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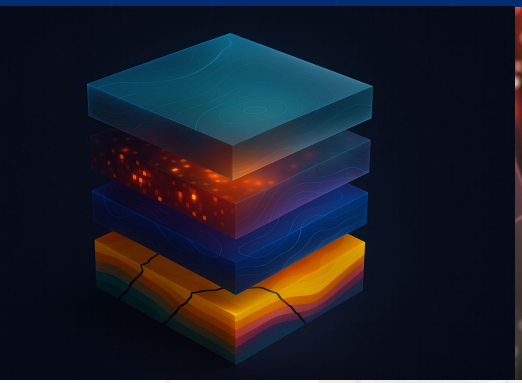
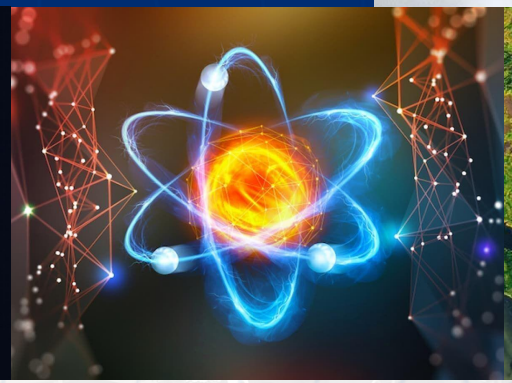
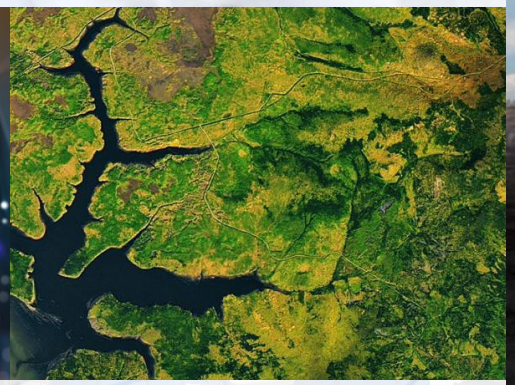
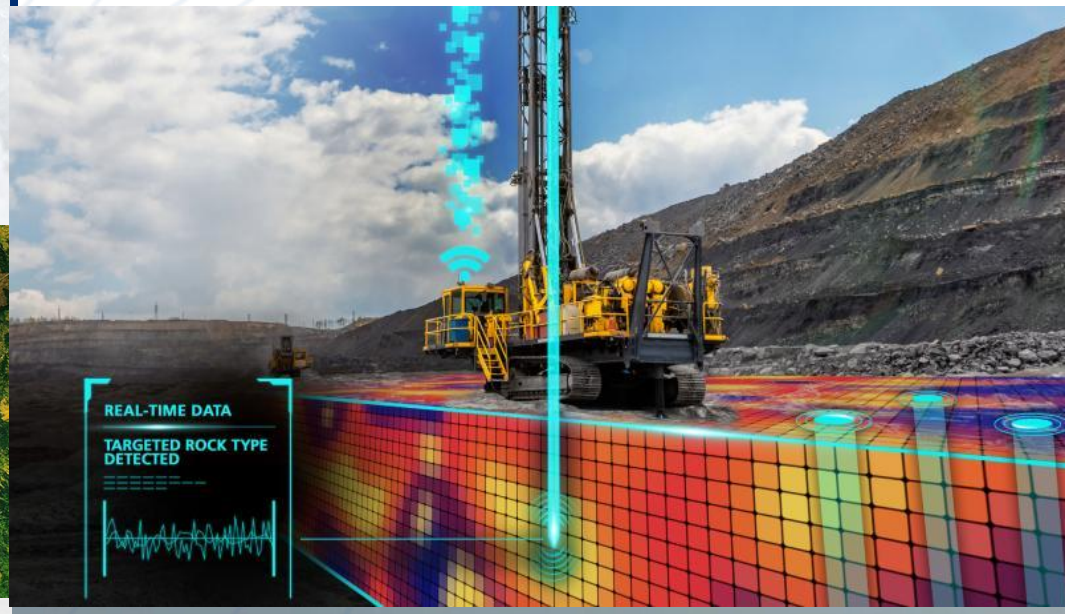
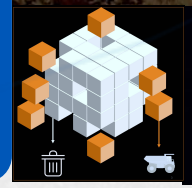


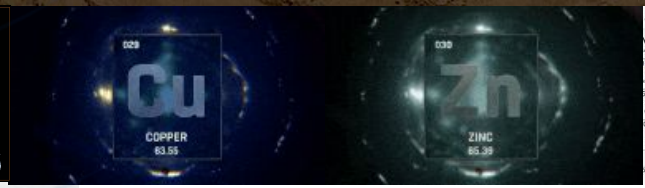


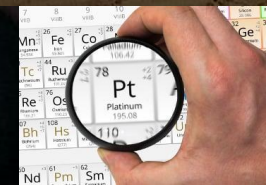




Is it time to rethink gold tailings characterisation using real-time portable and automated technologies?







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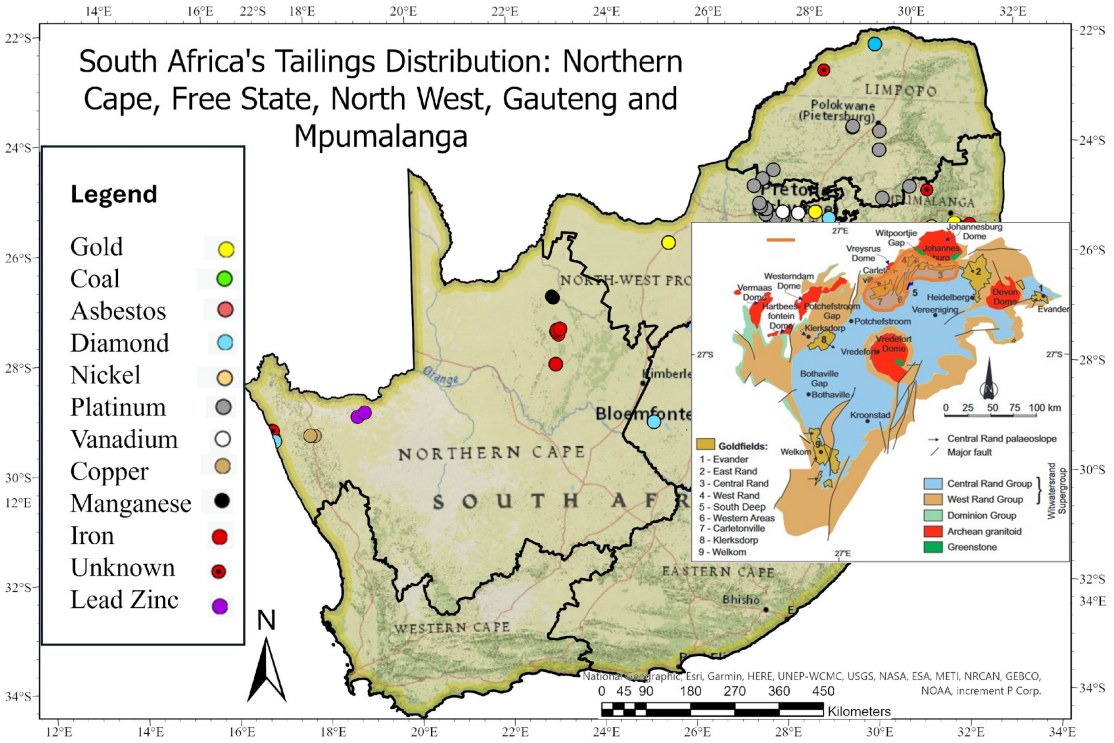
Background

