UNDERWATER TECHNOLOGY FOR POLAR RESEARCH

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Underwater vehicles in Polar Research

- Near-Ice Inspection & mapping
- Boundary layer Investigations
- Satellite data & model validation
- Sediment sampling
- Ice Shelf Cavity studies
- Physical Oceanographic mapping
- Lake exploration
- Erosion of ice shelf and glacier flow
- Biological sampling
- Insturument emplacement

‘Seeing is believing & sampling is proving’

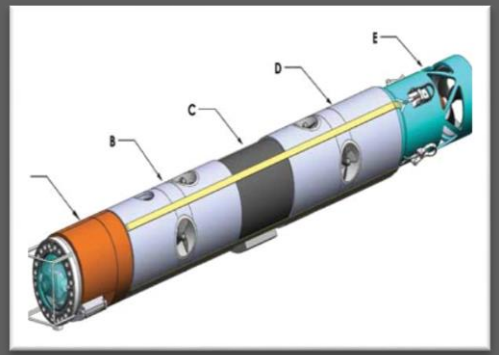
Prior Art

- Under Ice Sonar and cameras
  - Point mesaurement: Coverage is limited to onelocation & hence large number of instruments are required
  - Data latency
- Divers
  - Short duration
  - Hazardous

Underwater Vehicles at Antarctica

- Submersible Capable of Under Ice Navigation (SCINI)

  - MBARI, Moss Landing Marine Labs
- Woods Hole Oceanographic Institute
- University of Genova
- Ministry of Earth Sciences, India



Can we match this ?

Hope we can !

nature geoscience

ARTICLES

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Thick and deformed Antarctic sea ice mapped with autonomous underwater vehicles

G. Williams[1,2*†], T. Maksym[3*†], J. Wilkinson[4*†], C. Kunz[3,5], C. Murphy[6], P. Kimball[3] and H. Singh[3]

Satellites have documented trends in Antarctic sea-ice extent and its variability for decades, but estimating sea-ice thickness in the Antarctic from remote sensing data remains challenging. *In situ* observations needed for validation of remote sensing data and sea-ice models are limited; most have been restricted to a few point measurements on selected ice floes, or to visual shipboard estimates. Here we present three-dimensional (3D) floe-scale maps of sea-ice draft for ten floes, compiled from two springtime expeditions by an autonomous underwater vehicle to the near-coastal regions of the Weddell, Bellingshausen, and Wilkes Land sectors of Antarctica. Mean drafts range from 1.4 to 5.5 m, with maxima up to 16 m. We also find that, on average, 76% of the ice volume is deformed ice. Our surveys indicate that the floes are much thicker and more deformed than reported by most drilling and ship-based measurements of Antarctic sea ice. We suggest that thick ice in the near-coastal and interior pack may be under-represented in existing *in situ* assessments of Antarctic sea ice and hence, on average, Antarctic sea ice may be thicker than previously thought.

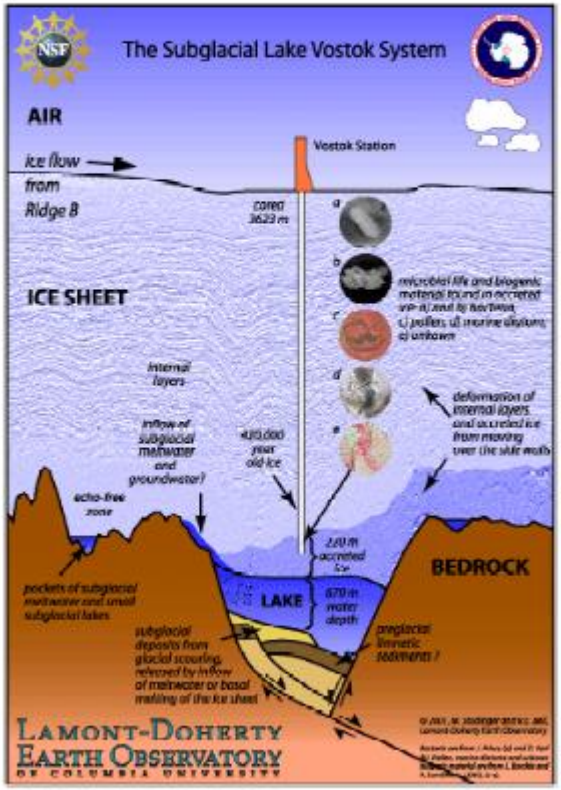
Buried Lake...

- Once a large surface lake in East Antarctica, Lake Vostok is now buried under more than 3.7 kilometers of ice.
- Covered with ice for millennia, cut off from light and contact with the atmosphere, Lake Vostok is one of the most extreme environments on Earth.
- Analysis of the life forms suggests Lake Vostok may harbor a unique ecosystem based on chemicals in rocks instead of sunlight, living in isolation for hundreds of thousands of years.
- These "extremophiles" could mimic life on other moons and planets, such as Jupiter's icy moon Europa.

