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ABSTRACTS

Abstracts of papers presented at the PCPRC/CSEG Symposium on Seismic Interpretation held at Zhuozhou City, Hebei Province, China, from September 15 to 18, 1987, jointly sponsored by the Petroleum Corporation of the People's Republic of China and the Canadian Society of Exploration Geophysicists.

***denotes speaker**

NORTH AMERICAN ROCKIES — A COMPRESSIONAL STRUCTURAL BELT

ROBERT L. COMER, *COMER & WILSON LTD.*

The regional geology of western Canada is reviewed, placing the eastern Cordillera, our area of interest, between the western Canadian sedimentary basin to the east and the western Cordilleran intrustives and volcanics to the west. The eastern Cordillera is an area of multiple overthrusts with significant amounts of hydrocarbons, mainly natural gas, trapped in the Mississippian and Devonian carbonates of these thrust sheets. The history of exploration, particularly with the seismic method, is discussed and the development of the current geological model is reviewed. This model is then compared to similar areas in the United States and the differences are examined for their implications for seismic exploration.

RECONSIDERATION OF GEOLOGIC STRUCTURE AT THE WEST MARGIN OF BA-XIAN DEPRESSION

FAN YA-LING, *BUREAU OF GEOPHYSICAL PROSPECTING, MINISTRY OF PETROLEUM INDUSTRY*

An exploratory well was drilled at a place which has been considered as an uplifted area without Palaeogene sediments. The well unexpectedly ran into Palaeogene formations and produced 9.3 tons of oil per day. This fact prompted us to reconsider the geological structure in this area. Thus, we performed a new comprehensive study of this geologic structure by using new seismic-processing and interpretation methods, including the use of new velocity parameters and new processing flow. As a result, we have obtained new important geological results, broadened the known area of sediment in the depression, and opened a new field for oil exploration. Our research method is highly effective and is also feasible for application to other similar areas.

A TEST OF THE USE OF SEISMIC DYNAMIC INFORMATION TO FIND SMALL FAULTS

GAO RU-ZENG, *PETROLEUM ADMINISTRATION OF SICHUAN*

Small faults, especially those interlayer faults with mini-throws (less than 50 m), bear a close relationship to accumulations of natural gas; this has been proven by a large body of drilling results. This paper presents a method for finding those faults which have throws less than 50 m by the method of small-fault forward modelling and instantaneous phase change.

In crack and fissure gas pools, the effect of small faults strongly attracts our attention; thus, an investigation of small faults was made on the so-called structure D. A total of 732 broken points were searched out which were not found by the conventional processing and interpretation of 3D surveys. In the target layer, the interrelationship among the clustered belt of small faults, the region of anomalous seismic-wave character and the discovery of gas upon drilling has been pointed out. Thus, one more foundation has been provided for increasing the rate of success in finding gas, for gaining new analysis results, and for working out well locations in the region.

COMPLEX STRUCTURES IN EASTERN HUDSON BAY

ROGER J. MAHONEY, *MAHONEY EXPLORATION CONSULTANTS LTD.*

The hard water bottom in Hudson Bay has provided an obstacle to obtaining usable seismic data. Extended arrays have been used in the past to improve the signal/noise ratio. Testing in the field was carried out to determine the optimum acquisition parameters. Extended source and receiver arrays were determined to be the desirable mode of shooting. A portion of the seismic acquisition programme was carried out over the eastern part of Hudson Bay. The presence of a major suture has long been recognized in eastern Hudson Bay. Seismic data revealed the presence of large anticlinal structures within the sutured zone. The extent and magnitude of the thrusting in the Belcher Group was also revealed. The section within the rifted area is interpreted to be post-Hudsonian orogeny (1700 Ma) in age. However, the section is interpreted to be Proterozoic in age and can be demonstrated to be pre-Phanerozoic. In all probability the section within the rift consists of volcanics and molasse

of the Belcher Group. There is a possibility that the section is younger, Neohelikian in age. If so, the possibility of finding hydrocarbons would be greatly enhanced. The structures within the rift are believed formed by the left-lateral motion of the Churchill plate with respect to the Superior plate. This relative motion, postdating the Hudsonian orogeny, has set up a series of en-echelon structures.

