DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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OVERSEAS VISIT TO MEXICO AND USA, 18 October to 24 November 1973

by

F.J. Moss

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TABLE 1. Equipment companies and Seismic contractors visited.

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SUMMARY

Mr F.J. Moss made an official visit to Mexico and the USA from 18 October to 24 November 1973. He attended the 43rd annual meeting of the Society of Exploration Geophysicists in Mexico, where he presented a paper on 'Deep Crustal and Upper Mantle Reflection Studies in Australia', visited seismic equipment manufacturers in Texas, USA, mainly to obtain information on seismic digital recording systems, and visited the United States Geological Survey in Menlo Park, California, USA to discuss the status of reporting on the joint BMR/USGS geological and geophysical surveys of Gosses Bluff, an impact structure in central Australia.

The Society of Exploration Geophysicists' meeting was an excellent conference attended by specialists in many fields of exploration geophysics. A number of papers of particular interest were presented in the technical sessions on the direct detection of hydrocarbons by seismic methods, improvements in seismic recording and processing techniques, and case histories in the use of seismic, gravity, and magnetic techniques in the discoveries of particular petroleum fields. The Australian and West German invited papers on deep crustal reflection studies were the outstanding contributions in a Symposium on this subject.

Information on the latest types of seismic digital recording systems and other seismic equipment was obtained from equipment manufacturers at the SEG meeting and in visits to fourteen equipment manufacturers and seismic contractors in the USA. An Instantaneous Floating Point gain control, seismic digital recording system, capable of expansion to more than 24 seismic channels, of handling all energy sources and of being upgraded to incorporate software-controlled field processing facilities is recommended for BMR's future needs. The Texas Instruments Inc. DFS IV and the Sercel Inc. SN 338B systems appear to be the most suitable on the market. T.I.'s attention to component testing and systems check-out procedures, proven field experience, and back-up facilities for training, advice, and trouble-shooting appear to be the best available in the industry.

Further joint studies on the interpretation of the geological and geophysical data from the Gosses Bluff surveys are recommended to bring the project to a satisfactory conclusion. Dr D. Milton, the principal USGS geologist on the project, proposes to visit BMR, for a period of 2-3 months late in 1974, to cooperate with his co-workers in the Geophysical Branch on completing the interpretation and reporting requirements.

It is recommended that a senior geophysicist should attend all annual Society of Exploration Geophysicists meetings to report back to BMR on recent advances in geophysical exploration technology.

INTRODUCTION

Mr F.J. Moss, Geophysicist Class 4, Seismic Gravity and Marine Section, Bureau of Mineral Resources, Geology and Geophysics (BMR) made an official visit to Mexico and the USA from 18 October to 24 November 1973. He attended the 43rd annual international meeting of the Society of Exploration Geophysicists (SEG) held jointly with the 5th meeting of the Asociacion Mexicana de Geofisicos de Exploracion in Mexico City, Mexico, from 21 to 25 October. He visited a number of seismic equipment manufacturers in Houston, Dallas, and El Paso, Texas, from 29 October to 13 November and the United States Geological Survey (USGS) in Menlo Park, California, from 14 to 21 November.

The main purpose of Mr Moss's visit to the USA was to study the latest developments in seismic digital recording systems and seismic techniques. The SEG meeting was considered to be an excellent venue for obtaining up-to-date information prior to his visits to equipment manufacturers.

Mr Moss presented a paper on 'Deep Crustal and Upper Mantle Reflection Studies in Australia' at the SEG meeting in response to an invitation by Professor R.P. Meyer, Wisconsin University, Madison, Wisconsin, USA, convenor of a special 'Deep Crustal Reflections Symposium' at the meeting. This was one of seven invited papers from throughout the world in this, the first symposium held specifically on the use of seismic reflection techniques to study the deep parts of the Earth's crust and upper mantle. An extended version of the paper is being prepared under the joint authorship of F.J. Moss and J.C. Dooley for publication in 'Geophysics'.

Discussions were held with exhibitors of equipment at the SEG meeting and visits were made to leading seismic equipment manufacturers and contractors in the USA, mainly to obtain information for an in-depth study of seismic digital recording systems for consideration against BMR's future needs. The opportunity was also taken to discuss ancillary seismic equipment, including cables, geophones, oscillographs, seismic remote firing systems, and seismic telementry equipment.

The visit to the USGS in Menlo Park was mainly for discussions with Dr D. Milton of the Astrogeologic Branch on problems of reporting on the joint BMR/USGS surveys of Gosses Bluff, an impact structure in central Australia. A seminar on deep seismic sounding techniques was given by the author at the National Center for Earthquake Research, also in Menlo Park.

Detailed progress reports on all visits made on the overseas tour are on BMR File 73/863.

43rd ANNUAL MEETING OF THE SOCIETY OF EXPLORATION GEOPHYSICISTS, MEXICO CITY, MEXICO

The annual meeting of the Society of Exploration Geophysicists is the most significant international meeting of geophysicists engaged in petroleum and mineral exploration. Expected changes in geophysical exploration and technology required to meet future energy needs, significant case histories, and reviews of activities that indicate directions of change and technical developments are discussed in depth. The 43rd annual meeting was no exception.

