



WP

9

Agenda Item:

4.2.3

Person Responsible:

XXXIII SCAR Delegates Meeting

Auckland, New Zealand, 1-3rd September 2014

STANDING SCIENTIFIC GROUP ON GEOSCIENCES (SSG-GS)

Executive Summary (1 page)

Title: Standing Scientific Group on Geosciences Report to the Delegates

Authors: W. Berry Lyons, Jesús Galindo-Zaldivar, Naresh C. Pant

Introduction/ Background: (Summary of SSG Geosciences)

GS continues to play a role in SCAR science both at the disciplinary and multidisciplinary level. GS scientists from many nations are involved and take leadership roles in two of SCAR's ongoing SRPs: Past Antarctic Ice Sheet dynamics (PAIS) and Solid Earth Response and Influence on Cryosphere Evolution (SERCE). Our interdisciplinary activities include in the Expert Group (GNSS Research and Application for Polar Environment) GRAPE. Demo GRAPE, an initiative of GRAPE, will begin within the next months involving new contributions from South Africa and Brazil to the original program. ADMAP continues to be a productive program as a special issue of the journal *Tectonophysics* comprised sixteen papers updating ADMAP's contributions to geomagnetic studies of the Antarctic regions. ANTPAS also continues to produce important scientific results including an overview of permafrost conditions in the Antarctic Peninsula and an inventory of paleoclimatic records from the McMurdo Dry Valleys. A special issue of the journal *Geomorphology* is currently being prepared for publication. Also the GIANT, IBCSO and CGG groups have relevant results. New activities include the development of a Geo-Heritage action group that will aid in helping to develop criteria for the protection of special geological features in the Antarctica. The Antarctic volcanism expert group also will aim to study different aspects and interactions of volcanic activity. The geological mapping update of the Antarctica will be focused in the integration of all the available geological data, mainly in Transantarctic mountains. The XII International Symposium on Antarctic Earth Sciences (ISAES) is currently being planned for the summer of 2015 in Goa, India. Proceedings of the symposium are likely to be published by the Geological Society of London in their Special Publication Series.

Important Issues or Factors: (what do the SCAR Delegates need to be aware of)

A new observing system is being proposed "Antarctic Near-Shore and Terrestrial Observing Systems" –ANTOS. This is an interdisciplinary program that will involve all three SSGs.

Wider recognition of sites of geological significance in Antarctica can be achieved by development of a geo-conservation register, to promote and recognize intrinsically valuable geological and geomorphological sites. This is being attempted within the SSG-GS group and it has got a boost with the recognition of Stornes Peninsula as an ASPA of geological significance.

One new Expert Group (Antarctic volcanism) and two new Action Groups (Geo-Heritage and geological mapping update of Antarctica) are being proposed.

Recommendations/Actions and Justification: (what actions are you requesting of the Delegates and why they should agree)

- 1) Continuation of the SSG GS Expert Groups
 - a. GIANT
 - b. ADMAP
 - c. ANTPAS
 - d. IBCSO
- 2) Continuation of Action Group
 - a. CGG
- 3) Discontinuation of Action Group
 - a. Multibeam Data Acquisition
- 4) Establishment of new SSG GS Expert Group
 - a. Antarctic Volcanism

- 5) Establishment of new SSG GS Action Group
 - a. Geoheritages in Antarctica
 - b. Geological Mapping update of Antarctica
- 6) Endorsement of Dr. Phil O'Brien as SSG GS representative to SCATS
- 7) Requesting endorsement by SCAR for UN resolution on Global Geographic Informations Management regarding the rule of importance of Global Geodetic Reference Frame development and sustainability;
 - a. that SCAR shall take into account the UN GGIM resolution and shall be involved in UN GGRF WG activities and SCAR president will send a letter of support to UN initiative.
 - b. Further, we recommend that SCAR SSG GS GIANT EG will be involved in the collaboration with UN GGRF WG.
- 8) Approve the establishment of the ANTOS program and the creation of an EG/AG to oversee its development, implementation and its interdisciplinary nature.

Expected Benefits/Outcomes:(if the actions are taken what outcomes are expected)

Active groups have been recommended for continuation while one group (Multibeam Data Acquisition) is being recommended for discontinuation on the suggestion of its leader.

New Expert Groups and Action Group have been proposed following the ideas emerging from Horizon Scan.

Partners: (will this involve others both within and outside of SCAR?)

SSG GS that continues to be active have linkages with other scientific groups through programs such as ANTPAS and GRAPE. The new group Geoheritages in Antarctica will have linkages with Antarctic Conservation and LS conservation groups. In addition Volcanology of Antarctica will have possible linkages with a wide variety of groups in LS and PS.

Budget Implications:(What funds are requested or other commitments by SCAR?) Current budget needs are expected to be similar for the existing scientific groups within GS-SSC

- 1) We request funds as per following details
 - a. USD 20,000 towards support for the XII ISAES (as projected earlier).
 - b. To approve USD 29,500 for the year 2015 and USD 31,000 for the year 2016 for EG and AG activities.
 - c. To reallocate unspent amount of SSG GS for the period 2013-14 from EG and AG for travel support for XII ISAES 2015.

SSG GEOSCIENCES

(Should be no longer than 8 pages, excluding appendices)

1. Chief Officers

Chief Officer

Dr W Berry Lyons
 Director Byrd Polar Research Laboratory
 The Ohio State University
 1090 Carmack Road
 Columbus,
 OH 43210-1002
 USA
 Tel: +1 614 688 3241 Fax: +1 614 292 4697
 E-mail: lyons.142@osu.edu

Deputy Chief Officer

Dr Jesús Galindo-Zaldivar
 IACT (CSIC-UGR) y Dpto. Geodinámica Facultad de Ciencias
 Universidad de Granada 18071
 Granada
 Spain
 Tel: +34 958 24 33 49
 Fax: +34 958 24 85 27
 E-mail: jgalindo@ugr.es

Secretary & GeoReach Editor:

Dr Naresh C. Pant
 Associate Professor
 Department of Geology
 Centre of Advanced Study University of Delhi
 Delhi - 110007
 India
 Tel: +91 995 378 1350
 E-mail: pantnc@gmail.com

2. Major Future Initiatives and Actions

Two of the major Scientific Research Programs (SRP's), Past Ice Sheet Dynamics (PAIS) and Solid Earth Response and influence on Cryosphere Evolution (SERCE) represent the Geosciences Group. The progress of these programs is separately presented in the Delegates Meeting and hence is not repeated here.

