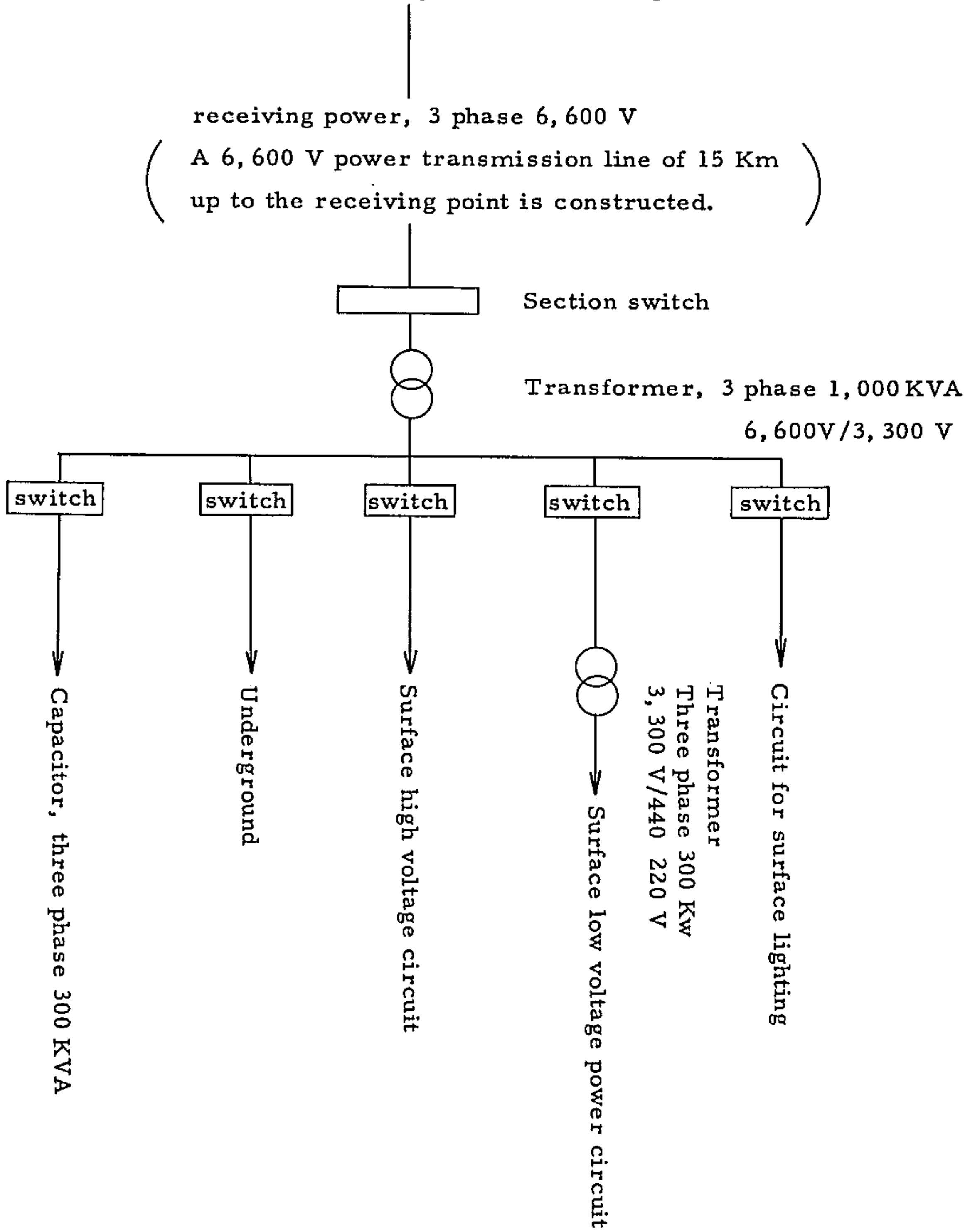
A transformer which is set up at the winding machine room is single phase 5 KVA (3, 300 V/110V) of capacity.

A transformer which is set up at the underground pump room, is three phase 3 KVA 3 (300V/110V) of capacity.

Post-mounted transformers are set up near the load for surface lighting. The transformers are 2 units of single phase 20 KVA (3, 300V/110V).

Polyvinyl cab-tyre cable is used in the mine for the underground wiring. For the surface wiring, outdoor type polyvinyl cable is used up to sheds and in the sheds polyvinyl wiring is planned as a rule.

C. Substation at the receiving point and surface power distribution



A substation is built at the receiving point of 6,600 V electric power. The station is a one-storied fireproof building of 100 m^2 in floor space, in which cubicle type electrical equipment are installed. Surface electrical machinery and apparatus are distributed through overhead power line from the station.

D. Power transmission line up to the receiving point

Fifteen Kilo-meter of three phase 6,600 V power transmission line is provided up to the receiving point. The line is overhead line, and its size is 38 mm^2. The poles are wooden H-pole, and the pole interval is 100 m.

E. Miscellaneous

The safety lamp facility is self-service type, and 204 safety lamps and two charging apparatus, which capacity is 204 of lamps per set, are provided.

Thirty gas inspectors are provided.

A small scale private telephone exchange station is provided for communication, and telephones are set up at needful places underground and surface.

6-3-3 Coal Preparation

(1) Outline

This equipment is a plant to make raw coal into products, which is 35 mm or smallersized dust coal, by means of screening, hand picking and crushing.

Plant capacity is 225 ton/day or 22.5 ton/hr in raw coal, and its design is almost based on the following plan.

a. Particle size of raw coal is as shown in RRB'S Grain Diagram (R. O. M. Coal)

b. Particle size of dust coal is as shown in RRB'S Grain Diagram (Product)

c. Quantity of the waste : 25 tons/day

d. Quantity of clean coal : 200 tons/day

e. Working hours : 10 hours/day

(2) Operation line

When raw coal is discharged into a 5 m hopper (1), the over 200 mm sized out of the raw coal is separated by a grizzly which is provided at the top of the hopper.

The over 200 mm sized is crushed into under 200 mm size by hand, then it is discharged into the hopper, but according to circumstances, it is eliminated from the line.

Fixed amount of raw coal is drew from the hopper with control by a electro-magnetic feeder (2), then it is fed into a Ripple-Flo vibrating screen with 35 mm opening, through a belt conveyor (3).

The undersized through the vibrating screen is carried directly to product storage pile through a belt conveyor (8).

The waste in the oversized is removed by a picking men, and the remains is crushed into 35 mm-size by a impact crusher (6), then it joins the undersized.
The waste removed is carried to rock disposal by a belt conveyor (9).

As the capacity of the product storage pile is for two days, and that of the rock disposal is for two or three days, trouble on their transportation for some period does not give affection to the plant operation.

Fig. 6-6 RRB'S GRAIN DIAGRAM

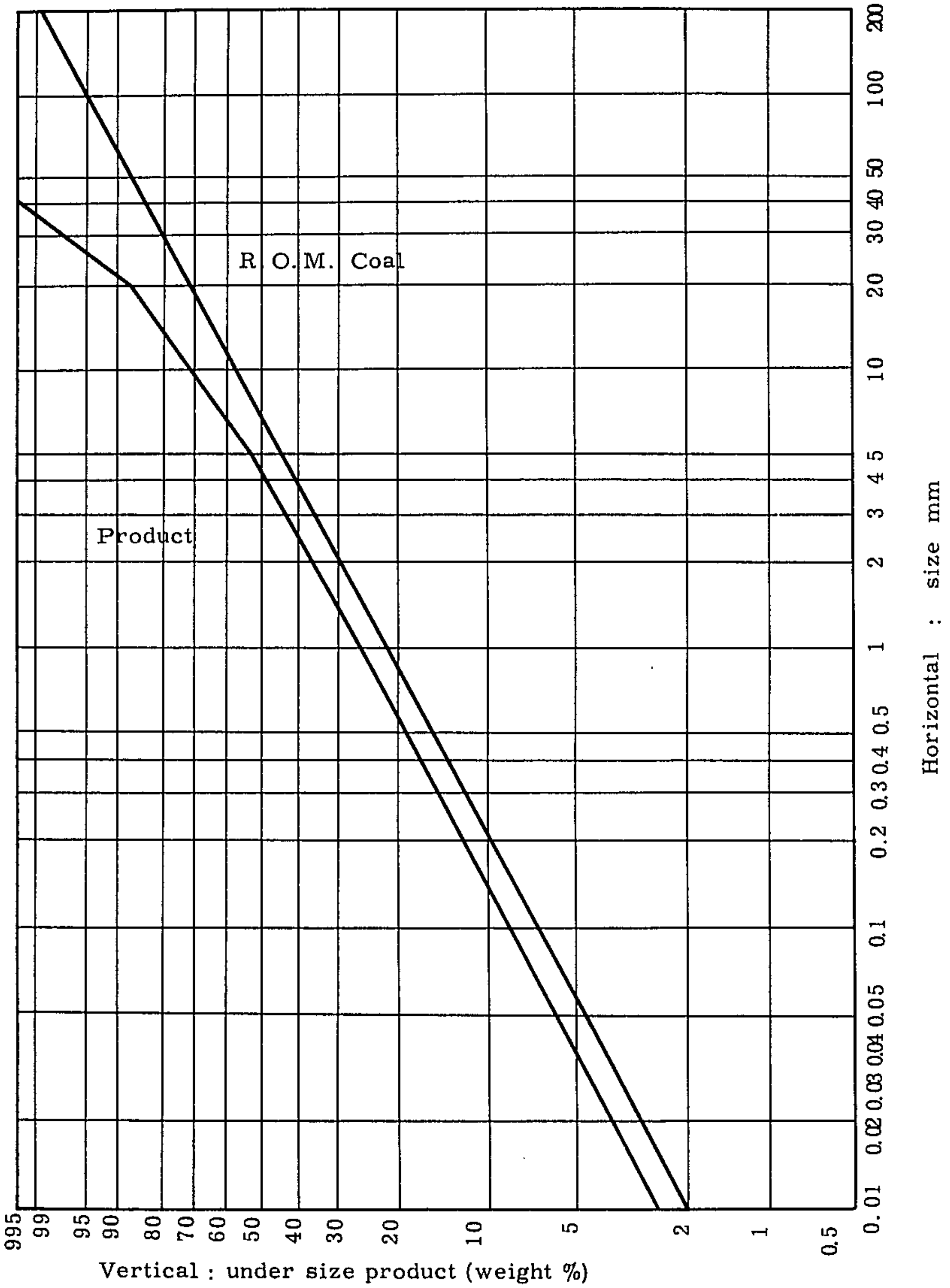


Fig. 6-7 FLOWSHEET OF COAL PREPARATION PLANT

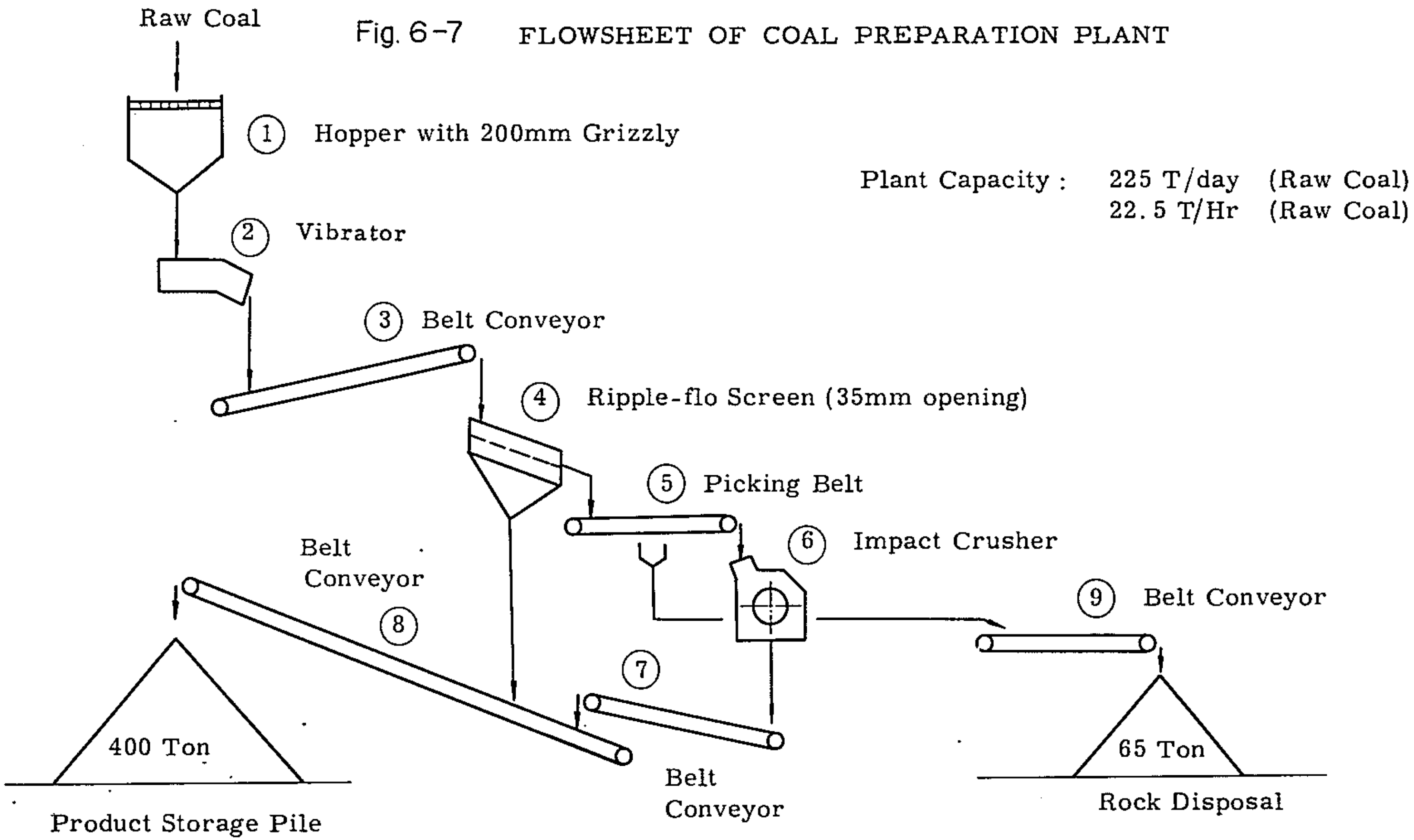


Table 6-10 Specification of Preparation Equipment

Item	Specification of Equip.	Cap. t/h	Speed		Main Dimension m.m.				Motor		Remarks
			m/min.	r/m	Width	Length	Hight	Slope	Type,	Kw	
1	Feed Hopper				2,000	2,000	2,000				With 200 m.m. - opening grizzly
2	Vibrating Feeder RH - 22BDT	27		3,000	Trough 458	914		2 - 3	Vibrator	0.42	
3	Belt Conveyor	"	22		600	31,000	Lift 8,000	15	G.M.	3.75	
4	Vibrating Screen Ripple Flo SH Type	"		800	910	1,830		20	I.M.	3.75	Opening 35 m.m.
5	Picking Belt	8	10		600	3,000		0	G.M.	1	
6	Impact Crusher SAP-IL Type	6		650 (20m/s)	1,220	1,490			I.M.	11	Crush to -35 m.m.
7	Belt Conveyor Baby Type	6			350	4,800		15	P.M.	0.75	
8	Belt Conveyor	25	60		350	30,000	Lift 1,800	15	G.M.	3.75	
9		6	10		600	7,000		0	G.M.	1	

6-3-4 Equipment of Work Shop and Carpenter's Works

The proposed field to be mined is too far from the centre of city, therefore it is necessary to provide with the equipment for the work shop and carpenter's works for mining operation.

The equipment are as follows:

Table 6-11 Equipment of Work Shop

Work Shop	Name of Machine		Power	Unit	Remarks
for machine works	2,140 mm	lathe	5.5 Kw	1	
	650	shaper	2.2		
	1,310 x 290	Vertical milling machine	3.7		
	700	drilling machine	1.5		
		sharpner	-	1	air powered
		Screw cutting machine	1	1	
		grinder for tools	1	1	
		sawing machine	1.5	1	
		grinder	0.75	1	
		hydraulic press	-	1	portable
		crane	4.4	1	including-beam
		measuring apparatus		1	
		tools		1	
for steel arch works	150t	press	5.5	1	
	1t	electrical block	1.4	1	
	19Kw	welder	19	3	
for minecar works	3t	chain block		2	including-beam
		oil press		1	including surface plate, anvil and others
		tools		1	

Work Shop	Name of Machine	Power	Unit	Remarks
for electrical machine	grinder	0.75	1	
	small type drilling machine	0.40	1	
	electric drill	0.40	1	
	welder	19.00	1	
	chain block		2	
	measuring apparatus		1	
	tools		1	
for wood works	circular sawing machine	1.5	1	
	band sawing machine	2.2	1	
	automatic planer	2.2	1	
	fret saw	0.2	1	
	universal woodworking machine	2.2	1	
	pattern maker's lathe	1.5	1	
	tools		1	
	others		1	

6-4 Manpower Requirement

The detailed plan for manpower requirement is as shown in Table 6-12.

The total manpower required to mine this area numbers 240 that is 203 workers, 27 foremen, 3 senior foremen, and 7 supervisors.

In this case, miner's productivity becomes 0.99 MT/man/shift and overall employee's productivity becomes 0.83 MT/man/shift. But in case of including miner's absentee in 10 percentages, total manpower requirement numbers 263 men.

In addition to this worker, 46 workers is required for developing the next mine.

Table 6-12 Manpower Requirement in Detail

Working Place \ Manpower					Number of Workers	Number of Foreman
Mine being operated	Under-ground	panel (inside)	coal face	coal face	16	2
				others	12	1
			sub-total		28	3
			entry driving		14	3
			maintenance		22	3
			transportation		16	3
		total			80	12
		panel (outside)	entry driving		11	3
			maintenance		2	-
			transportation		20	-
			sub-total		33	3
			general		30	5
	total				143	20
	Surface	direct	transportation		15	3
			screening		5	2
			others		15	-
			sub-total		35	5
		indirect	survey & others		15	2
			others		10	
			sub-total		25	2
	total				60	7
ground-total					203	27
Development for other mine					(40)	(6)

6-5 Cost Estimation

6-5-1 Total Initial Expenses

The total initial expenses amount to 5.5 million dollars, including indirect investment, interest during construction and working capital as well as mining equipment.

Table 6-13 Total Estimated Capital Requirement (U.S. $, 000)

Capital cost	Percentage	Sum	Remarks
Mining equipment		3,747	
Indirect investment			
Field	2 %	75.1	
Engineering	2 %	76.5	
Overhead & administration	5 %	195.1	
Contingency	10 %	409.5	
Fee (insurance-taxbase)	2 %	90.2	
Others	8 %	368.1	
Sub-total		1,214.5	
Total		4,961.5	
Interest during construction		372.2	
Working capital		163.3	
Total		535.5	
Grand-Total		5,497.0	

6-5-2 Mining Equipment Cost

The sum of money required for mining equipment amount to 3.7 million dollars, the details of which are shown in the following Table 6-14.

Table 6-14 Mining Equipment ($, 000)

Equipment	Total Sum	1st Year	2nd Year
Exploration	119	119	-
Entry Development	505	179	326
Coal winning & Driving	260	56	204
Transportation	842	498	344
Drainage	39	11	28
Ventilation	21	-	21
Compressed Air	182	91	91
Electrical	207	207	-
Safety Lamp & Communication	53	35	18
Power Substation	210	210	-
Coal Preparation	98	-	98
Water Supply & Others	35	17	18
Packing & Wasting	281	-	281
Other Surface	288	154	134
Next Mine Development	607	-	607
Total	3,747	1,577	2,170

6-5-3 Estimated Total Cost

Grand cost to consumer becomes 41 $/MT as shown in 6-15.

The unit quantities in operating and maintenance supplies to be consumed per ton are applied with the records of coal mine which is working steep seams in Japan.

Calculation of supply cost is mostly based on the material prices, investigated in N. P. C., Cebu.

Wages in the labor cost include such allowances as wellfare, shift differencial and overtime service. Workers wage varies according to their engagement, but in this estimation ₱ 11-₱15 per worker, ₱ 40 per foreman, and ₱ 100 per supervisor are taken.

Facilities maintenance cost is estimated average 4.6% of annual facility investiment.

Depreciation of indirect investment, field survey cost and entry development cost are calculated by the unit of production method. And other depreciation years are as follows; mining equipment and entry driving equipment -- 4 years; transportation, ventilation and drainage equipment -- 7 years; preparation and packing equipment -- 8 years; other surface equipment -- 20 years.

Rate of interest is assumed 7.5% per year.

Table 6-15 Estimated Cost Statement

Cost	$/MT	Remarks
at mine		
Operating & Maintenance supplies	5.52	Production
Labor	3.39	200 MT/day 60,000 MTPY
Facilities maintenance	1.92	
Power	1.20	
Sub-total	12.03	
Other		
Housing subsidy	0.20	
Administration	0.20	
other expenses	0.10	
Depreciation	19.52	
Depletion	0.10	
Interest	3.81	
Others	0.54	
Sub-total	24.47	
Total	36.50	
Transportation charge	4.50	5¢/MT-Kmx 90 Km to the Power Plant
Grand total	41.00	

6-6 Suggestions

6-6-1 The geological conditions are not clear without the detailed survey. At present, the mining plan up to -100 meter level has been made. However, this is just being made on the assumption that the natural condition such as roof condition, coal seam condition, etc. are stable. Under such conditions, the life is only 2.6 years. It means that the mining area should be removed to the next field in Cebu Island.

6-6-2 Since the geological conditions, such as dip of coal seam, thickness of seam, etc. are calculated under a certain assumption, there may be some difference in the length of entries and others.

6-6-3 Supposing the life is 2.6 years, the depreciation and interest become very high amounting 23.33 $/MT. In this depreciation cost, the term of building depreciation is calculated for 20 years. In this case, prefablicated construction or others should be studied.

6-6-4 The price of imported goods from Japan is estimated 1.5 times the current price. Since every price is rising, review thereof should be made at the actual construction.

6-6-5 The development schedule may be prolonged according to the workers condition and ability.

CHAPTER 7

COAL RESERVES AND POSSIBILITY OF APPLYING FOR THE DETAILED SURVEY

CHAPTER 7. COAL RESERVES AND POSSIBILITY OF APPLYING FOR THE DETAILED SURVEY

7-1 Coal Reserves and Presumption of the Workable Reserves

As described in the clause of purpose, the aim of this reconnaissance survey was to seek for a possibility of exploration in the coal area of Cebu in future by collecting data and fact finding on the geological features and mining conditions.

It was actually no time to try and trenching there and only the suitability of prospecting method has been judged by investgating the geological and mining condition on the coal fields. The reliable coal reserves are able to be estimated by the results of detailed field survey and drilling.

However, the study has been done for the coal reserves based on the Plates 6-3, 6-4 and 6-5 by Barnes and others which are available in the Argao-Dalaguete region, and workable reserves have been presumed on all coal regions in Cebu.

Of the figure which is reported on the "Coal Resources of the Philippines" by Spencer and Vergara, the measured reserves in category of more than 75 cm in thickness which are considered as recoverable are picked up for the coal regions in Cebu and recoverable reserves are computed as shown in Table 7-1.

Table 7-1. Measured Coal Reserves

Unit: 1,000 MT

Regions	Measured reserves	Mined or lost in mining	Remaining reserves	Recoverable reserves
Danao-Compostella				
above drainage level	3,068			
below drainage level (-100 m)	673			
Sub-total	3,741	1,692	2,049	820
Uling				
above drainage level	774	-	774	310
Toledo				
above drainage level	38	9	29	12
Argao-Dalaguete				
above drainage level	1,808	295		
below drainage level (-100 m)	124	-		
Sub-total	1,932	295	1,637	655
Total	6,485	1,996	4,489	1,797

Note: Mined or lost coal in mining was assumed to be blocks which are 75 cm or more in thickness.

Recoverable reserves was estimated as 40% of the remaining reserves on the assumption of 80% safety factor and 50% recovery percentage.

On the other hand, a rough calculation has been conducted to 100 meters in depth for the blocks, where the seam outcrops continue and is more than 75 cm thick, on the geologic data in the Argao-Dalaguete region. It has been revealed by the above mentioned calculation that 740 thousand MT of coal is recoverable in the Argao-Dalaguete region. This figure corresponds to 655 thousand MT of Argao-Dalaguete shown in Table 7-1.

Since these two figures roughly coincide with each other, it is considered that the estimate of total recoverable reserves of 1,797 thousand MT given in Table 7-1 is fairly reliable.

Coal reserves in category of more than 75 cm thick in the indicated areas adjacent to the measured areas are shown in Table 7-2, based on the same data.

Table 7-2 Indicated Reserves

Unit: 1000 MT

Regions	Indicated	Recovery Percentage	Recoverable Reserves
Danao-Compostella	3,927	35 %	1,374
Uling	-	"	-
Toledo	-	"	-
Argao-Dalaguete	3,071	"	1,075
Total	6,998	-	2,449

Indicated reserves are 2,449 thousand MT as seen in the Table 7-2. Though the estimate is not based on detailed exploration, the figure is expected to be probable taking into consideration the continuity of coal outcrops.

Thus, the total recoverable reserves comprising measured and indicated is 4,246 thousand MT, which is deemed as maximum recoverable reserves.

However, the geological condition which is led by obtained information and inspection on the coal areas is revealed as follows.

(1) The coal bearing formations or coal bearing parts in the formations are generally thin, 50 to 300 meters in thickness and the marine limestone beds exist closely above or below coal bearing part or coal seams. So, it is considered that the environment was not stable for the accumulation of the organic debris in the coastal plain swamps that were often flooded by the adjacent sea.

This resulted in the lack of continuity of the coal seams.

(2) Geological structure is complicated accompanying with many folds and faults, and with steep dipping strata.

(3) The coal thickness violently varies by minor fault accompanied near or in the seam itself. Some minor faults are found in the seams and rocks at working mines.

In Japan, there are Neogene coal fields of northern Hokkaido (e. g., Tenpoku and Teshio etc.) as the same type in the Philippines. Due to small sedimentary basin, fluctuation of coal seam thickness, many folds and faults and so forth, thus geological structure is highly complicated, and not suitable for modern mining in large scale. The instances of exploitation on the Neogene coal fields are very rare. The geologic age of coal fields in Japan mainly belongs to Paleogene (e. g., Miike, Sorachi, Yubari etc.).

Therefore, it is thought that development of modernized mine in large scale cannot be anticipated in Cebu.

From the standpoint of workability based on the geologic data in the Argao-Dalaguete region, the amount of workable reserves which can be systematically developed instead of Camote mining may be said to total approximately 500,000 MT. Recoverable coal reserves of 740 thousand MT mentioned before in the Argao-Dalaguete region include a small amount of reserves in the isolated fields. It is, therefore, estimated that the workable reserves in this region, which is actually transportable from underground, are about 500 thousand MT in aggregation of main systematically workable fields such as Bayabas, Calagasan and Gransina etc. except Camote mining area.

This figure corresponds to 30 percent for a total quantity of 1,730 thousand MT, which summed up 655 thousand MT in Table 7-1 and 1,075 thousand MT in Table 7-2, of measured and indicated reserves of the Argao-Dalaguete region. In case this percent is applied to whole Cebu Island, the workable reserves which is above to be systematically developped are calcurated about 1,200 thousand MT.

Of course this reserves, 1,200 thousand MT, should be clarified by detailed geological survey including surface exploration and drilling.

7-2 Detailed Exploration for the Mine Development

The development of the coal mine needs the considerable investment and, therefore, a highly reliable result of geological survey is required. For response to this requirement, the trenching is a successful method of prospecting in the area of steep dip strata. Trench is usually dug by man-power with using hand tool. The geological structure and mode of occurrence on coal seam are interpreted in detail at first by obtaining the sequence of strata and the faults in the trench, and then by correlation of strata and coal seams.

Even if the trenching method is able to be adopted in the area, it should be done by drilling to clarify the seam structure, coal quality and seam variation in deep area.

Thus, the number of drill hole in the geologically complicated area will be increased than them in the stable area.

In the complicated structural coal area, there are many cases that the seams are frequently faulted by minor faults less than one meter throw near or along coal seams in the underground. This is a fact of which local operators know well in Cebu. It is often impossible to get the exact aspect on mining by geological survey on the surface and drilling and in such a case it is mostly confirmed by entry along seam in the underground.

7-3 Prospecting Condition in Cebu

The vegetation in the distributed area of coal bearing formation is not thick but the slope of surface is mostly gentle and the cover soil is generally thick, more than three meters. Additionally the limestone boulders and its talus from the near limestone peaks cover the surface. So, the places which the trenching by man-power is able to be applied are rare. Digging of coal along outcrop line at some intervals to confirm the continuity of seam is also very hard. In the only Argao-Dalaguete region, the continuity of coal seams is able to be checked by tracing the mined-out places at surface.

A number of drill holes will be required in the most coal areas in

Cebu under the abovementioned situation. Drilling should be done to the oblique direction for steep by inclined strata. It is necessary to insert the casing pipe into the hole for proteching the trouble due to many limestone boulders among the thick covered soil. It is, therefore, forecasted that some troubles are encountered at the event of drilling.

(1) Argao-Dalaguete region

There are the results of exploration which carried out the field work from September, 1952 to December, 1954. Nevertheless, there are some doubtful places for the structural relationship and identification of seam outcrops and the variation of seam thickness. It is, accordingly, required to excavate the covered soil by using bulldozer in order to get prospecting results of the higher reliability compared with previous working.

(2) Danao-Compostela region

The big obstacle for prospect in this region is absence of more detailed geologic and topographic maps, especially old mine maps which are showing the location and extent of underground, and information of mining production. If the old mine map is compiled, the state of existing seams will be inferred on that map and consequently the effective plan of exploration will be made up. In this region there are some areas where it is appeared to be difficult to do the excavation by bulldozer because of very thick overburden and the exploration in such areas may be mainly carried but by drilling. As the rock facies change may be suppose to be considerably violent, the establishment of geological stratigraphy may be very hard and the interpretation of geological structure may be more difficult. -

The difficulty on the surveying in this area can be surmised from the fact that in spite of the survey made by the team of Melendres and eleven others as one of the Coal Special Project, their report which was undergoing preparation in 1957 has been never published.

It is, therefore, necessary to have a few steps of preliminary or secondary geologic survey and detailed prospect. Accordingly, a term of more than two years and a large amount of expense will be required to promote the exploration including preparation of old mine maps.

(3) Uling region

Coal seams are interbedded with limestone and clastic rocks in the old mine area. As seen on plate 5-2, it is appeared that the coal seams do not extend at the north eastern and south-western sides adjacent old mine where limestone is predominant. The important seam for working is only No. 5 and the lateral extension of underground coal seam was broken by encountering some small faults. Although the topographical situation is very suitable for development, whole production is estimated only less than 100 thousand MT. It is probably caused on the unstable conditions of coal seams.

In Alpaco area the main workable bed is one seam, and the surface is in gentle undulations and covered soil is thick.

It is considered that this region is scarcely worth exploring.

(4) Toledo region

The confirmation by driving along seam in the underground will be need in addition to drilling because coal seam is thin and lenticular. Coal seam is one or two with one meter more or less in thickness containing many partings.

Necessity of exploration in this region will be appraised to be lower than it in the Uling region

7-4 Cost of Exploration

Judging from the abovementioned conditions of each regions, the Bayabas-Balaas area and the Gransina-Mantalongon area in the Argao-Dalaguete region will be able to be consider as the object if the detailed exploration will be planned.

The outline of the exploration plan is following.

(1) Bayabas-Balaas area (Plate 6-9)

Around the visinity of Calagasan, trenchings at intervals of 200 or 300 meters and core drillings at intervals of 300 or 500 meters should be done in this area.

Drillings aim at the main seam at the depth of 100 meters below drainage level.

Road construction to drilling points		1,700 m
Repair of existing rough road		5,000 m
Trenching by bulldozer	20 places	4,700 m
Core drilling	8 holes	2,450 m

(2) Gransina-Mantalongon area (Plate 6-10)

Trenchings at intervals of about 200 meters and 2 holes of core drillings should be done around the Gransina where coal seams seem to be well developped comparatively.

At the southern part of the area, only trenchings are planned at intervals of about 400 meters at this stage of survey.

Road construction to drilling point		300 m
Trenching by bulldozer	12 places	4,900 m
Core drilling	2 holes	650 m

It takes about three months for field work at each areas, and its cost is estimated approximately at 820,000 pesos and 430,000 pesos, as shown on Table 7-3 and 7-4.

Since abovementioned plan has been made on the map, detail of field work, such as location or depth of drilling, should be considered as changeable with the progress of the survey.

Besides, the exploration for deeper area than 100 meters below the drainage level, or the more detailed survey at the southern part of the Gransina area should be conducted at the next stage, if necessary.

Table 7-3 Cost of Field Work for the Detailed Exploration in the Bayabas-Balaas Area

Staff, Machines	Number	Price (₱)	Days	Total Cost (₱)
Geologist	2	40/day	90	7,200
Labour	4	11/day	90	3,960
Miscellaneous man	2	10/day	90	1,800
Bulldozer	3	1,200/day	90x2 90x1	255,600
Drilling	8	150/m	(2,450m)	367,500
Track	1	100/day	90	9,000
Jeep	2	100/day	90	18,000
Trailer house	5	150/day	90	67,500
Gasoline		0.76/1		8,100
Sub-total				738,660
Over head				73,866
Total				812,526 ≒ ₱820,000 (¥33,800,000)

Table 7-4 Cost of Field Work for the Detailed Exploration in the Gransina-Mantalongon Area

Staff, Machine	Number	Price (₱)	Days	Total Cost (₱)
Geologist	2	40/day	90	7,200
Labour	4	11/day	90	3,960
Miscellaneous man	2	10/day	90	1,800
Bulldozer	2	1,200/day	90	216,000
Drilling	2	150/m	(650m)	97,500
Track	1	100/day	90	9,000
Jeep	1	100/day	90	9,000
Trailer house	4	150/day	90	54,000
Gasoline		0.76/l		5,400
Sub-total				394,860
Overhead				39,486
Total				434,346 ≒ ₱440,000 (¥18,500,000)

7-5 Possibility of Detailed Exploration in Future

From abovementioned, possibility of detailed exploration for the four coal regions in future is summarized as follows.