- The Witwatersrand Basin, South Africa's most historically **prolific gold-producing region**, home to hundreds of legacy **tailings storage facilities (TSFs)** and **secondary gold resources.**
- Mining sector shifts toward **circular economy principles** and **urban mining** strategies, these TSFs are becoming a critical targets for resource recovery.
- However, current approaches to tailings evaluation often rely on **outdated or labour-intensive** sampling and characterisation protocols.



Portable and automated technologies

- **Portable XRF (pXRF)** offers the same capabilities as a lab based XRF, provides near-instant elemental assays, including proxy signals for Au-bearing phases such as Fe, As, S, and trace metals (U, Th).
- **Quantitative X-Ray diffraction** (QXRD) captures bulk mineralogical phases associated with gold entrapment and mineral weathering.
- **Tescan Integrated Mineral** Analyser (TIMA) is technologies useful for mine waste valorisation {grade, elemental deportment, locking, grind size, hardness etc (Tomáš et al., 2018)}

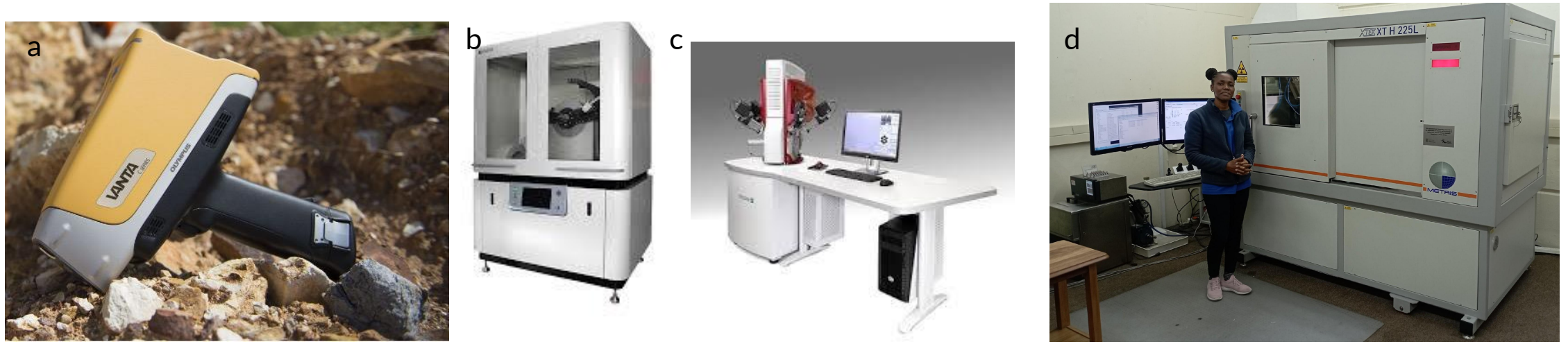


Figure 2 (a) pXRF; (b) QXRD; (c) TIMA; (d) X-ray CT

Case study area

- Driefontein (West Rand) and Ergo Processing (East Rand), Gauteng region, an ongoing study since 2018
- Hand grab, borehole tailing and waste rock sampling

