Reconstructed plutonium fallout from an Antarctic Plateau snowpack using ICP-SFMS

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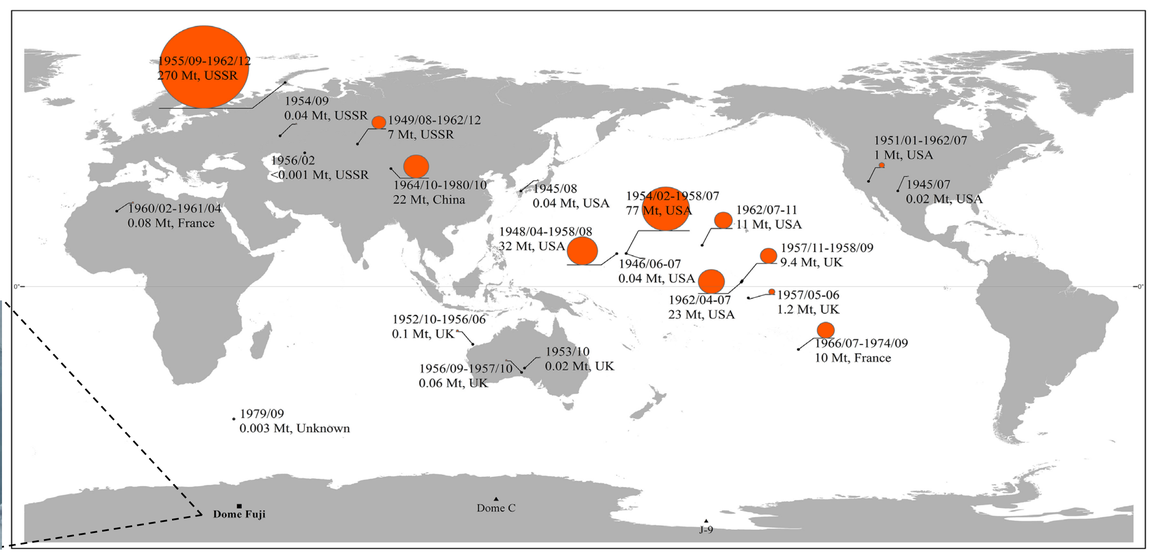
Introductions

Atmospheric nuclear explosions during the period from the 1940s to the 1980s are the major anthropogenic source of plutonium (Pu) in the environment. The radioactive Pu released from nuclear activities was spread globally via the atmosphere, and the Pu fallout can be detected in seawater, marine sediments, soil, river sediments, and ice cores from mid-latitude alpine glaciers, the Arctic, and Antarctica. In this study, we applied inductively coupled plasma sector field mass spectrometry (ICP-SFMS) to an Antarctic snowpack. The purpose of this study was to examine the ability of ICP-SFMS to assess and utilize the potential of the Antarctic snowpack as a natural archive of ^{239}Pu fallout. Minimal sample pretreatment was performed on the Antarctic snow samples; thus, the Pu in the samples was not preconcentrated nor purified. Isobaric species that interfere with ^{239}Pu were carefully examined. Variations in the ^{239}Pu concentrations with snow depth were explored and compared with the nuclear test history and previous results from other Antarctic and Northern Hemispheric sites.

Site & Sampling

* Dome Fuji

- 77°18'S, 39°47'E, 3785m a.s.l.
- 80 samples from a 4-m snowpit in Dec. 2007



Distribution of atmospheric nuclear activities during the period from the 1940s to the 1980s. The source data sets available in reference (Johnston, 2009) are grouped by site and date. The size of the filled circles represents the sum of the estimated nuclear yield for each group. The sampling site (Dome Fuji) and previous study sites (J-9 and Dome C) are indicated.

Measurements & Methods

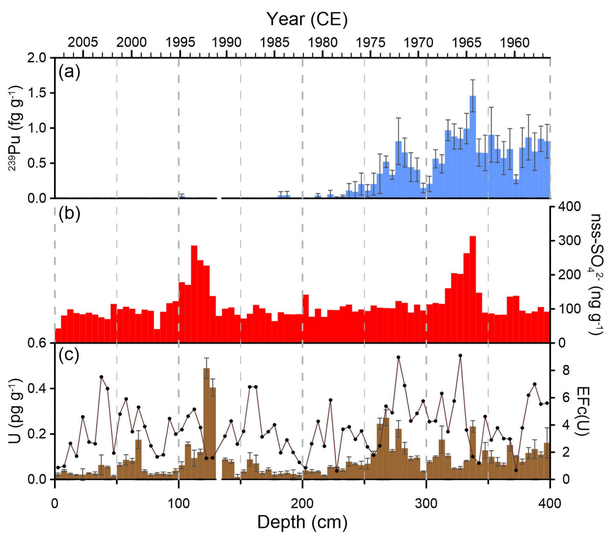
To determine the Pu concentrations in the Antarctic Plateau snow samples, we used an ICP-SFMS (Element2, Thermo Scientific, Bremen, Germany) coupled with an Apex high-efficiency sample introduction system (Apex HF, ESI, USA). The Pu concentration was measured in the low-resolution (LR, m/Δm ~ 300) mode.

Semi-quantitative estimation

- Sensitivity of heavy elements in ICP-SFMS is strongly correlated to their masses.
- First ionization energy for Pu and U are very close (6.02 eV and 6.19 eV, respectively)

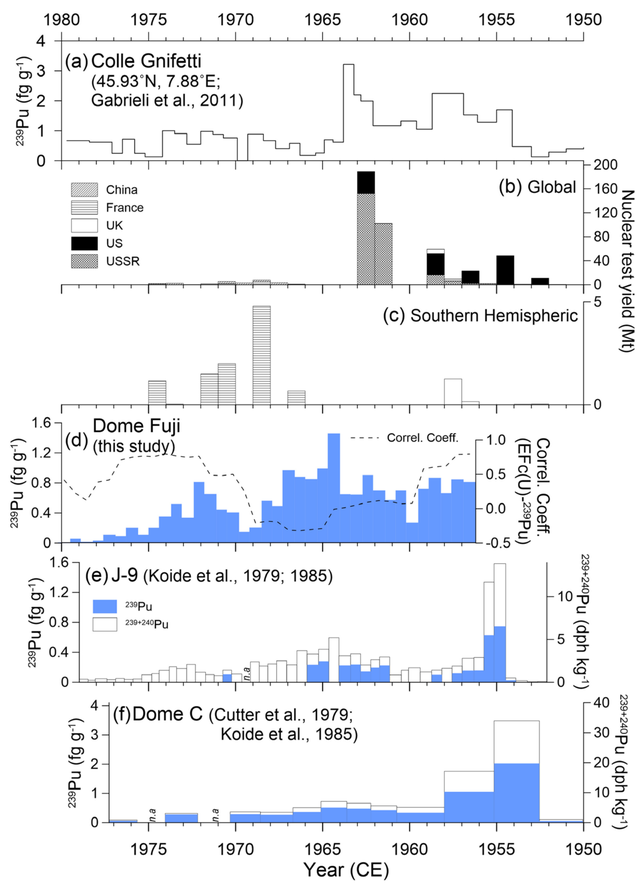
→ They should have a similar behavior when ionized in the plasma. (Gabrieli et al., 2011)

- Calibration, ^{238}U
  - 0.1, 0.2, 0.5, 1, 2, and 10 pg g^{-1}(1 pg g^{-1} = 10^{-12} g g^{-1}), single element ICP-MS stock solution
  - Accuracy: CRM (SLRS-5)
    - Heimburger et al., 2013: U, 93±6 pg g^{-1} (n=25)
    - We determined the U concentrations in 500-fold (0.18 pg U g^{-1}) and 100-fold (0.94 pg U g^{-1}) diluted and undiluted SLRS-5 solutions, and the recoveries were 109(±5)%, 116(±4)% and 103(±2)%, respectively.
  - Detection limits: ^{238}U (0.005 pg g^{-1}), ^{239}Pu (0.053 fg g^{-1})
- Interference: **^{238}U^{1}H^{+} (major),** ^{207}Pb^{16}O^{16}O, ^{204}Pb^{35}Cl (minor)
  - 0.1-100 pg g^{-1} U solutions: ^{238}U^{1}H/^{238}U ratio was 2.3(±0.1)×10^{-5},
    : the isobaric contribution of ^{238}U^{1}H was expected to be <0.01 fg g^{-1} → no ^{238}U^{1}H^{+} interference was detectable.
  - 10-1000 pg g^{-1} Pb solutions: ^{207}Pb^{16}O^{16}O formation rate, 1.2(±0.2)×10^{-5} (fg ^{207}Pb^{16}O^{16}O)/(pg Pb)
    : the isobaric contribution was estimated to be <0.001 fg g^{-1}
  - ^{204}Pb^{35}Cl: we measured four 100 pg Pb g^{-1} solutions with Cl concentrations of 50, 100, 500, and 1000 ng g^{-1}, respectively. The ^{204}Pb^{35}Cl/Cl ratios were 2.9×10^{-5} (fg ^{204}Pb^{35}Cl)/(ng Cl) for 50 to 500 ng Cl g^{-1} and 5.1×10^{-5} for 1000 ng Cl g^{-1}.
    : the isobaric contribution of ^{204}Pb^{35}Cl to ^{239}Pu would be less than 0.015 fg g^{-1} below 500 ng Cl g^{-1}.



Depth profiles of the (a) ^{239}Pu, (b) nss-SO_4^{2-}, and (c) U concentrations (bars), as well as the U enrichment factor (EFc(U), line). The x-axis is shown only for the depth intervals analyzed.

Results & Discussion



(a, d–f) Reconstructed ^{239}Pu concentrations for the same periods at (a) Colle Gnifetti in the Alps and at (d) Dome Fuji, (e) J-9 and (f) Dome C, Antarctica.
(b) Global and (c) Southern Hemispheric atmospheric nuclear yields by country and year from 1950 to 1980.
For the Dome Fuji results, the 10-year moving correlation coefficient between EFc(U) and ^{239}Pu is shown (dashed line).
The ^{239}Pu concentrations for J-9 and Dome C are calculated from the $^{239+240}$Pu activity (in disintegrations per hour (dph) kg^{-1}) (Koide et al., 1979; Cutter et al., 1979) and the ^{240}Pu/^{239}Pu ratios (Koide et al., 1985).
For J-9, the ^{240}Pu/^{239}Pu ratio was reported for only 15 (of 48) samples in the reference (Koide et al., 1985). The depth-age models for J-9 and Dome C are refined relying on a nss-SO_4^{2-} peak dated to the year 1964.

Conclusion

Pu concentrations in the reconstructed Pu fallout record for the period after 1956 CE increased and decreased in agreement with past atmospheric nuclear testing. Two peaks and two dips associable with historical events were observed, and the highest peak in 1964(±1) CE approximately coincided with the maximum concentration of non-sea-salt sulfate caused by the Mt. Agung eruption in 1963 CE. Enhanced Pu fallout in the 1970s was attributed the geographical proximity of the Southern Hemispheric nuclear test sites. Our results suggest that by improving the instrumental sensitivity and precision, the potential of the Antarctic ice sheet as an archive of Pu fallout can be further explored and utilized for understanding atmospheric dispersion and for dating ice cores.

References

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Gabrieli, J. et al., (2011) *Atmos. Environ.* **45**, 587-593. Heimburger, A. et al., (2013) *Geostand. Geoanal. Res.* **37**, 77–85. Koide et al., (1979) *Earth Planet. Sci. Lett.* **44(2)**, 204-223. Koide et al., (1985) *Earth Planet. Sci. Lett.* **72(1)**, 1-8. Cutter et al., (1979) *Nature* **279**, 628-629.

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Abstract List – Poster (Wed/Thu)

Poster Presentation

No.	Day	Time	Presenter	E-mail	Institution/Organization	Abstract no.	Session no.	Title
1	WED/THU	13:30-15:00	Carina Haeger	carina.haeger@gfz-potsdam.de	GFZ Potsdam, Germany	A029	02	Decompensative gravity anomalies reveal structure of the upper crust of Antarctica.
2	WED/THU	13:30-15:00	Folker Pappa	folker.pappa@ifg.uni-kiel.de	Kiel University, Germany	A043	02	Crustal thickness and density structure of Antarctica – new insights from petrological and gravity modelling
3	WED/THU	13:30-15:00	Evgenii Mikhalskii	emikhalsky@mail.ru	VNIIOkeangeologia, Russia	A048	02	The early Neoproterozoic Polkanova Series in the westernmost Enderby Land: another manifestation of Tonian ocean
4	WED/THU	13:30-15:00	Antonia Ruppel	antonia.ruppel@bgr.de	Federal Institute for Geosciences and Natural Resources (BGR), Germany	A056	02	Late Neoproterozoic–Early Paleozoic deformation and cooling of Sør Rondane and implications for the final assembly of Gondwana: Evidence from 40Ar/39Ar and U-Pb geochronology
5	WED/THU	13:30-15:00	Antonia Ruppel	antonia.ruppel@bgr.de	Federal Institute for Geosciences and Natural Resources (BGR), Germany	A057	02	Aerogeophysical survey over the Forster Magnetic Anomaly and its implications for revealing the tectonic evolution of central Dronning Maud Land
6	WED/THU	13:30-15:00	Jörg Ebbing	joerg.ebbing@ifg.uni-kiel.de	Kiel University, Germany	A062	02	Investigating the characteristics of a potential West Antarctic mantle plume with geodynamic models
7	WED/THU	13:30-15:00	Monika A. Kusiak	mona.kusiak@gmail.com	Polish Academy of Sciences, Institute of Geological Sciences, Poland	A081	02	Eoarchean crust in East Antarctica: zircon isotopic evidence
8	WED/THU	13:30-15:00	Anya Reading	anya.reading@utas.edu.au	University of Tasmania, Australia	A098	02	Investigating the Deep Continent Beneath the Interior of East Antarctica Using the 'agrid' Research Environment
9	WED/THU	13:30-15:00	German Leitchenkov	german_l@mail.ru	Research Institute for Geology and Mineral Resources of the World Ocean, Russia	A172	02	Precambrian evolution of the Ruker granite-greenstone terrain of the East Antarctica: structure, age and geodynamic setting.
10	WED/THU	13:30-15:00	Samantha Hansen	shansen@geo.ua.edu	The University of Alabama, USA	A175	02	The Transantarctic Mountains Northern Network (TAMNNET): Versatility of a Polar Seismic Array
11	WED/THU	13:30-15:00	Vanda Sergeeva	wanda@list.ru	VNIIOkeangeologia, Russia	A178	02	The early stage of the Australia-Antarctica break-up
12	WED/THU	13:30-15:00	Maria Carmen Rey Moral	c.rey@igme.es	Instituto Geológico y Minero De España (IGME), Spain	A180	02	UNRAVELING THE ARCHITECTURE OF THE ANTARCTIC PENINSULA AND ITS EASTERN CONTINENTAL MARGIN BASED ON POTENTIAL DATA MODELLING
13	WED/THU	13:30-15:00	Devsamridhi Arora	devsamridhiarora@gmail.com	University of Delhi, India	A196	02	Tracing segments of Columbian orogenesis in Vestfold hills, Princess Elizabeth Land and SE Indian shield
14	WED/THU	13:30-15:00	Fernando Bohoyo	f.bohoyo@igme.es	Instituto Geológico y Minero De España (IGME), Spain	A210	02	Deep structure and tectonic evolution of the South Orkney Microcontinent (northern Weddell Sea, Antarctica)
15	WED/THU	13:30-15:00	Dmitry Golynskiy	dmitry.a.golynsky@gmail.com	VNIIOkeangeologia, Russia	A222	02	Ground magnetic surveys and petrophysical studies of the Bunger Hills
16	WED/THU	13:30-15:00	Alexander Golynsky	sasha@vniio.nw.ru	VNIIOkeangeologia, Russia	A227	02	New airborne magnetics view of Princess Elizabeth Land crustal structure
17	WED/THU	13:30-15:00	Young-Gyun Kim	younggyun.kim@gmail.com	Kangwon National University, Korea	A234	02	High mantle temperature beneath the proto-Adare Basin, Ross Sea, Antarctica, as the possible cause of synchronous rifting across the continental-ocean boundary
18	WED/THU	13:30-15:00	Fausto Ferraccioli	ffe@bas.ac.uk	NERC/British Antarctic Survey, United Kingdom	A271	02	Tectonic architecture of a major pull apart basin in Victoria Land unveiled from aeromagnetic and gravity imaging
19	WED/THU	13:30-15:00	Fred Davey	f.davey@gns.cri.nz	GNS Science, New Zealand	A300	02	Cenozoic Continental Tectonics in North-Western Ross Sea, Antarctica.
20	WED/THU	13:30-15:00	Erica Emry	erica.emry@nmt.edu	New Mexico Institute of Mining and Technology, USA	A312	02	Quantitative assessment of Antarctic crustal models using numerical wave simulations
21	WED/THU	13:30-15:00	Fausto Ferraccioli	ffe@bas.ac.uk	NERC/British Antarctic Survey, United Kingdom	A322	02	A composite Precambrian Wilkes Terrane unveiled in East Antarctica
22	WED/THU	13:30-15:00	Hyung Rae Kim	kimhr@kongju.ac.kr	Kongju National University, Korea	A363	02	Augmenting coverage gaps in the ADMAP-2 grid with Swarm satellite magnetic observations
23	WED/THU	13:30-15:00	Nikita Borovkov	nikita.borovkov812@yandex.ru	The All-Russia Scientific Research Institute for Geology and Mineral Resources of the Ocean, Russia	A382	02	PETROLOGY AND GEODYNAMIC SIGNIFICANCE OF OPX GRANITOIDS MASSIVES LOCATED IN BUNGER OASIS, EAST ANTARCTICA
24	WED/THU	13:30-15:00	Tom Jordan	tomj@bas.ac.uk	British Antarctic Survey, United Kingdom	A400	02	Geophysical glimpse of sub-ice shelf bathymetry and underlying geology of the Thwaites Glacier system
25	WED/THU	13:30-15:00	Fausto Ferraccioli	ffe@bas.ac.uk	NERC/British Antarctic Survey, United Kingdom	A457	02	Inferred Mesoproterozoic to late Neoproterozoic tectonic evolution of the Gamburtsev Province in interior East Antarctica
26	WED/THU	13:30-15:00	Fausto Ferraccioli	ffe@bas.ac.uk	NERC/British Antarctic Survey, United Kingdom	A465	02	Decoding signs of Precambrian and Pan-African age tectonics between the Recovery Frontier and western Dronning Maud Land in East Antarctica
27	WED/THU	13:30-15:00	Fragoso, R.A.		Universidade Federal do Rio de Janeiro, Brazil	A486	02	BUILDING UP THE NEW GEOLOGICAL MAP OF GONDWANA (1:5M) – ANTARCTICA'S ROLE IN CONECTING EAST AND WEST
28	WED/THU	13:30-15:00	Samantha Hansen	shansen@geo.ua.edu	The University of Alabama, USA	A041	03	Investigating Ultra-low Velocity Zones in the Southern Hemisphere using an Antarctic Dataset
29	WED/THU	13:30-15:00	Sheng Fan	sheng.fan.geology@gmail.com	University of Otago, New Zealand	A110	03	Modelling the crystallographic preferred orientation (CPO) of a fast-shearing Antarctic ice glacier from seismic anisotropy
30	WED/THU	13:30-15:00	Jinhoon Jung	jhjung87@kopri.re.kr	Korea Polar Research Institute, Korea	A301	03	THE PRELIMINARY RESULTS OF THE SEISMICITY IN THE VICINITY OF THE JANG BOGO STATION OBSERVED ON THE KOREA POLAR SEISMIC NETWORK
31	WED/THU	13:30-15:00	Yongcheol Park	ypark@kopri.re.kr	Korea Polar Research Institute, Korea	A474	03	INSTALLATIONS OF AN INFRASOUND NETWORK AT JANG BOGO STATION AND OCEAN BOTTOM SEISMOGRAPHS IN THE SEA NEAR THE TERRA NOVA BAY
32	WED/THU	13:30-15:00	Ricarda Dziadek	ricarda.dziadek@awi.de	Alfred Wegener Institute for Polar and Marine Research, Germany	A018	06	Geothermal heat flux measured in the Amundsen Sea Embayment
33	WED/THU	13:30-15:00	Ricarda Dziadek	ricarda.dziadek@awi.de	Alfred Wegener Institute for Polar and Marine Research, Germany	A024	06	Geothermal heat flux investigations with thermal crustal 2D models
34	WED/THU	13:30-15:00	Mareen Lösing	mareen.loesing@ifg.uni-kiel.de	Christian-Albrechts-Universität zu Kiel, Germany	A060	06	Bayesian/stochastic inversion of geophysical data for Solid Earth heat flux in Antarctica
35	WED/THU	13:30-15:00	Tom Jordan	tomj@bas.ac.uk	British Antarctic Survey, United Kingdom	A094	06	The South Pole Heat Flux Anomaly, identification, origin, and implications
36	WED/THU	13:30-15:00	Felipe Napoleoni	felipe.a.napoleoni@durham.ac.uk	Durham University, United Kingdom	A127	06	Plans to quantify geothermal heat production over Ellsworth- Whitmore Mountains, West Antarctica.
37	WED/THU	13:30-15:00	Alex Burton-Johnson	alerto@bas.ac.uk	British Antarctic Survey, United Kingdom	A204	06	Heterogenous Antarctic crustal heat production
38	WED/THU	13:30-15:00	Audrey Huerta	adhuerta@gmail.com	Central Washington University, USA	A459	06	Estimates of Antarctic Heat Flow: Insights from Geodynamic Models
39	WED/THU	13:30-15:00	Stewart Jamieson	Stewart.Jamieson@durham.ac.uk	Durham University, United Kingdom	A058	08	The pre-glacial landscape of Antarctica (and its influence on ice sheet behaviour)
40	WED/THU	13:30-15:00	Alina Boronina	al.b.s@yandex.ru	Saint Petersburg State University, Russia	A069	08	On the formation of the ice cauldron on the Dålk Glacier (Larsemann Hills, East Antarctica)
41	WED/THU	13:30-15:00	Sergey Popov	spopov67@yandex.ru	Polar Marine Geosurvey Expedition, Russia	A161	08	Ice thickness and bedrock topography of Mac. Robertson, Princess Elizabeth and Wilhelm II Lands (East Antarctica) according to the Russian data collected from 1971 to 2018

Poster Presentation

No.	Day	Time	Presenter	E-mail	Institution/Organization	Abstract no.	Session no.	Title
42	WED/THU	13:30-15:00	Jun'Ichi Okuno	okuno@nipr.ac.jp	National Institute of Polar Research, Japan	A267	08	Crustal motion and gravity change in East Antarctica inferred from GIA modeling
43	WED/THU	13:30-15:00	Chaoyang Zhang	zhang.6404@osu.edu	The Ohio State University, USA	A450	08	GOCE constrained Antarctic crustal thickness and dynamic topography
44	WED/THU	13:30-15:00	German Leitchenkov	german_l@mail.ru	Research institute for geology and mineral resources of the world ocean, Russia	A080	11	New bathymetric and multi-channel seismic data from the NW Weddell Sea: Implications for the late Cenozoic glacial history of the South Orkney Islands continental shelf
45	WED/THU	13:30-15:00	Jan Erik Arndt	Jan.Erik.Arndt@awi.de	fred Wegener Institute for Polar and Marine Research, Germa	A244	11	IBCSO V2.0: A collaborative effort towards improved bathymetric information
46	WED/THU	13:30-15:00	Jude Castelino	judste@bas.ac.uk	British Antarctic Survey, United Kingdom	A375	11	Evidence of accelerated glacial retreat on King George Island, South Shetland Islands
47	WED/THU	13:30-15:00	Dustin Schroeder	Dustinms@stanford.edu	Stanford University, USA	A017	11	A subglacial hydrologic switching hypothesis for silt sorting and deposition during ice sheet retreat in the in the Amundsen Sea Embayment.
48	WED/THU	13:30-15:00	Matthew Chadwick	machad27@bas.ac.uk	British Antarctic Survey, United Kingdom	A032	13	Reconstructing Antarctic sea ice extent during MIS 5e
49	WED/THU	13:30-15:00	Werner Nel	wnel@ufh.ac.za	University of Fort Hare, South Africa	A074	13	Classifying synoptic air circulation patterns over the Southern Indian Ocean: Observations from Marion Island on recent change and current landscape impacts.
50	WED/THU	13:30-15:00	Li Wu	wuli@tongji.edu.cn	Tongji University, China	A020	14	Late Quaternary deep stratification-climate coupling in the Southern Ocean: implications for changes in abyssal carbon storage
51	WED/THU	13:30-15:00	Zhihua Chen	chenzia@fio.org.cn	The First Institute of Oceanography, China	A070	14	Glacial–interglacial cycles of ice sheet dynamics and paleoceanography in the Amundsen Sea sector, West Antarctica
52	WED/THU	13:30-15:00	German Leitchenkov	german_l@mail.ru	Research Institute for Geology and Mineral Resources of the World Ocean, Russia	A149	14	Seismic stratigraphy of the upper continental rise and abyssal plain off Marie Byrd Land
53	WED/THU	13:30-15:00	Michael Bollen	bolmi518@student.otago.ac.nz	University of Otago, New Zealand	A212	14	Diatom micropaleontology and paleomagnetics of the sediment core RS15-LC42: Insights to paleoceanographic processes at the continental rise.
54	WED/THU	13:30-15:00	Elisabetta Olivo	eolivo@inogs.it	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy	A219	14	The Whales Deep Basin - Houtz and Hayes Bank system (Southeastern Ross Sea, Antarctica): a scenario for Pleistocene continental outer shelf and slope processes evolution
55	WED/THU	13:30-15:00	Jiyoung Shin	jyshin@kopri.re.kr	Korea Polar Research Institute, Korea	A389	14	Magnetic mineral properties linked to iceberg-derived sediment transport in the Scotia Sea (Southern Ocean)
56	WED/THU	13:30-15:00	Laura De Santis	ldesantis@inogs.it	Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Italy	A435	14	The ODYSSEA Drift depositional archive (Ross Sea, Antarctica)
57	WED/THU	13:30-15:00	Jaewoo Jung	jaewoojung87@yonsei.ac.kr	Yonsei University, Korea	A117	15	Microbial alteration of Fe-bearing minerals in freezing condition
58	WED/THU	13:30-15:00	Chaewon Chang	cwchang@kopri.re.kr	Korea Polar Research Institute, Korea	A276	15	Analysis of main ion components and variation in shallow ice core in Northern Victoria Land (GV7, Styx) using ion chromatography.
59	WED/THU	13:30-15:00	Seokhyun Ro	xenonist@naver.com	Inha University, Korea	A277	15	Reconstruction of environmental proxies including conductivity, dust and ionic components from Styx firn core using Continuous Flow Analysis system combined with Melter and Ion Chromatography system
60	WED/THU	13:30-15:00	Duhyeong Lee	dhlee@kopri.re.kr	Korea Polar Research Institute, Korea	A356	15	Proton-Induced Crystallization of Amorphous Solid Water
61	WED/THU	13:30-15:00	Yongsu Baek	windstar527@gmail.com	Kyungpook National University, Korea	A359	15	Existence of IO2H and its role in the formation of I2 in icy water
62	WED/THU	13:30-15:00	Yunhak Lee	yhlee@kopri.re.kr	Korea Polar Research Institute, Korea	A361	15	Freeze concentration effect enhanced fluorescence analysis method for Fe(II)
63	WED/THU	13:30-15:00	Svetlana Shostak	sa.shostakk@gmail.com	Kyungpook National University, Korea	A365	15	Ice Surface Sulfuric Acid Formations via the Oxidation of Sulfurous Acid by Hydrogen Peroxide
64	WED/THU	13:30-15:00	Hyunyoung Chung	hychung@kopri.re.kr	Korea Polar Research Institute, Korea	A368	15	Chemical reactions between hexavalent chromium and iodide in ice
65	WED/THU	13:30-15:00	Kitae Kim	ktkim@kopri.re.kr	Korea Polar Research Institute, Korea	A369	15	Enhanced chemical processes in ice and its impact on cold environment
66	WED/THU	13:30-15:00	Taeuk Han	taeukhan@kopri.re.kr	Korea Polar Research Institute, Korea	A372	15	Enhanced removal of Cr(VI) in the presence of rice husk biochar in frozen aqueous solution
67	WED/THU	13:30-15:00	Jaehyeock Bang	kevinpotter@snu.ac.kr	Seoul National University, Korea	A391	15	Low Energy Electron Transmission and Trapping in Crystalline Ice Films
68	WED/THU	13:30-15:00	Bomi Kim	bomi@kopri.re.kr	Korea Polar Research Institute, Korea	A403	15	Chemical Detection and Characterization in Quasi-Liquid Layer on Ice Using in-situ Raman Spectroscopy
69	WED/THU	13:30-15:00	Heejin Hwang	heejin@kopri.re.kr	Korea Polar Research Institute, Korea	A484	15	Plutonium fallout reconstructed from an Antarctic Plateau snowpack using inductively coupled plasma sector field mass spectrometry
70	WED/THU	13:30-15:00	Keehwan Lee	khlee1009@yonsei.ac.kr	Yonsei University, Korea	A118	17	Characteristics of clay minerals deposited in the sediment: Larsen Ice Shelf B embayment, Antarctica
71	WED/THU	13:30-15:00	Claudio Mazzoli	claudio.mazzoli@unipd.it	University of Padova, Italy	A136	17	The Antarctic barnacle Bathylasma corolliforme as geochemical archive of environmental conditions in the Ross Sea
72	WED/THU	13:30-15:00	Claudio Mazzoli	claudio.mazzoli@unipd.it	University of Padova, Italy	A138	17	Latitudinal screening of Southern Ocean limpet isotope compositions and incremental banding across the Polar Front
73	WED/THU	13:30-15:00	Julie Zurbuchen	asimms@geol.ucsb.edu	University of California Santa Barbara, USA	A187	17	Late Holocene ice mass changes recorded in a relative sea-level record from Joinville Island, Antarctica
74	WED/THU	13:30-15:00	Olivia Truax	olivia.truax1@gmail.com	University of Otago, New Zealand	A238	17	Holocene paleoceanographic evolution at the Ross Sea-Southern Ocean interface
75	WED/THU	13:30-15:00	Marcello Blaxell	marcello.blaxell@canberra.edu.au	University of Canberra, Australia	A362	17	Deglaciation of large East Antarctic glacial basins that are grounded below sea level: A preliminary study of the Denman Glacier system
76	WED/THU	13:30-15:00	Gerhard Kuhn	gerhard.kuhn@awi.de	Alfred Wegener Institute for Polar and Marine Research, Germany	A071	17	Marine ecosystem response to Late Pleistocene climate conditions - evidence from snow petrel stomach oil deposits ("mumiyo") in East Antarctica
77	WED/THU	13:30-15:00	Marcelo A Reguero	wrm@mrecic.gov.ar	Instituto Antártico Argentino (IAA), Argentina	A086	20	Paleobiological inferences of the Antarctic dinosaur Antarctopelta oliveroi (Ornithischia: Ankylosauria) based on the bone histology of the holotype specimen
78	WED/THU	13:30-15:00	Docho Dochev	dochev@gea.uni-sofia.bg	Sofia University, Bulgaria	A095	20	Palynological study on parts of the Byers Group, Livingston Island, Antarctica – proxy for age, palaeoenvironmental and palaeoclimatic assessment
79	WED/THU	13:30-15:00	Jose Ogorman	joseogorman@fcnym.unlp.edu.ar	Museo de La Plata, Argentina	A111	20	SEARCHING ON THE BOUNDARY: A RICH VERTEBRATE ASSEMBLAGE ON THE ANTARCTIC UPPERMOST MAASTRICHTIAN
80	WED/THU	13:30-15:00	Marcelo A Reguero	regui@fcnym.unlp.edu.ar	Instituto Antártico Argentino (IAA), Argentina	A182	20	FIRST REPORT OF A SKELETAL PATHOLOGY OF A MOSASAUR FROM THE SOUTHERN HEMISPHERE
81	WED/THU	13:30-15:00	Marcelo A Reguero	wrm@mrecic.gov.ar	Instituto Antártico Argentino (IAA), Argentina	A269	20	The early radiation of modern whales: new insights from Eocene records from Antarctica.
82	WED/THU	13:30-15:00	Soledad Gouiric Cavalli	sgouiric@fcnym.unlp.edu.ar	Museo de La Plata, Argentina	A353	20	Jurassic marine fishes from the Antarctic Peninsula: a key to understand the evolution of Southern Gondwanan ichthyofaunas

