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Leonardo da Vinci and His Contributions to Cartography

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Abstract: The archetypal Renaissance figure Leonardo da Vinci was truly a universal man (Ital. – *uomo universale*). There is no area of human activity that failed to attract his attention, or that does not bear a trace of his deliberations. In the field of fine art, Leonardo is famous for his masterpieces: the *Mona Lisa*, the *Last Supper*, the *Virgin of the Rocks*, and other, unfinished works, for example, *St. Jerome in the Wilderness*, and the *Adoration of the Magi*. He did not leave any works of sculpture, though he did create sketches and drawings. His legacy includes approximately 13,000 sheets of notes and drawings of anatomy, architecture, war and flying machines, plants and animals, all annotated in a reversed mirror-script. In his works of art, he brought his compositions to perfection by using the principles of perspective and the techniques of *chiaroscuro* and *sfumato*. Leonardo designed war machines and produced several plans and topographical maps for the powerful men of his time, under whose patronage he worked, such as dukes, kings and popes. This article presents a brief account of his most famous cartographical works: the plan of Imola, three topographic maps of Tuscany, the Chiana valley, the Pontine Marshes and western Tuscany, and a world map (*Mappa Mundi*). Leonardo skilfully made use of his fascination with landscapes, incorporating them as backdrops in his masterpieces.

Keywords: Leonardo da Vinci, Renaissance, art, science, cartography, map

1 Introduction

The Renaissance genius Leonardo da Vinci is renowned in artistic and scientific circles as the creator of the *Mona Lisa* and the *Last Supper*, and as the inventor of many machines and various kinds of weapons. He is less well known, even among cartographers, as a land surveyor and cartographer. The purpose of this article is to provide a brief overview of his contribution to cartography. Just as Leonardo could not separate science from art, neither could he isolate the disciplines of surveying, cartography and geography. For him, these sciences overlapped, as they did for his contemporaries. He did not distinguish between them; they were present simultaneously. For example, when preparing to paint a picture of a particular subject, Leonardo would first sketch numerous anatomical drawings and perspectives in his notebook, study the composition and proportions with great attention to detail, and accurately select the figures, placing them within a harmonious whole by assigning them specific personality traits. He would watch and record each detail with great earnestness. Leonardo studied Euclid's *Elements* with Alberti and Fr. Luca Pacioli and collaborated with them on the *Divine Proportion*. He used a similarly detailed approach when producing maps. He gained deep insight into the disciplines of surveying and mapping in centuries past and then, realizing the distinctive practical purposes that could be derived from them, constructed measuring instruments as tools to enhance his knowledge. Leonardo da Vinci viewed the world from the perspectives of an engineer, scientist, inventor, painter, sculptor and musician. He studied everything, from the movement of water to the inner workings of the human body. He wanted to understand anything that moved: water, air, bird flight, the motion of the planets and the human body, all of which he sketched and described in mirror-script.

He knew how to take advantage of his skills, and was thus always able to remain in the service of the wealthy elite. Leonardo had been working as a military and a civil engineer since 1480 under the patronage of the Duke of Milan, Ludovico Sforza, when Louis XII took the

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Leonardo da Vinci i njegov doprinos kartografiji

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Sažetak: Arhetipski renesansni čovjek Leonardo da Vinci bio je uistinu univerzalni čovjek – *uomo universale*. Nije poznato područje čovjekove djelatnosti koje nije privuklo njegovu pažnju ili u kojem nije ostavio trag svojega promišljanja. U likovnoj umjetnosti poznat je po remek-djelima: *Mona Lisa*, *Posljednja večera*, *Djevica na stijenama* i po više nedovršenih djela, na primjer *Sv. Jeronim u divljini* i *Poklonstvo kraljeva*. Od skulptura nije ostavio ni jedno djelo, nego su ostali samo crteži i skice. Njegova ostavština broji oko 13 000 listova zabilješki i crteža iz anatomije, arhitekture, ratnih i letećih strojeva, biljaka i životinja, a sve je opisao zrcalnim pismom. U svojim umjetničkim djelima koristio se zakonom perspektive, kompoziciju je doveo do savršenstva, a koristio je dvije tehnike: *chiaroscuro* i *sfumato*. Za moćnike svojega doba – vojvode, kraljeve i pape, pod čijim je patronatom bio, projektirao je ratne strojeve te izradio nekoliko planova i topografskih karata. U ovom članku ukratko su obrađena njegova najpoznatija kartografska djela: plan grada Imole, tri topografske karte Toskane: dolina Chiana, močvara Pontino i zapadna Toskana, te karta svijeta *Mappa mundi* u obliku sfernih isječaka globusa. Leonardo je vješto iskoristio svoju očaranost krajolicima koristeći ih kao pozadinu na svojim remek-djelima.

Ključne riječi: Leonardo da Vinci, renesansa, umjetnost, znanost, kartografija, karta

1. Uvod

Renesansni genije Leonardo da Vinci poznat je u umjetničkim i znanstvenim krugovima kao tvorac *Mone Lise* i *Posljednje večere*, kao pronalazač mnogih strojeva i raznog oružja, ali je manje poznat čak i kartografima kao mjernik i kartograf. Svrha je ovog članka dati kratak pregled da Vincijeva doprinosa kartografiji. U njegovim se djelima ne može odvojiti znanost od umjetnosti, kao ni kartografija od mjerništva i geografije. Sve te znanosti on je, kao i drugi univerzalni ljudi njegova doba, stopio u jedno; sam ih nije ih znao razlikovati, sve su nastupale istovremeno. Tako na primjer, kad se sprema za slikanje neke teme, prethodno crta u svojoj bilježnici mnoge anatomske crteže i perspektive, detaljno razrađuje kompoziciju i proporcije, s velikom pažnjom pristupa svakom detalju, precizno odabire likove, slaže ih u skladnu cjelinu dajući im karakterne osobine. S velikom ozbiljnošću promatrao je i bilježio svaki detalj. S Albertijem i fra Lukom Paciolijem proučava Euklidove *Elemente* te surađuje na knjizi *Divina proportione*. Tako je i za izradu karte prethodno proučio dotadašnje spoznaje i znanja iz prošlih stoljeća o izmjeri i kartiranju, a zatim uvidjevši praktične potrebe i sam konstruirao mjerne instrumente. Leonardo da Vinci kao inženjer, znanstvenik, pronalazač, slikar, kipar i glazbenik, proučavao je sve: od kretanja vode do unutarnjeg sklopa ljudskoga tijela. Zanimalo ga je sve što je u pokretu: voda, zrak, ptičji let, gibanje planeta i ljudski organizam; sve je crtao i opisivao zrcalnim pismom.

Prvi je započeo s prikazom terena iz ptičje perspektive. Da bi poletio kao ptice u visine, više od dvadeset godina proučavao je njihov let te je konstruirao stroj za letenje i padobran. Fasciniran ptičjim letom nije trpio njihovu zatočenost u krletkama; često ih je kupovao na sajmovima, odnosio u prirodu i puštao na slobodu. Vedre naravi, uvijek dobro raspoložen nije trpio ni ljudsku potlačenost – svi njegovi napori bili su usmjereni k novom svijetu za novog čovjeka.

Ostala područja u kojima je Leonardo da Vinci dao svoj veliki doprinos jesu: anatomija, kiparstvo, slikarstvo, optika, matematika, geometrija, arhitektura, urbanizam, glazba, geologija, botanika i zoologija.

Figure 1. Map of Italy: city-states 1494
(Wikimedia Commons, public domain)
Slika 1. Karta Italije: gradovi-države 1494.
(Wikimedia Commons, javno dostupno)

Duchy in 1499. The new French king offered him the post of military engineer. By 1502, Leonardo was in the service of the Borgia family. Governor Charles d'Amboise called him to Milan in 1506, and he later enjoyed the patronage of Maximilian Sforza in 1510 and Pope Leo X in 1513. After the death of Louis XII, the young François I become Leonardo's greatest protector. The painter Ingres portrayed Leonardo dying, according to legend, in the arms of King François I (Blevins 2010).

2 The Renaissance

The Renaissance, spanning the 15th and 16th centuries, was the first period in the history of art whose existence was recognised by its own protagonists, who coined a name to describe it. (*Fr. Renaissance* – 'rebirth'). It was one of the greatest movements in the culture of Western Europe and led to a shift in science, philosophy, literature and the fine arts (URL1). The Renaissance is divided into Early (*Ital. Quattrocento* – 1400), High, and Late (*Ital. Cinquecento* – 1500). The Renaissance first emerged in Italy, in the city of Florence in the province of Tuscany, and then spread to other cities: Padua, Rome, Venice, and Milan.

The classical period was considered the pinnacle of human creative power, so all the arts and sciences that had been flourished then were revived. During the Renaissance, Florence was dubbed the 'New Athens,' because among its citizens it gained a reputation to rival that of the Athens of ancient Greece. Representatives of the Early Renaissance in Italy included Masaccio, Donatello, and Filippo Bruneleschi. The High Renaissance was epitomized by three of the greatest artists of all time: Leonardo da Vinci, Michelangelo Buonarroti and Raffaello Santi (URL1).

The torrent of creative energy that emerged during the Renaissance overflowed from Italy to the Netherlands, Germany and France.

During this time, the ideal of the artist as an individual inspired by God and successful in the creation of different kinds of art – the universal man (*Ital. uomo universale*) – reigned supreme.

2.1 Italian cities

The social organization of the time resembled that of ancient Greece. Various city-states, such as Milan, Venice, Ferrara, Florence, the Papal State, Naples, etc. (Fig. 1) competed with and fought against each other (URL1). These city-states were developing manufacturing methods, merchandising, publishing and science, and participating in the Age of Discovery. Internal conflicts were characterized by constant battles between certain noble families who sought to rule individual cities, such as the Viscontis and Sforzas in Milan, the Medicis in Florence, the Gonzagas in Mantua, the Estes of Modena and the Ferraris (URL2).

