

APPROACH TO GROUNDWATER BODY DELINEATION IN CROATIA

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General hydrogeological settings

From the hydrogeological, even water management viewpoint, Croatia is composed of two regions of almost equally large surface – the northern and southern Croatia (Fig. 1). The Danube river basin drains the northern part of the country, whereas the Adriatic river basin drains the southern part of the country.

Northern Croatia covers the southwest part of the Pannonian basin and comprises an area of 29.900 km² of Croatian territory. A large lowland along the two magistral Danube tributaries - the Sava and Drava rivers and their major tributaries, and the Danube river in the easternmost part - dominates this region. Quaternary sediments form thick and highly permeable aquifers of intergranular porosity within the lowland. The aquifers are covered by semipermeable silty-clayey deposits (aquitard) which thicken eastwards, from the thickness of 1-5 m in the west to more than 50 m in some sites in the east (Brkić, 1999). Aquifer recharge by precipitation infiltration depends exclusively on the thickness and lithologic composition of the covering aquitard and is estimated to 10-20 % of the mean annual precipitation, or even higher in some places in the western areas.

Within the Pannonian region there are isolated mountainous areas, built of mostly poorly permeable or impermeable sedimentary and igneous rocks. The exceptions are the mountain aquifers with fissured porosity in Triassic dolomites and Miocene limestones.

The karst region includes the southern part of Croatia (Fig. 1). It occupies an area of about 30.100 km², or 53 % of Croatian territory. This region is a part of the "classical" karst - the Dinaric karst. It is composed of Mesozoic carbonate rocks (limestones and dolomites) and is characterized by all the phenomena of the "classical" karst, and is internationally accepted as the "locus typicus" of the global karst. Mesozoic carbonate rocks form karst (cavern) aquifers, whose main characteristics are the abundance of all karst geomorphological forms and deficiency in surface water (Fig. 2). However, the large area and a high quantity of precipitation result in the large abundance of groundwater. The main characteristics of the Adriatic coast are high groundwater quantities that flow from the high karst belt, the impact of sea water intrusion and the existence of poorly permeable flysch layers that serve as underground barriers.

