

CONDICIONANTES GEOLÓGICOS E IMPLICAÇÕES GEOMECÂNICAS

João Pedro Silva Pereira

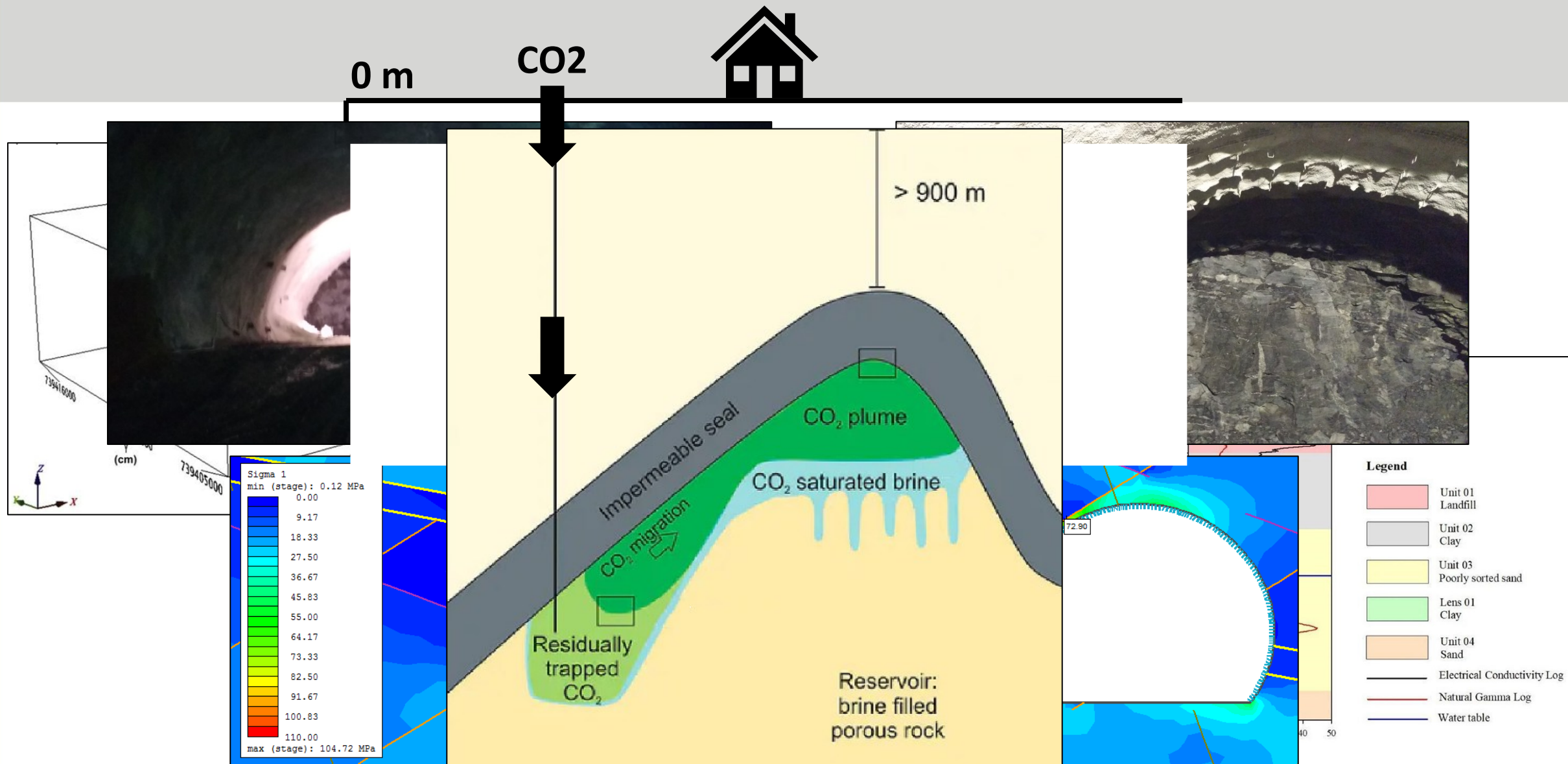
São Paulo, 26/03/25

Seminário Internacional

Captura e Armazenamento de Carbono

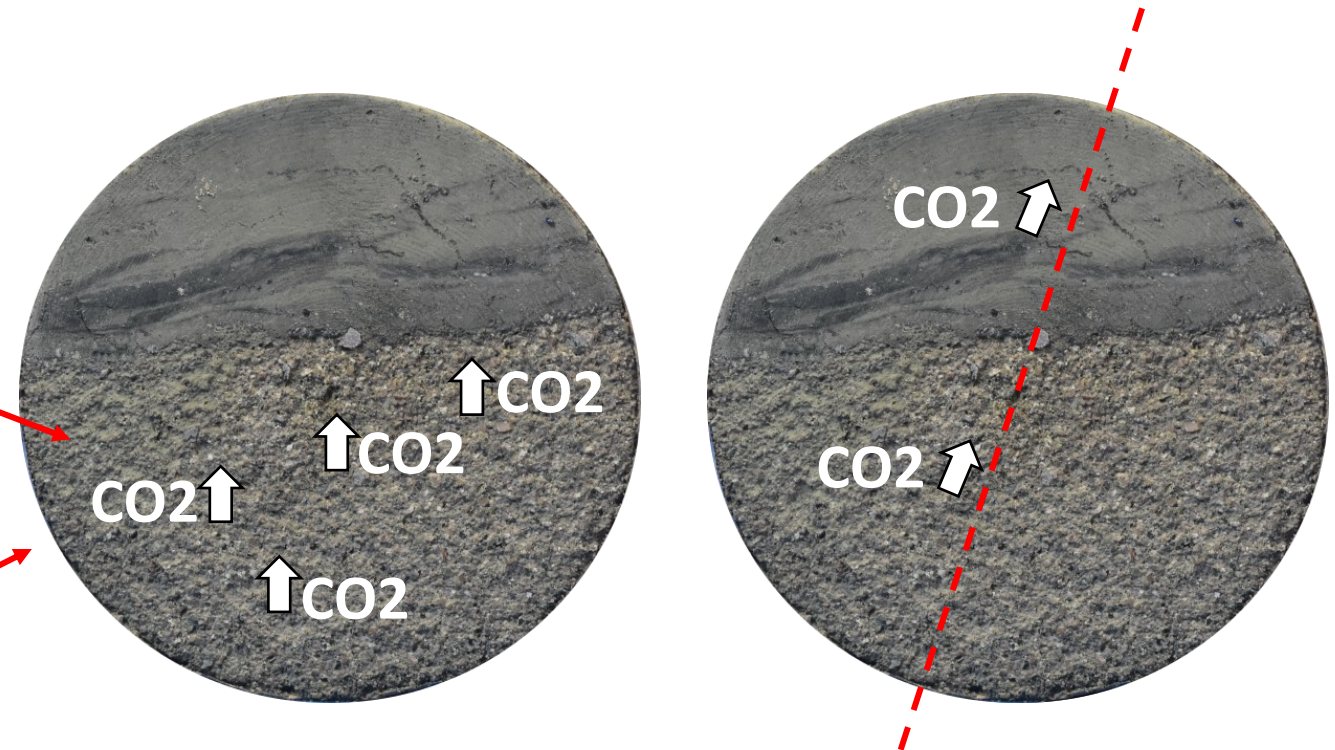
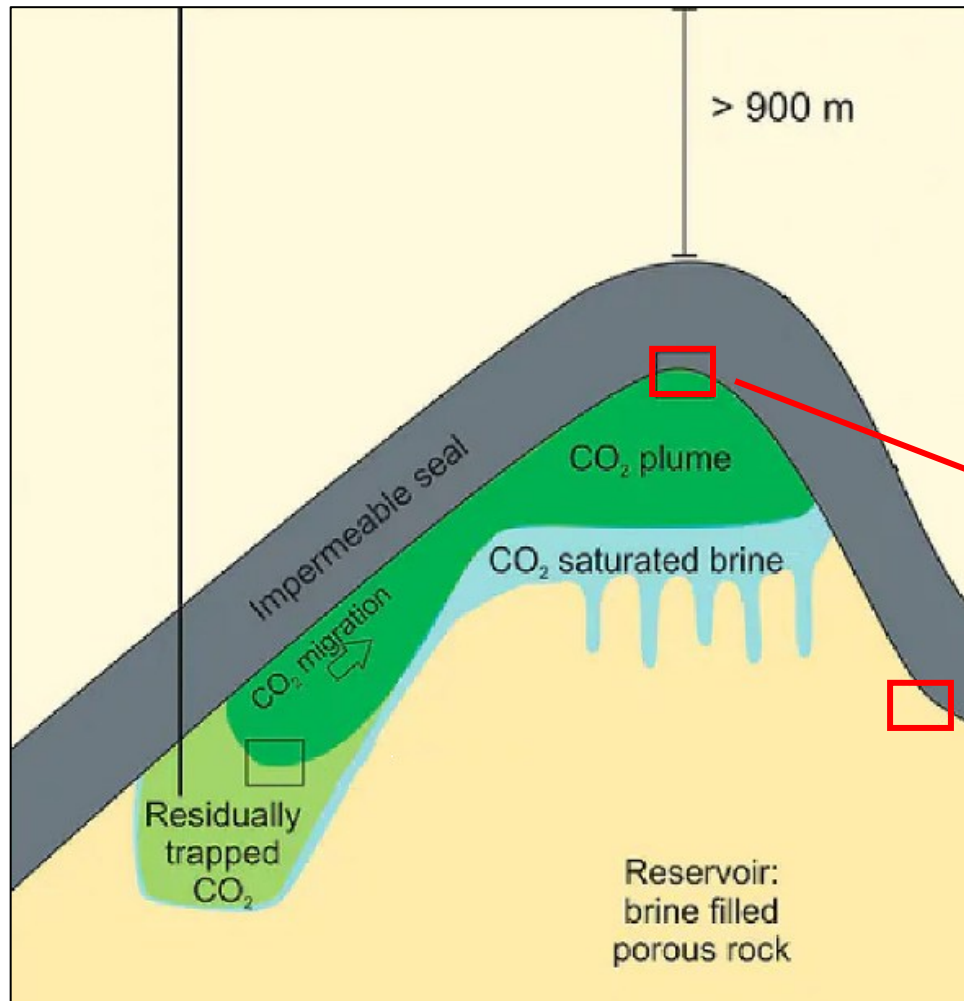
Desafios na Descarbonização e no Licenciamento





Flude e Alcade (2022) Barbosa et al. (2024)

