Towards improved geological maps of Antarctic rocks and surficial deposits

Datasets for studies of glacial dynamics and climate change

Simon Cox[1], Paul Morin[2]
Convenors

[1]GNS Science, [2]Polar Geospatial Centre

Discussion Themes

1.10-1.40	**Background**
1.40-3.00	**State of knowledge review**
3.00-3.20	Break
3.20-3.40	**Database model**
3.40-4.00	**Classification issues**
4.00-4.30	**Base datasets**
4.30-5.00	**Building the team and workplan**

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1. Background

Overview of the idea and need.

Discussion on the scope, usefulness and purpose of such a dataset.

Who are the key end-users?

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Introduction: Simon Cox

Looking for a core group of people

Provide feedback

Provide data and work

Find students

Attendees: A full list of attendees was not collected at the workshop, but those present included:

Chris Carson	Geoscience Australia	Australia
Jo Whittaker	Institute for Marine and Antarctic Studies	Australia
Jacqueline Halpin	Institute for Marine and Antarctic Studies	Australia
Yingchun Cui	Institute of Oceanography SOA	China
Surya Sankarasubramanian	Indian Institute of Technology Bombay	India
Shridhar Jawak	NCAOR	India
Amar Jeet	Panalink, Delhi	India
Massimo Pompilio	Istituto Nazionale di Geofisica e Vulcanologia	
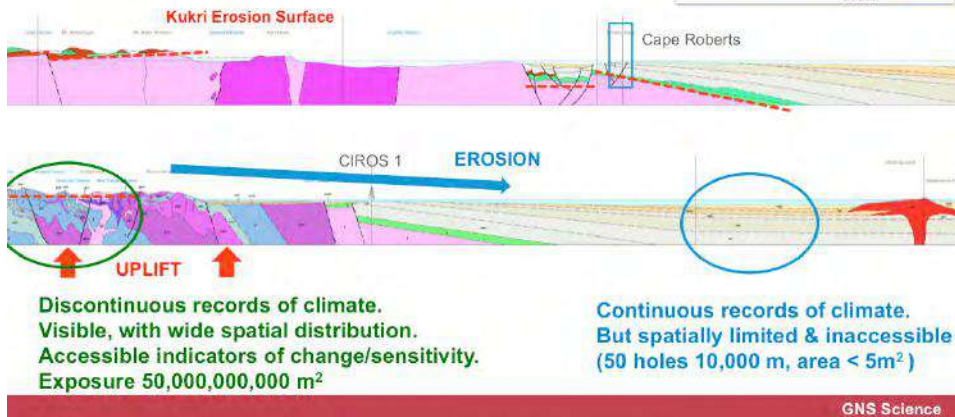
Offshore versus onshore geology: Simon Cox

Records of climate offshore are expensive to collect and spatially limited.

Records onshore provide a lot more spatial data, more cheaply and is logistically less complicated.

Other disciplines are looking onshore already.

Global sea level change is recorded in the ice change through the Transantarctic Mountains.

There is limited post Miocene morphology (surficial geology) in the old map series.

Its difficult to get a regional overview.

Many different scales, levels of detail and classification schemes. E.g. The New Zealand 1:250,000 geological map of southern Victoria Land (QMAP 22) turned two units (till and scree) into c. 70 units.

50,000 km² rock and moraine
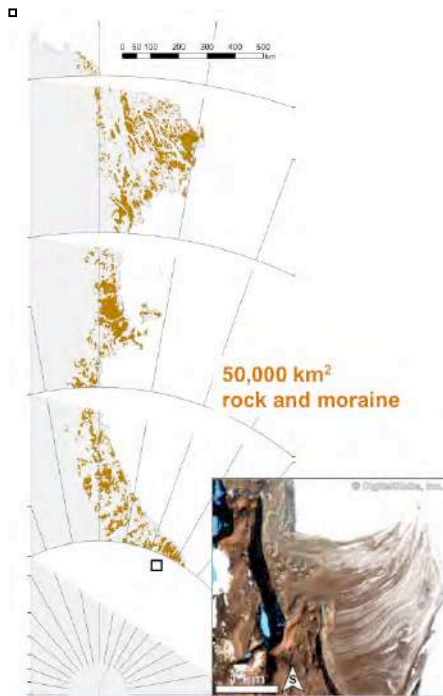
Context

There is still considerable uncertainty about the past effect that Antarctic ice has had on sea level, and its potential contribution to future sea level rise.

