Guarani Aquifer System (SAG): a rich but stingy and (still) misunderstood water resource

Dr. Ricardo Hirata
CEPAS|USP Vice-Diretor
Institute of Geosciences
University of São Paulo

What is the SAG?

(*Guarani Aquifer System*)

SAG is a huge hydrogeological system (>1,1Mkm^2, covering partially Argentina, Brazil, Paraguay and Uruguay) localized in an area of immense water demand (15M inhabitants, agriculture….)

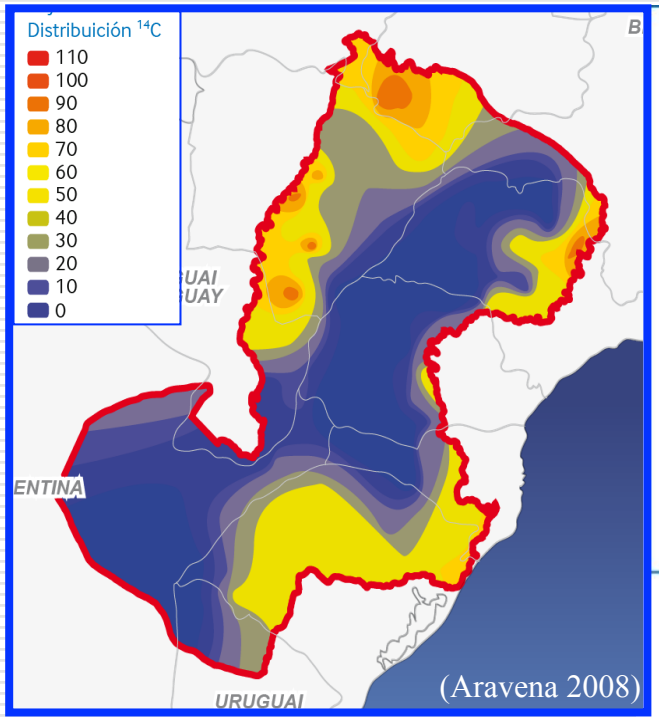
The Guarani Aquifer System Project - PSAG

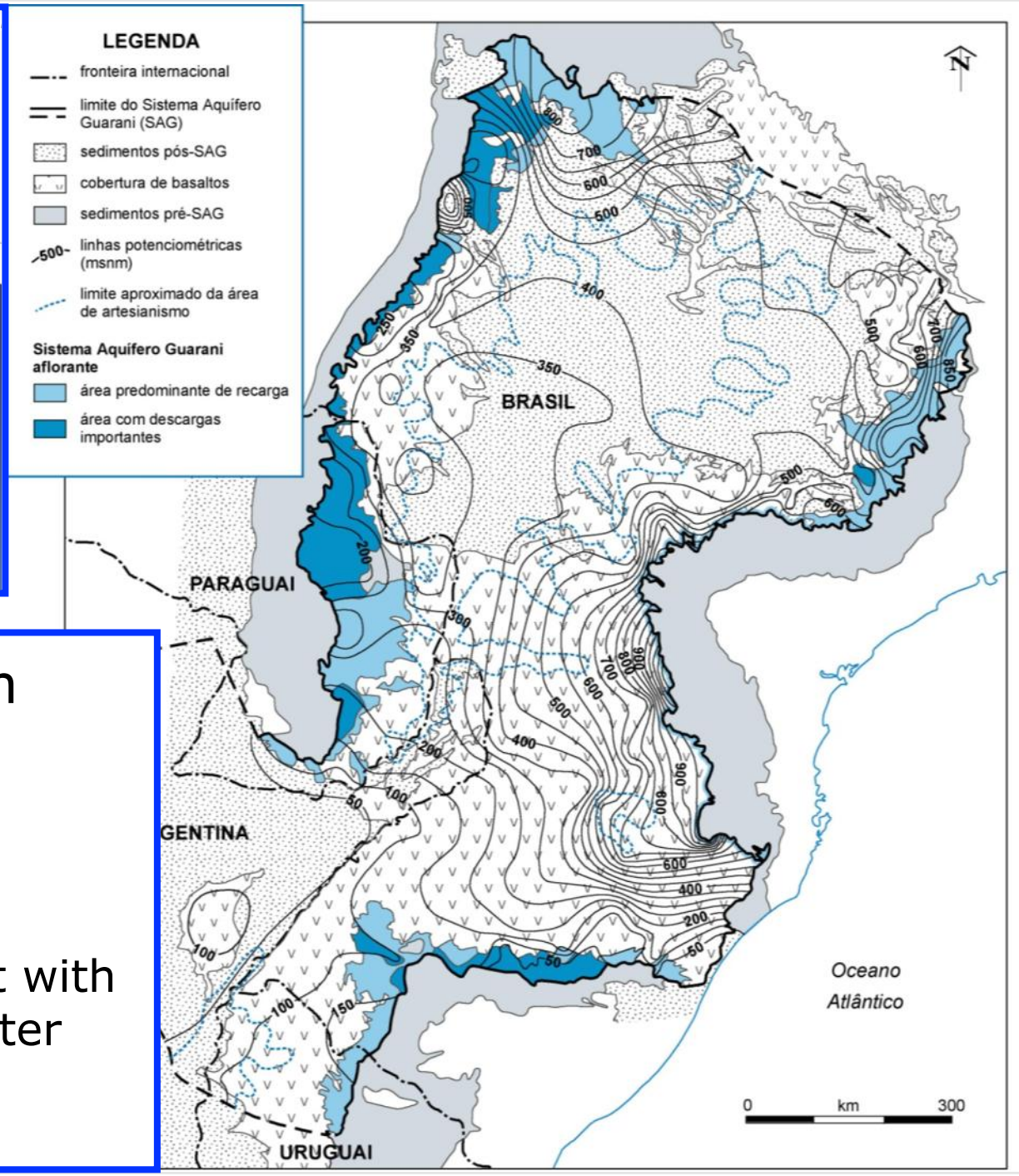
PSAG was in essence *preventive* and in spirit *cooperative*