In the Uling and Toledo regions of central Cebu, the main workable seam is only one in the former, and one or two lenticular beds having about one meter thick in the latter. Coal reserves are not much in the both regions. Therefore, the possibility of exploration in these regions will be low grade.

In the Danao-Compostela region of northern Cebu, detailed geologic and topographic map and especially mining map are lacked. Rock facies of the formations change violently in the region. So that it is necessary to have a step of preliminary exploration before the detailed survey. Accordingly, the prospect in this region including preparation of old mine maps will require a term of more than two years and a large amount of expense. It is, therefore, impossible to regard as the objective area for detailed survey at this stage.

In the Argao-Dalaguete region of southern Cebu, it is able to make a plan for detailed exploration as the geologic information by Barnes and others is available. Of this region, the Bayabas-Balaas and Gransina-Mantalongon areas will have some potentiality of the exploitation for coal mine. It is estimated that a term of field work needs about three months in each area and its cost is at least 820 thousands pesos in the former area and 440 thousands pesos in the latter area. However, the necessity of subsequent exploration will be considered because of the complicated structure.

CHAPTER 8

FEASIBILITY OF THE COAL MINE DEVELOPMENT

CHAPTER 8. FEASIBILITY OF THE COAL MINE DEVELOPMENT

8-1 Possibility of the Coal Development

This mining plan was designed assuming that the coal seams exist in continuance of 1, 000meters long, however, the seams are separated into blocks by faults in fact. There is high probability to find new faults in the area by the detailed survey, moreover the existence of secondary faults branched from the faults and/or minute faults are concerned about. Those faults probably exert serious influences upon the mining operation.

Besides, the coal seams around the drainage level are difficult to be excavated by systematic mining system, because those have been already mined unorderly by Camote Mining System or the other small scale mining system. This fact would be a bad factor that would cause mine accidents like flood damage and spontaneous combustion, for the mining in the lower parts.

According to the results of rock test, the compressive strength of the rocks are about 100 Kg/cm^2, and some rocks have a good expansibility after absorbing water. Judging from these properties of the rocks, it is afraid that the mining operation in a panel beyond faults after driving across them and maintenance of the entries around them are in very much difficulty from the viewpoints of not only work but also safety.

When a mine development is planned, the mine life is usually estimated for 15 to 20 years owing to consider the depreciation, housing expenses and other factors. However, minable coal reserves by systematic mining system is supposed to be about 100, 000 tons per field in Cebu Island, though we don't confirm it. The mine life per field are estimated at about two years from the coal reserves, therefore, because new fields have to be developed in turn, double unit of main equipment are necessary to remove the mine to a new field. It causes an increase of the capital investment, and brings about a rise in the cost.

Meanwhile, the coal reserves mentioned above means a quantity of coal in an area up to the depth of 100 m under the drainage level.

Accordingly the coal reserves deeper than that should be estimated after further exploration and investigation. However, according to experiences in Japan, geological conditions show a tendency to become worse in proportion as the depth from the surface ground, for example, the number of faults increase and a thickness of coal seam becomes thin down with the depth.

Supposing that this tendency can be applied to Cebu Island, it can be expected naturally that a coal seam is continued to deeper zone than the depth of 100 m under the drainage level, but the coal recovery of the this zone should be estimated at less than 50% of that of the upper area, and in any case, there is no possibility for the mine life to extend to ten years.

This mining plan was made on the presumption that the geological conditions of the proposed mining area are good, as it was described before. Though the daily production was designed at 200 tons, the true geological conditions are questionable for the designed plan. So that, a final design of the working faces can be established only after the geological conditions of the faces are confirmed by detailed investigation and development of the entries. In case of thin coal seam to be mined and soft roof, if a fault is there, even if it is small one that its vertical displacement is about 0.5 - 1 m, the proposed production per face is impossible to be achieved because of the fault, so the addition of another face is necessary. It is natural in above case that a increase of the capital investment and a rise in the operation cost with a decrease of the mining productivity may result. In addition, the skill of laborers for the systematic mining system is a problem also.

A rate of the depreciation in the total cost is especially high. The depreciation was estimated through a legal usefull life in Japan of each equipment, and the usefull lives are more than two times the mine life: It means that those equipment should be used at other mine after the finished of the operation in a mine.

A removal of the buildings is thought to be a big problem in the cost, because the removal expense and the re-construction cost had to be added.

Besides, that the roads for transportation in mountains and swamp are difficult to maintain in the rainy season is a factor of unstable coal supply to the consumers.

As it was described above, the natural, geological and mining conditions of the coal regions in Cebu Island are very severe for the development, compared with those of mines under development in foreign countries in general.

However, when both the external factors like the situation of energy and socio-economy in the Philippines, and the inner factors like the daily output of 200 tons and the cost which may be on a border line are taken into consideration, we can not deny all the necessity of the development of coal mine in Cebu Island.

Accordingly, the detaild survey to confirm the coal reserves and mining conditions should be made and final decision, whether it will be developed or not, has to be made by the result of this survey.

8-2 Future Courses of the Exploration

If a coal-burning thermal power plant constructed in Cebu Island, futher exploration to confirm 1,200,000 metric tons of coal reserves in Cebu Island should be carried out. However daily 400 MT of coal is required to be supplied to the station as long as 33 years, and it is difficult to supply such quantity of coal from Cebu Island only.

Accordingly, the explorations to find the supply sources of coal have to be carried out also in the other Island. Consequently, if the coal reserves in Cebu Island is assumed at 1,200,000 MT, following three cases are thought as for the supply sources of coal.

(1) (200 tons/day x 2 mines x 10 years) + A + B

(2) (200 tons/day x 1 mine x 20 years) + A + B

(3) A + B

A : Domestic coal from other island

B : Imported coal

In the cases of (1) and (2) the coal mine development in Cebu Island is affirmed, and in the case of (3) it is denied.

In the case of (1), coal will be supplied from Cebu Island only for first ten years, and after that time it will be supplied from the other islands or foreign country.

In the case of (2), the coal mine development will be performed in Cebu and the other islands at the same time, and after ten years the imported coal will be added to the domestic coal though it depends upon the quantity of the domestic coal.

As it can be known through the mentioned above, not only the coal development in Cebu Island but also the domestic coal reserves in the other islands hold the key to the supply of coal fuel to the thermal power plant in any case out of the three cases.

Accordingly, it is proposed that the exploration of coal reserves in the other islands, including the estimation of the development cost, must be performed to make a long-term stabilizing coal supply schedule.

CHAPTER 9

THERMAL POWER PLANT DEVELOPMENT SCHEME

CHAPTER 9. THERMAL POWER PLANT DEVELOPMENT SCHEME

9-1 Load Forecast

9-1-1 Outline of Electric Power Situation of Cebu Island

As of December 1973, the total generating capacity of the power system of Cebu Island was 49.4 MW (at generating end) its greater part (85%) was concentrated at the city of Cebu. Power supply to the area around Cebu City is carried out by VECO (a private electricity enterprise), while at other regional communities power supply is undertaken by 19 private or municipal electricity enterprises operating small independent power systems of around 0.1 - 2.5 MW each.

NPC, a state-owned electric power enterprise, is assuming responsibility of power generation and transmission in regard to the program for achieving nationwide electrification of the Republic of the Philippines and has plans for interconnection of all systems and expansion of power source facilities for Cebu Island.

Regarding the power demand on Cebu Island, the per capita energy production as of 1973 for Cebu City and environs was 315 kWh and the ratio of electrification was approximately 50%, but for Cebu Island as a whole these figures were only 110 kWh and 20% respectively.

As of March 1974, the electric power facilities owned by VECO were all thermal power generating facilities with a total capacity of 51.1 MW. Fuel for the facilities is mostly Bunker Coil (57,000 MT annually), and only small quantity of coal of domestic production is used. The ratio of coal consumption to total fuel is approximately 17% is terms of calory. Fuel costs in March 1974 were $10.10/MT for coal and $78/kl for Bunker C fuel.

The growth rate of power demand during the past 10-year period (1964 - 1973) was 10.8% with breakdown of 12.1% for the first 5-year period and 7.7% for the latter 5-year period indicating a recent slowing-down in the growth rate of power demand. Particularly, after the upward revision of electricity tariffs effectuated due to the rises in petroleum prices in October 1973 (the average unit sales price of electricity prior to revision of tariffs was $0.12/kWh), the power demand seems decreasing not far from on increasing trend though it might be only a temporary path.

Table 9-1, Table 9-2, and Table 9-3 which follow show the outline of the power system, the demand growth for the past 10 years, and the upheaval in the price of Bunker C oil for power plants during the past one year, respectively.

9-1-2 Load Forecast for Cebu Island

The forecast of the future power demand basically involves estimation on the basis of past records by means of trend-wise approach or sectral analysis of demand type. While, at the same time demand size in the future should also be approached from a strategic angle so that the size may make a target value to be achieved in relation to the economic and social development program for the entire area the power system is related. Accordingly, the construction of power generating facilities should naturally be taken up following increase of power demand, while, on the other hand it should also be implemented to stimulate planned activities in the region.

As techniques of forecasting power demand the macro method and micro method are generally used. The macro method is to estimate demand from the correlations of electric energy consumption with macroscopic national (or regional) economic indexes such as GNP and population.

In the micro method, the demand growth in the power system under consideration is estimated primarily by the type of use and by district. The population growth rates, electrification rates, specific plans for industrial development, living standards, etc. are key-factors which make basis of the estimation for individual sectors by the type of use. The figures estimated for individual sectors are finally added up and totalled to make the forecast for the entire power system.

The load forecast given in this Report followed the above fundamental line to the possible extent. Actually the micro method was resorted to as the basic measure to give the most probable value. The figures obtained by the micro method were, then, checked and confirmed

Table 9-1 Statistic of VECO Power System in 1973

Plant Statistics:	Steam Turbine	Bunker-Burning Diesel	Total
Rated Capacity (KW)	13,600 (1,800x2 / 5,000x2)	37,500 (4,500 x 5 / 5,000 x 3)	51,100
Generation (KWH)	45,919,560	175,645,860	221,565,420
Diesel Fuel Used (MT)	-	3,846	3,846
Bunker Fuel Used (MT)	13,637	39,311	52,948
Coal Fuel Used (MT)	23,515	-	23,515
Lube Oil Used (MT)	3.8	657	660.8

Fuel Prices:	March 31, 1973 Prices	Dec. 1, 1973 Prices
Bunker Fuel	24.426 $/t	43.615 $/t
Diesel Fuel	0.2420$/liter	0.4480$/liter
Coal (10,000 btu/1b)	6.46 $/t	10.384 $/t

Market Statistics:	No. of Customer	KWH Sold	Revenue ($)
Residential	41,605	52,845,155	1,777,800
General Service	5,522	33,629,939	1,173,700
General Power	469	82,870,251	1,866,100
Flat Rate	2,082	911,696	29,600
Street Lighting	17	3,111,696	85,200
Gov't Offices/Bldgs	280	4,249,558	115,000
Total	49,975	177,618,306	5,047,400

System Peak Load	Yearly Maximum	Monthly Maximum
Night Peak (KW)	41,200	38,292
Day Peak (KW)	36,100	34,083

Table 9-2 Actual Data of Energy Production

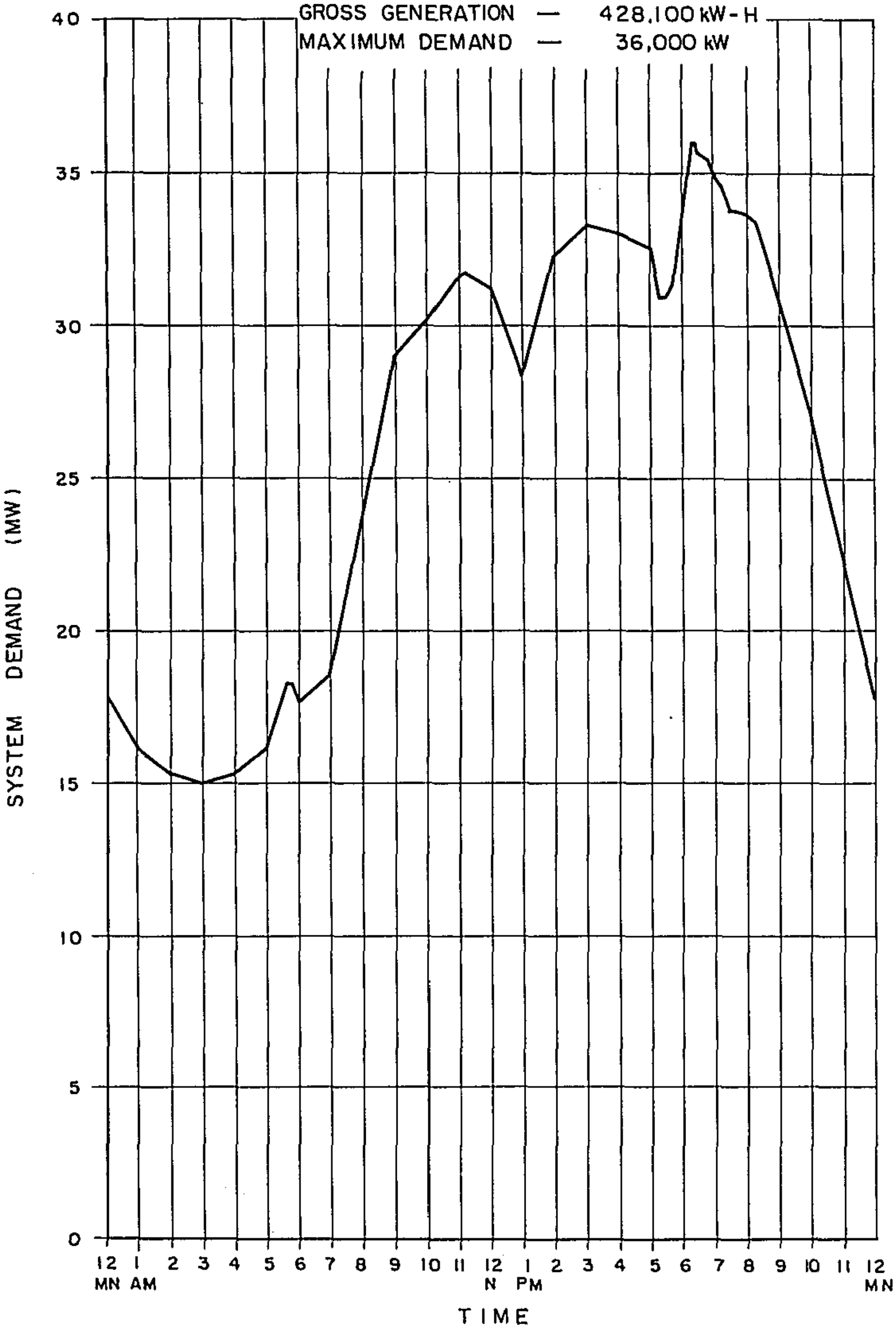
Visayan Electric Co., Inc., (VECO)

		1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	Average
Energy Generation												
Steam	GWH	71.2	67.4	75.7	73.3	71.6	57.2	73.4	42.0	34.5	45.4	
Diesel	"	3.7	20.3	31.0	47.3	71.3	106.3	99.3	137.2	168.0	175.7	
Total	"	74.9	87.7	106.7	123.6	142.9	163.5	172.7	179.2	202.5	221.6	
Maximum Demand	MW	16.6	19.5	22.3	24.4	28.4	30.9	31.9	34.8	37.7	41.2	
Rate of Growth	%	12.2	17.7	13.9	9.7	16.4	8.8	3.2	9.1	8.2	9.2	10.8
Energy Sold	GWH	56.2	67.5	83.8	96.9	112.3	124.5	141.6	147.4	165.7	177.6	
Annual Load Factor	%	51.5	51.2	54.4	57.8	57.4	60.5	61.8	58.8	61.4	61.2	

Table 9-3. Increase of Price of Bunker Fuel in Cebu City

	1973/Mar.	1972/Dec.	1974/Mar.
Price of Bunker Fuel ($/Kl)	24.4	43.6	77.0 (78.2 for Bataan Thermal)

Fig 9-1 LOAD CURVE FOR CEBU CITY AND SUBURBS TAKEN ON MARCH 6, 1974 (WEDNESDAY)



by the macro method from a macroscopic standpoint. Further, taking unforeseenable changes in social and economic aspects into consideration, a certain margin was provided to the figures on positive and negative sides; that is, in our approach the future demand was forecasted in a certain range and not in a specific value.

In the micro method as applied as basic measures, data and records of actual demand in the past years were utilized to the possible extent; customers were classified into brackets of residential, commercial, industrial, flat rate, street lighting and governmental office, and the future growth rates in number of customers and salable energy for each category were estimated through statistical analysis. (see Table 9-4).

Such micro method was actually performed for the VECO Power System centered around Cebu City which comprises approximately 90% of the power demand of Cebu Island. However, for other rural areas (electrified by only 5% in spite of having 50% of the population of Cebu Island) for which such basic data are not available, future demand was forecasted on the basis on the electrification ratio of 42% to be achieved in the year 1990 which is given as target in the rural electrification program established by the Government of the Philippines.

There are 12 various enterprises (their major lines of business are, copper, cement, beer, coconut, sugar) on Cebu Island which have their own factory power plants amounting to a total installed capacity of 150 MW. The power plants are quite independent of the power system around Cebu City and are scattered across the island. In particular, Atlas Copper Mining on the west coast has private generating facilities of 103 MW and is further planning a power plant of 50 MW x 2 units. As for the other enterprises, viewed from their present situation of operation and degrees of depreciation of power plants, it is considered uneconomical for them to change their power source from their power plants to system network of electricity utility. Thereofre, these enterprises possessing their own generating facilities were excluded from the present load forecast. In case the power systems are interconnected in the future, and these factories come into the systems, the power systems would possibility receive power from these private plants rather than make supply to them. (According if such enterprises are to be considered in the load forecast they will constitute a negative margin.)

The future power demand from 1974 to 1985 was forecasted based on the line of thinking as above mentioned and the result is shown in Table 9-5. According to the forecast power demand will grow to 175 MW in ten years from now to 1983, that is, at the annual average growth rate of 13.5%. This growth rate is slightly higher than the average growth rate of 10.8% for the past 10 years, but could be taken appropriate and reasonable when considering the facts that the level of power demand already reached up to the limits of installed capacity in September 1973 and again that the rate is low compared with that obtained by the macro method described below. (see Table 9-5)

As a macro approach, calculations were made based on the correlations between the National Development Plan of the Republic of the Philippines and the electric energy requirement of the Philippines as a whole, and between the entire Philippines and Cebu Island with respect to energy demand.

Firstly, it was assumed that per capita requirement in terms of kWh in relation to per capita GNP would in the future approach to the mediam value taken for the countries of the world. It was also assumed that the growth rate of GNP itself would be 7% until 1983 and 6% until 1988. As for population growth rate, 3% and 2% were respectively taken for the periods up to 1983 and until 1988. As a result, the growth rate of power demand for the entire Philippines will be 15.7% until 1983 and 13.2% until 1988. If the growth rate of electric energy demand in the past years of the entire Philippines is taken as 100, that of Cebu Island is 118. Assuming that this relation will continue in the future also, the growth rate of power demand of Cebu Island until 1988 would be an average of 14.9%. This rate was taken to be the maximum value.

While, if it is assumed that the growth rate of GNP of the country does not go as planned, the forecast should be more appropriate based on the trend of the latest 5 years which was less than 10%. In this case the power demand would increase at an average growth rate of 11.4% up to the year 1988. This rate was taken as the minimum value.

The results of the forecast are shown in Fig. 9-2.

Table 9-4 Figures used for Load Forecast in VECO System

	1973 (kWh)	Past Trend '62 - '69 (%)	Past Trend '62 - '73 (%)	Forecasted Growth Rate '74 - '80 (%)	Forecasted Growth Rate '81 - '85 (%)
(1) No. of Customers					
Residential	41,605	7.8	7.4	7.0	7.0
Commercial	5,522	7.3	6.2	6.0	6.0
Industrial	469	6.4	5.5	5.5	5.5
Flat-Rate	2,082	3.8	3.8	-	-
Street Lightings	17	8.1	7.6	6.0 (Street Lightings and Gov. Buildings)	5.0 (Street Lightings and Gov. Buildings)
Gov. Buildings	280	4.1	4.1		
(2) Consumption per customer					
Residential	1,270	9.0	8.2	8.0	6.0
Commercial	6,090	10.3	9.2	9.0	7.0
Industrial	176,695	12.8	9.7	9.5	7.5
Flat-Rate	437	6.3	6.3	-	
Street Lightings	183,000	-	-	0 (Street Lightings and Gov. Buildings)	0 (Street Lightings and Gov. Buildings)
Gov. Buildings	15,175	5.7	10.4		

Table 9-5-(1) Load Demand Forecast for Cebu Grid

		1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Increase (%)
I Cebu City Area														
(1) No. of Customers														
Residential	(10^3)	44.5	47.6	50.9	54.5	58.3	62.4	66.8	71.4	76.3	81.7	87.4	93.5	7.7
Commercial	(")	5.8	6.2	6.5	6.9	7.3	7.8	8.3	8.8	9.3	9.8	10.4	11.1	6.0
Industrial	(")	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	5.5
Flat-Rate	(")	2.0	1.5	1.0	0.5	-	-	-	-	-	-	-	-	
Street Lightings / Gov. Buildings	(")	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	6.5
Total														
(2) Consumption per customer														
Residential	(MWH)	1.4	1.5	1.6	1.7	1.9	2.0	2.2	2.3	2.4	2.6	2.7	2.9	7.7
Commercial	(")	6.6	7.2	7.9	8.6	9.4	10.2	11.1	11.9	12.7	13.6	14.6	15.6	8.3
Industrial	(")	193.5	211.9	232.0	254.0	278.2	304.6	333.5	358.5	385.4	414.3	445.4	478.8	8.7
Flat-Rate	(")	0.4	0.4	0.4	0.4	-	-	-	-	-	-	-	-	
Street Lightings / Gov. Buildings	(")	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3	0
(3) Annual Consumption														
Residential	(GWH)	62.3	71.4	81.4	92.7	110.8	124.8	147.0	164.2	183.1	212.4	236.0	271.2	14.5
Commercial	(")	38.3	44.6	51.4	59.3	68.6	79.6	92.1	104.7	118.1	133.3	151.8	173.2	14.7
Industrial	(")	96.8	106.0	139.2	152.4	166.9	182.8	233.5	251.0	308.3	331.4	356.3	430.9	14.7
Flat-Rate	(")	0.8	0.6	0.4	0.2	-	-	-	-	-	-	-	-	

(Continued)

Table 9-5-(2)

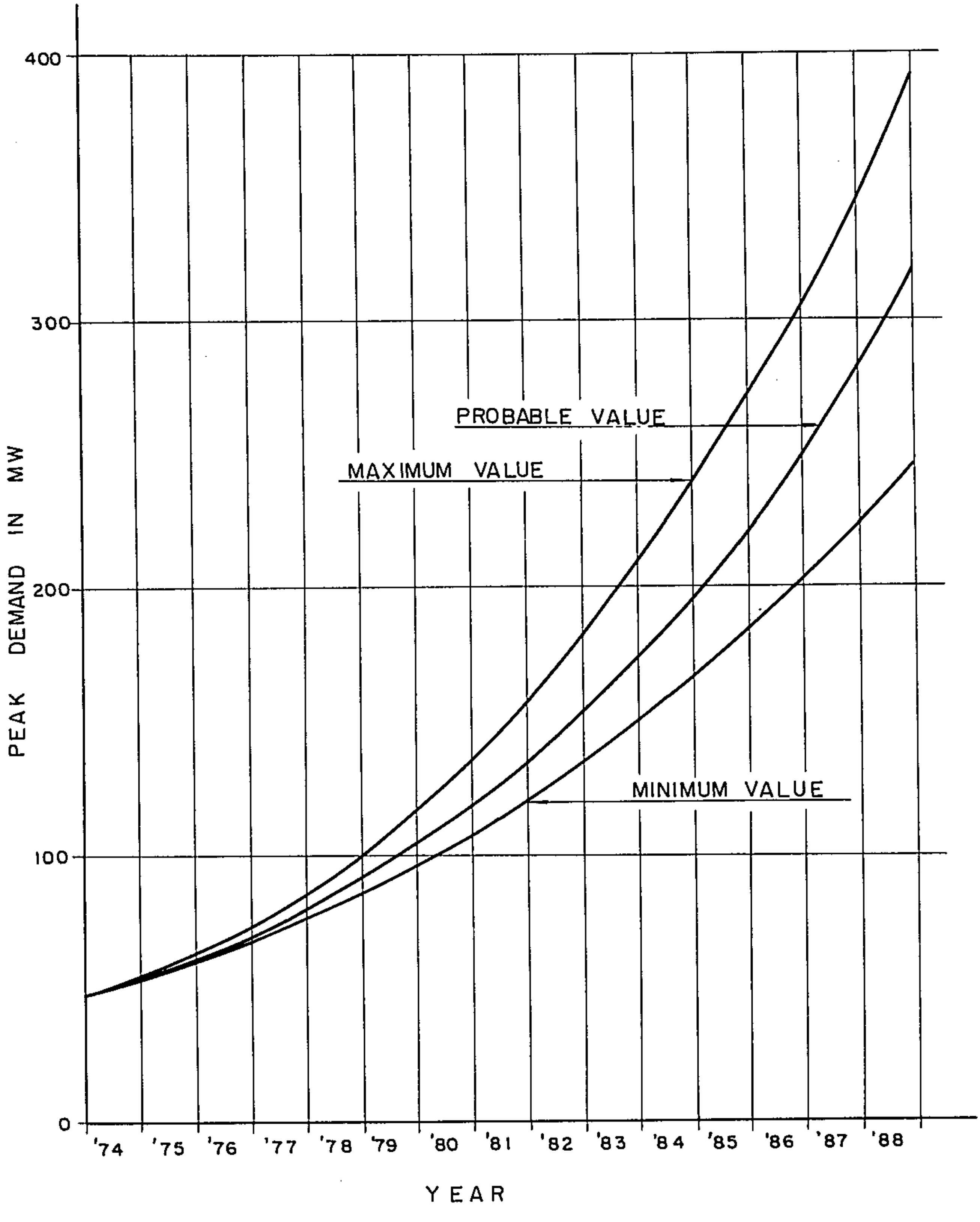
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Increase (%)
Street Lightings (GWH) / Gov. Buildings(")	3.7	3.7	4.9	4.9	4.9	4.9	4.9	6.2	6.2	6.2	6.2	7.4	6.5
Total	201.9	226.3	277.3	309.5	351.2	392.1	477.5	526.1	615.7	683.3	750.3	882.7	14.5
Transmission Loss(%)	17.0	16.5	16.0	15.5	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	-
Energy Production (GWH)	243.3	271.0	330.1	366.3	413.2	461.3	561.8	618.9	724.4	803.9	882.7	1038.5	14.2
Annual Load Factor (%)	60	60	60	60	60	60	60	60	60	60	60	60	-
Max. Demand (MW)	46.3	51.6	62.8	69.7	78.6	87.8	106.9	117.8	137.8	152.9	167.9	197.6	14.2
II. Danas City Area													
Energy Production (GWH)	2.5	2.9	3.5	4.1	4.8	5.7	6.6	7.5	8.7	10.0	11.5	13.2	16.4
Max. Demand (MW)	0.6	0.7	0.8	0.9	1.1	1.3	1.5	1.7	2.0	2.3	2.6	3.0	17.4
III. Mactan Area													
Energy Production (GWH)	11.5	11.7	11.8	12.0	12.1	12.3	12.5	12.8	13.0	13.3	13.6	13.9	1.7
Max. Demand (MW)	2.4	2.4	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.8	2.8	2.9	1.7
IV. Sogod Area													
Energy Production (GWH)	4.7	5.0	5.4	5.8	6.2	6.8	7.4	8.0	8.8	9.7	10.6	11.7	8.7
Max. Demand (MW)	0.8	1.0	1.1	1.3	1.4	1.6	1.8	2.0	2.3	2.5	2.8	3.1	13.1

(Continued)

Table 9-5-(3)

		1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Increase (%)
V. Bogo Area														
Energy Production	(GWH)	4.2	4.6	5.1	5.7	6.4	7.1	8.0	9.0	10.1	11.3	12.7	14.2	11.8
Max. Demand	(MW)	1.3	1.5	1.7	1.9	2.1	2.4	2.7	3.0	3.3	3.7	4.1	4.5	12.2
VI. Sibonga Area														
Energy Production	(GWH)	1.5	2.2	3.0	3.9	4.9	6.0	7.3	8.8	10.5	12.4	14.5	16.9	26.3
Max. Demand	(MW)	0.7	1.0	1.4	1.7	2.1	2.5	2.9	3.4	3.9	4.4	5.0	5.7	21.2
VII. Toledo City Area														
Energy Production	(GWH)	2.2	2.8	3.6	4.4	5.4	6.5	7.7	9.1	10.6	12.3	14.3	16.5	20.0
Max. Demand	(MW)	1.0	1.2	1.5	1.8	2.1	2.5	2.8	3.2	3.7	4.1	4.7	5.2	16.3
VIII. Bol-Joon Area														
Energy Production	(GWH)	0.7	1.0	1.4	1.8	2.3	2.8	3.4	4.1	4.9	5.8	6.8	7.9	26.3
Max. Demand	(MW)	0.3	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.1	2.4	2.7	22.2
Cebu Grid System														
Energy Production	(GWH)	270.6	301.2	363.9	404.0	455.3	508.5	614.7	678.2	791.0	878.7	966.7	1132.8	13.5
Max. Demand	(MW)	53.4	59.9	72.4	80.6	90.9	101.9	122.6	135.4	157.5	174.8	192.3	224.7	13.5
Annual Load Factor	(%)	57.8	57.4	57.4	57.2	57.2	57.0	57.2	57.2	57.3	57.4	57.4	57.6	-

Fig 9-2 LONG-RANGE LOAD FORECAST



9-2 Scale and Timing of Development of Thermal Power Plant

9-2-1 Fundamental Thinking

In order to cope with the increase of demand as forecasted in 9-1, it is necessary to provide power facilities without delay in the area. For this purpose, the optimum capacity, number of units, and timing of development of the power plant must be determined. The selection of these optimum values is made through economic evaluations based on comparisons of annual costs over the long term. Further, in addition to comparision of annual costs, the amount of funds required in the most recent years is also a factor which should be considered to make sure the feasibility of the plan from viewpoint of monetary availability.

According to the results of the present studies, there is only little possibility to find good sites for a hydroelectric project or geothermal project which can serve as an alternative of a thermal power plant. Therefore, only thermal power plants were made for the objective of the development and accordingly the study in regard to the size and timing was made of them.

As described in Chapter 8, the quantity of coal produced within Cebu Island is insufficient, and until the results of the investigations are obtained of the coal field on Mindanao and other islands, the quantity of coal produced in the country and the price could not be made clear. For this reason, it is impossible to determine at the present whether the thermal power plant should be a dual fired plant or a uni-oil fired plant. In this connection, for convenience sake, annual costs of uni-oil fired thermal plant was adapted as basis of evaluation, upon an assumption that if a coal fired thermal power plant would be planned in place of a uni-oil fired plant, its annual costs would not exceed that of a uni-oil fired plant. (In other words, it was assumed that it would be possible to obtain coal in such quantity and price as will make the annual costs of the two equivalent.)

9-2-2 Capacity Required and Proposed Power Plants for Development

The total supply capacity required for the Cebu Island Power system is as shown in Table 9-6: the size of capacity is a sum of the peak demand calculated in 9-1 plus power reserve. This reserve required should be estimated in view of supply reliability aimed at probable faults of power supply facilities due to unforeseenable causes. The reserve for Cebu Island was taken at 10% of peak demand from viewpoint of economy.

As indicated in Table 9-6, the required supply capacity will be 112 MW in 1979, 193 MW in 1983 and 354 MW in 1988, while the capacity presently owned is 51 MW.
Consequently, when the diesel power plant of 10MW x 5 units of which the construction is scheduled to start very soon is taken into account, there will be shortage of supply capacity of 11 MW in 1979, and 92 MW and 253 MW 10 and 15 years later respectively.

Table 9-6 Peak Balance

(MW)

	1975	1977	1979	1983	1988
Peak Demand	60	81	102	175	322
Reserve Required	6	8	10	18	32
Required Capacity	66	89	112	193	354
Existing Supply Capacity	51	51	51	51	51
Diesel Capacity under Construction	30	50	50	50	50
Supply Capacity to be Developed	15	12	11	92	253

To determine the capacities and timings of the power plants which should be developed to cope with this shortage of supply capacity in the 10-year period from now, three alternative plans were taken up for the study for the development of thermal power plants. For the study, unit capacity of 50 MW and 75 MW were considered for the following reasons to the exclusion of small capacity less than 50 MW and big capacity in excess of 75 MW.

(1) Steam type thermal power plants were selected regardless of the type of fuel. Especially, from viewpoints of effective utilization of domestic resources, diversification of energy resources and regional development, it is considered the most desirable to develop coal-fired thermal power plants to the possible extent.

(2) Scale merit should be pursued.

(3) System capacity of the Cebu grid will be only about 200 MW even 15 years from now.

