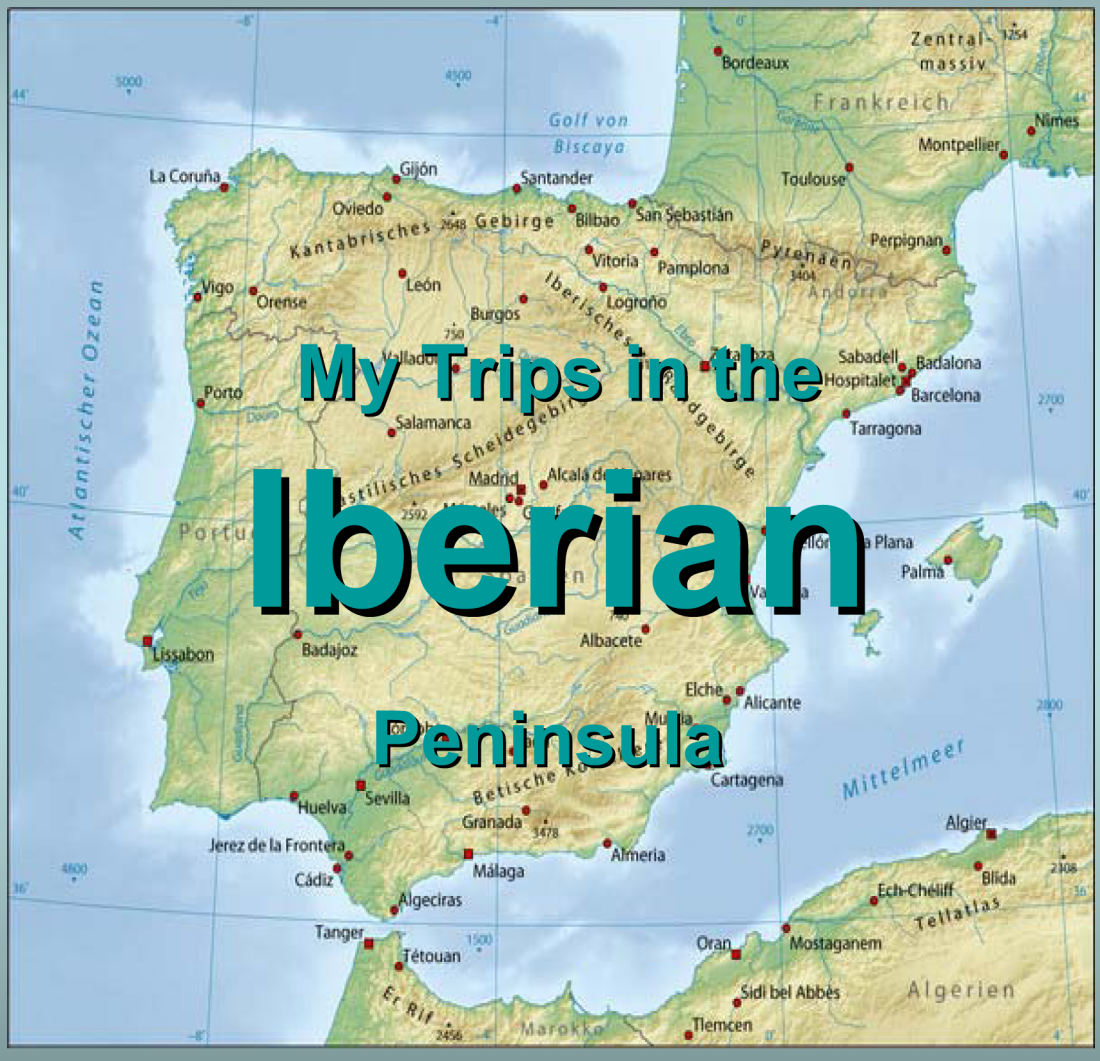
Fathi Habashi



My Trips in the

Iberian

Peninsula

2015

My Trips in the Iberian Peninsula

Volume derived from

Fathi Habashi

Department of Mining, Metallurgy, and Materials Engineering
Laval University, Quebec City, Canada

2015

The Book

The present volume is derived from *De Re Metallica. A Metallurgist on the Move*, which is a diary of the trips the author has undertaken during his professional career. He visited many industries, universities, research centres, and museums and participated in many conferences. The book therefore reflects the state of extractive metallurgy since he left his home country Egypt and went to study in Vienna. *De Re Metallica* is in seven volumes fully illustrated mainly by coloured photographs. It includes a short history of the place visited and its main sightseeing sites. Volume 1 Egypt, Volume 2 Canada, Volume 3 United States, Volume 4 Latin America, Volume 5 Asia [in two parts], Volume 6 Europe [in two parts], and Volume 7 Russia & other countries. Total number of pages was 5500.

Since these volumes could not be separated and therefore they will not be available to many readers, I decided to split the book into selected 29 small units, each representing one country or a group of countries closely related geographically. The present volume is one of these volumes.

The Author

Fathi Habashi, Professor Emeritus at Laval University in Quebec City. He holds a B.Sc. degree in Chemical Engineering from the University of Cairo, Dr. techn. degree in Inorganic Chemical Technology from the University of Technology in Vienna, Dr. Sc. *honoris causa* from the Saint Petersburg Mining Institute, Dr. *h.c.* from National Technical University in Lima, and Dr. *h.c.* from San Marcos University also in Lima. He held the Canadian Government scholarship at the Mines Branch in Ottawa, taught at Montana College of Mineral Science & Technology, then worked at the Extractive Metallurgical Research Division of Anaconda Company in Tucson, Arizona, before joining Laval in 1970. His research was mainly directed towards organizing the unit operations in extractive metallurgy and putting them into a historical perspective.

Published by:

Métallurgie Extractive Québec
800 Alain, #504, Québec City, Québec, Canada G1X 4E7
Tel.: (418) 651-5774. E-mail: Fathi.Habashi@arul.ulaval.ca
http://pages.infinit.net/habashi
http://works.bepress.com/fathi_habashi/

Distributed by:

Laval University Bookstore Zone
Pavillon Maurice-Pollack, Cité Universitaire, Québec City, Canada G1V 0B4
Tel.: (418) 656-2600, Fax: (418) 656-2665
E-mail: conseiller@zone.ul.ca

Dépôt légal 2015

- Bibliothèque nationale du Québec, Montréal
- National Library of Canada, Ottawa

ISBN 978-2-922686-36-4

Fathi Habashi, *My Trips in the Iberian Peninsula.*

Page set up in Québec City by **Jean-François Morin**.

Printed in Québec City by **Les Copies de la Capitale, Inc.**

Métallurgie Extractive Québec is a non-profit publisher registered in Québec City #2240676462 devoted to diffusion of extractive metallurgy literature.

To Nadia,
Hani, and Hatem
with love

Other Books by the Author

Published by Métallurgie Extractive Québec, Québec City and distributed by Laval University Bookstore except otherwise stated.

Technical

F. Habashi, *Principles of Extractive Metallurgy*:
- Volume 1: General Principles (422 pages), 1969 (reprinted 1980) (out of print), Gordon & Breach Science Publishers.
- Volume 2: Hydrometallurgy (468 pages), 1970 (reprinted 1980) (out of print), Gordon & Breach Science Publishers.
- Volume 3: Pyrometallurgy (493 pages), 1986 (reprinted 1992) (out of print), Gordon & Breach Science Publishers.
- Volume 4: Amalgam and Electrometallurgy (380 pages), 1998.

F. Habashi (editor), *Handbook of Extractive Metallurgy*, 4 volumes, 2 500 pages, WILEY–VCH, Weinheim, Germany, Also: John Wiley, 605 Third Avenue, New York, NY 10158-0012.
F. Habashi (editor), *Alloys. Preparation, Properties, Applications*, 312 pages, WILEY–VCH, Weinheim, Germany (out of print). Now available from Métallurgie Extractive Québec.
F. Habashi, *Metallurgical Chemistry*, American Chemical Society, Washington, DC, Manual (279 pages), Audio Course (MP3 CD, 5 hours playing time). Now available from Métallurgie Extractive Québec.
F. Habashi, *Metals from Ores. An Introduction to Extractive Metallurgy*, 2003, 475 pages.
F. Habashi, *Pollution Problems in the Mineral and Metallurgical Industries*, 1996. 150 pages.
F. Habashi, *Textbook of Hydrometallurgy*, 2nd edition, 1999, 750 pages.
F. Habashi, *Textbook of Pyrometallurgy*, 2002, 600 pages.
F. Habashi, *Kinetics of Metallurgical Processes*, 1999, 376 pages.
F. Habashi (editor), *Progress in Extractive Metallurgy*, Vol. 1, Gordon & Breach 1973, 239 pages (out of print). Now available from Métallurgie Extractive Québec.
F. Habashi, *Chalcopyrite. Its Chemistry and Metallurgy*. McGraw-Hill International Book Company 1978, 177, pages (out of print). Now available from Métallurgie Extractive Québec.
F. Habashi, I. N. Beloglazov, and A. A. Galnbek (editors), *International Symposium. Problems of Complex Ores Utilization*, Mineral Processing & Extractive Metallurgy. Special Issue, Gordon & Breach 1995, 280 pages (out of print). Now available from Métallurgie Extractive Québec.
F. Habashi, *Aluminum. History & Metallurgy*, 2008, 160 pages.
F. Habashi, *Researches on Rare Earths. History and Technology*, 2008, 125 pages.
F. Habashi, *Researches on Copper: History, Metallurgy*, 2009, 400 pages.
F. Habashi, *Gold: History, Metallurgy, Culture*, 2009, 277 pages.
F. Habashi, *Researches on Asbestos*, 2011, 115 pages.
F. Habashi, *Mineral Processing for Nano-Scientists*, 2011, 170 pages.
F. Habashi, *Extractive Metallurgy of Copper*, 2012, 412 pages.
F. Habashi, *Pyrite. History, Chemistry, and Metallurgy*, 2012, 115 pages.
F. Habashi, *Pressure Hydrometallurgy*, 2014, 242 pages.
F. Habashi, *De Re Metallica. A Metallurgist on the Move*, 7 volumes, 2015, 5523 pages.

Historical

F. Habashi (editor), *Gellert's Metallurgic Chymistry*, 1998, 500 pages.
F. Habashi, D. Hendricker, C. Gignac, *Mining and Metallurgy on Postage Stamps*, 1999, 335 pages.
F. Habashi, *Extractive Metallurgy Today. Progress and Problems*, 2000, 325 pages.
F. Habashi, *From Alchemy to Atomic Bombs*, 2002, 350 pages.
F. Habashi, *Schools of Mines. The Beginnings of Mining and Metallurgical Education*, 2003, 604 pages.
F. Habashi, *Ida Noddack (1896–1978). Personal Recollections on the Occasion of 80th Anniversary of the Discovery of Rhenium*, 2005, 164 pages.
F. Habashi, *Readings in Historical Metallurgy*, Volume 1: Changing Technology in Extractive Metallurgy, 2006, 800 pages.
F. Habashi, *Postage Stamps: Metallurgy, Art, History*, 2008, 125 pages.
F. Habashi, *The Copts of Egypt*, 2006, 92 pages.
F. Habashi, *Chemistry and Metallurgy in the Great Empires*, 2009, 272 pages.
F. Habashi, *Science, Technology, and Society*, 2009, 316 pages.
F. Habashi, *Aqua Science Through the Ages. An Illustrated History of Water*, 2010, 166 pages.
F. Habashi, *Mining and Civilization. An Illustrated History*, 2010, 510 pages.

Preface

De Re Metallica. A Metallurgist on the Move is a diary of the trips the author has undertaken during his professional career. He visited many industries, universities, research centres, and museums and participated in many conferences. The book therefore reflects the state of extractive metallurgy since he left his home country Egypt and went to study in Vienna. The book is in seven volumes fully illustrated mainly by coloured photographs. It includes a short history of the place visited and its main sightseeing sites. Volume 1 Egypt, Volume 2 Canada, Volume 3 United States, Volume 4 Latin America, Volume 5 Asia [in two parts], Volume 6 Europe [in two parts], and Volume 7 Russia & other countries. Total number of pages was 5500.

Since these volumes could not be separated and therefore they will not be available to many readers, I decided to split the book into selected 28 small units each representing one country or a group of countries closely related geographically as shown below.

1	Arab Countries	Jordan, Kuwait, Morocco, Syria, Tunis
2	Austria	
3	Australia & Southeast Asia	Australia, Cambodia, Indonesia, Malaysia, Philippines, Thailand, Vietnam
4	Balkans	Albania, Bosnia, Bulgaria, Croatia, Greece, Romania, Serbia, Slovenia
5	Baltic Countries	Latvia, Lithuania, Poland
6	Brazil	
7	Canada	
8	Caribbean	Cuba, Puerto Rico, Venezuela
9	Caucasus	Armenia, Azerbaijan, Georgia
10	Central Asia	Afghanistan, Kazakhstan, Mongolia, Uzbekistan
11	Central Europe	Czech Republic, Slovakia, Hungary, Switzerland
12	Chile and Argentina	
13	China	
14	Egypt	
15	England and France	
16	Germany	
17	Iberian Peninsula	
18	India	
19	Italy and Vatican	
20	Japan and Korea	
21	Low Countries	

22	Mexico	
23	Middle East	Iran, Turkey
24	Peru and Bolivia	
25	Russia	
26	Scandinavia	
27	South Africa	
28	USA	

I hope in this way the book will available to a large number of readers.

Fathi Habashi
Fathi.Habashi@arul.ulaval.ca

Table of Contents

1. Gibraltar 1
2. Spain 9
3. Portugal 76
Name Index 123
Subject Index 125

Chapter 1

Gibraltar

Tariq ibn Ziyad 4
The myth of Heracles 5
Salinity of the Mediterranean 6

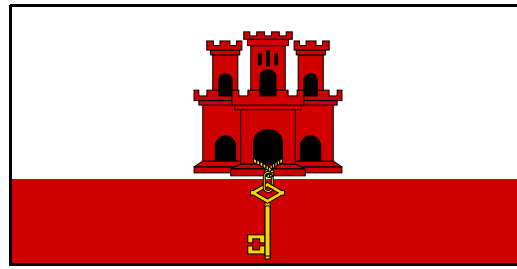


Figure 1.1: Flag of Gibraltar.

On a British Airways flight from London Heathrow to Marrakesh, in 1997, a stop was made in Gibraltar Airport. Later, on two boat trips from Tangier in Morocco to Algeciras in Spain, Gibraltar was in magnificent view (Figures 1.2–1.8).

Figure 1.2: Gibraltar at the entrance of the Mediterranean Sea.

Figure 1.3: Gibraltar, UK.