We would like to know if there's life on Jupiter's frozen moon Europa. We'd also like to know if there's life in Antarctica's ice-covered Lake Vostok.

- Lake Vostok about the size of Lake Ontario, which lies buried under thousands of meters of ice high on the Antarctic Plateau, is thought to be home to unique habitats and microorganisms. Confirming the existence of life forms and unique biological niches without contaminating the pristine lake waters, however, is a difficult scientific and technical challenge with international ramifications.

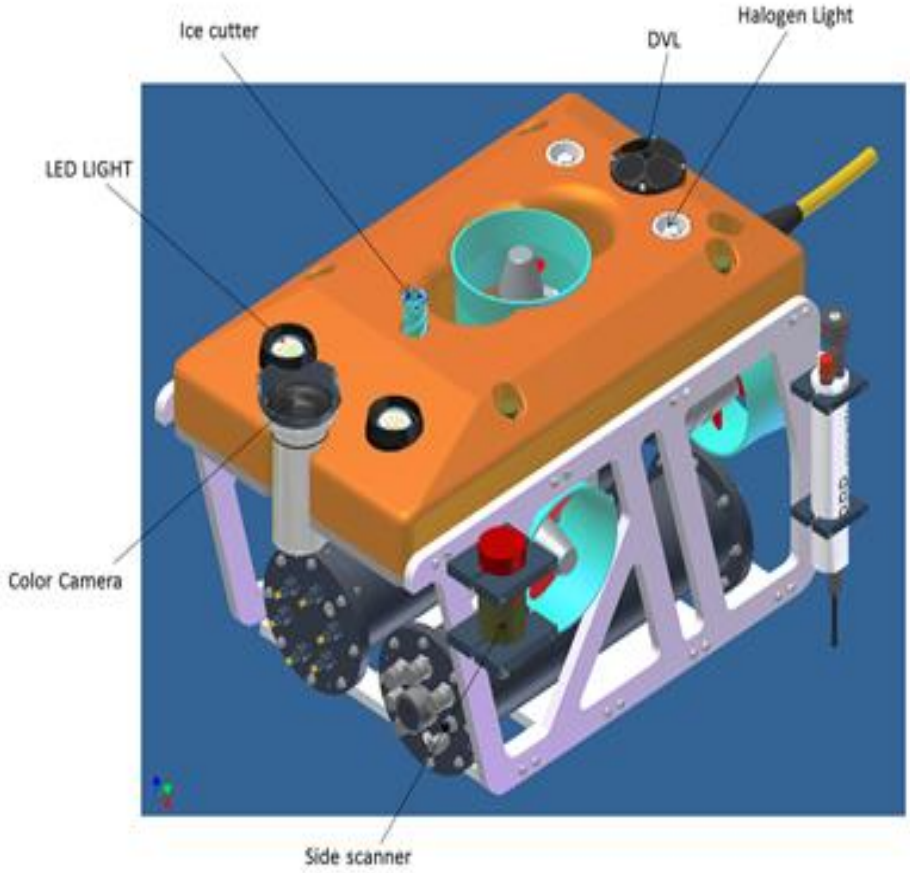
- An ice core -- one of the world's longest -- was drilled by a joint U.S., Russian, and French team at Russia's Vostok Station on the lake's western shore. But coring was stopped roughly 100 meters (328 feet) above what is thought to be the surface of the water to prevent contamination of the lake. The ice layers reveal a 400,000-year environmental record with microorganisms present throughout most of the core.



