PREFEASIBILITY STUDY REPORT

FOR

THE [illegible] MINE PROJECT

IN

THE [illegible] OF SRI LANKA

FEBRUARY 198[illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFEASIBILITY STUDY REPORT
FOR
THE BAJA TALAMANCA COAL DEVELOPMENT PROJECT
IN
THE REPUBLIC OF COSTA RICA

Feb. ~~MARCH~~ 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of the Republic of Costa Rica, the Government of Japan decided to conduct a survey on the Baja Talamanca Coal Development Project and entrusted the survey to the Japan International Cooperation Agency (JICA). The JICA sent to Costa Rica a survey team headed by Mr. Shunsuke Sato four times during the period from June 1981 to September 1982.

The team exchanged views with the officials concerned of the Government of Costa Rica and conducted a field survey on the coal seams and the feasibility of their development in Baja Talamanca area. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my appreciation to the officials concerned of the Government of the Republic of Costa Rica for their close cooperation extended to the team.

Tokyo, February 1983

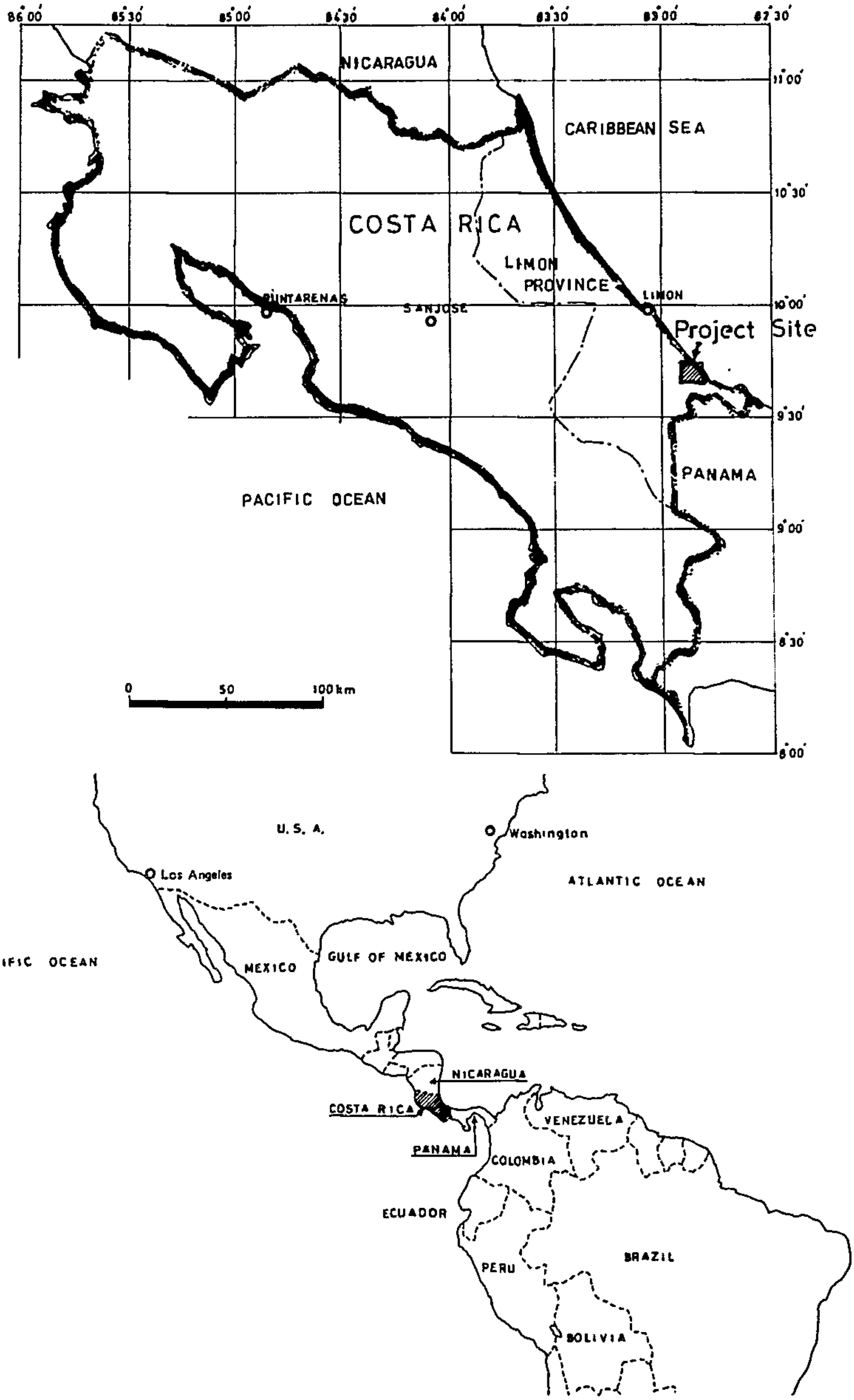
Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

ABBREVIATION

JICA	Japan International Cooperation Agency
IGN	Instituto Geografico National
ICE	Instituto Costarricense de Electricidad
S.A.	Sociedad Anónima
kg	kilogram
km	kilometer
km^2	square kilometer
m	meter
cm	centimeter
mm	millimeter
m.t.	metric ton
asl	above sea level
bsl	below sea level
N	North
S	South
E	East
W	West
JIS	Japan Industrial Standards
ASTM	American Society for Testing Material Standards
Btu/lb	British Thermal Unit per pound
%	percentage
°C	degree centigrade
HGI	Hard Grove Index
FSI	Free Swelling Index
tpa	metric ton per annum

Figure I   Location of Project Site



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I. INTRODUCTION

I. INTRODUCTION

1. BACKGROUND OF THE SURVEY

The Republic of Costa Rica, which currently produces no coal, has been reported to have some limited amount of outcrops of coal and lignite. However, no systematic investigation has been made, therefore, the geological data are scarcely available for any evaluation of the feasibility of mining in the country. Although in 1979, a reconnaissance survey of coal was conducted in Baja Talamanca area by ICE (Instituto Costarricense de Electricidad), the geological data obtained and their interpretation were not enough to give any reliable appraisal of the coalfield.

Since around 1980, Costa Rica took notice of the possible existence of coal reserves in her country as important energy resources as well as petroleum, and in view of her lack of know-how of exploration and development of coalfield, began negotiations with many countries seeking both technical and financial assistance to assess the coal reserves in Baja Talamanca to start with.

Among many technical missions from various countries which visited Costa Rica to analyze the present situation, there was a preliminary survey mission dispatched by the Japanese Government through JICA in compliance with the request of the Government of Costa Rica. The Japanese mission submitted to the Costa Rican government a recommendation report of survey methods, dispatch of technical experts and engineers, equipment, and machinery that can be provided, as well as financial services (assistance). The Costa Rican government, having deliberated over the analyses reports by these missions, signed the contract with the Japanese government on March, 1981.

In June 1980, the Japanese government dispatched through JICA a technical survey mission consisting of seven specialists, who conducted the field investigation with topographic mapping and geological survey. This report deals with the results of the analyses and interpretation of the data obtained from this field survey.

2. OBJECT OF THE SURVEY

The main purpose of this technical survey mission is, in compliance with the request of the Costa Rican government, to conduct a surface geological survey in the virgin coalfield, Baja Talamanca, in the Limon Province of the country, covering an area of approximately 140 km^2, in order to elucidate the occurrence of coal seams. The responsibility of JICA for this purpose is to dispatch the survey team of technical experts, to bear its expenses (including the supply of new surveying apparatus), to draw up topogrammetric mapping) then, based on the map, to conduct the field geological survey and to prepare the geological map which is to be the basis of all the consideration of this coal project in future.

Another but similarly important purpose of this technical survey mission is to give technical advice to the Costa Rican counterparts and transfer technical know-hows during the whole period of study for both field survey and indoor mapping.

3. CONTENTS OF THE SURVEY

3-1 Preparatory Survey

The survey mission left Japan on June 15, 1981. In San Jóse, the capital of Costa Rica, at the Instituto Geográfico, details of the preparatory survey such as aerial photograph were discussed and necessary data were collected and at the same time materials including new surveying apparatus were presented to Costa Rica in accordance with the provision of the contract between the two governments. The survey mission performed a field reconnaissance survey, at the projected area and the Inception Report, in which future schedule of the project as well as technical procedures were proposed in detail, were finalized. Both parties approved and signed the proposal.

