

**POSTGRADUATE INSTITUTE OF SCIENCE
UNIVERSITY OF PERADENIYA**



**M.Sc. Programmes in Gemmology/Industrial Minerals
2011/2012**

1. INTRODUCTION

Sri Lanka has produced some of the most valued gemstones and possesses some of the best quality mineral deposits known to the mankind. Although the gem and mineral based industries are established in Sri Lanka, considerable proportion of this mineral wealth is exported at very low prices without adequate processing and value addition. Due to self-insufficiency or inadequate technology to exploit and process its own mineral resources, some of the mineral-based industries in Sri Lanka have to import certain raw materials at extremely high costs. In this regard, creation of opportunities for postgraduate training and research in the fields of gemmology and industrial minerals has been a long-felt need.

Having recognised this need, an M.Sc Programme in Gemmology was on offer since 1997/1998. Although two batches of students opted for this course, due to extremely limited number of graduates embarking on a gemmology-related field, this offer is currently not adequately made use of. On the contrary, the number of science graduates entering other mineral-based industries is rising, but presently they lack opportunities for training and research in the field of industrial minerals. Therefore, the present M.Sc. Programmes have been designed to cater to these fluctuating demands for postgraduate training and research in the fields of Gemmology and Industrial Minerals.

2. OBJECTIVES OF THE PROGRAMME

- To train personnel in the fields of gemology and industrial minerals and on related aspects at postgraduate level.
- To provide an opportunity to (i) improve the skills in mineral exploration with emphasis on gem minerals, gemmology and management of gem and jewellery industry **or** (ii) exploit and process industrial minerals to use as industrial raw materials.
- To provide necessary background knowledge for research in gemmology/industrial minerals.

3. PROGRAMME ELIGIBILITY & ADMISSION PROCEDURE

The minimum requirement for either of the M.Sc. Programmes is a B.Sc. General or Special Degree in Science or B.Sc. in Engineering/Agriculture from a recognized university or any other equivalent qualification/s acceptable to the Postgraduate Institute of Science (PGIS), University of Peradeniya. A limited number of students could be accommodated in both programmes each year. Candidates who meet the eligibility requirement will be required to sit an aptitude test and/or a subject related examination. The successful candidates will be called for an interview and the selected candidates will be admitted to their desired programme.

4. PROGRAMME FEE

(N.B. The programme fees given below may be revised.)

	<i>M.Sc. programme fee</i>
<i>Local candidates</i>	<i>Rs. 100000/-</i>
<i>SAARC countries</i>	<i>US \$ 3300/-</i>
<i>Other countries</i>	<i>US \$ 6600/-</i>

Programme fee shall be paid in two installments (*50% at registration and the next 50% within six months from registration*). Other payments including registration fee, medical fee, library subscription, examination fee and deposits (science and library) should be paid according to the procedure stipulated by the PGIS.

5. THE STRUCTURE OF THE PROGRAMMES AND DURATION

The structure of the two programmes is such that they will run concurrently commencing with courses in geology in the first semester. The courses in geology consist of basic geology, mineralogy, exploration, mining, and related topics. In the Semester II, the programmes diverge so that the students could either specialize in Gemmology or Industrial Minerals. The special courses in gemmology focus on various aspects of gemstones like colour enhancement, fashioning, valuation etc. The special courses in industrial minerals are blending various aspects of geology, chemistry, physics, mathematics, and engineering in the study of minerals, to give the student a comprehensive knowledge about the processes of formation, exploration, mining, processing and utilization of industrial minerals and rocks.

The programmes will be conducted at the Departments of Geology and Chemistry, the National Gem and Jewellery Authority and Geological Survey and Mines Bureau. These programmes consist of course work and a research project.

Course work will be conducted over a period of two semesters of 15 - weeks each (*during weekends and/or weekdays*) which will stretch into about 12 months. The course work part of the programme consists of compulsory and optional courses conducted through lectures, tutorials, assignments, laboratory and field classes. Course work also includes a compulsory field/industrial training course of two to four weeks duration and a seminar course. Satisfactory completion of a minimum of 24 credits of course work (*with a GPA not less than 3.00*) is required for either of the programmes in addition to the six credits allocated for the full-time research project (*Students who achieve a GPA in the range of 2.75 - 2.99 for course work are eligible only for the award of the Postgraduate Diploma*).

