Towards a Predictive Model for Opal Exploration using a Spatio-temporal Data Mining Approach

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1. Introduction

Australia produces over 90% of the world's precious opal from highly weathered Cretaceous sedimentary rocks within the Great Artesian Basin. Since opal was first discovered around 1870, opal mining has been carried out by private operators working a claim no larger than 50 x 50 m, usually in the direct vicinity of areas that have yielded precious opal in the past. Currently there is no formal exploration model for opal and there are several models for its formation in the geological environment (e.g., Rey, 2013). Here we make the first systematic attempt to formulate a predictive model for opal exploration using a powerful data mining approach, which considers almost the entire Great Artesian Basin as a potential reservoir for precious opal (Figure 1; Merdith et al., 2013).

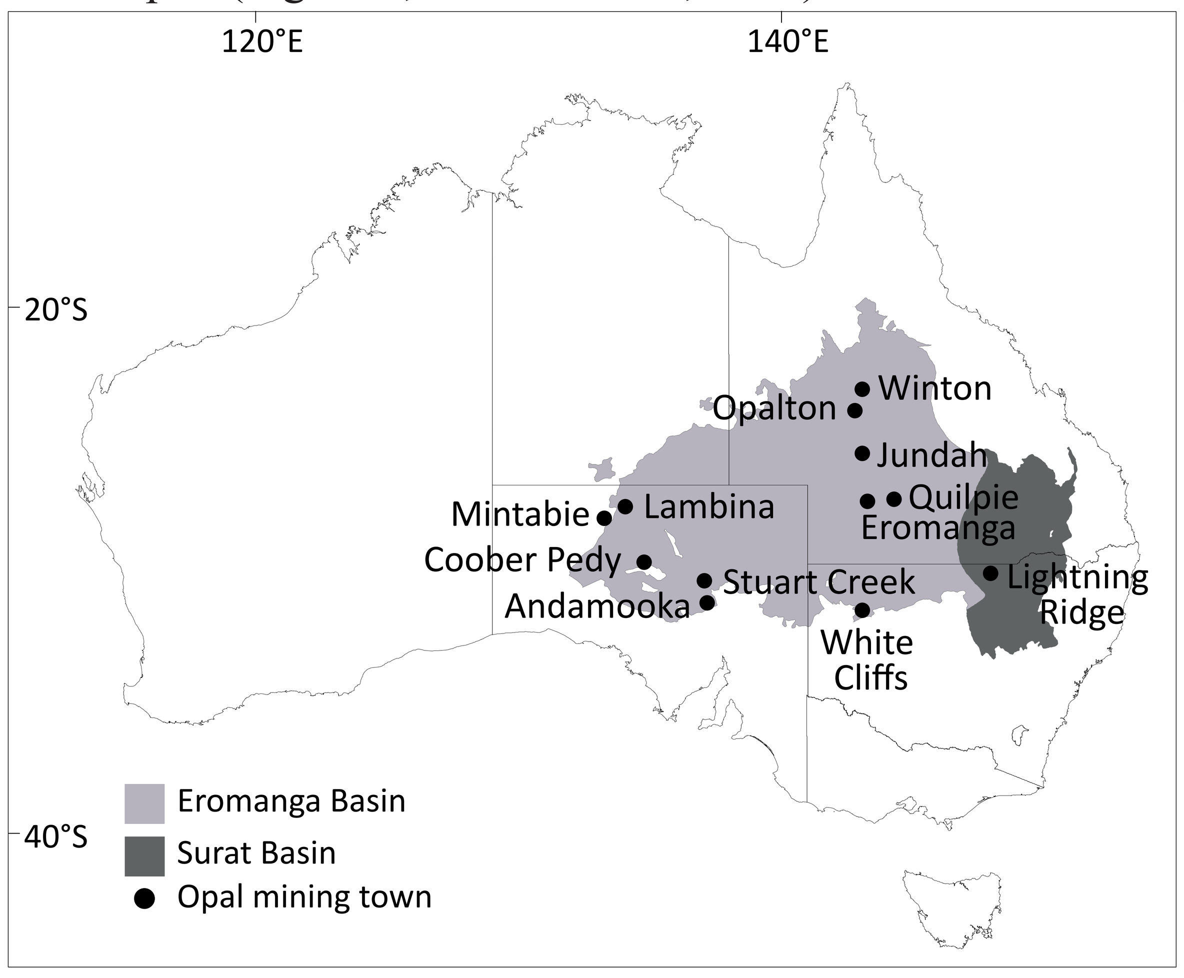
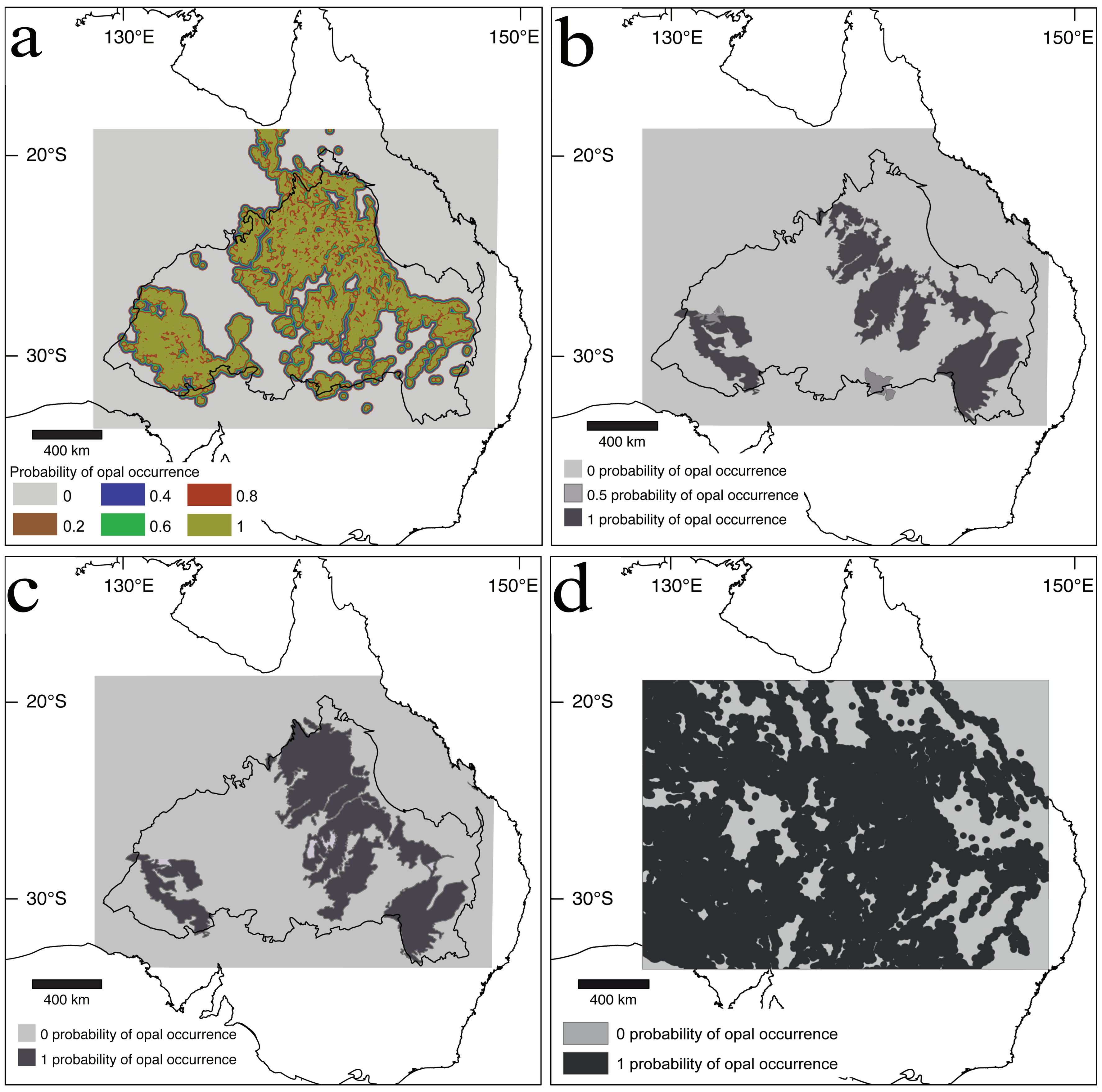


Figure 1 Map of Australia showing the extent of the Eromanga and Surat basins and the location of the major opal producing townships. The Eromanga and Surat basins represent the southern eastern and western extents of the Great Artesian Basin. . In Australia, sedimentary opal is found within fractures and primary and secondary pore spaces in the top 30 m of heavily weathered Cretaceous sedimentary rocks within the Eromanga and Surat basins. The stratigraphy of Eromanga and Surat basins is dominated by alternating layers of sandstones, claystones and siltstones that were deposited ca 125 Ma to 95 Ma as a consequence of a sequence of regressions and transgressions.