The TAM are a key target for climate change studies, containing sequences of glacial deposits and landforms that record the waxing and waning of Antarctica's ice masses.

Studies to date have been mostly localised, whereas regional overviews spanning the continent, pinpointing the locations of deposits and indicating their mode of formation, age, and likely source, will improve understanding of Antarctica's climate role.

Geological maps should provide key underpinning information!

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Published Geological Maps

Numerous regional-scale geological maps published during the latter part of last century – at 1:250,000 scale or greater.

Mostly focussed on identification of basement rock-types and their distribution.

Spatial reliability is highly variable (!!!).

Relatively little attention paid to classification and description of glacial deposits and landforms.
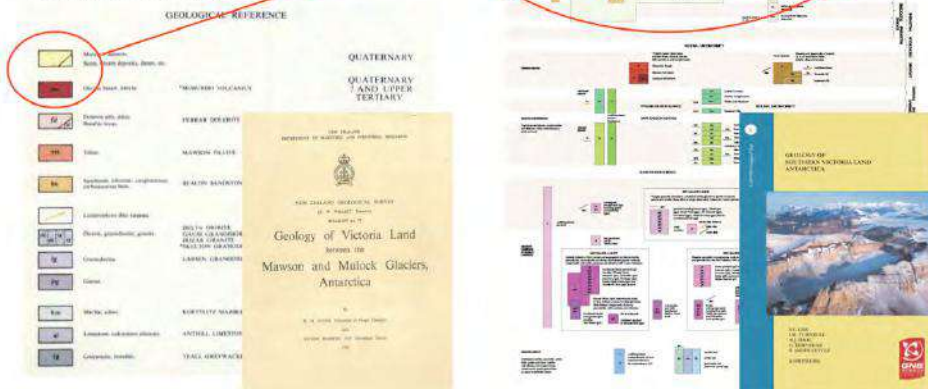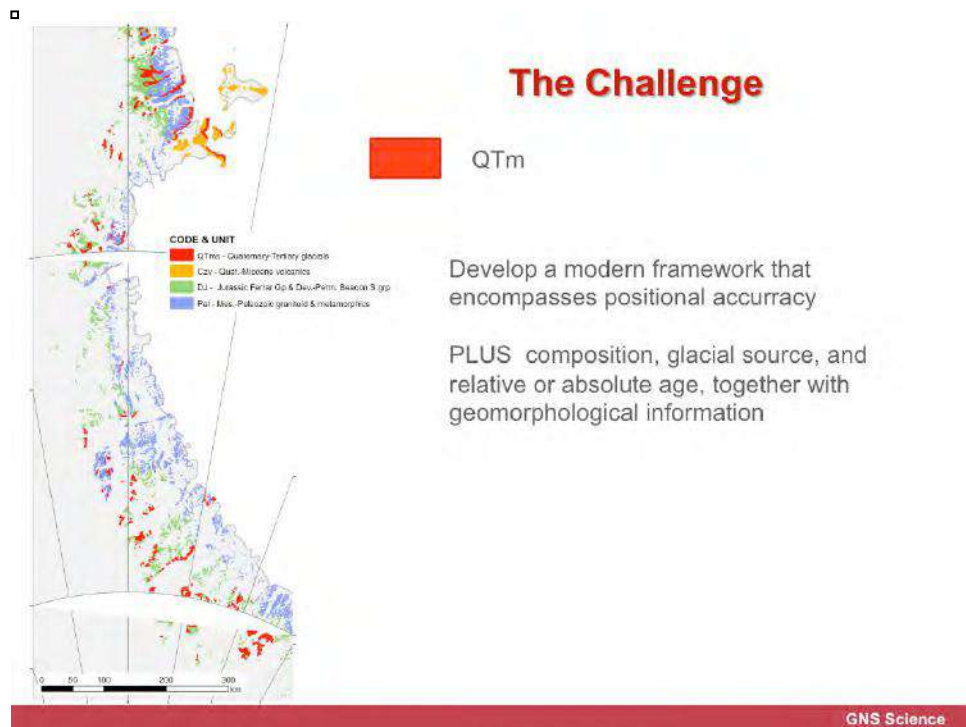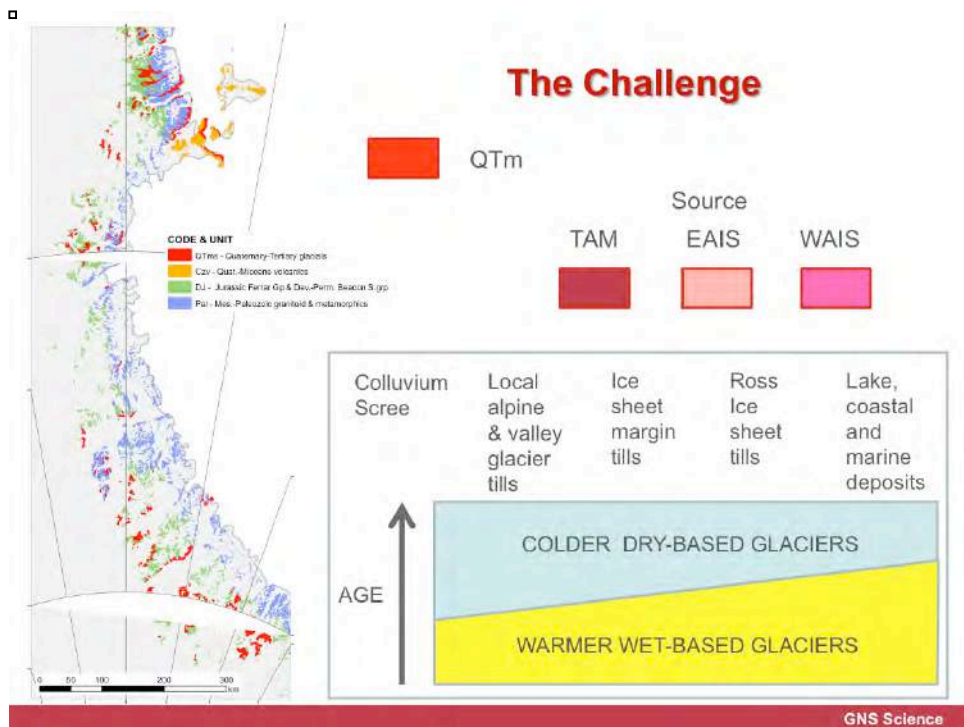
SCALE
- 1,000,000
- 500,000
- 250,000
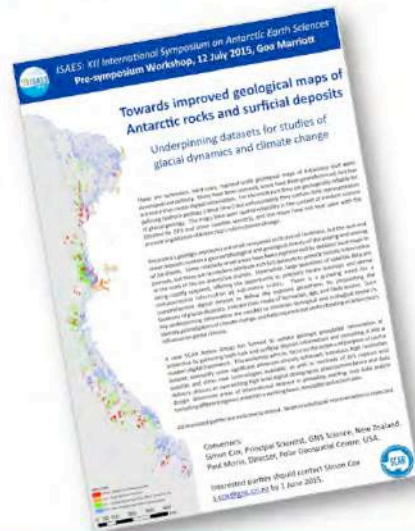- <50,000

