Заместителю начальника Управления кадров СПбГУ
А.Д. Смородинцевой

копия:
Директору института наук о Земле СПбГУ д.г.н. К.В. Чистякову
Начальнику отдела организации научных исследований И.А. Румянцеву
зав. кафедрой Гидрологии суши к.г.н. Г.В. Пряхиной

ОТЧЁТ О КОМАНДИРОВКЕ

Старшего преподавателя каф. Гидрологии суши д.г.-м.н. С.В. Попова
на научный симпозиум «International Symposium on Five Decades of Radioglaciology» и рабочее совещание по международному проекту BEDMAP3.
Стэндфордский университет, Стэнфорд, США, 16-13 июля 2019 г.

Симпозиум по радиогляциологии *«International Symposium on Radioglaciology»* является самым значимым специализированным научным форумом по радиолокационным исследованиям Земли и планет Солнечной системы. Он проходит один раз в четыре года собирая, без преувеличения, всех ведущих специалистов в этой области. Симпозиум этого года был посвящён юбилею, пятидесятилетию радиогляциологических исследований: *«International Symposium on Five Decades of Radioglaciology»*. Соответственно, многие доклады носили ретроспективный характер.

В ходе симпозиума автором представлено в общей сложности четыре научных доклада: один устный и три стендовых (согласно условиям конференции, каждый участник мог сделать только один устный доклад):

1. *Popov S. Review of 55 years of Russian radio-echo sounding investigations in Antarctica // International Symposium on Radioglaciology, Stanford University, Stanford, California, USA, 8-12 July 2019, 81A2967.*
2. *Popov S, Soboleva O, Kiselev A, Masolov V. Ice thickness and bedrock topography Mac. Robertson, Princess Elizabeth and Wilhelm II Lands (East Antarctica) according to the Russian data collected from 1985 to 2018 // International Symposium on Radioglaciology, Stanford University, Stanford, California, USA, 8-12 July 2019, 81A2988.*
3. *Boronina A, Popov S., Grigoreva S., Chetverova A., Pryakhina G. On the formation of the ice cauldron on the Dålk Glacier (Larsemann Hills, East Antarctica).*
4. *Sukhanova A., Popov S., Polyakov S., Kashkevich M. 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).*

Устный доклад – первый по счёту. Два последних доклада официально в программе (и в тезисах) не представлены. Первый слайд устного доклада и постеры прилагаются (прил. №1). Тезисы внесены в систему Pure. Устный доклад, помимо тезисов, также представлен в виде научной статьи в журнал *Annals of Glaciology*, и к моменту подготовки настоящего отчёта проходит стадию рецензирования. После опубликования в начале 2020 года статья будет внесена в систему Pure.

Международным антарктическим сообществом под эгидой СКАР образован амбициозный научный проект Bedmap3. Он представляет собой третью генерацию проекта (после Bedmap и Bedmap2) пополнения базы данных по мощности антарктического ледника и высотам подлёдного рельефа с последующим изданием соответствующих карт и цифровых моделей. В рамках

радиогляциологического симпозиума проходило первое рабочее совещание, на котором обсуждались различные организационные и технические вопросы. Автор сделал короткое выступление о российских материалах, которые потенциально могли бы быть внесены в базу данных Bedmap3. Первый слайд доклада представлен в прил. №2. На момент составления настоящего отчёта подготавливаются официальные письма в Роснедра для получения официального разрешения на передачу данных.

Финансирование поездки осуществлялось из средств гранта РФФИ №17-55-12003 ННИО, при частичной поддержке СПбГУ по Мероприятию 5.

30 сентября 2019 года

старший преподаватель каф. Гидрологии суши СПбГУ д.г.-м.н. С.В. Попов


THE REVIEW OF FIFTY-FIVE YEARS OF RUSSIAN RADIO-ECHO SOUNDING INVESTIGATIONS IN ANTARCTICA
Sergey Popov
Polar Marine Geosurvey Expedition;
St. Petersburg State University
IGS 2019
Five Decades of Radioglaciology
Stanford University,
Stanford, CA, USA
July 9, 2019

Ice thickness and bedrock topography of Mac. Robertson, Princess Elizabeth and Wilhelm II Lands (East Antarctica) according to the Russian data collected from 1985 to 2018

IGS 2019 Five Decades of Radioglaciology
Stanford University
Stanford, California, USA
8 –12 July 2019

