Etablishing the first continuous Holocene tephrostratigraphy on Kerguelen Archipelago, subantarctic Indian Oean

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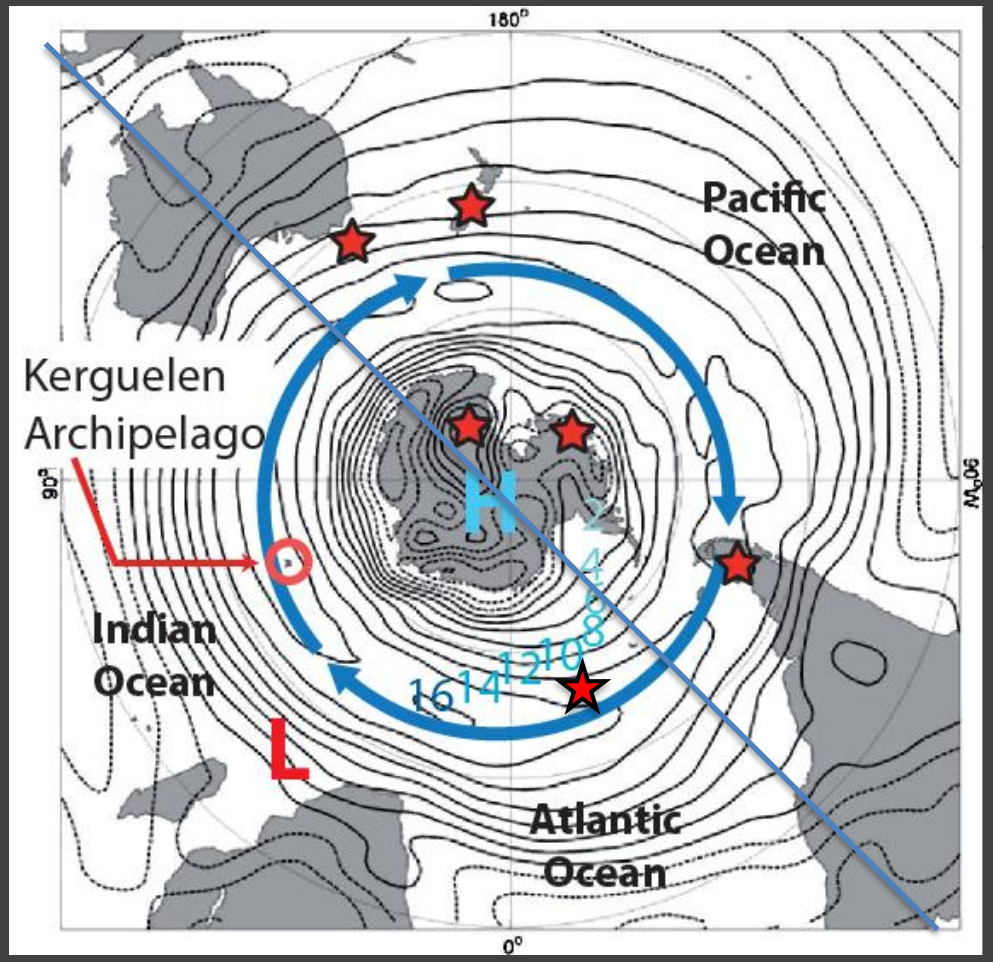
EGU – General assembly 2020
Session :
Limnogeology – reading the geological record of lakes

Southern Indian Ocean: a gap in the knowledge of past global climate variability

Paleo-zonal circulation reconstructions



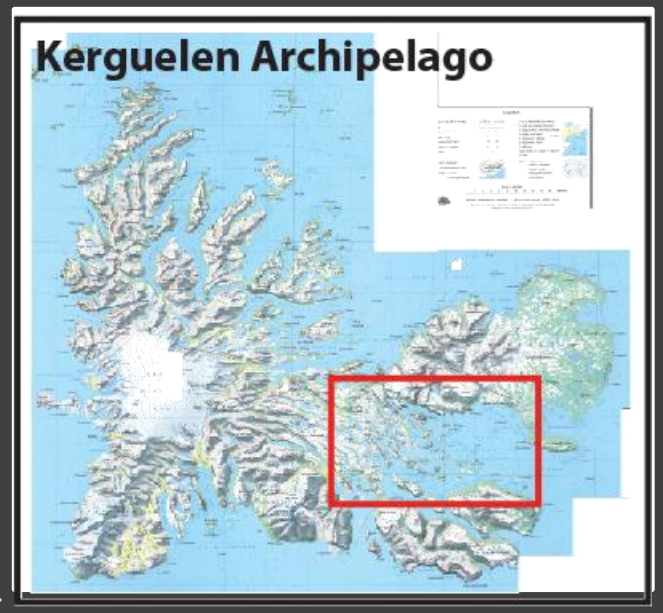
1961–1990 mean zonal westerly winds at 850 Hpa
NCEP/NCAR reanalysis
Contour interval : 2m.s-1
negative contours are dashed