(4) Turbines and boilers of a unit capacity of 50 MW or 75 MW are advantageous from technical and economical points of view in regard to manufacturing.

The three alternatives considered are;

Alternative A.	No. 1, 50 MW (1979); No. 2, 50 MW (1982);
	No. 1, 75 MW (1984); No. 2, 75 MW (1987)
Alternative B.	50 MW (1979); No. 1, 75 MW (1982);
	No. 2, 75 MW (1985); No. 3, 75 MW (1988)
Alternative C.	No. 1, 75 MW (1979); No. 2, 75 MW (1983);
	No. 3, 75 MW (1986); No. 4, 75 MW (1988)

The annual costs of the various power plants were calculated for the period of serviceable years of 33 years. Further, for the estimation of variable costs, it was assumed that large-capacity thermal power plants of high efficiency would be operated to supply the base load.

According to the results of calculation, the cost of Alternative A is the smallest in terms of the present value amounting to 202 million dollars.

A generator capacity of 75 MW may be rather excessive for the system in 1979 if considered from viewpoint of system reliability. However, in the study, unit capacity of 75 MW was considered in Alternative C from the early stage of development, because it was thought that a scale merit might be expectable in view of cost per kW which was estimated at $530/kW for 50 MW unit and $480/kW for 75 MW unit.

From the above, judged from the viewpoints of economy and system operation, it is desirable to promote development of thermal power plants in accordance with Alternative A. As a conclusion, development should firstly be implemented by the construction of a dual fired thermal power plant in 50 MW capacity, which will require a monetary investment of about 38 million dollars. (Detail of construction cost will be described in Chapter 10)

Fig 9-3 DEVELOPMENT PROGRAM

CASE - A

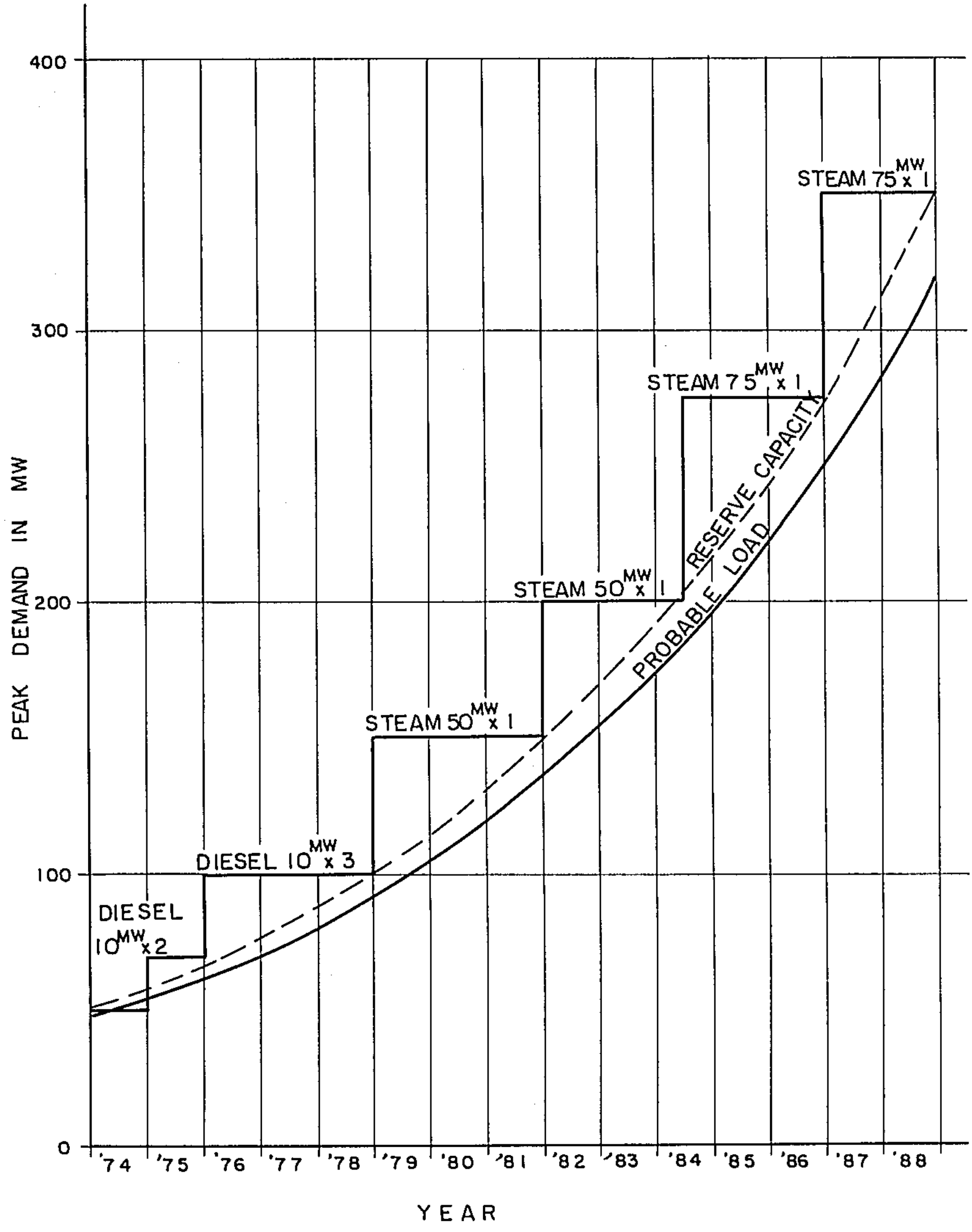


Fig 9 -4 DEVELOPMENT PROGRAM

CASE - B

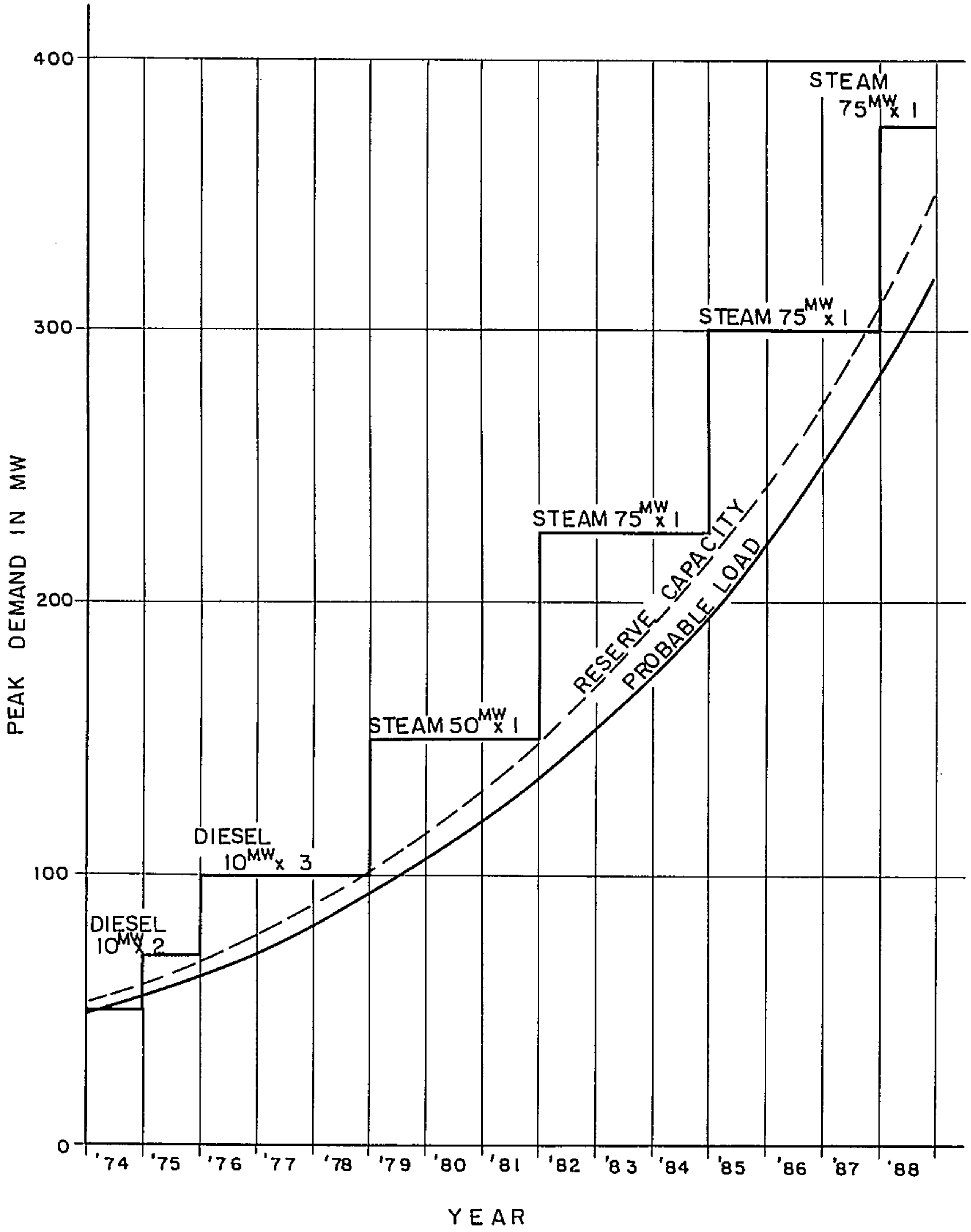
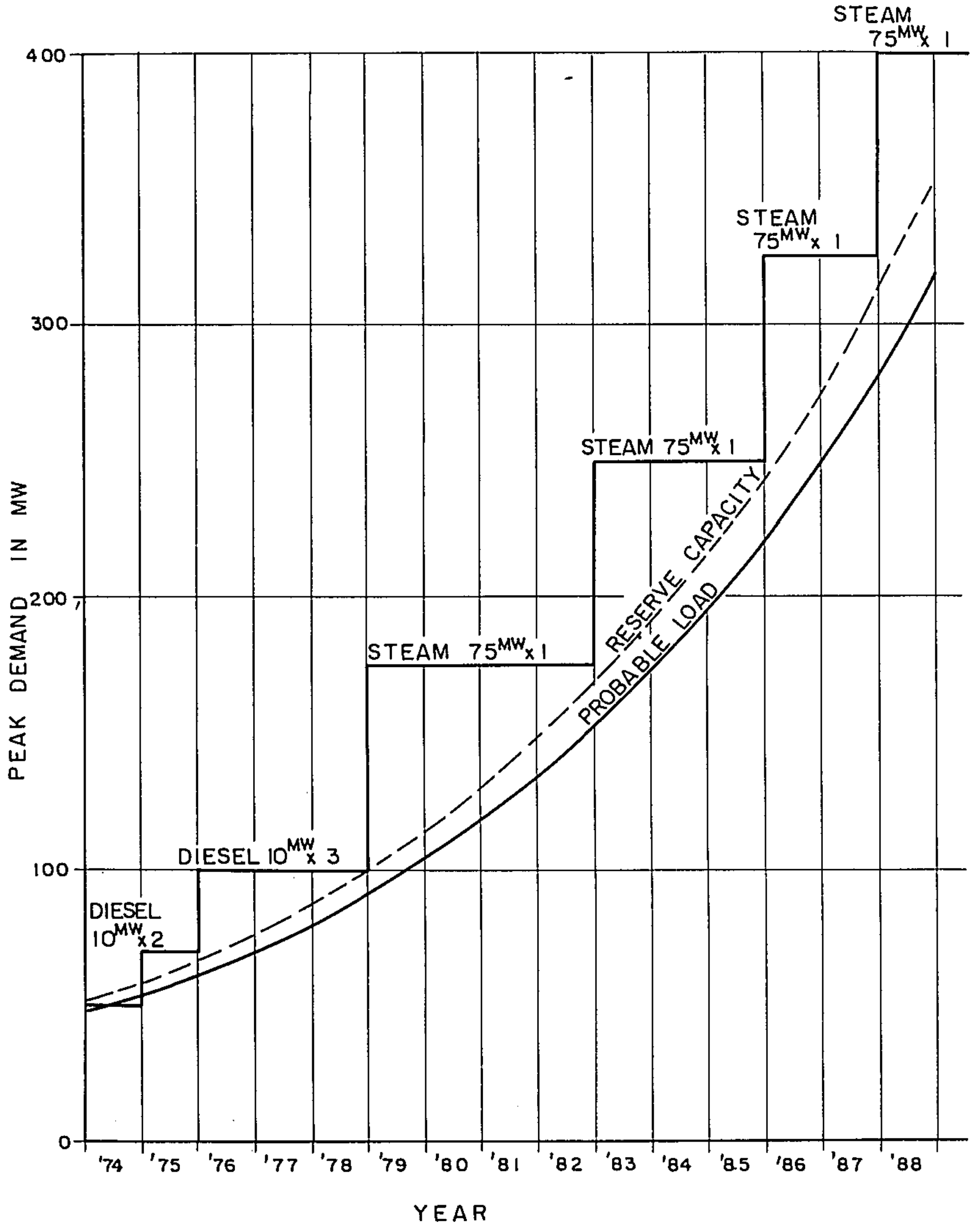


Fig 9-5 DEVELOPMENT PROGRAM

CASE — C



CHAPTER 10

DUAL FIRED THERMAL POWER PLANT

CHAPTER 10 DUAL FIRED THERMAL POWER PLANT

10-1 Basic Thinking of Development

The abnormal rise in petroleum prices which took place after the oil crisis in October 1973 has necessitated a review of energy policies.

Particularly, in regard to thermal power plants, necessity of coal fired power plants is more heavily weighing, instead of uni-oil fired power plants, from the viewpoint of saving of fuel costs, effective utilization of domestic resources, diversification of energy resources and regional development.

However, a coal fired thermal power plant requires a greater initial investment than a uni-oil fired power plant by approximately 20% as shown in Table 10-1 because of appurtenant facilities pertinent to coal fired plants such as coal handling facilities, and ash disposal ponds.

Therefore, to guarantee the economy of a coal fired thermal power plant in relation to a uni-oil fired plant, it is required that coal is obtainable in a sizable quantity at a price lower than Bunker C oil and further that the less is the quantity of coal available, the cheaper the price of coal should be.

In view and on the basis of such requirement the following factors should be clearly revealed;

(1) Economics of using only Cebu Island coal which is estimated at 1.2 million tons.

(2) Relation between the scale of development and marginal cost, which would be preconditions for coal field surveys to be conducted on Mindanao and other islands.

(3) Further, a reasonable quantity and price in case of importing coal from outside the country.

In the following clause, study will be made to detail on the additional construction cost required for a coal fired thermal power plant, the price ranges of coal which will make the coal fired plant economically justifiable in relation to the quantity of coal to be used, and the economics of a coal fired power plant as compared with a uni-oil fired power plant.

10-2 Construction Cost of Thermal Power Plant

10-2-1 Basis for Estimation of Construction Cost

The estimation of construction cost was conducted of a steam-turbine power plant of 50 MW x 2 units or 75 MW x 2 units. The estimate does not include the costs of 5 units of diesel-engine generating equipment, 10 MW each, to be provided in advance at the site and costs of transmission and distribution lines and switchyard facilities.

The basis for the estimation of the construction costs are as given below.

(Domestic Currency and Foreign Currency)

The CIF prices of equipment and materials, as well as a part of the installation cost were estimated as foreign currency requirement, while overland freight in the Philippines, the greater part of the installation cost and civil work costs were estimated in domestic currency.

It was assumed that all thermal power plant equipment would be imported from overseas.

(Taxes)

Taxes were not taken into account.

(Interest during Construction)

As interest during construction, 3.5% and 10% per annum was assumed for foreign currency requirement and domestic currency requirement, respectively.

(Contingency)

As amount equipment to 8% of total direct costs was taken as contingency.

(Engineering Fee)

Costs of difinite study including preparation of designs and specifications as well as construction supervision were estimated at 5% of total direct costs and entired as engineering fee to be paid out to the consultant.

(Rate of Exchange)

All of the monetary requirements were expressed in U.S. dollars on the basis of an assumed rate of exchange between dollars and pesos at

₱6.60 to $1.00.

It should be noted that because of extreme difficulty to forecast trend of prices due to abnormal rise which is taking place after oil crisis, all construction costs were estimated on the basis of present prices. Accordingly, it is necessary to review and modify the estimate when the time-table for construction is decisively established.

Costs of civil works were estimated based on data collected during field survey. However, since several data and information which are indespensable for designing the power plant such as detailed survey maps and data for marine conditions were not made available, adjustment of the construction cost may become necessary depending on the results of detail design.

10-2-2 Construction Cost of Thermal Power Plant

Construction costs of a thermal power plant with 2 units of 50 MW or with 2 units for 75 MW will be as given in Table 10-1, respectively for uni-oil fired and dual fired type.

As seen in Table 10-1, the construction cost of a dual fired thermal power plant is 10 million dollars higher than a uni-oil fired plant in the case of 2 units of 50 MW and 13.5 million dollars higher in the case of 2 units of 75 MW, that is, a dual fired plant is more costly than a uni-oil plant by about 20%. This is because a dual fired plant requires more facilities and equipment than uni-oil plant, including additional boiler equipment, facilities for storage and conveying of coal, and facilities for ash disposal. The breakdown of the construction costs are given in Tables 10-3 through 10-6. And unit construction costs are indicated in Table 10-2.

According to the cost estimate for the coal fired thermal power plant in "Addendum No. 1 to the Feasibility Report on the Development of Cebu Electric Power Grid Project" prepared by NPC (February 1974), unit cost is $480/kW for the first 50-MW unit and $396/kW on average for 1st and 2nd units inclusive. The estimate in this present report are higher than these figures.

This is partly because of prevailing prices are very high after the oil crisis and partly because the estimate of costs in the NPC report in regard to civil works were anyhow seemingly too low.

Table 10-1 Construction Cost

(10^3 $)

	50 MW			75 MW		
	1 U	2 U	Total	1 U	2 U	Total
Uni Oil Fired Thermal Power Plant	30,000	23,000	53,000	40,500	31,500	72,000
Dual Fired Thermal Power Plant	38,000	25,000	63,000	51,000	34,500	85,500

Table 10-2 Unit Construction Cost

($/KW)

	50 MW			75 MW		
	1 U	2 U	Total	1 U	2 U	Total
Unit Oil Fired Thermal Power Plant	600	460	530	540	420	480
Dual Fired Thermal Power Plant	760	500	630	680	460	570

Table 10-3 Construction Cost Oil Fired Steam Power Plant (50MWx2)

(10^3\$)

Items	1st Unit		2nd Unit	
	F.C	D.C	F.C	D.C
1. Civil Works, Structure, Piers and Improvement	1,500	5,600	600	2,200
2. Boiler Plant Equipment	7,400		7,500	
3. Turbine Generator	5,300		5,400	
4. Misc. Power Plant Equipment	1,700		300	
5. Switchyard and Transformers	800		800	
6. Erection Works	300	1,600	200	1,400
7. Insurance and Freight	1,000		900	
Total Direct Cost	18,000	7,200	15,700	3,600
8. Engineering	900	400	800	200
9. Contingency	1,400	600	1,300	300
10. Interest During Construction	700	800	700	400
Grand Toral	21,000	9,000	18,500	4,500
	30,000		23,000	
Unit Construction Cost (US \$/KW)	600		460	
	530			

Table 10-4 Construction Cost Coal/Oil Fired Steam Power Plant (50MWx2)

(10^3\$)

Items	1st unit		2nd unit	
	F.C	D.C	F.C	D.C
1. Civil Works, Structure, Piers and Improvement	1,700	6,900	700	2,400
2. Boiler Plant Equipment	8,300		8,300	
3. Coal Handling Operaters Conveyors and Ash Disposal Equipment	3,400		600	
4. Turbine Generator	5,300		5,300	
5. Switchyard and Transformers	800		800	
6. Misc. Power Plant Equipment	1,600		300	
7. Erection Works	600	1,900	200	1,500
8. Insurance and Freight	1,300		1,000	
Total Direct Cost	23,000	8,800	17,200	3,900
9. Engineering	1,200	500	900	200
10. Contingency	1,900	700	1,400	300
11. Interest During Construction	900	1,000	700	400
	27,000	11,000	20,200	4,800
	38,000		25,000	
Unit Construction Cost (US \$/KW)	760		500	
	630			

Table 10-5 Construction Cost Oil Fired Steam Power Plant (75MW x 2)

($10^3$$)

Items	1st Unit F.C	1st Unit D.C	2nd Unit F.C	2nd Unit D.C
1. Civil Works, Structure, Piers and Improvement	2,200	7,200	900	2,900
2. Boiler Plant Equipment	10,000		10,000	
3. Turbine Generator	7,200		7,200	
4. Misc Power Plant Equipment	2,200		700	
5. Switchyard and Transformers	1,100		1,100	
6. Erection Works	500	2,100	400	1,900
7. Insurance and Freight	1,400		1,200	
Total Direct Cost	24,600	9,300	21,500	4,800
8. Engineering	1,300	500	1,200	300
9. Contingency	2,000	800	1,800	400
10. Interest During Construction	1,000	1,000	900	600
Grand Total	28,900	11,600	25,400	6,100
	40,500		31,500	
Unit Construction Cost (US $/KW)	540		420	
	480			

Table 10-6 Construction Cost Coal/Oil Fired Steam Power Plant (75MWx2)

(10^3\$)

Items	1st Unit		2nd Unit	
	F.C	D.C	F.C	D.C
1. Civil Works, Structure, Piers and Improvement	2,300	9,000	1,000	3,500
2. Boiler Plant Equipment	11,200		11,200	
3. Coal Handling Operaters Conveyors and Ash Disposal Equipment	4,600		1,000	
4. Turbine Generator	7,200		7,200	
5. Switchyard and Transformers	1,100		1,100	
6. Misc. Power Plant Equipment	2,200		500	
7. Erection Works	500	2,700	300	2,100
8. Insurance and Freight	2,000		1,200	
Total Direct Cost	31,100	11,700	23,500	5,600
10. Engineering	1,600	600	1,200	300
11. Contingency	2,500	1,000	1,900	500
12. Interest During Construction	1,200	1,300	900	600
Grand Total	36,400	14,600	27,500	7,000
	51,000		34,500	
Unit Construction Cost (US \$/KW)	680		460	
	570			

10-3 Economic Range of Coal Utilization; Quantity VS Price

10-3-1 Required Amounts of Coal and Oil

The amount of coal and oil required to operate a dual fired thermal power plant with 2 units of 50 MW is indicated in Tables 10-7 and 10-8. As ample amount of coal may not be obtainable, a dual fired thermal power plant using both Bunker C oil and coal was considered for the present study. Requirements of oil and coal were estimated for various mixing ratios.

10-3-2 Economic Relation between Quantity and Price of Coal

As stated previously, a dual fired thermal power plant with 2 units of 50 MW requires an additional construction cost of about 10.0 million dollars over a uni-oil fired thermal power plant (about 20% higher than the latter), and further requires additional variable costs of $0.30 - 0.70/MT for disposal of ash.

Accordingly economic boundary of coal price in relation to used amount of coal or vice versa, the relation between marginal price and quantity of coal of which guarantees economic superiority of a dual fired thermal power plant to a uni-oil fired thermal power plant can be sought on the basis of with additional costs and the price of oil.

The various elements (interest rate, annual load factor, calories produced, efficiency, etc. used for calculation of annual cost are indicated in Table 10-9.

The relation between price and used amount of coal which defines economic boundary for a dual fixed plant is given in Fig. 5 in Chapter 2 and Table 10-10.

For example, supposing price of oil at $70/kl and if 8.8 million metric tons of coal, or 0.27 million tons on annual basis, which is coal requirement at the dual ratio of 100% is available, the power plant will be economical at the coal price up to $37.9/MT. At the dual ratio of 100%, if the price of oil rises from $70/kl to $90/kl, the power plant can

Table 10-7 Consumption of Oil

(kL)

	Plant Factor %	Oil Mixed Rate	$50^{MW} \times 1^{U}$ / 50^{MW}	$50^{MW} \times 2^{U}$ / 100^{MW}	$50^{MW} \times 2^{U}$, $75^{MW} \times 1^{U}$ / 175^{MW}	$50^{MW} \times 2^{U}$, $75^{MW} \times 2^{U}$ / 250^{MW}	$50^{MW} \times 2^{U}$, $75^{MW} \times 3^{U}$ / 325^{MW}
1 Hour	100	100	13.8	27.6	47.6	65.8	84.9
1 Day	"	"	330	660	1,120	1,580	2,040
1 Month	100	"	9,940	19,900	33,620	47,380	61,130
(30 Days)	70	"	6,960	13,900	23,540	33,160	42,790
1 Year	70	100	84,600	169,200	286,400	403,500	520,600
	"	90	76,200	152,300	257,700	363,100	468,500
	"	80	67,700	135,400	229,100	322,800	416,500
	"	70	59,200	118,500	200,500	282,400	364,400
	"	60	50,800	101,500	171,800	242,100	312,400
	"	50	42,300	84,600	143,200	201,700	260,300
	"	40	33,800	67,700	114,500	161,400	208,200
	"	30	25,400	50,800	859,100	121,000	156,200
	"	20	16,900	33,800	572,700	80,700	104,100
	"	10	8,500	16,900	286,400	40,300	52,100

Oil Grade 9,800 kcal/L

Efficiency 50^{MW} 31.9%

75^{MW} 34.5%

Table 10-8 Consumption of Coal

(MT)

	Plant Factor %	Coal Mixed Rate	$50^{MW} \times 1^{U}$ / 50^{MW}	$50^{MW} \times 2^{U}$ / 100^{MW}	$50^{MW} \times 2^{U}$, $75^{MW} \times 1^{U}$ / 175^{MW}	$50^{MW} \times 2^{U}$, $75^{MW} \times 2^{U}$ / 250^{MW}	$50^{MW} \times 2^{U}$, $75^{MW} \times 3^{U}$ / 325^{MW}
1 Hour	100	100	21.7	43.5	73.6	103.8	134.0
1 Day	"	"	520	1,040	1,770	2,490	3,220
1 Month	100	"	15,700	31,300	53,000	74,700	96,500
(30 Days)	70	"	11,000	21,900	37,100	52,300	67,500
1 Year	70	100	133,300	266,600	451,500	636,500	821,700
	"	90	120,000	240,000	406,400	572,900	739,500
	"	80	106,700	213,300	361,200	509,200	657,400
	"	70	93,300	186,600	316,100	445,600	575,200
	"	60	80,000	160,000	270,900	381,900	493,000
	"	50	66,700	133,300	225,800	318,300	410,800
	"	40	53,300	106,700	180,600	254,600	328,700
	"	30	40,000	80,000	135,500	191,000	246,500
	"	20	26,700	53,300	90,300	127,300	164,300
	"	10	13,300	26,700	45,200	63,700	82,200

Coal Grade $12{,}000\ ^{BTU}/1B$

Fixed water 7%

Efficiency 50^{MW} : 31.9%

75^{MW} : 34.5%

Table 10-9 Conditions for Annual Cost Calculation of Steam Plant (50MW x 2 Unit)

Interest Rate	7.5 %
Depreciation Rate	3.03 %
Annual Salary	US $ 1,600/person
No. of Persons	Oil fired 120, Coal fired 140
Operation and Maintenance Cost	2 % of construction cost
Administration Cost	8 % of total operation and maintenance cost
Exchange Rate	6.6 ₱/$
Ash Disposal Cost of Coal	0.4 $/MT
Plant Factor	70 %
Station Service Use	Oil Fired 5%, Coal Fired 7.5%
Thermal Efficiency at Generating End	31.9 %

economically well do with coal supply at prices up to $ 50.4/MT

In case availability of coal is limited to only 4.4 million metric tons (in this case, dual ratio would be 50%) or 2.6 million metric tons (dual ratio 30%), the price of coal should be less $33/MT or $27/MT respectively. (see Table 10-10)

As a note, even if one of the two 50-MW units be built exclusively for coal firing with the other unit exclusively for oil-burning, as a countermeasure for the case of inadequate availability of coal, the economic range would hardly shift. (see Fig. 10-1)

The study is based on an assumed serviceable life of 33 years. In case 22 years should be taken for serviceable life instead, the annual expense to recover the construction cost additionally required for exclusive coal firing thermal power plant would naturally increase, while on the other hand, the required quantity of coal decreases. Consequently, the economic range with respect to inter-relation between quantity and price of coal would also be almost the same as the case of the present study made for a serviceable of 33 years. (see the parenthesis in Table 10-10).

10-4 Economics of Dual Fired Thermal Power Plant

10-4-1 Case of Use of Cebu Island Coal

As described in Chapter 7, the quantity of recoverable coal is very limited and is estimated to be 1.2 million tons or less. If the coal reserve is developed, the cost of coal would be $41/MT (including costs of detail survey, and transportation cost of approximately $7/MT), as described in Chapter 6.

Even if coal is quite recoverable to the estimated maximum amount of 1.2 million metric tons, the quantity is equivalent only to 14% of the total coal requirement for a dual fired thermal power plant with 2 units of 50 MW at dual ratio of 100%. Further, the power plant can not do well economically unless coal is available at an extremely cheap cost (or price) of $6/MT or less.

Consequently, in case the thermal power plant is to depend excluding on the coal of Cebu Island, it will be impossible to sufficiently

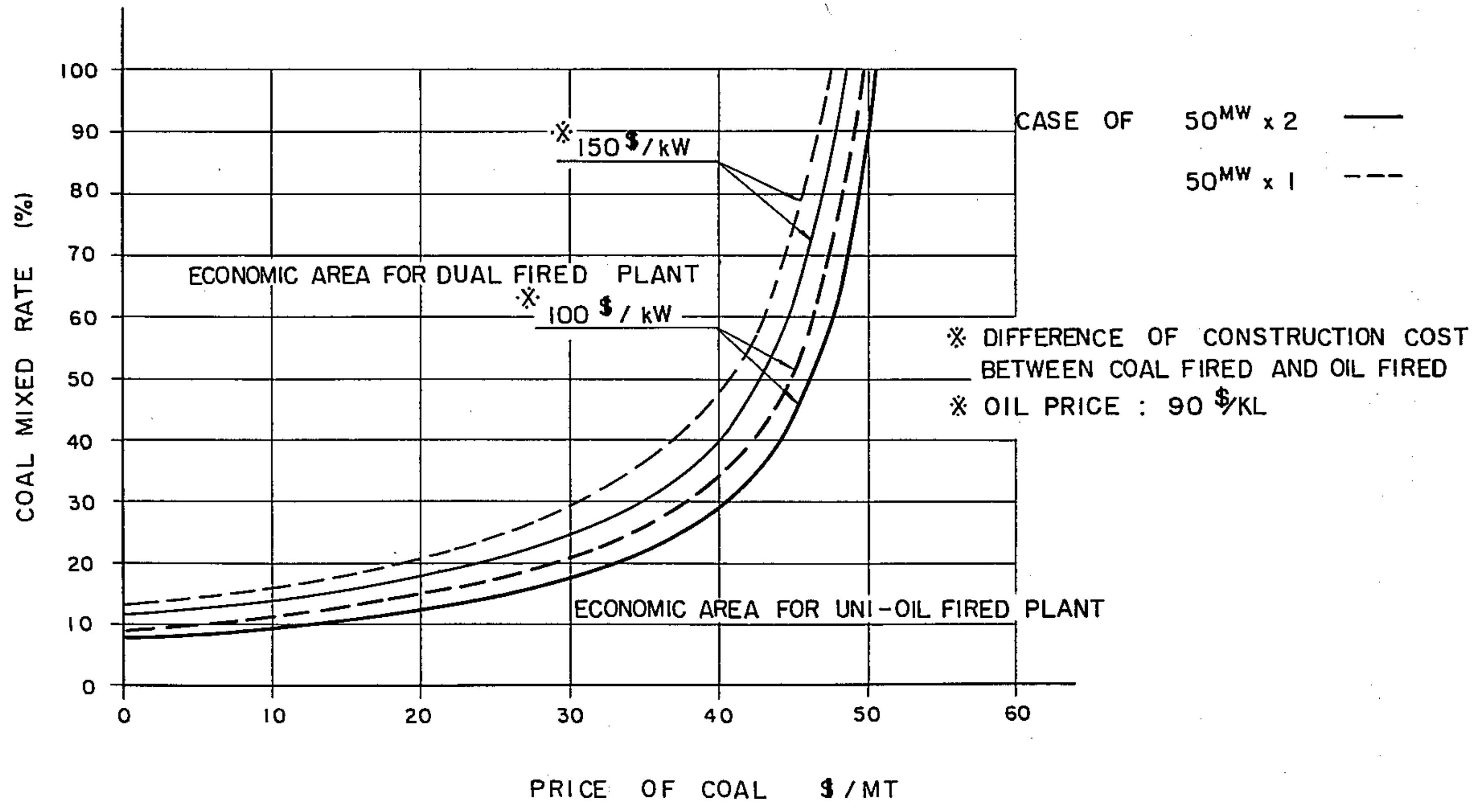
Table 10-10 Marginal Price and Amount of Coal Required (50MW 2 Unit)

Dual Rate (%)	Oil Price ($/KL)	Amount of Coal Required (10^3 MT)			Marginal Price of Coal ($/MT)	
		One year	20 years	33 years		
100	90	266	5,320	8,780	50.4	(49.6)
	70				37.9	(37.3)
70	90	187	3,740	6,170	48.6	(47.5)
	70				36.0	(35.1)
50	90	133	2,660	4,390	46.1	(44.6)
	70				33.4	(32.2)
30	90	80	1,600	2,640	40.3	(37.8)
	70				27.4	(25.4)
20	90	53	1,060	1,750	33.0	(29.3)
	70				19.8	(16.8)

Figures in the parenthesis show marginal price of coal based on the plant service life for 20 years.

Fig 10-1. ECONOMIC BOUNDARY OF RECOVERABLE COAL

(for Dual Fired Thermal Power Plant)



make up the incremental construction cost involved for dual firing and the economic loss would be 1.4 million dollars on annual basis, which means a total loss of 17 million dollars in terms of present value discounted at a rate of 7.5% p.a.

