History of Seismic Prospecting In ONGC - A Chronological Sketch of Events

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Introduction

Hydrocarbon exploration has come a long way since the days, where, if the explorer's truck broke down, they just began drilling a well (wild-catting). Until well into the twentieth century, the search for hydrocarbons was confined to deposits directly observable in the form of surface seeps. When all the accumulation in an area that could be discovered by such simple means had been exploited, it became necessary to deduce the presence of hydrocarbon in directly by downward projection of geological information observable in the surface. When this technique reached the point of saturation, new methods were needed to know beneath the surface. This involved physical measurements at the earth surface that could give information about the structure or composition of concealed rocks that might be useful for locating the reservoir in the sub surface. To mention, some of such measurements which could help in imaging sub surface are- gravity, magnetic, reflection/refraction of acoustic waves, resistivity etc.

Throughout the history, the tools and the techniques of exploration geophysics have been continually improved both in performance and economy. This progress has been in response to an unrelenting pressure to develop new capabilities after existing ones have become inadequate to find new reservoirs. In addition to the areas newly opened for exploration, most geophysical surveys are undertaken where previous ones have failed because the instrument, field technique, processing or interpretational methods were not able to image sub surface to the desired precision. Reservoirs that could be located with the existing technology arc the only ones that will be discovered and remaining will not be found until the technology improves sufficiently. Thus the exploration geophysicist finds himself on the accelerating treadmill that must run faster and faster just to stay where he is.

The earliest effort to locate hydrocarbon-bearing structures by geophysical tool in 1915 involved gravity measurements (EVCTOS balance). At about the same time, seismic refraction methods were adopted and successfully located some big structures (mainly salt domes) and obtained information about sub surface geometry and interface velocities. Seismic refraction, however, could not provide detailed image of geological structures and anomalous features. Experiments with seismic reflection methods were carried out in 1919. It was not until 1927, however, that reflection methodology was put to work for routine hydrocarbon exploration. By the early 1930, seismic reflection became the most widely used tool of all geophysical techniques, the status it has maintained ever since.

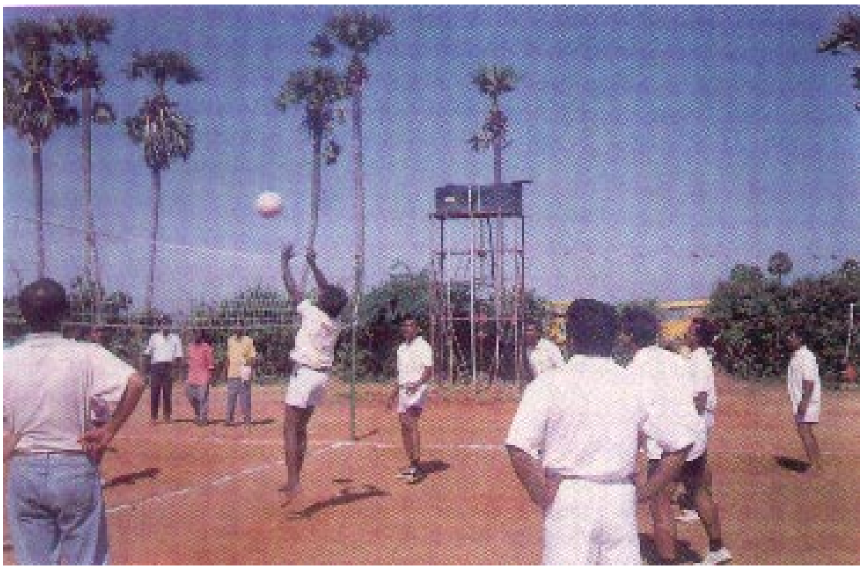
Since the end of World War II, continual progress has been made by oil companies and equipment manufacturers in developing new and improved tools. Most of the advancements in the seismic reflection methods were initiated with the primary objective of eliminating noise that interferes with reflections i.e. improvement in signal to noise ratio. A number of techniques, starting from the use of equipment having vacuum tubes with thermal stylus/ optical recording, transistorized equipment with analog magnetic recording, use of single receiver to multiple receivers etc., were introduced during 1930s - 50s to achieve better signal to noise ratio, dynamic range, greater safety, economy or flexibility in the field operations. Evolution and implementation of Common Reflection Point (CRP) was a quantum jump in the seismic reflection technique. Multi-fold data acquisition and start of offshore surveys during 60s needed seismic recording equipment with increased number of channels and improved capabilities. This also necessitated search for alternate energy sources, which would be convenient, safe and fast. Above scenario led to development of digital recording equipment with large number of channels, low energy sources, remote blasting through RF, portable mechanized drills etc. Most of the low energy sources e.g. weight-drop, flexi choc, sparker, air gun, vibrators etc were developed during this period.. In 1963, digital recording equipment was employed on a widespread basis and digital computers were programmed to process the data thus acquired. Presentation of tape-recorded data on time corrected record sections became common practice. The recording techniques and methodologies have ever since been greatly improved over the years e.g. from analog recording to advanced 24-bit Sigma Delta recording and from 2D to 3D, to 4D, to 3D-3C etc., full advantage being taken of the increased storage capacity and speed of the computers as well as other advances made by the mathematicians, communication and computer engineers in signal processing.

