Lithostratigraphic mapping through saprolitic regolith using soil geochemistry and aeromagnetic surveys

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ABSTRACT:

The Neoproterozoic Central African Copperbelt located in southern Democratic Republic of Congo (DRC) and the northwestern Zambia and contains 51% of the world's cobalt reserves and significant resources of copper, zinc, nickel and gold. A good understanding of the geology is critical for successful mineral exploration. However, geological mapping is hindered by low topographic relief, limited outcrop, and a generally deep (15-100m) weathering profile.

INTRODUCTION:

The Neoproterozoic Katanga Supergroup is composed of carbonate and siliciclastic metasedimentary rocks (Table 1). Stratiform and discordant megabreccia bodies cut rocks of the Roan, Nguba and at least the lowermost Kundelungu groups and are interpreted to represent the remnants of diapiric evaporites which were later largely dissolved (Selley et al., 2018). Original sedimentary compositions were affected by post-sedimentation diagenetic and hydrothermal alteration in the study area.

METHODOLOGY:

- Stratigraphic contacts and structures were mapped from airborne magnetic data (Fig 1.a)
- Areas with outcrop or containing drill holes and/or trenches were utilized to "pin" geological lithologies with soil geochemical results using major element and trace element ratios
- Soil multielement geochemistry results were interpreted manually using ioGAS^{TM} software and results validated against drillhole weathering profiles
- The 25,317 soils samples were prepared by sieving 2kg of B horizon material. The <180 um fraction was analysed by ALS Johannesburg using MS-ME61 method

Table 1. Study area stratigraphic column integrated with Congolese Copperbelt Stratigraphy after Cailteux et al., 2005.