Modified after Shulmeister et al., 2004

Reconstructing the Westerlies at Kerguelen should bridge this gap

Kerguelen: (almost) nothing in the middle of (really) nowhere…

A good place for our purpose



Local tephrostratigraphy: a potential tool for synchronizing paleclimate records

Kerguelen: an active volcanic area throughout the Holocene

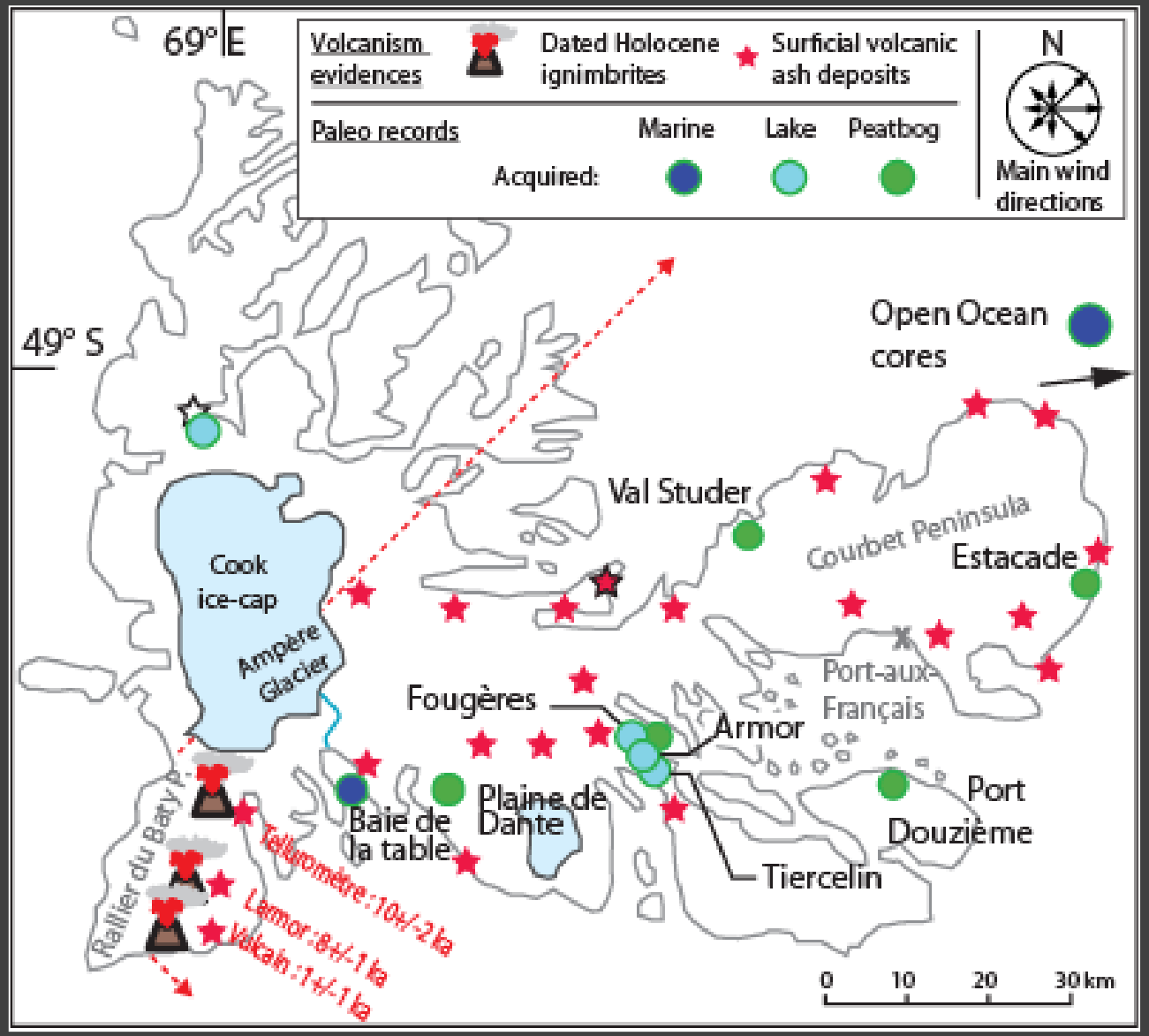
Obvious evidences of past major volcanic eruptions in the field

No published Holocene eruption dates

(+)
Synchronizing records

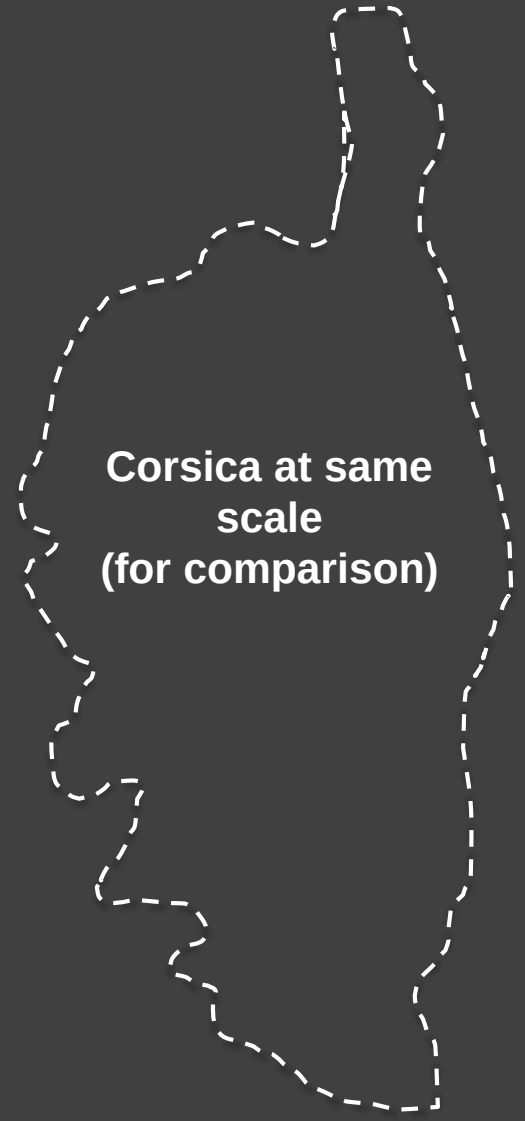
(-)
Alteration of climate-erosion relationship

