Article

Origins of a Lasting Bathymetric Endeavour

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Isobaths first appeared on European charts in the sixteenth century, but bathymetric charts did not become widespread until after 1850. Nomenclature and terminology lacking clearly defined rules, a Commission on Sub-oceanic Nomenclature was created by the Seventh International Geographic Congress (Berlin, 1899), which was also entrusted with the publication of a general bathymetric chart. Convened in Wiesbaden (April 1903), it adopted features proposed by Julien Thoulet. The 24 sheets of the first edition, printed in 1905 at Prince Albert of Monaco's expense, that had been hastily prepared, came in for some criticism. A new commission decided in Monaco (1910) to add contour lines to show terrestrial relief. Once the second edition was completed in 1931, responsibility for the Chart was transferred to the International Hydrographic Bureau.

Bathymetry

'Bathymetry: the art or science of measuring depths (in the sea)'. One cannot suspect, with this accurate and terse definition of the *Oxford English Dictionary*, the progress in the complex history of this field of marine cartography and the increasing number of sectors of human activity in which it has played a part (Rainier III of Monaco, 2003). Another feature is that, to provide a global vision of bathymetry of the world Ocean a century ago, the guidelines of a bathymetric chart were defined by an international Commission; with various ups and downs, this endeavour was updated four times. Presently, this *General Bathymetric Chart of the Oceans* is produced using the most advanced technologies and presented in the form of a digital atlas. It has proved its ability and its will to adjust to scientific and technical advancements during a conference held in Monaco recently (*The History...*, 2003; *Charting the Secret World...*, 2003).

Mankind has always been both intrigued and fascinated by the ocean depths. But it was only in the last decades of the sixteenth century that specific data related to the depth of the seas and oceans appear on European charts in two forms: soundings expressed by figures at a specific spot, and contour lines (isobaths) connecting locations of a same depth. The first known example of an isobath appeared on a chart of the Dutch river Spaarne, drawn by Peter Bruinsz in 1584. The process developed slowly; the best-known examples in the marine field in the eighteenth century are shown in the book *Histoire physique de la mer* (1725) by Luigi-Ferdinando Marsigli [1658-1730] and in an important study by Philippe Buache [1700-1773], 'géographe du Roi'. In Marsigli's book, two charts of the Gulf of Lions have a contour line representing the edge of the continental shelf, sep-

arating the 'pleine' from the 'abyme'. Amongst the illustrations of his 'Essay of physical geography where general views are suggested on the sort of skeleton of the Globe, made up of mountain ranges crossing both the seas and the land', Buache (1756) includes a chart of the English Channel with a spacing of ten fathoms between the bathymetric contours.

When thematic cartography was developed at the beginning of the nineteenth century, in the marine sector it especially applied to currents, which were important for navigation. Bathymetric charts did not actually begin to become widespread until the middle of the nineteenth century, for scientific and technical reasons encouraged by economic factors. Scientists showed a growing interest in the study of the sea, resulting in the definition of methods and naming of oceanography. Positioning kept making progress since marine timekeepers became reliable. For soundings, improvements concerned both the connection between the ship and the sea bottom (hemp rope, pianoforte wire, steel cable) and sounding devices (Carpine, 1996). Laying transatlantic cables provided a further impetus (McConnell, 1990).

Matthew Fontaine Maury [1806-1873] played a decisive role on this subject. In the fifth edition of his *Explanations and Sailing Directions to accompany the Wind and Current Charts* printed in 1853, plate 14, drawn by William Flye, professor of mathematics of the United States Navy, represents the basin of the North Atlantic Ocean. The areas between the shore line and the isobaths of 1,000, 2,000, 3,000, and 4,000 fathoms were differentiated by increasingly lighter shades of grey as the depth increased. This plate was redrawn and improved in the following editions until 1858. In 1855, this bathymetric chart of the North Atlantic was reproduced in the first edition of *The physical geography of the sea* which, over about 20 years, underwent many editions and translations.

