ANNEXURE-I

Department of Earth Sciences
Pondicherry University, Puducherry-605014

The Department of Earth Sciences will offer an **M.Tech course in Exploration Geoscience** from 2010-11 session. This course is aimed at producing geologists with specialized training in exploration of earth resources including minerals, petroleum and ground water.

Eligibility:

M.Sc Geology/Applied Geology/Marine Geology with minimum 55% mark or equivalent grade.

Course Structure:

Semester	Core Courses			Elective Courses		
	Course #	**Name of the Course**	**Credits**	**Course #**	**Name of the Course**	**Credits**
I	EASC 611	Mineral Exploration	4	EASC 614	Statistical methods in geology	3
	EASC 612	Exploration geophysics	4	EASC 615	Advanced structural analysis	3
	EASC 613	Remote sensing & GIS applications in exploration geoscience	4	EASC 616	Basin analysis and Micropaleontology	3
II	EASC 621	Petroleum Exploration	4	EASC 624	Modern analytical methods in geoscience	3
	EASC 622	Groundwater Exploration	4	EASC 625	Principles and applications of isotope geology	3
	EASC 623	Geoexploration Lab	4	EASC 626	Mapping methods, GPS and cartography	3
III	EASC 711	Professional Training	6			
	EASC 712	Mini Project	8			
	EASC 713	Seminar	4			
IV	EASC 721	Dissertation	15			
	EASC 722	Viva-voce	3			
Credits to be earned			60			12

EASC-611: Mineral Exploration 4 Credit

Ore forming processes and ore deposit types. Lithological and geochemical characteristics of ore deposits. Distribution of ore deposits in space and time.

Selection of area for prospecting. stages of geological prospecting, regional and detailed exploration; objectives and practices of these stages.

Prospecting criteria for important ore types: magmatic sulphides and chromite; pegmatitic depsoits of Sn and rare metals; magmatic, meteoric, sea water and other hydrothermal deposits of Au-Ag, base metals, W-Mo, U; skarn deposits; sedimentary and supergene deposits.

Principles of geochemical prospecting. Methods and applications of exploration geochemistry. Field and laboratory analytical methods. Treatment of geochemical data. Integration of data sets for evaluation of mineral potential.

Geological aspects of pitting, trenching and bore hole drilling. sampling and assaying. Evaluation of exploration data and ore reserve estimation. Introduction to geostatistical estimation of reserves.

Texts/References

Peters, W.C. 1987. Exploration and mining geology. 2nd edition. John Wiley & Sons, New York.
Rose, A.W., Hawkes, H.E. & Webb, J.S. 1979. Geochemistry in mineral exploration. Academic Press, London.
Levinson, A.A. 1974. Introduction to exploration geochemistry. Applied Publication Co., CalgaryMarjoribanks,
R.W. 1997. Geological Methods in Mineral Exploration and Mining, Chapman & Hall, London.
Kuzvart, M. and Bohmer, M. 1986. Prospecting and Exploration of Mineral Deposits, Elsevier, Amsterdam, 1986.
Edwards, R.P and Atkinson, K. 1986. Ore Deposit Geology and its Influence on Mineral Exploration, Chapman & Hall, New York.
Moon, C.J., Whateley, M.K.G. and Evans, A.M. 2006. Introduction to mineral exploration, 2nd edition. Blackwell Publishing Ltd. Oxford.

EASC-612: Exploration Geophysics 4 Credit

Gravity method: Gravitational force; Gravitational acceleration; Gravitational potential, Earth's gravitational field, Collections; corrections and presentation of Gravity data, Regional and residual anomalies, Gravity anomaly over buried objects of known shape: sphere, cylinder, Gravity corrections: Free-air correction, Bouguer correction, Latitude correction, Terrain correction. Interpretation of gravity anomalies with case studies.

Magnetic method: Geomagnetic field, Induced magnetism, Remanent magnetism, Susceptibility, Field survey method, Equipment, Data processing, Qualitative and quantitative interpretation of magnetic data.

