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Paradigmatic Tendencies in Cartography: A Synthesis of the Scientific-Empirical, Critical and Post-Representational Perspectives

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Abstract

Maps have been important elements of visual representation in the development of different societies, and for this reason they have mainly been considered from a practical and utilitarian point of view. This means that cartographers or mapmakers have largely focused on the technical aspects of the cartographic products, and cartography has given little attention to both its *theoretical* component and to its *philosophical* and *epistemological* aspects. The current study is dedicated to consider these views.

In this study the main trends, thoughts and different directions in cartography during positivism/empiricism, neo-positivism and post-structuralism are reviewed; and cartography is analysed under the modernism and post-modernism periods. Some of the arguments proposed by philosophers such as Ludwig Wittgenstein and Karl Popper are examined as important contributions in our understanding of the development of cartography and mapping. This study also incorporates the idea or *concept of paradigm,* which has been taken from the field of the epistemology of sciences. The aforementioned opens a space to analyse cartography in terms of a paradigm shift.

In the analysis of each trend within contemporary cartography – from the second half of the twentieth century until today – it is necessary to keep in mind the theoretical scheme of a scientific discipline (object of study, research aims, methods and approaches, and results). This helps to determine the *body of knowledge* in cartography. It is also important to consider the epistemological context in which the tendencies are developed: positivism/empiricism, realism/structuralism and idealism/hermeneutic.

In this way, by considering three epistemological levels - essentialist/ontical (scientific), deconstructive (sociological), and ontological (emergent) - some paradigmatic tendencies are postulated. The first level results in tendencies such as *cartographic communication*, *cartographic semiotics*, *analytical cartography* and *cartographic visualisation* - all of these belong to the scientific-empirical

perspective. In the second level, we have *critical cartography,* belonging to the critical perspective and that confronts the scientific stances. Finally, in the third level the so-called *post-representational cartography* arises in open opposition to the traditional representational cartography.

Kurzfassung

Im Entwicklungsprozess verschiedener Gesellschaften sind Karten immer wichtige Elemente visueller Darstellung gewesen. Karten wurden meist aus einer praktischen und utilitaristischen Sicht betrachtet. Das heißt, dass sich Kartographen oder Kartenmacher gezielt auf die technischen Aspekte kartographischer Produkte fokussiert haben, und Kartographie sich nur wenig mit den theoretischen Komponenten und philosophischen oder epistemologischen Aspekten auseinandergesetzt hat. Diese Arbeit verfolgt das Ziel, diese Sichten zu analysieren.

Diese Studie untersucht die verschiedenen kartographischen Denkrichtungen, die während des Positivismus/Empirismus, des Neo-Positivismus und der Post-Strukturalismusperioden entstanden sind und analysiert Kartographie der Moderne und post-moderner Perioden. Argumente von Philosophen wie Ludwig Wittgenstein und Karl Popper werden untersucht als wichtige Beiträge zu unserem Verständnis der Entwicklung der Kartographie. Diese Arbeit berücksichtigt auch das *Konzept des Paradigmas,* welches aus dem Gebiet der wissenschaftlichen Epistemologie adaptiert wurde. Dies eröffnet die Möglichkeit, Kartographie hinsichtlich eines Paradigmenwechsels analysieren zu können.

Wenn man die Tendenzen der zeitgenössischen Kartographie – von der zweiten Hälfte des zwanzigsten Jahrhunderts bis heute – studiert, muss der theoretische Rahmen einer wissenschaftlichen Disziplin (Forschungsobjekt, Forschungsziel, Arbeitsmethodik und Ergebnisse) berücksichtigt werden. Dies erlaubt es, das *gesammelte Wissen der Kartographie* zu ermitteln. Ebenfalls wichtig ist die Berücksichtigung des epistemologischen Kontexts, in dem diese Tendenzen entstanden: Positivismus/Empirismus, Realismus/Strukturalismus und Idealismus/Hermeneutik.

Unter Berücksichtigung dreier epistemologischer Ebenen – Essenzialisten/ontisch (wissenschaftlich), dekonstructiv (soziologisch) und ontologisch (emergent) –

werden ausgewählte paradigmatische Tendenzen postuliert. Die erste Ebene ergibt Tendenzen wie *die kartographische Kommunikation, die kartographische Semiotik, die analytische Kartographie* und die *kartographische Visualisierung*, die alle zu der wissenschaftlich-empirischen Perspektive gehören. Zur zweiten Ebene gehört die *kritische Kartographie*, welche der kritischen Perspektive zugeordnet ist und die wissenschaftliche Standpunkte konfrontiert. Die so genannte *post-repräsentative Kartographie* entsteht aus der dritten Ebene im offenen Widerstand zur traditionellen repräsentativen Kartographie.

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1 Introduction

1.1 Motivation

Cartography has commonly been considered to be a *science*, a *technique*, and an *art* in the design, construction and study of maps. An analysis of cartography in the *philosophical* and *epistemological* terms, however, raises important aspects. For instance, a *positivist* perspective of sciences, denies art as part of cartography. On the other hand, from a *humanist* viewpoint the subjective aspect of maps is emphasised, and at the same time the scientific view on the discipline is criticised. If one focuses only on the *technological* aspect of cartography, their emphasis is put on a *pragmatic* vision of the "reality" leaving aside other aspects. In turn, if maps are examined from *historical* and *hermeneutic* points of view, then they are considered *texts* which convey a *political-cultural-social context*, in which the power relation and subjectivity acquire relevance. Therefore, in this study, besides highlighting epistemological and philosophical issues, cartography is also considered as a solid body of knowledge to understand of our world with all its different facets.

The present study incorporates Thomas Kuhn's *concept of paradigm*. It deals with the trends, thoughts and different tendencies which contemporary cartography has experienced during the so-called modern and post-modern periods. Thus, current trends in cartography are analysed with regard to the extent they can be identified as paradigm shifts. For each cartographic trend it is necessary to have in mind the theoretical schemes of a scientific discipline (study object, research aim, method, and results) which are supposed to determine its body of knowledge. The above will reveal if cartography had or has its own paradigms, which would imply it has its own autonomy, or if its body of knowledge comes from other sciences. Finally, the theoretical character of the study should help us to understand the discipline beyond its practical-technological aspects. It represents a theoretical contribution, because the analysis of the cartographic tendencies stresses, from an epistemological viewpoint, their scientific, deconstructivist, and ontological levels.

1.2. Thesis Structure, Hypotheses, Questions and Objectives of Investigation

This introductory section begins with the following research hypotheses:

- An internal analysis of contemporary tendencies in cartography and mapping allows the comparison with the evolution of scientific knowledge and the development of sciences and disciplines in general, within the context of the philosophical and epistemological periods of modernity and post-modernity.
- Although cartography is considered a relatively new science in comparison to the physical and social-human sciences, it has a solid theoretical framework in the context of sciences, and can also develop its own paradigm-shifts within the scientific revolution approach.

The study is divided in three parts. Part A analyses in Section 2 and 3 the theoretical bases. The links among philosophy - emphasizing the relationship between object, subject and image - epistemology, as the theory of scientific knowledge, and contemporary cartography are analysed in Section 2. It addresses the research question:

- Does the development of cartography have epistemological and philosophical bases like other scientific disciplines?

This question leads to the following research objective:

- To analyse the philosophical and epistemological bases of cartography during its contemporary development.

First, in the traditional way of knowledge theory, the different so-called "*isms"* are examined in their relationship between subject-object. Second, three epistemological-philosophical perspectives are analysed: *positivism-empiricism*, *neo-positivism* (logical positivism) and, *postmodernism* (post-structuralism). Within every period the impact on cartography and mapping is described. Then, the

consolidation of geography as scientific discipline and its effect in cartography during the positivist period is considered. Cartography as discipline has then been taking the scientific features corresponding to the positivist context.

Subsequently two great contemporary philosophers of the logical positivism are analysed: Ludwig Wittgenstein and Karl Popper. Emphases are put on how cartography grasps epistemological aspects in the knowledge construction. Although the two aforementioned authors did not directly write about cartography and mapping, their legacy has had an important contribution in our understanding of maps. The evolution of contemporary cartography can be linked to Wittgenstein's trajectory (First and Second Philosophy). On the other hand, the cartographic products and the different stages of map creation can be linked to Popper's Three Worlds Theory. The statements of the two authors mentioned above are related under stances of scientists who rather belong to the cartographic field such as Herbert (2002), Lois (2000, 2009), Cauvin et al. (2010), Chengming and Jizhou (2005), Liansheng (1997), and Neytchev (2001). During the postmodernism new tendencies and perspectives arose from social theory. Their relationships with cartography and mapping are also discussed. The aim of this comprehensive Section 2 is to consider the theoretical bases of cartography, as this should help to understand the discipline beyond its technological issues.

The second major theoretical base of this study is the paradigm concept developed by Thomas Kuhn in the context of the history and philosophy of science (Kuhn 1962, 1970). This topic is dealt with in Section 3. The term paradigm has several interpretations, but in general it includes a scientific community (in a particular field of knowledge) in which common aims and criteria during a determined period of time are shared. These periods are also called *normal science*. The replacement of one paradigm by another is known as *scientific revolution* or *crisis period*. Therefore, the study incorporates Kunhn's epistemological concept of paradigm in order to be later applied to the discipline. Thus, it analyses the extent to which contemporary tendencies in cartography can be identified as paradigmatic elements within the scientific community.

Part B focuses on a review and the state-of-the-art of tendencies in cartography, thus covering the subsequent three sections and answering the following research questions:

- Does cartography have a solid body of knowledge as compared to Geography (the discipline most closely related to it)?
- Does cartography have its own tendencies according to the scientific and social context from which it developed?

This implies the two research objectives:

- To analyse the trends, perspectives and approaches in cartography and mapping within the modern and the so-called postmodern periods.
- To check whether the tendencies that have developed in cartography are part of the evolution of the scientific thought in the social context.

Section 4 deals with several authors and theoreticians who analysed the discipline during its contemporary development under certain paradigms and currents (Peterson 2002, Perkins 2003, Wood 2003, Ramirez 2004, Edney 2007, Ormeling, 2007, Sui and Holt 2008, Cauvin et. al 2010). It also discusses geo-visualisation (DiBiase 1990, DiBiase et al. 1992, MacEachren 1994, 1995, MacEachren and Kraak 2001), analytical cartography (Moellering 2000, 2001, Tobler 1976, 1979), and cyber-cartography (Fraser Taylor 2005, 2009) approaches.

Starting in the second half of the twentieth century, various authors, beginning with Robinson (1952) up to MacEachren (1995) and Fraser Taylor (2005), developed scientific trends. Tendencies such as cartographic language, cartographic communication model, analytical cartography, geo-visualisation and cyber-cartography are framed into a neo-positivist approach of modernity. Therefore, in epistemological terms, cartography and mapping try to reach a representation (depiction) of the geographical space as faithfully as possible: accurate, precise, secure and objective. This is considered the main aim of cartography: to reach an objective representation of the world. In other words, in this case, the metaphor of the map as *reflection* or *mirror* of “reality” is valid.

Although in Section 4 critical cartography is described as a new tendency, beginning in the 1980s, Section 5 deepens its treatment in the postmodernist context. The critical perspective is a historicist view of cartography which poses a conception of the map as a text or vehicle of *power and knowledge* (Harley 1988a, 1988b, 1989, 2001). Thus, there is a historical critique of the power of maps in different times and places, and a contemporary critique of maps regarding ethical considerations and values (Crampton and Krygier 2006, Wood and Krygier 2009, Crampton 2010). The section examines John B. Harley's legacy and his link with postmodernist thinkers such as Michel Foucault and Jacques Derrida. In this way, the critical approach points out that maps act as *rhetorical* devices which implicitly and explicitly pass massages of hegemony and power in a specific social-political context. Here, the map is a subjective device, biased, loaded of values and meanings. Thus, in agreement with the so-called postmodern authors, it is stated that the critical perspective constitutes a *paradigmatic shift* that breaks with the objectivity and neutrality claimed by the previous stances.

Continuing in the postmodern cartography context, Section 6 focuses on new map conceptions which are challenging the previous ones (Latour 1987, 1999, Crampton 2003, Pickles 2004, Casti 2005, Wood and Fels 2008, della Dora 2009). Additionally, since the end of the 2000s, some authors like Rob Kitchin, Chris Perkins and Martin Dodge have taken a *post-representational* stance in which cartography and maps are seen to be beyond the previously established formal and positivist aspects. Thus, the traditional *ontological* conception of maps is criticised and replaced by an *ontogenesis* conception (Kitchin and Dodge 2007, Kitchin 2008, Kitchin et. al 2009). This conception proposes that a map is not an epistemologically *stable and secure* product (as taken for granted in the scientific and critical approach), but rather the result of the moment: it is in a state of continuous *re-creation* and *re-interpretation* according to the context in which it is situated. The map is seen to be in *action*. It is in a *state of becoming*. This new perspective is discussed in this study as a possible ongoing *emergent paradigm* in Kuhnian terms, due to considerations regarding the epistemological and ontological bases of the discipline.

Part C covers Sections 7 and 8 and asks the following research questions:

- Do the current trends in cartography constitute paradigmatic elements of the discipline?
- Does cartography have its own paradigms according to the paradigm-shift concept in Kuhnian terms?

These questions lead to the following research objectives:

- To verify whether the developmental tendencies in cartography corresponding to the experienced paradigmatic trends in the development of modernity and post-modernity.
- To examine the scopes for own paradigms in cartography according to an epistemological framework.

Section 7 analyses whether there is a possibility for paradigms in cartography as defined in Kuhnian terminology. Here, in methodological terms, two approaches are proposed. The first one is called “criteria of contrast” (e.g. study object, research aims, method and approach, results, etc.). These criteria are applied to identify formal and factual sciences and also to differentiate between regional and quantitative geography. The second methodological procedure is named “tendency distribution in the epistemological-space”. Here, contemporary cartographic tendencies are located under the three philosophical-epistemological bases of modernity and post-modernity: positivism-empiricism, realism-structuralism, idealism-hermeneutics. As shown in sections 4, 5 and 6 (Part B) several cartographic tendencies have occurred since the second half of the twentieth century. Will, in epistemological terms, these tendencies shape groups or clusters or are they isolated? If there are disparate trends, can we propose some internal paradigm-shifts within the discipline? The two applied methodological criteria allow the identification of some internal *worldviews* - as termed by Kuhn - during the contemporary development of the discipline.

The final Section 8 discusses the results obtained in Section 7. At first, seven paradigm tendencies in cartography are proposed, based on the criteria of

contrast and the opinions of the authors reviewed. On the one hand, the body of knowledge of the discipline is characterised through the distinction between the so-called scientific and critical approaches (i.e. contrasting paradigms), and on the other hand by the transition between both stances. Also, the so-called post-representational cartography is considered a paradigmatic proposal which challenges previous approaches. Here, the ontologically secure map is doubted. In Kuhnian terms it deserves a state of alert regarding a new worldview in cartography and mapping.

The second part of Section 8 returns to Kuhn. His scientific revolution theory is discussed under the scope for own paradigms in cartography. In epistemological terms, three levels are examined: scientific, sociological and ontological.

At the end of Part C it is pointed out that, if the development of cartography and mapping is considered to take into account the epistemological coordinates, then three paradigm-shifts in Kuhnian terms can be postulated: scientific-empirical, critical and post-representational.

Despite the fact that the three paradigmatic shifts have been triggered by technological development, the theoretical statements made in this study go beyond technological issues in cartography and mapping. This theoretical contribution is emphasised through philosophical and epistemological considerations about the development of the cartographic discipline.

2 Philosophy, Epistemology and Cartography

2.1 Introduction

This section introduces the link between philosophy - emphasizing the relationship between object, subject and, image, epistemology as theory of scientific knowledge, and contemporary cartography. Three epistemological perspectives are analysed: positivism and empiricism, neo-positivism (logical positivism) and, postmodernism (post-structuralism). For every period its impact on cartography and mapping is described. First, the consolidation of geography as a scientific discipline and its impact in cartography during the positivistic period is considered. Cartography as a discipline covers all the scientific features corresponding to the positivistic context. Then, during the logical positivism period two great contemporary philosophers are analysed: Ludwig Wittgenstein and Karl Popper; and how cartography grasps the epistemological aspects in knowledge construction. These authors did not write about cartography and mapping (i.e. not explicitly) but their legacy has had an important contribution in our understanding of maps. The evolution of contemporary cartography from an epistemological point of view can be considered as Wittgenstein's trajectory (first and second philosophy). On the other hand, the cartographic products and the different stages of map creation can be linked to Popper's Three World Theory. Finally during the postmodern period new tendencies and perspectives arising from social theory and their relationship with cartography and mapping are also discussed.

2.2 Philosophy and Epistemology: Some Scopes

There are several definitions of philosophy. According to Johannes Hessen, a look on the evolution of the philosophical thinking shows two elements that are essential for the concept of philosophy: a) a "conception of me" and b) a "conception of the universe". So, philosophy represents both *conceptions* at the same time (Hessen 1976). Therefore, the author verbally states that "Philosophy is an attempt of the human spirit to come to a conception of the universe by means

of the self-reflexion about its theoretical and practical functions" (cited after Vargas Mendoza, 2006)[1].

To achieve this aim, philosophy attempts to formulate and answer some *questions*. Philosophical questions are fundamental. They are - see above - *internal conception* (about me) and *external conception* (about the universe). Therefore, they are placed within the limits of human comprehension. This means that philosophical questioning by the human spirit leads to both man's *interior world* and man's *exterior world*.

In philosophy, *epistemology* concerns the nature, origins, and limits of knowledge (i.e. a theory of the knowledge). The *philosophy of sciences* and the *epistemology of sciences* are both theories concerning the *scientific knowledge*. According to Mario Bunge, epistemology, or the philosophy of science, is the branch of philosophy that studies the scientific research and its product, the scientific knowledge (Bunge 1998). Thus, the theory of scientific knowledge differs from that of other types of knowledge, such as technical, technological, artistic and religious. The scientific knowledge is rational, factual, objective, methodical, self-corrective or progressive, general, systematic and accumulative.

On the other hand, mapping and cartography have always been considered the *science*, *technique* and *art* of the design, construction and study of maps. This implies three important aspects of maps: to imagine it, to use it and to interpret it. When cartography and mapping are considered from a philosophical and epistemological point of view, then important considerations concerning our *knowledge of the world* arise.

[1] "La filosofía es un intento del espíritu humano para llegar a una concepción del universo mediante la autorreflexión sobre sus funciones valorativas teóricas y prácticas" (Vargas Mendoza 2006).

2.3 Cartography and Knowledge of the World: Philosophical and Epistemological Implications

If cartography and mapping have contributed to the development of mankind as a "form of knowledge", then the way *to conceive* or "*to think"* a map according to a socio-political-cultural context is different. It is necessary to bear in mind that such contexts underpin the philosophical basis for understanding the physical world.

In his prominent book "Teoria del Conocimiento" ("Theory of Knowledge", 1976) Johannes Hessen states that there exist some partial problems inside of the General Theory of Knowledge, such as possibility, origin, essence and kinds of knowledge. Philosophically, three elements participate in all issues of knowledge: a *subject*, an *object* and an *image* (of the object which - the object - is captured by the subject). Depending on the degrees of importance assigned to each of these elements different philosophical currents originated; for instance *objectivism*, *subjectivism*, *realism*, *rationalism*, etc.

If knowledge is considered as the relationship between an *object* and a *subject* which are having a mutual contact, the question is: Can the subject really capture the object? There the following perspectives arise: *dogmatism, scepticism, subjectivism, relativism, pragmatism* and *criticism*. When the dual structure of the cognoscible subject is considered to comprehend *rational knowledge* and *sensible knowledge*, the query is: Is reason or is experience the source and basis of human knowledge? This question leads to *rationalism, empiricism, intellectualism and apriorism*. When the relationship between the subject and the object is considered, the question is: Is it really the object that determines the subject or is it the subject that determines the object? This question leads to the rise of *objectivism*, *subjectivism, realism, idealism and phenomenalism*. When the form or kind of knowledge is considered, the question arises: Are there other kinds of knowledge besides *rational knowledge*, for example *intuitive knowledge* or *experiential knowledge*. Last not least, the *truth's criterion* plays a role, asking if a knowledge is true. Here the question is: Which *criterion* indicates whether a specific *knowledge* is true or not? (For more details see Hessen 1976).

Table 2.1 Different *isms* treating the relationship between subject-object in the context of the Theory of Knowledge.
Adapted from Hessen (1976).

Human Knowledge	**Subject-Object Relationship**	**Epistemological and Philosophical Perspectives ("isms")**
Possibilities of Human Knowledge	Can the subject really *capture* the object?	• *Dogmatism* • *Scepticism* • *Subjectivism* • *Relativism* • *Pragmatism* • *Criticism*
Origin of Human Knowledge	Is *reason* or *experience* the source and base of human knowledge?	• *Rationalism* • *Empiricism* • *Intellectualism* • *Apriorism*
Essence of Human Knowledge	Is it the *object* that determines the subject or is it the *subject* that determines the object?	• *Objectivism* • *Subjectivism* • *Realism* • *Idealism* • *Phenomenalism*

In other words, these epistemological problems regarding the theory of knowledge are also important when we think about maps, because maps have always been conceived as a form of knowledge or as "devices" which contribute to the knowledge of the world.

These considerations are relevant when *the* controversial question rises in cartographic literature: Do maps represent or do they create reality?[2] In this inquiry, terms like geographical space, Earth surface, terrain, landscape, and so on, are replaced by the *concept of reality*. The two verbal terms involved in the query (to represent, to create) give rise to different epistemological viewpoints. On the one hand, *to represent reality* implies elements of the *exterior world*, and in this case notions about the object, objectivism and empiricism (sensible knowledge) are engaged. On the other hand, *to create reality* entails an *internal* and a *mental*

[2] This proposal is derived from an article by Laura Hebert (2002), implying the entirety of both the physical and social/human aspects.

world (mind). Thus, conceptions about the subject, subjectivism, rationalism (rational knowledge) and idealism are involved.

Therefore the answer, to the previous question has philosophical and epistemological scopes, depending on which point of view is being considered. When the map *represents reality* it leads to a *scientific* approach of knowing the world, and when the map *creates reality* it acts as a guide to a *humanistic* approach for knowing reality. Similar aspects occur if a map has the two functions at the same time. At some point there has to be an epistemological division because both approaches require different study objects, methodologies and results.

Another significant consideration concerns the nature of the cartographic representation[3] in the relation between the object, subject and image. It is important to evaluate whether the potential of a map corresponds to what it is supposed to *reflect* (from the external world) or to the memory of a subject that it *activates.* Again, the answer is depending on which philosophical and epistemological perspectives are considered. If a map *reflects* the world, then it leads to an *external* perspective (objective). On the other hand, if a map *actives* a subject's memory, then it leads to an *internal* perspective (subjective).

[3] This scope is derived from a paper by Carla Lois (2009).

2.4 Different "Isms" and their Repercussions in Cartography and Mapping

In philosophy and epistemology of science it is common to classify trends of thought with the suffix "ism". Thus, different scientific conceptions (or scientific knowledge) such as *positivism*, *falsificationism*, *historicism*, *structuralism*, *relativism*, *objectivism*, *pragmatism*, *realism*, and others have been established. These tendencies can be analysed by identifying the visions and perspectives that distinguish them. Nevertheless, in this work only some of the main tendencies that occurred during the modern and postmodern periods will be considered. Certainly, further in-depth analysis is needed for the other isms.

2.4.1 Positivism and Empiricism

During the eighteenth and nineteenth centuries the following *motto* prevailed in western societies: "Faith in progress, dominance of nature, and use of reason". The progress referred to the industrial and transportation revolution, nature to the territories and landscapes, and reason was emphasised with respect to scientific issues. This conception was initiated by Auguste Comte with the *"Discours sur l'Esprit positif"* (1844) (A General View of Positivism, published in English in 1865) and was called Philosophical Positivism. Main exponents of this school of thought are, i.a., John Stuart Mill, David Hume, Bertrand Russell, Alfred Jules Ayer, and Rudolf Carnap.

According to George Wright, *positivism* shows three essential features: a) methodological monism; b) the assumption that exact natural sciences establish the ideal canon or methodology of all sciences, including the human and social sciences; and c) the causal explanation (Wright 1971).

Positivism considers a *monistic conception* of reality. *Monism* states that reality is unique, and it has to be understood and explained by the physical sciences (in the first instance), and by the social sciences (in a later instance). The empirical-inductive method or *positive method* (from detail to general) was used as study approach for deepening the knowledge about the physical and social world. This

method has two stages: first, *induction*[4] leads from facts to law and theories; second, these laws and theories are established by means of predictive *deductions*.[5]

The *positivistic period* is characterised by emphasizing the scientific knowledge. Facts and phenomena have to be observed, measured, verified, and expressed in *laws*. In other words, facts and phenomena of the physical world must be scientifically explained. It uses causal explanations with a deterministic cause-effect relation[6]. Science first adopts the "mechanistic Newtonian model" (in physical sciences) and later applies it to the "biological Darwinian model" (in social and human sciences). Another feature of science is its objectivity: observations and explanations must be free of value assignments (neutrality of sciences).

In addition, *empiricism* is "an epistemology in which it is assumed that learning, memory, and ideas are primarily derived from one's sensory experiences" (Slife and Williams 1995). In other words, according to *empiricism*, knowledge comes from experience, from evidence, and from direct contact with reality. So, *empiricism* can be associated with *positivism*, because both of them originate from the positivistic viewpoint that "reality" is observable (by human sensor perception).

Given the positive spirit of the epoch (especially in the nineteenth century), in science in general and in geography and mapping in particular, all exponents and researchers shared the positivist epistemological approach. This meant that a high scientific spirit was developed within the positivistic movement.

On the other hand, during the period of positivism the following events impacted the development of the geographic discipline in Europe (Gómez Mendoza et al.

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[4] Induction is the process which leads from details to the general, using particular observed data to derive general laws.

[5] Deduction proceeds from the general to the particular, using a general law to explain particular cases.

[6] Causality is the relationship between an event (the cause) and a second event (the effect), where the second event is understood as a consequence of the first one.

1988; Varcárcel 2000), and also established the basis for cartography and mapping.

1. European space is organising itself for the exploration of the world, triggered by the need for raw materials, food and work[7] (Vico and Bentancor 1999).

The link between cartography and political geography is documented by Matthew Edney in his work “Recent Trends in the History of Cartography”. He refers to several authors who investigated the “colonial and imperial cartography” as well as “cartography and nationalism” during the modern period (cf. Edney 2007). Jeremy Crampton emphasizes the facts that are governing maps in the context of cartographic political economy (cf. Crampton 2010). Cartographic research in the nineteenth century was carried out by the military and therefore it heavily focused on surveying technology and military topography (Kanakubo 1990). Thus, the European exploration was supported by mapping and cartography whose products, i.e. the maps, are invested in a *scientific key*.

2. A new profession is created: the scientist. His mission is to discover the order of the world, in particular of the natural world[8] (Vico and Bentancor 1999).

According to this assignment, it is no coincidence that topographic cartography precedes the thematic. In the first stage the “formal maps” which depict real objects of the world were constructed by mapmakers. These topographic maps mainly contained *natural* elements and “visible” *artificial* elements of the Earth’s surface. In the second stage, *abstract* or *ideal* elements were depicted as thematic maps[9]. Methods and techniques were improved to reach higher levels of precision, accuracy and objectivity in the representation. These cartographic

[7] “El espacio europeo se organiza para la exploración del mundo por necesidad de materias primas, alimento y trabajo”.

[8] “Se crea una nueva profesión, el científico. Su misión es descubrir el orden que existe en el mundo, en particular el mundo natural”.

[9] The historical evolution of thematic cartography is described by Colette Cauvin et al. (2010).

methodologies were coined within the epistemological framework currently in force.

The first independent professional cartographers appeared in the 19th century. According to Árpad Papp-Váry "cartographers of that century only became cartographers through their practical work; they originally were geographers, copperplate engravers, engineers and army officers" (Papp-Váry 1989:103).

3. Authors in geography are individuals of their time, influenced by momentary ideas and collaborators in the expansion of knowledge[10] (Vico and Bentancor 1999).

The Germans Alexander von Humboldt (1769-1859) and Carl Ritter (1779-1859) were the precursors of modern geography (Schmithüsen 1970). The former analysed observable relationships of the physical phenomena, and the latter introduced the human factor into the man-environment relationship. These resulted in a systematic cartographic representation, especially with Humboldt's contributions in the field of physical geography (i.e. relief representation through contour lines). Similarly, according to Kanakubo (1990), "the geographer's attention was turned towards maps which influenced the progress in geographical research systems". Therefore, cartography and mapping are considered forms of scientific knowledge.

4. In the second half of the nineteenth century formal education is institutionalised, explorations and research is systematised[11] (Vico and Bentancor 1999).

If cartography is conceived as a spatial representation, it is then not strange that the formalised curricula for geographical topics also incorporated cartographic issues such as scale, projection, symbols and colour, among other. The

[10] "Los autores de Geografía (…) son hombres de su época, influidos por las ideas del momento y colaboradores en la expansión del conocimiento".

[11] "En la segunda mitad del siglo XIX se institucionaliza la enseñanza formal, se fomenta la exploración y se sistematiza la investigación".

construction and updating of atlases was a form of systematisation of acquired spatial and geographical knowledge.

5. The creation of Learned Societies enables the exploration of the world and the academic discussion of the acquired knowledge[12] (Vico and Bentancor 1999).

Concerning cartography and mapping: research in map projection, relief representation, map colour, and the construction of various types of atlases were efforts made during this period. Thus, the second half of the nineteenth century was the period in which *theoretical cartography* began to flourish. The geographical associations provided the basis for the development of the cartographic associations during the second half of the twentieth century, e.g., the International Cartographic Association (ICA) founded in 1959.

Crampton (2010), quoting Turnbull (2003), points out that:

> A centralized knowledge base went hand in hand with the emerging modern political state, a unique system of measurement (the metric system), and common set of instruments […]. Such a centralized, almost panoptic system is characteristic of rational scientific knowledge-creation (Crampton 2010: 56).

This statement illustrates the positive spirit of the great surveys of the eighteenth and nineteenth centuries, which were carried out using the Enlightenment principles of rationality, precision and instrumental surveying and mapping. In other words, cartography and mapping - as a form of knowledge - achieved the *epistemological objectives* of the positivistic project.

2.4.2 Logical Positivism or Neo-Positivism

In the first third of the twentieth century a questioning and criticism of the conceptions of positivism evolved especially regarding the new developments in

[12] "La creación de Sociedades Científicas habilita la exploración del mundo y la discusión académica de los conocimientos adquiridos".

sciences. Consequently a new proposal for the philosophy of knowledge was propelled. This epistemological reflection is known as *logical positivism*, especially in the scientific and philosophical context of the German – speaking region. A key feature of the logical positivism or *logical empiricism* is the experimental verification of the theoretical statements (through the verification process), and their validation. This proposal is a revitalized and changed formulation of the positivistic inheritance.

In 1929, a notable group of scientists and philosophers of sciences, linked with the universities of Berlin and Vienna, founded a collective known as the Vienna Circle[13] (Murzi 2004). The Vienna Circle's philosophers sought to re-conceptualize empiricism by means of their interpretation in the physical and formal sciences. "Their radically anti-metaphysical stance was supported by an empiricist criterion of meaning and a broadly logicist conception of mathematics. They denied that any principle or claim was synthetic *a priori*"[14] (Uebel 2006).

This new philosophical perspective is also known as *neo-positivism*. This approach considers several aspects of the traditional positivism of the nineteenth century, sharing aspects such as: monist conception of reality, unity of sciences, and emphasis in the explanation[15] of facts and phenomena, more than mere comprehension[16]. But, there is a notable difference to the old positivistic method: this time, the hypothetical-deductive method (from the general to the particular) is used. Induction is replaced by the deductive-via which descends from the logical

[13] The Vienna Circle units the physical and sensorial empiricism from Ernst Mach with the logical mathematic school from Bertrand Russell (1872-1970) and their disciple Ludwig Wittgenstein (1889-1951). This organisation had a conception of philosophy of science and knowledge of positivistic character, including the rationalistic tradition.

[14] A synthetic *a priori* proposition is a one that, being *a priori,* i.e. universal and necessary in character, has the extensive property of the *a posteriori* propositions, allowing to increasing our knowledge.

[15] Explanation leads to understanding reality through laws and principles (knowledge of general cases).

[16] Comprehension leads to understanding reality through descriptive terms (knowledge of particular cases) without establishing laws. In epistemological terms, there are no laws for uniqueness.

statements to the observation or “facts”. These facts turn into in “verifiers” of the statements. The neo-positivistic project has three pillars: *the fundamental role of the facts*; the introduction of *theoretical constructions,* and the use of the *formal language* (Valcárcel 2000).

In the scientific context, high objectivity - separation between facts and values - is required, as well as an extreme rigor on the precision of the results, verification of hypothesis and validation of pertinent theories. Scientists, besides occupying the common method of sciences - the scientific method - must use a common language that is accurate and precise: the mathematical and the logical language (influenced by the Vienna Circle). Regarding the specific function of language Valcárcel states:

> Semiotics is the ultimate foundation of the scientific communication, removing to the thought as subjective activity, except in the strict work of combining the signs. In it the deductive or analytical process is based, whose tautological nature assures the quality to it of *true*[17] (original emphasis, translated from Valcárcel 2000: 201).

