Editorial

We wish all the members and fellows of IGU, learned scientists and young researchers "A VERY HAPPY NEW YEAR". We are happy that IGU is celebrating its 50th annual convention during 08-12 January 2014. Important events pertaining this convention (including special sessions on "Sustainability of Earth System –The Future Challenges"; IGU-International Council for Science Union; and AGU-IGU interaction) will be covered in the April issue; the last issue being brought out by the present editorial team.

In the October, 2013 issue we have brought out an editorial on ``the importance of Geophysics". Some of the learned readers felt we have over emphasized the use of Geophysics and touched upon the contribution of Physics, Geology and Mathematics in a limited way. Some felt the quoted definitions are not fully projecting the genesis and development of Geophysics. Some felt the role of Geophysics in Atmospheric and Space sciences is much more focused compared to studies covering solid earth. We are happy the editorial served the purpose of attracting the attention of the learned scientists. If one goes through the editorial it is evident that we have clearly acknowledged the role played by all these sciences in building Geophysics. In reality we urged the Geophysicists to strengthen their knowledge base in these fields to achieve better results. We have basically stressed in the editorial the need for proper co-operation amongst scientists from different branches of earth system , to meet targets that are vital for sustaining better quality of life. After a level all the sciences become inter dependant and the boundaries that segregate them become diffused, as quality research needs use of same or similar hard and soft wares. The theoretical/ experimental/ field data acquisition procedures adopt more or less same strategies to get quality out put. We only want a strong scientific community that can play a vital role in planning and execution of developmental programs. Such a strong body can emerge only through proper bondage and mutual respect. In this issue we are covering some specifics to high-light the importance of Geophysics. We do hope the details given below are of use to the scientific community.

Geophysics - Basic and Applied Science:

Geophysicists are striving hard to properly make use of wealth of knowledge available from fundamental sciences in solving specific problems of interest to the entire earth system. During the last 5 to 6 decades Geophysics has provided apt solutions to many complicated problems. Since significant growth is witnessed in the last couple of decades and as editorials cannot cover all the significant developments, readers are requested mainly to view this editorial as a medium in clarifying some doubts about the efficacy of geophysical techniques and projecting the importance and limitations of Geophysics.

Geophysics as a basic science develops theoretical models to understand various aspects of structure and evolution of solid earth, ocean, atmosphere and space. While developing models covering the first two segments of earth system (solid earth and ocean) the theoreticians invariably try to understand the basics associated with number of input parameters, by refining models from linear to non linear status, assuming number of boundary conditions. In doing so some subjectivity is introduced as the problems involve non-linear quantities and situations. The importance of such models is basically appreciated by only those scientists who know the difficulties associated in deciphering various input parameters that are not accessible for examination. Some inherent problems have surfaced due to such subjectivity. Because of inherent limitations we are yet to solve many problems. At the same time we are proud to say that we have solved many problems by properly deciphering various signals and developed models that can be classified as apt. Geophysicists, however, need to know their strengths and weaknesses and try to address a problem using logically acceptable approaches and results.

Significant strides have been made in developing different data acquisition and processing technologies, by trying to understand different sets of processes responsible for evolution and structure of surface and sub surface formations, invoking logical analogies and rational thinking. Identifying different geophysical anomalies/ signatures and deciphering them in a meaningful way requires a considerable experience, competence and commitment. One needs to know properly the limitations and importance of various geophysical data sets to elicit solutions to various problems. As such, one has to properly analyze different anomalies both as independent entities and as part of an integrated system. The oft used parameters, viz., gravity, magnetics and electro-magnetics, temperature, velocity, density, resistivity/ conductivity and other parameters need to be studied keeping in view their variance in time and space. Efficacy of various algorithms is verified/ tested by comparing the generated theoretical models with observed laboratory and field models. One has to appreciate the efforts made by the dedicated experts in properly deciphering the physical meaning of various input parameters, in developing different algorithms.