Requires establishing a tephro-stratigraphy

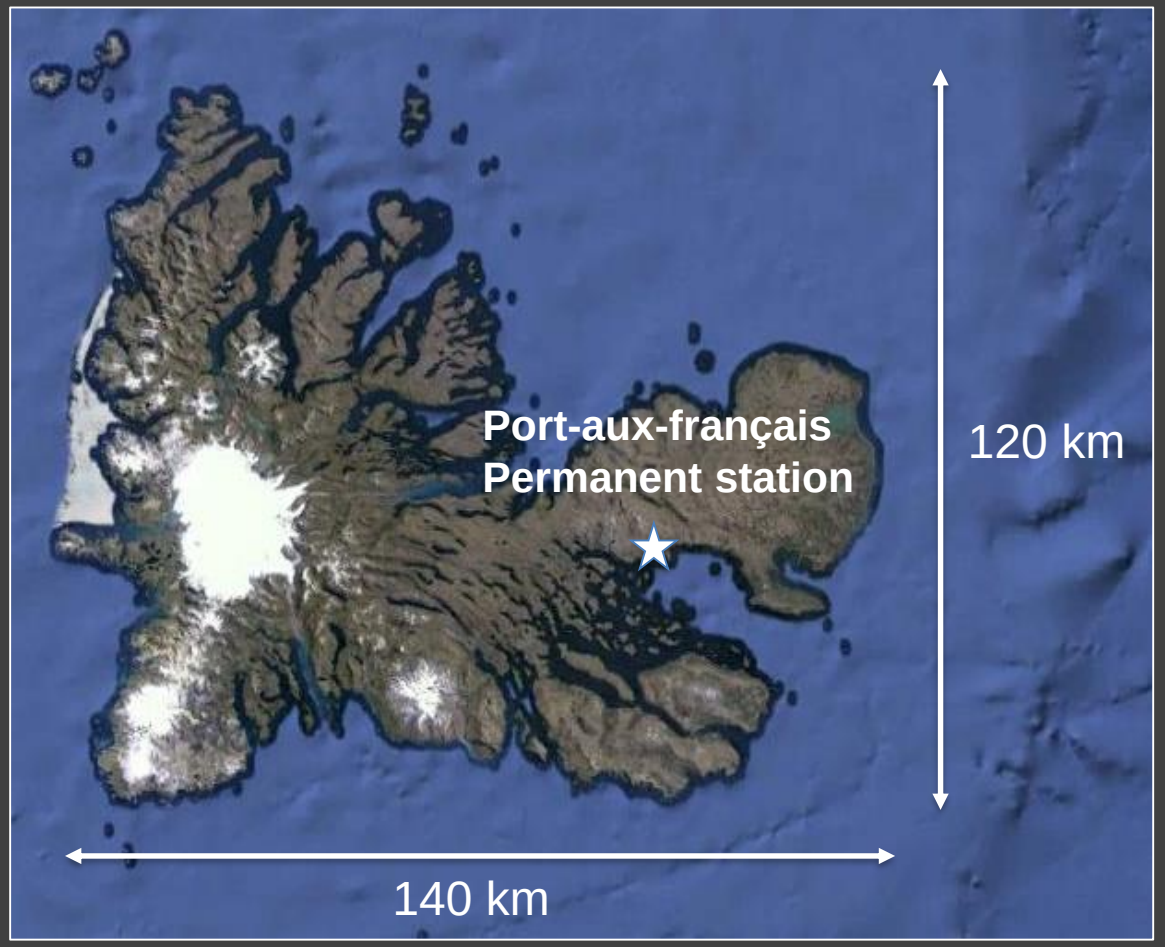


Volcanic deposit inventory by Bertrand Moine, peat coring by Nathalie van der Putten (cf. van der Putten et al., QSR, 2015)

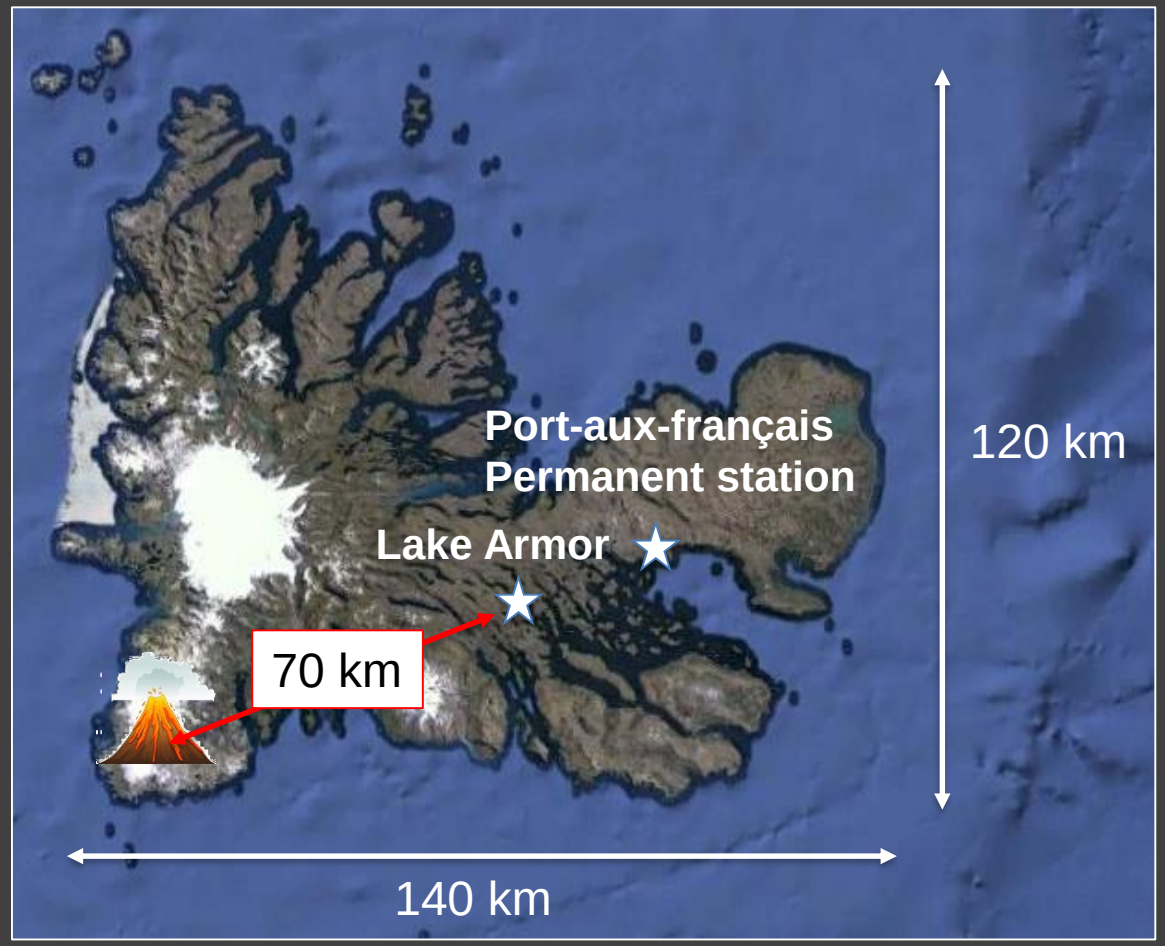
Kerguelen: a not-that-small world { Hundreds of lakes / Logistics is a nightmare



Where to find the good archives?



