Towards a classification of coastal ribbon lithology using a new global data base

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Control factors of pristine river chemistry

- **Azonal factors**
  - **lithology (minerals solubility)**
  - **tectonics (relief, uplift rate, age of rocks)**
  - **hydrology (lake / wetlands occurrences)**

- **Zonal factors**
  - **climate (runoff, temperature)**
  - **soil / vegetation (pCO_2, C/N)**
  - **vegetation (net primary production)**
  - **distance to oceans**

Towards global pictures of riverine changes

– Geographic Information Systems : combination of multiple informations

– Information layers now available at fine resolutions (1 to 50 km) for most Earth System components (runoff, river network, relief, lithology...) to map past natural river state

– Socio-economic layers (water uses, environmental pressures, water needs) still being developed or available at coarser resolutions

– First global maps of present river state are coming out

– Here : Lithology of the coastal ribbon has been estimated using a new digital map of the continental surfaces targeted to riverine material transfer (Dürr et al. 2005 Glob. Biogeochem. Cycles accepted) identifying 15 lithological types

– These types may be used to answer questions related to erosion, water chemistry, and aquifer porosity

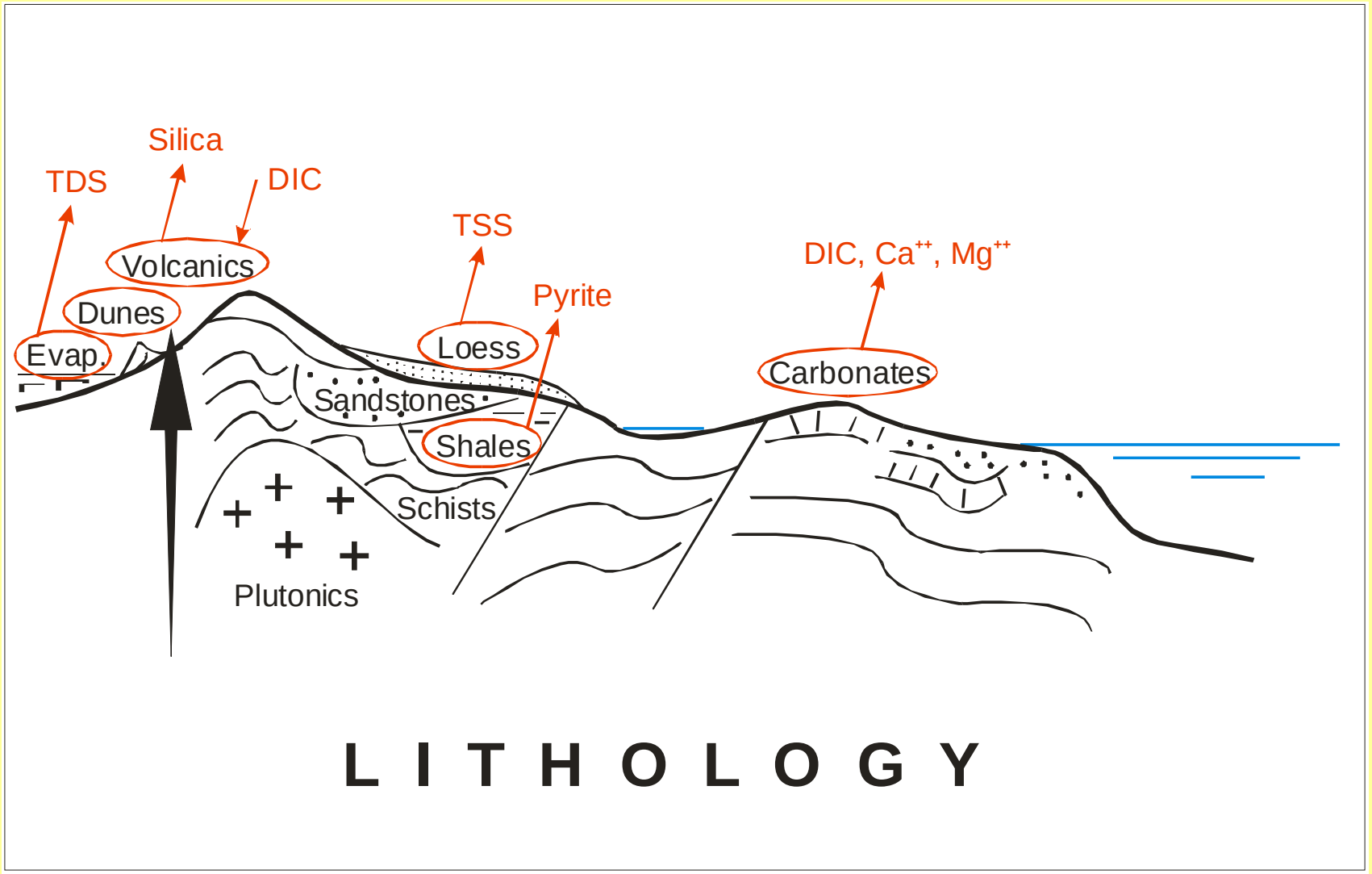
Why a new map of global lithologies?

- **Geological Maps give mainly rock ages, not rock types (for sedimentary rocks)**

- **Geochemical cycles**
  - **Water as chemical agent**
  - **Continental / tectonic erosion**
  - **Water quality**

- **Problems**
  - **Resolution / complex folded in mountains**
  - **Sedimentary rocks**
  - **Loess / Dunes**
  - **Precambrian Carbonates**
  - **Evaporites**
  - **Quaternary glaciation extent**

A new database : digital global lithology



Conceptualisation process of the Lithologic World Map for hydrologic purposes

Examination of previous works

Resolution too coarse or maps too general

Decision: new attempt of a Lithologic World Map
in vector mode and for our specific (limited) purposes

Base map:

Geological World Map

(UNESCO, 4 sheets, 1:25.000.000, Dottin et al. 1990)

Digitised map by Water Systems Analysis Group (2000), University of New Hampshire; corrected and refined by Dürr et al. 2005

New attempt of a Lithologic World Map

- Water & Ice

- Sedimentary
- **Alluvial, Dunes, Loess, Non/Semi Consolid.**
- **Evaporites**
- **Carbonates**
- **Mixed**
- **Silici-Clastic**

- Volcanic — **Acid & Basic**
- Plutonic — **Acid & Basic-ultrabasic**
- Complex
- Metamorphic
- Precambrian (Shield) exc. Sedim.&Complex

Base map:

Geological World Map (1:25.000.000)

corrected and refined

Material & Sources:

- Previous works
- Geological World Atlas (1:10.000.000)
- World Map of Hydrogeological conditions
- Lithologic Maps FAO
- Soil Map FAO
- Regional studies, map of soluble rocks China …

Main tool for corrections:

Geological World Atlas, Regional studies, Encyclopaediae, Personal communications…

