Mikael Hård, Andreas Lösch, Dirk Verdicchio (ed.) (2003): Transforming Spaces. The Topological Turn in Technology Studies. (http://www.ifs.tu-darmstadt.de/gradkoll/Publikationen/transformingspaces.html)

A Sound Survey: The Technological Perception of Ocean Depth, 1850 – 1930

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Introduction: Data Volumes of Depth

> „It has often been said that studying the depths of the sea is like hovering in a balloon high above an unknown land which is hidden by clouds, for it is a peculiarity of oceanic research that *direct observations* of the abyss are impracticable. Instead of the *complete picture* which *vision* gives, we have to rely upon *a patiently put together mosaic representation* of the discoveries made *from time to time* by sinking instruments and appliances into the deep“[1].

The oceans were 'deep' well before the founding of the ocean sciences in the 1850s, but what lay beneath the waves out on the sea had hardly ever been tangibly experienced. Neither had approximately 60 years of scientific exploration rendered the oceans transparent, as the statement by the oceanographers John Murray and Johan Hjort from the year 1912 reveals. Oceanographic research could not rely on "direct observations". Instead, it had to create its image of ocean depth through remote investigation. Depth-sounding instruments created the outlines of this new object of science. Since the middle of the 19th century the notion and image of ocean depth no longer existed independently from its scientific definitions, experimental studies, measurements, and charts.

The single data points slowly gained in the processes of depth sounding were organized into profiles and contours which met the eye as coherent *pictures* by means of scaling, outlining and shading. What became familiar as authentic "sections" through the bottom of the ocean strictly speaking reproduced mathematical relations or functions: the "profile" or "section" related measured numbers to the distance between two geographical locations, suggesting a mimetic relationship between data and nature. The profile prompted the identification of an abstract line — an isoline — with a mountain range. Two "sections" of the northern Atlantic Ocean from the work of Murray and Hjort (Figure 1) illustrate this relation: Figure B shows a depth profile with the vertical scale 500 times enlarged as compared to the horizontal scale. Figure A shows this depth in its "natural scale": depth variations disappear into a straight line mirroring how the oceans were perceived before their deliberate scientific exploration: as predominantly plane. Only by amplifying could sounded depth be depicted as deep.[2]

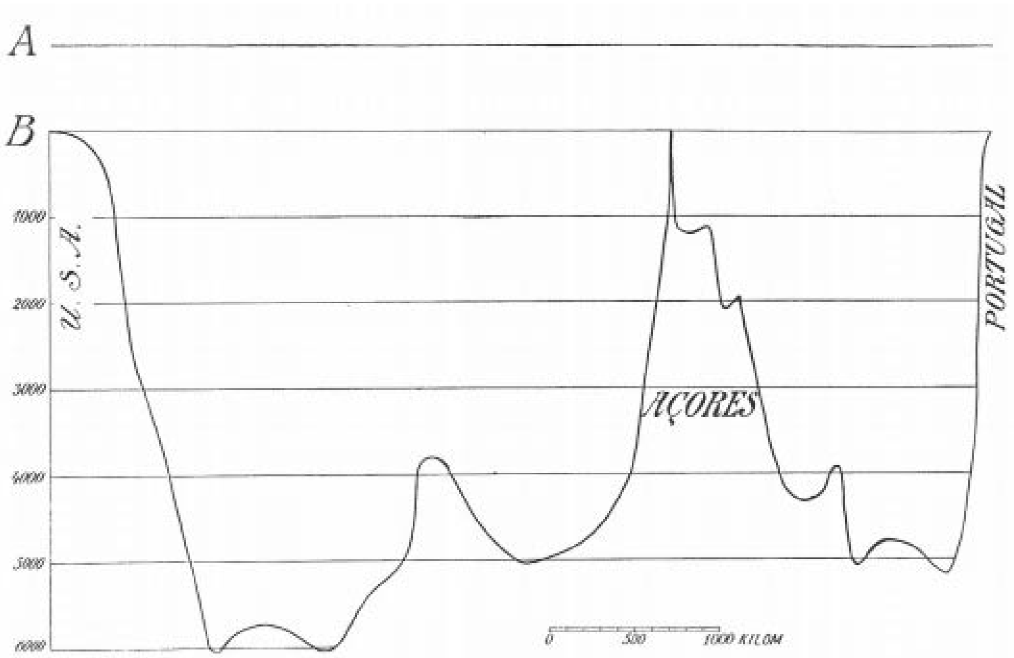

FIG. 152.—SECTION SHOWING THE FORM OF THE BOTTOM OF THE ATLANTIC OCEAN ALONG THE PARALLEL OF 40° N. B shows the vertical scale exaggerated 500 times as compared with the horizontal. On the natural scale the section looks like a straight line (A).

Figure 1

Furthermore, the ocean bottom's relief and its details depended on the construction of trustworthy and swiftly working sounding devices. Up to the 20th century, the immensely time-consuming procedure of lowering instruments, fastened to long lines, into the deep sea confined the crews aboard a ship to "single spot" soundings. In the course of the 19th century depth measurements expanded when numerous oceanographic expeditions opened the scientific *reconnaissance* of the oceans; moreover, oceanography intensified the ocean surveys by accelerating the sounding process. In the early 1920s, the reflected sound signal replaced the line and the lead. Acoustic sounding took over as the most rapid method of depth measurement, and the echo became the reliable indicator of ocean depth. With echo sounding, new and refined soundings could be produced at a new rate.

