Compilation of the 1:500 000 State Regolith Map of northern Western Australia

Presented by

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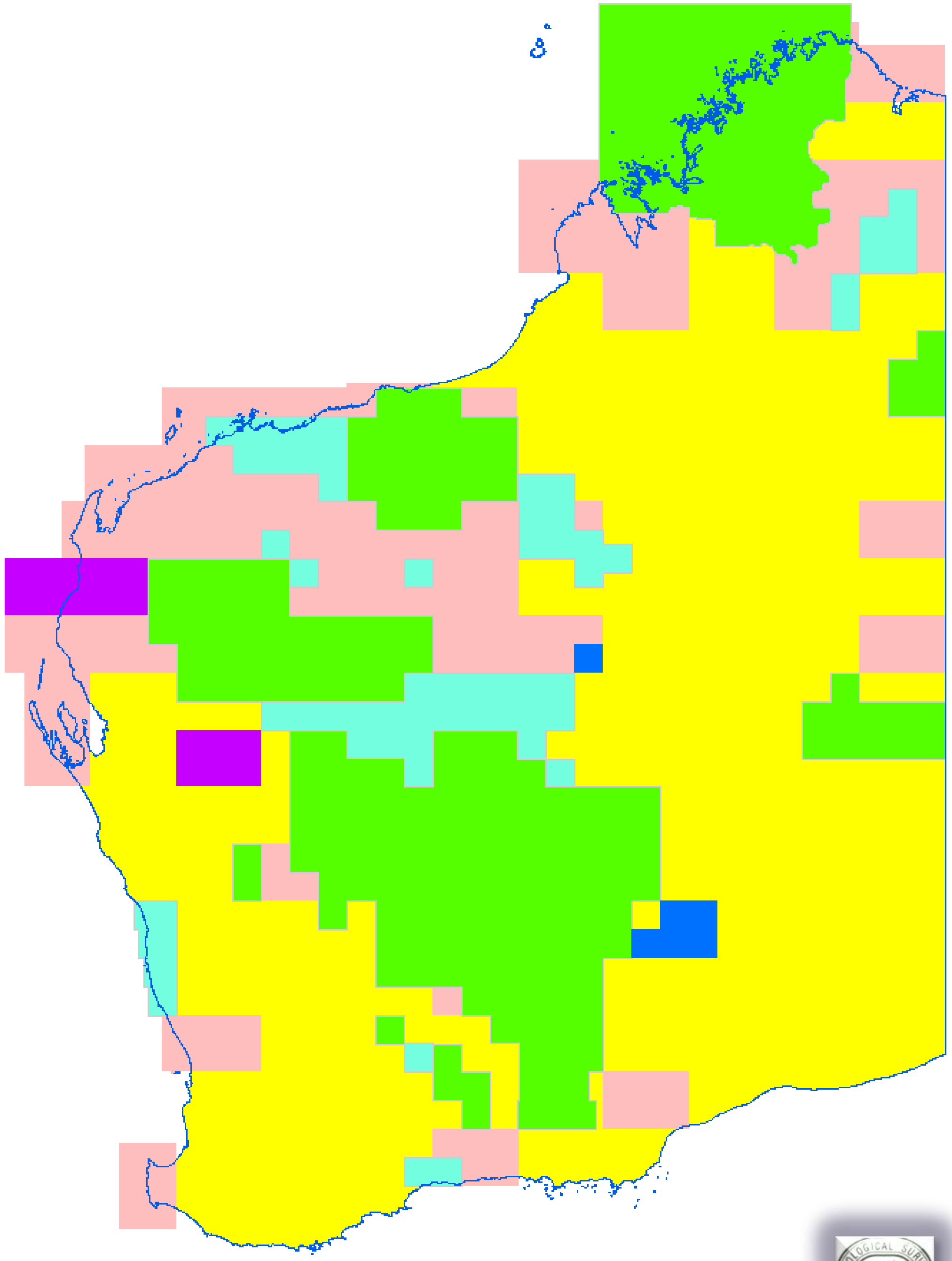
Compilation of the regolith digital layer

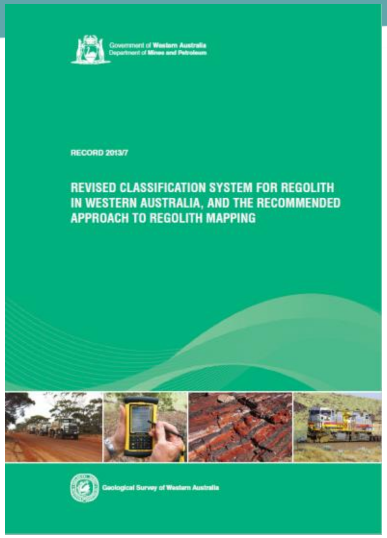
Geographic distribution of the existing GSWA digital map layers containing regolith data

Legend

- Coastline outline
- 1:100k regolith
- 1:250k regolith
- 1:100k digital product geology
- 1:100k paper/CAD Series maps
- 1:250k surface geology
- 1:250k paper/CAD Series maps



