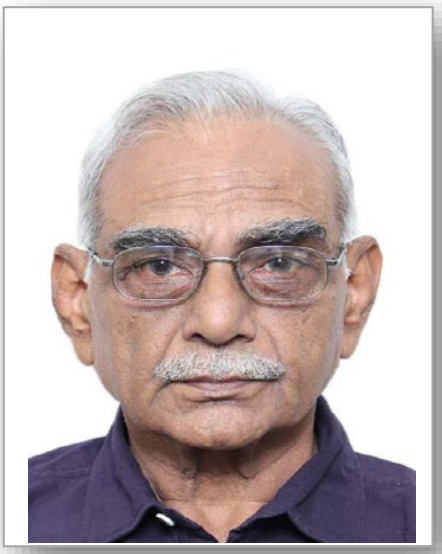
'Opportunities and efforts led to a fulfilling career - my untold stories'

*- Niranjan Chandar Nanda**



Mr. Niranjan C. Nanda worked for ONGC India for 37 years and after making outstanding contributions in exploration for hydrocarbons, his association has continued with ONGC till date. After retirement, apart from freelance consulting for various E&P companies in India and abroad, Mr. Nanda has taken on the task of promoting awareness about two significant issues: first, the need to remain grounded in our science and not let it suffer due to pressure for quick data interpretation; second, to share his experience with younger geophysicists and motivate them to take on future challenges. Specifically, he brough out the need to focus on data evaluation, a further step for value addition to the routinely carried out interpretations. He conducted several training courses and workshops on seismic interpretation at different work centres of ONGC and outside, notably in GERMI, (Gujarat Energy Research and Management Institute), Gandhinagar. He has been a visiting faculty member at Andhra University, Vishakhapatnam, and M.S. University, Vadodara, India, and taught seismic interpretation techniques to postgraduate geoscience students. Specifically, he brought out the need to focus on data evaluation, a further step for value addition to the routinely carried out interpretations.

Earlier, his tireless efforts in guiding ONGC coworkers to aim for accurate and detailed definition of reservoirs earned him the **National Mineral Award by the Government of India in 1987** in the field of geophysics. He received an Honorary LifeMembership from SPG (Society of Petroleum Geophysicists), India, in 2006, and a similar award at the GEOINDIA 2008 Convention held at New Delhi, for his contributions to the science of geophysics. He also got awarded the **B.S Negi gold medal** for lifetime contribution in petroleum geophysics by **SPG, India in 2013.** Mr. Nanda also served ONGC as a member of the Advisory Council Committee for reviewing projects and advising in various work centres of ONGC and R&D institutes in Dehradun, Ahmedabad, and Vadodara.

Mr. Nanda authored a book titled "*Seismic data interpretation and evaluation for hydrocarbons exploration and production - a beginner's guide*" in 2016 published by Springer. In 2021, he published its revised and enlarged second edition dealing with non-conventional reservoirs.

Satinder Chopra

* Petroleum Geophysicist, Consultant, Cuttack, Odisha. Email: ncnanda@yahoo.com

This memoir is about my activities during and after my career in ONGC and is filled with reminiscences and reflections of the past moments, places, and people I was associated with and about the prevailing working ecosystems during a period spanning more than six decades. It is also an opportunity to share some of my thoughts on technical issues in particular, and on my perception on the prevailing practices and the future exploration challenges in our country.

Student days

I was born in 1938 in the small town of Cuttack in Odisha. I was an intelligent student, but my interest in studies was outmatched by that in sports activities. These became so intensive that studies were neglected, and my grades were not good enough to get me into one of the top professional colleges. I was fascinated by the professional case histories of patients narrated by my eldest brother, who was doing his medicine course and wished to become a doctor. But this idea was vetoed by the family since one member had already taken up the profession. Engineering was out for the same reason, as my other elder brother was about to graduate in electrical engineering. I therefore picked geophysics, then a relatively new science, and on a Government of Orissa scholarship, joined Banaras Hindu University. I received the postgraduate degree in exploration geophysics in 1959 and joined Oil and Natural Gas Commission (ONGC), a Government of India organization for petroleum exploration. I was thus destined to be a geophysicist and my professional journey started. Today in hindsight, I marvel at the similarities between the two sciences, medicine, and geophysics, in their ways of logical investigation and interpretations for proper prognostications, and with many of the innovative technologies in medical science that were later applied to seismology.