Charles Goodwin has argued in his ethnographic study of the interplay of laboratory practices aboard a ship that instruments and theories need to come together so that one can actually *see* underwater features.[3] He claims that an "*architecture for perception*" is constituted not only through texts but through "tools" that shape perception "through the way in which they construct representations".[4] This paper takes up Goodwin's argument and tries to expand it by reflecting on a notion from Bruno Latour: The paper argues that ocean depth became historically evident with the "optical consistency"[5] of enormous quantities of sounded data woven into a rich graphic texture. The notion of "optical consistency" does not only stress the theoretical and practical unity and integrity of an abstract concept like ocean depth but also its stability in transport and translation. The interplay of oceanographic questions and assumptions, technical conditions, and specific modes of graphic representation enabled and limited what became perceptible and apparent as ocean depth.[6]

Breaking the Seal. The Mid-19th Century Opaque Ocean

In 1858 Lieutenant Matthew F. Maury of the U. S. Navy asserted that until the middle of the 19th century "the bottom of what sailors call 'blue water' was as unknown to us as is the interior of any of the planets of our system".[7] "Was it creditable to the age that the depths of the sea should remain in the category of an unsolved problem? Beneath its surface was a sealed volume, abounding in knowledge and instruction that might be both useful and profitable to man. The seal which covered it was of rolling waves many thousand feet in thickness. Could it not be broken?"[8]

Maury's perception of the ocean as "sealed volume" and "unsolved problem" indicates a novel, scientific approach to depth. Maury took prominent efforts to instigate and organize international cooperation to investigate the oceans and became known as the "founding father" of the new field of physical oceanography.[9] The developing telegraph industry helped to stimulate deep-sea soundings: The project to lay submarine telegraph cables across the Atlantic Ocean in the late 1850s depended on accurate depth measurements and further motivated the development of sounding techniques.[10] By the mid-19th century, well-organized systematic soundings, samplings, and chartings of the oceans were underway.

In Maury's time, deep-sea sounding meant lowering a piece of heavy sounding lead fastened to strong twine into the sea.[11] Around 1850, the use of a sinker detaching mechanically from the sounding line when hitting bottom enabled the construction of a first simple and practical instrument to measure depth.[12] Further rationalizations of sounding techniques led to a replacement of the twine by steel wire on manually operated winches. The development of the steam-powered winch effectively shortened the time-consuming procedure of hauling the sounding line back in.

However, Maury objected, there was "but little reliance to be placed upon deep-sea soundings of former methods".[13] Even with the innovations of his times, sounding remained a tedious method involving many difficulties and uncertainties. A single sounding could take up to three hours, during which the ship's position needed to be determined accurately. Undercurrents operated on the line, making it impossible to hold the line vertical over the initial sounding point. The exact moment at which the sinker reached bottom was difficult to estimate, allowing the line to slacken by its own weight. Thus, as Maury pointed out, "the sounding reported is rarely, if ever, a true 'up and down' measure".[14]

Line sounding technology did not create a convincing representational space for ocean depth: the deep sea remained a highly opaque object of study to the young field of oceanography. Remote sampling of the sea bottom was considered a weak substitute for vision: "Man can never see — he can only touch the bottom of the deep sea, and then only with the plummet. Whatever it brings up thence is to the philosopher *matter* of powerful interest".[15] Studying the ocean "volume" from its surface required a rather *material* approach. The scientists had to use some sort of body as a sinker, they measured the amount of rope or line paid out, and they considered sample-taking a proof that bottom had at least been reached.[16]

Profiling and Outlining Depth. Late 19th Century Oceanographic Reconnaissance

With the aid of the detachable weight sounder, records of deep-sea soundings were rapidly accumulating in the second half of the 19th century. The *profile* and the *contour line map* acquired shape as dominant modes of graphically representing ocean depth.[17] Maury prepared the first bathymetrical map of the North Atlantic Ocean, published in 1854 (Figure 2).[18] Isolines connected places of the same measured depth, drawn in at 1,000, 2,000, 3,000, and 4,000 fathoms. The shading indicated areas of same-depth intervals. This "orographic" chart literally drew the Atlantic space into the centre of perception: the shading gave depth to the area, while the surrounding continents stayed white and shallow. Maury attached notes of doubt to great and thus highly questionable depths and to possibly erroneous soundings on the basis that "other soundings, near the same place on the chart, render the probability of any such depth of water in that part of the ocean still more questionable".[19] Ocean depth had gained evident contours; however, depth was still shady, sketchy, expected to become more profound with more data points to add and compare, so that the sketch would develop into a precise plan.

