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Sulfide, Oxide, Sulfate and Stable (S and C) Isotope Footprints of Au in the Kundana Camp, Western Australia

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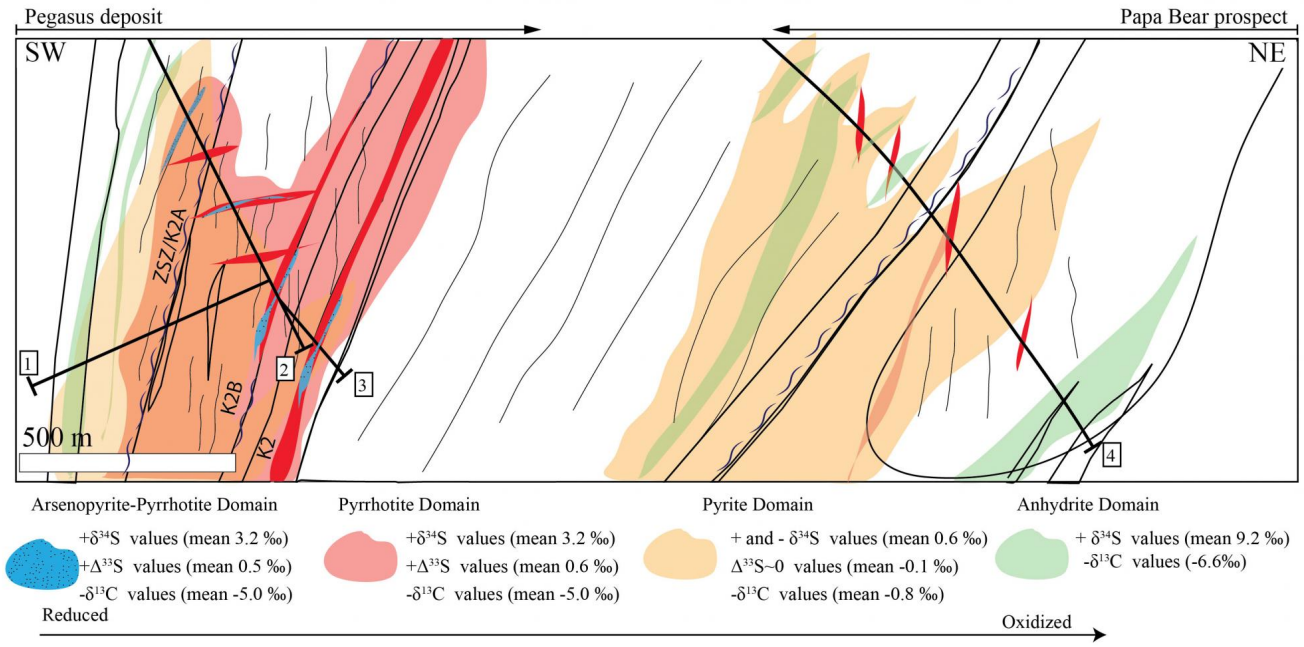
The Kundana Au camp totals ~103 t of Au and is mostly controlled by NW-trending shears, emplaced along lithological contacts (e.g., the K2 shear zone along shale and basalt). High-grade mineralization (>30 ppm Au) is spatially related to steeply west-dipping laminated veins and shallow dipping veins within the Pegasus deposit. Discrete mineralization in veinlets (<1 ppm Au) is located 1 km NE of Pegasus, in the Papa Bear prospect. Petrographic observations across the Pegasus deposit and Papa Bear prospect indicate that scheelite, pyrrhotite, arsenopyrite, and variable amounts of sphalerite were precipitated with native Au in veins and altered wall rocks. The above mineral association is consistent with strong correlation coefficients (i.e., >0.5) between Au and Ag, Te, W, As, Pb, Zn, and S as revealed by bulk geochemical analyses. In contrast, CO_2 yields low correlation coefficients (i.e., <0.3) with all the aforementioned elements. The $\delta^{13}C$ values of calcite do not reveal a precise pattern with regards to Au-mineralized intervals. However, there are broad differences between the $\delta^{13}C$ data recorded in the Pegasus deposit and the Papa Bear prospect with mean values of -5.0 (2.3‰ SD) and -0.8‰ (1.9‰ SD), respectively. Systematic SEM-EDS reveal that pyrrhotite ± arsenopyrite domains are dominant in mineralized sites at Pegasus and Papa Bear and transition to pyrite-pyrrhotite, pyrite ± anhydrite domains, whereby Au records background contents of 10 ppb. The $\delta^{34}S$ values of pyrrhotite and pyrite range from -2.7 to 9.0‰ (1.3‰ SD) and from -10.0 to 10.8‰ (1.9‰ SD), respectively. The negative $\delta^{34}S$ values in pyrite and its association with anhydrite (with $\delta^{34}S$ values from 7.2 to 10.2‰, 0.8 SD) suggest that pyrite was replaced by anhydrite under oxidizing. Extreme positive $\delta^{34}S$ values in pyrite, of up to 10.8‰, are inherited from SO_2 that underwent disproportionation to sulfide (H_2S) by reacting with water. In contrast, pyrrhotite in pyrrhotite ± arsenopyrite assemblages displays dominantly positive $\delta^{34}S$ in samples with up to 30 ppm Au, suggesting reduced fluid conditions during mineralization. The $\Delta^{33}S$ values in pyrrhotite and pyrite yield values from -0.2 to 1.4‰ (0.3‰ SD) and from -0.3 to 1.3‰ (0.3‰ SD), with samples with $\Delta^{33}S$ values of up 1.4‰ in pyrrhotite which is spatially coincident with graphitic shales adjacent to laminated veins hosted by the K2 shear zone. The combined mineralogical, geochemical, and multiple S and C isotope data imply that auriferous fluids were initially oxidized as evidenced by pyrite ± anhydrite assemblages and, focusing in shear zones and reacting with graphitic shales, underwent significant reduction. The latter interaction also resulted in S remobilization as evidence by MIF-S recorded in pyrrhotite within auriferous veins.


Pegasus deposit
Papa Bear prospect
SW
NE
ZSZ/K2A
K2B
K2
1
2
3
4
500 m
Arsenopyrite-Pyrrhotite Domain
+δ34S values (mean 3.2 ‰)
+Δ33S values (mean 0.5 ‰)
-δ13C values (mean -5.0 ‰)
Pyrrhotite Domain
+δ34S values (mean 3.2 ‰)
+Δ33S values (mean 0.6 ‰)
-δ13C values (mean -5.0 ‰)
Pyrite Domain
+ and - δ34S values (mean 0.6 ‰)
Δ33S~0 values (mean -0.1 ‰)
-δ13C values (mean -0.8 ‰)
Anhydrite Domain
+ δ34S values (mean 9.2 ‰)
-δ13C values (-6.6‰)
Reduced
Oxidized