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 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).

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.

Hastings Technology Metals Limited are thanked for providing drillcore information.

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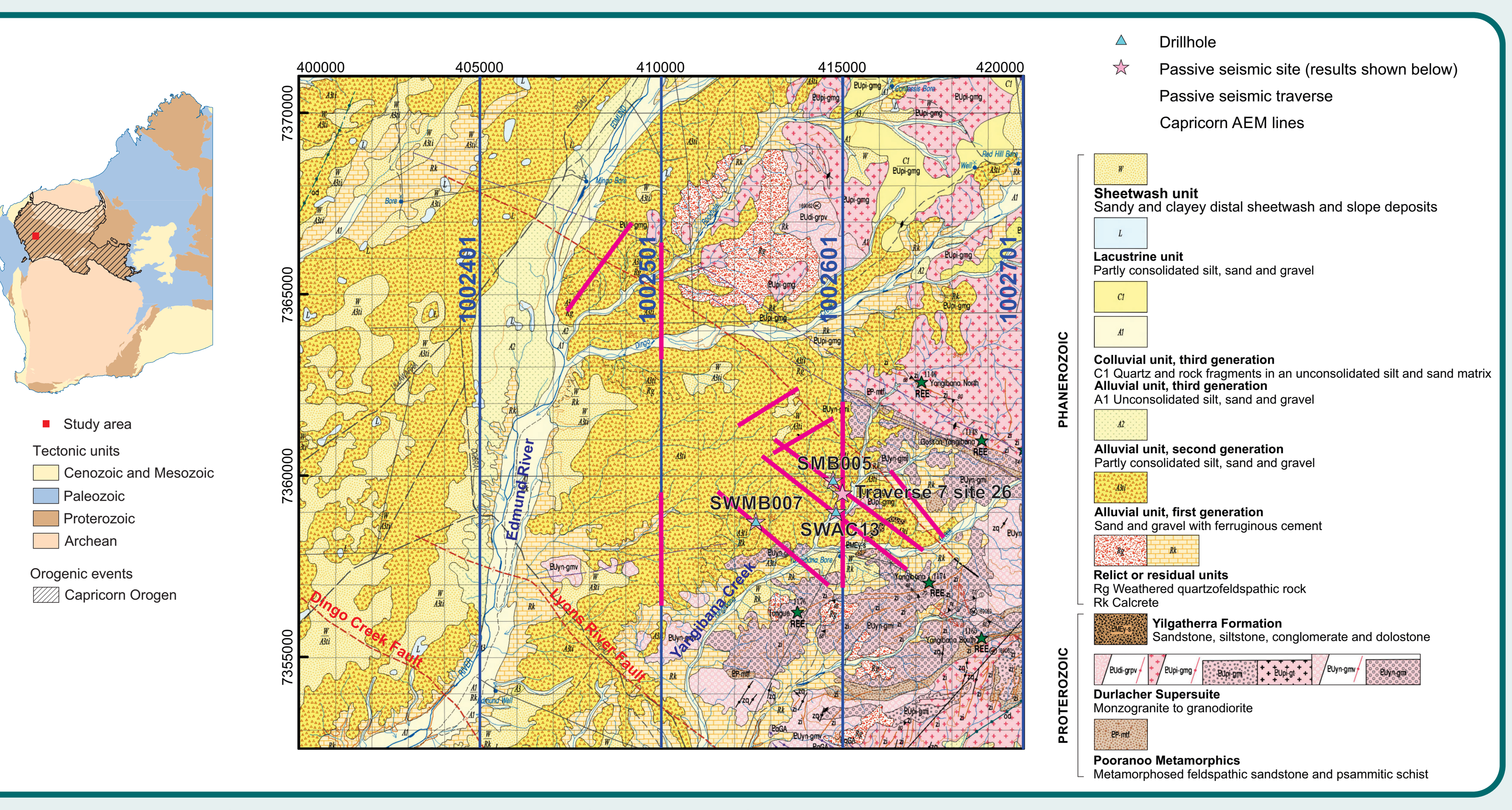

Figure 1. Extract of the Edmund 1:100 000 Geological Series map showing the project area, passive seismic traverses and acquisition sites, AEM survey lines, and the locations of the drillholes.