S.V. Popov[1,2], O.B. Soboleva[1], A.V. Kiselev[1], V.N. Masolov[1]

Contact: spopov67@yandex.ru

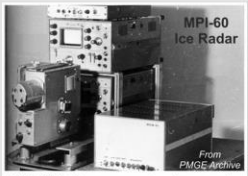
1- Polar Marine Geosurvey Expedition (PMGE), St. Petersburg, Russia
2- Saint Petersburg State University (SPBU), St. Petersburg, Russia

The first Russian multidisciplinary investigations of the wide area of Mac. Robertson and Princess Elizabeth lands (East Antarctica) was conducted during 1971-1974 (Operation "Amery"). They included airborne radio-echo sounding and reflection seismic mostly on the Amery Ice Shelf. The first imagination about the structure of the glacier and subice morphology were obtained.

After the short interruption the airborne radio-echo sounding investigations has been resumed in 1985 and since 1986 this kind of work has carried out with space between profiles of 5 km. MPI-60 ice radar fixed to airplane (Ilushin Aircraft IL-14 had been used until 1990; after that Antonov Aircraft AN-2 has being used till nowadays) are using since that time.

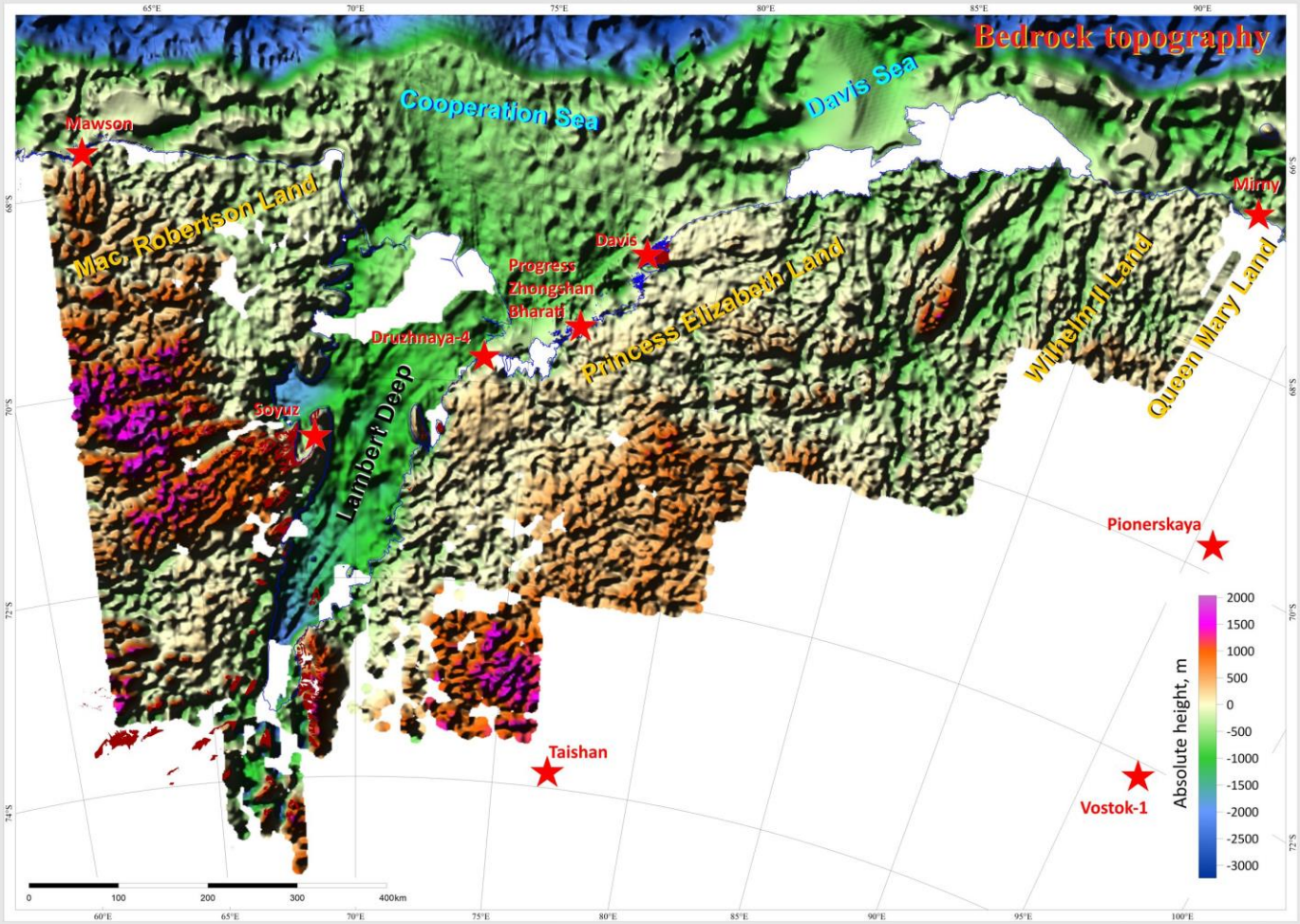
New deep-penetrating radar for airborne geophysical investigations RLK-130, was designed by PMGE and has being utilized with MPI-60 since 2015:

