Departamento de Geologia

COURSE SYNTHETIC FORM:

EARTH SYSTEMS AND SUSTAINABLE DEVELOPMENT

1 – Name, Credits and Functioning	
Course	Earth Systems and Sustainable Development
Degree(s)	Geology and Natural Resources (compulsory) Applied Geology and Environment (optional)
Level [i] / Positioning in the Curricular Plan	4 / 4th year, 7º semester
Credits *(European Credit Transfer System)*	6 (4 of Lectures + 2 of Lab work)
Teaching (during 15 weeks)	30 h + 22,5 h (2 h Lect + 1,5 h Lab per week)
Contact hours (during 15 weeks)	30 h (2 h per week of open tutorial)
Required time for learning (school semester)	82,5 h (including the time needed for assessment preparation)

2 – Rationale / Objectives (200 words maximum)

This discipline is mostly projected to students planning a professional career in Economic Geology or in different fields of Applied Geology. The main purposes of the programme are, therefore, centred on the introduction and discussion of concepts and problems related to Environment and Geology, following the Sustainable Development perspective, given particular emphasis to vectors and valences of geo-scientific contributions to the analysis of: *i)* global change and its effects on the critical balances in major examples of earth systems and between them (the latter conceived as cycles); *ii)* environmental risks and impacts in several human-disturbed earth systems; *iii)* sustainable management of geological (mineral, water, soil and energetic) resources; and *iv)* the environment as an emerging economic sector. The programme addresses also the methodologies suitable for the identification, characterisation, monitoring, mitigation and remediation of several types of environmental impacts, as well as those that enable definition of the boundary conditions to be used in the construction of predictive models, taken advantage of paradigmatic case studies.

3 – Background requirements (70 words maximum)

The proposed contents and learning methods assume that students are able to mobilise their knowledge in different issues, thus presupposing achievement in all disciplines of lower levels, as well as in, at least, two disciplines whose programmes include issues related to Mineral Resources and/or Hydrogeology. Competences usually developed in Computation Applied to Geology, and in Geological Information Systems, are also useful.

4 – Syllabus Plan and Content (250 words maximum)

Lecture Programme

I – Natural Systems (4 h): Complexity, variety and dynamic. Earth Systems; main problems and variables in their characterisation and classification; pristine systems versus disturbed systems.

II – Sustainable Development (4 h): concept evolution and consolidation of a paradigm; main economic, ethical and legal consequences, particularly in the EU framework; future perspectives and impacts on the management of geological (mineral, water, soil, coal and hydrocarbon) resources. Indicators for Sustainability; the biological, geological and cultural diversities and their reflection on the eco-management and eco-efficiency concepts; the role of Science, Technology and Innovation.

III – Global Environment and Geological Knowledge (11 h): Overview and strengthening of the notions and major features related to the *i)* water, C, N, P and S cycles; and *ii)* chemistry and circulation of atmosphere, oceans, surface and groundwaters. Main problems and methodologies of analysis that, according to the geological point of view, come form: *i)* soil covering; *ii)* acid rain; *iii)* climatic change; and *iv)* demographical increase and respective spatial distribution.

IV – Sustainable Management of Geological Resources and Environmental Market (11 h): Direct and indirect uses; (global) market; elements of profit-cost analysis; product life cycles and value chains; investment and risk factors. Eco-management of metallic and non-metallic raw materials. Energy eco-efficiency and its implications on the use of fossil fuels. The relative importance of both geothermy and hydroelectric dumps in the Renewable Energy framework and respective impacts on heat and water supply. Management of water and soil. Waste management: reduction, treatment and valuing.

Needs and effects of material consumption decrease, re-use and recycle; some technological challenges. Evaluation of the environmental risk: major problems; characterisation, monitoring, mitigation and remediation; the development of predictive models; case studies.

Lab Programme

Selected sets of problems designed to assist concepts and approaches covered in Lectures. These sets are organised in 6 independent guiding texts, containing also the most pertinent background concepts and equations, as follows:

- Modelling biogeochemical cycles I and II;
- Human population; main consequences of the expansion and demographic explosion;
- Contamination, treatment and quality of surface waters;
- Atmospheric pollution and its effects;
- Residual waters and urban solid wastes; general characteristics and some aspects related to their treatment

5 – Learning Outcomes / Competences [ii]

- Recognise the variables suitable for characterisation and classification of the major Earth Systems; in this context, know how to select the methodologies of analysis that allow distinguish the natural signatures from those induced and/or introduced via human activity.
- Be aware of the Sustainable Development concept and realise how to conciliate the different attributes that converge to it, as well as the different factors that can promote it.
- Elucidate the crucial character of the geological knowledge in the integrative reasoning of the effects caused by global change, besides those (directly or indirectly) created by human activity in varied earth systems.
- Gain an understanding and operate the concepts of eco-management and eco-efficiency and recognise their importance in the sustainable management of water, soil, mineral and energetic (fossil fuels, in particular) resources
- Demonstrate and construct adequate frames of analysis that enable to objectively compare the environmental impacts triggered by exploitation activity (inherited and active) and other environmental aggressions, and argue / justify or suggest what are the available means appropriate to monitoring and minimise them.
- Identify and assess the relative importance of reduction, re-use and recycle processes and the emerging consequences for the sustainable management of raw material and energy.
- Explain and analyse the different energetic solutions (advantages-disadvantages, global costs-benefits, natural characteristics of the region, *etc.*); précis of the role of Renewable Energies (past, present and future) and new energetic vectors (hydrogen, in particular) .
- Be aware of the main factors that rule the “environmental market” and, in this context, explain what kind of answers may be given by Geology to some of the fundamental questions.

