CCOP-DANIDA
Institutional Capacity Building Project ICB-CCOP1
Sulu Sea—East Sabah Basin Case Study Dissemination Seminar
September 26, 2007
Manila, Philippines

Report on proceedings and discussions at the Seminar

Date and Venue:

The seminar was held on 26 September, 2007, in Department of Energy, Philippines
Address: Department of Energy
Fort Bonifacio, Taguig City, 1201 Philippines
Tel: (63-2) 812 4016, 840 1401 to 21, local 237/285-287
Website: http://www.doe.gov.ph

Local Organizer: Department of Energy

Participants:

Fourteen (14) participants from Philippines attended the seminar.
The represented agencies/institutes were:

- Department of Energy (DOE), Philippines
- National Institute of Geological Sciences, University of the Philippines
- CCOP Technical Secretariat

The total participants of the seminar were seventeen (17) detailed name list of participants is attached in Annex 1.

Program:

The detailed program of the seminar is provided in Annex 2.

Background and Purpose of the Meeting:

This dissemination seminar is a planed activity of the ICB-CCOP1 Project. The objective of Dissemination Seminar is to disseminate the outputs and impacts of the ICB-CCOP 1 project implementation to DANIDA and stakeholders of the Philippines.

Record of Proceedings and Discussions at the Meeting:

Ms. Baby Novelwin Ernestina A. Santos, a geologist of the Petroleum Resource & Development Division, was the master of the opening ceremony. Mr. Ramon Allan V. Oca, Deputy Permanent Representative of Philippines to CCOP, Director, Energy Resource Development Bureau, Department of Energy (DOE) Philippines, delivered the welcome Speech. He reviewed the project implementation, especially on the Sulu Sea-East Sabah basin joint case study. He was glad to praise the current outputs and impacts from case study and capacity building (Annex 3).

On behalf of CCOP, Dr. Hee-Young Chun, Director of CCOP Technical Secretariat made a comprehensive welcome speech. First, he thanked the Department of Energy for the hospitality and kindness for allowing to use their premise for this dissemination seminar. He said it was refreshing to see that the project had come to this stage and reached tremendous achievements along the way, indicating the DANIDA-funded project Institutional Capacity Building Project ICB-CCOP1 had reached its prominent milestone in CCOP history. He heartily appreciated the support of the Royal Danish Government, the hard work of Mr. Liu Liqun, the project coordinator and Mr. Ioannis Abatzis, the senior advisor to ICB-CCOP1 Project. Finally, on behalf of CCOP, he expressed his deep appreciation to Mr. Horacio C. Ramos, Permanent Representative of the Philippines to CCOP, Director Mines and Geosciences Bureau (MGB), and Mr. Ramon Alan Oca, Deputy Permanent Representative of the Philippines to CCOP and Director, Energy Resource Development Bureau, Department of Energy for their contribution and unwavering support to the ICB project and to the ICB project Philippine team members for the enthusiasm, involvement and inputs to the project (Annex4).

Afterwards, Mr. Liu Liqun, ICB-CCOP1 Project Coordinator, gave a brief review of the ICB-CCOP1 Project implementation and summarized the outputs and impacts of the project, especially the outputs and impacts from the Sulu Sea- East Sabah basin cross-border joint case study. He gave his sincere thanks to DOE for the support and deep involvement in the project implementation.

Then, Mr Guillermo H. Ansay. National Coordinator of the Philippines, DOE, presented the outputs from Philippines during the project implementation. He reviewed the joint cross-border case study and introduced the challenges and how these challenges were addressed, and the final achievements of the Project. He highlighted that the outputs from the case study would benefit both Philippines and Malaysia oil industry with the more understanding of petroleum potential of the Sulu Sea-East Sabah basin through the ICB joint case study. Toward the capacity building, he reported that the young geoscientists, including female geoscientists, were able to enhanced their knowledge, got new information and technologies through participating the project activities, such as workshop, seminar, training course, field study and working meeting. The knowledge learned is shared to all staff in the Petroleum Resource & Development Division and has been useful in their own assessment of other sedimentary basins for investment promotions. The benefits from the granted software and postgraduate grants, were also introduced. Through the project implementation, the networking and future partnership between DOE and PETRONAS as well as with other CCOP Member Countries, has been further enhanced. Finally, he expressed the sincere thanks to Royal

Danish Government, CCOP Technical Secretariat, PETRONAS and DOE Management for supporting.

Afterward, Mr. Archivald Mel F. Cordero, ICB-CCOP1 Project postgraduated grants receiver, reported his postgraduate research on Strontium Isotope Stratigraphy (SIS) of Kennon and Mirador Limestones of the Baguio District, Benguet Province, Philippines under the support of the ICB-CCOP1 Project postgraduate grants (Annex 5). The main objectives of the research is to resolve the stratigraphic ages of the Kennon and Mirador limestones, to arrive at an accurate numerical age for the two mentioned limestones using SIS, and to demonstrate the usefulness of SIS in Philippine stratigraphy.

Finally, he gave his sincere thanks to the Royal Danish Government through the ICB-CCOP1 Project to provide the financial support.

After all presentations, Dr. Francisco G. Delfin Jr. Assistant Secretary, Department of Energy, Philippines, made the closing remarks. He said, this project, combining the data from Malaysia and Philippines had led to a better understanding of the Sulu Sea-East Sabah basin, that of course, help us increase the prospect of the basin and consequently reduce the exploration risk. So by that measure alone, reducing exploration risk to benefit oil company, this project can be deem successful. Secondly, by providing the opportunities, through training, software grant, interaction in both our PERONAS colleagues and CCOP colleagues, the project has also enhanced the capability, especially the human resources capacity of DOE. This is the second measure of success of the project. Thirdly, besides the project activities, training, workshop, meeting, seminar, field study and software granted, the networks between the organization as well as personal relationship has been built. Those three accounts indicated the great success of the ICB-CCOP1 Project implementation. Finally, he expressed his sincere thanks to Royal Danish Government for generously providing the financial assistance to this project, to Dr. Hee-Young Chun, Director CCOP Technical Secretariat, Mr. Ioannis Abatzis, Representative of Denmark to CCOP, Mr. Liu Liqun, ICB-CCOP1 Project Coordinator, Mr. Simplicio P. Caluyong, PPM Project Coordinator, and their own research team members from DOE for efficient implementing the project. On behalf of the Energy Resource Development Bureau, he hopes the closing of this seminar is also the beginning of further more project cooperation (Annex 6).