2.1. Past Antarctic Ice Sheet dynamics (PAIS)

Lead proponents: C. Escutia (Spain), R. DeConto (Canada), K. Gohl (Germany), R. Larter (UK), R. Powell (USA), L. De Santis (Italy), M. Bentley (UK)

Progress being presented separately in the Delegates meeting on 1.9.2014.

2.2. Solid Earth Response and influence on Cryosphere Evolution (SERCE)

Lead proponent: Terry J. Wilson (USA)

Progress being presented separately in the Delegates meeting on 1.9.2014.

2.3. Consolidate the Action Group on Geohertiage and Geo-Conservation in Antarctica.

Proposal by C. Carson.

The geoscience community has a lot to offer in understanding surface processes and landscape vulnerability and spatial issues with defining areas for special management.

Geological “values” would include:

Rare, unique or spectacular mineral localities. – For example, Störness Peninsula.

Localities of special scientific significance – Features that may not be particularly special in themselves but which were the subject of landmark science. A non-Antarctic example would be the Cretaceous-Tertiary boundary bed in the Appenines where the iridium anomaly was first detected. It is not a particularly remarkable road cutting for the area but represents a feature of world importance. Another example might be rocks that are not particularly rare except for the fact that they are extremely old allowing access to early earth crustal forming process. The Napier Complex is currently undergoing a renaissance of research utilising rocks of great antiquity exposed (e.g. Mount Sones Orthogneiss at ca. 3.8 Ga). Also rocks comprised relatively common minerals in rare combinations which are of great scientific importance for providing rare insight into the geological history of an area).

Fossil localities harbouring spectacular, rare or unique material of intrinsic scientific value – (e.g. Marine Plain in the southern Vestfold Hills).

Landforms or outcrops of special significance – For example, raised beaches, relict penguin rookeries, potentially fragile surficial and soil features (e.g. ‘patterned ground’), some moraines and other peri-glacial features.

Budget request: 3000 \$.

2.4 New Expert Group on Antarctic Volcanism.

Proposed by Massimo Pompilio (Italy) and John Smellie (UK)

Volcanoes are widespread, at environmentally strategic locations across the entire continent; several still active

- Part of one of Earth’s largest crustal rift zones – the West Antarctic Rift System
- Outstanding probes of the Earth’s inaccessible lithospheric interior
- Erupted tephra ubiquitous in marine & ice cores; unrivalled tools for regional climate and time correlations
- Tephra are isochronous correlateable surfaces whose sources and ages can be determined
- Subglacial eruptions are unrivalled sources of palaeo-ice sheet parameters (e.g. age, thickness, thermal regime)
- Volcanic heat during subglacial eruptions has the potential to modulate ice-sheet behaviour and stability, and influence global climate

So volcanic studies are crucial for a holistic understanding of the palaeoenvironmental, palaeoclimatic & geological evolution (past and future) of the Antarctic Continent

Aims

To promote the study of Antarctic volcanism and disperse information.

To discuss protocols, methods, best practices.

To integrate and share geological information.

To facilitate regional correlations (e.g. tephrochronology).

To compile, integrate and publish data bases (e.g. outcrop maps, geochemistry).

To identify priorities, critical issues, future scientific directions.

To develop collaborations and international joint research projects.

To exchange data and ideas with other SCAR Scientific Programs or Expert Groups.

To provide a clear route map for obtaining expert advice in case of volcanic crises, e.g. Deception Island, Mt Erebus, Mt Melbourne

To develop productive links with related science disciplines (e.g. glaciology, biology, modelling).

Budget request: 6000\$

2.5. New Action Group on Geological Mapping in Antarctica.

Introduction

There are numerous, hard-copy, regional-scale geological maps that were developed last century. Many have been scanned, some have been georeferenced, but few are more than raster digital information. For the most part they are geologically reliable for defining bedrock geology ('deep time'). Unfortunately they contain little representation of glacial geology, the maps have poor spatial reliability in the context of modern science (located by GPS), and the maps have not kept pace with the present focus of Antarctica's role in climate change.

Antarctica contains substantial areas of rock and cover deposits that contain a geomorphological and geological history of the waxing and waning of Antarctica's ice sheets. Some relatively small areas have been represented by detailed local maps in journals, but there are no modern attribute-rich GIS datasets to provide holistic information at the scale of the ice sheets/ice shelves. Meanwhile, large quantities of satellite data are being rapidly acquired, offering the opportunity to locate outcrops and derive compositional information.

There is a growing need for a digital dataset to comprehensively define the exposed geosphere, for pinpointing the locations of glacial deposits, indicate their mode of formation, age, and likely source. Such key underpinning information on the geosphere and its history can be used to constrain biological and ecological research, identify geoindicators of climate change, and help improve our understanding of Antarctica's role in climate change.

Terms of Reference

This group will facilitate an integrated programme to promote the capture of existing geological map data, update its spatial reliability, improve representation of glacial sequences and geomorphology, and enable data delivery via web-feature services.

Objectives

- Solicit wide international representation.
- Debate and decide on GIS-data structure and delivery mechanism. Debate the relative merit of a distributed database like OneGeology, versus a centralised database model. Ensure adopted process enables retention of academic and custodial rights (sovereignty) as/where necessary.
- Convert geological maps into GIS-databases and smart web feature services.
- Improve definition of glacial geology and geomorphology using satellite imagery and remote sensing, local age-dating studies
- Find a host for web services, perhaps utilising Geoserver or ArcGIS Server; in WMS smart image form or in WFS feature form (utilising GeoSciML).
- Prepare paper outlining geological nomenclature and classification issues that arise.
- Highlight areas for targeted research and/or the need for new geological field work
- Facilitate exchanges of early career and other scientists with an interest in spatial representation of the geosphere.

Steering Committee

Simon Cox (New Zealand, Co-Chair)
 Paul Morin (USA, Co-Chair)
 Mark Rattenbury (New Zealand)
 TBC (United Kingdom, Italy, Germany, Korea, China?)

Duration

2015-2018

Activities

Scoping meeting 2015
 Synthesis meeting 2016
 Strategy development meeting 2017
 Plan delivery 2018

Budget request (2015-2016)

US\$3000 p.a. (further funds will be solicited from NAPs and others)

2.6 GNSS (Global Navigation Satellite System) Research and Application for Polar Environment (GRAPE) Giordiana De Franceschi (Report in Section 3)

DemoGRAPE (Lucilla Alfonsi, PI) is a project recently approved by the Italian Program for Antarctic Research (PNRA) and it is going to start within the next months. The initiative was born within GRAPE (GNSS Research and Application for Polar Environment), the SCAR Expert Group. SANSA (South Africa) and INPE (Brazil) will join the project by contributing with GNSS ionospheric measurements collected at the South African and Brazilian Antarctic stations during the Antarctic summer expedition 2015-2016.