Poster Presentation

No.	Day	Time	Presenter	E-mail	Institution/Organization	Abstract no.	Session no.	Title
83	WED/THU	13:30-15:00	Javier Gelfo	jgelfo@gmail.com	Museo de La Plata, Argentina	A390	20	New fossil vertebrates from the Paleogene of Seymour/Marambio Island, James Ross Basin, West Antarctica
84	WED/THU	13:30-15:00	Yagmur Gunes	gunesya@itu.edu.tr	Istanbul Technical University, Turkey	A283	21	Revealing microbial influences on alteration of basaltic rocks as inferred from water and rock chemistry: Implications for Weathering processes on King George and Deception Island, Antarctica
85	WED/THU	13:30-15:00	Carolina Henriquez Valenzuela	chenriquezv6@gmail.com	Universidad Andres Bello, Chile	A320	21	Inorganic and organic carbonate precipitation in the Laguna Timone Maar, Pali Aike volcanic field, southern Patagonia.
86	WED/THU	13:30-15:00	Carolina Henriquez Valenzuela	chenriquezv6@gmail.com	Universidad Andres Bello, Chile	A452	21	Preliminary results on the geomicrobiology of the sedimentary substrate of the Laguna Timone maar, Patagonia
87	WED/THU	13:30-15:00	Anelize Bahniuk Rumbelsperger	anelize.bahniuk@ufpr.br	Parana Federal University, Brazil	A468	21	Patagonia Modern Microbial Carbonates: Potential Areas To Better Understand Early Life
88	WED/THU	13:30-15:00	Tobias Staal	tobias.staal@utas.edu.au	University of Tasmania, Australia	A083	22	A computational framework and 3D model, 'agrid', for interdisciplinary Antarctic research.
89	WED/THU	13:30-15:00	Belinda Smith Lyttle	b.smith.lyttle@gns.cri.nz	GNS Science, New Zealand	A237	22	GeoMAP dataset of the Antarctic Peninsula
90	WED/THU	13:30-15:00	Simon Cox	s.cox@gns.cri.nz	GNS Science, New Zealand	A253	22	GeoMAP on REMA
91	WED/THU	13:30-15:00	Simone Darji	dsimone24@gmail.com	M.G. Science Institute, India	A272	22	SCENARIO OF GLACIER ICE DYNAMICS OF EASTERN AND WESTERN PARTS OF ANTARCTICA
92	WED/THU	13:30-15:00	Prashant	sh.prashantpandit@gmail.com	TERI University, India	A311	22	Spectral approach to map blue ice area of the Polar Record Glacier, East Antarctica
93	WED/THU	13:30-15:00	Alex Burton-Johnson	alerto@bas.ac.uk	British Antarctic Survey, United Kingdom	A445	22	Evidence for a permanent lava lake in British Territory: Remote sensing of Mt. Michael, South Sandwich Islands
94	WED/THU	13:30-15:00	Jeronimo Lopez Martinez	jeronimo.lopez@uam.es	University Autonoma of Madrid, Spain	A476	22	The northern Antarctic Peninsula region spectral library of ice-free areas to support ground truthing and validation of satellite information
95	WED/THU	13:30-15:00	Michael Wethington	wethi002@umn.edu	Polar Geospatial Center, USA	A462	20	Using Very- and Ultra-High resolution Digital Elevation Models in Antarctic Biological Research
96	WED/THU	13:30-15:00	Popov Sergey	spopov67@yandex.ru	Polar marine geosurvey expedition, Russia	A164	23	Organizing the runways in the area of the Russian Antarctic stations in East Antarctica sector during the seasons of the 59 - 64rd RAE (2013/19)
97	WED/THU	13:30-15:00	Banyu Firdaus Soeriawidjaja	banyufirdaus@pukyong.ac.kr	Pukyong National University, Korea	A371	23	Photostable polymeric nanoparticle containing organic near-infrared dye with enhanced biocompatibility under hyperthermal irradiation at low-temperature.
98	WED/THU	13:30-15:00	Xiaopeng Fan	heaxe@163.com	Jilin University, China	A424	23	The development of portable hot water drill and hot-point drill for temperature measurement of mountain glacier
99	WED/THU	13:30-15:00	Dongwoo Kim	hiroo@kaist.ac.kr	KAIST, Korea	A433	23	Use of Local-area Differential GNSS System for Polar Exploration
100	WED/THU	13:30-15:00	Jayun Ha	llprince612@gmail.com	Pukyong National University, Korea	A434	23	Microemulsion with near-infrared dye for surface adhesion and photothermal effect
101	WED/THU	13:30-15:00	Paula Enciso	penciso@fcien.edu.uy	Faculty of Sciences UdelaR, Uruguay	A470	23	Evaluation of dyes obtained from Antarctic red algae in DSSC
102	WED/THU	13:30-15:00	Palmira Cuellar Ramirez	palmira@comunidad.unam.mx	UNAM/RedLAtM/YESS Community, Mexico	A436	24	The importance of global-south scientists engagement for the Antarctic preservation; opportunities to new policies and climate action to citizens
103	WED/THU	13:30-15:00	Jeronimo Lopez-Martinez	jeronimo.lopez@uam.es	University Autonoma of Madrid, Spain	A477	24	Consideration of geological heritage in the Antarctic protection system: current situation and future perspectives
104	WED/THU	13:30-15:00	Jeronimo Lopez-Martinez	jeronimo.lopez@uam.es	University Autonoma of Madrid, Spain	A479	24	Steps for the SCAR advice to the Antarctic Treaty System about identification and conservation of Antarctic geological values
105	WED/THU	13:30-15:00	Deniz Vural	vrl.dnz@gmail.com	Istanbul Technical University, Turkey	A488	24	A national point of coordination and outreach steps
106	WED/THU	13:30-15:00	Sergio Goncalves Junior	sjrgoncalves@gmail.com	Rio de Janeiro State University (UERJ), Brazil	A112	25	Insights on the formation and long-term accumulation of perchlorate in Antarctica: A potential source of salinity to the subglacial environment
107	WED/THU	13:30-15:00	Yufang Zhang	zhyufangtuzi@163.com	Beijing Normal University, China	A159	25	Simulating Antarctic subglacial hydrology processes beneath Pine Island Glacier, West Antarctica, using GlaDS model in Elmer/Ice
108	WED/THU	13:30-15:00	Paul Augustinus	p.augustinus@auckland.ac.nz	The University of Auckland, New Zealand	A315	25	Subglacially-precipitated carbonates reflect sub-Ice Sheet Hydrology
109	WED/THU	13:30-15:00	Yu Cai	caiyu13834585@163.com	Nanjing University, China	A030	26	Variations of Lake Ice Phenology on the Tibetan Plateau from 2001 to 2017 Based on MODIS Data
110	WED/THU	13:30-15:00	Stephen Trumble	stephen_trumble@baylor.edu	Baylor University, USA	A065	26	Running on Empty: Leopard Seal Lipid Profiles Expose a Precarious Existence
111	WED/THU	13:30-15:00	Guohui Yao	249393314@qq.com	Nanjing University, China	A102	26	Identification of mountain glacier in the central Himalaya using ALOS-2 PALSAR data
112	WED/THU	13:30-15:00	Catherine Chong	Catherine.ChongSze@student.imu.edu.my	International Medical University, Malaysia	A103	26	Polymicrobial biofilms from Signy Island (Antarctica) and ROS production by bacterial isolates resistant to heavy metals
113	WED/THU	13:30-15:00	Yayue Sun	15072303971@163.com	Tongji University, China	A167	26	Penguins feathers as bioindicators of mercury contamination in Ross Sea and Zhongshan station of Antarctic: geographical and temporal trends
114	WED/THU	13:30-15:00	Yoichi Fukuda	fukuda@kugi.kyoto-u.ac.jp	Kyoto University, Japan	A171	26	A New Project on Interaction of the Solid Earth and the Antarctic Ice Sheet
115	WED/THU	13:30-15:00	Seunggoo Kang	ksg9322@kopri.re.kr	Korea Polar Research Institute, Korea	A228	26	Seismic image for water column in the Ross Sea from multi-channel seismic data using the frequency domain reverse time migration based on analytic Green's function
116	WED/THU	13:30-15:00	Docho Dochev	dochev@gea.uni-sofia.bg	Sofia University, Bulgaria	A230	26	Field data about sedimentological and volcanological successions exposed on Livingston Island, Antarctica
117	WED/THU	13:30-15:00	Hanna Asefaw	hasefaw@ucsd.edu	Scripps Institution of Oceanography, USA	A317	26	Paleodirection and Paleointensity Estimates from the Erebus Volcanic Province, Antarctica
118	WED/THU	13:30-15:00	Byeonghoon Kim	ginew@snu.ac.kr	Seoul National University, Korea	A376	26	Discovery of subglacial lakes in Thwaites Glacier basin using Cryosat-2 radar altimetry
119	WED/THU	13:30-15:00	Iris Maria Tusa	iris.tusa@gmail.com	The National Institute of Research and Development for Biological Sciences, Romania	A383	26	Study on human body adaptation to Antarctic environmental conditions using red blood cells as biomarkers
120	WED/THU	13:30-15:00	Corina Itcus	corina.itcus@gmail.com	The National Institute of Research and Development for Biological Sciences, Romania	A385	26	Diversity and Structure of microbial communities in Glacier Ice and Subglacial Streams, King George Island, Antarctica

A029

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Decompensative gravity anomalies reveal structure of the upper crust of Antarctica.

Carina Haeger[1,2†], Mikhail Kaban[1]

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Isostatic gravity anomalies are often used to investigate crustal structures. However, compensating masses significantly reduce the gravity effect of unknown sedimentary and upper crustal structures. To separate these effects, we apply the so-called decompensative corrections to the isostatic anomalies for the Antarctic continent using satellite gravity data, which reach values of up to ±70mGal. In the calculations, we also take variations of the effective elastic thickness of the lithosphere and Moho depth into account. As Antarctica is almost entirely covered by thick ice shields impeding in-situ measurements, information about upper crustal structures and sedimentary basins is still sparse and the analysis of decompensative anomalies offers new insights. The obtained decompensative anomalies well correspond to the known sedimentary basins, such as in the areas of the Filchner-Ronne Ice Shelf and Lambert Graben, and also suggest the existence of other large sedimentary deposits both in West and East Antarctica, which are not or only sparsely mapped by existing seismic surveys, e.g. in coastal Dronning Maud Land and Enderby Land. A dipole-like structure exists at the Transantarctic Mountains and the Wilkes Subglacial Basin, suggesting the presence of isostatic disturbances linked to the dynamic uplift of the Transantarctic Mountains and thick sedimentary accumulations in the east. Extended positive anomalies in East Antarctica are likely related to the old and dense cratonic crust as well as to isostatic disturbances caused by the transition from local to regional compensation around the Lambert Graben.

A043

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Crustal thickness and density structure of Antarctica – new insights from petrological and gravity modelling

Folker Pappa[1†], Jörg Ebbing[1], Fausto Ferraccioli[2]

[1]Kiel University, Institute of Geosciences, Germany, [2]British Antarctic Survey, United Kingdom

Significant discrepancies of 10-20 km exist in estimates of the Moho depth in several regions of the Antarctic continent. We evaluate existing Moho depth models and compare them with 1) inversions from satellite gravity data of our own, which are constrained by seismic estimates, and 2) Airy-isostatic Moho depth models. The comparison reveals a spatially variable buoyancy contribution from the lithospheric mantle beneath contrasting sectors of East Antarctica. Moreover, the evaluation confirms that a lower density contrast at the Moho is present under East Antarctica than beneath West Antarctica, demonstrating that classical gravity inversion approaches are not suitable for assessing the Moho depth of the Antarctic continent, and density variations due to temperature and petrology need to be considered.

We thus performed comprehensive and consistent modelling in 3D to investigate the thermal and density structure of the Antarctic lithosphere. A new Moho depth map of the continent is derived that is consistent with gravity gradient data measured by the GOCE satellite and is in line with seismic crustal thickness estimates. It includes varying density contrast at the Moho and exhibits detailed thickness changes in East Antarctica, also in regions with sparse or absent seismic station coverage. Intra-crustal density variations are inverted from airborne gravity data and evaluated against thermodynamic modelling results of potential crustal rock compositions. Among other implications, the results allow us to better estimate sub-glacial heat flow values, which substantially control the ice-sheet's behaviour in terms of velocity and basal melting.

A048

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

The early Neoproterozoic Polkanova Series in the westernmost Enderby Land: another manifestation of Tonian ocean

Evgenii Mikhalsky[1†], Nikolay Rodionov[2]

[1]VNIIOkeangeologia, Russia, [2]VSEGEI, Russia

The metamorphic Polkanova Series was distinguished in early 1970-s by E.N. Kamenev in Polkanova Hills in the Prince Ulaf Coast (44°East, 68°South), some 10x1–3 km large flatland. Structurally lower part of Polkanova Series is composed of intercalated biotite-amphibole plagiogneisses and biotite (+/-clinopyroxene) amphibolites with minor biotite gneisses. These lithologies occur in members some tens of meters to few hundred meters thick. Thinner boudinaged marble and calc-silicate beds of garnet-sillimanite-bearing gneisses occur. Structurally upper part is composed of intercalated biotite and biotite-garnet plagiogneisses up to few hundred meters thick. Thinner and rare members of amphibolites and high-aluminous schists occur. All rocks are migmatitic.

Leucosome forms conformable layers composed of plagiogranite to two-mica granite and pegmatite. Chemical analyses indicate sub-alkaline basic, intermediate and acidic compositions. Acidic compositions correspond to tonalite and (mostly) granodiorite in the terms of normative AQP and Ab–An–Or classifications. Primitive mantle normalized spiderdiagram reveals moderate enrichment in LILE and slight Nb–Ta troughs. The REE distribution is unfractionated or slightly fractionated with moderate LREE enrichment.

Zircons from two tonalitic orthogneisses and one leucosome sample were analyzed by U–Th–Pb SIMS SHRIMP. Eight and nine concordant analyses on zircon grain magmatic cores with oscillatory zoning were obtained for two orthogneisses indicating protolith crystallization ages of ca 945 Ma and ca 980 Ma. The first sample also yielded a few ca 1000 Ma analyses. Zircon metamorphic overgrowths in the orthogneisses yielded clusters of concordant analyses at ca 600 Ma or ca 530 Ma. A leucosome sample yielded only two oval-shaped high-U grains dated to ca 480 Ma. Nd isotopic compositions of the two orthogneisses (epsilonNd(i) = -4.8 and 3.7; TDM = 1.87 Ga and 1.2 Ga) indicate derivation from primitive mantle and previously existed crustal sources.

We interpret these data indicating emplacement of mafic to felsic magmatic rocks at ca 980 Ma and their high-grade (migmatitic amphibolite facies) metamorphism at ca 530 Ma. The bulk composition of the Polkanova Series suggests it was derived from sedimentary-volcanic precursors which represent early Neoproterozoic mantle additions to the crust under convergent geodynamic settings (a magmatic arc).

Our ca 980 Ma age of the Polkanova Series protolith correlates well with ca 1000–950 Ma zircon U–Pb ages reported from the Rayner Province in the Enderby Land and its continuation into the Mac.Robertson Land (Fitzsimons, 2003). In these areas, however, juvenile additions of this age are generally lacking. On the contrary, juvenile Tonian (ca 1000–900 Ma) oceanic arc super terrane has been distinguished in the Sør Rondane Mountains and westward terrain (TOAST; Elburg et al., 2015, Jacobs et al., 2015). However, these areas can not be readily correlated with the Polkanova Series due to misfit in magnetic anomaly patterns and geological record in Lützow-Holm Complex lying in between (Ruppel et al., 2018). Thus our preferred correlation of the Polkanova Series is the Palghat-Cauvery Suture Zone of southern India and further continuation into Madagascar as the Ikalamavory Domain or into Sri Lanka as Kadugannawa Complex.

A056

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Late Neoproterozoic–Early Paleozoic deformation and cooling of Sør Rondane and implications for the final assembly of Gondwana: Evidence from 40Ar/39Ar and U-Pb geochronology

Antonia Ruppel[1] [†], Joachim Jacobs[2], Andreas Läufer[1], Lothar Ratschbacher[3], Jörg Pfänder[3], Benita-Lisette Sonntag[3], Marlina Elburg[4], Nicole Krohne[5], Detlef Damaske[1,6], Frank Lisker[5]

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Sør Rondane is located in eastern Dronning Maud Land and represents a key area to study the tectono-thermal history of the eastern part of the East African-Antarctic Orogen. New and published 40Ar/39Ar and K-Ar ages from five structural domains span 660-480 Ma. This age range is well in line with the intrusion of at least three generations of syn- to post- tectonic granitoids. The weakly deformed SW Terrane S contains the oldest cooling ages and is intruded by the oldest granitic intrusion at ca. 630 Ma. This terrane represents the root of a Tonian island arc that escaped much of the Late Neoproterozoic accretionary deformation and is interpreted as a mega-boudin. Its northern margin is constrained by the Main Shear Zone, which exhibits 40Ar/39Ar amphibole and biotite cooling ages of ca. 570-525 Ma and is intruded by ca. 570-560 Ma granitoids. The adjacent four terranes record 40Ar/39Ar cooling ages between 510 and 480 Ma, coeval with the youngest magmatic pulse in the region. Both, crystallization ages of granitoids and 40Ar/39Ar cooling ages record an eastward younging trend that may represent the outward growth of the East African-Antarctic Orogen. The long lasting igneous and cooling history of Sør Rondane is best explained by repeated phases of accretion, magmatism, and reactivation, i.e. collage-style tectonism, pre-dating the incorporation into Gondwana. This accretionary tectonism probably occurred along the ice-covered Valkyrie Craton. This new fragment was then sandwiched between the Kalahari and Indo-Antarctica cratons, resulting in today's East Antarctica.

A057

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Aerogeophysical survey over the Forster Magnetic Anomaly and its implications for revealing the tectonic evolution of central Dronning Maud Land

Antonia Ruppel[1†], Graeme Eagles[2], Joachim Jacobs[3], Wilfried Jokat[2], Andreas Läufer[1]

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The proposed suture between West and East Gondwana is assumed within Dronning Maud Land but still remains enigmatic. In this regard, a prominent NE-SW trending magnetic lineament, the Forster Magnetic Anomaly (FMA), is of major interest. The FMA was first identified during aerogeophysical surveys carried out by the AWI between 2001 and 2005, and lies well to the south of isolated mountainous outcrops that do not directly help to identify the anomaly source. One hypothesis suggests that the FMA represents a major suture between rocks with African affinities and Archean to Mesoproterozoic ages in the West and juvenile Early Neoproterozoic rocks of the recently defined TOAST (Tonian Oceanic Arc Super Terrane) in the East.
We present a new aeromagnetic data set, gathered by Polar 6 in 2015/16 and 2016/17 out of Neumayer and Kohnen stations. The new survey densifies our existing survey profiles from 10 km to 5 km line spacing over the FMA. The new data contribute to an improved imaging of the FMA and will provide new information for a better understanding of the final amalgamation of Gondwana in Dronning Maud Land.

A062

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Investigating the characteristics of a potential West Antarctic mantle plume with geodynamic models

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Located far away from the margins of either Large Low Shear Velocity Province, West Antarctica is no typical region to expect a hotspot fed by a deeply rooted mantle plume. Also, neither a large-scale flood basalt province nor a clearly age-progressive hotspot track have been identified - both common surface signatures of a plume. However, recent studies provided evidence that the ice cover in Marie Byrd Land conceals one of the largest volcanically active provinces in the world, as well as a distinctively elevated surface heat flux. In addition, volcanic rock samples show a geochemical signature similar to that of ocean island basalts, glacial isostatic adjustment models indicate low viscosities in the upper mantle and seismic tomography reveals distinct zones of slow seismic velocities extending at least down to the transition zone. Altogether, these findings have kept a debate on the existence of a plume alive over the past 30 years. Our study addresses this long-standing hypothesis using geodynamic models as a novel approach in this discussion. We have developed an instantaneous model setup with the mantle convection code ASPECT: as an initial state, we utilize a three-dimensional lithosphere scale model of the Antarctic continent that combines satellite gravity gradients and seismological data. Then we insert a thermal anomaly beneath the lithosphere, simulating ponding plume material. This setup enables the testing of various plume parameters and positions, in order to investigate if a plume can consistently explain the elevated heat flux and low upper mantle viscosities. Thus, our study aims at an evaluation of the likelihood as well as the characteristics of a West Antarctic mantle plume from a geodynamic point of view.

A081

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Eoarchean crust in East Antarctica: zircon isotopic evidence

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There is little evidence as to the nature of the Earth's earliest crust. However, the ongoing investigation at the micro- and nanometer scale of zircon, the oldest known witness to the early history of the Earth, has given us some insight into early Earth differentiation. One of the areas where ancient rocks have been documented is the Napier Complex in East Antarctica (Black et al., 1986), where rocks older than 3.7 Ga occur in the Tula Mountains of Enderby Land (Harley, 1997; Harley et al., 2019; Kelly and Harley, 2005; Kusiak et al., 2013). Ancient gneisses have also been identified at Aker Peaks in the eastern Napier Complex of Kemp Land (Belyatsky et al., 2011). Authors record an age of 3981±8 Ma to infer the presence of early Archean to Hadean crust in Kemp Land with a minimum age of 4 Ga. The only previous study on Hf in zircon from the Napier Complex (Choi et al., 2006) assumed that zircon growth took place at 3.85 Ga. Positive εHf(t) values obtained were explained as the result of derivation of the protolith from the depleted mantle. For our study, zircon grains from mafic and felsic orthogneisses from Aker Peaks were analyzed by Sensitive High Resolution Ion Microprobe and (split-stream) Laser Ablation Inductively Coupled Plasma Mass Spectrometry to collect U-Pb and Lu-Hf isotopic data in order to identify the presence of Eoarchean rocks in Kemp Land. Zircon from mafic two-pyroxene orthogneiss yields magmatic upper intercept U-Pb ages of ca. 3.70 Ga, which are interpreted as protolith ages. Zircon from the tonalitic orthogneiss are more complex with ages between 3.81-3.78 Ga, the oldest of which may be xenocrystic. Our new U-Pb data substantiate that gneisses from Aker Peaks record 207Pb/206Pb ages >3.7 Ga, similar to the Tula Mountains in Enderby Land. This extends the known range of Eoarchean rocks in the Napier Complex. Both areas also underwent high-grade metamorphism at 2.5 Ga, establishing a uniformity of crustal evolution over a distance of >200 kilometres.

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A098

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Investigating the Deep Continent Beneath the Interior of East Antarctica Using the 'agrid' Research Environment

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A number of recent studies have combined multiple datasets to produce overview maps and interpretations of tectonic structure the East Antarctic continent. In this contribution, we address the non-uniqueness of such interpretations for the interior of East Antarctica through the use of 'agrid', a 3D model and computational framework for interdisciplinary studies relating to the deep continent. Through our novel, exploratory approach, we aim to progress the understanding of East Antarctic tectonics, including the formation of Gondwana and previous supercontinents. The computational environment 'agrid' provides a multidimensional model environment, with flexible input and output functionality (more details are given in a separate presentation at this meeting). This environment is built using the Python programming language and features an accessible user interface, such that minimal coding skills are required in its use for research. Export formats (e.g. netCDF) are interoperable for a wide range of applications. The multidimensional grid is populated by datasets (including seismic wavespeed, free-air gravity, Bouguer gravity, digital elevation) in a way that facilitates dynamic updating as the underlying geophysical compilations improve. The use of metadata, (e.g.) on input value provenance and error bounds, is a feature of 'agrid', and we make use of this functionality to provide bounds on output uncertainty in our investigations of the Antarctic interior.

Using a probabilistic segmentation of the East Antarctic lithosphere, we construct multiple possible interpretations of the tectonics of the East Antarctic interior. These are based on major tectonic features found in the neighbours of East Antarctica in Gondwana, and elsewhere. We test these interpretations against appropriate single-variate datasets to ascertain the range of tectonic interpretations that could be supported by the currently available data coverage and resolution. We find that it is possible to exclude some tectonic scenarios but that other scenarios, notably those that include enigmatic terranes in the interior without coastal exposure, remain highly likely. We also gain insight into the sensitivity of available data, and the optimal locations for new field data collection initiatives for the various datasets with regard to resolving questions of tectonic structure. Through our comparative study, the best possible output models, and accompanying uncertainty information, may be taken forward for use by (e.g.) glacial isostatic adjustment modellers and other interdisciplinary research users.

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Precambrian evolution of the Ruker granite-greenstone terrain of the East Antarctica: structure, age and geodynamic setting.

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The part of East Antarctic craton exposed within Prince Charles Mountains can be subdivided on two tectonic provinces. The Ruker province involves paleo- neoArchaean Ruker granite- greenstone and paleoproterozoic Lambert terrains. The Reiner province consists of the Fisher volcano- plutonic complex and the Beaver granulite- gneiss terrain. The studied Rymill massif and mount Bloomfield located at north-western boundary between the Archaean Ruker terrain and proterozoic Lambert terrain. Thus it is a key are to study the relationship between the Archaean and Proterozoic terrains. The Ruker terrain consist of Paleo- Mezoarchaean Mowson orthogneiss series an metasediments of Menzies, Ruker and Sodruzhestvo series of Mezoarchaean, Paleo- and Neoproterozoic age, correspondingly.

The studied area comprises Mowson orthogneiss (mainly migmatized granitic gneisses and hornblende- biotite schist) and Menzies series volcano- sedimentary rocks. The latter involves weakly metamorphosed sediments (conglomerates, kyanite- staurolite and mica quartzites) and volcanic rocks (biotite- hornblende and chlorite- mica schists) occurring as E-W trending tectonic nappes or blocks. At mount Rymill the Mowson and Menzies series rocks are intruded by metabasite sills, doleritic dykes and granite pegmatites. Mount Bloomfield consists only of orthogneisses of tonalite-trondhjemite- granodiorite compositions intruded by gabbro sills.

The southern part of mount Rymill consists of Mowson series orthogneiss comprising zircons yielding an age of 3164.2±9.2 Ma and 3163.2±7.8 Ma interpreted to date a protolith crystallization age. The rocks are deformed and metamorphosed (M1) and occur as dome- like structures. The maximum time of Menzies series sediments deposition is thought to be about 3.1- 3.0 Ga. The Mowson orthogneisses forming a dome- like structure at mount Bloomfield similar to tht at southern part of Rymill massif were dated at 2798.4 ±8.3 Ma. They intruded by granite veins with 2690±31 Ma zircon crystallization age interpreted to date a minimum time of Neoarchean tectono- thermal event (metamorphism M2). The lower interceptions of discordia lines suggest significant radiogenic Pb loss at 1000- 900 Ma and c. 541 Ma. These are in good agreement with time of Rayner and Pan-African tectono- thermal events affecting significant part of the Prince-Charlies Mountains.

Our geological data has shown that the north- western part of Ruker terrain has a mosaic structure typical for granite- greenstone areas elsewhere. It is formed by granite gneiss domes mantled by greenstones filling synformes separating an individual domes. The granite gneisses, particular at mount Bloomfield are similar by chemical composition to TTG- gneiss. Geochemical features of metavolcanic and intrusive rocks suggest their formation in environments similar to riftogenic or withinplate settings. Our data suggest that mowson series rocks are polymetamorphic and have been metamorphosed under granulite to epidote- amphibolite facies. The oldest high- gradient metamorphic event M1 responsible for the major transformation of the rocks is thougt to occur at the time of c. 2800 Ma orhtogneiss protolith emplacement. The presence of Archaean detritial zircons in Menzies sediments suggest that they were partially derived from basement Mowson orthogneiss during the rifting of continental crust of the Ruker terrain.

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

The Transantarctic Mountains Northern Network (TAMNNET): Versatility of a Polar Seismic Array

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Between 2012-2015, the Transantarctic Mountains Northern Network (TAMNNET) was operated in Victoria Land, Antarctica. Data from this network have made a wide range of investigations possible. Originally, TAMNNET was developed as a structural seismology experiment to further our understanding of the origins of the Transantarctic Mountains and the Wilkes Subglacial Basin, and associated analyses have provided new constraints on the crustal and upper mantle structure within this area. This data has also been incorporated into large-scale investigations of Antarctic tectonics. However, the TAMNNET data have also provided new insight into local microseismic events, particularly near David Glacier and the Drygalski Ice Tongue, and have been used to investigate the distribution of ultra-low velocity zones along the core-mantle boundary outside the continent. This presentation will highlight the major contributions from TAMNNET and will illustrate the versatility of polar seismic initiatives.

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

The early stage of the Australia-Antarctica break-up

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The studied regions include typical magma-poor margins of Australia and Antarctica. The south-eastern Indian Ocean located between these continents started to form in Late Jurassic. The rifting between Australia and Antarctica was characterized by long history (approximately during 70 – 80 Ma) and extreme crustal extension with mantle unroofing. The break-up of the Australian and Antarctica occurred about 83 million years ago. The boundary between transitional crust and oceanic crust is recognized from different geophysical criteria but mostly by changes in crustal structure. The early stage of sea-floor spreading developed in ultra-slow (between 1 and 17 mm/y) and non-uniform regime during Late Cretaceous – Late Eocene. The oceanic crust of this stage is constrained by C33o and 18 polarity chron. Pre-breakup Australia-Antarctica continent with Archean and Mesoproterozoic crust characterized by a thick, firm and cold lithosphere and this conditions were used for a physical simulation of the Australia-Antarctica break-up. The lab modeling showed an asymmetric mode of spreading and ridge jumps. These processes can explain gaps for Late cretaceous-Early Tertiary reconstructions of Australia and Antarctic Plates. The early stage of continent separation was characterized extremely slow sea-floor spreading (less than 1 mm/yr) which accompanied formation oceanic core complexes (known as Diamantina Zone in the Western South Australian Basin). Physical experiments suggest that formation of such structures occur as a result of interruption in sea-floor spreading.

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A180

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

UNRAVELING THE ARCHITECTURE OF THE ANTARCTIC PENINSULA AND ITS EASTERN CONTINENTAL MARGIN BASED ON POTENTIAL DATA MODELLING

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The study of the Antarctic Peninsula architecture and its eastern continental margin is based on available gravity and magnetic data. It is widely accepted that igneous and metamorphic rocks mainly compose the Antarctic Peninsula, separated from South America during the opening of the Drake Passage in the Oligocene, as part of the Mesozoic-Cenozoic Andean orogenic belt. It was formed by processes related to the subduction of Pacific Ocean floor at its western margin, still active northward of the Hero fracture zone, where the Bransfield Backarc basin developed. Rifting of the South Orkney Microcontinent from the Antarctic Peninsula also in Oligocene led to development of the Powell Basin. The largest part of the Antarctic Peninsula eastern margin is a continental passive margin gradually escaping to the Weddell Sea ocean floor.

The Bouguer gravity anomaly grid of 10 km resolution displays anomalies ranging from -120 to +300 mGal. The most conspicuous features are short-wavelength (less than 100 km) gravity lows corresponding to the Antarctic Peninsula and the Larsen Ice shelf. To the east, the two long-wavelength gravity highs are related to Weddell Sea and Powell Basin oceanic crusts. At the northwest, the Phoenix oceanic crust shows a NE trending gravity high related to the South Shetland Trench. The continent ocean boundary located at the eastern margin of the Antarctic Peninsula is characterized by the gradual increase in the Bouguer anomaly coinciding with the magnetic anomaly pattern. In the free air anomaly map, a linear offshore high with N-S trend traces continental shelf edge by combining the effects of sharp topographic change on the continental shelf edge and a gradual thinning of the continental crust.

3D Euler deconvolution analysis, a method that does not rely on depth and density constraints, allowed estimating the anomaly source locations. Some well-focussed set of solutions has been determined by using structural index 1 to obtain results from contacts and a 20x20 km window size to reach crustal structures. In the Antarctic Peninsula depth sources less than 10 km may be related to the Pacific Margin Anomaly batholiths, in Bransfield Strait between 10 and 12 km depth discontinuities are associated to the rifting process and in South Shetland Trench between 12 and 20 km are probably linked to the subduction slab. At the eastern Antarctic Peninsula margin, a group of solutions follows an outstanding N-S trend close to 55°W. They represent the deeper solutions obtained reaching more than 50 km depth and are probably related to the boundary where thinned continental crust originates. The south-western Powell Basin and northwest of the Weddell Sea are outlined with a set of solutions ranging from 12 to 20 km that marks the outer edge of the continental crust and the presence of oceanic crust. Additionally, four 2.5D combined magnetic-gravimetric models were produced to demonstrate that the oceanic crust starts roughly at 48°W where it coincides with the well-defined set of 3D Euler solutions.

A196

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Tracing segments of Columbian orogenesis in Vestfold hills, Princess Elizabeth Land and SE Indian shield

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The Vestfold Hills are rocky, coastal hills on the north side of Sorsdal Glacier on the Ingrid Christensen Coast of Princess Elizabeth Land, Antarctica. These are mostly referred to as the Archean block of Princess Elizabeth Land and like other Archean cratons in East Antarctica, it consists predominantly of felsic orthogneisses (termed as Mossel and Crooked Lake gneisses) with subordinate mafic granulite and paragneiss.

This work examines the charnockite and granite association of the Vestfold hills which are reported to be a part of Mossel gneisses. It is established that the two pyroxene charnockite is a product of solid-solid amphibole to orthopyroxene transformation and the temperature of metamorphism of this assemblage is estimated to be 720 °C and 810 ºC. The associated granite is used to determine the age of formation by using chemical dating of texturally constrained monazite grains. Ages estimated are dominantly Paleoproterozoic and one point of Mesoarchean age has been detected. Similar Paleoproterozoic and Archean aged charnockites and pelitic granulites are reported from Rengali-Riamal sector of India and are indicated to be a part of the exhumed lower continental crust of the Singhbhum craton. The data from Vestfold granulites is collated with the available geological data of Archean charnockite–enderbite massifs of Rengali-Riamal sector and is compared with other terrains of SE Indian shield. The Vestfold - Singhbum connections are discussed in light of the evolution of Columbia supercontinent.