3-2 Topographic Mapping

1) Preparation of Aerial Photograph

The aerial photographs of the projected area on a scale of approximately 1 to 30,000 taken by the Costa Rican government in 1976, were obtained at the Instituto Geographico. The photographs were confirmed to meet the following technical requirements and to be useful for mapping:

- The photographs should overlap by more than 60 percent.
- They should overlap side by side more than 20 percent.
- The whole mapping area should be covered so that the stereoscopic views are made possible.
- The parts covered with clouds should be less than 5 percent of the whole mapping area.

2) Ground Control Point Survey

The ground control point survey consisting of two survey teams was a joint operation between the two countries: Each team consisted of one Japanese surveyor, one Costa Rican surveyor (from ICE), and assistants. The survey covered the following areas:

Traverse survey	approx. 40 km
Leveling survey	approx. 10 km

The results of the survey were compiled for use in aerial triangulation.

3) Aerial Triangulation

Aerial triangulation was carried out principally by the Costa Rican engineers, with technical assistance from the Japanese engineers, using the method of Independent

Model Block Adjustment. However, as the aerial triangulation was not so accurate, the stereo plotting machine, Precision plotter A-8, was used for remeasurement. The number of models used for aerial triangulation was 21. While calculating for re-measurement, computer failure occurred happened and the operation was delayed. However, with the cooperation of the Costa Rican counterparts, the whole process of the topographic mapping was completed as scheduled.

4) Stereo-plotting, Editing, Tracing

Stereo plotting was conducted jointly by two Japanese engineers newly dispatched to the team from Japan and the Costa Rican engineers of the Instituto Geographico, using the plotting machines of the institute. The plotting machines used for mapping were two "C-8" plotters and one "A-8" plotter. The aerial photographs of the three courses were processed by three plotters respectively, thus the whole operation progressed smoothly, enabling them to make up for the delay at the aerial triangulation operation

Number of sheets plotted (Scale 1:10,000)		8 sheets
Areas plotted by Japanese experts		107 km^2
	by Costa Rican experts	43 km^2
	Total	150 km^2

3-3 Surface Geological Survey

1) Field Survey in Costa Rica

The surface geology was surveyed in two phases as a matter of convenience in relation to the Japanese fiscal years. The first phase was from January 4, 1982 to March 19 (for 82 days) and the second phase was from May 29 to September 1 (for 96 days), totaling 178 days. On each phase, the Japanese party surveyed with the cooperation of the Costa Rican party in two teams, each of which consisted of one Japanese geologist, one Costa Rican geologist (from ICE) and several laborers. The purpose during the survey was to transfer geological exploration techniques on the virgin coalfield to the Costa Rican counterparts. In the second phase, the survey encountered difficulties due to geographical inconvenience of the projected area and adverse weather, but the whole operation was completed well, covering the whole area of 140 km^2

2) Works in Japan

After the survey mission returned to Japan, the results of the field survey were studied and compiled into the geological map and other geologic figures such as the columnar sections of the stratigraphic sequences and the structural map as shown in the attached contents of figures. And the occurrence and the potential reserves of coal were estimated.

4. ORGANIZATION OF TECHNICAL SURVEY MISSION

The technical survey mission was organized by the following seven members:

Name	Working for:	In charge of:
Chief: Shunsuke Satoh	Dia Consultant Co., Ltd.	General administration and geology
Member: Katsumi Wada Member: Kaneharu Nakamura	Asia Air Survey Co., Ltd. "	Topographical mapping team-A Ground control point survey Aerial triangulation
Member: Akira Saitoh Member: Shuichi Onda	" "	Topographical mapping team-B Stereo plotting, Editing and final drawing
Member: Yutaka Tobe Member: Hisashi Mitsui	Dia Consultant Co., Ltd. "	Geological survey team Surface geological survey (including cleaning, sampling, analyses and interpretation)

During the period of the field survey, each team worked in cooperation with the following Costa Rican counterparts:

- Topographical mapping team-A

  Mr. J. Alvarado, Engineer, (Field Coordinator) from ICE

  Mr. G. Gonzalez, Perito Topografo (Team Field Chief) from ICE

  Mr. R. Garcia, Perito Topografo (Team Field Chief) from ICE

- Topographical mapping team-B

  Mr. Jorge Varela A., Chief of Fotogrametria, Instituto Geografico and his staff

- Gelogical survey team

  Mr. Luis Malavassi and Mr. Kenneth Bolaños, Geologists belonging to Basic Geology Office, Geology Department of Instituto Costarricense de Electridad (ICE)

5. SURVEY PERIOD AND ITINERARY

The field survey was conducted from June 15, 1981 to September 1, 1982 with some intermissions in between as shown in Table I, showing the spheres covered by survey, itinerary, and contents of works.

Table I Working Progress in Costa Rica

In Charge:	Name	1981	1982
		Jun Jul Aug Sep Oct Nov Dec	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
General administration & geology	S.Satoh	— (15 days)	— (14 days) —— (24 days)
Topographical mapping team (A)	K.Wada	———— (69 days)	
	K. Nakamura	———— (69 days)	
Topographical mapping team (B)	A.Saitoh	————	(82 days)
	S.Onda	————	(83 days)
Geological survey team	Y.Tobe		———— (82 days) ———— (96 days)
	H.Mitsui		———— (82 days) ———— (96 days)

Middle of Jan.,1983— Final draft to be completed (in Japanese & English)

End of Feb.,1983 ——Final report consists of Japanese and English ones including summary report in Japanese

II. CONCLUSION (SURVEY RESULTS)

II CONCLUSION (SURVEY RESULTS)

1. OUTLINE OF COAL RESOURCES

The Lower Coal-bearing Member of the Gatún formation occurs widely throughout the survey area. In the northern Hone Creek Synclinal area, the member occurs in a relatively stable manner, however, coal distribution is extremely poor because of the constantly changing sedimentary environment caused by repeated marine transgression and regression of sea water. Therefore, this area shows no value as a coalfield.

The central part, consisting of many fault blocks, shows existence of coal seams but here, too, the continuous occurrence of thick coal seams cannot be expected because of violent changes in sedimentary environment which probably caused the seams to thin out. This area is also poorly valued as a coalfield except a block bounded by Volio I Fault and Volio II Fault where a coal seam with a thickness of 2 m is found for over 1 km in length, which is prospective for mining on a small scale.

The southern folding area surpasses other areas both in stability of geological structure and in occurrence of coal seams. Its western part near the Talamanca Mountain Range is characterized by thick sediments which consist of medium to coarse sandstones and many faults, and is, therefore, not expected to bear continuous and thick coal seams. The geological structure is stable in the central and eastern parts where coal seams are well observed. Carbón Volio Area and Carbón Uno Area look prospective on a small scale, each bearing two coal seams of around 1 m in seam thickness.

Generally minable coal seams in this area are restricted in their extent and cut into small blocks by many faults judging from many geological evidences in the field. This phenomenon will be understandable from the bload geotechtonic situation of the Costa Rica in the Central America where no major coal field would be expectable. Though the geological informations obtained from this survey are not enough in restoring the palaeotopography of this coal field, it will be assumed that the coal seams developing in this coal field would be deposited during a short period in a local basin, such as swamp or lagoon formed beside the mountain range which had been made during the middle to late Neogene age when the Talamanca mountain range was formed, under frequent marine transgressions.

2. EVALUATION OF THE COALFIELD

The geological survey indicates low potential coalfield as a whole except the Carbon Volio Area which bears three coal seams of V-1, V-7, and V-9, and the Carbón Uno Area which bears two coal seams: U-3 and U-6 each with seam around 1 m thick, showing some prospect of mining on a small scale.

The investigation and exploration of the remaining area is not considered worthwhile due to poor occurrence of coal seams, and if there is any good occurrence, the geological structures have fractures caused by block faulting.

The property of the five coal seams mentioned above show around 12% moisture content, 10 – 25% ash content, and 4,500 – 5,500 kcal/kg (as received base) calorific value, and be used as steam coal.