Genesis

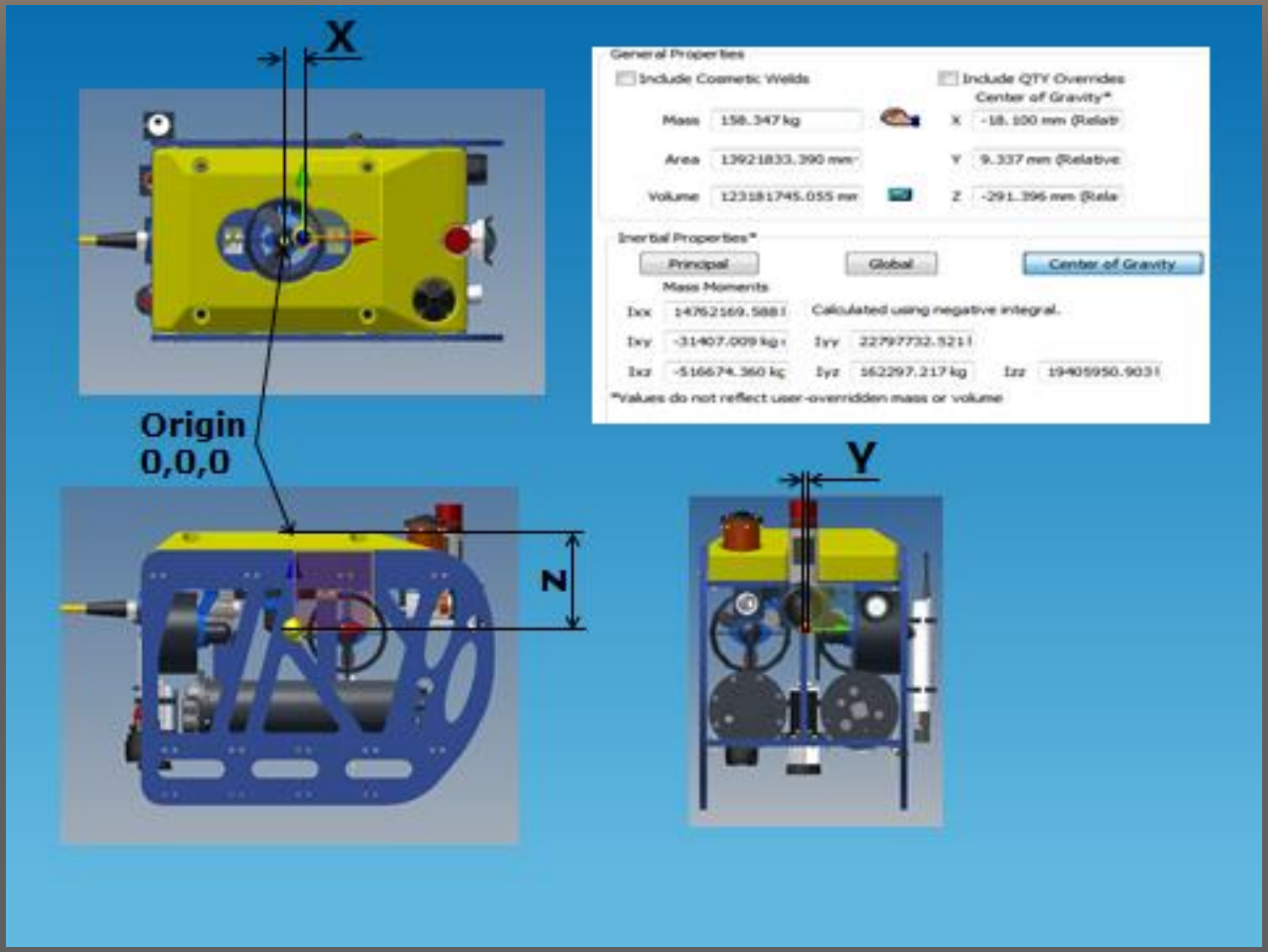
- A shallow water/Polar Remotely Operated Vehicle (PROVe) was designed and developed by NIOT
- Depth rating : 500 metres
- Pay load
  - Lights, cameras
  - Water Sampler
  - DO, Conductivity, Temperature
  - Irradiance meter
  - Bottom corer
  - Ice corer !!!!
  - Scanning Sonar

Specifications of PROVe

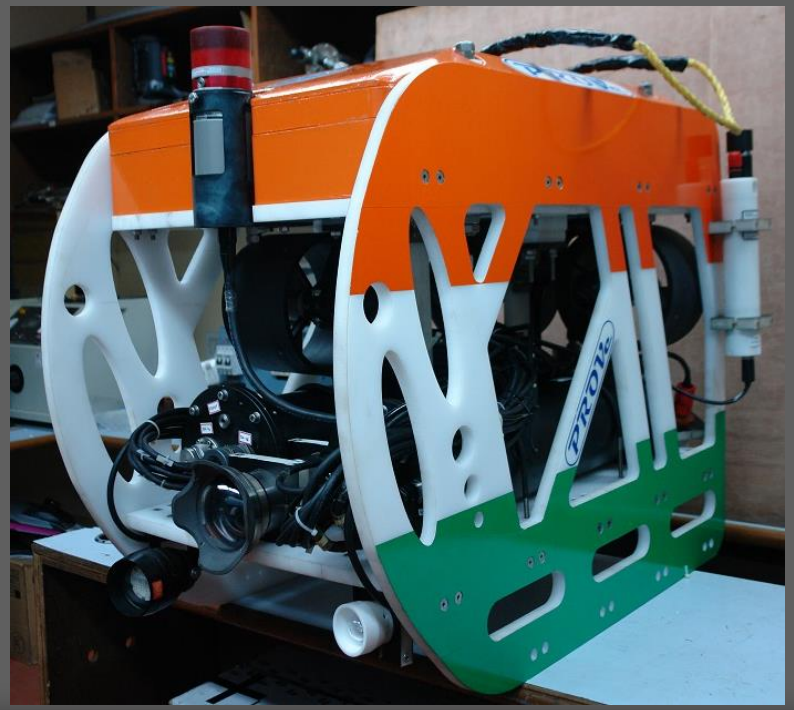


Diving Depth	500m
Weight	170 kg
Dimension	1.0 x 0.6 x 0.9 m
Speed	~ 2 knots (attained)
Pay load	10 kg
Frame	Polypropylene
Buoyancy	Syntactic foam
Power	300V DC, 5 kW
Propulsion	4 BLDC thrusters
Navigation	DVL and compass aided
Umbilical	Uniflex, Buoyant

