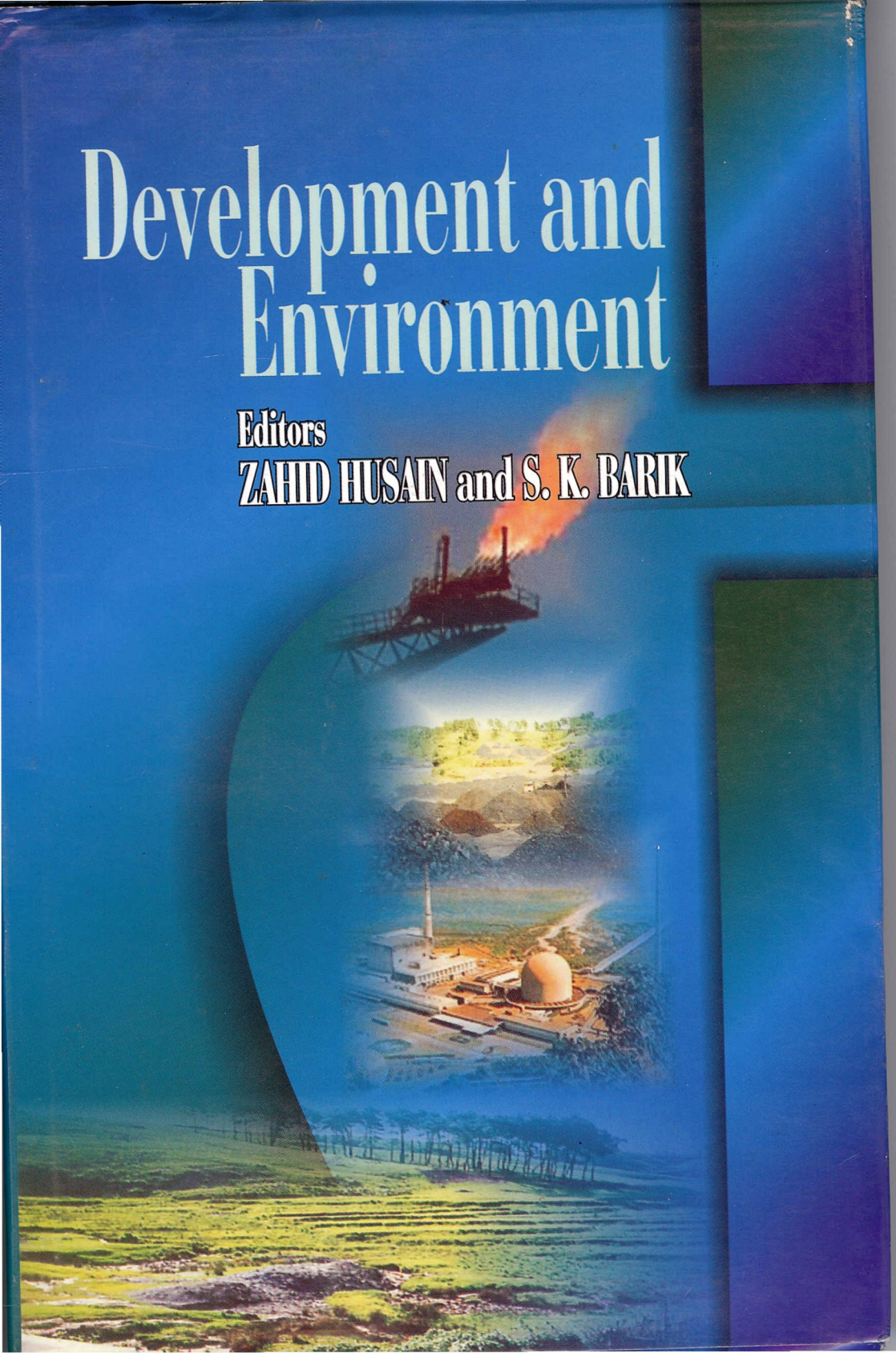
Development and Environment

Editors
ZAHID HUSAIN and S. K. BARIK



DEVELOPMENT AND ENVIRONMENT

DEVELOPMENT OF GEOENERGY RESOURCES AND ITS IMPACT ON ENVIRONMENT AND MAN OF NORTHEAST INDIA

Editors

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Regency Publications
New Delhi

ISBN 81-87498-96-X

Published by Regency Publications, 20/36-G, Old Market, West Patel Nagar, New Delhi 110 008 and printed at Radiant Printers, New Delhi, Phone: 5546 2898; Telefax: 2588 4571.

Email: regency@satyam.net.in • www.regency-books.com

Dedicated to
Environment and Development
of the People
of
North East India

Preface

North-East India Council for Social Science Research, the premier social science research organization of 30 years standing, held a seminar on Environmental and Sociological Implications of Mining of Coal, Limestone and Uranium and Exploration of Oil and Natural Gas in North East India on 5–6 June 2003. The present volume contains some of the selected papers presented to the seminar. North East India is endowed with huge mineral resources including limestone, coal, natural gas and uranium. Coal is found in all the states of North East India. But except in Assam and Meghalaya coal mining has not been undertaken elsewhere. Mineral resources are largely untapped. In Assam coal mining is done by Coal India Limited. In other states, coal mining is done by private mine owners in most unscientific way causing much environmental hazards, sociological damages and demographical imbalance in the mining areas. Hydrocarbon exploration is mostly done in upper Assam and in adjoining Nagaland and Arunachal Pradesh. Till now maximum petroleum explorations are conducted in the plain areas where geology is favourable. The exploration and exploitation of oil resources should be made in such a way that meet the present need without compromising the needs of the coming generations. Operational activities interact with the environment through long term physical, chemical and biological changes. Pollution control measures should be taken at every stage of exploration and exploitation of hydrocarbon resources of North East India.