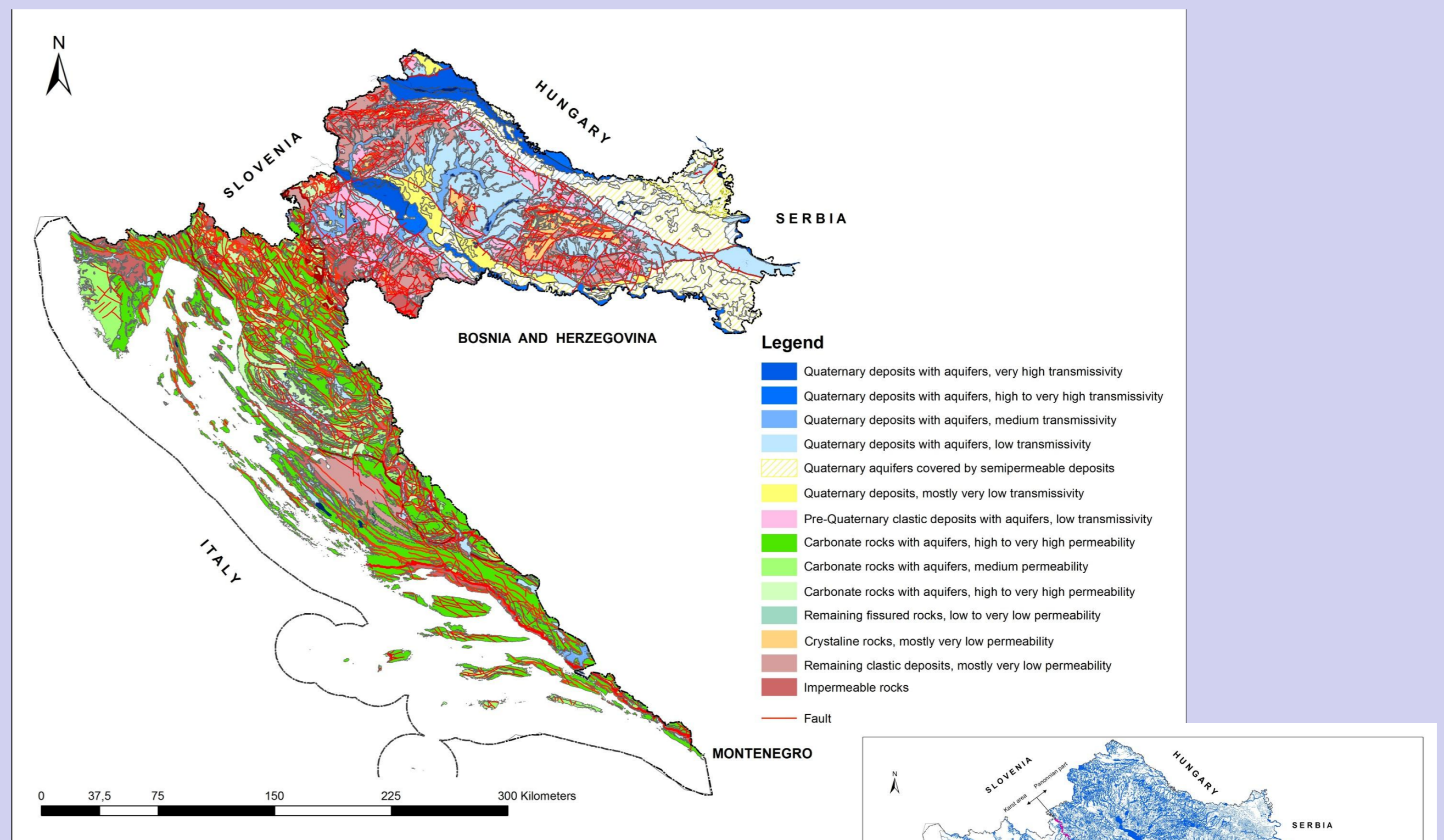


Fig. 1: Hydrogeological units of Croatia

An initial characterisation of groundwater bodies – The first phase

The delineation of groundwater bodies is carried out by means of the Base geological map of the Republic of Croatia in scale 1:100.000, Hydrogeological map in scale 1:200.000, Hydrogeological map in 1:300.000 and reports of the Croatian Geological Survey, Department of Hydrogeology and Engineering Geology, prepared in the framework of the Water Management Master Plan of the Republic of Croatia – Chapter Groundwater, as well as other published and unpublished studies.

The basis for identification of groundwater bodies was the analysis of the following elements:

- geological composition of the terrain (lithostratigraphic units and structural-tectonic relations)
- porosity (intergranular, fissure, fissure-cavernous)
- geochemical composition of aquifer (silicate, carbonate)
- hydrogeological characteristics (hydrogeological units according to porosity, hydraulic conductivity and transmissivity of aquifer)
- covering aquitard
- direction of groundwater flow
- discharge of springs and wells
- groundwater recharge
- relations with surface flows
- position of groundwater bodies within a river basin defined in the Water Management Master Plan of the Republic of Croatia

461 groundwater bodies are separated in the frame of an initial characterisation, of which 314 groundwater bodies in the Pannonian part of Croatia and the remaining ones in the karst area (Fig. 3).