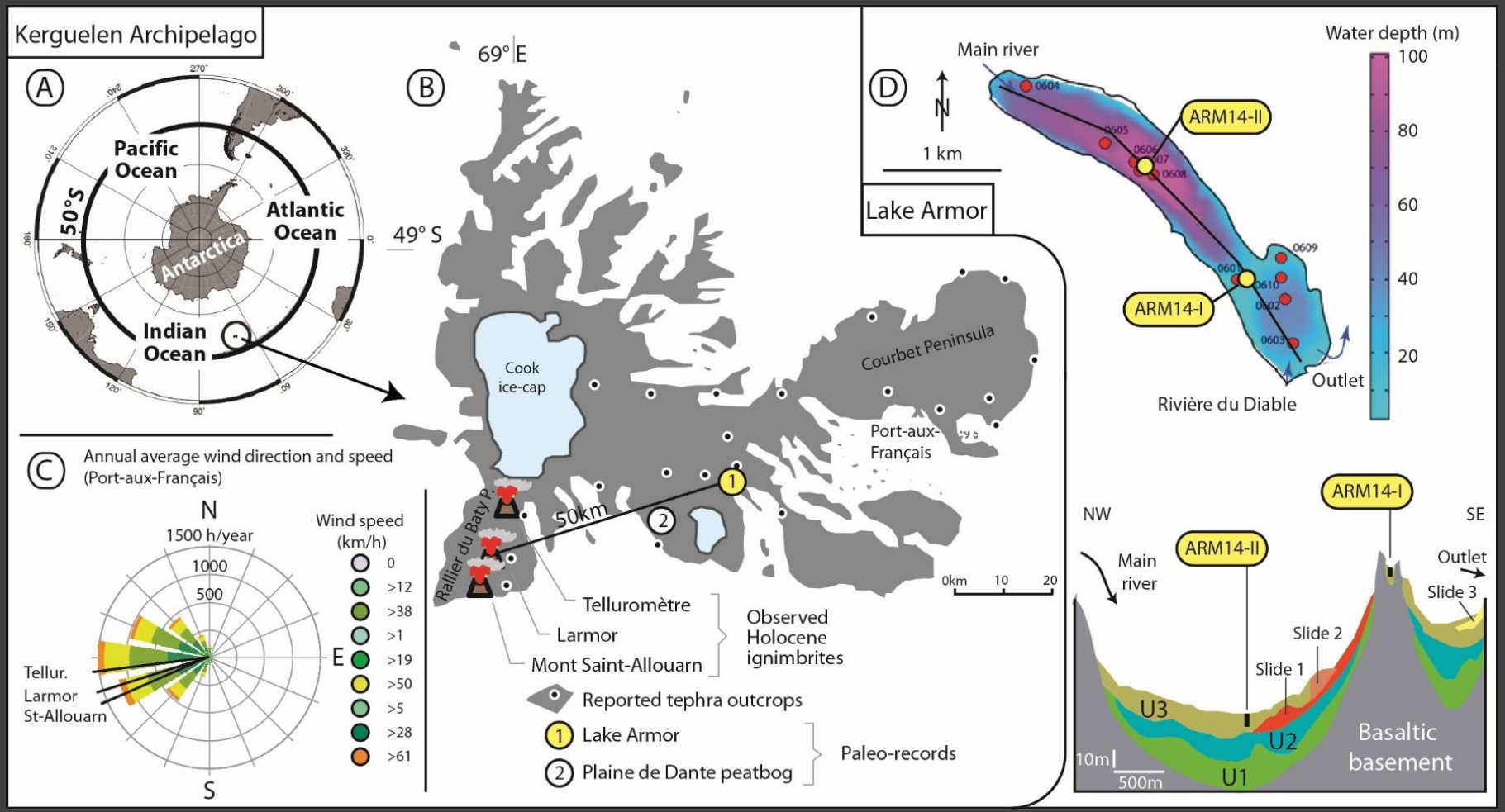
2014 coring PALAS survey



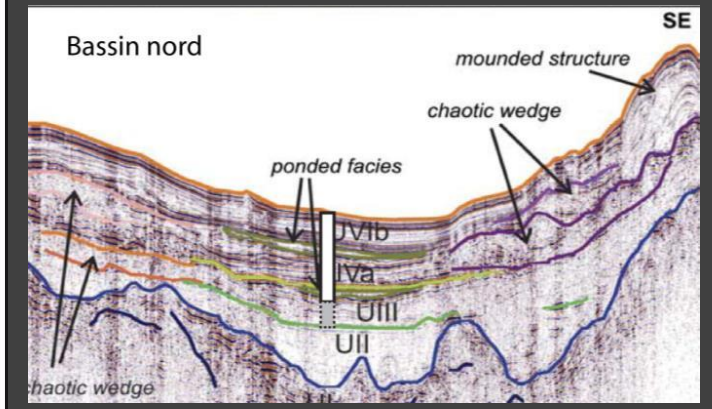
Lake Armor

Already known, ‘’hard’’ shelter,
70 km from volcanic area

Lake Armor: location, bathymetry, seismic transect and coring site selection



Site 1: shallow depocenter, disconnected from river inputs ➔ aerosol and volcanic records



