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SECTION FOR CARTOGRAPHY

CARTOGRAPHY IN CROATIA 1991 - 1995
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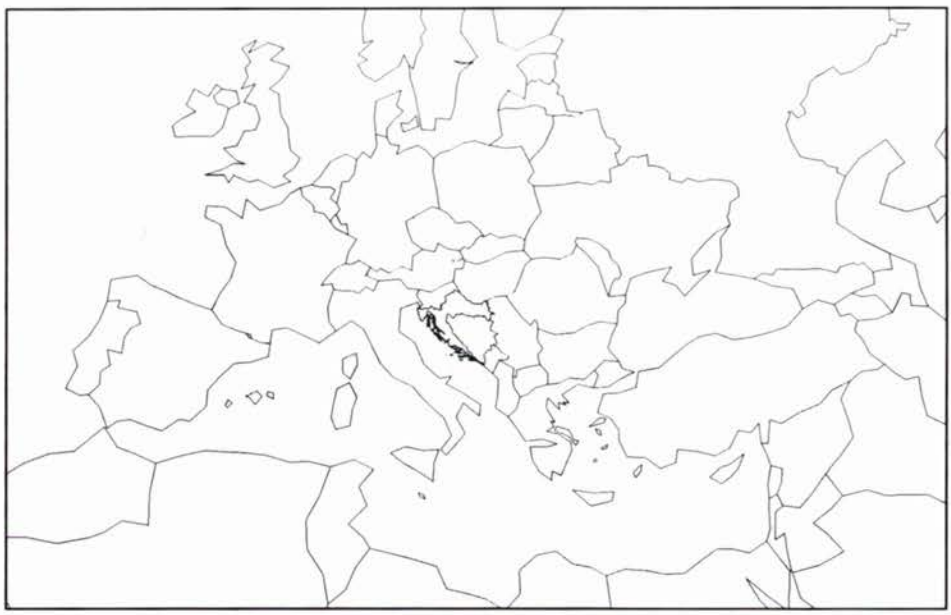
to the International Cartographic Association



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CARTOGRAPHY IN CROATIA 1991 - 95

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1. INTRODUCTION

On 25th June, 1991 the Parliament of Croatia took a decision to break all the relations with Yugoslavia and declared Croatia to be an independent and sovereign state.

The Union of the Geodetic Societies of Croatia decided on 12th November, 1991 to detach itself from the Union of geodesy engineers and surveyors of former Yugoslavia, and on 25th May, 1993 Croatian Geodetic Society was founded. Within the scope of the Society there was also the Section for Cartography founded, which gathers all cartographers from Croatia. Through the Section for Cartography, Croatia is this year, here in Barcelona, becoming a member of the International Cartographic Association.

Since Croatia appears this year for the first time with the national report at the International Cartographic Conference, it is inevitable to mention a few fundamental data on maps that Croatia has at its disposal, on cartographic institutions and their activity.

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2. OFFICIAL CARTOGRAPHY

The production of topographic and cadastral plan at the scales of 1:500, 1:1000, 1:2000 and 1:2500 and of the Croatian state map at the scale of 1:5000 was conducted in Croatia by the Administration for Geodetic and Cadastral Affairs being the integral part of the Ministry for Civil Engineering and Environmental Care. This Administration was thus renamed into the State Geodetic Administration which is competent, among other things, also for the official cartography. Similar as the previous Administration, this new State Geodetic Administration has got no productive section. The official plans and maps in Croatia are mostly produced in the Photogrammetric Company in Zagreb, in the Geodetic Company in Rijeka, Geodetic Company in Split and Geodetic Company in Osijek, on the basis of the order submitted by the State Geodetic Administration.

