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GEBCO Centennial Special Issue – Charting the secret world of the ocean floor: the GEBCO project 1903–2003

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Abstract

This special issue of Marine Geophysical Researches presents five papers dealing with GEBCO, the General Bathymetric Chart of the Oceans, which celebrated its Centennial in April 2003, hosted by the International Hydrographic Bureau and the Principality of Monaco. Over the past 103 years GEBCO has been the sole body dedicated to compiling all available data to produce standardized maps of the oceans and seas covering 71% of planet Earth. Over time GEBCO has undergone a complete transformation as sparse 500 m contours on paper charts were replaced by digital grids with ever-increasing resolution. The 2003 Centennial saw the release on two CDROMS with the first global 1′ grid, produced by methods unheard of in 1984, when GEBCO's last 6th Edition paper chart set was published. In GEBCO's second century, the thrust is towards global grids that will capture the resolutions available with evolving deep-water swath mapping technologies, as well as vast improvement in the details of the shallow continental shelves that have traditionally been the preserve of the hydrographic community. As little more than 10% of the oceans have been mapped to the desired level of detail, there is much to be done. However refinements in satellite altimetry appear to offer an interim stop-gap as more multi-beam sonars ply the oceans and as the littoral countries of the world map their adjacent marine areas for submission under Article 76 of UNCLOS (United Nations, 1983, 1999). In addition GEBCO is becoming increasingly proactive, with outreach to the public via the internet and a new GEBCO Map of the World, active data-scrounging, and encouraging development of the first drifting buoys for acquiring data in the inaccessible areas of the Antarctic, SW Pacific, and Arctic Oceans.

Introduction and Background

For over 100 years the prime mover for compiling the bathymetry of the world's oceans and seas has been GEBCO, the General Bathymetric Chart of the Oceans. Initiated in 1903 by His Serene Highness Prince Albert I of Monaco, by 1984 GEBCO had published five editions of paper charts covering the world. Sixteen charts at 1:10 million scale in Mercator projection covered the world from 72 °S to 72 °N, and two charts in Polar Stereographic projection at 1:6 million scale covered the Arctic and Antarctic. The bathymetry was shown by hypsometric tints and contours of corrected depths at intervals of 500 m with a 200 m contour more or less defining the continental shelf-break. The track-line control was shown in light grey lines. The history of GEBCO has been chronicled by Carpine-Lancre et al., (2003).

Following the publication of the Fifth Edition in 1984 by the Canadian Hydrographic Service (IHO/IOC/CHS, 1984), GEBCO found itself at a crossroads. Traditionalists favored continuation of the past with ever more precise contours every 500 m. New activists schooled in digital techniques argued that the ever-increasing amount of data allowed description of the intervals between contours through the use of grids. Traditionalists countered that since most of the oceans were devoid of track-line soundings, the grids must of necessity be so coarse as to be unable to replicate the original contours.

The matter was eventually resolved in favor of the oncoming digital revolution. This was fortunate because there was little interest and no financing available for publishing an only slightly improved sixth edition. The first step was the publication of the GEBCO Digital Atlas, a CDROM with digitized contours and track-line soundings and graphic display software (Jones, 1997). In addition, the development of satellite altimetry from Geosat and ERS-1 gave sea surface heights along tracks every 2–3 km at the Equator, and sophisticated analysis of the sea surface slope showed the gravitational effect of the underlying submarine structures. When the thickness of the less dense sedimentary cover was taken into account, then a sort of synthetic bathymetry could be derived (Smith and Sandwell, 1994, 1997). This now provided approximate bathymetry in sparsely or unmapped areas. The result was the release at the 2003 GEBCO Centennial of the first gridded dataset at 1′ intervals (IOC-IHO, 2003). The recently developed GTOPO30 land topography (U.S.G.S., 1997) was used for the land areas.

GEBCO is an international project under the joint auspices of the Intergovernmental Oceanographic Commission (IOC) of UNESCO, and the International Hydrographic Organization (IHO). Although its officers are divided equally between candidates from both organizations, the transition from analog contours to digital grids reflects the changing professional backgrounds of the thirty or so GEBCO stalwarts who spend 10 days each year at the annual get-togethers, many at their own expense. Marine geophysicists with an abiding interest in whole regions or oceans now outnumber hydrographers seconded by national agencies. Within the Sub-Committee for Digital Bathymetry (SCDB) this has resulted in an attitude of getting on with the job and making up the methodologies as needed. Within the GEBCO Guiding Committee, the setting of policy continues with the job of defining tasks, canvassing nearly 80 hydrographic offices, and then delegating responsibilities, provided there is financial support. The major contribution of the IHO continues to be within the Sub-Committee for Undersea Feature Names (SCUFN), the IHO-DCDB (Data Center for Digital Bathymetry) and the World Data Center for Marine Geology and Geophysics (WDC MGG) at the National Geophysical Data Center (NGDC) in Boulder, Colorado, and massive support for the International Bathymetric Charts (IBCs) (see below).