A210

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Deep structure and tectonic evolution of the South Orkney Microcontinent (northern Weddell Sea, Antarctica)

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Around the Scotia Arc are located a set of sudmerged banks of continental, intermediate or volcanic nature that are key to understand the origin and development of this major structure. The South Orkney Microcontinent (SOM), located in the central sector of the South Scotia Ridge, northern Weddell Sea (WS), is the largest continental bank (70000 km2). Its shelf has depths ranging from 200 m at NW, deepening to 1800 m towards SE. The Southern Orkney Islands represent the unique emergent part of the SOM.
Since the mid 60's to the most recent researches, like DRAKE2018 campaign (BIO Hesperides), the SOM has been a key objective to understand the fragmentation processes of the Antarctic Peninsula (AP) from South America and the paleoclimatic and paleogeographic evolution of this region. Previous studies includes seismic, gravimetric, magnetic, bathymetric data and two ODP sites (695 and 696), located at SE of the SOM, with sedimentary record from late Eocene. The present-day location is due to the separation from the AP, that started about 34 Ma ago, because the opening of the Powell Basin (PB).

Geological and geophysical modelling allows to characterize the nature of the margins and the complex structure of SOM that respond to different tectonic phases since the Mesozoic. The average thickness of the crust is 25 km, according to seismic tomography and gravimetric modelling. The northern margin is abrupt, with a through that exceeds 5500 m deep, characterized by a band of negative gravimetric anomaly of up to -220 mGal. It is the result of the thrusting of the SOM over the Scotia Sea due to the present sinister transpressive regime. The western margin is determined by normal faults, as a passive margin structure, after the development of the PB. The arched southeastern margin is characterized by a transition of the continental shelf to the Jane Basin through a large normal fault, meanwhile in the westernmost part develops an intermediate basin and a basement high, result of the crustal thinning from 20 to 8 km, as indicate the gravimetric models. The construction of this margin has been developed in the context of the subduction of the oceanic crust of the WS until about 20 Ma ago.

The northern part of SOM is characterized by the highest gravimetric anomaly values of free air, with up to 200 mGal, and negative magnetic anomaly values. The central and southern sectors are characterized by N-S trend positive values of gravimetric anomaly with a pattern of relative maximum and minimum, related to three tectonic graben, Airy, Bouguer and Eötvös basins, with up to 4 km sedimentary thicknes. In the central part is located a band of positive magnetic anomaly, up to 600 nT, that can be related to the Pacific Margin Anomaly. In the southern edge is located a band of positive magnetic and gravimetric anomalies justified as intrusive bodies of basic rocks, about 50 km and 3 to 8 km of thickness, constrained by modelling and related with the subduction of the oceanic crust of WS.

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Ground magnetic surveys and petrophysical studies of the Bunger Hills

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The Bunger Hills consist of granulite-facies paragneisses and orthogneisses intruded by voluminous plutonic rocks ranging from gabbro, through quartz monzogabbro and quartz monzonite, to granite, and were emplaced between c. 1170–1150 Ma (Ravich et al., 1968; Stüwe and Powell, 1989; Sheraton et al., 1990; Sheraton et al. 1992). Ground magnetic surveys during last three seasons (2017-19) in central part of the Bunger Hills completed by the Polar Marine Geosurvey Expedition and VNIIOkeangeologia acquired 270 line-km of magnetic data. The major goal was to augment (boost) the magnetic image of the Paz Cove batholith at its boundary with basement rocks and make possible to characterize anomalies and their origin with geological information. The petrophysical data set representing the study area comprises c. 500 samples, collected in the course of RAE 62-64. This data set was completed by samples collected for the follow-up of magnetic anomalies during field trips, and in addition a large number of in situ susceptibility measurements were made in selected areas.

The banded magnetic patterns with high-gradient zones throughout the boundary of the Paz Cove batholith are mainly associated with a finely interlayered sequence of orthopyroxene-bearing tonalitic orthogneiss and predominantly garnet–cordierite ± sillimanite gneiss, with minor psammitic gneiss, mafic gneiss, garnet ± biotite granitic gneiss, and rare calc-silicate. This was verified in the field by in situ susceptibility measurements, for instance, migmatized and mylonitised orthogneiss and schists have generally high magnetizations with the average susceptibility value of about 34.3*10-3 SI, whereas paragneiss of roughly 0.32*10-3 SI. Among metagabbroic rocks of the compositionally varied Paz Cove batholith monzodiorites, diorites and gabbrodiorites yield modal susceptibility value of the order of 25.1*10-3 SI, and monzogabbroids and gabbroids are less magnetic with susceptibilities of about 4.04*10-3 SI, when blastomylonitic gabbroids show susceptibilities in the range 1.1-103*10-3 SI with modal value 11.6*10-3 SI. Garnet-bearing leucocratic granites are characterized by bimodal volume susceptibilities centered on values of roughly 0.3*10–3 and of 3.09*10–3 SI, whereas biotite-bearing granites have generally higher magnetizations with the average susceptibility value of about 11.0*10–3 SI.

High magnetization of the Paz Cove plutonic rocks does not correlate with the observed magnetic anomaly pattern which exhibit predominantly negative anomalies with amplitude up –1490 nT and therefore possibly affected by their strong remanent magnetization. The most intense negative anomalies are associated with quartz-bearing monzodiorites and granodiorites. Our preliminary results allow suggesting that very pronounced negative aeromagnetic anomalies with varying shapes, trends, and intensities registered in the vicinity of Law Dome in Wilkes Land may be also associated with ca. 1170–1150 Ma strongly reversed magnetization rocks composed the Paz Cove batholith (Aitken et al. 2014; Golynsky et al., 2018).

A227

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

New airborne magnetics view of Princess Elizabeth Land crustal structure

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The airborne surveys over the Prince Charles Mountains and surrounding areas completed by the Polar Marine Geosurvey Expedition were performed with a standard profile spacing of 5 km and tie-line interval of 15–25 km (Golynsky et al., 2006a; 2006b). The aeromagnetic data reveal the spatial boundaries of the Archaean cratons in the southern Prince Charles Mountains and Vestfold-Rauer areas and differentiate the inner structure of the Rayner mobile belt. The total amount of the Russian high-quality aeromagnetic data recently collected over Princess Elizabeth Land exceeded more than 61,000 line-km. They clearly depict the extent of continuous tectonic belt characterised by predominantly low amplitude, linear/curvilinear NE-SW-trending magnetic anomalies that is extremely straightforward and unique relative to the other regions of the East Antarctic. A prominent system of alternating linear positive and negative magnetic anomalies trending NE-SW at the eastern shoulder of the Lambert Rift is associated with the predominantly orthogneissic Pickering Series and paragneissic Manning Series (Laiba, & Kudriavtsev, 2006; Golynsky & Golynsky 2007; Harrowfield et al., 2005). Based on U-Pb zircon ages and chemical comparisons, these rocks are nearly identical to those of the Beaver Complex (Mikhalsky et al., 2013), but the two regions show different magnetic anomaly attributes (Golynsky, Masolov, et al., 2006). The most outstanding Robertson anomaly is reflected by amphibolite-facies rocks only occur in Robertson Nunatak where mafic schists and subordinate orthogneiss crop out. Isotopically juvenile rocks from the Fisher Terrane and Robertson Nunatak may represent a small-scale oceanic arc extending eastward across the Lambert Rift. Two fragments of this oceanic arc are displaced for a distance of about 50-60 km along dextral strike-slip system of faults that are most likely related to Cretaceous transtensional tectonics associated with break-up of India and Antarctica. These faults dissect the Permo-Triassic Amery Group in the northern Prince Charles Mountains (Boger, Wilson, 2003) and offset metamorphic isograde in the southern Prince Charles (Kamenev et al., 1993). At the Manning Nunataks, mafic granulites can be related to metamorphism of island arc basalts, whereas the felsic volcanic arc orthogneisses have no obvious relation to subduction of oceanic crust (Liu et al., 2014). Protolith ages range from ca. 1347 to 1020 Ma, indicate the Rayner continental arc was a long-lived site of crustal accretion. Thus, aeromagnetic surveying over Princess Elizabeth Land has imaged a unique Stenian-aged accretional orogen in East Antarctica (Mikhalsky et al., 2015; Liu et al., 2016). The orogen may be traced uninterruptedly from the Clemence Massif to the southern margin of the Vestfold Hills crustal block and further eastwards to 88° E near the coast (Golynsky et al., 2018). The discovered Mesoproterozoic tectonic belt occurs in a conspicuously congruent sigmoidal zone with roughly N-S orientation near the coast. It may be used as an anchor point for tight reconstruction of India relative to East Antarctica that also may help to unravel the history of continental breakup and amalgamation in the Indo-Antarctica continent what requires further investigation.

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

High mantle temperature beneath the proto-Adare Basin, Ross Sea, Antarctica, as the possible cause of synchronous rifting across the continental-ocean boundary

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Rifting across the continent-ocean boundary (COB) is a fundamental process of continental breakup. There are few examples to show transition from continental rifting to seafloor spreading on extended continental lithosphere, however, it is rare to see rifting across the COB at present. One example of rifting across the COB is Gakkel Ridge-Laptev Sea margin, Arctic, but propagation along a rift axis across the COB is neither continuous nor synchronous. Synchronous rifting along a rift axis continued across the COB was uniquely found in adjacent two oceanic basins, the Adare Basin (AB) in the immediately north and the Northern Basin (NB) in south, which were formed by the Cenozoic rifting between East and West Antarctic plates. The oldest magnetic anomalies on either side of a basin traced linearly through the AB and NB indicate synchronous onset of rifting (Davey et al., 2016). It is noted that those basins evolved from two different lithospheres, oceanic and continental ones, respectively, meaning that there was the COB between proto-AB and -NB. The reason for such a synchronous rifting is not well understood and then we try to get some insight into it from subsurface heat flow observation and thermodynamic modeling over the lithospheric scale. Marine heat flow measurements using a few-meter-long heat probe have been carried out in the eastern flank of the Adare Trough (AT; a fossil rift valley of the AB) for three Araon expeditions in 2015 (ANA05B), 2016 (ANA06C), and 2019 (ANA09C). Observation results of 75-125 mW/m2 are anomalously higher heat flow by ~20 % than one estimated from its formation age. High heat flow beneath the AT stems solely from higher basal temperature by ~200°C because thermal disturbance by volcanism in the study area, which could modulate results from subsurface marine heat flow, seems to be negligible when considering its timing as old as 2 Ma (Panter et al., 2018). Using the full three-dimensional finite element model with Arbitrary-Lagrangian fluid dynamic technique, extension of widely-accepted three layers of the Earth (asthenosphere, lithospheric mantle, and crust) for 20 Myrs under constant extensional velocity (7 mm/yr) is modeled based on Cande et al. (2000). Synchronous rifting between the proto-AB and -NB across the COB has been simulated only when anomalously warmer mantle temperature by ~200°C is applied beneath proto-AB. Implementation of various thermal structure shows rifting situations different from what we know in the study area. Modeling results can be explained in terms of depth-integrated lithosphere strength, that is, where temperature elevation in the oceanic lithospheric proto-AB reduces the lithospheric strength by a factor of 2-3 to the similar level of continental lithospheric proto-NB. We argue that a difference in lithospheric strength between proto-AB and -NB was negligible in the onset of rifting between East and West Antarctic plates and thus that those responded to far-field extension force in the same manner resulting the similar extension width. Our argument is also consistent with a hypothesis of hot mantle intrusion in the region occurred during the Late Cretaceous and the occurrence of low seismic velocity beneath the AT at present. Our integrated analysis may improve understanding of stalled propagation crossing the COB such as the case of the East Gakkel Ridge-Laptev Sea margin.

A271

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Tectonic architecture of a major pull apart basin in Victoria Land unveiled from aeromagnetic and gravity imaging

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Geological and geophysical investigations in Northern Victoria Land (NVL) in East Antarctica, has led to the interpretation that major terrane bounding and intra-terrane fault systems that were active during the early Paleozoic Ross Orogen were reactivated as major right-lateral intraplate strike-slip fault systems in the Cenozoic, possibly starting from ca 48 Ma (the age of a pseudo-tachilite found along the Priestley Fault and the age of the oldest Meander alkaline intrusive dated so far). One of the main tectonic structures in NVL that has been inferred to relate to such intraplate reactivation processes is the Rennick Graben (RG), but its age, extent and kinematics have remained both poorly constrained and controversial. In detail, the RG has been previously interpreted either as an extensive left lateral Cretaceous(?) pull-apart basin linked to the Victoria Land Basin within the proto-West Antarctic Rift System (WARS), or as a much more localised Cenozoic right-lateral basin, seemingly un-connected to the Cenozoic margin of the WARS itself.

Here we present results from a new project (REGGAE) that aims to re-investigate the architecture and evolution of the RG by analysing aeromagnetic, aerogravity and land-gravity and bedrock topography images and models, and combine the geophysical evidence with new independent structural and thermochronology constraints.

We show that enhanced aeromagnetic and isostatic residual gravity maps provide tantalising new geophysical views of the RG. The geophysical images reveal the spatial extent of part of a Jurassic tholeiitic Large Igneous Province preferentially preserved within the RG. They also help define the inherited structural architecture of the underlying Ross-age basement, including for example the more highly magnetic arc basement of the northern part of the Wilson Terrane and a complex subglacial thrust fault belt located between the western flank of the RG and the eastern margin of Wilkes Subglacial Basin (WSB).

Our geophysical interpretations indicate that the RG is a major composite right-lateral pull-part basin that extends from the Oates Coast to the Southern Cross Mountains crustal block, which is part of the uplifted rift flank of the Ross Sea Rift. We further propose that the RG is likely to be kinematically connected with both the western edge of the WARS and the eastern margin of the WSB. Hence, we conclude that the RG is part of wider and more distributed region of the continental lithosphere in East Antarctica that was affected by Cenozoic transtensional stresses, which ultimately led, starting from ca 33 Ma, to accelerated oceanic transform faulting in the adjacent oceanic lithosphere located between southeastern Australia and Tasmania.

A300

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Cenozoic Continental Tectonics in North-Western Ross Sea, Antarctica.

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The north-western region of the Ross has been subjected to several extensional events during the Cenozoic. New ocean crust formation (43 – 26 Ma) in the Adare Basin off north-western Ross Sea can be traced directly into the Northern Basin underlying the adjacent continental shelf, implying a continuity of emplacement of oceanic crust. Steep gravity gradients along the margins of the Northern Basin suggest that little extension and thinning of continental crust occurred before it ruptured and new oceanic crust formed, unlike most other continental rifts and the Victoria Land Basin further south. A pre-existing weak crust and localisation of strain by strike slip faulting may be factors allowing the rapid rupture of continental crust. A narrow ridge (Hallett Ridge) forms the eastern margin of the Adare and Northern basins. The subdued magnetic anomaly over most of the ridge indicates that it is continental. To the east are the older (60 Ma), but narrower, rifts of Central Basin and Central Trough. The deep water (2000m) of the Central Basin extends as far south as the Northern Basin to the west. It separates the Iselin Bank from the western Ross Sea continental margin. Gravity modelling indicates a thin crust (basement ~5km) with sharp margins, probably oceanic, underlying the central part of Central Basin. The rift continues south into the continental Central Trough graben. The Transantarctic Mountains form the western rift margin of the Ross Sea and traverse Antarctica, separating East from West Antarctica. They were primarily uplifted about 55 – 50 Ma, between the times of the extensional episodes forming Central Basin and Northern Basin, along a major lithospheric boundary between the cold East Antarctica craton and warm mobile West Antarctica. Since 26 Ma, only minor, largely extensional, episodes have occurred along the East - West Antarctic boundary in the Ross Sea region.

A312

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Quantitative assessment of Antarctic crustal models using numerical wave simulations

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The structure of the Antarctic crust is important to our understanding of processes occurring within the Antarctic cryosphere as well as to the Earth's response to ice mass loss. With the increase in geophysical studies of Antarctica, crustal structure has become much better defined beneath many regions. Several crustal models have been created from seismic-derived and/or gravity-derived data, and some of these models incorporate sets of crustal receiver functions either as a priori constraints or to validate model results. However, receiver function constraints do not exist throughout large regions of Antarctica due to a lack of seismic coverage; given this, we search for additional metrics by which we can compare and contrast Earth models. One approach that has been utilized for other continents is to forward model accurate synthetic waveforms through existing seismic velocity models to identify which models most accurately reproduce seismic waveform datasets. Such waveform datasets may come from accurately determined seismic events1,2 or from ambient seismic noise3.

In an effort to assess existing Antarctic crustal models using a different metric to identify regions where crustal structure is still most uncertain, we have collected a suite of available seismic- and gravity-derived Antarctic crustal models. In the absence of accurately determined 'ground-truthed' seismic events in Antarctica1, we use a frequency-time normalization approach4 to extract Rayleigh waves from ambient seismic noise, with periods of 15-55 seconds that are sensitive to crustal structure. We split the observations into two separate validation datasets. The first dataset includes all station-station cross-correlations, with at least one seismic station in each pair that has not been previously used to constrain prior tomographic inversions (a true validation dataset), and the second dataset includes all available station-station cross-correlations, including those that may have been used to constrain some of the models we are testing. We construct sets of Earth models from the available crustal models underlain by two different upper mantle models. We forward model synthetic waveforms using a finite difference approach5 through each of the Earth models and measure the phase delays between the synthetic waveforms and the ambient seismic noise dataset. Results from our waveform validation study and identification of the poorly characterized regions of Antarctic crust are forthcoming and will be presented.

1 IASPEI Ground Truth (GT) reference events (2019), http://www.isc.ac.uk/gtevents/
2 Bao and Shen (2016), J. Geophys. Res., 121.
3 Gao and Shen (2012), Bull. Seism. Soc. America, 102(6), 2611-2621.
4 Shen et al. (2012), Bull. Seism. Soc. America, 102(4), 1872-1877.
5 Zhang et al. (2012), Geophys. J. Int., 188, 1359-1381.

A322

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

A composite Precambrian Wilkes Terrane unveiled in East Antarctica

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The enigmatic Wilkes Subglacial Basin (WSB) is one of the largest tectonic features in East Antarctica. It stretches from the George V Coast (where it is ca 600 km wide) for over 1,400 km towards South Pole (where its width is less than 100 km) in the almost entirely ice covered hinterland of the Transantarctic Mountains (TAM). The origin of the subglacial basin itself is hotly debated. Competing models include: i) a relatively simple Cenozoic downwarped flexural basin imposed upon an assumed uniform Precambrian cratonic lithosphere and linked to the uplift of the TAM or; ii) a more complex basin system that also includes older Mesozoic to Cenozoic extensional and transtensional sub-basins that were over-deepened by glacial erosion and associated flexure (e.g. Paxman et al., 2019 JGR).

Comparatively less attention has however been placed so far on the Precambrian basement of the WSB, which is buried beneath cover rocks, including Devonian to Jurassic age Beacon sediments intruded by Ferrar tholeiites and inferred deeper Cambrian to late Neoproterozoic sedimentary basins associated with the cratonward edge of the Ross Orogen and the break-up of Rodinia respectively.

Here, we exploit a compilation of aeromagnetic anomaly data modified from ADMAP 2.0 (Golynsky et al., 2018, GRL) that includes levelling onto the longer-wavelength satellite magnetic anomaly data from the MF7 model and a new compilation of airborne gravity datasets (modified from Scheinert et al., 2016, GRL) as well as new continental-scale constraints from satellite gravity (Pappa et al., 2019, G3) to help unveil the nature and architecture of the Precambrian crust underlying the WSB.

We relate a prominent linear magnetic low along the western flank of the WSB to a ribbon of Archean crust presently located at upper crustal level. With the aid of depth to source estimation of gravity anomalies we construct a simple 2D forward model showing that this ribbon is in part underlain by a dense (underplated?) lower crustal body of inferred Paleoproteorozoic age. This anomalously dense body is interpreted as having been uplifted at mid to upper crustal level during a major Paleoproterozoic transpressional orogenic event that also formed the prominent Mertz Shear Zone, which is partially exposed along the coast of George V Land. A prominent regional magnetic high and residual gravity low over the previously identified Central Basins of the WSB is interpreted as reflecting buried Mesoproterozoic igneous basement rocks potentially akin to the well-known Mesoproterozoic Gawler Range volcanics and intrusives.

Further to the east, we re-examine the nature of the previously recognised Prince Albert Fault System, which exerts significant structural controls on the eastern flank of the northern WSB. We propose that this may represent a fundamental lithospheric-scale structure, potentially a major Mesoproterozoic suture zone linked to a recently proposed suture in Australia at the edge of the Mt Isa Terrane/George Town inlier region.

Overall, our new interpretations of the basement hidden beneath the WSB suggest that the underlying Wilkes Terrane is as a composite Precambrian basement terrane. We conclude that: a) this cryptic composite terrane holds new clues to unravel the processes that affected East Antarctica and its Australian neighbour from Archean to Mesoproterozoic times; b) that the heterogeneity in the Precambrian basement is an important element to consider in tectonic models for the more recent WSB and c) basement heterogeneity is likely a source of increased intra-crustal geothermal heat flux variability beneath this key sector of the East Antarctic Ice Sheet.

A363

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Augmenting coverage gaps in the ADMAP-2 grid with Swarm satellite magnetic observations

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The recently released second-generation Antarctic digital magnetic anomaly compilation, ADMAP-2, includes roughly 3.5 million line-km of terrestrial, airborne, and marine survey data. The new near-surface database more than doubles that of the initial ADMAP-1 compilation. It also helps to fill ADMAP-1's regional coverage gaps over the Gamburtsev Subglacial Mts, Dronning Maud Land, the Wilkes Subglacial Basin, and the Transantarctic Mts. However, ADMAP-2 still exhibits significant regional coverage gaps around mostly the South Pole and in areas of East Antarctica and the Southern Ocean. Some of these areas like the Ross Ice Shelf, Princess Elizabeth Land and the Recovery Basin have been surveyed, but the data have yet to be incorporated into the ADMAP-2 compilation, whereas other areas like inland Terre Adelie still must be surveyed. ADMAP-2's coverage gaps were filled by anomaly predictions from crustal magnetization models that jointly satisfy both the near-surface and satellite magnetic data over the area. These gap estimates have much greater sensitivity for the combined anomaly observations than the predictions from only gridded near-surface anomaly interpolation or the downward continuation of satellite magnetic anomalies.

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

PETROLOGY AND GEODYNAMIC SIGNIFICANCE OF OPX GRANITOIDS MASSIVES LOCATED IN BUNGER OASIS, EAST ANTARCTICA

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Opx-bearing granitoids are essential for geodynamic modelling and reconstructions. Particularly, they are key petrologic indicators for syn-orogenic and post-orogenic events. Our research objects are two opx granitoids missives: Algae Lake Pluthon and Booth Peninsula Pluthon. They are undeformed intrusive bodies embedded between gt-opx-pl gneiss, felsic granulites and high grade metapelits sequence of late mesoproterosoic time. Rocks of these intrusions are not foliated and have typical igneous textures. These intrusions are formed by different rock types and can be applied to anorthosite-mangerite-charnockite association. Algae Lake Pluton is located in SW part of Banger Hills and its area is around 15 km2. Booth Peninsula Pluthon is in NE part of the Bunger Oasis and has an area about 10 km2. Opx-bearing granitoids here are jotunites and mangerites (Pl 70-50%, Afsp 10-15%, Qz 20-15%). Accordingly, rock composition varies from gabbro-diorite to monzonite and monzodiorite on QAPF diagram. Gabbroic and anorthosite-like rocks are concentrated at the edge of Pluthons. Central parts of Pluthons are composed by opx-qz monzonites and charnockites. Obtained bulk geochemistry are plotted on Frost et al., 2001, 2008 classification dyagramms for charnockites. According to this our rocks are ferroan and alkali-calcic. Opx granitoids Rare and REE patterns are fare from MORB and close to Rapakivi granites. They are enriched in light TR. There is Eu anomaly demonstrated gradual distribution of felsic material. Obtained U-Pb (zircon, SHRIMP) concordia age for Algae Lake opx monzonites is 1170±9.2 Ma. For the Booth Peninsula Massive we provide two U-Pb (zircon, SHRIMP) concordia age determinations. Sample with opx monzodiorite lithology is 1177±8.9 Ma while opx monzonite rock is 1191±5.7 Ma. Zircons are homogeneous, but with coarse edges. We can assume possible further metamorphic events.

Opx (Hy) is essential mafic mineral for such kinds of rocks. It consists of cpx solid solutions which are used for TP calculations. Bt-opx monzodiorites have idividual grains of cpx. Bt is charachteristic for felsic types and has no reaction rims with opx. Main mineral here is perthite, antiperthite, quartz. Preliminary TP parameters calculations were based on pyroxene thermometry and barometry, bt, feldspar solid solutions, mt/timt solid solitions. They provide last equilibrium conditions around 800-1000C and 2.5 kbar. These parameters correspond with dry, CO2 rich, high pressure conditions of granulite facies.

Intrusion of charnockite-related magma is supposed to be syn-orogenic event. Obtained geochemical isotopic data (Sheraton et al., 1991; Tucker et al., 2016, 2017 and our preliminary data) reveal that studied rocks have sufficient crust influence. On tectonic diagrams (Pearce et al., 1984; Whalen et al., 1987) they are within syn-orogenic fields and A-type granites. According to Frost et al., 2001, 2008, ferroan and alkali-calcic types are formed in intraplate settings on continents in the same time with partial melting of basaltic parents mixing with some amount of crust material. They also can be interpreted as a result of delamination of thin continental crust at the end of collision orogeny. The source of charnockite-related magma is still under discussion. According to Nd-Sr systematic diagram by Fourcad (1998) opx granites from Bunger Oasis overcame complex metamorphic events and results from partial melting of mafic low continental crust. Sector III corresponds to continental crust. Position of points are at field of less restitic component. After Fourcade (1998)

Thanks to their specific geochemistry opx granitoids are essential for reconstruction of geodynamic

circumstances of their formation time. Geochronology data provides that intrusion (1200Ma) event happened at the maximum of granulite metamorphism (1170-1200Ma). We suggest different sources of charnockite-related magma. Under such geodynamic conditions both mantle and crust melting can occur. It results in assimilation or hybridization between mantle and crust related melts.

A400

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Geophysical glimpse of sub-ice shelf bathymetry and underlying geology of the Thwaites Glacier system

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The fast changing Thwaites Glacier system is the focus of intense international scrutiny as its vast scale, deep link into the heart of West Antarctica, and accelerated mass loss, mean it will likely make an increasingly significant contribution to global sea level change. Key to the evolution of this glacier system are its basal conditions, shear margin stability, and link to the warm Antarctic Circumpolar Current offshore. However, the marginal ice shelves and thick interior ice sheet have thus far limited our understanding of both bathymetry and the underlying geology. During the 2018/19 field season as part of the NERC/NSF International Thwaites Glacier Collaboration (ITGC) the British Antarctic Survey carried out a detailed airborne survey of the ice shelf and grounding line regions. This survey collected gravity, magnetic, LIDAR and 600 MHz radar data. Here we discuss the initial magnetic and gravity data processing and present the first look into these new and key datasets, together with a preliminary gravity-derived estimate of the sub-ice shelf bathymetry beneath the Thwaites, Crosson and Dotson ice shelves. Our new data reveals the complexity of the sub-ice shelf bathymetry and sub-ice geology, which must be factored in to future projections of the evolution of Thwaites and adjacent glaciers.

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Inferred Mesoproterozoic to late Neoproterozoic tectonic evolution of the Gamburtsev Province in interior East Antarctica

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The Gamburtsev Subglacial Mountains are underlain by anomalously thick crust (50-60 km thick) and over 200 km thick lithosphere, which is thought to reflect the assembly of a mosaic of geophysically distinct but still poorly understood Precambrian lithospheric provinces in East Antarctica.

With the aid of enhanced magnetic and gravity images, depth to magnetic and gravity sources and 2D models we present an interpretation of the crustal architecture and the tectonic evolution of the basement of the Gamburtsev Province (GP). We recognise several major fault systems that segment the GP into distinct, Northern, Central and Southern domains. When combined with independent but arguably still relatively ambiguous (in terms of their exact source regions) sediment provenance constraints we interpret our geophysical results as revealing a collage of thrusted arc and back arc-related terranes of inferred ca 1.3-1.0 Ga age in the Northern and Central domains of the GP.

Dense lower crust beneath these two domains is modelled in order to reconcile independent passive seismic and gravity-derived crustal thickness estimates. The anomalously dense lower crust here may reflect either widespread magmatic underplating linked with an inferred long-lived Mesoproterozoic to Neoproterozoic accretionary orogenic setting, or alternatively flake tectonics, as proposed, for example, from recent seismic and gravity modelling of the Albany Fraser Orogen in Australia.

By analysing these data together with the ADMAP 2.0 magnetic anomaly compilation, we propose that these arc terranes in the GP may be related to the Tonian Oceanic Arc Superterrane in the interior of Dronning Maud Land, and may therefore reflect much more widespread accretion of juvenile arc-related crust in East Antarctica. These arc terranes are clearly distinct from the Archean Ruker Craton to the north, the Lambert Province and the South Pole province. We propose that the latter may represent an anorogenic Mesoproterozoic igneous province formed either within or perhaps at the margin of the composite Mawson Craton and that this province may have ties with part of the Granite-Rhyolite Province in Laurentia.

The age of the collision of the inferred GP arc terranes against Greater India and the composite Mawson Craton is still highly uncertain, with ca 1 Ga and Pan-African ages both being previously proposed. By examining our potential field images of the GP together with the ADMAP 2.0 compilation and satellite gravity gradient data from GOCE we therefore address potential tectonic linkages between the Gamburtsev Suture and the Kuunga and Shackleton sutures, as well as the East African Antarctic Orogen. Finally, to explore the broader geodynamic setting of the Gamburtsev Province within both Rodinia and Gondwana we also present preliminary plate reconstructions in

GPlates, which are being constructed by combining the recent magnetic and gravity images for East Antarctica with global geophysical and geological datasets.

A465

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

Decoding signs of Precambrian and Pan-African age tectonics between the Recovery Frontier and western Dronning Maud Land in East Antarctica

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The region between the Shackleton Range and western Dronning Maud Land contains important, but nevertheless still relatively cryptic and fragmented geological records of the complex and multi-stage Proterozoic to early Cambrian history of East Antarctica. An improved knowledge of the structure and history of this region is important in the quest to enhance our understanding of the linkages between East Antarctica and the geodynamic evolution of the Nuna, Rodinia and Gondwana supercontinents.

Here we combine analyses of: 1) new aeromagnetic and aerogravity datasets collected over the previously poorly explored Recovery Glacier catchment merged with the recent ADMAP 2.0 and AntGG magnetic and gravity compilations; 2) GOCE satellite gravity gradient and satellite magnetic data (MF-7 & LCS models) and 3) some preliminary plate tectonic reconstructions in GPlates to re-examine the crustal architecture and help unravel some of the key tectonic and magmatic events that affected the basement of this part of East Antarctica.

Several distinct Precambrian terranes have been recognised from geological investigations within the Shackleton Range, namely the Southern, Northern and Eastern terranes (Will et al., 2010). In the Southern Terrane, a belt of juvenile Paleoproterozoic crust, including 1850-1810 Ma magmatic rocks and medium to high-grade ca 1710 to 1680 Ma metamorphic rocks occur in a ca 150 km long E-W trending linear belt. We propose that a prominent aeromagnetic and satellite magnetic anomaly over parts of the Southern Terrane, which also partially correlate with exposed magnetite-rich felsic gneisses in the Fuchs Dome area to the north, delineate parts of a dismembered ribbon Paleoproterozoic arc terrane. We further speculate that this juvenile arc terrane was originally part of a much larger and wider Paleoproterozoic to Mesoproterozoic accretionary orogenic system, which we can now trace from aeromagnetic imaging to extend continuously from Australia to South Pole.

North of the Shackleton Range suture zone of inferred Pan-African age and of the Northern Terrane, completely different magnetic and gravity anomaly signatures are imaged, and these help delineate the extent of the Coast Land Block. This block exhibits a low regional magnetic signature that appears to resemble the one observed over parts of the Paleoproterozoic Yavapai Province in Laurentia. Rift-related Keweenawan-age (ca 1.1 Ga) igneous rocks are exposed in small coastal outcrops. These rocks can now be traced, based on aeromagnetic and residual gravity anomalies much further into the interior of East Antarctica and are inferred here to represent parts of a Large Igneous Province that intruded the older Paleoproterozoic(?) basement of the Coats Land Block.

Intriguing sets of variably arcuate magnetic anomaly belts are imaged from the interior of western

Dronning Maud Land and the northern margin of the Coats Land Block to the Recovery Glacier region. We infer that the sources of these anomalies could be ribbons of Grenvillian-aged arc-related crust, similar to remnants of arc crust entrained e.g. in the Namaqua-Natal and Maud orogenic belts in South Africa and western Dronning Maud Land respectively and as granitoids in the Eastern Terrane of the Shackleton Range. We put forward the hypothesis that these terranes may originally have been more linear, but were subsequently deformed into more complex orocline-like structures, possibly as a result of Pan-African age orogenic processes associated with the final amalgamation of East and West Gondwana. These Pan-African age orogenic processes likely also led to the formation of complex arrays of crustal-scale shear zones, which we can now image, at least at reconnaissance-scale, geophysically beneath this part of the East Antarctic Ice Sheet.