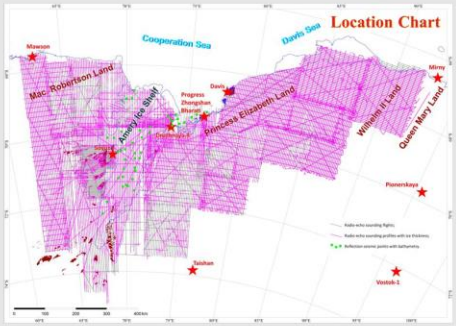
Operating frequency	130 MHZ
Pulse repetition freq.	10 kHz
Pulse length	0.5 – 15 μs
Pulse power	200 W.

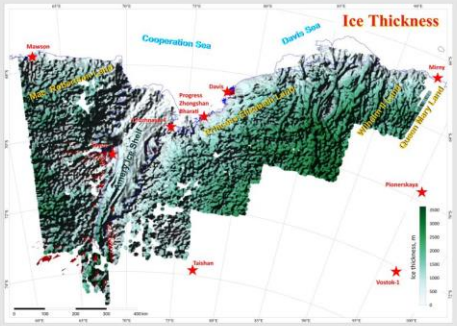


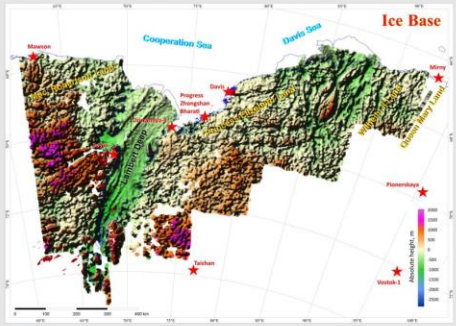
MPI-60 Deep-penetrating radar designed by PMGE has being used since 1980s until now. Its technical characteristics are:

Operating frequency	60 MHz
Pulse repetition freq.	5 kHz
Pulse length	~0.08 μs
Pulse power	5.7 kW
Receiver sensitivity	165 dB









The authors express their gratitude to the Russian Antarctic Expedition for their help in the implementation of airborne geophysical surveys as well as to the PMGE staff whose competence, experience and dedication enabled to obtain the quality data.

RFBR RUSSIAN FOUNDATION FOR BASIC RESEARCH This study was funded by RFBR according to the research project No 16-05-00579.

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

A. Boronina[1], S. Popov[2,1], S. Grigoreva[1], A. Chetverova[1,3], G. Pryakhina[1]

al.b.s@yandex.ru

1 Saint Petersburg State University (SPbU), St. Petersburg, Russia
2 Polar Marine Geosurvey Expedition (PMGE), St. Petersburg, Russia
3 Arctic and Antarctic Research Institute (AARI), St. Petersburg, Russia

IGS 2019 Five Decades of Radioglaciology
Stanford University
Stanford, California, USA
8 –12 July 2019

Background

Russian Antarctic stations and field bases are the main elements of the Russian Antarctic expedition (RAE) infrastructure. 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 the ice cauldron, which had the size of 183×220 meters and was 43 meters in deep, was formed in the Larsemann Hills region. The reasons of the formation and evolution of the dip remain questionable.

Let us consider some of them.