Objectives: To establish a sustainable development and environment protection of the SAG

PSAG was a GEF-supported initiative, implemented by the four countries and the Organization of American States (OAS), under supervision of the WB, with advice from GWMATE, and contributions of the IAEA and the BGR (Germany)

May 2003 – January 2009

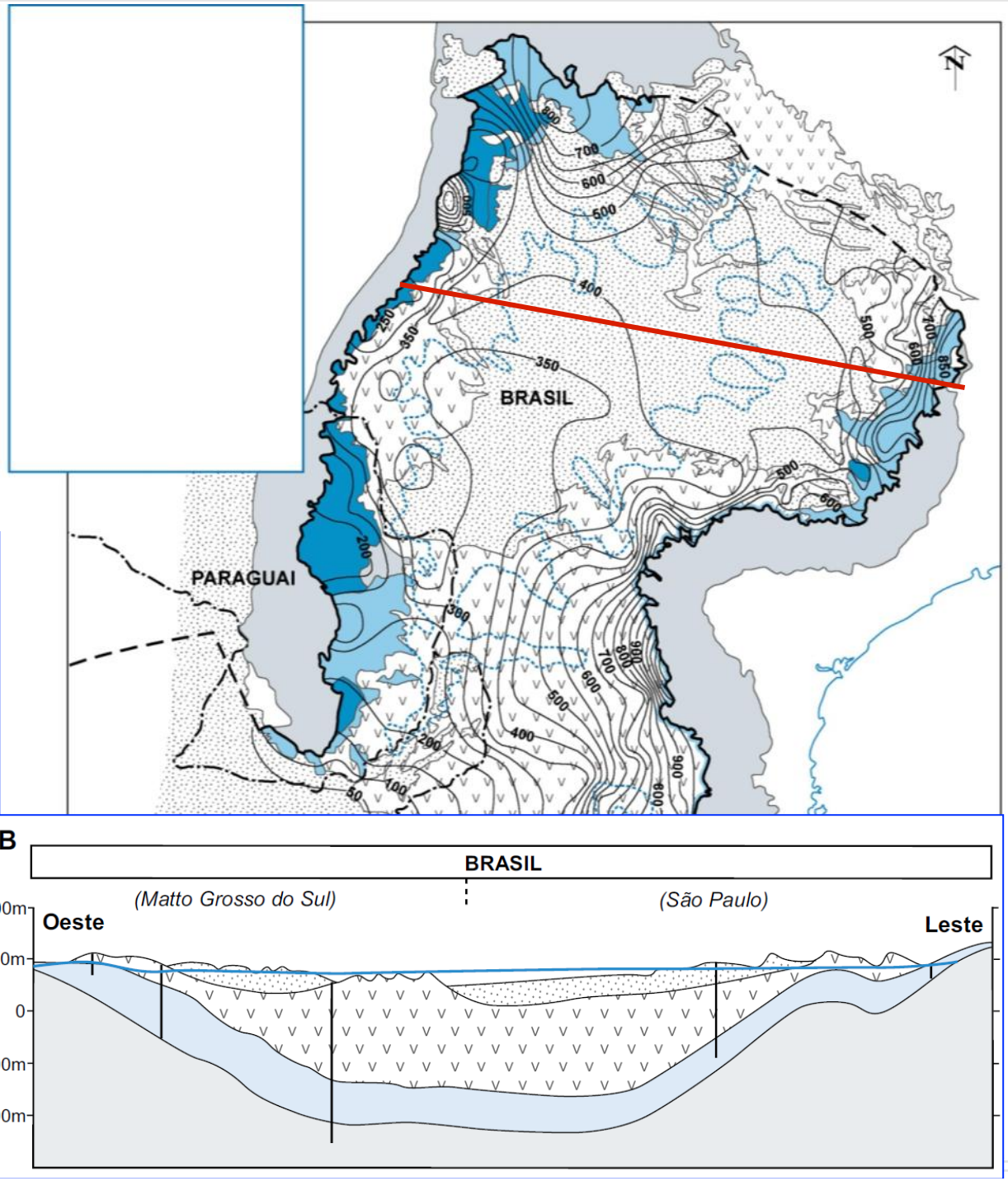




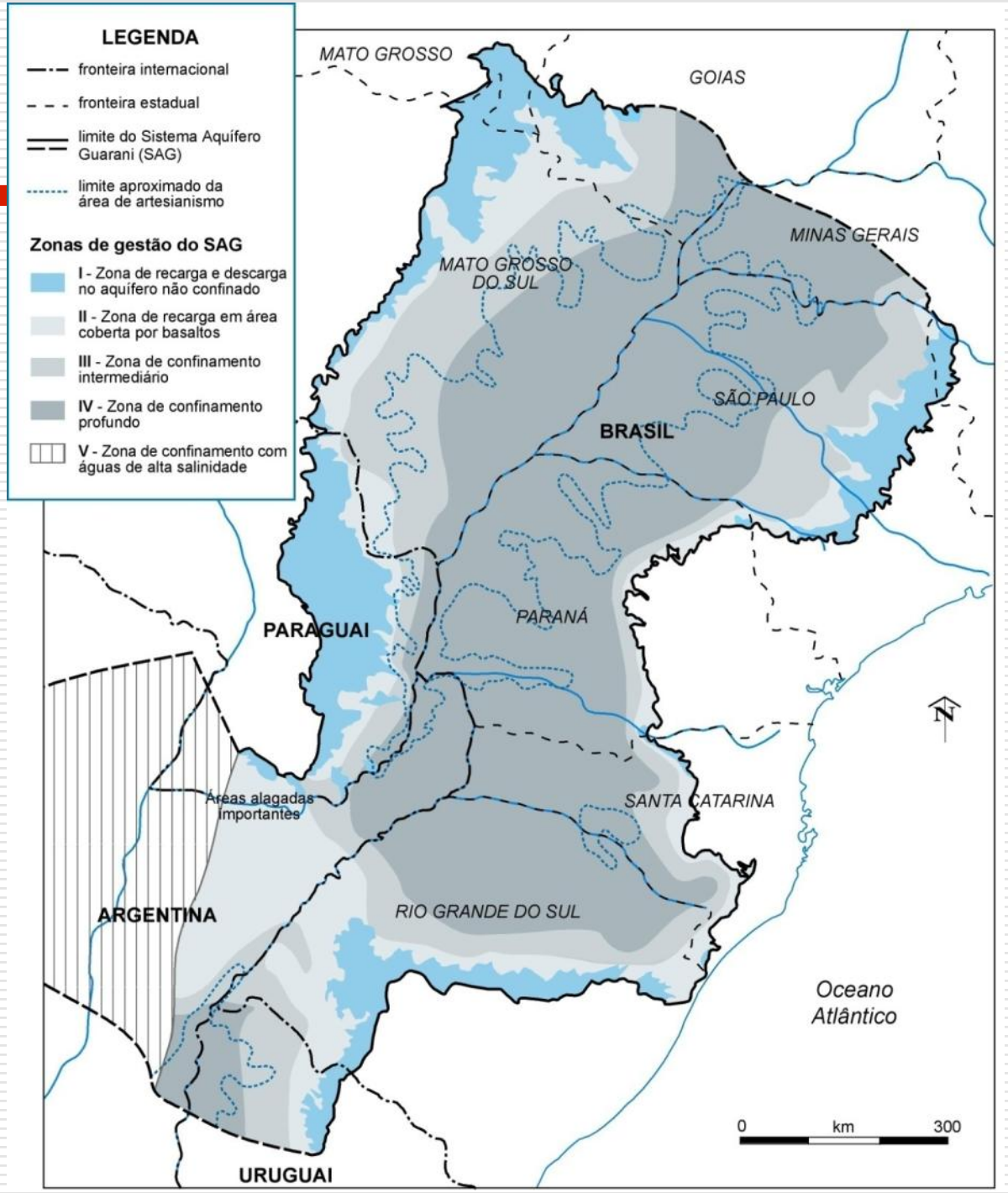
What did we learn from the PSAG?

