Direct hydrocarbon indication using remote sensing and nuclear magnetic resonance in the area of interest

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Abstract

Using ingenious remote sensing (RS) expertise as well as corroborating field data derived from the nuclear magnetic resonance (NMR) theory, commercially relevant anomalies are identified, delineated, and geologically substantiated. Prior knowledge on the economic feasibility of acreage is provided; recommendation on the most appropriate area for targeted seismic is given; the identification and geological validation of the best spot for appraisal act are provided as a result of RS-NMR studies. A key feature of NMR is that the resonance frequency of a particular substance is directly proportional to the strength of the applied magnetic field. It is exploited in imaging techniques. If a sample is placed in a magnetic field, then the resonance frequencies of the sample's nuclei depend on where in the field they are located. Radio-frequency magnetic fields penetrate both soft and hard rocks allowing higher resolution mapping of anomalies and can easily be used for exploration with a boat, plane, helicopter, or truck. The application of three integrated disciplines of remote sensing acumen, scientifically validated NMR field work and the ultimate authentication of the findings through geology and geophysics (G&G), exercises a strong, innovative, and efficient toolkit. These studies de-risk the exploration program by identifying and validating drilling locations. They also help in the assessment of probable reserves of hydrocarbons, ores, and groundwater prior to drilling with a remote determination of important geological characteristics of their bedding up to a depth of 6000m. This RS-NMR technology is a time and cost-effective solution to remodel the ways and means of petroleum exploration.

Keywords: Hydrocarbon exploration, remote sensing, nuclear magnetic resonance, electromagnetism, derisking, drilling location validation, reservoir estimation

Introduction

The application of various geophysical, non-traditional, and aero-cosmological methods increase the probability of determining the boundaries of the contours of hidden deposits (up to 40-60%), which improves drilling efficiency (Kovalev and Chubby, 2010). However, remote sensing methods for obtaining the most relevant geological characteristics of reservoir rocks (type and porosity), useful horizons, and efficient areas’ anomalies remains a difficult task, which in turn makes it difficult on taking decision on drilling wells (Kovalev et al. 2004 and Kovalev et al., 2010b). Currently, several remote sensing methods of exploration are undergoing pilot testing in Russia, Ukraine, Canada, and other countries. None of these ways of exploration, or the existing remote sensing methods from space can determine the porosity of reservoir rocks, traps and effective areas bearing hydrocarbon anomalies. The Sevastopol State University of Russia proposes a method for obtaining these characteristics using resonant-test equipment “POISK”, which uses remote sensing data and measurement results produced by mobile remote field equipment (weight up to 80 kg). A remote geo-holographic image is created from this instrumental setup for detection and contouring of the hydrocarbon deposits. More details can be found in Kovalev et al., 2009, Kovalev and Chubby, 2010, Kovalev et al., 2010.

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The field survey part of remote sensing technology is based on the use of microwave radiation of gigahertz frequency generators for resonant excitation of atoms of substances in hydrocarbon-saturated rocks and metal atoms contained in various types of oil (Kovalev and Chubby, 2010; Kovalev et al., 2010; Antipenko, 1999; Shnyukov and Gozhik, 2007). This POISK equipment works on the principle of NMR Spectroscopy. NMR spectroscopy, also called as magnetic resonance spectroscopy (MRS), is a spectroscopic technique for observing local magnetic fields around atomic nuclei. The sample is placed in a magnetic field and the NMR signal is produced by the excitation of the nuclei sample with radio waves into nuclear magnetic resonance, which is detected with sensitive radio receivers. The intramolecular magnetic field around an atom in a molecule changes the resonance frequency, thus giving access to details of the electronic structure of a molecule and its functional groups. As the fields are unique or highly characteristic of individual compounds, in modern organic chemistry practice, NMR spectroscopy is a definitive method to identify monomolecular organic compounds.

**Methodology**

At the first step, hydrocarbon samples from the same play type are analyzed and the frequency spectrum of the reference elements is recorded. After that, decoding of the satellite images is carried out using the POISK stationary equipment and radiation chemical technologies (Kovalev and Chubby, 2010a; Shnyukov and Gozhik, 2007; Patent No. 35122, 227-2305, 2007A000247) utilizing nanogels prepared from the reference elements. This stage identifies the types of hydrocarbon anomalies (oil, gas, oil and gas), determines the borders of contours of anomalies, and also provides the estimated depths of occurrences of hydrocarbon collectors in anomalies. Promising anomalies are then selected for detailed examinations. Further fieldwork is planned and carried out for confirming the boundaries of the hydrocarbon anomalies, identifying reservoir rocks and determination of their porosity, demarcation of hydrocarbon traps, and depth and reserves estimations.

