2D CWT analysis of shale dewatering features

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Summary

Polygonal faults are fine grained sedimentary formations play a major role in the flow of pore water and hydrocarbons in sedimentary basins. They are usually associated with normal faults with modest throw (10 to 100 m). The strain characteristics allow differentiating them from normal faults and they strike in differed directions. The major question to address is whether these faults are completely random or whether they have a preferred strike orientation. Geologist believe they are complete random with some evidence from real data indicates a possible orientation. In this work, we implement 2D continuous wavelet transform to characterize the orientation of these features.

Theory

2D Continuous Wavelet Transform

$$\mathcal{F}(i,j,x,y) = FT^{-1}\left\{ij\hat{f}(k_x,k_y)\widehat{\psi}(ik_x+jk_y)\right\} \quad (1)$$

Magnitudes and Voices:

$$mag(i,j) = |\mathcal{F}(i,j,x,y)| \quad (2)$$

$$voc(i,j) = \mathbb{R}\left[\mathcal{F}(i,j,x,y)\right] \quad (3)$$

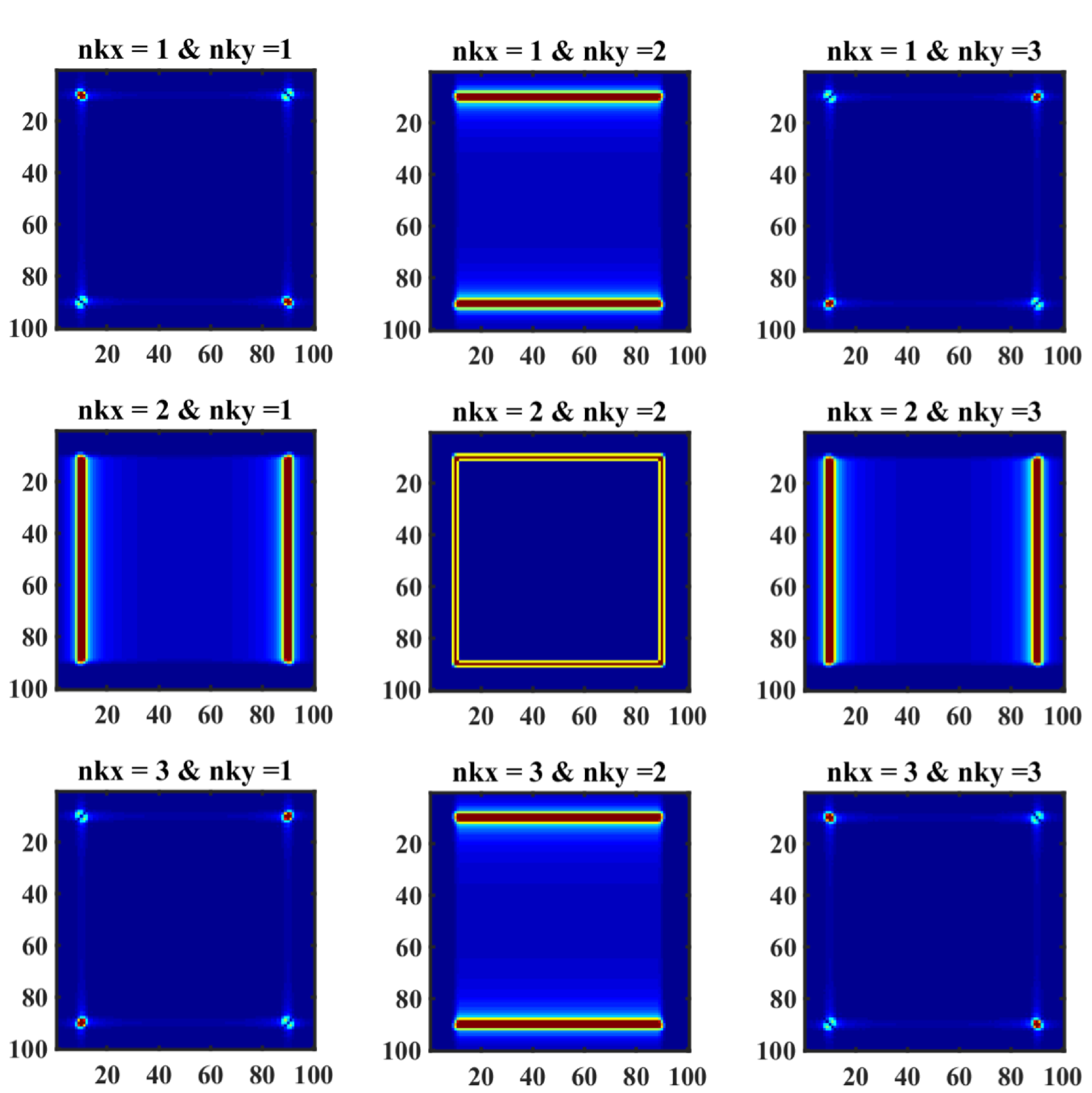

Figure 1: A synthetic square seperated into 9 components using nkx=3 and nky=3.

Real Data Example

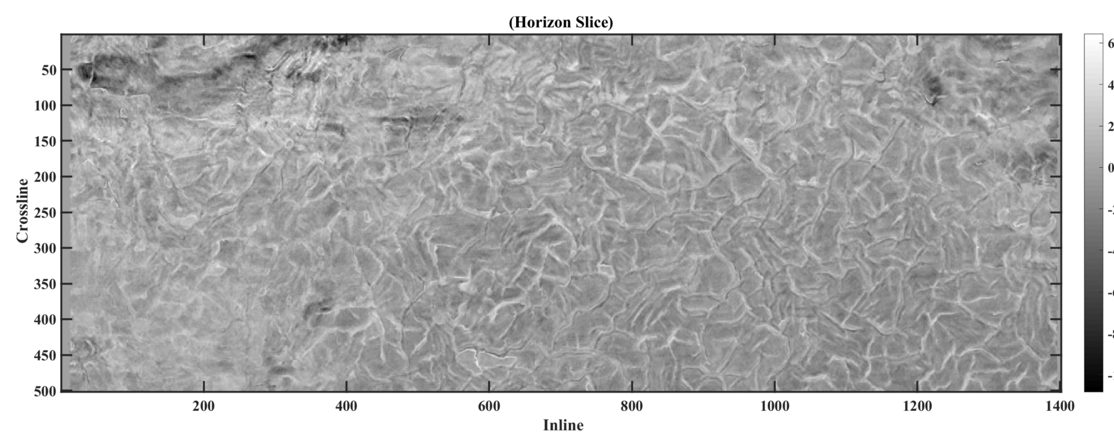

Figure 2: A slice through Artmis data offshore Australia with pronounced fault features.

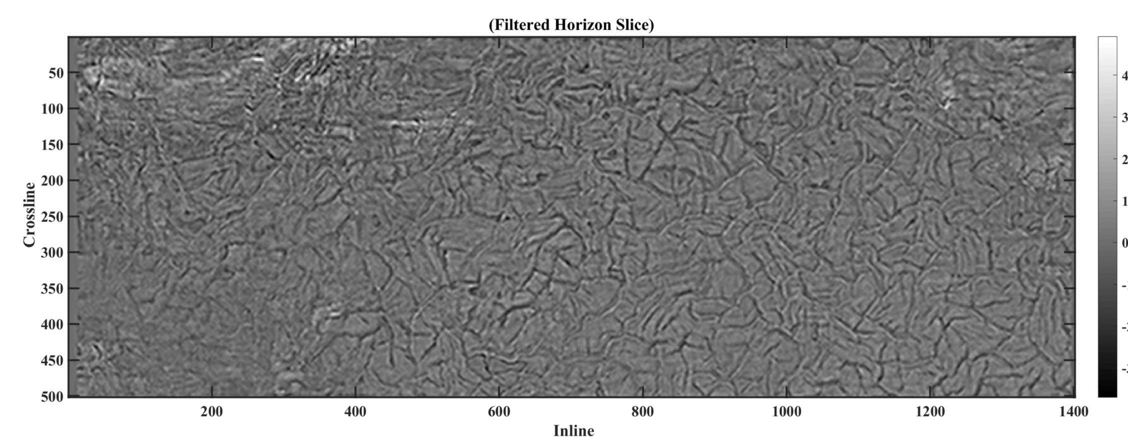

Figure 3: The slice in figure 1 after we suppressed the DC component.

