On the Development of Map Projections

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Abstract: *Many important persons gave their contribution to development of theory and practice of map projections through the history. In scripts of professor Frančula on map projections, more than 100 individuals were mentioned by whose credit today we have a great number of map projections and possibility of their usage. Basic information about around twenty persons important for the development of map projections over two and a half millennia were gathered and arranged in this paper. In addition, a historical review of map projections is given, and procedure of world map creation which served as illustration is explained.*

Key words: *map projection, history of map projections, cartographers*

1 Introduction

In the production of maps, first, the points from the physical earth's surface are transferred onto ellipsoid (sphere) surface according to established rules, and afterwards the ellipsoid (sphere) is projected into the plane. Map projections serve this purpose. The goal of studying map projections is to create a mathematical basis for the production of maps and solving theoretical and practical tasks in cartography, geodesy, geography, astronomy, navigation and other fields.

Hence, we can say that map projections are a method of projecting the ellipsoid surface or sphere in a plane. The following topics are usually of particular interest in studying of map projections:

- Mathematical basis of the map
- Constructing a network of meridians and parallels
- Graphic way of construction
- Analytical way of construction (mathematical formulae and calculating)
- Basic cartographic equations
- Study of distortions (lengths, surfaces, angles)
- Selection of a projection

In this paper, dedicated to Professor Nedjeljko Frančula on the occasion of his 70th birthday, a review of the history of map projections is given. Afterwards, basic information about around twenty probably most important persons for the development of map projections over two and a half millennia, were arranged. Finally, the procedure of creating world maps in different map projections is explained.

2 History of Map Projections

Map projections have been developed with the development of map production and cartography in general. The development of many sciences, technical achievements and needs of everyday life have gradually initiated wider and wider demands for the production of various topographic and thematic maps in various scales and for various purposes, which requested continuous growth of map projections and improvement of mathematical basis of maps (Lapaine, 1996).

The beginnings of map projections date as far as two thousand years ago, originating from the time when old Greek scientists introduced mathematical principles into the basis of projecting the earth and starry sky and started to apply the graticule. The works of Anaximander, Eratosthenes, Thales, Apolonious and Hipparchus played an important role in the development of cartography.

It is believed that Thales of Miletus made the first map in a projection 600 years B.C. It was a map of the heavenly sphere in gnomonic projection. Stereographic and orthographic projections belong to the oldest projections and were used by the Greek astronomer and mathematician Hipparchus for the purpose of making maps of the heavenly sphere about 150 B.C. Hundreds of map projections have been invented ever since.

In the 2nd century, Ptolemy wrote the capital work *Geography* and included into it the description of map compilation and determination of the earth's dimensions, as well as the construction of map projections. The period of

O razvoju kartografskih projekcija

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Sažetak: *Mnoge značajne osobe dale su tijekom povijesti svoj prinos razvoju teorije i prakse kartografskih projekcija. U skriptama prof. Frančule o kartografskim projekcijama navedeno je više od 100 pojedinaca čijom je zaslugom danas dostupan velik broj kartografskih projekcija i mogućnost njihove upotrebe. U ovome su radu prikupljeni i obrađeni osnovni podaci o dvadesetak osoba značajnih za razvoj kartografskih projekcija tijekom dva i pol tisućljeća. Osim toga, dan je pregled povijesti kartografskih projekcija i objašnjen postupak izrade karata svijeta koje su poslužile kao ilustracije.*

Ključne riječi: *kartografska projekcija, povijest kartografskih projekcija, kartografi*

1. Uvod

Pri izradi karata najprije se točke s fizičke Zemljine površine prenose po određenim pravilima na plohu elipsoida (sfere), a zatim se elipsoid (sfera) preslikava u ravninu. U tu svrhu služe kartografske projekcije. Cilj proučavanja kartografskih projekcija ponajprije je stvaranje matematičke osnove za izradu karata, a zatim i rješavanje teorijskih i praktičnih zadataka u kartografiji, geodeziji, geografiji, astronomiji, navigaciji i drugim područjima.

Možemo, dakle, reći da su kartografske projekcije načini preslikavanja plohe elipsoida ili sfere u ravninu. Pri proučavanju kartografskih projekcija obično su sljedeće teme od posebnog interesa:

- ❑ Matematička osnova neke karte
- ❑ Konstrukcija slike mreže meridijana i paralela
- ❑ Grafički način konstrukcije
- ❑ Analitički način konstrukcije (formule i računanje)
- ❑ Osnovne kartografske jednadžbe
- ❑ Proučavanje deformacija (duljine, površine, kutovi)
- ❑ Izbor projekcije.

U ovome radu, posvećenom prof. Nedjeljku Frančuli u povodu njegova 70. rođendana, najprije je dan pregled povijesti kartografskih projekcija. Zatim su obrađeni osnovni podaci o dvadesetak vjerojatno najznačajnijih osoba za razvoj kartografskih projekcija tijekom dva i pol tisućljeća. Na kraju je objašnjen postupak izrade karata svijeta koje su izrađene posebno za ovu prigodu u različitim kartografskim projekcijama.

2. Povijest kartografskih projekcija

Razvoj kartografskih projekcija tekao je usporedno s razvojem izradbe karata i kartografije općenito. Razvoj mnogih znanosti, tehnička dostignuća i potrebe svakidašnjega života s vremenom su inicirali sve šire zahtjeve za izradbom raznovrsnih topografskih i tematskih karata različitog mjerila i namjene, što je zahtijevalo neprekidno povećavanje broja kartografskih projekcija i usavršavanje matematičke osnove karata (Lapaine, 1996).

Počeci kartografskih projekcija stari su oko dvije i pol tisuće godina, otkad su grčki znanstvenici prvi uveli matematičke principe u temelje preslikavanja Zemlje i zvjezdanoga neba te počeli primjenjivati mrežu meridijana i paralela. Veliku su ulogu u razvoju kartografije odigrali radovi Anaksimandara, Eratostena, Talesa, Apolonija i Hiparha.

Smatra se da je prvu kartu u nekoj projekciji izradio Tales iz Mileta 600. godine pr. Kr. Bila je to karta nebeske sfere u gnomonskoj projekciji. Među najstarije se projekcije ubrajaju stereografska i ortografska, koje je upotrijebio poznati grčki astronom i matematičar Hiparh, također za izradbu karata nebeske sfere oko 150. godine pr. Kr. Od toga doba do danas izumljeno je nekoliko stotina kartografskih projekcija.

U 2. st. Ptolemej je napisao kapitalno djelo *Geografija* u koje je uključio opis sastavljanja karata i određivanje Zemljinih dimenzija te konstrukciju kartografskih projekcija. Epohu srednjovjekovlja u Europi obilježila je pojava

Middle Ages in Europe was characterised by the so-called monastery maps reflecting a religious image of the world.

Special development of cartography started during the renaissance – the period of great geographic discoveries. Accurate, reliable maps to be used for state government and military purposes, for the development of trade and maritime affairs. Such maps could be produced only through the application of a mathematical basis and land survey results. The first to have appeared were topographic maps.

At the end of the 16th and beginning of 17th century, the compilation and publication of geographic atlases was a very significant event in further development and popularisation of cartography, which was carried out by the famous Dutch cartographers Ortelius and Mercator. Mercator was the first who ever applied conformal cylindrical projection which is still being used successfully for maritime navigation charts.

In the production of world maps and the maps of larger territories, quadrangle projection and Apianus projection used to have large application in that time, and they were used as archetype for later more detailed pseudocylindrical projections. In the 17th century, a new sinusoidal pseudocylindrical projection for the world map was suggested by the French cartographer N. Sanson.

Detailed work on the scientific basis of cartography and the beginnings of topographic studying of the earth, and as a result, further growth of accuracy and reliability of maps are regarded as the characteristics of the 18th century. A series of new projections suggested by R. Bonne, J. H. Lambert. J. L. de Lagrange, L. Euler and others, was introduced into the cartographic practice.

The renaissance came to an end with the introduction of elementary mathematical analysis into the development of map projections. Such analysis was applied especially to the Mercator projection in which the rhumb lines were shown as straight lines, and to projections where all parallels are divided by meridians in true interspaces, regardless of whether the parallels are circular arcs (Werner's projections) or straight lines (sinusoidal). Map projections become more complex: instead of those having graticule simply drawn because they consist of circular arcs and straight lines, there are such that are delineated by means of tables of trigonometric functions.

Murdoch (1758) consciously required that the total area of the projected territory should be correct, but he did not insist on the constant local scale of the area. The first intentional preservation of area in each point was made by Lambert (1772) by inventing cylindrical, azimuthal and conical equivalent projections. Halley proved geometrically the conformity of stereographic projection, and Lambert did it with differential calculus, and invented also three new conformal projections. Many map projections were also created in the 19th and 20th centuries, but the basic principles were laid by 1772, and especially in that year.

The most significant contribution of cartographers, geodesists and mathematicians of the 19th century to the theory of map projections was the establishment of firm mathematical principles. Lambert and Lagrange made an important beginning in 1770s, but especially Gauss and Tissot gave large contributions until 1880. Other researchers as e.g. Airy, Clarke, Schwartz and Pierce concentrated on more specific, but more complex tasks, and Germain, Gretschel and Craig gathered various works by other scientists into special monographs. New projections by Mollveide, Albers, Gall and others contain simpler application of mathematics, but still deserve the titles according to their inventors. Rapid development of the theory of map projections in this period is emphasised by a number of new projections and a number of published books and articles (Snyder 1993).

According to Frischauf (1905), the beginning of the theory of projecting one surface onto another belongs to J. H. Lambert, who dealt with the general problem of projecting a sphere and spheroid into the plane in his *Anmerkungen und Zusätze zur Entwerfung der Land- und Himmelscharten* (Remarks and Additions to the Establishment of Land and Sky Maps) in the third part of his *Beyträge zum Gebrauch der Mathematik und deren Anwendung* (Contributions of the Usage of Mathematics and its Applications, 1772). Lambert's colleague, J. L. Lagrange was inspired by his separation of variables in the expression for the arc length differential in conformal projection and he solved the problem of conformal projecting the rotational surfaces publishing it in two treatises *Sur la construction des cartes géographiques* (About the Construction of Geographic Maps, Nouveaux Mémoires de l'Académie Royal de Berlin, 1779).

At the beginning of the 19th century, military institutions started to produce topographic maps at large scales for which mathematical basis has special importance because the distances and directions were determined on these maps.

In 1822 the Royal Scientific Society in Copenhagen raised a question: to find a general solution to the problem – a part of a given surface should be projected onto another given surface so that the image is similar to the origin in its smallest details. C. F. Gauß was awarded for the solution of this problem. His work was first published in Schumacher's *Astronomische Abhandlungen* in 1825. Lagrange's and Gauß' treatise are in the volume No. 55 of Ostwald's classics of exact sciences. C. G. J. Jacobi (1866) noticed in his *Vorlesungen über Dynamik* (Lectures on Dynamics), in the 28th lecture *Die kürzeste Linie auf dem dreiachsigen Ellipsoid*. *Das Problem der Kartenprojektion* (The shortest line on a three-axis ellipsoid. The problem of map projection), the following about the work by Gauß: "It contains Langrange's work that is only a little bit supplemented without being mentioned." Apart from that, Gauß gave only the examples of projecting rotational surfaces.

The projection of ellipsoid with various axes into the plane was processed in the above mentioned lectures by C. G. J. Jacobi. He gave the first announcement of such a solution in *Monatsberichten der Berliner Akademie* and in the 19th volume of *Crelles Journal*. The complete solution together with other problems (projection of the rotational surface, cone, cylinder into the plane) was reported by L. Cohn on the basis of Jacobi's heritage in the 59th Volume of *Crelles Journal* under the title *Über die Abbildung eines ungleichachsigen Ellipsoides auf einer Ebene, bei welcher die kleinsten Teile änlich bleiben* (About the projection of the ellipsoid with unequal axes tzv. samostanskih karata, koje su odražavale religioznu predodžbu svijeta.

Osobit je razvoj kartografije započeo za renesanse – razdoblja velikih geografskih otkrića. Postale su nužne točne, pouzdane karte za upravljanje državom, za vojničke potrebe, za razvoj trgovine i pomorstva. Takve su karte mogle biti sastavljene samo primjenom matematičke osnove i rezultata izmjere zemljišta. Najprije su se pojavile topografske karte.

Krajem 16. i početkom 17. st. značajan je događaj u daljnjem razvoju i popularizaciji kartografije bio sastavljanje i objavljivanje geografskih atlasa u izdanju poznatih nizozemskih kartografa Orteliusa i Mercatora. Mercator je prvi primijenio konformnu cilindričnu projekciju koja se do danas uspješno upotrebljava za pomorske navigacijske karte.

Pri izradbi karata svijeta i teritorija većih dimenzija široku su primjenu tada imale trapezna projekcija i Apianova projekcija, koje su poslužile kao prauzori za kasnije razrađene pseudocilindrične projekcije. U 17. je stoljeću novu sinusoidalnu pseudocilindričnu projekciju za kartu svijeta predložio francuski kartograf N. Sanson.

Razrada znanstvene osnove kartografije i početak topografskog proučavanja Zemlje te kao rezultat toga daljnje povećanje točnosti i pouzdanosti karata obilježuju 18. stoljeće. U kartografsku je praksu uveden niz novih projekcija što su ih predložili R. Bonne, J. H. Lambert, J. L. de Lagrange, L. Euler i drugi.

Renesansa je završila uvođenjem elementarne matematičke analize u razvoj kartografskih projekcija. Takva je analiza posebno primijenjena na Mercatorovu projekciju u kojoj su loksodrome prikazane kao pravci i na projekcije u kojima su sve paralele podijeljene meridijanima u istinitom razmaku, bez obzira jesu li paralele kružni lukovi (Wernerova projekcija) ili pravci (sinusoidalna). Kartografske projekcije postaju složenije: umjesto onih čije se kartografske mreže jednostavno crtaju jer se sastoje od kružnih lukova i pravaca, pojavljuju se takve koje se crtaju uz pomoć tablica trigonometrijskih funkcija.

Murdoch (1758) je svjesno postavio zahtjev da ukupna površina preslikanog područja bude korektna, ali nije ustrajao na konstantnosti lokalnog mjerila površine. Prvo namjerno očuvanje površinske vjernosti u svakoj točki učinio je Lambert (1772) u svojem izumu cilindričnih, azimutalnih i konusnih ekvivalentnih projekcija. Halley je geometrijski dokazao konformnost stereografske projekcije, a Lambert je to učinio diferencijalnim računom te izumio također tri nove konformne projekcije. Mnoge su kartografske projekcije nastale i u 19. i 20. stoljeću, ali su osnovna načela postavljena do 1772. i osobito u toj godini.

Najznačajniji prinos kartografa, geodeta i matematičara 19. st. teoriji kartografskih projekcija bio je uspostavljanje čvrstih matematičkih načela. Lambert i Lagrange napravili su značajan početak 1770-ih, ali su osobito Gauß i Tissot dali velike prinose do 1880-ih. Drugi istraživači, kao Airy, Clarke, Schwartz i Peirce, usredotočili su se na specifičnije, ali složenije zadatke, dok su Germain, Gretschel i Craig skupili različite radove drugih znanstvenika u posebne monografije. Nove projekcije Mollweidea, Albersa, Galla i drugih sadrže jednostavniju primjenu matematike, ali ipak zaslužuju nazive prema svojim izumiteljma. Ubrzani se razvoj teorije kartografskih projekcija u tom razdoblju uočava brojem novih projekcija i objavljenih knjiga i članaka (Snyder 1993).

Prema Frischaufu (1905) početak teorije preslikavanja jedne plohe na drugu pripada J. H. Lambertu, koji se u *Anmerkungen und Zusätze zur Entwerfung der Land- und Himmelscharten* (Napomene i dopune zasnivanju karata zemljišta i neba) u trećem dijelu svojih *Beyträge zum Gebrauch der Mathematik und deren Anwendung* (Doprinosi uporabi matematike i njezine primjene, 1772), bavio općenito postavljenom zadaćom preslikavanja sfere i sferoida u ravninu. Lambertov je kolega J. L. de Lagrange bio nadahnut njegovim razdvajanjem varijabli u izrazu za diferencijal duljine luka pri konformnom preslikavanju te riješio problem konformnog preslikavanja rotacijskih ploha i objavio ga u dvije rasprave *Sur la construction des cartes géographiques* (O konstrukciji geografskih karata, Nouveaux Mémoires de l'Académie Royal de Berlin, 1779).

Početkom 19. st. vojne ustanove počele su izradu topografskih karata u krupnim mjerilima, za koje matematička osnova ima posebnu važnost jer su se na tim kartama određivale udaljenosti i smjerovi.

Godine 1822. postavilo je Kraljevsko znanstveno društvo u Kopenhagenu nagradno pitanje: naći opće rješenje zadatka – dio zadane plohe preslikati na drugu zadanu plohu tako da slika bude u najmanjim dijelovima slična izvorniku. Za rješenje zadatka nagradu je dobio C. F. Gauß. Taj je rad najprije objavljen u Schumacherovim *Astronomische Abhandlungen* 1825. godine. Lagrangeova i Gaußova rasprava sadržane su u svesku broj 55 Ostwaldovih klasika egzaktnih znanosti. C. G. J. Jacobi (1866) primijetio je u svojim *Vorlesungen über Dynamik* (Predavanja o dinamici), u 28. predavanju *Die kürzeste Linie auf dem dreiachsigen Ellipsoid. Das Problem der Kartenprojektion* (Najkraća linija na troosnom elipsoidu. Problem kartografske projekcije), o Gaußovu radu sljedeće: "U njemu je sadržan Lagrangeov rad, koji je samo malo dopunjen, a da nije spomenut". Gauß je osim toga dao samo primjere preslikavanja rotacijskih ploha.