The cost of Cebu Island coal which is estimated at $41/MT loco at power plant site is lower than the economic price boundary of $51/MT which corresponds to the case of operation under supply of coal in adequate amount (dual ratio 100%, 7.8 x 10^6 MT). Consequently, in case the coal of Cebu Island is used in mixture with the coal of the origin of other areas, the price boundary beyond which such imported coal should not exceed from economic viewpoint will be raised, or in other words, be more relaxed. This price boundary could be used as an indicator in the survey of coal fields of Mindanao and other island which should be promoted on the premise that the domestic coal fields including Cebu should be developed as a link of regional development or energy policy to ensure more domestic resources (see Table 10-11).

Table 10-11 Variation of Marginal Price of Coal ($/MT)

Oil Price	Dual Ratio	Marginal Price of Coal		
($/Kl)	(%)	A	B	B - A
90	100	50.4	51.9	1.5
	50	46.1	48.0	1.9
70	100	37.9	37.4	0.5
	50	33.4	30.5	2.9

A: : Marginal price of total amount of coal required (from Table 10-10).

B : Marginal price of coal imported to Cebu, in case 1.2 million MT of coal in Cebu could be used.

10-4-2 Case of Exclusive Use of Coal from Areas Other than Cebu Island

In case a dual fired thermal power plant be developed without expecting yield of coal on Cebu Island but in expectation of the possibility of development of coal fields on Mindanao or other islands outside of Cebu, or import from abroad, justifiable range of coal price in relation to the amount of coal requirement which ensure economy of the plant over an alternative uni-oil fired plant will be along the analysis previously described in 10-3-2.

The available quantity and cost of domestic coal which can be producted outside of Cebu Island are not exactly tangible until detailed surveys on coal fields are completed in the future. And, as regards the coal to be imported from outside the country, the market price will likely fluctuate along with possible rise of oil price regardless of production cost. Since it is rather impossible at the present to depict a clear picture with regard to quantity (especially in case of domestic coal) and price of coal to be used in future for the thermal power plant on Cebu Island.

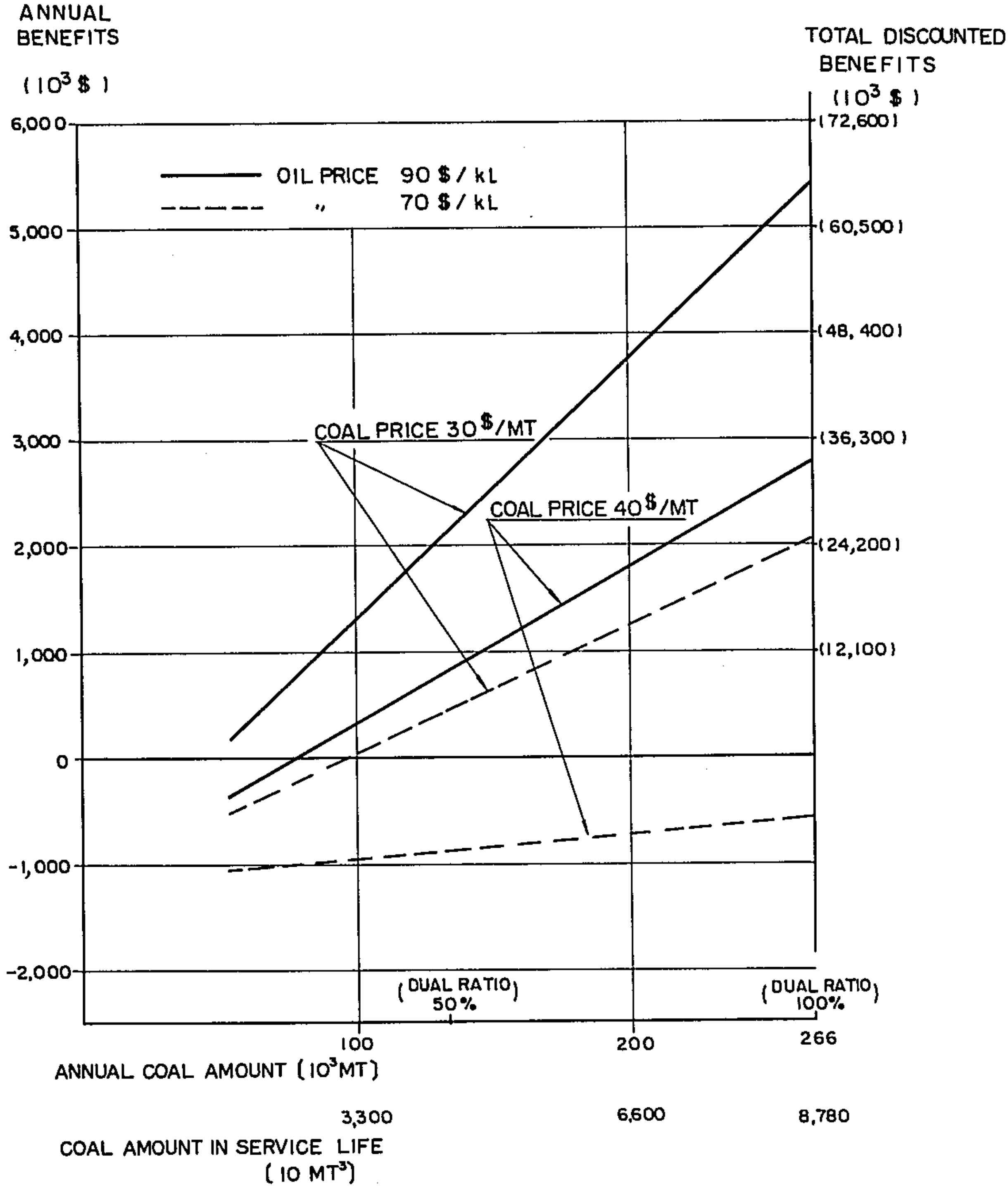
For this reason, justifiability of a dual fired thermal power plant was studied on the basis of gains-or-loss. Over a uni-oil fired plant for various cases of combination of required amount of coal, coal price and oil price.

According to our study, if price of oil is \$90/kl the dual fired plant can well do economically sofar as the price of coal is below \$30/MT. However, in the case of oil price at \$70/kl, the dual fired plant would be totally disadvantageous from economic viewpoint if the price of coal is around \$40/MT, regardless of the quantity of coal used under whatever dual ratio. While, if the price of oil is \$90/kl and if coal is available at a price of \$40/MT in a sufficient amount, that is, annual 266×10^3 MT over a period of 33 years, the dual fired thermal power plant can save \$2.7 million, annually over uni-oil fired plant. (total gains of about \$35 million in terms of present value at a discount rate of 7.5% p.a.).
Even if the available quantity of coal is halved, \$800,000 equivalent gains are still expectable.

In effect, in case the price of oil should rise close to $80, and if domestic or imported coal can be obtained in a quantity of approximately 2.7 million MT (approximately 30% in terms of dual ratio) at the price of approximately $40/MT, a dual fired thermal power plant can complete adequately with a uni-oil fired thermal power plant (see Fig. 10-1, 10-2).

Fig 10-2. BENEFITS ~ COAL AMOUNT

(for Dual Fired Thermal Power Plant 50MW x 2)



CHAPTER 11

PRELIMINARY DESIGN OF POWER PLANT

CHAPTER 11 PRELIMINARY DESIGN OF POWER PLANT

11-1 Study on Site

Several locations centered around Cebu City have been contemplated by NPC as possible sites for construction of the power plant.

The outlines of the sites are as given below.

(1) Liloan A Site

The Liloan A Site is located approximately 15 km north along the shore from Cebu City. The powerhouse site is on a sloped tableland with undulations at an elevation of 10 to 15 m above sea level. The tableland around the site is cultivated at parts although there are no houses in the surrounding area. The overburden is thin and the land is almost formed of coral. The site is located approximately 2 km distant from a trunk road.

Mactan Island lies at a distance of about 8 km from this site and the waters in-between are comparatively calm.

(2) Liloan B Site

The Liloan B Site is adjacent to the Liloan A Site but is on flat land 1 to 2 m above sea level. The powerhouse site is in a coconut plantation while there are scattered houses in the area. Of the sites investigated in the present study the Liloan B Site is located far from the shore of oppositely-lying Island and waves of the waters are liable to become high. The site is close to a trunk road.

(3) Naga Site

The Naga Site is a marshland with no habitation in the surrounding area and located approximately 20 km southwest along the shore from Cebu City. The site is close to a trunk road.

(4) Fernando Site

The Fernando Site is located approximately 35 km southwest along the shore from Cebu City.

The powerhouse site is a flat piece of land along a trunk road 1 to 2 m above sea level and covered with a coconut grove. There are fishermen's dwellings scattered in the surrounding area.

(5) Sangat Cove Site

The Sangat Cove Site is located 4 km further southwest from the Fernando Site.

The powerhouse site is a tableland 5 to 7 m above sea level.

Although it would be possible to build a thermal power plant at any one of these sites, the Liloan B Site seems the most advantageous from the following viewpoints:

(1) Proximity to load center,
(2) Ease in reclamation,
(3) Proximity to Cebu Port, and ease in unloading and hauling of materials.

However, before making final choice of the power plant site, superiority of the site should naturally be examined costwise on the comparison basis in particular regard to important construction costs of civil structures on which the topographical and marine conditions would impose several restraints. In particular, construction costs for sea berths, ash ponds, intakes and discharge facilities, are greatly affected by topographical and marine conditions.

At present, however, it is impossible to evaluate relative superiority of the candidate sites from such aspects based only on the data obtained during the recent visit to the fields. Therefore, it is necessary to implement various surveys as recommended in 11-4-3 of this report without delay to collect supplementary data and make final decision on the matter.

11-2 Construction Schedule

A proposed construction schedule of Cebu Thermal Power Plant is shown in Fig. 11-2. Several key milestone on the schedule will be the following as counted from the date of start of the definite study including preparation of specifications, detail designs and others which are anticipated to immediately follow the feasibility study.

Placement of order for main equipment	9 months
Start of civil work	26 months
Start of equipment installation	37 months
Boiler firing	42 months
Start of operation	50 months

The entire period of construction is approximately 4 years. This time schedule is for the case of construction of one unit of 50 MW, but even for the case of 75 MW, the schedule would be roughly the same.

According to the load forecast, it is necessary to start operation of a 50 MW steam plant by the end of 1978, and in such case, preparations for construction including feasibility study must be completed by the beginning of 1975.

11-3 Preliminary Design of Thermal Power Plant

The thermal power plant was designed in a structure which may conveniently accommodate additional unit for exclusive burning of coal in the future.

It was also taken into consideration that the diesel plant which is scheduled by NPC to start construction ahead of the proposed steam plants would be located in the same site as this steam plant as shown in Fig. 11-3, 4.

The general features of equipment and facilities are as indicated below.

(1) Power Plant Equipment

The capacity and number of units of equipment were taken as follows:

Diesel plants	10 MW x 5 = 50 MW	
Steam plants	50 MW x 1 = 50 MW	present plan
Steam plants	50 MW x 1 = 50 MW	present plan
Steam plants	75 MW x 3 = 225 MW	future addition
Total	375 MW	

(2) Specifications of Major Equipment

The specifications of the major equipment for the 50 MW steam plant are as given below.

1) Steam Turbine

Output	50,000 kW
Rotation	3,600 rpm
Steam pressure	102 kg/cm^2
Steam temperature	525 °C
Exhaust pressure	700 mmHg
Type	Exhaust, non-reheated

2) Boiler

Steam pressure	106 kg/cm^2
Maximum evaporation	215 ton/hr
Main steam temperature	525 °C
Type	Outdoor

3) Generator

Capacity	58,824 kVA
Voltage	13,800 V
Power factor	0.85
Number of poles	2
Frequency	60 Hz

4) Main Transformer

Frequency	60 Hz
Voltage	13.8/115 kV
Capacity	60 MVA
Connection	△/Y

(3) Switchyard Structure

The design of switchyard structure prepared by NPC was partially changed as explained below and newly made as shown in Fig. 11-5. The layout of the switchyard based on the revised design is indicated in Fig. 11-3.

Points of Change

1) It is planned that the electricity obtainable at the proposed 50 MW steam plant will be put into 115 kV and 69 kV systems by a three-winding transformer. But, according to the load forecast, the power demand on the 69 kV system will not be very large even in the far future, and it is very likely that the electricity from the projected diesel plants would be sufficient to meet demand for the time being. Therefore, the transformer with tertiary winding of the steam plant #1 as designed by NPC was changed to the conventional transformer, and one of the lines which connect 115-kV bus to 69 kV bus was eliminted.

2) NPC is considering to supply power for start-up of the steam turbine from the 13.8 kV bus of the diesel units. But a system which can dispense with starting power source equipment and has the circuit breaker for low-voltage synchronization will be more advantageous economically than high-voltage synchronization while there will be no problem in reliability.

3) According to NPC plan, the 115-kV system is to be 1-line, 2-CB type which is the standard arrangement of NPC. Though, if it is taken into consideration that the 115 kV system will be interconnected by double-circuit at VECO Banilad Substation, and further that the reliability of circuit breakers has recently improved, then it is judged more advantageous to adopt a 1-line, 1-CB system which simplifies the control system and leads to economy.

(4) Coal Storage Yard

The capacity of the coal storage yard was determined so that it could hoard coal just sufficient for one-month operation of the power plant after future addition of uni-coal firing units (325 MW).

Storage capacity	100,000 tons
Height of pile	7 m
Storage yard area	18,000 m^2

(5) Ash Disposal Pond

Ash pond capacity	sufficient to dispose waste ash from 1 unit of 50 MW (uni-coal firing) for 10-year period
Total ash quantity	20,000 tons
Height of pile	4.5 m (an average of 2.5 m depth below sea level and 2.0 m above sea level)
Ash pond area	60,000 m^2

In order to reduce the initial investment, the capacity of the ash disposal pond was determined as just sufficient to dispose ash for 10 years operation of 1-unit of 50 MW. Therefore, if additional units are provided also in coal firing, the ash disposal pond will be filled up earlier than the assumed date. Accordingly, it is necessary to carry out investigations and studies beforehand for the expansion of the ash disposal pond or for the locating of a new pond.

It should be noted that approximately one half of the disposed coal ash can be utilized as fly ash to make an admixture for cement. In case such utilization of ash be substantiated, expectable benefit is not only the sales revenue from marketing of fly ash but also resultant elongation in the life of the ash disposal pond. In view of such merits, a market survey should also be carried out for fly ash.

Further, in case there is low and marshy land in the vicinity of the site, the ash waste can be used for landfill. This would be another question to be studied.

(6) Equipment for unloading and Conveying

The proposed system of equipment for unloading and conveying coal is shown in Fig. 11-6.

In addition to such equipment, coal blending equipment would also be necessiated in case Cebu coal is to be used in the future; it is desirable that coal be feeded to boilers in as homogeneous condition as possible to guarantee stable operation of the power plant.

11-4 Particular Cares in Construction

11-4-1 Water Supply for Power Generation

A thermal power plant requires large quantity of water in its operation as indicated below.

Capacity	Water Requirement
50 MW x 1 unit	200 to 250 tons/day
50 MW x 2 units	350 to 400 tons/day

Besides, in case a diesel power plant with 5 units of 10 MW each are provided simultaneously approximately 150 tons of water would be further needed per day.

According to the plan of NPC, the water for power generation is to be supplied by pumping up underground water. In such case not only test borings would be required to confirm available quantity of supply from underground water but also the following tests will have to be carried out.

(1) Investigation of Underground Water

1) Measurement of ground water table

2) Measurement of water temperature and electricity conductivity

3) Study on the quality of water (chemical composition)

(2) Investigation of Water-Bearing Stratum

1) Investigation of spatial spread of water-bearing stratum

(Geologic investigation, boring, electric underground exploration, underground elastic wave exploration)

2) Permeability Investigations of Water-Bearing Stratum (Pump-up test, field permeability test)

In case such tests reveal that the underground water is not satisfactory enough both in quantity and in quality, it will become necessary to consider equipment for intake from river water and water distillation plant.

Therefore, it is necessary to start investigations as soon as possible.

11-4-2 Investigations at Power Plant Construction Site

The designs of civil structures of a thermal power plant are subject to applicable construction methods and overall arrangement of project components which are primarily determined on topographical and geological conditions. Therefore, it is necessary to carry out the following investigations without delay.

(1) Preparation of detailed seabottom charts of the surrounding area of the power plant

(2) Detail surveying of power plant site

(3) Detailed investigation of ground bearing capacity of power plant site

(4) Continuous measurement of marine and meteorological conditions at power plant site and analysis of past records on such conditions.

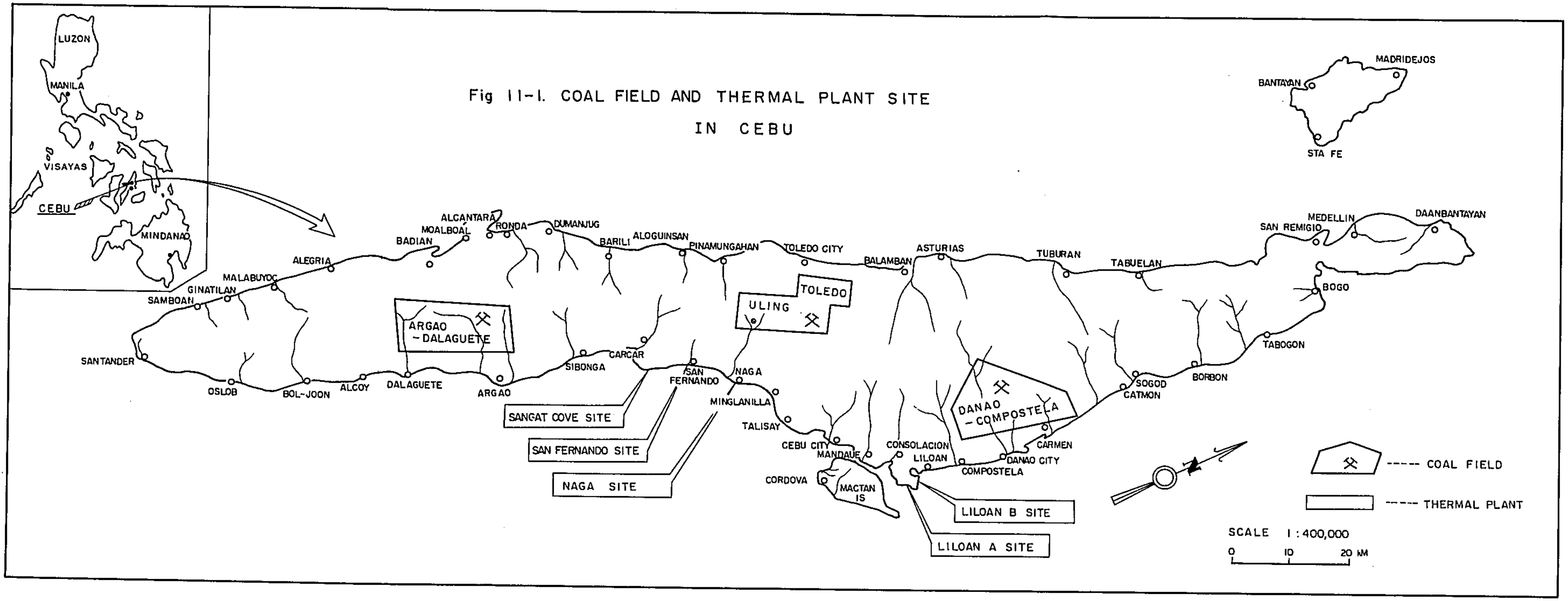
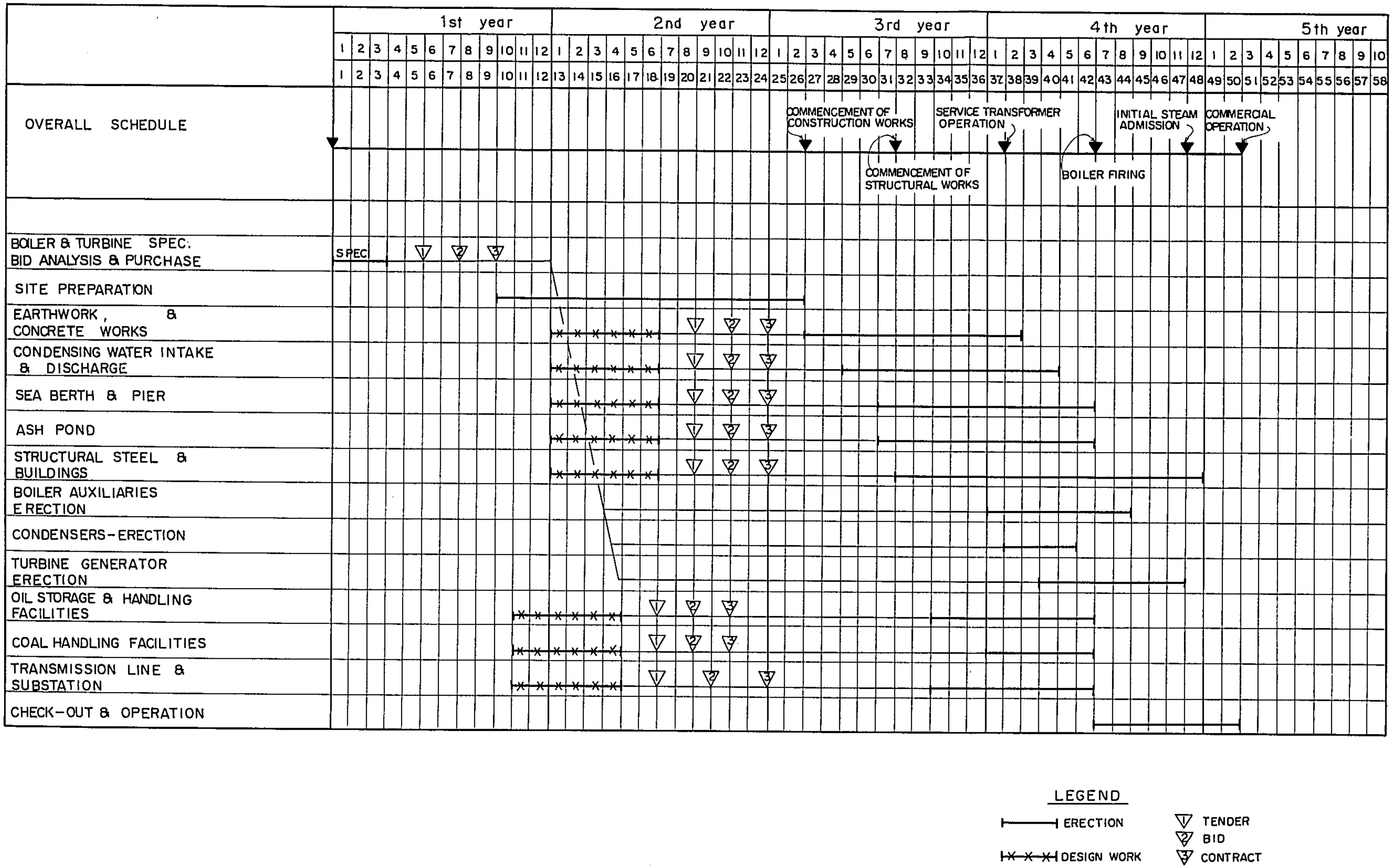


Fig 11-1. COAL FIELD AND THERMAL PLANT SITE IN CEBU

Fig 11-2. CEBU THERMAL POWER PLANT
PROPOSED CONSTRUTION SCHEDULE



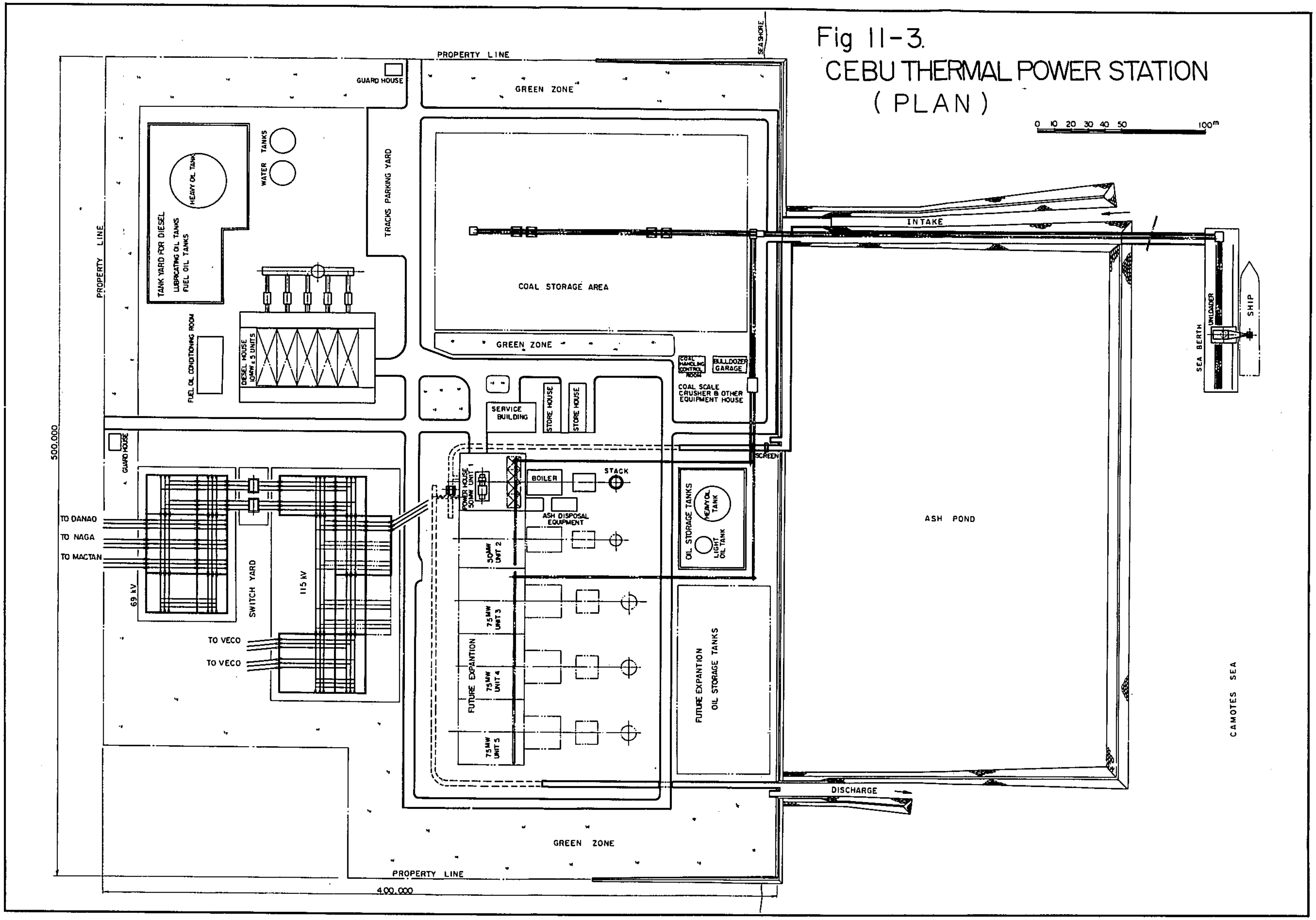
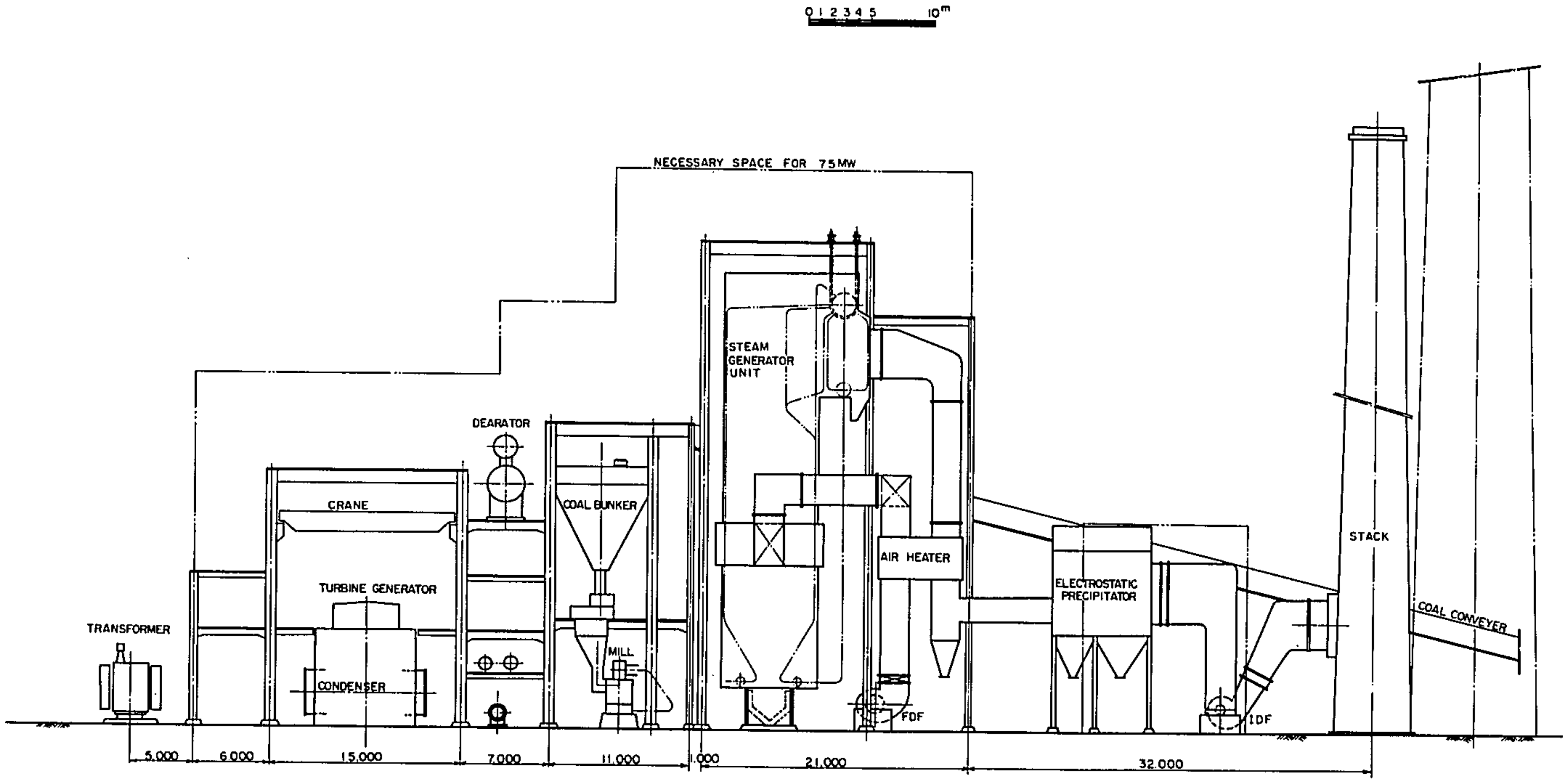


Fig 11-3.
CEBU THERMAL POWER STATION
(PLAN)
0 10 20 30 40 50 100m
PROPERTY LINE
GUARD HOUSE
GREEN ZONE
WATER TANKS
HEAVY OIL TANK
TANK YARD FOR DIESEL
LUBRICATING OIL TANKS
FUEL OIL TANKS
TRACKS PARKING YARD
COAL STORAGE AREA
INTAKE
SEA BERTH
UNLOADER
SHIP
FUEL OIL CONDITIONING ROOM
DIESEL HOUSE
GREEN ZONE
BULLDOZER GARAGE
COAL SCALE CRUSHER & OTHER EQUIPMENT HOUSE
SERVICE BUILDING
STORE HOUSE
STORE HOUSE
500,000
SCREEN
BOILER
STACK
ASH DISPOSAL EQUIPMENT
POWER HOUSE 50MW UNIT 1
OIL STORAGE TANKS
HEAVY OIL TANK
LIGHT OIL TANK
ASH POND
TO DANAO
TO NAGA
TO MACTAN
69 kV
SWITCH YARD
115 kV
50MW UNIT 2
75MW UNIT 3
FUTURE EXPANTION
75MW UNIT 4
75MW UNIT 5
TO VECO
TO VECO
FUTURE EXPANTION
OIL STORAGE TANKS
CAMOTES SEA
DISCHARGE
GREEN ZONE
PROPERTY LINE
400,000

Fig 11-4.