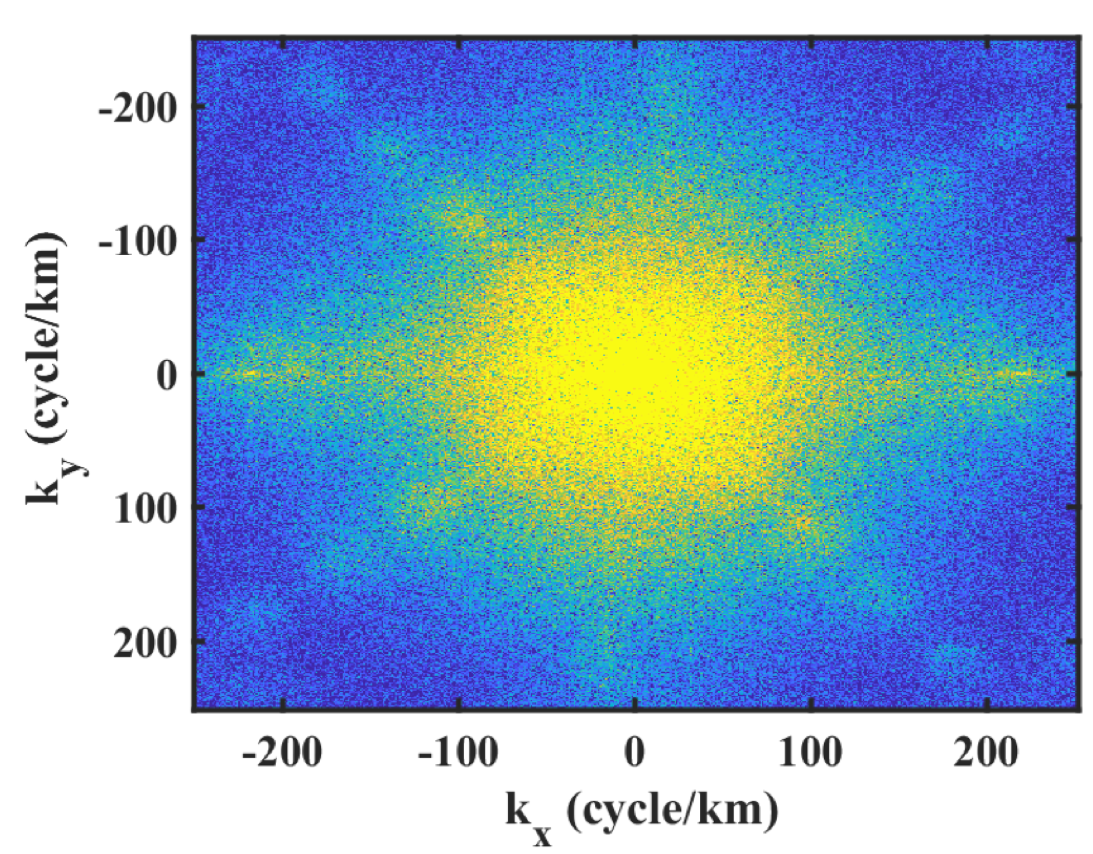

Figure 4: $k_x k_y$ transform of the slice in figure 2. The periodicity of the features can be seen as a diagonal trend .

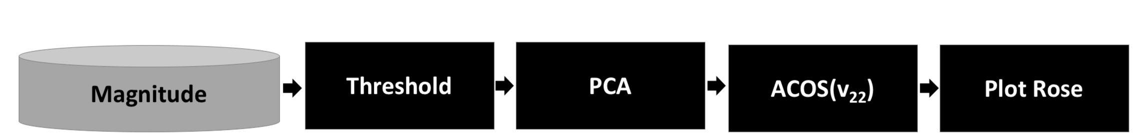

Figure 5: The workflow to characterize the periodic feature on Figure 2. We separated the slice into a 25 components and applied a statistical threshold. Then we run a PCA to cluster the events in preferred orientations.