Fig. 2: The map of surface waters

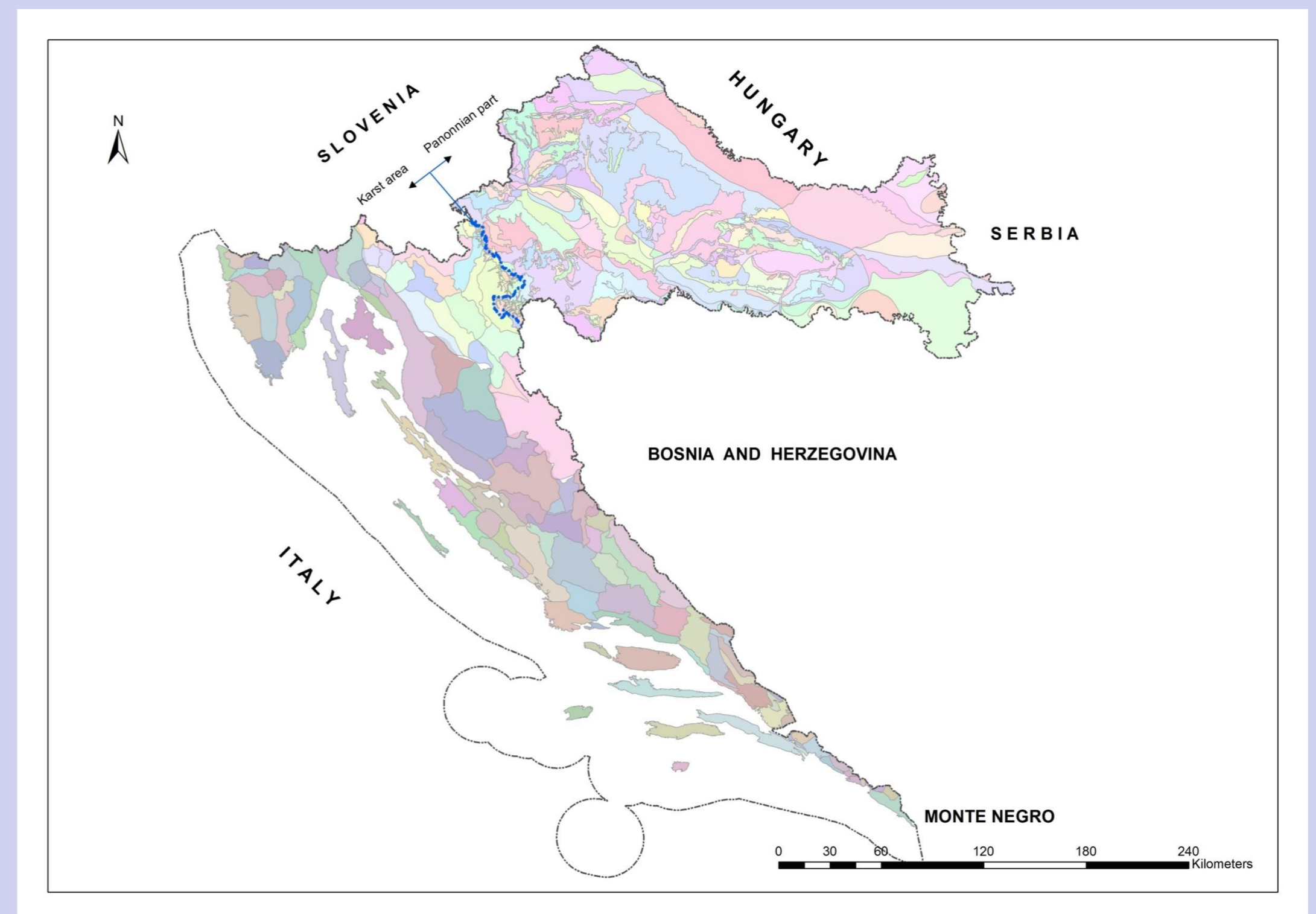
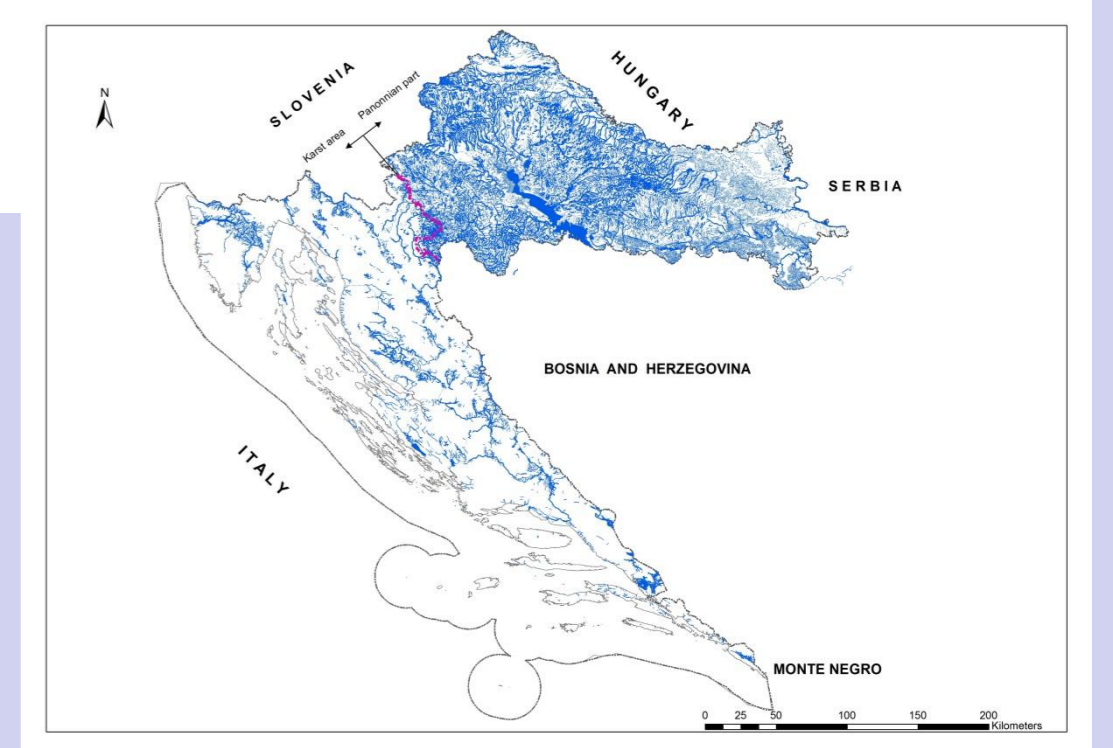