Preslikavanje raznoosnog elipsoida u ravninu obradio je u spomenutim predavanjima C. G. J. Jacobi. Prvi je nagovještaj takva rješenja dao 1839. u *Monatsberichten der Berliner Akademie* i u 19. svesku *Crelles Journala*. Potpuno rješenje uz druge zadatke (preslikavanje rotacijske plohe, stošca, valjka u ravninu) priopćio je L. Cohn na temelju Jacobijeve ostavštine u 59. svesku *Crelles Journala* pod naslovom *Über die Abbildung eines ungleichachsigen Ellipsoides auf einer Ebene, bei welcher die kleinsten Teile änlich bleiben* (O preslikavanju raznoosnog elipsoida u ravninu, pri čemu najmanji dijelovi ostaju slični). Taj rad sadrži također vrlo jednostavnu teoriju konformnog preslikavanja jedne plohe na drugu. U predavanjima o dinamici Jacobi objašnjava: "Uspjeh rješenja zadatka konformnog preslikavanja elipsoida into the plane, whereby the smallest parts remain similar). This work also contains also a very simple theory of conformal projection of one surface onto another. In the lectures about dynamics, Jacobi explains: "The successful solving of the problem of conformal ellipsoid projection is achieved by means of adequate substitution and method leading to one partial differential equation. The noticed ellipsoid point will be determined by intersection of two curves of curvature". Disintegrating the ellipsoid surface into the elements limited by curves of curvature, Legendre already determined this surface (*Exercises du calcul integral*, Exercises in integral calculus, 1811) and found corresponding variables by means of which the known projection problem could be solved. Ernst Schering gave a complete solution of the problem on the basis of Jacobi's announcement in his work *Über die konforme Abbildung des Ellipsoides auf der Ebene* (About the conformal projection of ellipsoid into the plane) for which he was awarded in 1858 with the reward of the Faculty of Philosophy.

Surrounded by numerous works on cartography the majority of which is dealing with the methods of constructing graticules, we should by all means look back on the classical work, the cornerstone of the theory of map projections by N. A. Tissot *Mémoire sur la représantation des surfaces et les projections des cartes géographiques* (Treatise on surface presentation and geographic map projections, Paris 1881) the basic part of which, chapters from I to IV, already appeared between 1878 and 1880 in *Nouvelles Annales des Mathématiques*, 2e série. According to K. Zöppritz (1884), the work by Tissot was also noticed in Germany and Austria, and E. Hammer translated it into German under the title *Die Netzentwürfe geographischer Karten nebst Aufgaben über Abbildung beliebiger Flächen aufeinander* (Presentations of graticules of geographic maps including the problems on projecting one arbitrary surface onto another, Stuttgart 1887), in which many presentations of graticules and tables were added.

After 1900, about fifty monographs on map projections in about ten languages were published (Snyder 1993). There are a few in English which are quoted very often. In chronological order related to the first publication, these are Hinks (1912-1921) *Map projections*, Deetz and Adams (1921-44) *Elements of Map Projections*, Steers (1927-70) *An Introduction to the Study of Map Projections*, Melluish (1931), *An Introduction to the Mathematics of Map Projections*, Richards and Adler (1972) *Map Projections for Geodesists, Cartographers and Geographers*, Maling (1973-92) *Coordinate Systems and Map Projections*, Snyder (1982) *Map Projections Used by the U. S. Geological Survey* and Snyder (1982) *Map Projections: A Working Manual*. There is also the latest manual by Bugayevskiy and Snyder (1995) *Map Projections – A Reference Manual*. One should also mention longer treatises with special topics about map projections by Adams (1918-45), Young (1920), Thomas (1952), Lee (1976) and Snyder (1985).

The following monographs in German should be mentioned: Maurer (1935) *Ebene Kugelbilder*, Wagner (1949) *Kartographische Netzentwürfe*, Merkel (1956, 1958) *Grundzüge der Kartenprojektionslehre*, Hoschek (1969, 1984) *Mathematische Grundlagen der Kartographie*, Kuntz (1983) *Kartennetzentwurfslehre*, then a series of works by Bulgarian geodesist Hristow, published in Zeitschrift für Vermessungswesen, i.e. in books (1943, 1955) and the German translation from Czech Fiala (1957) *Mathematische Kartographie*.

In French there are: Driencourt and Laborde (1932) *Traité des projections des cartes géographiques* and Reignier (1957) *Les systčms de projection et leurs applications*.

Many monographs were written in the former Soviet Union, and the most prominent authors are: Kavrayskiy (1934, 1958-60), Solov'ev (1937, 1946), Graur (1938, 1956), Urmayev (1941), Ginzburg and Salmanova (1956), Meshcheryakov (1968), Pavlov (1974), Vakhrameyeva, Bugayevskiy and Kazakova (1986). The book by Bulgarian geodesist Hristow (1957) was also published in Russian.

Geoinformation systems (GIS) enable today solving some problems directly from databases, problems that have been so far solved only on geographic maps (various cartometric problems). On the basis of that fact, we could come to the conclusion that geoinformation systems lessen the significance of geographic maps. If we look upon it from that point of view, then it really is true, but on the other hand geographic maps are very important for every GIS. They have a very important role in creation of databases, but also as one of the forms in presenting the output data (Sijmons 1992).

Since each geographic map is made in a certain map projection, one can come to the conclusion that map projections are esspecially important in creating geoinformation systems. In the creation of national digital bases of geodetic, topographic and cartographic data that must make the foundations of each GIS being prepared for the territory of the entire state, the method of digitising the existing maps is very important (Teng 1991, Sowton 1991). Therefore, the majority of GIS software also contain the module for digitising. In the application of this module, it is necessary to be familiar with the map projection of the origin and projection constants (e.g. geographic longitude of the mean meridian or the latitude of the standard parallel, and linear scales along them).

These data are indispensable in order to transform co-ordinates from the local digitizer system into the system of source map projection and then by means of inverse equations of map projections into the system of geographic co-ordinates. It would thus be possible for GIS software as one of the presentation forms for output data to offer geographic map in one of a great number of the most important map projections. In order to draw such a map, it is necessary to calculate rectangular co-ordinates x, y in the selected map projection from the geographic co-ordinates.

The production of software for any GIS thus requires the basic and inverse equations for a larger number of map projections. Hence, the computer aided methods in the map production and first of all geoinformation systems have not reduced, but increased the importance of map projections. More than 1000 publications on map projections published after 1960 and registered in the bibliography of Snyder and Steward (1988) prove that this statement is correct.

postiže se odgovarajućom supstitucijom i metodom koja vodi na jednu parcijalnu diferencijalnu jednadžbu. Uočena točka elipsoida bit će određena presjekom dviju krivulja zakrivljenosti". Rastavljanjem plohe elipsoida na elemente ograničene krivuljama zakrivljenosti već je tu plohu odredio Legendre (*Exercices du calcul integral*, Vježbe iz integralnog računa, 1811) i pritom pronašao odgovarajuće varijable s pomoću kojih se poznati zadatak o preslikavanju mogao riješiti. Ernst Schering dao je potpuno rješenje tog zadatka na temelju Jacobijevih nagovještaja u radu *Über die konforme Abbildung des Ellipsoides auf der Ebene* (O konformnom preslikavanju elipsoida u ravninu), za koji je 1858. nagrađen nagradom Filozofskog fakulteta Georgia Augusta.

U okruženju mnogobrojnih radova o kartografiji, od kojih se većina bavi metodama konstrukcije kartografskih mreža, trebalo bi se svakako osvrnuti na zaista klasično djelo, kamen temeljac teorije kartografskih projekcija N. A. Tissota *Mémoire sur la représentation des surfaces et les projections des cartes géographiques* (Rasprava o prikazivanju ploha i projekcijama geografskih karata, Pariz 1881) čiji se osnovni dio, poglavlja I do IV, pojavio već između 1878. i 1880. u *Nouvelles Annales de Mathématiques*, 2e série. Prema K. Zöppritzu (1884), Tissotov je rad bio zapažen i u Njemačkoj i Austriji, te ga je E. Hammer preveo na njemački pod naslovom *Die Netzentwürfe geographischer Karten nebst Aufgaben über Abbildung beliebiger Flächen aufeinander* (Prikazi kartografskih mreža geografskih karata uz zadatke o preslikavanju jedne proizvoljne plohe na drugu, Stuttgart 1887), u kojem su pridodani mnogi prikazi kartografskih mreža i tablice.

Nakon 1900. objavljeno je pedesetak monografija o kartografskim projekcijama na desetak jezika (Snyder 1993). Na engleskom jeziku ima ih nekoliko koje se vrlo često citiraju. Kronološkim redoslijedom prema prvome izdanju to su Hinks (1912-21) *Map projections*, Deetz and Adams (1921-44) *Elements of Map Projection*, Steers (1927-70) *An Introduction to the Study of Map Projections*, Melluish (1931) *An Introduction to the Mathematics of Map Projections*, Richardus i Adler (1972) *Map Projections for Geodesists, Cartographers and Geographers*, Maling (1973-92) *Coordinate Systems and Map Projections*, Snyder (1982) *Map Projections Used by the U. S. Geological Survey* i Snyder (1987) *Map Projections: A Working Manual*. Tu je i najnoviji priručnik Bugajevskoga i Snydera (1995) *Map Projections – A Reference Manual*. Svakako treba spomenuti i dulje rasprave s posebnim temama o kartografskim projekcijama Adamsa (1918-45), Younga (1920), Thomasa (1952), Leeja (1976) i Snydera (1985).

Na njemačkom jeziku treba istaknuti sljedeće monografije: Maurer (1935) *Ebene Kugelbilder*, Wagner (1949) *Kartographische Netzentwürfe*, Merkel (1956, 1958) *Grundzüge der Kartenprojektionslehre*, Hoschek (1969, 1984) *Mathematische Grundlagen der Kartographie*, Kuntz (1983) *Kartennetzentwurfslehre*, zatim niz radova bugarskoga geodeta Hristova, objavljenih u Zeitschrift für Vermessungswesen, odnosno u obliku knjiga (1943, 1955) i njemački prijevod s češkog Fiala (1957) *Mathematische Kartographie*.

Na francuskom se jeziku ističu: Driencourt i Laborde (1932) *Traité des projections des cartes géographiques* te Reignier (1957) *Les systčms de projection et leurs applications*.

U bivšem je Sovjetskom Savezu napisano mnogo monografija, a najistaknutiji autori su: Kavrajskij (1934, 1958-60), Solov'ev (1937, 1946), Graur (1938, 1956), Urmajev (1941), Ginzburg i Salmanova (1957), Meščerjakov (1968), Pavlov (1974), Vahramejeva, Bugajevskij i Kazakova (1986). Na ruskom je jeziku objavljena također knjiga bugarskoga geodeta Hristova (1957).

Danas geoinformacijski sustavi (GIS) omogućuju da se neki zadaci koji su se do sada gotovo isključivo rješavali na geografskim kartama (različiti kartometrijski zadaci) sada rješavaju izravno iz baza podataka. Na temelju te činjenice moglo bi se zaključiti da geoinformacijski sustavi umanjuju važnost geografskih karata. Ako se to promatra s navedenog stajališta, onda i jest točno, no s druge su strane karte vrlo važne za svaki GIS. One imaju vrlo važnu ulogu pri stvaranju baza podataka, ali i kao jedan od oblika prezentacije izlaznih podataka (Sijmons 1992).

Budući da se svaka karta izrađuje u određenoj kartografskoj projekciji, može se zaključiti da su kartografske projekcije osobito važne pri stvaranju geoinformacijskih sustava. Pri stvaranju nacionalnih digitalnih baza geodetskih, topografskih i kartografskih podataka, koje moraju činiti temelj svakoga GIS-a što se radi za područje čitave države, važna je metoda digitalizacije postojećih karata (Teng 1991, Sowton 1991). Zbog toga većina GIS-softvera sadrži i modul za digitalizaciju. U primjeni toga modula nužno je poznavati kartografsku projekciju izvornika i konstante projekcije (npr. geografsku dužinu srednjega meridijana ili širinu standardne paralele i linearna mjerila uduž njih).

Ti su podaci nužni da bi se koordinate iz lokalnog sustava digitalizatora transformirale u sustav kartografske projekcije izvornika i potom s pomoću inverznih jednadžbi kartografske projekcije u sustav geografskih koordinata. Time je omogućeno da GIS-softver kao jedan od oblika prezentacije izlaznih podataka nudi kartu u nekoj od većeg broja najvažnijih kartografskih projekcija. Da bi se takva karta nacrtala, nužno je iz geografskih koordinata izračunati pravokutne koordinate x, y u izabranoj kartografskoj projekciji.

Pri izradi softvera za bilo koji GIS potrebno je, prema tome, poznavati osnovne i inverzne jednadžbe za veći broj kartografskih projekcija. Dakle, kompjutorski podržane metode u izradi karata i poglavito geoinformacijski sustavi nisu umanjili nego su povećali važnost kartografskih projekcija. Da je ta tvrdnja točna svjedoči više od 1000 radova o kartografskim projekcijama objavljenih nakon 1960., a registriranih u bibliografiji Snydera i Stewarda (1988).

3 Important Persons for Development of Map Projections

Table 1. List of all persons who are mentioned in scripts of professor Frančula on map projections.

Airy, G. B.	La Hire, Ph. de
Aitov, D. A.	Lagrange, J. L.
Albinus, H.-J.	Lambert, J. H.
Apolonius	Lamé, G.
Baltzer, H. R.	Lapaine, Milj.
Bašlavin, V. A.	Lapaine, Mir.
Bernoulli, J.	Laskowski, P.
Bessel, F. W.	Leibniz, G. W. von
Bilajbegović, A.	Leighly, J. B.
Bonne, R.	Maxwell, J. C.
Borčić, B.	Mercator, G. Kremer
Branderberger, A.-J.	Meshcherjakov, G. A.
Bronštejn I. N.	Milnor, J.
Bugayevskiy, L. M.	Mittermayer, E.
Canters, F.	Mollweide, K. B.
Clarke, A. R.	Moritz, H.
Colvocoresses, A. P.	Muminagić, A.
Čubranić, N.	Nestorov, I. G.
Dahlberg, R. E.	Newton, I.
Daskalova, M. J.	O'Keefe, J. A.
De Lucia, A. A.	Oresme, N.
Descartes, René – Cartesius	Peters, A. B.
Dinostratus	Petrović, S.
Dupin, F. P. Ch.	Podunavac, B.
Eckert-Greifendorf, M.	Postel, G.
Eggert, O.	Radošević, N.
Ehlert, D.	Różicky, J.
Euler, J. A.	Salishchev, K. A.
Everest, G.	Salmanova, T. D.
Fiala, F.	Sanson, N.
Gall, J.	Schödlbauer, A.
Gauss, C. F.	Seeger, H.
Gilbert, E. N.	Semendjajev, K. A.
Ginzburg, G. A.	Simpson, Th.
Goode, J. P.	Snyder, J. P.
Graur, A. V.	Solov'ev, M. D.
Greenberg, A.	Svečnikov, N. S.
Grossmann, W.	Tahles of Miletus
Hammer, E. H. H. von	Tissot, N. A.
Hayford, J. F.	Tolstova, T. I.
Helmert, F. R.	Tutić, D.
Hipparchus	Vakhrameyeva, L. A.
Hristow, W. K.	Van der Grinten, A. J.
Hudde, J.	Vojnova, V. V.
Jordan, W.	Vučetić, N.
Jovanović, V.	Vincenty, T.
Jovičić, D.	Wagner, K.-H.
Kavrayskiy, V. V.	Weise, K. H.
Kazakova, Z. L.	Winkel, O.
Kneissl, M.	Wolfrum, O.
König, R.	Žarinac-Frančula, B.
Krasovskiy, F. N.	Žic-Nejašmić, M.
Krüger, J. H. L.	Živković, A.

Many people dealt with theory of map projections and wrote about them (Snyder, Steward, 1988). If we look in the scripts on map projections written by professor Frančula (2000), we can see that he quoted more than hundred persons, citing their papers or projections or procedures named after them. List of names of all these persons can be found in Table 1.

Among persons from Table 1, most are cartographers, geodesists and mathematicians. Since there are too many of them to be dealt in details in one paper, we decided to make a narrower selection. This selection is shown in Table 2.

Hereafter follow basic information about persons from Table 2.

Table 2. Alphabetical list of persons presented in more detail in this paper, and which are extremely important for development of cartographic projections.

Airy, George Biddell – *British astronomer, mathematician and cartographer*

Aitov, David A. – *Russian cartographer*

Bonne, Rigobert – *French engineer, mathematician and cartographer*

Clarke, Alexander Ross – *British geodesist, mathematician and officer*

Eckert-Greifendorf, Max – *German geographer and cartographer*

Gall, James – *Scottish clergyman and astronomer*

Gauss, Carl Friedrich – *German mathematician, astronomer and geodesist*

Gilbert, Edward N. – *American mathematician*

Goode, John Paul – *American geographer and cartographer*

Hammer, Ernst Hermann Heinrich von – *German geodesist and cartographer*

Hipparchus – *Old Greek philosopher*

Jordan, Wilhelm – *German geodesist and mathematician*

Kavrayskiy, Vladimir Vladimirovich – *Russian cartographer*

Krüger, Johann Heinrich Louis – *German mathematician and geodesist*

Lambert, Johann Heinrich – *German physicist, mathematician and astronomer originating from France*

Mercator, Gerhard Kremer – *Flemish geographer and cartographer*

Mollweide, Karl Brandon – *German mathematician and astronomer*

Postel, Guillaume – *French geographer, linguist, astronomer, diplomat, professor of mathematics*

Sanson, Nicolas – *French cartographer and geographer*

Thales – *Old Greek philosopher and mathematician*

Tissot, Nicolas Augustes – *French cartographer*

Van der Grinten, Alphons J. – *American cartographer*

Winkel, Oswald – *German cartographer*

3. Osobe značajne za razvoj kartografskih projekcija

Tablica 1. Popis svih osoba koje se spominju u skriptama prof. Frančule o kartografskim projekcijama

Airy, G. B.	La Hire, Ph. de
Aitov, D. A.	Lagrange, J. L.
Albinus, H.-J.	Lambert, J. H.
Apolonije	Lamé, G.
Baltzer, H. R.	Lapaine, Milj.
Bašlavin, V. A.	Lapaine, Mir.
Bernoulli, J.	Laskowski, P.
Bessel, F. W.	Leibniz, G. W. von
Bilajbegović, A.	Leighly, J. B.
Bonne, R.	Maxwell, J. C.
Borčić, B.	Mercator, G. Kremer
Branderberger, A.-J.	Meščerjakov, G. A.
Bronštejn I. N.	Milnor, J.
Bugajevskij, L. M.	Mittermayer, E.
Canters, F.	Mollweide, K. B.
Clarke, A. R.	Moritz, H.
Colvocoresses, A. P.	Muminagić, A.
Čubranić, N.	Nestorov, I. G.
Dahlberg, R. E.	Newton, I.
Daskalova, M. J.	O'Keefe, J. A.
De Lucia, A. A.	Oresme, N.
Descartes, René – Cartesius	Peters, A. B.
Dinostrat	Petrović, S.
Dupin, F. P. Ch.	Podunavac, B.
Eckert-Greifendorf, M.	Postel, G.
Eggert, O.	Radošević, N.
Ehlert, D.	Różicky, J.
Euler, J. A.	Sališčev, K. A.
Everest, G.	Salmanova, T. D.
Fiala, F.	Sanson, N.
Gall, J.	Schödlbauer, A.
Gauss, C. F.	Seeger, H.
Gilbert, E. N.	Semendjajev, K. A.
Ginzburg, G. A.	Simpson, Th.
Goode, J. P.	Snyder, J. P.
Graur, A. V.	Solovjev, M. D.
Greenberg, A.	Svečnikov, N. S.
Grossmann, W.	Tales iz Mileta
Hammer, E. H. H. von	Tissot, N. A.
Hayford, J. F.	Tolstova, T. I.
Helmert, F. R.	Tutić, D.
Hiparh	Vahramejeva, L. A.
Hristov, V.	Van der Grinten, A. J.
Hudde, J.	Vojnova, V. V.
Jordan, W.	Vučetić, N.
Jovanović, V.	Vincenty, T.
Jovičić, D.	Wagner, K.-H.
Kavrajskij, V. V.	Weise, K. H.
Kazakova, Z. L.	Winkel, O.
Kneissl, M.	Wolfrum, O.
König, R.	Žarinac-Frančula, B.
Krasovskij, F. N.	Žic-Nejašmić, M.
Krüger, J. H. L.	Živković, A.