Seismic industry has made great strides and contributed significantly in the growth of upstream oil industry Present day technologies viz., 3D pre-stack depth imaging, reservoir modeling, 4D seismic, 3D-3C, 4D-3C, 3C-VSP, AVO etc., have reduced uncertainties of the business. Developments in the seismic have completely revolutionized the exploration methodology and brought far-reaching qualitative changes in the working. It has been influential in the effort to establish more hydrocarbon in place, recover more from the established hydrocarbon in place which would otherwise have remained invisible or uneconomic. Imagine! What would have happened to this business without the innovations of last 10-15 years without 3D seismic? Without desktop workstations (?) Without communication net (?) A pattern of contraction, demoralization and even migration of activities to low risk areas would have prevailed. Thanks to the continuous developments in the seismic industry, which extended life to the oil companies that, would have been written off years ago.

Quest for hydrocarbons in India began in the dense and swampy jungles of Assam in the year 1889. Leaving behind the geological reasoning, legends has it that an elephant traveling over an oil seepage sparked off an earnest hunt for petroleum. The exploration was to trace the footsteps of the elephant back to the seepage and then dig bay dig with Drake type wooden rigs (Digboy oil field). And so began the history of hydrocarbon exploration in India. A small incident led to the present day 30 MMT of annual oil production and 6 Billion Tonnes of reserves.

Camp of a Sesimic Party

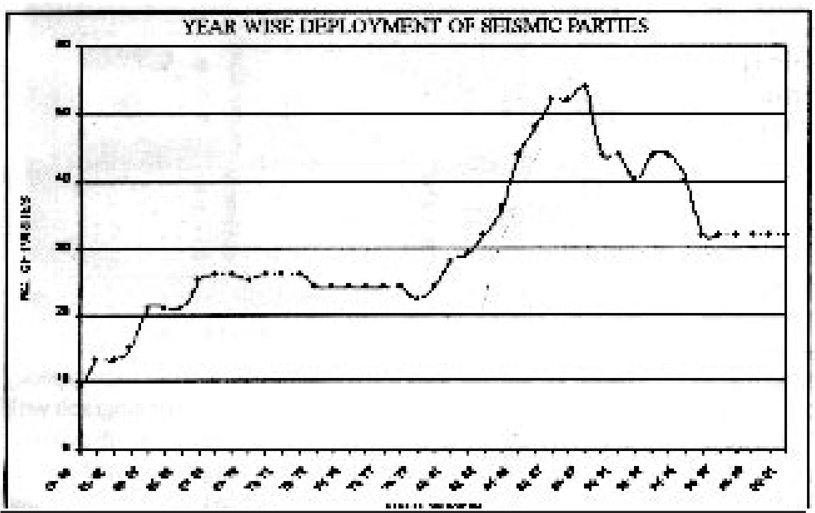
Geophysical prospecting for hydrocarbons played an important role to put India on the oil map of world during last five decades. Ever since the government of India decided that exploration and production of hydrocarbons will be taken up indigenously and made it a national policy with exclusive responsibility of the state in 1955. This decision of government of India was based on the need of hydrocarbons in the country and political situation prevailing at that time. Western countries were of the opinion that except Assam there is no possibility of hydrocarbon habitat in rest of India. Secondly, whatever effort they wanted to put was on hydrocarbon sharing basis where India was to get nominal share in the find. They were neither ready to sell the equipment required for hydrocarbon exploration, nor train Indian scientists/engineers in this domain. India at that point of time was following a socialistic dream and wanted self sufficiency in hydrocarbons, technically as well as economically. Obviously, India turned to Soviet block for help and support in this matter. Soviet block knowing the importance of hydrocarbons in geopolitical scenario wanted a foothold in Middle East and Southeast Asia. As such need of India for hydrocarbons and Soviet block's ambitions had become complimentary to each other. In 1956 Geological Survey of India, Directorate of Oil and Gas was converted to ONGC by an act of Parliament. As a consequence of this decision, the government of India recruited geologists, geophysicists, and drilling engineers to start ONGC with its headquarters at Dehradun and Sh. K D Malaviya as its chairman. Geophysical exploration was first introduced by this first batch of apprentice geophysicists, who were the pioneers of seismic prospecting in ONGC. At the time when ONGC came into being, most of the hydrocarbon wealth of India was undiscovered and even proper resource appraisal was also not made.



Party Members enjoying a game of Volley Ball after field work

Mr. Kalinin, a renowned geologist from USSR, made the first resource appraisal, took up all the activities of exploration and guided the geoscientists of ONGC in its formative stages. On the basis of geological studies some locations were identified for drilling in Gujarat and Assam. With highly encouraging leads from the first oil well named Lunej-1 and subsequently from Ankleshwar in Gujarat, followed by a similar discovery in Rudrasagar in Assam, ONGC formulated a deliberate strategy to increase geophysical activities in all the prospective sedimentary basins of India. These activities kept pace with the sweeping winds of change in seismic technology worldwide. Today ONGC has developed a high degree of expertise and carries out most of the seismic operations in all the three aspects of Acquisition, Processing and Interpretation both on land and off shore on its own.

