

## FORUM

### EARTH SCIENCES IN CATALONIA: 1990-1995\*

#### Research centres

Research in the Earth Sciences in Catalonia is mostly conducted in three types of institutions: universities, centres devoted exclusively to research, and museums.

The universities with Departments of Geology are the «Universitat de Barcelona» (UB), the «Universitat Autònoma de Barcelona» (UAB). The «Universitat Politècnica de Catalunya» (UPC) and the «Universitat de Girona» (UG), while they do not have specific Departments of Geology, teach and undertake research in the Earth Sciences.

The research centres are members of the Spanish general research institution «Consejo Superior de Investigaciones Científicas» (CSIC), and the Geological Survey (Servei Geològic de Catalunya: SGC) supported by the autonomous government of Catalonia.

A major goal of geology is to conserve and exhibit geological objects (fossils, minerals, rocks, etc.). Hence in Catalonia, the museums play a leading role in scientific research. The main museums are the «Institut de Paleontologia Miquel Crusafont» in Sabadell, and the «Museu del Seminari» and «Museu Martorell», both in Barcelona. There are many more museums in Catalonia in which amateur geologists exhibit their collections and conduct research.

The exact number of researchers in the Earth Sciences is not easy to calculate. However, there are more than 150 professionals. In the UB, UAB, and the «Institut Jaume Almera» CSIC alone more than 100 researchers were being employed in 1992. The majority of these researchers were devoted exclusively to research in geology and geophysics. A smaller number also work in materials science.

#### Research interests

Below we summarize the main interests of Catalan researchers in the Earth Sciences. Their aims and progress are also commented on.

#### Regional Geology

The main purpose of this research field is geological mapping. The Geological Survey – in this case the «Servei

Geològic de Catalunya»– undertakes the mapping of Catalonia. The tradition for geological mapping dates from the beginning of this century and is founded on the work of both amateur and professional geologists. Today many Catalan geologists are employed around the world in the mapping of regional geology.

#### Igneous petrology

The Pyrenees and Catalan Coastal Chains are the principal areas in which geochemical and mapping research is conducted. The geochronological dating of successive thermic events has been one the main goals in recent years. Regrettably there is no laboratory capable of dating by radioactive decay (Rb/Sr, Sm/Nd, K/Ar, etc.) in Catalonia and samples have to be sent abroad.

#### Metamorphic petrology

Two main lines of research are currently being conducted: on the one hand, the study of metamorphic systems by the empirical measurement of geothermometers and the modelling of the metamorphic reactions produced within these systems; and, on the other hand, the study of relationships between metamorphism and deformation at a range of scales. This is a very new field of research in Catalonia. Previously, studies were concerned only with igneous rocks.

#### Sedimentology

Research in this field has undergone a recent expansion because of interest shown by oil companies. The exceptional conditions of the outcrops, mainly in the South Pyrenees, has led to the organisation of training courses by Catalan researchers for oil professionals from the world's leading companies. Catalan sedimentologists also lead sedimentological research teams around the world, chiefly in Latin America.

#### Stratigraphy and Geological History

The intensity of research in regional geology has meant renewed research on all regional stratigraphic scales. The aim is to produce a revised lithostratigraphic catalogue of formations throughout Catalonia with a rapidly changing geological history, mainly from the Cretaceous to Recent. The complexity of the geological formations results in a large number of small stratigraphic units. Moreover, a detailed biostratigraphy is contributing to the creation of continental stratigraphic scales and to the revision of the former stratigraphic divisions according to time. The most important results from this field are found in the Tertiary bio- and chronostratigraphic units.

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### **Tectonics**

Tectonics are closely linked to the main areas of the Earth Sciences: to sedimentology and stratigraphy when studying the surficial structures; to igneous and metamorphic petrology when studying the deformation of deep crust. However, recently geophysics and tectonics have become very closely linked. Thus in Catalonia, geology and geophysics have been progressively integrated since the 80s in all research centres. The results are encouraging as many scientific publications demonstrate. There are two main lines of scientific research in tectonics: the brittle deformation interacting with sedimentary processes, and rock deformation in deep zones of the crust in metamorphic conditions. All these aspects are analysed mainly through field research. Recent research has focused on conceptual and modelling perspectives of tectonic activity.

### **Neotectonics and active tectonics**

This research field sheds light on the behaviour of faults and other phenomena producing earthquakes. It is important to establish the seismic risk in Catalonia, given its dense population, and the great concentration of industry and roads. In fact, Catalonia has a low to moderate seismic activity, but a general understanding of neotectonics is useful in identifying the impact of modern tectonics in this area.

