

Fathi Habashi

My Trips in the Low Countries



2015

My Trips in the Low Countries

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.

© 2015 by Fathi Habashi. All rights reserved

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.infinet.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-xx-x

Fathi Habashi, *My Trips in the Low Countries*.

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

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

No part of this book may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and recording, or by any information storage or retrieval system, without written permission by the publisher.

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. Introduction	1
2. Belgium	4
3. Netherlands	43
Name Index	59
Subject Index	61

Chapter 1

Introduction



Figure 1.1: Flag of Belgium.



Figure 1.2: Flag of Netherlands.

In the Middle Ages, the Low Countries were a number of independent states (Figure 1.3). The Dukes of Burgundy were able to unite 10 of the 17 territories while others, such as the bishoprics of Liege and Utrecht, were ruled by pro-Burgundian bishops. The Burgundian Dukes established their court at Brussels, a parliament at Mechelen, and a university at Leuven (1425). They established the Order of the Golden Fleece to tie nobility of the Low Countries and of neighbouring territories to the House of Burgundy.

The Southern Netherlands was one of the most urbanized regions of Europe. Gent¹, Brugge², and Ieper³ were large wealthy cities because of a flourishing textile industry. They were however dependent on wool imported from England. The Flanders, Zeeland, and Holland were dominated by few families dealing in far-distance trade. In 1477 Charles the Bold died and his daughter Margaretha married Maximilian (Figure 1.4), son of Holy Roman Emperor Frederick III (1415–1493)⁴. Their son Charles, raised at the court in Brussels, was to inherit the Burgundian and the Habsburgian territories, Spain, Hungary, and the Bohemian lands and became Charles V (Figure 1.5).

¹ In English Ghent, in French Gand.

² In French Bruges.

³ In French Ypres.

⁴ Was Duke of Austria as Frederick V from 1424, the successor of Albert II as German King as Frederick IV from 1440, and Holy Roman Emperor as Frederick III from 1452. He was born in Innsbruck.

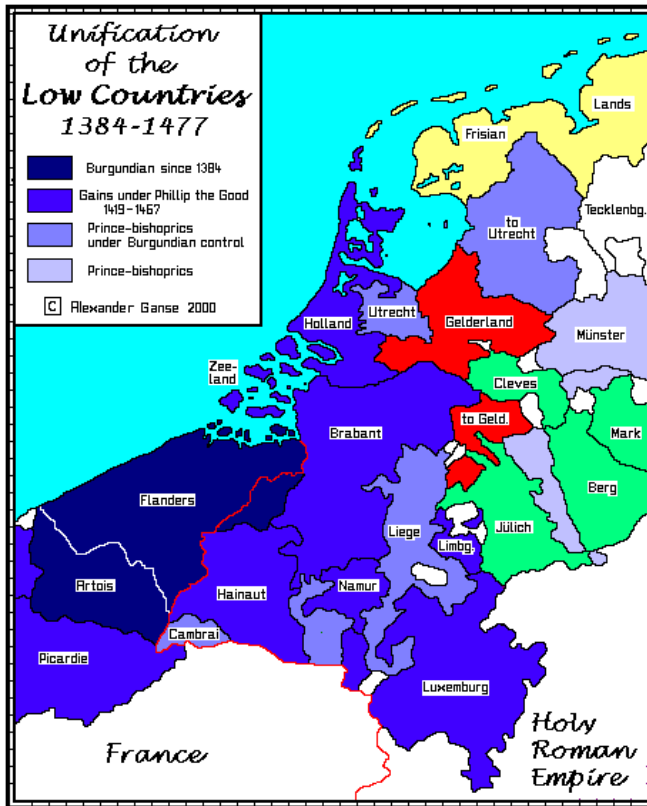


Figure 1.3: The Low Countries before unification.

In 1477 the rule of the Austrian began and in 1506 the Netherlands was inherited by the future Habsburg Emperor and King of Spain Charles V. In 1555, the Dutch rebelled against Philip II of Spain because of the imposition of new taxes and the religious persecution of Protestants by the Spanish Inquisition. The revolt escalated into the Eighty Years' War, which ultimately led to Dutch independence. In 1578 Amsterdam abandoned the Spanish and Catholic cause and Calvinists took over. Public Catholic worship was outlawed and churches were confiscated.

The Dutch Republic became known for its religious tolerance. Jews from the Iberian Peninsula, Huguenots from France, prosperous merchants and printers from Flanders, and economic and religious refugees from the Spanish-controlled parts of the Low Countries found safety in Amsterdam. The influx of Flemish printers and the city's intellectual tolerance made Amsterdam a centre for the European free press.

After the French Revolution French troops occupied Holland in 1795 and established the Batavian Republic. In 1813 The Netherlands regained independence and became the Kingdom of the Netherlands headed by Willem I of the House of Oranje-Nassau.



Figure 1.4: Maximilian I.



Figure 1.5: Young Charles V.

Chapter 2

Belgium

Brussels	7	Antwerp	31
Solvay conferences on physics	8	Ghent	31
Africa Museum	12	Metal industry in Belgium	34
Université libre de Bruxelles ..	12	Zinc and Cadmium	36
European Parliament	13	Copper	38
Berlin Wall fragment	18	Germanium	38
Atomium	18	Cobalt	39
Cathedral	20	Radium	40
Waterloo	20	Uranium	41
Erasmus House	27	Lead	41
Liège	27	Tin	41
Leuven	29	Manganese	42
Mechelen	31	Iron and Steel	42

In 1830, nine provinces broke away from the Kingdom of the Netherlands and formed the Belgian State (Figure 2.1). The German Prince Leopold of Saxe-Coburg who was Queen Victoria's uncle was elected as King. A few years later, his son King Leopold II (1835–1909) (Figure 2.2) who ruled from 1865 until his death, made Belgium an empire by privately annexing a huge territory in Africa which later became known as the Belgian Congo. During World War I the Germans did not respect the neutrality of Belgium. They invaded the country and used poisonous gases (Figure 2.3) for the first time at Ieper near the northern border with France [see map].

After the war, the German East African Protectorates known as Rwanda–Urundi were placed under the authority of Belgium by the League of Nations. With the independence of the Belgian Congo in 1960 (now known as Zaire, the name given by the first Portuguese explorers) and Rwanda–Urundi in 1962 (now the two states Rwanda and Burundi) Belgium lost its empire. However, during the preceding century, important industrial activities took place both in Belgium and in its African colonies.

When the nine provinces that broke away from the Kingdom of the Netherlands to form the Belgian State in 1830 a linguistic problem became evident: in the Flanders region Flemish is spoken, a Dutch dialect, while in the Wallonia region French is spoken (Figure 2.4).



Figure 2.1: Map of Belgium.



Figure 2.2: King Leopold II (1835–1909).



Figure 2.3: German Army using poisonous gas at Ieper in 1914.