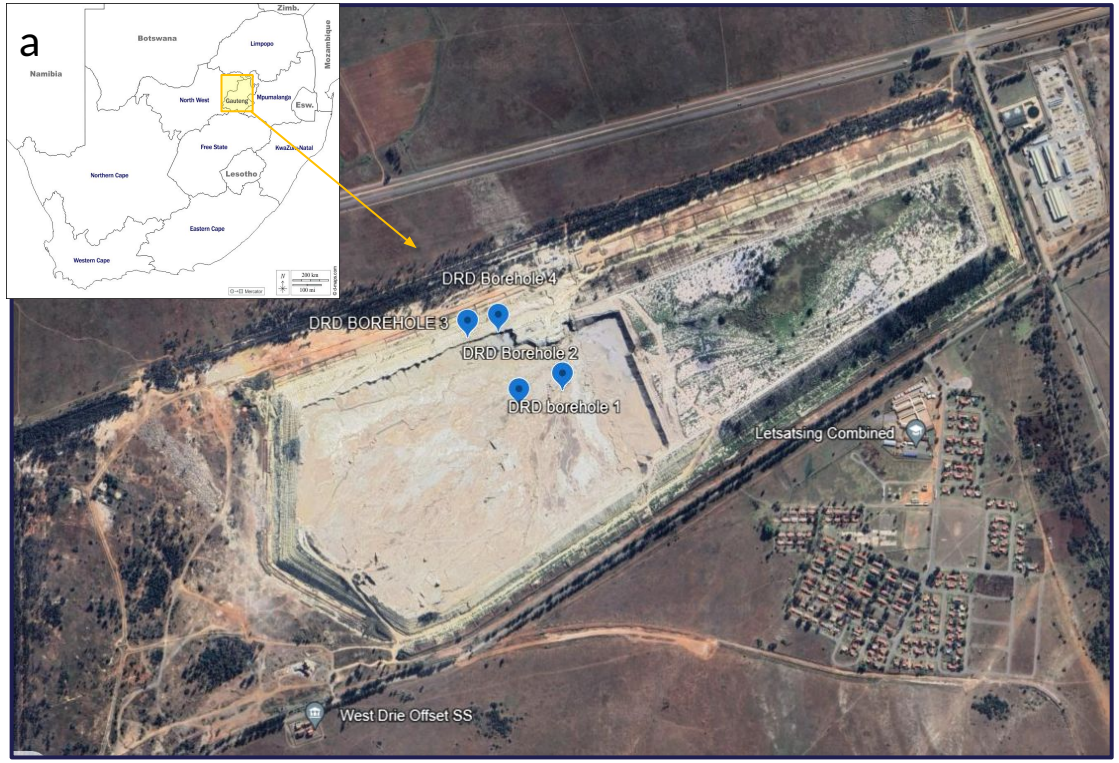
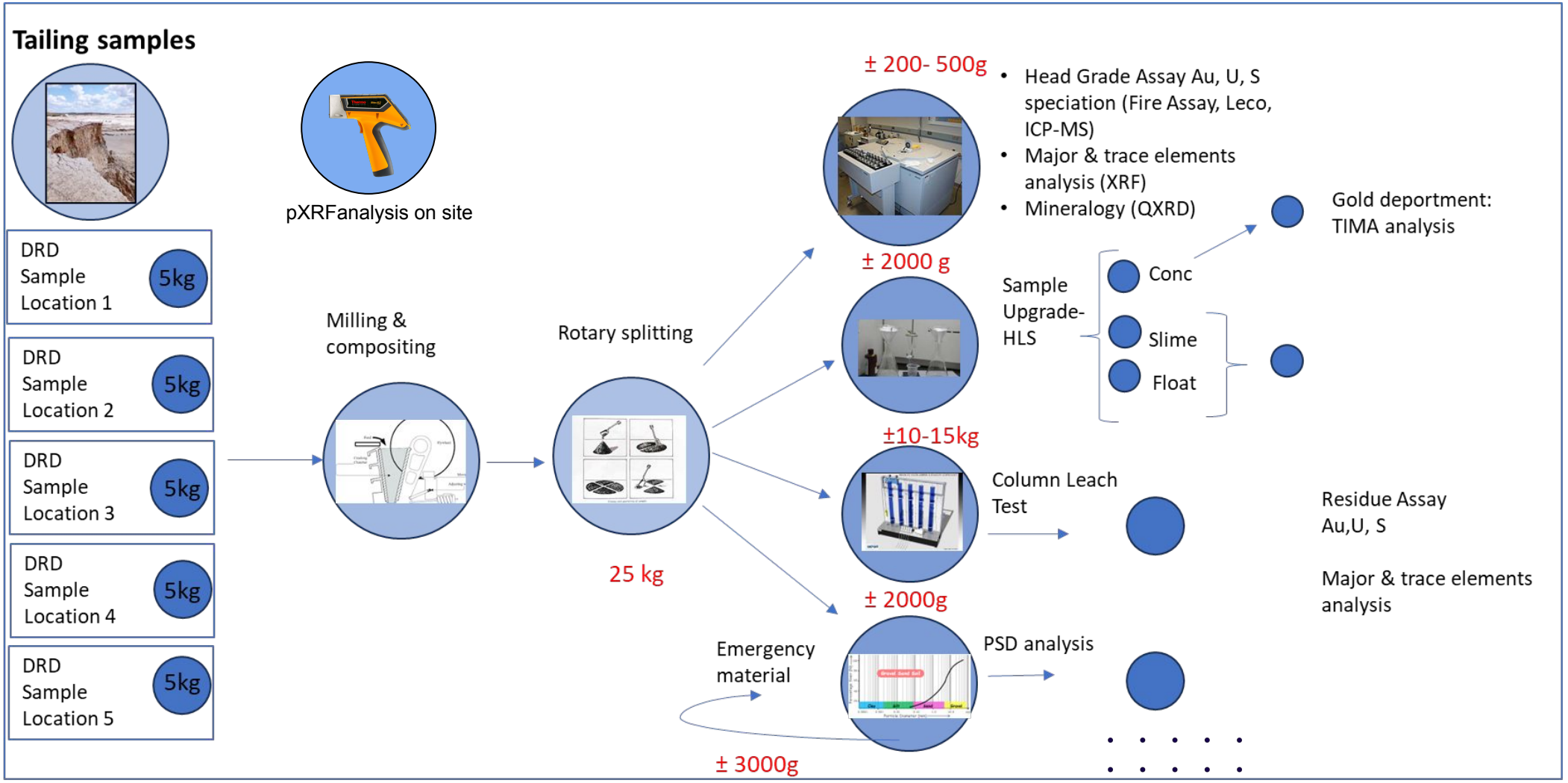


Figure 3 (a) Map of Driefontein Dump 3 showing sampling position (b) Hand grab samples (Driefontein) ; (c) Waste rock (Low grade ore) dump site

Integrated characterisation framework



Geochemical data- Portable XRF

- Borehole logging and XRF data collection (Vanta hand-held device)
- Hand grab (10) and composite borehole samples (99)

a

Borehole Log		Borehole number 2			Borehole Coordinates	
Depth (m)						Comments
From	To	Sample No	Soil classification	Lithology description (colour)	Graphic Log	Moisture Content (%)
0	1,5	L6528	Silt	Light brown		Semi moist (15)
1,5	3,0	L6529	Silty clay	Grey light red		Moist (30)
3,0	4,5	L6530	Clay	Red grey		Moist (60)
4,5	6,0	L6531	Clay	Red grey		Moist (60)
6,0	7,5	L6532	Clay	Red grey		Moist (75)
7,5	9,0	L6533	Clay	Red		Moist (55)
9,0	10,5	L6534	Clay	Redish grey		Moist (60)
10,5	12,0	L6535	Clay	Greyish red		Moist (50)
12,0	13,5	L6536	Clay	Greyish red		Moist (60)
13,5	15,0	L6537	Clay	Greyish light red		Moist (50)
15,0	16,5	L6538	Clay	Grey		Moist (65-75)
16,5	18,0	L6539	Clay	Grey light red		Moist (50)
18,0	19,5	L6540	Clay	Grey light red		Moist (50)
19,5	21,0	L6541	Clay	Red grey		Semi moist (15)
21,0	22,5	L6542	Silt	Grey light red		Semi moist (15)
22,5	24,0	L6543	Silty clay	Grey		Semi moist (15)
24,0	25,5	L6544	Silty clay	Grey		Semi moist (15)
25,5	27,0	L6545	Silty clay	Grey		Semi moist (30)
27,0	28,5	L6546	Silty clay	Grey		Semi moist (30)
28,5	30,0	L6547	Silty clay	Grey		Semi moist (30)
30,0	31,5	L6548	Clay	Greyish yellow		Moist (50)
31,5	33,0	L6549	Silty	Yellow-light grey		Moist (65)
33,0	34,5	L6550	Clay	Greyish yellow		Moist (50)