Electrical Methods: Electrical properties of rocks, Flow of current through ground surface, Apparent resistivity, Electrode arrangements, VES and CST and their qualitative interpretation, Quantitative interpretation of VES curves with case studies.

Electromagnetic methods: Electromagnetic spectrum and induction, EM frequency and depth of penetration, EM response of conductors, Classification of EM methods and their description: Telluric current method, Magnetotelluric method, CSMT/CSAMT, Tilt angle method, Turam method, VLF method, Transient EM methods, Ground Penetrating Radar,

Induced Polarization Methods: Earth's polarization, IP measures, Time and frequency domain techniques, Field surveys, Equipments, Data acquisition and interpretation**.**

Seismic Methods: Basic principles, Types of seismic waves and their propagation characteristic, Seismic velocities in Earth's materials, Refraction and reflection seismic methods: Basic principal, field procedure, data acquisition and interpretation, Siesmic startigraphy, Detection of hydrocarbons.

Radiometric Methods: Basic principles, Radioactive elements in rocks, Gamma ray spectrum and spectrometer, Radon sniffer, Data collection and interpretation.

Thermal methods: Thermal conductivity of rocks and minerals, Temperature measurements, Field surveys, Interpretation.

Borehole geophysics and tomography: Different geophysical logs, Equipment; measurements and interpretation, Earth imaging and electrical resistance, Seismic and radio-tomography,

Airborne, marine and satellite geophysics: Airborne survey, Data acquisition, Equipment , Measurement, Data processing and interpretation, Marine geophysics, Satellite-gravity-magnetic and thermal imegary.

Texts/References

Dobrin, M.B. and Savit, C.H. Introduction to Geophysical Prospecting, McGraw Hill, New York, 1988

Sheriff, R.E. and Geldart, L.P. Exploration Seismology, Cambridge University Press, Cambridge, 1995.

Telford, W.M., Geldart L.P., and Sheriff, R.E. Applied Geophysics, Cambridge University Press, Cambridge, 1990.

DS Parasanis. Principle of Applied Geophysics (Chapman and Hall, London)

PB Sharma. Environmental and Engineering Geophysics (Cambridge University Press)

TS Ramakrishna. Geophysical Practice in mineral exploration and mapping (Geological Society of India, Memoir 62), 2006.

EASC-613: Remote Sensing & GIS Applications in Exploration Geoscience **4 Credit**

Remote sensing principles. Introduction to Remote Sensing: History & Concepts – dvantages of Remote Sensing over conventional surveys. Aerial Remote Sensing concepts, Aerial vs Satellite Remote Sensing.

Satellite Remote Sensing. Electromagnetic radiation, Physics of Remote Sensing, energy, source, energy interaction with atmosphere and earth objects and spectral response pattern. Spectral, spatial, temporal and radiometric resolution. Platforms, Sensors. Data acquisition mechanisms of satellites.

Image interpretation techniques. Basics of Visual interpretation techniques. Digital Image interpretation. Image rectification and restoration – Image enhancement - image classification and image interpretation – image merging

Geoinformatics. Definition & Concepts. Input Sources (Satellite, Aerial & Ground based). Computer based Geospatial data base generation. Data modeling on Natural Resources, Eco Systems and Natural Disasters. Information Systems.

Remote sensing applications in mineral, petroleum and groundwater exploration.