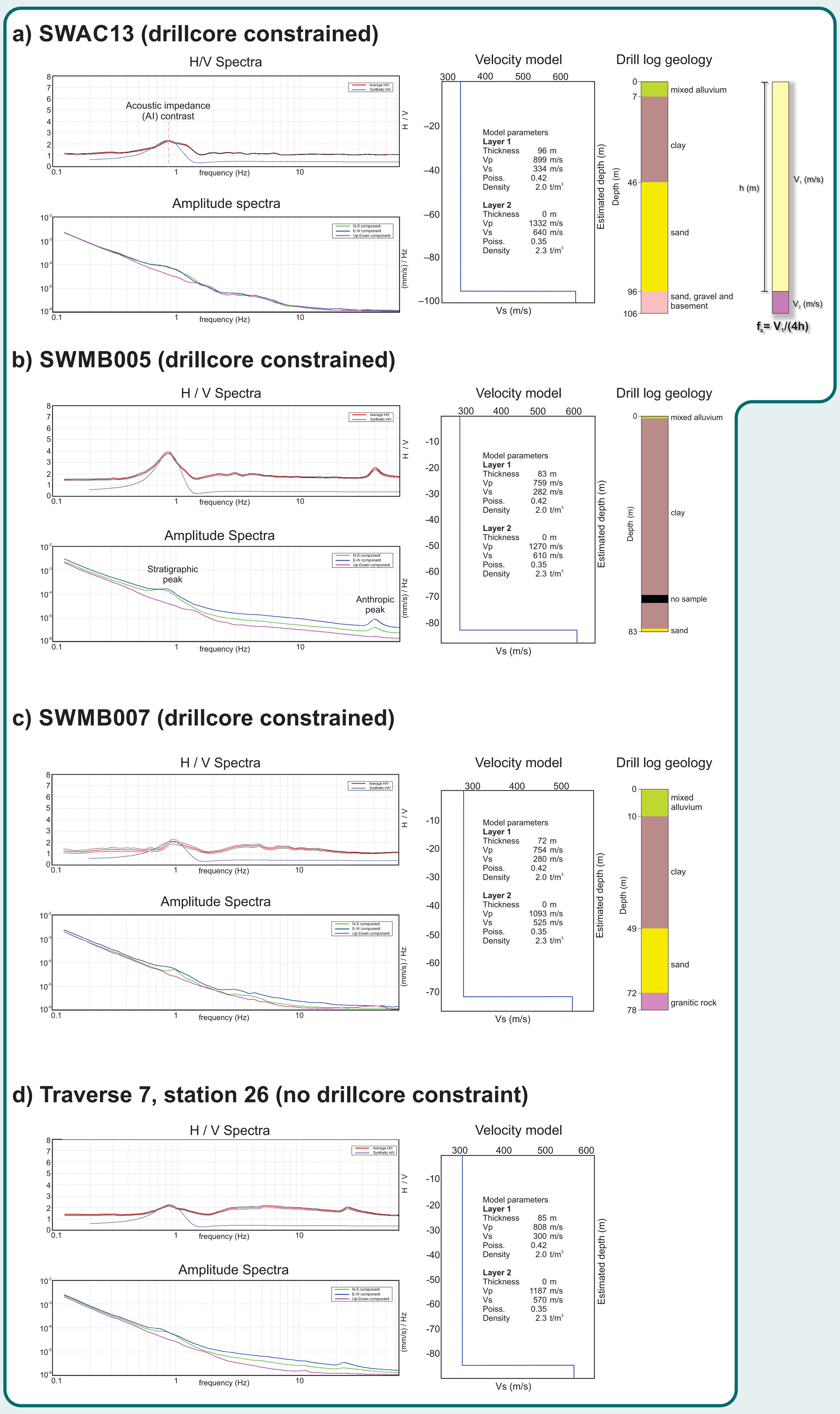

Figure 3. HVSR measurements showing observed and synthetic H/V spectra ratios, corresponding three-component amplitude spectra, velocity model, and available drillcore logs: a) HVSR measurements at drillhole SWAC13; b) HVSR measurements at drillhole SWMB005; c) HVSR measurements at drillhole SWMB007;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

