KNOWING TO MANAGE THE TERRITORY, PROTECT THE ENVIRONMENT EVALUATE THE CULTURAL HERITAGE

Geodetic field operations for cartography

an overview over the first Portuguese geodetic mission in the colonial territories

1907-1910

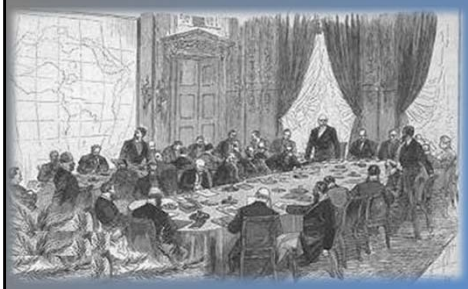
PAULA SANTOS AND ANA ROQUE
Project FCT – HC0075
IICT

With the independence of the American colonies, Africa became the center of the European attention.

Explorers
Roberto Ivens and Hermenegildo Capelo
Portuguese expedition to the inland of the Austral Africa, 1877

For an organized and scientific occupation of those countries, several expeditions were carried out and institutions especially devoted to African studies were created in many European countries.

The Portuguese Commission of Cartography (PCC) was created at the 19th April 1883 to elaborate and publish the cartography of the Portuguese colonies as well as any other studies related to them.



Berlin conference: 15th Nov1884 – 26th Fev1885

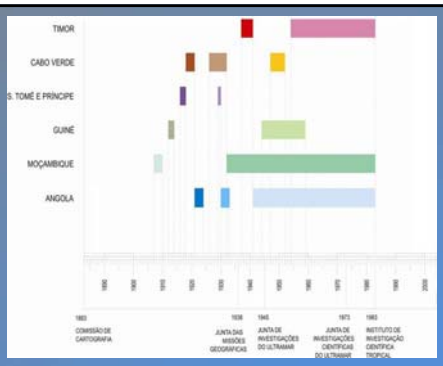
At the Berlin Conference 14 European countries discussed and sketched the new map of Africa supported by the "Principle of Effectivity"

which

supposed the geographical knowledge of the territory, the existence of a reliable cartography and the definition of its boundaries.

To provide the necessary accuracy it´s indispensable a geodetic coverage of this territories.

For this purpose the PCC created temporary geodetic Missions.



Year after year, those missions, covered geodetically the Portuguese overseas countries contributing to an accurate cartography.

TS 02K– Surveying History, paper no5816
Paula Santos and Ana Roque
Geodetic field operations for cartography: an overview over the first Portuguese geodetic mission in the colonial territories (1907-1910)

Mozambique was the first territory being object of geodetic works to cartographic and cadastral needs.

For that, was created the Geodetic Mission of Eastern Africa (1907-1910) - MGAO

In 4 campaigns including 26 months of fieldwork this mission, directed by the Admiral Gago Coutinho established a triangulation chain, with 2 bases and 2 astronomical stations, covering Mozambique coast from the south to Bazaruto's lighthouse.

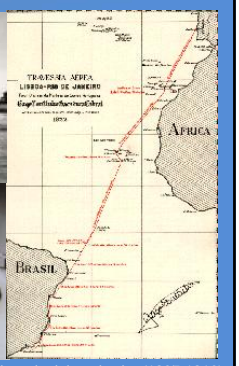
17.2.1869 – 18.2.1959

Gago Coutinho was a famous admiral of the portuguese navy.

He´s activity can be divided in 4 main areas:

- navy
- geographical works
- aerial navigation
- nautical history and history of the portuguese discoveries

Gago Coutinho together with Sacadura Cabral were the first to cross the south atlantic ocean by air from Lisbon (Portugal) to Rio de Janeiro (Brazil) using navigation tables especially adapted for this purpose and a sextant of his own invention.



- **1898 Delegate for the demarcation of Timor frontier**
- **1900 Delegate for the demarcation of Zambeze frontier**
- **1901 Delegate for the demarcation of North Angola frontier**
- **1904 Delegate for the demarcation of Tete frontier**
- **1907 Chief of the geodetic mission in eastern Africa**
- **1912 Delegate for the demarcation of Barotze frontier**
- **1915 Chief of the geodetic mission of S. Tomé and Principe**

Gago Coutinho considered himself mostly a colonial geographer, since from 1898 and for 20 years, he lived in the African backwoods, sleeping in camping tents, working for bounderies demarcations and geodetic triangulations in Timor, Mozambique, Angola and S. Tomé.

A precise surveyor, he used his experience from the navy in the field operations and adapted some methodologies and instruments to the difficulties of the field work in Africa.

