SCAR Working Group on Geodesy and Geographic Information
Coordinators Meeting 26/27 July 1999, Heppenheim

Some remarks about the naming of regions in Antarctica and the implementation of regional names in a GIS

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Introduction

In traditional cartography regional names are placed on topographic maps without drawing boundaries and the position varies according to cartographic needs, i.e. scale, competition with other thematic contents and generalisation. In Europe regional names have developed over centuries and are well accepted. In the case of Antarctica regional names often seem to be introduced more or less randomly with no respect to the physical, environmental conditions and we also have to deal with multiple naming of identical regions.
Against this background I hesitated when Dr. Sievers asked me to deal with regional names and to define boundaries of Antarctic regions.

15 years ago I was working in a project dealing with the conception and implementation of a GIS concerning geomorphological features. One of the main problems we had to deal with was the definition of boundaries between the different features which have received their generic name from traditional usage, for example hill and valley. In daily life everyone uses these terms, but no one thought about the point where he leaves the valley and enters the hill. But for a Geographical Information System (GIS) it is a basic need to have precise positions and fixed boundaries between different objects and clear and unequivocal definitions of the objects.
To obtain good definitions we looked at well-known compendiums of geomorphology and found definitions like this: A hill is a rise you may walk on with no preparations concerning food and weather protection, but for climbing on a mountain you need to be prepared against changing weather conditions and you have to carry food with you. [1] [2]

This example illustrates the problem encountered with definitions written using a natural language (German, English, ...): the inherent ambiguity of the language used. Different individuals may understand such definitions differently. And if we need the definition in more than one language the number of problems has to be multiplied by the number of languages.

The problem of naming Antarctic regions seems to me very similar to the above-mentioned geomorphological problem. Everyone thinks to know for example where "Enderby Land" is situated. But if you ask people to draw the borders most will hesitate or refuse. A look into the "Composite Gazetteer of Antarctica" shows that there are three positions of the reference (centre) co-ordinates:

Name	Source	Latitude	Longitude	Class	Ref. No.
Enderby Land	AUS	70°00'00,0" **S**	50°00'00,0" **E**	1	4253
Enderby Land	RUS	69°00'00,0" **S**	51°00'00,0" **E**	1	4253
Enderby Land	USA	67°30'00,0" **S**	53°00'00,0" **E**	1	4253

Table 1: Entries 'Enderby Land' in the Composite Gazetteer of Antarctica (CGA)

[1] LOUIS & Fischer (1979:93): "Uns will scheinen, daß man der eingebürgerten Wortbedeutung nahe kommt und zugleich eine wissenschaftlich erwünschte Klärung der Begriffe erreicht, wenn man als Hügel nur solche Erhebungen bezeichnet, bei denen ein kräftiger Mensch für Auf- und Abstieg nur einen sehr kleinen Teil eines Tages braucht. Zu einem Hügel kann man ohne Zeitplan und ohne Vorsorge für Nahrung und Wettersturz aufsteigen und wieder zurückkehren. Eine Erhebung fängt dagegen an, ein Berg zu sein, wenn bei einer Besteigung die angedeuteten Vorkehrungen empfehlenswert sind; sie ist sicherlich ein Berg, wenn diese Vorkehrungen notwendig werden."

[2] We solved our problem by ignoring the traditional terms and introducing descriptive morphometric terms (rise, depression) for geomorphological features (visit http://uggg-pc-s1.uni-geog.gwdg.de/pg/sara/sara-e.htm to see some results)

There are several reasons which might have led to these discrepancies:
- navigational problems and insufficient description of the area at time of the discovery and first naming
- cartographic necessities according to scale and thematic contents of different maps (generalisation, displacement) which were used by the different organisations to define the centre point.

On traditional maps these shifts in placing a geographic name did not cause much trouble because the borders of the regions are individually interpreted by each map reader.

But if we use a GIS for storing geographical names we expect identical results from retrieval runs. One mechanism which ensures this aim is the storing of precise boundaries for the validity of names of each geographic feature. To obtain these boundaries we need unequivocal definitions of the geographical regions, that means, we first have to develop rules to define regions. A set of well-defined instructions will also help to increase acceptance of the regional names.

After this introduction I will first give some remarks about the theoretical background of regional names, i.e. what is a regional name and how should we store it in a GIS, before I report some experiences from practical dealing with regional names.

