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GAS DEVELOPMENT IN ETHIOPIA*

Country Paper

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Gas Development in Ethiopia

I. Introduction

Ethiopia is a non petroleum producing country. The only significant hydrocarbon deposit that has been discovered is the Calub natural gas field, located in the Ogaden Sedimentary Basin in the eastern part of Ethiopia/the Calub gas reserve is estimated to be about 68 billion cubic meters. This reserve could serve a large portion of the nation's commercial energy need and replace at least a portion of the firewood and animal waste now intensively used as a house hold energy, thereby ameliorating the catastrophic deforestation process in the country.

In order to asses the possibility of utilizing the gas and condensate, the Ethiopian Government assisted by the World Bank launched a development programme which started with the prefeasibility study in 1985.

The full scale Gas Utilization requires the construction of a 1100 km pipeline from the producing field to the main inland market, the cost of which makes the transportation's cost very high, and pipe line would have to operate at a high load factor to be commercial. One way to improve pipe line economic is to develop a market for the gas prior to the construction of a pipe line, thereby reducing the time required to build up the pipe line deliveries.

Therefore, in order to establish market acceptance a feasibility study of small scale Gas Utilization Project was conducted in 1988, to be followed by an appraisal study by World Bank Experts who recommended a recycling project and the transportation of the liquids to be by trucking. Reserve estimation and Reservoir Simulation Studies followed in 1991.

Now the Project Preparation study is being conducted and the engineeing study is expected to follow as soon as it is completed.

The market studies conducted so far recommend the rentability of utilizing the Calub gas for local market. Export will be considered of additional large gas fields are discovered in the future. The full scale utilization of the Calub gas could be implemented possibly by the year 2000.

The Calub Gas Development Project Preparation study which is not completed yet will look into the institutional questions of the new gas establishment. The paper will look briefly as to how the petroleum sector is presently set up within the Ministry of Mines and Energy.

II. The Sedimentary Basins of Ethiopia

Ethiopia has area of 1,223,000 sq.kms., of which about 35% is covered by sedimentary basins filled with rocks of different ages.

These Sedimentary basins are distributed in five areas having hydrocarbon potential (Annex 1).

Basin No	Names of Basin	Area (sq.km)
1	Ogaden	350.000
2	Red Sea	80,000
3	Gambella	17,000
4	Mekele	6,000
5	Blue Nile	6,000

Of these, the onshore Ogaden and the predominantly offshore Red Sea basins, which constitute the bulk of the sedimentary deposits, are the two most prospective areas for petroleum exploration.

Potential target in the latter are believed to be mainly Tertiary and Quanternary deposits with a possible but as yet unconfirmed upper jurassic sequence underneath; while in the former, they are upper Paleozoic to Mesozoic deposits.

The other known but small sedimentary areas-Gambella, Mekele and Blue Nile-are considered to have less potential and remain relatively unexplored.

III. The Ogaden Basin

The Ogaden basin where the gas was discovered is the southeastern lowlands of Ethiopia constitute this intracratonic, mainly upper Paleozoic-Mesozoic basin which covers about 350,000 sq. kms.

IV. Calub Gas Field Development

In 1973 Tenneco made a major gas/condensate discovery in the Ogaden basin when they drilled the Calub 1 well. The field was subsequently released to the Ministry of Mines and Energy (MME) of Ethiopia. Technoexport and later on Zarubezhgeologia from the Soviet Union (now Russian Republic) operating on a service contract under the supervision of the MME's Oil and Gas Exploration and Development Organization (OGEDO) drilled and completed eight delineation development wells. The ninth well is being drilled in the Calub Gas Field estimated inplace reserves were calculated to be 68 billion cubic meters of gas plus liquids. Recoverable reserves are estimated to be 5.4 billion cubic meters of gas plus approximately 7 million barrels of liquid . Nearby structures allow speculative reserves in the immediate area which could be similar to the proven reserve.

The Calub field is located on a regional high within the Ogaden Basin known as the Calub Saddle. Minimum structures have been mapped on the Calub saddle within 80 kilometers of the Calub Field. The nearby Hilala-1 well tested 5.7 MMCFGD and the adjacent Shilabo and Magan wells also tested gas. At present, drilling of Hilala 4 west of Calub field, is in progress and gas discovery is expected.

There are two productive sandstone formations in the Calub Field which showed also reservoir gas and liquids in nearby structures; the Traissic Adigrat at 2740 meters depth and the Permain Calub at 3600 meters. The Adigrat has been penetrated in most test wells, however the deeper and more prolific Calub sandstone was not reached in many of the structures. It is probable that much more gas and condensate remains to be added to the recoverable reserves of the Calub Saddle.

As outlined earlier in my introduction, about 90% of Ethiopia's energy consumption consists of fuelwood and other biomass fuel for household cooking and other energy uses. Deforestation has already occurred to a considerable extent and has reached crisis proportions. Additionally petroleum product imports, although small in quantity, represent significant use of the country's foreign exchange. Therefore, it is important for the country to embark on gas utilization, in order to create opportunities for the gas to replace the fuelwood, minimize import of petroleum and also serve as raw material for the fertilizer industry.

With this objective, a World Bank funded prefeasibility study for Ethiopian gas utilization was completed in 1985 by GDC, Inc., a subsidiary of the Institute of Gas Technology, Chicago, Illinois. More recent studies have supplemented and updated the GDC, Inc. report. These studies for internal gas utilization have focused on conversion to electric power, industrial, commercial, residential, and vehicular use. Export potential considered includes LNG, LPG, ammonia/urea, methanol, synthetic gasoline and petrochemicals. The estimated cost for a 1000 ton/day ammonia, 2500 ton/day DAP, and 600 ton/day urea plant is U.S. dollars 395 million. A basic gas distribution system for Addis Ababa and Dire Dawa would be U.S. dollars 8.8 million and 1.2 million respectively.