Uranium is the basic raw material for the nuclear programme of the country. With the formulation of Atomic Energy Programme in 1948, the search for uranium had commenced. The exploitation of this valuable material is now being carried out by the Uranium Corporation of India Limited (UCIL). The technology

adopted by the UCIL is comparable with the best practiced any where in the world. Domiasiat Project in West Khasi Hills district of Meghalaya may bring about a positive development in the social and economic scenario of West Khasi Hills. The project is likely to generate economic opportunities for the people of Meghalaya.The adoption of state of the art technology with environmental monitoring mechanism adopted by the UCIL minimizes health hazards. Nuclear energy will stage as a major source of power which could be made safe and dependable source of energy of the future. But it has to be handled with care by strictly following the International Atomic Energy Agency regulations and as adopted by Atomic Energy Regulatory Board of the country.

We take this opportunity to thank His Excellency the Governor of Meghalaya Mr. M.M. Jacob, Professor G.D. Sharma, Vice-chancellor, Nagaland University, Dr. R. Gupta, Chairman Uranium Corporation of India, Mr. H.K. Mazhari and Dr. S.Q. Hoda, Regional Director, Atomic Minerals Directorate for Exploration and Research who contributed much to the success of the seminar.

We congratulate Dr. Zahid Husain and Dr. S.K. Barik for editing the volume and Regency Publications, New Delhi, for expeditious publication of this volume.

4 June 2004
Shillong-793003

B. Datta Ray
Secretary,
North-East India
Council for Social
Science Research

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Technological Strategies for Effective and Safe Mining Activity

S. Aravamudhan

Section I: Introduction

An awareness as to what the resources are and how to relate it to the development leads to the kind of considerations as it appears in flow-chart diagrams and schemes of Figure 1. This is the stage set for the starting point in Figure 2. It is first of all necessary to document the occurrence of resource materials. This should be made in such a way that while considering further for utilising them — when critical balances as required in the flow-diagram of Figure 2 have to be accounted for — the occurrence data does not stand out with ambiguities either Qualitatively or Quantitatively. Only this can bring confidence among those concerned with resource management, and enable them to look for effective scientific methods and technical assistance in minimizing the environmental degradations and reducing the consequential hazards. The critical question of whether the natural resources occurring in a region have to be made available for use or not must depend upon only this awareness among all.

More specifically, the unwanted consequences can be categorized as in the flow-chart diagram of Figure 3. The diagram indicates which are the aspects that require all-time monitoring with preparedness for possibly on-the-spot inferences and

measures at short notices. The diagram also lists out the considerations that are the durable considerations for the sustainability of the activities. All these are to be tackled with the advantages from the fast-developing technological means.

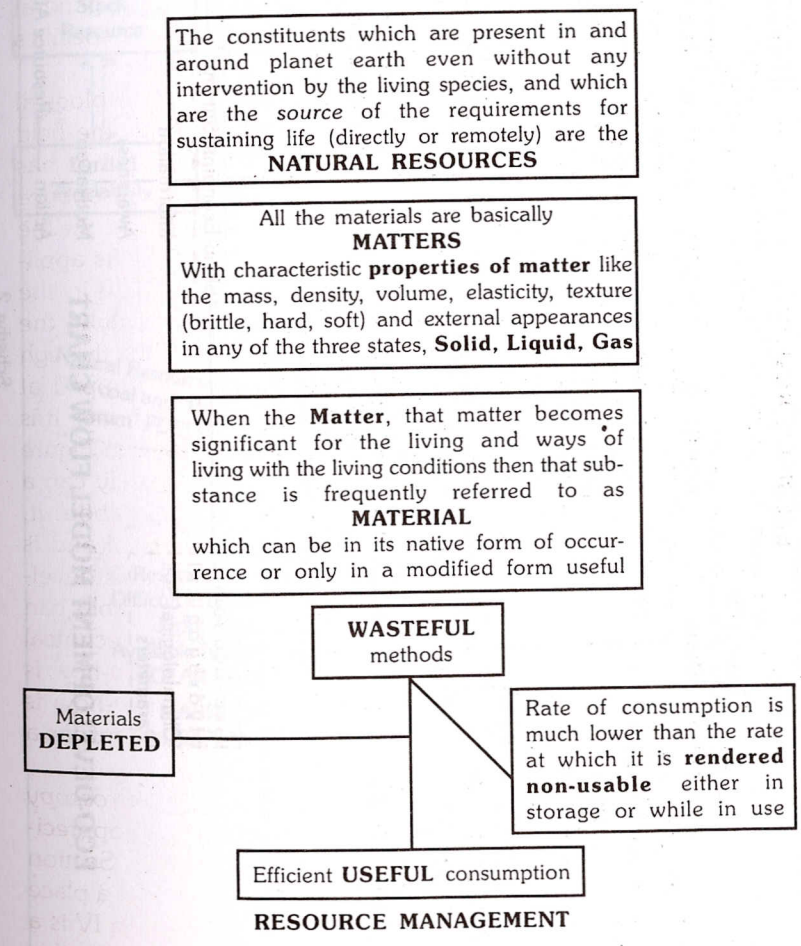
It is in this context that this article is set out. How can the specialist in a technological aspect get to know the specifics of the requirement at a spot? How much of it depends on the people on the spot and how much of it depends on people who have the know-how for the tasks to take the necessary initiatives. This broad-based important question when answered on a general footing the out come is bound to be untraceable for the specifics of the regions which might appear to have been diluted.

It is the purpose of this paper to highlight a technological aspect that has been known to have great potential in the field of mining for minerals and exploration for oil. The author has been pursuing the research in the *Nuclear Magnetic Resonance Spectroscopic Technique* and has known its capabilities. At the same time the author is aware that this technique and its applicability in such contexts is much less known even now in the North East India,[1] where the requirements for an activity in the region can seemingly be known after the activity has gone through a full swing operation to let out the cry for it to be stopped at short notice because of the disadvantages to the inhabitants. It is not much evident whether a consideration of the kind in Figure 2 has been made and when? Belatedly then, how quickly can a specialist appear in the scene to claim what is known about it, which can be done? This type of predicament is typical and is the irony that cannot be recognized in a region, which is developing. The example of the efforts in this paper probably can provide an insight to the several specialists in various technical aspects to go to the rescue to the places where the know-how is not available, and it is not even known that the know-how is available. Then only arises the question of whether to opt for a technological strategy or not.