There was an excellent technical program at the meeting, the only hitches in the proceedings being troubles with bulbs blowing on projectors because of fluctuations in power and with the inexperience of the Mexican projectionists. The Mexicans, however, proved to be excellent hosts to the conference and provided entertainment which included a 'Fiesta Charra' - a Mexican style rodeo, a visit to the 'Ballet Folklorico' and a 'Noche Mexicana' - a night with musicians and folk dancers, food, drink, and a fireworks display held in Chapultepec Park in Mexico City.

3834 registered for the meeting, including 2202 delegates and exhibitors from most countries with active petroleum and mineral exploration activities, 1481 ladies, and 151 students. It provided an excellent opportunity to meet other geophysicists and discuss areas of activity and problems in petroleum exploration elsewhere in the world, and to view and discuss the latest types of geophysical equipment developed to tackle the problems.

Four special addresses were given and 160 scientific papers were presented in four concurrent sessions on General Geophysical, Mining, Geothermal, Oceanographic, and Research topics. Eighty-two companies exhibited equipment and displayed particular features of their activities and services; the equipment exhibition was only open concurrently with the technical sessions. The most popular technical sessions were those on 'Direct Detection of Hydrocarbons and Velocity' and 'Digital Systems and Deconvolution'. Unfortunately the latter session was held concurrently with the 'Deep Crustal Reflections Symposium' and the author obtained little information other than in the abstracts provided.

Reprints of papers were not generally available at the meeting; abstracts are published in Geophysics (Society of Exploration Geophysicists, 1973). Recent excellent SEG publications on display at the meeting included an 'Encyclopedic Dictionary of Exploration Geophysics' (Sheriff, 1973), and a monograph on 'Pitfalls in seismic interpretation' (Tucker & Yorston, 1973). A 'Safety Manual for Geophysical Field Operations' (International Association of Geophysical Contractors, 1974) was also on display. Copies of these publications have been requested for the BMR Library.

Sessions attended dealt mainly with petroleum exploration using seismic, gravity and magnetic techniques; it was impossible to attend all technical sessions and to obtain more than an overview of the exhibits. A number of papers of particular interest were presented on direct detection of hydrocarbons by seismic methods, improvements in seismic recording and processing techniques, and case histories in the use of seismic, gravity, and magnetic methods in the discoveries of particular petroleum fields. A number of the papers on the direct detection of hydrocarbons presented at the meeting had been presented earlier in October 1973 at a symposium sponsored by The Geophysical Society of Houston (1973). Copies of the proceedings of that symposium have also been requested for the BMR Library.

A breakthrough in the direct detection of hydrocarbons has been made by recording seismic data digitally with very accurate measurements of signal amplitudes, mainly using 'Instantaneous Floating Point' (IFP*) amplifiers and applying particular seismic data processing techniques to enhance various diagnostic characteristics of seismic reflections including amplitude, frequency, phase, and apparent dip. In geological environments known to be favourable for petroleum accumulation the increases in seismic reflection amplitudes over zones of higher reflectivities associated with petroleum traps produce so-called 'Bright Spots'. As an aid to interpretation the processed data may be compared with simulated data from computer generated models using information on acoustic and density changes observed in the geologic section, in well logs. Particularly worthy of note is a paper on the significance of colour displays in the direct location of hydrocarbons, by N.A. Anstey, in which he illustrated the use of colour as the display mode for the auxiliary seismic variables, generally interval velocity and reflection strength. Considerable success has been achieved in using the 'Bright Spot' technique to identify the

* Licensed under Texaco, Inc. patent.

existence and extent of some oil and gas zones and to support and clarify structural and stratigraphic interpretations in different areas and environments world-wide, including Gulf of Mexico, North Sea, Canada, Indonesia, Nigeria, and Venezuela.

Other very interesting papers in the general and research sessions dealt with the use of seismic recording systems, up to 248 channels being recorded simultaneously with closely spaced individual detectors or groups of detectors, and the directional beaming of seismic energy. Improvements in field processing systems, using mini-computers, have led to higher efficiency and more economical processing. Much emphasis was placed on computer applications to processing and analysis of seismic data, and considerable advances have been made recently in a number of other fields including 3D migration processing and displays.

Deep Crustal Reflections Symposium

Seismic soundings of the crust and upper mantle contribute significantly to the study of regional geology and to the interpretation of gravity and magnetic fields in seeking a better understanding of petroleum and metalliferous provinces and their potential for discovery of economic deposits. The 'Deep Crustal Reflections Symposium' was successful in bringing together scientists who are actively engaged in using seismic reflection methods for studying the deeper parts of the crust and upper mantle. Australia, together with the USSR (which was not represented at the meeting), Western Germany, and Canada have done more in the systematic collection and interpretation of deep crustal seismic reflection information than other countries. However, studies in this field are still in their infancy.