| Group	Subgroup	Formation	Map Unit	Lithology
Kundelu-ngu	Ngule - Gombella	Upper Ku	u-Ku	
		Mid-Ku	m-Ku	
		Lower Ku	l-Ku	Diamictite, carbonate and siltstone
Nguba	Bunkeya	Monwezi	X.12	Siltstone, mudstone
			X.11	Interbedded mudstone-siltstone and sandstone turbidite deposits
			X.10	
			X.9	
	? 'Minibasin'		X.8	Mudstone and siltstone
			X.7	
			X.6	
			X.5	
			X.4	?
			X.3	Dolomite and calcareous mudstone
			X.2	?
			X.1	Mudstone
		Serie Recurrent	Ng 2.1	Interbedded mudstone and dolomite
	Muombe	Kakontwe	Ng1.3 -	Dolomite
		Kaponda	Ng1.2	Dolomite interbedded with siltstone
		Mwale	Ng1.1	Debrite interbedded with turbidites
Roan	Mwashya	Kafubu ?	R 4	Siltstone-mudstone turbidites
		Kamoya?		Calcareous siltstone
	Dipeta	Dipeta	R 3.2	Dolomite with evaporite textures
		R.G.S.	R 3.1	Interbedded hematic mudstone and dolomite with evaporitic textures
	Salt Breccia			Heterogeneous megabreccia with a dolomite cement matrix
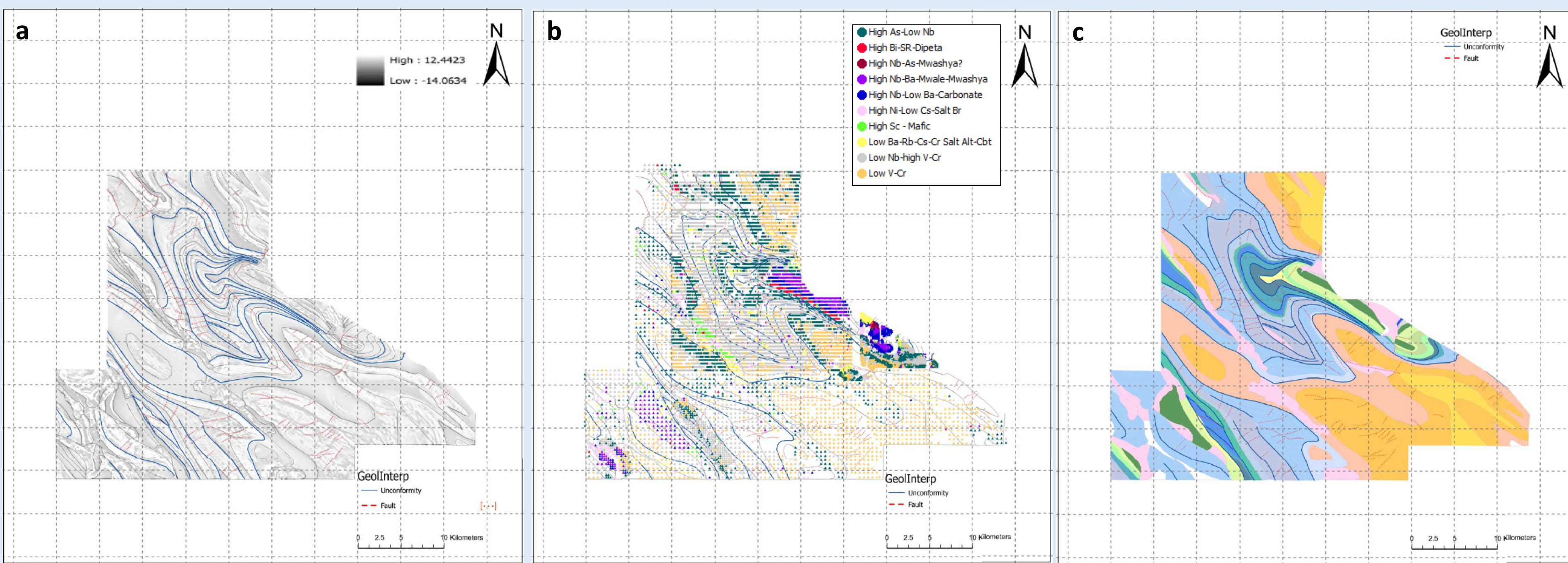
Figure 1a, airborne magnetic survey RTP VD1. **b**, soil geochemical characteristics. **c**, lithostratigraphic map derived from integrated airborne geophysical surveys and soil geochemical surveys (see Table 1 for legend).
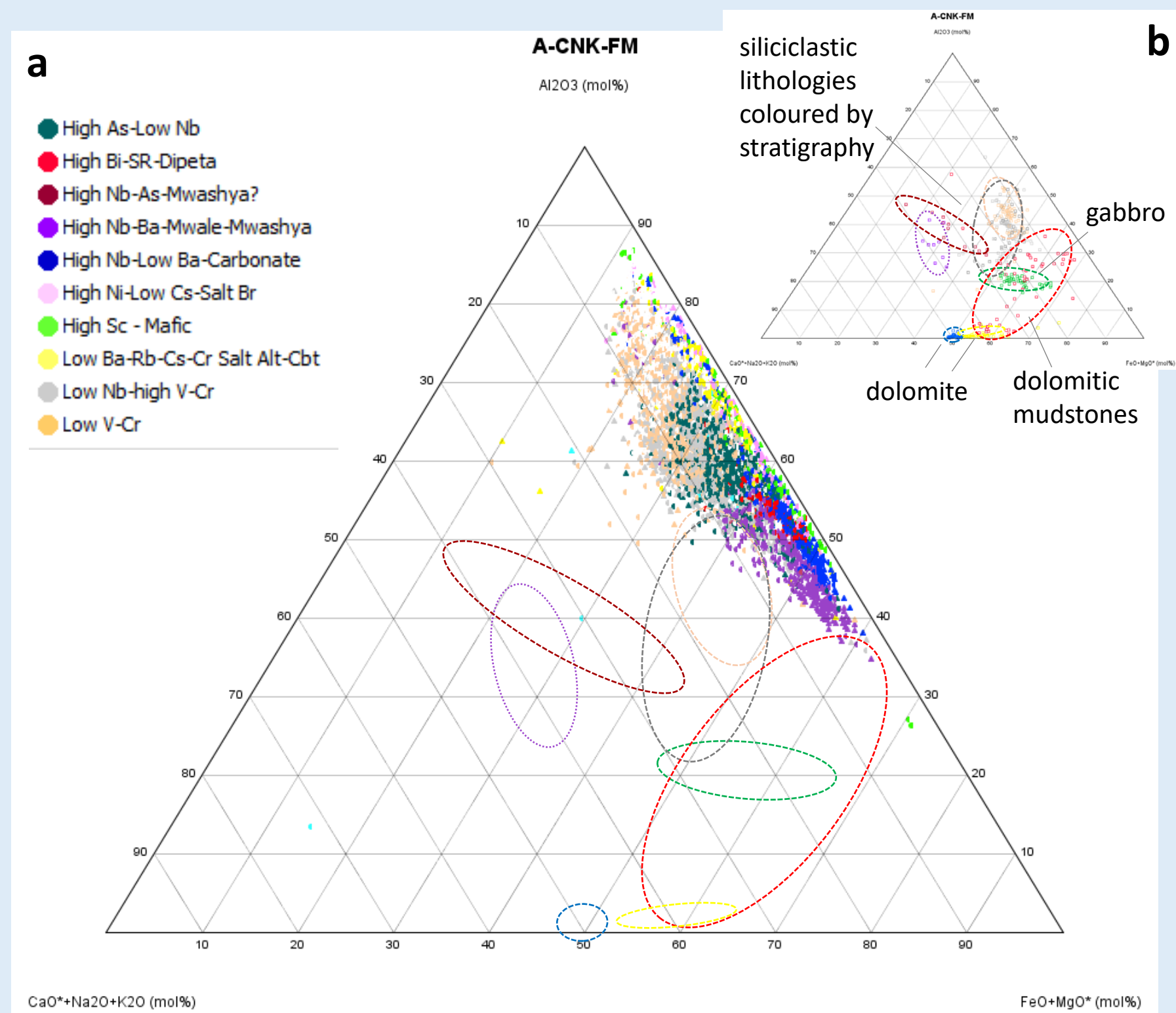