In this report, the theoretically minable coal reserves, were computed with each reserve calculation area classified into proved, probable, and possible reserve, by employing the Japan Industrial Standard (JIS). In general, the minable coal reserve, which is directly related to the actual evaluation of the objective mining area at that time, was calculated by multiplying both safety and extraction factors to the proved reserves among the theoretically minable coal reserves. This time however, the computation of minable coal reserves was intentionally postponed because the sedimental condition caused an unstable coal seam development, also difficulty was considered in determining extraction rate in the virgin field. As a result, the proved, probable, and possible reserves are estimated at 2 million t, 1.3 million t, and 3 million t, respectively, as shown in Table II. The safety and extraction factors stipulated in the JIS are summarized in Appendix B.

Table II-1 Summary of Coal Reserves on Five Coal Seams

(1,000 m.t.)

Area	Coal seam		Proved reserves	Probable reserves	Possible reserves	Total
Carbon Volio	V-1	Eastern block	355	393	857	1,605
		Western block	30	98	636	764
		Total	385	491	1,493	2,369
	V-7	Eastern block	120	119	-	239
		Western block	102	173	-	275
		Total	222	292	-	514
	V-9	Eastern block	612	-	-	612
		Western block	609	-	-	609
		Total	1,221	-	-	1,221
	Subtotal		1,829	783	1,493	4,104
Carbon Uno	U-3		133	328	1,122	1,583
	U-6		53	171	354	577
	Subtotal		186	499	1,476	2,160
Grand total			2,015	1,282	2,969	6,264

3. SUMMARY

This project is the first systematic geological survey of the virgin coalfield, Baja Talamanca in the Province of Limón, which covers an area of about 140 Km^2. The geological condition of coal seams was clarified and a preliminary assessment of the coalfield was made. The first phase of the field geological survey was conducted in 1981 and the second phase was conducted in 1982. As a result, stratigraphy of a wide variety was established and complicated geological structures were elucidated successfully.

For second purpose of the project, techniques were transferred satisfactorily.

3-1 Evaluation of the Coalfield

The geological condition of the coalfield as a whole is summarized as follows:

1) The coal-bearing strata of the Neogene (Tertiary) Gatún Formation were deposited under an unstable environment. In the littoral basin of fresh to brackish water, the marine water level oscillated remarkably with repeated transgression and regression during sedimentary period of coal-bearing member. Because of this unstable environment, generally, coal seams would not be expected to develop stably. Although there are places where numerous coal seams occur, the seams are mostly very poor in thickness.

2) Due to the sedimentary environment mentioned above, geological phenomena such as thinning-out, pinching-out, splitting, and wash-out are commonly observed in this coalfield. Coal seams and rock facies vary remarkably in lateral direction. For example, coal seams change into calcareous rocks laterally in the conspicuous interfingering phenomena in an extreme case.

   During the first phase of the field survey, the team found it extremely difficult to correlate formations as well as to elucidate geological structures from the remarkable change in rock facies and scarcity of regional key beds.

3) These Neogene formations were extensively dislocated by crustal movement (orogenic movement) such as numerous faultings and foldings. As a result, geological structure became extremely complicated, so that the stable structures divided into very small units.

4) In spite of the above-mentioned geological conditions, the team has successfully selected few geologically stable areas with coal seams as prospective mining areas. The remaining area was considered to be of no value as a coalfield. Accordingly, in future, only those areas regarded as prospective would be adequate for investigation in detail.

Although small in scale, real minability would be clarified.

The prospective areas are the following five blocks:

Carbón Volio Area	V-1	Coal Seam-bearing block
	V-7	Coal Seam-bearing block
	V-9	Coal Seam-bearing block
Carbón Uno Area	U-3	Coal Seam-bearing block
	U-6	Coal Seam-bearing block

(Note) In addition to the five blocks mentioned above, is a Sand Box Area which is slightly less prospective. Sand Box Area is structurally stable and is expected to be highly minable in view of its location between Carbón Uno Area and Carbón Volio Area. However, all the coal seams interbeded in the sequences of predominant sandstone are extremely tnin and it is difficult at this stage to count them as minable.

5) All the five areas above chosen as prospective, however, are isolated from one another. For mining economy, unfortunately there is no case of exploiting multiple coal seams at one location. Their theoretical coal reserves are not big enough both in terms of proved reserves and probable reserves except Seam V-9 because each unit of the seams' the stable structures is relatively small and their thickness is remarkably thin. Seam V-9 is observed to be 1.70 m thick in the field and having good quality with scarcely any partings. However, structurally it is divided into two small blocklets, one area dips gently near the anticlinal axis and another area dips steeply at the southwestern flank of the anticline.

Actually recoverable coal reserves for each block would be roughly less than half of the theoretical reserves, furthermore, each block probably has a recoverable reserve of a few 100 thousands to 10 thousands tons.

6) As these coals seams are mostly distributed below the drainage level (below the main portal level), the underground mining method below the drainage level must be adopted to exploit these coals. There are some coal seams which can be mined by open-cut mining, but the amount is negligibly small. Therefore, mining cost would be higher in a coalfield with underground mining than with open-cut mining because various extra investments must be used taken for drainage, ventilation, hoisting-up, underground haulage, mine safety, and against possible spontaneous combustion.

7) Coal from this coalfield belongs to non-coking, steam coal, and is classified into sub-bituminous coal under A.S.T.M. although the coal belongs to Brown Coal under JIS.

Also there might be large number of qualities if the coal is produced without preparation. Judging from higher sulphur contents of 3 – 4%, some coals, such as Seams V-1, V-7, and U-6, were deposited under littoral environment affected by sea water. Whereas, coals from Seam V-9 that appeared to be deposited in a stable environment of fresh water show relatively low sulphur content. To burn these coals with high sulphur content for bulk use, particular measures, such as blending before use of processing desulphrization for environmental protection, should be taken. On the whole, these coals are good enough for local use as steam coal.

3-2 Recommendation

There are isolated five blocks in this coal field, of which the viability of coal development on a small scale has been discussed in the preceding paragraph. It has also been found that the total amount of coal reserves of whole blocks is not much. Therefore, careful planning for further exploration and exploitation has to be made by referring to the following geological and technical recommendations in order to justify the further works and also to save unnecessary expense.

1) For the further feasibility study on the above-mentioned five blocks, a detailed geological surface survey, such as trenching and tracing of coal outcrops, which would be done by transferred geological survey techniques, have to be carried out by own fund to grasp the exact occurrence of coal seams and coal quality at first before further exploratory works.

   If the result is positive, a few numbers of exploratory drilling for the dip side area has to be followed by considering the economy in order to confirm the extent of coal seams to the dip side.

   While conducting these detailed geological surveys, the economical review by reflecting the following restrictions in mining has to be taken into account every time. Thus, all works would be programmed in a minimum scale under the minimum budget.

2) Since large scale development is out of consideration in this coal field due to the above-mentioned reasons, only an underground mining on a small scale may be made with small investment. Mining of coal seams less than 1.0 m in thickness on a gentle dip would be extremely difficult technically and economically. It would be recommended to adopt a small scale and labour intensive mining method in combination with a partly mechanized haulage system rather than a highly mechanized mining method for the large mine. In other words, the development has to be carried out by driving incline shafts and levels along the coal seams as much as possible in order to minimize the

development cost.

3) At present, coal mining engineers are not available in Costa Rica. Therefore, in order to implement a mining project even in small scale, it would be required to invite coal mining engineers from the advanced countries in coal mining industry, who are capable of designing and construction as well as being well-acquainted with mine safety, and to employ some skilled underground coal mining labourers (foremen or operators). At the same time, it is desirable to establish a training institution for coal mine labourers near the mine site proposed.

The most important point for the feasibility study in developing these small scale reserves would be (a) to minimize the production cost as much as possible, (b) to find out the exact and appropriate demands in order to maintain an appropriate balance between supply and demand.

For coal development in Costa Rica, it is recommendable to use its own effort in finding the true status of the country's coal and lignite resourdes in order to establish the country's policy on energy. Also, the continued geological survey in other coal fields may encourage further application of survey techniques and methods, that were transferred by JICA's mission, and provide additional training to coal geologists in Costa Rica.

Reference 1

"Small-scale Mining"

At this stage, it is too early to assume the mining plan for this coal deposit because exploration was limited to the surface geolgoical survey and no drilling had been conducted during this survey period.

