HYDROGRAPHIC WORK RECENTLY CARRIED OUT BY THE ITALIAN ROYAL NAVY IN THE AEGEAN SEA, THE RED SEA, AND THE INDIAN OCEAN.

(Extract from various articles published in the *Rivista Marittima,* Rome, October and December 1939, and February 1940, by Captain Mario BONETTI).

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WORK IN THE AEGEAN SEA.

The survey of the Italian islands of the Aegean Sea, since their occupation in 1912, was restricted during a few years to partial surveys of the most important anchorages, carried out during the years 1924, 1926 and 1927, by the surveying boats *De Lutti, Mario Bianco* and *Scilla.*

The charts of the Aegean Sea were still those based on the surveys effected by the British Admiralty in 1863 and previously. While these charts were correct and sufficiently detailed in the immediate vicinity of islands and channels, they gave very limited indications regarding the nature of the sea bottom offshore.

The increase in the military and political importance of our possessions, together with a question of national prestige, rendered imperative a fuller knowledge of the configuration of the islands and neighbouring seas.

In 1922, the Military Geographical Institute undertook the survey of the islands and their geodetic connection. This work was finished before the beginning of the surveying expedition, and proved a great asset to the subsequent work of our surveyors, who were thus able, for their determinations along the coast and for their soundings, to use the vertices of the triangulation effected by the Army surveyors.

In 1924, at the start of our surveys in the Aegean Sea, it was found necessary to carry out a new determination of the fundamental astronomical co-ordinates. The following determinations were effected :

Rhodes	:	latitude, longitude, azimuth;
Lero	:	latitude, longitude; (1)
Coo	:	latitude, azimuth of Lero.

Having finished in 1930 soundings in the Gulf of Syrte, thus completing the survey of our Mediterranean colonies, the Hydrographic Institute had drawn up an extensive programme, which included a complete survey of the coast and seas of our possessions in the Aegean Sea and the determination of the survey of the coast of Erythrea, from Sciab-Sciac to French Somaliland. The work was to be carried out at a continuous rhythm: in the Aegean Sea during the summer of 1933, in the Red Sea during the winter and spring of 1933-34, and again in the Aegean Sea during the summer of 1934.

The aim of the full programme of surveys in the Aegean Sea was to furnish the necessary data for the drawing up and publication of charts on the scale shown on graph (not reproduced here).

The photography of the coast was to be carried out on the scale of 1 : 20,000; the soundings required different scales owing to depth and to the scale which prevails on charts, viz.:

1. — Bays, coves and anchorages offering particular interest: (working scale of 1 : 10,000, and eventually 1 : 5,000).
2. — Coastal soundings down to 40 metres (working scale of 1 : 20,000).

(1) G. ROMAGNA MANOIA : *Annali Idrografici,* Vol. XII, Parte II.

3. — Soundings offshore for sheets to be published on the scale of 1 : 60,000; down to 200 metres (working scale 1 : 40,000) (greater depths 1 : 60,000).

4. — Soundings offshore for sheets on the scale of 120,000 (working scale 1 : 80,000).

5. — General charts (working scale 1 : 50,000).

After examining the nature of the sea bottom and the configuration of the coast, the Head of the expedition decided to modify the limits originally set for work carried out from boats. It has not been possible to limit this work to depths of 40 metres, which are often only a few metres distant from the coast, as the latter is very cut out and shows sudden, deep depressions. Certain zones, studded with islets and rocks, and where the considerable depths show great and sudden variations, required an exploration of the bottom on a greater scale than that at which the boats could have operated, and where, further, they could not have prudently hazarded. In consequence, the work carried out from boats was extended to depths of 150 and even 180 metres.

The work was to have begun at Rhodes and to have spread successively to Scarpanto, Caso, Piscopi, Nisiro, Sirina, Simi, Stampalia etc. going northwards.

However, it was found more advisable to give priority to the northern zone, and, as a result, some of the work already commenced had to be left to a later date.

In addition to the sub-marine relief, it was decided to carry out magnetic measurements in the islands of Stampalia, Patmo, Coo and Rhodes.

Lastly, in co-operation with the Air Ministry, planimetrical photographs of the islands were taken, on the scale of 1 : 10,000, in order to speed up the work of surveying by means of the abundant details furnished by these photographs. The Commander of the troops at Lero was put in charge of part of this work.

The programme evolved naturally necessitated very rapid operations on account of the limited time. For surveying the coast, determining and constructing principal and secondary signals, three expeditions were organised in charge of a Naval Lieutenant, and they left Italy respectively on the 26th February, 5th March and 1st April 1933.

Two ships were detailed to the sub-marine relief : the *Milazzo* (Commander Mario GRASSI) which reached Lero on the 29th April, and the *Magnaghi* (Commander Mario BONETTI, Head of the Expedition) which reached Lero on the 25th May.

A Lucas apparatus for great depths, and a Langevin Florisson ultra-sonic echo sounder with optic analyser, were mounted on the *Milazzo*, which also carried two motor launches and a sounding machine with fish lead.

The *Magnaghi* carried a Lucas apparatus for great depths, an echo-sounder (the Fathometer of the Submarine Signal Corporation), a Langevin Florisson ultra-sonic apparatus with optic analyser and Marti recorder. It also carried six boats for sounding; two steam driven and four motor driven, and all having a sounding machine "Magnaghi" with fish-lead. (See *Hydrographic Review*, Vol. XI, N° I, May 1934, page 128). Two motor launches were also fitted with ultra-sonic echo-sounders which could be utilised down to depths of 60 metres: one was a SCAM echometer, with optic analyser, the other one a Hughes magneto-striction apparatus, with recorder.

The expedition also possessed two Diesel driven boats, to be used either for taking soundings or for navigating from one island to another. These boats reached Porto Lago on the 11th July.

The first two expeditions having gone to Rhodes, a survey of that coast was commenced, taking as starting point the limit reached to westward by the boat *Scilla*.

On account of the change in the programme which I have mentioned, these two expeditions sailed for Lero, after about one month's work. On the other hand, the third expedition left Scarpanto, where work had not been started, and went to Patmo.

Progress was slow during the first few weeks, owing to the numerous indentations of the coast which call for a very careful survey, and also owing to some disagreement with the determinations effected by the Military Engineers. After checking and eliminating all doubtful points, and noting the abundance of details furnished by air photography, work was carried out much more swiftly.

When the *Magnaghi* arrived in its turn, the Head of the Expedition, after an interview with the Commander of the *Milazzo* and an examination of the work already achieved, noted that the coastal survey was progressing less rapidly than the work carried out at sea, and that, therefore, it was necessary to take the proper measures in order that the ships did not remain without work or did not progress at too slow a rythm.

Conditions of the terrain, and consequently of the work, encountered by the expeditions, were, in fact, far more serious and difficult than had been anticipated. The islands of the Aegean Sea are characterised by their wildness and the many landslides which have occurred there; in many parts, the coast falls abruptly into the sea and the granite cliffs are quite inaccessible, which renders the placing of detail signals for coastal soundings extremely difficult. Roads are rare and often not practicable. It was necessary to split up the work, on account of the presence of numerous islets and isolated rocks, and this took up considerable time.

As a result, it became necessary to reinforce with part of the ships' crews, the various groups which had not been sufficiently numerous to overcome the difficulties of these local conditions. New groups were formed with officers and crew to help with the coastal survey, and whenever possible, native workers were employed ,who also served as guides. Further, to make up for the lack of roads, local motor boats, which could be hired at reasonable prices, were largely used. This also increased the autonomy of each group which could go from island to island without the help of the ships, without impeding their work, and without having recourse to the steamers of the regular lines which are quite frequent.

In this way, the independant groups effected the coastal survey and determination of signals in the island of Patmo, the group Lisso-Archi, the islands of Lero, Calino, Pserimo, Coo, Nisiro, Piscopi and a big part of Simi, moving gradually from North to South.

The groups from the *Magnaghi* effected the same work in the island of Gaidaro, the Levito group, the island of Stampalia and neighbouring islets, and the island of Simi, in co-operation with the above mentioned parties.

The *Milazzo,* with its personnel, effected the same work in the island of Farmaco.

The programme of the ships' work was drawn up in such a way as to benefit by the comparative autonomy of the two units. As the sole base for supplies was Port Lago, all the zone closest to this base, and particularly all soundings on the scales of 1: 40,000 and 1: 60,000 around the islands of Patmo, Lisso-Archi group, Lero, Calino, Pserimo, Coo and Nisiro, was allotted to the *Milazzo,* on account of its more restricted autonomy. On the other hand, the *Magnaghi,* with its greater autonomy, was able to effect the soundings in the offing, on the scales of 1: 80,000 and 1: 150,000, the soundings on a larger scale of the vast zone around Stampalia, and also the soundings in the smaller zone surrounding the island of Piscopi.

Meteorological conditions often impeded seriously the progress of the work. The regimen of winds in the Aegean Sea during the summer months is well known: in July, August and September, North-western and North winds prevail, with a clear sky and rising barometer. The regularity and force of the wind, together with sudden and often violent squalls, produce whirpools which are detrimental to the good operation of ultra-sonic apparatus. This wind drops for brief intervals, but a heavy fog then renders marks invisible, especially when the distance is considerable.

Another difficulty is due to the absence of good anchorages, on account either of great depths or of the small shelter which they offer.

The *Milazzo,* which effected soundings in a better protected zone, was frequently obliged to interrupt its work, even in zones under the lee of the islands, and to move to a more southerly part; it was also obliged, more than once, to return to Port Lago because the anchorage in the Coo roadstead was not practicable and that none other offered sufficient shelter.

After the first ten days of July, the work of the *Magnaghi* was also rather restricted, owing to the irregular action of the ultra-sonic apparatus, due, as mentioned above, to whirlpools. Fortunately, during the month of October, there was a lengthy period of calm when the work was speeded up to maximum and the programme completed.

The regimen of the winds not only impeded the work of the ships but also that of the surveyors on land, which had to be interrupted often when it was too difficult to obtain sights, and when, in exposed and high stations, the violence of the wind prevented the use of measuring instruments.

It is, therefore, easy to understand that these difficulties were even greater with regard to the boats.

The necessity of operating off detached islands, without having recourse to the ships, engendered the scheme of autonomous groups, generally placed under the leadership of a Lieutenant. These groups were supplied with camping equipment, abundant fuel and food, and constituted temporary bases at points chosen along the coast to ensure a good anchorage for the boats. After completing operations in a certain zone, the group moved by its own means to another spot and established a new base there. This scheme enforced long absence of the groups from the ships, on islets lacking in everything, and for lengths of time generally greater than was anticipated, on account of meteorological conditions. The *Magnaghi* was, therefore, obliged to provide all supplies.

We give below a brief summary of the work carried out by the different groups.

There were a steam-lauch, two motor boats and a boat transporting material, for the coastal survey of the group Patmo-Lisso-Archi.

This group landed at Porto Croce di Patmo and went later to Porto S. Nicola, on the north coast of the island, then to Lisso and Archi. In accordance with instructions received from the Hydrographic Institute, the greater part of operations in the vicinity of the Lisso-Archi group, was carried out on the scale of 1: 10,000, which considerably increased the number of working days. In all, the group was absent during 50 days, and returned when the work was practically completed, leaving on this spot the steam-launch only, which then went to Paterna to effect soundings in the Saracena zone, North-West of Lero.

A second expedition went to Gaidaro at the same time and was entrusted also with the coastal survey. This group was given a steam-launch and a motor-boat, in order that the soundings and survey could be kept abreast, and in this way all the work was completed in about 20 days.

A much longer period, however, was required for the operations of the Levita-Chinaro islands, which, with the intermediate islets of Laro and Mauro, constitutes a sort of barrier, parallel on the eastern side to the Greek island of Amorgo. Surveying work took up a lot of time, as there was only one determined station on the island of Levita and as the other vertices were very far away. As there was some uncertainty in the results obtained, it was decided to carry out a small independant triangulation. Soundings were very long, owing to the difficulty of the trips from one island to another, and the group remained absent 62 days from their ship.

The Calino-Coo group comprised four boats which went from Port Lago to Xerocampo, on the southern coast of the island of Lero. This port served as a base for taking soundings along the north coast of Calino. The group went first to Port Vathy, on the east coast of Calino; then to Cardamena on the south coast of the island, as the condition of the sea did not permit operations along the north coast of Coo. After completing soundings on the south and east coasts, and while it was impossihle to establish a base on the north coast of Coo, the group went to Pserimo, and from this base completed the soundings of the coast of Coo, under rather difficult conditions due either to the state of the sea or to the distance separating the base from the zone of operations.

This group remained absent during 39 days.

The topographical and marine survey effected by the Stampalia group was rendered very difficult by the presence of numerous islets. Whilst the principal ship operating in this region was anchored, at least during the night, at Livadia, two groups were sent to survey the island and a third to survey the Conupla group in the South-East. As soon as part of the coast was surveyed, another expedition was formed with three boats, which established its base at Port S. Giovanni, on the western coast, which, however, did not offer sufficient shelter. The camp was once completely torn down by the wind. Further, it was impossible to utilise Port Panormo, on the northern coast, as, when the wind is fierce, the sea washes into the roadstead to such an extent that no ship can remain there. The expedition then went to Port Vathy and Port Scala and remained absent during 30 days.

