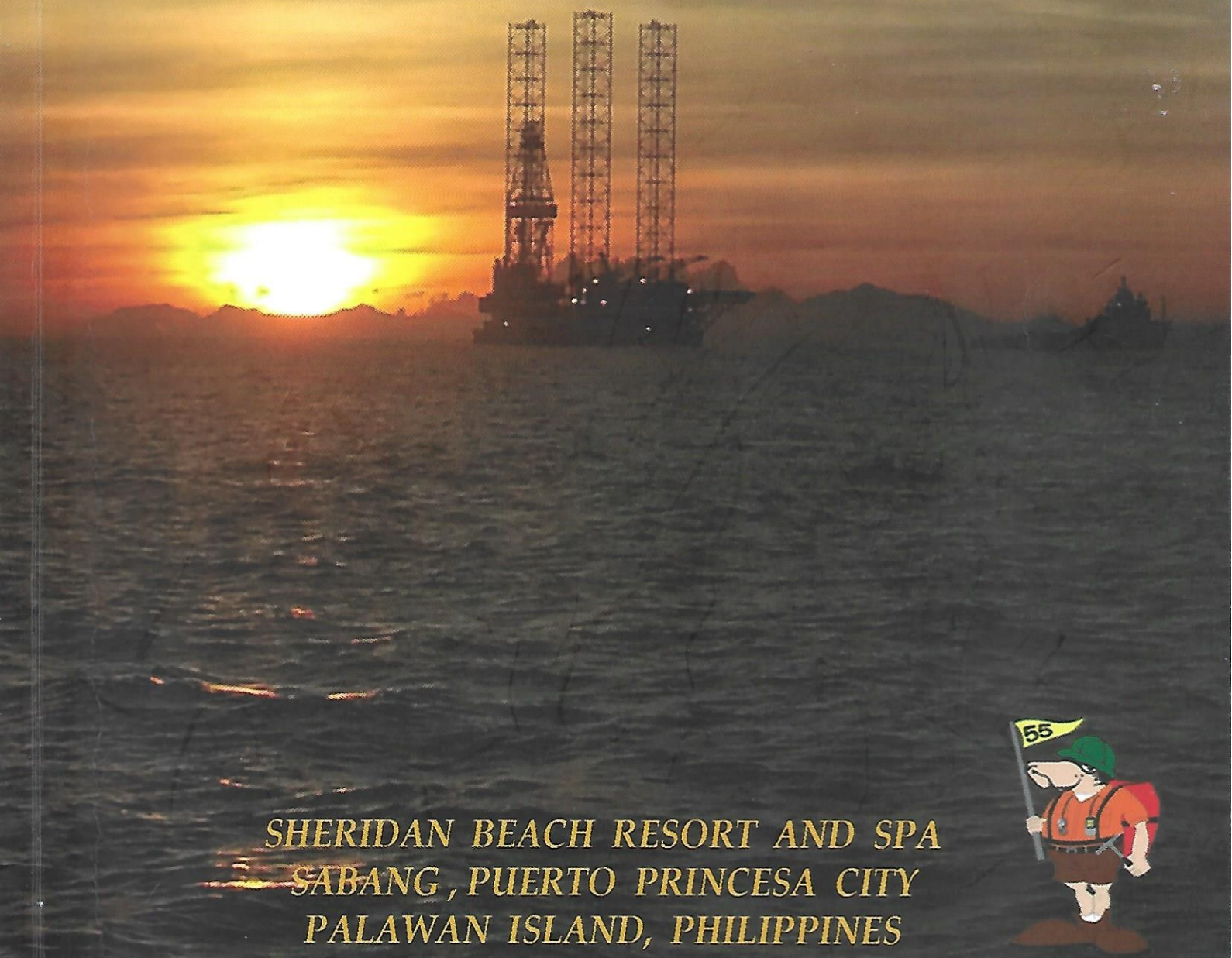
PETROLEUM GEOLOGY AND EXPLORATION OF PALAWAN AND SURROUNDING AREAS

AN INTERNATIONAL OIL AND GAS CONFERENCE
12 - 13 NOVEMBER 2014



SHERIDAN BEACH RESORT AND SPA
SABANG , PUERTO PRINCESA CITY
PALAWAN ISLAND, PHILIPPINES

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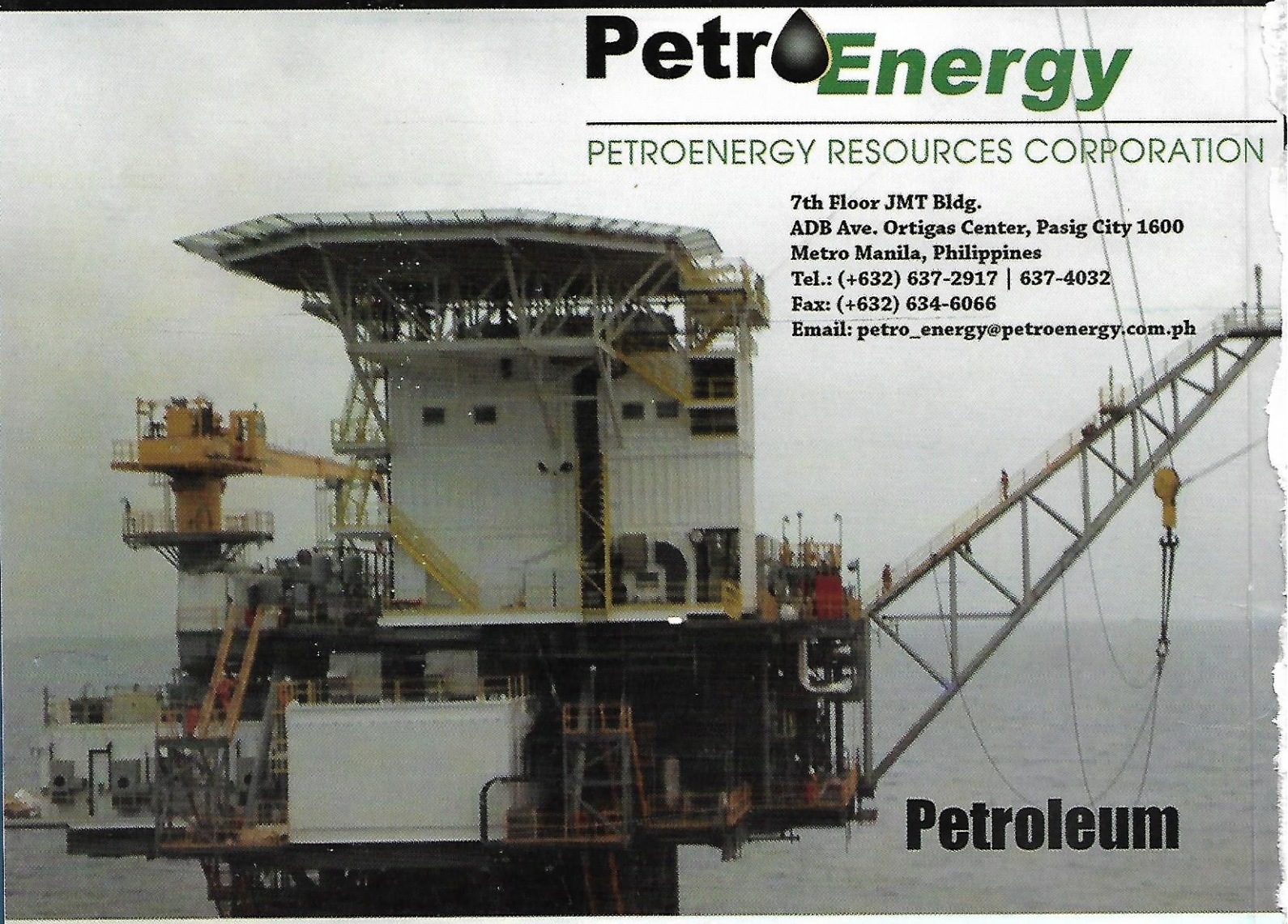
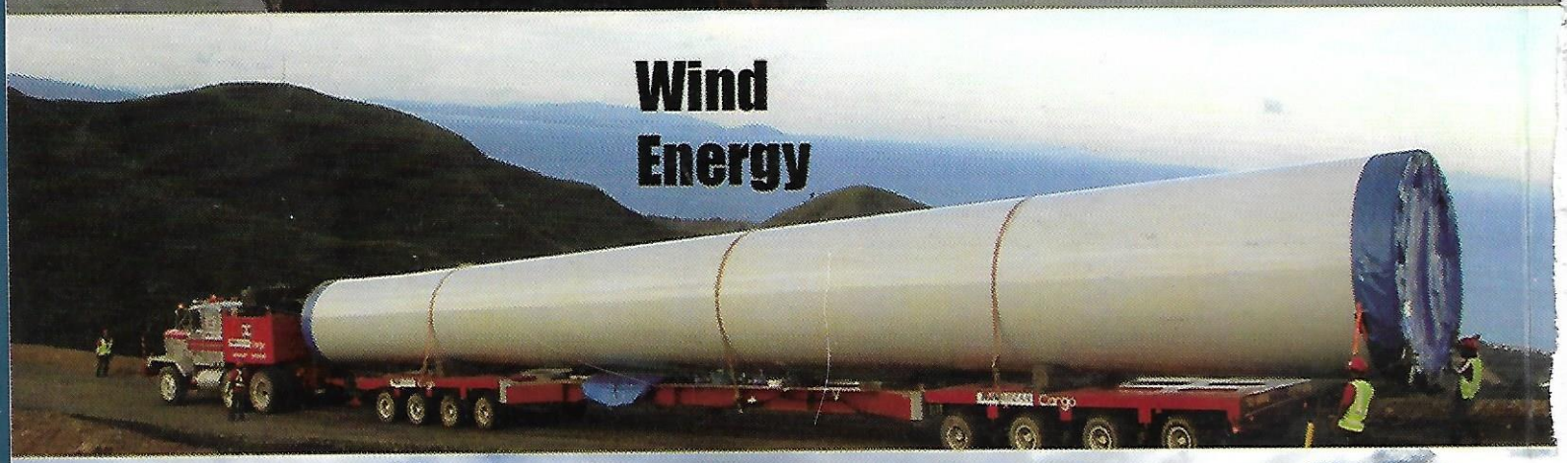




AFAG, Inc.

Association of Filipinos for the Advancement of Geoscience, Inc.

ARTURO A. MORADO, JR.
Chairman, Organizing Committee
Palawan '14 International Oil and Gas Conference
and Field Trip (Palawan '14)
President
Association of Filipinos for the Advancement of Geoscience, Inc.