Ideally, the projected daily production rate considered achievable with the present wells, 100 MMCFGD, would be transported to the nearest industrial city, Dire Dawa, via a 16 inch line and from Dire Dawa to the capital, Addis Ababa, through a 14 inch line. Two compressors would be required. The cost of this major project is estimated to be U.S. dollars 395 million.

A minimal development project (gas recycling) would strip liquids and reinject gas resulting in liquids only production.

At the rate of recycling about 1 MMCFGD it is estimated that 6200 tons of LPG, 12700 tons of gas oil and 15,000 tons of gasoline could be extracted annually. The liquids would be trucked. This project was estimated (1989) to require U.S. dollars 30 million but latest estimated is about 60 million.

Before embarking upon the implementation phase of the gas recycling project, MME with the World Bank fund, will soon initiate, through specialized agencies, a reservoir engineering and well simulation study. In addition, relevant project preparation studies such as definition of Institutional set-up and the necessary management structure, determination and recommendation of gas pricing policy and preparation of preliminary design will be conducted within the first half of 1991. This project, being one of the priority projects of the MME, its implementation phase, (construction, erection and commissionary) is assumed to materialise in 2-3 years time.

V. Institutional set-up of the Petroleum Sector of Ethiopia

Presently in Ethiopia, the overall petroleum activities (upstream and downstream) are divided into two main bodies and both function under the Ministry of Mines and Energy (MME). There is the Ethiopian Petroleum Corporation established under the law of the country by Proclamation No. 146 of 1978. Its power and duties stated in the proclamation among other things include:

- construct and operate factories, machinery, tanks and pipelines, for the refinery, distilling, distributing and marketing of petroleum, oil gases and other hydrocarbon substances or mixture thereof;
- import, sell and export crude oil and petroleum, oil, gas and refined petroleum;
- engage, where necessary, in the transportation of petroleum, oil, gas and other hydrocarbon substances or mixtures thereof by appropriate means.

This Corporation is headed by a General Manager, who is responsible to the Vice Minister for Energy of the MME.

The second sector, which deals mainly with petroleum operations, i.e. exploration, evaluation, development and production of oil and gas, in the process of being legally institutionalized under the Vice Minister for Mines of the MME. Presently however, all petroleum operations are handled by project offices, namely the Oil and Gas Project Coordinating Office (OGEPCO) and the Petroleum Exploration Promotion Project (PEPP). Negotiations for petroleum operations with petroleum companies are handled by a committee composed of senior members of the Ministry, and representatives of the project offices.

