A seamless digital regolith map of Western Australia: a potential resource for mineral exploration and environmental management

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Abstract

Existing 1:250 000-scale geological maps have been synthesized and simplified to produce a seamless digital regolith map of Western Australia. Lithological units have been assigned to one of nine subdivisions, comprising areas of outcrop, residual or relict units (representing in situ regolith, or remnants of an earlier landscape), and seven transported regolith units (slope deposits, alluvium, lake deposits, calcrete, sandplain, coastal deposits, and tidal deposits). Significant areas of mining activity have also been identified. Where digital versions of geological maps were available, polygons were recoded according to the regolith classification scheme of the Geological Survey of Western Australia. For hard copy (analogue) maps, polygons were hand drawn, labelled, and scanned. All compilations were combined, edge-fitted, and the data gridded to reduce and standardize the complexity of the linework. The final product can be viewed online using GSWA's GeoVIEW.WA software.

KEYWORDS: Regolith, regolith maps, digital data, Western Australia.

Regolith and regional mapping

Regolith is the mostly unconsolidated mantle of weathered rock that covers large parts of Western Australia. Typically, regolith has been viewed as an impediment to discovering bedrock mineralization but, as it is derived from the physical and chemical weathering of bedrock, the distribution and composition of various types of regolith can be used as pathfinders to bedrock-hosted mineralization. Furthermore, regolith can host mineralization in its own right, including economic gold (Glasson et al., 1988), nickel (Burger, 1996; Hellsten et al., 1998), and bauxite (Taylor, 1990) deposits. The State's mineral production in 2002–03 was worth more than $17 billion. The regolith accounted for over 40% of this, including 5% of gold production, 25% of nickel industry production, and all mineral sands production, the latter worth almost $1 billion.

Maps showing the distribution of different regolith types (e.g. Figs 1 and 2) are important sources of data in formulating mineral exploration programs and understanding the results of regional geochemical surveys. Cornelius et al. (2001) used regolith mapping to identify ferruginous duricrust ('laterite') sampling sites for regional (9-km triangular grid) geochemical surveys, to indicate areas of mineralization in the southwest of the State. Morris et al. (2003) combined regolith mapping, geochemistry on widely spaced regolith samples (one per 16 km^2), geophysics, and bedrock mapping to delineate several areas of potential mineralization on the northeastern margin of the Archaean Yilgarn Craton. Morris et al. (2003) emphasized that regolith geochemistry can only be confidently interpreted when combined with regolith mapping, especially in areas with significant transported regolith — in the area of their study, transported material accounted for about 80% of regolith cover. Traditional approaches to regional geochemical surveys using stream sediment, soil, or lag as sample media (e.g. Fletcher, 1986) have been augmented by selective extraction techniques, and the use of other sample media, such as silcrete and calcrete (e.g. Lintern, 2001). In formulating such geochemical programs, regolith maps showing the distribution of targeted sample media are crucial.

Regolith maps also have potential for use in environmental management; for example, maps showing the distribution of lacustrine and alluvial deposits have direct application for the management of salt-affected areas. A knowledge of regolith distribution would also play an important role in infrastructure planning, flood mitigation, catchment management, and waste disposal.