2.7 Progress on XII International Symposium on Antarctic Earth Science (ISAES), India:

Preparations for organization of 12th ISAES-2015 hosted by National Centre for Antarctic and Ocean Research (NCAOR) at Goa, India are progressing satisfactorily. Venue has been finalized and a core group of 22 members Scientific Program Committee is active in finalizing the structure of the symposium. A webpage <http://isaes2015.ncaor.gov.in/> is functional where preliminary registrations can be done. Submission of session proposals has began from 1st August 2014. The symposium venue has been finalized.

The proceedings of the symposium is likely to be published by the Geological Society of London as *Special Publication Series*.

2.8 Geo-heritage- Stornes Peninsula- Antarctic Specially Protected Area (ASPA-174) and beyond. A presentation of the geo-heritage value of Stornes Peninsula, the first 'hard-rock' ASPA in Antarctic highlighting the geological basis of the new ASPA declared in the Larsemann Hills is proposed for SSG-GS meeting in Auckland in August 2014. In general, sites of geological and geomorphological significance are underrepresented in conservation in Antarctica. Wider recognition of sites of geological significance in Antarctica can be achieved by development of a geo-conservation register, to promote and recognise intrinsically valuable geological and geomorphological sites. Discussion will focus on development of a geo-register to promote geo-heritage features. Features on the register that are especially fragile, or otherwise likely to be disturbed, threatened or become vulnerable by human activity, can be identified as such and area management protocols for conservation, under the Antarctic Treaty, can be more readily invoked, developed and substantiated.

2.9 SCAR supporting the United Nations resolution on UN Global Geodetic Reference Frame

United Nations takes a resolution within the Committee on Global Geospatial Information Management regarding the rule of importance of Global Geodetic Reference Frame development and sustainability.

Reporting the resolution it should briefly resumed that:

The General Assembly, Reaffirming the purposes and principles of the Charter of the United Nations,

.....
Reaffirming further its resolution 57/253 of 20 December 2002, in which it endorsed the Plan of Implementation of the World Summit on Sustainable Development (“Johannesburg Plan of Implementation” 4 September 2002), and means of implementation which included, inter alia, strengthening cooperation and coordination among global observing systems and research programmes for integrated global observations, taking into account the need for building capacity and sharing of data from ground-based observations, satellite remote sensing and other sources among all countries,

.....
Noting resolution 2011/24 taken by the Economic and Social Council at its 47th plenary meeting in New York on 27 July 2012, in which it: established the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM); encouraged Member States to hold regular high-level, multi-stakeholder discussions on global geospatial information, including through the convening of global forums, with a view to promoting a comprehensive dialogue with all relevant actors and bodies; and emphasized the importance of promoting national, regional and global efforts to foster the exchange of knowledge and expertise, to assist developing countries in building and strengthening national capacities in this field,

.....
Acknowledging that the Global Geodetic Reference Frame depends on participation from nations all around the globe, and the need to take action to strengthen international cooperation;

Endorses decision 3/102: Global Geodetic Reference Frame of the Committee of Experts of UN-GGIM on the work of its third session; that the Committee of Experts of UN-GGIM establish a Working Group, with equitable regional representation, to develop a global geodetic roadmap that addresses key elements of the Global Geodetic Reference Frame development and sustainability;

urges Member States and relevant international organisations to enhance global cooperation in providing technical assistance in geodesy for those countries in need to ensure the development, sustainability and advancement of a Global Geodetic Reference Frame;

Urges Member States to implement open geodetic data sharing to contribute to the global reference frames and regional densifications through relevant national mechanisms and inter-governmental cooperation, and in coordination with the International Association of Geodesy (IAG);

Invites Member States to commit to improve and maintain national geodetic infrastructure as an essential means to enhance the Global Geodetic Reference Frame;

Invites Member States to have multilateral cooperation that addresses infrastructure gaps and duplications towards the development of a more sustainable Global Geodetic Reference Frame;

Invites Member States to develop outreach programs that make the Global Geodetic Reference Frame more visible and understandable to society.

Looking at the report of the 12 June 2013, UN GGIM Report for consideration of the **Global Geodetic Reference Frame (GGRF)** initiative, we should see at page 3:

“ The GGRF also supports a range of scientific endeavors that improves the understanding of the Earth system and informs government policy by providing a capability for:

(a) Monitoring of the solid Earth for displacement, subsidence or deformation of the ground and structures, due to tectonic, earthquake, volcanic and other natural phenomena, as well as human activity;

- (b) Monitoring of variations in sea level (coupled with climate change and global warming), the major ice sheets and global mass transport;
- (c) Monitoring variations in the Earth's rotation such as polar motion and the length of the day;
- (d) Monitoring the atmosphere with satellite geodetic techniques including the composition and physical state of the ionosphere and troposphere;
- (e) Monitoring the temporal variations in the gravity field of the Earth;
- (f) Determining satellite orbits, including earth observation and navigation satellites; and
- (g) Determining positions, and their changes with time, of points on or above the surface of the Earth with the utmost accuracy."

It has been noticed that most of these points are corresponding to **items and actions developed within SCAR GIANT EG.**

It is an important argument for SCAR Delegates Assembly in order to justify the **scientific interest in the initiative for SCAR.**

Therefore all above considered SSG GS propose to SCAR Delegates the following recommendation.

SSG GS Recommendation

Considering the United Nations resolution that the Committee of Experts of UN-GGIM (Global Geospatial Information Management)

establish a Working Group, with equitable regional representation, to develop a global geodetic roadmap that addresses key elements of the Global Geodetic Reference Frame development and sustainability;

Considering that UN-GGRF WG involved different nations and principal institutions related to Geodetic reference frame;

Considering that SCAR is interested to develop and outreach all scientific aspects in Antarctica

We **recommend** that SCAR shall take into account the UN GGIM resolution and shall be involved in UN GGRF WG activities.

Particularly we **recommend** that SCAR president will send a letter of support to UN initiative.

Moreover, we **recommend** that SCAR SSG GS GIANT EG will be involved in the collaboration with UN GGRF WG.

