INTERNATIONAL WORKSHOP ON ELECTROMAGNETIC INDUCTION IN THE EARTH

The 16th workshop on electromagnetic induction in the earth was held at College of Santa Fe, New Mexico, USA from 16 to 22 June, 2002. In addition to the main workshop, a pre-workshop – Summer Electro Magnetic Immersion (SEMI) was also organized from 12 to 15 June. The pre-worhshop at Santa Fe, provided a good opportunity to have hands on experience with the latest electromagnetic field equipment and also the software. Several reputed geophysical companies participated in the workshop. About 70 delegates attended the pre-workshop and about 230 delegates the main workshop representing many countries.

The research papers in the main workshop were arranged in 12 sessions with a total of 228 abstracts in which 56 were oral, 5 reviews and 167 posters.

The following are the highlights of the various sessions:

Session 1: Laboratory Measurements (10): G. Nover opened the session with a review. He deomonstrated the effect of electrical conductivity parameters on the chemistry of pore fluid in rock samples. Contrasted to this, mantle relevant mineral phases like olivine exhibit 'semiconduction' under mantle temperatures and pressures. This is demonstrated in the laboratory experimental studies. Apart from this, partial melting also increases the conductivity in thermally activated regions, if the molten phase is interconnected. Jeff Roberts in his lab measurements of geothermal reservoir rocks observed that intact samples showed a gradual increase in resistivity when pore pressure is decreased below the phase-boundary pressure of free water, while fractured samples show a larger and more abrupt resistivity increase at the onset of boiling. Electrical resistance tomography using resistivity contrasts determined by lab experiments indicates that active fractures can be identified.

Session 2: Industry Applications (21): From the study of various EM applications to the industry, the following observations can be made. Petroleum exploration using various EM geophysical methods seems reasonably steady. Geothermal exploration has shown a bit downward trend and may probably decline until economic factors improve. EM applications for groundwater exploration seems to have increased, in view of the need for water becoming increasingly apparent in many parts of the world. Some interesting papers were presented in this session regarding the detection or monitoring of resistive hydrocarbon layers, among which detection of hydrocarbon layers by controlled source marine-e.m and combined use of TEM and DC data proved to be an effective way of mapping and rapidly appraising oil sand leases.

Session 3: 2-D vs. 3-D Interpretation (14): In recent years, fast and more reliable codes to calculate the forward electromagnetic response of 3-D models have been developed and used for interpretation. This has facilitated 3-D trial and error attempts to fit the data. Apart from this, attempts are being made in the development of 3-D inversion codes. Among the codes, the prominent being Machie and Madden, 1993; Alumbaugh and Newman, 2000; Zhdanov et al. 2000; Sasaki, 2002; Newman et al. 2002. In the session most authors used 3D forward modelling routine to explain the data while a few made attempts to use inversion technique. Some authors have made a critical comparison of the 2-D models obtained using inversion techniques with the 3-D forward models for better understanding of the subsurface structure.

Session 4: Natural Electromagnetic Source Effects (12): Effect of auroral and equatorial electrojets was discussed in the session. The source effects can be large mainly near the edges of current spreading. The main errors here are the underreading of the depth values to the conductive mantle. This was demonstrated by scale modelling experiments. The effect of equatorial systems showed a decrease in apparent resistivity during day time in contrast to night time. Another interesting paper presented was on geomagnetically induced current (GIC) systems. GIC are of special interest at high latitudes where they can harm the normal operation of power transmission systems and buried pipelines. The characteristics of GIC's are studied during two large geomagnetic storms.

Session 5: Modelling and Inversion (47): The session on modelling and inversion is dominated by the development of 3-D modelling schemes apart from a few papers on the development of 2-D and 1-D modelling schemes. Joint use of magnetovariational, LOTEM, TEM and DC resistivity techniques along with MT/EM data are also gaining importance. Among the various papers presented, the interesting ones are – the relation between magnetotelluric phase (>90°) and anisotropic nature of the subsurface

structure, representation of resistivity subsurface sections in the form of temperature maps and melt fraction sections, application of parallel algorithms in 3-D modeling to reduce computation time etc.

Session 6: Local and Regional Studies (55): Several interesting EM Induction case histories from different regions of the world were presented in this session.

Session 7: Oceanic Studies (12): Oceanic electro-magnetic studies have been dominated by marine magnetotelluric studies in different parts of the world. Papers from Scripps Institute of Oceanography and Woods Hole Oceanographic Institute of USA dominated this session, although some papers were also presented from Southampton Oceanography Centre, UK. Among these papers natural and artificial source methods were used. Very long frequency data have been used, the frequency range being 0.2 Hz to 0.0002 Hz. The depth of investigation varies from 100/ 200 m below the sea bed to as deep as a few tens of kilometres. One of the interesting papers was about the mapping of the resistive hydrocarbon formations using controlled source electromagnetic techniques. Another interesting paper was on the volcanic sediments using natural source methods.

Session 8: Global Studies (7): Deep mantle conductivity structures have been studied using long period measurements on land, ocean and also from MAGSAT data. One of the interesting papers was about the detection of nuclear explosions by measuring the direct electromagnetic pulse (EMP) along the seismic signals. Another interesting paper was about the electrical structure of the planet Mars from the martian vector magnetic field.