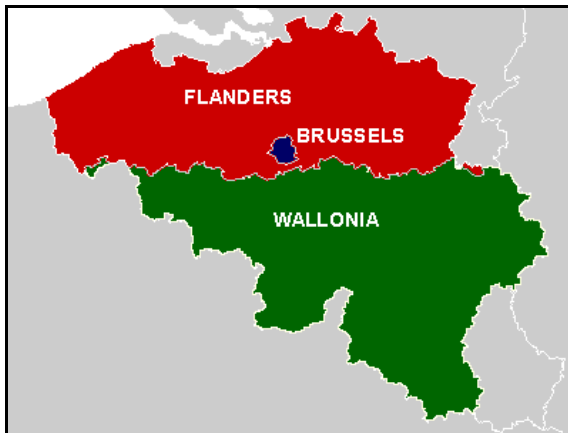


Figure 2.4: The Flanders and the Wallonia regions of Belgium.

Table 2.1: Visits to Belgium

Dates	Places visited	Purpose of visit
June 1980	Brussels	Nonferrous industry in Olen, Hoboken, and Overpelt Host: Dr. Michel Van Heck, former Laval researcher then manager at Métallurgie Hoboken-Overpelt
	Mechelen	Dr. Michel Van Heck

Dates	Places visited	Purpose of visit
	Antwerpen	Cultural visit
	Waterloo	Cultural visit
	Atomium	Cultural visit
November 1987	Liège	University of Liège. Host: Prof. Corneille Ek
September 1997	Leuven	Catholic University Library, Noddack Archives. Host Prof. Pietre Van Assche
November 2011	Brussels	European Parliament seminar. Host: Dr. Vladko Panayotova, MP
	Waterloo	Cultural visit
	Atomium	Cultural visit

BRUSSELS

Brussels (Figures 2.5–2.8) was founded in the 10th century as a fortress town by a descendant of Charlemagne. Although historically Dutch-speaking, Brussels became increasingly French-speaking over the 19th and 20th centuries. Today a majority of inhabitants are French speaking, including a significant population of immigrants with French as second language, and both languages have official status.



Figure 2.5: La Grand-Place.



Figure 2.6: La Grand-Place.

Solvay conferences on physics

In 1911, the First Solvay Conference on Physics devoted to the theory of radiation and quanta took place at Métropole Hotel (Figures 2.9–2.10) in Brussels. Ernest Solvay (1838–1922) (Figure 2.11), the son of a Belgian salt refiner, while working at the Brussels Gas Works, was looking for uses for the ammonia produced. The Gas Works made coke from coal in order to produce the city gas necessary for heating in houses and for street illumination. Solvay was aware of a wet method of manufacturing sodium carbonate in which ammonia played an important role, but this method was never applied because of low yield and other technical problems. After several years of testing and the building of pilot plants, one of which blew up, he built finally the first successful plant in 1865 at Couillet. The process proved to be more economical than the Leblanc Process, and by the end of the century it had displaced it completely.

Solvay became a very wealthy man; he donated his fortune to a Foundation that carries his name. The Foundation used to invite distinguished scientists of that time to Brussels to discuss problems of mutual interest. The conference held in Hôtel Métropole in Brussels is commemorated by the large photograph on display in the lobby showing Solvay surrounded by his distinguished guests (Figures 2.10–2.11).



Figure 2.7: La Grand-Place, 2011.



Figure 2.8: La Grand-Place, with Vladko Panayotov and his wife Marinela from Bulgaria, 2011.



Figure 2.9: A historic picture of Métropole Hotel at the beginning of the 20th century.



Figure 2.10: Hôtel Métropole, 2011.

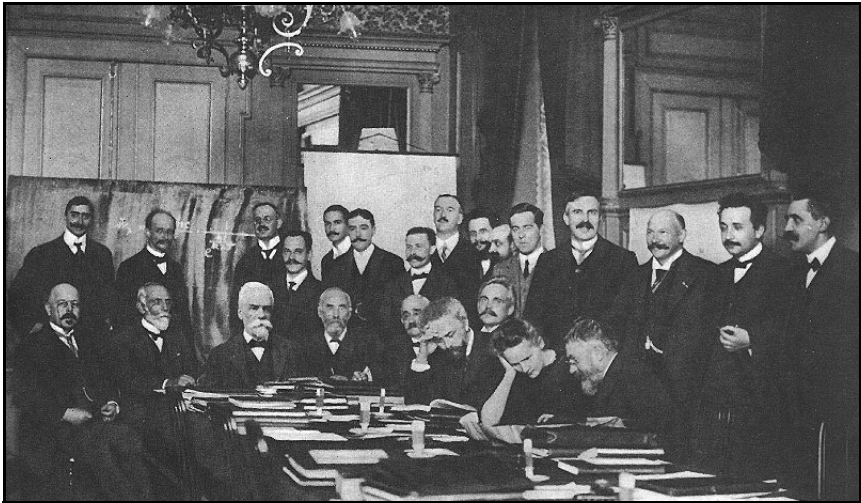


Figure 2.11: Meeting of scientists in Brussels at Hôtel Métropole in 1911 at the invitation of Ernest Solvay. Seated (L–R): Nernst, Brillouin, Solvay, Lorentz, Warburg, Perrin, Wien, Curie, Poincaré. Standing (L–R): Goldschmidt, Planck, Rubens, Sommerfeld, Lindemann, de Broglie, Knudsen, Hasenoehrl, Hostenet, Herzen, Jeans, Rutherford, Kamerlingh Onnes, Einstein, Langevin

Africa Museum

Belgium has an excellent museum devoted to Africa. Le Musée Royal de l'Afrique Centrale was founded in 1897 by Leopold II at Tervuren, a suburb of Brussels (Figure 2.12). It started as Palais des Colonies — an extension of the International Exhibition of that year. A year later, its name was changed to Musée du Congo. In 1904 it moved to its present location which is a magnificent building with all the necessary documentation of Africa: its people, vegetation, animals, minerals, etc.

Université libre de Bruxelles

After independence in 1830, there were three state universities in the country: Ghent, Liège, and Leuven. The Free University of Belgium, as it was originally known, was inaugurated in Brussels in 1834. In 1836 it changed name to the Université libre de Bruxelles. In 1963 courses were given in French and Flemish. In 1969 the French and Flemish entities separated into two distinct universities: the Vrije Universiteit Brussel and the Université libre de Bruxelles.

The Department of Extractive Metallurgy is a large and well organized department headed by Prof. René Winand who visited Laval University few years earlier. He had succeeded Prof. Declory who was an authority on the metallurgy of uranium. At the time of the visit [1980], Prof. Winand had four assistants, the senior one was Dr. André Fontana. There were 14 graduate students and 18 technicians. The reason for the large number of technicians is the numerous pilot plants for metal extraction.



Figure 2.12: Musée Royal de l'Afrique Centrale at Tervuren.