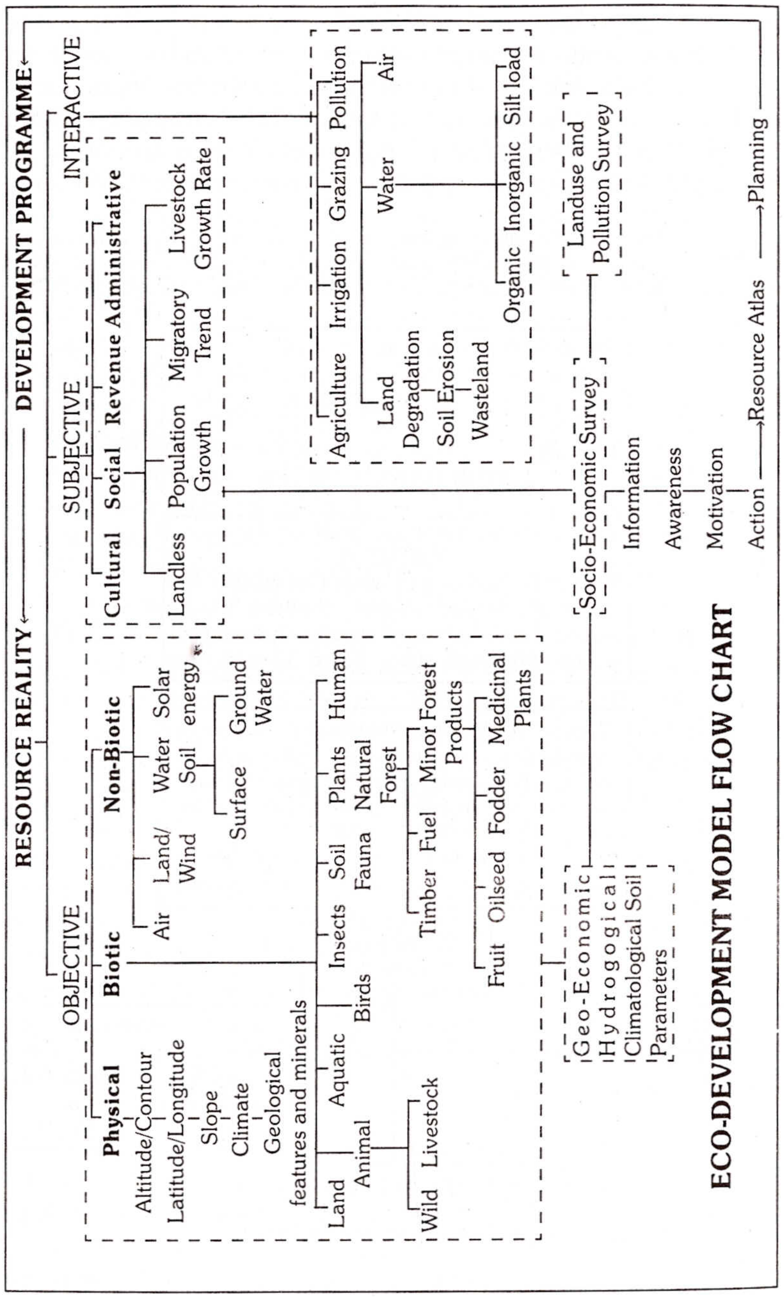
The technique of *nuclear magnetic resonance spectroscopy* is described in section II to enable the average public to appreciate what is being told about its potential in the context. Section III is an effort to try to explain how this technique can find a place in such considerations of mining and exploration. Section IV is a documentation which is available in the actual applications in this

area to highlight the fact that even the simple introduction to this technique as given in the previous sections could be enough to recognize the capability of this technique by reading reports and seek to look for the specialists considerations appropriately. Section V is an elaboration for the benefit of that cross section of the public which makes up the scientific community. Section

Fig. 1: The four Schemes given below appear in the article "Recognising and Utilising Resources" by this Author published in *Environmental Issues of North East India*, Edited by Zahid Husain, Regency Publications, New Delhi. p. 219 (2003).