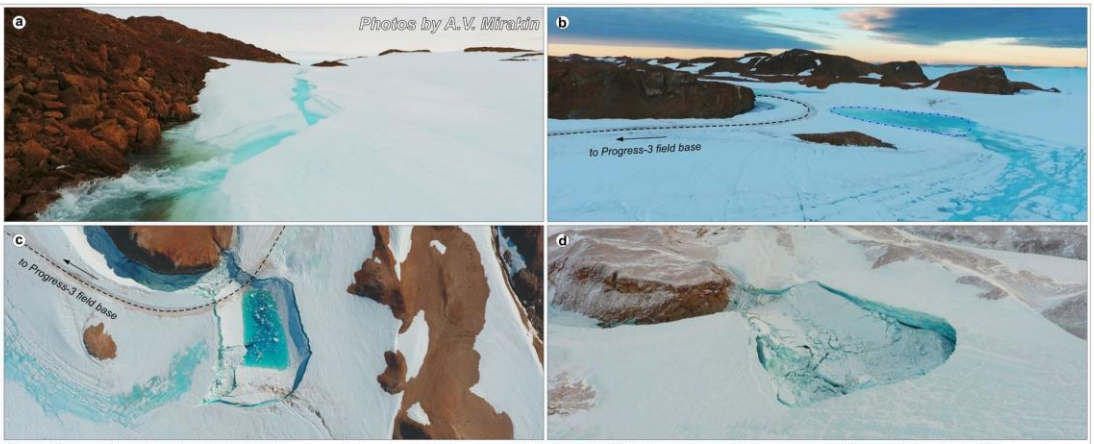


Fig. 1. Stream from Boulder Lake (a), location of the subglacial / intraglacial reservoir (b), the process of the primary collapse of the glacial surface (c), ice depression area near Russian field base Progress-1 (d)

Field studies

The study of this object was carried out during two field seasons (2017/19). The scope of work is presented in Fig. 2. The tachometric survey was realized in the area between the Boulder and «Ledyanoe» lakes and the depression. The scheme of the heights of glacier surface, which was based on 460 measurement points, is demonstrated in the Fig. 3. According to this scheme glacial flow lines were created and calculated approximate location of the stream bed of intraglacial channel. The potential stream falls in the intraglacial reservoir from the South-Eastern part. Moreover, in the same region the GPR-profiling was accomplishing. The GPR-profiling was attended in the area of the estimated location of the subglacial river. GPR survey was completed by investigations with self-potential method. The position of the flooded canal of water filtration from Lake Boulder to Lake «Ledyanoe» was determined by a linear negative anomaly (Fig. 4).

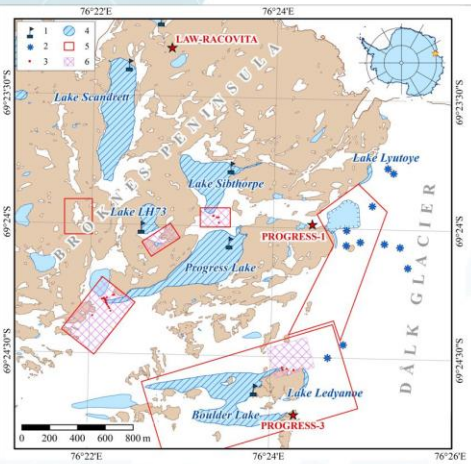


Fig. 2. Chart of the field studies location in the Eastern part of the Broknes Peninsula

1 – water measurements stations; 2 – glaciological marks; 3 – points for mechanical drilling; 4 – areas of bathymetric surveys; 5 – GPR profiles; 6 – areas of investigations with self-potential method.

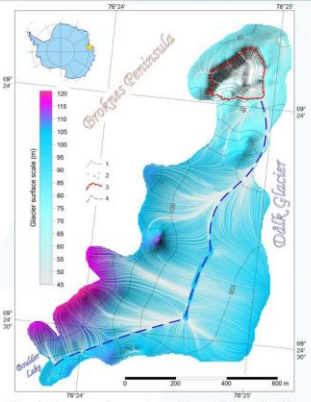


Fig. 3. Ice surface elevation of the glacier, ice flow lines and the estimated position of the subglacial river

1 – ice surface contours (m); 2 – measurements points; 3 – contour of depression in Dålk Glacier; 4 – estimated location of the subglacial river. Gray line are the ice flow lines.

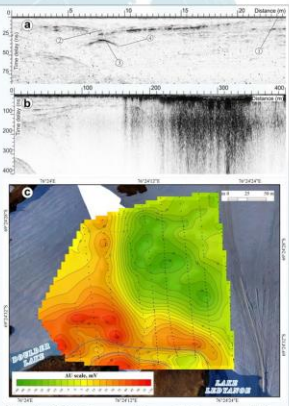


Fig. 4. GPR time-section which crossed the subglacial tunnel formed with discharge of Boulder Lake (a) and located in the «blue spot» (b), results of the investigations with self-potential method (c)

1 – direct wave; 2 – return signal from the upper part of the tunnel; 3 – return signal from the bottom part of tunnel; 4 – diffracted wave.