Goals: Simon Cox

Define Qt unit by source (Transantarctic Mountains, EAIS, WAIS), age or composition, etc.

A spatially accurate, holistic map of all Antarctica will be the most relevant to other disciplines

The Challenge

QTm

Source

TAM   EAIS   WAIS

| Colluvium Scree | Local alpine & valley glacier tills | Ice sheet margin tills | Ross Ice sheet tills | Lake, coastal and marine deposits |

COLDER DRY-BASED GLACIERS

AGE

WARMER WET-BASED GLACIERS

CODE & UNIT

QTm - Quaternary-Tertiary glacials
Czv - Quat.-Miocene volcanics
DJ - Jurassic Ferrar Gp & Dev.-Perm. Beacon S.grp
Pal - Mes.-Paleozoic granitoid & metamorphics

0 50 100   200   300 km

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Open discussion stimulated by Session 1

Comment: (Cliff Atkins) We are missing the capture of some data, e.g. wet-based glaciers leave little trace. We need to get better at recording this information. We need to find ways to map areas that have been ice affected but now leave little trace of that interation.

Comment: (Gary Wilson) The ice information in the rock record goes back to the Neogene or older, c.f. not just the Quaternary.

Comment: Chronology is very important and difficult to get.

Question: (Simon Cox) How (what quality) are the geological maps outside of Victoria Land?

Comment: (Jerónimo López-Martínez) A surficial geology map is very different from a morphological map. The Japanese Survey has an excellent database of maps. British Antarctic Survey has good maps and the Spanish have maps from the Antarctic Peninsula. Need to keep a wide focus on objectives, i.e. all of Antarctica.

Question: How do we integrate basement rock versus surficial deposits?

Question: Do we want bedrock geology? Answer: Yes. For example bedrock geology at a 1:250 k scale and surficial geology at a 1:100 k scale, and potentially down to 1:25 k in some areas.

2. State of Knowledge

Key geological datasets

Short overviews of past/current/future
geomapping work by various national programs

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Sources (Simon Cox)

Gondwana 1:5 million scale geology

Classify by either lithology or chronology

Bedrock Geology 1:10M - Geoscience Australia on OneGeology (Tingey data from the 1970′s)

Landcare New Zealand have created 'environmental domains' of Antarctica based on existing 1:10 million scale maps

SCAR geoscience map catalogue – is it up to date?
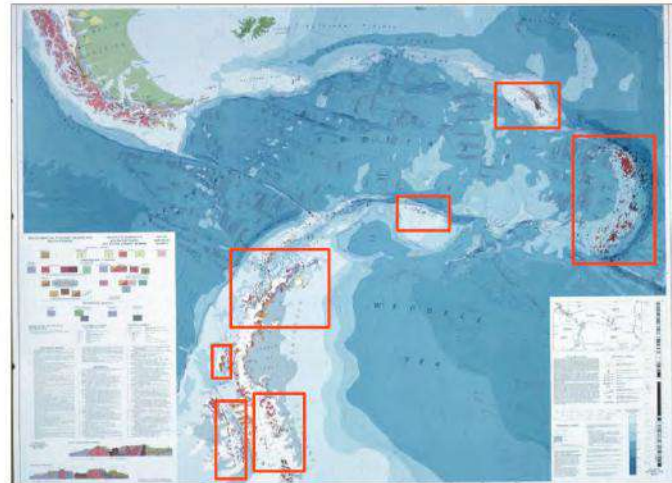
Current BAS Geological Mapping Operations

Burton-Johnson, A.

The British Antarctic Survey, Cambridge, UK

alerto@bas.ac.uk

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Eastern Graham Land

Scotia Sea area

Adelaide Island

South Orkney Islands

Palmer Land

James Ross Island

Alexander Island

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Alex Burton-Johnson (BAS; UK)

Largely bedrock geology

Limited (but developing) surficial geology
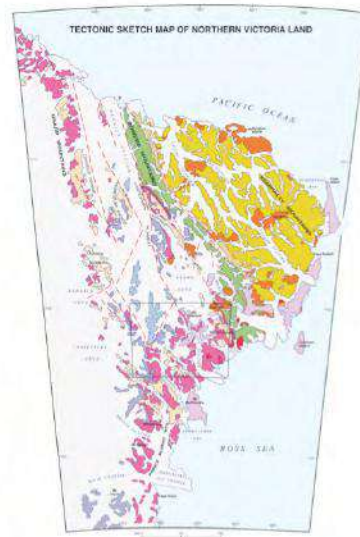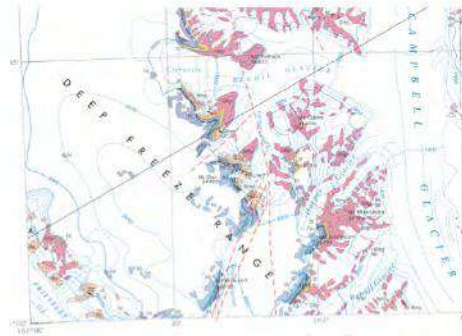
New BAS Geomap 2 series

Update of previous 500G series 1979-1982

Geomap1 not digitised

Laura Crispini (University of Genova; Italy)

Introduction to Gigamap
1:250k mapping

TECTONIC SKETCH MAP OF NORTHERN VICTORIA LAND

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Laura Crispini (University of Genova; Italy)

