



Australian Journal of Earth Sciences

An International Geoscience Journal of the Geological Society of Australia

ISSN: 0812-0099 (Print) 1440-0952 (Online) Journal homepage: www.tandfonline.com/journals/taje20

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To cite this article: S. Shahrestani, J. Tang, M. Sami, I. V. Sanislav & A. Kumar (2026) Catchment basin analysis of regional geochemical gold data in Queensland, Australian Journal of Earth Sciences, 73:3, 373-382, DOI: [10.1080/08120099.2026.2680261](https://doi.org/10.1080/08120099.2026.2680261)

To link to this article: <https://doi.org/10.1080/08120099.2026.2680261>



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Catchment basin analysis of regional geochemical gold data in Queensland

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ABSTRACT

This study incorporates background correction and dilution correction methods for delineating Au geochemical anomalies using data of catchment outlet sediments from two horizons: top outlet sediments (TOS, 0–10 cm) and bottom outlet sediments (BOS, 60–90 cm), collected across the entire Queensland region as part of the National Geochemical Survey of Australia (NGSA) project. The dataset comprises Au concentrations from catchments covering numerous lithological units, which were merged into seven dominant lithologies for analysis. Multiple regression analysis was applied to estimate background Au values owing to lithology, enabling separation of background signals from mineralisation-related anomalies. Results show that dilution-corrected Au residuals improve anomaly detection, with BOS samples outperforming TOS in spatial alignment with 26 of 30 known gold deposit clusters, compared with 14 clusters identified by raw TOS data. The BOS horizon benefits from enrichment in fine sediment fractions (<75 µm) and reduced effects of surface weathering, providing a more stable and representative geochemical signal. Elevated Au levels associated with dominant lithologies may mask true anomalies, underscoring the importance of background correction.

KEY POINTS

1. Dilution-corrected Au data clearly improve the detection of geochemical anomalies compared with raw data in both TOS and BOS horizons and show a stronger match with known gold deposits.
2. The BOS dilution-corrected data perform best overall, identifying 26 out of 30 known gold deposit clusters, while the raw datasets, particularly TOS, detect much fewer clusters.
3. Some known deposits (e.g. Miclere, 309, Pajingo–Scott Lode) are upgraded from moderate anomaly classes (Q2–Q3) to the highest class (Q4) after applying background and dilution corrections.
4. Although the corrected maps improve detection of true anomalies, they also show additional anomalous catchments in southwest and central Queensland, which may reflect a combination of possible concealed mineralisation, lithological background effects and secondary geochemical processes.

ARTICLE HISTORY

Received 19 February 2026
Accepted 19 May 2026

KEYWORDS



Sample catchment basin approach; background correction; dilution correction; geochemical anomaly; gold mineralisation; Queensland


Introduction

Distinguishing geochemical signals associated with anomalous sources, such as mineralisation, from background variation using regional stream sediment data is a common approach in geochemical exploration (Carranza & Hale, 1997; Shahrestani *et al.*, 2024). Catchment outlet sediment geochemistry mainly reflects the lithological units located upstream of the sampling site. Therefore, the chemical composition of a catchment outlet sediment sample cannot be used to estimate metal concentrations in downstream sediments, and Euclidean distances are only meaningful when measured along the drainage network. To address these limitations, the sample catchment basin approach (SCBA) has been developed, in which the upstream catchment of each catchment outlet sediment is treated as its zone of influence (Bonham-Carter *et al.*, 1987). This approach allows the formulation of simple equations for background

correction and dilution correction of catchment outlet geochemical anomalies (Bonham-Carter & Goodfellow, 1986; Shahrestani *et al.*, 2020).

Background correction recognises that elevated metal concentrations in catchment outlet samples do not necessarily indicate anomalous sources, as they may result from naturally high background levels in upstream lithological units (e.g. Shahrestani *et al.*, 2019). In contrast, geochemical signals derived from mineralisation can be significantly diluted by mixing with large volumes of sediment from barren or non-mineralised areas. This study applies the SCBA to a regional catchment outlet geochemical dataset covering the entire state of Queensland, Australia, with the aim of delineating geochemical anomalies associated with gold mineralisation. The paper first outlines the background and dilution correction methods, then describes the catchment outlet sediment geochemical dataset

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 Supplemental data for this article can be accessed online at <https://doi.org/10.1080/08120099.2026.2680261>.

Editorial handling: David Huston

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and finally evaluates the performance of the SCBA technique by comparing the resulting anomalies with known gold occurrences as indicators of true positive anomalies.

Materials and methods

Background and dilution correction in SCBA

Two main approaches have been used to estimate lithology-related background values from catchment outlet geochemical data: the weighted mean elemental concentration method and multiple regression analysis (Bonham-Carter *et al.*, 1987). Shahrestani *et al.* (2019) showed that the multiple regression approach performs better than the weighted mean method for estimating background values controlled by lithology. In the multiple regression framework, a regression model is developed between independent variables representing the relative area of lithological unit j within the sample catchment basin i and the dependent variable, which is the measured elemental concentration in catchment outlet sediment (Y_i). In this model, the regression coefficients represent the background concentrations of major or trace elements associated with the upstream lithological units:

$$Y'_{\text{Reg}_i} = b_0 + \sum_{j=1}^m b_j \bar{X}_{ij} \quad (1)$$

where $\sum_{j=1}^m \bar{X}_{ij} = 1$, and b_0 and b_j illustrate the regression coefficients determined by the least-squares technique to minimise the quantity $\sum_{i=1}^n (Y_i - Y'_{\text{Reg}_i})^2$. Accordingly, Y'_{Reg_i} is the expected background value owing to lithology at the basin outlet. To prevent the singularity problem, the multiple regression modelling can be constrained through the origin (*i.e.* setting $b_0 = 0$) (Bonham-Carter & Goodfellow, 1986), considering that the regression coefficients imply the average concentration of the major and trace elements of interest in lithological units (b_j). However, Bonham-Carter *et al.* (1987) indicated that catchment outlet geochemical data should be log-transformed because elemental concentration distributions are generally non-normal. This implies that the regression model is multiplicative rather than additive. In this formulation, singularity is avoided by allowing small rounding errors in the areal proportions of lithological units within each catchment basin, which leads to more stable and realistic regression fits. Residual values (*i.e.* $Y_i - Y'_{\text{Reg}_i}$) are calculated by subtracting the expected elemental values owing to lithology (Y'_{Reg_i}) from the measured elemental values (Y_i), which can be either positive or negative. Positive residuals are referred to as an anomalous source, such as mineralisation.