Figure 2.13: Place Luxembourg in front of the European Parliament. The statue shown is that of John Cockerill (1790–1840), the English metallurgist who introduced the coke blast furnace technology in Belgium.

European Parliament

The European Parliament is located in Place Luxembourg (Figures 2.13–2.16). A seminar was organized by member of parliament Dr. Vladko Panayotov from Bulgaria entitled Responsible Mining in the EU to which the writer was invited to present a paper entitled “The Metal Industry Today. Progress and Problems” (Figures 2.17–2.19). A guided tour of some parts of the Parliament was organized after the conference (Figure 2.20).



Figure 2.14: Details of statue of John Cockerill (1790–1840).



Figure 2.15: European Parliament buildings.



Figure 2.16: Entrance to the European Parliament buildings. Photo by Fathi Habashi 2011.

The flyer features the logo of the Alliance of Liberals and Democrats for Europe (ALDE) at the top left, which consists of a circle of twelve yellow stars surrounding a blue stylized figure of two people. To the right of the logo, the text reads "Alliance of LIBERALS and DEMOCRATS for Europe" in a smaller font, followed by "SEMINAR" in a large, bold, blue font. Below this, it states "An initiative by ALDE MEPs" and "Prof. Vladko PANAYOTOV and Dr. Theodoros SKYLAKAKIS". A prominent green horizontal band contains the title "RESPONSIBLE MINING IN THE EU" in white, bold, uppercase letters. Underneath this band, the subtitle "Best practices to overcome the raw materials crisis" is written in a blue, bold font. A central photograph shows a natural landscape with a rocky cliffside, green and autumn-colored trees, and a body of water with reeds in the foreground. Below the photo, the event details are listed in bold blue text: "Thursday 10th November 2011", "09:30 - 12:30", and "Room Paul Henri Spaak 5 B 001, European Parliament, Brussels". At the bottom, a green band contains the text "For more information and registration please visit our website: www.alde.eu/events-seminar/".

© European Parliament 2011

Figure 2.17: Flyer announcing the seminar.



Figure 2.18: Seminar in Room Paul Henri Spaak, 2011.



Figure 2.19: Seminar in Room Paul Henri Spaak, 2011.



Figure 2.20: European Union flag. Photo by Nadia Habashi 2011.

Berlin Wall fragment

A fragment of the demolished Berlin Wall is kept as a souvenir in Brussels' Luxembourg Square, not far from the European Parliament (Figure 2.21).

Atomium

Belgium was host of the World Exhibition in 1958. The Atomium constructed on this occasion at Heysel/Heizel Metro station shows a unit cell of a body-centred metallic crystal (Figures 2.23). It is 103-metre tall structure with nine steel spheres each about 20 metres diameter connected by means of escalators. The spheres were clad with aluminum but, in 2006, the cladding was replaced by stainless steel. It is an engineering achievement similar to the Eiffel Tower in Paris with the difference that in the Atomium the metal parts are welded together while in the Eiffel Tower they are riveted.



Figure 2.21: A fragment of Berlin wall. Photo by Nadia Habashi, 2011.

Cathedral



Figure 2.22: Brussels' Cathedral.

Waterloo

The Battle of Waterloo took place near Brussels on June 18, 1815 between the armies of the First French Empire of Napoléon Bonaparte and the Alliance of the United Kingdom, Prussia, and Austria under the commanders the Duke of Wellington and General von Blücher (Figures 2.24–2.26). It was important for the allies to stop Napoleon from reaching Brussels. A memorial in the form of a statue of a lion (looking towards France) on a hill, with 226 stairs, called La Butte du Lion was constructed in 1826 during the reign of King William I of the Netherlands to commemorate the

bravery of his son, the prince of Orange, who was wounded there during the battle. It was this battle that marked the downfall of Napoleon.



Figure 2.23: Atomium near Brussels, 2011.



Figure 2.24: Napoleon.



Figure 2.25: Blücher.



Figure 2.26: Wellington.



Figure 2.27: Waterloo Battle.



Figure 2.28: Visiting Waterloo.



Figure 2.29: Visiting Waterloo with Prof. Marinela Panayotova from Bulgaria.



Figure 2.30: Waterloo lion on the top of the hill.



Figure 2.31: Waterloo lion on the top of the hill.



Figure 2.32: Waterloo Museum with Prof. Marinela Panayotova from Bulgaria.



Figure 2.33: Waterloo Generals.

Erasmus House

In 1521, Erasmus (1466–1536) (Figure 2.34), the humanist reformer of Rotterdam, stayed at the home of his friend Pieter Wychman who was teaching in one of the suburbs of Brussels. The House was transformed in 1932 into a museum and a study centre sheltering early manuscripts of Erasmus' works (Figures 2.35–2.37). Erasmus is known to have said, "When I get a little money I buy books; and if any is left I buy food and clothes."



Figure 2.34: Erasmus of Rotterdam.



Figure 2.35: Visiting Erasmus House. Photo by Nadia Habashi, 2011.

LIÈGE

Liège, known in Flemish as Luik and in German as Lüttisch, was formerly an independent city ruled by prince-bishops, had important coal fields and became a metallurgical centre for steel and zinc industries. Napoleon made it a part of France in 1794 and this status was maintained until 1815 when the city became part of the Kingdom of Netherlands. The University of Liège was founded in 1817 by William of Orange (1772–1843), King of Netherlands and Belgium who ruled from 1815 to 1840, when he was forced to abdicate.



Figure 2.36: Visiting Erasmus House in 2011. Photo by Nadia Habashi.

Metallurgy was taught at the Faculty of Science, since founding the University of Liège, and mining since 1825. In 1828, the University decided to create Special Schools separate from its system, because it was accused of giving theoretical instead of practical teaching. The School of Mines was founded 1838. In 1835 two state universities were founded: one in Ghent and the other in Liège, each with four faculties and a Special School annexed for engineering studies. In 1836 a School of Arts, Manufacturing, and Mining was created as a separate unit of the Faculty of Sciences. Two years later (in 1838), it was separated into: School of Arts and Manufacturing and School of Mines

In 1893, a fifth faculty was created in the University and it grouped disciplines such as Mechanical, Chemical, and Metallurgical Engineering and was named Technical Faculty. In 1937, the name was changed to its present name Faculty of Applied Sciences. The laboratories were destroyed during World War II.



Figure 2.37: Visiting Erasmus House in 2011. Photo by Nadia Habashi.

The Department of Metallurgy was founded by Eugène Prost, author of 2 volumes on metallurgy. He was succeeded by Maurice Rey, then in 1946 by Eugène Frenay, father of Jean Frenay who was at that time [1987] Assistant Professor in the Department. Chairman in 1987 was Corneille Ek who acted as host.

