THE BLACK SEA CONTINENTAL SHELF. STUDIES AND RESEARCH OF MARINE HYDROGRAPHY AND HYDROLOGY IN THE SECOND HALF OF THE 20TH CENTURY

OCTAVIAN ŞELARIU*

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Etudes et recherches de hydrographie et de hydrologie marine dans la plate-forme continentale du secteur roumain de la mer Noire pendant la seconde moitié du XXe siècle. L'auteur évoque, pour l'histoire de l'océanographie roumaine, les résultats de ses recherches hydrologiques assidues menées, presque deux décennies (1959–1977), dans les eaux maritimes territoriales de la Roumanie et de plus au lange de la plate-forme continentale de la mer Noire, sur deux profils d'environ 100 miles marines chacun dans une première étape et sur 7 profils, dont 5 plus longs (90–110 Mm) et plus courts (30 Mm). On mentionne ces résultats par étapes, soulignant leurs particularités distinctives. Le texte marque le moment d'une première caractérisation océanographique complexe d'un segment significatif de nord-ouest de la mer Noire.

EARLY BEGINNINGS

The first Romanian marine hydrography and hydrology research in the Black Sea is documented in the volume *The Sulina Arm. An outlet to sea* (Danube European Commission, 1856), later followed by bathymetric measurements connected with the construction of Sulina and Constanţa ports.

A remarkable cartographic achievement by A. Cătuneanu, the *Marine Map – Romania's coastline*, awarded in 1910 the gold medal in Paris, was published on the eve of the 19th and the dawn of the 20th centuries.

After the First World War, the Romanian Hydrological Service, Marine Department, embarked upon a series of coastal topohydrographic investigations (1925–1926) at the Danube mouths, an active field campaign starting in 1937, initially on the coasts of Mangalia. Unfortunately, the outbreak of the Second World War interrupted this activity.

We would mention in brief that in the inter-war period, the north-western parts of the Black Sea focused the attention of some outstanding Romanian scientists – biologists, geographers and geology specialists such as Grigore Antipa, Ion Borcea, Constantin Brătescu, Radu Ciocârdel, and others.

As a result, the Marine Zoology Station and the Bio-oceanographic Research Station, representing an important marine research nucleus on the Black Sea coasts, were set up at Agigea (1926) and in Constanţa (1932), respectively.

After the Second World War, the new Maritime Hydrography Direction (1954–1955) decided on the topographic revision and updating of the Romanian coastline and territorial waters. Works developed in three successive stages as follows:

1959–1960

Considerable efforts were made towards a common action of *marine hydrographical and hydrological* surveys first of the territorial waters and next of hydrological alone the continental shelf on two profiles of cca. 100 miles each: one east-south-east of Gura Portiţei and the other east of Mangalia.

* Assoc. professor, *Mircea cel Bătrân* Naval Academy, Fulgerului Street, no.1, 900218, Constanţa.

In view of the above, a former gun boat of the Military Marine, The Stihi, was re-equipped, fitted for hydrological investigations, and turned into a surveying vessel (NH 112). It was equipped with new propellers, installations for navigation, for hydrographic and hydrological surveys, for launching specific equipment into the sea to collect and assay hydrological, hydrobiological and sedimentological samples; for water chemistry determinations, a micro-laboratory, a semi-automated meteorological station, etc. were ready for research-work.

In order to enlarge the field of investigation, a temporary collaboration was concluded with specialists from the Hydrography Direction, the Romanian Academy Laboratory of Marine Biology and the Hydrology Laboratory of the Institute for Hydrotechnical Studies and Research.

A first step in undertaking systematic works of marine hydrography, bathymetry and hydrology was to establish a topographic base on the shore and canvas the lines of bathymetric sounding and of hydrological profiles.