Group photo of the ICB-CCOP1 Project Dissemination Seminar

Opening Ceremony of Dissemination Seminar

Mr. Liu Liqun, Project Coordinator, Reviewing the Implementation of the ICB-CCOP1 Project

Mr. Guillermo H. Ansay Introduced the Output & Impact of ICB-CCOP1 Project

Focus on the Presentation

Mr. Archivald MelF. Cordero reported the Impact of the Project Postgraduate Grant

DR. FRANCISCO G. DELFIN JR. Delivering the Closing Remark

Farewell Dinner

Annex 1

CCOP-DANIDA Institutional Capacity Building Project ICB-CCOP 1
Sulu Sea—East Sabah Basin Case Study Dissemination Seminar
September 26, 2007
Department of Energy
Fort Bonifacio, Taguig City, Philippines

DISTINGUISHED GUESTS

NAME	POSITION / ADDRESS
1) DR. FRANCISCO G. DELFIN JR. 	Assistant Secretary Energy Resource Development Bureau Department of Energy (DOE) Energy Center, Merritt Road, Fort Bonifacio Taguig City, Metro Manila 1201, Philippines E-mail: fgdelfin@doe.gov.ph Tel: (63-2) 840 2074 Fax: (63-2) 840 2167
2) MR. RAMON ALLAN V. OCA 	Director Energy Resource Development Bureau Department of Energy (DOE) Petroleum Resources Development Division, Energy Center, Merritt Road, Fort Bonifacio Taguig City, Metro Manila 1201, Philippines E-mail: ramonallan@yahoo.com or rvoca@doe.gov.ph Tel: (63-2) 840 2068, Fax: (63-2) 840 2068
3) MR. RESTITUTO G. TAGANAS, JR. 	OIC-Acting Assistant Director Geothermal &Coal Resources Development Division Department of Energy , Energy Center, Merritt Road, Fort Bonifacio, Taguig City, Metro Manila, Philippines Tel: (63-2) 840 2254, Fax: (63-2) 840 2254 E-mail: rtaganas@doe.gov.ph
4) MR. ISMAEL U. OCAMPO 	Chief SRS, Geologist, Petroleum Resource Development Division, Department of Energy (DOE) Petroleum Resources Development Division, Energy Center, Merritt Road, Fort Bonifacio Taguig City, Metro Manila 1201, Philippines Tel: (63-2) 812 4016, Fax: (63-2) 840 2206 E-mail: iocampo@doe.gov.ph

LIST OF PARTICIPANTS

NAME	POSITION / ADDRESS
PHILIPPINES	
1) MR. GUILLERMO H. ANSAY 	Senior Science Research Specialist / Geologist Petroleum Resources Development Division Department of Energy (DOE) Energy Center, Merritt Road Fort Bonafacio, Taguig City, The Philippines Tel: (63-2) 812 4016, 840-1401 to 21 local 365/237/287 Fax: (63-2) 840 2206 E-mail: gansay@doe.gov.ph
2) MR. REDENTOR D. PASCUAL 	Supervising Science Research Specialist / Geologist Petroleum Resources Development Division Tel: (63-2) 812 4016, Fax: (63-2) 840 2206 E-mail:rpascual@doe.gov.ph red_pascual@yahoo.com

NAME	POSITION / ADDRESS
3) MS. MA. CORAZON STA. ANA 	Senior Science Research Specialist Department of Energy (DOE) Energy Center, Merritt Road Fort Bonafacio, Taguig City, The Philippines Tel: (63-2) 812 4016, 840 1401 to 21, local 237/285-287 Fax: (63-2) 840 2206 E-mail: cocostaana@yahoo.com cstaana@doe.gov.ph
4) MR. NEIL O. PESA 	Senior Science Research Specialist / Mining Engineer Petroleum Resources Development Division Department of Energy (DOE) Energy Center, Merritt Road Fort Bonafacio, Taguig City, The Philippines Tel: (63-2) 812 4016, Fax: (63-2) 840 2206 E-mail: npesa@doe.gov.ph
5) MR. DEMUJIN F. ANTIPORDA 	Senior Science Research Specialist / Geologist Petroleum Resources Development Division Department of Energy (DOE) Energy Center, Merritt Road Fort Bonafacio, Taguig City, The Philippines Tel. (63-2) 812 4016, Fax. (63-2) 840 2206 E-mail: dfa68@yahoo.com
6) MR. JED B. ARAGONES 	Senior Science Research Specialist / Geologist Petroleum Resources Development Division Department of Energy (DOE) Energy Center, Merritt Road Fort Bonafacio, Taguig City, The Philippines E-mail: jedevabam@yahoo.com Tel: (63-2) 812 4016, Fax: (63-2) 840 2206
7) MS. BABY NOVELWIN ERNESTINA A. SANTOS 	Science Research Specialist II / Geologist Petroleum Resources Development Division Department of Energy (DOE) Energy Center, Merritt Road Fort Bonafacio, Taguig City, The Philippines Tel: (632) 812-4016, Fax: (632) 840-2206 E-mail: bneasantos@doe.gov.ph
8) MS. ARLYNE JOY A. ROQUE 	Science Research Specialist II / Mining Engineer Petroleum Resources Development Division Department of Energy (DOE) Energy Center, Merritt Road Fort Bonafacio, Taguig City, The Philippines Tel: (632) 812-4016, Fax: (632) 840-2206 E-mail: ajaroque@doe.gov.ph
9) MR. RONALD ALLAN F. BONIQUIT 	Science Research Specialist II / Geologist Petroleum Resources Development Division Department of Energy (DOE) Energy Center, Merritt Road, Fort Bonifacio Taguig City, Metro Manila 1201, Philippines Tel: (632) 812-4016, Fax: (632) 840-2206 E-mail: rboniquit@doe.gov.ph
10) MR. ARCHIVALD MEL F. CORDERO 	National Institute of Geological Sciences College of Science University of the Philippines Diliman, Quezon City, Philippines 1101 Tel. (63)(2) 9242709 Mobile: +639274215517 E-mail: archivald@gmail.com

NAME	POSITION / ADDRESS
CCOP TECHNICAL SECRETARIAT	
1) DR. HEE-YOUNG CHUN 	Director CCOP Technical Secretariat 24th Floor, Room 244-245, Thai CC Tower 889, Sathorn Tai Road, Sathorn, Bangkok, 10120 THAILAND Tel: (66-2) 672 3080 to 81, Fax: (66-2) 672 3082 Website: www.ccop.or.th E-mail: hychun@ccop.or.th
2) MR. LIU LIQUN 	ICB-CCOP1 Project Coordinator CCOP Technical Secretariat 24th Floor, Room 244-245, Thai CC Tower 889, Sathorn Tai Road, Sathorn, Bangkok, 10120 THAILAND Tel: (66-2) 672 3080 to 81, Fax: (66-2) 672 3082 Website: www.ccop.or.th E-mail: liu@ccop.or.th Mobile: (66-81) 985 5765
3) MR. SIMPLICIO P. CALUYONG 	PPM Project Coordinator CCOP Technical Secretariat 24th Floor, Room 244-245, Thai CC Tower 889, Sathorn Tai Road, Sathorn, Bangkok, 10120 THAILAND Tel: (66-2) 672 3080 to 81, Fax: (66-2) 672 3082 Website: www.ccop.or.th E-mail: sim@ccop.or.th Mobile: (66-81) 827 0527

