Mapping Magnetic Lineaments in the Foothills of Northeastern British Columbia using 2-D Wavelet Transform

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Abstract

Summary

This work describes the use of wavelet transform technique to map lineaments in High Resolution Aero Magnetic (HRAM) data. This technique is completely automated and therefore much faster, more cost-effective, and less subjective than traditional approaches to mapping lineaments. Preliminary results are very encouraging and reveal lineament that are likely to be missed using traditional lineament mapping techniques.

Introduction

The crystalline basement rocks of the Western Canada Sedimentary Basin (WCSB) have been extensively faulted over the last two billion years. Some of these fractures and faults have propagated into the intra-sedimentary rocks of the basin and often appear as linear to curvilinear features on the HRAM data. These lineaments play a major role in oil, gas, mineral and groundwater exploration because they control structure in the intra-sedimentary section as well as in the crystalline basement rocks. For this reason, we consider mapping of lineaments in HRAM data to be one of the most important stages in geological interpretation of an area.

Traditionally, lineament detection and mapping in HRAM data is carried out by visual inspection of a set of enhanced and filtered images of the total magnetic intensity. These filters (for example the horizontal gradient and the analytic signal) are carefully designed to pick lineaments that are associated with faults, fractures, and geological contacts. Going through this process thoroughly over a full range of wavelengths can be a very tedious operation. For this reason we have experimented with an alternative technique based on wavelet analysis to detect lineaments. This alternative technique is much faster, cost-effective and less biased by the interpreter's pre-conceived ideas.

Methodology

We normally use Fourier (FFT) based analytical techniques to produce enhanced filtered maps to interpret lineaments in HRAM data. By doing this we assume that signals in the HRAM data are stationary in a mathematical sense. The FFT uses cosines and sines to represent a signal and is most useful for representing stationary signals. However, HRAM data contains non-stationary components: for example, discontinuities and abrupt changes in the signal that are attributed to geology that are not evenly distributed. Hence, an FFT is not entirely suitable for analyzing such signals. In this case, wavelet analysis is more suitable to represent non-stationary signals. Wavelet transforms (Daubechies, 1990; Hassan, 2004) decompose an input signal into coefficient matrices which maps all the spatial relationships at multiple scales.

We used 2-D wavelet transform provided in the MATLAB wavelet toolbox to map lineaments in an HRAM data from the Foothills of northeastern British Columbia (Figure 1). The area is located at the eastern edge of the Canadian Cordillera deformed belt and contains numerous economic deposits of oil and gas. Prominent faults in the area trend in the northwestern direction with less obvious, but equally important faults trending in the northeastern direction.

Results

The results of 2-D wavelet analysis of the selected HRAM data are shown in Figures 3, 4 and 5, which reveals lineament information in four directions; E-W, N-S, NE-SW and NW-SE**.** We believe that most of the E-W lineation are related to residual acquisition footprints. There are few N-S trends, but those seen are significant geologically. The NW-SE trends are related to Laramide structures. The NE-SW trends are related to wrench faulting originating in the basement and reactivated periodically through the Phanerozoic.

It is also of interest to note that many lineaments could be easily missed if only traditional mapping techniques are used.

Concluding remarks

This study demonstrates that wavelet transform analysis can be a very powerful tool in detecting and mapping lineaments in HRAM data. Furthermore, this technique is fast, cost-effective and less subjective than traditional mapping of HRAM data.

References

Daubechies, I., 1990, The wavelet transform, time-frequency localization and signal analysis: IEEE Trans. Inf. Theory, **36**, 961-1005

Hassan, H.H, Mapping HRAM lineaments using 2-D wavelet transform in the Sundre area, West Central Alberta, Canada, Society of Exploration Geophysicists International Exposition and 74th Annual Meeting, 2004.