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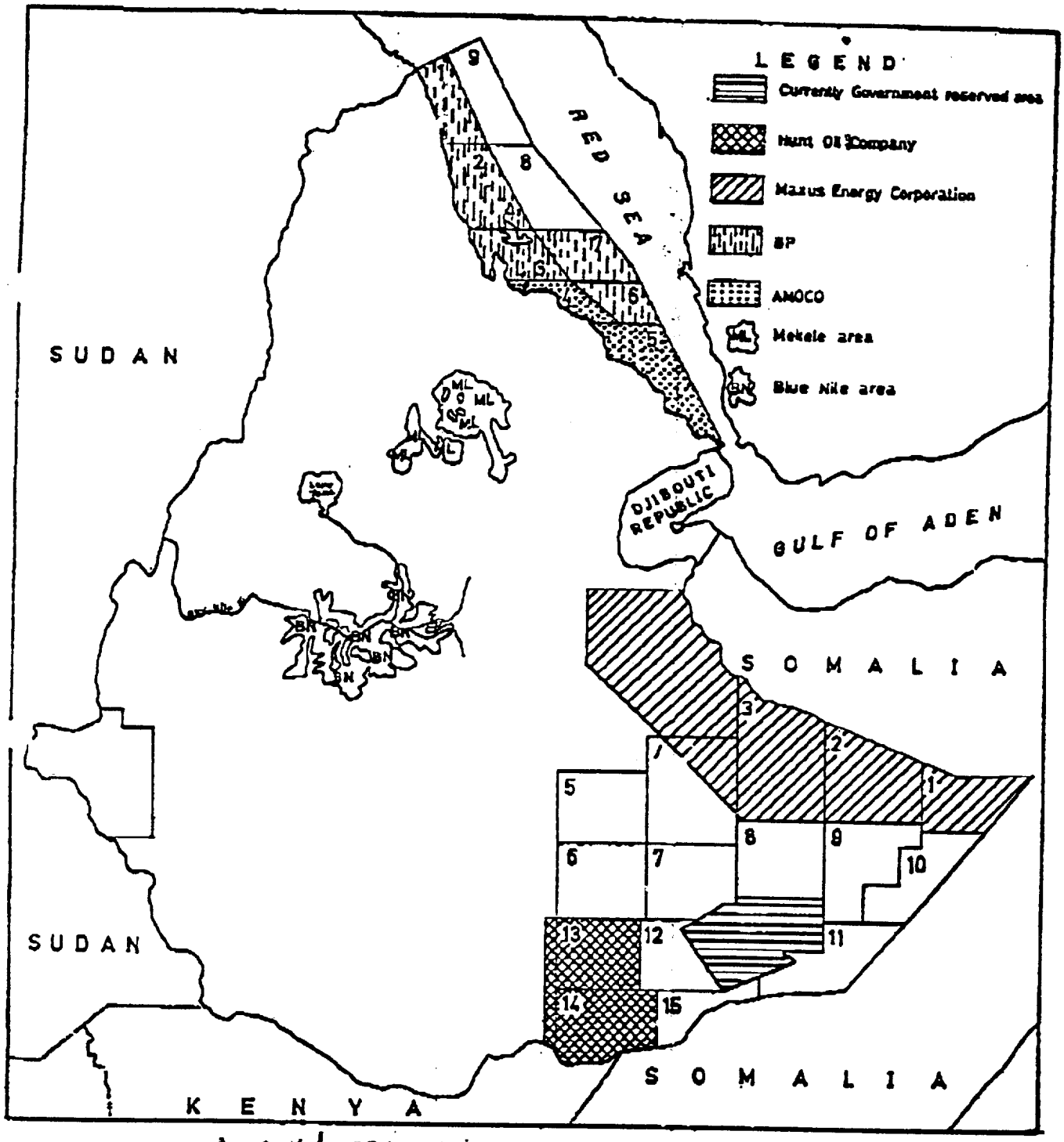
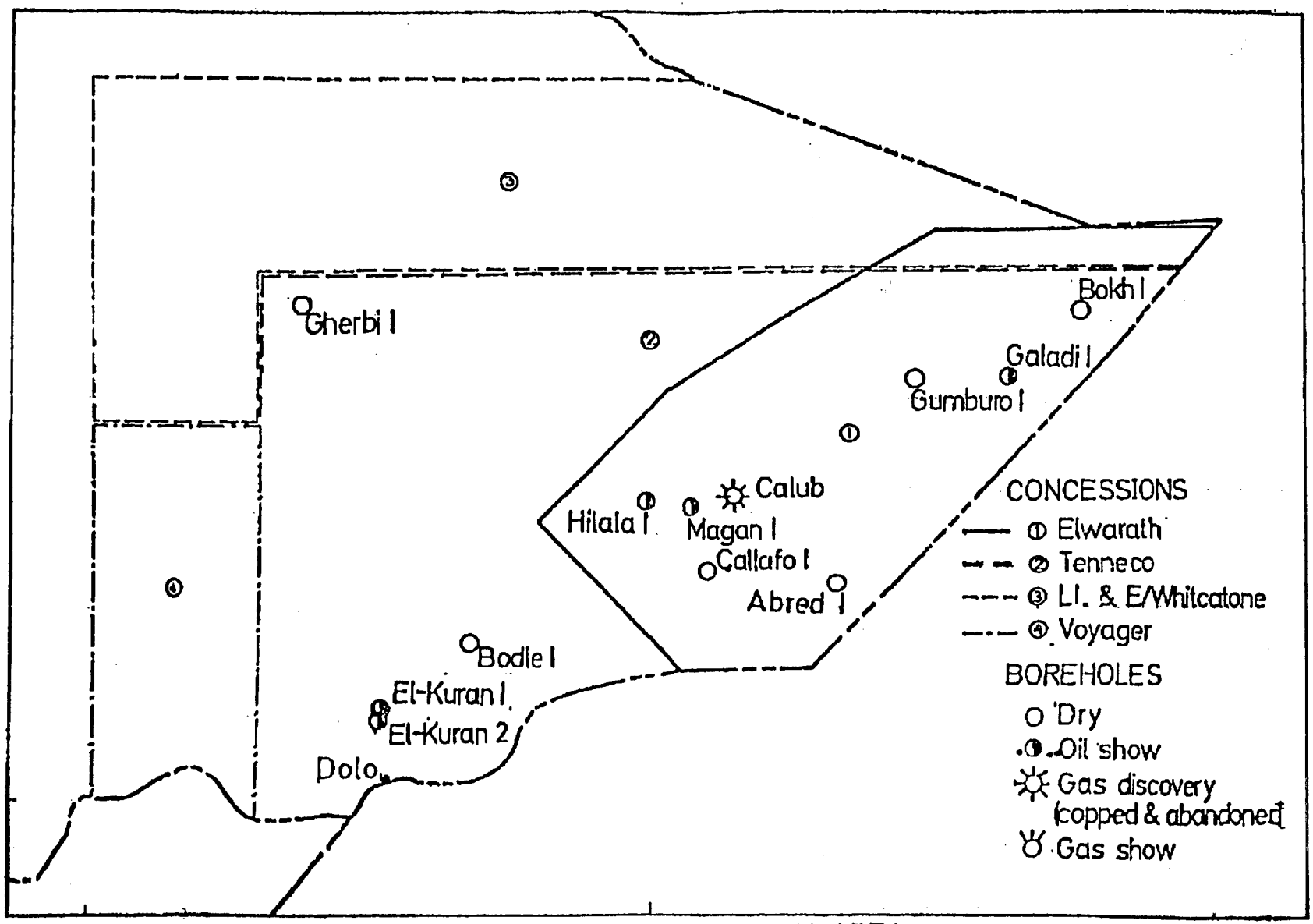
- SSI, 1991, Reservoir simulation study.
- Expro, 1987 PVT analysis.
- GDC, 1985 Prefeasibility study of the Calub Gas.



Annex I.-ETHIOPIA-Acreage delineation map, 1986
(Courtesy of Ministry of Mines & Energy-"Bidding Procedure for First Round Application for Blocks for Exploration").