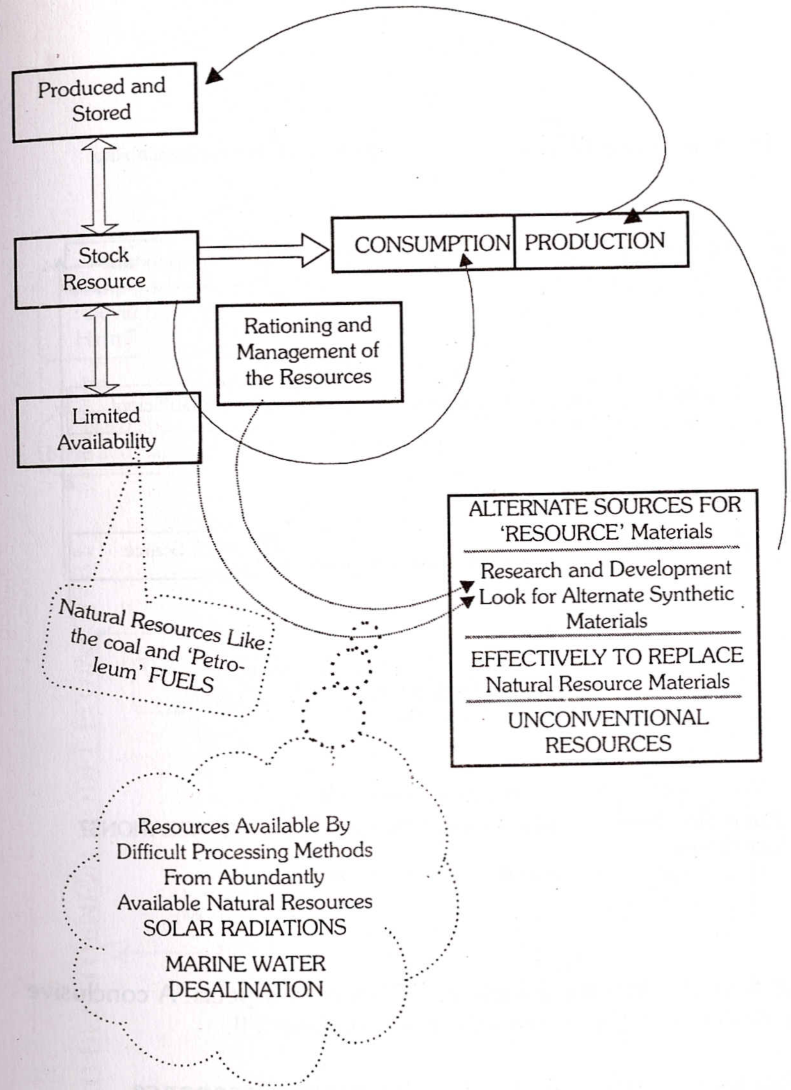


Scheme 1

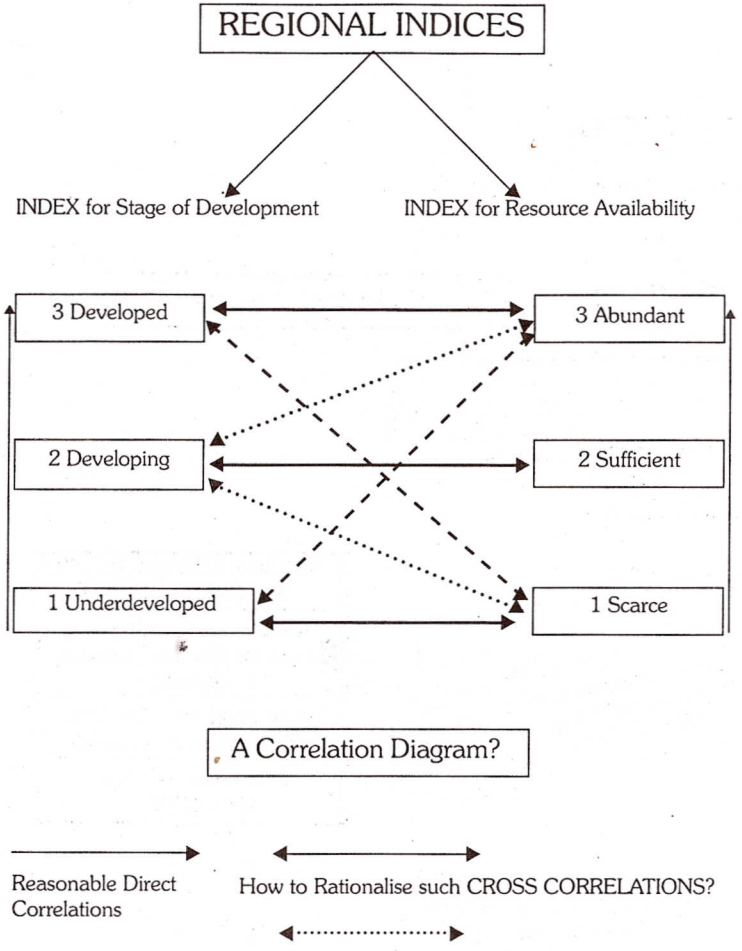


ECO-DEVELOPMENT MODEL FLOW CHART

Scheme 2



Scheme 3



Scheme 4

VI is to consider the relevance for regional aspects. A conclusive summary is what is intended in the section VII.