Country has an endowment of 26 sedimentary basins within on-land and offshore areas. Total hydrocarbon resources are estimated to be about 20 Billion Tonne. In addition, on a very preliminary estimate, nearly 10 Billion Tonne of resources have been prognosticated for deep waters beyond 200 m isobaths. Augmenting ONGCs reserve accretion portfolio by harnessing largely domestic and moderately foreign acreage is an immediate priority. On domestic front, enhanced input levels within identified thrust areas of both producing and frontier basins are being expanded to capitalize on known prospects for quick returns. Efforts are also cm to rope in virgin areas like sub-trappean Mesozoic; deep waters areas for substantial reserves accretion. Deployment of seismic parties (including contractual parties) since 1950s in ONGC is shown below



Adoption of new geophysical techniques like multi-component 3D, 4D, VSP / Tomography, AVO etc. and use of Interactive Interpretation Workstations (IIWS) with enhanced visualization capabilities and state of the art compute intensive software certainly reduced uncertainties of the business and enabled faster and informed decision making thus reducing the cost of finds.

Major accretion followed a logical sequence of appropriate technological induction/up-gradation. Therefore, it is imperative to introspect and upgrade the technology to the desired level.

Growth of Seismic Prospecting in ONGC

The seismic prospecting in ONGC has undergone a series of changes and advances since its inception in late 50's. The developments are mostly in the field of instrumentation, data processing, communication, and interpretational techniques. These advances are mainly attributed to the aggressive exploration strategy, which is aimed at accelerated reserve accretion and maximizing the production. The quest is unending. A brief description of historical developments during this period is mentioned at the onset.

Late Fifties and Sixties

Seismic surveys commenced in late 1950s with the deployment of analog/optical system. Mr. Yarapolk from USSR was the chief geophysical adviser who trained and guided geoscientists of ONGC and implemented seismic data acquisition techniques. He was chiefly responsible for giving shape to the seismic data acquisition in this country. The first seismic crew headed by Mr. A. M. Awasthi, conducted 2D single fold seismic data acquisition using 24-channel CC-26-5 ID analog equipment in the foothills of Jwalamukhi and Janouri area in Himachal Pradesh. The data was recorded directly on photo paper with the help of an oscillograph. American systems such as Pll, P22, HTL5000, HALL & SEARS, and Russian systems like CC-24-л CC-26-51D were in use up to middle/late sixties. Later on analog magnetic recording equipment viz. MS-15A and GEOSPACE were introduced with the advantage of reproducing the data at any time. Transistorized seismographs PT-100 were introduced in late sixties as these systems had advantages of portability, power consumption, ease of reproduction, higher dynamic range etc. Different make geophones viz. Russian make 17 Hz, 4 Hz sensors for refraction surveys, 10 Hz sensors etc. were used with imported reversible cables during this period. Later under the technical guidance of ONGC, indigenously made reversible cables were put in use. Computation and interpretation of seismic data were done manually by the field crews and based on the study, time structure maps were generated. Conventional methods i.e. 2D seismic single fold surveys were in practice and these surveys had successfully led to identification of broad structures and basin configuration.

Topographic surveys, an integral part of the seismic date acquisition for precise positioning on ground used to be carried by Prismatic Compass, Dumpy Level and Plane Tabling. Survey of India contributed significantly in providing manpower and also training to ONGC survey crews.

Offshore seismic survey started in Western continental margin in 1963, by hiring the vessel S. S. Mahindra. PT-100 PMR-7 seismograph with floating cables and marsh geophones were used for first offshore surveys. Navigation was through shore based DECCA system. During this period explosives was used as energy source on land as well as in offshore. Logistics and environment were conducive for conducting any kind of surveys as these surveys were new to the public and their curiosity along with the feeling of national cause did not create many problems for survey crews. The land crews used to stay in tents without basic amenities like electricity and clean water but the members were highly motivated, full of zeal and enthusiasm to find hydrocarbon bearing structures. They were pioneers on whom the responsibility of finding hydrocarbons was entrusted. They were more concerned about goal than the modalities/comforts in the true explorationist's spirit. During this period, a number of oil fields like Cambay, Ankleshwar, Kalol, Sanand, North Kadi etc. in Cambay basin and Galeki, Lakwa, Rudrasagar etc. in Assam were discovered.

For processing of analog data, an analog processor GEO-DATA was introduced. This was basically a plotter of the seismic traces with static corrections. Static corrections were applied by shifting levers. In feet, this was the beginning of seismic data processing in ONGC. Computer Services Division (CSD) was established in 1969 with the responsibility to process the seismic data. During the same time Honey Well -400, a second-generation computer was commissioned. Interpretation of these plots was done manually by picking time values and drawing time structure maps. Oil production during 1961 was merely 0.01 MMt, which reached to nearly 3 MMt by the end of sixties.