Gigamap Project

Eight sheets published at 1:250 k scale from Northern Victoria Land

Three sheets published on geomorphology

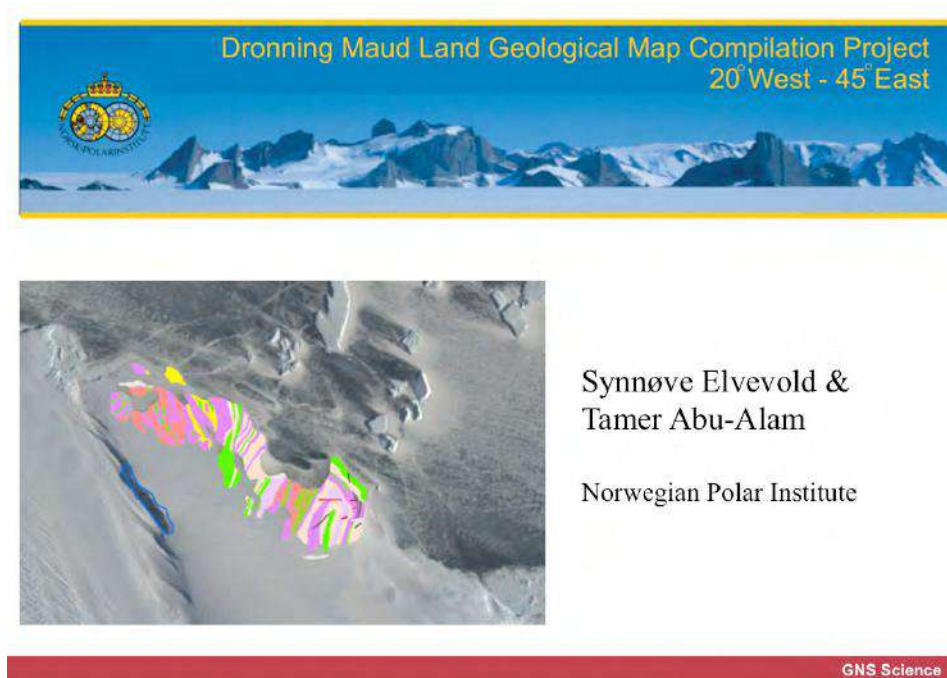German colleagues are also working in NVL.

Some geophysical maps exist

There are some petrophysical maps at a detailed scale.

We identify a need for projecting geology between outcrops

.TIF files are available but not yet GIS

Tamer Abu-Alam (Norwegian Polar Institute, Norway)

Creating a geological map of Dronning Maud Land

Creating one database from disparate sources

Bedrock geology map including chemistry data, structural data and age data.

1:250 k scale

Poor agreement between landsat and rock outcrop.

79 geological maps georeferenced

Moraines were mapped as a single unit

An 'unknown' unit was also used.

Comment: (Simon Cox) We record who went where in our GIS, this can be useful, for example to ecologists, who can identify areas where few people have visited.

Comment: Prioritise smaller scale maps over larger scale maps when assigning information (e.g. rock type) to a polygon. I.e. 1:1 k takes priority over 1:250 K.
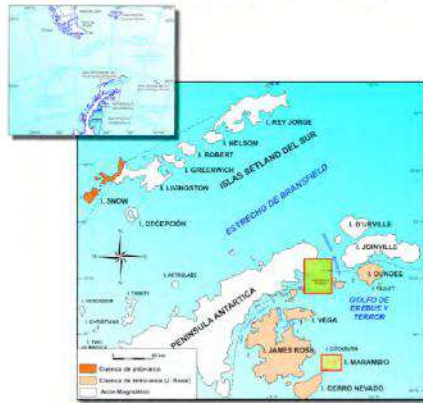
Manuel Montes (IGME; Spain)

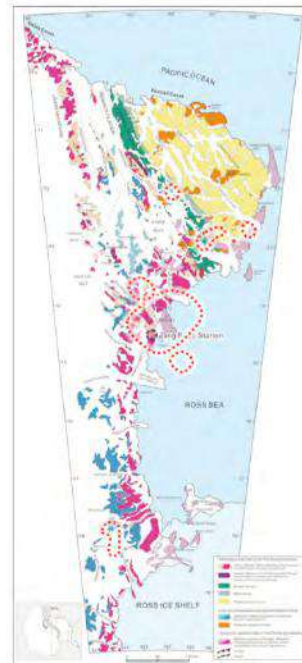We have maps of the Antarctic Peninsula

Hope bay is mapped at 1:10 k scale

Seymour Island is mapped generally at 1:20 k scale with some areas mapped at 1:5 k scale.