6 – Indicative reading list (text books and supplementary sources of information)

Major

- Berner E.K., Berner R. A. (1996). *Global Environment: Water, Air, and Geochemical Cycles.* Prentice Hall, New Jersey: 376 pp.
- Ernst W. G. (ed. – 2000). *Earth Systems; Processes and Issues.* Cambridge Univ. Press, 566 pp.
- Jacobson M.C., Charlson R.J., Rodhe H., Orians G.H. (2004). *Earth System Science; from biogeochemical cycles to global change*. Elsevier Academic Press, Amsterdam, 527 pp.
- Schellnhuber H.J., Crutzen P.J., Wiiliam C.C., Claussen M., Held H (eds. – 2004). *Earth System Analysis for Sustainability*. The MIT Press – Dahlem University Press, Berlin, 454 pp.
- Mungall C., McLaren D. J. (eds. – 1991). *Planet Under Stress*. Oxford Univ. Press, Toronto: 344 pp
- Vaughan D.J., Wogelius R.A. (2000). *Environmental Mineralogy.* EMU Notes in Mineralogy, 2, Budapest, 434 pp.

Additional

- Abbot P. L. (1996). *Natural Disasters*. Wm. C. Brown Publishers, Dubuque, IA: 438 pp.
- Ball P. (2001). *Life's Matrix: a Biography of Water*. University of California Press, Berkeley: 417 pp.
- European Environment Agency (1998). *Europe's Environment: the Second Assessment*. Office for Official Publications of the European Communities, Elsevier Science Ltd, Luxembourg: 293 pp.
- Hill M. K. (1997). *Understanding Environmental Pollution*. Cambridge Univ. Press, London: 316 pp.
- Kiely G. (1998). *Environmental Engineering*. McGraw-Hill International Editions, Boston, 979 pp.
- Mason B. J. (1992). *Acid Rain*. Clarendon Press, Oxford. 126 pp.
- Mawhinney M. (2002). *Sustainable Development; understanding the green debates*. Blackwell Pub., Oxford, 190 pp.
- Montgomery C. W. (1995). *Environmental Geology.* 4th Edition. Wm. C. Brown Publishers, Dubuque, IA: 496 pp.
- Strahler A., Strahler A. H. (1973). *Environmental Geoscience: Interaction Between Natural Systems and Man*. John Wiley & Sons, New York. 511 pp.
- Villas Bôas R. C., Lelio F. Filho (eds. - 2000). *Technological Challenges Posed by Sustainable Development: The Mineral Extraction Industries*. CYTED/IMAAC/UNIDO: 410 pp.

Additionally, pertinent sets of web-information sources are given to students.

7 – Other Elements of Study and Classroom Guiding

Lectures

- Detailed summaries of lectures and study guides

Labs

- Guiding text for each set of problems

8 – Assessment

	Relative Weight in the Final Grade (%)
Alternative 1 (*)	
• <u>Formative Assessment</u> o 6 Lab works (including discussion of numerical results, thus calling for the understanding and use of concepts covered in lectures)	60
• <u>Summative Assessment</u> o 2 interim tests including multiple choice and constructed (short and long written) responses of questions regarding the lecture programme.	40
Alternative 2	
• Final Examination (**)	100

(*) Continuous assessment and tutorial work that measure the individual student progress during the school semester. In each component, students must demonstrate an acceptable level of achievement of the course outcomes, *i.e.* a threshold criterion of 50% of the respective mark.

(**) It consists of a mixture of selected (multiple choice) and constructed (short and long written) response items plus 3 questions concerning Lab problems (numerical performance and results discussion).

[i] Both Degrees (in *Geology and Natural Resources* and in *Applied Geology and Environment*) have a curricular programme of 8 semesters (4 years long). Disciplines included in these programmes are ordered according to a gradual and coherent sequence of levels (1 to 4) that follow a framework of learning outcomes, recognising a student progression characterised by an increase of its autonomy and of the responsibility that is expected of the learner in the guidance given and the tasks set. Disciplines of level 1 assume no previous knowledge of Geology, thus having an introductory (and transversal) character. Disciplines of level 2 provide an essential grounding in many fundamental concepts and techniques common to all branches of Geology. Disciplines of level 3 offer a core programme of advanced and integrative topics oriented to: (1) the manipulation of relatively complex database and production of simple numerical modelling included in quantitative approaches to common problems in Geology; and (2) the use of key-concepts in solving either transversal problems (eventually as a project work) or specific issues preferentially dealing with questions directly related to the course (Degree) objectives. Disciplines of level 4 are designed in order to favour the consolidation of the professional profile defined for the course (Degree) and should also include advanced themes of synthesis demanding the rational use of the knowledge obtained along the entire learning path.

[ii] Learning outcomes are here used in the sense given by the glossary of the *Tuning Educational Structures*, i.e.: (…) *statements of what learner is expected to know, understand and/or be able to demonstrate* (and do) *after a completion of a process of learning* (…). Therefore, competences represent a combination of attributes (broadly referring to aptitude, proficiency, capability, skills and understanding, *etc.*) that reflect the qualification (degree or extent) to which a person is able of performing them.