The hydrological line had over 100 equi-distant lines, 12 miles long, each profile featuring 5 stations/points in which the ship was to anchor and make determinations of water temperature, salinity and density, alkalinity, soluted oxygen content, marine currents, elements of waves, sea roughness, meteorological observations and collect samples from the superficial sea-bed layer.

In this stage, numerous measurements were performed at depth stations and horizons of all the previously established points of the hydrological network of territorial waters, and of two more 80–90 m-long profiles in open sea each; during 1960, measurements were repeated four times every season.

1961–1969

In the autumn of 1960, after hydrographic-hydrology surveys conducted in the previous stage had been concluded, a tripartite international meeting was held attended by maritime hydrography bodies from the Soviet Union, Romania and Bulgaria. An important comprehensive plan was drafted, involving the joint collaboration in matters of complex maritime research-work, *exclusively hydrological*, of the whole shelf from the western and north-western parts of the Black Sea.

The idea was to obtain a series of hydrological profiles quasi-normally oriented to the coastlines of each of the three participant countries. It was agreed for all research ships to go to sea simultaneously four times a year, and for hydrological measurements to be common in content. It was considered, and rightly so, that the synoptic benefits of simultaneity would prove efficient in the interpretation of the data obtained. Another Protocole provision stipulated (rather domineeringly) that annually centralised results obtained by the Romanian-Bulgarian side should be delivered to the Soviet part at the end of each year, who in its turn was to give the other two partners a general synthesis of the whole western portion of the Black Sea (unfortunately, a commitment never fulfilled).

The maritime programme assumed by the Romanian side was completed in nine years (1961–1969), a minor change having been made in the positions of two stations on the Sulina profile.

Under the continental shelf hydrological project, Romania was assigned five profiles, three of them of appreciable length with the following orientation: eastward – *Sulina*, 90 miles; south-eastward – Sfântu Gheorghe, 110 mile; *Mangalia* – east-north-eastward, 90 miles, and two shorter profiles 30 miles each: *Gura Portiței*, east-south-east and *Constanța* eastern orientation.

The five profiles totalled 39 stations each time the ship went out to sea (the vessel anchored or drifting at depths of over 70 m), the researchers worked diligently and often in the very difficult conditions of a rough sea.

In the case of our investigations, an expedition to sea lasted for some 5–6 days/month, the complete working programme being repeated four times/year in February, May, August and November, considered to be characteristic months, hence the term “standard hydrological profiles”.

1970–1977

As from 1970, after having given up the previous profiles new ones were chosen. They had an altogether different orientation in order to get a better coverage of Romania's entire continental shelf; however, the working programme formerly established and the seasonal rate of sea-goings (February, May, August and November) were maintained.

Besides, an important aspect was the addition of some fixed multi-diurnal stations for an interval of 48–72 hours were located in the central area of the shelf and equipped with self-recording devices (thermo-bathygraph and currentgraph) which supplied diagrammatic information on temperature variations with the depth and data on the sea currents.

At the same time, additional sedimentological and hydrological surveys went on in various points or positions off the continental shelf.

GLOBAL DATA 1959–1977

The schematic location of an almost twenty-year-long marine research into the continental shelf of the Romanian Black Sea littoral area (Fig. 1).

Out of a huge amount of data, some hydro-physical considerations on *marine hydrology* (A) and *submarine hydrography* (B) are further presented.