During his work, all the operations contributing to the geodetic covering of one country were exhaustively described in several reports that, later on, served as a guide to other geographers.


MGAO field team


Recognition


Measurements of azimuthal and zenithal angles

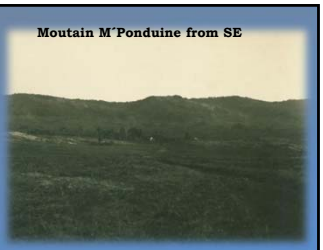

Measure of baselines


Astronomical observations

Recognition

Using a compass and a pedometer the team, travel by foot, with a local guide, through the zone to map on, to choose the local to built the benchmarks, that will define the triangulation chain, if possible on the top of the mounts.

Moutain M´Ponduine from SE

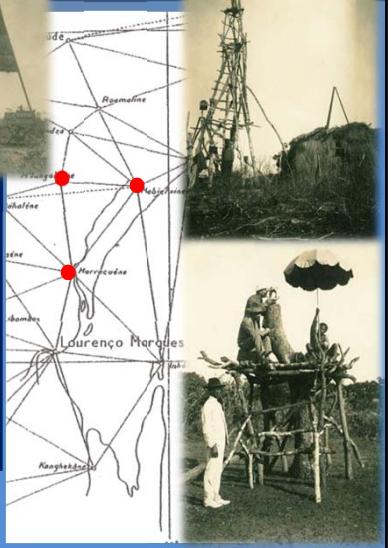


Cutting vegetation to open a "street"

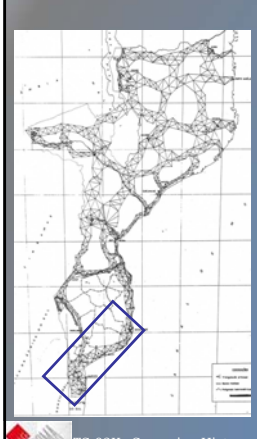
Recognising land from the top of a tree

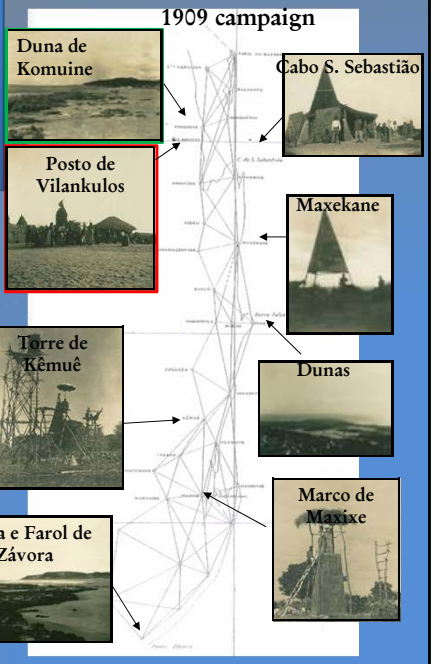
In plane ground that work was so much more difficult that Gago Coutinho said "*it was necessary to use techniques similar to navigation like to set a course with the compass,... , recognise land and make observations with the sextant at the top of the trees, to sound, ..., to find the most highest and suitable point*" .

The triangulation network consists in a sequence of triangles, forming geometric figures, carefully choosed in order to decrease the influence of the observations errors and to allow checking the results.



The triangulation network established by the MGAO was defined by 83 benchmarks covering an area of 40000 Km². The distance between them depends of the topography and accuracy standards, but usually was 30 km.

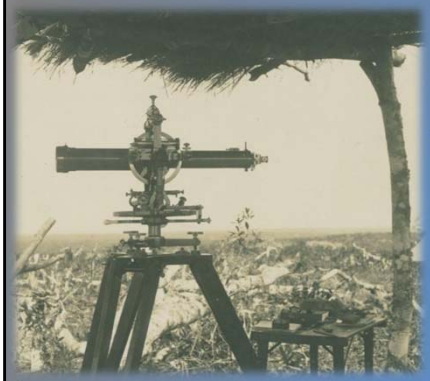




To guarantee the visibility they were signalized with wood, metal or bright signs like *heliums (day) or projectors (night).*

Sometimes, due to existent obstacles or the curvature of the earth, the measurements were done at the top of wood towers to assure inter-visibility.

The azimuthal and zenithal angles of the triangles were measure with theodolites made by Salmoiraghi under specifications of Gago Coutinho to adapt it to the specific conditions in Africa.