The reserves are comparatively small and each coal seam is about 1.0 m or less except for Seam V-9 which is 1.7 m thick. Furthermore, each objective block closed up to be the objective for development in this survey is scattered.

The biggest deposit, Seam V-9, has theoretical reserves of approximately 1.2 million m.t. However, as this deposit is located in the structually disturbed area between two big faults, it is very difficult to expect its stable distribution within the delineated area in the report. Therefore, under conservative estimation, a kind of room and pillar mining method mainly consisting of driving entries along the coal seam might be allowed.

If two portals are opened in Seam V-9 reserve calculation area, a total of 6 to 8 driving faces would be operated in the most optimistic case.

Under the following assumptions, the estimated coal production from one drivage tunnel will be calculated by the following formula:

Assumptions:

a) The specification of drivage along the coal seam is 6′ x 6′ for 1.7 m thick mining height and the roof is to be supported by wooden props and bars.

b) The advance rate of driving face is estimated at 2 m/day on a raw coal basis.

c) Coal density of raw coal is 1.5.

Formula:

$$3.35\ m^2 (6' \times 6') \times 2m/day \times 1.5 = 10\ m.t./day/face$$

Therefore, estimated total coal production from these two portals is 60 to 80 m.t./day or 18,000 to 24,000 m.t./year on a 300 working day basis.

The estimated minable reserves of Seam V-9 block where about 1.2 million m.t. of theoretical coal reserves were computed is about 400,000 m.t. assuming both 55% extraction rate by room and pillar mining method and 60% geological safety factor by considering safety pillar of surface outcrop and unpredictable faults.

Therefore, mining life of this block under the above-mentioned mining method is assumed to be about 22 to 17 years. However, this is a rough estimation made under the most optimistic assumptions. Before the feasibility study, at least certain numbers should be drilled to obtain the exact seam contour and isopach of Seam V-9 for designing a master mining plan.

For mining coal seam about 1 m thick, the estimated coal production at one driving face is to be modified to:

$$1.52\ m^2\,(4' \times 5') \times 2\ m/day \times 1.5 = 5\ m.t./day$$

Therefore production rate from one portal would become roughly about half of that of Seam V-9.

In the case where two areas such as Seam V-9 and V-1 of the Carbón Volio area are developed simultaneously, the theoretical total production rate would be increased about 27,000 to 36,000 m.t./year. (90 to 120 m.t./day)

This is the so-called "Small-scale Mining" in Japan by considering minimum initial investment and economical operation.

Reference 2

Briefing of Coal Industry Statistics in Japan and World.

Representative statistics of the Japanese coal industry and the world coal resources and production are shown in Tables II-2,3,4, and 6.

Table II-2. Demand and Supply of Coal in Japan, 1981

('000 Metric Tons)

	Domestic Coal				Imported Coal				Total			
	Cok' Coal	Steam'Coal	Anthracite	Total	Cok' Coal	Steam'Coal	Anthracite	Total	Cok' Coal	Steam'Coal	Anthracite	Total
Steel Industry	3,275	-	-	3,275	61,128	-	56	61,184	64,403	-	56	64,459
Gas Industry	623	-	-	623	700	-	39	739	1,323	-	39	1,362
Cokes Industry	1,188	-	-	1,188	3,655	3	4	3,662	4,843	3	4	4,850
Electric Power	-	9,286	-	9,286	-	3,574	-	3,574	-	12,860	-	12,860
Paper Industry	-	326	-	326	-	136	-	136	-	462	-	462
Chemical Ind.	-	16	-	16	-	334	76	410	-	350	76	426
Cement Ind.	3	2,489	-	2,492	-	8,125	161	8,286	3	10,614	161	10,778
Others	60	1,954	34	2,048	213	197	363	773	273	2,151	397	2,821
Total	5,149	14,071	34	19,254	65,696	12,369	699	78,764	70,845	26,440	733	98,018

Remarks: Paper Industry includes Pulp industry.

Table II-3. Coal Production from Coal Mines in Japan, 1981

(Metric Tons)

Coal Mine	Coking Coal	Steaming Coal	Total	Number of Workers
Sunagawa	51,917	874,718	926,635	1,016
Ashibetsu	464,547	430,819	895,366	1,247
Miike	2,083,187	2,804,386	4,887,573	3,901
Minami-Oyubari	890,174	100,826	991,000	1,441
Takashima	562,204	140,296	702,500	1,037
Yubari-Shinko	454,883	233,272	688,155	1,552
Mayachi	407,169	150,031	557,200	772
Horonai	-	1,205,614	1,205,614	1,334
Akabira	377,080	745,075	1,122,155	1,370
Nakago	-	52,926	52,926	19
Taiheiyo	-	2,452,330	2,452,330	2,130
Ikeshima	585,612	834,054	1,419,666	1,447
Higashi-Takiguchi	-	3,520	3,520	-
Sanbi	-	43,521	43,521	2
Sorachi	116,609	898,565	1,015,174	711
Others	-	508,916	508,916	148
Total	5,993,382	11,478,869	17,472,251	18,127

Table II-4. Statistics of Imported Coal in Japan, 1981

(Metric Tons)

Country	Coking Coal	Steaming Coal	Anthracite	Total
North Korea	-	-	114,906	114,906
China	1,271,450	1,304,983	362,310	2,938,743
Vietnam	-	-	172,218	172,218
Philippines	-	-	1,568	1,568
Indonesia	53,785	4,850	-	58,635
Poland	64,940	-	-	64,940
U.S.S.R.	954,840	270,906	21,810	1,247,556
Canada	9,275,541	1,108,092	-	10,383,633
U.S.A.	23,666,535	2,330,317	10,971	26,007,823
South Africa	3,139,582	1,852,980	49,711	5,042,273
Australia	27,293,267	5,398,527	19,821	32,711,615
New Zealand	177,390	-	-	177,390
Total	65,897,330	12,270,655	753,315	78,921,300

Table II-5. Fuel Consumption of 9 Electric Power Companies in Japan, 1981

Items		1979	1980	1981
Coal	(1,000 tons)	4,430	5,008	5,507
Heavy Oil	(1,000 Kl)	28,529	26,529	26,372
Crude Oil	(1,000 Kl)	18,526	13,432	14,332
Light Oil	(1,000 Kl)	89	106	113
Naphtha	(1,000 Kl)	2,330	1,376	986
NGL	(1,000 Kl)	2,916	2,984	2,420
LPG	(1,000 tons)	570	736	808
LNG	(1,000 tons)	11,005	12,320	12,526
Gas	(10^6 N m^3)	1,265	1,378	1,314
Mean Calorific Value (Kcal/kg)	Coal	4,983	5,182	5,420
	Heavy Oil	9,720	9,728	9,740
	Crude Oil	9,267	9,282	9,320

Table II-6. World Coal Resources and Production

(1,000,000 m.t.)