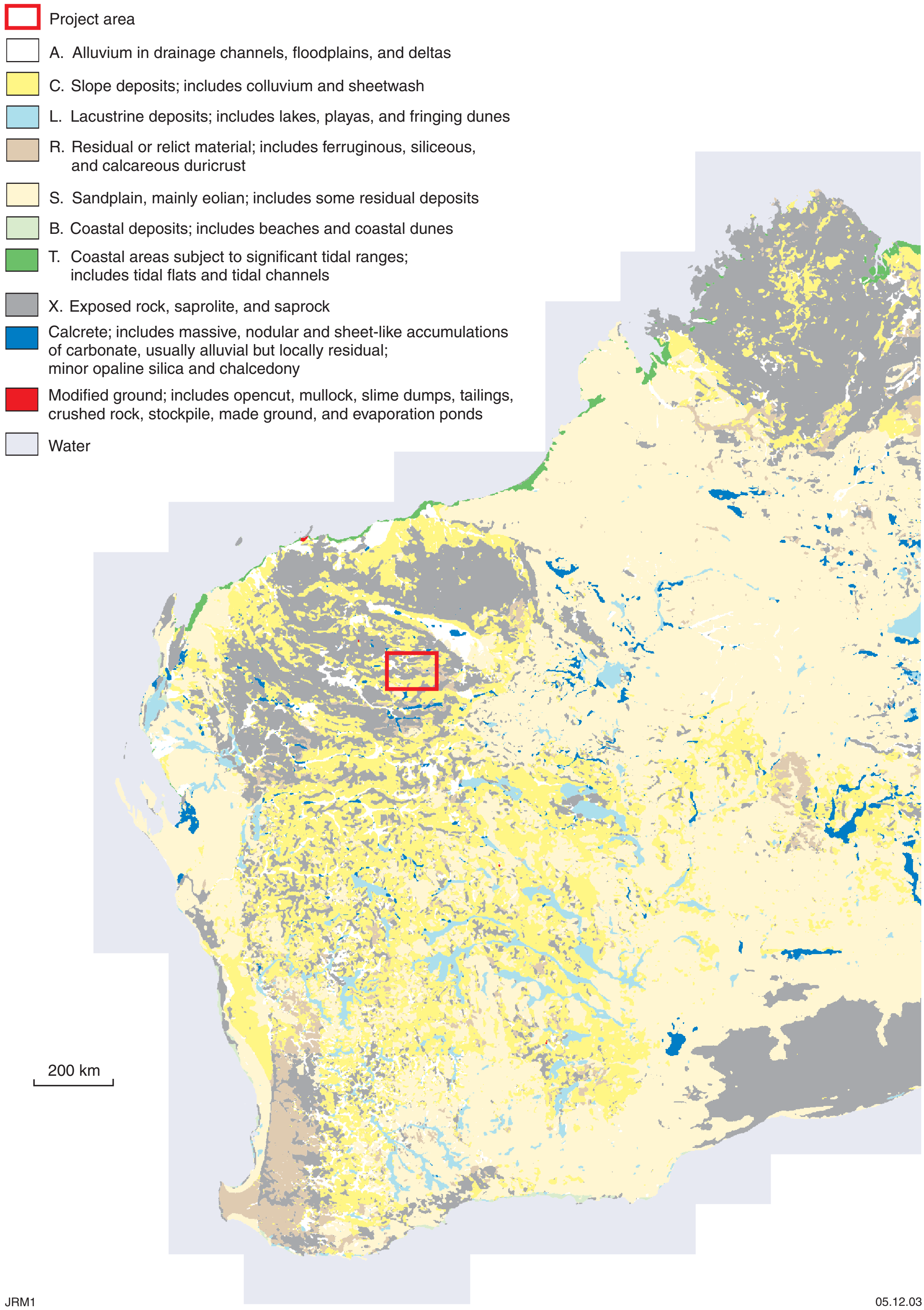

Figure 1. Regolith distribution in Western Australia, gridded at 1300-m cell size. The red rectangle shows the area covered in Figure 2