In regional geochemical exploration, the spatial extent of background areas is typically much larger than that of mineralised zones. As a result, background materials contribute more strongly to the sediment load transported to catchment outlets. The mixing of sediments derived from anomalous and non-anomalous sources therefore leads to a reduction, or damping, of metal concentrations in catchment outlet sediment

samples. To correct for the dilution of geochemical anomalies caused by the mixing of mineralisation-related signals with sediments from barren background areas, the following equation has been proposed (Carranza & Hale, 1997; Hawkes, 1976):

$$Y_a = 100 A_i (Y_i - Y'_{\text{Reg}_i}) \quad (2)$$

where A_i denotes the area size of each sample catchment basin, and Y_a signifies dilution-corrected residuals of the element of interest.

Geology

Queensland geology is complex and reflects a long tectonic and sedimentary history extending from the Paleoproterozoic to the Cenozoic (Figure 1). The geological architecture of Queensland is fundamentally defined by five principal tectonostratigraphic elements that reflect a sequential history of crustal development and evolving rock systems (Withnall *et al.*, 2013). The foundational core consists of Paleoproterozoic and Mesoproterozoic assemblages of the North Australian Craton, which were amalgamated with other microcontinents during the Paleoproterozoic (Betts & Giles, 2006). In the Mount Isa Province, the early basin fill is characterised by bimodal volcanism and thick successions of marine siliciclastics (Bain & Draper, 1997). The Etheridge Province contains upper Paleoproterozoic marine metasedimentary successions associated with metabasalt and metadolerite (Withnall, Hutton, *et al.* 2009), while the Croydon Province is dominated by silicic volcanics and related granites. Deep seismic profiling has identified major crustal discontinuities, such as westward-dipping sutures, indicating that this cratonic basement grew through the accretion of distinct microcontinents (Korsch *et al.*, 2012).

The eastern margin of the state comprises the Tasmanides, a composite of orogenic belts—the Thomson, Mossman and New England orogens—that developed between the Neoproterozoic and the Triassic as part of the Terra Australis Orogenic System (Cawood, 2005). The Thomson Orogen contains metasedimentary rocks with siliciclastic protoliths and early Paleozoic ocean floor rocks, while the Mossman Orogen is dominated by deep-marine turbidites and shallow-marine limestone. Within the New England Orogen, the Wandilla Province represents an accretionary wedge containing deep-marine siliciclastic sediments associated with chert, mafic volcanics and blueschist metamorphic rocks (*e.g.* Fergusson *et al.*, 1990). Further west, the Yarrol Province features Upper Devonian–Mississippian volcanic successions and oolitic limestones, while the Connors–Auburn Province is defined by subaerial terrestrial felsic volcanics and granitoids (Withnall *et al.*, 2009). Widespread igneous activity and post-tectonic sedimentation have further modified the state's surface. The Kennedy Igneous Association forms an expansive belt of Carboniferous–Permian granitoid plutons and felsic volcanic fields (Bain & Draper, 1997). Dominating the modern landscape is the Great Australian Superbasin, which contains fluvial Jurassic quartzose sandstones and Lower Cretaceous marine mudstones. This superbasin was significantly influenced by the Whitsunday Province, which supplied enormous volumes of felsic and intermediate volcanic sediment (Bryan *et al.*, 2012).

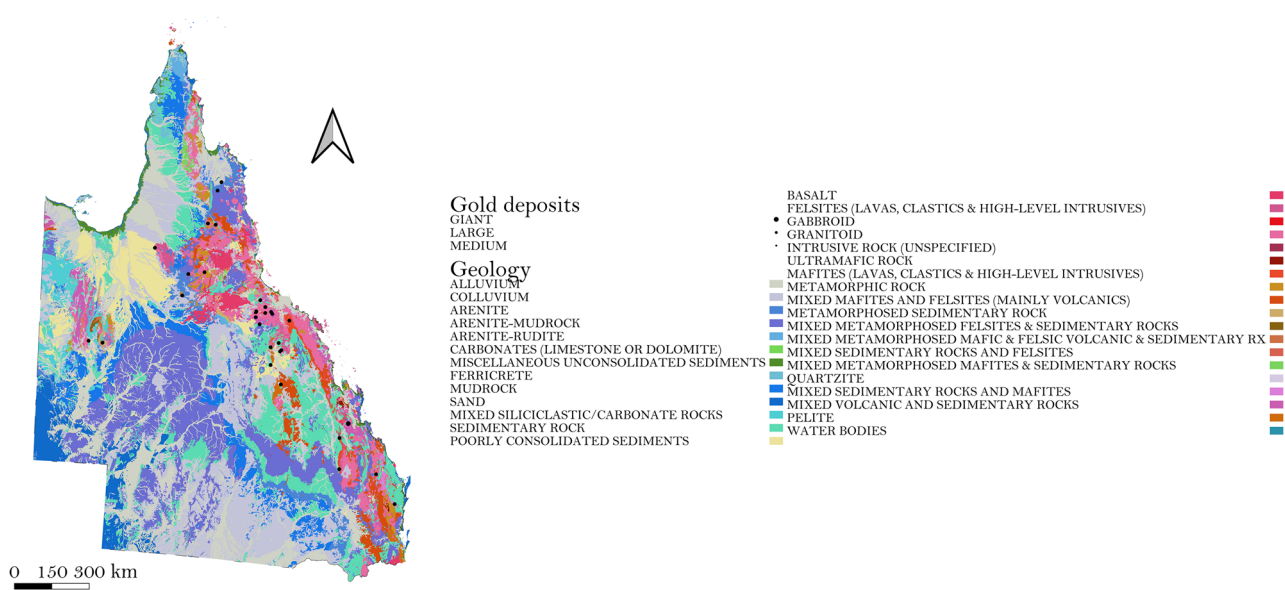


Figure 1. Geological map of the entire state of Queensland showing the main rock types (adapted from the Geological Survey of Queensland, 2012).