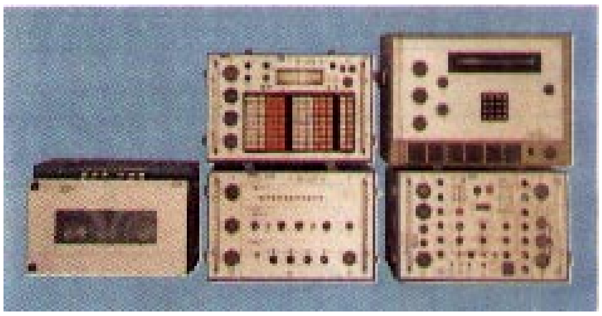
Seventies

The organization started growing multi dimensional and oil production picked up. The oil production increased to 3.94 MMT by 1971. The Nation's demand, however, was 17.91 MMT. Discovery of oil from major structures and rising demand necessitated more rigorous exploration efforts. Introduction of new techniques in seismic like CDP, Vibroseis and Marine surveys along with sophisticated digital instruments with increased channel capacity (24 to 48 channel) during this period resulted in finer detailing of subsurface and finding more hydrocarbons. Strangely enough, number of channels were increased in dozens instead of tens, which was legacy of Americans where basic accounting is done in dozens (first seismic equipment was designed in USA).

CDP seismic surveys were first undertaken using PT-100 seismograph with 24 channels, during 1972 by a crew headed by Dr. YB Rao. That time roll along switch and blasters were indigenously designed to meet the requirement of CDP surveys. By this time almost all the geophones were replaced by SM-4, 10 Hz geophones. Cables were imported as well as indigenous.

First fully equipped geophysical vessel M V Anveshak was commissioned in 1975 for conducting 2D CDP seismic surveys with digital recording equipment DFS IV having dual tape transport and 48 channels, neutrally buoyant streamer with hydrophones. Streamer could be kept at any depth up to 20 m in the water with the help of birds. Bolt airgun arrays were used for energy source. Navigation system was MAGNAVOX, a transit satellite based system NSS, in conjunction with Doppler Sonar and Gyro for dead reckoning. This was considered the most reliable and accurate state of the art navigation system. Such navigation aids were not available even to the Indian Navy at that time. Besides this, contract survey vessels such as Soviet Vessel "Academic Arkhangelsokey" in addition to survey vessels from CGG and Western Geophysical were also engaged for offshore data acquisition to meet the need of exploration. The giant field Bombay High was first discovered as a result of the survey carried by the Soviet Vessel. CGG and Western Geophysical did detailing of the Bombay High field.

On land seismic crews were then equipped with DFS III and SN-328 systems (Channel capacity of 24 to 48) with Binary Gain Amplifiers that exhibited higher dynamic range from 60 db to 84 db and better S/N ratio. At the same time SN-338 seismograph was introduced featuring low-level



SN-338 Seismic Data Recording Unit

multiplexing and with IFP having modular expansion capacity of 24 to 72 channels. Subsequently, DFS IV seismograph with channel capacity up to 120 and with IFP having 84 db dynamic range was also commissioned. Rota-long switch and remote blasting systems from I/O were introduced with these systems. Introduction of digital recording systems could overcome the problems of signal distortion, non-linearity of magnetic material and data thus recorded could be directly processed by digital computers, which became available in 1971. Digital era in seismic recording and processing started worldwide in early 1970s and ONGC almost concurrently adopted it. With the advent of new techniques, strength of geophysical parties gained momentum and expanded in all the dimensions.

Vibrators from PRAKLA with correlator stacker, as an alternate source of energy were introduced in 1976 and a seismic crew equipped with SUMMIT-VII seismograph having BGA and 48-channel capacity with vibroseis operations was sent to Iraq.

Topo surveying did not change much except that Auto Level replaced the Dumpy Level. However, Plane Tabling continued to be necessary part of the surveying for making maps.

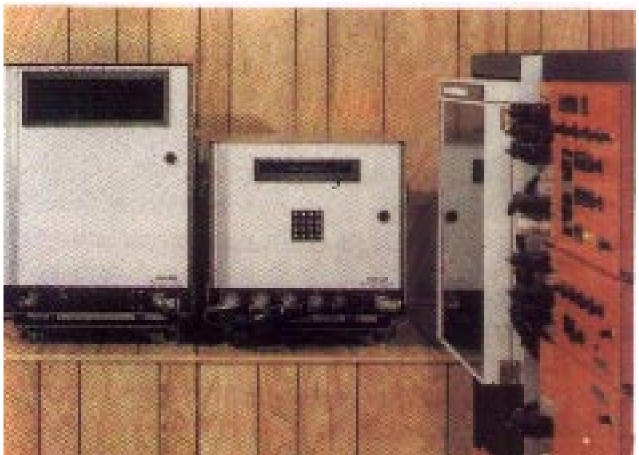
Processing of digital data started way back in 1971 with the introduction of a dedicated computer system TIOPS-880 for the purpose of seismic data processing. This computer had 24K word memory, which could process analog as well as digital data. With the CDP technique in use and the huge amount of data acquired in the offshore, need for processing of larger volume of data was felt direly Introduction of IBM-370/145 computer with MVS operating system having 1 MB memory and array processor in 1975 was a quantum jump in the seismic data processing. This system was expected to meet the processing needs of onshore data and onshore 2D data acquired by ONGC. IBM computer was equipped with PHOENIX application software. Data was processed by creating punch cards for individual jobs.