2.10 Support the publication of the Bathymetric Map of the Drake Passage. This is a compilation of the available bathymetric data of different countries (UK, Spain, Korea, USA, and others) and will be published in the GEOMAP series of BAS (UK) as an SCAR product. A request of 2000 \$ is need to partially cover the publication costs.

3. Major Activities and Significant Progress

3.1 Antarctic Digital Magnetic Anomaly Map Project (Marta Ghidella)

It is proposed that the new chairman will be Detlef Damaske.

3.1.1 Publication of a Special Issue in Tectonophysics (Year 2013)

The ADMAP Expert Group concreted the publication of a special issue in the Tectonophysics, volume 585. Its title is "**RECENT ADVANCES IN ANTARCTIC GEOMAGNETISM AND LITHOSPHERIC STUDIES**", and was edited by Fausto Ferraccioli, Ralph von Frese, and Marta Ghidella.

The issue presents 16 papers to update the Antarctic geoscience community on ADMAP's investigations of the core, external, and crustal magnetic fields of the Antarctic region south of 60°S. These papers also include studies of the region's rock magnetic properties, and summarize the numerous marine, airborne, and satellite magnetic surveys that will be compiled into a new digital Antarctic magnetic anomaly map for enhanced crustal studies. It was published on February 11, 2013

<http://www.sciencedirect.com/science/journal/00401951/585>

3.1.2 Initiation of the second-generation magnetic anomaly map for the Antarctic region south of 60°S, ADMAP-2.

As a result of the ADMAP Expert Group meeting at SCAR'2012 in Portland, Oregon, funding was secured from the Korean Polar Research Institute (KORPI), In-Cheon, Republic of Korea, to help modernize the database and compile an improved magnetic anomaly map of the Antarctic. The three-year project will incorporate more than 3 million line-km of new airborne and marine magnetic survey data, as well as enhanced satellite magnetic gradient observations from the Swarm mission.

The ADMAP steering committee met over 30 Jul. - 1 Aug. 2013 at the Korean Polar Research Institute (KOPRI). The meeting resulted in (A) milestones for completing the project, (B) an overview of the new magnetic survey data for ADMAP-2, and (C) enhanced formats for digitally archiving airborne and marine survey data and metadata.

2. Year 2014

3.1.3 ADMAP-2 splinter meeting at EGU

The ADMAP-2 project splinter meeting was held at EGU 2014 in Vienna on Thu 1 May 2014, convened by Fausto Ferraccioli and Detlef Damaske.

Representatives from the UK, Germany, Italy, Australia, Korea & France attended -and the World Magnetic Anomaly Project team was also represented.

The main points raised were:

1. According to the original plan of the steering committee developed at KOPRI in August 2013 a preliminary ADMAP-2 magnetic anomaly compilation should be presented as early as the ISAES meeting in 2015 and the IUGG meeting in 2015. A closer to "definitive" product & associated MS (e.g. for GRL) could be presented at AGU 2015.
These milestones were recognised both by the convenors and attendees of the splinter meeting as being ambitious, as the volume of new data is large compared to ADMAP-1, and the latter project took more than 5 years to complete.
The level of progress and hence the feasibility of the steering committee initial aspirations should be critically reviewed at the SCAR Meeting in Aug. 2014 (NZ- Auckland).
2. Continuation strategies: a) maintain original data level?, b) upward continue to common regional level, or c) drape over Bedmap2 (potentially preferred option?). Potentially all three products could be delivered?
3. How often should the database be updated? Versions could potentially be implemented e.g. ADMAP-2.0, 2.1-but would e.g. yearly updates make sense? Depends e.g. on how often the ADMAP Working Group can access new magnetic datasets and whether a data manager can be maintained to do this; the advantage is that errors could be fixed and feedback from the users could also lead to improved versions (including feedback from users outside the main geomagnetic community)

4. The recommendation was that contact with the World Magnetic Anomaly Project should be maintained & a rep. informed and invited to the main ADMAP-2 Working Group meetings

3.1.4 Recent ADMAP-2 publications (referred to during the Splinter Meeting presentations)

1. Ferraccioli, F., von Frese R. and Ghidella M., 2013. Recent advances in Antarctic Geomagnetism and Lithosphere Studies. *Tectonophysics*, 585 (Guest Editors Special Issue).
2. Golynsky, R. Bell, D. Blankenship, D. Damaske, F. Ferraccioli, C. Finn, D. Golynsky, S. Ivanov, W. Jokat, V. Masolov, S. Riedel, R. von Frese, D. Young, ADMAP Working Group, 2013. Air and shipborne magnetic surveys of the Antarctic into the 21st century. *Tectonophysics*, 585, 3-12, 10.1016/j.tecto.2012.02.01
3. Mieth, M. and Jokat W, 2014. New aeromagnetic views of the geological fabric of southern Dronning Maud Land and Coats Land, East Antarctica. *Gondwana Research* 25, 358-367.
4. Mieth, M, Jacobs, J., Ruppel A., Damaske D., Läufer A., Jokat, W., 2014. New detailed aeromagnetic and geological data of eastern Dronning Maud Land: implications for refining the tectonic and structural framework of Sør Rondane, East Antarctica. *Precambrian Research* 245, 174-185.
5. Aitken A.R.A., Young D.A, Ferraccioli F., Betts P.G., Greenbaum J.S., Richter T.G., Roberts J.L., Blankenship D.D, and Siegert M.J., 2014. The subglacial geology of Wilkes Land, East Antarctica. *Geophysical Research Letters* 41, 2390–2400, doi:10.1002/2014GL059405.
6. Damaske D., Schreckenberger B., and Goldmann F., 2014. A High Resolution Aeromagnetic Survey over the Mesa Range, northern Victoria Land, Antarctica. *Polarforschung*, in review.
7. Jordan, T.A., Ferraccioli F., Ross N., Corr H.F.J., Leat P.T, Bingham R.G., Rippin D.M., le Brocq A., Siegert M.J., 2013. Inland extent of the Weddell Sea Rift imaged by new aerogeophysical data. *Tectonophysics*, 585, 137-160, 10.1016/j.tecto.2012.09.010.
8. Jordan, T.A., Neale, R.F., Leat, P.T., Vaughan, A.P.M., Flowerdew, M.J., Riley, T.R., Whitehouse, M.J., Ferraccioli, F., 2014. Structure and evolution of Cenozoic arc magmatism on the Antarctic Peninsula: A high resolution aeromagnetic perspective. *Geophysical Journal International*, in review.