Theoretical aspects

In the case of Antarctica it seems relative easy to define the properties of geographic basic objects. We only have to deal with a reduced number of geographic objects, and we have for example definitions such as by ARMSTRONG et al. (1974, 1977) for features like ice shelf, inland ice, etc. We can also use the catalogue of the ADD, for example.

But what is a region? Is it identical with a basic object or is it composed of different basic objects, which have some common attributes?

Is an ice shelf like Quarisen (Fig. 1) a region or is the region composed of the ice shelf itself and the feeding region situated in the hinterland?
If the first thesis is true, what is the minimum size of a region? Is the Filchner-Ronne-Schelfeis a region? And what about Berkner Island, Hemmen Ice Rise, and all the other ice rises and ice rumples? Did we properly consider the differences in significance of Quarisen and Filchner-Ronne-Eisschelf, if we call both a region?
If we use the second definition, what is then the ice ridge of Soråsen? Do the western, middle and eastern parts of Soråsen belong to different regions (i.e. Riiser-Larsenisen, Quarisen, Ekstrømisen)? Or is Soråsen itself a region with the consequence that there is an overlap between different regions.

Definition "Regional Names"

What is a region? What are the rules to define it? How are the borders defined and how are they stored in a GIS? What happens if we need visualisations at different map scales?

In the last few weeks I tried to collect some definitions from literature about "region" which can be summarised as shown below: I will only show some of the definitions and avoid boring you with nearly 100 hundred years of research history about "regional science" as it

is called in the US, or "Landschaftskunde" , "Raumforschung" or "Regionalforschung" as we call it in Germany.

Figure 1: Shelf ice Quarisen and it's surrounding (from Satellitenbildkarte/ Satellite Image Map Dronning Maud Land 1 : 2 000 000, Draft Version 4.2 BKG, Frankfurt am Main 1998)

Definitions of "REGION"

A region is an area of the surface of the earth with more or less arbitrary borders.

A region is an area characterised by uniform spatial structures.

A region is an area of homogeneous surface units.

A region is an area which is dominated by one geographic factor.

A region is an area which is dominated by a set of geographic factors.

A region is an area which may vary in size but must be characterised by
- uniform natural components,
- or uniform historic (administrative) development (with borders independent of natural components). (After LIEDKE 1994)

If we agree with this definition we further have to agree about fundamental rules on the structure of a region: Is there a hierarchical structure inherent to the term "region", i.e. is a

region the sum of subregions and is it part of a major region? Or are all regions equivalent with respect to their order? It seems to be useful to define a hierarchical structure, but then we will have to deal with the problem as how to define different levels of hierarchy and to identify characteristics of regions of the same level.