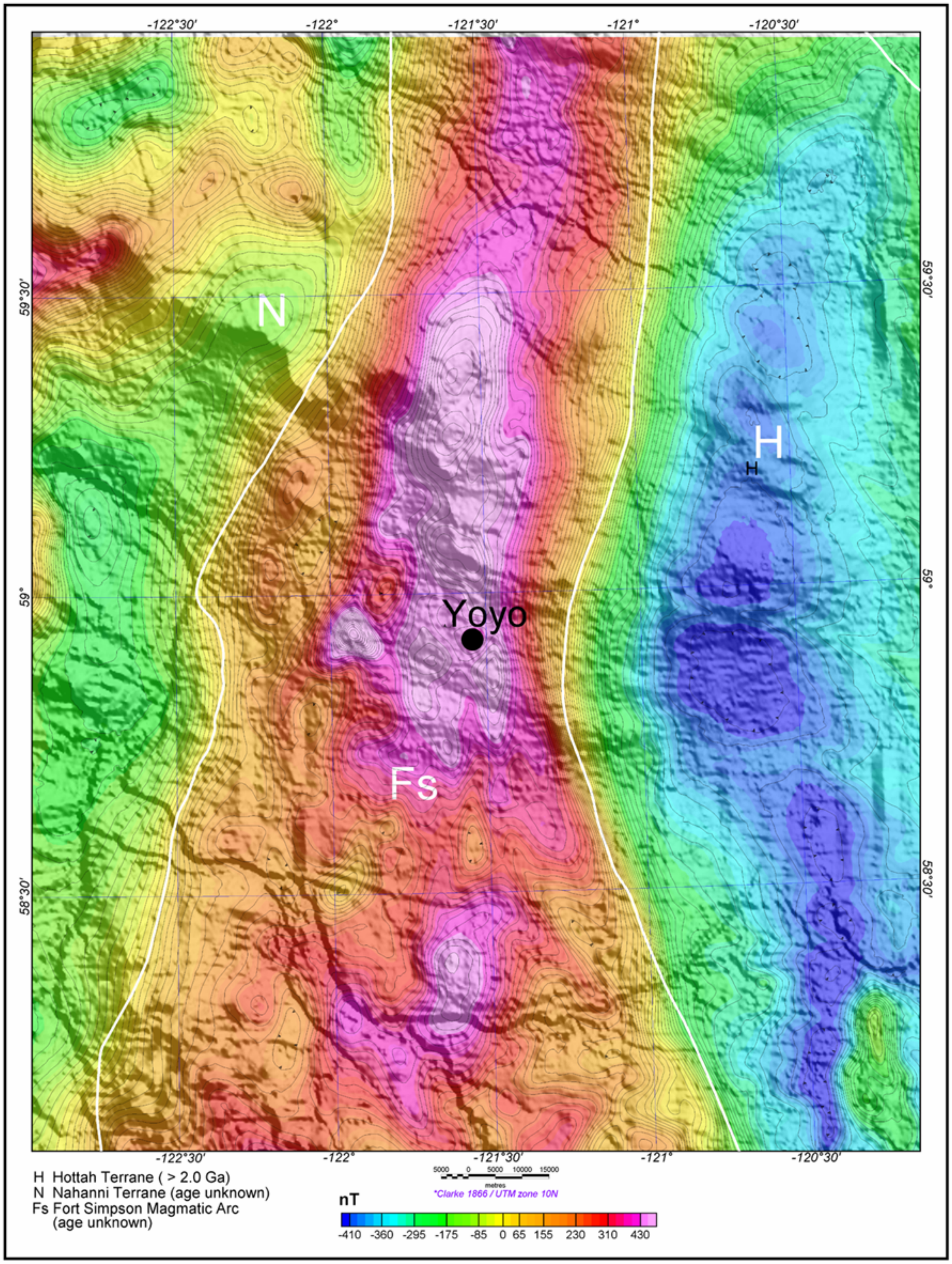

Figure 1. The total magnetic intensity map of the selected area draped on topography. Prominent structural terrane boundaries in the area are plotted in white.