Within these environments, specific mineral systems like stratabound Cu and iron oxide Cu–Au deposits are linked to deep crustal fluids and plutonism (Wang & Williams, 2001). The geological history concludes with widespread Cenozoic intraplate basaltic volcanism, expressed as lava fields, scoria cones and maars, with some age progressions consistent with plate motion over hotspots (Cohen *et al.*, 2007). The readers are referred to Jell (2013) and references therein for the detailed geology of Queensland. Data related to gold mineralisation in the entire Queensland have been collected from the Geological Survey of Queensland (<https://geoscience.data.qld.gov.au/data/dataset/ds000004>).

Catchment outlet sediment geochemical data

The National Geochemical Survey of Australia (NGSA) is a continental-scale geochemical mapping program led by Geoscience Australia in collaboration with state and territory geological surveys, conducted between 2006 and 2011 to establish a nationally consistent geochemical baseline for Australia (de Caritat & Cooper, 2011; Johnson, 2006). The survey collected catchment outlet sediments from 1186 large drainage catchments, covering approximately 81% of the Australian continent at an average sampling density of one site per 5200 km² (de Caritat & Cooper, 2011). Catchment outlet sediments are interpreted as overbank deposits formed during relatively infrequent high-magnitude flood events (approximately once in 100 years), rather than through seasonal or gradual sediment accretion. The underlying assumption of overbank sampling is that material collected at the lowest point of the catchment represents a homogenised and integrated average of the different lithological sources within the drainage basin. Further details of the NGSA catchment outlet sediment geochemical survey are provided by Tang and Brown (2011) and Reimann and de Caritat (2017).

In this study, Au is one of 68 elements analysed in the regional NGSA catchment outlet geochemical dataset for Queensland. Au data are available for 309 catchment basins, together with 30 duplicate samples, corresponding to an average sampling density of approximately one sample per 5500 km². This sampling density was assessed by progressively reducing a higher-density geochemical dataset to the final density, whereby the nearest sampling point was substituted for each target site. Catchment basins were delineated using the GEODATA 9 Second Digital Elevation Model (DEM-9s) version 2 (Lech *et al.*, 2007). The Australian Nested Catchments and Sub-Catchments (ANCS-C) database (Hutchinson *et al.*, 2000), developed at the Australian National University, was used to define catchments, with a threshold area of 5000 km² adopted as the benchmark for catchment outlet sediment sampling. Sampling sites were generally located near catchment outlets; however, in areas with internal or weakly defined drainage, samples were collected at or close to the lowest topographic point (Figure 2).

The NGSA sampling protocol was adapted from the work of Åyräs and Reimann (1995) and forms the basis of the FOREGS geochemical mapping field manual (Salminen *et al.*, 1998). The sampling medium primarily consists of transported regolith, with an emphasis on overbank and floodplain sediments at catchment outlets. At each site, sediments were collected from two depth intervals: surface samples from 0 to 10 cm, referred to as top outlet sediments (TOS), and deeper samples from approximately 60 to 90 cm, referred to as bottom outlet sediments (BOS). Two particle-size fractions (<2000 µm and <75 µm) were collected to improve the signal-to-noise ratio. Duplicate precision analysis using the half absolute relative difference (HARD) shows comparable variability between the coarse (<2 mm) and fine (<75 µm) fractions. The HARD is calculated using the formula:

$$\text{HARD} = \frac{|A1 - A2|}{A1 + A2} \times 100 \quad (3)$$

where A1 and A2 are the gold concentrations of duplicate samples. The mean HARD values for the coarse and fine fractions are relatively high, at 40.95% and 44.21%, respectively, with overlapping 95% confidence limits. These high values reflect the well-known nugget effect and inherent heterogeneity of gold in stream sediments. However, the similarity between the

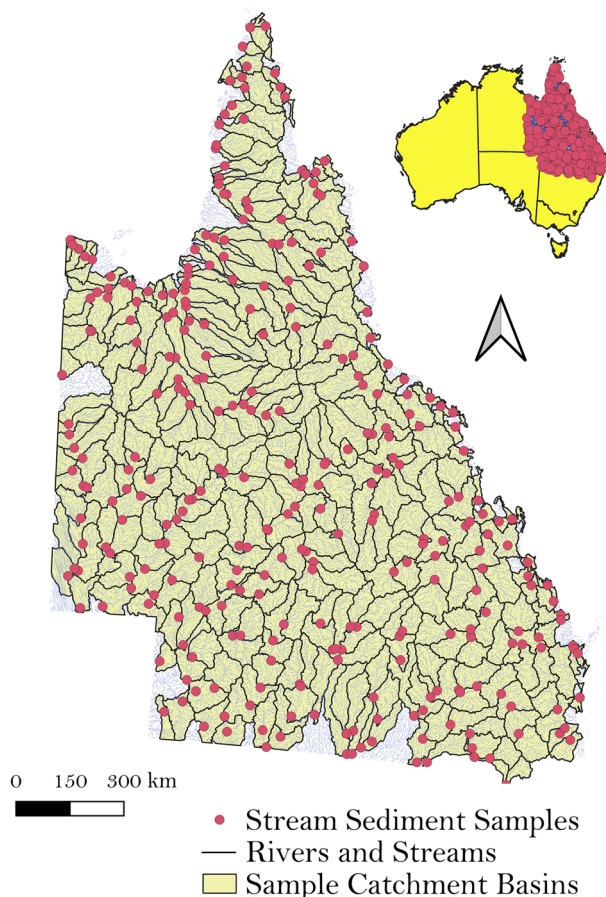


Figure 2. Spatial distribution of catchment outlet sediment geochemical samples and the underlying catchment basin corresponding to each sample.