The island of Ofidusa is similar to a wall rising out of the sea; it is cut in two, and offers only one point of access from the sea with very little shelter. It was therefore necessary to await very calm weather to send out the surveyors, either because of the risk incurred by the ship in lowering and hoisting in the boats, or of the fact that the local motor boats absolutely refused to approach the coast. The survey was completed in two days, by sending out a group at dawn with a motor boat, whilst the ship itself effected soundings. The smaller soundings were effected by a group of three boats.

Surveyors worked during 30 days on the group of islands Sirina and Adelfi.

The above brief report shows that the work carried out by the boats was hard and tedious, and that the surveyors required great skill, endurance and a spirit of sacrifice. The greater part of the work was carried out by the boats of the *Magnaghi,* as those of the *Milazzo,* much smaller, less sea-worthy and fitted with weaker motors, could only be employed in fair weather and in well protected zones.

The two Diesel driven boats proved inadequate for taking soundings, on account of their great speed, which could not be reduced without impairing the running of the motor, and on account of the strong vibrations. One of these boats, however, was utilised, in spite of the frequent breakdowns to the adjustments for reducing the speed, by placing a big mat on the bows and two sacks full of sand on the sides. The other boat, which had greater speed and vibrations, was utilised for the requirements of the Naval Base, the latter having given in exchange a steam-launch, P.D. type, which was manned by the crew of the *Milazzo* and which proved very useful.

Modifications were made to the motor-boats in order to decrease trouble arising from waves and wind. Copying an arrangement prevalent on all local sailing boats, the sides were bolstered with wash boards and wave screens in canvas, which offered a better protection and greatly improved working conditions.

At the same time as topographical and marine surveys, magnetic stations were established, comprising declination, dip, and horizontal force measurements in the islands of Patmo, Lero, Stampalia and Coo. Declination measurements were also made in the islet of Conigli, south of Gaidaro.

Two tide-gauges were established, one at Coo and the other at Portolago; and mareometrical scales were established in the zones where the boats operated. The tidal influence was not very great, and oscillations showed a maximum of 20 cm.

Systematic measurements of currents were not possible, owing to the difficulty in anchoring the ships, and to the great depth of the most appropriate spots.

Currents are, however, noticeable in the channels between the islands and vary according to meteorological conditions.

In the vicinity of the island of Piscopi and especially in the channel between that island and Antitilo, they are very strong and produce quite marked eddies.

The planimetrical photographs effected by the Military Commander of Lero comprise the coast of Gaidaro, of Patmo; of the Lisso-Archi group, the Levita group, of Lero and of Calino.

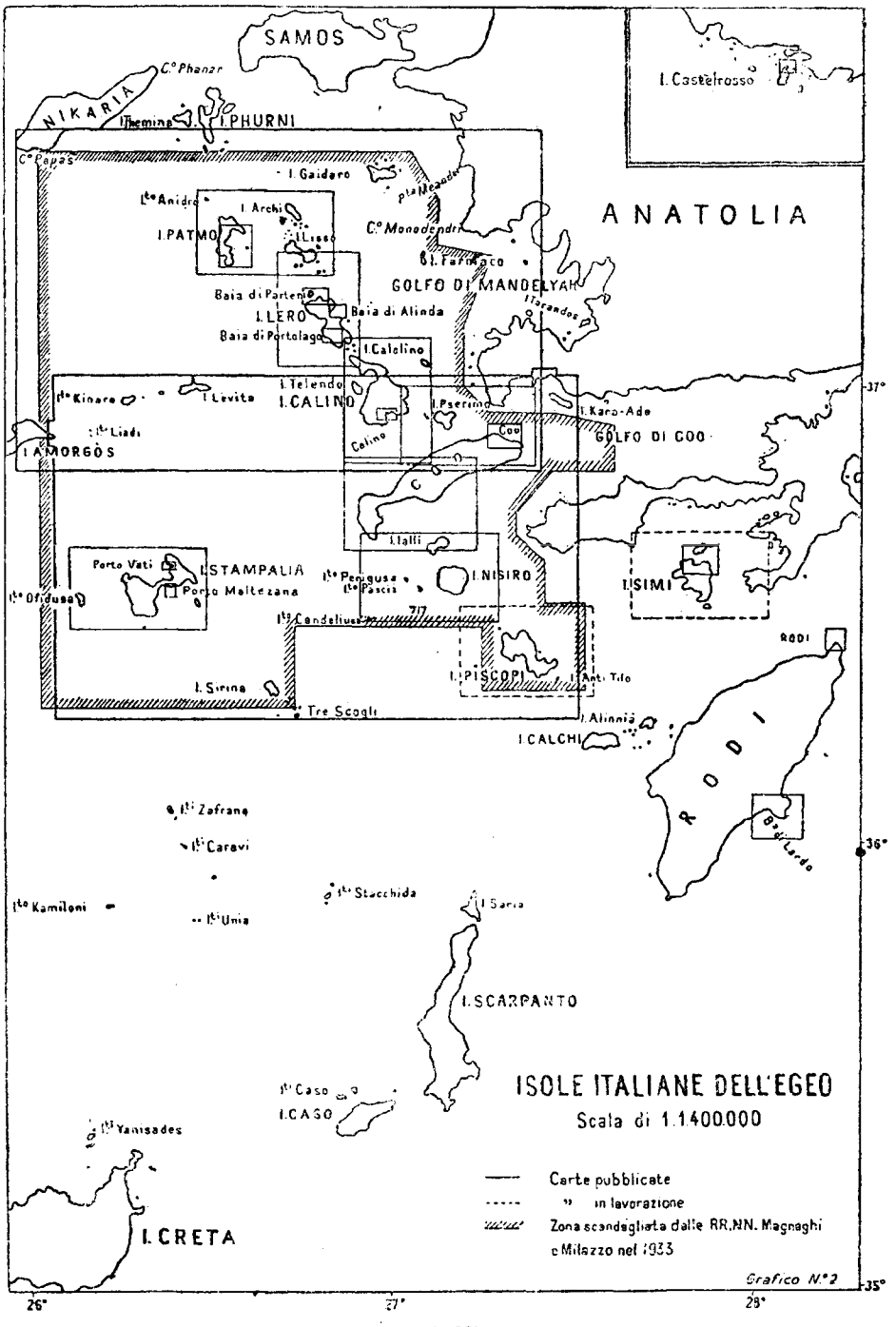
The main problem has been the means of communication between the ships and the surveying groups, owing to the physical configuration of this zone composed of islands, islets and small archipelagoes separated by wide stretches of sea, and beaten by wind and sea water.

This problem has been solved by the use of field wireless stations. Two sets were brought with us from Italy, and two more were sent out at the request of the Head of the Expedition who had found them useful and practical. With these sets it was possible to communicate over longer distances than had even been expected, and they worked easily and well.

In this way, the Head of the Expedition was in constant touch with operations and cognisant of the needs of the surveying parties; the latter communicated in advance the quantity and quality of the food and material required, and the main ship scheduled its work in order to be, at a given date, near the likely base of the surveyors, from whence the supplies were carried rapidly in the boats. It was thus possible to reduce loss of time

to a minimum, as well for the main ship as for the boats, and also to avoid nautical difficulties due to unfavourable anchorages and greatly varying conditions of sea and wind. These difficulties frequently occurred, when the surveying parties embarked and disembarked in the open sea and when rapidity was indispensable.

During the latter part of October, the two ships returned to Tarente in order to effect the necessary preparations for the work to be carried out in the Red Sea.



Graph N° 2.

These operations, as foreseen, only covered half of the programme originally drawn up.

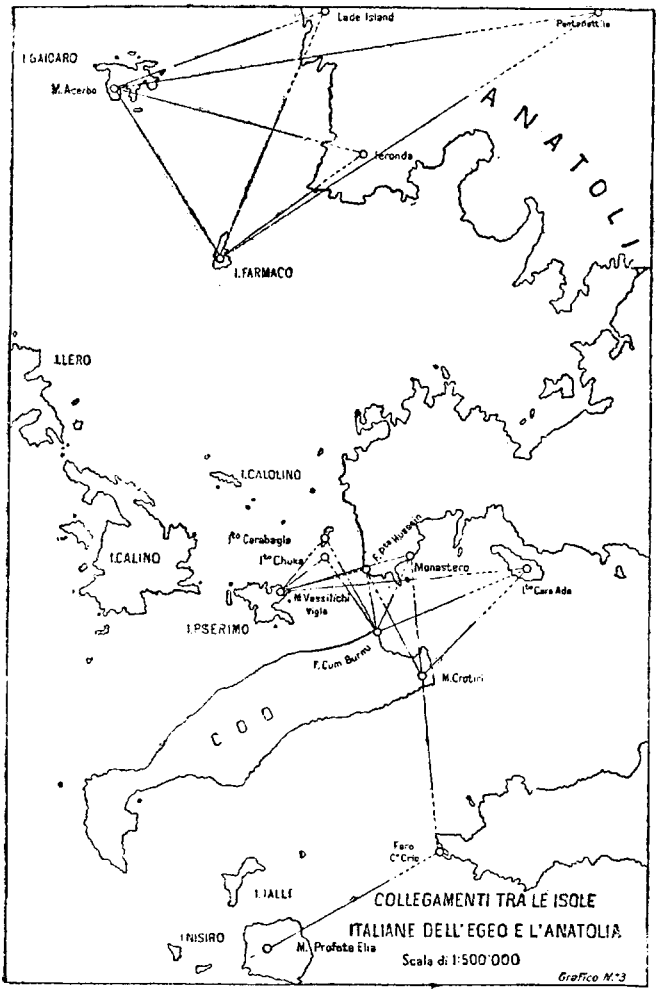
The *Magnaghi* effected in all 9,120 soundings, plotted by angles; 150,000 were also obtained, by means of the continuous recording instruments. The boats effected in all 22,630 soundings, plotted by angles, and 36,700 interpolated soundings.

The *Milazzo* effected 9,292 soundings, plotted by angles and 158,123 interpolated soundings.

The original programme for the drawing up of charts has not been carried out, as the Directors of the Hydrographic Institute deemed it preferable to issue charts of the islands on a bigger scale. This was rendered possible by the quality of the work accomplished. Finally, the charts were published as shown on graph N° 2.

The group of Italian islands of the Aegean Sea is comprised in a maritime zone limited on the North-East by the coast of Anatolia and on the North, West and South-West by Greek islands. It was therefore necessary to connect them to some of the principal points of this coast and of these islands, and to determine points which could be used for sounding operations.

When the expedition was being prepared, the Turkish and Greek Governments were approached with a view to allowing the personnel to disembark in the most suitable localities for access to points where determination was deemed necessary.



Graph N° 3.

The Turkish Government did not grant this authority. It was, therefore, necessary, to obtain determination by resection, by choosing points easy to identify and already shown on existing charts.

By means of stations on our own islands, it was possible to determine 9 points on the coast of Anatolia (Graph N° 3).

The Greek Government granted authority for disembarking and for constructing signals; they also communicated the list of triangulation vertices effected by their Geodetic Office, and also the geographical co-ordinates of these vertices.

It was thus possible to erect and determine signals on the Greek islands of Furni and Chinaro, which were immediately utilised for sounding operations, and a full programme was drawn up for effecting the geodetic connection.

On account of an erroneous interpretation given by part of the Greek press regarding the presence of our boats and men in the islet of Chinaro, it was necessary to make new agreements, and a meeting was arranged with the Greek surveying ship *Nautilus*, at Port Tigani, in the island of Samos.

Following agreements with the Captain of this ship, we encountered no difficulties in erecting two pyramids on Mount Kerketef of Samos and on Mount Provatokefala of Icaria. In agreement with the local authorities, measures were taken, as originally intended, to send the necessary personnel and instruments for the geodetic connection of these points with the visible vertices of our triangulation. Before leaving Port Tigani, we met by appointment the Sub-Manager of the Greek Hydrographic Office, who informed us that his Government had already effected geodetic connections with the surrounding continental countries, and that they wished these determinations to have the character of an international geodetic connection, in accordance with the rules applied in previous cases. The work was, therefore, to be carried out by surveyors of two different nationalities, and with scrupulous exactness. Consequently, it was necessary to enter into new agreements with the two Hydrographic Offices with regard to requisites and also to decide on the best period of the year.

The determination of a signal on the Greek island of Amorgo being required for sounding operations, it was decided, in order to avoid any possible disagreement, to carry out this determination in the presence of an officer of the surveying ship *Nautilus*.

As it was impossible to effect the connection during the present campaign, and owing to the special character of this determination, the Head of the Expedition had pillars constructed on Mount Vardia, in the island of Stampalia, on Mount Scumberda of Lero, at Gaidaro and at Levita.