3.2 GRAPE (GNSS Research and Application for Polar Environment) Expert Group cross link between SSG PS and GS.

Chair: *Giorgiana De Franceschi, Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy.*

3.2.1 Report 2013-2014

The goal of the Expert Group GRAPE (2012-2015), built on the former Action Group GWSWF (GPS for Weather and Space Weather Forecasting), is to continue to intensify the international efforts to build and coordinate a robust network of collaborations able to answer a variety of space weather related needs through ad hoc data sharing and model development.

Since the last GRAPE business meeting held in Portland (OR-USA) during the XXXII SCAR, a number of activities have been successfully pursued that can be briefly summarised as follow:

- 1) The GRAPE WEB has been designed and issued on October 2012: www.grape.scar.org, and will be maintained by the INGV team.
- 2) The GRAPE Special Issue has been published on *Annals of Geophysics* (De Franceschi and Candidi, 2013). This Special Issue collects reports on the recent work performed in the Polar Regions and on the datasets collected by the instrumentation deployed across various countries. This collection will set the starting point for further research in the field, especially in the perspective of the new and very advanced space system that will be available in the next few years. The papers included in the special issue describe the deployment of instrumental arrays to observe the ionospheric scintillation phenomenon

and the hardware/ software development to store the relevant data and to make them available in appropriate formats. Other papers deal with more proper scientific analyses of the available data, ranging from the analysis of the relation between scintillation and conditions in the interplanetary medium to the evaluation of the effects taking place in the near Earth regions, in the inner magnetosphere and in the statistical representation of ionospheric conditions. A climatological description of the scintillation scenario is given both for the Polar Regions and for the mid-latitudes. Finally, a different, but not less relevant, analysis is given with respect to the water vapor content and its effects at tropospheric levels.

- 3) A new project has been accepted on October 2013 and funded by the Italian National Program for Antarctic Research. The project, named DemoGRAPE and born into GRAPE, aims to realize a demonstrator to provide on selected case studies an empirical assessment of the delay and of the corruption induced by the ionosphere on satellite signals in the Polar Regions. DemoGRAPE will demonstrate the usefulness of the proposed system to several scopes, from the applications to positioning, to space weather, to solid Earth and polar cap dynamics investigation, to the monitoring of cryosphere evolution, etc... DemoGRAPE will experiment the use of Cloud computing platform to create an innovative technological tool. The proposal is supported by international partners already involved in GRAPE (UK, Brazil, Poland, South Africa, and USA) that expressed their interest in data/algorithms sharing and offering their polar infrastructures to host experimental equipment for ionospheric monitoring and for the ICT platform to be developed in CLOUD environment.
- 4) A GRAPE dedicated session has been organized and accepted for the **XXXIII SCAR Biennial Meetings and Open Science Conference** to be held in Auckland, New Zealand 23 August - 3 September, 2014. Twelve abstracts have been submitted to the GRAPE session (no. 11). The session chair is Giorgiana De Franceschi (INGV, Italy), the co-chairs are Emilia Correia (INPE, Brazil) and Mike Terkildsen (BOM, AU).
- 5) Efforts have been spent to support early career researchers and researchers coming from developing countries for their participation to the SCAR OSC 2014. One early career researcher from INGV (Italy) and one researcher coming from SANSA (South Africa) obtained a SCAR travel grant of 1000USD to attend the GRAPE session and to present a paper.

3.2.2 Plans

Efforts will be addressed to maintain and update the current GRAPE web (www.grape.scar.org) that will highlight the subgroups activities of GRAPE and the national/international projects of common interest. The GRAPE portal will maintain the link to other useful databases for easy access, and will encourage the collaboration, data sharing and cooperation in scientific investigations.

Further and more close interaction are foreseen with SCADM above all for what concerning the CLOUD attempt in managing GRAPE data and tools.

GRAPE EG is expected to be active along the next 4 years (2015-2018).

Publication:

De Franceschi Giorgiana and Candidi Maurizio, GRAPE, GNSS Research and Application for Polar Environment, Expert Group of SCAR. *Annals of Geophysics*, Special Issue, Vol. 56, No2 (2013), ISSN 2037-416X. <http://www.annalsofgeophysics.eu/index.php/annals/issue/view/488>

3.3 SCAR EXPERT GROUP ON ANTARCTIC PERMAFROST, SOILS AND PERIGLACIAL ENVIRONMENTS (ANTPAS)

3.3.1 SCIENCE HIGHLIGHTS

The Antarctic Permafrost, Soils and Periglacial Environments Expert Group has framed the development of several international collaborations in Antarctica, mainly through collaborative access to national research funds (Brazil, Italy, Portugal, Spain, USA, etc.). A special issue of *Geomorphology* is being prepared for publication in 2014. In 2013, the main highlights by EG members were:

- An overview of permafrost conditions in Antarctic Peninsula, showing that the dramatic warming of the climate over the last decades has influenced the properties and distribution of permafrost [1]. Whereas permafrost is continuous in the South Orkney Islands (60–61°S) and along the eastern Antarctic Peninsula (63–65°S), it is discontinuous in the South Shetland Islands (62–63°S), and occurs only sporadically in the Palmer Archipelago and Biscoe Islands along the western Antarctic Peninsula (64–66°S). Permafrost then becomes continuous on Alexander Island (71–74°S) along the western Antarctic Peninsula as the maritime climate shifts to a more continental climate. Recent measurements suggest that permafrost is absent or close to 0 °C in the upper 14 m of the highest ice-free areas (67 m a.s.l.) near Palmer Station. Permafrost temperatures elsewhere along the western Antarctic Peninsula region range from –0.4 to –1.8 °C in the South Shetland Islands (62–63°S) to –3.1 °C at Adelaide Island (67°34' S).

- Understanding the inventory of paleoclimate records in the McMurdo Dry Valleys as well as monitoring the rapid decay of these valuable permafrost records. In [2], we measured the actual ice-free area of the McMurdo Dry Valleys using Landsat data. This provides a baseline for detecting change to Antarctica's glacial and permafrost landscapes and actually informs how big "Antarctica's largest ice free area" really is. In [3] we took a new look at the record of Ross Sea Ice Sheet advance and retreat as recorded in Garwood Valley's permafrost and paleolake deposits. This work agreed well with previous ice sheet reconstructions from the on-land sedimentary record, but highlighted the most complete and detailed record of paleolake conditions in the Dry Valleys region yet discovered. Most importantly, though, in [4] we showed that these valuable permafrost records of paleoclimate change are at risk in many of Antarctica's ice-cored permafrost terrains. Changing insolation patterns have initiated the catastrophic and accelerated melting of Garwood Valley ground ice, leading to thermokarst erosion of Pleistocene and Holocene deposits. This rapid melt may be a leading indicator of more widespread melting of ground ice in the Ross Sea sector.

