UGC
MODEL
CURRICULUM

EARTH SCIENCES

UNIVERSITY GRANTS COMMISSION
NEW DELHI
2001
FOREWORD

Renewing and updating of the Curriculum is the essential ingredient of any vibrant university academic system. There ought to be a dynamic Curriculum with necessary additions and changes introduced in it from time to time by the respective university with a prime objective to maintain updated Curriculum and also providing therein inputs to take care of fast paced development in the knowledge of the subject concerned. Revising the Curriculum should be a continuous process to provide an updated education to the students at large.

Leaving a few, there have been many universities where this exercise has not been done for years together and it is not uncommon to find universities maintaining, practicing and teaching still on the Curriculum as old as five years or even more than a decade. Not going through the reasons for this inertia, the University Grants Commission, realising the need in this context and in relevance to its mandate of coordinating and maintaining standard of higher education, decided to adopt a pro-active role to facilitate this change and to ensure that the university Curriculum are soon updated to provide a standard education all over the country.

Curriculum Development Committee for each subject was constituted with the respective Convenor as its nodal person. The Committee besides having five subject experts drawn from the university system, was given a wider representation of various sub subject experts attending meetings of the Committee as the esteemed co-opted members which kept on changing from time to time as the need arose. The Committees, therefore, had representations from a large number of experts and had many meetings before final updated Model Curricula were presented to UGC.

The University Grants Commission and I as its Chairman are grateful to the nodal persons, a large number of permanent and co-opted members in different subjects and their sub disciplines for having worked seriously with committed devotion to have produced a UGC Model Curriculum in 32 subjects within a record period of 18 months.

The exercise would not have been possible without the support of our entire academic community. We can only hope that the results will fulfil their expectations and also those of university community and Indian society.

The UGC Model Curriculum has been produced to take care of the lacuna, defects/shortcomings in the existing Curricula in certain universities, to develop a new Model Curriculum aiming to produce the one which is compatible in tune with recent development in the subject, to introduce innovative concepts, to provide a multi disciplinary profile and to allow a flexible cafeteria like approach including initiating new papers to cater to frontier development in the concerned subject.

The recommendations have been compiled by panels of experts drawn from across the country. They have attempted to combine the practical requirements of teaching in the Indian academic context with the need to observe high standards to provide knowledge in the frontier areas of their disciplines. It has also been aimed to combine the goals and parameters of global knowledge with pride in the Indian heritage and Indian contribution in this context.
Today all knowledge is interdisciplinary. This has been duly considered. Flexible and interactive models have been presented for the universities to extend them further as they would like. Each institution may have to work out certain uniform structures for courses at the same level, so that effective interaction between subjects and faculties is possible. The tendency across the country is now to move from the annual to the semester system, and from award of marks to award of credits. There is perceptible growing interest in modular framing as well.

The recommendations while taking all these features into account, have also made provisions for institutions who may not be in a position to undertake radical structural reform immediately. In any country, especially one as large and varied as India, academic institutions must be allowed enough autonomy and freedom of action to frame courses according to specific needs. The recommendations of the Curriculum Development Committees are meant to reinforce this. The purpose of our exercise has been to provide a broad common framework for exchange, mobility and free dialogue across the entire Indian academic community. These recommendations are made in a spirit of openness and continuous improvement.

To meet the need and requirement of the society and in order to enhance the quality and standards of education, updating and restructuring of the curriculum must continue as a perpetual process. Accordingly, the University Grants Commission constituted the Curriculum Development Committees. If you need to seek any clarification, you may contact Dr. (Mrs.) Renu Batra, UGC Deputy Secretary and Coordinator of CDC who shall accordingly respond to you after due consultation with the respective nodal person of the concerned subject.

The University Grants Commission feels immense pleasure in forwarding this Model Curriculum to the Hon’ble Registrars of all Universities with a request to get its copies made to be forwarded also to the concerned Deans and Heads of Departments requesting them to initiate an early action to get their Curriculum updated. The University Grants Commission Model Curricula is being presented to the Registrar of the university with options either to adopt it in toto or adopt it after making necessary amendments or to adopt it after necessary deletion/ addition or to adopt it after making any change whatsoever which the university may consider right. This UGC Model Curriculum has been provided to the universities only to serve as a base and to facilitate the whole exercise of updating the Curriculum soon.

May I request Hon’ble Vice Chancellor and the Hon’ble Registrar including the esteemed Deans, Heads of Departments, Members of the Faculty, Board of Studies and Academic Council of the Universities to kindly update their Curriculum in each of the 32 subjects in consultation with Model Curriculum provided here. This has to be done and must be done soon. May I request the Academic administration of the universities to kindly process it immediately so that an updated Curriculum is adopted by the university latest by July, 2002.

The University Grants Commission requests the Hon’ble Registrars to confirm that this time bound exercise has been done and send a copy of the university’s updated Curriculum in each subject to UGC by July 31, 2002. It is a must. It has to be done timely, failing which, the UGC may be forced to take an appropriate unpleasant action against the concerned university.

The UGC looks forward for your active participation in this joint venture to improve the standards to achieve excellence in higher education.

December 2001

HARI GAUTAM
MS (SURGERY) FRCS (EDIN) FRCS (ENG)
FAMS FACS FICS FIACS DSc (HON CAUSA)
CHAIRMAN, UGC
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PREAMBLE

Need of a New Syllabus

Under the subject of GEOLOGY we study the Earth. The term Earth Sciences is a further enlargement of the perspectives covered under Geology and is defined as the science dealing with all aspects of Earth in which we live. A thorough understanding of the Earth processes and their ramifications have great relevance to the societal development and the progress of the nation. At present, GEOLOGY as an independent subject is being taught at many Universities and Colleges. However, there is hardly any uniformity in the contents of the syllabi of these courses. In spite of the fact that syllabus revision is a continuous process in the University education system and is mandatory on the part of the concerned Departments, most Geology Departments are continuing with several years old course contents, oblivious of on-going rapid advancements in the field of Geological Sciences. With many natural calamities like earthquakes, landslides and floods affecting the nation and the society, it has become imperative that GEOLOGY, which incorporates the science of these natural hazards, should be taught rather effectively at the school and the University level. The course contents at the University level, should therefore, keep pace with the development in the modern sciences without forgetting our national heritage and ancient wisdom in a variety of Sciences.

