6. Hydrogeological zones and groundwater resources balance baseflow map of the Czech Republic

Jiri Sima

General content

- Regional hydrogeological units
- Groundwater resources assessment
- Water balancing – background for water management

Regional units in hydrogeology

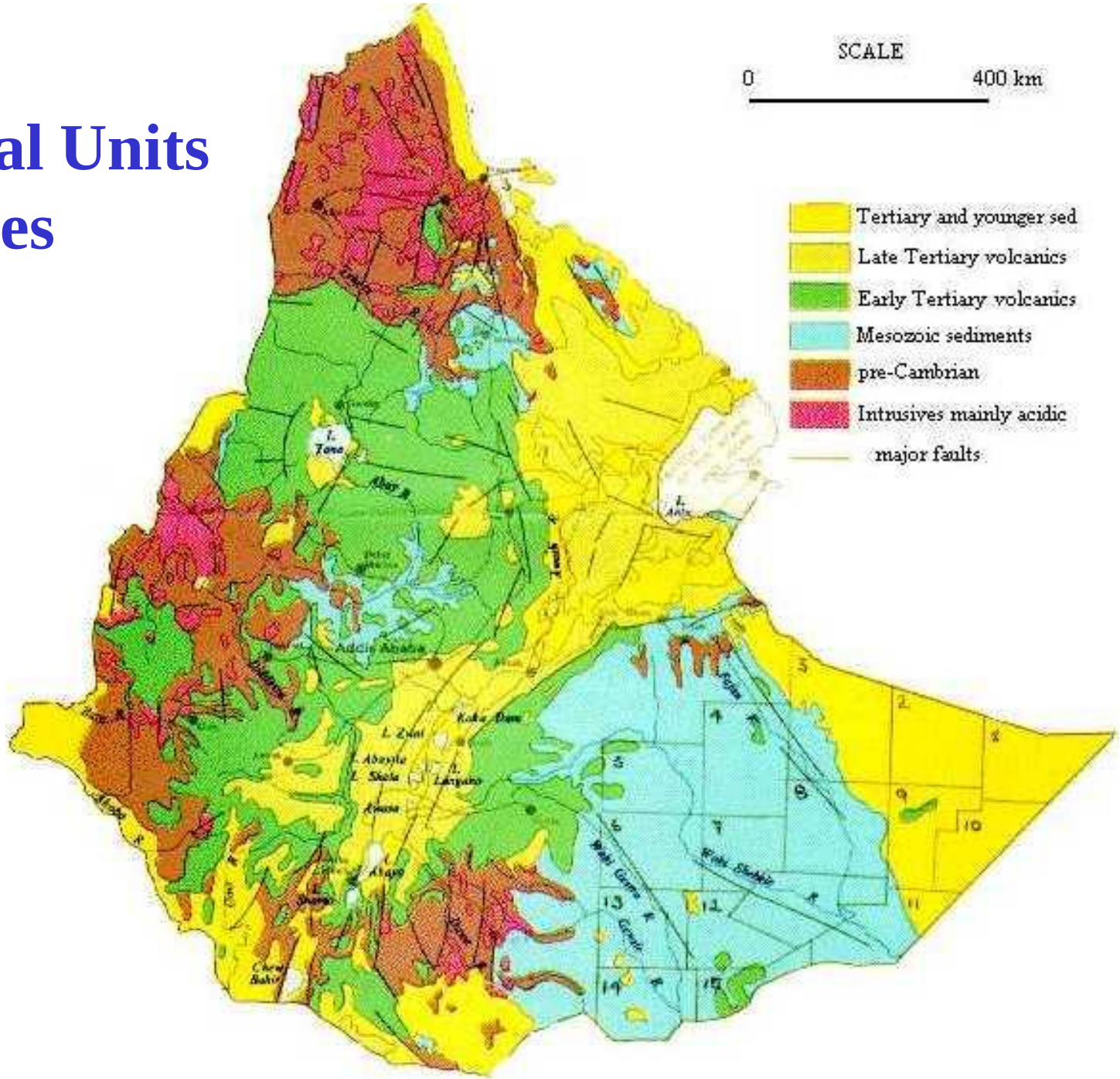
- Hydrogeological provinces
- (Hydrogeological regions),
- Hydrogeological zones
- Aquifers, flow system inside aquifers
- *groundwater province*, *groundwater basin*, *groundwater zone*, *groundwater body*,

Hydrogeological province =

the area unit with one type of geological structure and therefore similar occurrence of groundwater

- **rift valley province**
- **plateau volcanic province**
- **Mesozoic sedimentary rocks province**
- **basement rocks province**
- **Tertiary and Quaternary fluvial and lake deposits**