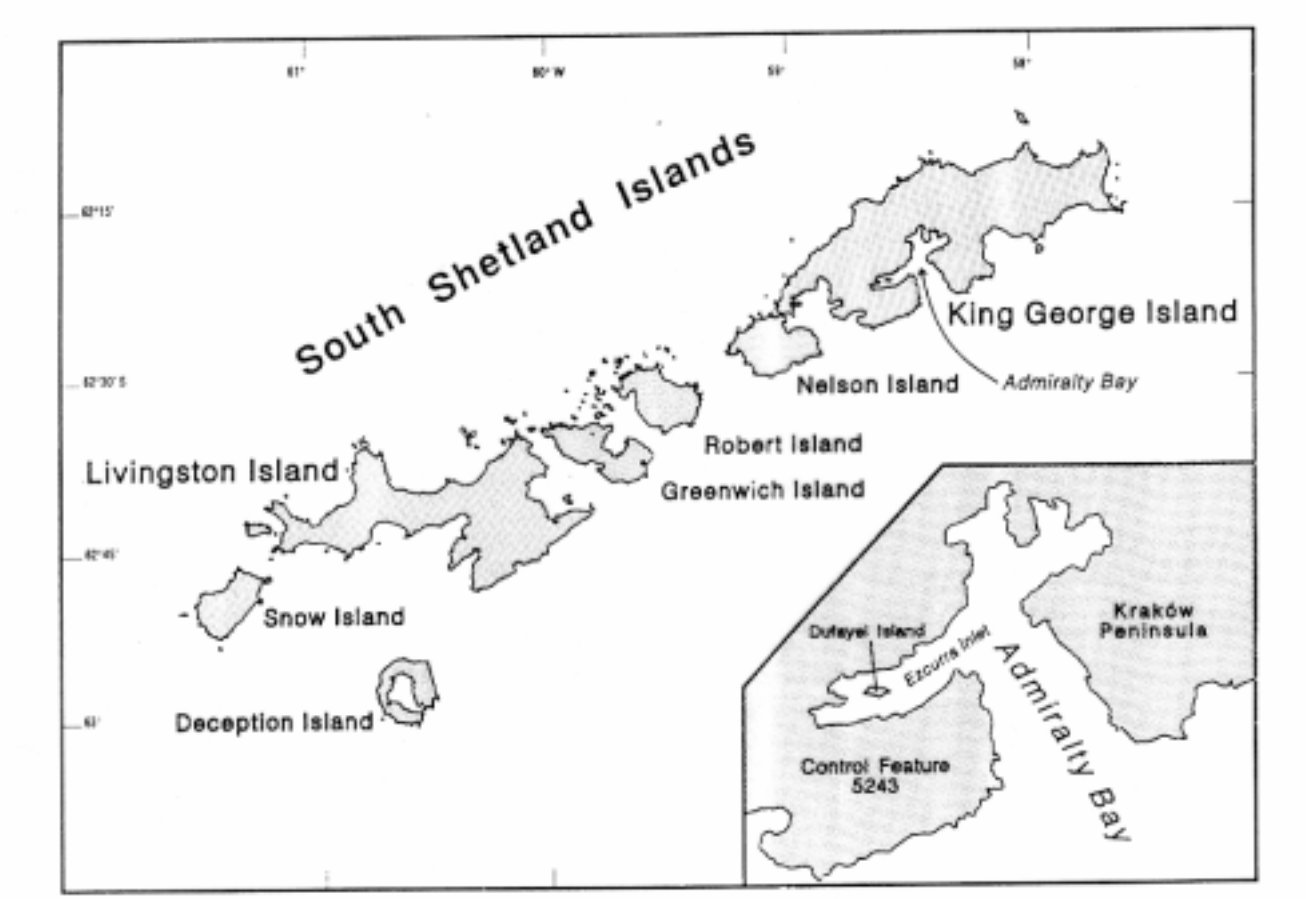

Figure 5.1. Place-names in the South Shetland Islands, Antarctica.

Figure 2.: Usage of 'Control Features' in the Antarctic Digital Database (ADD) Version 1.0

Another problem might be that regions at the tops of the branches have different significance, because names have been distributed unevenly throughout Antarctica. In the ADD Version 1.0 this problem was solved by introducing "control features" to ensure that a place-name appears at its correct level in the hierarchy even if its parent feature has not been named. For example, control feature 5243 (Fig. 2) is a substitute name for the large unnamed peninsula of King George Island to restrict this area to the same level as Kraków Peninsula.

There are two strategies to define regions within a hierarchy: top down or bottom up.

Top down means first to define a super region Antarctica and then to divide it into smaller regions like West and East Antarctica. This may cause problems when we are working on lower levels and will find out that a border line drawn previously at a higher level will crosscut smaller objects; this whould be in contradiction to the idea of hierarchy.

Using a bottom up approach means first to define the basic objects and to group them into regions of a higher level. This means that we have to agree on the question: What is a basic unit, i.e. how is a region of the lowest level defined?
FRANK ET AL (1986) pointed out that various studies have been undertaken to capture some of the distinctions between different types of regions, so evident to human observers but at the same time so difficult to express in formal terms. The goal of such studies has been to identify the regional types by easily observable macroscopic features. This requires a method of counting features in the area of interest which might be used to characterise it and to identify types of regions using statistical methods. This attempt requires an identification of features not based on subjective classifications in order to obtain comparable results.
One attempt to avoid the pitfalls of subjective interpretations is to use numerical parameters like the network of watersheds or stream lines or other morphographic identification marks derived from a digital elevation model (DEM).
At a first glance, this attempt seems to be an ideal solution. But it was observed that DEMs derived from maps of different scale and DEMs derived by different methods and DEMs of different density show variations which might lead to different results. (O'CALLAHAN & MARK1984)

The great advantage of using numerical parameters is that they are computable and may be reviewed. Therefore, I recommend to use numerical values or parameters derived from a DEM (like ice divides) as much as possible . Since not all features can be described in this way, we have to look for other possibilities.