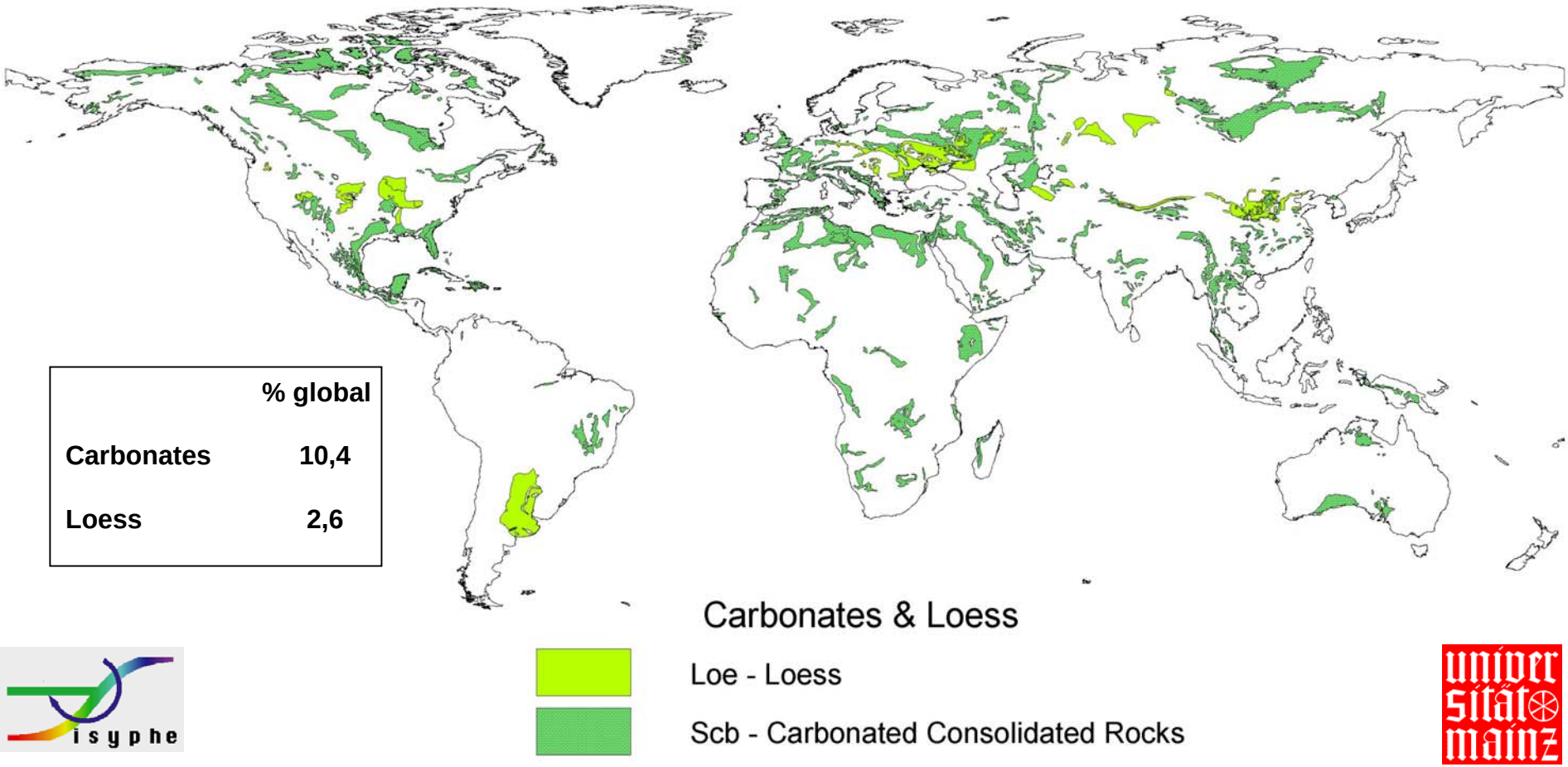
New Digital Lithologic World Map

Targeted to riverine fluxes

isyphe

universität mainz

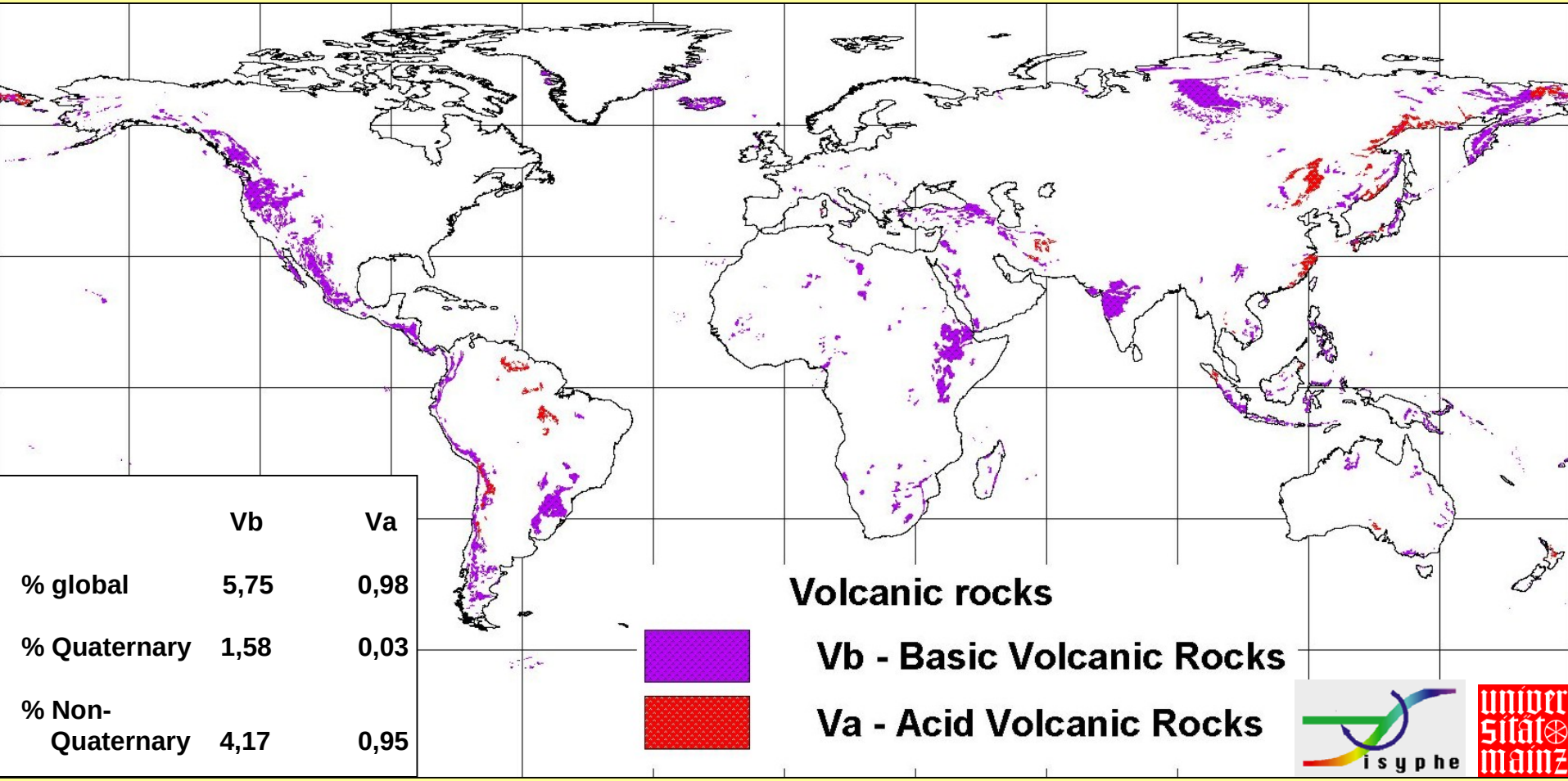
Distribution of Carbonate Rocks & Loess (H. Dürr 2003)



	% global
Carbonates	10,4
Loess	2,6

- Loess are found in periglacial positions, e.g. Chinese Loess Plateau, Lower Paraná, Middle West, S. Russian Plain
- Carbonate rocks can be found in any continent, under any climate
- Small carbonate outcrops can still be missing (e.g. N. Borneo)

Acid & Basic Volcanic Rocks (H. Dürr 2003)