A STUDY OF SMALL-MAGNITUDE STRUCTURES IN THE YT AREA

ZUO CHEN-MEI, *GEOPHYSICIAL SURVEY, JILIN OILFIELD*

In the past few years, following the discovery and development of the so-called YT oilfield in Jilin Province, it has been hoped that more traps like the YT structures could be found. However, after seismic prospecting, only many small-magnitude structures (SMS) have been found. Their closures range from 8 to 30 m and the closed areas from 1 to 5 km^2. We are concerned with the question of whether these SMS are worth drilling for oil and gas.

Since in the YT area there are developmental sand beds whose connectivity is good and whose water-driving force is active, we have also concerned ourselves with whether or not such small traps (in both magnitude and area) can gather oil and gas. According to pressure-testing data, the pressure gradient in one of the reservoirs is 0.001756 atm/m (0.1779 kPa/m). After calculation, we find that structures with areas of 1 to 5 km^2 and closures from 6 to 12 m are big enough to capture oil and gas under this pressure gradient.

Therefore, in the past years, we have consciously emphasized the study of SMS and achieved better geological results through field operation, data processing, data interpretation and comprehensive research.

COMPLEX STRUCTURE AND STRATIGRAPHY — AN APPLICATION OF 3D SEISMIC

FRED M. PETERSON, *ENCOR ENERGY CORP. INC.*

The maximum benefit of 3-dimensional seismic techniques relative to the conventional approach is achieved when "out-of-plane" energy content dominates a reflection profile. This situation will quickly occur in areas of complex 3-dimensional structures. The Terra Nova area in the Jeanne d'Arc basin offshore Newfoundland is an example. Comparisons between high-quality conventional seismic and a 3D survey and interpretation will illustrate the increased structural resolution of the 3D approach. Stratigraphy will also vary in more than one dimension so that again a 3D approach can provide much improved information. Examples from the Terra Nova 3D survey illustrate some fascinating stratigraphic patterns yet to be unravelled by explorationists. 3D seismic is demonstrated to be one of the explorationist's most powerful tools in resolving complex structure and stratigraphy.

THE APPLICATION OF SEISMIC INFORMATION TO THE RESEARCH OF SALT STRUCTURES

DOU MAO-ZE, *THE J.H. PETROLEUM ADMINISTRATION*

The so-called QJ depression is a typical saline lacustrine depression in China. Research has been carried out based on factual drilling results and, in particular, on a variety of seismic information from the depression. This paper deals with the characteristics and classification of the salt structures for analysing and understanding the formation mechanism, distribution, and petroleum potential of salt structures. These would be valuable for exploration for oil and gas in similar basins elsewhere.

LONG-PERIOD MULTIPLE SUPPRESSION BY MODEL FITTING

DAVID HUTCHINSON, *TECHCO GEOPHYSICAL SERVICES LTD.*, AND BRIAN LINK*, *KELMAN SEISMIC PROCESSING INC. (FORMERLY, SEISCOM DELTA UNITED CANADA LTD.)*

Conventional techniques for long-period multiple suppression have had limited success largely because they make assumptions which are often not substantiated by real data observations. Some algorithms have attempted to model the multiple energy only, which leads to the problem of indeterminate residual errors due to the existence of all other energy forms.

The proposed technique attempts to model both primary and multiple hyperbolic energy and explicitly calculates scalars for the models to amplitude-fit these models to each trace. The output is then just the input trace less the scaled multiple waveforms.

Examples shown will illustrate the algorithm's effectiveness on synthetics, land data, and marine data. Of course, any algorithm that relies on velocity discrimination to suppress multiples will break down at some point as the delta-T difference decreases. However, we hope to show that that point is significantly reduced with this technique.