LEUVEN

Leuven [Louvain in French] (Figure 2.38) is about 30 km east of Brussels. The Catholic University of Leuven (Figure 2.39) was founded in 1425. During the occupation in World War I, the Germans shot the burgomaster, university rector, and all the city's police officers. The university library was deliberately destroyed on August 25, 1914. Hundreds of thousands of volumes of manuscripts were lost. The world was outraged over this and the library was completely rebuilt later (Figure 2.40).

At the initiative of Prof. Pieter van Assche of the Catholic University, the Library acquired the papers of Ida Noddack, the discoverer of rhenium in 1925, and made them available to researchers. This was the reason why I visited the Library at the invitation of Van Assche, who visited Laval University few years earlier.



Figure 2.38: City Hall.



Figure 2.39: Catholic University Library.



Figure 2.40: Catholic University Library.

MECHELEN

Mechelen is famous of its huge 13th century cathedral (Figure 2.41).

ANTWERP

Antwerp (Figure 2.42) is commercial city located on the eastern bank of the river Scheldt, which is linked to the North Sea by the estuary Westerschelde. The city has one of the largest seaports in Europe.

GHENT

Ghent (Figure 2.43) is located at the confluence of the Rivers Scheldt and Lys. In the Middle Ages it was one of the largest and richest cities of northern Europe. Today it is a busy city with a port and a university founded in 1815. August Kekulé (1829–1896) (Figure 2.44) was Professor of Chemistry at the University of Ghent from 1858 to 1867.



Figure 2.41: Mechelen Cathedral.



Figure 2.42: Antwerp on the Scheldt.



Figure 2.43: Ghent.

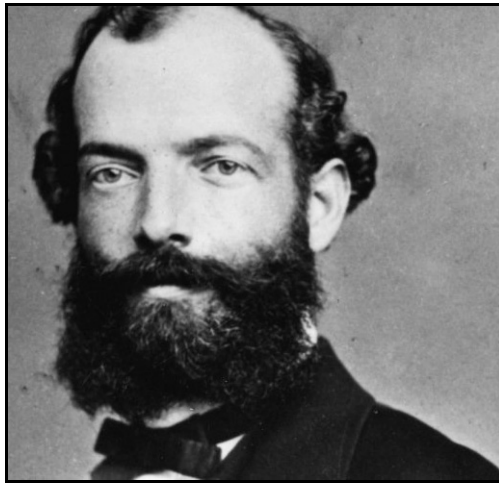


Figure 2.44: August Kekulé (1829–1896) Professor of Chemistry at the University of Ghent.

METAL INDUSTRY IN BELGIUM

The Société Générale de Belgique was the main organization running the Congo for the Government. Under the Société Générale was the Comité Spécial du Katanga that was specialized in running the mines discovered. A part of this Comité, the Union Minière du Haut Katanga was the metal-producing organization. The Belgians first discovered rich copper and cobalt ores, then rich radium ores that flooded the market after Madame Curie's discovery of the radioactive metal and its medical value. Then uranium became important when atomic bomb production began. Other ore deposits were also discovered.

The nonferrous metal industry is mainly in the hands of two large companies: Metallurgie Hoboken-Overpelt (Figure 2.45) and the Société des Mines et Fonderies de Zinc de la Vieille Montagne. Metallurgie Hoboken-Overpelt is a subsidiary of Union Minière. Metallurgie Hoboken-Overpelt has its headquarters at Hoboken and three large metallurgical complexes:

- Hoboken Works (Figure 2.46) produces lead, tin, bismuth, antimony, arsenic, copper, niobium, tantalum, indium, selenium, tellurium, and precious metals.
- Olen Works (Figure 2.47) is a copper refinery, and also produces cobalt, germanium, silicon, radium, and uranium.
- Overpelt Works produces zinc and cadmium.

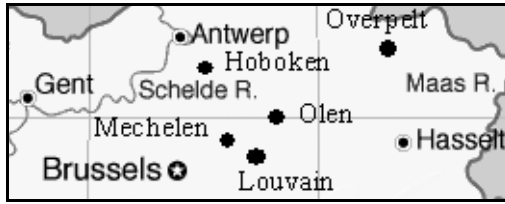


Figure 2.45: Location of Olen, Hoboken, and Overpelt.



Figure 2.46: Hoboken Works the River Schelde.



Figure 2.47: General view of Olen Works.

The company has grown as a result of different mergers. Its origin dates back to 1887 when a lead refinery was started at Hoboken on the right bank

of the River Scheldt, a few kilometres south of Antwerp, for desilverising lead bullion. It merged in 1919 with Compagnie industrielle Union at Olen (founded in 1908), which was manufacturing chromium salts and turpentine by-products. Then in 1970 there was a merger with the Compagnie des métaux d'Overpelt-Lommel et de Corphalie, an important producer of zinc. Hence the company became known as Metallurgie Hoboken-Overpelt.

Zinc and Cadmium

Belgium's only nonferrous metal ore, a deposit of the mineral calamine, a hydrated zinc silicate, was found at a place called Kelmis or La Calamine on the road between Liège and Aachen. This deposit was worked in the fifteenth century together with copper ores to make brass — an industry that was flourishing greatly in that district. In 1806, Abbé Dony (1759–1819) (Figure 2.48) of Liège developed a process for the reduction of calamine to produce metallic zinc by distillation in clay retorts made from the high quality clay found near Liège (Figure 2.49). The Société des Mines et Fonderies de Zinc de la Vieille Montagne has its headquarters at Angleur. At present, the company has four plants in Belgium: at Balen (near Mol), at Flône, at Angleur, and at Grâce Hologne; as well it has four plants in France, and a mine in Sweden.

The distillation process was superseded after World War I by the electrolytic process and the last distillation plant closed in the 1970s. Cadmium is a by-product of the electrolytic process.



Figure 2.48: Abbé Dony developed the zinc industry in Belgium.