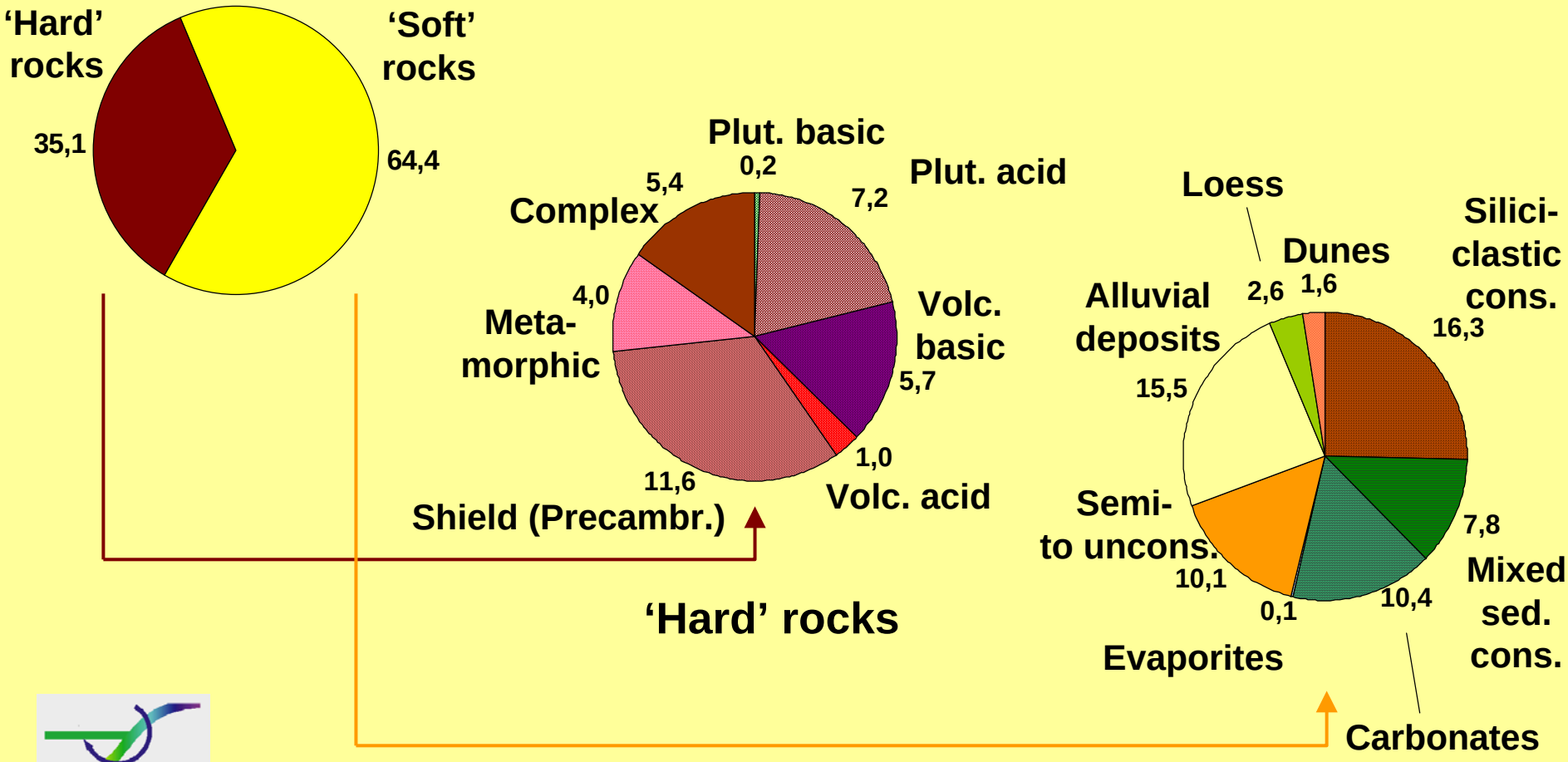


	Vb	Va
% global	5,75	0,98
% Quaternary	1,58	0,03
% Non-Quaternary	4,17	0,95

- Quaternary Volcanic rocks distribution strictly follows the recent tectonics in ocean rifts (Iceland), Circum-Pacific fire belt, East African Rift, etc. …

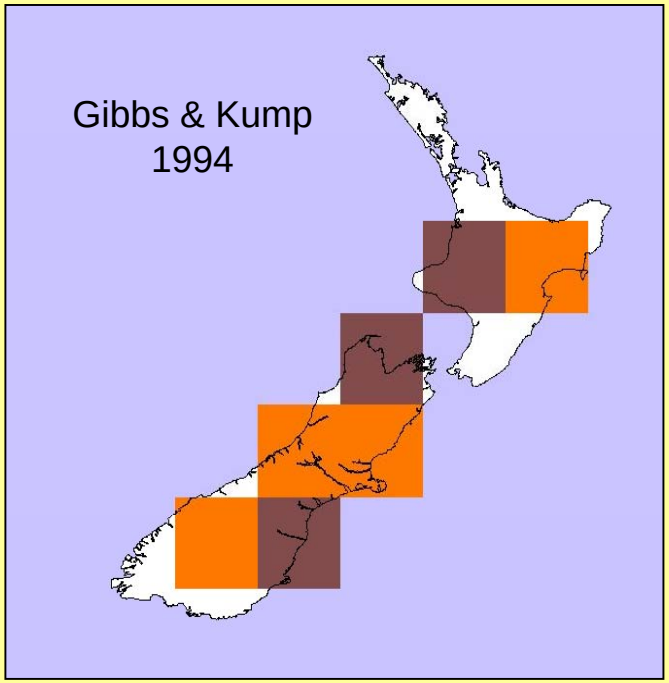
- Former traps deposits (Parana, Deccan, Tunguska …) still control present day river chemistry

Global Lithology analysis (Dürr et al. 2005 GBC)

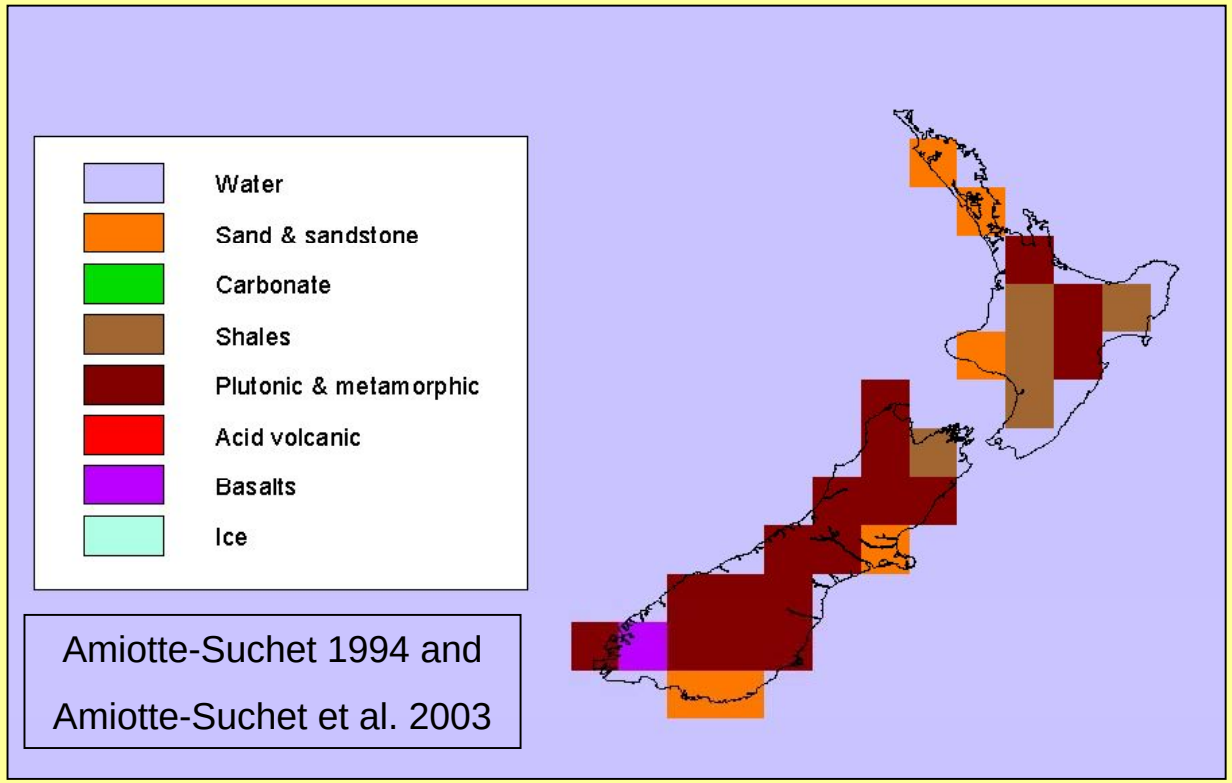


Representation of lithology :