Simplifying and recoding from old to new



GSWA Record 2013/7

GSWA regolith classification system expands Anand et al. 1993 RED scheme

1st – landform

2nd – composition

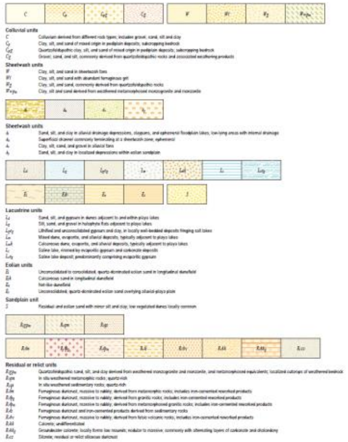
3rd – parent

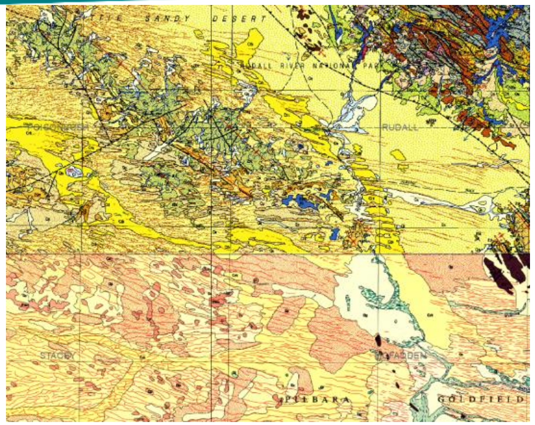
Webb 1:250 000

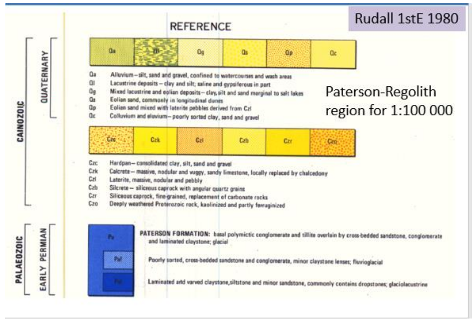
Simplify codes to 1st and 2nd qualifier

e.g. ferruginous duricrust derived from monzonite

_Rr-f-pm _Rr-f



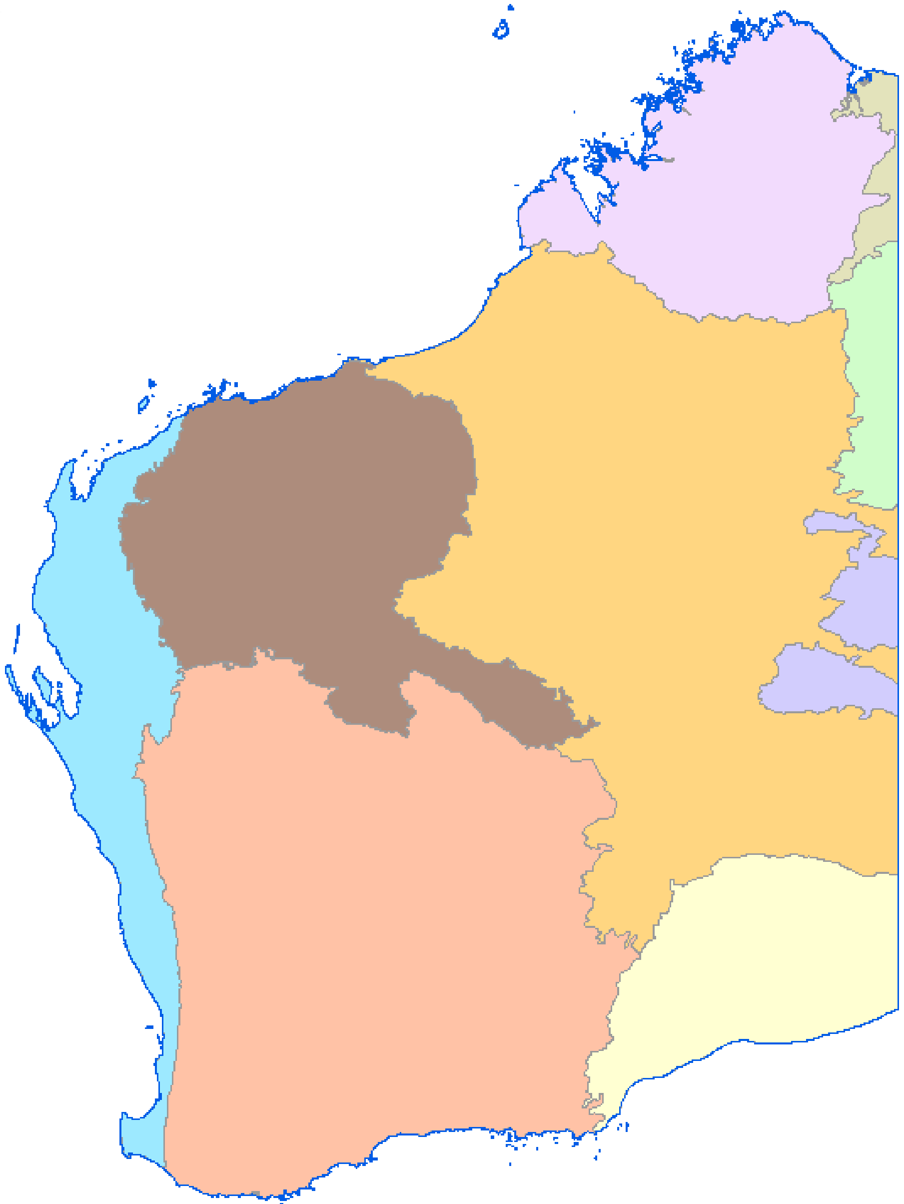




Translate 'old' codes narratives to current regolith record system, e.g. Czl various narratives; according to map scale, and person mapping

SHEETNUM	CODE	DESCRIPTN	NEWCODE	JNCODE	SYMBOL
e5106	Qa	Sand, silt, clay; minor gravel: alluvial and l	_A	f5015;Cza	Cza; Alluvium - partly consolidated silt, sand, and gravel
e5106	Qb	Clay, silt: alluvial and lacustrine	_A	g5202;Qa	Qa/Pza; Alluvium
e5106	Qs	Sand, silt; minor gravel: mixed alluvial and	_Aa	e5106;Qa	Qa; Sand, silt, clay; minor gravel: alluvial and lacustrine
e5106	Qcd	Calcareous sand, partly oolitic: coastal aeo	_Bd	e5106;Qb	Qb; Clay, silt: alluvial and lacustrine
e5106	Qz	Red sand, fine to medium; minor silt: aeol	_E	f5113;Qd	Qd; Clay, silt, sand
e5106	Czl	Laterite, pisolitic or massive: pedogenic	_Rr-f	g5001;Q	Q; Deposits of mixed or uncertain origin--alluvial, colluvial, elluvial and eolian clay, silt, sand and gravel
e5106	Qci	Silty clay, black organic clay: tidal flat and	_Tm	g4904;Qa/Tt	Qa/Tt; Alluvium: deposits of Gascoyne River--clay, silt, sand and gravel
e5106	Qcs	Clay, silt, sand; minor salt: supratidal mud	_Tu	f5010;Qa	Qa; Alluvium
e5106	Qpb	Calcareous and quartzose sandstone, fine	_X-k-s	f5016;Qa	Qa; Alluvium - unconsolidated silt, sand and gravel
e5106	Kb	Sandstone, fine to very coarse; mudstone	_X-l-s	f5015;Qa	Qa; Alluvium - unconsolidated silt, sand, and gravel
e5106	Km	Sandstone, fine to medium, well-sorted; l	_X-l-s	g4904;Qa	Qa; Alluvium: deposits of Gascoyne River--clay, silt, sand and gravel
e5106	Kr	Sandstone, fine to coarse, poorly sorted; r	_X-l-ss	e5209;Qa	Qa; Alluvium-unconsolidated silt, sand, and gravel
e5107	Qs	Sand, silt; minor gravel: alluvial and aeolia	_Aa	g5202;Qa	Qa?; Alluvium
e5107	Qb	Clay and silt: black soil	_Aa-cb	f5006;Qb	Qb; Alluvium. Unconsolidated sand, gravel and pebbles; over kunkar or granite
e5107	Qcb	Quartzose sand, shelly in places: beach rid	_Bb	i5105;Qpv	Qpv; Alluvium of mature drainage
e5107	Czk	Calcrete, minor chalcedony: evaporitic pe	_Rr-k-k	g4904;Qpw	Qpw; Areas subject to intermittent flooding; mixed alluvial and eolian - sand, silt and clay, minor pebbles
e5107	Qci	Silty clay, black organic clay: minor salt: tid	_Tf	f5113;Qr	Qr; Mixed gigai and gravel flood plain; low slope deposit
e5107	Qcs	Clay, silt, sand; minor salt: supratidal mud	_Tu	i5005;Qra	Qra; Alluvium: mud, silt and sand
e5107	TRb	Mudstone, sandy mudstone, laminated to	_X-c-s	h5014;Qra	Qra; Alluvium-clay, sand and loam
e5107	Phc	Mudstone, calcareaous, fossiliferous; sand	_X-k-s	e5107;Qs	Qs; Sand, silt; minor gravel: alluvial and aeolian
e5107	Pn	Mudstone, calcareous, micaceous; limest	_X-k-s	e5106;Qs	Qs; Sand, silt; minor gravel: mixed alluvial and aeolian
e5107	Ja	Sandstone, fine to medium; interbedded	_X-l-s	f5011;Cza	Cza; Alluvium - partly consolidated silt, sand, and gravel; old alluvium dissected by present-day drainage
					Cza; Alluvium--clay, silt, sand and gravel, partly

$$\textit{Landscape} = \frac{\textit{rock type + rock structure+climate+weathering+erosion}}{\textit{Time}}$$



- Barkly-Tanami Plains Province
- Central Australian Ranges Province
- Kimberley Province
- North Australian Plateaus Province
- Nullarbor Plain Province
- Pilbara Province
- Sandland Province
- Western Coastlands Province
- Yilgarn Plateau Province

Geomorphological physiographic units after Pain et al. (2011)

Physiographic units are equivalent to tectonic units for lithostratigraphic units

Lithstrat	A-cib-YEG
Regolith	_Rs-ck-pg-PIP (100k, 250k)
	_Rs-ck-PIP (500k)

