Karst genesis modelling of a regional Mediterranean aquifer (Lez, France)

Leonardi V.[1], Massonnat G.[2], Darey J.[1,2], Planteblat C.[3] and Gal C.[3]

[1] Hydrosciences - Université de Montpellier - CC 057 - 163 rue Auguste Broussonnet - 34090 Montpellier - France

[2] Total - EP/DEV/ Field Reserves Development, CSTJF - Avenue Larribau - 64018 Pau Cedex - France

[3] Euro Engineering – 4 rue Jules Ferry - 64053 Pau Cedex - France

N°abstract N°1604

25-29th September 2016 Montpellier, France CORUM CONFERENCE CENTER 43rd IAH congress

Introduction

The Lez aquifer (Montpellier, France) developed in a Mediterranean setting, through several stages.

Problem : The Messinian crisis is considered as mainly having driven the architecture of the karst conduits.

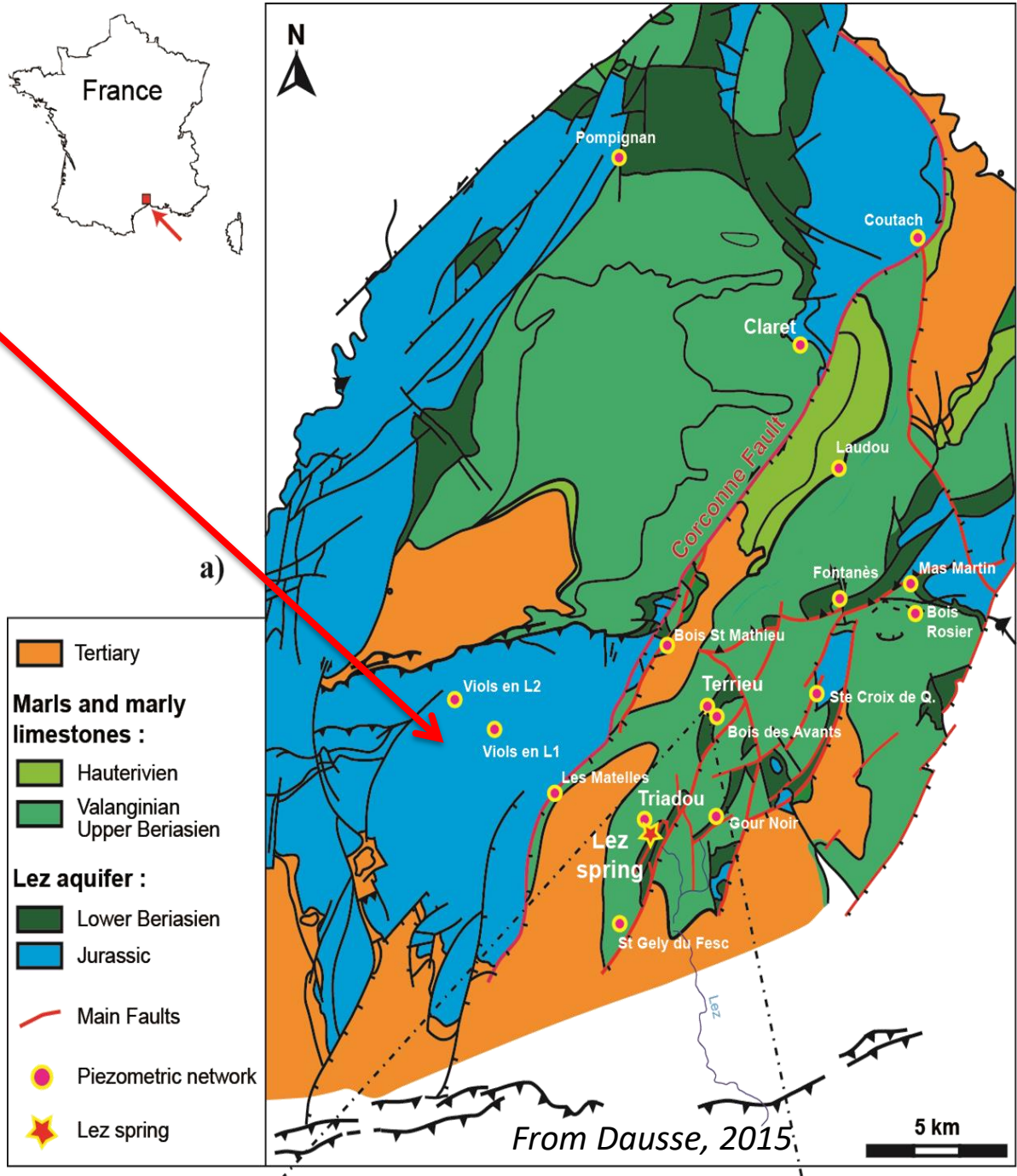
Questions : Is this stage the most important in terms of impact on Lez aquifer architecture, and how does it compare with the previous stages?

Tools : To answer to these questions, a numerical model (GODIAG, TOTAL S.A.) has been constructed for the Lez aquifer. It allows to test several scenarii of the evolution of the karstic network through time.

Lez Karst Aquifer :

Sedimentology, Structure and Karstogenesis

Jurassic : marine deposits (reef and intern platform). At the end of Jurassic, evidences of karstic morphology (Bodeur, 1996).



Lez Karst Aquifer :

Sedimentology, Structure and Karstogenesis

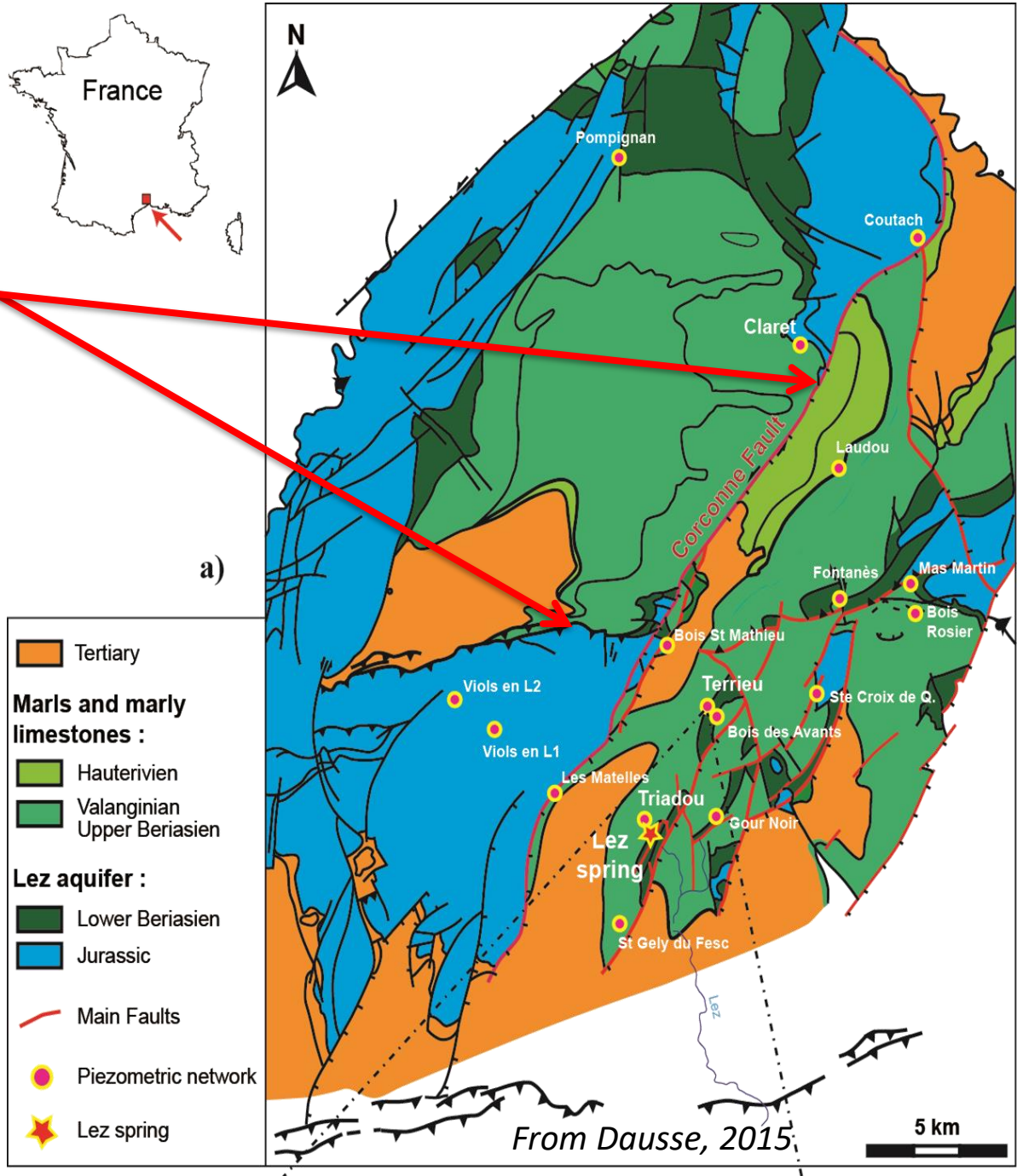
Early Cretaceous : marine deposit (boundary of the Vocontian basin).

