Преглед НЦД 13 (2008), 74–90

Nadežda Pejović and **Žarko Mijajlović**
Faculty of Mathematics
University of Belgrade

REVIEW OF THE DIGITIZED BOOK *FUNDAMENTALS OF MATHEMATICAL AND PHYSICAL GEOGRAPHY* BY PAVLE VUJEVIĆ

Abstract. The book *Fundamentals of Mathematical and Physical Geography* (in Serbian *Основи математичне и физичке географије*) is one of the first university textbooks on geography written in Serbian. The author of the book is Pavle Vujević (1881-1966), a notorious Serbian climatologist, Professor at the Belgrade University and member of the Serbian Academy of Science and Arts. The book consists of two volumes and it was printed several years after the First World War. For many generations of students of geography this textbook was an entering point into mathematical and physical geography and astronomy. This book is rather comprehensive; it consists of 815 pages and four sections. The first volume is made up of two sections, *Mathematical Geography* and *Physical Geography*, while the second volume covers *The atmosphere* and *Oceans*. The first book is in fact an introduction into astronomy. It covers in details all basic notions and facts of this science known at the time when the book was written. In the second volume there are explanations of the chemical composition of the Earth's atmosphere, climate types and their secular changes, then composition and physical characteristics of World oceans, the ebb-tide phenomena and the characteristics of the seabed. The book is digitized and it is included into the NCD *Virtual library* (http://elib.matf.bg.ac.yu:8080/virlib/). We present the contents of the book, also some interesting facts related to the book, including changes in terminology and definitions in this area since the book was published.

Key words: mathematical geography, geophysics, atmosphere, oceans

Introduction

We consider that one of the significant aims of digitization is to describe and comment digitized items. On this occasion we decided to write about an important university textbook which influenced a lot of development and a way of teaching of mathematical geography in Serbia at the university level. This is the book *Fundamentals of Mathematical and Physical Geography* (in Serbian *Основи математичне и физичке географије*), written by Professor Pavle Vujević. The book is one of the first university textbooks on geography written in Serbian and it was printed several years after the First World War in the newly built Kingdom of Serbs, Croats and Slovenienes.

In the country pauperized and destroyed by war it was difficult to find a foreign university textbook. Therefore, it was necessary to write own textbooks. Having written this textbook Pavle Vujević fulfilled this purpose. The book was printed, as its author mentions in the Preface, due to the great engagement of Jovan Cvijić who was then Rector of the Belgrade University. The textbook *Основи математичне и физичке географије* consists of two parts organized in the framework of four chapters. The first part *Математична географија* (Mathematical Geography) contains only one chapter with the same title, whereas in the second part *Физичка географија* (Physical Geography) there are three chapters: *Геофизика* (Geophysics), *Атмосфера*

(Atmosphere) and *Океани* (Oceans). The textbook was printed in two volumes with a total of 815 pages. The first volume contains the first two chapters, the second one the third and fourth chapters. The first volume *Математична географија и Геофизика* was printed in the Printing House of the Kingdom of Serbs, Croats and Slovenes in Belgrade in 1923, whereas the second volume *Атмосфера и Океани* was printed in the same printing house in 1926. Since Pavle Vujević was educated in Western Europe and knew foreign languages, in the course of writing this textbook the very contemporaneous textbook and scientific literature was used.

Contents of the Volumes

The first volume *Математична географија и Геофизика* contains 348 pages and it consists of an Introduction, first and second chapters. The first chapter *Математична географија* has 15 sections, whereas the second chapter *Геофизика* has six sections. The first chapter *Математична географија* is composed of the following sections: *Оријентација на хоризонту* (Horizon Orientation), *Оријентација на небу* (Orientation on the Sky), *Облик и величина Земље* (Shape and Size of the Earth), *Оријентација на Земљиној површини* (Orientation on the Earth Surface), *Географско одређење места на Земљи* (Geographic Determination of a Position on the Earth's Surface), *Појмови о светском систему* (Notions on the World System), *Закони планетарног кретања* (Laws governing Planetary Motions), *Карактеристика планетарних путања* (Characteristics of Planetary Orbits) , *Одређивање звезданих удаљења* (Determination of Distances to Stars), *Земљина кретања* (Motions of the Earth), *Положај Земље и Земљине осовине према еклиптици* (Positions of the Earth and its Axis with respect to Ecliptics), *Гравитациони утицај небеских тела на Земљина кретања* (Gravitational Influence of Celestial Bodies on the Motions of the Earth), *Време и одређивање времена* (Time and its Determination), *Апсолутно кретање Сунчевог система* и *непомичних звезда* (Absolute Motion of the Solar System and immovable stars) and *Положај Земље у васиони* (Earth's Position in the Universe). The second chapter *Геофизика* is composed of the following sections: *Земљина густина и маса* (The density and Mass of the Earth), *Земљина кора и језгро* (The Crust and Core of the Earth), *Подела копна и мора* (Subdivision of Land and Sea), *Земљотреси* (Earthquakes), *Земљина магнетичност* (Terrestrial Magnetism) and *Електрицитет у ваздуху и земљи* (Air and Ground Electricity).

The second volume *Атмосфера и Океани* has 467 pages numerated as continuation of the first one by numbers from 349 till 815. It contains the third and fourth chapters.

The third chapter *Атмосфера* has 11 sections; the fourth one *Океани* has seven sections. The third chapter *Атмосфера* is composed of the following sections: *Општи појмови о ваздуху* (General Notions about the Air), *Топлота* (Heat), *Температуре* (Temperatures), *Вертикална и хоризонтална подела температура* (Vertical and Horizontal Subdivisions of Temperatures), *Ваздушни притисак* (Air Pressure), *Ветрови* (Winds), *Кружење воде* (Water Circulation), *Поремећаји у ваздуху* (Perturbations in the Air), *Климатски типови* (Climate Types), *Периодске промене климата на Земљи* (Periodical Climate Changes on the Earth) and *Географска подела животиња и биљака на копну* (Geographic Subdivision of Animals and Plants on Land). The fourth chapter *Океани* (Oceans) consists of the following sections: *Топографија океана* (Topography of Oceans), *Хемијски састав и физичке особине океанске воде* (Chemical Structure and Physical Properties of Oceans Water), *Живот у океанима* (Life in Oceans), *Састав океанског дна* (Structure of Ocean Floor), *Таласи* (Waves), *Океанске струје* (Ocean Currents) и *Плима и осека* (Tide and Ebb).

Already a mere inspection of these titles indicates that Vujević's textbook is comprehensive and large. In addition to geography it also treats in details other sciences overlapping with it: astronomy, meteorology, climatology, oceanography and geophysics. For a majority of notions their historical roots are given which is rarely the case for modern textbooks. With regard to the enormous quantity of information and use of the very contemporaneous references for that time Vujević's textbook has all properties of an encyclopedia. In addition to all of this it contains many nice illustrations.