CONDICIONANTES GEOLÓGICOS



CONDICIONANTES GEOLÓGICOS

- Porosidade e permeabilidade
 - Propriedades da rocha selante
- Estratigrafia

- Geologia estrutural

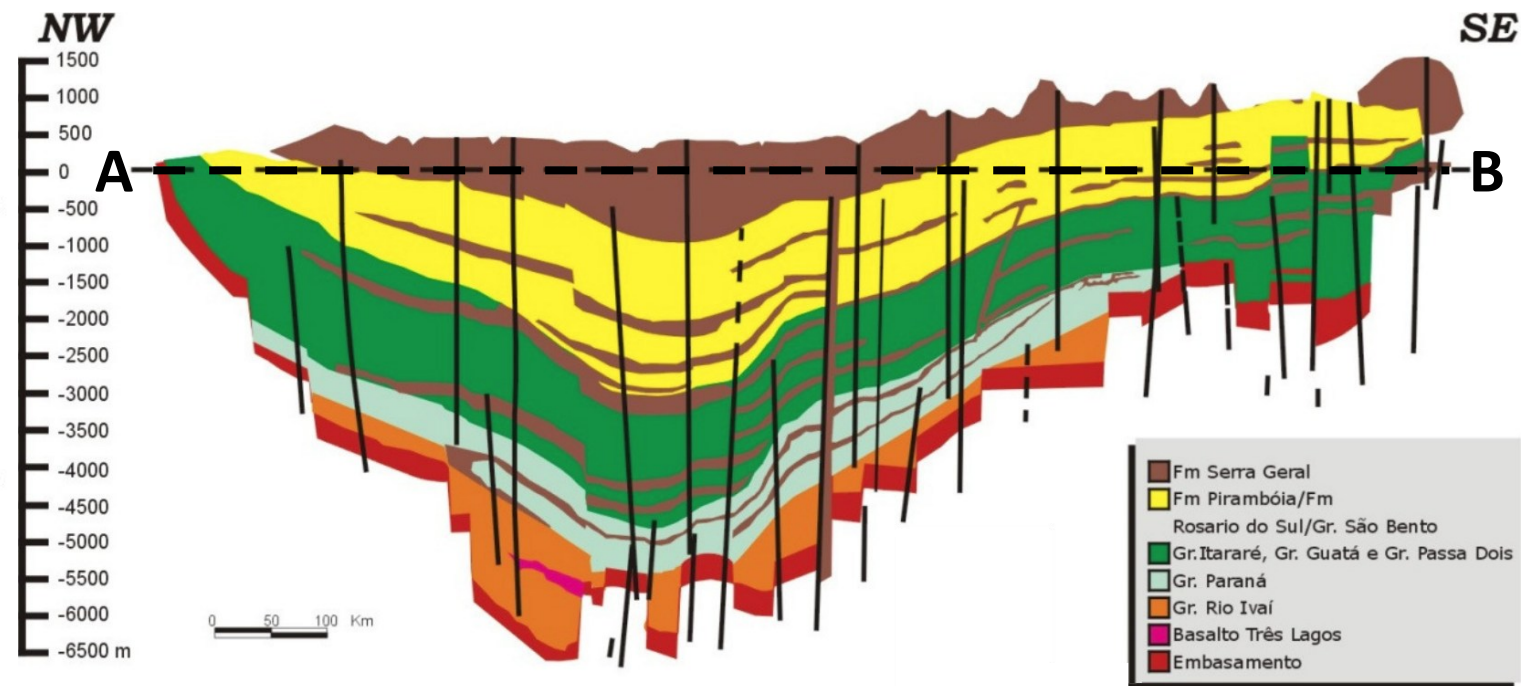
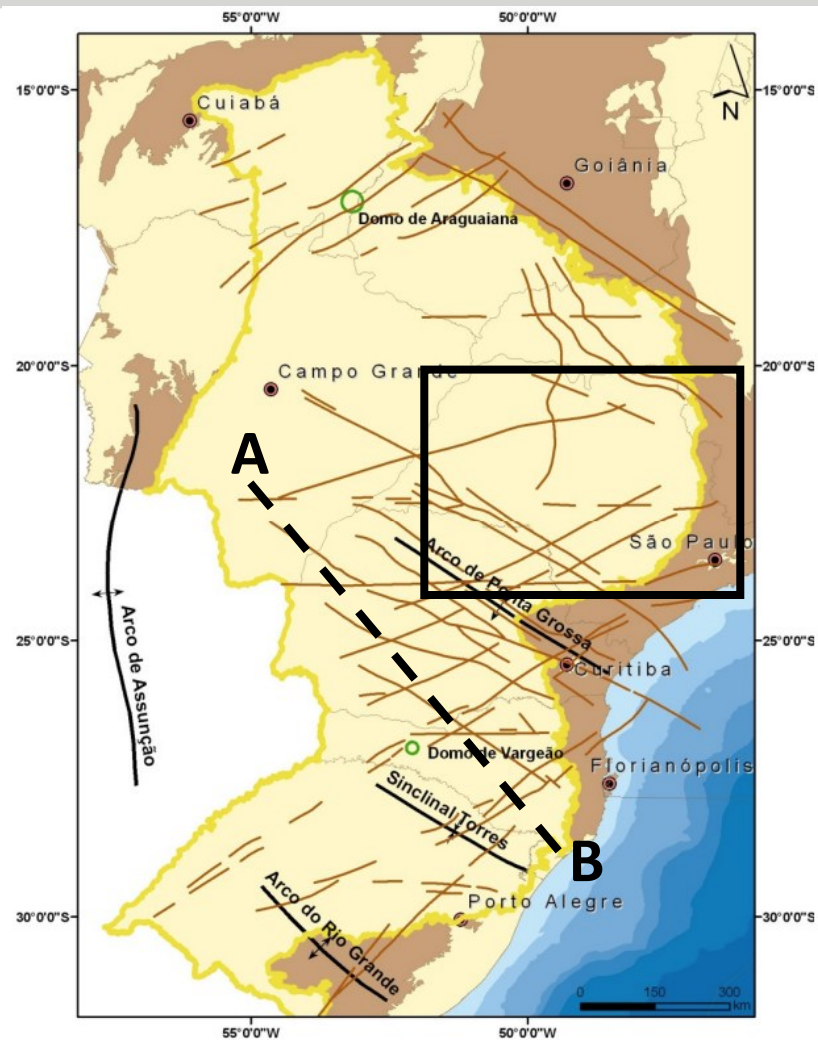
- Estado de tensões
 - Temperatura
- Profundidade

O IPT E A ESTOCAGEM SUBTERRÂNEA DE GÁS NATURAL (ESGN)

- Parceria IPT-Petrobras com apoio Finep
- Busca por reservatórios para ESGN associada ao gasoduto Bolívia-Brasil
- Concentração das investigações na Bacia do Paraná - Bloco Bauru (Estado de São Paulo e nordeste do Paraná)

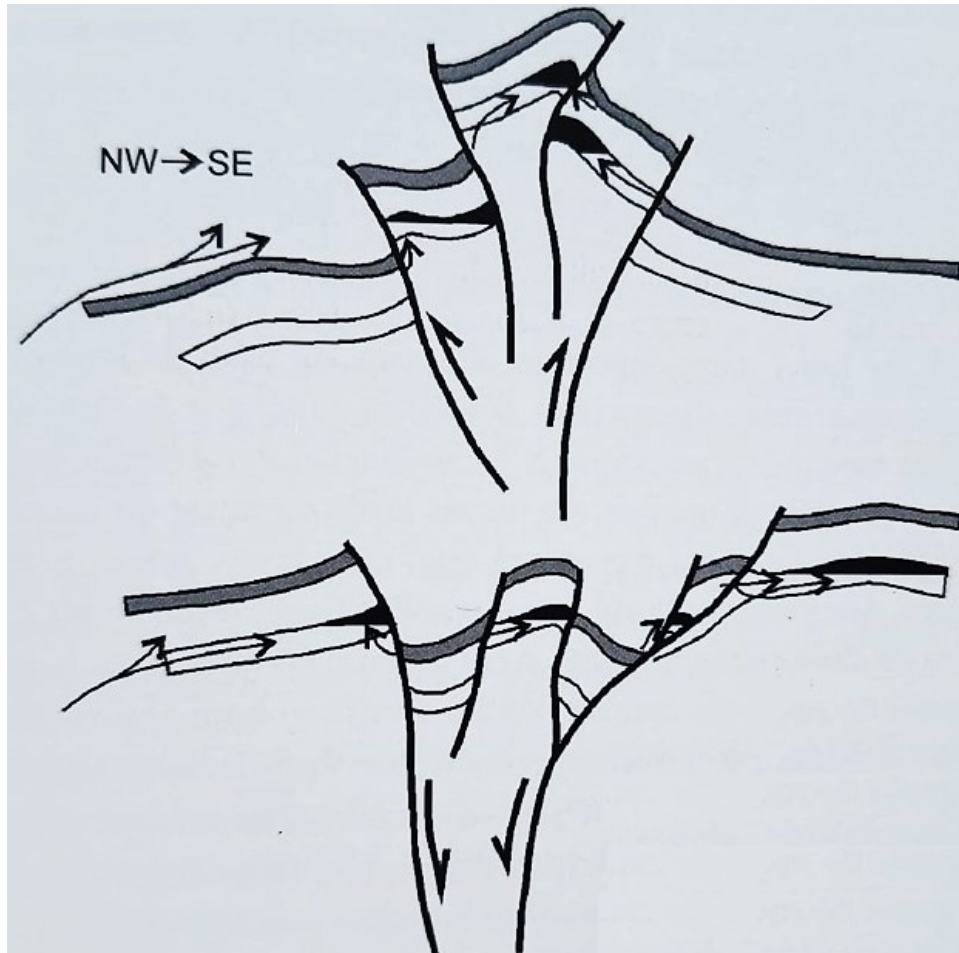


ESGN NA BACIA DO PARANÁ

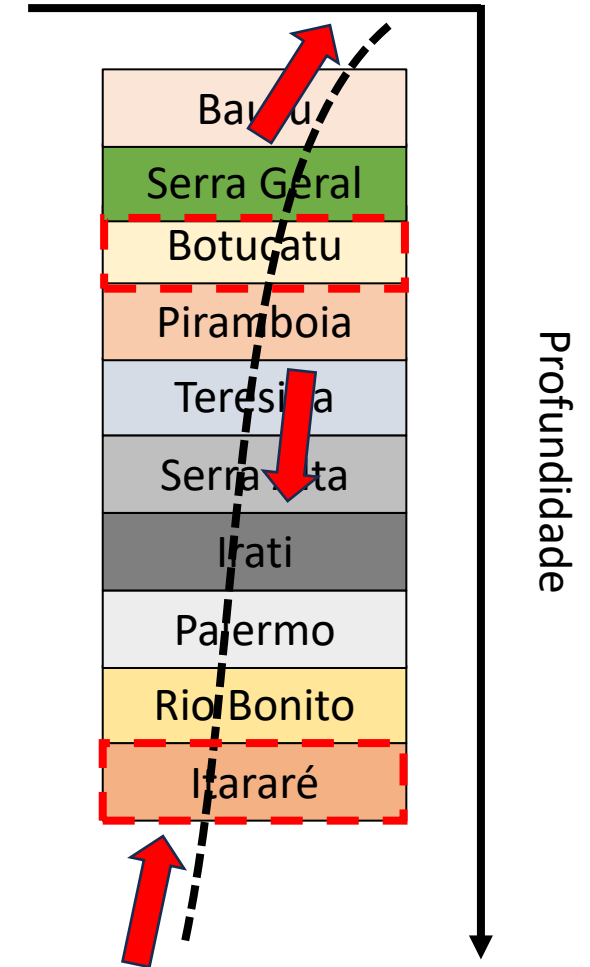


ANP (2017)