A SEISMIC INTERPRETATION METHOD FOR THE MA JIA-TAN OVERTHRUST STRUCTURE AND AN ANALYSIS OF ITS CHARACTERISTICS

LI JIU-LING* AND YANG ZHENG-QING, *CHANGQING PETROLEUM EXPLORATION BUREAU*

The Ma Jia-Tan overthrust structure is an important component of the western-edge fault-fold zone in the Shan-Gan-Ning basin. This paper describes a mainly seismic method of interpretation of the structure in terms of the regularities of overthrust structures. By identifying the décollement surface and the characteristics of the different structures below and above this surface, and by

analyzing the characteristics of thin-skinned overthrust structures, interpretational results are achieved for the structure and recommendations for drilling are presented.

SEISMIC ESTIMATION OF BASAL SAND STRATIGRAPHY — A FIELD EXAMPLE

JOHN D. BOYD, *BOYD EXPLORATION CONSULTANTS LTD.*

Oil is produced in the Alliance area of eastern Alberta from a Lower Cretaceous basal quartz sand deposited on the pre-Cretaceous erosional surface. Sand thickness and quality have been controlled by paleotopography and by subsequent reworking.

The thickness and quality of the reservoir vary abruptly. Closely spaced drilling is necessary to increase the oil recovery from the reservoir. Initial two-dimensional seismic had proven that the top of the reservoir produced a reflection which could be analyzed to predict reservoir structure and quality. A 9.7-km^2 3D survey was therefore recorded in the area, to be used for development drilling.

The survey was recorded in an area of rugged topography. Although a completely regular pattern of shot holes was impossible, the resulting stack was of good quality. "Bin sharing" during stacking smoothed out some of the large fluctuations in stacking fold from bin to bin.

The resulting survey was extremely successful in planning a drilling program. Its cost effectiveness can be demonstrated by comparing dry-hole costs of $100,000 to 3D seismic costs of $25,000/km^2. The total survey was recorded and processed for less than the cost of three dry holes. Drilling results to date prove that many more dry holes would have been drilled without the survey in order to find the production that has been developed up to this time.

TIME-DEPTH CONVERSION OF 3D DATA FROM THE AREA OF WELL H29

CHEN PU-DA*, CHEN JUN-XIANG AND XIA YOU-MIN, *XINJIANG PETROLEUM ADMINISTRATION BUREAU*

It is well known that accurate velocity is required for time-depth conversion of 3D data. This paper presents a method of automatic computation of the average velocity via dip correction and transformation of the Dix formula; average velocity values obtained are then filtered and smoothed. The time-depth conversion is performed on the basis of the average-velocity contours of the main reflectors. Because the average-velocity contours can reflect the velocity variations both horizontally and vertically, the depth contours obtained by this method show significantly decreased depth error, and there results a much better agreement between the interpreted structural configuration and the well data. The velocity contouring method, accuracy analysis and corresponding results are also presented in this paper.

SURFACE-CONSISTENT EFFECTS: A UNIFIED APPROACH TO DECONVOLUTION AND STATICS USING PHASE BALANCING

DAVID HUTCHINSON, *TECHCO GEOPHYSICAL SERVICES LTD.*

It is well known that seismic arrival times are influenced by variations of thickness and velocity of layers near the ground surface. The shape of the arriving wavelet is also affected, i.e., the variations in arrival times are frequency dependent. Traditionally, shifts which are independent of frequency are processed as statics, and frequency-dependent shifts are processed as deconvolution. The two processes are treated quite separately.

This paper defines the process of phase balancing and states that "residual deconvolution" or "frequency-dependent statics" would be equivalent terms, either of which could describe this process.

It is suggested that phase balancing requires constraints on the numerical solution if it is going to be reliable, and surface-consistent phase corrections are advocated in order to reduce the number of variables to be determined for each data set and increase the reliability of this result. The geophysical validity of the surface-consistent model is discussed and an example of zero-phase seismic filtering due to a real weathering anomaly is given. It is demonstrated that all conventional deconvolutions break down in adverse circumstances, and so a residual process, such as phase balancing, is required.