Kartografskim projekcijama i pisanjem o njima bavili su se zaista mnogi (Snyder, Steward, 1988). Pogledamo li u skripta o kartografskim projekcijama što ih je napisao prof. Frančula (2000), možemo vidjeti da on navodi imena više od stotinu osoba, bilo da citira njihove radove, bilo da se po njima nazivaju neke projekcije ili postupci. Popis imena svih tih osoba nalazi se u tablici 1.

Među osobama iz tablice 1, najviše je kartografa, matematičara i geodeta. Budući da ih je previše za detaljnu obradu u jednom članku, odlučili smo napraviti manji izbor. Taj je izbor prikazan u tablici 2.

U nastavku slijede osnovni podaci o osobama iz tablice 2.

Tablica 2. Abecedni popis osoba detaljnije prikazanih u ovome članku, a koje su izuzetno značajne za razvoj kartografskih projekcija

Airy, George Biddell – *engleski astronom, matematičar i kartograf*

Aitov, David A. – *ruski kartograf*

Bonne, Rigobert – *francuski inženjer, matematičar i kartograf*

Clarke, Alexander Ross – *engleski geodet, matematičar i časnik*

Eckert-Greifendorf, Max – *njemački geograf i kartograf*

Gall, James – *škotski svećenik, kartograf i astronom*

Gauss, Carl Friedrich – *njemački matematičar, astronom i geodet*

Gilbert, Edward N. – *američki matematičar*

Goode, John Paul – *američki geograf i kartograf*

Hammer, Ernst Hermann Heinrich von – *njemački geodet i kartograf*

Hiparh – *starogrčki filozof, astronom i matematičar*

Jordan, Wilhelm – *njemački geodet i matematičar*

Kavrajskij, Vladimir Vladimirovič – *ruski kartograf*

Krüger, Johann Heinrich Louis – *njemački matematičar i geodet*

Lambert, Johann Heinrich – *njemački fizičar, matematičar i astronom francuskog podrijetla*

Mercator, Gerhard Kremer – *flamanski geograf i kartograf*

Mollweide, Karl Brandon – *njemački matematičar i astronom*

Postel, Guillaume – *francuski geograf, jezikoslovac, astronom, diplomat, profesor matematike*

Sanson, Nicolas – *francuski kartograf i geograf*

Tales – *starogrčki filozof i matematičar*

Tissot, Nicolas Augustes – *francuski kartograf*

Van der Grinten, Alphons J. – *američki kartograf i geograf*

Winkel, Oswald – *njemački kartograf*

Thales

(Greek Θαλῆς)

(Miletus, ca. 625. B.C. – ca. 547. B.C.)

Old Greek philosopher and mathematician

Tales

(grčki Θαλῆς)

(Milet, oko 625. pr. Kr. – oko 547. pr. Kr)

Starogrčki filozof i matematičar

Thales of Miletus was the first Greek philosopher, scientist and mathematician, one of seven Wise Greek Men. Unfortunately, no writings by Thales were preserved, so it is hard to determine his ideas or to be completely certain about his mathematical conclusions. In many books on the history of mathematics, Thales is credited with these theorems: a circle is bisected by any diameter, the base angles of an isosceles triangle are equal, the angles between two intersecting straight lines are equal (ceiling angles are considered), two triangles are congruent if they have two angles and one side equal, an angle in a semicircle is a right angle. Last mentioned theorem is today called the *Thales theorem*. He used the properties of similarity and in that way he measured the height of pyramids and the distance of the boat on the open sea. It is reported that Thales predicted an eclipse of the Sun in 585 B.C. Prediction of Moon eclipse was well known at this time, but it was hard to say when the eclipse of Sun would occur, since this phenomenon could not have been seen from all the parts on Earth. Still, the most important thing mathematicians attribute to him is the fact that Thales was the first to give logical foundations for proving the theorems. In other words, he was first to emphasize that it is not sufficient just to observe the phenomena, but they must be proven.

He believed the Earth was a flat disc floating on water, i.e. on an infinite ocean and that all things come to be from water. Despite those, today unacceptable theses, Tales' greatness is that he was the first recorded person who tried to explain his attitudes by rational rather then by supernatural means, as many did before him.

It is believed that Thales made the first map in a projection 600 B.C. It was a map of the heavenly sphere in gnomonic projection.

Tales iz Mileta bio je prvi grčki filozof, znanstvenik i matematičar, jedan od sedam grčkih mudraca. Na žalost, nije očuvano ništa od njegovih pisanih djela, tako da je teško odrediti njegove nazore ili biti potpuno siguran u njegove matematičke zaključke. U mnogim knjigama o povijesti matematike pripisuju mu se ovi teoremi iz geometrije: promjer dijeli krug na dva jednaka dijela, kutovi uz bazu jednakokračnog trokuta su jednaki, kutovi između dvaju pravca koji se sijeku su jednaki (misli se na vršne kutove), dva su trokuta sukladna ako imaju jednaka dva kuta i jednu stranicu, kut na polukružnici je pravi kut. Posljednji navedeni teorem danas se naziva *Talesovim teoremom.* Iskoristio je svojstva sličnosti i tako izmjerio visinu piramide i udaljenost lađe na pučini. Zabilježeno je da je Tales predvidio pomrčinu Sunca 585. god. pr. Kr. Predviđanje pomrčine Mjeseca onda je bilo uobičajeno, ali je bilo teško izreći kada će biti pomrčina Sunca, budući da se ta pojava nije mogla vidjeti sa svih dijelova na Zemlji. Ipak, ono najvažnije što mu matematičari pripisuju jest činjenica da je Tales prvi dao logičke temelje dokazivanju teorema. Drugim riječima, prvi je naglasio da nije dovoljno samo opažati pojave, već ih treba i dokazati.

Smatrao je da Zemlja ima oblik diska koji pluta na vodi, tj. na beskonačnom oceanu, i da su sve stvari oko nas sačinjene od vode. Unatoč tim danas neprihvatljivim tezama, Talesova je veličina u tome što je bio prvi koji je svoja stajališta pokušavao objasniti logičkim razmišljanjem, a ne nadnaravnim pojavama kao mnogi prije njega.

Smatra se da je prvu kartu u nekoj projekciji izradio Tales 600. godine pr. Kr. Bila je to karta nebeske sfere u gnomskoj projekciji.

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

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URL: HAZU – životopisi poznatih matematičara, http://www.hazu.hr/~duda/tales.html, 5.3.2007

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URL: Wikipedija – slobodna enciklopedija (hrvatsko izdanje), http://hr.wikipedia.org/wiki/Tales, 5.3.2007

Hipparchus

(Greek Ἵππαρχος, Hipparkos)

(Nicaea, now Iznik, ca. 190. B.C. - Rhodes, ca. 120. B.C.)

Old Greek philosopher, astronomer and mathematician

Hiparh

(grčki Ἵππαρχος, Hipparkos)

(Niceja, danas Iznik, oko 190. pr. Kr. – Rodos, oko 120. pr. Kr.)

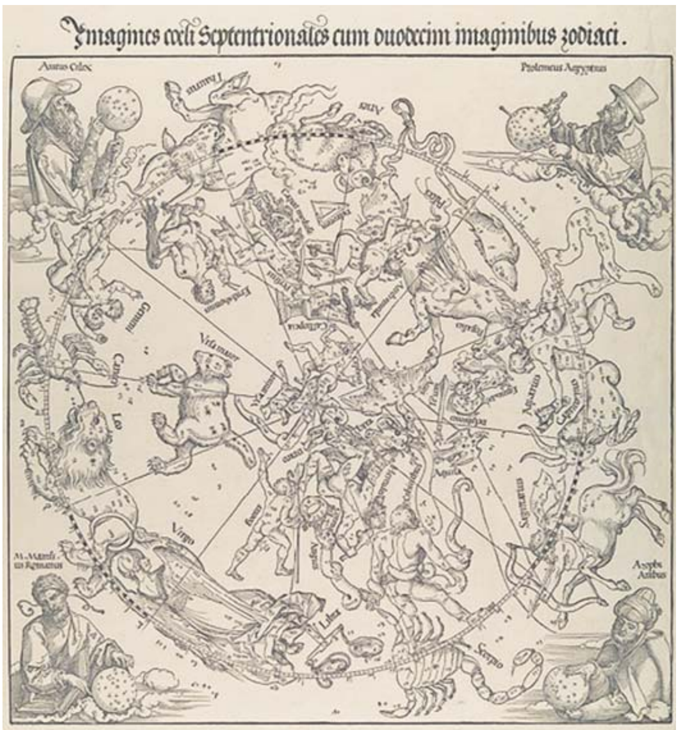
Starogrčki filozof, astronom matematičar

He is considered the greatest astronomical observer, and by some, the greatest overall astronomer of antiquity. He had been conducting very precise measurement of stars' positions and their apparent sizes, which he defined in a scale from 1 to 6. He measured the length of tropical year and synodic month; he discovered precession of equinoces and non-uniformities in lunar motions. He created the first big catalogue with 850 stars, was the first to determine positions on Earth with usage of geographical latitudes and longitudes, and he founded trigonometry. Ptolemy included Hipparchus' results in his works. Hipparchus' synthesis of astronomy excelled his work. Although he had written at least 14 books, only his comments on Arat's popular astronomic epic remained preserved from later scribes. Around 150 B.C., he used the stereographic and the orthographic projection, which belong to the oldest projections, to create a map of celestial sphere.

Smatra se najvećim astronomskim opažačem, a po nekima i najvećim antičkim astronomom. Obavljao je vrlo točna mjerenja položaja zvijezda i njihovih prividnih veličina koje je definirao u ljestvici od 1 do 6. Mjerio je duljinu tropske godine i sinodičkoga mjeseca, otkrio precesiju ravnodnevica i nejednolikosti u Mjesečevu gibanju. Izradio je prvi veliki katalog s 850 zvijezda, prvi je položaje na Zemlji određivao s pomoću geografskih širina i dužina, osnovao trigonometriju. Njegove je rezultate Ptolemej uvrstio u svoja djela. Hiparhova je sinteza astronomije nadmašila njegov rad. Iako je napisao najmanje 14 knjiga, jedino su se njegovi komentari na Aratov popularni astronomski ep sačuvali od kasnijih prepisivača. Oko 150. godine pr. Kr. za izradu karata nebeske sfere upotrijebio je stereografsku i ortografsku projekciju, koje se ubrajaju među najstarije projekcije.

Celestial Map of the Norhen Sky by Albrecht Dürer, 1515. This, together with its southern sky companion, were the first printed star charts.

Nebeska karta sjevernog neba Albrechta Dürera, 1515. Ta je karta, zajedno sa pratećom kartom južnog neba, prva tiskana karta zvjezdanog neba.



Source / Izvor

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Gillaume Postel

*(Barenton, France, March 25, 1510 –
Paris, September 6, 1581)*

French linguist, geographer, astronomer, diplomat, professor of mathematics

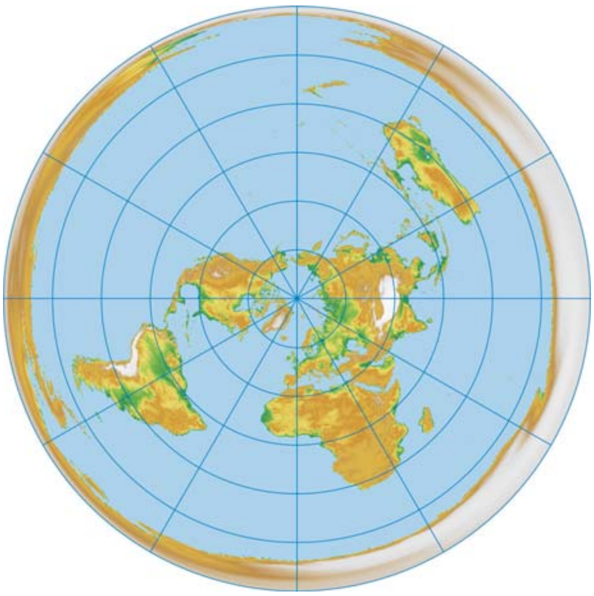
Gillaume Postel

*(Barenton, Francuska, 25. III. 1510 –
Pariz, 6. IX. 1581)*

Francuski jezikoslovac, geograf, astronom, diplomat, profesor matematike

French linguist, adept at Semitic languages (Arabic, Hebrew and Syriac), as well as Classical languages (Ancient Greek and Latin), and in 1538 in his work *Linguarum Duodecim Characteribus Differentium Alphabetum Introductio* he gave an introduction to alphabetic characters of twelve different languages. In 1544, he published work *De orbis terrae concordia* in which he advocated a universalist world religion. He was extremely tolerant to other religions at the time when such a tolerance was not accustomed. It is believed that he spent the years 1548 to 1551 travelling to Israel and Syria, to collect manuscripts. After this trip, he earned the title of Professor of Mathematics and Oriental Languages at the Collčge de France in Paris. After several years, Postel resigned his professorship and travelled all over central Europe, including Austria and Italy. He was considered an originator of the equidistant azimuthal projection. Although this projection was possibly developed by the Egyptians for star charts, Postel was the first one to use it in 1581 and it was named after him the *Postel projection*.

Francuski jezikoslovac, poznavao je semitske jezike (arapski, hebrejski i sirijski) i klasične jezike (starogrčki i latinski), a 1538. u svom djelu *Linguarum Duodecim Characteribus Differentium Alphabetum Introductio* daje uvod u alfabetske znakove dvanaest različitih jezika. Godine 1544. objavio je djelo *De orbis terrae concordia* u kojem zagovara vjerski univerzalizam. Bio je iznimno tolerantan prema drugim vjerama u doba kada takva tolerancija nije bila uobičajena. Smatra se da je od 1548. do 1551. putovao u Izrael i Siriju u potrazi za rukopisima. Nakon tog putovanja imenovan je profesorom matematike i orijentalnih jezika na Collčge de France u Parizu. Nekoliko godina nakon toga Postel je napustio profesorsko mjesto i putovao po srednjoj Europi, uključujući Austriju i Italiju. Smatra se pronalazačem ekvidistantne azimutalne projekcije. Iako postoji mogućnost da su tu projekciju za izradu karata zvijezda osmislili još Egipćani, Postel ju je prvi upotrijebio 1581. godine i po njemu se naziva *Postelovom projekcijom*.



Postel projection

Postelova projekcija

Map of the World in normal aspect equal-area azimuthal projection (the projection of the map extends from the North Pole to 60 degrees south latitude) is used for designing the emblem of the United Nations

Karta svijeta u uspravnoj ekvidistantnoj azimutalnoj projekciji (područje preslikavanja prostire se od Sjevernog pola do paralele s geografskom širinom $\varphi = -60°$) poslužila je za izradu amblema Ujedinjenih naroda

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

Snyder, J. P., Voxland, P. M. (1989): An Album of Map Projections, USGS Professional Paper 1453. U.S. Geological Survey, Denver

URL: Wikipedija – slobodna enciklopedija (englesko izdanje), http://en.wikipedia.org/wiki/Guillaume_Postel, 5.3.2007

Gerardus Mercator

(Flanders, Belgium, March 5, 1512 – Duisburg, Germany, November 2, 1594)

Flemish geographer and cartographer

Gerardus Mercator

(Flandrija, Belgija, 5. III. 1512 – Duisburg, Njemačka, 2. XII. 1594)

Flamanski geograf i kartograf

Out of need for more accurate mapping of larger Earth territories on marine charts and related to distortions appearing during this process, map projections and practical cartography developed in the 16th century. Mercator was educated in ‘s–Hertogenbosch in the Netherlands. He studied mathematics and astronomy at the Belgian University of Leuven and in 1532 he obtained the title of master. He was educated for engraver and globe maker. He travelled a lot and began to be interested in geography. He returned to Leuven and started to learn and work with Gemma Frisius (astronomer and mathematician) and Gaspar Myrica (engraver and goldsmith). They worked together to construct globes, maps and astronomical instruments. The conformal cylindrical projection is named *Mercator projection* after him. The normal aspect of the Mercator projection has special importance in navigation, because the rhumb lines are represented as straight lines in this projection. The Transverse Mercator projection is used in many countries for official cartography. The Universal Transverse Mercator projection (UTM) is used in military (NATO).

Iz potrebe za što točnijim preslikavanjem velikih dijelova Zemlje na pomorske karte i u svezi s deformacijama koje se pritom javljaju, razvijaju se u 16. stoljeću kartografske projekcije i praktična kartografija. Školovao se u ‘s-Hertogenboschu u Nizozemskoj. Studirao je matematiku i astronomiju na belgijskom Sveučilištu u Leuvenu i godine 1532. stekao naziv magistra. Učio je za bakroresca i izrađivača globusa. Mnogo je putovao te se počeo zanimati za geografiju. Vrativši se u Leuven, počeo je učiti i raditi s Gemmom Frisiusom (astronom, matematičar) i Gasparom Myricom (graver i zlatar). Zajedno su sudjelovali u izradi globusa, karata i astronomskih instrumenata. Po njemu se konformna cilindrična projekcija naziva *Mercatorovom projekcijom.* Uspravna Mercatorova projekcija ima posebnu važnost u navigaciji jer se loksodrome preslikavaju u toj projekciji kao pravci. Poprečna Mercatorova projekcija upotrebljava se u mnogim zemaljama u službenoj kartografiji. Univerzalna poprečna Mercatorova projekcija (UTM) u vojnoj je uporabi (NATO).