To simplify our task, we should use a general definition like this:

A **regional name** is the name of a natural feature in space like:
- waters; seas, lakes, rivers, ...
- elevation: mountains, hills, ridges, escarpments,...
- lowlands and hollows: plains, plateaus, valleys, gorges, ...
- units of uniform vegetation: forest, peat, moor land, ...
- other units with natural properties

Adopting this to the area of our interest we may define

An Antarctic regional name is the name of

- a natural feature in the Antarctic like
- glaciological features: inland ice, shelf ice, glacier, ice stream, ice rise, ...
- rock outcrop: mountain, nunatak, ...
- waters: lake
- islands: island
- coastal features: cape, harbour, ...
- ...

or

- an area which was named during the expedition of its discovery.

The use of this definition has the advantage that we can benefit from the "Composite Gazetteer of Antarctica" as an inventory of features to be defined.

ENEA
COMPOSITE GAZETTEER OF ANTARCTICA

HISTORY AND STRUCTURE OF THE SCAR COMPOSITE GAZETTEER OF ANTARCTICA

Annex F - Class Description

CLASS NAME	CODE	DESCRIPTION	EXAMPLES
Lands	1	Large continental areas, entirely or partly defined by natural boundaries	Land, Territory
Elevated features - a	2a	Large conspicuous heights	Mount, Mountain, Volcano
Elevated features - b	2b	Moderate to low heights	Hill, Knob, Mound, Moraine, Nunatak
Elevated features - c	2c	Alignments and highland systems	Chain, Group, Massif, Range
Elevated features - d	2d	High summits	Needle, Peak, Ridge, Summit, Top
Elevated features - e	2e	Mountain passes	Col, Crossing, Gap, Pass, Saddle
Elevated features - f	2f	Slopes and walls	Buttress, Cliff, Escarpment, Slope
Elevated features - g	2g	Valleys	Canyon, Gorge, Gully, Valley
Elevated features - h	2h	Plains of variable altitude	Flat, Highland, Plain, Plateau, Table
Coves and harbours	3	Any kind of coastal indentation, usually large and/or deep	Anchorage, Bay, Bight, Dock, Cove, Fjord, Harbour, Inlet
Seas	4	Sub-division of the salt water partially covering the Earth's surface	Sea
Islands	5	Islands and any kind of isolated feature (usually small) emerging from the water	Archipelago, Island, Reef, Skerry, Stack
Sea floor	6	Any submarine feature	Bank, Deep, Patch, Shoal, Trench
Sea coasts	7	Any kind of shore between land and sea	Coast, Beach, Strand
Capes and coastal projections	8	Any kind of land feature projecting into the sea	Arm, Cape, Headland, Peninsula, Promontory, Point , Tongue
Sea access	9	Any kind of sea passage between two lands or between a land and an ocean	Entrance, Channel, Narrows, Passage, Sound, Strait
Fluvial features	10	Any kind of fluvial feature	River, Stream, Rapids
Inland water features	11	Any kind of lacustrine feature	Lagoon, Lake, Pond, Pool
Ice features	12	Any kind of ice-made feature, except cracks	Glacier, Iceberg tongue, Ice fall, Névé
Ice cracks	13	Any kind of ice crack	Chasm, Crevasse
Man-made features	14	Any kind of man-made feature, including historic monuments	Camp, Monument, Station, Base, Wharf
Round features	15	Any feature having a circular shape	Amphitheatre, Arena, Basin, Cave, Circle, Hole
Rookeries	16	Nesting and breeding places of a penguin colony	Rookery

Table 2: Annex F of CGA

In Annex F of the 'Composite Gazetteer of Antarctica – class description' 23 classes of features are described. Ignoring the man-made features and rookeries we have a list of 21 classes with a lot of subclasses and about 16,000 individual objects.

According to the definition, we can divide the classes into two groups:
- natural features defined by topographic, morphometric, or glaciologic properties, and
- man-made subdivisions as a relict of the history of discovery of the Antarctic.

The class 1 – large continental areas – is dominated by names of this origin. For example, "Neuschwabenland" is a very heterogeneous area composed of ice shelves, mountains, escarpments, nunataks and plateaus. The only homogeneous aspect for this kind of region is the history of discovery, which in the case of "Neuschwabenland" was determined by the distribution of sea ice of the adjacent ocean, the range of the reconnaissance planes, and first of all by the political aim which was to claim as much as possible of the discovered land for Germany.

One aim of defining borders of Antarctic regional names is to integrate this data set into the ADD.