Gago Coutinho wanted a high precision theodolite with special characteristics not found yet in any catalogue bringing toghether the best of those used in Europe and United States and the Repsold´s used in Portugal and South Africa.

Salmoiraghi Theodolite

maker	Filotécnica A. Salmoiraghi & C. Milão, Itália
model	geodetic
dimensions	height: 40 cm Diameter of azimuthal circle:27 cm Diameter of zenithal circle:17cm Telescope lenght: 70 cm
materials	Bronze, steel, iron, brass, platinum (200 g), glass

Brief history:

In 1909 the Colonial Office of Portugal ordered to Filotécnica Salmoiraghi to built 4 theodolites under specifications of Gago Coutinho.

To provide the highest accuracy was required a covered horizontal circle, …, and scales engraved in platinum to avoid the oxidation of the clima in Africa.

During the 1st field campaign Gago Coutinho noticed that the instrument was far from ideal being its principal defects the ocular thumbscrew and the circles, at the time very difficult if not impossible to engrave accurately.

Some improvements made them operational being used in the São Tomé and Principe geodetical Mission (1915-1917), also directed by Gago Coutinho, and the first Cape Verde geographical mission (1918-1921).

TS 02K– Surveying History, paper no5816
Paula Santos and Ana Roque
Geodetic field operations for cartography: an overview over the first Portuguese geodetic mission in the colonial territories (1907-1910)

Measure of baselines

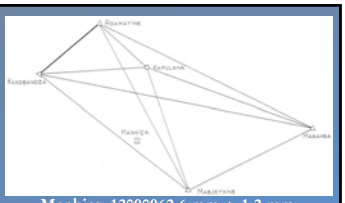
To scale the geodetic network were measured, every 200 km, lines about 10 km called baselines.

For 6 decades in those measures were used invar wires with 8, 24 the most used or 48 m.

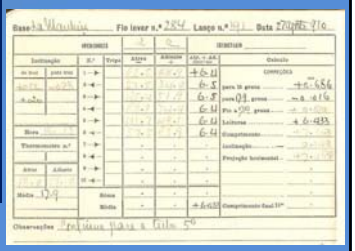
Gago Coutinho was the first portuguese surveyor using invar wires, precisely in this geodetic mission.

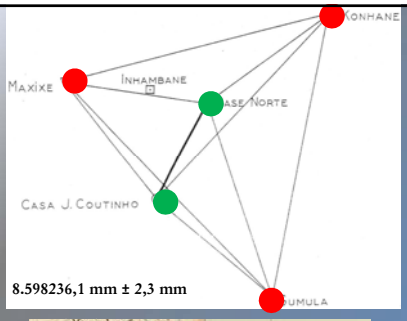
For a long time he study hardly this equipment concluding that after 10 years, the invar wires reach its final lengthning of a third of a millimetre. Using the appropriate procedures it was possible an accuracy of 1/1000000.

The MGAO measured 2 baselines: Manhiça (12km) and Inhambane (8 km).

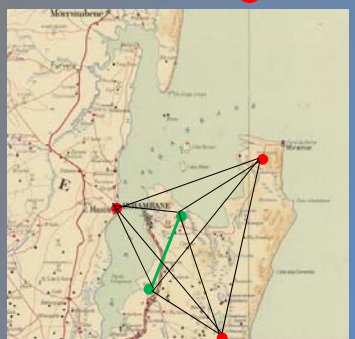


Manhiça: 12090962,6 mm ± 1,2 mm





8.598236,1 mm ± 2,3 mm

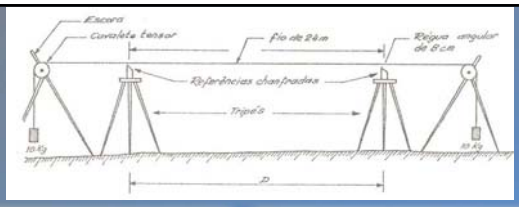


north

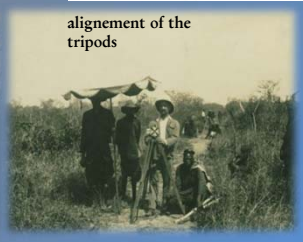
south

TS 02K– Surveying History, paper no5816
Paula Santos and Ana Roque
Geodetic field operations for cartography: an overview over the first Portuguese geodetic mission in the colonial territories (1907-1910)

A requisite for a baseline is to have a plane ground without obstacles where several tripods are placed each 24 m.



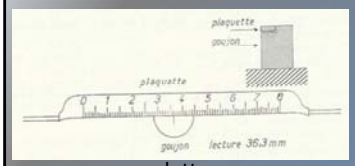
alignement of the tripods



levelling

A special tripod supports the wires wich tension is regulated by a 10 kg weight.