Vehicle hydrostatic and stability analysis

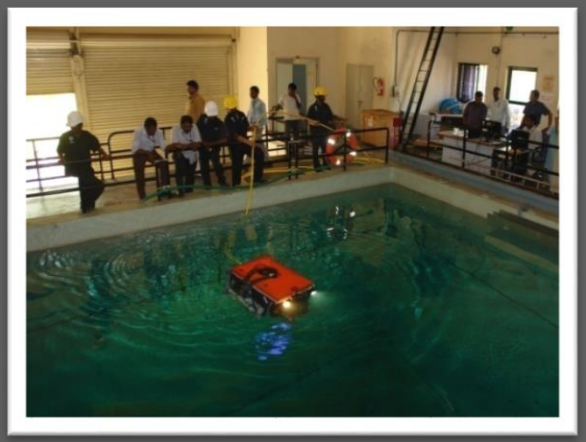


Vehicle Frame Development



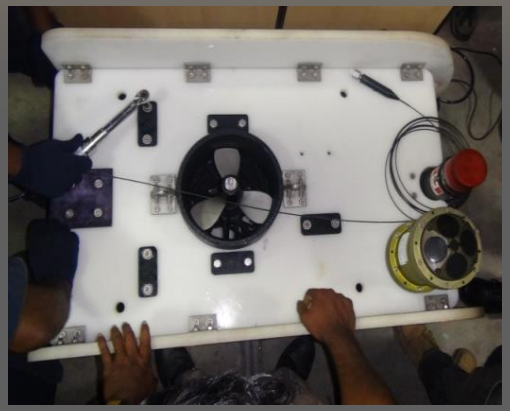
ROV Integration and Testing at ATF

- Integration of vehicle subcomponents
- Integrated dry test was carried out with surface control unit, deck power system, umbilical cable and ROV
- Integrated wet test was carried out at ATF and Idukki Lake
  - Sensors and subcomponents tested
  - Vehicle maneuvered in 4 DOF



