Monash University Science

Implicit 3D geological modelling applied to structurally complex mineral deposits – it's all about geometry

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Implicit modelling is capable of generating internally consistent geological 3D models directly from borehole intersections, numerical data and structural data. Manual digitisation of cross-sections is not necessary because spatial interpolation calculations and mathematical fitting functions are used to generate 3D isosurfaces of ore grades and rock units.

Using the software package Leapfrog (by ARANZ Geo), we demonstrate that ore body geometries and mineralisation trends obtained from implicit 3D geological models can be linked to local and regional structural patterns observed in the field. Results show that structural features and trends that may be unrecognizable in traditional, explicit 3D models become apparent during implicit modelling.

Case study #1: Navachab gold deposit, Namibia

The Navachab open pit gold mine is located at the steep northwestern limb of a regional scale, shallowly doubly-plunging anticline (Kisters, 2005). Gold occurs in several sets of auriferous quartz-sulfide veins and within bedding-parallel massive sulfides, which are hosted in amphibolite facies Neoproterozoic metasediments within the Pan-African Damara belt. Crosscutting mafic and felsic dykes postdate the mineralisation at Navachab.

Drill core logging data and assay results from RC and DC drill holes were used to model formation boundaries implicitly (lithological volume model) and assay values (grade shell model). An isotropic interpolation was chosen to generate an unbiased and uninterpreted 3D model in order to identify and analyse ore delineation and to pinpoint key areas for fieldwork. Surface mapping in high grade key areas of the Navachab Main Pit revealed that gold mineralisation is hosted in stacked, folded quartz-sulfide veins which vary in thickness and form packages of higher vein frequency (smaller spacing). The veins crosscut bedding at an high angle and form upright folds with shallowly NE plunging fold axes. The orientation of these fold axes differs to those of the first order (regional) domal structure, where the plunge is shallower at the surface and becoming steeper at depth, resembling the orientation of the massive sulfide mineralisation. Consequently, the gently dipping auriferous quartz veins must have been emplaced in a different stress field than the massive sulfides.

The orientation of the enveloping surface of the folded, auriferous quartz-sulfide veins coincides with the high grade zones computed in the implicit 3D geological model (Fig. 1). Their downward continuity has been drilled to a length of about 1000m. However, the lateral extent of the veins is restricted and is most probably controlled by changes in host rock lithology. This work shows that a combination of bias-free implicit 3D modelling and careful fieldwork helps to improve the understanding of structurally complex deposits.