Figure 1.4: A satellite photo showing Algeciras and Gibraltar.

Figure 1.5: Airport.

Figure 1.6: City view.

Figure 1.7: Ferry ship Boughaz of Comarit Company for crossing Strait of Gibraltar.

Figure 1.8: On board of Comarit Ship Boughaz from Tangier to Gibraltar. Photo by Nadia Habashi, 1997.

TARIQ IBN ZIYAD

Under the orders of the Umayyad Caliph Al-Walid I, Tariq ibn Ziyad (Figure 1.9), a Muslim, possibly Berber general, led a large army from the north coast of Morocco, to conquer the Visigothic Hispania in 711–718 A.D. He consolidated his troops at a large hill now known as Gibraltar. The rock was named Djebel Tariq, the Mount of Tariq, subsequently corrupted into Gibraltar.

Figure 1.9: Tariq ibn Ziyad on paper money.

The Kingdom of Castile annexed Gibraltar in 1309. It remained under Spanish rule until 1704, when it was captured by an Anglo-Dutch fleet in the name of the Habsburg ruler Charles VI. Following Charles' death the colony grew rapidly during the 19th century as Gibraltar became a key British naval base and stopping point for vessels en route to India via the Suez Canal. Ceuta on the African side has been a Portuguese colony in 1415 then Spanish in 1580 (Figure 1.10).

THE MYTH OF HERACLES

The Greek hero Heracles [Hercules for the Romans] is famous for his strength and for his numerous adventures. He used his superhuman strength to smash through a mountain and by doing so he connected the Atlantic Ocean to the Mediterranean Sea and formed the Strait of Gibraltar. One part of the split mountain is Gibraltar and the other is either Monte Hacho in Ceuta or Jebel Musa in Morocco. These two mountains taken together have since then been known as the Pillars of Heracles. They have received much attention by artists after Columbus discovered America in 1492. Until then the navigation outside of the pillars had been limited to coastline navigation. Monuments were erected in Gibraltar and in other places commemorating the Greek myth (Figures 1.11–1.13).

Figure 1.10: Location of Gibraltar, Ceuta, and Tangier.

SALINITY OF THE MEDITERRANEAN

According to oceanographers the evaporation of water from the Mediterranean Sea is greater than the inflow of water from rivers and rain. This makes the water of the Mediterranean more saline than that of the Atlantic and produced a water deficit in the sea that requires additional inflow to maintain the sea level. The Mediterranean's high salinity and water deficit leads to thermohaline circulation with the Atlantic which has two parts:

- A swift current brings water from the Atlantic into the Alboran Sea through the Strait of Gibraltar at and near the surface. As a result, the surface water of the Alboran sea is lower saline Atlantic water mixing as it progresses eastward with the higher saline Mediterranean water.
- The higher saline water of the Mediterranean Sea is denser and sinks to the lower depths of the Alboran Sea and flows out into the Atlantic Ocean through the Strait of Gibraltar.

Figure 1.11: The myth of Hercules monument.

Figure 1.12: The myth of Hercules monument.

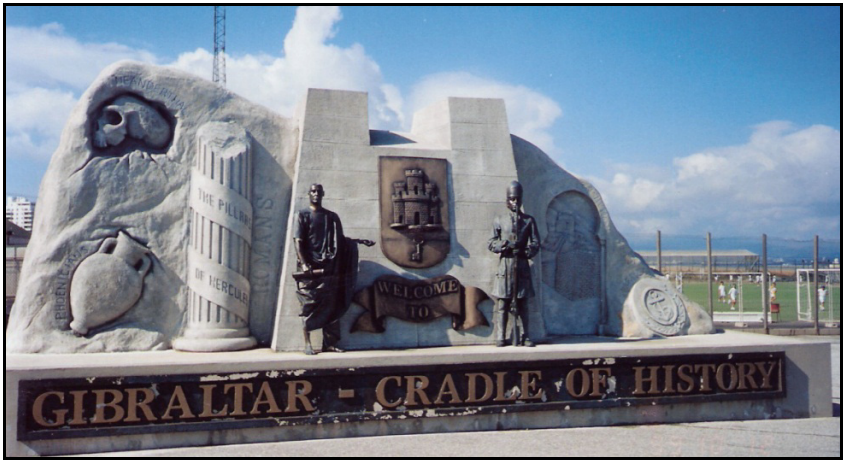


Figure 1.13: The myth of Hercules monument.

Chapter 2

Spain

Historical Introduction 9
- **Arab conquest** 10
- **Re-conquest** 12
- **Spanish Empire** 13
- **Silver from the colonies** 13
- **Charles V** 13
- **Decline** 14
- **Spain and the Napoleonic wars** 15
- **Spanish Civil War** 15

Madrid 16
- **Egyptian temple** 22
- **Complutense University** 23
- **Junta de Energía Nuclear** 23
- **CENIM** 23
- **Técnica Reunidas** 23

Escorial 23
Toledo 24
Algeciras 27
Cádiz 27
- **Torre Tavira** 32

Seville 33
- **University of Seville** 41

Granada 43
- **Alhambra** 43

Córdoba 49
- **Medina Azahara** 52

Barcelona 52
- **Antoni Gaudí i Cornet** 58
- **University of Barcelona** 60

San Sebastián 61
- **REWAS** 66

Culture 68
- **Semana santa** 68
- **Traditional dress** 71
- **Flamenco dance** 73
- **Bullfighting** 74

Figure 2.1: Flag of Spain.

Historical Introduction

The peninsula of Iberia was part of the Roman Empire (Figure 2.2). After the fall of the Roman Empire, the Suevi, Vandals, and Alans entered Spain, but they were defeated by the Visigoths who, by the end of the 6th century, has occupied virtually the whole of the peninsula (Figure 2.3). The Visigoth was originally a settlement in southwest France with their capital

at Toulouse. They extended by conquest over all of the Iberian peninsula shifting their capital to Toledo. The Moors arrived in the 8th century.

Figure 2.2: The Iberian peninsula as part of the Roman Empire.

Arab conquest

The Moors from North Africa led by Tariq ibn-Ziyad invaded Spain, displacing the Visigoths, and established Al-Andalus in 711. By 790 they were in control of nearly the whole Iberian peninsula (Figure 2.4). A Muslim force sent to put down a Christian rebellion in the northern mountains was defeated and the Kingdom of Asturias was established and became the main base for Christian resistance to Islamic rule for several centuries.

When the Umayyad Caliphate, was overthrown by the Abbasids, Abd-al-Rahman III, grandson of the last caliph of Damascus, escaped to Iberia and declared the independence of the Caliphate of Córdoba in the 10th century.

The caliphate plunged into a civil war and splintered into the so-called "Taifa Kingdoms." They were defeated by an alliance of the Christian kingdoms in a decisive battle in 1212. By 1250, nearly all of Iberia was back under Christian rule with the exception of the small Muslim kingdom of Granada.

Figure 2.3: Visigoth kingdom.

Figure 2.4: Arab control of Iberia in 790.

Figure 2.5: Shrinking of Arab control in 1210.

Re-conquest

In the 15th century, the most important among the separate Christian kingdoms that made up the old Hispania were the Kingdom of Castile, the Crown of Aragon, and the kingdom of Portugal. The death of King Henry IV of Castile in 1474 set off a struggle for power. Isabel I of Castile retained the throne and ruled jointly with her husband, King Ferdinand II of Aragon whom she had married in 1469. The monarchs oversaw the final stages of the Reconquista of Iberian territory from the Moors with the conquest of Granada, conquered the Canary Islands, and expelled the Jews and Muslims from Spain in 1492.

Spanish Empire

Isabella and Ferdinand authorized the 1492 expedition of Christopher Columbus to the New World. This and subsequent expeditions led to an influx of wealth into Spain, that would prove to be a dominant power of Europe for the next two centuries (Figure 2.6).

Figure 2.6: Spanish Empire in 1600.

Isabella the Catholica arranged strategic marriages for each of her five children. Her first born, a daughter named Isabella, married Afonso of Portugal. Her second daughter married Philip the Handsome, son of the Habsburg Maximilian I, King of Bohemia (Austria) and entitled to the crown of the Holy Roman Emperor. Her son, Juan, married Margaret of Austria, further maintaining ties with the Habsburg dynasty. Her fourth child, Maria, married Manuel I of Portugal. Her fifth child, Catherine, married King Henry VIII of England and was mother to Queen Mary I of England.

Silver from the colonies

In the 1520s, large-scale extraction of silver from the rich deposits of Mexico's Guanajuato began to be greatly augmented by the silver mines in Mexico's Zacatecas and Bolivia's Potosí from 1546. These silver shipments re-oriented the Spanish economy leading to the importation of luxuries and grain. They also became indispensable in financing the military capability of Habsburg Spain in its long series of European and North African wars.

Charles V

The Spanish Empire reached its maximum extent in Europe under Charles I of Spain, as he was also Emperor Charles V of the Holy Roman Empire. Charles V (1500–1558) (Figure 2.7) became king in 1516. As he approached the end of his life he made provision for the division of the Habsburg inheritance into two parts. On the one hand, Spain and its posses-

sions overseas and the Habsburg possessions in the Netherlands and on the other hand was the Holy Roman Empire itself.

Figure 2.7: Charles V (1500–1558).

Philip II became king on Charles V's abdication in 1556. Spain largely escaped the religious conflicts that were raging throughout the rest of Europe, and remained Roman Catholic. Philip saw himself as a champion of Catholicism, both against the Ottoman Turks and the heretics.

In the 1560s, plans to consolidate control of the Netherlands led to unrest, which gradually led to the Calvinist leadership of the revolt and the Eighty Years' War. This conflict consumed much Spanish expenditure during the later 16th century. Conflicts included an attempt to conquer England — a supporter of the Dutch — in the unsuccessful Spanish Armada, an early battle in the Anglo-Spanish War (1585–1604), and war with France (1590–1598).

Decline

Economic and administrative problems multiplied due to the wars in Europe and the problems associated with the expulsion of the Jews and Moors from Spain. The great plague of 1596–1602 killed about 10% of the population. Philip II died in 1598, and was succeeded by his son Philip III. In his reign (1598–1621) Spain was involved in the Thirty Years' War. Philip III was succeeded in 1621 by his son Philip IV (reigned 1621–1665). During the reign of his successor Carlos II (1665–1700), Spain was gradually being

reduced to a second-rank power. Carlos II, having no direct heir, was succeeded by his great-nephew Philip V, a French prince, in 1700. Spain became culturally and politically a follower of absolutist France.

Spain and the Napoleonic wars

After briefly opposing the French Revolutionary Wars, the alliance with France continued only to be blockaded by the British. In 1805 a major Franco-Spanish fleet was annihilated at the Battle of Trafalgar. Carlos IV's failure to enforce the trade embargo of the Spanish colonies with Britain led Napoleon I, Emperor of the French to invade Spain in 1808 and depose Ferdinand VII (1784–1833) (Figure 2.8), who had been on the throne after his father's abdication thereby triggering Spain's War of Independence.

Two years of revolution and anarchy followed until in 1871 Amadeus of Savoy, the second son of King Victor Emmanuel II of Italy, was crowned King of Spain. However, following an army rebellion Spain was declared a republic.

Figure 2.8: Ferdinand VII (1784–1833).

Figure 2.9: General Francisco Franco (1892–1975).

Spanish Civil War

Spain's neutrality in World War I allowed it to become a supplier of material for both sides, prompting an economic boom. In the 1930s, Spanish politics were polarized. In 1934, an armed rising of workers in Asturias and Catalonia, was forcefully put down by the government. In 1936, the left united in the Popular Front and was elected to power. Violence erupted

again. On 17 July 1936, General Francisco Franco (1892–1975) (Figure 2.9) led the colonial army from Morocco to attack the mainland. Spain faced a prolonged civil war. The Nationalists received military aid from Nazi Germany, Fascist Italy, and Portugal, while the Republic was supported by organized far-left volunteers in the International Brigades. The war ended in March 1939 when Madrid fell. The Republic was destroyed and Francisco Franco emerged as dictator of Spain.

Table 2.1: Visits to Spain.

Dates	Cities visited	Purpose of visit
December 1977	Madrid	Complutense University
		CENIM
		Atomic Energy labs
	Toledo	Cultural visit
March 1997	Madrid	Cultural visit
	Algeciras	Cultural visit
	Cádiz	Cultural visit
	Seville	University of Seville
March 1999	Madrid	Cultural visit
	Escorial	Cultural visit
	Granada	Cultural visit
	Cordoba	Cultural visit
April 1999	Barcelona	University of Barcelona
	San Sebastián	Preparation for REWAS conference
September 1999	San Sebastián	REWAS conference
October 1980	Madrid	Técnica Reunidas
May 2000	Barcelona	University of Barcelona
October 2008	Barcelona	Transit to cruise ship

MADRID

The Roman Empire established a settlement on the banks of the Manzanares river in what is now the city of Madrid. In 1561, Philip II moved his court from Toledo to Madrid, installing it in the old castle. Since then the city became the political centre of the monarchy (Figures 2.10–2.20).

Figure 2.10: General view.

Figure 2.11: El Prado Art Gallery.

Figure 2.12: Royal palace.

Figure 2.13: Monument to Cervantes in Plaza de España.

Figure 2.14: National Archaeological Museum.

Figure 2.15: National Archaeological Museum.

Figure 2.16: National Archaeological Museum.

Figure 2.17: Alfonso el Sabio [The Wise] (1221–1284), King of Castile, León and Galicia.

Figure 2.18: National Archaeological Museum.

Figure 2.19: Museum of the Americas.

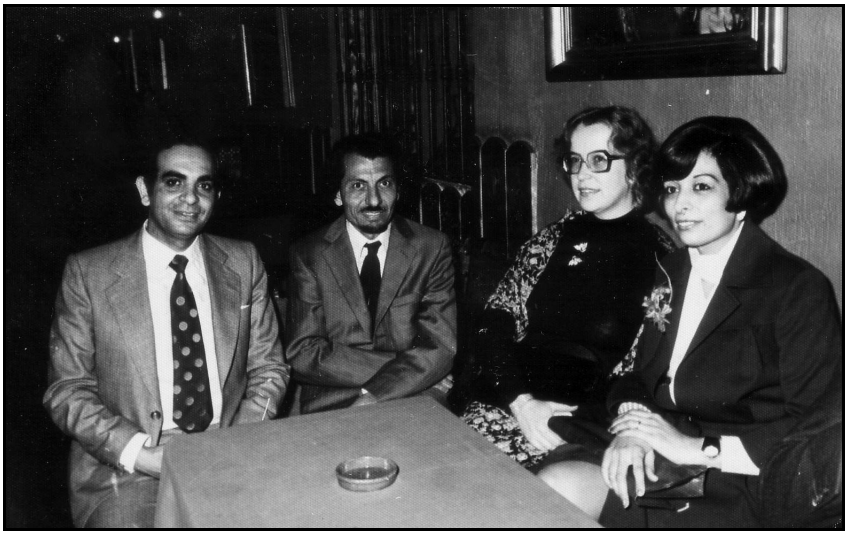


Figure 2.20: With family members in Madrid. December 1977.