MESSAGE

15 years ago when we staged a similar conference in Puerto Princesa, we found that Palawan and its people are beautiful and fascinating. After that experience, my co-organizers and I promised ourselves that if we would put up another conference, it would be in Palawan. It took us one and a half decades, but here we are, we made it!

I am very pleased that AFAG continues to further its main objective of promoting geoscience as a tool for nation-building. Palawan '14 aims to be a forum for various workers from different petroleum exploration and production companies and educational and research institutions where information and new ideas on the petroleum geology and exploration of Palawan and surrounding areas are shared and discussed. Additionally, this gathering fosters camaraderie which usually facilitates future contacts and exchange of ideas among the delegates. Ultimately, however, it is our hope that our modest efforts in putting up the Palawan '14 events can help boost the petroleum exploration activities in the Philippines and its neighbors.

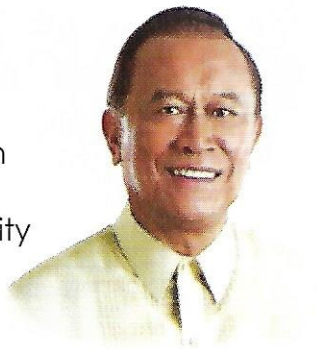
On behalf of AFAG, I would like to express my sincere appreciation of the support given to us by the various local government units of Palawan and our sponsors. Also, thank you to all the delegates to the conference and participants of the field trip. All of you make these events happen and successful.

Congratulations to AFAG, especially to my fellow members of the Organizing Committee.

Salamat po at mabuhay tayong lahat!

ARTURO A. MORADO, JR.

Republic of the Philippines
Provincial Government of Palawan
OFFICE OF THE GOVERNOR
Capitol Complex, Puerto Princesa City



MESSAGE

Welcome everyone to the Palawan '14 International Oil and Gas Conference!

The Province of Palawan, for its development, is focused on its Infrastructure, Health, Education, Livelihood, and Protection of the Environment (I. H.E.L.P.) Program. The contribution of our geologist plays a vital role in attaining the program's objective. Through your effort and resilient dedication, we are able to achieve the necessary knowledge and technicality on how we can attain a truly sustainable developed Province. Palawan, a rich repository of natural gases is truly indebted to all of you who have given your time and effort in order for us to learn and implement the proper extraction, consumption and production of these natural resources, that leads to the economic stability of our beloved Province.

I give my admiration and support to all the men and women behind the Palawan '14 International Oil and Gas Conference, the Association of Filipino for the Advancement of Geoscience, Inc. (AFAG) and the South East Asia Petroleum Exploration Society (SEAPEX), may your relentless dedication in such a noble profession be truly instrumental in achieving a progressive Filipino towards a progressive and sustainable Philippines.

Congratulations and mabuhay!

JOSE CH. ALVAREZ

Republic of the Philippines
DEPARTMENT OF ENERGY
Energy Center, Rizal Drive cor. 34 th Street,
Bonifacio Global City, Taguig

MESSAGE

Greetings to the officers and members of the Association of Filipinos for the Advancement of Geoscience, Inc. (AFAG) as you hold the Palawan '14 International Oil and Gas Conference.

Realizing the potential of the country as a catalyst of power reforms and development, we laud AFAG's initiative of holding such conference that will truly highlight the vast wealth of the country when it comes to energy.

It is our ardent desire that this event signal a positive outlook to the local energy sector that will create an influx in prospective energy developers and investors.

As we look for a brighter future for our thousand-island nation, we anticipate your success and we look forward to the next endeavors of our organization.

You can be assured of the Department's support in all your programs and undertakings.

Mabuhay and more power!

CARLOS JERICHO L. PETILLA
Secretary

Republic of the Philippines
PROVINCIAL GOVERNMENT OF PALAWAN

VICTORINO DENNIS M. SOCRATES
Vice-Governor

MESSAGE

In solidarity with the Association of Filipinos for the Advancement of Geosciences, Inc. (AFAG), it is my pleasure to join in welcoming you all to the Best Island tourist-destination in the World and to this 2014 International Oil and Gas Conference, with the theme, "Petroleum Geology and Exploration of Palawan and Surrounding Areas".

Thank you for choosing Palawan as venue for this important event, which should indeed highlight our vocation to put our natural resources at the service of the human community, "to cultivate and keep the garden" (Gen. 2:15). Allow me therefore to wish you not only a pleasant stay but also a fruitful conference in terms of upgrading knowledge and capacities in your particular field.

Congratulations to the organizers and participants for making this 2014 International Oil and Gas Conference happen!

Mabuhay

VICTORINO DENNIS M. SOCRATES

ASSOCIATION FOR THE ADVANCEMENT OF GEOSCIENCES (AFAG)

The Association of Filipinos for the Advancement of Geoscience (AFAG) is a non-profit, non-stock corporation organized under the laws of the Republic of the Philippines whose main purpose is to promote geology and related fields of geosciences.

AFAG does this through their education and outreach program that engages fellow geoscientists and laymen as well. It is one of the sponsors of a nascent geology degree program in a rural university in the Bicol Region. It regularly conducts seminars and conferences in various fields of geoscience, with particular emphasis on resource development and geohazard identification and analysis.

AFAG has a long-term program with university Geology majors that aims to strengthen their appreciation and understanding of the future profession beyond the academic emphasis of the universities offering Geology degrees. For this purpose, AFAG has a well-organized mentoring system where established geologists give the students insights on the practice of geology based on their actual experiences. The mentoring methods used range from anecdotal sharing to actual field excursions.

AFAG keeps itself abreast of the issues and concerns that impact the geology profession, e.g., sustainability of mining, geohazard and disaster management, and even ethical issues pertaining to the practice of the geology profession.

AFAG believes that a public made aware of the geological underpinnings of our society is better able to cope with geology-based concerns that arise regularly.

Inception

AFAG is not only an association, an organization of geologists. It is a realization of a vision, or a dream, initiated by a band of geology students in 1959 when geologists were a rarity in a sea of professionals. These dreamers - talented, confident of themselves, but sticking out like angular pebbles in claystone, - found a name for themselves: *Association of Filipino Amateur Geologists (AFAG).* From the very start, AFAG made clear that it was not a UP geology organization, but an association of students of geology, no matter from which school they were.

At that time, *amateur* in AFAG meant the days when a ragtag dozen UP students surreptitiously held meetings at the Adamson University, teaching courage and rights and rocks; AFAG was the long bawdy line of dirty jeans perched on two sides of the bridge to the Chemistry Pavilion. Although some professors were wont to dismiss AFAG as an organization of stragglers, still Dr. Mateo Tupas and Ray Punongbayan accepted them with respect, for which we walked tall in the dimly lighted corridors of the 3rd Pavilion.

During those days, they were *amateurs* who basked in the thought that they knew a lot, and the world laid before them like a mountain that they should climb, not merely to take delight in the scenery but to see the rocks.

AFAG was a time of truth and innocent exuberance

The members of AFAG knew that they were smart, but the world of rocks always looked so vast, and places were far away and there they must go. The mountains were Sierra Madre, never

The members of AFAG knew that they were smart, but the world of rocks always looked so vast, and places were far away and there they must go. The mountains were Sierra Madre, never mind if it was just Montalban in view every day. Just talking of the rocks that might be out there was already a joy. They did not know then that there was very little they knew. And they would not have believed had anyone told them so. That was because they were amateur geologists.

They held a piece of rock that they picked from the ground differently. They were always ready to share it with a friend and it somehow acquired a smell of the different hands that held it close to their eyes, so close to their noses. Those little rocks even evolved a characteristic smell that they knew could come only from the fondness of so many hands. That rock-smell was part of their being young, of being an amateur geologist, when they showed a piece of rock even to a special friend the way another would have offered a little flower. That was when rocks were a wonder and even brought romance.

Core values

Now, many years later, and with so many accolades and names appended to the top roster of many mining and oil exploration companies, *AFAG* is a respected name. They have become professionals who have made some contributions in the practice of geology. They have imbibed certain core values as they made progress in their work as professionals. These core values are: Global Awareness, Environmental involvement, Objectivity, Social responsibility, Competence, Integrity, Excellence, Nationalism, Camaraderie, Entrepreneurial spirit. Taken together, these core values spell GEOSCIENCE.

AFAG has since been renamed Association of Filipinos for the Advancement of Geosciences in 2003.

A few of them have strayed from the chosen path of geological career, but these core values remain close to their hearts, they find comfort in the folds of the organization and proud to be part of it.

For all their success, they have not rested in their efforts to advance geosciences. They continue to grow, blossom and bear fruit; they rise up, layer by layer; they flow into cracks and crevices, leaving gems of wisdom behind.

Fifty-five years have elapsed since AFAG came into being, the number of geologists have multiplied since then. AFAG has also grown, but the members have not forsaken their *AFAG* roots.

PALAWAN '14 CONFERENCE PROGRAM		
Tuesday, 11 Nov		
1400 - 1700	Registration	Convention Center Lobby
1800 - 2100	Icebreaker	Lawn and Gazebo Area
Wednesday, 12 Nov		
Time	Paper	Author/s
0800 - 0930	Registration	Convention Center
0930 - 0945	Opening Address	Arturo A. Morado, Jr.
0945 - 1000	Welcome Address	Governor Jose C. Alvarez
1000 - 1030	Keynote Address	Sec. Jericho Petilla
1030 - 1100	Coffee Break	Convention Hall Room C
1100 - 1130	Oil Price : The Big Picture	Lyrna Esmeralda-Hewitt
1130 - 1200	Using Oligocene to Pliocene limestone formations to constrain the collision history of Palawan Island and the Dangerous Grounds at the southeastern margin of the South China Sea	Stephan Steuer, Dieter Franke, Florian Meresse, Dimitri Savva, Manuel Pubellier, Jean-Luc Auxietre
1200 - 1230	The East Palawan Basin: A New Perspective on Petroleum Prospectivity	Ballesteros, Mark
1230 - 1400	Lunch Break	Restuarant
1400 - 1430	Helping to Unlock the Resources of the Philippines and the South China Sea with SAR and VHR Satellite Imagery	Wiiliams, Alan
1430 - 1500	The Wedge Side Story NW Palawan Inboard Half-Graben System	Mambuay, Lara Angeli T., Karla S. Valdellon, and Dennis V. Panganiban
1500 - 1530	Gravity-Magnetic Lineaments in Recto Bank, West Philippine Sea	Manuel, Geronimo A., Carlos, Daniel. P., Collar, Frank, Pellejera, Nicole.B.
1530 - 1600	Coffee Break	Convention Hall Room C
1600 - 1630	When Seismic is Not Enough - A Case Study Utilizing Full Tensor Gravity for Hydrocarbon Exploration in the Palawan Region, Philippines	Mataragio, James
1630 - 1700	Calcareous Nannofossil Biostratigraphic Studies on Selected Sedimentary Formations in the Visayan Basin	Allan Gil S. Fernando, Adrian Raymund C. Fernandez, Clarence Y. Magtoto, Jose Dominick S. Guballa, Abigael L. Castro, Yolanda M. Aguilar, Kevin L. Garas, Yukito Kurihara, Ryoji Wani, Hiroki Hayashi, Robert G. Jenkins, Takehiro Nanjo, Shungo Kawagata, Chie Kusu, Akari Okada, Hideki Wada, Ryuichi Majima and Tomoki Kase
1700 - 1730	Young Volcanism in northern Palawan: Mt. Bugtong Bukid and the Origin of Lake Manguao (Danao)	Dr. Carlo A. Arcilla and James Refran
1900 - 2200	Dinner and Cultural Show	Lawn and Gazebo Area