According to Valcárcel (2000), epistemologically there exist two worlds: the world of *analytic knowledge* and the world of *synthetic knowledge*. The former one is recognized as a rational activity, the world of the logical statements: analysis in a strict sense, deduction, the world of signs and their rules, the “world of truth”. The world of the theoretical statements acquires an absolute pre-eminence; thus the new philosophy is *analytical*. The latter one - synthetic knowledge - is the world of experience, of facts, i.e. it is empirical. This synthetic knowledge verifies the validity of the theoretical statements. Therefore, the truth or falsehood of the scientific theories is verified.

In summary, the neo-positivistic approach has the following characteristics regarding the bonds among philosophy, epistemology and science: The “new science” is structured according to abstract parameters that attempt to explain

[17] La semiótica es el fundamento último de la comunicación científica, desalojando al pensamiento como actividad subjetiva, salvo en la estricta labor de combinar los signos. En él reposa el proceso deductivo o analítico, cuya naturaleza tautológica le asegura la cualidad de “verdadero”.

reality on the basis of theoretical models. The new science has a formal structure which is expressed by a logical language. The hypothetical-deductive method is the unique scientific method capable of creating new knowledge. Thus, a new profession has come into existence: the professional scientist who is contracted for doing prospective studies. Science finally acquired a practical character. Its new concern will be to create an order which has to adjust itself to the theoretical models.

2.4.3 Geography and Cartography under the Logical Positivism Approach

Both geography and cartography were impacted by the neo-positivistic approach. In the geographic discipline, the previous regional perspectives were criticised and new proposals arose. *Quantitative geography* is the new paradigm[18] in geographical studies. Relationships and *spatial distributions*, in terms of spatial geometry, are the study objects of geography under this approach. Any phenomenon (natural or human) can be analysed and spatially expressed in a geometric form. The majority of these spatial relations were depicted through cartographic methodologies (Chorley and Hagget 1967).

On the other hand, the objective of quantitative geography is to explain spatial phenomena through their prediction. Thus, its results must be expressed by laws applying the hypothetical-deductive method. The tools used in this method are: models, hypotheses, laws and theories (Harvey 1969). Nevertheless, a relevant aspect is the use of quantitative technologies such as mathematics, statistics and cartography of correlations. In cartography, processes related to in - and output of geospatial data are automated. The intensive application of these technologies and methodologies led to a revolution in the analysis and synthesis of geographical studies.

Similarly, in the context of neo-positivistic paradigm, authors such as Richard Chorley, Peter Hagget and David Harvey developed the theoretical-scientific framework for the geographical discipline. Thus, theoretical geography came into

[18] The term paradigm introduced by Thomas Kuhn in 1962 will be discussed in the following section.

being in which theory is the axis and orientation of the research and explanation of geographical phenomena (cf. Chorley and Hagget 1967; Harvey 1969).

In the field of cartography, Jeremy Crampton (2010) documents *how mapping became scientific* during the neo-positivistic period. He also reports the influence of Arthur Robinson, and his links with prominent geographers such as Richard Hartshorne, and their work at the Office of Strategic Services (OSS) in the United States of America. The author mentions how, by Robinson's contribution, cartography acquired the *status of scientific discipline*:

> Perhaps Robinson's best known contribution is his development of the map as a communication system. This focus had the goal of improving the efficiency and functionality of maps as communication devices via empirical experimentation (Crampton, 2010: 54).

This statement highlights the neo-positivistic context to which cartography belonged. During the same period perceptual and cognitive studies of mapping and map use were also initiated. In addition, there were attempts to introduce semiology, modelling theory, and cognition theory to cartography. Thus research and methodologies are framed within the epistemological viewpoint of sciences.

In his article "The Science of Cartography" Papp-Váry mentions several factors which have accelerated the development of map making and map production after the Second World War. He calls these factors *the demand for cartography* (cf. Papp-Váry 1989). The author describes the evolution of cartography as a *science* in terms of structural units. He considers how the situation in cartography matches each of the requirements for a new science:

> The subject of cartography […] can be described as the study of geographic space or of the graphical manifestation of spatial phenomena. The object of cartography is to produce maps which are able *to reflect reality as exactly as possible* (emphasis added, Papp-Váry 1989: 104).

The above statement shows the epistemological perspective considered in cartography during the neo-positivistic era. In the object-image-subject relationship, reality (the object) is conceived independently from the subject. The image (map or representation) which the subject grasps from reality must be *accurate* and *transparent,* and *free of value* by the subject (cartographer or mapmaker). Cartography is adapted to the parameters of the new science. Thus the objects of study, the research objectives, methodologies and results, are framed in the epistemological and philosophical project of the modern period just as in geography and similar sciences.

2.5 Ludwig Wittgenstein. A philosophical Framework Applied to Cartography

2.5.1 Wittgenstein's Early Work: *"Tractatus logico-philosophicus"*

Ludwig Wittgenstein (1889-1951) was an Austrian-born British philosopher and linguist. He is considered to be one of the main philosophers of all times who influenced the philosophical development from the twentieth century until today. Although he was not a member of the Vienna Circle, Wittgenstein's philosophy belongs to the logical positivistic approach. He published his contribution to the history of thought in two important and controversial books: "*Tractatus Logico-Philosophicus*" (1922, English version) and "*Philosophical Investigations*" (1953) (Richter 2004a). In philosophy much has been written only about these two books of Wittgenstein (Monk 2005).

Wittgenstein never directly treated philosophy issues regarding cartography and mapping. Nevertheless, in this chapter the philosophical and epistemological aspects of his reflexions in relation to cartography are discussed. At this point, any further considerations are only suggestions that should be subject to deeper analysis.

According to Wittgenstein, the relationship between *language* and *world* can be presented through a model *by proxy*[19]. Thus, a relationship by proxy between a model of reality and reality itself is established. These claims are of critical importance for understanding the world through language. The most important of Wittgenstein's contributions to world knowledge is: *language is a model of reality*, and reality is comprehended by us through language. Similarly, if these insights are critical to Wittgenstein's thought, then cartography, "conceived as a model of reality", will also have important epistemological considerations. In this sense there are many visual models to depict reality in cartography. Consequently, these models establish a relation "by proxy" between their component and the external elements which are represented in a map form (relation object-image).

[19] Proxy is understood, more generally, as a person who represents another person. In other words a person authorized to act for another (Thesaurus Dictionary). This analogy is applied here to the relationship between language and world.

Therefore, a general reading of Wittgenstein's first work, especially of his *Tractatus*, leads to a relation between its content and the *nature* and *objectives* of cartography. Several of the propositions defined by Wittgenstein can be applied to cartography and mapping, because one of the traditional objectives in cartography is *to represent reality* (i.e. to depict) and primarily to depict the physical objects of the world. This representation is made through certain "devices" (material and digital). Similarly, there is also the parallel creation of an *image of the external world* but this image is inside our minds (internal world).

The map is then a representation of reality and the map must be created. There is a one-to-one (biunique) correspondence between what is represented and reality: the symbol on the map represents, in this case, the objective element that belongs to reality. In general terms, in Wittgenstein's early philosophy there is a coincidence with the first stage of development of modern cartography: Both in the positivistic and neo-positivistic context, the map is considered to be an objective, accurate and genuine device that depicts the real physical world.

On the one hand, the most important contributions of the *Tractatus* are the *picture theory of meaning* and the *doctrine of logical atomism*[20]. These theories are intimately connected. The picture theory states that language draws a picture of reality (for more details see Richter 2004b). The pictorial nature of thought and language is analysed by Pasquale Frascolla as a way to understand Wittgenstein's approach. Essentially this picture theory of meaning states that "our language and our thought have sense and reference, because there are paintings, figures or representations of the things of the world" (for more details see Frascolla 2007).

From an epistemological perspective, Wittgenstein's main contribution is not only about language, but about a theory of the world, namely a *theory of knowledge of the world*. In his atomistic view, Wittgenstein claims that the world is composed of

[20] Bertrand Russell conceives logical atomism as the view that reality consists of a great many ultimate constituents or "atoms". The position as "logical" atomism is an attempt to arrive through reason at what must be the ultimate constituents and forms constituting reality (Carey 2008).

facts; states of affairs and objects, each one having a correspondence in language: propositions; elementary of propositions; and names respectively. He points out that names refer to the objects of reality, hence *the meaning of the object is in its reference* (Clack 1999).

According to Richter (2004a) some important and representative propositions from the *Tractatus* are[21]:

1. The world is all that is the case.
4.01. A proposition is a picture of reality.
4.0312. […] Propositions *show* the logical form of reality. They display it.
4.5. […] The general form of a proposition is: This is how things stand.
5.4711. To give the essence of a proposition means to give the essence of all description, and thus the essence of the world.
5.6 *The limits of my language* mean the limits of my world.

If language is a perfect analogy of the world, the *cartographic language* - in the context of map symbols - is an important epistemological contribution to the theory of knowledge. According to Yu Liansheng, map symbols belong to the scientific symbols, and at the same time possess the features of visual images. He describes the philosophical level of map symbol and the exploration of its information function (cf. Liansheng 1997). Consequently, the essence of map symbol, its characteristics, its poly-functions and its information function are all perfectly related to the one-to-one relationship established by Wittgenstein between language and world (here world is conceived as reality).

On the other hand, Pavel Neytchev, in the context of information exchange among people, states similarities between the units of natural and of map languages in the realms concerning the syntactic components of cartographic sentences. He claims that the map language is a double-articulated code, and later on defines the syntactic patterns of cartographic sentences (for more details see Neytchev 2001). Neytchev's contribution can be perfectly compared to Wittgenstein's claim,

[21] The numbers at the beginning of the listings correspond to the chapter and subchapter classification in the *Tractatus logico-philosophicus* (from Wittgenstein, last edition 2005).

presenting the function of the cartographic language in the context in grammar and syntactic. There is a connection among “map language”, natural language and knowledge of the world or reality.

Both authors, Liansheng and Neytchev, are important for understanding the cartographic language on the knowledge of the world. Liansheng establishes the philosophical levels of map symbols and the exploration of their information function by analysing the essence, characteristics, function and laws of operation from ideological, cultural and philosophical considerations. Neytchev compares the units of the natural language (in the system, in the text, in the speech act) to the unit of the map language (in the system, in the text, in map language usage). An important aspect is the units of language used by Neytchev: basic sign, combined sign, and assembled sign. These are the same components used by Wittgenstein in his description of the elements that belong to language: propositions, elementary propositions and names (see Table 2.2).

Table 2.2 Knowledge of the world and language according to L. Wittgenstein. Adapted from B. Clack (1999) and P. Neytchev (2001).

In the **world**	In the **language**	Units of the **map language**	
		In the text	In the map language usage
Objects	Names	Separate cartographic sign (cartographic word)	Component of cartographic utterance
States of affairs	Elementary propositions	Compound cartographic sign (cartographic sentences)	Cartographic utterance
Facts	Propositions	Map (cartography textual work)	Cartographic *communiqué*

2.5.2 Wittgenstein's Late Work: "Philosophical Investigations"

In the second stage of Ludwig Wittgenstein's work (also called Wittgenstein's later philosophy) he carried out a critical analysis of his first document *"Tractatus"*. This critique is compiled in the book "*Philosophical Investigations*" published by G.E.M Anscombe in 1953, two years after of the philosopher's death. Although this later phase of his work was more remote from science, it was a source of inspiration for many philosophers and scientists because of its scope and considerations (cf. Richter 2004b).

This part of Wittgenstein's philosophy is considered by his followers to be postmodernistic[22]. Wittgenstein rejects the supremacy of the *declarative language* and the essentialistic vision of the language. Using the language more things can be done than only describe the physical world. In this way Wittgenstein considers numerous problems and puzzles in different fields such as semantics, logic, and philosophy of mathematics, philosophy of psychology, philosophy of action, and philosophy of mind. His main contribution is the "language-games", namely, the language functions in the context of known-rules: all prepositions that are out or beyond these rules are inconceivable and meaningless. The meaning and reality of the world belongs to several contexts; therefore the descriptive language is only one aspect. In this context, for Wittgenstein the aim of philosophy is to clarify these *rules* or *language-games* for understanding the world. Consequently, all concepts which fall outside of these rules are considered to be contradictions, antinomies, meaningless or senseless (Richter 2004a). This part of Wittgenstein's work is more flexible than the rigid approach of his *Tractatus* where in the ideal language, a meaning must correspond to every word and to every meaning a word. Now, the meaning of the words depends on the context.

Since the 1990ies, important contributions in cartography have been coming from outside the discipline, or are not unique in the academic context. Therefore, these contributions are framed in the deconstructionistic or poststructuralistic

[22] Postmodernism is a term that designates a wide number of artistic, cultural, literary and philosophical movements of the twentieth century which are critical and conflicting to the modernistic period.

approaches (see below). In this sense, there is a strong criticism to how mapping has been done and developed until this day. The main exponent of this development is John B. Harley who considered cartography to be far from being an objective and accurate discipline (according to the positivistic approach). On the contrary, cartography is full of subjectivities, and maps, in particular, are full of intents and inaccuracies. The meaning of maps is, however, valid according to the social context in which they are used or incorporated (Harley 1989).

This new movement in the development of cartography is called "critical cartography". For Crampton and Krygier (2006), this new trend challenges academic cartography by linking geographic knowledge with power. In this way, in the post-war period, cartography underwent a significant solidification as a science, while at the same time other mapping practices were occurring. The authors focus their analysis on the theoretical critical and critical mapping practices considering critical cartography in a historical perspective.

At this point it is also important to consider Tomasz Zarycki's pragmatic approach to map analysis. He states patent differences between *map semantics* and *map pragmatics* in the context of traditional division of semiotics (semantics, syntactic and pragmatics)[23]. He claims that while the semantic analysis of maps will concentrate on the assessment of the extent to which the criteria of the objective map-making - or about "the rules of objective representation" - are fulfilled by particular maps; "pragmatic analysis" should concentrate on establishing the nature of actual social contexts and other criteria of acceptability of maps (cf. Zarycki 2001a).

According to Zarycki, in the map semantics approach, the "map is conceived as a tool for the description of reality"; on the other hand, in the map pragmatic

[23] *Semantics* deals with the meaning of the symbols (relationships sign-vehicle/referent); *syntactics* deals with the formal proprieties of signs and symbols (relationships sign-vehicle/sign-vehicle); and *pragmatics* deals with all the psychological, biological and sociological phenomena that surround the functioning of cartographic signs (relationships sign-vehicle/interpreter). *Referent* is the object. *Interpreter* implies the concept (thought or reference). Extracted from Freitag (2001), Kavouras and Kokla (2008), and Gartner (2009).

approach, the "map is conceived as a form of creation/negotiation of reality"; the "map is considered to be a tool of symbolic domination". The "rules of cartographic communication are objectively given and must be respected" in map semantics; whereas in map pragmatics the "rules which govern the cartographic communication are unstable and must be established, analyzed and related to some social context of their existence". Finally, in the map semantics approach, "maps are created by a cartographer on the basis of his/her knowledge about reality". In the map pragmatic approach "maps are designed not only by those who make them but also by the interests of those whom they serve. The map appears to be under the direct and indirect influence of the potential or actual users" (Zarycki 2001a).

When Zarycki describes the characteristics of the semantic map and of the pragmatic map, there is a connection between Wittgenstein's earlier approach and the later Wittgenstein. This means that the features of map semantics belong to the strict criteria of objectivity when Wittgenstein sets up a one-to-one relation between language and reality. Nevertheless, the conceptions of map pragmatics are different. These elements coincide with the evolution of thought of the later Wittgenstein, when he claims that the descriptive language is only one part of the different kinds of languages used by people. The maps are pragmatically analysed in the context of post-structuralism and social theory[24] which claim other alternatives for seeing and understanding the world.

In summary, Wittgenstein's thought evolution ("first" and "second Wittgenstein" or namely his early and later philosophy) is manifested in a semiotic approach to cartography when map semantics and map pragmatics are confronted (see Table 2.3). Hence, it can be claimed that Wittgenstein's philosophy of his *Tractatus*, when applied to cartography, belongs to the scientific and objective cartography approach. On the other hand, Wittgenstein's thought in "*Philosophical Investigations*" corresponds to critical cartography[25], namely an alternative

[24] Social theory refers to the use of abstract and often complex theoretical frameworks to describe, explain, and analyse the social world (New World Encyclopaedia).

[25] Critical cartography aspects will be analysed in the section "Critical Cartography in the Context of Post-Modernism".

cartographic approach. The first cartographic approach belongs to the traditional positivism or neo-positivism of sciences, and the second one goes beyond academia, namely to the post-structuralism or deconstructionism perspective[26].

Table 2.3 Parallelism between Wittgenstein's philosophy and cartography's evolution during the modern and post-modern period.

Ludwig Wittgenstein's Philosophy	Cartographic Perspective
"Early Wittgenstein": *"Tractatus Logic-Philosophicus"* (1921) Key aspect: **Language – World**	Modern cartography: Scientific cartography Positivism and Neo-positivism approach of mapping (e.g. semantics maps)
"Late Wittgenstein": "Philosophical Investigations" (1953) Key aspect: **Language-games**	Post-modern cartography: Critical cartography Deconstructionism and post-structuralism approach of mapping (e.g. pragmatic maps)

[26] These perspectives belong to the postmodern period. Post-structuralism and Deconstructionism, will be analysed in the following chapters of this section and in the Section "Critical Cartography in the Context of Post-Modernism", respectively.

2.6 Popper's Theory of Three Worlds

Karl Popper (1902-1994) was close to the Viennese school of logical positivism and he wrote basic books on the philosophy of science (cf. Moritz 1995). One of Poppers' major contributions to the theory of knowledge is about the various worlds of knowledge. For Popper there are basically two kinds of knowledge: "subjective knowledge" and "objective knowledge". Popper, together to John Eccles, introduced the "Three Worlds Model" in their book "The Self and its Brain" first published in 1977 (see Popper and Eccles 1993).

Popper's theory of the three worlds establishes a distinction among the *world in itself*, the *subjective world* and the *objective world*. The world itself remains, in a Kantian language, a *neumenon*[27], that is unknowable to the man. From this world we only can study the phenomena. The second world is that of the individual conceptions of thought, a completely subjective world, it is exclusively dependent on man's point of view. The third world is an objective world because of its inter-subject validation of conceptions which initially had an individual character (Mejia Soto 2004).

In his description of the three worlds Popper states:

> First, there is the physical world – the universe of physical entities – […] this I will call "World 1". Second, there is the world of mental states, including states of consciousness and psychological dispositions and unconscious states; this I will call "World 2". But there is also a *third* such world, the world of the contents of thought, and, indeed, of the products of the human mind; this I will call "World 3" (original emphasis, Popper and Eccles 1993: 38)[28]

[27] Neumenon is a posited object or event as it appears in itself independent of perception by the senses. Noumenon is the thing in itself, reality as it is in itself (it remains unknowable). According to the Theory of Knowledge of Immanuel Kant, presented in his "Criticism of the Pure Reason", the intellect does not know the things as they are in themselves (noumena) but as they construct themselves (phenomena).

[28] Elements that belong to World 1 are for instance: stars and planets; atoms and molecules; tables and chairs; trees and animals, etc. To World 2 belong feelings, emotions, thoughts, pains, joys, wishes, etc. According to Gattei (2009) among others, words and prepositions; books and symphonies; laws; numbers and triangles (also

In this way, World 3 "is inhabited by the set of products of all our cultural activities and comprises all human works from the point of view of their logical and objective content" (Gattei 2009). According to Popper "one may say that World 3 is man-made only in its origin, and that once theories exist, they begin to have a life of their own: they produce previously invisible consequences, they produce new problems" (Popper and Eccles 1993).

Helmut Moritz deepens Popper's three worlds and their characteristics; the reality of World 3 in the field of mathematics and logic, and their relation with exact thinking in the context of philosophy for scientists (Moritz 1995). On the other hand, from cartography/GIS Manfred Buchroithner analyses potential multimedia spatial information in the overall system of the Three-World-Model after Popper and Eccles (for more details see Buchroithner 1997).

2.6.1 Theory of Three Worlds and Cartography

In the field of cartography, Carla Lois (2009) analyses cartographic images and geographic imageries, and her claims have important considerations. She states that the iconic presence of the map makes the absence of the object that the map represents visible. For instance, other than from space we cannot see the complete Earth (because of its spherical form and size), but by means of maps (e.g. world atlases) we can well view it. In other words, the object is present (we are even standing on it) but it is not visible, indeed we cannot see it in its whole form.

> This means that there is a visual absence but not an absence of the object. But the object's representation is an image that not only pre-exists the object but, having been constituted in a permanent mediation, it replaces it: the *representation builds the object*[29] (emphasis added, translated from Lois 2009).

problems, theories, and arguments) belong to World 3. Indeed, elements of World 3 (e.g. a symphony) can have a physical presence in World 1 (a symphony recorded on a compactdisc); it belongs, however, still to World 3.

If this quote is analysed in the light of Popper's interaction between World 2 and World 3, then it has important ontological and epistemological scopes. A map depicts elements that belong to World 1 (e.g. the Earth). In this sense, the interpretation of the map's content (World 2) generates a *map image*[30] which belongs to World 3. The map as a device belongs to World 1 (artificial), but the map image belongs to World 3. Popper stated that elements of World 3 acquire independent existence or autonomy. Thus, in the epistemological relationship between object-subject-image, the map image *becomes* the object. This means that the various map images that depict the objects, are transformed into the objects themselves. In other words, the images are objects of reality or the images are reality itself.

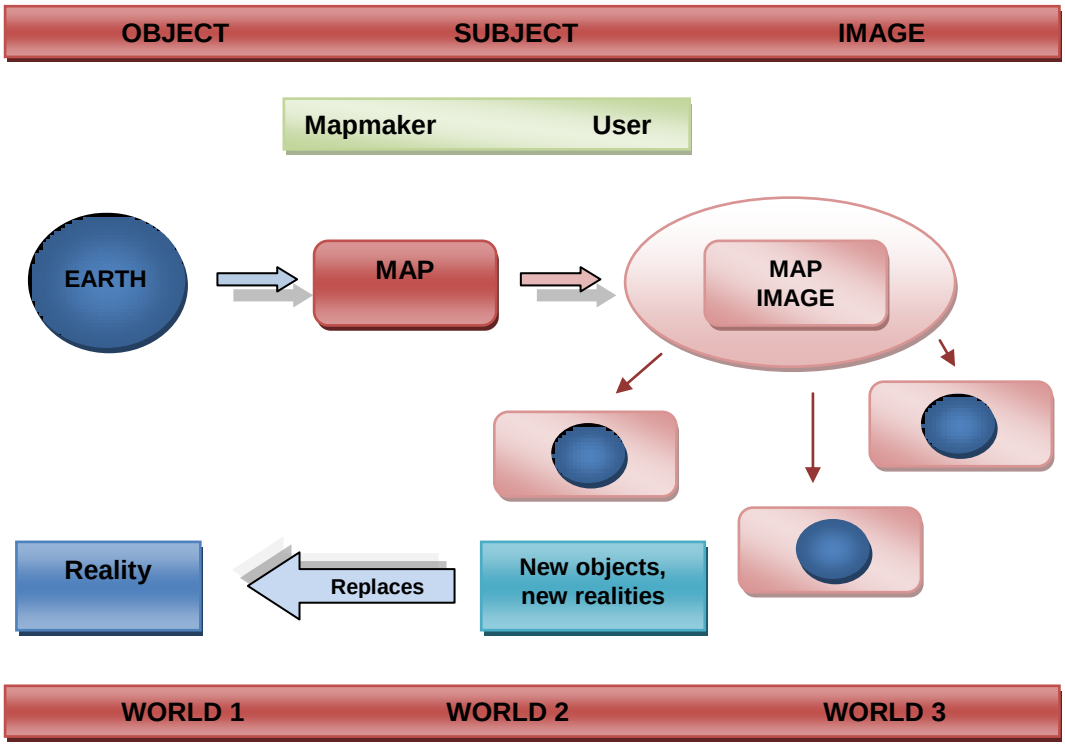

Figure 2.1 Interaction between Popper's Three Worlds Model and the construction of new realities through maps in an ontological approach.

[29] "Es decir, es una ausencia visual y no una ausencia del objeto. Pero la representación del objeto es una imagen que no sólo preexiste al objeto sino que, al constituirse en una mediación permanente, lo reemplaza: la representación construye al objeto".

[30] In this case, "map image" correspond to "mental map" or "cognitive map".

Figure 2.1 depicts “Earth” as an object belonging to World 1 which is knowable though cartography. The subject is represented by the interaction between the mapmaker and the user through the “map”, and this belongs to World 2. The mapmaker designs and creates the map and the user reads and interprets it. Then the user generates a “map image” (image) which belongs to World 3. From this mental image new images are generated by the user. This images are called “new objects” and “new realities” (belonging World 3), because they replace the phenomena of World 1.

On the other hand, according to Li Chengming and Wang Jizhou (2005), as the map is a tool for transmitting information about reality from the producer to the user, three elements must be considered: spatial cognition, mapping language and map interpretation. In this way…

> Through spatial cognition people get the knowledge of objects, phenomena in around environment, and at last shape an image map in head. Map language includes symbols system and mapping rule, and it is used to transform the imago map into real map […]. Map interpretation means the process that users derive the information what they care for from the map (Chengming and Jizhou 2005).

The contribution of Chengming and Jizhou regarding Popper’s Three World Model will be presented next. The “information transfer model” of map (depicted in Figure 2.2) details the internal processes between object world - map object into space cognition, image map, map language, and “actual” map. Doing a parallelism between this Figure and Figure 2.1, “Space cognition based on language map” corresponds to “image map”. Therefore, the “object world cognition” equals the “new object” shown in the above figure.

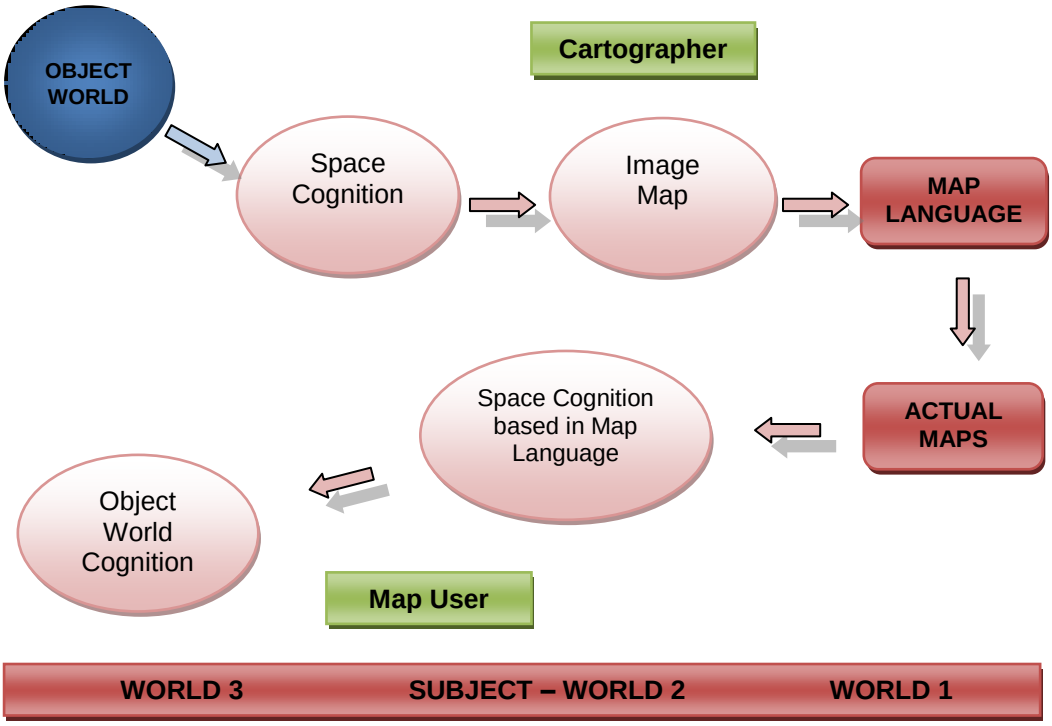

Figure 2.2 Popper's Three Worlds Model and information transfer model of maps in a cognitive approach.

Figure 2.2 depicts the information transfer process in a sequence. First, in World 1 we have an *object world* which is knowable through mapping and cartography. The interaction between World 2 and the subject, *space cognition* and *image map* are generated - by the *cartographer*. Then the *map language* and the *actual map* are created. The map language corresponds to World 3 and the actual map belongs to World 1 (as a physical device). Next the *map user*, drawing information from actual map, creates *space cognition* based on the map language. Again, in this stage of the sequence there is a relationship between the subject and World 2. Finally, in this interaction, the map user forms the *object world cognition* which is a *new real object* belonging *World 3*.

In the information transfer model, the map user establishes an *object world cognition* as a result of the process. In Lois's statements (2009), the image map replaces and builds the object, creating new objects and new realities. The information transfer model corresponds to a *cognitive* approach and the construction of new realities is an *ontological* approach. But according to Popper's

Three World Model both elements belong to *World 3*. In other words, these elements are derivative creations that acquire a *life of their own* which escapes their creator.

> These are immaterial objects (though they might be at times contained into material objects, such as in the case of books and music scores), as opposed to the inhabitants of World 1; and whereas World 2 inhabitants are subjective, they are objective; furthermore, as to autonomy, despite that they are products of the human mind, once created, they have consequences that their own creators had nor foreseen nor could predict (Gattei 2009: 57).

Independently to the approach considered (ontological or cognitive) both correspond to elements *belonging to World 3*. The relationship between World 3 and World 2 is also important. The cognitive approach includes: space cognition based on map language by the *map user*, and the actual map based on space cognition and image map by the *cartographer*. The ontological approach includes the subject - mapmaker, user - and the image - map image. According to Popper's statements these relationships can be subjective, but the final products are *objective*. In other words, the created objects (in this World 3) *are as real as* the objects belonging to World 1.

Another aspect of the relationship between Popper's Three Worlds Model and cartography has to do with the term *map* (see Table 2.4). Cauvin et al., (2010) say that the name of the product of cartography is *map* which is more familiar and more ancient than the discipline itself. They define the map concept and divide it into seven components (see table below). On the other hand, the same table shows the content of World 3 by Popper and Eccles (1993) broken into "work of art and science, and technology" and "human language". The cartographic products such as: "map mental image and map model" and "map language" (or cartographic language) fall into this classification. These elements belong to World 3 because of their cognitive nature.

Table 2.4 Parallelism between "Popper's Three Worlds Model", products of cartography, and definitions and components of maps.
(1-7) extracted from C. Cauvin, F. Escobar and A. Serradj (2010), (see below);
(*) from Popper and Eccles (1993)

Popper's Three Worlds (*)		**Cartography's product**	**Definition and component of map**						
			(1)	(2)	(3)	(4)	(5)	(6)	(7)
World 3 (the products of the human mind)	Work of Art and Science (including Technology)	Map mental image Map model	■	■				■	
	Human language	Map language			■				
World 2 (the world of the subjective experiences)							■		■
World 1 (the world of physical objects)		Map device				■			

(1) Map is a geometric representation (of the planet; with relative positions; with non-spatial attributes)
(2) Map is a constructed model (reduction; selection; generalisation)
(3) Map is a graphical, iconic model using symbols (visual; audio; tactile; others)
(4) Map on a base (permanent; temporary; virtual)
(5) Map at a given time within a context (historical; social; technological; scientific)
(6) Map with specific purposes (presenting and transferring information, providing locations; exploring patterns; revealing visible or invisible relations; exchange and consultation)
(7) Map involving choices (scientific; subjective; empirical)

Table 2.4 shows that most of the criteria defined by Cauvin et al. (2010) in definition and components that belong to World 3 ("map mental image" and "map model") are considered. The map belongs to these categories when they are regarded as a geometric representation, as a model by generalisation and selection, and for specific purposes (this task involves new information and decisions derived from map analysis). When a map is considered as a cartographic language (graphical and iconic model using symbols and signs), this implies that the map belongs to the human language as a product of the human mind. According to the Table 2.4, two criteria fall in the content of World 2: "map context" and the "choice for aims of maps". These criteria are subjective because feelings and decisions are involved (for more detail there is a wide body of literature authored by John B. Harley). Finally, only one criterion belongs to World 1: the map considered as permanent base device (i.e. material), independent whether it is temporary or virtual. In this regard, Robinson et al. (1995) mention six major technological revolutions[31] starting at the time that cognitive images were first transcribed into tangible cartographic products (for more details see Robinson et al. 1995).

Finally, the criterion "map with specific purposes" needs a closer view. It is considered to belong to World 3 because they contain creations of new information with the help of the map. This new information is as real as the previous one from the data-input set. But the specific proposals which motivate this information quest can have different viewpoints (scientific, political, educational, etc.). As a result, these purposes can be subjective and experiential, and therefore they would fall into the realm of World 2.