IBM-370/145 System

Interpretation of the data thus processed was done on paper sections. Synthetic seismograms were generated on the computer and used to calibrate the seismic reflections on the paper sections. Time values of the prominent reflections were picked and time structure maps were prepared manually to infer structural details of the sub-surface. This period witnessed discovery of new oil fields like giant Bombay Off shore and a number of small oil fields.

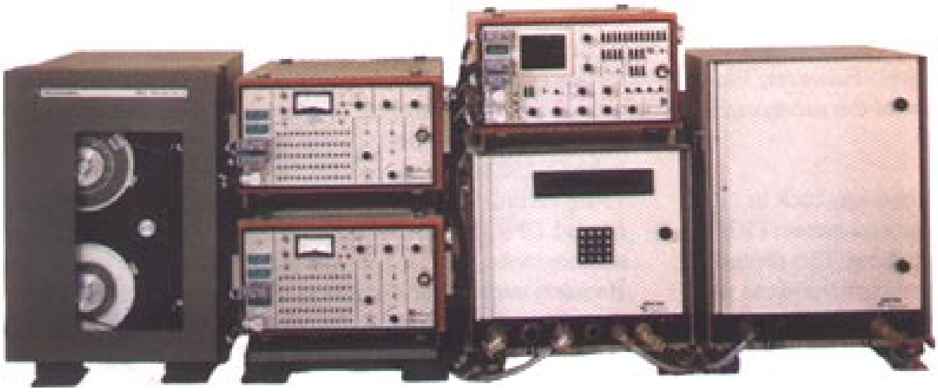
Eighties

By this time, indigenous production increased to 10.51 MMt during 1980-81. However, the demand-production ratio remained same as the domestic demand also increased to 26.71 MMt. To meet the fast growing needs and fulfill commitments to .the nation, an exploration strategy was formulated which necessitated aggressive efforts on seismic exploration. In the changing scenario where easy to find oil was nearing an end, exploration strategy shifted from structural to stratigraphic or subtle traps. Exploration of such traps was not only technologically difficult but conceptually challenging. This syndrome demanded high quality data, compute intensive processing and vital visualization tools to understand the sub surface in 3-dimensions. The technology up gradation became necessary at this moment The latest digital seismographs like DFS V from Texas Instruments and SN 358 from SERCEL (with CS2502 correlator stacker for vibroseis operations) with 15-bit recording were then introduced which replaced DFS HI and DFS IV systems starting from 1984. These digital seismographs provided 96 channels expandable up to 240 channels with better dynamic range up to 84 db and also portability as the size of the modules was very small as compared to the earlier ones. CMOS/VLSI circuitry drastically reduced the size of the modules. This helped in conducting seismic surveys in logistically challenging areas e.g. Schuppen Belt in Nagaland, Cachar in Assam etc. Calcutta city was also surveyed with MDS-10 seismograph (which is generic to SN-358 and DFS V systems) using vibrators as energy source during 1982-83. As the need grew, adoption of latest technology proved to be of immense help. To meet the demand of the exploration, seismograph SN-348, 15-bit recording, capable of handling 480 channels with line telemetry was introduced in 1984, At the same time, GEOCOR IV, a sign-bit recording seismograph with 1024 channels capacity and line telemetry was also introduced in 1985. The latest techniques like 3D surveys and VSP surveys were introduced during this period. The first 3D campaign was done with GEOCOR IV seismograph in 1985-86 using vibrators as energy source in Balol field of Cambay basin. Subsequently, 3D surveys were also carried by merging capabilities of two DFS V seismographs.



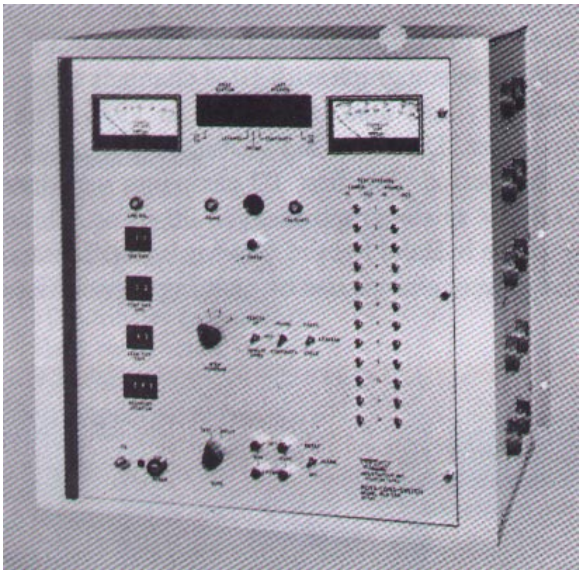
MDS-10 Seismic Data Recording Unit

VSP surveys were first attempted in 1985 using DSS-10 instrument with PERKINLELMER and MicroVax2 system for in field processing, which was procured exclusively for VSP surveys. GEOLOCK 2 well geophone was used in all the VSP campaigns. In offshore, VSP surveys were done by EG&G and DSS-10 equipment. A pilot project to monitor fire front in Balol in-situ combustion (time-lapse seismic) was also undertaken.