Annex 2

CCOP-DANIDA Institutional Capacity Building Project ICB-CCOP 1
Sulu Sea—East Sabah Basin Case Study Dissemination Seminar

September 26, 2007
Department of Energy
Fort Bonifacio, Taguig City, Philippines
Tel: (63-2) 812 4016, 840 1401 to 21, local 237/285-287

13:00 **Registration**

13:30 **Opening ceremony**
Welcome Speech by **MR. RAMON ALLAN V. OCA**
Deputy Permanent Representative of Philippines to CCOP
Director, Energy Resource Development Bureau, Department of Energy (DOE)
Welcome Speech by **DR. HEE-YOUNG CHUN**
Director of CCOP Technical Secretariat

Group Photo

14:20 **Brief Introduction of the ICB-CCOP1 Project Implementation**
Mr. Liu Liqun, ICB-CCOP 1 Project Coordinator, CCOP Technical Secretariat

14:35 **Outputs and impact of the ICB-CCOP1 Project implementation**
National Coordinator of the ICB-CCOP1 Project
Research Grant Output
Mr. Archivald Mel F. Cordero

15:00 **Closing Remarks** by **DR. FRANCISCO G. DELFIN JR.** Assistant Secretary, Department of Energy

15:10 **Snack**

16:00 **End of the Seminar**

17:30 **Dinner** (hosted by ICB-CCOP1 Project)

Annex 3

WELCOME ADDRESS BY DEPUTY PERMANENT REPRESENTATIVE OF PHILIPPINES TO CCOP AND DIRECTOR, ENERGY RESOURCE DEVELOPMENT BUREAU, DEPARTMENT OF ENERGY (DOE), PHILIPPINES

MR. RAMON ALLAN V. OCA

at the opening ceremony of CCOP-DANIDA
Institutional Capacity Building Project ICB-CCOP1
Sulu Sea—East Sabah Basin Case Study Dissemination Seminar
September 26, 2007, Department of Energy

Assistant Secretary Francisco G. Delfin Jr.
Dr. Hee-Young Chun, Director of CCOP Technical Secretariat
Mr. Liu Liqun, ICB-CCOP Project Coordinator,
Mr. Simplicio Caluyong
Staff of the PRDD

Good afternoon,

It is my pleasure to welcome you all to the Dissemination Seminar of the **CCOP DANIDA Institutional Capacity Building Project ICB-CCOP1 Sulu Sea – East Sabah Basin Case Study** here in the Department of Energy**.**

I understand this is one of the final activities of this three-year project that will end this December 2007. From the report of the PRDD research team, I read that the Danish Ambassador was able to attend the first workshop and fieldwork in Sabah, Malaysia for this case study, where the staff from Petronas and the Department of Energy together with representatives from the different CCOP Member Countries conducted mapping and sampling of outcrops.

From that time in February 2006 until late last month, there have been a lot of exchanges of information and cooperative technical work that have been done to complete the expected output for this project. Aside from the workshop and seminars, the research team from the Petroleum Resources Development Division have been to Petronas office and staff of Petronas have visited the Department of Energy to compile and merge maps the have been generated on both sides of the basin. After all these activities, the final project report has been submitted to CCOP Technical Secretariat for compilation and publication.

This project has also given us the opportunity to train our staffs thru the workshops and seminars that were conducted during the project. In addition, we were able to freely promote the Sulu Sea area to the other CCOP Member Countries. Technical softwares were also provided by the project, including training in the applications, during the course of the project to the PRDD. As a result, these have added to the technical competency of the staffs especially the junior staffs that were able to attend these activities.

To our distinguish guest, Dr. Chun, Mr. Liqun and Mr. Caluyong, welcome!

Annex 4

WELCOME SPEECH BY DIRECTOR OF CCOP TECHNICAL SECRETARIAT

DR. HEE-YOUNG CHUN

at the opening of CCOP-DANIDA
Institutional Capacity Building Project ICB-CCOP1
Sulu Sea—East Sabah Basin Case Study Dissemination Seminar
September 26, 2007, Department of Energy

Dr. Francisco G. Delfin Jr. assistant Secretary, Department of Energy
Mr. Ramon Alan V. Oca, Deputy Permanent Representative of Philippines to CCOP and Director, Energy Resource Development Bureau, Department of Energy (DOE)
Ladies and Gentlemen

Good Afternoon,

It is my great pleasure to welcome you all to CCOP-DANIDA Institutional Capacity Building Project ICB-CCOP1 dissemination seminar of the Sulu Sea-East Sabah Basin Case Study today. First of all, I would like to thank the Department of Energy for the hospitality and kindness for allowing us to use their premise for this dissemination seminar.

It is refreshing to see that the project has come to this stage and reached tremendous achievements along the way, indicating the DANIDA-funded project Institutional Capacity Building Project ICB-CCOP1 has reached its prominent milestone in CCOP history. Thanks to the support of the Royal Danish Government, the hard work of Mr. Liu Liqun, the project coordinator and Mr. Ioannis Abatzis, the senior advisor to ICB-CCOP1 Project.

The accomplishments of the cross-border case study will not be possible without the close cooperation among the host countries. I would like to take this opportunity to express my appreciation and congratulations to Mr. Guillermo Ansay and Mr. Redentor Pascual for their roles as National Coordinators and their team members for the time and efforts they diligently devoted for the success of the Sulu Sea-East Sabah case study of ICB Project.

At one point or another, I believe most of you here have been involved with ICB Project. I sincerely hope that the Project has helped you enhance “Capacity Building” in your expertise, learn new knowledge, applied and improved this knowledge, particularly friendship and expanded your net working in CCOP and ASCOPE Members and Invited Guest Speakers in the Region and GEUS through ICB-CCOP Phase 1 Project. If so, then the project has accomplished its goal.

Finally, on behalf of CCOP, I would like to express my deep appreciation to Mr. Horacio C. Ramos, Permanent Representative of the Philippines to CCOP, Director Mines and Geosciences Bureau (MGB), and Mr. Ramon Alan Oca, Deputy Permanent Representative of the Philippines to CCOP and Director, Energy Resource Development Bureau, Department of Energy for your contribution and unwavering support to the ICB project and to each one of you in the Philippine team for the enthusiasm, involvement and inputs to the project. In this occasion, our sincere thanks also should go to our case study Malaysian partner for their cooperation, dedication and hard work on case study.