The identification of hydrocarbon saturated bodies is based on the principles of the resonant phenomena, wherein the atoms of elements comprising the hydrocarbons and rock are exposed to radio-frequency radiation (NMR spectroscopy). Gigahertz frequency microwave radiation generators are designed to transmit radio-frequency resonant radiation with a rotational electromagnetic field in the radiation energy channel. Frequency resonance spectra of atoms of reference chemical elements (Ni, V, C, P, S, etc.) and information-energy spectra (integral spectra) of oil samples and reservoir rocks of various porosity are modulated to the operating frequency of the microwave generator (Kovalev and Chubby, 2010; Kovalev et al., 2010; Kovalev et al., 2011; Patent No. 35122, 227-2305, 2007A000247). Resonance spectra (NMR spectra) of atoms contained in oil, rock, and other substances serve as reference elements and are recorded on NMR special equipment in the frequency range from 60 to 250 MHz. Resonant information and energy spectra of substances (so-called integral spectra) are recorded directly from samples of various types of oil using high-frequency units of resonant test equipment “POISK” (Kovalev and Chubby, 2010; Kovalev et al., 2010; Kovalev et al., 2011; Patent No. 35122, 227-2305, 2007A000247). The information and energy spectra of the identified substances are transferred to working magnetic carriers (so-called “working matrices”), and the atomic spectra of metals are transferred to so-called “test matrices” and are used for resonant energization of these substances (reference elements) in the subsoil (up to depths of 6 km) by exposure to modulated microwave generator signals (Kovalev and Chubby, 2010; Kovalev et al., 2004; Kovalev, 2007; Patent No. 35122, 227-2305, 2007A000247). A set of “reference” metals that different types of oil contain was studied by Russian and Ukrainian scientists (Antipenko, 1999; Shnyukov...
and Gozhik, 2007). To establish reference elements in oil, a neutron activation method was applied to determine the concentration of metals and nonmetals. The elemental composition of the samples and the amplitudes of their integral spectral characteristics (so-called information and measurement spectra) were recorded in the database of the stationary equipment “POISK” and used as recognition signs of hydrocarbons and reservoir rocks of various porosity at depths up to 6 km (Kovalev et al., 2014; Patent No. 227-2305, 2007A000247). Prior to field surveys, the stationary and portable “POISK” equipment is tested in laboratory before being used in the field to identify oil samples and rock samples at various distances (25m and 50m) so as to calibrate the equipment for further remote detection and identification of oil and reservoir rocks. By adjusting the sensitivity threshold of measuring equipment, selective identification of each reference element or type of oil and rock samples located close to each other is achieved to ensure lack of mutual influence (Kovalev et al., 2010).

The complete application of the above methodology adopts the following steps:

**Step-1: Sample studies and database preparation**

Oil and gas samples from nearby fields (same play) are collected and analyzed for the NMR studies. The presence of rare earth metals, especially tungsten and titanium (in micro-quantity) are determined in the oil sample. According to their ratio, oil origin can be determined (for example, what country the oil is from). The same approach is implemented in the NMR survey, i.e., frequency spectra (Figure 1) of these elements are recognizable when we search for hydrocarbon accumulations. Certain elements such as vanadium (V), nickel (Ni), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), chromium (Cr), phosphorus (P), sulphur (S), etc. are distinguished in oil composition. In the case of gas, C₂H₆, C₃H₈, C₄H₁₀, C₅H₁₂, and non-hydrocarbon substances such as H₂, H₂S, CO₂, N₂, He, and other inert gases are distinguished in the gas composition. These elements are the main markers known as reference elements in the identification of oil and gas. Each element has its own (inherent) nuclei oscillation frequency. Integral electromagnetic spectra (information and

![Figure 1: Integrated information-energy spectrum of an oil sample. Descriptions have been deliberately removed from the axis, this is not for public use and viewing.](image-url)
measurement spectra) are recorded from oil samples by exciting metal atoms when oil samples are introduced into the "atomization furnace" (temperature = 2500 °C) using special spectral equipment which is a part of the "POISK" equipment set. Thus, the so-called "working search diagnostic matrices" for the further hydrocarbon studies are recorded.