The entire programme duration will be 15 - 18 months inclusive of 3 - 6 months for the research project. Continuous attendance is compulsory during the period of research work. In order to pass the

M.Sc. degree, the research project has to be completed successfully. The research project shall be graded on a pass/fail basis and will not be considered in the computation of the GPA.

Programme Summary

Course Code	Course	Lecture hrs.	Practical hrs.	No. of Credits
Semester I				
Common Courses for M.Sc. Programme in Gemmology/Industrial Minerals				
ETS 501	Basic Geology and Geology of Sri Lanka	30	30	3
ETS 502	Mineral and Crystal Chemistry & Elementary Crystallography	15	-	1
ETS 503	Crystallography ¹	15	30	2
ETS 504	Geochemistry of the Elements & Geochemistry and Geophysics in Mineral Exploration	30	D	2
ETS 505	Introductory Structural Geology ²	15	-	1
ETS 506	Exploration and Mining Methods	15	-	1
ETS 507	Environmental Engineering	15	-	1
ETS 508	Data Analysis in Geology*	15	-	1
ETS 509	Photogeology, Remote Sensing and Geographical Information Systems*	15	30	2
	<i>Total</i>			<i>14</i>
Semester II				
Special Courses for M.Sc. Programme in Gemmology				
ETS 510	Fundamentals of Gemmology	30	-	2
ETS 511	Descriptive Gemmology I	15		1
ETS 512	Descriptive Gemmology II	15	-	1
ETS 513	Management of Gem Industries and National and International Gem Trade	15	-	1
ETS 514	Colour Enhancement and Value Addition	15		1
ETS 515	Fashioning and Evaluation of Gemstones	15		1
ETS 516	Advanced Gemmology	15	-	1
ETS 517	Gems and Gem Resources of Sri Lanka	15	F	1
ETS 518	Optical Mineralogy *	15	30	2
ETS 519	Gems in museums and personal collections *	15	-	1
ETS 520	Special Topics in Gemmology **	30	D	2
	<i>Total</i>			<i>14</i>
Special Courses for M.Sc. Programme in Industrial Minerals				
ETS 524	Industrial Minerals and Constructional Materials	15		1
ETS 525	Mineral-based Industries of Sri Lanka (1 credit)	15		1
ETS 526	Industrial Minerals Field Course		F	1
ETS 527	Instrumental Analysis	30		2
ETS 528	Valuation of Mineral Deposits and Economics of Mining	15		1
ETS 529	Minerals and Bulk Materials Handling in Industry	15		1
ETS 530	Minerals Processing & Process technology	30	F	2
ETS 531	Problems relevant to Processing and Use of Industrial Minerals	15		1
ETS 532	Computer applications in mineral processing	15	D	1
ETS 533	Metallurgy	30		2
ETS 534	Thermodynamics of Mineral Formation and Mineral Processing*	15		1
ETS 535	Surface-chemical processing*	15		1
ETS 536	Solid/Liquid separation and fine particle processing*	15		1
	<i>Total</i>			<i>16</i>
Common Courses for M.Sc. Programme in Gemmology/Industrial Minerals				
ETS 597	Seminar			1
ETS 598	Field and Industrial Training		F	1
ETS 599	Research Project	(3 - 6 months)		6
	<i>Total</i>			<i>8</i>

¹ Compulsory for Gemmology and Optional for Industrial Minerals

² Compulsory for Industrial Minerals and Optional for Gemmology

* Optional courses. Students are required to obtain 5 credits from optional courses.

** Special Topics to be offered by foreign experts will be notified to the students each year.

F - Field excursion, D - Demonstration

All courses without (*) are compulsory or optional for the other M.Sc. Programme

6. PROGRAMME CONTENTS

Common Courses in Geology

ETS 501: Basic Geology and Geology of Sri Lanka (3 credits)

Introduction to Geology. The earth. Structure of the Earth. Processes shaping the earth; the agents (rivers, oceans, glaciers and wind), their actions (weathering, soil formation, erosion, transportation, mass movements and deposition) and the landforms. Study of Earth's internal processes: earthquakes, volcanism, plutonism, deformation, orogenesis and metamorphism. Plate Tectonics. Geological Time Scale.