The relationship between phase balancing and other processes is then discussed to show that it has a natural place in the processing sequence together with datum statics, deconvolution, and residual surface-consistent statics.

Finally, a synthetic and a real data example are shown in which the conventional processes cannot adequately stabilize the waveform. In both cases, the surface-consistent phase-balancing process has sufficient information to differentiate between structural changes and surface effects and appears to have produced a higher-frequency, accurate and reliable product.

APPLYING SEISMIC INFORMATION TO DISCOVER A NEW TYPE OF OIL-BEARING TRAP

YAO JI-FONG, *LIAOHE PETROLEUM BUREAU*

Thanks to the application of up-to-date techniques and new methods and the enhancement of geologic comprehensive research, new types of oil-bearing traps have been found. The verified geological reserves and the controlled geological reserves we have gained since 1983 are four times as much as we had gained by the end of 1982; and the prospecting period was abbreviated greatly. Great economic benefit has obviously been gained in the Damintun basin, thus providing the experience for prospecting in minor basins of continental facies.

We take the seismic information as the dominant factor and deal with magnetic-survey, well-logging, drilling and

marginal geologic data to do in-depth studies of: an ancient buried-hills carbonate reservoir, a shale-piercement structural reservoir, and a foreset sandstone reservoir, through application of the seismic stratigraphic method. This paper discusses the method and the tangible results which have been achieved.

THE SEISMIC METHOD IN PRODUCTION OPERATIONS

ROY O. LINDSETH (PRESENTED BY VERNE A. STREET), *TEKNICA RESOURCE DEVELOPMENT LTD.*

The geophysicial method has generally been considered an exploration tool, but increased resolution, inversion technology, and new techniques in data handling have been responsible for increased use in reservoir development and production operations. These methods allow optimum development-drilling programs to be developed, and can assist in the planning of secondary recovery operations.

SEISMIC STRATIGRAPHIC INTERPRETATION OF ALLUVIAL FANS AROUND BING-XIAN UPLIFT

YANG YUN-LING et al., *GEOLOGICAL SURVEY, SHENG-LI OILFILELD*

The Bing-Xian uplift is located northeast of the Dongying depression. It is a buried hill which is mainly made up of granite gneiss. Some dozens of alluvial fans of various sizes had grown in the lake around it in the Paleogene, forming a fan-skirt 20 km in length. After using improved seismic acquisition methods and achieving increased interpretive accuracy, the topography of the buried hill and the sizes and distribution of valleys were basically determined. Combining examination of the seismic reflection character of the alluvial fans with drilling and well-logging data, we found clear relationships between valleys and alluvial fans, confirmed and constrained the sizes and distribution of alluvial fans, and discovered complex pools of the order of some square kilometres in area. At present, these pools are gradually being developed.

PRACTICAL APPLICATION OF THE REFLECTIVITY METHOD

ZOLTAN HAJNAL* AND B. PANDIT, *UNIVERSITY OF SASKATCHEWAN*

A practical method is developed for the selection of computational parameters when the reflectivity technique is applied to determine the theoretical seismic response of a horizontally layered earth. The quick and actual earth-model-based design of the parameters eliminates computation of numerical noise-contaminated synthetic records.

The derived seismograms are clean and are generated without costly experimental computer runs. The control of numerical artifacts permits computation of model responses which have intricate acoustic characteristics.

RECOGNITION OF SPECIAL GEOLOGIC BODIES AND STUDY OF TRAPS IN LONG-GU SUBBASIN

ZHAO CUI-FEN, *BUREAU OF GEOPHYSICAL PROSPECTING, MINISTRY OF PETROLEUM INDUSTRY*

To search for additional reserves and/or to tap the potential resource from productive oil and gas provinces has become of increasing current importance. This is being realized with the increase in the degree of seismic exploration and the high development of seismic exploratory techniques.