In Figure 1, the vertical axis is the amplitude of the spectrum of hydrocarbon atoms and metal atoms that are part of the oil (Ni and V, etc.). With use of amplitude magnitude of the reference atoms of metals, i.e., according to their content, it is possible to recognize the type of oil and in which region it was produced. For each oil sample (depending on the region, type of field, oil quality), the right side of the spectrum will always show different responses. This feature is recognized by the POISK equipment and identifies the specific type of oil in the reservoir. It improves the reliability of detection.

**Step-2: Remote sensing and image processing**

Characteristics of hydrocarbon and ore anomalies in the survey area of interest are identified by deciphering digital and analog satellite images taken in various spectral ranges of the ultraviolet (200 nm to 380 nm), visible (380 nm to 760 nm), and infrared (760 nm to about 14,000 nm) spectra. Anomaly forecasting is carried out visually and automatically using proprietary programs for processing satellite analog images (Figure 2). The necessary images are received by the UNISCAN-24 data-receiving station from remote sensing space satellites (USA, EU, and Russia).

![Figure 2: Interpretation of satellite analog images, identification, and delineation of areas with anomalies.](image)

On satellite analog data images, characteristic electromagnetic fields (spectra) that exist over each type of "deposits" (oil, water, ore, etc.) are recorded. Characteristic electromagnetic fields of a specific frequency are...
formed over the deposit (anomaly), i.e., on the ground surface due to various chemical, thermal, and electrochemical processes in rocks with prolonged migration (diffusion) of oil, gases, and other metals in ores from deeper depths to the surface. Specialized processing of satellite images is done using chemical reagents (nanogels), phosphors, and sensitizers (layers of mixtures) which are selected for each type of deposit (oil, gas, ore, salt water, fresh water, etc.) to amplify and highlight spectral anomalies associated with petroleum accumulations. This enhanced processing of the image is done in a small-size nuclear reactor. This POISK technology enables us to "visualize" the characteristic electromagnetic fields in the form of "high brightness zones" on satellite images (Kovalev and Chubby, 2010; Kovalev et al., 2009; Kovalev et al., 2010; Kovalev et al., 2011, Patent No. 227-2305, 2007A000247).

At this stage, the primary boundaries of hydrocarbon and various ore anomalies, tectonic faults and tectonically shielded hydrocarbon traps and flows of underground geothermal and water aquifers (in faults) are determined.

Processing of satellite digital images in the visible spectrum provides only the preliminary visible signs of various anomalies, whereas the accuracy of identification and delineation of anomalies by the processing of analogue images (by POISK’s patented technology) is significantly higher than digital image processing. Accuracy in the results after processing satellite analogue images is also higher than traditional methods and approaches to geological exploration.

The method of predicting the depth of geological bodies of any origin is based on the change in the position of anomalies (shift of the maximum/peak frequency in the signal spectrum over distance) with the displacement of satellites and geometric parameters of the survey.

In the process of evaluating the site, the POISK Group processes many satellite images taken from different angles (Figure 3).

Figure 3: Example of satellite images covering a research area (shown with a red outline in the center).
Knowing the angle at which a satellite image was taken (supplied by any satellite imaging company), the depth of occurrence can be calculated (Figure 4) as follows.

\[ h = \tan \beta \times b_1 \text{ (or } b_2) \]

where, \( h \) is the depth of the top (\( h_1 \)) or bottom (\( h_2 \)), \( \beta \) is the angle of inclination of the satellite, and \( b_1 \) (or \( b_2 \)) is the distance from the starting point of increasing (\( b_1 \)) or decreasing (\( b_2 \)) maximum frequency value to the intersection with the satellite observation line at various shifts of the anomaly.

**Step-3: Field survey**

Interpretation of space photographs (films) is carried out using radiation and chemical technologies by visualizing the boundaries (contours) of areas with hydrocarbon anomalies in Step 2. These boundaries get refined in the field using mobile equipment and GPS receivers and then are plotted on a map of the search
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The contouring method is similar to existing aerospace remote control methods and ground sounding, however, the probability of identifying reservoir rock types and hydrocarbon anomalies with the help of POISK field equipment increases sharply (Kovalev and Akimov, 2009; Kovalev et al., 2009, 2010; Antipenko, 1999; Patent No. 35122, 227-2305, 2007A000247).