ESGN NA BACIA DO PARANÁ

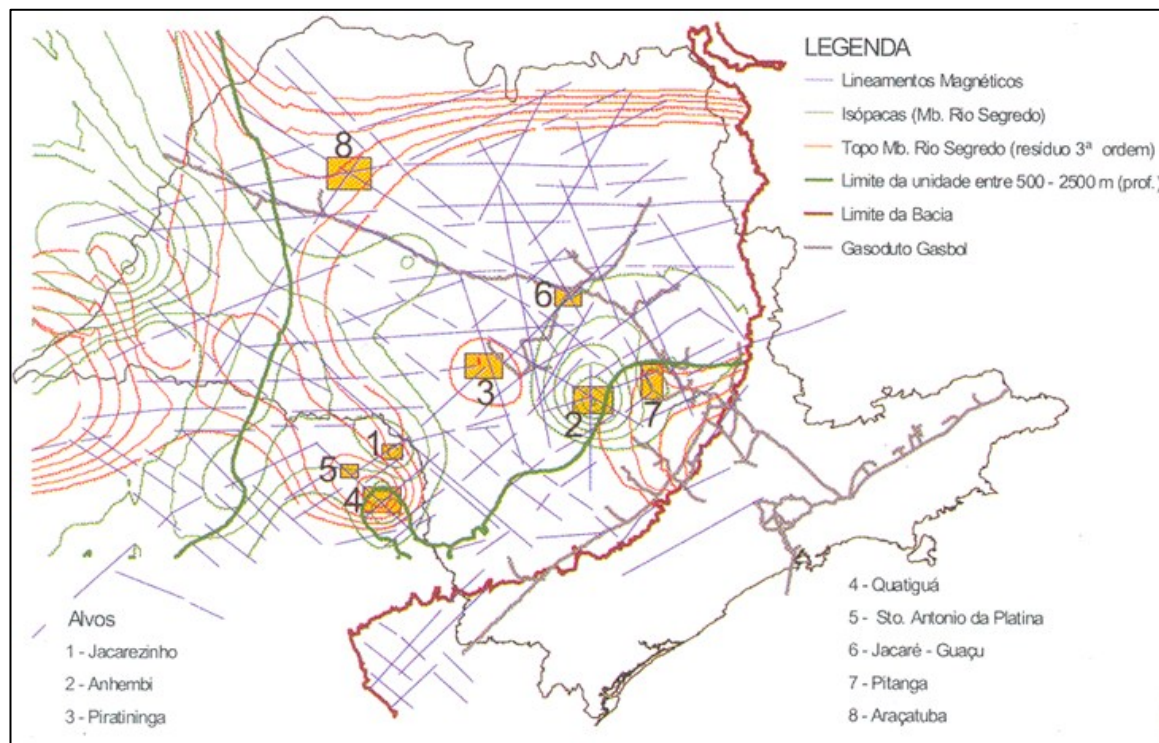


Rostirolla et al. (2000)

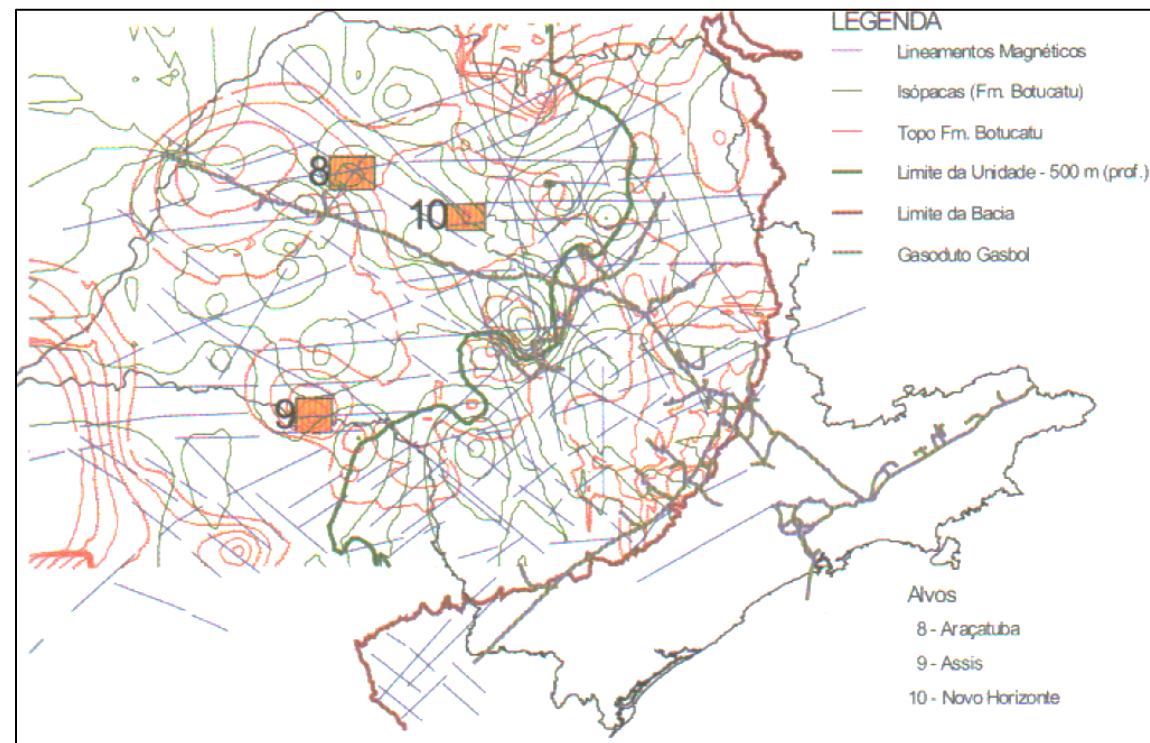


ESGN NA BACIA DO PARANÁ

■ Alvos selecionados



Reservatório Itararé

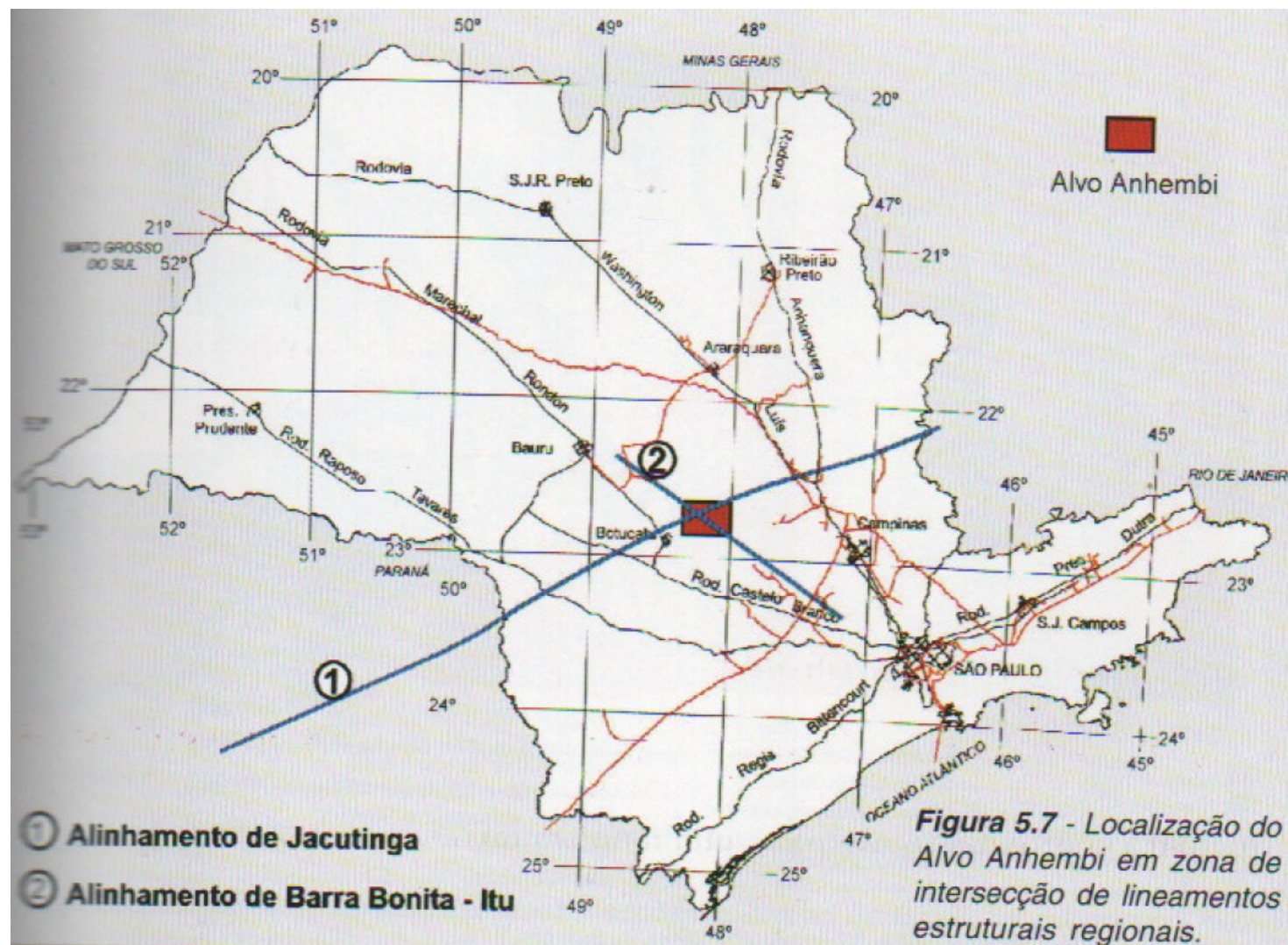


Reservatório Botucatu

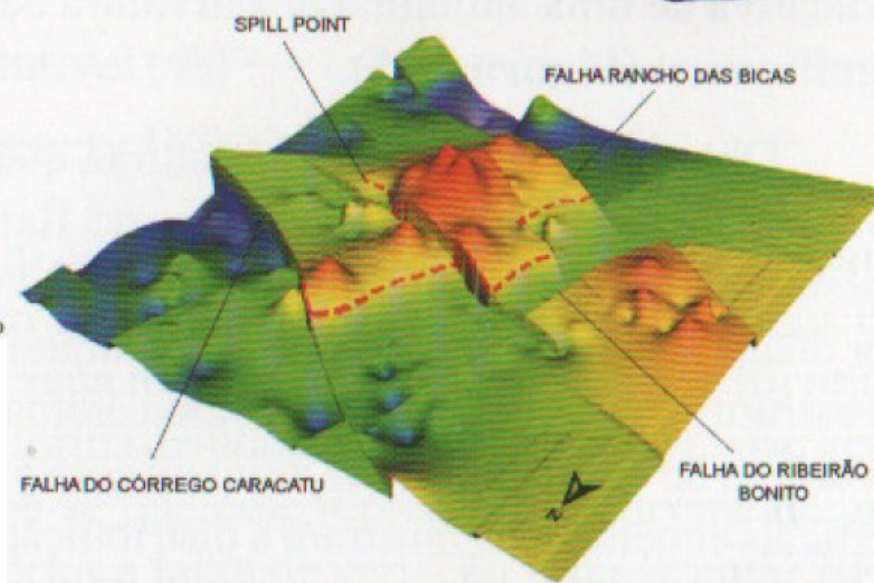
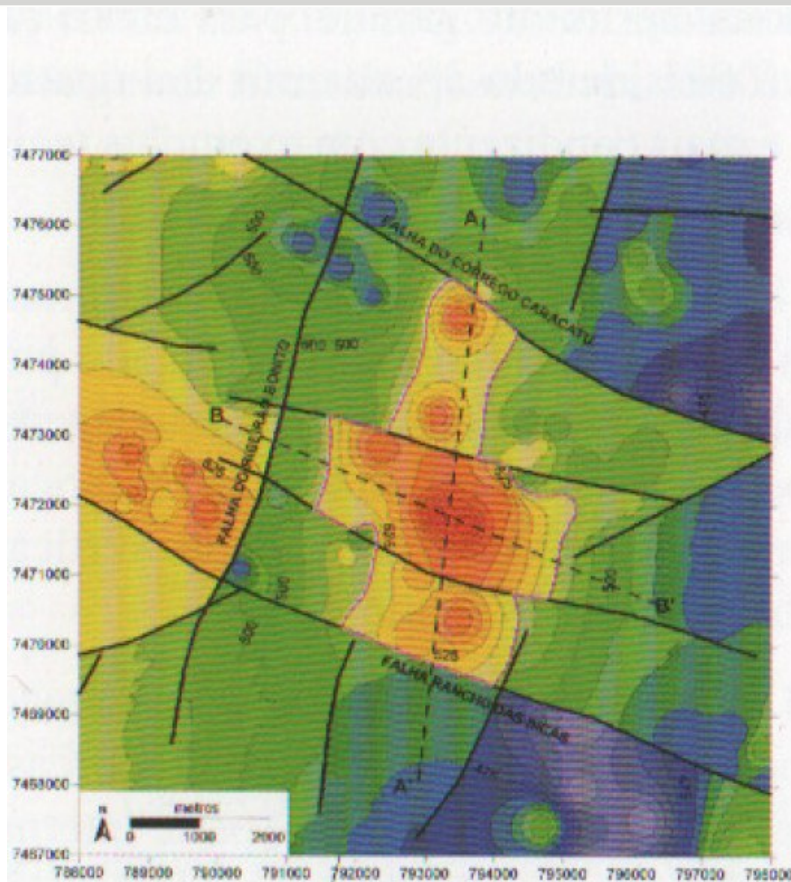
QUALIFICAÇÃO DOS ALVOS