the resolution issue ; the classification issue ; Examples for New Zealand



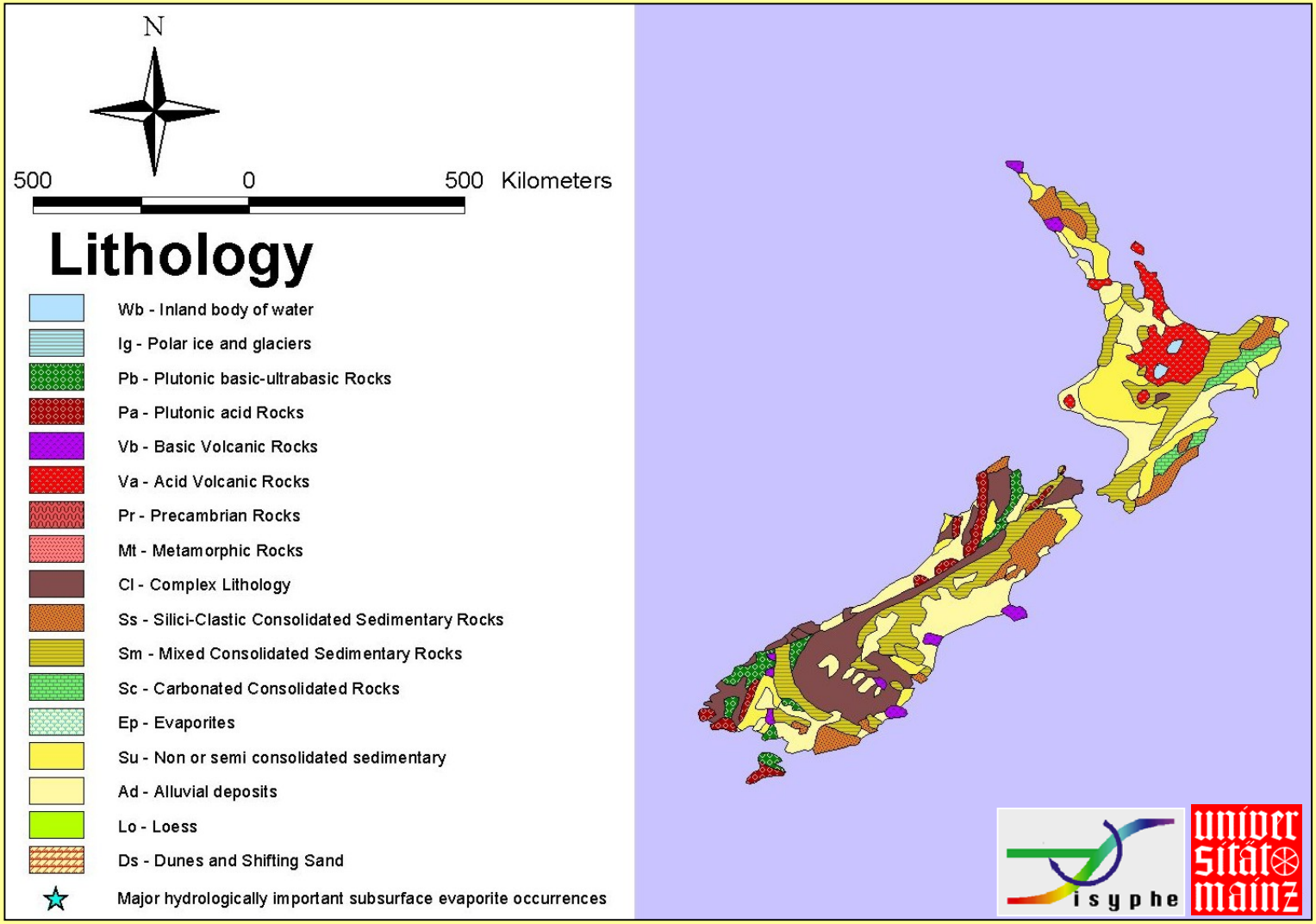
Resolution 2° x 2°



Resolution 1° x 1°

New Lithological World Map (H. Dürr 2003)

The New Zealand example



Vector format , various grid resolutions possible :

0,5° x 0,5° for global analysis

down to 5’ x 5’ or 10’ x 10’ feasible

- The distribution of lithology can be modified by its transformation when using gridded scale

Lithology of the coastal ribbon

- Surface lithology of the global coastal ribbon,
  here defined at 50 km depth

- needed by various scientific communities, working on

  - coastal erosion,

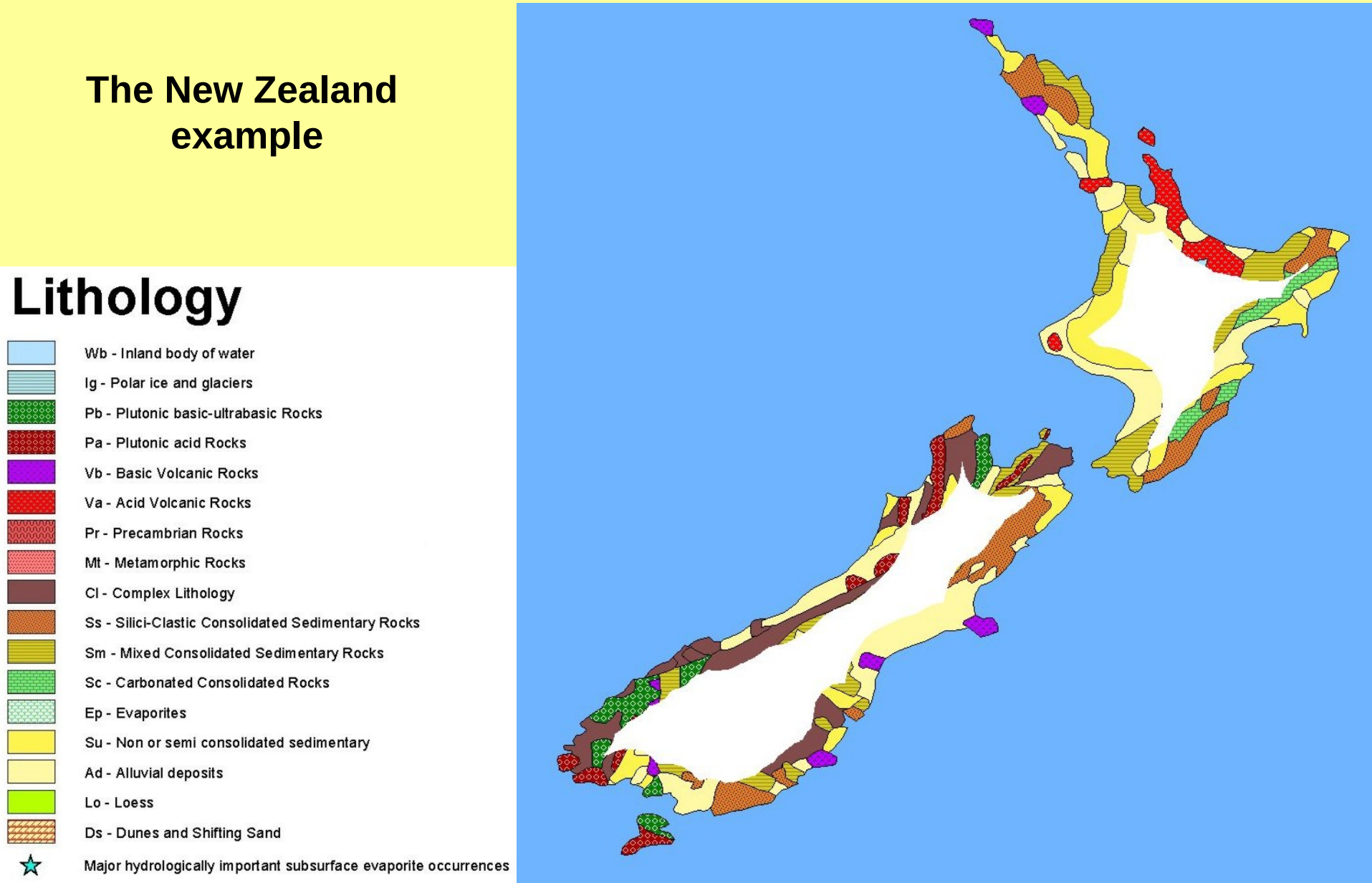
  - water resources management,

  - coastal ecology etc.

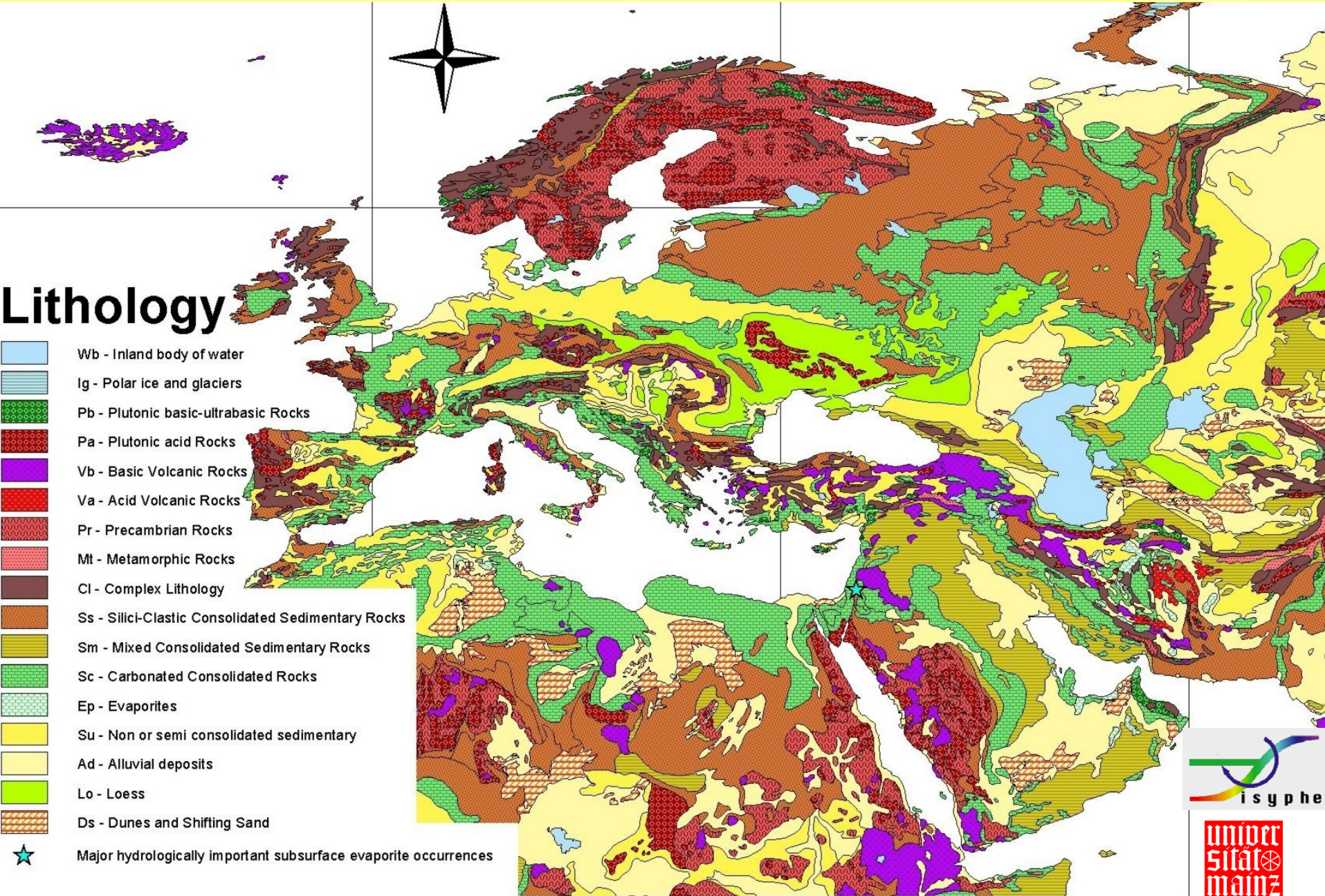
  - estimating global direct inputs of groundwater
    to the coastal zone (e.g. karst regions on the coasts,
    coastal alluvial aquifers)