Professional years

At that time, during the late fifties and sixties the top priority at ONGC, a nascent national oil and gas exploration enterprise, was large-scale acquisition of reconnaissance gravity and magnetic surveys and seismic data so that the country could quickly assess its hydrocarbon resource potential. I began as gravity and magnetic (GM) observer where life was tough with 10 –12 hours of daily hard work. Often, the surveys were carried out on foot for 10 – 15 miles with the load of the gravimeter on our backs in the inhospitable terrains such as the treacherous Rann of Kutch, tall and steep sand dunes in the Thar desert, the marshy and swampy tidal plains of Bengal and Orissa and the dense, elephant-infested jungles of Assam, where the thundering trumpets would be spine chilling. Field operations lasted 8 – 9 months a year and were carried out from camps of pitched tents in remote areas where living facilities were extremely poor and with no communication links with headquarters. Vehicle breakdowns would often strand us in the field for most of the night, until a rescue party could trace us. In one such instance, the experience of getting stranded in the lonely patch of the vast plains of the Rann of Kutch for 8 hours in the hot sun and without water due to the breakdown of the jeep is still fresh in my mind. Fortunately, one of the working laborer, a native, knew his way to proceed on foot to the camp, about 20 kms away and brought the rescue party by the evening. But the zeal to learn and the youthful motivation to work for the country were enough to see the hard days through.

In 1967, I was shifted to a seismic crew. The company of a large number of crew members with more vehicles, interesting electronic equipment, proximity of the camps to the towns, presented better overall facilities that made life somewhat comfortable. Seismic operations were more interesting, challenging, and demanding as missing a shot due to misfire and losing the explosives in the shot hole, paper jamming in the magazine (analog recording instruments were in use), faulty receiver channels or inadmissible noise levels in the records, were regarded as

deficiencies on the part of the observer. Technical, operational, and important administrative problems on and off the fields were the responsibility of the observer.

Maiden sea voyage with Anweshak

With the discovery of Mumbai High field, departmental marine seismic surveys were planned, and I was chosen for the offshore group, where sailing in high seas for a fortnight would earn you seven days off at the headquarters. This seemed a better option than the vagrant life on a land crew. Marine seismic data acquisition technology was new to us; it was completely different from onshore work and seemed quite advanced and complex in comparison. A new seismic vessel M.V Anweshak was being built at Jacksonville, USA and fitted with marine seismic equipments and gadgets with satellite navigation system that would be the first of its kind to be used in India. A short training course in USA in satellite navigation system (1974) led to bearing the responsibility of calibrating the navigation system along with my senior geophysicist, Late R. K. Banerjee, during the maiden voyage of the newly built *Anweshak* fromJacksonville, USA, to Mumbai in 1975. It was monsoon time and the Pacific Ocean and the Arabian Sea in particular were rough with severe rolls and pitches of the small ship. Enduring sea sickness and operating and monitoring the system successfully in a twelve-hour rotational shift during the 51 days voyage of the ship was a moment of pride in my professional life.

Marine data acquisition continued round the year, mostly on the western coast and the operations shifted during monsoon to the east coast of India. So intense was the urge to explore hydrocarbons that earlier structures mapped by the GM surveys after confirmation from raw on-board seismic sections, were recommended for drilling to save exploration time. This resulted in several major discoveries on the west coast. I sailed for about four years till 1979, when I was posted in seismic data interpretation section. Many interesting anecdotes, concerning my sailing ,however, are left untold fearing this read may become too long. Briefly, these include the seizure of the vessel Anweshak by custom authorities on its arrival at Mumbai port from USA and not allowing us to deboard before completing a rigorous check for suspected contrabands brought in the ship, Anweshak engine room catching a dangerous life threatening fire mid-sea while returning to port and the infamous hunger strike by the geophysicists on board during a sail, that made the insolent Captain of the ship to climb down.