Geological Units - provinces



Division inside provinces into groundwater zones

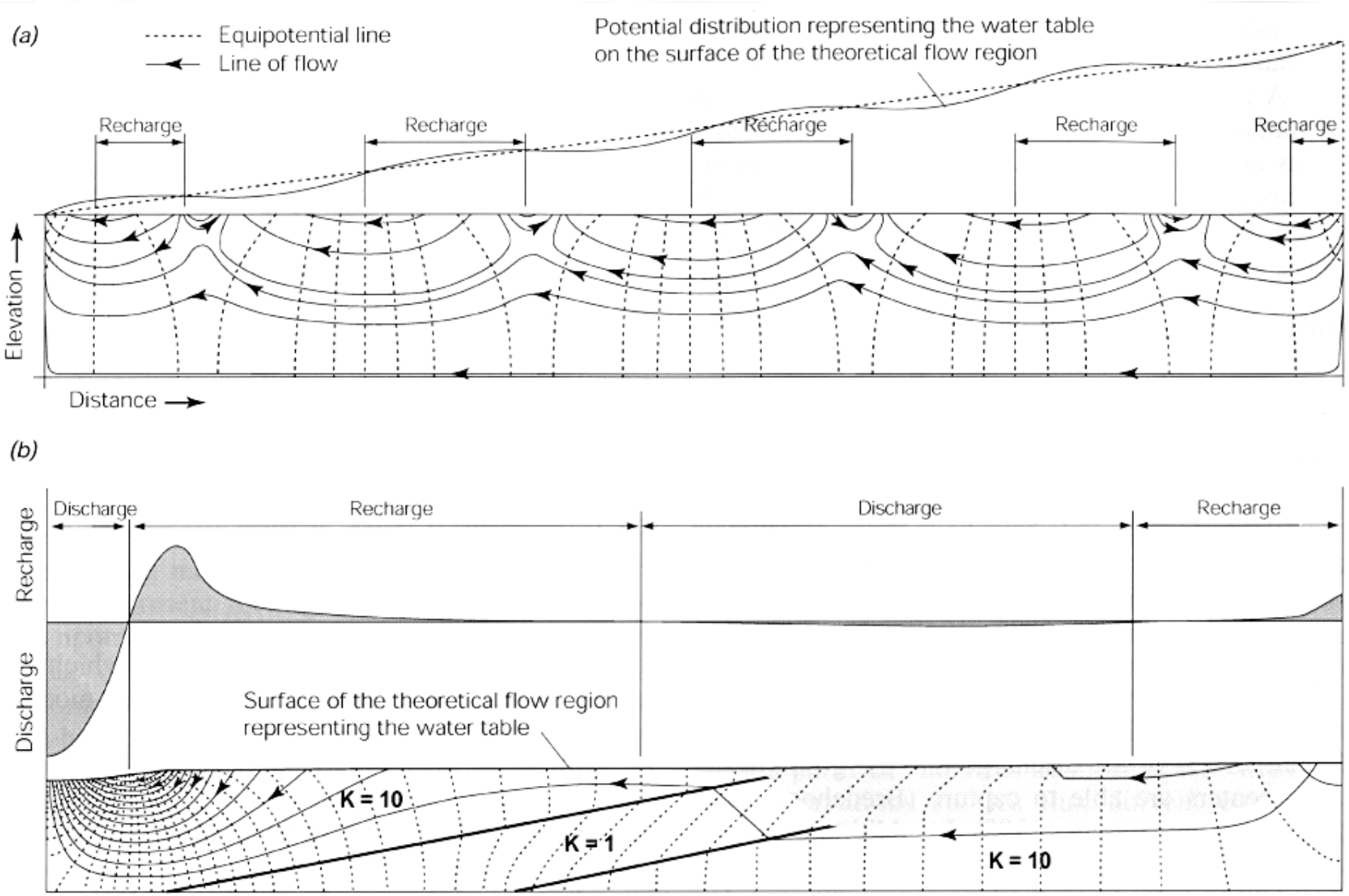
Groundwater zone is a hydrogeological unit (region), where groundwater flow is closed and could be strictly defined, conceptualized, evaluated and modeled.

Groundwater zone is based on groundwater flow concept and mostly it could be connected to the aquifer extent, or with the river basin in case of surficial aquifers.

AQUIFER

- definition of the aquifer, a three-dimensional body of earth material which is saturated with flowing groundwater;
- aquifer containing the groundwater is bounded by a closed surface called the “boundary surface” of the flow system;
- inflow (continuous or intermittent) of water to the system and outflow from it occur through at least part of the boundary surface

Flow net – system (Alan Freeze)



Definition of groundwater zone

is long-term process, which has to be periodically repeated, as the knowledge on groundwater occurrence, groundwater resources and function of groundwater systems will grow up.

Example:
In Czech Republic the groundwater zoning is incorporated into the water law, and the delineation of zones was upgraded Four times till the valid zones were established in 2006.

