RECONNAISSANCE PALEOMAGNETIC DATING OF REGOLITH SAMPLES FROM THE NORTHERN TERRITORY

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INTRODUCTION

Reconnaissance palaeomagnetic dating of regolith samples from the Northern Territory was conducted as part of a much larger project to study regolith materials and their distribution across the entire Northern Territory. This broader project involved collaboration between staff from the Northern Territory Geological Survey and CRC LEME. The aim was to provide a regolith-landform framework map of the Northern Territory with supportive regolith characterisation, and to shed light on the evolution of major landscape domains and their associated weathering history.

Little is known about the ages of regolith materials in the Northern Territory beyond the range of radiocarbon dating (~50 ka). The pilot palaeomagnetic sampling program was planned to help address the issue of the lack of age control of NT regolith materials and landforms.

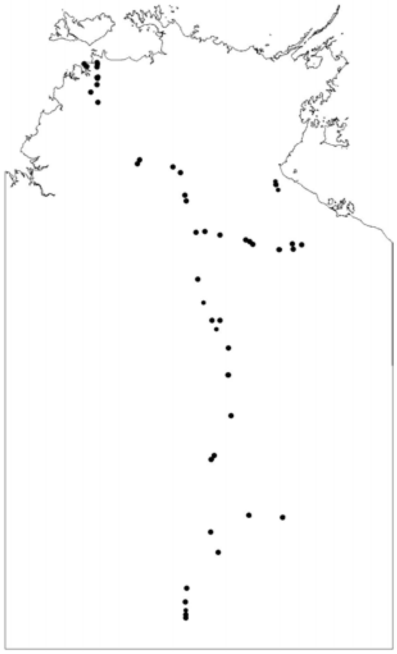

Figure 1: Trans-NT Regolith Traverse observation sites shown as black circles.

METHODS

A simple geomorphic "provinces" map was prepared as a general guide for project fieldwork, including pilot sampling for palaeomagnetic regolith age determinations, by extracting information from existing TM imagery, NT geological maps and the Australian regolith map.

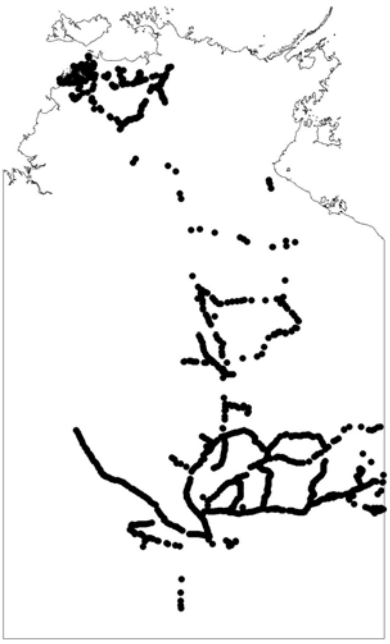

Figure 2: NT Regolith characterisation sites (black circles). At each site, the regolith is characterised, a photographic record of the immediate landscape context is taken and for some 600 sites, a whole sample geochemistry has been determined.

A Trans-NT traverse was completed during September-October 2003. The Stuart Highway was the major access route from south of Alice Springs through to the Darwin coastal plain. Such a large-scale regolith calibration traverse (Fig 1.) has not been previously undertaken in the NT or, perhaps, anywhere else in Australia. A wide range of imagery e.g., radiometrics, Landsat TM, magnetics, elevation data and Aster imagery was used during the traverse to assist in recognising regolith variations and sampling contexts. Many regolith samples were collected from across the Northern Territory (Fig 2). Sample locations for palaeomagnetic age determination are shown separately in Figure 3.

PALEOMAGNETIC SAMPLES AND LABORATORY MEASUREMENTS

Fifteen oriented block samples were collected for paleomagnetic dating by Craig in 2003/2004, as part of the early reconnaissance traverse of regolith in the Northern Territory. Further samples were collected by Pillans in 2005. Typically, at least 4 oriented blocks, with several specimens from each block, are required from an individual site to provide reliable paleomagnetic age estimates. However, for the pilot project time constraints meant that this was not always possible. Strongly oxidised hematitic saprolite and mottled sediment generally yield better paleomagnetic results than ferricrete, and these were preferentially sampled where practicable. Blocks were oriented with a Brunton compass, and a sun compass was used to check for any local magnetic deviations.

In the laboratory, several specimens were cut from each block, and were subject to stepwise thermal demagnetisation. Remanences were measured on the ScT 2-axis cryogenic magnetometer at the ANU Black Mountain Paleomagnetic Facility, Canberra. Magnetic susceptibilities were measured on a Digico bulk susceptibility bridge, to monitor possible mineralogical changes with increasing temperature. Characteristic Remanent Magnetisations were identified by Principal Component Analysis (Kirschvink 1980).