[31] According to Robinson et al. (1995) mapping in the Western world has seen the following technical advances: manual, magnetic, mechanical, optical, photo-chemical, and electronic technologies. All these technologies had impacts on the map as a device belonging Popper's World 1.

2.7 Postmodernism and Poststructuralism

Postmodernism is a term of cultural character which arose in the last quarter of the twentieth century. This term designates a cultural change of radical features that tried to identify the end of *modernity* (Valcárcel 2000)[32]. It questions the scientific, epistemological, cultural and ideological assumptions, which support the development of the Western culture since the age of Enlightenment. This questioning is the most striking feature of postmodernism.

For the postmodernists, knowledge and truth are always relative to a particular culture or to a historical period. According to William Gorton, this applies not only to moral and aesthetic judgments, but also to the claims for truth made by the natural and social sciences (Gorton 2010).

> Thus science does not offer a method for arriving at universal, objective truths that transcend time and place. Rather, it represents one way of knowing that reflects certain values, beliefs and interests of modern, Western society. Moreover, for postmodernists there is no fixed, universal human nature. Instead, human nature (our beliefs, values, desires, interests, and even our emotions) is itself a product of a particular history or social configuration – or, as postmodernists sometimes say, human nature is *socially constructed* (original emphasis, Gorton 2010).

The postmodernists reject the uncovering of patterns, structures or laws that purportedly transcend history and culture as deeply misguided attempts by social scientists. These attempts were made in the nineteenth century, especially during the validation of positivism applied in social sciences (for more details see Gomez Mendoza et al. 1988). For postmodernists, the understanding of a particular society must be local and contextual.

According to José Ortega Valcárcel, a theoretical criticism arises, which analyses the incongruities and contradictions of the philosophies that govern the cultural, social, scientific, philosophical, epistemological patterns of the modern society. It is

[32] Valcárcel is drawing here on the work of J. Friedman (1989).

a criticism directed to the foundations of modernity. This is called poststructuralism.

> The corroboration of a new time and the new culture is formulated. The new culture defines itself as *postmodernism*. The new time defines itself as *postmodernity*. Theoretical criticism or poststructuralism, and a new culture or postmodernism make up postmodernity[33] (original emphases, translated from Valcárcel 2000: 242).

The postmodern culture is sustained on the criticism of modernity. This criticism begins with the Frankfurt School (founded in Germany), which arose towards the end of first third of the twentieth century, and acquired relevance after of the Second World War. The main thinkers of this school are: Theodor W. Adorno (1903-1969), Herbert Marcuse (1898-1979), Walter Benjamin (1892-1940), Erich Fromm (1900-1980), Max Horkheimer (1845-1973) and Jürgen Habermas (1929-) (Bretow 2002; Gorton 2010; Valcárcel 2000). This intellectual movement criticises the modern capitalism and its theoretical and epistemological supports. The original critical theorists argued that a social scientist should not – and cannot - be a neutral observer of the social world. In this way, "in place of orthodox Marxism they aimed to produce a new theory that could at once explain the failure of socialism in the Western liberal democracies and also provide a critique of what they saw as oppressive features of developed capitalist societies" (Gorton 2010).

Science and technology do not escape this critical movement:

> The interpretation of the capitalism from the perspective of the *domain* constitutes a fundamental feature of the critical conception of this *school*. In accordance with it, science and technology constitute the axis and the support of this domain[34] (original emphases, translated from Valcárcel 2000: 244).

[33] "Se formula como afirmación de un tiempo nuevo y una cultura nueva. La nueva cultura se define como *posmodernismo*. El tiempo nuevo corresponde a la *posmodernidad*. Crítica teórica, o postestructuralismo y nueva cultura o posmodernismo, configuran la posmodernidad".

[34] "La interpretación del capitalismo desde la perspectiva del *dominio* constituye un rasgo fundamental de la concepción crítica de esta *escuela*. De acuerdo con ella, la ciencia y la técnica constituyen el eje y el soporte de ese dominio".

From this intellectual movement, other authors who were related to the European political left, also became prominent during the second half of the twentieth century. A French intellectual group in the field of culture and social sciences included authors such as: Michel Foucault, Jacques Derrida, Gilles Deleuze and Félix Guattari, Jean Baudrillard, and Jean-Francois Lyotard. They all doubted the assumptions held since Enlightenment.

According to Valcárcel (2000), Deleuze and Guatteri (from the viewpoints of philosophy and psychoanalysis) investigated the relationship between capitalism and mental disorder, and between capitalism and desire. In other words, there is a relation between the social system and the individual impulses. Foucault formulates equivalent conclusions regarding the relationship between power and knowledge. Foucault states that "there is no truth outside of power" and he links the truth (i.e. objectivity) with the social horizon. Derrida tackles the relationship between language and thought. The fundamental idea is that language shapes reality; even more, language is reality. Finally, Lyotard sets out the narrative knowledge[35] and he poses that science is a "subset of knowledge".

Other philosophers in the context of the history of science and epistemology, like Thomas Kuhn, take the truth of the scientific knowledge as *relative* because it is socially conditional. Therefore, this *scientific truth* does not exceed the status of a discourse (Kuhn 1970; Hall 2006).

> Poststructuralism is profiling as a criticism to the rationality of the Enlightenment. It supports an intellectual trend with authors like J. Baudrillard and J. F. Lyotard which has been marking antirationalism. It has to be distinguished from the denunciation of the scientific discourse. Structural theories and conceptions of universal character are rejected. The assumptions on which the modern world has been constructed are denounced. This means, the rational subject, ration and, scientific knowledge are identified with the truth[36] (translated from Valcárcel 2000: 247).

[35] For Lyotard, narrative knowledge is the kind of knowledge prevalent in "primitive" or "traditional" societies, and is based on storytelling, sometimes in the form of ritual, music and dance (from Woodward 2005).

[36] "El postestructuralismo se perfila como una crítica a la racionalidad de la Ilustración. Alimenta una corriente intelectual en la que destacan autores como J. Baudrillard y J.F.

Table 2.5 in a schematic way presents a comparison between the neopositivist epistemology and the postpositivist epistemology of sciences (Romaniuk and Paillalef 2010). The former one corresponds to the *modern* period and the latter one belongs to the philosophy of the *postmodern* period. The left column of the table shows the aims, methods, and contexts established by the Vienna Circle which were valid during the logical positivism. The right column contrasts the new conceptions regarding the same aspects mentioned above, in the context of postpositivism, especially that of the second half of twentieth century and even nowadays.

Lyotard, de acentuado antirracionalismo. Se distinguen por la denuncia del discurso científico. Rechazan las teorías estructurales, las concepciones de carácter universal. Denuncian los presupuestos sobre los que se ha construido el mundo moderno, es decir, el sujeto racional, la razón y el conocimiento científico, identificado con la verdad".

Table 2.5 Comparison between the neopositivistic and postpositivistic approaches in epistemology and philosophy of sciences.
Translated from Romaniuk and Paillalef (2010).

Neopositivistic Epistemology (Vienna Circle)	**New Philosophy of Science (Postpositivist)**
to unify all sciences with one unique method	to attend the diversity and specificity of every discipline
to formalise the language of science (without bearing in mind the use contexts, and sometimes not even the meaning)	the meaning depends on the context interest in the practices of scientists
human rationality = scientific reason	extended the concept of rationality
ideal of ethic neutrality of science	to recognise and to study links between science and society, between science and its historical context, science and psychological processes, etc.
attention to the method, to the language of science and the logical aspects of theories	focus in the practices of scientists, how the scientific communities behave, how decisions are made, etc.
distinction between discovery context, justification context, and application context	distinction of contexts is artificial

On the other hand, the postmodern approach is not new. According to Valcárcel (2000) the postmodern movement is a fresh outbreak of the great antirationalistic movement of the end of the nineteenth century and the first third of the twentieth century. This movement is known as Historicism[37]. The author points out that the roots of postmodernity correspond to the *philosophies of the subject*, because in historicism the importance is given to the subject (or the individual). Therefore, in the right column of Table 2.5, when reading the distinctive features of the foundations of postmodernism or poststructuralism, characteristics of historicism

[37] According to Kahan (1997) historicism is a mode of thinking that assigns a central and basic significance to a specific context, such as historical period, geographical place and local culture.

can be seen. For instance, the recognition and study of the links between science and its historical context is a feature of historicism.

2.7.1 Postmodernism and Cartography

Cartography and mapping, as science or discipline in the scientific context, have neither escaped the criticism of the postmodern period. This is known as the contemporary *critique of cartography*. Nikolas Huffman has, from a backdrop of map design in postmodernism, analysed maps and mapping within the postmodernistic framework. He addresses the postmodern critique by outlining four different definitions of postmodernism and its relation to some cartographic critiques. These categories are: mapping and the postmodern style; cartography and postmodern social theory; capitalism and economy of mapping; and cartography and poststructuralism (for more details see Huffman 1996).

Huffman mentions some "postmodernists" in cartography such as Denis Wood, John B. Harley, Richard Helgerson, Barbara Belyea and Robert Rundstrom. These authors question the apolitical and scientific status for cartography.

> These critiques have disputed the way that language and the production of meaning have been theorized in cartography research on maps and mapping, and introduced *new ways* of understanding how we interact and communicate with and through maps. […] They have also pointed towards a broader sociology of mapping in which maps and mapping can be understood as *artefacts within our social and material culture*, and have demanded that greater attention be paid to issues of representation, politics, and social action (emphases added, Huffman 1996: 35-36).

The above statement points at new tendencies in contemporary cartography which fall within the postmodernistic context. These new ways of understanding maps are referred to as being alternative to the scientific-empirical approach in cartography during modernity. Thus the map is an artefact (material or ideal) within the social and cultural context in which it is created and used, and is no longer a device with an objective, neutral and free-value character. In other words, all these

new visions in cartography and mapping are framed within the new postpositivistic epistemology of sciences.

In his analysis of cartography from a postmodernistic point of view, Huffman (1996) mentions that cartography has been influenced by the postmodern social theory, especially by Foucault's social critique (1969), which was adopted by Harley (1988a, 1988b, 1989, 2001) and applied to cartography. "Concepts like *power-knowledge*, *episteme*, and *discourse*, were applied to the role of maps in creating and sustaining social and political power within a given society". The author also refers to Belyea (1992) with her reworking of Foucault and cartography, and considering Latour's recent work in the sociology of sciences (Latour 1990). Wood claims that "maps are *weapons of power* that create the territory desired by those empowered to make and enforce maps" (Wood 1992).

When Huffman analyses cartography and poststructuralism, he highlights a "crisis of representation"[38] made by the poststructuralist philosophy of language. In this way, "in cartography, this work has focused on the language of maps as complex social and cultural objects and on how maps construct and are constructed by society and language". He mentions Derrida's philosophical critique and the adoption of Derrida's approach by John B. Harley who analyses *maps as texts* "that seek[s] to reveal the underlying political interests and prejudices embodied in maps" (Harley 1989).

Section "Critical Cartography in the Context of Post-Modernism" provides a deeper analysis of Harley's legacy and his drawings from Foucault' power-knowledge relationship, and from Derrida's hermeneutics applied to cartography. In this way, the poststructuralistic and postmodernistic approaches in the field of cartography, conceived as a *social activity* and maps as *devices of power and persuasion*, are

[38] Huffman summarises the crisis of representation in two major tenets. "First, all human language and meaning is based on the interpretation of signs that are ultimately indeterminate and always open to further analysis. Second, […] all human knowledge […] is mediated through language structures that shape our perspectives on the world around us, as well as constituting such personal concepts as self and subjectivity" (Huffman 1996: 41). This poststructuralistic position has important repercussions on the map's conception.

seen with a different perspective in comparison to the modern period of cartography.

3 Paradigms in the History of Science

3.1 Introduction

This section deals with the term paradigm as described by Thomas Kuhn, in the context of the history and epistemology of science. Paradigm-shifts or "scientific revolutions" are analysed and their application in natural and social sciences is shown. Basically, the paradigm concept implies several interpretations but it generally includes a scientific community in a defined field which shares common aims and criteria during a certain period of time. These periods are called "normal science". The replacement of one paradigm for another is known as a "scientific revolution" or "crisis period". Kuhn proposes the incommensurability concept. This means that every paradigm has its own internal logic. Therefore the criteria of one paradigm cannot be applied to another. As a consequence each paradigm comprehends different world-views. The aim of this section is to study the reasons for a paradigm-shift as a basis for its analysis in cartography.

3.2 Kuhn's Paradigm Shift

In 1962 Thomas Kuhn published his book "The Structure of Scientific Revolutions"[39] from which the term *paradigm* arose. According to Kuhn paradigms are:

> Accepted examples of actual scientific practice - examples which include law, theory, application, and instrumentation together - that provide models from which spring particular coherent traditions of scientific research (Kuhn 1970: 11).

In other words, paradigms are "universally recognized scientific accomplishments which have validity for a certain period of time". In the postscript to the 1970 edition of his book, Kuhn constructs a generalisation to the term paradigm due to

[39] A complete outline and study guide of the book "The Structure of Scientific Revolutions" by Thomas Kuhn has been prepared by Frank Pajares (Pajares 2005).

the difficulties derived from the multiple connotations[40]: “the paradigm is what is shared by members of a scientific community in particular" (Kuhn 1970).

The concept of paradigm is widely used in epistemology, and the scientific knowledge is placed into a *historical* and *social* context. In his theory Kuhn developed two essential components of the paradigm: a “disciplinary matrix” and a “sociological component”. In other worlds, the *scientific thought* does not progress via a linear accumulative, but on the contrary this thought is circular, *rupturistic*[41] and recaptures previous approaches or perspectives.

In this way Kuhn argues that periodic revolutions - called paradigm shifts - are immanent to science in which the nature of the scientific inquiry within a particular field is abruptly transformed. This evolution of science includes “normal” science periods with a central paradigm followed by anomalies and revolutions (“crisis periods”). The arising of a new paradigm is an answer to the crisis.

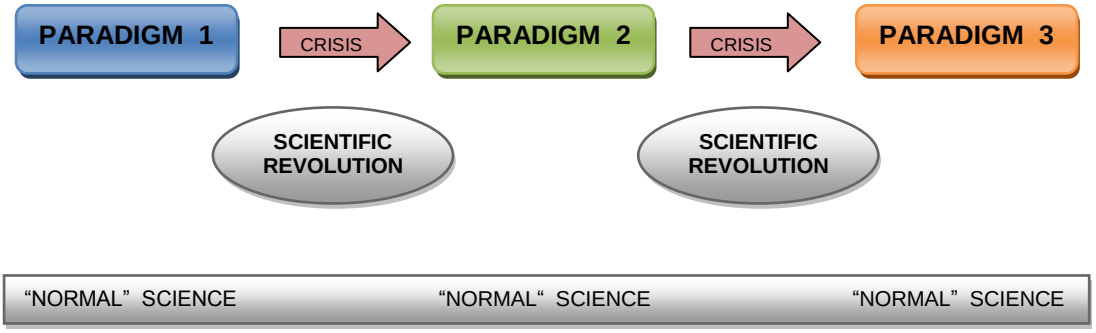

Figure 3.1 Paradigms accompanied by scientific revolutions during periods of crisis and “normal” science.
Adapted from Kuhn (1970).

Figure 3.1 depicts a period of “normal” science that contains a determined paradigm (Paradigm 1) followed by a period of crisis where a scientific revolution takes place. A new period of “normal” science then arises accompanied by a new

[40] In this postscript Kuhn points out that "the term paradigm has been applied in at least twenty-two different manners". He refers to the criticism made by Margaret Masterson in her article "The Nature of a Paradigm" (Masterson 1970).

[41] Here *rupturistic* is considered to be synonymous of change, rupture, revolution.

paradigm (Paradigm 2) until another period of crisis comes. This crisis is solved with the rising of yet another paradigm (Paradigm 3), and so on thorough time.

In summary, according to Kuhn's legacy the term paradigm characterises a *scientific tradition* including its theory, textbook problems and solutions, its methodological apparatus, and its philosophy of science. Therefore, paradigms govern *normal science*. It is the scientist's task to apply the paradigm to the solution of puzzles[42]. A failure to solve these puzzles is the fault of the *scientist* not of the paradigm. Nevertheless, persistent failure makes a puzzle an anomaly and threatens a revolution, which may end the paradigm's hegemony. A *revolution* is a fundamental change in the way of thinking about or of visualising something; in this case it is a *change* of paradigm.

Through the concept of paradigms it is possible to explain the historical evolution of both physical sciences and of social sciences, because they are defined by concepts, methods, theories, approaches and problems. In Table 3.1 some examples of paradigm shifts in the natural sciences such as physics, chemistry and biology are shown. Both ancient and new paradigms are also considered to be *world views*, i.e. the philosophical and epistemological scope of "viewing" the world or reality.

For all conceptions or "world views" listed in the left column of Table 3.1 with exception of geology, the old paradigms were replaced by new ones. In geology, for the better explanation of the "plate tectonic theory" this theory was complemented considering the former "continental drift theory" (for more detail, see Kuhn 1970). In other words, the continental drift theory was not rejected but it was integrated into the new plate tectonic theory. Examples of this are more common in natural sciences than in social sciences. Thomas Kuhn was primarily a Physician and later he became a theoretician of the history of sciences.

[42] Normal Science is puzzle-solving. Doing research is essentially like solving a puzzle. Puzzles have rules and puzzles generally have a predetermined solution (Kuhn 1970).

Table 3.1 Some paradigm shifts in natural sciences according to Thomas Kuhn. Paradigm shifts (indicated with *) are broadly described by Kuhn is his book "The Structure of Scientific Revolutions" (1970).

Field of study	Replaced paradigm (world view)	New paradigm (world view)
Physics (Astronomy)	Ptolomaic cosmology *	Copernican cosmology ****
Physics (Mechanics)	Aristotelian mechanics	Classical mechanics
Physics (Mechanics)	Classical mechanics	Quantum mechanics
Physics	Newtonian physics	Einsteinian relativistic
Chemistry	Phlogist theory *	Chemical reactions and combustion theory *
Biology	Lamarckism approach	Natural selection theory
Geology (Earth's sciences)	Continental drift theory	Plate tectonic theory

On the other hand, Kuhn considers scientific knowledge as *social* (Reyes 2005). According to Hall (2006) this implies that scientists can be naturally grouped into content-related disciplines or "invisible colleges" that are not consciously apparent to their respective members:

> Each college tacitly shares a) a theory-laden vocabulary (based on implicit connotations as well as explicit definitions), b) an unspoken set of examples of what the discipline believes to represent "good science", and c) a lot of other uncritically held assumptions about their discipline inherited from their education as scientist (Hall 2006).

Consequently, a scientific community cannot practice its trade without a set of *received beliefs*. According to Kuhn these beliefs form the foundation of the "educational initiation that prepares and licenses the student for professional practice" (cited after Frank Pajares). The nature of a "rigorous and rigid" preparation helps to ensure that the received beliefs exert a "deep hold" on the student's mind (Pajares 2005).

Kuhn also developed the concept of *incommensurability* in the framework of studying a scientific "revolution", where there was a progression from an earlier paradigm (disciplinary matrix[43]) to a newer one.

> Scientific revolutions may occur when new observations can no longer be adequately explained within an existing paradigm (the observations are anomalous). In some cases the anomalies can only be accommodated in theory based on new exemplars, models and/or symbolic generalizations. These changes often require new vocabulary and often alter the meaning and connotations of existing vocabulary. Even where the same words are used within each of the paradigms, there is often no longer a direct logical correspondence in their meanings. In other words, the world view (created by symbolic generalizations, models, exemplars and their associated theory-laden vocabulary) held by practitioners of one paradigm is logically *incommensurable* with that held by the alternative paradigm. Even though practitioners of both paradigms are looking at the same data, they see different worlds (emphasis added, Hall 2006).

In Kuhn's theory a new paradigm is *incompatible* with the paradigm which it substitutes or replaces. Therefore, a relation of "incommensurability" is generated. It implies that every individual theory fixes a meaning to all its terms in a holistic way. If a small change happens in the theory, then the meanings of all the terms may change in a radical way.

This situation becomes clear when physical magnitudes are compared. For instance, terms like "mass", "velocity", and "energy" have completely different meanings in the Newtonian classical mechanics compared with the Einsteinian relativity. In the Special Relativity Theory the mass-energy equivalence principle ($E=mc^2$) arises, which is not valid in classic mechanics (Reichenbach 1957).

[43] According to Kuhn the concept of "disciplinary matrix" includes four major components: 1) Symbolic Generalisations – deployed by authors without question or introspection, and immediately understandable by the groups; 2) Models – including those with heuristic* and metaphysical assumptions that provide the group with preferred analogies or even with an ontology; 3) Exemplars – which are unquestionable and accepted concrete examples of how to solve a particular kind of problems; 4) Values – in the sense of providing a predictive or epistemic value (Hall 2006). * In Philosophy, the adjective heuristic is used when an entity *X* exists to enable understanding of, or knowledge concerning, some other entity *Y*.

Therefore, the concepts of mass, velocity, and energy have different meanings in each of the theories; or these concepts have incommensurability between them.

Another important aspect of the theory of paradigms corresponds to the "revolution as changes of world view". Kuhn asserts that when *paradigms change*, the *world itself changes* with them. In other words, during scientific revolutions, scientists see new and different things when looking with familiar instruments at places that they have looked at before. According to Pajares:

> This difference in view resembles a *gestalt shift, a perceptual transformation* - "what were ducks in the scientist's world before the revolution, are rabbits afterwards" (original emphasis by Pajares 2005).

This transformation of the world view is proposed because it changes not only a set of theoretical laws and a set of examplary achievements, but the engagement series until then shared by the scientific community (Romaniuk and Paillalef 2010):

- ways of raising problems in a field[44]
- ways of speaking about the world (lexical)
- ways of seeing the world (ontological assumptions)
- ways of knowing the world in a reliable way (gnoseological assumptions)
- types of work, rules, instruments, techniques (methodological and practical assumptions)

This new manner of seeing the world covers philosophical and epistemological aspects of reality, due to lexical, ontological, gnoseological and methodological assumptions. For these reasons the theory of paradigms has impacted fields like philosophy, history and sociology of science. This is the *sociological* component of the theory. One example of this change in vision is seen in the philosophy of science during the twentieth century. In the first half of twentieth century the Vienna Circle was a milestone in logical positivism or neo-positivism. However, the criticism of the conceptions of this approach (internal and external criticism)

[44] Translated from Romanuik and Paillalef (2010).

allowed the emergence of other conceptions which were different and embedded into the post-positivistic approach[45].

After Kuhn there are authors who continue with the diffusion and illustration of the paradigm notion towards new disciplines (Saldivia 2010). For instance, in the social sciences, Guillermo Briones conceives the paradigm concept as "a conception of the study object of a science, the general problems to be studied, the nature of its methods and techniques, the information needed and, finally, of the way of explanation, interpretation or comprehension of the results of the performed research"[46]. In other words, each paradigm has own study objects, research aims, methodologies, approaches and research results.

[45] Kuhn's legacy is viewed by postmodern and poststructuralistic thinkers as having called into question the enterprise of science by demonstrating that the scientific knowledge is dependent on the culture and historical circumstance of groups of scientists rather than on their adherence to a specific method, as has been the aim of the Vienna Circle in the logical positivism approach.

[46] Translated from Saldivia (2010). Saldivia is drawing here on the work of G. Briones (1987).

3.3 Paradigms in Geography

The concept of paradigms can also be applied to the development of modern Geography (nineteenth and twentieth century). Some specific paradigms have been consolidated according to the historical, philosophical, cultural, economic and political contexts. Different geographies have arisen inside these paradigms. Each one presents its own study objects, research aims, methods and results (Hernández 1982; Gomez Mendoza et. al 1988; Capel 1998).

Table 3.2 Classical paradigms in geography, geography types and main representatives during modern period of Western geography.
Compiled by author.

PARADIGM (Validity period)	**GENERATED GEOGRAPHIES**	**MAIN REPRESENTATIVES**
Positivism (18^{th} c. - 19^{th} c.)	- Environmentalism and Geographical Determinism	F. Ratzer; E. Reclus; P. Kropotkin
Historicism (1st third 20^{th} c.)	- Regional Geography or - Landscape Geography	V. La Blache; A. Hettner; R. Hartshorne; S. Passarge; O. Slutter; C. Sauer; M. Sorre
Logical positivism (1950's-60's 20^{th} c.)	- Quantitative Geography - Theoretical Geography	I. Burton; D. Harvey; R. Chorley; P. Haggett; W. Bunge
Phenomenology (1970's-80's 20^{th} c.)	- Humanistic Geography - Idealistic Geography - Perception Geography - Spatio-temporal Geography	- Yi Fu Tuan - L. Guelke - D. Lowenthal; P. Gould; K. Lynch - T. Hagerstrand
Radicalism (1970's-80's 20^{th} c.)	- Radical Geography	D. Harvey; W. Bunge; I. Lacoste; R. Peet
Current tendencies (1980's-90's, 20^{th} and 21^{th} centuries)	- Post-modern geographies[47]	

Table 3.2 summarises the geographic paradigms, generated geographies and their main representatives or authors according to the classical literature on Western geographical thinking.

[47] For more details about postmodern geographies see Valcárcel (2000).

On the other hand, Horacio Capel attempts to explain the evolution of the geographic thinking in the nineteenth and twentieth century by comparison between *positivistic* and *historicistic* stances. These two great traditions of Western thinking have been seen as two irreconcilable and conflicting conceptions (Capel 1983).

Table 3.3 Essential features of positivism and historicism.
(*) In the *inductive* methods, dominant in the positivism of the *nineteenth century*, as well as in the *deductive* ones of the middle of the *twentieth century.*
Extracted and translated from Capel (1983).

Positivism	**Historicism**
Methodological Monism (unity of the science and the scientific method)	Contrast between nature and history
Scientific Reductionism or Naturalism	Affirmation of the specificity of the human sciences
Nomothetic	Idiographic
Explanation	Comprehension
Scientific knowledge uses only the reason	Empathic knowledge is valued as well as the use of faculties like sensibility and intuition
Prediction	Inability to do predictions in human sciences
Non-historicality	Emphasis on historical development
Axiological Indifference	Appraisal
Importance of theory (*)	Inductive methods without previous theories
Empiricism	Idealism

Table 3.3 summarises in schematic manner the contrast between the two opposite paradigms: positivism and historicism. In this way, two opposing world views with respect to the philosophical, epistemological and methodological aspects of the knowledge in sciences are presented.

Capel (1983) poses the question: *are there Paradigms in Geography*? He answers that since beginning of the nineteenth century the history of geography could be interpreted as a *pendulum motion* between the positivistic and historicist stances. During the development of geographical thinking this pendulum movement has two phases:

> The former would have its origin in the central period of Enlightenment […] and it would dominate in the middle of the nineteenth century and, again, one century later with the triumph of the quantitative revolution. The latter would impregnate the romanticism of the beginning of the nineteenth century, the anti-positivism movement of the turn-of-the-century historicism, and of the first third of the twentieth century, and appears again in the reaction against to the neo-positivism of the "critical" and "radical" geographies[48] (Translated from Capel 1983).

This statement implies that the diversity of paradigms (e.g. those shown in Table 3.2) or geographic traditions[49] established during the development of the modern period of geography can be reduced to this pendulum movement which fluctuates between these two tendencies - positivism and historicism.

On the other hand, it is important to emphasise two other significant aspects of the theory of paradigms within the *scientific context*. First, although Kuhn explored the ideas of paradigms and incommensurability primarily in the temporal process of the change from one paradigm to another (Hall, 2006), two paradigms *can survive* side-by-side at the same time, with direct consequences for the communication between holders of the different paradigms. Second, regarding the discussion between *science and discipline*, Kuhn's analyses applied in the scientific communities have also to be considered in general *disciplines*, whether they are scientific or not (Garcia-Sierra 1999).

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[48] Las primeras tendrían su origen en el período central de la Ilustración […] y dominaría a mediados del siglo XIX y, otra vez, un siglo más tarde con el triunfo de la revolución cuantitativa. Las segundas impregnarían el romanticismo de principios del siglo XIX, la reacción antipositivista del Historicismo finisecular y del primer tercio del siglo XX, y aparecen nuevamente hoy en la reacción frente al neopositivismo de las geografías "críticas" y "radicales".

[49] According to Capel (1983) these "geographic traditions" are: physical, chorological, landscape, ecological, spatial and, social or socio-spatial.

It implies that the concept of paradigm can also be used for all those disciplines which are not regarded *strictly* scientific. Therefore, according to Garcia-Sierra (1999), it is better to use the term *disciplinary community* rather than *scientific* community.

4 Tendencies in Contemporary Cartography

4.1 Introduction

This section is a compilation of the major tendencies and perspectives which arose during the formal and academic development of cartography and mapping in the second half of twentieth century. Several authors and researchers have labelled these changes in the discipline with different terms: tendencies, trends, shifts, perspectives, approaches, paradigms, paradigmatic shifts, etc. This revision considers the “changes” in the cartographic western literature that have had those characteristics pointed out by Thomas Kuhn in his work about the paradigm concept (Kuhn 1970). These changes surreptitiously include i.a., the epistemological and philosophical basis, visions and perspectives within the scientific context, methods and technologies applied, and social context.

In chronological order, the tendencies have been considered by the following authors. First, Raul Ramirez’s traditional and modern components in theoretical cartography are pointed out. Second, Daniel Sui’s and James Holt’s three major paradigms referring to map conception are treated. Along the same line, Michael Peterson mentioned some paradigms associated with cartographic research and Internet. *Cartographic Communication Model*, *Analytical Cartography* and *Maps and Internet* are presented as important tendencies in the Peterson’s historical context. Third, *Cartographic Visualisation* initiated by Alan MacEachren is considered as a renewal change in comparison with traditional cartographic communication. Then, in the context of *cyberspace* and digital cartography, the scopes made by David Fraser Taylor as a basis of the *cybercartography* paradigm are presented. Next, Ferjan Ormeling’s historical analysis of contemporary cartography, in which he identifies some paradigmatic changes, is set forth. Finally, the contribution of Colette Cauvin, Francisco Escobar and Aziz Serradj about the main milestones during the last sixty years in the history of thematic cartography is analysed.

4.2 Traditional and Modern Components in Theoretical Cartography

In his book draft “Theoretical Cartography” Raul Ramirez highlights a difference in modern cartography between theoretical and applied cartography (see Ramirez 2004). For Ramirez there exist three major trends within the theoretical cartography:

> The theory of *cartographic language*, the theory of *cartographic modelling*, and the theory of *cartographic communication*. They intend explain the origin of cartography as a science, and comprise the *classical theory of cartography*” (original emphases by Ramirez 2004: 1).

The above statement mentions the rise of three *traditional components* or directions of theoretical cartography: the *linguistic direction*, the *modelling direction*, and the *communication direction*. Below is a summary of these traditional components.

4.2.1 Cartographic Language, Modelling and Communication

Cartography Language assumes that maps have a language that corresponds to the natural language used to express spatially related elements. Thus, the cartographic language is composed of four elements: alphabet, grammar, reading and writing. In the 1970s its main representatives were L. Ratajski, J. Morrison, A. Vasmut and J. Bertin (Ramirez 2004). The cartographic language emphasizes that the language of the map has both an *alphabet* and a *grammar*, and that the first one had already been assumed (for instance line, point, area and volume).

Cartographic Modelling assumes that maps are models of the phenomena which are spatially represented. Cartography is considered to be a model of reality (i.e. especially of the physical world). This modelling is composed of four elements: generation of the model, analysis, interpretation, and evaluation (testing). In the 1980s its main exponents were C. Board, K. Salishchev and J. Pravda (Ramirez 2004). This trend is based on the concept that a map is a *representational* and

conceptual model of the real world, that there is a set of laws in maps (scale, presentation and generalisation), and that maps are mathematically precise structures.

Cartographic Communication considers maps as a way of communication. It has its origin in the need to demonstrate that in the design and production of maps the opinion of users must be considered, because every model of communication is composed of a source, a message and a receiver. This approach bears two elements: a *model of communication* and the *theory of communication* (the latter one as frame of reference). The major authors during the 1970s, of the "communication representatives", were A. Kolacny, L. Ratajski, J. Morrison, C. Board and A. Robinson and B. Petchenik (Kanakubo 1990). This trend is based on the communication model of Claude Shannon derived from mathematics or signal-processing theory respectively (Shannon 1948)[50]. This tendency will be analysed in greater detail further below.

4.2.2 Geo-Spatial Data Manipulation, Processing and Visualisation

Raul Ramirez (2004) also identifies three *modern components* in cartography which are directly related to the manipulation, processing and visualisation of geo-data. The following represents brief descriptions of those components.

Geo-Spatial Data Manipulation examines the representation of the terrain, including a) the analytical study of cartographic documents, b) cartographic projections and their distortions, c) cartographic generalisation, d) cartographic transformation, and e) quality of spatial data.

Geo-Spatial Data Processing analyses of the spatial information, including the conceptual study of the topological representation data which is one of the structures used for analytical purposes. It includes the conceptual points of view a)

[50] The components of this model are: an information source, the message, a transmitter, the signal, a carrier or channel, noise (secondary signal that obscure or confuse the signal carrier), a receiver, and a destination. This model was adopted in cartography to explain how maps work.

digital mapping and, b) geographic information and land information systems. These systems are used for the acquisition, storage, management, and analysis of spatial data. Authors such as M. Goodchild and M. Molenaar may be mentioned as representatives of this view (Ramirez 2004).