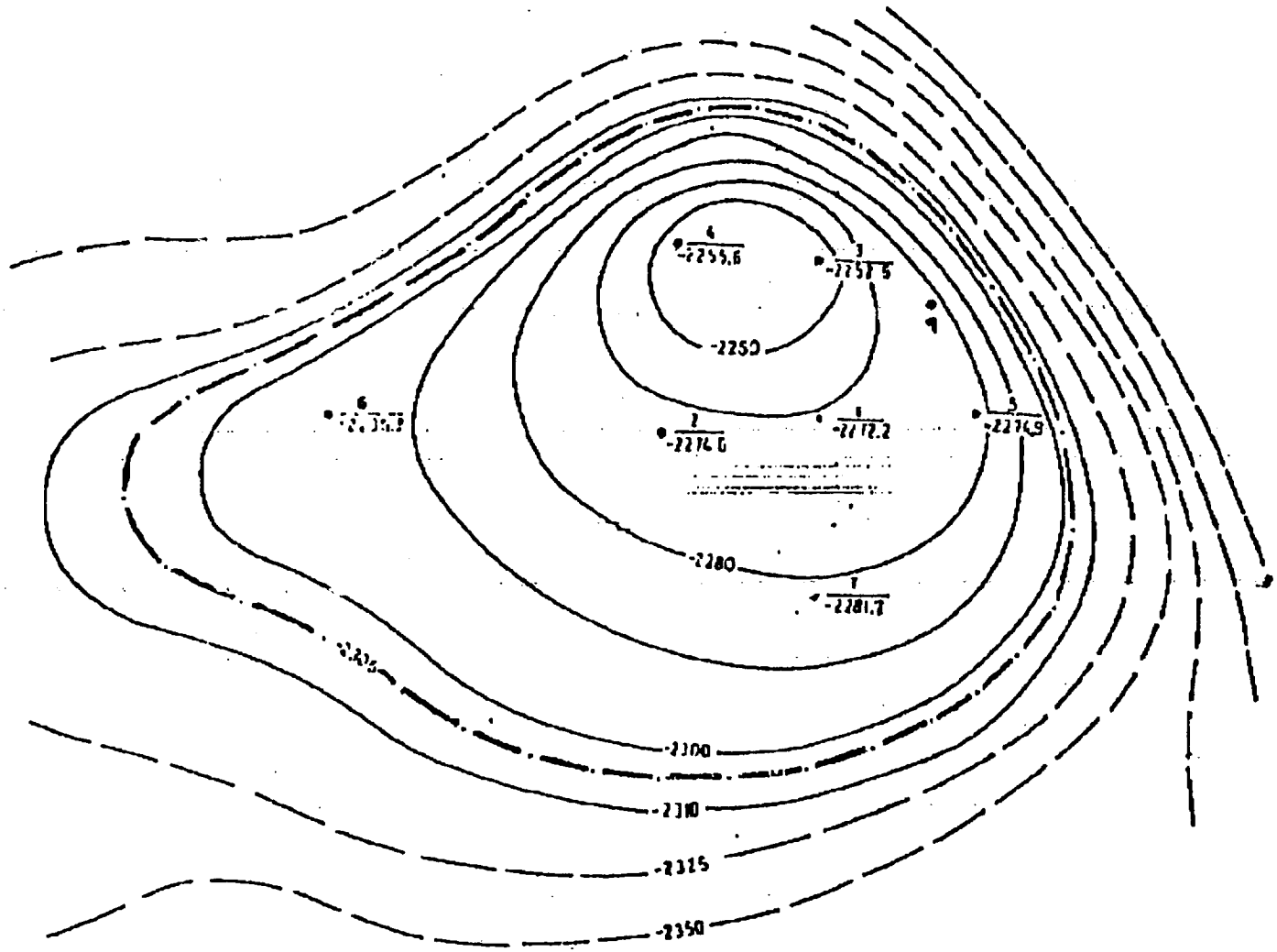


Annex 2. OIL CONCESSIONS OGADEN AREA (BEFORE 1974)
(Courtesy of John Walsh)