'Old' mapping codes	Current regolith codes GSWA Record 2013/7	Simplified to 1st and 2nd order qualifier	Physiographic units suffix (Pain et al., 2011)
Ama Amphibolite	Xmm	_X-m	_X-YIP
Cczk Calcrete on cemented colluvium derived from ultramafic rock	Rku	_R-k	_R-k-PIP
CzCb Colluvium; dissected gravel deposits derived from Fortescue Group	Clm	_C-l	_C-l-PIP

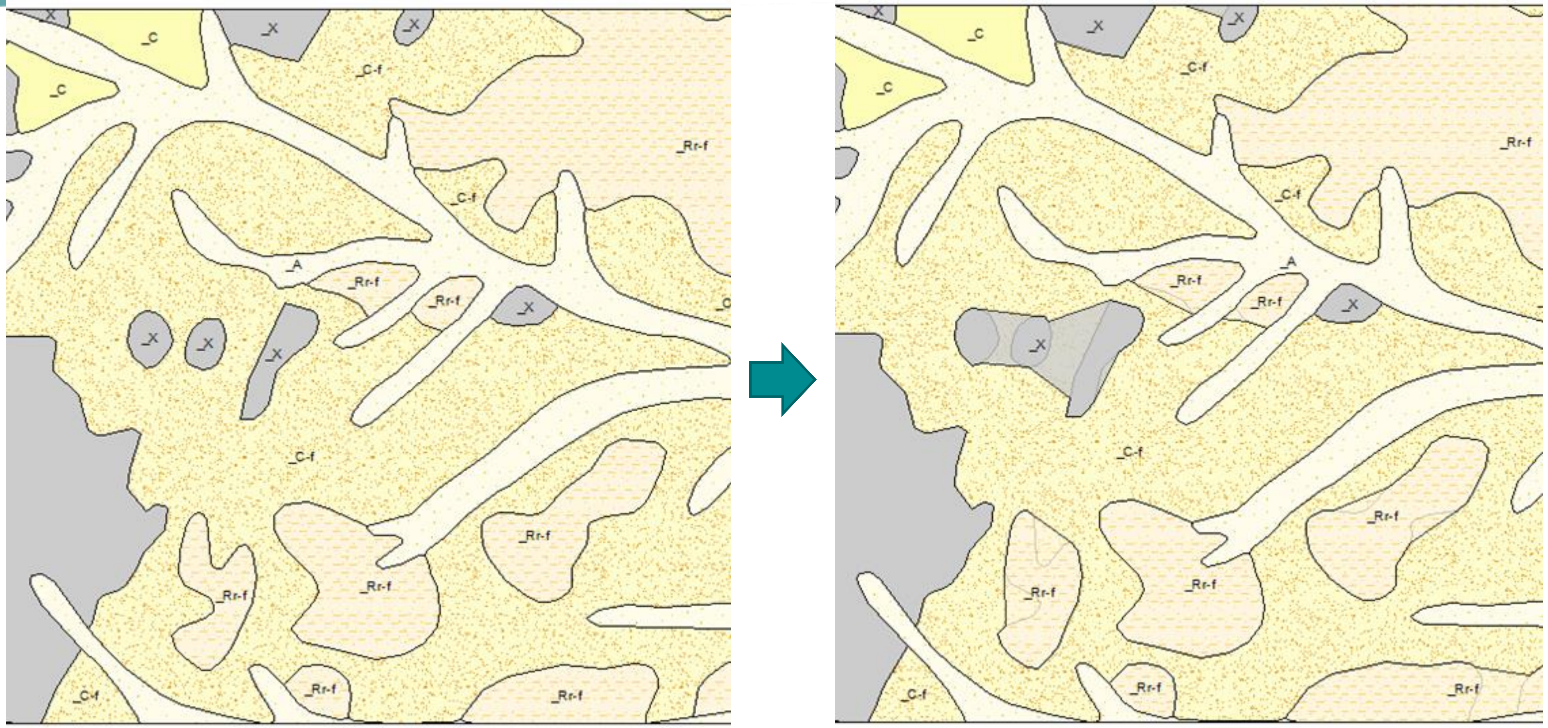
Table 1. An example of code conversion to the current Regolith Record 2013/7 including the physiographic province suffix

Semi-automated spatial downscaling

Aggregation

Performed in GIS environment using in-house build aggregation tool for ArcMap

- Define and isolate geological units to be aggregated
- Aggregate units with desired size and distance from each other
- Preserve alluvium



Map Scale	1:100 000	1:250 000	1:500 000
Polygons in m²	12 000	75 000	300 000
Width in m	100	250	500

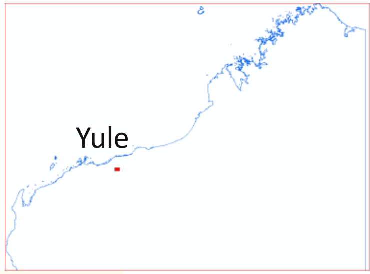
Table 2. Cartographic minimum area and width criteria for polygons at the given map scale