Compared to what GEBCO is tasked to do, it continues to run on a shoestring. The bulk of its support comes from the Natural Environment Research Council in the United Kingdom. Within the last year there were even efforts to cut out all IOC Ocean Mapping funding in order to address the tsunami threat. Most of GEBCO's activity derives from its many geophysical stalwarts whose research activities parallel or include various components of GEBCO. Following the Centenary in 2003 GEBCO embarked on an outreach program. With a \$2.9 million grant from the Nippon Foundation in Japan, GEBCO initiated a graduate degree program in Ocean Mapping at the Center for Coastal and Ocean Mapping at the University of New Hampshire (CCOM-UNH). The first class of a half dozen students graduated in late 2005.

For years various GEBCO participants have been very active in another IOC-IHO activity begun in the late 1970's. This was the establishment of what was to become a series of eight regional projects called the IBCs. For instance I am Vice-Chairman of IBCM, the International Bathymetric Chart of the Mediterranean and Black Seas, which was the first. This was followed by IBCCA for the Caribbean, IBCEA for the Eastern Atlantic, IBCWIO for the Western Indian Ocean, IBCSWP for the Southwest Pacific, IBCAO for the Arctic Ocean, IBCSEP for the Southeast Pacific, and recently an IBCSO for the Southern Ocean (circum-Antarctica). These IBCs work on a much finer scale of 1:1 million, originally with 20 m contours for the shelf and 200 m contours in deeper waters. These are primarily undertaken by the regional hydrographic offices, but much geophysical input has, in the case of the Mediterranean and the Arctic, resulted in additional overlays of Bouguer gravity and magnetics, and in the case of IBCM, also Plio-Quaternary isopachs, seismicity, and recent bottom sediments.

In recent years GEBCO has become proactive. Activities under consideration include outreach to the public via the internet, and a search for philanthropists and foundations interested in leaving their mark on posterity by underwriting the cost of data conversion and related activities. Areas of development include GEBCO booths at professional meetings, publication and distribution of a new GEBCO Map of the World, and a pilot program of active data-scrounging in poorly mapped areas. GEBCO interests also initiated the development of the first SSPARR drifting echo-sounding buoys for acquiring data in the inaccessible areas of the Antarctic, SW Pacific, and Arctic Oceans.

The Marine Geophysical Researches Special Issue

The GEBCO Centenary Commemoration on 14–16 April 2003 at the Salle des Variétés in Monaco had 26 presentations. These were made available to attendees on two CDROMs, as either PDF or Powerpoint files or both. Unfortunately only three of these papers were made available for this special issue. The five papers below focus on four aspects of the GEBCO program.

Larry Mayer's paper dwells on the rapid and exciting changes that are occurring in ocean mapping using multibeam sonars. On the one hand the observations themselves have become much more reliable and robust due to vast improvements in the sonar systems, computer processors and algorithms, navigation, motion sensing, and measurement of the sound speed structure of the water column. In parallel the analysis software has greatly speeded up data analysis, with widely implemented improvements like CUBE (Calder and Mayer, 2003). Furthermore, visualization software has allowed the results to be examined in detail and understood by an ever-growing audience. Accompanying the changes has been acceptance of some of the recommendations of Scientific Committee on Oceanic Research (SCOR) Working Group 107 (2002) on Improved Global Bathymetry. In one case this has involved the planned installation of multibeams on all NOAA's survey vessels with the intention that they operate while at sea. Now that the bathymetric data are being routinely acquired, great changes are occurring in the standardization and analysis of the attendant backscatter data, perhaps leading eventually to routine and accurate characterization of the seafloor.

The paper by Karen Marks takes a look at the publicly available global bathymetric (and topographic) grids. DBDB5 was the first global bathymetry grid, with 5′ (~8 km) spacing between nodes. The publication of the GEBCO 5th Edition and the assembly of DBDM5 by the U.S. Naval Oceanographic Office appear to have gone hand in hand (*viz*. Frank Marchant of NAVOCEANO was an early member of the GEBCO SCDB). DBDB5 was a tremendous step forward, but the paucity of data and the large node spacing resulted in misusage of the data. Anecdotally, I had to dissuade a number of mythologists from the idea that Moses could have crossed from Sinai to Saudi Arabia via a shallow sill that DBDB5 showed in the Gulf of Aqaba in the northern Red Sea. A detailed seismic survey in 1976 (Ben-Avraham et al., 1979) showed that minimum depths were over 800 m.