Following the Antarctic Treaty we should not represent regions in the region layer of the ADD, since these are identical with the territorial claims of the different nations (British Antarctic Territory, Australian Antarctic Territory, Tierra de O'Higgins, ...). This might be a separate layer within the ADD showing all territorial claims.
For the remaining approx. 40 objects of class 1 we can refer to the definition of the Gazetteer:

***A region of the type 'land' is a large continental area, entirely or partly defined by natural boundaries*.**

From Australia we received a proposal defining regions by using sectors starting at the coast and ending at the south pole and which are defined by longitudes as given in the table of Fig. 3.

If we continue with this method we will encounter near the south pole a funny situation: With only a few steps we will cross a lot of regions and we will recognise no difference between these regions.

I would prefer to find other, "more natural" boundaries limiting these regions against the polar plateau:

- a fixed distance from the coast
- a fixed latitude
- a fixed elevation
- a change in slope of the inland ice
- a change in curvature of the inland ice sheet (the border between convex and concave relief elements)
- ice divides

For most of the other geographic objects selected from Annex F of the CGA we have to define rules to separate the features from each other.

Enderby Land	45°	–	55° E
Kemp Land	55°	–	60° E
Mac.Robertson Land	60°	–	73° E
Princess Elizabeth Land	73°	–	87° 43' E
Wilhelm II Land	87°43'	–	91°53'E
Queen Mary Land	91°53'	–	100°28' E
Wilkes Land	100°28'	-	136° E
George V Land	142°	-	155° E
Oates Land	155°	-	164° E

