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Copernicus and Geography

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COPERNICUS AND GEOGRAPHY

Though Copernicus' historic role is associated with his astronomical theory and with its scientific and ideological consequences his works in other fields, including geography, continue to attract attention. This current interest is not only due to the geographers' quest for their own scientific tradition but also to the fact that some other problems are involved, for instance to what extent were the different fields of Copernicus' activity mutually interdependent? [1] This report is therefore intended to present the most essential facts related to his geographical interests in the broad sense, i.e. as (1) the general problems of the sciences of the Earth, and as (2) cartography, together with the explanation of the origin and influence of those sciences to some extent.

I. THE PROBLEMS OF PHYSICAL GEOGRAPHY AND GEOPHYSICS

Some interests of the great astronomer, which according to the modern classification of the sciences would come into the scope of physical geograpy and geophysics, have already been pointed out by different authors; [2] as evidence have been used not only his principal work, the *Revolutions,* but also numerous manuscript documents, among them notes in his own hand upon a copy of Ptolemy's *Cosmographia* which is now kept in the library of Uppsala University. [3]

[1] Cf. the study by Thomas E. Goldstein, "The Influence of the Geographic Discoveries upon Copernicus, *Organon*, 9, 1972.

[2] That Copernicus was interested in these problems was already pointed out by Simon Stevin in the *Memoire* of 1605.

[3] Incun. 32, 10, cited after L. A. Birkenmajer. In this article I have made use of a number of minor papers by different authors, primarily the fundamental studies by L. A. Birkenmajer: *Mikołaj Kopernik*, Cracow, 1900; *Stromata Copernicana*, Cracow, 1924; "Marco Beneventano, Kopernik, Wapowski a najstarsza karta Polski" (Marco Beneventano, Copernicus, Wapowski and the Oldest Map of Poland), *Rozprawy Akademii Umiejętności, Wydz. Mat. Przyr.*, Ser. A, XLI, 1901 (this study was used by Vidal de la Blanche in *Annales de Géographie, Bibliographie,* 1902, publiée 1903).

(1) In the *Revolutions* Copernicus presented the Earth in its actual situation in the Universe indicating the diverse relations to other celestial bodies and describing its three motions, the revolving motion about its own axis, the circulation around the Sun, and the conical motion of the Earth's axis known as the precession. This latter motion is, in his opinion, due to the influence of the Moon. He pointed out that weight is a result of the natural tendency to concentrate into spheres. This induced Alexander Humboldt, a student of Copernicus' work who devoted much space to him in the second volume of the *Cosmos,* to suggest that Copernicus had intuitively sensed the law of gravitation in nature which was later discovered by Newton. Some historians used to compare Copernicus, the discoverer of a "new heaven", to Columbus, the discoverer of a new continent, which is not a very fortunate comparison.

(2) As it is seen from chapter 3 of book I (as well as from the afore-mentioned notes), Copernicus was interested in the Earth not only as a heavenly body and its relations with the other planets and with the Sun. He cherished so to say a more direct interest in the Earth; for instance he estimated the ratio of the solid mass of the Earth to its waters, including the ratio of the areas occupied by land and sea, respectively. He studied meticulously the opinions of the scientists of antiquity and referred to them both as regards the place of the Earth within its planetary system (the Pythagorean suggestions concerning the motion of the Earth) and its size.

Ptolemy's picture of the *oikoumene* as extending over the Earth down to half its circumference was supplemented by Copernicus with later data concerning the Far East and the discoveries due to the Spanish and Portuguese rulers, above all the discovery of America, which "according to geometric calculations" appears to be located diametrically opposite to Ganges India ("Ipsam enim Americam geometrica ratio ex illius situ Indiae Gangeticae e diametro oppositam credi cogit"). This chapter 3 which was intended to show how land together with water constitute one sphere ("quomodo terra cum aqua unum globum perficiat") contains toward its end a text which, though obviously subservient to his astronomical theory, is nevertheless of geophysical character: "... both land and water tend to one centre of gravity that is not different from the centre of the whole Earth which, because it is heavier, is filled with water in its clefts; and therefore the amount of the waters is small as compared to that of the lands, though on the surface itself more water may be visible. In any case the Earth must, together with its waters, have such a shape as is cast by its own shadow: and this latter covers the Moon with segments of a perfect circle." [4]