Available online as a GIS through our webserver – see http://www.igme.es/infoigme

Jusun Woo
(Korea Polar Research Institute; Korea)

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Jusun Woo (Korea Polar Research Institute; Korea)

Not specifically mapping focussed at this stage.

Expedition to the Mount Joyce area in 2011-2012.

Expedition to the Eureka Spurs area in 2013-2014 looking in particular at metamorphic geology and McMurdo Volcanic Group rocks.

Korea has mapped around the Jang Bogo station near Mount Melbourne looking at the McMurdo Volcanic Group rocks.

□

Stewart Jamieson (Durham University; UK)

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Subglacial mapping of the Weddel Sea.

Interpretive mapping with MODIS, MOA and radarsat AMM-1 data for ridges and valleys

Mapping at approximately 1:100 k scale

Definition of buried alpine landscapes

Currently mapping Ellsworth Mountains to Dronning Maud Land

This helps extend the geology beneath the ice

Mapping to same key as onshore geology

We map the nunataks first.

Comment: This landscape is comparable to NW Scotland

Chris Carson (Geoscience Australia, Australia)

Ad hoc digitising of (mainly) university projects of basement geology

Limited mapping of surficial deposits or geomorphology (at the moment)

The OneGeology data uploaded by Australia represents the Tingey data from the 1970's.

Simon Cox (Presenting on behalf of Paul Morin, PGC Minnesota; USA

Entire continent at 32-42 cm stereo

Currently available to NSF funded projects but can be distributed once they make a derivative product

2m DEM resolution (precision) with accuracy ± 10m

2m – 8m DEMs posted down to 85°S

Still need people on the ground to calibrate

Affected by atmospheric correction, different shading, weathering and oxidation

Comment: There is an analogue here between Antarctica and Mars / other planets.

3. Database Model

How can we make such a collaboration work?
- distributed vs. centralised database model.

Options for hosting web services?

International standards (GeoSciML).

What is needed to ensure adopted process retains an appropriate level of academic and custodial/sovereign rights?

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Database Models (Simon Cox)

How do we deliver this information?

'Geoscience Markup Language' (GeoSciML) is a Geography Markup Language (GML) for the Earth Sciences. It is the language used for OneGeology. This is becoming the defacto GIS language for geology. It is ultimately based on ISO international standards for data exchange over the internet.

OneGeology covers the globe, except for Antarctica (some exceptions). See http://portal.onegeology.org. It is a is a distributed database model, not a centralised database model. Almost all of the Antarctic Treaty partners have their geological surveys at least participating in OneGeology if not serving geological map data through the portal. So where are all the Antarctic geological maps?

The Commission for the management and application of Geoscience Information (CGI) overseas writing of GeoSciML. It is a commission of the International Union of Geological Sciences. The use of GeoSciML could be appropriate for Antarctica
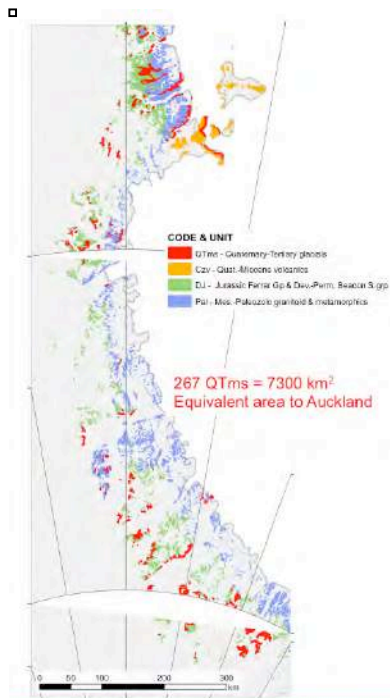
LIKE

Conversion of geological maps into GIS-databases accessible to ALL as smart **web feature services**

Retain academic and custodial rights (sovereignty) as/where necessary

e.g. web services utilising Geoserver or ArcGIS Server; in WMS smart image form or in WFS feature form (utilising GeoSciML) Perhaps a distributed database model like OneGeology, not a centralised database model

Spatially accurate for integration with latest satellite data and DEM's

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4. Classification

Introduce the expectation that there could be considerable nomenclature and classification issues, and differing interpretations.