Vehicle Performance Testing in Environmental Chamber at NIOT

ROV placed in Environmental Chamber



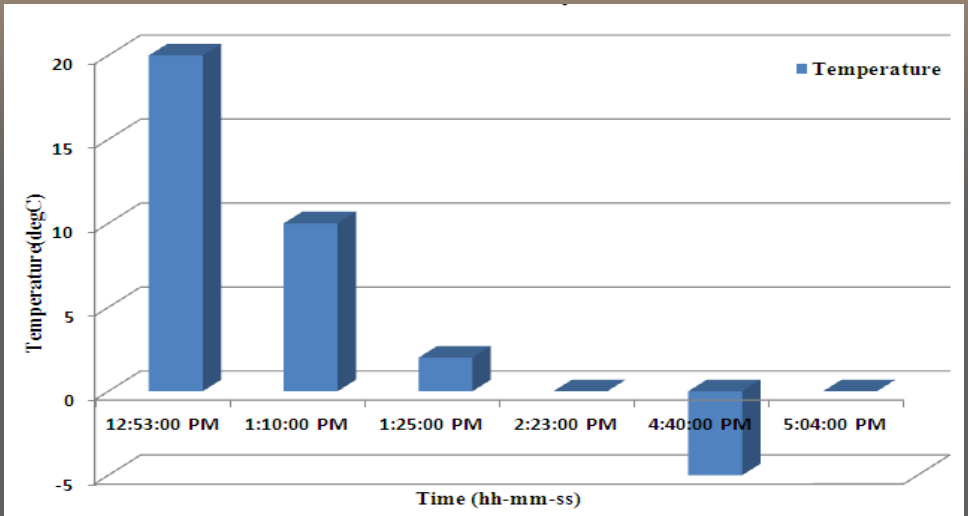
Ready for test with power

After the test

Status of Sensors after test

Checking of Torque of fastened bolts

Environmental Chamber Test



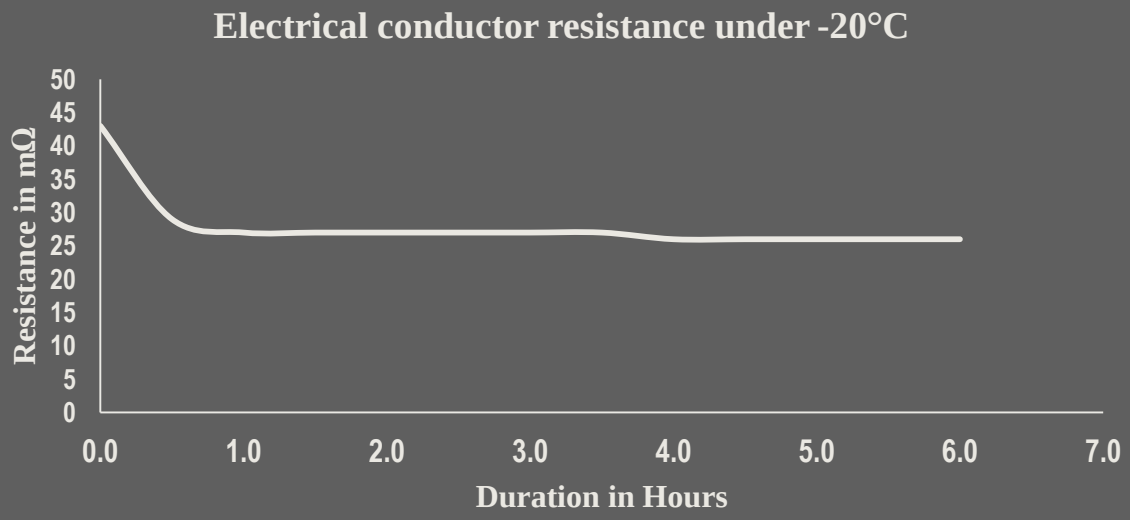
Stage	Temp (°C) in Test Chamber	Test Duration			System Status	DTS temp	DVL Temp	Load test
		Start time	End time	Duration(min)		(°C)	(°C)	
1	20	12:53	01:08	15	ON	33.4	28.5	Color Camera,B&Wcamera, LED-4no's,Compass,DVL,SONAR,SBG,Thruster 4no's cranking Tested in all conditions
2	10	01:10	01:20	10	ON	35.0	24.4	
3	2	01:25	02:20	55	OFF	28.3	5.2	
4	0	02:23	04:30	117	OFF	7.7	0.7	
5	-5	04:34	05:04	30	OFF			
6	0	05:10	05:20	10	ON	4.6	-1.7	

Influence of low temperature on cables

Umbilical cable

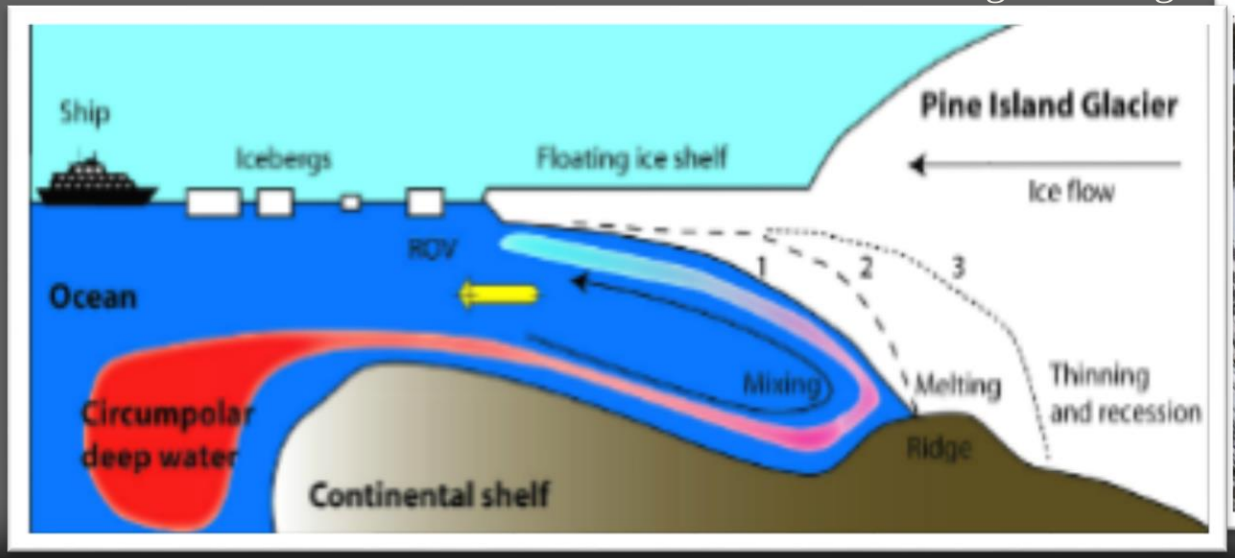
- Power conductor resistance found to reduce by 38% @ -20 deg. C. The influence of the change shall be taken care by the deck power converter control system.
- Optical core performance remains unaffected.
- Umbilical mechanical load carrying performance found intact.