The following papers were presented at the symposium and will probably be published later in 'Geophysics':

Deep Continental Reflection Profiling Probabilities for the Future, by J. Oliver, Cornell University

Deep Crustal Reflection Recording using Vibroseis Methods - A feasibility Study, by K.H. Waters and J.C. Fowler, Continental Oil Co.

Feasibility Studies for Deep Crustal Reflection Work, by R.P. Meyer and J.F. Gettrust, University of Wisconsin.

Deep Crustal Reflections from a Vibratory Source, by E.J. Mateker, Jr. and A.K. Ibrahim, Western Geophysical Co.

Observations of Deep Crustal Reflections in Central Europe by R.O. Meissner, University of Kiel and G. Dohr, Preussag AG

Deep Crustal and Upper Mantle Reflection Studies in Australia by F.J. Moss and J.C. Dooley, Bureau of Mineral Resources

The Structural and Attenuation Characteristics of the Crust using Synthetic and Field Reflection Seismograms by E.R. Kanasewich, University of Alberta.

J. Oliver stressed the success of reflection profiling techniques in petroleum exploration and indicated the goals of the USA program for the Geodynamics project, which calls for application of seismic techniques with good resolution in studying the deeper parts of the crust and upper mantle. He pointed out problems with environmental control bodies in projects using large explosives charges, as in the large scale seismic refraction projects in the USA in the late 1950s and early 1960s, and indicated the need for the use of small explosives charges or non-explosives sources in seismic reflection techniques for a program of detailed studies of the crust and the upper mantle in the USA to start soon.

Papers by Waters & Fowler, Meyer & Gettrust, and Mateker & Ibrahim dealt with experimental feasibility studies in the USA using Vibroseis techniques. Field techniques and data processing applied to the results of a survey by the Continental Oil Co. in Oklahoma, in which the University of Wisconsin participated, were discussed in the first two presentations. Arrays of geophones were set up and vibrators were used at particular distances up to 64 km away from the arrays. Low-frequency geophones, 1 Hz in the recording by the University of Wisconsin team, 5-20 Hz sweeps, and up to 120 sweeps of 30 s duration were used. Digital filtering techniques with 5-15 Hz filters were applied. Results were poor but both teams claimed that they had successfully recorded deep crustal reflections. Mateker & Ibrahim were more successful in obtaining results of poor to fair quality in North Dakota using four vibrators with a 6-24 Hz sweep, 8-Hz geophones in groups of 48 arranged in crosses, of arm length approximately 200 m, and 64 sweeps per group length to record 1000% CDP coverage at near-vertical incidence.

Results similar to those in Australia, were reported on from Europe by Meissner & Dohr, who discussed deep crustal reflections obtained at near-vertical incidence on long running records on normal reflections surveys, on special near-vertical observations in selected areas, and wide-angle observations in the range of 20 to 200 km. They concluded that the Mohorovicic Discontinuity consists of lamellae, with gradual average increase in velocities, which may be interspersed with thin lower-velocity layers giving rise to locally high reflection coefficients. Dohr (1972) and Meissner (1973) give considerable information on recent deep crustal seismic reflection studies in Europe and on the interpretation of seismic data indicating that the boundary between the crust and the upper mantle is a transition zone.

E.R. Kanasewich indicated that, from his experience in Canada, deep crustal reflection information recorded in continuous profiling at near-vertical incidence gives a unique seismic cross-section with the highest resolution. Complicated structure in Canada yielded complex seismograms with reflections which could only be separated using velocity filters and migration to their true subsurface positions. He showed how spectral analyses of field and theoretical seismograms can be used to determine the fine structure of discontinuities and the attenuation characteristics of the crust.

The results of Australian studies in this field are given by Moss & Dooley (in prep.). Stimulating discussions followed the presentation of the papers, and requests have been received for exchange of information to assist in judging the potential of deep crustal reflection profiling techniques.

VISIT TO SEISMIC EQUIPMENT COMPANIES AND CONTRACTORS, USA

At the SEG meeting, contacts were made with equipment manufacturers and contractors, and information on seismic equipment was obtained for study prior to follow-up visits to companies in the USA. There was little opportunity at the meeting to spend much time in discussions with particular exhibitors because of the large number of exhibits, the opening of booths only at the times of technical sessions, and the large crowds in attendance.

Visits were made to 14 seismic equipment manufacturers and contractors in Texas, the home of the principal manufacturers of seismic equipment in the world; 11 visits were made in Houston, 2 in Dallas, and 1 in El Paso. Equipments studied included planned and developed seismic digital recording systems and ancillary seismic equipment. The visits generally involved tours of manufacturing plants, demonstrations of equipment, and discussions with geophysical engineers. The companies visited are listed in Table 1 together with their main equipments or services of interest. Details of particular visits are given in BMR File 73/863, and detailed information on equipments are in brochures and manuals held in Geophysical Branch.