In 1872, the British *Challenger* expedition marked a historical break in scientific ocean surveying with the sheer *number* of data collected.[20] In the course of three and a half years its route spanned the globe, returning "with an impressive collection of deep-sea soundings" (about 400).[21] In the prevalent historical literature, the *Challenger* expedition is said to have drawn the broad outline of the deep sea, leaving later voyages to conduct only follow-up-work, 'filling in the blanks'. However, as ocean surveys expanded massively in the imperialist race for space, *Challenger*'s quantity of data actually proved quite small compared to the numbers of measurements gathered by subsequent expeditions: "Now the oceans were to be surveyed in breadth and depth".[22]

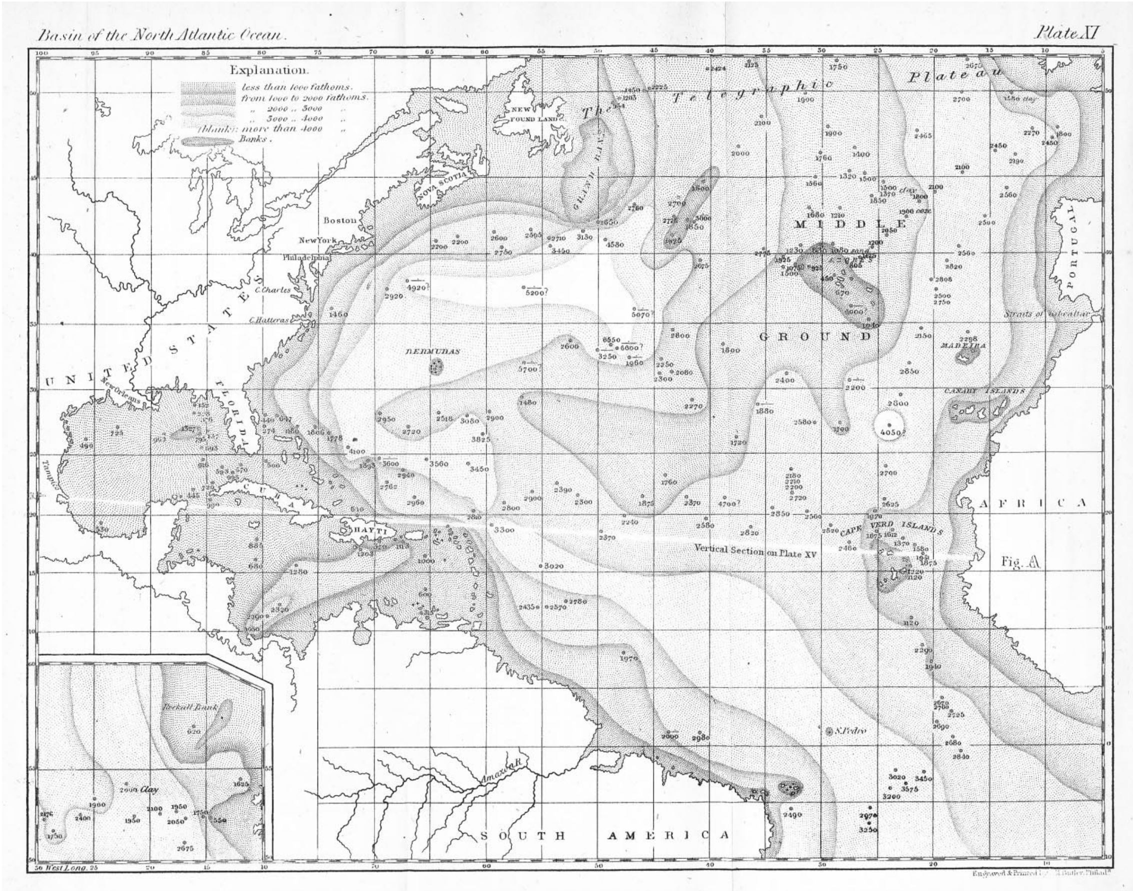

Figure 2

In view of the allegedly complete ocean register to be set up, representing depth became a question of data compilation. In 1886 Murray began to place all depth soundings exceeding 1,000 fathoms (2,000 meters) recorded up to that time in a map of the North Atlantic and had contour lines drawn in. Inclusion of new soundings and redrawing of the contour lines maintained this chart. The total number of soundings deposited in 1912 amounted to roughly 6,000 (Figure 3).[23] Filling the bathymetric chart with isolines did not just mean *inserting* new data into the existing chart, but also comparing data to decide whether a specific sounding was probable or improbable. In a doubtful case, the graphic net of available data would outweigh any single measurement. Both, however, kept provisional character. Interpolations were grounded on probabilities anticipating a higher density of measurements in the future. The ocean's "true image"[24] became a matter of completeness yet to achieve.