Section II: What is Nuclear Magnetic Resonance

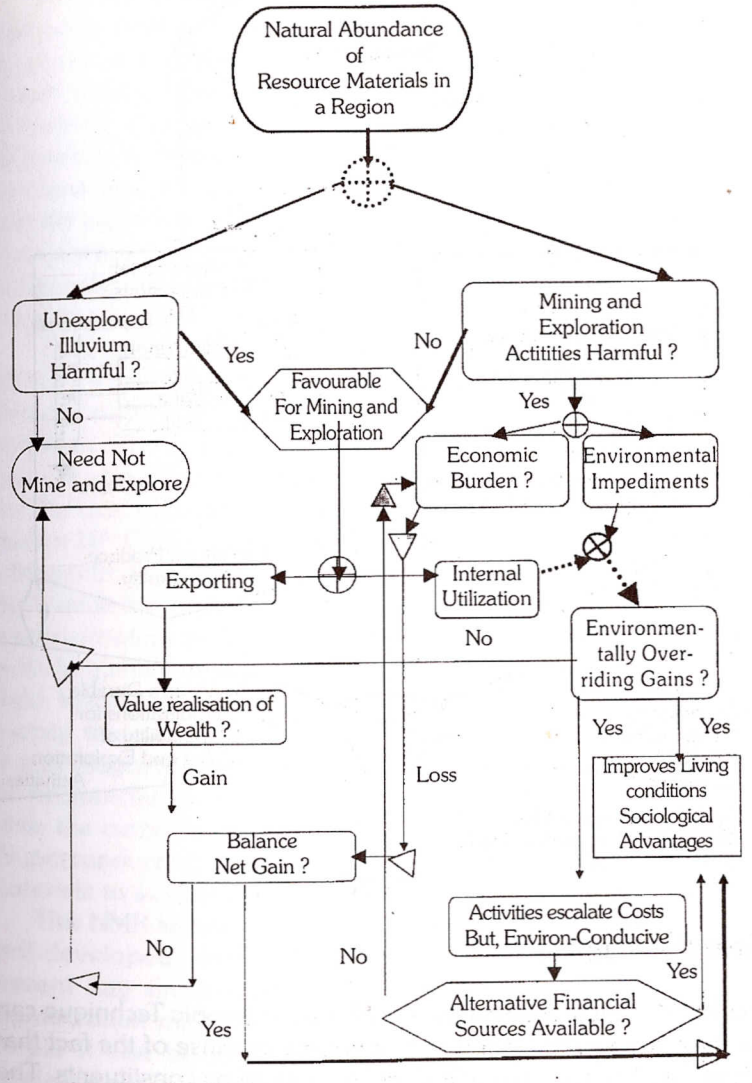


Fig. 2

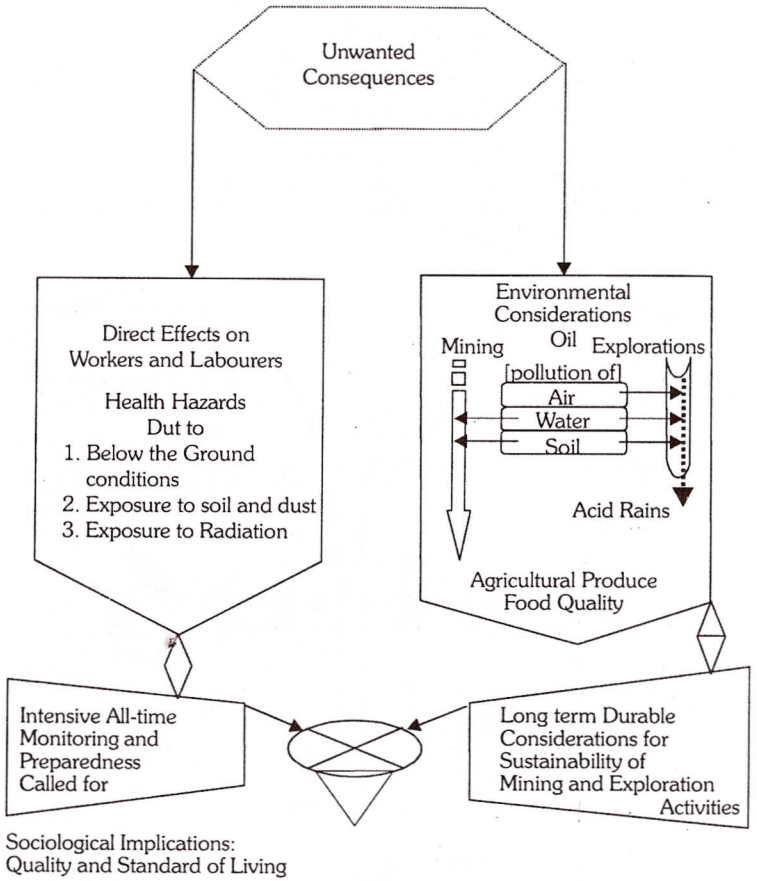


Figure 3

Spectroscopy?

Nuclear Magnetic Resonance (NMR) Spectroscopic Technique can be used to monitor chemical compounds because of the fact that atoms, and hence, the molecules have nuclei as constituents. The nuclear property which this NMR technique makes use of is the possibility that nuclei have magnetic moments (describable as that of tiny bar-magnets). Physicists associate these Nuclear Magnetic Moment values with the characteristic Nuclear Spin Quantum Numbers.[2]

Nucleus, being a tiny bar-magnet,[3] can align in an external magnetic field and this alignment can undergo alterations in presence of Electromagnetic radiations (Visible light is an example of Electro-magnetic radiation) at appropriate frequency by absorbing energy from these radiations. This value of the frequency is related to the product of the nuclear magnetic moment and the external magnetic field values as given by a specific equation which ensures a value for the frequency when resonance occurs at a value for the Magnetic Field. A list of NMR frequencies for a few nuclear species at a given value of external magnetic field appears in NMR Table 1.

The Figure 4 "A *Scheme for Detecting NUCLEAR MAGNETIC RESONANCE SIGNAL*" depicts an experimental situation and the consequences of the Energy-absorption from the Electromagnetic radiation. The frequency of these NMR signals can be detected in the Radio Frequency range of the Electro magnetic radiations. For the case of protons (1H nuclei, a frequency of 300MHz (Mega Hertz=10^6 Cycles per Second) is typical for a sample placed in a Magnetic Field of 7.05 T (Tesla=10^4 Gauss). At this Magnetic Field value the 13C nuclei have a resonating frequency of 75MHz (approximately ¼ of the Proton resonance frequency) in the radio frequency region. Similarly, at any given specified Magnetic Field Value other nuclei can be detected at characteristic frequency that can be related to the Proton Resonance frequency at that Magnetic Field value. These spectrometers that are built for frequencies up to 100MHz were mostly using Electromagnets while the currently available HIGH-FIELD Spectrometers require "Superconducting" Magnet Systems which use super conducting materials to sustain the flow of constant high currents.

This NMR technique is a currently fast-growing technique with well-developed Methods applicable in various contexts. The present day spectrometer capabilities are astonishing and its sophistication makes it very remote for the public to know how simple it can be to get results in a specified contexts. The specialists are preoccupied more in increasing the potential of this technique from the well-established requirements in general, the specific requirements of when and where it can be implemented is left for practicing spectroscopists. It is up to the public to reach out for such practicing spectroscopists who also happens to be specialising in the technique and derive the most of what is