Middle Cretaceous : Durance Isthmus (and no marine sediments during Late Cretaceous) : Bauxite fills previous karstic networks (Combes, 1971).

Lez Karst Aquifer :

Sedimentology, Structure and Karstogenesis

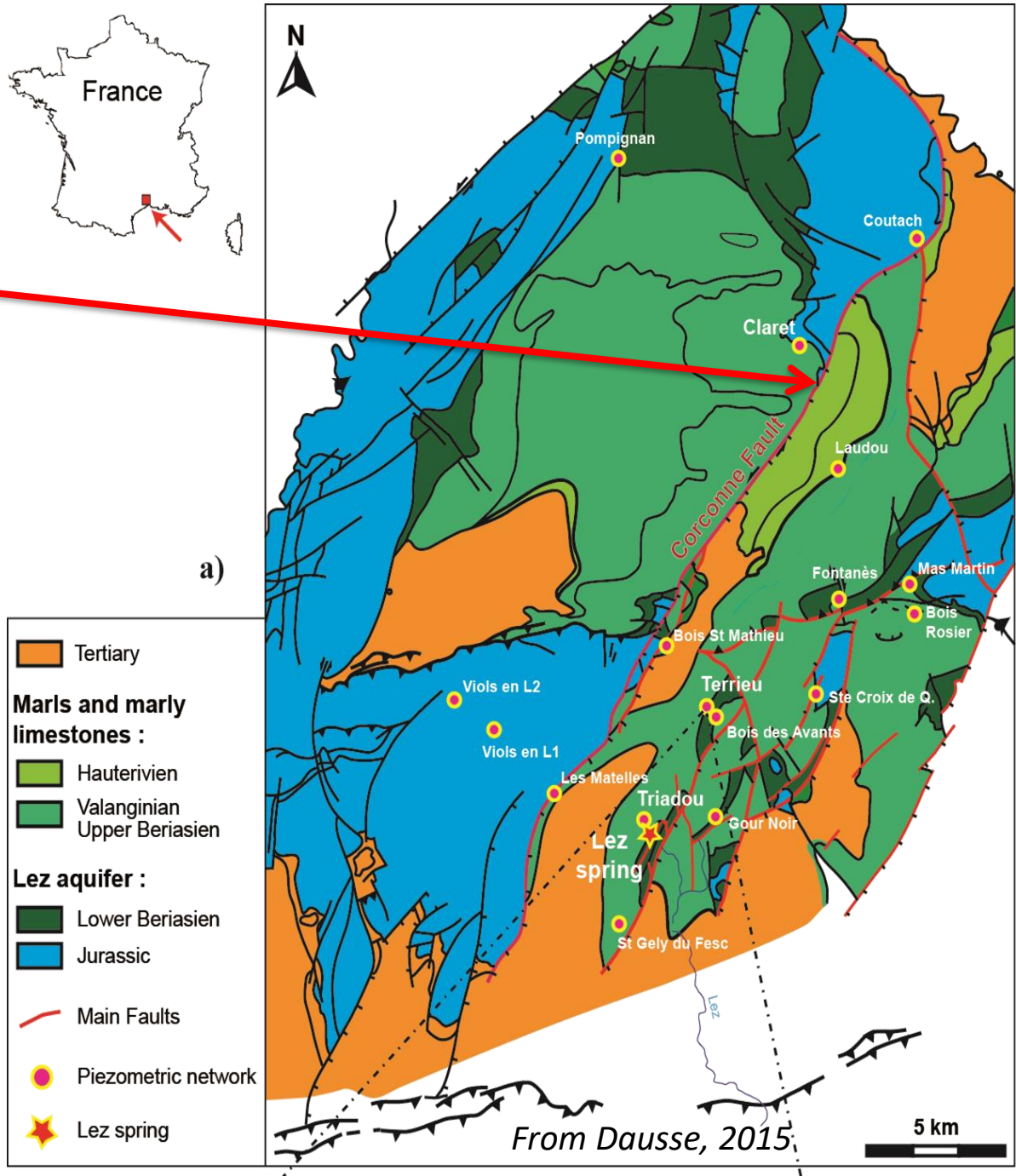
Late Cretaceous to Eocene : Pyrenean orogenesis with compressive structures : Pic Saint Loup, major strike-slip faults (Cevennes, Corconne-Matelles …). Evidences of karstic features during Paleocene (Husson et al., 2012).



Lez Karst Aquifer :

Sedimentology, Structure and Karstogenesis

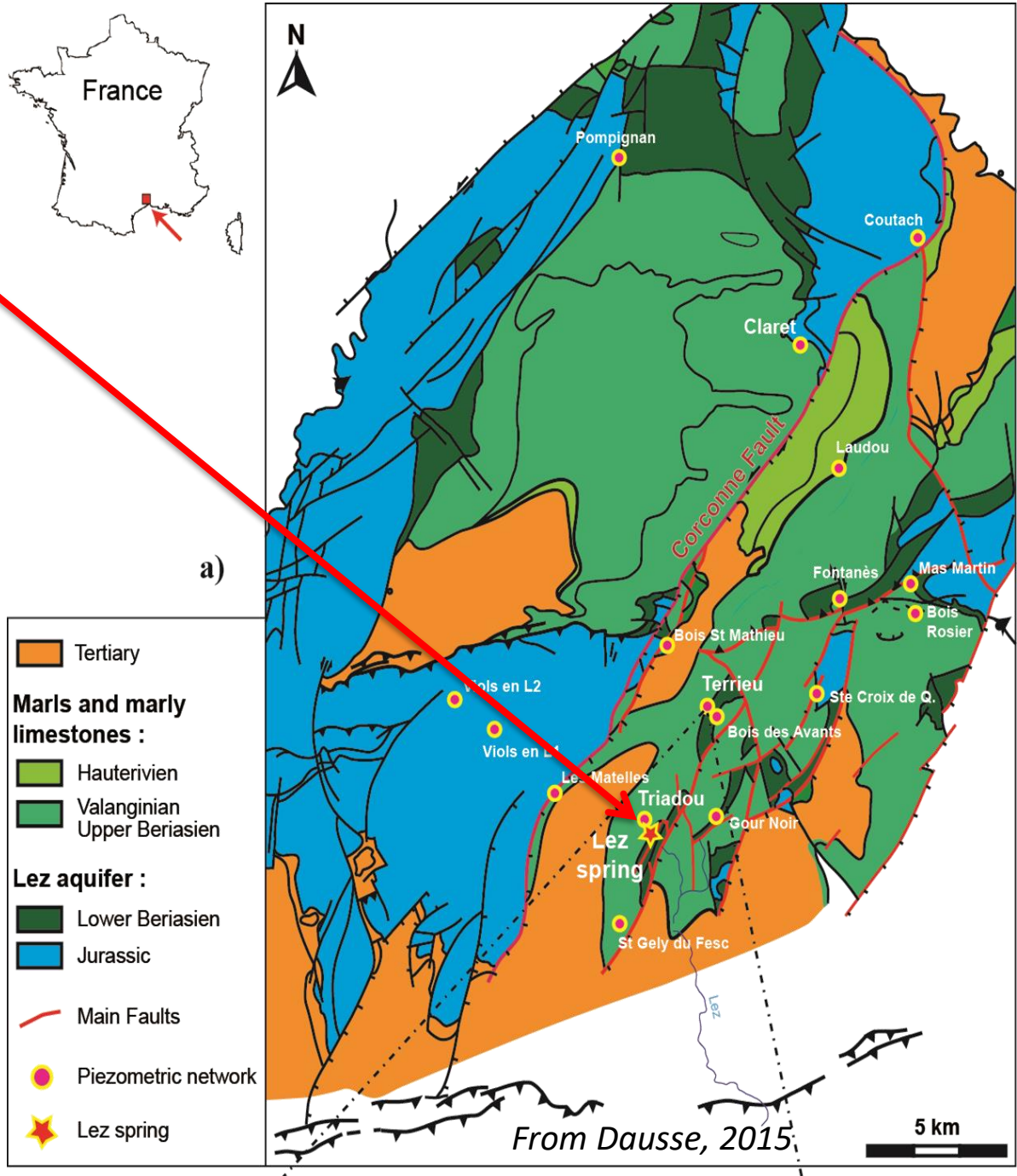
Oligocene : Major faults play in normal shift during the opening of the Gulf of Lion : the Lez reservoir is deepened on the eastern compartment bounded by the Corconne-Matelles fault.



Lez Karst Aquifer :

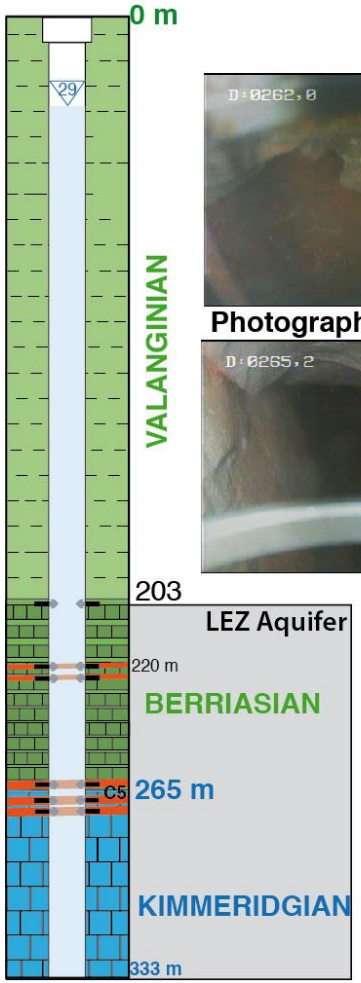
Sedimentology, Structure and Karstogenesis

Messinian crisis : the water base level falls down, and the karstic network deepens (Mocochain et al., 2011). The major spring of Lez is an outlet of a deep karstic network.