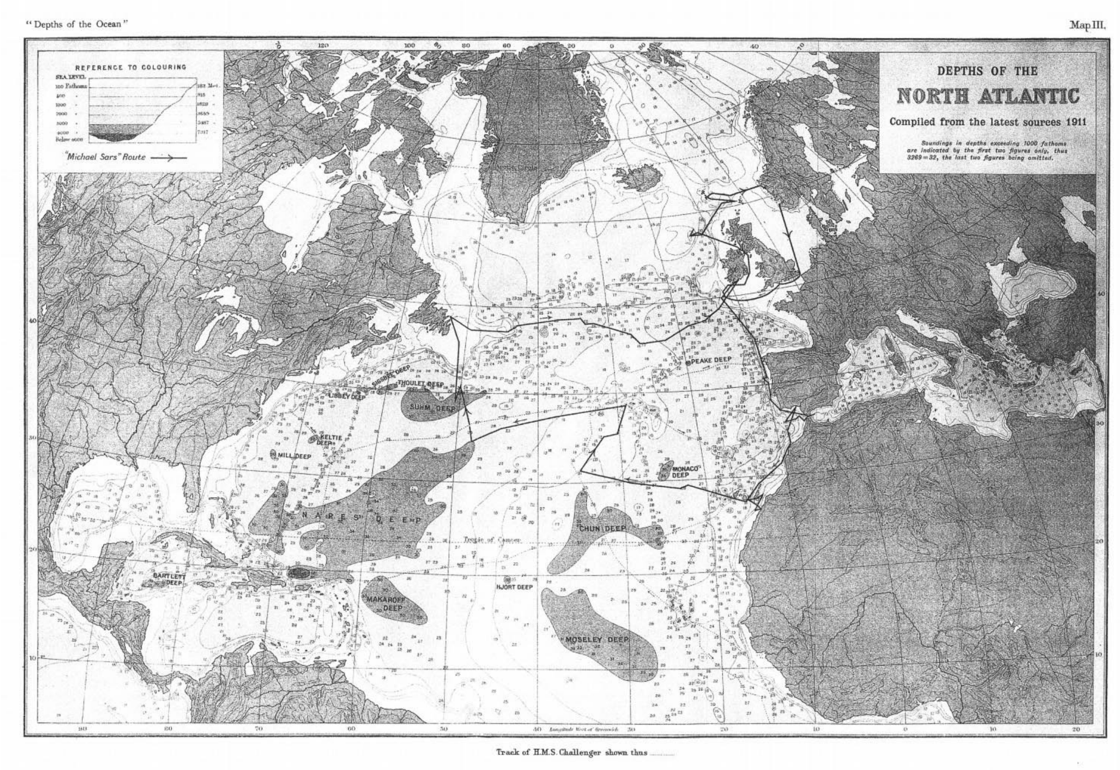

Figure 3

To come back to Bruno Latour's notion of "optical consistency", this technique of collecting and arranging measurements in charts served as "a new way of accumulating time and space" in transportable and stable forms.[25] Those "immutable mobiles" captured refined sounding techniques, intensified surveys, and graphically compiled results, to bring the deep sea closer to *terra firma*.[26] In subsequent years, the development of submarine acoustic sounding technology supported further exploring the measure of depth. Providing oceanographers with a means to create *continuous* profiles of the sea floor, acoustic sounding technology created the grounds for claiming coherence and reliability in depth representation.

Time of Sound. Acoustic Sounding after World War I

The growth of underwater sound studies, Robert Beyer stated in his history of acoustics, came "as a result of two modern catastrophes — the sinking of the *Titanic* in 1912 and the onset of World War I in 1914".[27] Concerns about underwater navigational aids and questions of inter-ship signalling had stirred interests in sound signal technology after the turn of the century. The study of sound signalling and above all sound ranging devices also served military purposes of detecting enemy ships and submarines. Submarine detection devices, both active echo ranging devices and passive underwater microphones or "hydrophones", first attempted to ascertain the *direction* of an object or a sound source.[28]

Attempts to sound depth acoustically instead focused on determining the exact *distance* of a sound source by measuring the time taken for a sound generated aboard a ship to travel to the sea bottom and back.[29] The new sounding technique no longer relied on the substantiality of line, lead, and bottom sample, but supported a notion of the ocean "volume" that had been introduced by physical oceanography in the past decades. It hinged on a different kind of 'materiality': water. Waves propagating through water by way of water's compression through a sonic disturbance materialized the oceanic space as a *body* of specific acoustic properties. Depth sounding changed from the tactile operation of groping in the muddy ground to an operation involving the sense of hearing. Sounding depth now meant *listening* to *sounds* of depth. The acoustic response became sufficient proof that ground had been reached. Moreover, in contrast to wire sounding, oceanographers not only trusted the sound signal and its echo to propagate reasonably 'straight' through the water; they also expected to be able to completely calculate the small degrees of acoustic signals bending in water in the future, using detailed hydrographical analysis.[30]

Faith in the new method was sufficient to replace the "direct" measurement of depth with an "indirect" method:[31] Determination of depth changed to a problem of *time* measurement. Depth was translated from paying out and measuring the *length* of quantity of line to the high precision measurement of the very short time a sound signal took to travel. The velocity of sound in water being roughly 1,500 m/s, echo sounding shortened the sounding process even in deepest depths from a few hours to a few seconds. Measurements of very short times in turn enabled oceanographers to take their measurements at very short time intervals. Since the echo soundings did not require a material connection between ship and sea floor except for the water itself, the measurements could be taken without having to interrupt the journey. Compared to the method of line sounding "from time to time", the number of deep-sea echo soundings could instantly be multiplied to quasi-infinite density.

Profundity. The German Atlantic Expedition, 1925-1927

Frequency had become the measure of space gained. In long-time processes of repeated oceanographic research since 1850, the ocean ground had emerged as a profiled and plotted landscape. Now sound began to outline that landscape fluently, eloquently. Depth seemed to articulate itself instantaneously: single data points dissolved into mountains, ridges, and reliefs. Resembling a narrated or written story, the texture of instrumental, graphical, and pictorial depth representation depended on the thickness, the richness of its *plots*.