Figure 6 to 9 show the normalized magnitude withe yellow arrows indicating the direction of the 2D wavelet operator. This preferred orientation allows us to run PCA on these slices and count the event in that orientation. For display purposes, we show the magnitudes for 4 out of 9 component analysis. To generate the rose diagram, we used a 25-component analysis.

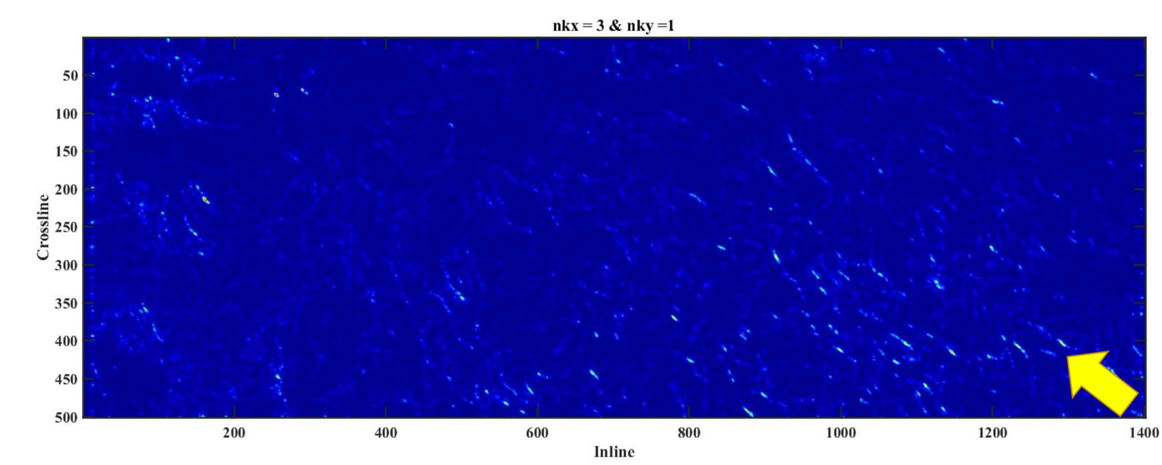

Figure 6: The magnitude at components nkx=3 and nky=1.

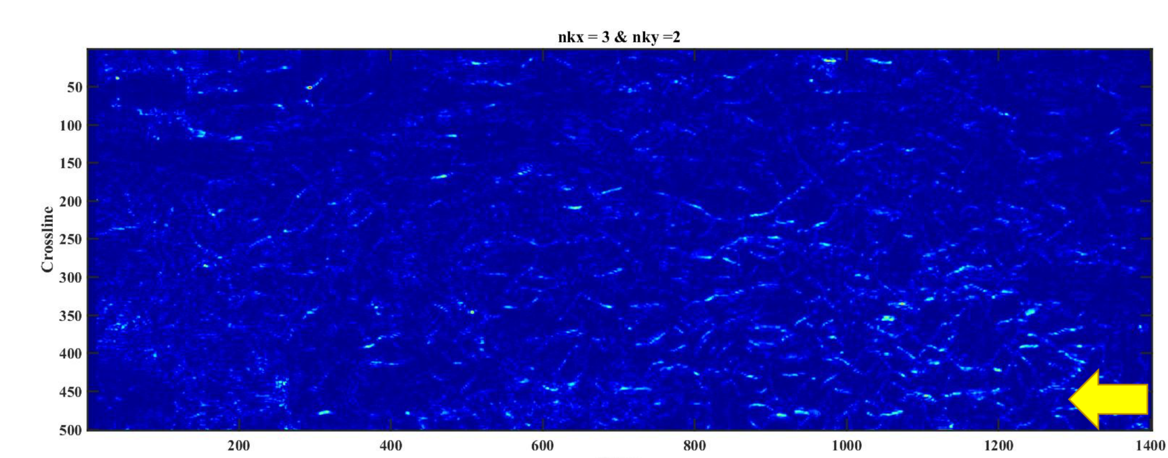

Figure 7: The magnitude at components nkx=3 and nky=2.