2. Methodology and Datasets

Our methodology uses all known locations where opal has been mined to date. Its formation and preservation in weathered Cretaceous host rocks is evaluated by a joint analysis of large digital data sets that include regional geology, regolith and soil type, topography, radiometric data and depositional environments through time (Landgrebe et al., 2013) (Figures 2a-f). By combining these data sets as layers enabling spatio-temporal data mining using the GPlates PaleoGIS software (Landgrebe et al., 2008), we produce the first opal prospectivity map for the Great Artesian Basin (Figure 3).



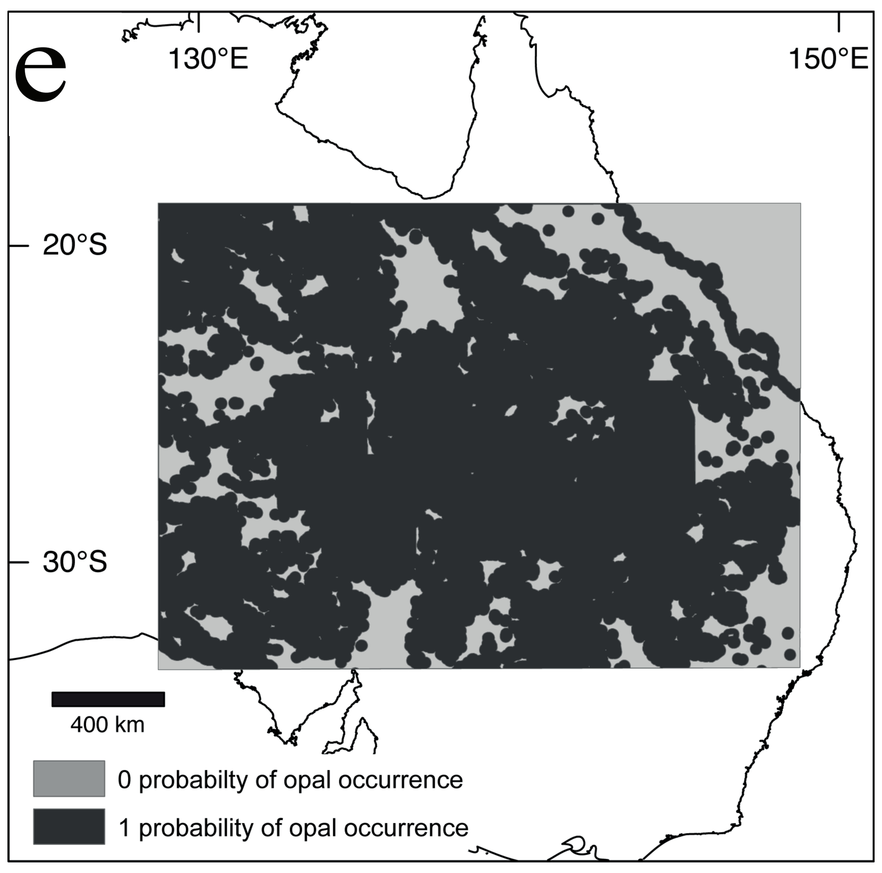
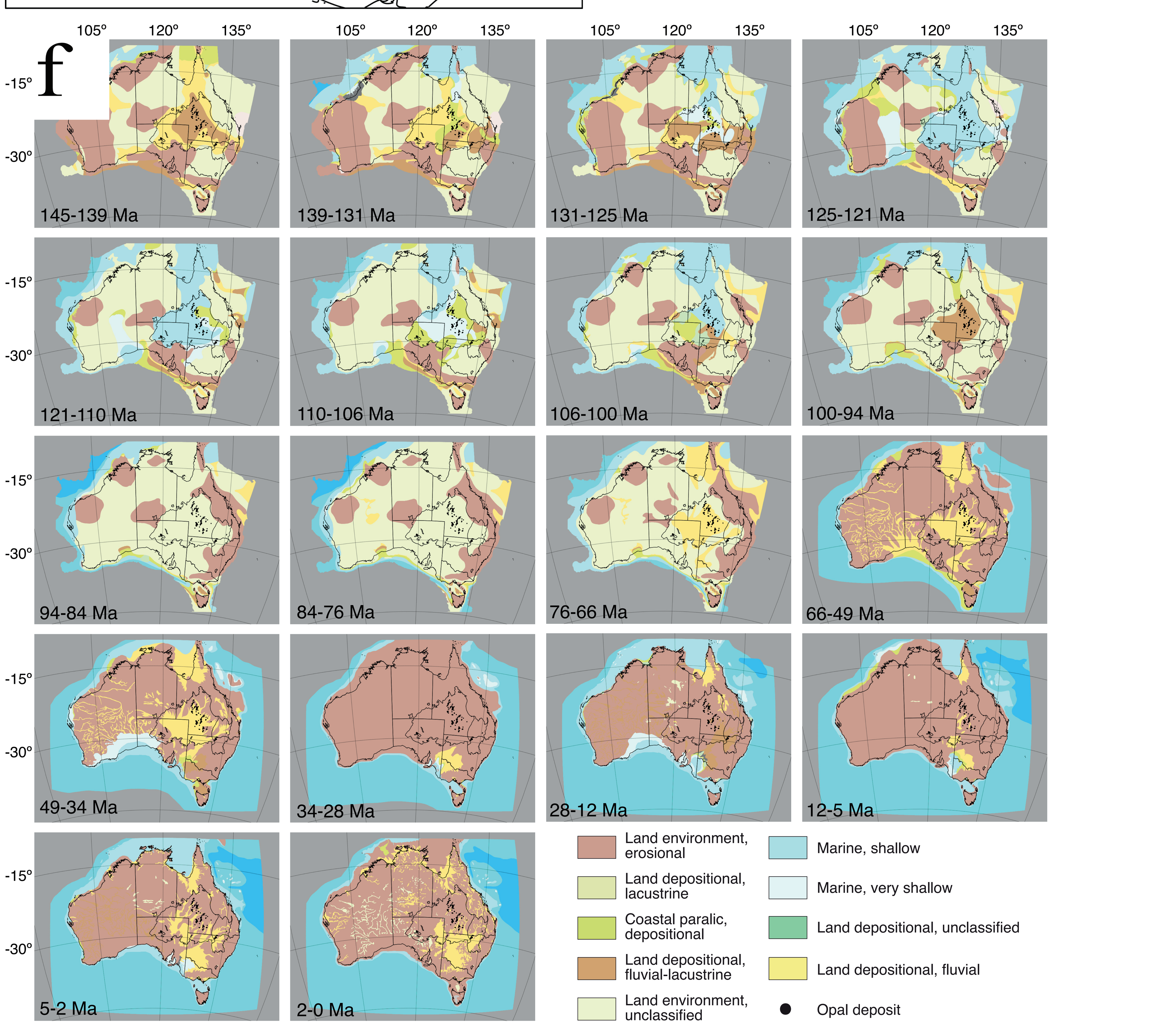