Biography of Academician Pavle Vujević

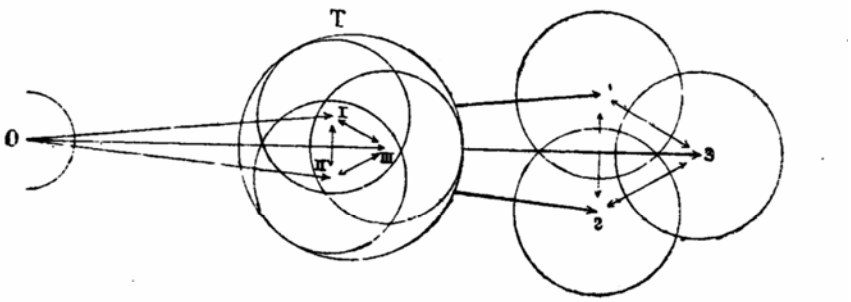
Pavle VUJEVIĆ (1881–1966)

Pavle Vujević (1881–1966) was born in Ruma. His education started in Novi Sad where he finished the Serbian Orthodox Gymnasium in 1899. He studied geography in Vienna at *Wiener Geographische Schule* (Vienna School of Geography) *famous* in that time. During his stay in Vienna he made acquaintance and became friend of Milutin Milanković who was then also a student. After finishing his studies he wrote his PhD thesis in geography. He took his PhD degree in 1904 at the age of 23. He improved his knowledge in climatology in Berlin and Potsdam. Invited by Jovan Cvijić he came to Belgrade in 1907 to become an assistant-professor on the subject of climatology and meteorology at the Faculty of Philosophy of the Belgrade University founded shortly before. After the retirement of its Director Milan Nedeljković the Astronomical and Meteorological Observatory was divided into two separate establishments. Vojislav Mišković was appointed as Director of the Astronomical Observatory, whereas Pavle Vujević became Director of the Meteorological Observatory. With his textbook *Основи математичне и физичке географије* Vujević contributed significantly to the improvement of teaching geography and meteorology at the Belgrade University. This textbook served to numerous generations of students for the purpose of learning not only geography and meteorology, but also climatology, oceanography, geophysics and geodesy. More details con-

cerning Vujević's biography can be found in [**6**]. A full member of the Serbian Academy of Sciences and Arts he became in 1958.

The First Volume: Mathematical Geography And Geophysics
I Part: *Mathematical Geography*

In Introduction**,** Vujević presents Laplace's hypothesis about formation of the Solar System and the planet Earth [Fig. 1]. (The references to the plots contained in the present article the reader can find in the digital copy of Vujević's book at the following address http://elib.matf.bg.ac.yu:8080/virlib/). He gave a short presentation of the development of natural studies, as well as their relationship with geography. In his second figure he presents a nice plot from which it is seen that *astronomy* appears as a cradle of studying nature. The Earth as a celestial body occupies the central point in this and together with many other celestial bodies appears as the subject in astronomical studies.



Скица 2.

Plot 2 Explanation T=Earth

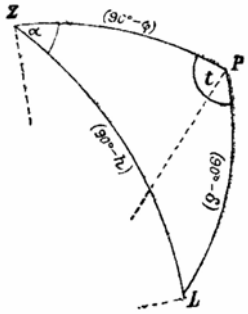
O = astronomy	I. Land Geology	1. Geomorphology (physical geography
= physics	II. Waters Hydrology	2. Oceanography
= chemistry	III. Air=Meteorology	3. Climatology

On the other hand, in geography the basic subject is the terrestrial spheres. In this science the outer terrestrial envelops, land, water and air, are presented as spheres [Fig. 2] intersecting one another, thus appear as the point of overlapping of scientific disciplines studying them. These disciplines are *geology, hydrology* and *meteorology.* Their mutual influences have contributed to developing of new scientific branches: *geomorphology, oceanography* and *climatology,* also presented by circles in Fig. 2. Just this relationship is described in Vujević's book. This textbook was an indispensable reading to many generations of students of many specialties whose interest included not only geography, but astronomy, meteorology, climatology, oceanography, geophysics and geodesy as well.

In the first chapter *Математичка географија* Vujević presents systematically the most part of what was known in astronomy then. He described the Earth, as a planet of the Solar System, in details: its formation, shape, size, motions, orientation, mass, density, day-night cycle, twilights, cycle of annual seasons, gravitation, seismity, its position among the planets, as well as the position of the Sun among stars. For this reason this chapter could be equally entitled as *Astronomy.*

In the first section of this chapter *Оријентација на хоризонту* one introduces and describes the following notions: sky line, horizon, main points of the horizon, gnomon and determination of distances and direction at the horizon.

In the second section *Оријентација на небу* one presents the astronomical spherical coordinate systems: horizon, equatorial and ecliptic ones and the relations between the horizon and equatorial coordinates and between the equatorial and ecliptic ones. In the book motions of stars, culmination and circumpolar stars are also mentioned. In addition, the apparent motion of the Sun and zodiac constellations through which the Sun passes apparently within a year following a great circle across the celestial sphere, the ecliptic, are also described. The descriptions are more frequent than the formulae. For instance, the apparent diurnal paths of stars and their upper culminations for an observer at the North Terrestrial Pole, Equator and a medium latitude are plotted in [Fig. 9].



Скица 12.

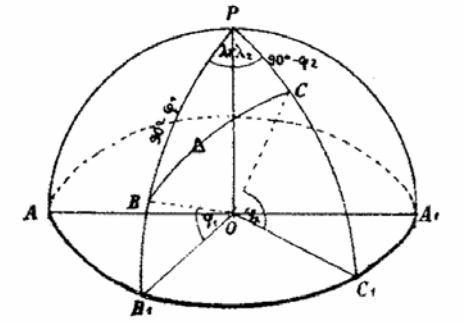
The author probably supposed that the descriptive way was more acceptable to most of the students who possessed a modest mathematical knowledge. It is curious that the spherical triangle in [Fig. 12] is referred to as *astronomical triangle,* being a better name indeed because that notion was introduced by astronomers. Vujević often gives the origin for many words, i. e. notions, such as, for instance, *tropical belt*. Namely, it is written in the book that the solar *tropics* were used for the first time by Homer in his Odyssey because he writes that the island of Syros, belonging to the Cyclades, lies north of tropical *lands,* thus north of the solar tropic. For this reason the zone between the tropics was named *tropical zone*.