Site 2: Northern deep basin, fed by main tributary ➔ terrigenous input record

Seismic from Heirmann et al., Ant. Sci., 2012

Arnaud et al., 2020, https://eartharxiv.org/5jnu6

Lake Armor: coring operations

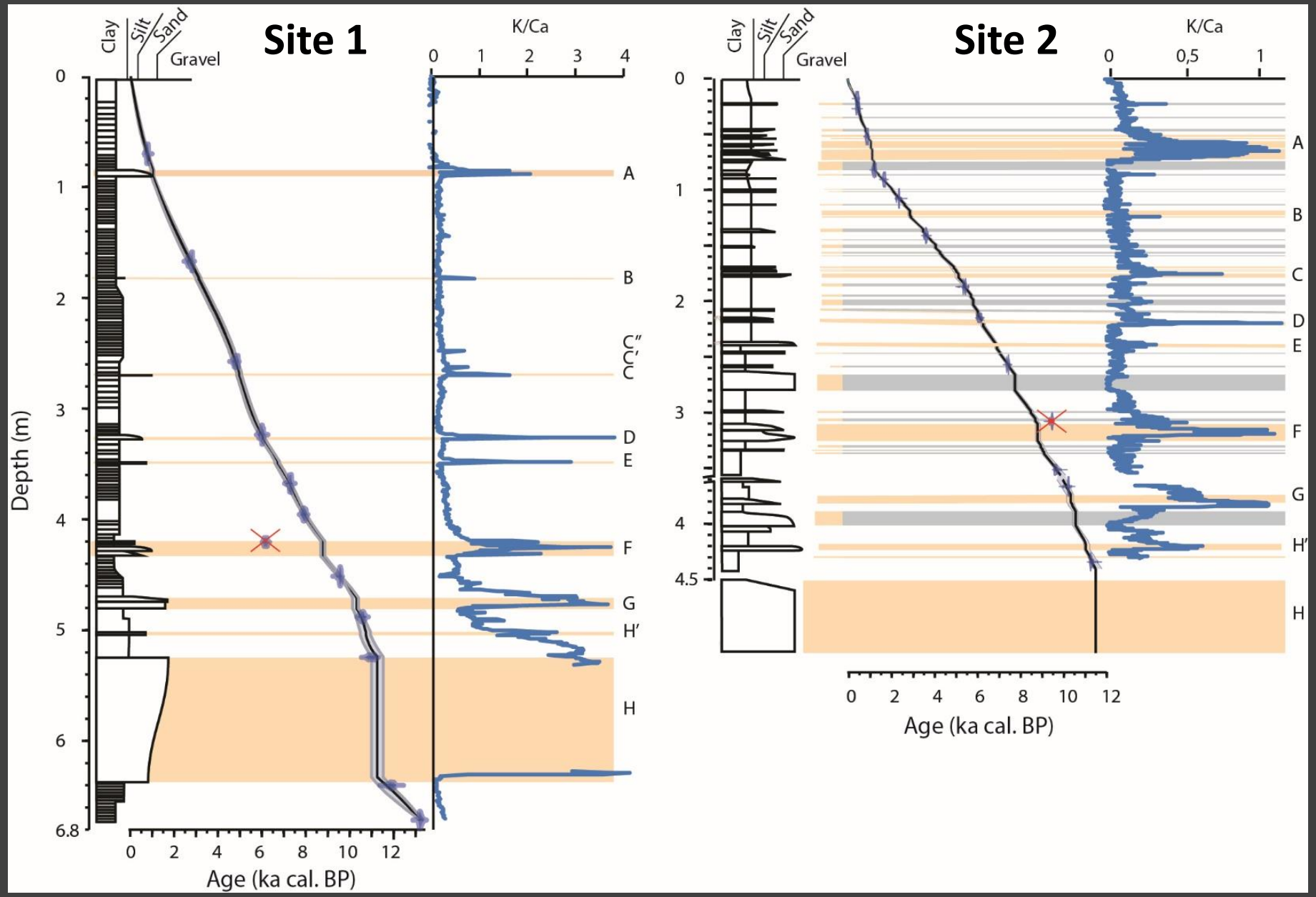
Lake Armor: Lithological description, K/Ca profiles, age models

Site 1 sediment : organic matter + interbedded volcanic material

Site 2 : several reworked deposits

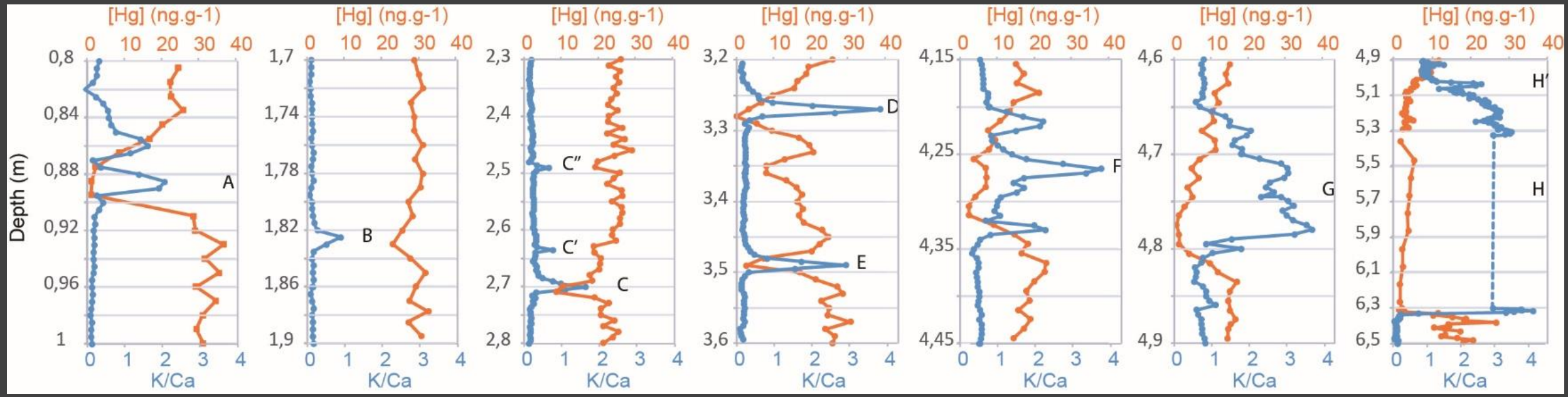
K/Ca = recent volcanic material vs. bedrock basalt