A486

Session02: Structure, evolution, and heterogeneity of Antarctica's continental lithosphere

BUILDING UP THE NEW GEOLOGICAL MAP OF GONDWANA (1:5M) – ANTARCTICA'S ROLE IN CONECTING EAST AND WEST

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On the new Geological Map of Gondwana each continent presents specific challenges. Antarctica is a major Gondwana-derived fragment representing today an isolated piece of continental crust at the south pole. This continent has predominant passive margins that formed in 100 m.y. recording the initiation and the end of Gondwana breakup events, starting between southern Africa and South America at ca. 165 Ma and ending in its connection with Australia at ca. 80 Ma. Because of this, Antarctica is a key-fragment connecting all the main East Gondwana terranes, containing important piercing points on its coastal outcrops, crucial to Gondwana reconstruction. Some of these piercing points are pointed out below. The Mawson Craton was a major continent involved on Gondwana's amalgamation, comprising rocks from Terre Adélie- George V Coast on Antarctica and from the Gawler Craton, on Australia. It presents rocks ranging from the Mesoarchean to the Calymmian. The regions of Bunger Hills and Windmill Islands in East Antarctica are part of the Albany-Fraser Orogen, a Mesoproterozoic mobile belt interpreted as a result of the amalgamation of Yilgarn Craton (Australia) and the Mawson Craton, during the formation of Rodinia. Dronning Maud Land on East Antarctica comprises the southernmost exposure of the Eastern African Orogen, which expands from the Arabian Peninsula through Africa, Madagascar, Sri Lanka and southern India, also bordering the Antarctic counterpart of the Kalahari Craton (South Africa), the Grunehogna Craton. Exposed along the Prince Harald and Prince Olaf Coasts of East Antarctica, the Lützow-Holm Complex is composed by medium to high grade metamorphic rocks, with protolith age ranging from the Neoarchean to the Ediacaran, reworked during the amalgamation of Gondwana, and correlated to metamorphic rocks from Sri Lanka. The evolution of its Paleo-Pacific Margin, the Transantartic Mountains and the continental fragments Marie Byrd and Thurston Island record the evolution of a convergent Gondwana margin from the Cambrian to the Cretaceous. This active margin registers one of the younger mobile belts from the Pan-African times, the subduction-related Ross Orogen, which is correlated with the Delamerian Orogen, further east in Australia. It had experienced subduction, fragments accretion, rifting of fragments (e.g. Patagonia block), and major extension, as the hyperextended continental crust of Zealandia block throughout the Paleozoic and the Mesozoic times. Gondwana breakup initiated with the Jurassic Ferrar LIP, prolonged to southern Africa. Antarctica within the Gondwana map has a major issue: the actual icecap that covers most of its extension. To avoid leaving Antarctica a blank continent on the Gondwana map, we adopted the image with BEDMAP 2 data showing its sub-ice topography. Along with this image, tectono-structural lineaments were traced in the map like some Mesozoic rift valleys, structures and the greatest mountains that delineate pre-Neoproterozoic cratons and Neoproterozoic-Cretaceous mobile belts. This is a contribution to IGCP-628 "*The geological map and tectonic evolution of Gondwana*".

A041

Session03: Interpretation of Observed Seismic and Acoustic Signals from the Solid Earth and the Cryosphere

Investigating Ultra-low Velocity Zones in the Southern Hemisphere using an Antarctic Dataset

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Given limited seismic coverage of the lowermost mantle, less than one-fourth of the core-mantle boundary (CMB) has been surveyed for the presence of ultra-low velocity zones (ULVZs). Investigations that sample the CMB with new geometries are therefore important to further our understanding of ULVZ origins and their potential connection to other deep Earth processes. Using core-reflected ScP waves recorded by the recently deployed Transantarctic Mountains Northern Network in Antarctica, our study aims to expand ULVZ investigations in the southern hemisphere. Our dataset samples the CMB in the vicinity of New Zealand, providing coverage between an area to the northeast, where ULVZ structure has been previously identified, and another region to the south, where prior evidence for an ULVZ was inconclusive. This area is of particular interest because the data sample across the boundary of the Pacific Large Low Shear Velocity Province (LLSVP). The Weddell Sea region near Antarctica is also well sampled, providing new information on a region that has not been previously studied. A correlative scheme between 1-D synthetic seismograms and the observed ScP data demonstrates that ULVZs are required in both study regions. Modeling uncertainties limit our ability to definitively define ULVZ characteristics but also likely indicate more complex 3-D structure. Given that ULVZs are detected within, along the edge of, and far from the Pacific LLSVP, our results support the hypothesis that ULVZs are compositionally distinct from the surrounding mantle. ULVZs may be ubiquitous along the CMB; however, they may be thinner in many regions than can be resolved by current methods. Mantle convection currents may sweep the ULVZs into thicker piles in some areas, pushing these anomalies toward the boundaries of LLSVPs.

A110

Session03: Interpretation of Observed Seismic and Acoustic Signals from the Solid Earth and the Cryosphere

Modelling the crystallographic preferred orientation (CPO) of a fast-shearing Antarctic ice glacier from seismic anisotropy

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The flow behaviour of natural ice is fundamentally influenced by the ice crystallography because dislocation glide on the ice basal-plane is much easier than on other planes. Consequently, an anisotropic crystallographic preferred orientation (CPO) will develop as the c-axes of polycrystalline ice keep rotating and lining up under stress. The CPO records the ice deformation history and has been associated with accelerating rate of ice flow. Understanding CPO and measuring CPO across large ice masses is important in assessing the ice flow response to global warming. Measurements of seismic anisotropy have been proven practical in constraining the large scale CPO of ice flow because the sound wave travels up to 5% faster along the c-axes of ice crystals.

Here we present active-source seismic observations on a fast-flowing shear margin in the lower-stream of the Priestley Glacier, Antarctica. Four strings of single-component or three-component geophones were deployed parallel or perpendicular to the ice flow direction. The geophones recorded the seismic waves from seventeen separated explosive sources, where each source was buried at the depths of ~2 m. Source and receivers were all placed in hard ice leading to very high data quality with no noise from scattering events. We extracted the direct ray-path P-wave and S-wave arrival times and shear wave splitting (SWS) parameters from the raw geophone measurements. The regional seismic anisotropy was quantified from the P-wave and S-wave velocities and the SWS parameters relative to the ray path azimuth and inclination. These data were compared with the velocities and splitting parameters expected for different ray paths, as generated from forward models of the polycrystalline elastic stiffness tensor based on experimentally deformed ice samples. The result shows that the fast-flowing ice shear margin in the Priestley Glacier is dominated by a CPO with the c-axis clustered perpendicular to the shear plane. This CPO is likely to be critical in controlling the rate of marginal deformation associated with further glacier flow and with ice shelf break-up. The result suggests that it is essential to consider the anisotropic ice CPO in ice-sheet modelling to predict the future sea level.

A301

Session03: Interpretation of Observed Seismic and Acoustic Signals from the Solid Earth and the Cryosphere

THE PRELIMINARY RESULTS OF THE SEISMICITY IN THE VICINITY OF THE JANG BOGO STATION OBSERVED ON THE KOREA POLAR SEISMIC NETWORK

Jinhoon Jung[KORPI], Yongcheol Park[KORPI †]

The Extreme Geophysics Group (EGG) at the Korea Polar Research Institute (KOPRI) has operated a seismic network called KPSN (Korea Polar Seismic Network) since 2011 to monitor volcanic activities, tectonic movements, and lateral migrations of ice streams in the vicinity area of the Jang Bogo station. Currently, the KPSN consists of 17 broadband seismic stations spanning from the Mt. Melbourn to the David glacier. About 9,100 events were extracted by a STA/LTA method, and pre-processed by removing the mean and linear trend, and filtering the waveform ranging from 2 to 9 Hz. After manual picking of the first arrivals for each event, the locations of 2,669 events were determined using the Non-Linear Global-Search Earthquake Location (NonLinLoc) method. We divided the located events into three groups according to the located area and seismic mechanism: 1) group 1 (David Glacier): The group 1 dominates the events occurred by the interaction between the fast-flowing glacier and bedrock. 2) group 2 (Mt. Melbourne): The most events of group 2 infers results from volcanic activities, 3) group 3 (Nansen ice shelf area): group 3 implies that the events caused by the movement of the glacier. The seismograms from each group show different frequency ranges and waveforms. The focal mechanism and waveform modeling will be performed to find source characteristics and their origins.

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A474

Session03: Interpretation of Observed Seismic and Acoustic Signals from the Solid Earth and the Cryosphere

INSTALLATIONS OF AN INFRASOUND NETWORK AT JANG BOGO STATION AND OCEAN BOTTOM SEISMOGRAPHS IN THE SEA NEAR THE TERRA NOVA BAY

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The Jang Bogo Station is located on the Terra Nova Bay in where there are many volcanoes and glaciers generating icequakes. These volcanic activities and glacial movements generate many long wave sound signals as known as infrasound signals. A seismic network, Korea Polar Seismic Network (KPSN), has been installed and monitored activities of Mt. Melbourne and several glaciers since 2011, and an infrasound network has been installed at the Jang Bogo Station since 2015 as an auxiliary tool to detect infrasound signals by gas emission from Mt. Melbourne. The network consists of three Chaparral sensors (model 25) locating on triangle geometry with ~100m distance away among the sensors. Four-port manifold on the model 25 is extended to eight sides with eight ~30m-long porous hoses to reduce wind noise for each sensor.

The KPSN, currently, consists of 17 broadband stations and covers areas from the North, Mt. Melbourne, to the South, the upstream of the David Glacier. The division of Polar Earth-system Science focused on the research named "Characterizing mantle domain beneath West Antarctic Rift System and Antarctic mid-ocean ridges", and install OBSs (Ocean Bottom Seismographs) in the sea near the Jang Bogo station to extend the observing coverage of the KPSN from 2017. Our OBS system is "NAMMU," manufactured from K.U.M, which integrates a titanium pressure tube with broadband seismometer "Trillium Compact 120 sec.", data logger "6D6", and a battery pack. To retrieve data and maintain OBS we visit the Terra Nova Bay during every Antarctic summer season, and change the battery pack and memory card from OBSs and redeploy them. The continuous data from OBSs will be integrated with the data from the KPSN.

A018

Session06: Antarctic geothermal heat flux

Geothermal heat flux measured in the Amundsen Sea Embayment

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Due to a complex tectonic and magmatic history of West Antarctica, the region is suspected to exhibit strong heterogeneous geothermal heat flux variations. Although the maximum ice extent has retreated from the shelf since the last glacial maximum, the trends of offshore GHF patterns and the overall order of magnitude are hypothetically related to those areas onshore where the West Antarctic Ice Sheet (WAIS) rests on geologically related structures. High-resolution GHF will aid the understanding of the paleo-retreat of the ice sheet in the Amundsen Sea Sector. This presentation builds on our previous studies in which we discussed geothermal heat flux based on 26 in-situ temperature measurements that were conducted in 2010 in the Amundsen Sea Embayment (ASE) in West Antarctica. We found, that the shallow (3 m) in-situ temperature measurements were likely influenced by inter-annual bottom-water temperature variability, leading to GHF estimates biased towards lower values (mean = 33 mWm-²). During RV Polarstern expedition PS104 in early 2017 we collected additional 28 in-situ temperature measurements in marine sediments (11 m) for deriving geothermal heat flux in the ASE, which will overall improve the spatial coverage of this region. Furthermore, we monitored the vertical temperature profile of the water column at these stations, which allows to map Circumpolar Deep Water (CDW) distributions across the inner Pine Island Shelf with greater detail.

A024

Session06: Antarctic geothermal heat flux

Geothermal heat flux investigations with thermal crustal 2D models

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The most rapidly changing parts of the Antarctic Ice Sheet have been observed in Amundsen Sea Sector/Bellingshausen Sector of West Antarctica. Various processes contribute to the (in)stability of the ice sheet here. For instance, inflow of modified, warmer Circumpolar Deep Water, geothermal heat from the underlying crust and the crusts flexural response to unloading of the ice mass. Our objective is the investigation of geothermal heat flow in this sector, which is poorly constrained, albeit providing a crucial boundary condition for ice sheet models and related sea level rise predictions. We discuss airborne, high-resolution magnetic anomaly data from the Amundsen Sea Sector, to provide additional insight into deeper crustal structures related to the West Antarctic Rift System in the Amundsen/Bellingshausen sector. With the depth-to-the-bottom of the magnetic source (DBMS) estimates, we reveal spatial changes at the bottom of the igneous crust and the thickness of the magnetic layer that can be further incorporated into tectonic interpretations and serves as a proxy for geothermal heat flow estimates. The DBMS results and further available datasets (e.g. crustal thickness) are synthesized in high-resolution, thermal 2D models of the crust in two representative profiles along Pine Island and Thwaites Glacier. Because crustal parameters, such as radiogenic heat production, thermal conductivity, crustal thickness and Moho temperatures yield large uncertainties, we test the models under variations of these parameters. Our models reveal elevated heat flow distributions ranging between 50 mW/m² and 100 mW/m² and further advance the understanding of the thermal crustal state in this sector.

A060

Session06: Antarctic geothermal heat flux

Bayesian/stochastic inversion of geophysical data for Solid Earth heat flux in Antarctica

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The limitations of directly measuring the geothermal heat flux in Antarctica require estimating the heat flux from geophysical models and/or data. In recent years, estimates have been made from seismological and magnetic data which show largely varying heat flux values, both in amplitude and spatial extent.
In order to reconcile and validate the existing studies, we perform Bayesian inversion based on thermal modelling. Our aim is to evaluate the uncertainties of the different approaches and to study the interdependency between parameters. A one-dimensional steady-state heat equation with constant internal heat production rates and thermal conductivities is employed in a first numerical attempt. For Bayesian analysis we use the Metropolis-Hastings implementation of the Markov Chain Monte Carlo method, which accepts the next random iteration with a certain probability even if the suggested step is less likely than the previous. From such calculations, we can estimate the posterior distribution of the geothermal parameters. First tests using different Moho depths estimates show that the heat flow changes slightly, but that the correlations between the parameters does not effectively change. Varying the Curie depth, on the other hand, leads to noticeable differences in the surface heat flux, which confirms the important constraint that can be given by a known crustal isotherm. However, an incorrect assessment of the Curie isotherm does seriously affect the estimates.
As a consequence, we propose to incorporate more information on possible tectonic provinces, surface temperature and radiogenic heat production from rock samples. As the next step, we want to extend an existing inverse modelling framework for integrated geophysical-petrological modelling in order to model subglacial heat flux. From our study, we expect to get new insights in the geothermal structure of Antarctica, which will help with future studies on the coupling of Solid Earth and Cryosphere.

A094

Session06: Antarctic geothermal heat flux

The South Pole Heat Flux Anomaly, identification, origin, and implications

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Geothermal flux is an important factor in slow flowing interiors of ice sheets where it can provide a dominant control on basal melting. This in turn influences subglacial hydrology, ice sheet dynamics, and the preservation of paleoclimate records in deep englacial layers. Direct measurement of geothermal flux beneath an ice sheet is challenging. Geophysical studies, typically using magnetic or seismic observations, provide alternative and often contrasting regional geothermal flux estimates, but spatial resolution is low and the uncertainties are difficult to quantify.
Here we present estimates of geothermal flux of between 58 and 120 mWm-2 on a 60 km profile beneath the 3 km thick ice divide upstream of South Pole. These higher resolution estimates are based on airborne radar imaging of englacial layers, which shows the ice sheet is drawn-down towards the bed due to enhanced basal melting. Tracing and dating these englacial layers allowed construction of 1D models of melt rate and geothermal flux. Adjacent radar lines showing a similar layer pattern suggest this geothermal heat flow anomaly may be ~100 km long and ~50 km wide. We propose that a combination of elevated radiogenic heat production in Proterozoic granitoids and hydrothermal circulation on faults is the most likely cause of this anomaly. Hydrological models indicate water from this region of enhanced melting feeds dynamic lakes in catchments on both sides of the ice divide. Changes in basal water flow from this region of melting can be triggered by minor perturbations in surface slope, and may have the potential to explain past variability in ice flow around South Pole. We conclude that radar imaging is a useful tool for locating regions of locally enhanced geothermal heat flux in the interior of East Antarctica where they may increase the sensitivity of certain regions to externally imposed change.

A127

Session06: Antarctic geothermal heat flux

Plans to quantify geothermal heat production over Ellsworth- Whitmore Mountains, West Antarctica.

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It is believed that high geothermal heat flux (GHF), in areas where isolated subglacial lakes are found, may be promoting the necessary conditions for a relatively rapid ice-base melting, and accumulation of this water due to favourable topographic configurations. Understanding GHF is important because it influences ice flow and subglacial hydrology.

Present GHF maps have only been derived from Antarctic-wide compilations of geophysical data. So far GHF has been derived from radiogenic flux, as estimated from the magnetic properties of the rocks (Fox-Maule et al., 2005; Martos et al., 2017), and from the seismic properties of the upper mantle (Shapiro and Ritzwoller, 2004; An et al., 2015). These estimations assume homogenous heat production. However, small spatial variations in the geology may significantly impact crustal heat production (Sandiford and McLaren, 2002; Burton-Johnson et al., 2017). Moreover, it is known that steep-sided topographies can augment GHF locally within valleys (van der Veen et al., 2007). GHF in the Ellsworth-Whitmore Mountains (EWM) remains poorly quantified, and relies on continental compilations with almost no significant measurements in the study area. Here we outline plans to calculate GHF in the EWM region using a combination of geochemical analysis and modelling. The work will feed into a wider project tackling uncertainties on subglacial hydrology and subglacial lake evolution in the region.

We present the basic workflow for the Geothermal Heat Flux (GHF) calculation in the EWM region. We will provide regional estimates of Geothermal Heat Flux (GHF) using a recently developed technique (Burton-Johnson et al., 2017) and applying it to rock samples from two polar rock archives (BAS (UK), and Byrd Polar (US)). As in previous studies (Carson et al., 2014; Burton-Johnson et al., 2017) we will use the radioactive decay of the heat producing elements (HPE) abundances of archive samples from the regional geological units to calculate and map the region's geothermal heat production. We will combine geological analysis and geophysical modelling following Leat and others (2018) and van der Veen and others (2007) to quantify the crustal structure of the EWM terrain.

A204

Session06: Antarctic geothermal heat flux

Heterogenous Antarctic crustal heat production

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As the climate changes, the Antarctic ice sheet represents the single largest potential source of sea level rise. A key parameter controlling how the ice sheet flows remains poorly constrained: the amount of heat supplied to the base of the ice sheet from the underlying Antarctic continent (geothermal heat flow or flux). Geothermal heat flux affects deep ice temperature and rheology, and can lead to basal melting and sliding at the ice-bed interface.

Very few direct measurements of heat flux exist from Antarctica, so geophysical models are used in glaciological modelling. However, these models are unrealistically homogeneous and there is significant disagreement between them. A major limitation is that they focus on estimating heat flux at the base of the crust and then use idealised crustal properties to derive the total subglacial heat flux.

In particular, these models do not account for variations in heat within the crust produced by decay of Heat Producing Elements (HPEs, primarily K, U, Th), which can account for as much as ~80% of the heat flux at the Earth's surface. The distribution of HPEs is heterogeneous at a range of scales, and fundamentally tied to the geological evolution of the lithosphere in space and time. Regional ice sheet models have shown that localised regions of high HPE-enriched crust can impact the organisation of ice flow in slow-flowing regions, underscoring the need for improved knowledge of both the magnitude and spatial variability of heat production in the Antarctic crust.

We have assembled the first database of Antarctic-wide geochemical data and use these data to explore regional heat production variations (in a Gondwana framework) in order to better understand patterns with age, rock type and tectonic history. For example, mean heat production rates for Antarctic Archean, Proterozoic and Phanerozoic rocks exceed global averages and are higher and more variable than those currently used in Antarctic geothermal heat flux models. Felsic igneous rocks that intruded during/after the Ediacaran-Cambrian assembly of Gondwana are particularly HPE-enriched, and require further identification/mapping across East Antarctica. In the future, we plan to use this geochemical database to develop empirical predictors of heat production and other thermal properties that are tailored directly to Antarctica.

We are exploring approaches for segmenting the Antarctic lithosphere to extrapolate known geology into the subglacial interior and prescribe thermal properties with depth. Our ultimate aim is to work towards more accurate predictions of Antarctic geothermal heat flux for use by (for example) the ice sheet modelling community.

Session06: Antarctic geothermal heat flux

Estimates of Antarctic Heat Flow: Insights from Geodynamic Models

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Results from thermomechanical models of tectonic systems can be used to constrain the magnitude and spatial variability of geothermal heat flux across continents. In the case of the Antarctic Continent, models of the unique geologic evolution provide constraints on the past and current thermal structures of East and West Antarctica. For example, previous modeling results that successfully simulate the Mesozoic to Cenozoic tectonic evolution of the West Antarctic Rift System (WARS) show that the geometry and evolution of the WARS was a direct consequence of the initial and evolving thermal structure of the lithosphere (Huerta & Harry, 2007). Specifically, model results constrain the initial temperature of the top of the lithospheric-mantle to have been ~730° C at the onset of extension, and the model further constrains the evolving thermal structure and heat flow of the region. Thus, this suite of successful simulations can be used to constraint the spatially and temporally varying contributions of mantle and crustal heat sources to the surface geothermal heat flux.

A058

Session08: Evolution of Antarctic topography and bathymetry: understanding links between erosion, deposition, isostasy and ice sheet behaviour

The pre-glacial landscape of Antarctica (and its influence on ice sheet behaviour)

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The geomorphology of the hidden subglacial landscape of Antarctica is relevant to our understanding of the stability of the Antarctic Ice Sheet and also to that of global interactions between plate tectonics and surface processes. The subglacial landscape of Antarctica is less well known than that of the moon or Mars and much of our understanding of its evolution comes from coastal or offshore locations. However, we believe that the geomorphological record that lies beneath the ice holds significant potential for understanding changes in the Antarctic, but that the lack of coherent hypotheses about the origins of the subglacial landscape is holding back understanding. We approach this problem by using southern hemisphere land masses in Africa and Madagascar as analogies to consider interactions between plate movement, tectonics, fluvial incision, weathering and glacial erosion. We suggest that the landscape evolution of Greenhouse Antarctica before ca.34 Ma, has analogues with typical passive margin evolution (e.g. South Africa) associated with the breakup of Gondwana. This changed river base levels and caused rapid erosion on the flanks of rifts and was accompanied by the uplift of rift-margin mountains. coastal plains, plateaux, escarpments and large low-gradient continental river basins characterised Antarctica before glaciation. Intense weathering would also strongly influence the landscape under the warm conditions. In Icehouse Antarctica, we propose that expansion and contraction of ice produced waves of warm-based erosion which were most effective where flow directions were maintained regardless of ice sheet scale, and where pre-glacial topography steered ice. There may have been thresholds of glacial behaviour whereby topography controlled significant jumps in ice volume between mountain icefields and ice sheet scale glaciation. Glaciers exploited the main features of the fluvial topography so troughs continually deepened and become marine and then increasingly reverse-sloped. We therefore suggest the modern ice sheet should more sensitive to climate and ocean changes than in the past.

A069

Session08: Evolution of Antarctic topography and bathymetry: understanding links between erosion, deposition, isostasy and ice sheet behaviour

On the formation of the ice cauldron on the Dålk Glacier (Larsemann Hills, East Antarctica)

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Russian Antarctic stations and field bases are the main elements of the Russian Antarctic expedition (RAE) infrastructure where annual all-year and summering investigations are carried out. Intensive logic operations, which are indicative for them, demand special attention for questions of studying of hazardous hydrological and glaciological processes. The depressions of the surface of the ice sheet, which are caused by the floods (e.g. jökulhlaup), are considered to be the most destructive and catastrophic phenomenon in the Polar Regions.
At the end of January 2017, roughly the same natural event took place in the Larsemann Hills region. The ice cauldron, which had the size of 183×220 meters and was 43 meters in deep, was formed in the western part of the Dålk Glacier. The fragment of the route, which connected the Progress Station and the point of formation of logistic traverse to the Antarctic inland, was destroyed by the depression. The reasons of the formation and evolution of the dip remain questionable. According to primary assessments the triggered impulse, which caused its formation, was the outburst of the Boulder Lake. For the purpose of studying this hydrological system and acceptance or refutation of forwarded hypothesis, the complex hydrological, geophysical and glaciological research was accomplished during the field seasons of 2017-2019. It included the bathymetric surveys of lake, which were involved in flood formation, GPR surveys with a frequency of 75 MHz, 150 MHz, 500 MHz and 900 MHz, and also self-potential method; installation of glaciological markers for the observation of the dynamics and ablation of the Dålk Glacier.
According to GPR data and self-potential method data, the presence of tunnel from the Boulder Lake and connected lake «Ledyanoe» was found. This fact proves that these lakes cause the formation of flood outburst. On the way to Prydz Bay the stream was flowing on the surface but partly penetrated inside the glacier through the crevasses. The detected flooded areas in the region between the depression and system of lakes Boulder – «Ledyanoe» show this. The outflow channel from the dip was not found, so it is necessary to consider some hypothesis of its formation and further evolution. According to the first one, depression was formed as a result of outburst of the filled intraglacial cavity and flow channel was closed because of the fast flow glacier. Mathematical modelling of the dip formation demonstrates the flood volume estimated as 708,700 cub. m and maximal discharges about 140 cub. m/s. At the same time, the second hypothesis assumes that subsidence of the glacier surface was the consequence of the outburst of subglacial reservoir, where water streams were coming through the crevasses. Following the results of the recent research, it was concluded that formation of the depression had several stages and was more complicated than it had suggested earlier. This scientific work was supported by the Russian Foundation for Basic Research in the framework of the scientific project No 18-05-00421.

A161

Session08: Evolution of Antarctic topography and bathymetry: understanding links between erosion, deposition, isostasy and ice sheet behaviour

Ice thickness and bedrock topography of Mac. Robertson, Princess Elizabeth and Wilhelm II Lands (East Antarctica) according to the Russian data collected from 1971 to 2018

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Russian (former Soviet) scientific investigations in Antarctica have been started since 1956. After eight years, the first radio-echo sounding (RES) tests were done and very perspective new geophysical method was adopted for future investigations. RES is the most effective way to study ice sheet structure as well as bedrock topography and morphology. The first Russian airborne RES survey was carried out in February 1968 in Enderby Land. Afterwards, ground-based and airborne RES have covered about 6 mln. sq. kilometers of Antarctic territory from Filchner-Ronne Ice Shelf in the West to Wilhelm II Land in the East.

Russian geophysical investigations of 1971-1974 were adjusted to study the Lambert rift zone which is one of the most massive (about 1.000 km long) tectonic structure of Antarctica. The investigations included airborne RES and reflection seismic on the Amery Ice Shelf. These data firstly demonstrated relief of the sea bottom under the ice shelf and are using until now. After the short interruption when we work in West Antarctica this kind of investigations were resumed in 1985 on new scientific and technique base. Since 1986 till nowadays airborne RES with 5 km distance between profiles has been carried out on the extensive coastal area of eastern Antarctica and about 500 km inland, including the lands of Mac. Robertson, Princess Elizabeth and Wilhelm II. For the last 5 years short-range Antonov aircraft and ice-penetrating radar with frequency 60 MHz and 130 MHz is allying for the ice sheet and bedrock topography studying.

Since 2004 to 2014 ground-based RES in the band of Mirny-Vostok and Progress-Vostok logistic traverse have been completed. Ground-based RES results were provided by geodetic and glaciological observations Received data are the most reliable complement to the aerogeophysical dataset.

Bedrock topography and ice thickness maps on lands of Mac. Robertson, Princess Elizabeth and Wilhelm II compiled on RES data collected during twenty-seven field seasons and reflection seismic collected on three field seasons are demonstrated in our presentation.

This study was funded by RFBR research project No 17-55-12003 NNIO_a

A267

Session08: Evolution of Antarctic topography and bathymetry: understanding links between erosion, deposition, isostasy and ice sheet behaviour

Crustal motion and gravity change in East Antarctica inferred from GIA modeling

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Geodetic and geomorphological observations in the coastal part of Antarctica indicate the uplift trend associated with the removal mass of the Antarctic Ice Sheet (AIS) in the last deglaciation. The deglaciation histories of the AIS inferred from the comparisons between the geomorphological sea-level records and glacial isostatic adjustment (GIA) modeling shows the monotonic Holocene retreat for the AIS (e.g., Whitehouse et al., 2012). However, GNSS observations in some regions in the coastal part of Antarctica cannot be explained the amplitudes of the uplift by only glacial rebound due to the last deglaciation of the AIS. Also, recent studies (e.g., Kingslake et al., 2018) concerning bedrock topography in the margin of AIS inferred that some portions of the ice sheet may be re-advancing after retreating behind the present-day margin in mid-to-late Holocene. The comparisons between the far-field sea-level records and its numerical results indicate that the melted AIS volume is about 2-3 m as the equivalent sea-level change since the mid-Holocene in previous studies (e.g., Nakada & Lameck, 1988, Stocchi et al., 2009). However, the melting regions of AIS in mid-to-late Holocene are not identified. Therefore, the uncertainty related to the Holocene melting of AIS may be caused to arise the discrepancy between GNSS observations and numerical predictions (e.g., Bradley et al., 2015). On the other hand, GNSS observations include not only the components of the GIA due to the last deglaciation and also elastic deformation due to present-day surface mass balance. (e.g., Hattori et al., 2018). In this presentation, we will show the crustal deformation rates and gravity changes calculated by the GIA modeling using the previously published deglaciation histories and the comparisons with these observations obtained from East Antarctica. We intend to estimate the influences of Holocene AIS mass changes and choice of mantle viscosity profiles on the geodetic measurements in East Antarctica.

A450

Session08: Evolution of Antarctic topography and bathymetry: understanding links between erosion, deposition, isostasy and ice sheet behaviour

GOCE constrained Antarctic crustal thickness and dynamic topography

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We investigated the utility of combined GOCE gravity anomaly and Bedmap2 terrain estimates to enhance the AN1 seismic surface wave-inferred Antarctic Moho estimates south of 60oS. The misfit of the terrain gravity and seismic Moho gravity effects at 250 km altitude yielded the Moho enhancements. The enhancements also included adjustments for GOCE's terrain-correlated gravity anomalies, which we interpreted for dynamic topography effects that constrain crustal stress to achieve isostatic equilibrium. Analysis of the Moho enhancements suggests that they are mostly within seismic errors of a few km or less. However, gravity Moho estimates that are deeper than the seismic estimates tend to characterize hotter lithosphere where mantle density may be lower than that assumed for the gravity estimates. These Moho differences infer higher crustal heat flow for the Pacific-Antarctic Ridge, Kerguelen Plateau, and the prominent crustal band that extends from the Pacific-Antarctic Ridge through Victoria Land and the Ross Sea into Marie Byrd Land and along the western margin of the Antarctic Peninsula Microplate to the Scotia Ridge.

A080

Session11: Applied bathymetry for understanding Quaternary history and change

New bathymetric and multi-channel seismic data from the NW Weddell Sea: Implications for the late Cenozoic glacial history of the South Orkney Islands continental shelf

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Morphology of the South Orkney Islands (SOI) continental shelf was significantly shaped by repeated advances and retreats of ice caps centered on the SOI at least since late Pliocene. Several glacial troughs and the mid-shelf break mark the maximum extent of ice grounding, which supposedly reached 300-350 m water depths (Dickens et al., 2014). This research aims to provide further insight into reconstruction of the late Cenozoic paleoenvironments and ice-sheet dynamics on the SOI shelf.

Our studies are based on ca. 500 km of new multibeam and multi-channel seismic (MCS) data collected by the RV "Akademik A. Karpinsky" on the SOI shelf in 2018. Additionally, we investigated previously collected MCS data (ca. 1900 km) available from the Antarctic Seismic Data Library System for Cooperative Research (SDLS). Analysis of the new (2018) and SDLS seismic data and their correlation with the ODP Leg 113 drill holes (Jane Basin) allows mapping of the post-Late Miocene and late-Pliocene/Quaternary units on the SOI shelf, which range in thickness from 0 to 500 m and from 0 to 250 m, respectively. Low resolution of seismic records prevents identification of relatively small glacial-related deposits, but erosional troughs and well-developed grounding zone moraines can be distinguished in the MCS sections. The mid-shelf break, previously interpreted as the terminal limit of the grounded ice extent by Dickens et al. (2014), is well recognized in the MCS data, but we also discovered a more distal position of grounding ice that is located ca. 30-50 km seawards. Several MCS lines surveyed in 2018 exhibit presence of buried glacial landforms likely deposited during the Pleistocene ice-sheet advances.

Bathymetric maps available for the SOI region include a 500m resolution circum-Antarctic IBCSO grid (Arndt et al., 2013) and a 300m resolution regional compilation based on the 1986-2012 multibeam surveys (Dickens et al., 2014). In 2018, a detailed multibeam survey was conducted in the Signy glacial trough area, covering a ca. 1500 sq. km polygon with sounded depths ranging from 180 to 400 m. As a result, a 30m resolution bathymetric grid (and better for shallow parts of the polygon) was created, which significantly improves the existing visualization of the Signy trough morphology and allows to describe several moraine ridges on the flanks of the trough. Bathymetric profiles built along the aspect lines across these moraine ridges are very similar to the asymmetric wedge-like morphology of the mid-shelf break described at the mouths of the Signy and Orwell troughs by Dickens et al. (2014), with amplitudes of ~ 10-30 m and slope gradients up to 2-4 degrees. Observed moraine ridges mostly have south-facing slopes. Additionally, numerous iceberg plough-marks were observed at least down to 370 m water depths. Description of the Signy trough bottom will be improved after processing of the side-scan data collected by the same sonar (Atlas Hydrosweep MD/30).