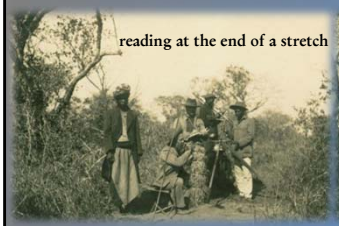
In a special graduate reference - reglette - the field operator reads the values to sum or deduct to the 24 meters. And so on till covering the baseline length.



reglette

Reading the reglette and register of the respective value in the field note book

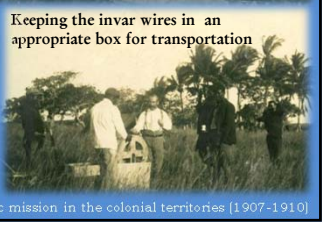
reading at the end of a stretch



Moving the invar wires to the next front length

end of the base

Keeping the invar wires in an appropriate box for transportation



Astronomical observations

The geodetic network is positioned through astronomical observations of latitude and longitude and oriented by mean of azimuths.

In one extremity of each baseline this mission observed 2 azimuths and latitudes, by a method adapted by Gago Coutinho

For lack of the adequate instrument, it was not possible to determinate longitudes, so these values were obtained from the Astronomical Observatory of Cape Town by triangulation.

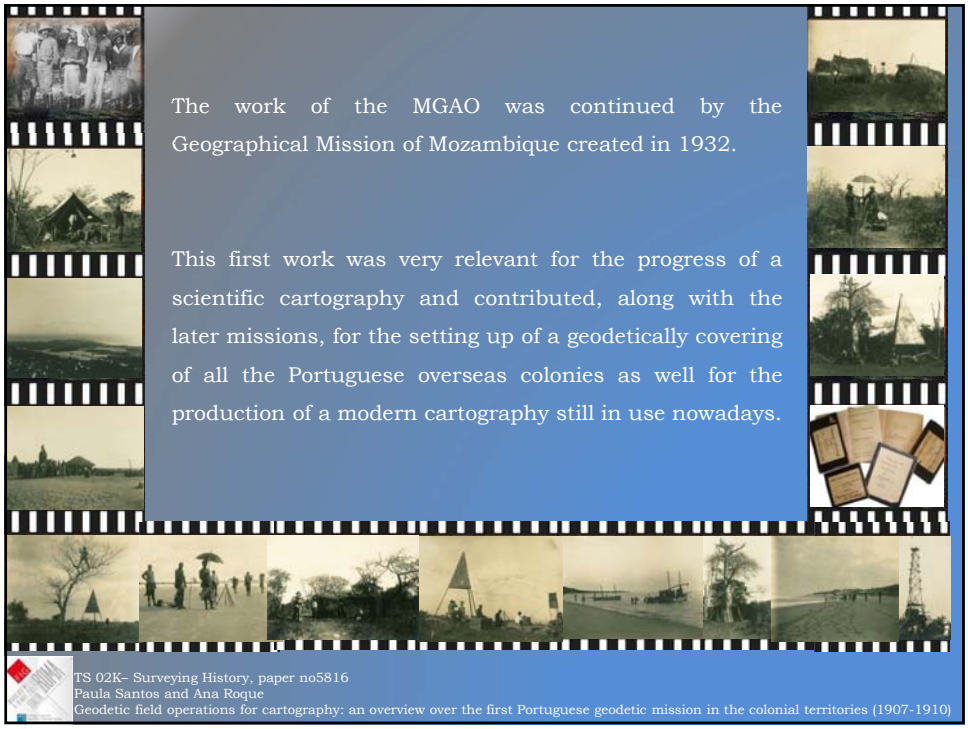
Field observatory

Troughton & Simms

In the first years, geodetic and cartographic survey were made simultaneously.

With a plane table and an alidad the hills, valleys, courses of rivers, villages were drawn in a cartographic document.

The alidad´s observations were completed by telemeters (distances) and barometers (heights) measurements. The toponymy was collected in the villages.


The work of the MGAO was continued by the Geographical Mission of Mozambique created in 1932.
This first work was very relevant for the progress of a scientific cartography and contributed, along with the later missions, for the setting up of a geodetically covering of all the Portuguese overseas colonies as well for the production of a modern cartography still in use nowadays.
TS 02K– Surveying History, paper no5816
Paula Santos and Ana Roque
Geodetic field operations for cartography: an overview over the first Portuguese geodetic mission in the colonial territories (1907-1910)