In view of the need of a model syllabus for GEOLOGY (or Earth Sciences) which could be ideally followed by various Universities or which could provide a basic framework for formulating one’s own syllabus, the University Grants Commission constituted a Curriculum Development Committee for Earth Sciences and nominated Prof. V.K. Gairola, Department of Geology, Banaras Hindu University, as its nodal person along with Prof. A.M. Pathan, Vice Chancellor, Karnataka University and Prof. D.M. Banerjee, Department of Geology, Delhi University as Members of the Core Committee. Dr. Surender Singh, Education Officer, UGC functioned as the Member Secretary to the Committee.

Mechanism of Consultations

Suggestions for the formulation of a new Curriculum for GEOLOGY courses in the Indian Universities were invited from experts from different parts of the country. This exercise was undertaken to get feed back from a wider cross section of the academia and organizations involved in disseminating the knowledge about our Earth. Constructive responses were received from Dr. S.V. Srikantia (Bangalore), Prof. K. S. Valdiya (Bangalore) Prof. K.L. Rai, (Raipur), Prof.
A.K. Gupta (Allahabad), Dr. S. Mukherjee (New Delhi); Prof. R.K. Lal (Varanasi), Prof. M. Joshi (Varanasi), Prof. G.C. Chaudhary (Varanasi), Dr. M.P. Singh (Varanasi), Dr. Satyendra Singh (Varanasi), Dr. V. N. Bajpai (Delhi) and Prof. P.K. Bose (Jadavpur). Several other experts were also contacted and invited for discussion, but due to other compulsions they could not spare time for this task.

Participants in CDC Meetings

Four meetings of the C.D.C. for Earth Sciences were held at the UGC premises in New Delhi between December, 2000 and February, 2001. These meetings were attended by experts representing different branches of Geology where they deliberated upon all aspects of Earth Science Curricula and identified the lacunae in the existing system. These experienced experts, mostly drawn from leading teaching institutions, have remained parts and parcels of our present educational system for several decades and are thoroughly conversant with all the weaknesses and strengths of our educational and social systems. Considering the fact that uniformity of syllabi in all teaching institutions of the country may not be feasible, due to shortage of finances, manpower or political will, an attempt has been made by the present Committee to provide a model syllabus so that inter-institutional and inter-state movement of students becomes feasible without much difficulty. The meetings were held with different sets of participants in order to concentrate on specific subjects in each meeting. The meetings were held in the following order with names of the participants in each meeting.

Core Committee Members remained common to all the meetings.

1st Meeting
Prof. Ashok SAHNI, Panjab University, Chandigarh
Prof. Somnath DASGUPTA, Jadavpur University, Calcutta
Prof. Ashok M. PATWARDHAN, Poona University, Pune

2nd Meeting
Prof. Pratul Kumar SARASWATI, Indian Institute of Technology, Mumbai
Prof. Vedharaman RAJAMANI, Jawaharlal Nehru University, New Delhi
Prof. Sampat Kumar TANDON, University of Delhi, Delhi
Prof. Mihir DEB, University of Delhi, Delhi

3rd Meeting
Prof. Vinod Kumar GAUR, Indian Institute of Astrophysics, Bangalore
Prof. Kharag Singh VALDIYA, Jawaharlal Nehru Centre for Advanced Research, Bangalore
Prof. R.K.S. CHAUHAN, Indian School of Mines, Dhanbad
Prof. R.C. LAKHERA, Indian Institute of Remote Sensing, Dehradun
4th Meeting
Only Core Committee Members attended this meeting

Apart from formal meetings, ideas were exchanged over e-mail with large number of geoscientists and their suggestions have been incorporated in the final report. Informal discussion and exchange of notes with some members (Prof. K.B. Powar, New Delhi; Prof. Thigale, Pune; Prof. Chavadi, Dharwar) of last Earth Science Panel of UGC was of great help in formulating the present syllabi. The wisdom contained in the last revision of the Geology Syllabus under the stewardship of Prof. Gaur and Prof. Dave has been incorporated, wherever feasible.

Basic Framework of the Proposed Undergraduate Syllabus
Most Universities have a three-year long undergraduate level course leading to the degree of B.Sc. (Honours). Those opting for B.Sc. Hons course in Geology, study Geology along with two other subsidiary subjects in the first two years. In the third year, the students concentrate only on the Honours subject. The undergraduate curriculum has been prepared keeping this aspect in mind. As Geology is not taught at the pre-University or the 10 + 2 level (except in few cities), teaching of this subject would require special attention and treatment. In view of this fact, the CDC participants felt that in the First Year of the undergraduate course, the students should be given exposure to all the branches of Geology. Hence, emphasis has been given to those aspects of Geology which would make students aware of larger perspectives of the subject and develop interest in the study of Earth processes. In the Second and Third years, the same sub-branches and some new branches of Geology will be covered at higher academic levels, incorporating certain topics which are normally covered at the Masters’ level. This has become necessary in view of the rapid advancements in the field of Earth Science and the necessity of keeping pace with the modern developments. The concept of jumping steps in the ladder has become a necessity in order to catch up with the pace in which science is progressing today. The courses have therefore been framed, keeping in mind the rapid developments in the field of Earth Science, perception of the society to the science per se and ultimate needs of the country.