Discuss the difference between geological vs geomorphological data.

Will we need an overarching high level digital stratigraphic plan/nomenclature and data design?

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Classification (Simon Cox)

Traditionally geologists have mapped using a 'bottom up' approach. Here we propose using a 'top down' approach where we assign geological information to rock polygons

We have started using the rock polygons from ADD v.6 rck01

This approach can be very useful to other end-users, for example biologists, ecologists, remote sensors, etc.

Question: (Simon Cox) At what stage do we distinguish between geology and geomorphology?

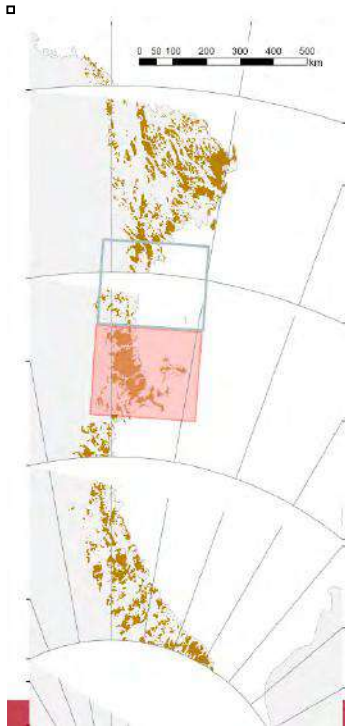Typically geology maps use either a lithostratigraphic or chronostratigraphic classification

We map the presence of material

Geomorphology crosses the lith- and chrono-stratigraphic information.
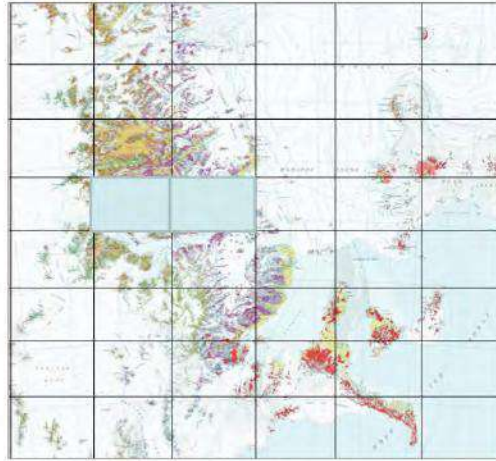
Nomenclature (Simon Cox)

Lithology versus chronography

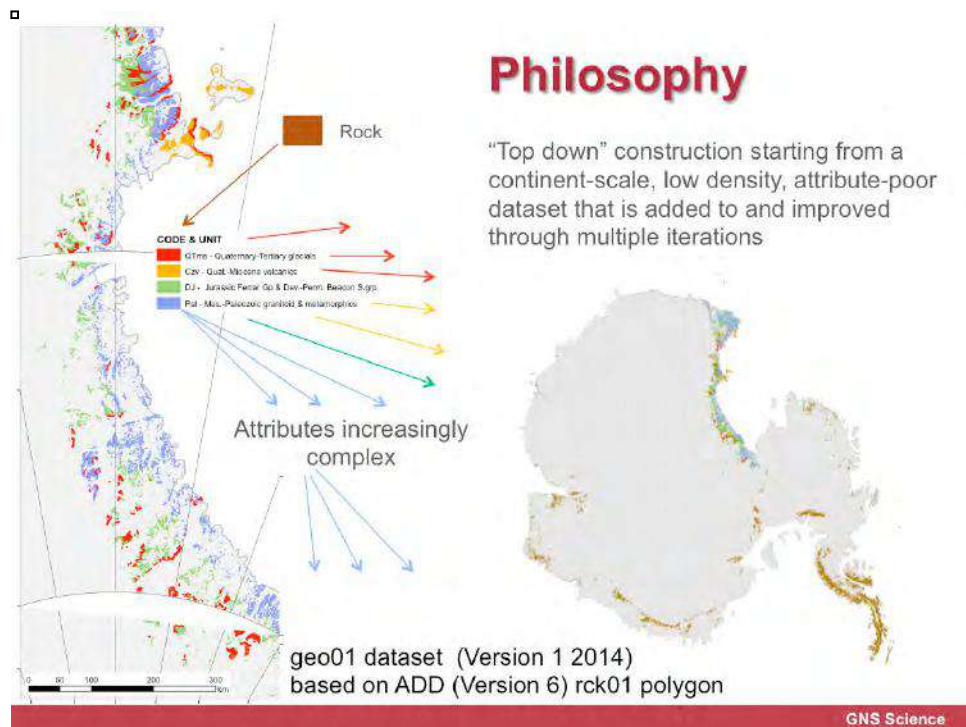Comment: (Stewart Jamieson) Add top level labels to detailed data, possibly