Egyptian temple

Due to the construction of the Aswan Dam in 1960, many monuments were in danger of being destroyed. The UNESCO made an appeal to countries to help save these monuments. Thanks for the aid given by Spain the Egyptian government donated a temple to the Spanish people in 1968. The temple originally stood in the Nile Valley not far from Aswan. It was dismantled in 1969 and shipped to the Spanish port Valencia, from where it was taken by train to Madrid where it was reconstructed and open to the public in 1972 (Figure 2.21).

Figure 2.21: Egyptian temple.

Complutense University

The Complutense University of Madrid is the largest university in Spain and was founded in Alcala de Henares in 1499. In 1836, during the reign of Isabel II, the University was moved to Madrid. [complutense = native]. Host: Prof. Filipe Calvo y Calvo (1919–1991) (Figure 2.22), Chairman Department of Metallurgy and author of *La España de los Metales* (1964). Guide: Jean-Marie Guilemany [originally from Barcelona, moved back later].

Figure 2.22: Prof. Filipe Calvo y Calvo (1919–1991).

Junta de Energía Nuclear

Professor J. L. Otero of the University arranged for a visit to the laboratories of Atomic Energy. Guide: Alberto Moral Bieto, Division of Materials [1977].

CENIM

Centro Nacional de Investigaciones Metalúrgicas, known by the acronym CENIM, is a government research organization devoted to metallurgy. Host: Antonio de la Quadra Herrera [1977].

Técnica Reunidas

A consulting firm doing research in pressure hydrometallurgy and solvent extraction, developed the solvent extraction of zinc [Scorpion process]. Host: Eduardo Díaz Nogueira [October 1980 after trip to Kuwait].

ESCORIAL

El Escorial (Figure 2.23) is a historical residence of the king of Spain, in the town of San Lorenzo de El Escorial, 45 kilometres northwest of Madrid was constructed by King Philip II (1527–1598) (Figure 2.24) the son of Charles V in 1563–1584. It is the burial site of most of the Spanish kings.

Figure 2.23: El Escorial.

Figure 2.24: King Philip II (1527–1598).

TOLEDO

Toledo (Figures 2.25–2.29), 70 km south of Madrid, was called Tulaytulah under Arab rule. Toledo was famed for religious tolerance and had large communities of Muslims and Jews until they were expelled from Spain in 1492 (Jews) and 1502 (Muslims). In the 13th century, Toledo was a major cultural centre under the guidance of Alfonso X, called El Sabio [The Wise], for his love of learning. The Toledo School of Translators was commenced under the Archbishop of Toledo continued rendered academic and philosophical works in Arabic into Latin. Guide: Prof. Josep-Maria Guilemany.

Figure 2.25: General view.

Figure 2.26: Puerta Bisagra.

Figure 2.27: Toledo Cathedral.

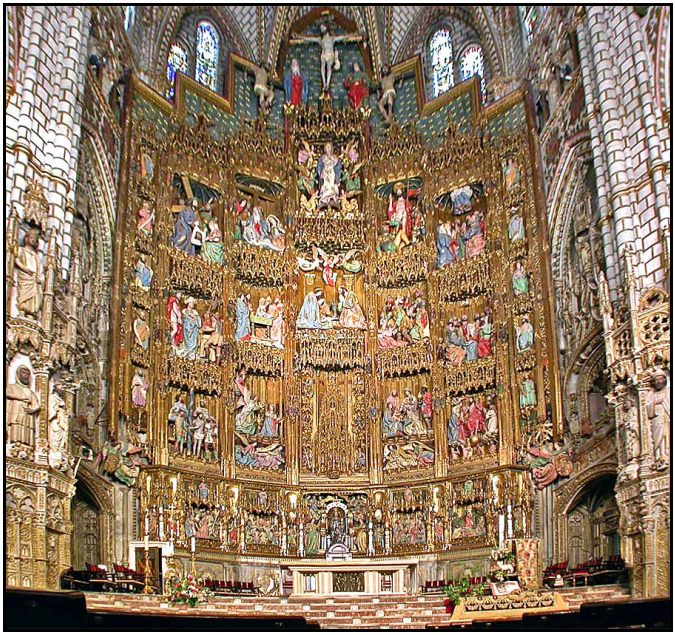


Figure 2.28: Toledo Cathedral.

Figure 2.29: Bridge across Tajo River.

El Greco, born Doménikos Theotokópoulos (Δομήνικος Θεοτοκόπουλος) (1541–1614), was a Greek emigrant who lived in Toledo. He was a painter, sculptor and architect of the Spanish Renaissance. Typical of his paintings are shown in Figures 2.30–2.31.

ALGECIRAS

Algeciras was founded in 711 by the invading Moors, as the first city created by the Arabs on the occupied Spanish soil. It was named al-Jazirah al-Khaḍra' (الجـــزيرة الخضـــراء), i.e., Green Island. It was reached by ferry from Tangier on the way to Andalusia (Figure 2.32).

CÁDIZ

Cádiz (Figures 2.33–2.38), is an ancient Phoenician town that fell in 500 BC to Carthage. During the Age of Exploration, Christopher Columbus sailed from there on his second and fourth voyages, and the city later became the home port of the Spanish fleet. In April 1587 a raid by the Englishman Sir Francis Drake occupied the harbour for three days, capturing six ships and destroying 31 others. The attack delayed the sailing of the Spanish Armada by a year.

Figure 2.30: Painting by El Greco.

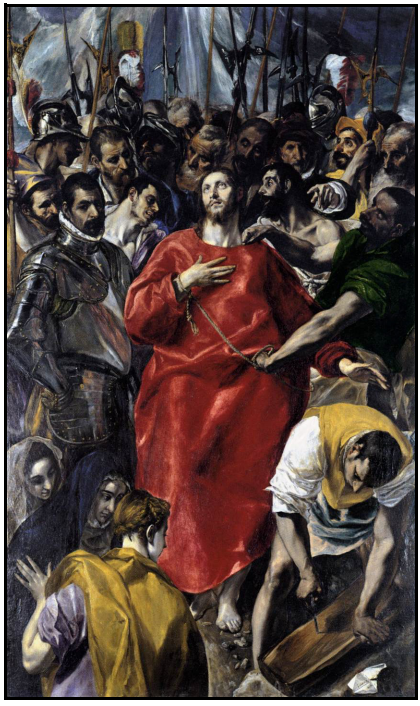


Figure 2.31: Painting by El Greco.

Figure 2.32: Algeciras. Photo by Fathi Habashi, 1997.

Figure 2.33: Map of Andalucia showing Algeciras, Cádiz, Seville, Cordoba, and Granada.

Figure 2.34: Map of Cádiz.

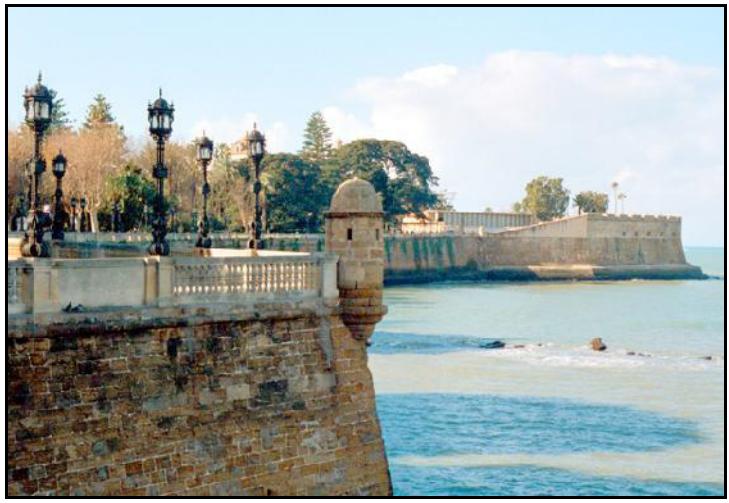


Figure 2.35: Cádiz.

Figure 2.36: Cádiz, 1997.

Figure 2.37: Cádiz, 1997.

Figure 2.38: Archaeological Museum holds lead ingots from Phoenician time.

Torre Tavira

The Tavira Tower (Figure 2.39) is an 18th century observation tower containing Cámara Obscura [Dark Room] constructed around 1778 in Cádiz. It is named after Antonio Tavira the watchman at the palace of Marquis of Rocaño. The camera obscura was used to observe the movement of people in the town. The device consists of a room with a hole in one side. Light from an external scene passes through the hole and strikes a surface inside where it is reproduced, upside-down (Figure 2.40). By placing a mirror inclined at 45° inside, the image of objects outside is reflected to the horizontal plane.

Figure 2.39: Torre Tavira.

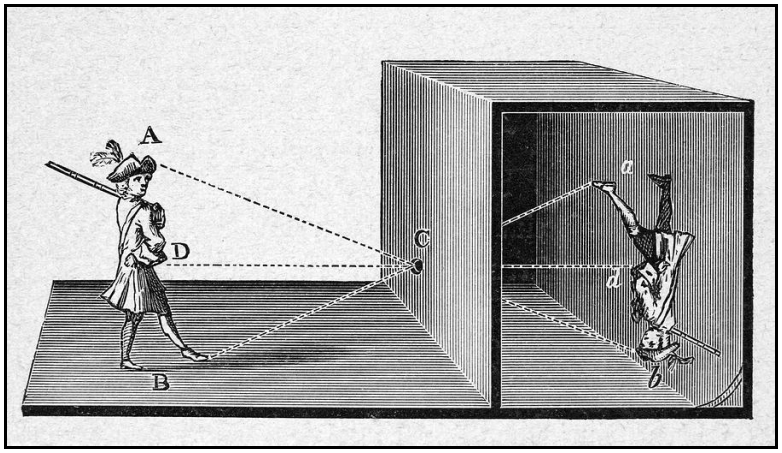


Figure 2.40: Principle of the cámara obscura.

SEVILLE

Seville is situated on the plain of the River Guadalquivir (Figures 2.41–2.44). The name of the river comes from the Arabic Al-wadi al-kabir (الوادي الكبير).

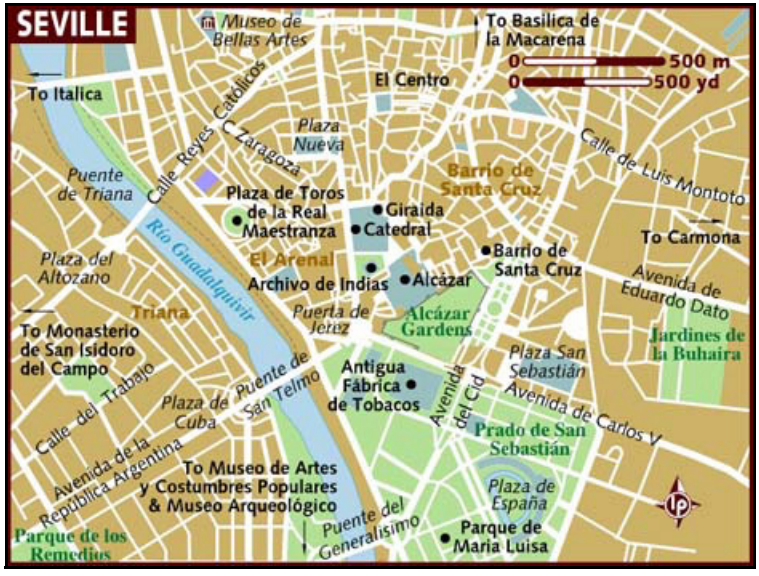


Figure 2.41: Seville on Guadalquivir River.

Figure 2.42: Bridge across Guadalquivir River, 1997.

Figure 2.43: Torre del Oro was built in the 1200s by the Almohad dynasty to serve as a watch tower to guard the Gualdalquivir River.

Figure 2.44: General view.

Plaza de España (Figures 2.45–2.51) was built for the Ibero-American Exposition of 1929. By the walls of the Plaza are many tiled alcoves, each representing a different province of Spain. The buildings now house central government departments.

Figure 2.45: Plaza de España.

Figure 2.46: Plaza de España.

Figure 2.47: Plaza de España.

Figure 2.48: Plaza de España, 1997.

Figure 2.49: Plaza de España.

Figure 2.50: Plaza de España.

Figure 2.51: Seville Cathedral with Giralda, one of the largest in the world, originally a Muslim mosque. Columbus is buried there.

The Archivo General de Indias is housed in the ancient Casa Lonja de Mercaderes, is the repository of documents illustrating the history of the Spanish Empire in the Americas and the Philippines (Figure 2.52).

Figure 2.52: Archivo General de Indias.

Figure 2.53: Park.

Figure 2.54: Isabel La Católica Street.

University of Seville

University of Seville (Figures 2.55–2.57) was founded under the name of Colegio Santa María de Jesús in 1505 and elevated to a university status in 1551. The main building is known as the Old Tobacco Factory, named for its original use. Built in the 18th century, the tobacco factory was the largest industrial building in the world at that time and remained a tobacco factory until the 1950s. This building is also the setting for opera Carmen by Bizet. Carmen was a fictional worker in the tobacco factory.

Figure 2.55: Façade of the University building.

Figure 2.56: Interior of the University building.

Figure 2.57: Faculty members of Department of Chemical Engineering. Rafael Romero Aleta, Nieves Iglesias González, and Inmaculada Palencias Pérez. Photo by Nadia Habashi.

GRANADA

Granada (Figure 2.58), known in Arabic as غرناطة (Ġirnāṭa) is located at the foot of the Sierra Nevada mountains, at the confluence of three rivers, the Beiro, the Darro, and the Genil.

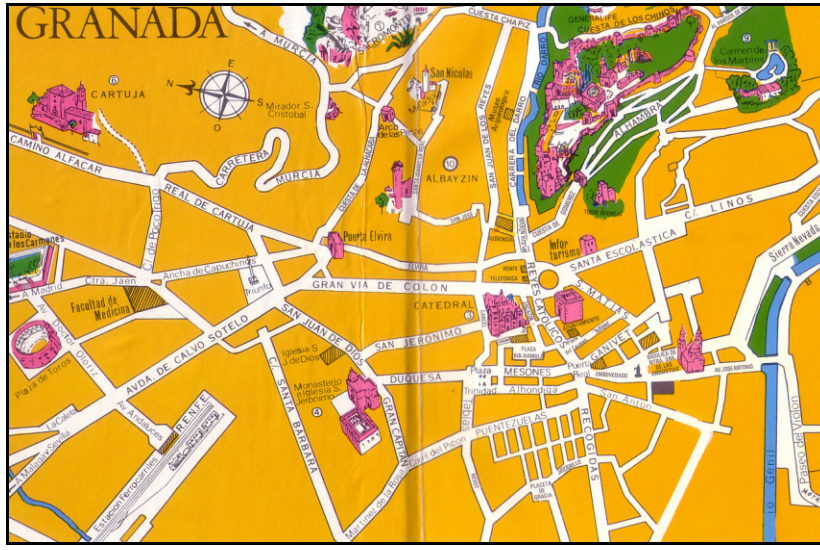


Figure 2.58: Granada and Alhambra.