CEBU THERMAL POWER STATION
SECTION (UNIT 1, 2)



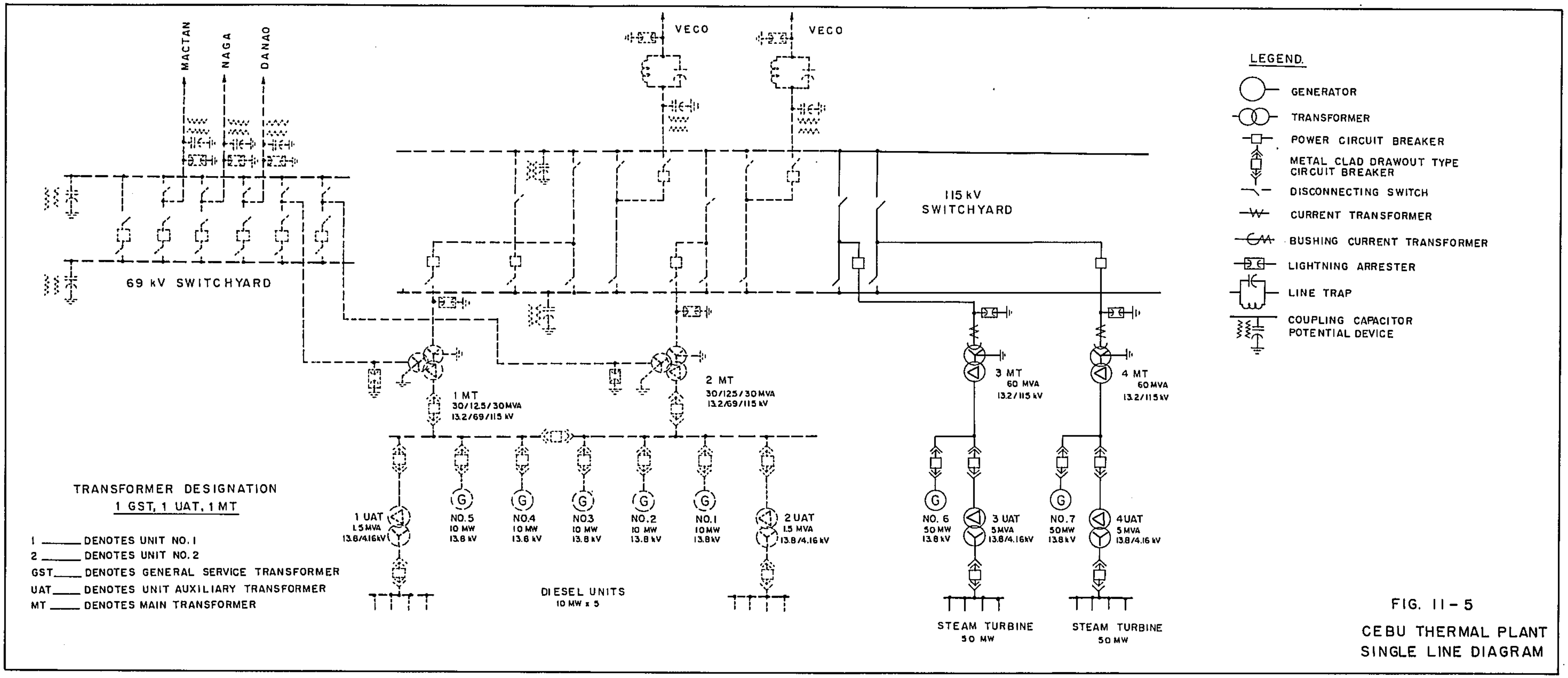
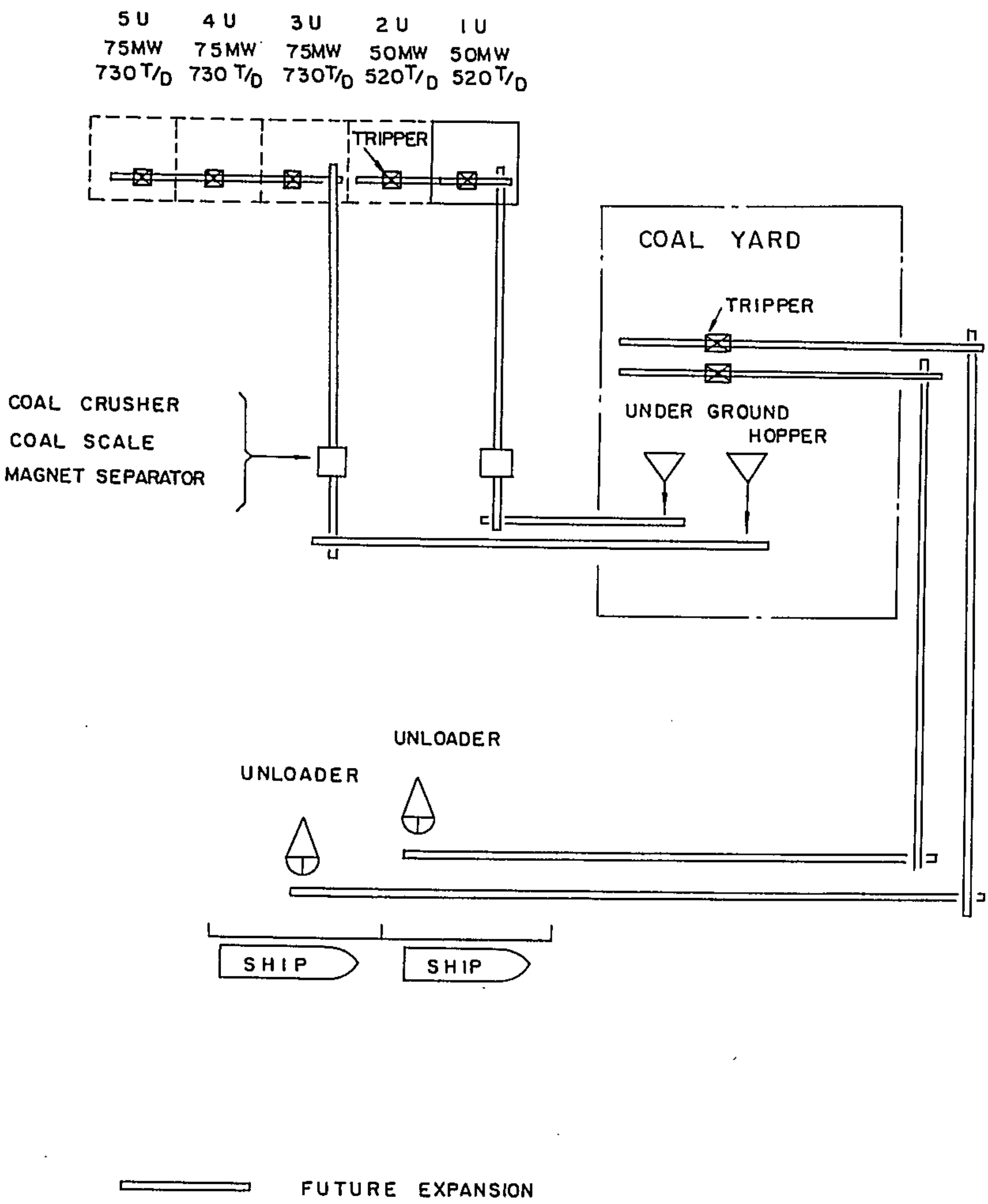


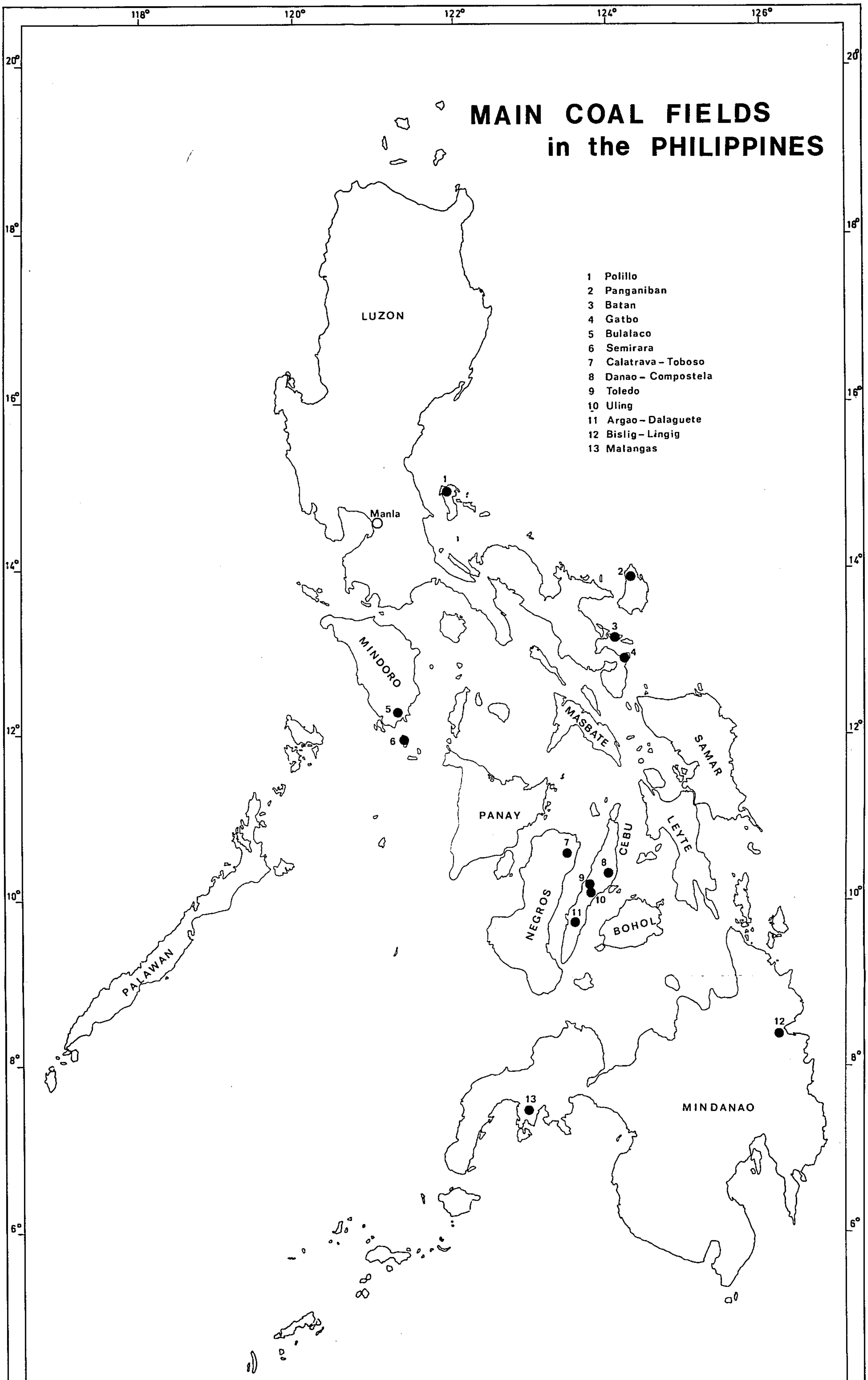
FIG. II-5
CEBU THERMAL PLANT
SINGLE LINE DIAGRAM

Fig II-6. COAL HANDLING SYSTEM



PLATES

PLATE 1


MAIN COAL FIELDS
in the PHILIPPINES
1 Polillo
2 Panganiban
3 Batan
4 Gatbo
5 Bulalaco
6 Semirara
7 Calatrava - Toboso
8 Danao - Compostela
9 Toledo
10 Uling
11 Argao - Dalaguete
12 Bislig - Lingig
13 Malangas
LUZON
Manla
MINDORO
MASBATE
SAMAR
PANAY
CEBU
LEYTE
NEGROS
BOHOL
PALAWAN
MINDANAO
118°
120°
122°
124°
126°
20°
18°
16°
14°
12°
10°
8°
6°

MAIN COAL FIELDS in the PHILIPPINES

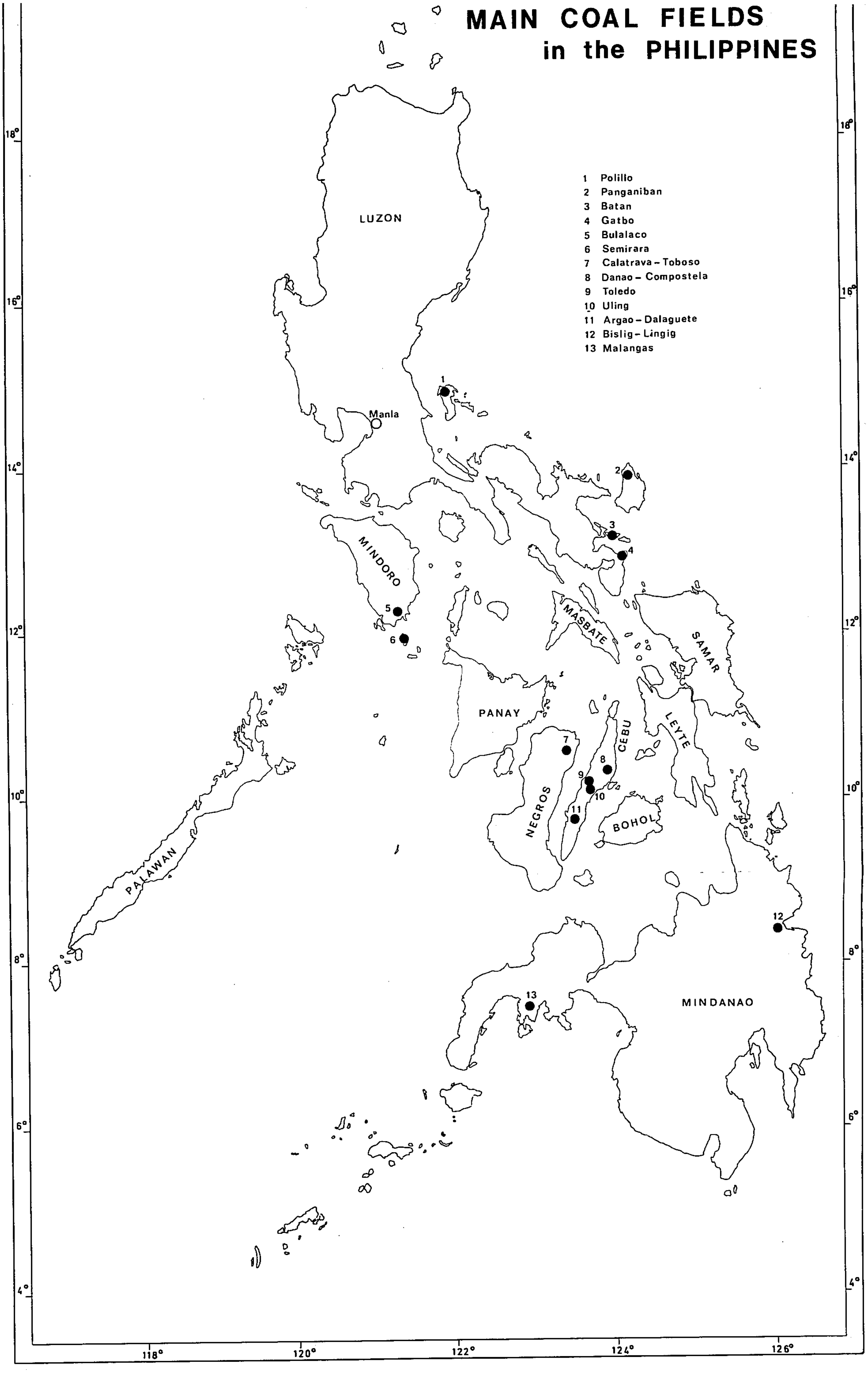
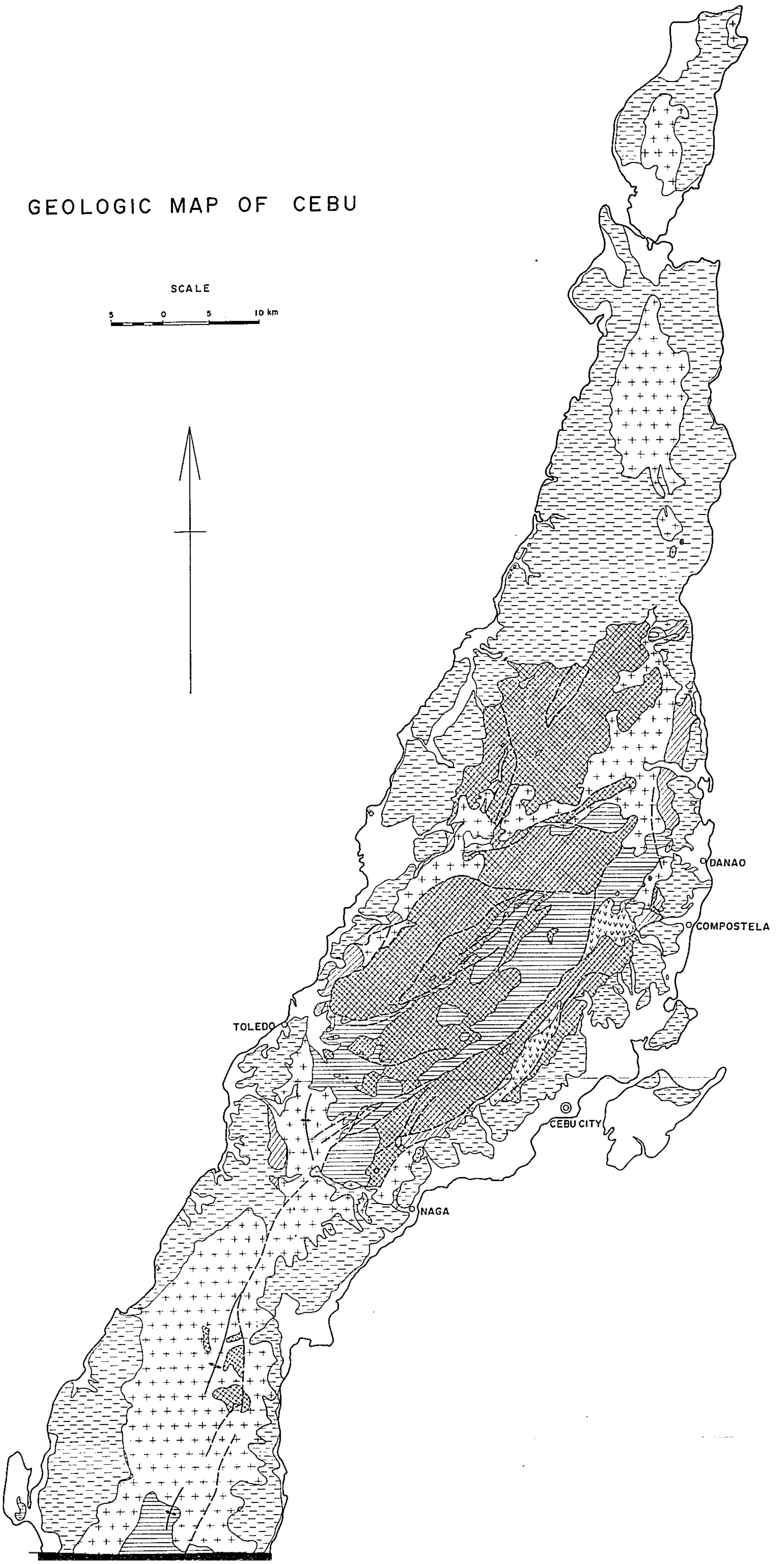
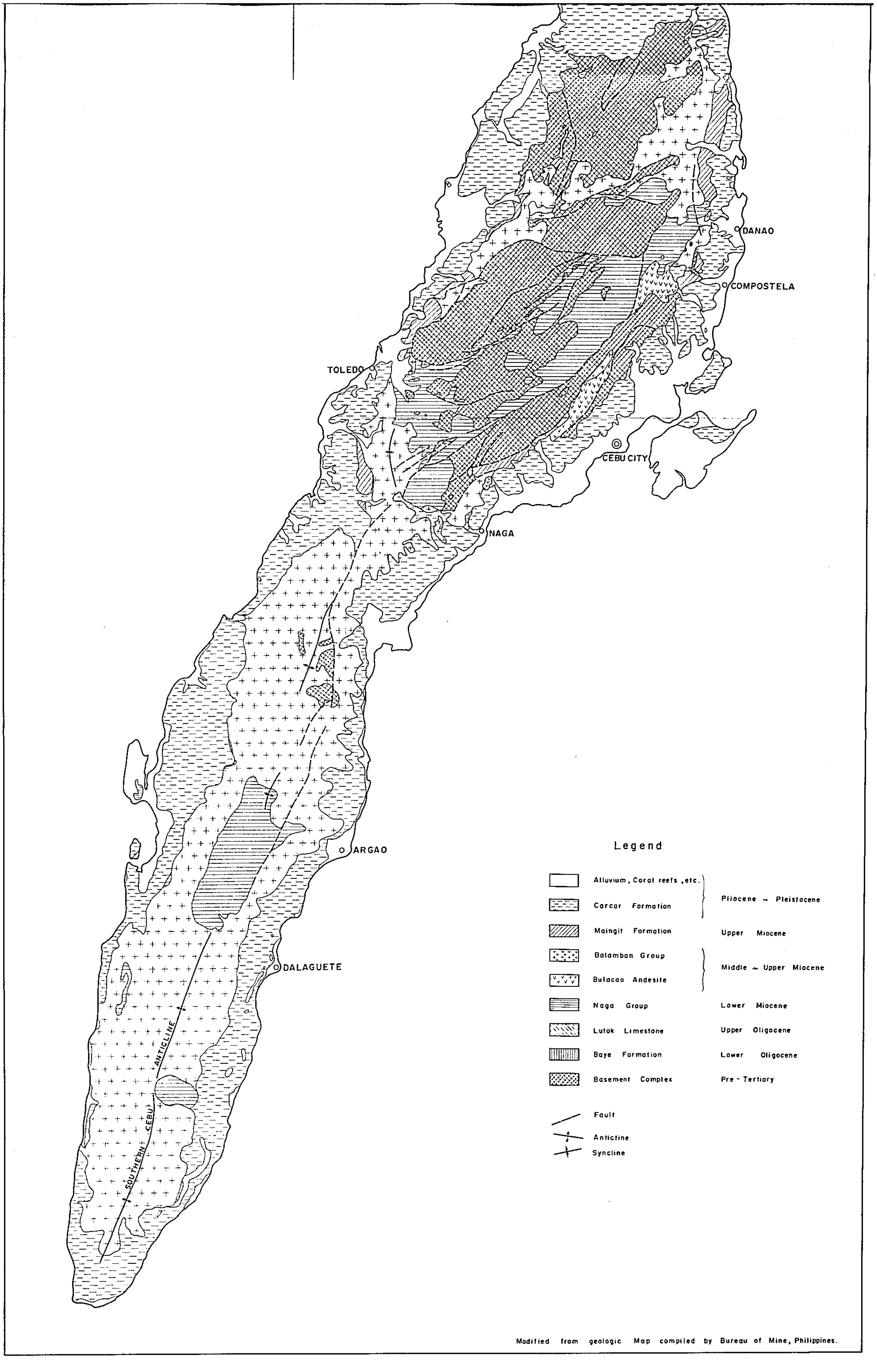


PLATE 2-1



GEOLOGIC MAP OF CEBU
SCALE
5
0
5
10 km
DANAO
COMPOSTELA
TOLEDO
CEBU CITY
NAGA



Modified from geologic Map compiled by Bureau of Mine, Philippines.

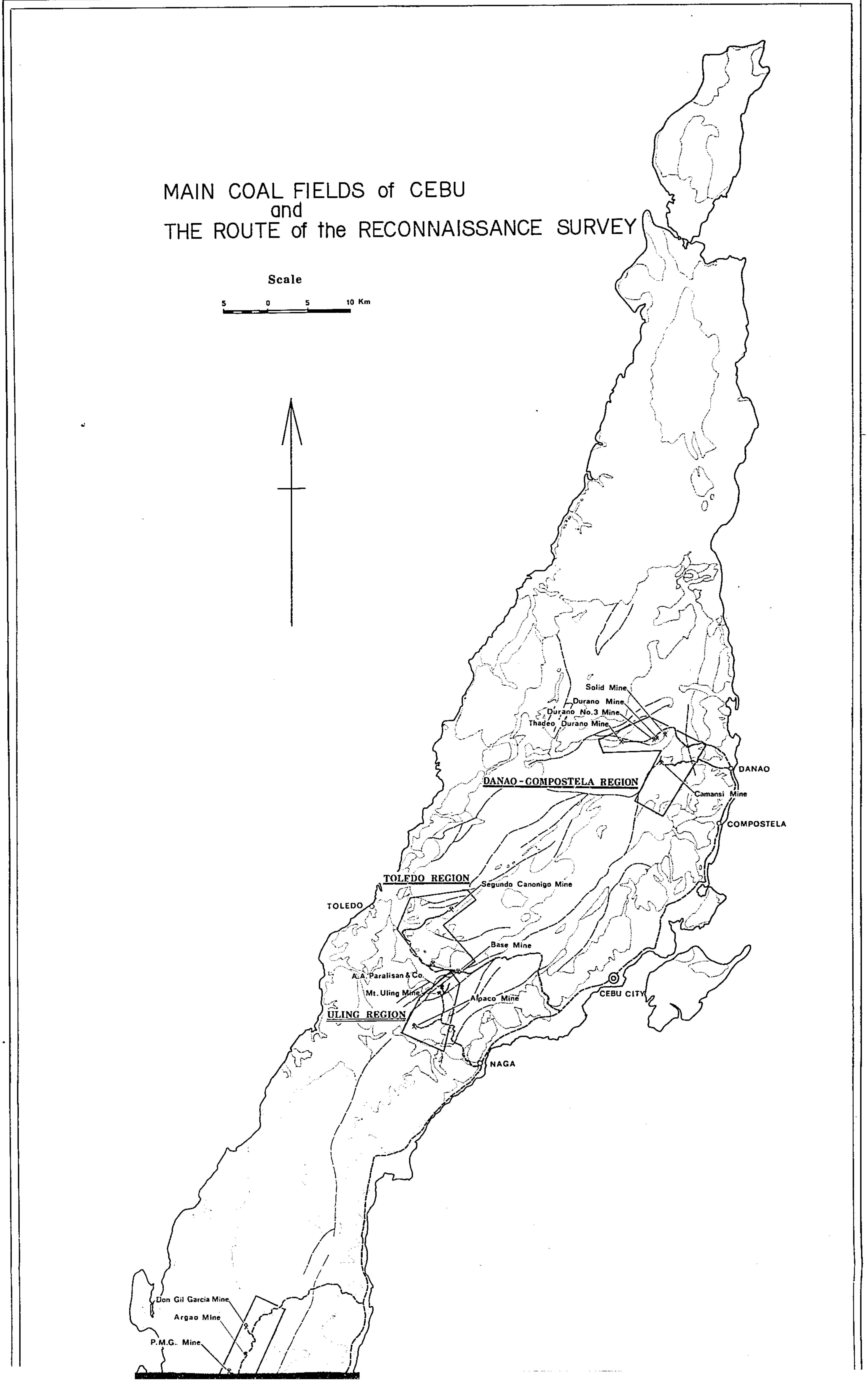
PLATE 2-2

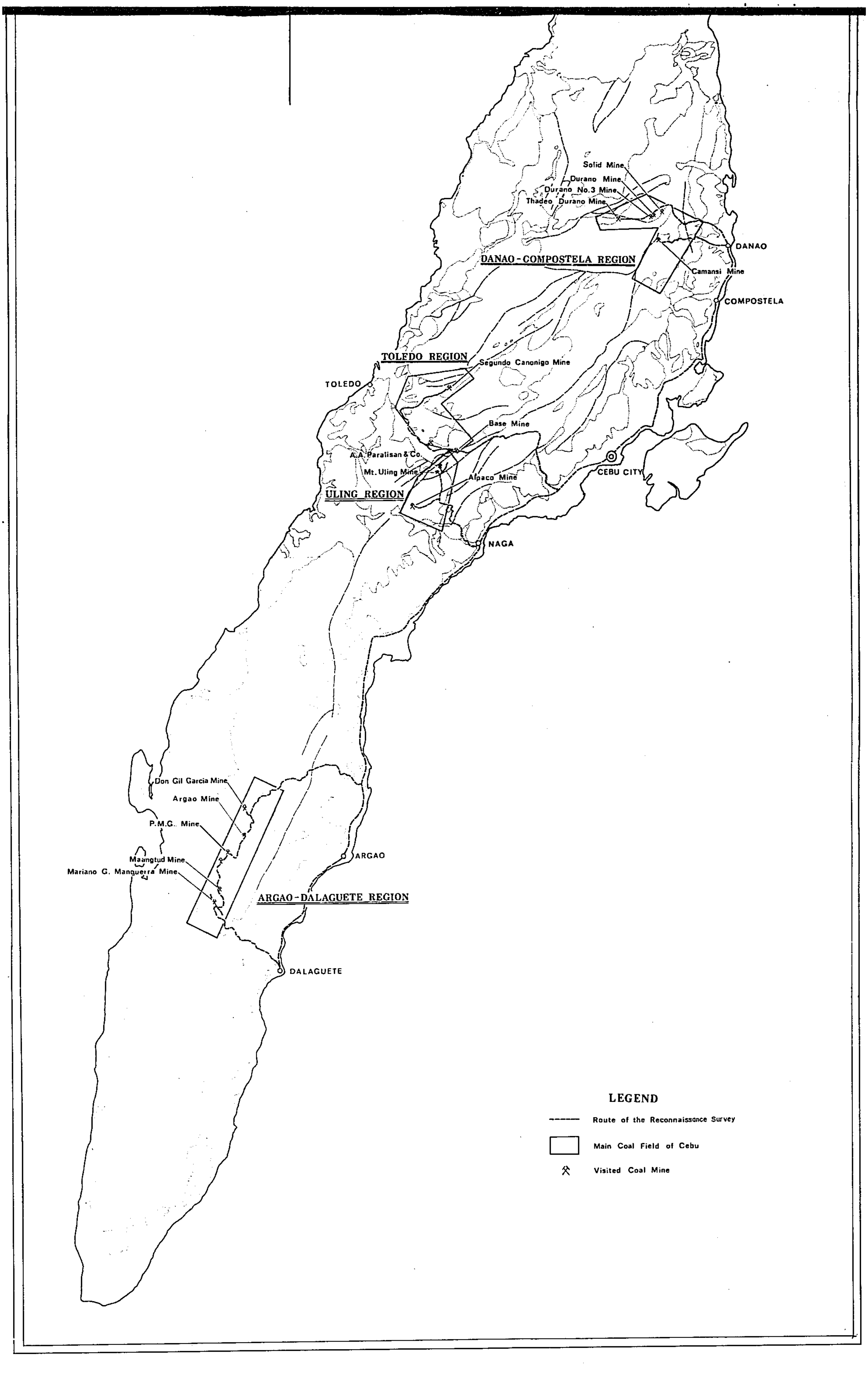
STRATIGRAPHIC CORRELATION CHART

AGE			REGION: CEBU (Geologic Map, Plate-2 Compiled by Bureau of Mine)	ARGAO-DALAGUETE (Barnes et al, 1956)	TOLEDO and ULING (Alberding, 1940)	DANAO COMPOSTELA (Alberding, 1940)
QUATERNARY	PLEISTOCENE & RECENT		Carcar Formation	Carcar Formation and	Carcar Formation	Carcar Formation
TERTIARY	PLIOCENE	PLIOCENE				
TERTIARY	PLIOCENE / MIOCENE	MIO-PLIOCENE	Maingit Formation		Maintig Formation	Barili Limestone (Maintig Formation)
TERTIARY	MIOCENE	MIDDLE AND UPPER	Balamban Group Bulacao Andesite	...Balamban Group undifferentiated	Balamban Group: Toledo Shale Mt. Uling Limestone	Balamban Group: Toledo Shale Danao Coal Measures ◎ Mt. Uling Limestone
TERTIARY	MIOCENE	LOWER	Naga Group	Argao Group: Linut-od Formation ◎ Butong Limestone Calagasan Formation ◎	Naga Group: Malubog Formation: ◎ Alpaco Silt Binabac Limestone Cantabaco Shale Cebu Orbitoid Limestone Cebu Coal Measure ◎	Naga Group: Malubog Formation ◎ (with Binabac Limestone) Cebu Orbitoid Limestone
TERTIARY	EOCENE TO OLIGOCENE		Lutok Limestone Baye Formation			
CRETACEOUS	MIDDLE TO UPPER		Basement Complex	Pandan Formation	Basement Complex	Basement Complex

◎ Coal bearing unit

Modified from Barnes et al. 1956

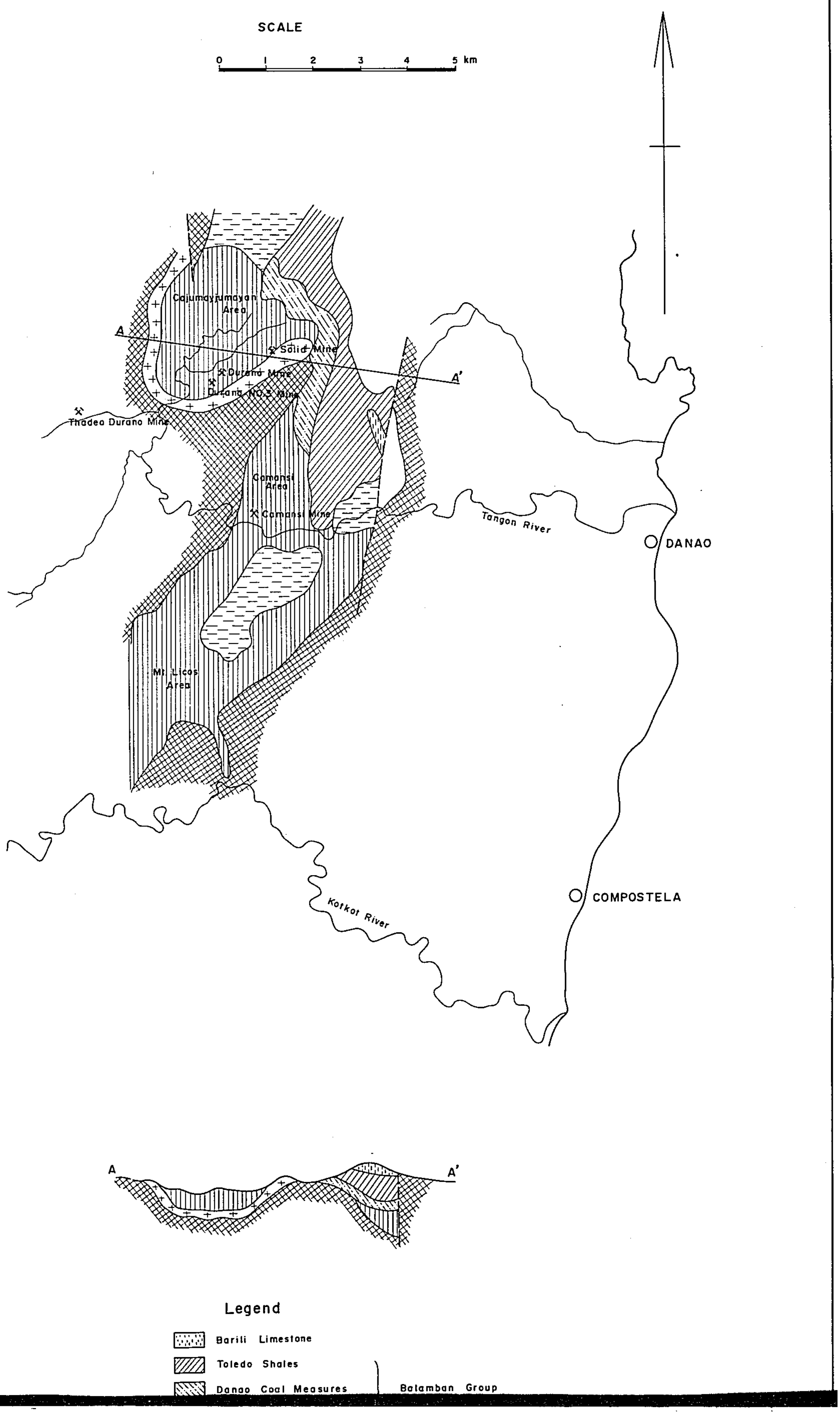

MAIN COAL FIELDS of CEBU
and
THE ROUTE of the RECONNAISSANCE SURVEY
Scale
5 0 5 10 Km
Solid Mine
Durano Mine
Durano No.3 Mine
Thadeo Durano Mine
DANAO
DANAO-COMPOSTELA REGION
Camansi Mine
COMPOSTELA
TOLEDO REGION
Segundo Canonigo Mine
TOLEDO
Base Mine
A.A. Paralisan & Co.
Mt. Uling Mine
Alpaco Mine
CEBU CITY
ULING REGION
NAGA
Don Gil Garcia Mine
Argao Mine
P.M.G. Mine