(Interacting with geophysicists at the 2008 SPG Conference held at Hyderabad)

Joining the interpretation section after spending two long decades in field operations was a great relief. Soon after, I also got an opportunity of visiting Singapore for a few months' exposure in seismic data processing rat DIGICON, a processing company. In the interpretation section I was fortunate to be placed under the legend, Late B. Gunturi, who was a remarkable person and an outstanding seismic data interpreter having several years of experience in foreign oil and gas companies in the USA. He was a hard task master and would pose technical questions without giving the answers and asking us to find them by ourselves. I learnt a lot from him in the process. One morning, the then Head of offshore operations Late V. L. N. Sastry, a wonderful leader and a geophysicist by profession called me and my young colleague, a bright geophysicist, Mr. M. K. Sen to his office to give us a queer job of compiling the seismic time structure maps for all horizons prepared by various interpreters till date in the entire west coast offshore. This was a herculean task; collecting and collating the seismic time maps and naming serially all the structural closures (e.g., B1, B2 etc.,) that were mapped at different times and by different interpreters with details. The details included the seismic horizon mapped (H1, H2 etc., the geophysicists then were not accustomed to name the geologic formations or age), the structural closure type (anticlinal / fault closure), the closure area and its relief. We had little idea then that the future exploration strategy and the plan for offshore exploratory inputs such as the need for the number of drilling rigs, overall requirement of personnel with attendant ancillaries, and financial cost would be made based on our input. The serial names of the structures were later changed to specific names after discoveries, e.g., B-57 came to be known as Mukta, but some of the remnant names B – 80, B-129 etc., are still in use today.

Seismic interpretation was immensely exciting which provided me chances to meet people from other disciplines. I found poor communication among the geoscientists; the geophysicist had hardly any interaction with members of other disciplines, the geologists, log analysts and reservoir engineers. Geologists and geophysicists worked in their own tight compartments. The geologists were generally content with the initial time contour maps from the geophysicist and executed exploration plans without needing any more information. Unfortunately, the geophysicist, unaware of the exploration game, was satisfied with his sole role ending with preparation of preliminary time maps.

Exploration being basically a geological game, the geologists obviously had prominence in the organization, and this bothered the geophysicists, tending to make them indifferent to the situation. I tried to make communication more effective with geologists and reservoir engineers to hard-sell the importance of seismic role in exploration and development of fields. Fortuitously, I was posted then (1983) in the "development geology" group under a geologist, as head, with several development geologists who were involved along with the reservoir and production engineers in developing the fields. My job was to prepare fresh seismic depth structure maps of the oil and gas fields honoring the reservoir depths, thickness and fluid contacts as found at the wells and propose locations for drilling delineation wells (these wells were expendable) based on the maps . It required qualitative estimation of reservoir parameters to estimate the volumetrics and to decide accordingly the number of delineation/appraisal wells required to be drilled for field development. I found the task extremely stimulating and demanding but at the same time quite satisfying as seismic was accepted by the management to be of vital importance.

Spawning of 'Reservoir Geophysics'

In 1982, I was associated with CFP, France, the consultants to ONGC for exploration and development of fields on the west coast offshore including the development of the giant Mumbai High. During the 3-month long work association in Paris I learnt the workflows and industry practices of seismic data evaluation, and on returning to India soon started adopting the procedures. Reservoir geophysics took root in the organization in 1983 and started

with conventionally processed 2D seismic data without workstation. Prediction of reliable reservoir parameters necessitates good calibration between seismic and well data, which required preparing synthetic seismograms prepared by computers, a means not available then to the working groups. I found the calibration through CVL for seismic calibration to be quite effective and it could be done by manually plotting the sonic log on a seismic time scale with a little innovation made by my junior colleague Mr. Y. E. R. Sastry.