Alhambra

The Alhambra (Figures 2.60–2.66) (Arabic: الْحَمْـرَاء, Al-Ḥamrā'), built by the Moorish king Mohammed ben Al-Ahmar of the Kingdom of Granada, is a Moorish citadel and palace developed in the 11th century as a military stronghold that dominated the whole city. But it was in the 13th century, with the arrival of the first monarch of the Nasrid dynasty, Mohammed I ibn Nasr (1238–1273), that the royal residence was established in the Alhambra.

Figure 2.59: Monument to Isabel la Católica.

Figure 2.60: Alhambra.

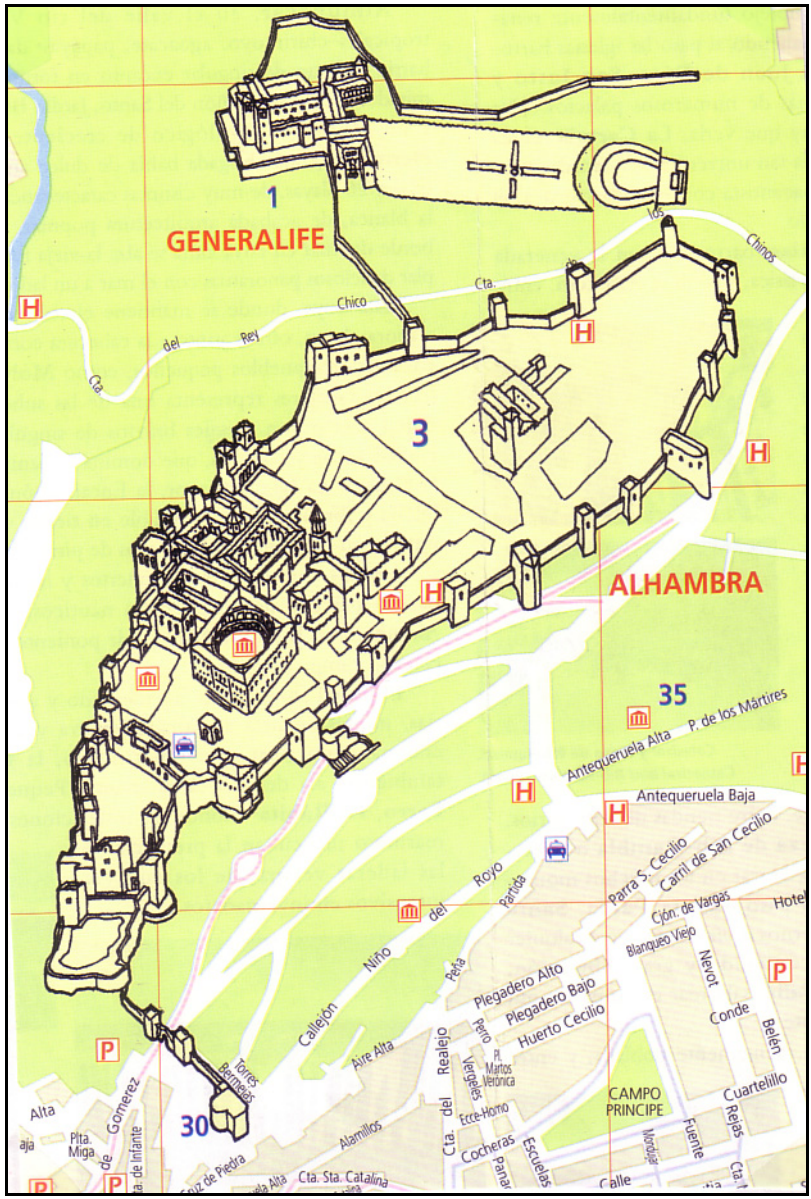


Figure 2.61: Map of Alhambra.

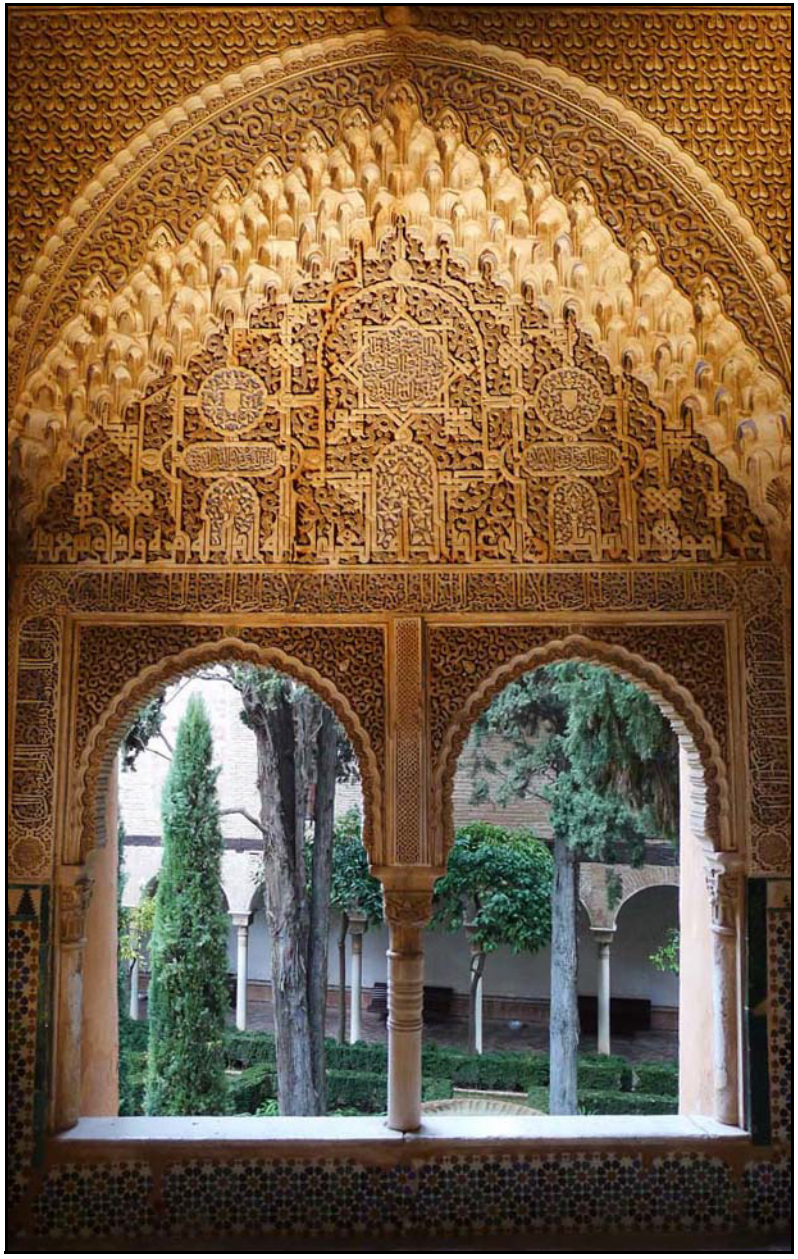


Figure 2.62: Alhambra palace.

Figure 2.63: Alhambra palace.

Figure 2.64: Alhambra palace.

Figure 2.65: Alhambra palace.

Figure 2.66: Alhambra palace.

CÓRDOBA

Córdoba (Figure 2.67) was an Iberian and Roman city in ancient times and in the Middle Ages it became the capital of an Islamic caliphate. In 784, Abd al-Rahman I started the Great Mosque of Córdoba (Figures 2.68–2.70) using columns, capitals, and bases recycled from the previous site occupant, the Visigoth Church of San Vicente, and the ruins of other Visigoth and Roman buildings. During the Reconquest, this structure was used as a church, and it was partly reconstructed as a cathedral in the 16th century.

It has been estimated that in the 10th century and beginning of the 11th century, Córdoba was the most populous city in the world, and was the intellectual centre of Europe. It was home for the Jewish philosopher Moses Maimonides (1135–1204).

Figure 2.67: Córdoba.

Figure 2.68: Córdoba great mosque.

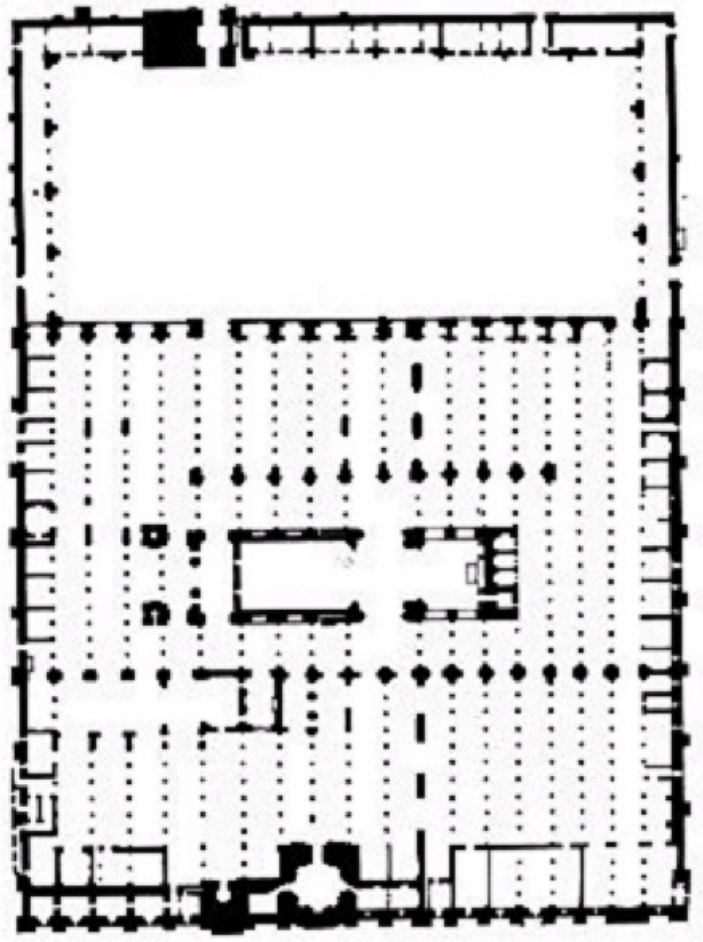


Figure 2.69: Plan of the mosque.

Figure 2.70: Córdoba great mosque.

Medina Azahara

Medina Azahara (Arabic: المدينـــةُ الـــزهراء meaning "beautiful town") (Figures 2.71–2.73) is the ruins of a vast, fortified Arab Muslim medieval palace-city built by Abd al-Rahman III al-Nasir, (912–961) Ummayad Caliph of Córdoba, and located on the western outskirts of Córdoba. The complex was extended during the reign of his son Al-Hakam II but after his death soon ceased to be the main residence of the Caliphs. In 1010 it was sacked in a civil war, and thereafter abandoned, with many elements re-used elsewhere. Its ruins were excavated starting from the 1910s.

BARCELONA

Barcelona, (Figures 2.74–2.79) is the capital of Catalonia and the second largest city in Spain, after Madrid. Founded as a Roman city then merged with the Kingdom of Aragon. The city was a Republican stronghold during the Civil War, and the fall of the city on 26 January 1939 caused a mass exodus of civilians who fled to the French border. The autonomous institutions of Catalonia were abolished, and the use of the Catalan language was suppressed in public.

Figure 2.71: Ruins of Medina Azahara.

Figure 2.72: Ruins of Medina Azahara.

Figure 2.73: Ruins of Medina Azahara.

Figure 2.74: Barcelona Castle.

Figure 2.75: Art gallery.

Figure 2.76: The harbour with monument to Christopher Columbus and Customs House.

Figure 2.77: Barcelona, 2000. Photo by Fathi Habashi.

Figure 2.78: The Port of Barcelona.

Figure 2.79: Barcelona, 2000. Photo by Nadia Habashi.

Antoni Gaudí i Cornet

Antoni Gaudí i Cornet (1852–1926) was a Catalan architect. Famous for his Sagrada Família (Figure 2.80) and other works (Figures 2.81–2.83).

Figure 2.80: Sagrada Família by Gaudí.

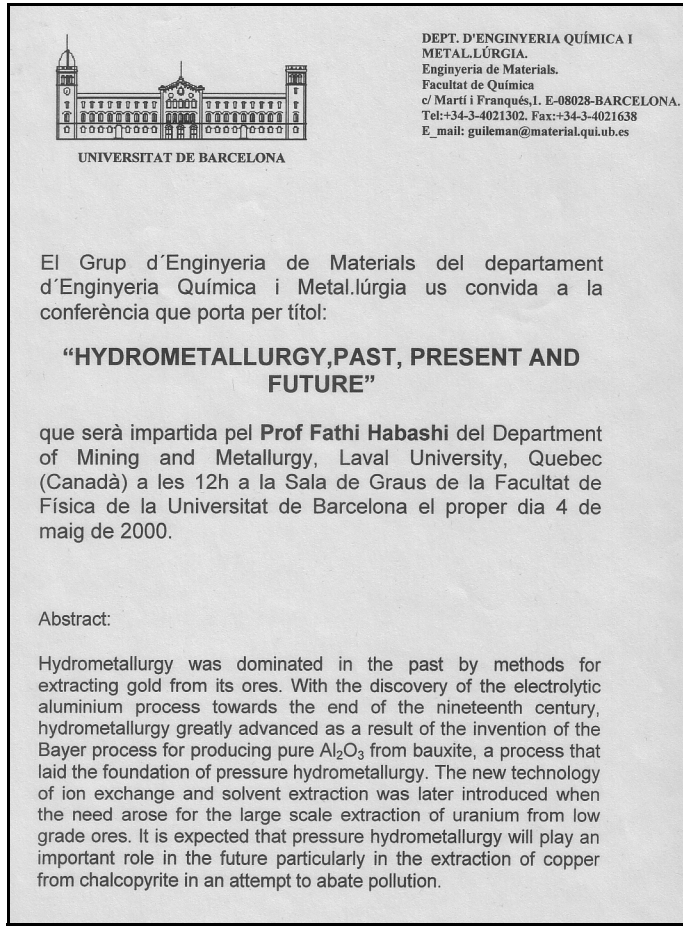
Figure 2.81: Gaudí building.