Conversations concerning the preparation of this work were continued between the Hydrographic Offices of the two countries during the last months of 1933 and the first months of 1934, and all details were settled. It was agreed that each Hydrographic Office would send an expedition composed of two officers and the necessary subordinate staff; further, there would be three secondary groups, comprising each two soldiers from each nation, who would handle the sighting instruments (heliographs, helioscopes, collimating lamps).

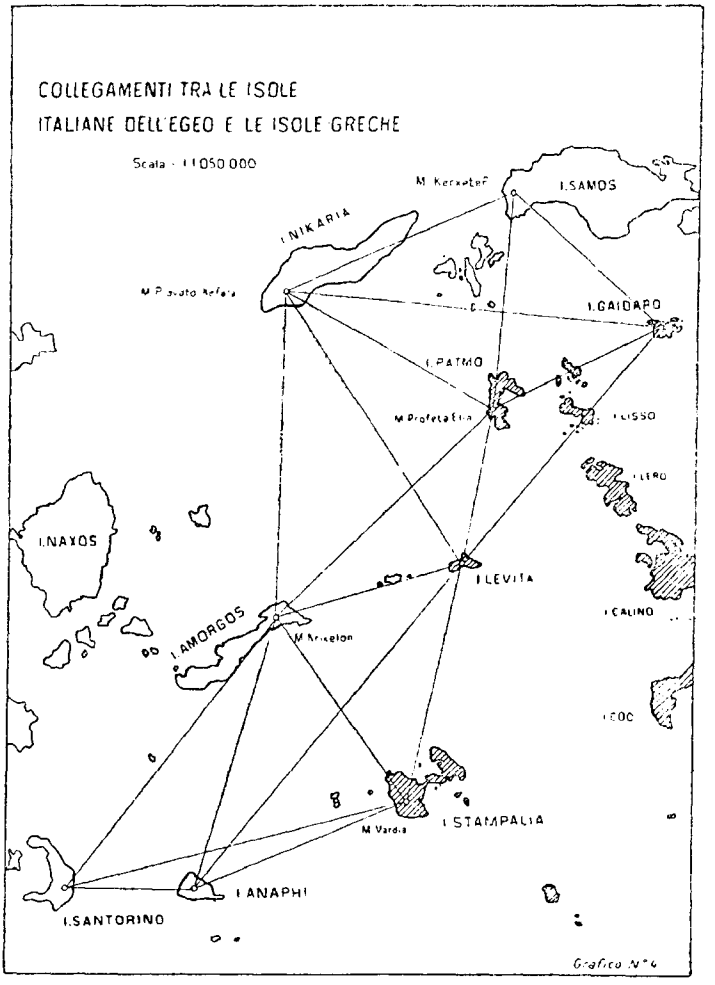
Observations were to be executed with great precision in order to obtain a closure of triangles inferior to 3 seconds of arc. Measurements were to be effected simultaneously by the two Greek and Italian observers, one from the central pillar, the other from a "false station", by alternating the two positions. Sighting was to be effected by means of heliostats by day, and collimating lamps by night. After completing observations at each station, the observers were to exchange results. A motor-boat was to be hired in common for the trips of the different groups, and two wireless sets were also to be supplied.

During the latter half of April 1934, the two expeditions met at Samos and split up into various groups. Work was limited to the connection between the Cyclades and the Italian islands of the Aegean Sea, leaving for another time the connection with the island of Crete.

A triangulation net was established with four quadrilaterals comprising the Italian islands of Gaidaro, Patmo, Levita and Stampalia and the Greek islands of Samos, Icaria, Amorgos, Anafi and Santorino. Angular observations were made by day, in the early hours of the morning and before sunset, by means of heliostats.

Bad weather conditions impeded observations at Gaidaro and at Levita, and made it necessary to prolong the stay in these islands.

Communications between observers and sighting stations were maintained by the field wireless and with conventional optical signs. The two parties fraternised in their common task, which was perfectly executed to their mutual satisfaction.



Graph N° 4.

One of the Italian officers who had a little more time, effected magnetic measurements in the islands of Samos, Icaria, Anafi, Amorgos and Levita.

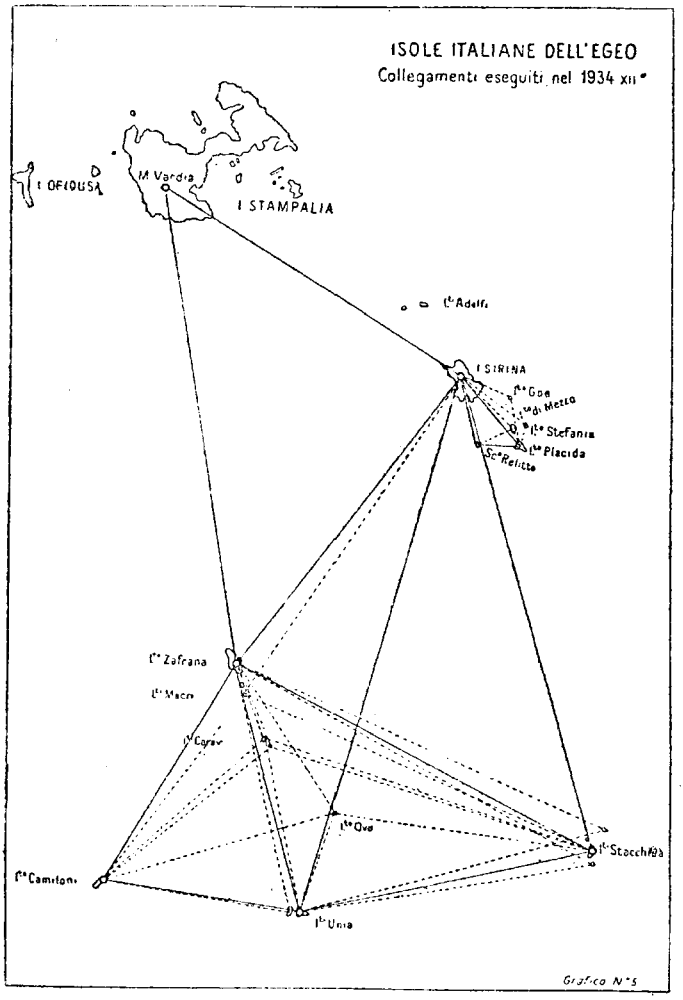
In the same year 1934, two expeditions left for the Aegean Sea: one, headed by two officers, was entrusted with the establishment of sounding signals, and their determination, in the island of Rhodes and the Calchi group, and with the topographical survey of the coast of the islands and neighbouring islets; the other, under the leadership of one officer, was to effect the angular connection and topographical survey of the islets and rocks in the maritime zone comprised between Stampalia and Candia.

The first expedition started work on the 14th April, and having finished at Rhodes on the 28th August, moved on to Calchi to complete the survey of the whole group.

The survey of the island of Rhodes was effected with comparative rapidity and without too much difficulty, except in certain parts where the coasts is very high, rocky and abrupt, and where a motor driven sailing boat was required for effecting the necessary trips.

The survey of the Calchi group was more difficult owing to the bad weather and sea conditions, owing to the rarity of determined points, which are visible from practically no spot on the coast, and also owing to the rocky nature of the coast, high, abrupt and deeply indented. Weather conditions were overcome by alternating the survey of Calchi, Alimnia and the other islets, in order to benefit by the best conditions.

The second expedition went to Stampalia on the 16th April, to begin placing the signals, and this was then continued at Sirina, Zafrana, Stachida, Unia, Camila and on the neighbouring islets. The angular connection of all the islands was effected, determining by resection the smallest islands, and this was followed by the topographical survey (Graph N° 5).



Graph N° 5.

The work carried out by these two expeditions was for the purpose of constituting the necessary preparation for a subsequent marine survey; but up to the present it has not been possible to send the surveying ship, owing to its being required for more important surveys, and also to political circumstances. However, the programme has been drawn up and will be carried out as soon as possible.

WORK IN THE RED SEA.

Surveys of the coast of Erythrea were begun in 1880, and carried out as follows :

1880-82 Partial survey of the Bay of Assab.

1886 - Survey of the Port of Massaua and vicinity; survey of the anchorage of Adiuz.

1891-92 Survey of the southern canal of Massaua up to the island of Umm Namus and relative anchorages; survey of the Bay of Anfila.

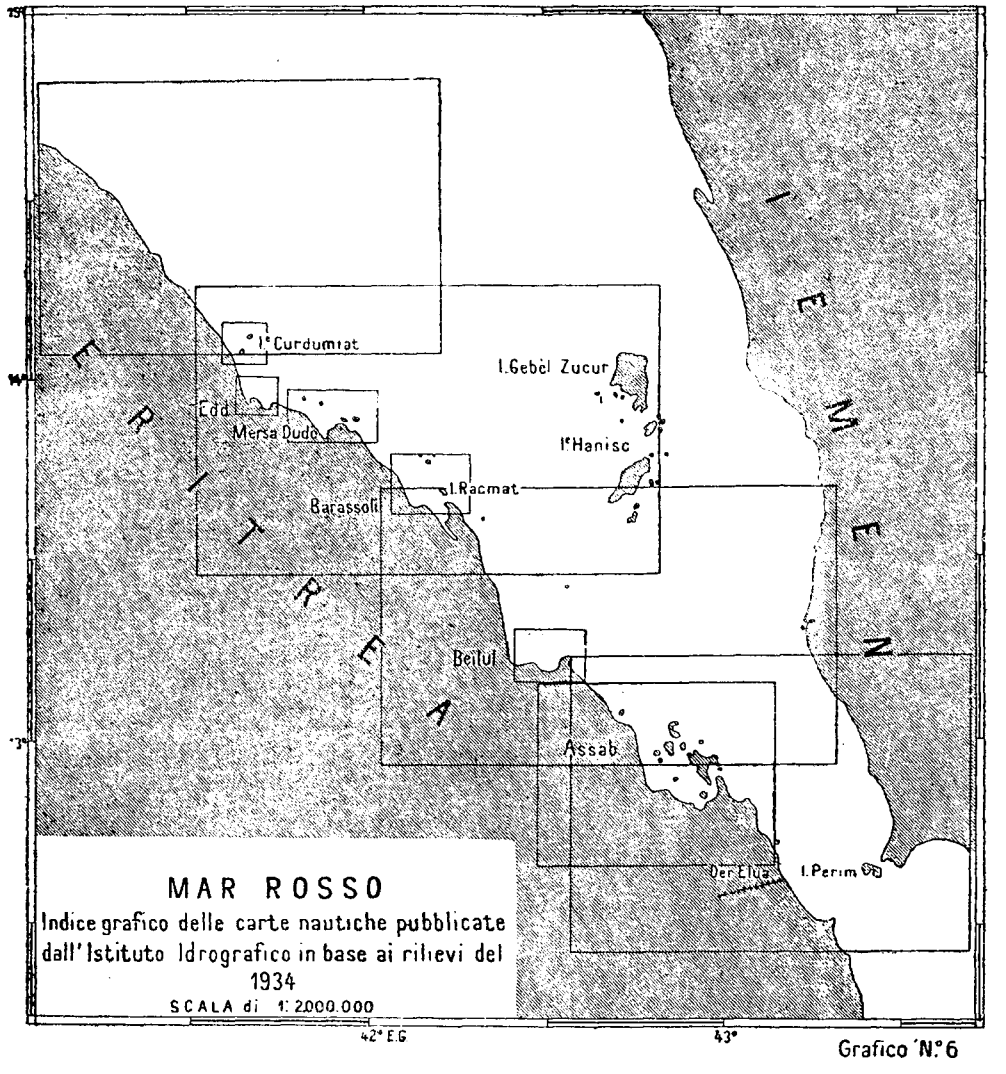
1892-93 Survey of the northern canal of Massaua up to the island of Arat and anchorages there comprised.

1895-96 Soundings west of Arat to complete the work of the previous expedition. Survey of Eid anchorage.

1904 Survey of the zone of Ras Midir and Ras Sciacs; unimportant surveys in the northern canal of Massaua.

1910-11 Survey of the northern canal of Massaua up to Taclai.

1913-14 Survey of the northern canal of Massaua from Taclai to the frontier; survey of the southern canal of Massaua.



Graph N° 6.

As can be noted from this list, the work at the beginning covered limited and isolated regions; they were then extended, and based on an organised programme which was in full swing in 1914. At that time, the survey of the coast from the northern frontier to the Sciab Sciac lighthouse (fixing the limits and taking soundings of all the northern canal of Massaua), the survey of the zone between Massaua and the Dahalac islands, and the southern canal of Massaua up to the Bay of Ouachil, had been completed, but work in this region remained unfinished, as the surveying ship *Staffetta* had to be sent home owing to an epidemic of fever on board.

Surveys in the Red Sea were practically abandoned during the Great War. Survey and soundings of the Mersa Fatma cove in the Bay of Ouachil were alone effected, in order to ensure the safety of the exportation of potash from the Dancala trough.