I wish you all a very fruitful seminar.

Thank you

Annex 5

THE REPORT OF THE UTILIZATION AND IMPACT OF THE ICB-CCOP PROJECT POSTGRADUATE GRANT

Archivald Mel Cordero
University Research Associate
National Institute of Geological Sciences
College of Science
University of the Philippines
Diliman, Quezon City 1101

1. Impact of ICB-CCOP1 Project Postgraduate Grant

The grant awarded by ICB-CCOP1 Project was used for acquiring laboratory services needed for this research and for the acquisition of laboratory equipment. Through the grant the research has materialized and is coming into fruition. Due to the lack of equipment in the Institute, analyses needing specific equipment such as X-ray diffraction and X-ray fluorescence, the samples were sent to different laboratories abroad. Thus the researcher can say that the grant is an important factor, if not the most essential factor for the study. Through the grant, new avenues have been opened for the researcher. It made it possible for this researcher to communicate and consult with several experts in the field of geology specifically in strontium isotope stratigraphy and to contribute something new to Philippine geology. The researcher is also expanding his horizons on different studies as well involving different isotopes such as Sr/Ca and Oxygen and Carbon isotope studies. Without the financial assistance given by the ICB-CCOP Project this would not at all be possible.

As a pioneering work in Philippine geology, the grant is a crucial factor not only for this research but to the Philippine stratigraphy as a whole. This research aims to improve the stratigraphy of the Philippines which has remained problematic for a long time thus it is imperative to utilize new tools such as stable isotopes for the advancement of geology in the country.

2. Budget Allocation and Expenditures

Expenses	Budget
Major element Analysis	25,755.00 = 563.448
X-Ray Diffraction analysis	18,283.00 = 400.00
Field Expenses	20,000.00 = 437.541
Supplies and Equipment	30,000.00 = 656.311
Sundries	5,000.00 = 109.385
Total Expenses **Remaining Budget**	**Php 99, 038 =US$ 2166.685** **US$ 2833.315**

Currency Exchange as of August 10, 2007: **US$ 1= Php 45.78**
Note: Sr analysis cost is not yet included and is still pending.

The remaining budget for this research would be used to continue the research started in the Baguio district. Although several analyses has already been finished additional laboratory work and fieldworks would still be done to gather more samples, to give more precise data and to augment the present result of the study.

3. Acknowledgement

The researcher would like to thank the ICB-CCOP1 Project and all its members for awarding the grant, which made possible for this research to continue. The research would also like to thank my adviser Dr. Marietta De Leon for her patience and guidance. To Tony Allan of CSIRO and Dr. John McArthur for sharing there wisdom and knowledge of SIS. To John Hunt of Spectrachem Analytical Limited and Tony Chrisitie of Geology and Nuclear Science (GNS) Minerals Laboratory for their assistance in the analyses of the samples.

4. Research Report

ABSTRACT

Several studies on the stratigraphy the Baguio district have already been done. However these researches left some questions yet to be answered specifically on the true relationship of Kennon and Mirador limestones. Thus a new approach in the studying these limestones has been utilized, Strontium Isotope Stratigraphy (SIS).

During the course of the research, several fieldworks were done to gather samples for different preservation analyses. Suitable samples were sent to different laboratories for X-Ray diffraction and X-Ray fluorescence. Micropaleontological analysis was also utilized in this research.

X-Ray diffraction revealed limestone samples from Mirador were relatively more preserved than the samples from Kennon limestone. Traces of ankerite and feldspars were detected in the Kennon samples. X-Ray fluorescence also showed traces of silicates (0.16% for Mirador and 5.21% for Kennon) in some of the samples. On the otherhand, micropaleontology revealed the presence of Sphenolithus heteromorphus in the Mirador samples which is very useful in arriving at a possible new relative age which is Early Miocene to Middle Miocene.

I. Introduction

The geology and stratigraphy of the Baguio District has been studied extensively in the past years (Leith, 1938; Peña, 1970; Balce, 1980; De Leon et al., 1991; Aurelio and Peña, 2004) in part due to the mineral economic importance of the area. Several stratigraphic columns have been suggested by numerous authors to give an idea on the different ages of the different lithology present in the area. Structural, paleontological, and sedimentological analyses have been utilized to give precise ages and properties of these lithologies.

However, some units in the area remain problematic due to inconsistencies in ages resulting from the different analyses and interpretations of different authors (UNDP, 1987; Maleterre, 1989; Nilayan-Tan, 1994). Two particular units in question are the Kennon Limestone with its type locality in Camp 3 along Kennon Road and the Mirador Limestone with its type locality in Mirador Hill.

The author proposes a new tool on the dating of the two limestone bodies in question, Strontium isotope stratigraphy or SIS. Strontium isotope stratigraphy has already been utilized by some workers (Burke, et al., 1982; Ludwig et al., 1988; Mckenzie et al, 1988; Mcarthur et al., 1994; Whitford et al., 1996; Eisenberg et al., 1996; Allan et al., 2000; Graham et al, 2000; Sharaf et al, 2005) and is slowly becoming popular to aid in the dating of problematic units utilizing both outcrop and deep sea samples, working hand in hand with biostratigraphy and chronostratigraphy to yield more precise ages.

Review of Related Literature

Wickman in 1948 first postulated that the 87Sr/86Sr of Strontium in seawater increases as one valued function of time since the products of weathering in continental areas which includes Sr are deposited in the oceans. He noted that a record of the increase in Sr can be determined from marine limestone, gypsum, and other marine precipitates as they incorporate Sr during their formation in seawater. Several authors (Peterman et al., 1970; Veizer and Compston, 1974) tested this postulate and discovered that the value of 87Sr/86Sr ranges from 0.707 to 0.709 during the Phanerozoic contrary to Wickman's idea. Various maxima and minima had been documented by both Burke et al. (1982) and Koepnick et al. (1985) in the evolution of 87Sr/86Sr throughout the Phanerozoic which showed that dating and correlation of marine sediments with the use of Sr is effective.