Geo-Spatial Data Visualisation includes the conceptual study of all processes and forms of spatial data display, the results of analysis and planning. It comprehends a) conventional methods, which include 2D representations on traditional paper and graphic computer screen representations, and b) alternative methods (e.g. holography). It is these technologies which provide the means for generating truly three dimensional (3-D) static and dynamic displays, supported by the current multi-media technologies. During the 1990s, Alan MacEachren and David DiBiase were precursors of theoretical research in this field (Slocum et al. 2007).

Ramirez further develops each component, especially the theoretical ones supported by graphic diagrams. He describes the major contributions to the development of the theoretical components in the light of cartographic theory (for more details see Ramirez 2004). Also in the 1980s, in the context of revolutionary changes in cartography, Joel Morrison defines four sets of processes along the same line followed by Ramirez. These are data capture, data manipulation, data visualisation, and cartographic products (cf. Morrison 1986).

In summary, the main contribution by Ramirez is the systematisation of the different tendencies developed during the second half of twentieth century. His differentiation of the so-called *traditional* components (linguistic, modelling and communication views), which were maintained through time, is outstanding. The classification of geo-spatial data (manipulation, processing and, visualisation) which has had validity so far, especially the current visualisation approach. It is also useful in the context of new technology information and mass-media in which images play an important role (Pápay 2005). Similarly, the manipulation and processing of geospatial data in the context of geo-technology information is important because the increasing amount of this type of data from diverse sources like remote sensing and global positioning systems.

4.3 Cartographic Research Paradigm and Research Focus

Daniel Sui and James Holt studied the visualisation and analysis of public-health data. They argue that to better understand cartograms as a type of thematic map, (in opposition to choropleth maps) some *paradigms* should be embraced in them. Thus, they mention three cartographic research paradigms which can be found in cartographic literature of the post-World War II period (see Sui and Holt 2008). For these authors three major paradigms can be identified:

> According to three different conceptualization of the *essence* of a map: (1) the map as image; (2) the map as a model or computational tool; and (3) the map as intent or social construction (emphasis added, Sui and Holt 2008: 5).

The authors also declare that the research focus can differ substantially, depending if it is on *map construction* or *map use*. A description of the three paradigms and the emphasis on research by Sui and Holt, (2008), is given below.

4.3.1 Map: Image, Model, Social Construction

According to Sui and Holt (2008) “the map as an image” is a paradigm also known as the *communicative/cognitive tradition*. It conceives the map as image emphasizing:

> The appropriate look and effective design of maps. In terms of map construction, this paradigm focuses on the design and visual symbols, the use of colour, the graphical hierarchy […]; in terms of map use, it stresses map reading, visualisation, and communication (Sui and Holt 2008: 5).

Regarding this issue, Daniel Montello made a detailed historical review about cognitive map-design research in the twentieth century considering map perception, map cognition and communication models under theoretical and empirical approaches (Montello 2002). He considers Arthur Robinson’s book *The*

Look of Maps (published in 1952), as an articulator of cognitive map-design research in several countries.

On the other hand, "the map as a model" is another paradigm known in analytical tradition in which maps are conceived as a tool for analysis and modelling:

> In terms of map construction, it emphasizes data structure and algorithm development […]; in terms of map use, this tradition often stresses analytical modelling and hypothesis testing of the clustering patterns of the phenomena being mapped (Sui and Holt 2008: 5).

Furthermore, this is a paradigm framed within the field of analytical cartography, defined in the late 1960s by Waldo Tobler as an attempt of mathematical and quantitative analysis to solve concrete problems (Tobler 1976). Keith Clarke and John Cloud (2000) also continued the historical description of analytical cartography and its current application in parallel to Harold Moellering's work. For Moellering (2000, 2001) this approach has grown into a broader and deeper scientific specialisation that includes the development and expansion of the analytical/mathematical spatial theory and model building. Tobler's concept of cartographic transformation (Tobler 1979), Nyerges's deep and surface structure, and data levels (Nyerges 1980), and Moellering's real and virtual maps (Moellering 2000) have all been important contributions for the development of this paradigm in cartography.

Finally, "the map as intent/social construction" is a paradigm framed in the critical tradition led by J. Brian Harley (Crampton and Krygier 2006). According to Sui and Holt (2008)…

> Critical cartography represents a major epistemic break from the cognitive and analytical traditions; instead of conceptualizing the map as an objective, unproblematic device for communication, this paradigm reveals *the new nature of map* […] (original emphasis by Sui and Holt 2008: 6).

The last phrase of the statement actually cites the name of the Harley's book (2001) in which a new dimension in the interpretation of maps is revealed. Sui and Holt, supported by authors like Denis Wood (1992), Jeremy Crampton (2001) and John B. Harley (2001), point out that…

> Because maps often make reality as much as they represent it […], mapping is, in fact, practices of power-knowledge. Many seemingly neutral maps express interests that are often hidden; thus, embedded in all maps is a set of power relation (Sui and Holt 2008: 6).

According to Crampton (2010), as politics of mapping, critical cartography and Geographic Information Systems (GIS) question what kinds of people and objects are formed through mapping.

> Maps produce knowledge in specific ways and with specific categories that then have effect (i.e., they deploy power) (Crampton 2010: 9)[51].

In terms of map construction this vision emphasizes the inherent distortion and biases of all maps, their power relation and ethical consideration. In terms of map use "the potential propaganda nature of maps for political hegemony and control" should be recognised. This sentence explains the reasons that led Sui and Holt to employ the term "map as intent/social construction". Here the term of *intent* is synonymous to "purpose". In other words, the purpose of map is to deploy power-knowledge. This topic will be discussed in greater detail in the next section.

[51] This statement covers an important epistemological issue which was analysed in the previous chapter.

4.4 Paradigms in Cartography: Cartographic Research and Internet

Michael Peterson developed some scopes about paradigms in cartography. First, he draws on some of Kuhn's arguments about the typical pattern of a mature science or discipline which has successive transition from one paradigm to another through a process of revolution or change (Kuhn 1962). He also considers the characteristics of the paradigms pointed out by Kuhn. Further, Peterson argues that the concepts of paradigm and paradigm-shift are related to the rapid changes in cartography produced by the introduction of the Internet (Peterson 2002).

Regarding the paradigms in cartography Peterson, drawing on Kuhn (1962), states that "a paradigm is a common core of beliefs about what represents a valid area of research", because research is guided by paradigms. In this way he identifies four paradigms within cartography: cartographic communication, analytical cartography, cartographic visualisation[52], and power of maps[53].

4.4.1 Cartographic Communication Model

Peterson (2002) states as a paradigm that cartographers began to view the cartographic communication process as a series of steps derived from communication theory. The map is considered to be a transmitter of messages encoded by means of a graphical language. This message is then decoded by the reader. Peterson proposes *cartographic communication model* which shows several stages between the cartographer and the map user.

A key aspect in his view is that maps are composed of elements that communicate information. Thus...

[52] *Cartographic Visualisation* will still be further detailed later in this section.

[53] The *Power of Map* will be further analysed in the section "Critical Cartography in the Context of Post-Modernism".

> Improving the design of these elements through scientific methods would improve the communication potential of the map (Peterson 2002: 3).

In this sense cartography drew theories and methodologies from psychology, psycho-physics and cognition. Peterson mentions that the interest in research related to cartographic communication faded during the 1990s, with the introduction of new tools like personal computers. Nevertheless, for this author…

> The research direction had a long-term influence on cartography because it had led to an increased understanding and interest in the discipline about communication with maps (Peterson 2002: 3).

The above statement is in agreement with Jeremy Crampton when he describes *how mapping became scientific* (Crampton 2010). The scientific status of maps and cartography has significantly been coined by Arthur Robinson's experience and career, especially in the Office of Strategic Services (OSS) and at the University of Madison-Wisconsin[54]. Crampton also details how cartography became a scientific discipline (for more details see Crampton 2010). These events occurred during the validation of the cartographic communication paradigm, of which the *map communication model* (MCM) was the most important contribution.

Several graphical models about cartographic communication by classical authors such as A. Kolacny, J. Morrison, L. Ratajski, C. Board, W. Grygorenko, A. Robinson and B. Petchenik have been, among others, compiled by U. Freitag (2001), J. Ramirez (2004), and M. Lechthaler (2010). These authors detail the elements that participate in the cartographic communication process.

[54] Arthur H. Robinson (1915-2004), American geographer and cartographer, was a prolific writer and influential philosopher on cartography. Some generations of cartographers were influenced by his textbooks *The Look of Maps* (1952), *The Nature of Maps* (1976), and *Elements of Cartography* (1995) (some of them with co-authors). According to MacEachren (1995) Robinson initiated a more "objective approach to map symbolisation and design based on testing the effectiveness of alternatives".

4.4.2 Analytical Cartography

Peterson (2002) notes that the analytical cartographic approach focuses on the *transformations of information* inherent to the cartographic procedures. The author highlights that…

> It was in contradiction to the communication school because the *procedures* were more central than the map product or its use (emphasis added, Peterson 2001: 3).

This statement describes a change in comparison to the map communication model of cartographic communication. Emphasis is put on the application of mathematical models and the subsequent application of technology. This new approach, which led to a paradigmatic shift, can be understood when Kitchin and his co-authors point out that analytical cartography emerged in the early 1970s "offering a purely mathematical way of knowing the world […]" (Kitchin et al. 2009: 6)[55]

Furthermore, Peterson mentions that Harold Moellering's work shows the origin and nature of analytical cartography and W. Franklin's oeuvre its practical applications. Finally, he contends that…

> The goals of analytical cartography which could be as mechanistic as improving the efficiency of a certain algorithm, were no match for the broader and more noble goal of improving the map as a form of communication (Peterson 2002: 3).

The above statement indicates that for Peterson the interest in the area of research remains limited. However, upon deeper analysis, according to Kuhn's theory of paradigm (Kuhn 1970), this can be interpreted in a different way: If this approach has not prospered (as a normal process of scientific development), this could be an indication that these approaches correspond to the basis of another paradigmatic shift. In fact, several authors concur in that analytical cartography

[55] This statement made by the authors implies that, in Kuhnian terms, analytical cartography proposes a "new view" (mathematical model) in comparison to traditional cartography (communication model).

was the foundation for the emergence of the current geographic information science (i.a. Ormeling 2007, 2010, Moellering 2000, 2001).

4.4.3 Maps and Internet

Finally, in the early 2000s Peterson shows that research in cartography will cover a new area, corresponding to the potential of the Internet as a major technological medium for cartography, especially in map distribution. For Peterson "an individual map distributed through the Internet may not by itself communicate as much as the corresponding map on paper […however…] the Internet makes it possible to distribute the map to many more people" (Peterson 2002). In other words, map communication comes to more individuals through the Internet.

The author considers that similar to Kuhn's paradigm shift, "the Internet has introduced a rapid, discontinuous change in cartography". Thus all the paradigms mentioned above or "essentially everything we know about maps and their construction" could be replaced and lose their validity.

The above statement has to be discussed. Peterson considers the Internet as a paradigm-shift in Cartography. Nevertheless, he mentions other four paradigms in the discipline during the last half of the twentieth century which will be impacted by this new paradigmatic shift. The aforementioned statement is, however, controversial with Kuhn's statements about the development of paradigms.

Peterson's scope about new technological aspects is significant because it may generate important changes in cartography's theoretical, epistemological and philosophical bases. Technology is an important aspect in the production of knowledge (cf. Buchroithner and Azócar 2011). Indeed, as already mentioned, David Fraser Taylor proposed *Cybercatography* as a new theoretical construct which "offers an unprecedented opportunity for deeply rethinking the way we design, produce, disseminate and use maps on the Internet" (Cybercartography 2008).

4.5 Cartographic Representation and Visualisation

In his book "How Maps Work" Alan MacEachren proposes a fundamental dichotomy in the approaches to the study of how maps work. First, he considers issues in the private realm of the map percipients with emphasis on the perceptual and cognitive processing of sensory information. Second, he balances this approach with an analysis of the map's semiotics on functional and lexical grounds, and the analysis of the map's public realm. Finally, he concludes how this advocated integrated perspective might be applied to an emerging area of cartographic concern (in the early 1990s): how maps work as visualisation tools. In other words, how maps are used as applications in geographic visualisation (MacEachren 1995).

According to MacEachren, a representational view of cartography has two levels of analysis. The first one is *the private/perceptual – cognitive* one where:

> Attention is directed to how human vision and cognition represent concepts about the world and the contents of a visually displayed map, i.e. how meaning is derived from maps. […] The private focus is particularly concerned with the process of vision as a hypothesis about what is seen and the role of conceptual categories and knowledge schemata in assigning meaning to the representation derived by vision (MacEachren 1995: 15-16).

The second level is *the public/social* one where:

> Attention is directed to the ways in which symbols and maps represent, i.e. how maps are imbued with meaning. […] The public focus is concerned with developing logical systems for creating meaningful representations and understanding in a broader context how symbols acquire meaning at multiple levels (MacEachren 1995: 15-16).

These two levels summarise this new perspective in cartography in a scientific view: geo-visualisation under semiotic/cognitive approaches.

In addition, Michael Peterson schematically shows the beginning of cartographic visualisation through two emblematic figures: the *visual thinking/visual communication* developed by DiBiase in 1990 (Figure 4.1), and the *visualisation cube* developed by MacEachren in 1994 (Figure 4.2). For DiBiase…

> Cartography is defined into two fundamental activities: visual thinking and visual communication. Visual thinking occurs in the private realm and consists of the activities of exploration and confirmation. Visual communication, the public realm of cartography, involves synthesis and presentation (Peterson 2002: 4).

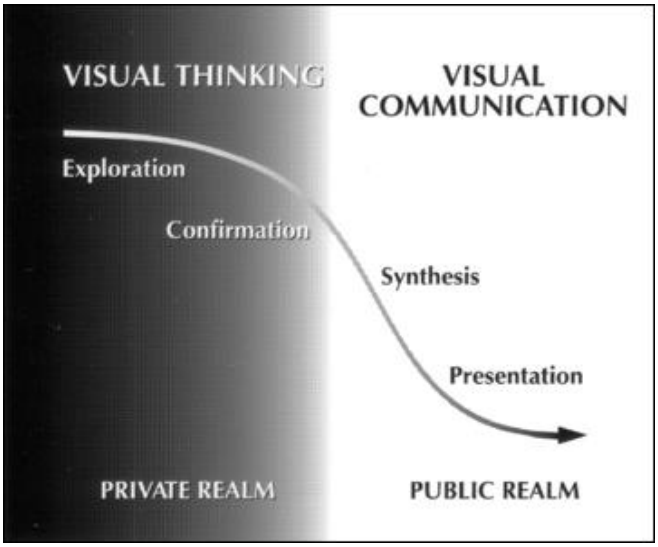

Figure 4.1 Visual thinking and visual communication in cartography (after D. DiBiase 1990).

On the other hand, MacEachren introduced the "cartography cube" or "visualisation cube" "that added the two dimensions of human-map interaction and the presenting known/revealing known. Visualisation […] takes place in the high interaction-private-revealing part of the cube" (Peterson 2002: 4).

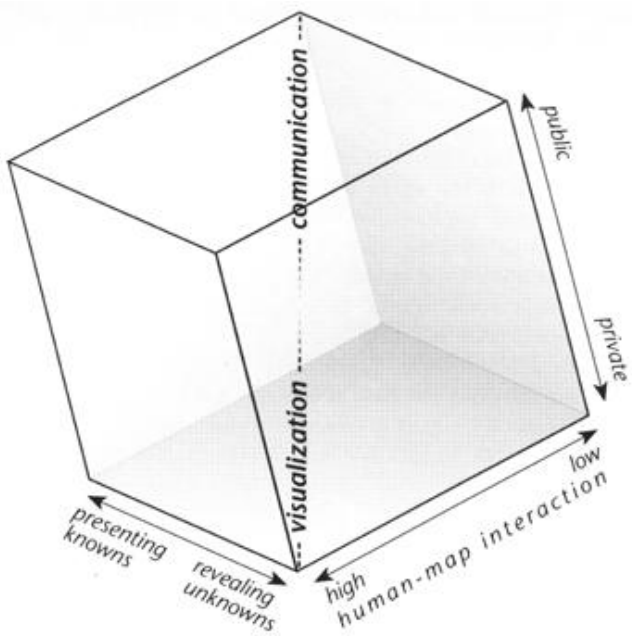

Figure 4.2 Cartographic cube showing relationships between visualisation and communication (after A. MacEachren 1995).

Inversely, cartography takes place in the low-public-presenting known part of the cube. In this way, MacEachren (1995) depicts cartography as a cubic map-use space in which visualisation and communication stand in opposite. Table 4.1 show a synthesis MacEachren and DiBiase's contributions and the integration between visualisation and communication in the context of cartography. Also the participation of the cartographic approaches in visualisation and communication are shown.

Table 4.1 Integration between visualisation and communication approaches. Adapted from MacEachren (1994) and DiBiase (1990)

	VISUALISATION	**COMMUNICATION**
Visualisation approach	Visual thinking	Visual communication
Scientific research phase	Exploration/Analysis	Synthesis/Presentation
Map use (or realm)	Private	Public
Interaction human-map	High	Low
Data relation	Revealing unknown	Presenting known
Cartographic approach	Cartographic visualisation	Cartographic communication

Nevertheless, for Peterson the distinction between maps for presentation and maps for exploration may be artificial, because everyone who uses a map engages in the process of cartographic visualisation. The author draws from Unwin (1994) to state that the "elite" aspect of cartographic visualisation emphasizes the use of graphics in the development of ideas, rather than in their presentation. In this way Peterson notes:

> The distinction between analysis and presentation with any type of graphic display is a tenuous one, especially in cartography. […] Every map can be used for analysis, even maps on paper that are designed for *presentation* (original emphasis by Peterson 2002: 4).

A solution is, in part, provided by Mirjanka Lechthaler (2010) when she mentions the scope of Menno-Jan Kraak's and Ferjan Ormeling's model of cartographic communication and relationship between scientific visualisation and cartography (Kraak and Ormeling 2003). In the context of scientific visualisation…

> The cartographic presentation is a cognitive process which has to get the essence of spatial phenomenon, if it is represented adequately. […] The objective of cartography […] is to convey spatial information and their spatial relationships, the aims of communication, exploration and analysis (Lechthaler 2009: 387).

For a profound review of the theoretical bases of visualisation in science and of cartography in visualisation see DiBiase et al. (1992). Here, for a better understanding of the geo-visualisation approach, in the following some further statements shall be presented.

Kraak and Ormeling (2003) point out that before the GIS era, paper maps and statistics were probably the most prominent tools available for researchers to study their geospatial data. Since the early 1990s, people have access to large and powerful sets of computerised tools like spreadsheets, databases and graphic tools. So, comparing the *on-screen approach* with the *traditional approach* not only reveals a difference in processing effort and time, but that the user can interacts with the map and the data behind it. Thus…

> The map should now be seen as an interface of geospatial data that can support productive information access and exploratory activities, while it retains its traditional role as a presentation device (Kraak and Ormeling 2003: 175).

The relationship between cartography and Geographic Information Systems (GIS) on one hand and scientific visualisation[56] on the other has, from a cartographic perspective, resulted in a synthesis called geo-visualisation. Thus, according to MacEachren and Kraak (2001):

> Geovisualisation integrates approaches from scientific visualisation, (exploratory) cartography, image analysis, information visualisation[57], exploratory data analysis (EDA) and geographic information systems (GIS) to provide theory, methods and tools for visual exploration, analysis, synthesis and presentation of geospatial data (any data having geospatial referencing) (Kraak and Ormeling 2003: 175).

In this way the authors conclude that in a geovisualisation environment maps are used to stimulate (visual) thinking about geospatial patterns, relationships and trends. So, they might also offer different insights and would probably have more impact than traditional cartographic representation methods.

The above statements actually summarise MacEachren's thought of providing a new perspective to the scientific approach of cartography in comparison with the communication-cartographic paradigm. The semiotic/cognitive approach proposed by MacEachren is complemented with the early contributions by DiBiase, MacEachren, Krygier and Reeves (1992), Kraak and Ormeling (1996) and also by MacEachren himself regarding scientific visualisation, geovisualisation and their relationships to cartography and mapping.

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[56] Scientific visualisation focuses on the use of computer graphics to create visual images which aid in the understanding of complex, often massive numerical representation of scientific concepts or results. Also scientific visualisation has been defined as a multidisciplinary methodology and its specific goal is to act as a catalyst between scientific computation and scientific insight (Ed Ferguson 1991).

[57] Information visualisation is the interdisciplinary study of the visual representation of large-scale collection of non-numerical information, and the use of graphical techniques to help people understand and analyse data. In contrast to scientific visualisation it focuses on abstract data sets that do not have an inherent 2D or 3D geometrical structure.

In other words, geovisualisation represents a further development in cartography that takes advantage of the ability of modern computers to render changes to a map in real time, allowing users to adjust the mapped data at the same time.

Geovisualisation research has continued to flourish and spread during the 2000s, especially with respect to the cognitive approach. Indeed, in 2009, cognitive issues in geographic information visualisation have been published in the scientific journal *Cartographica*. There, some topics of interest in the current fundamental empirical research and state-of-the-art evaluation methods within the interdisciplinary empirical research domain of geographic information visualisation and cognition have been shown (for details see Fabrikant and Lobben 2009).

Similarly, Menno-Jan Kraak reviews the development of cartography as seen by the International Cartography Association (ICA) Comission on Geovisualisation, from 1970 until the end of 2000. Those tendencies are: cartography, computer cartography, geovisualisation, and visual analytics[58]. During this period the amount and diversity of data increased. This was also a period where developments in cartography began to be much more technology-driven (for details see Kraak 2008).

Kraak (2008) points out that the *visual analytics* approach has been translated into the GIScience domain as *geovisual analytics*. It is about analytical reasoning and decision making. This new trend[59] "requires a multidisciplinary approach with strong analytical capabilities in which geovisualisation is a major thought-provoking tool" (2008: 164). In other words, this shows the importance of cartographic representation and visualisation in the transition from *geovisualisation* towards *geovisual analytics*.

[58] Visual analytics is based on the intuition that highly interactive and dynamic depictions of complex and multivariate databases amplify human capabilities for inference and decision making, as they facilitate cognitive tasks such as pattern recognition, imagination, association, and analytical reasoning (Thomas and Cook 2005).

[59] Here Kraak is drawing on the work of Andrieko et al. (2007).

4.6 Cybercartography Paradigm

The concept of cybercartography was introduced by David Fraser Taylor in 1997 during the International Cartographic Conference-ICC in Sweden. For the author…

> The central argument made was that if cartography was to play a more important role in the information era, then a *new paradigm* was required (emphasis added, Fraser Taylor 2005: 1).

It implies that the importance of maps and mapping and the utility of cartography must be reasserted and demonstrated in the context of rapid advances in information and communication technology. Fraser Taylor sees the paradigm of cybercartography not as a break from past ideas and practice,

> But as an evolutionary and integrative process which incorporates important elements from the past, redefines others, and introduces new ideas and approaches to both cartographic practice and theory (Fraser Taylor 2005: 2).

For Fraser Taylor the dominant paradigm until the 1990s has been cartography as a science. Indeed when he analyses the technological background of the discipline he notes:

> There has always been a strong formalist base to cartography as a discipline and computer technology has led to an emphasis on productive techniques to which GIS has added a strong emphasis on *positivism* (emphasis added, Fraser Taylor 1994: 53).

Thus, the emergence of this new paradigm has a strong scientific component, but the author sees:

> Cartography as both an *art and science*, and has a qualitative as well as a quantitative element (emphasis added, Fraser Taylor 2005: 3).

This joining of art and science in cartography is an important aspect, because inside the paradigmatic scientific approach there has traditionally been a gap

between aesthetics and accuracy as objectives to be attained by the cartographic products. In this sense, the paradigmatic aspect pointed out by Fraser Taylor implies a process of integration through the new technologies, which became massive during the early 1990s.

In summary, for Fraser Taylor cybercartography is…

> The organization, presentation, analysis and communication of spatially referenced information on a wide variety of topics of interest and use to society in an interactive, dynamic, multimedia, multisensory and multidisciplinary format (Cybercartography 2008).

Similarly, Maria Del Carmen Reyes (2005) also sees the emergence of a new paradigm in cartography that "is transforming the manner in which a map is conceived, produced, and used".

> There is currently a need to focus on *epistemological* and conceptual issues behind cybercartography, in order to develop a common language amongst researchers and a *theoretical framework* that results in the scientific advancement of this discipline (emphases added, Reyes 2005: 65).

For a paradigmatic approach this requirement is also evident for Elvia Martinez and Maria del Carmen Reyes (2005) when they draw on Kuhn's ideas and then relate them to Fraser Taylor's statements. Kuhn considers that scientific knowledge is social. The concept of paradigm is also used by Kuhn "to depict the network of convention and compromises, created among scientific communities in order to produce and legitimate scientific knowledge" (Martinez and Reyes 2005).

In a similar way, according to these authors, this process occurs when Fraser Taylor argues that cybercartography is a new paradigm in cartography. In this case, there is a group of researchers that share an epistemological view and generate a new body of knowledge. Thus, this body of knowledge can be validated both theoretically and empirically.

On the other hand, to this day, the main products of cybercartography are c*ybercartography atlases*. According to Fraser Taylor "a cybercartography atlas is a metaphor for all kinds of qualitative and quantitative information linked through their location". For more detail about types of atlases and research in this field see (Cybercartography 2008).

As a result, for Fraser Taylor…

> Cybercartographic atlases transform cultural, socio-economic and environmental data into interactive and multisensory narratives. […] These atlases present several narratives of the same *reality*. People can be become active *creators* of map narratives, not just passive ones (original emphasis by Fraser Taylor 2009).

With cybercartographic atlases, as a specific product of cybercartography, there has been a shift from map user to map creator. In other words, cybercartographic *users* can become *creators*. Thus the cartographic process is democratised in new ways (for processes of democratisation also see Ormeling 2007, 2010). Cartography already belongs neither really to academia nor to the professional cartographers.

Finally, according to Fraser Taylor the underlying philosophy of the cybercartographic atlas is as follows:

> Just as the map was a key navigational tool in the Age of Exploration, so the cybermap can provide an aid to navigation in the information era (Fraser Taylor 2009).

This metaphor implies that technological changes have always had an impact throughout cartography. Here, the author mentions two significant historical events (i.e. exploration era and information one) in which maps, supported by technology, have generated and still can generate new knowledge again.

4.7 Paradigm Changes in Cartography

Ferjan Ormeling compares the general cartographic practice in the 1970s with the situation until 2010. He identifies several changes and their consequences for the future of cartography. In his article about the transformation of the map into a multifunctional signpost he points out some paradigm changes in cartography (Ormeling 2010).

Briefly, the author shows several definitions of the term cartography through time. First, in 1820 the term merely encompassed the *production of maps* (map production). In 1960s cartography was defined as the *communication of spatial information*. This is a process subject to specific rules in the design of the maps for a proper presentation of geographic information. In 1967, the application of Kolácný's model[60] (Kolácný 1969) in cartography provided a scientific approach to the transfer of information. Thus, psychophysiological research was applied in cartography. For this reason, as from the 1980s, the term cartography referred to the *production and use of maps* (Ormeling and Kraak 1987).

Ormeling notes that after 20 years of automation, with computer-assisted cartography it was not only possible to produce maps but…

> Once one had stored the spatial information needed to draw maps in the computer, one could also begin doing some calculation: determining area, measuring distances, and carrying out visibility analysis (Ormeling 2010: 7).

The author highlights that these works belong to analytical cartography and that the new methods of analysis gave birth to the geographic information systems (GIS). For more information regarding analytical cartography and GIS the reader is referred to Moellering (2000), and for the relationships between cartography and

[60] According to Czech cartographer Kolácný creation and utilisation of cartographic products are two components (cartographer's universe and user's universe) of an interrelated process in a "stimulus-response" model (Lechthaler 2010). This incorporates multiple feedback loops and interconnections in the previously simplified "map communication model" composed by the cartographer, map and percipient (Crampton 2010). Therefore, this model became more complex with Kolácný's contribution.

geographic information systems see Cassettari et al. (1992), Grelot (1994) as well as Lee (1995).

Further, Ormeling states that the arrival of digital geographic files led to a revolution in map production. In this way,…

> Once the information was digitally stored in a file, one could easily visualise that which was needed for a certain purpose from that file (Ormeling 2010: 7).

The above statement meant that for the first time in cartography it was possible to separate the *storage function* from the *communication function* of the map (cf. also Ormeling, 2007). The author exemplifies this important change with a complete nautical chart, comparing it to a digital version for individual use. In other words, with digital files (containing geographic information) it is possible to display on screen only the information required for specific objectives.

Already in 1992 Ormeling had analysed core concepts in cartographic communication, when he pointed out two revolutions in cartography. In the first one, called the *communication revolution,* he sees maps as a means of spatial information transfer, in the second one, the *digital revolution,* as a separation of storage and display functions (Ormeling 2007).

According to Ormeling this results in the following:

> This breakthrough changes the content of the term cartography once again: now cartography stands for *passing on spatial information to support decision making* (original emphasis by Ormeling 2010: 7).

In summary, despite mentioning the term *paradigm* only in the subtitle of his article, it is possible to infer a paradigmatic shift in the development of cartography from Ormeling's publications: A first paradigm was map production. Then, via visualisation the spatial (geographic) information became a second paradigm: map production *and* map use. Meanwhile during the automation of processes, the analytical cartographic (current geo-visualisation) and geographic information

sciences were encompassed. Finally a third paradigm is considered: spatial information to support decision making. The separation between storage function and the communication function was the great impulse for the emergence of this paradigm shift.

4.8 Cartographic Trends and Paradigms since 1950

One of the latest studies regarding the development of cartography was made by Colette Cauvin, Francisco Escobar and Aziz Serradj. In their book entitled "Thematic Cartography and Transformations" (2010, Vol. 1) they identified the general trends and paradigms that arose from 1950 to 2009. They divided the second half of the twentieth century and the first decade of the twenty-first century into three periods (see below) and pointed out some milestones such as books or remarkable events, dominant paradigms or ideas, technological changes, and crosscutting current of thought (Cauvin et al. 2010).

The first period (approx. 1950-1975) was dominated by two paradigms or ideas: "the map as a channel of communication" and the "rules of graphical semiology". Two major books are commonly associated with this period: *The Look of Maps* by A. Robinson (1952) and *Semiology of Graphics* by J. Bertin (1967) respectively. It ends with the Vienna Congress (1975) in which cartography was - once again - defined as science and the value of theoretical cartography was highlighted. During this period a fundamental change in cartography in the aspects of graphic concept, language, perception of signs, and the function of maps took place.

The second period (about 1975-1995) experienced three dominant paradigms or ideas: the "theory of symbolization and design", the "experimental and exploratory cartography" and, the "inclusion of ethical and social aspects". One of the major technological changes in this period was the complete separation between *storage* and *representation* of data, and the proliferation of GIS and multiple data processing. This meant that a temporary map (on the screen) substituted a permanent (paper) map.

During this second period some trends revived, such as: *graphical perception and cognition* in which the reader of a map should be stimulated by the map and no longer considered a simple recipient of its message. Later, the *context in which maps are produced* was also a conceptual trend in cartography. In this sense the historical, political and social context implicitly or explicitly interferes in map production. Another important trend is the *exploratory use of maps*. Visualisation in

scientific computing allows maps to have a new role: as a useful means of obtaining spatial information for the users.

Finally, the authors distinguish a third period (roughly 1995-2009) in which there arose a new paradigm for the twenty-first century: geovisualisation. In this period two changes can be identified: the *integration of cartography into GIS* and the *shift from the communication paradigm towards scientific visualisation*. In this way the aforementioned visualisation paradigm allows the exploration of the information in a dynamic way, by means of the development of the man-computer interaction. The objective is not to obtain an “optimal map” but an “efficient map”, based on the concept of *visual perception* and *spatial thinking*.

The new elements in the context of geovisualisation are: multiple representations, dynamic cartography, animation, interactive maps, multimedia, hyper-maps, web maps, maps on demand. There exists also something like collaborative cartography in which the reader is an active participant (for more details see Cauvin et al. 2010).

Table 4.2 summarises the tendencies in cartography since the second half of the twentieth century. These listed authors have had a theoretical vision of cartography and mapping. The changes identified by them have a certain similarity with Kuhn’s paradigm shifts (explicitly or implicitly) in that these changes are visions or perspectives which are different from each other. The different modes in conceive cartography (as discipline, as science), maps (as models, devices, products), methods of analysis and technologies used, etc. All these aspects lead to a concentration on study objects, objectives of research, methods and results.

Table 4.2 Main tendencies and changes in cartography and mapping during the second half of the twentieth century.