Importance of ZONES

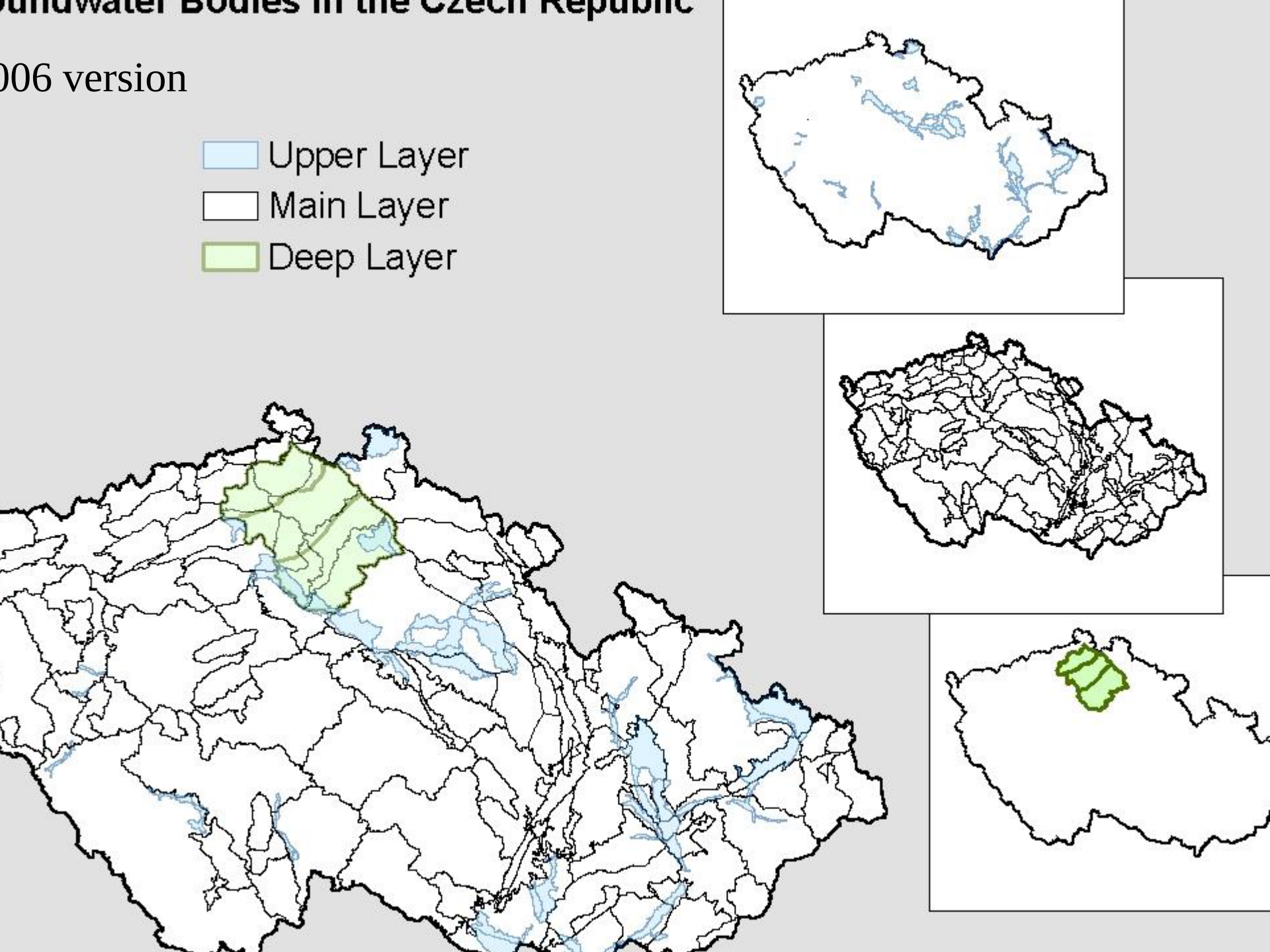
Zoning in Czech republic is approved by the central authorities as territorial planning base for the preparation and performance of hydrogeological research and surveys, evaluation and management and protection of
of groundwater resources.

A hydrogeological zone is defined as a tectonically and geologically demarcated area with similar hydrogeological conditions on whose territory a certain type of groundwater circulation predominates.


Hdyrogeological zones
of 1986
Before new
legislation

undwater Bodies in the Czech Republic

006 version



Partition of the territory into zones

1. Phase
Aspects of structural geology,
stratigraphy and lithology were the main starting points

2. Phase
Aspect of hydrogeology, extent of aquifers, flow systems
the hydrological conceptual model

3. Phase
Groundwater flow systems - surface water interactions
for conjunctive water management

Legal system of the European Community
brought new term:

groundwater body
which is
volume of groundwater in the aquifer

Groundwater body has to be protected against pollution,
against overuse (water mining), has to be monitored in the focus of quantity and quality.

Results of monitoring have to be reported to the EC,
if the trend to worsening appears, the adequate measures has to be taken.

Flow System - Smallest Unit

Aquifer is not the smallest area unit in hydrogeology

- one aquifer should to be drained to several streams, so several flow system should exist within one aquifer

- flow system has defined drainage and other connections to the streams of the surface water

- flow system of groundwater within one aquifer, with only one drainage base is the smallest unit in hydrogeology in the conjuctive surface - groundwater management

Zone = water management

Water management balance - comparison of total abstractions by industry and public water supply in hydrogeological zone to groundwater long-term resources)