Phenomenological model

The obtained field results helped to confirm and supplement the initial hypothesis of the development of the outburst flood. The presence of a drainage channel from Boulder Lake and Lake «Ledyanoe» confirms their involvement in the formation of the outburst flood. We think that the beginning of the flood is related to this. However, later events could develop in different ways (Fig. 5). According to the first hypotheses, after the outburst of the lakes, the stream was moving towards the bay in the near-surface part and filled the cavity which exists in the glacier (or the intraglacial reservoir). The walls of the glacier could not stand it and reservoir outbursted. This was the cause of the glacier roof failure. According to the second hypothesis, the flow mostly went along the cracks to the glacier bed. Thus, it could fill the subglacial lake, which is probably exists. Similarly, this lake was outbursted. Due to a sharp decline in the level of the surface of the glacier subsided.

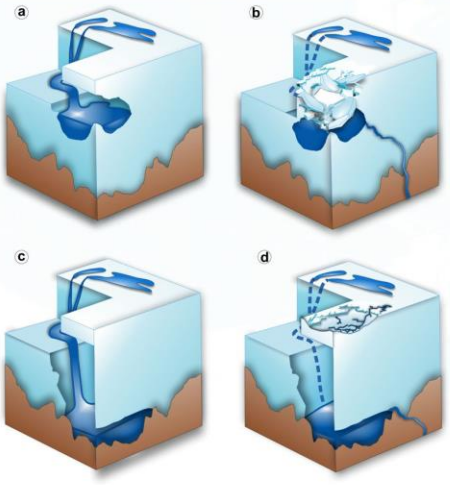


Fig. 5. Possible options for the formation and evolution of the outburst flood and depression in the Dålk Glacier

Mathematical model

Unfortunately, this is currently a phenomenological model, but we believe that the first hypothesis is more real. For this reason, we decided to simulate the outburst of an intraglacial reservoir. The outburst parameters of the intraglacial reservoir in the Dålk Glacier were estimated by Yu.B. Vinogradov's model with same changes (the ice sheet it was taken into account). The series of hydrograph calculations of outburst flooding was carried out for tunnel lengths of 764 m, 821 m, 971 m and 1134 m. The minimal value corresponded to the water flow down through the Dålk Glacier. The maximum value was related to connected to the distance between the depression and the ice front of the Dålk Glacier (Prydz Bay). The outflow continued until complete devastation of the reservoir. Mathematical modelling of the dip formation demonstrates the flood volume estimated as 708,700 cub. m and maximal discharges about 140 cub. m/s.

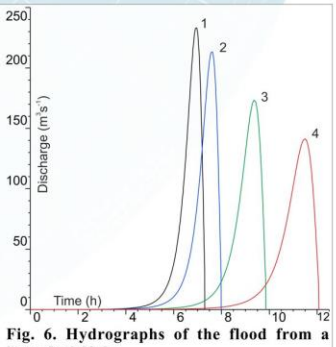


Fig. 6. Hydrographs of the flood from a intraglacial lake

tunnel lengths: 1 – 764 m; 2 – 821 m; 3 – 971 m; 4 – 1134 m.

RFBR

This study was funded by RFBR according to the research project No 18-05-00421 «Main features of formation and development of the Antarctic subglacial floods».

IGS 2019
Five Decades of Radioglaciology

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

Sukhanova A.A.[1], Popov S.V.[2,1], Polyakov S.P.[3], Kashkevich M.P.[1]

[1]Saint-Petersburg State University, Russia; [2]Polar Marine Geosurvey Expedition (PMGE), Russia; [3]Arctic and Antarctic Research Institute, Russia

suhanova.anastassiya@yandex.ru

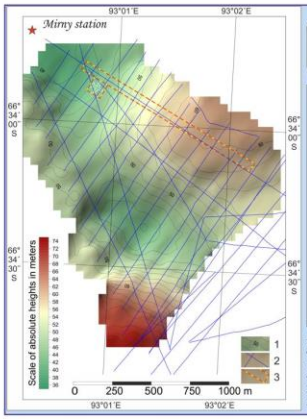
INTRODUCTION

When performing logistic operations of the Russian Antarctic Expedition (RAE) within the areas of the Russian polar stations and field bases, organizing and safe exploitation of the snow-runways play a serious role. Special attention is being paid to airfields situated close to outlet and shelf glaciers. Such areas are characterized with formation of crevasses which often cannot be traced on the surface because of the snow-firn layer overlapping them.