fractions suggests that sample reproducibility is not strongly influenced by grain size. Therefore, the nugget effect, which typically causes higher variability in coarser fractions owing to the presence of coarse gold particles, does not preferentially affect the coarse fraction in this study. **Figure 3** shows the scatter plot of Au concentrations from the original and duplicate samples for both horizons (TOS and BOS). Overall, some samples show a considerable nugget effect, where duplicate pairs deviate noticeably from the 1:1 line. However, 74% of the TOS duplicates and 40% of the BOS duplicates show absolute deviations lower than 0.001 ppm. These results suggest that greater caution is required when interpreting the geochemical maps of the BOS horizon.

Two depth intervals are used to assess the effects of weathering and human activities, particularly recent events such as mining and agriculture. The bottom of the soil (BOS) generally reflects conditions before significant human impact in the area, whereas the top 10 cm is influenced by seasonal changes, local flora and fauna, and ongoing human activities. A main purpose of analysing the two size fractions is to evaluate the nugget effect commonly seen in many mineral deposits, as well as the tendency for certain elements to concentrate more in either the coarser or finer fractions. For example, gold commonly concentrates in the coarser fraction in epithermal systems because microscopic gold particles remain trapped within the host silica gangue (Hastie *et al.*, 2021; Saunders & Burke, 2017).

Au concentrations were determined by aqua regia digestion followed by ICP-MS analysis at Actlabs Pacific Pty Ltd (Perth, Western Australia), within an analytical range of 0.1–5000 ppb. Approximately 25.0 ± 1.0 g of each sample was digested using aqua regia (50 mL concentrated hydrochloric acid followed by 20 mL concentrated nitric acid) at 95 ± 3 °C for 4 h, resulting in partial dissolution of silicates and oxides. The TOS and BOS Au datasets contain 42 and 27 left-censored values, respectively, which were replaced using maximum likelihood estimation with left-censored truncated normal imputation (Antweiler & Taylor, 2008; Sanford *et al.*, 1993). The resulting datasets were subsequently transformed using the centred log-ratio (clr) method

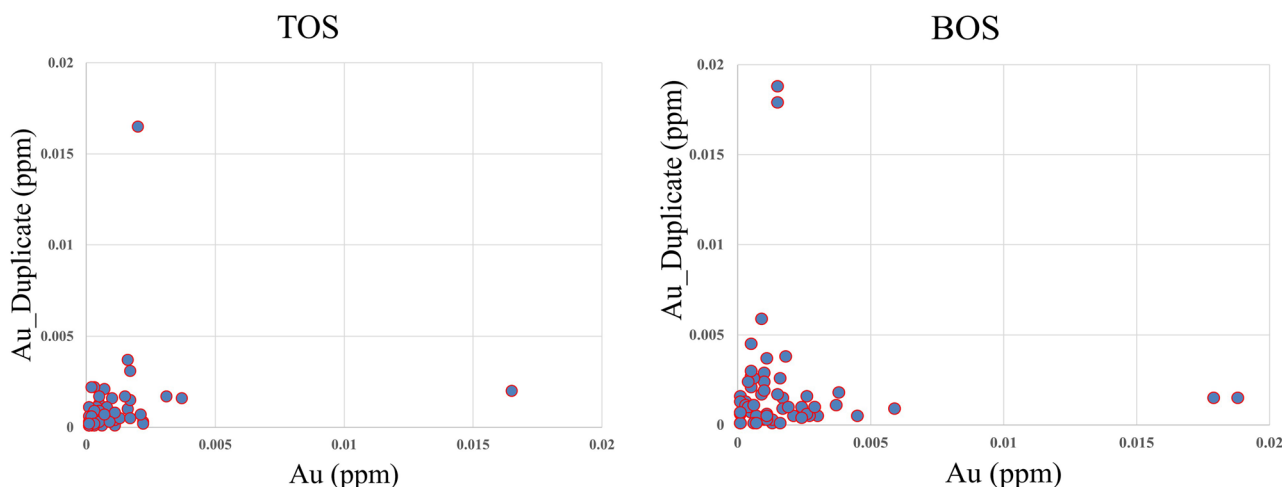


Figure 3. Scatterplots of the original samples and their corresponding duplicates for the TOS (left) and BOS (right) gold datasets.