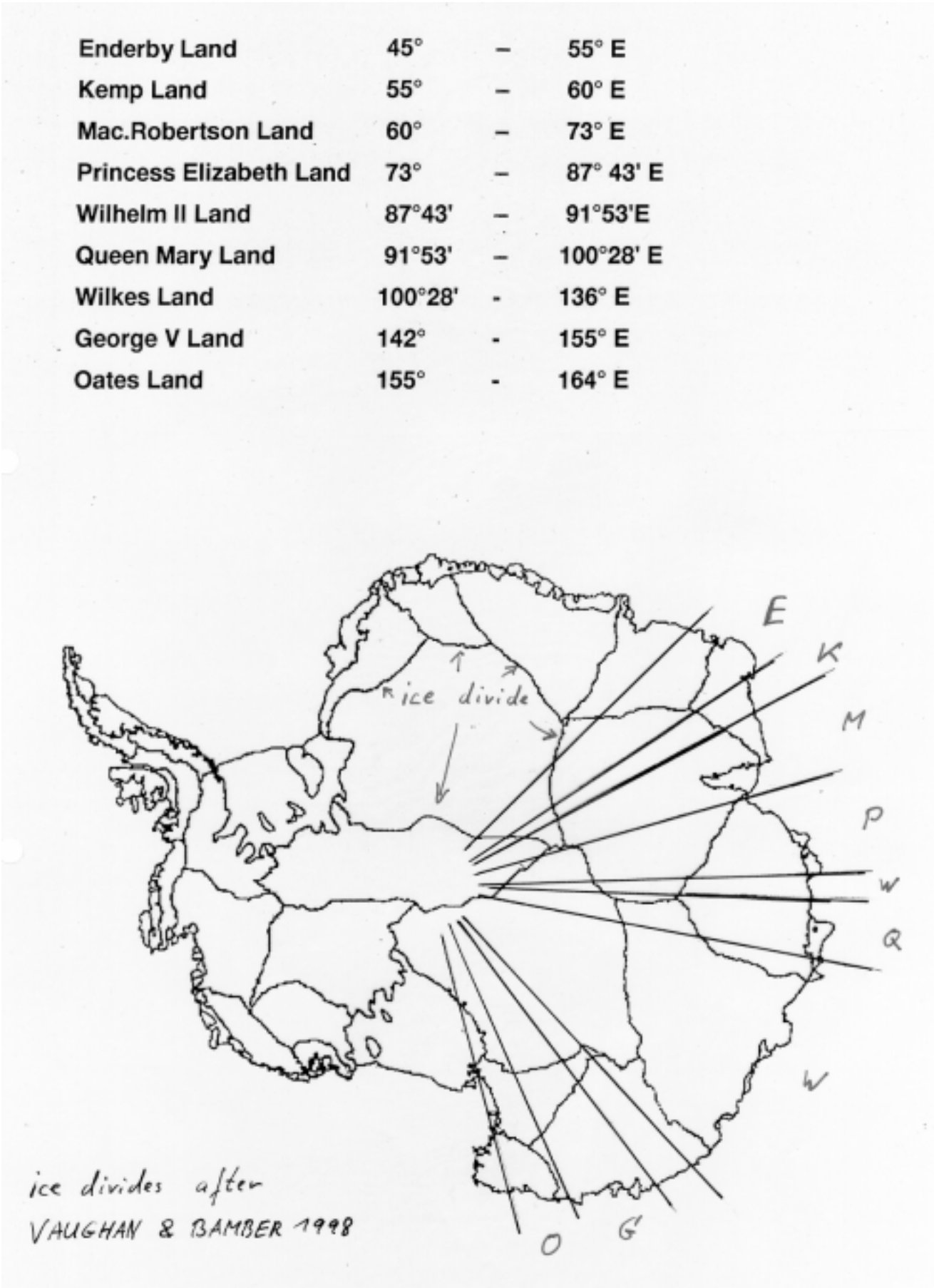

Figure 3: Australian proposal for naming of Antarctic Regions: Sectors reaching from the coats to the pole.

Integration of "regional names" into the ADD

If we remember that the data should be integrated into a GIS, we have to consider the type of GIS data model we should use, which means that the questions arises whether we need to define point, line or polygon topology?

Therefore, we should discuss the necessity of defining border lines for every object , or would it be helpful to define some objects to be a **point feature** represented by a pair of co-ordinates only; for example, we may represent very small nunataks or small lakes as a point feature. And if we accept this proposal we may also define **line features** represented by a set of co-ordinate pairs. This seems ,for example, useful for cracks, even if we all know that these objects have a spatial dimension.

All other objects are **polygon features** with more or less clearly defined boundaries. The uncertainty of boundaries should be expressed by two types of lines, **definite and indefinite lines**, respectively, by an attribute describing the uncertainty. We could derive the other attributes from the CGA and the ADD (.ie. Organisation responsible for naming, date of approval, hierarchy level, etc...).

Concerning the basic objects we could differentiate between single objects and groups of objects (nunatak – group of nunataks). Grouping of identical objects should be done by using the smallest circle or ellipse which surrounds all members, or by connecting the most extreme points of the members.

The question about introducing three GIS-data types of regional names is correlated to the question as to which data source should be used to derive the boundaries of regional names?

In theory, we should use the best available maps, i.e. the maps of the highest resolution and all available satellite imagery and aerial photographs to determine the boundaries, but for the purpose of digitisation we should use the layers of the ADD, because this offers a homogeneous data set covering Antarctica at a uniform scale and will support data integrity of the different layers of the ADD. Using other data sources involves the danger of producing inconsistencies in geometry.

Table 3 shows some possible 'natural' criteria that can be applied for the separation of single objects. Objects to be stored as point or line features are indicated by the letters P or L.

Single Basic Object	Code Annex F CGA	'natural' boundaries or Point (**P**) / Line (**L**) –Object
Mount (single)	02a	Significant change in morphology, **P** (summit)
Nunatak	02b	Limit of rock outcrop, **P** (summit)
Moraine	02b	Limit to rock, limit to ice, **L**(flow direction**)**
Mountains	02c	Limit to glacier, inland ice
High summit	02d	**P** (highest point)
Mountain pass	02e	**P**
Slope and walls	02f	Significant change in morphometry
Valley	02g	**L** (flow direction)
Plain, Plateau	02h	Change in slope, curvature
Sea	04	Ice front, shore line
Island	05	Shore line
Sea floor	06	
Sea coasts	07	
Capes and coastal projections	08	Coast line, **P** (most seaward point)
Sea access	09	
Lake	10	Shore line, **P** (centre point)
Ice shelf	12	Grounding line, ice front
Ice rise, rumple, island	12	Grounding line
Glacier	12	Limit to rock outcrop, not/slowly moving ice, **L** (flow direction)
Ice stream	12	Limit to not/slowly moving ice, **L** (flow direction)
Ice cracks	13	**L**
Man made features	14	----
Round features	15	**P** (centre point)
Rookeries	16	---

Table 3: 'natural' criteria to separate single objects based on classes of the CGA

Practical experiences – Example: Wohlthatmassiv

For practical work I used the ADD as background and a satellite image on my desk to draw some borders of regional names in the Wohlthatmassiv

Using this definitions a lot of new problems arose:
- How to define a significant change in morphometry?
- Where is a significant change in slope or curvature?
- What does the generic part of a geographic name in a foreign language really mean?

Back again I struggled with the task of where to draw the boundaries of glaciers, single mountains, or mountain ranges.

After discussions with colleagues from our institute I decided to avoid all discussions about precise positions of boundaries and to reduce the dimension of the regions:

- all more or less rounded features are represented as a point object ,and
- all objects which have a direction are represented as a line object.