The applied and application oriented basic geophysics needs to provide apt solutions to numerous problems posed by the number of unknown factors responsible for generating different types of data. In deciphering the acquired data, using a specific instrument that has its own advantages and limitations, the applied geophysicists develop models using specific signals by combining subjective and objective judgments. Since the target is not visible to the eye and as the processes responsible for generating a specific set of data vary in time and space the specialist does introduce some subjectivity. Those who have no appreciation for such a predicament, in the part of a field geophysicist, usually pass comments saying both the technique and the practitioner are useless. As such, applied geophysicists are constantly in a state of stress in explaining the error limits of the derived models. Till recently a 2-D approach has been given weightage, due to number of constraints, including logistic difficulties in acquiring 3-D models. Such a practice is found inappropriate in producing apt results. Using a combination of subjective and objective judgments and accessible data sets, the Earth Scientists, to a considerable extent, have already explored easily amenable hidden resources. Geologists are presently asking geophysicists to specifically tell how a surface feature is extending and dipping at depth, especially in severely folded, sheared, thrusted and faulted terrains. For this one cannot follow a simple two dimensional approach. We need to have a 3-D coverage (better if a 4-D approach is adopted) and have number of criss-cross profile coverage in developing different 3-D models. Such a change has already been introduced in acquiring seismic data. In case of Gravity, Magnetics and Electro-magnetics, it is necessary to alter the linear profiling approach and develop models taking into consideration intricate lateral and vertical compositional and structural variations. Such a change is rather difficult due to various inherent limitations of these techniques. In spite of acquiring best possible high resolution data, even in the case of seismic, we are not definite about finer structural and compositional variations, as various parameters do have significant area specific variations in their basic structure. It is essential to note that one cannot come out with a specific conclusion from the derived values of velocities, densities etc., as the same values are found to be fitting well with different types of rock strata. As such, it has become imperative to have an integrated approach even to bring out a reasonably acceptable model. These complexities and limitations need to be explained explicitly by the geophysicists to geologists, to make things clear from the beginning. In many fields of applied science, such as geology, there are often tensions and disagreements between scientists who specialize in analyses of problems using mathematical models to describe sets of collected data, and those that rely on on-the-ground observations and empirical analyses. One common source of these disagreements arises from applications of geophysics -- studies of variations in gravity or Earth's magnetic field -- that use models that are strictly (from a mathematical point of view) non-unique. For example, using theories derived from Isaac Newton's studies of gravitational attraction, a geophysicist who measures local variations in gravitational acceleration that are produced by contrasts in the density of rocks below Earth's surface can calculate an infinite set of mathematically valid sources (with different shapes, depths, and contrasts in density) that would explain the measured gravity difference (or anomaly). This theoretical non-uniqueness leads many geologists to conclude that such geophysical information is of limited value, given the infinite number of possible correct answers to those numerical problems.