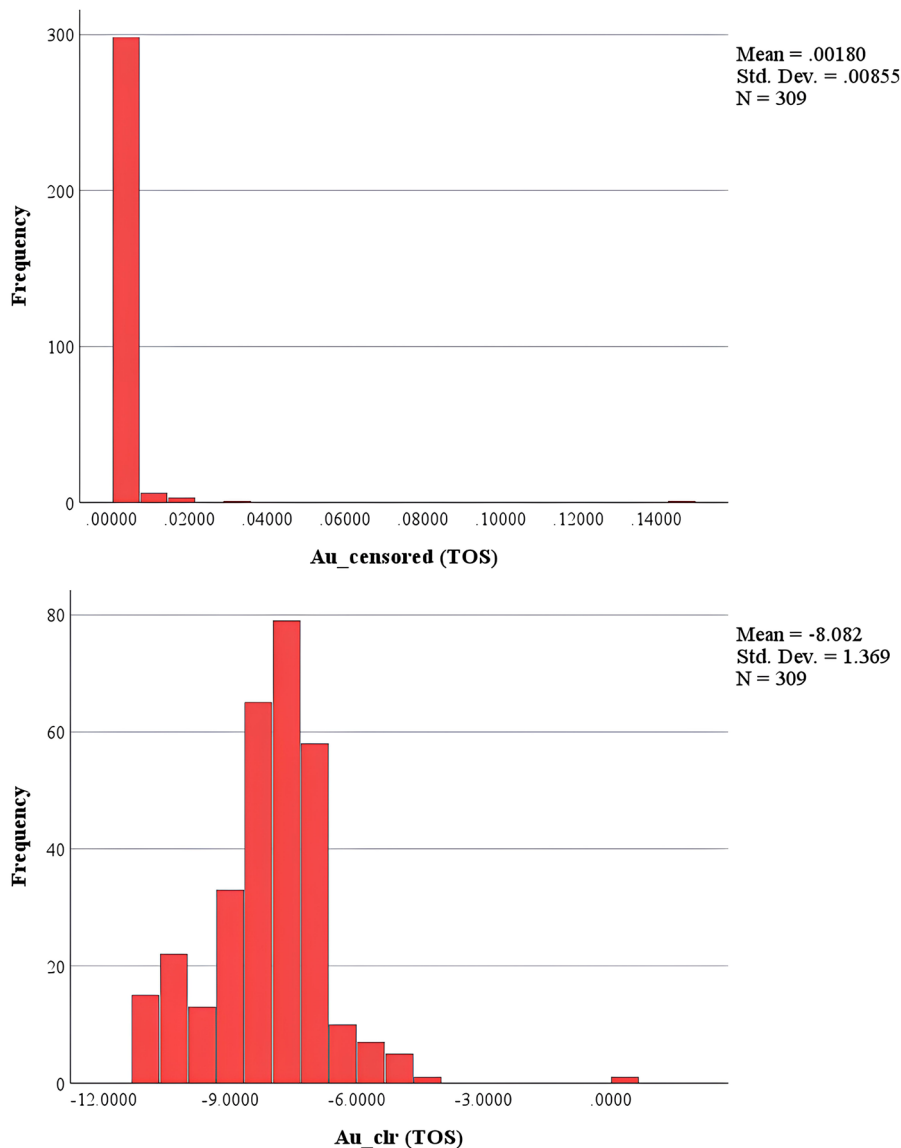


Figure 4. Histograms of the censored-replaced (top) and log-transformed (bottom) data for the TOS horizon.

prior to analysis. **Figure 4** shows the histograms of the censored-replaced and clr-transformed Au data. Although the clr-transformed data still display a left-truncated distribution, the histogram is much closer to a normal distribution than the censored-replaced data. This is important because regression analyses on geochemical data generally assume an approximately normal distribution.

Results and discussion

Figure 5 shows the geochemical anomalies identified from both raw and dilution-corrected residuals of Au data collected from two sediment layers, the TOS and BOS horizons (supplemental data, **Table S1**). The anomalies are classified according to quartiles. Since raw and processed geochemical data may yield different distributions, this classification ensures that each quartile contains an equal proportion of data (e.g. Liu *et al.*, 2024; Wang & Zuo, 2022). While there are some similarities between the

geochemical maps, there are also notable differences. To evaluate how well each anomaly map identifies geochemical anomalies, a common approach is to compare them with the locations of known mineral deposits, which serve as evidence of true positive anomalies. In total, there are 30 clusters of gold deposits nearby, including giant deposits (more than 150 tonnes), large deposits (50–150 tonnes) and medium deposits (5–50 tonnes) (supplemental data, **Table S2**). **Table 1** shows the number of mineral clusters found in each anomaly category (Q1 to Q4) for the four geochemical maps: raw Au data from the TOS and BOS horizons and their corresponding dilution-corrected values. The results show that dilution-corrected Au values perform better in identifying geochemical anomalies for both horizons. In particular, the BOS dilution-corrected data detect 26 out of 30 clusters, while only 14 clusters are captured by the raw TOS data.

To explore the performance of different geochemical maps in more detail, **Figure 6** focuses on the Charters Towers Goldfields