1

2

b

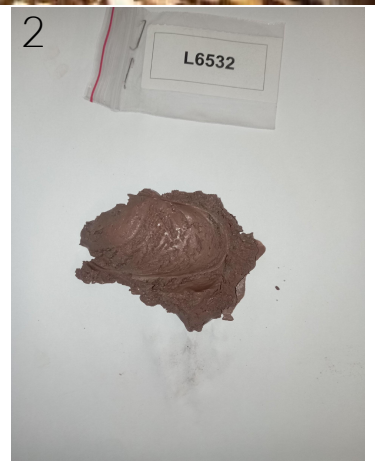
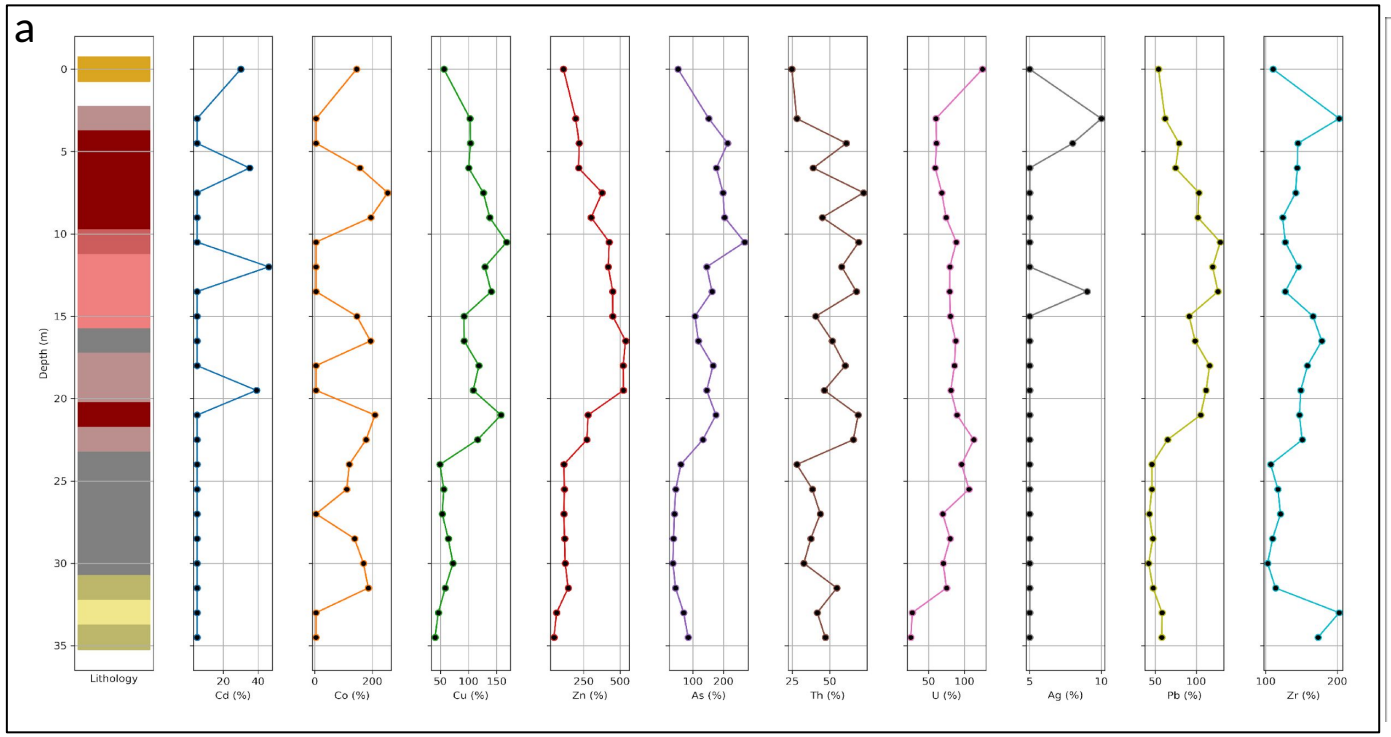


Figure 4 (a) DRD Borehole logs ; (b) pXRF used to analyse samples

Geochemical data visualization and monitoring

- Geochemical database **development** and **elemental monitoring**
- pXRF-derived lithogeochemical signatures (e.g., Si, Al, K, Mg, Ca, Ti, P)
- Detrital **provenance indicators** (e.g. Zr, Hf, Th, Sc, Ce, Y) aid in further interpretation (i.e. **sediment maturity** of tailing material)