Thursday, 13 Nov		
0900 - 0930	Reservoir Characterization of Pagasa and Lower Matinloc Formations by Using AVO and Multi-Attribute Analysis, Southwest Palawan Basin, Philippines	Mia Urbano
0930 - 1000	The Development and Regional Setting of the Sandakan Basin	Lunt, Peter
1000 - 1030	Identification of Stratigraphic Hydrocarbon Accumulations using the Controlled Source Electromagnetic Method	Filipov, Allan
1030 - 1100	Coffee Break	Convention Hall Room C
1100 - 1130	Tectonic Comparison Between the Palawan and the Northern South China Sea Continental Margin	Chun-Feng Li,, Wei-Nan Liu, Jiabiao Li, Hesheng Shi
1130 - 1200	Regional Satellite Gravity Interpretation, NW Palawan and Recto Bank Area	Collar, Frank
1200 - 1230	Play Based Exploration - Frontier to Nearfield/Infield Settings	Gerhard J. Brink
1230 - 1300 1300 - 1330 1330 - 1400	Lunch	Restaurant
1400 - 1430	The Petroleum Potential of the West Luzon Basin: Analogy with the Mindoro Basin?	Ballesteros, Mark
1430 - 1500	Reconstruction of the Tectonic Evolution of Palawan Island and Surrounding Seas Using Onshore Structural and Offshore Seismic Data	Kristine Joy Taguibao, Mario Aurelio, Monina T. Forbes, Manuel Pubellier, Dimitri Savva, Coleen Carranza, Florian Meresse, Dieter Franke and Stephan Steuer
1500 - 1530	Geometry of the Nido Limestone and Related Carbonates: Insights to a Mid-Neogene Bimodal Structural Deformation the Edge of a Thinned Continental Microplate.	Aurelio, M.A., Morado, A.A., Taguibao, K.J. L., Forbes, M.T., Franke, D, and Steuer, S.
1530 - 1600	Coffee Break	Convention Hall Room C
1600 - 1630	Revisiting the Petroleum Prospectivity of the Shallow Water Portion of NW Palawan, Philippines	Morado, A. A., et al
1630 - 1700	The Baragatan 1A Well: Implications for Offshore SW Palawan Exploration	Jaime A. Bacud, Monina T. Forbes and Raymundo B. Savella
1700 - 1730	PECR5	Guillermo H. Ansay
1730 - 1830	FIELD TRIP BRIEFING	Anthony Ferrer, Mario Aurelio
1900 - 2200	Dinner	Lawn and Gazebo Area

Oil Price: The Big Picture

Lyrna L. Esmeralda-Hewitt
Synergy

Abstract

We saw crude prices sharply rise to US$143.95 per barrel in July 2008, and we saw it bottom out to US$39.41 in February 2009. Since then, we saw prices climbing steadily to finally stabilize at a price band of US$100-120 per barrel. Beginning June 2014, we saw prices declining, breaching the price floor of US$100 per barrel in September and now approaching the US$80 per barrel price level.
Why is there no cause for alarm?

There are three factors that affect the oil price (or any commodity for that matter): overall financial liquidity, market fundamentals, and lastly market sentiment. "Liquidity" reflects the volume of money available in the market to buy a particular asset class. The term "market fundamentals" captures classical supply-demand analysis. "Market sentiment" is more difficult to define but it is in essence the overall attitude of investors toward a particular asset, security or a larger financial market.

These three factors have in the last few months caused a significant decrease in oil prices. Notwithstanding this decrease, we believe that the outlook for the oil market, and the markets that are inextricably linked to it by substitution economics, remains cautiously optimistic. This view is grounded in an appreciation of the historical price patterns, their causes, and an understanding of current and future production costs. The demand for energy and petroleum products, despite modest growth in large economies, will continue to increase apace with population growth; supply, however, remains shrouded in the application of technology, the outcome of war and exploration campaigns, and, the often changeable decisions of regulators.

Lyrna L Esmeralda-Hewitt is a Senior Economist at Senergy within the Reserves and Asset Evaluation practice of the UK firm. She provides commercial and technical advisory services on acquisitions and divestments, commercial negotiations, asset evaluations, company valuations, strategic planning, economic analysis, exploration evaluation, competent persons reports, reserve and resource estimation, unitisation services, and expert advice services. She is the incumbent Section Secretary and Program Co-Chair of the SPE Singapore Section and a member of the Asia Chapter Committee of the Association of International Petroleum Negotiators. She is also an active member of SEAPEX. She holds a BSc in Economics degree from the University of the Philippines and an MBA from the Ateneo de Manila University.

Using Oligocene to Pliocene Limestone Formations to Constrain the Collision History of Palawan Island and the Dangerous Grounds at the Southeastern Margin of the South China Sea

Stephan Steuer[1], Dieter Franke[1], Florian Meresse[2], Dimitri Savva[3], Manuel Pubellier[3], Jean-Luc Auxietre[2]

[1] Federal Institute for Geosciences and Natural Resources BGR, Stilleweg 2, 30655 Hannover, Germany, stephan.steuer@bgr.de
[2] Total E&P Exploration, 2 Place Jean Millier, 92078 Paris La Défense Cedex, France
[3] École Normale Supérieure ENS, 24 Rue Lhomond, 75231 Paris Cedex 5, France

Abstract

The link between the deformation of southern and central Palawan Island and the deformation of the adjacent offshore wedge is investigated. The wedge is a continuation of the Palawan fold and thrust belt and bounds the Borneo-Palawan trough to the Dangerous Grounds and to Palawan Island.

Key parameters for the understanding of the development of this wedge are two limestone formations: The Oligocene to Middle Miocene Nido Limestone and the Upper Miocene to Lower Pliocene Tabon Limestone. While the Nido limestone is widely distributed in the area, the Tabon Limestone is restricted to the western shelf of southern and central Palawan Island. The initiation of the thrust belt formation and also the development of the Borneo-Palawan trough is constrained by the Nido limestone, which was deposited from shortly before the breakup of the eastern South China Sea (~35 Ma, (Barckhausen and Roeser, 2004)) until the Early Miocene. It likely developed on top of a forebulge of the Borneo-Palawan wedge and can therefore be linked with the collision of the Dangerous Grounds and Borneo. The end of the wedge development can be constrained by the Tabon limestone. With an age of ~9 to ~4 Ma, this limestone sequence overlies unconformably the offshore wedge.

Further offshore, the seismic reflector associated with the top of the Nido platform limestone (18-20 Ma) can be used to constrain the timing of the unconformities and the rifting and collision history of the Dangerous Grounds. This platform is continuous in the Palawan-Borneo trough and gets patchy towards the Dangerous Grounds. In the Dangerous Grounds the image of this key reflector changes and here it merely forms the top of a clastic layer. Carbonates remain abundant but mainly as isolated reefs that grew on top of tilted fault blocks.

The unconformity characteristics supplemented with tentative ages indicate that Luconia and the southern Dangerous Grounds were sub-aerial during the Early Miocene, while the Reed Bank, the northern Dangerous Grounds and parts of the central Dangerous Grounds were mostly submerged except for some islands concentrated on the western edge of the Borneo-Palawan trough. This trough is interpreted as a foreland basin where the flexural forebulge provided shallow marine conditions that promoted reef growth. As the carbonate deposition migrated from the Borneo-Palawan trough towards the Dangerous Grounds we suggest that this flexural forebulge also migrated eastward.

References:

Barckhausen, U., Roeser, H.A., 2004. Seafloor spreading anomalies in the South China Sea revisited, in: Clift, P., Kuhnt, W., Wang, P., Hayes, D.E. (Eds.), Continent-Ocean Interactions in the East Asian Marginal Seas. American Geophysical Union, Geophys. Monograph Series, pp. 121-125.

The East Palawan Basin: A New Perspective on Petroleum Prospectivity

Mark Ballesteros
Searcher Seismic

Abstract

The basins adjacent to the island of Palawan are the most prolific hydrocarbon producing areas in the Philippines. To date, however, all of the production and most of the exploration effort has been focussed on northwest Palawan. A recent review of the area based on new regional seismic data (Ballesteros & Robinson, 2012) has identified significant depocentres in the East Palawan Basin that were largely undocumented previously and suggests the area could have significant hydrocarbon potential.

Although the potential of the East Palawan Basin has be recognised previously (eg. Poblete and Morado, 2000), the lack of sufficient, good quality data has hampered efforts to address some key risks. These concerns include an apparent lack of depocentres of sufficient thickness and/or aerial extent to contain adequate volumes of potential source rocks, the perception that the area has low geothermal gradients and therefore any source rocks that may be present are likely to be immature and lack of good quality reservoirs due to the prevalence of volcanic-rich source provenance.

Review of the available (although sparse) geological data in conjunction with the new regional seismic data provides reason for encouragement on all these fronts and reinforces the potential for significant petroleum potential in the area.

The new seismic data provides clear evidence for the existence of Paleogene rift basins in the East Palawan area that were previously not documented due to poor seismic data quality. Total sediment thickness exceeds 8,000 m in some areas. The rifts appear analogous to the Paleogene basins of northwest Palawan that are typically considered the primary petroleum system in that area. In addition, a second phase of rifting is interpreted in the Miocene, concurrent with the proven petroleum system in the Mindoro Basin.