3 Leonardo da Vinci

Leonardo da Vinci epitomized the Renaissance ideal of the universal man (Fig. 2). In him, powerful intelligence and scientific curiosity were harmoniously combined with a love of nature. He studied everything, from the movement of water to the functioning of the human body. He was an engineer, scientist, anatomist, musician, painter, sculptor, thinker, architect, mathematician, botanist, writer and cartographer. He noted all his observations and findings in notebooks in mirror-script. Leonardo is best known as a painter, as the creator of the *Mona Lisa*, the *Virgin of the Rocks* and the *Last Supper* (URL1).

3.1 Childhood

Leonardo da Vinci was born on 15 April 1452 in the small town of Vinci, near Florence, in the province of Tuscany (URL3). He was born out of wedlock to Catherine, a peasant girl, while his father was Antonio del Piero

Znao je prepoznati i lukavo iskoristiti mogućnost za nesmetan rad tako da je gotovo uvijek bio u službi nekog bogatog moćnika. Kao vojni i civilni inženjer bio je 1480. godine pod patronatom Milanskog vojvode Ludovica Sforze, 1499. godine novi francuski kralj Luj XII. ponudio mu je službu vojnog inženjera, 1502. godine već je u službi obitelji Borgia, 1506. godine odlazi u Milano na poziv upravitelja Charlesa d'Amboisea, 1510. godine je kod Maximiliana Sforze, a 1513. kod pape Leona X. Nakon smrti Luja XII., mladi francuski kralj Franjo I. postaje najveći Leonardov zaštitnik. Prema legendi slikar Ingreas prikazao je umirućeg Leonarda na rukama kralja Franje I. (Blevins 2010).

2. Renesansa

Renesansa je prvo razdoblje u povijesti umjetnosti 15. i 16. stoljeća koje je bilo svjesno svojega postojanja i koje je samo sebi iskovalo ime (*franc. Renaissance* – preporod). Ono je jedan od najvećih pokreta u kulturi zapadne Europe, koje je dovelo do preokreta u znanosti, filozofiji, književnosti i likovnim umjetnostima (URL1). Renesansu dijelimo na ranu (tal. *quattrocento* – 1400.), koja traje cijelo 15. stoljeće, i visoku ili kasnu (tal. *cinquecento* – 1500.), koja traje do sredine 16. stoljeća. Pojavila se najprije u Italiji, u pokrajini Toskani, u gradu Firenci, a zatim i u drugim gradovima: Padovi, Rimu, Veneciji, Milanu.

Antika je smatrana vrhuncem čovjekovih stvaralačkih snaga, pa su sve umjetnosti i znanosti koje su cvjetale u antici ponovno bile oživljene. Firenca je za renesanse dobila naziv nova Atena jer je među svojim građanima stekla takav ugled kakav je Atena imala u vrijeme stare Grčke. Predstavnici su rane renesanse u Italiji: Masaccio, Donatello, Filippo Brunelleschi i drugi. Visoku renesansu personificiraju tri najveća umjetnika svih vremena: Leonardo da Vinci, Michelangelo Buonarroti i Rafael (URL1).

Renesansa je prenijela bujicu stvaralačke energije iz Italije u Nizozemsku, Njemačku i Francusku.

U to doba vladala je ideja genijalnog umjetnika, pojedinca nadahnutog od Boga, koji je bio uspješan u različitim vrstama umjetnosti – univerzalni čovjek (tal. *uomo universale*).

2.1. Talijanski gradovi

Društveno uređenje sličilo je onome u antičkoj Grčkoj; bilo je više gradova-država: Milano, Venecija, Ferrara, Firenca, Papinska država, Napulj, ... (sl. 1) koje su se natjecale i ratovale jedna protiv druge (URL1). Ti gradovi-države razvijali su manufakturnu proizvodnju, trgovinu, tiskarstvo, znanost, sudjelovali su u geografskim

Figure 2. Statue outside the Uffizi Gallery, Florence, Leonardo da Vinci by Luigi Pampaloni, 1837–1839 *(Wikimedia Commons, public domain)*

Slika 2. Statua Leonarda da Vincija ispred galerije Uffizi u Firenci, autor Luigi Pampaloni, 1837–1839 *(Wikimedia Commons, javno dostupno)*

otkrićima. U unutarnjim sukobima stalne su borbe između plemićkih obitelji koje nastoje samostalno vladati pojedinim gradovima: u Milanu dominiraju Visconti i Sforze, u Firenci obitelj Medici, u Mantovi Gonzage, u Modeni Ferrari i d'Este (URL2).

3. Leonardo da Vinci

Renesansni ideal univerzalnog čovjeka utjelovio je Leonardo da Vinci (sl. 2). Moćna inteligencija i znanstvena radoznalost bile su u njemu skladno spojene s ljubavlju prema prirodi. Proučavao je sve, od kretanja vode do funkcioniranja ljudskog tijela; bio je inženjer, znanstvenik, anatom, glazbenik, slikar, kipar, mislilac, arhitekt, matematičar, botaničar, pisac i kartograf. Sva svoja opažanja i pronalaske crtao je u bilježnice i opisivao zrcalnim pismom. Leonardo je najpoznatiji kao slikar, autor *Mona Lise*, *Djevice na stijenama* i *Posljednje večere* (URL1).

3.1. Djetinjstvo

Leonardo da Vinci rođen je 15. travnja 1452. u malome gradiću Vinci pokraj Firence, u pokrajini Toskani (URL3). Rodio se u izvanbračnoj zajednici od oca Piera

Figure 3. The Arno Valley, Leonardo da Vinci, 1473 *(Wikimedia Commons, public domain)*
Slika 3. Dolina Arno, Leonardo da Vinci, 1473. *(Wikimedia Commons, javno dostupno)*

Figure 4. The Baptism of Christ, Andrea Verrocchio, 1472–1475 *(Wikimedia Commons, public domain)*
Slika 4. Krštenje Kristovo, Andrea Verrocchio, 1472–1475. *(Wikimedia Commons, javno dostupno)*

Vacche, a wealthy Florentine notary. As an illegitimate son, he did not bear his father's surname, and instead signed his name as *Leonardo di ser Piero da Vinci* (Leonardo (son of) Mr. Piero of Vinci) or in abbreviated form, Leonardo da Vinci. His father was married several times, and his mother married another man, so Leonardo had several half brothers and sisters. He was informally taught Latin, geometry and mathematics. In the mid 1460s, the family moved to Florence, the artistic and intellectual centre of Italy, where Leonardo studied with the best teachers.

3.2 In Verroccio's studio

At the age of fourteen, Leonardo began an apprenticeship with Andrea di Cioni, known as Verrocchio, whose workshop was claimed to be one of the best in Florence. There Leonardo learned various skills: sketching and drafting, metalwork, leatherwork, plastering and carpentry, as well as artistic skills such as drawing, painting, sculpting and modelling. In 1472 he was admitted to St. Luke's Guild of Florentine painters and became a master in his own right, although he was still considered Verrocchio's assistant until 1476. Around 1473 he produced his first known drawing (Fig. 3), the Arno Valley, in ink on paper.

In Verrocchio's painting *The Baptism of Christ* (Fig. 4), Leonardo painted some of the striking parts: the kneeling angel and the background landscape. His teacher was so elated by the quality of his student's work that that he vowed never to touch a brush again, and from then on dedicated himself to sculpture.

3.3 Scientific and theoretical studies

In addition to the arts, Leonardo made contributions to anatomy (Figs. 7 and 11), botany, zoology (Fig. 6), geology, mathematics, optics, mechanics, astronomy, aerodynamics (Figs. 8 and 10), hydraulics (Fig. 12), structural and civil engineering, urban planning and the production of weapons.

His scientific theories and artistic innovations were based on careful observation and precise documentation. More than any of his contemporaries, he understood the importance of precise scientific observation. He committed his scientific theories by hand to numerous notebooks. Since Leonardo's handwriting could not be easily deciphered, his full legacy was not revealed in the years following his death. Leonardo understood the influence of the moon on the tides, postulated the origin of fossilized shells, made many meteorological and geological discoveries ahead of his time, and understood the formation of the continents (URL3).

He was fascinated by the study of physiognomy (Fig. 5), the science positing that facial features, movements and posture revealed details about the character of a person.

3.4 The discoverer and inventor

Leonardo produced many drawings, including sketches of military areas (Fig. 9), and designs for civil engineering. He wanted to create a "new machine" – a precursor to the machine gun, a catapult and a tank for a

Antonija del Vaccha, bogatoga firentinskog bilježnika, i majke Caterine, seljačke djevojke. Kao nezakoniti sin nije imao očevo prezime pa se potpisivao *Leonardo di ser Piero da Vinci* (Leonardo (sin) gospodina Piera iz Vinče) ili skraćeno Leonardo da Vinci. Otac se ženio više puta, a majka se udala za drugog čovjeka tako da je Leonardo imao više polubraće i polusestara. Neformalnu izobrazbu imao je iz latinskoga, geometrije i matematike. Sredinom 1460-ih obitelj se preselila u Firencu, tada umjetničko i intelektualno središte Italije, gdje je Leonardo učio kod najboljih učitelja.