Practical: Study of Different Satellite Data Products. Techniques of Visual interpretation. Techniques of digital image processing. Satellite data interpretation for resources mapping. Satellite data interpretation for various hazard zone mapping. Onscreen Digitization, Editing, Labeling and Preparation of vector layers. Generation of non-spatial and spatial data base. GIS Analyses (Buffering and Overlay)

Texts/References

American Society of Photogrammetry, Manual of Remote Sensing, ASP Falls Church, Virginia, 2nd Volume, 1983.
Curran, P. Principles of Remote Sensing, Longman, London. 1985.
Lillisand, T.M. and Kiefer, P.W, Remote Sensing and Image Interpretation, John Wiley & Sons, New York. 1986.
George Joseph, Fundamentals of Remote Sensing, Cambridge University Press, 2nd Edition.
Nag P. & M. Kudrat, Digital Remote Sensing, Concept Publishing Co., New Delhi, 1998.
Drury S.A, A Guide to Remote Sensing - Interpreting Images of Earth, Oxford Science Publications, Oxford. 1990.
Sabins, F.F.Jr., Remote Sensing Principles and Interpretation, Freeman, Sanfrancisco. 1978.
Jain AK Fundamentals of Digital Image Processing, Prentice Hall, N.J1989.
William K.Pratt, Digital Image Processing, John Wiley & Sons, Inc., Third Edition, 2003.
Lo.C.P, Applied Remote Sensing, Longman, London, 1986
Chouhan, T.S., Readings in Remote Sensing Applications, Scientific publishers.

Ramasamy, SM., Remote Sensing in Geology, Rawat Publishers
Deman, MCJ, Smith G.S and H.T.Verstappen (eds.) Remote Sensing for resources development and environmental management, A.A.Ballkema Publishers, Totterdam, Netherlands.
Paine, D.P 1981: Aerial photography and image interpretation for resource management, Wiley and Sons, New York. 1986.
Gary L.Prost Remote Sensing for Geologists - A Guide to Image interpretation, Gordon and Breach Science Publishers, The Netherlands. 1997.
Ramasamy, SM. Trends in Geological Remote Sensing - Rawat Publishers,Jaipur
Rao, D.P. Remote Sensing for Earth Resources, Second Edition, Association of Exploration Geophysicist, Hyderabad p.212, (CERS-236), 1999.

EASC-614: Statistical Methods in Geology **3 Credit**

Introduction to organization and description of data: distributions and joint distributions; Introduction to Probability, discrete and continuous probability distributions, Introduction to statistical inference sampling distributions, point and interval estimation, hypothesis testing involving one and two univariate populations. Linear models for analysis of variance. Linear and multiple regression. Introduction to multivariate techniques, PCA, factor analysis, linear discriminant analysis.

Texts/References

Harry Frank and Steven C. Althoen "Statistics concepts and applications" Cambridge University Press (1994)
Pitman, J. Probability, Springer-Verlag, (also Narosa Publ.), 1993. Creighton, J.H.C. First Course in Probability Models and Statistical Inference, Springer- Verlag, Berlin, 1994. Davis, J.C. Statistics and Data Analysis in Geology, John Wiley & Sons, New York, 1986.
Walpole, R.E. and Myers, R.H. Probability and Statistics for Engineers and Scientists, Macmillan, 1989.
Johnson, R.A. and Wichern, D.W. Applied Multivariate Statistical Analysis, Prentice Hall, New Jersey, 1982.
Cooley, W.W. and Lohnes, P.R. Multivariate Data Analysis, John Wiley & Sons, New York, 1971.
Morrison, D.F. Multivariate Statistical Methods, McGraw-Hill, New York,1967. Spiegel, M.R. Probability and Statistics, Schaums Outline Series, McGraw-Hill Intl., Singapore, Asian Student Edition, 1982.

EASC-615: Advanced Structural Analysis **3 Credit**

Stress, strain and rheological behavior of earth materials. Strain analyses from naturally deformed rocks. Overview and mechanics of fold; foliation; fault and joint. Petroleum trap formation; hydrocarbon migration; reservoir structural geology. Basin formation. Structurally hosted mineral deposits. Granite emplacement, mountain building,

Text/References

Davis and Reynolds: *Structural Geology of Rocks and Regions*.
Ragan: Structural Geology: *An Introduction to Geometrical Techniques.*
McKlay: *Thrust Tectonics and hydrocarbons*
Pollard and Fletcher: *Fundamentals of Structural Geology*
Burbank and Anderson: *Tectonic Geomorphology*