Within Long-Gu subbasin, the depositional features are similar to those of other land-facies lake-basins. In general, there was supply of sediments from multiple sources, and there were multiple depositional systems and tectonic movements. As a result, various sand bodies within depositional sequences are superimposed vertically, and they often change in lithology laterally. A certain advantage has been gained by using seismic information to recognize the subtle trap which changes in geometric configuration and is controlled by complicated elements.

MANNVILLE (LOWER CRETACEOUS) POINT BAR EXPLORATION USING 2D AND 3D SEISMIC DATA: A CASE HISTORY

MARK I. LAKE* AND TOM MORGAN, *NORWICH RESOURCES CANADA LTD.*

The Plover Lake North oilfield is located in west-central Saskatchewan, 50 km southeast of Provost, Alberta. It was discovered in May, 1985, when Tricentrol Oils and Murphy Oil drilled the well A16-35-35-27W3. The well was located on an Upper Mannville seismic anomaly. A sand body of Waseca age was found, containing 28 m of net heavy (11 to 12° API or 986 to 933 kg/m^3) oil pay.

Additional drilling and seismic acquisition has led to the delineation of several pools contained in point bars within a fluvial system. Some of the geological and geophysical aspects of one of these pools, the 'A' Pool, will be presented.

The point bar sands are thick (up to 35 m) and display excellent porosity and permeability (32 percent and 2 to 4 darcies). Shale plugs have been identified within the channel system, representing abandoned channels. The fluvial system is emplaced in, and is laterally equivalent to, the "regional" Waseca sand-shale unit.

During the development of the field, 20 km^2 of high-quality 3D seismic data were acquired. The survey used dynamite as the energy source, and was designed around a 30-m x 30-m bin size.

This presentation will step through the exploration phase of this play, concentrating on the compilation of a portion of the seismic data base, and some of the wells that have been drilled to date.

It is concluded that the seismic technique is a viable and cost-effective method for exploring for this type of reservoir.

QUANTITATIVE SEISMIC INTERPRETATION FOR AN OIL POOL RELATED TO A TURBIDITE SAND LENS

LIU WEN-LIN* AND LIU ZHENG-XIN, *RESEARCH INSTITUTE OF PETROLEUM EXPLORATION AND DEVELOPMENT, BEIJING*

Located in the Niu-Zhuang Liuhu area of the Dongying depression (Sheng-Li oilfield) the Wang-50 oil pool is related to a turbidite sand lens body, accompanied by deltaic sediments. Seismic modelling studies have been carried out on this oil pool, combined with well data. The boundary of the sand lens body is outlined qualitatively in terms of seismic waveform signatures obtained from seismic modelling. By using a quantitative amplitude interpretation template made in accordance with the seismic modelling, seismic reflection amplitudes are quantitatively interpreted and thus an isopach map of the sand lens body is generated.

SEISMIC INTERPRETATION OF UPPER ELK POINT (GIVETIAN) CARBONATE RESERVOIRS OF WESTERN CANADA

R. JAMES BROWN*, *UNIVERSITY OF CALGARY*, NEIL L. ANDERSON, *PETREL ROBERTSON LTD.*, AND LEONARD V. HILLS, *UNIVERSITY OF CALGARY*

The documentation of reflection-seismic signatures from producing hydrocarbon reservoirs and subsequent joint geophysical and geological analysis can establish criteria which enable one to recognize similar reservoirs in seismic data from different but related areas. This has been carried out on the seismic signatures of several carbonate reservoirs of the Upper Elk Point Subgroup (Givetian Stage) of the Middle Devonian Series of western Canada.

The principal producing hydrocarbon reservoirs of the Upper Elk Point Subgroup are in the Rainbow Member (Rainbow Lake area), the Upper Keg River Reef and Zama Members (Zama area) of northwestern Alberta, the Keg River Formation (Senex area) and the Winnipegosis Formation (southern Saskatchewan). Geologically they comprise Keg River and Winnipegosis Formation bioherms which developed in evaporitic basins, Keg River biostromes which developed on the Keg River shelf, and Muskeg Formation biostromes which developed as shoals above the Keg River bioherms.