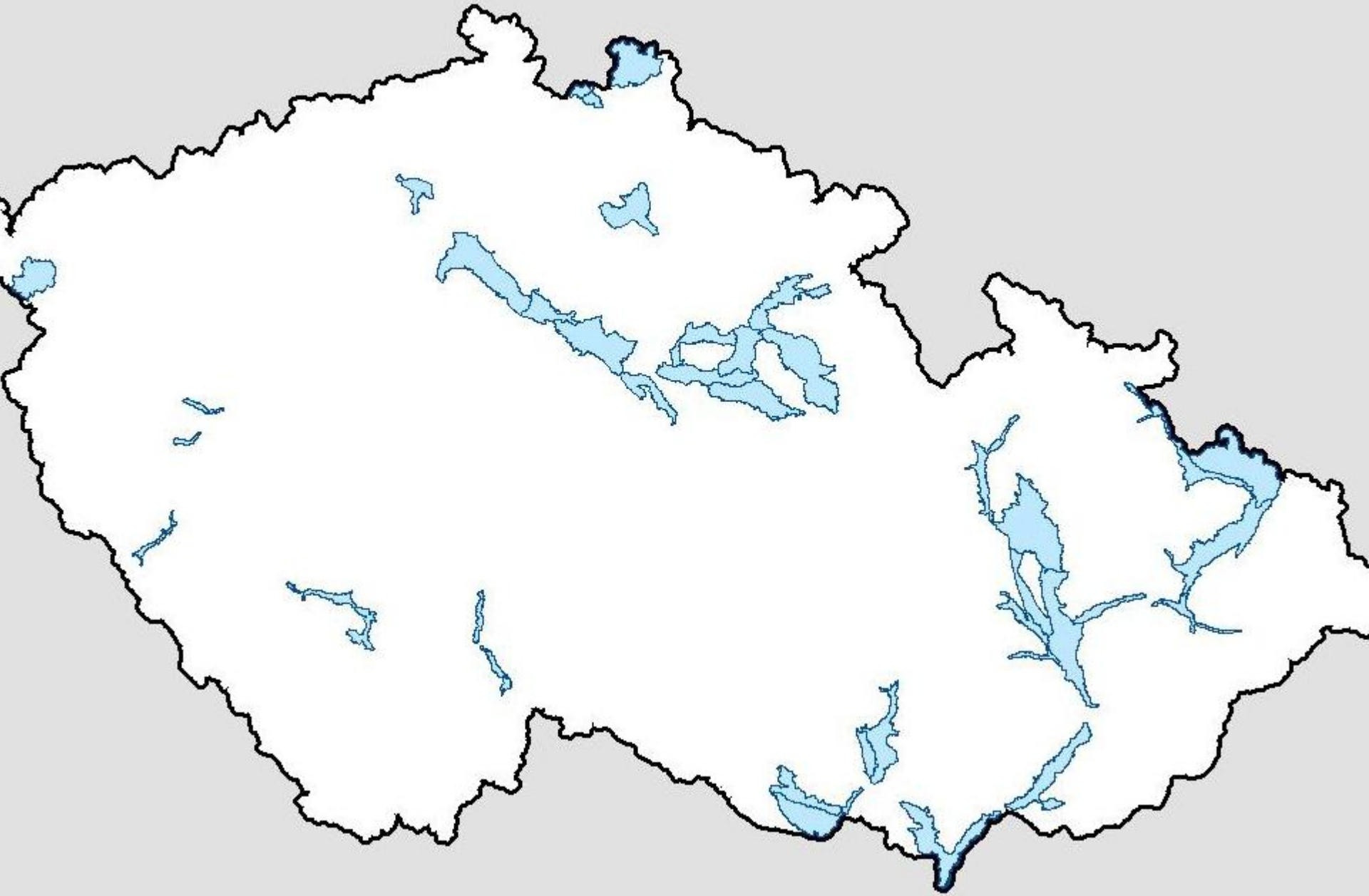
Hydrogeological zones and groundwater bodies of 2006

152 zones divided in three horizons:

- Upper horizon: Fluvial quaternary deposits, only significant for groundwater abstractions (38 zones), boundaries: geological, but simplified, average area: 130 km^2