Figure 2.82: Gaudí building.

Figure 2.83: Gaudí building.

University of Barcelona

The University of Barcelona was founded in 1450.



UNIVERSITAT DE BARCELONA

DEPT. D'ENGINYERIA QUÍMICA I METAL.LÚRGIA.
Enginyeria de Materials.
Facultat de Química
c/ Martí i Franqués,1. E-08028-BARCELONA.
Tel:+34-3-4021302. Fax:+34-3-4021638
E_mail: guileman@material.qui.ub.es

El Grup d´Enginyeria de Materials del departament d´Enginyeria Química i Metal.lúrgia us convida a la conferència que porta per títol:

"HYDROMETALLURGY,PAST, PRESENT AND FUTURE"

que serà impartida pel **Prof Fathi Habashi** del Department of Mining and Metallurgy, Laval University, Quebec (Canadà) a les 12h a la Sala de Graus de la Facultat de Física de la Universitat de Barcelona el proper dia 4 de maig de 2000.

Abstract:

Hydrometallurgy was dominated in the past by methods for extracting gold from its ores. With the discovery of the electrolytic aluminium process towards the end of the nineteenth century, hydrometallurgy greatly advanced as a result of the invention of the Bayer process for producing pure Al_2O_3 from bauxite, a process that laid the foundation of pressure hydrometallurgy. The new technology of ion exchange and solvent extraction was later introduced when the need arose for the large scale extraction of uranium from low grade ores. It is expected that pressure hydrometallurgy will play an important role in the future particularly in the extraction of copper from chalcopyrite in an attempt to abate pollution.

Figure 2.84: Announcement for lecture, May 2000.

Figure 2.85: Host Prof. Josep-Maria Guilemany.

Figure 2.86: Meeting metallurgy students.

SAN SEBASTIÁN

San Sebastián (Figures 2.88–2.95), known as Donostia in Basque, on the coast of the Bay of Biscay and 20 km away from the French border is the capital of the Basque Country. The main economic activities are commerce and tourism. At times, governments tried to suppress Basque linguistic identity. Nowadays, the Basque Country within Spain enjoys an extensive cultural and political autonomy and Basque is an official language along with Spanish. Some researchers have shown similarities between the Basque language and the Caucasian languages, especially Georgian.

Figure 2.87: Dinner with Prof. Guilemany, his co-worker Prof. Viktor Sobolev, and wives.

Figure 2.88: View of San Sebastián.

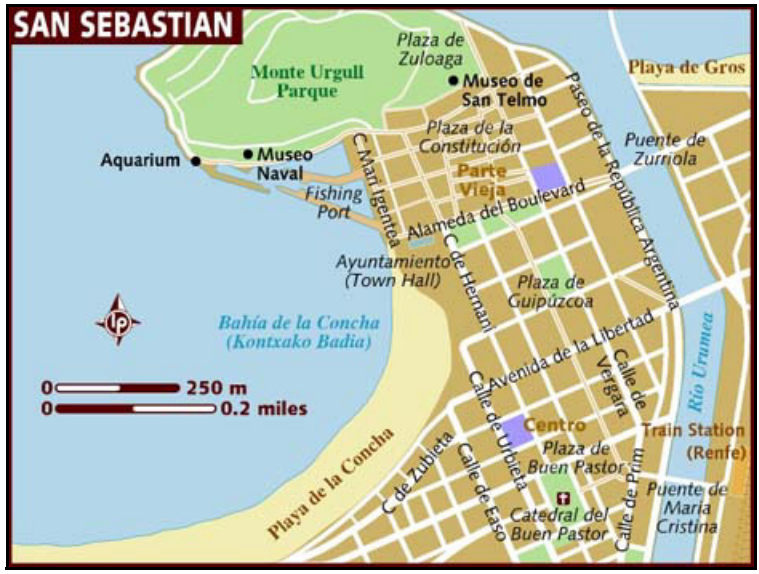


Figure 2.89: Map of San Sebastián.

Figure 2.90: City Hall.

Figure 2.91: Convention Centre.

Figure 2.92: Luxury hotels.

Figure 2.93: Bridge.

Figure 2.94: San Sebastián, September 1999. Photo by Nadia Habashi.

Figure 2.95: Monument to Queen María Christina of Austria (1858–1929), the second wife of King Alfonso XII and regent of Spain during the minority of her son Alfonso XIII. She was popular because her time was prosperous.

REWAS

REWAS is acronym for Global Symposium on Recycling, Waste Treatment, and Clean Technology.

Figure 2.96: Some members of REWAS Organizing Committee studying the submitted abstracts. Standing: Rudolfo Solozabal [San Sebastián]. Sitting from left: John Hager [Colorado School of Mines], Norbert Piret [Duisburg, Germany], Rick Kenney [Hazen Research], Brajendra Mishra [Colorado School of Mines], Ibrahim Gaballah [Nancy]. Photo by Fathi Habashi, April 1999.

Figure 2.97: San Sebastián September 1999. Meeting María del Carmen Ruiz [Argentina]. Photo by Nadia Habashi.

Figure 2.98: Conference name card.

CULTURE

Semana santa

Semana santa is the week before Easter is celebrated in Spain, particularly in Andalusia, in a curious way (Figures 2.99–2.105).

Figure 2.99: Semana santa in Granada, 1999.

Figure 2.100: Semana santa in Granada, 1999.

Figure 2.101: Semana santa in Granada.

Figure 2.102: Semana santa in Granada.

Figure 2.103: Semana santa in Granada.

Figure 2.104: Semana santa in Granada.

Figure 2.105: Semana santa in Granada.

Traditional dress

Colourful dresses, special headdresses, and fans are Spanish tradition (Figures 2.106–2.109).

Figure 2.106: Traditional dress in feasts.

Figure 2.107: Traditional dress in feasts.

Figure 2.108: Traditional headdress.

Figure 2.109: Typical hand fans for ladies.

Flamenco dance

Flama in Spanish means flame, and "enco" is a suffix which means pertaining-to. Flamenco dance (Figures 2.110–2.111) has its beginnings in the 18th century.

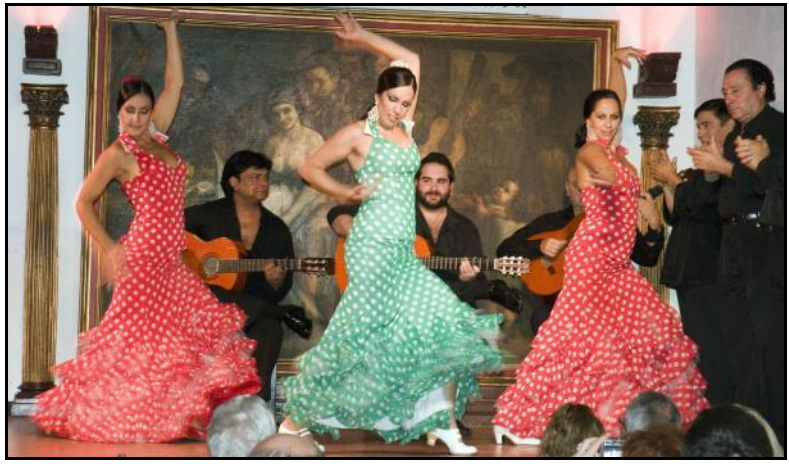


Figure 2.110: Flamenco dance.

Figure 2.111: Flamenco dance.

Bullfighting

Bullfighting (Figures 2.112–2.113) is a cruel blood sport. However, Spaniards consider it an exciting test of bravery, skill, and grace. It is believed that it was introduced into Hispania by the Emperor Claudius, as a substitute for gladiators, when he instituted a short-lived ban on gladiatorial combat.

Figure 2.112: Bullfighting.

Figure 2.113: Bullfighting.

Chapter 3

Portugal

Historical Introduction 76
- **Colonies** 83
- **Lisbon earthquake** 84

Portuguese Science and Technology 86
- **University of Coimbra** 87
- **Brazil** 87

Transfer of the Seat of Empire 88
- **Portuguese scholars** 88
- **Cork** 89
- **Modern Portugal** 91

Lisbon 91
- **São Jorge Castle** 105
- **Lisbon's Water Aqueduct** 105
- **Royal Coach Museum** 107
- **Maritime Museum** 108
- **Military Museum** 109
- **City of Lisbon Historical Museum** 110
- **Gulbenkian Museum** 110
- **Société Anonyme de Produits et Engrais Chimiques** 115
- **Química de Portugal** 116
- **Instituto Superior Técnico** 117
- **Instituto Nacional de Engenharia e Tecnologia Industrial** 117
- **Universidade Nova de Lisboa** 120

Évora 121

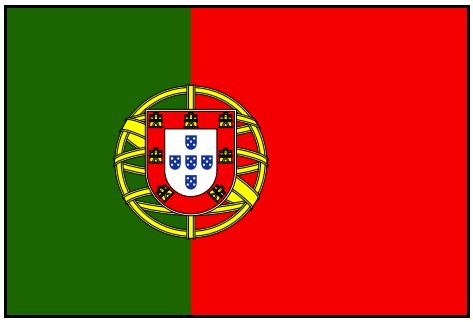


Figure 3.1: Flag of Portugal.

HISTORICAL INTRODUCTION

Modern Portugal was inhabited by the Lusitanians before the Roman occupation in 139 BC. Later, the Visigoths invaded the region and the population was Christianized. Moslem rule came with the Moors from North Africa in 711 AD. During their occupation, the Moors introduced many agricultural products such as sugar cane, olives, oranges, and others. Portugal became part of Spain until Afonso Henriques (1109–1185) (Figure 3.4) declared himself King in 1147 after his victory over the Arabs. In 1255, Lisbon became capital of the kingdom.

Figure 3.2: Portugal and her neighbours.

Figure 3.3: Portugal main cities.

Figure 3.4: Afonso Henriques (1109–1185), first king of Portugal.

A period of instability followed as a result of quarrels related to the inheritance of the throne. King João I (1357–1433) (Figure 3.5) unified his country and his son Prince Henrique the Navigator (1394–1460) (Figure 3.6) developed a new type of ships known as the caravel that was capable of sailing in stormy seas at high speeds. Prince Henry founded a naval arsenal, an observatory, and the first school for the study of geography and navigation in Europe. He created better charts, improved ship-board instruments as the compass, the astrolabe, and the quadrant. He also compiled more detailed astronomical tables. His purpose was to extend Portuguese trade and spread Christianity.

Figure 3.5: King João I (1357–1433).

Figure 3.6: Prince Henrique the Navigator (1394–1460).

Early caravels had an overall length of 15 to 30 m and narrow ellipsoidal frame, their bows lifted to on-coming waves and their high sterns prevented them being swamped from behind. making them fast and manoeuvrable. They were easier to navigate, with 1 to 3 masts, with triangular sails. The caravel could sail upriver in shallow coastal waters. The limited capacity for cargo and crew were their main drawbacks, but did not hinder its success.

After the fall of Constantinople in 1453 into the hands of the Turks and their threatening to invade eastern Europe, the kings of Portugal considered themselves responsible to defend the Christian faith, and their flag with a large cross became the symbol of Christianity (Figure 3.7).

Figure 3.7: A Portuguese caravel carrying the flag of the empire that was the symbol of Christianity.

In 1488, Bartholomeu Dias (1451–1500) (Figure 3.8) reached the Cape of Good Hope, proving that the Far East was accessible by sea. In 1498, Vasco da Gama (1469–1524) (Figure 3.9) reached the west coast of India, Pedro Álvares Cabral (1460–1526) (Figure 3.10) discovered Brazil, and Ferdinand Magellan (1480–1521) (Figure 3.11) discovered the Philippines. By the middle of the sixteenth century the Portuguese Empire reached its zenith. The Empire was based mainly on the trade of gold, ivory, slaves from Africa, and spices from Asia until gold and diamonds were discovered in Brazil.

Torre de Belém (Figures 3.12–3.13), a symbol of the Portuguese Empire, stands today at Belém, a suburb of Lisbon. It was built to be a fortress and a prison during the reign of King Manuel I (1469–1521). It was from there that Portuguese explorers sailed off across unknown seas in their search of new lands. In 1960, another monument was erected, also in Belém, on the occasion of the 500th anniversary of the death of Prince Henrique. The "Monument to the Discoveries" shows the Prince leading a group of important persons (Figures 3.14–3.15).

Figure 3.8: Bartholomeu Dias (1451–1500).

Figure 3.9: Vasco Da Gama (1469–1524).

Figure 3.10: Pedro Álvares Cabral (1460–1526).

Figure 3.11: Ferdinand Magellan (1480–1521).

Figure 3.12: Torre de Belém.

Figure 3.13: Torre de Belém.

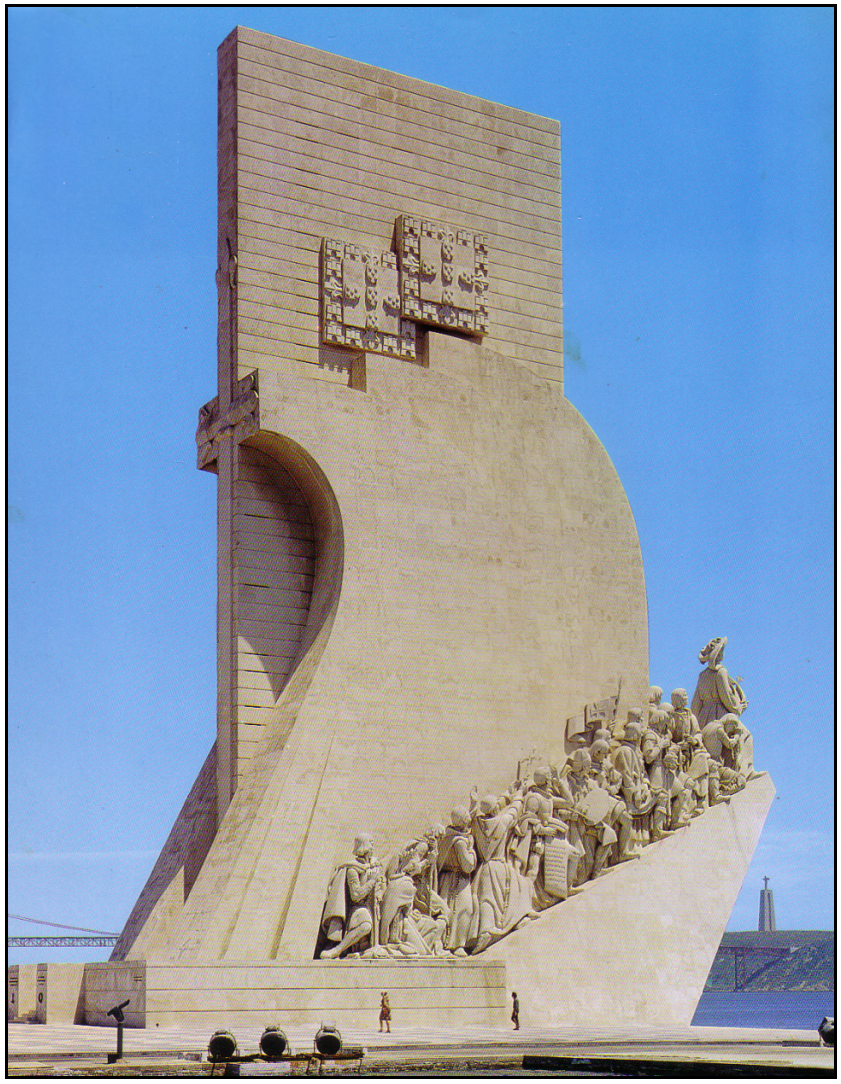


Figure 3.14: Monument to the discoveries in Belém.