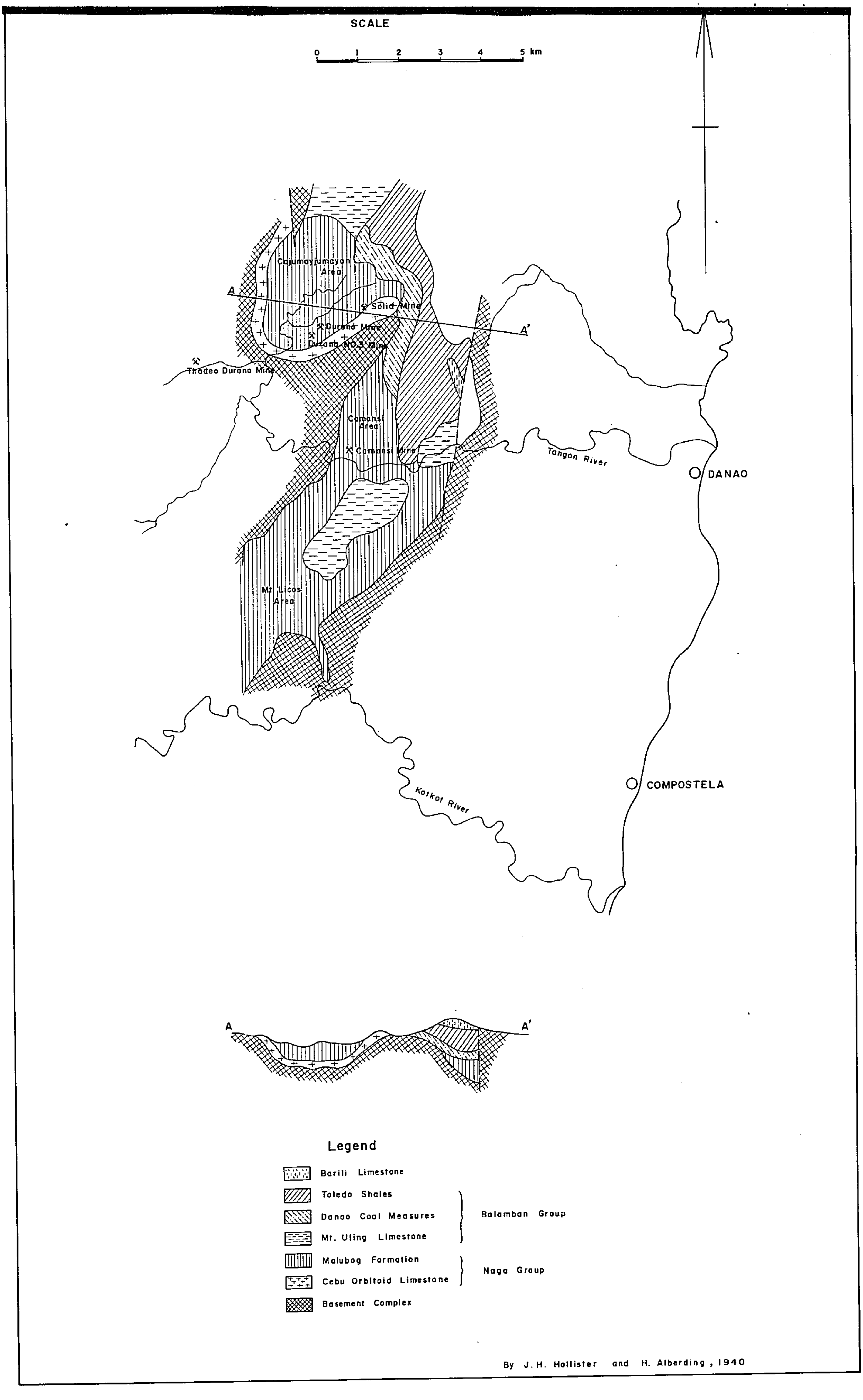


Solid Mine
Durano Mine
Durano No.3 Mine
Thadeo Durano Mine
DANAO
DANAO-COMPOSTELA REGION
Camansi Mine
COMPOSTELA
TOLEDO REGION
Segundo Canonigo Mine
TOLEDO
Base Mine
A.A. Paralisan & Co.
Mt. Uling Mine
Alpaco Mine
CEBU CITY
ULING REGION
NAGA
Don Gil Garcia Mine
Argao Mine
P.M.G. Mine
Maangtud Mine
Mariano G. Manquerra Mine
ARGAO
ARGAO-DALAGUETE REGION
DALAGUETE
LEGEND
Route of the Reconnaissance Survey
Main Coal Field of Cebu
Visited Coal Mine

PLATE 4

GEOLOGIC MAP AND SECTION OF DANAO — COMPOSTELA REGION

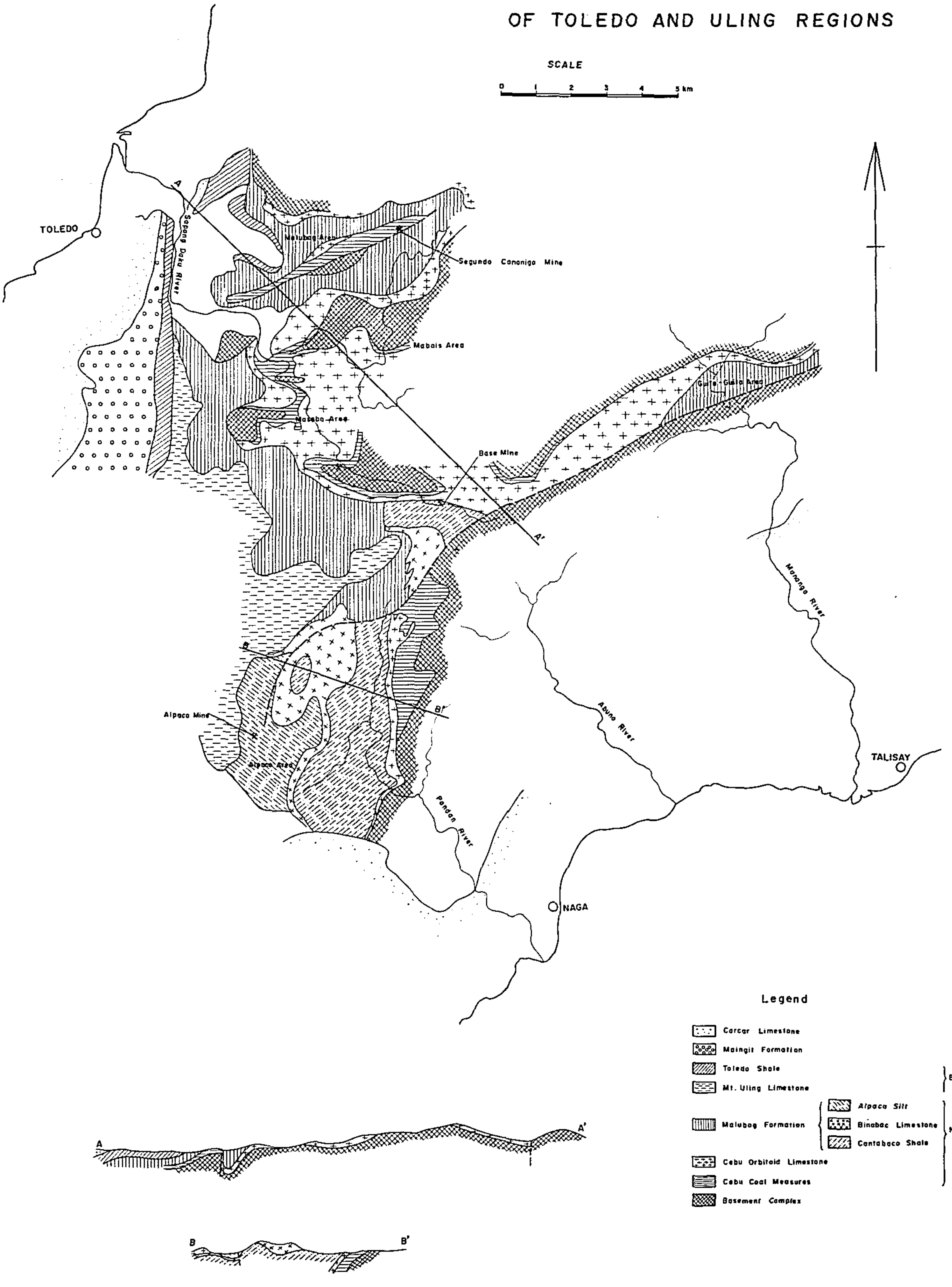




SCALE
0 1 2 3 4 5 km
Cajumayjumayan Area
Solid Mine
Durano Mine
Durano NO.3 Mine
Thadeo Durano Mine
Camansi Area
Camansi Mine
Tangon River
DANAO
Mt. Licos Area
Katkat River
COMPOSTELA
A
A'
Legend
Barili Limestone
Toledo Shales
Danao Coal Measures
Mt. Uling Limestone
Malubog Formation
Cebu Orbitoid Limestone
Basement Complex
Balamban Group
Naga Group
By J.H. Hollister and H. Alberding, 1940

PLATE 5-1

GEOLOGIC MAP AND SECTIONS OF TOLEDO AND ULING REGIONS



By J. H. Hollister and H. Alberding, 1940

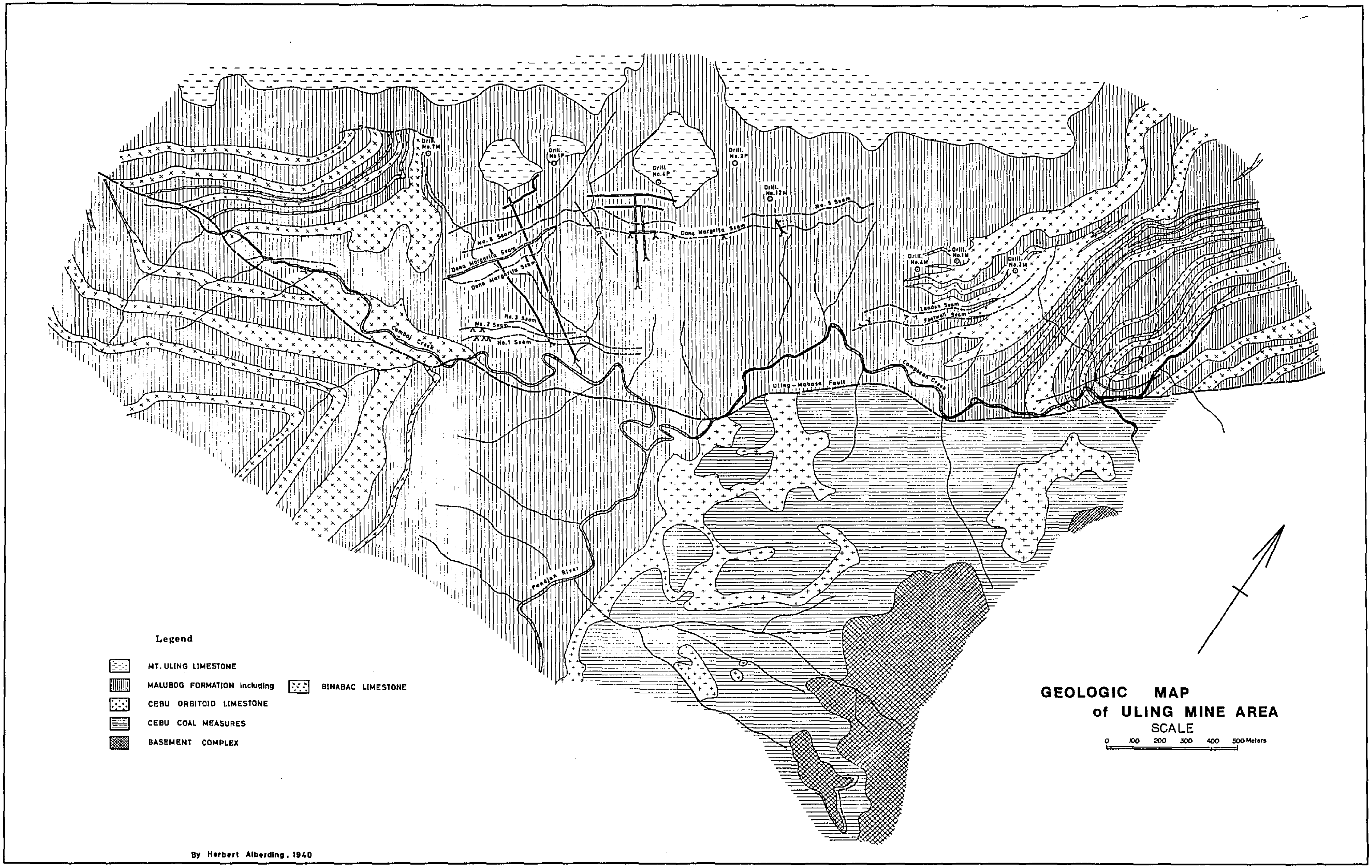
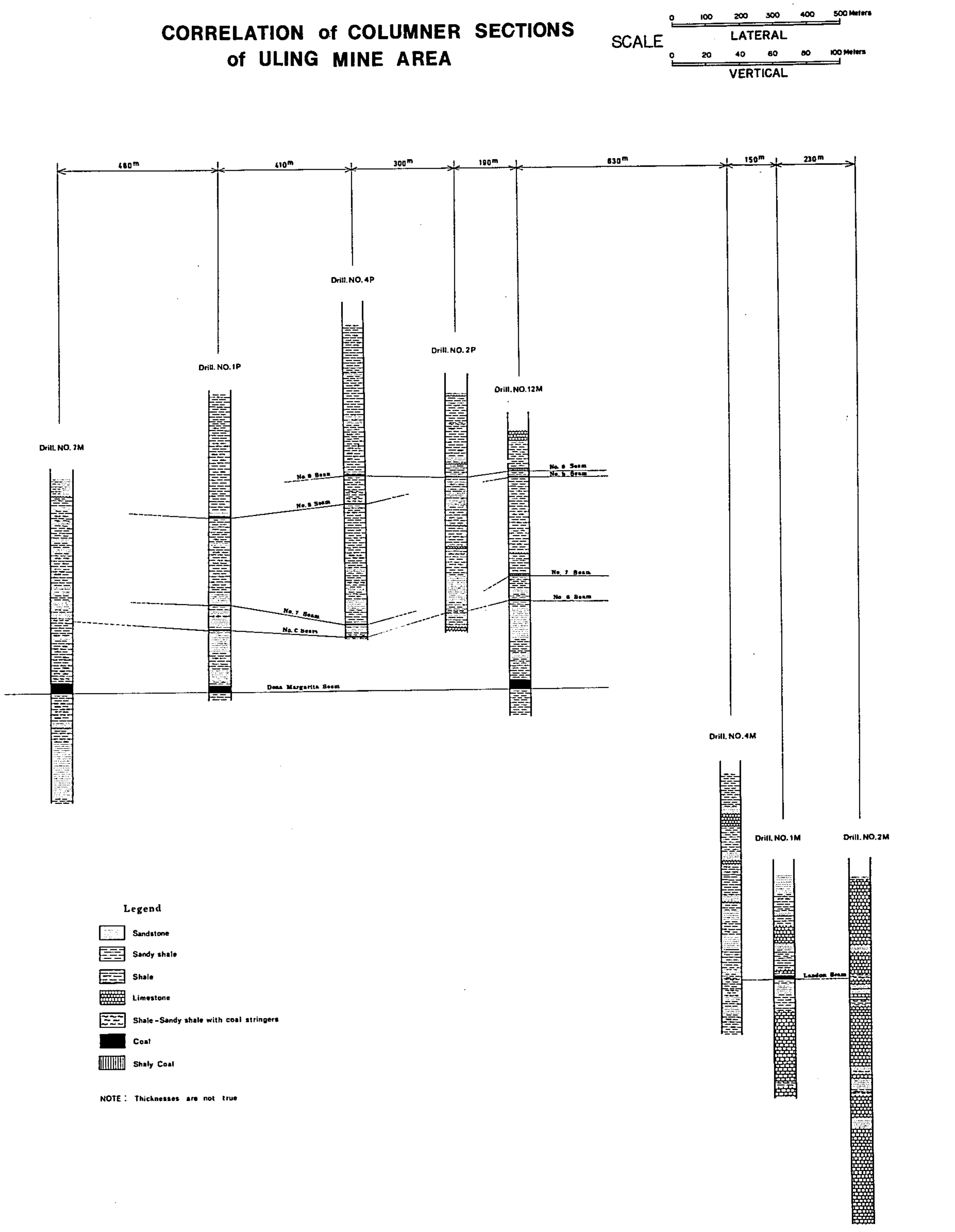

Drill. No.7M
Drill. No.1P
Drill. No.2P
Drill. No.4P
Drill. No.12M
Drill. No.4M
Drill. No.1M
Drill. No.2M
No. 6 Seam
Dona Margarita Seam
No. 3 Seam
No. 2 Seam
No. 1 Seam
Landah Seam
Footwall Seam
Combal Creek
Campacan Creek
Uling-Mabasa Fault
Pandjan River
Legend
MT. ULING LIMESTONE
MALUBOG FORMATION including
BINABAC LIMESTONE
CEBU ORBITOID LIMESTONE
CEBU COAL MEASURES
BASEMENT COMPLEX
GEOLOGIC MAP
of ULING MINE AREA
SCALE
0 100 200 300 400 500 Meters
By Herbert Alberding, 1940

PLATE 5-3

CORRELATION of COLUMNER SECTIONS of ULING MINE AREA



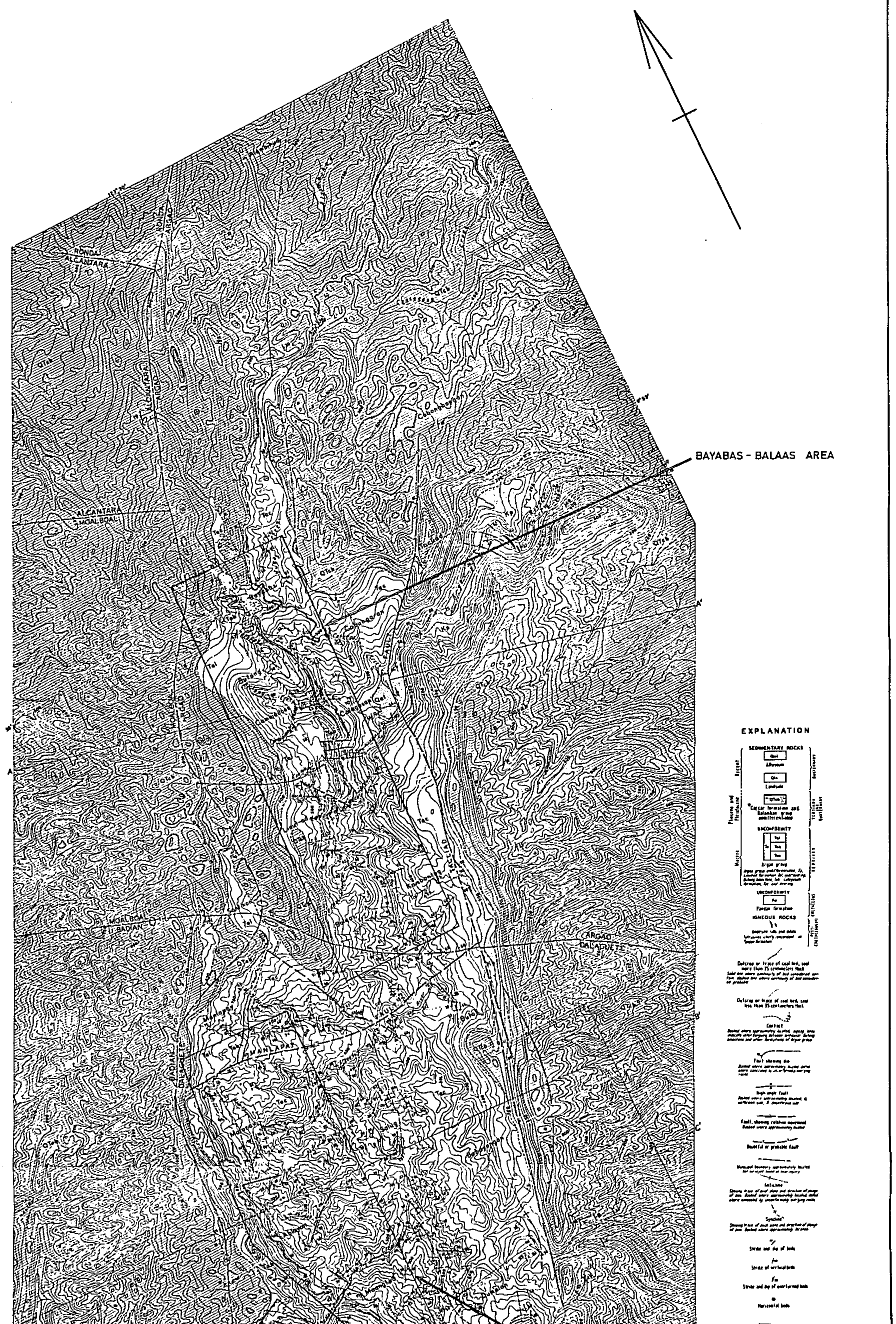
By Herbert Alberding, 1940

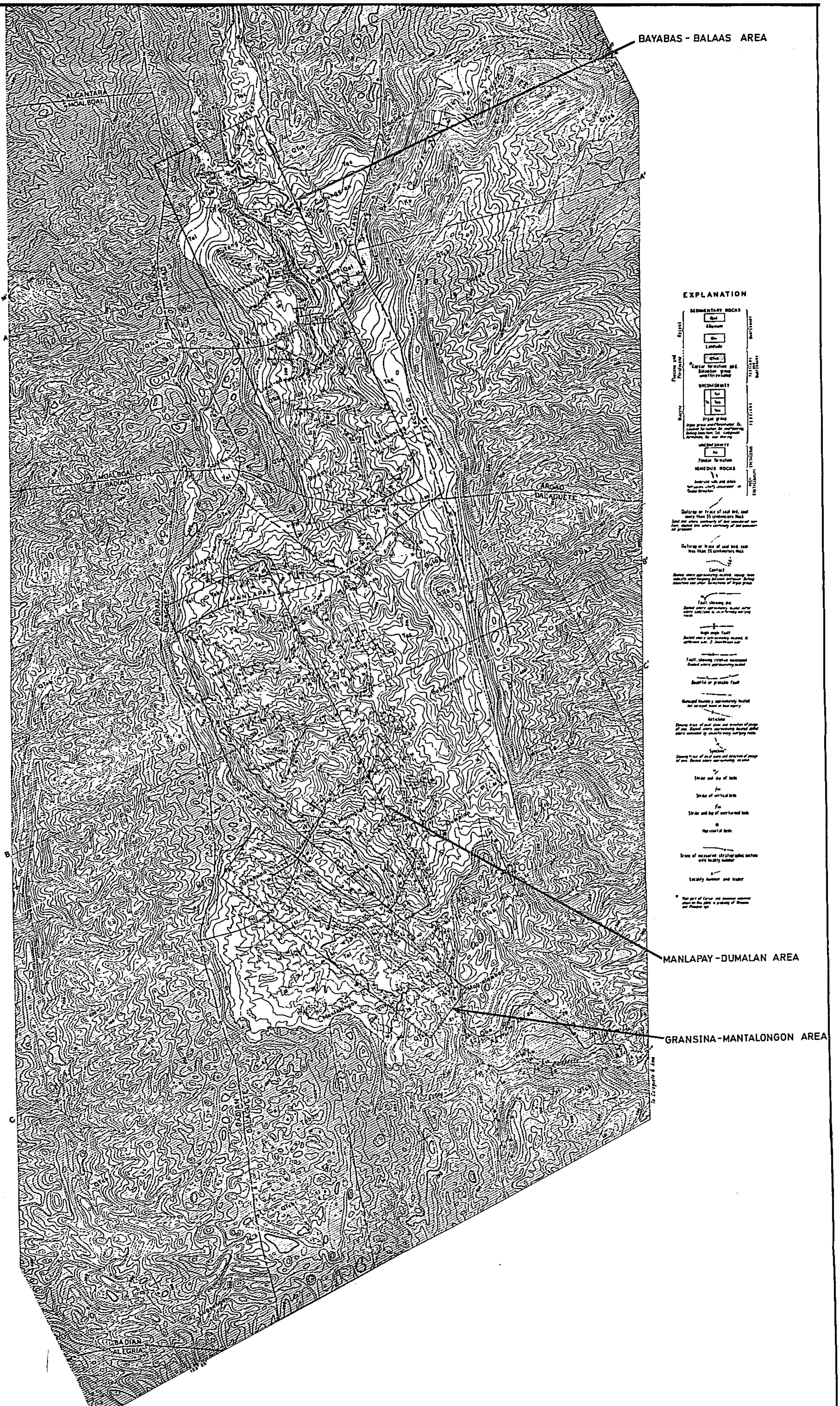
PLATE 6-1

GEOLOGIC MAP of ARGO-DALAGUETE REGION

Scale

0 1 2 3 km





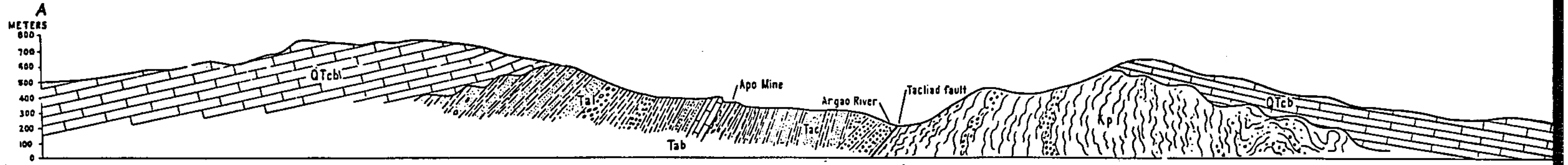
By Harley Barnes, Cresencio P. Jongco, Generoso C. Lazaga, Juan E. Pilac and Harold E. Vokes, 1956

PLATE 6-2

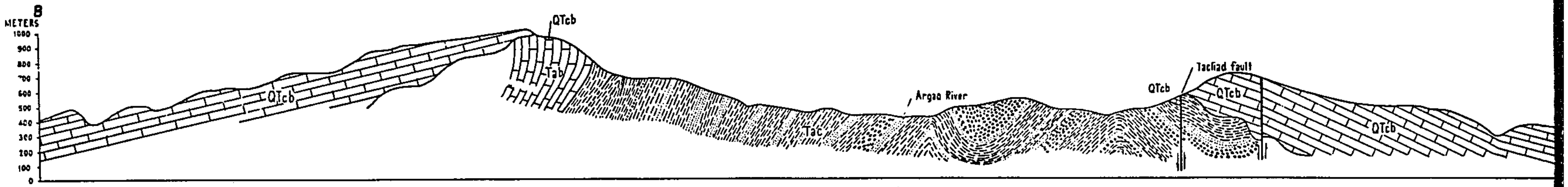
Geologic Sections of Argao-Dalaguete Region

Scale

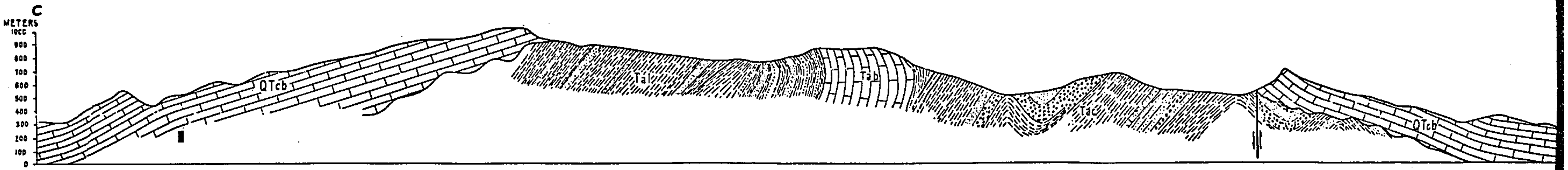
0 1 2 km



Section along line A-A'



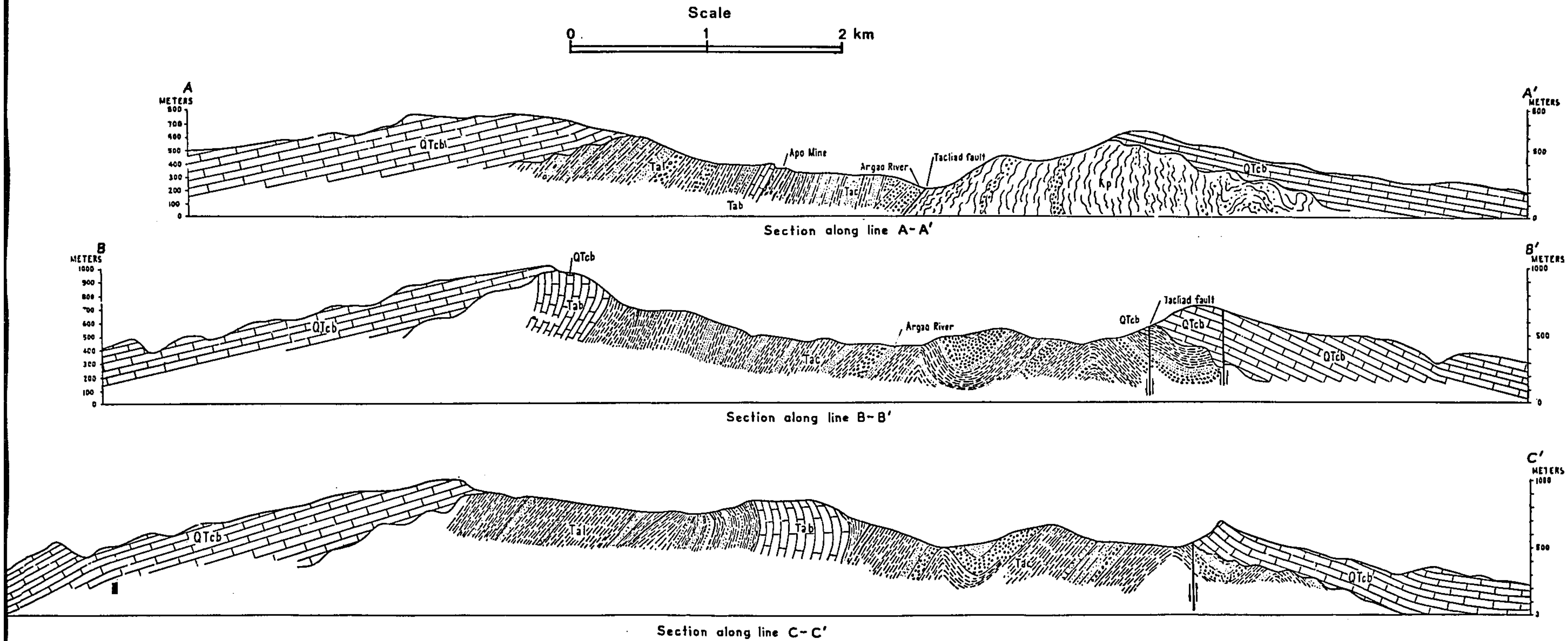
Section along line B-B'



Section along line C-C'

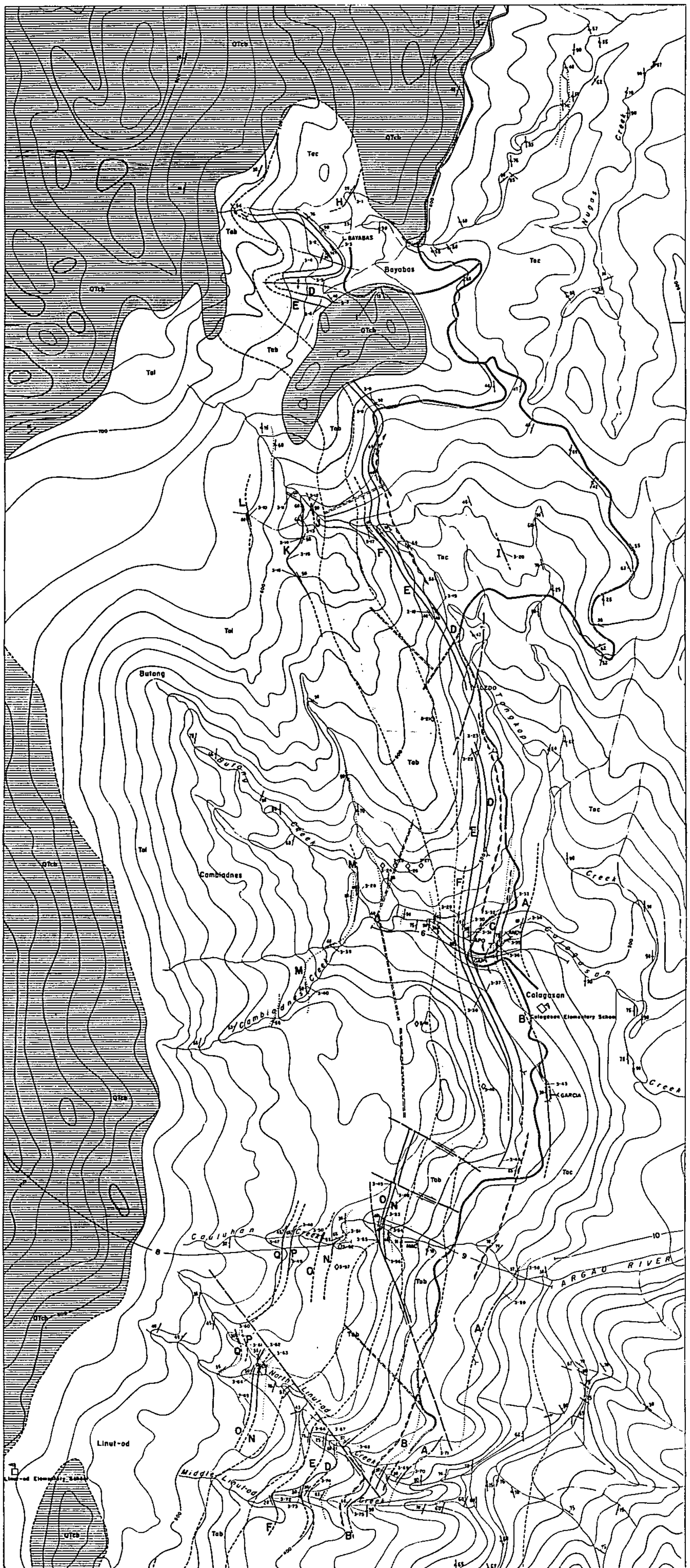
By Harley Barnes, Cresencio P. Jongco,
Generoso C. Lazaga, Juan E. Pilac and Harold E. Vokes, 195

Geologic Sections of Argao–Dalaguete Region



By Harley Barnes, Cresencio P. Jongco,
Generoso C. Lazaga, Juan E. Pilac and Harold E. Vokes, 1956

PLATE 6-3



EXPLANATION

Pliocene to Recent(?)	QTcb — Carcar formation and Balamban group, undifferentiated	TERTIARY AND QUATERNARY
	UNCONFORMITY	
Miocene	Ta: Tal, Tab, Tac — Argao group	TERTIARY

Argao group, undifferentiated, Ta; Linut-od formation, Tal, coal-bearing; Butong limestone, Tab; Calagasan formation, Tac, coal-bearing, showing orbitoid-rich sequence.