Additional examination of the identified anomalies (lenses, ore bodies, areas of underground accumulation of freshwater and geothermal waters) using field equipment (NMR equipment) of the POISK equipment set and small-sized highly efficient installations of point electromagnetic sounding. The width of the flows of underground fresh and geothermal waters, the direction of migration of fresh waters, and fluid hydrocarbon flows are determined using portable meters of electric and magnetic fields (in 3 coordinate axes - X, Y, Z).

The modulated signal from a high-frequency microwave generator is transmitted at a certain angle into the Earth for resonant perturbations of the atoms of the reference element or the entire identified substance (Kovalev and Chubby, 2010; Kovalev et al., 2009; Kovalev et al., 2010; Patent No. 35122). The perturbed elements generate a response electromagnetic field characteristic to the substance (oil, rock etc). Each generated characteristic electromagnetic field is successively registered by a sensitive receiver device, tuned to the resonant inherent frequency of atoms of reference elements or the integral spectrum of a substance (oil, rock, etc.), which provides their selective identification at various depths (Kovalev and Chubby, 2010). Depth of occurrence is measured geometrically by the tangent angle of inclination of antennas and distance from the generator to the identified anomalies (Figures 5 and 6).

This allows linking the contours of productive anomalies to the map of the survey area. In addition, it allows constructing geological sections by measuring the depths of hydrocarbon reservoirs and ore bodies. Based on the constructed network of deep geological sections (2D), a volumetric anomaly format (3D) is built and the forecast resources in them are calculated. Based on the data obtained, an assessment is made of the prospects for industrial development of the identified anomalies (Kovalev and Belyavsky, 2015; Kovalev and Akimov, 2009).

Figure 5: Method of delineation of the site and determination of horizon depths of petroleum manifestations by using NMR equipment POISK.
By selecting the most effective distance between generators and receivers the maximum signal amplitude is registered. Such a technique enables estimating the thickness of potential hydrocarbon-bearing horizons (Figure 6) and generates simplified cross-sections and depth columns. An example of a depth column is given in Figure 7.

**Figure 6:** Receiver signal amplitude variation during resonant excitation in an oil area at a depth of ~3760 m. L is the distance (m) from the generator installation site to signal receiver.

**Figure 7:** Depth column at measuring point (Utah, USA). Total capacity of oil reservoirs \( H = h_1 + h_2 = 70 \) m; Total capacity of oil-saturated rocks - 140m
Figure 7 shows a deep column of oil and gas saturated rock occurring from 2600 m to 2760 m. There are various depth intervals at which rocks are saturated with gas or water, as well as rocks from which oil cannot be recovered due to geological reasons like dense limestones, dense clayey sandstones, etc.). These intervals are removed from the total thickness of the hydrocarbon reservoir, and we get $h_1$ - useful thickness of the 1st layer and $h_2$ - useful thickness of the 2nd layer. The results shown in Figure 7 are achieved by integrating the reservoir properties, including depth of porous interval, provided by the client and results from RS-NMR study. These reservoir properties have been extrapolated over the hydrocarbon anomalies based on the depth of accumulation occurrence identified by POISK technology. In the reservoir no. 1 ($h_1$) porosity is more than 10%, and in the reservoir no. 2 ($h_2$), it is more than 7%. The rest of the reservoir has a low porosity of the rocks. At these intervals, it is impossible to recover the commercial oil inflows. Thus, the reservoir with a capacity of 160 m will be divided into two oil layers (1st layer 2610-2640 m, and 2nd layer 2700-2720 m), and the rest of the reservoir has only oil impregnation. This is considered when calculating forecast resources.

**Case study-1, Utah, USA**

RS-NMR studies done in an area of 160 km$^2$ in Utah (USA, 2013), made it possible to change the decision of customer on the selection of 2nd location of drilling well on the basis of oil anomalies having low porosity rocks (Figure 8). New drilling location was recommended in oil traps which also confirmed the seismic profiles, in which measured porosity of rock (>15%) using field equipment POISK (Figure 9).
In Figure 8, the green zone, in the southwest part of the area, shows discovered field through seismic and electrical exploration methods. The results from RS-NMR study are shown by the dotted lines and coincided with the previously discovered field. But the present study also highlights the presence of oil accumulation at the north of the green zone, which was completely missed during the previous interpretation.

In addition, the red dotted line (results from RS-NMR study) indicates the continuation of the commercial deposit to the northeast of the area, which was not explored previously and resulted in the addition of an oil reserve to client portfolio.