3.2. U Verrocchijevoj radionici

U svojoj četrnaestoj godini započeo je naukovanje kod Andree di Cione, nazvanog Verrocchio, čija je radionica slovila za jednu od najboljih u Firenci. Ondje je Leonardo učio skiciranje i izradu nacrta, obradu metala i kože, rad sa žbukom i tesarstvo, kao i umjetničke vještine: crtanje, slikanje, izradu skulptura i modeliranje. Godine 1472. primljen je u ceh firentinskih slikara sv. Luke i tako postao kvalificirani majstor, iako je i dalje, sve do 1476., smatran Verrocchijevim pomoćnikom. Oko 1473. nastaje njegov prvi poznati crtež (sl. 3) u tehnici tinta na papiru – *Dolina Arno*.

Na Verrocchijevoj slici *Krštenje Kristovo* (sl. 4) najživotnije dijelove slike, klečećeg anđela i pozadinski pejzaž, naslikao je upravo Leonardo. Njegov učitelj bio je toliko ushićen kvalitetnim radom svojega učenika da se zarekao kako nikada više neće dotaknuti kist te se od tada potpuno posvetio kiparstvu.

3.3. Znanstvene i teorijske studije

Osim umjetnosti, dao je doprinose anatomiji (sl. 7 i 11), botanici, zoologiji (sl. 6), geologiji, matematici, optici, mehanici, astronomiji, aerodinamici (sl. 8 i 10), hidraulici (sl. 12), niskogradnji, tehnici proizvodnje oružja i urbanistici.

Njegove znanstvene teorije, kao i umjetničke inovacije, temeljile su se na pažljivom promatranju i preciznom dokumentiranju. Bolje nego bilo tko od njegovih suvremenika shvaćao je važnost preciznog znanstvenoga opažanja. Znanstvene teorije sadržane su u rukopisu u mnogobrojnim bilježnicama. Budući da se Leonardov rukopis ne može lako čitati, ostavština mu nije raznesena nakon njegova života. Razumio je utjecaj Mjeseca na plimu i oseku, pretpostavio podrijetlo fosiliziranih ljuštura, preduhitrio je mnoga meteorološka i geološka otkrića, shvaćao formiranje kontinenata (URL3).

Bio je fasciniran proučavanjem fiziognomike (sl. 5) kao znanosti koja prema crtama lica, pokretima i držanju tijela zaključuje o karakteru osobe.

3.4. Pronalazač – izumitelj

Radio je crteže – skice iz područja vojnog (sl. 9) i civilnog inženjerstva. Htio je stvoriti „nove strojeve“:

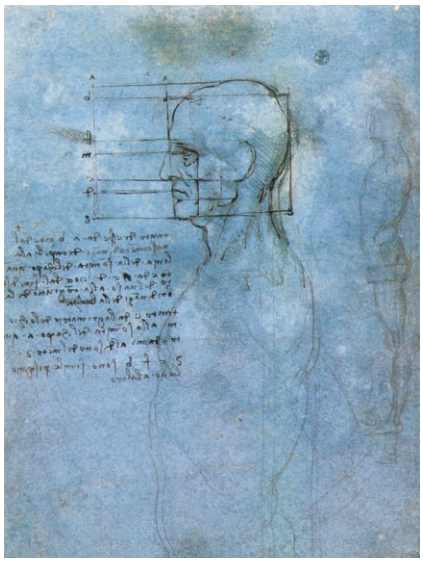


Figure 5. The proportions of the head *(Wikimedia Commons, public domain)*
Slika 5. Proporcije glave *(Wikimedia Commons, javno dostupno)*

Figure 6. Study of a horse from Leonardo's diaries, around 1480 *(Wikimedia Commons, public domain)*
Slika 6. Studija konja iz Leonardova dnevnika, oko 1480. *(Wikimedia Commons, javno dostupno)*

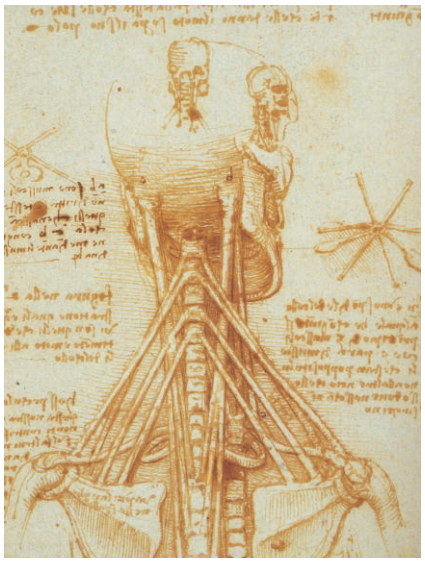


Figure 7. Anatomical studies, around 1509 *(Wikimedia Commons, public domain)*
Slika 7. Anatomska studija, oko 1509. *(Wikimedia Commons, javno dostupno)*

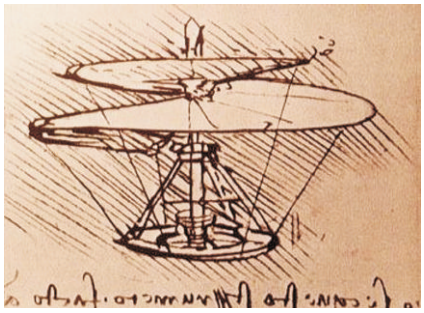


Figure 8. The forerunner of the propeller *(Wikimedia Commons, public domain)*
Slika 8. Preteča propelera – zračni vijak *(Wikimedia Commons, javno dostupno)*

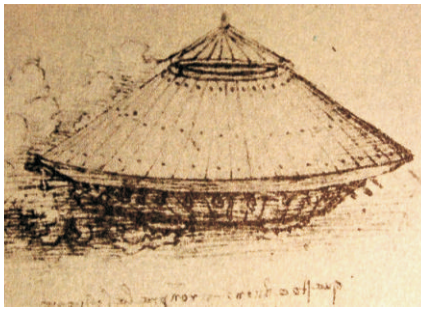


Figure 9. Sketch for the first tank *(Wikimedia Commons, public domain)*
Slika 9. Skica prvoga tenka *(Wikimedia Commons, javno dostupno)*

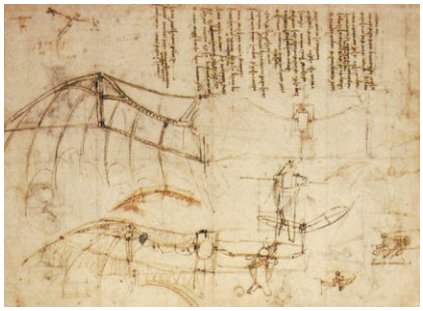


Figure 10. Sketch of a flying machine *(Wikimedia Commons, public domain)*
Slika 10. Skica letećeg stroja *(Wikimedia Commons, javno dostupno)*

"new world." He was disappointed when he realized that his invention of a diving suit could be used to destroy people and consequently destroyed his own studies on the subject. He also developed new ideas for tools and machines using cogwheels and gears, such as a bicycle and helicopter (Fig. 8).

3.5 The artist

3.5.1 The Mona Lisa

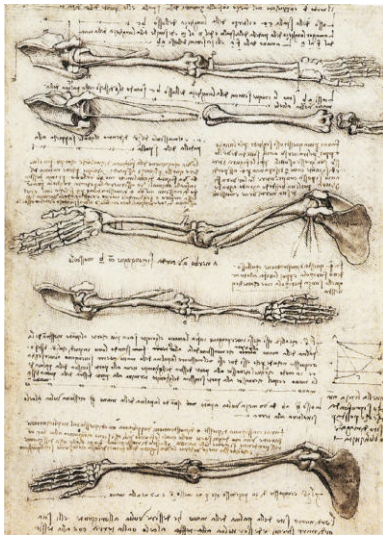
One of the few portraits painted by Leonardo that has been preserved to the present day is the famous *Mona Lisa* (Fig. 13). This portrait is also known as *La Gioconda* (URL3). Lisa del Giocondo was the wife of a Florentine merchant, Francesco del Giocondo. After four years of work on the painting, Leonardo had not yet finished it. Even when he did, he did not hand it over to the client, but kept it and took it with him on all his travels. There are many ideas and suspicions about his reason for doing this, as well as about the identity of the sitter. Some researchers go so far as to claim that no model existed, and that Leonardo painted his ideal woman. According to some theories, there is a great similarity between the Mona Lisa and her creator, and therefore it is assumed that Leonardo painted himself. Shortly before his death, Leonardo sold the painting to the French king François I and it was kept in the chateau of Amboise. The *Mona Lisa* moved frequently: it hung in Versailles in the collection of Louis XIV, in the Louvre, in Napoleon's bedroom, and then in 1911 it was stolen from the Louvre and found two years later in Florence. In 1956 it was heavily damaged by an acid attack and in the 1960s and 70s it was exhibited in New York, Tokyo and Moscow. Today it is kept behind bulletproof glass at the Louvre Museum in Paris. The strongest impression the subject leaves on the viewer is her mysterious smile, which has caused many debates, and her inscrutable expression. The smile is more apparent in the eyes than in the mouth – the melancholy awareness of one who "knows" something that others do not know. The observer feels observed. The *Mona Lisa* remains Leonardo's secret. Besides the mystery smile, this work is famous for the importance of its technical innovations. Leonardo used two techniques: *sfumato* and *chiaroscuro*. The hazy *sfumato* effect is achieved using fine transitions in the paint, especially noticeable on the delicate, airy clothes and enigmatic smile. *Chiaroscuro* (Italian: 'light and shadow') is a modelling technique using the contrast ratio between light and shadow and is applied to the sensitive hands of the model (URL3).