Basic Framework of the Proposed Postgraduate Syllabus
The post-graduate course in most Universities is of two years duration. Some educational institutions give instructions for three years and award M.Sc. (Applied Geology) or M.Tech degrees. The proposed Syllabus is targeted for the two-year course in the Indian Universities. We have proposed TWELVE CORE COURSES, ONE SPECIAL PAPER and ONE project oriented DISSERTATION. Emphasis has been laid on intensive and extensive field training which constitutes the backbone of geological studies. The curriculum for the First year consists of EIGHT theory papers, accompanying practicals and TWO field training sessions. The curriculum for the
Second year consists of FOUR theory papers, ONE special paper of double weightage and ONE field based / project oriented DISSERTATION work also of double weightage. Choices for special papers could be many. Only a selected few have been included in the proposed syllabus. Special paper as well as choice of dissertation topics will enable the students to make decision about their future activities, whether to go for advanced research or prepare for jobs immediately after obtaining the Master’s degree.

Special Recommendation
The expert members strongly felt that Geology or Earth Sciences as a teaching subject should be included at the 10 + 2 level. Through this report, we are urging UGC to negotiate with the Board of Secondary Education for introduction of Geology/Earth Sciences as a subject at the Secondary Education level.

Acknowledgements
The Members of the Core Committee for the Curriculum Development in Earth Sciences are grateful to all the subject experts for their cooperation and help in formulating the new Syllabus. Thanks are especially due to the expert members for sparing their valuable time and coming all the way to New Delhi for participating in deliberations of the meetings. Dr. Surender Singh, Member Secretary arranged and coordinated all meetings at the UGC premises and provided required facilities for healthy deliberations. Being trained as a geoscientist, Dr. Surender Singh actively participated in the scientific deliberations of the CDC and gave important suggestions. It was only through the technical inputs given by the participating members that the present syllabus could be formulated within the stipulated time frame. At the end, we would like to put in record, that the primary credit goes to Professor Dr. Hari P. Gautam, Chairman, University Grants Commission, for recognizing the need of updating the Curriculum in our Universities especially in the field of Earth Sciences and for giving free hand to the Core Committee Members as far as the functioning of the expert group was concerned. We appreciate his interactive role in this matter.

(V.K. GAIFOLA)
Nodal Person

(A.M. PATHAN)
Member Core Committee

(D.M. BANERJEE)
Member Core Committee

Dated: April 10, 2001
# OPTIMUM CONTACT HOURS AND MARKING SCHEME FOR B.Sc. COURSE

## FIRST YEAR

<table>
<thead>
<tr>
<th>Marks</th>
<th>Theory</th>
<th>Practical</th>
<th>Field Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper I</td>
<td>Introduction to Geology – I</td>
<td>75 hours</td>
<td>100 hours</td>
</tr>
<tr>
<td>Paper II</td>
<td>Introduction to Geology – II</td>
<td>75 hours</td>
<td>100 hours</td>
</tr>
</tbody>
</table>

Total Marks: Theory: 200 + Practical: 100 + Field Work: 50=350

## SECOND YEAR

<table>
<thead>
<tr>
<th>Marks</th>
<th>Theory</th>
<th>Practical</th>
<th>Field Work</th>
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<tbody>
<tr>
<td>Paper III</td>
<td>Earth’s Processes and Resources</td>
<td>75 hours</td>
<td>100 hours</td>
</tr>
<tr>
<td>Paper IV</td>
<td>Petrology and Earth’s History</td>
<td>75 hours</td>
<td>100 hours</td>
</tr>
</tbody>
</table>

Total Marks: Theory: 200 + Practical: 100 + Field Work: 100 = 400

## THIRD YEAR

<table>
<thead>
<tr>
<th>Marks</th>
<th>Theory</th>
<th>Practical</th>
<th>Field Work</th>
</tr>
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<tbody>
<tr>
<td>Paper V</td>
<td>Dynamics of the Earth</td>
<td>80 hours</td>
<td>160 hours</td>
</tr>
<tr>
<td>Paper VI</td>
<td>Structural Geology</td>
<td>80 hours</td>
<td>100 hours</td>
</tr>
<tr>
<td>Paper VII</td>
<td>Natural Environment (including elements of Remote Sensing, Hydrogeology and Engineering Geology)</td>
<td>80 hours</td>
<td>100 hours</td>
</tr>
<tr>
<td>Paper VIII</td>
<td>Energy Resources and Mineral Exploration</td>
<td>80 hours</td>
<td>100 hours</td>
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</tbody>
</table>

Total Marks: Theory: 400 + Practical: 200 + Field Work: 150 = 750
DETAILS OF UNDERGRADUATE SYLLABUS

FIRST YEAR COURSES

Paper I: Introduction to Geology — 1


Generation of oceanic currents, surface currents and global ocean Conveyor system; wave erosion and beach processes; ocean as a thermostat for the earth’s surface heat balance.

Atmospheric circulation, weather and climate changes. Land-air-sea interaction, Earth’s heat budget and global climatic changes.

Rock weathering. Erosion and transportation by wind, rivers, glaciers and oceanic currents. Soil formation, soil profile and soil types. Sediment transport by the wind, rivers and glaciers. Glacial periods: causes of glacial ages and glacio-eustasy.


Chemical bonding and compound formations. Minerals: definition and classification, physical properties and chemical composition. Silicate structure.

Petrological microscope: its parts and functioning. Optical mineralogy: refractive index, twinkling, birefringence, pleochroism, interference colours, extinction angle and twinning.
Practical

Study of important geomorphological models. Reading topographical maps.

Use of Clinometer and Brunton Compass. Laboratory exercises on structural geology problems: Completion of outcrops, drawing and interpretation of cross-sections through elementary representative geological structures.

Study of elements of symmetry of at least one representative crystal from normal classes of seven crystal systems.

Study of physical properties of minerals in hand specimen.

Study of the optical characters of important minerals using polarizing microscope

Paper II : Introduction to Geology — 2

Magma: definition, composition, origin, Bowen’s reaction series. Magmatic differentiation and assimilation. Texture, structure and classification of igneous rocks.