Figure 9 shows the proposed well locations 17-1 and 17-2, based on the RS-NMR study in the southern oil anomaly. These recommended drilling locations were superimposed on the geological section based on seismic data. It showed that proposed locations were covering two different layers in the boundary of the porous reservoir rocks. Later the client drilled wells in the anomalies proposed by POISK, which were successful.

Figures 8 and 9 confirmed POISK’s results by comparison with the results of seismic surveys and drilling of exploration wells. Earlier without considering RS-NMR studies, the customer drilled 4 dry wells at the cost of about 10 million dollars. The cost of our RS-NMR work amounted to not more than 1% of the cost of one empty well in an onshore area.
Case study-2, Atlantic offshore

POISK Group was contracted in 2021 to perform remote sensing of the area located in the shallow marine sector of offshore West Africa. There were already 2D and 3D seismic lines in the area, but the operator did not have any seismic data. Several wells had been drilled in the deep marine section which proved the presence of the mature petroleum system, but nothing was found in the shallow marine section. POISK Group was contracted by the block operator to perform a step-1 and step-2 study of the survey area. Except for the area coordinates, no information was available with POISK Group, i.e., anomalies were identified without oil samples, without any chemical composition data, and without well data. All the input data were taken from POISK group’s database of oil samples.

White coloured bright spots in Figure 10 show the anomalies in support of the oil accumulation. Based on the results from the RS-NMR study, the client purchased only 1000 LKM of 2D seismic data crossing the anomalies out of 4000 LKM of available 2D seismic data.

![Figure 10: Topographic map with anomalies associated with petroleum accumulations.](image)

After reprocessing and interpreting the 2D seismic data, the mapped traps were found in line with identified anomalies from RS-NMR study (Figure 11). Dynamic analysis of some representative seismic lines proved the anticipated saturation of the potential traps. In addition, the previously drilled well (location NGK-1 in Figure 11) is exactly at the centre of the biggest and brightest anomaly which is the highest oil producing well in the area. This unambiguously confirms the effectiveness of the technology even without any availability of input data (samples, wells, their location, and productivity, etc.).
Conclusions

RS-NMR is the only technology in the world that combines analogue data image processing and NMR studies to explore hydrocarbons. The reliability of the obtained results based on NMR and remote sensing data after step 1 and 2 is 60%-80%, and after performing fieldwork in step 3 it increases to about 90%. It is possible to finalize the 3D seismic data acquisition area without investing time and money in 2D seismic and other geophysical surveys. If seismic is already done in any area, this RS-NMR technology helps in identifying and validating drilling locations. It also helps in the assessment of probable reserves of hydrocarbons, ores, and groundwater before drilling. This technology is very useful in remote and topographically challenging areas. This technology detects hydrocarbon and geothermal waters up to the depth of 6000m, ore bodies up to 1500 m, and underground drinking water aquifers up to depths of 1000 m. Depth accuracy of the identified anomaly after step 2 is 100m and after step 3 is 30-50m. RS-NMR is a highly cost-effective and time-effective technology for identifying the focus area of hydrocarbons and other minerals in offshore and onshore areas. In identifying a focused exploration area or validating a well location in the area of 1000 sq. km., cost for doing RS-NMR studies is less than 1% of the cost for doing the geophysical surveys (like seismic) or drilling a well. The total time for the execution of RS-NMR exploration work on a survey area of 1000 sq. km. is approximately 2 months for step-1 and 2. More than 350 projects have been completed using RS-NMR technology of POISK Group in Russia, USA, Indonesia, Ukraine, and in many other countries not only for oil and gas but also for mineral, groundwater, and geothermal energy exploration.
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**N. I. Kovalev** is the dean of the Faculty of Nuclear Chemical Technologies of the Sevastopol National University of Nuclear Energy and Industry. He did his graduation from the Caspian Higher Naval School in 1972 and served for 17 years on submarines of the Northern Fleet. During this working tenure, Mr. Kovalev was a military engineer-radiochemist, captain of the 1st rank. After that Mr. Kovalev was transferred to the radiochemical faculty of the Sevastopol All-Russian Military Medical University, where Mr. Kovalev headed the graduation department, and after his retirement he was appointed dean of the Faculty of Nuclear Chemical Technologies of the Sevastopol National University of Nuclear Energy and Industry. Since 2002, he has headed research laboratories and production centre at POISK Group Russia. Mr. Kovalev is a leader of the breakthrough scientific and technical direction on new technologies for remote search of hydrocarbons, minerals, underground and underwater man-made hazardous objects. The practical results of his works have been highly appreciated and recognized around the world. Mr. Kovalev is the owner of 15 patents for inventions, the author of more than 60 scientific papers, three monographs, six textbooks.