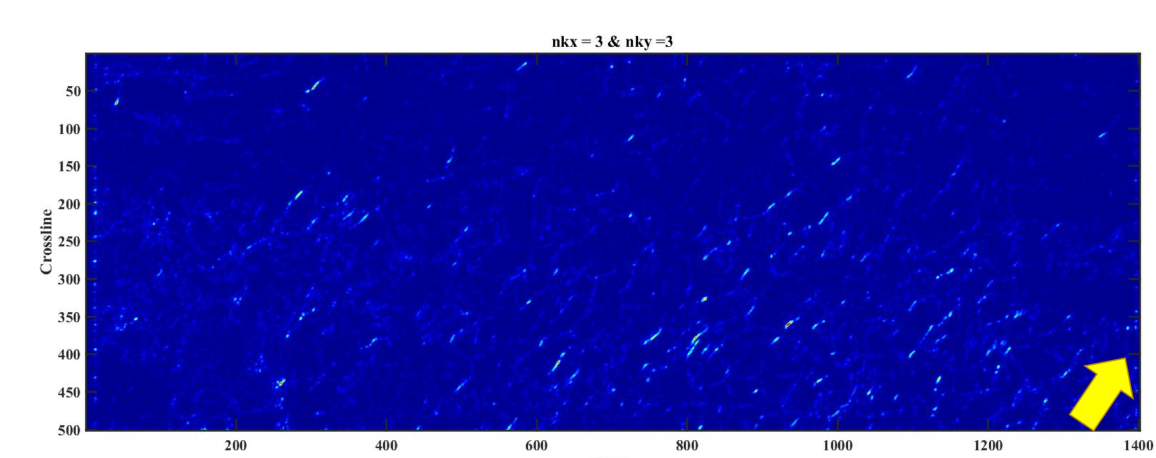

Figure 8: The magnitude at components nkx=3 and nky=3.

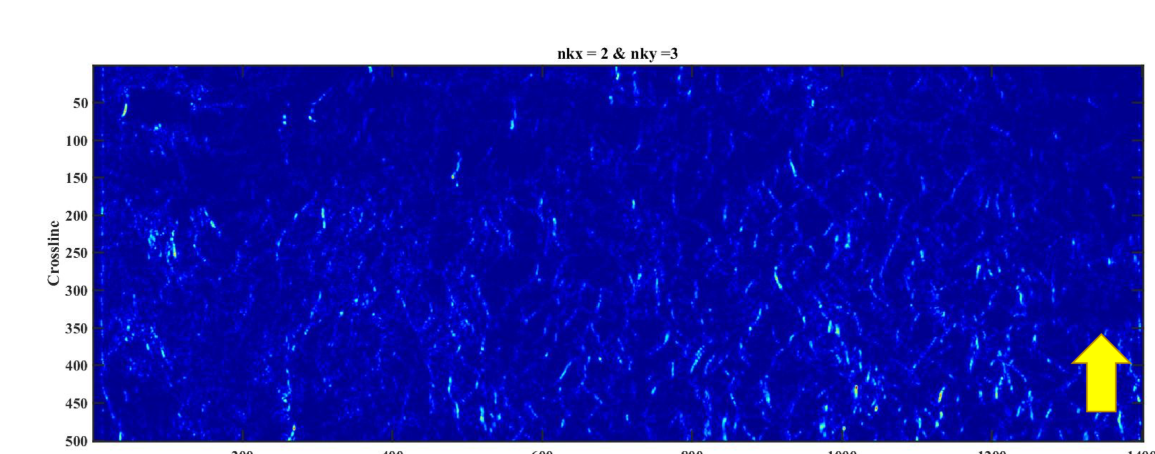

Figure 9: The magnitude at components nkx=2 and nky=3.