Views on Cartographic Development	**Tendencies and paradigm shifts Cartography and Map Conception**
Traditional components and modern components (R. Ramirez, 2004)	Cartographic language Cartographic modelling Cartographic communication Geo-spatial data manipulation Geo-spatial data processing Geo-spatial data visualisation
Cartographic research paradigm and research focus (D. Sui & J. Holt, 2008)	The map as image The map as model The map as intent/social construction
Paradigm in cartography: cartographic research and internet (M. Peterson, 2002)	Cartographic communication Analytical cartography Cartographic visualisation Power of maps Maps and Internet
Cartography: representation and visualisation (A. MacEachren, 1995) (J.M. Kraak and Ormeling, 1996, 2003)	Cartography as graphic communication Cartography as geo-visualisation
Cyber-cartography paradigm (F. Taylor, 2005)	Traditional cartography Cyber-cartography
Paradigm changes in cartography (F. Ormeling, 2007)	Production of maps Map production and map use Spatial information to support decision making
Cartographic trends and paradigms (C. Cauvin, F. Escobar & A. Serradj, 2010)	The map as a channel of communication Rules of graphical semiology Theory of symbolisation and design Experimental and exploratory cartography Ethical and social aspects Geovisualisation

5 Critical Cartography in the Context of Post-Modernism

5.1 Introduction

This section analyses cartography and mapping in the so-called postmodernistic period which challenges the positivism-empiricism and logical positivism approaches of modernity. The emergence of the critical cartography movement from social critical theory since the 1980s is presented. Jeremy Crampton, John Krygier and Chris Perkins analysed the new practices in cartography in the context of information and communication technology (ICTs). In the field of critical perspective, the contribution of John Harley about cartography as social construction is considered more in detail. He draws upon Jacques Derrida's and Michel Foucault's statements about deconstruction and power-knowledge, respectively. This has important implications in cartography, especially for the analysis of maps as "cartographic text" and maps as devices or artefacts of power. In summary, the aim of this section is to show the relationships between cartography and social theory and the new viewpoints which can be considered as a paradigmatic shift in the Kuhnian sense in comparison with the traditional or "more scientific" approach.

5.2 Towards a Postmodern Cartography

Several authors have defined *postmodern cartography* as the period of the discipline that began in the 1980s (Crampton 2001; Crampton and Krygier 2006; Kitchin et. al. 2009). Since then, cartography and mapping have been seen from different points of view and perspectives, which differ significantly with respect to the period of modern cartography or traditional cartography.

The key feature of all postmodern thought is a distinct opposition to, or break from, modernism (Valcárcel 2000). According to Valcárcel postmodern criticism is based on the critique of modernity. Here, proposals, worldviews, theories, rational and

scientific grounds are criticised. In other words, the *universalistic discourse*[61] of modernity is criticised, and cartography and mapping are not immune to this new trend.

Nikolas Huffman (1996) established the differentiation between "postmodernism" and the modern period or "modernism", dividing its many uses into four categories[62]: postmodern style in architecture, art and literature; postmodern social theory; the political economic of late capitalism and; poststructural philosophy. Of these, the two categories that are important for the development of cartography during the new times are postmodern social theory and poststructural philosophy.

The postmodern architectural style is also important. It emerged in the late 1960s in the wake of the international style of "modernism". So, Huffman (1996) relates it to new styles in cartography by asking: what would a stylistically postmodern map look like? In doing so, he points out that…

> The ultimate goal is not to confuse or disorient to the readers, but to encourage them to read deeper into the map and the mapping process, and to challenge the objective and scientific mystique of the *map as mirror of the world* (emphasis added, Huffman 1996: 38).

This statement by Huffman[63] shows the philosophical nature of this postmodern period with respect to modernism. A new perspective arose which makes a powerful criticism to the scientific, cultural and philosophical bases of modernism. Thus, the metaphor of the map as a reflection or mirror of reality is questioned.

Nevertheless, there are some authors who do not have a radical position in this modernism-postmodernism debate. From the viewpoint of human geography, Laurence Berg, for instance, says that the hegemonic representation of the debate

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[61] In philosophical terms a universalistic discourse contends that there is a unique reality which can be made known to us through of science, especially factual sciences.

[62] Huffman (1996) analyses each of these categories and their impact on cartography and mapping.

[63] Here, Huffman is drawing on the work of Wood (1992).

between modernism and postmodernism has contributed to the “two perspectives as unitary, monolithic and opposed essences” (Berg 1993). However, he suggests that an intermediate position between modern and postmodernistic approaches should be found. He recognizes that certain postmodern and some modern discourses are closely related and that these may not differ so radically. Consequently, modernism and postmodernism coexist next to each other in a continuum, rather than in a binary logic and in false dichotomies.

5.3 Critical Cartography

Since the 1990s the field of cartography has been flourishing with writings that identify maps as *social* issues and expressions of *power and knowledge* (Edney 2007). The precursor of this trend was the Englishman John Brian Harley (1932-1991), a theoretician in the history of cartography, who considered cartography not only as a science that describes places by means maps, but also as a science that is capable to contributing a social dimension (Cosgrove 2007). Some of his eminent writings were compiled in the book "The New Nature of Maps: Essays in the History of Cartography" in 2001. After Harley's death in 1991, leading figures that have picked up from where he left off include Denis Cosgrave, Denis Wood, Jeremy Crampton, John Krygier, Marianna Pavlovskaya, and John Pickles (Perkins 2003).

The aim of critical cartography is to reduce the gap between a technically oriented map design and the theoretical analysis of power in society. In this sense critical cartographers do not aim to invalidate maps, instead, the criticism is a careful analysis and identification of map *attributes* that are usually taken for granted (Crampton and Krygier 2006). Critical cartography often invokes "social theory" in order to examine categories of knowledge such as race, territory, boundaries or identity that are produced or reproduced by maps. For this reason, critical social theory seeks to *problematise mapping* as the social practice linking relationships between mapping and the exercise of power (Harley 2001)[64].

Often the "production of space" is mentioned (e.g. Casti 2005). In this sense, critical cartographers argue that "mapping creates a specific spatial knowledge and meaning by identifying, naming, categorizing, excluding, and ordering" (Crampton 2010). Crampton made a distinction in which…

[64] These relationships between cartography and power are exemplified by John B. Harley in his articles such as "Maps, Knowledge, and Power" (1988), "Power and Legitimation in the English Geographical Atlases of the Eighteenth Century" (1997) and "New England Cartography and the Native Americans" (1994) (cf. Harley 2001).

> Critical cartographers do not argue that physical space is produced by the process of mapping, but rather that new ways of thinking about and treating space are produced (Crampton 2010: 46).

In addition, Crampton and Krygier (2006) define "critical cartography" as a *one-two punch* of new mapping practices and theoretical criticism. This critical cartography challenges academic cartography by linking geographic knowledge with political power - and is therefore political. They also say that a criticism is not a project of finding faults and errors, but an examination of the assumptions in a field of knowledge. Thus its purpose is to understand and suggest alternatives to the categories of knowledge that are used. So, criticism does not seek to escape from categories but rather to show how they came into being, and what other possibilities there are.

In their 2006 article Crampton and Krygier answer the question "what is critique?" First, they refer to the critical theory of the Frankfurt School[65]. They point out that for Michel Foucault "knowledge was established and enabled through historically specific power relations". However,

> Foucault's conception of power was more subtle, one that emphasized the politics of knowledge. Power did not emanate from the top of a class hierarchy, but rather was diffused horizontally in a highly differentiated and fragmented fashion (Crampton and Krygier 2006: 14).

The authors state that the term *critique* stand for a politics of knowledge:

> First, it examines the grounds of our decision-making knowledge; second, it analyses the relationships between power and knowledge from a historical perspective; and third, it resists challenges and sometimes overthrows our categories of thought. […] Furthermore, the purpose of critique as a politics of

[65] The Frankfurt School was founded in Germany in 1923 and moved to New York in 1933 when Adolf Hitler came to power. Its main exponents are Max Horkheimer, Theodor Adorno, Walter Benjamin, Herbert Marcuse and Jürgen Habermas. They sought to release the emancipatory potential of a society repressed by technology, positivism and ideology to dispel harmful and illusory ideologies by providing an emancipation philosophy which could challenge existing power structures (Crampton and Krygier 2006).

> knowledge is not to say that our knowledge is not *true*, but that the truth of knowledge is established under conditions that have a lot to do with *power* (original emphases by Crampton and Krygier 2006: 14).

Crampton and Krygier also identify two areas in critical cartography where the "traditional disciplinary modes of cartography" have come in question: on one hand, a theoretical enquiry which seeks to examine the social relevance of mapping, its ethics and power relations; on the other hand, the development of open-source and pervasive mapping capabilities.

Jeremy Crampton (2010) named these movements: theoretical critiques and critical mapping practices. In the former, the critique comes from *inside* cartography, but the critics draw subject from other disciplines. In the latter, however, the focus is almost entirely from *outside* the field of academic cartography.

This movement is the "one-two punch" called *undisciplined cartography* by Crampton and Krygier (2006). That means, these two trends, theoretical critiques and critical mapping practices respectively, resist and challenge the received method and practice of mapping that had been established when cartography became an academic discipline. For this reason, and according to these authors, cartography is "undisciplined": freed from the confines of the academic and opened up to the people.

The first trend developed by critical authors in the context of "cartography as social construction" will be analysed later in this section. The second trend, which is discussed below, corresponds to the so called "new practices" in cartography.

5.3.1 Critical Cartography and its New Practices

Before indicating the new cartographic practices, it is important to mention that Denis Wood and John Krygier (2009) have presented the topic of critical cartography in a historical perspective *within* cartography. According to them,

academic geographers and cartographers believe that critical cartography is a recent academic phenomenon developed during the late 1980s and early 1990s. Criticism, however, more broadly defined and understood, has been part of mapmaking from its earliest days. In other words, critique has been always existed in the history of cartography.

For instance, the authors mention Mercator's critique of both the Ptolemaic Conical Projection, popularised during the renaissance, and the plane charts, (known as *portolanos*), long used by sailors. Later, the Mercator projection was criticised by Johann Heinrich Lambert (in 1772), James Gall (in 1855) and recently by Arno Peters (in 1974). These were emphatic critiques embedded in novel ways of making maps, in novel map subjects, or both.

Wood and Krygier further point out that the profession of cartography has also been criticised from within. They refer to the internal critique mentioned in Max Eckert's volume *Die Kartenwissenschaft* (Map Science) published in 1921-25, in Arthur Robinson's textbook *Element of Cartography* (1953), and in Erik Arnberger's *Handbuch der Thematischen Kartographie* (Manual of Thematic Cartography; 1966). All these critics were directed towards transforming cartography into a science. Some of them were based on the methods used (mainly with regards to the psychological tests).

Wood and Krygier assert the comments from Wood, Fels, Harley, Woodward, Rundstrom and Pickles, stating:

> Overturning the paradigm of Eckert and Robinson by shifting attention from the *form* of the map, with which the profession was obsessed, to its *meaning for behaviour*. Instead of asking whether the brain was overcharged by the density of symbols, these critics asked how the body of subject was constructed by the map, that is, how the map oppressed, subjugated, or otherwise impinged on people (original emphasis by Wood and Krygier 2009: 6).

In a similar way, Perkins (2008) argues that in critical cartography map use is best interpreted applying methodologies from the social sciences, employing a mixture of ethnographic and textual methods.

Beside the internal critique there is an external one. Wood and Krygier (2009) give several examples of indigenous communities (especially in North America), who build their own maps with the help of new geo-technologies. *First Nations* or *Indigenous Mapping* offers a critique of the official mapmaking with respect to its prerogatives, its form, and its content. *First Nations Mapping* has also ties to other forms known as *counter-mapping*. Counter, means: the mapping of professional cartographers. Wood and Krygier mention, among others, new projects such as ethno-cartography, eco-mapping, bioregional mapping, community mapping, public participation GIS (PPGIS), participatory rural appraisal, green mapping, and Parish mapping.

All these new *performances* have been used by artists. According to Wood and Krygier (2009)…

> Map artists do not reject maps. They reject the authority claimed by professional cartography uniquely to portray reality as it is. In place of such professional values as accuracy and precision, art maps assert values of imagination, social justice, dreams, and myths; […] Artists insist that their maps chart social and cultural worlds every bit as *real* as those mapped by professional cartographers" (original emphasis by Wood and Krygier 2009: 9).

The above statement is another example of the *undisciplined cartography* mentioned by Crampton and Krygier (2006). In this context, art maps contest not only the authority of professional mapmaking institutions (government, business, academia, science), but they also reject the world that such institutions bring into being. Thus, the project of art mapping is nothing less than the remarking of the world (Perkins 2003).

In the same sense, Kitchin et al. (2009), when defining that critical cartography is avowedly political in its analysis of mapping praxis, also assert that critical cartography is…

> …however, decidedly not against maps, but rather seeks to appreciate the diverse ways in which maps are produced and used by different individuals and groups (Kitchin et al. 2009: 12).

As example of individuals and groups producing and using maps, Olga Paraskevopoulu, Dimitris Charitos and Charalampos Rizopoulos (who come from outside of the field of cartography), indicate alternative ways of mapping, especially in urban landscapes. These alternatives mapping practices also challenge the traditional cartography conception, where new location-sensory technologies such as Global Position System (GPS) are being employed (Paraskevopoulou et al. 2008).

The authors mention several projects that question and criticise location detection technologies and traditional mapping techniques, such as *Urban Tapestries* (in 2002), *Bio Mapping* (in 2004), and *Amsterdam Real Time* (in 2002). These projects intend to raise public concern about the accuracy and ethics of these technological applications (see Paraskevopoulou et al. 2008). They also categorise location-specific art projects with respect to two mapping technologies: namely *spatial annotation* and *tracing mapping*.

For Paraskevopoulou and co-authors…

> All these projects employ location-aware technologies in an attempt to re-attach aspects of the everyday life to urban space either by embedding information and/or emotions on this space or by using the trails of humans or objects for representing spatial events (Paraskevopoulou et al. 2008: 7).

In other words, new aspects of reality are mapped. These new “objects” have traditionally not been considered by professional or scholarly cartography, and therefore, these alternative cartographies can be considered new practices.

In this respect Chris Perkins has reviewed collaborative community mapping in the United Kingdom. He details local alternative cartographies, such as Parish mapping, Green maps, artistic map, Open source mapping and cycle mapping (for more details see Perkins 2007). All these alternatives can be defined as *local mapping* that is produced collaboratively by *local people*. Mapping practices mostly employ geospatial technologies (GPS, GIS, digital cartography). With the support of these tools, community mapping offers new possibilities of emancipation activities[66] for marginalised groups.

Similarly, Sophia Liu and Leysia Palen analysed the rise of *map mashups*[67] in the context of crisis information management. They have conducted a qualitative study that considered several of the crisis map mashups for mapping hazards and disasters (Liu and Palen 2010). They claim that "crisis map mashups" are becoming a *neo-cartography* because of these new tools that have emerged among nonprofessional cartographers in the context of the emergence of neo-geographic practices.

In summary, the following table shows some of the new cartographic practices that have arisen during the critical cartography period. These practices challenge the conventions and rules of the modern cartographic scientific approach. Sometimes the terms community mapping, participatory mapping, and collaborative mapping are considered synonymous. In Table 5.1 some cartographic projects (cited by Perkins 2007; Paraskevopoulou et al., 2008), and the main types of maps are shown. These maps have been created with the participation of local people and

[66] In the context of the geospatial information, emancipation activities refer to all those practices that certain social groups realize for a major access and use of the spatial information supported by new information technologies. Previously this information had a restricted use and was administered only by the government and state organisations with an official character.

[67] A mashup is a website that combines two or more sources of content into one tailor-made experience. Then, map mashups combine or "mash up" multiple sources of data which are displayed in some geographical form. All this is made using application programming interfaces (APIs) and extensible markup language (XML) in the context of Web 2.0 technology (more details see Liu and Palen 2010 as well as Haklay et al. 2008).

local communities using geospatial technology and geoweb[68]. As can be seen in this table most of the new cartographic practices expanded during the decade of the 2000s, although the first project had already emerged at the beginning of the 1990s.

Table 5.1 New cartographic practices challenging professional and scientific cartography. For literature references and details see text of Chapter 5.3.1.
(*) Examples of "Crisis Map Mapshups" were compiled by Liu and Palen (2010)

NEW PRACTICES	CARTOGRAPHIC PROJECTS (place and year of initiation)	TYPE OF MAPS
Counter-mapping Ethno-cartography Community mapping Public Participation GIS Participatory mapping Locative media Participatory 3D modelling Collaborative mapping	Parish Mapping (England, 1996) Green Maps (New York, 1992) OpenStreetMap (United Kingdom, 2004) Cycling Maps (United Kingdom, 2005) Urban Tapestries (London, 2002) The PDPal (New York, 2002) Bio Mapping (London, 2004) Amsterdam Real Time (Amsterdam, 2002) Cabspotting (San Francisco, 2006) MILK (Netherlands, 2003)	Map mashups (e.g. Crisis map mashups)*

In conclusion, according to the examples mentioned above this assault on the presumptions of professional cartography - or modern cartography - extends to its most fundamental categories of knowledge. For that reason this *movement* called "critical cartography" together with the new cartographic practices implies epistemological and philosophical implications on the discipline.

[68] According to Haklay et al. (2008) the term "GeoWeb" or "Geospatial Web" implies the merging of geographic (location-based) information with the abstract information that currently dominates the Internet. The emergence of the Geospatial Web, particularly Web Mapping 2.0, had led to increases in geobrowsing activities (e.g. browsing through Google Maps or Google Earth).

5.4 Cartography as Social Construction

According to Chris Perkins (2003) some studies in cartography continued to implicitly adopt *scientific approaches* concerned with improving the efficiency of the way in which maps communicate (Robinson's legacy). This means comparing different designs of the same map, comparative analyses of map designs in different genres, and differing user perceptions of mapping products. Nevertheless,…

> These empirical studies almost all implicitly take an a-theoretical view of the map as a "mirror of the world", or as part of a system of cartographic communication, largely isolated from social and historical context (Perkins 2003: 334).

Additionally, della Dora (2009) in her article about performative atlases[69], states that:

> Matthew Edney (1993), Christian Jacob (2006), and Jeremy Crampton (2001) have argued for a history of cartography "without progress", in which maps are no longer assessed in terms of accuracy versus inaccuracy but, rather, are valued as "social constructions" that are always contingent on the specific cultural, social, and technical relations at different places and times (della Dora 2009: 241).

From the above statement a clear difference to the traditional or modern cartography can be seen. The view that cartography produces objective, neutral and scientific maps has been challenged. Nowadays, there is an alternative for cartography in which maps are recognized as social constructions. So the map is no longer the "mirror of the reality" from an objective viewpoint (Crampton 2001).

[69] According to della Dora, atlases are conceptualised as mnemonic tools activated through different types of personal encounters (always contingent) that are at once visual and tactile. "As a mnemonic device, the atlas is thus always *in process* through a diverse set of interrelated practices […]. Exploring the atlas means transforming these micro-performances into a mental movement of the entire body over territory" (della Dora 2009: 249).

Similarly, he has points out that recent developments in cartography have gone well beyond the *model of maps as communication.* He describes these developments…

> …as an *epistemic break* between a model of cartography as a communication system, and one is which it is seen in a field of power relations, between maps as presentation of stable, known information, and exploratory mapping environments in which knowledge is constructed (original emphasis by Crampton 2001: 253).

An important contribution made by the postmodernist approach is that a map can be seen as a *text*; hence, it is not an objective form of knowledge, but rather has numerous hidden agendas or meanings. Brian Harley, a historian of cartography and maps, elaborated this perspective in cartography on topics such as “maps, knowledge and power”, “deconstructing of map”, and “silences and secrecies in maps”.

Harley’s main papers were published in book form (Harley 2001), and give the vision of the map as *a social construction*. He suggests a new research agenda for cartography by arguing that maps play an important role in different societies and that they often reinforce the *status quo* or the interest of power. He also suggests (especially in the history of cartography) to research the historical and social context in which maps are created and employed.

Harley proposes an epistemological shift in the way of interpreting the *nature of cartography*. He questions the premise that cartographers are based in a “scientific” or “objective” knowledge creation. Thus, the question arises whether the concept of a *progressive science* is a myth created largely by cartographers in the course of their professional development through the “normative models” of cartography (Harley 2001).

The belief in the progress in cartography means that through the application of a scientific perspective we can make representations of reality which become more and more objective and accurate (Edney 1993).

For Harley, the link between reality and representation has dominated the cartographic thinking. This linkage has also led cartography away from the path of the "normal science" that had been around since the Enlightenment. This relation has offered a ready-made epistemology and has been "taken as a fact" in the history of cartography (Harley 2001). These ideas about objectivity in cartography and mapping also have been debated in 1996 by Matthew Edney in "Theory and the History of Cartography. "Cartographic history has been dominated by an empiricism that treats the nature of maps as self-evident and which denies the presence of any theory" (Edney 1996). The aim is to suggest an alternative epistemology, embedded in social theory rather than in scientific positivism, which is more adequate for the history of cartography. In this context, Harley proposed the *deconstructionist* method (see below) to break the association between reality and representation.

5.4.1 Deconstruction and Cartographic Text

Deconstruction is an approach which rigorously pursues the meaning of a text to the point of undoing the oppositions on which it is apparently founded, and the point of showing that those foundations are irreducibly complex, unstable or impossible. Deconstruction has had an enormous influence in psychology, literary theory, cultural studies, linguistics, feminism, sociology and anthropology (Reynolds 2002). Deconstruction, in simple terms, is a notable postmodern technique that enables the researchers to uncover hidden meanings and agendas (Hallisey 2005).

In the context of cartography John Harley developed three threads of argument in the pursuit of the deconstructionist strategy (Harley 1989). First, he examines the *cartographic discourse* under the light of some of Foucault's ideas[70] about the play

[70] Michel Foucault played a critical role in the development of the postmodern perspective that knowledge is constructed in concrete historical situations in the form of discourse; knowledge is not communicated by discourse but is discourse itself, can only be encountered textually. Foucault performs what he calls "genealogies," attempts at deconstructing the unacknowledged operation of power and knowledge, to reveal the ideologies that make domination of one group by another seem "natural" (Brewton 2002).

of rules within discursive formation. Then, he draws one of Derrida's central positions to examine the *textuality of maps* and its rhetorical dimension. Finally, he returns to Foucault to consider how maps work in society as a form of *power-knowledge*.

According to Harley (1989), one of Foucault's primary units of analysis is the discourse, which has been defined as "a system of possibility for knowledge". So, Harley related the *discourse* with *rules* and he asked a question about which type of rules has governed the development of cartography (see Figure 5.1).

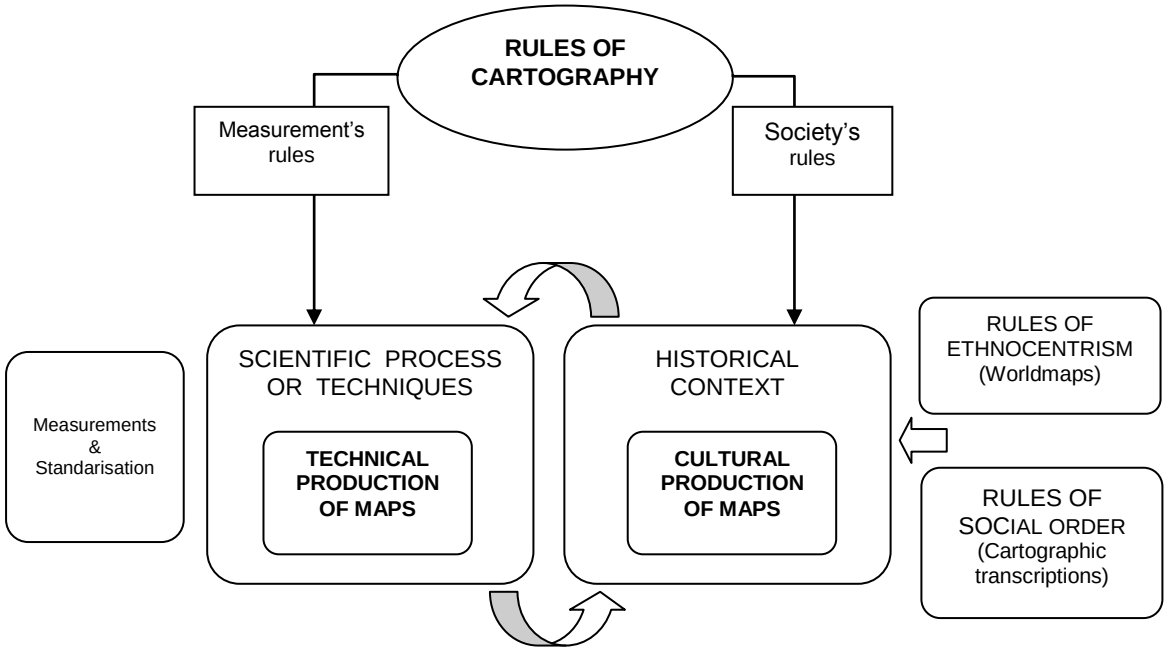

Figure 5.1 Rules of cartography according to Harley (1989) considering the Foucauldian discourse approach. Slightly changed.

He pointed out two distinctive sets of rules that underlay and dominate the history of Western cartography since the seventeenth century. One set may be defined as governing the "technical production of maps" and the other set relates to the "cultural production of maps" (see Figure 5.1).

For more information on the Foucauldian discourse applied in geography, cartography and mapping see Jeremy Crampton and Stuart Elden (2007).

So, the first set of cartographic rules can be defined in terms of scientific epistemology (e.g. scientific rules, measurement rules). For the second set of rules, Harley gives two instances: “rule of ethno-centricity” and “rules of the social order” or rules of hierarchy of the space (for more details see Harley 1989). He claims that…

> To discover these rules, we have to read between the lines of the technical procedures or of the map’s topographic content. They are related to values, such as those of ethnicity, politics, religion, or social class, and they are also embedded in the map-producing society at large (Harley 1989: 5).

The author suggests that these rules operate both within and beyond the orderly structures of classification and measurement and they go beyond the stated purposes of cartography. Harley notes that the interplay between social and technical rules is a universal feature of cartographic knowledge:

> In maps it produces the “order” of its features and the “hierarchies of its practice”. In Foucault’s sense, the rules may enable us to define an *episteme* and to trace an archaeology of that knowledge through time (original emphasis by Harley 1989: 6).

Concerning the rhetorical and textual dimensions in the context of cartography as social construction, Harley draws from Jacques Derrida that the model of text can be applied to other types of texts and not necessarily to the literary texts. For Harley, maps communicate as much as to provide a powerful rhetoric, and therefore can be critically examined as texts themselves. So, for him “text” is a better metaphor for maps than “the mirror of nature” is. Maps are *cultural texts*. By accepting their *textuality*, we are able to embrace a number of different alternative possibilities in reading and meaning (Harley 1989).

Deconstruction, as discourse analysis in general, demands a closer and deeper reading of the cartographic text than has been the general practice in either cartography or the history of cartography. For Harley, the philosophy of

deconstruction made by Derrida[71] to broaden such interpretation to all maps is helpful.

According to Brian Harley we can show how the cartographic (i.e. scientific) "fact" is also a symbol (i.e. a metaphor). This means that in "plain" scientific maps, science itself becomes the metaphor. He mentions several examples in which we can trace the contours of a metaphor in a scientific map, and understand how the text works as an instrument operating on social reality (for examples see Harley 1989).

Furthermore, in the deconstructionist theory the play of rhetoric is close to that of the metaphor. Harley argues that, notwithstanding the efforts of "scientific" cartography to convert culture into nature and to "naturalise" social reality, it has remained an inherently rhetorical discourse. Therefore, for him "there is nothing revolutionary in the idea that cartography is an art of persuasive communication".

Harley's position is to accept that rhetoric is part of the way in which all texts work and that all maps are rhetorical texts. In turn, this stance is carried out to cartographic terms, for example…

> The steps in making a map (selection, omission, simplification, classification, the creation of hierarchies, and "symbolization") are all inherently rhetorical. In their intentions as much as in their applications they signify subjective human purposes rather than reciprocating the workings of some *fundamental law of cartographic generalization* […] The issue in contention is not whether some maps are rhetorical, or whether other maps are partly rhetorical, but the extent to which rhetoric is a universal aspect of all cartographic text (original emphasis by Harley 1989: 11).

These statements exemplify maps as a social construction and also challenge the scientific stance of cartography which was maintained until the late 1980s: maps

[71] In his analysis John B. Harley cites Jacques Derrida's book "On Grammatology" (translated in 1976). In this book Derrida introduces the term *deconstruction* to describe the manner that understanding language as "writing" (in general) renders infeasible a straightforward semantic theory (Derrida 1976).

as a mirror of the world. In Kuhnian terms, it is a new viewpoint or another worldview. This change in the map conception and its interpretation can be considered as a paradigmatic shift inside of the discipline.

5.4.2 Power and Maps

Throughout history of cartography, maps have been understood as an *instrument of power*[72] for states and municipal administrations, strategic military planning units, colonialism, and any centralised power structures.

Maps are powerful tools. They are created by those who have authority and power, and for this reason they are powerful. Thus, maps are important documents or tools about the possession of a territory or an area, or the knowledge about the location of certain places of value.

Jeremy Crampton (2010) points out that mapping is embedded in a specific relation of power:

> That is, mapping is involved in *what* we choose to represent, *how* we choose to represent objects such as people and things, and *what* decisions are made with those representations (original emphases by Crampton 2010: 41).

Chris Perkins mentions different authors who have investigated the power-relation in mapping. He also notes different areas in which maps act as power, such as mapping in imperial projects, in commercial *élites*, military power and geopolitics, and in property relationships (Perkins 2003).

John Harley has to be considered one of the pioneers of the history of cartography who showed the power relation in maps, and consequently the power of

[72] The relationships between maps and power are not unique to postmodern cartography. Throughout history, the practical use of maps as means of power has been documented; however, the novelty is that this relation began to be systematically investigated from the second half of the 1990 onwards. For this reason, in this section the chapter of "Power and Maps" has been included within the cartography of the postmodern period.

cartography as a social practice. He drew concepts such as power-knowledge from social sciences to cartography (cf. Harley 2001).

In the context of how maps work in society *as a form of power-knowledge* Harley (1989) proposed a distinction between *external* and *internal* power in cartography. It helps to understand how power works through cartographic discourse and the effects of that power in society (Figure 5.2).

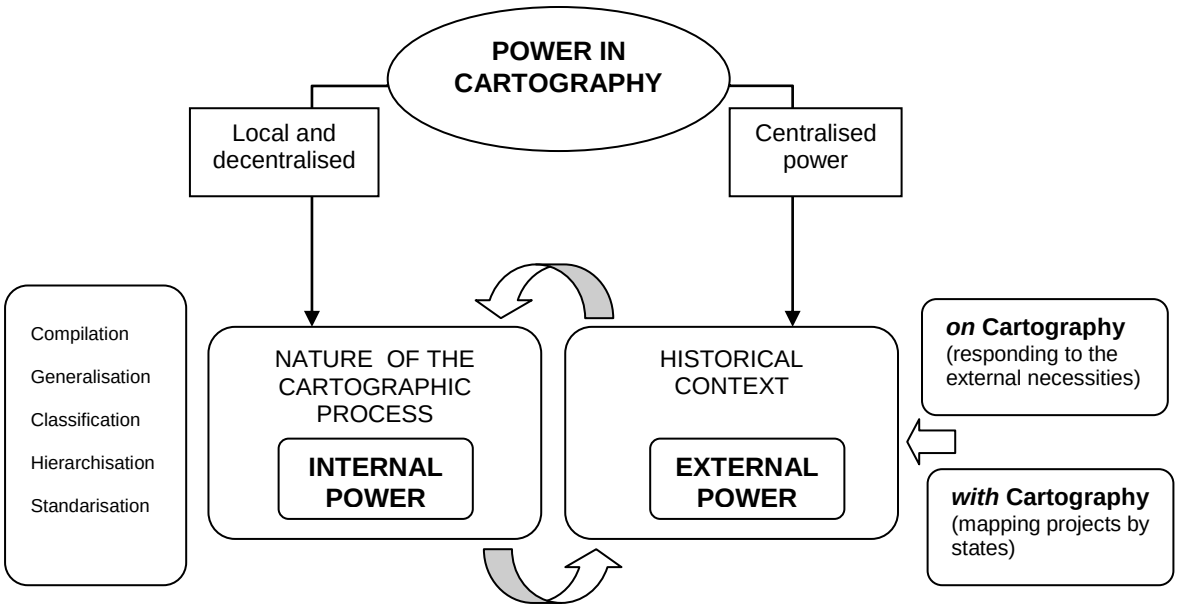

Figure 5.2 Power of cartography according to Harley (1989) considering a Foucauldian power-knowledge approach. Slightly changed.

On the one hand, the most familiar sense of power in cartography is that of *external power* to maps and mapping. Here power is exerted *on* cartography and power is also executed *with* cartography. It is an external power, often centralised and exercised bureaucratically, imposed from above, and it manifests itself in particular acts or phases of deliberate policy (especially centres of political power: monarchs, ministers and the states; for more details see Harley 1989).