Lithology of the coastal ribbon

The New Zealand example



Total vs. Coastal ribbon lithology – Europe example



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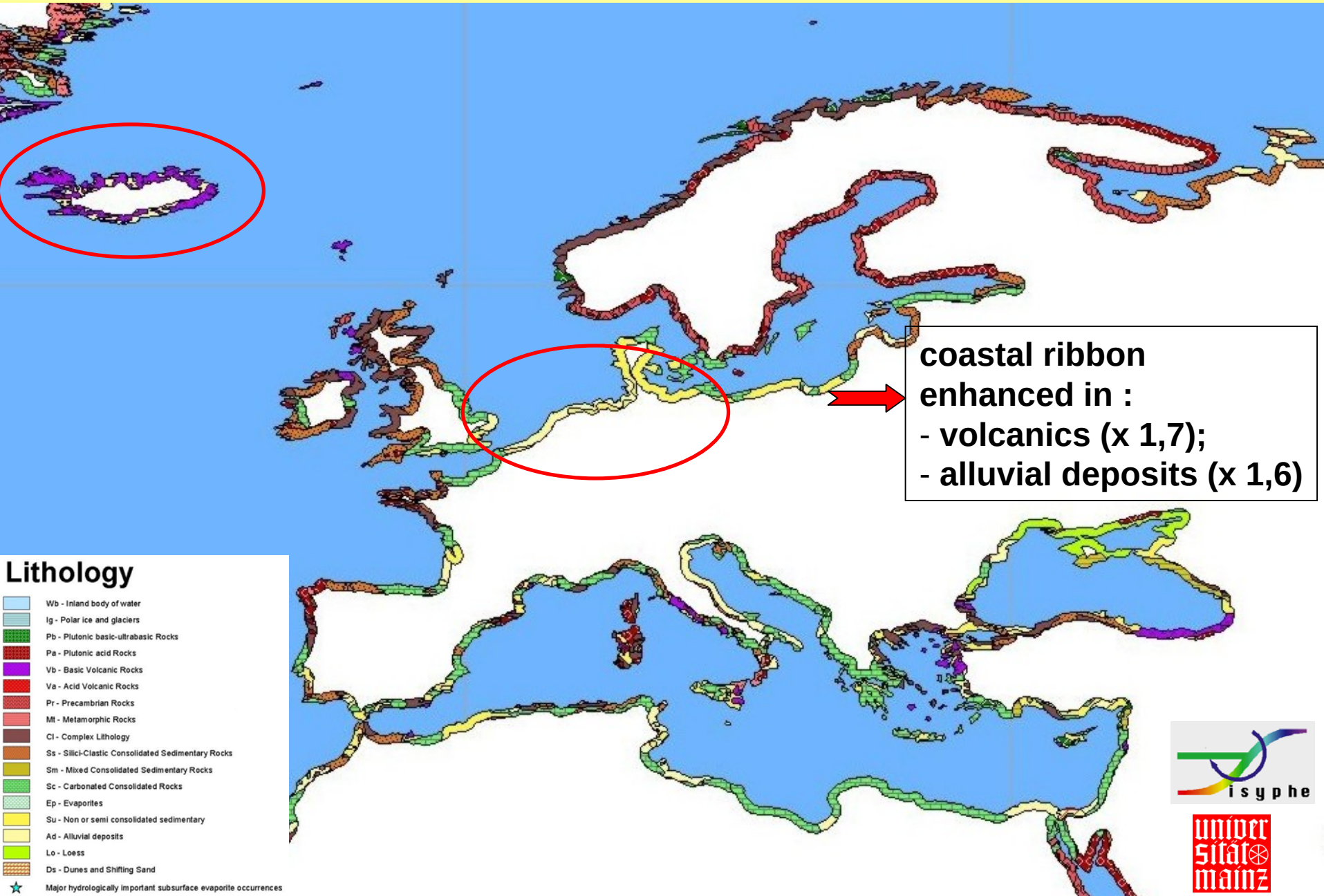