In the third section *Облик и величина Земље* the Earth is modeled as a spherical body. In addition the historical development of this model was presented, including the method of Eratosthenes, Earth measuring by Arabs, the triangulation method of Snellius and Kepler's one. Further on the Earth spheroidal model is mentioned where the proofs for this approximation are given: the Huygens law of centrifugal force, Newton's proofs for the spheroidal shape of the Earth, Cassini's measurements in France, Clairaut's theorem about the Earth's flattening and geodetic measurements in the XIX century. Finally, he presents the Earth's model in the form of geoid giving the proofs for this model by presenting the procedure of measuring the perturbations in the Earth's gravity. He mentions the measurements of the Paris meridian on the basis of which the basic length unit, *meter,* was defined.

The book contains many historical matters of interest. An example is the Earth measuring by *Eratosthenes* (276–194 BC). The distances between two places were expressed then in *stadia* (1 stadion = 158 m) and determined on the basis of camel route. The distance between Alexandria and Asuan was known to Eratosthenes. He knew that in Asuan there was a deep well in which the Sun was reflected only once within a year. Very cutely Eratosthenes concluded that this was the day of summer solstice. Using this astronomical fact he found the perimeter of the Earth to be equal to 39 815 km which is very near the true value. This was a result of a genius. Only in the XVIII century the measurements yielded for the perimeter of the Paris meridian a value of 40 000 km and from it the length unit, *meter,* was derived as $1/(40 \times 10^6)$ the

length of the Paris meridian perimeter. It should be mentioned that in the book for the second pendulum one uses an expression now almost forgotten in the Serbian language. The measurements of the Earth's flattening by using the second pendulum are presented in the table (p. 46 in the book).

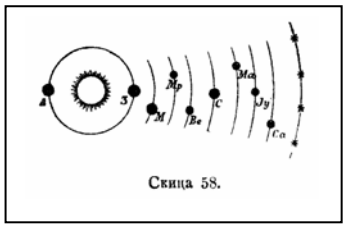
In the fourth section *Оријентација на Земљиној површини* the author presents the network of parallels and meridians, the coordinate system taken from astronomy. Vujević also writes about the distance on the surface of a sphere applied to places on the terrestrial surface, thus the elements of spherical trigonometry are also present.

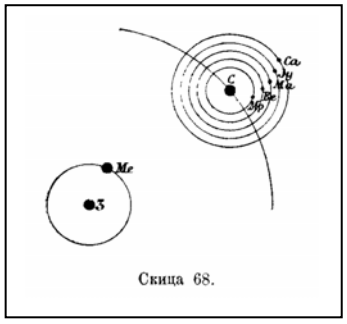


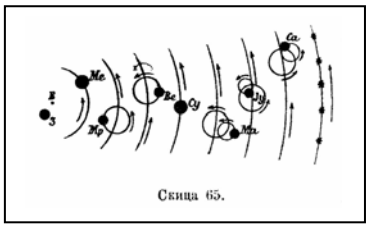
Скица 35.

Of interest is the history of adopting the prime meridian for the Earth described by Vujević on page 55, as well as the origin of the names geographic longitude and latitude, also of the notions of *orthodrom* concerning direction and *loxodrom* concerning slope used in the navigation. In [Fig. 35] the determination of the shortest distance between two places on the terrestrial sphere is presented by using *astronomical triangle* introduced by astronomers for the purpose of determining the angular distances between two celestial bodies on the celestial sphere.

In the fifth section *Географско одређивање места на Земљи* the author derives the methods of determining geographic latitude such as the Horrebow–Talcott, the methods using culminations of stars, circumpolar stars, measuring shadows and measuring time. He also derives the methods of determining geographic longitude: by using light signals, telegraph, chronometer, lunar and solar eclipses, culminations of Moon and eclipses of satellites of other planets. The author presents the methods of geodetic determination of geographic coordinates such as triangulation, spherical excesses and photogrammetry. At the end he presents the procedures for determination of altitude above the sea level: by leveling and by applying trigonometric, barometric and thermometric methods. It is interesting that in this section in addition to the notion of *astronomical refraction* [Fig. 38] the author also mentions that of *terrestrial refraction* [Fig. 39] which arises on the occasion of determining the place positions on the terrestrial surface. One should remind that this phenomenon concerns the light refracted in some air layers without passing through the entire atmosphere of the Earth.


Скица 58.


Скица 68.


Скица 65.

The sixth section *Појмови о светском систему* concerns the historical review of comprehending the world. In the following order the systems proposed by

Pythagoras, Eudox, Hipparchus, Ptolemy, Heraclides, Copernicus, Tycho Brahe and Galileo are mentioned. The authors of the present article have selected a few interesting figures presenting the geocentric systems of Pythagoras [Fig. 58], Hipparchus-Ptolemy [Fig. 65] and Tycho Brahe [Fig. 68]. The heliocentric system of Copernicus is described in details, as well as Galileo's exact proofs which contributed significantly for this system to be generally accepted.

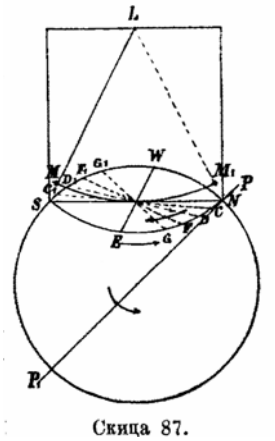
In the seventh section *Закони планетарног кретања* one presents Kepler's laws derived by Kepler empirically and after this Newton's law of general gravitation followed by a description of the way in which Newton obtained Kepler's laws theoretically starting from his gravitation law. The calculation of perturbations and the Titius–Bode progression explaining the heliocentric distances of the planets given in *astronomical units* (distance between Earth and Sun) are also mentioned. In this connection the author mentions the discoveries of minor planet Ceres (1801) and new planet Neptune (1846) where the latter one was discovered *with the point of a pen.*

We should note that this chapter devoted to astronomy was written for students of geography. For this reason the derivation of Kepler's laws from Newton's gravitation law was given descriptively and without any complicated mathematical calculations. We should remind that Newton for the purpose of this derivation introduced *the differential calculus* [Fig. 73].

The eighth section *Карактеристика планетарних путања* concerns general characteristics of planet motions, the motion of planets in the heliocentric reference frame, true motion of the Moon, its phases and the apparent motion of the Moon and finally the eclipses of the Moon and Sun.

The presentation of the true motions of planets is systematic and clear being followed by an explanation of their apparent motions. Of interest is the explanation of the apparent motion for the outer planets (those farther from the Sun than Earth) given by Copernicus and which was the strongest proof of his heliocentric theory. In the case of eclipses Vujević uses words *umbra* and *penumbra* in the Serbian language instead of the corresponding words of Slav origin.