Today the State Geodetic Administration has got within its competence also the production of topographic maps at the scale of 1:25 000 and smaller scales, which used to be under the authori-

ty of Military-geographic Institute in Belgrade. The military cartographic office is organized within the frame of the Administration for Civil Engineering in the Ministry of Defence of the Republic of Croatia, as an administrative section, as well as in Headquarters of Corps Areas, in the Navy Headquarters of Croatia and in the Air Force Headquarters, as an operative section. The systematic work on the geotopographic protection of the Croatian Army started at the beginning of the year 1992 by establishing the Geodetic Department in Ministry of Defence.

In March 1992, a meeting was held in Ministry of Defence with the competent geodetic and cartographic experts in the Republic of Croatia with the purpose of finding optimal solution to the problem of providing the maps and other data for the Croatian Army (Horvat, 1995).

2.1. Topographic and cadastral plans

Today's topographic and cadastral plans are available only for one fifth of the state territory and they are made at the following scales:

- 1:500 for old city centres and certain smaller areas
- 1:1000 for towns and larger settlements
- 1:2000 and 1:2500 for poorly built-up and agricultural area.

For the remaining part of the state territory there are still only cadastral plans at the scale of 1:2880 (exceptionally 1:2904) originating from the graphical survey made in the last century at the territory of the Habsburgs Monarchy of that time. The cadastral plans of the graphical survey do not have the representation of relief.

The contents of the topographic and cadastral, and especially cadastral plans, do not reflect always and in everything the real situation in the field because of not being regularly updated.

2.2. Croatian State Map 1:5000

Croatian State Map at the scale of 1:5000 has been made in the last thirty years for more than 70% of the territory of the Republic of Croatia. Large part of the material has become obsolete, because so far not much attention has been given to its maintenance and updating.

The Photogrammetric Company from Zagreb, having 80 employees specialized for performing all tasks within the area of photogrammetry, has made 18 sheets of the Croatian state map 1:5000, ordered by the State Geodetic Administration, using digital methods and in collaboration with the firm GEOFOTO. The map sheets are made on the basis of the photogrammetric survey at the scale of 1:10 000 and processed by means of photogrammetric stereo-instruments using the software Microstation.

2.3. Topographic and general maps

From the period of the First World War the cartographic activity has been connected with the military institutions outside of Croatia, so that all publications of topographic maps stated below, belong to the production of the Military-geographic Institute in Belgrade. Topographic maps up to the scale of 1:300 000 inclusively, are made in Croatia in 3° zones of the Gauß-Krüger projection. The scale at the central meridian is 0,9999.

Further in the text, there are the data about the topographic maps of Croatia. The map contents of single parts of Croatia reflect the situation of the landscape according to the years given in parenthesis (State Geodetic Administration 1995):

Topographic map 1:25 000 (TK 25):
- South Dalmatia, from Makarska to Prevlaka, (1971 - 1973)
- Istria, Gorski kotar and the territory of Kvarner (1974 - 1976)
- border with Slovenia (1984 - 1986)
- the rest of the territory (1977 - 1979).

Topographic map 1:50 000 (TK 50):
- Istria, Gorski kotar, Lika and northern Dalmatia (1978 - 1979)
- border with Slovenia (1985 - 1986)
- the rest of the territory (1980 - 1981).

Topographic map 1:100 000 (TK 100):
- West Croatia (1979 - 1981)
- East Croatia (1982 - 1984).

Topographic map 1:200 000 (TK 200):
- East Croatia (1984)
- West Croatia (1985).

General map 1:300 000 (PTK 300) (1984 - 1985).
General map 1:500 000 (in Lambert's conformal conical projection, 1989).

For all above mentioned maps from the scale of 1:25 000 to 1:500 000, the publishing and fair draughts can be found in Military-geographical Institute in Belgrade, and Croatia has only a definite number of printed maps. Therefore the State Geodetic Administration ordered at the end of 1994 the elaboration of the Study on the substitution of fair draughts and renewal of topographic maps which will be finished in June this year, suggesting new method for updating and reproduction of the topographic maps. The elaboration of the study is lead by the firm GEOFOTO from Zagreb in collaboration with the Faculty of Geodesy from Zagreb, Landestopographie from Bern, ITC from Enschede and the Photogrammetric Company from Zagreb (Gojčeta 1995).

