

ASTRONOMY, GEODESY AND MAP-DRAWING IN MOLDOVA SINCE THE MIDDLE AGES TILL THE WORLD WAR I

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SUMMARY: A short outline of the history of astronomy, astronomical navigation, geodesy and map-drawing in Moldova since the Middle Ages till the World War I is presented. The contribution of Rudjer Bošković to the determination of geographical coordinates of Galați and Iași and the triangulation of Montenegro in 1879-1880 by Russian military geodesists has been discussed as well.

1. INTRODUCTION

Antic peoples knew the astronomical navigation: Chinese, Amerindians, Egyptians, Phoenicians and Greeks. Many of them used the Astrolabe since the III century BC at least. It was described by Hipparchos approximately in 180 BC, as Phoenicians oriented their ships using the constellations, knowing that the Polar star does not change its position on the sky. Chinamen invented the magnetic compass in X century BC. This last penetrated in Europe from China in XI century through Arabian countries. The Naval maps were used in XII – XIII centuries. The "bâton de Jacob" was invented in 1320 by Levi ben Gerson, the solar rings and the quadrant were used in the epoch of Great geographical discoveries (Retinschi, 1979).

2. ASTRONOMICAL NAVIGATION IN MIDDLE AGE IN DANUBEAN COUNTRIES

In 1716 the former Moldavian prince Demetrios Cantemir (1673-1723), member of the Academy of Sciences in Berlin, drew up the first map of Moldova, which was included in "*Descriptio Moldaviae*" (Cantemir, 1716) and published separately in the Hague in 1737. Cantemir wrote: "Bellow (from Cetatea Alba, our note) on the border of Danube river the field of Chilia lays out. The Main town is Chilia¹.

The citadel is not great but has a famous market where ships from nearest ports on Black Sea as well as from other farther Egyptian, Venicean and Ragusan ports stayed...

¹ The Moldavian name is Chilia, while the Turkish name is Chili, the actual Greeks call it Lycostomon (Other people wrote erroneously Lytrostomon and Lythostromon, see e.g. Leunclavii Pandect). Bonfinius and some other name it Achillea; Stanislaus Sarnicius suppose that it is Tomos, but this is the citadel where Ovidius Naso was imprisoned. It is difficult to give favor to any one of these opinions".

One has documents, proving that Moldavian ships sailed to Venice and Genova in XIV-XV centuries. Some Venetian documents show the presence in Mediterranean Sea of a "nave del valacho", i.e. of Stephen the Great (1457-1504) (Retinschi 1979). It is known also (Retinschi 1979) that he built an "Arsenal for ships" and a lighthouse in Vatoped and Zografu on Athos Mount in 1472 and 1473 respectively. Taking account of the complicate continental border line, especially between Apennines and Sicily and in Aegean Sea, as well as of the great length of the Ionic Sea we can suppose that the astronomical navigation was used in Danubean countries in Middle Ages besides the magnetic compass. Except Chilia, Cetatea Alba (situated in the place of the antic Tyras and Middle Ages Maurocastro), Galati in Moldova and Brăila, Mangalia (former Callatis) and Constanta (former Tomis) in Walachia were known as ports.

3. ASTRONOMY, GEOGRAPHY AND GEODESY IN MOLDOVA TILL 1812

In 1640-1821 at the *Academia Domnească* (Prince Academy) in Iași courses of sciences (*epistimes*) and astronomy were taught. Astronomy and Physics were taught at the initial stages of the foundation of the Academy after a manuscript by the Greek philosopher Teophil Corydaleu (1563-1646), which studied at the University of Padova. Chrisant Notara (Hrisanthos Notaras), born in Peloponnesos and died in Bucharest in 1731, disciple of Jean Dominique Cassini and the Patriarch of Jerusalem since 1707 published in Paris in 1716 for his students from the Academies in Iasi and Bucharest a Course of Geography, Geodesy and Astronomy entitled "Introductio ad geographiam et sphaeram". He exposed the methods of astronomical calculations of geographical coordinates and calculated although erroneous but for the first time the coordinates of Bucharest and Târgoviste towns. He gave for Bucharest 47° for the longitude and 45° for the latitude while the correct values are $26^\circ 5' 46''$ and $44^\circ 24' 50''$. Supposing that the longitudes were measured from the Hierro Island meridian ($\sim 18^\circ$ W, see e.g. the map by Delisle (Mappemonde a l'usage du Roi; Par Guillaume Delisle, Premiere Geographe de S.M. XVIIeme siècle; Amsterdam; Chez Jean Covens et Corneil Mortier Geographe)) the Notara error was about 3° for the longitude and less than 1° in latitude. In spite of this error Notara was a remarkable professor and scientist.