Alvos	Lineamentos estruturais	Isópacas reservatório	Estrutura local	Contorno	Selo	FC
Reservatório Botucatu						
Assis	MB	R	R	MB	Basalto	0,4
Araçatuba	MB	MB	-	R	Basalto	0,35
Novo Horizonte	B	MB	-	R	Basalto	0,23
Reservatório Rio Segredo						
Jacarezinho	B	MB	MB	B	Diamictito	0,8
Anhembi	MB	MB	MB	R	Diamictito	0,7
Piratininga	B	-	MB	MB	Diamictito	0,7
Santo Antônio da Platina	B	R	-	MB	Diamictito	0,4
Jacaré-Guaçu	MB	R	B	R	Diamictito	0,4
Araçatuba	B	-		MB	Diamictito	0,35
Reservatório Campo Mourão						
Anhembi	MB	MB	MB	R	Diabásio diamictito e siltito	0,7
Quatiguá	MB	B	MB	R	Diamictito e siltito	0,7
Pitanga	MB	R	MB	R	Diamictito e siltito	0,4
MB = Muito bom; B = Bom; R = Regular; FC = Fator de confiabilidade (0 a 1)						

ALVO ANHEMBI



ALVO ANHEMBI

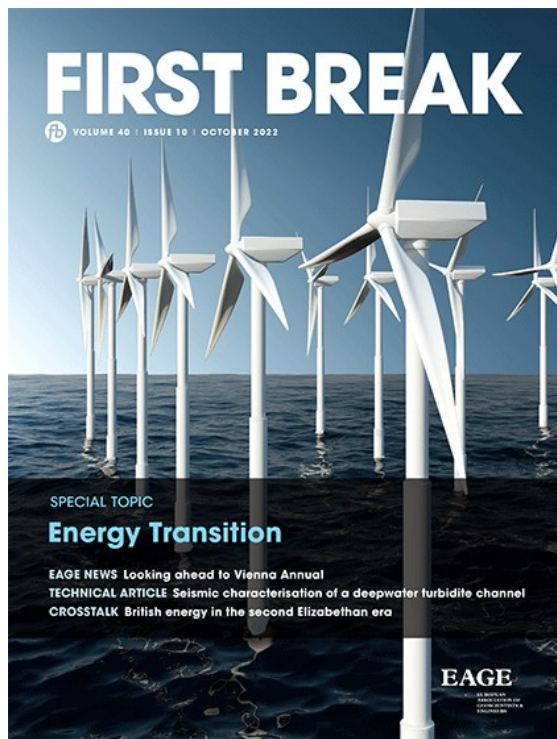


177 a 1.543 milhões de m³ de gás



E PARA O CO2? É A MESMA COISA?

Sim! e Não!



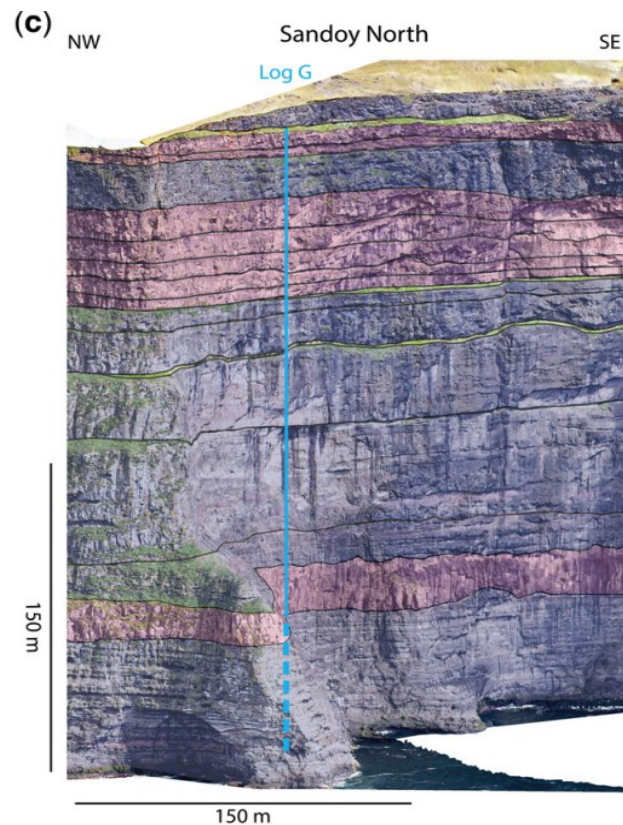
Why CCS is not like reverse gas engineering

Philip Ringrose^{1,2*}, Jamie Andrews³, Peter Zweigel¹, Anne-Kari Furre¹, Ben Hern³ and Bamshad Nazarian¹ demonstrate that while many of the tools used for subsurface work are similar, such as seismic surveys and subsurface reservoir modelling, there can be significant differences when applying hydrocarbon subsurface industry experience to CO₂ capture and storage projects.

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OUTROS TIPOS DE RESERVATÓRIO

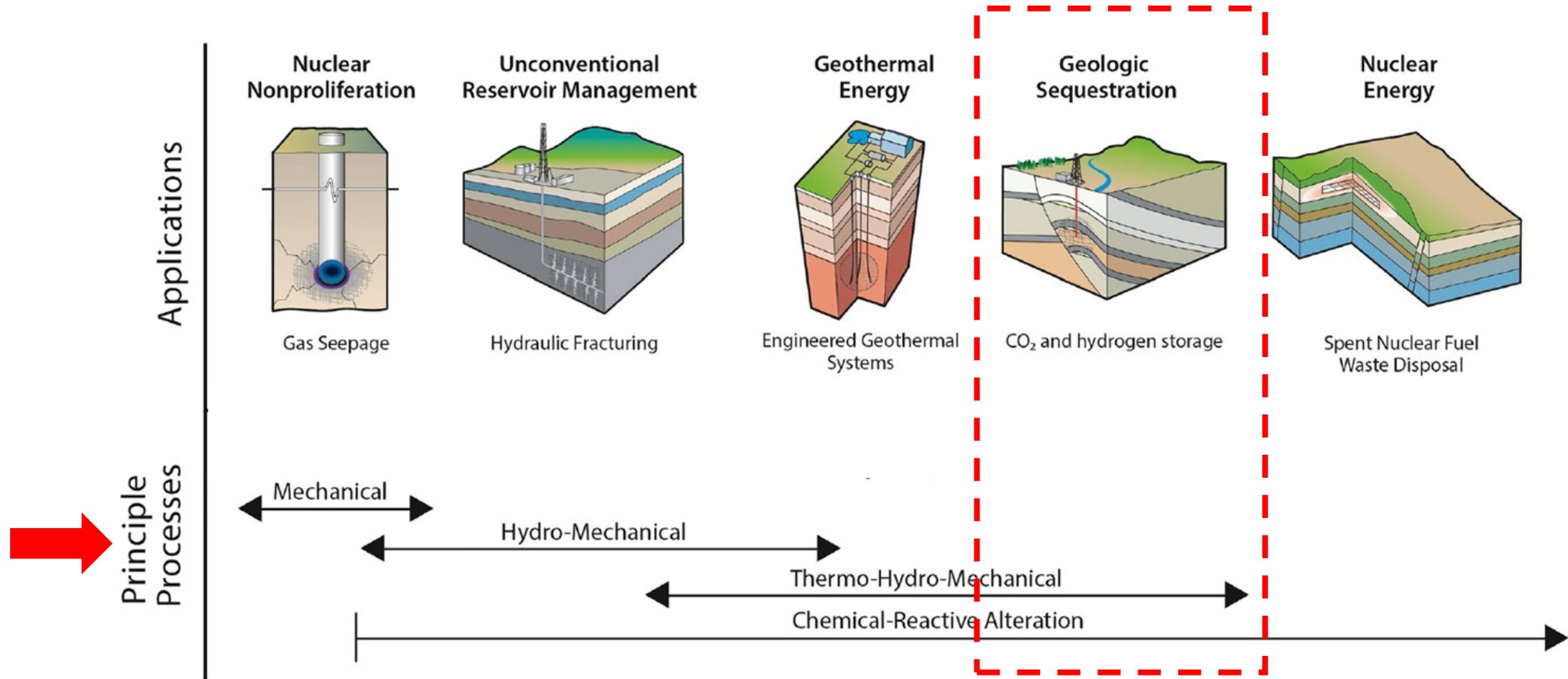


Rosenqvist et al. (2024)



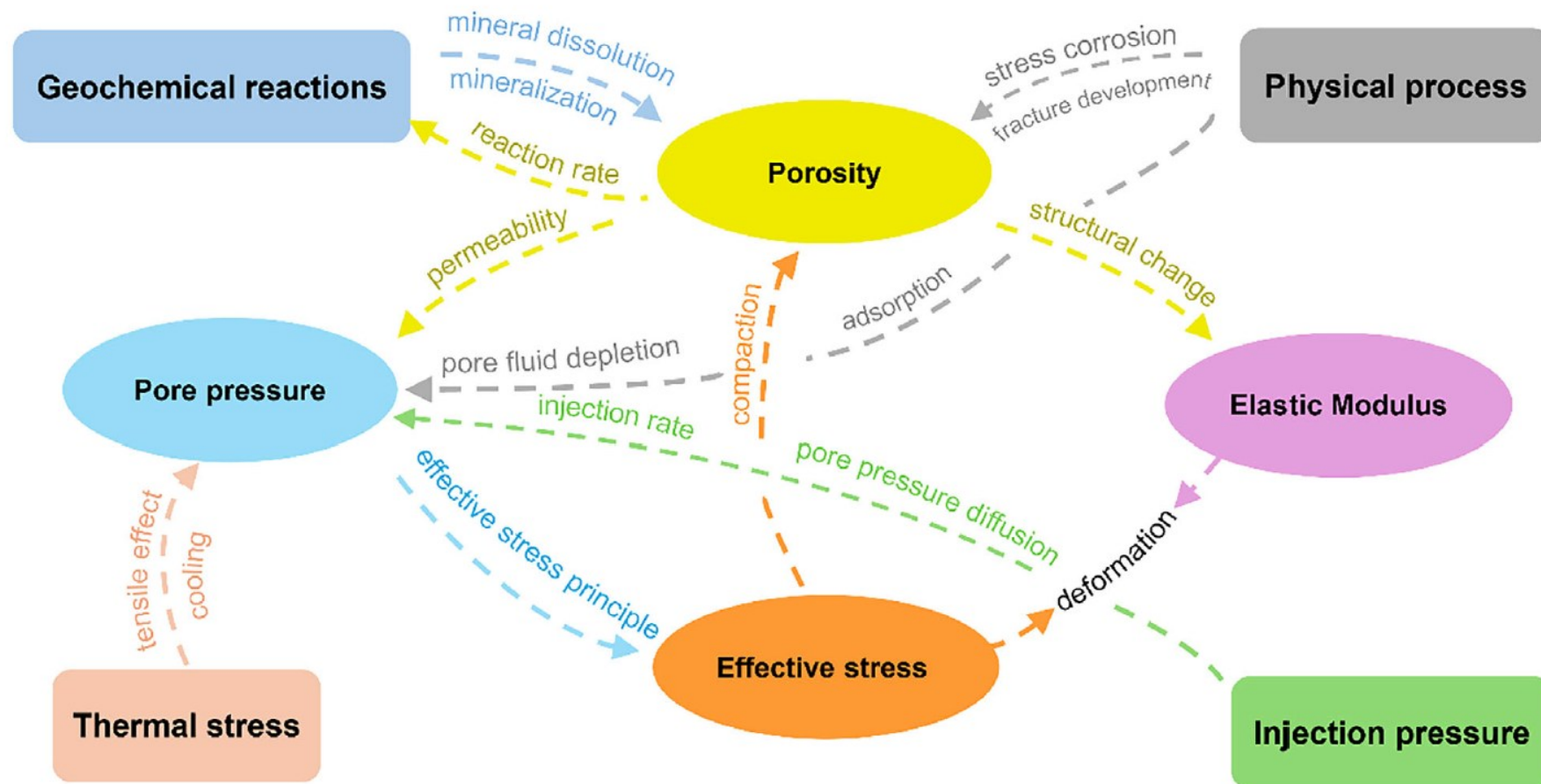
Pereira (2024)

O QUE OCORRE NO RESERVATÓRIO?