In the ninth section *Одређење звезданих удаљења* the methods for determining the solar parallax are presented: Aristarchus' one, Hipparchus' one and that using planet transits. The trigonometric method of determining the parallax of the Moon and the ones for determining star parallaxes are also presented. To remind: to determine the parallax of a celestial body means to determine its distance. In an interesting paragraph Vujević mentions that Kepler influenced astronomers to observe the transits of Mercury and Venus over the disc of the Sun. As a response to this initiative Halley predicted that the transits of Venus would take place in 1761 and in 1769, whereas Ruđer Bošković on Halley's initiative calculated the positions of places which offered the most favorable conditions of observing this phenomenon. In the book the method, used by Lalande and Lacaille in 1751 for the purpose of determining the distance of the Moon, is also presented. In describing how distances to stars are determined, not only the method of annual parallax is presented, but also that of determining star distances by using relative parallaxes.

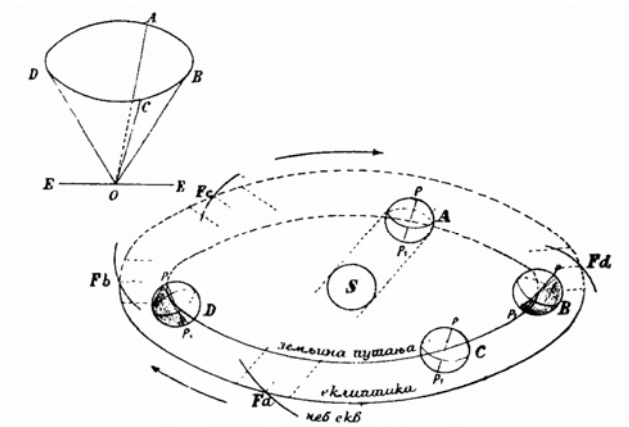


Скица 87.

In the tenth section *Земљина кретања* by using a historical approach Vujević gives proofs in favour of the diurnal motion of the Earth where he presents experiments concerning the terrestrial gravity, flattening of the Earth, free fall and deviations of

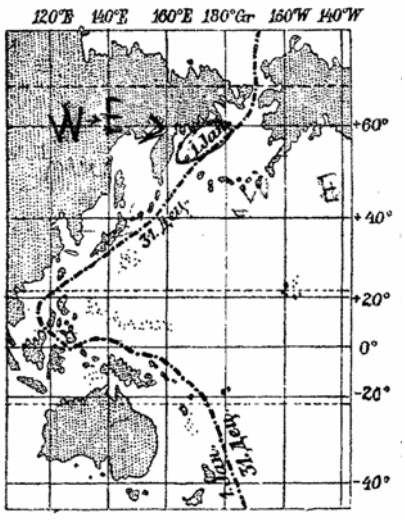
horizontal motions. He also gives proofs in favour of the annual motion of the Earth by mentioning the determination of the annual parallax of stars, light aberration, eclipses of Jupiter's satellites and "shooting stars" or meteors. The plot presenting Foucault's pendulum concerning the terrestrial rotation [Fig. 87] is interesting.

In the eleventh section *Положај Земље и Земљине осовине према еклиптици* the consequences of the diurnal and annual motions of the Earth are described : day-night cycle and cycle of annual seasons. Some terms used by Vujević seem obsolete now. They concern notions like twilights, white nights, etc. Nowadays astronomers define two kinds of twilights: dawn (in the morning) and dusk (in the evening).



Скица 113.

In the twelfth section *Гравитацијони утицај небеских тела на Земљина кретања* the author describes periodical perturbations, precession, nutation and motion of the Earth's poles, as well as secular perturbations, oscillations of ecliptic inclination, motion of line of apsides, changes of eccentricity of the Earth's orbit. In this section the precessional and nutational motions of the terrestrial rotation axis, [Fig. 113] and [Fig. 114], as well as the motion of the terrestrail poles [Fig. 117], are described.



Скица 125. — Датумска граница до 1845. године.

In the thirteenth section *Време и одређивање времена* the author presents the systems of sidereal time and of mean solar time, to describe the astronomical concept of year (tropic, sidereal, lunar, civil), notion of month (sidereal, synodic, tropic, draconistic, calendar) and the two calendars, Julian and Gregorian, afterwards. Further on the systems of local, international and zonal times, as well as the International Date Line, named also *nautical date line* by him, are described. In [Fig. 125] the International Date Line used by 1845 is presented. From 1845 the meridian opposite to the Prime Meridian has been adopted as the new International Date Line.

In the fourteenth section *Апсолутно кретање Сунчевог система и непомичних звезда* unlike the preceding ones, the topic is the true motion of the Solar System

where the coordinates of the apex of that motion are given. The true motions of stars, in astronomy known as their proper motions, are also mentioned. Herschel's very interesting method based on plots [Fig. 128] for determining the positions of the apex and antiapex for the motion of the Solar System is also present in this book.

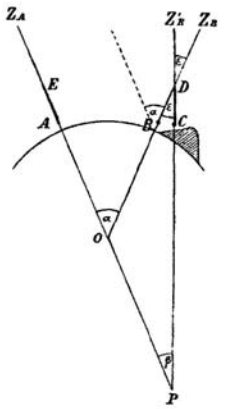
In the fifteenth section *Положај Земље у васиони* the author gives the idea of distances both within the Solar System and also of enormous ones within our Galaxy. After this there is a description of the structure of our Galaxy, of star types, star luminosities, of star clusters and nebulae.

The way in which Vujević tries to inform the readers on enormous distances in the universe is very interesting. The distances within the Solar System are described through the time needed to a human being (speed 30 km per day) and a train (speed 60 km per hour) to travel them. In this way one obtains that a walking human being needs 36 years to reach the Moon and a rapid train 9 months. In another example a person would walk to reach the Sun 13,600 years, a rapid train 285 years. The space of the Solar System is compared wth a vast desert in which a few bodies, like oases, can be found at some places. However, a real desert, according to him, could be the Milky Way only, because the distance between the Sun and the nearest star is 200,000 times that between the Sun and the Earth.

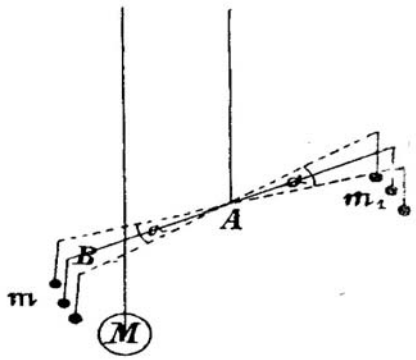
II Part: *Physical geography*

The part of the book *Физичка географија* occupies in Vujević's book a much larger space than *Математична географија.* Whereas Математична *географија* coincides with the first chapter, *Физичка географија* comprises the second (*Геофизика*), the third (*Атмосфера*) and the fourth (*Океани*) ones.

Second Chapter *Geophysics*. Geophysics is the science studying the interior of the Earth, its density, mass, the state of heat in the core and the terrestrial magnetism. The basic task of geophysics is, as said by Vujević, the determination of the Earth's density.