On the basis of the suggestion given by the Faculty of Geodesy, the Ministry of Defence of the Republic of Croatia initiated the action for the purpose of facsimile publishing the topographic maps by scanning them for the four-colour print. So far this method has been used for processing and printing 313 sheets TK 25, TK 50 and PTK 300 for the area of Croatia and Bosnia and Herzegovina. This method is not used for making true facsimiles, because the following items are changed:
- the entire marginal information
- the names of the sheets according to the new sheet index
- the names of single settlements and objects in coordination with Croatian language.

Apart from that, the border between the Republic of Croatia and other states established after the disintegration of Yugoslavia has been added.

Furthermore, Ministry of Defence has published the sheet Korčula 1:300 000, which has been scanned and raster-to-vector transformed in nine separate layers according to the number of colours on the map.

In order to make it possible for the military cartographic system to meet the requirements of Croatian Army in the future, certain cartographic preparations have been performed or are being performed at the moment:
- a book of reference Topografsko znakovlje (Topographic symbols) has been made in the classical and digital form
- a single-colour scanning of the existing maps at the scale of 1:25 000 and 1:200 000 has been made with the resolution of 300 dpi for the area of Croatia and Bosnia and Herzegovina

- the satellite SPOT data have been provided for the area of Croatia and Bosnia and Herzegovina (46 scenes), that can be used as the sources in updating the maps (Horvat, 1995).

2.4. Nautical charts

The only institution which makes and publishes the nautical chart in Croatia is the Hydrographic Institute of the Republic of Croatia. After the Second World War, the Hydrographic Institute has made and published the following nautical charts (Lovrić 1988):

- harbour and passage plans at the Adriatic Sea at the scales of 1:3000 till 1:20 000,
- a series of coastal charts of the eastern Adriatic coast, in which the majority of charts are made at the scale of 1:80 000, and some charts at the scales of 1:60 000, 1:50 000 or 1:40 000,
- a series of 16 coastal charts at the scale of 1:100 000, which make navigational unities,
- a series of sailing charts at the scale of 1:200 000 of the Adriatic and Ionian Sea, in which the map of Malta is at the scale of 1:300 000,
- a series of 7 sailing charts of the Adriatic Sea at the scale of 1:750 000,
- general chart of the Adriatic Sea at the scale of 1:1 000 000.

2.5. Thematic maps

The most significant thematic maps which are made for the whole territory of the Republic of Croatia are the Fundamental geological map at the scale of 1:100 000, the Fundamental pedological map at the scale of 1:50 000, Vegetation map at the scale of 1:100 000 and Geomorphological map at the scale of 1:100 000.

This maps were made on the basis of field mapping, usually at the scale of 1:25 000, and then, on the basis of professional and cartographic processing.

In the last four years, the work on the geological map, which was once a mutual project of the republics of former Yugoslavia, has not been continued. The work on the pedological map is reduced to the supplementation of the original with new data. Two sheets of the vegetation map have been published, and the international financial support is being waited in order to enable the publishing of six finished sheets. The originals of eleven sheets of the geomorphological map have also been finished, and the sheets of the original geomorphological map at the scale of 1:500 000 have been published.

For the purpose of civil air navigation, two sheets of aeronautical chart have been published at the scale of 1:500 000, and four and more maps of ICA - procedure at the scale of 1:100 000 to 1:500 000 for all civil airports.

The largest number of thematic maps, especially through the application of digital procedures, is made within the scope of spatial planning.

2.6. Databases and geoinformation systems

The Ministry of Defence of the Republic of Croatia has financed the establishment of the database about the trigonometric points of all orders at the territory of Croatia and its neighbouring countries (about 50 000 points) for the military cartographic system. The coordinates of all points have been recalculated from the state coordinate system into WGS84 (Horvat, 1995).