DFS-V, Seismic Data Recording Unit Integrated with FPCS (Full Precision Correlator Stacker)

Adoption of new technologies, higher targets and technical expectations changed the very dimensions of seismic field party into those of a mini project. Rigorous training in operation and maintenance of equipment was imparted to Geophysicists and Engineers.



Rota-Long Switch RLS-240

During this period, advanced topo survey instruments were introduced. Tg compass theodolite was deployed for staking lines and tying coordinates, and combination of T2 theodolite and EDM was deployed for measuring angle and distance respectively.

Second offshore survey vessel M V Sagar Sandhani with a helipad was acquired in 1986. The vessel was equipped with DFS V seismograph having 120-channel, PRAKLA streamer and Bolt air gun arrays to perform the current state of art offshore 2-D and 3-D seismic surveys concurrently with gravity and magnetic surveys.

Integrated navigation system used were MAXIRAN (short-range shore based) and ARGO (long-range shore based) systems in conjunction with the satellite-navigation MAGNAVOX with Doppler Sonar and Gyro systems. In addition, it had onboard seismic data processing system ND 570 for quality control and basic processing including 3D binning. First offshore 3D campaign was acquired by Sagar Sandhani under the technical collaboration with GSI, Singapore.

During this decade the geophysical parties had undergone a great change. The infrastructural facilities including communication were improved. To meet the production requirement of the parties, low-tech areas such as shot hole drilling and cable laying were farmed out. With increasing demand for quality, quantity, the environment problems also grew in quantum measures.

Encoder Model Enc-300   Decoder Model Dec.300

With the ever-increasing load of processing, in house infrastructure for processing of the complete data was inadequate and data started piling up. Changing demand of exploration and multi objective, the reprocessing need also started growing. To cope up with the pace, data were even sent abroad for processing. The demand for processing, reprocessing and special processing continued to increase because of rapid growth in the exploration activities and need for imaging geologically complex sub surface accurately. To meet this demand VAX -11/780 system having 2MB memory and two Marco Arithmetic Processor MAP-300 with VMS operating system and Phoenix application software was introduced in 1981. This system used terminals for submitting jobs instead of card punching. The system was quite interactive and user friendly than the IBM 370/45. Exploration activities were at its peak during this period. Enhancement of seismic data coverage, introduction of more number of channels, 3D surveys, ever increasing data collection from offshore, and increased efforts on-land necessitated introduction of a powerful computer. As a consequence, IBM3083-JX3 with 4 array processors and terminals having main memory of 32 MB was commissioned at GEOPIC.

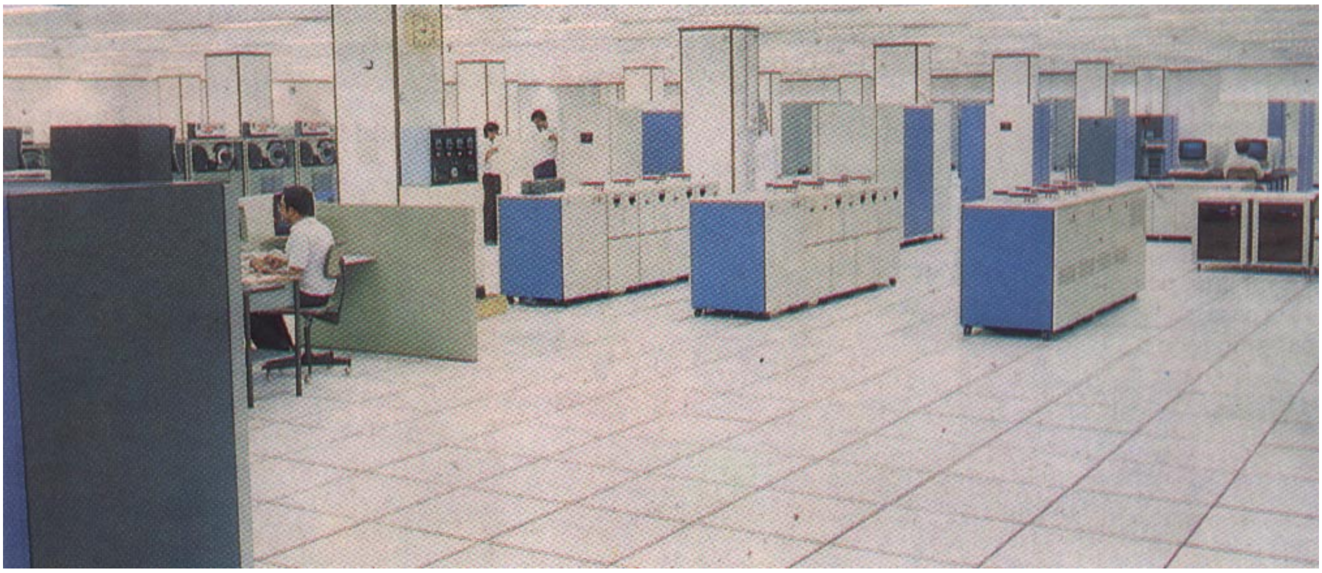
MV Sagar Sandhani

To distribute the load of processing on the centralized system at GEOPIC, different regions of ONGC were also equipped with computers to process the data generated in the regions. TATA-ELXSI M-6400 computer with DIGICON application software equipped with Explorer UWS was installed at Mumbai. At the same time during 1987-88, ND-570 computer with SINTRON operating system and GECO application software with Charisma-1 IIWS was commissioned at Chennai. EC-1061 with MVS operating system and DSS-3 application software with INGOS-IM