### **Geophysics**

Together with other geoscientists, geophysicists have collaborated in identifying specific problems related to crust structure. By using geophysical methods and techniques – refraction and reflexion seismics, gravimetry, aeromagnetism, magnetotellurics, thermic conductivity, numeric modelling, etc – the crust structure of large geological units (mountain chains, basins, platforms, etc ) has been established. The discovery of the continental lower crust subduction in the Pyrenees has helped improve our understanding of plate tectonics. Elsewhere the systematic use of paleomagnetism has broadened our understanding of regional stratigraphy.

### **Geomorphology**

Improved geomorphologic maps have been drawn and now attention is focused on evaluating the dangers of recent natural processes exacerbated by human activity: erosion, floods, snow and ice dynamics. The Pyrenees and Antarctica are the two main areas where research is being conducted using both field and teledetection techniques. Many of the research programs can be included in so-called environmental geology. Together with the Geological Survey and ski resorts a continuous survey of snowslides has been introduced over the last few years to avoid human risk. Similarly, studies on contamination from mines and quarries are being undertaken. Finally, research is being conducted into desertification and landscape degradation.

### **Hydrogeology**

The need for drinking water and water for irrigation is becoming a dramatic problem for mankind. Hydrogeology

contributes to the finding of solutions to this problem. Hydrogeologists adopt a multidisciplinary approach, based on sedimentology, meteorology and human impact studies. In recent years, as elsewhere in the world, researchers in this field have focused attention not only on seeking new water resources, but also on examining and, if possible, preventing the contamination of ground water reservoirs.

### **Marine Geology**

This is a new and dynamic field of research in Catalonia. There are two teams of researchers, often working in collaboration, that have made important contributions in various ocean areas as can be seen in table 6, presented below.

### **Paleontology**

The contribution of Catalan researchers to different groups of fossils are made through the specialized journals. Many of international paleontological journals are not included in recently established parameters of SCI and analogues, but communication between paleontologists around the world is more efficient than in other scientific fields precisely because of their high degree of specialization. Each specialist in a particular fossil group has direct and personal communication with the majority of their colleagues. The main contributions in paleontology in recent years have been in systematics, paleoecology and biostratigraphy. Important discoveries concerning hominids found in Catalonia, and elsewhere but studied in Catalan laboratories, have been reported in the international scientific press. The museums, as in many countries, are currently suffering reductions in personnel and budgets.

### **Mineralogy**

The main fields of mineral research are: characterization of minerals and discovery of new mineral species; mineralogenesis and mineral ores; clay minerals and ceramics; geochemistry and evolution of potash basins. Many small research groups work in this field in close cooperation with their colleagues abroad.

### **Outline of a quantitative analysis**

The fact that geological research is mainly regional, means that scientific papers are frequently published in regional languages and in national journals that do not fulfil the conditions required by recent measurement systems on scientific quality, such as SCI and analogues, and as a result these journals are not taken into consideration. Consequently, the figures for the publication of research results in the Earth Sciences are hardly comparable to those from the classical sciences of physics, chemistry or medicine.

Here we present data on the geological research conducted in Catalonia in an attempt to evaluate: (1) the budget assigned to this research field; (2) the results, as illustrated by the number of publications, and (3) the geographical areas in which Catalan researchers are working.

Table 1. Public funding for geological research (in thousands of dollars)

	1990	1991	1992	1993	1994	1995
CSIC – Institut Jaume Almera	1.131	841	2.152	2.193	1.959	1.407
CSIC – Observatori de l'Ebre	-	12	12	12	-	25
CSIC – UEI de Geologia Marina	-	-	24	34	24	10
Universitat de Girona	-	-	14	14	28	14
Universitat de Barcelona	610	676	1.837	2.531	1.313	1.148
Universitat Autònoma de Barcelona	139	153	191	231	161	143
Universitat Politècnica de Catalunya	-	92	137	241	357	437
Inst. de Paleontologia Miquel Crusafont	-	16	34	50	37	19
Servei Geològic de Catalunya	-	-	90	2	34	83

Table 2. Amounts devoted to special projects and research infrastructure, supplied by DGICYT and CICYT (in thousands of dollars)

	1990	1991	1992	1993	1994	1995
CSIC – Institut Jaume Almera	0	0	221	517	0	248
CSIC – Observatori de l'Ebre	0	145	0	0	41	0
Universitat de Girona	0	0	0	0	64	0
Universitat de Barcelona	101	132	313	133	657	339
Universitat Autònoma de Barcelona	0	0	0	152	0	0
Universitat Politècnica de Catalunya	0	69	0	103	0	2
Servei Geològic de Catalunya	172	0	0	0	0	0