Picking the exact phase of a reflection from the top and bottom of the reservoir and its depth had to be accurate for proper definition of reservoir geometry and the lateral facies changes within it. This was hard to achieve especially from 2D data, mostly unmigrated, which usually had considerable time delays in the onset of reflection causing time misties. Offshore well velocity surveys were also scarce then, adding to the problem of uncertainty about velocity. Notwithstanding the technological handicaps, the need for the geophysicists to have close interaction with the geologists and the engineers was felt for effective interpretation of seismic data. In 1985, the then Director of Exploration and an eminent geologist Late S. N. Talukdar, desired that I tour the different ONGC work centers and make geoscientists aware of the role of seismic in reservoir delineation through my presentations. It was a very interesting experience of sharing and learning ; I came into contact with many geoscientists and reservoir engineers at the working level, as well as management level, and was able to discuss different viewpoints.

E&D days – foreign assignments; 3D seismic initiation

I was at first disappointed on being called back to the corporate headquarters, but it turned out to be eventful. I was chosen as a member of ONGC delegation to Tanzania headed by Late Col. S. P. Wahi, Chairman ONGC at the time, on an official request from the petroleum minister of Tanzania to help exploration for hydrocarbons in the Karoo basin there. The group consisted of two geologists, Mr. D. N. Basu, and Mr. M. K. Rangaraju and me. It was a challenging task to evaluate a basin on the basis of a pile of seismic sections and a few wells with no maps available and that too within three days so that the Chairman could take a decision on the matter then and there. It was worrying me at first but eventually found the way to timely complete the task. It was a lesson learnt to evaluate basins within a short, stipulated time.

(Outside the lodging area in Houston in 1987 for the IIWS trainees, from left Late D. V. Valmiki, Mr. N. C. Nanda, Late C. V. Subbarao, and Late I. A. Siddique)

I was shifted in 1987 to the all-important Exploration and Development directorate (E&D) then headed by Late P. K. Chandra who soon after became the Member (Exploration) and then Vice Chairman of ONGC. My new assignments were challenging but equally absorbing. The assignment involved both technical and corporate management skills including answering parliamentary questions. E&D was the principal advisory body to Member (E) for taking final decisions on all issues pertaining to exploration and development in all the basins, on land and offshore. I was head of the Geophysics group, and my team was responsible for all issues pertaining to geophysics including reviewing regional interpretation reports from the regions, examining the proposals for drilling locations and quality checks of data of field parties. That same year I received the prestigious National MineralAward from the Government of India for outstanding contribution in the field of geophysics. It was an encouraging gesture on the part of ONGC to recommend my name for the award and helped me strive better to do what I believed in. My scope of job also included induction of state-of-the-art seismic techniques and technologies in the organization for improved exploration and development of hydrocarbons. I proposed to conduct 3D seismic surveys on a large-scale in the onland basins to help delineate better the reservoirs of the oil and gas fields on priority. The initiation for 3D acquisition, processing, and interpretation resources, for both human resource and material, were geared up on priority basis from scratch. A small batch of interpreters selected from different regions including me was sent in 1987 to Houston, USA for training in 3D interactive interpretation workstation (IIWS).

(With Late P. K. Chandra, Vice Chairman, ONGC during the PTTEP presentation)

During this period another important accomplishment was the timely completion of a foreign project - interpretation of seismic and log data for estimation of volumetrics of the Offshore Thailand 'B' structure natural gas field of PTTEP, the national oil company of Thailand. The prestigious project was an offshoot of a MOU signed between the Government of India and the Government of Thailand for assistance in the oil and gas sector. The group consisted of Mr. P. K. Upadhya, Geophysicist (E&D), Mr. N. C. Banik, Geophysicist (INTEG, GEOPIC) and Mr. R. Venkatrangean, Geologist (E&D) and me. The final presentation was made before the PTTEP geoscientists, and the report was accepted in 1989. This was extremely satisfying as it gave me the needed confidence in managing and handling consultancy projects dealing with foreign companies.

