Neotectonics and landscape characterization in the Gawler Craton, South Australia
Insights through high-resolution remote sensing

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The Gawler Craton hosts significant economic mineralization within South Australia (e.g., Tarcoola gold mine, Figure 1). Due to the limited number of outcrops and surface features indicative of mineral occurrences in the region, exploration for new deposits is particularly challenging in this part of Australia. Here we present a study on identifying surface and subsurface lineaments manually and automatically. We compare these datasets in order to (1) visually assess similarities and differences that may affect interpretation and (2) identify areas of potential linkage between surface and subsurface features. These areas might point towards zones of prevailing tectonic activity and thus could represents zones of enhanced fluid flow and mineral potential.

The Study Area in the Gawler Craton

The study area and datasets used in this study are shown in Figure 1. Datasets considered to be associated with surface features are digital elevation models (DEM) and radiometrics, while subsurface features are more likely to be expressed in magnetic and gravity datasets. To better visualize the topography in the DEM and the different regions in the radiometric we applied Sobel edge detection filters to obtain horizontal (G_x) and vertical gradient (G_y) components that we combine into the mean gradient components shown in Figure 1a (DEM) and b (radiometric).

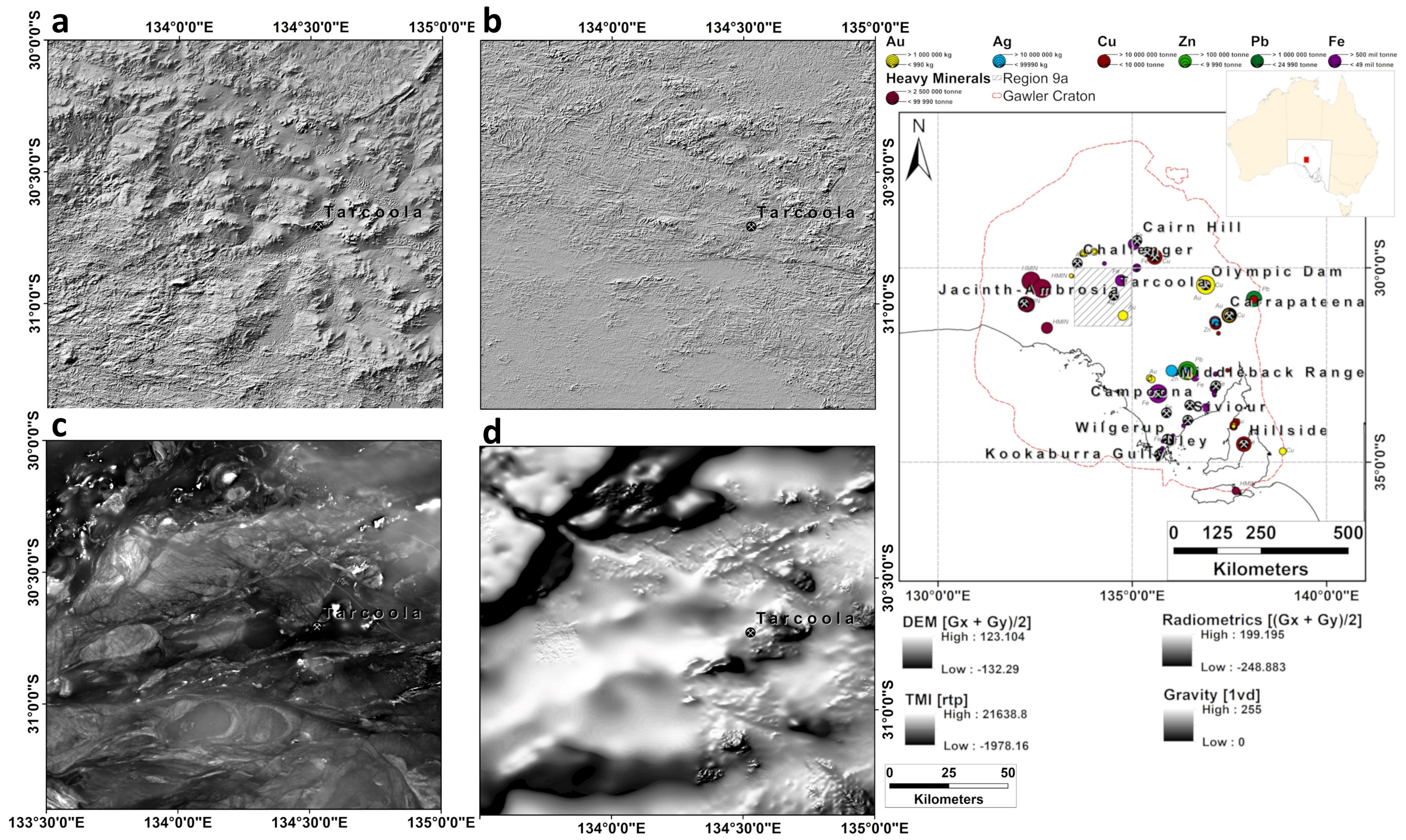

Figure 1: (a) Mean gradient component of DEM (b) Mean gradient component of radiometric dose (c) Total magnetic intensity reduced-to-pole (d) Gravity first vertical derivative. In the upper right an overview map of the Gawler Craton with quantification of the yearly production of existing mines is shown.

Surface Lineaments

We assume that the DEM and radiometric data represents surficial features and are considered the surface layers in this study. Figure 2 shows the manually and automatically extracted lineaments from both datasets overlaid on the DEM. The automatically extracted lineaments were obtained using PCI Geomatica (PCI Geomatics, 2019). Below the figure the probability density functions (PDF) of the orientations are shown. On the right side of the figure, rose diagrams visualize the difference in principal orientations of the data.