The seismic signatures of these reservoirs are documented and analyzed on the basis of time-structural drape (e.g., over Precambrian basement highs), velocity-generated time-structural relief (pullup, pulldown) and seismic image, as rendered by the reflection data. The analysis places constraints upon geological phenomena such as differential compaction, reef- and basement-focused salt dissolution, paleotopography, lateral and vertical facies variations, regional dip, and reservoir morphology, and elucidates further the relationships between these reservoirs and the adjacent sedimentary sections, particularly in those cases where well control is sparse.

Three example reefs will be presented, each typical of a particular area and environment (Rainbow Member, Upper Keg River Reef Member, and Winnipegosis Formation). The role of salt encasement and dissolution and the resulting seismic effects thereof will be given particular attention.

AN ATTEMPT TO PREDICT NATURAL GAS IN THE TIANCHI STRUCTURE

PAN CUN-HUAN* AND JIANG JIA-YU, *CHANGQING PETROLEUM EXPLORATION BUREAU*

By using information on gas pools from well data and through high-quality special processing of seismic data, we make a seismic lithological interpretation of the reflection anomalies from target horizons, identify gas pools in the targets, and thereby outline the favourable accumulation zones. This paper describes an attempt to predict natural gas existing within Lower Palaeozoic sequences in the Tianchi structure by means of those techniques mentioned above. Through wavelet processing, triple instantaneous-parameter processing and G-Log processing, together with general computation of pseudo-Poisson's ratio, combined with well data, we carefully identify the subtle reflection anomalies near the Ordovician erosional surface and give a geological interpretation of them from the viewpoint of seismic stratigraphy. Thus, we make original predictions of the gas-bearing area of the structure and point out prospective areas for drilling.

KEG RIVER AND LEDUC REEF CARBONATES — EXPLORATION EXAMPLES WITH 3D SEISMIC

FRED M. PETERSON, *ENCOR ENERGY CORP. INC.*

The Upper Devonian Leduc and Middle Devonian Keg River are two of the major productive reef carbonates in western Canada. Exploration has been carried out in western Canada for these reservoirs, using seismic, since 1947 and is actively continuing today. A total of 1.25 x 10^9 m^3 of oil in place has been proven.

A brief review of the geological/geophysical environments for these reservoirs will be used to illustrate the basis of the exploration effort. Some examples of the conventional seismic manifestation of these reefs and the application of 3-dimensional techniques to their exploration and development will be presented.

THE INTERPRETATION OF SEISMIC DATA FROM THE SHA-1 MEMBER OF THE THIN-BED SANDSTONE IN DONG-PU DEPRESSION

ZHAO SHI-HUA, *BUREAU OF GEOPHYSICAL PROSPECTING, MINISTRY OF PETROLEUM INDUSTRY*

When the thickness of a bed is less than a quarter of the characteristic seismic wavelength, then basically, the reflection amplitude of the thin bed varies linearly with the thickness of the bed; when the thickness of a bed equals a quarter of the wavelength, a tuning amplitude is reached. A high-accuracy seismic forward model of a thin sand bed can be obtained by use of comprehensive well-log data of better quality. A relative-amplitude-preserved seismic section can be obtained by use of an extraction of the perfected wavelets and a deconvolution technique. Then, using well-log data extrapolation, not only can we delineate the areal distribution of a thin sand bed, we can also interpret the thickness of the sand bed quantitatively. After a comprehensive analysis, we can determine the oil-water contact and provide some parameters for computing reserves. In the Dong-Pu depression, we have expanded the area of oilfields and predicted some new prospect zones by means of this method.

A RANDOM WALK THROUGH A KEG RIVER CARBONATE SHOAL USING 3D SEISMIC TO EXAMINE A TYPICAL ANOMALY IN THE KIDNEY/PANNY AREA

KENNETH I. MITCHELL, *UNOCAL CANADA LTD.*

Since the discovery of oil at Amoco's 2/3-11-96-6W5 test well at Panny in 1983, the east Peace River Arch has been an active exploration area. An estimated 55 million bbl (8.7 x 10^6 m^3) of recoverable oil has already been discovered in similar Keg River reservoirs deposited over Precambrian structural highs.