Reviewing the geographical position of Moldova Dumitru Cantemir in the same year gives the geographical coordinates of the extreme points of Moldova (Cantemir, 1716): "Moldova lays out in latitude from $44^\circ 54'$ to $48^\circ 51'$. Her longitude is not well determined but the most of the geographers put her West border, with Transylvania at $45^\circ 39'$; Her East border, which made a sharp angle in Akkerman, named by its habitants Cetatea Albă, counted them as $53^\circ 22''$ ". According to Cantemir the North-

South length of Moldova was $3^\circ 57'$ and the East-West length was $7^\circ 43'$. The real positions of the Western point of the former Moldova is $24^\circ 52'$ and of the sharp angle on the Dniester bend, read from the actual maps (Stroe and Bran 1994), is $30^\circ 24'$. The southern point of Moldova to the south of the Kuhurlui lake has $45^\circ 17'$ N. The northern point near Costrijauca (actually in Ukraine) had $48^\circ 38'$. So, the errors of Cantemir were $+13'$ for the northern point and $-23'$ for the southern point.

How to explain the errors of $20^\circ 47'$ and $22^\circ 58'$ in longitudes? Supposing that the longitudes were measured relatively to the Hierro Island meridian ($\sim 18^\circ$ W), we can conclude that Cantemir erred by approximately 3° for the Western point and about 5° for the Eastern point. Such errors are characteristic of many of the maps drawn up till the beginning of the XVIII century (see e.g. Carte de la Partie Européene et Asiatique de l'Empire de Russie; avec l'indication de chemins et routes de Postes, ainsi que de nouvelles démarcations et de la repartition actuelle en gouvernements, Redigée d'après le grand Atlas et d'Autres Cartes du Dépôt géographique Imperial de St.-Petersbourg. Publié et se trouve a Vienne chez T. Mollo, 1812.). In addition to the Map of Moldova Cantemir he drew up the Map of Caucasus Mountains and of the Caspian Sea and established the meridian of the North Azerbaijan and Dagestan during the 1722 - 1723 Iran Campaign of the Russian Czar Peter I.

Amfilohie Hotiniul, the episcop of Hotin, was one of the teachers of mathematics, geography, astronomy and physics in Moldova. He was born approximately in 1735 in North Bessarabia and studied at the Monastery school in Putna and thereafter at the Academy founded by Petru Movilă in Kiev. He spoke Romanian, Slavonian, Russian, Greek, Latin and Italian languages. He was epithrop of a school in Hotin where he taught theology and natural sciences. In 1772-1775 he traveled to Italy where he bought books for his school, which he translated into Romanian and adapted for the conditions of the country. In 1795 he published "De obște gheografie" ("General Geography") by Clod Buffie and "Elemente aritmetice arătate firești" ("The elements of arithmetics") in Iași. Subsequently, in 1796, he wrote "Gramatica de la învățătura fizicii" ("The Grammar of Physics") (Hotiniul, 1990) which was conserved at the Vernadsky Library in Kiev and at the Library of the Romanian Academy in Bucharest. The manuscript was published in 1990 in Chișinău by the Moldavian Academy of Sciences. It has 4 chapters, including one dedicated to physics, the second to astronomy, the third to atmospheric physics and the final to geology. The first part deals with the Newtonian Mechanics, optics and acoustics. The second part includes cosmology, heliography, selenography, planetography, comets and stars. His books contain interesting considerations on the extrasolar and extragalactic astronomy, on the possibility of the existence of extraterrestrial life and so on. Amfilohie died approximately in 1800 at the monastery Zagavia near Iași.

In 1761 the astronomer Ruder Bošković, the founder of the Astronomical Observatory in Brera traveled from Constantinople to Poland and passed Walachia and Moldova. He found in Iași astronomical instruments for studying of eclipses, planets. Particularly, Venus was studied by means of these instruments. He measured the geographical coordinates of Galați and Iași (Boskovich, 1784; Ionescu, 1928; Stavinschi and Mioc, 1998). The coordinates of Galați (the yard of Saint Archangels' Church): $25^{\circ} 42' 00''$ longitude relatively to Paris Observatory, or $28^{\circ} 02' 14''$ relatively to Greenwich Observatory and $45^{\circ} 26' 03''$ latitude. The latitude of Iași (the yard of Saint Haralambie Church) was measured as $47^{\circ} 10' 24''$. Bošković performed the first measurement of the coordinates with precision of 1 arcsecond.