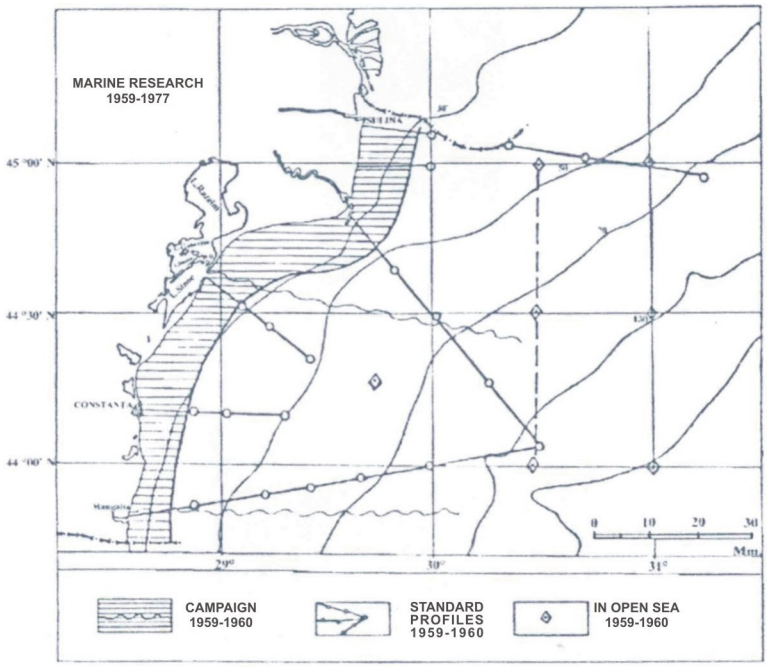

Fig. 1 – The schematic location of marine research into the continental shelf.

A. Marine hydrology

- *Water temperature* [19]: major seasonal sea-surface thermal variations, with significant local influences on the littoral waters at the Danube mouths; appreciable specific stratifications at depth – in *summer*, direct vertical variation (high temperature decreases in the active sea-layer (0–75 m); in *winter*, inverted thermal stratifications (slight increases with depth and a tendency to isothermy); the effect of wind on surface water ("upwelling").

• *Chemical composition and salinity*: salmastrian waters influenced by the Danube inflow; divergent and progressive increase of salinity towards the open sea and to the south; at depths below 25 m there is a tendency of hydrochemical homogenisation of salinity values ≥18‰; *thermo-saline regime* [18]: impacts especially water density, as well as other physical magnitudes (submarine hydro-acoustic, etc.), the water convection movement involved in the adequate organisation of waters on the shelf versus the central-deep areas of the Black Sea infested with sulphuratted hydrogen (Fig. 2).

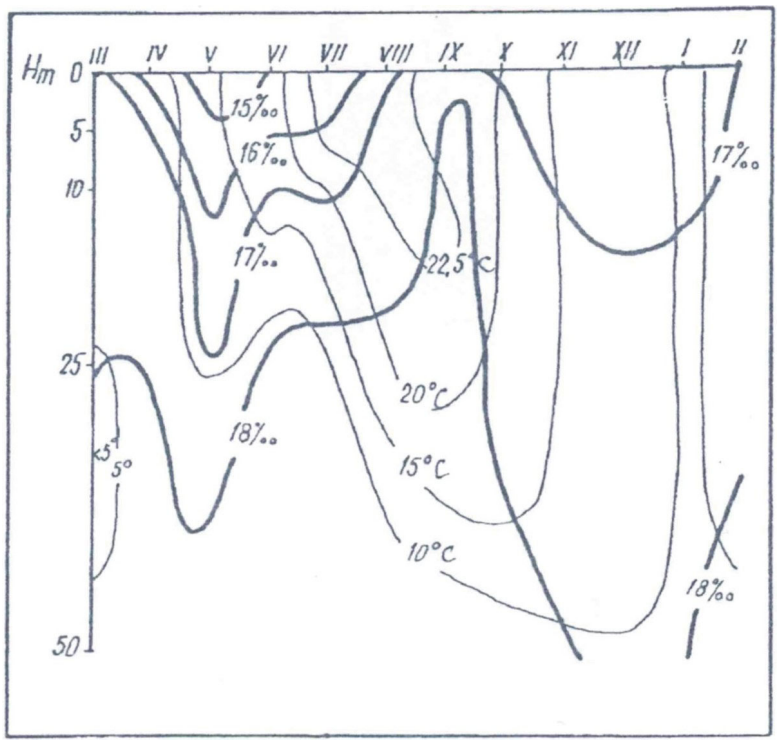

Fig. 2 – Temperature and salinity isopleths in the north-west of the Black Sea.