Numerous improvements in the methodology to utilize Sr have already been applied and much understanding about the advantages and limitations of the Sr as a means for dating have led many researchers to use different materials for analysis (McArthur, 1994). Biogenic carbonate, marine carbonate cements, apatite, barite, marine fossils (foraminiferid, conodont shells, fish teeth and bones, belemnites, brachiopod and oyster shells, etc…) , and even indurated carbonates (Whitford et al., 1996) are now used in strontium isotope stratigraphy. Age curves derived from 87Sr/86Sr defined by a number of researchers are now accurate and reliable to be used in correlation with other

materials for stratigraphy; Cenozoic (DePaolo and Ingram, 1985), Neogene (DePaolo, 1986; Capo and DePaolo, 1990; Hodell, 1991; Oslick et al., 1994), Late Cretaceous to Recent (Hess et al., 1986), Late Eocene to Oligocene (Millet et al., 1988) , Miocene (Miller et al., 1991), Late Cretaceous (McArthur et al., 1994), Jurassic and Early Cretaceous (Jones et al., 1994). For the Mid-Cenozoic where this study would focus, strontium isotope sea-water curves have already been compiled from samples of both DSDP and ODP cores with good chronstratigraphic age controls (Hess et al., 1989; Hodell et al., 1991; Denison et al., 1993; Oslick et al. 1994; Sugarman et al., 1995). Howarth and MacArthur (1997 and 2001) also constructed a best-fit sea water curve for the period of 0 to 509 million years using the LOcally WEighted regression Scatter plot Smoother or LOWESS based on 1800 data points using data of several researchers. This curve also gives a 95% confidence intervals for prediction of numerical ages from 87Sr/86Sr.

Nowadays, SIS is used to correlate marine sediments (Hess et al., 1989; McArthur et al., 1994; Sugarman et al., 1995), determine duration in stratigraphic gaps (Miller et al., 1988), and estimate biozones and stages extent (McArthur et al., 1993a; Allan et al., 2000; Graham et al., 2000), and determine environment of deposition of sediments (Schmitz et al., 1991).

II. Study Area

The study area is located at the southwestern portion of the Luzon Central Cordillera and is part of the Benguet province. It is situated between two sedimentary basins in Luzon, the Central Luzon Valley and the Cagayan basin and is approximately 250 kilometers from Manila (Figure 2). Its geology is composed of metamorphosed basement rocks, ophiolitic sequences, and intrusive complexes dated as Late Cretaceous to Eocene (Balce, 1980; UNDP, 1987; Maleterre, 1989; Mitchell; Leach, 1991;) and sedimentary units spanning from Cretaceous to Plio-Pleistocene (Balce et al., 1980; De los Santos, 1982; De Leon et al., 1998; Peña, 1998).

Pugo Formation

Considered as the oldest stratified unit in the area (Late Eocene to Paleocene), the Pugo formation is composed of a sequence of basaltic and andesitic volcanic rocks with interbeds of sandstones, chert, and pyroclastic rocks (Peña, 1998) which are slightly metamorphosed to metamorphosed. Hydrothermal alteration was also observed in some portions of the units in different locations (De Leon et al., 1998).

Zigzag Formation

This formation unconformably overlies the Pugo Formation. Its type locality is in the Upper Bued River canyon near the Zigzag part of Kennon Road (Leith, 1938) thus its name. Leith (1938) describes the formation as an almost entirely clastic sequence. The formation is divided into two parts, with the upper portion composed of tuffaceous conglomerates and sandstones with interbeds of siltstones and shale. The red and green

color of the siltstone beds make it distinct from the dark colored shale and grayish sandstones. The lower part of the formation on the other hand is composed of medium to fine grained red and green colored sandstone beds with some conglomerates. Limestone lenses were also identified within the formation. The age of this formation given by several authors ranges from Early Oligocene to Early Miocene.

Kennon Limestone

This unit unconformably overlies the Zigzag formation and is in turn overlain by the Klondyke formation. Previous workers describe this unit as a limestone unit with gray and buff calcarenites, calcirudites, and calcilutites with a thickness of 198 meters in its type locality in Camp 3 along Kennon Road (Nilayan-Tan, 1994) while De Leon (1995) describes it as composed of calcareous mudstone and mudstone arkosic-sequence. Balce et al. (1980) considers this limestone body as part of Kennon formation along with the Twin Peaks unit composed of a sequence of sandstones and mudstones while Peña (1998) separates the latter from the limestone unit and includes it with the basal portion of the Klondyke formation. Paleontological analysis by several researchers gives an age range of Early Miocene to Middle Miocene.

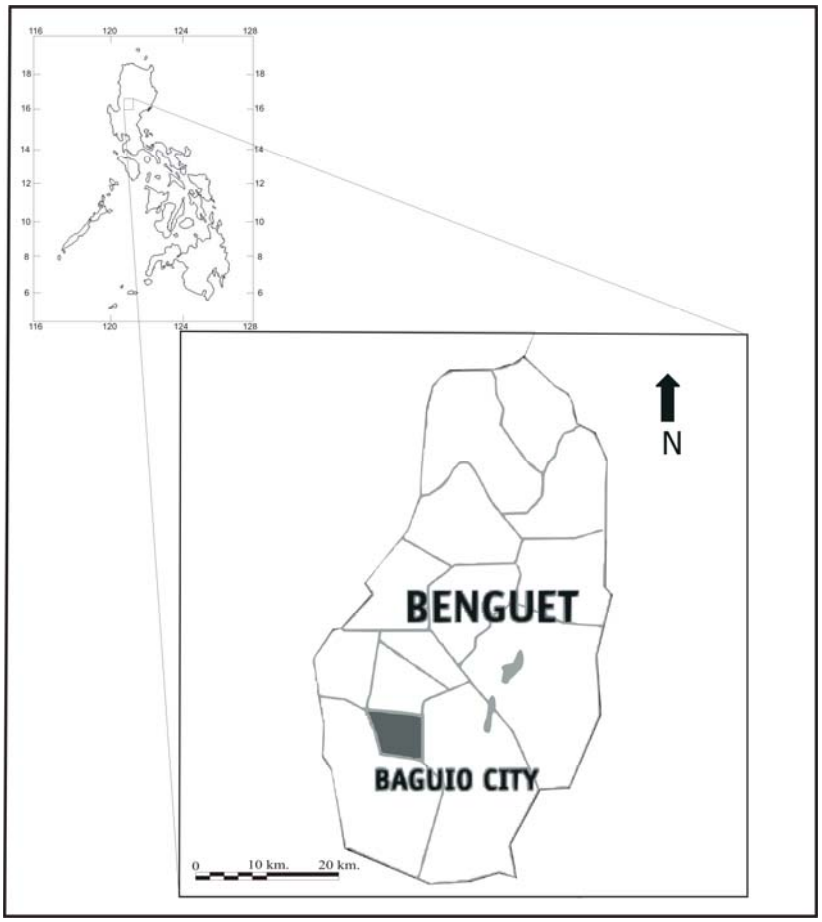


Figure 1. Index map of the study area

Klondyke Formation

This formation was named by Leith (1938) based on its type locality in the Klondyke Hot Springs. It is mainly composed of sandstones, mudstones, few limestone units, and is dominantly conglomeratic. Volcanic breccias and some pyroclastic rocks are also found within the formation (Peña, 1998; Aurelio and Peña, 2004). It is unconformably underlain by the Kennon Limestone and overlain by the Amlang Formation (Lorentz, 1984), while some portions are also overlain by the Mirador Limestone (De los Santos, 1982; Peña, 1998). Durkee and Pederson (1961) separately mapped its basal portion composed of calcareous mudstones and sandstones as part of the Twin Peaks Formation while Balce (1980) considered it as part of the Kennon Formation. Several workers gave an age range of Middle Miocene to Late Miocene for this formation.