Oil and gas shows in the Dumaran-1A well, located on the western flank of the East Palawan Basin, provide evidence that a working petroleum system exists in the area. Good quality source rocks are evident in the Lower Miocene sediments in the Mindoro Basin, and similar depositional environments may have been present in the northern part of the East Palawan Basin. A burial history reconstruction calibrated using data from the Managuin-2 well from the Mindoro Basin indicates substantial volumes of Miocene and older sediments in the northern East Palawan Basin are likely to be mature for the generation of oil and gas. Taken together, this evidence supports the potential for the presence of a working Miocene petroleum system in the area. Additional potential exists for a Paleogene petroleum system by analogy with Northwest Palawan Basin.

Finally, a review of well data from the area indicates widespread deposition of continentally-derived, quartz-rich sandstone during the Miocene, probably eroded from the Cuyo-Mindoro Platform. These sandstones provide good quality reservoirs in many locations and are considered likely to be present in the East Palawan Basin.

In summary, the available data suggests the East Palawan Basin has all the necessary ingredients for one or more viable petroleum systems that could result in large hydrocarbon accumulations. The area is very poorly explored and appears to provide an excellent opportunity for new exploration initiatives.

References

Ballesteros, M. and P. Robinson, 2012, Insights into the Petroleum Potential of the Western Philippines from New Regional Seismic Data, AAPG ICE Singapore. AAPG Search and Discovery Article#10471. www.searchanddiscovery.compdfz/documents/2012/10471ballesteros/ndx_ballesteros.pdf.html

Poblete, R. G. and A.A. Morado, 2000, The NW Sulu Sea Basin, Philippines An Attractive Frontier Area for Petroleum Exploration. www.doe.gov.ph/microsites/archives/win_opp/cd/POBLETE/nw_sulu_sea_basin_master.htm

Helping to Unlock the Resources of the Philippines and the South China Sea with SAR and VHR Satellite Imagery

Alan Williams
CGG-NPA Satellite Mapping

Abstract

The unexplored central part of the South China Sea which lies between Vietnam, the Philippines, Brunei and Malaysia, variously referred to as the Spratlys Islands, the Farasan Islands or the Nansha Islands, has the potential to provide the SE Asia economy with major resources of both energy (oil & gas) and food (fisheries). The existence of commercial oil and gas discoveries in adjacent parts of the Philippines, Vietnam, Brunei and Malaysia which are direct analogues of this part of the South China Sea is tantalising. However, progress towards accessing these resources has been complicated by the lack of an agreed base map as much of the charting of this region dates back to the 19th century. A recent satellite remote sensing study by NPA Satellite Mapping is helping to address these issues by providing a new, fully independent digital map using multi-pass medium and high resolution optical data.

Satellite SAR (Synthetic Aperture Radar) is a proven oil seep detection method which in this region has identified groups of repeating slicks, some of which have been subsequently developed as oil discoveries. Examples from the Sabah Basin in Malaysia and the Kutei Basin, Indonesia will be shown. Similar seep signatures have been mapped in undrilled parts of the South China Sea region which hint at the existence of new petroleum systems.

Conventional optical data has also been effective in remapping all surface and shallow water features and has identified some errors in existing charts, as in parts of the South Palawan Basin. Such information is crucial when planning new seismic acquisition in shallow water areas of pinnacle reefs such as Reed Bank.

VHR data (0.5m resolution) has also proved effective in identifying the true nature of surface features, and also in monitoring construction activities on occupied islands, reefs, cays and rocks within the Spratlys region.

The Wedge Side Story: Northwest Palawan Inboard Half-Graben System

Mambuay, Lara Angeli T., Valdellon, Karla S. and Dennis V. Panganiban
The Philodrill Corporation

Abstract

It is generally believed that the hydrocarbons of the producing fields in and around Service Contract 6B were generated and sourced from the Malampaya half-graben west of the productive carbonate reef area. Migration to the east was vertically facilitated by the main bounding fault of the half-graben. This study presents a modified play concept of NW Palawan invoking the existence of an inboard half-graben system whose up-thrown ramp is the present locus of the producing fields in and around SC 6B. The location and orientation of the inboard half-graben can be discerned from the observed thickening of the Pre-Nido section from the carbonate platform area towards the east as mapped on 3D seismic. Geochemical studies undertaken by previous workers indicate a different oil signature for the producing fields in this area as compared to oils in the Galoc/West Linapacan and Calauit areas. This may be due to the different source areas for these oils. Proving the existence of this in-board half-graben system will open up new exploration areas in the NW Palawan basin. Future follow-on work is planned to further define the existence, extent, orientation, size and petroleum productivity of this in-board system.

Gravity-Magnetic Lineaments in Recto Bank, West Philippine Sea

Manuel, G. A.[*] Carlos, D. P.[*], Collar, F.[**], Pellejera, N.B.[*]
[*]Forum (GSEC 101) Limited
[**]Cosine Ltd.

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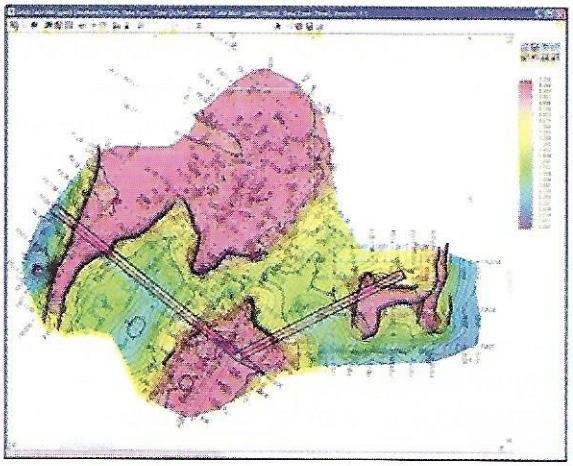

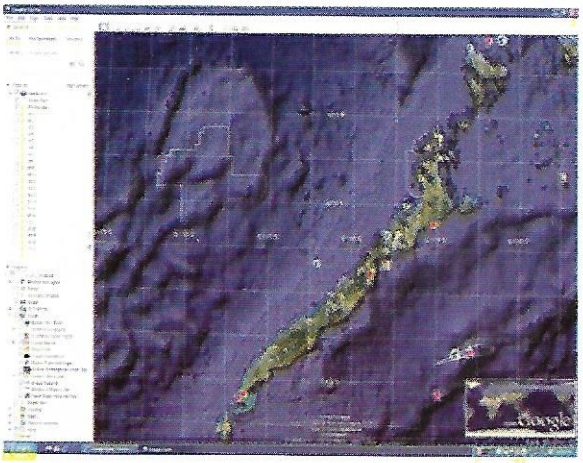

The Recto Bank is a group of shallow reef platforms around 40 meters deep with abundant pinnacles growing to 6 meters or less below sea level. It covers an area of around 12,000 sq km and is situated approximately 70 nautical miles west of Palawan Island. Current geologic theories suggest that the underlying basement is fragmented due to extensional stresses. Beneath the platform limestones are Oligocene to Early Cretaceous clastic sediments, with some rare carbonates. In the deep waters, seismic data indicate the shallow sediments to be of clastic lithology. While the boundaries between shallow and deep areas are already manifestations of deep crustal lineaments, further investigation is needed to map them and ascertain the underlying structural style. Forum acquired 2200 km of marine gravity and magnetic data in 2011 and had these processed and interpreted by geophysical contractors. Owing to the geologic complexity of the area, a review of this interpretation and the employment of a new approach to the isolation of geophysical anomalies is attempted in order to gain insights on the sub-carbonate geology.

When Seismic is Not Enough - A Case Study Utilizing Full Tensor Gravity for Hydrocarbon Exploration in the Palawan Region, Philippines

James Mataragio and Colm Murphy
Bell Geospace Inc

Abstract

The offshore Palawan and Sulu Sea basins occur within the rifted stable block that separated from mainland China as a direct consequence of the opening of the South China Sea during Oligocene time. These prominent sedimentary basins include NW Palawan, SW Palawan, The Reed Bank and Sulu Basins. They are characterized by complex extensional and compressional structures such as thrust faults, steeply dipping normal faults, half-grabens and fault blocks.

For many years hydrocarbon exploration in the Palawan region has been focused on understanding the tectonic history and deposition mechanisms of basins in relation to complex structures that have later reshaped the basins and formed potential hydrocarbons traps. Seismic data has been an important and integral part of the exploration workflow for subsurface imaging. However, due to the tectonic complexity of this region, the growing interest in exploring deeper parts of the basins has been hindered by little or no data coverage. New players venturing to explore in new areas of deep waters have been forced to acquire new data to supplement the limited data available. In order to justify the high costs involved and maximize the acquisition of high resolution seismic, potential areas for detailed work must first be prioritized using cost effective but less expensive techniques.

Airborne Gravity Gradiometry surveys are cost effective and can cover relatively large areas within a short amount of time. The technique is suited for both frontier- and prospect-level exploration. Airborne Gravity Gradiometry has been used with success in the past for mapping structures similar to those characterizing Palawan basins therefore assisting in seismic interpretation.

In May 2012 a high resolution Full Tensor Gravity Gradiometry survey was flown over the southern part of Mindoro Island, Philippines to assist in imaging sub-surface structures. Subsequently, the data was used to interpret structures where none or limited seismic data existed. Additionally, the data was used to confirm or better define the structures previously seen in seismic profiles and to identify new features.

In this paper a case study from Mindoro is presented to demonstrate how exploration initiatives in the Palawan basins could benefit from using the Full Tensor Gravity approach that was successfully used in adjacent Mindoro Island.

Calcareous Nannofossil Biostratigraphic Studies on Selected Sedimentary Formations in the Visayan Basin

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Abstract

The Visayan Basin is a northeast-southwest trending sedimentary basin located in the central part of the Philippines. The basin consists of Cretaceous volcanic flows and intrusives, and folded and slightly metamorphosed Cretaceous sediments that are overlain by Eocene and younger sedimentary formations, including the marine sediments that were deposited from Late Oligocene to Pleistocene (Porth et al., 1989). Although the Visayan Basin has been targeted for petroleum exploration over the past 100 years (e.g., Rillera and Durkee, 1994), very few calcareous nannofossil studies have been done in the area (e.g., Muller et al., 1989; Fernando et al., 2008; 2013). Since 2003, however, several fieldworks have already been conducted in the Visayan Basin as part of the research program on the "Cenozoic molluscan faunal study and refinement of Cenozoic formations in the Philippines" by the Mines and Geosciences Bureau, Philippines (MGB) and the National Museum of Nature and Science, Tokyo (NMNS). As part of this program, samples for microfossil analysis (mainly foraminifera and calcareous nannofossils) were collected to establish the age of the mollusk-bearing units and, at the same time, refine the stratigraphy and age of the sedimentary formations where the fossil mollusks were collected. The present study covers selected sections from Bohol Island, southeast Negros and northwest Leyte.