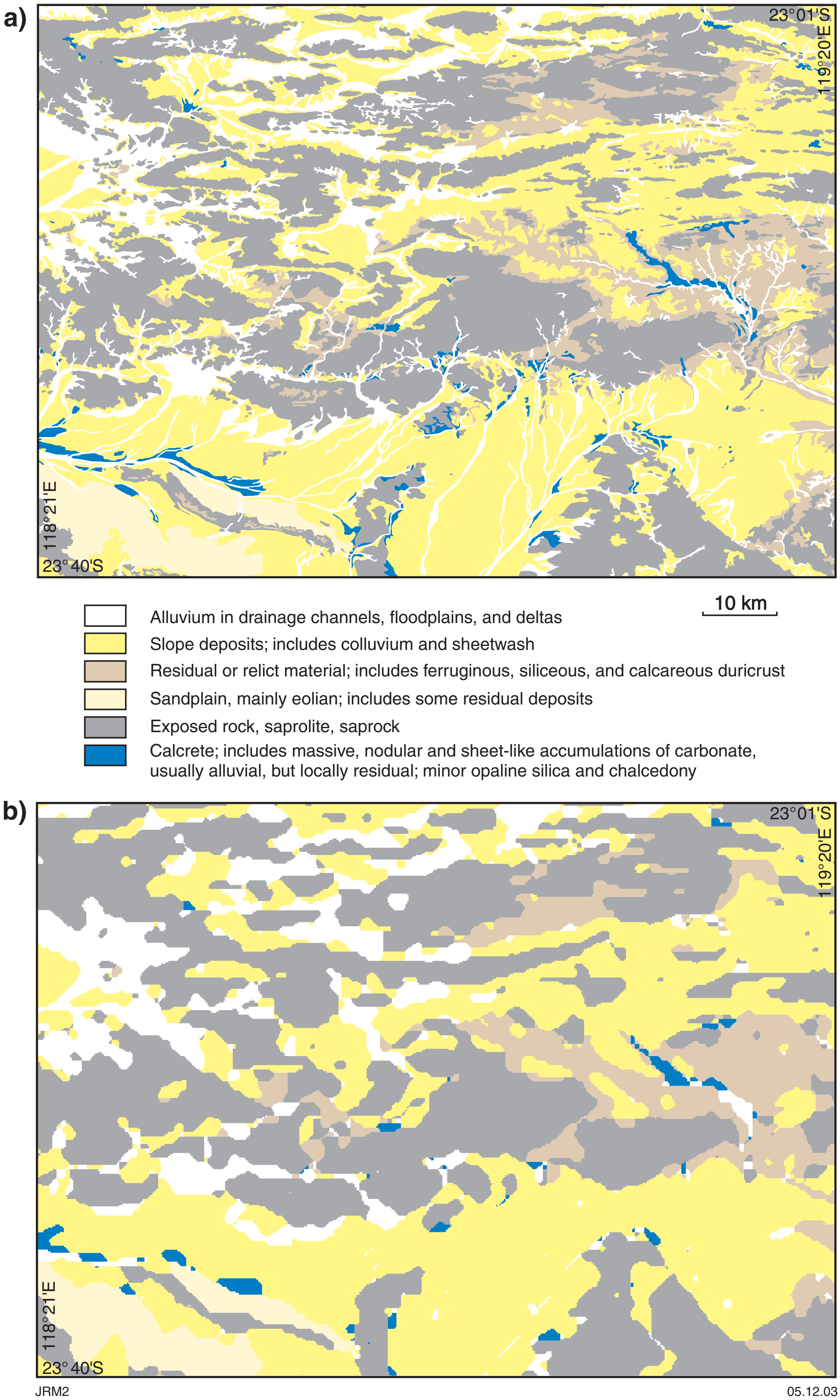

Figure 2. Regolith data between latitudes 23°01' and 23°40'S, and longitudes 118°21' and 119°20'E: a) ungridded; and b) gridded using a 500-m cell size

The digital data can also be used in formulating sampling strategies. For selected areas, the distribution of regolith types can be determined, and their area can be calculated. The spatial relationship between these units and others (e.g. outcrop and residual or relict units; lacustrine and alluvial deposits) can also be estimated. Intersection of regolith coverage with solid geology coverage means that further attributes can be added to regolith polygons, such as the composition of outcropping units.

The Geological Survey of Western Australia's (GSWA) State regolith map (Fig. 1) displayed at 1:500 000 scale will complement the existing 1:500 000-scale interpreted bedrock geology map for Western Australia (Vanderhor and Flint, 2001). As both are digital products, intersecting the two coverages will allow interrogation of both datasets to determine, for example, the composition of regolith designated as outcrop, the likely composition of proximal slope deposits, and the possible parent rock-type to residual or relict regolith units.