These first beginnings have evolved to ETOPO2 on a 2′ grid, and then to the 2003 GEBCO 1′ grid. Recently the internet has brought us the Scripps SRTM30-Plus 30″ (~926 m) grid (http://topex.ucsd.edu/WWW_html/srtm30_plus.html), using the SAR topography from the 2000 Shuttle Mission on land, with reinterpolated Smith and Sandwell (1994, 1997) data, and GeoMapApp©, the brainchild of the late Bill Haxby (www.geomapapp.org) which hosts multibeam bathymetry on grids as fine as a hundred meters from the LDEO archives. The appearance of these improvements over GEBCO's 1′ grid has resulted in discussions on revamping GEBCO's archaic bathymetric editing processes (occasioned by the hand contouring of sparse track-line soundings). The coherent nature of swath-mapped polygons makes them good candidates for bodily insertion into volatile grids available on the internet. This indicates to me the path that the ultimate implementation of the Global Ocean Mapping Project (GOMaP) will take (see below).

The paper by Jakobssen compares the new IBCAO compilation of the Arctic Ocean with the earlier manually contoured GEBCO Sheet 5.17 of the Arctic based upon considerably less sounding data. The IBCAO is the first IBC to be prepared with completely digital methods, by earth scientists and hydrographers. It is innovative in that for the graphical presentation, the land areas have been shown in hypsometrically tinted shaded relief with the superposition of glaciers.

The papers by Jean Mascle and Caroline Huguen describe two interesting areas in the eastern Mediterranean, mapped by high resolution Simrad multibeam systems. These surveys are part of a multinational compilation pioneered over the past decade by the French (Hall, 2005; Loubrieu et al., 2005; Huguen, 2001), and recently published as two posters (MediMap Group et al., 2005). This effort has thus far resulted in over 40% multibeam coverage of the Mediterranean, which presumably will, upon completion, become the first area to have been mapped according to the original goals of the GOMaP project.

GOMaP was annunciated at the millennium by Peter Vogt and others (Vogt, 2000, 2001, 2002; Vogt et al., 2000, 2001; Carron et al., 2001). It lays out an action plan to use multibeam sonar to map all the world's oceans, and has on its letterhead Walter Cronkite's (1996, p. 282) observation that "Perhaps even more important than space exploration for our immediate future is our examination of the Earth's oceans. They cover 71% of the Earth and we still know so little about them and what lies at their bottom".

While the estimated budget for GOMaP amounts to $8–16 billion, spread over at least several decades (Vogt et al., 2001), it represents a chance to finally do for the oceans what the 2000 space shuttle Endeavor SRTM STS-99 flight did in 10 days for earth topography – a proper mapping of the surface of the earth's lithosphere. This surface is one of the primary geophysical layers, influencing weather, oceanic circulation, and climate, as well as revealing the surficial geology and fabric of much of Earth's recent tectonic history.

Some five years ago the estimates for completing such a survey of the oceans were 225 years for the areas deeper than 500 m, and 600 ship years for the 50–500 m depth interval (Vogt et al., 2001). The rapid progress in development of AUVs suggests that an effort similar to that of the Ocean Drilling Program, with many AUVs operating from a large mother ship, could greatly increase efficiency and reduce costs. While the impetus for GOMaP seems to have lagged recently with the onset of huge budget deficits and plans to put people on Mars, a small coterie maintains the flame (Cormier et al., 2004), while ongoing academic and UNCLOS surveys slowly decrease the areas remaining to be surveyed.

Concluding Remarks

It is fitting that Marine Geophysical Researches has a special issue on the GEBCO Centennial. Over the years the journal has published bathymetric maps of relatively large areas surveyed by swath sonar (viz. Dziak et al., 2001), as well as earlier compilations including the various ridge programs (Purdy et al., 1990; Macdonald et al., 1992; Cochran et al., 1993; Scheirer et al., 1996; Fisher and Goodwillie, 1997; Lourenço et al., 1998). Recent trends suggest that in future such maps will more likely be printed as meeting posters, and digitally available as downloadable internet graphic files and grids, with the details discussed in published articles with smaller graphics.

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