- The thermophilic bacterial strains of the genus *Geobacillus* capable of growing at temperatures from 40 to 75°C were isolated from the permafrost of the Deception Island containing volcanic ashes [5]. In the investigated area, high temperatures were observed in fumaroles and geothermally heated soils occurring all over the island. These geothermal oases are probably the source of *Geobacillus* sp. cells for the surrounding permafrost rocks. This work is the first investigation of the microorganisms of ancient thermal ecosystems preserved in permafrost.

In addition, a special issue of *Geomorphology* entitled "Permafrost and periglacial research in Antarctica: new results and perspectives" edited by M. Guglielmin and G. Vieira with the best selection of the oral presentation of the last SCAR OSC in Portland. This Special Issue is already available online and will be printed in the next month.

3.3.2 Publications

[1] Bockheim J, Vieira G, Ramos M, Lopez-Martinez J, Serrano E, Guglielmin M, Wilhelm K, Nieuwendam A. (2013). Climate Warming and Permafrost Dynamics in the Antarctic Peninsula Region. *Global and Planetary Change*, 100, p. 215-223.

[2] Levy, JS (2013) How big are the McMurdo Dry Valleys? Estimating ice-free area using Landsat image data. *Antarctic Science*, Volume 25, Issue 01, p 119-120.

[3] Levy JS, Fountain AG, O'Connor JE, Welch KA, Lyons WB (2013). Garwood Valley, Antarctica: A new record of Last Glacial Maximum to Holocene glaciofluvial processes in the McMurdo Dry Valleys. *GSA Bulletin*, v. 125 no. 9-10 p. 1484-1502.

[4] Levy JS, Fountain AG, Dickson JL, Head JW, Okal M, Marchant DR, Watters J (2013). Accelerated thermokarst formation in the McMurdo Dry Valleys, Antarctica. *Scientific Reports* 3, Article number: 2269 doi:10.1038/srep02269.

[5] Mironov VA, Shcherbakova VA, Rivkina EM, Gilichinsky DA. (2013). Thermophilic Bacteria of the Genus *Geobacillus* from Permafrost Volcanic Sedimentary Rocks. *Microbiology*, Vol. 82, No. 3, p 389–392.

3.4 SCAR EXPERT GROUP ON GEOSPATIAL INFORMATION – GEODESY (GEODETIC INFRASTRUCTURE IN ANTARCTICA) (GIANT)

With respect to the activities planned for 2012 to 2014, the planned tasks were fulfilled as follows:

To facilitate contact and information exchange, a GIANT mailing list has been set up, which currently about 30 people are subscribed to.

A “SCAR Summer School on Polar Geodesy” was realized in March 2014, with financial support by SCAR through SSG Geosciences. For more details, see below.

At EGU 2013 a session (G6.3 „Geodesy in Antarctica“) was organized and held in form of the new EGU PICO format.

The website of the “SCAR GNSS Database” was relaunched to facilitate an automatic generation of the respective web pages. Information on GIANT has been included at the new SCAR website.

Short report on EG GIANT Business Meeting

The GIANT business meeting took place in Auckland, 23 August 2014, 09:00 – 12:30.

The meeting was attended by 15 participants coming from 9 different countries.

In the following we give some notes according to the schedule of the meeting:

(1) Reports on GIANT program projects

Project 1 (Permanent Observatories)

Kazuo Shibuya (Japan) stepped back from the chair because of retirement. He communicated via e-mail the participation of Koichiro Doi. The Japanese station Syowa is still operation a complete geodetic observatory in Antarctica. Sergei Gulyaev (New Zealand) reported on the activities to set up further VLBI observatories, where efforts are now concentrated on location(s) at the NZ South Island, and future plans are made for Scott Base.

Project 2 (Crustal Movements from GNSS)

Mirko Scheinert (Germany) reported on the relaunch of the website of the “SCAR GNSS Database”. Substantial work has been fulfilled to facilitate an automatic generation of the respective pages. The website will be officially available within the next weeks, information will be given via the GIANT mailing list.

Comprising all data of the SCAR GNSS Epoch Campaigns (as well as some permanent GNSS stations such as the IGS stations in Antarctica) an update of station coordinates and velocities was computed, which enables further analyses in geodesy and geodynamics. A respective paper is already accepted for publication:

A. Rülke, R. Dietrich, A. Capra, E. Dong Chen, J. Cisak, T. Eiken, A. Fox, L. D. Hothem, G. Johnston, E. C. Malaimani, A. J. Matveev, G. Milinevsky, H.-W. Schenke, K. Shibuya, L. E. Sjöberg, A. Zakrajsek, M. Fritsche, A. Groh, C. Knöfel, M. Scheinert (2014): The Antarctic regional GPS network densification - status and results. IAG Symposia series, Springer (Proc. IAG General Assembly, Potsdam 2013)

Project 3 (Gravity Field)

Mirko Scheinert (Germany) reported on the progress in the compilation of free-air gravity anomalies in Antarctica. A gridded dataset shall be released soon, accompanied by a respective publication.

Project 4 (Tide Gauge Data)

Graeme Blick (New Zealand) reported on the NZ activities (tide gauge series at Scott Base and Cape Roberts). Matt King (Australia) reported that at AAD there is almost no interest to support the necessary measures to maintain tide gauge observatories. Generally, it was stated that

tide gauge stations in Antarctica and records are in a bad shape, only for some of them it is possible to estimate trends in sea-level change over a time period of sufficient length. However, GIANT emphasizes the utmost importance of long (and calibrated) tide gauge time series. Efforts should be undertaken to improve this situation. Also, it was stressed that it should be requested that tide gauge data shall be archived at PSMSL (Permanent Service of Mean Sea Level).

Project 5 (Antarctic Geodesy Summer School)

Mirko Scheinert (Germany) reported on this project. The “SCAR Summer School on Polar Geodesy” was successfully organized and held at Estación Patagonia Subantártica Grey, Parque Nacional Torres del Paine, Patagonia, Chile, 11 to 20 March 2014.