On the basis of the first experiences acquired through the test work with different tools, through the insight and getting acquainted with the situation referring to GIS technologies and their application in the western developed countries, the City of Zagreb Central Cadastral Office has made in collaboration with the City of Zagreb Data Processing Center the necessary documentation and invit-

ed the tenders for program and computer equipment necessary to establish the GIS of the city of Zagreb. GIS of the city of Zagreb is developed within the frame of the project Digital cadastral model using the program package SYSTEM/9 (UNISYS V. 5.3.) (Šurina et al., 1993). Sun's SPARC center 2000 located in Data Processing Center is a data server for ten SUNSparc and twenty PC workstations across city. Data Processing Center of the city of Zagreb is acting as a central database, training center and applications developing center, and Central Cadaster Office and Planning Department have so far been the centres for data acquisition, various analyses, plotting centres and public services (Bušelić et al., 1994).

Within the scope of the City of Zagreb GIS, the projects Unique spatial units register and Digital land register are being worked on. The Unique spatial units register is being made on the basis of 360 sheets of the Croatian State Map 1:5000 and it encompasses 136 cadastral municipalities, 316 settlements, 334 local communities, 5000 census circles, 7000 streets and squares, 200 000 objects and house numbers (Bušelić et al., 1992). All 360 sheets have been scanned and transformed into the vector form, and the database is finished for about 15% of the planned contents. Within the frame of the project Digital land register, 33 cadastral plans at the scale of 1:1000 of the municipality Trnje have been scanned and raster-to-vector transformed.

The Photogrammetric Company from Zagreb produced the database of the political and territorial division of the Republic of Croatia on the basis of the order submitted by the State Geodetic Administration, digitizing the maps at the scales of 1:25 000 and 1:100 000.

For already a longer period, the Photogrammetric Company from Zagreb participates in the establishment of the information system for road management, run by the public enterprise Hrvatske ceste (Croatian Roads). Within the scope of this very complex project the fundamental database for roads has been created and additionally supplemented with the basic data about the land. On this basis various thematic maps have been made which should primarily make the work on the categorization and classification of roads in Croatia easier. The information part of the project referring to the use of the program package ARGIS is supported by the firm TEB-Inženjering from Zagreb.

The Photogrammetric Company from Zagreb has made in 1992 in collaboration with the Institute for Cartography at the Faculty of Geodesy the Study on the establishment of the Official Topographic and Cartographic Information System of the Republic of Croatia, as ordered by the State Geodetic Administration (Administration for Geodetic and Cadastral Affairs 1992). This year the same institutions have finished the Designing Project of the Official Topographic-Cartographic System. In the elaboration of this project the German Amtliches Topographisch-Kartographisches Informations-System (ATKIS) has been taken as the model (State Geodetic Administration 1995).

3. COMMERCIAL CARTOGRAPHY

3.1. Cartographic Department of The Miroslav Krleža Lexicographical Institute in Zagreb

It deals with the production of topographic and thematic maps for encyclopedias, atlases and occasional maps. In this work it uses the traditional cartographic technology. In the Cartographic Department of the Lexicographical Institute there are 4 geographers, 2 cartographer-editors and 10 cartographers working.

The list of the published works in the period between 1992 and 1995:

- Geographic Atlas of the Republic of Croatia (together with Školska knjiga, Zagreb), 1992
- Geographic Map of the Republic of Croatia and the Republic of Bosnia and Herzegovina 1:1 000 000, 1992
- Road Map of the Republic of Croatia and the Republic of Bosnia and Herzegovina 1:1 000 000, 1992

- Geographic Atlas of the Republic of Croatia, second edition (in collaboration with Školska knjiga, Zagreb), 1993
- A Concise Atlas of the Republic of Croatia (and the Republic of Bosnia and Hercegovina), 1993 (in English)
- The Map of the Adriatic Sea with the coast and islands 1:400 000, 1993
- The Road Map of Croatia, Bosnia and Herzegovina, Slovenia 1:500 000, 1995.