Country	Year of reference	Economically recoverable hard coal	Economically recoverable lower ranks	Measured reserves, all ranks	Total resources, all ranks	Percent of world resources	1981 production Hard coal	1981 production Lower ranks
Soviet Union	1979	104 000	129 000	276,000	5,926,000	43 5	544 2[e]	159 8
North & Central America								
United States	1974	107,183	116,076	397,657	3,599 657	26 4	682 6	45 7
Canada	1976	1,607	4,299	16 091	474,412	3.5	33 3	6 8
Mexico	1979	1,200	384	1,980	3,280	<0 1	7 6	—
Total North & Central America		109 990	120,759	415,728	4,077,349	30 0	723 5	52 5
South America								
Brazil	1978	189	924	1,590	15 807	0.1	5 3[1]	—
Chile	1979	26 5	1,150	1,381	4,426	<0 1	0 8	—
Colombia	1979	1,010	25	2,073	10 063	<0 1	5 5[1,2]	—
Venezuela	1979	134	6 3	178	9,178	<0 1	—	—
Other		—	150	309	10 748	<0 1	—	—
Total South America		1,359 5	2,255 3	5,531	50,222	0 4	11 6	—
Africa								
Botswana	1977	3,500	—	7,000	107,000	0.8	0 4	—
South Africa	1975	25 290	—	58,749	92,511	0 7	130 3	—
Morocco	1979	50	—	100	140	<0 1	0 8	—
Mozambique	1976	240	—	240	425	<0.1	0 6	—
Swaziland	1961	1,820	—	2,020	5 020	<0 1	0 2	—
Zaire	1978	600	—	600	N/A	N/A	—	—
Zambia	1979	24	—	32	130	<0 1	1 3	—
Zimbabwe	1977	734	965	2,500	8,310	<0 1	2.0	—
Other		496	417	1,400	4,361	<0 1	0 2	—
Total Africa		32 754	1,382	72,641	217,897	1 6	135 8	—
Asia								
China	1979	99 000	—	600 000[1]	1,465 000	10 8	596 6[1]	23 4
India	1978	12 610	1,588	22,634	114,034	0 8	125 0	5 8
Indonesia	1979	10 9	528 4	674	20 117 6	0 15	—	—
Bangladesh	1978	242	—	1,053	N/A	N/A	—	—
Japan	1979	1 050	18	8 707	8,707	<0 1	17.5	—
North Korea	1976	300	300	2,300	7,200	<0 1	35 0[e]	13 1
Pakistan	1972	—	645	646	646	<0 1	1 1	—
South Korea	1978	116.3	—	182	1,231	<0 1	20 0	—
Thailand	1978	—	246	246	N/A	N/A	—	1 5
Turkey	1978	186 2	1,728 1	4 209	5 412.7	<0 1	4 2[1]	16 5
Other		411.3	222	25,093 5	25 570 5	0 2	10 6	3 8[e]
Total Asia		113 926 7	5,275 5	665,744 5	1 648 918 8	12.1	810 0	64 1
Europe								
West Germany	1979	23 991	35 150	99 000	285 300	2 1	95 6	130 0
Poland	1978	27 000	12 000	76 000	184 000	1 4	163 0	35 6
Yugoslavia	1971	70	16,500	177 680	181 477	1 3	0 5	51 1
United Kingdom	1977	45 000	—	45 000	149 500	1 1	125.3	—
East Germany	1978	N/A	25 000	N/A	30 000	0 2	—	267 0
Czechoslovakia	N/A	2,700	2 860	12,950	20 090	0 15	27.3	95 3
Austria	1978	—	65 4	132 5	201 5	<0 1	—	3 1
Belgium	1978	440	—	670	3 287	<0 1	6 1	—
Bulgaria	1979	30	3 700	4,454	6 354	<0 1	6 5	31 5
France	1977	550	60	1,473	1 708	<0 1	20 3	2 9
Greece	1976	—	1,550	3,600	4 750	<0 1	—	25 2
Hungary	1966	225	4,000	4 850	9 400	<0 1	3 2	25 3
Ireland	1979	55	—	55	95	<0 1	0 1	—
Italy	1979	—	31	33	55	<0 1	—	2 0
Spain	1979	398	553	1 082	4,595	<0 1	14 8	20 9
Other		73 3	16 534	18 151 6	24 020 6	0 2	8 9	30 2
Total Europe		100 532 3	118 003 4	445 131 1	904 833 1	6 6	471 1	719 1
Oceania								
Australia	1979	25 400	33 940	82,900	779 900	5.7	92 2	32 9
New Zealand	1979	35	176	211	4 179	<0 1	2 0	0 2
Total Oceania		25 435	34,116	83 111	784,079	5 8	94 2	33 1
Total World		487,917.5	410,731.2	1,963,886 6	13,609,298	100	2,790.4	1,028 6

e estimate
1 Adjusted to marketable coal equivalent
2 Gross production

(by WORLD COAL Vol.8,No.6)

III. GENERAL GEOLOGY OF COSTA RICA

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GENERAL CONDITION

Central America is a zonal isthmus connecting the continents of North America and South America. It is characterized by the central backbone mountain range running NW-SE along the central line of the zone, which forms a part of the circum-Pacific orogenic belt.

The central backbone mountain range comprises the northern line and the southern line. The northern Cordillera continues from Sierra Madre in southern Mexico eastwardly to Guatemala, Honduras, and to northern Nicaragua out to the Caribbean Sea. The southern Cordillera runs NW-SW along the southern coast of Lake of Nicaragua through Costa Rica and Panama with repeated ups and downs, and going through Colombia, it connects with the Andes Mountains.

Costa Rica constitutes a main part of the Southern Central American Orogenic Belt, known as a geologic unit. This orogenic belt extends from southern Nicaragua to northwestern Panama through Costa Rica. In Costa Rica, this orogenic belt is divided into three tectonic zones in terms of tectonic history and igneous activities. They are (1) outer arch; (2) inner arch; and (3) Limón Basin.

The outer arch is situated along the Pacific coast, connecting the peninsulas Santa Elena, Nicoya, Osa, and Burica. The inner arch consists of Cordillera Talamanca, Cordillera Central, and Cordillera Guanacaste. The Limón Basin covers the Atlantic coastal plain and northern Costa Rica.

2. GEOLOGICAL HISTORY

The orogenic movement in Costa Rica can be divided into three tectonic phases in close association with igneous activities: (1) Pre-Tectonic Phase; (2) Orogenic Phase; and (3) Post-Tectonic Phase.

2-1 Pre-Tectonic Phase

This phase is marked by the geologic process in which the Nicoyan Complex was formed. The geophysical data from the Caribbean coastal area show no evidence of true continental crust. It is assumed that when the Nicoyan Complex was formed, there was no continental mass exposed in this area and that the closest land was Nuclear Central America to the north. At first an arc of volcanic islands presumably existed along the axis of the Outer Arch. These volcanic islands with lavas were one of the important supply source of sediments in the complex. Graywacke and conglomerate were also deposited and an environment suitable for deposition of chert and aphanite limestone was formed. Sedimentation and volcanism that occurred concurrently formed the base of a sedimentary basin where the Cretaceous geosynclinal sediments were to be deposited later.

The igneous rocks which erupted during the Pre-Tectonic Phase, belong to the ophiolite group, characterized by spilitic basalt, diabase, and gabbro. During the initial stage of the Nicoyan Complex, foldıng the Santa Elena peridotite was created along a big fracture, ımmediately followed by gabbro and diabase, and then, a vast extrusion of lava-flow, basalt, and agglomerate continued. Due to scarcity of data, the exact age of the Nicayan Complex cannot be determined, but is assumed to be before the Senonian (the late Cretaceous).

2-2 Orogenic Phase

The principal orogeny began in late Cretaceous, and Inner Arches. The initial stage is represented by basaltic volcanism which took place in the Eocene concurrently with marine sedimentation. In view of the fact that the volcanic rocks are accompanied with the Eocene sedıments in the Limón Basin as well as in the Cordillera, the center of the Eocene volcanism presumably existed along the present axis of the Cordillera Talamanca. Contemporaneously with the initial folding and volcanism of the Cordillera, the Limón Basin was formed to the northeast and the Terraba Basin to the southeast. These two basins were probably linked at least up to the late Oligocene.

The initial Tertiary volcanism was largely andesitic in the Limón Basin and basaltic in the Inner Arch. In the Terraba Basin the only igneous activity was the mafic hypabbysal intrusives. The initial orogeny continued to the intermittent folding of the Cordillera Talamanca and to separation of the Limón Basin and the Terraba Basin. In these basins, marine sedimentation lasted throughout the Oligocene and the Miocene. While the Terraba Basin was very stable, the Limón Basin was subjected to folding and subsidence, resulting in accumulation of very thick sediments. This orogenic phase reached a climax at the beginning of the Miocene with intense folding and activities of plutonic granodiorite, elevating the Cordillera Talamanca. The final stage of this orogenic phase is represented by basaltic and intermediate volcanism that occurred during the late Miocene and the Pliocene Periods. The Aguacate Formation is the product of this stage.

2-3 Post-Orogenic Phase

This phase is characterized by the general elevation of the Inner Arch, with continuing deposition in the basins of Limón and Terraba. The deposition took place once again during this phase with more intensity, resulting in Suretka Formation which is composed of very thick layer of very coarse conglomerate with boulder to cobble sizes. The volcanic activities of the post-Orogenic Phase in the Inner Arch is represented by the volcanic Cordillera Central, the volcanic Cordillera Guanacaste and the Chirigui volcano. This relatively gentle volcanism is chiefly represented by calcalkaline or Pacific type rocks, or in other words by combination of basalt–andesite–rhyolite–quartz–latite.