Consistent age-models



Arnaud et al., 2020, https://eartharxiv.org/5jnu6

High resolution detection of volcanic material: K/Ca and Hg



K/Ca
=
recent volcanic material vs. bedrock basalt

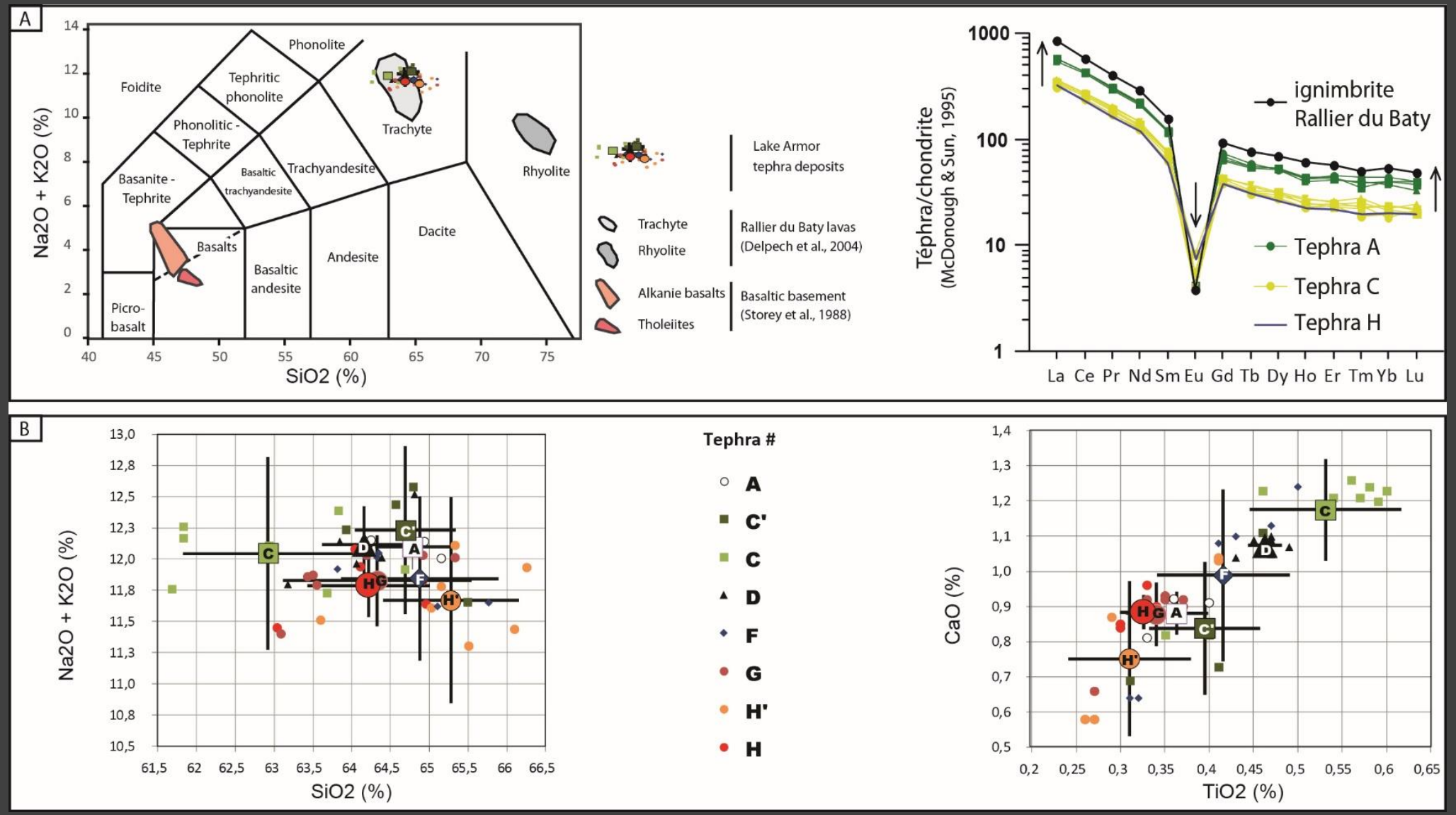
Depleted Hg
=
Dilution of atmospheric Hg input

Arnaud et al., 2020, https://eartharxiv.org/5jnu6

Geochemical characterisation of volcanic deposits

All deposits fall in the trachyte range, comparable to previously published Kerguelen acidic volcanic material