3.5.2 Portrait

The drawing in Fig 14 was long thought to be a self-portrait of Leonardo da Vinci in old age. But according to the latest research, it is not a portrait of the great master. The drawing shows a man of around 75-80 years of age. Sadly, Leonardo did not reach that age. The drawing probably shows Leonardo's father, Ser Piero da Vinci, or his beloved uncle, Francesco da Vinci, both of whom died at about the age of 80. The fact that none of Leonardo's contemporaries mentioned that the great master suddenly aged physically in later life supports this hypothesis (URL4). The portrait hangs in the Reale Library in Turin.

3.5.3 The Virgin of the Rocks

One of Leonardo's most important paintings, which was commissioned in the early Milanese period of his work, is *The Virgin of the Rocks* (Fig. 15), which was produced in two versions. The first, in which an angel points a finger at the infant John the Baptist, was



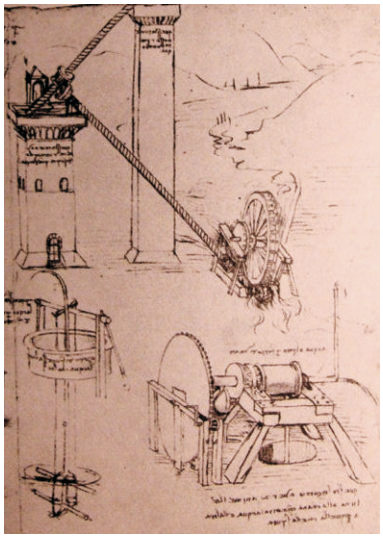


Figure 11. (left) Study of the movement of the arm *(Wikimedia Commons, public domain)*

Slika 11. (lijevo) Studija pokreta ruke *(Wikimedia Commons, javno dostupno)*

Figure 12. Sketch of hydraulic pumps *(Wikimedia Commons, public domain)*

Slika 12. Skica pužne pumpe: vodeno kolo, vijci i vodotoranj *(Wikimedia Commons, javno dostupno)*

preteču strojnice, katapult i tenk za „novi svijet". Razočarao se kad je shvatio da bi se njegov pronalazak ronilačkog odijela mogao upotrijebiti za uništavanje čovjeka, pa je sam uništio svoje studije o tome. Korištenjem zupčanika i zupčastog prijenosa došao je do novih ideja za alate i strojeve: bicikl i helikopter (sl. 8).

3.5. Umjetnik

3.5.1. Mona Lisa

Jedan od rijetkih portreta koje je Leonardo naslikao, a koji je ostao sačuvan do današnjih dana, glasovita je *Mona Lisa* (sl. 13). Portret je također poznat kao *La Gioconda* (URL3). Lisa del Giocondo bila je žena firentinskoga trgovca Francesca del Giocondoa. Nakon četiri godine rada na slici, Leonardo je nije u potpunosti dovršio. Nakon završetka slike nije ju predao naručitelju, nego ju je zadržao za sebe i nosio na sva svoja putovanja. Postoje različita nagađanja i sumnje oko toga postupka, kao i o točnosti imena osobe na slici. Neki istraživači tvrde da uopće nije postojao model, već da je Leonardo naslikao idealnu ženu. Prema nekim teorijama uočljiva je velika sličnost Mona Lise i njezinoga tvorca, te se pretpostavlja da je naslikao sam sebe. Kratko prije svoje smrti Leonardo je prodao sliku francuskomu kralju Franji I., koji ju je čuvao u dvorcu Amboise. Potom je *Mona Lisa* promijenila više „adresa": bila je u Versaillesu u kolekciji Luja XIV., u Louvreu, u Napoleonovoj spavaćoj sobi, zatim je 1911. godine bila ukradena iz Louvrea i pronađena nakon dvije godine u Firenci; 1956. godine jako je oštećena u „atentatu" kiselinom, u 1960-im i 1970-im godinama izlagana je u New Yorku, Tokiju i Moskvi. Danas se čuva iza neprobojnog stakla u muzeju Louvre u Parizu. Najjači dojam na promatrača ostavlja tajanstveni osmijeh, koji je izazvao mnoge rasprave, i iznimno blag pogled. Na osmijeh više ukazuju oči nego usta; on predstavlja melankoličnu svijest onoga koji „zna" nešto što drugi još ne znaju. Promatrač se osjeća promatranim. *Mona Lisa* ostaje Leonardova tajna. Osim po misterioznosti osmijeha, ovaj rad je poznat i po veličanstvenosti tehničkih inovacija. Leonardo je koristio dvije tehnike: *sfumato* i *chiaroscuro*. *Sfumato* je magloviti efekt načinjen finim prijelazima boje, posebno uočljiv na nježnoj prozračnoj odjeći i zagonetnom osmijehu. *Chiroscuro* (svjetlo i sjena) tehnika je modeliranja pomoću omjera kontrasta između svjetlosti i sjene, što je primijenjeno za senzitivne ruke modela (URL3).

Figure 13. Mona Lisa, 1503–1507 *(Wikimedia Commons, public domain)*

Slika 13. Mona Lisa, 1503–1507. *(Wikimedia Commons, javno dostupno)*

Figure 14. Portrait, 1512 *(Wikimedia Commons, public domain)*

Slika 14. Portret, 1512. *(Wikimedia Commons, javno dostupno)*

Figure 15. The Virgin of the Rocks, 1505 -1508 *(Wikimedia Commons, public domain)*
Slika 15. Djevica na stijenama, 1505–1508. *(Wikimedia Commons, javno dostupno)*

Figure 16. St. John the Baptist, 1514 *(Wikimedia Commons, public domain)*
Slika 16. Sv. Ivan Krstitelj, 1514. *(Wikimedia Commons, javno dostupno)*

created between 1483 and 1485 and now hangs in the Louvre in Paris. Leonardo painted another version in 1505–1508, which hangs in the National Gallery in London. Less than a year after his arrival in Milan, the painting made Leonardo well known everywhere, and many came to admire and respect him. For the subject of the painting, he chose an apocryphal event from the childhood of Christ, in which the infant John the Baptist encounters the Holy Family in Egypt. In this scene, John recognizes Jesus and prays to him as the Christ. Leonardo worked on the composition for a long time, as though unwilling to finish the job, as was his custom (by the end of his life he had only completed a few works). The background landscape was painted using a technique known as atmospheric perspective, in which colour is used to evoke a distant landscape (URL3).

3.5.4 St. John the Baptist

St. John the Baptist is the last of Leonardo's surviving paintings (Fig. 16). The saint's hand pointing upwards has given rise to a great deal of interpretation, and his mysterious smile has prompted many debates, rather like the Mona Lisa. In contrast to the torso, which looks solid and strong, the face and entire expression are incredibly spiritualised, mysterious and gentle. This is at odds with the biblical description of John the Baptist, which portrays him as an uncompromising, austere ascetic and preacher.

3.5.5 The Last Supper

From 1495 to 1497 Leonardo worked on his masterpiece *The Last Supper* (Fig. 17), a wall fresco in the refectory of the Monastery of Santa Maria delle Grazie in Milan. His stylistic innovations are even more apparent in *The Last Supper*, which recreates a traditional topic in a completely new way. Instead of viewing the apostles as individual figures, Leonardo grouped them in threes in a dynamic composition around the figure of Jesus Christ, who sits alone in the middle of the picture (URL3). The fresco shows the last meal Jesus shared his disciples before his arrest and death. It captures the moment when Jesus says, "One of you will betray me". Christ is calm and peaceful at the centre, while the apostles react each in their own way using animated gestures (URL3). The Apostle Peter has grabbed a knife, and his face is shown in the light, as are those of the other apostles. Only the face of Judas Iscariot is shown in deep shadow.

The composition is perfect. In terms of the perspective, the lines diverging to infinity converge at Jesus' right eye. To date, the significance of the white chair in the middle of the picture is unclear, nor whether it is occupied. The painting has attracted great speculation; some have even noticed a small child.

3.5.6 Vitruvian Man

Figure 18 shows a man with his arms and legs extended in two positions. In the first position the arms are extended horizontally while the legs are drawn together – the human body in the form of a square. The height of the man is equal to the width of his extended arms, or the side of the square. In the second position, the arms are raised and the legs are spread apart – the human body now forms a circle. Many interesting conclusions have been drawn from the size ratio of the individual body parts in this drawing. All agree on the message - that man is the measure of everything, even the universe. Some calculations show that the ratio of the radius of the circle drawn and the radius of a smaller circle, which could be drawn in the space above the head, represent the comparative radii of the Earth and the Moon. Others have found a mysterious connection to the "sacred geometry" of the position and size of the Pyramids of Giza in Egypt. However, the most convincing explanation regarding the ratio of Vitruvian Man's body parts are that they represent the golden ratio. Leonardo da Vinci created this drawing and described it in mirror-script according to Vitruvius' studies on proportions (URL5).

3.5.2. Portret

Dugo se smatralo da je crtež na slici 14. autoportret Leonarda da Vincija u starijoj dobi, no prema najnovijim istraživanjima to uopće nije portret velikog majstora. Na crtežu je prikazan čovjek u dobi od oko 75 do 80 godina. Leonardo na žalost nije doživio te godine. Crtež vjerojatno prikazuje ili Leonardova oca Ser Piera da Vincija ili voljenog strica Francesca da Vincija, koji su obojica umrli u dobi od oko 80 godina. U prilog ovoj tezi ide i činjenica da Leonardovi suvremenici nigdje nisu spomenuli fenomen da je veliki majstor u kasnijim godinama jako ostario (URL4). Portret se nalazi u knjižnici Reale u Torinu.