3. GEOLOGY AND GEOLOGICAL STRUCTURE

Based upon the orogenic history mentioned above, let us review the geology and the geological structure of Costa Rica.

The geological structure of northern Central America may be considered a part of the North American Continent because it can be well correlated with that of Mexico. On the other hand, southern Central America correlates with the northwestern part of the South American Continent. Costa Rica is located roughly at the center of southern Central America.

Of the southern Cordillera in Central America, the volcanic cordillera along the Pacific coast continuing from the northwest comprises the Quarternary volcanoes with the strikes controlled by a huge fault structure called the Nicaraguan Graben running from E1 Salvador to central Costa Rica. The area north of San José except the peninsulas is thus extensively covered with the Quarternary volcanic rocks.

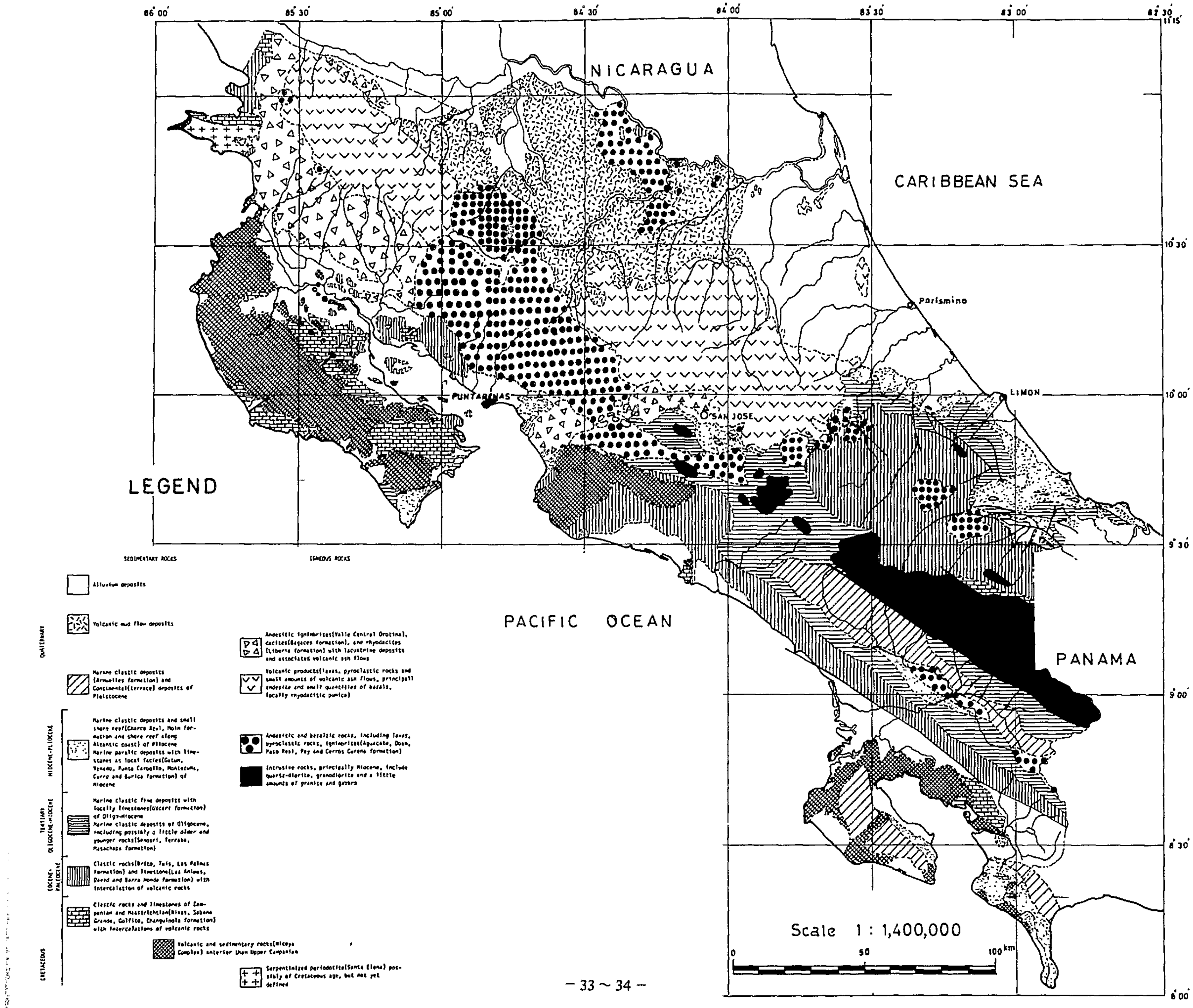
Parallel to the above, a summit line that connects the high mountains of the Talamanca class (3,000 m asl) is running southeast from central Costa Rica. These mountains are mainly composed of the Eocene and Oligocene Series of the Palaoegene System with the Miocene intrusion of granodioritic igneous rock forming the backbone of these mountains. Mt. Chirripó (3,819 m asl) in this mountain range is the highest non-volcanic mountain in Central America.

In terms of the three zones mentioned before (5-1), the Outer Arch is composed of the Cretaceous or older igneous rocks and metamorphic rocks, forming the basement of southern Central America, which is called the Nicoyan Complex and which is accompanied by intrusion of basic igneous rocks in the late Cretaceous.

From the late Cretaceous to the Tertiary, orogenic movement and igneous activities occurred extensively on the whole. Cordillera Talamanca of the Inner Arch attained its remakable elevation as the results of the early Neogene intense folding and granodioritic activity.

Later in the Quarternary period, volcanic activity was vigorous as represented by Cordillera Central and Cordillera Quanacaste, and in Limón Basin a very thick pile of conglomerate accumulated.

Figure III Geological Map of Costa Rica



IV. GENERAL OUTLOOK OF BAJA TALAMANCA COAL FIELD

IV. GENERAL OUTLOOK OF BAJA TALAMANCA COAL FIELD

1. LOCATION AND AREA

Baja Talamanca Coal Field under investigation lies in the Limón Basin covered with thick Tertiary sediments including the coal-bearing Gatún Formation. The Limón Basin extends from around 50 km north of Limón City which is the capital of Limon Province, to Boca del Toro, Panama for 160 km having a width of 30–60 km in zonal distribution along the Caribbean Sea coast.

The survey area covers 140 km^2 demarcated in trapezium near 9°40′ N and 82°50′ W on the border between Costa Rica and Panama, and is adjacent to Cahuite Town, a tourist resort with a population of about 2,000 and to Bribri Town which is famous for Indian Reservation.

2. CLIMATE AND TOPOGRAPHY

The survey area facing the Caribbean Sea has high temperature and high humidity. Its precipitation is 3,000–5,000 mm a year and its average temperature is 20–30°C throughout the year under the influence of the tropical trade wind from the northeast. There are rainy seasons from May to November called winter, and a dry seasons from December to April called summer by the local people.

The high precipitation raises the ground water level and accelerates the growth of vegetation, thus forming a swamp with tropical plant in the low land along the coast and a jungle on the relatively high land. In this area, small scale plantations of banana, cacao, and sugar cane are observed.

The survey area is 200–500 m above sea level bound on the north by Rio Estrella drainage system and on the south by Rio Sixaola drainage system. This area is regarded as the marginal hill of Cordillera Talamanca, which is the backbone of Costa Rica.

These drainage systems are controlled by major geological structures. Meandering main rivers, form subsequent valleys with strikes corresponding to formations or faults, and their branch creeks that cross these main drainage systems, are observed at Hone Creek, Rio Boucuares, Rio Carbón, Rio Sand Box, Quebrada Carbón, and other creeks.

In this area, the mountains, Fila Carbón and Sand Box, have simple geological structures. The geological structures along the marginal area of synclines are steep hills consisting of hard sandstone. The inland area does not show clear and continuous structural ups and downs because there are complicated structure that cut into many blocks. The hills in general have structural highs that are predominantly composed of hard sandstone, which formed steep hills by resisting erosion.

3. CONDITION OF ACCESS

To reach the survey area, it takes about 30 minutes by air from the metropolis San José to Limón, the capital of the Province; four hours by car, or six hours by train. From Limón to our survey base Cahuita, it takes an hour by car.