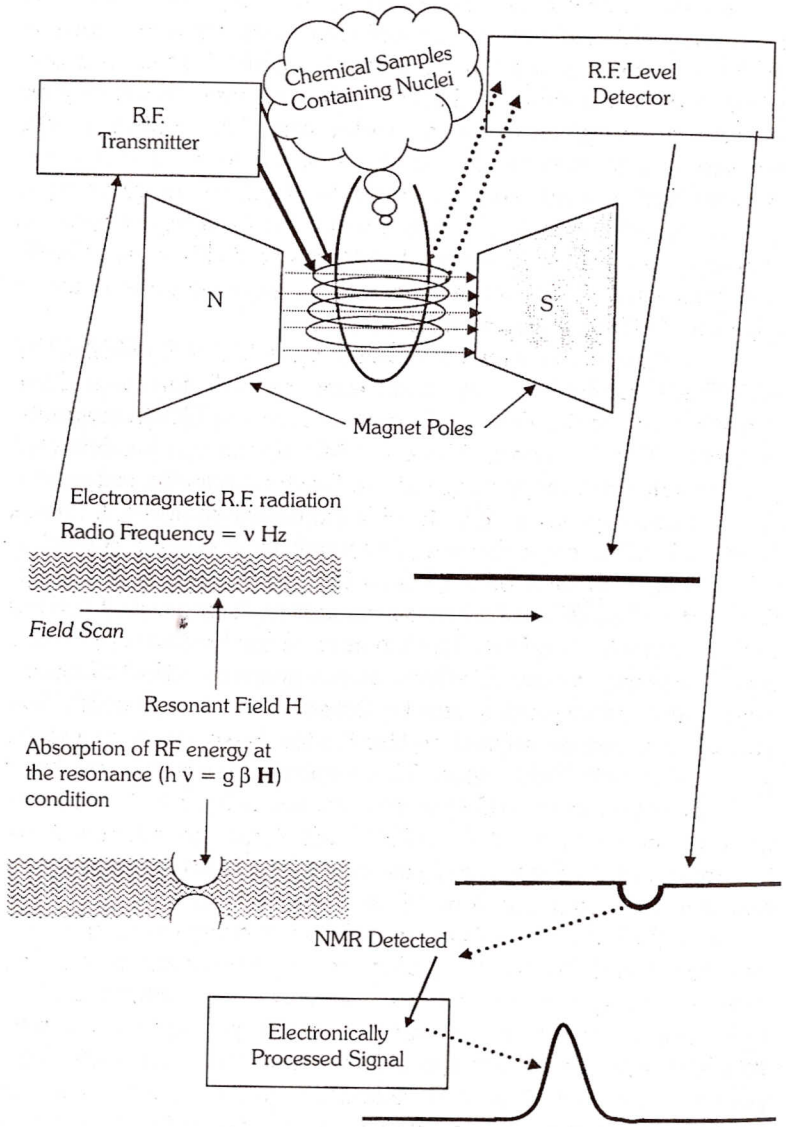


Figure 4: A Scheme for Detecting Nuclear Magnetic Resonance Signal

Table 1. NMR[4]

NUCLEUS Isotope	*Spin*	*Natural Abundance%*	*Sensitivity Relative[a]*	*Absolute[b]*	*NMR Frequency (MHz) at[c] 2.3488 T* $V_{2.3488}$
^{1}H 'Proton'	½	99.98	1.00	1.00	100.00
^{13}C 'Carbon'	½	1.108	1.59×10^{-2}	1.96×10^{-4}	25.144
^{15}N 'Nitrogen'	½	0.37	1.04×10^{-3}	3.85×10^{-6}	10.133
^{31}P 'Phosphorus'	½	100.00	6.63×10^{-2}	6.63×10^{-2}	40.481
^{33}S 'Sulphur'	3/2	0.76	2.26×10^{-3}	1.72×10^{-5}	7.670
^{207}Pb 'Lead'	½	22.6	9.16×10^{-3}	2.07×10^{-3}	20.921

a. For Equal number of Nuclei
b. Product of Relative Sensitivity and Natural abundance
c. 2.3488 T = 2.3488 Tesla = 2.3488×10^{4} Gauss = 2.3488 Kilo Gauss

The NMR Frequency at any specified Magnetic Field Value 'H' in Gauss can be calculated by the equation: $\nu_H = [\nu_{2.3488} \times \mathbf{H}] / 2.3488 \times 10^4$

Table 2. Sources and Quantum of Air-Contaminants

(in millions of tonnes per year)

Source	*Carbon Monoxide*	*Sulfur Oxides*	*Hydro-carbons*	*Nitrogen Oxides*	*Total with Miscellaneous*
Transport-ation	66	1	12	6	86
Industry	2	9	4	2	25
Power Plants	1	12	<1	3	20
Space heating (homes and factories)	2	3	1	1	8
Refuse Disposal (mostly incinerators)	1	<1	1	<1	4
Totals	72	25	18	12	143

Molecular formula	*Name of the Chemical*
CO	Carbon Monoxide
SO_2	Sulfur Dioxide
NO; NO_2	Nitrogen Oxides
CH_4	Hydrocarbons (methane)

From a book[5] on Concepts of Ecology which reproduces this table by permission of the National Tuberculosis and Respiratory Disease Association.

available and what is possible. In most of the cases it is the initiatives from the public that can be ascertained as wanting, while certain utilization criteria are evaluated.

Section III: How does the NMR Technique find its Relevance in the Context of Mining for Minerals and Exploration for Oil?

To facilitate an appreciation of the subject of the title of this Section, we may consider, for further specification to follow, the Table I, of "Sources and Quantities of AIR CONTAMINANTS" as reproduced. It can be seen that the Air Contaminants are essentially Chemical (molecular) products like (1) Carbon Monoxide (2) Sulfur Oxides (3) Hydrocarbons (4) Nitrogen Oxides etc. These chemical compounds contain (atoms with their characteristic) Nuclear Species as constituents and such NUCLEI are as follows: (1) 13C (2) 33S (3)1H and 13C (4)14N and 15N which can be looked up in the Chemical Periodic Table for their characteristic properties. The additional information at present is that the above nuclear species can be detected by NMR to reveal the nature of the molecular species in which they are located and can be estimated quantitatively also by NMR. One of the advantages of using NMR technique for these purposes is that NMR is a non-destructive technique and hence the tested sample can be recovered intact without any changes due to measurement process. Similarly wherever there are Chemical compounds to be monitored, since inevitably nuclei are present in them, NMR is a possible technique which can be applied. It is this aspect that is crucial, that wherever a chemical compound has to be studied, estimated and/or monitored, the NMR technique can be an obvious choice. What the people have to find out from the specialists is the capability of this widely applicable technique for the specific chemical contexts and the requirements with reference to the specific chemical specimen. Such an effort might provide a simple solution to what otherwise would have been a complex situation.