It was organized by M. Scheinert, TU Dresden (Germany), and (locally) by C. Cardenas, Dirección de Programas Antárticos y SubAntárticos, Universidad de Magallanes, Punta Arenas (Chile). SCAR supported the realization of this summer school by a fund of \$5,000. Further, it was supported by Technische Universität Dresden, Germany, the German Society of Polar Research and the Russian Antarctic Expedition, St. Petersburg, Russia. Having background in different geoscience disciplines, 10 (graduate and PhD) students participated in this summer school (3 Argentina, 3 Chile, 2 Germany, 1 Russia, 1 USA).

Lecturers were: Carlos Cardenas (Chile), Reinhard Dietrich (Germany), Andreas Richter (Germany), Gino Casassa (Chile), Mathias Braun (Germany), Jorge Strelin (Argentina), and H.-G. Maas and R. Kotschinsky (Germany) as guests.

Topics included:

GNSS methods in Antarctica

reference frame issues, plate kinematics, glacial isostatic adjustment

geodetic methods to determine the mass balance of ice sheets

solid earth tides and ocean tides

multi-spectral and synthetic aperture radar systems for glaciological applications

glaciology: ice sheets and glaciers, glacier structure, ice flow and mass balance

glacial geology, morphology, stratigraphy and chronology

geophysical investigations in polar regions

Seminars, practical exercises and excursions complemented the program.

(2) Reports on national programs related to GIANT and highlights on research related to

GIANT

National reports and reports on highlights of research with regard to GIANT, resp., were given by:

New Zealand (Graeme Blick)

Australia (Matt King)

USA (Terry Wilson)

Denmark (René Forsberg)

Italy (Alessandro Capra)

Russia (report was given by Mirko Scheinert)

In summary, it can be stated that the group is very active and that a fruitful cooperation exists. Highlights comprise ongoing GNSS measurements for geodetic and geodynamic applications (focus on glacial isostatic adjustment and to understand the earth's rheological structure – see also SERCE) or airborne geodesy and geophysics (focus on gravity field and geoid in Antarctica).

(4) GIANT within SERCE actual and next cooperation

Terry Wilson (USA) shortly reported on SERCE (SCAR Scientific Program on Solid Earth Response and Cryosphere Evolution). EG GIANT is very much welcome to actively participate in SERCE. T. Wilson referred to the SERCE meeting scheduled for the same day, afternoon session.

(5) UN resolution to support the Global Geodetic Reference Frame (GGRF)

Alessandro Capra explained the activities to support a UN resolution on Global Geodetic Reference Frame. GIANT gives strong support to this initiative. A resolution shall be adopted by

the SCAR Delegates Meeting, thus, the respective documents will be prepared and introduced at SSG Geoscience business meeting.

TERMS OF REFERENCE

GIANT chair: Alessandro Capra (Italy), co-chair: Mirko Scheinert (Germany)

GIANT Program Objectives:

Maintain and develop geodetic infrastructure in Antarctica (permanent observatories, GNSS and especially collocated techniques)

Contribute with data and expertise to the realization and maintenance of a precise reference frame in Antarctica

Contribute data and solutions for further analyses, especially for geodynamic applications (e.g. GIA)

Maintain a close interdisciplinary cooperation (especially to assist SCAR scientific program SERCE)

Provide information on technology and data access

Support scientists of neighbouring disciplines in the application of geodetic techniques (esp. GNSS)

Develop communication and outreach, support the education of early career scientists

GIANT Working Groups

1. Permanent Observatories

Project Leader: Koichiro Doi (Japan)

- 1) Facilitate new geodetic observatories or repeat measurements at existing observatories (GNSS, Gravity, Tide gauge observations)
- 2) Compile a list of existing data and collocations
- 3) Encourage site operators to make data freely accessible
- 4) Publish links to IERS WG3 on site surveys
- 5) Publish links to the web sites for the services for seismic and geomagnetic networks including IRIS (<http://www.iris.edu/hq/>) and Intermagnet (<http://www.intermagnet.org>)
- 6) Collaborate with other SCAR scientists to identify requirements for space geodetic sites
- 7) Publicise the Ant2000 datum resolution and make available recommended practices for the use of IGS products with this datum

2. GNSS observations for geodetic and geodynamic applications

(project title updated from former title “Crustal Movement from GNSS observations”)

Project Leader: Mirko Scheinert - Germany

Project Co-Leader: Matt King (Australia)

- 1) Encourage and support coordination of regional episodic GNSS campaigns for reference frame densification or other targeted science applications.
- 2) Maintain “SCAR GNSS Database”
- 3) Incorporate linkage / metadata information for permanent GNSS stations, especially links to: IGS, UNAVCO, Polenet/Anet; identify GNSS stations around Antarctica and compile information and data.
- 4) Encourage the use of appropriate site standards to allow multimodal use of the data (cf. 7)
- 5) Cooperate with IAG Subcommission 1.4f for ITRF densification
- 6) Provide network solutions to compare with other solutions, like from POLENET
- 7) Encourage data sharing / cooperation and open access to data according to common rules of good scientific practice; cooperation with/linkage to SERCE, SCAGI and SCADM

3. Gravity Field

Project Leader: Mirko Scheinert - Germany

- 1) Compile surface gravity data, promote new surveys (especially aerogravimetric surveys)
- 2) Compile metadata on all kinds of gravimetric surveys and observations in Antarctica, linkage to further databases (especially Bureau Gravimetric International)
- 3) Utilise gravity data for precise regional geoid determination in Antarctica
- 4) Collaborate with IAG Subcommission 2.4f “Gravity and Geoid in Antarctica”
- 5) Promote absolute gravity observations to provide a reference to gravity datum. These observations are best taken at bases, preferably collocated with continuous GNSS sites. Update information on absolute gravity observations.
- 6) Promote gravity ties of airborne and relative gravity surveys to absolute gravity points

4. Tide Gauge Data

Project Leader: Graeme Blick (New Zealand)

Project Co-Leader: Matt King (Australia)

- 1) Update the connections between tide gauge benchmarks and GNSS sites on GIANT web page
- 2) Encourage gauge operators to calibrate gauges and make offsets available with tidal observations
- 3) Provide best practice examples of the establishment of tide gauges, both bottom mounted and acoustic, including data communication systems and gauge calibration techniques
- 4) Provide tide gauge data to Permanent Service of Mean Sea Level (PSMSL)
- 5) Publicise the application of tide gauge data to key science questions through the GIANT web page

Planned activities 2014 – 2016

1. Participation in the ISAES 2015; support of workshops (planned in the framework of SERCE) on GNSS data archiving and technology
2. Organize a session at EGU 2016 on GIANT related issues, focus shall be given on the scientific applications of geodetic measurements in geodesy, geodynamics and glaciology
3. Realize analyses of all GNSS data available to come up with best estimates of station coordinates and velocities to further infer plate motion, vertical uplift and further geodynamic parameters (extension of Rülke et al. (2014))
4. Development of web services, increase GIANT visibility to scientific public, especially update information on GIANT at SCAR website
5. Endorsement of UN resolution, interaction with UN GGRF working group
6. Examine possibilities to carry out a second summer school related to polar geodesy in 2016; elaborate a respective concept (also in close cooperation with SERCE)

Financial Plan

GIANT requests a funding of \$10,000 for the period 2015 – 2016.