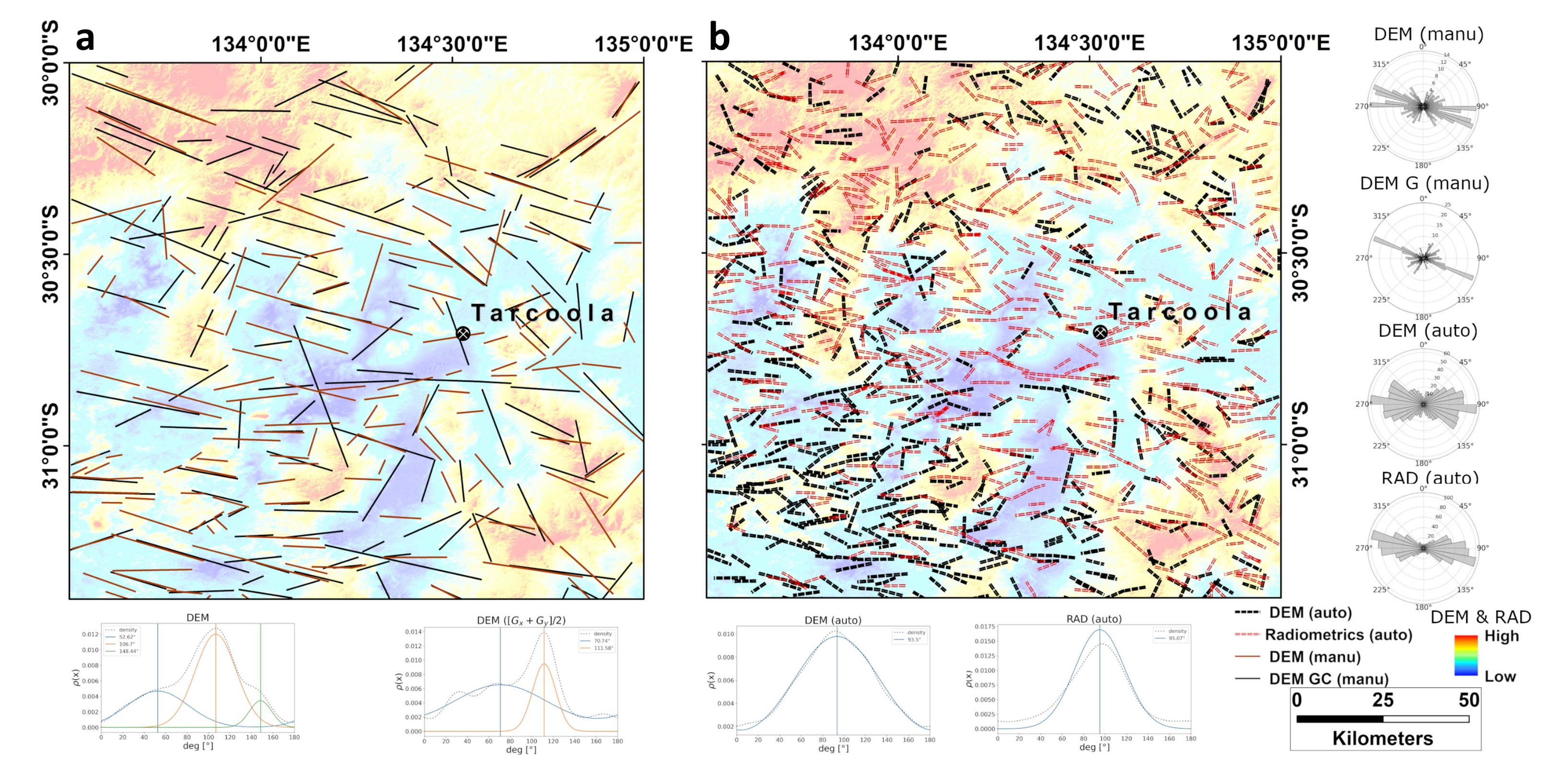

Figure 2: (a) Manual interpretation of lineaments derived from DEM and mean gradient of DEM. (b) Lineaments automatically extracted using PCI Geomatica from the DEM and the radiometrics. Rose diagrams show the lineament orientations along with the kernel density estimates for each dataset with vertical lines indicating dominant directions.

Subsurface Lineaments

The two approaches used to automatically identify lineaments in gravity and magnetic data are: PCI Geomatics (2019) and a single set of 'worms' resulting from multi-scale edge detection (Foss et al., 2019). Figure 3 shows a comparison between the lineaments considered to represent subsurface features. The PDF of orientations are displayed below and the rose diagrams to the right visualize the differences in principal orientations.