Figure 2 Associations between opal occurrences and (a) regional geology, (b) regolith type, (c) soil type, (d) topography, (e) radiometric data and (f) depositional environment. The association of each individual opal location with every data set was extracted then extrapolated throughout the rest of the dataset in order to find 'like' occurrences. Where the dataset matched the assocation a probability of '1' was given. Where there was a mis-match, a probability of '0' was given. Each data set was saved as a separate layer (Figures 2a-f). For the regional geology, a gradational buffer zone in 5 km increments was used to reflect the association between the proximity of an opal location to a geological boundary. The total buffer distance was 25 km, reflecting the mean plus two standard deviations of this association. For the topographic and radiometric data sets, a buffer zone of 18 km reflecting the mean plus one standard deviation was used. A full description of the palaeogeographic dataset is presented in Landgrebe et al. (2013).



3. Results

Our approach reduces the entire area of the Great Artesian Basin to a mere 6% that is deemed to be prospective for opal exploration (Figure 3; Merdith et al., 2013). It successfully identifies two known major opal fields (Mintabie and Lambina) that were not included as part of the classification dataset owing to lack of documentation regarding opal mine locations, and it significantly expands the prospective areas around known opal fields particularly in the vicinity of Coober Pedy in South Australia and in the northern and southern sectors of the Eromanga Basin in Queensland. Additionally, a recently discovered opal find near Lighting Ridge falls within the predicted zone of opal occurence that was formulated using our approach.