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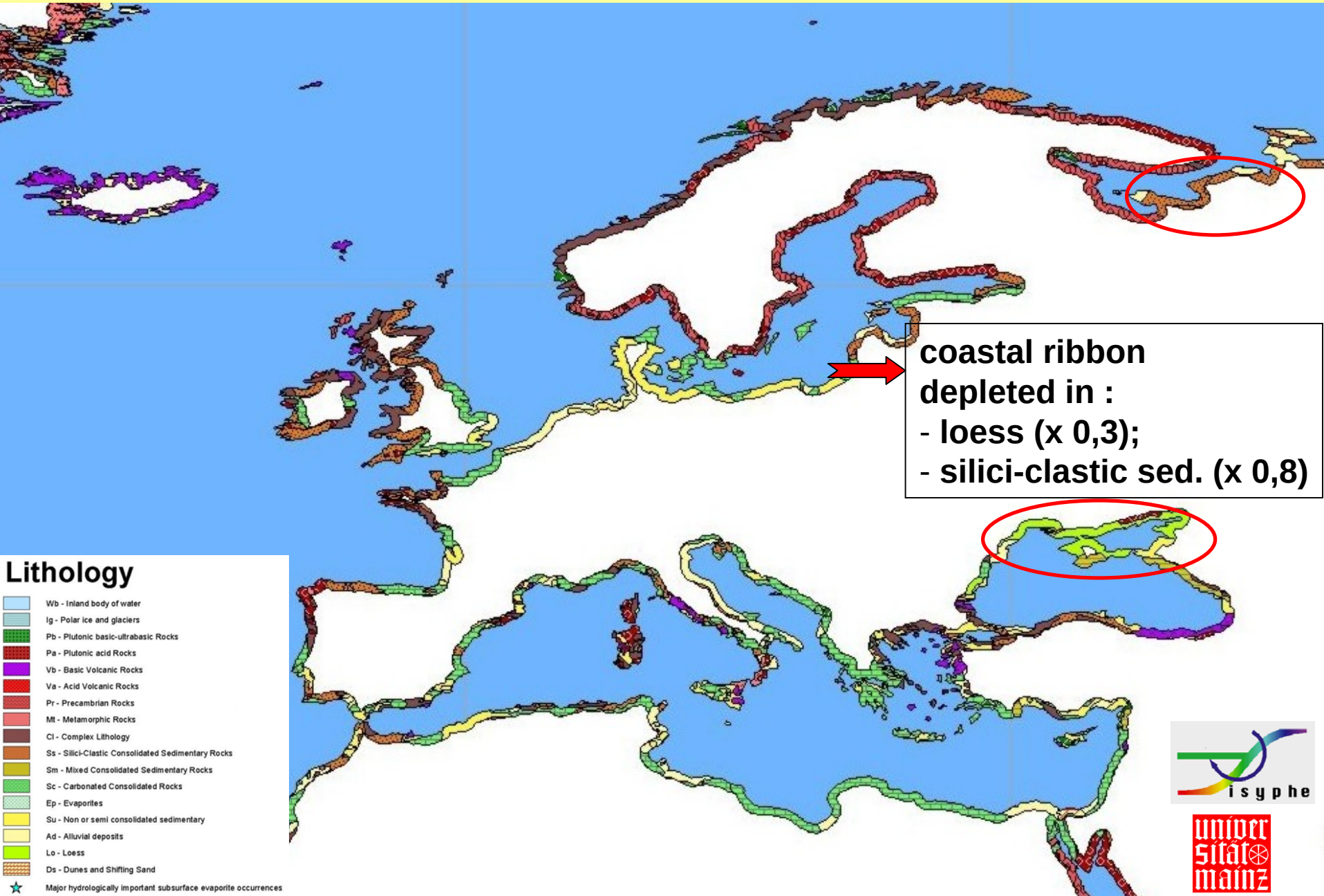
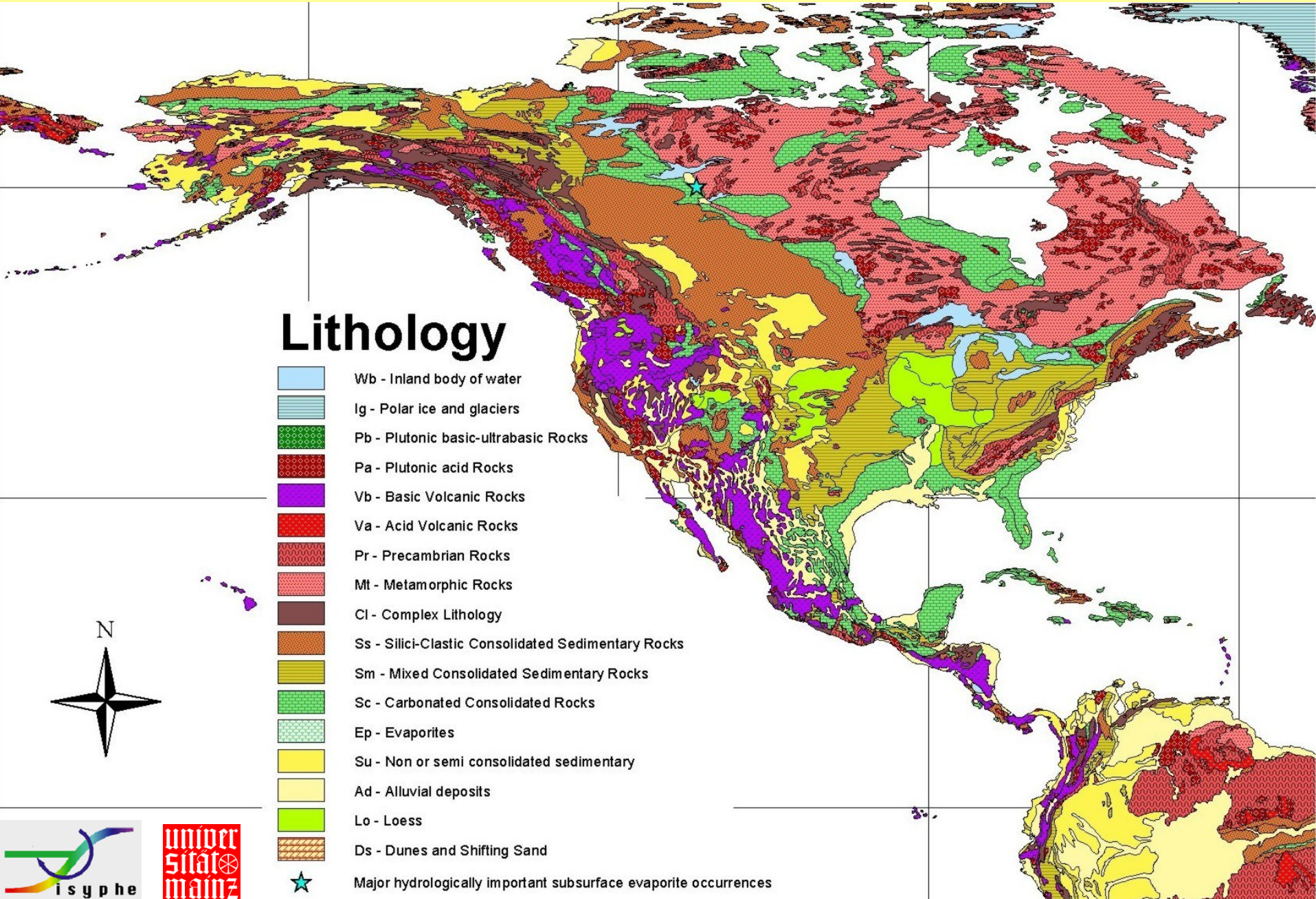


Total vs. Coastal ribbon lithology – North America example



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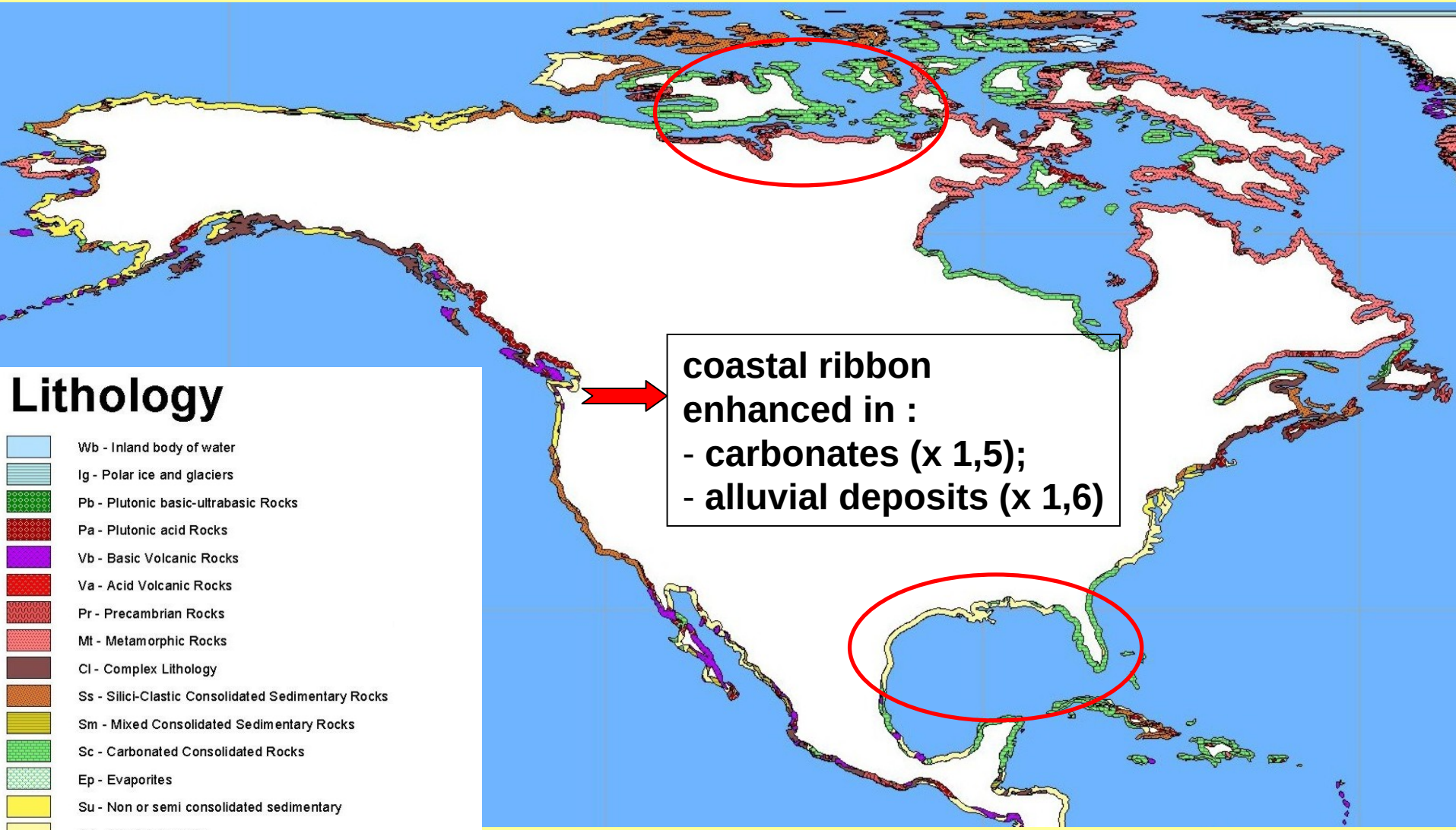

Lithology

- Wb - Inland body of water
- Ig - Polar ice and glaciers
- Pb - Plutonic basic-ultrabasic Rocks
- Pa - Plutonic acid Rocks
- Vb - Basic Volcanic Rocks
- Va - Acid Volcanic Rocks
- Pr - Precambrian Rocks
- Mt - Metamorphic Rocks
- Cl - Complex Lithology
- Ss - Silici-Clastic Consolidated Sedimentary Rocks
- Sm - Mixed Consolidated Sedimentary Rocks
- Sc - Carbonated Consolidated Rocks
- Ep - Evaporites
- Su - Non or semi consolidated sedimentary
- Ad - Alluvial deposits
- Lo - Loess
- Ds - Dunes and Shifting Sand
- ★ Major hydrologically important subsurface evaporite occurrences