EASC-616: Basin Analysis and Micropaleontology 3 Credit

Basin Analysis: Classification of sedimentary basins according to tectonic environment. Plate tectonic concepts; Major mechanisms involved in formation, subsidence, and filling of sedimentary basins. Facies analysis: Principles, siliciclastic and carbonate facies models. Basin modeling and its uses, Basin modeling techniques. Sequence stratigraphic concepts from outcrop to seismic stratigraphic scales and including well log analysis. Seismic data interpretation: 2D, 3D, utility, pitfalls. Basin mapping methods- structure and isopach contouring, lithofacies and biofacies maps, preparation of stratigraphic cross-sections and palaeogeographic synthesis; regional and global stratigraphic cycles. Heat flow analysis for understanding maturity of the basin. Resource potential of sedimentary basins, use of modeling in hydrocarbon generation and exploration.

Micropalaeontology: Introduction to micropalaeontology; sampling methods and sample processing techniques for micropalaeontological studies; brief description of major microfossil groups used in hydrocarbon exploration; environmental significance of microfossils and paleo-environmental interpretation; biostratigraphic classification, dating and correlation of stratigraphic sequences by microfossils; application of micropalaeontology in sequence stratigraphy with special reference to Indian sedimentary basins.

Text/References

Miall, A.D. Principles of Sedimentary Basin Analysis, 3rd Edition, Springer-Verlag, Berlin, 2000.
Busby, C.J. and Ingersoll, R.V. Tectonics of Sedimentary Basins, Blackwell Science, Oxford, 1995.
Reading, H. Sedimentary Environments: Processes, Facies and Stratigraphy, Blackwell Science, Oxford, 1996.
Haq, B.U. and Boersma, A. Introduction to Marine Micropaleontology, Elsevier, Amsterdam, 1998.

Bignot, G , Elements of Micropaleontology, Graham & Trotman, London, 212p, 1985
Brasier, M.D, Microfossils, George Allen & Unwin, London, 193p, 1980
Emery, D & Myers, K.J. (eds.),Sequence strategraphy, Blackwell. Sci., Oxford, 1996.

EASC-621: Petroleum Exploration 4 Credit

Origin of petroleum and natural gas; Physical and chemical properties of petroleum and related substances; conversion of organic matter, migration and accumulation of oil and gas; Traps and trapping mechanism; characteristics of source rocks, reservoir rocks.

Types of petroliferous basins and their relation to hydrocarbon potential. Geographic and stratigraphic distributions of oil and gas.

Methods and techniques for petroleum exploration, Surface indications and direct detection of hydrocarbons. Sub-surface geological methods and mapping techniques ; brief idea about geologic interpretations of seismic data. Drilling methods, drilling equipments, drilling fluids, well-logs; subsurface mapping techniques Reservoir management; non conventional gas hydrates and coal bed methane. Estimation of reserves and resources. Petroleum economics, production and development geology.

Texts/References

Tissot, B.P. and Welte, D.H. Petroleum Formation and Occurrence, 2nd Edition, Springer- Verlag, Berlin, 1984.
Levorsen, A.I, Geology of Petroleum, CBS Publishers and Distributors, New Delhi
North, F.K. Petroleum Geology, Allen & Unwin, London, 1985.
Hunt, J.M. Petroleum Geochemistry and Geology, 2nd Edition, W.H. Freeman, San Fransisco, 1996.
Sahay, B., Rai, A. and Ghosh, M. Wellsite Geological Techniques for Petroleum Exploration, Oxford & IBH, New Delhi, 1984.
Selley, R.C. Elements of Petroleum Geology, 2nd Edition, Academic Press, London, 1997.

EASC-622: Groundwater Exploration 4 Credit

Hydrological cycle-precipitation, runoff, base flow, infbviltration, evaporation, transpiration. Aquifer characteristics: Hydrological properties of rocks- porosity, permeability, storativity, specific yield and specific retention.