- The SAG is a very complex system that stores an enormous amount of water, but with a very low groundwater velocity (<1,5 m/y)

90% of SAG area is confined by basalts with a very restrict recharge/discharge zones associated to the outcrops



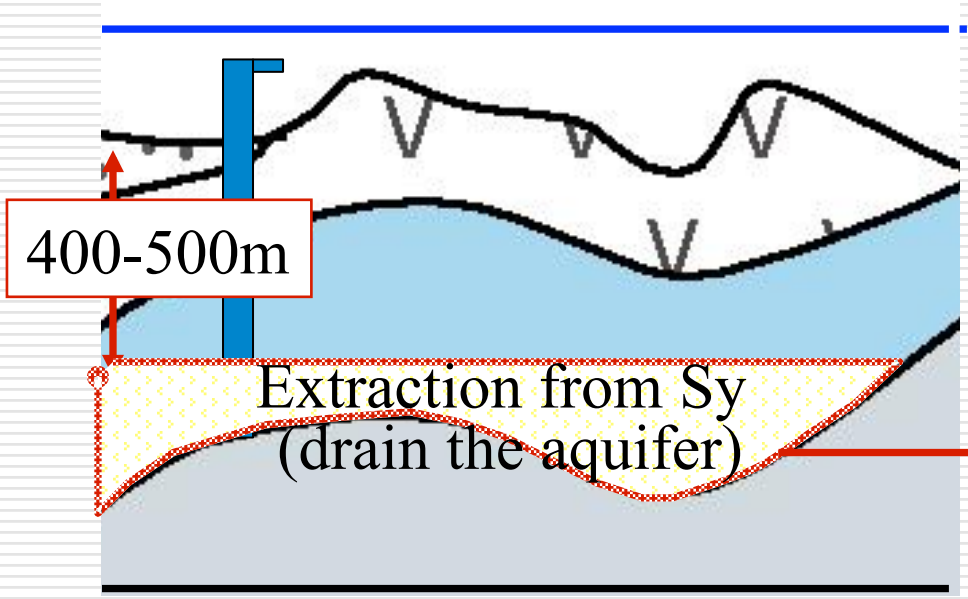
Zones of management



Zones of management

ZONE I *Unconfined*	**ZONE II** *Basalt-covered recharge*	**ZONE III** *Intermediate confined*	**ZONE IV** *Deep confined*	**ZONE V** *Confined saline water*
- Outcrop area - Recent water - Direct recharge from rainfall - Renewable resource	-Closely-ZI adjacent zone with important vertical recharge through fractured basalts	-No significant recharge occurs -Old waters (>10ky) -Mined exploitation	- Same of ZIII Exploitation limited up to 400mbs of dynamic level in wells	- Saline no potable water