Multibeam bathymetric data was processed using the Qimera software license provided by QPS for the duration of the cruise. This study is supported by the Russian Foundation for Basic Research (grant no. 19-05-00858).

A244

Session11: Applied bathymetry for understanding Quaternary history and change

IBCSO V2.0: A collaborative effort towards improved bathymetric information

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The International Bathymetric Chart of the Southern Ocean (IBCSO) project aims to create high-resolution bathymetric compilations for the waters off Antarctica. Detailed knowledge of seafloor morphology is fundamental to almost all marine and maritime scientific activities. The size, remoteness and harsh ice conditions around Antarctica necessitates strong international collaboration to map the Southern Ocean. This is facilitated via connections to international bodies such as the Scientific Committee on Antarctic Research (SCAR) and the General Bathymetric Chart of the Ocean (GEBCO) project, which operates under the joint auspices of the Intergovernmental Oceanographic Commission (IOC) and the International Hydrographic Office (IHO).
In 2013, the first version of IBCSO was published. It included contributed data of over 30 institutions from 15 countries. Since 2017, IBCSO is part of the new Nippon Foundation - GEBCO - Seabed2030 project and work on a second version has begun. The new version will include numerous new data sets of high-resolution swath bathymetry surveys from various institutions and builds on the largest database of bathymetric soundings for the Southern Ocean. Furthermore, IBCSO V2.0 will also cover a larger area extending up to 50° S, instead of only 60° in the first version. With this extension, the new bathymetric model will now also include important submarine features like the Drake Passage, the South Sandwich Arc, and the southern parts of the Kerguelen Plateau and Campbell Plateau. We will present the current status and time plan of the project. In addition, we will highlight areas that are most notably improved compared to the previous version, but will also show where still major data gaps persist to raise awareness and potentially mapping efforts.

A375

Session11: Applied bathymetry for understanding Quaternary history and change

Evidence of accelerated glacial retreat on King George Island, South Shetland Islands

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Glacial retreat has become a common occurrence globally due to significant increase in temperatures in the last century. Since the 1980s, retreat has accelerated on the Antarctic Peninsula and sub-Antarctic islands and has been associated with rapid increase in atmospheric and oceanic temperatures. New high-resolution swath bathymetry surveys along the glacier margin in King George Bay and Fjords of Admiralty Bays on King George Island reveal an assemblages of landforms related to the former flow and retreat of tidewater glaciers. In King George Bay, transverse ridges that we interpret as recessional moraines are superimposed on streamlined bedforms oriented parallel to glacier flow. Available satellite data show that this glacier has retreated more than 3000 m in the last 3 decades. Thus, the series of small (less than 2 m high) transverse ridges, interpreted as push moraines produced annually, imply a retreat of 100 m/yr. Large terminal moraines also occur and likely mark the stable extent of the glacier during the mid-twentieth century. The termini of glaciers in the fjords of Admiralty Bay were already close to the shoreline in the early 1990s and would have retreated beyond the shoreline shortly after. The glacial lineations and terminal moraines are relatively older and are partially covered by sediments delivered to the bays by meltwater streams. The observations are consistent with the general pattern of glacial retreat on the western Antarctic Peninsula between 64°S and 70°S since the 1990s. However, the shallow topography (

A017

Session11: Applied bathymetry for understanding Quaternary history and change

A subglacial hydrologic switching hypothesis for silt sorting and deposition during ice sheet retreat in the in the Amundsen Sea Embayment.

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A late Holocene silt unit has been observed and dated in sediment cores across the inner continental shelf of Pine Island Bay, West Antarctica. The small scale and fine sorting of this unit suggests origins in subglacial meltwater. The estimated thickness and deposition rate for this unit imply punctuated, rather than, continuous deposition. This, combined with its location seaward of large, similar scale bedrock basin, has led to the interpretation of this unit as the result of subglacial lake outburst events in these basins. However, the fine-scale sorting of the silt unit is problematic for this energetic interpretation, which should mobilize and deposit a wider range of sediment sizes. To resolve this discrepancy, we present an alternative mechanism for generating this silt unit.

We hypothesize that the silt was sorted by a distributed subglacial water system and deposited in the bedrock basins noted above when the grounding line of the Paleo Pine Island Ice Stream was much further out on the continental shelf. As the grounding line retreated across a sediment-to-bedrock transition and toward bedrock basins the surface slope steepened, and increased the subglacial hydrologic gradient. We hypothesize that this caused a transition from a distributed hydrologic system to a more efficient, concentrated subglacial water system. The higher flow speeds associated with this transition would then be sufficient to erode the silt stored in the basins until they were emptied, depositing the silt unit across the apron in front of the ice sheet. Our mechanism is supported by observation of stratigraphy in sediment cores. This mechanism explains the observations of sediment size, sorting, volume, and deposition rate more easily than outburst-based hypotheses.

This mechanism also suggests that similar silt units observed elsewhere in Antarctica place constraints on the character and physical parameters of the subglacial water systems as the ice sheet retreated. Furthermore, we argue that the ice sheet repeatedly occupies the same flow paths over multiple glacial cycles. This reoccupation form the observed bedrock channel systems, preconditioning water flow, slip, and tractions during retreat.

A032

Session13: Past Climate Variability of the Southern Ocean and its Global Teleconnections

Reconstructing Antarctic sea ice extent during MIS 5e

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Marine Isotope Stage (MIS) 5e marks the peak of the last interglacial (130-116 ka) and is an important 'process analogue' for understanding the high latitude climatic feedbacks and forcings active under future anthropogenic warming. The Antarctic sea ice extent is a critical part of the Earth's climate system through its impact on global albedo and its roles in Southern Hemisphere atmospheric and oceanic circulation. Previous studies have assumed the peak warming and minimum sea ice extent were synchronous throughout the Southern Ocean and concurrent with the Antarctic peak warming in ice core records.

This study presents new Southern Ocean sea ice reconstructions for MIS 5e based on the diatom species assemblage record in marine sediment cores. The new MIS 5e records have robust age models which, when combined with the best dated reconstructions from published records, allow the differences in the age of peak warming and minimum sea ice extent throughout the Southern Ocean to be examined. Using sediment cores from south of 55 °S creates a novel synthesis for assessing the evidence for the considerable MIS 5e sea ice reduction (67% in the Atlantic sector) predicted by models.

A074

Session13: Past Climate Variability of the Southern Ocean and its Global Teleconnections

Classifying synoptic air circulation patterns over the Southern Indian Ocean: Observations from Marion Island on recent change and current landscape impacts.

Werner Nel[1†]

The climate of the Southern Ocean has shown significant changes over the last forty years and observations from Marion Island show that the current changes in the climate are driven by changes in the synoptic weather systems. As an illustration an objective synoptic climate classification based on a single station principal component (PCA) and cluster analysis of the daily meteorological observations of the Marion Island weather station (46°52'59"S, 37°52'01"E, 24 m a.s.l.) were undertaken. The data uses the daily weather station record over a 50-year period and the PCA analysis indicated 8 distinct synoptic circulation patterns that can occur over the Southern Indian Ocean. Linear regression show that the circulation patterns in clusters with increasing frequency of occurrence appears to be a southward placement of a sub-tropical high pressure system with resulting influx of maritime air masses from lower latitudes. In contrast, clusters with decreasing frequency of occurrence represent situations with relatively low mid-latitudinal pressure gradient with a weak polar front and its travelling low pressure systems with cool, moist maritime polar air masses or northward meridional air flow of cold Antarctic air in the westerly ascending limb of a Rossby wave. Temperature trends at Marion Island were placed in comparison to other sub-Antarctic islands in the South Atlantic and South Indian Ocean using the NASA/GISS station data from the GHCNv.3 and SCAR database. Stations used were selected on location in proximity of the sub-Antarctic zone and availability of long-term temperature records. Of all stations, Marion Island shows the strongest warming trend and mean annual temperatures of most sub-Antarctic islands are positively correlated with their nearest neighbours and individual station data from these locations thus appear representative for larger regional trends. Currently on Marion Island, synoptic air circulation patterns influences the thermal characteristics of soil, river dynamics, intensity of rainfall, frequency and magnitude of snowfall, soil frost dynamics, needle ice development, aeolian erosion and a host of other abiotic processes. Future changes in synoptic air circulation patterns will affect the landscape dynamics of sub-Antarctic islands and its direct and indirect interactions with ecosystem processes.

A020

Session14: Marine sedimentary records of Antarctic ice-sheet dynamics and Southern Ocean history during the Late Cainozoic

Late Quaternary deep stratification-climate coupling in the Southern Ocean: implications for changes in abyssal carbon storage

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The Southern Ocean plays an important role in modulating Pleistocene atmospheric CO2 concentrations, but the underlying mechanisms are not yet fully understood. Here, we report the laser grain size distribution and Mn geochemical data of a 523-kyr-long sediment record (core ANT30/P1-02 off Prydz Bay; East Antarctica) to trace past physical changes in the deep Southern Ocean. The core sediments are predominantly composed of clay and silt-sized material. Three grain size end members (EM) as well as three sensitive grain size classes (SC) were discerned, interpreted as Ice Rafted Debris (EM1 and SC1), and coarse (EM2 and SC2) and fine (EM3, SC3) materials deposited from bottom nepheloid layers, respectively. Ratios of EM2/(EM2+EM3) and SC2/SC3 reveal changes in the local bottom current strength, which is related to the deep ocean diapycnal mixing rate, showing higher values during interglacial periods and lower values during glacial periods. MnO was enriched at each glacial termination, probably caused by abrupt elevations in Antarctic bottom water (AABW) formation rate. Lower AABW formation rate and reduced deep diapycnal mixing during glacial periods enhanced deep Southern Ocean stratification, contributing to glacial atmospheric CO2 drawdown. The elevated AABW formation and enhanced deep diapycnal mixing during glacial terminations alleviated such deep stratification, promoting deeply sequestered CO2 to outgas.

A070

Session14: Marine sedimentary sequences from the Antarctic continental slope and rise: Records of ice-sheet dynamics and Southern Ocean history during the Late Cainozoic

Glacial–interglacial cycles of ice sheet dynamics and paleoceanography in the Amundsen Sea sector, West Antarctica

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Sediment core AMS01 was dredged from the northwestern continental rise of the Amundsen Sea and measured to reconstruct the history of Antarctic ice sheets and Southern Ocean circulation during the Late Quaternary. Core's color reflectance, grain size and geochemical proxies exhibit glacial-interglacial cycles likely linked to ice-sheet dynamics, marine productivity and bottom water formation since MIS9 (about 340 ka BP). The interglacial layers of MIS9, MIS7 and MIS5 show brown colors, lower sedimentation rates, reduced IRD, higher biogenic components and higher Mn concentrations, indicating warmer climate conditions with large-scale retreat in ice sheet and sea ice, elevated marine productivity and activated bottom water formation. In comparison, glacial layers such as MIS8c, MIS8a, MIS6 and MIS2 are characterized by gray or variegated colors, higher sedimentation rates, more IRD, lower biogenic components and lower Mn contents. These interglacial-layer features suggest that the continental rise become a proximal environment near the ice-sheet ground lines and/or sea ice edge where more terrigenous sediments are delivered meanwhile marine productivity and bottom water ventilation are restrained. Besides the glacial-interglacial scales of changes, the interstadial MIS8b marked by a thin layer of light brown, low IRD, high marine productivity and oxidative signal is found typically resembling interglacial environments. Here, our results indicate that the ice sheet in Amundsen region is better controlled by regional ocean circulation more sensitive to climate changes over East Antarctica in the past. Keywords: West Antarctica; the Amundsen Sea; Late Quaternary; glacial-interglacial cycles; ice sheet history; paleoproductivity; bottom water formation

Session14: Marine sedimentary sequences from the Antarctic continental slope and rise: Records of ice-sheet dynamics and Southern Ocean history during the Late Cainozoic

Seismic stratigraphy of the upper continental rise and abyssal plain off Marie Byrd Land

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During the Antarctic summer season of 2019, a field marine geophysical survey took place in the poorly studied part of the West Antarctic Continental Margin and oceanic basin, off Marie Byrd Land between 135E and 155E. This research was undertaken by the Polar Marine Geosurvey Expedition (PMGE) and VNIIOkeangeologia onboard the RV «Akademik A. Karpinsky». In total, 2260 km of multichannel seismic (MCS), magnetic, gravity and multibeam data along 8 profiles were acquired during the cruise, with an additional 240 km of multibeam survey collected along the length of a submarine channel adjacent to IODP borehole U1532 (Leg 379). One of the new seismic lines provides a direct correlation (via Japanese and German lines) of the survey area with IODP-379 sites. MCS profiles were acquired using 560-channel, 7000-m-long streamer and airgun array of 37 l total volume.

All MCS data have undergone preliminary processing onboard and the stacked seismic sections show good resolution, allowing identification of several seismic stratigraphic units formed under different depositional environments. The thickness of sedimentary succession in the studied area ranges between 2-2.5 km. The upper part of seismic stratigraphy exhibits conspicuous changes in the acoustic reflection pattern which are interpreted to correlate with full glaciation of West Antarctica in the Middle Miocene. Sedimentation from this time was influenced by both downslope and along slope (current-controlled) processes, with their respective roles becoming more noticeable approaching the upper continental rise.

The current-controlled sedimentation becomes increasingly dominant in the shallow glacial section with drift deposits common across the study area. A preliminary distinction between two sets of drifts is observed with smaller north-eastward facing individual drifts common in the east, while further west the sections are dominated by much larger south-west facing drift complexes. This reflects a change in the nature of sedimentation between the Amundsen and Ross Seas and may be of interest for the understanding of both oceanographic patterns and the advancement of ice across the continental shelf during the glacial periods.

Session14: Marine sedimentary sequences from the Antarctic continental slope and rise: Records of ice-sheet dynamics and Southern Ocean history during the Late Cainozoic

Diatom micropaleontology and paleomagnetics of the sediment core RS15-LC42: Insights to paleoceanographic processes at the continental rise.

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Here we present a study on the diatom micropaleontology and paleomagnetics of the 11.75 m sediment core RS15-LC42, collected by the Korea Polar Research Institute. The core was obtained from continental rise in the Central Basin, downslope from the mouth of the Joides Trough. An age model was derived for the core based on the magnetic reversal stratigraphy, diatom biostratigraphy, and relative paleointensity records. The favoured age model, supported by the FO of Thalassiosira antarctica (FAD = 0.23 – 0.56 Ma) between 5.40 and 5.65 mbsf indicated a largely continuous sedimentation record back to 1.34 Ma, with a possible ~80 kyr hiatus at ~9.4 mbsf from 0.99 to 1.07 Ma. Throughout this interval, glacial-interglacial cycling changed from obliquity forced 40 kyr cycles to eccentricity forced 100 kyr cycles, with a drastic increase in amplitude at ~400 – 600 ka. Analysis of diatom assemblages revealed that the upper 3.25 m (~300 ka) had very few taxa present indicative of reworking, with accompanying low absolute diatom abundance, while laminated silty intervals below 3.25 mbsf displayed greater absolute diatom abundances, alongside evidence of extensive regional reworking of sediments from the continental shelf. The results from diatom analyses in light of sedimentological characterisation completed prior suggest that periods of elevated reworking (low energy intervals) are the result of sediments sourced from the continental shelf being transported downslope through gravity flows, where they are entrained in the Antarctic Slope Current and deposited as low energy drift deposits behind topographic highs. Coarse grained intervals with low reworked taxa diversity and suppressed absolute diatom abundance are suggested to be the result of enhanced bottom currents resulting in the winnowing of fine grained sediments, including diatomaceous material. These findings have implications for oceanographic variability throughout the Pleistocene in the Ross Sea, especially with respect to production of Ross Sea Bottom Water, and unravelling changes in the paleointensity of the Antarctic Slope Current.

A219

Session: Marine sedimentary sequences from the Antarctic continental slope and rise: Records of ice-sheet dynamics and Southern Ocean history during the Late Cainozoic

The Whales Deep Basin - Houtz and Hayes Bank system (Southeastern Ross Sea, Antarctica): a scenario for Pleistocene continental outer shelf and slope processes evolution

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The Eastern Ross Sea outer shelf and slope are key areas to study past interactions between ocean and ice sheet dynamics. This region is located seaward of the West Antarctic Ice Sheet in the Pacific sector of Antarctica and is influenced by the southern branch of the Ross Sea Gyre. The area of study covers the outer shelf between the Houtz and Hayes Banks. This area includes the mouth of the Whales Deep Basin, a large glacial trough carved by ice streams during the LGM, and the continental slope, cut by the Ross Sea, Whispers, Explora and Shackleton Canyons.

New multibeam, single channel seismic profiles and oceanographic datasets of this area were collected in February 2017 by the OGS Explora, in the frame of the PNRA/Whispers project. ADCP and XBT measurements suggest that cold and dense water generated on the continental shelf (Ross Sea Bottom Water) crosses the shelf edge of the Whales Deep Basin, mixes with relatively warm Circumpolar Deep Water (CDW), and contributes to the Antarctic Bottom Water (AABW) formation. Part of this AABW flows downslope while part of it is geostropically adjusted and flows along slope.

The analysis of the new geophysical data, combined with those collected in 2015 by the N.B. Palmer under the NSF Whales Deep project, reveals a wide range of morphological structures, including gullies, canyons, channels, ridges, slide scars, iceberg scours and mega-scale glacial lineations, that are presumably related to ice-sheet dynamics on the shelf and oceanic bottom currents on the slope. The reconstruction of different slope processes suggests a strong interplay between ocean circulation and ice sheet dynamics in this area during times of maximum ice sheet advance on the continental shelf.

The analysis and correlation of the seismic units from the shelf to the slope, combined with the information from the deep drilling sites DSDP 271 and IODP U1522, show that the continental margin underwent at least four main episodes of ice sheet advance and retreat in the past 2 Ma (possibly since 0.65 Ma). These episodes are characterised by the occurrence of main erosive events, followed by glacial and interglacial sediment deposition.

Our multi-proxy depositional scenario of the continental margin evolution in the Pleistocene suggests that the interplay between the West Antarctic Ice Sheet, the local ocean circulation and glacio-isostasy could explain the recurrent advances/retreat recorded in the sediments at this location. Further geological constraints are needed to provide age and to confirm the dynamics of the proposed scenario.

Session14: Marine sedimentary sequences from the Antarctic continental slope and rise: Records of ice-sheet dynamics and Southern Ocean history during the Late Cainozoic

Magnetic mineral properties linked to iceberg-derived sediment transport in the Scotia Sea (Southern Ocean)

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In the Southern Ocean, magnetic susceptibility (MS) is widely utilized as a proxy of terrigenous input in sediments, and has also provided a successful age control by its analogous variations with dust records of Antarctic ice cores. However, the cause of the linkage between MS and dust records still remains controversial. Here we conducted a detailed rock magnetic study of the Scotia Sea sediments to identify magnetic mineral assemblages that mainly contribute to MS signals. From analyses for concentration, grain size, and mineralogy of bulk and particle-size specific samples, we demonstrated that contribution of multidomain magnetite in the coarse to medium silt-sized fraction dominantly controlled an increase of MS values during the last glacial period. The silt fraction also accompanies hematite input associated with relatively hematite-rich sand-sized fraction. Although finer detrital magnetite and bacterial magnetosome are relatively significant during the Holocene, they are not the main factor for MS variations. Therefore, the most plausible transport mechanism for magnetic minerals in the sand to medium silt fractions is ice rafted debris (IRD) input. In the further analyses for the principal magnetic components, we separated two IRD components dominated by silt and sand-sized fractions, respectively, probably from different sources. Their absolute contributions show different behavior during the deglacial period, which could reflect ice sheet variability of IRD sources, such as the Antarctic Peninsula and East Antarctica. This can also provide an explanation for why gravel-sized IRD fluxes do not match MS variations in the Scotia Sea.

A435

Session14: Marine sedimentary sequences from the Antarctic continental slope and rise: Records of ice-sheet dynamics and Southern Ocean history during the Late Cainozoic

The ODYSSEA Drift depositional archive (Ross Sea, Antarctica)

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The Ross Sea Ice Shelf hosts the join East and West Antarctic Ice Sheets. This is one of the major areas for Antarctic Bottom Waterformation (the Ross Sea Bottom Water, RSBW), representing the densestocean water mass, filling the deepest ocean basins connected to thesouthern ocean. Periodic refill of the RSBW occur through formation of dense, cold and saline water masses (brine) forming on the shelf at the Ross Sea permanent polynya by freezing and salt rejection (high-salinity shelf water, HSSW). The HSSW periodically overspill the shelf area and descend along the slope. This mechanism represents the engine of the global ocean circulation regulating the climate: high production of HSSW would strength the global thermohaline circulation in association to warm conditions.

The Hillary Canyon, crossing the Ross Sea continental slope, represents one of the main conducts through which the HSSW descends the slope to reach the deeper ocean. On its western levee, there is a mounded depocentre that was mapped and ground-sampled during the Italian Antarctic Research National Program (PNRA) ITRS17-ODYSSEA expedition on board the RV OGS-Explora (January-February 2017). The geophysical data allowed to interpret such bathymetric feature as a sediment drift (ODYSSEA Drift), formed by along-slope, contour currents sediment transport and accumulation through several thousands years. Contour currents transported and deposited the sediments that descent the Hillary Canyon by means of the HSSW. Therefore, the depositional sequence of the ODYSSEA Drift potentially contains the record of the variability of HSSW formation, the along slope current intensity in association to climate change, and the interplay between the two bottom currents.

A multidisciplinary investigation was applied to 6 gravity cores collected in the proximal and distal area of the ODYSSEA Drift. The cores were analysed to reconstruct the age model combining AMS radiocarbon dating on foraminifera tests, biostratigraphy, and the sediment palaeomagnetic record; the sediment physical properties (wet bulk density, water content and grain size); and compositional characteristics (XRF core scan and geochemistry). Three main lithofacies were distinguished and associated to depositional processes and climatic conditions:

1) finely laminated and bioturbated sediments characterized by a relatively high Ca content with common presence of biogenic component. Such facies was associated to contour current deposition during relatively warm conditions.

2) Bioturbated sediments with abundant, sparse and/or layered Ice Rafted Debris, and high Ca content. The onset of this facies is characterized by a prominent Mn peak that was associated to bottom ocean oxygenation through ice sheet melting/decay.

3) Laminated, barren sediments associated to steady strong bottom currents under harsh climate conditions. Further preliminary data interpretations are discussed.

A117

Session15: Ice core sciences and Ice chemistry

Microbial alteration of Fe-bearing minerals in freezing condition

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Role of microbial activities in mineral alteration/transformation has been of great interests for more than two decades, because unpredicted modification of mineral structure is frequently accounted in the process of biological structural Fe-respiration. Batch experiments of microbe-mineral interaction under the various temperatures (from 15 ℃ to -10 ℃, pH 7) were performed to understand the mechanism of biogeochemical reaction with Fe-bearing minerals at low temperature. Implications of feasible Fe source to the Southern Ocean in the light of biological dissolution of Fe-bearing minerals will be discussed.

Session15: Ice core sciences and Ice chemistry

Analysis of main ion components and variation in shallow ice core in Northern Victoria Land (GV7, Styx) using ion chromatography.

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Since the major ion components (F-, Na+, Cl-, SO42-, Ca2+, etc.) of ice sheets of Antarctica originate mainly from atmospheric fine dust and gas, their composition and concentration change characteristics restore the past atmospheric environment changes. Recovered fluoride ion (F-) recordings in polar regions are known as representative proxies that point to past large-scale volcanic activity, along with nss-SO42-, and can identify specific local volcanic activities where no nss-SO42-. However, there are few comparable data except for some studies in the Antarctic region related to large-scale volcanic activity, because the F- content of polar snow and ice core is contained in sub-ppb.

In this study, we reconstruct the F- record of 80 m shallow ice core obtained from GV7 (70° 41'S, 158° 52'E, 1950 m) and the main ion components record of 47 m shallow core from Styx (73° 51.10'S, 163° 41.22'E, 1623 m) located in Northern Victoria Land, Antarctica. The concentration range of F- was found to be 0.05 μg/L to 2.12 μg/L in GV7 and 0.04 μg/L to 122 μg in Styx. As a result of calculating the contribution to the main origin of F-, F- showed the highest contribution of volcanoes and other factors (coal burning, etc.) than sea salt or crust. It is believed that the F- influx into Victoria Land mainly comes from volcanoes and other factors.

Session15: Ice core sciences and Ice chemistry

Reconstruction of environmental proxies including conductivity, dust and ionic components from Styx firn core using Continuous Flow Analysis system combined with Melter and Ion Chromatography system

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The Continuous Flow Analysis (CFA) system combined with melter and Ion Chromatography (IC) system have been used as useful methods for measurement of environmental proxies from ice core. In this study, we improved a CFA system (conductivity detector and laser absorption particle sensor) combined with a melter for firn core and six IC instruments to obtain high-resolution proxy data. The melter was carefully operated to overcome percolation effect of melted firn core samples. The proxies of oceanic environmental changes and volcanic eruptions were determined due to the proximal location of northern Victoria Land to Ross Sea, Transantarctic Chain and several volcanoes including Mt. Erebus. Conductivity and particle in firn core were continuously determined and high-resolution (about 2 cm) ion records (F-, MSA, Cl-, NO3-, SO42-, Na+, NH4+, K+, Mg2+, Ca2+) were obtained by the IC system. Our CFA system was applied in analysis of a firn core drilled at Styx glacier (73°51´S, 163°41´E; 1623 m a.s.l; 0.13 Mg m-2 yr-1 accumulation rate) located on northern Victoria Island, Antarctica, during 2014-2015 austral summer.

A356

Session15: Ice core sciences and Ice chemistry

Proton-Induced Crystallization of Amorphous Solid Water

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Amorphous solid water (ASW) is a metastable solid form of water. It has attracted the ice researchers' attention because of the astrochemical significance and its similarities to supercooled liquid water. Metastable ASW changes its phase into crystalline ice (CI) at enough high temperature. In this poster, we report that excess protonic impurities can promote the crystallization of ASW, unlike other impurities that disturb the crystallization. ASW films were doped with excess protons from dissociated HCl and its crystallization fractions were determined from O−H stretch vibration changes using a reflection–absorption infrared spectroscopy (RAIRS) instrument. By comparison of HCl-doped and NaCl-doped ASW samples, facilitated crystallization by excess protons was confirmed. Kinetic analysis showed the lowering of the apparent activation energy from 63.4 kJ·mol−1 without HCl to 48.5 kJ·mol−1 with 0.1 ML HCl. Such accelerated crystallization effect was observed when HCl was adsorbed not only on the ASW films but also in the films, and the crystallization initiated where HCl was located. This study shows one of the uncommon properties of protons in water and ice and will contribute to understanding ices at very low temperatures.

A359

Session15: Ice core sciences and Ice chemistry

Existence of IO2H and its role in the formation of I2 in icy water

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With the help of quantum mechanical methods, the reaction mechanisms of the iodine molecule were detailed. Rather than the previously known I−·O2 complex, a molecular form of IO2H species is found to be much more consistent with experimental results. The new species can explain the pH and photo-irradiation dependences of the reactions. Proper charge transfers in IO2H species are also observed for the formation of initial iodine radical. On the basis of both experimental and theoretical results, singlet and triplet reaction channels are suggested for the enhanced production of iodine radical in bright and dark conditions, respectively. In terms of thermodynamics, the IO2H is mostly formed by the diffusion-limited process without requiring any reaction barriers. Any subsequent reactions after the photon energy absorption, are also mostly diffusion-limited. As a result, the entire process is less sensitive to the temperature, which is not thermodynamic control but kinetic control, allowing them to occur in the icy water environment. Adsorption of iodide and oxygen on Ih ice surface were studied using quantum mechanical/effective fragment potential (QM/EFP) scheme. The surface binding energies are dependent on surface heterogeneity. The oxygen weakly binds with ice surface, however, once iodide bind with ice surface, then, I−·O2 complex strongly bind with the ice surface.

A361

Session15: Ice core sciences and Ice chemistry

Freeze concentration effect enhanced fluorescence analysis method for Fe(II)

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Fe(II) is one of ubiquitous transition metal ion in nature, as well as very important in living organism and environment. Moreover, abnormal level of Fe(II) can potentially induce many problem, such as numerous diseases and pollution. Thus, selective and sensitive analysis method of Fe(II) has highly demanded and among the various method, fluorescence has been attracted as a good efficiency. To improve previous fluorescence analysis method, we introduce the fluorescent naphthalimide derivative containing N-oxide chemistry for the selective detection of Fe(II) by using freezing and thawing methods. Interestingly, the probe showed strong fluorescence enhancement in the presence of Fe(II) owing to acceleration of the deoxygenation process during the freeze. Accelerated reaction in ice is mainly associated with freeze concentration effect. In addition, we found out the reaction occurred in liquid grain boundary through the confocal fluorescence microscopy images. Until now, this analysis method combining fluorescent probe based N-oxide chemistry and freeze concentrate effect is the first trial of detection Fe(II).

A365

Session15: Ice core sciences and Ice chemistry

Ice Surface Sulfuric Acid Formations via the Oxidation of Sulfurous Acid by Hydrogen Peroxide

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Presence of H2SO4 in the atmosphere causes varieties of environmental problems. As known, H2SO4 can be yielded by the oxidation of H2SO3. In the atmosphere, H2SO3 originates from abundant SO2 and moisture. Recently, a mechanism of H2SO3 formation on the ice surface has been described.1 Also, the rise of H2O2 concentration in polar core ice during the last decades has been observed. To the best of our knowledge, the detailed molecular mechanism of the H2SO3+H2O2 reaction resulting in the H2SO4 formation has been poorly investigated. Thereby, we suggest the possibility of oxidation of H2SO3 by H2O2 on the ice surface. Here, ab initio gas phase calculations have been done to understand the mechanism of H2SO4 formation by oxidation of H2SO3 with H2O2 in the gas phase as well as on the ice surface. Thermodynamic and kinetic control of the reaction with corresponding energy barriers has been investigated. In the gas phase, one stepwise and three concerted reaction pathways have been found. The former proceeds via the formation of HOSO(OOH) intermediate which has been previously suggested in the experimental study.2 The role of H2O as a proton transfer mediator has been shown. One stepwise and one concerted pathway with the addition of one H2O molecule have been found. The stepwise mechanism proceeds via double proton transfer with the formation of (HO)3S(OOH) intermediate which has not been reported previously in the literature. It has been demonstrated that the addition of a water molecule can decrease the reaction barrier by as much as 16.0 kcal/mol. Additionally, the mechanisms of the HSO3−+H2O2 reaction have been found possessing lower activation barriers than that for the H2SO3+H2O2 reaction. Further, ice surface calculations have been carried out. Two reaction mechanisms of H2SO3+H2O2 and one mechanism of the HSO3−+H2O2 reaction on ice surface have been revealed.

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A368

Session15: Ice core sciences and Ice chemistry

Chemical reactions between hexavalent chromium and iodide in ice

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Chromium is ubiquitous in nature and commonly used heavy metal in many industrial processes. Chromium mainly exists as hexavalent chromium (Cr(VI)) and trivalent chromium (Cr(III). Cr(VI) has higher toxicity and is more mobile than Cr(III). Recently, it is reported that certain chemical reactions can be accelerated in frozen solution compared to those in aqueous solution. These phenomena are explained with the freeze concentration effect that concentrated solutes and protons in liquid regions between ice crystals when aqueous solution becomes frozen. In this context, the enhanced reduction of Cr(VI) with organic and inorganic compounds such as hydrogen peroxide (H2O2), nitrite (NO2−), and phenolic compounds in frozen solution were also reported.
In this presentation, we will show a new mechanism of Cr(VI) reduction by iodide (I-) in frozen solution. In frozen solution, the redox chemical reactions that Cr(VI) is reduced to Cr(III) and I- is oxidized to molecular iodine (I2) was enhanced which was negligible in aqueous solution. The formed I2 is known as selective and nontoxic reagent in organic synthesis that acts in iodination, oxidation, and as Lewis acids. The mechanism of these redox chemical reactions in frozen solution and its environmental implications will also be discussed.

A369

Session15: Ice core sciences and Ice chemistry

Enhanced chemical processes in ice and its impact on cold environment

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Ice is ubiquitous in nature and provides a place for chemical reaction, especially in cold environments. According to Arrhenius's Equation, chemical reactions take place slowly when temperature drops. However, several chemical processes are known to be accelerated by freezing.
Takenaka et. al. founds that the NO2- oxidation to NO3- in the presence of O2 which is very slow reaction in aqueous solution was significantly accelerated (appx. 105 times) by freezing. The main driving force for the accelerated chemical reactions in ice is ascribed to the Freeze Concentration Effect (when solution is frozen the existed organic/inorganic chemicals are separated from ice crystals and highly concentrated in unfrozen part or ice grain boundaries in ice). In this talk, we will introduce enhanced chemical processes with laboratory experimental results such as 1)accelerated dissolution of metal oxides(iron oxide and manganese oxide) in ice, 2) rapid removal of toxic heavy metals(hexavalent chromium and arsenite) and organic pollutants by freezing, and 3) activation of iodine species in ice. The detailed experimental conditions and mechanistic explanations will be discussed in the presentation.