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

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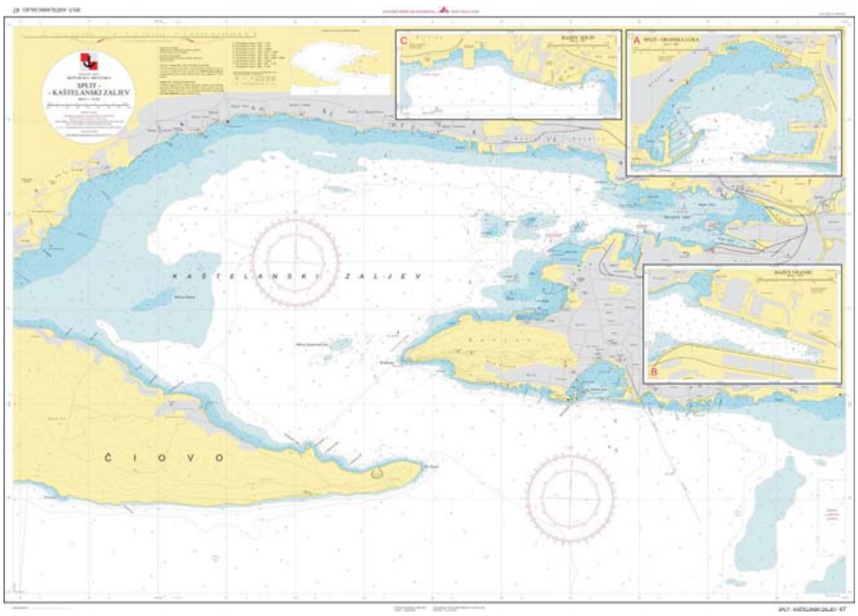
URL: Wikipedija – slobodna enciklopedija (englesko izdanje), http://en.wikipedia.org/wiki/Mercator, 26.2.2007.



Marine charts are usually made in the normal aspect Mercator projection

Pomorske karte redovito se izrađuju u uspravnoj Mercatorovoj projekciji

Nicolas Sanson

(Abbeville, September 20 or 31, 1600 – Paris, June 7, 1667)

French cartographer and geographer

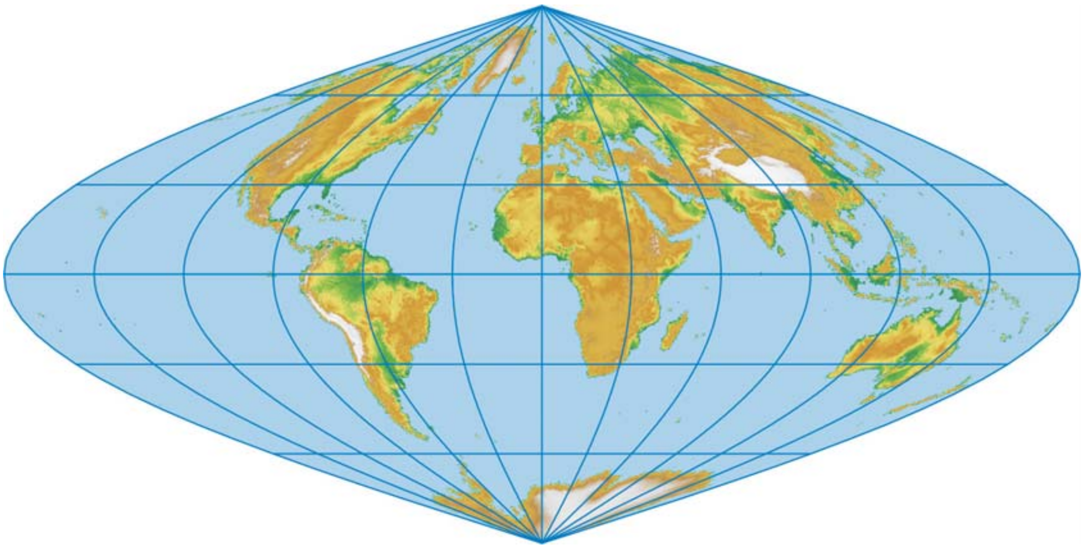
He was born in Abbeville, where as a young man he studied history. He moved to Paris and founded craft in Rue d'el Arbe, St. Germain. He was a *Royal Geographer* from 1630 to 1665. He lectured geography both to Luis XIII and Luis XIV. In period from 1618 to 1667, he made atlases and illustrated texts. He produced about 300 maps in total, out of which two maps of North America are particularly important: *Septentrionale* (1650) and *Le Canada ou Nouvelle France* (1656). He proposed a new sinusoidal pseudocylindrical projection for world map. This projection is named after him the *Sanson projection*, and it is an equivalent sinusoidal pseudocylindrical projection in which all the parallels and the central meridian are mapped in real size.

Nicolas Sanson

(Abbeville, 20. ili 31. XII. 1600 – Pariz, 7. VI. 1667)

Francuski kartograf i geograf

Rođen je u Abbevilleu, gdje je kao mladić studirao povijest. Preselio se u Pariz i osnovao djelatnost u Rue d'el Arbe, St. Germain. Od 1630. do 1665. bio je *kraljevski geograf*. Podučavao je geografiji Luja XIII. i Luja XIV. U razdoblju od 1618. do 1667. izrađivao je atlase i ilustrirao tekstove. Ukupno je izradio oko 300 karata, od kojih su posebno značajne dvije karte Sjeverne Amerike: *Septentrionale* (1650) i *Le Canada ou Nouvelle France* (1656). Predložio je novu sinusoidalnu pseudocilindričnu projekciju za kartu svijeta. Ta, po njemu nazvana *Sansonova projekcija* ekvivalentna je sinusoidalna pseudocilindrična projekcija u kojoj se sve paralele i srednji meridijan preslikavaju u pravoj veličini.



Map of the World in the Sanson projection

Karta svijeta u Sansonovoj projekciji

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

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Rigobert Bonne

(Raucourt, 1727 – Paris, 1795)

French engineer, mathematician and cartographer

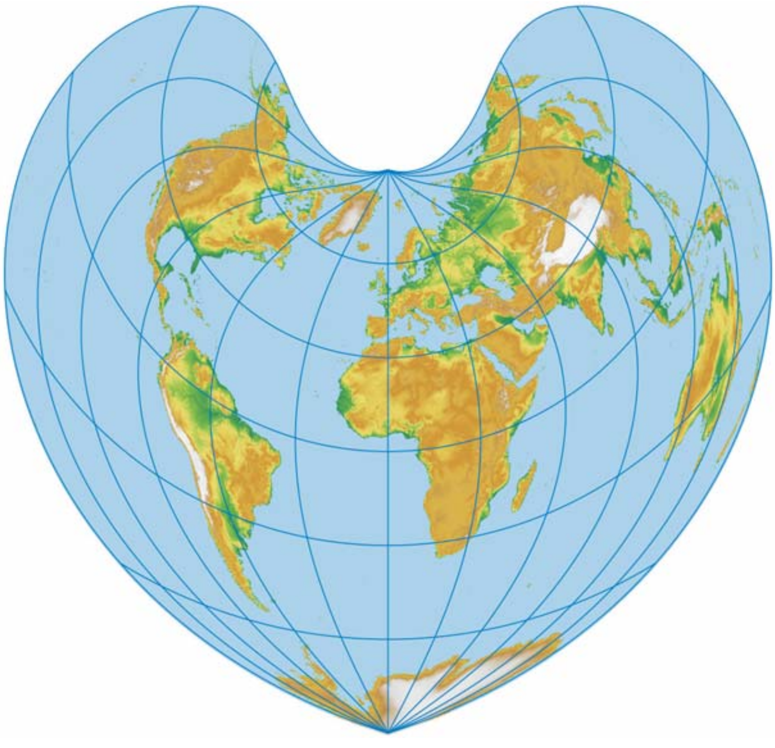
Rigobert Bonne was a hydrographer at the Royal Court in Paris (Hydrographe du Roi ŕ Paris). His main interest was the production of marine charts. He also published several atlases. Of significance is *Atlas Encyclopédique*, produced in collaboration with his son and with Nicolas Demarest and Bory de St. Vincent. In 1752, Bonne proposed a pseudoconical equal area map projection in which all the parallels and the central meridian are projected free of all distortion, for the map of France. Although the projection was developed in rudimentary form by Claudius Ptolemy (about year 100) and further developed by Bernardus Sylvanus (1511), it was named after Rigobert Bonne.

Rigobert Bonne

(Raucourt, 1727 – Pariz, 1795)

Francuski inženjer, matematičar i kartograf

Bio je hidrograf na Kraljevskom dvoru u Parizu (Hydrographe du Roi ŕ Paris). Njegov glavni interes bila je izrada pomorskih karata. Objavio je i nekoliko atlasa. Značajan je *Atlas Encyclopédique* koji je izradio u suradnji sa sinom te Nicolasom Demarestom i Boryjem de St. Vincentom. Godine 1752. Bonne je za kartu Francuske predložio pseudokonusnu ekvivalentnu projekciju u kojoj se sve paralele i srednji meridijan preslikavaju bez deformacija. Iako je projekciju prvi razvio Klaudije Ptolemej (oko 100. godine), a unaprijedio Bernardus Sylvanus (1511), imenovana je po Rigobertu Bonneu.



Map of the World in the Bonne projection
Karta svijeta u Bonneovoj projekciji

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet
Snyder, J. P., Voxland, P. M. (1989): An Album of Map Projections, USGS Professional Paper 1453. U.S. Geological Survey, Denver
URL: Wikipedija – slobodna enciklopedija (englesko izdanje), http://en.wikipedia.org/wiki/Bonne_projection, 26.2.2007.
URL: Image Archive – Bonne, Atlas Encyclopédique, http://www.ic-maps.co.uk/ArchiveBonneAtlasEncyclopedique.htm, 26.2.2007.

Johann Heinrich Lambert

(Mülhausen, August 26, 1728 – Berlin, September 25, 1777)

German physicist, mathematician and astronomer originating from France

Johann Heinrich Lambert

(Mülhausen, franc. Mulhouse, 26. VIII. 1728 – Berlin, 25. IX. 1777)

Njemački fizičar, matematičar i astronom francuskog podrijetla

He encompassed algebra, spherical geometry and perspective with his mathematical studies. He was the first to prove (1768) that π is an irrational number and made the first systematic use of hyperbolic functions. His work on theory of parallel lines (1766) is of particular importance. In his work *Photometry* (*Photometrie*, 1760), he clearly distinguished concepts of brightness and luminance and in that way he set the foundations of photometry. Besides, he researched refraction of light in the atmosphere, comet paths and related to this, he discovered new properties of conics. In his astronomical works, there is first mention of double stars. Lambert presented in 1772 a (conformal conical) projection which was named after him *Lambert's conformal conic projection.* This projection is today still in use for the requirements of airplane navigation and in some countries as official state projection. In Croatia, this projection is the official map projection for general topographic maps. The equivalent azimuthal projection was also named after Lambert. The Transverse Mercator projection of sphere is also called the *Lambert–Gauss projection*. *Lambert's theorem* is

Svojim matematičkim istraživanjima obuhvatio je algebru, sfernu trigonometriju i perspektivu. Prvi je dokazao (1768) da je π iracionalan broj i prvi se sustavno služio hiperboličkim funkcijama. Posebno je značajno njegovo djelo o teoriji paralelnih pravaca (1766). U djelu *Fotometrija* (*Photometrie*, 1760) jasno je razlučio pojmove sjaja i rasvjete i tako položio temelj fotometrije. Osim toga, istraživao je lom svjetlosti u atmosferi, zatim staze kometa i u svezi s tim otkrio nova svojstva konika. U njegovim astronomskim radovima prvi se put govori o dvojnim zvijezdama. Lambert je 1772. godine predstavio (konformnu konusnu) projekciju koja se po njemu naziva *Lambertova konformna konusna projekcija*. Ta je projekcija i danas u uporabi za potrebe zrakoplovne navigacije i kao službena kartografska projekcija u nekim državama. U Hrvatskoj je to službena kartografska projekcija za pregledne topografske karte. Po njemu se naziva i ekvivalentna azimutalna projekcija. Poprečna Mercatorova projekcija sfere naziva se i *Lambert-Gaussovom projekcijom*. U računu izjedna-

Lambert Conformal Conic projection (standard parallels: 20° i 60°)

Lambertova konformna konusna projekcija (standardne paralele: 20° i 60°)

Transverse Lambert Azimuthal Equal-Area projection

Poprečna Lambertova azimutalna ekvivalentna projekcija known in the adjustment calculus. According to Frischauf (1905), the beginning of the theory of projecting one surface onto another belongs to J. H. Lambert, who dealt with generally given problem of projecting a sphere and spheroids into the plane in his *Anmerkungen und Zusätze zur Entwerfung der Land- und Himmelscharten* (Remarks and Additions to the Establishment of Land and Sky Maps) in the third part of his *Beyträge zum Gebrauche der Mathematik und deren Anwendung* (Contributions to the Usage of Mathematics and its Application, 1772).

čenja poznat je *Lambertov stavak*. Prema Frischaufu (1905) početak teorije preslikavanja jedne plohe na drugu pripada J. H. Lambertu, koji se u *Anmerkungen und Zusätze zur Entwerfung der Land- und Himmelscharten* (Napomene i dopune zasnivanju karata zemljišta i neba), u trećem dijelu svojih *Beyträge zum Gebrauche der Mathematik und deren Anwendung* (Doprinosi uporabi matematike i njezine primjene, 1772), bavio općenito postavljenom zadaćom preslikavanja sfere i sferoida u ravninu.

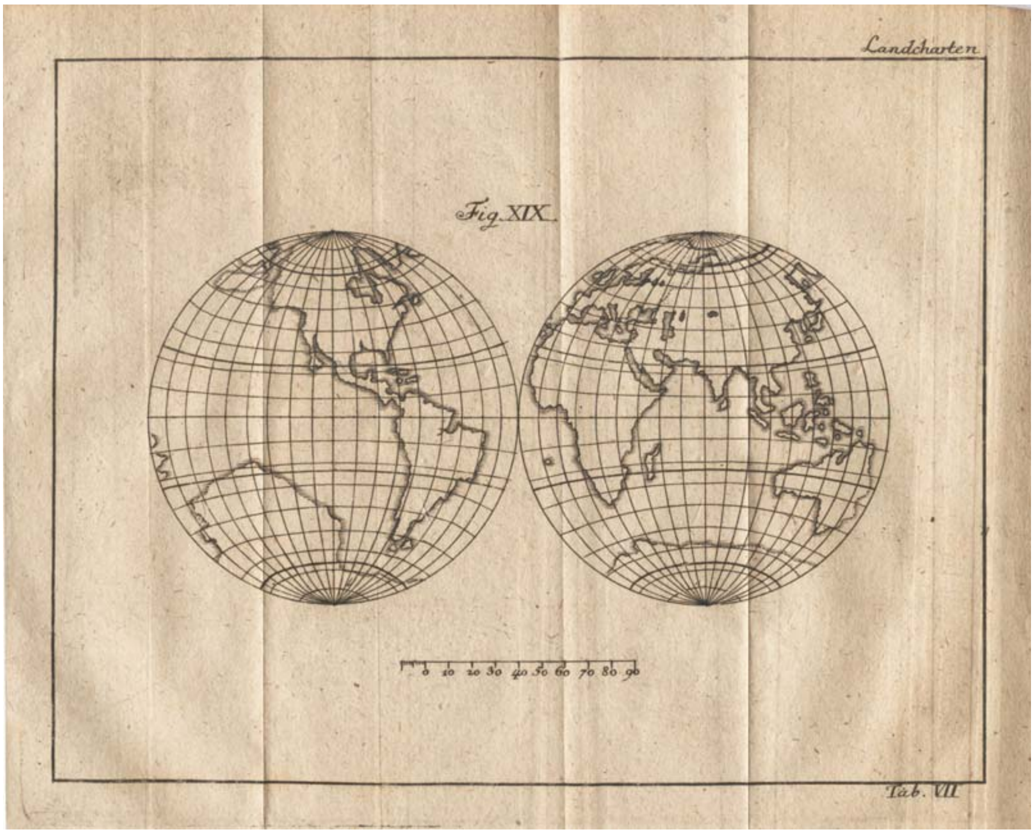


Table VII with figure XIX from Lambert's work Beyträge zum Gebrauche der Mathematik und deren Anwendung, Dritter Theil, published in 1772

Tabla VII sa slikom XIX iz Lambertova djela Beyträge zum Gebrauche der Mathematik und deren Anwendung, Dritter Theil, objavljenog 1772.

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Karl Brandan Mollweide

(Wolfenbüttel, February 2, 1774 – Leipzig, March 10, 1825)

German mathematician and astronomer

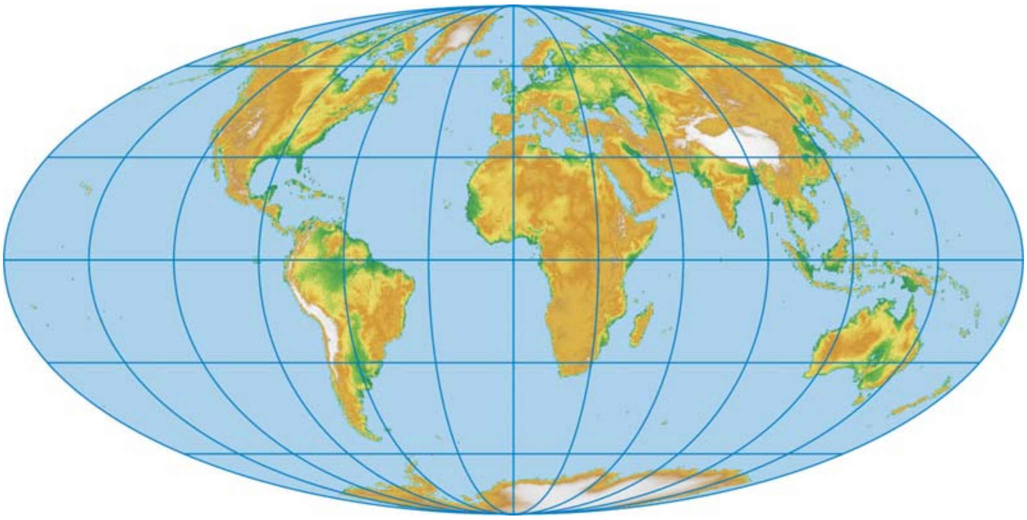
Mollweide was an observer at the Observatory of the Leipzig University until 1816. In 1812, he obtained the title of a full professor of astronomy, and from 1814, a full professor of mathematics. From 1820 to 1823, he was the Dean of the Faculty of Philosophy. He discovered spherical trigonometric formulae, which were named *Mollweide's formulae* after him. He discovered and published the pseudocylindrical equal-area projection (1805) that was, in his honor, named the *Mollweide projection.*

Karl Brandan Mollweide

(Wolfenbüttel, 3. II. 1774 – Leipzig, 10. III. 1825))

Njemački matematičar i astronom

Mollweide je do 1816. bio motritelj na Sveučilišnoj zvjezdarnici u Leipzigu. Godine 1812. imenovan je redovitim profesorom astronomije, a 1814. redovitim profesorom matematike. Od 1820. do 1823. bio je dekan na Filozofskom fakultetu. Otkrio je formule sferne trigonometrije koje su po njemu dobile ime *Mollweideove formule*. Pronašao je i objavio pseudocilindričnu ekvivalentnu projekciju (1805) koja je njemu u čast nazvana *Mollweideova projekcija*.



