

Review EGU sphere

Title: Naturally fractured reservoir characterization in heterogeneous sandstones: insight for Uranium In Situ Recovery (Imouraren, Niger)

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### **Evaluation of the overall quality of the preprint ("general comments")**

This is a very concise and well-presented research work integrating multifaceted analysis techniques of reservoirs and fracture networks applied for the very first time to ISR of uranium resources.

The problem is well addressed in the introduction and well developed throughout the manuscript. Despite the fact that the reader has to read 8 pages before arriving at the results, the results are very rich and with a lot of detail (which sometimes makes it difficult to read).

After a very detailed quantitative and typological fracture analysis, the manuscript emphasizes the role of various types of tectonic structures on the anisotropy of the permeability of the Imouraren uranium reservoir controlling favorable versus unfavorable fluid flow pathways, and makes suggestions for the future ISR infrastructures management. This is a very nice case of applied research.

In addition, the authors propose a nice model of the 3D architecture of the reservoir coherent with all the new data collected. This 3D model is from far the best one has been produced up to now of the Imouraren uranium deposit.

For all these reasons, this article appears to me of high interest for the whole geoscientist and industrial community, and particularly for the ISR actors in uranium resources.

In my opinion, the manuscript just requires some corrections/modifications of second order before final publication.

### **Individual scientific questions/issues ("specific comments")**

Is "attenuation by fracture networks" what is searched with ISR production?

Is "Mode I" still relevant in modern fracture analysis knowing that in 3D all three "modes" are represented in the same fracture?

I am surprised to do not see any description of "horizontal" compressive structures. These are mentioned and illustrate in a previous Areva internal report from oriented bore-holes data and supported with field pictures. These "horizontal" set is obviously difficult to document from satellite images but should be observable on new drill-cores and OBI data. I wonder what can be the influence (favourable or unfavourable) of such fault set in the permeability behaviour, the fluid flow and finally in the recommended ISR infrastructure... (as said by the authors in line 651 ...the impact of faults and fractures on top and basal seals integrity...).

If I have correctly understood, the 4 fracture sets identified at the basin scale (ENE-SWS, ESE-WNW, N-S and NNE-SSW; section 4.1.1) are not the same as the 3 main fracture sets defined from circle area sampling from satellite images (NE-SW, NW-SE and E-W; sections 3.1.2 and 5.1), and retained for the discussion and conclusions. Why don't they match? Why the shift between those sets? What happens with the "N-S Arlit fault type" sets as warned in lines 523-525)? Additionally to these

questions, I note that the basin scale lineaments are not sub-orthogonal (set 1 vs set 2, pag 8). Their shift to NE-SW and NW-SE makes them sub-orthogonal. It looks like a simplification of regional sets orientation to make them sub-orthogonal at the deposit scale? Isn't it a little bit abusive?

### **List of technical corrections ("technical corrections": typing errors, etc.)**

#### Abstract

Line 12. Why "complex" reservoir? Better "heterogeneous"...

Line 18. Mode I fractures. Is this still relevant in modern fracture analysis?

Line 18. Is "brecciated" needed?

Lines 26-27. Is "attenuation" what is searched with ISR production?

#### Keywords

You could add "ISR"

#### Introduction

Line 35. "...especially the transition to low-carbon energies (Evans et al., 2009)" not needed

Line 60. "...following the brittle-ductile transition of such porous rocks..." This is confusing here when talking about sedimentary rocks! Needs precision or better remove it.

Fig. 1b. Add in the legend the meaning of the arrows indicating N120E, N070E and N030E (fault sets)

Fig. 1c. Strange to publish in 2024 à cross section with vertical faults!!!

#### Material and Methods

Line 136. "...the size of these circular sample surfaces is of the same order of dimensions as a set of ISR cells". I like this.

Line 228. Are these two piezometers indicated in Fig. 1D? In my paper copy the quality of the image is not enough to check for these two piezometers.

#### Results

Please review Figure 2 information in relation with text from lines 245 through 262.

- Line 251. Figure 2d (e?)
- Line 252. d? d is the figure cited for the set N060 (line 247). Please check.
- Line 255. Figure 2f shows strata not fractures!!! Figure 2f. Please draw a fold axis, or indicate fold limbs dip (strata without any dip information = no meaning).
- Line 259. Where is Madaouela in Fig. 2a?

Lines 272-273. "These data were used to characterize the structural organization of lineament networks affecting the Tchirezrine II reservoir at the scale of ISR project, i.e. ranging from meter to hundred meters scales" Not needed, already said in methodology. Deleting other sentences like this one could help to reduce the length and repetitiveness of the manuscript.

Line 299. "...we were unable to find a specific value (i.e. which is lower 300 than censored ones)". Not clear why... Maybe you can add complementary information.

Line 367. "... generally clays or oxidized products...". Please explain how you identify such products from OBI, or specify this is done from drill-core direct observation (it is confusing here because you start de paragraph saying from OBI, line 364).

Lines 410 through 435 are a little bit indigestible...

#### Discussion

Line 478-481. (NE-SW and NW-SE)... Maybe better ENE-WSW and WNW-ESE to summarize sets 1 and 2 (page 8)... which are not really sub-orthogonal!!!

See also "specific comments".

#### Conclusions

Nice conclusions!!!

Line 666. Conclusion 1. I still have my doubts about “sub-orthogonal” sets... See specific comments.

### Figures

Figure 1. Text in D is unreadable.

Figure 2. Please review information in relation with text from lines 245 through 262.

Figure 10. Arrange horizontally.

Figure 11. What does “Imola” mean? Why strata traces are so irregular? It isn't nice...