(The PTTEP conference room (left) and with the Indian ambassador to Thailand at the presentation there)

Antagonism to 3D seismic

In 1990, I was transferred as head of INTEG, the interpretation section in GEOPIC. The interactive interpretation workstation (IIWS) was installed sometime in 1987. The interpreters were not quite conversant with the new technology in the beginning and by late 1988 many 3D interpretation projects were piled up awaiting interpretation. We had an excellent group of conscientious geoscientists eager to work. Projects were scheduled for individual groups with clear and precise objectives and with a set time limit. This and regular periodic interaction with the groups led to timely completion of projects with submission of brief and concise reports. Ironically, the depth maps prepared from 3D data showed lesser aerial closures and reduced in -place reserves than the earlier initial estimates for a number of fields, under field development plan. This rang an alarming bell with top management, causing lots of antagonism towards 3D in the organization. The geologists being not fully conscious of 3D technology were not receptive to the technology, and several geophysicists, too, were skeptical of the switch from 2D to 3D seismic. They argued careful reprocessing of the existing 2D data could deliver similar subsurface images, and the more costly 3D survey was unnecessary. People seemed to be in no mood for a change, perhaps fearing that the new technology and techniques would mask their skill. They wished to continue doing what they knew best and felt threatened by the change! On a few occasions, the antagonism was so strong that a few geologists and reservoir engineers proclaimed that 3D seismic was responsible for yielding fallacious low reserve estimates that would make several assets marginal for development. I argued that the seemingly disappointing results from the 3D data might be due to improper/poor quality data acquisition and sloppy interpretation but not due to the technology that is based on scientific principles. It made me prepare a compendium "3D Atlas" to compare results of 3D and 2D surveys over many prospects in various basins of India to prove my point. A key section through each prospect was selected from old 2D seismic data, reprocessed with optimal parameters, and then juxtaposed to a 3D profile. Both the seismic segments had identical display parameters for easy comparison of the images of the same subsurface. The earlier prepared 2D maps (based on well depths and trends in seismic time map) and the 3D maps were put side-by-side which clearly and decisively demonstrated the superiority of 3D technology to put an end to the conflict. The unpublished compendium also contained very useful information about the details of the fields, such as year of discovery, reservoir parameters, number of productive and dry wells drilled and the year of conducting 3D seismic surveys (mostly much after the discovery well)to fully realize the exploration history of the oil/gas field and the opportunity

lost in timely utilization of 3D seismic . I was ably assisted and helped by two young colleagues, Mr. Satinder Chopra, Geophysicist (who later migrated to Canada) for reprocessing of the lines, and Mr. D. K. Pande, Geologist (who subsequently became Director, Exploration) for providing the detailed geologic information on the oil and gas fields.

(With Mr. D. Ray, another legend from ONGC, at one of the ACB meetings)

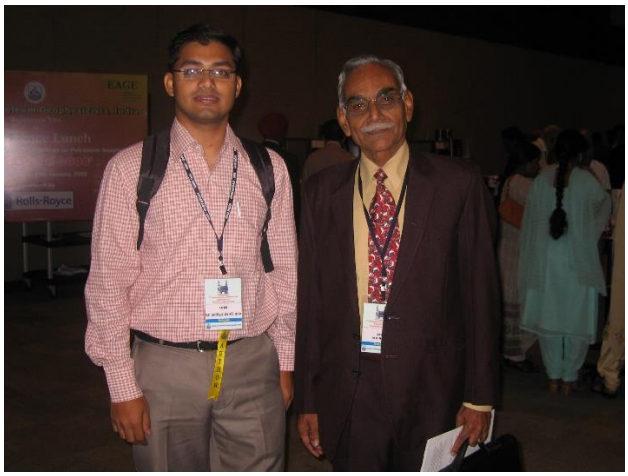
My stay in INTEG was cut short when I was transferred to Chennai in 1993 from where I superannuated in 1996. As the head of interpretation groups in Chennai, my role evolved to somewhat managerial responsibility for overseeing exploration in two large basins, Krishna Godavari, and Cauvery. Prospects were evaluated and proposals made for exploratory and appraisal well locations for drilling. The proposals were to be presented before the regional exploration board (REXB) consisting of representatives from all institutes and work centers for approval. This needed the presenters to be adept in the skill of articulation and impressive displays to successfully sell their proposals amidst stiff competition from others. Often many interesting potential locations proposed were vetoed because of an unimpressive and shoddy presentation. Proper demeanor is the key to success; qualities such as humility, open-mindedness, alertness, self confidence, and above all the courage of your convictions need to be developed. Consequently, I spent a lot of time and effort in conducting rehearsals before the final meeting to make the young geoscientists more mature and 'battle-ready' in this field of the exploration game.