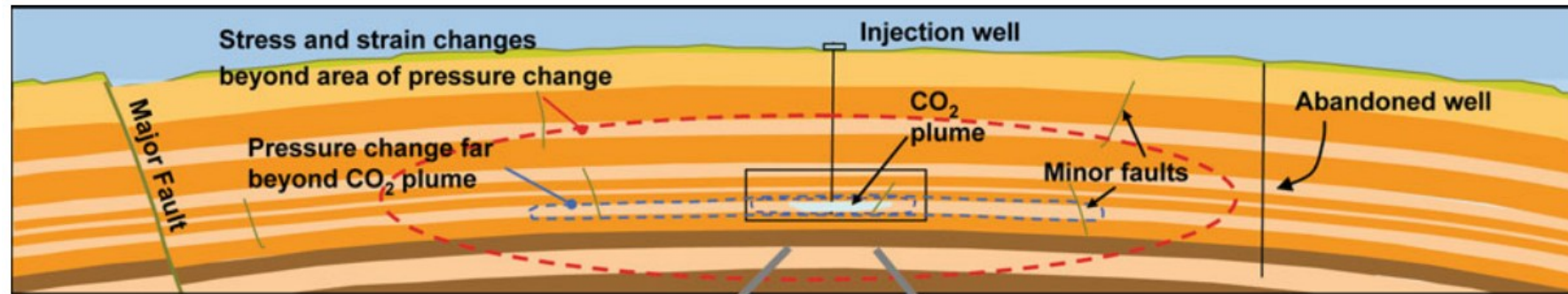
Viswanathan et al. (2022)

O QUE OCORRE NO RESERVATÓRIO?

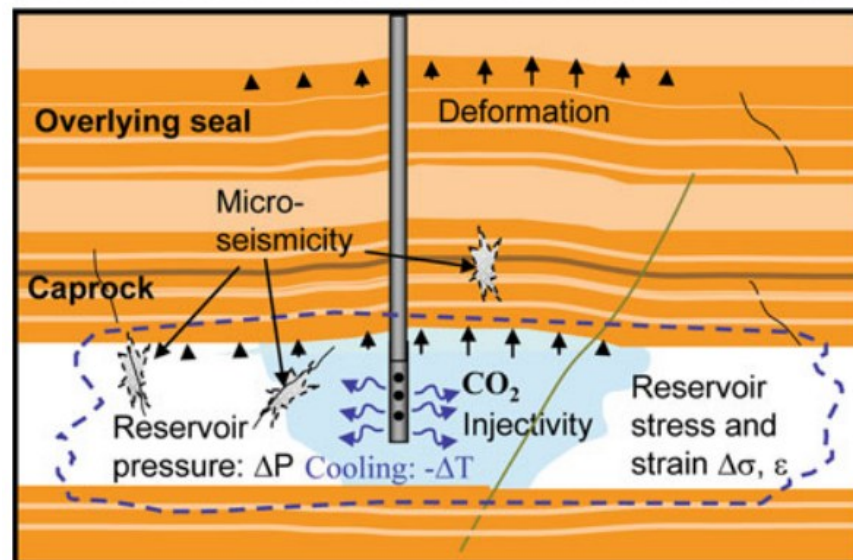


Lu et al. (2025)

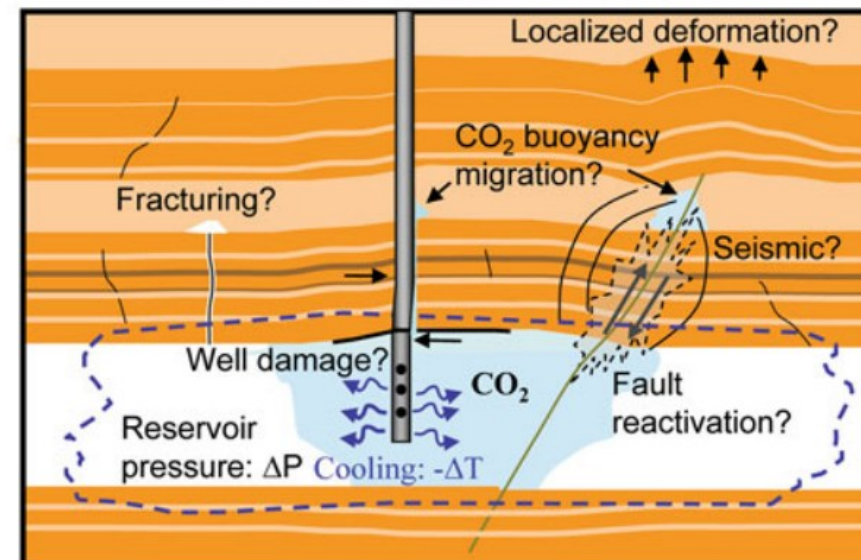
IMPLICAÇÕES GEOMECÂNICAS



Injection-induced stress, strain and deformation



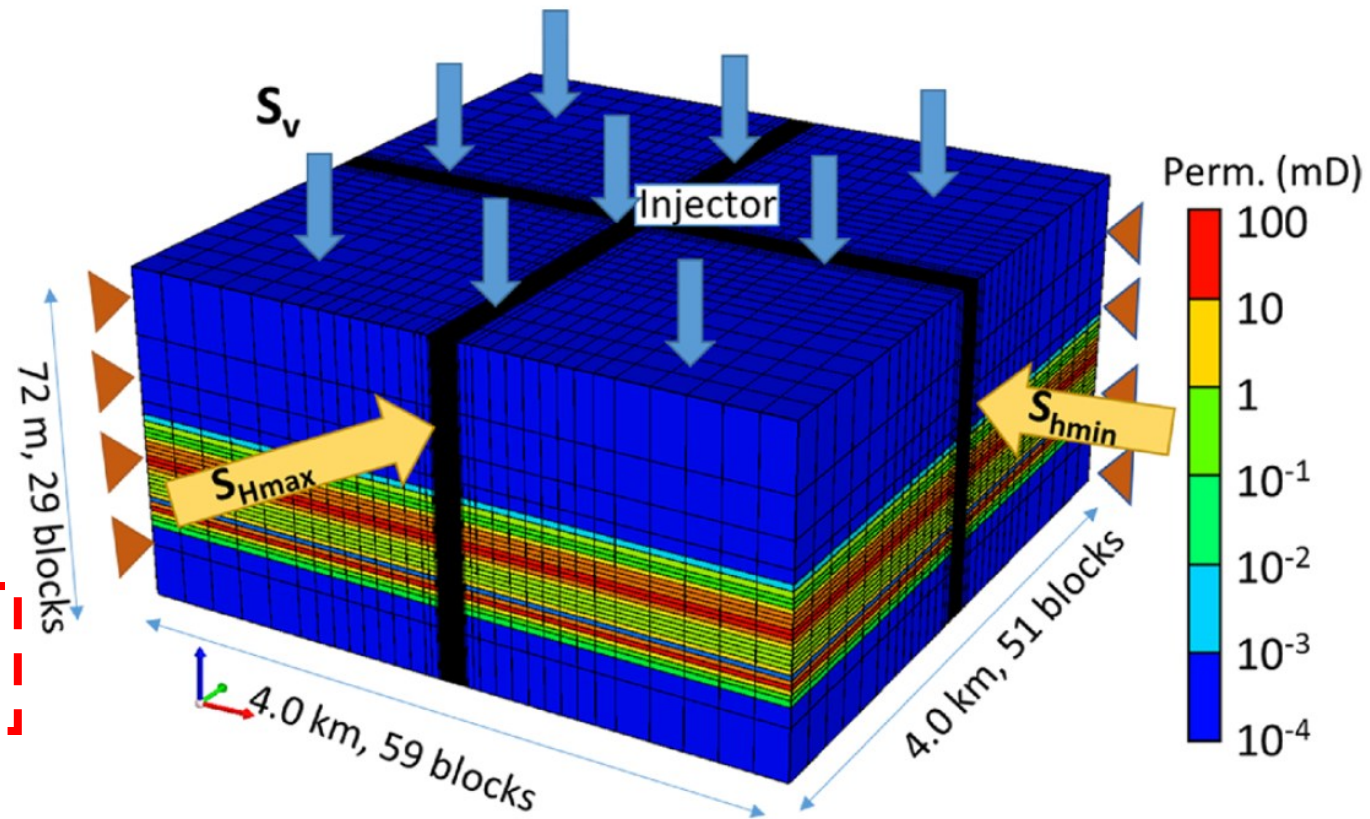
Unwanted mechanical changes



Rutqvist (2012)