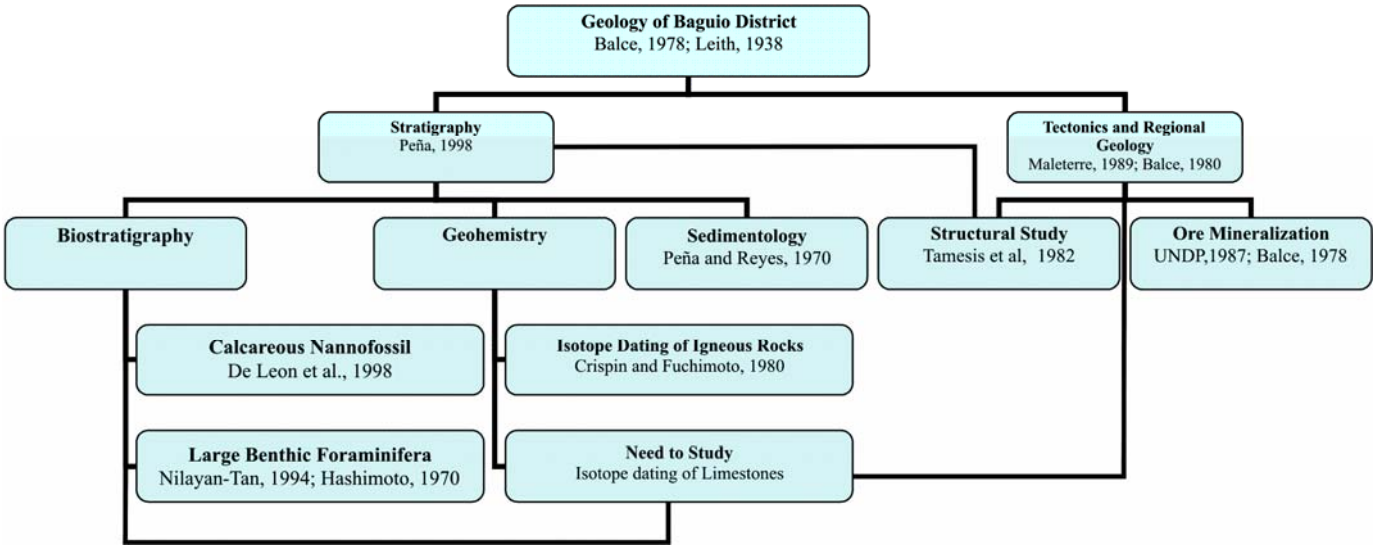
Mirador Limestone

Leith (1938) first named this limestone body that spans a very wide range in the Baguio District with its type locality in Mirador Hill, Baguio City and is described as mainly coralline limestone. De los Santos (1982) placed it as unconformably overlying the Klondyke formation and is underlain by the Baguio Formation. Several authors on the other hand argue that the Mirador Limestone is also a part of the older Kennon Limestone (Balce, 1980; Maleterre 1989; Nilayan-Tan, 1994). Analyses for age dating yielded unsuccessful results for this unit thus it remains an unresolved issue. Peña (1998) gave an age of Late Miocene for this unit.

Baguio Formation

De los Santos (1982) describes the formation as composed of pyroclastic rocks overlying the Mirador Limestone located in several areas within Baguio. Peña (1998) also considers the conglomerates on Mt. Santo Tomas as part of the formation which was identified by Dumapit (1966) as Pico Pyroclastics. Several authors also consider the Baguio Formation as equivalent to the Cataguintingan Formation located in some parts of La Union. Age dates for this formation ranges from Late Miocene (Peña, 1998) to Pliocene (Maleterre, 1998).

Figure 2. Literature Map on the studies done on Baguio District



III. Objectives

The main objectives of the study are as follows:

A. To resolve the stratigraphic ages of the Kennon and Mirador limestones.
B. To arrive at an accurate numerical age for the two mentioned limestones using SIS.
C. To demonstrate the usefulness of SIS in Philippine stratigraphy.

IV. Methodology

A. $^{87}Sr/^{86}Sr$ Analysis

The selected bulk limestone samples would be broken into chips and rinsed with de-ionized water in an ultrasonic bath for the removal of pore fluids. It would then be air dried and weighed. Grains of uniform color and texture would then be handpicked with the aid of a binocular microscope. After which the picked samples would be grounded by hand using an agate mortar and pestle. The ground samples would then be sent into a laboratory for Strontium isotope analysis.

B. Assessment of the preservation state of samples

In doing Strotium isotope stratigraphy several methods are needed to ensure accurate data and consequently precise ages are established. As was discussed above different samples have already been utilized in SIS (Strontium Isotope Stratigraphy) and all have been proven to be useful in giving pertinent data whether deep sea cores or outcrop samples. No matter what material is used in SIS the state of preservation of materials used should be assessed (McArthur, 1994). Several tools have been suggested by different researchers in SIS and some powerful tools in measuring alteration will also be applied on this work.

B.1. X-Ray Diffraction

X-ray Diffraction or XRD would help detect crystalline contaminants in the samples to be used. It could detect up to 0.5% of well-crystallized impurities. Although not sufficient enough, with its sensitivity to detect low amounts of alteration especially in aragonite and calcite, XRD is a useful method in SIS.

B.2. Major Element Analysis

Although using XRD analysis could not determine every contaminant in the sample, chemical analysis for major elements would help in the detection of other impurities. Silicate materials for example can be determined by this method as was done by

Whitford et al. (1996) to analyze Darai Limestone samples for SIS. McArthur (1994) further proved the importance of major element analysis in the Recent Namibian phosporite samples. The leaching of Sr from micas due to aggressive dissolution techniques gave higher Sr values for the samples compared to what was expected. Although it is good for samples to be pure, contaminant can still be tolerated if it does not contribute Sr to the analysis (McArthur, 1994). Such is the case of the belemnites from the German Chalk. Although silicified in some portions the unsilicified well preserved parts were still used for analysis and showed a good 87Sr/86Sr record for Cretaceous seawater (McArthur, 1993).

These tools would go hand in hand to test for alteration in the samples. No one tool can stand on its own to determine accurately the preservation state of the material to be used in this work.