Philosophical Change

Conventional "bottom up" construction

QMAP SVL built from 72 sheets @1:50,000

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Philosophy

"Top down" construction starting from a continent-scale, low density, attribute-poor dataset that is added to and improved through multiple iterations

Rock

Attributes increasingly complex

geo01 dataset (Version 1 2014)
based on ADD (Version 6) rck01 polygon

CODE & UNIT

GTms - Quaternary-Tertiary glacials
Czv - Quat.-Miocene volcanics
DJ - Jurassic Ferrar Gp & Dev.-Perm. Beacon S.grp.
Pal - Mes.-Paleozoic granitoid & metamorphics

5. Base Datasets

What base datasets are available to work to and what precision is desirable?

ADD v6 rck01 and mrn01 are great for regional work, but will not match the decimetre- resolution satellite data now becoming available.

Should GIS capture and delivery utilise vector or raster data?

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Slides: Simon Cox

Need a base dataset. Will eventually need to link to new m-scale satellite datasets and can inform assessment of hyperspectral data.

Rock Classification Example (Alex Burton-Johnson, BAS)

ADD is traced from aerial images so has problems

> Some areas are poorly georeferenced
>
> Some areas shadows are included in the rock polygon
>
> There was a tendency when making the ADD layer to over-estimate the rock outcrop. The philosophy being it was better to capture everything then miss something.

We are running automated rock classification from landsat tiles for the Antarctic Peninsula. This provides 30m resolution

This relies on choosing well illuminated tiles. Strato-cumulus clouds can cause problems.

The coastline has been updated.

Question: How did you compensate for shadow? Answer: (ABJ) I used the

6. Team & Work Plan

Determine areas of international interest in providing existing map data and/or compiling different regions.

Establish a working team, timetable and action plan. What other resources are needed?

Should/can GeoMap science objectives be cross-mapped with the SCAR Horizon Scan questions?

Team Work and Plan (Simon Cox)

Phases:

Phase 1	2014 – 2015	Collaboration
Phase 2 continent-wide data set	2015 – 2016	The 1st phase of a
Phase 3	2016 – 2017	Improvements
Phase 4	2017 - ?	Modelling

Get involved

Re-marketing: this is a geosphere dataset for other scientists (c.f. geologists)

GeoMap can underpin many of the key 80 questions. *See* Mahlon C. Kennicutt II, Steven L. Chown et al.: "Six Priorities for Antarctic Research", Comment in Nature 512, 23–25; 7 August 2014 (doi:10.1038/512023a). The catalogue of 80 questions is available in supplementary material. GeoMap probably maps to, or underpins: Q3, 5, 8, 21, **25**, 26, **29, 32, 38, 39, 40**, 43, 45, 74, 75, 79 (bold= stronger relationship). The Antarctic Roadmap Challenges Project: We should align 'us' to 'them' and provide feedback for August 15

GeoMAP Action Plan

Phase 1   2014-2015
Develop international collaboration (& recognition of need) for provision of underpinning spatial geological information.

Phase 2   2015-2016
Geological attributes to continent-wide dataset. Build sources.
Adopt data formats and delivery mechanism. Peer-review.
Meet Malaysia August 2016.

Phase 3   2017-2019
Improve precision of regional geology and depiction of glacial sequences. Integrate remote sensing, detailed studies. Develop 1st dataset(s) outlining glacial deposits and landforms, their age and content.

Phase 4
Use in source characterisation, ice modelling, exploration for geo-indicators of climate change, biological and ecological studies.

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