Zone III: intermediate confined



Original potentiometric level

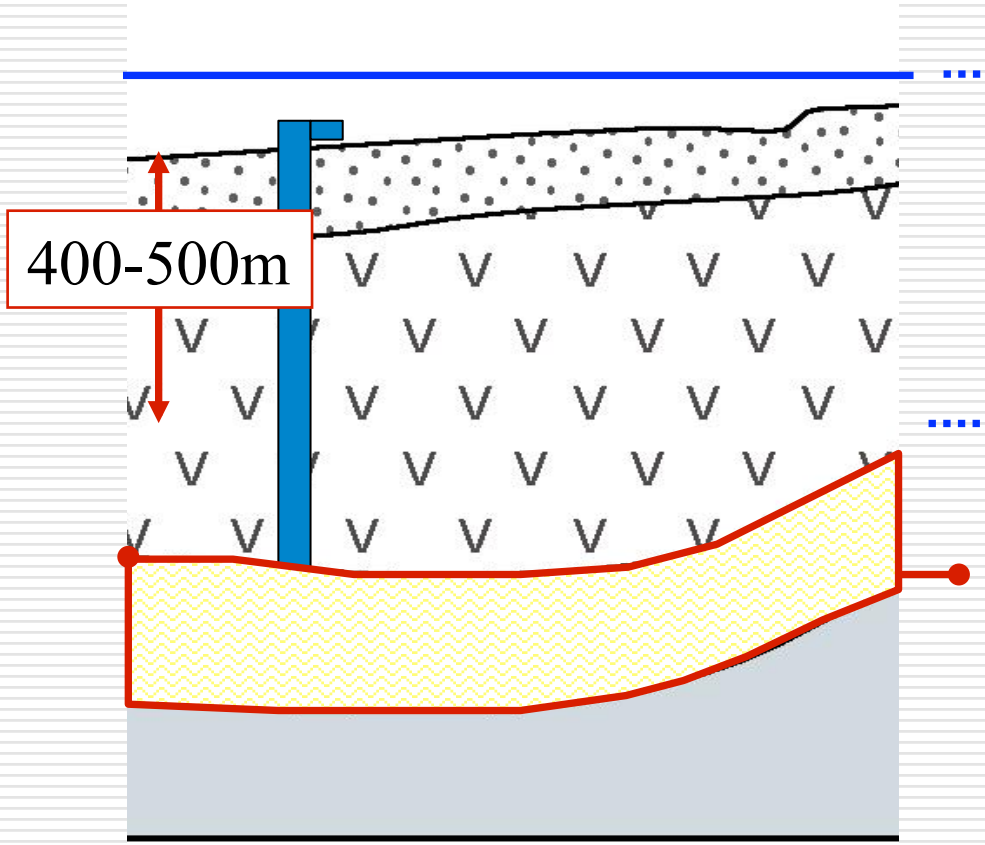
Extraction from Storativity

Max. limit of extraction

Not accessible water
(400-500mbs)

Non-renewable resource – mining extraction
Not accessible water using conventional pumping equipment