Maury's role was prominent in promoting bathymetry. Nevertheless, none of the six series of his *Wind and current charts* included bathymetric data. The figure erroneously given as a 'part of an early bathymetric chart' in *The Times Atlas of the Oceans* and in its translations represents a track chart where 'ship tracks are identified by name, date, time of passage, and logged observations' (National Oceanic ..., 1982).

From then on, bathymetry was quickly and definitively adopted in all categories of cartographic material: flat and relief charts, atlases and globes. These charts also became a regular feature in the reports from oceanographic expeditions, covering a restricted sector or the oceans as a whole. Two countries were particularly involved: Germany, under the impetus of Otto Krümmel [1854-1912], professor at Kiel, and Alexander Supan [1847-1920], professor at Gotha, and Great-Britain, where John Murray [1841-1914] became the main expert with the assistance of the specialised publisher, Bartholomew from Edinburgh.

Nomenclature and Terminology

Bathymetric charts not only indicate depths by contour lines, they also include toponyms, i.e. the name of a topographic feature of the underwater relief in a precise location. These toponyms belong to the field of nomenclature. Generally speaking, these denominations include two terms: the 'specific' one corresponding to a unique submarine feature and the 'generic' one representing special forms ('convex' or 'concave') of the underwater relief. The selection of these generic terms and their definitions belong to the field of terminology.

From the time that modern science progressed, these two distinct but complementary fields kept on improving, in the natural sciences as well as in chemistry and physics. A significant step was achieved through choices made under the impulse of Linnaeus in zoology and botany. Whatever the field concerned, the objective was to set up and codify universally adopted and applied principles. In the maritime domain, Charles Pierre Claret de Fleurieu [1738-1810] published the first in-depth study in 1800: *Observations sur la division hydrographique du globe, et changemens proposés dans la Nomenclature générale et particulière de l'hydrographie.*

The multiplication of bathymetric charts demonstrated that, due to the lack of international agreements, nomenclature and terminology were used at random. Hugh Robert Mill [1861-1951], librarian of the Royal Geographical Society, and Otto Krümmel established a list of proposed terms to describe the forms of submarine relief. They consulted the best qualified specialists: Admiral Sir William Wharton [1843-1905], Sir John Murray, Prince Albert I of Monaco [1848-1922], Admiral Stepan Ossipovitch Makaroff [1849-1904], and Professor Julien Thoulet [1843-1936]. They decid-

ed to take the opportunity of the Seventh International Geographical Congress to submit the matter to specialists.

The Berlin Congress (1899)

This meeting was quite remarkably well organised and widely attended. According to a general trend to make research more professional, participants were mostly University professors. Another feature was the important position given to the sea, as evidenced by the logo '*Terra Marique*'.

The first of the three sessions devoted to oceanology was held on 30 September 1899. Talks were delivered by Professor Hermann Wagner [1840-1929] of Göttingen, Krümmel and Mill on the adoption of a systematic nomenclature for basins and oceanic depths. A very animated discussion ensued, the Germans displaying a dogmatic rigour and Sir John Murray unrelentingly objected to the efforts to lay down strict principles. The rivalry between the British and the Germans had been amplified by the recent production of two general bathymetric charts. Supan's *Tiefenkarte des Weltmeeres* accompanied his article published in August in *Dr. A. Petermanns Mitteilungen*. In September, Murray presented his *Bathymetrical chart of the oceans* at the annual meeting of the British Association for the Advancement of Science. Finally, the decision was taken to create a Commission; eight members were chosen at once: Prince Albert I of Monaco, Krümmel, Mill, Sir John Murray, Supan, Thoulet, Otto Irminger [1836-1923], Secretary of the Royal Danish Geographical Society, and Josef Luksch [1836-1901], Professor at the Naval Academy of Fiume.

The following resolution was drafted: 'Terminology and nomenclature of sub-oceanic relief. The Congress nominates an international committee on the nomenclature of sub-oceanic relief, charged with instigating the preparation and publication of a bathymetrical map of the oceans before the time of the meeting of the next Congress'. It was adopted during the closing plenary session.