Section IV: The Potential of the NMR Technique Vindicated by the Possible Applications Reported Till Now[6]

IV.1 Indicative Typical Titles of Contributions at the (International) Experimental NMR Conference

(The recent 44th Conference of the above series was held in USA in April-May 2003)

1. Combined NMR and MRM Study of Cross linking in Polymers and COALS
2. Solid state Multinuclear and High Resolution 1H and 13C NMR Study of GEOCHEMICAL SAMPLES
3. Mobile NMR: QUALITY AND PROCESS Control
4. Phase Change of water in Hardening CEMENT: Detected by Deuterium NMR
5. Mechanistic studies on the DETOXIFICATION OF THE CHEMICAL warfare Agent VX: 18O Induced Shifts in the 13C and 31P
6. Observation of DRYING PROCESSES IN TEXTILES by Magnetic resonance microscopy
7. Structure Elucidation at the LIMITS OF DETECTION – Chasing a Shrinking target
8. NMR Spectroscopy of LEAD-207 in Inorganic Materials
9. CHARACTERISATION OF OIL using 129 Xe NMR
10. 13 C NMR study of small molecules chemisorbed on commercial fuel cell grade *GRAPHITE-SUPPORTED* and polycrystalline Platinum electrodes

These titles above are listed mainly to indicate that NUCLEAR MAGNETIC RESONANCE (spectroscopic) TECHNIQUE can address to the investigation of materials of interest in the sort of questions that arise in the context of mining and oil explorations.

IV.2 A Listing of the Quality of the Results and the kind of Problems Addressed to in such Contributions as Above

With 1.7 mm submicro NMR probes the limits of detection has dropped to making the acquisition of GHSQC data of 0.05 micromoles possible in 24 hrs. (Sensitivity considerations typically one encounters in trace analysing for Pollution Control studies)

NMR is useful in and facile method for studying decontamination reactions of chemical warfare (CW) agents. Many of the solvent systems are AQUEOUS, and the reactions can easily be monitored without extraction or manipulation of the highly toxic and/or lethal samples

Mobile NMR requires small instruments including small magnets. Small magnets applied to conventional-size objects provide inhomogeneous magnetic fields. The applications were made with WELL LOGGING and the principles of the method have been suggested for use in medicine, process control and product control.

Modern NMR spectroscopy is prospective non-destructive analytical tool for investigating the composition and isotope fractionation of natural samples. So far this technique found no wide application in geochemistry, especially, to dating the fossil samples of geochemical and geological origin. A number of such samples, powdered or absorbed on inorganic oxides, coals etc., were investigated by means of multinuclear solid state MAS NMR. These could be correlated with data on 14C labelling and spore-pollen diagrams.

The 129 Xe resonance frequency and relaxation times are sensitive to local environment. These properties can be used in Characterising oils using 129 Xe NMR. Investigations were made using 129 Xe NMR to characterize oils in terms of composition, aromatic content, carbon chain length, degree of saturation, and viscosity. Oil water content can be estimated using the well-known Xe oil/water partition coefficient (20:1).

The cross-link characteristics of polymer and coal samples were studied both NMR and magnetic resonance microscopy and the technique is being directed toward the study of the degree of cross-linking of in Argon Premium Coals of various ranks.

Some examples of NMR techniques for FOOD materials

(A few examples from the Contributions at the 2nd Alpine Conference on Solid State NMR: New Concepts and Applications held during Sept. 2001 at Chamonix Mont-Blanc, France where the present author participated contributing a paper)

1. Effects of Hydration on Gluten Dynamics as studied by 13C and 1H solid state NMR

2. Solid state NMR spectroscopy for the study of FLOUR Gluten

Results: Mixing of gluten with water produces a complex polymeric network which determines the elasticity and extensibility of dough, two fundamental properties for the food applications of wheat flour. The effect of water on dough rheology has been deeply investigated while understanding of the interactions between water and gluten is far to be reached. The dynamics of the whole protein resulted to be strongly affected by hydration.

Flour quality depends upon the nature and proportion of its main components (10% protein (gluten) and 85% (starch) and also on minor components (lipids or pentosans). To promote an improved quality control of the product, understanding at the molecular level is required. The effect of starch on gluten was also investigated showing that, at room temperature, gluten maintains its structure and dynamics. The effect becomes clearer under heating and cooling, reflecting gelatinisation and retrogradation.

IV.3 For the Applications in Human Health Hazards (Medicine)

Considerable important materials are available in the following two reference books to indicate the potential of NMR Spectroscopic technique in the context of Health Hazards to workers and Labourers. Few examples would be cited to illustrate this potential.

In the book on:

1. "NMR in Medicine and BIOLOGY: Structure Determination, Tomography, In Vivo spectroscopy" (Particular Page # 173–202).[7]

.2. "MR Imaging and Spectroscopy in pharmaceutical and Clinical Research" Consists of all clinical applications and the Research trends.[8]

Section V: For the Scientific Community; Little More Elaboration of the NMR Technique and Applications

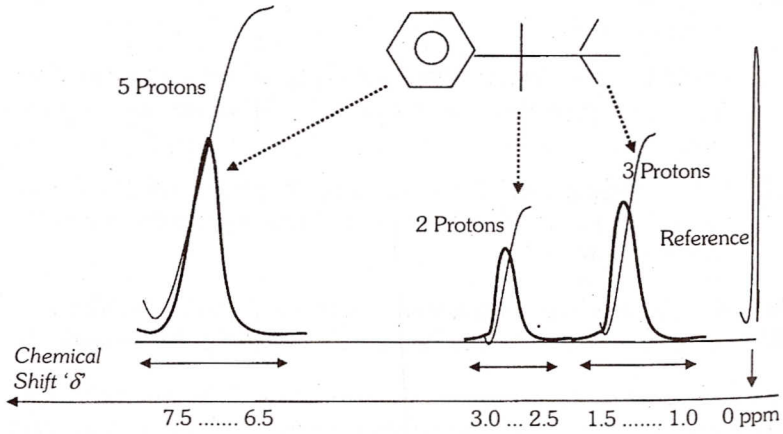
As indicated in the previous sections, the NMR Spectroscopic Technique is helpful in characterizing chemical compounds and in finding structures of molecules because of the possibility to

detect, estimate and locate the nuclear species of the atoms which make up the molecule.