Zone IV: Deep Confined



Original potentiometric level

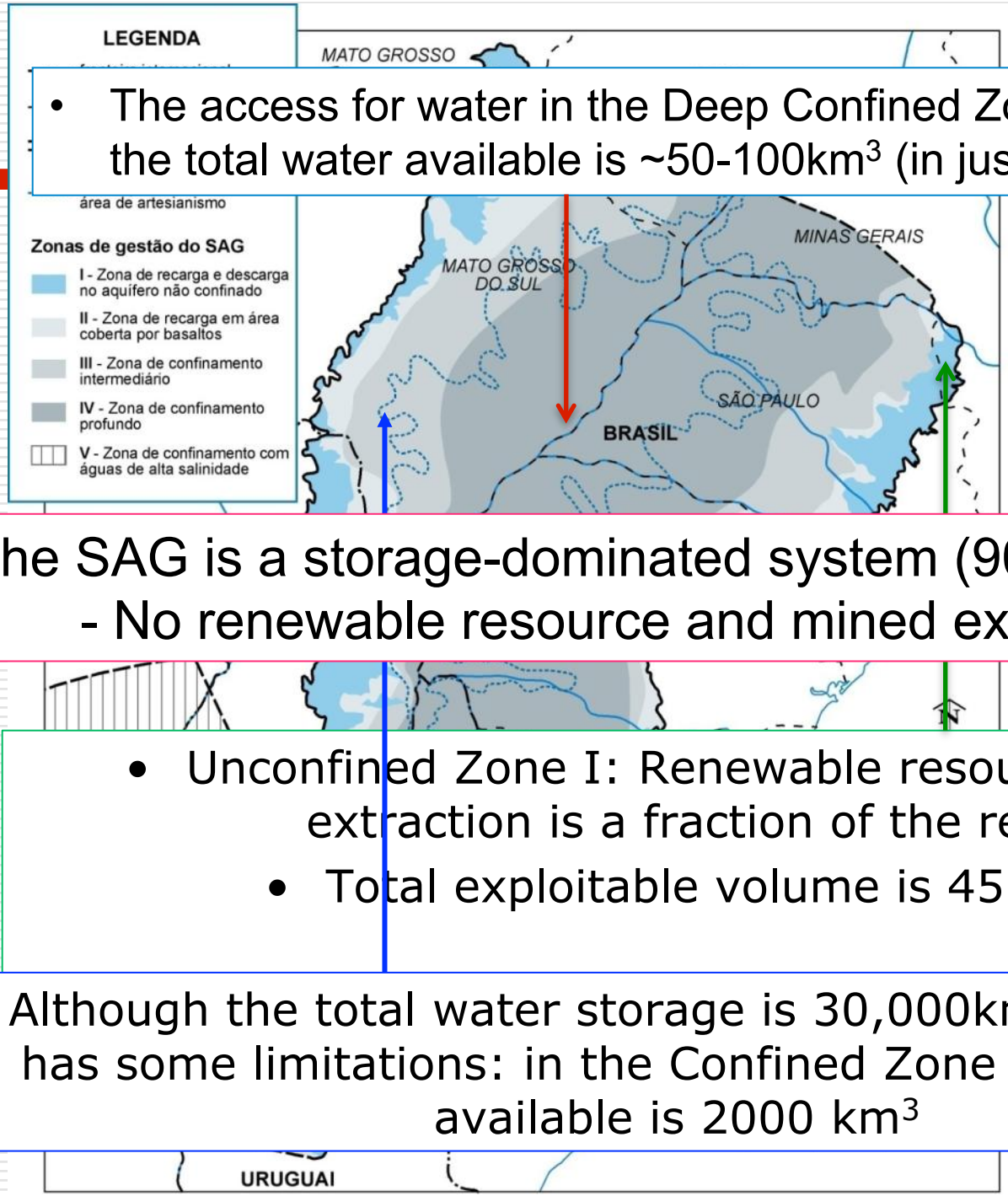
Extraction from Storativity

Max. limit of extraction

Not accessible water
(SAG major volume of water)

Non renewable resource: mining extraction

- Although SAG has a huge water storage, the