Seismic Digital Recording Equipment

Seismic digital recording techniques were introduced into petroleum exploration work in recent years and are now widely used on seismic surveys. In its summary of geophysical activity in the Western Hemisphere for 1972, the Society of Exploration Geophysicists (1974) indicated that 97% of all marine seismic crews and 78% of all land seismic crews used digital recording equipment. With this equipment, low signal levels can be recorded and the data are in a form suitable for processing directly with digital computers. BMR is equipped only with seismic analogue recording and processing systems and uses contract digital processing facilities. To provide improved seismic data recording and processing flexibility with lower overall costs, it is planned to update the systems by purchasing seismic digital recording equipment, and by processing with mini-computers at BMR and on the new CSIRO Cyber 76 computer.

Seismic digital recording systems fall mainly into two categories: binary gain ranging with one seismic amplifier for each seismic information channel, and IFP systems with only one seismic amplifier and seismic information multiplexed before amplification. The principal advantages of an IFP system are: a single system transfer function; and amplification over the full gain range of the system, adjusted in a few microseconds at each sample interval just prior to the instant of digitizing, to give higher small signal resolution to about 13 bits precision. It maintains this precision even for burst-outs and for weak signals near strong signals.

The characteristics of the 12 main types of seismic digital recording systems studied are listed in Table 2. The specifications of the equipments are very similar generally. The Sercel, T.I., and GUS systems, however, have alternative non-standard tape formats; the GUS systems also have high-density recording of 8000 bpi compared to a maximum of 1600 bpi for other systems which use standard SEG A, B, or C tape formats. SEG A and B tape formats were recommended as standards for binary gain recording (Northwood, Wiesinger & Bradley, 1967) but SEG A tape format could not be used for recording more than 24 seismic information channels plus auxiliaries. SEG C tape format, IBM compatible, 4 bytes per sample and full word floating point, was recommended (Meiners, Lenz, Dalby & Hornsby, 1972) to accommodate developments including floating point recording, 1600 bpi recording density c.f. 800 bpi for SEG A and B, and the need for larger data words to meet requirements of field compositing. Meiners et al. (1972) also recommended that SEG A and B tape formats should be updated for 1600 bpi recording density in addition to 800 bpi.

The IFP systems available, mainly the DFS IV, GS-2000, SN 338B, and COBA 1, and the binary gain ranging systems are all expandable to more than 24 channel recording. The DFS IV can record up to 248 seismic channels where others can nominally record less. The main disadvantage of multi-channel recording with more than 24 channels on IFP systems is that the sample rate may be reduced to 4 ms or 8 ms sampling, because of the limitation of the multiplexing rate. Multi-channel systems with more than 24 channels are used to record from closely-spaced individual geophones or groups of geophones along traverses or on grids to allow more versatility in later filtering and more accurate 2D or 3D migration processing.

A more recent trend in seismic land surveys has been to augment the field digital seismic recording systems with small computers, capable of use with all presently used seismic energy sources, including explosives, weight dropping and Vibroseis, which required field correlation facilities, and field stacking facilities for common depth point (CDP) multiple coverage work. The augmented systems control the recording process and allow data processing to be done in the field as a monitoring operation. In 1972, 98% of all surveys recorded CDP coverage, and 37% of land surveys and 97% of marine surveys used non-dynamite sources (Society of Exploration Geophysicists, 1974).

The T.I. CFS.I, Electro-Tech. FUTURA, Sercel TIGRE, and D.D.S. COBA 3 systems fall into the above category. The Electro-Tech. COMMAND and the Seismograph Service Corp. (S.S.C.) PHOENIX are examples of off-line mini-computer software-controlled processing systems for field use, which operate at lower cost and obviate delays in processing caused by sending data from the field to major computing centres.

The basic requirement for BMR to carry out experimental seismic surveys in poor reflection areas and surveys to assist in sedimentary basin studies, making use of modern technological developments, is for a system with

IFP capability such as the DFS IV, GS-2000, SN 338B, or COBA 1. The system should be capable of readily expanding the number of seismic channels, upgrading to incorporate software-controlled field processing facilities at a later date, capable of handling all energy sources including Vibroseis (which requires field correlation facilities), and have facilities for field stacking for CDP work. It should preferably be a well-proven system, with many similar in operation; check-out procedures for units in the equipment and the entire system should also be well-proven. The supplier should be capable of providing expert training and trouble-shooting if required.

The Texas Instruments Inc. DFS IV system particularly appears to meet these requirements. At the end of 1973, 116 DFS IV systems were in operation throughout the world by Geophysical Services Inc., other companies, and government bodies. The Sercel Inc. SN 338B system is also highly regarded by Seiscom-Delta and other contractors, but little information is available on its general usage, which is mainly outside the Western Hemisphere. The other IFP systems noted in Table 2 are not widely used. Two systems not included in Table 2, the SIE Inc. RS-49R and the Digital Data Systems MANPAQ, are essentially portable seismic analogue systems with digital recording on magnetic tape cartridges. Transcription facilities are required to convert data to SEG B or C tape formats. These systems would be excellent for engineering or other seismic surveys in areas inaccessible to truck-mounted equipment. Cartridge recording has the advantage that the magnetic tapes are fully sealed from dust, which can be a major problem on land seismic surveys.

Systems costs, where available, are included in progress reports in BMR File 73/863.