[4] "...puto manifestum terram simul et equam uni centro gravitatis inniti nec esse aliud magnitudinis terrae, quae cum sit gravior, dehiscentes eius partes aqua expleri; et idcirco modicam esse comparatione terrae aquam, etsi superficie tenus

(3) Copernicus employed astronomical knowledge and astronomical instruments in measurements that were of basic importance for cartography. Thus, in connection with his cartographic interests, he determined the geographic latitudes of Frombork, Toruń and Olsztyn. In the *Revolutions* and in other works his interest in plane trigonometry as applied to land-surveying, "geodesy", a word used in book I which was perhaps borrowed from Aristotle [5]) is obvious. He had at hand such instruments as the dioptra, the astrolabe (in addition to the strictly measuring device called chorobates) which could be used in geodetic measurements.

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When compared to the extremely complex origin of his heliocentric theory, which had its roots in such different sources as the Pythagorean suggestions concerning the revolution of the Earth, the Platonic philosophy of cult of the Sun, the contemporary critiques of Aristotle and of Ptolemy as well as his own observations of the disagreement between the Ptolemaic system and reality, Copernicus' physical-geographic interestsin the Earth seem simply to derive from his astronomical studies, especially where they refer to the terrestrial globe (the Earth as a whole) or to measurements of coordinates. In his considerations, which in modern terms could be defined to be physico-geographical and geophysical, he concentrated on the essential features of the structure of the terrestrial globe as a planet. To prove that the Earth is a sphere he used mainly astronomical facts without taking recourse to the geographic ideas that had been developed in the Renaissance to the extent of becoming elementary truths. It is known that the idea of the Earth being spherical had become so obvious (among others, owing to the several editions of Ptolemy with the cartographic mapping of the *oikoumene*) by that time that it could be freely used on maps both by the Italian traveller and cartographer Paolo Toscanelli (1397–1482) and by the German traveller and author of the famous globe of 1492 Martin Behaim (1459–1507) and even by Columbus who used that idea to persuade the laymen at the Spanish royal court to aid his westward journey to Ganges India. The maps of fragments of the terrestrial globe or the globes themselves which became more and more frequent at the turn of the 15th and 16th centuries owing to the geographic discoveries and the cultural needs of the Renaissance were only representations and models furnished by the geography of that time. But it was only astronomy that could provide solid

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plus forsitan aquae appareat. Talem quippe figuram habere terram cum circumfluentibus aquis necesse est, qualem umbra ipsius ostendit: absoluti enim circuli amfractibus Lunam deficientem efficit." All quotations from the *Revolutions* in this paper are taken retranslations from the Latin-Polish edition of the first book of the *Revolutions*, PWN, Warsaw, 1953.

[5] Birkenmajer's suggestion, *Mikołaj Kopernik*, part I, p. 336 (note).

evidence of the spherical shape of the Earth before this sphericity was empirically proved by a travel "around the world". Though the news of the great geographical discoveries and the travellers' exploits which inflamed the contemporary minds must have reached Copernicus he probably did not see much use in them as regards the justification of his theory if he ignored Columbus' travels which were thought to have brought him to south-east Asia by sailing westward. Nor did he include Magellan's travel around the world (1519–1522) among the proofs of the Earth's sphericity. Only in his explanation how "land together with water constitute one sphere" Copernicus mentions the news of the discovery of a new continent which was widely spread under the name of America by Waldseemüller in his *Cosmographiae Introductio* (1507). This continent, which was discovered by admiral Amerigo Vespucci in 1501 was to be one of the proofs that the mass of the solid part of the Earth is incomparably bigger than its waters. The whole chapter 3 of book I, in fact, is mainly devoted to finding the ratio of the mass of waters to the lands and to prove that the location of the waters indicates that both the land and the waters tend to "one centre of gravity that is not different from the centre of the whole Earth." Hence he diverges from the peripathetic theory more by assuming that the solid mass exceeds incomparably the volume of the waters than by the concept of a different pattern of the elements; the latter, which owing to the geographical discoveries have been "integrated", as Goldstein puts it, by Copernicus and hence are as if entirely different from the peripathetic idea fo the spherical system: land, water, and air. [6]

II. COPERNICUS' CONTRIBUTION TO THE GEOGRAPHY AND CARTOGRAPHY OF POLAND'S NORTHERN AREAS: POMERANIA, PRUSSIA AND LIVONIA

The following are evidence of his activities in this respect.