Introduction to theory of groundwater flow; flow nets; regional groundwater resource estimation; well hydraulics; role of groundwater in geologic processes.

Trans-boundary aquifers, groundwater quality, saline water intrusion, groundwater contamination.

Groundwater exploration: Surface and subsurface geological, geophysical and remote sensing methods, hydrogeomorphic mapping using various remote sensing techniques.

Water well construction techniques: Methods for sedimentary and hard rock terrain; Pumping test – procedures and analysis of data.

Artificial recharge of groundwater. Groundwater modeling, groundwater law, watershed. management. Rain water harvesting techniques and designing for various terrain conditions.

Texts/References

Fetter, C.W. Applied Hydrogeology, CBS Publishers & Distributors, New Delhi, 1990.
Freeze, R.A.and Cherry, J.A. Groundwater, Prentice Hall, New Jersey, 1986.
Karanth, K.R. Groundwater Assessment, Development and Management, Tata McGraw Hill, New delhi, 1987.
Appelo, C.A.J. and Postma, D. Geochemistry, Groundwater and Pollution, A A Balkema, Rotterdam, The Netherlands, 1993.
Todd D.K. Groundwater Hydrology, John Wiley & Sons, New York, 1980.Raphael G.Kazmann, Modem Hydrogeology by, Harper and Row Pub., New York, 1972.
Davis and Dewiest, Hydrogeology , John Wiley and sons, Inc., New York.
Ward, Andy D. and Stanley, W. Trimble, ***Environmental Hydrology***, Lewis Publishers, 2003.
CGWB: Manual for artificial recharge to groundwater, published report of CGWB 2009.

EASC-623: Geoexploration Lab **4 Credit**

Part 1: Geological & Geochemical Exploration

Advanced ore microscopy. Fluid inclusion analysis. Exercises on geological and geochemical prospecting. Soil geochemistry and stream sediment geochemistry in different geological terrains. Geochemical analysis and interpretation of primary and seconday haloes. Selection of targets based on ore guides and geochemical anomalies. Exercises on calculation of resources/reserves and categorization of resources/reserves.

Part 2: Geophysical Exploration

Measurement of geophysical properties of rocks and minerals. Geophysical data processing, presentation. Geophysical data interpretation and modeling.

EASC-624: Modern Analytical Methods in Geoscience 3 Credit

Concepts in analytical chemistry; Classical and rapid methods of analyses; Atomic absorption spectrometry; Inductively coupled plasma-emission & mass spectrometry; X-ray diffraction analysis; X-ray fluorescence analysis; electron probe micro analysis and other surface analytical techniques; neutron activation analysis, mass-spectrometry.

Texts/References

Potts, P.J. A Handbook of Silicate Rock Analysis, Blackie, London, 1987.
Thompson, M. and Walsh, J.N. A Handbook of Inductively Coupled Plasma Spectrometry, Blackie, London, 1983.
Van Loon, J.C. Analytical Atomic Absorption Spectroscopy, Academic Press, London, 1980.
Jeffery, P.G. and Hutchinson, D. Chemical Methods of Rock Analysis, Pergamon Press, Oxford, 1981.
Rollinson, H.R. Using Geochemical Data, Longman, New York, 1993.

EASC-625: Principles and Applications of Isotope Geology 3 Credit

Introduction to nuclear systematics, analytical techniques and mass spectrometry, equations of radioactive decay and radiogenic growth. Application of K-Ar, Rb-Sr, Sm-Nd, Re-Os, U-Th-Pb systematic in geochronology, petrogenesis and oregenesis. Introduction to stable isotope geochemistry, O and H isotopes in the hydrosphere, atmosphere and lithosphere, C and S isotopes and in the Earth's reservoirs and their applications in ore geology. Fundamentals of cosmogenic nuclides and their applications.