Therefore within the areas of the stations snow-runways may frequently be prepared not only on the parts of glaciers, but also on the ice covering lakes and bays. In this case safety of aviation operations is due to detecting the crevasses within the ice cover and to estimating its thickness. Remote sensing methods, especially ground-penetrating radar (GPR), can provide significant help when detecting the crevasses. GPR allows to identify dangerous heterogeneities in the ice medium timely and to determine the thickness of the ice cover and the depth of distribution of various objects within the ice quite accurately. This, in turn, helps to prevent dangerous accidents.

Fig. 1. Dangerous objects in the glaciers:
a, b - crevasses, c - heavy machinery, failed in a crevasse in the Mirny station area

MIRNY STATION



Research in the area of Mirny station was carried out during the seasonal work of 59 - 62 RAE (2012 - 2017) and aimed at restoring the aviation support of the station, interrupted in 1992. During the survey, geophysical studies were carried out by GPR method in order to inedtify dangerous crevasses within the body of the glacier. According to the results of the survey, numerous near-surface crevasses were revealed, in the wave field characterized by lower intensity of the reflected electromagnetic signal.

According to the GPR data, it became possible to determine the width of the main crevasses, which varied from 0.3 to 1 m. Further it allowed to highlight a safe area suitable for the creation of an airfield. When choosing the main axis of the snow-runway, the wind rose and the slopes of the daily surface of the glacier, which according to the results of geodetic works do not exceed 2.5 %, were also taken into account. As a result of the research, a medium-haul aircraft BT-67 "Turbobustler" landed successfully on the snow-runway of the Mirny station in February 2016.

Fig.2 Location chart of the scientific works in the Mirny station area:
1 - contours of absolute heights in meters; contour interval is 2 m
2 - GPR lines of the 61st RAE
3 - axis of the runway

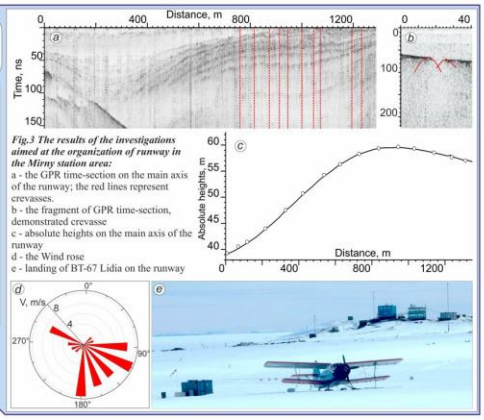


Fig.3 The results of the investigations aimed at the organization of runway in the Mirny station area:
a - the GPR time-section on the main axis of the runway; the red lines represent crevasses.
b - the fragment of GPR time-section, demonstrated crevasse
c - absolute heights on the main axis of the runway
d - the Wind rose
e - landing of BT-67 Lidia on the runway

MIRNY STATION

The results of the research aimed at creation of a snow-runway next to the Mirny station showed that the flow rate of the glacier within ate area reach the value of 60 meters per year. It causes permanent deformations of the glacier and formation of new crevasses. Therefore, during the field seasons of the 63rd and 64th RAE (2017-2019) monitoring GPR surveys aimed at detecting dangerous crevasses were performed within the snow-runway of the Mirny station. Due to the results of the work of the 63rd RAE the snow-runway was reduced by 600 m because of the wide crevasses occurred in the southern part of the airfield. During the 64th RAE dangerous crevasses within the airdrom were not revealed.

Fig.4 Runway area near the Mirny station:
a - landing of An-2 plain in 64th RAE;
b – processing of GPR investigations.

PROGRESS STATION

In addition to monitoring work at the Mirny station, similar studies were carried out during this period at the snow-runway of the Progress station. Due to the performed GPR survey, no dangerous crevasses were detected. The width of the identified faults located at the surface did not exceed 0.5 m. Thus, the area of the runway in the area of the Progress station was determined as safe for transport operations.