Earth Materials: the formation, characteristics and classification of minerals and rocks. The physical and chemical properties of minerals, and the important rock-forming and economic mineral groups. Igneous, sedimentary and metamorphic rocks and their relationship to mineral deposits. Maps; topographical and geological maps and aerial photographs. Introduction to the geology of Sri Lanka. Laboratory exercises focus on the field identification of minerals and rocks.

ETS 502: Mineral and Crystal Chemistry and Elementary Crystallography (1 credit)

Fundamentals of crystal chemistry and factors controlling the chemistry of minerals. Physical and chemical impurities in minerals. Calculations of structural formulae and end-member compositions from chemical analyses, estimates of ferric-ferrous iron ratios, distribution coefficients. Solid solution and exsolution in minerals, mineral chemistry of common gem and industrial minerals. Structure of minerals, their symmetry and elementary crystallography

ETS 503: Crystallography (2 credits)

Crystals, crystal forms, habits and Miller Indices, crystal symmetry, Crystal systems and symmetry classes, space lattices, space groups. Twin crystals

ETS 504: Geochemistry of the Elements and Geochemistry and Geophysics in Mineral Exploration (2 credits)

Chemical elements, their stable and radioactive isotopes. Their abundance and processes which govern their distribution in geological materials. Geochemistry of chemical elements in gems and industrial minerals. Geochemical exploration techniques. Lithogeochemical, paedo-geochemical and hydro-geochemical techniques: volatile and airborne surveys, surveys in contaminated terrains, isotope methods. An introduction to the use of geophysics to find gem-bearing sediments and deep-seated ore deposits emphasizing gravitational, magnetic, electromagnetic, seismic, induced potential, and other relevant methods.

ETS 505: Introductory Structural Geology (1 credit)

Geological structures in rocks: folds, faults, joints, foliations, lineations etc their identification and classification. Structural geological maps and cross-sections and their construction. Geological structures and field distribution of ore bodies. Some case studies of examples of (a) structural geologically controlled mineralizations. (b) Structural geological problems of mining.

ETS 506: Exploration and Mining Methods (1 credit)

General overview of mining methods, Legal aspects of mining. Preliminary, exploratory drilling and providing up of ore bodies types. Selection of mining techniques to suit ore-body size, shape and rock strength. Mining equipment and factors affecting choice of methods. Surface mining methods, alluvial and bedded deposits, vein deposits and massive deposits. Underground mining methods and equipment. Mining methods practiced in Sri Lanka.

ETS 507: Environmental Engineering (1 credit)

Environmental Impacts of Mining Operations: mine wastes and their potential impacts on the surrounding environment; waste rock and refuse dumps, the monitoring of mine wastes; rehabilitation and reclamation of mined out and waste dump areas.

Environmental Impacts of Mineral Processing Operations: pollution aspects of mineral and metal extraction, including the effects on biological systems, noise and dust; heavy metals and other toxic pollutants in liquid effluents and tailings from minerals operations; methods for the disposal of tailings and the rehabilitation of tailings impoundments.

ETS 508: Data Analysis in Geology (1 credit)

Planning of data collection for an experiment, geoscientific methods, sampling, the nature of data (precision, accuracy, distribution etc.), data analysis, statistical tests, geological modelling with computers and computer simulation.

ETS 509: Photogeology, Remote Sensing and Geographical Information Systems (2 credits)

Aerial photogrammetry, topographic measurements, orographic measurements, geological measurements, remote sensing with satellite images and other remotely collected terrain data, Terrain analysis. Introduction to fundamentals of spatial data management and GIS technology as applied to the mapping, display, and analysis of mining data, Computer usage and applications.

Special Courses in Gemmology**ETS 510: Fundamentals of Gemmology (2 credits)**

Gems; basic properties, hardness scale, Nature of light, laws of reflection and refraction, refractive indices, refractometers. Polarised light, uses of polariscope. Pleochroism, Dichroscope, Electrical, magnetic and thermal properties of minerals. Specific gravity and methods of determinations.

Colour and causes of colour in gemstones. Gemmological instrument, hand lens, microscope, gemmological microscope, polarising microscope, special optical properties, chatoyancy, asterism, luminescence play of colours, labradorescence. Inclusions and study of inclusions. Emission and absorption spectroscopy and spectroscopes.