3.5.3. Djevica na stijenama

Najvažnija od njegovih slika, nastala po narudžbi, iz ranoga milanskog razdoblja je *Djevica na stijenama* (sl. 15), i to u dvije verzije. Prva verzija, na kojoj anđeo pokazuje prstom na malog Ivana, nastala je 1483–1485. godine i nalazi se u Louvreu u Parizu. Druga verzija, nastala 1506–1508. godine, nalazi se u Nacionalnoj galeriji u Londonu. Ni godinu dana nakon dolaska u Milano Leonardo je po toj slici postao svuda poznat, svi su mu se divili i poštovali ga. Izabrao je apokrifan moment Isusova djetinjstva, kada dijete Ivan Krstitelj susreće Svetu Obitelj na putu u Egipat. U toj sceni Ivan prepoznaje Isusa i moli mu se kao Kristu. Leonardo je radio na kompoziciji dugo vremena, kao da mu se nije dalo dovršiti započeto, što mu je bio običaj (do kraja života dovršio je tek nekoliko djela). Pozadinski krajolik oslikao je na način atmosferske perspektive, bojom je dočarao udaljeni krajolik (URL3).

3.5.4. Sv. Ivan Krstitelj

Sveti Ivan Krstitelj posljednja je sačuvana Leonardova slika (sl. 16). Svečeva ruka uperena prema gore izazvala je mnoga tumačenja, a njegov tajanstveni osmijeh, baš kao i Mona Lisin, potaknuo je mnoge rasprave. Za razliku od torza, koji se doima čvrsto i snažno, lice i cjelokupan izraz produhovljeni su i nevjerojatno zagonetni i nježni, što je, sudeći po opisu u Bibliji, u neskladu sa značenjem sv. Ivana Krstitelja, beskompromisnog i suzdržanog pustinjaka i propovjednika.

3.5.5. Posljednja večera

Od 1495. do 1497. godine Leonardo je radio na svojem remek-djelu, *Posljednjoj večeri* (sl. 17), zidnoj freski u blagovaonici samostana Santa Maria delle Grazie u

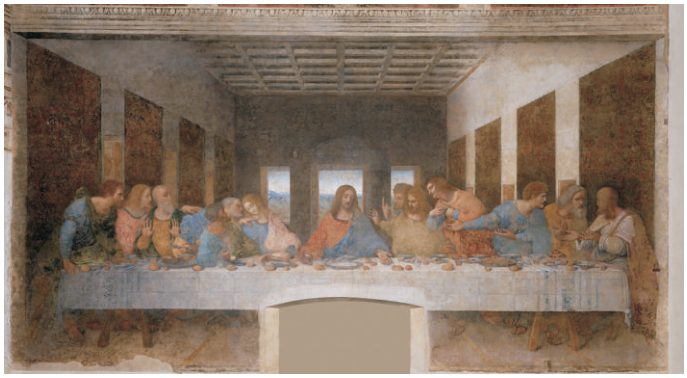


Figure 17. The Last Supper, 1498 *(Wikimedia Commons, public domain)*
Slika 17. Posljednja večera, 1498. *(Wikimedia Commons, javno dostupno)*

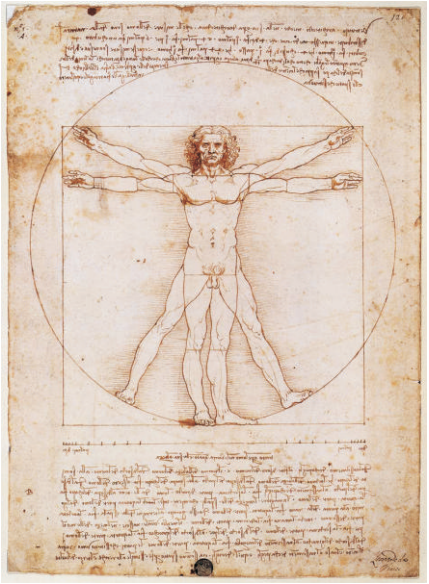


Figure 18. Vitruvian Man, around 1485 *(Wikimedia Commons, public domain)*
Slika 18. Vitruvijev čovjek, oko 1485. *(Wikimedia Commons, javno dostupno)*

Milanu. Stilističke inovacije još su uočljivije na *Posljednjoj večeri* – tradicionalnu temu rekreirao je na potpuno nov način. Umjesto prikaza apostola kao individualnih figura, grupirao ih je po troje u dinamičnu kompoziciju oko lika Isusa Krista, koji je sam u sredini slike (URL3). Slika prikazuje posljednji obrok koji Isus dijeli svojim učenicima prije svojeg uhićenja i smrti. Prikazan je posebni trenutak kada Isus kaže: „Jedan će me od vas izdati". Krist predstavlja mirno i spokojno središte, dok apostoli reagiraju svaki na svoj način živahnim gestama (URL3).

Apostol Petar zgrabio je nož, lice mu je prikazano u svjetlu kao i drugim apostolima, samo je lice Jude Iškariotskoga prikazano tamno u sjeni.

Kompozicija je dovedena do savršenstva. U linearnoj perspektivi linije koje se udaljavaju imaju nedogled u desnom Isusovu oku. Do danas nije razjašnjeno koje je značenje bijelog naslonjača u sredini slike, sjedi li netko na njemu? I uz tu Leonardovu sliku vezana su mnoga nagađanja, neki su čak uočili i malo dijete.

3.6 The cartographer

The demand for skilled cartographers increased during the 16th century in conjunction with the spiritual and intellectual awakening of the Renaissance. Topographic surveying methods developed thanks to the compass, tape measure and other tools that allowed for more accurate measurements. Scientists and artists were interested in the natural world and produced maps similar to those of Leonardo da Vinci. The earlier flat landscape depictions containing isolated symbols for mountains gave way to continuous depictions of land using different graphical symbols. Forests and fields were depicted on an oblique view of the continuous plane, while three-dimensionality was achieved using sloped lines and shading. But it took another fifty years to follow Leonardo's example and develop more natural symbols to depict mountains (URL6).

Leonardo da Vinci is little known as a cartographer, even to connoisseurs of cartography. Usually only a short account is given of two or three of his maps, or the odd landscape drawing. His maps and manuscripts are scattered throughout many libraries of Europe, particularly in Italy, France and the UK. It should be noted that Leonardo made notes in mirror-script, but when describing maps intended for the general public, he used ordinary script (Oberhummer 1909).

The Royal Collection in Windsor Castle is the most complete collection of cartographic works by Leonardo da Vinci. This paper deals with several maps from this collection in more detail.

Other material is contained in Leonardo's monumental opus *Codice Atlantico*, housed in the Accademia dei Lincci. Most of these maps were created during the artist's journey through central Italy in 1502. The maps are not copies, but are the result of free sketching the details of particular landscapes. Some were created by rapid drawing, while others were produced very carefully in colour, using a pen or brush.

Leonardo was a pragmatist who sought permanent positions with a regular income to be able to engage freely in his intellectual work. In 1502, as he turned fifty, he entered the service of Duke Cesare Borgia. In order to acquire his patronage, he sought to create high quality maps that would assist in waging successful warfare, because the period was marked by frequent conflicts between cities. Maps were rare, and high quality, accurate maps even more so. In his role as the Duke's architect and engineer, Leonardo supervised work on the construction of the fortifications of the papal army in central Italy, and designed war machines. In this period, he also drew several topographic maps (URL6).

Imhof (1965) explains how high quality maps developed as a more realistic depiction of landscape features began to emerge on maps, when naturally gifted scientists and artists showed an interest in mountains. The earliest, best examples of this development are the maps of Tuscany made by Leonardo da Vinci in 1502 to 1503. These maps show, for the first time, land masses, individually and continuously connected, as seen from above.

3.6.1 Street plan of Imola

To create the plan of Imola (Fig. 19), Leonardo walked all the distances himself and measured all the features of the map, including streets and fields. He had no tools, nonetheless he achieved an accurate representation of the fortress in the city. It is the oldest surviving example of a map for which the viewing point is located at the zenith (Blevins 2010).

The walls, courtyards, and even individual buildings, such as the cathedral and the castle of Rocca Sforzesca, are plotted on the map with geometric accuracy. Outside the city walls, the road and the course of the Torrente Santerno River can be distinguished. According to (URL7), the fields that surrounded the city were originally depicted in light green, while the moat surrounding the fortification and the meanders of the River Santerno were light blue. The parts near the river appear blacker, but were originally done in light ochre. The dark group of houses within the walls were red. The wind rose gives different types of winds in mirror-script: *mezzodi* (south), *scirocho* (southeast), *levante* (east), *greco* (northeast), *septantrione* (north), *maesstro* (northwest), *ponente* (west), and *libecco* (southwest). The position of Imola was determined by reference to neighbouring places, directions and distances. The street plan is set within the arc of a circle whose diameter is 42 cm.

This survey of Imola is just one in a series that Leonardo executed by order of his patron Cesare Borgia. Later, he visited many other places such as Urbino, Pesaro, Rimini, and Cesena, and produced maps of them all (Oberhummer 1909).

3.6.2 Topographic map of the Chiana Valley in Tuscany

This map by Leonardo shows the Chiana Valley in Tuscany (Fig. 20). All the water courses and points of topographical relief are drawn with great attention to detail. The observer has the impression of an oblique view of the landscape as seen from above. It can be assumed that Leonardo's fascination with flight originated from a desire to create such maps. Forests and fields supported

3.5.6. Vitruvijev čovjek

Na slici 18 prikazan je čovjek u dva položaja ruku i nogu. U prvom su položaju ruke horizontalne, a noge skupljene – ljudsko tijelo ucrtano je u kvadrat. Visina čovjeka jednaka je širini rastvorenih ruku, odnosno stranici kvadrata. U drugom položaju ruke su podignute, a noge raširene – ljudsko tijelo sada je opisano kružnicom. Iz odnosa veličina pojedinih dijelova tijela na tom crtežu, može se doći do mnogih zanimljivih zaključaka. Svima je zajedničko to da je čovjek mjera svega, pa i svemira. Neki su izračuni pokazali da se omjer radijusa upisane kružnice i radijusa male kružnice (koja se može upisati iznad glave) odnosi kao omjer radijusa Zemlje i Mjeseca. Drugi su našli misterioznu povezanost „svete geometrije" s položajem i veličinama piramida kod Gize u Egiptu. Ipak, najvjerodostojnije su činjenice koje se dobiju iz omjera pojedinih dijelova tijela Vitruvijeva čovjeka, jer su ti omjeri u zlatnom omjeru. Crtež je izradio i zrcalnim pismom opisao Leonardo da Vinci prema Vitruvijevim studijama o proporcijama (URL5).

