RELATIVE DETERMINATIONS OF GRAVITY AT SEA

in the Western Mediterranean Basin

(Cruises of French Submarines *Fresnel*, 1933 et *L'Espoir*, 1936).

by

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(Extract from Comptes Rendus 1933 à 1936

du Comité National de Géodésie et de Géophysique, Paris).

NOTE OF THE I.H.B.

Ingénieur hydrographe en chef MARTI died in December 1938 after a very long illness. His death brings a great loss to the French Hydrographic Service.

The installation of the gravimetric apparatus on these relatively spacious vessels offered no particular difficulty.

With a view to obtaining knowledge of the time with the requisite accuracy, there was installed in the ship's wireless room, on each expedition, a group of four marine chronometers protected from the hull vibrations by elastic shock absorbers. To facilitate the comparison of the four chronometers with each other at any instant, and to make readings more rapid, there was installed a graphic recording device with four pens registering on a band of paper, loaned by the Hydrographic Service, which was operated by very sensitive oscillographs. These in turn were caused to function by the electric interrupters of the chronometers. As the current required for the interrupters was only 2 to 3 milliamperes, this did not adversely influence the operation of the instruments of precision.

Finally, as it is essential for the reduction of the gravimetric observations to know the depth of the ocean in the region under exploration, there was installed on the *Fresnel* a "home-made" acoustic sounding apparatus to enable the depth to be determined at the same instant the gravimetric observations were made (that is, during the dives), and this by making use of the recording device installed for the purpose of chronometer comparison. On the *Espoir* use was made of a new acoustic sounding apparatus especially designed for the bathymetric exploration of the ocean, and which permitted soundings to be taken as frequently as desired without even slowing the vessel.

These various installations of instruments were made, for both expeditions, by the *Centre d'Etudes* of the French Navy, Toulon.

CARRYING OUT THE OBSERVATIONS.

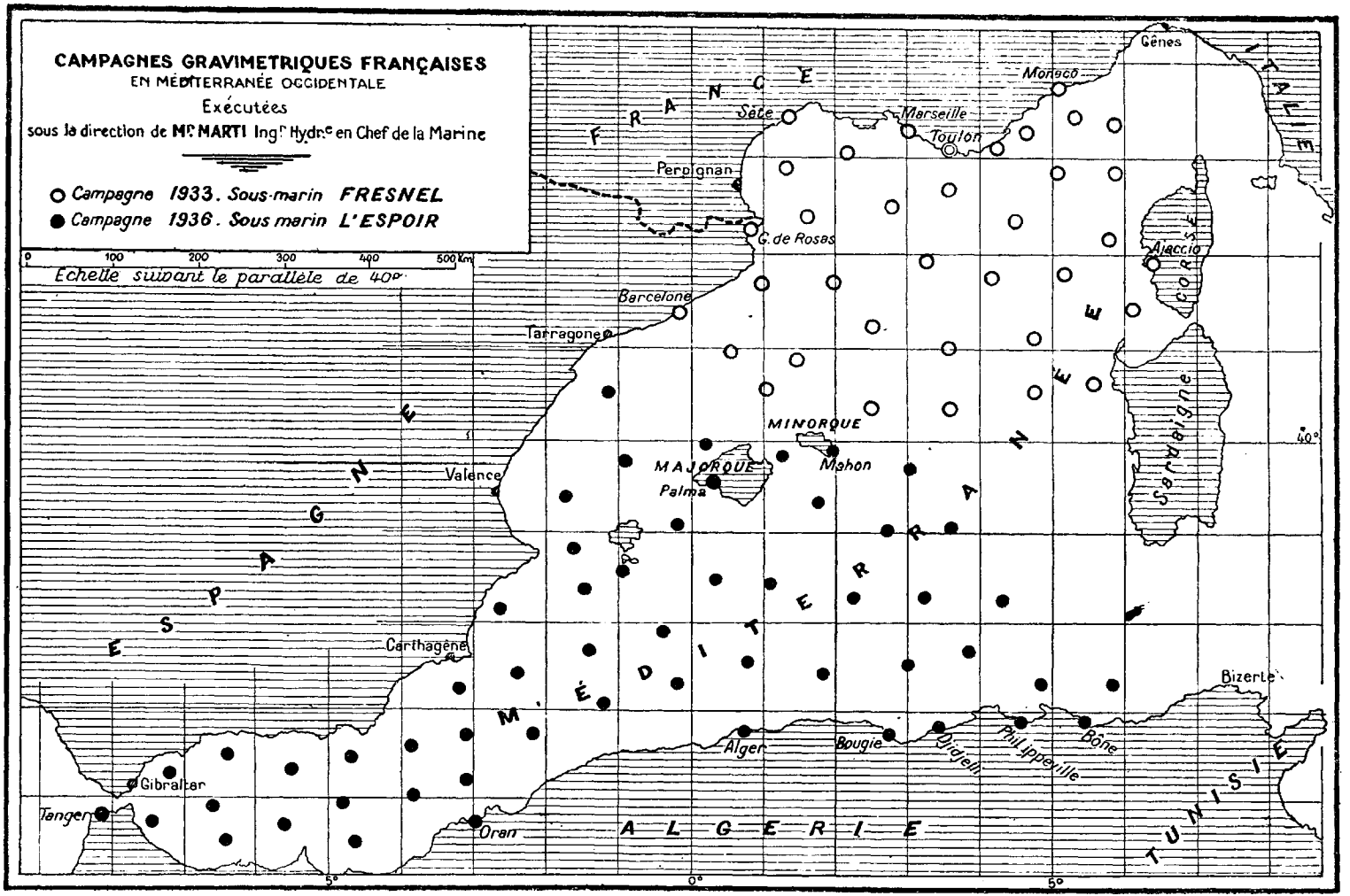
In 1936, as in 1933, gravimetric observations were carried out immediately before the start of the voyage at the submarine mooring dock in the inner basin of Missiessy (where, as has just been stated, there is a gravimetric intensity of 980.495 gals) ; this in order to check the installation and to determine whether any derangement of apparatus had occurred during the installation.