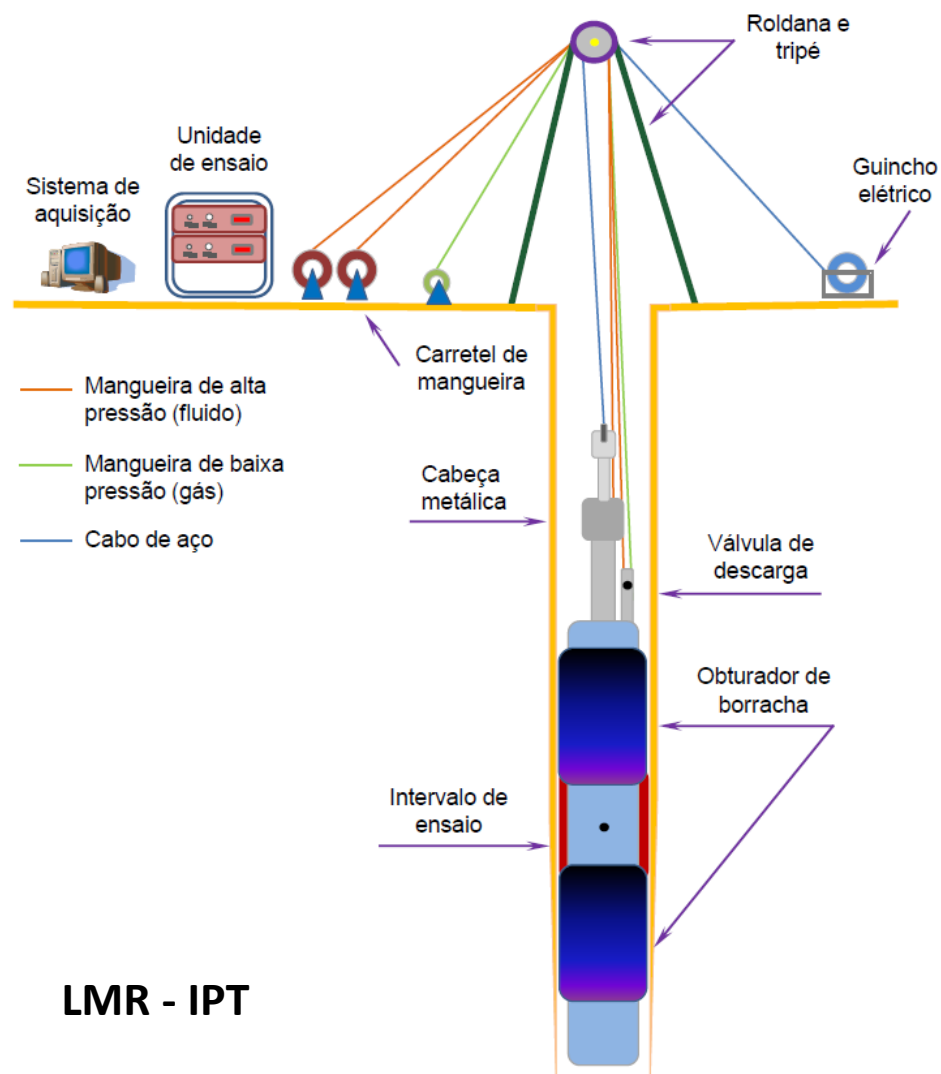
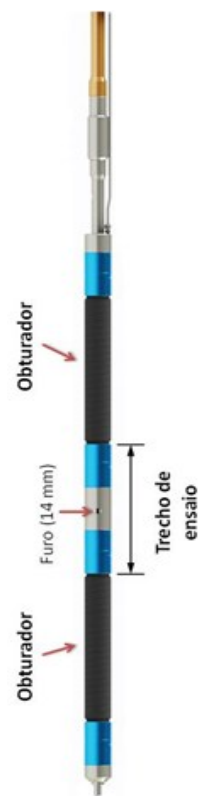
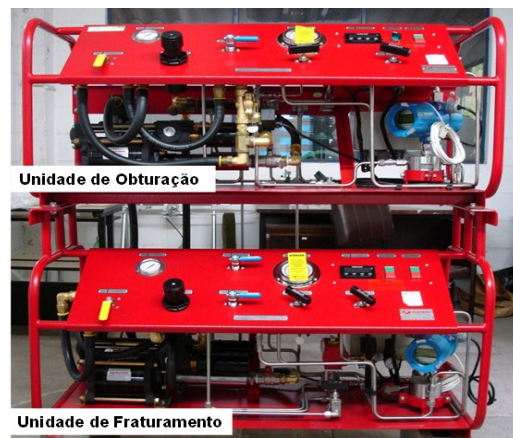
COMO PROJETAR E P(REVER)?

- Modelos numéricos acoplados
- Dados de entrada
 - Modelo geológico estrutural
 - Perfil de Temperatura
 - Propriedades petrofísicas das litologias
 - Estado de tensões
 - Comportamento no tempo
- Monitoramento e calibração dos modelos



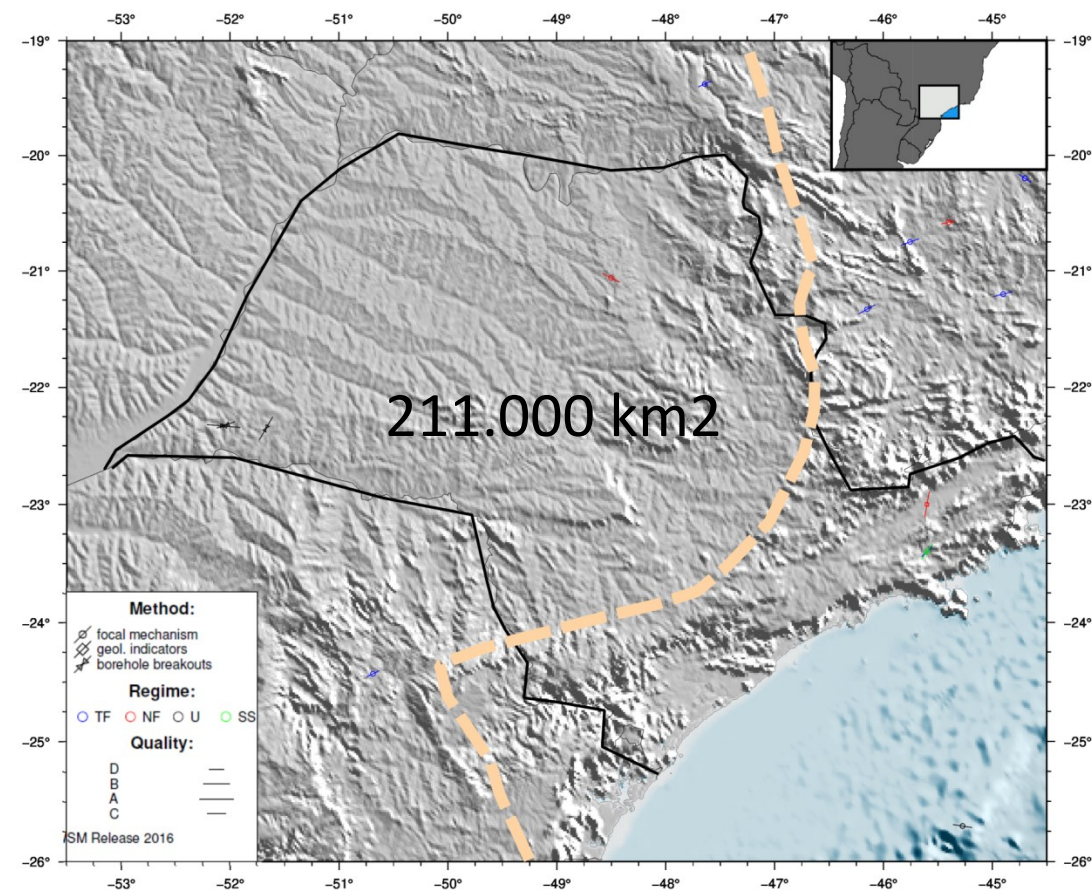
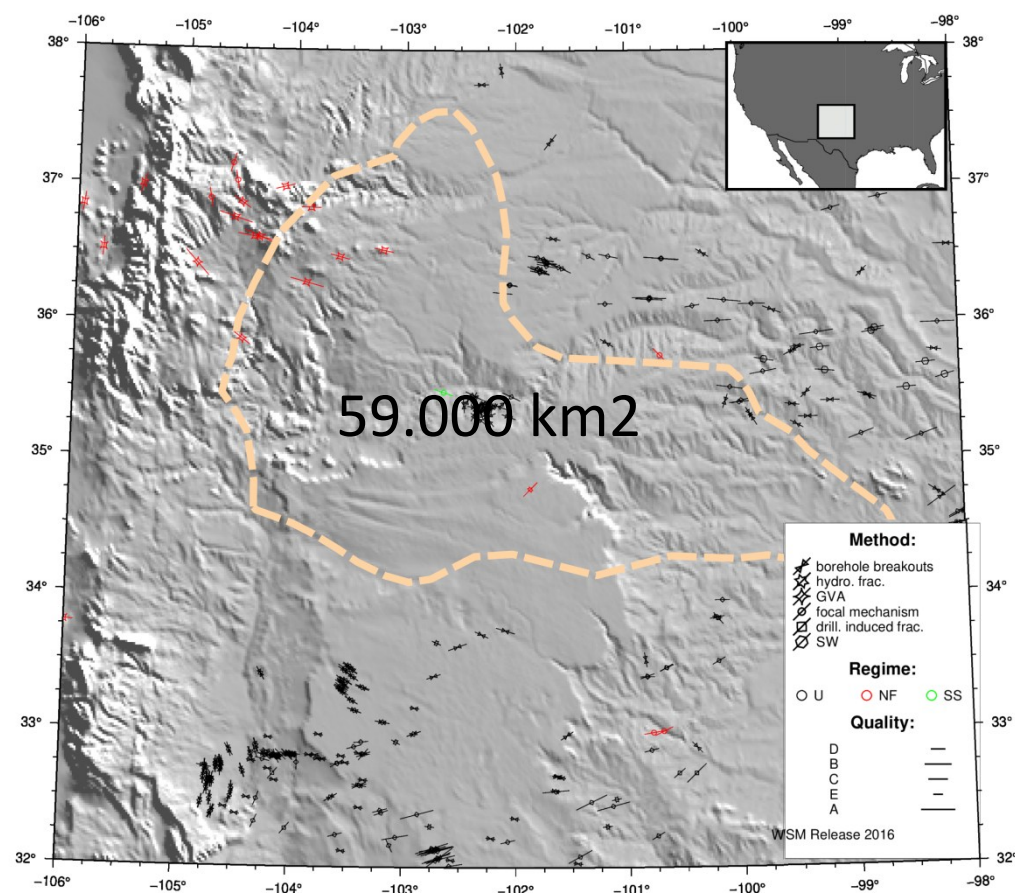
Jung et al. (2020)