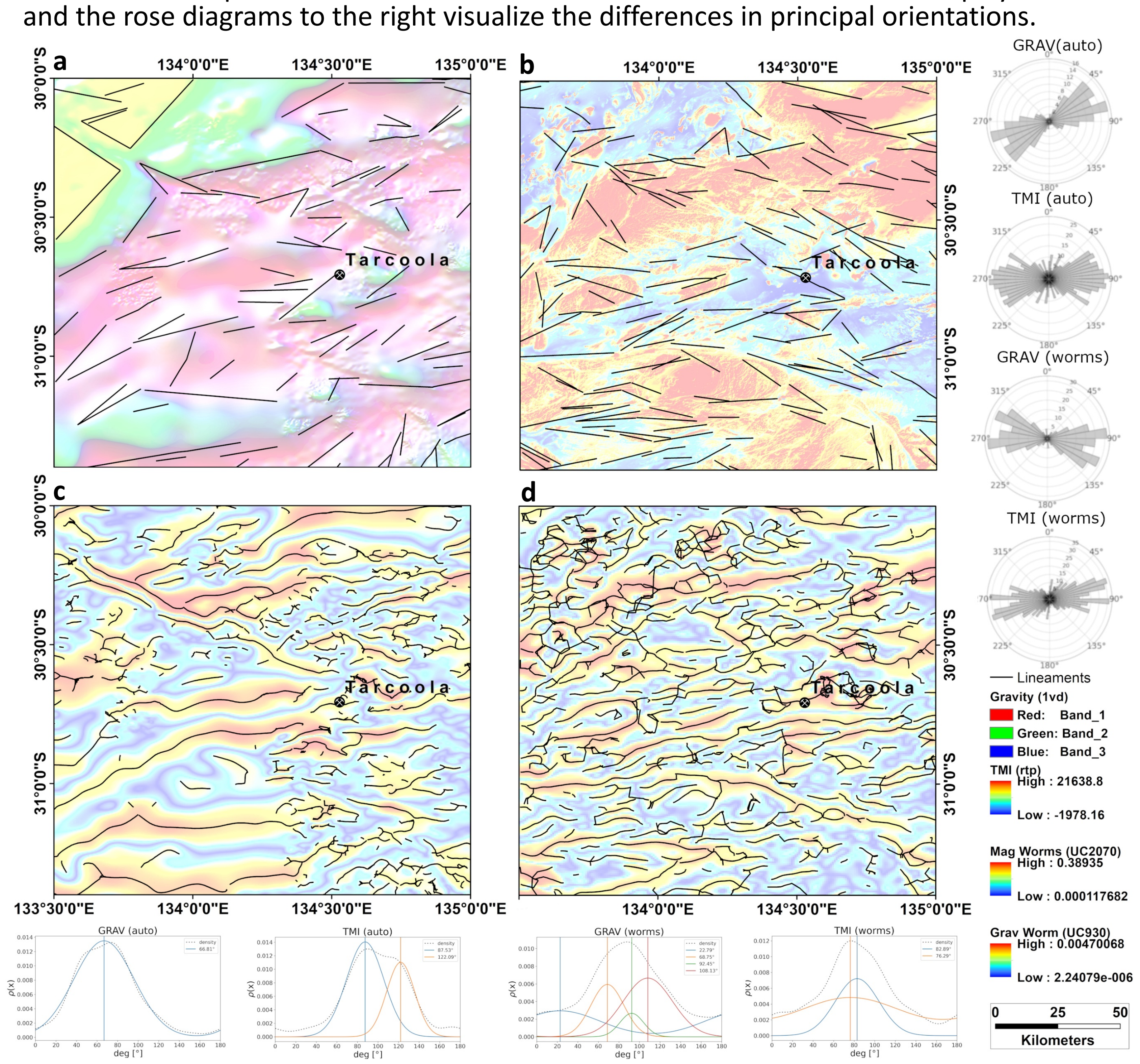

Figure 3: Automatically extracted lineaments from (a) Gravity using PCI Geomatics (2019) (b) TMI RTP using PCI Geomatics (2019) (c) Gravity upward continued to 931m providing "worms" (d) Magnetic upward continued to 2070m providing "worms". Rose diagrams show the lineament orientations along with the kernel density estimates for each dataset.