Figure 3: Location of NT palaeomagnetic age determination samples. Some localities contain multiple samples.

RESULTS

Paleomagnetic age estimates from weathered regolith are based on the assumption that weathering processes have produced secondary iron oxides that preserve a record of the magnetic field at the time they formed. Resultant ages therefore relate to the time of weathering, not to the age of the rocks. The ages of weathering-induced magnetisation are obtained by comparison with the Australian Apparent Polar Wander Path (AAPWP) and the Geomagnetic Polarity Time Scale (GPTS).

A summary of results for all sites is given in Table 1, with the resultant paleomagnetic poles plotted in Figure 4, compared with the AAPWP of Schmidt & Clark (2000). Ages for poles are calculated by interpolation between dated control points (black dots) on the APWP, with uncertainties estimated from the 95% confidence limits of the poles.

The majority of sites yielded specimens with a well defined reverse polarity magnetisation. The preservation of reversed polarity remanences indicates acquisition prior to the Brunhes/Matuyama polarity transition at 0.78 Ma (Pillans & Bourman 1996). Thus, at least some of the secondary iron oxides were formed prior to 0.78 Ma, and are no younger than early Pleistocene in age.

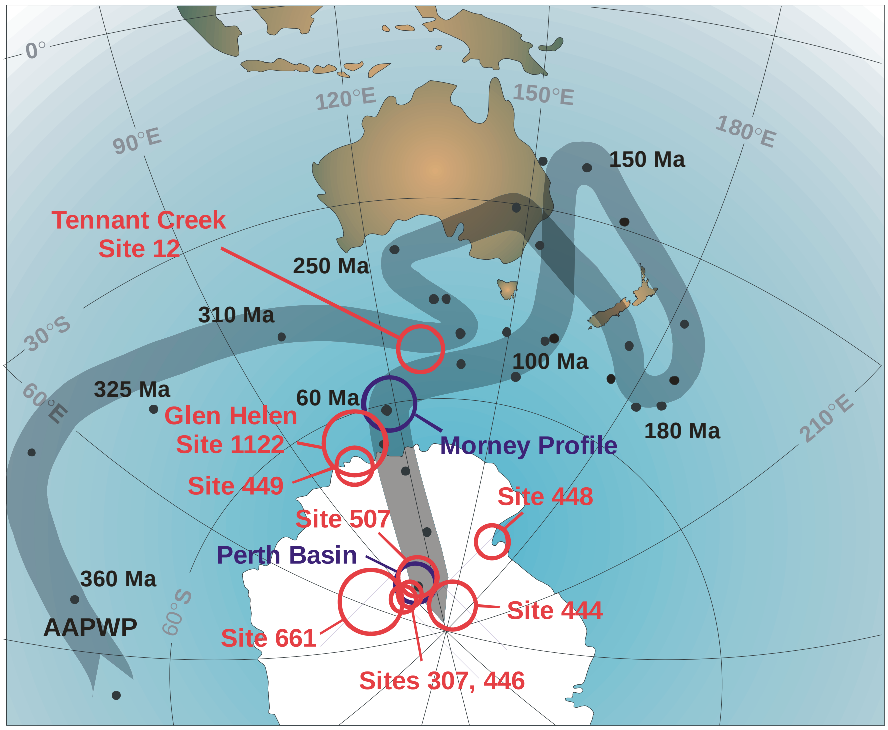

Figure 4: Reconnaissance paleomagnetic poles from Northern Territory sites (this work), Morney Profile (Idnurm & Senior 1978) and Perth Basin (Schmidt & Embleton 1976), plotted on the Australian Apparent Polar Wander Path (after Schmidt & Clark 2000).

Several poles intersect, or lie close to, the Late Tertiary segment of the APWP, and have estimated mean ages in the range 0 to 10 Ma. These include sites from the Darwin-Adelaide River region. The poles are similar to a Late Tertiary overprint pole, from strata in the Perth Basin, which Schmidt & Embleton (1976) attributed to a widespread episode of lateritisation. [Note that the polar wander path has been revised since Schmidt & Embleton published their paper, so their original age estimate is no longer considered to be valid - they determined an age of Late Oligocene to Early Miocene (20-25 Ma), but the revised age is Pliocene (around 6 Ma)].

Two sites from Adelaide River (Site 448 and 449) and one from Dneiper Station (Site 661) yield poles that do not intersect the APWP (Fig. 4). The reason(s) for this are unclear, and no age estimates are made.

The paleomagnetic pole from Glen Helen, west of Alice Springs (Site 1122) yields an estimated mean age of 47 Ma, but with a large uncertainty (about ±15 Ma). For example, it partly overlaps the paleomagnetic pole obtained the regionally extensive 60 Ma Morney weathering profile in southwest Queensland (Idnurm & Senior 1978).