Outcrop or trace of coal bed; coal more than 35 centimeters thick
Solid line where continuity of bed considered certain, dashed line where continuity of bed considered probable. Letter used to show correlation of beds. Triangle marks coal outcrop with undetermined strike and dip

Outcrop or trace of coal bed; coal less than 35 centimeters thick

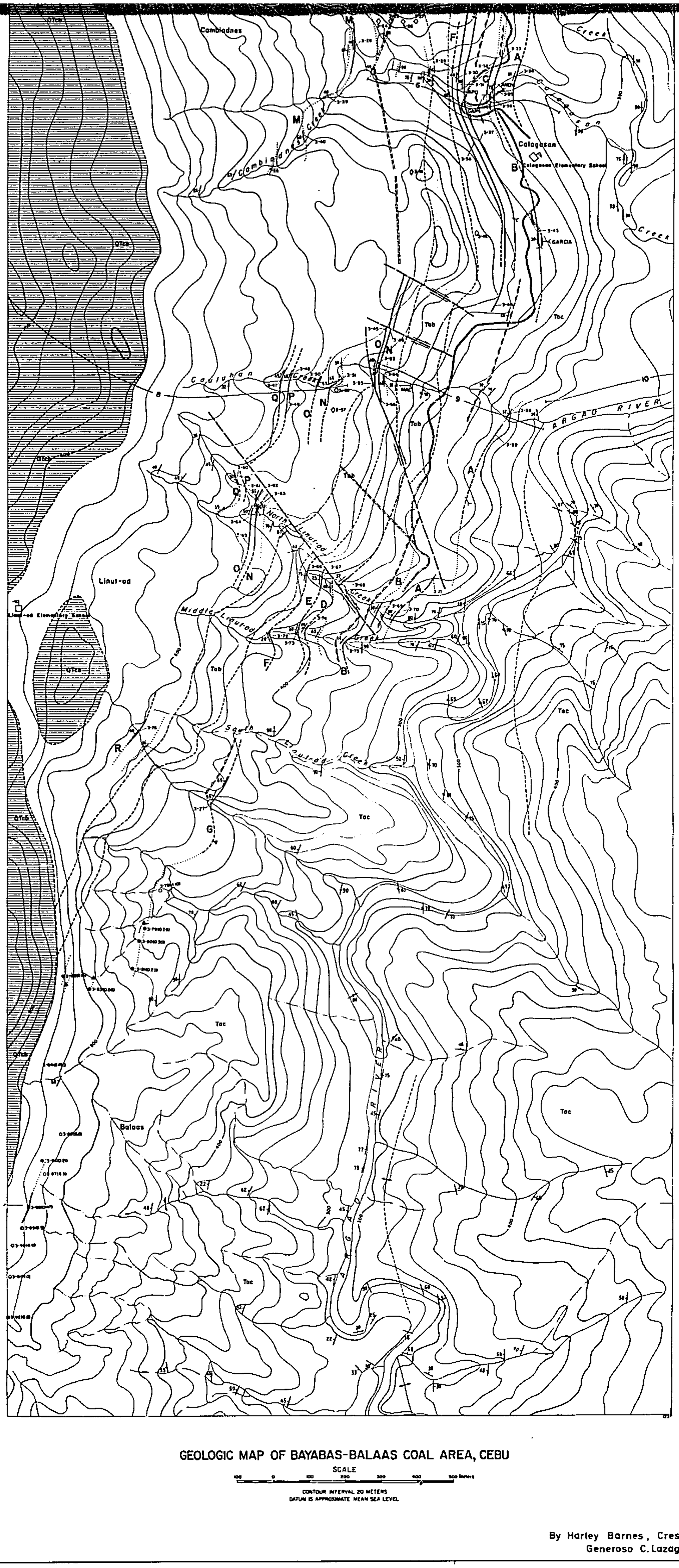
Contact
Dashed where approximately located

Doubtful or probable fault

Fault, showing relative movement
Dashed where approximately located

Anticline
Showing trace of axial plane
Dashed where approximately located

Syncline
Showing trace of axial plane
Dashed where approximately located



EXPLANATION

Pliocene to Recent(?)	QTcb — Carcar formation and Balamban group, undifferentiated	TERTIARY AND QUATERNARY
	UNCONFORMITY	
Miocene	Ta: Tal, Tab, Tac — Argao group	TERTIARY

Argao group
Argao group, undifferentiated, Ta; Linut-od formation, Tal, coal-bearing; Butong limestone, Tab; Calagasan formation, Tac, coal-bearing, showing orbitoid-rich sequence

Outcrop or trace of coal bed; coal more than 35 centimeters thick
Solid line where continuity of bed considered certain, dashed line where continuity of bed considered probable. Letter used to show correlation of beds. Triangle marks coal outcrop with undetermined strike and dip

Outcrop or trace of coal bed, coal less than 35 centimeters thick

Contact
Dashed where approximately located

Doubtful or probable fault

Fault, showing relative movement
Dashed where approximately located

Anticline
Showing trace of axial plane
Dashed where approximately located

Syncline
Showing trace of axial plane
Dashed where approximately located

Strike and dip of beds

Strike of vertical beds

Strike and dip of overturned beds

Trace of measured stratigraphic section with locality number

Locality number and leader
Number before dash designates locality number series; number after dash designates locality. Number without dash designates locality also shown on regional map, plate I.

Diamond drill hole with locality number

Hand-auger drill hole that struck coal
Locality number is followed by number in parenthesis showing thickness of coal in meters.

Hand-auger drill hole that did not strike coal
Locality number is followed by number in parenthesis showing depth of hole in meters.

Proposed Location of Trench

Proposed Location of Diamond Drilling

====== Proposed Location of Road

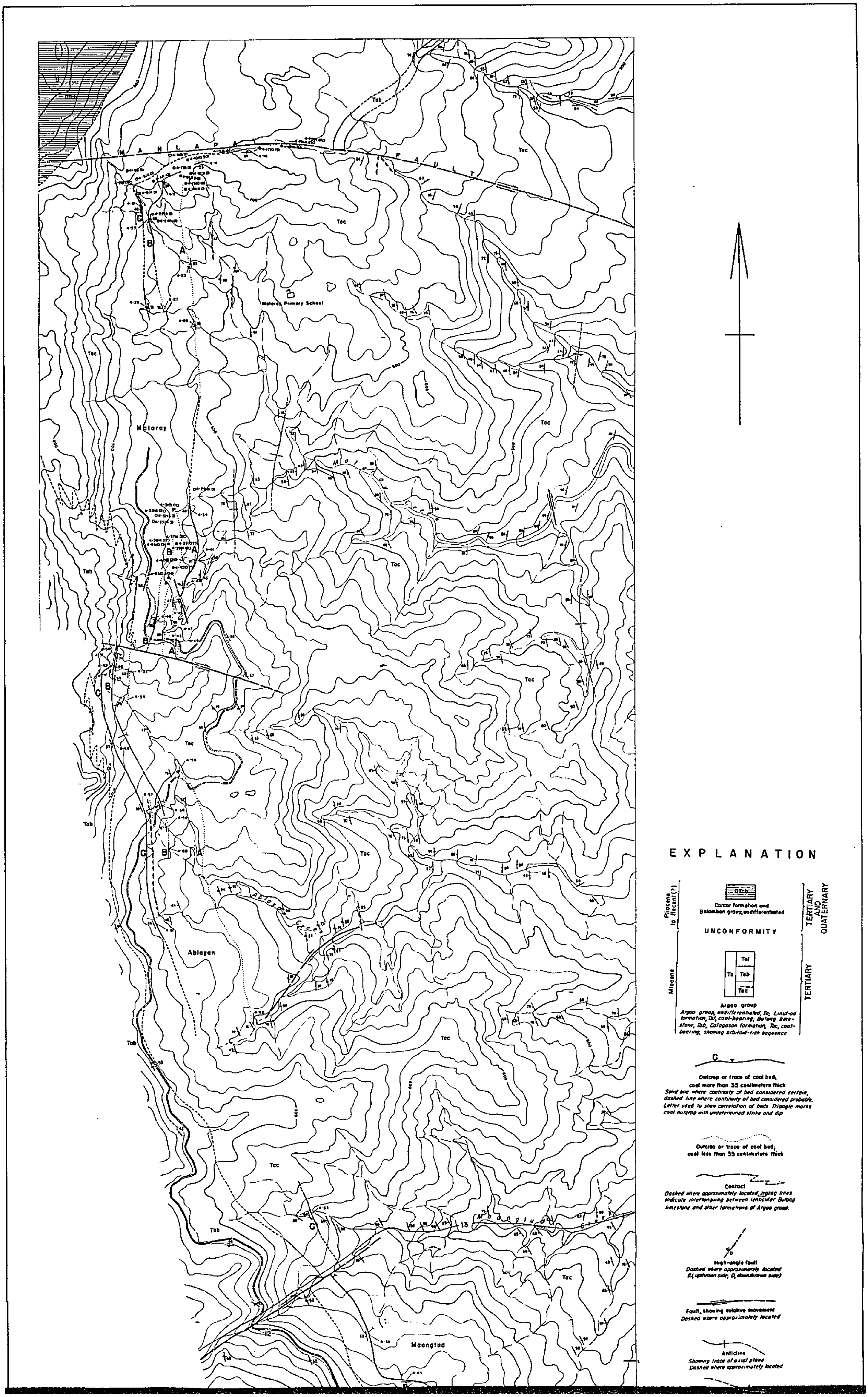
GEOLOGIC MAP OF BAYABAS-BALAAS COAL AREA, CEBU

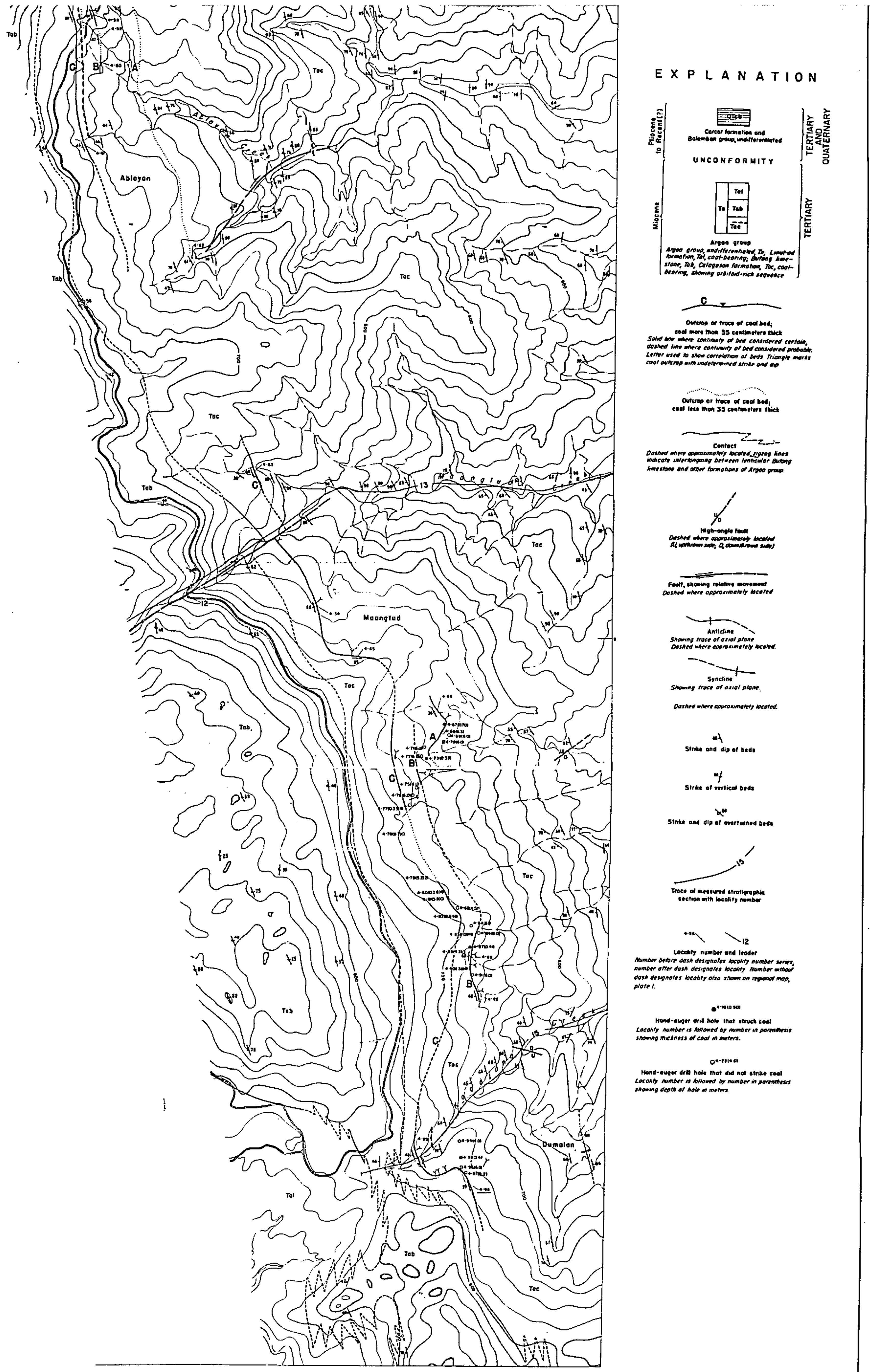
SCALE
100 0 100 200 300 400 500 Meters

CONTOUR INTERVAL 20 METERS
DATUM IS APPROXIMATE MEAN SEA LEVEL

By Harley Barnes, Cresencio P. Jongco, Generoso C. Lazaga, Juan E. Pilac and Harold E. Vokes, 1956

PLATE 6-4


MANLAPAY FAULT
Maloray Primary School
Maloray
Ablayan
Maangtud
Tac
Tab
EXPLANATION
Pliocene to Recent(?)
QTcb
Carcar formation and Balamban group, undifferentiated
TERTIARY AND QUATERNARY
UNCONFORMITY
Miocene
Ta
Tal
Tab
Tac
TERTIARY
Argao group
Argao group, undifferentiated, Ta; Linut-od formation, Tal, coal-bearing; Butong limestone, Tab, Calagasan formation, Tac, coal-bearing, showing orbitoid-rich sequence
C
Outcrop or trace of coal bed; coal more than 35 centimeters thick
Solid line where continuity of bed considered certain, dashed line where continuity of bed considered probable. Letter used to show correlation of beds Triangle marks coal outcrop with undetermined strike and dip
Outcrop or trace of coal bed; coal less than 35 centimeters thick
Contact
Dashed where approximately located, zigzag lines indicate intertonguing between lenticular Butong limestone and other formations of Argao group.
U
D
High-angle fault
Dashed where approximately located (U, upthrown side; D, downthrown side)
Fault, showing relative movement
Dashed where approximately located
Anticline
Showing trace of axial plane
Dashed where approximately located.



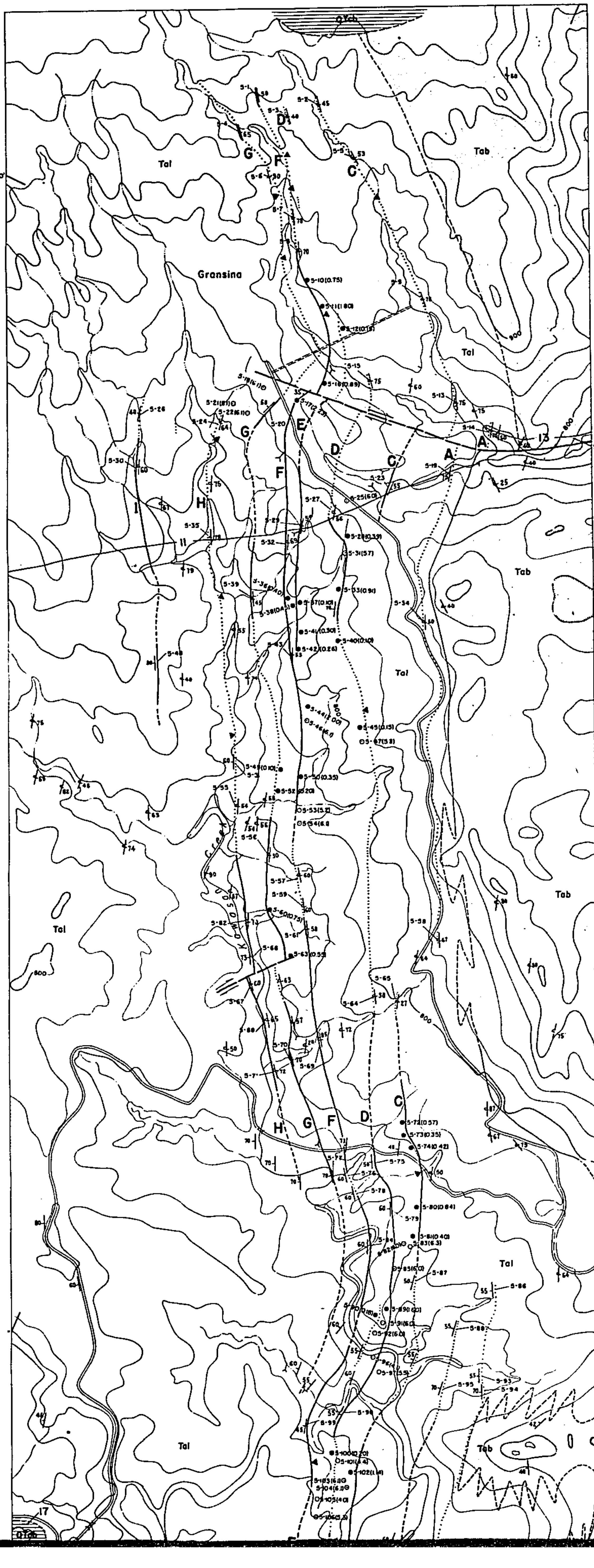
GEOLOGIC MAP OF MANLAPAY-DUMALAN COAL AREA, CEBU

SCALE

CONTOUR INTERVAL 20 METERS
DATUM IS APPROXIMATE MEAN SEA LEVEL

By Harley Barnes, Cresencio P. Jongco, Generoso C. Lazaga, Juan E. Pilac and Harold E. Vokes, 1956

PLATE 6-5



EXPLANATION

Pliocene to Recent (?)	QTcb — Carcar formation and Balamban group, undifferentiated	TERTIARY AND QUATERNARY
	UNCONFORMITY	
Miocene	To: Tal, Tab, Tac — Argao group	TERTIARY

Argao group, undifferentiated, To; Linut-od formation, Tal, coal-bearing; Butong limestone, Tab; Calagasan formation, Tac, coal-bearing.

C — Outcrop or trace of coal bed; coal more than 35 centimeters thick

Solid line where continuity of bed considered certain; dashed line where continuity of bed considered probable. Letter used to show correlation of beds. Triangle marks coal outcrop with undetermined strike and dip.

Outcrop or trace of coal bed; coal less than 35 centimeters thick

Contact

Dashed where approximately located, zigzag lines indicate intertonguing between lenticul^r Butong limestone and other formations of Argao group.

Fault, showing relative movement

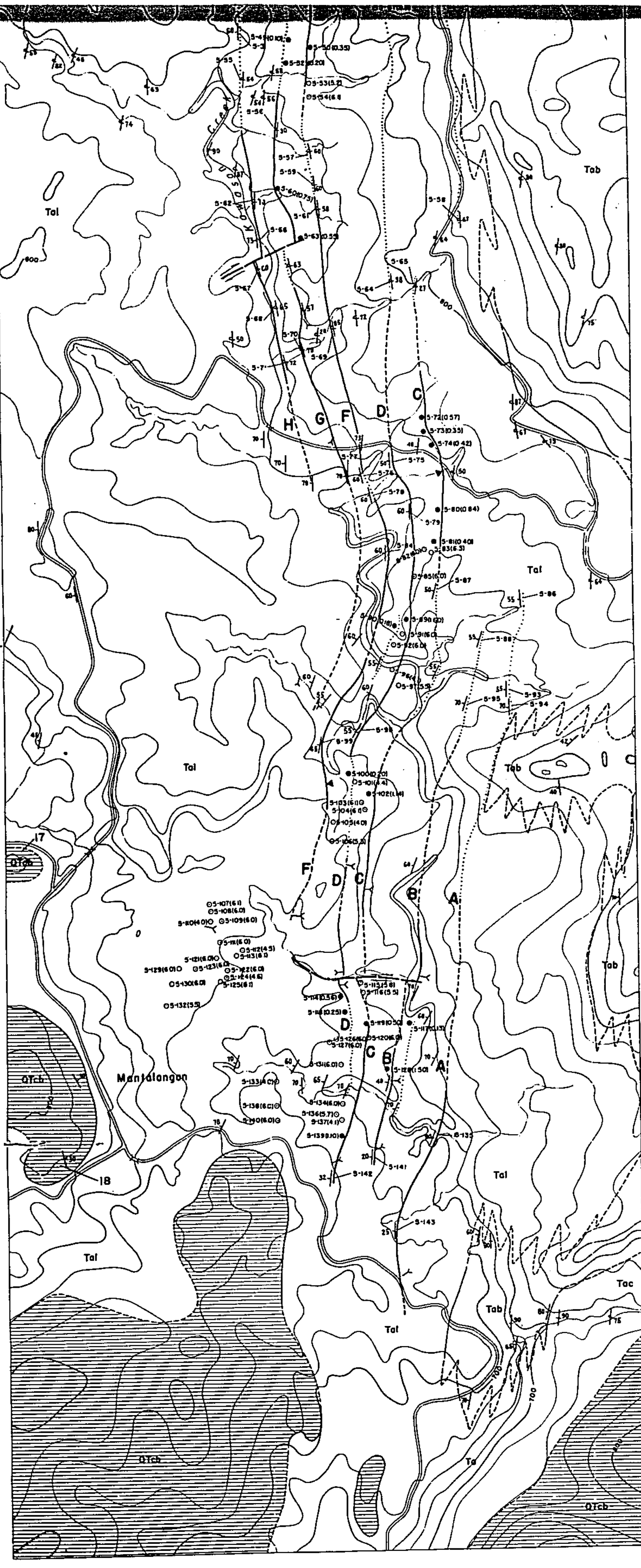
Dashed where approximately located.

40 — Strike and dip of beds

50 — Strike of vertical beds

73 — Strike and dip of overturned beds

—II—



Pliocene to Recent | Balamban group, undifferentiated | TERTIARY AND QUATERNARY

UNCONFORMITY

Miocene | TERTIARY

Ta	Tal
	Tab
	Tac

Argao group

Argao group, undifferentiated, Ta; Linut-od formation, Tal, coal-bearing; Butong limestone, Tab; Calagasan formation, Tac, coal-bearing.

Outcrop or trace of coal bed; coal more than 35 centimeters thick
Solid line where continuity of bed considered certain; dashed line where continuity of bed considered probable. Letter used to show correlation of beds. Triangle marks coal outcrop with undetermined strike and dip.

Outcrop or trace of coal bed; coal less than 35 centimeters thick

Contact
Dashed where approximately located, zigzag lines indicate intertonguing between lenticular Butong limestone and other formations of Argao group.

Fault, showing relative movement
Dashed where approximately located.

Strike and dip of beds

Strike of vertical beds

Strike and dip of overturned beds

Trace of measured stratigraphic section with locality number

Locality number and leader
Number before dash designates locality number series; number after dash designates locality. Number without dash designates locality also shown on regional map, plate I.

Hand-auger drill hole that struck coal
Locality number is followed by number in parenthesis showing thickness of coal in meters.

Hand-auger drill hole that did not strike coal
Locality number is followed by number in parenthesis showing depth of hole in meters.

Proposed Location of Trench

Proposed Location of Diamond Drilling

====== Proposed Location of Road

GEOLOGIC MAP OF GRANSINA-MANTALONGON COAL AREA, CEBU

SCALE

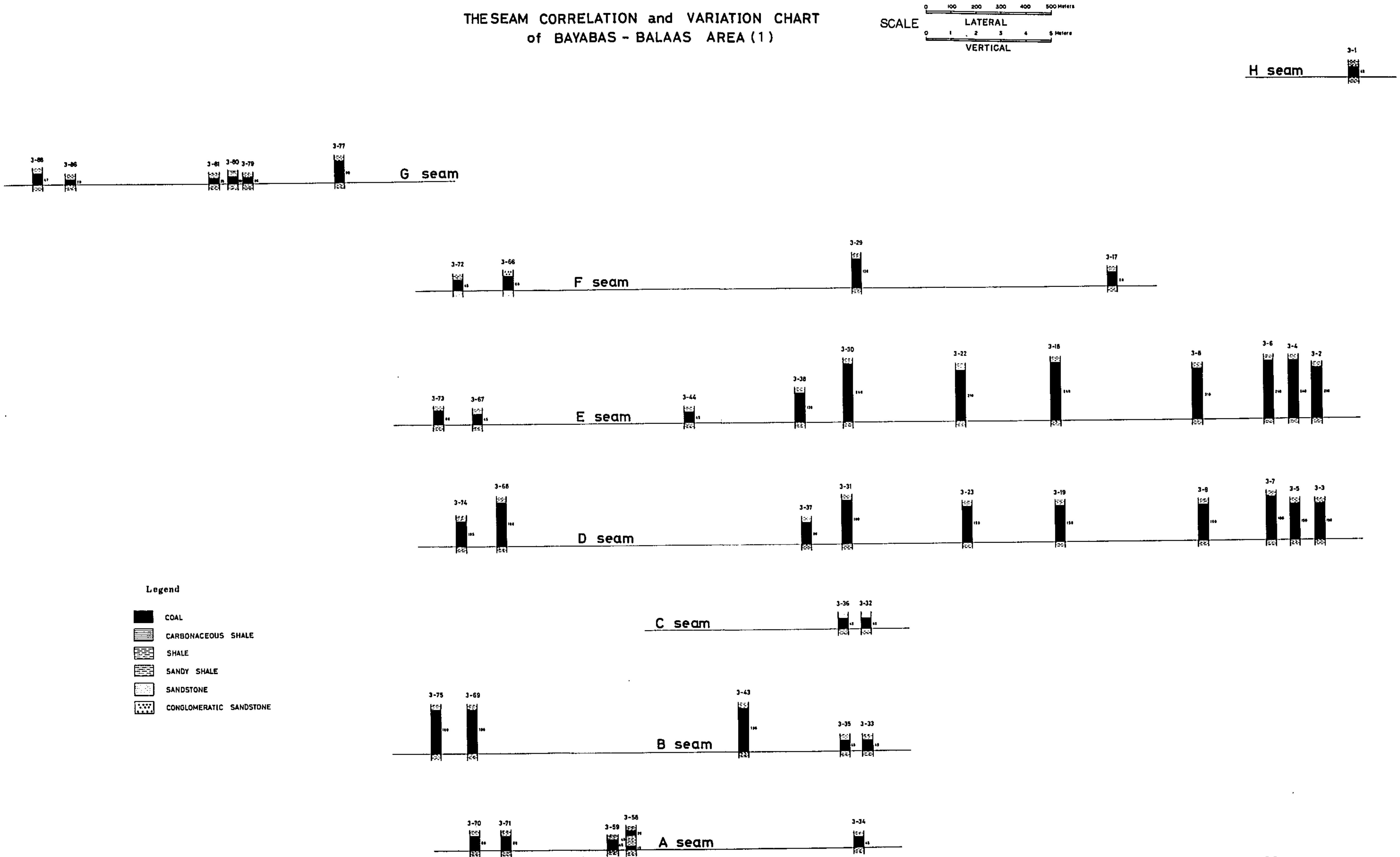
100 0 100 200 300 400 500 Meters

CONTOUR INTERVAL 20 METERS
DATUM IS APPROXIMATE MEAN SEA LEVEL

By Harley Barnes, Cresencio P. Jongco,
Generoso C. Lazaga, Juan E. Pilac and Harold E. Vokes, 1956

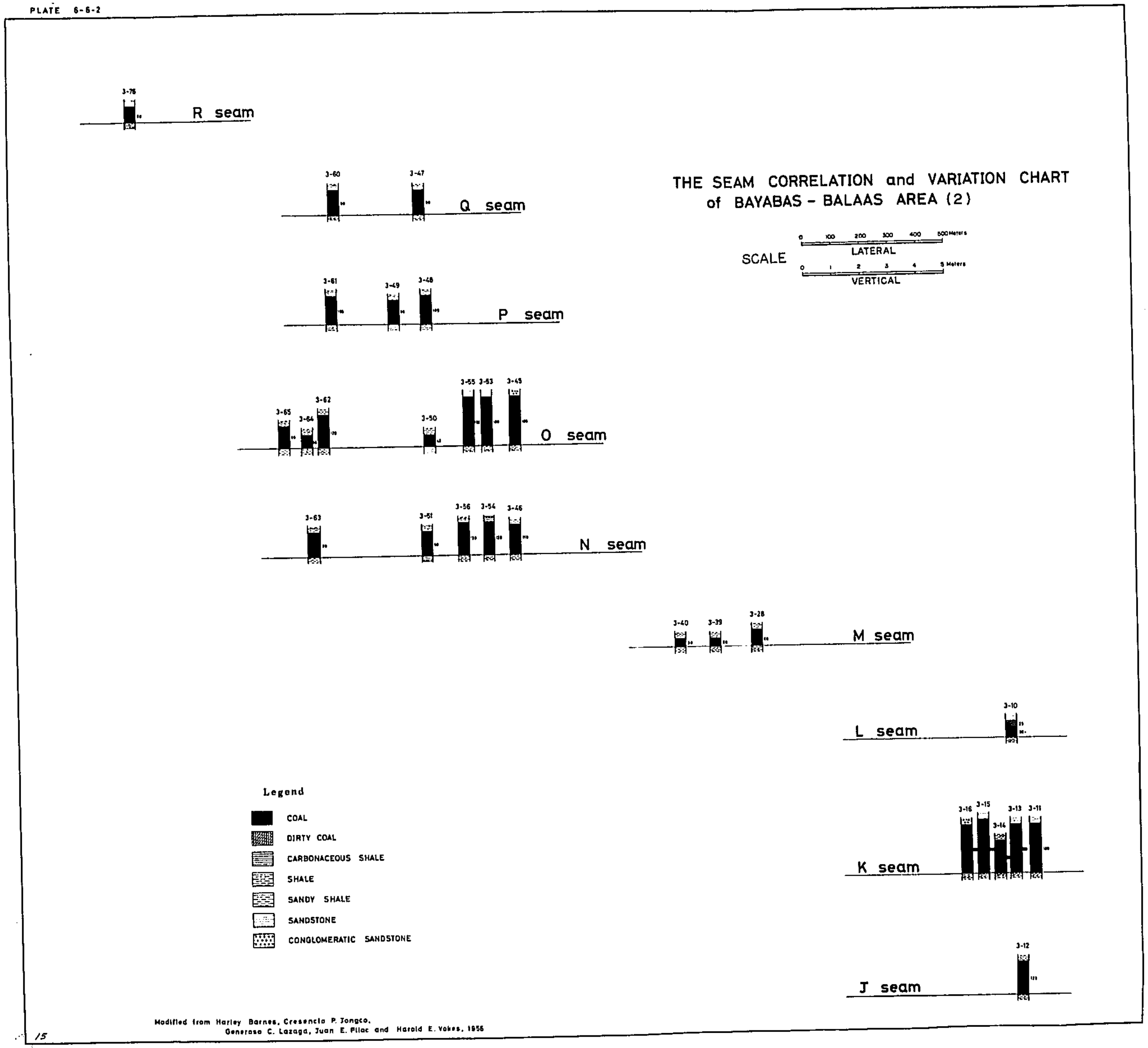
PLATE 6-6-1

THE SEAM CORRELATION and VARIATION CHART of BAYABAS – BALAAS AREA (1)