Seismic has been an effective tool in locating the Precambrian highs and their trends. When this information is combined with a sound geologic model, exploratory wells can be drilled with a high rate of success. But these targets can be small (1/4 section [0.6 km^2] and less) and their seismic expression is sometimes subtle. Many good, porous and fractured reservoirs have become disappointments as they produce at high water cuts before payout is even achieved. Therefore, the play is a good one but must be approached with caution.

Using a 3D seismic data volume (and some 2D data), a typical Precambrian high is examined at Hunt Creek (Twp 93, Rge 9 W5M). Observations are made about the size, shape and trend of the Precambrian highs and the draping Keg River reservoir. Subtle features of the anomaly which may complicate the exploration process are discussed.

Seismic should continue to be effective in this Keg River play. It is likely that techniques such as 3D will play an increasingly important role in the exploitation and development of these reservoirs.

INTENSIVE SEISMIC INTERPRETATION AND ANALYSIS OF ITS RESULTS IN THE EARLY ASSESSMENT OF A MARINE RESERVOIR

YANG SHI-YING, *BO-HAI PETROLEUM CO.*

After preliminary drilling has established commercial deposits of oil and gas within the trap zone of interest, the next main step for geophysicists is to define the reservoir by seismic interpretation: reservoir top and base geometry, thickness variation, areal distribution, lithologic variation, as well as other related geological parameters, to supply a basis for preliminary reservoir calculation.

To approach this task, conventional processing and interpretation do not provide sufficient accuracy for these objectives. Different geological problems should have different special interpretation methods tailored to the desired results. This aspect of interpretation is covered in the paper, with practical examples from the Liao-Dong Bay and South Bo-Hai marine areas.

THE SEISMIC SIGNATURE OF A SWAN HILLS (FRASNIAN) REEF RESERVOIR IN ALBERTA, CANADA

NEIL L. ANDERSON, *PETREL ROBERTSON LTD.*, R. JAMES BROWN*, *UNIVERSITY OF CALGARY*, AND RONALD C. HINDS, *HINDS GEOPHYSICAL INC.*

Swan Hills Formation (Frasnian Stage) carbonate buildups of the Beaverhill Lake Group are not typical western Canadian Devonian reefs, either from a geological or a geophysical standpoint. These complexes are generally of low relief and considerable areal extent and are overlain by and encased within the relatively high-velocity shale of the Waterways Formation which thins but does not drape across the reefs. Consistent with this, prereef seismic events are not significantly pulled up beneath the reefs; nor are postreef events draped across them. Indeed, the seismic images of these reefs are effectively masked by the high-amplitude overlying Beaverhill Lake Group and underlying Gilwood Member events and cannot be distinguished from that of the basin fill. However, it is possible, indirectly, to identify the reefs on conventionally processed seismic sections because the image of the encompassing Beaverhill Lake/Gilwood interval varies significantly laterally, from onreef to offreef positions.

One such Swan Hills Formation reef, the Snipe Lake reef, has an areal extent of about 90 km^2 and typical relief of some 40 m above the platform facies. The reef is recognized through the laterally varying interference phenomena which are associated with the lateral variations in thickness of the Swan Hills Formation. These phenomena include: an offreef interference peak between the Beaverhill Lake reflection trough and the Gilwood reflection peak which dies out laterally going onreef; a lateral variation in the amplitude of the Gilwood reflection peak being usually of higher amplitude offreef than onreef, and a tendency for the Gilwood event to appear as a double

peak onreef. Through modelling, these seismic-image characteristics are seen to be predictable geophysical manifestations of the inherent geological variations.

SEISMIC REFLECTION CHARACTERISTICS OF THE REEFS IN THE CHANG-XING FORMATION OF THE UPPER PERMIAN IN EASTERN SICHUAN

CHEN TAI-YUAN, *PETROLEUM ADMINISTRATION OF SICHUAN*

The reef complex in the Chang-Xing Formation of the Upper Permian of the eastern Sichuan basin is an irregular dome-shaped body composed of reef core, backreef sands and reef talus. Its general thickness is 70 to 120 m, 50 to 70 m greater than that of the adjacent contemporaneous offreef facies sediments.