C. Micropaleontological Analysis

Strontium isotope stratigraphy on its own would not be sufficient do give precise ages for the Kennon and Mirador limestones. Biostratigaphy would still be needed to tie up with SIS to yield accurate results in this work. Earlier works in other countries such as Indonesia, New Zealand, and Papua New Guinea using land samples have already proven the benefits of biostratigraphy in SIS (Whitford et al., 1996; Allan et al., 2000; Graham et al., 2000; Sharaf et al., 2005).

Samples that would be collected would be subjected to thin section analysis for nannofossils. Earlier works such as Nilayan-Tan (1994), De Leon (1996), and Hashimoto et al. (1969, 1970, 1977, and 1978) would be used as reference in the micropaleontological analysis for this research.

V. Significance of the study

This study would be the first known work of its kind in the country and would aid in the further development of stratigraphy in the Philippines.

One problem in the study of stratigraphy in the country is the availability of biostratigraphically reliable data especially in tectonically active areas. Absolute dating techniques cannot always be applied thus alternative tools should be used. The correlation of SIS and biostratigraphy in this work would help resolve these problems. Using the developing and emerging technology of SIS, it would be possible to arrive at precise ages for problematic areas similar to the Baguio district. This work would also help improve the correlation of other lithology related to the study area.

VI. Results and Discussion

A. Field Sampling and Sample Preparation

During the duration of the research, several fieldworks were made on the study area for reconnaissance and sample collection. Each sample collected has approximate dimensions of 15 cm. by 10 cm. Sample locations were located using a Global Positioning System (GPS) device for accuracy. The samples were cut into 2 cm thick slabs using a rotary marble cutter at Teresa Marble Corporation. Through ocular inspection the most preserved samples were picked for several sample preservation analyses which were all sent to different laboratories.

Figure 3. Kennon Limestone at its type locality in Km. 125-126 in Kennon Road, Baguio City

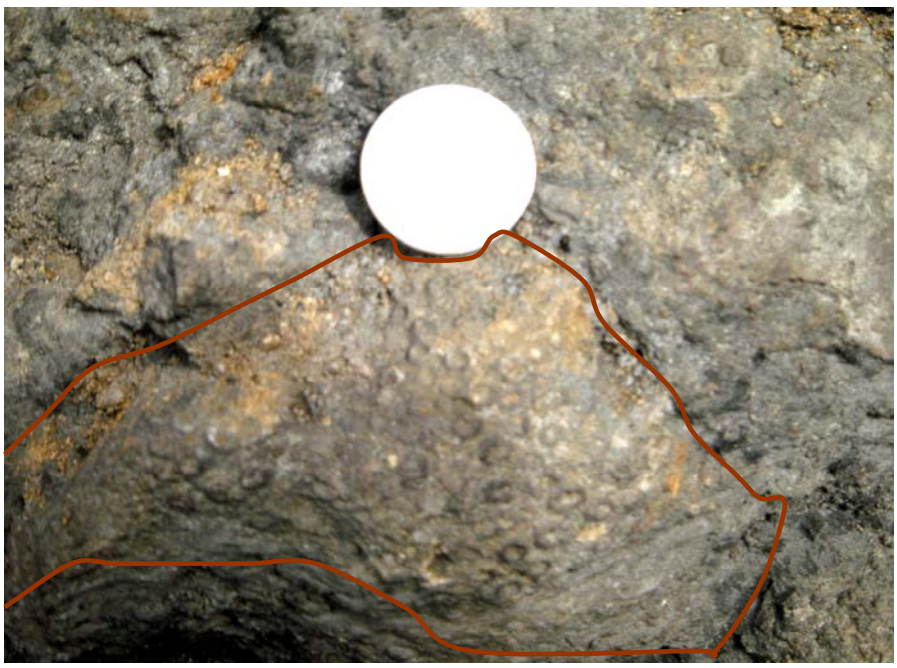


Figure 4. A portion of the Kennon Limestone showing a possible coral head (marked by red border)

Figure 5. Mirador Limestone at its type locality in Mirador Hill below the Lourdes Grotto in Baguio City

B. Assessment of the Preservation of Samples

B.1. X-Ray Diffraction (XRD)

Samples chosen for XRD analysis were cut into 100 gram portions. The samples were sent to Geology and Nuclear Science (GNS) Minerals laboratory in New Zealand for qualitative bulk samples analyses to determine clay fractions present in the limestones. A representative sub-sample is first cut and crushed in a ring-mill to less than 2 mm grain-size. A sub-sample is extracted and ground under absolute ethanol, in an agate mortar and pestle. The ground sample is top-loaded onto a stainless steel powder mount holder which was then analyzed using a Philips X'Pert PRO MPD diffractometer, cobalt k-alpha radiation (40 kV and 35 mA), scanning angular range (2 – 80 degrees 2-Theta), step-size 0.020 degrees, 0.50 second per step, and scanning speed 0.04 degrees per second.

The four analyzed samples yielded different results regarding presence of clay and other alteration minerals. It showed NRMBC-9/3-1 as being most preserved relative to the other samples on the other hand KR-12/8-2 showed the presence of a few alteration minerals such as ankerite and feldspars (Table 3).

Sample ID	Calcite	Ankerite	Quartz	Feldspar	Hematite
KR-12/8-2	A	T	T	T	T
KR-12/8-3	A	M	-	-	-
LGM-12/8-1	A	M	-	-	-
NRMBC-9/3-2	A	-	-	-	-

Table 3. Result of qualitative bulk sample limestone analyses
Note: 1) A – abundant (> 60%), M – minor (5 – 20%) and T – trace (< 5%)

B.2. Major Element Analysis

Samples analyzed for X-ray Fluorescence (XRF) or major element analyses were grounded into powder form using an agate mortar and pestle. The samples were then dried at 110° C. Approximately 25 grams from each sample were sent to Spectrachem Analytical in New Zealand for Loss on Ignition (LOI) and Major Oxides analysis to determine the presence of elements at concentrations from 0.001% to 100% which is ideal for materials of unknown origin or composition. The procedure is calibrated using Siemens standard samples containing known concentrations of all the elements present. Results of the tests showed NRMBC-9/3-2 having the least amount of silicates (0.61%) while KR-12/8-2 having the most amount of silicate in the sample (5.21%).