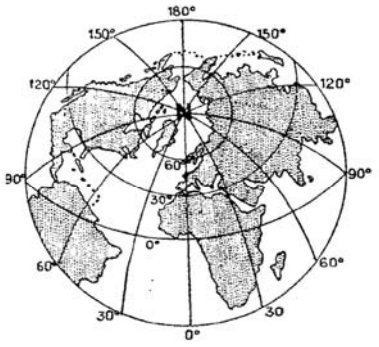
Скица 130.



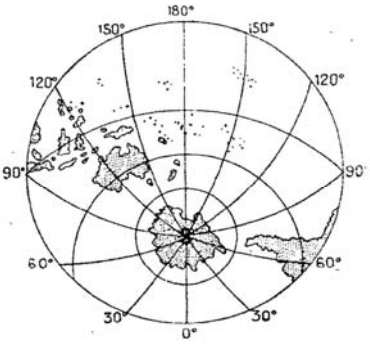
Скица 131.

The first section of this chapter *Земљина густина и маса* concerns the methods of determining the density and the mass of the Earth. In the book one finds interesting descriptions of the first methods which is practically absent in modern textbooks. An example is on p. 197 where one presents Sir Isaac Newton's (1643–1727) procedure of determining the density and mass of the Earth on the basis of the plumb deflection

in the vicinity of a hill. On p. 198 one finds the *torsion balance method* [Fig. 131] proposed by Henry Cavendish (1731–1810) in late XVIII century.



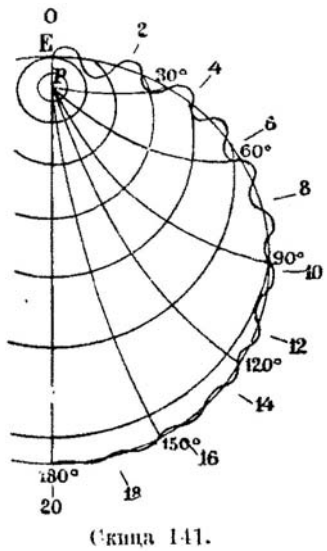
Слика 136. — Копнена земљина полукугла



Слика 137. — Водена земљина полукугла.

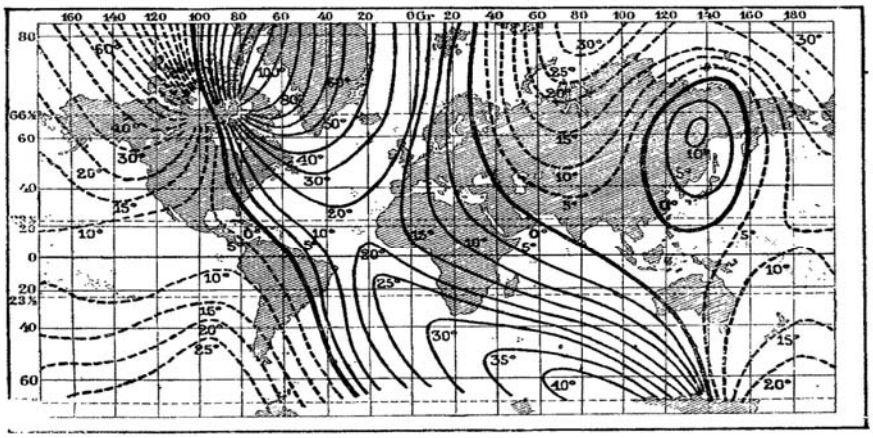
In the second section *Земљина кора и језгро* the composition of the Earth's crust and its density are described, then the chemical composition of the core and its density. Here one finds the explanations and data on the pressure and temperature in the Earth's interior, also on the elasticity of the Earth, as well as on the non-uniform distribution of gravity on the Earth and isostasy. The origin of oceans, mountains and volcanoes is described. Vujević also writes about less known phenomena. For instance, on p. 220 one finds that due to the action of the Moon and Sun in addition to the two diurnal water tidal waves (well known) there are also in the Earth's crust two ground tidal waves (less known) causing the ground beneath our feet to move alternatively up and down twice a day with a difference of 20 cm.

In the third section *Подела копна и мора* the horizontal and vertical distributions of the land and sea on the terrestrial surface are presented. Vujević's description of the land-sea distribution is interesting [Fig. 136, Fig. 137]. In the former figure it is seen that the land hemisphere of the Earth contains more water (54.5%) than land (45.5%), whereas the water hemisphere is dominated by water with 88.7%, land is 11.3% only. In the same figures one finds that the pole of the land hemisphere is situated somewhere between London and Paris, whereas the pole of the water hemisphere is east of New Zealand.



Слика 141.

In the fourth section *Земљотреси* the elements of the earthquake field are described in an illustrative way, the propagation of an earthquake and the instruments for its measuring. The phenomena concerning earthquakes are presented in details: seismic waves and earthquake phases, duration and power of an earthquake, seismic activity, the size and form of the area under earthquake and frequency of earthquakes. The ways of determining the epicentre and hypocentre are described, as well as the causes and periods of earthquakes, also seismic areas on the Earth. Here one finds that on the Earth on the average 26,000 earthquakes a year take place, i.e., 70 a day. In [Fig. 141] the way of earthquake propagation is presented, also types of internal and external waves, as well as the epicentre and hypocentre.



Скица 145. — Изогоне за почетак 1900. год. (по Neumayer-у). — Линије западних (——) и источних (– – –) деклинација.

In the fifth section *Земљина магнетичност* the elements of terrestrial magnetism and the determination of the magnetic intensity are presented. The regular and irregular terrestrial magnetic fields are described, as well as the local and regional areas of a perturbation, then variations in the terrestrial magnetism: secular, annual, diurnal followed by the theories of their origin and magnetic perturbations. The influence of the Sun on the terrestrial magnetism is explained: eleven-year period, 27-days period and the causes of magnetic perturbations. A description of the solar magnetic field is given and hypotheses on the origin of the terrestrial magnetic field.

At this place one finds interesting notes concerning the etymology of the word *magnet*. Namely, on p. 288 one finds that as early as in the Antiquity a stone capable of attracting small iron objects was known. The stone was named magnetite after the locality of Magnesia in Asia Minor where it was discovered. Further on, on p. 289 there is a note that Chinese as early as in the tenth century BC knew the properties of magnetic needle, that its point is always directed towards the north, but that it is unknown if this knowledge was used in everyday practice. One finds that the sailors from the XII century began to use the magnetic needle for the purpose of orientation. In addition, Vujević says that in the XV century Christopher Columbus navigating in the Atlantic Ocean discovered what we call today magnetic declination, the angle between a meridian on the surface of the Earth and the direction of magnetic needle. The lines along which the magnetic declination has the same value are known as *isogones* (*isogonic lines*). In Fig. [145] the complicated system of isogones is presented because the geographic and magnetic poles of the Earth do not coincide. From this figure it is seen that the north magnetic pole is in the arctic part of North America.