The areas of the reefs range from less than 1 to several km^2 and the largest may reach tens of square kilometres. The reservoirs in the reef complex are mainly porous dolomite and dolomitic limestone lenses in backreef sands with cumulative thicknesses of tens of metres, porosities of 7 to 16 percent and limited lateral extent.

Based on a great deal of seismic and integrated data analysis, this paper reports on the interpretation of the seismic reflection characteristics of reefs and their porous dolomites on seismic sections in the region. Three kinds of important reflection anomaly are described: the Shuanglong type, the Shibaozhi type and the longer-time-interval type, which can constitute the criteria for finding reefs. To date, 67 of these seismic reflection anomalies have been delimited in the region under study.

A CARBONATE RESERVOIR STUDY ON THE DONG-SHA MASSIF IN THE PEARL RIVER-MOUTH BASIN

HU XING-YUAN* AND YANG JIA-MING, *SOUTH CHINA SEA PETROLEUM BUREAU*

The Dong-Sha massif, located in the eastern Pearl River-mouth basin within the northern shelf of the South China Sea, is bordered to the north by the Zhu I depression, to the south by the Zhu II depression, and to the west by the Panyu uplift. Its eastern margin, which is part of the basinal margin, is confined arbitrarily by the 1000-m isopach contour of the sedimentary rocks. To the east of the Dong-Sha massif lies the Dong-Sha massif area. The Dong-Sha massif, of an areal extent of 13 500 km^2, is a persistent positive structural unit, extensively overlain by Miocene sediment with a common lack of Eocene. Within the Lower Miocene (Zhujiang Formation), the lower portion is sandstone-prone, while the upper portion is predominated by carbonate. During the post-Middle Miocene, however, an open-marine environment appeared with deposition of outer littoral clay on the massif. Thus, an excellent combination of reservoir and seal has been created, with juxtaposition, upward, of sandstone, carbonate and argillaceous rock. Both sandstone and carbonate could have served as conduits for hydrocarbon migration from the depression to the massif. However, hydrocarbons accumulated mainly in the carbonate which is the extensively distributed reservoir on the massif, resulting from the absence of a stable seal between the sandstone and carbonate. Of the total of 8 wells drilled to date on the massif, 6 wells have oil shows, and one of them has daily oil production as high as 360 m^3. Drilling also confirms the seismic interpretation that carbonate reef banks have been well developed on the massif, with encountered porosities up to 35 percent. On the Dong-Sha massif to date, not only has China's greatest oilfield produced by a carbonate reef bank been discovered, but also satisfying results in regional and local seismic-stratigraphic studies have been obtained. Thus, characteristics of hydrocarbon migration and accumulation and exploration prospects have been more clearly defined by regional seismic-stratigraphic study on the carbonate platform; while, by means of local seismic-stratigraphic analyses on the reservoirs of oilfields, we have mapped the porosity distribution, attaining our goal of using seismic information to evaluate reservoir quality.

INTERPRETATION OF A SMALL UNDERWATER-FAN SAND BODY

WANG DA-CHANG, *BUREAU OF GEOPHYSICAL PROSPECTING, MINISTRY OF PETROLEUM INDUSTRY*

This paper presents the application of 3D amplitude slices and velocity slices to interpretation of lithology, particularly in sedimentary basins that are simple in tectonic structure, rich in reflectors and good in quality of seismic data. The amplitude slice and velocity slice can be used to analyze the depositional environments of various geologic bodies and to infer the lithology of the bodies and interpret the lateral changes in lithology more reasonably. Also, these slices can be used to delineate the sandbodies and to find the favourable reservoirs.

In the paper, an example of the interpretation of a small underwater fan is used to illustrate the application of 3D amplitude and velocity slices to lithological interpretation.