The "German Atlantic Expedition", conducted on board the survey vessel *Meteor* from 1925 to 1927, combined oceanic *reconnaissance* and acoustic *connaissance* in making space. For one, the *Meteor* followed the path of the *Challenger* and succeeding journeys, making use of the data gathered during the observations on those earlier expeditions. Secondly, the *Meteor* was the first expedition to apply the new technology of acoustic sounding to a systematic deep-sea survey of the South Atlantic Ocean. By making use of echo sounding, the *Meteor* is said to have "provided new resolution to the picture of the ocean's floor"[32].

The scientists aboard the vessel stressed that it worked along a fine-meshed net of research "stations" laid over the breadths and the depths of the South Atlantic, replacing the "spot checks" of previous deep-sea research.[33] A dense sampling grid of fixed, equidistant points framed the territory under oceanographic investigation.[34] Between 20 ° N and 55 ° S, more than 300 stations were arranged in 14 cross-sections, narrowly spaced in intervals of 5 °. The total length of the *Meteor* voyage, proceeding from station to station along the cross sections, was to encompass about 130,000 kilometres. Deep-sea soundings along the cross sections amounted to roughly 60,000 soundings at 30,000 spots no more than 20 minutes apart.[35] This proceeding averaged to a sounding every 3 to 4 km, allowing a survey density that — according to an approximation done by the scientist concerned with the *Meteor's* soundings — would have taken the time of seven years of sounding day and night were it to be conducted with wire sounding.[36]

The expedition worked thoroughly, exactly, and systematically — *soundly* in every respect. Having replaced former "incomplete", "sporadic", and "single"[37] soundings with new extensive data by way of "continuous"[38] measurements is considered one of the most striking features of the expedition. Combining the method of continuous acoustic sounding with a strong survey grid, the expedition systematically framed a large oceanic space into 14 morphological profiles (Figure 4).[39]

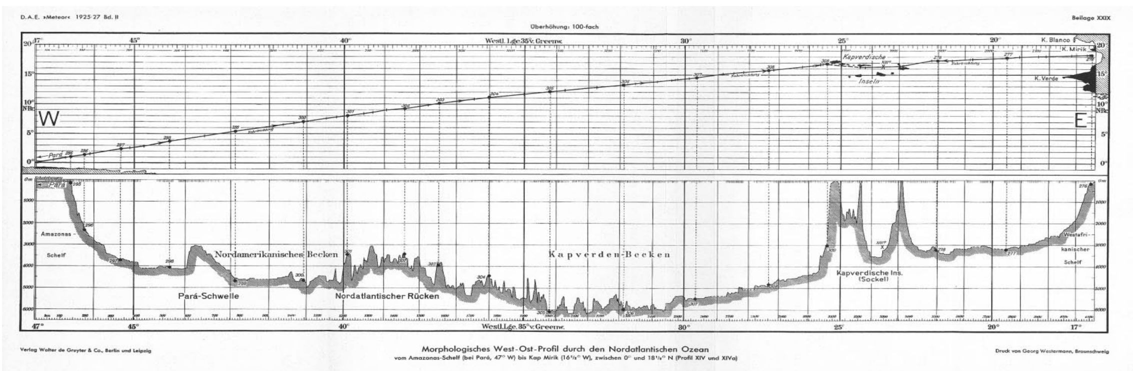

Figure 4

The great amount of data gained during the voyage was graphically processed in such a way as to "make perceptible the outline of the traversed oceanic space at first sight"[40]. The bathymetric map transported the new sea floor topography into popular books and atlases of the world's oceans (Figure 5). Its visual accentuations, numeric and textual elements presented the Atlantic Ocean as completely outlined, labelled, and charted terrain.

Conclusion: The Scientifically Sound Ocean

"Actually we are learning that in the deep sea we must use sophisticated systems if we are to be able to *see* the *unexpected*",[41] the oceanographer Fred Noel Spiess stated in 1980. The history of deep-sea sounding argues against the traditional notion of science simply visualizing hidden objects. Rather, the hidden object to be unveiled was gauged and defined in the process of depth measurement itself. Technological mediation provided the grounds and the conditions to present the ocean volume as the evident space that had always existed. Within this composition, the "unexpected" turned into the instrumentally perceptible and calculable quantity of length or time that could be transposed into profiles and contours.

Accordingly, oceanic space by 1930 was no longer a "sealed volume" opaque to direct human observation. It had become a technoscientific space fully resting on the history of refining the techniques of sounding and adding detail to the graphical images. The accumulation of data rendered the oceanographic fabric dense, compact, and really *opaque* with new significance: the ocean volume emerged not as *obscure*, but as scientifically coherent and convincing, tight and sound. The "immutable mobiles", the profile and the chart, neither concealed nor exposed this construction — they offered a third solution instead: the *transparent* ocean. Through rich hydrographical volumes of scientific data the oceanic volume was cleared, allowing the gaze to its solid ground.