A372

Session15: Ice core sciences and Ice chemistry

Enhanced removal of Cr(VI) in the presence of rice husk biochar in frozen aqueous solution

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Owing to properties of biochar (BC), which is produced by biomass pyrolysis (oxygen-free or limited condition), such as carbon-rich, high porous and insoluble, it has attracted great attention as a low-cost and sustainable adsorbent material for removal of environmental pollutants in water. However, application of BC is still limited because its actual performance is quite lower than that of commercial materials. Therefore, many researches to increase the performance of BC has extensively conducted and developed materials such as activated BC, engineered BC and so on.

According to the Arrhenius Equation, chemical reactions slow down as temperature drops and it is commonly accepted that ice is inert as reaction media. However, many researchers recently found that it can act as reactive reactor and some reactions such as redox conversion and ion dissolution from solid particle are accelerated during freezing. It is because solutes, protons, and/or solid particles dramatically accumulate in the grain boundary (i.e., the liquid brine) by exclusion from ice crystals under freezing process. Therefore, freezing of pollutants containing aqueous solution with BC can be a one of promising methods to improve BC performance without other treatment techniques due to the freeze concentration effect.

This study assessed the feasibility of freezing process as a technique to improve the BC performance in a heavy metal polluted aqueous system. To this end, hexavalent chromium (Cr(VI)), one of the representative heavy metals, was used as sample and the removal of Cr(VI) by rich husk BC in ice (i.e., at -20 ℃) was compared with the corresponding reaction in water (i.e., at 25 ℃). According to the results, freezing process is not only a useful method for upgrading BC performance, but also significantly enhanced removal efficiency of Cr(VI). Considering our research results, the detailed Cr(VI) removal mechanism, the environmental implication and application will be discussed at the presentation.

A391

Session15: Ice core sciences and Ice chemistry

Low Energy Electron Transmission and Trapping in Crystalline Ice Films

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We studied the interaction of low energy (0-10 eV) electrons with crystalline ice film. An ice film was prepared by H2O vapor deposition on a Pt(111) substrate at 150 K for thickness of >100 BL inside a vacuum chamber and was annealed at 165 K to produce a crystalline ice film with a flat (0001) surface. We irradiated low energy electrons, produced from an electron flood gun, onto the ice film at 95 K. The amount of trapped electrons was estimated by measuring the film voltage with a Kelvin probe at various incident energies of the electrons. In previous works, low energy electrons were trapped in thin H2O film very efficiently, however most of electrons just transmit through thick crystalline ice film.

A403

Session15: Ice core sciences and Ice chemistry

Chemical Detection and Characterization in Quasi-Liquid Layer on Ice Using in-situ Raman Spectroscopy

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Chemical reaction rate of certain unique reactions are enhanced when temperature decreases especially in ice phases, while fundamentally the reaction rate slows down at low temperature.
Freeze concentration effect (chemicals dissolved in the water are concentrated in ice grain boundaries between ice crystals, known as Quasi-Liquid Layer (QLL)) is the main reason for the enhanced chemical reactions in ice phase. QLL in ice has been receiving attention in various research field because of its unique physical and chemical properties such as concentration effect and pH changes. However, chemical behaviors in QLL is not clear and the analytical methods to verify its properties are restricted. We investigated chemical characterization methods using in-situ Raman spectroscopy to detect the ion concentration and determine their species within QLL on ice. In this study, iodate (IO3-) solution was used as target material for chemical detection and graphical mapping. The sample was prepared and frozen on the low temperature stage attached on the Raman spectroscope and measured their chemical species in-situ. Nearby 100 times freezing concentration effect in QLL was measured. And also the result of chemical mapping was perfectly overlapped in QLL. This research proposed that the in-situ detection and characterization of chemical species concentrated in QLL could be able by Raman spectroscopy. We expect that our methods could suitable for the chemical characterization in various natural ice media (such as ice bergs, ice particle, snow, sea ice, etc.).

A484

Session15: Ice core sciences and Ice chemistry

Plutonium fallout reconstructed from an Antarctic Plateau snowpack using inductively coupled plasma sector field mass spectrometry

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Anthropogenic plutonium (Pu) in the environment is a result of atmospheric nuclear testing during the second half of the 20th century. In this work, we analyzed a 4-meter deep Antarctic Plateau snowpack characterized by a low snow accumulation rate and negligible snow impurities. These sample conditions enabled us to measure the snowpack Pu fallout by applying inductively coupled plasma sector field mass spectrometry to a few mL of snow melt without purification or preconcentration. Pu concentrations in the reconstructed Pu fallout record for the period after 1956 CE increased and decreased in agreement with past atmospheric nuclear testing. Two peaks and two dips associable with historical events were observed, and the highest peak in 1964(±1) CE approximately coincided with the maximum concentration of non-sea-salt sulfate caused by the Mt. Agung eruption in 1963 CE. Enhanced Pu fallout in the 1970s was attributed the geographical proximity of the Southern Hemispheric nuclear test sites. Our results suggest that by improving the instrumental sensitivity and precision, the potential of the Antarctic ice sheet as an archive of Pu fallout can be further explored and utilized for understanding atmospheric dispersion and for dating ice cores.

Session17: Paleoenviromental changes in Antarctica and Southern Oceans since the last Glacial Maximum

Characteristics of clay minerals deposited in the sediment: Larsen Ice Shelf B embayment, Antarctica

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Mineralogical and geochemical investigations of marine sediments from the continental shelf around Antarctica provide significant clues about the stability and proximity of ice shelves, and the influx of terrigenous sediments and meltwater during deglaciation. Since clay minerals are major components of continental shelf sediments, their paleoceanography and paleoclimatology are revealed by their clay mineral assemblages, structures, and chemistry. A whole round core of marine sediment (EAP13-GC17, 236 cm below the sea floor) was collected on the northwestern Larsen B embayment of the Antarctic Peninsula (the ARA13 Cruise Expedition by the Korea Polar Research Institute, 2013). Four sedimentary facies (U1–U4) were clearly distinguished. An increase in the clay mineral ratio of smectite/(illite+chlorite) was clearly identified in the open marine condition, which was strongly indicated by both a heavier isotopic composition of δ13C and δ15N (-24.4 ‰ and 4.3 ‰, respectively), and an abrupt increase in 10Be concentration (~30 times). An increase in the average values of the crystal packet thickness of illite (~1.5 times) in U1 also indicated sediments transported in open marine conditions. Based on the clay mineral composition in U1, the sediments are likely to have been transported from the Weddell Sea. These clay mineralogical assessments conducted in this region have significant implications for our understanding of paleodepositional environments.

Session17: Paleoenviromental changes in Antarctica and Southern Oceans since the last Glacial Maximum

The Antarctic barnacle Bathylasma corolliforme as geochemical archive of environmental conditions in the Ross Sea

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Our research aims to unravel the sclerochronological banding characteristics of the Antarctic barnacle Bathylasma corolliforme (Hoek, 1883), as well its paleoceanographic archive potential encoded in elemental and isotopic variations of its skeletal plates. B. corolliforme is widely spread in Antarctic waters across a large bathymetric gradient and occurs as a frequent component of uplifted Holocene and Pleistocene deposits around Antarctica. The plates show a regular annual increment formation, in phase with the strong polar seasonality and sea-ice formation. Animal anatomy and skeletal banding have been visualized with micro-computed tomography. Compositional changes hold information on temperature and salinity variations. Current research combines 14C-dating of recent barnacles collected across the last decades, to trace the 14C-bomb-spike in relation to the incremental banding. The mixing gap between low-Mg calcite with MgCO3 contents of 0 to 5.5 mol%, and high-Mg calcite with MgCO3 contents of 10.5 to 20 mol% can be comfortably distinguished with Raman spectra. Our XRD and µ-Raman spectra acquired from several specimens of B. corolliforme from the Ross Sea consistently indicate that all plate elements are exclusively made of low-Mg calcite, typical for thoracic barnacles. The low (below 2.0 to ~2.7 mol%) MgCO3 estimate is further consistent with extremely low water temperatures in the Ross Sea. Raman spectra show coherent peaks for low-Mg calcite, with optimal overlap between Recent, subrecent, Holocene and Pleistocene specimens. Fluorescence background levels of Raman spectra are higher in modern samples and decrease with time, indicative of a general loss of organic matter in the skeletal plates with time. The low-Mg calcite mineralogy instead is resilient to diagenesis and isotopic or elemental patterns remain unharmed and can be used as archives in fossil Antarctic sediment sequences. Oxygen isotope values for Holocene samples (0.3-5.9 ka BP) from the Ross Sea revealed an isotopic variability for δ18O between 3.5 and 5.3 ‰ V-PDB (Burgess et al. 2010, EPSL). Our modern δ18O data of live-collected individuals are on average 0.7 ‰ lower than the pre-industrial Bathylasma specimen of Burgess et al. (2010), which dated to 299 yrs cal BP. This ~0.7 ‰ δ18O-shift is beyond the typical intra-specimen δ18O variability and reflects recent changes of bottom water conditions, possibly related to anthropogenic climate change with shifting meltwater discharge and modified seasonal sea-ice formation. The decadal scale barnacle longevity offers the potential to complement oceanographic records prior to instrumental time-series in the Ross Sea.

Session17: Paleoenviromental changes in Antarctica and Southern Oceans since the last Glacial Maximum

Latitudinal screening of Southern Ocean limpet isotope compositions and incremental banding across the Polar Front

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Skeletal carbonate proved to be a valuable archive of oceanographic information in the Southern Ocean, including Antarctica. Most data refer to marine sublittoral and water column situations while little consideration has been conceded to the intertidal or nearshore habitat. The δ18O and δ13C shell calcite stable isotope composition of three gastropod limpets was evaluated alongside with their incremental banding to test its value to decipher nearshore environmental conditions in the Southern Ocean. We used living and recently dead shells from a wide latitudinal range spanning 75–52°S with strongly differing temperature and salinity conditions. North of the Antarctic Polar Front, Nacella magellanica and Nacella deaurata were collected from the Falklands and from southern Patagonian fjords. The 'Antarctic limpet' Nacella concinna (syn. Patinigera polaris) occurs within the Antarctic Polar Front and was recorded from the Antarctic Peninsula, Signy Island (South Orkneys) and South Georgia. Around the Antarctic Peninsula, N. concinna is one of the few large carbonate secreting taxa, which offer clear annual banding and wide increments needed for high-resolution studies to eventually complement historical temperature timeseries. Skeletal mineralogy has been examined with x-ray diffractometry (XRD), micro-Raman spectroscopy (μ-Raman) and staining of thin-sections with Feigl solution, all indicating a calcitic mineralogy. Consequently, the shells are resilient to diagenesis and can be used as archives of e.g. archeological shell middens or raised beaches in Patagonia and, in perspective, in uplifted Holocene to Last Glacial deposits in Antarctica. The external annual banding has been used to determine growth rates and individual longevities. In thin section, the different limpet species show extremely fine increments within annual bands, which are compared with a sclerochronological approach. All three species are highly abundant in rocky intertidal to subtidal habitats, show distinct external/internal growth banding, and their heaviest oxygen isotope composition is always at or very close to equilibrium with seawater for all three species. Patagonian fjord limpets display a 'tail' of depleted oxygen isotope values resulting from seasonal meltwater runoff, reflecting higher temperatures and strongly lowered salinity. The potential presence of a growth rate-dependent 'kinetic' vital effect was tested with parallel ontogenetic transects along the longest and shortest axes in N. magellanica. Coeval transects reproduce the same isotopic variability patterns with slight δ18O depletion at the faster-growing longest shell axis. N. concinna from the Antarctic Peninsula shows an oxygen isotope range of 2.7–4.3‰ δ18O V-PDB, and ontogenetic cross-shell transects closely match the annual temperature amplitude.

A187

Session17: Paleoenviromental changes in Antarctica and Southern Oceans since the last Glacial Maximum

Late Holocene ice mass changes recorded in a relative sea-level record from Joinville Island, Antarctica

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Our understanding of the response of the Antarctic Ice Sheet to past climate changes is limited by the scarcity of paleoenvironmental records. One of these critical needs are better sea-level records for constraining glacial-isostatic models (GIA). Here, a new, and arguably the best-dated, RSL curve for Antarctica is presented based on beach ridges from Joinville Island on the Antarctic Peninsula. We find that sea level has fallen ~5 m over the last 3100 years, with a significant increase in the rate of RSL fall from 1320 ± 125 to 1540 ± 125 cal yr BP. This increase in the rate of RSL fall is likely due to the viscoelastic response of the solid Earth to terrestrial ice mass loss from the Antarctic Peninsula, similar to the Earth response experienced after ice mass loss following acceleration of glaciers behind the collapsed Larsen B ice shelf in 2002. Additionally, slower rates of beach-ridge progradation from 695 ± 190 to 235 ± 175 cal yr BP, were potentially caused by a glacial advance during the Little Ice Age. This rapid response of the Earth recorded in the sea-level record further supports recent assertions of a more responsive Earth to glacial unloading than currently assumed and the need to use a lower upper mantle viscosity in GIA models for the Antarctic Peninsula. Thus, currently used GIA models may not accurately capture the ice mass changes of the Antarctic ice sheets at Holocene time scales.

Session17: Paleoenviromental changes in Antarctica and Southern Oceans since the last Glacial Maximum

Holocene paleoceanographic evolution at the Ross Sea-Southern Ocean interface

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Reconstructions of Antarctic oceanography from past intervals of warming are a crucial component of estimating the sensitivity of marine-based glaciers and ice shelves to atmospheric and oceanic changes in the twenty first century. Here, we present a high-resolution multi-proxy record of Antarctic paleoclimate evolution during the last 6,200 yr from a sediment core, RS15-GC57, retrieve from Robertson Bay, a previously unstudied embayment west of Cape Adare. By interpreting the diatom assemblage, magnetic and physical properties, and bulk sediment geochemistry of core RS15-GC57 in the context of modern instrumental datasets from Robertson Bay we reconstruct Holocene climate variability at the interface between the EAIS and the Southern Ocean.

The most prominent feature in proxy records from core RS15-GC57 is a rapid (~200 yr) environmental transition dated to ~3,200 cal yr BP, coincident with the rapid termination of the mid-Holocene climatic optimum and onset of "Neoglacial" cooling in marine sediment cores from Adélie Land and the Antarctic Peninsula. In Robertson Bay, the mid-Holocene is characterized by low biogenic and terrigenous accumulation, < 7 months of sea ice, and winnowing of sediment by strong currents. A baseline shift in environmental proxies at ~3,200 cal yr BP marks the onset of modern-style water mass circulation, sea ice duration (>9 months), and influence of modified Circumpolar Deep Water (mCDW) in the bay. We propose that the rapid late Holocene transition observed in Robertson Bay and along the Pacific and Indian Ocean sectors of the East and West Antarctic Ice Sheets is associated with the late Holocene stabilization of the Antarctic Ice Sheet in Ross Embayment.

Following the termination of regional meltwater forcing, mCDW influence and sea ice duration in Robertson Bay may be modulated by centennial trends in the Southern Annular Mode (SAM). Between 1,000 cal yr BP (950 CE) and 500 cal yr BP (1450 CE), the diatom assemblage from Robertson Bay indicates a decrease in coastal fast ice and increase in mCDW upwelling concomitant with a southward migration of the Southern Hemisphere westerly winds. Since 500 cal yr BP, increased sea ice duration in Robertson Bay indicates that icier conditions observed in the Ross Sea and the Antarctic Peninsula during the "Little Ice Age" persisted at the northern margin of the East Antarctic Ice Sheet during a northward migration of the Southern Hemisphere westerly winds.

Session17: Paleoenviromental changes in Antarctica and Southern Oceans since the last Glacial Maximum

Deglaciation of large East Antarctic glacial basins that are grounded below sea level: A preliminary study of the Denman Glacier system

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Past deglaciation timings of the EAIS have been increasingly studied in recent decades, however, there remains a large portion of the EAIS between Princess Elizabeth Land (80° E) and King George V Land (150° E) that has no geological constraints. This represents around a third of the coastline of the EAIS and so it is important to constrain the past extents of ice in these regions. Furthermore, the ice sheet in this region is grounded almost exclusively below sea level and potentially prone to Marine Ice Sheet Instability.

In this study we investigate whether topographic differences of subglacial basins have an impact on the sensitivity of large ice sheets to changes in climate. Using cosmogenic 10Be exposure dating of glacial erratics and bedrock we aim to provide geological constraints on the deglaciation of the Denman Glacier basin, which is grounded below sea level. Samples for this study were collected from Mt Strathcona, Cape Jones and the Bunger Hills during the Australian National Antarctic Research Expeditions (ANARE) from 2015-2019 as part of Australian Antarctic Science project 4318.

We present preliminary data that suggest the retreat and stabilisation of the Denman Glacial system may have been completed earlier than areas where the ice-sheet is grounded above sea level. Exposure ages reveal that Cape Jones, proximal to the grounding line, was deglaciated approx. 11 ka, consistent with a major phase of ice retreat at nearby Bunger Hills. Ages from Mt Strathcona, ~90 km from the grounding line, are all pre-LGM.
The deglaciation age at Cape Jones reflects a stabilisation of the ice sheet in the Denman Basin that was 2-7 ky earlier than several previously studied areas of the EAIS such as Dronning Maud Land, Enderby Land and Mac Robertson Land; all of which are contain glacial basins grounded above sea level. Our results confirm earlier evidence from 14C and Optically-Stimulated Luminescence (OSL) dating that parts of the Bunger Hills were ice free early following the LGM (~20 ka). Whilst the exposure ages from Mt Strathcona indicate that it was not covered by ice during the most recent glacial period, it is also possible that cold based ice was present and did not drop glacial erratics. Furthermore, due to sampling difficulties there were no samples taken from the lower elevations of Mt Strathcona. We are currently processing samples Mt Sandow, another site that is ~90 km inland of the grounding line, which are significantly fresher in appearance and will help to better constrain the dynamics of this part of the Denman Basin.

The evidence from Cape Jones and the Bunger Hills indicate that this region of the EAIS is more sensitive to climatic changes, possibly due to being grounded below sea level. More work is needed to properly understand the timings of deglaciation of these 'low lying' glacial basins. We are currently in

the process of expanding these preliminary results to include a further five locations from the margins and interior of the Denman Glacial system, with eyes to expand this study to other topographically similar basins, such as the Aurora Basin.

A071

Session17: Paleoenviromental changes in Antarctica and Southern Oceans since the last Glacial Maximum

Marine ecosystem response to Late Pleistocene climate conditions - evidence from snow petrel stomach oil deposits ("mumiyo") in East Antarctica

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Fossil stomach oil of snow petrels (Pagodroma nivea) forms unique deposits of so-called mumiyo in the vicinity of the bird's nests in ice-free areas of Antarctica. The deposits are indicators for un-glaciated terrestrial sites but also provide records of the occupation histories of the inland breeding localities by snow petrels as well as for productive foraging areas off the coast. New 14C ages of mumyio deposits from Dronning Maud Land (East Antarctica) evidence that the mountain ranges of the Wohlthat Massif were recurrently occupied by breeding snow petrels for more than 58 thousand years (ka). This is much longer than previously known and supports the importance of the ice-free areas as refugia for snow petrels during glacial times.

Some mumiyo deposits are laminated and contain an intact stratigraphy making them suitable for nearly continuous paleo-studies. We conducted high-resolution XRF elemental scans (500 µm step size) and C, N, and S analyses in order to investigate changes in the proportions of mineral grains, guano and stomach oil in individual deposits to trace changes in environmental parameters like the frequency of nest occupation by snow petrels. Profiles from different deposits reveal a consistent pattern for the region, pointing to frequent nest occupation of the terrestrial sites in DML between 46-42 ka.

In order to detect changes in the foraging habitat of the snow petrels we analysed the fatty acid and n-alcohol composition of the mumiyo and conducted first stable isotope measurements (δ13C and δ15N) on bulk material. While lipids show some indications for post-depositional alteration (e.g., low proportions of un-saturated compounds), a positive correlation between δ13C and δ15N values of bulk material independently of the deposit or the age of the specific sample likely indicates an original signal that is not severely altered by degradation. During glacial times higher δ15N in mumiyo point to prey composition of higher trophic levels, relative to the post-LGM and Holocene.

This pattern either reflects a shift in foraging location or in prey species available on glacial/interglacial time scales, likely in response to sea-ice conditions and nutrient supply in surface waters of the Southern Ocean.

A086

Session20: Evolution of the biota of West Antarctica: a Gondwana perspective

Paleobiological inferences of the Antarctic dinosaur Antarctopelta oliveroi (Ornithischia: Ankylosauria) based on the bone histology of the holotype specimen

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A detailed histological study of Antarctopelta oliveroi, from the Upper Cretaceous of Antarctica, is performed in order to increase the knowledge on the ankylosaur bone histology and its taxonomical and paleobiological implications. The main objectives of this contribution are: to infer the ontogenetic stage of the holotype specimen of Antarctopelta oliveroi (MLP 86-X-28-1); to evaluate the degree of interelemental histological variation; to compare with the histology of other ankylosaurs; to provide information about the phylogenetic affinities of Antarctopelta using dermal armor histology; and to evaluate the influence on the growing of Antarctopelta due of living in an ecosystem affected by strong, high latitude seasonality. Several postcranial elements from the holotype specimen (e.g. osteoderms, appendicular bones, dorsal ribs, ossified tendons) were included in the sample. The bone histology reveals that the specimen was sexually mature but possibly still growing at time of death. Primary cortical bone, mostly composed of fibrolamellar bone tissue interrupted by growth marks, reveals cyclical growth strategy as reported for other ankylosaurs and non-avian dinosaurs. The number of growth marks preserved in the cortical bone is, however, strongly variable among different kind of elements. Dermal armor histology supports nodosaurid affinities of Antarctopelta. Histological data reveals an osseous pathology in the individual. The bone histology of Antarctopelta indicates that, as other Southern Hemisphere polar dinosaurs, there are not evident differences in growth strategy compared with low latitude relatives. Therefore, no evident physiological modifications appears to be linked with the distribution of ankylosaurs and other non-avian dinosaurs in higher latitudes (>60° S).

A095

Session20: Evolution of the biota of West Antarctica: a Gondwana perspective

Palynological study on parts of the Byers Group, Livingston Island, Antarctica – proxy for age, palaeoenvironmental and palaeoclimatic assessment

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Palynological studies on parts of the Byers Group, Livingston Island have provided new data on its palynological content, palaeo-oceanographic setting and palaeoclimatic assessment. The Byers Group, exposed on the Byers Peninsula, comprises thick Upper Jurassic-Lower Cretaceous sedimentary and volcanic succession, deposited in marginal fore-arc environments. This succession is of regional significance and it has important implications for the palaeogeographical evolution of the northern Antarctic Peninsula. The sedimentary succession of the Byers Group is composed mainly of marine mudstone dominated sequences with subordinate sandstones, siltstones and conglomerates, and alluvial and lacustrine volcanoclastic sediments. According to different authors the Byers group includes different formations and members, as some of them – the President Beaches Formation and the overlying Chester Cone Formation occupy a large area of the western part of the Peninsula. The President Beaches Formation is at least 600 m thick and mudstone dominated. The mudstones of the President Beaches Formation (PBF) as well as the Sealer Hill Member recognized within the Chester Cone Formation have yielded comparatively rich palynoflora, represented by dinoflagellate cysts, gymnosperms and pteridophyte spores of considerable morphological diversity. Age indicative within them are the encountered key dinocyst taxa. The palynoflora data from the President Beaches Formation are directly calibrated to the ammonite finds obtained from the sandstone bodies and suggest Late Berriasian age for the sampled interval. The overall composition of the dinocyst assemblages and palynofacies data are combined for palaeoenvironmental interpretations. The encountered diverse dinocyst association is dominated by Oligosphaeridium and Gribroperidinium representatives, considered to be more typical for middle shelf depositional environments with normal marine salinity conditions. The input of terrestrial material, however, has been high during the deposition of these units, since the ratio of continental to marine palynomorphs (C/Mratio) is approximately high in them. An anoxic interval is evidenced within the President Beaches Fm demonstrated by significant parts of grey greenish amorphous organic matter (AOM) most probably of marine (algae) origin which accounts up to 60% in the slides. According to palynofacies analysis principles large amounts of AOM are directly related to anoxic low-energy conditions. Heightened marine productivity and high nutrient levels are not supported by the encountered dinocyst associations, so the anoxia could be linked to the existing submarine volcanism in the area.A warm temperate palaeoclimate with high humidity is suggested for the Late Berriasian in the studied area. The land vegetation probably consisted mainly of pteridophyte-spore producing plants and coniferous forests with equal Araucariacites and Podocarpidites in them.The Byers Group palynoflora shows strongest affiliation to those from the Cretaceous of Australia, New Zealand and South America.

A111

Session20: Evolution of the biota of West Antarctica: a Gondwana perspective

SEARCHING ON THE BOUNDARY: A RICH VERTEBRATE ASSEMBLAGE ON THE ANTARCTIC UPPERMOST MAASTRICHTIAN

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SEARCHING ON THE BOUNDARY: A RICH VERTEBRATE ASSEMBLAGE ON THE ANTARCTIC UPPERMOST MAASTRICHTIAN

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The Maastrichtian-Danian López de Bertodano Formation comprises a thick sequence of marine deposits that is well exposed on Seymour (=Marambio) and Vega islands. The Lopez de Bertodano Formation yielded vertebrates such as chondrichthyes, teleosts, marine reptiles (plesiosaurs and mosasaurs), a dinosaurs, and birds. The Cretaceous horizons (Maastrichtian in age) of the López de Bertodano Formation could be divided into two informal units: the Molluscan Units (Unit 9 to Unit 7) and the Rotularia Units (Unit 6-Unit 2). On the last three Summer Antarctic fieldtrips to the Cretaceous deposits the work has been focused on the prospection of the uppermost levels of the López de Bertodano Formation (Unit 8 and Unit 9) with the final objective of determine the faunal composition below the K/Pg boundary. This systematic prospection was followed by immediate extraction in the case of small vertebrates (less 2 meters in length) and sequencial extraction through several fieldtrips in the case of the large marine reptile specimens (more than 5 meters in length). The first result is the recovery of an almost complete skeleton of an elasmosaurid (7 meter in length). The extraction spent about a month since, at least half ot the specimen, was buried in the frozen soil (permafrost). The specimen IAA-Pv 752, is extremely relevant, it is the first well-preserved elasmosaurid from the López de Bertodano Formation that kept both cranium and

postcranium. A preliminary comparison indicates the presence of several interesting features such as 1) high coronoid process, 2) relatively short mandibular symphysis, 3) wide symphyseal mandibular sulcus and 4) atlas-axis complex without a ventral keel. Some of the characters such as 2, 3 and 4 are also observed in the aristonectine elasmosaurids indicating that the IAA-Pv 752 is going to provide crucial clues about the transition between aristonectine and non-aristonectine plesiosaurs

A182

Session20: Evolution of the biota of West Antarctica: a Gondwana perspective

FIRST REPORT OF A SKELETAL PATHOLOGY OF A MOSASAUR FROM THE SOUTHERN HEMISPHERE

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Paleopathological studies have been used to understand the history of injuries and diseases in extinct forms. Examples of paleopathologies have been widely observed and recognized among fossil vertebrates, including dinosaurs and various marine reptiles. Paleopathology studies represent a vast field of novel information in etiological terms and insight to resulting limitations affecting behaviour and provide a glimpse of the possible survival strategies under which these reptiles lived. Infections are a well-recognized complication of injuries, as noted in dinosaurs and marine reptiles, with joint infections specifically noted in shoulders of pliosaurs. Spondyloarthropathy has been previously recognized as pan-phylogenetic in mammals and as isolated phenomenon in Dimetrodon, Diadectes, Ctenorhachis, mosasaurs, hadrosaurs, ceratopsia. It is predominantly vertebral in distribution, although peripheral joints have sometimes been affected. Northern Patagonia and the Antarctic Peninsula have rich records of Upper Cretaceous (Campanian and Maastrichtian) marine reptiles. However paleopathologys have not been previously reported from in these abundant and diverse marine reptile assemblages. We describe a left scapula belonging to a juvenile mosasaurs (Plioplatecarpinae, indet.) from the López de Bertodano Formation (upper Maastrichtian) of Marambio Island (Seymour Island), Antarctic Peninsula, representing the first report of a skeletal pathology of a mosasaur from the southern hemisphere. Macroscopic examination of the scapula revealed a remodelled, deeply excavated and expanded gleno-humeral joint with adjacent linear disruption. X-ray examination revealed a deep excavation expanding the glenoid fossa, with disorganized subchondral bone and a focal spherical defect. The diagnostic considerations are infectious arthritis and spondyloarthropathy. The former is characterized by erosions with reactive new bone formation, the latter, by disorganized trabecular patterns underlying the articular surface. The spheroid defect recognized radiologically and presences of the surface defect (indicative of a draining sinus) are parsimonious with the diagnosis of infectious arthritis. The articulation of the scapula and humerus was disrupted by the glenoid fossa expansion, compromising its normal function as a fulcrum. The limb was thus rendered flail, unable to contribute to propulsion or directionality (steering). The individual survived long enough for partial healing, in the form of new bone formation. This process may occur as rapidly as within a few days in mammals, but commonly is more prolonged (e.g., month) in reptiles. However given the high growth rate and endothermic of hydropelvic mosasaurs, new bone deposition may have occurred much faster than in extant squamates. The individual did not continue to grow for a long time after the appearance of the lesion. Although not directly related to the mosasaur death, this condition may have contributed to

the demise of the animal by reducing its effectiveness at obtaining food or increasing susceptibility to fatal disease, additional injury, or even predation. A juvenile mosasaur with this condition would eventually make it an easy prey.

A269

Session20: Evolution of the biota of West Antarctica: a Gondwana perspective

The early radiation of modern whales: new insights from Eocene records from Antarctica.

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The Eocene La Meseta Formation of Marambio (Seymour) Island has yielded a fragmentary but globally significant assemblage of archaic cetaceans, including the oldest basilosaurids (a group of stem taxa fully adapted to life in water) and the second-oldest mysticete (Llanocetus denticrenatus). Antarctica, Peru and New Zealand are the only localities worldwide at which stem and crown cetaceans co-occur. Basilosaurids are mostly represented by fragmentary and isolated specimens, whereas toothed mysticetes include a relatively complete skull. A series of expeditions over the past decades has yielded numerous additional specimens, including a fragmentary skull and a partial atlas likely referable to Basilosauridae, three teeth hinting at the existence of a gigantic species of Llanocetus, and several pachyosteosclerotic postcrania. The antiquity of the basilosaurids from the La Meseta Formation implies a rapid dispersal of the family to the Southern Hemisphere, possibly via Australasia. At an estimated body length of up to 12 m, the new Llanocetus specimens are far larger than other archaic mysticetes, suggesting that gigantism may have originated more than once in baleen whale evolution. Their morphology supports the idea that mysticetes followed a suction-assisted raptorial feeding strategy prior¬ to the emergence of filtering.

A353

Session20: Evolution of the biota of West Antarctica: a Gondwana perspective

Jurassic marine fishes from the Antarctic Peninsula: a key to understand the evolution of Southern Gondwanan ichthyofaunas

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Mesozoic ichthyofaunas from Gondwana have a high potential to provide new and abundant material and thus are of utmost importance for understanding better the evolutionary history of fishes. The Jurassic is a crucial and meaningful period in the evolutionary history of numerous fish groups when many of the clades that we know today originated or diversified. Argentina conducted many successful vertebrate paleontological campaigns in Antarctica for the last 20 years. To date, the prospection for and collection of fossil vertebrates has covered extensive areas in Marambio (= Seymour), Vega, and James Ross islands, where mostly fossil-bearing units ranging from the Late Cretaceous to Paleogene in age are exposed. Conversely, the Jurassic in Antarctica remained little explored. Jurassic marine fishes are only known from the Ameghino Formation (=Nordenskjöld) and the Latady Group. In light of the widespread Jurassic outcrops occurring in Antarctica, the Argentinian vertebrate paleontological campaigns are currently extending the prospection of areas of interest – emphasizing on the recovery of fishes – to specific sectors of Antarctica, where Jurassic marine units are exposed. To date, three fieldwork seasons have been carried out, two (2016, 2018) to the Ameghino Formation (Kimmeridgian-Berriasian) and more recently (2019), to the southwestern part of James Ross Island (Tumbledown Cliffs). The preliminary results of these field trips show that the taxonomic diversity of fishes from the Ameghino Formation is greater than what had been previously reported. Additionally, the numerous bromalites recovered –bearing fish remains – are fundamental to understand the dietary habits of these organisms. The study of the Antarctic fish material will provide new evidence for the phylogeny, paleoecology, paleobiology and morphological disparity of these taxa, but also will inform about predator-prey interactions, paleobiogeography, paleoenvironments, and fossil diagenesis. These data will be useful to improve the understanding of the evolutionary history of the major clades of fishes that inhabited the seas surrounding Gondwana during the Mesozoic. The combined studies will provide a better picture of the biodiversity, paleobiogeography, and paleoenvironments during the Jurassic in Southern Gondwana. Moreover, the study of ancient Antarctic ichthyofaunas are also of interest to understand the climatic changes undergone in the Antarctic continent and how these affected the life of the fishes that lived there.