3.6. Kartograf

Potražnja za kvalitetnim kartografima u 16. stoljeću povećavala se paralelno s duhovnim i intelektualnim buđenjem renesanse. Metode topografske izmjere razvijale su se zahvaljujući kompasu, mjernim vrpcama i drugim pomagalima koja su omogućila točnija mjerenja. Znanstvenici i umjetnici zanimaju se za svijet prirode te izrađuju karte slične kartama Leonarda da Vincija. Prethodni plošni prikazi krajolika s izoliranim simbolima za planine ustupili su mjesto kontinuiranom prikazu terena različitom kartografikom. Prikaz šuma i polja podržan je kosim pogledom kontinuiranog terena, a trodimenzionalnost je postignuta pomoću linija nagiba i sjenčanjem. Slijedeći da Vincijev primjer, tek nakon pedeset godina kartografi su razvili primjereniju kartografiku za prikaz planina (URL6).

Leonardo da Vinci malo je poznat kao kartograf čak i prijateljima kartografije. Najčešće se uz vrlo kratko obrazloženje spomenu njegove dvije ili tri karte, ili poneki crtež krajolika. Njegove su karte, kao i rukopisi, razasuti po mnogim bibliotekama Europe, posebice u Italiji, Francuskoj i Velikoj Britaniji. Potrebno je istaknuti da je Leonardo svoje ideje, skice i crteže opisivao zrcalnim pismom, dok se pri opisu karata, ako su one bile namijenjene široj javnosti, služio običnim normalnim pismom (Oberhummer 1909).

Kraljevska kolekcija u Windsoru (Royal Collection in Windsor Castle) najpotpunija je zbirka kartografskih

Image available in printed version.
Slika dostupna u tiskanom primjerku.

Figure 19. A Plan of Imola, around 1502 *(Courtesy of the Royal Collection Trust / © Her Majesty Queen Elizabeth II 2013)*
Slika 19. Plan grada Imole, oko 1502. *(ljubaznošću Royal Collection Trust / © Njezina Veličanstva kraljice Elizabete II., 2013.)*

djela Leonarda da Vincija. Upravo iz te zbirke prikazano je nekoliko karata koje ću detaljnije obraditi.

Drugi materijal sadržan je u monumentalnom djelu Accademie dei Lincci *Codice Atlantico*. Većina tih karata nastala je na umjetnikovu putovanju kroz središnju Italiju 1502. godine. Karte nisu kopije nego su rezultat slobodnog skiciranja svih detalja krajolika; neke su nastale crtanjem „u žurbi", dok su neke opet izrađene vrlo pažljivo u boji, perom ili kistom.

Leonardo je postupao pronicavo te je tražio stalnu službu s redovitim primanjima kako bi se nesmetano mogao baviti intelektualnim radom. U pedesetoj godini života, godine 1502. ušao je u službu vojvode Cesarea Borgie. Da bi zadobio njegov patronat, nastojao je izraditi kvalitetne karte koje bi pomogle uspješnom ratovanju, jer su u to vrijeme bile česte borbe između pojedinih gradova. Karte su bile rijetke, a još rjeđe su bile kvalitetne i točne karte. U okviru svojih mogućnosti, kao glavni vojvodin arhitekt i inženjer, Leonardo je nadzirao radove na gradnji utvrda papinske vojske u središnjoj Italiji, te je dizajnirao ratne strojeve. U tom je razdoblju iscrtao i nekoliko topografskih karata (URL6).

Imhof (1965) obrazlaže nastanak kvalitetnijih karata: realističniji prikaz zemljišnih oblika pojavio se na kartama kada su se prirodno nadareni znanstvenici i umjetnici počeli zanimati za planine. Najraniji i najljepši primjeri tog razvoja su karte Toskane Leonarda da Vincija iz razdoblja od 1502. do 1503. godine. Te karte prvi put prikazuju reljefne oblike, pojedinačno i kontinuirano povezane, kao što je vidljivo iz ptičje perspektive.

Image available in printed version.
Slika dostupna u tiskanom primjerku.

Figure 20. A Map of the Valdichiana, 1502 *(Courtesy of the Royal Collection Trust / © Her Majesty Queen Elizabeth II 2013)*
Slika 20. Dolina Chiana u Toskani, 1502. *(ljubaznošću Royal Collection Trust / © Njezina Veličanstva kraljice Elizabete II., 2013.)*

Image available in printed version.
Slika dostupna u tiskanom primjerku.

Figure 21. A Map of the Pontine Marshes, around 1515 *(Courtesy of the Royal Collection Trust / © Her Majesty Queen Elizabeth II 2013)*
Slika 21. Karta močvare Pontino, oko 1515. *(ljubaznošću Royal Collection Trust / © Njezina Veličanstva kraljice Elizabete II., 2013.)*

Image available in printed version.
Slika dostupna u tiskanom primjerku.

Figure 22. Map of Western Tuscany, 1503-1504 *(Courtesy of the Royal Collection Trust / © Her Majesty Queen Elizabeth II 2013)*
Slika 22. Karta zapadne Toskane, 1503–1504. *(ljubaznošću Royal Collection Trust / © Njezina Veličanstva kraljice Elizabete II., 2013.)*

the oblique view of continuous terrain and three-dimensionality was achieved through sloping lines and cross-hatching.

This map covers eastern Tuscany between Arrezo, Siena and Perugia. The scale is roughly 1:300 000, the map is oriented towards the river estuary, and the source of light is to the right (south). In addition to the extension of Lake Transimeo that is displayed in blue with three fairly prominent islands, there are large, long underwater areas that no longer exist because they have been drained due to the River Arno and River Tiber (Oberhummer 1909).

When he saw these topographic maps (which are not strictly topographical in today's terms), Duke Cesare Borgia was amazed and highly respectful of the great artist, since accurate, detailed maps represented a great advantage in warfare. Thus, the maps became an extremely important strategic tool, and Leonardo gained the much-desired patronage of the Duke (URL3).

3.6.3 Map of the Pontine Marshes

This map (Fig. 21) shows the southern part of the Pontine Marshes with Monte Circeo hill and the Terracina mountains. The curved contours of the lower part of the flooded coast are over-stylised, as is obvious to even a casual observer. The mountains are illuminated from the left, and the wetlands and dense sand hills, are drawn very realistically. The orientation is to the north-east (Oberhummer 1909). Two Roman roads (Via Appia and Via Latina) passed through the marshes, which are located between the Tyrrhenian Sea, the Albanian mountains and Monti Lepinia. For centuries, the marshes were a source of malaria. Several Roman emperors and popes tried to drain them. Giuliano de Medici hired Leonardo to produce a project, but it failed. It was not until 1935, with the construction of an embankment, drainage channels several thousand kilometres long and 124 000 workmen, was the project of draining the wetlands successfully completed (URL8). New towns arose: Latina, Sabaudia, Pontinis, Aprilia and Pomezia. Today, crops, fruit and vegetables are cultivated on the fertile land.

3.6.4 Map of Western Tuscany

This map shows the west coast of Tuscany (near Leghorn, with Luccia and Volterra). This is an area that the artist, born in Vinci near Emporia, knew well. The approximate scale is 1:300 000 and the orientation is to the west. The sea is shown in blue, the terrain in sepia, and the mountains, several of which are topped by

3.6.1. Plan grada Imole

Da bi izradio plan grada Imole (sl. 19), Leonardo je sam prohodao sve udaljenosti i tako izmjerio cijeli sadržaj karte, uključujući ulice i polja. Pritom nije imao nikakvih pomagala, a postigao je točan prikaz tvrđava u gradu. To je najstariji primjer sačuvane karte grada i prva karta za koju je oko promatrača smješteno u zenitu (Blevins 2010).

Prikaz zidova, dvorišta, čak pojedinačnih objekata kao što su katedrala i dvorac Rocca Sforzesca, geometrijski su točno iscrtani. Izvan grada prepoznaju se ceste i tok vodotoka Torrente Santerno. Prema (URL7), na originalu su polja koja okružuju grad prikazana svijetlozeleno; obrambeni jarak koji okružuje fortifikaciju i meandri rijeke Santerno su svijetloplavi. Dijelovi pokraj rijeke ispali su više crni, a na originalu su svijetlooker. Tamne grupe kuća unutar zidina su crvene. Na ruži vjetrova mogu se zrcalnim pismom pročitati različite vrste vjetrova: *mezzodi* (jug), *scirocho* (jugoistok), *levante* (istok), *greco* (sjeveroistok), *septantrione* (sjever), *maesstro* (sjeverozapad), *ponente* (zapad), *libecco* (jugozapad). Položaj grada Imole određen je zapisom susjednih mjesta, smjerova i njihovim udaljenostima. Plan grada opisan je lukom kružnice čiji je dijametar 42 cm.

Izmjera Imole samo je jedna u nizu koje je Leonardo obavio po narudžbi svojega patrona Cesarea Borgie. Nakon 1502. kartograf Leonardo bio je u više mjesta: Urbino, Pesaro, Rimini, Cesena i druga, te je za sve njih izradio plan naselja (Oberhummer 1909).