In the December 2011 issue of *GSA Today,* Richard Saltus and Richard Blakely, two U.S. Geological Survey scientists with extensive experience using gravity and magnetic field models to help improve the understanding of a number of geological problems, presented several excellent examples of unique interpretations that can be made from "non-unique" models [*GSA Today*, 2011; 21 (12): 4 DOI:10.1130/G136A]. Their motivation for this article is to improve communication among various geologists regarding the ability (and limitations) of gravity and magnetic field data to yield important information about the sub-surface geology of an area or region. This communication barrier is an important issue, because a great deal of our understanding of the geology of Earth and the planets is primarily derived from these types of geophysical measurements. More practically, geophysical tools such as gravity and magnetic field measurements are used in mineral and hydrocarbon exploration, so the utilization of these methods can aid economic development by locating sub-surface mineral resources more efficiently than other techniques (such as drilling and excavating). In their article, Saltus and Blakely advocate a holistic approach to geological studies. By combining other observations -- such as the surface location of a fault or the likely density contrast between a set of different rock units based on their composition -- the infinite array of theoretical solutions to some of these potential-field geophysical models can be narrowed down to a few, or even one, best interpretation(s). They present a number of examples where this approach can successfully solve important geological issues -- one of the best is an analysis of magnetic anomaly data from the Puget Sound area that allows a detailed image of the active Seattle Fault zone to be constructed. The raw data from a geophysical survey must often be converted to a more useful form. This may involve correcting the data for unwanted variations; for example, a gravity survey would be corrected for surface topography. Seismic travel times would be converted to depths. Often a target of the survey will be revealed as an *anomaly*, a region that has data values above or below the surrounding region. The reduced data may not provide a good enough image because of background noise. The signal-to-noise ratio may be improved by repeated measurements of the same quantity followed by some sort of averaging such as *stacking* or signal processing. Once a good profile is obtained of the physical property that is directly measured, it must be converted to a model of the property that is being investigated. For example, gravity measurements are used to obtain a model of the density profile under the surface. This is called an inverse problem. Given a model of the density, the gravity measurements at the surface can be predicted; but in an inverse problem the gravity measurements are known and the density must be inferred. This problem has uncertainties due to the noise and limited coverage of the surface, but even with perfect coverage many possible models of the interior could fit the data. Thus, additional assumptions must be made to constrain the model. Depending on the data coverage, the model may only be a 2-D model of a profile. Or a set of parallel transects may be interpreted using a 2½-D model, which assumes that relevant features are elongated. For more complex features, a 3-D model may be obtained using tomography. The final step in a project is the geological interpretation. A positive gravity anomaly may be an igneous intrusion, a negative anomaly a salt dome or void. Electrical conductivity of the earth provides information about porosity, water saturation, salinity, clay content that cannot be duplicated by other geophysical methods of investigation. However, there is a complex relationship between conductivity structure and the geophysical data measured at the Earth's surface. In various fields of investigation, interpreting geophysical responses with a locally one-dimensional (1-D) approximation to earth structure often yields useful results, especially if constrained to avoid artifacts not demanded by the data. However, in many instances, the locally 1-D assumption breaks down, and the lateral variations in structure must be included explicitly in a quantitative model. Pellerina and Wannamaker [Computers and Electronics in Agriculture 46 (2005) 71–102] discussed the state of the art in modeling and inversion of 1-D, 2-D, and 3-D earth conductivity structures. They have addressed pertinent issues that include capabilities and limitations of the various common field measurement systems, methods to predict the geophysical response, and incremental response sensitivity to earth structure, in addition to techniques for iteratively estimating an earth model that maximizes resolution without sacrificing model stability. A region of higher electrical conductivity may have water or galena. Geophysics is used in mining. This needs slightly different approach, using boreholes for acquiring data. Geophysical tools provide information about the physical properties of the subsurface. Geophysical data, if properly acquired, processed, constrained and interpreted, can be transformed into site models (typically subsurface geologic models). These site models can be of great practical utility in as much as they provide subsurface control in inter-boreholes areas and at sub-borehole depths. Geophysical tools are routinely used to image the subsurface of the earth in support of mining-related geotechnical investigations, including the detection and mapping of abandoned underground coal mines. Commonly employed geophysical methods include seismic refraction, seismic reflection, seismic tomography, ground-penetrating radar (GPR), electro-magnetics (EM), electrical resistivity, induced polarization (IP), magnetics, self potential (SP) and gravity. Geophysical tools are designed to measure specific *parameters*, and are generally used to measure spatial variation in these specific *parameters* within a study area of interest. Ground-penetrating radar (GPR) instruments, for example, are designed to measure the two-way travel times and amplitudes of reflected pulsed electromagnetic radiation. During the course of a typical GPR survey, these tools are used to measure spatial variations in the travel times and amplitudes of EM radiation that has been reflected from subsurface horizons (or features) of interest. The usefulness of a specific geophysical tool is a function of site conditions. Variables include (but are not limited to) accessibility, areal extent, density of vegetation, topography, soil thickness and lithology, groundwater salinity, etc. Site conditions must be taken into consideration during the pre-planning phase, to ensure the technique(s) selected have a reasonable probability of working well in the study area. The specific *parameters* measured by geophysical tools are functions of the *physical properties* of the earth's sub-surface. For example, the travel times and amplitudes of the reflected pulsed electromagnetic radiation recorded during a GPR survey, are functions of the variable electrical and magnetic properties of the subsurface (including dielectric constant, magnetic permeability, conductivity and EM velocity) along the respective ray-paths. The dielectric constants and EM velocities assigned to each of the two layers on the GPR profile were determined/ estimated on the basis of in-situ GPR field tests. The arrival time of the reflected event (water/ sand interface) at any trace location on the GPR profile is a function of the EM velocity of water; the amplitude of the GPR event at any trace location is a function of the contrasting dielectric constants of water and sand (Courtesy: Neil Anderson and Ahmed Ismail; Department of Geology and Geophysics; University of Missouri-Rolla, Rolla, Missouri 65401**)**.