Скица 158. — Поларна светлост у облику драперије.

In the sixth section *Електрицитет у ваздуху и земљи* the author describes the elements of electricity, changes of tension, theory of ions, the annual and diurnal runs of electricity, then electricity in land and air, as well as the causes of positive electricity in the air and negative one in land. The part of the sixth section *Поларне светлости* (*Aurorae Borealis*) is of special interest. In it one describes the types of aurorae, their altitude, physical properties, as well as the geographic distribution. Their diurnal and annual periods, as well as the influences of the Sun

and the Moon on the frequency of their occurring, are presented. The hypotheses on the origin of this interesting and beautiful phenomenon are also included.

Second Volume: *Atmosphere and oceans*

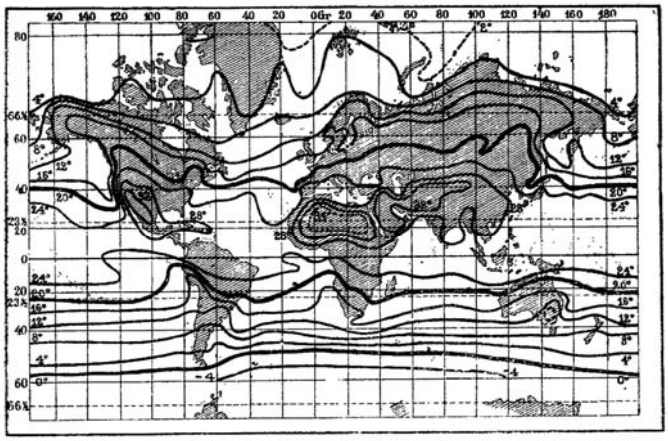
III part *Atmosphere*

In *Увод* (*Introduction*) to this chapter Vujević describes the gaseous envelope of the Earth and the scientific branches studying the atmosphere. That branch having the main atmospherical phenomena as its subject is meteorology. The branch studying the climat in different parts of the Earth is climatology. In Vujević's words climatology appears as a link between meteorology and geography.

The first section *Опити појмови о ваздуху* describes the air composition just above the surface of the Earth, as well as the air composition at higher altitudes, to continue with the air pressure and its decrease with altitude, also the thickness of the atmosphere and its mass.

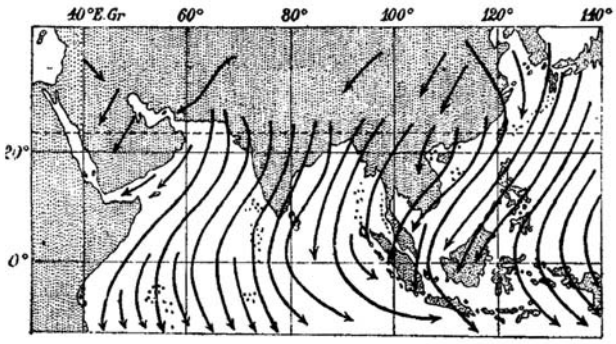
In the second section *Топлота* the heat sources on the Earth are the subject, as well as the solar constant, solar climate, the air influence on the solar climate and the factors changing the theoretical heat conditions. Here one obtains information on the heating and cooling of the land, sea and atmosphere, also on the air influence on the black-body emission from the surface of the Earth.

In the third section *Температуре* the relationship between the heat and temperature is described. In addition we have the methods of temperature measuring, the influences of land, sea and topography on the temperature of the atmosphere, the diurnal and annual run of temperature and the study of mean temperatures. The temperature types, equatorial, tropical, moderate and polar ones, as well as the perturbations in the annual temperature run, diurnal variability and the mean variability of month temperatures, are presented.



Слика 178. — Подела ваздушних температура у јулу (по *Кöppen*-у).

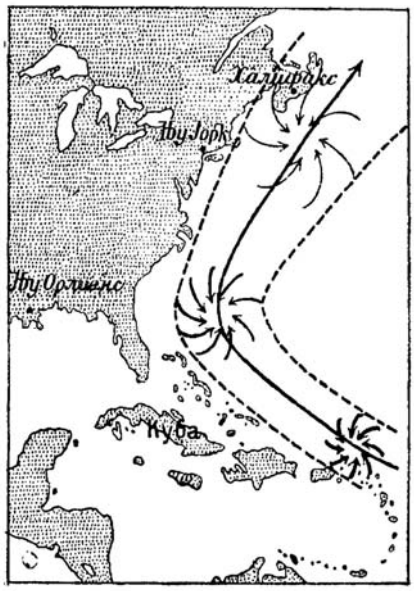
In the fourth section *Вертикална и хоризонтална подела температура* at first the temperatures within atmospheric layers are described, to be followed by a description of the heat conditions at various geographic latitudes. The other aspects concerning the air temperature are presented in details: mountain temperatures, the amount of the vertical temperature gradient, its diurnal and annual periods. At the end the subdivision of temperatures at the surface of the Earth is given, followed by the importance of maps of isotherms, subdivision of air temperatures at the sea level, mean temperatures of parallels and of the Earth as a whole, as well as temperature anomalies, continentality and oceanity for a given place. Vujević describes how *isotherms*, lines of the same temperature, are obtained from hard measurements carried out every day throughout the world. The isotherms for July are presented in [Fig. 178].



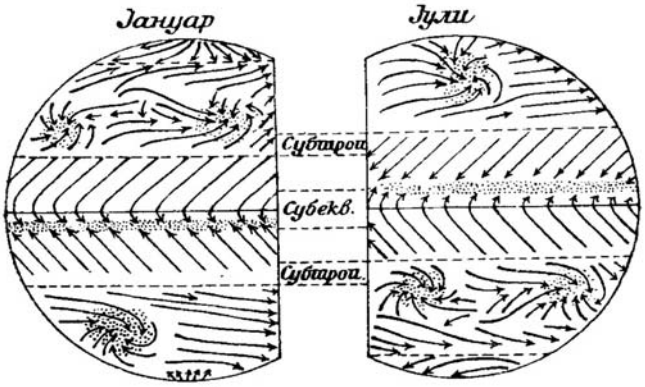
Скица 190. — Зимски монсун у јужној Азији.

The fifth section *Ваздушни притисак* deals with the diurnal and annual oscillations of the air pressure, reduction of the barometric state to the normal values and sea level and subdivision of air pressure along the surface of the Earth. Like the preceding section the text is followed by nice plots and illustrations which give the distribution of air pressure in various regions. For instance, from [Fig. 182?] it is seen that the lowest pressure upon the Earth in January takes place within the belt of the warmest continental regions, therefore in the central parts of Brazil, South Africa and Northern Australia.