Bohol Island

In Bohol Island, nannofossil analysis of the samples resulted to the recognition of a Late Miocene sedimentary unit (sandstone-siltstone sequences) in the municipality of Danao that was previously mapped as part of a Middle Miocene Formation. The NN11 (CN9) nannofossil zone was established based on the occurrence of the nannofossil markers *Discoaster quinqueramus* and *Discoaster berggrenii*. The mollusk-bearing sandstone-siltstone sequences are tentatively included in the "Danao Clastics", a proposed lithostratigraphic unit in the island. An ongoing sedimentological study and calcareous nannofossils analysis of recently collected samples aim to clarify and verify the stratigraphic relationship of the "Danao Clastics" with the other lithostratigraphic units exposed in the area.

Negros Island

In Negros Island, where several sections were investigated, the results include:

a) the recognition of a Late Oligocene sedimentary unit in southeast Negros that was previously mapped as Late Miocene to Early Pliocene;
b) confirmation of the Late Oligocene to earliest Miocene age of Escalante Formation (assigned to NP24 - NN1 nannofossil zones) based on the occurrence of marker taxa like *Cyclicargolithus abisectus, C. floridanus, Reticulofenestra bisecta, R. daviesii, Discoaster deflandrei, Helicosphaera recta, Sphenolithus ciperoensis, S. distentus, S. predistentus* and *S. delphix*; and
c) Revision of ages of several sedimentary formations in Candoni (west-central Negros Island) using both calcareous nannofossil and planktonic foraminifera data.

The result of the nannofossil studies in the southeastern part of Negros Island is significant as it is one of the few localities in the Philippines where the fossil mollusk *Vicarya* can be found. The Oligocene age obtained from calcareous nannofossils, therefore, suggests that Negros Island includes the oldest fossil record of *Vicarya* in the Philippines and probably in Asia.

Northwest Leyte

Northwest Leyte is located in the northeastern part of the Visayan Basin. The area is known as one of the very few localities in the world with well-preserved fossils of chemosynthetic mollusks representing cold-seep assemblages (Majima et al., 2007; 2010). Investigation of several sections revealed a diverse assemblage of Pliocene to Pleistocene calcareous nannofossils. The nannofossil assemblage observed in the samples confirms the Pliocene age of the chemosynthetic mollusk assemblages which occur within the NN12 - NN15 nannofossil zones. The Pliocene is recognized based on the occurrence of *Amaurolithus tricorniculatus, Ceratolithus armatus, Discoaster tamalis, Discoaster blackstockae, Reticulofenestra pseudoumbilicus* and *Sphenolithus abies*. The Pleistocene, on the other hand, is recognized based on the occurrence of large (>5um) *Gephyrocapsa* spp., large circular forms of *Pseudoemiliania lacunosa* and the LO of *Calcidiscus macintyrei*.

Based on the established nannofossil biostratigraphy, there is a considerable gap within the investigated sections, corresponding to the NN16 – NN18 nannofossil zones. This suggests an erosional and/or non-depositional event spanning at least 1.8 million years during the Late Pliocene. This can correspond to the basin-wide unconformity during the Late Pliocene-Pleistocene interval reported in the Visayan Basin (Porth et al., 1989). A diverse assemblage of the nannofossil group known as scyphosphaerids is also reported from the Pliocene mudstones of the investigated sections, within the NN13 – NN15 nannofossil zones. This probably corresponds to the abundance acme of the genus previously reported by Siesser (1998) from the Late Miocene to Late Pliocene interval (NN9 - NN15 nannofossil zones). This study marks the first documented observation of this event in the Philippines that can be very useful in biostratigraphic, paleoceanographic and paleoenvironmental studies, particularly in the Visayan Basin.

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Young Volcanism in northern Palawan: Mt. Bugtong Bukid and the Origin of Lake Manguao (Danao)

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Abstract

The most common perception of Palawaln is that of a currently inactive geologic terrane, with no earthquakes and volcanoes. Based on mapping by students of the NIGS, UP Diliman and some geochemical data, we discuss the nature of the volcanic field in Bugtong Bukid, Calauag, Taytay, Palawan which is probably, in terms of area covered, the largest Recent volcanic flow in the Philippines! This volcanic eruption, yet undated, is probably Recent but now inactive. The lava flow was fluid, and its large extent was able to dam an active stream which eventually formed Lake Manguao (or Lake Danao), which is one of the largest freshwater lakes in the Philippines. The lavas are remarkably fresh, and preliminary geochemical data suggest these are free from subduction signatures, making them the only lavas of their kind in the Philippines todate. The geochemical signature of the lava suggests it formed similar to OIB or rift-related volcanoes, but more study is needed to pin down its petrologic origin. The geomorphic youth of the lava flows is also shown in the absence of developed drainage systems where the lava flows meet the ocean near the Calauag area. The marine-biological implication of this is that the beaches and nearshore areas in the lava zones are relatively free from terrestrial fluvial input, explaining in part why extensive pearl farming can be conducted in proximal areas. The mysterious origin of the volcano should not threaten the geologically "stable" nature of Palawan because it is not likely to erupt again (soon), but even makes the geological story of the Palawan islands more exciting.

Reservoir Characterization of Pagasa and Lower Matinloc Formations by Using AVO and Multi-Attribute Analysis, Southwest Palawan Basin, Philippines

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Abstract

Several distinct high amplitude anomalies occur in both the Lower Matinloc Formation and Pagasa Formation equivalent in the Southwest Palawan Basin, Philippines. The main objective of this study is to conduct a thorough investigation on the nature, occurrence, extent and reservoir potential of these high amplitude anomalies. This study explores the possibility that either these high amplitudes are associated with reservoir sands. On a regional scale, the cross plot analysis for all the wells revealed that no generalized P-Impedance and Gamma Ray (GR) relationship could be established for the whole area. However, P-Impedance can be an effective lithology indicator when the cross plot analysis is applied in small intervals and over small regions. Similarly, density was able to discriminate sands from shales in the Lower Matinloc Formation (Upper Miocene Section). But it is not a good lithology discriminator for other formations. Due to great variations of rock physics parameters, it is required to establish local relationship before computing multi-attributes or applying inversion techniques. Fluid replacement modeling and AVO analysis indicate that water wet and gas saturated sands have same AVO response. The sands can be classified as Type 2 and Type -4, per Young et. al., (2003) AVO response classification. Multi-attribute analysis and GR prediction showed that the high amplitude anomalies are associated with shale to shaley sands. The bright amplitudes in the area correspond to shales. Therefore, these bright amplitudes are not associated with reservoir or fluids.

Keywords: Acoustic Impedance, AVO Modeling, Multi-Attribute Analysis, Southwest Palawan Basin

The Development and Regional Setting of the Sandakan Basin

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Abstract

Exploration in the Sandakan Basin is focussed on a sequence of Late Miocene sediments that are analogous to Late Miocene deposits in Brunei, NW Sabah, Tarakan and Kutei. This review looks at why the Sandakan clastics are closely analogous to these adjacent, and commercially very important, petroleum systems; what initiated deposition and therefore what is the Sandakan Basin? What is the composition of the clastics, as well as what was the timing and control of tectonism and burial history that allowed hydrocarbon generation and entrapment?

Such a large-scale review requires a regional sedimentary framework, but existing reconstructions are hampered by the difficulty of combining onshore mapping work with oil industry data from younger sections offshore, and with data crossing between Malaysian and Philippine jurisdictions. In addition there is a strong contrast between the history of the west (south Palawan and NW Sabah) and the east (the Dent Peninsula and the Sandakan Basin), each with a very different tectonic setting.

The Middle Miocene and older sections also have some hydrocarbon potential. In the overthrust, imbricated (and strongly eroded) western area are the Aboabo gas discovery, the Tiga Papan oil field, as well as oil seeps in older rocks such as on the Kudat Peninsula and possibly on Balabac island. In the less disturbed geology to the east a few deep wells such as 333-1 had oil shows in the older section, and old survey data in east Sabah reports oil and gas seeps onshore, as well as coaly source rocks in several places.

The new reconstruction attempts to highlight similarities and differences in this older geological period, through the use of palaeogeographic sketches.

Identification of Non-Structural Hydrocarbon Accumulations using the Controlled Source Electromagnetic Method

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Abstract

Exploration in frontier areas is often focused on large structural highs. Initial wellbores are often positioned in the most favourable structural position and only during development and exploitation does the non-structural or stratigraphic nature of the traps become apparent. In some areas the main plays are stratigraphic but in general, though they are significant contributors to global hydrocarbon resources, most stratigraphic hydrocarbon accumulations are found by accident. It is difficult to imagine that future exploration would focus on synclinal areas. However, if data interpretation indicates hydrocarbons are trapped in unexpected places such as in a down-flank position, this would cause a rethinking of the geology and petroleum system. CSEM is one method that is used to distinguish the existence and extent of hydrocarbon accumulations and when integrated with other geological and geophysical information, can aid in the interpretation and analysis of non-structurally trapped hydrocarbons.

Controlled source electromagnetics, or CSEM has been used as an exploration tool for over a decade. Certain geologic occurrences can be thought of as a three-dimensional geo-body, such as an accumulation of hydrocarbons. If the accumulation is saturated enough with hydrocarbons it creates a resistivity contrast to the surrounding media and an anomaly can be detected. This is particularly useful in determining if a reservoir is saturated enough to contain an economic accumulation of hydrocarbons. A CSEM response is generated in areas where the saturation is at least 55%. A combination of seismic amplitude variations and a CSEM anomaly can distinguish saturated gas reservoirs from under-saturated or "fizz gas" accumulations. As more CSEM data is acquired, anomalies related to the presence of hydrocarbons are detected in places that leave no doubt that there is a stratigraphic or undetectable structural trap present. In some cases, further analysis of the data leads to the re-positioning of exploration wells.

Basin floor fan reservoirs are particularly well suited for CSEM. These deposits are already anomalous coarse grained sediments encased in shale. When saturated with hydrocarbons, they are more resistive than the surrounding shales, allowing them to be detected using the CSEM method. If a basin floor fan within the zone of CSEM detection is saturated with hydrocarbons, an anomaly should be detected. The size of this anomaly can be integrated with other data to determine the actual volume of saturated reservoir rock. This result can be used to calculate reserves in place, further de-risking the target.