Survey work in the waters of Erythrea were resumed during the years 1923-24 by the surveying ship *Magnaghi* which completed survey and soundings in the southern canal of Massaua up to Sciab Sciac.

The triangulation of the Duhalac archipelago was also begun at this time, from the island of Dahalac Chebir towards the north-east, with basic measurements in the island of Nora (Graph N° 6).

In 1928, work was resumed in the Dahalac archipelago, and for this purpose, the *Magnaghi,* with Commander Luigi RUBARTELLI, arrived at Massaua during the latter part of October and started work at once, which was continued without interruption until 4th July 1939. During that time, a complete survey of the northern canal of Massaua was effected through the Dahalac archipelago. This survey joins up in the south with the work of the 1892-93 and 1924 expeditions and reaches in the north-east the edge of the central trench of the Red Sea.

The work lasted longer than had been expected owing to the difficulties encountered and also to the following facts :

a) unfavourable weather conditions, especially fog, which frequently impeded work on land and sea;

b) great irregularity of sub-marine bottom with numerous shoals; this necessitates a great quantity of soundings and also limits and endangers the carrying out of soundings by the ship.

Another obstacle arose at the beginning, when the bench marks were not found on the vertices of the old triangulation. It was therefore necessary to take angular measurements again from the vertices of the old triangulation, in order to obtain accurate bases for sounding operations.

Operations on land comprised the measurement of bases, triangulation, the fixing of detailed points and the coastal survey of the islands in that region.

A base of 1224 metres was measured on the outer Harmil island with four invar wires; this was carried out during the night to avoid heating the wires. The azimuth of the base was determined from observations of the Pole star.

The extension of the base, effected in accordance with the Bessel method, was applied to the side of the triangulation Romià-Seil Harmil of 15505 metres.

This triangulation comprised 43 triangles with 29 vertices. The observations, as already mentioned, were impeded not only by the well-known refraction of these regions, but also by persistent and frequent fogs, by wind, and in the first months, by rain. For some of the vertices, it was necessary to erect rather high platforms in order to increase the height of the station so that the other vertices could be perceived, and, vice versa, be perceived by them. (Graph N° 7).

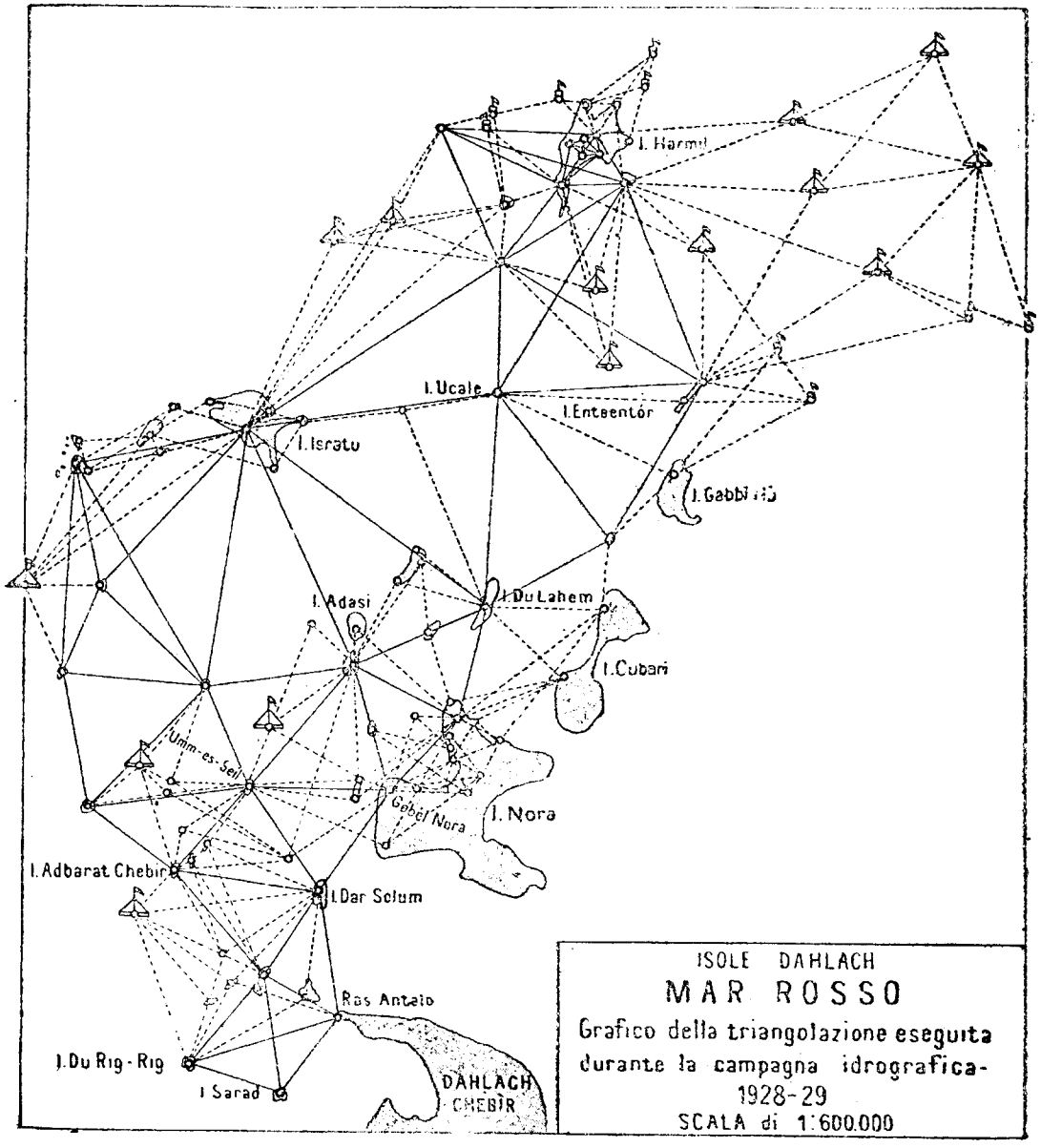
The value of the base by means of the triangulation, starting from the known side Umm es Seil — Gebel Nora, differed from the measured value by 0 m. 90.

If one takes into account the fact that the co-ordinates of the starting point, belonging to the triangulation of 1924, are still based on those of the triangulation points of 1892, and that, in 1924, a difference had already been found between the value of the base

measured on Nora and the value obtained by the summary triangulation relating to the points of 1892, it can be asserted that angular observations have been effected with great care. Further, the triangle closures are all inferior to 5 seconds, and about half are inferior to 3 seconds.

Points of detail have been determined by direct resection from the apex of the pyramids. Some of them were constituted by floating signals, utilised for the first time on a large scale by our surveying ships, and found to be very useful.

The survey was carried out on 24 islands of the archipelago with a total length of coast of 250 km.



Graph N° 7.

Operations at sea were rendered very difficult by the fact that the marine survey had to be carried out on a larger scale owing to the general unimportance of the depth of the sea in that whole region, due to the irregular bottom and to the existence of numerous rocks and shoals.

More than 200,000 soundings were recorded, either by angular measurements or by interpolation. It should be noted, in this connection, that with the present systems which enable continuous sounding, there is little difference between the soundings with stations and those which are interpolated, the latter giving the same certainty of determination as those resulting from angular measurements.

The surveying ship was fitted with an ultra-sonic Langevin apparatus, the indications of which were frequently checked with a Lucas or a Magnaghi. The Marti recorder was not used, owing to the small scale of the recording strip as compared with the depth generally measured. The boats utilised the modified Magnaghi sounder with fish-lead.

Three tide-gauges were placed in the islands of Nora, Isratu and Harmil for determining the datum of soundings. The diagrams obtained have furnished sufficient results for the harmonic analysis of the tidal phenomenom.

At Harmil, on one of the pillars of the base, an astronomic station was established with the prismatic astrolabe.

The particular configuration of the islands of this archipelago, which are very low and devoid of characteristics, with ill defined contours, creates the need of a special system of signalisation, so as to constitute very noticeable marks for fixing the position at sea and for defining transits which will facilitate navigation through the archipelago. In this way, during the campaign, fifteen permanent signals were established to ensure the facility and safety of navigation by day in the most difficult parts of the canal and during the frequent fogs.

By means of the data obtained, chart N° 649 was issued, on the scale of 1: 120,000, and the principal anchorages and a few distinct details were also inserted on a larger scale.

During the expedition, three complete magnetic stations were established for determining declination, horizontal and vertical force, at Massaua, Isratu and Harmil. A fourth station comprising only the measurement of declination, was established at Ras Antalo (Dahalac Chebir).

Measurements of comparative gravity were also effected at Massaua, Asmara and Harmil. The latter locality, of which we possess, by means of triangulation, the geodetic co-ordinates, and by means of astronomical observations, the geographic co-ordinates, is therefore determined as "Laplace fix".

A certain amount of oceanographical research was also included in the programme of work; its object was to complete that effected during the campain of 1923-24, and to reinforce thereby our primacy in the study of the Red Sea.

The research in question comprised three parts :

a) Study of the central zone of the Red Sea, north of the Suachin archipelago. This zone is a key point for tides, and has always been known for its important currents, sometimes transversal, which might lead one to suspect the existence of rotary tidal currents.

b) Study of the currents of the Suez Gulf, more particularly in the Giubal channel, which is another central point for tides.

c) General measurements in the Red Sea and especially in the vicinity of Bab el Mandeb during the summer months, owing to the absolute lack of accurate information during that period.

As the work assigned to the *Magnaghi* covered a limited zone, the assistance of the *Lepanto* and of the gun-boat *Porto Corsini* was asked for and obtained.

Part of the work was based on complete liberty in choosing points and times of observation; the rest was dependent on the duty of the ships or other expeditions in hand. Wind and sea conditions were generally adverse, and prevented work of as lengthy duration as would have been necessary and desirable. While it was not possible, therefore, to reach right away the goal in view, the research carried out has considerably enriched our knowledge of the Red Sea, and added to the patrimony of scientific investigations effected by our Navy.

In addition to oceanographical research, biological research was also carried out, which gave very interesting results, and thanks to which much material was collected; also chemical research, with samples of water, were taken at different depths.

As already stated, the survey programme for 1933 comprised the completion of the survey of the coast of Erythrea from Sciab Sciac to the frontier of French Somaliland, to be effected in one season, during the last months of 1933 and the first months of 1934.

The coast to be surveyed measured about 740 km. It was far from any supply base, devoid of roads, rough in its soil and its climate, and little known even by the authorities of the Colony. No previous survey had been made, with the exception of a partial survey of the Bay of Assab effected during 1880-82, English plans of the anchorages of Beilul and Racmat, and an Italian plan of the anchorage of Edd, and of a limited zone including the Edd anchorage.

It was therefore necessary to send out a party of officers and men in advance to reconnoitre the ground, to choose the places serving as vertices for triangulation, and to determine rapidly these vertices, in order that the ships could commence their work at sea as speedily as possible; secondly, the expeditions were to effect the topography of the coast, the construction of secondary signals and definite angular measurements.

The expeditions left Lero before the completion of the Aegean Sea campaign, on 18th September 1933, and reached Massaua on the 3rd October.

The work at sea was given to two units, the *Magnaghi* and the *Ostia*. The *Ostia* left on 17th November and arrived at Massaua on the 1st December. The *Magnaghi* returned on 29th October to Tarento, coming from the Aegean Sea, and left again, with fresh supplies, on the 14th December. It reached Massaua on the 2nd January 1934, after stopping 9 days at Port Said for repairs to the electric refrigerator.

The *Mabnaghi,* in charge of Commander Mario Bonetti, was fitted with a Lucas sounder, an ultra-sonic Langevin-Florisson apparatus with optical analyser and Marti recorder, and a S.C.A.M. Echoscope with rotating analyser.

A Jäderin apparatus with invar wire was also taken, to measure the bases as set out in the programme, and a prismatic astrolabe for the mgnetic stations, as well as all necessary equipment for magnetic observations.

Four field wireless sets were likewise included (two for the use of the expeditions which left in September), as they had proved their great usefulness during the Aegean Sea campaign.

The ship was fitted with six soundings boats: two P.D. steam boats, two modern motor-boats, type S.M.I., two motor whaleboats. All these boats were fitted with the modified Magnaghi sounder, with fish-lead. The two petrol motor boats carried, one an ultra-sonic apparatus with S.C.A.M. Echometer, the other a magneto-striction Hughes apparatus with recorder for depths down to 60 metres.

The *Ostia,* in charge of Commander Mario Grassi, was fitted with a Lucas sounder, an ultra-sonic Langevin-Florisson apparatus with optical analyser, a motor-boat for taking soundings with a modified Magnaghi sounder with fish-lead.

As already stated, the programme comprised the complete survey of the coast between Sciab Sciac and Ras Dumeira, measuring 740 km. including the islands. Three charts were to be drawn up and issued, on the scale of 1: 120,000, in addition to plans of the more important anchorages.

The survey of the coast was to be effected on the scale of 1: 30,000 in order that the soundings from the boats should be on the same scale. The scale for surveying ships had been fixed at 1: 60,000 covering a zone of 15 miles width. Whenever possible, soundings on a smaller scale were to be effected for filling in the exterior of this zone.