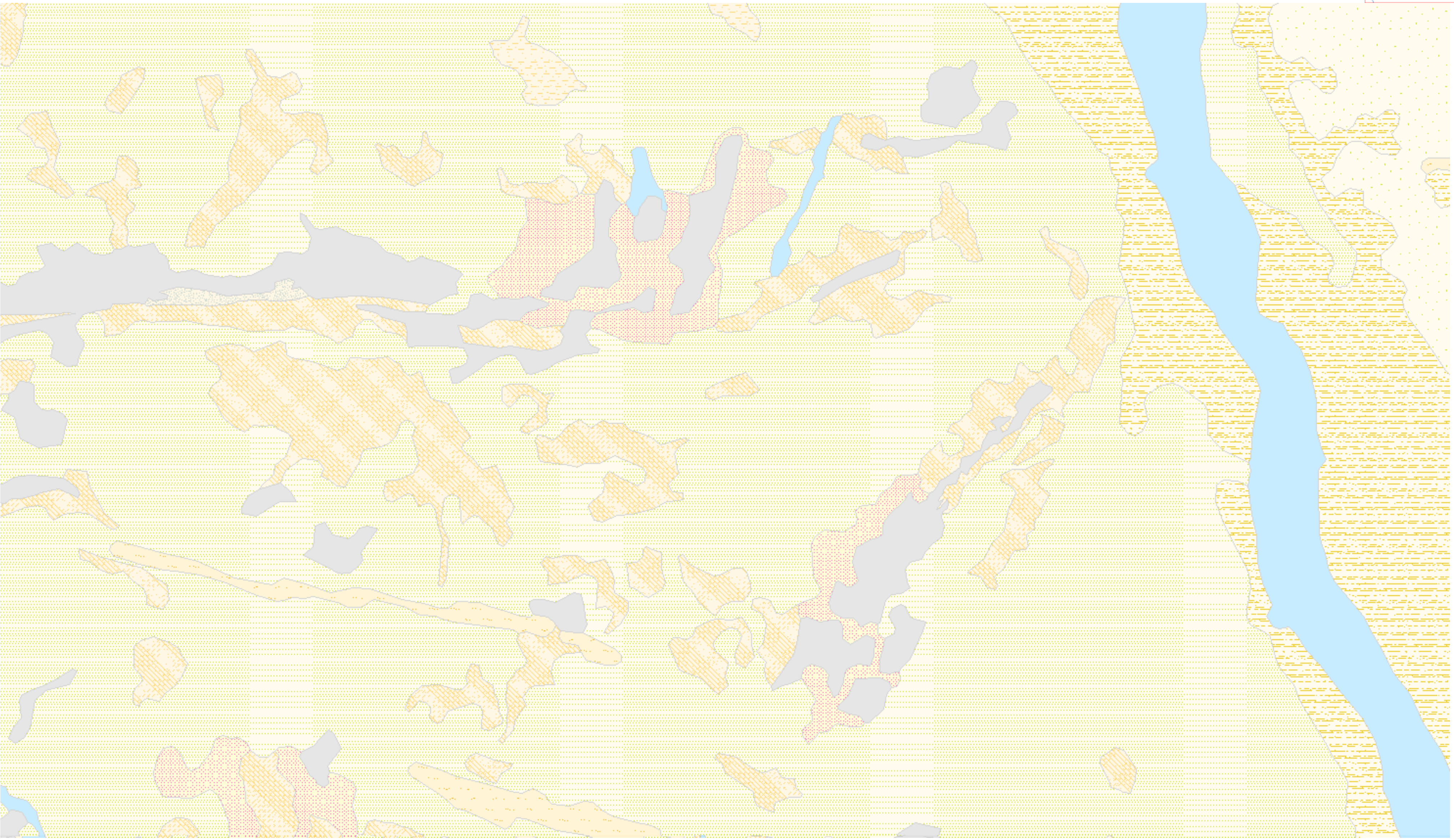
Generalisation

Using **GeoScaler** tool for generalizing surficial and geology maps

- Developed at LNC (Labaratorie de cartographie numerique et de photogrammetrie), Quebec Division, Geological Survey of Canada (Hout-Vézina et al., 2012)

- Requires ArcGIS Spatial Analyst/ArcInfo licenses
- Eliminates microfeatures
- Simplifies polygon contours
- Manual editing for edge fitting and topology cleaning



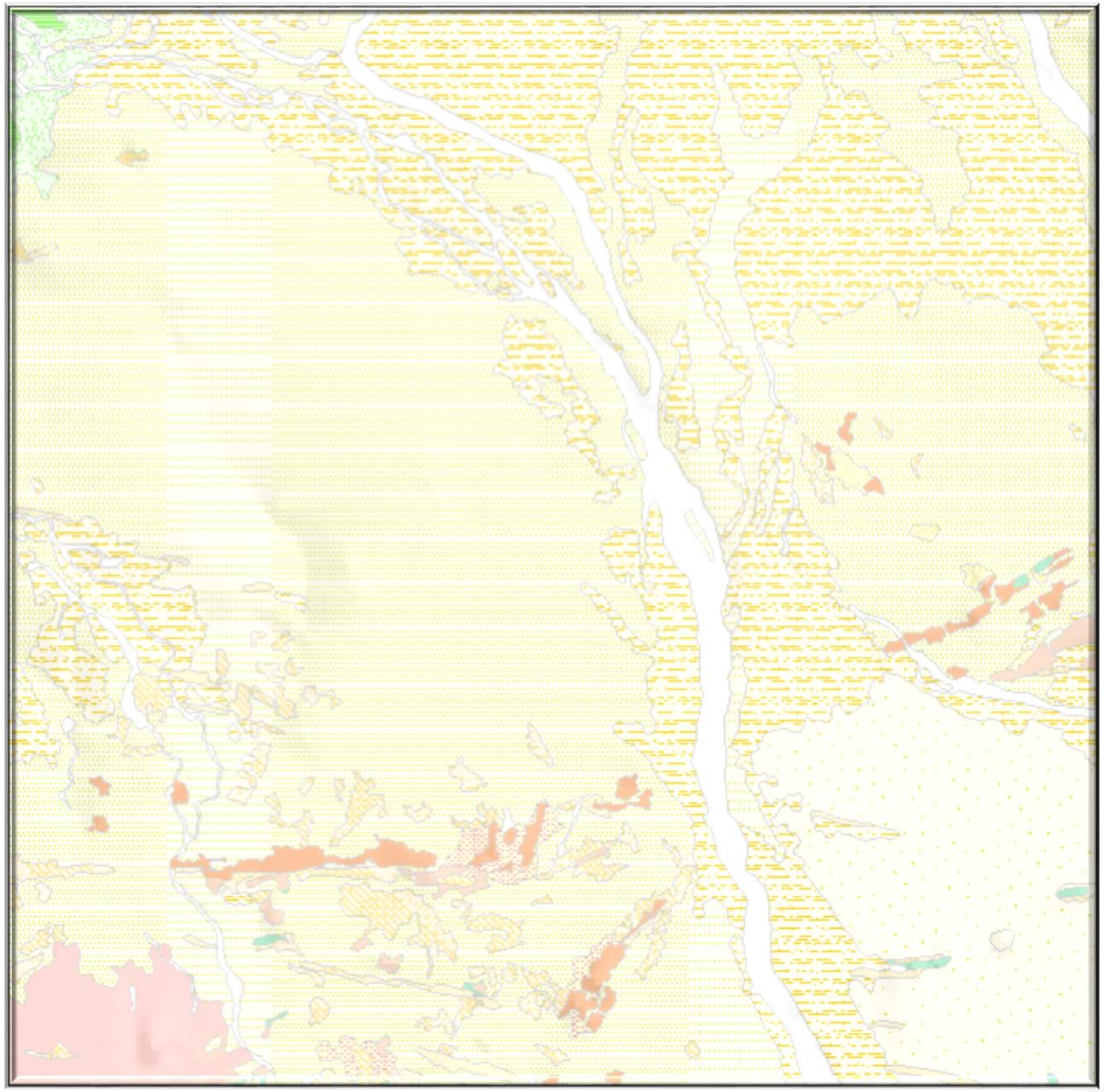


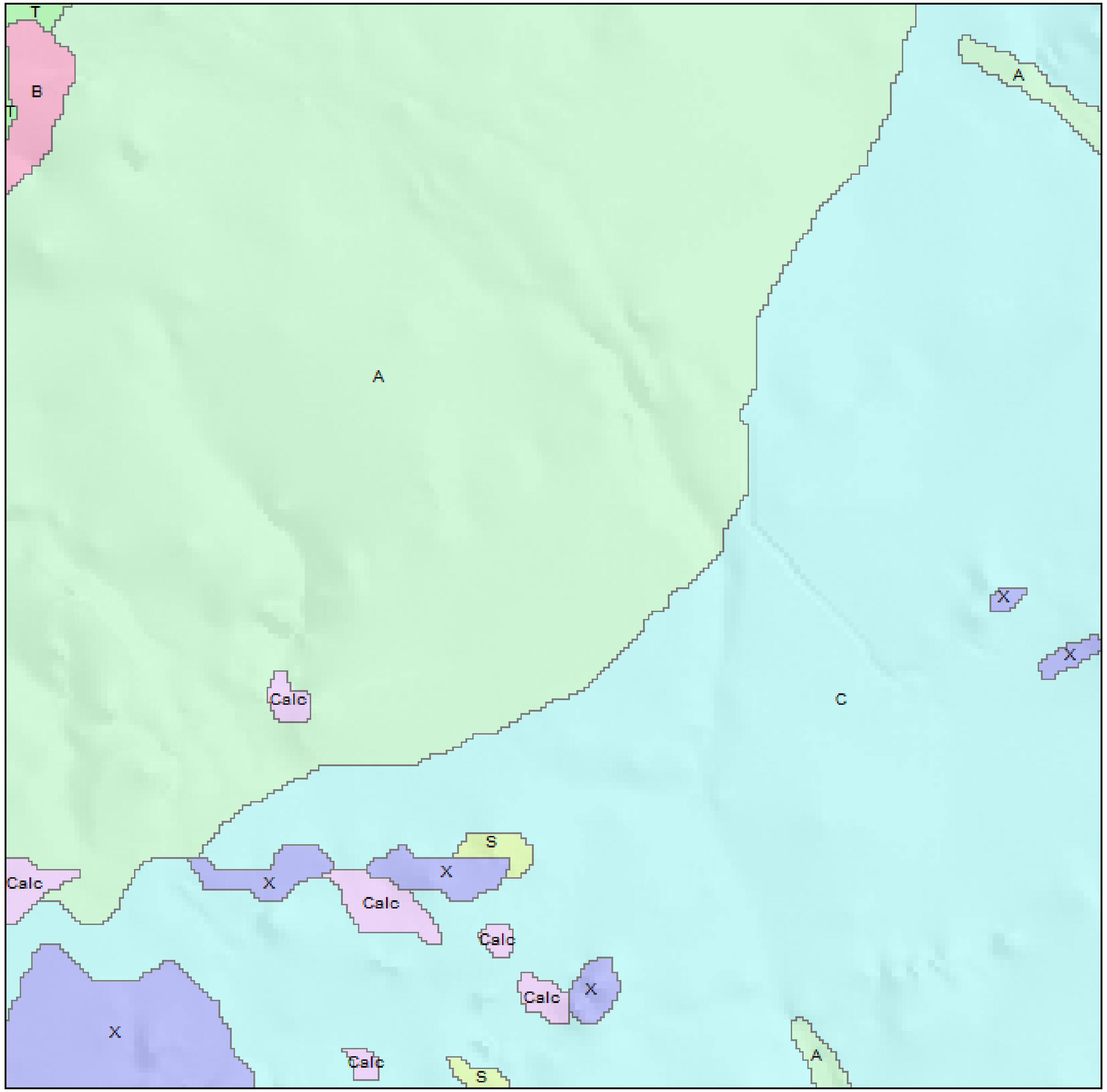
1:500 000 State Regolith Map over the Yule map sheet; 2003 edition