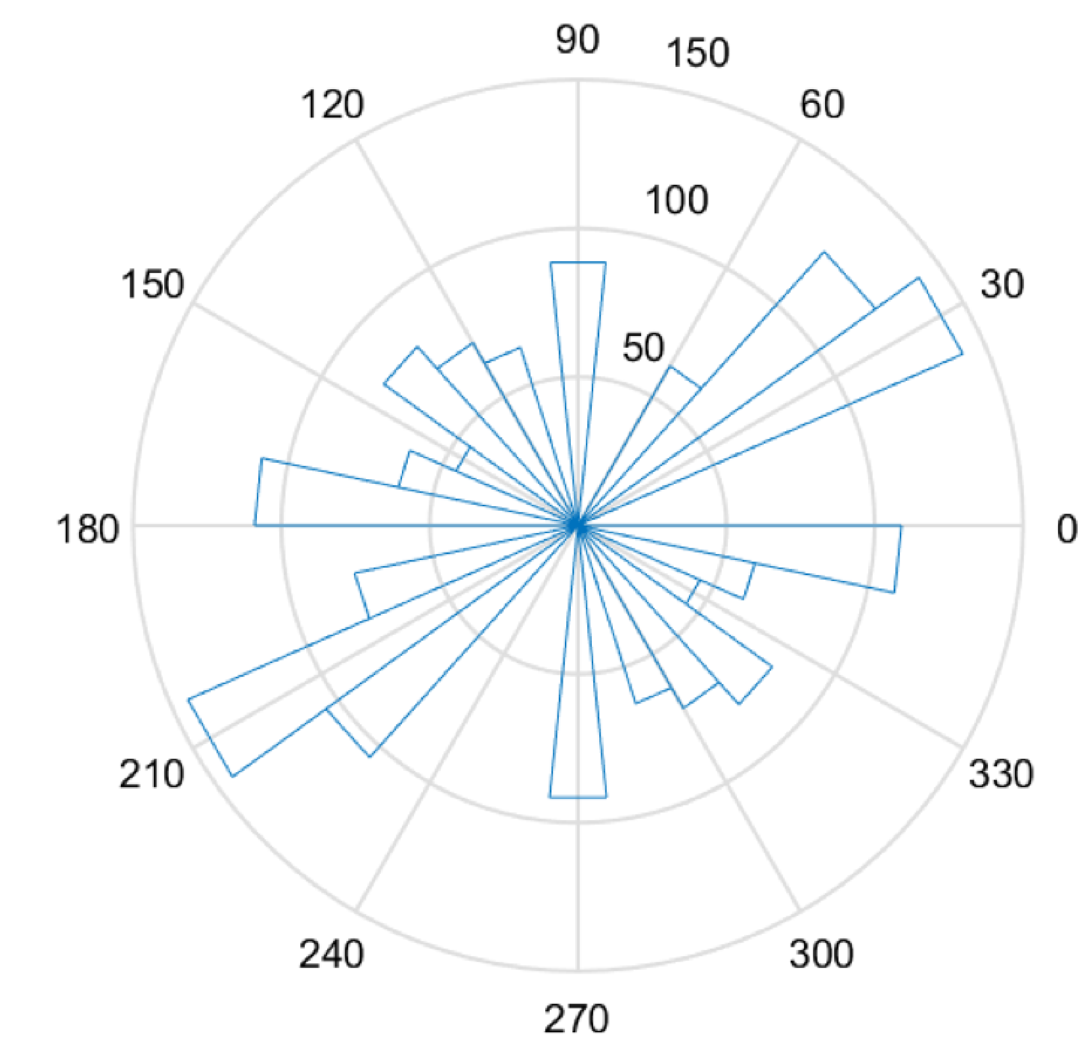

Figure 10: The rose digram for the slice shown in figure 3.

Conclusion and Future work

1. The peridodicity seen on the $k_x k_y$ transform encouraged us to use the 2D CWT to charchterize the features
2. The fault considered in this analysis are 150 m and larger.
3. Currently the threshold is purely statistical where we reject the last 10% and better calibration is needed to make the model more geologically acceptable.
4. A possible limitation is considering a fault that changes strike as two events.

Contact Information

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