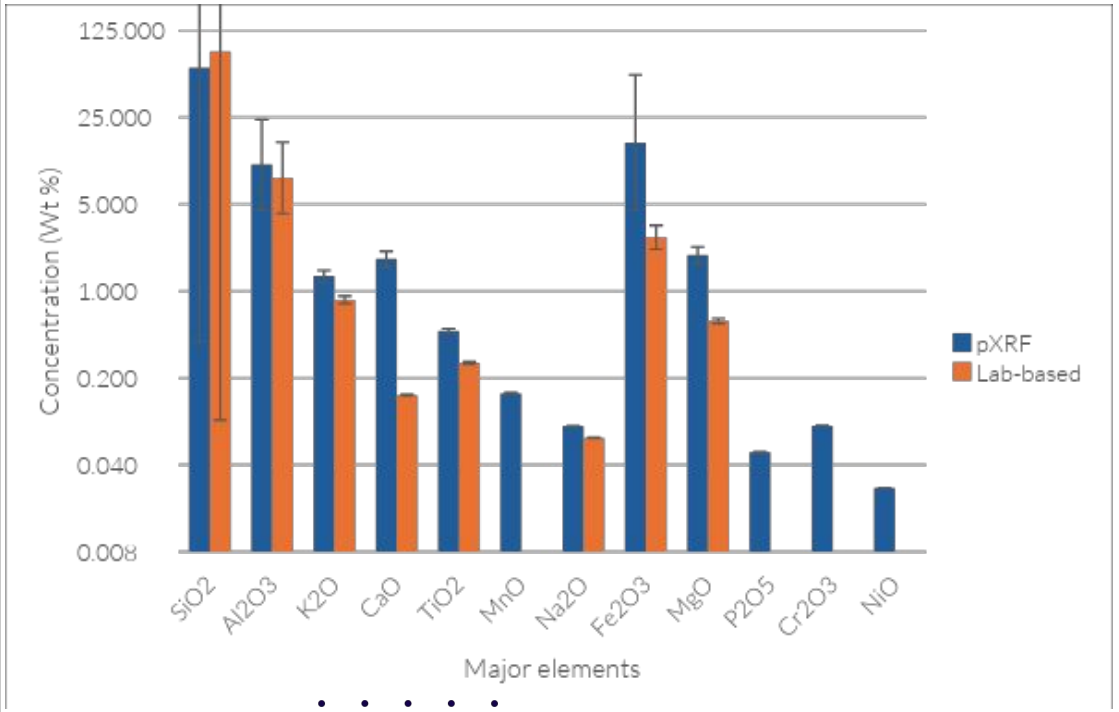


Figure 5 (a). Visualization plot, useful in deleterious elemental monitoring (b) Comparison of pXRF and lab-based analysis

Mineralogy- Bulk phase composition

- Analysed both hand grab and boreholes sample with QXRD
- Comparison of previously and recently analysed samples
- Anticipate dominating mineral phases

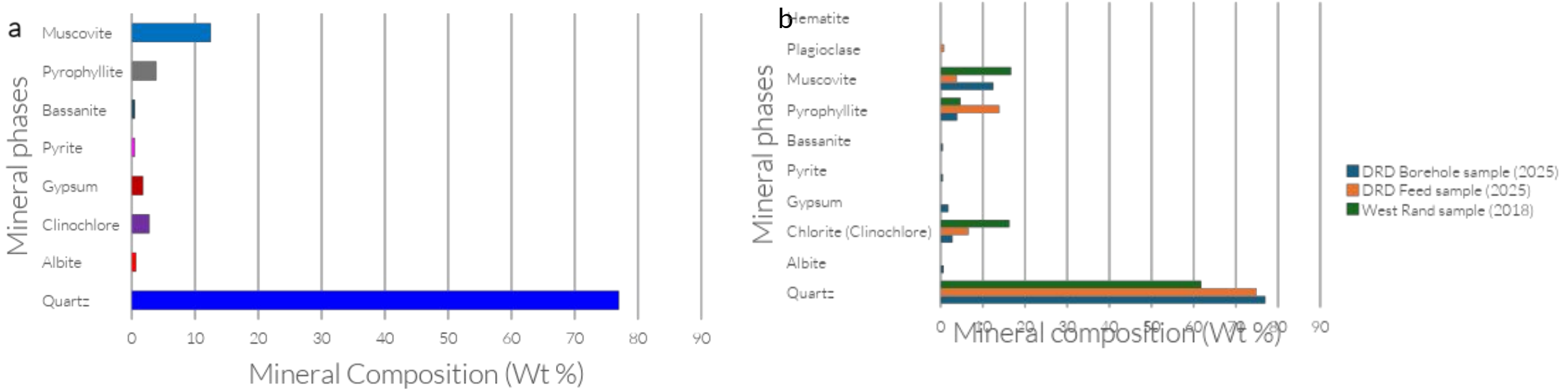
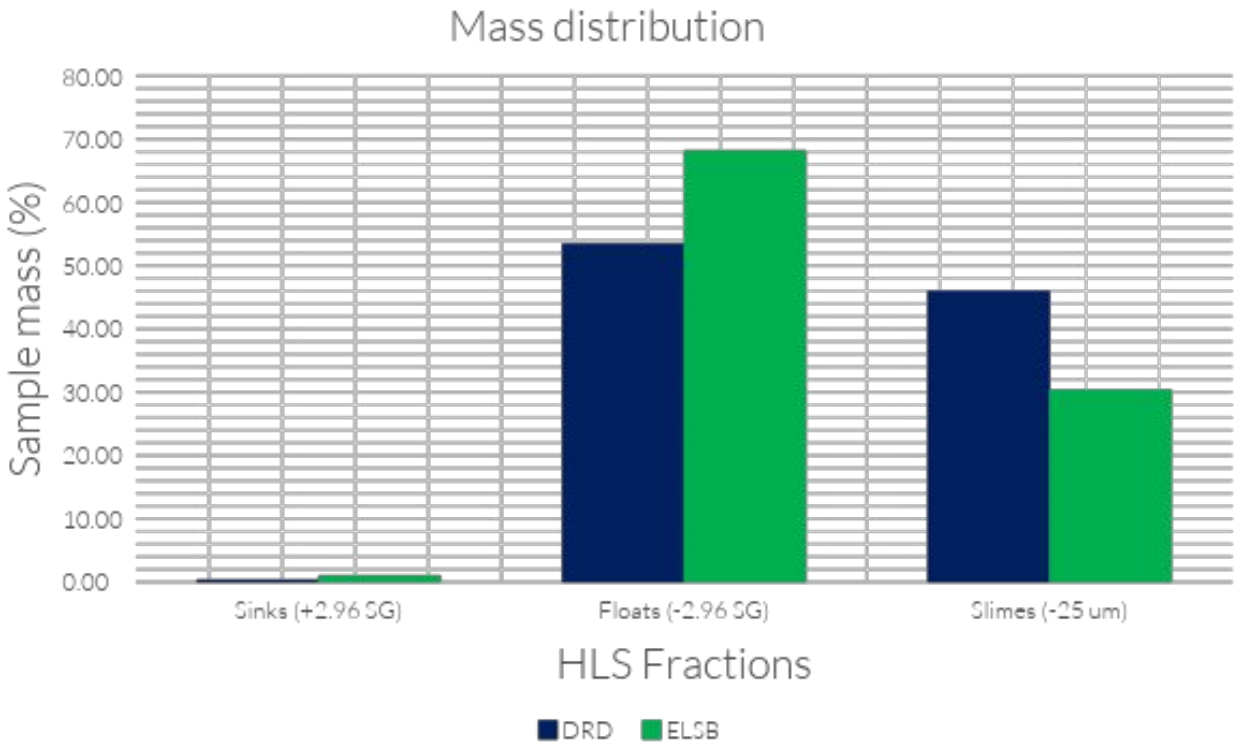