The scientific geodesy in Moldova begun with Gheorghe Asachi (1788 – 1869), known mainly as Romanian artist, writer and politician. He founded in Iași (Iassy) a "class of engineers-borders makers" (1814-1819), where he taught mathematics and geodesy. Asachi studied mathematics, engineering sciences and astronomy (with professor Burg) at the Polytechnic University in Vienna in 1805-1808. Asachi published "Spicuitorul moldo-român" ("Moldavian and Romanian Selections") – a scientific and industrial journal (1841), "Arhiva Albinei pentru arheologie și industrie" (The Bee Archive for Archaeology and Industry) (1844-1847) "Calendare" ("Calendars") and "Almanahuri de învățătură și petrecere" (Teaching and Popularization Almanachs) (1844-1870). He made meteorological observations and archaeological investigations, took part in the founding of the Museum of the Natural History. Before Andronache Donitch (1760-1829) and Costache Conachi (1777-1849), who mounted the first refractors in Iași in the beginning of XIX century with the diameter of 13 cm, made geodesic investigations. Among pupils of Asachi were Fotachi Ghețu and Osvald Scarlat.

4. THE MEASUREMENTS OF THE 30° MERIDIAN ARC IN 1816-1852

The measurements of the 30° meridian length from the Danube Delta through Pulkovo to the Arctic Ocean were realized in 1816 - 1852 after the Bucharest Peace treaty, when Bessarabia went under Russia, under conduction of Karl I. Tenner, Vasilii Ya. Struve, N.H. Zelande and H. Hansten. In Bessarabia triangulation was realized under general supervision of General Karl I. Tenner. The total length of the meridian arc belonging to Bessarabia was $3^{\circ} 24'$, corresponding to a total length of 430 km, or to about 14% of the total arc of $25^{\circ} 20' 08''$ (about 2800 km) measured by Struve (1856-1857). The 300 meridian measurements had the first basis near Ismail in South Bessarabia (the village of Staro Nekrasovka on the Danube River at the latitude of $45^{\circ} 20' 03''$). The triangulation from the Southern point to Dvina River, included 125 first class trian-

gles and 5 bases. The subsequent triangulation from the $56^{\circ} 30'$ to northern part of the Botnik gulf included 100 triangles and 3 base. The triangulation under the conduction of Zelande on the territory of Sweden (from $65^{\circ} 50'$ N.L. to $69^{\circ} 03'$ N.L) included 21 triangles and 1 basis. The final stage of the Danube- North Ocean triangulation from $68^{\circ} 54'$ and $70^{\circ} 40' 11''$, made under conduction of H. Hansten, included 12 triangles and 1 basis.

5. THE GEODESIC, TOPOGRAPHICAL, AND MAP MAKING WORKS IN THE BALKANS IN XIX CENTURY TILL THE BEGINNING OF THE XX CENTURY BY RUSSIAN CZARIST ARMY

In 1801 – the description of the South and Western borders of the Black Sea from Odessa to Sinop including Bosphorus and from the cape Stephakos to Samsun, was performed by I. M. Budishchev and other.

In 1817-1819, 1822-1827 the first topographical works in Bessarabia were undertaken by Russian Army. In 1828 – 1833 Moldova, Walachia and a part of Bulgaria were surveyed by Colonel Berg, Captain Tuchkov, Officers Duhamel, Liven, and Verighin. In 1846-1851, the triangulation of Bessarabia under the direction by K.I. Tenner was made. In 1848 the basis in Romancauti village was measured by means of the device of Struve.

1853-1855, the triangulation of Bessarabia region under the direction of Colonel V.V. Fedorov was undertaken.

In 1856 – 1857, appeared the book by V.Ya. Struve "Arc de meridien de $25^{\circ} 20'$ entre le Danube et la mer Glaciale, mesuré depuis 1816 jusq'en 1855..." (see Novoksanova, 1967; Ilvitskaya, 1981; Mihailov, 1984). The Russian edition was published in 1861.