Lez Karst Aquifer :

Jurassic – Cretaceous Boundary



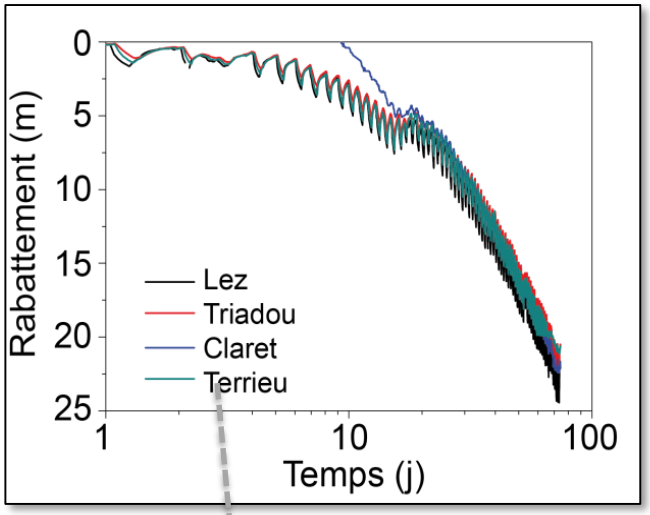
Triadou Well

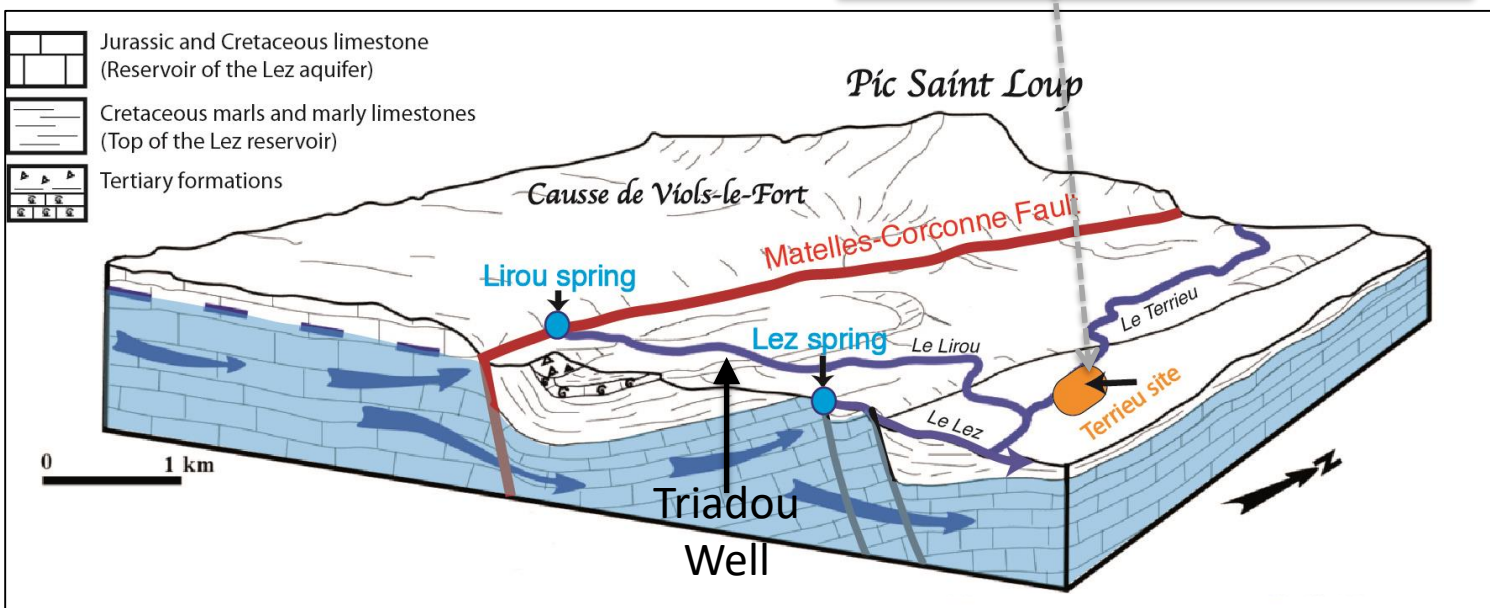
Photography at 265 m

Recent work (Dausse, 2015) has shown the impact of the karstification at the Jurassic – Cretaceous boundary on the fluid transfer, for confined or unconfined area.

At which period did the boundary karstify?