The road is completely paved from San José to Limón, and paved 70% from Limón to Cahuita. From Cahuita, there is an unpared road going into the survey area with regular bus services running four times a day from Limón to Cahuita, Bribri, and to Sixaola. The eastern marginal survey area could be reached by this road, except during the rainy flood season when the road is cut off; the road itself is located in the low land area and the rivers are not well controlled. Within the survey area, houses are scattered in hamlets along the creeks and there are passes for men and horses. Cars cannot pass beyond the entrances to the main rivers. During the rainy season, even these roads became muddy and that made it extremely difficult to survey the field.

V. TOPOGRAPHIC MAP MAKING FOR BAJA TALAMANCA COAL FIELD

V. TOPOGRAPHIC MAP MAKING FOR BAJA TALAMANCA COAL FIELD

1. PRELIMINARY STUDIES

Before starting the execution of the survey, discussion for survey and mapping activities in Costa Rica, plan of operation and survey schedule for topographic map making for this project etc. was held between JICA topographic survey team and IGN (Instituto Geografico National) of Costa Rica.

IGN has the same function as the Geographical Survey Institute of Japan. They execute ground surveys, photogrammetric surveys, remote sensing surveys and sell and printing topographic maps, aerial photos and satellite images.

1-1 Coordination System in Costa Rica

Costa Rica uses the Lambert conical projection and to make the scale error less, the 1: 10,000 plane rectangular coordinate system is used and divided into two areas at 10° north latitude line: Costa Rica Norte and Costa Rica Sud.

Parameter of coordinate system in Costa Rica is as follows:

Earth ellipsoid: Clark 1866

a: 6,378,206.4 m

b: 6,356,583.8 m

e^2: 0.006768658 m

Standard datum of geographical coordinates:

	Latitude	Longitude
Costa Rica Norte	84° 20′	10° 28′
Costa Rica Sud.	83 40	9 00

Scale factor at standard datum of geographical coordinates: 0.99995696

FE	500,000.000 m
FN	271,820.522 m

1-2 Survey Equipment of IGN

IGN has enough photogrammetric survey equipment to produce small scale and large scale topographic maps.

Main equipment for IGN photogrammetric surveys is as follows:

(1) Aerial camera

(2) Automatic photo processor

(3) Rectifier

(4) Copying press machine

(5) Pricking device

(6) Plotting instrument

first class plotting instrument C-8 2 sets

second class plotting instrument A-8 1 set

1-3 Existing Topographic Maps in Costa Rica

There are three scales: 1:50,000, 1:25,000, and 1: 10,000 of national base maps in Costa Rica. 1:50,000 scale national base maps cover all of Costa Rica (total 133 sheets) and this scale of national base map was completed in 1971.

1:25,000 scale national base map making started in 1953 and stopped in 1962. A total of 99 sheets of 1: 25,000 scale national base maps have been published.

1:10,000 scale national base map making started in 1974 and 20 sheets of 1: 10,000 national base maps have been completed up to present and cover the main city.

Also, 1:200,000 and 1:500,000 scale geographic maps have been published in Costa Rica.

1-4 Checking of Existing Survey Data and Other Data

To map the Baja Talamanca area, in a topographic scale of 1:10,000, existing survey data and other data were checked before starting the survey work:

(1) Checking of existing aerial photos and the quality of the aerial photos (to determine if they are usable for machine plotting work)

(2) Checking of existing control points. Location, results and accuracy of triangulation points, traversing points and bench marks in the project area.

(3) Ability of staff of IGN and IGN equipment for aerial triangulation, machine plotting, and tracing works.

The results from the above items were as follows.

(1) Project area was completely covered by 1:30,000 scale existing aerial photos which were taken in 1976 and the qualities such as photo image, overlap, sidelap, tilt, tip, and crab were usable for the 1:10,000 scale topographic map making.

(2) There are five triangulation points at the top of the mountain in the project area (distance between triangulation points is approximately 10 km).

Also there are eight traversing points which were surveyed and established in 1980 – 1981 along the main road.

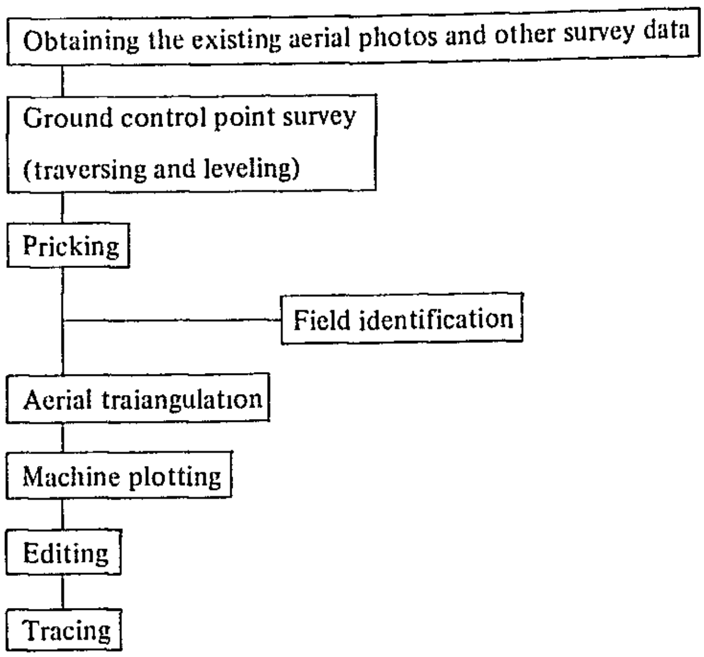
These triangulation points and traversing points have X and Y coordinates and elevation based on Lambert conical projection.

(3) IGN has sufficient capacity and equipment for producing 1:10,000 scale topographic maps by photogrammetry method.

2. EXECUTION OF SURVEY WORK

Based on the preliminary survey and the checking of the existing survey data, undermentioned survey was planned between JICA topographic survey team and IGN and survey work was executed by JICA topographic survey team and the staff of IGN and ICE.

Survey work plan



2-1 Ground Control Point Survey

The project area is covered by a dense jungle. The eastern side of the project area is the Caribbean Sea and the southern side of the project area is the border line between Costa Rica and Panama. Total project area is approximately 140 km^2. There is only one main road around the project area. Along this road, there are 8 traversing points which were surveyed and established in 1980 1981.

Ground control point survey was executed by traversing based on the above traversing points. Elevation of ground control points was observed by indirect leveling using traversing method and elevation was checked by connecting these elevations to the national bench marks in the project area. Ratio of closing error of traversing was approximately 1:30,000. Equipment used for traversing was as follows:

(1) Electro-optical distance meter AGA Geodimeter 14A

(2) Theodolite Wild T-2

2-2 **Pricking**

For the aerial triangulation, pricking for clear points on the aerial photo image (such as corners of the roads and houses) was executed.

Total 14 points were pricked and X and Y coordinates and elevation were observed by traversing.

2-3 **Field Identification**

To obtain the necessary data for the topographic maps (example: names of the villages, rivers, etc.), the IGN staff identified the field.

2-4 **Aerial Triangulation**

Aerial triangulation methods used in IGN of Costa Rica are as follows:

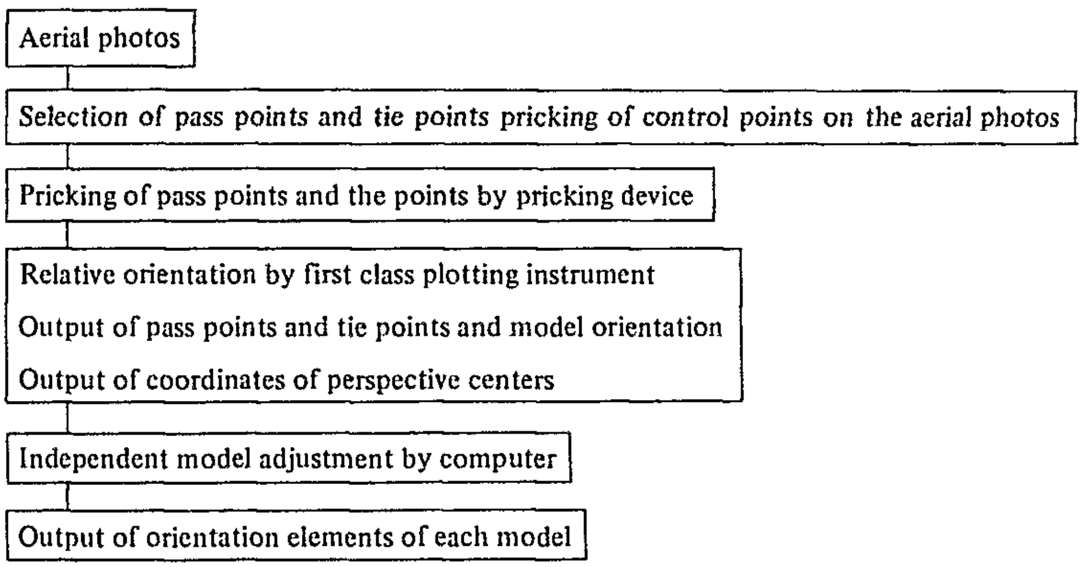
(1) Mechanical orientation.