ETS 511: Descriptive Gemmology I (1 credit)

Classification of gemstones, systematic description of crystallography, physical properties, optical properties, absorption spectra, chemical properties, special gemmological features, diagnostic features and occurrences of common and less common gemstones.

ETS 512: Descriptive Gemmology II (1 credit)

Synthetic gemstones, history of synthesis, methods of manufacture, methods of differentiation between natural and synthetic stones. Imitation gemstones, glass and plastic imitations; organic materials. Pearls, corals, ivory and shells and amber and others

ETS 513: Management of Gem Industries and National and International Gem Trade (1 credit)

Basic management principles, management of gem industries, practice, procedures and legal aspects of local, national and international gem trade.

ETS 514: Colour Enhancement and Value Addition (1 credit)

Treatable gems and their identifications. Outline of gem enhancement methods; development of doublets, triplets and foil backs and their detections; dyeing and irradiation; heat treatment - principles and practice, types of furnaces; diffusion and other types of enhancement: recent advances in enhancement and value addition.

ETS 515: Fashioning and Evaluation of Gemstones (1 credit)

Outline of methods used for gem cutting, styles of gem cutting and polishing, units of measurement. Principles, philosophy and economics of evaluation. Principles involved in grading of diamonds, colour grading of gemstones

ETS 516: Advanced Gemmology (1 credit)

Introduction to quantitative and qualitative analytical techniques; chemical methods, atomic absorption spectroscopy. X-ray Fluorescence, Fluorescence Emission Spectroscopy, Electron Microscopy, Mossbauer Spectroscopy, Electron Probe Micro Analysis. Current research in gemmology and new instruments and techniques.

ETS 517: Gems and Gem Resources of Sri Lanka (1 credit)

Historical background; gems of Sri Lanka, mode of occurrence, distributions and origin of gems, gem industries and socio-economic aspects of gem industries in Sri Lanka.

ETS 518: Optical Mineralogy (2 credits)

Principles of optical mineralogy and systematic study of optical properties of important minerals and their identification using polarising microscopes. Study of interference figures.

ETS 519: Gems in Museums and Personal Collections (1 credit)

Gem Bureau, Ratanapura, Nilani Gems, Ratnapura, Bhadra Marapone's Museum, Ratnapura, Gem and Jewellery Authority Collection. British Crown Jewels Collection (Tower of London). Smithsonian Institution Collection

ETS 520: Special Topics (2 credits)

New techniques in gem identification. Recent technological advances in fashioning. New Treatment Methods, Modern Synthetic Stones, e-Marketing of gems on Internet.

ETS 597: Seminar (1 credit)

Students have to give seminar/s on various aspects of gemmology based on a literature survey

ETS 598: Field and Industrial Training (1 credit)

Field experiences in gem deposit location, mining, panning and identification of gems. Familiarization of heat treatment techniques. Duration of this course is two to four weeks and at the end of the course each student have to submit a report for evaluation.

ETS 599: Research Project (6 credits)

Candidates proceeding to the M.Sc. Programme will undertake a research project on a topic agreed upon by the programme coordinator. The candidates will be given the option of selecting a research problem in a preferred area that falls within the disciplines of courses undertaken. The project will be carried out under the guidance of a supervisor/s. The project will be undertaken on a full time basis with a minimum period of four months. The project could be conducted at the Department of Geology, or Chemistry or at his/her working place, if facilities are available. However, in the latter case the work has to be supervised by an external supervisor at the work place, in addition to the supervisor attached to the University of Peradeniya. At the end of the research project the candidates are required to present their results in the form of a dissertation and a seminar. A candidate should obtain a pass on the research project for the award of M.Sc degree.

Special Courses in Industrial Minerals

ETS 524: Industrial Minerals and Constructional Materials (1 credit)

The geology, origin, occurrence, and classification of the chief categories and deposits of commercial, non-metallic minerals and rocks. The requirements of industry as regards the physical and chemical properties of industrial minerals and rocks, and their uses; Geologic and physicochemical factors affecting the stability of industrial minerals and construction materials under conditions of natural weathering and exposure to salts and other pollutants. Economics of industrial rocks and minerals; some mineral processing techniques and potential uses of mineral processing by products.