The following items shall be supported:

- Support the further development and management of “SCAR GNSS Database” at Technische Universität Dresden
Requested funding: \$3,000 for two years
- Support the travel of younger scientists to relevant conferences, especially ISAES 2015
Requested funding: \$4,000
- Support of travel to participate in respective meeting(s) of UN GGRF working group in 2015 and 2016

3.5 SCAR EXPERT GROUP ON INTERNATIONAL BATHYMETRIC CHART OF SOUTHERN OCEANS (IBCSO)

In 2013 we have completed and released the first version of the IBCSO. It covers the area south of 60 degree S and has a resolution of 500x500m. The digital bathymetric model as well as a paper chart are publicly available via the project’s website www.ibcso.org <<http://www.ibcso.org>> . These products have been presented on several international conferences, including this years SCAR OSC.

Here, we also held a meeting last Tuesday to discuss the future development of IBCSO. We identified so far missing, newly acquired and planned bathymetric data sets that can improve the IBCSO in a second version. We also discussed that a following version of the IBCSO should have an increased extent up to 50 degree S to cover the ACC gateways. Furthermore, we envisioned to hold another IBCSO meeting at the next SCAR conference in 2016 to arrange the data available to that moment to be transferred to the IBCSO data base and to get the work started on the second version.

The financial request for meeting is 5000\$.

3.6 SCAR EXPERT GROUP ON GEOHERITAGE AND GEO-CONSERVATION **Activities and request already indicated in section 2.3.**

3.7 SCAR ACTION GROUP CONNECTING GEOPHYSICS WITH GEOLOGY: KEY AREAS FOR UNDERSTANDING THE BUILDING STONES OF ANTARCTICA

Chair: Joachim Jacobs, Detlef Damaske, Fausto Ferraccioli

Background

- Less than 1% of Antarctica is outcropping, there are still unmapped areas

- Visited areas have been studied to highly varying degrees
- Systematic aero-geophysical surveys covering geological accessible areas extend the knowledge into totally ice-covered terrain, revealing the sub-ice geology.
- Major lineaments and the spatial extent of individual tectonics blocks thus become apparent in their broader context.
- However, connection of the exposed geology and the geophysics is still often loose.
- Key areas need to be identified where detailed geological field studies and focussed geophysics should be carried out to fully understand the significance of major geophysical lineaments and the boundaries of tectonics blocks.
- Because of Antarctica`s central position in all plate reconstructions *the bedrock geology under the Ice Sheet* is needed to fully *understand supercontinent assembly and break-up through Earth history*.

Aims

- Identify highest priority areas where possible lineaments and/or tectonic block boundaries intersect with outcrops.
- Most of these areas are likely in logistically demanding regions, thus there is a need to coordinate and develop multinational capabilities in geophysics and geology.
- International expeditions to these key areas will provide improved geological and geophysical maps, which will form a firm base for interpretation.
- We should identify critical drill sites to collect rocks to test our geologically/geophysically hypotheses. Moraine material at the transition from the interior ice sheet to the mountain ranges should be given more attention.
- Improve connections to adjacent continents within Gondwana/Rodinia and project the knowledge of these into Antarctic.
- Our work is vital the new Gondwana map initiative (R. Schmitt, Brazil).

Methods

Integrated study of:

- Surface geology, moraines / ice rafted debris, bore holes
- Aerogeophysics (magnetics, radar, gravity), surface geophysics, seismic studies

AG meetings held

EGU, Vienna, 2013, 18 participants from 7 countries

DML map compilation workshop, Tromsø, 2014

SCAR, Auckland, 2014, 20 participants from 12 countries

Key areas, as of SCAR 2014

East Antarctica

- 1) Central Dronning Maud Land, intersection of the Forster Magnetic Anomaly with the main mountain range, test suture zone hypothesis (Nor, BGR, AWI, Ind, SA)
- 2) Shackleton Range, Recovery Basin Region, Pan-African suture zone, extension into interior parts of East Antarctica (BAS)
- 3) Gamburtsev Mts. (Ch, BAS, Rus)
- 4) Denmen Glacier area, correlations with mobile belts in SW Australia (BAS, BGR, Aus)
- 5) Lake Vostok (Rus)

West Antarctica

- 6) West Antarctica, seismic vs. topographic architecture, xenolith studies (USA, AWI)
- 7) Marine geology-geophysics, Antarctic Peninsula, Scotia Sea (Spain)

AG should be continued for another 2 years period to allow more groups to join and to accommodate new key areas.

Next planned meetings

ISAES 2015, Goa
EGU 2016, SCAR 2016

Budget request

2015 3000 US\$, travel support (ISAES, Goa)
2016 5000 US\$, travel support (EGU, SCAR)

4. Budgetary Implications

4.1 XII ISAES 2015 Budget

USD 20,000 towards travel support (As projected in last report)

4.2 SSG Expert and action groups

| <i>GROUP</i> | <i>Year 2015</i> | <i>Year 2016</i> |
|-----------------------|------------------|------------------|
| ADMAP | 10000 | 5000 |
| IBCSO | | 5000 |
| GIANT | 7000 | 3000 |
| CGG | 3000 | 5000 |
| GRAPE | 4500 | 4000 |
| A. Volcanism | 3000 | 3000 |
| Geoheritage | | 3000 |
| Mapping Antartica | | 3000 |
| <i>BatDrake (map)</i> | 2000 | |
| TOTAL | 29500\$ | 31000\$ |

4.3. To reallocate unspent amount of SSG GS for the period 2013-14 from EG and AG for travel support for XII ISAES 2015.

Appendices

e.g. further details of particular proposals or reports