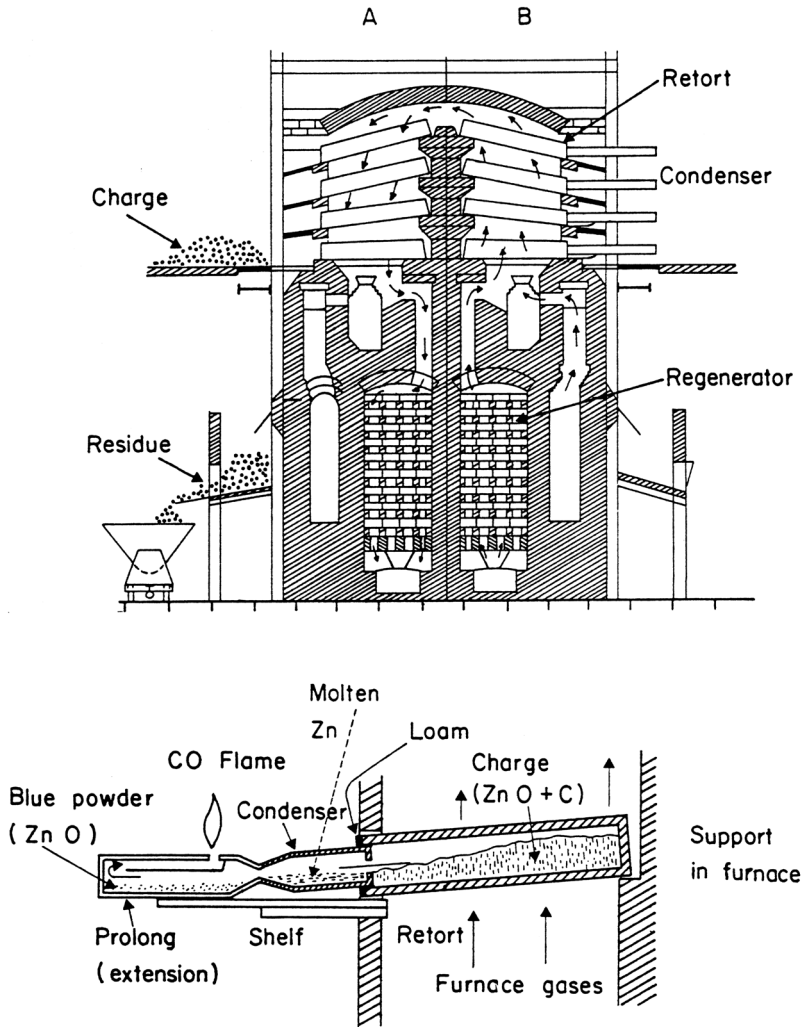


Figure 2.49: Production of zinc by distillation from a mixture of ZnO and carbon in retorts.

Zinc and cadmium are also produced at Overpelt from imported sulfide concentrate by the Metallurgie Hoboken-Overpelt company. Katangan zinc ores are treated by the leaching–electrolytic process at Kolwezi by La Société Métallurgique Katangaise, founded in 1948. Cadmium is recovered as a by-product and the sulfur dioxide produced during the ore treatment is used to make H_2SO_4 by the Société Générale Industrielle et Chimique du Katanga.

Copper

The Kipushi mine near Elizabethville proved to be the richest copper mine of the Union Minière du Haut Katanga. A smelter (Figure 2.50) was erected to treat these ores using coke imported from Belgium. Elizabethville, the chief city of Haut Katanga, was founded in 1910 and named after Elizabeth, Queen of the Belgians at that time; it is presently known as Lumumbashi. Blister and black copper from the Congo was shipped to Olen for refining and recovering the precious metals collected in the anodic slimes. The Olen refinery which belongs to Metallurgie Hoboken-Overpelt is now one of the largest in the world.

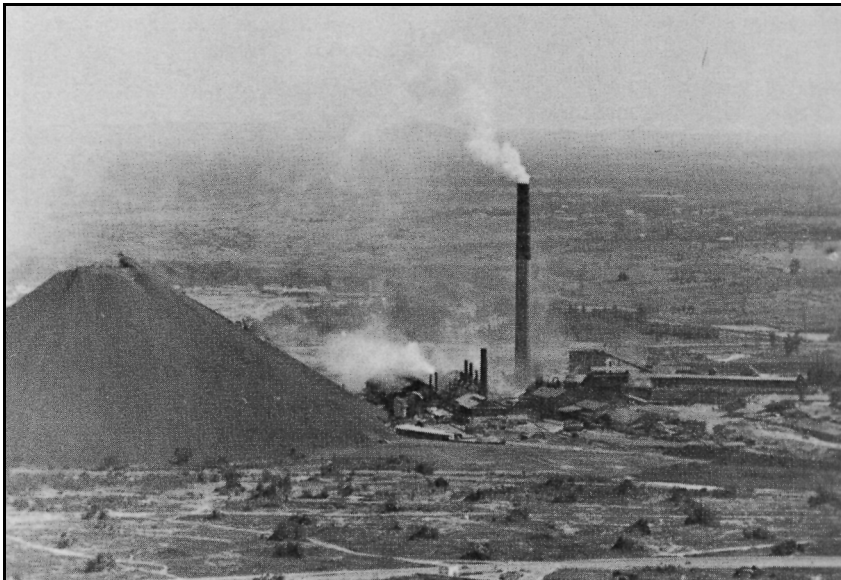


Figure 2.50: Copper smelter near Elizabethville in Haut Katanga.

Germanium

The copper–zinc ores of Katanga are characterized by containing a germanium mineral known as renierite $(\text{Cu,Fe})_3(\text{Fe,Ge,Zn,Sn})(\text{S,As})_4$. By selective flotation, the copper concentrate obtained is enriched in germanium. During smelting of the concentrate in shaft furnaces in Kolwesi, germanium becomes enriched in the dust which analyses typically 0.36% Ge, 28% Zn, 3% Cd, 25% Pb, 1.5% Cu, and 7.3% As. The dust collected from the bag filters is mixed with H_2SO_4 to form a paste then baked in a rotary kiln at 450–500 °C to form sulfates which are leached with water. Practically all the germanium is found in solution.

After a purification step to remove arsenic and iron, MgO is added to precipitate magnesium germanate, Mg_2GeO_4 , in a cake containing 8–10% Ge, 10–18% Cu, 15–20% Zn, 1–1.5% Cd, and 0.7–2% As. The cake is then shipped to Olen for treatment with HCl to form $GeCl_4$, which is a colourless liquid (boiling point 85 °C) and can be purified by fractional distillation to a high-purity semiconductor-grade liquid (Figure 2.51). The tetrachloride is then hydrolysed by high purity water in quartz containers (to avoid contamination) in dust-free, clean rooms and the GeO_2 thus obtained is reduced to metal by hydrogen. The metal must then be melted and drawn to a monocrystal bar which is then zone-refined.

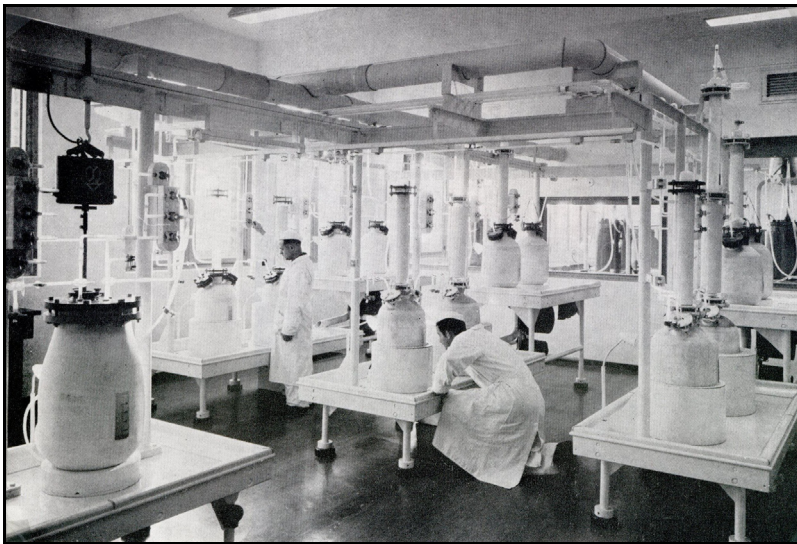


Figure 2.51: Distillation of germanium tetrachloride.