On the other hand, Harley defines the *internal power* in cartography very differently. Here, the focus of inquiry shifts from the place of cartography in a juridical system of power, to the political effects of what cartographers do when they make maps. According to Harley's view…

> Cartographers manufacture power… It is a power embedded in the map text: we can talk about the power of the map just as we already talk about the power of the word or about the book as a force for change. In this sense maps have politics (Harley 1989: 13).

Similarly, power comes from the map and it traverses the way maps are made. The key to this internal power is the *cartographic process*. So, to catalogue the world is to appropriate it, all technical processes represent acts of control over its image which extend beyond the professed uses of cartography. Thus, the world is disciplined and normalised.

Harley exemplifies the *standardisation* and *normalisation* of the world through an analogy between factories and cartographic workshops. In the former, the goods manufactured are standardised and in the latter, *world's images* are standardised by cartographers. There exists also another analogy between scientific laboratories and maps: In the first the explanation of the processes of the physical world are created with formulas, and in the second nature is reduced to a *graphical formula*.

Taking into account Foucault's considerations, Harley does not suggest that power is deliberately or centrally exercised. He says that it is a *local knowledge* which at the same time is *universal* and usually passes *unnoticed*. To consider the effects of cartography in society, or the "logic of the map" upon human consciousness, Harley suggests that…

> We have to consider for maps the effects of abstraction, uniformity, repeatability, and visuality in shaping mental structure, and in imparting a sense of the places of the world (Harley 1989: 13).

From an epistemological viewpoint, Harley pointed out that, whilst the map *is* never the reality, it helps *to create* a different reality. Once embedded in the published text, the lines on the map acquire *authority*. Thus, maps are authoritarian images, and even without the users being aware of it, a map can reinforce and legitimate the *status quo* inside of a society.

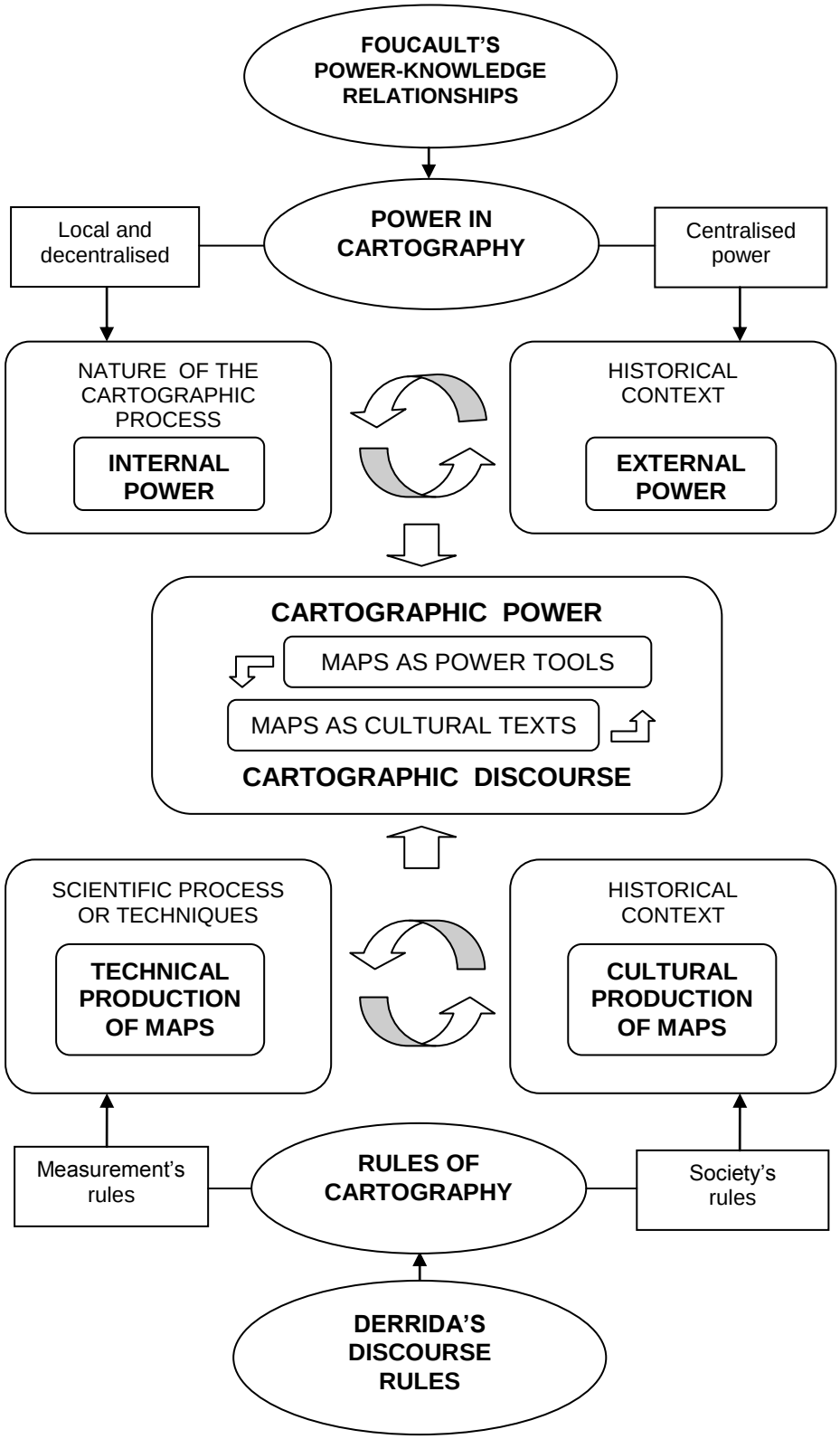

Figure 5.3 Power play of the cartographic discourse, according to Harley (1989). Slightly changed.

Figure 5.3 summarises Foucault's and Derrida's contributions which were incorporated into cartography by John Harley. It shows by means of the so-called external and internal power of cartography and the types of rules that have governed cartography through time, that the *cartographic discourse* acquires a strong power. Therefore the cartographic power and the cartographic discourse are mutually reinforced through *maps as tools of power* and *maps as cultural texts* respectively.

This approach was originally applied to old maps (Harley 1988a, 1988b, 1994, 1997), but the social implications of maps have been a major topic in analysing modern maps. Authors such as Denis Wood and Mark Monmonier have worked on these topics, especially in their books "The power of maps" (Wood 1992) and "How to lie with maps" (Monmonier 1996).

Similarly, regarding the relationship between politics and cartography, Gyula Pápay (2006) points out that on the political level the emergence of a complete sense of possession has had an ambivalent effect in history as a result of maps. He writes that…

> On the one hand, maps were required as instruments of the preservation of possession or power; on the other hand, they were kept secret to ward off foreign claims (Pápay 2006: 1).

In this sense, maps play a double game: they can document claims to power and are thus a means of the presentation of power, and they can also be used to deny power by means of hiding of cartographic documents. For example, Pápay (2006) made a historical examination of the relationship among politics, secrecy, and cartography political maps.

6 Post-Representational Cartography

6.1 Introduction

In this section the so-called post-representational cartography is analysed. Since the first decade of the twentieth century several authors from social sciences and social theory have been proposing new map conceptions in comparison with a scientific-empiricism approach. This new tendency not only challenges the modern period but also the critical perspective assumed in cartography and mapping. Here, there is a group of authors who can be located in a transitional phase towards a cartography which challenges the traditional proposals. Authors such as John Pickles, Martin Dodge, Rob Kitchin and Chris Perkins propose to analyse cartography and mapping beyond representational knowledge (i.e. accurate and objective maps) and so consider it as a set of spatial practices (that do work in the world). The epistemological foundations, proposals and challenges to a post-representational cartography are analysed.

6.2 What is Post-Representational Cartography?

Post-representational cartography is a new perspective in mapping that is contrary to the viewpoint of “maps as truth” and wants to go beyond the “maps as social constructions” approach. The former is the view of modern or traditional cartography, and the latter one is framed in postmodern cartography.

Maps as truth, from a postmodern perspective, implies a cartographic activity that is academic, scientific, objective, freed of values, whose aim is to represent reality (i.e. the territory) in an accurate and precise way. In this sense, the metaphor “the map as mirror of the world” is valid: i.e. to depict the reality (geographical, spatial, and territorial) and various aspects as they are.

In this way, the postmodern approach considers cartography as an academic and scientific pursuit which has largely consisted of theorising about the best way to

represent and communicate that *truth*. In this quest, the main approach has been the cartographic communication model.

On the other hand, unlike the scientific approach, John Harley (1989) argued that the process of mapping is the *creation of knowledge*, rather than simply revealing it. Therefore, maps are based on the values and judgments of the individuals who create them. Thus, maps are a reflection of the culture in which they are inserted. In this sense, maps are social constructions, i.e. *expressions of power/knowledge*.

In summary, cartographic approaches envision two different ideas about the ontology of maps: maps as *objective truths* and maps as *social constructions*.

Despite those differences, there are authors who point out that both stances actually conceive maps as *inherent truth*. John Harley, Denis Wood and John Fels note that…

> The map itself remains ideologically neutral, with ideology bound to the subject of the map and not the map itself (cited by Kitchin 2008: 211).

Along these lines Crampton (2001) questions the *ontological grounds* of cartography and he identifies the map as a *contingent product*. In other words, the map is imbued of the historical conditions, depending on the time and space in which it is produced and read. Therefore, the map is unable of reflect the truth.

In the same way Kitchin and Dodge (2007) carried out a historical revision about an ontological crisis in cartography and they suggest a proposal which goes beyond the critiques of the ontological basics of cartography. In other words, they have called for a radical action “rethinking maps” (see below).

6.3 Transition towards a Post-Representational Cartography

Rob Kitchin, Chris Perkins and Martin Dodge in their article “Thinking about maps” attempt to rethink the epistemological map status. Considering a post-

representational theory of mapping, they are summarising the current development in cartography in two stages: from ontic knowledge to *ontology*, and from ontology to *ontogenesis* (see Kitchin et al. 2009).

Similarly, the social constructivist approach has brought many contributions to the rethinking of maps in cartography. However, some authors claim that the criticism developed by Harley did not go far enough in rethinking the ontological bases for cartography (Kitchin et al. 2009). Authors such as Barbara Belyea (1992), Denis Wood (1993), and Jeremy Crampton (2003) agree that Harley's application of Foucault is limited and incomplete.

In general, this new so-called *post-representational approach* points out that *Harley's strategy* - i.e. to uncover the ideology inherent in the representation - as the actual *counter mapping,* does not challenge the *ontological status* of maps. These simply reveal the politics of mapping: there arises a question about the ideology of the topic of a map (as Harley did), but not about the *map itself* (Kitchin et al. 2009).

Table 6.1 summarises different map concepts that have arisen during the period of postmodern cartography. It also includes a comparison between the modern cartography approach and the last period called post-representational cartography. Although it considers the methodology by Kitchin et al. (2009), this table also includes other authors, such as Jeremy Crampton, Emanuela Casti, and Veronica della Dora.

Table 6.1 Map conception and cartographic approaches according to various authors. (*) Post-representational cartography is actually part of postmodern cartography.

PERIOD	AUTHOR	MAP CONCEPTION
Modern Cartography	A. Robinson (1955)	Maps as *objective*, *scientific* representations Maps as *truths* Maps are *transparent* and ideologically *neutral*
Post-Modern Cartography	B. Harley (1989)	Maps as *ideologically* laden representations Maps as cultural *texts*
	J. Crampton (2003)	Maps as *historical products* operating within "a certain horizon of *possibilities*"
	E. Casti (2005)	Maps as locus of *semiosis*, *self-referential* through iconisation
	D. Wood and J. Fels; (2008)	Maps as c*onstructions* that produce the world Maps as *prepositions*
	B. Latour (1987, 1999)	Maps as *immutable* mobiles Maps as *actants*
	V. della Dora (2009)	Maps as *fluid* objects always in the making Maps as *mnemonics*
Post-Representational Cartography (*)	J. Pickles (2004)	Maps as *inscriptions* Maps as unstable and complex *texts*
	R. Kitchin and M. Dodge (2007)	Maps as *practices* (spatial practices that do work in the world) Maps as suites of cultural practices involving *actions* and *affects* Maps as *mutable* mobiles

The new conceptions of maps belonging to the post-modern cartography period will be treated below. As Harley's position has already been analysed, the section shall begin with Jeremy Crampton.

6.3.1 Maps as a Historical Product: Horizon of Possibilities

Along this line, Jeremy Crampton draws from Heidegger's ideas when he proposes a shift from understanding cartography as a set of *ontic knowledge* to

examining its *ontological* terms[73] (Crampton 2002). This means questioning the "project" of cartography itself. Crampton also considers Edney's approach (Edney 1993) when he argues for the development of a non-progressive history of cartography: a historical ontology that, rather than being *teleological,* is *contingent* and *relational*.

For Crampton…

> A historical ontology […] suggests that the way things are, their being, is in fact a historical product operating within a certain *horizon of possibilities* (original emphasis by Crampton 2002: 6).

For this reason, maps are also historical products operating within a certain horizon of possibilities (Crampton 2003). This implies the possibility of an unfolding of the being of maps and mapping, how maps are conceptually framed in order to make sense of the world (Crampton 2002).

Therefore, maps are products of the here-and-now, no better than maps of previous generations, simply different to them. This conception differs considerably from the progressive approach of cartography which states that maps have a constant improvement across the history.

6.3.2 Maps as Locus of Semiosis: Self-Reference of the Map

This perspective has been set forth by Emanuela Casti (2005) who considers a semiotic approach, namely a theory of cartographic semiosis[74]. She mentions that…

[73] J. Crampton refers to Heidegger's work to analyse two kinds of knowledge: "ontic knowledge", which concerns the knowledge of things as such, and "ontological knowledge", which concerns the conditions of possibility for ontic knowledge. For more details see Crampton (2002).

[74] For E. Casti "semiosis is the process whereby information is produced and transmitted" (Casti 2005).

> A semiotic approach shifts the emphasis from maps intended as *a mediation* to maps taken as *agents*, whereby actions to be carried out on territory are determined (original emphasis by Casti 2005: 1).

Casti elaborates these ideas from the hermeneutical approach, or more specifically from cartographic hermeneutics, which conceive the map as a tool of intervention between society and territory. In this sense maps play an important role as agents capable of deploying self-referential information to effectively mould human intervention on territory (Casti 2005). She also deals with the concepts of *self-reference* and *iconisation*. Self-reference is defined by Casti as…

> …the ability of a map to be accepted as such and, at the same time, to play a role in communication that is independent of the intentions of the cartographer who produced it (Casti 2005: 10).

This statement implies that the hermeneutic approach goes beyond the deconstructive one. According to Harley, the author of map (a cartographer) has the intention of communicating something. For Casti, however, maps with their own sets of rules produce additional meanings that affect the perception that observers have of certain places.

On the other hand, Casti defines iconisation as…

> …the communicative issue whereby the self-referential mechanisms of the map are used to convey conjectures as truth (Casti 2005: 11).

For her the map itself is also an icon, namely, “an instrument by means of which one carries out a metamorphosis of the world”. In these terms, a map is conceived as a *locus of semiosis*, self-referential through iconisation. Thus…

> Cartography semiotic has shown not only that maps can convey complex information but also that this information is always the product of iconization, and that it is connected with reality but cannot simply be superimposed upon it (Casti 2005: 12).

As a result, to join these two concepts - self-reference and iconisation - Casti concludes that the map as a model *replaces* rather than *represents* territory. In this way, the map does not *stand for* the territory, but the map *becomes* territory. In summary, this posture again questions the metaphor of the map as the mirror of reality. The map is not the reflection of the territory.

6.3.3 Maps as Propositions: *Perimap and Epimap*

John Krygier and Denis Wood rethink maps and the discourse about maps, pointing out that “maps are propositions”. In some of their articles they pose this conception by means of graphical schemes to facilitate its comprehension (Krygier and Wood, 2009).

Along the lines of Kitchin (2008) and Kitchin et al. (2009) they analyse the work of Denis Wood and John Fels (2008a, 2008b), and argue that maps produce the world by making *propositions* which are placed on it. Maps achieve their work by exclaiming such propositions in the form of *postings* of information on the maps.

An important idea from Wood and Fels is the *paramap*[75]. All maps have an inherent authority which is conveyed by the map through the so-called paramap. This paramap “can be broken down into a *perimap* element and *epimap* elements”. The former involves of the production surrounding a map, and the latter the discourse circulating a map to shape its reception (for details see Wood and Fels 2008b).

For Tom Koch “the paramap consists of the *peri*map (elements of which include ancillary maps, legends, scales, and so on) and a broadly conceived *epi*map including the article within which a map may be embedded” (Koch 2008).

[75] According to Tom Koch, Wood and Fels (various publications) argue that the map image itself cannot be understood except as embedded in a *paramap* “that sorrounds and extends a map in order to present it” (Koch 2008: 49).

For Wood and Fels this authority (of maps), albeit apparently descriptive, is inherently prescriptive". On the other hand, for them…

> The map is nothing more than vehicle for the creation and conveying of authority about and ultimately over, territory (Wood and Fels 2008b: 190).

From this can be concluded that *maps are* a *prescriptive* and not a descriptive system of propositions[76]. This proposal leads to the following:

> Given that we *see maps* as systems of propositions (as *arguments*), nothing could be further from what we have in mind. This question is *not* for us how things are arranged for the eye, but how the design promotes and constrains, how it directs, the construction of meaning. It is not about the "presentation of information." It is about the construction of meaning as a basis for action. It is for us a question of cognition (original emphasis by Wood and Fels 2008: 194).

In this manner these authors propose that *cognitive linguistics*[77] is an appropriate model for thinking about cartography. It means that map design should be rethought as a form of *cognitive cartographics.* In short, for Kitchin et al. (2009) this implies that employing the cognitive cartographic approach will create a non-representational approach to map design on the construction of meaning rather than graphic design and the nature of signs.

Finally, the *perimap* and *epimap* elements are related to Harley's posture about the internal and the external power of cartography respectively. According to the rules of cartography pointed out by Harley, the "technical production of maps" corresponds to the perimap, and the "cultural production of maps" is associated with the epimap elements.

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[76] A descriptive map only describes space (i.e. a territory), whereas a prescriptive map produces and reaffirms territory.

[77] Tom Koch mentions that Wood and Fels use cognitive linguistic as an interpretative tool. "They propose a *cognitive cartographics* in which *mental maps* are replaced by cognitive, mental spaces as a flexible frame within which meaning is constructed. That construction is played out in the layout of the map itself" (Koch 2008: 49).

6.3.4 Maps as Immutable Mobiles: Stable Form of Knowledge

Drawing from Latour's ideas, Kitchin, Perkins and Dodge (2009) called maps immutable mobiles. Bruno Latour (1999) uses examples of cartography to show the extent to which the production of Western scientific knowledge grew in importance through time. In other words, he shows how from a historical viewpoint the cartographic practices and the mapping technologies helped Western hegemony.

In this way, based on Latour (1999) maps are considered *immutable mobile*, i.e maps are…

> …stable instruments for the transfer of knowledge from one place and time to another, or containers of information gathered at a specific geographic location, returned to a "centre of calculation[78]", and then plunged once more into circulation (cited by della Dora 2009: 252).

For Latour the scientific basis of map-making and map-use became conventionalised. Thus, maps increasingly took on the status of immutable mobiles:

> Map became a stable, combinable and transferable form of knowledge that is portable across space and time (Kitchin et al. 2009: 18).

On the other hand, the adjective "immutable" is, in part, because to that cartography theory and practices *disciplines* its practitioners and also it *silences* other local mapping knowledge (i.e. indigenous cartographic practices are considered of minor status compared to the technical/professional cartography). For Latour…

> The immutability, combinability and mobility of maps allowed exploration, trade and ultimately colonialism to develop by allowing control to be exerted from afar and

[78] Key sites of cartographic practices which came to dominate the world during the Renaissance are considered "centres of calculation".

> knowledge about new territories to be effectively transported globally (Kitchin et al. 2009: 19).

This approach is consistent with Casti's claims (Casti 2005), because maps do not simply represent space at a particular time, but rather maps *produce new space-times*. In a way similar to Crampton's statements (Crampton 2003), maps *open up new possibilities* creating new geographies and histories.

6.3.5. Maps as Actants: Social Context of the Map

This is another perspective of maps that emerge in the postmodern period. According to Bruno Latour (cf. Kitchin et al. 2009), to understand maps it is necessary to examine…

> …the cultures, technologies and mechanics of how a particular form of mapping came to gain immutability and mobility to reveal its contingencies and relationalities (Kitchin et al. 2009: 19).

In this way Latour develops the Actor Network Theory (ANT) which is "a framework for considering how maps work in concert with other actants and actors to transform the world" (Latour 1987). This network corresponds to the social context in which the map is created and developed.

According to Kitchin et al. (2009), Latour's contribution, is that…

> Maps do not have meaning or action on their own; they are part of assemblage of people, discursive processes and material things. They are deployed in an actor-network of practices rather than existing as de-corporalized, a priori, non-ideological knowledge objects (Kitchin et al. 2009: 20).

The above statement implies a philosophical and epistemological change. The emphasis is not on *what* the map represents, but on *how it* is *produced* and *how it works* in the world. In this way the map became an *actant* and not a *static* object.

This vision about the map differs with the scientific approach in which the map is considered an isolated object inside a laboratory or workshop.

6.4 Foundations for a Post-Representational Cartography

As summarised in Table 6.1, the two main directions which aim towards the post-representational cartography evolved in following way: maps as *inscription* and maps as *practices*. These developments have to be attributed to John Pickles (2004) and to Rob Kitchin, Chris Perkins and Martin Dodge (2009).

6.4.1 Maps as Inscriptions: Social Life Affected by Maps

According to Kitchin et al. (2009), several other theorists in cartography have been following similar lines of enquiry to those followed by Crampton, seeking to transfer map theory from ontic knowledge to ontology.

John Pickles (2004) attempted to extend Harley's observations beyond the ontic status, calling for a post-representational cartography. This perspective understands maps not as mirrors of nature, but as producers of nature. In his sense…

> A map is not a representation of the world but an inscription that does (or sometimes does not do) work in the world (Pickles, 2004: 67)[79].

Pickles proposed a shift based on the discussion of maps made until the 2000s. This debate had previously been focused on how the historical transformations in social life have influenced mapping techniques and map use. Instead, he now proposes to analyse the ways in which the form of cartographic reasoning affected social life.

In this way, Pickles draws attention to the necessity of a post-representational cartography, a de-ontologised cartography and denaturalised histories of cartography. He postulates a recognition that the alternative cartographic practices have an ontological status just like those developed in scientific fields.

[79] Kitchin and Dodge (2007) are also drawing on the work of Pickles (2004).

According to Kitchin and Dodge (2007) and Kitchin et al. (2009), denaturalised histories of cartography consist of genealogies of how cartography has been *naturalised* and *institutionalised* across space and time, as a particular form of scientific practices and knowledge. Moreover, a de-ontologised cartography accepts "counter mappings" as having the same ontological status as scientific cartography.

6.4.2 Maps as Practices: a State of Becoming

Kitchin et al. (2009) call the period of cartography that began after the 2000s "from ontology to ontogenesis". They also declare their worry about the *ontological security* of the map[80], a preoccupation that is implicit to other authors such as Crampton, Pickles and Latour. In other words,…

> The map might be seen as diverse, rhetorical, relational, multivocal and having effects in the world, but is nonetheless a coherent, stable product – a map (Kitchin and Dodge 2007: 334).

Nowadays this position regarding map security has been rejected by those that have adopted the performative and ontogenetic understandings of mapping. In this way:

> Maps rather are understood as always in a state of becoming; as always mapping; as simultaneously being produced *and* consumed, authored *and* read, designed *and* used, serving as a representation *and* practice; as mutually constituting map/space in a dyadic relationship (original emphases by Kitchin et al. 2009: 22).

These authors put out maps as practices and they base their analysis on four main authors: James Corner, Tim Imgold, Vincent del Casino and Stephen Hanna (see

[80] In general terms ontological security involves having a positive view of oneself, the world and the future. This term moved to the field of cartography, its foundational ontology is that the world can be objectively and truthfully mapped using scientific techniques that capture and display spatial information. Therefore, the ontological security of a map is referred to the knowledge underpinning cartography and map use as learned and constantly reaffirmed (Kitchin and Dodge 2007).

Table 6.2). In this period, cartography is considered a *relational perspective* with a constellation of ongoing processes, rather than a unified representation of reality (Kitchin et al. 2009).

Table 6.2 Map conceptions supporting post-representational cartography. Adapted from R. Kitchin, C. Perkins and M. Dodge (2009).

AUTHOR	MAP CONCEPTION
J. Corner (1999)	Maps as *re-creations* of territory Maps and territories are *co-constructed*
T. Ingold (2000)	Maps as views from somewhere bound within the *practices* and *knowledge* of their makers Maps as *histories* in movements
V. del Casino Jr. and S. Hanna (2006)	Maps as "mobile subjects" whose meaning *emerges* through socio-spatial practices Maps as both representations and practices *simultaneously*

James Corner (1999) argues that a territory does not precede a map, but that space becomes territory through *bounding practices* that include mapping. In this way, "maps and territories are co-constructed". This argument is similar to that of Casti about the mechanism of territorialisation (cf. Casti 2005). Corner also suggests that cartographic research and practice needs to focus on mapping actions and mapping effects and not solely on the construction of maps *per se*.

Tim Ingold (2000) shows an approach to mapping grounded in cultural practice (indigenous maps). He defines mapping as "way-finding practices" which consist of the moving of people within several places inside a region. These movements are recorded as mobility and they are opposed to location in the Cartesian sense, i.e. these mapping practices "do not detail location in space but histories in movement that constitute place."

According to Vincent del Casino Jr. and Stephen Hanna several works in postmodern cartography reproduce a series of binaries that separate maps as

representations of space from spatial practices. Examples of these binaries are: representation/practice, production/consumption, and map/space. The authors suggest a way to interrogate these binaries, which are implicit in traditional and postmodern cartography. They state that maps are not only representations of a particular context, space and time, but that maps are…

> …mobile subjects, infused with meaning through contested, complex, intertextual and, interrelated sets of socio-spatial practices (del Casino Jr. and Hanna 2006: 36).

They are interested in applying the methodological assumptions and processes towards thinking of a map as a space. Thus,…

> As such, map and mapping are both representation and practice (read: performance) simultaneously. Neither is fully inscribed with meaning as representations nor fully acted out as practices (del Casino Jr. and Hanna 2006: 36).

After examining the ontological status of maps and drawing on the aforementioned authors Kitchin and Dodge (2007) point out that a conceptual turn in *how to think* about maps and cartography is significant:

> That is a shift from ontology (how things are) to ontogenesis (how things became) – from (secure) representation to (unfolding) practice (Kitchin and Dodge 2007: 335).

Therefore, according to these authors, a map is always a result of the moment, of the context. A map only exists in *practice*. Therefore, a map is not a *product* but it always is *process*. The map *happens* or *occurs* only when someone interprets a given visual form, so it is always *practical*.

For Rob Kitchin and Martin Dodge, a spatial representation[81]…

> …is rather a set of points, lines and colours that takes form as, and is understood as, a map through mapping practices (an inscription in a constant state of re-

[81] Kitchin and Dodge present a thematic map concerning the "Population change in Ireland, 1996-2002" and they ask: "Is the image a map"? (for more details see Kitchin and Dodge 2007).

> inscription). Without these practices a spatial representation is simply coloured ink on a page. […] Practices based on learned knowledge and skills (re)make the ink into a map and this occurs *every time* they are engaged with – the set of points, lines and areas is recognized as a map; it is interpreted, translated and made to do work in the world. As such, maps are constantly in a state of becoming; constantly being remade (original emphasis by Kitchin and Dodge 2007: 335).

These ideas are also shared by Veronica della Dora (della Dora 2009). Her approach is focused in the process of encountering and performing maps, more than maps as finite representations. She calls for "a re-conceptualization of maps as fluid objects that are always in the making". For her the cartographic representations are "mutable mobiles" (i.e. maps and atlases). They are transitory and fleeting products of specific physical encounters in space and in time.

On the topic of the *ontogenetic understanding of maps,* and according to this new perspective, Kitchin and Dodge (2007) state that…

> Maps *emerge in process* through a diverse set of practices. Given that practices are an ongoing series of events, it follows that maps are constantly in a state of becoming; they are ontogenetic (emergent) in nature. Maps have no ontological security, they are of-the-moment; transitory, fleeting, contingent, relational and context-dependent. They are never fully formed and their work is never complete. Maps are profitably theorized, not as mirrors of nature (as objective and essential truths) or as socially constructed representations, but as emergent (original emphasis by Kitchin and Dodge 2007: 340).

The statement is very important for cartography because considered as profession it is repositioned as a *processual science*, as opposed to a *representational* science. This means that cartographic research becomes refocused as a *science of practices*, *not representations*. Consequently a so-called *post-representational* view of cartography is currently around 2010 emerging.

For Kitchin and Dodge…

> The important question is not *what a map is* (a spatial representation or performance), nor *what a map does* (communicates spatial information), but *how the map emerges* through contingent, relational, context-embedded practices to solve relation problems (their ability to make a difference to the world); to move from *essentialist* and *constructivist cartography* to what we term *emergent cartography* (emphases added, Kitchin and Dodge 2007: 342).

The above statement means that post-representational cartography has a different perspective to that of traditional cartography and, even of historical critical cartography. In fact, from an epistemological perspective for Kitchin and Dodge…

> What this means is that science of cartography (how maps are produced) and critical analysis of cartography (the history and politics of cartography) are both positioned as processual in nature. Rather than one asking technical questions and the other ideological, both come to focus on how maps *emerge* through practices; how they come to be in the world (original emphasis by Kitchin and Dodge 2007: 342).

The authors add:

> Cartography shifts from being ontical in status, wherein the ontological assumptions about how the world can be known and measured are implicitly secure, to an ontological *project that questions* more fully the work maps do in the world (emphasis added, Kitchin and Dodge 2007: 343).

This statement, again, reflects the scope of current cartography and the changes in perspective that it contains. These new conceptions evidence a perspective shift in maps and mapping, which represents the basics for the post-representational cartography, a new way of thinking in cartography.

Additionally, this perspective has effects on the philosophical and epistemological foundations of cartography. In this sense it is possible to visualise a *paradigmatic shift* in gestation that goes beyond of an *ontical* and *ontological* approach of the discipline.

7 Possibility of a Paradigm in Cartography

7.1 Introduction

This section presents two ways of analysing whether there exist some paradigms in Kuhnian terms in cartography. First, the so-called "criteria of contrast" used in the distinction of the science types are applied. These criteria establish the differences between formal sciences and factual sciences and also distinguish between regional and quantitative geography. Second, a "tendency distribution in the epistemological-space" analysis is applied. The distribution or location of tendencies permits the identification of paradigmatic-shifts according to epistemological and philosophical coordinates. The term "coordinates" corresponds to the three bases of modern thought: positivism-empiricism, realism-structuralism, and idealism-hermeneutics. This approach is applied to the modern geographic thought and then to the cartography of the modern and post-modern period. The aim is rather to locate cartographic tendencies according to the so-called epistemological coordinates than to describe the technological changes that occurred during the development of the discipline.

7.2 Criteria of Contrast

Mario Bunge (1998) made a comparison between factual and formal sciences. The *criteria of contrast*[82] which are important to distinguish these two types of

[82] In the literature these "criteria of contrast" are also called "contrasting parameters". In this study, however, they are named "criteria of contrast" due to their epistemological and theoretical nature. A criterion of contrast is an indicator that permits to describe distinctions between types of sciences (e.g. formal/factual sciences, physical/social sciences). Some criteria of distinction are the following:

- Study object: main subject (topic) analysed in each discipline or science
- Research aims: led to an explanation and prediction of reality (through laws and generalisations) or only a description of reality (through unique and particular cases)
- Research method: covers the general methodology used: hypothetical-deductive or empirical-inductive or both
- Statement type: refers to the establishment of synthetic propositions (e.g. factual sciences) or analytical ones (e.g. formal sciences)
- Purpose or finality: distinguishes between explanation and prediction of reality (i.e. natural/physical sciences) or only its description (i.e. human/social sciences).

critical sciences are, among others: study object, research aims, methods and techniques, results in research or/and practice, purpose or finality. These criteria can be adapted according to the different sciences and disciplines. Thus, criteria of contrast are used to reach the proposed objectives to verify whether the development tendencies in cartography correspond to the paradigmatic trends experienced in the development of sciences in general.

Table 7.1 shows the comparison between factual sciences and formal sciences. A first criterion is the *study object.* In this case, facts and phenomena of our experience are studied by factual sciences (i.e. physics, chemistry, biology) and entities of ideal character - in an abstract way - are treated by the formal sciences (i.e. mathematics, logic, geometry). Certain *research methods* are used by the respective science types and associated with it. Then different *statement types* are established: There is on the one hand the *empirical contrast* with *synthetic* propositions in the factual sciences, on the other hand the *logic-deductive demonstrations* with *analytical* propositions or statements in the formal sciences.

According to the above methods, the *purpose* or *finality* is to reach the desirable knowledge. In this case the purpose is descriptive, explicative and predictive for the phenomena belonging to the factual sciences in comparison to purposes about the construction of the abstract thought system of the formal sciences.