Fig. 3: The map of groundwater bodies separated in the first phase

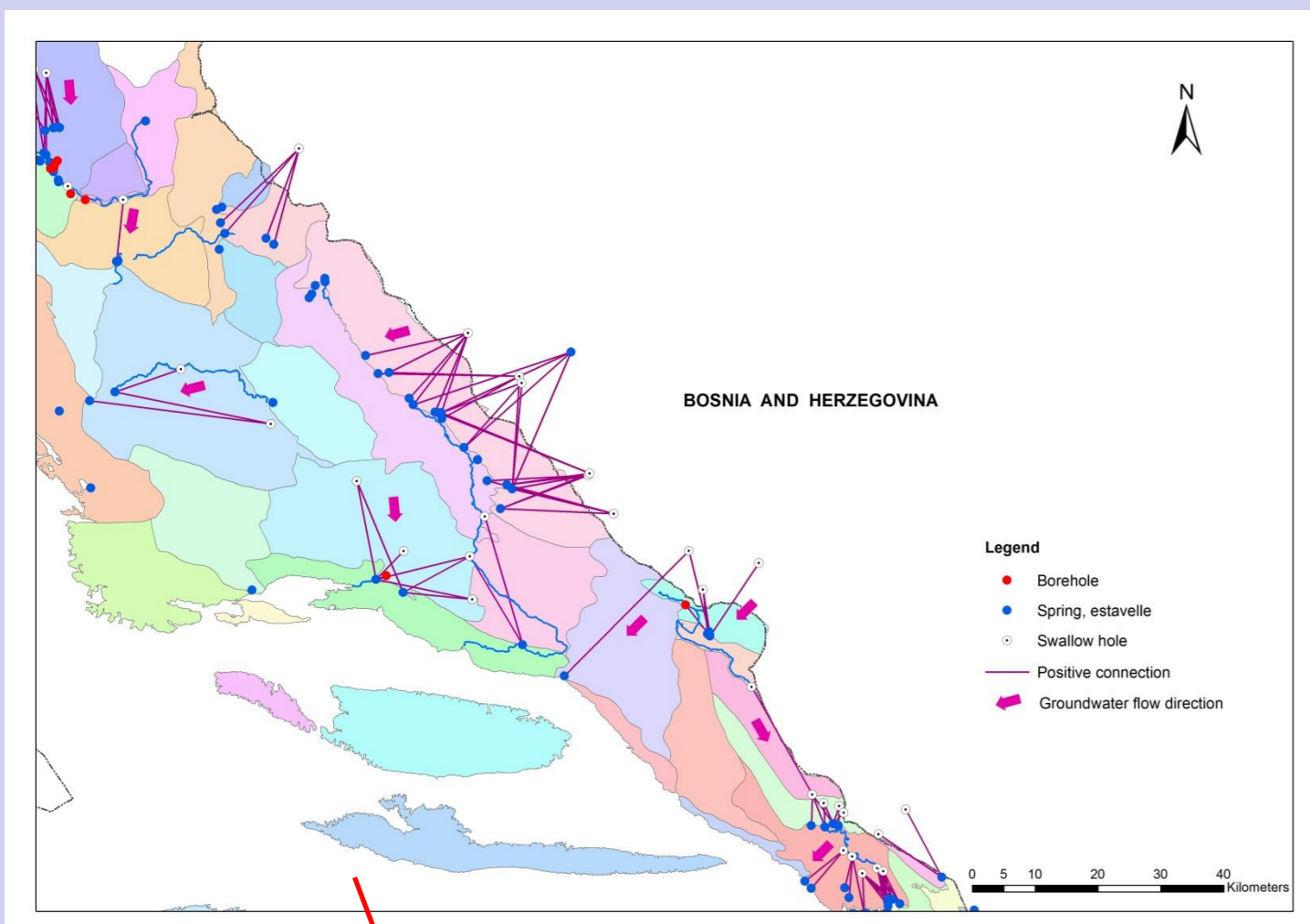