Sediments: origin, transportation, deposition, consolidation and diagenesis. Sedimentary fabrics and textures. Classification of sedimentary rocks: Terrigenous and chemical sedimentary rocks.


Definition and scope of palaeobiology, process of fossilization, preservation potential of organisms. Elementary ideas about origin of life, evolution and fossil record. Systematic classification of organisms—their characters, environmental factors and geological distribution of mollusca, brachiopoda, echinodermata and arthropoda.

Principles of stratigraphy, geological time scale, lithostratigraphic, chronostratigraphic and biostratigraphic units, stratigraphic correlation. Physical and structural subdivisions of Indian subcontinent and their characteristics. A brief account of the different geological formations of India.


Application of statistics, trigonometry, algebra and calculus to the study of Geology. Use of computer in geological studies.
Practical

Study of megascopic and microscopic characters of important rock-forming and ore-forming minerals.

Study of morphological characters of phyla included in the theory syllabus.

Preparation and study of stratigraphic maps

Geological Field Training

Students will be required to carry out field work for 7-10 days in a suitable geological area to study the elementary aspects of field geology and submit a report thereon.

SECOND YEAR COURSES

Paper III: Earth Processes and Resources

Factors controlling mineral availability. Global mineral reserves and resources. Distribution of mineral deposits in space and time.

Conventional and non-conventional energy resources: coal, petroleum, atomic minerals; and water, sun, wind, hot springs and sea waves.

Rock forming minerals - silicates, oxides and sulfides: chemical composition, physical properties and systematic classification.


Global tectonics and metallogeny through geological times. Geological setting, mineralogical characteristics and Indian distribution of important mineral deposits related to metals like iron, manganese, chromium, copper, lead, zinc, gold, aluminum, and non-metals related to refractory, fertilizer, cement, chemical and gemstone industry including building stones. Examples from Indian stratigraphic records. Methods of mineral exploration, exploitation and processing.

Environmental implications of exploitation of mineral resources

Practical

Study of physical and optical properties of additional rock and ore forming minerals (other than those covered under Paper II). Study of association of ore forming minerals. Preparation of maps
showing distribution of important ores and other economic minerals in India. Study of metallogenic maps.

**Paper IV : Petrology and Earth's History**

Petrology: Rock associations in time and space. Concept of rock series, system, phase and component. Chemical potential and phase rule. Basic principles of equilibrium thermodynamics. Phase equilibria in two and three component silicate system. Mineralogical characteristics of acid-igneous, alkaline, basic igneous and ultra-mafic rocks.

Equilibrium and non-equilibrium reactions in metamorphic processes; composition - paragenetic diagrams; projective analysis; pressure-temperature-composition (including fluid) and evolution of pelitic, basic and calcareous rocks.

Chemistry of weathering processes. Diagenesis of terrigenous and chemical sediments. Dynamics of eolian, fluvial, near-shore and deep-sea environments. Concept of sedimentary facies; basic principles of palaeoenvironment and palaeoclimate analyses.

Earth's History: Ontogeny and variation in fossil assemblages. Identification of fossils: methods of description and illustration; taxonomic categories and codes of systematic nomenclature.

Applications of palaeontologic data in palaeoecology, evolution, stratigraphy and palaeogeographic reconstructions.

Morphology, environment and geological distribution of mollusca, brachiopoda, echinodermata, arthropoda and anthozoa.

Basic ideas about micropalaeontology and microfossils. A brief study of vertebrates and plant fossils.

Stratigraphic classification and correlation. Methods of collecting stratigraphic data, identification of stratigraphic contacts and unconformities. Facies concept in stratigraphy. Classification, geographic distribution, lithological characteristics, fossil contents and economic importance of Precambrian and Phanerozoic successions of India.

**Practical**

Study of morphological characters of important fossil phyla designated in theory paper. Exercises in showing the major stratigraphic and lithotectonic units in hand drawn map of India. Study of important primary sedimentary structures in hand specimen and under microscope. Microscopic study of sedimentary textures and diageneric features in sedimentary rocks. Microscopic study of major igneous and metamorphic textures. Laboratory exercises in graphic plots for petrochemistry and interpretation of paragenetic diagrams.
Geological Field Training

10 days of actual geological mapping and visit to economic mineral deposits in some appropriate area followed by laboratory processing of rock samples, ores and fossils collected during the field work.

THIRD YEAR COURSES

Paper V : Physics and Dynamics of the Earth


Earth movement through time: orogenic and epiorogenic phases, evidence of continental drift, evidence of sea floor spreading, origin and significance of mid-oceanic ridges and trenches, evolution of Plate Tectonics theory, nature and types of plate margins, geometry and mechanism of plate motion, and evolution of oceans and continents.


Practical

Morphometric analysis from topographical maps.

Study of sections across continental margins, island arcs and plate tectonics models.

Study of geohazard maps and introduction to basic geophysical instruments used for understanding the dynamics of the Earth.

Paper VI : Structural Geology

Geological significance and recognition of unconformities.


Foliation: descriptive terminology, origin and relation to major structures. Lineation: descriptive terminology, kinds and origin, relation to major structures.

**Practical**


**Paper VII : Natural Environment (Including Elements of Remote Sensing, Hydrogeology and Engineering Aspects)**


Shifting of river courses: their impact on soil erosion, landslides and floods.

Environmental considerations in the location and construction of large dams, reservoirs and tunnels.

Application of remote sensing techniques in planning of large engineering structures and urban development. Introduction to aerial photographs, satellite imageries and preparation of photogeological maps. Application of remote sensing techniques mapping the soil cover, forest cover, degraded land and surface water reserves.


**Practical**

Preparation and interpretation of water table maps. Introduction to geological interpretations of remote sensing data. Photogeological study of aerial photographs. Introduction to modern analytical techniques of geological, geophysical and geobotanical surveys for environmental study. Case studies of environment related problems.