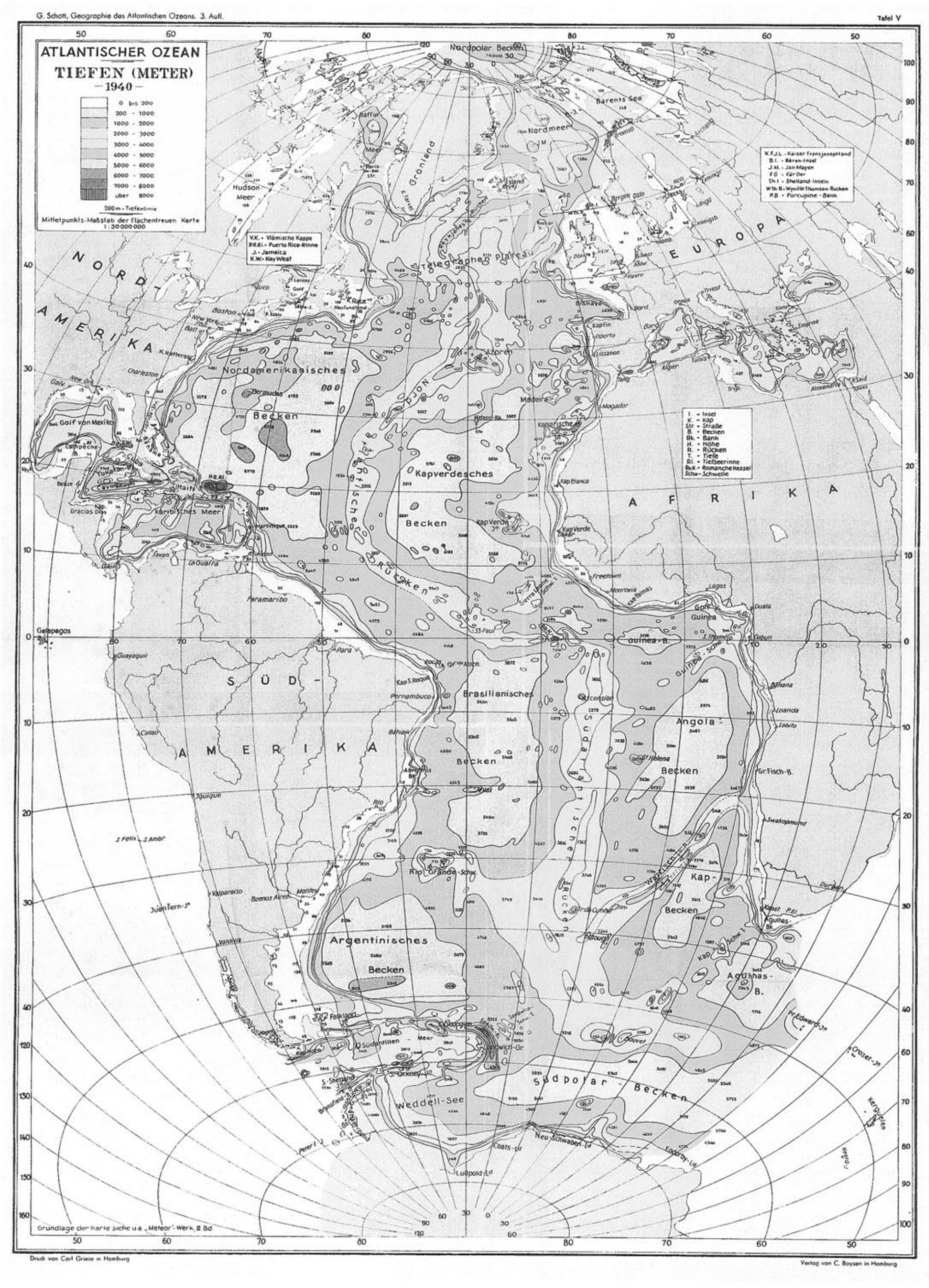
G. Schott, Geographie des Atlantischen Ozeans. 3. Aufl.
Tafel V
ATLANTISCHER OZEAN
TIEFEN (METER)
— 1940 —
NORD-AMERIKA
EUROPA
AFRIKA
SÜD-AMERIKA
Nordamerikanisches Becken
Kapverdesches Becken
Brasilianisches Becken
Angola-Becken
Kap-Becken
Argentinisches Becken
Südpolar-Becken
Weddell-See
Golf von Mexiko
Karibisches Meer
Telegraphen Plateau
Nordmeer
Barents See
Guinea-B.
Agulhas-B.
Druck von Carl Griese in Hamburg
Verlag von C. Boysen in Hamburg

Figure 5

Notes

1 Murray/Hjort 1965 [1912], p. 22, emphasis added.

2 "It is necessary, in order to be able to see anything in the sections, to exaggerate the scale of depth in comparison with the scale of horizontal distance. [...] This exaggeration of the vertical scale allows of the representation of a number of details, but, of course, the lines look very much steeper than they really are. One must not imagine that the continental slopes are so marked as they appear in the figure, for the angle is usually not so much as two degrees, the slope being similar to that of our common roads and railways"; ibid., p. 213.