ESTADO DE TENSÕES



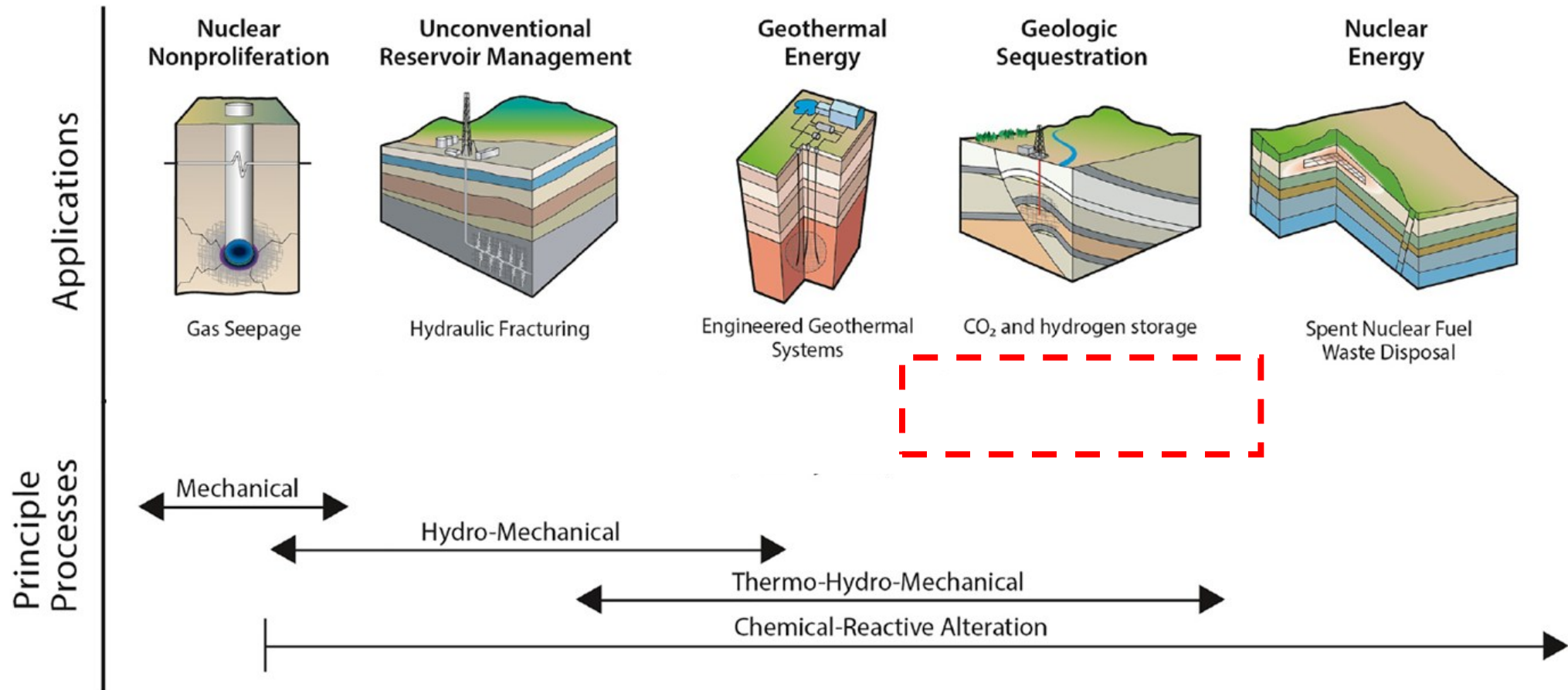
LMR - IPT

ESTADO DE TENSÕES



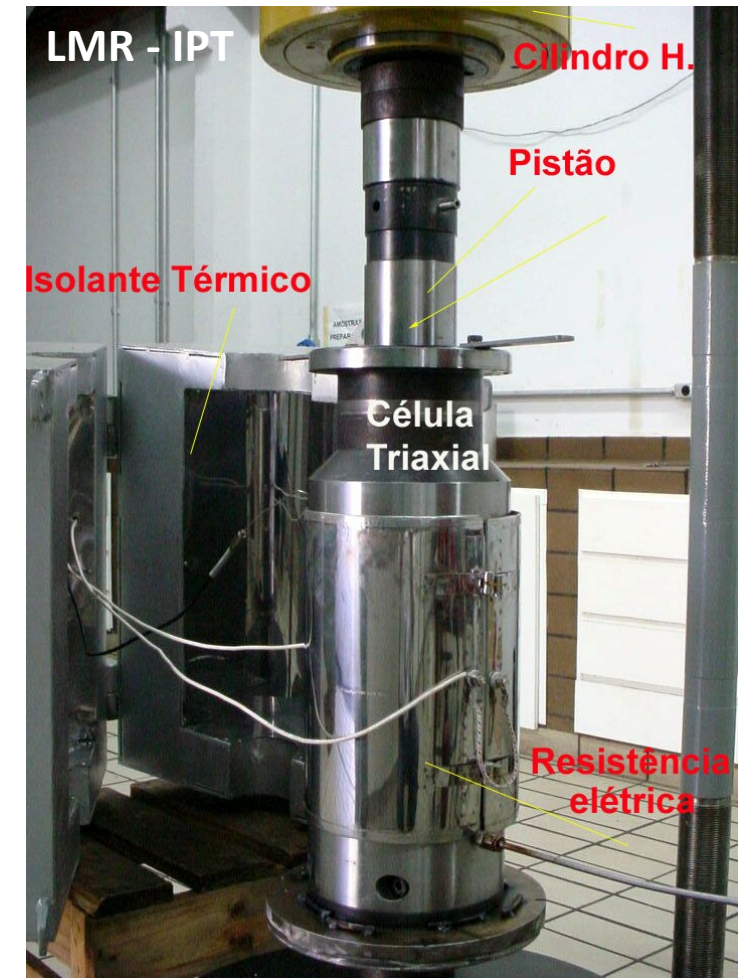
Heidbach, O., M. Rajabi, X. Cui, K. Fuchs, B. Müller, J. Reinecker, K. Reiter, M. Tingay, F. Wenzel, F. Xie, M. O. Ziegler, M.-L. Zoback, and M. D. Zoback (2018): The World Stress Map database release 2016: Crustal stress pattern across scales. Tectonophysics, 744, 484-498, doi:10.1016/j.tecto.2018.07.007 (PDF)

COMPORTAMENTO NO TEMPO

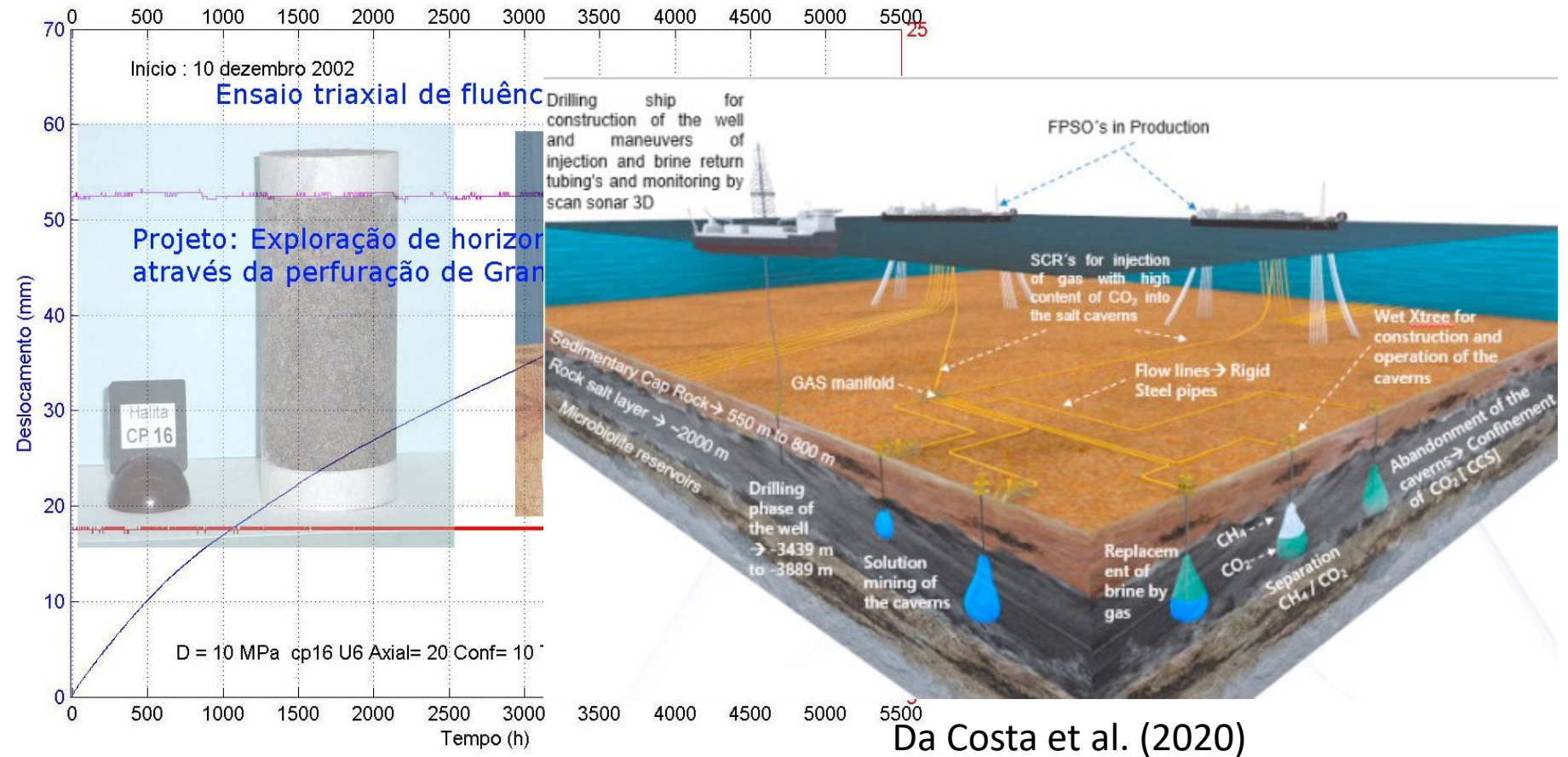


Viswanathan et al. (2022)

COMPORTAMENTO NO TEMPO

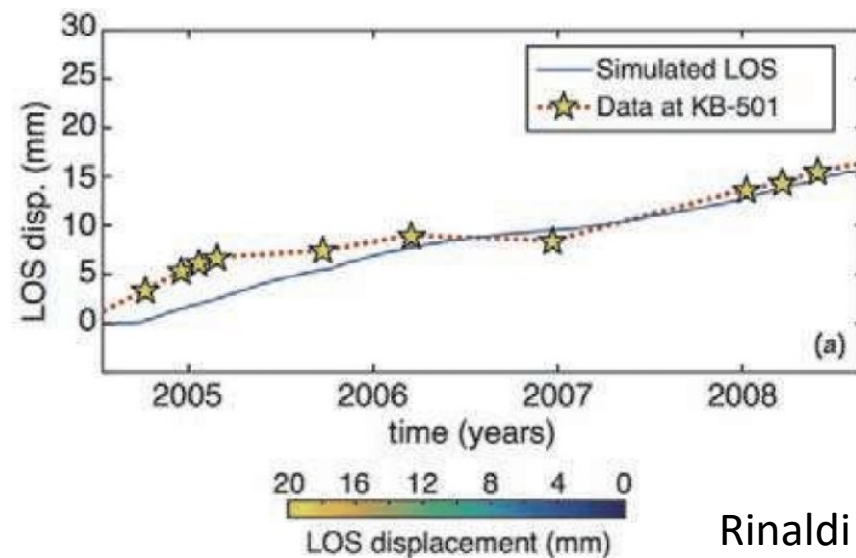
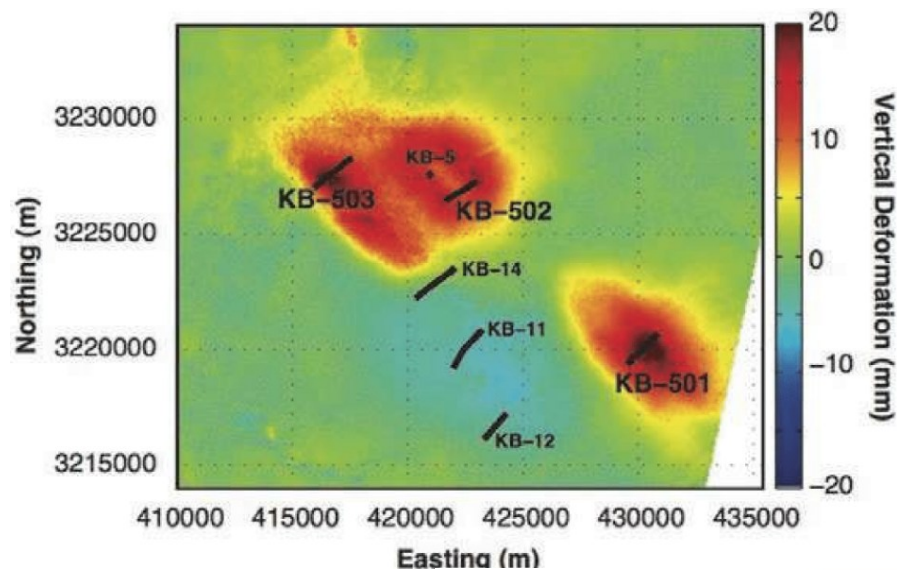