Other Seismic Equipment & Services

Equipment or services of interest are listed in Table 1 and discussed in detail in BMR File 73/863. They included seismic cables, geophones, oscillographs, seismic remote firing systems, seismic telemetry including transmission line equipments other than normal seismic recording systems, high-resolution seismic digital recording systems specifically for engineering and shallow marine surveys, and geophysical data based systems and geophysical contractual services.

Cables. Cable manufacturing and testing techniques were demonstrated mainly by the Custom Cable Co., the principal supplier of cables for making seismic cables and geophone cables used by BMR. Manufacturers are currently having problems in obtaining plastics for cable manufacture.

Geophones. The latest ranges of digital grade geophones were discussed at Geospace Corp., Walker-Hall-Sears Inc., and Electro-Technical Labs. Geospace have been having problems with cracks in cables, because of faults in moulding processes; a considerable number of sets of geophones have been returned from overseas for recabling, at considerable inconvenience to the user company. Walker-Hall-Sears is a new company which has got together a group of geophysical engineers with many years of experience in geophone design and manufacture. It claims considerable success in producing a new generation of very-low-distortion digital grade geophones which have wafer top and bottom positioning springs and a bottom-mounted helical compression spring, and carried out some very convincing comparison tests with its own and other geophones to prove these claims.

Oscillographs. SIE Inc., is still the industry's main supplier of seismic recording oscillographs. Discussions were held with Geospace on specifications for a modified MR 101A oscillograph for display of marine records. SIE does not make a similar recorder but is associated with a company in Canada which has since supplied specifications and details of an equivalent oscillograph to BMR.

Seismic remote firing systems. BMR wishes to purchase a seismic source synchronizer for remote firing in CDP and refraction surveys. Input/Output Inc. and GUS Manufacturing Inc. both make suitable systems which use coded digital signals for reliable and safe operation. Input/Output systems are used by a considerable number of companies throughout the world and are known to be generally reliable. The GUS RPT-144 system appears to be slightly superior, with the time break and up-hole time displayed in a coded digital form, but it is more expensive than the Input/Output system and is not so well known in the industry.

Seismic telemetry systems. The Aquatronics TELSEIS system is in use throughout the world. Its successful application to seismic surveys in difficult areas was demonstrated with a number of slides on surveys in Alaska, Indonesia, Peru, and the Middle East. Its main advantages are that no cables are required, since the transmission link is by radio, and it has a range of about 20 km. GUS Manufacturing Inc. developed a similar system but did not market it, mainly because of problems in obtaining allocation of transmission frequencies in the USA and possible problems in security of transmitted information. GUS has developed the GUS BUS seismic transmission system which uses a one-pair land line to which transmitters may be connected at any spacing along the line. Demonstrations of this equipment indicated that transmission line losses were low and trace equalization of all signals was accomplished. Considerable advantages are claimed in some circumstances over the TELSEIS type system which uses essentially line-of-sight recording.

High-resolution seismic digital recording systems. Quantum Electronics Corp. and Input/Output Inc. are both developing high-resolution systems, the DAS-1 and DHR-16 respectively, for shallow marine continuous profiling and engineering surveys. These systems will probably record up to 8 channels of information with ½, 1, or 2 ms sampling. BMR will be advised of detailed specifications of the equipments when these become available.

Services. Seismic contracting services were discussed mainly with Aquatronics, Seiscom-Delta, and Geophysical Services Inc. (GSI).

The most rewarding visit was to GSI, where a number of seminars were attended on seismic data acquisition, pre-processing, analysis, and post-processing. GSI offers a service to set up an integrated exploration interpretation system on any data base and has experience in setting up data bases for national oil enterprises and private companies, for initial reconnaissance in relatively unexplored land and marine areas, and in mature petroliferous provinces. Some discussions were held on the use of the advanced scientific computer (A.S.C.) the TIMAP, multiple-application processers, and the TIADD automatic data display systems. Brochures on these systems, and a number of brochures advertising GSI's services, are also held in Geophysical Branch.

VISIT TO UNITED STATES GEOLOGICAL SURVEY, MENLO PARK, CALIFORNIA, USA

BMR and the USGS co-operated on a detailed geological and geophysical investigation of Gosses Bluff, an impact structure in central Australia, in 1968 and 1969. This impact structure, which shows a striking similarity to lunar impact features, is the most fully studied structure of its type anywhere in the world, and a considerable effort has gone into field studies. Preliminary results from the joint BMR/USGS project have been published in a leading article in 'Science', (Milton et al., 1972) and in BMR records and reports on the geological and geophysical work done by the BMR (Glikson, 1969; Young, 1972; Brown, 1973). However, final reporting on the project has been delayed by resignations, by other commitments of BMR and USGS staff, and by the need for the principals on the project to get together to complete the work for publication in BMR's Bulletin series.

During the week's visit to Menlo Park discussions were held with Dr D. Milton of the Astrogeologic Branch of the USGS, the main geological worker on the project, to determine what is required to bring the project to a satisfactory conclusion. The status of interpretation and reporting on individual aspects of the work was examined.