Annex 3 CALUB CONDENSATE GAS FIELD

Structural Map of the Adigrat Formation Roof

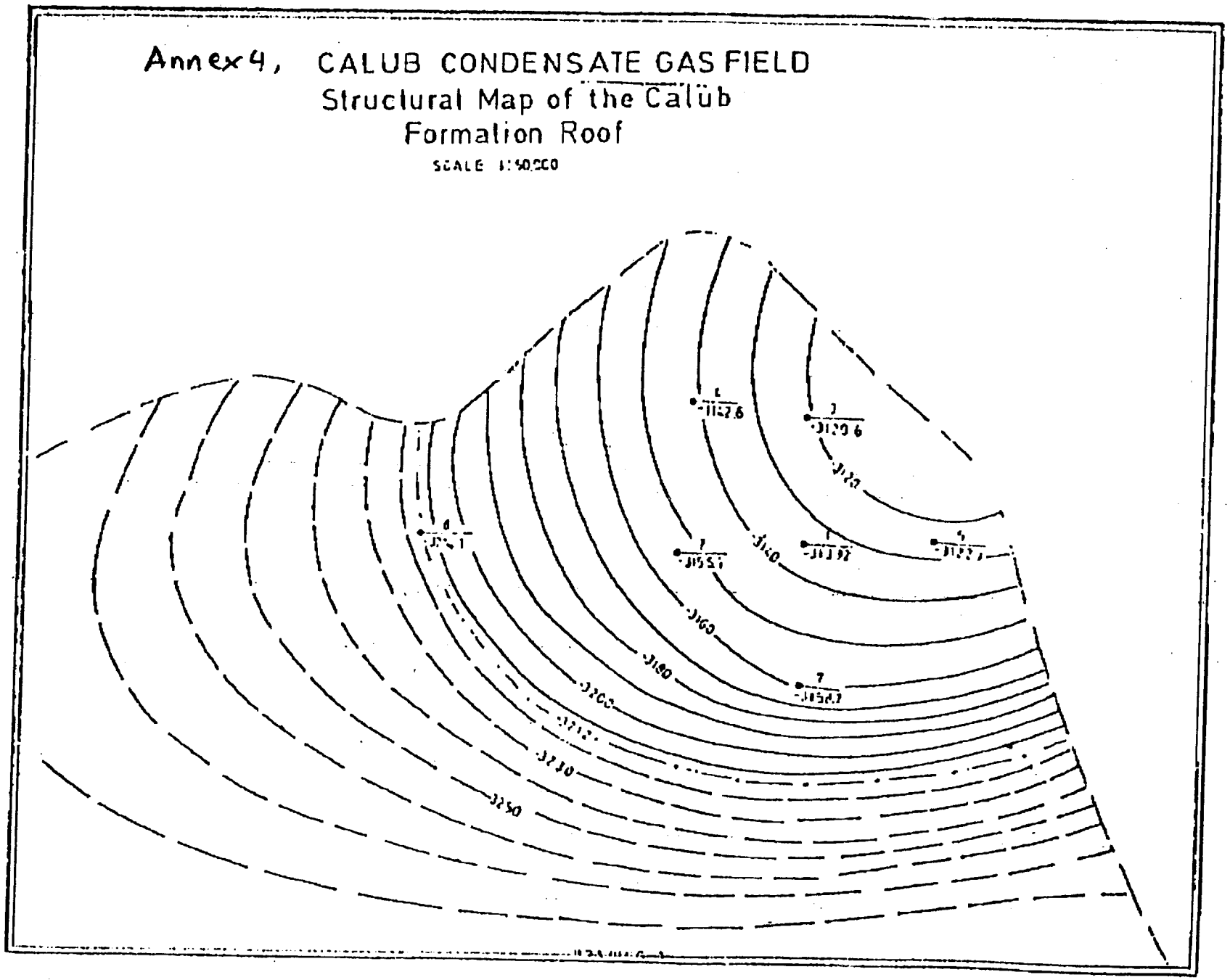
SCALE 1:50,000



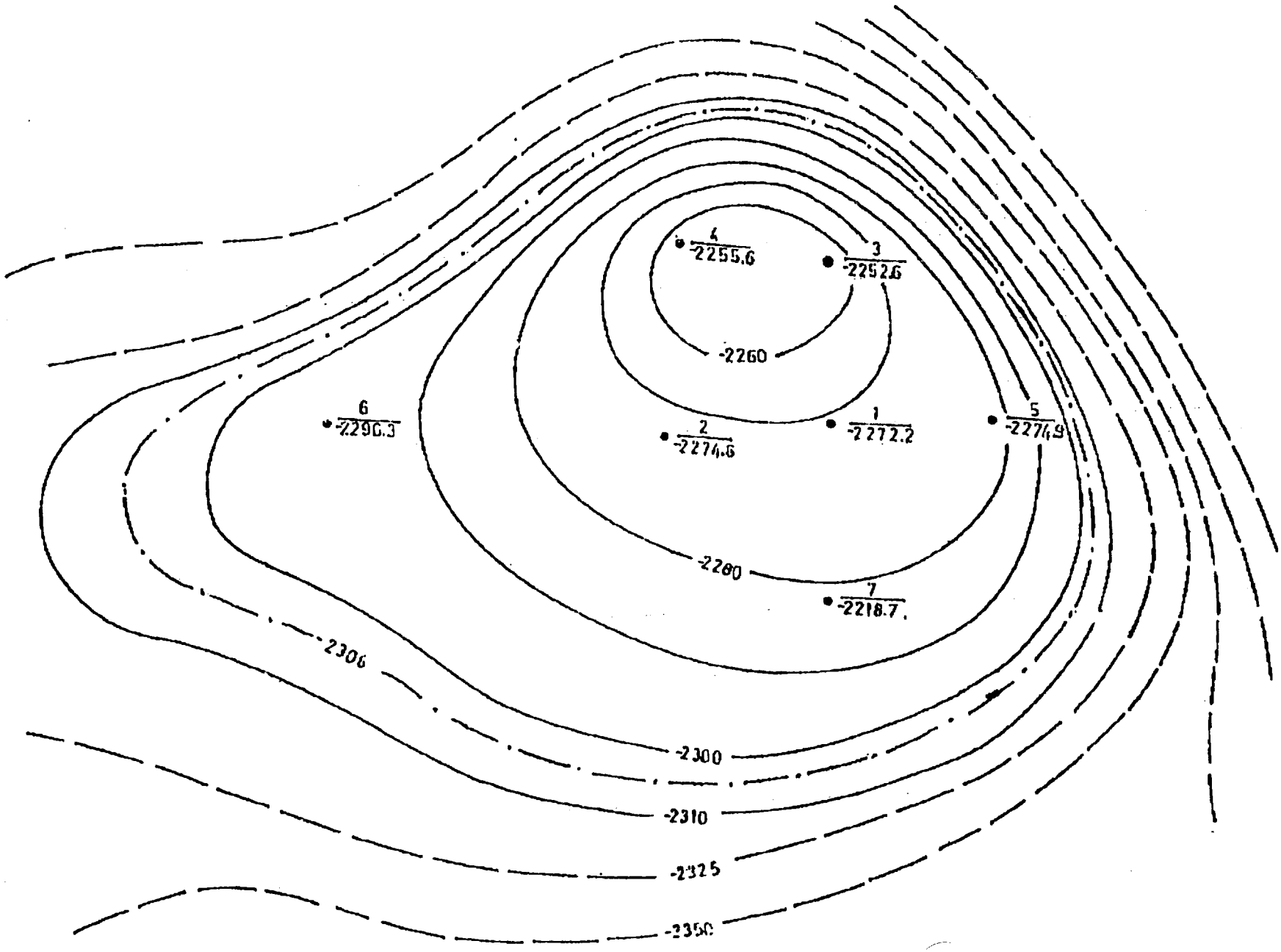
Annex 4, CALUB CONDENSATE GAS FIELD

Structural Map of the Calüb Formation Roof

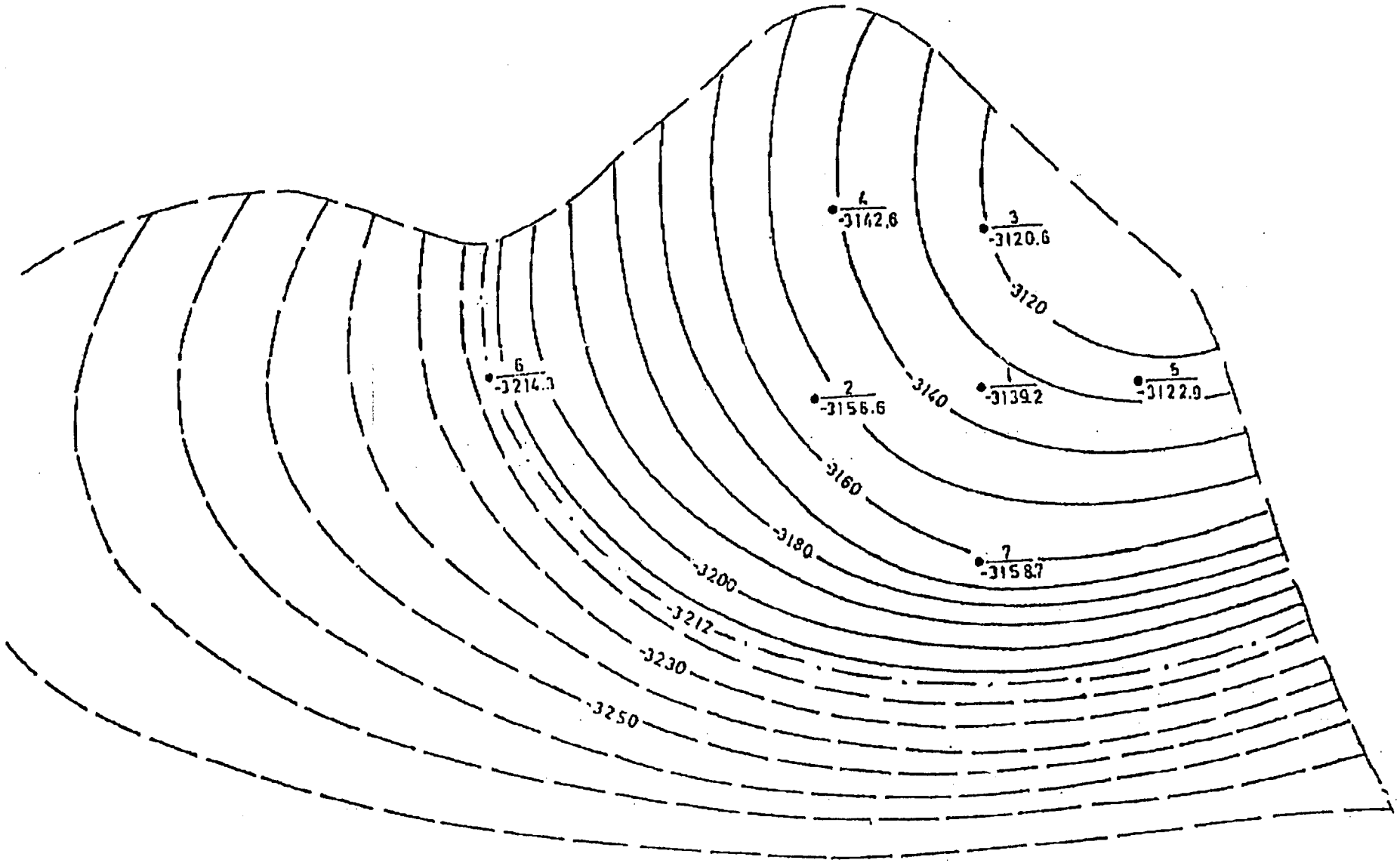
SCALE 1:50,000



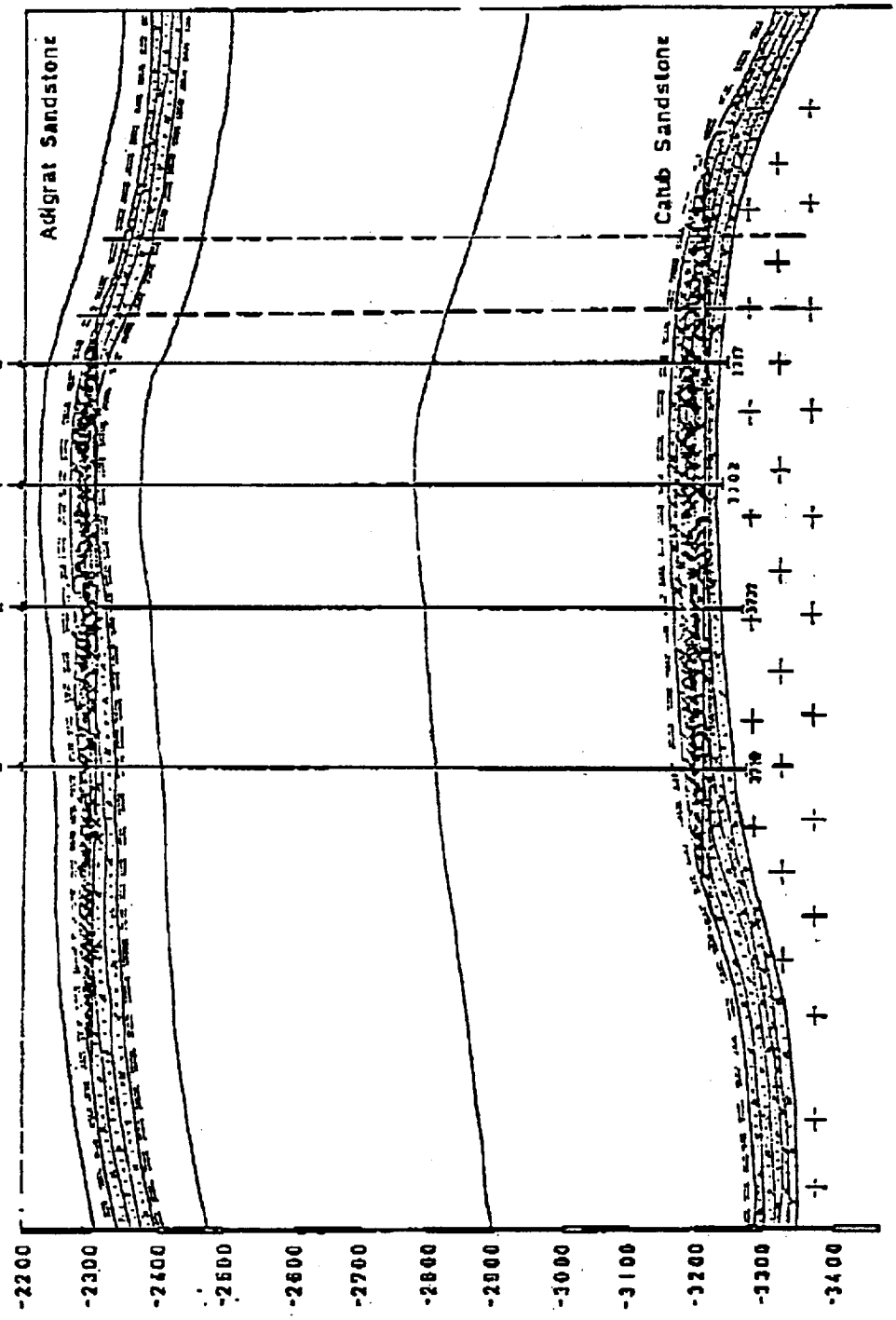
Annex 5 SIRUCTURAL MAP OF THE ADIGRAT FORMATION ROOF



Annex 6 STRUCTURAL MAP OF THE CALUB FORMATION ROOF



Annex V Schematic Geologic Cross Section



Well: CALUB-3
Formation: CALUB SANDSTONE
perforations: 3590-3641 meters (11,780-11, 946 feet)