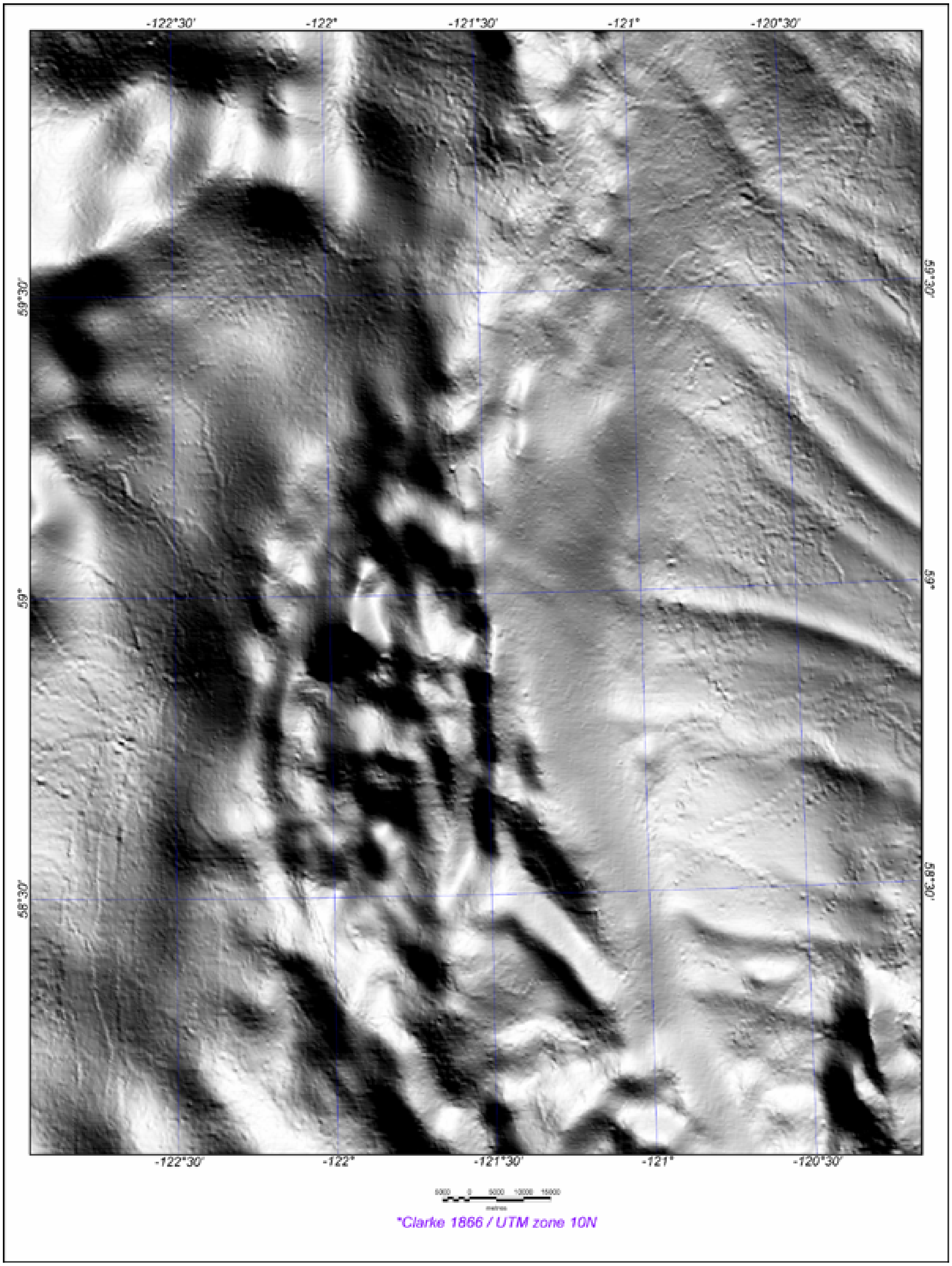

Figure 2. Image of the total magnetic intensity grid plotted with northeast-shaded grayscale. This image was used by 2D wavelet transform to produce the images shown in Figures 3, 4 and 5.