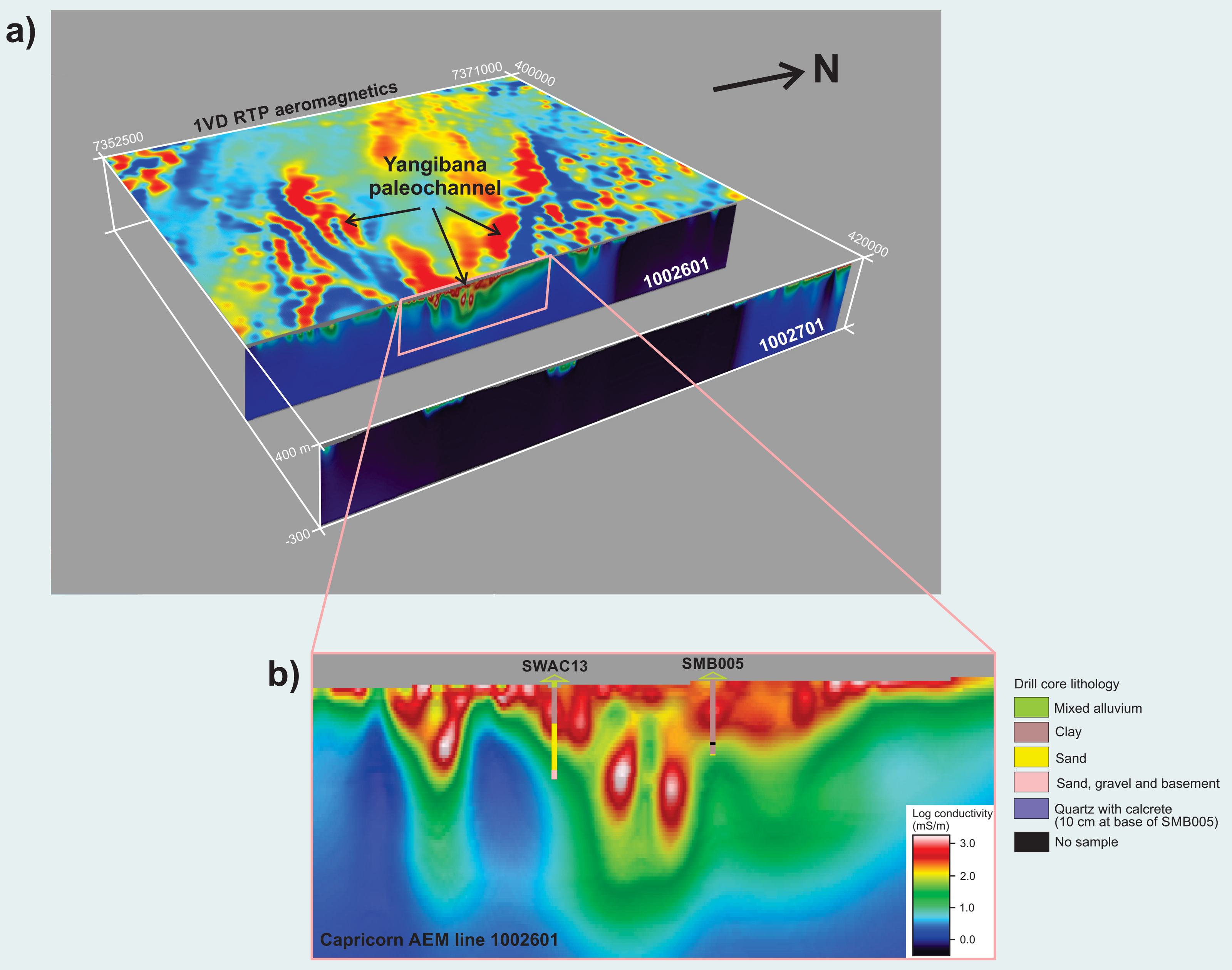

Figure 4. Three-dimensional diagram of the paleochannel: a) AEM data showing the paleochannel in plan view and the conductivity sections from the 2D inversion of the AEM data in profile view; b) drillcore data projected onto conductivity section 1002601.

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