Porous aquifers

Upper Layer of Groundwater Bodies

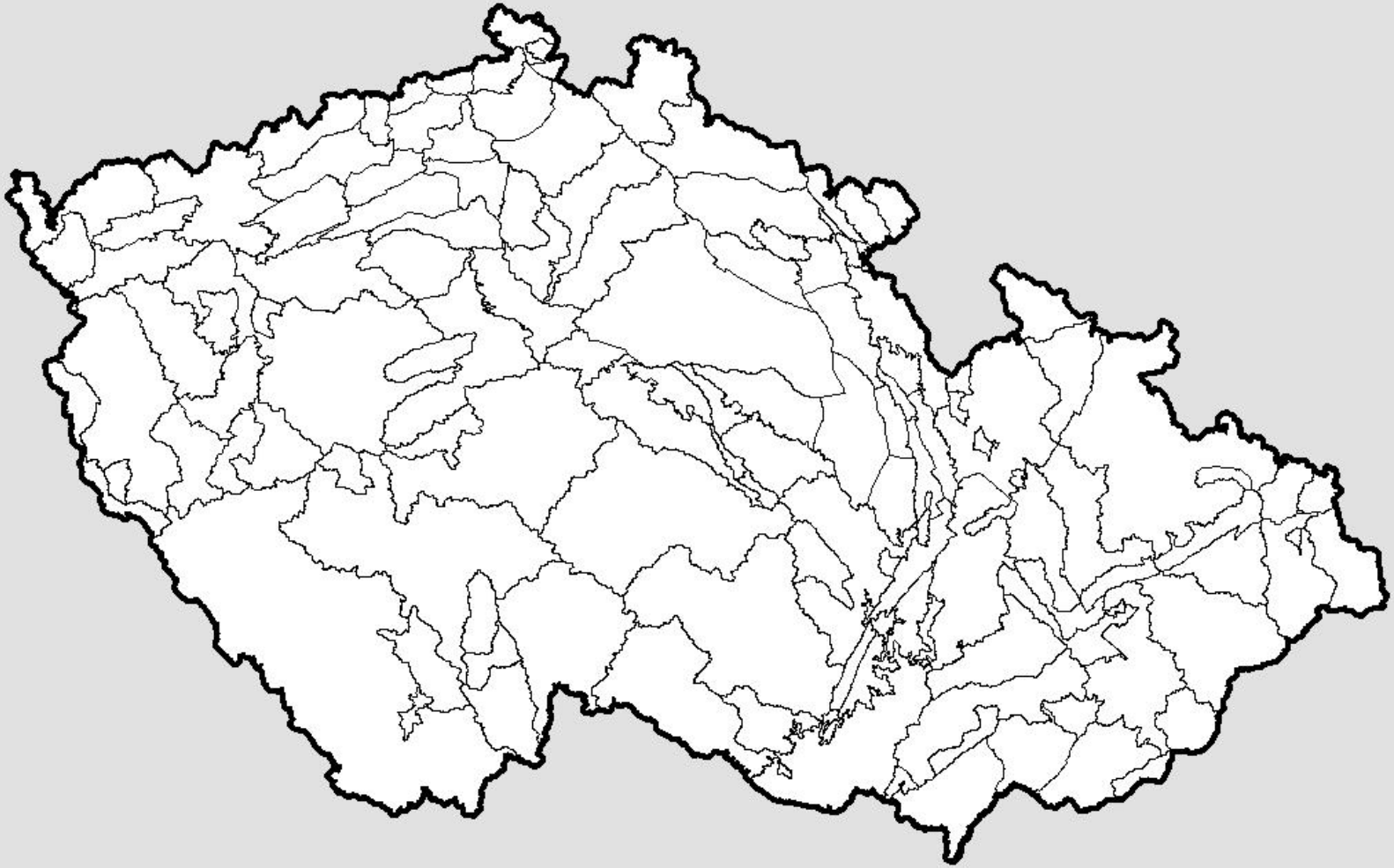


„Main“ horizon – surface presentation on maps

all types of hydrogeological zones – outcropping aquifers in sedimentary, volcanic and basement rocks (111 zones)

Fissured and karst aquifers

Main Layer of Groundwater Bodies

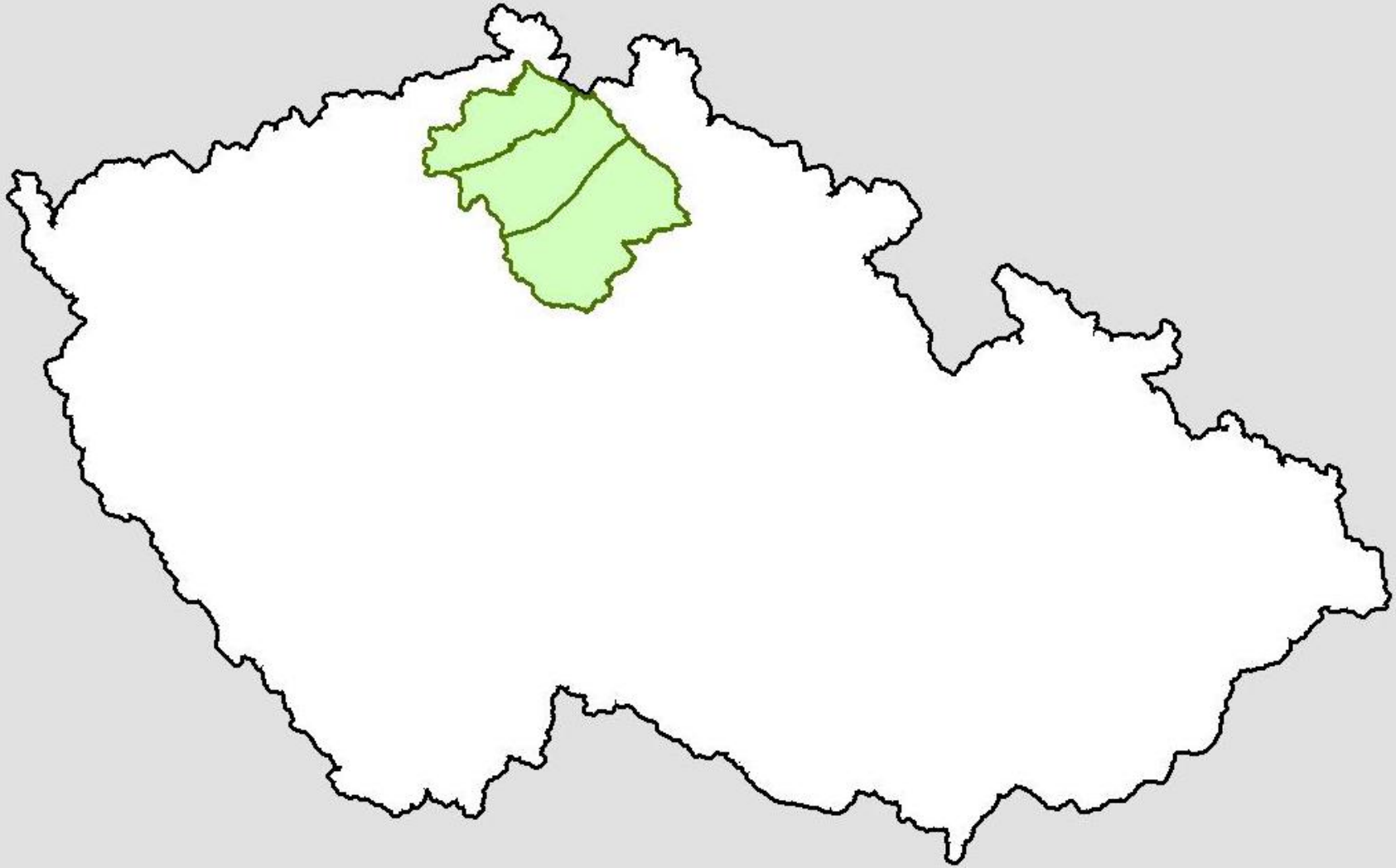


Last zone

Deep horizon: 3 zones in cenomanian sandstone used for abstractions or significantly affected by human activity – former uranium mining (acid discharge in 100 m deep boreholes)

Fissured aquifers

Deep Layer of Groundwater Bodies



Natural Characteristics of Groundwater

Conceptual model of groundwater bodies in zone

Main characteristics – mineralisation (TDS), transmisivity, permeability, natural background of hydrochemistry, link between groundwater and surface water, vulnerability of groundwater to pollution