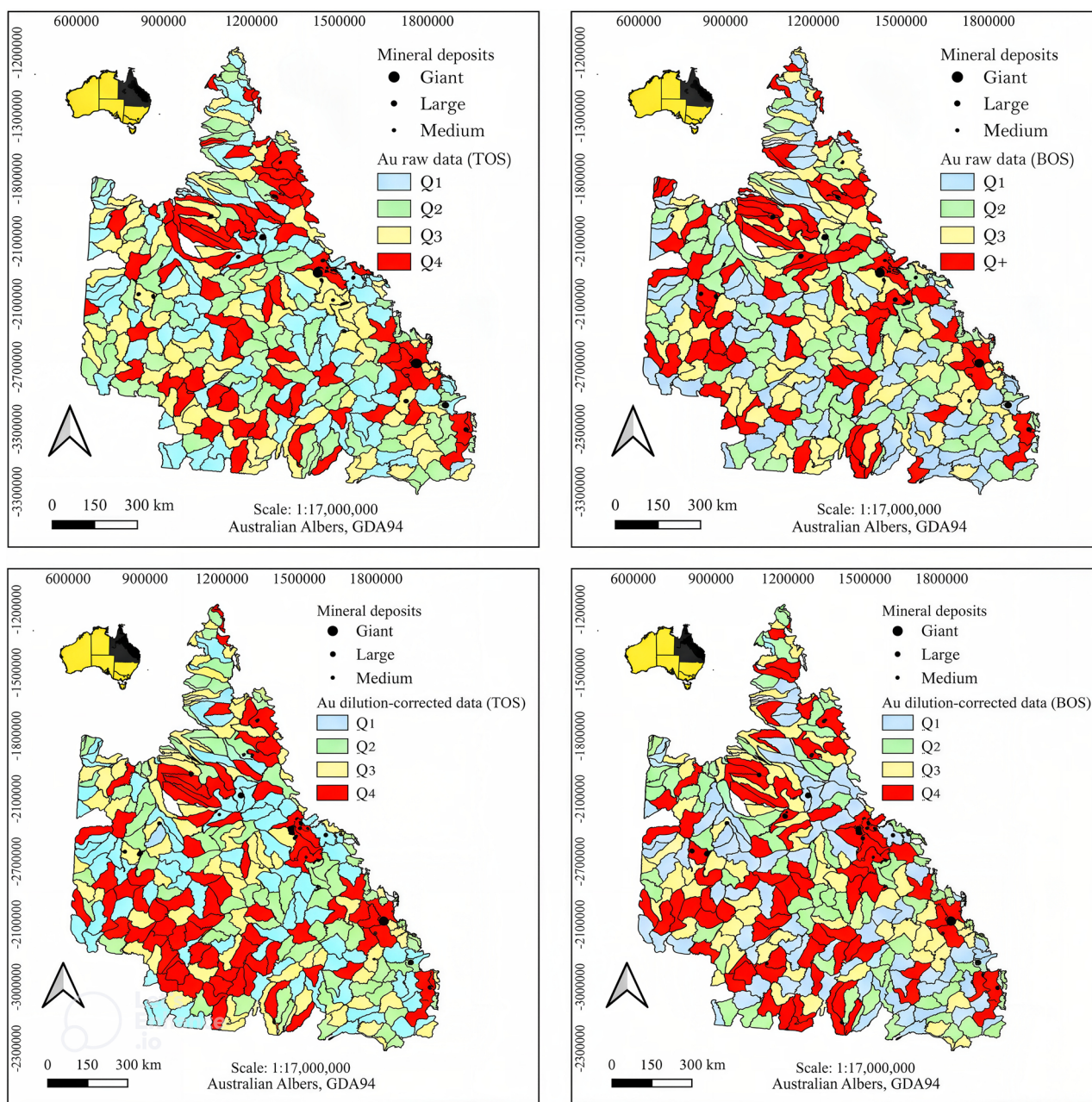


Figure 5. Classified geochemical map delineated from unprocessed and dilution-corrected catchment outlet geochemical anomalies from the entire Queensland for both BOS and TOS horizons.

Table 1. Performances of each anomaly map in delineating geochemical anomalies corresponding to known gold mineral occurrences.

Class	Anomaly maps			
	Au raw data (BOS)	Au dilution-corrected data (BOS)	Au raw data (TOS)	Au dilution-corrected data (TOS)
	Number of deposit clusters (out of 30)			
Q1	1	3	6	6
Q2	3	0	1	1
Q3	5	1	9	3
Q4	21	26	14	20

in the Burdekin River region and several other deposit clusters in the Suttor River area. Three deposits—Miclere, 309 and Pajingo–Scott Lode—are initially classified in the moderate

anomaly groups (Q2–Q3). However, after removing background values related to lithology and applying dilution correction, these deposits are elevated to the highest anomaly class (Q4).

The dilution-corrected anomaly maps for both the BOS and TOS horizons also highlight several anomalous catchments in central and southwestern Queensland, where no confirmed giant, large or medium (G-L-M) gold deposits exist. Nevertheless, according to Tang and Brown (2011), several strong gold anomalies are inferred from the NGSA along the Thomson, Diamantina–Western Rivers and Eyre Creek areas, as shown in Figure 7. This figure illustrates that at least five catchment basins fall into the Q3 anomaly class based on the BOS raw data but move into the highest Q4 class after removing background