There are few regional-scale regolith maps available for much of Western Australia, the exceptions being the 1:1 000 000-scale map of the Kalgoorlie area (Chan, 1991) and CSIRO soil and land-use series maps (e.g. Bettenay and Hingston, 1961) — most are at a scale of 1:250 000 (e.g. Craig and Churchward, 1995), including GSWA regional regolith geochemistry series regolith maps (e.g. Kojan and Faulkner, 1994; Morris and Verren, 2001). Until the synthesis of regolith data throughout the State, discussed here, it was necessary to combine maps over the area of interest in an ad hoc fashion, and attempt to deal with discrepancies in the complexity and coding of regolith between adjacent map sheets. Completion of the State regolith map means that these issues have largely been resolved. Furthermore, as the product is digital, areas of interest are not restricted by map-sheet boundaries.

Data sources

The major source of map data is the GSWA 1:250 000-scale geological series maps, so that the capture scale for the State regolith map was maintained at 1:250 000. Of the 163 1:250 000-scale maps that cover Western Australia, 73 (45%) are available as vector data and the remaining 90 are raster images. Where 1:100 000-scale maps covering a complete 1:250 000 map sheet are available (WILUNA*, SIR SAMUEL, DUKETON, LEONORA, LAVERTON, MENZIES, EDJUDINA, KURNALPI), these were used in compiling the final map. Publication of the 1:250 000-scale geological maps span an interval of almost 40 years, from the RAWLINSON map sheet (Wells and Forman, 1964) through to DAMPIER – BARROW ISLAND (Hickman and Strong, 2001). No attempt has been made to modify the geological coverage on these maps, apart from simplification of some drainage areas, and ensuring smooth map-edge transitions.

Table 1. Classification of regolith units

	Code	*Designation*	*Description*
	R	Residual	Includes ferruginous, siliceous, and calcareous duricrust
	X	Exposed	Exposed rock, saprolite, and saprock
Depositional (D)	C	Colluvium	Slope deposits, including colluvium and sheetwash
Depositional (D)	S	Sandplain	Mainly eolian, includes some residual deposits
Depositional (D)	L	Lacustrine	Includes lakes, playas, and fringing dunes
Depositional (D)	A	Alluvium	In drainage channels, floodplains, and deltas
Depositional (D)	B	Coastal	Includes beaches and coastal dunes
Depositional (D)	T	Tidal	Coastal areas subject to significant tidal ranges; includes tidal flats and tidal channels
Depositional (D)	Calc	Calcrete	Includes massive, nodular, and sheet-like accumulations of carbonate, usually alluvial–colluvial, but locally residual; minor opaline silica and chalcedony
			Anthropogenic areas
		Made ground	Areas artificially filled with earth materials
		Mining	Areas of land where metallic or non-metallic mineral deposits are being extracted
		Stockpile	An accumulation of ore-bearing rocks for milling

SOURCE: Hocking et al. (2001)

Classification of regolith

Since 2001, regolith on all GSWA geological maps has been classified according to a hierarchical scheme discussed by Hocking et al. (2001). This scheme uses the current landform position, regolith composition, and (where known) the parent lithology to classify regolith, and is loosely based on the Relict–Erosional–Depositional (RED) scheme of Anand et al. (1993). The classification scheme adopted for the State regolith map (Table 1) is based upon the nine primary (landform-based) codes of the GSWA regolith classification scheme. The adoption of this scheme attempts to maintain some level of consistency with the GSWA approach to classification of regolith, and at the same time preserve as much information as possible from the original maps. However, in many cases it has not been possible to determine if calcrete is residual or depositional, and all such units have been grouped as 'calcrete'. As these maps were compiled by various geologists over a long time period, there are often inconsistencies between map sheets that reflect slightly different interpretations of the same, or similar, rock or regolith units, or different levels of subdivision of the regolith. The remaining category comprises anthropogenic areas, including made ground, mining areas, ore stockpiles, and areas of infrastructure.