Dr Milton is preparing a detailed geological map of Gosses Bluff at a scale of 1:5000 and a regional map to include the outer zone at a scale of 1:50 000. The maps still require much compilation work, and the geological contribution to the bulletin has not been started. The structure as inferred by Brown (1973) from analysis of the seismic data poses some problems of interpretation, especially in the area outside the raised rim of the inner zone. The main part of the 'time depression' in the formations at considerable depth in the outer zone is probably caused by near-surface velocity variations. Detailed study of the zones of brecciation in the outer zone indicate a high degree of coincidence with the depressions. Some more detailed analysis of the seismic data is necessary. The gravity results suggest that the main gravity expression of Gosses Bluff is caused by density variations in the near-surface formations, and the magnetic results (Young, 1972) suggest that the basement is relatively undisturbed under the Bluff.

It is considered now, from the preliminary revised interpretation of the seismic results, that they generally agree with the concept of a relatively flat basement under Gosses Bluff. Also it is suggested that the so-called coincidence of the Gosses Bluff feature being situated on the highest part of the buried Gardiner-Tyler anticline is suspect.

The finalizing of the work on this project will take longer than was anticipated and it can only be done satisfactorily if the participants all work together for a period of 2-3 months. Dr Milton paid a brief visit to BMR in February 1974 when further discussions were held with BMR staff on the status of the project. He proposes to return to BMR for a period of 2-3 months later this year, during which time every effort will be made to complete the reporting.

Keen interest was shown in BMR's deep crustal and upper mantle reflection work at a seminar given at the National Center for Earthquake Research. The methods used in this work were discussed further with Drs J. Healy and J. Eaton, the leading USGS geophysicists involved in deep crustal and upper mantle seismic studies in the USA. Their main experience is in the use of large-scale seismic refraction techniques, and they had little information to contribute on reflection studies, but they were keenly interested in the BMR work in this field.

CONCLUSIONS

The annual international meeting of the Society of Exploration Geophysicists was an excellent meeting of specialists in many fields of exploration geophysics. In particular the papers presented on petroleum exploration topics and the informal discussions with others actively engaged in the industry were found to be stimulating and rewarding in ideas. All participants were willing to explain equipments and methods used and results obtained, and all information, technical papers, and brochures requested were freely given. The desire to remain in contact for exchange of information was expressed by geophysicists of many organizations.

The worldwide energy shortage and the contribution geophysicists may make to exploration for further energy resources was a major topic discussed at the meeting. Considerable interest was shown in the future of petroleum exploration activities in Australia.

The 'Deep Crustal Reflections Symposium' was an excellent venue for the discussion of objectives, techniques, results of previous studies, and interpretation in this field. The Australian and West German papers were generally considered to be outstanding contributions in the symposium.

Discussions with equipment manufacturers, at the equipment exhibition at the meeting and in visits to equipment companies, provided information on recent technological developments in seismic digital recording systems and other seismic equipment. Personal contacts made will be useful when further information on seismic equipment is required.

An Instantaneous Floating Point gain control, seismic digital recording system, capable of expansion to more than 24 seismic channels, handling all energy sources and upgrading to incorporate software-controlled field processing facilities is recommended for BMR's future needs. The Texas Instruments Inc. DFS IV and Sercel Inc. SN 338B systems appear to be the most suitable on the market. The Texas Instruments Inc. attention to component testing, systems check-out procedures, proven systems field use, and back-up facilities for training, advice and trouble-shooting are excellent, but little is known of Sercel Inc. reputation in these matters.

The visit with Dr D. Milton at the United States Geological Survey in Menlo Park, California, USA assisted in determining the status of reporting on the Gosses Bluff joint BMR/USGS surveys and indicated the need for further joint studies in the interpretation of the geological and geophysical data to bring the project to a satisfactory conclusion. Dr Milton proposed to visit BMR, to work with the BMR geophysicists to this end, for a period of 2-3 months late in 1974.

It is recommended that a senior geophysicist should attend all annual Society of Exploration Geophysicists' meetings to report back to BMR on recent advances in geophysical exploration technology. Preferably such visits should be of limited duration and cover not more than one or two main themes for additional studies.