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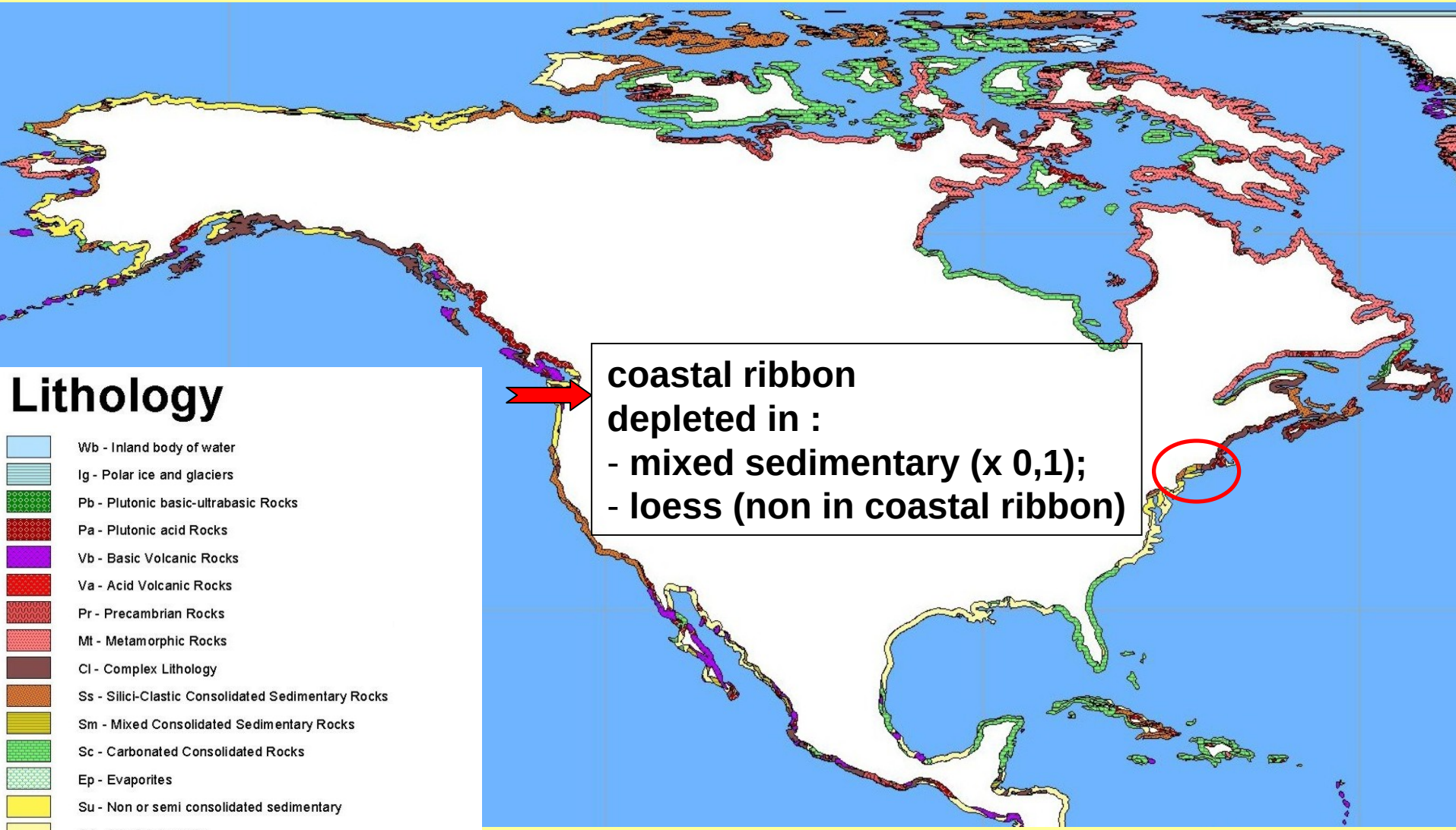

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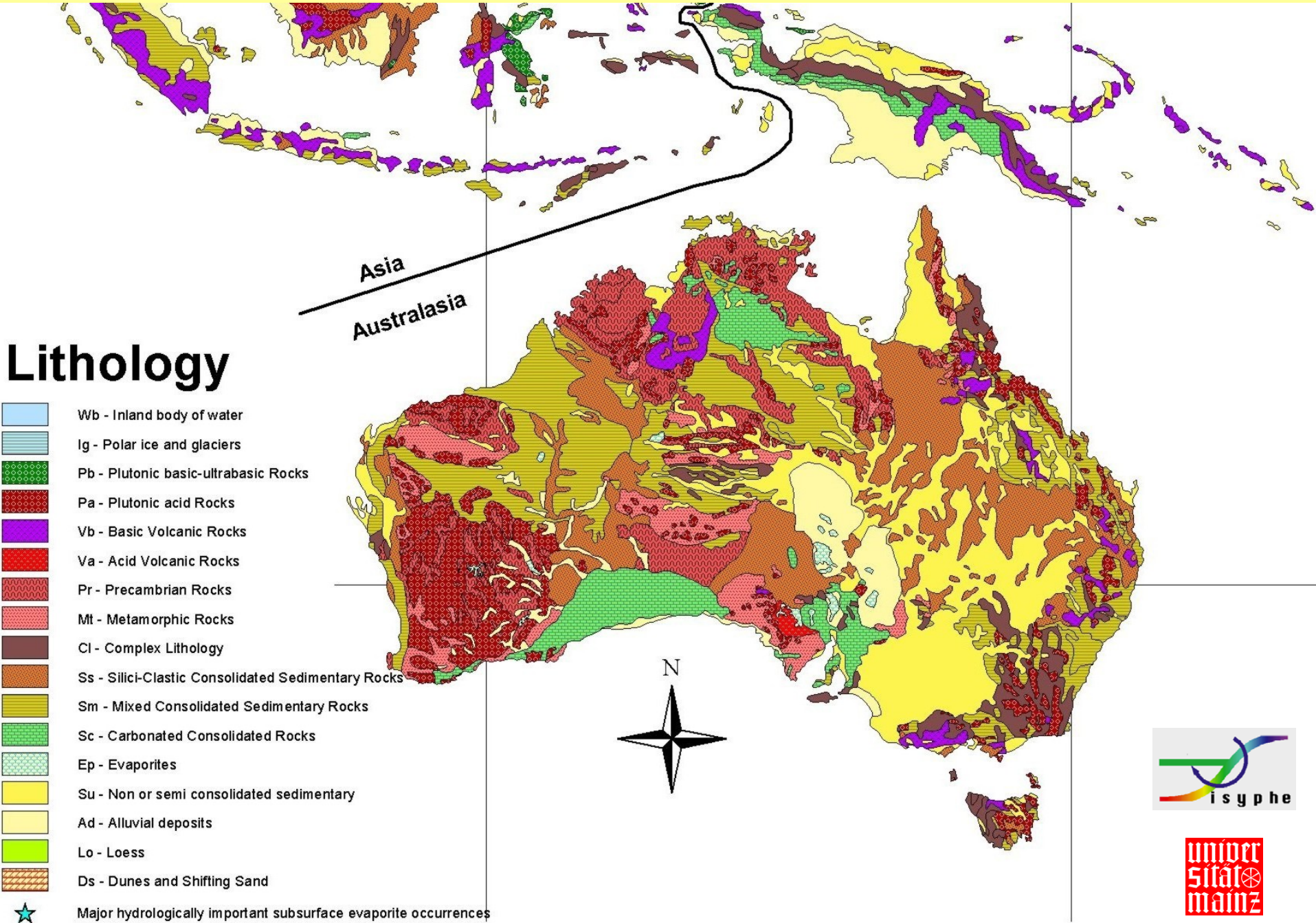
Total vs. Coastal ribbon lithology – Australasia example