3.2. Kartografija-Učila, Zagreb

Kartografija-Učila was formed in 1947 and employs today 19 people. The basic activity of this institution is school cartography. Within its scope, the wall maps and globes, geographic and historical atlases, as well as reference maps are produced.

In the last four years Kartografija-Učila has managed to follow the syllabus with its new contents in the geographic atlases for primary and secondary schools. The atlas Croatian Historical Maps which illustrates the past of Croatia in its historical frame has been produced. The wall maps: The Republic of Croatia - physical map 1:500 000, Territorial constitution of the Republic of Croatia 1:500 000, Croatian cultural and historic monuments 1:500 000, Mountainous Croatia 1:130 000 have also been produced. The wall maps of Europe at the scale of 1:3 000 000 and Asia at the scale of 1:10 000 000 have been made as well.

3.3. INA-Oil Industry d.d.: Informatics sector-Department GIZIS (Geographic and Information systems)

In the Department GIZIS there are ten people working, and they have the latest hardware and software (MicroStation, MGE) of the firm Intergraph at their disposal. They work on the production of maps using digital methods and on the development of geographic and land information systems.

In the last four years they have made a few digital topographic maps 1:25 000, the digital map of the Republic of Croatia 1:300 000, GIS of the reconstruction of the town Vukovar destroyed through the war devastations in 1991, demographic GIS of the Republic of Croatia and Bosnia and Herzegovina (Brukner 1994).

3.4. Cartographic Laboratory Križovan

The Cartographic Laboratory Križovan is a small private firm for the production of topographic and thematic maps founded in 1992 having five employees. So far they have made a few significant cartographic products. The Road Atlas of Croatia with Slovenia and Bosnia and Herzegovina on it having maps at the scale of 1:1 000 000 was published in 1992.This year the Road and Tourist Map of Istria and Cres-Lošinj at the scale of 1:110 000 was also published.

4. ACADEMIC CARTOGRAPHY

4.1. Institute for Cartography at the Faculty of Geodesy University of Zagreb

The Institute for Cartography is one of the five institutes at the Faculty of Geodesy University of Zagreb. It was founded on 22nd May 1956. The Institute has 12 members, among whom five have constant obligations in teaching cartography. Today the Institute has the equipment and accessories which make the entire execution of even the most complex cartographic tasks, as well as the reproduction of maps possible.

Until today, more than 200 Diploma thesis have been made at the Faculty of Geodesy, 10 Master's thesis and 6 doctoral thesis defended in the field of cartography.

According to the syllabus adopted in 1978, the teaching of cartography was organized within the

frame of the subjects: Geodetic drawing, Topography, Cartography I, II, III and IV.

According to the new syllabus from 1994, after the first six mutual semesters, the students have got the possibility to choose the Photogrammetry and Cartography as one of the three orientation opportunities in the seventh and eighth semester.

In the fifth semester all students attend the courses in General Cartography (2+2) and in the sixth semester in Map Projections (2+2).

In the directed studies Photogrammetry and Cartography in the seventh semester, the obligatory subject is Digital Cartography I (2+2) and in the eighth semester Cartographic Reproduction (2+2). During these studies the students can also select the subjects: Mathematical Cartography, Digital Cartography II, Cartographic Generalization, Topographic Cartography, Thematic Cartography, Use of Maps, Cartographic Symbols and two seminars Cartography and GIS, and Practical Cartography.

From 1991 until today the cartographic researches have been developing within the frame of the scientific project Cartography and Geoinformation Systems financed by the Ministry of Science and Technology.

One of the topics within the scope of this project is Map Projections and Geoinformation Systems. In the Master's thesis (Lapaine 1991c) the theory of map projections on the basis of the analytical geometry, linear algebra and differential geometry has been developed. The suggested approach is general enough in order to encompass all laws of the classical theory. In order to respond to the demands of the time we live in, it is directed to the immediate application of the computer.