The water molecule has the chemical formula H_2O. Accordingly the water molecule is made up of two Hydrogen atoms and one Oxygen atom. The nucleus of the Hydrogen atom is called Proton and it has a "Spin" property specified by the corresponding quantum "number" with value '½'. By looking up the NMR Table it is possible to know that 1H (proton) nucleus can be detected by NMR technique with available NMR Spectrometers.

Water weighs 1gm for a volume of 1ml. The molecular weight of water is 18gms. 1ml of water contains as many as the order of 10^{22} protons. A given sample of water can give rise to Proton Magnetic Resonance signal from which this number can be verified and used for calibration purposes in an experiment. This is called "Proton Counting" and in general this "spin counting" provides the means for measurement of concentrations with detectable nuclei and using appropriate prior calibrations. This is the principle of "Concentration" measurements of molecular species by NMR which is necessary for experiments to monitor the extents of pollution.

Below is a drawing which displays how an NMR spectrum of the molecule with molecular formula C_6H_5–CH_2—CH_3 can be obtained on a chart paper from a spectrometer.



Range of Chemical Shift values possible for Protons is typically **0 to 10 ppm** in **'δ' Scale**

For the nuclei present in a particular electronic surrounding in a molecule, there can be a characteristic range of values of the NMR Chemical Shift Parameter and these are well documented in the form of Tables to look up for such informations.

Similarly the biologically important molecules can be estimated by detecting the ^{31}P nucleus of the Phosphorus atoms typically in Inorganic phosphates Pi, Adenosine Di Phosphate ADP, and Adenosine Tri Phosphate ATP. In addition these phosphorus compounds show sensitively pH dependences. This becomes a convenient NMR parameter to vary pH and study the biological reactions or by monitoring the value of the NMR parameter (Chemical Shift) it would be possible to infer about the acidity level in solutions and hence know the status and extent of reactions. These are biologically important molecules in energy cycles and monitoring these chemical processes have proved useful in monitoring the health of individuals as to the 'normal' or 'abnormal' being "excess" or "deficient" and not the critically required levels.

Section VI: Can this Technique be Applied in the Regional Context?

These matters as these appear simple, can be brought to the people of a region so that in terms of these simple descriptions they would be able to look for solutions to their problems at any context and put it across to the specialists and look for further suggestions about the feasibilities. Or, alternatively, the specialists can be told about the requirement in a place where there is a requirement to monitor particular chemical species or a particular biological targets and inquire as to the utility of the NMR Spectroscopic Technique. That the NMR technique has such potentials as these is not even known at a popular level to the on-the-spot operation managers and it is this process which requires greater attention.

Since the specialists keep making rapid strides, and the mining and oil exploration activities seem to be in full swing where a present situation is favourable even in a developing region, the activities degrade the living condition since the situations are not the same as elsewhere, where these seem to have an established

advantage. When these activities are in progressive stages, late realizations cannot simply stop these activities without follow-up measures. Stopping them at any spur of the moment would be causing more damage than continuing the activity. These follow-ups required may be more expensive than continuing the activity with its ill consequences. Hence a Scheme as in Figure 2 must be exhaustively considered before initiating these activities.

Section VII: Conclusions

From the considerations above, for the utility of the NMR Spectroscopic technique for the Coal Mining and Oil Exploration in general,[9] it is obvious that in any particular Regional context, it is the people of the region who should take away their attention from only "the on-the-spot, ephemeral, requirements and enable an all-round and perennial confluence of the flowing advantages from every possible technological means for the activities to be managed scientifically and not be motivated by the mere monitory prospects even if it be for the altruistic purpose of financing the needy cross section of the public.

REFERENCES

1. In fact, in the Website "http://www.environmental-expert.com", the contents make no reference to the Nuclear Magnetic Resonance Technique even though some of the applications which are illustrated in the later sections of this article would come under the purview for inclusion. Hence a person in a particular region, for the sake of information looks up such sources there is no probability that the seeker would ever come to know about the potentials of NMR technique.
2. "NMR in Medicine and Biology": K.H. Hausser and H.R. Kalbitzer, Springer Series on "Physics In Life Sciences", Springer-Verlag (1991) pp. 1–6.
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4. "Transient Techniques in NMR of Solids": B.C. Gerstein and C.R. Dybowsky, Academic Press (1985).
5. "Introductory Concepts in Biology": G.C. Becker, The Macmillan Company, NY, p. 242, Table 19–1 (1972).
6. Abstracts from "Experimental NMR Conference" and "Alpine conference on Solid State NMR". These are International conferences held periodically. Indian Institute of Petroleum (IIP), Dehradun, conducts extensive research of petroleum products and processes using the Nuclear Magnetic Resonance technique, in their NMR Divisions. These are reported in the annual meetings of the National Magnetic Resonance Society in India.
7. Same as reference #2 above in this list.
8. "MR Imaging and Spectroscopy in Pharmaceutical and Clincal Research": Editor-N.R. Jagannathan, J.P. Brothers Medical Publishers (P) Ltd. New Delhi, India (2001).
9. (a) "The Geochemistry of Coal", Journal of chemical education, Vol. 66 (3), p. 242 (1989); (b) "NMR of Coals and Coal Products", W. Meiler and R. Meusinger, Annual reports on NMR Spectroscopy, Vol. 23, p. 375–409 (1991); (c) In the "Specialist Periodical Reports" of the Royal Society, London, occasionally NMR of heterogeneous Systems are reviewed where in "Geological Earth Studies" find special reference.