Figure 7(a). Bulk mineralogy of borehole (D6530) (b). Bulk mineralogy of borehole(D6530), DRD feed sample and West Rand sample

Material Separation Stage- Heavy liquid separation

- Analysis significant in Wits gold tailing valorisation (grades <1g/t)
- Discriminate fraction with the most recoverable gold
- Sink samples were further analysed with TIMA



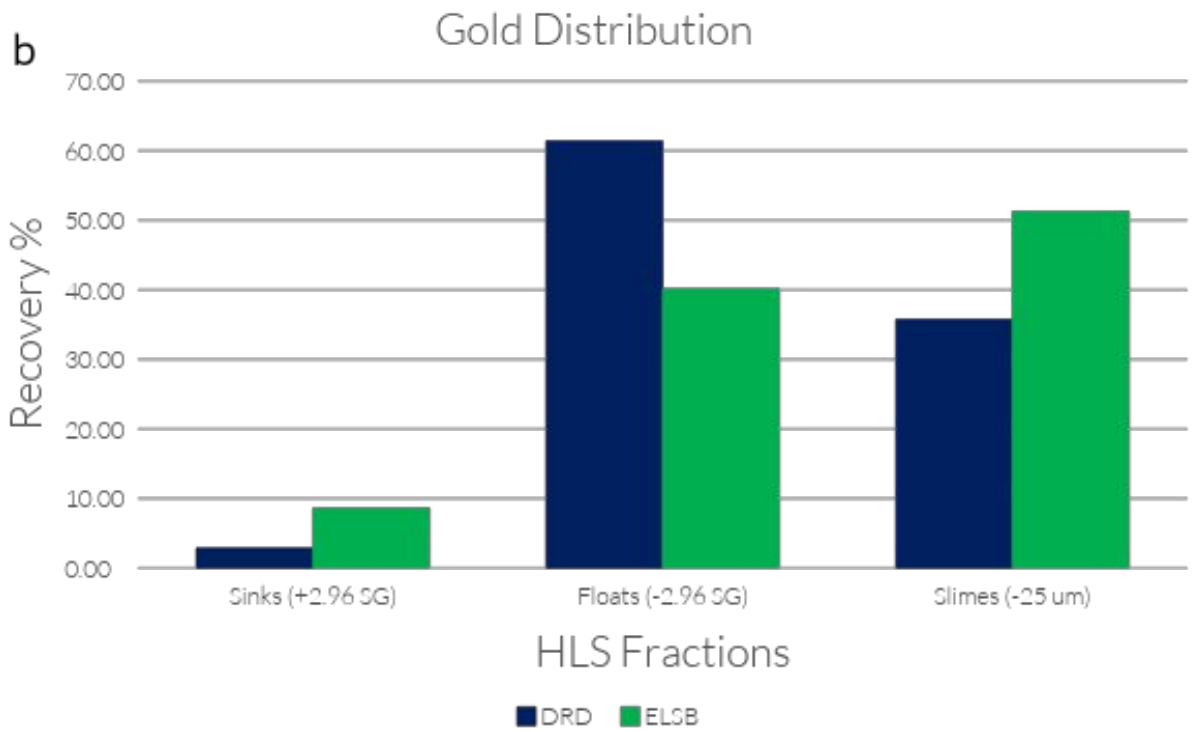


Figure 6 (a). Mass distribution HLS fractions (b). Gold distribution of HLS fractions

Mineralogy: TIMA (Bright Phase Search)

- Back Scatter Electron image (heat map)
- DRD sink sample showing gold grains locked in quartz grain.
- Data useful for planned leaching experiment and gold recovery

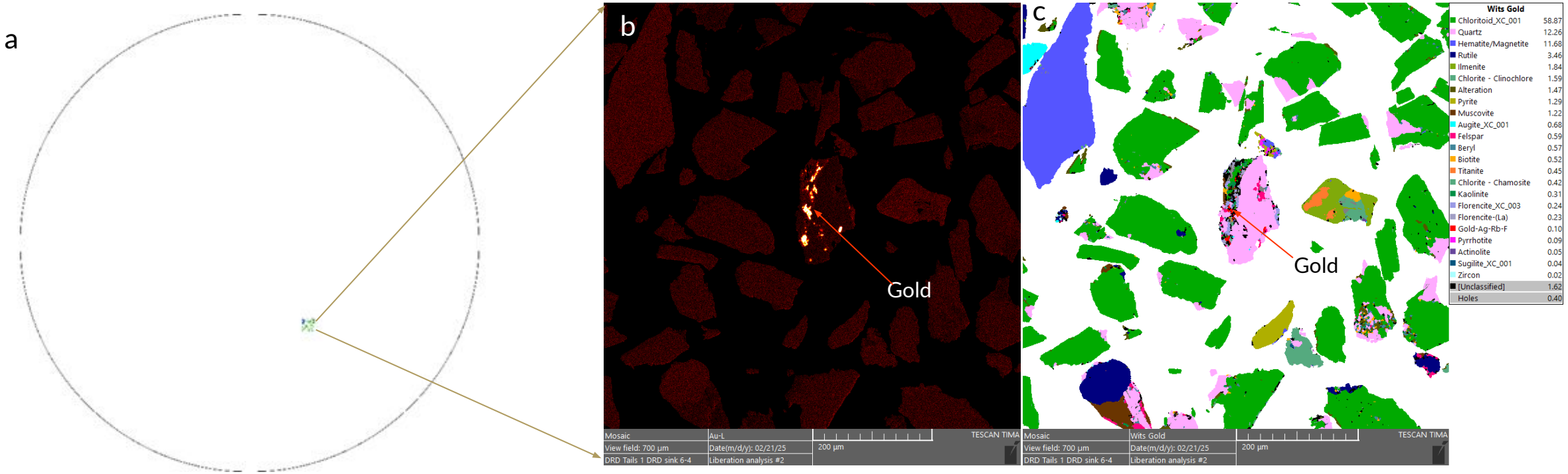


Figure 7(a). Full view sink sample; (b). DRD Sink sample composition and gold deportment (Heat map); (c) False colour map