accessible water is limited to up to 400-500 m of dynamic level in the most extensive area of the aquifer, the Zone IV.



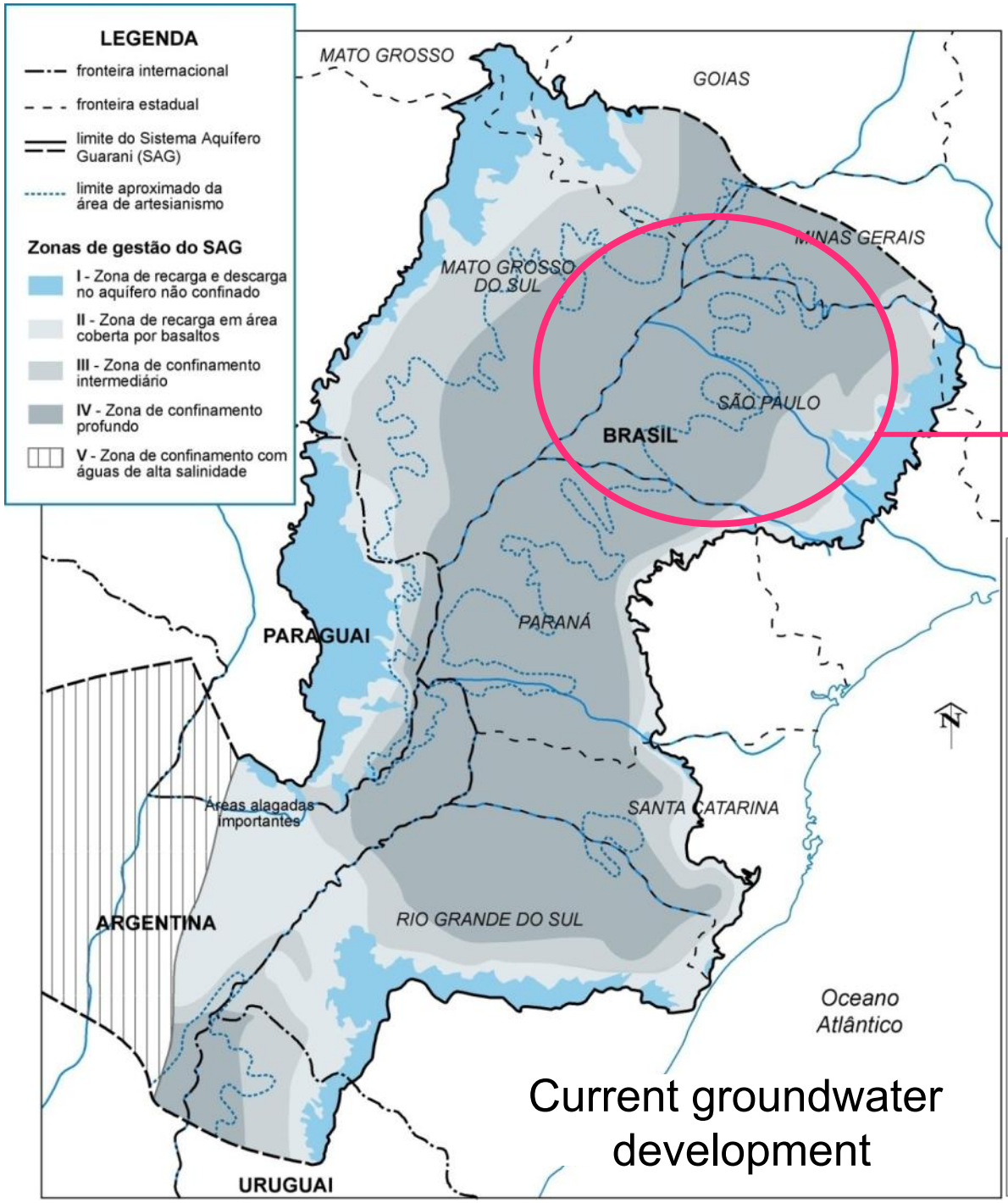
- The access for water in the Deep Confined Zone IV is limited, and the total water available is ~50-100km^3 (in just one extraction)