Geo-physically interesting results can be achieved only by using proper weighting and regularization. In recent years, widespread interest in data measurement integration has brought new value to gravity and magnetic methods, particularly in simultaneous joint inversion (SJI) applications. For example, it is demonstrated that a seismic-gravity SJI can improve complex imaging configurations involving dyke-like structures. Another example is, where the technology is applied to real data sets, showing how gravity can improve thrust-belt and sub-basalt imaging. Within the scope of SJI, magnetic inversion may be used in the same way as gravity to improve seismic imaging where seismic coverage or illumination is poor (De Stefano, Progress in Electro-Magnetics Research Symposium Proceedings, Moscow, Russia, August 2012).

It is usually assumed seismic reflection technique provides better sub-surface structural images and one can have details about composition of the sub surface formations from the refraction technique derived velocity information. However, even these geophysical techniques have some limitations. With the advances in seismic modeling capabilities and increased computer performance, survey planning has moved away from the traditional CMP-based fold concept towards sub-surface illumination studies in complex 3-D earth models. This is reflected in the number of recently published papers. In particular, 3-D ray-tracing followed by target-oriented binning methods is extensively applied to simulate the target coverage, which would be obtained by different seismic survey configurations. The aim is to relate the modeled target illumination to the seismic image quality of the target structures after seismic processing. Uniform coverage is considered the ideal result, and any deviations, like shadow zones and variable sub-surface fold, indicate regions where imaging problems or acquisition related amplitude variations (i.e., acquisition footprints) may be expected. Sub-surface coverage modeling consists of (a) calculating the reflection points on the target horizon (usually by 3-D ray-tracing) for a specific survey configuration, (b) then binning these "events" in an orthogonal grid resembling the regular trace spacing or binning grid in a 3-D seismic cube, and (c) finally calculating various attributes or distributions of attributes for each bin cell. Sub-surface coverage modeling is a valuable tool to analyze the effect of shooting direction and other survey parameters upon the subsurface illumination. It can be applied during survey planning, for online sub-surface coverage QC, and as supplementary information to aid the interpretation of the processed seismic data. In many studies, relative comparisons and qualitative analysis are sufficient and easily interpretable. Still, the underlying assumptions and limitations need to be considered to avoid pitfalls. For quantitative analysis and comparisons with real seismic data, even more care has to be taken. Seismic processing, and in particular migration, act like a strong spatially and temporally variable filter, significantly affecting the amplitudes and image quality. In contrast, sub-surface coverage modeling will produce results based on perfect, but unrealistic, processing and sampling. Therefore, a calibration of real data with modeled results is essential. For all investigations it is recommended to adjust the modeling and analysis parameters in order to resemble the acquisition and processing settings as well as possible.

Reliable results can only be obtained if:

- a realistic 3-D geometry (rather than 2-D) is employed in the modeling,
- an offset range is selected which resembles the usable offsets during processing, and
- a representative 3-D subsurface model is used for the modeling.