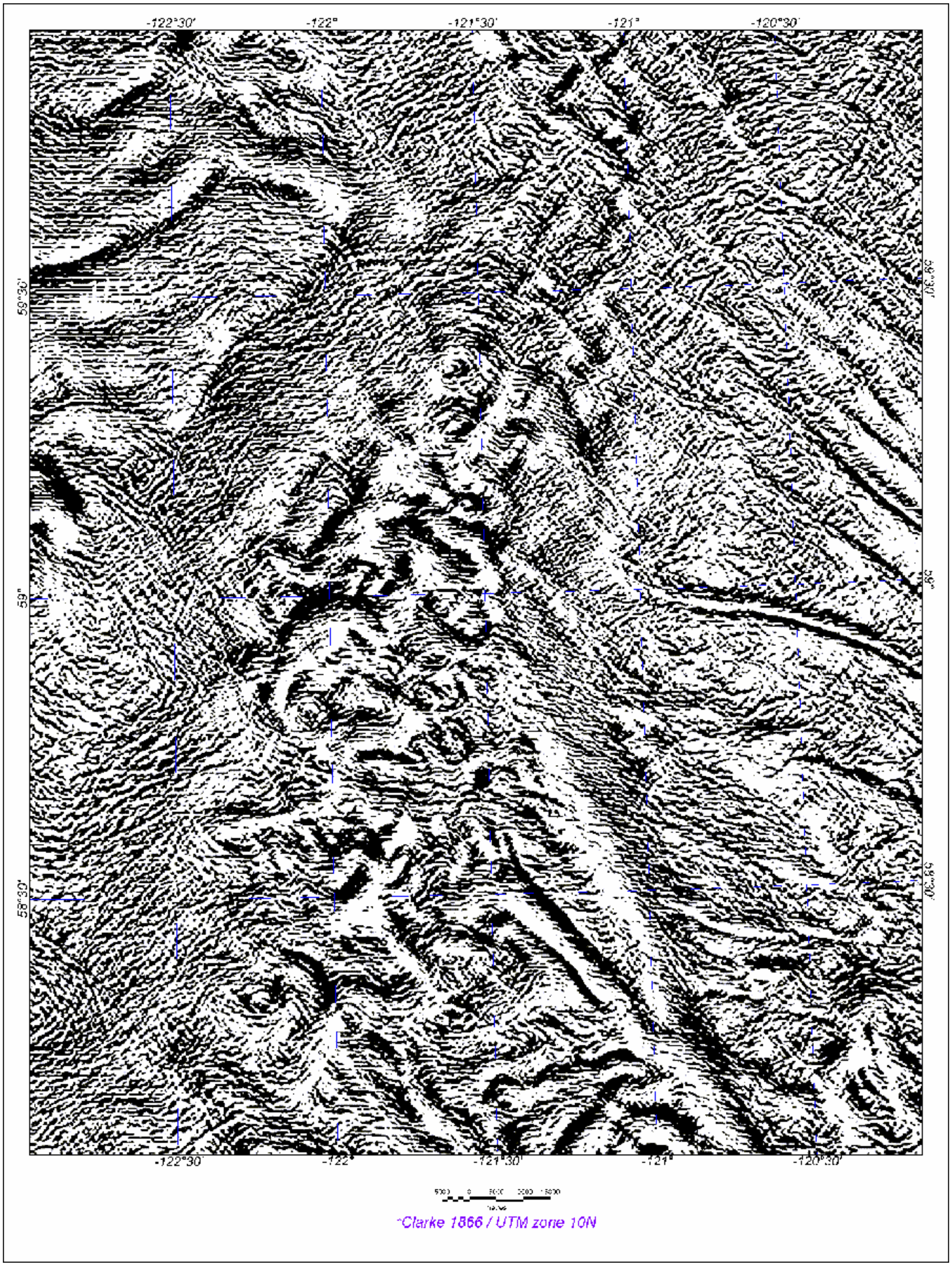

Figure 3. The result of 2-D wavelet transform showing the E-W lineaments of the area.

Figure 4. The result of 2-D wavelet transform showing the N-S lineaments of the area.