* Capitalized names refer to standard 1:250 000 map sheets.

Map compilation methodology

For areas covered by vector data, attribute tables describing the features of each geological unit were edited to conform to the regolith classification approach (Table 1). On joining the edited tables to the map sheet, geological boundaries between polygons of the same type were removed (i.e. dissolved). After this simplification, printouts were checked and geological boundaries on map-sheet edges were aligned to create a seamless coverage.

For raster images, a simplified regolith coverage was created on a transparent overlay according to the regolith classification, and polygons colour-coded according to regolith type (Table 1). Polygons less than about 250 m^2 were omitted. The resulting compilations were scanned and the different regolith layers separated and attributed automatically according to the colour coding. The resulting map was checked and the individual map compilations were combined and edge-checked. Finally, the digital and hardcopy coverages were combined into one dataset. The coverage was divided in two at latitude 26°S, and each half checked for level of detail. Some areas still required simplification.

Because of the resulting file size, subsets of the data were gridded separately, with sufficient overlap between data in each file to allow seamless rejoining. Gridding is a process by which the data are automatically simplified according to the level of complexity required. Choosing larger cell sizes produces a simplified coverage. Polygons were gridded using 150 m, 500 m, 800 m, and 1300 m cell sizes. Following gridding, individual segments were recombined, and the linework further simplified (smoothed) by two passes of a majority filter (3 × 3 pixel). Further improvement of the linework was achieved by resampling to a smaller cell size (one third of the original cell size) using the nearest neighbour option. Another two passes of the majority filter over the new cell-size grid was then necessary to smooth the data. The data were then converted back to polygons, and checked for null-grid codes (unlabelled polygons) and 'sliver' polygons (i.e. small polygons erroneously created during joining of lines during the compilation or editing process). The boundaries between similar polygons were then dissolved.

In order to present the data at an appropriate scale for viewing, polygons smaller than a predetermined area or perimeter were removed. Selection of a low perimeter value ensured that elongate polygons of small area (typical of drainages) were not selectively removed. Any remaining angularity in the linework was removed using a 'bendsimplify' operator, and the data were then checked for label errors.

Map viewing

Regolith cover of the State (Fig. 1) can be viewed using GSWA's GeoVIEW.WA web-based software, along with other data layers such as bedrock geology, mining tenements, roads, towns, and mineralization information from the Survey's WAMEX and WAMIN databases. The original scale of capture (1:250 000) for regolith is preserved, but the dataset is displayed at the scale most relevant to the user's needs. Three separate versions of the regolith have been grouped into one layer. Each version has been gridded at a different pixel size, with the version shown in GeoVIEW.WA dependent on the display scale of the map (Table 2). Enlarging the pixel size reduces the number of polygons (compare Figs 2a and 2b), therefore improving the speed of display.

Table 2. Designated pixel size (m) used for gridding data, and related range in scale

Pixel size (m)	*Minimum scale*	*Maximum scale*
500	n/a	1:1 499 999
800	1:1 500 000	1:2 999 999
1300	1:3 000 000	n/a

NOTE: n/a: not applicable

Discussion

The new regolith map of Western Australia has synthesized existing geological information using a standard approach to the classification of regolith. As the product is fully digital, the data can be interrogated, and the original data can be displayed at selected levels of complexity by gridding the data using a suitable pixel size. A simplified map generated from this dataset (Fig. 3) shows the distribution of regolith in terms of three components: residual or relict, erosional (essentially outcrop), and depositional (transported) regolith, the latter produced by combining the seven depositional regolith subdivisions of Table 1. Figure 3 shows that regolith is dominated by depositional material (67% of regolith coverage), especially in the Yilgarn Craton. The map also shows that few relict and residual units are visible at this scale (1:11 000 000). Of the depositional regolith material, sandplain makes up the highest proportion (64%), followed by slope deposits (25%) and alluvium (5%).

Figure 3. Regolith distribution in Western Australia simplified to areas of relict or residual regolith (R), exposed rock (X), and depositional regolith (D), derived from the original dataset

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