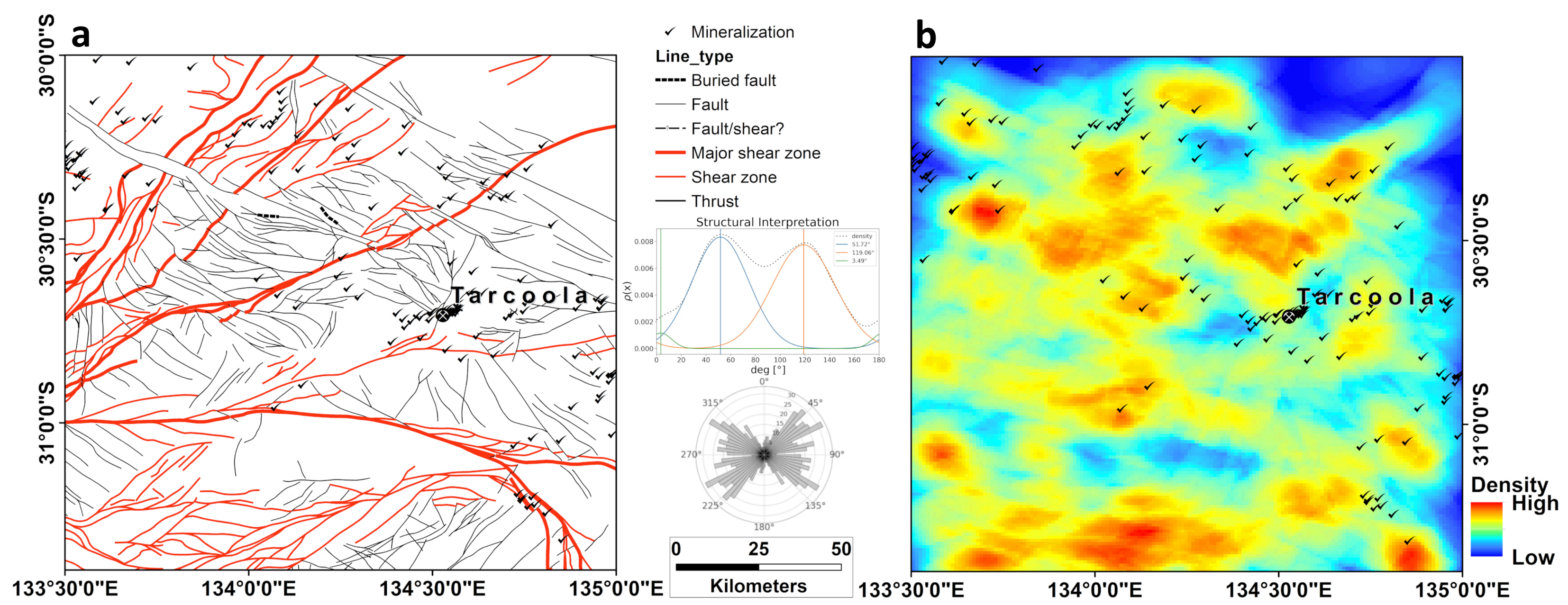

Figure 4: (a) Interpretation of the TMI in combination with field data, and drill core logs (courtesy: M. Pawley, GSSA). (b) Lineament density map of the manually interpreted lineaments (Figure 2a) and the structural geological interpretation of the study area (Figure 4a). Check marks are locations of known mineralization.

Lineament Densities

We postulate that through a line density map, we may be able to infer a potential relationship between lineaments that are representative of both, the surface and subsurface, and consequently indicating potential faults or large-scale lineament trends (Figure 4). Areas that exhibit large numbers of surface and subsurface lineaments might be areas of enhanced fluid flow and hence increased mineral potential. Figure 5 shows various lineament density maps based on the surface and subsurface lineaments. The top two images (a and b) include the manual interpretations, while the bottom panels (c and d) include automated worm interpretations.