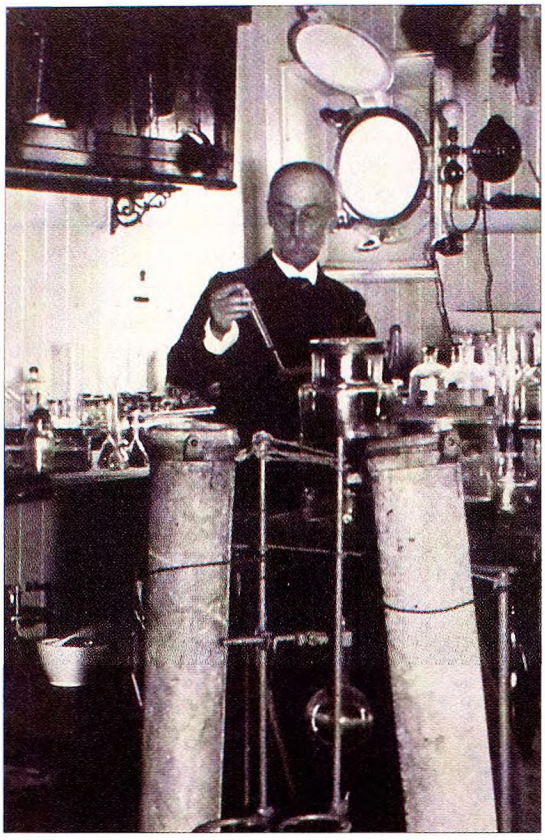
Thoulet and His First Memorandum

Considering the role, essential but swiftly overlooked, played by Julien Thoulet in the creation of the Chart, his training and work deserve to be recalled. Very early on, he became interested in geography and cartography. After working as an engineer for several years in Europe and the United States, he took his degrees and prepared a PhD thesis in Paris. In 1882, he was appointed to the Faculty of Nancy, holding the Chair in mineralogy until he retired.

In 1886, he spent six months on board *Clorinde*, a French Navy vessel, off Newfoundland. The results were given in ten papers, the most important being accompanied by several bathymetric charts. From then on, he emphasised the importance of isobaths, of bathymetric charts, and the urgent need for a general chart of the World Ocean. Furthermore he decided to devote a large part of his time and efforts to 'pure' (i.e. physical) oceanography (Carpine, 2002). In 1899, with the support of Prince Albert I of Monaco, whose acquaintance he had made more than ten years before, he published a *Carte bathymétrique des îles Açores*. He had a sound experience of laboratory techniques and work at sea, and was a skilled draughtsman.

In the first issue of 1901 of the *Bulletin trimestriel de la Société de géographie de l'Est*, Thoulet published a detailed paper entitled *Projet d'une carte générale des grandes profondeurs océaniques*. He first pointed out the interest of such a general chart, more detailed than the previous charts by Supan and by Murray, but less detailed than the hydrographic charts intended for navigation. Then, he expounded the main characteristics to be given to the chart. The scale would be one to ten million at the Equator. Between 72° N and 72° S, the Mercator projection would be used and for the earth's caps between 72° latitude and the poles, the gnomonic projection. The Greenwich meridian would be chosen as the zero degree meridian, as had been recommended by the Washington Conference in 1884. Nevertheless, Prince Albert of Monaco, although very much in favour of international decisions, went on using the Paris meridian until 1902, both in the hand-written indications in his log books and in the printed lists of his oceanographic stations. Each polar zone would be divided into four quadrantal sheets and the area on Mercator projection into twenty-four rectangular sheets, limited by the 0°, 90°, 180° and 270° meridians and the 45°, 64° and 72° parallels of latitude. These thirty-two sheets would be in 'double-elephant' paper size (73 x 113 cm).