VAX-11 / 780 SYSTEM

IIWS were installed at Calcutta and Baroda. With the enhanced processing capabilities, all the data could be processed in house. The first onshore 3D campaign was processed by GSI as a part of technical collaboration. At the same time concurrent efforts were made to learn and induct 3D processing of on-land data in house. During 1989-90 a first 3D campaign was processed by ONGC at GEOPIC. RCC Mumbai and Chennai also tested their capabilities of 3D processing. The regional computers' capacity and speed was however not adequate to process the 3D data. The available processing computers were capable to perform special processes such as FK and Kirchoffs migration, PIVT, Trace attributes VSP processing, mapping and contouring etc. For processing of VSP data. Micro VAX-2 processing systems were also commissioned.

Interpretation of the data still continued to remain a manual effort until 1987 when one crystal Interactive Interpretation Workstation was inducted at GEOPIC. This IIWS was capable of interpreting 3D seismic data, perform geophysical modeling, making maps, synthetic seismograms and generating basic attributes and providing various types of visualizations. However majority of the data were interpreted manually. The valuable acquired and processed dataset required special visualization and interpretation tools to extract finer detail of the sub surface. Three more IIWSs from GEOQUEST were inducted in 1989 at GEOPIC. which were capable to cater the need for 2D/3D interpretation. This provided numerous utilities for data manipulations and better visualization by integrating various exploratory data for precise mapping of subtle features. Understanding the need of advanced interpretation of 2D/3D seismic and other geoscientific data at other



IBM-3083/JX3 System

work centers, SIDIS-2000 IIWSs with better visualization tools and advanced state of the art application software form GSl were introduced in 1992 in Baroda, Calcutta and Jorhat, which could cater to the need of data analysis by integrating various geoscientific data

During this period, number of oil field like South Bassein, Panna, Hira, Mukta, Tapti in Bombay offshore and Gandhar and other small fields in Cambay and Assam were discovered. K.G. and Cauvery basin were brought on to the oil map of India. By the end of this decade, production reached to 34 MMt yet the gap between demand and production could not be narrowed down. However, only 40% of the resources could be converted into reserves at the end of this decade.

Nineties to till date :

Finding new oil in 90s became increasingly technologically more difficult and conceptually challenging. At the same time, economic accountabilities and environmental constraints enhanced in quantum measures. Consequently, future exploration investments were to be made on more convincing expectations and our commitments to the nation were to be met under lesser availability of economic resources. In absence of easy to find hydrocarbon from giant structures, main emphasis came to search of subtle traps and delineation of known fields to maximize the economic value of the fields. Such exploration demanded finer study of the sub surface and hence the seismic data with higher fidelity. MDS-16 DX and SN-368 line telemetry seismographs from HGS and CGG respectively, capable of recording more than 1000 channels, having built-in roll along and line roll facility, were introduced. More and more 3D campaigns were planned. As the needs grew, technology up gradation became inevitable. DFS V system, which was widely in use, became old. By this time there has been significant development in the acquisition technology. The latest system SN-388 from SERCEL with the capacity of recording 8000 channels, 24-bit SIGMA DELTA technology came in the market. These systems have unmatched dynamic range of 110 db and ensure highest fidelity of the signal recording and have inbuilt QC module. Understanding the importance and benefits of these recording systems, ONGC procured such seismograph during 1996 which are widely used in line telemetry and mostly engaged in acquiring 3D campaigns. Two RF telemetry seismographs "OPSEIS-EAGLE" make having similar features of SN388 were also procured to meet the requirement of data acquisition in logistically difficult areas, which operate with radio telemetry system. During the same period advanced vibrator electronics Advance-PELTON-2 with QC module and real time DGPS were also procured for vibrator crews in operation. Taking advantages of the cutting edge technology, quality became buzzword in whole acquisition. In house developed on-board processing software PC-PRO (PC based processing software) has been in use for online QC while acquiring data in the field proved to be of immense help. Near surface modeling through advanced up hole surveys became a routine for all the field crews. BISON instrument procured during early 90s for mapping near surface have been in use for this purpose. In house developed INSM, a PC based software is being used effectively for modeling near surface enabling identification of adequate shooting medium and data correction for static near surface variations.

Hither to SM-4 digital grade geophones have been in use through out are gradually being replaced by low distortion SM-24 type geophone which are more suited to take maximum advantage of the 24-bit seismographs in use. For VSP surveys with slim tools GEOLOCK-2S were introduced and walk away and off set VSP surveys were conducted successfully.