Map of the World in the Mollweide projection

Karta svijeta u Mollweideovoj projekciji

Map of the World in the Mollweide projection is used for designing the logo of the International Cartographic Association – ICA

Karta svijeta u Mollweideovoj projekciji poslužila je za izradu logotipa Međunarodnoga kartografskog društva (International Cartographic Association – ICA)

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

Snyder, J. P., Voxland, P. M. (1989): An Album of Map Projections, USGS Professional Paper 1453. U.S. Geological Survey, Denver

URL: Wikipedija – slobodna enciklopedija (englesko izdanje), http://en.wikipedia.org/wiki/Karl_Mollweide, 26.2.2007.

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Carl Friedrich Gauss

(Braunschweig, April 30, 1777 – Göttingen, February 23, 1855)

German mathematician, astronomer and geodesist

Carl Friedrich Gauss

(Braunschweig, 30. IV. 1777 – Göttingen, 23. II. 1855)

Njemački matematičar, astronom i geodet

A versatile mathematical genius and one of the greatest mathematicians of all time (*princeps mathematicorum*). He showed his great mathematical talent already in childhood, and he achieved first scientific results as a mathematics student in Göttingen. Relating to theory of circle division, he solved (1796) the problem of construction of regular polygons with a ruler and a compass. He was promoted in 1799 based on his doctoral thesis in which he gave a proof of extremely important, so called fundamental theorem of algebra. In his publication *Investigations in Arithmetic (Disquisitiones arithmeticae*, 1801) he set the foundations for the modern theory of numbers. His *General Investigations of Curved Surfaces* (*Disquisitiones generales circa superficies curvas*, 1828) represent a new stage in the development of differential geometry and foundation of its progress until the present day. In this work he introduces systematic usage of parametrical representations of surfaces, two basic square forms, spherical projection, and based on this, the concept of curvature in the point of surface. The basic theorem about invariability of curvature of surface during its isometric projection was proved (*Theorema egregium*). His contribution to theory of errors during measurement is also very important, and it was represented as the theory of least squares in the work *Theory of the Combination of Observations Least Subject to Errors* (*Theoria combinationis observantium erroribus minimis obnoxiae*, I – III, 1821 – 26), according to which the most adequate value of measured scale is the one in respect of which sum of errors' squares is minimal. His researches in the field of basic geometry are of particular importance, although he didn't publish anything about it. He had been managing the observatory in Göttingen for a long time, and he had been calculating mathematical tables for the needs of astronomy for ten years, which were afterwards in use for decades. Many things are named after him, like *Gaussian curve*, *Gaussian elimination method* during the solving of system of linear equations, *Gaussian sum mark*, *Gaussian condition for tetragon with diagonals*, *Gauss-Krüger projection*, etc. Between years 1821 and 1825, during the calculations of Hanover's triangulation for projection of ellipsoid into the

Svestrani matematički genij i jedan od najvećih matematičara uopće (*princeps mathematicorum*). Izvanrednu matematičku darovitost pokazao je već u djetinjstvu, a prve znanstvene rezultate postigao je kao student matematike u Göttingenu. U vezi s teorijom dijeljenja kruga riješio (1796) problem konstrukcije pravilnih poligona ravnalom i šestarom. Promoviran je 1799. na temelju disertacije, u kojoj je dokazao izvanredno značajan tzv. fundamentalni teorem algebre. Djelom *Istraživanja u aritmetici* (*Disquisitiones arithmeticae*, 1801) postavio je osnove suvremenoj teoriji brojeva. Njegova *Opća istraživanja zakrivljenih ploha* (*Disquisitiones generales circa superficies curvas,* 1828) nova su etapa u razvoju diferencijalne geometrije i osnovica njezina napretka sve do danas. U tome djelu on uvodi sustavnu uporabu parametarskoga predočenja ploha, dvije osnovne kvadratne forme, sferno preslikavanje i na osnovi toga pojam zakrivljenosti u točki plohe. Dokazan je i osnovni teorem o invarijantnosti zakrivljenosti plohe pri njezinu izometričkom preslikavanju (*Theorema egregium*). Značajan je i njegov prilog teoriji pograšaka pri mjerenju, izložen kao teorija najmanjih kvadrata u djelu *Teorija kombiniranja uz najmanje pogreške opažanja* (*Theoria combinationis observantium erroribus minimis obnoxiae*, I-III, 1821-26), prema kojoj je najpogodnija vrijednost mjerene veličine ona za koju je zbroj kvadrata pogrešaka najmanji. Osobito su značajna i njegova istraživanja u području osnova geometrije, premda o tome nije ništa objavio. Dugo je upravljao opservatorijem (zvjezdarnicom) u Göttingenu, a za potrebe astronomije deset je godina računao matematičke tablice koje su zatim desetljećima bile u uporabi. Po njemu se naziva mnogo toga, npr. *Gaussova krivulja*, *Gaussova metoda eliminacije* pri rješavanju sustava linearnih jednadžbi, *Gaussova oznaka za sumiranje*, *Gaussov uvjet za četverokut s dijagonalama*, *Gauss-Krügerova projekcija* i dr. Između 1821. i 1825. godine Gauss je pri izračunavanju hannoverske triangulacije za preslikavanje elipsoida na ravninu primijenio način preslikavanja koji danas nosi naziv Gauss-Krügerova projekcija. Prof. dr. Louis Krüger objavio je 1912. knjigu o toj projekciji, a 1919. zbirku formula za praktičnu primjenu. Od tada se ta projekcija naziva plane, Gauss used a projection procedure which is today called the Gauss-Krüger projection. Professor Dr. Louis Krüger published a book about that projection in 1912, and in 1919 a collection of formulae for practical usage. Since then, this projection had been called Gauss-Krüger. During the 20th century, this projection was the official map projection in many countries. It is also known as Mercator's projection.

Gauss-Krügerova, a tijekom 20. stoljeća bila službena kartografska projekcija u mnogim državama. Poznata je i pod nazivom poprečna Mercatorova projekcija.

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet
Gusić, I. (1995): Matematički rječnik, Element, Zagreb
Kovačec, A. (gl. ur., 2000): Hrvatska enciklopedija, sv. 1., Leksikografski zavod Miroslav Krleža, Zagreb
Wolf, H. (1994): Ausgleichungsrechnung I, 2. Aufl., Dümmler, Bonn
URL: The MacTutor History of Mathematics archive, http://www-history.mcs.st-andrews.ac.uk/Biographies/Gauss.html, 26.2.2007.

George Biddell Airy

(Alnwick, July 27, 1801 – Greenwich, January 2, 1892)

British astronomer, mathematician and cartographer

George Biddell Airy

(Alnwick, 27. VII. 1801 – Greenwich, 2. I. 1892)

Engleski astronom, matematičar i kartograf

He graduated at Trinity College, Cambridge, in 1823. Since 1826, he had been a professor of astronomy and mathematics at Cambridge, and since 1828 the director of the Cambridge observatory. His main interest was astrometry and optics, especially wave optics. In 1861, Airy suggested arithmetic mean from the deformation on main directions, for the comparison of two projections to the middle square deformations on the whole area of projecting. This criterion is named *Airy's criterion* after him. In the same year, he presented an azimuthal projection which is named *Airy's projection* after him.

Diplomirao je 1823. na Trinity College u Cambridgeu. Od 1826. bio je profesor astronomije i matematike u Cambridgeu, a od 1828. ravnatelj zvjezdarnice u Cambridgeu. Bavio se astrometrijom i optikom, posebno valnom. Airy je 1861. godine za usporedbu dviju projekcija prema srednjim kvadratnim deformacijama na cijelom području preslikavanja predložio aritmetičku sredinu iz deformacija po glavnim pravcima. Po njemu se taj kriterij naziva *Airyjevim kriterijem*. Iste je godine predstavio azimutalnu projekciju koja se po njemu naziva *Airyjeva projekcija*.

Source / Izvor

Airy, G. B. (1861): Explanation of a projection by balance of errors for maps applying to a very large extent of the earth's surface and comparison of this projection with other projections, Philosophical Magazine and Journal of Science, 22, 409-421.
Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet
Kovačec, A. (gl. ur., 1999): Hrvatska enciklopedija, sv. 1., Leksikografski zavod Miroslav Krleža, Zagreb
Snyder, J. P., Voxland, P. M. (1989): An Album of Map Projections, USGS Professional Paper 1453. U.S. Geological Survey, Denver
URL: Enciklopedija Britannica, http://www.britannica.com/eb/article-9005227/Sir-George-Biddell-Airy, 5.3.2007
URL: Wikipedija – slobodna enciklopedija (englesko izdanje), http://en.wikipedia.org/wiki/George_Biddell_Airy, 5.3.2007

James Gall

(1808 – 1895)

Scottish clergyman, cartographer and astronomer

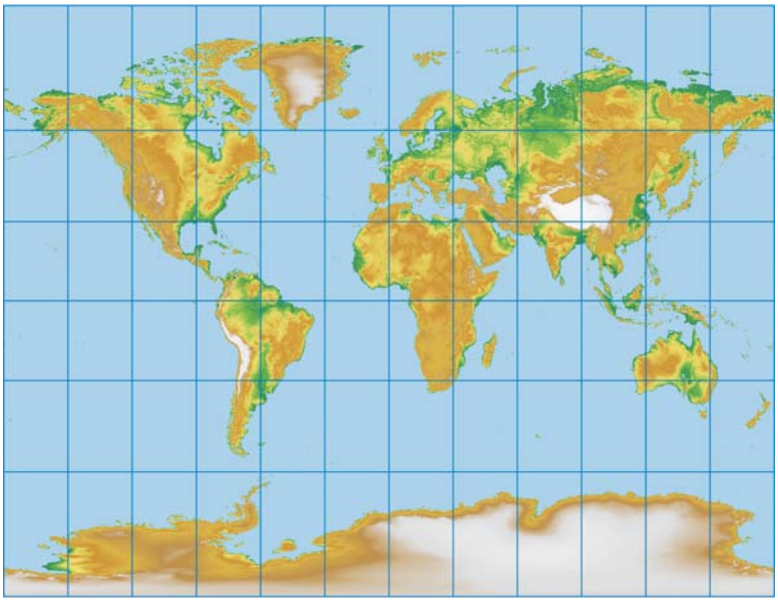
James Gall was a Scottish clergyman, but his contribution to astronomy and cartography is also very important. He was a son of a famous publisher, raised in Edinburgh. He joined his father's business in 1838, but he quickly left it to pursue a religious career. He studied on the University in Edinburgh and then New College. He published several religious works, and he excelled with his works in astronomy: *Easy Guide to the Constellations* (1870) and *People's Atlas of the Stars.* Gall is the author of three map projections (*Gall isographic*, *Gall stereographic* and *Gall orthographic projection*), whose purpose was to reduce distortion on constellation maps. He presented his work in Glasgow, at the meeting of *British Association for the Advancement of Science* and explained it more fully in an article published in the *Scottish Geographical Magazine* entitled *Use of Cylindrical Projections for Geographical, Astronomical and Scientific Purposes* in 1885. *Gall projection* excels among perspective cylindrical projections that found greater use in practice. In this projection, the point of view is on the sphere's surface, and this is why it bears the name Gall stereographic projection, and the cylinder cuts the sphere alongside the parallels with the latitude $\varphi_0 = \pm 45°$.

James Gall

(1808 – 1895)

Škotski svećenik, kartograf i astronom

James Gall bio je škotski svećenik, a važan je i njegov prinos astronomiji i kartografiji. Sin poznatog izdavača, odrastao u Edinburghu. U očev posao uključio se 1838. godine, ali ga ubrzo napušta slijedivši svećenički poziv. Studirao je na Sveučilištu u Edinburghu i na New College. Objavio je nekoliko djela vjerske tematike, a istaknuo se djelima na temu astronomije: *Easy Guide to the Constellations* (1870) i *People's Atlas of the Stars*. Gall je autor triju kartografskih projekcija (*Gallova izografska*, *Gallova stereografska* i *Gallova ortografska projekcija*), namjena kojih je smanjivanje distorzije na kartama zviježđa. Svoj rad predstavio je u Glasgowu na sastanku *British Association for the Advancement of Science* i detaljnije opisao 1885. u članku koji je objavljen u časopisu *Scottish Geographical Magazine* pod naslovom *Use of Cylindrical Projections for Geographical, Astronomical and Scientific Purposes.* Među perspektivnim cilindričnim projekcijama, koje su našle veću primjenu u praksi ističe se *Gallova projekcija.* U toj se projekciji točka promatranja nalazi na površini sfere pa joj odatle i naziv Gallova stereografska projekcija, a valjak siječe sferu uzduž paralela sa širinom $\varphi_0 = \pm 45°$.



Gall Stereographic projection

Gallova stereografska projekcija

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

URL: Gazetteer for Scotland – geographical encyclopaedia, http://www.geo.ed.ac.uk/scotgaz/people/famousfirst2379.html, 26.2.2007.

URL: Wikipedija – slobodna enciklopedija (englesko izdanje), http://en.wikipedia.org/wiki/James_Gall, 26.2.2007.

Alexander Ross Clarke

(Reading, Berkshire, England, December 16, 1828 – Strathmore, Reigate, Surrey, February 11, 1914)

British geodesist, mathematician and officer

Alexander Ross Clarke

(Reading, Berkshire, Engleska, 16. XII. 1828 – Strathmore, Reigate, Surrey, 11. II. 1914)

Engleski geodet, matematičar i časnik

A geodesist whose work is primarily remembered for defining different reference ellipsoids. He was born in England, and he spent his childhood in Jamaica. He returned back to England and in 1847 he joined the British army, and was assigned to the Royal Engineers. He served in Canada from 1851 to 1854. In the year 1856, he became the director of the measurement department, and in 1858 he published his first article on the history of land surveying in Great Britain. In June 1862, he was elected as a member of the Royal Society. His ellipsoids from 1858, 1866 and 1880, which are named after him (for example *Clarke 1866* or *Clarke 1880)* are famous. He received a gold medal from the Royal Society (1887) for his contribution of determining shape and size of Earth. A. R. Clarke was interested in map projections as well. In the year 1862, he used the least squares method for his perspective projection with minimal deformations for part of terrestrial sphere, margined with determined spherical circle. He determined parameters for several continental areas, and he published his projection called *Twilight* as well, which presents most of the Earth's land. All these projections are classified as perspective projections with minimum or low-error distortions.

Geodet čiji se rad pamti ponajprije po definiranju različitih referentnih elipsoida. Rođen je u Engleskoj, a djetinjstvo je proveo na Jamajci. Vratio se u Englesku i 1847. godine pristupio britanskoj vojsci, redu kraljevskih inženjera (*Royal Engineers*). Od 1851. do 1854. služio je u Kanadi. Godine 1856. postao je ravnateljem odjela za izmjeru, a 1858. objavio je prvi članak o povijesti britanske geodetske izmjere. U lipnju 1862. izabran je za člana Kraljevskog društva (*Royal Society*). Poznati su njegovi elipsoidi iz 1858., 1866. i 1880. godine, koji se po njemu i nazivaju (npr. *Clarke 1866* ili *Clarke 1880*). Nagrađen je zlatnom medaljom *Royal Societyja* (1887) za prinos određivanju oblika i veličine Zemlje. A. R. Clarke bavio se i kartografskim projekcijama. God. 1862. upotrijebio je metodu najmanjih kvadrata za svoju perspektivnu projekciju s minimalnim deformacijama za dio Zemljine sfere omeđen zadanom sfernom kružnicom. Odredio je parametre za nekoliko kontinentalnih područja, te objavio također svoju projekciju nazvanu *sumrak* (Twilight) koja prikazuje najveći dio Zemljina kopna. Sve te projekcije ubrajaju se u perspektivne projekcije s minimalnim ili malim deformacijama.

Clarke ellipsoids parameters

Parametri Clarkeovih elipsoida

Name Ime	Semi Major Axis Velika poluos a [m]	Flattening of the ellipsoid Spljoštenost elipsoida μ
Clarke 1858	6378293.65	1 / 294.26
Clarke 1866	6378206.4	1 / 294.978698
Clarke 1880	6378249.15	1 / 293.465

Source / Izvor

Borčić, B. (1955): Matematička kartografija, (Kartografske projekcije), Tehnička knjiga, Zagreb
Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet
Snyder, J. P., Voxland, P. M. (1989): An Album of Map Projections, USGS Professional Paper 1453. U.S. Geological Survey, Denver
URL: Royal Engineers, http://members.aol.com/reubique/clarke.htm, 26.2.2007.
URL: Wikipedija – slobodna enciklopedija (englesko izdanje), http://en.wikipedia.org/wiki/Alexander_Ross_Clarke, 26.2.2007.