**Paper VIII : Energy Resources and Mineral Exploration**

*Geology of fuels:* definition, origin of coal stratigraphy of coal measures, fundamentals of coal petrology, peat, lignite, bituminous and anthracite coal. Indian Coal deposits.

Radioactive minerals: Mineralogy, geochemistry, detection and measurement of radioactivity, prospecting techniques, distribution in India. Radioactive well logging. Nuclear waste disposal.


Practical

Hand specimen study of different types of coals, selected radioactive minerals and their host rocks. Exercises in showing distribution of various mineral deposits, fuel resources and hydrocarbon resources on map of India. Laboratory exercises in solving exploration related problems.

Geological Field Training

20 days’ fieldwork including geological mapping of structurally complex area. The field report should be based on the mapping as well as laboratory work on the rock samples collected during the fieldwork.
# OPTIMUM CONTACT HOURS AND MARKING SCHEME FOR M.Sc. COURSE

## FIRST YEAR

<table>
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<th>Marks</th>
<th>Theory</th>
<th>Practical</th>
<th>Field Work</th>
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<tbody>
<tr>
<td>Paper I</td>
<td>Remote sensing in Geology, &amp; Geomorphology</td>
<td>100 in each paper</td>
<td>50 in each practical field work</td>
</tr>
<tr>
<td>Paper II</td>
<td>Structural Geology &amp; Tectonics</td>
<td>50 hours</td>
<td>67 hours</td>
</tr>
<tr>
<td>Paper III</td>
<td>Igneous and Metamorphic Petrology</td>
<td>50 hours</td>
<td>67 hours</td>
</tr>
<tr>
<td>Paper IV</td>
<td>Sedimentology</td>
<td>50 hours</td>
<td>67 hours</td>
</tr>
<tr>
<td>Paper V</td>
<td>Mineralogy, Instrumentation and Analytical Techniques</td>
<td>50 hours</td>
<td>67 hours</td>
</tr>
<tr>
<td>Paper VI</td>
<td>Ore Geology and Mining Geology</td>
<td>50 hours</td>
<td>67 hours</td>
</tr>
<tr>
<td>Paper VII</td>
<td>Palaeobiology and Stratigraphy</td>
<td>50 hours</td>
<td>67 hours</td>
</tr>
<tr>
<td>Paper VIII</td>
<td>Geochemistry</td>
<td>50 hours</td>
<td>67 hours</td>
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Total Marks: Theory: 800 + Practical: 400 + Field Work: 300 = 1500

## SECOND YEAR

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<th>Theory</th>
<th>Practical</th>
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<tbody>
<tr>
<td>Paper IX</td>
<td>Hydrogeology</td>
<td>100 in each paper</td>
<td>50 in each practical</td>
</tr>
<tr>
<td>Paper X</td>
<td>Fuel Geology</td>
<td>50 hours</td>
<td>67 hours</td>
</tr>
<tr>
<td>Paper XI</td>
<td>Geophysical Exploration and Engineering Geology</td>
<td>50 hours</td>
<td>67 hours</td>
</tr>
<tr>
<td>Paper XII</td>
<td>Environmental Geology</td>
<td>50 hours</td>
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Marks: 300 including theory and practical

- Paper XIII | Special Paper | 100 hours | 150 hours |
- Paper XIV | Project Oriented Dissertation | 300 including field work, seminar and dissertation |

- Total Marks: 400 + Practical: 200 + Special Paper: 300 + Project Oriented Dissertation: 300 = 1200
- Grand Total: First Year: 1500 + Second Year: 1200 = 2700
DETAILS OF POSTGRADUATE SYLLABUS

FIRST YEAR COURSES

Paper I: Remote Sensing in Geology, and Geomorphology


Geological Studies: image characters and their relations with ground objects based on tone, texture and pattern; principles of terrain analysis, evaluation of groundwater potential, rock type identification; and interpretation of topographic and tectonic features.


Practical


Books Recommended

Paper II : Structural Geology and Tectonics


Mechanics of folding and buckling. Fold development and distribution of strains in folds.

Fractures and joints: their nomenclature, age relationship, origin and significance. Causes and dynamics of faulting, strike-slip faults, normal faults, overthrust and nappe.

Planar and linear fabrics in deformed rocks, their origin and significance.

Concept of petrofabrics and symmetry: objective, field and laboratory techniques. Graphic treatment. Types of fabrics, fabric elements and interpretation of fabric data on microscopic and mesoscopic scale. Use of Universal Stage in petrofabrics. Significance and limitations of $\pi$- and $\beta$-diagrams.

Geometrical analysis of simple and complex structures on macroscopic scale.


Practical

Preparation and interpretation of geological maps and sections. Structural problems concerning economic mineral deposits. Recording and plotting of field data. Plotting and interpretation of petrofabric data and resultant diagrams. Study of large scale tectonic features of the Earth.

Books Recommended


**Paper III : Igneous and Metamorphic Petrology**

**Igneous Petrology**

Physics of magma generation in the mantle, their nature. Factors affecting magma and evolution of magma. Phase equilibrium of single, binary, ternary and quaternary silicate systems, its relation to magma genesis and crystallization in the light of modern experimental works.

Criteria for classification of the igneous rocks. Norms - CIPW, and Niggli values, Zavaritskii number; Rock suite, series: petrographic provinces and associations.

Petrogenesis of major igneous rock types such as ultramafic/komatiite, basaltic, granitic and alkaline rocks.

**Metamorphic Petrology**

Mineralogical Phase rule of closed and open systems..

A detailed description of each facies of low-pressures, medium- to high-pressures, and very high pressure with special reference to characteristic metamorphic zones and subfacies. Nature of metamorphic reactions and pressure-temperature conditions of metamorphism. Isoreactiongrad, Schreinmakers rule and construction of petrogenetic grids.