Among others, epistemology of science aims at taking into account some criteria for the distinction between the types of sciences or disciplines which help to increase our particular knowledge of the physical and abstract world.

Table 7.1 Criteria of contrast for factual and formal sciences based on the conception of Bunge (1998).

Factual Sciences	CRITERIA OF CONTRAST	Formal Sciences
Facts and phenomena of the experience	**STUDY OBJECT**	Entities of ideal character
Empirical contrasting	**RESEARCH METHOD**	Logic-deductive demonstration
Synthetic propositions	**STATEMENT TYPE**	Analytical propositions
Description, explanation and prediction of phenomena of the universe	**PURPOSE (FINALITY)**	Construction of abstract systems of thought

7.3 Contrasting Paradigms in Geography: An Example

According to the peculiarities of each discipline, there exist other criteria of contrast apart from those mentioned above. In geography for instance there are: paradigm's name, tendency or school of thought, general methods, cartographic product (as practical result). These criteria are useful to differentiate internal tendencies in a discipline.

Some criteria of contrast which establish the differences between two traditional tendencies in the field of geography are presented in Table 7.2. As shown in previous sections, during the first half of twentieth century there was a distinct difference in the geographic thought between traditional regional geography and a new trend called quantitative geography. The former is underpinned by historicism and the latter by neo-positivism. In Table 7.2 these differences are presented according to the established criteria of contrast. For the traditional geography, the study object is *the region* (or a specific place) and for the quantitative geography

the spatial relationship. For more details regarding these tendencies see Harvey (1969), Capel (1983, 1988), Gomez Mendoza et al. (1988), and Valcárcel (2000).

Table 7.2 shows the *general method* and the more specific *methods and techniques* (i.e. approaches) used in geographic tendencies. Regional geography applied the empirical-inductive method, and its approaches were classificatory, comparative and historical. Quantitative geography, however, used the hypothetical-deductive method, and its technical approaches were mainly statistics, modelling and data correlation. These techniques permitted the verification of previously established hypothetical statements.

When considering the *research results*, regional geography led to typologies and the classification of places and regions in the world. These typologies are considered to be particular or unique cases. It means that typologies are only valid for specific spatial units and not for other. On the other hand, the research results of quantitative geography led to generalisations, laws and theories regarding the spatial relationships or spatial distribution of the phenomena under study. In other words, the idea was to apply laws and generalisations that would be valid for all spaces and places. The *cartographic products* used in both tendencies have also been considered as another criterion of contrast. As a derivation of the research results, monographic maps were made in regional geography, whereas statistical and correlation maps were made in quantitative geography. The latter products, especially the correlation maps, were supported by computational and programming techniques.

Table 7.2 Criteria of contrast for two paradigmatic tendencies within the field of geography.

Classical Geography	**CRITERIA OF CONTRAST**	**Modern Geography**
Historicism	**PARADIGM'S NAME**	Neo-positivism
Regional Geography	**TENDENCY /SCHOOL**	Quantitative Geography
Regions, places	**STUDY OBJECT**	Spatial relations
Description of the directly observed physical world (region)	**RESEARCH AIMS**	Explanation and prediction of spatial relations
Empirical-inductive	**GENERAL METHOD**	Hypothetical-deductive
Classificatory; comparative; historical	**METHODS AND TECHNIQUES (APPROACH)**	Statistics; modelling; correlations
Typologies; particular cases; unique cases	**RESEARCH RESULTS**	Generalisations, laws and theories
Monographic maps	**CARTOGRAPHIC PRODUCTS**	Statistical and correlation maps

To sum it up: Whereas Table 7.1 establishes the differences between types of sciences Table 7.2 shows some criteria for the establishment of trends *within* a particular science or discipline. These tendencies or schools of thought can be regarded as paradigmatic shifts themselves owing to their contrastive nature in Kuhnian terms (cf. Section "Paradigms in the Epistemology of Science"). From an epistemological viewpoint, these trends also support our knowledge of a specific part of *reality*.

7.4 Comparing Tendencies in Cartography inside the Epistemological Space

A second methodological criterion applied to this study is the triangular model derived from Eric Sheppard's discussion about representing Critical Geography and Geographic Information Systems (GIS), which are related with the three complementary ontologies empiricism, realism and idealism (cf. Sheppard 2005). In the field of cartography, Menno-Jan Kraak and Ferjan Ormeling used a triangular figure to characterise geospatial data in their three components: location, attribute and time (see Kraak and Ormeling 2010).

This triangular model will, for our purposes, be (re-)named "Tendency distribution in the epistemological space". *Tendencies* mean thoughts, trends, perspectives and approaches which have been developed within a science or discipline (i.e. geography and cartography). *Epistemological space* refers to the philosophical and epistemological context analysed. In this way, some of the following figures depict the three main underpinnings of the modern period: positivism-empiricism, realism-structuralism, and idealism-hermeneutics. Thus, the triangular model shows how tendencies are distributed within the *epistemological coordinates* of modernity that frame sciences and disciplines.

The paradigmatic tendencies in geography (listed in Table 3.2, Section 3), this time assigned according to their epistemological space, are shown in Figure 7.1. In the positivism/empiricism coordinates there represent three tendencies with a regular distribution: determinist geography, quantitative geography and theoretical geography (left apex). Radical geography is the only tendency in the realism/structuralism coordinates (right apex). A group of six tendencies, however, is distributed in the idealism/hermeneutic coordinates: regional geography, spatial-temporal geography, and the so-called post-modern geographies. Finally, in the top apex humanistic geography, idealist geography and perception geography are shown in a rather concentrated pattern.

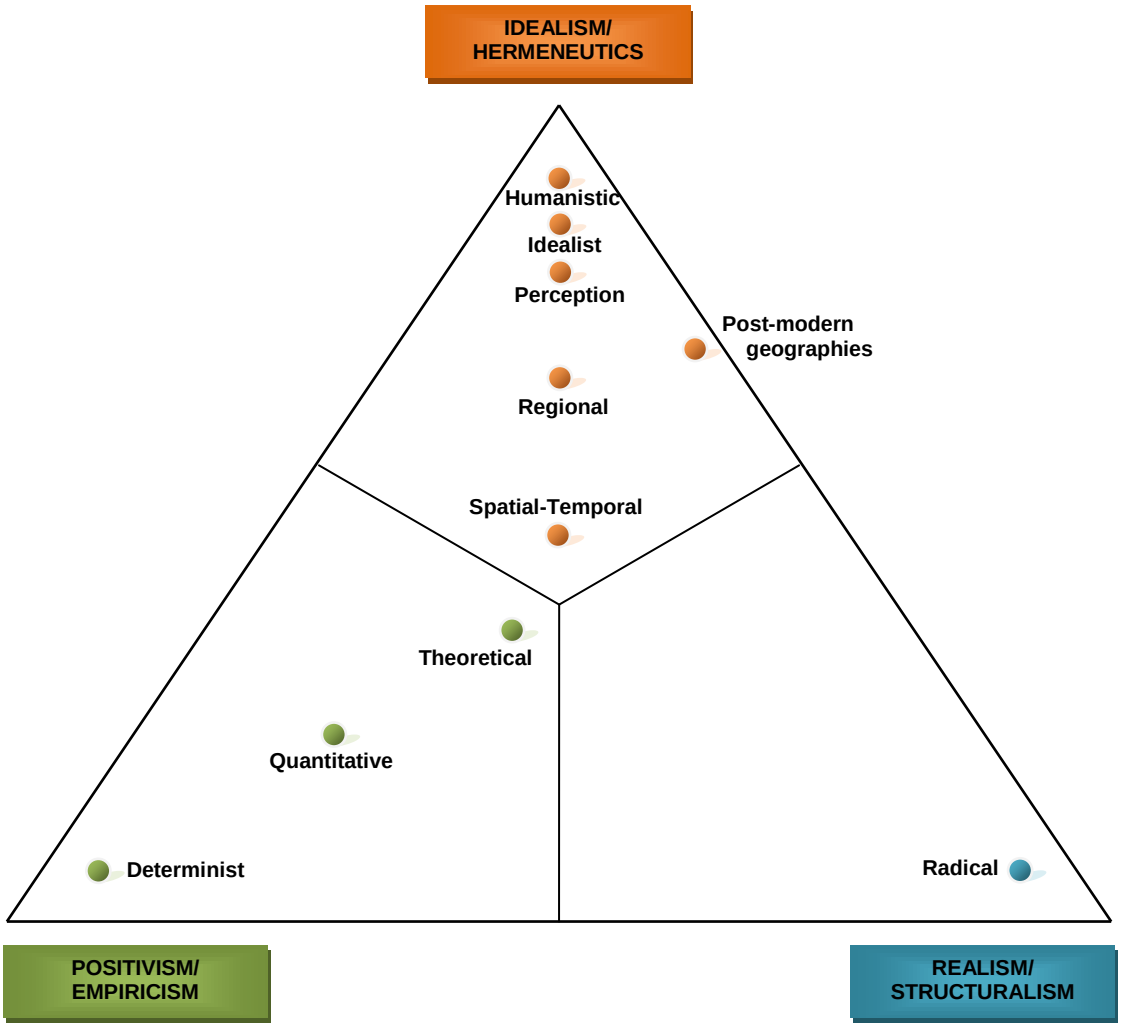

Figure 7.1 Triangular graph of geographic paradigms (or paradigmatic tendencies) according to the epistemological bases of Modernity.

In the following the contemporary tendencies in cartography described in the sections “Tendencies in Contemporary Cartography”, “Critical Cartography in the Context of Post-Modernism” and “Post-Representational Cartography” are analysed the above introduced triangular model with the so-called epistemological coordinates of the modern and post-modern period.

Figure 7.2 is a derivative of Figure 7.1. It depicts the tendencies that were developed during the second half of the twentieth century, the so-called *contemporary cartography*, according to the three approaches belonging to the scientific-empirical perspective. These are the *mathematical*, the *cognitive* and the *semiotic* approaches. Four tendencies are, with a regular distribution, located

inside this epistemological space: *Analytical Cartography* at the mathematical coordinate (left apex), *Cartosemiotics* or *Semiotic Cartography* at the semiotic coordinate (right apex) and *Cartographic Communication* at the cognitive coordinate (top apex) can be located close to the tips of the triangle. The location of *Cartographic Visualisation* corresponds to the cognitive-semiotic approach, according to MacEachren (1995). In this way, a clear separation of the approaches among contemporary tendencies in cartography can be depicted. This will be discussed in more detail in the following section.

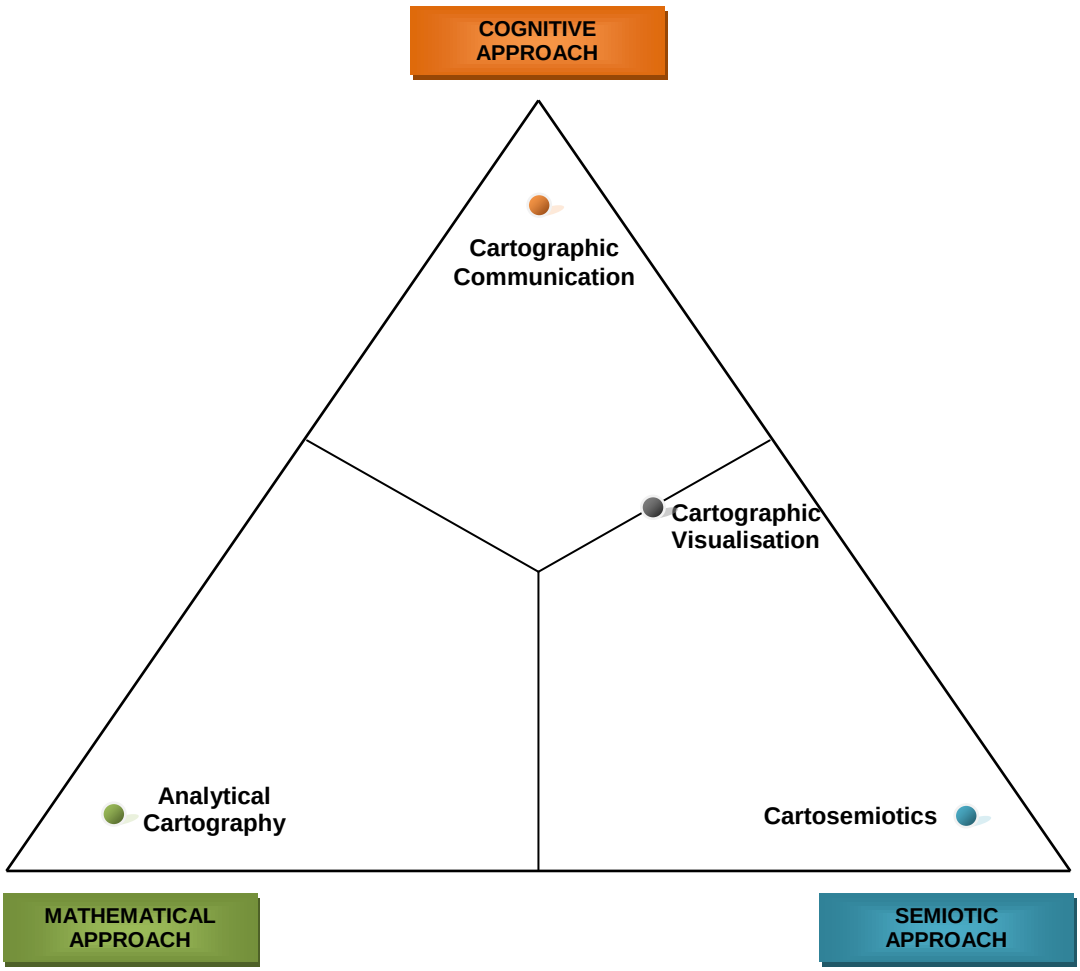

Figure 7.2 Triangular graph showing the paradigmatic tendencies in Contemporary Cartography of Modernism using the scientific-empirical approach.

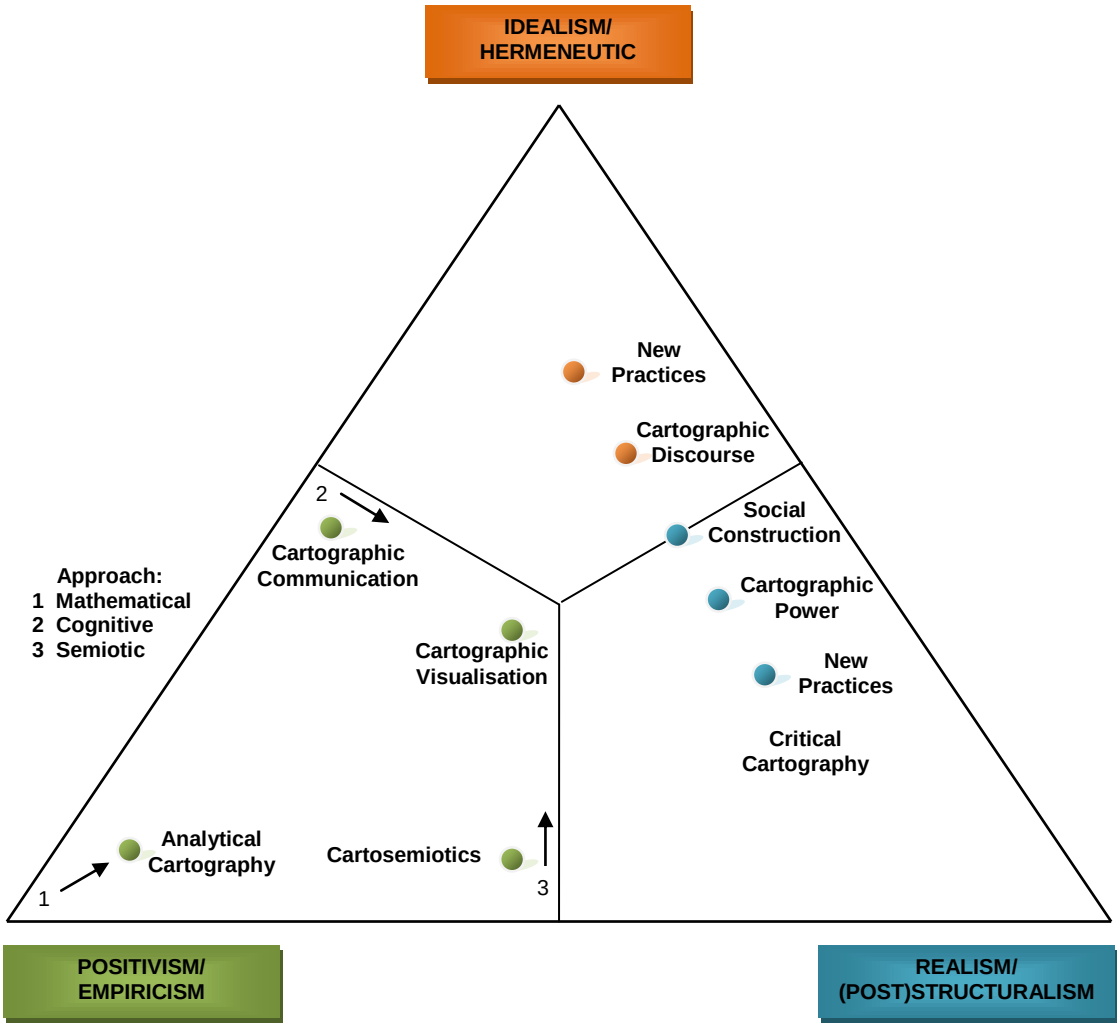

Figure 7.3 Tendencies in cartography during Modernism and Post-Modernism using the scientific-empirical and critical approaches.

Figure 7.3 integrates aspects of Figures 7.1 and 7.2. It shares the epistemological space with Figure 7.1, however, this time the structuralism axis is replaced by the post-structuralism coordinate. *Critical Cartography* which pertains during the post-modern period is included. The scientific-empirical perspective belonging to the positivism-empiricism coordinate of Figure 7.2 has been considered. Inside this perspective three approaches are maintained: mathematical, cognitive and semiotic. Thus, the contemporary tendencies in cartography are situated in this part of the triangular model (left apex). On the right side of Figure 7.3 are, in a concentrated pattern, whose tendencies located which belong to the Critical

Cartography[83]. The *Social Construction* is shown sharing both the idealism/hermeneutic and the realism/post-structuralism spaces. Next to the social construction, the *Cartographic Discourse* is located at the idealism/hermeneutic coordinate and the *Cartographic Power* at the realism/post-structuralism axels. In the same way, the so-called *New (Cartographic) Practices* are considered sharing both the post-structuralism and the hermeneutic coordinates.

A concept similar to that of Figures 7.1 and 7.3 has been applied in Figure 7.4. There, however, the three philosophical-epistemological bases of the modern period have been replaced by the *ontology secure* of map according to Kitchin (2008). This implies a sequence of *ontic-ontological-emergent* levels. Thus, there is an ontic level which is essentialist within the positivism/empiricism coordinates (left apex of Figure 7.4). The ontological level which is focused on a constructivist perspective is, similar to post-structuralism coordinate, located at the right apex. The ontogenesis level which pertains to emergent coordinate (Pickles 2004, Kitchin and Dodge 2007, and Kitchin, Perkins and Dodge 2009) is located at the top apex. According to these authors, the *Representational Cartography* approach would belong to both, the ontic and the ontological coordinates. The new map conceptions that arose during the so-called *Post-Representational Cartography*[84], would belong to the ontogenesis coordinates.

Figure 7.4 also shows that Arthur Robinson's *cartographic communication tradition* and Alan MacEachren's *cartographic visualisation* share ontical and essentialist coordinates (left apex). This fosters by philosophical, ontological and epistemological underpinning the scientific-empirical approach.

Furthermore Figure 7.4 summarises stances stated by authors who draw from social theory and human geography which have been applied to cartography and mapping (right apex). This is the case for John B. Harley's legacy and a group of his followers who belong to critical cartography. In this way John B. Harley, Jeremy Crampton, Denis Wood and John Fels are located in a concentrated

[83] This tendency was analysed in the Section "Critical Cartography in the Context of Post-Modernism".

[84] This approach was analysed in Section "Post-Representational Cartography".

pattern at the centre of the ontical-ontological coordinates. Similarly, there are also some authors in the critical context that can be classified in a transitional stage between the ontical-ontological and ontological-ontogenesis approaches (e.g. Emanuela Casti and Bruno Latour). In this transitional space a group of thinkers including James Corner, Tim Ingold, Vincent del Casino and Stephen Hanna, and Veronica della Dora are also located (right side of figure). They all occupy an intermediate position, with a concentrated pattern between representational and post-representational cartography.

Some other authors consider cartography with a post-representational stance: especially John Pickles who is followed by Rob Kitchin, Chris Perkins and Martin Dodge (top apex of Figure 7.4). Within the epistemological space model, they form a different grouping in respect to other stances. The proposals of these thinkers are under an *emergent knowledge* approach in the ontological-ontogenesis transition coordinates.

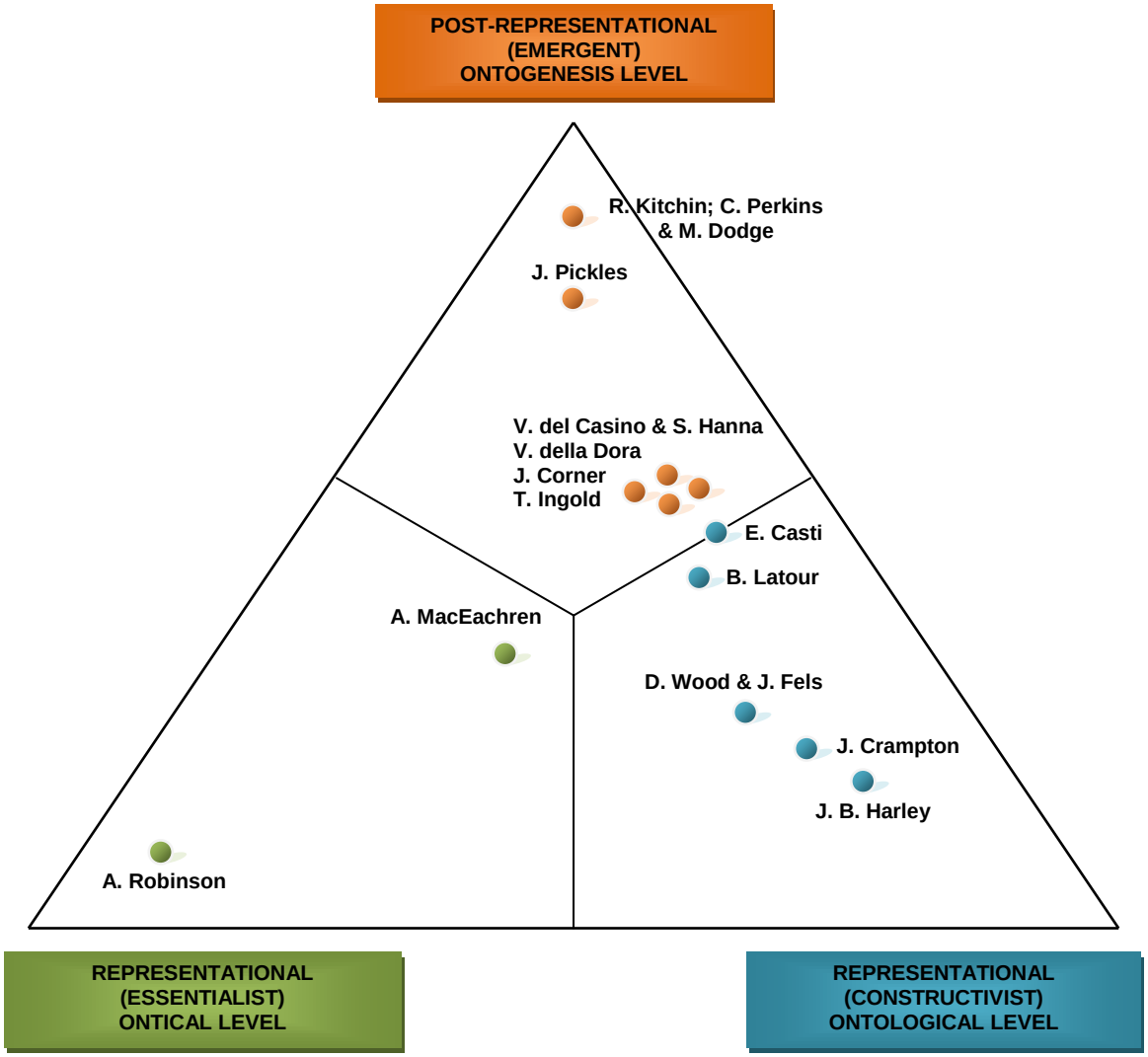

Figure 7.4 Tendencies in cartography during the Modern and Post-Modern Periods making use of representational and post-representational approaches.

To conclude, through the triangular graph presented above it is possible to locate the different cartographic tendencies within the so-called *epistemological space* of contemporary cartography and post-modern period. The distribution of these tendencies inside the figure (concentration-dispersion pattern) permits the identification of some paradigmatic shifts (or their absence), according to the so-called scientific communities of the Kuhnian terminology. This will be discussed in the next section.

8 Scopes for Paradigms in Cartography

8.1 Introduction

This section discusses the results obtained through the use of the “criteria of contrast” and the “tendency distribution in the epistemological space” which were applied to the cartographic tendencies treated in the previous section.

First, some paradigmatic tendencies in cartography are analysed according to the criteria of contrast. The denomination of explicit and implicit paradigms and tendencies made by authors during the contemporary cartographic development is also examined. Second, the transition from the scientific-empirical period to critical cartography is explained through the discussion of the works of representative thinkers of modernism and post-modernism. Here, the body of knowledge in the discipline is highlighted. Subsequently post-representational cartography as a paradigmatic trend (in ontological terms) in comparison to traditional representational cartography is proposed. Then a categorisation of the cartographic tendencies is made, considering three epistemological levels: scientific (essentialist), sociological (constructed) and ontological (emergent). As a result the paradigmatic cartographic tendencies, the scientific-empirical and critical paradigms, and the representational and post-representational paradigms in cartography are obtained. Finally, a return to Kuhn’s thought is used to analyse the scopes and limitations for cartography’s own paradigms. In Kuhnian terms, cartography is a multi-disciplinary field with several internal paradigms, but its consolidation through a real revolutionary change depends on the persuasive power of the cartographic community in its social-scientific context.

8.2 Paradigmatic Tendencies as in Other Sciences (Geography)

8.2.1 Proposed Paradigm Tendencies in Cartography

According to second major hypothesis posed in this study (cf. Section 1), "cartography is considered as a relatively new science in comparison to the physical and social-human sciences". Nevertheless, cartography has a solid theoretical framework in the context of sciences, and can also develop its own paradigm shifts. To verify whether the development of these tendencies in cartography correspond to the paradigmatic trends experienced in the development of modernism and post-modernism, the so-called criteria of contrast are used. The criteria considered in this study are – as already mentioned in the previous section: study object, research aims, methods and techniques (approaches), research results, and cartographic product result (cf. Table 8.1).

Derived from a literature review of contemporary cartographic development, six tendencies are proposed in this study and then applied the criteria of contrast: Cartographic Language (i.e. Cartosemiotic), Cartographic Communication, Analytical Cartography (i.e. Cartographic Modelling), Cartographic Visualisation, Critical Cartography and the so-called Post-Representational Cartography (Table 8.1).

Table 8.1 shows that different *study objects* are established for each tendency. For example, map language/map symbolism, map image/map design, map model, map-use, map content, and the map proper. Along this line, different *research aims* target each tendency. Nevertheless, there are some similarities between Cartographic Language and Cartographic Communication: in both cases the aims are about "rules and generalisation". But in the former one they are used to create symbolism in map language and in the latter one in map design.

Regarding *methods and techniques,* the majority of tendencies uses systematic research methodologies (inherent to sciences and disciplines), but Table 8.1 highlights their *approaches* and the combination of them. For instance, in Cartographic Language we have the linguistic/semiotic approach, and in

Cartographic Visualisation the cognitive/semiotics one. The hermeneutic-deconstructivist and ethnographical-processual approach in Critical and Post-Representational Cartography, respectively, are also considered. According to the nature of the maps, the integration of approaches, instead of some isolated approach, is common. In other words, each tendency uses different approaches according to its research aims and study objects. This means that the tendencies in cartography have different worldviews - in Kuhnian terms - in which distinct study objects lead to different methods and approaches.

Consequently, these different approaches lead to specific *research results* considering maps as study objects. For instance, research results can lead to "representational and conceptual models of the real world" - in the digital environment of Analytical Cartography, in contrast to the "visual thinking and visual communication mapping" of Cartographic Visualisation; or to research results with an internal scope: "graphic mode for expression of geospatially related data" of Cartographic Language, in contrast to the results of a more extended ambit: "maps as social construction and power instruments" of Critical Cartography.

As shown in Table 8.1, each tendency yields specific *cartographic products* like: "cartographic alphabet, grammar, reading and writing" in the Cartographic Language, and "virtual map with spatial deep and surface structural and data levels" in Analytical Cartography. There are pragmatic cartographic products such as "functional and optimal maps effectiveness" in Cartographic Communication, and "synthesis-presentation maps and exploratory-analysis map" in Cartographic Visualisation. There exist also controversial ones like the "historical devices/artefacts context-dependent" in Critical Cartography and "emergent maps" in Post-Representational Cartography.

Table 8.1 Tendencies in contemporary cartography analysed by the criteria of contrast.

TENDENCIES / CRITERIA OF CONTRAST	Cartographic Language	Cartographic Communication	Analytical Cartography	Cartographic Visualisation	Critical Cartography	Post-Representational Cartography
STUDY OBJECT	Map language/ symbolism	Map image/ design	Map model	Map-use space	Map content	Map per se
RESEARCH AIMS	Rules and generalisations in map language	Rules and generalisations in cartographic communication	Analytical modelling and hypothesis testing of mapped phenomena	How map work as visualisation tools	Uncover the power-knowledge practices embedded in maps	How maps emerge through cultural, social and spatial practices
METHODS AND TECHNIQUES (APPROACHES)	Linguistic-semiotics	Perceptual/ cognitive (psycho-physical)	Analytical/ mathematical	Cognitive/ semiotics	Hermeneutic-deconstructivist	Ethnographical – processual
RESEARCH RESULTS	Graphic mode for expression of geospatially related data	Cognitive map-design and map use (map reading)	Representational and conceptual model of the "real" world	Visual thinking and visual communication mapping	Maps as social constructions, and instruments that exert power	Maps in a state of becoming (in process) only existing in the practice
CARTOGRAPHIC PRODUCT RESULTS	Cartographic alphabet, grammar, reading, and writing	Functional and optimal map effectiveness	Virtual map with deep and surface spatial structures and data levels	Synthesis/ presentation maps and exploration/ analysis maps	Historical devices/ artefacts, context-dependent	Emergent maps

In summary, the *criteria of contrast* used in the differentiation of formal and factual sciences, and internal paradigm shifts in geography (cf. previous section), are also useful for the identification of some paradigmatic tendencies in cartography. The six tendencies developed since the 1950s until today show specific differences which can be considered as paradigms of their own. Each tendency has particular features that distinguish it to the others. According to what has been discussed above, cartography has a solid body of knowledge, just as other scientific disciplines such as geography. In turn, the current tendencies can be considered to be paradigmatic stances within the cartographic discipline.

Next, an analysis of the tendencies in cartography according to some of the main authors is discussed. There are authors who belong to or herald a specific trend (e.g. A. MacEachren in Cartographic Visualisation and D. Fraser Taylor in Cybercartography) and others who have analysed the cartographic development such as Peterson (2002), Ramirez (2004), Cauvin et al. (2010) and others. Table 8.2 relates tendencies with the respective authors involved.

Table 8.2 Contemporary cartographic tendencies and associated representative authors.

TENDENCIES / **AUTHORS**	**Cartographic Language**	**Cartographic Communication**	**Analytical Cartography**	**Cartographic Visualisation**	**Critical Cartography**	**Postrepresen-tational Cartography**
R. Ramirez, (2004)	■	■	■	■		
D. Sui & J. Holt, (2008)		■	■		■	
M. Peterson, (2002)		■	■	■	■	
A. MacEachren, (1995)		■		■		
F. Ormeling, (2007)		■	■	■		
R. Kitchin et al. (2007)		■			■	■
C. Cauvin et al. (2010)	■	■	■	■	■	

Table 8.2 shows that Cartographic Communication is mentioned by all the analysed authors. Most authors in cartographic literature consider *Cartographic Communication* to be an explicit paradigm in the discipline. They also mention Robinson's legacy as a cornerstone of the discipline. In other words, Cartographic

Communication is the most important and traditional issue in the development of cartography. Cartographic Language is probably associated with the former; for this reason it is called a tendency only by Ramirez (2004) and Cauvin et al. (2010). Nevertheless, the cartosemiotic body of literature is quite considerable, especially in Eastern Europe and Russia (see Schlichtmann 1999; Wolodtschenko 2011; also Commission on Theoretical Cartography, International Cartographic Association ICA). Recently "Cartographic Language" has been proposed as a new paradigm in the context of hermeneutics for stylistic diversity in topographic maps by Alexander Kent and Peter Vujakovic (for details see Kent and Vujakovic 2011).