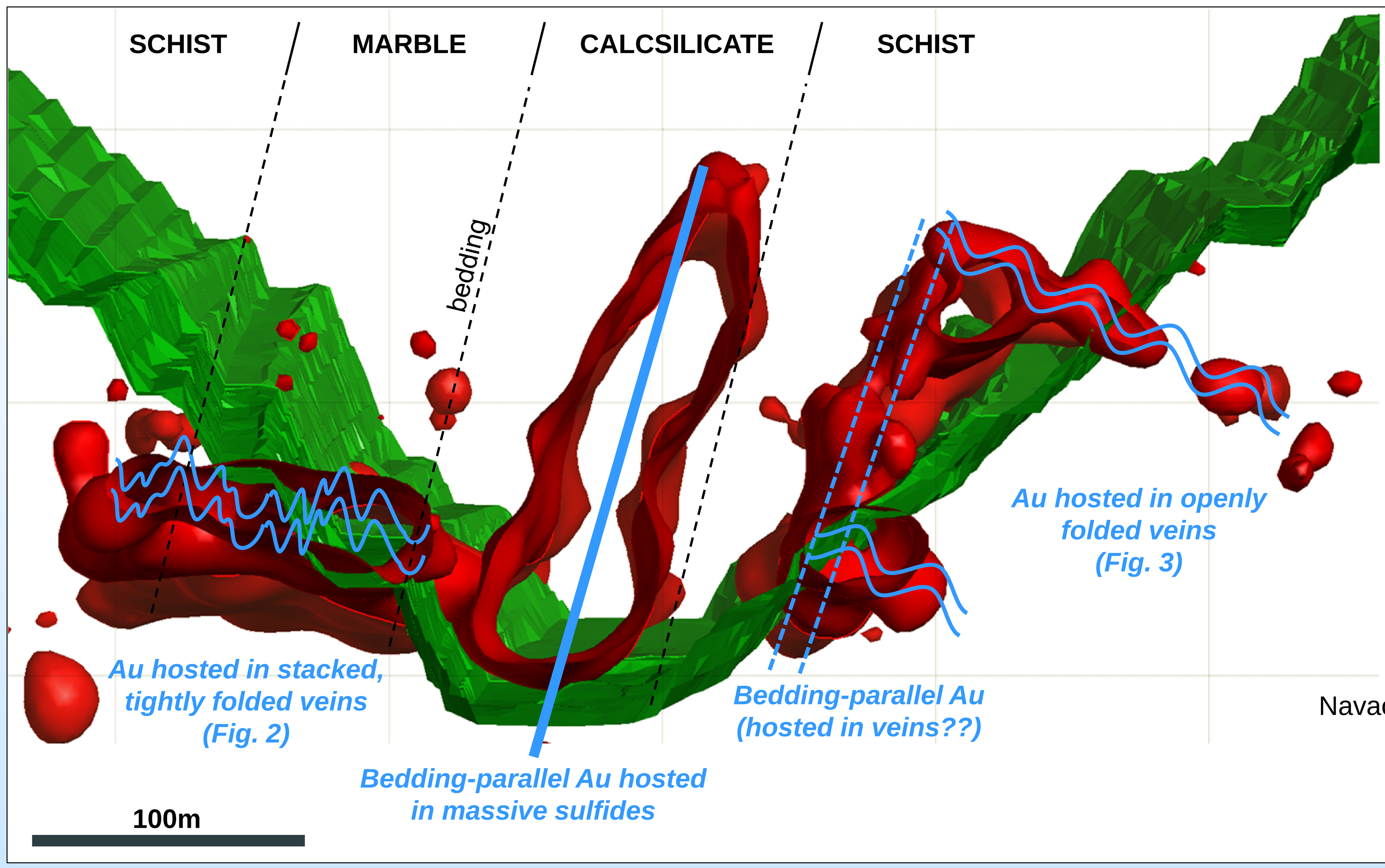

Figure 1: WNW-ESE slice through the central part of the Navachab Main Pit (green) and the isotropically interpolated high grade ore zone (red). Schematic annotation of mineralisation trends observed in the field (blue). Auriferous quartz-sulfide veins are hosted in marbles (Okawayo formation) and in silicified biotite schists (Spes Bona formation).