(2) Independent model adjustment by computer.

Due to a particular distribution of these control points, aerial triangulation for this topographic mapping was executed by method (2).

Input data of each model coordinate was obtained from relative orientation stage by first class plotting instrument C-8.

Flow chart of aerial triangulation work was as follows:



Equipment used for aerial triangulation was as follows:

(1) Plotting equipment First class plotting equipment C-8

(2) Pricking device Sild PUG-4

(3)	Computer	IBM host computer

Data of aerial triangulation was as follows:

(1)	Number of courses	3 courses
(2)	Number of models	21 models
(3)	Photo scale	1:30,000
(4)	Focal length of aerial camera	153.195 mm
(5)	Overlap	60%
(6)	Sidelap	40%
(7)	Flight altitude	4,500 m
(8)	Number of pass points	6 points/model
(9)	Number of tie points	2 points/model
(10)	Control points (horizontal)	23 points
(11)	Control points (vertical)	1:10,000
(12)	Mapping scale	1:10,000

Residual error (mean square error) of control points by aerial triangulation was as follows:

(1)	X and Y	less than 2 m
(2)	Elevation	less than 2.5 m

2-5 Machine plotting

Machine plotting was executed with the cooperation of IGN's staff and IGN's equipment.

Special attention was paid to drawing contour lines because the project area is covered by dense jungle with very complex topographic features.

For these areas covered by clouds, aerial photos of adjacent courses were used to minimize blank areas.

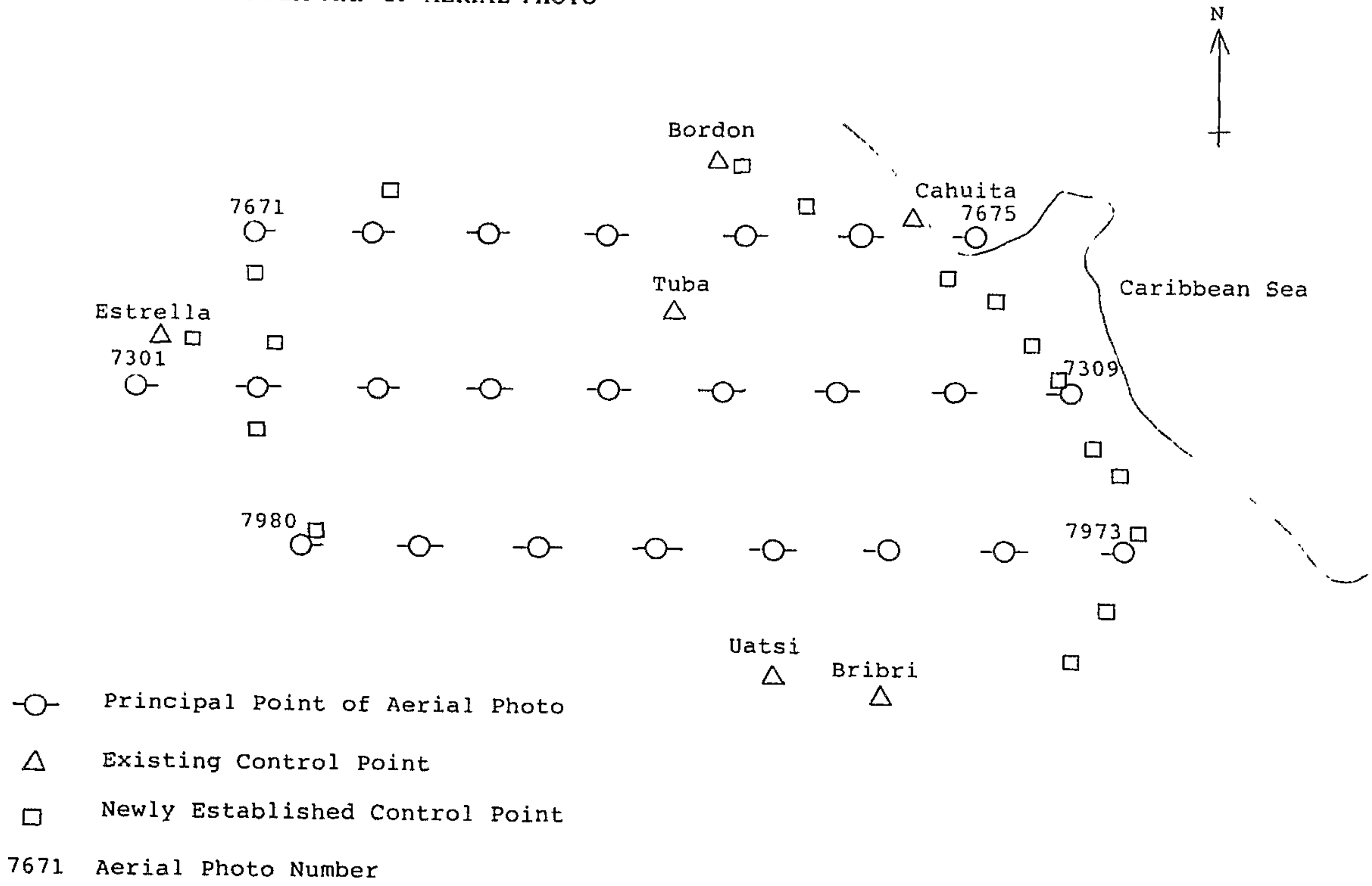
Data for machine plotting is as follows:

(1)	Aerial photography used	photo scale 1:30,000 taken in 1976
(2)	Mapping scale	1:10,000
(3)	Number of sheets	8 sheets
(4)	Mapping area	150 km^2
(5)	Equipment used for plotting	first class plotting equipment: C-8 2 sets second class plotting equipment: A-8 1 set

2-6 Editing and Tracing

Based on the Costa Rica standard, IGN's staff edited and traced to complete the topographic maps.

INDEX MAP OF AERIAL PHOTO



EXECUTION OF SURVEY WORK

1. Ground Control Point Survey

Date:	From 22 June to 30 July 1981
Lodging:	Cahuita and Puer
Survey party:	2 parties (each party consisted of the following)
	No. 1 Mr. Katsumi Wada Mr. R. Garcia (ICE counterpart) 4 survey assistants from ICE
	No. 2 Mr. Kaneharu Nakamura Mr. G. Gonzalez (ICE counterpart) 4 survey assistants from ICE
Vehicle:	Toyota Land Cruiser 2 units

2. Pricking

Date:	From 31 July 1981 to 8 August 1981
Lodging:	Cahuita and Puerto Limon
Survey party:	2 parties (Each party consisted of same persons as ground control point survey.)
Vehicle:	Toyota Land Cruiser 2 units

3. Field Identification

Date:	September 1981
Survey party:	Surveyor's of IGN

4. Aerial Triangulation

Date:	From 10 August to September 1981
Execution:	Aerial triangulation was executed at IGN by Mr. Katsumi Wada and Mr. Kaneharu Nakamura of JICA topographic survey team and IGN staff.

5. Machine Plotting, Editing, and Tracing

Date:	From 28 September to 18 December 1981
Execution:	Machine plotting and editing were executed IGN by Mr. Akira Saito and Mr. Shuuichi Onda of JICA topographic survey team and IGN staff. Tracing was executed by IGN staff.