ETS 525: Mineral-based Industries of Sri Lanka (1 credit)

Industrial minerals and constructional materials of Sri Lanka. Existing industries: Cement, ceramic, lime and tiles industries. Potential industries: Production of fertilizer from apatite, production of lime, magnesium oxide, processing of mineral sands.

ETS 526: Industrial Minerals Field Course (1 credit)

Excursion/s to or a field camp/s in open-pit and underground mines of Sri Lanka in order to: (a) examine different bodies of mineralisation, their modes of occurrence and relationship to the host rocks, and geological controls of mineralisation, (b) identify the different methods of mining, and problems associated with mining operations and how to overcome the problems or suggest improvements. The objective of the Field course is to improve the quality of geological observations and the use of field data in geological interpretation and planning mining methodology and operations.

ETS 527: Instrumental Analysis (2 credits)

Introductory Analytical Chemistry. General principles of Analytical Chemistry; Errors and handling small data sets; Sensitivity and detection limits; Sample Preparation Techniques. Analytical Methods. Titrations; Electrochemical Methods; Chromatographic Methods; X-Ray Analytical Methods: X-Ray powder Diffraction (XRD) and X-Ray Fluorescence (XRF); Absorption Spectroscopy Methods: Atomic Absorption Spectroscopy; UV-Visible absorption spectroscopy of molecules; and Infra-Red absorption spectroscopy. Practicals: Experiments involving instrumental methods will include Atomic Absorption Spectrophotometry (AAS); UV and Visible Spectrophotometry; Infra-Red spectrophotometry; Electrochemical techniques including pH, ion-selective electrodes, and Electrogravimetry; Fire assaying.

ETS 528: Valuation of Mineral Deposits and Economics of Mining (1 credit)

Mineral reserve calculation methods; supply and demand factors and their projection; capitalization, discounting and amortization of mineral deposits; marketing including cartels, taxation, legislation and national interest. The feasibility study and prediction of project costs. Evaluation of capital costs for mine and processing plant. Evaluation of operating costs for mining and processing plant. Overall valuation of project worth by various criteria, such as present value, discounted cash flow, internal rate of return, break even point. Sensitivity analysis. Sources of finance.

ETS 529: Minerals and Bulk Materials Handling in Industry (1 credit)

Bulk material handling: various types of conveyors, feeders including reclamation equipment, storage equipment and design for coarse and fine materials/ores (dry or wet); slurry transport (by pumps, gravity etc.) and storage.

Production of some industrial mineral based products e.g. lime, cement and clays.

ETS 530: Mineral Processing Process Technology (2 credits)

The necessity for minerals beneficiation; mineralogical assessment; comminution - fracture, liberation, size-criteria, energy-size relationships; crushing, grinding and attrition; screening and classification, cyclones; concentration processes - density, electrical, magnetic and other physical

methods. Interfacial phenomena, surfactants, flotation; liquid-solid separation - flocculation, thickening, agglomeration, filtration; cyanidation, amalgamation, leaching; drying. This topic is complemented by practical demonstrations of equipment design and operation at a Minerals Engineering Pilot Plant.

Material Balances in process flows: Component and total mass balances of reactive and non reactive systems including recycling. Batch and steady state flows.

Fluid Mechanics: Basic fluid properties, Hydrostatics, stability of floating bodies, viscosity, shear stresses and friction in fluid flow, friction factor and pressure drop relationships in pipe and open channel flows. Velocity and shear stress distributions in laminar and turbulent flow.

ETS 531: Problems relevant to Processing and Use of Industrial Minerals (1 credit)

The course will focus on current problems (a) in mineral processing, (b) hindering better industrial utilization of minerals, and (c) on technological improvements envisaged for potential industrial minerals.

ETS 532: Computer Applications in Mineral Processing (1 credit)

Review of the basic concepts of computer hardware and software used in mineral industry, and their functions. A short course on Expert Systems in the Mineral Industry will be given covering topics such as Artificial Intelligence; Knowledge-based Systems; The Nature of Expert Systems; Expert System Tools; Examples of Expert Systems; and the Applications of Expert Systems in the Mineral Industry.