The sixth section *Ветрови* contains detailed descriptions of the wind direction and speed, frequency and velocity of winds from various directions, diurnal and annual periods of wind speed, what causes a wind, cyclones and anticyclones, the general system of winds at the surface of the Earth, equatorial belt (called *belt of doldrums* by sailors), zones of passat winds subtropic zones, zones of western winds, subpolar wind system and zone of monsoon winds. The theory of general air circulation on the Earth and the nomenclature of diurnal winds: coastal light winds, valley breeze and mountain breeze. A nice schematic presentation of theoretical systems of planetary winds in January and July is given in [Fig. 191].



Скица 211. — Средњи правац оркана при источним обалама Северне Америке.



Скица 191. — Теоријски систем планетарних ветрова у јануару и јулу (по *W. M. Davis*-у).

The seventh section *Кружење воде* is devoted to all aggregate states of water and the belts concerning water in the atmosphere: evaporation, water vapour in the air, diurnal and annual run for the absolute and relative humidity, condensation of water vapour, fogs and clouds, atmospheric precipitation (dew and hoar-frost, hard rime, ice, rain, snow, hale), measuring atmospheric precipitation, then rain distribution during a day and in months (for equatorial belt, tropical belt beyond equator, monsoon rains, passat rains, winter rains of western coasts, summer continental rains, and subtropical winter rains).

The eighth section *Поремећаји у ваздух**у*** treats cyclones and their influence on weather and tropical storms, air tubes and cascade winds as consequences of cyclones (fen and storm). Nice presentation of *hurricanes* near the eastern shores of North America is given, Fig. [211].

The ninth section *Климатски типови* gives a detailed description of all climate types: equatorial climates (oceanic and continental), tropical climates (oceanic, monsoon, continental and mountain), subtropical climates (rainy, monsoon, Mediterranean, desert and mountain), climates of the temperate zones (patagonic, western and eastern coastal regions, continental) and polar climates.

In the tenth section *Периодске промене климата на Земљи* all important periods of climate change are described – 11-years, 7-years, 35-years and the secular one.

In the eleventh section *Географска подела животиња и биљака на копну* the influence of the climate factors on the biosphere is described, on the life of plants and animals, on life zones and the causes of origin for the area of given biological species.

IV part *Oceans*

In this chapter Vujević writes about *oceanography* the science having studying of oceans, and which applies physics, chemistry and mathematics.

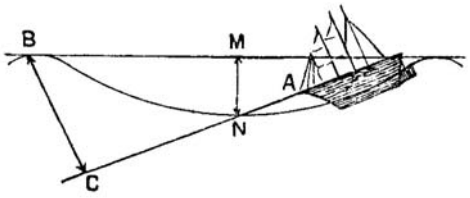
In the first section of this chapter *Топографија океана* examinations of the ocean are described, as well as the terminology of submarine forms. The reliefs of the Atlantic, Pacific and Indian Oceans, as well as that of the Mediterranean Sea and its bordering branches are presented.

In the second section *Хемијски састав и физичке особине океанске воде* a detailed description of the composition and salinity of the oceanic water is given, as well as the geographic salinity subdivision on the ocean surface and salinity variations with ocean depth. The salinity of closed and bordering seas, such as the Mediterranean Sea, Black Sea, Adriatic Sea, Persian Gulf, Red Sea and the North Sea, is described. The causes of the salinity differences upon the surfaces of oceans and seas are discussed, as well as the relationship between the salinity and density of ocean waters. The temperature distribution on the ocean surfaces and within oceans is described, as well as the causes of low temperatures of ocean water at large depths. The transparency, colour and phosphorence of the oceanic water are explained.

In the third section *Живот у океанима* Vujević mentions that oceans are craddle of life and that the life in oceans is much more diverse than on land. According to the conditions of propagation of sunlight or permanent darkness the oceans are divided into two regions: illuminated where both plants and animals live and the dark one inhabited by animals only. At this place readers can learn that within oceans there are three life zones: littoral (coasts and shallow seas), pelagic (open sea) and abyssal (dark zone deep inside).

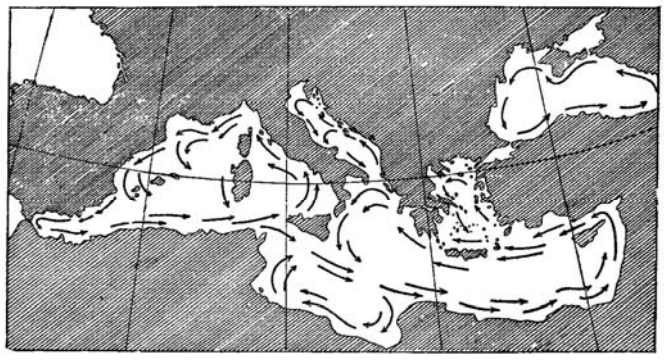
The fourth section *Састав океанског дна* describes the classification of oceanic sediments. Vujević also here has some interesting historical notes, for instance that something concerning the composition of sea bottom was known as early as in the antiquity. So, *Herodotus* writes that on the bottom of the Mediterranean Sea, at a depth of 20 m, on the day of navigating from the Nile mouth towards open sea, there is ooze. In Herodotus' opinion this sediment ioriginated from land. Only in the XVIII century the first theory concerning the composition of sea bottom was proposed. Later the patterns from the sea bottom were studied microscopically and in this way their

structure became well known. After this it was established that also land lyme rocks with fossile shellfish and snails must have been bottoms of earlier seas.



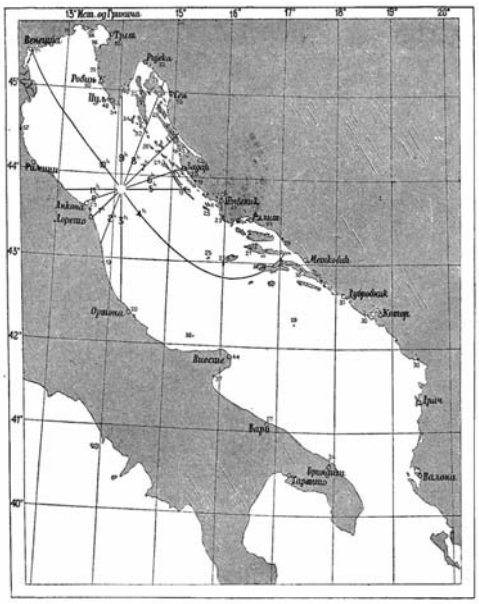
Скица 231.