Wilhelm Jordan

(Ellwangen, Germany, March 1, 1842 – Hanover, April 17, 1899)

German geodesist and mathematician

Wilhelm Jordan

(Ellwangen, Njemačka, 1. III. 1842 – Hannover, 17. IV. 1899)

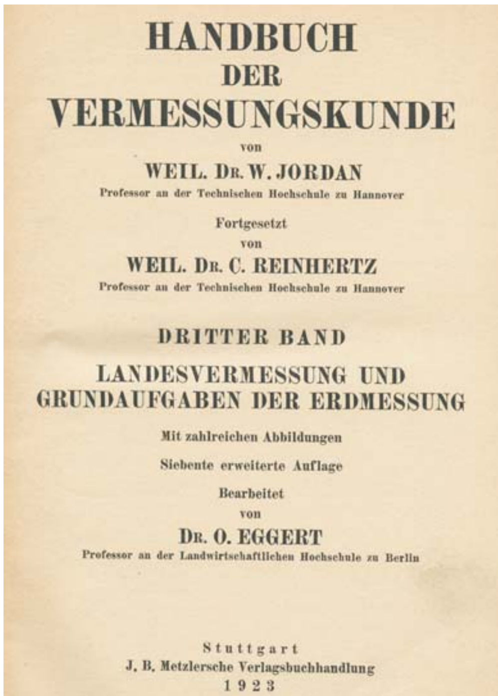
Njemački geodet i matematičar

Dr. phill. h. c., worked as a professor at the polytechnic institute in Stuttgart (1865 – 68) and in Karlsruhe (1868 –81). In 1847, Jordan took part in the expedition of Gerhard Rohlfs to Libya. As a member of the German Society of Geometers, he worked on restructuring the German geodetic school system, and in 1887 he founded the magazine *Kalender für Vermessungswesen und Kulturtechnik*, which was published regularly once a year till 1949. From 1881, he was professor of geodesy and practical geometry at the technical university Hanover and he had been working on his most significant work – handbook of geodesy which is today known under the title *Jordan-Eggert–Kneissl: Handbuch der Vermessungskunde*. He is remembered for his algorithm for bringing the matrix to reduced form, which is used for finding the inverse of a matrix. The method was named the *Gauss – Jordan algorithm* after him and Carl Friedrich Gauss. In 1896, Jordan suggested a formula for determination of mean square distortion in the given point in order to compare two projections according to mean square distortions in the whole area of projection. This criterion is named the *Jordan criterion* after him.

Dr. phil. h. c., radio je kao profesor u Politehničkom institutu u Stuttgartu (1865-68) i Karlsruheu (1868-81). Godine 1874. sudjelovao je u ekspediciji Gerharda Rohlfsa u Libiju. Kao član Njemačkog društva geometara radio je na restrukturiranju njemačkoga geodetskog školstva, a 1877. osnovao je časopis *Kalender für Vermessungswesen und Kulturtechnik* koji je jednom godišnje redovito izlazio do 1949. godine. Od 1881. predaje geodeziju i praktičnu geometriju na Tehničkoj visokoj školi u Hannoveru i radi na svom najznačajnijem djelu – geodetskom priručniku koji je danas poznat pod naslovom *Jordan-Eggert-Kneissl*: *Handbuch der Vermessungskunde*. Poznat je po algoritmu za svođenje matrice na reducirani oblik, koji se upotrebljava za nalaženje inverzne matrice, a koji se po njemu i Carlu Friedrichu Gaussu naziva *Gauss-Jordanov algoritam*. Jordan je 1896. godine predložio formulu za određivanje srednje kvadratne deformacije u danoj točki u svrhu usporedbe dviju projekcija prema srednjim kvadratnim deformacijama na cijelom području preslikavanja. Po njemu se taj kriterij naziva *Jordanovim kriterijem*.

Title page of Jordan's work Handbuch der Vermessungskunde, published in 1923

Naslovnica Jordanovog djela Handbuch der Vermessungskunde, objavljenog 1923.



HANDBUCH
DER
VERMESSUNGSKUNDE
von
WEIL. DR. W. JORDAN
Professor an der Technischen Hochschule zu Hannover
Fortgesetzt
von
WEIL. DR. C. REINHERTZ
Professor an der Technischen Hochschule zu Hannover
DRITTER BAND
LANDESVERMESSUNG UND
GRUNDAUFGABEN DER ERDMESSUNG
Mit zahlreichen Abbildungen
Siebente erweiterte Auflage
Bearbeitet
von
DR. O. EGGERT
Professor an der Landwirtschaftlichen Hochschule zu Berlin
Stuttgart
J. B. Metzlersche Verlagsbuchhandlung
1923

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

Jordan, W. (1875): Zur Vergleichung der Soldner'schen rechtwinkligen sphärischen Coordinaten mit der Gauss'schen conformen Abbildungen des Ellipsoids auf die Ebene. Zeitschrift für Vermessungswesen, IV, 27-32.

Jordan, W. (1896): Der mittlere Verzerrungsfehler, Zeitschrift für Vermessungswesen, XXV, 249-252.

URL: Wikipedija – slobodna enciklopedija (englesko izdanje), http://en.wikipedia.org/wiki/Wilhelm_Jordan, 5.3.2007

URL: Wikipedija – slobodna enciklopedija (njemačko izdanje), http://de.wikipedia.org/wiki/Wilhelm_Jordan, 5.3.2007

Alphons J. Van der Grinten

(1852 - ?)

American cartographer

Alphons Van der Grinten described, in patent specification from 1904, a graphical way of constructing a projection, which bears his name today. The *Van der Grinten projection* is the most famous projection in the group of circular projections. According to distortion characteristics, it belongs to the group of arbitrary projections. Meridians are mapped as circles symmetrical in relation to the central meridian, which is mapped as a straight line. The Van der Grinten projection is often used for political world maps, although it is not suitable for this purpose because of large surface distortions. For example, Greenland is three times smaller than Australia, and in Grinten's projection it is larger than Australia. The *National Geographic Society* used this projection for reference world maps from 1922 to 1988, afterwards it was replaced with the Robinson projection.

Alphons J. Van der Grinten

(1852 - ?)

Američki kartograf i geograf

Alphons Van der Grinten opisao je u patentnoj specifikaciji iz 1904. godine grafički način konstrukcije projekcije, koja danas nosi njegovo ime. *Van der Grintenova projekcija* najpoznatija je projekcija u skupini kružnih projekcija. Po svojstvima preslikavanja ubraja se u skupinu uvjetnih projekcija. Meridijani se preslikavaju kao kružnice simetrične u odnosu na srednji meridijan, koji se preslikava kao pravac. Van der Grintenova projekcija često se upotrebljava za izradu političkih karata svijeta, iako za tu svrhu zbog velikih deformacija površina nije prikladna. Npr. Grönland je tri puta manji od Australije, a u Van der Grintenovoj je projekciji veći od Australije. *National Geographic Society* upotrebljavao je tu projekciju za karte svijeta svojih izdanja od 1922. do 1988. godine, nakon čega je zamijenjena Robinsonovom projekcijom.

Map of the World in the Van der Grinten projection

Karta svijeta u Van der Grintenovoj projekciji

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

Snyder, J. P., Voxland, P. M. (1989): An Album of Map Projections, USGS Professional Paper 1453. U.S. Geological Survey, Denver

URL: Map Projections, http://www.progonos.com/furuti/MapProj/Normal/ProjOth/projOth.html, 26.2.2007.

URL: Maps on stamps, http://sio.midco.net/mapstamps/vandergrinten.htm, 26.2.2007.

David A. Aitoff

(1854-1933)

Russian cartographer

A Russian cartographer who proposed a map projection suitable for world map in 1889. This projection was named the *Aitoff projection* after him, and it was created by modification of transverse equidistant azimuthal projection. The modification of the projection is, that a perimeter circle of half-sphere map with longitude $\varphi = \pm 90°$ is replaced with ellipse, within which whole terrestrial sphere will be mapped. In that projection, the pole is the point, relation of length of the Equator to the length of central meridian is 2 : 1, and according to distortion characteristics, the projection is arbitrary.

Three years later, inspired by Aitoff's projection, professor of geodesy Ernst Hermann Heinrich von Hammer devised a projection called the *Hammer–Aitoff projection*, which was created by modification of the transverse equivalent azimuthal projection, in the same manner as the Aitoff projection was created by modification of the equidistant azimuthal projection. The projection is equal-area, the pole is a point, and relation of Equator length to the length of the central meridian is 2 : 1.

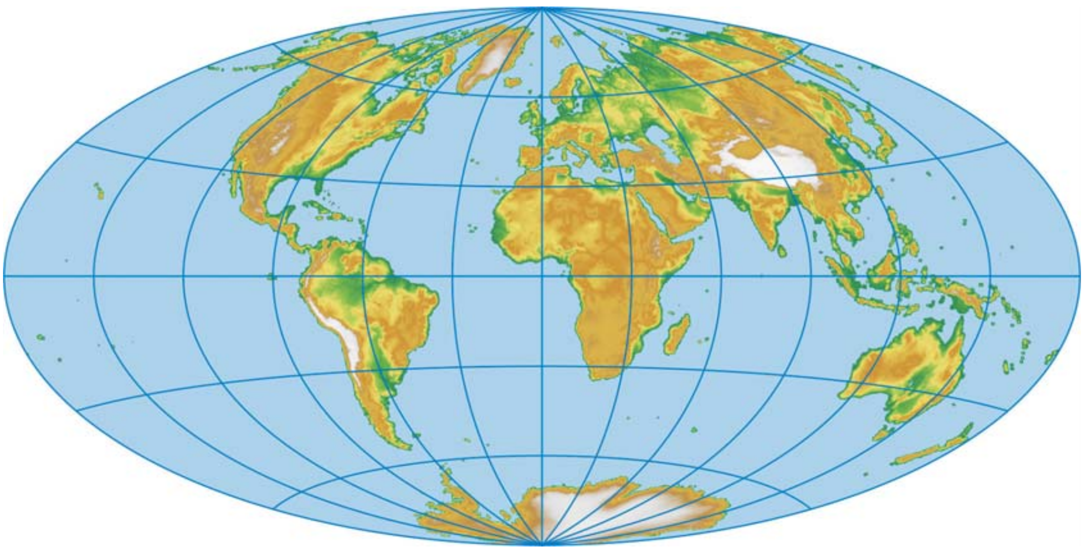
David A. Aitov

(1854-1933)

Ruski kartograf

Aitov je 1889. godine predložio projekciju pogodnu za izradu karata svijeta. Ta se projekcija po njemu naziva *Aitovljeva projekcija,* a nastala je modifikacijom poprečne ekvidistantne azimutalne projekcije. Modifikacija projekcije sastoji se u tome da se obodna kružnica karte polusfere s duljinom $\varphi = \pm 90°$ zamijeni elipsom, unutar koje će se preslikati čitava Zemljina sfera. U toj projekciji pol je točka, odnos duljine ekvatora prema duljini srednjeg meridijana je 2:1, a prema vrsti deformacija projekcija je uvjetna.

Tri godine potom, inspiriran Aitovljevom projekcijom, profesor geodezije Ernst Hermann Heinrich von Hammer izradio je projekciju, nazvanu *Hammer-Aitovljeva projekcija*, koja je nastala modifikacijom poprečne ekvivalentne azimutalne projekcije na isti način kao i Aitovljeva projekcija modifikacijom poprečne ekvidistantne azimutalne projekcije. Projekcija je ekvivalentna, pol je točka, a odnos duljine ekvatora prema duljini srednjeg meridijana je 2:1.



Map of the World in the Aitoff projection
Karta svijeta u Aitovljevoj projekciji

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet.

Snyder, J. P., Voxland, P. M. (1989): An Album of Map Projections, USGS Professional Paper 1453. U.S. Geological Survey, Denver

URL: A general algorithm for the inverse transformation of map projections using Jacobian matrices, http://atlas.selcuk.edu.tr/paperdb/papers/130.pdf, 27.2.2007.

URL: Wikipedija – slobodna enciklopedija (englesko izdanje), http://en.wikipedia.org/wiki/Aitoff_projection, 22.2.2007.

Johann Heinrich Louis Krüger

(Elze, September 21, 1857 – June 1, 1923)

German mathematician and geodesist

He finished the study of mathematics in Berlin. During his studies, he developed a passion for geodesy and at the age of 27, he became a doctor in that area. At Institute of Geodesy in Berlin he was firstly an assistant, then a professor and after that, the headmaster. The Gauss–Krüger projection (conformal transverse cylindrical projection of ellipsoid into the plane) was named after great German scientist Carl Friedrich Gauss. Professor Dr. Louis Krüger published a book on this projection in 1912, and in 1919 a collection of formulae for practical usage. Since then, this projection has been called *Gauss–Krüger*. In the Gauss–Krüger projection, the central meridian of the given area is mapped as a straight line and serves as the x axis of the rectangular coordinate system in the plane; the central meridian of the given area is mapped in its real length, i.e. without linear distortions or the linear scale along this meridian is constant, and the whole projection is conformal. This projection was used in many countries for official cartography.

Johann Heinrich Louis Krüger

(Elze, 21. IX. 1857 – 1. VI. 1923)

Njemački matematičar i geodet

Završio je studij matematike u Berlinu. Još za studija razvio je strast prema geodeziji i u 27. godini doktorirao na tom području. U Geodetskom institutu u Berlinu bio je najprije asistent, zatim profesor, a nakon toga i ravnatelj. Gauss-Krügerova projekcija (konformna poprečna cilindrična projekcija elipsoida u ravninu) dobila je ime po velikom njemačkom znanstveniku Carlu Friedrichu Gaussu. Prof. dr. Louis Krüger objavio je 1912. knjigu o toj projekciji, a 1919. zbirku formula za praktičnu primjenu. Od tada se ta projekcija naziva *Gauss-Krügerovom*. U toj projekciji srednji meridijan zadanog područja preslikava se kao pravac i služi kao os *x* pravokutnoga koordinatnog sustava u ravnini; srednji meridijan područja preslikava se u pravoj duljini, tj. bez linearnih deformacija ili je linearno mjerilo uzduž njega konstantno, a cijela je projekcija konformna. Ta je projekcija u službenoj uporabi u mnogim državama.


VERÖFFENTLICHUNG
DES KÖNIGLICH PREUSZISCHEN GEODÄTISCHEN INSTITUTES
NEUE FOLGE № 52

KONFORME ABBILDUNG
DES ERDELLIPSOIDS IN DER EBENE

VON

PROF. DR. L. KRÜGER

POTSDAM
DRUCK UND VERLAG VON B. G. TEUBNER IN LEIPZIG
1912

Title page of Krüger's work Konforme Abbildung des Erdellipsoids in der Ebene, published in 1912

Naslovnica Krügerovog djela Konforme Abbildung des Erdellipsoids in der Ebene, objavljenog 1912.

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

Krüger, L. (1912): Konforme Abbildung des Erdellipsoids in der Ebene. Potsdam: Veröffentlichung des Königlich Preuszischen Geodätischen Institutes, Neue Folge No. 52. BG Teubner, Leipzig.

URL: Wikipedija – slobodna enciklopedija (njemačko izdanje), http://de.wikipedia.org/wiki/Johann_Heinrich_Louis_Kr%C3%Bcger, 26.2.2007.

Hermann Heinrich Ernst von Hammer

(Ludwigsburg, April 20, 1858 – Stuttgart, September 11, 1925)

German geodesist and cartographer

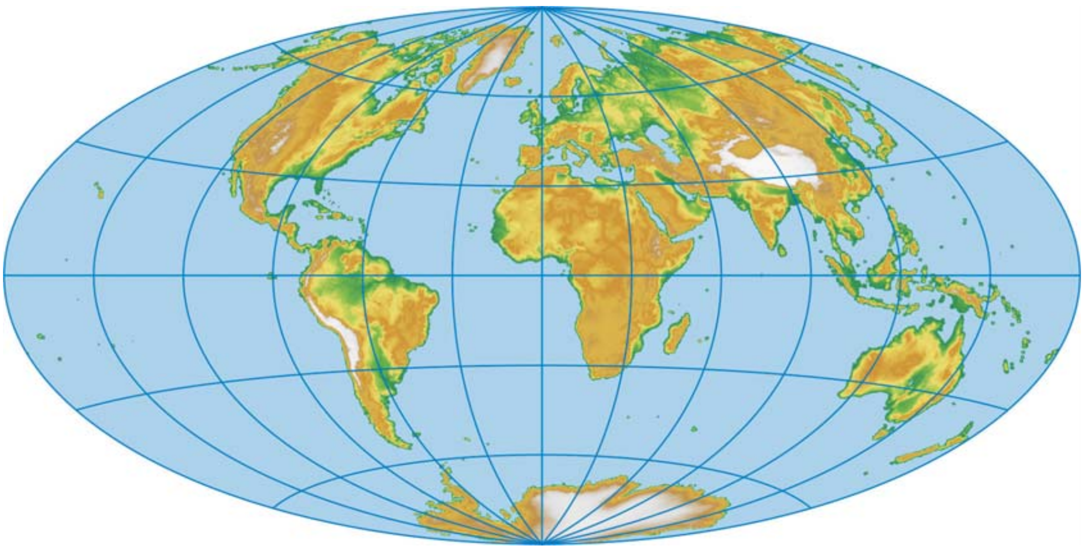
He studied (1874 – 78) at high technical school (Techincshe Hochschule; now Technical University) in Vienna, where he worked from 1878 to 1884 as a teaching assistant, and from 1884 as a professor of geodesy. In the year 1885, he published his famous textbook of flat and spherical trigonometry with special accent on usage in geodesy and spherical astronomy. This book had several later editions. In 1887, he translated from French to German the famous work of A. Tissot on cartographic projections. In 1892, he presented projection that was named *Hammer projection* after him. The projection was created by modification of the transverse equivalent azimuthal projection in the same way as the Aitoff projection was created by modification of the transverse equidistant azimuthal projection, so it is known as the *Hammer–Aitoff projection* as well. The projection is equivalent, the pole is a point, and the relation of Equator length to the length of central meridian is 2 : 1.

Hermann Heinrich Ernst von Hammer

(Ludwigsburg, 20. IV. 1858 – Stuttgart, 11. IX. 1925)

Njemački geodet i kartograf

Studirao je (1874-78) na visokoj tehničkoj školi (Technische Hochschule; sada Tehničko sveučilište) u Beču, gdje od 1878. do 1884. radi kao asistent, a od 1884. kao profesor geodezije. Godine 1885. objavio je svoj poznati udžbenik ravne i sferne trigonometrije s posebnim naglaskom na uporabu u geodeziji i sfernoj astronomiji. Taj je udžbenik doživio nekoliko izdanja. Godine 1887. preveo je s francuskog jezika na njemački glasovito djelo A. Tissota o kartografskim projekcijama. Godine 1892. predstavio je projekciju koja je po njemu nazvana *Hammerova projekcija*. Nastala je modifikacijom poprečne ekvivalentne azimutalne projekcije na isti način kao i Aitovljeva projekcija modifikacijom poprečne ekvidistantne azimutalne projekcije, pa je poznata i kao *Hammer-Aitovljeva projekcija*. Projekcija je ekvivalentna, pol je točka, a odnos duljine ekvatora prema duljini srednjeg meridijana je 2:1.