(1) A map, probably of Varmia and the western part of Ducal Prussia (i.e. the Prussian territory belonging to the Teutonic Order), which the Teutonic Knights were anxious to capture. For this purpose they hired a Hans Lilienthal (Fabian von Losseinen, that is from Łężany) who in July 1510 wrote to the representative of the Order, John Schönberg: "Ich hab groszen fleysz gethan dy mappa zu obirkommen, hab yn allen kameren doctoris Nicolai gesucht, ist nyrgen zu phynden. Ich vorsehe mich, er hab dy mete genomen oder in Kasten geslossen." [7]

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[6] T. E. Goldstein, *op. cit. Cf.* also H. Guerlac, "Copernicus and Aristotle's Cosmos", *Historical Ideas*, vol. 29, 1968, pp. 109-13.

[7] The State Archives at Kaliningrad (formerly Königsberg) OBA. Ferstreuter, *Kopernicus-Forschungen*, 1943, p. 229.

(2) The Varmian bishop Fabian von Losseinen's letter of 17 May 1517; during a dispute with the town Elbląg over the delimitation of the western part of the Vistula Bay he asks canon Tideman Giese to fetch to the court for the trial a map of the area, "topographicam eius descriptionem, quam doctor Nicolaus depinxit." [8]

(3) The Varmian bishop Maurice Ferber confirms in his letter of 19 July 1529 addressed to Alexander Sculteti, a citizen of Gdańsk and canon of the bishoprics of Livonia, the receipt of a map made to his order by Sculteti and Copernicus' "mappa sive descriptio terrae Livoniensis". In that period of delimitation of the boundaries between Poland and the land called Inflanty it undoubtedly appeared reasonable to utilize Copernicus' cartographic experience if in the same letter Ferber encourages Sculteti to join his efforts with those of Copernicus: "ut mappam sive descriptionem terrarum Prussiae habere possimus." [9]

That first map of Livonia, which was in part prepared by Copernicus himself, has not survived. It is known, however, to have come into the hands of the canon of Cracow and cartographer Bernard Wapowski. In a letter to the bishop of Chełm Jan Dantyszek, dated 5 March 1533, he expressed his thanks for the map which was brought to him by the bishop of Frombork Fabian Emmerich, a close associate of Sculteti. From Wapowski's letter it also follows that the map, which had no cartographic coordinates, was relatively accurate in its western part and contained mistakes in the borderland of Russia and Finland. [10] It is possible that the map was used by Olaf Magnus, who lived at Gdańsk in 1527 to 1537, in preparing his *Carta Marina* of 1539, for he had contacts with the scholars of Varmia. [11]

(4) Polish historians of cartography, among them B. Olszewicz, [12] in virtue of indirect evidence surmise that the materials for the northern part of Wapowski's *Tabula Sarmatiae* published in 1526 had been furnished by Copernicus.

(5) Casper Schütz's mention that the river Pregoła, "quam Copernicus latine Praegorem dixit" flows out from a marsh etc. and another concerning the place of origin of the river Bersza "Copernico Versae" [13] cited

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[8] The Archives of the chapter at Frombork, rep. 128. Reprinted in H. Schmauch, "Neues zur Copernicusforschung", *Z. f. Geschichte u. Altertumskunde Ermlands*, vol. 26, 1938, p. 643.

[9] The Archives of the chapter at Frombork, Fol. A, *Epistolae Mauritii 1528–37*, f. 115.

[10] This is mentioned by L. Arbusow, who refers to K. Buczek, in his "Übersicht über die Kartographie Livlands bis 1595", *Sitzungsberichte der Ges. f. Altertumskunde zu Riga. Vorträge von Januar bis November 1934*, Riga, 1935.

[11] Cf. E. F. Warep, "O vliyanii naučnoi deyatelnosti Kopernika na kartografiyu Estonii," *Actes du XI[e] Congrès International d'Histoire des Sciences, Varsovie–Cracovie, 24–31 Août, 1965*, vol. IV, pp. 267–9.

[12] Cf. *Dziewięć wieków geografii polskiej* (Nine Centuries of Polish Geography), a collection ed. by B. Olszewski, Warsaw, 1967, p. 59.

[13] *Historia Prussiae*, I, 2 and II, 1.

without reference to any source and repeated by Ch. Hartknoch [14] imply — in the opinion of L.A. Birkenmajer [15] — the existence of some, now lost writings by Copernicus.