In the fifth section *Таласи* the theory of formation of ocean waves, including their size and propagation speed, are presented. One describes wind waves, earthquake and explosion waves, immovable and internal oceanic waves, as well as the waves in shallow waters and hitting seashore by sea water, its power and action. In Fig. 231 we find an interesting presentation of the relative altitude determination for an ocean wave in open sea by observing. Since a ship is always somewhat inclined towards the wave trough, so observed from the deck the wave seems higher than it really is. Hitting seashore by sea water is described at the same place [Fig. 237]. At shallow shores we have breaking, foaming and splashing of waves, whereas in the case of steep shores no real hitting takes place, instead the waves move vertically and the sea level begins to oscillate. In this way during great winter storms enormous water jets can attain a height of 30 m.



Скица 245. — Струје у Средземном и Црноме Мору.

The sixth section *Океанске струје* treats observing and measuring of ocean streams, as well as the causes of their arising. The streams in the Atlantic, Pacific, Indian and Arctic Oceans, also in closed seas: Mediterranean, Black, Aegean, Adriatic and North ones, are described.



Скица 256. — Изорахије Јадранскога Мора са лучним добима појединих места (по R. v. Sterneck-y). Бројеви крај обала и острва означују амплитуду полудневних морских доба при сизигијама, у центиметрима.

In the seventh section *Плима и осека* two enormous waves moving on ocean surfaces from east to west across the entire Earth from the ocean surface to the bottom are described. Due to these waves the sea surface near shores rises and falls twice a day. These phenomena are known as *flood* and *ebb,* respectively, or *tide.* The effects of the Moon are additionally described, a relationship between the lunar culminations and high water level during flood at the same place. For instance, if there is a time lag t of the high water with respect to lunar culminations on one day, it will be also repeated on the next days with the same value. This is the effect of the Moon. After this we have a dynamical theory of tides, influence of the terrestrial rotation and interference followed by a mathematical theory of harmonic analysis. The tides taking place in the Mediterranean Sea and its bordering branches are described. In [Fig. 256] we have the Adriatic Sea with given lunar lag effect for some places.

Conclusion

In the first part Математична *географија* of university textbook *Основи математичне и физичке географије* by Pavle Vujević *astronomy* is represented very well. This chapter on astronomy is equipped with figures, tables, maps and diagrams. Vujević's simplicity and easiness of writing in presenting complicated astronomical phenomena are to be specially emphasized. Some formulae are derived, others given only. Of course, in astronomy there are very complicated formulae where the derivation requires a lot of space and mathematical knowledge. Astronomical phenomena are presented by Vujević in most cases descriptively so that students who are not mathematicians can understand the text.

In the second part *Физичка географија* we find pages containing descriptions of some geophysical, atmospherical and oceanic phenomena. These descriptions are written in a manner admitting to those who are not physicists to understand them easily. In this matter Vujević realized his intention to make a student of geography more familiar with basic knowledges of astronomy, mathematics and physics.

The book contains a large number of historical notes concerning the source and origin of many notions concerning geophysics, astronomy and other disciplines dealing with our planet. Many words used by Vujević in his book have been already forgotten or they have not been used since a long time. For this reason this book appears as a good place for studying the development and changes in our terminology concerning the given disciplines. On the other hand, as shown by these volumes, it is most likely Vujević's merit that many technical words and notions of these disciplines have been introduced in the Serbian language.

Bearing in mind the methodical way of writing for this geography textbook, its contents, clearness and easiness of expressing we recommend it also to the students and teachers of secondary schools of our times, not only in geography, but also in mathematics, astronomy, physics, geophysics and geodesy. University textbook *Основи математичне и физичке географије* by Pavle Vujević has been digitalized and it is in the Virtual Library of the National Digitalization Centre http://elib.matf.bg.ac.yu:8080/virlib/.

References

1. P. Vujević, *Fundamentals of mathematical and physical geography*, Part I, Printing Shop of the Kingdom SCS, Belgrade, 1923 (in Serbian).
2. P. Vujević, *Fundamentals of mathematical and physical geography*, Part II, Printing shop of the Kingdom SCS, Belgrade, 1923 (in Serbian).
3. R. Karljiković, *Geometry for high schools – Part three Trigonometry*, Printed by Bookshop Rajković and Ćurković, 1931 (in Serbian).
4. N. Pejović, "*Spherical trigonometry" by Rista Karljiković,* Proc. Conf. *Development of astronomy in Serbia* IV, Publ. Astr. Soc. Rudjer Bošković, **7**, 2006, 189–199, 2006 (in Serbian).
5. N. Pejović. *Digitization of mathematical textbooks used in Serbia in the past,* NCD Review **12** (2008).
6. T. Rakićević, *Pavle Vujević*, ed. Life and works of Serbian scientists, SANU, Belgrade, 1998, 139–175 (in Serbian).
7. N. Pejović, Ž. Mijajlović, *Astronomy in the textbook "Fundamentals of mathematical and physical geography"* by Pavle Vujević, Proc. Conf. *Development of astronomy in Serbia* V, Publ. Astr. Soc. Ruđer Bošković **8** (2008), 189–199 (in Serbian).

Надежда Пејовић, Жарко Мијајловић
Математички факултет
Београд

ПРИКАЗ ДИГИТАЛИЗОВАНЕ КЊИГЕ *ОСНОВИ МАТЕМАТИЧНЕ И ФИЗИЧКЕ ГЕОГРАФИЈЕ* ПАВЛА ВУЈЕВИЋА

Резиме. У овом чланку представљамо део једног од првих универзитетских уџбеника из географије писаних на нашем језику. Написан је после Првог светског рата. Наиме, реч је о уџбенику *Основи математичне и физичке географије* професора Павла Вујевића који је штампан редом у две књиге 1923. и 1926. у Београду. Уџбеник се састоји од четири поглавља: *Математична геофрафија, Геофизика, Атмосфера и Океани* у обиму од 815 страница. Иако веома велики, уџбеник је методички лепо написан, попут монографије. У овом чланку је представљен посебно занимљив I део *Математична географија* који се састоји од истоименог првог поглавља посвећеног астрономији. Енциклопедијски су побројани и објашњени до тада уведени астрономски појмови са детаљним и јасним описима. II део *Физичка географија* је много обимнији, обухвата три поглавља: *Геофизика, Атмосфера* и *Океани*. У овом чланку укратко су представљени садржаји ова три поглавља као и њихове занимљивости. Уџбеник *Основи математичне и физичке географије* Павла Вијевића је дигитализован и налази се у Виртуелној библиотеци Националног центра за дигитализацију (Virtual library, http://elib.matf.bg.ac.yu:8080/virlib/). Дигитализација ових књига део је пројекта електронског архивирања српских књига са математичким и астрономским садржајем штампаних у прошлости. У чланку су поменути и други разлози зашто је овај уџбеник изабран за укључење у Виртуелну библиотеку.

nada@matf.bg.ac.yu
zarkom@matf.bg.ac.yu