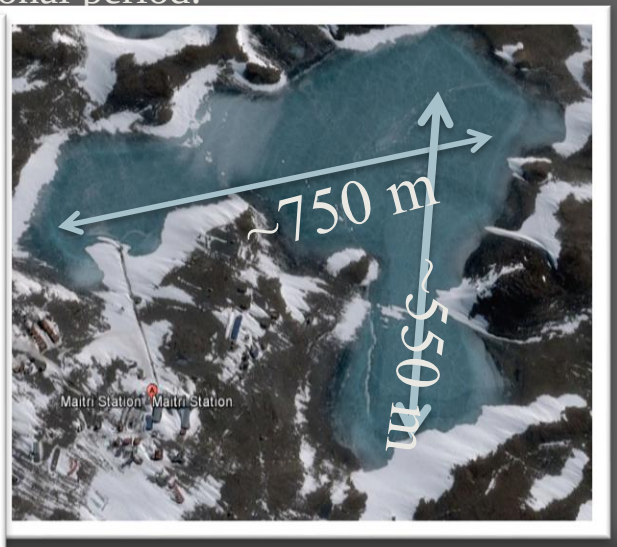
Other interconnecting cables are tested and found intact.



Mission Plan in Priyadarshini Lake, Antarctica

- Maximum Water depth is 6 m (E-W Maximum length is 750 m and N-S length on the western side is 550 m; width varies between 20 m to 50 m).
- System ***launching*** with chain pulley block by erecting a permanent pole near launching station.
- ROV ***powering*** up by means of mains powered deck power converter or portable generator set.
- Surface ***navigation*** for 400 m in transects to perform lake bed photography in grid with 25 m spacing.
- Lake bed ***sampling*** at selected locations based on the lake bed images and sea floor property (with sediments, benthic abundance, rocky floor etc).
- CTDO, Irradiance ***sensor data*** will be collected during the navigational period.





Preperation at Antarctica

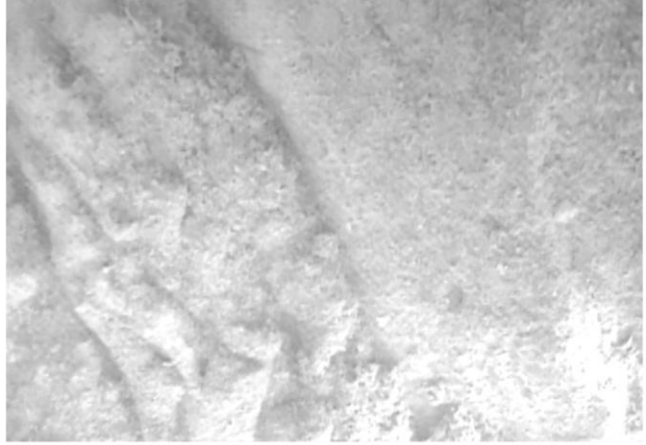
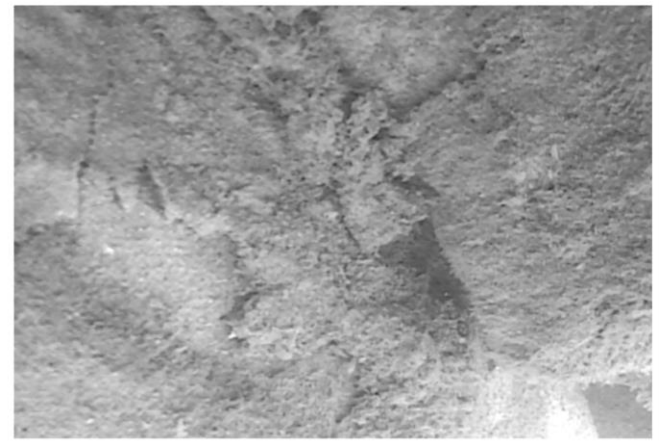
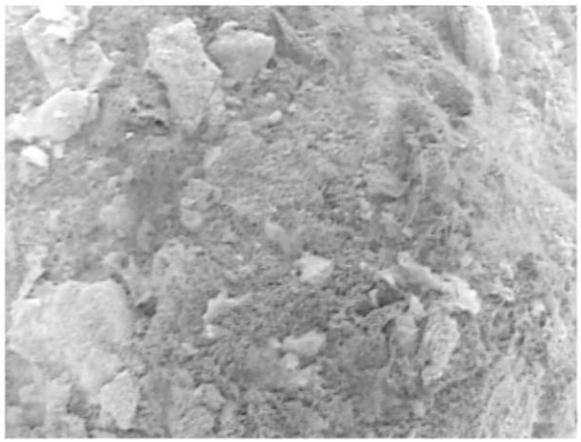
- Equipment was lying in crates for 2 months
- Team unpacked and sorted out the material
- Garage/workshop as working bay
- Sub zeo temperatures, winds , Static electricity, stiff cables and Skuas