Cobalt

In 1914 cobalt-containing copper ores were discovered at the Katanga Mine of the Union Minière. Extraction of cobalt began in 1924 and two years later Katanga became the world's leading producer, a position which she has maintained ever since; between 1940 and 1960 she produced more than 50% of the world's cobalt. The importance of cobalt is in the production of high-speed tool materials and permanent magnet alloys. Three types of ores were processed:

- Copper oxide ore containing minor amounts of cobalt (5% Cu and 0.2% Co). This is concentrated by flotation to 26% Cu and 1% Co, leached by acid, and the solution electrolysed selectively for the recovery of both metals (Jadotville plant north west of Lumumbashi).

- Cobalt–copper oxide ore containing approximately equal quantities of the two metals (2.3% Cu and 2% Co). This is concentrated by flotation to 10% Cu and 8% Co, then reduced in an electric furnace to produce two alloys:
 - A heavy red alloy: 89% Cu and 4.5% Co. This is refined to copper at the local smelter.
 - A light white alloy: 42% Co, 15% Cu, and 34% Fe. This is sent to Olen where it is dissolved in acid and cobalt separated by precipitation as carbonate.
- Mixed ores containing both cobalt and copper oxides and cobalt and copper sulfides. These are separated by flotation to get two products:
 - A sulfide concentrate: 46% Cu, 0.4–2.5% Co. This was roasted and leached.
 - An oxide concentrate: 20% Cu and 1.7% Co. This was treated by leaching as well as by reduction in electric furnace.

Thus, Katanga became an important metallurgical centre where all modern extractive metallurgical processes were applied locally, and the Olen refinery became one of the most diversified nonferrous metallurgical operations in Europe.

Radium

When Madame Curie discovered and isolated radium in 1898, she did not patent her discovery so that the World can benefit from it. In 1902 a small plant was erected east of Paris to treat on a nonprofit basis the Joachimsthal residue shipped from Bohemia, a province of the Austrian Empire, for radium recovery to be used for cancer treatment. But, in 1903, the Austrian Government declared an embargo on the export of ore and residue and started treating the ore. As a result, exploration for radium started. Ores were discovered in Cornwall, in Portugal, in Madagascar, in Sweden, in Norway, in Fergana (Russia), in Colorado, in Utah, and at Great Bear Lake in Canada. Plants were erected and small amounts of radium were produced at a very high cost — \$100 000/gram. Important pitchblende deposits were discovered in Haut Katanga between 1913 and 1915, but exploitation was not started until after the armistice because efforts were concentrated on copper production for conducting the war.

In 1921, the Union minière began shipping a very high-grade ore, containing 50% U_3O_8 from Shinkolobwe (near Jadotville) to Olen; production began in mid-1922. The richness of this ore, and the consequent lower production costs forced the immediate shut down of almost all other radium-producing operations in the world.

Between 1922 and 1933, Belgium produced 326 grams of radium at a price fluctuating between \$70 000 to \$30 000/gram. However, when Canada entered into the market in 1932 producing radium at Port Hope, Ontario from the rich deposits at Great Bear Lake she was able to compete with the Belgian radium. The markets were divided between Belgium and Canada and the price was stabilized at \$40 000/gram. The discovery of cobalt 60 and other radionuclides for cancer treatment forced the shutdown of Canadian radium operations in 1954 and the Belgian in 1960. Since then, radium has become a nuisance in uranium producing regions.

Uranium

In the 1920s and 1930s the Union Minière du Haut Katanga company, operating in the then Belgian colony of Congo, had a monopoly of the world uranium market. The uranium mined in Congo was mostly transported to the refinery for uranium ore which was located in Olen. During World War II, Belgium was occupied by the German army and as a result the headquarters of the Union Minière moved to London. The president of the company at that time, Edgar Édouard Sengier was advised in 1938 in all secrecy by the British physicist Henry Tizard not to let any uranium ore from the Congo to fall into the hands of the Germans who were working on uranium fission and possibly on atomic bomb. A year later, almost the same thing happened in the United States when Albert Einstein on behalf of US physicists wrote to President Franklin Roosevelt to tell him about uranium and atomic fission for military purposes. Sengier then in 1940 shipped secretly more than a thousand tons of the rich pitchblende stock pile from Shinkolobwe to New York. By 1943, the mine was in production again. This was the material from which the first atomic bombs were made.

Metallic uranium was produced in 1980 at Olen from a yellow cake containing 80% U_3O_8 by dissolution in nitric acid, purification by organic solvents, production of UO_3 , UO_2 , UF_4 , then reduction by calcium.

Lead

From a modest start in 1887 as a lead bullion desilverising operation, the Hoboken Works has become one of the most up-to-date lead smelters and refineries. Extensions have been added to recover by products of lead refining such as As_2O_3 , antimony, tin, bismuth, copper, precious metals, and sulfuric acid. Slag from lead blast furnaces was sold for dam construction.

Tin

Tin ore has been produced at Manono in north Katanga since 1910 by the Compagnie Géologique et Minière des Ingénieurs et Industriels Belges

known as Géomines. The deposit also yields a niobite–tantalite concentrate that was treated at Hoboken.

Manganese

Manganese ore containing 48–50% Mn has been mined at Kisenge (120 km from Dilolo) since 1950 by the Société Minière de Kisenge. In collaboration with the zinc producers, a battery plant was established.

Iron and Steel

Belgium had all the requirements for a strong steel industry; notably rich coal and iron ore deposits that were the most important in continental Europe. When the iron ores were near exhaustion, the Lorraine deposits containing phosphorus could be used since their problem had been solved by Sidney Thomas (1850–1885) in England in 1870. The Belgians were the first in continental Europe to adopt the use of coke in the blast furnace; this took place in 1824 at the Cockerill plant at Seraing near Liège. The Belgian steel industry was mainly oriented towards the export of manufactured steel products such as tram cars, locomotives, and rails. Belgian engineers built and constructed railways and tramways all over the Continent, in China, Russia, Egypt, Turkey, Brazil, Argentine, and Mexico.

Chapter 3

Netherlands

Amsterdam	44	Geleen	54
Maritime Museum	51	Delft	54
Rijksmuseum	51	Leiden	56
Museum of the Tropics	51		

After the separation of the nine provinces from the Kingdom of the Netherlands in 1830 to form the Belgian State, the Netherlands (Figure 3.1) was still a great empire with colonies in the East Indies [Indonesia], South Africa [the Cape Colony], and in the Caribbean. During World War I she was neutral but during World War II she was occupied by Nazi troops and after the war all her colonies became independent.