- largely from 250k map sources
- manual drawing
- generic regolith codes
- very rasterized

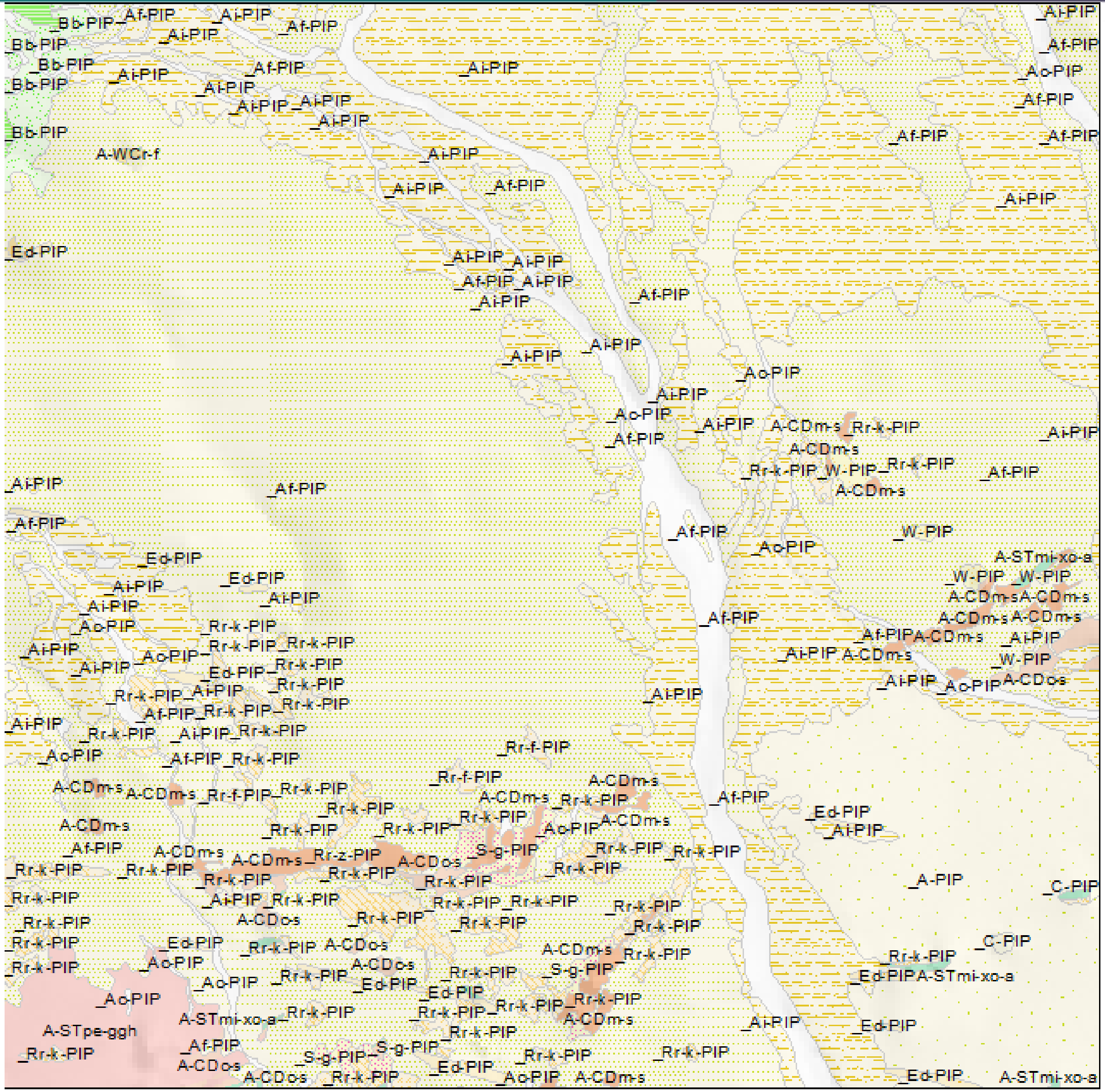
1:500 000 State Regolith and IBG maps over the Yule map sheet; 2019 edition

- all regolith coverage available at 100k scale
- revised regolith classification scheme
- compiled using an automated algorithm for polygon generalization