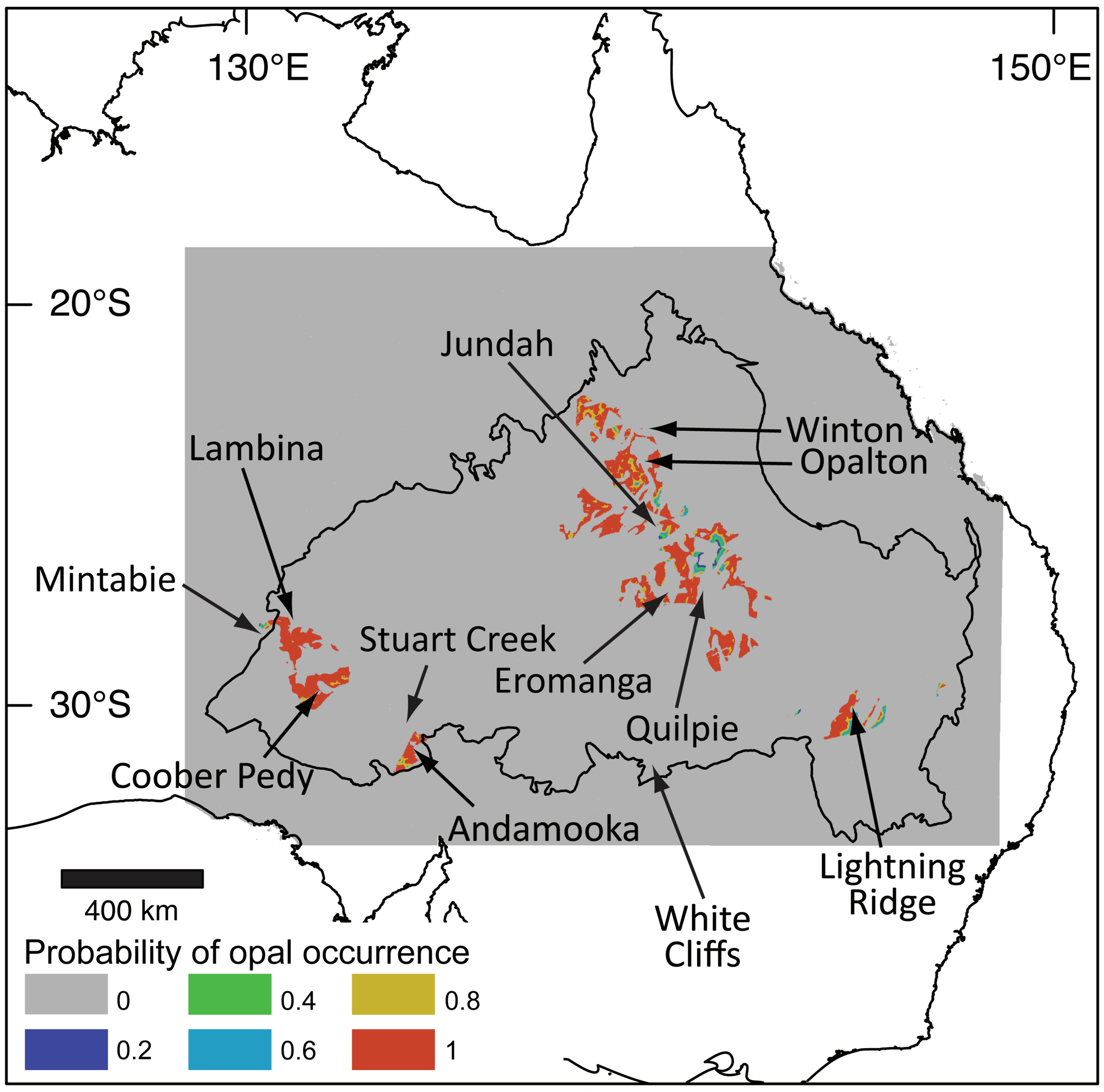


Figure 3 Opal prospectivity map based on assimilation of geological, soil type, regolith type, topographic, radiometric and paleographic datasets. The major mining centres around Lambina and Mintabie have been correctly identified. They were omitted from the input dataset as the accurate location of opal mines was not known from existing maps and reports. A large region northeast of Coober Pedy appears to be highly prospective as do several large areas proximal to known opal fields within the eastern part of the Eromanga Basin in Queensland.

4. References

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