Figure 2. a, weathering paths across an A-CNK-FM diagram from unweathered drillcore (**b**) towards Al_2O_3 apex.
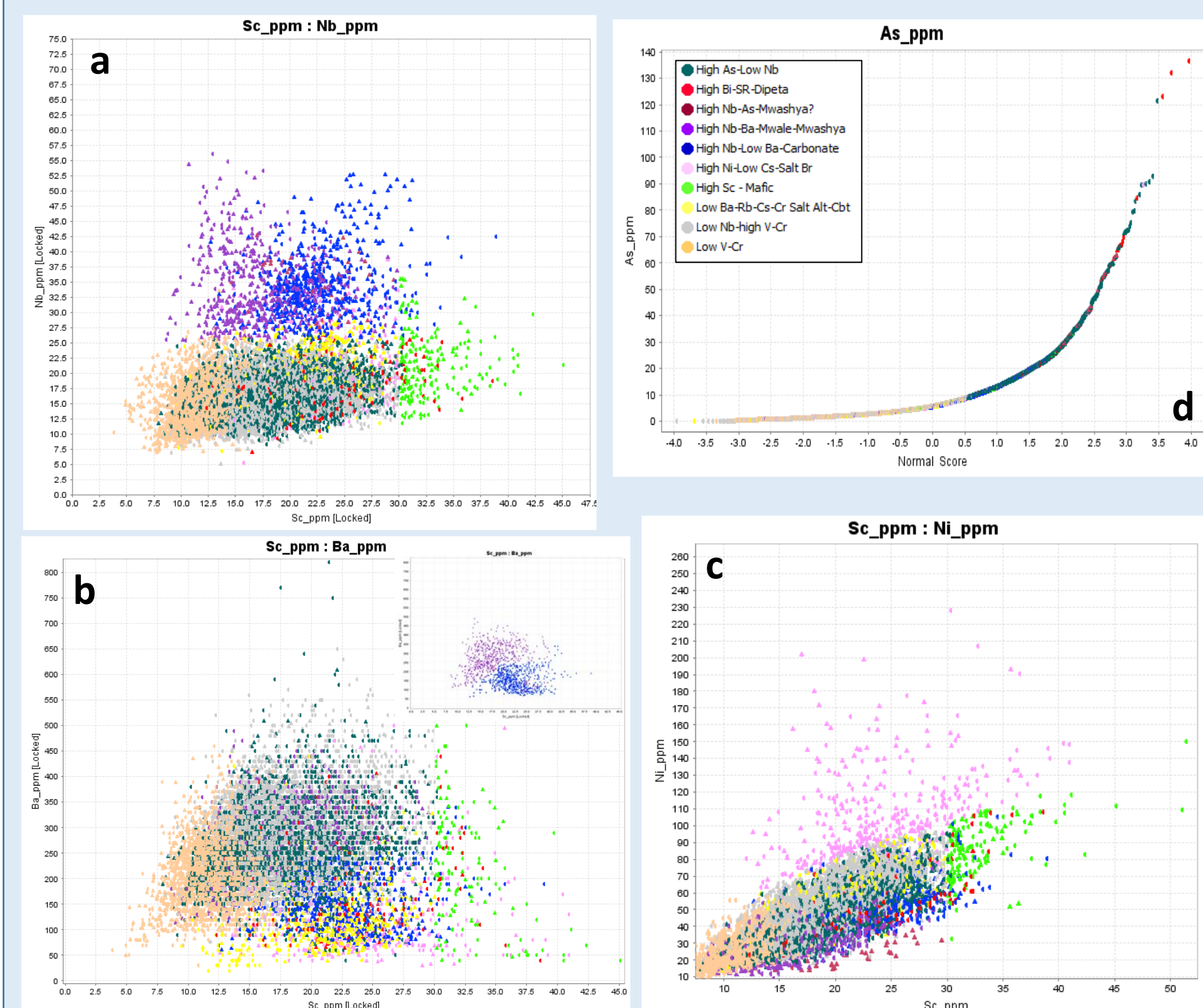