Reservoir Fluid Composition

Component	Wt. %	Mol. %
N_2	6.69	4.58
CO_2	0.24	0.09
C_1	73.01	87.39
C_2	7.45	4.76
C_3	2.96	1.29
iC_4	0.88	0.29
nC_4	1.10	0.36
iC_5	0.77	0.20
nC_5	0.47	0.13
C_6	0.84	0.19
C_7	0.77	0.15
C_8	0.73	0.12
C_9	0.55	0.08
C_{10}	3.52	0.37

Annex 8 Average Molecular Weight of C_{10}. Fraction: 187

Well: CALUB-3
Formation: ADIGRAT SANDSTONE
Perforations: 2721-2754.5 meters (8928-9038 feet)

Calculated Recombined Fluid Composition

Component	Wt. %	Mol. %
N_2	7.21	5.25
CO_2	0.98	0.45
C_1	65.96	83.99
C_2	8.40	5.71
C_3	3.71	1.72
iC_4	1.13	0.40
nC_4	1.50	0.53
iC_5	0.96	0.27
nC_5	0.64	0.18
C_6	1.28	0.30
C_7	1.28	0.26
C_8	1.20	0.21
C_9	0.90	0.14
C_{10}	4.85	0.59

Annex 9 Average Molecular Weight of C_{10}. Fraction: 168.

Well: CALUB-2
Formation: ADIGRAT SANDSTONE
Perforations: 2740-2754 meters (8990-9036 feet)

Reservoir Fluid Composition

Component	Wt. %	Mol. %
N_2	10.68	7.95
H_2S	0.00	0.00
CO_2	0.79	0.37
C_1	61.94	80.74
C_2	8.62	5.99
C_3	3.89	1.84
iC_4	1.23	0.44
nC_4	1.69	0.61
iC_5	1.03	0.30
nC_5	0.72	0.21
C_6	1.28	0.31
C_7	1.33	0.28
C_8	1.24	0.23
C_9	0.94	0.15
C_{10}	4.65	0.58

Annex 10 Average Molecular Weight of C_{10}. Fraction: 168.
Average Density of C_{10}. Fraction: 0.808 g/cc.