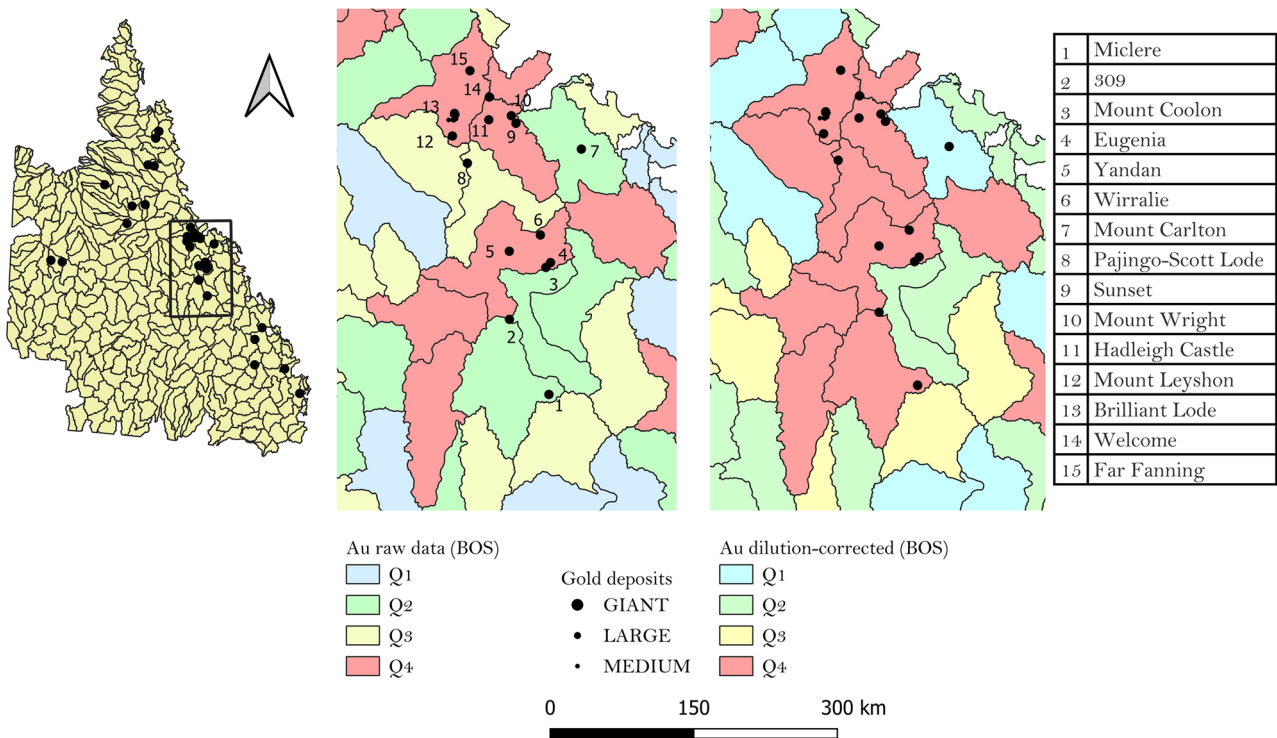


Figure 6. Comparison of Au raw and dilution-corrected BOS data in capturing mineral occurrences of the Charters Towers Goldfields in the Burdekin River and other deposit clusters in the Suttro River.

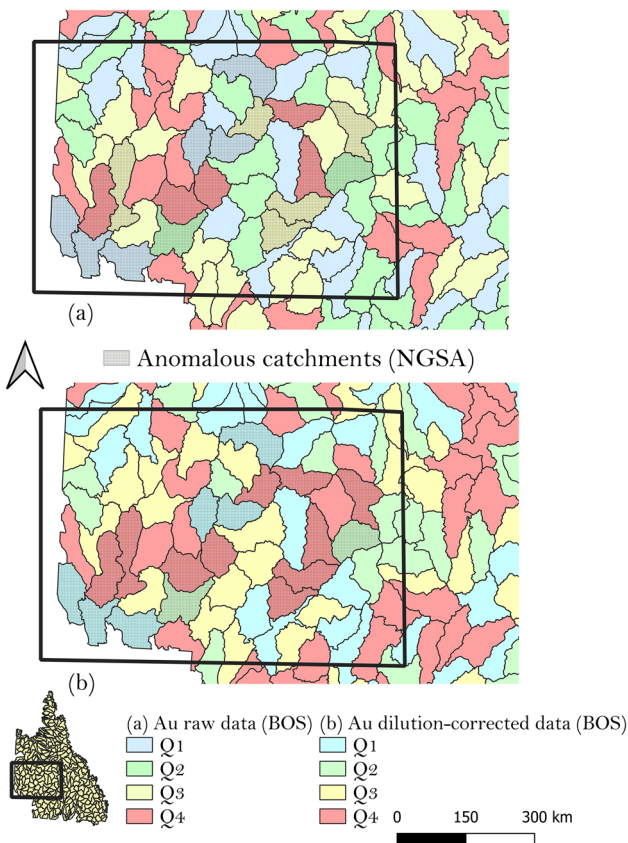


Figure 7. Gold anomalies identified from the NGSAs along the Thomson, Diamantina-Western Rivers, and the Eyre Creek (Tang & Brown, 2011).

effects and correcting for dilution in the Au geochemical anomalies. Several possible explanations may account for these anomalous responses across southwest Queensland. One possibility is concealed mineralisation within older basement rocks underlying the Eromanga Basin, where anomalies may reflect geochemical leakage or dispersion through transported cover rather than exposed mineralisation. In addition, extensive weathering, transported regolith, sediment recycling, groundwater transport, hydromorphic dispersion and concentration within paleodrainage systems may contribute to elevated or redistributed Au concentrations over broad areas. Many of these catchments are also dominated by siliciclastic sedimentary units, including arenite, arenite–mudrock, arenite–rudite and mudrock lithologies, which generally display relatively high estimated background Au values (Table 2). Therefore, some anomalies may reflect elevated regional background values rather than true mineralisation-related responses. Analytical uncertainty may also contribute to some elevated Au concentrations, as several catchments, including Eyre Creek, show relatively large differences between original and duplicate analyses. A similar situation is observed in northern Queensland, where elevated Au–Sn–W anomalies occur within extensive mid Mesozoic to Cenozoic alluvial and deep lead cover sequences. This suggests that comparable regional-scale processes related to transported cover and secondary geochemical dispersion may also operate in southwestern Queensland.

To highlight the importance of background correction in analysing catchment outlet sediment geochemical data, Table 2 shows the ranking of seven dominant lithologies based

Table 2. Rank of each of the seven dominant lithologies according to their estimated background (b_j) using the multiple regression analysis for both BOS and TOS horizons, and the number of deposit clusters (30) hosted by seven major lithological units.

Group name	Main lithologies	Approx. area (km ²)	Background Au rank (BOS)	Background Au rank (TOS)	Number of hosted deposit clusters
Alluvium	Alluvium	265 039	4	7	1
Unconsolidated sediments	Colluvium; poorly consolidated sediments; sand; miscellaneous unconsolidated sediments; ferricrete; water bodies	453 469	7	6	1
Siliciclastic sedimentary	Arenite; arenite–mudrock; arenite–rudite; mudrock; pelite; sedimentary rock; mixed siliciclastic/carbonate rocks; mixed sedimentary rocks and felsites; mixed sedimentary rocks and mafites; quartzite; carbonates (limestone or dolomite)	662 404	1	1	15
Granitoid intrusive	Granitoid; intrusive rock (unspecified)	85 778	2	3	7
Felsic volcanic	Felsites; mixed mafites and felsites (mainly volcanics); mixed volcanic and sedimentary rocks	75 986	3	4	1
Mafic volcanic	Basalt; mafites; gabbroid; ultramafic rock	31 788	6	5	3
Metamorphic	Metamorphic rock; metamorphosed sedimentary rock; mixed metamorphosed felsites and sedimentary rocks; mixed metamorphosed mafic and felsic volcanic and sedimentary rocks; mixed metamorphosed mafites and sedimentary rocks	25 729	5	2	2