The empire suffered a decline when King Sebastian was defeated and killed during his campaign in support of a Berber leader against another in Morocco at the battle of Al Kasr Al Kabir (Alcazarquivir) in 1578 [*see* Morocco]. Two years later, Philip II of Spain exploited the situation and invaded Portugal and kept her captive for 60 years. During this period, the Spanish Inquisition laws were applied and Portugal lost many intellectuals and craftsmen. The revolution of 1640 ended the sixty-year period of dual

monarchy in Portugal and Spain under the Spanish Habsburgs and the Portuguese dynasty was restored with the help of the British. Dutch, English, and French competitors began to seize many of Portugal's colonies.

Figure 3.15: Details of monument to the discoveries in Belém with Prince Henrique the Navigator leading.

During the 1700s there was, once again, a brief time of prosperity in Portugal with the resources of Brazil supplying the wealth. However, in 1775 Lisbon was almost completely destroyed by an earthquake and this was followed by the Napoleonic occupation of the country in 1807. The Royal family migrated to Brazil when this occupation was eminent.

In the first half of the 19th century, Portugal was distinguished by dynasty quarrels. King Carlos and his heir were shot dead in 1908. The new king, Manuel II, was driven from the throne in the revolution of 1910 and the country was proclaimed a republic. The Portuguese Republic retained her colonies in Africa in spite of a draining economy due to fighting the national liberation movements. It was only after the military coup of 1974 that the remaining overseas colonies in Africa were granted independence.

Colonies

The Portuguese Empire started in 1415 and ended in 1976. The Empire included colonies in Africa, Asia, and South America. A large number of slaves from Africa were transported to the South American colony to work in agriculture and in the mines (Figure 3.16).

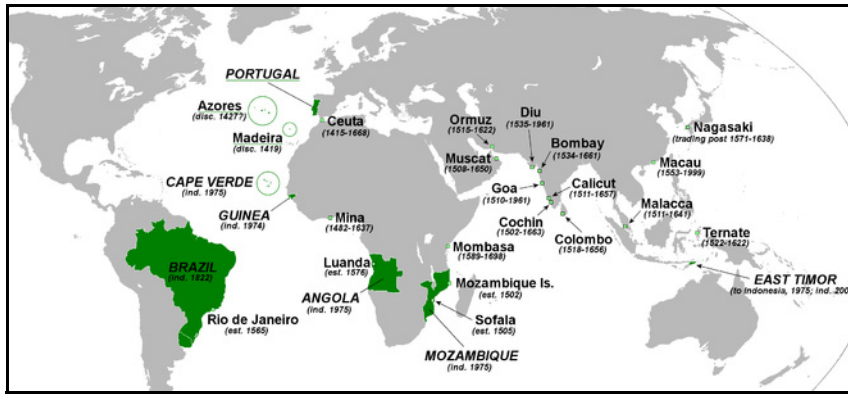


Figure 3.16: Former Portuguese colonies.

Lisbon earthquake

A violent earthquake shook Lisbon on November 1, 1755 in the morning. It was one of the most destructive and deadly earthquakes in history, killing between 60 000 and 100 000 people. The catastrophe struck on a Catholic holiday and destroyed almost every important church. The earthquake disrupted the country's colonial ambitions. Prime minister Sebastião de Melo (1699–1782) known today as Marquis of Pombal, immediately began organizing the recovery and reconstruction.

Melo studied at the University of Coimbra and then served briefly in the army. In 1738, he was appointed ambassador to Great Britain, in 1745 ambassador to Austria, and in 1755 Prime Minister. Impressed by English economic success, he successfully implemented similar economic policies in Portugal. He abolished slavery in the Portuguese colonies in India, reorganized the army and the navy, and ended discrimination against non-Catholic Christians in Portugal. He created the basis for secular public schools, introduced vocational training, and added departments of mathematics and natural sciences to the University of Coimbra. He also created several companies and guilds to regulate commercial activity. He ruled with a heavy hand, imposing strict laws upon all classes of Portuguese society.

Following the earthquake, King Joseph I gave his Prime Minister even more power, and Melo became a powerful dictator. In 1758, while the Jesuits were trying to protect native Americans in the Spanish and Portuguese colonies, Melo accused them of treason, expelled them in 1759 and confiscated their assets. Portugal was the first country to expel the Jesuits throughout Europe and its colonies, which culminated in 1773, when Pope Clement XIV abolished the order.

Today, Lisbon's most important square and busiest underground station is named in his honour. There is an imposing statue of the Marquis in the square as well (Figures 3.17–3.18).

Figure 3.17: Statue of Marquis of Pombal in Lisbon.

Figure 3.18: Marquis of Pombal on the top of his monument.

PORTUGUESE SCIENCE AND TECHNOLOGY

The trade of spices from the East was most profitable. Portugal itself is the world's largest producer of cork — the protective tissue of dead, impermeable cells formed by cork cambium (phellogen). It is periodically stripped from the trunks of the cork oak for commercial use. The rulers of the Empire favoured importing everything that could not be found in the country and were not concerned with developing a local industry and in this way they ignored science and technology.

University of Coimbra

The University of Coimbra, (Figure 3.19), the first university in Portugal, was founded in 1290 by King Dinis in Lisbon and was composed of the Faculties of Arts, Law, Canon Law and Medicine. In 1308, however, it moved to Coimbra, returned to Lisbon a number of times, but in 1537, during the reign of João III, the university moved definitively to Coimbra.

Figure 3.19: University of Coimbra.

In the 18th century, the Marquis of Pombal made radical reforms in the University, especially regarding the teaching of sciences, in accordance to his Enlightenment and anticlerical creed. During many decades it was the only university in Portugal, until 1559 (a university in Évora operated between 1559 and 1759), and again between 1759 and 1911 (University of Lisbon and University of Porto were created in 1911). The only Portuguese Nobel Prize winner was Egas Moniz (1874–1955) in Medicine in 1949. Chemistry was first taught at the University of Coimbra in 1772 and in Rio de Janeiro in 1920.

Brazil

With the discovery of Brazil in 1500 a new market for the so-called brazilwood came into existence — a bright red wood of genus Caesalpinia became popular for cabinet work but also for the extraction of a red dye. The logs were rasped to a coarse powder, moistened with water and allowed to ferment for weeks. The water extract gave bright red colour with fabrics mordanted with aluminum or tin salts. The colouring principle of brazilwood was isolated by the French chemist Michel Eugène Chevreul in the 19th century, who called it brazilin.

Between 1532 and the 1700s, sugar cane and tobacco plantation were introduced in the north of Brazil by Christianized Jews from southern Por-

tugal, utilizing slaves from Portuguese African colonies. The country became the largest sugar producer in the world but the industry soon declined because of lack of innovation, and competition with more efficient plantations in the Caribbean islands. Iron production started in 1591 from local ores in the São Paulo region at the rate of about 100 kg daily. In 1693 gold was discovered in Ouro Preto. The first mint in Brazil was installed in Bahia in 1695. Production of gold, however, declined due to exhaustion of the mines in the 1780s. In 1729, diamonds were discovered and Brazil became an important producer.

TRANSFER OF THE SEAT OF EMPIRE

In 1808, the Portuguese royal family, who was driven out of Portugal by Napoleon, made Rio de Janeiro capital of the Portuguese Empire. This imposed the creation of several institutions, including educational and scientific ones. In 1821, King João VI returned to Portugal leaving his son Dom Pedro as regent of Brazil. In 1822, quarrels with the Portuguese government led Dom Pedro to proclaim Brazil's independence as Pedro I. In 1831 he abdicated in favour of his son Pedro II (1825–1891) returned to Portugal, and succeeded in deposing his brother from the throne. In 1888, Pedro II abolished slavery. However, under pressure from powerful land owners who lost due to the abolition of slavery, he abdicated (General Fonseca's ultimatum) and Brazil proclaimed a republic in 1889.

Ouro Preto was founded in 1698 as a mining settlement when gold was discovered there and within a decade it became the centre of the greatest gold and silver rush in the Americas. Almost two tons of gold were sent from there to Portugal each year. It became the capital of the Portuguese colony and Rio de Janeiro flourished into a major port to serve the capital. In 1875, the Brazilian Geological Survey was founded and a year later, the emperor Pedro II inaugurated the first School of Mines in Brazil.

Portuguese scholars

During the reign of Queen Maria I (1777–1816) and under the influence of her British allies and Army Chief William Carr (Viscount Beresford), the creation of industry in Brazil, based on local raw materials, was prohibited in 1785 so that Portugal and England could sell their manufactured products there. This naturally hampered the development of the metallurgical and chemical industries. However, in 1790, as a result of the development in the mining industry, the Portuguese government sent three graduates from the University of Coimbra to visit the main mining centres in Germany, France, Bohemia, and Hungary for a period of ten years. On their return, they were immediately appointed in the administration of the Empire.

One of these scholars was the Brazilian mineralogist José Bonifácio de Andrade e Silva (1763–1838), who was appointed in 1800 as the first professor of metallurgy at the University of Coimbra. There he described two new minerals, which he called petalite and spodumene. It was from these minerals that the Swedish chemist Johan Arfwedson discovered lithium in 1818. After returning to Brazil in 1819 he was appointed Minister of State.

The lack of qualified personnel in the growing iron industry was deeply felt. In 1803, German technicians were hired to examine the newly discovered coal mines in Brazil. In the 1800s, coffee plantations were introduced in the São Paulo region, and from the 1850s to the early 1900s, natural rubber in the Amazon valley.

Cork

Cork (Figures 3.20–3.23) is the bark tissue that is harvested from *Quercus suber* (the Cork Oak). It is composed of a hydrophobic substance, and because of its impermeability, buoyancy, elasticity, and fire resistance, it is used for wine stoppers. It is also a great acoustic insulating material. Portugal produces approximately 50% of cork harvested annually worldwide. Once the trees are about 25 years old the cork is stripped from the trunks every nine years. The trees live for about 200 years.

Figure 3.20: Removing cork from trees.

Figure 3.21: Cork harvest.

Figure 3.22: Cork for wine bottles.

Figure 3.23: Sheets of cork for acoustic insulation.

Modern Portugal

In 1910, there was a revolution that deposed the monarchy. Amid corruption, repression of the church, and the near bankruptcy of the state, a military coup in 1926 installed a dictatorship that remained until another coup in 1974 that ended the rule of António de Oliveira Salazar. The new government instituted sweeping democratic reforms and granted independence to all of Portugal's African colonies in 1975. Macau was returned to Chinese sovereignty in 1999. After a referendum in 1999, East Timor voted for independence after being attacked by Indonesia.

Table 3.1: Visits to Portugal.

Dates	Cities visited	Purpose of visit
May 2–7, 1981	Lisbon	Instituto Superior Técnico
	Setúbal	Société Anonyme de Produits et Engrais Chimiques
	Barreiro	Química de Portugal
	Sacavem	Laboratório Nacional de Engenharia e Tecnologia Industrial [LNETI]
July 7–15, 1984	Lisbon	Sociedade Portuguesa de Química 7. Encontro Anual
	Sacavem	Laboratório Nacional de Engenharia e Tecnologia Industrial [LNETI]
	Évora	Cultural visit
October 1–8, 1987	Lisbon	Laboratório Nacional de Engenharia e Tecnologia Industrial [LNETI]
June 1–6, 1996	Sacavem	Instituto Nacional de Engenharia e Tecnologia Industrial [INETI]
	Évora	Cultural visit

LISBON

Lisbon (Figures 3.24–3.46) is one of the oldest cities in the world, predating other modern European capitals such as London, Paris, and Rome by hundreds of years. It was captured by the Moors in the 8th century. In 1147, it was re-conquered by the Crusaders and since then it has been a major political, economic, and cultural centre of Portugal.

Figure 3.24: Lisbon and Belém.

Figure 3.25: Lisbon and her surroundings.

Figure 3.26: Lisbon Metro.

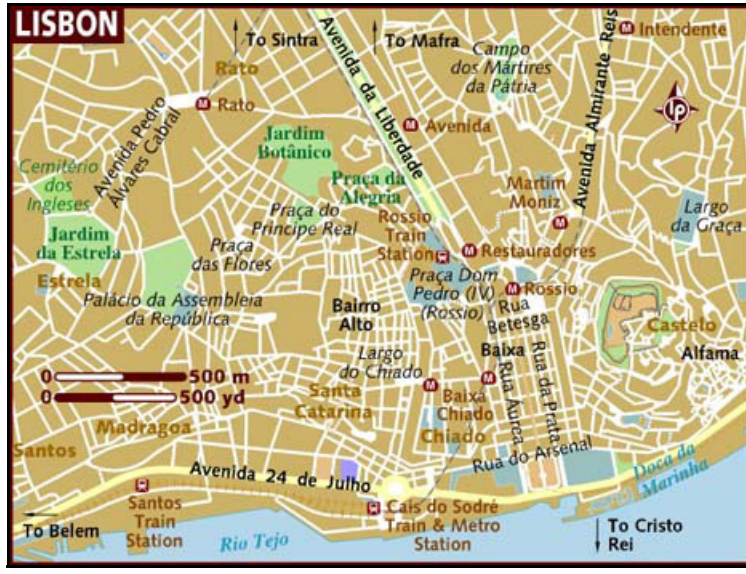


Figure 3.27: Map of Lisbon showing Rossio, the Castle, and Alfama, the oldest district of Lisbon.

Figure 3.28: Downtown Lisbon: Rossio Square at the top and Commerce Square at the bottom of the map.

Figure 3.29: April 25 Bridge [referring to April 25, 1974 when the dictatorship was reversed] connecting the city of Lisbon to the municipality of Almada on the left (south) bank of the Tejo River.