(6) Copernicus' cartographic and geographical works were also used by his disciple and first advocate of the Copernican theory, a professor of Wittenberg University Joachim Rheticus. He came to Frombork in March 1538, at the age of 25, to learn Copernicus' teaching. Throughout his stay, i.e. till August 1541, he also cherished a vivid interest in the geography of Prussia. This is evidenced not only by the *Encomium Prussiae* appended to the *Narratio Prima* (1540) but also in the *Tabula Chorographica auff Preussen und etliche umbliegende lender* which he mentioned in his letter to Duke Albrecht at Königsberg and in his *Chorographia* (1541) which was to illustrate the principles of drawing maps which he had developed in connection with his geographic interests. Because Rheticus' fellow-traveller to Prussia, Henry Zell, published the *Tabula Prussiae* in Nuremberg in 1542, it was to this edition that — as K.H. Burmeister convincingly argues — Rheticus' *Tabula Chorographica* of Prussia could have been incorporated; and the latter was completed, to use Rheticus' own words, "mit hulffe etlicher guter herren und freunde", among them Copernicus himself. [16] Thus the geographical--cartographic works of Copernicus which previously had been regarded as lost reappeared, as Burmeister has shown, in Zell's map which is now available. [17]

(7) The general opinions about geography made by Rheticus in the *Chorographia* can be assumed to reflect Copernicus' own views, for it is commonly thought that "Copernicus was the intellectual father of Rheticus' *Chorographia*" and that Rheticus himself was "Copernici viva vox". [18] In the *Chorographia* Rheticus emphasized the necessity of a close relation between geography and astronomy "for without knowing the geographical latitude or longitude of a town it is impossible to calculate either eclipses, or the motions of the Sun, the Moon, the planets or the stellar heaven with reference to it." As a matter of fact, for the "real beginning of geography" he took considerations of "how can the Earth be studied in relation to the space of the heaven." [19] In his opinion, the purpose of geography, a "superior science", a "useful art", consisted in

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[14] *Alt- und neues Preussen*, pp. 7f.

[15] *Mikołaj Kopernik*, p. 335.

[16] Dedication letter to Duke Albrecht reprinted by K. H. Burmeister, *G. J. Rheticus*, vol. 3, *Briefwechsel*, pp. 32–8.

[17] K. H. Burmeister, "Georg Joachim Rheticus as a geographer and his contribution in the first map of Prussia", *Imago Mundi*, vol. 23, Amsterdam, 1969, pp. 73–6.

[18] J. Staszewski, "Chorografia Jerzego Joachima Retyka", *Zeszyty Geograficzne WSP w Gdańsku*, vol. III, 1961, pp. 153ff. Cf. also L. A. Birkenmajer, "Marco Beneventano", p. 13.

[19] J. Staszewski, *ibid.*, pp. 166 and 167.

"drawing maps of lands according to reliable rules", that is by increasing the number of itineraries with geographical coordinates and by compiling chorographic tables. Subsequently "such tables should be dealt with by a genuine and scrupulous mathematician who, following the example of Ptolemy, would renew geography."[20] Rheticus' *Chorographia* is closely connected with these views not as a description of lands in Ptolemy's sense but as a work outlining "the principles of drawing chorographic tables".[21] If Copernicus, whom Rheticus calls an "eminent mathematician", subordinated all his astronomical activities to mathematics, then he could not but subordinate geography to that queen of then sciences too, and Rheticus followed his master's example.

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The picture of Copernicus' cartographic activities which is today with so many difficulties being fitted together from fragments of facts contained in the documents that survived up to now would been incomparably more complete if it had been compiled by Jan Brożek (1585–1652), who collected many materials concerning the works of Copernicus. Brożek collected those materials — which later got lost — on his journey to Varmia and Prussia in 1618, which he undertook in order to get presonally acquainted with the land in which Copernicus spent most of his life and which he knew very well as administrator of the diocesses of that region.[22] Nevertheless what we do know at present about Copernicus' cartographic works and the circumstances of their origin is solid evidence that they coincided with the general national objectives of Poland, which among others included the preparation of an accurate map of the country and which was sponsored by B.Wapowski. Copernicus' participation in that is evidence of his socio-political commitment (in the dispute against the Teutonic Order, the delimitation of the boundary with Inflanty etc.).