In the toe-thrust play, offshore Sabah and Brunei, exploration has focused on the crest of the structures. CSEM has been acquired on the crests of active toe thrusts since 2005. Only when X-lines were acquired in 2013 did CSEM detect resistive anomalies on the flanks. This indicates the possibility of charged stratigraphic traps in the pinchouts, and associated amplitude anomalies, interpreted from seismic data.

Other areas in SE Asia clearly indicate a CSEM anomaly down-dip from the structural high. However, most operators continue to doubt CSEM, resulting in dry holes and many untested flank or down dip hydrocarbon accumulations. Acquisition of CSEM early in the exploration phase and proper integration with other geologic and geophysical data will aid in de-risking drilling decisions.

Tectonic Comparison Between the Palawan and the Northern South China Sea Continental Margin

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Abstract

Recent studies in the northern South China Sea (SCS) continental margin based on gravimetric, magnetic, seismic, and lithofacies data have clearly defined residual Mesozoic basins, which show relatively weak Cenozoic magmatism and extension. Four major unconformities [Pz/T–J, T–J/J, J/K, and Mesozoic/Cenozoic (Pz, Palaeozic; T, Triassic; J, Jurassic; K, Cretaceous)] are identified. Accordingly, three major phases of marine deposition developed but were subsequently terminated by tectonic compression, uplift, erosion, faulting, rifting, and/or magmatism. The tectonic transition from the Tethyan to Pacific regimes was completed by the end of the Middle Triassic (ca. 220 Ma), reflecting widespread Mesozoic orogeny. The transition from an active to a passive continental margin occurred at the end of the Early Cretaceous (ca. 100 Ma); this was accompanied by significant changes in sedimentary environments, due likely to an eastward retreat of the palaeo-Pacific subduction zone and/or to the collision of the West Philippine block with Eurasia. The overall Mesozoic evolution of southeast China comprised almost an entire cycle of orogenic build-up, peneplanation, and later extension, all under the influence of the subducting palaeo-Pacific plate. Continental margin extension and rifting continued into the early Cenozoic, eventually triggering the Oligocene opening of the SCS. Due to the close proximity between the Palawan and the northern South China Sea continental margin before the Cenozoic rifting and seafloor spreading, their basement structures and evolutionary history are expected to be similar. Similar to its northern counterpart, the Palawan Continental Block (PCB) is defined by quiet magnetic anomalies, and moderate depths to the top and bottom of the magnetic layer. The PCB is found to be a favorable area for Mesozoic hydrocarbon exploration.

A General Structural Review of West Philippine Sea from Gravity Data and a Proposed Concept to Explain the Recto Bank.

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Abstract

Current exploration interest offshore west of Palawan has prompted a general geological structural review based upon commercial marine gravity data and published free air satellite gravity data.

Useful structural information has been derived.

The Recto Bank structure, a 150 km diameter sub-circular platform that dominates the local bathymetric map, remains enigmatic.

The relief around most of the perimeter is sharp, between 1500 and 4000m above the background sea floor level, but isostatic modelling suggests that it is under compensated at the Moho by at least 50%. A resultant subsiding mass could explain the thickness of carbonate and its persistence and growth at the sea surface.

The reef carbonates only account for part of the topopgraphic relief above background sea floor, and they overlie a sequence of elevated sediments also contained within the periphery. It would seem that earlier uplift must have occurred within the outline.

It is difficult to explain those observations by conventional mechanisms and so a pre-Cretaceous catastrophic impact event is proposed as a possibility to be considered and some geological and geophysical evidence which would be consistent is put forward in support of that concept.

Play Based Exploration - Frontier to Nearfield/Infield Settings

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Abstract

Frontier exploration in SE Asia is venturing into challenging settings and often into previously overlooked play types. Emergence of these potentially important play types demand high fidelity datasets for better characterization and experienced interpreters with a background in analogous settings for prospect maturation. A holistic approach, that warrants the use of diligent integrated workflows centered on geological and seismic tasks, is essential to unravel these frontier exploratory realms. Amongst others there are:

- Deepwater depositional systems with added elements of complex structural styles
- Syn-Rift and deformed Syn-Rift Plays and siliciclastic depocenters with poor quality seismic often below carbonate platforms
- Low Resistivity Low Contrast (LRLC) reservoirs in various settings
- Deeper clastic plays below carbonate terrains
- Carbonate Plays including karsts
- Stratigraphic Trap delineation in diverse depositional settings
- Complex structural regimes, requiring structural analysis, restoration and fault seal analysis - inputs to petroleum systems modeling and prospect maturation
- Fractured Basement Plays

Exploration on the other hand, requires an independent overview and workflow "looking from the outside in". This approach inherently applies a Play-Based Exploration (PBE) methodology with the explicit intent of generating new prospects and well-proposals. Development and production teams typically have a short term focus, work flow process and aptitude for problem solving which revolve around advanced technologies. Reservoir distribution "truths" are more often than not well cemented by the time of production rates decline and when re-exploration becomes pertinent.

Advanced subsurface imaging and illumination at reservoir levels and especially at depth, drives much of this frontier and modern re-exploration. Likewise, additional well data as new control points are often very important to have. Here not only do we interpret reflection configurations with more confidence but relate those to coherent structural and depositional models which may improve or surpass current thinking through models that are better constrained with additional data. New concepts and technology result in better definition of stratigraphic trapping elements within any tectono-stratigraphic setting.

A play based exploration approach and mindset fosters conceptual models fit for frontier exploration in the absence hard data and for infield exploration to challenge current dogma and expand on the regional understanding of the petroleum system. This process ultimately defines new and additional potential reserves within the context of rigorously applying structural and stratigraphic concepts and principles.

The Petroleum Potential of the West Luzon Basin: Analogy with the Mindoro Basin?

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Abstract

The West Luzon Basin is located the West Philippines Sea adjacent to the island of Luzon and includes 4 blocks offered as part of the PECR5 bid round. The basin is situated in the forearc adjacent to the Manila Trench in water depths up to 4000+m. Although the basin is virtually unexplored – no wells have been drilled in the area and seismic coverage is sparse – a review of the regional tectonics suggests the area may be related to the Mindoro Basin, where a proven petroleum system is present, and may therefore have significant hydrocarbon potential.

The current forearc setting of the West Luzon Basin raises a number of concerns regarding the hydrocarbon exploration potential of the area. Due to the paucity of seismic data, the extents and thickness of the sedimentary section are poorly constrained. In addition, there is no well data to provide stratigraphic or lithological control and the presence of potential source rocks and reservoirs is therefore speculative. Furthermore, forearc basins typically have relatively low heat flow, increasing the risk that any potential source rocks remain immature.

Despite these uncertainties, however, a review of the available data in conjunction with the regional tectonic evolution of the area suggests that there is reason for encouragement that the area may have significant hydrocarbon potential.

Satellite gravity data shows a low in the area west of Manila Bay that may be related to a significant sedimentary basin. Seismic data acquired as part of a scientific survey over the area supports the presence of a basin in the area containing over 4 kilometres of relatively undeformed sediments. In addition, gravity modelling of an east-west transect across the area suggests these sediments may be underlain by an additional 7 to 8 kilometres of older, more deformed sediments (Hayes and Lewis, 1984). The seismic data also suggests the possibility that large structures are present in the area.

The tectonic history of the Philippines is amongst the most complicated in the world. Consideration of the relative movements of the various terranes is essential to understanding the evolution of the sedimentary basins in the Philippines, and is particularly important when evaluating areas such as the West Luzon Basin where so little data is available.

A review of the plate reconstructions of the area by Hall (2001) reveals that the West Luzon Basin has only occupied the current position in the forearc adjacent to the Manila Trough for the last 3 to 4 million years. Prior to that, throughout much of the Miocene, the West Luzon Basin was situated along the eastern flank of a major left-lateral strike-slip zone. Reconstructing the movements of the basin through the Miocene suggests that through the Middle and late Miocene it was situated adjacent to Palawan, and more specifically the Mindoro Basin.

Mindoro Basin has a proven Miocene petroleum system associated with the Semirara formation, as demonstrated by the results of the Managuin-2 well, which tested 300 BOPD in an open hole DST. Geochemical analysis of samples from that well indicate good to excellent source potential in the basal part of the Miocene section. Burial history reconstructions utilising the Managuin-2 data suggest that the top of the oil window occurs at depths significantly less than 4000m. Given that the West Luzon and Mindoro Basins appear to have been adjacent through much of the Miocene it is not unreasonable to suggest they should share a common thermal history over that time period. This suggests that, by analogy, potential source rocks in

the relatively undeformed sediments in the West Luzon Basin could be mature, even if the recent heat flow is lower than the Mindoro Basin due to its position in the forearc. Additional, independent support for this premise comes from the Central Luzon Basin, where available well control indicates 'middle mature' Miocene sediments occur at depths ranging from 2000 to 4000m.

Good quality, quartz-rich clastic reservoirs are also present in the Miocene section of the Mindoro Basin, and long distance transport of continental-affinity material is demonstrated by quartz-rich turbidites encountered in the Sulu Sea east of the Cagayan Ridge at ODP Site 768. One likely source of these sands is from the continental crust that comprises the basement on the Cuyo-Mindoro Platform to the east and the West Luzon Basin may have been well situated to receive sediments from this provenance as well. If so, it suggests the best potential clastic reservoirs in the present day West Luzon Basin may have source provenance from the west rather than from the apparently obvious provenance from the ophiolite complex associated with the Zambales Mountains to the east.

In summary, the West Luzon Basin is a virtually unexplored deep-water basin that could have significant petroleum potential. The basin appears to have a similar Miocene history to the Mindoro Basin, where drilling results demonstrate the presence of a working petroleum system. Available data indicate the basin contains more than 4000m of relatively undeformed sediments that are likely to be Miocene to recent in age, and that this section may be underlain by an even greater thickness of older Tertiary sediments that may also have petroleum potential.

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Reconstruction of the Tectonic Evolution of Palawan Island and Surrounding Seas Using Onshore Structural and Offshore Seismic Data

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Abstact

With both continental and ophiolitic rocks underlying the island, Palawan presents a natural laboratory for the understanding of the structural and tectonic history of the south-eastern margin of the South China Sea. We present structural data gathered from around 450 km of onshore transects from El Nido in the north to Brooke's Point in the South, correlated with offshore seismic data from South China Sea and Sulu Sea. Palawan Island resulted from the amalgamation of various rock units formed initially at different tectonic settings, including the formation of Late Paleozoic to Mesozoic olistostromes in a mega subduction system that later accretes to form the eastern margin of continental Asia. This eastern Asian continental margin then stretches allowing the deposition of Cretaceous to Eocene sedimentary basins within rift-blocks, eventually to be affected by compressional deformation and metamorphism. Convergent tectonics ensues after syn-rift deposition, marked in the central and southern sections of the island by obducted Cretaceous ophiolites. As oceanic crust forms in the deeper South China Sea to the west starting in Early Oligocene, Palawan Island and the surrounding shallower seas become sites of deposition of Neogene sedimentary basins.