3.6.2. Topografska karta doline Chiana u Toskani

Ta Leonardova karta prikazuje dolinu Chiana u Toskani (sl. 20). S posebnom pozornošću detaljno je prikazao sve vodotoke i oblike reljefa. Promatrač ima dojam da kosim pogledom promatra krajolik iz ptičje perspektive. Može se pretpostaviti da Leonardova ideja za letom potječe iz želje za prikazom takvih karata. Prikaz padina i nagiba (trodimenzionalnost) postignut je kosim crticama i tehnikom sjenčanja.

Karta obuhvaća istočnu Toskanu između Arreza, Siene i Perugie. Mjerilo je oko 1:300 000, orijentirana je prema ušću (slijevu) rijeka, izvor svjetla je zdesna (jug). Osim protezanja jezera Transimeo, koje je prikazano plavom bojom, sa svoja tri prilično prenaglašena otoka, u dolini Chiana primjećujemo velike i dugačke površine pod vodom koje više ne postoje jer su isušene zbog rijeka Arno i Tibera (Oberhummer 1909). Vidjevši te topografske karte (one nisu strogo topografske u današnjem smislu), vojvoda Cesare Borgia ostao je zapanjen i pun strahopoštovanja prema velikom umjetniku Leonardu, jer posjedovati točnu kartu s puno detalja značilo je imati veliku prednost u ratovanju. Tako je karta postala iznimno važno strateško oruđe, a Leonardo je zadobio željeni vojvodin patronat (URL3).

3.6.3. Karta močvare Pontino

Karta (sl. 21) prikazuje južni dio močvare Pontino s brežuljkom Monte Circeo i planinama Terracina. Krivulje u donjem, plavljenom dijelu obale previše su zaobljene, što se vidi golim okom. Planine su osvijetljene s lijeve strane, a močvara i posebno gusti pješčani brežuljci iscrtani su vrlo prirodno. Orijentacija je prema sjeveroistoku (Oberhummer 1909). Kroz močvaru, koja je smještena između Tirenskog mora, Albanskih brda i Monti Lepinia, prolazile su dvije rimske ceste: Via Appia i Via Latina. Stoljećima je močvara bila izvor malarije. Nekoliko rimskih vladara i papa pokušavalo ju je isušiti, te je u toj namjeri i Giuliano de Medici angažirao Leonarda na izradi projekta. Tada taj pothvat nije uspio. Tek je 1935. izgradnjom nasipa, kopanjem drenažnih kanala u dužini od više tisuća kilometara i radom 124 000 muškaraca uspješno završen projekt isušivanja močvare (URL8). Doseljavanjem stanovništva nastali su novi gradovi: Latina, Sabaudia, Pontinis, Aprilia i Pomezia. Danas se na plodnoj zemlji uzgajaju žitarice, voće i povrće.

3.6.4. Karta zapadne Toskane

Na toj karti (sl. 22) prikazana je zapadna obala Toskane (obala pokraj Leghorna te Luccia i Volterra). To je područje koje je umjetnik, rođen u Vinci pokraj Emporia, dobro poznavao. Približno je mjerilo 1:300 000, orijentacija prema zapadu. More je prikazano u plavoj boji, teren u smeđoj sepiji, a planine, najčešće okrunjene gradovima, crtane su u perspektivi s izvorom svjetla slijeva (jug). Rijeke su prikazane dvostrukim linijama, a gradovi i sela vinjetama (Oberhummer 1909).

Vjerojatno su te tri karte Toskane namijenjene za osobnu uporabu Cesarea Borgie jer tekst na njima nije ispisan zrcalnim pismom. One su izvanredan primjer detaljne izmjere Italije iz 15. stoljeća, ali se takve karte nažalost rijetko mogu pronaći.

3.6.5. Leonardovi krajolici i skice

Kartograf Leonardo izradio je nekoliko desetaka raznih skica i krajolika. To su najčešće skice riječnih tokova (rijeke Arno i Loire), kanala za sprječavanje poplava, gradova Firence i Milana, planovi ulica, krajolici dolina i planina. Na slikama 23 i 24 prikazani su krajolici

Image available in printed version.
Slika dostupna u tiskanom primjerku.

Image available in printed version.
Slika dostupna u tiskanom primjerku.

Figure 23 and 24. A view of the River Adda valley, 1511–1513 *(Courtesy of the Royal Collection Trust / © Her Majesty Queen Elizabeth II 2013)*
Slika 23 i 24. Pogled na dolinu rijeke Adda, 1511–1513. *(ljubaznošću Royal Collection Trust / © Njezina Veličanstva kraljice Elizabete II., 2013.)*

towns, are drawn in perspective with the light source from the left (south). The rivers are depicted by double lines, and the towns and villages by vignettes (Oberhummer 1909).

These three maps of Tuscany were likely intended for Cesare Borgia's personal use, as the text on them is not written in mirror-script. They are outstanding examples of 15th century detailed surveys of Italy, of which unfortunately, only a few have been found.

3.6.5 Leonardo's landscapes and sketches

As a cartographer, Leonardo made several dozen different sketches and landscapes. These are mostly sketches of watercourses (the Arno and the Loire), flood prevention channels for Florence and Milan, street plans, and valley and mountain landscapes. Figures 23 and 24 show the landscape of the River Adda valley. A street plan of Imola is shown in Figure 25. Figure 26 shows sketches of three rivers: the Brembana, Trompia and Sabbia. A sketch of a channel is shown in Figure 27. Finally, Figure 28 shows the chateau of Amboise, which was given to Leonardo as a residence by the French King François I, and in which the great artist died.

3.6.6 Leonardo's landscapes in paintings

The fact that Leonardo da Vinci painted actual landscapes in his masterpieces, rather than imaginary ones, has been discovered only recently. Smith Webster carried out the first investigations in 1985, and Donato Pezzutto researched the *Mona Lisa* in 2011. It turned out that the landscape around the *Mona Lisa* corresponds to the topography indicated on the map of the Chiana valley. In *The Annunciation*, the River Arno can be recognized in the direction of Serravalle and Florence. The River Adda valley towards Lake Lecco corresponds to the landscape in the painting *Madonna of the Yarnwinder*, while the *Virgin* and *Child with Saint Anne* shows a landscape that matches the Sesia valley and Monte Rosa (Pezzutto 2012).

Leonardo's knowledge of the landscape of his native land, especially the River Arno and Chiana valley, proved useful in embellishing his masterpieces. Each of his paintings is an expression of his artistry, scientific observation and reasoning. This is a clear example of how art and science are inextricably linked in the work of Leonardo da Vinci. In the modern age, such figures are rare or non-existent.

3.6.7 Map of the World – Mappa mundi

The *Mappa Mundi* (Fig. 29) from the Royal Collection in Windsor Castle, made in about 1514, is attributed to Leonardo da Vinci because it was found in his collection of manuscripts. This map is presented in eight segments (each three-dimensional section of the globe is shown in two dimensions). Each segment is an equilateral spherical triangle, representing one-eighth of the Earth's surface, rather than the spherical "two angles" typical at that time. Richard Henry Major says this map is special due to three characteristics. First, it is the earliest known map on which the name of America appears. Secondly, it is the first to separate the west coast of America from Asia. Thirdly, it is the only known map that contains an indication of the existence of a great southern polar continent, before the discovery of the Magellan Strait (URL9).

According to Oberhummer (1909), F. von Wieser dated the map to around 1515-16, which is slightly later than the date set by R. H. Major. Wieser recognized the map as one of the types of charts on which Magellan

doline rijeke Adda; plan ulica Imole prikazan je na slici 25, na slici 26 su skice triju rijeka: Brembana, Trompia i Sabbia; skica kanala je na slici 27, a na slici 28 prikazan je dvorac Amboise koji je Leonardu dodijelio francuski kralj Franjo I. za prebivalište, gdje je veliki umjetnik i preminuo.

3.6.6. Leonardovi krajolici na slikama

Da je Leonardo da Vinci prikazao krajolike na svojim remek-djelima, i to ne neke apstraktne i nepoznate nego konkretne i stvarne, poznato je tek od nedavno. Prva ispitivanja proveo je Smith Webster 1985., a zatim Donato Pezzuto nešto kasnije, 2011. na slici *Mona Lise*. Pokazalo se da prikazani krajolik oko *Mona Lise* odgovara topografiji na topografskoj karti doline Chiana. Na slici *Navještenje* prepoznata je rijeka Arno ako se promatra krajolik u smjeru Serravalle i Firence. Dolina rijeke Adda prema jezeru Lecco odgovara krajoliku na slici *Madona s vretenom*, dok je na slici *Djevica* i *dijete sa svetom Anom i janjetom* prikazan krajolik koji odgovara topografiji doline Sesia i planine Monte Rosa (Pezzutto 2012).

Poznavanje krajolika svojega zavičaja, posebno rijeke Arno i doline Chiana, pokazalo se korisno u ukrašavanju najvrjednijih Leonardovih remek-djela. Svaka od njegovih slika nastala je kao izraz njegove umjetničke ekspresije, ali i znanstvenog promatranja i zaključivanja. To je zoran primjer kako je veliki znanstvenik i umjetnik Leonardo da Vinci još jednom čvrsto povezao znanost i umjetnost. U današnje doba nema više takvih primjera, ili su prilično rijetki.