3 Goodwin 1995, p. 250.

4 Ibid., p. 254; 256.

5 Latour 1986, pp. 7-9.

6 An extended version of this text has been published under the title "Depth Records and Ocean Volumes: Ocean Profiling by Sounding Technology, 1850–1930" in History and Technology; Höhler 2002c; compare also Höhler 2002a; 2002b. The analysis of the construction of ocean depth as 'reality' is greatly indebted to studies of representational practices which inspiringly combine semiotics and materiality in 'reality'-formation. See Butler 1993 on the concept of the performative, stressing repetition and repeated citing in processes of "materialization" of norms. The paper also profited very much from Donna Haraway's work on spatialization and map-making practices involving "recursive layers of stories and metaphors"; Haraway 1997, pp. 135-141. Striking in her work is the clear and repeated idea that to "be 'made' is not to be 'made up'" and that constructions are "about contingency and specificity but not epistemological relativism" (p. 99). This view is conditional for political claims that not "all views and knowledges are somehow 'equal', but quite the opposite" (p. 137).
Recently, Helen Rozwadowski made a similar argument concerning technology's mediating role in shaping the image of the mid-nineteenth-century deep-sea floor. Exploring deep-sea research in the context of the Atlantic telegraph cable projects in the 1850s and 1860s, she argues that the "ocean-scape" took shape only within a complex interaction of instruments, methods, interpretations, and motivations for depth measurement; Rozwadowski 2001.

7 Maury 1858, p. 114.

8 Ibid.

9 The term "hydrography" was used to address the physical geography of the oceans and the practice of ocean charting. The term "oceanography" came up only in the 1880s and by 1900 it was in general use. See Rozwadowski (1996) concerning late-19th-century naturalists forging the emerging discipline of oceanography by embracing questions of natural philosophy as well as hydrography. "Practitioners of early ocean science", Rozwadowski claims, "were defined more by the act of going to sea than by a shared body of specialized knowledge or common methods" (p. 409). According to the American oceanographer Henry Bigelow, oceanography in the first half of the 20th century denoted a comprehensive field of research, encompassing the world beneath the sea surface and the contact zones of sea and atmosphere. Oceanography investigated the bottoms and margins of the sea, the seawater, and its inhabitants. The inclusiveness of geophysics, geochemistry, and biology were stated as characteristic for a young science; see Schlee 1973, p. 12.

10 See Dibner 1959; Hunt 1997 for a more recent work on the electrical engineering of telegraph cables. Concerning the relations between submarine telegraph cable laying and depth sounding see Rozwadowski 1997, pp. 112 ff.; McConnell 1990; McConnell 1982, pp. 49 ff. Rozwadowski (1997, pp. 118 ff.) has pointed out that once the 1858

cable was laid, cable entrepreneurs and the public ceased to worry about the nature of the sea bottom. From the 1860s onwards, the ocean scientists were the ones most concerned about the accuracy of ocean depth measurements.

11 Rozwadowski 1998, p. 84. Notice the chapter on technological development at sea in Rozwadowski 1997, pp. 325 ff., and on sounding technology, pp. 337 ff. On deep-sea sounding instruments prior to and after the 1850s, see further McConnell 1982, pp. 49-72.

12 The detachable weight sounder was developed in 1852 by the U. S. Navy officer John Brooke. It consisted of a cannon ball fastened to a thin metal rod for taking bottom samples and mechanically detached from its clamp when hitting ground, allowing the lighter sampling rod to be hauled up alone; McConnell 1982, pp. 51 f.

13 Maury 1858, p. 114.

14 Ibid., p. 142.

15 Ibid., p. 179, emphasis added.

16 McConnell 1982, p. 50.

17 By the mid-19th century the use of isolines had become common. Bathymetrical contours were first used in the beginning of the 18th century. Murray/Hjort 1965 [1912], p. 3.

18 The map "Basin of the North Atlantic Ocean" was republished in Maury 1859, plate XI. For further explanation see p. 142 and p. 167. The map was reproduced in Murray/Hjort 1965 [1912], Map I.

19 Maury 1858, p. 142.

20 See Charnock 1973; Linklater 1972; Deacon 1971, pp. 333 ff.

21 Deacon 1962, p. 191. The ocean bottom was sounded 370 times. "With this new data cartographers finally were able to draw charts showing several main features, such as basins and mountain ranges of the ocean bottom."

22 Ibid., p. 116.

23 Murray/Hjort 1965 [1912], p. 131.

24 Ibid., p. 210.

25 Bruno Latour illustrates the technique of accumulating time and space by way of an "immutable mobile" with the example of the print and publishing technology of the Renaissance; Latour 1990, pp. 31 ff.

26 On the significance of data for giving and fixing "evidence" in the process of constructing a scientific fact see Amann/Knorr Cetina 1990; Wetzel 1994, especially p. 299. David Gugerli (1999, p. 132) speaks of "sociotechnical evidence" of a scientific construction.

27 Beyer 1999, p. 197.

28 Ibid., pp. 197-202, on underwater sound ranging in the period 1900-1925, focusing largely on studies in Britain and the USA. See Hackmann 1984, chapter I and IX, for an introduction to sound ranging devices before and during World War I, concentrating on British research.