on their estimated background values (b_j) calculated using multiple regression analysis for both the BOS and TOS horizons. The table also identifies how many of the 30 deposit clusters are hosted within each of these major lithological units. Among them, siliciclastic sedimentary and granitoid intrusive units contain the largest number of deposit clusters—15 and 7, respectively. These lithologies also have the highest estimated background ranks, with siliciclastic sedimentary and granitoid units ranking first and second for BOS, and first and third for TOS horizons. This finding emphasises that elevated elemental values in catchment outlet samples draining different lithologies across a wide area do not necessarily indicate geochemical anomalies from mineralisation. In this case study, the lithologies hosting most of the mineral deposits also show the highest background levels. Therefore, these naturally high Au values related to lithology can affect the classification of geochemical anomalies when comparing raw data with background-corrected datasets.

In this study, all lithological units are grouped into seven dominant rock types; however, there is considerable variation within each major unit (Table 2). Ideally, there should be a balance between the density of sediment sampling and the degree to which lithological units are merged. This balance affects the analysis of outlet sediment data at the catchment basin scale in two ways. First, multiple regression analysis is sensitive to very small values of the independent variables, which in this case are the relative area sizes of each lithological unit (Shahrestani *et al.*, 2019). Small independent variables can produce unrealistic or extreme background values (b_j), which then influence the expected background values at the basin outlet. Second, sediments derived from very small lithological units are less likely to reach the sampling sites in large catchment basins, as their geochemical signals are diluted by sediments from more dominant rock types. The classification approach used in this study aims to address both issues by setting X_{ij} values (representing the area of lithological units in each catchment) less than 20 km² to zero, thereby avoiding extreme background values. However, this threshold is somewhat subjective. To determine an optimal merging threshold, a

trial-and-error approach is recommended, where more detailed and uniform lithological groups are created stepwise, and dilution-corrected values are recalculated for each stage. The best threshold will be the one that produces the most robust anomaly delineation. Clearly, increasing the density of stream sediment sampling will improve anomaly detection by better capturing true anomalous sources (*e.g.* Shahrestani *et al.*, 2018). However, the assumption that each lithological unit erodes uniformly and contributes equally to sediment based solely on its area is an oversimplification. Different rock types have varying hardness and weathering rates, which affect how much sediment they produce. Therefore, relying only on the size of upstream rock areas to estimate their contribution can overlook important differences in sediment sources (Shahrestani *et al.*, 2024).

It should be noted that SCBA assumes that sediment collected at the catchment outlet provides a homogenised geochemical signature representative of all upstream lithologies. This assumption is partly satisfied when overbank deposits are sampled, as flood processes promote sediment mixing. However, the assumption may break down when samples are collected from basins or local depressions, where sediments accumulate from multiple directions, and mixing is limited, potentially resulting in biased or non-representative geochemical signatures.

The BOS horizon performs better than the TOS horizon in delineating geochemical anomalies related to gold mineralisation. Antweiler and Taylor (2008) noted that ore elements are enriched in the <75 μm fraction in nearly 90% of BOS samples and 60–70% of TOS samples, compared with their corresponding <2000 μm bulk fractions. Owing to this higher sensitivity and enrichment in the finer fraction, they described the BOS horizon as the best sampling medium for geochemical anomaly delineation. In this study, gold anomalies derived from BOS samples (60–90 cm depth) show better spatial correlation with known gold deposits than those from TOS samples (0–10 cm). This is largely because deeper sediments are less affected by surface processes such as weathering, erosion and contamination, and thus provide a more stable and representative geochemical signal of the underlying catchments

over time. This study focuses on a single-element Au dataset to highlight the importance of background correction in anomaly delineation. Most multivariate statistical methods rely on correlations between the target element and associated pathfinder elements. However, Antweiler and Taylor (2008) reported no strong correlation between Au and other trace elements in the dataset. This limitation needs advanced machine learning and deep learning approaches to better delineate geochemical anomalies, which is beyond the scope of the present research.

Conclusions

This study highlights the importance of background correction and dilution adjustment in identifying gold geochemical anomalies from outlet sediment data. By analysing two sediment horizons (TOS and BOS) across Queensland as part of the NGS project, the results show that dilution-corrected Au values improve anomaly detection significantly. The BOS horizon performs better than TOS, showing stronger spatial agreement with known gold deposits owing to enrichment in finer sediment fractions and less influence from surface weathering and contamination. Grouping numerous lithological units into seven dominant rock types allowed effective estimation of background values, but very small lithological areas can cause unrealistic background estimates. To address this, a threshold was applied to exclude small units, reducing distortion. The findings also reveal that elevated Au values linked to certain lithologies can mask true anomalies, emphasising the need for background correction. Although this study focuses on uni-element Au data, the weak correlation with other elements suggests that future work should incorporate advanced multivariate or machine learning methods to enhance anomaly detection.

Acknowledgements

The authors gratefully acknowledge the Geological Survey of Queensland for generously providing regional geochemical data for the entire Queensland, which greatly contributed to this study.

Author contributions

CRedit: **S. Shahrestani**: Conceptualization, Formal analysis, Methodology, Software, Visualization, Writing – original draft; **J. Tang**: Conceptualization, Data curation, Investigation, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing; **M. Sami**: Conceptualization, Methodology, Supervision, Writing – review & editing; **I. V. Sanislav**: Investigation, Supervision, Validation, Writing – review & editing; **A. Kumar**: Methodology, Validation, Writing – review & editing.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data are provided as electronic supplemental data files.

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