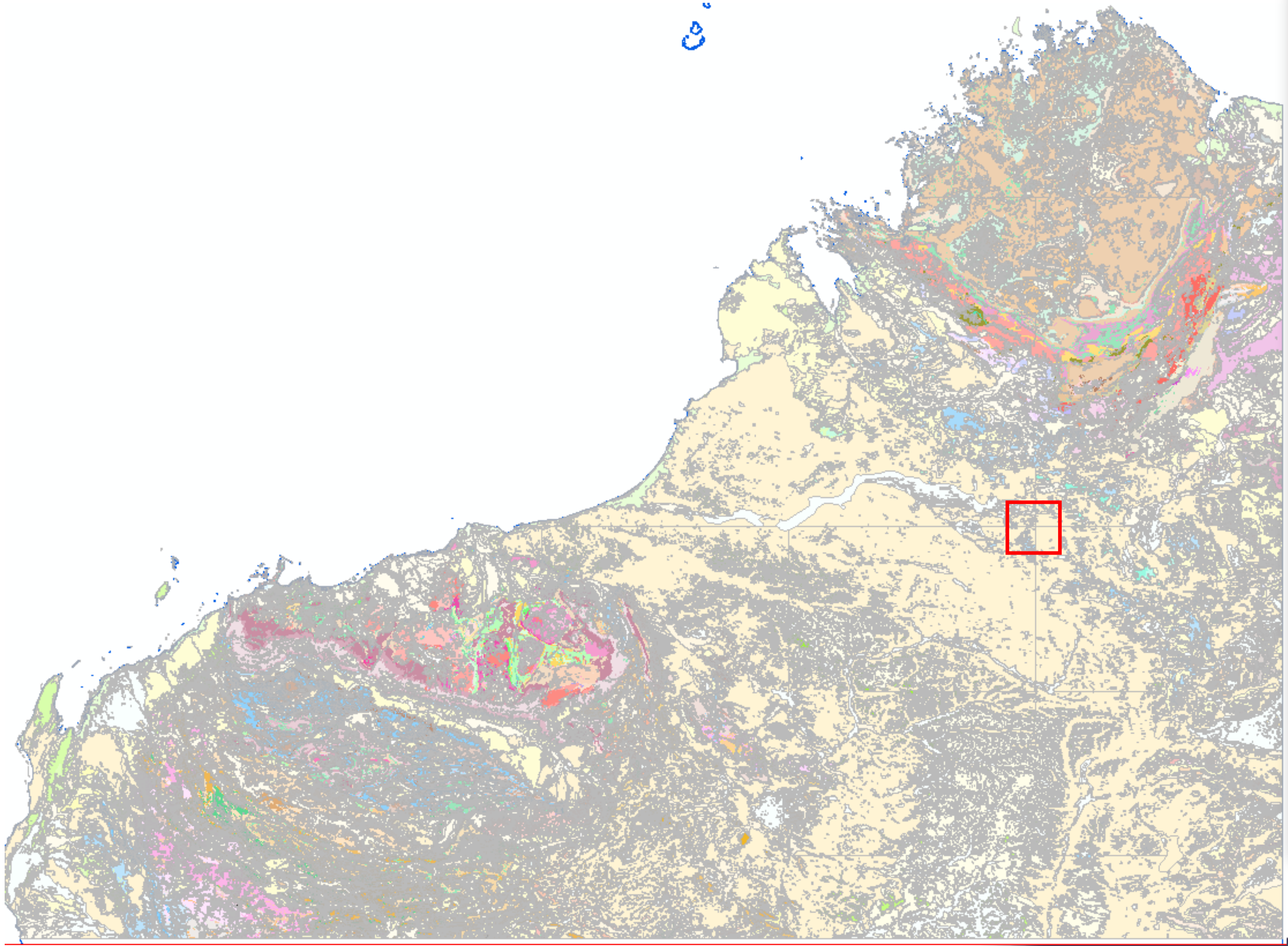


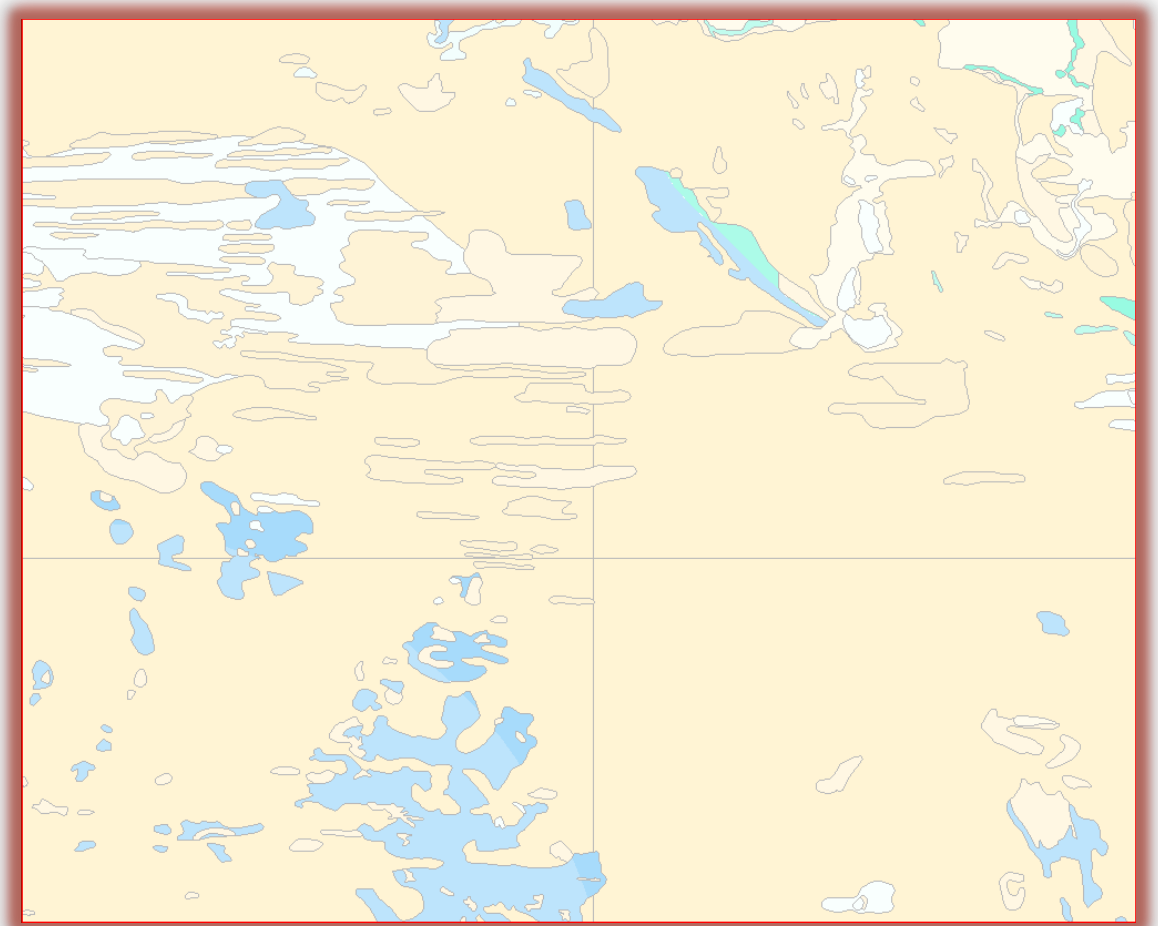
1:500 000 State Regolith Map over the Yule map sheet; 2003 edition



1:500 000 State Regolith and IBG maps over the Yule map sheet; 2019 edition

- For performance purposes, large polygons have been split along the 250 000 margins, creating long linear lines in the map

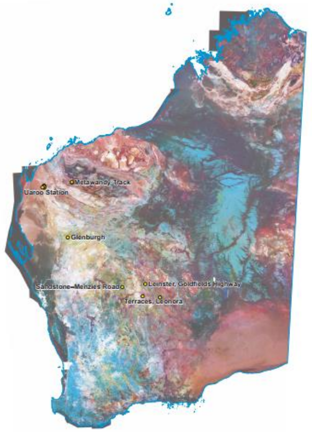




REGOLITH GEOCHRONOLOGY

Collaborative project with John de Laeter Centre

- (U–Th)/He dating of iron oxide minerals in lateritic duricrust
- To understand weathering, landscape evolution and paleoclimate history
- The technique of dating secondary Fe-oxides in weathering systems has been demonstrated by:
  - dating of duricrust from the Kimberley area (2016 pilot project)
  - dating of ferruginous duricrust from the Boddington gold mine (GSWA Record 2018/13)



Fifteen samples from the Yilgarn Craton and Capricorn Orogen are currently being analysed

- Ternary KTU radiometric image of WA draped on a digital elevation model (DEM), showing the locations of ferruginous duricrust sampled for dating
- Areas in blue and green represent the radiometric responses for U and Th present in minerals such as zircon and monazite, which are commonly resistant to chemical weathering
- Residual regolith, including ferruginous duricrust, generally has high radiometric responses for Th and U

The Terraces, Leonora: ferruginous duricrust – regolith profile on granite sampled for (U–Th)/He dating

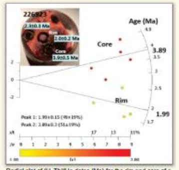
Regional duricrust ages will be combined with the State regolith map:

- to highlight patterns and variation of ferruginous duricrust ages in WA
- to understand the evolution of landscape and past climatic conditions
- to detect the distribution of economic mineral signatures in the cover

Late Miocene – Pliocene pisolitic duricrust nodules at Boddington gold mine

Nodules: 5.8 – 1.3 Ma

Boddington gold mine, South West Terrane



Radial plot of (U–Th)/He-dates (Ma) for the rim and core of a large pisolite at Boddington gold mine (GSWA sample 226923)