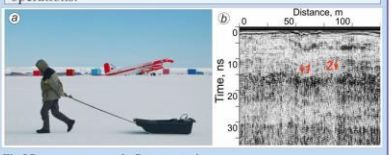
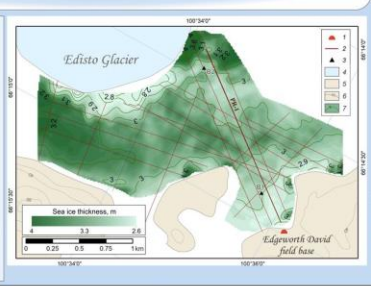


Fig.5 Runway area near the Progress station:
a - processing of GPR investigations; b - GPR time-section: 1, 2 - crevasses.

BUNGER OASIS FIELD BASE

The aim of the investigations was to seek for a safe site for organizing a snow-runway at the area of the Bunger Oasis field base. Taking into account the location of the infrastructure of RAE within the Bunger Oasis, central part of the epishelf Transcription Gulf, situated 7 km far from the base, was chosen as the most appropriate site. During the summer field season of the 64th RAE (2018/2019), geophysical survey with GPR method was carried out within the area to obtain estimates of thickness of the bay ice and to detect crevasses in the sea ice.



Conducted GPR survey showed that sea ice thickness varies from 2.9 to 3.1. Moreover, no signs of discontinuities of the ice layer were found. The area of investigations was identified as a safe site suitable for landing of light and medium aircraft. However, due to the specifics of the relief of the oasis, the removal of weathering products of rocks to the surface of the ice layer took place. Under the influence of solar radiation, the processes of thawing in the areas of subsidence of such particles increased, and this led to the formation of cavities on the surface. Their dimensions don't meet the requirements for runway coatings. As a result, in the studied area, the boundaries of the sites suitable for the organization of runways were determined.

Fig. 6. Scheme of surveys and ice cover thickness in the area of theTranskriptsii Gulf:
1 – field bases in the work area; 2 – GPR lines; 3 – points of mechanical drilling; 4 – glacier; 5 – rocks; 6 - contours of absolute heights; contour interval is 20 m; 7 – contours of sea ice thickness; contour interval is 0.1 m.

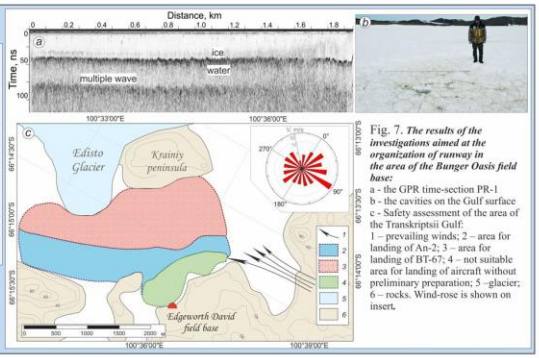


Fig. 7. *The results of the investigations aimed at the organization of runway in the area of the Bunger Oasis field base:*
a - the GPR time-section PR-1
b - the cavities on the Gulf surface
c - Safety assessment of the area of the Transkriptsii Gulf:
1 – prevailing winds; 2 – area for landing of An-2; 3 – area for landing of BT-67; 4 – not suitable area for landing of aircraft without preliminary preparation; 5 –glacier; 6 – rocks. Wind-rose is shown on insert.

CONCLUSIONS

As a result, the main results of GPR sounding carried out in the area of the Russian Mirny, Progress stations and the Bunger Oasis field base during the austral summer field season of 59-64 RAE (2012-2019) have been presented.

The GPR data made it possible to determine intraglacial (englacial) crevasses and to choose the most favorable field for the landing. It proves that this geophysical method is effective in it's simple implementation in the field works. In the future investigations in Antarctica the creation of the classification of crevasses for safety reasons of transport operations is planned.

RFBR
RUSSIAN FOUNDATION FOR BASIC RESEARCH

This study was funded by RFBR according to the research project №17-55-12003 «Glacier dynamics, subglacial hydrology and mass balance of the Vostok Lake area based on comprehensive analysis of geodetic GNSS observations and GPR data»


RUSSIAN INPUT FOR
BEDMAP3 INTERNATIONAL
SCIENTIFIC PROJECT
Sergey Popov
Polar Marine Geosurvey Expedition;
St. Petersburg State University
IGS 2019
Five Decades of
Radioglaciology
Stanford University,
Stanford, CA, USA
July 8, 2019