Table 3. Amounts received in 1993, through contracts, for scientific research and the number of researchers

	Amounts (in thousand \$)	Number of researchers
Faculty of Geology	1.462	59
All Science Faculties	4.917	534
All UB Faculties	9.062	2.196

### Research funding in the Earth Sciences in Catalonia

Table 1 shows the amount of funding (in thousands of dollars) received for research work in the Earth Sciences at various centres in Catalonia from 1990 to 1995 from a range of government bodies. In some years this information was not

available (indicated with -). Table 2 shows the amount (in thousands of dollars) devoted to special projects and research infrastructure from 1990-1995.

Additionally, funding is received from external institutions. These amounts, in some cases, represent an important contribution to the research programs of some university departments. To illustrate this, table 3 shows the data supplied by the «Fundació Bosch i Gimpera» in relation to the University of Barcelona corresponding to contracts signed in 1993 by the Faculty of Geology. In the table is also indicated, by way of comparison, the amounts received by all Science Faculties (Mathematics, Physics, Chemistry, Biology and Geology), and all Faculties of the University of Barcelona. The number of researchers is also shown.

Table 4. Number of papers in the Earth Sciences published in magazines included in SCI by researchers from the respective centres

	1990	1991	1992	1993	1994	1995
CSIC – Institut Jaume Almera	16	14	34	14	25	22
Universitat de Girona	-	-	-	-	1	1
Universitat de Barcelona	23	14	21	20	19	29
Universitat Autònoma de Barcelona	3	1	10	3	3	10
Universitat Politècnica de Catalunya	11	4	8	10	3	5
Inst. de Paleontologia Miquel Crusafont	1	0	0	2	6	6
Servei Geològic de Catalunya	8	2	4	3	1	1

Table 5. Total number of Earth Science publications by researchers at the Universitat Autònoma de Barcelona (UAB) and the Institut Jaume Almera (IJA) in comparison with the number published in magazines included in SCI

	<i>Total UAB</i>	<i>SCI UAB</i>	<i>Total IJA</i>	<i>SCI IJA</i>
1990	43	3	70	16
1991	39	1	52	14
1992	38	10	67	34
1993	30	3	39	14
1994	28	3	78	25
1995	47	10	92	22

in SCI, table 5 shows the total number of publications at two research centres compared with those published in magazines included in SCI.

#### Earth Sciences research by Catalans around the world

Research in the Earth Sciences is mainly conducted on field expeditions. Therefore an important element for determining the extent of topics handled by Catalan researchers is to know the areas that have been the subject of their studies. A study is available (Salvador Reguant: «La geologia de Catalunya avui dia: entre la fixitat de la imatge i la dinàmica de la realitat». In Joan Vilà Valentí «10 reflexions sobre la ciència», Barcelona 1996) which includes information on

Table 6. Countries in which catalan researchers of UB, UAB, and IJA have worked from 1990 to 1994

EUROPE: Spain, Andorra, France. Italy, Belgium, The Netherlands, Germany, United Kingdom
Greece, Slovakia, Poland, Bulgaria, Macedonia, Romania, Ukraine, Russia.
AFRICA: Morocco, Algeria, Kenya, Reunion.
ASIA: Russia, Turkey, Iran, Pakistan, India, Tibet, China
NORTH AMERICA: Canada, United States, Mexico
CENTRAL AMERICA: Cuba, Hispaniola, Nicaragua
SOUTH AMERICA: Colombia, Bolivia, Ecuador, Argentina, Chile, Easter Island
OCEANIA: Tahiti, Moorea, Huahine
ANTARCTICA: South Shetlands (Livingstone, Snow, Robert and Nelson)
OCEANS AND SEAS: Mediterranean, Black, Atlantic, Indian, Pacific, Arctic, Antarctic

#### Publications on Earth Sciences (1990-1995)

Table 4 shows the number of papers in the Earth Sciences published in magazines included in the Science Citation Index by researchers from the different centres, according to information available.

In some cases, it seems that the information is not entirely correct. However, as indicated above, in the Earth Sciences the number of publications in magazines included in SCI is not the most accurate estimate of the value of the research being undertaken. Nearly all research in geology is conducted regionally and published in regional or national magazines. To estimate the partial value of the test based exclusively on the number of publications in magazines included

this topic with reference to researchers of the «Universitat de Barcelona» (UB), the «Universitat Autònoma de Barcelona» (UAB) and the «Institut Jaume Almera» (IJA) from 1990 to 1994. The results can be summarized as shown in Table 6.

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