Table 3.1: Visits to the Netherlands.

Dates	Places visited	Purpose of visit
October 1962	Amsterdam	Sightseeing, transit to West Berlin by train
November 1987	Geleen	Visit to Stamicarbon
October 30–November 6, 1993	Amsterdam	Cultural visit
	Leiden	Cultural visit
August 1999	Delft	Technical University



Figure 3.1: Map of the Netherlands.

AMSTERDAM

Amsterdam is the capital city of the Netherlands and the most populous city, but it is not the seat of the Dutch government, which is The Hague.



Figure 3.2: Amsterdam Airport, 2011 [Photo by Nadia Habashi].



Figure 3.3: Amsterdam Airport, 2011 [Photo by Nadia Habashi].



Figure 3.4: Amsterdam Airport, 2011 [Photo by Nadia Habashi].



Figure 3.5: Amsterdam Airport, 2011 [Photo by Nadia Habashi].



Figure 3.6: Amsterdam Airport, 2011 [Photo by Nadia Habashi].

Amsterdam (Figures 3.8–3.11) is characterized by the many canals and windmills. The Royal Palace (Figure 3.12) was built as City Hall in the 17th century and became residence of king Louis Napoléon during the French occupation and later of the Dutch royal family.



Figure 3.7: Amsterdam Railway Station.



Figure 3.8: Map of Amsterdam showing the numerous canals.



Figure 3.9: Typical view in Amsterdam.



Figure 3.10: A windmill in Amsterdam. Photo by Fathi Habashi, 1993.



Figure 3.11: In a shopping centre. Photo by Fathi Habashi, 1993.



Figure 3.12: City Hall.

Maritime Museum

The Museum (Figure 3.13) tells the story of the maritime past of the Dutch Empire including ship models, paintings, photographs, maps, atlases, globes, travel stories and descriptions of foreign countries in manuscript and print, one of the most extensive collections in the world.



Figure 3.13: Maritime Museum.

Rijksmuseum

The Rijksmuseum (Figure 3.14) is a Dutch national museum dedicated to arts, crafts, and history.

There is also an Egyptian temple in the Rijksmuseum in Leiden donated by Egypt for the Netherlands help to save ancient Egyptian remains flooded on the construction of the High Dam (Figure 3.15).

Museum of the Tropics

The Tropenmuseum (Figures 3.16–3.17) was founded to show Dutch overseas possessions, and the inhabitants of these foreign countries, such as Indonesia.



Figure 3.14: Rijksmuseum.



Figure 3.15: Egyptian temple in Rijksmuseum in Leiden.



Figure 3.16: Museum of the Tropics.



Figure 3.17: Interior of the Museum of the Tropics.

GELEEN

The State-owned coal mine “Maurits,” the biggest in Europe, was located in Geleen. The State Mines Carbon, known as Stamicarbon, was founded in 1947 in the coal mining district of Limburg, the most southern province of the Netherlands, for the washing and purification of coal. In 1956, urea plant was commissioned in Geleen. During the 1960s and 1970s coal mines that were located in this part of the province were closed. The State mining company DSM (privatized in 1989) however remained active in Geleen, now purely as a chemicals producer. Geleen is a short train ride from Köln in Germany. The plant visited was treatment of phosphate rock by nitric acid (Figure 3.18). Host: Ing. Marcel Tanke, who visited Laval University a year earlier.



Figure 3.18: DSM plant in Geleen.

DELFT

Delft is a university city where the University of Technology was established in 1842 by King William II of the Netherlands as a Royal Academy to train civil servants for the Dutch East Indies. The school rapidly expanded its research and education curriculum, becoming first a Polytechnic School in 1864, Institute of Technology in 1905, gaining full university rights, and finally changing its name to Delft University of Technology in 1986 (Figures 3.19–3.20).

Martinus Hendrik Caron (1883–1958) (Figure 3.21) was born in Indonesia, became professor of metallurgy at Delft University from 1928 till 1951 and advisor to Billiton Company. Devised in 1924 the ammonia leaching process for treating nickel laterites in Indonesia that contain appreciable acid-consuming gangue minerals, the process was adopted during World

War II by US metallurgists to exploit the Cuban deposits. Jacobus van't Hoff an alumnus of the University was awarded the first Nobel Prize in Chemistry in 1901. Host: Prof. Markus Reuter (Figure 3.22).

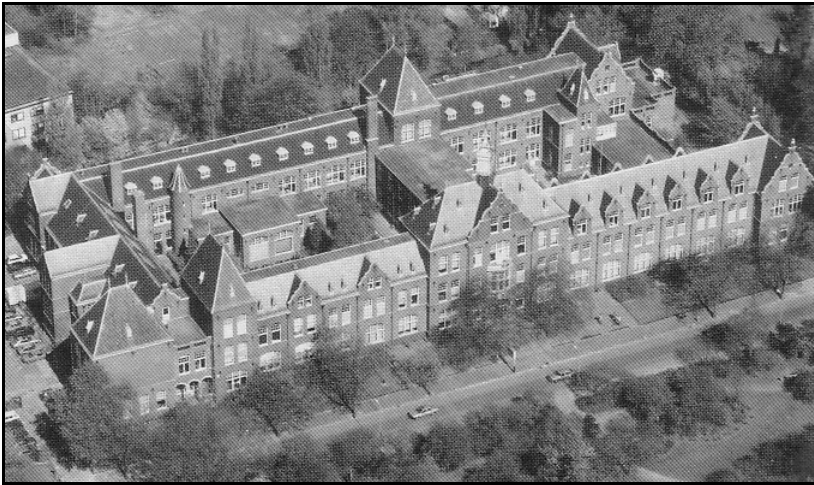


Figure 3.19: Delft University of Technology.



Figure 3.20: Delft University of Technology library.

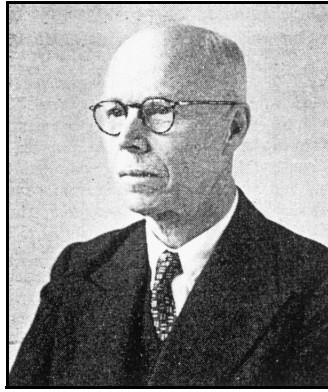


Figure 3.21: Martinus Hendrik Caron (1883–1958).



Figure 3.22: Professor Markus Reuter. Photo by Nadia Habashi, 1999.

LEIDEN

Leiden is a university city, home to Herman Boerhaave (1668–1738) (Figure 3.24) a botanist, humanist and physician of European fame. He is regarded as the founder of clinical teaching and of the modern academic hospital. He was the first to isolate urea from urine. A museum in the city carrying his name is devoted to the history of science (Figures 3.25–3.26). His student, the physician Gerhard van Swieten (1700–1772), was hired by Maria Theresa in 1745 to reform the University of Vienna.