Mineralogy: TIMA and MLA (Bright Phase Search)

- Back scatter BSE image heat map comparison
- Showing variation in terms of gold deportment
- Mineral liberation result have similarities however varies in composition of host minerals

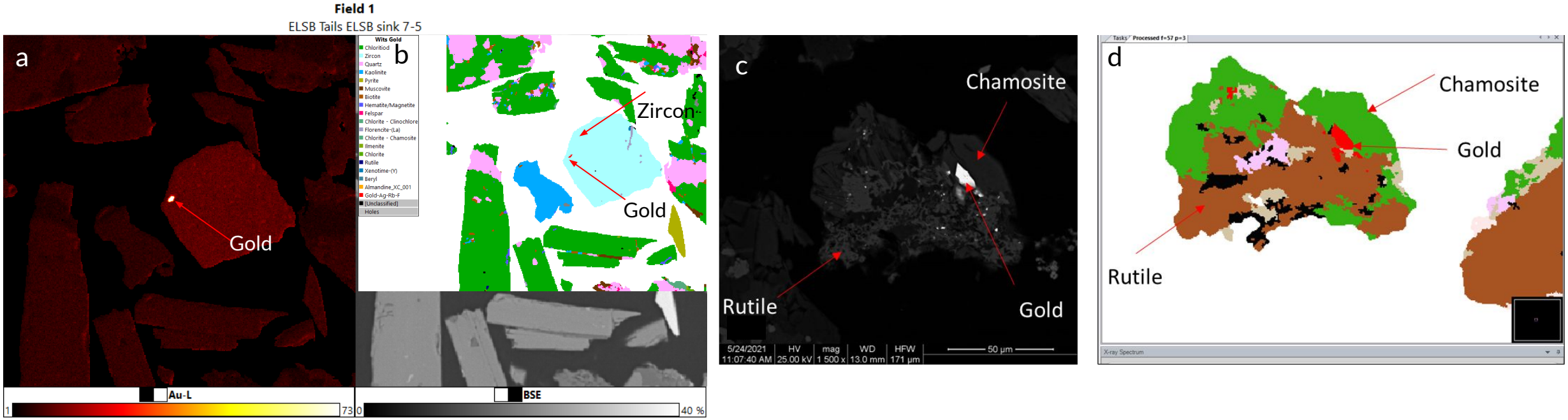
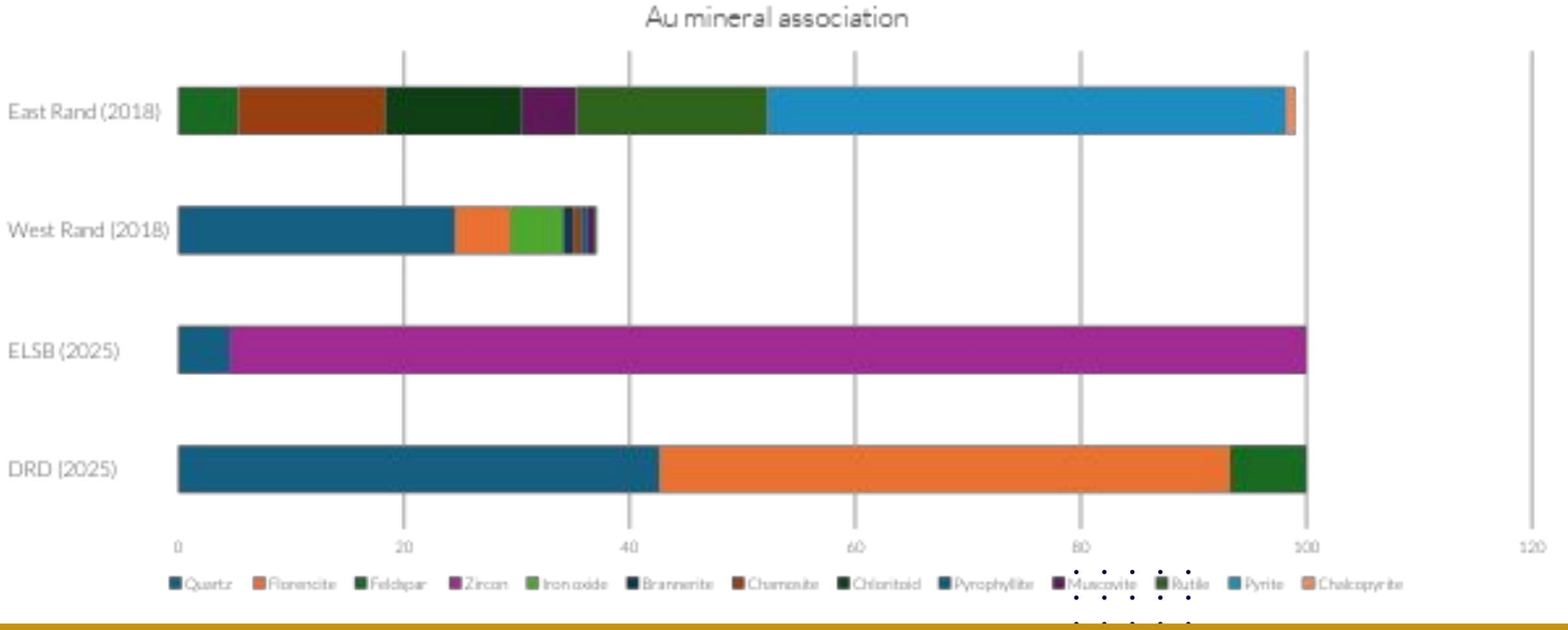


Figure 7(a) and (b). Gold deportment with gold locked in zircon ELSB sample (2025) ; (c). bse image showing gold containing minerals; (d). false colour image East Rand sample (2018) and gold grains locked in chamosite and rutile.