In the work (Lapaine, Frančula 1991), the basic formulas of general conic perspective projections have been derived. The formulas have a simple form, convenient for obtaining graphic presentations by means of a computer. In the work (Lapaine 1992) it has been shown, that general conic, cylindric and plane perspective projections have a common basis, and can therefore be studied together.

Gilbert's perspective projections Two Worlds, although insufficiently known, has really special visual properties which make it very interesting and announce a possibility of replacing the three-dimensional globe. In the work (Lapaine, Frančula 1992) a modification of Gilbert's projection has been suggested for the purpose of designing the world map which could serve as the basis for the production of different thematic maps. The modification is comprised in a different selection of cartographic pole and application of general perspective projection instead of orthographic projection. The researches about this projection are continued (Lapaine, Frančula 1993, Lapaine, Sudeta, Frančula 1994).

The Sphere and the Rotational Ellipsoid is the second research topic within the above mentioned project. While researching the loxodromes on the sphere, the parametrization induced by the Mercator's projection can be applied. So far it has been proclaimed that the isometric latitude has no geometric significance. After noticing the connection between the loxodrome and the isometric latitude, one can reach a new, very simple geometric definition of the isometric latitude (Lapaine 1993).

At the Faculty of Geodesy in Zagreb, the digitizing of the municipality borders of Croatia from the map at the scale of 1:1 000 000 with the central meridian 16°30' has been made. The database of points in Gauß-Krüger projection has been obtained by Helmert transformation from the local system of digitizer on the basis of larger number of control points. The area of the Republic of Croatia can now be determined as the sum of the areas of all municipalities, while the area of a single municipality is computed by means of rectangular coordinates of points at its borders taking thereby into account the correction because of the projection (Frančula, Lapaine, Vučetić 1993, 1994, Lapaine, Frančula, Vučetić 1993, 1994a,b, Lapaine 1994a).

The Transformations and Geoinformation Systems is the third topic within the above mentioned project. The basic information used in all types of today's geoinformation systems come from tradi-

tional sources: maps and plans. This information comes into the databases through the procedure which starts with the digitizing of maps. One computer system for eliminating the deformations, i.e. the transforming of map contents into the theoretical dimensions has been developed by M. Lapaine at the Faculty of Geodesy University of Zagreb. The title of the system is KARTOMATIKA (Lapaine 1994b,c).

The relations between rectangular coordinates *x, y, z* and geodetic coordinates are well known. The inverse problem of computing φ, λ and *h* from the given *x, y* and *z* has been studied by many authors who have suggested different methods of its solution. Lapaine has collected about 100 publications which deal with the inverse problem of transformation (Lapaine 1991a,b). From the geometric point of view, the problem lies in finding the intersection of rotational ellipsoid with the normal drawn from any point of space onto the ellipsoid. Only five algorithms for direct transformation from spatial rectangular coordinates into spatial ellipsoidal coordinates have been published: Heikkinen (1982), Ozone (1985), Borkowski (1989), Lapaine (1991a,b). Although the first three sometimes fail, all five algorithms are of approximately the same accuracy with respect to the errors resulting from rounding up. Referring to the distribution of errors, the best is Lapaine's algorithm (Lapaine 1991b, Hekimoğlu 1995).

The fourth topic within the above mentioned project unites the works from the field of Thematic Cartography and Geoinformation Systems. Today's possibilities of automation in cartography enable the production of perspective presentations by means of computer. At the Faculty of Geodesy University of Zagreb a few computer perspective presentations have been so far made by means of the program SURFER, as for example the presentation of the Zagreb Upper Town and Kaptol (Lapaine, Lovrić 1992), and of the part of Medvednica (Lapaine, Sudeta et al. 1992, Sudeta et al. 1992).

In the papers of Frangeš (1992, 1995) the offered patterns of the packages AutoCAD and ARC/INFO have been analyzed. The analysis has shown that these program packages own numerous patterns which are however not always sufficient. Therefore, the new original patterns have been generated. The first group of patterns has been generated according to the patterns on old maps, and the second according to the patterns applied in the Geography of Croatia (Institute for Geography at the University in Zagreb 1974-1975).