Special care should be taken when drawing general conclusions from sub-surface coverage modeling studies where simplified models or acquisition geometries are used (Courtesy: Hoffman et al., PGS Geophysical).

For a good interpretation the geophysics model must be combined with geological knowledge of the area. From the details given above one can understand the complexity in acquiring geophysical models that can satisfy fully the geologists. What is needed is a good understanding between different specialists and their appreciation of each other's capabilities and limitations. The one who is given the responsibility of eliciting proper information from a set of data sets has to use his judgment in removing hay from the grain. And for this he has to take into view the importance and limitations of various data sets --- Geologic, Geochemical, Geochronological, and Geophysical and give due credit to every scientist/ technical expert who has boldly made use of innovative strategies in generating and processing/ interpreting the data. Such a leadership quality, of sharing the benefits and bearing responsibility for the failures, can produce better results and help the organization in meeting various targets.

Since it is not possible to cover various facets of surface geophysical studies in an editorial, we urge the readers to make use of the details given here to basically understand the importance and limitations of geophysical techniques in addressing the geological issues.

In this Issue

Nine papers are included in this issue. In the first paper "Gas-hydrates, …. next generation", K. Sain and H.K. Gupta have presented a review on the use of gas hydrates as a significant and viable major energy resource of future. It is expected that the gas hydrates will be produced commercially by 2020. In the second paper "Deep crustal …. Gondwana correlations", T.R.K. Chetty has presented the structural framework of the EGMB that constitutes a network of deep crustal shear zones. It is emphasized by him the importance of different shear zones in developing tectonic models and Gondwana correlations. He has suggested that there is a strong need for detailed modern mapping techniques to have meaningful interpretations of multiple events of magmatism, metamorphism and deformation. In the third paper "An overview …… holistic approach", Murthy and Reddy have pointed out that holistic or integrated coastal zone management is essential to understand the structure and dynamics of coastal ecosystem especially in arresting coastal environmental degradation. In the fourth paper, "A study …. GIS tools", Das and Harinarayana have analyzed all the aspects related to possible oil spills and gas leakages with special reference to Gujarat State. In the fifth paper "Efficacy …. Modeling" Padmavathi Devi et al., have detailed about the Physical Model experimentation using resistivity profiling over metallic sheet like target in different orientations with different electrode configurations viz., two electrode, three electrode, Wenner and Dipole-Dipole. In the sixth paper "New Palaeomagnetic …. Kachchh Basin, Northwest India", Venkateswarlu et al., have presented new palaeomagnetism results from twelve dyke samples. The study shows that the dykes from two of the three localities have normal directions while the third has a reverse direction; similar to the Deccan volcanic province directions. In the seventh paper "Influence of …… south India", Chandrasekhar and Kumar have presented results of a study on equatorial counter electrojet (CEJ) at a newly established equatorial remote station located in the Kanyakumari district of Tmilnadu. In the eighth paper "Fractal ….. Indian Ocean", Uma and Selvaraj have detailed about fractal dimensional analysis to investigate cyclonic disturbances over the north Indian Ocean using the Hurst exponent. Through the last paper "South Indian …. Monsoon rainfall", Prasad and Singh have identified an important role of the annual oscillation of the equatorial troughs in Indian Ocean (IO) as monitored in satellite observed cloud data, in inter annual variability of ISMR. In addition to the above a review by U. Raval on the book "Principles, Integrated Exploration and Plate Tectonics" by D.C. Mishra, is included.

We look forward to continued support from the learned scientists to IGU.

A Success Story:

The successful launching of Mangalyaan space orbiter with a pay load of more than 1300 kg on 5th November 2013, on an expedition to the Mars opened a new chapter in the Indian Space History. ISRO successfully put the orbiter in the Sun-Centric orbit on 01 December 2013. This was a positive development. We look forward to successful completion of the voyage to Mars and entry into the Mars orbit on 24th September 2014.

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