COMPORTAMENTO NO TEMPO



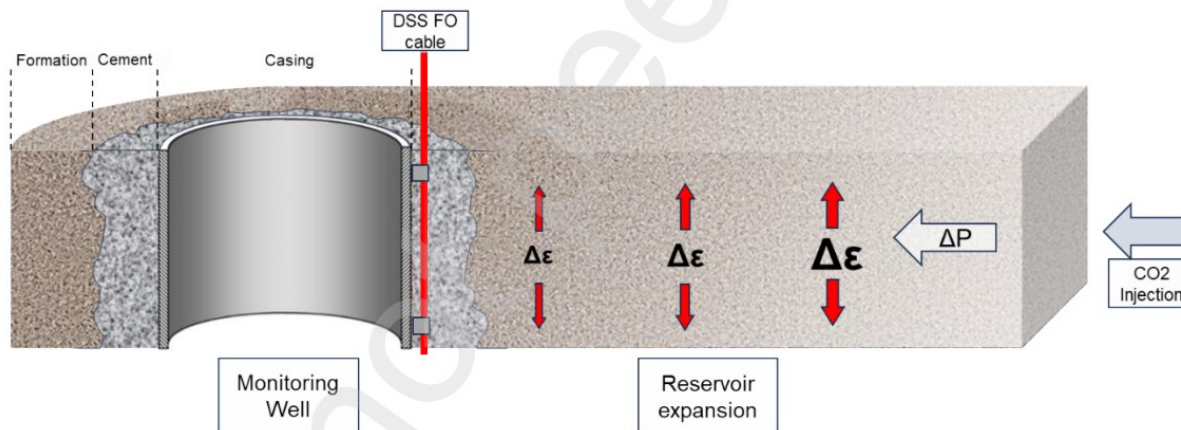
MONITORAMENTO CONTÍNUO

- Deformações em superfície e subsuperfície



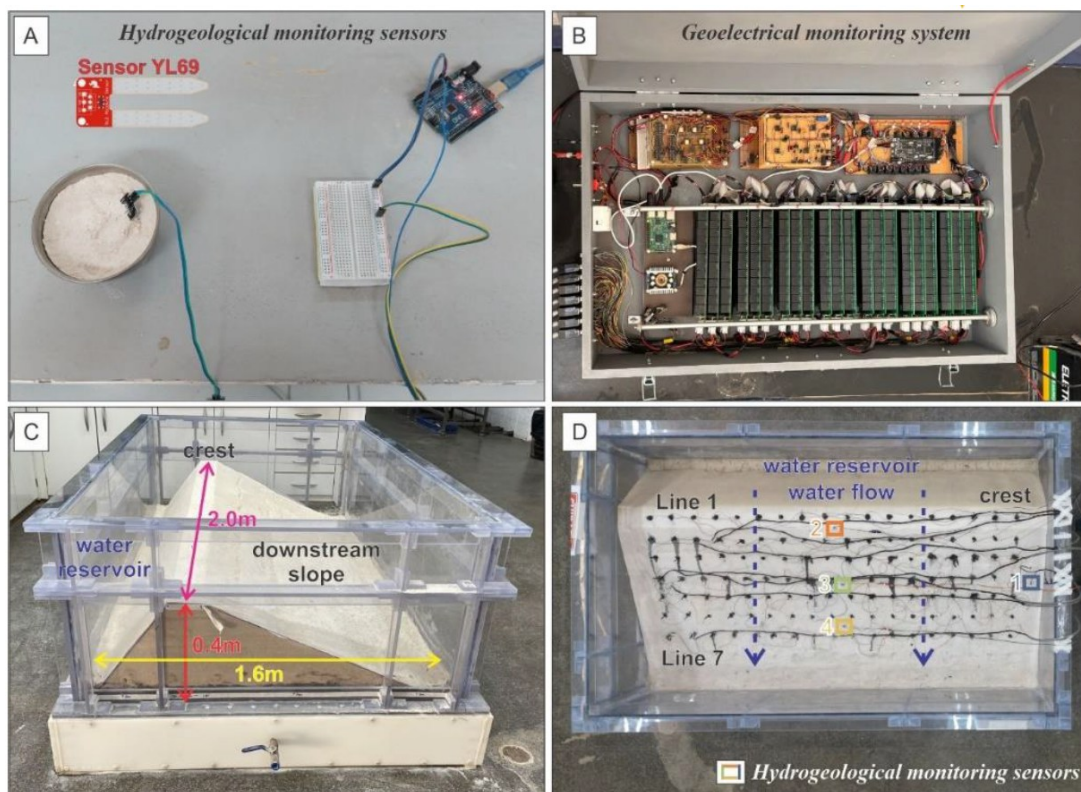
Rinaldi e Rutqvist (2017)

Rieger et al. (Preprint at SSRN)

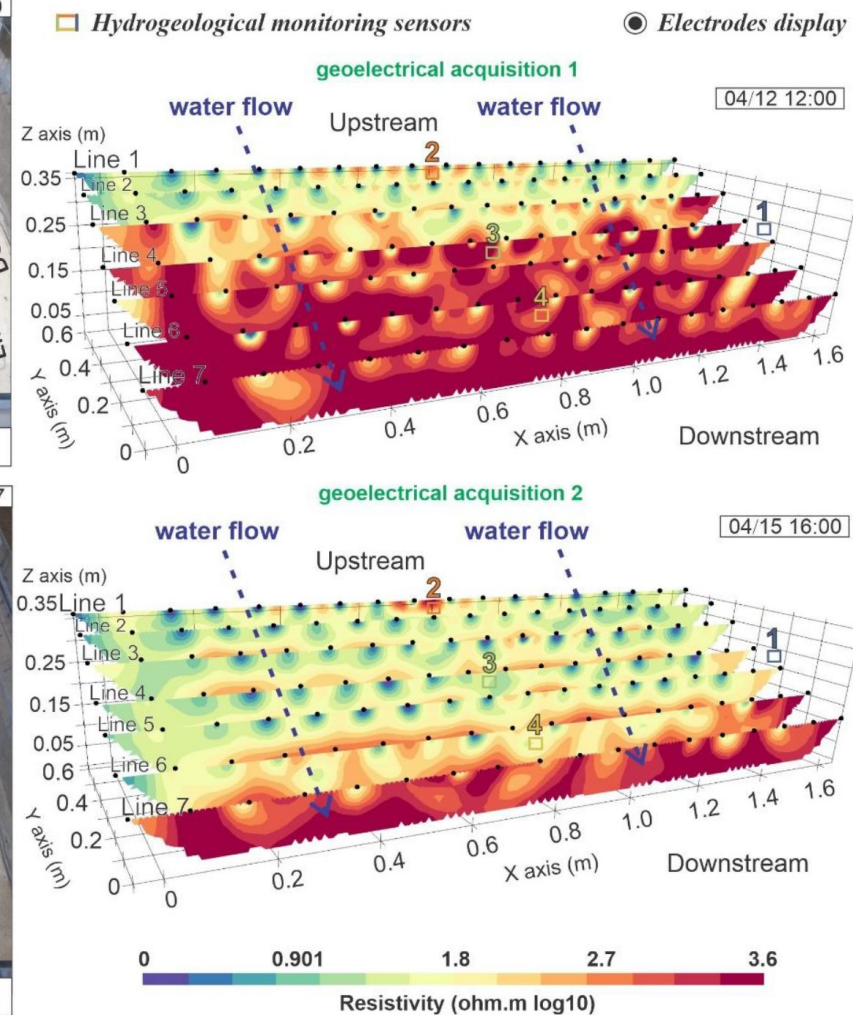
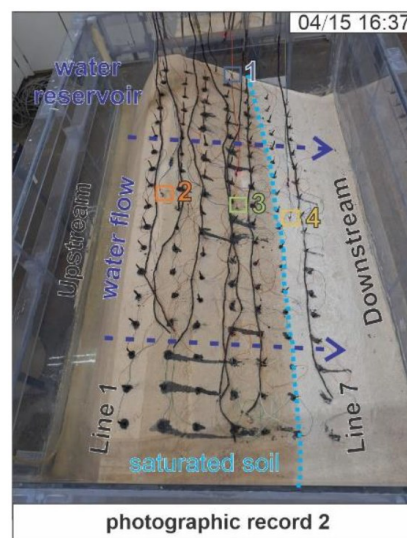
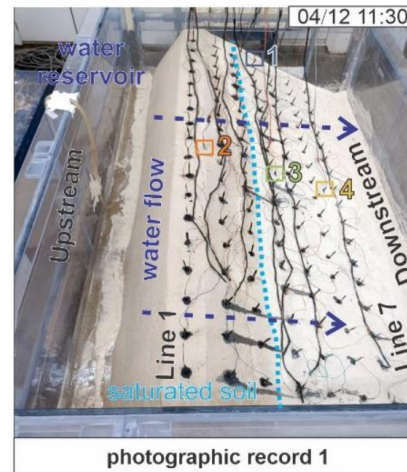


MONITORAMENTO CONTÍNUO

■ Sensores multipropósito

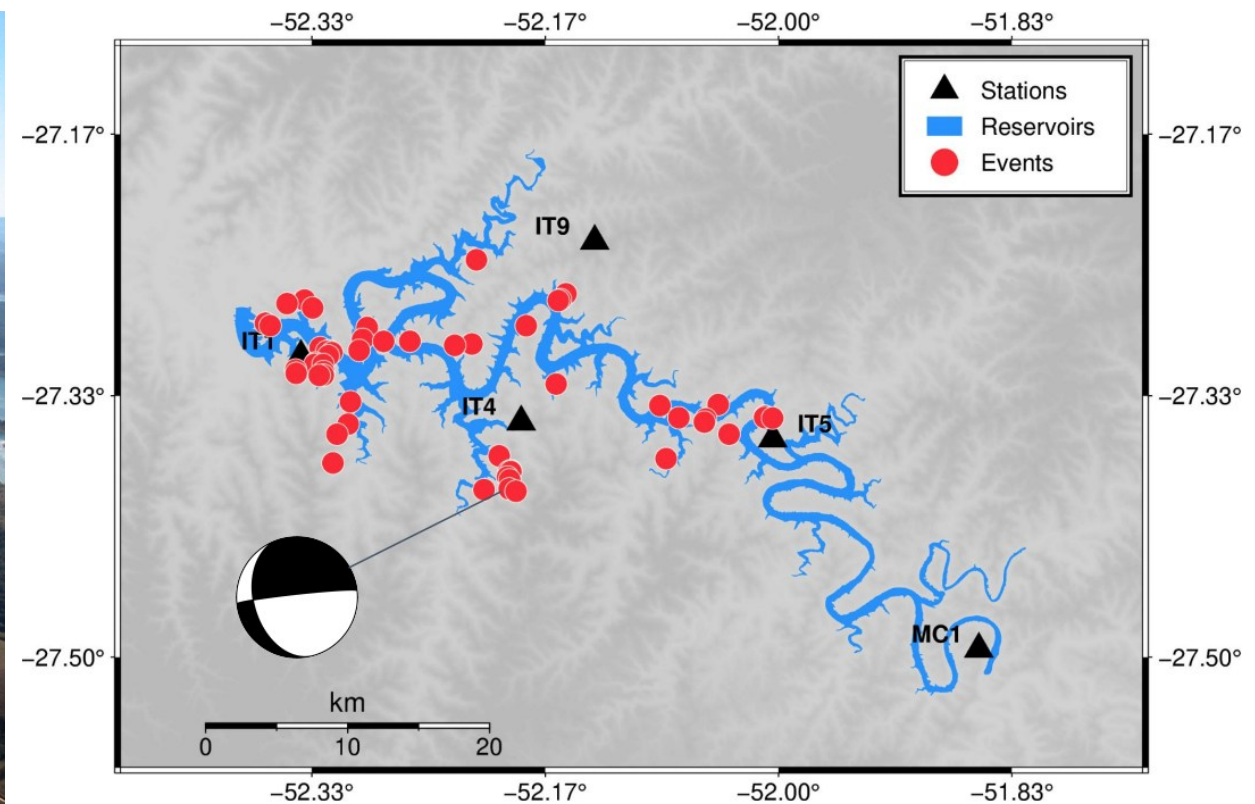


Guireli Netto et al. (2024)



MONITORAMENTO CONTÍNUO

■ Sismicidade Induzida



Schirbel et al. (2023)



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