A390

Session20: Evolution of the biota of West Antarctica: a Gondwana perspective

New fossil vertebrates from the Paleogene of Seymour/Marambio Island, James Ross Basin, West Antarctica

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We present here an advance of the results of the 2019 austral summer field trip to the Paleogene outcrops of Marambio/Seymour Island, under the project "Vertebrate Paleontology of the James Ross Basin, Antarctic Peninsula" of the Instituto Antártico Argentino (Dirección Nacional del Antártico). Different fossiliferous localities of Cross Valley (Paleocene), La Meseta and Submeseta (both Eocene) formations, were prospected. More than 100 kg of sieved sediment from several Eocene localities, were prepared in bags in order to search for microvertebrates remains at the lab. Among the preliminary results, a large number of fossil vertebrates can be accounted; this collection includes several penguin, sharks, teleostean, whales and land mammals. Besides, an extensive level with starfish in life position in the intermediate levels of the Submeseta Formation, close to the Marambio station.

The works in Cross Valley Formation allow the recovery of some vegetable remains but as usual it was completely sterile for vertebrates specimens. New remains of the Gadiformes Mesetaichtys were found in different level and localities of La Meseta and Submeseta formations. A very well preserved skull assigned to a large penguin with the bill complete and preserved in several pieces (Aves, Sphenisciformes) was found in Bartonian levels of the Submeseta II Allomember in the Submeseta Formation. This finding constitutes the only penguin skull with the bill completely preserved and without evident deformation.A further analysis of this material will permit to improve our knowledge about the anatomy and paleobiology of the giant penguins that live in Antarctica during Eocene times. A second bird was found in a coetaneous neighboring locality. It consists in a fragment of mandible belonging to a Pelagornithidae, a medium-small pseudo-toothed bird.

Although the land mammal record in the mentioned outcrops is less common since the marine nature of these Paleogene sediments, their only known fossil record in Antarctica came from these level as a consequence of postmortem transport. A complete tibia bone of around 300 mm length was collected also from Southern Bartonian levels of the Submeseta Formation, being the first terrestrial mammal found in the locality DPV 13/84. Additionally, a fragmentary tooth, of an indeterminate large terrestrial mammal was found in levels of Cucullaea I Allomember at the classic locality IAA 1/90. The specimen has a thinner enamel than sparnotheriodontids and astrapotherians from the same levels, a main crested-cusp and only part of the external enamel preserved. Among cetacean record an Archaeoceti tooth was found in the same levels, but in the near locality named Col. Victor and another one, preliminary assigned to a Pelagiceti since the wear over their cusp, was found in the Submeseta Formation levels of IAA 4/12. Pelagiceti were already recorded in Antarctica but until now, only in the lower levels of Cucullaea I Allomember of La Meseta Formation.

Despite the continuous paleontological work in these outcrops since 1980s , the abundance and quality of the mentioned discoveries reveal a high probability of make new, important and quality

findings in the Paleogene outcrops of Seymour Island. The erosive process over these units, exposes each year fossil vertebrates, that will not be preserved for long time since the Antarctic weather inclemencies. Localities considered exhausted in their vertebrate fossil record as RV-8200 or IAA 1/90 still allow the recovery of new birds and mammals taxa in the last field works. Plus that, several new localities as DPV 6/84 or IAA 2/16 still needs to be systematically worked.

Session21: Geomicrobiology of Antarctica and Patagonia

Revealing microbial influences on alteration of basaltic rocks as inferred from water and rock chemistry: Implications for Weathering processes on King George and Deception Island, Antarctica

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Rock samples with a basaltic composition were collected from South Shetland Island Group, King George and Deception Islands, Antarctica for experimental studies. A series of biotic and abiotic laboratory experiments with a different composition of basalts were carried out under various environmental conditions (e.g agitated-shaken and non-agitated-non-shaken, grain size). A moderately halophilic bacterium Virgibacillus marismortui was used in the biotic experiments carrying basalt and minimized nutrient medium. The experimental setup was carefully designed to monitor changes in water and rock chemistry as a result of microbial and chemical alteration. Periodically taken aliquots were analyzed for major cations (Si, Al, Fe, Mg, Na, Ca), pH and microbial cell counts. Our results demonstrated that elemental release behavior did not show significant changes in agitated and non-agitated abiotic experiments. Compared to the abiotic experiments, element release behavior and concentration were significantly high in the biotic experiments after 22-day incubation. The concentration of Fe (136 µg/L) Ca (314 µg/L) and Mg (240 µg/L) is at least fivefold higher in the non-agitated biotic experiments than their abiotic counterparts. The experimental data also revealed that the greater amount element released from non-agitated samples during the biotic experiments. SEM images of the reactive basalt samples from the end of the leach experiments revealed plate-like crystals and burrow-like structures on the grain surfaces supporting hydrous Mg bearing formations as a result of bacterial activity. Consistently, EDX analysis of the reactive basalt samples from the biotic experiments showed enrichment in Mg, C, O further supports the possible formation of hydrous (?) Mg-carbonate on the surface.

This study provides strong evidence that bacteria can significantly contribute to basalt dissolution and the surface of basalt can carry traces of microbe-mineral interaction under saline conditions. Therefore, our results may help to better understand the dissolution mechanisms of basalts in aqueous saline environments, which is demonstrated to be common on Mars' past conditions.

A320

Session21: Geomicrobiology of Antarctica and Patagonia

Inorganic and organic carbonate precipitation in the Laguna Timone Maar, Pali Aike volcanic field, southern Patagonia.

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The Timone Lagoon is a Lower Pleistocene maar immersed in the Pali Aike Volcanic Field, located in Patagonia, northeast of Punta Arenas city. The Timone Lagoon was covered by an ice sheet at 14 ka. The brine waters contain Na (ca.16700 - 24300 mg/L) and Cl- (ca. 18800 - 29400 mg/L) where an abundant precipitation of carbonate is produced under extreme environmental conditions including high salinity, high pH (> 9.6), temperatures close to zero degrees, and low annual precipitation (ca.250 mm). The development of carbonates is conditioned by a series of factors, such as: saturation of Ca+2 ions, pH, environmental conditions, climatic and hydrological, as well as petrological and textural parameters (mineral composition, porosity, permeability of the sedimentary material) and biological control.

Special emphasis was devoted to the study of a deposit of carbonates located above the level of the lagoon, referred as thrombolites, and calcareous crusts developed in the surface of clasts in its flood zone. The mineralogy of thrombolites consists of calcite and monohydrocalcite, while the calcareous crust is composed of calcite and aragonite. The mineral phases present in the sediment samples are mostly plagioclase, potassium feldspar, biotite, amphibole and olivine, which comes from the adjacent rocks and the unconsolidated quaternary sedimentary fill.

In order to understand the origin of the carbonates, either organic and/or inorganic,
a physicochemical water analysis was elaborated. This research examined mineralogy/composition of sediments and microscopic petrography, X-ray diffraction, scanning electron microscopy, microbiological and isotopic studies of adjacent carbonates. The isotopic investigation revealed that the formation of the carbonate the biological control is important, especially the ancient thrombolites present in the lagoon; without discarding a not less amount of inorganic precipitated carbonate such as the carbonate crust. The δ13C signal in carbonate deposits is an effective tool to distinguish between inorganic and biologically induced precipitation, where negative values of ‰ δ13CVPDB (-0.1 to -0.4) are characteristic of inorganic precipitation, while positive values of ‰ δ13CVPDB (+0.2 to +5.7) are linked to biologically induced precipitation.

The great extreme environment diversity found from the North of Chile to the Patagonia and Antartic includes bio-geological ecosystems that have been barely explored. These geobiologial ecosystems offer sites of great interest to conduct research about the origin of life on Earth.

A452

Session21: Geomicrobiology of Antarctica and Patagonia

Preliminary results on the geomicrobiology of the sedimentary substrate of the Laguna Timone maar, Patagonia

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The Laguna Timone is located about 40 km east of the Andean cordillera and immediately north of the Magellan Strait, at an elevation of 250-300 m.a.s.l. The area is characterized by low rates of precipitation (250 mm per year), low temperatures and strong winds. Surficial waters of Laguna Timone are characterized by saline and alkaline brines. As in many crater-lakes of the Pali Aike volcanic field, stationary carbonate precipitation occurs in the flood zone of the lakes, commonly removed by the effect of westerlies. The Laguna Timone corresponds to a lower Pleistocene lake-filled maar of the Pali Aike volcanic field, which is the southernmost expression of the Patagonian basaltic plateau lavas. The area was covered by an ice sheet at 760 ka. The orientation of maars and cones indicate that volcanism occurred along NW-SE and E-W fissures of lithospheric scale that crosscut the sedimentary in-fill of the hydrocarbon-bearing Magallanes Basin. Samples of sediments were extracted at 50 cm and 100 cm depth in the substrate below the eastern shore of Laguna Timone maar, with the purpose of identifying the mineralogical habitat of microbial communities. This was done through Tescan microscopy and 16S rRNA sequencing techniques. At both levels the detected mineral constituents, ranging in size between 0.1-1.0 mm, are represented by detrital grains of: plagioclase (30%), quartz (25%), K-feldspar (10%), biotite (10%), amphibole (10%), olivine (8%), carbonate (4%), Pyroxene (1%), Fe-oxides (0.4 %), among other subordinate phases. Mafic phases, such as olivine and pyroxene, together with an amount of plagioclase derivates from weathering of local basalts and basaltic volcanoclastic deposits around the lake-filled maar. The provenance of other mineral phases, of average granodiorite composition, is contributed by mechanical remobilization of glacio-fluvial deposits formed during progressive cycles of advance and retreat of ice sheets, and formed ultimately by material derived from the Andean cordillera. Near-surface dissolution of plagioclase and olivine (ca. 40%) may contribute with dissolved divalent cations such as Ca2+, Mg2+ and Fe+2, increasing the alkalinity of surficial water. The bacterial genera and their abundances at different depths is as follow. At 50 cm: Nitrosospira (20%), Candidatus nitrotoga (15%), Enterobacter (10%), Geothrix (7%), Candidatus nitrosotalea (5%) and Candidatus planktophila (5%). It is remarkable the presence of Candidatus methanoperedens (2%) and Acidiferrobacter (2%). At 100 cm: C. methanoperedens (50%), Paenibacillus (13%), Propionibacterium (11%), Rhodoferaz (6%), Sideroxydans (5%), Arthobacter (5%) and Diaphonobacter (4%). On basis of previous works the identified bacteria are known for their role in biogenic processes such as: nitrification (NH3 -> NO2- or NO3-; Nitrosospira and C. nitrotoga) at 50 cm depth; methane oxidation (CH4 -> CO2; C. methanoperedens) at 100 cm depth. The detection of Arthrobacter species reveal metabolic activities in extreme environments. Rhodoferax and Sideroxydans have been related to the redox-cycle of Fe which is a key factor in the Carbon flux, speciation and mobility of elements in aqueous fluids in a wide spectrum of natural environments. The difference of bacterial genera could be related to the proximity to the atmosphere and surficial water and to physical properties of the substrate such as granulometry, porosity and permeability that provide the space for development and protection of microbial colonies. To clearly understand this last relationship we will carry out more detailed studies of granulometry and the finest material.

Session21: Geomicrobiology of Antarctica and Patagonia

Patagonia Modern Microbial Carbonates: Potential Areas To Better Understand Early Life

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Modern carbonate environments, where microbialites are forming under comparable geomorphological, biological, climatic, volcanic and tectonics characteristics, are possible analogs to improve our understanding of the physical-chemical processes involved the formation of ancient microbial carbonate deposits. Nevertheless, it is difficult to study a single modern example, which fulfills all the criteria required to define a realistic evolutionary model for Early Life. Thus, we have selected for our evaluation several modern locations containing microbialites, which form under variable environmental conditions, e.g., the Pantanal, Central Brazil, Patagonia, Chile, and Puna, Argentina. These environments present vastly different conditions, which can furnish important insights, and taken together provide fundamental information to decipher relationships between the inorganic and organic processes involved in carbonate reservoir formation. The primary goal of integrating studies of these three distinctly diverse environments located in varying geological settings is to develop an actualistic facies model representing the ancient conditions of the various lacustrine depositional environments, ranging from deep subaqueous, intermediate subaqueous, shallow subaqueous and subaerial systems. Highlighting, in Chile's Patagonia Torres Del Paine region, the Sarmiento and Amarga lakes are located in an area of glacial regression, which represents an environment with recent microbialite formation in a cold and arid climate. Additionally, in this cold, arid region, Lake Pali Aike, situated in the crater of a dormant volcano, is potentially an interesting case study. All these areas were described as carbonate precipitation associated with microbial activity. Each of these different regions is characterized by extreme environmental conditions, high temperatures during the day and very low temperatures at night and very strong winds. The methodology applied is based on macroscopic and microscopic observations of outcrop and drill core samples, the facies were defined and distinguished by textures and microbial fossil content. Changes in facies type are related to alternating paleo-water depths, as reflected by C&O stable isotope cycles resulting from fluctuations in the sources of meteoric water, also Clumped Isotope was applied. With the advent and application of new high-resolution microscopic and geochemical techniques, investigations of microbialites can now yield new information into the depositional conditions at the time of their formation and subsequent diagenesis, as well as providing insights into the paleoenvironmental evolution of the Earth's surface.

A083

Session22: Emerging Frontiers in Satellite Remote Sensing and Geoinformation in Antarctic Earth Sciences: Cross-disciplinary Advances

A computational framework and 3D model, 'agrid', for interdisciplinary Antarctic research.

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Numerous data compilations, models and interpretations are now available that constrain aspects of the crust and lithosphere of the Antarctic continent. A broad range of datasets must be combined for interdisciplinary studies. The Antarctic research community, therefore, needs a way of handling multiple models and constraints such that discrepancies may be understood. Models should be accompanied with uncertainty, provenance and likelihood information, to be taken forward for usage by (e.g.) GIA researchers and ice sheet modellers.

We present a computational environment 'agrid' that aims to provide a multidimensional model and framework for interdisciplinary research. This environment is built using Python high-level programming language, with the aim of providing an accessible user interface, such that minimal coding experience is required for effective use.

The multidimensional grid can be populated by datasets (e.g. seismic wavespeed, free-air gravity, geological databases, digital elevation) in a way that facilitates dynamic updating as the underlying geological and geophysical compilations improve. Rasters, unstructured grids, vector data as polygons or lines can be imported to the dynamic regular grid. The implementation is flexible and allows for stochastic models and increased dimensionality, e.g. changes over geological time. Metadata on data provenance and uncertainty are allowed for. Export formats (e.g. netCDF, ASCII and GeoTIFF) are interoperable for a wide range of applications, and the code also contains methods for 3D visualisation and generation of maps. We illustrate the framework through a comparison of constraints on the spatial variation of heat flow across East Antarctica.

A237

Session22: Emerging Frontiers in Satellite Remote Sensing and Geoinformation in Antarctic Earth Sciences: Cross-disciplinary Advances

GeoMAP dataset of the Antarctic Peninsula

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A new geological dataset has been compiled for the Antarctic Peninsula covering the area between 58°S & 74°S using available maps and datasets from BAS (British Antarctic Survey). The dataset was based initially on the Antarctic Digital Dataset (ADD) rock, moraine and lake polygons that were re-located and reshaped (as necessary) using the Landsat Image Mosaic of Antarctica (LIMA). Each polygon was given information on rock type, geological name, age, original map source-author bibliography and a source code. The GIS database employs international GeoSciML data protocols for feature classification and description of rock and moraine polygons that are attribute-rich and can be interrogated; including links to bibliographic source files for primary literature and maps. All new digital data are linked to the original published work. Many of the early maps left rock outcrops as 'unclassified', but recent work by Burton-Johnson & Riley (2015) provides a regional-scale interpretative framework of major structural units and boundaries. Where polygons were previously mapped "unknown", the regional interpretation was used to infer geology using a "?" symbol in the unit codes to clearly identify 'inferred data' from outcrops that have been visited and/or are better understood. A series of fault lines have been captured, many of which are interpreted and concealed beneath ice, but appear somewhat simplified at 1:250,000 scale. All fault line data contain information on accuracy and exposure, as well as source of information.

1569 structural measurements of bedding, foliation and lineation were also captured, located within areas of rock polygon outcrops they represent. Supraglacial features and glacial till, seasonal water and blue ice, have also been mapped and classified from the LIMA imagery. Data are presently in ArcGIS geodatabases and shapefiles, but can be easily opened in QGIS, or translated into other formats such as kml. The work was completed by the first three authors while visiting New Zealand on SCAR-supported student internships. It contributes to the international SCAR GeoMAP initiative to compile a unified geological dataset of Antarctica. Data for the Antarctic Peninsula form one of the larger GeoMAP datasets that will be released at the ISAES XIII conference.

Burton-Johnson A. & Riley T.R. (2015) Autochthonous v. accreted terrane development of continental margins: a revised in situ tectonic history of the Antarctic Peninsula. Journal of the Geological Society, 172, 822-835, 4 August 2015, https://doi.org/10.1144/jgs2014-110

A253

Session22: Emerging Frontiers in Satellite Remote Sensing and Geoinformation in Antarctic Earth Sciences: Cross-disciplinary Advances

GeoMAP on REMA

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The first version of GeoMAP (v.201907) will be released at the ISAES XIII meeting, providing a modern geological GIS dataset describing exposed bedrock and surficial geology of Antarctica. This poster illustrates the GeoMAP dataset draped over another recently released continent-wide dataset - the Reference Elevation Model of Antarctica (REMA).

GeoMAP construction occurred from 2015-2019 through an international effort involving ~18 key collaborators, 11 student volunteers, and much manual labour. The aim was to capture existing geological map data, update its spatial reliability, and improve representation of glacial sequences and geomorphology. The new GIS dataset comprises over 83,000 polygons that describe 'known geology' of rock exposures, rather than 'interpreted' sub-ice features, using a mixed chronostratigraphic- and lithostratigraphic-based classification. The map displayed here renders GeoMAP polygons with colours reflecting rock or deposit age, many of which will be difficult to see at a continent scale. A rich attribute table enables these data to be displayed or queried in a wide-variety of ways. Other data captured for GeoMAP, but not displayed here, includes a source bibliography of 502 polygons outlining maps and previous work, 1476 fault lines and 3850 structural data points. GeoMAP has potential to provide fresh perspectives, for example, through combined geological legends and interrogation of continent-wide time-space plots. It is also ideal for continent-wide perspectives and cross-discipline science.

GeoMAP has been displayed over a shaded greyscale image of REMA (Howat et al. 2019) relief, downscaled to 200 m resolution with data gaps filled by a 100 m DEM to provide visual continuity. REMA was constructed using the Blue Waters supercomputer and the open source photogrammetry software SETSM. A series of individual DEM's were developed from DigitalGlobe optical stereoscopic satellite images acquired from 2009-2017, then registered vertically to satellite altimetry measurements from Cryosat-2 and ICEsat. REMA has absolute uncertainties of less than 1m over most of its area and relative uncertainties of decimetres. Version 1 has been developed into a high resolution (8 m) terrain map covering ~98% of the Antarctic continental landmass.

Howat, I. M., Porter, C., Smith, B. E., Noh, M.-J., and Morin, P.: The Reference Elevation Model of Antarctica, The Cryosphere, 13, 665-674, https://doi.org/10.5194/tc-13-665-2019, 2019.

A272

Session22: Emerging Frontiers in Satellite Remote Sensing and Geoinformation in Antarctic Earth Sciences: Cross-disciplinary Advances

SCENARIO OF GLACIER ICE DYNAMICS OF EASTERN AND WESTERN PARTS OF ANTARCTICA

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The ice velocity is one of the important parameter of glaciology. The glaciers present at the periphery of Antarctica are fast moving except few of them which are small in size. The ice velocity of glaciers was estimated using ImGRAFT (Image Geo-Rectification and Feature Tracking toolbox) software which is based on Normalized cross correlation techniques. MODIS (Moderate Resolution Imaging Spectroradiometer) data was used to measured ice velocity of glaciers. Few glaciers were monitored for more than one decade to estimate the changes in the ice velocity along with the calving and advancement. The result determines that the velocity observed was higher for western glaciers than that of eastern region. Iceberg calving is an important event as it contributes to sea level rise. The iceberg calving is frequently observed at western part of Antarctica. The glaciers of Western portion show more velocity in compare with the eastern portion of the Antarctic. Moreover, the western glaciers show more calving events in comparison to the eastern part.

The present studies deal with the overall dynamics of the glaciers and its impacts on the climate change. Increase calving events and melt days has the huge impact on the glaciers. The increase in the ice velocity lead to advancement of the glacier which floats on the oceanic surface and eventually breaks. The western portion of Antarctica shows more surface melting in comparison to eastern part, due to which the western parts are more prone to melting and shows ablation in western part, whereas accumulation in eastern part. The western portion show negative mass balance in comparison to eastern part. All this factors are equally responsible for the health of glacier. Hence, it is important to monitor glaciers of eastern and western part of Antarctica. The study comprises all three major parameters i.e. ice velocity, melting and mass balance.

A311

Session22: Emerging Frontiers in Satellite Remote Sensing and Geoinformation in Antarctic Earth Sciences: Cross-disciplinary Advances

Spectral approach to map blue ice area of the Polar Record Glacier, East Antarctica

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Blue Ice Area (BIAs) are characterized by negative mass balance where wind and sublimation remove more snow and firm cover from the top of the ice sheet and exposing older, denser ice beneath. BIAs account for 1% of the Antarctic surface area and are widely scattered over the continent and mostly found in coastal or on the outlet glaciers at higher elevations. Previous research has shown that BIAs provide optimal hunting grounds for meteorites sought for paleoclimatic studies. The environmental sensitivity of BIAs to changing climatic conditions makes it popular among glaciologist, meteorologist, geologist, environmentalist and climatologist. For the research station in the Antarctic, BIAs is the BIAs of Polar Record Glacier, East Antarctica, using satellite-based remote sensing approaches, based on multiple indices method using spectral signatures and thresholding albedo values. This study revealed that more than 30% of the total surface area of the Polar Record Glacier has been covered with BIAs. The temporal analysis shows that there is significant variation in the spatial extent and total surface area of BIAs. This difference in the total area is influenced by the multiple factors, such as the geographical area, the katabatic wind, the direction of ice flow, rate of sublimation and ablation, wind pattern, variation in surface temperature, mass balance, etc. The analysis also inferred that the variation in parameters like albedo of the glacier causes significant variation in the surface area and spatial extent of BIAs. Polar Record glacier which once had an area of more than 500 km2 has now shrunk to around 350 km2 due to the high amount of ice calving from its tongue. Therefore, this study is an important attempt to investigate the further impact of BIAs on the mass balance of this glacier.

A445

Session22: Emerging Frontiers in Satellite Remote Sensing and Geoinformation in Antarctic Earth Sciences: Cross-disciplinary Advances

Evidence for a permanent lava lake in British Territory: Remote sensing of Mt. Michael, South Sandwich Islands

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Mt. Michael is an active stratovolcano on Saunders Island in the South Sandwich Islands; a remote, oceanic island arc in the southern Atlantic Ocean between South America and Antarctica. The arc contains some of the most active volcanoes in the British territory, yet little is known about their activity or behaviour. Previous analysis of satellite data from the 1990s suggested the existence of a lava lake inside Mt. Michael's crater, but there have been no long-term investigations to determine if this is a permanent feature or what dangers it may pose. Lava lakes are extremely rare with only a few global examples, and this would be the first on British territory.

As in-situ observations of Mt. Michael are extremely difficult due to its remote location, dangerous surrounding sea and inhospitable surface, Landsat and Sentinel satellite data was used to monitor activity and detect thermal anomalies within the crater. We identified persistent volcanic eruptions and plumes throughout the thirty-year period studied. On five occasions in 2006 and 2018 a thermal anomaly within the crater was detected in shortwave infrared bands centred on 1.65 μm and 2.2 μm. Conversion of at-sensor radiance to land surface temperature using the Planck Equation estimated the pixel-integrated temperature of the lava lake at 233-427 °C. Further analysis using the well-established dual-band method estimated the molten lava to be radiating at 1040-1259 °C, assuming a cooler crustal lava of 200 °C. These observations suggest the lava lake is a permanent feature.

Associated publication:

Gray, D. M., Burton-Johnson, A. & Fretwell, P. (In Review). Evidence for a lava lake on Mt Michael volcano, Saunders Island (South Sandwich Islands): Application of Landsat, Sentinel-2 and ASTER satellite imagery. Journal of Volcanology and Geothermal Research.

Session22: Emerging Frontiers in Satellite Remote Sensing and Geoinformation in Antarctic Earth Sciences: Cross-disciplinary Advances

The northern Antarctic Peninsula region spectral library of ice-free areas to support ground truthing and validation of satellite information

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The northern Antarctic Peninsula region ice-free areas, mainly located within coastal areas, are of interest for studying glacial, periglacial, fluvial, and coastal processes and landforms. Furthermore, these areas are of importance as they contain fragile ecosystems, sensitive to environmental changes and located within a region that is strongly affected by global warming. The implementation of Visible Near Infrared (VISNIR) reflectance is often applied to characterize and monitor soil surface conditions and features. In the case of regions such as Antarctica, VISNIR sensors may be limited when meteorological conditions are not optimal. However, they can still provide vital information when data is available. Spectroscopy data compiled into spectral libraries provide the necessary detail that can be implemented for ground truthing and for validation of remotely sensed satellite information. The objective of this work is to use site-specific spectral library data to characterize and monitor different complex surface covers that represent past and present dynamic conditions within ice-free areas of the South Shetland Islands and along the Danco Coast of the Antarctic Peninsula. This includes using field and laboratory spectra that are associated to selected test sites on Fildes Peninsula, Barton Peninsula, Hurd Peninsula, Byers Peninsula, Deception Island and Cierva Point. During several field campaigns, associated field observations of surface features and processes, soil and sediment sampling were carried out in the mentioned places. Furthermore, physical and chemical laboratory analysis of the samples were carried out. An integrated methodology was developed where all the information was compiled into a detailed georeferenced spectral library. Data were also obtained from remotely sensed multispectral satellite sensors LANDSAT family (5, 7 and 8) and SENTINEL2 to cover the entire ice-free areas as well as building a time series database. Results have shown that the spectral library provided the necessary details to spectrally differentiate the different complex land surface covers and processes and provided the necessary reference spectra to interpret and validate the multispectral information. SENTINEL2 data with a 10 m spatial resolution had a clear advantage with that of the LANDSAT family data with a 30 m spatial resolution. However, LANDSAT has the advantage of a much larger time series that goes back to the mid 80's of the last century. Therefore, a combined use of the multispectral data has been used to determine changes in the spatial distribution of the different surface covers and also the retreat of glacial ice-fronts. Within the VISNIR spectral range, vigour of vegetation covers such as mosses, lichens and grasses were well identified. A standard machine learning classification such as random forest was used to obtain their spatial distribution and results showed coverage fluctuations within different areas. Therefore, compilation of the spectral library was a useful tool for identifying different surface properties throughout the region. Labelled image-derived spectra using

multispectral data were an advantage for classification purposes in areas that present limited and difficult access.

A091

Session23: Advanced Technologies for Research and Operations in Polar Regions

Geophysical investigation in the Ukrainian marine Antarctic expedition of 2018: measuring equipment and methods of prospecting, some results

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In Ukrainian Marine Antarctic Expedition of 2008 the geophysical investigation has been carrying out from the board of "More Sodruzhestva" vessel on the route Cape Town port (South Africa) - Falkland Islands - King George Island, as well as on polygon in the area of Antarctic Peninsula. The studies were performed using mobile and direct-prospecting geophysical methods and were aimed at studying the deep structure of the oceanic lithosphere along the vessel route and detecting possible accumulations of hydrocarbons and other minerals. The approbation of methodological principles of the direct-prospecting geophysical methods and technologies using during the search for hydrocarbon accumulations was carried out in expedition. A significant amount of experimental work was carried out during preparation for expedition and after its completion on the Ukraine territory and in other regions of the world.

The used in Expedition mobile technology include modified methods of frequency-resonance processing and decoding of satellite images and photo images, vertical electric-resonance sounding (scanning) of cross-section, as well as instrumental complex for measuring the intensity of natural electric field of the Earth with fluxmeters. Separate methods of technology are based on the principles of "substance" paradigm of geophysical research, the essence of which is to search for a specific (the one sought in each particular case) substance - oil, gas, gas condensate, gold, zinc, uranium, etc. At various stages of research in marine expedition, the technology of integrated assessment of oil and gas prospects and ore potential of large exploration blocks and license areas was purposefully used.

In the southern Atlantic and in the region of Antarctic Peninsula, a significant number of local sites and big areas, which are promising for oil and gas searching, have been discovered and new evidence has been obtained in favor of their deep (abiogenic) origin. In the study areas (in Western Antarctica, including) the vertical channels for deep fluids and minerals migration have been revealed by vertical sounding of the cross-section, the widespread presence of salt layers of various thicknesses, as well as the melting zone (liquid state) of rocks in depth interval 194-225 km were established. The detected vertical channels of deep fluids and mineral migration are filled with various substances — granites, kimberlites, dolomites, and sedimentary and ultramafic rocks. The deep structure of some known volcanoes in Antarctica has been studied. The obtained results show that the roots of the examined channels of deep fluids and minerals migration (volcanoes, including) can be located in the molten (liquid) layer of rocks, as well as at depths of 470 km and 723 km. The materials obtained show that in the Antarctic region a significant role in the formation of its geological and tectonic structure belongs to volcanic activity.

A large amount of materials was received in expedition, further analysis and synthesis of which will accelerate and optimize prospecting process for various types of minerals, as well as deepen our understanding of the geological and tectonic structure of Earth and of mineral deposits formation.

A164

Session23: Advanced Technologies for Research and Operations in Polar Regions

Organizing the runways in the area of the Russian Antarctic stations in East Antarctica sector during the seasons of the 59 - 64rd RAE (2013/19)

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For logistic operations of the Russian Antarctic Expedition (RAE), maintaining the existing runways near the Russian wintering stations and field camps, as well as the creation of new ones, is of great importance. The presence of airfields ensures a mobility of personnel and a movement of goods, which greatly simplifies implementation of field work and provision of stations. One of the most significant is the airfield of Novolazarevskaya station, which is organized in a zone of "blue ice". Its distinctive feature is an ability to take airplanes on a wheeled landing gear, in particular, IL-76TD. Most airfields are organized on a snowy surface and are designed to receive airplanes on a ski landing gear, since the blue ice zones are few in number. In this regard, their identification, especially near infrastructure, is an important application. Zones of "blue ice" of sizes acceptable for organization of aerodromes are presumably located in the area of the Russian Progress and Mirny stations. The work aimed at their search and study was carried out in the period 2016-19 by conducting GPR and glaciological works.

In addition, until recently Mirny station was the only Russian station that does not have air traffic. In this regard, during the field work of 2013-2016 complex GPR, glaciological, geodesic and drilling investigations were conducted aimed at revealing the place and organizing the snow-runway. The work was complicated by the presence of numerous zones of crevasses located in the station area. However, the place was chosen, and on February 10, 2016, the medium-range DC-3T (BT-67) Turbobasler from ALCI was taken to the landing pad.

A371

Session23: Advanced Technologies for Research and Operations in Polar Regions

Photostable polymeric nanoparticle containing organic near-infrared dye with enhanced biocompatibility under hyperthermal irradiation at low-temperature.

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Polymeric micelles are versatile nanocarriers to carry hydrophobic moieties within the core in aqueous media. We report engineered polymeric micelles encapsulating highly photostable organic near-infrared (NIR) dye, IR788, for generating heat under NIR irradiation. In addition, the core of micelle is stabi-lized via semi-interpenetrating network formation (sIPN), which ensures stable loading under low tem-perature and enhances biocompatibility.

A424

Session23: Advanced Technologies for Research and Operations in Polar Regions

The development of portable hot water drill and hot-point drill for temperature measurement of mountain glacier

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The temperature of glaciers is an important index of glacier physical state, which reflects the climate, environment and movement conditions of glacier development. Up to now, in mountain glacier, a fair number of long-term observations of shallow temperature and 10 m snow temperature have been made. However, only a handful of measurement have been taken to measure the temperature near the bottom and vertical temperature distribution of glacier. According to the difficult logistics, portable hot water drill and hot-point were designed to drill access holes in mountain glacier. Then the temperature chain and heat flux sensor can be set in the hole for long-term monitoring. The lab experiment showed a good performance of designed equipment.

A433

Session23: Advanced Technologies for Research and Operations in Polar Regions

Use of Local-area Differential GNSS System for Polar Exploration

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Unmanned systems can replace human tasks in Polar Regions where humans are difficult to access due to exposure to low temperature, strong wind, and high radiation. Recently, the unmanned mission tasks of polar exploration have been expanded to glacier monitoring, ecosystem research, and inland exploration. To accomplish such unmanned exploration mission tasks successfully, precise and robust navigation system is one of the required capability. However, there exists several limitations on the polar navigation. For instance, Global positioning system (GPS), which is most widely used sensor for the positioning of unmanned systems, has limited vertical accuracy due to the low satellite visibility in high latitudes. Satellite-based augmentation system (SBAS) also has a drawback that the signal acquisition of the stationary satellite is difficult at high latitudes. Furthermore, magnetic compasses, which compute vehicle heading using horizontal component of geomagnetic force, become inaccurate as the user gets closer to the magnetic pole where the horizontal force is weak. Vision sensors are not available all the time due to the bad weather and the Polar night phenomenon. This motivated us to develop a robust and precise navigation system for polar exploration to estimate reliable position and heading of unmanned systems. The local-area differential architecture is selected as a base of the proposed navigation system. By utilizing the differential correction from the reference station, the navigation user can achieve accurate and reliable position and heading without using magnetic compass. In this study, the performance of satellite-based navigation in the Polar Regions is assessed through the simulations, and the feasibility of the proposed navigation system is analyzed using observation data from King Sejong station.