**Practical**

Megasopic and microscopic study of igneous lithotypes. Calculation of CIPW Norms, Preparation of variation diagrams.
Megascoptic and microscopic study of metamorphic rocks of different facies. Time relationship between deformation and recrystallisation. Graphic construction of ACF, AKF and AFM diagrams. Estimation of pressure and temperature from important models of geothermobarometry. Interpretation of reaction textures.

Books Recommended


Paper IV: Sedimentology


Evolution of sedimentary basins: tectonics and sedimentation.

Clastic petrofacades. Palaeoclimate and palaeoenvironment analyses.

Application of trace element, rare-earth element and stable isotope geochemistry to sedimentological problems.

Field and laboratory techniques in sedimentology: recording of sedimentary structures, preparation of lithologs, rock and thin section staining, cathodoluminescence, use of coulter counter.

Diagenesis and fluid flow. Diagenesis of mudstones, sandstones, and carbonate rocks: changes in mineralogy, fabric and chemistry.

Practical

Study of primary, secondary and biogenic sedimentary structures in hand-specimens, in photographic atlases, field photographs and wherever possible on the outcrops. Exercises related

Books Recommended

Sengupta, S., 1997: Introduction to Sedimentology, Oxford-IBH.

Paper V: Mineralogy, Instrumentation and Analytical Techniques

Mineralogy


Instrumentation and Analytical Techniques

Sampling and sample preparation, thin section and polished section making, dissolution procedures in geological and environmental samples. Sample etching, staining and modal count techniques. Techniques in photomicrography. Principles and geological application of cathodoluminiscence, thermoluminiscence, atomic absorption spectrophotometry, inductively coupled plasma-atomic emission spectrometry, X-ray fluorescence spectrometry, scanning and transmission electron microscopy, electron-probe microanalysis, X-ray diffractometry, thermal ionization and gas source mass spectrometry.
Practical

Microscopic study of rock forming minerals using optical accessories. Depending upon availability of facility, exercises in sample dissolution, determination of elemental composition of minerals and rocks by flame photometer and AAS, sample preparation for powder diffraction by XRD and interpretation of x-ray diffractograms of common minerals and components of the bulk rocks. Exercises on thin section and polished section making, etching and staining.

Books Recommended


Paper VI : ORE GEOLOGY AND MINING GEOLOGY

Ore Geology

Modern concept of ore genesis; spatial and temporal distribution of ore deposits — a global perspective. Comparison between Earth’s evolutionary history and evolutionary trends in ore deposits. Ore deposits and Plate Tectonics.

Mode of occurrence of ore bodies — morphology and relationship of host rocks. Textures paragenesis and zoning of ores and their significance. Concept of ore bearing fluids, their origin and migration; wall-rock alteration; structural, physico-chemical and stratigraphic control of ore localization.

Chemical composition of ores — bulk chemistry, trace elements, REE and isotopes (stable and radiogenic). Organic matter in ores and their significance.

Fluid inclusion in ores: principles, assumptions, limitations and applications.

Petrological ore associations with Indian examples wherever feasible: Orthomagmatic ores of mafic-ultramafic association - diamonds in kimberlite; REE in carbonatites; Ti-V ores; chromite and PGE; Ni ores; Cyprus type Cu-Zn. Ores of silicic igneous rocks - Kiruna type Fe-P; pegmatoids, greisens, skarns, porphyry associations; Kuroko-type Zn-Pb-Cu. Ores of sedimentary affiliation – chemical and clastic sedimentation, stratiform and stratabound ore deposits (Mn, Fe, non-ferrous ores), placers and palaeoplacers. Ores of metamorphic affiliations - metamorphism of ores, metamorphogenic ores. Ores related to weathering and weathered surfaces - laterite, bauxite, Ni/Au laterite.
Contemporary ore-forming systems e.g., black smokers, mineralized crusts, Mn nodules. Mineralogy, genesis, use and Indian distribution of ore minerals related to: Fe, Mn, Cr, Cu, Pb, Zn, Al, Mg, Au, Sn, W and U.

Mining Geology

Practical
Megascopical study of structures and fabrics of different ores and their associations. Mineralogical and textural studies of common ore minerals under ore-microscope and petrological study of other industrial and non-metallic minerals. Exercises in the determination of reflectivity and microhardness of common ore minerals. Diagrammatic representation of open cast and underground mining. Methods of mining survey. Exercises on mine sampling and determination of tenor, cut-off grades and ore reserves.

Books Recommended
Aroyaswami, R.P.N., 1996: Courses in Mining Geology. IV Ed. Oxford IBH.
Paper VII: Palaeobiology and Stratigraphy

Palaeobiology


Classification and significance of vertebrate palaeontology and micropalaeontology.

Stratigraphy


Completeness/incompleteness of stratigraphic records; preservation and net rates of accumulation in various basinal settings.

Study of palaeogeography, palaeoclimate and igneous and mountain building activities in the Indian subcontinent.

Practical


Books Recommended


Boggs, Sam Jr., 1995: Principles of Sedimentology and Stratigraphy, Prentice Hall
Earth Sciences


Paper VIII : Geochemistry

Origin and abundance of elements in the Solar system and in the Earth, and its constituents.

Atomic structures and properties of elements in the Periodic Table. Special properties of transition and rare earth elements. Geochemical classification of elements.

Radiogenic isotopes. Radioactive decay schemes of U-Pb, Sm-Nd, Rb-Sr, K-Ar, and growth of daughter isotopes. Radiometric dating of single minerals and whole rocks.

Stable isotopes: nature, abundance, and fractionation. Fluid interactions and biological processes.

Laws of thermodynamic; concept of free energy, activity, fugacity and equilibrium constant, thermodynamics of ideal, non-ideal and dilute solutions. Principles of ionic substitution in minerals; element partitioning in mineral/rock formation and concept of simple distribution coefficients and exchange reaction distribution coefficients; element partitioning in mineral assemblages and its use in the pressure-temperature estimation.