Each deposit has been characterised for further identification in other records

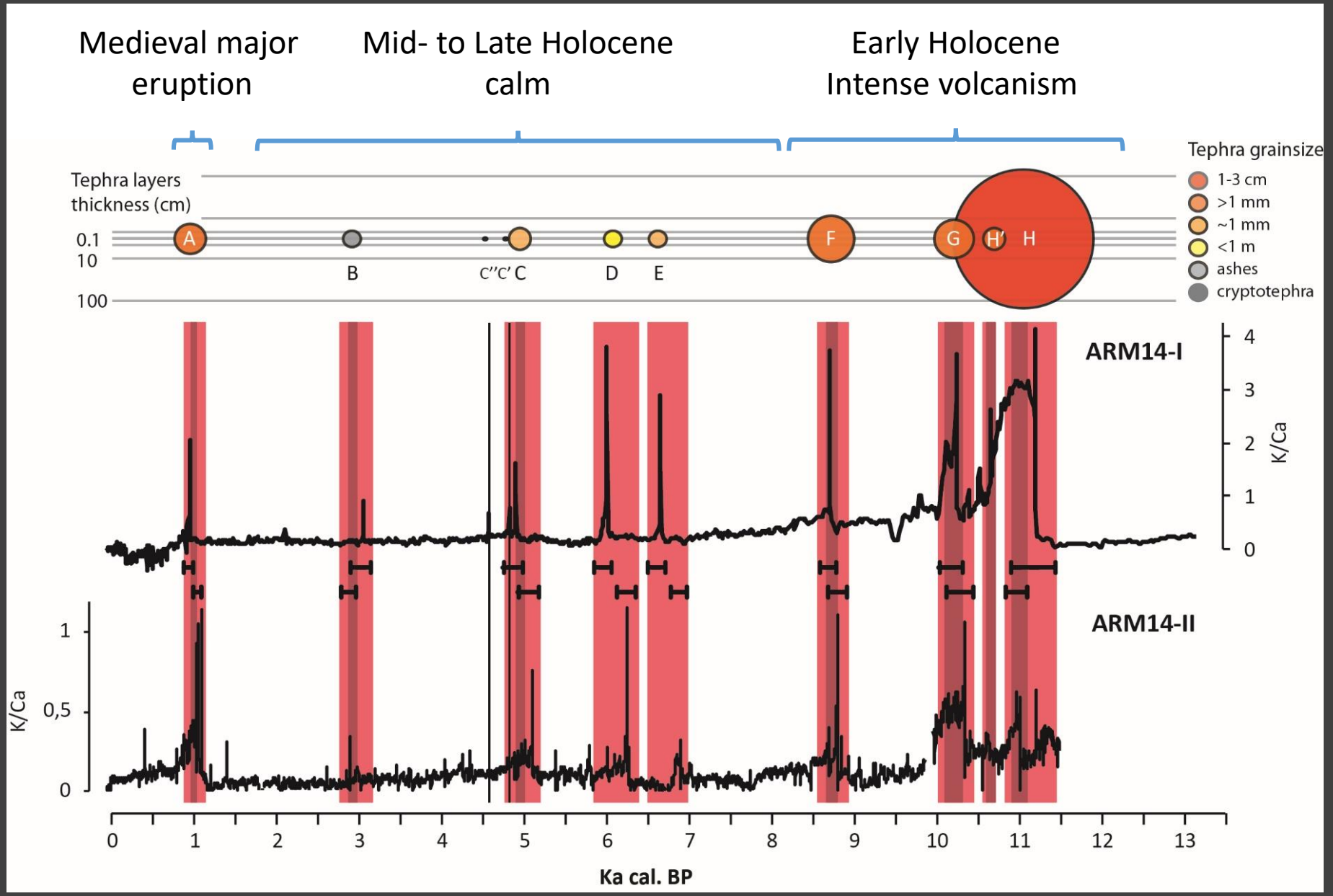


Arnaud et al., 2020, https://eartharxiv.org/5jnu6

Lake Armor-based Kerguelen tephrostratigraphy

Consistent sites 1 and 2 records

Documented thickness and grainsize of volcanic deposits



Arnaud et al., 2020, https://eartharxiv.org/5jnu6

Lake Armor-based Kerguelen tephrostratigraphy

Each deposit has been dated (with uncertainties) and characterised for further identification in other records

Tephra #		A	B	C''	C'	C	D	E	F	G	H'	H
Depth (cm)	Top	85	178	249	263	268,5	328	348	420	472	510	524,5
	Bottom	90,5	179	249	263	270,5	328	349,5	433,5	481	513	633
Age (cal. BP)	min95%	870-1000 cal. BP	2803	4423	4675	4766	5875	6510	8610	10054	10497	10900-11450 cal. BP
	best		**2950**	**4559**	**4805**	**4894**	**6003**	**6649**	**8705**	**10246**	**10737**	
	max95%		3045	4680	4913	4999	6087	6726	8796	10333	10995	
Thickness (cm)		6	2	<0,1	<0,1	3	1	1,5	13,5	9	3	1m thick -> 3cm pumices
Visual description		> 1 mm pumices	ash layer	cryptotephra	cryptotephra	~1 mm pumices	< 1mm pumices	~1 mm pumices	> 1 mm pumices	> 1 mm pumices	> 1 mm pumices	
Number of microprobe data		3	0	0	4	8	7	0	7	8	7	5
SiO2	%	**64,78**			**64,69**	**62,92**	**64,16**		**64,87**	**64,33**	**65,28**	**64,21**
	+/- 1 sigma	0,47			0,65	1,10	0,55		1,01	1,21	0,87	0,79
TiO2	%	**0,36**			**0,40**	**0,53**	**0,46**		**0,42**	**0,34**	**0,31**	**0,33**
	+/- 1 sigma	0,04			0,06	0,09	0,02		0,07	0,03	0,07	0,03
Al2O3	%	**15,58**			**15,68**	**16,50**	**16,53**		**15,84**	**15,76**	**14,82**	**15,75**
	+/- 1 sigma	0,17			0,75	0,74	0,13		0,89	0,46	1,16	0,34
MgO	%	**0,09**			**0,07**	**0,26**	**0,26**		**0,13**	**0,10**	**0,14**	**0,21**
	+/- 1 sigma	0,02			0,09	0,09	0,04		0,07	0,04	0,10	0,02
FeO	%	**5,04**			**4,61**	**4,94**	**4,38**		**4,79**	**4,45**	**4,79**	**4,52**
	+/- 1 sigma	0,29			0,22	0,45	0,28		0,16	0,12	0,38	0,14
MnO	%	**0,17**			**0,24**	**0,22**	**0,16**		**0,18**	**0,18**	**0,18**	**0,24**
	+/- 1 sigma	0,08			0,13	0,08	0,09		0,12	0,10	0,06	0,06
CaO	%	**0,88**			**0,84**	**1,18**	**1,07**		**0,99**	**0,88**	**0,75**	**0,88**
	+/- 1 sigma	0,06			0,19	0,14	0,02		0,24	0,09	0,22	0,05
Na2O	%	**6,85**			**6,80**	**6,24**	**6,19**		**6,45**	**6,51**	**6,52**	**6,24**
	+/- 1 sigma	0,05			0,32	0,39	0,19		0,33	0,18	0,34	0,22
K2O	%	**5,25**			**5,44**	**5,81**	**5,93**		**5,39**	**5,31**	**5,15**	**5,55**
	+/- 1 sigma	0,13			0,36	0,38	0,12		0,33	0,18	0,48	0,04