Pisolitic duricrust formed by the weathering of granite, Boddington gold mine

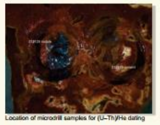
GSWA Record 2018/13, Wells, MA, Danisik, M and McInnes, BIA 2018

Miocene duricrust in the Kimberley, with cement younger than nodules

Nodules: Miocene, 22.4 – 10.4 Ma

Cement: Late Miocene – Pliocene, 6.7 – 2.3 Ma

Aluminous and ferruginous duricrusts on mesas developed on Carson Volcanics, northern Kimberley Plateau



Location of microdrill samples for (U–Th)/He dating

Sample showing nodules and cement textures

Curtin University

John de Laeter Centre

Research in this poster uses the TIMA instrumentation, funded by ARC LE140100150 at the John de Laeter Centre, Curtin University

Exploration Incentive Scheme

REGOLITH-LANDFORM DIGITAL LAYER

GSWA is currently producing a seamless State 1:500 000 regolith-landform digital layer of Western Australia, which will be available on GeoView.WA and complement the current State 1:500 000 interpreted bedrock geology layer. The compilation of the State 1:500 000 regolith-landform layer involves the combination of seamless 1:100 000 project geology layers (where available), 1:250 000 scale 1st edition surface geology, and 1:100 000 and 1:250 000 regolith layers available in GSWA database (Fig.1). This requires the polygons to be edited (aggregation and generalization) and the regolith units to be re-coded to comply with the current system used by GSWA (GSWA, Record 2013/7). The required steps to compile this digital layer are illustrated below

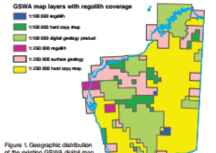


Figure 1. Geographic distribution of the existing GSWA digital map layers containing regolith data.

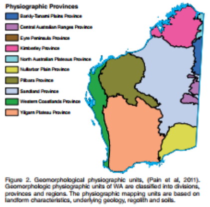


Figure 2. Geomorphological physiographic units, (Pain et al, 2011). Geomorphologic physiographic units of WA are classified into divisions, provinces and regions. The physiographic mapping units are based on landform characteristics, underlying geology, regolith and soils.

RE-CODING

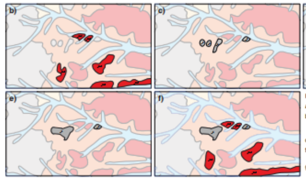
Recoding requires code translation to the current regolith classification system, as per GSWA Record 2013/7. The unit codes will be composed of a primary landform code qualifier, a compositional secondary code qualifier, and a physiographic unit suffix as exemplified in Table 1.

'Old' mapping codes	Current regolith codes *GSWA Record 2013/7*	Simplified to 1st and 2nd order qualifier	Physiographic unit suffix (Pain et al, 2011, Fig 2)
Ama Amphibolite	Xmm	_X-m	_X-YIP
Czck Calcrete on cemented colluvium derived from ultramafic rock	Rkku	_Rk	_Rk-PIP
Czcb Colluvium; dissected gravel deposits derived from Fortescue Group	Clm	_C-l	_C-l-PIP

Table 1. An example of 'old' regolith codes converted to the current Regolith Record 2013/07 including the physiographic province suffix

AGGREGATION

Aggregation implies merging neighbouring polygons of the same code. It is performed in GIS environment using in house built aggregation tool for ArcMap. To obtain the best results with aggregation a series of parameters need to be implemented. In the case the WA State regolith-landform layer map the parameters are listed and illustrated in Figure 3.



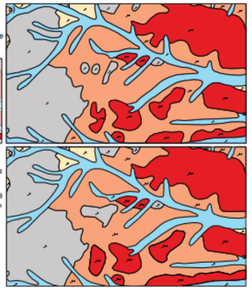


Figure 3. Steps in the aggregation process:

a) Before aggregation

b) and c) define and isolate the units to be aggregated e.g. _X (rock outcrops) and _Rr-f (ferruginous duricrust) polygons < 350 000 m²

d) and e) aggregate with desired distance (e.g. 200 m)

f) alluvium units preserved, replaces any interruption of aggregated residual or outcrop units

g) combined results after aggregation

GENERALIZATION

Resolving the 'small polygons' problem.

Generalization implies editing the layers original line work and polygon geometry to be legible at 1:500 000 scale by using the Geoscaler Arc GIS tool. This process includes removing, amalgamating or redrawing polygons that fall below the minimum areas restrictions of the aimed map scale (Table 2). An example of polygons that require the generalization process for the desired map scale is illustrated in Figure 4.

Minimum areas and widths for geological features

Map scale	1:100 000	1:250 000	1:500 000
Polygons in m²	12 000	75 000	300 000
Width polygons in m	100	250	500

Table 2. Cartographic minimum areas criteria for polygons to be legible at the given map scales

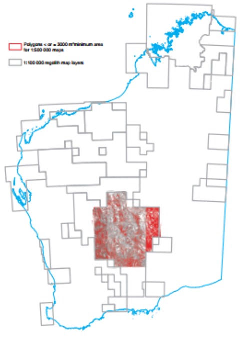


Figure 4. The distribution of polygons that are smaller than the minimum tolerable area (small polygons) in the Yilgarn and Musgraves regolith 1:250 000 map layers. Small polygons are highlighted in red.

GeoScaler

GeoScaler is a software that works as an ArcGIS geoprocessing tool (Fig. 5) designed for automated generalization of surficial and bedrock geology maps, in other words it can upscale or downscale the maps. It works by recalculating the geometry of the polygons and adjusting their dimensions from the original scale to the desired one. This involves four main steps: data preparation, cellular automata, post processing and raster to vectorconversion.

GeoScaler was developed at LNC (Laboratorie de cartographie numerique et de photogrammetrie) of the Quebec division of the Geological Survey of Canada.

Figure 5. Geoscaler is an ArcGIS tool free to download from www.geoscan.nrcan.gc.ca

An example of the new layer product, after aggregation of Geoscalar generalization is shown in Figure 6.

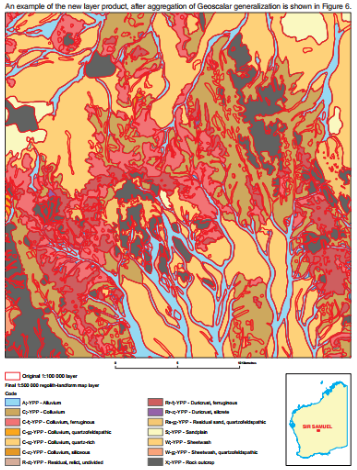


Figure 6. Map shows part of 1:500 000 regolith-landform layer of Western Australia, on Yilgarn Plateau Physiographic Province. Original map layer was downscaled from 1:100 000 to 1: 250 000 scale and then from 1:250 000 to 1:500 000 scale. The original 1:100 000 layer is shown in red contouring lines overlapping the final 1:500 000 map layer shown in colour.

References

Geological Survey of Western Australia 2013, A revised classification system for regolith in Western Australia, and the recommended approach to regolith mapping: Geological Survey of Western Australia, Record 2013/7, 26p.

Pain C, Gregory L, Wilson P., and McKenzie N. 2011, The physiographic regions of Australia, explanatory notes: Australian Collaborative Land evaluation Program, National Committee on Soil and Terrain, 35p.

Huot-Vezina, G., Boivin, R., Smirnoff, A., and Paradis, S.J., 2012. GeoScaler: Generalization tool (with a supplementary user guide in French); Geological Survey of Canada, Open File 6231, (2nd edition).