Groundwater use

93,4 % of inhabitants connected on public water supply

Drinking water: 48,8 % of groundwater (2011)

Use of groundwater: less than 30 % of existing groundwater resources

Most of groundwater (82 %) used for drinking water

Groundwater resources in zones

- **The method of baseflow calculation is the most common for regional assessment of dynamic groundwater resources and it represents volume of groundwater outflowing from individual groundwater zone (m3/s).**
- **Monitoring period of river gauging in time of 10 to 40 years is required for assessment of representative volume of groundwater resources.**
- **Dynamic groundwater resources represent important background information for national water balance and water management planning**

Map of Groundwater Run-off in the Czechoslovakia (1979)

Prepared by Czech / Slovak Hydrometeorological Institute

Water Management Research Institute

Czech / Slovak Geological Survey

Synthetic map

Derived information

Aquifer system

- geological map 1 : 1 000 000 (1966)
- Quaternary sediments 1 : 1 000 000 (1966)
- Hydrogeological map 1 : 200 000 (1974-76)
  (Water Master Plan map)
- manuscript of national Hydrogeological map
  1 : 200 000 (1972-76)

Basic aim

Groundwater resources potential

Long-term groundwater run-off

- specific groundwater run-off
- groundwater run-off coefficient

Aquifer system with significant role in groundwater run-off

Specific groundwater run-off

Amount of groundwater that is discharged from one square kilometer of aquifer

(effluent streams / recharged by groundwater from adjacent aquifers)

$l / s / km^2$

(expressed colors / in 8 degrees / 0.5 to 10)

Groundwater run-off coefficient

groundwater run-off ration in rainfall
(recharge to aquifers)

%

(expressed in isolines / variation 5 to 20)

Aquifers systems

Spatially distributed hydrogeological units restricted by boundaries with specific marginal conditions

System is generalized – smaller alluvial and deluvial aquifers are not shown (despite to the importance)

Groundwater run-off

Long-term river flow observation from about 250 river gauging stations

Period of observation 10 to 12 years (some observations 40)

Method of estimation Kille (1970)

Kille method

Processing the monthly minimum run-off in form of graph – linear part of graph represents amount of groundwater in river flow

Resulting estimation is valid for watershed above the station and is generalized considering climatical, morphological hydrogeological (aquifer) factors

Accuracy

Aquifers system – boundaries

Specific groundwater run-of - colors

Groundwater run-off coefficient – isolines (regional trends)

Map represents artificially non-influenced data (regional scale)

Legend

Color – long-term specific groundwater run-of + boundary

Isoline of groundwater run-off coeff.

Hatch – ornaments – types of aquifer systems

Indexes – stratigraphy / petrography

Boundary lines

Long-term specific gw run-off

Spec. Run-off	Degree	Significance	Color
less 0.5	I	Insignificant	yellow
0.5 – 1	II	Very low	d. yellow
1 – 2	III	Low	l. brown
2 – 3	IV	Medium	orange
3 – 5	V	Increased	green
5 – 7	VI	High	d. green
7 – 10	VII	Very high	l. blue
more 10	VIII	Extr. high	blue

Long-term run-off coeff.

- Isolines / expected isolines
- Isolines are not used in areas with remarkable fluctuation of values of groundwater run-off coefficient; the coefficient mean value given numerically below the data concerning the value of specific groundwater run-off

Aquifer systems

- One-aquifer
- Two-aquifer
- Multi-aquifer
- Territory without aquifer

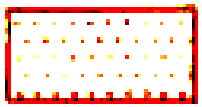
Continuous / non-continuous aquifers

Intergranular / fissured / karst porosity

Aquifer systems

A) Jednokolektorový zvodněný systém

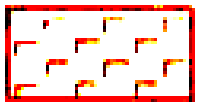
1. tvořený spojitým kolektorem



a) porous

b) Porous-fissured

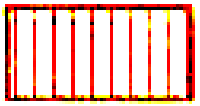
2. tvořený nespojitým kolektorem



a) přípovrchové zóny zvětralin a rozevřených puklin krystalinických hornin nebo zpevněných sedimentů; z hlediska tvorby odtoku podzemní vody jsou zvětraliny obvykle významnější než rozpukané horniny