Figure 3.30: Funicular.

Figure 3.31: Torre de Belém near Lisbon, 1996.

Figure 3.32: Jerónimos Monastery in Belém.

Figure 3.33: Jerónimos Monastery details.

Figure 3.34: Rua Augusta leading to Commerce Square.

Figure 3.35: Commerce Square.

Figure 3.36: Gate to Commerce Square.

Figure 3.37: Monument of King José I in Commerce Square.

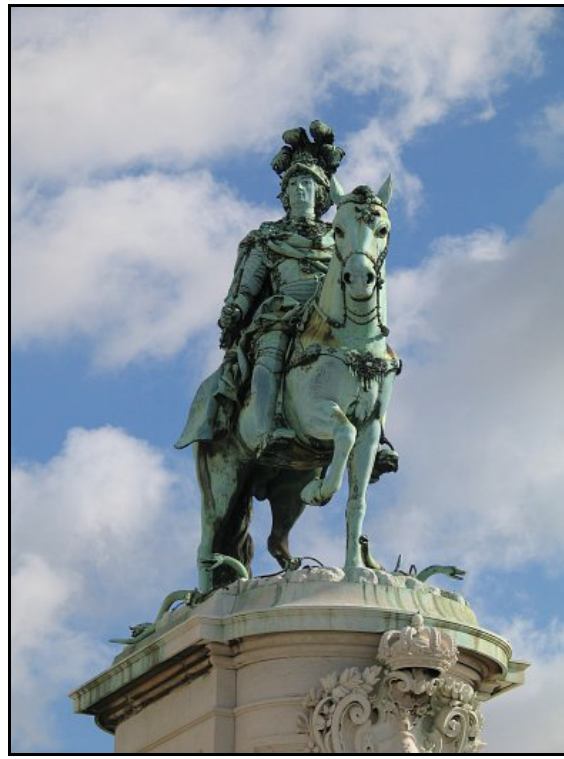


Figure 3.38: King José I (1714–1777) in Commerce Square. It was during his reign that the earthquake of 1755 took place.

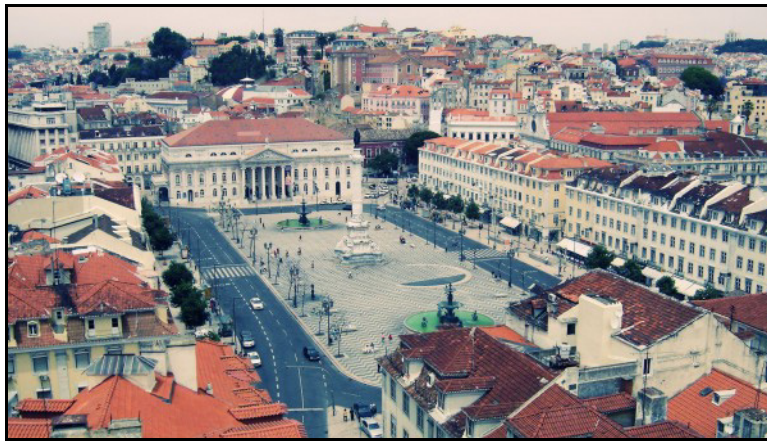


Figure 3.39: Rossio Square with monument of Pedro IV in front of the theatre.

Figure 3.40: Monument to Pedro IV (1798–1834) King of Portugal and as Emperor Pedro I of Brazil in Rossio Square.

Figure 3.41: Pedro IV in Rossio Square.

Figure 3.42: Camões Square named after Portugal's most honoured poet Luis de Camões (1524–1580).

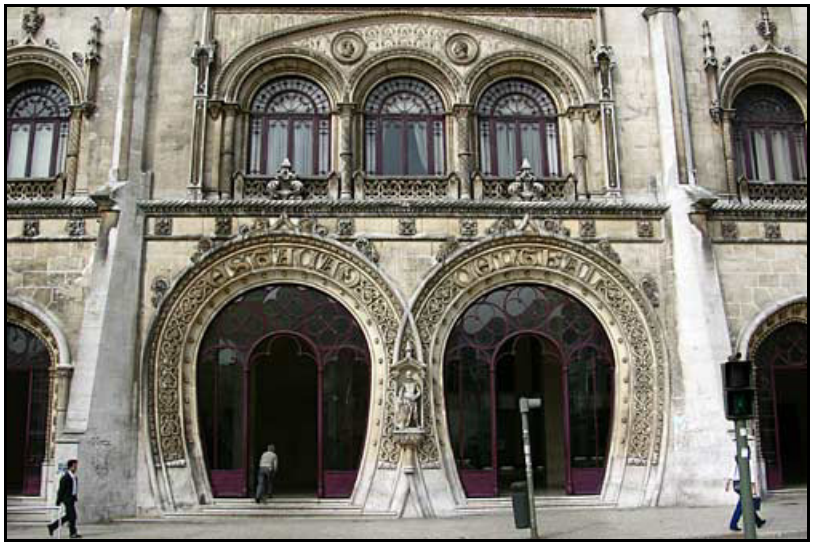


Figure 3.43: Entrance to Rossio railway station.

Figure 3.44: Bull fight arena.

Figure 3.45: A street in Alfama, the oldest district of Lisbon.

Figure 3.46: A street in Alfama, the oldest district of Lisbon.

São Jorge Castle

The Castle of São Jorge (Figures 3.47–3.48) is a Moorish castle overlooking the city and the Tagus River, located on top of the highest hill in the historic centre of the city. It is now a tourist attraction with restaurants and gift shops.

Lisbon's Water Aqueduct

A system of water supply from the era of King João V in 1732 and was concluded in 1834 (Figure 3.49). The water destined to supply the new network of fountains was conducted from the springs, located near Sintra. The arcade of 941 m long, 65 m high, and 29 m wide is not functioning since the 1960s.

Figure 3.47: Castle of São Jorge.

Figure 3.48: Castle of São Jorge.

Figure 3.49: Lisbon's aqueduct.

Figure 3.50: Royal Coach Museum.

Royal Coach Museum

The museum (Figures 3.50) is housed in the old Horse Riding Arena, formerly a Royal Palace which is now the official residence of the President

of Portugal. The collection gives a picture of the development of carriages from the late 16th through the 19th centuries.

Maritime Museum

The museum (Figures 3.51–3.53) is dedicated to all aspects of the History of navigation in Portugal with models of famous ships.

Figure 3.51: Marine Museum.

Figure 3.52: Marine Museum.

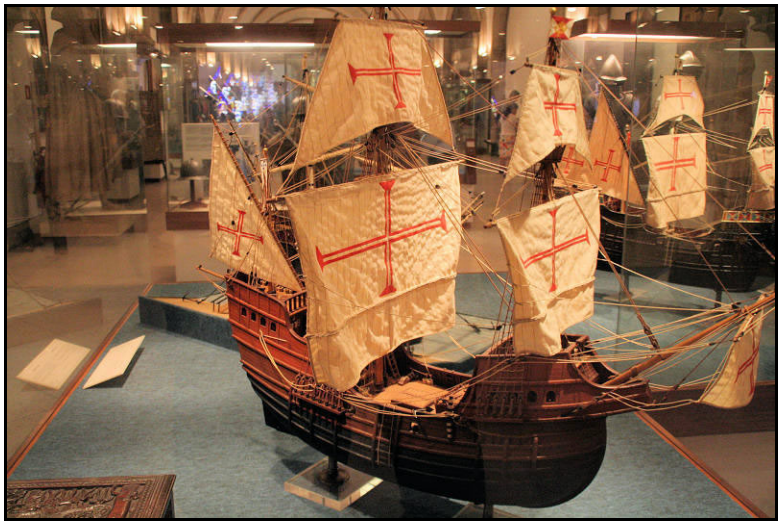


Figure 3.53: The Caravelle.

Military Museum

The museum (Figures 3.54–3.55) contains a large exhibition of weapons, uniforms and military historical documents.

Figure 3.54: Military Museum.

Figure 3.55: Military Museum.

City of Lisbon Historical Museum

The museum has a large model of Lisbon before the historic 1755 earthquake.

Gulbenkian Museum

Calouste Gulbenkian (1869–1955) (Figure 3.56) was born in İstanbul, he received an engineering degree from King's College in London. At age 22, he wrote a book on the management of petroleum resources, which came to the attention of the Turkish minister in charge of the oil fields of the Ottoman Empire. Gulbenkian engineered the creation of the Turkish Petroleum Company and set up a consortium between the Anglo-Persian Oil Company, Royal Dutch Shell, and Deutsche Bank. He became an extremely wealthy person.

He resided in Lisbon and was also an avid collector. He began collecting Greek and Roman coins in early boyhood and then expanded his activities in the early 1920s. Soon no museum or private collector could match his resources, determination, and his connoisseurship. Gulbenkian's executors funded the Gulbenkian Foundation in Lisbon with an endowment of $2.6 billion and an annual budget of $102 million. Housed in a palace-like structure, and set in a 17-acre park filled with a permanent sculpture display and a children's art centre, the foundation holds about 6 800 artefacts (Figures 3.57–3.65).

Figure 3.56: Calouste Gulbenkian (1869–1955).

Figure 3.57: Gulbenkian Museum in Lisbon.

Figure 3.58: Gulbenkian Foundation in Lisbon.

Figure 3.59: Ancient Egyptian statues.

Figure 3.60: Chinaware.

Figure 3.61: Chinaware.

Figure 3.62: Sculpture.

Figure 3.63: Mosque lamp.

Figure 3.64: Sculpture.

Figure 3.65: Artefacts.

Société Anonyme de Produits et Engrais Chimiques

Société Anonyme de Produits et Engrais Chimiques, known as SAPEC (Figure 3.66), is a Belgian company operating in Portugal since 1926. The company mines pyrite, roast it in multiple hearth furnace, makes sulfuric acid in lead chambers, produce phosphoric acid, ammonium phosphate, and ammonium sulfate from imported phosphate rock and ammonia. Pyrite cinder was treated at Química de Portugal in Barreiro [see below] but now shipped to China. Host: Carlos Martins Carreiro, Director of Research, a veteran of Mozambic War. Francisco Leal Gonsalves [Director General], M. Masson [plant Manager], M. Rolo [Superintendent].

Figure 3.66: SAPEC harbour.

Sulfuric acid is produced by the chamber process. In one unit producing 160 t/day acid, there are 24 small and 4 large chambers all are empty. In the other unit producing 120 t/day acid (the Kachkaroff Unit) there are 4 chambers: 2 filled with Raschig rings, 1 empty and 1 half filled. The plant operation is very inefficient. Roasting is interrupted often because of sticking of pyrite (temperature of roasting 800 °C). The agglomerated lumps are rejected. The cinder produced is small hard lumps and not a fine powder. Intense NO_2 gas is emitted at the stack. This comes from 600 kg/day NH_3 used in the chambers. The acid produced contains 1 g/L N_2O_3.

Phosphoric acid is produced by counter-current contact of phosphate rock with sulfuric acid in 8 reactors. Temperature controlled during the dissolution of the rock at 70 °C. This is done by cooling in the last two reactors. Nalcool flocculant is added during the digestion. This results in increased purity and larger size of product (diammonium phosphate).

H_3PO_4 is neutralized with ammonia gas at 60 °C (cooling is necessary) till pH 7.4 to form diammonium phosphate. The crystals are centrifuged and the mother liquor recycled. The crystals are relatively large and white as compared with the grey and small ones produced when no flocculent was added during digestion.

Química de Portugal

Química de Portugal is the largest chemical enterprise in Portugal, abbreviated Quimigal (Figure 3.67). It was nationalized on December 30, 1977 (after the revolution), and was the result of a merger of three enterprises. Total number of employees is about 9 000. The Barreiro plant is the largest with about 6 000 employees. It is an integrated industrial complex where the waste product of one plant is used as a raw material for another.

A unique operation there is the production of sulfuric acid from pyrite and the treatment of the cinder by two different processes to recover the nonferrous metals and the iron oxide. The two processes are:

- Duisburger Kupferhütte process: Roasting with NaCl then leaching.
- Kowa-Seiko process: Agglomeration with $CaCl_2$ then sintering at 1 250 °C to volatilize the nonferrous metals.

About 340 000 tons cinder are treated annually. Engineer in charge: Rui Manuel Campos de Motta Guedes.

Figure 3.67: Quimigal, Barreiro.

Instituto Superior Técnico

Prof. Helena Bastos at the Department of Metallurgy is working on hydrometallurgy. She spent a year with Prof. René Winand in Bruxelles; she is presently assisted by Mme Maria Lucelinda Cunha and Mme Fernanda Margerido. In 1984 I was invited to give a Plenary Lecture at the 7th Annual Meeting of the Portuguese Chemical Society organized by members of the Institute (Figure 3.68).

Instituto Nacional de Engenharia e Tecnologia Industrial

The Institute (Figure 3.69) originated from the National Laboratory of Industrial Engineering & Technology (LNETI) created in 1977 to absorb the services of R & D of the former Board of Nuclear Energy [established in 1954] and the former National Institute of Industrial Research [established in 1959] in addition to services for R & D in industry and energy of others departments of public administration. In 1992 it became National Institute of Industrial Engineering & Technology (INETI). In 2004 INETI absorbed the Geological and Mining Institute, changing its name to the National Institute of Engineering, Technology & Innovation (retaining the acronym INETI). Host: Dr. Armando d'Oliveira Sampaio, Director.

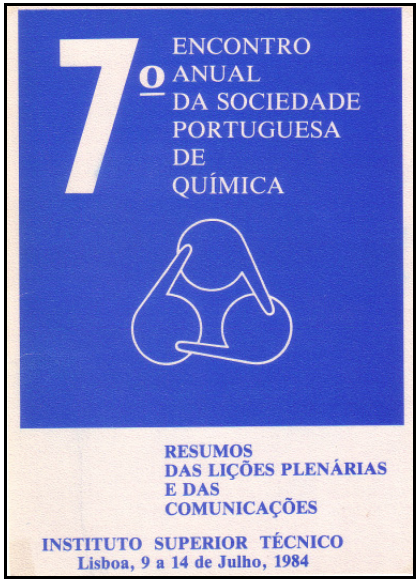


Figure 3.68: Meeting of the Portuguese Chemical Society, 1984.

Figure 3.69: National Laboratory of Industrial Engineering & Technology, 1981.