SAG exploitation

- The SAG is a storage-dominated system (90% of the area)
- No renewable resource and mined exploitation

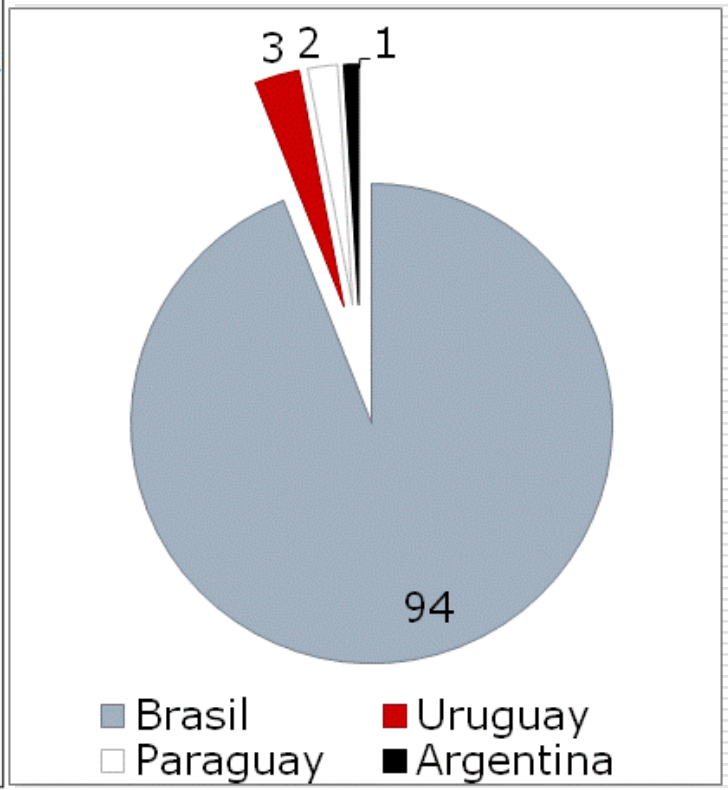
- Unconfined Zone I: Renewable resource and the extraction is a fraction of the recharge
- Total exploitable volume is 45 km^3/y

- Although the total water storage is 30,000km^3, the access has some limitations: in the Confined Zone III, the water available is 2000 km^3



Current groundwater development

94% of 1.04km^3/y is extracted in Brazil (of which ~80% in São Paulo state)