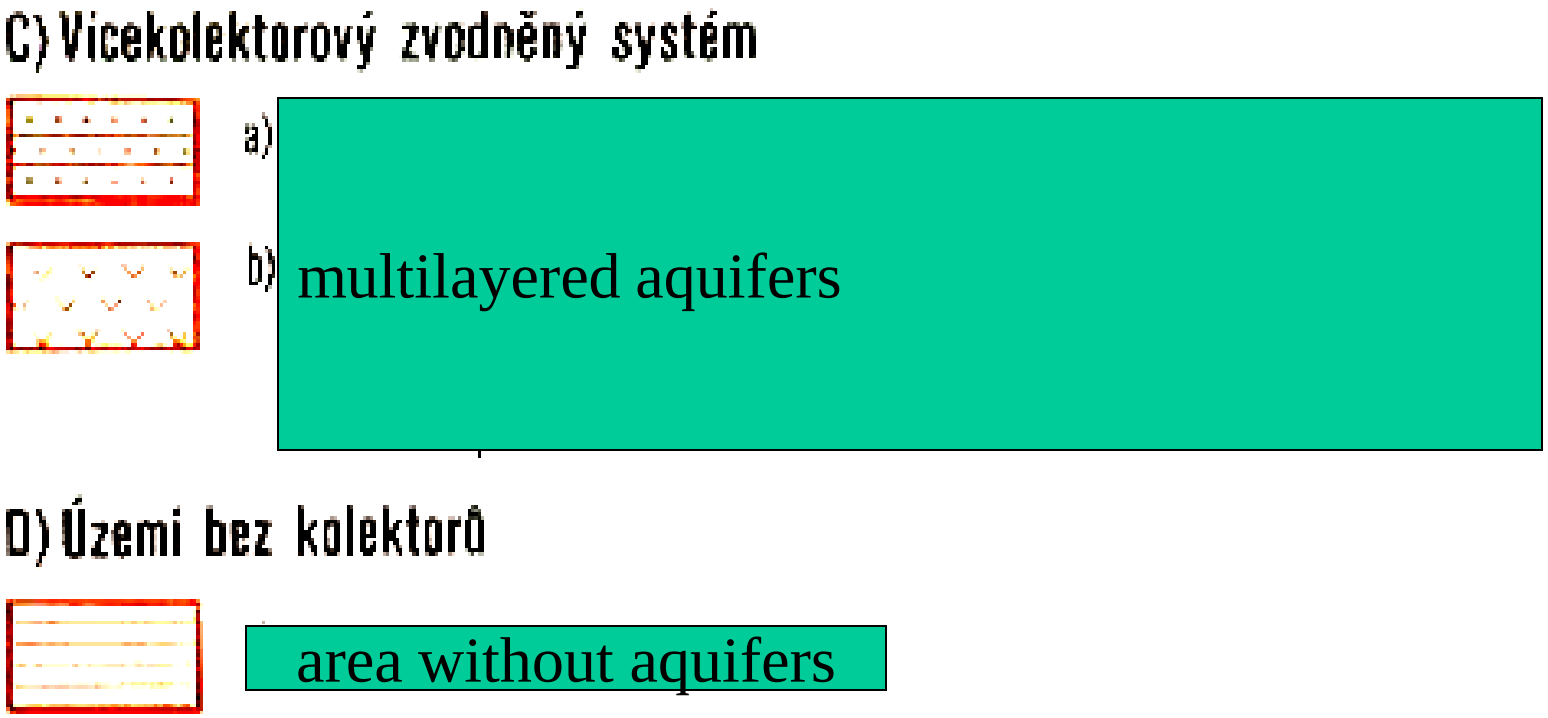
b) fissured

c) fissured-karst



d) fissured

Aquifer systems



Strat. and Petrograph. Indexes

Stratigrafické a petrografické indexy

Q	kvartér	P	perm	PA	nemetamorfované proterozoikum
N	neogén	C	karbon	f	fylity
Pg	paleogén	D	devon	g	svory a ruly, popř. metamorfity všeobecně, někdy s menšími tělesy vyvřelin
K	křída	S	silur	G	ortoruly, granulity, migmatity
J	jura	O	ordovik	γ	vyvřeliny všeobecně
T	trias	Є	kambrium	β	neovulkanity všeobecné