1858, the book by F.F. Shubert "Exposé des travaux astronomiques et géodesiques, exécutés en Russie dans un but géographique jusqu'à l'année 1855" was published. Next year the paper was published "Essai d'une détermination de la véritable figure de la Terre", by the same author where the idea of the triaxial Earth ellipsoid was forwarded.

1869-75, 1881, the triangulation was started of the Bessarabia region under the direction of E.A. Zhdanov, in 1881 under the direction by M.N. Lebedev

In 1870 the topographical survey of Bessarabia under the direction of Colonel E.A. Zhdanov were undertaken. The Kiperigel-measurer of altitude and distances was used.

M.P. Lebedev and S.T. Miroshnichenko measured by means of the telegraph the longitude difference between Chișinau and Nikolaev in 1880. The analogous measurement between Kiev and Chișinau by Russian officer P.A. Mioncinskii was made in 1885.

In 1879-1880 the Triangulation of Montenegro was realized by Russian military geodesists.

In 1881, the triangulation of the Bessarabia region under the direction by M.N. Lebedev was made.

In 1896, A.A. Tillo realized the hypsometric map of Russia, including territories of Austria and Romania.

In 1910 the Triangulation of Prut River was realized.

6. THE MEASUREMENTS OF GRAVITY

The Russian Geographical Society accepted in 1849 the project by A.N. Savich concerning the measurement of gravity which was realized in 1865, 1866 and 1868 by St.-Petersburg Academy and belongs to the Russian-Scandinavian meridian measurement. Particularly, R.E Lenz and A.N.Savich measured g in 1868 in Belin, Kremenets, Kamenets-Podolsk, Chişinău and Ismail (see Novoksanova, 1967; Ilvitskaya, 1981; Mihailov, 1984; ***, 1866). A.I. Vilkitskii measured the gravity in Chişinău and Aleksandrovsk of the Ekaterinoslav region in 1892.

7. OTHER ASTRONOMICAL, GEODESIC WORKS IN MOLDOVA AND NEIGHBORHOOD IN XIX CENTURY TILL THE BEGINNING OF THE XX CENTURY (Andonie, 1971)

During the War of 1855-1857 the Austrian Army geodesists measured the coordinates of the Serpents Island in the Black Sea.

In 1875 Romanian officer and astronomer Constantine Căpităneanu determined the longitudes difference between Iaşi and Cernăuţi with the view of perfection of the map of Romania. He built in Iaşi the first meridian instrument and published the results of his investigations in the journal "Buletinul Societăţii geografice Române" (Bulletin of the Romanian Geographical Society) (Căpităneanu, 1876). In 1877 Constantine Căpităneanu measured astronomically the longitudes difference between Galaţi and Bucureşti, Galaţi and Iaşi and Chişinău and Iaşi.

8. THE BESSARABIAN SOCIETY OF NATURALISTS AND AMATEURS OF NATURAL SCIENCES

In 1905-1906 the Bessarabian Society of naturalists and amateurs of Natural Sciences was founded with sections of Physical and Mathematical sciences, Chemical Sciences, Geological Sciences, Medicine. Astronomers A. Amaftunsky and N. Donitch, as well

as the geologist N. Goronovitch activated the popularization of astronomy. The main interests of Bessarabian astronomers were in Solar astronomy. Other important activities were concerned with mathematics. The Society existed till 1914 and published its Annals (The National Archive of the Republic of Moldova: Trudy Bessarabskogo Obschestva estestvoispytatelei i lyubitelej estestvoznaniya, 1904-1906, vol. 1, pt. 1; 1906-1907, vol. 1, pt. 2; 1907-1908, vol. 2, pt. 2/1; 1908-1909, vol. 2, pt. 2; 1909-1910, vol. 3, pt. 1; 1910-1911, vol. 3, pt. 2; 1910-1911, vol. 4, pt. 1; 1911-1912, vol. 4, pt. 2; 1912 – 1913, vol. 5.).

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**АСТРОНОМИЈА, ГЕОДЕЗИЈА И КАРТОГРАФИЈА У МОЛДАВИЈИ
ОД СРЕДЊЕГ ВЕКА ДО ПРВОГ СВЕТСКОГ РАДА**

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Стручни чланак

Дат је кратак извод из историје астрономије, астрономске навигације, геодезије и картографије у Молдавији од Средњег века до Првог Светског Рата. Допринос Руђера Бош-

ковића одређивању географских координата Galați и Iași и триангулација Црне Горе у периоду 1879-1880 од стране руских војних геодета такође су дискутовани.