In October 1996, after 37 years of service, which included enriching experiences in almost all branches of exploration geophysics, I was given a touching farewell by my colleagues, which I still cherish and feel nostalgic about, even today. This was the end of the saga of my career with ONGC. Looking back, I feel it was a great pleasure and privilege to have worked with so many wonderful people as a team, the juniors, peers and seniors over this long span of time.

The postretirement mission

Toward the end of my career at ONGC, I started to realize that geophysics was becoming prosaic and sought another vocation beyond seismic. I was interested in studying ancient history and religious epics. How-ever, an immediate offer of consultancy from Hardy Oil, a British company to reinterpret the PY-3-2 oil field (located in the Cauvery Basin in southeast India) at London, hooked me back to seismic. It is a unique field with severe variation in lateral velocity, which made the task of preparing accurate structure maps difficult. At the time the field was being developed by a consortium of ONGC, HOEC (Hindustan Oil Exploration Company), Tata Petrodyne, and Hardy Oil and Gas Co., with Hardy Oil as the operator. After this assignment I decided to come back to my roots in Cuttack to be with my eldest brother who had suffered a stroke. This was also the time when exploration for hydrocarbons

became a lucrative business for many private non-core E&P companies, notwithstanding the high financial risks involved in the ventures. These companies required professionals as advisers and I as a freelancer provided consultancy services to several of them. Of particular interest was the request for consultancy from the Director General of Hydrocarbons (DGH), the Petroleum Regulative Authority of India. The assignment was to reevaluate the seismic and log data to assess reserves of the D-6 deep-water offshore gas field of Reliance. This was a third opinion sought as the gas reserves estimated by two renowned foreign companies differed largely. This was shortly followed by another similar project from DGH for evaluating seismic data for estimating reserves for the onland oil and gas fields, Mangla and Aishwaria, in Rajasthan. Both the assignments were of great national concern and extremely interesting and challenging which was high learning for me. I also had occasions to visit several countries abroad along with geologist colleagues to evaluate foreign basins for hydrocarbons prospects on behalf of the companies, willing to bid for exploration license.



(With his tutelage Shiladitya Sen, student of IIT, Kharagpur, who presently works for Total Energies, at the SPG conference 2008, Hyderabad where his presentation got the first prize.)

Sometime in late 2008 ONGC chose me as a member of their Advisory Committee to review exploration and development projects at the different institutes, namely KDMIPE, GEOPIC and IRS (Institute of Reservoir Studies), and other work centers. This was extremely useful and rewarding to me as it kept me in touch with the latest developments in the field.

Bowing to the persistent pursuance for years from two of my earlier colleagues Late I. A. Siddique and Mr. Satinder Chopra, to write a book on seismic data interpretation, I finally decided to start working on it by collating my training/course materials used in seminars and classrooms, and the information gathered from rigorous literature studies from the net. The book titled "*Seismic data interpretation and evaluation for hydrocarbons exploration and production - a beginner's guide" took* almost three years to complete and was published by Springer in 2016. Complete isolation during the COVID 19 pandemic gave me the impetus to author its updated and enlarged second edition, including non-conventional reservoirs, published in 2021.

Perception on present and future exploration in ONGC

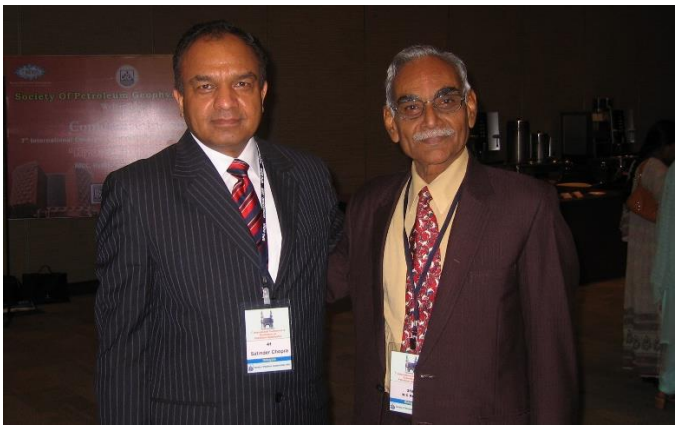
Attending review meetings at different institutes and work centers for many years as an Advisory Committee member gave me a chance to gain insight into the working style and thought process of the younger geoscientists in ONGC. The continuing progress in innovations in seismic technology of data acquisition,