Priyadarshini Lake

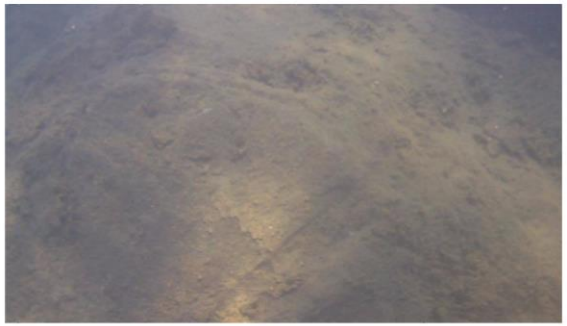
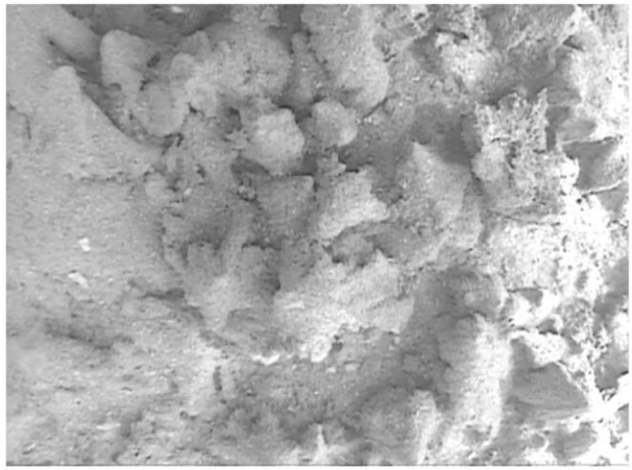
- Fresh water lake
- Maximum depth of 6 metres
- Rocky bottom with algal mats
- Water temperature ~ 1 ^{0} C

Operation in Lake



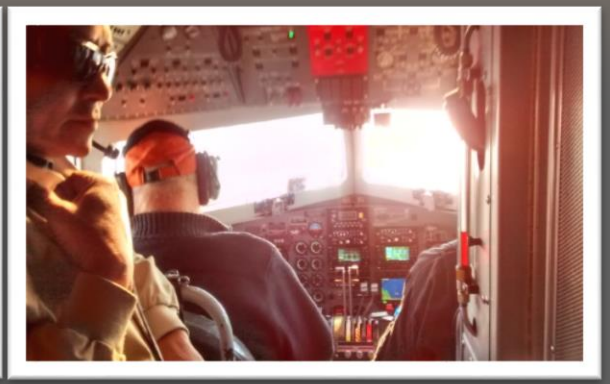
9th Feb Images

Frozen Lake

Testing Corers on Blue Ice

Shelf – New Arena



PROVe cargo shifted by Helicopter

Sorted boxes of PROVe on snow fall day

PROVe cargo onboard
Ivan Papanin Ship

Team in action for integration

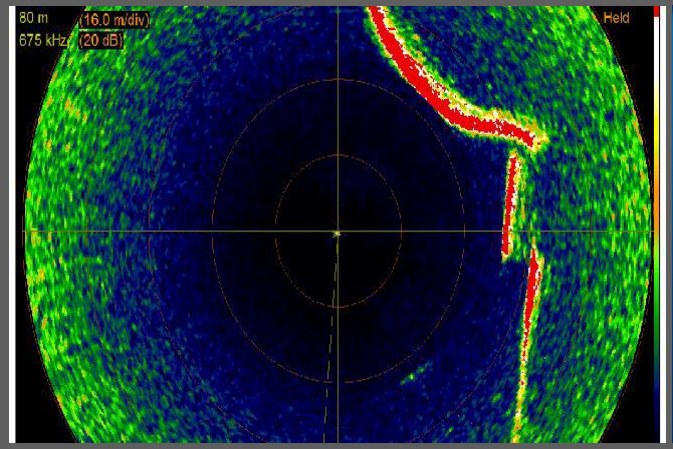
Console screen during dry test

Control console and power system

ROV is removed using ship crane

View from the starboard side (ROV test site)