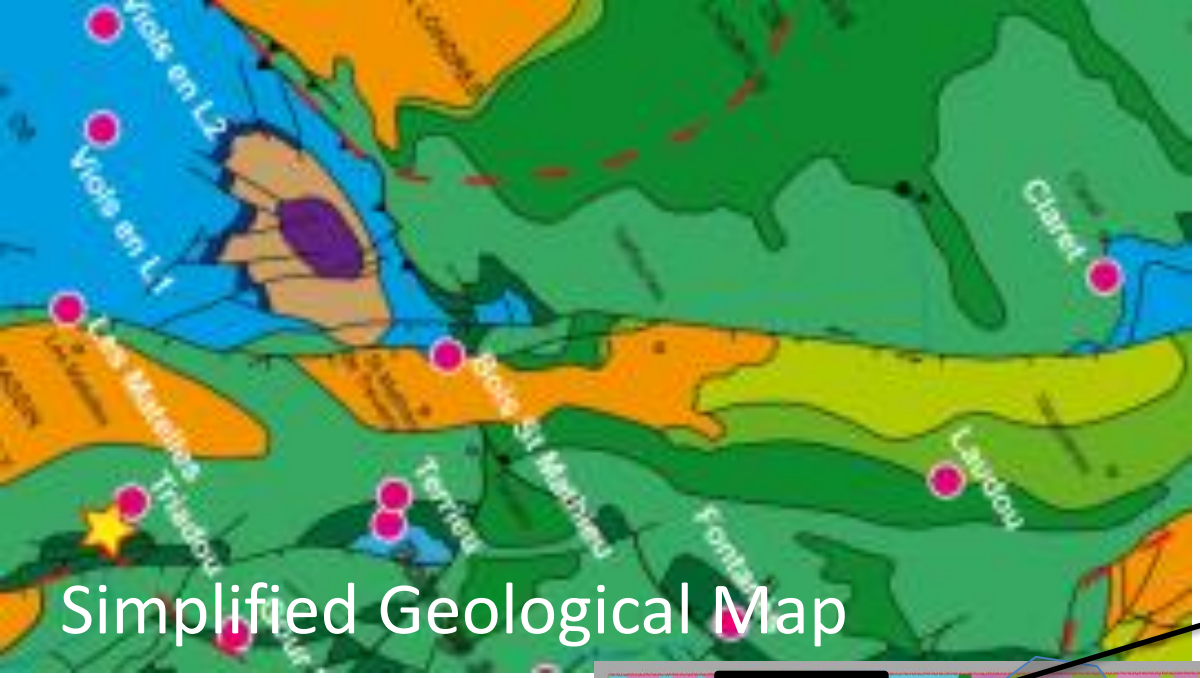
Effect of the pumping well of Lez



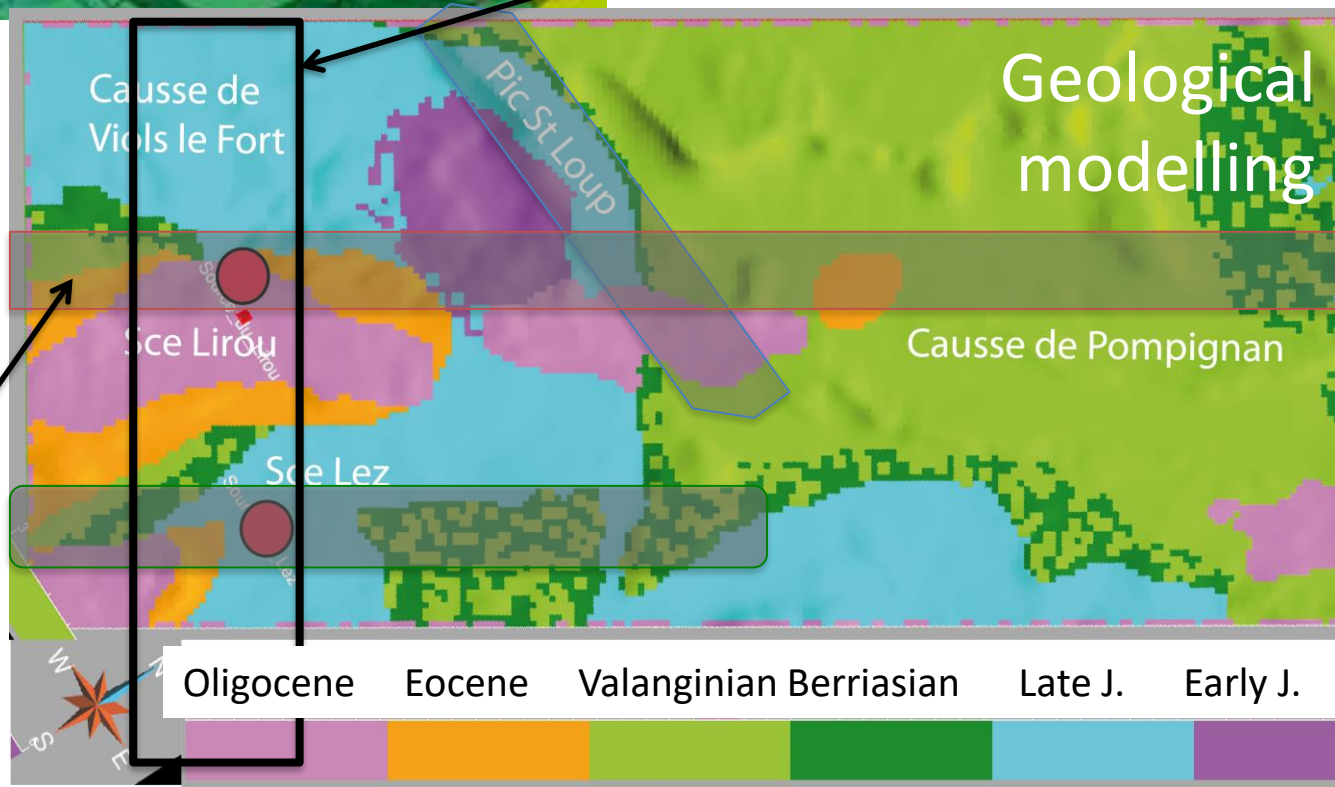


Lez Karst Aquifer : Godiag Modelling

Geological modelling with GoCad



Presentation of results in this area

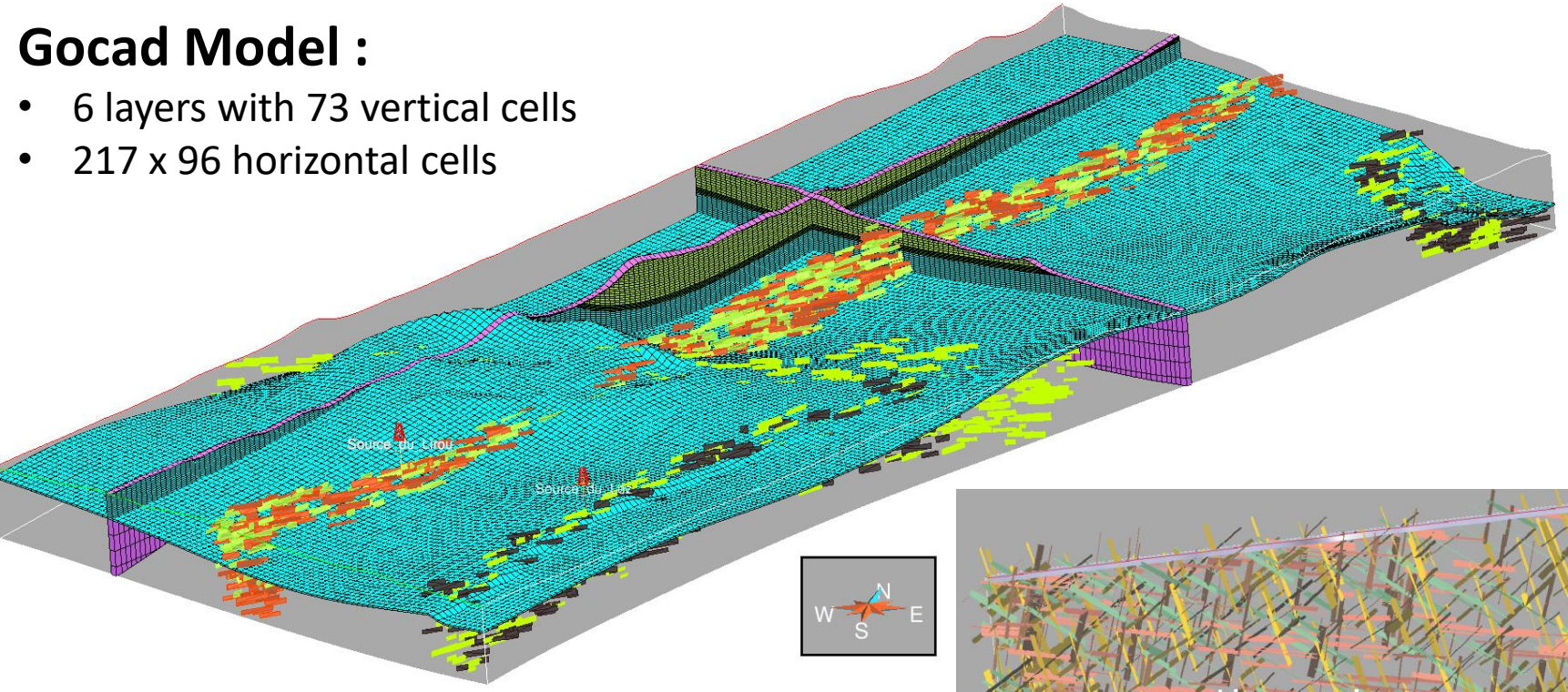


Major faults represented by fracture networks

Lez Karst Aquifer : Godiag Modelling

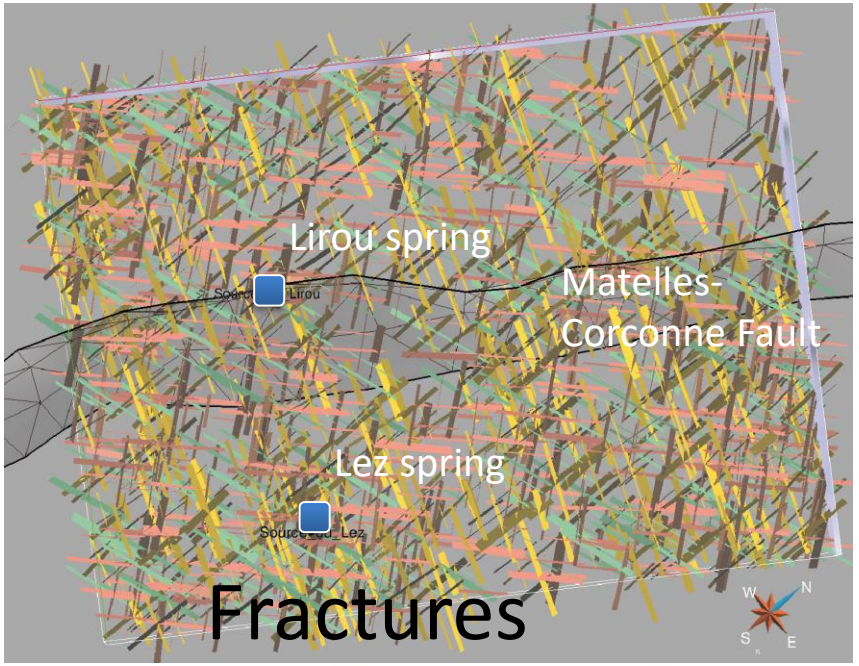
Gocad Model :

- 6 layers with 73 vertical cells
- 217 x 96 horizontal cells



Godiag Model :

- All cells x 2
- Fault zone represented by a fracture network
- 4 directions of fracture in Cretaceous and Jurassic formations are stochastically distributed



Lez Karst Aquifer – Godiag Modelling :
Scenarii

1st Scenario :

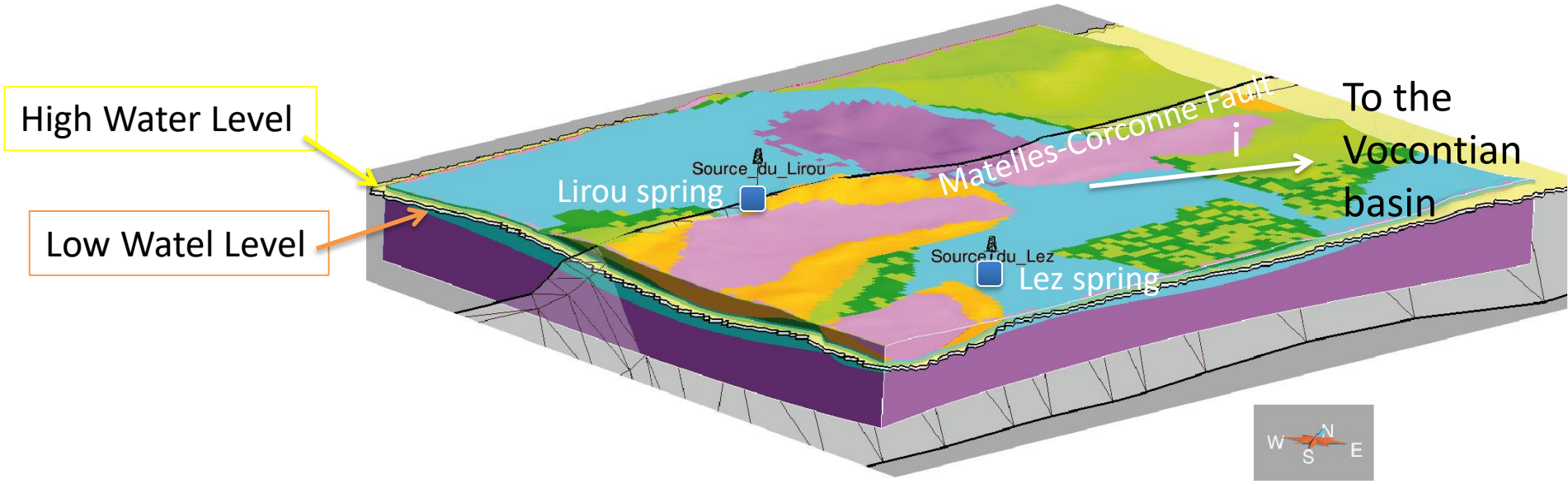
- 1 stage : Quaternary, water level variation from present day data.