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TABLE 1 EQUIPMENT COMPANIES AND SEISMIC CONTRACTORS VISITED

COMPANY	ASSOCIATED CONTRACTORS	EQUIPMENT OR SERVICES OF INTEREST
Texas Instruments Inc., HOUSTON	Geophysical Services Inc.	DFS III, DFS IV, CFS I
Electro Technical Labs, HOUSTON	Petty-Ray	SUM-IT VII, MDS-8, FUTURA II, COMMAND Complete outfitting of seismic crews Geophones cables
Gus Manufacturing, Inc., El PASO	own crews	HDDR 4000, 4200, 5000 RPT-144 Seismic source synchronizer with coded digital format GUS BUS transmission line telemetry system
Geospace Corp, HOUSTON	-	1700, GS-2000 Geophones Complete outfitting of seismic crews
Sercel, Inc., HOUSTON	CGG	SN328, SN338A, SN338B, TIGRE Manufacturing plant is in France
Digital Data Systems, HOUSTON	Western Geophysical Corp.	COBA 1, 2, 3 MANPAQ portable seismic digital recording system
SIE, Inc., HOUSTON	-	RS-49R, analogue system with cartridge digital recorder Oscillographs
Input/Output Inc., HOUSTON	-	DHR-16, high resolution 8 channel digital system for marine and engineering Seismic source synchronizer
Quantum Electronics Corp., HOUSTON	-	DAS-1, high resolution 8 channel digital system for marine and engineering Model 24 advanced 24 channel seismic correlator
Walker-Hall-Sears, Inc., HOUSTON	-	Geophones, high performance digital grade
Custom Cable Co., HOUSTON	-	Cable manufacture and testing
Geophysical Services Inc., DALLAS	-	Experience with TI equipment Seismic contracting services Data based systems
Seiscom-Delta, HOUSTON	-	Experience with Sercel, TI equipment Colour displays in seismic data processing
Aquatronics, DALLAS	own crews	TELSEIS, seismic telemetry system MULTIPAK, high resolution marine profiling seismic system