Previous to the arrival of the expeditions in the Colony, the Directors of the Hydrographic Institute had got into touch with the Government of Erythrea to obtain the necessary help and assistance, especially for the land parties who require motor transport, where this could be used, and also caravans of mules and camels.

The Government of the Colony, in addition to facilities for supplying personnel and animals, gave 45,000 lire for their upkeep. The Commander of the colonial troops furnished motor transport and mules with the necessary personnel. The Navy defrayed all other expenses.

Agreements were also made with the Military Geographical Institute and with Captain SANTONI, author of a new system of aerophotogrammetrical surveys, for taking photographs, in accordance with this system, of a strip of coast 10 to 30 km. wide showing all necessary details.

In this connection, the assistance of the Colonial Air Force was obtained.

The previous triangulation was connected to the side Sciab-Sciac — Conetto of 25,603.60 metres, starting from the side Dissei-Dule of 21,376,57 metres. This side had been reached from a base measured at Massaua of a length of 503 metres.

During the 1913-14 campaign, the measurement of a base in the zone Sciab-Sciac had been considered, which would serve to check the triangulation effected and to compensate the values obtained. As the campaign was interrupted, this could not be done.

It was decided to effect measurement of a base in the Sciab-Sciac zone, the enlargement of which would connect it to one of the sides of the old triangulation, the latter serving as starting point for the triangulation southwards.

To check the closure, a second base measurement was decided upon in the Assab zone; in the same locality, a magnetic station was to be established, and a third at an intermediate spot, Edd being chosen.

Having reached Massaua and using this program as a basis, the expeditions proceeded to organise the caravans, details of which had been fixed by the Chief Naval Commander in the Red Sea, in agreement with the Commander of the colonial troops and the Regional Commissariat of the Eastern Low Plain.

One of the expeditions reached Thio by sea on the 11th October and the second one disembarked on the same day at Assab. The first one was to reconnoitre the vertices of the old triangulation, and starting on the Sciab-Sciac — Conetto (Hatolè) side, to extend the triangulation in a south-easterly direction. While executing this programme, they were to examine and choose the most suitable ground, and to prepare it. The expedition comprised an autocar, 8 mules with conductors, 60 camels and 26 camel-leaders. After beginning the work, the Head of the expedition was obliged to return to Massaua to obtain more camels, as those furnished were of poor quality and many had died. This meant the loss of a month, and it was only at the end of December that the work could be started.

The expedition which disembarked at Assab was not able to find traces of the old survey which had been effected a very long time ago. They were therefore obliged to effect the temporary measurement of a base which could be rapidly extended, and use it as a starting point for the triangulation of the Bay, extending it to the South up to the frontier of French Somaliland and to the North until it joined the other expedition. They had at their disposal 4 lorries with two conductors and eight mules with their conductors, supplied by the Commander of Colonial troops.

By the end of October work had been started on the signals on the vertices of the triangulation, and on the angular observations.

Although the two expeditions had been sent well in advance, the difficulties of the ground and of communications were such that when the ships arrived it was not yet possible to commence soundings.

The *Ostia* reached Assab on the 9th December. The Commander decided that he and his crew would help in putting up the signals and determining them hurriedly, so on the 21st December it was possible to commence soundings, either with the ship, or with the boats.

The Commander of the *Magnaghi*, who directed the expeditions, having been apprised of how the work progressed, and desirous of speeding up the work on land, organised, as soon as he reached Massaua, a third party comprising three staff officers, who disembarked at an intermediate spot, i.e. Edd, with orders to extend the triangulation towards the North and the South in order to connect as soon as possible with the other groups. The help of the Government was called in, and they supplied 80 camels, two lorries and 12 mules. It was expedient to take particular care of water and food supplies, this zone offering practically no resources.

On the 17th January, the surveying ship went to Thio and grave instructions to the Lieutenant in charge of the northern expedition, to speed up the work. She then went to Edd where the expedition disembarked on the 18th with its equipment. This operation took up four days, as, owing to the condition of the sea, the boats could only go to and fro during the early hours of the morning.

As it was not yet possible to effect soundings along the coast, the *Magnaghi* went to Assab, where the boats and all the available personnel were utilised to complete the survey of the Bay and to speed up the soundings.

From that time, all the operations followed a regular rythm and were uninterrupted in spite of the unfavourable atmospheric conditions. The south-easterly wind and sea were a great obstacle, often preventing the work of the boats and rendering the work of the surveyors on land very hard. Measurements of the base were also made, but fixing the astronomical station was left to a later date, on account of the bad weather conditions.

After completing the survey of the Bay of Assab, and while the *Ostia* remained in the vicinity to effect soundings offshore the *Magnaghi* sailed northwards, starting from the frontier of French Somaliland, and began work. Several groups in boats were left in intermediate spots for autonomous operations, and contact with them was established by the field wireless sets.

Many sheltered spots were found along the coast of Beilul up to the islands of Cordumiat, which the boats utilised as temporary bases from whence they went by their own means to one point and another, in accordance with the progress of the work. The only inconvenience was the difficulty of landing supplies, owing to the condition of the sea. In this way, a group of boats remained several days blocked by the sea in the Cordumiat islands but did not lack food as fish was very abundant.

North of the Cordumiat islands and especially from Cabuie to Sciab-Sciac, the coast is very open and offers no shelter. About the middle of March, the wind having gone down, a first attempt to sound this zone was made and two boats were left at Cotatti where banks near the shore make up a mediocre shelter.

However, the wind freshened and increased, and the sea becoming heavy, rolled over the banks and smashed the cables of the boats one by one; these, not without damage, were dragged onto the beach which, luckily, was sandy.

As soon as they heard the news, the *Magnaghi* went to this place but found no anchorage, and was obliged to look for a shelter further south; as soon as conditions allowed it, it returned and was able to float one of the boats without too much difficulty, but the other one was more than half buried by the movements of the sand, and it was necessary to dig the sand all around and to use tackle sheers in order to lift it. These operations were just completed, when the wind freshened again and the ship was obliged to leave its anchorage.

Following this experience, it was decided to await better weather conditions, and the six boats put out to sea at the same time, two by two in three different zones; the surveying ship remained along the coast in order to help the boats in case of need.

The boats completed soundings in this zone in little more than two days and were then hoisted aboard.

For political reasons, the *Magnaghi* was obliged to interrupt its work during the first days of May in order to go to Hodeida. After 15 days interruption, the work was resumed until the end of June. For the same reasons, the *Ostia* was obliged to go to Mokka in the early part of May and to remain there at the disposal of the Colonial Government. Thus soundings remained uncompleted in certain offshore zones, and were subsequently carried out by the *Ostia* which was sent to the Red Sea for a month for this purpose.

A rapid examination of the characteristics of the region where the soundings were taken, will give an idea of the difficulties encountered and overcome.

The territory of the Dancala coast, which stretches south-east from Sciab-Sciac, is constituted at first by a long plain bordered by dunes along the shore, whilst the interior is formed firstly by a zone of nearly desert steppes, and then high grass and dense vegetation. Behind the plain, are hills of volcanic origin which rise gradually till they join the high chain of mountains at the back.

Going south-east, the vegetation disappears and is replaced by a vast sandy desert, interspersed here and there with acacias; at the foot of the mountains this desert zone becomes a veritable sea of sand which the wind lifts right up the sides of the mountains to a great height.

In the neighbourhood of Edd, the region becomes volcanic and remains thus right up to Dubhi, which rises in the distance S.S.W. of Edd. This volcano is called by the natives Mountain of the Devil, as they recall one of its recent violent eruptions.

The ground in this zone is barren and wild, generally of a reddish brown, with large streaks of black, where the lava resembles a magma of recent formation; by sharp contrast, the stretches of sand seem very white against this dark background.

The coastal plain rises gently to the foot of the high mountains, but is continuously interrupted by small volcanic cones and isolated hills which have the characteristic profile of a truncated crater.

The surrounding islands have the same characteristic right up to Assab; a little less wild, however, in the vicinity of Barassoli, and interrupted by the big palm oasis of Beilul, then going down to the sea again with the spur of Gebel Darma which forms the cove of Beilul.

South of Gebel Darma, along the sea, there is a zone of steppes which stretches for many kilometres beyond the beach; but the volcanic rock juts out again with a new spur which joins the sea at Assab; mounts Ganga and Sella rise behind with their characteristic shape which reveals an extinguished crater. From Assab, the volcanic rock, shaped like a hill, takes a southerly direction away from the coast, leaving along the sea a large plain with, here and there, a few emerging cones. Through the plain runs the Arsilé, whose waters are sometimes abundant like a torrent; on its banks, stretches the great oasis of Mergabela with a little vegetation. The curve of the bay extending to the east up to Raheita and then to Dumeira, then taking the general direction S. E., is formed by low and barren ground, with swamps and soft mud in the southern part of the curve and towards the Ras Sintian point, where, at times, given special tidal conditions, communication exists with the neighbouring islands. All the islands of the bay are of madreporical formation, low on the water, and some have practically the character of atolls. They are generally surrounded by dense and high mangrove trees which completely hide, at times, the contour of the coast.

It will be easy to understand, from this rapid description, what great difficulties the surveyors on land had to overcome. Local resources are practically void, at least in the greater part of the zone in question. Water is rare, wells are far from one another and from the habitations. Generally. this water is very salty and contains a lot of magnesia so that often it cannot even be used for the cattle; this compelled us to organise very carefully our supply of food and water from the surveying ship.

Great difficulties were encountered in the islands of the bay of Assab for establishing signals from where the horizon could be visible above the mangrove trees, and which, themselves could be seen. It was necessary to build real monuments, for which, in some cases 58 gabions, and in other cases 370 bags of sand, were required.

In most cases, the survey of the islands had to be effected from the sea, by fixing stations on the bank which surrounds the border of mangrove-trees and which emerges at low water.

Another kind of difficulty was found in the vicinity of the village of Edd, especially owing to the lack of communications. There was no path, even rudimentary, where a motor-car could pass; in many places, there were rivulets of lava, often broken up, where camels could not tread, but where, in some cases, mules could be used.

Owing to these conditions, work on land was limited to the coast line, by placing the vertices of the triangulation on neighbouring islands. A new difficulty arose when the Seil Abail reef, chosen as one of the vertices, was found to be quite inaccessible and had to be excluded, the triangulation being carried to interior points.

The numerous cases of tropical ulcers in the lower limbs which befell surveyors and their assistants, are due to the various circumstances mentioned above.

Work at sea was slowed down by meteorological conditions. The monsoon from the North-East of the Indian Ocean, rushing into the Gulf of Aden, and being canalised between the two banks of the southern Red Sea, then blows in the direction of the latter's axis with great intensity, and stirs up heavy seas. It blows thus nearly permanently for periods of at least 15 days, then quiets for two or three days, and resumes again with rapidly increasing violence.

Conditions at sea are, of course, closely linked to the wind, and have therefore greatly impeded the work of the surveying ships and of the boats.

In addition to heavy seas, the wind also produces a certain amount of obscurity due to the sand blown up.

In the early hours of the morning, the wind is feeble; but as it gathers strength, and as ascending currents due to heating are formed, the sand is lifted up, first in the shape of small isolated spouts, which extend rapidly and form a curtain, completely shutting out the summits of the highest mountains.

This phenomenom stops all work at sea and renders life difficult on shore.

When the monsoon declines, there are one or two days of excellent visibility, then a light N.E. wind rises saturated with humidity, which produces a dense fog and which the return of the monsoon blows away. When the monsoon finally subsides, which took place in 1934 about the latter end of May, the N.E. wind arises bringing a dense fog, and visibility is reduced to approximately one nautical mile.

I have mentioned the aerophotogrammetrical surveys effected by means of the Santoni method. For these surveys, it has been necessary to construct signs which can be recognised from high altitudes, with characteristic geometrical shapes, and as far as possible, white-washed. Of course, this system was rendered useless when the sand was stirred by the wind, and we have studied means of correcting this by erecting very high constructions which cast their shadow on the ground. Each main signal was to have a secondary signal at a distance of about 1 1/2 km., determined by distance and bearings. When the signals were constructed, and the triangulation elements communicated to the surveyors, the latter went from Asmara to Assab with their planes in order to reconnoitre from the air. This was continued during five days and during the return journey to Asmara.

Owing to bad atmospheric conditions, to the use of plates which were not quite adapted to the particular conditions of light in the region, and also to the lack of time which did not permit us to await better days, the results obtained were rather poor, and consequently we have made use of them on our charts in a very small way and only for details of secondary importance.

As set out in the programme, astronomical stations were effected at Thio, Edd and Assab, with the use of the prismatic astrolabe which was found to be very practical for field work.

Observations were very difficult, especially in the first months of the campaign, as the strong wind produces considerable vibrations on the surface of the mercury, in spite of all the systems invented to protect it.