• *Masses of water* [2]: temperature values associated with other hydrological variables (soluted oxygen, turbidity, etc.), used in resolving some differential equations of diffusion and thermal conductivity, enable the qualitative assessment of three masses of water in the Romanian Black Sea area:

1. coastal waters,
2. off-shore open sea surface waters,
3. deep waters.

Their differentiation and seasonal variations had concrete applications not only in physical hydrology, but also in marine hydrology (G. Müler, H. Skolka, in *Ecologie marină*, vol. III 1969, vol. IV 1973).

• *Marine waters dynamics* [5, 6, 12, 14]: level variations: data processed after a recording device planted in Constanța harbour: slightly perceptible semi-diurnal tide, mild but an obvious tendency of the sea-level to rise against a oscillating background; Waves, in open sea are important for navigation or maritime technologies – in low-depth area studied as breakers with significant impact on coastal morphodynamics; Marine currents, studied both in terms of sea-surface layer and of their vertical structure, are differentiated into: *drift currents* (wind-related), *density currents* (in the pre-deltaic marine area), and *inertia currents* (after a relative fall in the impulse force), but also *local circulation cells* induced by the configuration of the coastline or by various hydrotechnical structures designed for port activities or coastline defences.

B. Submarine hydrography

- *The sea-shore and the submarine coastal slope* [1, 3, 18] show major morphological imbalances in the processes of accumulation-erosion in the northern sector of a low, vulnerable coast and processes of abrasion and sliding in many portions of the unmanaged cliff of Singol Cape (Constanța North).

In general, there are obvious signs that the coast tends to retreat, concomitantly with the shrinking of the beaches due to human activity, reduced river sediment-load input to the sea, on the one hand, and to the deviation of the sea alluvia flow caused by the extension of hydrotechnical constructions on the submarine coastal slope, on the other.

- *Continental shelf* [2, 11, 16, 17], considered to be the continuation of Dobrogea land under the sea level[1], basically a flat submarine table with small slopes (0°04' – 0°09') extending up to the 128–130 isobath, which is the eastern end of the shelf marked by an evident scarp.
- *From a genetic viewpoint*, our continental shelf falls into the transgression-accumulation shelf category, following the well-known Holocene post-glacial transgression, resulting in the eustatic rise of the sea level affected also by negative epirogenetic movements and strong sedimentation.

Works of general bathymetric hydrography and detailed elevations in certain parts, as well as careful interpretation of the great many sedimentological samples made in the 1960s–1970s have enabled us to establish some submarine morphology features, e.g. a network of submarine valleys hidden under a thick alluvial layer, a finding argumented not so much bathymetrically as by granulometric and numerological values [10]. The main collector of the submarine valleys is the south-east-oriented submarine valley of the Danube which crosses the shelf up to parallel 44°, touching upon the continental slope through an impressive submarine canyon[2] (Fig. 3).