TABLE 2. CHARACTERISTICS OF MAIN SEISMIC DIGITAL RECORDING SYSTEMS. *

SPECIFICATION	DESCRIPTION	DESIRABLE SPECIFICATION	TEXAS INSTRUMENTS, INC. DFS-III	DFS-IV	ELECTRO-TECH LABORATORIES SUM-IT-VII	MDS-8	GUS MANUFACTURING, INC. HDDR-4000	HDDR-4200	HDDR-5000	GEOSPACE CORP. 1700	GS-2000	SERCEL, INC. 338A	338B	DIGITAL DATA SYSTEMS COBA 1
No. of data channels	Number of channels which can be recorded simultaneously	>48 Seism. + Anx.	24 Seism. Expand to 248	24,56,62 Seism. Expand to 248	24 Seism. Expand to 60	24 Seism. Expand to 96	24 Seism. Expand to 48	24 Seism. Expand to 196	24 Seism. Expand to 112	24 Seism. Expand to 60	48 Seism. Expand to 96	24 Seism. Expand to 48	24 Seism. Expand to 48	24 Seism. Expand to 120
Gain control method	IFP - one amplifier all channels. BGR - one amplifier per channel	IFP preferred-1 transfer Function	Binary Gain	IFP	Binary Gain	Binary Gain	Binary Gain	Binary Gain	Binary Gain	Binary Gain	IFP	IFP	IFP	IFP
Gain control range	Amount of dynamic gain range.	84-90dB	90dB	84dB,12dB steps	90dB	90db,6dB steps	90dB,6dB steps	90dB,6dB steps	90dB,6dB steps	90db.	90dB,6dB steps	84dB,12dB steps	84dB,12dB steps	84dB
Max. Gain	Maximum gain referred to system noise.	110dB+	120-126dB	96-126dB	108-132dB	132dB	114-132dB	114-132dB	114-132dB	108-120dB	108-120dB	108-120dB	108-120dB	108-120dB
Min. Gain	Minimum gain referred to system noise.	20dB-	18-24dB	12-42dB	18-42dB	20dB	24-42dB	24-42dB	24-42dB	18-30dB	18-42dB	24-36dB	24-36dB	24-36dB
Input signal range	Maximum signal before distortion	200-500 mv	131-65mvRMS	524-16mvRMS	870- mvRMS	700- mvRMS	440-55mvRMS	440-55mvRMS	440-55mvRMS	400-100mvRMS	725- mvRMS	220-55mvRMS	220-55mvRMS	160-40mvRMS
Noise	Noise level at system output, referred to input at full gain	1µV or less	0.1 µVRMS 8-248 Hz	1.2-0.1µV RMS	0.1µV RMS DC-125 Hz	0.1µV RMS	0.15 µV RMS 1-100 Hz	0.1-0.015µV RMS 1-100 Hz	0.15µV RMS	0.15µV RMS 5-250 Hz	0.15µV RMS	0.3 µV RMS	0.15 µV RMS	0.25µV RMS 8-248 Hz
Distortion	Harmonic distortion for input signal and frequency range	0.1% at full gain over range	0.1% 5-248 Hz	0.1% 5-248 Hz	0.1% 5-150 Hz 100 mv 1 Input	0.1% 5-250 Hz 700 mv Input	0.01% 1-100 Hz	0.03% 1-100 Hz	0.03% 1-100 Hz	0.1% 10-250Hz 0.3% 5-10 Hz 100 mv Input	0.1% 5-248 Hz	0.1% 5-125 Hz 50mv Input	0.1% 5-125 Hz 50mv Input	0.1% 5-250 Hz 40mv Input
Low-cut filters	Slopes and cut-off frequencies available	Wide range		Out,8,12,18,27Hz Slope 18,36dB/O	Out,9,12,16,21 29,38 Hz Slope 24dB/O	Out,9,12,16,21 29,38 Hz Slope 24dB/O	Out5,10,15 20? Hz Slope 24dB/O	Out,5,10.15,20 Hz Slope 24dB/O	Out,5,10,15, 20 Hz Slope 24dB/O	Out,12,20,32Hz Slope 12 or 24 dB/O	Out,12,20,32Hz Slope 18dB/O	Out,8,10,12.5 16,20,25 Hz Slope 12dB/O	Out,8,10.12.5, 16,20,25 Hz Slope 12dB/O	Out,6,12 Hz Slope 18 dB/O
High-cut filters	Slopes and cut-off frequencies available	Wide range		31,62,124,248 Hz Slope 72dB/O	31,62,125 Hz Slope 72dB/O	62.5,80,125 Hz	40,100 Hz	55,110,220 Hz	55,110,220 Hz	62,125 Hz Slope 80dB/O	50,100,200 Hz Slope 70dB/O	62.5,125 Hz Slope 72dB/O	62.5,125 Hz Slope 72dB/O	31,62,124 Hz Slope 78dB/O
Alias filters	Sample rate determined to prevent aliasing	Determined by sample rate	-	-	-	-	-	-	-	-	-	-	-	-
Frequency response	Amplifer frequency response	Flat DC-250Hz	3-248 Hz	3-248 Hz	0.5-125 Hz	5-250 Hz				5-250 Hz	0.1-248 Hz	3-125 Hz	3-125 Hz	3-250 Hz
Gain range attack rate	Rate in dB/S	Wide range		84KdB/S 1ms sample			300KdB/S	500KdB/S	500KdB/S	3000dB/S				
Gain range release rate	Rate in dB/S	Wide range		84KdB/S 1ms sample			37.5,75,150 300,600,3000 dB/S	37.5,75,150 300,600 dB/S	37.5,75,150, 300,600 dB/S.	100,150,200 dB/S				
Gain accuracy	Ability of system to write actual gain on digital tape	0.5% channel to channel	0.1%	0.1%	1.0%	1.0%				0.1%	0.2%	0.05%	0.05%	0.05%
Time standard accuracy	Accuracy of system timing	± 1ms or better	0.005%	0.005%	0.005%	0.005%	0.005%	0.005%	0.005%	0.01%	0.01%			0.005%
Sample rate	No.of samples per second Fast rate gives best high frequency reconstruction	1,2 or 4 ms	1,2,4,8 ms	1,2,4,8 ms	1,2,4,8 ms	1,2,4 ms	1,2,4 ms	1,2,4 ms	1,2,4 ms	2,4 ms	1,2,4,8 ms	2,4 ms	2,4 ms	1,2, 4 ms
Recording accuracy	A-D converter overall accuracy inc.quantization error which depends on no. of bits	.05% or better	± 0.05%	± 0.05%	± 0.02%	± 0.02%	± 0.05%	± 0.05%		± 0.1%				± 0.01%
Dynamic range	Signal range recorded on tape	>74dB	78dB	78dB	78dB	74dB	78dB	78dB		78dB (?)				96dB(?)
Channel isolation	Crossfeed ratio	Xfeed ratio > Dynamic range	80dB	80dB	80dB	80dB	80dB	80dB	100dB(?)	72dB		80dB	80dB	80dB
Number system	Binary number system 1^S comp. or 2^S comp.	As specified	1^S or 2^S comp.	1^S or 2^S comp.	2^S comp.	2^S comp.	2^S comp.	2^S comp.		2^S comp.				
No. of bits	No.of bits used in A-D conversion	15 bits	15	15	15	15	15	15	15	15		15	15	18
No. of tape tracks and width	Recording heads per tape As specified according to format	9 track-½"	9 track-½" 21 track-1"	9 track-½" 21 track-1"	9 track-½"	9 track-½"	14 track-½"	14 track-½"	14 track-½"	9 track-½"		21 track-1" 9 track-½"	21 track-1" 9 track-½"	
Tape format and density	Standard formats SEG and economical storage	SEG B or C	SEG A SEG B	SEG B,800-1600bpi SEG C,1600 bpi	SEG A SEG B	SEG B	8000 bpi	8000 bpi	8000 bpi	SEG A,800 bpi SEG B,800 bpi	SEG C	Own format 356 bpi.SEG B 800 bpi	Own format 356 bpi. SEG B,800 bpi	SEG C 800-1600 bpi
Power requirements	Power for entire system should be minimum	<4 KW	24 channel 440W	24 channel 484W	24 channel 720W				24 channel 600 W	24 channel 400 W	3.5KW (max)			1.25 KW
Temperature range	Operating temperature limit	0-40°C	0-+55°C(max)	0-+50°C	0-+50°C	0-+50°C							0-+45°C	
Recording linearity	A-D converter linearity-the accuracy of digital word from a known input analogue voltage	.02% or better	± 0.02%	± 0.02%	± 0.01%	± 0.01%	± 0.01%	± 0.01%		± 0.02%				± 0.005%
REMARKS				Read after write and playback facility					Playback facility with options for field processing		Read after write, computer controlled field processing		Read after write,field processing hardwire or softwire controlled	Reader after write and playback facility

* Information available December 1973