Fig. 4a: Example of groundwater bodies delineation in the karst areas

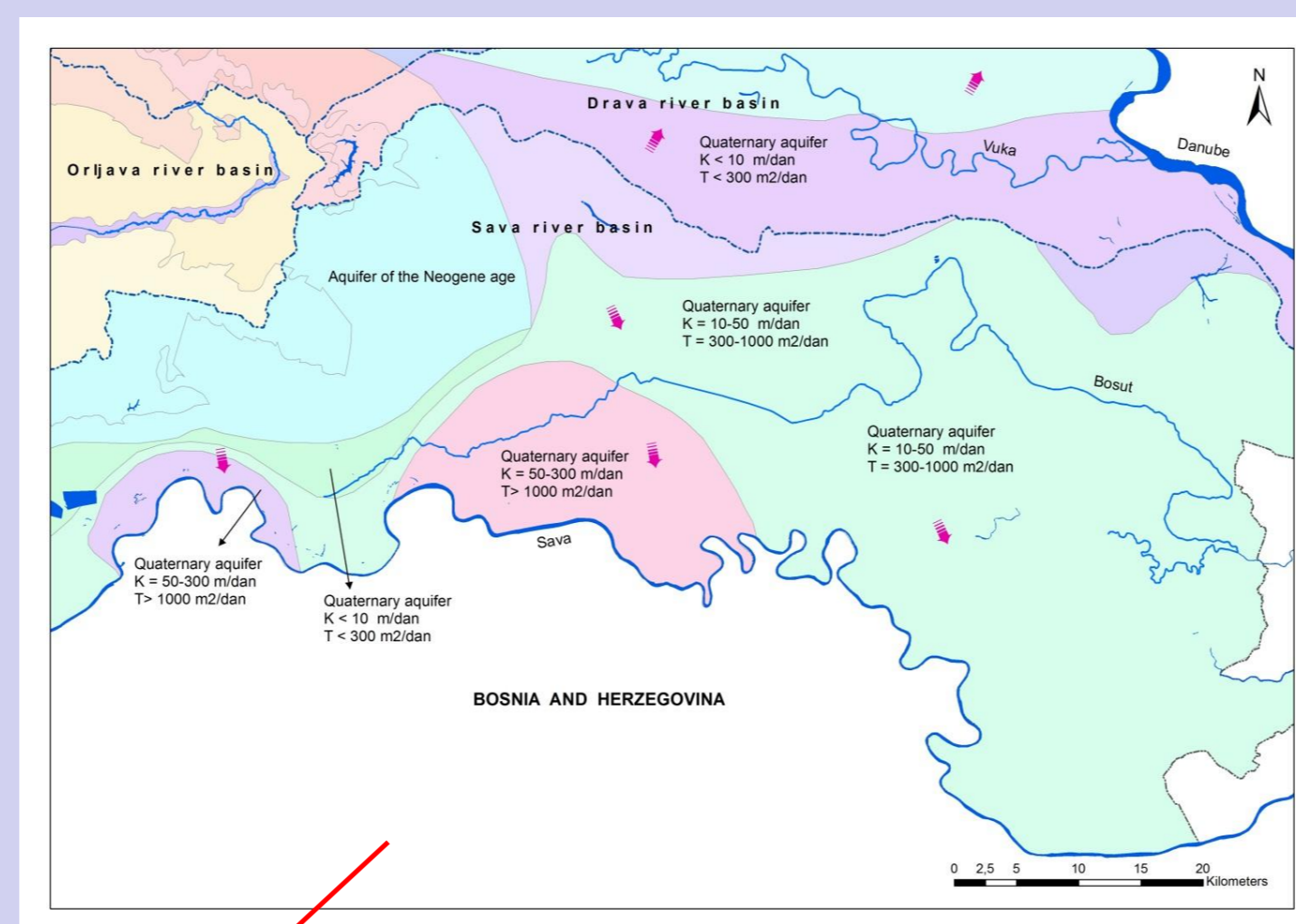