A434

Session23: Advanced Technologies for Research and Operations in Polar Regions

Microemulsion with near-infrared dye for surface adhesion and photothermal effect

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A highly photostable organic near-infrared (NIR) dye, IR788, converts light to heat. First, IR788-loaded polymer nanoparticles were prepared in aqueous phase to enhance stability and processability. Furthermore, we formulated water-in-oil microemulsion containing the nanomaterials to tune the adhesion property. We believe that the emulsified photothermal agents can be utilized in polar expeditions under sunlight.

A470

Session23: Advanced Technologies for Research and Operations in Polar Regions

Evaluation of dyes obtained from Antarctic red algae in DSSC

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Dye sensitized solar cells (DSSC) are photoelectrochemical devices that resemble natural photosynthesis because they use an organic dye to absorb light and produce a flow of electrons.
[1] They contain a nanoporous oxide layer with dyes attached to the surface. When photo-excitation of the pigment takes place, injection of an electron into the conduction band of the oxide occurs. The dye is then restored by the electron donation from the electrolyte, where a redox system such as the iodide/triiodide couple is contained. Iodide is finally regenerated by the reduction of triiodide at the counter electrode, and the circuit is completed through an electron migration at the external load.
[2] Today, many types of research are conducting around the search for the best dye in order to improve energy efficiency conversion. The use of natural dyes is an attractive alternative due to the low cost of fabrication and the environmental benefits related to their employment. More particularly, the search for clean sources of energy is relevant in the Antarctic area. DSSC constitute an alternative to partially solve the energy needs in this area, especially if we use dyes from red algae, that are in great abundance in South Seas.
[3] In this work, we study the extraction of dyes with different solvents, absolute ethanol and water. After that, we carried out spectroscopic and voltammetry studies in order to identify the dyes we extract and also to characterize and evaluate the potential use of them as sensitizers for DSSC. Finally, the cells were assembled with the different pigments obtained, evaluating its performance through electrochemical techniques as IV profiles and electrochemical impedance spectroscopy. These studies allowed us to obtain and compare the efficiency values of the energy conversion and the fill factor of the different cells.

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A436

Session24: Earth science informing environmental management and policy

The importance of global-south scientists engagement for the Antarctic preservation; opportunities to new policies and climate action to citizens

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Today we live in a changing world, where not only climate change is putting pressure on the different earth systems. Changes in geopolitics, business, and markets are putting more pressure on different ecosystems. Antarctica is well known as a thermal regulator for the earth's climate, although scientists have this information, it has not been enough to take concrete actions and stop those activities which put at risk.

Antarctica should be a priority for science diplomacy and science-policy interface worldwide, that is why RedLAtM, an atmospheric science organization, has started an initiative for young scientists in the global south specifically in Latin America and the Caribbean to help these countries adhere to the Antarctic treaty.

The global south must be positioned for Antarctica decision making in order to combat the scientific gap that still exists between north and south, as well as to improve the research networks in the white continent. The project called action for Antarctica, that empowers and develops capabilities especially atmospheric and climate scientists, to bring their knowledge to the highest level and their local governments, in order that all Latin America has a more equitable process in the Antarctic treaty system.

Finally, we facilitate the vision that scientists have the power to communicate to society the importance of polar areas and especially Antarctica and the importance it has for life as well as the climate literacy to achieve the Sustainable Development Goal 13-Climate Action.

A477

Session24: Earth science informing environmental management and policy

Consideration of geological heritage in the Antarctic protection system: current situation and future perspectives

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The methodology adopted to select the Antarctic geological heritage includes the identification of the most representative sites of interest (Geosites) within the previously recognized Antarctic Geological Frameworks, selected as geological contexts of international relevance. Criteria to propose Geosites include being the most remarkable places according to representativity, type locality or reference character, degree of scientific knowledge of the site, conservation status, observation conditions, scarcity, geological diversity, and association with other elements. The selection of Geosites is mostly based on their international geological relevance and does not require specific protection. Geosites may not need to be protected if the nature of the element and/or its location do not require it, if there are no threats, or if the general regulations within the Antarctic Treaty area provide sufficient protection. On the other hand, there may be Antarctic Specially Protected Areas with no Geosites, even if they include geological features that motivated or contributed to their designation as ASPA. This work develops a review and analysis of the geological features included in the current Antarctic Specially Protected Areas (ASPA) and Antarctic Specially Managed Areas (ASMA). The framework provided by the existing regulations and protection figures of the Madrid Protocol (specially under the Annex V about Area Protection and Management) to protect Antarctic geological values is compared with the categories of figures used for similar purposes by international organizations in other parts of the world. A series of criteria for the possible inclusion of certain Antarctic geological features in the geological heritage inventories or their possible designation as Geosite candidates are discussed, in comparison with criteria used in other parts of the world.

A479

Session24: Earth science informing environmental management and policy

Steps for the SCAR advice to the Antarctic Treaty System about identification and conservation of Antarctic geological values

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In the last few years, the Antarctic Earth sciences community has discussed and advanced consideration of the Antarctic geological values for their inventory and possible protection. An objective has been that SCAR provides advice to the Committee on Environmental Protection (CEP) of the Antarctic Treaty about a procedure to identify Antarctic geological heritage and develop conservation measures to protect elements in case it is needed. The aim of this work is to show the steps followed up to now in this process. A series of presentations focused on the convenience and possible methods to identify the Antarctic geological values and the issues associated to oversampling were presented into sessions dedicated to science advising policy in the last three SCAR Open Science Conferences (Auckland, New Zealand, 2014; Kuala Lumpur, Malaysia, 2016; and Davos, Switzerland, 2018). In 2014, the SCAR Delegates Meeting approved the formation of an Action Group on Antarctic Geological Heritage and Geoconservation within the Geosciences Group. This Action Group held meetings, open to the interested participants, during the biennial SCAR Meetings in 2016 (Kuala Lumpur) and 2018 (Davos). In addition, the topic of geoconservation was also discussed with the participants in the XII International Symposium on Antarctic Earth Sciences (ISAES), 2015 in Goa, India, like it will be in the XIII ISAES in July 2019 in Incheon, Korea. The presentations and discussions held in the mentioned meetings led to the acceptance by the Action Group, in Davos 2018, of a method to advance in the identification of Antarctic geological heritage. Two workshops held in Madrid, Spain, in November 2018, and Cambridge, UK, in March 2019 led finally to the preparation of the documents sent to the SCAR Standing Committee on the Antarctic Treaty System (SCATS) to prepare the SCAR advice to the CEP.

A112

Session25: Future opportunities for the exploration of Antarctic subglacial environments

Insights on the formation and long-term accumulation of perchlorate in Antarctica: A potential source of salinity to the subglacial environment

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The Antarctic environment has been used as a field laboratory for the search of life on Mars. Its dryness, lake salinities, and the extreme environmental conditions, are home to extremely tolerant organisms. The discovery of perchlorate on Mars by the Phoenix Mars Lander addressed the issue of existing liquid water as salty concentrated brines. Perchlorate salts have supercooling properties and high stability. For Antarctica, reports of high perchlorate concentrations were restricted to the Dry Valleys. Here we present a new insight of higher perchlorate concentrations (1.02 ± 0. 25 mg kg-1 and 25.92 ± 5.58 mg kg-1) in West Antarctica/Ellsworth Mountains, suggesting a broad spatial distribution and accumulation of perchlorate over Antarctica. Our aerosol measurements, combined with ice core data, support that (1) an active origin for perchlorate may exist in the Antarctic troposphere due to the action of UV-radiation and the snowpack geochemistry interacting with sea salt. The microscopic/molecular speciation of individual aerosols by means of speciation by Scanning Transmission X-ray microscopy with near edge X-ray absorption fine structure spectroscopy (STXM/NEXAFS), a unique signal of ClxOy-type-molecules is revealed; (2) Antarctica successively underwent interglacial warming phases which allowed leaching of salty crusts into subglacial and ice-covered lakes. The salty influx combined with the geothermal heat flux and the overlying ice sheet, may preserve water in its liquid state at the subglacial environment. With that insights, news studies should be conducted to explore perchlorate concentration and long term accumulation, even more the relation in subglacial enviroments.

A159

Session25: Future opportunities for the exploration of Antarctic subglacial environments

Simulating Antarctic subglacial hydrology processes beneath Pine Island Glacier, West Antarctica, using GlaDS model in Elmer/Ice

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Abstract: Antarctic subglacial hydrology plays an important role in ice dynamics via the modulation of basal friction. Increased basal water pressure accelerates glacial sliding and could increase the transport of ice to the ocean, leading to global sea level rise. Here, we use the Glacier Drainage System model (GlaDS) to study Pine Island Glacier (PIG), West Antarctica, one of the largest contributors to mass loss in Antarctica. GlaDS is a state of the art two-dimensional basal hydrology model which has the ability to simulate water pressure and flow through both distributed and channelized systems, as well as the exchanges between those systems.

We use basal meltwater inputs from a coupled temperature-traction inversion of PIG to compute distributions of water pressure and sheet discharge etc. We then enable the channelized drainage component in GlaDS to determine where we expect efficient drainage to form. Our results are broadly consistent with the current understanding of the glacier drainage system, showing high fluxes in the downstream area where shear heating generates large volumes of meltwater . We plan to compare our model predictions of effective pressure and drainage system with inversions of basal drag and driving stress. This should allow us to see the relationship between basal hydrology and basal sliding under PIG, and will allow us to predict how future changes in climate will effect ice sheet sliding. Our long-term goal is to couple hydrology and ice dynamics models together to enable more robust predictions of future sea level rise.

A315

Session25: Future opportunities for the exploration of Antarctic subglacial environments

Subglacially-precipitated carbonates reflect sub-Ice Sheet Hydrology

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Subglacially-precipitated carbonate (SPC) occurs in layers and as fissure-fills on bedrock hummocks in the Helliwell Hills of Northern Victoria Land (NVL), Antarctica. U– series dating of the carbonates demonstrates that most material grew near continously from 17 to 27 ka, although precipitates in growth position also formed during the last four glacial cycles as demonstrated by weighted mean U-Th ages of 162 ± 1 ka, 215 ± 2 ka, 254 ± 2 ka and 334 ± 4 ka. The combination of SPC micro-facies, high-resolution major and trace element mapping, δ18O and clumped isotope analyses of the SPCs indicate precipitation from sub-Ice Sheet meltwater. The SPCs have depleted δ13C driven by active microbial metabolism in the basal meltwater environment during SPC precipitation. Furthermore, the SPC isotopic and elemental geochemistry, combined with microbial DNA preserved in the SPCs, indicate that subglacial volcanism was active during their precipitation and likely induced melting of the local ice-sheet base. This meltwater was injected into interconnected basal hydrological systems and could have reached the ice sheet margin. The NVL SPC investigations are ongoing and have been expanded onto similar material collected from several locations around the EAIS margin.

A030

Session26: General Topics

Variations of Lake Ice Phenology on the Tibetan Plateau from 2001 to 2017 Based on MODIS Data

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Lake ice is a robust indicator of climate change. The availability of information contained in Moderate Resolution Imaging Spectroradiometer (MODIS) daily snow products from 2000 to 2017 could be greatly improved after cloud removal by gap filling. Thresholds based on open water pixel numbers are used to extract the freeze-up start and break-up end dates for 58 lakes on the Tibetan Plateau (TP), 18 lakes are also selected to extract the freeze-up end and break-up start dates. The lake ice durations are further calculated based on freeze-up and break-up dates. Lakes on the TP begin to freeze-up in late October and all the lakes start the ice cover period in mid-January of the following year. In late March, some lakes begin to break-up, and all the lakes end the ice cover period in early July. Generally, the lakes in the northern Inner-TP have earlier freeze-up dates and later break-up dates (i.e. longer ice cover durations) than those in the southern Inner-TP. Over 17 years, the mean ice cover duration of 58 lakes is 157.78 days, 18 (31%) lakes have a mean extending rate of 1.11 d yr-1 and 40 (69%) lakes have a mean shortening rate of 0.80 d yr-1. Geographical location and climate conditions determine the spatial heterogeneity of the lake ice phenology, especially the ones of break-up dates, while the physico-chemical characteristics mainly affect the freeze-up dates of the lake ice in this study. Ice cover duration is affected by both climatic and lake specific physico-chemical factors, which can reflect the climatic and environmental change for lakes on the TP.

A065

Session26: General Topics

Running on Empty: Leopard Seal Lipid Profiles Expose a Precarious Existence

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The climate of the Antarctic Peninsula is warming, resulting in less sea ice. These environmental changes may be pushing many Antarctic organisms beyond their normal physiological and behavior capabilities. The leopard seal (Hydrurga leptonyx) is an important Antarctic top predator but we know relatively little about its physiology and behavior. While leopard seals are known to consume a wide range of prey, including krill, cephalopods, fish, seabirds, and seals, the changing climate will likely alter the availability of leopard seal prey and thus affect the foraging patterns of leopard seals. The focus of our research is to understand the ability of leopard seals to adapt and respond to this changing habitat by examining their foraging behavior and physiology. The focus of this research is to examine the movements and diving behaviors of leopard seals in relation with measurements of their physiological capacity and also determine whether leopard seals are operating at or near their physiological capability: to determine if these apex predators have "reserve capacity" to buffer against the changing environment. During the 2018 field season, 10 leopard seals (7 females, 3 males; 147kg-540kg) were captured and tissue samples (blubber, Longissimus dorsi (LD), Pectoralis (P)) were collected for lipid/fatty acid (C14-C24) analyses. Percent contribution of total fatty acids was calculated based on double bonds (saturated (SFA), monounsaturated (MUFA), polyunsaturated (PUFA)) for all blubber and muscle tissues as change between corresponding blubber and muscle tissue. The relative percent contribution of SFAs was greater in all tissues for both sexes; there was a 25% increase in relative contribution of SFA between female LD blubber to LD skeletal muscle whereas a decrease in relative percent MUFA (45%) and PUFA (114%). More than half of the female LD samples had no detectable PUFAs. This pattern was similar between the female pectoralis blubber and muscle tissues (SFA, 21% increase in LD blubber; 32% decrease in MUFA and 99% decrease in PUFA between blubber and skeletal muscle). Male fatty acid analyses followed the same pattern (LD muscle;Pectoralis was not sampled) where relative percent SFA contribution in the blubber was 27% greater than the LD muscle. Unsaturated fatty acids decreased by 34% (MUFA) and 122% (PUFA) in the LD muscle when compared to LD blubber. Seventy-five percent of the male samples did not have detectable PUFAs in the LD skeletal muscle. These preliminary findings indicate 1) leopard seals appear to preferentially metabolize unsaturated fatty acids and 2) the leopard seal sampled prior to the winter months (April/May) have skeletal muscles with decreased MUFAs and depleted PUFAs when compared to corresponding blubber samples. Maintaining appropriate balance among fatty acid classes for thermoregulation (SFA) and sustained energy (MUFA/PUFA) is critical in this relatively extreme environment. These analyses provide evidence of the marginal energetic existence these predators experience in the Antarctic Peninsula. Ongoing analyses (free fatty acids in blood) are being performed to assess potential dietary role during sampling.

A102

Session26: General Topics

Identification of mountain glacier in the central Himalaya using ALOS-2 PALSAR data

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In order to study the application of SAR data in the identification of mountain glaciers in central Himalaya, six polarization decompositions were performed using ALOS 2 data, including coherent and non-coherent, to obtain 20 characteristic parameters, then combine it with the Landsat 8 image to select training samples and perform three SVM classifications. The results show that: classification accuracy of the incoherent decomposition characteristics based on the covariance matrix is the best, it can increased to 91% after adding local incident angle information. Recognition accuracy of 93% after recombination of multiple polarization parameters. The study also analyzed the influencing factors in the process of mountain glaciers identification, and found that polarization decomposition characteristic information and aspect are important factors affecting the identification of glaciers. The former is the main basis for identification, but the latter will amplify or attenuate the backscattered energy, confusing the distribution of features of different categories, and thus causing misjudgment. The fusion of different characteristics of polarization decomposition can effectively reduce the misjudgment between glacier and rock, and improve the classification accuracy.

A103

Session26: General Topics

Polymicrobial biofilms from Signy Island (Antarctica) and ROS production by bacterial isolates resistant to heavy metals

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Antarctic soils are constantly subjected to the extraordinarily harsh environmental conditions such as low temperature and freeze-thaw cycles. Soil microbes that dwell and survive under these environments are categorised as psychrophiles or psychrotrophs. These microbes have adaptive features like biofilm formation and reactive oxygen species (ROS) to overcome these extreme environments.

Biofilm formation contributes to resistance against environmental stresses as well as anthropogenic effects. Stress or toxins from the environments initiate survival mechanisms/pathways to protect these microbes. This will eventually leads to cross-adaptation for better survival by reinforcement. The current study focuses on above said survival mechanisms using heavy metals as stress factor.

The soil samples were collected from an expedition to Signy Island in Antarctica. The bacterial strains were isolated from the soil samples using 24 different media under 3 different temperatures viz 4℃, 10℃ and 15℃. The polymicrobial biofilms from soil samples were estimated by crystal violet assay. Microbial isolates that showed resistance to heavy metals like copper and zinc at various concentrations (0.03125mM- 4mM) were used for this study. Measurement of ROS production were quantified using peroxyitrite indicator, (DCFH-DA) for different time intervals with different concentrations of heavy metals exposure.

High-throughput 96-well format assay was used to evaluate biofilms formation. The results were varied depicting many ranges of conditions are able to support polymicrobial biofilm formation in vitro under psychrophilic conditions. Bacterial isolates showed remarkable resistance to copper and zinc. These heavy metals resistance strains were also observed to produce ROS at increasing levels of heavy metals.

A167

Session26: General Topics

Penguins feathers as bioindicators of mercury contamination in Ross Sea and Zhongshan station of Antarctic: geographical and temporal trends

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Feathers are confirmed as an important tool of assessing trace metal pollution for non-destructive biomonitoring has already been partially explored. This study has evaluated mercury pollution of feathers from Antarctic Adelie penguin. Feather samples were analyzed DMA-80 mercury analyzer .We measured the mercury levels in the feathers of different parts from the Adelie penguin, and then compared the differences in the mercury concentration levels of the Adelie penguins in the Antarctic Zhongshan Station and the Ross Sea area in 2019. Also different temporal changes in the concentration levels of mercury in penguin feathers collected at the same location in Zhongshan Station, Antarctica, were measured in 2015 and 2019, respectively. We found that the concentration of mercury in feathers of the chest and back increased from the root to the tip, and the level of mercury in the tip is close to twice of the root, while there is no regularity in Adelie penguin tail feathers. The mercury concentration in the chest and back of the penguin feathers were basically the same. At the same time, methylmercury in all parts of the feathers accounts for 70-90% of the total mercury content, indicating that mercury entering the penguin in any form is methylated in the feathers and eventually exists in the form of methylmercury.

In this study, we evaluated the mercury exposure in feathers of Antarctic Adelie penguins. Our specific objectives for this study were: 1) to assess mercury content of feathers from Adelie penguin and clarify the distribution characteristics and regularity; 2) to explain the variability of mercury content in adelie penguin feathers from different moulting areas in Arctic based on the assumed moulting pattern; at the same time, to survey the concentration changes of six target elements in feathers of Adelie penguin over time; 3) to provide a reliable biological indicator for monitoring mercury concentrations variability in polar environments by using the Adelie penguin feather as research objects .

Session26: General Topics

A New Project on Interaction of the Solid Earth and the Antarctic Ice Sheet

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A five years research project funded by JSPS (Japan Society for the Promotion of Science) has been started in July 2017. The title of the project is "Giant reservoirs of heat/water/material: Global environmental changes driven by Southern Ocean and Antarctic Ice Sheet" and is aiming to establish a new research area for Antarctic environmental system science. The project consists of 7 research topics, including Antarctic ice sheet and Southern ocean sciences, new observation methodology, modeling and other interdisciplinary topics, and we are involved in the topic, "Interaction of the solid Earth and the Antarctic Ice Sheet". The Antarctic ice sheet, which relates to the global climate changes through the sea level rise and ocean circulation, is an essential element of the Earth system for predicting the future environment changes.
Many studies of the ice sheet changes have been conducted by means of geomorphological, geological, geodetic surveys, as well as satellite gravimetry, satellite altimetry and other satellite observations. For these studies, one of the largest uncertainties is the effects of GIA (Glacial Isostatic Adjustment). Although GIA is a key to investigate the interaction between the solid Earth and the ice sheet changes, in-situ data for constraining GIA models are very few, in particular, in East Antarctica, and the main reason of the uncertainties comes from insufficient in-site observations. Thus we planned to conduct geomorphological, geological and geodetic surveys in the outcrop areas and the coastal areas including the surrounding areas of a Japanese station, Syowa, in East Antarctica. Combining these new observations with other in-site data, various satellite data and numerical modeling, we aim to estimate a precise GIA model, to construct a reliable ice melting history after the last glacial maximum and to obtain the viscoelastic structure of the Earth's interior.
A part of the first year activities, we have conducted absolute gravity measurements, GNSS observations and other field surveys near Syowa station and other areas. In the presentation, we will report the preliminary results of these surveys and the outline of other activities as well as the future research plans.
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Session26: General Topics

Seismic image for water column in the Ross Sea from multi-channel seismic data using the frequency domain reverse time migration based on analytic Green's function

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Marine seismic data have been commonly used to image the geological structures below the seafloor. Recently, acoustic images of the oceanic thermohaline structure from multi-channel seismic data were proposed, and several inversion methods that can calculate the oceanographic parameters from seismic data was developed. The thermohaline structure is commonly mapped by an onboard instrument such as CTD (conductivity, temperature, and depth) that measure depth profiles of temperature and salinity, either at single locations. It has practical limitations in the estimation of the volume for the thermohaline structure that can be sampled and in the horizontal resolution that can be achieved. The most significant benefit of observation for water column by seismic data is that it can continuously trace the thermohaline structures with high lateral resolution. In order to obtain the water column image from seismic data, classical seismic data processing methods including noise removal muting, frequency filtering, deconvolution, velocity analysis, and seismic data staking were applied as in the subsurface case. The only major difference is the frequency bandwidth. Seismic reflection events in the water column represent the boundaries between water masses and record the lateral and vertical extent of thermohaline fine structures. Therefore, the seismic oceanographic image needs more high-frequency component. Also, it is not a horizontal layer structure such as subsurface sediment. For that reason, a classical seismic data processing method that assumes the target structures as a horizontal layer has limitations in generating seismic images for various reflection events in the water layer. Reverse time migration (RTM) is the advanced method to construct a seismic image and has the advantage of preserving the real amplitudes of seismic wavefields. In addition, it can handle multi-pathing and steeply dipping layer. However, since this method requires a large amount of computing resource because of multiple wave propagation modeling procedure, it is difficult to calculate water column seismic image that includes the more high-frequency band (over 100 Hz). In this study, we propose the new RTM method for building accurate water column seismic image (migrated seismic image) and be applied to field data acquired from the Ross Sea, Antarctica. In this method, numeric calculation of the forward and backward modeled wavefield as performed in conventional RTM by assuming the constant speed of sound within the water column and applying an analytic Green's function to the unbounded half-space. This method provides a high-resolution seismic water column image at nearly full frequency band with minimal operator input compared to conventional seismic data processing, and it requires modest computational cost and relatively low memory compared to conventional RTM. This method was applied to several field data sets, and migrated images were verified by comparing with CTD profiles. Our proposed RTM method was successfully applied to the seismic data acquired from the Ross Sea and the accurately calculated water column seismic image allows us to better understand thermohaline structures in this area.

A230

Session26: General Topics

Field data about sedimentological and volcanological successions exposed on Livingston Island, Antarctica

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Livingston Island, the second largest island of South Shetland Archipelago is an area of extensive magmatism and sedimentation. Some ice free areas, such as Byers Peninsula, Hannah Point, Hurd Peninsula, and Barnard Point provide a very good potential for studying the outcropping rocks. The thick Upper Jurassic-Lower Cretaceous sedimentary and volcano-sedimentary sequences exposed on the Byers Peninsula are dominated by mudstones, sandstones, and rare levels of conglomerates and breccias. The sedimentary sequences are well dated based on ammonites, belemnites, palynomorphs, and fossil flora. Igneous rocks are present by almost magmatic facies – subvolcanic, hypabyssal shallow intrusion, effusive, explosive and volcanoclastic. Several basaltic cryptodomes are intruded into unconsolidated sediment rocks. The penetration of the basalts into wet sediments results in quench fragmentation and generation of in situ hyaloclastite. These textures are evidence for subaqueous setting of volcanism in this part of Livingston Island.

The rock sequences cropping-out at Hannah Point are composed mainly of different volcanic and volcanoclastic varieties and single fine-grained terrigenous sediments, and build thick volcano-sedimentary succession. Volcanic products include lava flows, pyroclastics, epiclastics, volcanic plugs and dykes. On Hannah Point are identified several single magmatic events, which allowed some reconstructions of the volcanic evolution to be made. Previous authors have analysed the age of basaltic andesite samples, corresponding to the mid and upper part of the succession using K-Ar dating. Results provide ages of 87.9 ± 2.6 and 67.5 ± 2.5 My respectively. The isotopic data is confirmed by fossil flora obtained recently from fine grained sediments.

Sedimentary successions exposed in the Hurd Peninsula consist mainly of siliciclastic sediments are included in Miers Bluff Formation, dated as Campanian/Maastrichtian (?Paleocene), based on calcareous nannofossils. The sedimentary complex is intruded by a number of dykes. The different volcanic rocks and smaller quartz-dioritic bodies are emplaced within Mount Bowles Formation (Campanian-Eocene). The north-eastern part of the peninsula is occupied by Hesperides pluton and some smaller intrusive bodies.

The magmatism on Livingston Island come to be younger from west to east: Upper Jurassic to Lower Cretaceous at Byers Peninsula, Upper Cretaceous at the central part (Hannah Point) and Eocene at Hurd Peninsula and Barnard Point. Along with this, the paleovolcanic setting changes from subaqueous at the most western part (Byers Peninsula) to subaerial at the central parts of the island (Hannah Point).

The depositional conditions for the sediments on the island are various. At the western part of the Byers Peninsula the gently dipping ?Kimmeridgian-Berriasian sediments are deposited in deep-marine paleoenvironments, while in the central part of the peninsula Berriasian-Valanginian sediments are shallow marine. In the eastern part of the Byers Peninsula sedimentary rocks Valanginian – Aptian in aged are deposited in non-marine conditions. The sedimentary beds exposed in the central part of the island (Hannah Point) are non-marine too and much younger (Coniacian-Maastrichtian). At the eastern part of the Island (Hurd Peninsula) lower and middle part of the anchimetamprphosed sedimentary sequences of Miers Bluff Formation (Campanian-Maastrichtian) are also formed in deep-marine

paleoenvironments, while upper parts of the formation (Maastrichtian-Paleocene) demonstrated the final regressive stage with coarse sedimentation.

A317

Session26: General Topics

Paleodirection and Paleointensity Estimates from the Erebus Volcanic Province, Antarctica

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Central to paleogeographic reconstructions is the theory that the Earth's historic magnetic field can be modeled by a geocentric axial dipole (GAD). A GAD field is the magnetic field generated from an imaginary bar magnet positioned in the center of the Earth and aligned along the spin axis. A predominantly GAD field, such as the modern field, gives rise to latitudinal variations in the magnitude and the inclination of the magnetic field vector. Compilations of paleodirectional data spanning the Plio-Pleistocene support a GAD field structure, whereas paleointensity databases over the same period lack the latitudinal dependence of intensity expected from a GAD field. To address this discrepancy, we have collected and analyzed samples from 135 lava flows around the Erebus Volcanic Province, Antarctica and conducted paleointensity and paleodirectional experiments to characterize the behavior of the paleomagnetic field in Antarctica during the Plio-Pleistocene.

A376

Session26: General Topics

Discovery of subglacial lakes in Thwaites Glacier basin using Cryosat-2 radar altimetry

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While the water between ice and bedrock plays an important role in ice dynamics, subglacial hydrology in most parts of Antarctica is still poorly known. In this study, we find previously unknown subglacial lakes in the Thwaites Glacier basin (TGB) using Cryosat-2 satellite altimetry. Some of newly-discovered lakes forms another tributary that is different from the lakes reported by Smith et al.,(2017), and their activities were sequential after the drainage of uppermost small-scale (< 5km diameter) lake. This suggest that even small pressure change occurring in the subglacial environment can trigger the drainage of larger subglacial lake when it is propagated to downstream. For the subglacial lakes that reported by Smith et al.,(2017), we also observed an additional drainage & filling events occurred in the end of 2017. The occurrence of this event is much earlier than the time predicted by the previous study, raising a possibility that there will be more fresh water beneath TGB. Additionally, peculiar behaviors of lake level are detected from multiple subglacial lakes that reacts differently to the supply of water from upstream. The discharge of fresh water by subglacial flood event thought to has very complicated mechanism, and further study on this issue is necessary.

A383

Session26: General Topics

Study on human body adaptation to Antarctic environmental conditions using red blood cells as biomarkers

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This study was conducted and developed for three years now, and it's aim is to analyze the influence of environmental conditions on the viability of RBC's in the extreme environment of Antarctica, in comparison with the viability in a normal environment, as a hematological adaptation. The study was focused on the Romanian research team, that has traveled in three different years to West Antarctica, King George Island.

We considered that the red blood cells can be excellent models for studies on environmental adaptations. The adaptations can be on an morphological, physiological or molecular level.

Human red blood cells (RBCs) or erythrocytes are specialized in the transport of respiratory gases in blood and have a definite life span of 120 days. In order to accommodate the maximum space for hemoglobin, RBCs lack a cell nucleus and most organelles.

Erythrocyte senescence is associated with cell shrinkage, plasma membrane microvesiculation, a progressive shape change from discocyte to spherocyte, cytoskeleton alterations associated with protein (spectrin) degradation, and loss of plasma membrane phospholipid asymmetry leading to the externalization of phosphatidylserine, that may represent one of the signals allowing macrophages to ingest the senescent erythrocytes (erythroptosis also called eryptosis).

Cell lesions and viability of cells related to senescence and apoptosis of nucleated cells, including nucleated erythrocytes, are well known and led to the definition of cell viability criteria like mitochondrial membrane potential ($\Delta\Psi m$) loss, cysteine protease activation, chromatin condensation and fragmentation and propidium iodide uptake.

We devised a new, rapid and simple flow cytometric assay for the measurement of the viability and ageing of human RBCs using calcein-AM.

Analyses revealed until now two regions that could be clearly and unambiguously defined: 1) the region of fluorescent RBCs with intact membranes which is related to the intracellular esterase activity and strongly correlated with the number of living cells, including ageing or dying cells; 2) the region of non-fluorescent dead cells with damaged cell membranes.

We also found that the loss of calcein fluorescence is associated with a decrease in the amount of ATP which is considered to be an indicator of viability for human erythrocytes. The loss of esterase activity is an early event which occurs prior to the phosphatidylserine exposure. These criteria are not applicable to human RBCs due to their lack of nucleus, mitochondria and others organelles.

Our results obtained by comparing the data collected from 3 persons, before and after a period of

approximately one month of staying in Antarctica, in three different years, same period of the year, demonstrates a clear influence on the viability of erythrocytes by its decreasing. This can mean a faster aging of erythrocytes. We are also doing a comparative study to see which of the climatic factors most likely influenced the viability of the RBC's viability.

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Session26: General Topics

Diversity and Structure of microbial communities in Glacier Ice and Subglacial Streams, King George Island, Antarctica

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In the context of climate change, we investigated the impact of glacier retreat on microbial communities from glacier ice and subglacial streams from King George Island, NW Antarctica, in relation with the spatial distribution and substrate geochemistry.

Samples for this study were collected from Barton Peninsula, Weaver Peninsula and Potter Cove areas. Illumina MiSeq sequencing of 16S rRNA gene carried out on glacier ice and subglacial stream samples highlighted variations of bacterial diversity with the type of habitat, location and geochemical characteristics.
Even though at the phylum level the diversity of microorganisms is similar among the samples with a dominance of Proteobacteria followed by Bacteroidetes, spatial variations were observed between peninsulas. High content of Gamma- and Betaproteobacteria characterized both the ice and glacial stream microbial communities, with a high content of Acinetobacter identified mainly in glaciers.

Physicochemical measurements indicate a low mineral content and slightly alkaline pH in glacier ice relative to subglacier water. All glacier ice samples were rather homogeneous, belonging to Na-HCO3 type, with a higher Ca content in the vecinity of subglacial streams, while the stream water was more heterogeneous, corresponding to Na-Ca-HCO3 and Na-Cl types, with a high Al, Fe and Sr content.

Analysis of the distribution pattern of bacterial communities in glacier transects and subglacial streams from King George Island in relation with the habitat geochemistry contributes to unravel the impact of melting glaciers on the resilience of the microbiome embedded in ice.

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