Mountain ranges are marked by the smallest surrounding ellipse or by a line connecting the extreme points free of snow and ice.

To avoid problems with names in foreign languages I dealt only with objects that were named by Germany (See sketch map in annex).

Now, it seems to be easy to do the job. But even with this reduced data set I had to face some problems:

- Concerning the problem of multiple naming for this region it seems clear that the German names were given first (during and after the German Antarctic Expedition of 1938/39). But for example the name " Otto-von-Gruber-Gebirge " was introduced by BRUNK in 1986 as a derivation from a Norwegian map naming this area "Gruberfjella". That means, we have to use the Norwegian name for this region even if there is a danger of confusion with the name "Gruberberge" (CGA Ref. Number 4583) situated at 72° S, 4°50' E, while "Gruberfjella (CGA Ref. Number 5733) is situated at 71°22' S, 13°25'E.

After BRUNK (1986) the Wohlthatmassiv is built up of six components:
Alexander-von-Humboldt-Gebirge, Petermannketten, and Otto-von-Gruber-Gebirge/ Gruberfjella, Payergruppe, Weyprechtberge, and Vorposten.
Norway uses the name Wohlthatmassivet only for the first three components.
Due to the character of the generic part "massiv", which means compact, high mountains I prefer the Norwegian interpretation, which is in accordance with the maps of KOSAK (1951).
From this experience I concluded, that every name has to be reviewed concerning the meaning of its generic part.

- For the range Petermannketten there are 4 names indicating that they are parts of these mountains:
  Östliche Petermannketten
  Mittlere Petermannketten
  Westliche Petermannketten
  Sojdre Petermankjeda
  But it is not clear, for instance to which part belongs the "Zwieselberg" or whether this is a separate range within the Petermannketten. The same question arose concerning the Schneide and Schneidengruppe. After BRUNK they are not part of the range Östliche Petermannketten, respectivly the range Mittlere Petermannketten. But on the Norwegian Map Series Dronning Maud Land 1: 250 000 these mountains are shown as parts of the regions mentioned.
  If we have an object A divided into 4 parts (east, middle, west and south A), this excludes in my understanding the existence of other subobjects within the area of object A. Therefore, and because we have some better information about this region, I would like to introduce the Norwegian usage for the German names.

- The layers of the ADD offer no information about the borders of glaciological objects. Where does a glacier start flowing?. We need the experience of experts who were already there, or we have to use, for example, satellite imagery to interpret the borders.

To avoid this problem I only have drawn some lines showing the main flow direction of the glaciers and ice streams.

To summarise my experience I would like to express my belief that it is necessary to have a look at the historic origin, the glaciologic, geographic or topographic meaning of a name, and the physical properties of the object.

For this investigation I used German, Norwegian and Russian maps of this area in order to join all names I found in a ARC/INFO annotation coverage, which was superimposed on the ADD layers of this region. This was a very time-consuming effort.

It seems to be possible to shorten the working time by integrating the CGA and the ADD in order to obtain a synoptic overview of objects and names. But instead of making the job easier some problems have now become clearly visible and new problems have appeared:

- for some objects we have names in different languages with more or less identical co-ordinates (Example: Enderby Land), that means, labels are plotted on top of each other, thus making the map unreadable,
- from the GCA we have no information about the date of naming the object, i.e. we are not able to decide which name was introduced first,
- the geometry of the ADD and the co-ordinates of the GCA does not fit very well, for example, in the case of the Schirmacheroase (Fig. 4) there are no objects to be found close to the points where the lakes named by India should be.