The depths would be shown in metres, not in fath-



Professor Julien Thoulet on board Princesse-Alice II, September 1903 (photo. Jules Richard)

oms. During the Berlin Congress, a proposal by Mill 'On the adoption of the metric system of units in all scientific geographical work' was adopted and the Stockholm Conference for the study of the sea recommended the use of metres for the planned charts. For the spacing of the isobaths, Thoulet proposed two hundred metres, as one hundred would be excessive, five hundred or one thousand insufficient. Lithological data were still too scarce to be included in the chart. A card index would be created to register the origin and details of the selected soundings. To keep the chart up to date, it was necessary to plan for frequent new editions. For nearly three years, Thoulet's memorandum was the only by-product of the Commission on Sub-oceanic Nomenclature. In October 1902, Ferdinand von Richthofen [1833-1905], who had been president of the Berlin Congress and responsible for the fulfilment of its resolutions, sent a letter to the members of the Commission, recalling that the bathymetric chart had to be prepared before the next Congress. He proposed that a meeting be held in Brussels or Wiesbaden the following April, in order to establish a future programme of work, to define the principles of Sub-oceanic Nomenclature and to take the necessary steps to produce and publish the chart.

At once, Thoulet revised his memorandum published the year before. He maintained his proposals for the scale, the projections and the limits of the thirty-two sheets. He added a system of notation of the sheets which were to be designated by capital Latin letters and Roman numerals: A I, B IV, C II, symmetrical in the two hemispheres and differentiated by the addition of a prime sign in the southern hemisphere: A' I, B' IV, C' II.

Thoulet also prepared a revised edition of his *Carte bathymétrique des îles Açores*, at a scale of one to one million. He wanted to prove that a general one to ten million chart would be convenient to generate charts of a larger scale very easily with the system of tenfold scale increase. Moreover the Azores chart would be the first step, for an oceanic area, towards the publication of the International Map of the World on the millionth scale. This project was presented by Albrecht Penck [1858-1945] during the Fifth International Congress for Geographical Sciences in Bern (1891) and discussed during all the subsequent congresses.

The Wiesbaden Meeting (1903)

The Commission on Sub-oceanic Nomenclature held its meeting in Wiesbaden, on 15 and 16 April 1903. Five of the members nominated in Berlin attended it: Prince Albert of Monaco, Krümmel, Mill, Supan and Thoulet. Sir John Murray apologised for not being able to be present. Luksch, who died in 1901, and Irminger, who resigned for reasons of ill health, were replaced by Makaroff, Fridtjof Nansen [1861-1930] and Otto Pettersson [1848-1941]; only the latter came to Wiesbaden. Alexander Agassiz [1835-1910], invited by Richthofen to participate in the work, seemingly declined this offer. Charles Sauerwein [1876-1913], Prince Albert's 'officier d'ordonnance', carried out the function of session secretary.

Prince Albert was elected chairman, then Thoulet explained at length his proposals supported by his charts: the A I sheet of the Atlantic Ocean at a scale of one to ten million, the corrected and updated Azores chart, and a diagram showing the position of all the charts. The ensuing discussion

concerned particularly the questions of scale and projection. Eventually, Thoulet's proposals were agreed to as well as those dealing with the use of metres and the choice of the Greenwich meridian. Two major modifications were introduced. The number of sheets on Mercator projection would be reduced from twenty-four to sixteen, the new latitudinal limits between the Equator and 72° N and S being only 46° 40' instead of 45° and 64°. The values chosen for the isobaths were: 200, 500, 1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000, and 9000 metres.

Then, questions of nomenclature and terminology were discussed. The principles adopted for the *Tiefenkarte* published by Supan in 1899 were to be respected. The German members of the Commission were asked to select and define about fifteen terms designating the most important forms of submarine relief. Afterwards these terms and definitions would be translated into English and French.

Neither the Berlin Congress nor its Executive Committee, chaired by Richthofen, were in a position to make available the large amount of money necessary for such an expensive publication. Prince Albert offered to take on all the expenditures of the Chart; this generous offer was unanimously adopted by the members of the Commission who expressed their deep gratitude.