29 Hackmann 1984, chapter I and IX; Drubba/Rust 1953, p. 394; Schott 1926; Peck 1909. "Echo sounders were the first peaceful application of this technology." Hackmann 1984, p. xxxiv.

Practicable echo sounding systems were developed as early as 1913, but only in the early 1920s the question of acoustic sounding became preeminent, leading to the replacement of line sounding. See Hackmann 1984; Schulz 1924; Maurer 1922, p. 348; Behm 1921. According to Alexander Behm, the sinking of the Titanic in 1912 motivated him to consider an apparatus to measure the depth of water with the help of reflected sound waves. Behm started his experiments in 1911/1912 but did not market his sounding devices until the 1920s. Behm claims to have coined the German term „Echolot"; Behm 1921, p. 243. His apparatus used explosive cartridges as a sound source, fired just below the watermark. The echo sound receiver consisted of an electrodynamic oscillator ("hydrophone"). The German navy had perfected the passive hydrophone technology ("Unterwasserhorchgeräte") during World War I. US, French, and British echo sounding devices made use of electrodynamic transmitters also to emit submarine sound signals in the audible range of the wave spectrum (roughly 10-40,000 Hz). For further details on the history of different sounding methods, of transducer technology, and of binaural listening technology in echo sounding see Höhler 2002c.

30 Measurements were always checked by reliable line sounding apparatus. The velocity of sound in water varied with water temperature, density, and salinity. Inhomogeneity of the ocean volume caused distortions of the sound beam through refraction. Intensity problems of sounding involved sound reflection, spreading, scattering and absorption. Bottom composition further influenced the results. Sound signals were often obscured by surrounding noises, for instance by the engines of the ship itself.

31 "The general principle of the acoustic method consists in general of substituting for direct measurement of the depth itself an indirect evaluation thereof by means of the time taken by a sound wave to travel over this depth or, to be more exact, over a submarine path which is connected with the depth by a well known formula." "Echo Sounding" (1924), p. 135.

32 Emery 1980, p. 697. On the subject of the Meteor Expedition and its pictures providing evidence of the South Atlantic Ocean floor see Höhler 2002a. Other than the Challenger, the Meteor expedition laid emphasis upon physical oceanography, applying and empirically studying the theory of ocean circulation. The Meteor's echo soundings composed the second volume of the 16 volumes published subsequent to the journey; see Defant 1932 ff.

33 "Stichproben"; Wüst 1953, p. 717.

34 Merz 1925, p. 575 ff. See also Wüst 1932.

35 Maurer 1933, p. 23 f.: "Plan und Durchführung der Lotungen an Bord". Maurer gives the exact number: 67388 soundings were taken during the expedition; p. 24.

36 Ibid., p. 1.

37 ("lückenhaft", "sporadisch", "vereinzelt"); Maurer 1933, p. 299.

38 ("laufend"); ibid., p. 24.

39 "Inzwischen sind nun von vielen anderen Schiffen der verschiedenen Kriegs- und Handelsflotten eine ganze Reihe solcher Profile veröffentlicht worden, nachdem erstmalig die 'Meteor'-Expedition, die hiermit die von ihr erzielten Lotungen, zu Profilen verarbeitet, vorlegt, systematisch größere Ozeanräume durch sehr engabständige Lotungen aufgenommen hatte." Ibid., p. 299.

40 "In der Tat ist ein derart graphisch verarbeitetes umfangreiches Zahlenmaterial sehr dazu geeignet, auf den ersten Blick die Großformen des durchfahrenen Meeresraumes erkennen zu lassen"; ibid.

41 Spiess 1980, p. 227, emphasis added.

Figures

Fig. 1: Section showing the Form of the Bottom of the Atlantic Ocean along the Parallel of 40° N. Murray John, Hjort Johan (1965): *The Depths of the Ocean*. Weinheim: Cramer [reprint of the edition from 1912, published by Macmillan, London], p. 212.

Fig. 2: Basin of the North Atlantic Ocean. Maury, Matthew Fontaine (1859): *The Physical*

Geography of the Sea. New York/London: Harper/Sampson Low, plate XI.

Fig. 3: Depths of the North Atlantic. Murray, John, Hjort, Johan (1965): *The Depths of the Ocean*. Weinheim: Cramer [reprint of the edition from 1912, published by Macmillan, London], map III.

Fig. 4: Morphological West-East Profile of the North Atlantic Ocean. Maurer, Hans (1933): *Die Echolotungen des „Meteor“*. Defant, Albert (Ed.) (1932 ff.): *Deutsche Atlantische Expedition auf dem Forschungs- und Vermessungsschiff „Meteor“, ausgeführt unter der Leitung von Professor Dr. A. Merz † und Kapitän z. S. F. Spiess, 1925-1927. Wissenschaftliche Ergebnisse*, herausgegeben im Auftrage der Notgemeinschaft der Deutschen Wissenschaft (16 Vols.). Berlin/Leipzig: de Gruyter, Vol. 2, supplement XXIX.

Fig. 5: Atlantic Ocean: Depths (Meter), 1940. Schott, Gerhard: *Geographie des Atlantischen Ozeans*. Boysen: Hamburg 1942 [3., revised edition, 1. edition 1912, 2. edition 1926], plate V.

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