Major Oxides (%)	KR-12/8-2	NRMBC-9/3-1	KR-12/8-3	LGM-12/8-1
SiO_2	5.21	0.16	0.66	1.11
Al_2O_3	1.66	0.13	0.29	0.57
Fe_2O_3	0.79	0.12	0.17	0.37
CaO	49.17	52.38	54.21	52.51
MgO	1.45	2.62	0.74	2.11
K_2O	0.08	0.01	0.01	<0.01
Na_2O	0.12	<0.01	<0.01	<0.01
SO_3	0.48	0.01	<0.01	<0.01
P_2O_5	0.04	0.09	0.01	0.04
TiO_2	0.08	0.01	0.01	0.02
MnO	0.05	0.09	0.02	0.04
SrO	0.16	0.08	0.06	0.07
LOI	40.51	44.19	43.44	43.11
SUM	99.79	99.88	99.62	99.95

LOI – Loss on Ignition at 1000°C
Table 4. Result Major Element Analysis for the four limestone samples in Baguio

C. Micropaleontological Analysis

The samples were also subjected to nannopaleontology for relative age dating using fossils. The limestones were grounded into powder using an agate mortar and pestle. The powedered samples were then smeared into microscope slides using a DPX mountant. They were then analyzed using a Carl Zeiss phase contrast microscope with a 1000X magnification. Results of the analyses revealed several identifiable nannofossils that are useful for relative dating. LGM-12/8-1 showed the presence of Sphenolithus heteromorphus (Figure 7) which gave an age of NN4-NN5 corresponding to the Early to Middle Miocene. Sphenolithus moriformis(Figure 8) were also found in NRMBC-9/3-1.

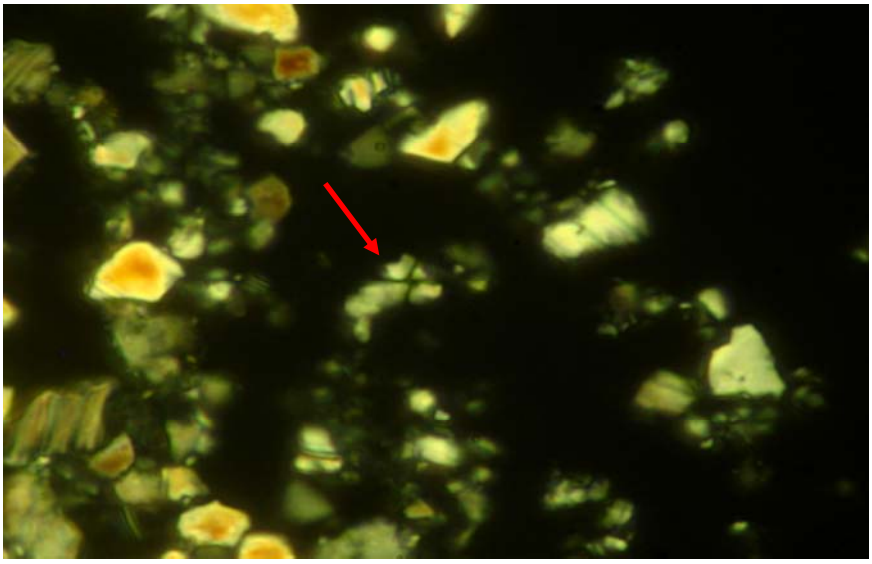


Figure 7. *Sphenolithus heteromorphus* in LGM-12/8-1
(indicated by the red arrow; cross-polars; 1000x magnification)

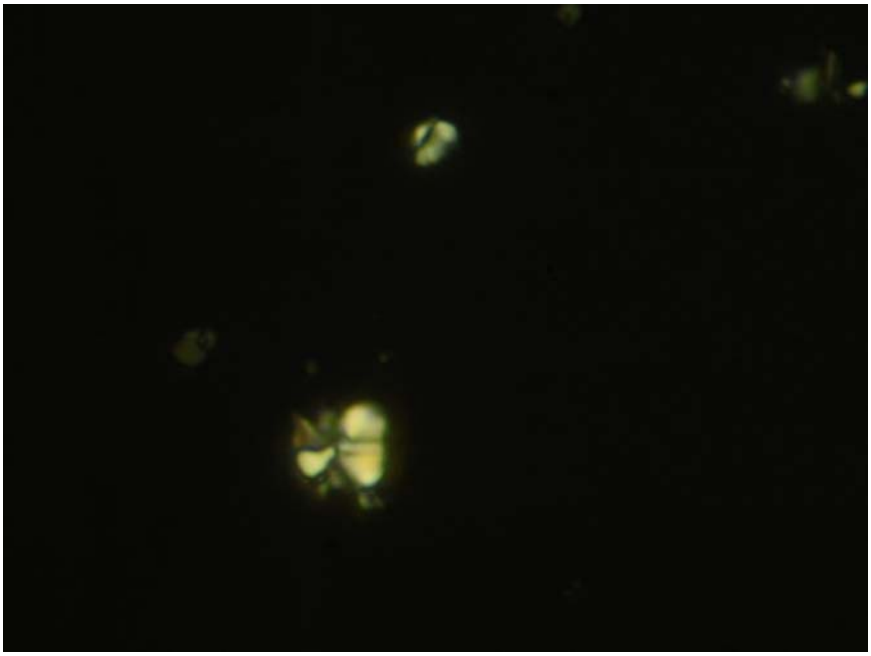


Figure 8. Sphenolithus moriformis in NRMBC-9/3-1
(cross-polars; 1000X magnification)

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Annex 6

CLOSING SPEECH BY ASSISTANT SECRETARY, DEPARTMENT OF ENERGY, PHILIPPINES

DR. FRANCISCO G. DELFIN JR.

at the closing ceremongy of CCOP-DANIDA
Institutional Capacity Building Project ICB-CCOP1
Sulu Sea—East Sabah Basin Case Study Dissemination Seminar
September 26, 2007, Department of Energy

Dr. Hee-Young Chun, Director of CCOP Technical Secretariat
Mr. Liu Liqun, ICB-CCOP Project Coordinator
Mr. Simplicio Caluyong,
Guest and staff of the PRDD

Good afternoon,

By combining Philippine and Malaysian data, this project has led to a better understanding of the evolution of the Sulu Sea Basin. This will eventually increase the prospectivity of the basin, and reduce the exploration risk which is crucial during these times of spiraling exploration costs.

The project has also helped DOE enhance its human resources capacity through technological trainings, donation of software and interaction with our Petronas colleagues.

In view of all these accomplishments, I would like to extend DOE's sincere gratitude, first to the Royal Danish Government for funding this project, to Dr. Hee-Young Chun and the CCOP Technical Secretariat for the administrative support to the project, to Mr. Liu Liqun, the Project Coordinator, Mr. Ioannis Abatzis, Representative of Denmark to CCOP, who unfortunately was not able to attend, to Mr. Simplicio Caluyong, for the constant support from the inception phase of the project to the final completion of the project, and to the research team members who have done a lot of work during the implementation of the project.

In behalf Secretary Angelo T. Reyes, thank you very much and we hope that this will further strengthen the cooperation among the CCOP member and donor countries. Maraming salamat po.