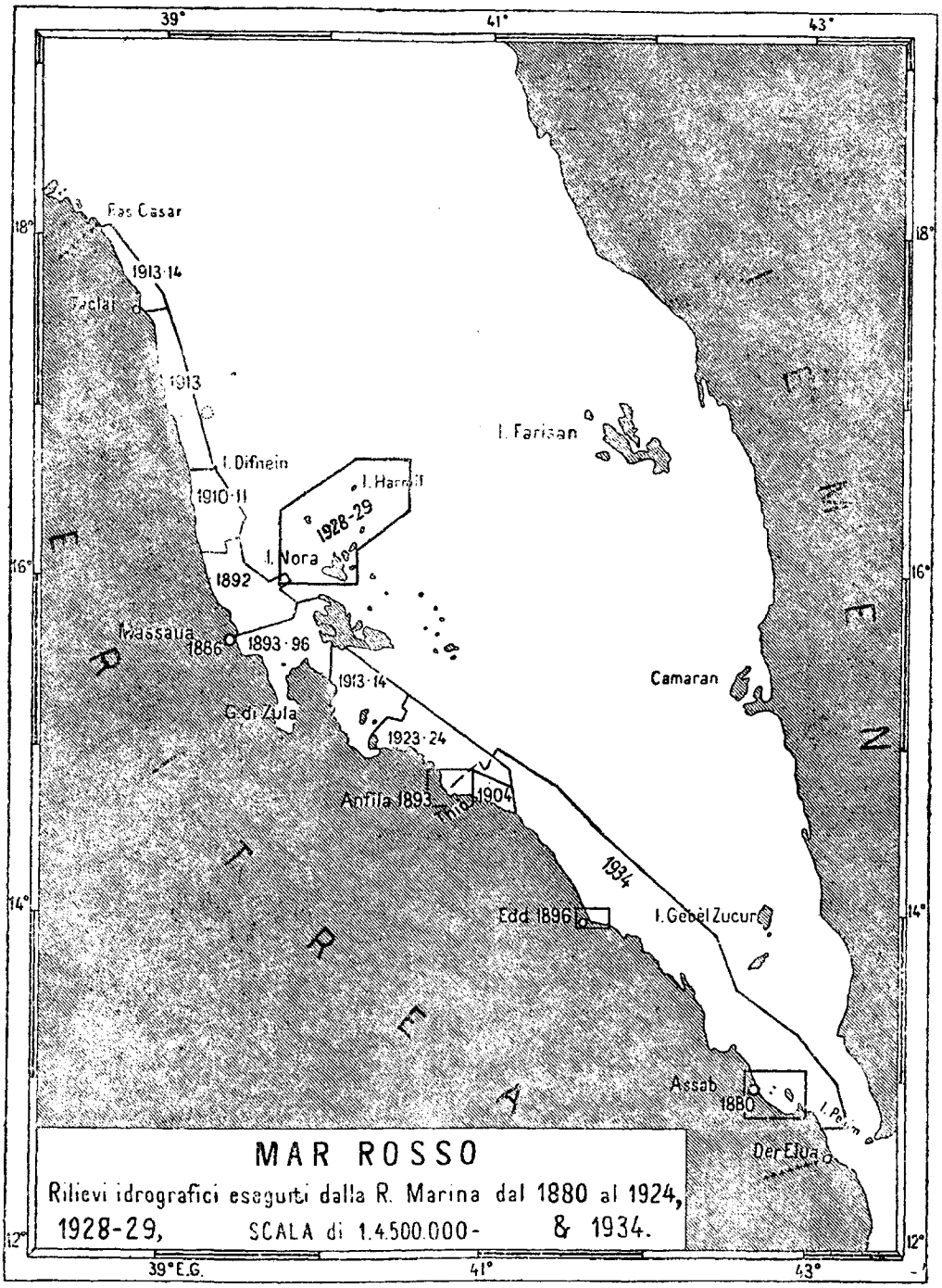
The two bases were measured at Assab and at Thio, and for this purpose, an invar four-wire apparatus was used, belonging to the Geophysical Section of the Turin University.

The measurement effected at Assah gave as definite value 1,032.150 m. During this measurement, an anomaly was shown by one of the wires. As it was noted that there was no error in the observations, a new gauging of the wire was effected, which revealed a variation as compared with the preceding gauging.

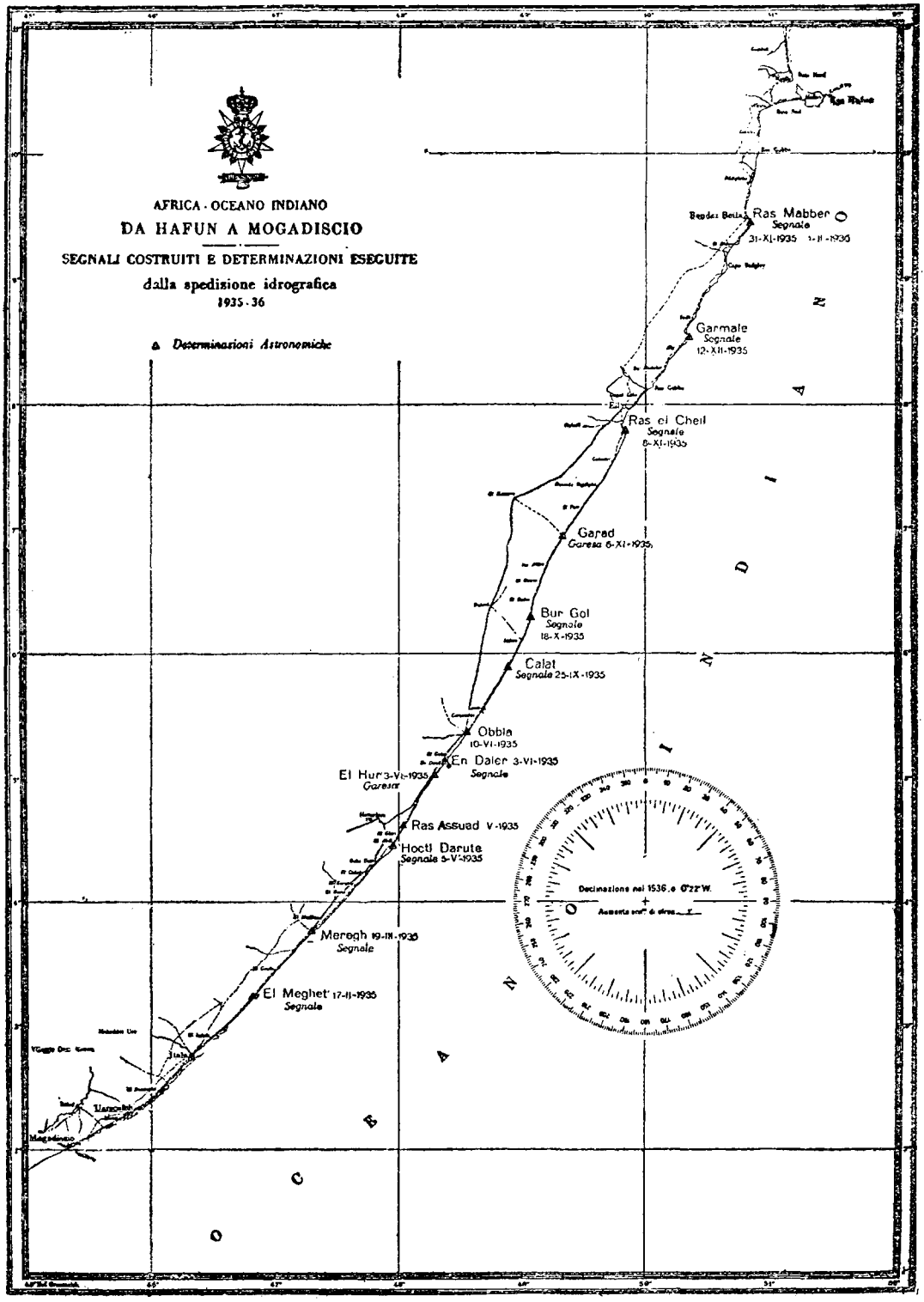
The measurement effected at Thio gave as definite length 1,007.809 metres. An anomaly was found, likewise, in one of the wires, but not similar to the preceding case. It was not possible to gauge the abnormal wire on the spot, owing to the differences which had taken place since the beginning.

The measurement adopted was, therefore, that given by the average of the three wires.

Stations of terrestrial magnetism were also established in the localities of Massaua, Thio, Edd and Assab, giving measurements of declination, dip and horizontal force.


39°
41°
43°
18°
16°
14°
12°
Ras Casar
1913-14
Taclai
1913
I. Difnein
1910-11
I. Harmil
1928-29
I. Nora
1892
Massaua
1886
1893-96
1913-14
G. di Zula
1923-24
Anfila 1893
1904
1934
Edd 1896
I. Gebel Zucur
Assab
1880
Der Elua
I. Farisan
Camaran
MAR ROSSO
Rilievi idrografici eseguiti dalla R. Marina dal 1880 al 1924,
1928-29, SCALA di 1.4.500.000- & 1934.
39° E.G.
41°
43°

Graph N° 8.


AFRICA - OCEANO INDIANO
DA HAFUN A MOGADISCIO
SEGNALI COSTRUITI E DETERMINAZIONI ESEGUITE
dalla spedizione idrografica
1935-36
▲ Determinazioni Astronomiche
Ras Mabber
Segnale
31-XI-1935
Garmale
Segnale
12-XII-1935
Ras ei Cheil
Segnale
6-XI-1935
Garad
Garesa 6-XI-1935
Bur Gol
Segnale
18-X-1935
Calat
Segnale 25-IX-1935
Obbia
10-VI-1935
En Daler 3-VI-1935
Segnale
El Hur 3-VI-1935
Garesa
Ras Assued V-1935
Hocti Darute
Segnale 5-V-1935
Meregh 19-IX-1935
Segnale
El Meghet 17-II-1935
Segnale
Declinazione nel 1936.0 0°22' W.

Graph N° 9.

The results of the whole of the work carried out by the two surveying ships and by the surveyors on land, have enabled four charts on the scale of 1: 20,000 to be drawn up, which charts complete the series of coastal charts of the Colony of Erythrea. A new complete chart of the Bay of Assab has also been published, and plans of the anchorages of the Dancala coast, of the islands of Cordumiat, of Edd, of Mersa Dudo, of Barassoli of Beilul (Graph 8).

During the stay at Massaua, various surveys of the Port were carried out, and subsequently a new edition of the plan of this port was published.

The *Ostia,* which had remained at Mokka for political reasons, and which was kept in the Red Sea, later completed the survey of the outer zone, which owing to meteorological conditions and lack of time, had not been finished. As a result of the many trips made by boats during the Ethiopian campaign, this same surveying ship was ordered to effect a complete survey of the Bay of Dachilia, north of Massaua and of the southern anchorage of Massaua; two new charts published were based on this work.

When the above mentioned work was carried out, it was possible to say that the survey of the whole coast of Erythrea was ended. In order to complete the survey of the Red Sea zone under the jurisdiction of the Colony, two vast zones North and South of the archipelago of the Dahalac islands, comprising the N.E. passage through that archipelago, have to be effected. Although these zones offer no particular interest to navigation, it would be better that a full survey be made, and the Hydrographic Institute will not fail, as soon as possible, to make preliminary studies thereof and to propose to the competent authorities, the execution of this plan.

WORK IN THE INDIAN OCEAN.

The length of the coast of Italian Somaliland, from the frontier of British Somaliland to the territory of Chenia, is approximately 2,400 km.

The charts of this coast were still based on very old surveys, some dating back to 1828; many points were uncertain and incorrect; the coast line was traced very approximately, and certain important points had an erroneous position amounting to one mile. Soundings were incomplete, covered a small area, and in some places the marine survey was limited to a very approximate line, which one was advised not to pass on account of dangers and obstacles not sufficiently identified.

When Italian interests began to centre on this coast, it was found necessary to make better surveys, some of which have been effected by ships of the Italian Royal Navy. These, however, were hurried operations, or surveys of anchorages carried out with the limited means of ships which are not specially fitted out for this purpose. Operations of this kind effected by the following ships of the Navy: *Staffetta* in 1889-99 and 1904, *Colombo* in 1901 and *Governolo* in 1905. were followed by specific surveys carried out by the *Staffetta,* fitted up as a surveying ship during the years 1907 and 1911. These surveys covered a length of coast of 500 km. from Foce del Giuba to Itala.

With the exception of the region from the mouth of the Giuba to Mogadiscio, the survey on land could not be extended towards the interior, as the working parties had to contend not only with topographical difficulties but also with the hostility of the inhabitants. As a result, the triangulation is faulty with small angles and important closure errors. Further, soundings carried out either by the surveying ship or by local canoes are incomplete on the coast, scattered and irregular offshore.

Better results were obtained between Mogadiscio and Itala. Triangulation is good with good closures; the strip of coast sounded was closely studied and the soundings are comparatively good, both near the coast and offshore.

Surveys north of Itala, which were to be carried out during the following years, were put off, on account of the Italo-Turkish war and the World War, and also the necessity of obtaining more urgent surveys.