The oldest weathering ages appear to be from Site 12, near Tennant Creek, where the reversed polarity of all specimens, and one pole position, are most consistent with an Earliest Permian age (~295 Ma), within the Permo-Carboniferous Reversed Superchron (Opdyke & Channel 1996). A second pole yields a late Cretaceous age (~75 Ma). The Permian paleomagnetic pole from Site 12 is similar to unpublished Late Carboniferous to Early Permian poles obtained from the Tanami area (e.g. Dead Bullock Soak) and Lancefield mine at Laverton in the eastern Yilgarn (Pillans in press) Clearly we are seeing a regionally extensive paleomagnetic signature of great antiquity. Whether this pole represents a weathering imprint, or is thermotectonic in origin, remains to be seen.

While these results are very preliminary, based on only a few specimens, they indicate the potential for paleomagnetic dating of regolith in the Northern Territory. Based on the reconnaissance paleomagnetic samples it is clear that relict ferruginous regolith is widespread in the Northern Territory. Furthermore, the results are consistent with paleomagnetic ages from southern Australia that indicate that major climatically-driven weathering episodes occurred in the late Tertiary (0-20 Ma) and early Tertiary-latest Cretaceous (55-75 Ma) (Pillans 2002). We are currently undertaking further work on ferruginous regolith samples from this poorly known (geochronologically) part of Australia.

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Table 1: Summary of paleomagnetic results.

SITE	LOCATION	COMP[1]	N(+)[2]	REMANENCE DIRECTIONS[3] Decl.	Incl.	k	α_{95}	SOUTH POLE Long.	Lat.	K	A_{95}	AGE (Ma)
	Tennant Creek (134.19°E, 19.61°S)											
12	Oxidised saprolite	HT	7(7)	185.7	71.5	882	2.26	128.9E	53.1S	345	3.61	295
	Mataranka (132.90°E, 14.78°S)											
20	Ferruginous sand	Scattered magnetic remanence directions; unsuitable for paleomagnetic analysis										
	Mandorah Road, Cox's Peninsula (130.73°E, 12.65°S)											
307	Oxidised saprolite (2 samples)	HT	14(14)	185.0	31.3	469	1.84	082.8E	83.6S	476	1.82	5
	Casuarina cliffs, Darwin (130.86°E, 12.37°S)											
444	Mottled sediment	HT	7(0)	359.0	-28.7	370	3.14	149.4E	86.9S	763	3.14	2
	Fanny Bay, Darwin (130.83°E, 12.42°S)											
446	Mottled sediment	HT	7(7)	184.1	32.8	2002	1.35	095.6E	83.3S	1922	1.38	5
	Adelaide River (131.10°E, 13.24°S)											
448	Oxidised saprolite	IT,HT	14(7)	352.4	-41.4	317	2.23	163.8E	77.1S	463	1.85	?
	Adelaide River (131.15°E, 13.43°S)											
449	Oxidised saprolite	HT	14(0)	013.0	-53.6	368	2.07	103.7E	66.1S	232	2.62	?
	Adelaide River (131.10°E, 13.17°S)											
507/8	Oxidised saprolite	HT	14(14)	184.1	-35.9	172	3.04	102.2E	82.1S	257	2.49	7
	Elkedra Station (135.65°E, 21.16°S)											
598	Ferricrete	Probably R polarity component masked by strong recent N polarity overprint										>0.78
	Dneiper Station (135.16°E, 22.79°S)											
661	Oxidised saprolite	HT	5(0)	011.5	-43.2	373	3.97	062.8E	79.1S	332	4.21	?
	Manners Creek Station (137.22°E, 22.52°S)											
823	Ferricrete	LT	5(0)	003.7	-50.5	131	6.69	116.5E	80.4S	99.8	7.69	modern
	Tanami Road (131.06°E, 21.63°S)											
1080	Ferricrete	Most specimens have R polarity component, but not well defined.										>0.78
	Glen Helen (132.12°E, 23.52°S)											
1122	Mottled sandstone	HT	5(4)	195.9	64.6	785	2.73	106.9E	63.7S	377	3.95	47
	Perth Basin (Schmidt & Embleton 1976)											
PB	Permian to Cretaceous seds.	HT	128(?)					109.9E	82.7S		2.4	6
	Morney profile, Qld (Idnurm & Senior 1978)											
MP			37(17)	017.8	-68.3		2.4	118.5E	59.8S		3.8	60

Notes: [1] LT = low temp component; IT = intermediate temp component (<580°C); HT = high temp component (>580°C)
[2] N = number of specimens; (+) = number of specimens with positive inclination
[3] k and K are Fisher precision parameters; α_{95} and A_{95} are semi-angles of 95% confidence.