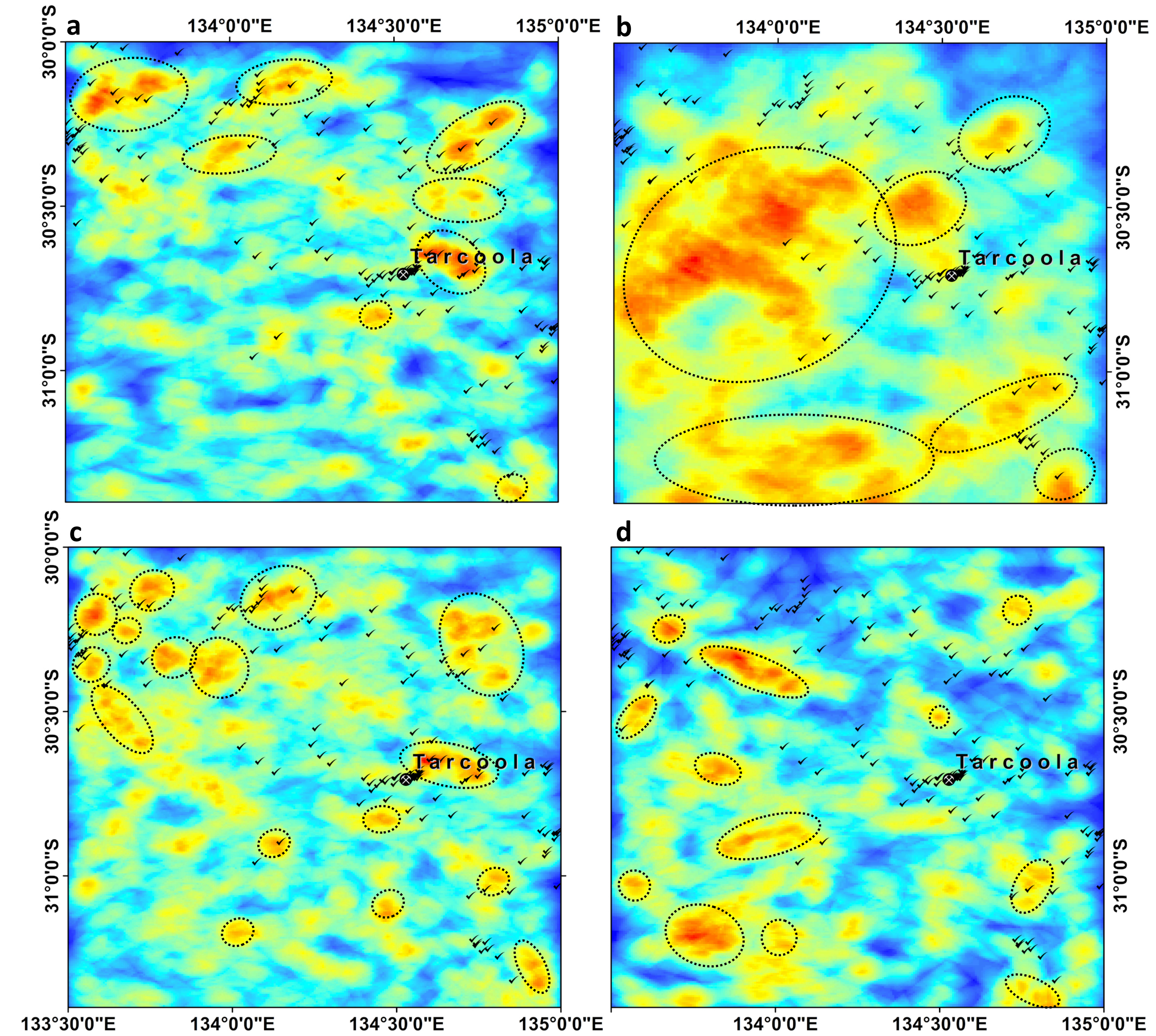

Figure 5: Density maps derived from the combination of different manually and automatically extracted lineaments. (a) Manual interpretation of the DEM and the DEM mean gradient components (Figure 2a), combined with the magnetic and gravity "worms" (Figure 3c & 3d). (b) Automatically extracted surface lineaments (Figure 2b) in combination with the structural geological interpretation (Figure 4a). (c) Automatically extracted surface lineaments (Figure 2b) and "worms" (Figure 3a & 3b). (d) Automatically extracted surface lineaments (Figure 2b) and automatically extracted subsurface lineaments (Figure 3a & 3b). Check marks are locations of known mineralization. Potential target areas are marked by the dotted ellipses.

Conclusions

Manually and automatically extracted lineaments highlight different areas and trends (Figure 2). This may highlight the significant impact of geologic knowledge guiding the manual interpretation and the range of mathematical parameters dictating results in the automated case.

The lineament density map extracted via PCI Geomatica (Figure 5d) shows high correlation with fault intersections based on the geologic interpretation (Figure 4a). The lineament density map using 'worms' (Figure 5a and 5c) correlates with the gold occurrence at Tarcoola gold mine.

Further analysis and validation is needed to identify the optimal workflow to compare the manual and automated approach to lineament extraction and connectivity of surface and subsurface features.

FOR FURTHER INFORMATION
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