In 1924, during a surveying campaign carried out in the Red Sea by the surveying ship *Magnaghi,* an expedition sent out to Somaliland determined the geographical coordinates of Cape Guardatui and noted that the position of this point was more easterly by 2,5 miles than had been plotted up to then on the chart.

The same expedition determined the geographical co-ordinates of the Hafun promontory, and effected soundings to be used in the publication of the anchorage plan of South Hafun. As a result of these determinations, the lighthouses of Cape Guardafui and Hafun were erected and also a radio-beacon in the vicinity of Guardafui. These navigational guides were welcomed with great satisfaction by all mariners, as they filled a great need, to which can be attributed many disasters which occurred in this region.

After 1924, no new survey was effected on the coast of Somaliland, either on account of more important work to be carried out in Libya, Aegean Sea and the Red Sea, and which monopolised the surveying branch of the Italian Royal Navy, or owing to the difficulties encountered which had not yet been solved.

However, the Hydrographic Institute of the Italian Royal Navy had prepared a programme in this connection and a study of the work to be carried out. The organisation and equipment were very much superior to those used to date, on account of the great technical and material difficulties to be overcome. By the end of 1934, a complete plan was established comprising several expeditions on land and two surveying ships, while the duration of all the work was estimated as 3 years.

The East African expedition comprised the complete survey of the coast of Somaliland, either for the safety of navigation, or to contribute to national prestige; later on, however, it was found necessary to modify these plans and to adapt them to present urgent necessities.

It was thus decided, in order to erase in a large part the uncertainty of the existing charts, to effect an accurate signalisation of the coast, between Ras Hafun and Mogadiscio, which coast, owing to its uniformity and lack of prominent points for identification, to the existence of dangers only a few miles from the shore, and to the presence of strong currents, renders navigation extremely difficult, even when meteorological conditions are not particularly bad.

An expedition was therefore organised, whose principal aim was to determine by the most accurate methods the geographical co-ordinates of about ten points, separated one from the other by approximately 100 km., and easy to identify from the sea either by means of their own characteristics or noticeable signals to be erected. In accordance with the contour of the coast and the suggestions made by mariners, a list of the most suitable localities had been drawn up, to serve as a basis for the surveyors.

The party, under the leadership of Lieutenants Emilio GARIAZZO and Vincenzo D'AMATO, comprised two officers and three N.C.O.'s or sailors. They left Genoa on the 5th January 1935 and reached Mogadiscio on the 22nd.

It was found, after getting into touch with the technical and administrative organisations of the Colony, that it was not possible to obtain motor-cars from the Military Authorities, as these vehicles were needed for the mobilisation; but three Chevrolet lorries were hired and fitted with bodies adapted to their work, which could be utilised wherever there were roads or paths; in the other parts, caravans were to be utilised. The original plan of reaching certain localities by sea had been abandoned, as local information had stressed the great difficulty of disembarking on the coast of Somaliland, owing to lack of means and to the condition of the sea.

The expedition left Mogadiscio on the 12th February 1935, as soon as the lorries were ready, and on the 1st February 1936, they embarked at Bendar Beila on the mailboat, which anchored there for this purpose, for their return trip to Mogadiscio. Thus the work was carried out without interruption during a whole year, during which they met with great vicissitudes which are set forth in a very interesting report.

The long and tedious journey is shown on graph N° 1, with the position of the signals and the dates when the various operations were carried out.

The state of the roads was greatly inferior to the somewhat optimistic information obtained at Mogadiscio. The first difficulties were encountered during the trip to El Meghet, where an astronomical station was established, and were due to frequent sinking into the sand. As the party moved northwards, the difficulties became even greater owing to the very bad conditions of the caravan paths; as a result, the lorries were frequently damaged and their utility diminished, so that, after reaching Obbia, caravans were exclusively used for transport.

A new difficulty arose when obtaining the necessary animals as they are not numerous or very hardy.

It is now necessary to give rapidly an idea of the ground covered, so as to understand the odyssey of this small group of men often left to their own resources, because, owing to other and far more serious events at the same time, their presence along the coast had become a negligible episode.

The coastline between Itala and Obbia is low, sandy and uniform, due probably to the two yearly monsoons which blow parallel to the coast and thereby give it its monotonous aspect totally devoid of irregularities.

The few small rocks along the coast are rectilineal and their axis is parallel therewith.

The sandy strip is quite wide, and, close to the sea, it is covered sparsely with grass which grows for a brief period when the rains come with each "tangambili" (1). Seen from the sea, the coast then has the aspect of an undulating meadow, but after a few days, it resumes its arid appearance and its yellow colour.

Two irregularities break the uniformity of the landscape : the *baads,* moving white dunes, formed of dry sand and entirely devoid of vegetation, the profile of which varies with the monsoon, and *level rocks,* formed of soft, friable limestone, which constitute a sort of stripes covered more or less with sand and give an undulating aspect to the landscape. It is easy to understand how the tracks, which are indicated very approximately on such a ground, most of the time without ballast, are extremely unwieldy for heavy traffic. Sometimes, during the rainy season, it is possible to utilise the strip of sand, but as soon as the effect of the rain decreases, there is the danger of sinking into the sand.

North of Obbia, the sand decreases and is replaced by hard, compact, brick-coloured rock. Parallel with the coast and with each other, are granite steps which increase in height as one goes towards the interior. Between these steps, are corridors of flat rocks. There are no human beings in this zone, but the fauna is rich and varied. As one advances towards the North, the soil is more rocky and barren, and tracks more difficult; there are, further, stretches covered with sand and rocky soil, which in the rainy season, bear grass and are peopled with passing herds. The cavities in the rocks retain the water, which is sometimes abundant, but in other places water is entirely lacking, and that found in the wells, is salty, non-potable and unfit for washing.

North of the 6th parallel, the rocky steps subside and disappear, to re-appear only in certain places. The coast then resumes the aspect and contour which it had south of Obbia, with isolated rocky ridges, sometimes accompanied by white dunes of the *baad* type.

Beyond Fosc, north of the 7th parallel, the coast shows high rocky steps, and the intervening corridors are streaked with deep slits; the shape of the steps is also interrupted by grottoes and caverns. The slits in the oueds are more and more abrupt and deep, wider, and in a general way, devoid of water. To cross these oueds, it is sometimes necessary to cover several kilometres in order to find a track where the caravan can descend to the bottom of the valley and come up on the opposite side.

The members of the expedition showed great courage, tenacity and experience, when their physical resistance was sorely tried by long marches in sandy or rocky and barren land, by the scarcity of water, by the climate, the lack of fresh food during consecutive months, and by tropical disease.

While proceeding along the coast and choosing the most appropriate spot for erecting prominent objects, the expedition also determined positions astronomically and fixed the plan of a signal, whenever there did not exist at that place a construction which could be restored or raised. At the beginning, the construction of new prominent objects was left to private enterprise; but all sorts of difficulties, due principally to the situation of the Colony, showed, when the first signals were erected, that it would be advisable for the members of the expedition to erect these constructions themselves with their own means. This decision speeded up the installation of signals, but increased the work of the expedition and their transport problems, as it was possible to find very little material locally.

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(1) *Tangambili signifies "the two sails" and indicates that during this period it is possible to navigate along the coast in both directions.*

The construction of signals requires a certain sagacity, as they must be visible from the sea and easy to identify by mariners, along a coast practically devoid of any characteristic sign, and also they must withstand the onslaught of winds which are often very powerful. These signals must also be of various shapes and colours to avoid confusion.

For astronomical determinations, the expedition had in its possession :

A zenith telescope, small model, Troughton & Simms.

Two sidereal chronometers with electrical transmission.

A field perforating chronograph.

Two short and long wave wireless sets.

The latitude was determined by the Horrebow Talcott method. To determine time, use was made of the method of the transit of stars on the meridian, by observing pairs of circumzenithal stars (Alessio method). At each point of the station a solid concrete pillar was erected, with good foundations. Great care had to be taken with regard to the construction of the shelter to protect the instruments against the monsoon and against sand. The chronometers were always carried with great attention, so that in spite of long journeys, they showed great regularity.

The reception of time signals, which the radio stations of Somaliland were to have transmitted, was always effected by the expedition's receiving sets. With regard to the first two stations, use was made of the time signals of Moscow and of Monte Grande (Buenos Aires), and for the other stations, observations were confirmed by at least three "stops". The stations generally used were: Moscow, Saigon, Pontoise, Norddeich and Monte Grande.

The signal for maritime operations was, generally, constructed in the vicinity of the astronomical pillar and its position determined by reduction to center.

The following stations were established : eleven complete astronomical stations of latitude only, the longitude being deducted from geodetic operations :

— *El Meghet* — Signal with concrete angles, height 5 m., painted in white and black checks.

— *Meregh* — Cylindrical signal in its lower part, and truncated in its upper part, total height 6 m. 70 painted in black and white horizontal stripes.

— *Hocti Darute* (Gallagois) — Cylindrical signal of 3 m. 50, topped with a cone, painted on the sides with vertical black and white stripes and in white on the upper part.

— *Ras Assuad* — Latitude station; longitude according to Gallagois — no signal because the Cape is easy to distinguish.

— *El Hur* — Signal constituted by the small fort of the garrison, quadrangular, height 8 m., painted with lime, with battlements, painted alternately in white and black.

— *Hen Dajer* — Latitude station, longitude deduced from that of Obbia. Signal constituted by a white concrete stone in the shape of a pyramid, height 3 m.

— *Obbia* — No signal, the locality being easy to identify by houses and the wireless aerial.

— *Calat* — Signal with concrete angles, height 4 m., painted white, with a large vertical black band in the centre of each side.

— *Bur Gol* — Concrete prominent object, white truncated pyramid, height 3 m.

— *Garad* — Signal constituted by the small fort of the garrison.

— *Ras El Chiel* — Locality easy to identify, signal constituted by a white, square pillar, height 2 m.

— *Garmal* — Signal with concrete angles, and with frieze, height 4 m. painted in white.

— *Ras Mabber* — Signal constituted by two concrete superimposed parallelepipeds, total height 2 m. 15.

In the zone between El Hur and Obbia, the two stations were connected by triangulation. This operation presented an unforeseen difficulty, on account of the sandy soil which was difficult to cross with lorries and very hard to cross on foot, and also of the wind and conditions of light and visibility. The very accurate triangulation necessitated three months' work for a distance of about 50 kilometres.

The work carried out by this expedition is certainly very useful; it has been instrumental in drawing up a chart of the zone between Mogadiscio and Ras Hufun, on the scale of 1: 1,000,000, whereon the prominent points of the coast are shown in their exact position, whereas on the previous charts the errors amounted often to several miles, and greatly confused mariners who could not make the points observed agree with the points surveyed.

This very arduous work, carried out by two young officers, shows the enthusiasm and energy with which they overcame difficulties which would have vanquished others of less stamina.

In 1907, when the *Staffetta* began its survey work on the coast of Somaliland, to which I have already referred, the Director of the Hydrographic Institute, Commander M. GIAVOTTO, had foreseen and set out most of these difficulties in a report which he read at the VI. Italian Geographical Congress. These difficulties centered round:

1°) the monsoon which blows in these regions during most of the year;
2°) the hostility of the natives;
3°) the distance from ports of refuge and supplies;
4°) the nature of the coast itself.

From the foregoing, it was estimated that the work could not be carried out by ordinary means and methods, and that at least it would be lengthy, costly and fraught with dangers.

Consequently, Commander GIAVOTTO, taking the peculiar conditions of the coast into account, had deemed that soundings should be taken principally from the surveying vessel, helped by the larger boats with good sea-going qualities, which would follow, outside the breakers, a line parallel with the coast and not a normal one, as is generally the case. For operations on shore, and owing to the contour of the coast and the hostility of the inhabitants which would have prevented the establishment of a wide-meshed triangulation net, he suggested a coastal polygonal net, with ranges of about 60 miles, of which the extremities would be fixed by complete astronomical stations. The length of the sides of the polygons could be obtained by setting out the triangles, by establishing at the extremities of each side, small auxiliary bases of a length proportionate to that of the sides, which could be measured rapidly and accurately with invar wires or telemeters.

I wished to recall what had been foreseen more than 30 years ago, because the difficulties encountered were the same, with the exception of the hostility of natives, and because the methods which were studied and which were later put into practice, do not differ greatly from those examined at that time.

With regard to meteorological difficulties, it is well known that on the coast of Somaliland, which faces the Indian Ocean and the Gulf of Aden, the monsoons divide the year into two parts : the S.W. monsoon in summer and the N.E. monsoon in winter.

The period of the S.W. monsoon generally extends from mid-April to mid-October. From the beginning, and during the whole of May, the monsoon is feeble and variable, with calm periods; but the direction which predominates is S.W. During June, July and August, the monsoon gathers strength and becomes a squall. During September, the wind remains violent but with periods of comparative calm. From the end of September until the first days of October, the S.W. monsoon ceases and a fresh N.E. breeze springs up almost immediately.