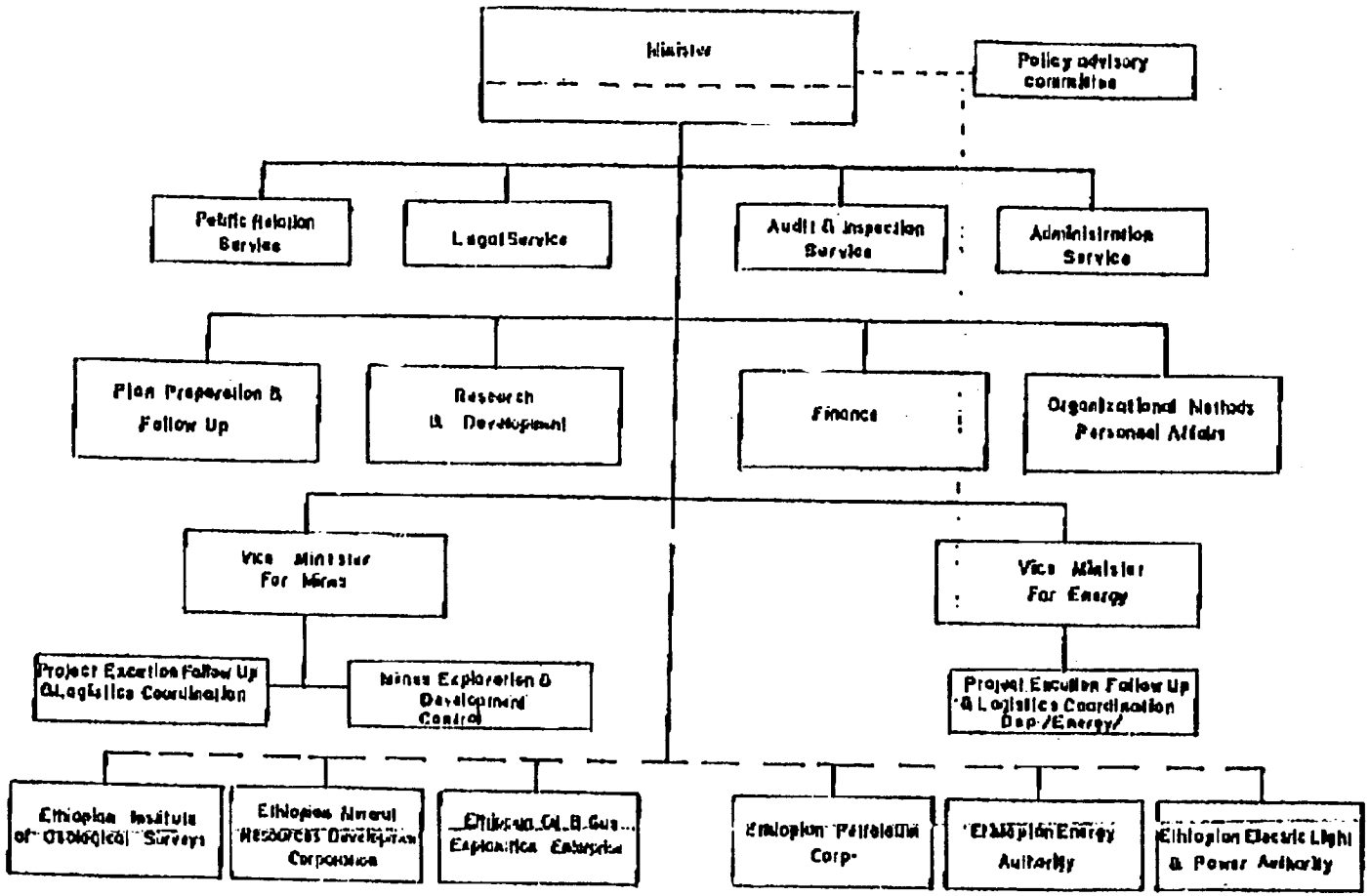
Well: CALUB-2
Formation: CALUB SANDSTONE
Perforations: 3633-3643 meters (11,989-12,022 feet)

Reservoir Fluid Composition

Component	Wt. %	Mol. %
N_2	7.95	5.44
CO_2	0.21	0.09
C_1	72.21	86.55
C_2	7.63	4.88
C_3	3.07	1.34
iC_4	0.87	0.28
nC_4	1.01	0.33
iC_5	0.66	0.18
nC_5	0.32	0.09
C_6	0.65	0.14
C_7	0.79	0.15
C_8	0.62	0.10
C_9	0.48	0.07
C_{10}	3.54	0.36

Annex 11 Average Molecular Weight of C_{10}. Fraction: 190.
Average Density of C_{10}. Fraction: 0.822.

Annex 12 MINISTRY OF MINES AND ENERE



Annex 13 Studies Conducted on the Gas Utilization

1.	Prefeasibility Study Calub Gas Utilization Study	
	-Study Conducted by	GDC. Inc of Chicago
	-Year of study	1985
	-Result of the study	Market study, Identify potential users, study tentative pipeline Route:
	-Recommendations	PVT study, additional 10 more wells to be drilled. Project is economically viable for local market
	-Proposed form of transport	16" & 14" pipeline (Calub-Dire Dawa-Addis)
2.	Feasibility Study, Small Scale Gas utilization study	
	-Study conducted by	GDC.Inc. of Chicago
	-Year of study	1988
	-Results of study	Establishmarket acceptance by supplying nearby markets with CNG and LPG.
	-Proposed form of transport	Trucking
3.	Appraisal Study of the Small Scale Gas utilization Study	
	-Study conducted by	Mr.EluMekkawi & DRS Solomon
	-Year of Study	1989
	-Result of study	Liquid extraction from the gas at the site and recycling the lean gas.
4.	Calub Gas Field Reservoir simulation study	
	-Study conducted by	SSI. London
	-Year of study	1991
	-Result of study	Gas reserve estimation and reservoir simulation.
5.	Small Scale Gas Development Project Preparation study (not completed)	
	-Study conducted by	Technip/Beicip France
	-Year of study	1992
	-Expected results;	

Market and Economics	Field Development
-Organization	-Product specification
-Petroleum products	-Gathering system selection
-Lean Gas use in fertilizer	-Gas reinjection
-Lean gas use for electric power	-Utilities
-Transportation of products	-Water supply
-Opportunity cost	-Training program
-Institutional arrangements	-Preengineering

6. PVT & Condensate Lab
Studies of the Calub Gas

-Study conducted by	Expro, London
-Year of study	1987/1992
-Result of study	PVT analysis condensate analysis result pending