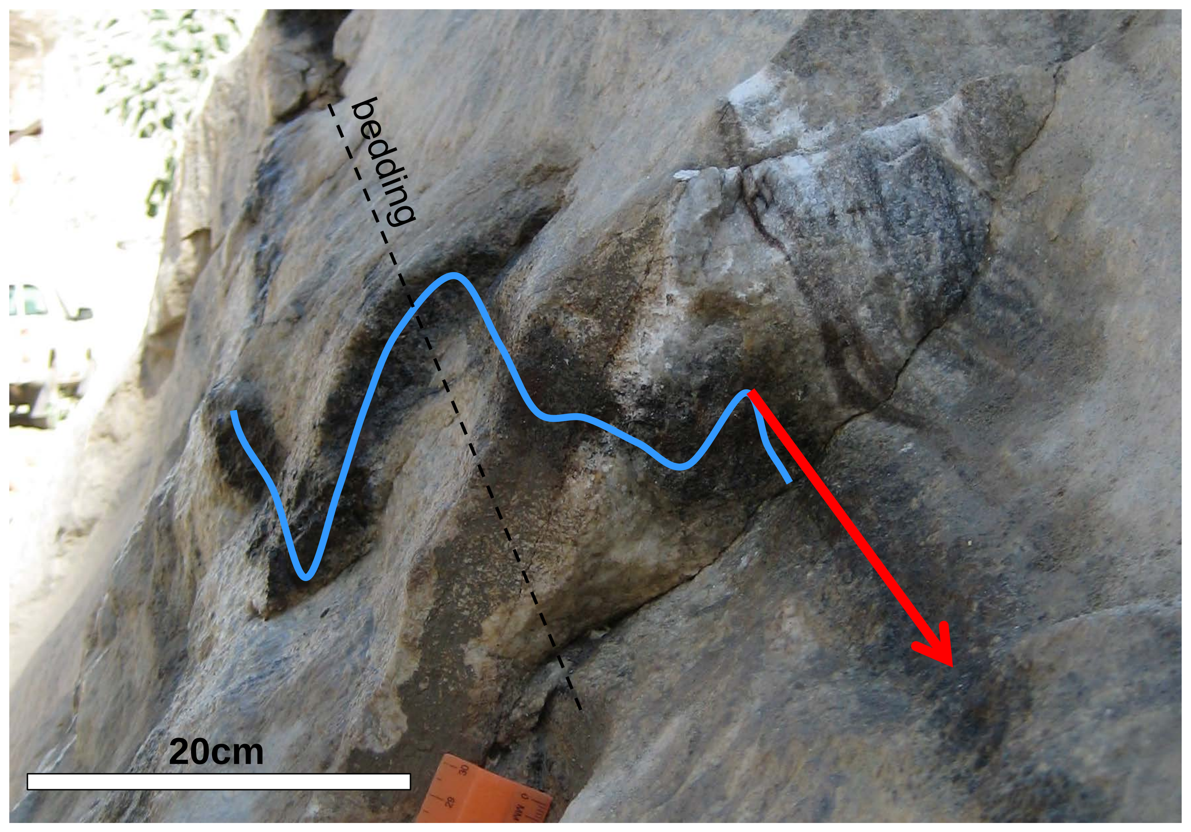

Figure 2: Asymmetrically, tightly folded auriferous quartz-sulfide vein (blue) crosscutting bedding of the marbles within the Okawayo formation. Looking SSW. Fold axis in red.

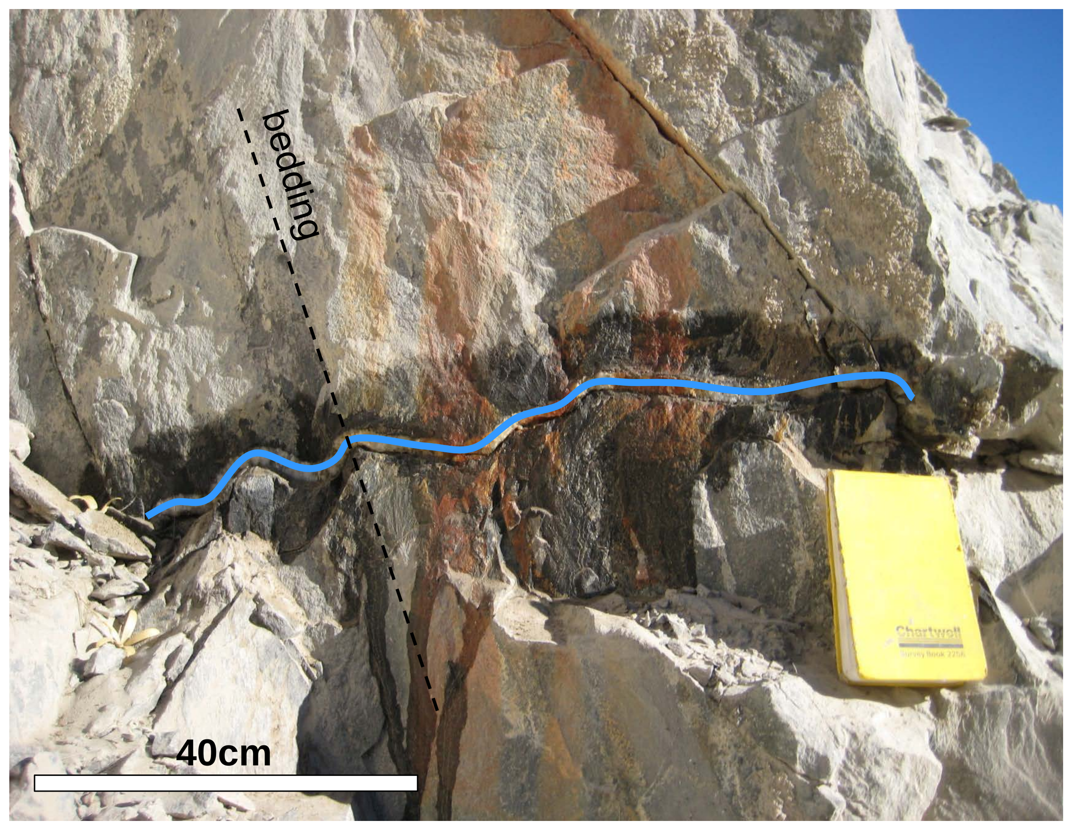

Figure 3: Openly folded auriferous quartz-sulfide vein (blue) within the silicified biotite schist of the Spese Bona formation. Looking SSW.

References
Kisters, A. F. M. (2005). Controls of gold-quartz vein formation during regional folding in amphibolite-facies, marble-dominated metasediments of the Navachab Gold Mine in the Pan-African Damara Belt, Namibia. South African Journal of Geology, 108(3), 365-380.

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