ETS 533: Metallurgy (1 credit)

Hydrometallurgical processes relating to the production of metals and compounds. Leaching processes and methods. Solution concentration and purification: Practicals to cover leaching methods and kinetic models, solvent extraction, use of ion exchangers and activated carbon for solution concentration and purification.

Metal recovery processes: Cementation, gaseous reduction, compound precipitation, electrowinning. Hydrometallurgical refining of metals. Application of these processes to Cu, Au, Ag, Ni, Al and U. Industrial extraction of metals (with flowsheets) including the extraction of Cu, Au, Ag and Ni and Al from their ores. Operations in extractive metallurgy utilising heat as the prime mover to accomplish chemical and structural changes, as in drying, calcination, roasting, sintering, smelting and converting, oxidation-reduction; Practices and equipment (furnace types) and their advantages and disadvantages.

Introductory pyrometallurgy related to extraction and refining processes used for recovery of gold, silver, copper and nickel. Fire refining: principles of fire refining of metals. Practicals may cover gold, silver and copper smelting and refining.

ETS 534: Thermodynamics of Mineral Formation and Mineral Processing (1 credit)

Thermodynamics of minerals and mineral reactions. Equilibrium and Eh-pH diagrams for minerals. Thermochemistry and thermodynamics review: enthalpy, combustion and heat balances; free energy and predominance diagrams for oxidation, reduction, sulphation (chlorination) processes at high temperatures. Thermodynamics of roasting reactions of sulphides, sulphates and oxides. Predominance diagram representation and kinetics of roasting. Physics and chemistry of melts and slags. Phase diagrams: simple, complex and their use in prediction of slag characteristics. Reactions between phases and detailed calculations of melts and slag composition e.g. for Ok Tedi concentrate. Solution chemistry: liquid-liquid and solid-liquid interactions, speciation; activity-concentration relationship;

ETS 535: Surface-Chemical Processing (1 credit)

Concentration of Minerals by Flotation. Surface chemical properties of minerals; Fundamentals of flotation; Flotation reagents, chemistry of flotation; Flotation Machines (including flotation columns); Flotation circuit design and industrial practice; Research Techniques Applied to Flotation; Industrial Practice and Flotation Process Control. Flotation of sulphide and non-sulphide metalliferous minerals; Coal flotation;

Coagulation, Flocculation and Dispersion. Principles of Coagulation, Flocculation and Dispersion; Colloids, Colloid Chemistry, and the Stability of Colloidal Dispersions; Industrial Applications of Coagulation and Flocculation.

Selective Flocculation in Mineral Extraction: The Surface Chemistry of Minerals; Properties of fine mineral particles; Colloids and their properties; Surface Phenomena in Coagulation and Flocculation; Inorganic coagulants; Polymeric Flocculants; Separation of minerals by Selective Flocculation processes.

ETS 536: Solid/Liquid Separation and Fine Particle Processing (1 credit)

Dewatering in mineral processing: principles, techniques and equipment covering screening, thickening, filtering and drying. Agglomeration - balling; briquetting and sintering. Small scale beneficiation techniques e.g. for gold and heavy mineral sands.

ETS 597: Seminar (1 credit)

Students will have to give seminar/s on various aspects of exploration, mining, processing, and utilisation of industrial minerals based on literature survey.

ETS 598: Field and Industrial Training (1 credit)

Industrial Training at a mineral processing plant in all aspects of mining and mineral processing, equipment, products, supervision and management of plant operation and process control. Waste disposal and managing the environment.

ETS 599: Research Project (6 credits)

Students are to take research projects in Mineral Processing or extractive metallurgy. The projects enable students to experience research procedure, handle data and draw together relevant information from various parts of their course work.

Students select topics, normally relevant to PNG and carry out the work under staff supervisors who guide them throughout the duration of the projects.

7. PROGRAMME EVALUATION

Programme evaluation will be as stipulated in the PGIS Handbook.

8. TEACHING PANEL

Mr. R.M.U.U.B. Amarasinghe, Dept. of Geology, Univ. of Peradeniya

B.Sc. (Perad.), M.Sc. (AIT, Bangkok)

Prof. K. Dahanayake, Postgraduate Institute of Science, University of Peradeniya

B.Sc. (Cey.), Ph.D. (Nancy)

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