It is easy to understand that on the coast of the Indian Ocean communications with the shore are difficult and not always possible. On the contrary, during this period, there is a high temperature and no wind on the coast of the Gulf of Aden; communications with the coast are always easy and possible.

The period of the N.E. monsoon extends from mid-October to mid-April; the wind is light and variable at the start, increasing progressively, with heavy seas; it begins to decrease in March. This wind is characterised by comparatively calm periods lasting one or two days and sometimes more. This is especially the case at the beginning and at the end, when the calm is greater and the periods longer.

The beginning and the end of the inversion periods of the monsoon are generally marked by a brief, but violent resumption of the monsoon, often accompanied by a heavy fall of rain. In the periods between monsoons, which are called "tangambili" (See Note 1), there are light and variable winds, the sea and land breezes alternating, and atmospheric disturbances with electric discharges and frequent squalls. During these periods, there is a swell on the Ocean which forms heavy breakers on the coast.

The duration of these periods which characterise the regimen of the Indian Ocean monsoons, does not follow a regular and unchanging rhythm. The indications obtained by people who have lived long on this coast and have collected local nautical data, correspond more or less exactly. Anyway, the dates which we indicate are only approximations around which can oscillate the beginning and the end of the meteorological phenomena. Further, these data do not refer to a definite locality, but to the whole basin of the Indian Ocean, as the transition of a monsoon to the following period of calm and vice versa does not occur simultaneously in the whole basin, but on the contrary, progressively along the coast.

In this way, the N.E. wind begins in the zone of Guardafui, and is only felt a few days later between Mogadiscio and the Ras Chiambone. The same phenomenom takes place when the wind disappears. Of course, for the S.W. monsoon, the above mentioned zones are inverted both at the heginning and at the end.

The absence of ports, both for shelter and for supplies, has not decreased since 1907. All along the coast of Somaliland, from Bender Ziada to Ras Chiambone, there is, strictly speaking, no real port. The only localities which might, by their contours, become ports, are Chisimaio in the South and the southern indentation of the Hafun peninsula in the North. But both are subject to the violent onslaught of the S.W. monsoon, and the second one, especially, would require a lot of work before it could be used in all seasons. Consequently, it is easy to understand the great practical difficulties which surveying vessels encounter along this coast. Although, in certain points, coal dumps can be constituted, there is a lack of lighters, equipment and personnel to carry it on board, and all this is difficult to improvise. The coast also lacks means for obtaining water and food, which are indispensable to ships working at sea and requiring to be autonomous in order to utilise the best periods of weather.

It should also be recalled that the periods when it is possible to obtain supplies in the favourable localities, are precisely those when the maximum work can be carried out, and, therefore, the former occupation has to be deducted from surveying activities.

There are also interruptions for cleaning the boilers, and for allowing the crew to rest after more continued labour than is normally the case; these interruptions can only take place in safe anchorages where water can be liberally supplied.

Beaconage is practically non-existent along the coast; at the most, it consists of small range lights which serve to reconnoitre anchorages.

One must add that, with the exception of certain points which have become more or less important ports of call, and which are generally far from each other, it is very difficult and even impossible, to establish regular connections between the sea and the coast owing to the latter's impracticability and to the presence at all times of an ocean swell which breaks sometimes hundreds of metres from the coast. It is easy to comprehend that the organisation of an expedition to survey the whole of the coast of Italian Somaliland in a comparatively short time, is not an easy matter. However, after due consideration of what was necessary, circumstances have often dictated that, in practice, it was better to act quite otherwise.

When first planning this expedition, the use of three land parties and two surveying ships, for a total period of two years and a half, had been considered.

In a general way, the following programme which we will now examine, corresponds to the plans made. With regard to work at sea, the coast was subdivided into three zones :

— The first comprising the coast of Somaliland to the Gulf of Aden, along which it is possible to work at sea, even during the S.W. monsoon.

— The second comprising the coast from Itala to the Cape of Guardafui, along which it is only possible to work during the "tangambili" and, in part, during the N.E. monsoon.

— A third zone comprising the coast between Mogadiscio and the Ras Chiambone, along which work is possible in the same way as in the previous case.

At the beginning, an improvement in the soundings and not a full survey had been decided upon for the portion Mogadiscio — Itala.

Based on the experience of the 1935-36 expedition, the parties sent on land were organised in such a way as to be entirely autonomus and not dependent in any way on the surveying ships.

For co-ordinating work on land before the arrival of the surveying ships, an Office of Works was organised with its Head Office in Mogadiscio; its role was also to make a first check of the surveys, in order to prepare, if necessary, corrections and revisals.

Further, this Office was in charge of the practical organisation and of relations with the civil and military authorities of the Colony regarding funds furnished by them and any requests for personnel or equipment.

The parties, numbering four, left Italy in August 1937. One was instructed to execute a series of astronomical stations for determining geographical co-ordinates aloong the coast from Bender Ziada to Hafun, and from Mogadiscio to Ras Chiambone, that is the coast not yet explored by previous expeditions.

The three other groups were instructed to establish the geodetic connection between the points of known geographical co-ordinates, to survey the coast and to erect all necessary signals for sounding operations.

In executing this task, the purpose of the campaign was kept in mind: mainly to draw up charts, without geodetic pretensions of a scientific order. In this way errors could be tolerated which only entailed very slight differences in the drawing, on the scale of construction of the chart.

In accordance with this hypothesis, a method was to be adopted, to determine the chain of signals between two astronomical stations, which permitted a maximum speed without impairing the requisite accuracy; and this, not only for technical reasons, but especially for practical reasons.

The system found to be the best consisted in a polygonal coastal net, measured with accuracy, with sides of approximately 4 km., with a signal at each vertex.

Before adopting this method, its practical and theoretical sides were carefully studied by the Hydrographic Institute. Special instruments were constructed and appropriate types of calculation established for the use of the different groups, who were likewise instructed in the execution of this new type of survey.

It was decided to follow the system of normal triangulation, when the contour of the soil, as is the case in certain parts of Midjertheyn, d,oes not necessitate the use of the polygonal net.

In principle at least, the polygonal method was to supersede all others and only to be abandoned when special conditions made it impracticable or less convenient than the others. Consequently, the parties were fitted out specially to utilise this method.

It consists in connecting two successive astronomical stations with a broken line made up of a series of sides of approximately 4 km. length. (Graph N° 10).

The length of each side is obtained by measuring the parallactic angles β subtended by two bases b about 200 m. long, and set out nearly normally to the side of the polygon at its extremities.

Two values of l are thus obtained, which is a check on gross errors and gives double accuracy by taking an average.

The bases are measured in their turn by measuring the parallactic angles σ sub tended at the extremities of the bases by an invar wire f six metres long, placed approximately in the middle of the base, one of the extremities lying on the base itself.

As a result, the parallactic angles β as well as the angles σ must be measured with great care by means of the Wild theodolite.

The following special instruments are required for taking these measurements :

a) an invar wire of 6 metres with a reference mark at each end and a drum on which the wire is rolled;

b) two strong tripods, one of which receives one of the ends of the wire, and the other has a pulley in which runs a cord fixed to the other end of the wire and carries a weight of 10 kilograms to ensure tension of this wire;

c) a telescope angle meter consisting of a telescope fitted with a level which rotates around a vertical axis with optical centering. The telescope carries an index which moves on a movable limb.

All these instruments together are called a wire stadimeter.

Azimuths of the sides are obtained by the astronomic measurement of the first side, which is then carried, according to the measurement of the angles, on the various sides. At the end of the polygon, another astronomical measurement of azimuth is made and compared with that obtained by calculation. When the polygonal line exceeds 50 kilometres, another astronomical measurement of azimuth is made in the middle.

In practice it has been found that errors attain a maximum of 0.1 per 1,000.

The group detailed to effect astronomical stations disembarked at Bender Cassim, then went to Hufun, and from there to Mogadiscio to establish the stations along the coast south of this point. This expedition under the leadership of Lieutenant Carlo GANDOLFO, finished its work in July 1938 and then returned to Italy.

The other groups carried out the following work : the first disembarked at Bender Cassim, went to Bender Ziada, and from there executed the survey of the coast of the Gulf of Aden and the southern part up to Hafun. This group then went to Mogadiscio and started the survey from that point towards Merca and Brava, and then more to the south until they joined at Gaschera on the 16th March 1939 another grouop coming from Chisimaio.

The two other parties disembarked at Mogadiscio. From there one went to Itala to effect the survey between that point and Obbia. They then returned to Mogadiscio, were reorganised, and left for Chisimaio, to effect the survey between Chisimaio and Ras Chiambone.

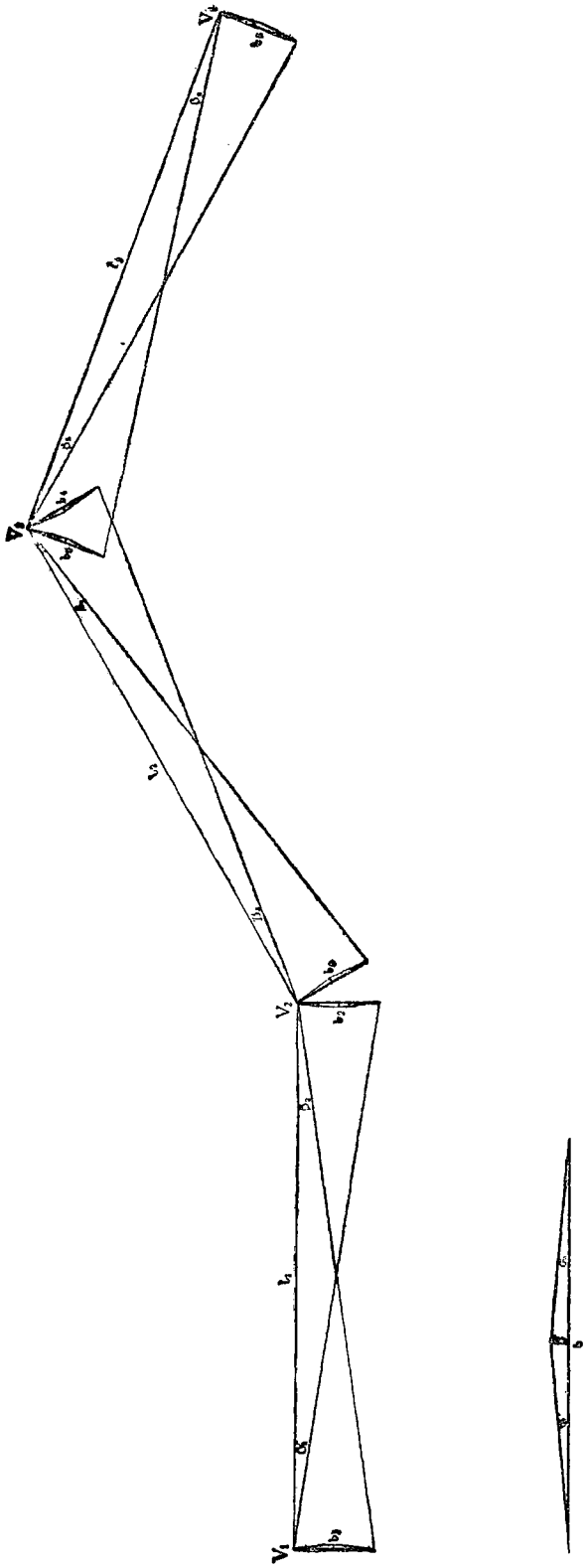
The other group went to Obbia and reached Ras Hafun in November 1938, joining up its survey work with that of the party which came from Bender Ziada; in January 1939, they went to Chisimaio, and from thence to Brava to join at Gaschera the group coming from Mogadiscio.

On the 13th March 1939, an N.C.O. with a few men from the expedition working between Chisimaio and Ras Chiambone, were detailed to place and determine by a speedy method the signals situated on the stretch Mogadiscio-Itala. This was due to the fact that the Hydrographic Institute, after examining the work carried out, had deemed it necessary to execute once again with the same methods and in the same way, the complete survey of the coast of that region. As the triangulation effected in 1911 was very good, it was decided to execute a polygonal survey in order to have a point of comparison between the two methods. This was hastily done and ended on the 21st April 1939 so as to enable the surveying vessels to undertake sounding operations.

The group that had reached Gaschera in the North then went to the zone in question and took all the necessary measurements for the polygons as well as the exact determination of all the signals erected.

Several of the officers had to be replaced for reasons of health. As soon as the work was finished in each section, the groups were sent home.

The last to leave were the Head of the expedition with a few N.C.O.'s who put up the necessary beaconage for the various anchorages of Somaliland, in accordance with the data resulting from the soundings effected.



Graph N° 10.

It is necessary to draw the attention of the reader to the work carried out by these various groups who laboured without any rest, overcame difficulties of every kind, and completed satisfactorily and in a short time, the heavy task assigned to them.

This result was reached by heavy sacrifices on the part of all those who took part in the expedition, which sacrifices they bore with great fortitude.