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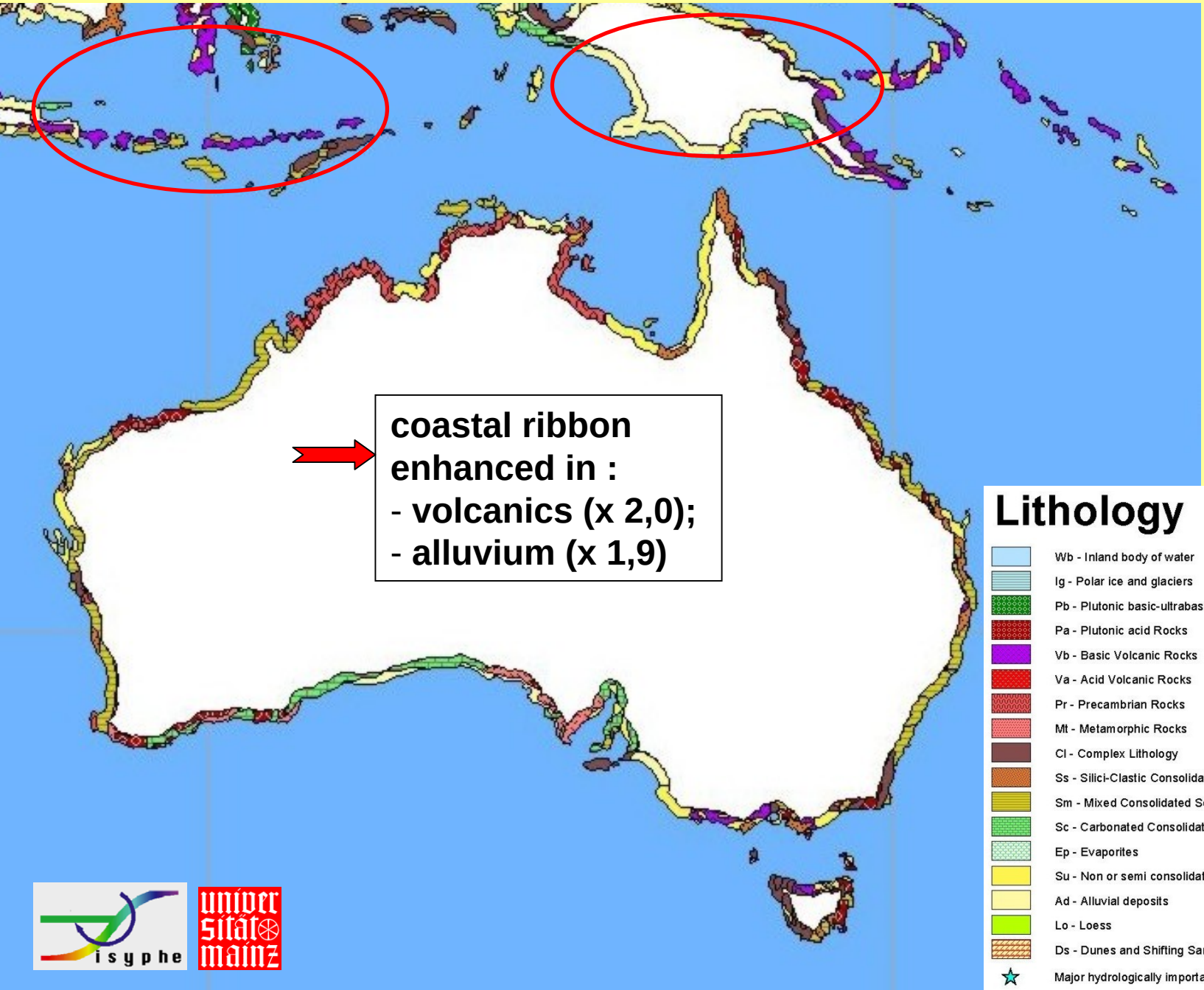

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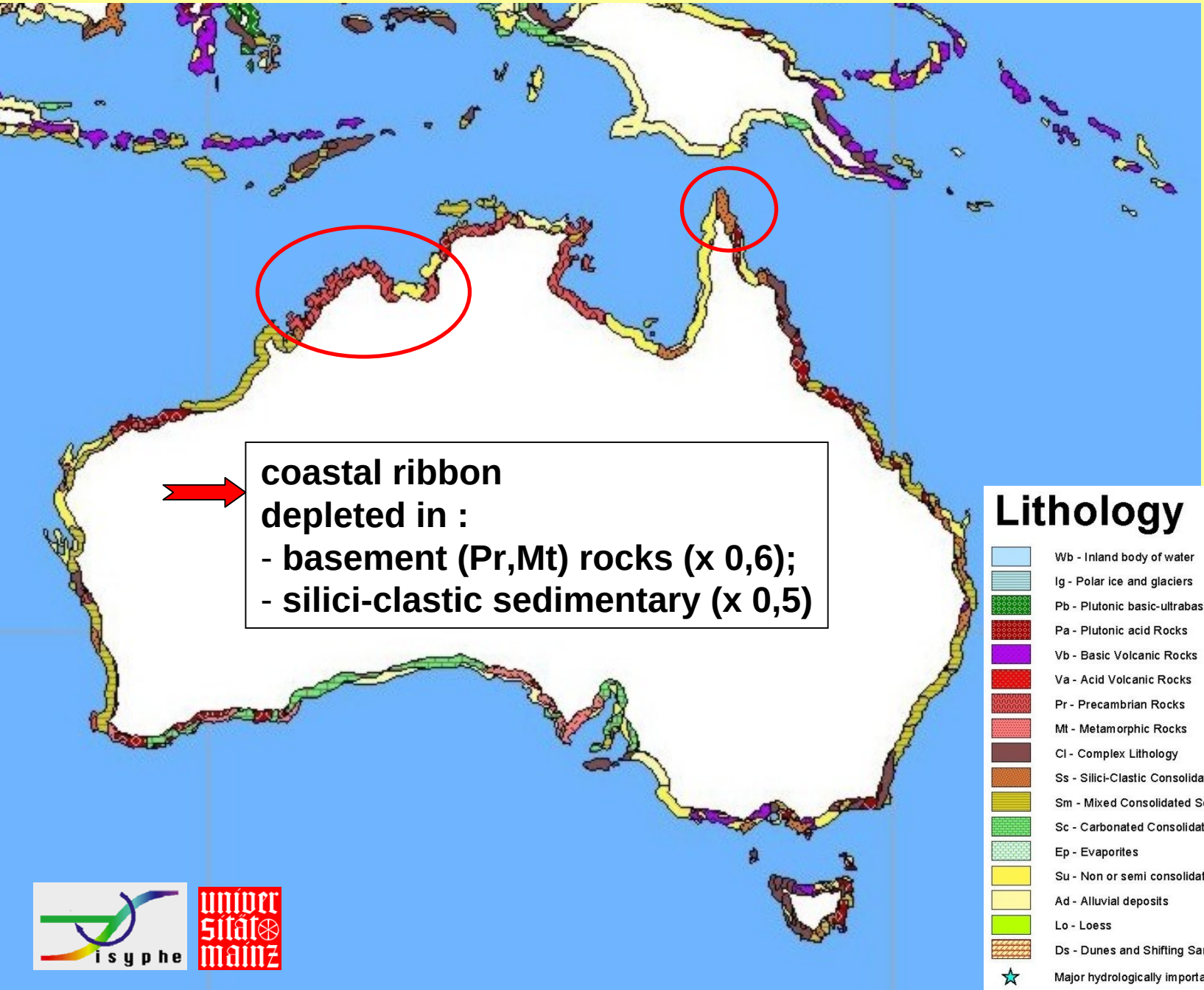

Total vs. Coastal ribbon lithology

Some examples for selected continents :
Ratio Coastal ribbon lithology (%) / total continental exorheic lithology (%)

	Precam., Metam., Plutonic	Volcanic (basic + acid)	Silici-clastic sedimentary	Carbonates + Mixed sedimentary	Semi- un-consolidated sed. + Alluvial deposits	Evaporites, Loess, Dunes
Africa	0,6	1,7 (7,5 → 4,3 %)	0,4	1,4	1,8 (24,5 → 43,0 %)	0,2 (4,0 → 0,7 %)
North America	1,1	1,0	0,9	1,0	1,4	0,0
South America	0,9	0,9	0,4 (16,3 → 5,7 %)	0,7	1,4	0,8
Asia	0,8	1,6	0,8	0,8	1,3	0,3
Total global	0,9 (25,0 → 22,1 %)	1,5 (13,8 → 9,4 %)	0,7 (19,0 → 14,2 %)	1,0 (18,2 → 18,9 %)	1,2 (24,0 → 28,3 %)	0,3 (3,8 → 1,1 %)

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But drops to 0,8 when compared to global exorheic total, and to 0,5 when compared to global coastal ribbon

But enhanced in carbonates only (x 1,5)

Conclusions

- New lithology map in vector mode allows for enhanced resolutions (0,5° x 0,5° for global analysis, down to ~5’ grid size feasible)

- New lithology map allows for more detailed approaches when addressing hydrological questions dealing with rock types

- Specific rock types generating specific fluxes have been distinguished

- Lithology of coastal ribbon : marked differences with respect to global mean values (e.g. generally enhanced in volcanic rocks (x 1,5) on all continents except N and S America and alluvial deposits (x 1,3) (all continents except Europe : 20,3 → 21,1 %)

Some Perspectives

- Connect coastal ribbon lithology to coastal relief types and establish lithology per coastal relief types

- Compare with existing assessment (lithology of global relief types) as in Dürr et al. 2005

- Establish estuarine typology – coastal ribbon lithology is one of the factors to be taken into account