2nd Scenario :

- 3 stages : Jurassic, Messinian, Quaternary.
- A water level for each stage (deep for Messinian stage).
- Jurassic : epikarst with a high density of fractures in the ten shallowest meters.

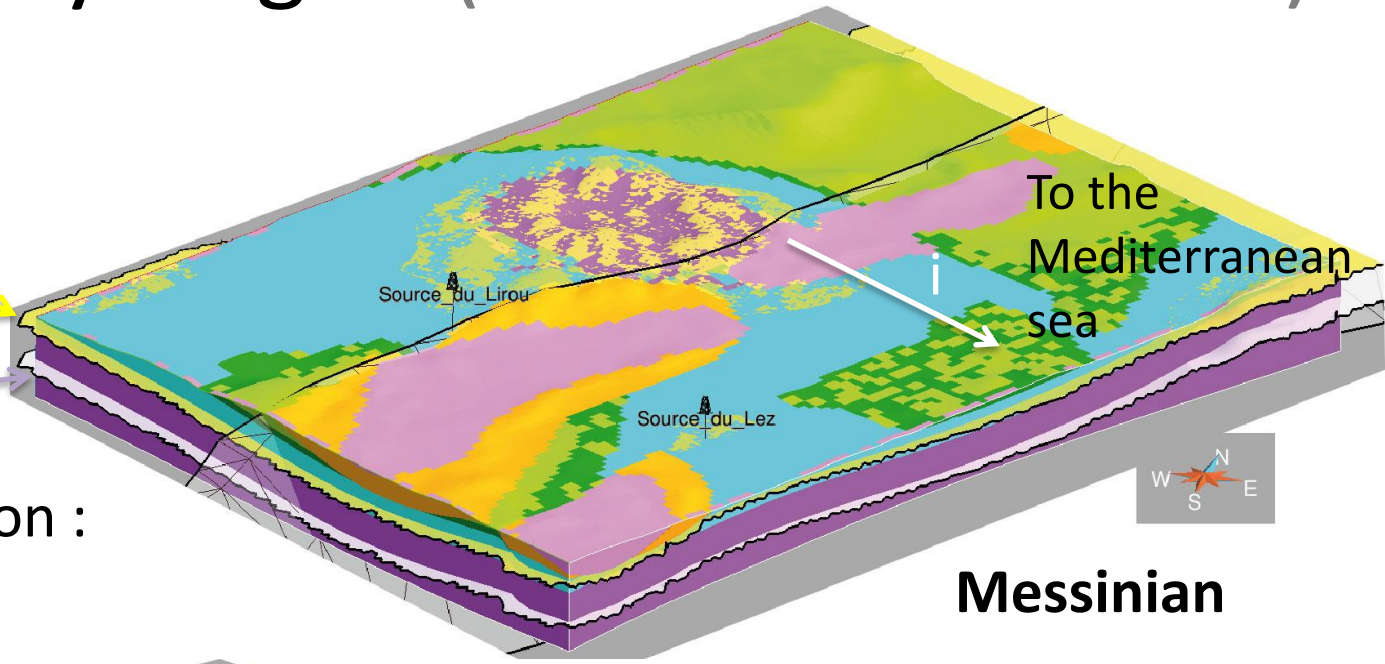
Constraints of the Jurassic stage

(2nd scenario)



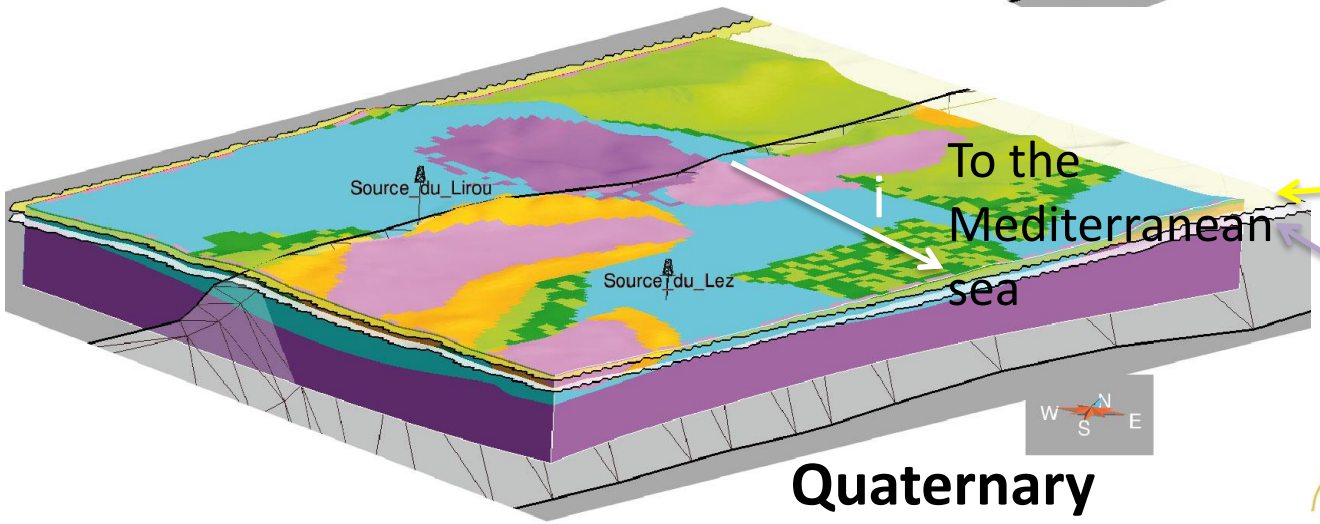
Surface of Infiltration :
Top of the Jurassic

Constraints of the Messinian and Quaternary stages (1st and 2nd scenarii)