3.6.7. Karta svijeta Mappa mundi

Autorstvo karte svijeta (sl. 29) kraljevske kolekcije iz Windsora (Royal Collections of Windsor Castle), nastale oko 1514. godine, pripisuje se Leonardu da Vinciju jer je pronađena u njegovoj zbirci rukopisa. Ta karta prikazana je u obliku osam segmenata (svaki trodimenzionalni isječak globusa prikazan je u dvije dimenzije). Pojedini segment je istostranični sferni trokut, a predstavlja jednu osminu Zemljine površine, ali ne u obliku sfernog dvokuta kao oblika koji je bio tada uobičajen. Richard Henry Major opisuje tu kartu kao posebnu

Image available in printed version.
Slika dostupna u tiskanom primjerku.

Figure 25. Sketches of the street plan of Imola, 1502 *(Courtesy of the Royal Collection Trust / © Her Majesty Queen Elizabeth II 2013)*

Slika 25. Plan ulica grada Imole, 1502. *(ljubaznošću Royal Collection Trust / © Njezina Veličanstva kraljice Elizabete II., 2013.)*

Image available in printed version.
Slika dostupna u tiskanom primjerku.

Figure 26. Three sketches of the course of the rivers Brembana, Trompia and Sabbia, with distances marked, around 1510 *(Courtesy of the Royal Collection Trust / © Her Majesty Queen Elizabeth II 2013)*

Slika 26. Tri skice tokova rijeka: Brembana, Trompia i Sabbia s upisanim udaljenostima, oko 1510. *(ljubaznošću Royal Collection Trust / © Njezina Veličanstva kraljice Elizabete II., 2013.)*

Figure 27. A scheme for a canal, 1503-1504 *(Courtesy of the Royal Collection Trust / © Her Majesty Queen Elizabeth II 2013)*
Slika 27. Skica za projekt kanala, 1503–1504. *(ljubaznošću Royal Collection Trust / © Njezina Veličanstva kraljice Elizabete II., 2013.)*

Figure 28. The Chateau of Amboise, 1517–1519 *(Courtesy of the Royal Collection Trust / © Her Majesty Queen Elizabeth II 2013)*
Slika 28. Dvorac Amboise (The Chateau of Amboise), 1517–1519. *(ljubaznošću Royal Collection Trust / © Njezina Veličanstva kraljice Elizabete II., 2013.)*

based his plans for the discovery of the south-west passage. The southern polar continent on the *Mappa Mundi* is located at a considerable distance from Africa and America, which aroused interest in contemporary circles, despite its vagueness and lack of detail. There are doubts concerning its authorship: some Italian experts, such as Marchese Girolamo d'Adda and G. Giori, do not believe that Leonardo was its author. The highest authorities on early American maps, H. Harris and M. Fiorini, however, support its authenticity. Von Wieser believes that there may have been an original drawing by Leonardo, but that this map may only be a third- or fourth-hand copy. Fortunately, our knowledge of Leonardo's cartographic work is not limited to one map of unreliable origin.

The contours of the New World are similar to those found on other globes, such as the Jagiellonian globe.

Figure 29. Mappa Mundi, 1514 *(Courtesy of the Royal Collection Trust / © Her Majesty Queen Elizabeth II 2013)*
Slika 29. Karta svijeta (Mappa mundi), 1514. *(ljubaznošću Royal Collection Trust / © Njezina Veličanstva kraljice Elizabete II., 2013.)*

North America is shown with two islands: one named *Bacalar* and the other *Terra Florida*. South America is shown as a large island with the strikingly printed name *America*, with the familiar names of coasts (Major 1865, URL9).

The map segments are interesting because of their unusual shape. Da Vinci's globe is divided into eight equal parts. The Equator and two meridians form the lines of demarcation. These parts form equilateral spherical triangles, and each page is a arc whose centre is at the intersection of two adjacent circular arcs. As the scale

zbog tri elementa koji se na njoj mogu prepoznati. Prvo, to je najranija karta do sada poznata na kojoj se pojavljuje naziv Amerika; drugo, na njoj prepoznajemo odvajanje zapadne obale Amerike od njezinoga spoja s Azijom; treće, to je jedina do sada poznata karta koja sadrži indikaciju o postojanju velikog južnoga kontinenta prije otkrića Magellanova tjesnaca (URL9).

Prema Oberhummeru (1909), F. von Wieser odredio je datum izrade te karte oko 1515–16., a to je nešto kasnije nego što ga je odredio Richard Henry Major. Wieser prepoznaje tu kartu kao jednu od tipova karata na kojima je Magellan temeljio svoje planove za jugozapadni prolaz. Južni kontinent na toj karti svijeta smješten je na prilično udaljenosti od Afrike i Amerike; takav prikaz pobudio je prilično zanimanje suvremenika unatoč svojoj nedorečenosti i nedostatku detalja. U pogledu autorstva postoje određene dvojbe; tako neki talijanski eksperti, kao što su Marchese Girolamo d'Adda i G. Giori, smatraju da veliki majstor nije njezin autor. Najveći autoriteti za rane američke karte H. Harrisse i M. Fiorini opet podržavaju njezinu autentičnost. Franz von Wieser smatra da ako Leonardov crtež i je originalan, karta može biti samo kopija iz treće ili četvrte ruke. Srećom da naše poznavanje Leonardova kartografskog djela nije ograničeno samo na jednu kartu nepouzdanog podrijetla.

Obrisi Novoga svijeta slični su onima na nekim drugim globusima, kao na primjer na Jagelonskom globusu. Područje Sjeverne Amerike prikazano je s dva otoka: jedan nosi ime *Bacalar*, a drugi *Terra Florida*. Južna Amerika prikazana je kao veliki otok s upadljivo ispisanim nazivom Amerika, zajedno s poznatim nazivima obala (Major 1865, URL9).

Segmenti te karte zanimljivi su zbog svojega neobičnog oblika. Da Vincijev globus razrezan je na osam jednakih dijelova. Za linije razdvajanja uzeti su ekvator i dvije meridijanske kružnice. Ti dijelovi formiraju istostranične sferne trokute, a svaka je stranica luk kružnice čiji je centar u sjecištu dvaju susjednih kružnih lukova. Mjerilo karte je vrlo sitno; unošenje naziva stoga nije ni u kom slučaju obilno. Ipak su s određenom pažnjom dani opisi kontura poznatog dijela svijeta. Ne treba nas čuditi što karta nema meridijana ni paralela; manuskriptne karte izrađene u to vrijeme nisu davale navigatorima nikakve informacije u smislu opasnosti ili tijeka puta (URL9).

Za tu Leonardovu kartu svijeta nije još određena projekcija. Više autora nastojalo je tijekom povijesti, dosta uspješno, otkriti način konstrukcije ovih „listova djeteline".

4. Zaključak

Polimat i univerzalni čovjek renesanse Leonardo da Vinci, čije je područje zanimanja iznimno veliko, dao je svoj doprinos i kartografiji. Dva su razloga njegova bavljenja kartografijom: prvi je njegova želja da olakša ljudima život kroz mirnodopske projekte kao što su regulacija vodotoka u svrhu obrana od poplava i isušivanje močvara za koje su bili prijeko potrebni pouzdani topografski prikazi, a drugi razlog bila je narudžba njegovih patrona u čijoj je bio službi: kako bi uspješno vodili bitke i osvajali nova područja (renesansna Italija bila je stalno u ratu), potreba za kartama bila je velika. U ovom članku dane su analize nekih njegovih planova i karata koje su ostale sačuvane tijekom stoljeća. To su: plan grada Imole u ortogonalnoj projekciji, tri topografske karte Toskane i karta svijeta (*Mappa mundi*).

Leonardo je trasirao novi pristup izradi karata: posebno oblikovanim znakovima prikazao je reljef kao kontinuiranu plohu, a trodimenzionalnost je postigao korištenjem malih crtica i sjenčanjem. Planine više nisu bile prikazane kao ravne prazne plohe sa skupinama simbola. Kasniji autori kartografi prikazivali su reljef na isti način kao i Leonardo, a može se reći da se isti princip u prikazivanju reljefa zadržao do danas (osim izohipsi). Leonardove karte bile su po kvaliteti iznad drugih karata toga vremena. Poznat kao veliki estetičar skladno je spojio znanost i umjetnost te se za njegove karte s puno argumenata može reći da su i umjetnička djela.

is very small, few titles have been added. Nevertheless, particular attention has been paid to describing the contours of the known world. It is not surprising that there are no lines of latitude or longitude, as manuscript maps made at the time did not provide any information for navigators regarding hazards or routes (URL9).

The construction of Leonardo's map of the world is not yet well understood. Throughout history several authors have tried with varying degrees of success to discover how he achieved the construction of the 'clover leaf'.

4 Conclusion

Leonardo da Vinci, the universal polymath and Renaissance man, showed a great interest in and made substantial contributions to cartography. There are two reasons why he concerned himself with cartography. The first was his desire to improve human life through peacetime projects, such as water flow regulation for flood control and drainage of wetlands, for which reliable topographical depictions were required. The second was to produce work commissioned by the patrons he served; for successful warfare and the conquest of new territories (Renaissance Italy was constantly at war) fuelled a great demand for maps. This paper analyses some of Leonardo's plans and maps that have survived through the centuries, particularly the plan of Imola in orthogonal projection, the three topographic maps of Tuscany and the *Mappa Mundi*.

Leonardo pioneered a new approach to mapping by designing special symbols to show relief as a continuous plane, and achieving three-dimensionality through the use of small lines and shading. Mountains were no longer presented as a flat, blank planes with groups of symbols. Later cartographers represented relief in the same way as Leonardo, and it can be argued that the same principles in the representation of relief have been maintained to this day (with the exception of contour lines). Leonardo's maps were of a superior quality to other maps of the time. Known as a great aesthete, Leonardo harmoniously integrated science and art, in his maps and other works of art.

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