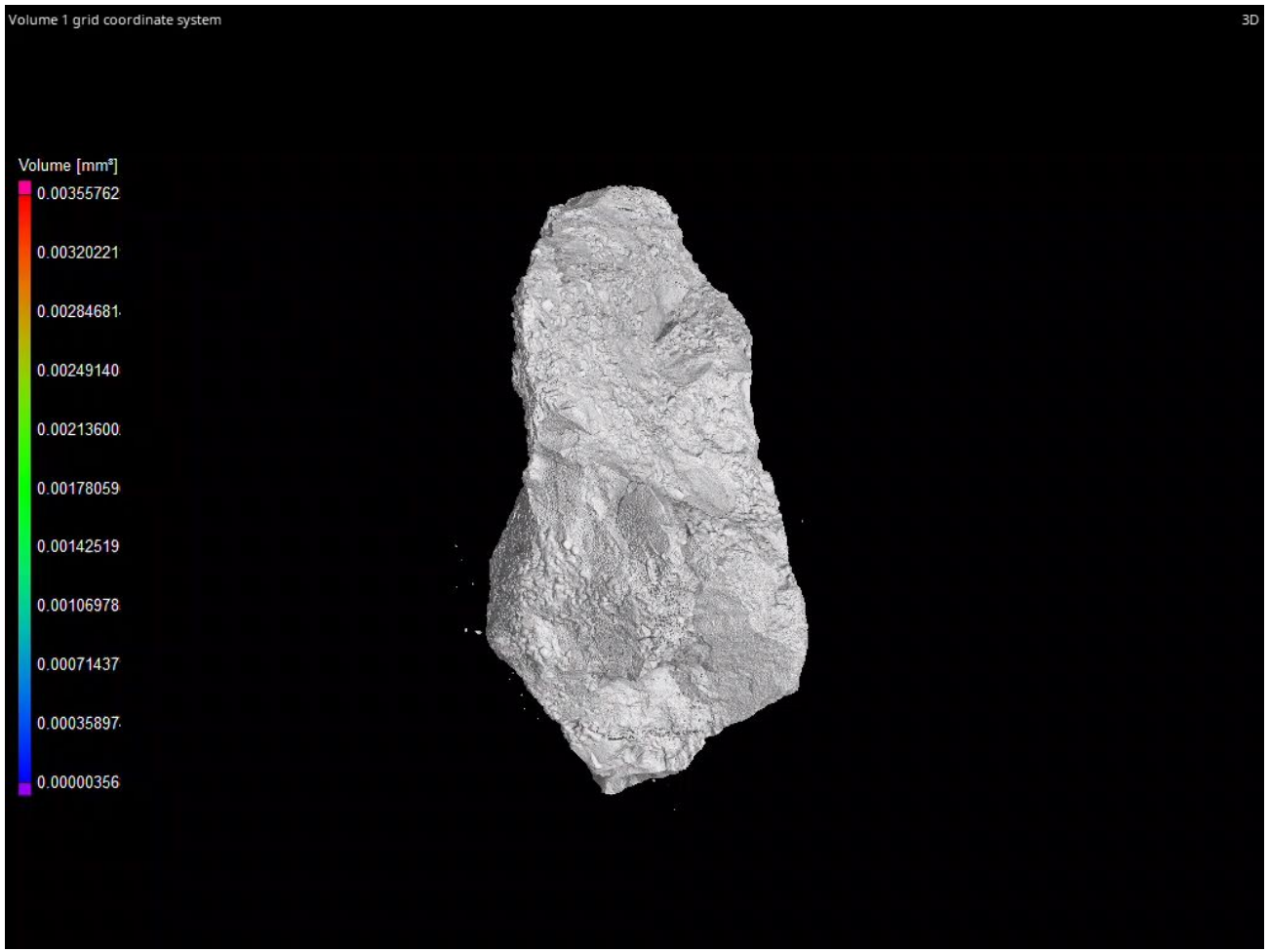
Residual gold(Au) mineral association

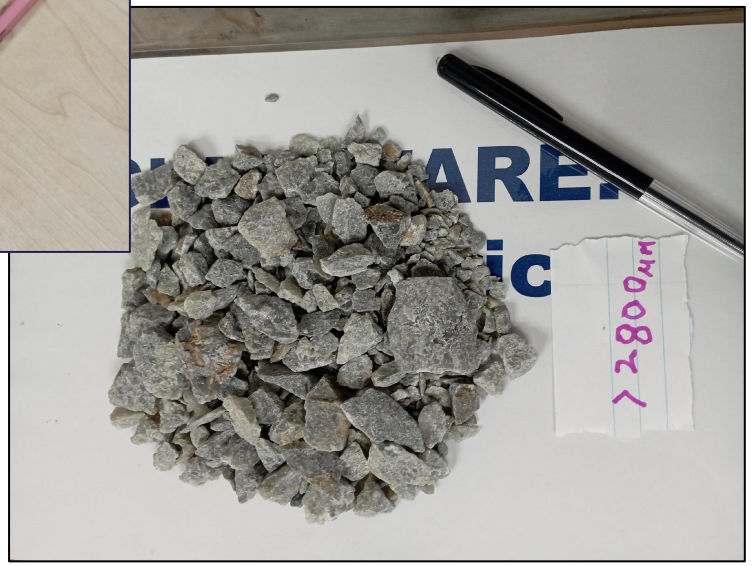
- TIMA data indicated of the minerals most commonly associated with mineral of interest



X-ray CT analysis

- X-ray CT used to study the gold significant in valorisation of low grade ores.





Insights drawn from study

- The study of different TSFs within the East and West Rand since 2018 revealed:
  - Strengthened the process of building a reliable Wits gold tailing geochemical database, efficiently with an improved turn around time.
  - Results from previously characterised tailing samples allowed a comparative review of studied TSFs.
  - Mineralogical and geochemical data allows for development of geometallurgical predictive models.
  - Homogenous or Heterogenous?

Conclusion

- Field campaigns across two TSFs in the **East and West Rand goldfields** demonstrated that **portable and automated** instruments can reveal fine-scale variability in TSFs chemistry.
- The **complexity** and **heterogeneity** of the Witwatersrand gold tailings calls for an **independent characterisation** of each mined TSF using recently improved automated technologies for further improved gold recovery.
- Findings suggest **integration** of portable and automated characterisation tools offers not merely an operational upgrade but a **conceptual rethinking** of how we engage with TSFs as urban mineral systems.

Thank You

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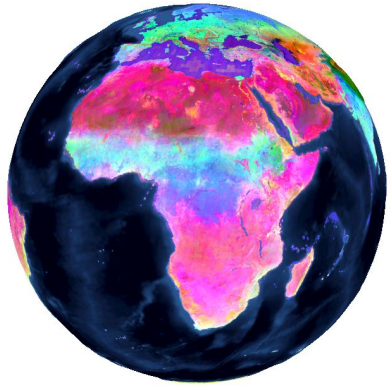

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