At the end of 1994 the Institute for Cartography made three-year contract for the following two projects with the State Geodetic Administration: Geodetic Dictionary and Croatian Cartographers. So far the designing projects have been made (Lapaine, Frančula et al. 1995, Lapaine, Lovrić et al. 1995).

In the last four years the members of the Institute for Cartography have made also 20 topographic and thematic maps among which the following should be pointed out: Cartographic presentation of the center of Zagreb at the scale of 1:3 000 intended for the guest of the city and Operational navigation chart 1:500 000.

4.2. Geographic Department at the Faculty of Sciences University of Zagreb

The Geographic Department is one of seven departments of natural sciences that make the Faculty of Sciences at the University of Zagreb. In the Geographic Department the studies are organized in three courses of studies where the cartography is lectured as well. So far, it is present only in the first year of studies, but the new curriculum plans to introduce the thematic cartography and GIS into the second and third year of studies.

By its different title and number of hours, cartography is adjusted to a single teaching course. In the course for Professor of Geography there is a subject Cartography (2+2, 2+2), in the course for Professor of Geography and History the subject Geographic knowledge of maps (1+1, 1+1) and in the course for Professor of Geology and Geography the subject Introduction into Cartography (1+2, 1+2).

The program in cartography lectures is made with the basic aim - to get acquainted with the geographic map and to learn people how to use it. Therefore it is necessary to have the knowledge about the Earth as the object of the geographic map, for example: shape, dimensions, movement of the Earth etc.

The lectures are accompanied and supplemented by exercises (cartometric procedures, profile production, production of ordinary projections, drawing of cartographic symbols etc.) as well as by going into the field (orientation, standpoint determination, assessment of the distance etc.). For the education of students it is very useful to visit the professional institutions and various thematic exhibitions.

Cartography is lectured in the postgraduate studies at the Geographic Department as well, as the course of lectures under the title Thematic cartographic presentations in the spatial planning and development.

5. OTHER ACTIVITIES

5.1. Publishing activity

In Croatia there is no journal with exclusively cartographic problems. The papers from the field of cartography are mostly published in the geodetic periodical. In Zagreb there is the geodetic journal Geodetski list being published continuously since 1947. Till the end of 1994 there were 154 articles from the field of cartography published in Geodetski list.

The monograph Descriptio Croatiae (Marković 1993) is the result of a thirty years long work of the Academy member Mirko Marković, of his long lasting efforts to gather and process the material. Descriptio Croatiae is up today the most integer and the broadest review of the cartography of Croatia and of the Croatian cartography till the end of the 19th century. It comprises the majority of what has been scattered around in numerous articles and studies in different journals and proceedings less approachable to the majority of readers. This work shortens the tiresome job of searching through and looking for the topics, maps and their authors to all the readers.

5.2. Map exhibitions

The Historical Archives of Split has prepared in 1992 a unique exhibition of cadastral maps with a beautiful catalogue the Treasure of Croatia in Archival Maps for Istria and Dalmatia. In 1993 the Museum for Arts and Craft in Zagreb prepared a great exhibition The Border of Croatia on the Maps from 12th till 20th century with the beautiful reproductions of 88 maps. In autumn 1994 the exhibition Older Geographic Maps in the University Library in Split has been made in Split, accompanied also by a very nice catalogue. The last exhibition of maps was held in the Arts Pavilion in Zagreb at the end of 1994 under the title Zagreb on Surveying-Cadastral Maps and in Land-Registers. The representative catalogue was published for the exhibition containing a lot of valuable articles and reproductions.

At the exhibition of maps within the frame of the 16. International Cartographic Conference in Cologne in 1993, Croatia had four maps, and this year in Barcelona it is going to be represented with 24 exhibits, among which there are 19 maps, three atlases and two books.

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