Practical

Rock/soil/sediments/water analysis in conjunction with Practical listed for Paper-V. Calculation of mineral formulae from the concentration of various oxides in minerals. Calculation of normative mineralogy from rock composition. Calculation of weathering indices in soil and sediments. Presentation of analytical data.

Books Recommended

SECOND YEAR COURSES

Paper IX: Hydrogeology

Ground water: origin, types, importance, occurrence, reservoirs and movement. Renewable and non-renewable groundwater resources; Hydrologic properties of rocks: porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissivity, storage coefficient. Hydrographs. Water table contour maps, hydrostratigraphic units, hydrogeology of arid zones and wetlands.


Artificial recharge of groundwater, Consumptive and conjunctive use of surface and groundwater, problem of overexploitation, groundwater legislation.

Water well technology: well types, drilling methods, construction, design, development and maintenance of wells. Water management in rural and urban areas, salt water intrusion in coastal aquifers, remedial measures.

Surface and subsurface geophysical and geological methods of groundwater exploration, hydrogeomorphic mapping using various remote sensing techniques. Radio isotopes in hydrogeological studies.

Practical


Books Recommended


Paper X: Fuel Geology (Coal, Petroleum and Atomic Minerals)

Coal
Definition and origin of kerogen and coal. Sedimentology of coal bearing strata. Rank, grade and type of coal. Indian and international classifications. Chemical characterization: proximate and ultimate analyses. Macroscopic ingredients and microscopic constituents, concept of ‘maceral’ and ‘microlithotypes’.


Coal forming epochs in the geological past. Geological and geographical distribution of coal deposits in India. Detailed geology for some important coalfields of India.

Methods of coal prospecting and estimation of coal reserves. Coal production and problems of coal industry in India.

Petroleum


Characteristics of Reservoir rocks and Traps (structural, stratigraphic and combination).

Oilfield fluid - water, oil and gas occurrence. Prospecting for oil and gas, drilling and logging procedures.

Oil bearing basins of India and the world. Geology of the productive oilfields of India. Position of oil and natural gas in India, future prospects and the economic scenario.

Atomic Fuel

Mode of occurrence and association of atomic minerals in nature. Atomic minerals as source of energy. Methods of prospecting and productive geological horizons in India.

Nuclear power stations of the country and future prospects. Atomic fuels and environment.
Practical


Megascopic and microscopic study of cores and well cuttings. Study of geological maps and sections of important oilfields of India and world. Calculation of oil reserves. Study of geological sections of U-Th bearing rocks of the country. Megascopic study of some uranium and thorium bearing minerals and rocks.

Books Recommended


Paper XI: Geophysical Exploration and Engineering Geology

Geophysical Exploration

Variation of gravity over the surface of the earth. Principle of gravimeters. Gravity field surveys. Various types of corrections applied to gravity data. Preparation of gravity anomaly maps and their interpretation in terms of shape size and depth.


Resistivity method: basic principles, various types of electrode configurations, Field procedure: profiling and sounding. Application of electrical methods in ground water prospecting and civil engineering problems.
Earth Sciences

Seismic methods: fundamental principles of wave propagation, refraction and reflection surveys for single interface, horizontal and dipping cases. Concept of seismic channel and multi-channel recording of seismic data. End-on and split spread shooting techniques. CDP method of data acquisition, sorting, gather, stacking and record section. Seismic velocity and interpretation of seismic data.


Engineering Geology


Geological consideration for evaluation of dams and reservoir sites. Dam foundation rock problems. Geotechnical evaluation of tunnel alignments and transportation routes, method of tunneling; classification of ground for tunneling purposes; various types of support.

Mass movements with special emphasis on landslides and causes of hill slope instability. Earthquakes and seismicity, seismic zones of India. Aseismic design of building. Influence of geological conditions on foundation and design of buildings.

Case history of engineering projects and geological causes for mishaps and failures of engineering structures.

Practical

Study of gravimeter, magnetometer and seismographs. Resistivity survey. Interpretation of underground structure on the basis of seismic data. Study of properties of common rocks with reference to their utility in engineering projects. Study of maps and models of important engineering structures as dam sites and tunnels. Interpretation of geological maps for landslide problems.

Books Recommended

Paper XII : Environmental Geology

Time scales of global changes in the ecosystems and climate. Impact of circulations in atmosphere and oceans on climate, rainfall and agriculture.

Carbon di-oxide in atmosphere, limestone deposits in the geological sequences, records of palaeotemperatures in ice cores of glaciers. Global warming caused by CO₂ increase in present atmosphere due to indiscrete exploitation of fossil fuels, volcanic eruptions and afforestation.

Cenozoic climate extremes, evolution of life, especially the impact on human evolution.

Impact assessment of degradation and contamination of surface water and ground water quality due to industrialization and urbanization. Water logging problems due to the indiscrete construction of canals, reservoirs and dams. Soil profiles and soil quality degradation due to irrigation, use of fertilizers and pesticides.


Practical

Study of seismic and flood-prone areas in India. Analyses for alkalinity, acidity, pH and conductivity (electrical) in water samples. Classification of ground water for use in drinking, irrigation and industrial purposes. Presentation of chemical analyses data and plotting chemical classification diagram. Evaluation of environmental impact of air pollution groundwater, landslides, deforestation, cultivation and building construction in specified areas.

Books Recommended

Keller, E.A., 1978: Environmental Geology, Bell and Howell, USA
Bryant, E., 1985: Natural Hazards, Cambridge University Press.