The Hammer-Aitoff projection

Hammer-Aitovljeva projekcija

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

Hammer, E. (1885): Lehr- und Handbuch der Ebenen und Sphärischen Trigonometrie, zum Gebrauch beim Selbstunterricht und in Schulen besonders als Vorbereitung auf Geodäsie und Sphärische Astronomie, 2. izd. 1987., 3. izd. 1907., 4. izd. 1916., J. B. Metzlersche Buchhandlung, Stuttgart.

Snyder, J. P., Voxland, P. M. (1989): An Album of Map Projections, USGS Professional Paper 1453. U.S. Geological Survey, Denver

Tissot, A. (1887): Die Netzentwürfe geographischer Karten nebst Aufgaben über Abbildung beliebiger Flächen auf Einander, Autorisierte Deutsche Bearbeitung mit einigen Zusätzen bezorgt von E. Hammer, J. B. Metzlersche Buchhandlung, Stuttgart

URL: Stuttgarter Mathematiker, http://www.kk.s.bw.schule.de/mathge/hammer.htm, 27.2.2007.

John Paul Goode

(Stewartville, Minnesota, November 21, 1862 – August 5, 1932)

American geographer and cartographer

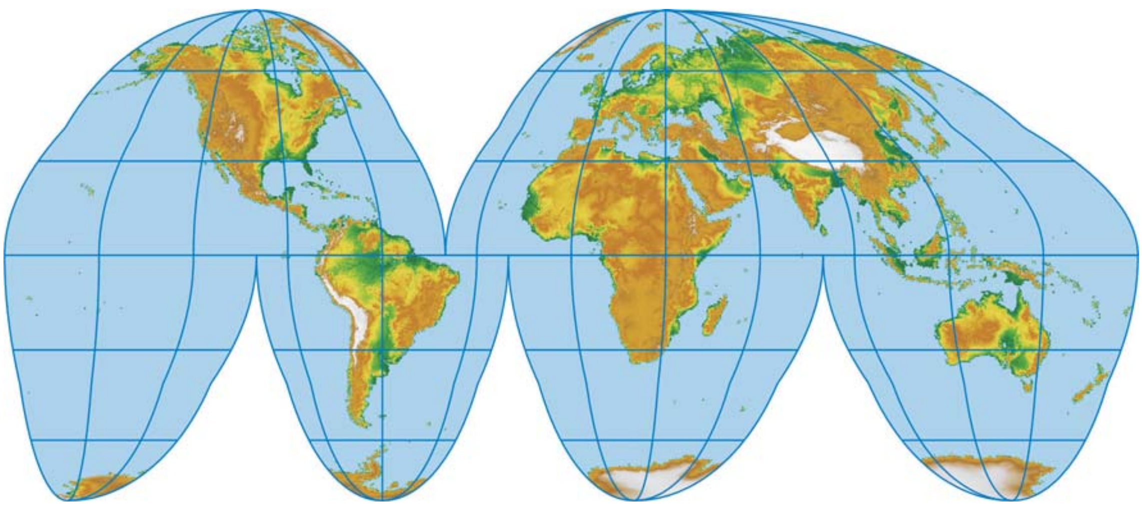
He graduated at the University of Minnesota in 1889. He received his doctorate in economics in 1901 at the University of Pennsylvania, where he taught geography from 1901 to 1917, and from 1917 to 1928 he taught at the University of Chicago as well. He is known as the inventor of asymmetrical interrupted projections. For about four centuries, interrupted projections were characterized by symmetry of representation. On the contrary, asymmetrical projections prevail today. In the year 1916, Goode suggested a way for reducing distortion in pseudocylindrical projections. By this way, any pseudocylindrical projection can be used for the creation of world maps by certain sections which are joined along the Equator. The central meridian is selected for each section. Its longitude should be selected in a way that distortions on that area are to be as small as possible. Goode is the author of a great number of maps and books in the area of geography. Significant is his atlas *Goode's School Atlas* (1923; many later editions), which is known today as *Goode's World Atlas*.

John Paul Goode

(Stewartville, Minnesota, 21. XI. 1862 – 5. VIII. 1932)

Američki geograf i kartograf

Diplomirao je na Sveučilištu u Minnesoti 1889. godine. Doktorski studij ekonomije završio je 1901. na Sveučilištu u Pennsylvaniji, gdje od 1901. do 1917. predaje geografiju, a od 1917. do 1928. predaje i na Sveučilišu u Chicagu. Poznat je kao pronalazač nesimetričnih prekinutih projekcija. Oko četiri stoljeća prekinute projekcije karakterizirala je simetričnost prikaza. Nasuprot tomu danas prevladavaju nesimetrične projekcije. Godine 1916. Paul Goode predložio je način smanjivanja deformacija u pseudocilindričnim projekcijama. Po tom načinu bilo koja pseudocilindrična projekcija može se upotrijebiti za izradu karata cijelog svijeta po pojedinim dijelovima koji su povezani uzduž ekvatora. Za svaki dio izabere se poseban srednji meridijan. Njegovu geografsku dužinu treba izabrati tako da na tom području deformacije budu što manje. Goode je autor velikog broja karata i knjiga iz područja geografije. Značajan je njegov atlas *Goode's School Atlas* (1923; mnogobrojna kasnija izdanja), danas poznat pod naslovom *Goode's World Atlas*.



The Goode projection, developed as merging the Sanson and the Mollweide projection

Goodeova projekcija nastala spajanjem Sansonove i Mollweideove projekcije

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

Snyder, J. P., Voxland, P. M. (1989): An Album of Map Projections, USGS Professional Paper 1453. U.S. Geological Survey, Denver

URL: Infoplease – encyclopedia, http://www.infoplease.com/ce6/people/A0821264.html, 27.2.2007.

URL: Online Encyclopedia, http://encyclopedia.jrank.org/Cambridge/entries/020/John-Paul-Goode.html, 27.2.2007.

URL: Wikipedija – slobodna enciklopedija (englesko izdanje), http://en.wikipedia.org/wiki/John_Paul_Goode, 27.2.2007.

Max Eckert-Greifendorf

(Chemnitz, April 10, 1868 – Aachen, December 26, 1938)

German geographer and cartographer

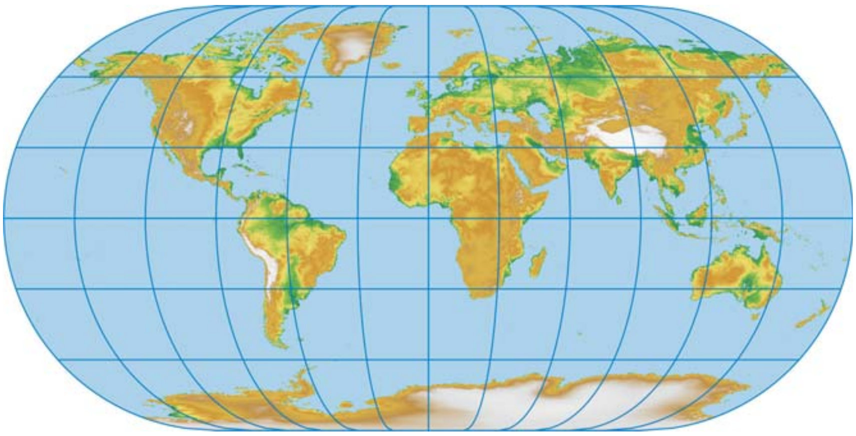
Eckert studied geography and national economy in Leipzig. From 1907 to 1937, he worked as a professor in vocational university in Aachen, where he taught economic geography and cartography. After World War I, he dedicated himself to cartography. Famous is his work *Die Kartenwissenschaft* (published in two volumes in Berlin 1921/25), in which he set the foundations of cartography as a scientific discipline. At the beginning of 20th century, Eckert proposed six new pseudocylindrical projections for the whole world map. The projections are known as *Eckert's projections I – VI.* In all six projections the pole is projected as a line half as long as the Equator. In the first two projections, meridians are broken at the Equator. This is their greatest flaw, so they are not used in practice. Eckert's projections III, IV, V and VI can be recommended for the creation of world maps.

Max Eckert-Greifendorf

(Chemnitz, 10. IV. 1868 – Aachen, 26. XII. 1938)

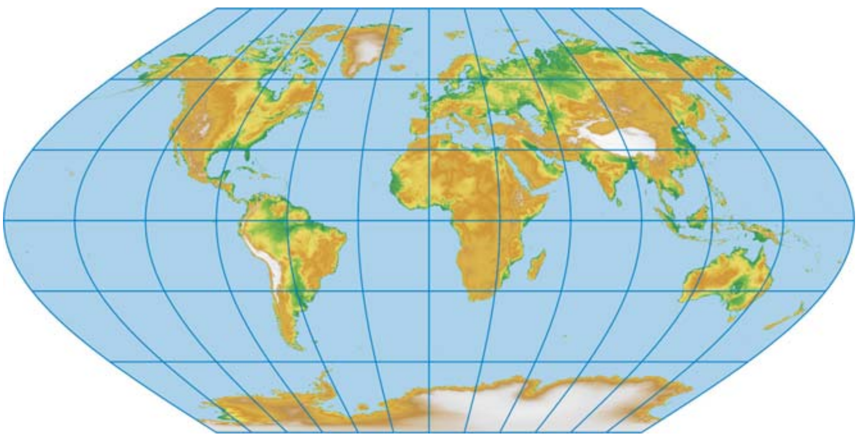
Njemački geograf i kartograf

Eckert je sudirao geografiju i narodno gospodarstvo u Leipzigu. Od 1907. do 1937. radi kao profesor na Visokoj tehničkoj školi u Aachenu, gdje predaje ekonomsku geografiju i kartografiju. Nakon Prvoga svjetskog rata posvetio se kartografiji. Znamenito je njegovo djelo *Die Kartenwissenschaft* (izdano u dva sveska u Berlinu 1921/25), u kojem je postavio temelj kartografiji kao znanstvenoj disciplini. Početkom 20. stoljeća Eckert je predložio šest novih pseudocilindričnih projekcija za izradu karata svijeta. Projekcije su poznate pod nazivom *Eckertove projekcije I–VI.* U svih šest projekcija pol se preslikava kao linija upola kraća od ekvatora. U prve dvije projekcije meridijani su izlomljeni na ekvatoru. To im je najveći nedostatak, pa se u praksi ne primjenjuju. Za izradu karata svijeta mogu se preporučiti Eckertove projekcije III, IV, V, VI.



Eckert III projection

Eckertova projekcija III



Eckert V projection

Eckertova projekcija V

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

URL: Wikipedija – slobodna enciklopedija (njemačko izdanje), http://de.wikipedia.org/wiki/Max_Eckert-Greifendorff, 27.2.2007.

URL: Die Internationale Liga der Antiquare (ILAB), http://www.ilab.org/db/detail.php?lang=de&membernr=1776&ordernr=4851., 27.2.2007.

Oswald Winkel

(Leipzig, January 7. 1874 – Leipzig, July 18, 1953)

German cartographer

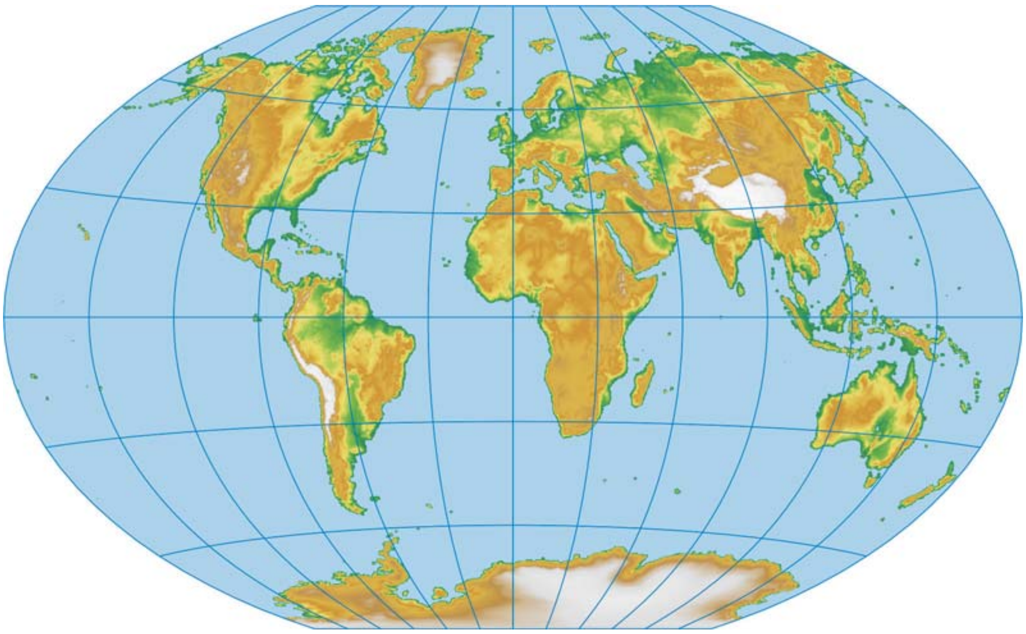
He assembled a great number of general and travelling maps for the guide and publisher Karl Beadeker. Oswald Winkel presented in 1921 a projection for the whole world map which was named after him the *Winkel (triple) projection*. This arbitrary projection is created as an arithmetical mean between the Aitov and the vertical equidistant cylindrical projection. Since the Aitov projection was created by modification of the transverse azimuthal equidistant projection, the Winkel projection is made of three projections, and this is why it is called *triple.*

Oswald Winkel

(Leipzig, 7. I. 1874 – Leipzig, 18. VII. 1953)

Njemački kartograf

Za vodiča i izdavača Karla Baedekera sastavio je i izradio velik broj preglednih i putnih karata. Godine 1921. za izradu karata svijeta predložio je projekciju koja je po njemu nazvana *Winkelova* (*trostruka*) *projekcija*. Ta uvjetna projekcija dobije se kao aritmetička sredina između Aitovljeve i uspravne ekvidistantne cilindrične projekcije. Budući da je Aitovljeva projekcija dobivena modifikacijom poprečne azimutalne ekvidistantne projekcije, Winkelova je projekcija, prema tome, izvedena iz triju projekcija pa joj odatle i naziv *trostruka*.



Map of the World in the Winkel projection (standard parallel: 50°28′)
Karta svijeta u Winkelovoj projekciji (standardna paralela 50°28′)

Source / Izvor

Bollmann, J., Koch, W. G. (2001): Lexikon der Kartographie und Geomatik. Spektrum Akademischer Verlag Heidelberg, Berlin.

Frančula, N. (1971): Die vorteilhaftesten Abbildungen in der Atlaskartographie. Disertacija. Institut für Kartographie und Topographie der Rheinischen Friedrich-Wilhems-Universität Bonn.

Frančula, N.: Kartografske projekcije, skripta, Geodetski fakultet Sveučilišta u Zagrebu, 2000.

Snyder, J. P., Voxland, Ph. M. (1989): An Album of Map Projections. USGS Professional Paper 1453. U.S. Geological Survey, Denver.

URL: Map Projections, http://www.progonos.com/furuti/MapProj/Normal/ProjMAz/projMAz.html, 26.2.2007.

Vladimir Vladimirovich Kavrayskiy

(1884 – 1954)

Russian cartographer

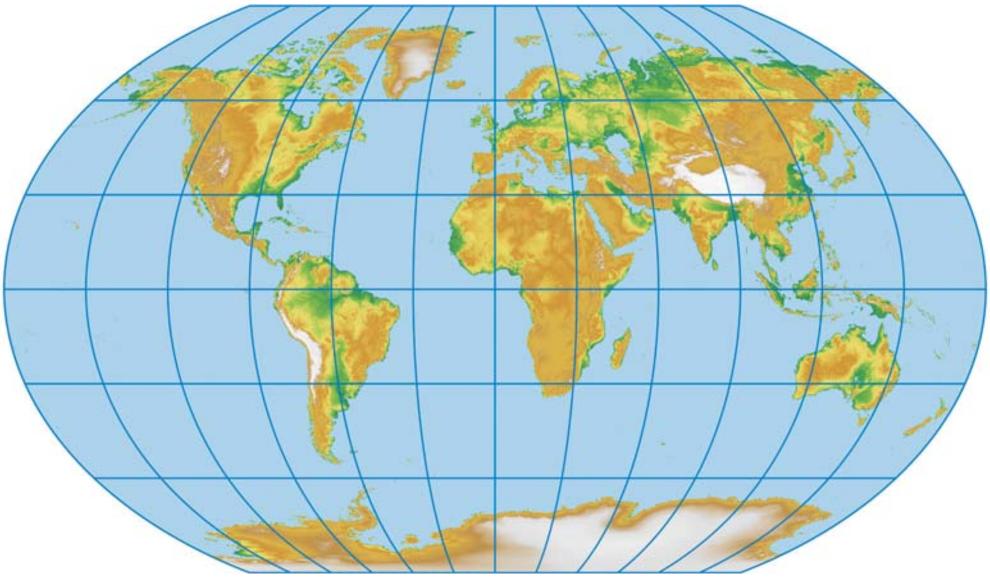
Vladimir Vladimirovič Kavrajskij

(1884 – 1954)

Ruski kartograf

A state prize winner of the USSR. He was an outstanding representative of the Kharkov scientific school in the field of astrometry and stellar astronomy, which was founded by Ludwig O. Struve (1858 – 1920). In 1936, Kavrayskiy proposed an *equa-area sinusoidal pseudocylindrical projection* for the world map. The pole in this projection is projected as a line whose length is equal to half of the Equator. The *elliptical pseudocylindrical projection of Kavrayskiy* is also called after him, and it is classified to the group of arbitrary projections. His monograph in three volumes about the theory of map projections, which was published postmortem, is also well-known.

Dobitnik državne nagrade SSSR-a. Istaknuti predstavnik harkovske znanstvene škole iz područja astrometrije i zvjezdane astronomije, koju je osnovao Ludwig O. Struve (1858-1920). Kavrajskij je 1936. godine predložio za izradu karata svijeta *ekvivalentnu sinusoidalnu pseudocilindričnu projekciju*. Pol se u toj projekciji preslikava kao linija duljine jednake polovici ekvatora. Po njemu se naziva i *eliptična pseudocilindrična projekcija Kavrajskoga*, koja se ubraja u skupinu uvjetnih projekcija. Poznata je njegova monografija u tri dijela o teoriji kartografskih projekcija, izdana posmrtno.