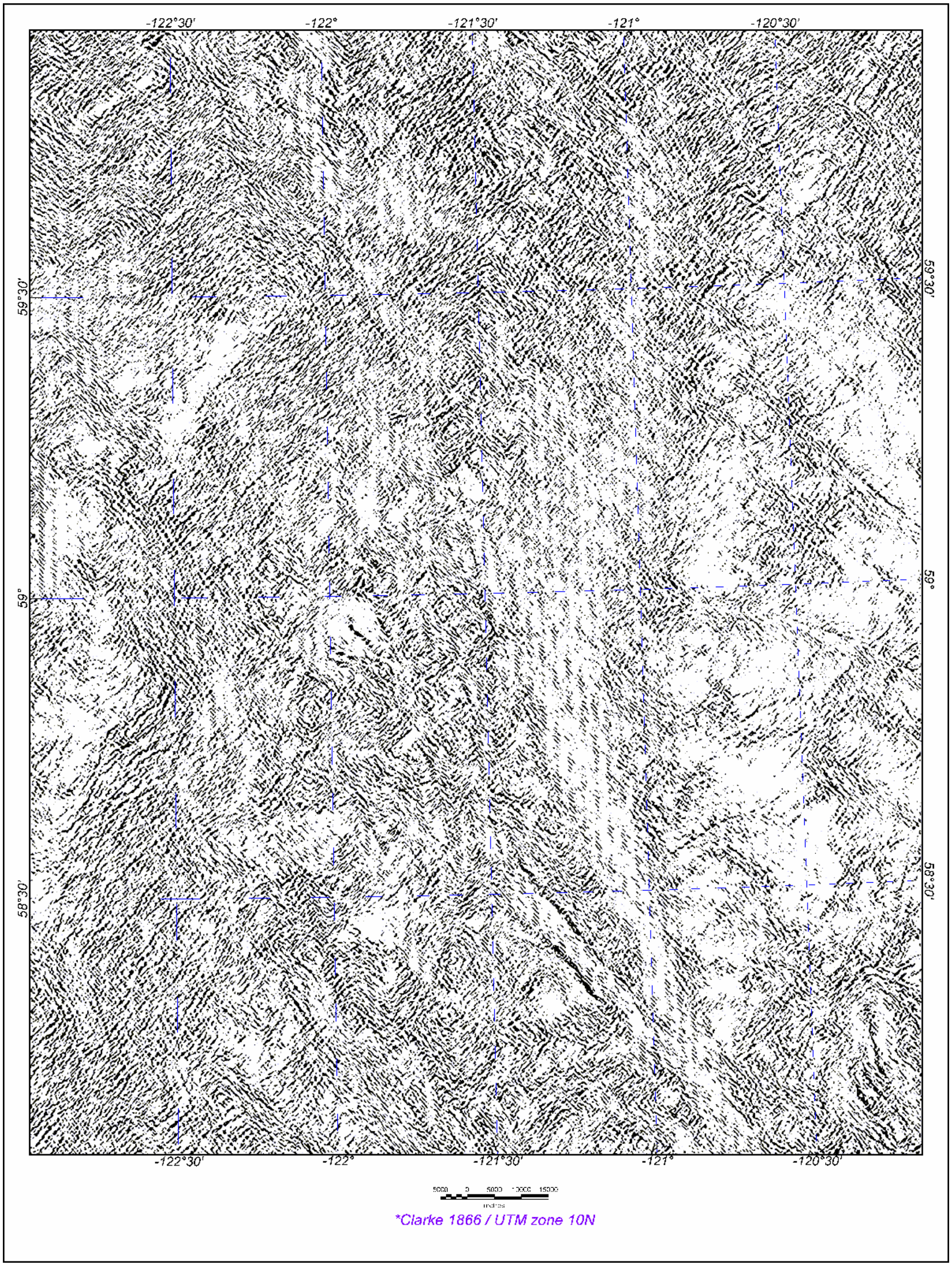

Figure 5. The result of 2-D wavelet transform showing the NE-SW and NW-SE lineaments.