Very soon, the decisions became effective. In July 1903, Supan published the list of terms for the major forms of submarine relief with their definitions in the *Dr. A. Petermanns Mitteilungen*. The English translation done by Mill appeared in the August issue of the *Geographical Journal*. With the assistance of his colleague in Nancy, Bertrand Auerbach [1856-1942], Thoulet prepared the French translation, printed in the last issue of 1903 of the *Bulletin trimestriel de la Société de géographie de l'Est*.

The terms actually used in the sheets of the first GEBCO edition are shown in bold in the above table. (The word 'crêtes' is always printed in the

Terminology of the Forms of Sub-oceanic Relief

SUPAN (1903)	MILL (1903)	THOULET & AUERBACH (1903)	Sous-Commission (1910)
Greater Forms			
Schelf	shelf	socle plateau continental	plateau continental talus continental
Becken	basin	**bassin**	bassin
Buchten	embayment	**golfe**	
Mulden	trough	**vallée**	dépression
Rinnen	gully	chenal	canal
Gräben	trench	**ravin**	fossé
Schwellen	rise	**seuil**	seuil
Rücken	ridge	**crête**	dorsale
Plateaus	plateau	**plateau**	plateau
			socle
Tief	deep	**fosse**	fosse
Höh	height	**haut**	haut-fond
Minor Forms			
Rücken	ridge	crête	crête
Kuppen	dome	dôme	
Bänke	bank	banc	banc
Riffe	reef	récif	récif
Gründe	shoal	haut-fond	
Kessel	caldron	caldeira	trou, gouffre
Furchen	furrow	sillon	sillon
			vallée = Thal, valley

plural due to the draughtsmen's insufficient knowledge of German.)

Preparation of the Chart

Soon after the Wiesbaden meeting, Sauerwein was appointed *Chef du Service de la Carte générale des océans*. The responsibility for the technical side of the cartographic work was assumed by Alphonse Tollemer [1850-1919] who, fifteen years beforehand, had been recommended by the French Minister for the Navy to Prince Albert and who, since then, shared his time between his duties at the Hydrographic Service and the Prince's service, drawing many charts and checking the list of oceanographic stations.

Within a few weeks, all available bathymetric data were provided by the main maritime nations: the British Admiralty, the French Hydrographic Service, the Ministry of the Imperial Navy in Berlin and the Coast and Geodetic Survey of the United States, and also by the cable-laying companies. The reports from oceanographic expeditions were also useful sources of information.

As it was decided that the Chart would be a first-hand work, previously published charts would generally be disregarded, considering that their sources could not always be checked. Here lies one of the weak points of this edition. Sauerwein had neither the scientific background nor the necessary intellectual rigour to assess the value of the data. Inconceivably, Thoulet was not asked to participate in this stage of the work. Tollemer was an excellent draughtsman, but the selection of the soundings to be used and their interpretation for drawing the isobaths were outside his expertise. However, he did the work, assisted by four colleagues of the Hydrographic Service: Jean Morelli [1859-1934], Jacques Lebas [1868-after 1925], René Lévêque [1870-1955], and Achille Normand [1870-1947], and two other draughtsmen, Bataille and René Bolzé [1867-after 1910].

Within a short period, the team prepared the preliminary drafts of the twenty-four sheets, with data updated to July 1903. They were presented during the session of the *Académie des sciences de Paris*, on 11 January 1904, by Prince Albert who gave comments on a preliminary note by Thoulet and Sauerwein. Without a break, the draughtsmen worked to produce the final 'minutes', the new data obtained up to 1 July 1904 being integrated.

Thoulet was officially delegated to represent the Prince at the Eighth International Geographic Congress held in several locations in the United States. During the session of 13 September 1904, in New York, he presented an account of the Chart. The same evening the report written by Richthofen on behalf of the Executive Committee of the previous Geographic Congress was examined; the part dealing with the Commission on Sub-oceanic Nomenclature ended with a *satisfecit* as it had carried out the task with which it had been entrusted. In spite of the strong objection of Sir John Murray to the use of the metre instead of the fathom, the Congress adopted a resolution thanking the Prince for his contribution and approving the features of the Chart.