Conventional/optical topographic surveying techniques are also being replaced by electronic surveying techniques viz. GPS since 1996, which provided accurate positioning. Real time dual frequency DGPS systems, which offer sub-meter accuracy in positioning and can do survey jobs including staking, leveling and positioning are being introduced gradually in the seismic crews.

In the quest to find more hydrocarbons, unrelenting efforts by introduction of cutting edge technology in time started yielding rewarding results in the form of enhance accretion of reserves, reduction of cost and early availability of exploration inputs. Acquisition of seismic data in Bombay offshore through Ocean Bottom Cable (OBC) with dual sensors in 1997 was the watershed in the use of latest tools in ONGC. Seismic offshore MV Sagar Sandhani has been. upgraded with latest 24 bit recording system, dual streamers and dual sources.

During late nineties, processing witnessed phenomenal growth. Mainframe monolith scalar computers that were in use up to middle nineties have been replace by latest client server computing and parallel processing architecture. These systems perform massive parallel computing with multiple CPUs facilitating quick through put and provide vital visualization for interactive processing. This allows optimization of the system by distributing processes across the network. Advent of such system made it possible to process large and complex 3D data sets at a lower cost in such shorter time. Turn around time of processing has fallen from a year to couple of months. Additional benefits have been observed in reprocessing of the earlier 3D data without waiting for longer period. Such systems are IBM SP-3 having 6 nodes at Baroda, 4 nodes at Jorhat 8 nodes at Chennai and 16 nodes at Mumbai. This hardware is equipped with GEOVECTEUR application software from CGG except at Mumbai, which has PGS Tensor application software. The software is capable of processing the data in pre-stacked and depth domain. However, the present requirement of advanced processing can be met with only if the numbers of nodes are increased to hundreds. Similarly GEOPIC is equipped with SGI Origin-2000 server with 20 nodes having Paradigm application software for processing. This system is also capable of processing seismic data in pre-stacked and depth domain. IRS Ahmedabad, KDMIPE Dehradun, and RCC, Calcutta are equipped with Sun workstation with PROMAX application software. They are single node machines.

For retrieval of valuable data on old magnetic media or on hard copies, the data archival systems were introduced during 1996. These systems transcribe into high-density media viz. DLT, 3490, 3590 etc. and could also convert paper sections into digital form for further use on workstations or processing. Such archival systems are available at Mumbai, Jorhat, Chennai, Calcutta and GEOPIC Dehradun. GEOPIC also has robotic tape library for handling huge data media.

the commissioning of the latest IIWSs, the era of manual interpretation has almost come to an end. Interpretation is now done on desktop workstations using state of the art application software in an integrated environment. The workstations for interactive interpretation have added new dimensions to the exploratory efforts in ONGC. Integration of various geoscientific data has been made easier. Enormous display capabilities made it possible to view data in different forms instantly, thus enabling faster and informed decision-making. The increased volume of the 2D and 3D seismic data over different prospects are being interpreted efficiently. Making use of various software, reservoir characterization is In early 1990s, interpretation

SGI'S ORIGIN 2000

of the most of the data was done manually on paper section and time structure maps were also prepared manually. However, some of the maps were generated by the computer aid. The color plots of various attributes generated with the help of computers were also used for analysis of the sub surface in conjunction with the time structure maps. As a matter of fact, the valuable data were underutilized and lot of hidden information remained invisible.

1995 witnessed a major change in the interpretation technology. Almost all the work centers were equipped with the powerful desktop Sun workstations using state of the art application software from Landmark. Gradually, to meet the requirement of the data analysis and volume of the data to be interpreted, subsequently new workstations from Silicon graphics with CGG software, Sun-Workstations with Geoquest application software were procured by different regions. With done to provide insight into the earth sub surface. These results are being used for identification of suitable locale for drilling and development of the field. Some of the work centers have gone a step ahead to model their reservoir in 3-dimensions and perform simulations. To provide online access to the various E&P data, EPINET project has been in advanced stage of implementation.

ONGC has been moving along the technology accelerations keeping pace with the technological changes in the global market. However, the advanced technologies viz. Tomography, geo-steering, multi-component 3D, 4D, VSP, AVO etc. have not yet found inroads in the industry. Many oil companies across the world have been benefited largely due to 4D seismic in terms of adding more reserves to the existing assets by locating by-passed oil and monitoring EOR projects. ONGC is yet to. appreciate the growing importance of 4D seismic studies. Multi component seismic has been proven the most powerful tool to understand rock and fluid properties in the sub surface. ONGC has to quickly adapt to the new order to reap the advantages of the cutting edge technology.

The last quarter of the 20th century has witnessed a great industrial revolution in the form of Information Technology. IT has changed the way we do business and has touched almost all the aspect of our life. It has been a powerful enabling factor in the growth of seismic industry. Up coming technological developments in the seismic e.g. Q-system by Schlumberger, AI and expert systems for data analysis, virtual reality, elastic model of the earth, full wave form inversion etc. are going to provide improved and faster decision making in the field of exploration. The pursuit is demanding and its course is uncertain but for the organization with vision and flexibility to reach for it, the prize to be obtained will be a great reward.

References

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