Boundaries

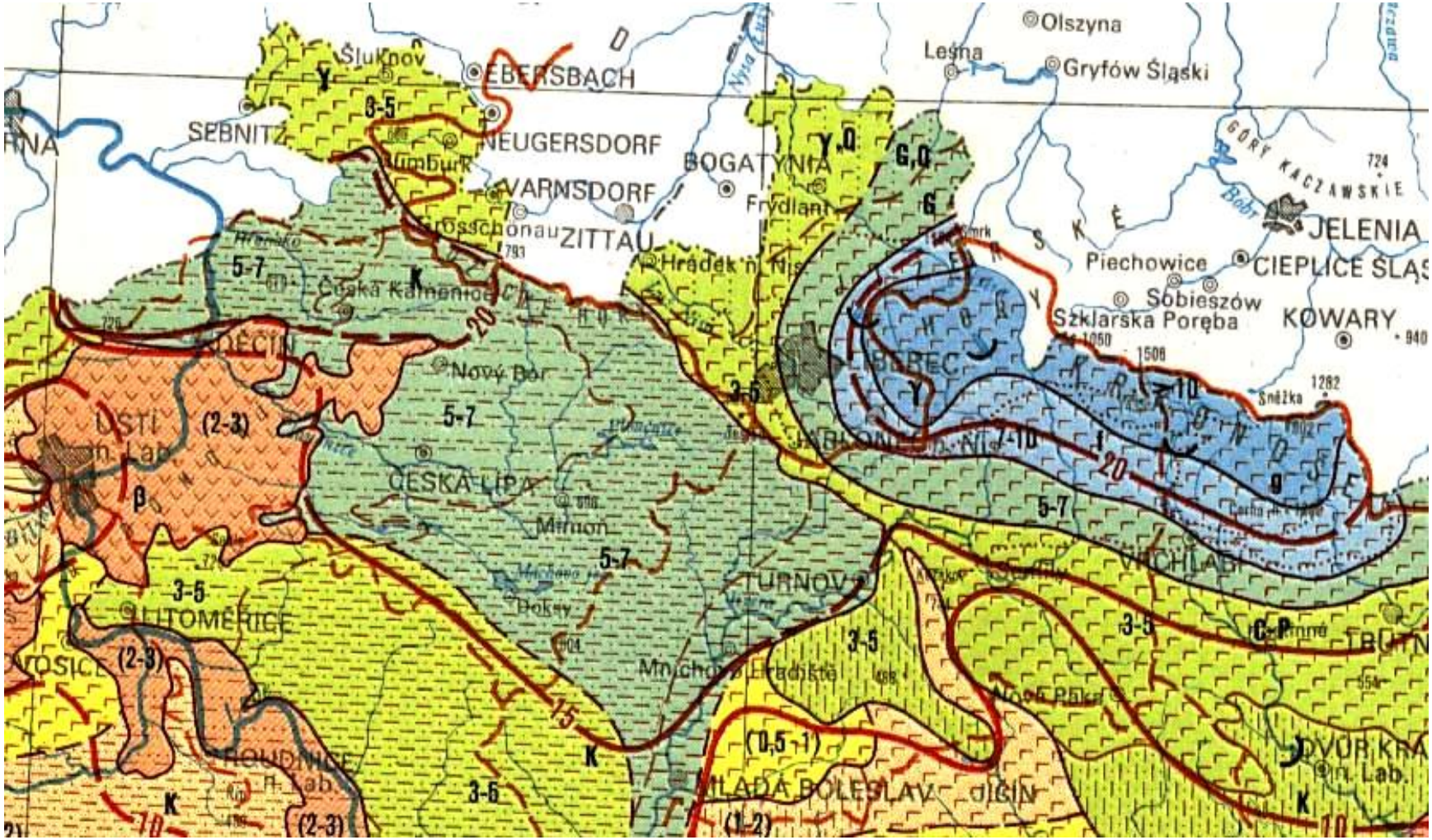
Bounds of values of specific run-off

Aquifer systems

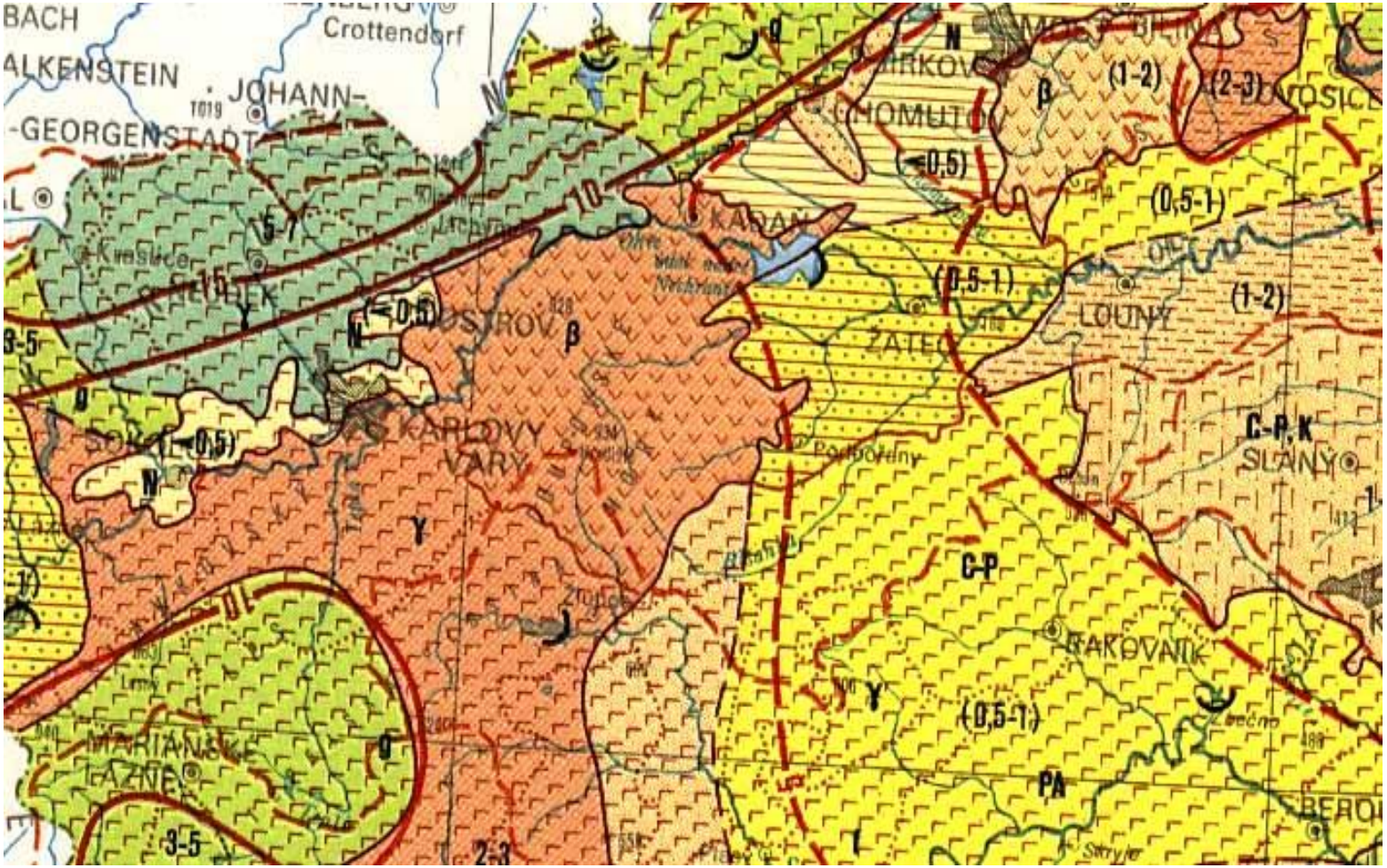
Stratigraphical and petrographical units

First and secon order waterhseds

North – Western Bohemia



Western Bohemia



Thank you