Elliptical Pseudocylindrical projection of Kavrayskiy
Eliptična pseudocilindrična projekcija Kavrajskoga

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet

Kavrayskiy, V. V. (1958): Izbrannyye trudy, Tom II; Matematicheskaya kartografiya, Vyp. 1, Obshchaya teoriya kartograficheskih proyektsiy, Izdaniye Upravleniya nachal'nika Gidrograficheskoy sluzhby VMF

Kavrayskiy, V. V. (1959): Izbrannyye trudy, Tom II; Matematicheskaya kartografiya, Vyp. 2, Konicheskie i tsilindricheskie proyektsiyi, ih primeneniye, Izdaniye Upravleniya nachal'nika Gidrograficheskoy sluzhby VMF

Kavrayskiy, V. V. (1960): Izbrannyye trudy, Tom II; Matematicheskaya kartografiya, Vyp. 3, Perspektivye, krugovye i drugie vazhneyshiye proyektsii. Navigatsionnye zadachi, Izdanie Upravleniya nachal'nika Gidrograficheskoy sluzhby VMF

URL: Astronomical Institute of Kharkov National University , http://www.astron.kharkov.ua/history/index.htm, 28.2.2007

Nicolas Auguste Tissot

(19th century)

French cartographer

He published his research on analyses of the distortion that occurs on map projections in 1859 and 1881. He devised the ellipse of distortion which indicates how the scale changes in every direction at a given point. This ellipse was named the *Tissot indicatrix* after him. Additionally, was pursued research studies of the projections which are best suited for representation of a certain part of the Earth's surface. One of the external perspective projections is called the *Tissot projection* after him. For the representation of relatively small parts of the Earth's surface in a plane, with minimal deformations of angles and lengths, Tissot proposed a specific projection, which was named after him the *Tissot compensational projection*.

Nicolas Auguste Tissot

(19. stoljeće)

Francuski kartograf

Godine 1859. i 1881. objavio je svoja istraživanja o analizi deformacija koje se pojavljuju pri kartografskim projekcijama. Uveo je elipsu deformacija koja pokazuje kako se mijenja mjerilo u jednoj točki u različitim smjerovima. Ta je elipsa po njemu nazvana *Tissotova indikatrisa*. Osim toga bavio se istraživanjem takvih projekcija koje su najpogodnije za prikaz određenoga dijela Zemljine plohe. Jedna od vanjskih perspektivnih projekcija naziva se po njemu *Tissotova projekcija*. Za prikazivanje relativno manjeg dijela Zemljine plohe u ravnini, a sa što manjim deformacijama kutova i duljina, Tissot je predložio posebnu projekciju koja je po njemu nazvana *Tissotova kompenzativna projekcija*.

The Tissot indicatrix and perspective projection
Tissotove indikatrise i perspektivna projekcija
Source / Izvor: http://de.wikipedia.org/wiki/Tissotsche_Indikatrix

Source / Izvor

Borčić, B. (1955): Matematička kartografija, (Kartografske projekcije), Tehnička knjiga, Zagreb
Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet
Snyder, J. P., Voxland, P. M. (1989): An Album of Map Projections, USGS Professional Paper 1453. U.S. Geological Survey, Denver
Tissot, A. (1881): Mémoire sur la représentation des surfaces et les projections des cartes géographiques, Gauthier-Villars, Paris
Tissot, A. (1887): Die Netzentwürfe geographischer Karten nebst Aufgaben über Abbildung beliebiger Flächen auf Einander, Autorisierte Deutsche Bearbeitung mit einigen Zusätzen bezorgt von E. Hammer, J. B. Metzlersche Buchhandlung, Stuttgart
URL: Wikipedija – slobodna enciklopedija (englesko izdanje), http://en.wikipedia.org/wiki/Nicolas_Auguste_Tissot, 26.2.2007.

Edward N. Gilbert

Edward N. Gilbert

American mathematician

American mathematician Edward N. Gilbert was the first (1973) to invent and construct a sphere that contained conformal projected sphere on each of its hemispheres. This sphere is named after him *Gilbert's globe.* Gilbert's globe can be projected into the plane by means of perspective or orthographic projection and accordingly one can obtain the *Gilbert projection*. With its round shape, this projection reminds of the globe, and at the same time it represents the whole Earth's surface.

Američki matematičar

Prvi je (1973) zamislio i konstruirao sferu koja na svakoj od dviju hemisfera sadrži konformno preslikanu sferu. Takva se sfera po njemu naziva *Gilbertovim globusom*. Gilbertov globus moguće je zatim s pomoću perspektivne ili ortografske projekcije projicirati u ravninu i dobiti *Gilbertovu projekciju*. Ta projekcija svojim okruglim oblikom podsjeća na globus, a istodobno prikazuje cijelu Zemljinu plohu.

The Gilbert projection
Gilbertova projekcija

Source / Izvor

Frančula, N. (2000): Kartografske projekcije, skripta, Sveučilište u Zagrebu, Geodetski fakultet
Lapaine, M., Frančula, N. (1993): Gilbert two-world projection. Proceedings, Volume 1 of the 16th International cartographic conference, Cologne 3-9 May 1993, Bielefeld, 66-82.
Lapaine, M., Sudeta, N., Frančula, N. (1994): Gilbert's globe. Proceedings of the 6th international conference on computer graphics and descriptive geometry, Vol. 1, Tokyo, 154-158.
Lapaine, M., Sudeta, N., Frančula, N., Vidović, R. (1995): Gilbert projection and Gilbert globe. Raum und Zeit in Umweltinformations-systemen, 9th International symposium on computer science for environmental protection CSEPN95, Teil II. Metropolis-Verlag, Marburg, 870-871.
Lapaine, M., Frančula, N. (1992): Modificirana Gilbertova projekcija. CAD Forum '92, Kompjutor u obnovi Hrvatske, Zbornik radova, CAD Sekcija SAH, Zagreb, 159-164.
URL: Gallery of map projections, http://www.galleryofmapprojections.com/Miscellaneous/Gilbert_Orthoapsidal.pdf, 27.2.2007.
URL: Lapaine, M: Kartografske projekcije, http://www.kartografija.hr/projekcije_dugo.pdf, 27.2.2007.
URL: Map making, http://www.wendycarlos.com/maps.html, 27.2.2007.

3 Procedure of Creating World Maps

Map projection is the method of projecting points from a surface of ellipsoid or a sphere into a plane. It is mostly defined by map projection equations $x = f_1(\varphi, \lambda)$, $y = f_2(\varphi, \lambda)$, where φ, λ are geographic coordinates on the ellipsoid or sphere, and x, y the coordinates in the projection plane. These equations, or functions f_1 and f_2 determine the properties of map projections. In practice, there are several hundred cartographic projections in use and in the next chapter the world is presented in some projections which are named after their authors or inventors.

For creating these world maps in a selected projection, it is necessary to have data about the graticule in vector form, geocoded raster data of texture for the whole world and vector data about the projection's frame. Input vector data are prepared in the AutoCad program and saved as a .dwg file. Raster data of texture for the whole world were obtained from the SRTM2 height data file (resolution 303 x 303). These are the data from international satellite mission Shuttle Radar Topography Mission (SRTM) and they are available on the Internet.

Transforming vector data from one projection to another is achieved by solving equations of direct cartographic problem:

$$x = f_1(\varphi, \lambda)$$

$$y = f_2(\varphi, \lambda)$$

where φ, λ are geographic coordinates on the ellipsoid or sphere, and x, y coordinates in projection plane. In case of raster data, pixels should be restructured so that they correspond to the position in certain map projection, and the whole procedure is comprised of transformation and resampling. Transformation of raster data is achieved by solving equations of inverse cartographic problem:

$$\varphi = g_1(x, y)$$

$$\lambda = g_2(x, y)$$

The principle used to resample raster is as follows. A mosaic of pixels is established in the transformed plane. Pixels in raster matrix have row and column coordinates. But, in the plane, each pixel occupies one part of it, i.e. infinite number of points. Hence it is necessary to select one point, and most often that point is the barycenter of square or rectangle which represents the pixels. Coordinates of these points in the original projection are calculated by inverse transformation, and then some resampling method is used to determine the value for these points (that in the most cases no longer overlap with barycenters of pixels in the original plane).

GRASS (Geographic Resources Analysis Support System) is open source GIS with possibility of processing raster and vector data, and it works on different operating systems. Since the raster data for the whole world are given in geographic coordinates, to accept these coordinates it is necessary to define a new geographic location. A geographic location is some geographic extent of interest that contains data sets that must all be in the same coordinate system. For the new geographic location, new coordinate system (map projection, datum or ellipsoid/sphere), working area and resolution are assigned. Vector data (frame, grid) and raster data (texture) are loaded in created geographic location.

Since raster data are given in geographic coordinates, and computer programs do not accept geographic coordinates, it is necessary to define a new, target coordinate system, which corresponds to equidistant cylindrical projection.

In order to transform loaded data (that are presented in equidistant cylindrical projection) into the selected projection, one should create a new geographic location in that projection. Firstly, in created geographic location, vector frame is transformed from one projection into another using module *v. proj* and the area that includes transformed frame is defined. Afterwards follows transformation of raster. Module *r. proj* reads world map in the equidistant cylindrical projection from the previously created geographic location, transforms raster in selected projection and saves it in current geographic location. Cubic interpolation was selected for resampling method of projected raster. Transformed frame from the vector form needs to be transformed into raster map.

Afterwards, using module *r.mapcalc,* calculations on the raster map are performed in order to remove the area which is out of frame. The graticule needs to be transformed into the selected projection as well. Created world raster in selected projection is saved as geocoded format *.tiff*, and the vector graticule as *.dxf*.

Finally, world raster and graticule in selected projection are loaded into CorelDraw. CorelDraw is graphic software which supports data input and processing in vector and raster form. Overlapping of raster image and graticule is performed, and the final appearance of illustration is achieved using different image editing tools.

5 Conclusion

The beginnings of map projections date as far as two thousand years ago, originating from the time when the old Greek scientists introduced mathematical principles into the basis of projecting the Earth and starry sky and started to apply the graticule. It is believed that Thales of Miletus made the first map in a projection 600 years B.C. It was a map of the heavenly sphere in the gnomonic projection. Stereographic and orthographic projections belong to the oldest projections and were used by the Greek astronomer and mathematician Hipparchus for the purpose of making maps of the heavenly sphere about 150 B.C. Hundreds of map projections have been invented so far.

Since each geographic map is made in a certain map projection, one can come to a conclusion that map projections are especially important in creating geoinformation systems. In the creation of national digital bases of geodetic, topographic and cartographic data that must

4. Postupak izrade karata svijeta

Kartografska projekcija je način preslikavanja točaka s plohe elipsoida ili sfere u ravninu. Najčešće se zadaje osnovnim kartografskim jednadžbama $x = f_1(\varphi, \lambda)$, $y = f_2(\varphi, \lambda)$, gdje su φ, λ geografske koordinate na elipsoidu ili sferi, a x, y koordinate u ravnini projekcije. Te jednadžbe, odnosno funkcije f_1 i f_2 određuju svojstva kartografskih projekcija. U praksi se upotrebljava nekoliko stotina kartografskih projekcija, a u prethodnom poglavlju prikazan je svijet u nekim projekcijama koje nose ime svojega autora ili pronalazača.

Za izradu tih karata svijeta u izabranoj projekciji bilo je potrebno imati podatke o geografskoj mreži u vektorskom obliku, georeferencirane rasterske podatke teksture za cijeli svijet i vektorske podatke o okviru projekcije. Ulazni vektorski podaci pripremljeni su u programu AutoCAD i spremljeni u *.dwg* datoteku. Rasterski podaci teksture za svijet dobiveni su iz datoteke visina SRTM2 (rezolucije 303 × 303). Riječ je o podacima međunarodne satelitske misije Shuttle Radar Topography Mission (SRTM), koji su dostupni na internetu.

Transformiranje vektorskih podataka iz jedne projekcije u drugu postiže se rješavanjem jednadžbi izravnoga kartografskog zadatka:

$$x = f_1(\varphi, \lambda)$$

$$y = f_2(\varphi, \lambda),$$

gdje su φ, λ geografske koordinate na elipsoidu ili sferi, a x, y koordinate u ravnini projekcije. U slučaju rasterskih podataka potrebno je piksele prestrukturirati tako da odgovaraju položaju u određenoj kartografskoj projekciji, a cijeli se postupak sastoji od transformacije i preuzorkovanja. Transformiranje rasterskih podataka postiže se rješavanjem jednadžbi inverznoga kartografskog zadatka:

$$\varphi = g_1(x, y)$$

$$\lambda = g_2(x, y).$$

Princip koji se primjenjuje pri uzorkovanju rastera je sljedeći. U transformiranoj ravnini uspostavi se mozaik piksela. Pikseli u rasterskoj matrici imaju koordinate retka i stupca. Međutm, u ravnini svaki piksel zauzima jedan njezin dio, tj. beskonačno mnogo točaka. Zato treba izabrati jednu točku, a najčešće je to težište kvadrata ili pravokutnika koji predstavljaju piksel. Inverznom transformacijom izračunaju se koordinate tih točaka u početnoj projekciji, a zatim se nekom metodom uzorkovanja tim točkama (koje se najčešće više ne poklapaju s težištima piksela u početnoj ravnini) odredi vrijednost.

GRASS (Geographic Resources Analysis Support System) je slobodni GIS s mogućnostima obrade rasterskih i vektorskih podataka, a radi na različitim operacijskim sustavima. Budući da su rasterski podaci za cijeli svijet dani u geografskim koordinatama, za prihvaćanje tih koordinata potrebno je definirati novi geografski prostor. To je prostor od interesa koji sadrži skup podataka što se nalaze u istom koordinatnom sustavu. Za novi geografski prostor zadaje se koordinatni sustav (kartografska projekcija, datum ili elipsoid/sfera) te radno područje i razlučivost. U kreirani geografski prostor učitaju se vektorski podaci (okvir, mreža) i rasterski podaci (tekstura).

Budući da su rasterski podaci dani u geografskim koordinatama, a računalni programi ne prihvaćaju geografske koordinate, potrebno je definirati novi, odredišni koordinatni sustav koji odgovara ekvidistantnoj cilindričnoj projekciji.

Kako bi se učitani podaci koji se nalaze u ekvidistantnoj cilindričnoj projekciji transformirali u izabranu projekciju potrebno je kreirati novi geografski prostor u toj projekciji. Najprije se u kreiranom geografskom prostoru vektorski okvir transformira iz jedne projekcije u drugu s pomoću modula *v.proj* i zada se područje koje obuhvaća transformirani okvir. Nakon toga slijedi transformiranje rastera. Modul *r.proj* čita kartu svijeta u ekvidistantnoj cilindričnoj projekciji iz prije kreiranoga geografskog prostora, transformira raster u izabranu projekciju i sprema ju u trenutačni geografski prostor. Za metodu uzorkovanja projiciranog rastera odabrana je kubična interpolacija. Transformirani okvir iz vektorskog oblika potrebno je pretvoriti u rastersku kartu.

Nakon toga s pomoću modula *r.mapcalc* provode se računanja na rasterskoj karti kako bi se uklonilo područje koje se nalazi izvan okvira. Mrežu meridijana i paralela također je potrebno transformirati u izabranu projekciju.

Izrađeni raster svijeta u izabranoj projekciji sprema se u geokodiranom formatu *.tiff*, a vektorska mreža meridijana i paralela u formatu *.dxf*.

Na kraju, raster svijeta i mreža meridijana i paralela u izabranoj projekciji učitani su u CorelDraw. To je grafički program koji podržava unos i obradu podataka u vektorskom i rasterskom modu. Izvršeno je preklapanje rastera i mreže, a konačan izgled ilustracije postignut je upotrebom različitih alata za obradu slike.

5. Zaključak

Počeci kartografskih projekcija stari su oko dvije i pol tisuće godina, otkad su grčki znanstvenici prvi uveli matematičke principe u temelje preslikavanja Zemlje i zvjezdanoga neba te počeli primjenjivati mrežu meridijana i paralela. Smatra se da je prvu kartu u nekoj projekciji izradio Tales iz Mileta 600. godine pr. Kr. Bila je to karta nebeske sfere u gnomonskoj projekciji. Među najstarije se projekcije ubrajaju stereografska i ortografska koje je upotrijebio poznati grčki astronom i matematičar Hiparh, također za izradbu karata nebeske sfere oko 150. godine pr. Kr. Od toga doba do danas izumljeno je nekoliko stotina kartografskih projekcija.

Budući da se svaka karta izrađuje u određenoj kartografskoj projekciji, može se zaključiti da su kartografske projekcije važne i u današnje doba pri stvaranju geoinformacijskih sustava. Pri stvaranju nacionalnih digitalnih baza geodetskih, katastarskih, topografskih i kartografskih podataka, koje moraju činiti temelj svakoga GIS-a što se radi za područje cijele države, važna je metoda digitalizacije make the foundations of each GIS being prepared for the territory of the entire state, the method of digitising existing maps is very important. In the application of this module, it is necessary to be familiar with the map projection of the origin and projection constants.

Hence, the computer aided method in the map production and first of all geoinformation systems have not reduced, but increased the importance of map projections. More than 1000 works on map projections published after 1960 and registered in the bibliography of Snyder and Steward (1988) prove that this statement is correct.

Many important persons gave their contribution to development of theory and practice of map projections through the history. In scripts written by professor Frančula (2000, 2004) on map projections, more than 100 individuals were mentioned by whose credit today we have a great number of map projections and possibility of their usage. In this paper, basic information about around twenty persons important for the development of map projections over two and a half millennia were gathered and arranged.

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postojećih karata. U primjeni toga postupka nužno je poznavati kartografsku projekciju izvornika i konstante projekcije.

Kompjutorski podržane metode u izradbi karata i poglavito geoinformacijski sustavi nisu umanjili, nego su povećali važnost kartografskih projekcija. Da je ta tvrdnja točna svjedoči više od 1000 radova o kartografskim projekcijama objavljenih nakon 1960., a registriranih u bibliografiji Snydera i Stewarda (1988).

Mnoge značajne osobe dale su tijekom povijesti svoj prinos razvoju teorije i prakse kartografskih projekcija. U skriptama prof. Frančule (2000, 2004) navedeno je više od 100 pojedinaca zaslugom kojih je danas dostupan velik broj kartografskih projekcija i mogućnost njihove uporabe. U ovome radu prikupljeni su i obrađeni osnovni podaci o dvadesetak osoba značajnih za razvoj kartografskih projekcija kroz dva i pol tisućljeća.

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