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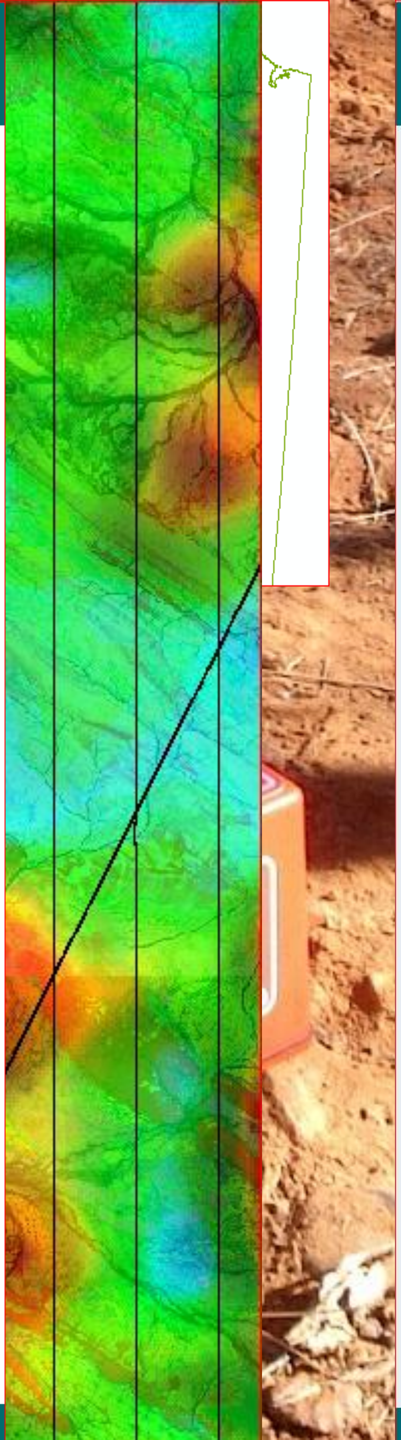

APPLICATION OF PASSIVE SEISMIC AND AEM TO 3D PALEOCHANNEL IMAGING: CAPRICORN OROGEN

INTRODUCTION

The aim of this project is to use multiple geophysical methods in conjunction with drilling information to produce a 3D model of the Yangibana paleochannel, located in the Gascoyne region, Western Australia (Fig.1). The results will inform landscape evolution studies and groundwater exploration.

ACQUISITION

In August 2018 the Geological Survey of Western Australia acquired shallow passive seismic data over the Yangibana paleochannel via a seismic survey. The survey was designed using regional magnetic and airborne electromagnetic data (AEM). The acquisition was carried out using the single station HVSR (horizontal-to-vertical spectral ratio) method with Tromino® instruments (Fig. 2). Data were acquired over nine traverses, with seven traverses crossing the paleochannel interpreted from the magnetic data. The remaining two traverses follow sections of two AEM survey lines from the Capricorn regional dataset.

The acquisition parameters were:

- 20 minutes recording time
- 100 m spacing between stations
- Line lengths between 2000 and 5200 m

Where available, drilling information and AEM conductivity sections were used to groundtruth HVSR measurements and to obtain velocities for HVSR measurements that lacked drillcore or AEM control. Drillcore data were provided by Hastings Technology Metals Limited.

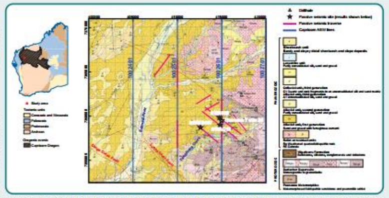

Figure 1. Extract of the Edmund 1:100 000 Geological Series map showing the project area, passive seismic traverses and acquisition sites, AEM survey lines, and the locations of the drillholes.

Figure 2. Field photos showing the typical sandy, lag dominated cover of the project area and two shallow passive seismic sites with Tromino instruments

PRELIMINARY RESULTS

The passive seismic method is a HVSR method that uses three-component measurements of ambient seismic noise to determine and evaluate fundamental seismic resonance frequencies.

Figure 3 shows a series of measured H/V spectra, where peaks indicate an acoustic impedance contrast at depth. In a simple two layer earth, the acoustic impedance contrast defines the boundary between two different geological units. Individual peaks indicate the resonance frequency of the site. Shear wave velocities (Vs) are required to derive depth estimates from the frequencies. Vs were estimated using the depth measurements from the drillhole sites (Fig. 3. a–c) and the equation relating frequency (fz), Vs and thickness (h) as $f_z = V_s/(4h)$.

Figure 3 a–c shows the comparison between H/V synthetic velocity models and the logged geology. The synthetic velocity models, with depths constrained by drillcore data, show that the acoustic impedance contrast measured is the interface between the regolith unit and granitic basement. The Vs values obtained from the model are 280–360 m/s for the regolith unit and 520–700 m/s for the granitic basement. The synthetic models show that the upper layer (regolith) velocities and frequency of the response are crucial parameters, while the lower layer (granitic basement) velocities have minimal effect on the synthetic model response. The Vs obtained from constrained models have been applied to HVSR measurements, without drillcore constraints, to obtain the depth to the basement of 85 m at station 26, traverse 7 (Fig. 3d).

The two coincident AEM lines have been inverted using Intrepid Geophysics 2.5D inversion code. Figure 4a shows the first vertical derivative of total magnetic intensity data in map view and conductivity sections from 2.5D inversion of AEM data. In conductivity section 1002601, the Yangibana paleochannel is associated with a highly conductive zone (Fig. 4b).

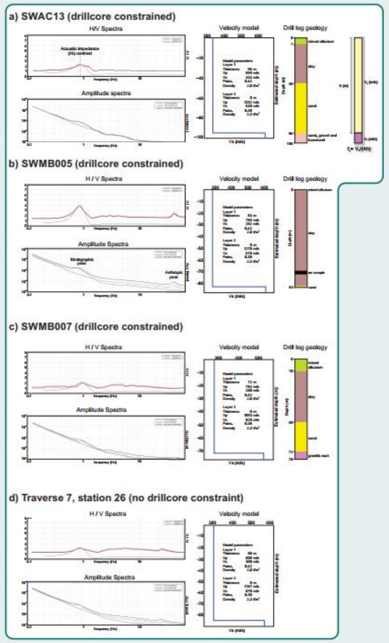

Figure 3. HVSR measurements showing observed and synthetic H/V spectra ratios, corresponding three-component amplitude spectra, velocity model, and available drillcore logs: a) HVSR measurements at drillhole SWAC13; b) HVSR measurements at drillhole SWMB005; c) HVSR measurements at drillhole SWMB007; d) HVSR measurements from station 26, traverse 7, with no constraints from drillcores.

CONCLUSIONS

The HVSR measurements from three drillhole sites indicate that the measured acoustic impedance is mapping the contact between the regolith and the granitic basement.

Drillcore data suggest that the source of the AEM conductive zone shown in Figure 4 is most likely due to clays and sandy clays of the paleochannel, which overlie non-conductive granitic basement of the Durlacher Supersuite. Another feature of the conductivity model are less conductive zones within the paleochannel itself. These zones appear to be associated with sand, which is typically non-conductive.

The transition from a highly conductive to a non-conductive response in the AEM data is consistent with the depth of the granitic basement derived from drillcore data. The AEM inversions will be integrated with the HVSR results to produce a 3D map of the Yangibana paleochannel.

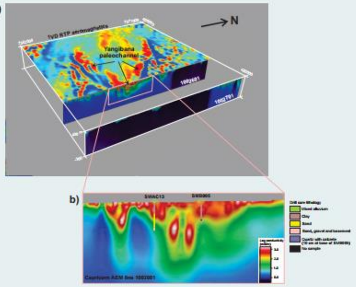

Figure 4. Three-dimensional diagram of the paleochannel: a) AEM data showing the paleochannel in plan view and the conductivity sections from the 2D inversion of the AEM data in profile view; b) drillcore data projected onto conductivity section 1002601.

Hastings Technology Metals Limited are thanked for providing drillcore information.

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Thank you