Fig. 4b: Example of groundwater bodies delineation in the Pannonian basin

Fig. 6: Aquifer porosity of groundwater bodies

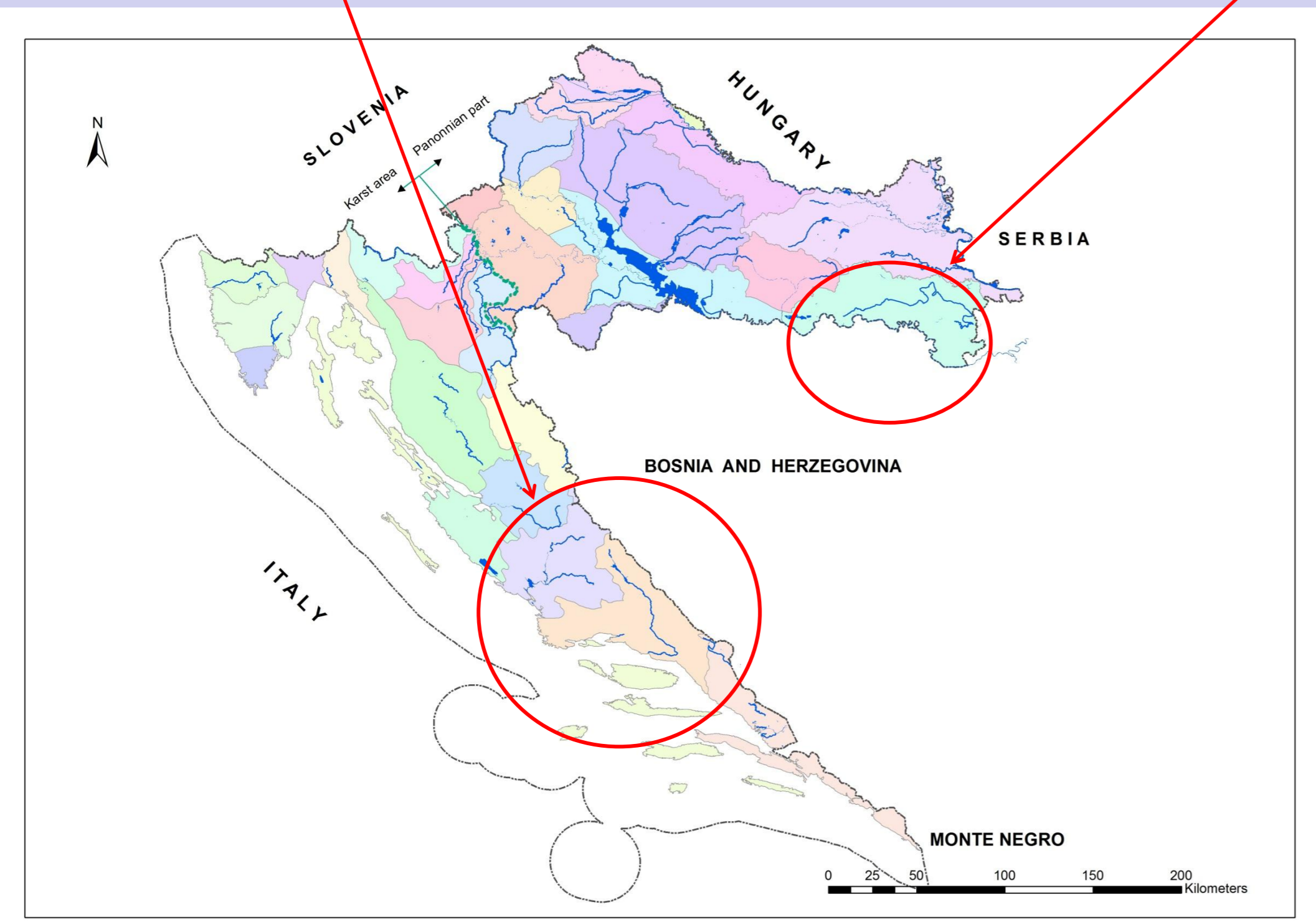
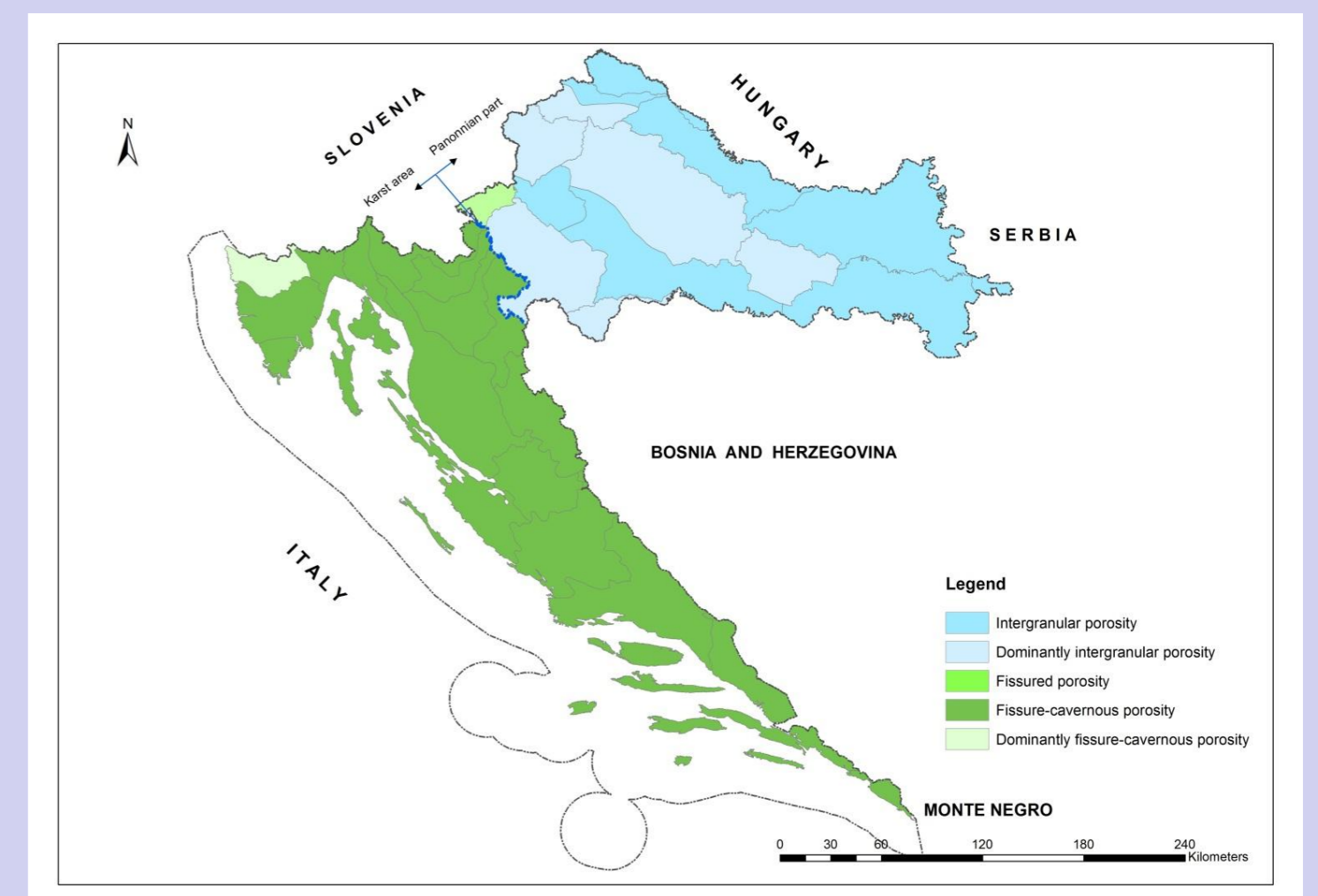