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[20] *Ibid.*, p. 166.

[21] *Ibid.*

[22] Brożek, who was not only a mathematician, astronomer and historian of science but also a cartographer and surveyor, before venturing on the creation of a complete cartographic picture of Poland (which was intended to exceed in accuracy that of Wapowski) decided to provide a full and adequate assessment of Copernicus' activities, including his contribution to the collection of itineraries to the geography and cartography of the areas known to him. The route of his journey which ran through Toruń, Chełmno, Grudziądz, Gdańsk, Elbląg, Frombork, Lidzbark, Dobre Miasto, Reszel, Janów, Mława and Toruń again, was drawn by himself on Casper Henneberg's map of Prussia, *Prussiae vere descriptio* (1603), which he had got as a gift from the mathematician Peter Crüger during his stay in Gdańsk in 1618 and which was subsequently stuck in between folios 94 and 95 of the atlas of Mercator (4th ed., Amsterdam, 1613, now in the collection of the Jagellonian Library in Cracow). The original Latin text of a letter concerning that journey to the rector of the Jagellonian University in Cracow, Basil Golinus, was published by E. Stamm, "Z historii matematyki XVII w. w Polsce" (A Contribution to the History of Mathematics in the 16th-century Poland), *Wiadomości Matematyczne*, vol. XL, 1936, p. 151; a translation into Polish was published by Henryk Barycz, in: Jan Brożek, *Wybór pism* (Selected Writings), vol. 1, 1956, pp. 436–9, together with a reproduction of the map.

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The easiness with which Copernicus' views on physico-geographic and geophysical problems and his cartographic achievements can be presented is not, unfortunately, matched by an equal easiness as regards the precise assessment of the role which was played by the geographical discoveries in his heliocentric theory. His *Revolutions* show that when he took recourse to geographical material he did it sparingly and with much cautiousness, even when it referred to the facts he wanted to explain, as for instance to the spherical shape of the Earth. In this work he employed only astronomical (mathematical) concepts and proved his theory with astronomical arguments only. L.A. Birkenmajer, the best expert on Copernicus, must no doubt have had solid reasons "to regard it as certain that Copernicus had brought from Cracow a permanent interest in geography which persisted all his life." [23] At the time of his studies, "in the last decade of the 15th century geography was lectured at Cracow University but sporadically, or very rarely, on the basis of extracts from Pomponius Mela, Paul Orosius, from Pierre d'Ailly's *Imago Mundi*, from Dionysius of Thessalonici, Prolemy and Strabo, and according to the local compilation of the Polish scholar Głogowczyk," as well as of Wawrzyniec Korwin. [24] It is also obvious that both at that time and later Copernicus learned the news about the geographical travels which were extending the area of the *oikoumene* and which paved their way to the culture of the Renaissance finding their resonance in Polish literature too. As Goldstein puts it, these travels enabled Copernicus "to envisage the terrestrial globe in concrete physical terms", [25] and perhaps even influenced the substance of chapter 3 of book I. Nevertheless the effect of the elementary ideas of the Earth developed by the geography of that time must not be overestimated, especially if it is recalled that this fragment of Copernicus' work as the only geophysical text in its rigorous subordination to the fundamental assumptions of his theory was merely intended to show that the Earth has a structure which is specific for planets. The astronomical roots of the heliocentric theory have also been brought up by Birkenmajer in his *Stromata Copernicana* from the humanist thought of the Italian Renaissance when he wrote about "the origin of a discovery illuminated by a document which had not been known before", that already at the turn of the 15th and 16th centuries Copernicus recognized the old astronomical theory as erroneous not only from the logical point of view (*ratione*) but also from the point of view of the senses, of experience (*sensu*) and that in those doubts he was backed

[23] *Stromata*, p. 74.
[24] *Ibid.*, pp. 74f.
[25] *Op. cit.*

by the views of the Pythagoreans and Plutarch as reported by the Italian humanist Georgius Valla, which, incidentally, is in agreement with a mention contained in the dedication letter to pope Paul III. This astronomical origin is reinforced by later evidence (both empiric and logical) of his theory which, as belonging to the scope of astronomy mathematics, was unshakable. Copernicus is therefore rightly visualized by artists and scholars against the background of the sky, of the stars and of astronomical instruments (and not against globes and geographic maps) as the fundamental works about him and the pictures show.