**G. A. Belyavsky**, is working as a consulting geoscientist for POISK Group Russia. Mr. Belyavsky is a Doctor of Geological and Mineralogical Sciences, Professor, full member of the Ukrainian Ecological Academy of Sciences. In 1957 he graduated from the Faculty of Geology of the Kyiv State (now National) Taras Shevchenko University. He began his career in the Far Eastern Geological Department of the USSR Ministry of Geology (Khabarovsk), where until 1959 he worked as a geologist on search expeditions. Mr. Belyavsky did his postgraduate study at the Institute of Geological Sciences of the Ukrainian SSR and became the head of the laboratory of marine engineering geology. During 1966–1982, he took part in the research expeditions to study the geological conditions of the ocean bottoms (Atlantic, Pacific, and Indian oceans, the Mediterranean and Black Seas) on the research ships of the Academy of Sciences of the Ukrainian SSR. He completed a six-month internship in the USA and Canada as a UNESCO fellow in 1973. After that Mr. Belyavsky established the first marine engineering and geological laboratory in Ukraine at the Institute of Geological Sciences for the development of express methods and special equipment for studying the engineering and geological properties of bottom sediments directly onboard. In 1989, Mr. Belyavsky defended his Ph.D. from Taras Shevchenko State University, where he worked at the geological, geographical, and economic faculties from 1985 to 1998. Subsequently, he worked at the Research Institute of Agroecology and Biotechnology of the UAAS, the National Agrarian University, the Ukrainian Institute for Environmental and Resource Research of the National Security and Défense Council of Ukraine, the A. Dumansky Institute of Colloid Chemistry and Water Chemistry of the National Academy of Sciences of Ukraine, and the National Aviation University. Since 2010, he has been the head of the Educational and Scientific Institute of Management and Environmental Safety of the State Ecological Academy of postgraduate education and management of the Ministry of Ecology of Ukraine. The results of many years of research by Mr. Belyavsky have been published in 240 scientific papers, 17 scientific monographs (some of them are co-authored) and 27 textbooks and manuals in the environmental field.
Andrey Sergeev is the consulting chief geologist of Poisk Group (Russia). He did M.Sc. (1987) and Ph. D. (2007) in geology from Moscow Oil and Gas University. Dr. Andrey also earned a masters in geoscience from Tulsa University, USA in 1998. He began his career as a Field Facilities Engineer with Gazprom (Russia) in 1988, and further worked with Amoco Eurasia Petroleum Company (USA), Pechoraneft Oil Co. (Russia), West Siberian Resources Ltd (Sweden), KazMunaiGaz EP (Kazakhstan) and Genoil (USA). During his working tenure Dr. Andrey has worked on a various roles including chief geologist, Head of the G&G department, and technical director. Dr. Andrey has played a crucial role in numerous discoveries worldwide and established commercial production of several oil and gas fields. In 2021, Dr. Andrey applied the RS-NMR technology in Sierra Leone offshore block for one of the block operators in Nigeria and witnessed a big discovery of petroleum accumulation.

Vipul K. Sahu is the Director of Wave Geo-Services Pvt. Ltd., providing project management and consultancy services to the oil and gas exploration industry in India and southeast Asia. He received his M.Tech. degree in applied geophysics from IIT Roorkee in 2003. He has been working in the E&P industry for 20 years. He started his career with National Geophysical Research Institute, Hyderabad where he studied and published research papers on crustal deformation in the Indo-Burmese arc region, Sumatra 2004 earthquake, and Coulomb stress analysis of Indian earthquakes. After that he worked with CGG-Veritas as a seismic data processor, Paradigm Geophysical as a customer support geoscientist, Reliance Industries Ltd. as a senior geophysicist, Essar Oil as a senior manager-geophysics, Asian Energy as a assistant VP-sales and Pangea Inc. Russia, as a regional sales director. During his working tenure, he has executed several successful techno-commercial projects including seismic data acquisition and processing in land and marine. At present, Mr. Sahu is representing many oil and gas service companies in India and promoting various unique technologies including RS-NMR technology of POISK Group Russia.