S R

Ministério da Indústria e Comércio

LABORATÓRIO NACIONAL DE ENGENHARIA E TECNOLOGIA INDUSTRIAL

DEPARTAMENTO DE TECNOLOGIA DE MATERIAIS

TELEX 42486 LNETI P – 1699 LISBOA CODEX · TELS.: 758 2712 - 758 6141 - 758 7211 - 758 9181

CONFERÊNCIA

por

PROF. F. HABASHI

(Univ. de Laval - Canadá)

Dia 6 de Outubro - 10H00 - Kinetics and Mecanisms of Leaching Process

- 15H00 - Precipitation Process in Hydrometallurgy

Dia 7 de Outubro - 14H30 - Energy, Heat Economy and Polution Problems in Extractive Metallurgy

LOCAL: Sala de Reuniões do S.M.E.

Figure 3.70: Announcement for lectures on October 1987.

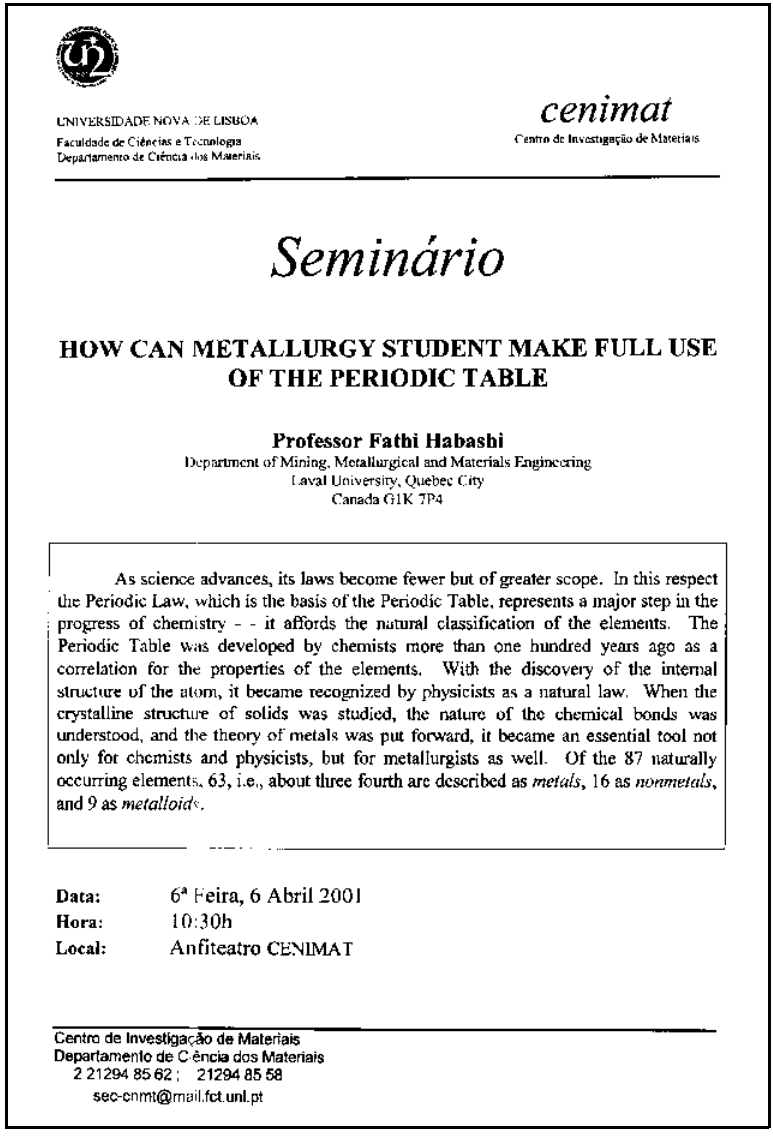
The Extractive Metallurgy Division is composed of 25 people, 14 of them engineers, and 2 with doctorate. Headed by Ing. Francisco Rodrigues (Figure 3.71) and assisted by Herique Casquinha (Figure 3.72). Major projects are: treatment of pyrite and recovery of uranium from phosphoric acid.

Figure 3.71: Dining with Francisco Rodrigues, Director of Mineral Beneficiation Department of LNETI, and wife Antoinette, 2001.

Figure 3.72: In Lisbon with Engineer Henrique Casquinha, 1981.

Universidade Nova de Lisboa

Mme Maria Lucelinda Cunha moved to Universidade Nova de Lisboa (Figures 3.73–3.74).



UNIVERSIDADE NOVA DE LISBOA
Faculdade de Ciências e Tecnologia
Departamento de Ciência dos Materiais

cenimat
Centro de Investigação de Materiais

Seminário

HOW CAN METALLURGY STUDENT MAKE FULL USE OF THE PERIODIC TABLE

Professor Fathi Habashi
Department of Mining, Metallurgical and Materials Engineering
Laval University, Quebec City
Canada G1K 7P4

As science advances, its laws become fewer but of greater scope. In this respect the Periodic Law, which is the basis of the Periodic Table, represents a major step in the progress of chemistry - - it affords the natural classification of the elements. The Periodic Table was developed by chemists more than one hundred years ago as a correlation for the properties of the elements. With the discovery of the internal structure of the atom, it became recognized by physicists as a natural law. When the crystalline structure of solids was studied, the nature of the chemical bonds was understood, and the theory of metals was put forward, it became an essential tool not only for chemists and physicists, but for metallurgists as well. Of the 87 naturally occurring elements, 63, i.e., about three fourth are described as *metals*, 16 as *nonmetals*, and 9 as *metalloids*.

Data: 6ª Feira, 6 Abril 2001
Hora: 10:30h
Local: Anfiteatro CENIMAT

Centro de Investigação de Materiais
Departamento de Ciência dos Materiais
2 21294 85 62 ; 21294 85 58
sec-cnmt@mail.fct.unl.pt

Figure 3.73: Announcement for lecture, 2001.

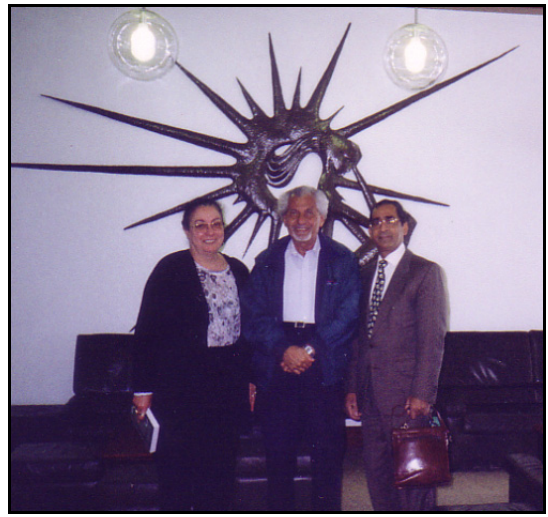


Figure 3.74: Prof. Maria Lucelinda Cunha and husband, 2001.

Évora

Évora (Figures 3.75–3.76) is a UNESCO World Heritage Site, an old Celtic town conquered by the Romans in 57 BC, 140 km east of Lisbon.

Figure 3.75: Roman Temple. From left: Dr. Ibrahim Gaballah [Nancy, France], and host Engineer Francisco Rodrigues [LNETI]. Photo by Nadia Habashi, 1996.

Figure 3.76: Évora, 1996. Photo by Nadia Habashi.

Name Index

A

Abd al-Rahman I 49
Abd al-Rahman III al-Nasir 10, 52
Afonso of Portugal 13
Alfonso X el Sabio 20, 24
Alfonso XII 66
Al-Walid I (Umayyad Caliph) 4
Amadeus of Savoy 15
de Andrade e Silva, José Bonifácio 89
Arfwedson, Johan 89

C

Cabral, Pedro Álvares 79
Calvo y Calvo, Filipe 23
de Camões, Luis 102
Campos de Motta Guedes, Rui Manuel 116
del Carmen Ruiz, María 67
Carr, William 88
Carreiro, Carlos Martins 115
Casquinha, Henrique 119
Catherine of Aragon 13
Charles V 13
Chevreul, Michel Eugène 87
Claudius 74
Clement XIV 84
Columbus, Christopher 13, 27
Cunha, Maria Lucelinda 117, 120

D

Dias, Bartholomeu 79
Díaz Nogueira, Eduardo 23
Drake, Francis 27

E

El Greco 27

F

Ferdinand II of Aragon 12
Ferdinand VII 15
Franco, Francisco 16

G

Gaballah, Ibrahim 66, 121
Gaudí i Cornet, Antoni 58
Gonsalves, Francisco Leal 115
Guilemany, Josep-Maria 24, 61

H

Habsburg 83
Hager, John 66
Henrique the Navigator 78, 83
Henriques, Afonso 76
Henry VIII 13
Heracles 5

I

Iglesias González, Nieves 42
Isabel la Católica 12, 44

J

João I 78
João VI 88
Joseph I 84

K

Kenney, Rick 66

M

Magellan, Ferdinand 79
Maimonides, Moses 49
Manuel I of Portugal 13, 79
Manuel II 83

Margaret of Austria 13
Margerido, Fernanda 117
Maria I of Portugal 88
de Melo, Sebastião 84
Mishra, Brajendra 66
Mohammed ben Al-Ahmar 43
Mohammed I ibn Nasr 43
Moniz, Egas 87
Moral Bieto, Alberto 23

N

Napoleon 88

O

de Oliveira Salazar, António 91
d'Oliveira Sampaio, Armando 117
Otero, J. L. 23

P

Palencias Pérez, Inmaculada 42
Pedro (Dom) 88
Philip II of Spain 14, 16, 23, 82
Philip III 14
Philip the Handsome 13
Philip V 15
Piret, Norbert 66
Pombal (Marquis) 84, 86

Q

de la Quadra Herrera, Antonio 23

R

Rodrigues, Francisco 119, 121
Romero Aleta, Rafael 42

S

Sebastian (King) 82
Sobolev, Viktor 62
Solozabal, Rudolfo 66

T

Tariq ibn-Ziyad 10

W

Winand, René 117

Subject Index

A

Abbasids 10
Acoustic insulation 90
Al Kasr Al Kabir 82
Al-Andalus 10
Alfama 93, 104
Algeciras 2, 27
Alhambra 43
Almohad dynasty 34
Al-wadi al-kabir 33
Ammonium phosphate 115
Ancient Egyptian statues 112
Andalusia 68
Anglo-Persian Oil Company 110
Anglo-Spanish War 14
Aragon 12
Archaeological Museum 31
Archivo General de Indias 39
Art gallery 55
Asturias 15
Aswan Dam 22

B

Barcelona Castle 54
Barreiro 115
Barreiro plant 116
Basque Country 61
Battle of Trafalgar 15
Bay of Biscay 61
Belém 79
Boughaz 4
Brazilian Geological Survey 88
Brazilin 87
Brazilwood 87
Bull fight arena 103
Bullfighting 74

C

Cádiz 27, 29
Caliphate of Córdoba 10
Calvinist leadership 14
Cámara Obscura 32
Camões Square 102
Cape of Good Hope 79
Carthage 27
Casa Lonja de Mercaderes 39
Castile 12
Catalan language 52
Catalonia 15, 52
Caucasian languages 61
CENIM 23
Centro Nacional de Investigaciones Metalúrgicas 23
Ceuta 5
Chinaware 113
City Hall 63
Coffee plantations 89
Commerce Square 98
Complutense University 23
Constantinople 78
Convention Centre 64
Córdoba 49
Cork 89
Customs House 55

D

Donostia 61
Duisburger Kupferhütte process 116

E

East Timor 91

Egyptian temple 22
Escorial 23
Évora 87, 121

F

Fall of Constantinople 78
Fans 73
Fonseca's ultimatum 88
Funicular 95

G

Gaudí building 58
Gibraltar Airport 1
Giralda 39
Gladiators 74
Gold and silver rush 88
Granada 10, 43, 68
Great plague 14
Guadalquivir river 33
Guanajuato 13
Gulbenkian Museum 110

H

Headdress 72

I

Ibero-American Exposition 35
INETI 117
Instituto Nacional de Engenharia e Tecnologia Industrial 117
Instituto Superior Técnico 117
Intellectual centre of Europe 49
International Brigades 16
Isabel La Católica Street 40

J

Jerónimos Monastery 97
Jesuits 84
Junta de Energía Nuclear 23

K

Kingdom
  Aragon 52
  Asturias 10
  Castile 5
Kowa-Seiko process 116

L

La España de los Metales 23
Lead ingots from Phoenician time 31
Lisbon 91
  aqueduct 107
  earthquake 84
Lisbon Historical Museum 110
Lisbon Metro 93
Lithium 89
LNETI 117
Lusitanians 76

M

Macau 91
Manzanares river 16
Maritime Museum 108
Medina Azahara 52
Military Museum 109
Monument
  Cervantes 18
  Christopher Columbus 55
  King José I 100
  Pedro IV 101
  Queen María Christina of Austria 66
  to the Discoveries 79
Moors from North Africa 10, 76
Most populous city in the world 49
Mozambic War 115
Museum of the Americas 21

N

Nasrid dynasty 43
National Archaeological Museum 19
Natural rubber 89
New World 13

O

Old Tobacco Factory 41
Ouro Preto 88

P

Petalite 89
Philippines 79
Plaza de España 18, 35
Port of Barcelona 57
Portuguese caravel 79
Portuguese Chemical Society 117
Portuguese Republic 83
El Prado 17
Puerta Bisagra 25
Pyrite cinder 115

Q

Química de Portugal 115, 116

R

Reconquista 12
Red dye 87
REWAS 66
Rio de Janeiro 88
Rossio railway station 103
Rossio Square 94, 101
Royal Coach Museum 107
Royal Dutch Shell 110
Rua Augusta 98

S

Sagrada Família 58
Salinity of the Mediterranean 6
San Sebastián 61
São Jorge Castle 105
São Paulo 88
SAPEC 115
Semana santa 68
Seville 33
Sierra Nevada mountains 43
Sintra 105
Slavery in Portuguese colonies 84
Spanish Armada 14, 27
Spanish Empire 13
Spanish Inquisition 82
Spodumene 89
Statue of Marquis of Pombal 85
Sugar cane 87
Sulfuric acid in lead chambers 115
Symbol of Christianity 79

T

Tagus River 105
Taifa Kingdoms 10
Tajo River 27
Tangier 6
  to Gibraltar 4
Tariq ibn Ziyad 4
Técnica Reunidas 23
Tejo River 95
Tobacco 87
Toledo 16, 24
Torre
  de Belém 79, 96
  del Oro 34
  Tavira 32
Toulouse 10
Trade of spices 86
Traditional dress in feasts 71
Tulaytulah 24
Turkish Petroleum Company 110

U

Umayyad Caliphate 10
UNESCO World Heritage Site 121
Universidade Nova de Lisboa 120
University
  Barcelona 60
  Coimbra 84, 87
  Seville 41

V

Visigoth Church of San Vicente 49
Visigothic Hispania 4
Visigoths 9, 76

W

World War I 15