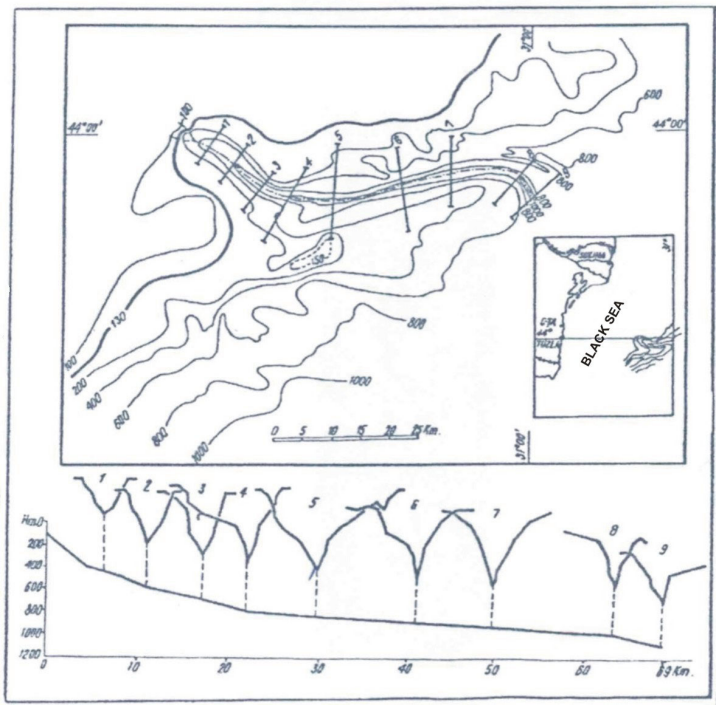

Fig. 3 – Submarine canyon in continuation of the submarine valley of the Danube.

[1] C. Brătescu, 1928 – "the real margin of Dobrogea should be looked for somewhere in the open sea and not at the present sea side".

[2] Surveyed and mapped in Romania during 1963-1964 [4], subsequently named by the Russians as Vyteaz [Vitenz] (?!) canyon.

Similar morpho-sedimentological interpretation criteria allowed to divide the continental shelf into an *inner shelf* in the west, strongly sedimented, and an *outer shelf*, beyond the 70 m isobath, deficient in terms of present-day sedimentation. The two sides are separated by a 55–65 m-deep transition zone.

Some relict littoral bars might exist at depths of 50–60 m and 70–80 m, an assumption supported by a slightly rougher granulometric texture and the presence of heavy minerals. In the canyon zone [4] (Fig. 3), one can detect traces of submarine slidings from the upper part of the continental slope.

A schematic geomorphological representation of the continental shelf in the Romanian sector of the Black Sea is given in Figure 4.

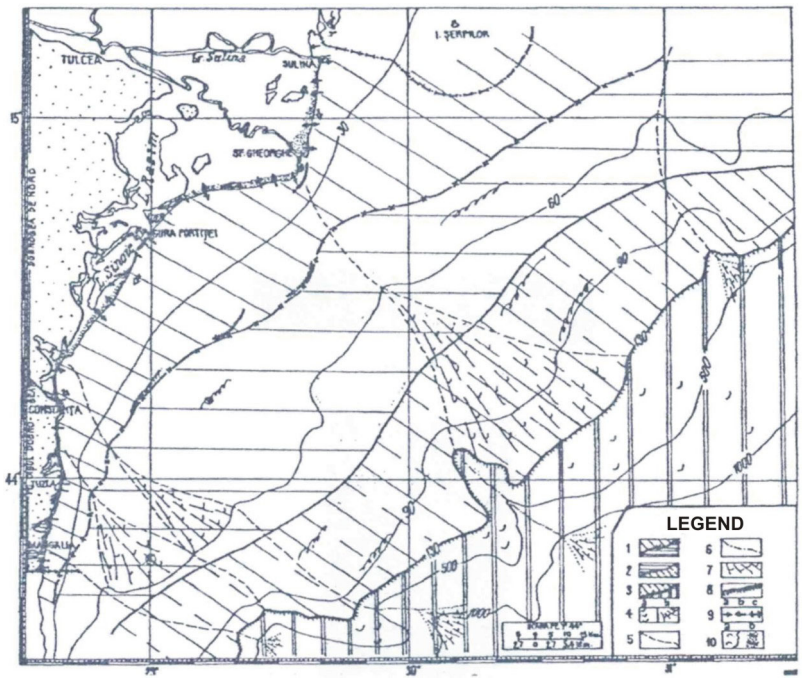

Fig. 4 – A geomorphological sketch of the continental shelf.

A generalised bathymetric picture of this part of the shelf presents its outer limit at the 130 m isobath, a schematic view of the internal and external shelf and some other details in the shelf area and the afferent continental slope.

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