Session 9: Seismic and Volcanic Effects (7): Deep electrical structure is presented in active volcanic and seismic regions. This has been studied near Kusatsu-Shirane Volcano, Gunma, Japan from wideband MT studies and self-potential variation study near a volcano, Miyakejima island, Japan. Apart from these studies other papers are devoted to seismically active regions – Bhuj region, India; Izmit region, Japan; Aswan seismic region, Egypt and Haiyuan region, China. One interesting paper in this session was on the perturbations of ULF e.m. measurements observed in the Surlari observatory, Romania related to intermediate depth earthquakes, which could be related to the conductivity changes at subsurface depths.

Session 10: Environmental Applications of EM (12): Environmental aspects were dominated by GPR (ground penetrating rada), AMT (audio-magnetotelluric), TAMT (transient audo magnetotelluric), TEM (time domain and transient electromagnetic), RMT (radio magnetotelluric) and DC resistivity techniques. These techniques are known to be effective for shallow depth investigations. They have been used to detect fractures in granite, aquifer parameters, to detect oil contaminated soils, groundwater pollution, to monitor the leakage of caustic liquid waste materials and vadose zone infiltration. One of the interesting papers in the session was on monitoring of the electrical potential of a living tree. A sinusoidal daily variation with double peak annual characteristics was observed.

Session 11: Geodynamic Model (18): Electrical structure of important geodynamic regions were presented in the session: prominent among them were – Serra da Cangalha impact structure in Brazil; San Andreas Fault in California; central Andes region, Chile; French Alps region, Slave Craton, Canada; northern British Columbia; active fault near Shizuoka, Japan; Dharwar region, India; Asia-India collision zone in Himalayas; Changbaishan mountain region, NE China and the Great Basin and Colorado plateau region, USA. In these regions the reason for high conductive lower crust is explained in a variety of ways. Some of the reasons ascribed are due to oxidizing conditions, hypersaline brines and water undersaturated crustal melting, partial melting, hydrothermal fluids etc.

Session 12: The Magnetotelluric Tensor (13): In this session estimation of magnetotelluric impedance tensor was debated in several interesting observations. The rotational property of the impedance tensor, decomposition of the tensor elements, phase tensor, impedance tensor estimation in controlled source and natural source fields, robust estimations of impedance tensor, estimations of tensor in AMT dead band range, dispersion relations, use of neural network in the estimation of impedance tensor were some of the important topic covered in the session. One of the interesting papers in the session was on the study of impedance tensor in a new set of series and parallel transformations and which the authors demonstrated with numerical and field examples. This method of estimation of tensor does not depend on direction of axes and hence may be advantageous in the measurement of the fields.

Finally, the workshop was well organized with the participation of some important personalities in the field of EM induction. These included Prof. Berdechevisky,

Russia; Prof. P. Weidelt and Prof. U. Schmucker, Germany; Prof. J. Weaver, Canada; Prof. J. Booker, USA; Prof. R. Banks, UK and Prof. Honkura, Japan.

The workshop was represented by 12 countries. It was decided by the working group that the 17th workshop will be in India at Hyderabad during September 2004, under the convenorship of Dr. B.R. Arora and the undersigned as the co-convenor.

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CORRESPONDENCE

CLIMATIC AND ENVIRONMENTAL SIGNIFICANCE OF CALCRETE-GYPSUM NODULES

The article entitled 'Calcretes and related Palaeosols in Phanerozoic Stratigraphic Records in India (*JGSI*, v.60, July 2002, pp.75-89) brings out with force the importance of studies on calcrete as a climatic indicator. In this context, the occurrence of calcrete and nodules partly of calcrete and partly of gypsum occurring in the Precambrian terrain falling in the rain-shadow area of the Western Ghat hill ranges in the Coimbatore district, Tamil Nadu, is interesting. The area receives an average annual rainfall of about 690 mm, precipitated in about 45 days in a year. The semi-arid climatic condition is obviously favourable for the formation of calcrete occurring as nodules on the surface and lining fractures and joints in gneisses traced widely.

According to Ramanujam (1968), during Mio-Pliocene times a tropical humid climate was prevalent in most parts of India. On the basis of studies on Landsat imageries, Subramanian and Muraleedharan (1985) identified the signature of a major palaeo-river channel and patches of black clay, considered to be palaeo-lacustrine sediments. Obviously, during Mio-Pliocene, streams transported and debouched sediments with calcrete nodules in lakes. Nodules partly of calcrete and partly of gypsum are confined to the black clay patches and are not traced in the area around.

The intimate association of calcrete and gypsum and the presence of kernels of calcrete in some nodules of gypsum suggest that gypsum is a secondary mineral after calcrete. Obviously, the interaction of the calcium carbonate of calcrete with hydrogen sulphide released by bacterial action in marshy desiccating lakes in post-Mio-Pliocene times when the climate turned dry, gave rise to gypsum.

The above picture suggests that the chemical alteration of calcium carbonate to gypsum was the result of environmental changes ushered in by a change from a humid to a dry climate. Black clay patches are known on rocks of different lithologies and ages in Peninsular India. Possibly atleast some of them are not derived from the subjacent rocks as in the Coimbatore area. Studies over a wide area may be suggestive of their modes of origin and palaeoclimatic significance.

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Jour. Geol. Soc. India, v.60, no.3

p.325, Legend of Fig.2: 'ramnants' should read as 'remnants'.

p.360, Second column, 12th line from top: 'for' should read as 'far'; last para, 3rd line: 106000' should read as 10600'.