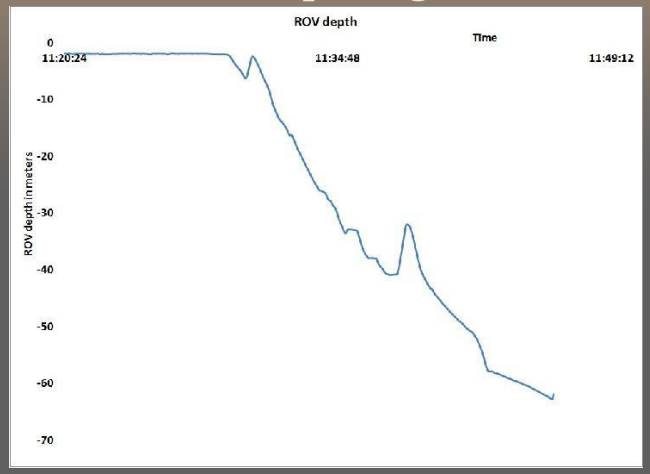
Operation from the Ship



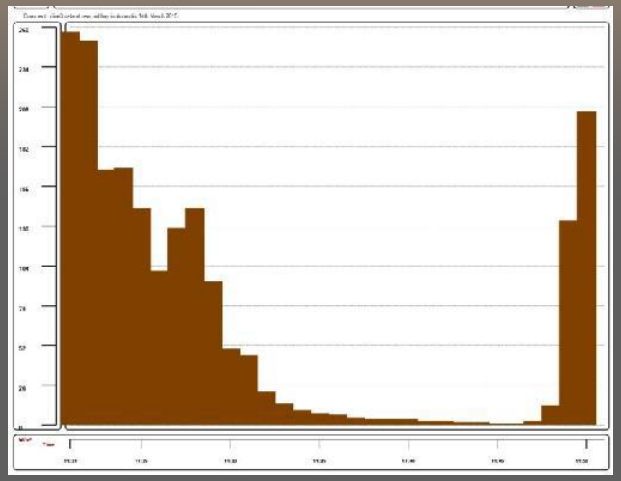
Location at Latitude:69.9648deg S ,Longitude:11.9677deg E
Depth-225m
Ambient conditions: -10degC to -13degC,wind speed:15 Knots

Scientific data acquired from on-board sensors

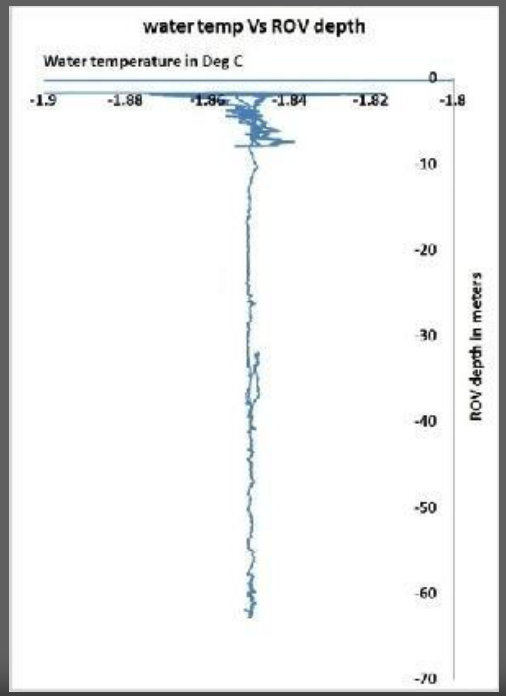
Depth log



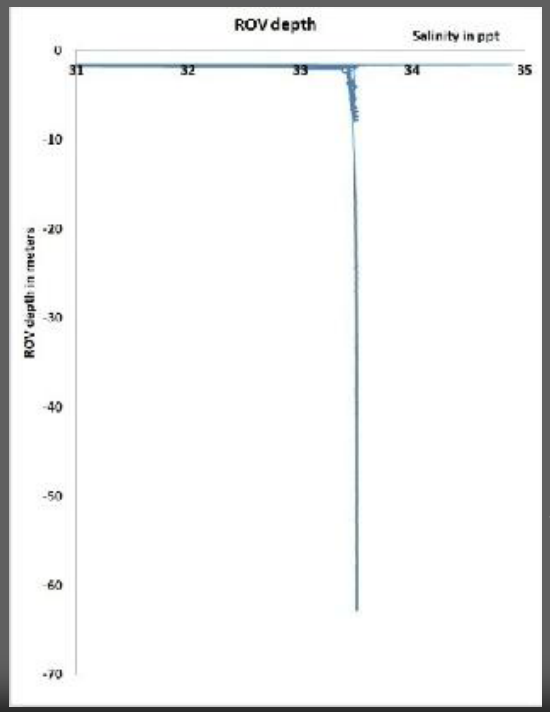
PROVe onboard irradiance



Water temperature log



Water salinity log



Problems Encountered

- Component failure : ‘Never bring one’
  - Operating and storage temperatures
- Operational time
- Umbilical cable stifness
- Vehicle has been redesigned for enhanced endurance and ease of operation

Work in progress !

Thank You