The annexed chartlet shows the grouping of the stations made ; during both of these expeditions an effort was made to space the stations about 60 to 80 kilometres apart.

In 1933 the observations at sea were staggered over the period from 10th November 1933 to 10th January 1934. On the whole their execution was considerably hindered by bad weather. Further, as the vessel had to avoid diving at night (as far as possible), and since the separation of the stations was rather considerable, it was generally impossible to occupy more than two stations per day during the winter season. From this double point of view (risk of bad weather and relatively short duration of daylight) the execution of the gravimetric observations must be considered much more advantageous in summer than in winter.

Consequently it was the summer season which was chosen in 1936 for the second expedition. The observations were scattered from 15th May to 15th July 1936 and the returns from the expedition were much greater owing to this fact. Actually 46 stations were made at sea, while in 1933 only 30 stations were occupied during the same period of time (two months).

The execution itself, strictly speaking, did not give rise to any incident. The apparatus of Professor F. A. Vening Meinesz, which is now well-known, has reached such a stage of



French Gravimetric Expeditions.

perfection and has been made automatic to an extent that its operation does not require any particular skill, so to speak, on the part of the observer.

Further, the comparison of the four chronometers had been simplified to the maximum extent by the use of the graphic recording device. In principle this comparison was made immediately after the reception of each radio time signal and also immediately before and after each gravimetric observation.

The determination of the rate of the standard chronometer was greatly facilitated by the very simple method devised by Professor F. A. Vening Meinesz, which consisted in connecting the electric interrupter of this chronometer directly in the circuit with the head phones by means of which the rhythmic W/T signals are received, and noting the first and last dotted signal observed during each of the five minute radio time signals.

The determination of the depth by the sound-wave echoes from the ocean bottom was relatively simple in 1933 and was accomplished at the instant of each gravimetric measurement thanks to the fact that the reception of sound signals from outside the hull is particularly favourable in a submerged submarine. But in this first expedition it was necessary to renounce the depth determinations during the time the vessel was proceeding on the surface from one station to the other, as the "home-made" apparatus on board did not permit echo soundings to be taken at great depths while cruising on the surface, especially under the unfavourable weather conditions which prevailed in general. In 1936, on the other hand, the vessel was equipped with an apparatus which was designed especially for the service intended, and soundings could be obtained easily whenever desired.

During each of these expeditions, a return to Toulon was provided for in the middle of the period of field operations, to check the measurements (by observations made in the wet dock for submarines at Missiessy) and to insure that no derangement to the gravimetric apparatus had occurred. The same check was made, of course, at the end of each expedition. These checks proved entirely satisfactory.

ABSTRACT OF RESULTS.

On the whole the expeditions have shown, just as we might have expected, that the principal difficulty in the gravimetric observations at sea, with the aid of the very remarkable apparatus at our disposal, was the keeping of the exact time. In spite of the employment of four marine chronometers, one may assume in general that on a submarine the rate of the standard chronometer is not known except approximately to within 0.1 to 0.2 seconds per diem.

This uncertainty in the measurement of the time results in an indecision in the determination of the intensity of the gravity by from 3 to 5 milligals. Although this is quite inferior to the accuracy attainable in observations ashore, it is still sufficient to render manifest the gravimetric anomalies which are found in the exploration of extensive submarine basins, such as those under investigation in the above-cited report.

The calculation of the rough observations, i.e., those simply referred to what they whould have been aboard a stationary vessel on the surface, has been completed for the expedition of 1933, and will probably be completed in a few months for the expedition of 1936. These results bring to light some rather important anomalies in the gravimetric intensity in those regions of the Mediterranean where the depths often exceed 2.500 metres.

The calculation of the influences of the known relief of the earth's crust, which is definitely rather long, cannot be completed until much later.

In any case the results will be published in the reviews devoted to these subjects. A detailed description of the methods of operation employed during the expeditions of 1933 and 1936 will be inserted in the next volume of the *Annales du Service hydrographique*, and a translation in French of the work of Professor F. A. Vening Meinesz on the observations of the gravimetric intensity at sea will be published under the auspices of the French National Committee of Geodesy and Geophysics.