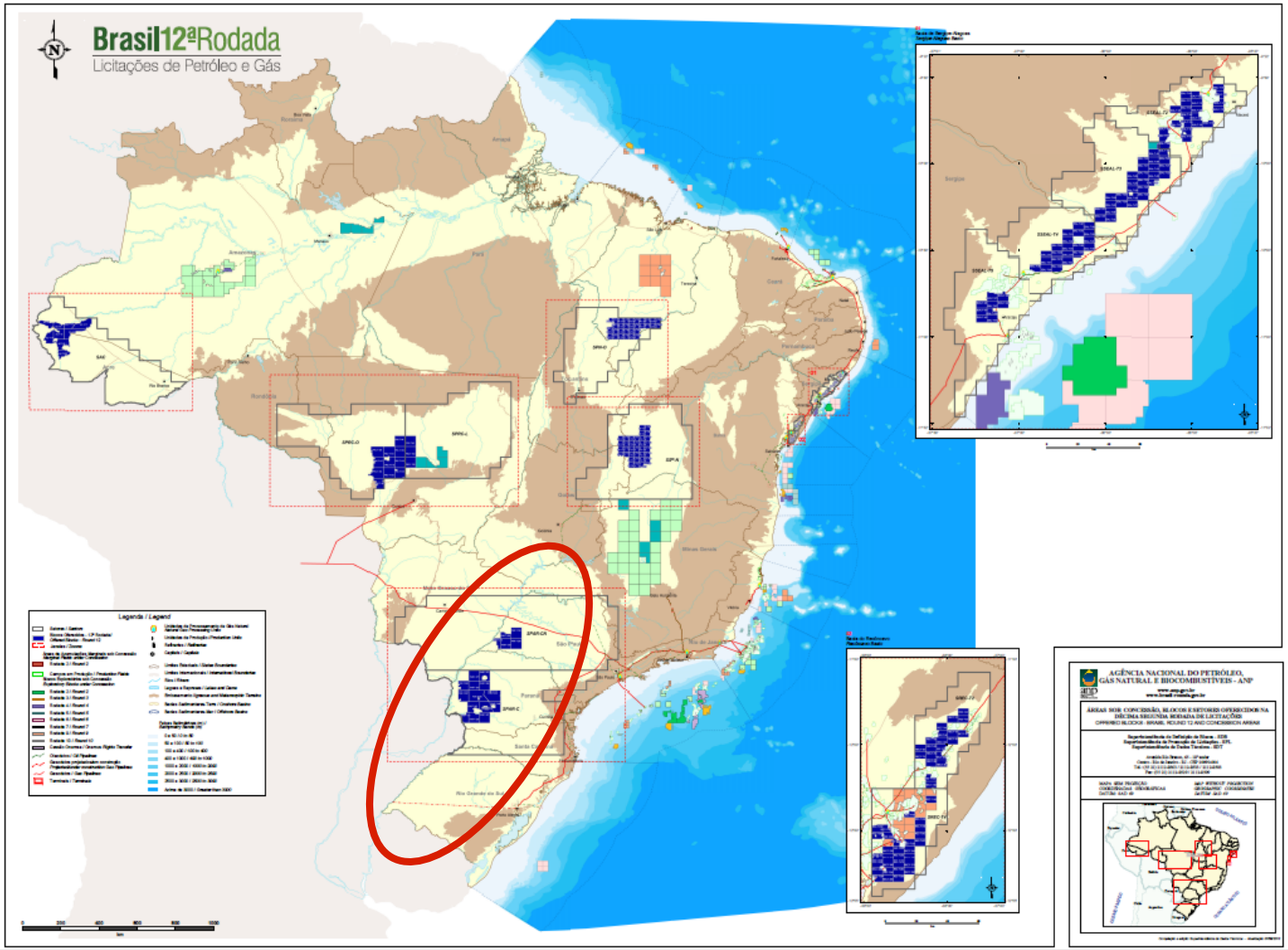


Management implications

- Transboundary issues have not been detected yet: problems are essentially local (no 'upstream-downstream' implications), requiring local scale resolutions

- There are some potential contamination problems associated to agriculture and urban activities; shale gas (future exploitation); and conflicts between urban and agricultural (agribusiness: sugar cane and citrus) water uses.

Brazilian National Petroleum Agency (ANP) included shale gas by rock fracture in the bidding of 11/28/2013



E-W section and (potential bearer gas) Irati Formation

- The SAG is very deep and it will be crossed by many gas production wells, with great risk of contamination.
- The distance between Irati and SAG is just 400m (safety?)
- Complex monitoring of the SAG in great depth (> 1,600m), requiring many wells of high cost (>US$1 million each)

Prof. L. Scheibe

Management implications

- No experiences in mining exploitation (80% of SAG water is older than 1000 years)
- It is necessary to create effective management tools in some areas (mainly in the deeper confined zone)

Management implications

- Adequate legal basis for management in all countries, but some limitations in controlling urban/agricultural activities in outcrop zones
- There are deficiencies in tools and capacity building for management measures implementation

- From the end of PSAG few actions among 4 countries have been done... *unfortunately we are loosing the project momentum*.

Prof. Ricardo Hirata
University of São Paulo
CEPAS|USP
rhirata@usp.br