Figure 3, scatter plots used to discriminate lithology: **a**, Sc versus Nb. **b**, Sc versus Ba. **c**, Sc versus Ni and **d**, probability plot of As.

RESULTS:

- Intense weathering of carbonate rocks and carbonate-rich breccias (after evaporites) formed residual soils that are amongst the most aluminum rich in the study area (Fig 2)

- Weathering of siltstones, mudstones, and diamictites produce residual soils which plot closer to the composition of unweathered drillhole samples (Fig 2). This is likely due to a higher proportion of less soluble minerals in siliciclastic rocks (Tiddy et al., 2019)

- Trace element distribution plots demonstrate that the soils over the Roan Group, Mwale and Kakontwe formations are enriched in Nb (Fig 3a) in addition to Fe (Fig 2) and that Kakontwe carbonates can be distinguished by low Ba content (Fig 3c)

- Anomalously high As is characteristic of two minibasin units in the Nguba Group and the base of the Lower Kundelungu

- Anomalously high Bi delineates residual soils over the Serie Recurrent

- Soils over the Upper Kundelungu are depleted in V and Cr and an elevated Sn:Sc ratio

DISCUSSION :

The strong relative enrichment of Al and Fe in soils over carbonate sedimentary rocks is probably due to significant volume reduction of clean dolomite units as Ca^{2+} and Mg^{2+} are almost completely lost due to weathering in equatorial climate zone. Topographic depressions located over thick carbonate successions in the study area suggests increased volume loss of carbonate rocks during weathering compared to siliciclastic rocks.

The heterogeneous salt breccia is mapped by three soil populations, a high-Ni, moderate-Sc group and a high-Ni-Sc group, both of which appear to be indicative of gabbro clasts, and a low Ba-Rb-Cs-Cr group which may represent altered siliciclastic rocks or carbonate lithologies. Work is currently focused on defining the geochemical signature of weathered altered sedimentary rocks.

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