A price estimate for the printing was requested from several French and foreign firms. The *Établissement géographique Erhard frères* in Paris was selected in October 1904. The sum of 27,635 francs would cover the stone engraving, the supply of the lithographic stones and paper, and the printing of five hundred 'colour' copies and five hundred 'black and white' copies. The latter would allow scientists and mariners to add their own data and observations or to examine the possibility of the relationship between the bathymetry and any feature of sea water or sea bottom they might superimpose in colour on the chart.

The printing, begun by mid-February, was completed on 15 May 1905. Consequently, the first GEBCO edition can in no way be dated 1903. Its 'chronology' is unquestionable: the principles to be followed for the preparation of the Chart were defined in 1903 during the meeting in Wiesbaden after discussion of Thoulet's memorandum. The most recent data used for the drawing were obtained and/or published in 1904, and the whole of the printing was carried out during the first half of the year 1905. The wrong indication ('*Date de la mise à jour de cette feuille. 1ère édition 1er juillet 1903*') printed on the sheets of the third GEBCO edition was particularly unfortunate as it gave rise to this endlessly-repeated error.

The First Edition

The Chart set was made up of a title page, a sheet with an assembly diagram and twenty-four map sheets. The grid was at intervals of 1° of longitude and latitude, the lines being intensified every five

degrees. The 200 metre isobath was shown by a dotted line, the 500 metre isobath by a dashed line, the 1000, 2000 and so on isobaths by firm lines. On the 'coloured' edition, the shallower area (0-200 metres) was left blank; from 200 metres downwards the blue-green tint of the eleven areas delimited by the chosen isobaths increased in intensity as the depth increased. On the black and white as well on the coloured edition, the land areas were printed in a flat buff colour.

The soundings were marked by a black dot, the number of metres and sometimes one or several letters corresponding to the nature of the sea bottom. Below 500 metres all the validated soundings were indicated. For the area from 0 to 500 metres, only a selection of the accepted sounding points were shown but all of them were used for drawing the isobaths. Therefore, the figures put forward in several papers about the number of soundings retained for drawing the chart are valueless, certainly underrated. No indication about the source of these figures or the calculating/estimating method employed was given by their authors. Tollemer alone would have been able to provide this information, which does not appear in the surviving archives.

The nomenclature of the *Tiefenkarten des Weltmeeres* by Supan was scrupulously respected. For the terminology of the submarine relief forms, seven of the terms, chosen by Supan and translated by Thoulet, were used. On the continents, there were no indications of physical geography (rivers or mountains), human geography (towns) or political geography (borders). Only the names of continents, sub-continents, the principal nations, archipelagos and the most important islands were mentioned. All the titles and feature names were in French, the sole language used on the Chart up to and including the fourth edition.

On 19 May 1905, the first copy was handed to Prince Albert. Immediately, sets of the Chart were sent to Thoulet and the other members of the Wiesbaden Commission, and to the Prince's main scientific assistant, Jules Richard [1863-1945], the Oceanographic Museum's director. Organisations and people who had subscribed (at the price of one hundred francs for the coloured edition and fifty francs for the black and white one) received their copies. On 5 June 1905, a set in colour was presented by Prince Albert to the *Académie des sciences* de Paris. A copy was also sent to the persons in charge of geographic bibliographies.

Favourable comments started to appear in the general and specialised press when Emmanuel de Margerie [1862-1953] stepped in. He was a very influential geographer-geologist and one of the directors of the *Annales de géographie*. In the issue of this serial dated 15 November 1905, he published a long and thorough analysis of the Chart. The most serious error was the faulty cutting of the sheets using Mercator projection, put along the 47° line of latitude instead of 46° 40'. Lithological data were included in contradiction with Thoulet's proposals and the decisions adopted in Wiesbaden. Numerous errors: misprints (even in the printer's name!), erroneous translations, were discovered. The responsibility for these failures rested upon Sauerwein and his lack of rigour. The memorandum of Thoulet, carefully prepared by a recognised specialist, should have been followed with the greatest attention. In spite of its approval in Wiesbaden, Margerie deplored the excessiveness of Supan's nomenclature leading to decisions as absurd as to move the North Sea to the location of the Norwegian Sea.