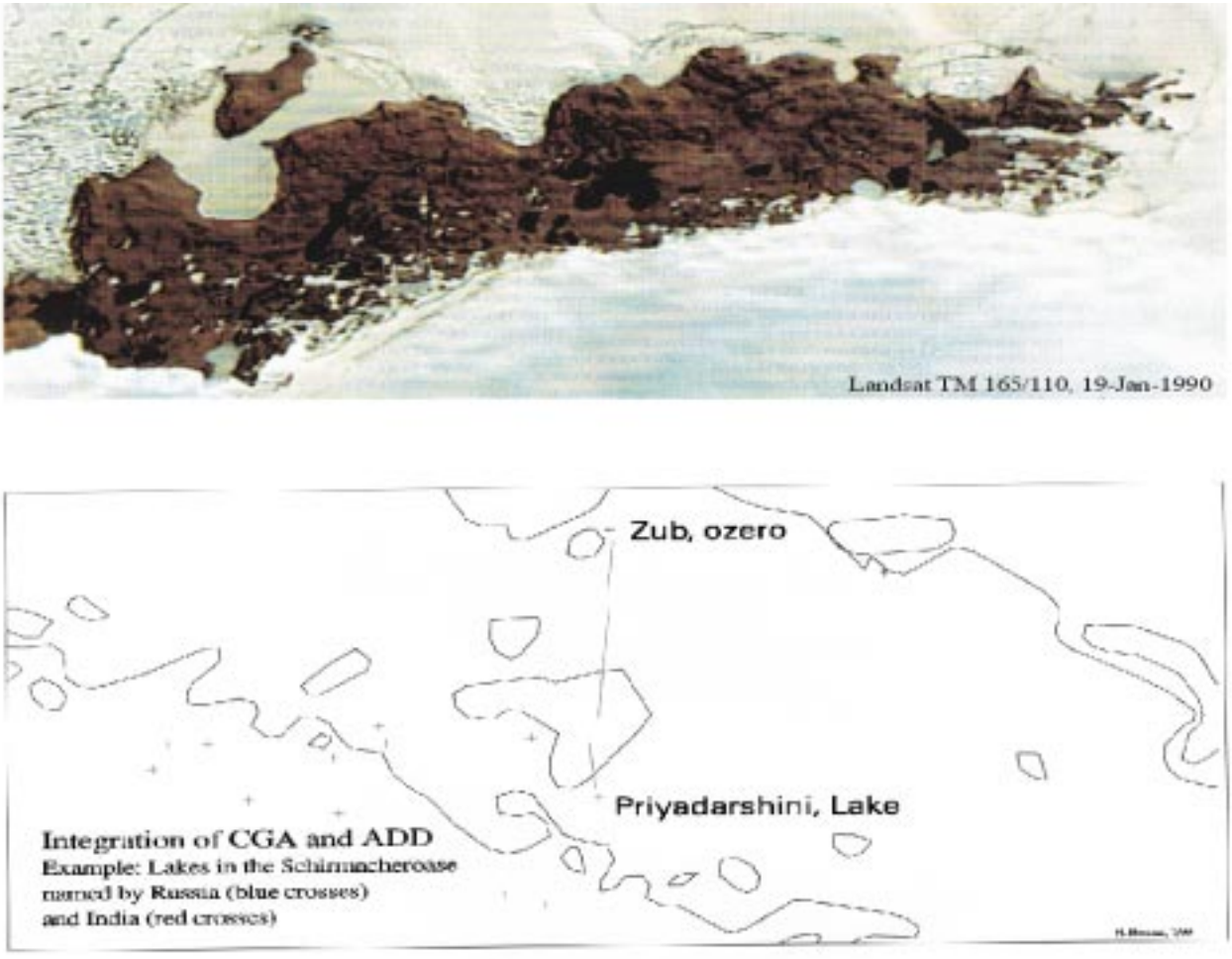

Figure 4: Integration of CGA and ADD. Example: Lakes in the Schirmacheroase

In the case of the lakes in the Schirmacheroase I believe that this is not a real problem, because if we follow the rule of historic priority we have to use the Russian or Norwegian names within the oasis. But it is impossible for me to exclude that there are any objects named first by India.

Conclusion - Future work

As a result of my investigations I recommend that:

- We should develop general rules for defining regions based on 'natural' boundaries wherever possible.
-
- Each contributing organisation to the CGA should
  - -- review the generic parts of the names,
  - -- review the usage of the names,
  - -- update the co-ordinates of the names,
  - -- **deliver cuttings from maps, annotated satellite imagery or aerial photographs, sketch maps based on the ADD, to be included in the CGA** (to allow easy identification of geographic objects by everyone),
  - -- add to the CGA the date of approval /the first publication, (to allow in the case of multiple naming the identification of the historic priority)
  - -- draw borders of each proposed name using the geometry of the ADD.

- In a first step the ADD should be supplemented by regional name layers of all contributing organisations.
- A subgroup of the WG GGI should derive general rules for defining borders of regional names from this data set and integrate all contributions.

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Annex: Regional Names – Example: Wohlthatmassiv/Dronning Maud Land 1 : 500 000 (BKG, Draft July 1999)

Regional Names - Example Wohlthatmassiv / Dronning Maud Land Draft 1 : 500 000