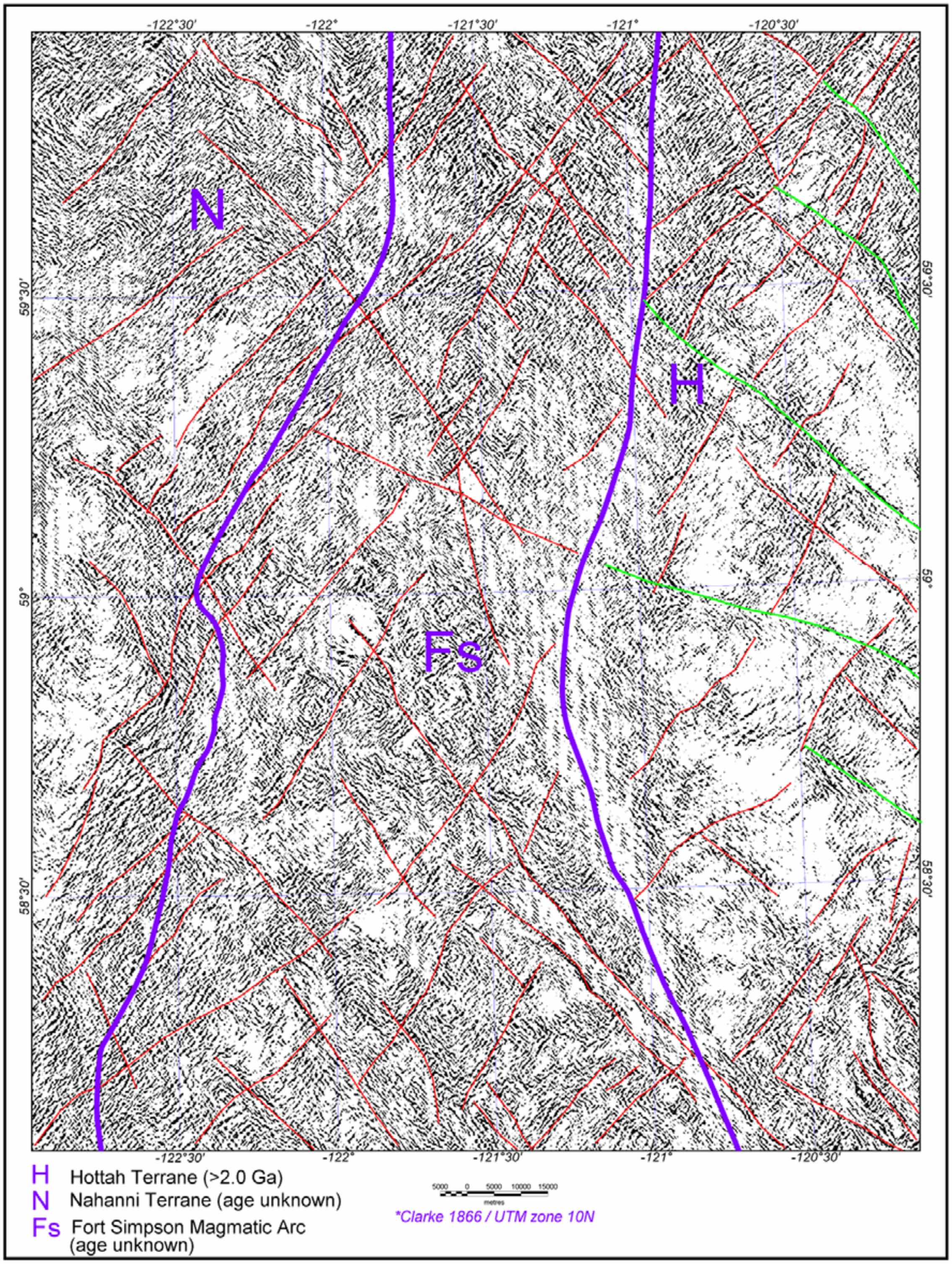

Figure 6. The result of 2-D wavelet transform shown in Figure 5 with preliminary lineament interpretation. Interpreted lineaments are plotted as red lines. Green lines represent dikes emplaced in the Hottah Terrane.