Text/References

Faure, G. Principles of Isotope Geology, 2nd Edn. John Wiley & Sons, New York, 1986.
Faure, G. and Mensing, T. M. Isotopes: Principles and Applications, 3rd Edn. John Wiley & Sons, New York, 2005.
Dickin, A. P. Radiogenic Isotope Geology, Cambridge University Press, Cambridge, 1995
Hoefs, J. Stable Isotope Geochemistry, 3rd Edn. Springer-Verlag, Berlin, 1987.
Rollinson, H. R. Using Geochemical Data: Evaluation, Presentation, Interpretation, Longman, Harlow, 1993.

EASC-626: Mapping Methods, GPS and Cartography 3 Credit

Basic Principles : Conventional Surveying and mapping (Chain survey, Plane Table survey, Surveying with Theodolite), Topo sheet reading- Definition and Nature of Cartography - History - Cartographic problems

GPS Mapping : Introduction- Satellite, Control and user segments- signal components- Errors in GPS observations – GPS positioning- Differential GPS - GPS Mapping methods (Conventional- Static- Kinematic- Semi Kinematic (Stop & Go) Rapid, Static, Mobile Mapping) – GPS applications.

Cartography: Map Projection Types of Map projections (Conical, Polyconic, Cylindrical, Equal area or Lamberts cylindrical, Mercators, Zenithal, Gnomonic) Map compilation - Map Design & Layout - Lettering & Toponomy - Mechanics of map construction. Computer Assisted Cartography : Input data types (point, line, polygon and Raster data) - Data source (Toposheet, Aerial Photo, Magnifier, Stereoscope, Video Camera, Digitiser board, Scanners) - Modelling Devices (Computer, Photo writter, Plotter) - Cartographic processes (Contouring, Density slicing, 3D Projection, Area Calculation, Volume Estimation) - Storage Devices - Output devices - Special Merits of Digital Cartography.

Practical: Toposheet reading. Preparation of Contours, Cross sections, 3D Block diagrams. Preparation of planimetrically controlled thematic map. GPS based static survey. GPS based mobile mapping.

Texts/References

Campbell, J 1984: Introductory Cartography, Printers Hall Englewood Cliffs, N.J

Monmonier, M.A 1982: Computer Assisted Cartography - Principles and Prospects, Prentice Hall, Englewood Cliffs, NJ

Qiheyans: Map Projection transformation, Principles and its Applications

Mishra R.P and Ramesh A, 1989: Fundamentals of Cartography, Concept publishing company, New Delhi.

Robinson A.H., Morrison J.L., Mucehreke P.C., and Kummer A.J., (1995) Elements of Cartography (6th Edition); John Weily & Sons.

Gunter Seeber: Satellite Gdodesy – Foundation, Methods and Applications, Walter de Gruyter, Berlin, New York, 1993.

P.J.G. Teunissen & A. Kleusberg (Eds) 1998: GPS for Geodesy, Springer Verlag, Germany

EASC-711: Professional Training **6 Credit**

Intensive field and laboratory training in exploration geoscience including mineral exploration and mining practices, petroleum well logging and related well site operations, groundwater exploration and aquifer modeling, geotechnical and geo-environmental investigations etc. Training will be conducted through professional organisations engaged in exploration of mineral, groundwater and pletroleum resources.

EASC-712: Mini Project **8 Credit**

Individual project work on exploration geoscience. One faculty member of the Department will be assigned as the Supervisor. The mini project will be a prelude to the M.Tech dissertation.

EASC-713: Seminar **4 Credit**

Seminar on a selected topic in exploration geoscience including preparation of a write-up and presentation document, and delivery of seminar talk.

EASC-721: Dissertation **15 Credit**

Individual project work on exploration geoscience. One faculty member of the Department will be assigned as the Supervisor.

EASC-722: Viva-voce **3 Credit**

General viva-voce examination covering all the courses offered in the M.Tech Exploration Geoscience programme.