Surface of Infiltration : Topography

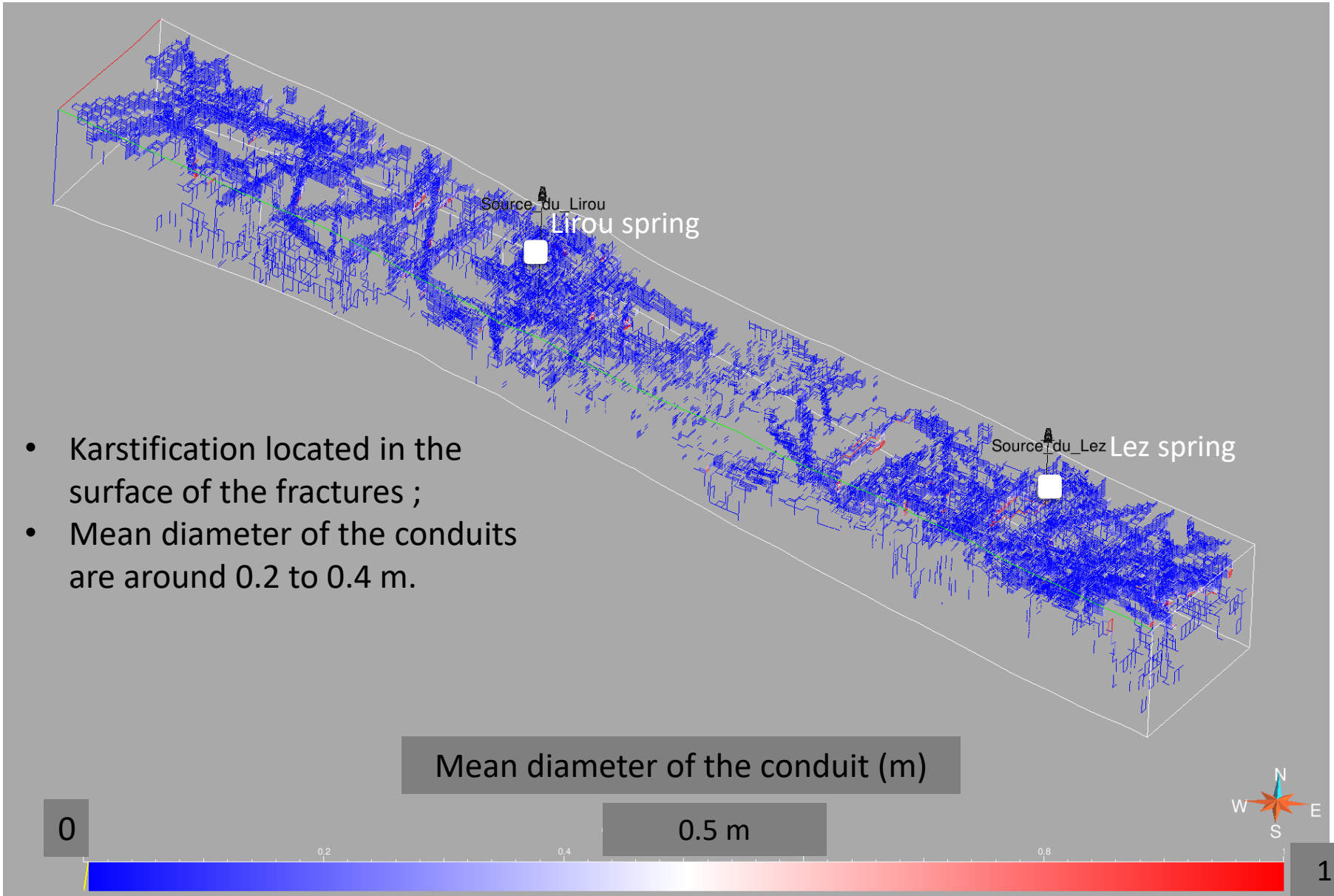
Messinian



Quaternary

Lez Karst Aquifer Modelling : Results

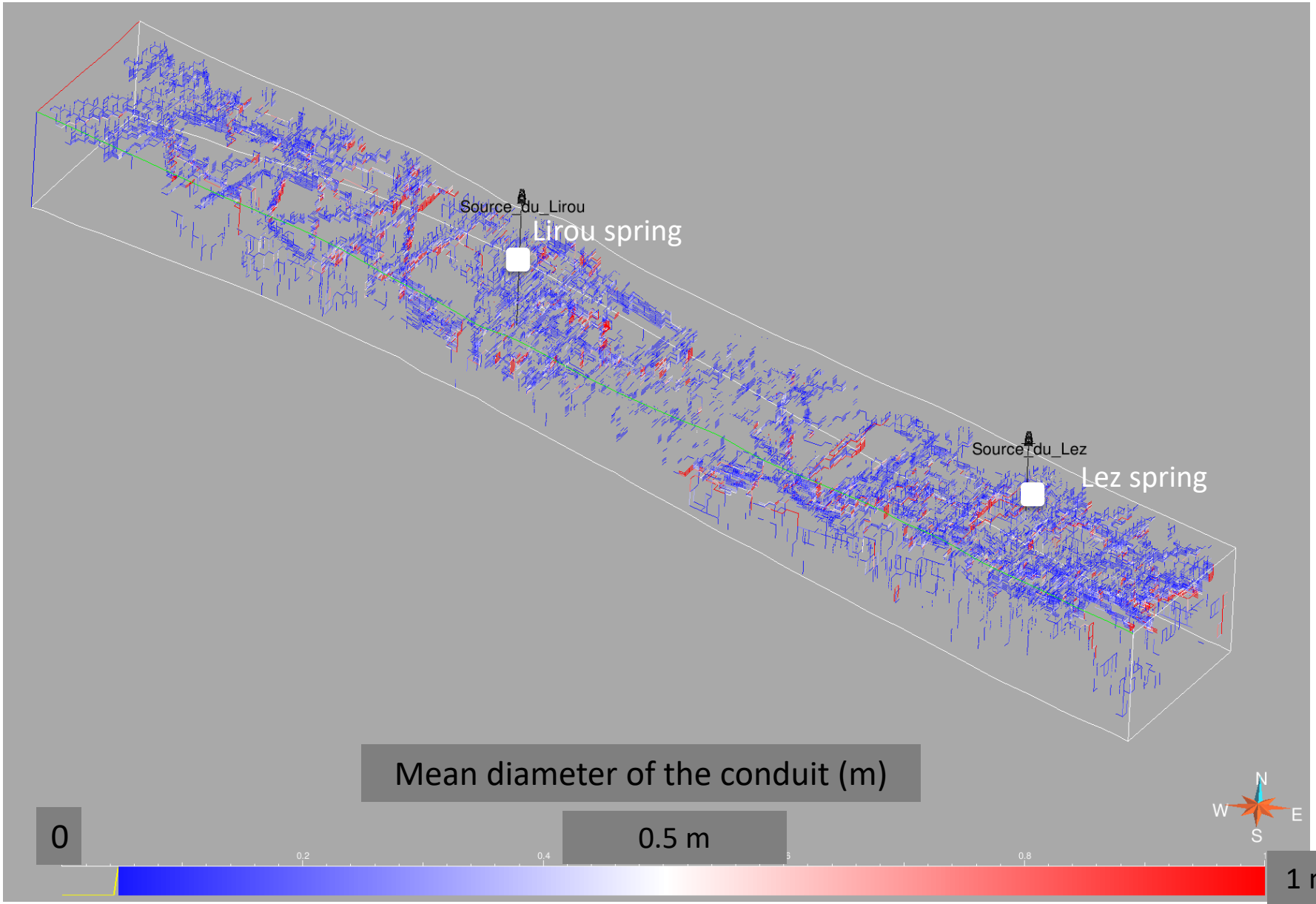
1st scenario : Beginning of the Quaternary stage



- Karstification located in the surface of the fractures ;
- Mean diameter of the conduits are around 0.2 to 0.4 m.