Thoulet was quite justified when he wrote 'For the project of the chart until Wiesbaden, I did everything and other people nothing; for its execution, others did everything and myself nothing'. However, the severe comments by Margerie had negative repercussions on Thoulet's relationship with Prince Albert. As to Sauerwein, he understood that a scientific career was not suitable for him and he resigned from his function 'for personal reasons'.

Preparation of the Second Edition

The analysis by Margerie was unfavourable to the Chart. One and a half years after the printing, less than eight per cent of the copies had been either sold or given away. However, Prince Albert always considered it an important contribution. During the *Exposition coloniale* organised in Marseilles in 1906, the Chart was displayed in the *Palais de la mer* devoted to oceanography and maritime fisheries. The project was still under way when the Prince started to include details on this subject in most of the talks he gave throughout Europe and in the United States, from Marseilles, Paris, Munich, Rome, Brussels, Madrid, Vienna to New York and Washington, D.C.

From the very beginning, Thoulet recommended

that the Chart must be frequently updated. Tollemer never stopped his quest for new bathymetric data and tirelessly introduced the related changes in the sheets. A second corrected and updated edition was immediately considered as an absolute necessity by Prince Albert. The project was included in an ever-increasing programme for his oceanographic endeavours: he founded an Oceanographic Institute in Paris; he launched the plan for an International Oceanographic Congress to be held on the occasion of the formal opening of the Oceanographic Museum in Monaco. In 1907, he created a *Cabinet scientifique* (Scientific Office), with Richard as Director, Henry Bourée [1873-1940], who replaced Sauerwein as aide-de-camp, as Head, and Tollemer as one of two Attachés.

With a praiseworthy perseverance, Thoulet tried to bring his '*magnum opus*' to the desirable level. In the first issue of 1907 of the *Bulletin trimestriel de la Société de géographie de l'Est*, he once more presented a memorandum. He was convinced that the 'defects' of the first edition could easily be amended, without great expense. The date of publication of each sheet would be mentioned in the future. The pending problems dealing with nomenclature and terminology, and the publication of specialised oceanographic charts, would be examined by an international commission. A catalogue of the soundings and of other documents used would be printed.

The last proposal led to the preparation by Tollemer of a volume, printed in 1910, in due time before the meeting of a new Commission in Monaco. Apart from Makaroff, who had been killed during the Russo-Japanese war, the members of the former Commission (Krümmel, Mill, Murray, Nansen, Pettersson, Supan and Thoulet) were invited as well as Margerie and Gerhard Schott [1866-1961], to come to Monaco. All attended, except Nansen, who was too busy, and Sir John Murray who sailed a few days afterwards on board the *Michael Sars* for a long cruise in the Atlantic.

The inauguration of the Oceanographic Museum was not only celebrated by festivities and a stream of speeches. Working sessions met under the chairmanship of Prince Albert: the Atlantic Commission and the Mediterranean Commission, both initiated two years before, during the Ninth Geographic Congress of Geneva; the Scientific Advisory Board of the *Institut océanographique*; and, last, during the afternoon of 1 April 1910, the new Commission for the Bathymetric Chart.

The meeting had been carefully organised by Bourée who exchanged very informative letters with Thoulet and asked Richard for advice. He prepared a synthesis of the criticisms written by Krümmel, Margerie, Schott and Thoulet, and an extensive agenda for the session during which he was the rapporteur. A lengthy discussion arose for the third item 'addition of rudimentary hypsometry to the continents; addition of important rivers and lakes, as well as a few names as points of reference.' In spite of the very strong opposition of Thoulet and Supan, this proposal issued by Margerie was adopted by a majority of votes. To avoid the failures of the first edition, the proofs of the sheets would be sent to the members of the Commission for examination and checking; Margerie would be responsible for hypsometry, Schott for bathymetry and Supan for nomenclature. The French terminology, felt unsatisfactory, would be revised by a sub-commission, which met on 27 April 1910.