Fig. 5: Aggregation of groundwater bodies – II. phase

Aggregation of groundwater bodies – The second phase

Aggregation of such large number of groundwater bodies was carried out on the basis of similarity of general «recharge – groundwater flow - discharge» scheme and position of groundwater bodies within a river basins.

In this manner, 15 groundwater bodies were identified in the Pannonian basin (Croatian Geological Survey, 2009) and 17 bodies in Dinaric karst and one groundwater body which include 13 large islands (Geotechnical Faculty Varazdin, University of Zagreb, 2009) (Fig. 5).

Groundwater bodies in vertical cross-section were not isolated.

In the Pannonian basin 8 groundwater bodies contain an intergranular porosity aquifer, within 6 groundwater bodies intergranular porosity aquifers are dominantly present and, to a significantly lesser degree, also fissure porosity aquifers, and there is also one groundwater body with an aquifer of only fissure to fissure-cavernous porosity (Fig. 6). Groundwater bodies of fissure-cavernous porosity are dominantly represented in the area of Dinaric karst (Fig. 6).

References

- Croatian Geological Survey (2005): Characterisation of groundwater bodies in the Black Sea catchment area in the frame of the implementation of the WFD.
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- Geotechnical Faculty Varazdin, University of Zagreb (2009): Assessment of Status and Risks for Groundwater Bodies in the Karst Part of Croatia.