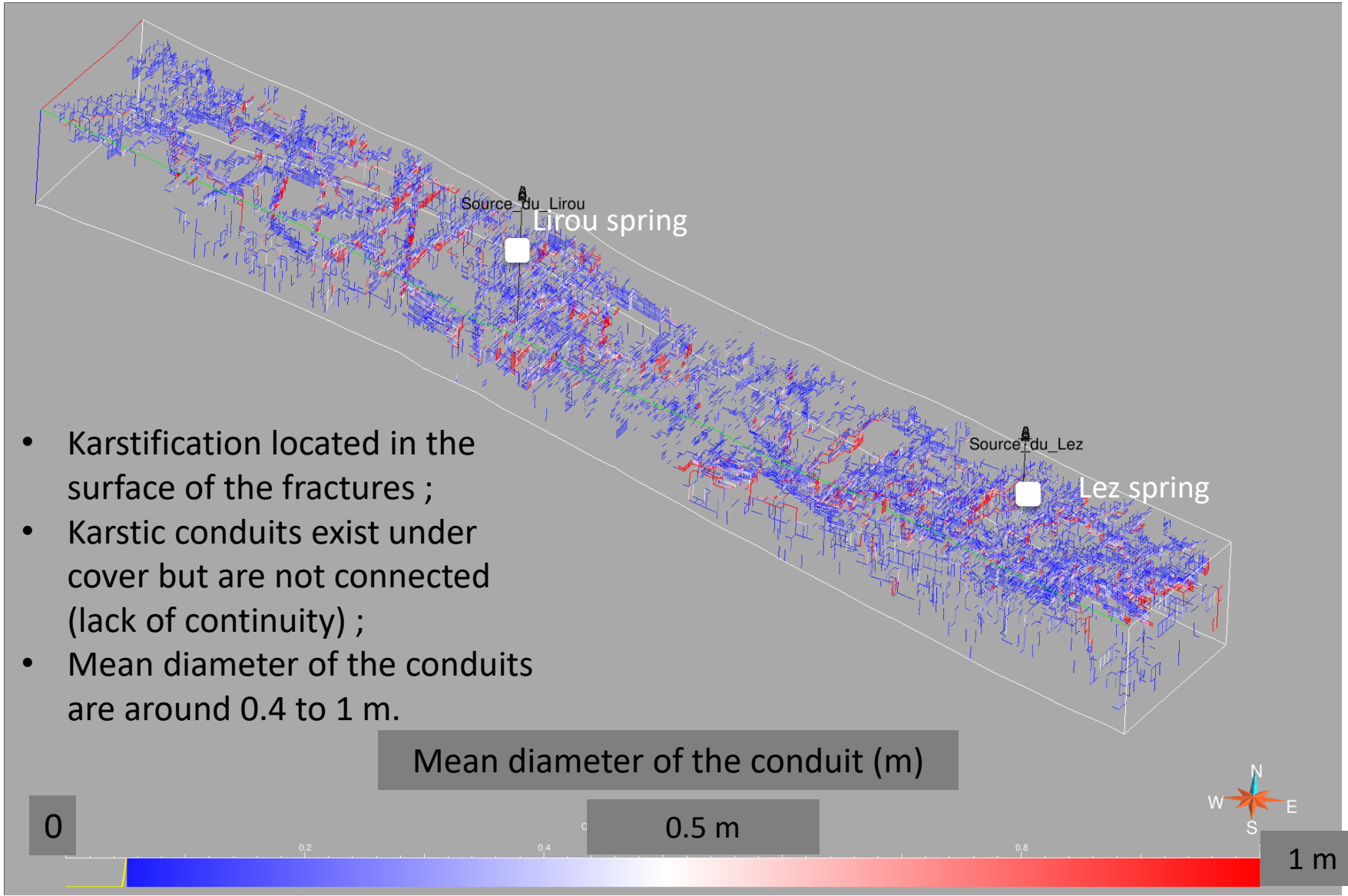
Lez Karst Aquifer Modelling : Results

1st scenario : Middle of the Quaternary stage



Lez Karst Aquifer Modelling : Results

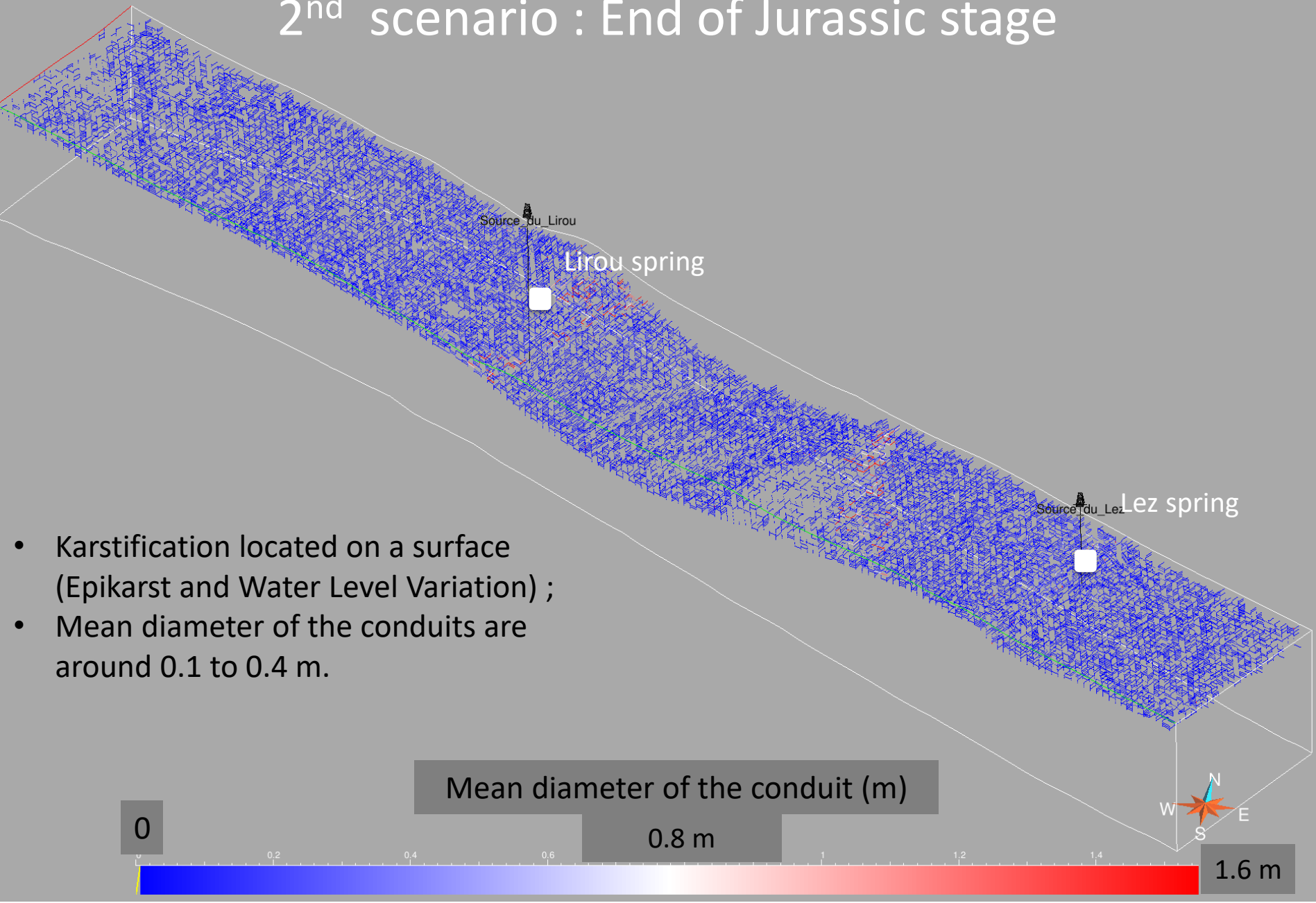
1st scenario : End of the Quaternary stage



- Karstification located in the surface of the fractures ;
- Karstic conduits exist under cover but are not connected (lack of continuity) ;
- Mean diameter of the conduits are around 0.4 to 1 m.

Lez Karst Aquifer Modelling : Results

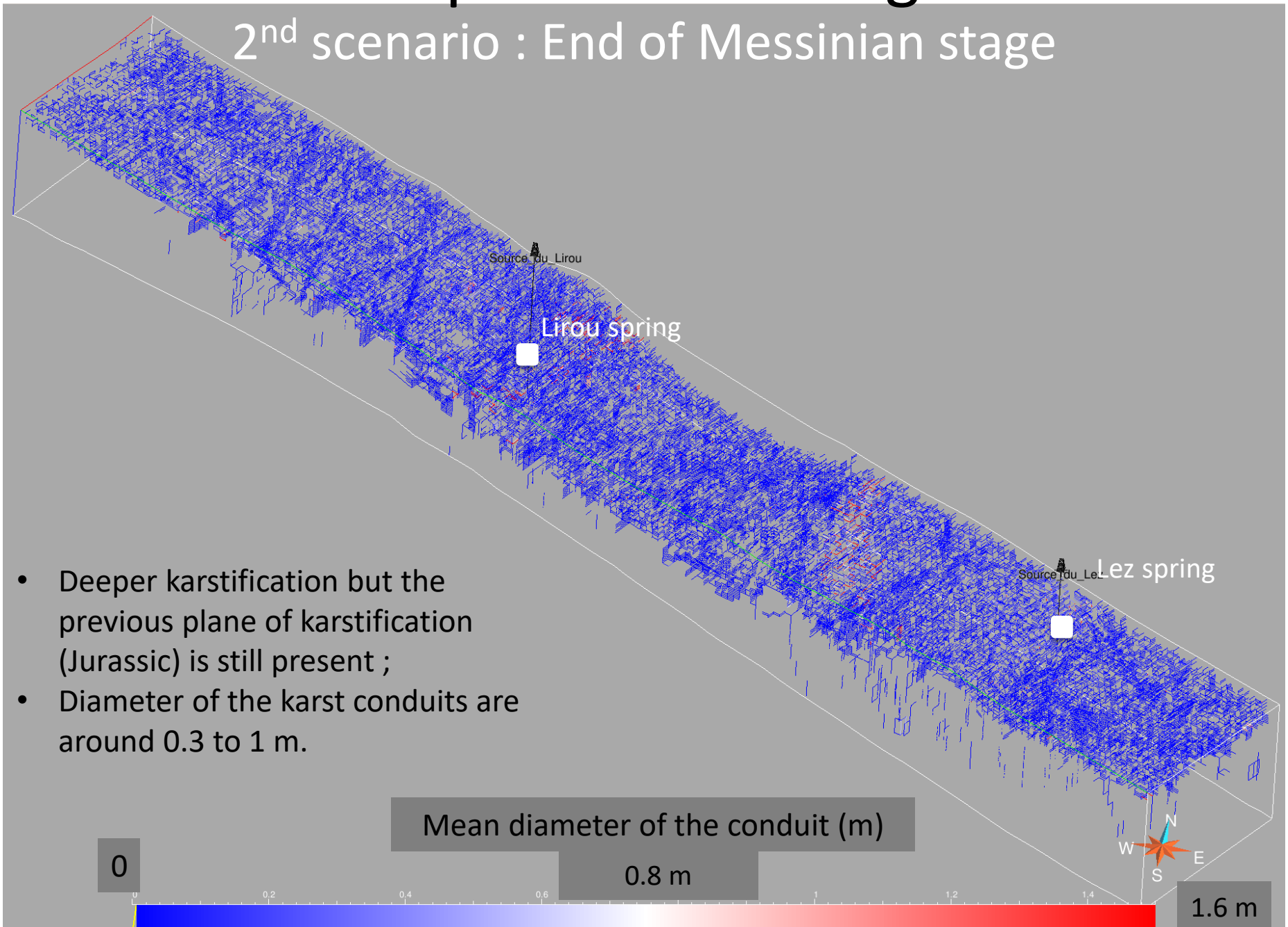
2nd scenario : End of Jurassic stage



- Karstification located on a surface (Epikarst and Water Level Variation) ;
- Mean diameter of the conduits are around 0.1 to 0.4 m.