Arnaud et al., 2020, https://eartharxiv.org/5jnu6

Perspectives: PALAS 2019 coring survey

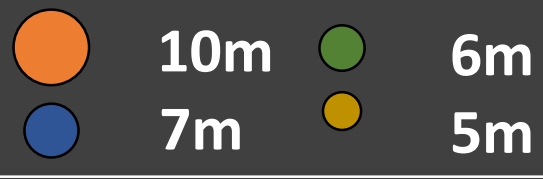
Past behaviour of the southern Ocean`s atmosphere

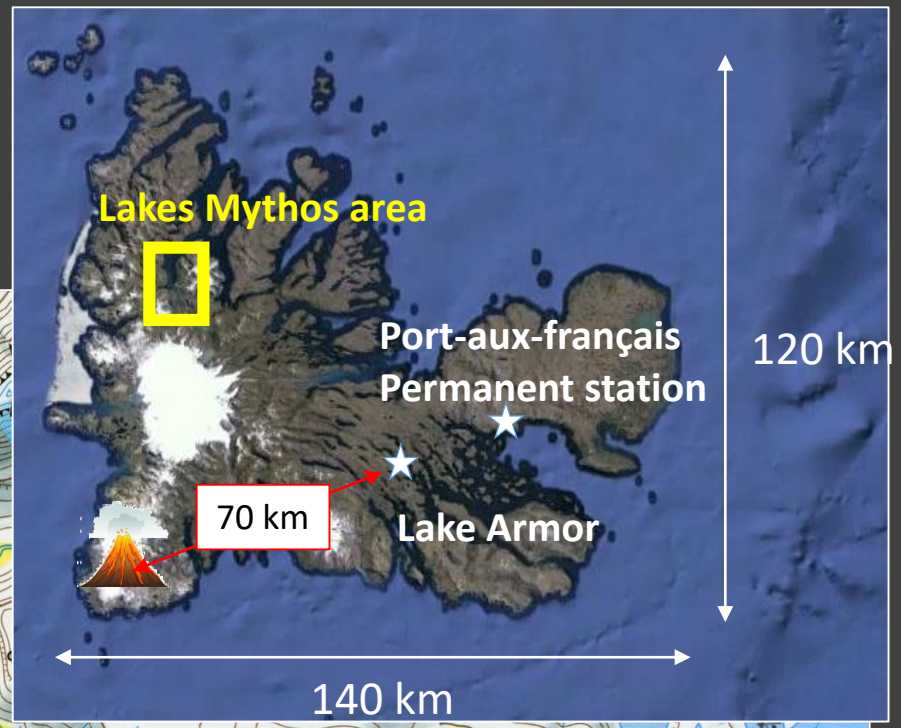
SOUTHSPHERE

Jostein Bakke / Dept of Earth science and Bjerknes Centre for Climate research / University of Bergen

6 cored lakes/ 14 coring sites
127m of cores / 110 rock samples
****
27 fieldwork days / 8 scientific fellows
2 base camps
6 Helicopter drop zones
4 tons of scientific stuff
****
2 PhD projects started in 2020

Maximum core length





Special Issue annoucement

"Lake Sediments: An Invaluable Archive of Earth Critical Zone Trajectories"

quaternary

Dr. Fabien Arnaud Website
Guest Editor
CNRS ; laboratoire EDYTEM
Interests: Paleoenvironmental reconstructions from lake archives: paleohydrology, climate, anthropogenic impact, metallic contamination.

Dr. Pierre Sabatier Website
Guest Editor
Université Savoie Mont-Blanc ; laboratoire EDYTEM
Interests: Paleoclimate, extreme events, Critical Zone, geochronology, lake and lagoon sediments

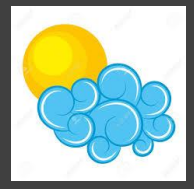
Dr. Charline Giguet-Covex
Guest Editor
Université Savoie Mont-Blanc ; laboratoire EDYTEM
Interests: Paleoenvironments, human-environment interactions, mountain agro-ecosystems, soil erosion, lake sediment DNA

Dr. Jean-Philippe Jenny Website
Guest Editor
INRAE ; laboratoire CARRTEL
Interests: Paleolimnology, global changes, carbon cycle, eutrophication, anthropocene

The Earth Critical Zone (ECZ) is the thin layer providing all necessary functions to sustain life on Earth. Understanding the functioning, legacy and long-term trajectories of the ECZ is thus crucial to preserve a safe operating space on Earth. Critical zone processes and their driving mechanisms, including climate (temperature, precipitation) and human impacts (pollution, agriculture, erosion) operate on a variety of time and space scales, hence precluding their direct monitoring. Lakes are present all over the world and their sediments collect most of the solid and dissolved fluxes from their catchment. **With this issue, we aim at enlightening how lake sediments are invaluable and sometimes, underrated, archives of ECZ.** This will concern the identification and long-term reconstruction of forcing **mechanisms (climate, geodynamics, human-induced pressures) as well as ECZ reactions, both through the biotic and the abiotic compartments.**

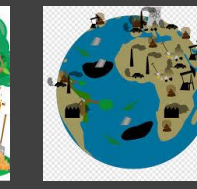
Methodological reviews will be particularly welcome in order to provide a valuable amount of technical, methodological and conceptual milestones for future researchers. We are also seeking for papers displaying and/or discussing emergent techniques, from field operations up to the most sophisticated lab analyses. Finally, we are keen to display the advancement in lake sediment-related computing science, including data management, meta-analysis or numerical modelling.











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