More particularly, this work concludes: 1) that there is a unique basement terrane in Palawan, represented by pre-Tertiary continental rocks derived from mainland Asia; 2) that the ophiolites of central and southern Palawan, considered by earlier workers as the other basement terrane, is part of the basement cover after the former was obducted between end-Eocene and pre-Middle Miocene; 3) that towards the end of obduction in Middle Miocene, there was continued convergence at the southeastern edge of the South China Sea. This is evidenced by the underthrusting of Late Oligocene to Early Miocene carbonates (Nido Limestone) below the ophiolite and younger rock formations in central and southern Palawan, and by a tectonic wedge (Pagasa Wedge) affecting Early to Middle Miocene clastics observed offshore in the southwest; and 4) that central and south Palawan became tectonically stable following the formation of the wedge, whereas the northern edge of the continental basement in north Palawan continues to collide until present times, albeit diminishing, with the Philippine Mobile Belt in the vicinity of the islands of Calamian, Mindoro and Panay.

Geometry of the Nido Limestone and Related Carbonates: Insights to a Mid-Neogene Bimodal Structural Deformation the Edge of a Thinned Continental Microplate.

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Abstract

This work aims to understand the structural deformation recorded in the Late Oligocene-Early Miocene Nido Limestone from the Calamian Islands in North Palawan to the NW Borneo Trough offshore Sabah, using offshore seismic profiles and onshore structural data. Offshore, the Nido Limestone can be traced for over 1,000 km from west of Busuanga Island in north Palawan to the NW Borneo Trough spanning a width distribution of around 200 km. In contrast to its widespread offshore occurrence, this carbonate sequence only outcrops onshore in Sabang, central Palawan where it hosts a UNESCO heritage underground river system. In Sabang, this carbonate formation called the St. Paul Limestone, rests unconformably over highly-deformed, partly metamorphosed Late Mesozoic to Early Tertiary turbidites. From Ulugan Bay southwards to the NW Borneo Trough, the Nido Limestone is thrust under a pile of 2 sets of accretionary wedges composed mainly of marine sedimentary and carbonate deposits from the Eocene (Pulute Wedge) to the Middle Miocene (Pagasa Wedge). The younger wedge is truncated by the Middle Miocene Unconformity (MMU). In contrast, from Ulugan Bay northwards to the Calamian Islands, the Nido Limestone rests on top of Eocene clastics or older crust and does not crop out onshore. The latitude-dependent contrasting geometrical configuration of the Nido suggests that this carbonate sequence has undergone a bimodal structural deformation after its deposition in the shallower sections of a thinned continental margin. This gave rise to an underthrust south segment and a northern segment that has retained its normal stratigraphic position albeit eroded/non-deposited onshore. This requires either a tear or a sharp bend between the two segments. Geographically, the region north of Ulugan Bay demarcates the tear/bend but the scarcity of offshore data in this area has hindered the establishment of the presence of any associated structure. Regardless of the nature of the segment boundary, the bimodal structural history differentially affecting Nido from north to south poses significant implications in the evaluation of the hydrocarbon potential of this carbonate body.

Revisiting the Petroleum Prospectivity of the Shallow Water Portion of NW Palawan, Philippines

Arturo A. Morado, Jr. and Jeoffrey Perfecto M. Micu
Pitkin Petroleum

Abstract

NW Palawan Area (NWPA) contains several producing oil and gas fields and is considered the most prospective region in the Philippines. To date, 37 exploration wells have been drilled on the shallow water (less than 200 meters) portion of the NW Palawan Area (NWPA-SW). It is estimated that the prospective area of this shallow water portion is at least 6,500 square kilometers stretching 220 kilometers from the Bacuit A-1 well on the south to the Dimipac-1 well on the north. The first well drilled in the NWPA is Pagasa-1 in 1971 while Dimipac-1, drilled in 1998, was the last exploration well in the NWPA-SW.

Of the 37 exploration wells drilled on NWPA-SW, 18 wells tested oil and/or gas for an impressive 49% discovery rate. Eight of these discoveries were commercially produced for a 21% commercial success rate, another impressive statistics. In spite of these impressive probability of success numbers, the drilling activity in the NWPA-SW has been dismal. The average number of exploration wells drilled per year since the Pagasa-1 well is 0.73. The exploration well density is one well per 171 square kilometers. If one looks at the field size distribution of the whole NWPA, the Camago-Malampaya Field is estimated to contain close to 1,000 million barrels of oil equivalent (MMBOE); while the next biggest field is estimated to be not more than 30 MMBOE. In theory, there should be several other accumulations between 30 and 1,000 million barrels of oil equivalent.

Most of the hydrocarbons found to date in the NWPA are attributed to source rocks within the Malampaya Graben, a large half-graben feature that stretches for more than 200 kilometers. It is also thought that some of the NWPA-SW discoveries, like the Nido fields, may have been sourced from another ("inboard") half-graben east of the Malampaya Graben. All of the exploration wells drilled in NWPA-SW purposely targeted Nido Limestone Formation targets, except four, which had the younger Galoc Clastic Unit (GCU) as their objectives.

It seems that the Nido Limestone Formation plays have already been drilled out in the NWPA-SW. There are probably some GCU prospects left, but most if not all of them will be in stratigraphic trapping configuration, which is traditionally difficult to define and considered high risk. It is therefore believed that the remaining substantial prospectivity of the NWPA-SW is within the pre-Nido Limestone, syn-rift clastics and perhaps the pre-rift rocks, including basement. These types of plays have never been deliberately pursued in the NWPA-SW, but have been proven to be commercially productive in similar basins in Indonesia and Vietnam.

The Baragatan-1A Well in SC 63: Implications for Offshore SW Palawan Exploration

Jaime A. Bacud and Monina T. Forbes
PNOC – Exploration Corporation

Abstract

The Service Contract (SC) 63 Consortium of PNOC Exploration Corporation, Dragon Oil Ltd and Nido Petroleum Ltd. drilled the Baragatan Prospect from May to July 2014 using UMW's newly built jack-up rig Naga 5. The well, Baragatan-1A,- reached a total depth of 2,681 meters Measured Depth (MD) (2,328 meters True Vertical Depth Sub-Sea (TVDSS)). It is located at a water depth of 48 meters in offshore SW Palawan, Philippines.

The Baragatan Prospect is a large NE-SW trending fault block within the SC 63 thrust wedge. It was drilled to test multiple levels of interpreted sandstone reservoirs within the Pag-asa Equivalent Formation. Three gas-charged sections, mostly on limestone reservoirs, were penetrated by the well:

1. Sandstone unit from 1,977 to 2,004 meters MD (1,785- 1,805 meters TVDSS)
2. Upper Limestone unit from 2,207 to2,236 meters MD (1,960-1,982 meters TVD SS)
3. Lower Limestone unit from 2,534-2,654 meters MD (2,210-2,312 meters TVD SS)

These reservoir sections showed prominent cross-overs indicating gas and C1 to C5 gas chromatograph readings. Minor oil shows were also observed in the upper limestone unit. However, the preliminary Logging While Drilling (LWD) data on these reservoirs indicated low gas saturations.

Preliminary results of the Baragatan-1A well confirmed the existence of reservoir-quality sections and gas, albeit with low saturations. It has likewise confirmed that a working petroleum system is present in the area particularly in the SW Palawan Thrust Belt.

While the Baragatan-1A well has not discovered commercial hydrocarbons, it has, however, provided the SC 63 Consortium with valuable new technical information which is being incorporated into current subsurface models as part of the on-going post-well evaluation work.

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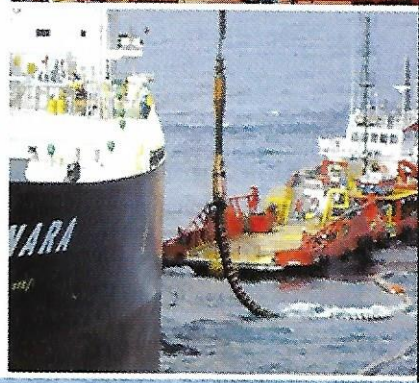

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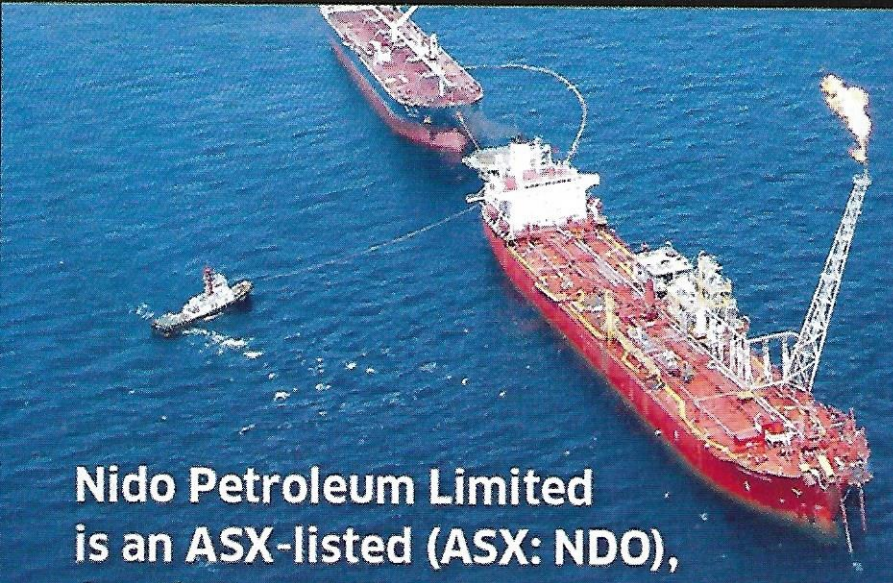

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www.nido.com.au

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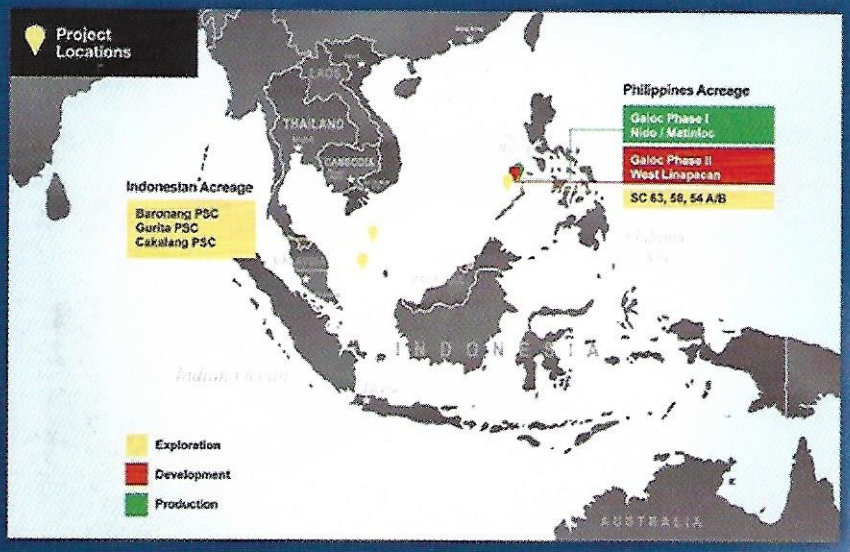

The Company holds significant acreage in the highly prospective North West Palawan Basin in the Philippines and the Penyu and West Natuna basins in Indonesia.