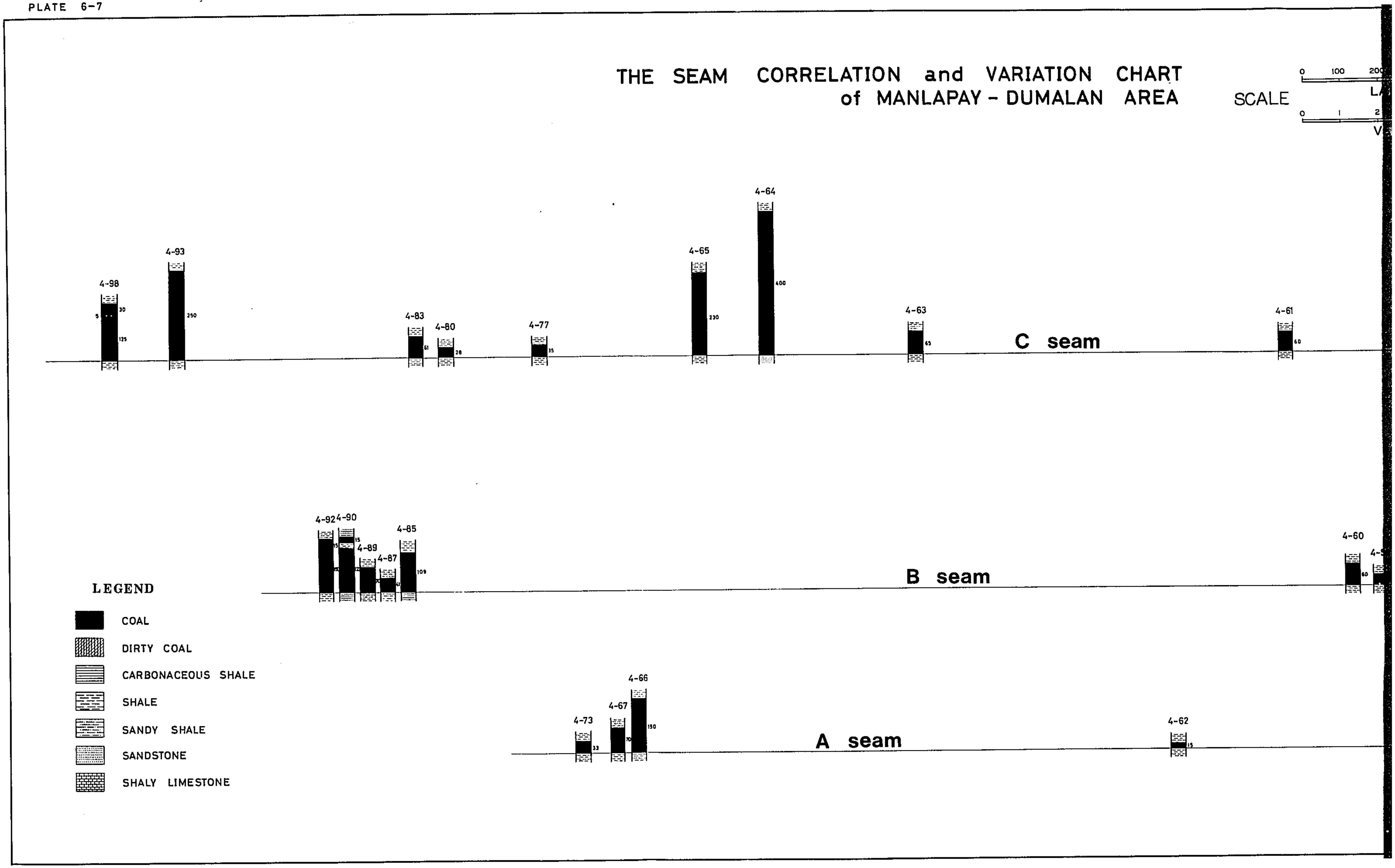
Modified from Harley Barnes, Cresencio P. Jongco, Generoso C. Lazaga, Juan E. Pilac and Harold E. Vokes, 1956

PLATE 6-6-2



Modified from Harley Barnes, Cresencio P. Jongco, Generoso C. Lazaga, Juan E. Pilac and Harold E. Vokes, 1956

PLATE 6-7


THE SEAM CORRELATION and VARIATION CHART
of MANLAPAY - DUMALAN AREA
SCALE
0 100 200
0 1 2
4-98
4-93
4-83
4-80
4-77
4-65
4-64
4-63
4-61
C seam
4-92
4-90
4-89
4-87
4-85
4-60
B seam
4-73
4-67
4-66
4-62
A seam
LEGEND
COAL
DIRTY COAL
CARBONACEOUS SHALE
SHALE
SANDY SHALE
SANDSTONE
SHALY LIMESTONE

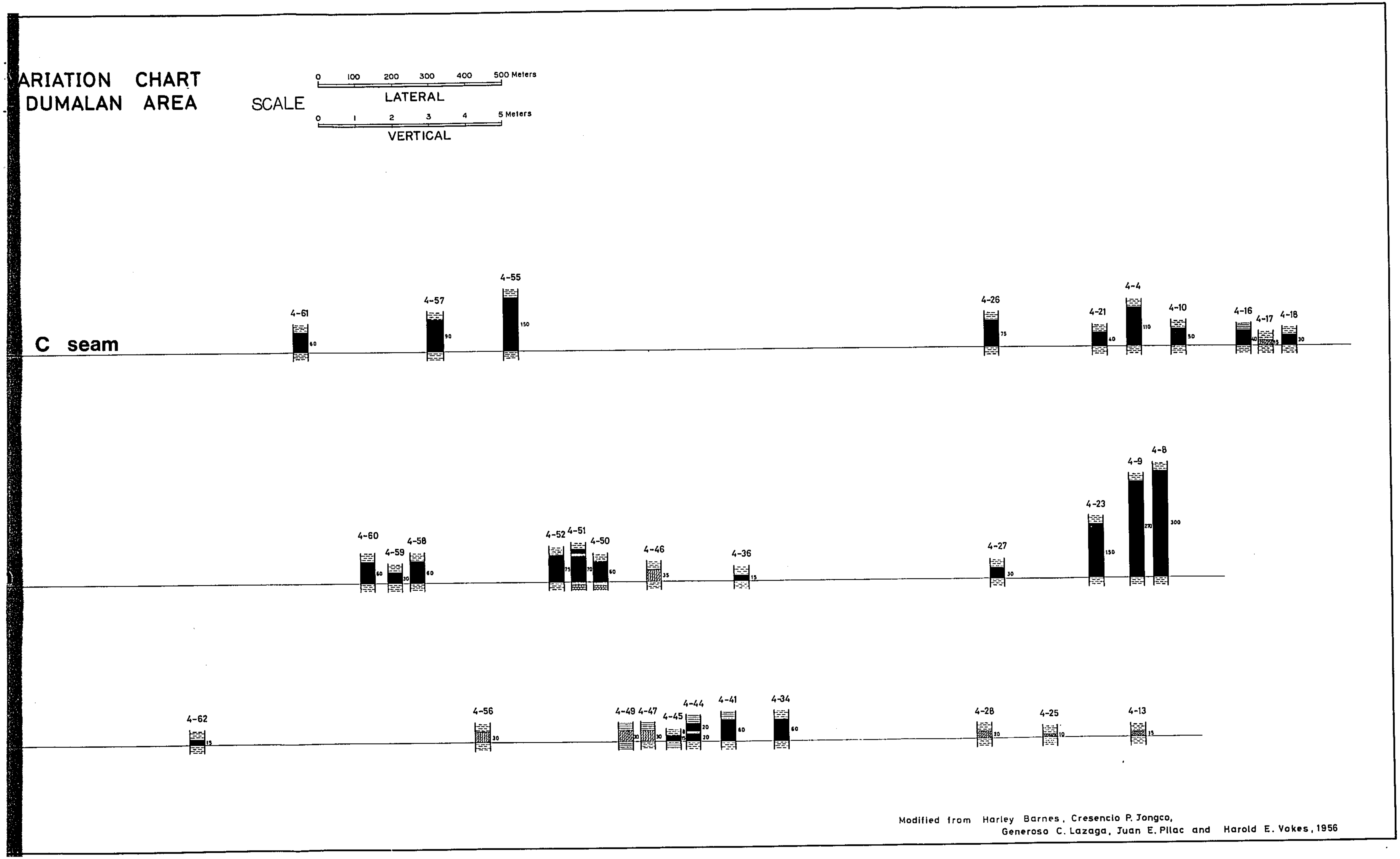
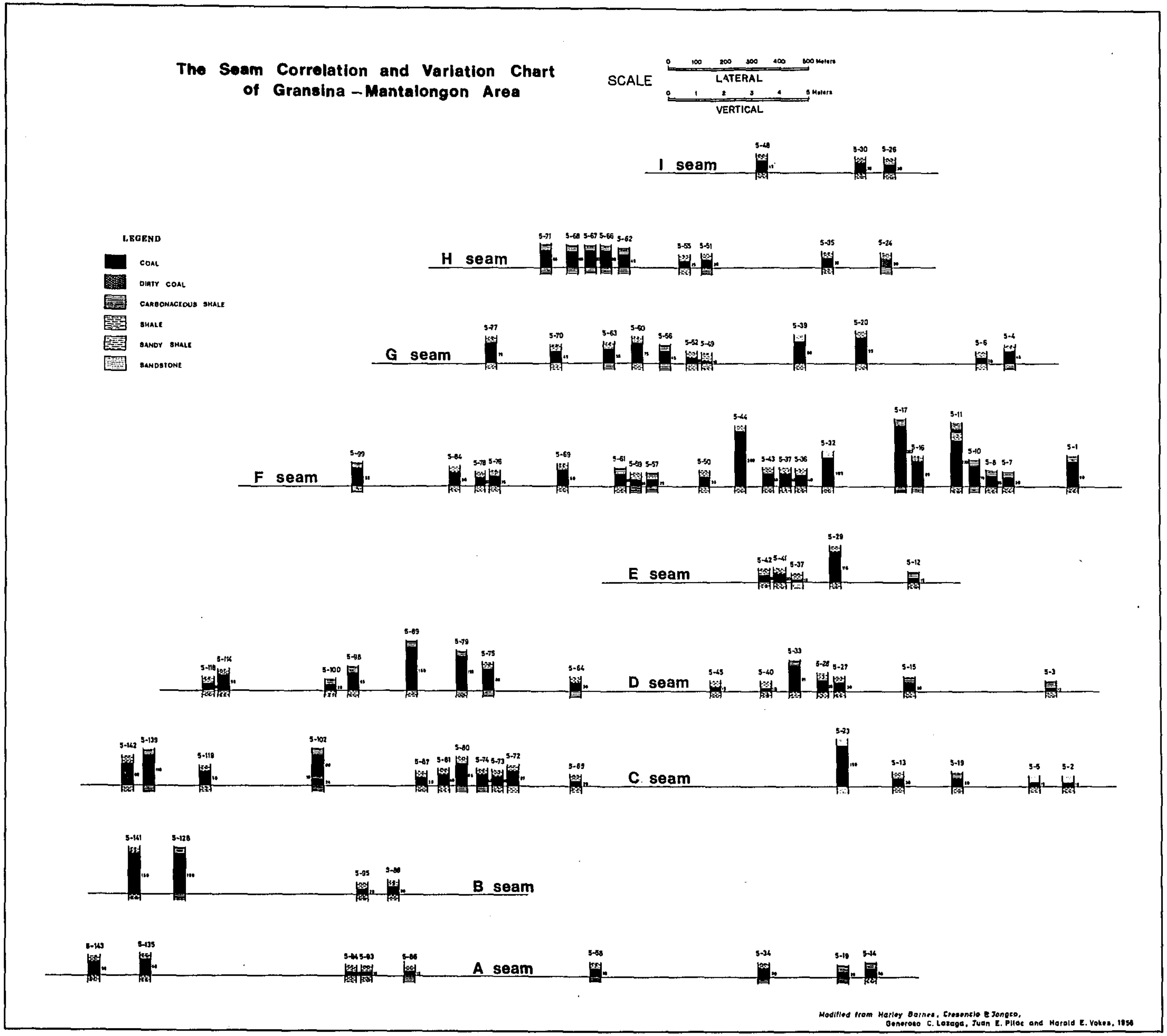
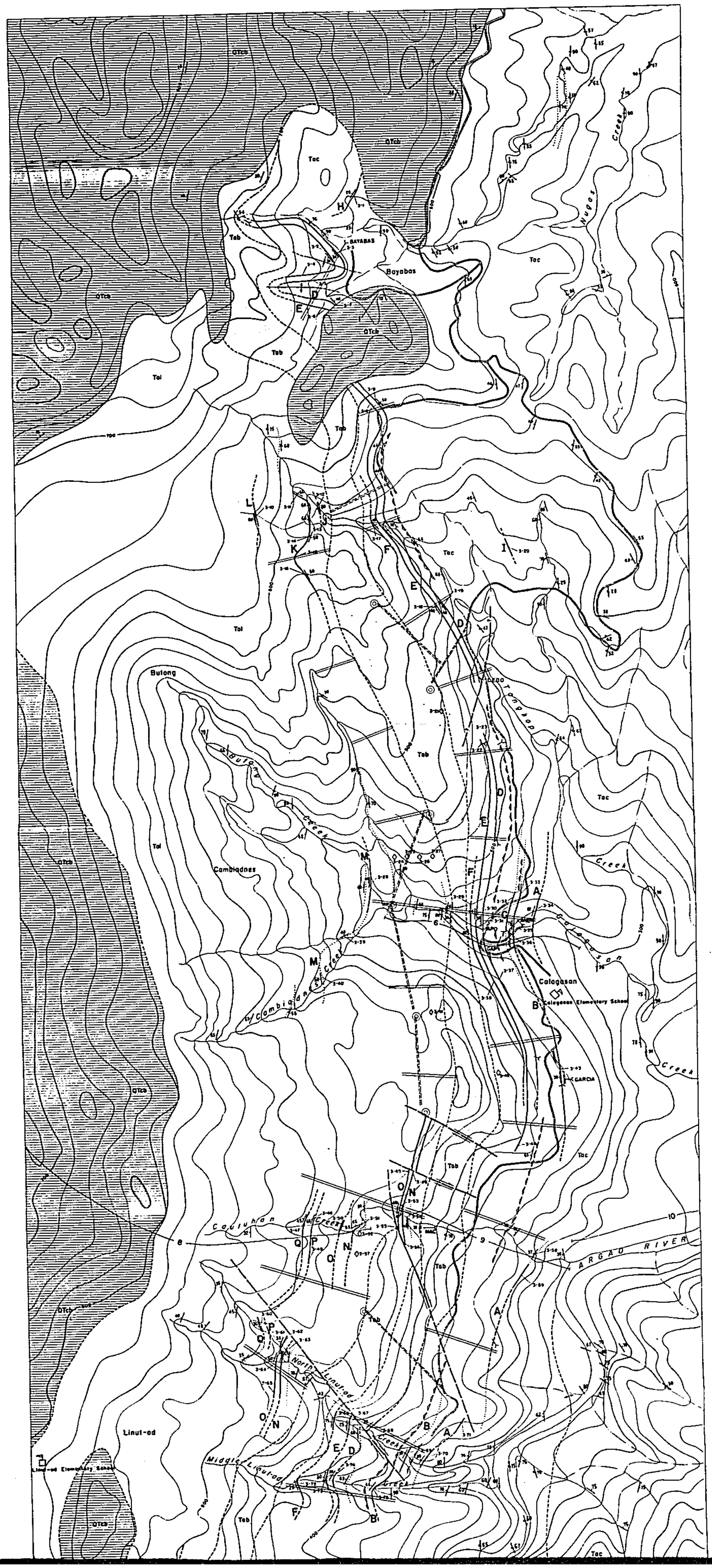

ARIATION CHART
DUMALAN AREA
SCALE
0 100 200 300 400 500 Meters
LATERAL
0 1 2 3 4 5 Meters
VERTICAL
C seam
4-61
4-57
4-55
4-26
4-21
4-4
4-10
4-16
4-17
4-18
4-60
4-59
4-58
4-52
4-51
4-50
4-46
4-36
4-27
4-23
4-9
4-8
4-62
4-56
4-49
4-47
4-45
4-44
4-41
4-34
4-28
4-25
4-13
Modified from Harley Barnes, Cresencio P. Jongco, Generoso C. Lazaga, Juan E. Pilac and Harold E. Vokes, 1956

PLATE 6-8



The Seam Correlation and Variation Chart
of Gransina – Mantalongon Area
SCALE
0 100 200 300 400 500 Meters
LATERAL
0 1 2 3 4 5 Meters
VERTICAL
LEGEND
COAL
DIRTY COAL
CARBONACEOUS SHALE
SHALE
SANDY SHALE
SANDSTONE
I seam
H seam
G seam
F seam
E seam
D seam
C seam
B seam
A seam
Modified from Harley Barnes, Cresencio B Jongco,
Generoso C. Lazaga, Juan E. Pilac and Harold E. Vokes, 1956

PLATE 6-9



EXPLANATION

Pliocene to Recent (?)	QTcb — Carcar formation and Balamban group, undifferentiated	TERTIARY AND QUATERNARY
	UNCONFORMITY	
Miocene	Ta; Tal, Tab, Tac — Argao group. *Argao group, undifferentiated, Ta; Linut-ad formation, Tal, coal-bearing; Bulong limestone, Tab; Calagasan formation, Tac, coal-bearing, showing orbitoid-rich sequence.*	TERTIARY

B

Outcrop or trace of coal bed;
coal more than 35 centimeters thick
Solid line where continuity of bed considered certain, dashed line where continuity of bed considered probable. Letter used to show correlation of beds Triangle marks coal outcrop with undetermined strike and dip

Outcrop or trace of coal bed;
coal less than 35 centimeters thick

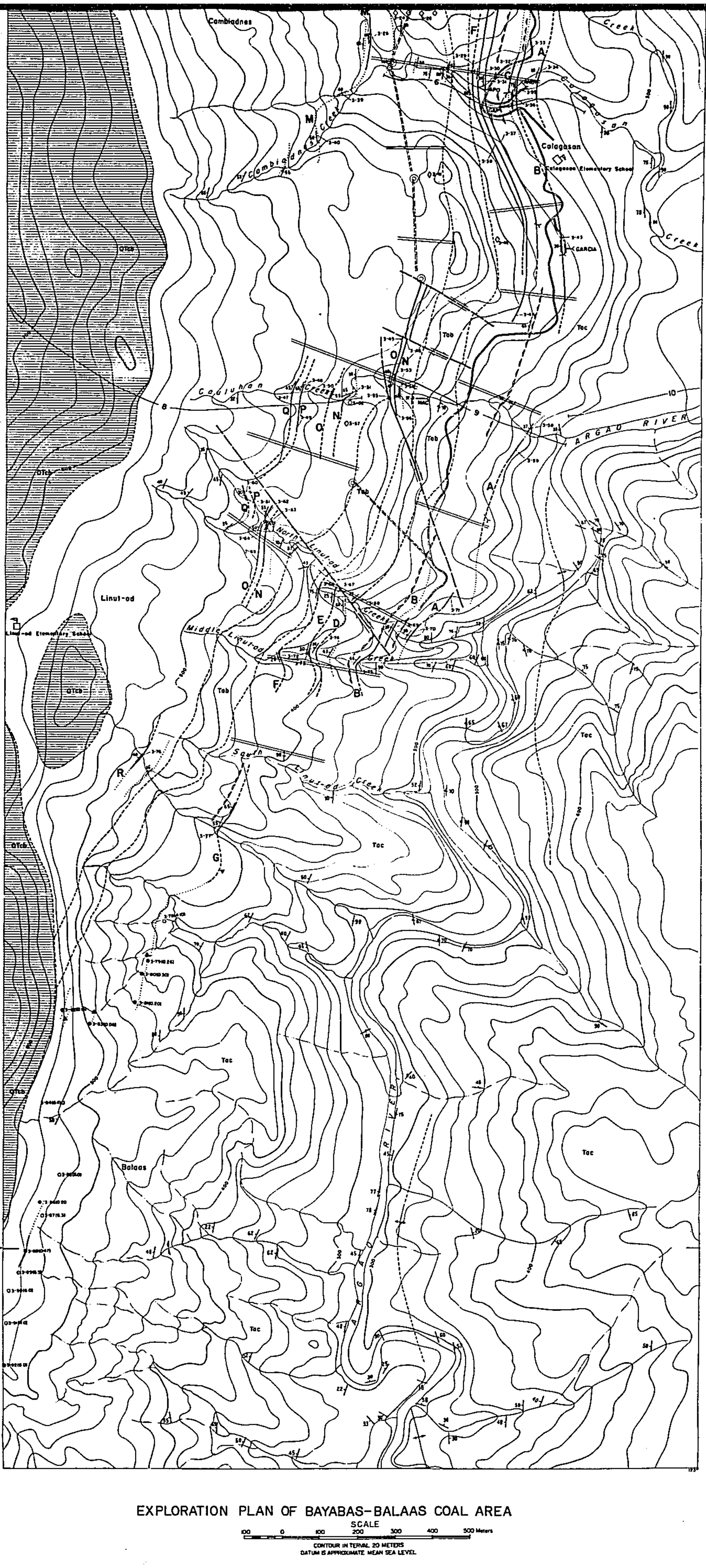
Contact
Dashed where approximately located

Doubtful or probable fault

Fault, showing relative movement
Dashed where approximately located

Anticline
Showing trace of axial plane.
Dashed where approximately located

Syncline
Showing trace of axial plane
Dashed where approximately located



EXPLANATION

Pliocene to Recent(?)	QTcb — Carcar formation and Balamban group, undifferentiated	TERTIARY AND QUATERNARY
	UNCONFORMITY	
Miocene	Ta: Tal, Tab, Tac	TERTIARY

Argao group

Argao group, undifferentiated, Ta; Linut-od formation, Tal, coal-bearing; Butong limestone, Tab; Calagasan formation, Tac, coal-bearing, showing orbitoid-rich sequence.

Outcrop or trace of coal bed; coal more than 35 centimeters thick

Solid line where continuity of bed considered certain, dashed line where continuity of bed considered probable. Letter used to show correlation of beds. Triangle marks coal outcrop with undetermined strike and dip

Outcrop or trace of coal bed; coal less than 35 centimeters thick

Contact

Dashed where approximately located

Doubtful or probable fault

Fault, showing relative movement

Dashed where approximately located

Anticline

Showing trace of axial plane. Dashed where approximately located

Syncline

Showing trace of axial plane. Dashed where approximately located

Strike and dip of beds

Strike of vertical beds

Strike and dip of overturned beds

Trace of measured stratigraphic section with locality number

Locality number and leader

Number before dash designates locality number series; number after dash designates locality. Number without dash designates locality also shown on regional map, plate I.

Diamond drill hole with locality number

Hand-auger drill hole that struck coal

Locality number is followed by number in parenthesis showing thickness of coal in meters.

Hand-auger drill hole that did not strike coal

Locality number is followed by number in parenthesis showing depth of hole in meters.

Proposed Location of Trench

Proposed Location of Diamond Drilling

Proposed Location of Road

EXPLORATION PLAN OF BAYABAS-BALAAS COAL AREA

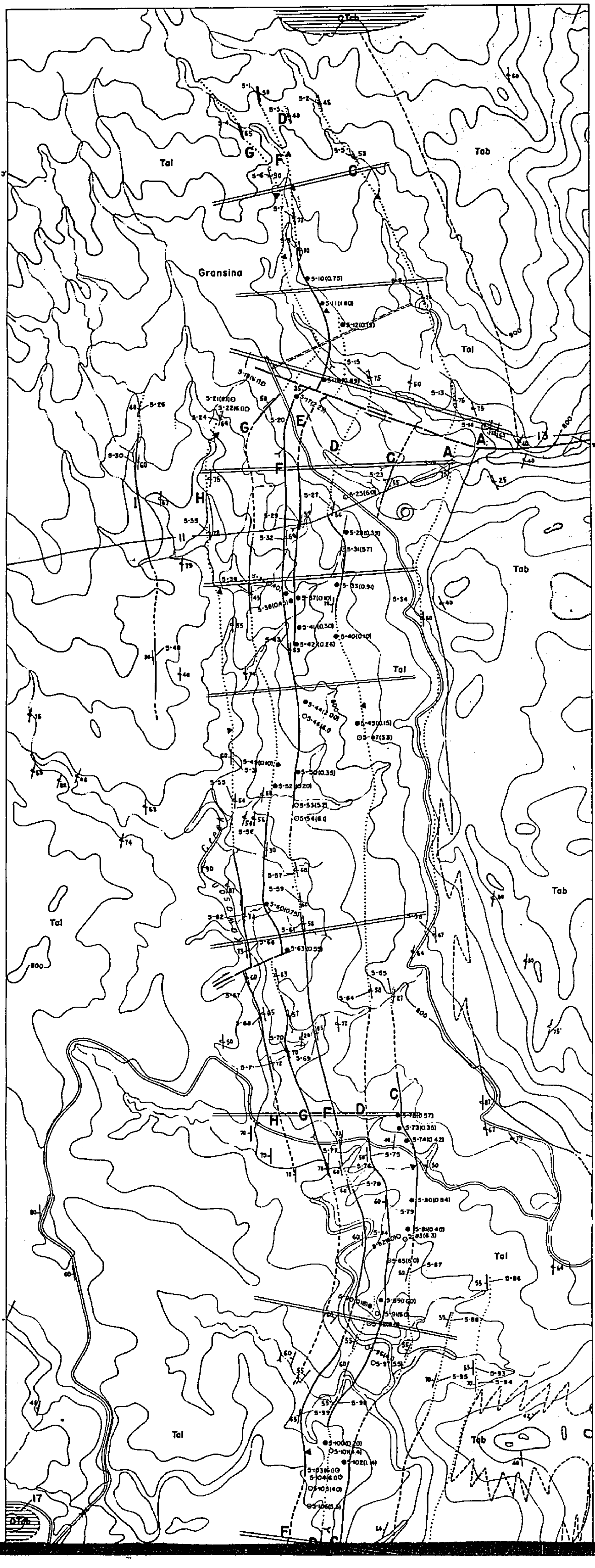
SCALE

100 0 100 200 300 400 500 Meters

CONTOUR INTERVAL 20 METERS
DATUM IS APPROXIMATE MEAN SEA LEVEL

By Harley Barnes, Cresencio P. Jongco,
Generoso C. Lazaga, Juan E. Pilac and Harold E. Vokes, 1956

PLATE 6-10



EXPLANATION

Pliocene to Recent (?) | TERTIARY AND QUATERNARY

QTcb

Carcar formation and Balamban group, undifferentiated

UNCONFORMITY

Miocene | TERTIARY

Ta	Tal
	Tab
	Tac

Argao group

Argao group, undifferentiated, Ta; Linut-od formation, Tal, coal-bearing; Butong limestone, Tab; Calagasan formation, Tac, coal-bearing.

Outcrop or trace of coal bed; coal more than 35 centimeters thick

Solid line where continuity of bed considered certain; dashed line where continuity of bed considered probable. Letter used to show correlation of beds. Triangle marks coal outcrop with undetermined strike and dip.

Outcrop or trace of coal bed; coal less than 35 centimeters thick

Contact

Dashed where approximately located, zigzag lines indicate intertonguing between lenticular Butong limestone and other formations of Argao group.

Fault, showing relative movement

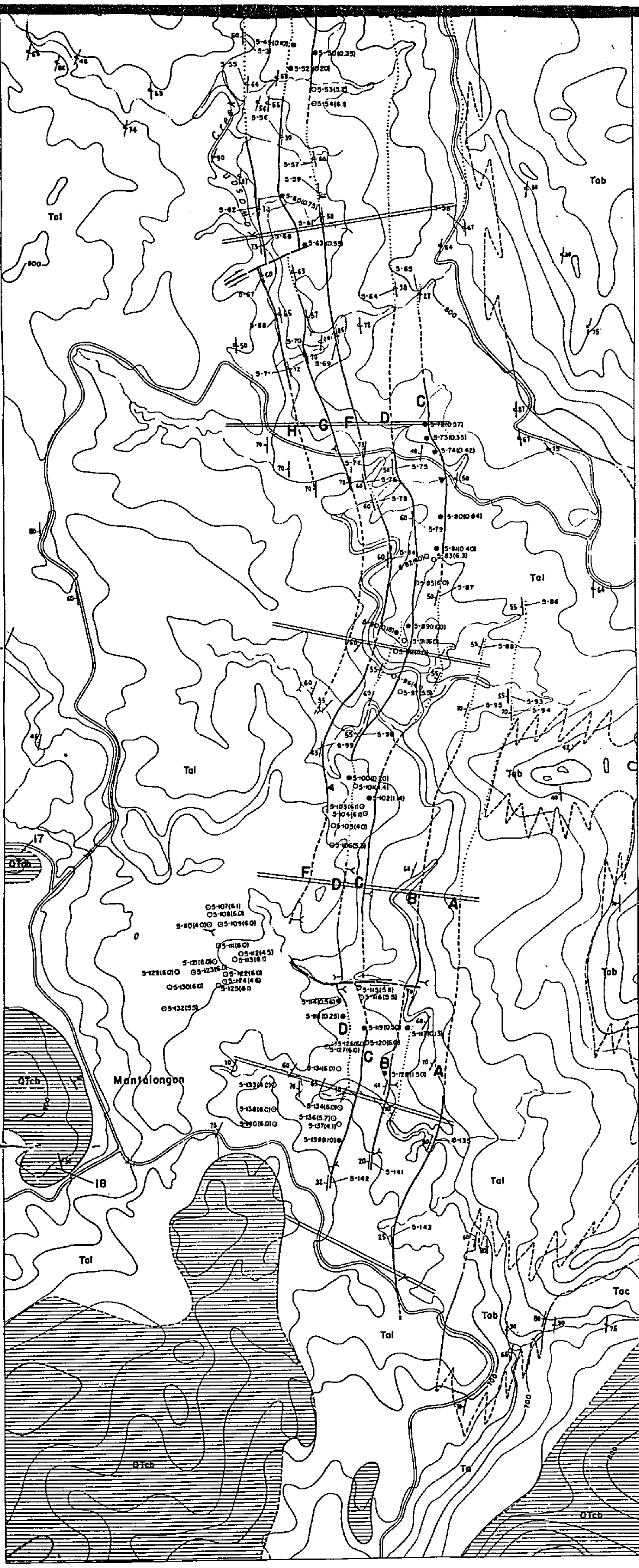
Dashed where approximately located.

Strike and dip of beds

Strike of vertical beds

Strike and dip of overturned beds

Trace of measured stratigraphic



Pliocene to Recent	Carcar formation and Balamban group, undifferentiated		TERTIARY AND QUATERNARY
	UNCONFORMITY		
Miocene	Ta: Tal, Tab, Tac	Argao group	TERTIARY

Argao group, undifferentiated, Ta; Linut-od formation, Tal, coal-bearing; Butong limestone, Tab; Calagasan formation, Tac, coal-bearing.

C

Outcrop or trace of coal bed; coal more than 35 centimeters thick

Solid line where continuity of bed considered certain; dashed line where continuity of bed considered probable. Letter used to show correlation of beds. Triangle marks coal outcrop with undetermined strike and dip.

Outcrop or trace of coal bed; coal less than 35 centimeters thick

Contact

Dashed where approximately located, zigzag lines indicate intertonguing between lenticular Butong limestone and other formations of Argao group.

Fault, showing relative movement

Dashed where approximately located.

45

Strike and dip of beds

50

Strike of vertical beds

75

Strike and dip of overturned beds

II

Trace of measured stratigraphic section with locality number

5-27 17

Locality number and leader

Number before dash designates locality number series; number after dash designates locality. Number without dash designates locality also shown on regional map, plate I.

5-12(0.16)

Hand-auger drill hole that struck coal

Locality number is followed by number in parenthesis showing thickness of coal in meters.

5-83(6.0)

Hand-auger drill hole that did not strike coal

Locality number is followed by number in parenthesis showing depth of hole in meters.

Proposed Location of Trench

Proposed Location of Diamond Drilling

Proposed Location of Road

EXPLORATION PLAN OF GRANSINA-MANTALONGON COAL AREA

SCALE

100 0 100 200 300 400 500 Meters

CONTOUR INTERVAL 20 METERS
DATUM IS APPROXIMATE MEAN SEA LEVEL

By Harley Barnes, Cresencio P. Jongco,
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