Lez Karst Aquifer Modelling : Results

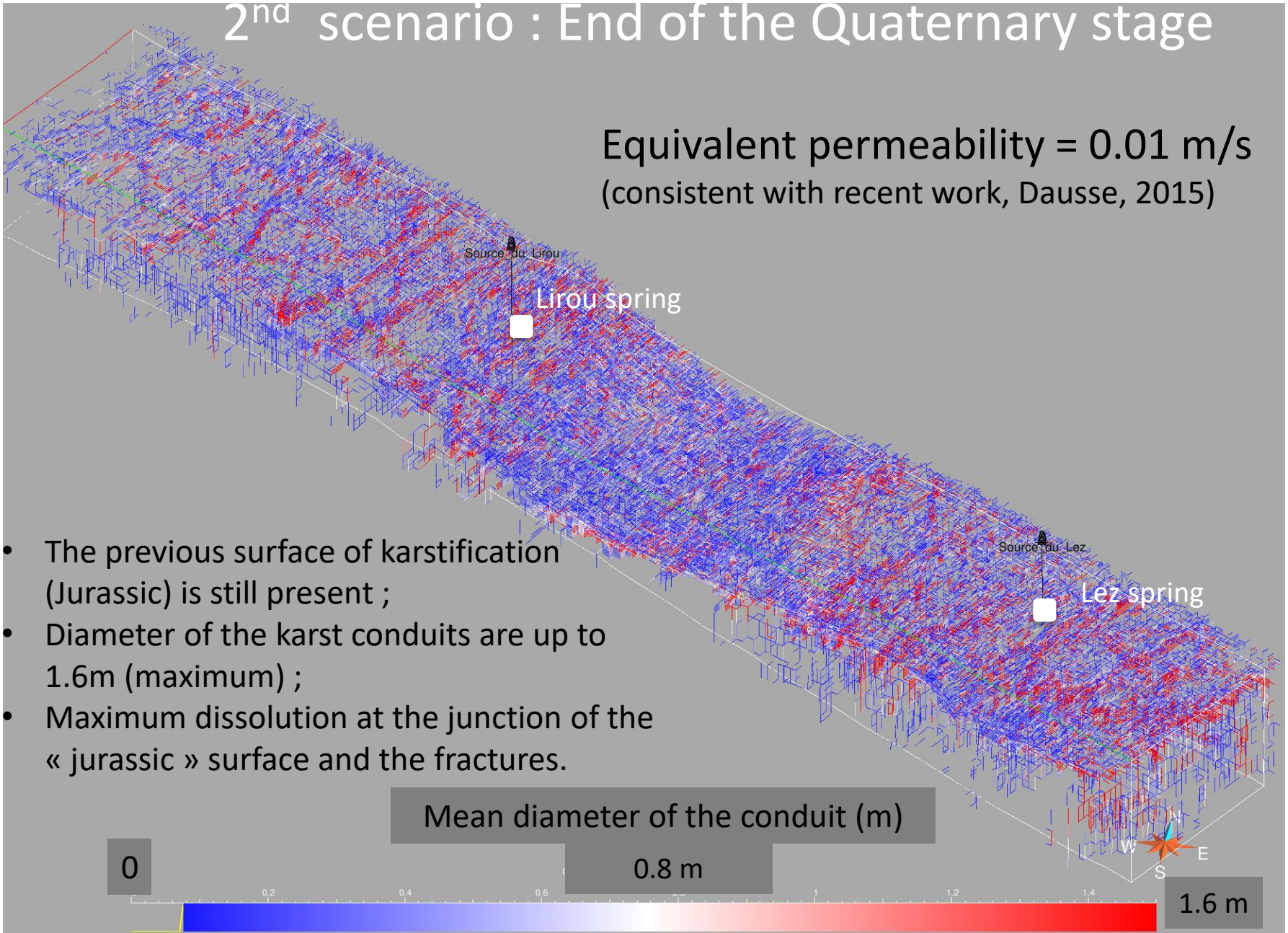
2nd scenario : End of Messinian stage



- Deeper karstification but the previous plane of karstification (Jurassic) is still present ;
- Diameter of the karst conduits are around 0.3 to 1 m.

Lez Karst Aquifer Modelling : Results

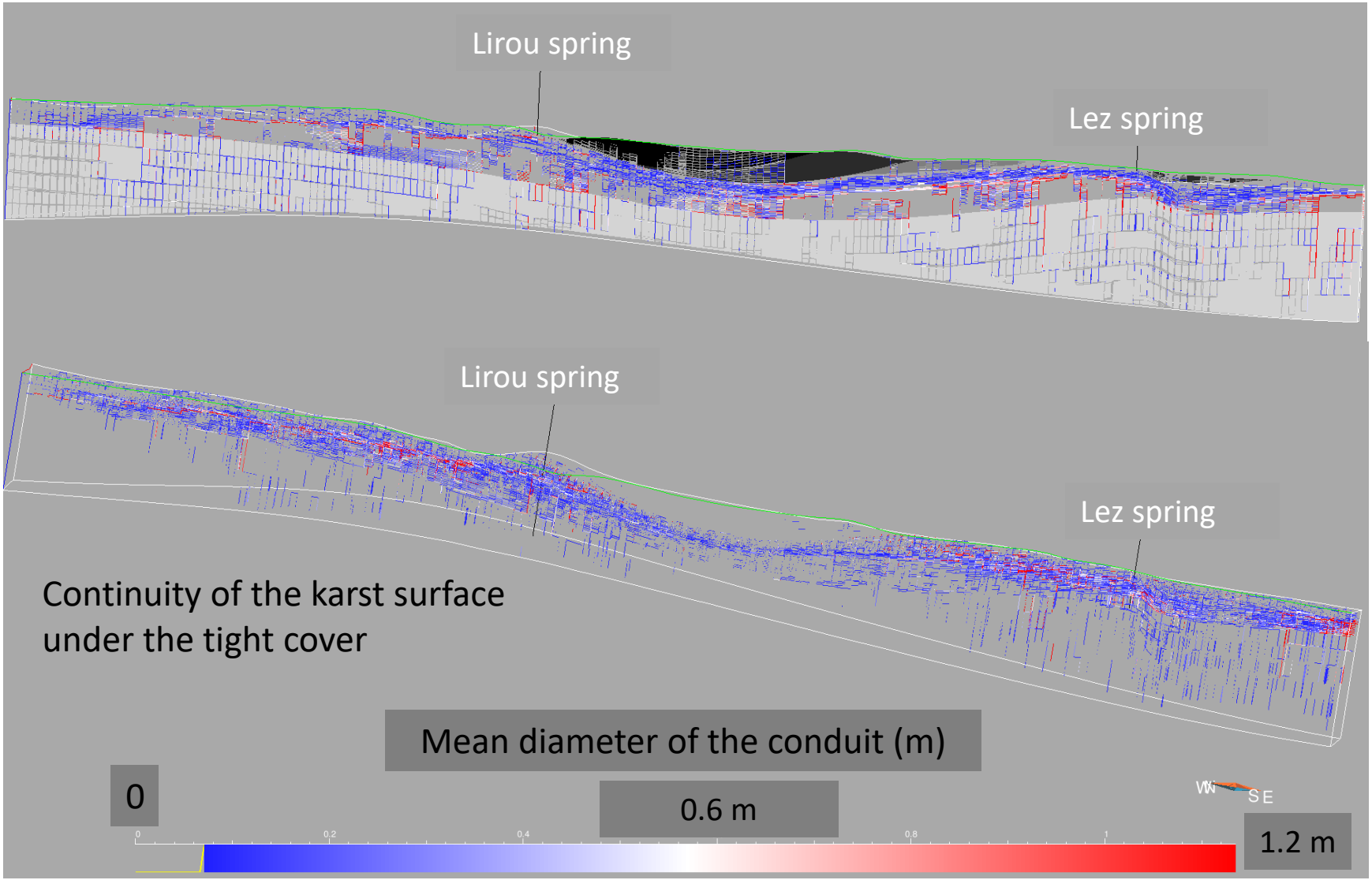
2nd scenario : End of the Quaternary stage



- The previous surface of karstification (Jurassic) is still present ;
- Diameter of the karst conduits are up to 1.6m (maximum) ;
- Maximum dissolution at the junction of the « jurassic » surface and the fractures.

Lez Karst Aquifer Modelling : Results

2nd scenario : Messinian to Quaternary stage



Conclusion

- Theses results of karstogenesis modelling show the importance of the early stage of Jurassic karst (continuity in confined area).
- The equivalent permeability computed from the modelled conduits is about 0.01 m/s, which is consistent with recent studies (Dausse, 2015).

Perspectives

The on-going models will aim :

- to represent the levels of karstification related to various water levels (in particular during the Messinian stage).
- to calibrate the intensity of karstification between Late Jurassic and Early Cretaceous, and weight the relative importance of each stage of dissolution.

References

- Bodeur, Y., 1996. La Flexure du bois de Monier (Herault); consequences de son jeu synsedimentaire, a la limite jurassique-cretace, sur la karstification du Tithonien. Documents - B.R.G.M., Colloque Formations superficielles et geomorphologie. Rouen, France vol. 248, p. 21.
- Combes, P.-J., 1971. Sur les conditions de mise en place des bauxites dans la partie meridionale du bassin de Bedarieux (Herault, France). Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences, Serie D: Sciences Naturelles 273, 2207–2210.
- Dausse A., 2015. Facteurs d'échelle dans la hiérarchisation des écoulements au sein d'un aquifère karstique - Analyse multi-échelles des propriétés hydrodynamiques et de transport de l'aquifère du Lez. PhD Université Montpellier, 232 p.
- Husson, E., Séranne, M., Combes, P.-J., Camus, H., Peybernès, B., Fondecave-Wallez, M.-J., Melinte-Dobrinescu, M.C., 2012. Marine karstic infillings: evidence of extreme base level changes and geodynamic consequences (Paleocene of Languedoc, south of France). Bulletin de la Société Géologique de France 183, 425–441. doi:10.2113/gssgfbull.183.5.425
- Mocochain, L., Audra, P., Bigot, J.-Y., 2011. Base level rise and per ascensum model of speleogenesis (PAMS). Interpretation of deep phreatic karsts, vauclusian springs and chimney-shafts. Bulletin de la Société Géologique de France 182, 87–93. doi:10.2113/gssgfbull.182.2.87