Paper XIII : Special Paper

A list of suggested courses is given here. Other topics may be added to the list depending upon the interest and specialization available in the concerned Faculty. Students will have the choice of selecting any one of these courses.
1. Advance Remote Sensing in Geosciences

Types and geometry of aerial photograph, tilt and relief distortion. Elements of photogrammetry, stereoscopy, stereovision, flight planning. Height and slope rectification of aerial photographs. Aerial photo-interpretation techniques. Recognition of photo-elements and terrain elements like tone, texture, pattern, shape, size; terrain elements like drainage pattern, density, type, landform characteristics, erosion behavior of rocks and soil material, vegetation characteristics, land use and associations.


Interpretation of lithology: rock types, discrimination of igneous, sedimentary and metamorphic terrain under different climatic conditions. Photo-interpretation of structural and landform elements. Tectonic features, features of glacial, fluvial, coastal, eolian and denudation landforms. Geomorphologic mapping and terrain evaluation.


Books Recommended


And other books suggested under Course-I
2. Rock Deformation and Structural Analysis


Use of stereographic and equal-area projections for representing different types of fabrics. Processes of structural analysis on mesoscopic and macroscopic scales.

Books Recommended


3. Exploration Geochemistry


Books Recommended


4. Sedimentary Environment and Sedimentary Basins

Modern laboratory techniques in sedimentological studies.

Detailed study of volcanoclastics, chemical precipitates. Clay deposits: mineralogy, physical
properties, chemistry and genesis. Processses of dolomitization and phosphatization. Origin of various types of cements.

Use of trace fossils, stromatolites, thrombolites and related structures in palaeoenvironmental analysis. Methods of palaeocurrent determination and basin analysis.


Sedimentation pattern and depositional environment of selected undeformed and deformed sedimentary basins of India representing Precambrian, Phanerozoic and Contemporary basins.

Books Recommended


And books recommended for course IV.

5. Experimental Petrology and Mathematical Geology

Experimental Petrology: High temperature-pressure techniques: hydrothermal apparatus and piston cylinder, Experiments on solid-solid dehydration and decarbonation reaction.


Books Recommended


6. Vertebrate Palaeontology and Palaeobotany

Vertebrate Palaeontology


Palaeobotany


Books Recommended

Seward, A.C., 1931: *Plant Life through the Ages*. Cambridge Univ. Press.
7. Marine Geology
Ocean morphology, deep ocean floor and various topographic features: ridges, sea mounts, coral reefs, continental shelf, continental slope, trenches and canyons; oceanic circulation, waves and currents; oceanic sediments and distribution of marine microfossils; stratigraphy, and geochronometry of deep-sea deposits; tectonic history of the oceans; chemistry of oceanic rocks; mineral resources of the oceans.

Books Recommended

8. Micropalaeontology
Surface and sub-surface sampling methods, processing of samples. Morphology, classification and evolution of foraminifera; detailed study of major morphologic groups, morphology and biometrics of important larger foraminifera; stratigraphy of foraminifera with special reference to India; palaeoenvironmental interpretation using microfossils. Morphology and geological distribution of ostracoda, calcareous nanofossils, radiolaria, conodonts and bryozoa. Role of micropalaeontology in hydrocarbon exploration. Deep-sea records with reference to Indian Ocean. Stable isotopic study of foraminifera and interpretation of palaeoecology.

Practical
Processing of samples, picking and mounting of fauna, study of morphological characters of selected microfossils; preparation of oriented sections of foraminifera. Exercises in biometry. Stable isotopic analysis or interpretation of existing isotopic data for palaeotemperature and palaeoenvironment reconstructions.

Books Recommended

9. Advanced Stratigraphy, Palaeogeography and Palaeoecology
Integrated comprehensive study of the state of the art in any selective/better known locality of India in a multi/interdisciplinary context. Systematics and macro-fossil based high resolution
biochronology with intra-basinal to intercontinental correlation (suprastage or higher), sea-level cyclicity, internationally correlatable coeval depositional sequences in context of sequence stratigraphy, coeval facies tracts and their characteristics from basin to margin vis-a-vis the international radio-chronologic, magneto-chronologic and sequence stratigraphic schemes.

Study and preparation of quantitative/qualitative faunal/floral similarity diagrams, correlation problems and tables, biofacies, maps, biostratigraphic range charts, palaeobiogeographic distribution maps and palaeogeographic maps of Stages or at higher level.

Palaeoecological analysis of the benthic macrofauna.

Community analysis (palaeosynecological aspects) - Community relics, fauna-substrate relationships, relation between benthic fauna and physico-chemical parameters of environments (e.g. salinity, oxygen, water energy, water depth etc.). Temporal pattern of communities - evolutionary changes in fauna with environments, transgression-immigration relationship, relation between transgression-regression and benthic faunas.

Books Recommended


10. Advanced Ore Geology


Specialized models of ore deposits related to mafic and intermediate to felsic intrusions and vein-deposits and ore deposits related to subareal and submarine volcanism. Detailed study of ore

Books Recommended

And books mentioned under Paper VI

11. Applied Coal Petrology

The concept of maceral and microlithotype. Origin of macerals, methods and tools of microscopic examination of coal, coal seam identification using microscopic methods. Concept of coal rank, microscopic techniques for the evaluation of rank of brown and banded coals. Application of rank studies in determining coalification time and temperature, Palaeo-geothermal gradient and burial depth. Applications of coal petrological methods in geology including oil and natural gas prospecting and characterization of coals for carbonization, gasification and hydrogenation processes.

Books Recommended

As recommended for Fuel Geology, Paper X.

12. Advanced Hydrogeology


Books Recommended

13. Impact of Geology on Environment
Environmental Problems - Natural and Biological Problems including physical, chemical and physiological. Environmental pollution due to mining, industries, energy resources, urbanization, climatic effects and water, with Indian examples. Role of sediments in pollution studies.
Environmental Management: Environmental controls, agricultural, landscape and cultural developments. Environmental Laws.

Books Recommended
As given for Paper XII

14. Petroleum Exploration

Books Recommended
Tissot, B.P. and Welte, D.H., 1984: Petroleum Formation and Occurrence. Springer Verlag