Analytical Cartography and Cartographic Visualisation are strong tendencies that have been accepted as paradigmatic shifts by Peterson (2002), Ormeling (2007) and Cauvin et al. (2010). However, Ramirez (2004) only considers them to be cartographic tendencies. The above mentioned analytical traditions are classified as paradigmatic research by Sui and Holt (2008). Furthermore, MacEachren (1995) is considered as a one of the main exponents of Cartographic Visualisation in the 1990s.

In the same sense, associated to visualisation, Cybercartography is presented as paradigm proper by Fraser Taylor (2005). Peterson (2002) also considers Cybercartography as a consolidated paradigm. Nevertheless, Hruby (2011) questions such claims arguing that Cybercartography has not the required characteristic according to Kuhn's paradigm concept. The current study agree with Hruby's critique in the sense that, if criteria of contrast like "study object" and "cartographic products results" are applied; thus would mean that "cybermaps" and "cybercartographic atlases" would be obtained. In this case, the object of study seems to be confused with the results.

In epistemological terms the above tendencies fall within the neo-positivist approach. The map conception conceived in Cartographic Communication, Cartographic Language, Analytical Tradition and Cartographic Visualisation belongs to the so-called *World 3* of the Popper's Three Worlds Theory. The map as a physical device pertains to World 1, but its contents and interaction with the mind of the user (i.e. map-mental image, map model, map language) are located

along the line of works of art, science and technology, and the human language realm. Since all of these are according to Popper a product of the human mind they belong to World 3 (cf. Buchroithner 1997).

Peterson (2002) and Sui and Holt (2008) consider critical cartography as an explicit paradigm which challenges the scientific character of the discipline (as mentioned in Section 4). Whereas for Cauvin et al., (2010) it is an important trend, for Kitchin et al., (2007) it is a starting point from which to formulate their critique on traditional cartography. Of all the authors mentioned, only Kitchin et al. (2007) consider the so-called post-representational cartography as a possible paradigmatic shift in cartography and mapping. This is an interesting intellectual bet that has not been mentioned by authors in recent papers - such as Cauvin et al. (2010) whose revision comprised only until the first decade of the twentieth-first century.

In summary, the six cartographic tendencies shown in Table 8.1 are considered explicit and implicit paradigms, and in some cases only as tendencies by the authors. Peterson (2002), Sui and Holt (2008), and Taylor (2005) mention an *explicit paradigm* in cartography, whereas Ormeling (2007) and Cauvin et al. (2010) point out trends that can be considered to be *implicit paradigms*. Only Ramirez (2004) sets up *explicit tendencies*. The most important aspect is that the adjective “paradigmatic” given to the cartographic tendencies (Table 8.1) by some thinkers in cartography (Table 8.2), is independent of the tendency’s features. In other words, as mentioned above, each tendency has its own features that make(s) it different from the others, independent of whether it is or is not paradigmatic.

It is important to emphasise that several German-speaking authors such as Erik Arnberger; Günter Hake, Dietmar Grünreich and Liquiu Meng; and Gyula Pápay (Arnberger 1970, Hake et al. 2002, Pápay 2005, 2009) do not explicitly mention paradigm shift in cartography, but they belong to the empirical and scientific tradition in the discipline. Similarly Rudi Ogrissek, Wolf Koch, and Ulrich Freitag made important contributions to the theoretical field of cartography (Ogrissek 1987, Koch 1995, 2002, 2004, Freitag 2001). The definition of conceptualisation in

cartography and geomatics builds upon important contributions from Jürgen Bollmann and Wolf Koch (see Bollmann and Koch 2001, 2002).

8.2.2 Distinction between Scientific-Empirical and Critical Approaches

Matthew Edney established a separation between the *empiricist paradigm* and the *critical paradigm* in the historical development of the discipline (Edney 2007). The current study agrees with Edney's proposal and further implies that cartographic language, cartographic communication, analytical cartography and cartographic visualisation constitute the empiricist paradigm posed by him. Additionally, within this perspective (shown in Figure 7.2 of the previous section) three approaches have been identified: the mathematical approach (in Analytical Cartography), the cognitive approach (in Cartographic Communication) and the semiotic approach (in Cartographic Language). Cartographic Visualisation uses a cognitive-semiotic approach.

In this study it is proposed that these tendencies are being consolidated within the empiricist paradigm mentioned by Edney (2007). During the second half of the twentieth century, cartographic tendencies which are autonomous of each other can be recognised.

When the criteria of contrast and the so-called epistemological-space are applied to the tendencies belonging to the scientific-empirical paradigm, they can be recognised as paradigmatic-shifts in Kuhn's terminology (1970). As shown in Figure 7.3 of the previous section, there is a clear separation between the tendencies that belong to the positivism/empiricism coordinates and those in the group formed by social construction, cartographic power and the new practices (i.e. critical cartography). This recent movement is bordered by the idealism/hermeneutic and realism/post-structuralism epistemological coordinates.

Based on the aforementioned statements it furthermore is proposed that the term "empiricist paradigm" can be substituted by "scientific-empirical paradigm". The name "scientific paradigm" is generic - as it is used in many sciences and

disciplines, but intrinsically there exist four paradigmatic cartographic tendencies in Kuhnian terms. The second paradigm (i.e. the critical paradigm) also has a generic name because several social disciplines go under its frame of reference. In cartography, however, specific map conceptions have been suggested in this critical context.

In philosophical and epistemological terms this paradigmatic differentiation is supported by Wittgenstein's philosophy. The statements of the so-called First Wittgenstein Philosophy - the language-world relationship - are in agreement with modern or scientific cartography. The Positivist and Neo-Positivist approaches in mapping go along this line. The majority of tendencies that conceive the map as an "exact reflection of reality" are framed within Wittgenstein's perspective. In turn, in the post-modern context, critical cartography represents Wittgenstein's later legacy in which language aspects are associated with the conception of pragmatic maps. Thus, the critical approach in cartography can also be interpreted in Wittengstein's terms.

These two contrasting paradigms in cartography can be compared with the positivism and historicism (or anti-positivism) stances established by Capel (1983) in the geographic field. The author grouped the diversity of geographic traditions inside these two big tendencies which have a *pendular movement*. Assuming that cartography is a recent discipline - from the second half of the twentieth century - this pendulum movement has only one direction in the discipline: from positivism towards anti-positivism.

If the empiricist paradigm (or paradigmatic tendencies within the scientific-empirical perspective) has been a milestone in the development of cartography, then the transition to the next paradigmatic tendency (i.e. critical cartography) must be taken into account as a contribution to the body of knowledge of the discipline.

8.2.3 Transition from the Scientific Paradigm to the Critical Paradigm

Alan MacEachren suggested a new perspective that was quite opposite to the traditional communication paradigm. He proposed a *representational* view of cartography considering three dimensions: visual perception, visual cognition and semiotics (MacEachren 1995). He identified differences between cartographic representation and visualisation, and proposed two primary-level analyses: public/social and private /perceptual-cognitive.

From a semiotic approach, MacEachren declared that syntactics and semantics belong to the private realm and pragmatics to the public one. In other words, MacEachren's insight is about cartographic representation in a visualisation context with a cognitive-semiotic approach. He further deepened the topic of cartography and mapping as representation of visual communication, through new theoretical and methodological tools.

On the other hand, Thomasz Zarycki suggested a semiotic approach in the study of maps. He critically analysed MacEachren's work on the semiotic perspective in cartography (Zarycki 2001a), concluding that MacEachren did not consider the importance of the pragmatic aspect by emphasizing only the syntactic and semantic dimensions. Zarycki showed remarkable differences between a *semantic map* and a *pragmatic map* which are feasible to be distinguished from an epistemological viewpoint. In other words, both map types are sufficiently different as to establish a different conception of maps.

The aforementioned statement implies that the pragmatic aspect of maps would belong to a different perspective, one that is external to the scientific approach in cartography. This means that the characteristics of a pragmatic map do not correspond to a scientific approach. These maps are far from being objective, secure, neutral and value-free artefacts.

Considering other aspects, Georg Gartner established several differences in the virtual platform context between Web-mapping in Web 1.0 and the semiotics of Web-mapping 2.0. He claims that the major change is a new emphasis in the

semiotic dimensions. Thus the former implies syntactic and semantic approaches, and the latter one a full potential in the pragmatics dimension research (Gartner 2009).

For Gartner “web mapping 2.0 enables the integration of social and technical aspects into models of cartographic communication, and the process of technological change is in itself leading to an important rethinking of mapping” (Gartner 2009: 68). In other words, nowadays there exists both a *collaborative* and a *participative* nature of web mapping in Web 2.0, which was not possible with Web 1.0, allowing in virtual platform environments a change in the research focus during the communication process towards user behaviour and interests.

During the first decade of the twenty-first century, with the big step forward of geo-technologies in the context of the world-wide web, a real democratisation of cartography and mapping occurred. In this context - as shown in Section “Critical Cartography in the Context of Post-Modernism” - authors such as Jeremy Crampton and John Krygier point out the “mapping practices” (Crampton and Krygier 2006) and Chris Perkins refers to “collaborative community mapping” (Perkins 2007). All these practices, which present a major participation of the user, have been consolidated from outside of the scientific-professional field. This heralds a change in focus from the cartographer/mapmaker to the user, in which users themselves can design and construct their own maps.

This democratisation of mapping implies that cartography as a practice has been “liberated” from its academic context. Thus, cartography is no longer the patrimony of professional cartographers, and map design has escaped from the formal and strict rules which have dominated it during the scientific approach period.

Returning to Zarycki’s critiques of MacEachren’s approach, the lack of pragmatic depth in MacEachren’s perspective is due to the fact that it is situated within the scientific-empirical paradigm of cartography. This paradigm does not consider mapping according to a social context as requested in the critical social theory. Rather the semantic map characteristics described by Zarycki belong to the syntactic and semantic dimensions. However, features of the *pragmatic maps* are

according to the *social theory*, which does not share the scientific approach. Thus this new approach is framed in a post-structuralist perspective.

MacEachren's contributions can be considered as the last comprehensive theoretical insight into the scientific perspective in cartography, before it underwent a strong counterweight from the critical paradigm. In fact, his opinion on the lexical approach to map representation through the pragmatic dimension is not sufficient to embed all of the aspects implied. In other words, MacEachren's stance has an epistemological difference that cannot be reconciled with the pragmatic perspective on mapping.

Consequently when Gartner highlights a potential cartographic research in web mapping 2.0 considering the pragmatics dimension, his call is concordant with the current context mentioned by Crampton and Krygier as well as Perkins on mapping practices and collaborative community mapping. Also, there are coincidences between Gartner and Zarycki when the latter one mentions "map making as actions" or when he compares "transmission of information" - the traditional approach in cartography - versus "interaction between map makers and map users".

If pragmatics is considered to be the study of "the relations of signs with their interpreters" (or the relationship between linguistic forms and their users) - according to Morris (1938) cited by Zarycki (2001b), then here it is proposed that the scope of the semiotic approach clearly parallels the democratisation of cartography, where the user has become a key player. Indeed, nowadays there are more and more users designing, creating and interpreting maps. Therefore, within cartographic semiotics (i.e. syntactic - semantic - pragmatic) the pragmatic approach of map representation has become an important element in this triad.

In summary, in this study a transition between the scientific-empirical paradigm and the critical one is proposed. In cartography this stage is analysed by MacEachren's cognitive-semiotic approach of visualisation. Criticism to this approach arose due to the superficial analysis in semiotic cartography, especially of its pragmatic dimension. The emphasis that Zarycki has put on the pragmatic

interpretation in mapping concerns its semiotic dimension. This perspective is closer to the critical paradigm. Similarly, from a technological context this stance is empowered by Gartner's posture on the social dimension in the currently distributed digital tools used in mapping and cartography.

This transition can be interpreted as a crisis or revolution in Kuhnian terms and this great change brings a renovation in map conceptions. For example, the statement that the "map as an *objective*, *scientific representation*" or the "map is *transparent* and ideologically *neutral*" – as in the traditional scientific cartography – is changed to conceptions such as "maps as an ideologically *laden representation*" (Harley 1989) or the "map as an *historical product* operating within a certain *horizon of possibilities*" (Crampton 2003).

Additionally, Harley's legacy, and his drawing from both Foucault's power-knowledge relationships and Derrida's hermeneutics approach applied to maps, has opened discussions for new developments and insights in cartography. Thus, at the end of the twentieth century these new map conceptions, supported by information communication technologies, give an account of alternative and radical visions which can be considered to be a paradigmatic shift.

8.2.4 Post-Representational Cartography: A Paradigmatic Proposal

The transition between the Scientific-Empirical Paradigm and Post-Representational Cartography, or between critical paradigm and the latter one, is not yet clear enough, but attempts have been made to clarify it. In his analysis of mapping practices Rob Kitchin compares different map ontologies, and states that the works by Denis Wood and John Fels are a transition between John Brian Harley's critical cartography and that of Rob Kitchin and Martin Dodge who are representatives of this new proposal, the so-called post-representational cartography (see Kitchin 2008). This transition from an *ontologically secure map* - taken for granted from the time of Arthur Robinson to that of John B. Harley - to the *ontologically insecure mapping* – was analysed in detail in Section "Post-Representational Cartography".

The proposal for a post-representational cartography was first set forth by John Pickles and was then further elaborated by Rob Kitchin, Chris Perkins and Martin Dodge (Pickles 2004; Kitchin et al. 2009). In Figure 7.4 of the previous section the tendency of post-representational cartography is located along the emergent coordinates (ontogenesis level) within the epistemological space. This figure also shows some authors who can be considered transitional between the constructivist approach and the emergent one, such as Emanuela Casti, Bruno Latour, Veronica della Dora, James Corner, Tim Ingold, Vincent del Casino and Stephen Hanna. Indeed, these authors are located in a transition zone from a critical paradigm to the post-representational stance.

When analysing the criteria of contrast proposed earlier in this study, the cartographic tendencies from cartographic language to critical cartography have an implicit common feature: they refer to an *ontologically secure map* (cf. ontological level in Table 8.3). Therefore, representational cartography conceived as a set of scientific and critical tendencies receives validation in an ontological sense.

According to the cartographic tendencies identified in this study (cartographic language, cartographic communication, analytical cartography, cartographic visualisation, and critical cartography), post-representational cartography goes beyond the distinction between the empiricist paradigm and the critical paradigm. So, the new cartographic practices mentioned by social theory authors (e.g. counter-mapping, ethno-cartography, collaborative mapping, cf. Table 5.1 Section 5) can be located outside the framework of cartographic representation. In this way, post-representational cartography considers that the map is ontologically insecure, meaning that the map is *emergent* and *mutable* depending to the context.

Post-representational cartography led to a rethinking about maps, both ontologically and epistemologically. Several map conceptions conceived during the post-modern period of the discipline such as “maps as inscriptions or maps as unstable and complex texts” (Pickles 2004), or “maps as spatial practices that do work in the world”, and “maps as suite of cultural practices involving actions and

affects" (Kitchin and Dodge 2007) are examples of the rethinking about maps that has been mentioned above. All these map conceptions are opposite to the traditional conceptions, i.e. those of the scientific approach (Table 5.2 in Section 5) exemplified by "map as an objective, scientific representation", or "maps are transparent and ideologically neutral", in other words: "maps as truth".

8.3 Paradigms in Cartography: An Epistemological Review

8.3.1 Returning to Kuhn

When the results of the application of the criteria of contrast (listed in Table 8.1) are analysed six stances in cartography can be considered as paradigmatic tendencies. In Kuhnian terminology, this may imply that each stance is a *normal science* period. From an epistemological perspective, if the analysis is carried out at a scientific level (with essentialist features) then four of these tendencies will be paradigmatic. These are: cartographic language, cartographic communication, analytical cartography and, cartographic visualisation (Table 8.3). It is, however, important to note that this is an analysis at the *internal level* of the discipline. In other words, as a scientific discipline or in scientific terms, during the second half of the twentieth century cartography shows four paradigms.

Thomas Kuhn highlighted the sociological character of the paradigm theory. For him, the scientific activity is one that takes place within a set of discourses. This statement can be related to Wittgenstein's term: "language games". Thus, the scientific discourse is one more language game within a myriad of games e.g. political, religious, cultural, etc. Here, Wittgenstein considered the social realm when referring to the different games, leading to a sociological level (being socially constructed).

The traditional paradigmatic tendencies in cartography could now be grouped in a context called scientific-empirical paradigm because of the emergence of the critical approach. This critical paradigm arose from outside of the cartographic scientific community and criticised the epistemological, philosophical and methodological basis of all the previous tendencies. In Kuhnian conceptualisation this is a critical paradigm, which by criticising the previous tendencies, leads the discipline to become Critical Cartography. Therefore, in *sociological terms* cartography contains two paradigms: a critical paradigm in opposition to the scientific-empirical paradigm (cf. Table 8.3).

Thus, in agreement with Edney (2007), a paradigmatic shift between the scientific-empirical and the critical stances is proposed. Edney affirms that in the history of contemporary cartography these two paradigms can be found: empiricist and critical. It is also proposed that within the scientific community (considering the scientists in the social theory) there exists a transformation of the world view as pointed out by Romaniuk and Paillalef (2010) who pose a change in the worldview not only because of changes in the modes of speaking, seeing and knowing the world, but also a change in the modes in which problems arise and the modes of work, rules, instruments and techniques.

The aforementioned implies that a transition or revolutionary break between the scientific perspective and the critical one shows the following changes (cf. Table 8.1). For instance, “map content” as a study object is a new way of understanding the world through cartography and mapping. In this way, uncovering the power-knowledge practices embedded in maps – as new research aims - is another mode of seeing and of speaking about the world. Similarly, the use of hermeneutic and deconstructivist approaches – posed by postmodernist thinkers like Foucault and Derrida - is another mode of using rules, instruments and techniques of work. These new modes become an alternative to the scientific-empirical perspectives.

This new vision conceives the map as a “social construction and as an instrument that exerts power” (Harley 1989). There develops a new alternative of knowing the world in a reliable way using the map as a context-dependent device or artefact. This means that between the scientific-empirical paradigm and the critical paradigm there has been a *transformation* in the worldview in which different problems, lexical, ontological, gnoseological, methodological and also practical assumptions have arisen during the last two decades, especially in the Western culture.

The concept of *incommensurability* developed by Kuhn is also applicable to this new way of conceiving cartography, therefore conceptions, methods and techniques inherent to the scientific paradigm are incompatible with critical cartographic conceptions. This must be interpreted in a different logic regarding scientific cartography for a better understanding of the critical literature in

cartography and mapping. Paraphrasing Kuhn: “even though practitioners of both paradigms are looking at the same data (in this case, at the *same map*), they see different worlds”.

This study proposes that, considering an ontological level of analysis, a post-representational paradigm is arising in opposition to the representational perspective (shown in Table 8.3).

Post-representational cartography arose from the emergent perspective developed by Kitchin and Dodge (2007), and Kitchin et al. (2009). This study agrees with these authors and adds that this stance can be interpreted as a revolutionary change which challenges traditional cartography as a *representation of the world.* Indeed, this new perspective goes beyond the “map content” as the study object. Post-representational cartography analyses the “map itself”; i.e. how maps emerge through cultural, social and spatial practices framed in an ethnographical-processual approach drawn from social theory.

Table 8.3 Cartographic tendencies associated to paradigmatic shifts according to epistemological levels.

CARTOGRAPHIC TENDENCIES	Cartographic Language	Cartographic Communication	Analytical Cartography	Cartographic Visualisation		
ESSENTIALIST (SCIENTIFIC LEVEL)	PARADIGMATIC TENDENCIES					
CARTOGRAPHIC TENDENCIES	Cartographic Language	Cartographic Communication	Analytical Cartography	Cartographic Visualisation	Critical Cartography	
CONSTRUCTED (SOCIOLOGICAL LEVEL)	SCIENTIFIC-EMPIRICAL PARADIGM				CRITICAL PARADIGM	
CARTOGRAPHIC TENDENCIES	Cartographic Language	Cartographic Communication	Analytical Cartography	Cartographic Visualisation	Critical Cartography	Post-Representational Cartography
EMERGENT (ONTOLOGICAL LEVEL)	REPRESENTATIONAL PARADIGM					POST-REPRESENTATIONAL PARADIGM

Like in the history of physics there was the Newtonian physics replaced by Einsteinian relativistic physics (what Kuhn considers a paradigmatic shift), a new proposal which challenges the representational conception - inherent to cartography and to the map as “knowledge of the world” - can be applied to the cartographic discipline. The difference with previous proposals is that the post-representational paradigm targets the ontological bases of the discipline. Traditionally, these knowledge ways - or ontological bases - had only been considered under positivist and neo-positivism perspectives and were key aspects during modernity. However, these ontological bases are now being analysed in a post-modern and poststructuralist context.

In summary, in this study the paradigms in contemporary cartography have been analysed in a Kuhnian sense, and different epistemological levels have been proposed. At the first level in the essentialist perspective - denominated *scientific level* - four cartographic paradigms are established. This is a local or internal level within the discipline, in which all paradigmatic tendencies are different from each other. This refers to the traditional body of knowledge of the discipline in scientific terms. In the second level, denominated *sociological level*, a constructivist perspective is assumed in a social context. This is an intermediate level in which a new cartographic discourse in opposition to the scientific one arises. Thus two paradigms that oppose each other are established: the critical paradigm and the scientific-empirical paradigm. Finally, the third level - called *ontological level* - considers an emergent perspective of knowledge. This is an external level that goes beyond the scientific and sociological stances. In consequence, the critical paradigm and the scientific-empirical paradigm are merged, because both worldviews share an ontologically secure map. Thus, the post-representational paradigm arises as a new ontological proposal. As a result, two new paradigms are proposed: a *Representational Paradigm* and a *Post-Representational Paradigm*, which correspond to the modern and post-modern periods in cartography, respectively. Thus, the post-representational paradigm arises as a new ontological proposal in cartography in opposition to the representational tradition.

8.3.2 On the Scope for Cartographic Paradigms

Three aspects can be integrated to analyse the concept of paradigm in cartography. First, the character of science or discipline of cartography has been extensively discussed. Independently of its status, according to Garcia-Sierra (1999) the term *disciplinary communities* (i.e. cartographic disciplinary communities) can be used instead of *scientific community* (i.e. cartographic scientific community). Second, two paradigms can survive side-by-side at the same time (Hall 2006). Third, a paradigm is what is shared by members of a disciplinary community in general, of which science is just one more community (Kuhn 1970).

Additionally, a paradigm is a conceptual tool which is applicable to the sciences and disciplines across their philosophical, epistemological, sociological, historical, methodological and practical bases. This implies that all scientific and disciplinary communities have generic paradigms, but the name or adjective given to the paradigms is related to the subjects and contents embraced by the specific field of knowledge. In this sense, there are no paradigms that are strictly unique to each discipline or science. The name or adjective of the paradigm is related to the subjects and contents embraced by the specific field of knowledge.

The period of the discipline's development analysed is brief when compared to that of the physical and social sciences, which have had a more extended theoretical and practical development; it encompasses only six decades. Nevertheless, scientific cartography and mapping have their bases in the positivist period of the eighteenth century. This period covers a historic interval from modernity to post-modernity. In this way, this period is enough to appropriately frame the discipline under the three bases of modernism and post-modernism (philosophical, epistemological and ontological). Therefore, as this cartographic period straddles the modern and post-modern periods, differences in its development can be established.

In this way, considering the development of cartography and mapping in an epistemological perspective, three *paradigmatic-shifts* in Kuhnian terms can be

distinguished: a scientific-empirical, a critical and a post-representational paradigm. The *scientific-empirical paradigm* of the discipline is consolidated in contemporary cartography by the following internal paradigmatic tendencies: cartographic language, cartographic communication, analytical cartography and, cartographic visualisation. Similarly, in a *sociological context*, the critical approach has all the features to be considered a *critical paradigm* opposing the scientific paradigm. Finally, in *ontological terms* a *post-representational paradigm* is proposed in open opposition to the representational tradition (including the critical and scientific-empirical paradigms).

In summary, in addition to the three *paradigmatic-shifts* mentioned above, four paradigms can be proposed in an *internal scientific context*: cartographic language, cartographic communication, analytical cartography and, cartographic visualisation. Two paradigms are defined by *sociological context*: scientific-empirical paradigm and critical paradigm. And two paradigms are established according to *ontological terms*: representational cartography and post-representational cartography.

The above proposal is based upon Kuhn's statements. Which paradigmatic stance will be consolidated? According to Kuhn a paradigm is dependent on the sociological context; it is dependent on the historical force of its discourse; it is dependent on the solidity of the disciplinary community. In other words, the consolidation of paradigms materialises through the persuasive power of the social acts. So, in the case for the consolidation of paradigms in cartography, this will depend on the persuasive power of the cartographic communities.

9 Conclusion

9.1. Insights

In this study the *philosophical* and *epistemological* bases of cartography during its contemporary development were analysed. During modernity, cartography as a scientific discipline gave rise to several *map conceptions* under the positivism-empiricism and neo-positivism frameworks. Nevertheless, current map conceptions have also been influenced by post-modernist and poststructuralist perspectives.

From a philosophical perspective, the investigation showed that there is a link between Wittgenstein's philosophy and cartography. His philosophical contribution and legacy, the first philosophy (language-world relationships) and the second one (language games), can be compared with the modernist and post-modernist cartographic development respectively. This means that within the first period, cartography followed strict rules to achieve *formal statements* and *generalisations* (i.e. semantic maps), whereas during the second period cartography and mapping *went beyond academic discourse* and attempts in the understanding of reality considering different social contexts (i.e. pragmatic maps). In other words, the positivist/neo-positivist approach and the critical approach in mapping can be interpreted in Wittgenstein's terms.

In the context of the neo-positivism approach, this study also contended that Popper's Three Worlds Theory is linked to cartography and maps. The construction of new realities through maps (ontological approach), and the information - transfer model of maps (cognitive approach) give account of elements belonging to *Popper's World 3*. For Popper, the so-called third world is the world of the contents of thought and the products of the human mind. Cartographically, products such as "map mental images", "map model" and "map language" fall into this category. These objects are *as real as* the objects belonging to the world of physical objects (i.e. "map device"). Additionally, the distinction between phenomena-representations (P-reps) and concept-

representations (C-reps) in the context of visualisation (from Ganter, cited by MacEachren 1994) also fall into this categorisation. The former ones are intended to represent the physical world (i.e. World 1) and the latter ones refer not to a thing (a physical object) but to an idea (i.e. World 3).

From an epistemological viewpoint of the history of sciences, the development of cartography can be seen under the *scientific revolution* stance and/or *normal science* periods according to the *paradigm* concept of Thomas Kuhn. This implies that cartography - as a way of knowledge - conceives a *worldview* according to the historical-social context. So, cartography is integrated by a scientific or disciplinary community, in which one or two paradigms are shared by the members of this community. In sociological terms, if cartography and mapping are considered as part of a scientific discourse, then they are a way (arbitrary) of knowledge for understanding reality.

The study reviewed the state-of-the-art in cartography and mapping from the second half of the twentieth century until today. This review revealed that some authors and theoreticians consider trends, perspectives and approaches as *explicit paradigms*, some as *implicit paradigms*, or simply termed them *tendencies*. It is proposed that the development of tendencies in cartography is framed in the philosophical and epistemological fundamentals of modernity and post-modernity: i.e. positivism and empiricism, neo-positivism (logical positivism) and post-structuralism. In this way, cartographic tendencies (paradigmatic or not) are concordant with the evolution of the scientific thought and the social context. On the one hand, traditional trends like cartographic communication, analytical cartography and cartographic visualisation arose under the *positivist* and *neo-positivist perspectives* of modernity, on the other hand, critical cartography arose in the *post-modernist context*.

In this way, the first hypothesis is confirmed. An internal analysis of the contemporary tendencies in cartography and mapping allows the comparison with evolutionary scientific knowledge and development of sciences and disciplines in the context of philosophical and epistemological periods of modernity and post-modernity.

9.2. Achievements

In a methodological attempt, this study examined scopes for paradigms in cartography through the application of “criteria of contrast” and “tendency distribution in the epistemological space”. The “criteria of contrast” implies the analysis of cartographic tendencies according to criteria such as: study object, research aims, methods and techniques or approaches, research results, and cartographic product results. The “tendency distribution in the epistemological space” considered cartographic tendencies under positivism-empiricism, realism-structuralism, and idealism-hermeneutic epistemological coordinates (adapted from Sheppard 2005).

Both indicators mentioned above allow us to consider the traditional cartographic trends as *paradigmatic tendencies* in Kuhnian terminology. According to the criteria of contrast, each tendency is different to the other. Similarly, within the epistemological space some tendencies are grouped, whereas others remain isolated. This implies that the tendencies are framed in different epistemological and philosophical perspectives. In a first approximation the tendencies in contemporary cartography analysed by the criteria of contrast are: cartographic language, cartographic communication, analytical cartography, cartographic visualisation, critical cartography, and post-representational cartography.

A second approximation was made by analysing cartographic tendencies in *three epistemological levels* (adapted from Kitchin 2008): *scientific* (essentialist or ontic), *sociological* (constructed), and *ontological* (emergent). First, at a *scientific level*, four paradigmatic tendencies were identified: cartographic language (cartosemiotics), cartographic communication, analytical cartography (cartographic modelling) and cartographic visualisation. These are internal paradigms considering cartography as *scientific discipline*. Then, two paradigms are identified at a *sociological level*: a scientific-empirical paradigm (which incorporates the aforementioned paradigmatic tendencies) and a critical paradigm. According to Kuhn, the scientific activity is one more discourse within a “Universe of Discourses”. Critical cartography arises as a paradigm in open opposition to the traditional scientific discourse that had been taken for granted in the discipline

during the first half in the twentieth century. Finally, at an *ontological level*, the ontological security of maps is questioned, with post-representational cartography arising as a new perspective in opposition to the representational tradition. Cartography as representation is implicitly incorporated into conceptions belonging to the empiricist and critical poses. In this way, two paradigms are suggested in Kuhnian terms: the representational paradigm and the post-representational paradigm.

In summary, according to these epistemological levels (scientific, sociological, and ontological) cartography and mapping present three paradigmatic-shifts: *scientific-empirical*, *critical* and *post-representational*. In Kuhnian terminology, a paradigm is justified and understood considering the conditions previous to the change. In this case, the post-representational paradigm in cartography has validity respecting the representational tradition (composed by critical and scientific perspectives). A critical paradigm in cartography is validated in opposition to the empiricist perspective. In turn, the scientific-empirical paradigm is constituted by internal and traditional cartographic tendencies (as described above).

The aforementioned statements allow the confirmation of the second hypothesis of this study. Although cartography is considered a relatively new science in comparison to the physical and social-human sciences, it has a solid theoretical framework in the context of sciences, and can also develop its own paradigm-shifts within Kuhn's scientific revolutions approach.

9.3. Outlook

9.3.1. Suggested improvements

The proposal suggested regarding paradigmatic tendencies in cartography and mapping can be refined especially when more extended scientific and disciplinary communities are considered. In the same way, the proposal of post-representational cartography as a paradigmatic-shift has to be continued.

A deep revision about the authors' underlying thinking in cartography is suggested. This intellectual task will help to locate thinkers and theoreticians in some paradigmatic tendencies. For instance, in this study the discussion of Zarycki's critique (2001a) to MacEachren's approach to map semiotics, makes sense when both statements are considered to belong to different paradigms or to a transitional stage between two paradigmatic visions.

Kuhn's concept of paradigm can be reviewed and analysed backwards in the history of cartographic representations. The current study was limited to the scientific-academic period of the discipline as it only encompasses a period of time beginning during the second half of the 20th century. There exists, however, a detailed history of cartography documented by John B. Harley and David Woodward (1987), and Matthew Edney (2006) among others. These contributions could be used as a conceptual framework for a revision in Kuhnian terms.

Finally, the links between the development of cartography and the development of philosophy and epistemology must be highlighted with additional theoretical research. This will help to strengthen the body of knowledge of the discipline.

9.3.2. Concluding remarks

The theoretical statements proposed in this study complement and go beyond technological issues in cartography and mapping. As an example, during the recent 25th International Cartographic Conference (ICC-Paris), Quansheng Du (2011) posed that theoretical cartography can contribute to GIScience from a philosophical perspective, i.e. ontological, epistemological and linguistic/semiotic aspects. This is a good example of complementary contribution. In a second case, Joel Morrison (1986) argued for a cartographic revolution in the 1980s. He claims "whether the technological revolution will lead to a more profound philosophical revolution, or even to philosophical evolution, remains to be seen" (1986: 183). He concluded that revolution is one of technology *not philosophy*. Today, we are also witnessing impressive changes which can be considered as a *new technological revolution* in the history of the discipline. For instance, the current context of information communication of technology (ICT) like web-mapping 2.0, location-based services (LBS), and 3G telecommunication, have had strong implications upon cartography. Therefore, answering to Morrison's statement, now is the time that technological revolution addresses to a *philosophical* - and *epistemological* - revolution in cartography. The theoretical aspects of this study emphasize these points of view.

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