Figure 3.23: Metallurgy students, 1999.

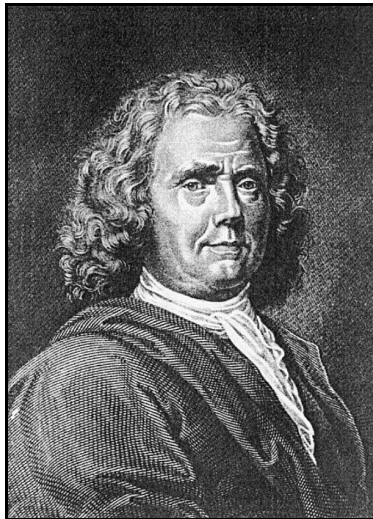


Figure 3.24: Herman Boerhaave (1668–1738).



Figure 3.25: Boerhaave Museum.



Figure 3.26: A book display in Boerhaave Museum.

Name Index

A

van Assche, Pieter 29

B

von Blücher, Gebhard Leberecht 20

Boerhaave, Herman 56

Bonaparte, Napoléon 20

Brillouin, Marcel 11

de Broglie, Maurice 11

C

Caron, Martinus Hendrik 54

Charles V 2

Cockerill, John 13–14

Curie, Marie 11, 40

D

Declory (Prof.) 12

Dony, Jean-Jacques 36

E

Einstein, Albert 11, 41

Ek, Corneille 29

F

Fontana, André 12

Frederick III 1

Frenay, Eugène 29

Frenay, Jean 29

G

Goldschmidt, Robert 11

H

Habsburg 2

Hasenoehrl, Friedrich 11

Herzen, Édouard 11

van't Hoff, Jacobus 55

Hostelet, Georges 11

J

Jeans, James Hopwood 11

K

Kamerlingh Onnes, Heike 11

Kekulé, Friedrich August 31

Knudsen, Martin 11

L

Langevin, Paul 11

Leopold of Saxe-Coburg 4

Lindemann, Frederick 11

Lorentz, Hendrik 11

Louis Napoléon 48

M

Maria Theresa 56

Maximilian I 1

N

Nernst, Walther Hermann 11

Noddack, Ida 29

P

Panayotov, Vladko 10, 13

Panayotova, Marinela 24

Perrin, Jean-Baptiste 11

Planck, Max 11

Poincaré, Henri 11

Prost, Eugène 29

R

Reuter, Markus 55
Rey, Maurice 29
Roosevelt, Franklin Delano 41
Rubens, Heinrich 11
Rutherford, Ernest 11

S

Sengier, Edgar Édouard 41
Solvay, Ernest 8, 11
Sommerfeld, Arnold 11
Spaak, Paul Henri 17
van Swieten, Gerhard 56

T

Tanke, Marcel 54
Thomas, Sidney Gilchrist 42
Tizard, Henry 41

W

Warburg, Emil Gabriel 11
Wellington (Duke) 20
Wien, Wilhelm 11
William I of the Netherlands 20
William of Orange 27
Winand, René 12
Wychman, Pieter 27

Subject Index

A

Africa Museum 12
Ammonia leaching process 54
Amsterdam 2
Amsterdam Airport 45–47
Amsterdam Railway Station 48
Angleur 36
Antwerp 31
Atomic bomb 41
Atomium 18

B

Balen 36
Batavian Republic 3
Battle of Waterloo 20
Belgian Congo 4
Berlin Wall 18
Billiton Company 54
Brugge 1
Brussels Gas Works 8
Brussels' Cathedral 20
Butte du Lion 20

C

Cadmium 36
Calamine 36
Cape Colony 43
Catholic University 30
City gas 8
City Hall 48
Cobalt 39
Cobalt 60 41
Cockerill plant 42
Cornwall 40
Couillet 8

Cuban deposits 55

D

Delft University of Technology 54
Distillation of germanium
 tetrachloride 39
DSM 54
Dukes of Burgundy 1
Dutch East Indies 54
Dutch Empire 51
Dutch national museum 51

E

East Indies 43
Egyptian temple 51
Eiffel Tower 18
Elizabethville 38
Erasmus House 27
European Parliament 13, 15
European Union flag 18

F

Fergana 40
Flanders 4
Flemish 4

G

Geleen 54
Gent 1
Géomines 42
Germanium 38
Germanium tetrachloride
 distillation 39
Ghent 31
Grand-Place 7–10
Great Bear Lake 41

H

- Haut Katanga 38
- Hoboken Works 34
- House of Oranje-Nassau 3
- Huguenots 2

I

- Ieper 1
- International Exhibition 12

J

- Jadotville plant 39
- Joachimsthal residue 40

K

- Kingdom of Netherlands 27
- Kipushi mine 38
- Kisenge 42
- Kolwezi 37

L

- Lead bullion desilverising 41
- League of Nations 4
- Leblanc Process 8
- Leiden 56
- Leuven 29
- Liège 27
- Limburg 54
- Lorraine deposits 42
- Luik, see *Liège*
- Lumumbashi 39
- Lüttisch, see *Liège*

M

- Madagascar 40
- Maritime Museum 51
- Maurits 54
- Mechelen 31
- Meeting of scientists in Brussels 11

- Metal industry in Belgium 34
- The Metal Industry Today. Progress and Problems 13
- Metallurgy of uranium 12
- Métropole Hotel 8
- Musée du Congo 12
- Museum of the Tropics 51

N

- Nickel laterites in Indonesia 54
- Niobite–tantalite concentrate 42

O

- Olen 40
- Olen Works 34
- Order of the Golden Fleece 1
- Overpelt Works 34

P

- Place Luxembourg 13
- Poisonous gases 4
- Port Hope 41
- Portugal 40
- Prince of Orange 21
- Production of zinc 37

R

- Radium 40
- Religious persecution of Protestants 2
- Renierite 38
- Responsible Mining in the EU 13
- Rhenium 29
- Rijksmuseum 51
- Rwanda–Urundi 4

S

- Scheldt river 31, 36
- School of Mines 28

Shinkolobwe 41
Société Générale de Belgique 34
Solvay conferences on physics 8
Spanish Inquisition 2
Stamicarbon 54
Sweden 40

T

Tervuren 12
Textile industry 1
The Hague 44
Theory of radiation and quanta 8
Tin ore 41
Tropenmuseum 51

U

Union Minière du Haut Katanga 34
Université libre de Bruxelles 12
University of Vienna 56
Uranium 41

Uranium metallurgy 12
Urea from urine 56

V

Vieille Montagne 34
Vrije Universiteit Brussel 12

W

Wallonia 4
Waterloo lion 25
Waterloo Museum 26
Windmill in Amsterdam 49
Wool 1
World Exhibition 18
World War I 4, 29
World War II 41, 43

Z

Zaire 4
Zinc production 37