processing, and interpretation (API) has made tremendous advances to make it the most significant and indispensable technology in the E&P industry. While the hardware and software are continually evolving to become more and more powerful, commensurate honing of the human-ware seems to be slow in keeping the pace. This is a concern; logical thinking and attitude of the human brain at utilizing the machine mindfully for a "holistic analysis" appears deficient. Acceptance of the results produced by interactive workstations deploying sophisticated software packages and powerful graphic displays as accurate, can be flawed. These are excellent tools available to the interpreter but overreliance on machine for results without mindful intervention of human brain can be extremely counterproductive. Seismic interpretation is essentially visualization of images that depends on the concepts, experience, creativity, and skills of the human interpreters, and, above all, on their aptitude, ability, and willingness to integrate geological and engineering data with seismic. Often the computer-generated interpretive results lacked validation by geologic models and conclusions/observations from other data sets. The workstations and the software playing a robotic upper hand in making the decision for the interpreter as solution to the exploration problem at hand could be highly risky.

Often, much emphasis is put on utilization of the latest technologies and techniques, believed to be the panacea for discovering more hydrocarbons. While their prowess and usefulness cannot be questioned yet, merely procuring these expensive software off the shelf and applying without understanding the mathematical and geologic assumptions inbuilt to the algorithms and most importantly its suitability to the quality of seismic data could end up producing imperfect results. It is also important that integrated seismic data interpretation is extended a step further to include data evaluation for adding value to the results rather than merely providing them as inputs. Value addition is interpreter providing his evaluation based on the interpretive results, the impact it may have on the geologic problem at hand and on the overall exploration venture to help the management in proper planning of exploratory inputs and the attendant cost.

Future exploration challenges

The geoscientists are required to find persistently new prospects for discovering hydrocarbons to replenish the country's reserves. But mapping potential prospects from the existing seismic data can be an impending problem as most of the cherry-picking has already been done earlier from onland as well as marine seismic data, except for the deep-water offshore areas where exploration and exploitation can be highly expensive.



(With Satinder Chopra, the present Chief Editor, GEOHORIZONS, at the 2008 SPG Conference held at Hyderabad)

Clearly, new inventive exploration strategies are to be mulled out by the geoscientists to meet the impending challenge.

Massive reprocessing and reevaluating of legacy seismic data

A simple way forward may be the reprocessing and reinterpreting the data, especially of the so-called mature basins both onland and offshore. The seismic data in these basins are yet not fully evaluated as several seemingly innocuous seismic anomalies still remain to be fully understood geologically for consideration. The bottom line is, until the data are sufficiently evaluated to explain geologically the seismic anomalies satisfactorily , the opportunity for finding new hydrocarbon plays/prospects in these petroliferous basins still remains, requiring exploration and at lower cost. The tremendous recent advances in seismic data processing and imaging algorithms and visualization aids, breed hope that the legacy seismic data can be greatly improved by reprocessing. Holistic re-evaluation of massive multidisciplinary exploration and engineering data by skilled and 'thinking' geoscientists with enough know-how and experience gathered by this time over the years can bear awarding results. Data mining and data analytics are expected to play a vital role in this endeavor to make it a success.

Acknowledgments:

I acknowledge the needed support and understanding from my wife Sucheta all these long years. She has been my strength and has stood like an anchor through the ups and downs in my professional life and in raising our two wonderful daughters. Looking back, it has been a fulfilling life together for both of us.

I also acknowledge Satinder Chopra, Chief Editor, GEOHORIZONS, for relentlessly urging me to write this memoir which has brought back many cherishing memories and reminiscences of the wonderful people I met and the different places I visited during the six decades of my professional life. G

Bioturbations at Radhanagar beach, Andaman, India. (Photo courtesy: Ritesh M. Joshi)