Nido is well positioned to deliver long-term shareholder value through its highly prospective assets and experienced Board and management team. The strategy to achieve this; is as follows:

- Build a high quality balanced portfolio of producing, development and exploration assets in SE Asian focus area;
- Priority focus on reserves and production growth to underpin the longer term growth of the Company;
- Provide shareholders with exposure to selective, high quality drilling opportunities which are material and able to be funded from cash resources, and
- Prudent management of the asset portfolio, and technical and commercial excellence in our decision making.

Producing assets include the Galoc Oil Field (22.88% interest), Nido A and B Fields (22.49% interest) and Matinloc Field (22.28% interest). Nido is also developing Galoc Phase II (22.88% interest), which aims to extend the strong existing performance of the Galoc Field, and the West Linapacan A and B Oil Fields (22.28% interest).

The Company has also entered into three Production Sharing Contracts (PSC) in the Penyu and West Netuna basins in Indonesia. Nido will earn a 10% participating interest in the PSCs and has the right to increase its stake to 20% in each.

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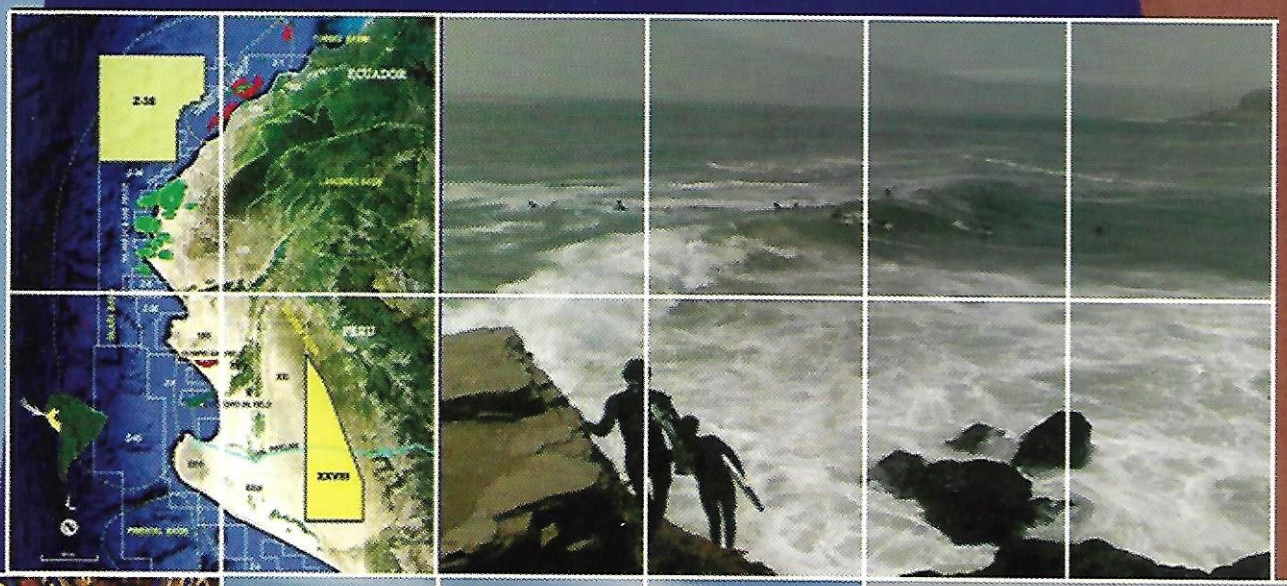
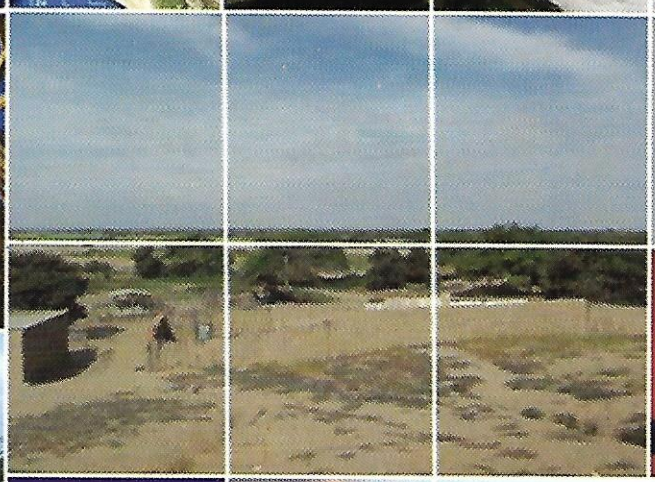
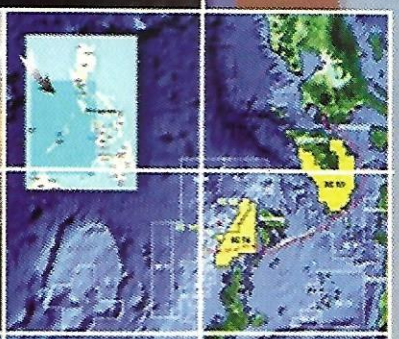
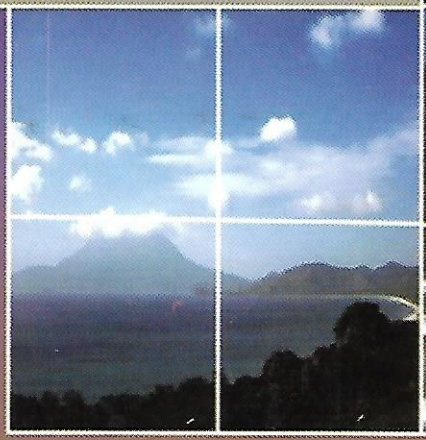
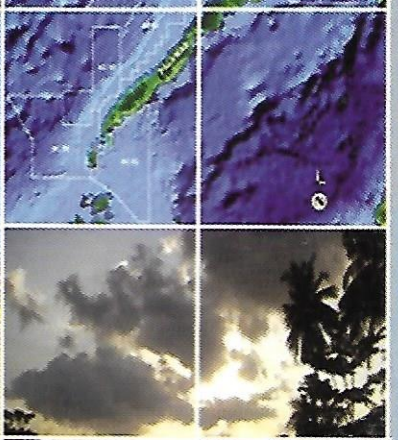
Achieving Your Goals is Our First Priority











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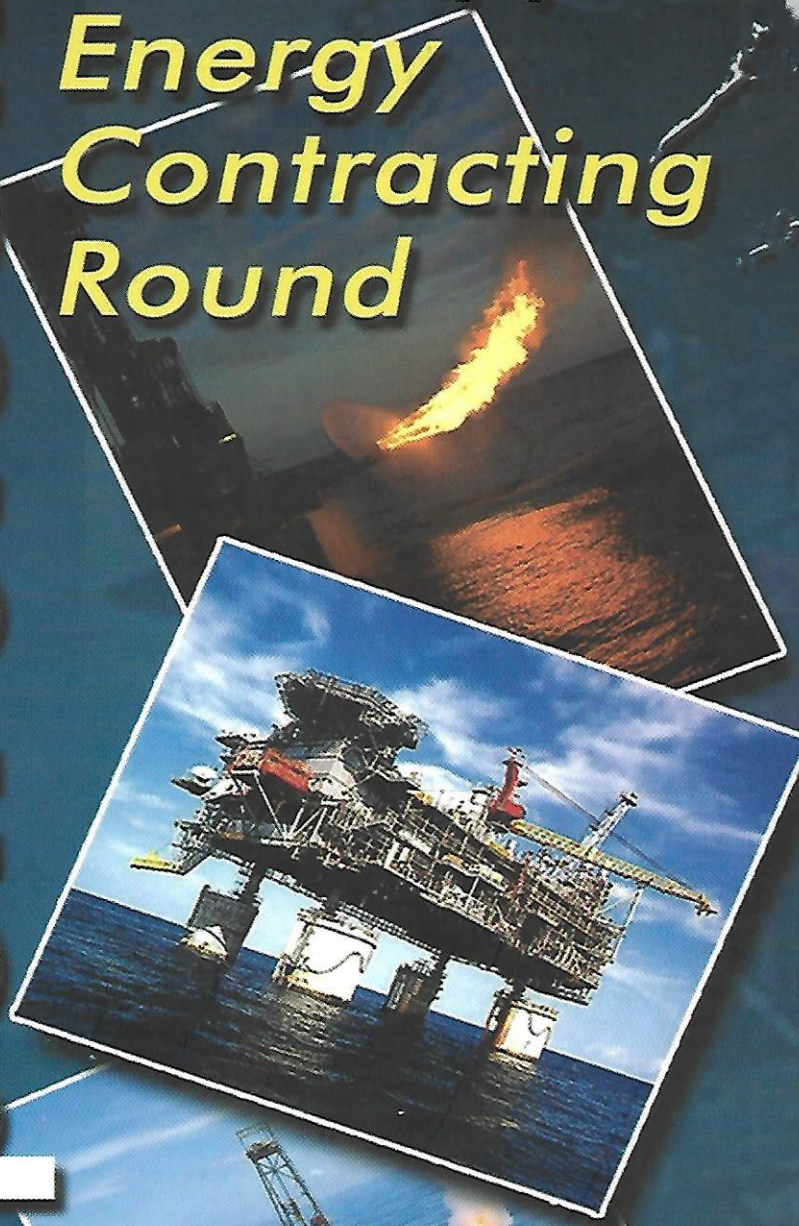

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