Prince Albert thought he could be confident in a smooth running of the second edition. However, problems appeared when the proofs of the first sheets were sent. Freely interpreting the decisions taken by the terminology sub-commission, Bourée dismissed the overly dogmatic principles set by Supan for the nomenclature. Several written consultations of the commission members were organised; Supan, being in the minority, handed his resignation in May 1912. At last, the first two sheets of the second edition were printed one month later.

The Second Edition

In many aspects, the second edition was identical to the previous one: format, scale, projections, use of metres for the depths, colours, and it was also lithographed. However, the division of the Mercator sheets was rectified and altered to 46° 40' latitude. According to the decisions of the Monaco Commission, the lithological data were eliminated and colour keys for bathymetry and hypsometry, as well as the listing of the sources used for the sheet, were printed in the margin. On the upper left corner, the date of the '*mise à jour*' (updating) was mentioned; these words, rather ambiguous, seemed to have been used with different meanings according to the sheets. The general title for the map sheets made reference to the *Cabinet scien-*

tifique created between the two editions. The main difference was the addition of the continental relief; the values of the contour lines were similar to those of the isobaths; the buff colour of the land areas became darker correlatively with height. Rivers, glaciers and many place-names were added on land.

Between June 1912 and summer 1914, eleven sheets were printed, most of them delayed by Margerie's continual requirements. Moreover, two supplementary volumes listing the corrections and the sources used for bathymetry and hypsometry were published in 1912 and 1914.

The printing of the Chart was totally interrupted by the outbreak of the First World War. The director and most of the employees of the printing works were mobilised, paper became scarce, new bathymetric data were no longer released. Prince Albert and Richard were anxious to resume the production of the remaining sheets as new sounding methods based on the propagation of sound and the use of ultrasound were revolutionising the field of bathymetry. A last volume of sources was printed in 1920 and a twelfth sheet a few months before Prince Albert's death, in June 1922.

In his will, the Prince bequeathed to Richard a large amount of money to bring to completion his two major oceanographic endeavours: the volumes of the *Résultats des campagnes scientifiques* and the *Carte générale bathymétrique des océans*.

Considering the state of the work as appraised by Morelli who had assumed the full responsibility after Tollemer's death, Richard expected that it would be finished in 1925 at the latest. But he met with growing difficulties: the printing works had a new director and became the *Institut cartographique*; strikes were frequent and the economic worsening had disastrous consequences for the value of the money available. As he already had before the war, Schott checked the bathymetry of the last sheets with great care and timeliness. But Margerie displayed a quite negative behaviour: at the same time he demanded countless (justified or unjustified) changes and corrections and he waited weeks or months before returning corrected proofs. In fact, he neglected the Chart to the benefit of more rewarding activities. In spite of all Richard's efforts, the last three sheets were not printed until January 1931, by which time the second edition was seriously out of date.

For years, Richard was aware that neither the *Cabinet scientifique*, which no longer existed, *de facto* if not *de jure*, nor the Oceanographic Museum would be in a position to cope with the rate of acquisition of new bathymetric data made possible by the new techniques. Only an international organisation could shoulder such a heavy responsibility. The International Hydrographic Bureau, the creation of which was decided by an International Conference held in London in 1919 and welcomed by Prince Albert in Monaco in 1921, was clearly the most suitable successor. Richard's proposal towards this solution was definitively ratified by the First Supplementary International Hydrographic Conference held in Monaco in 1929. The future of this important international endeavour seemed wisely assured.

The last word will be given by Thoulet 'The bathymetric chart of the oceans is a document which will increasingly tend towards perfection as successive editions come along, but which, in reality, will never be completed' (Thoulet, 1904).

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