THE KARAKORAM ANOMALY

Exploring the Greatest Mysteries in Modern Glacial and Geomorphological Science

Glacial Lake Outburst Floods and Surging Glaciers

The Karakoram Mountains, Shimshal Valley, Pakistan, 2015

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The Karakoram Anomaly Project

Pakistan 2015: Final Report

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Project Members

Sergiu G. Jiduc (RO, BSc, MSc, Project Founder, Leader and Geoscientist) - hello@sergiujiduc.com
Oliver J. Forster (UK, BSc, MSc, Project Co-Founder, Geoscientist) - oliverjforster@gmail.com
Tim Taylor (UK, Expedition Photographer) - info@timtaylorphotography.com
Matthew Farrell (BSc, AUS, Expedition Cinematographer) - info@flowstate.com.au

Project Field Collaborators

Mr Ali Muhammad Saltoro (PAK, Logistics and Mountain Guide)
Mr Ali Moscow (PAK, Kitchen Chef)
Mr Ali Sher (PAK, Camp Assistant)
Mr Ishuq Muhammad Hushe (PAK, Camp and Fieldwork Assistant)

Participating Organizations

Alpine Adventure Guides (PAK)
Alpine Expe Oradea (RO)
American Alpine Club (USA)
The Captain Scott Society (UK)
Forum for the Future (UK)
The Gilchrist Educational Trust (UK)
Laser Technology Inc. (USA)
The Mount Everest Foundation (UK)
Mountain Fuel (UK)
The Pakistan Meteorological Department (PAK)
The Royal Geographical Society (UK)
Shimshal Trust (PAK)
Trimble Geospatial Navigation (USA)
The United Nations GLOF Project (PAK)
The University of Edinburgh (UK)

Participating Individuals

Dr Ambrose Smith, CBE (UK)
Dr Anthony Newton (UK)
Dr Ghulam Rasul (PAK)
Dr Hugh Sinclair (UK)
Mr Adrian Ardelean (UK)
Mr Alin Buda (UK)
Mr Horia Pasculescu (RO)
Mr Vlad Lascu (RO)
Mr Razvan Muntianu (RO)
Mrs Paula Petru (RO)

Report Main Author: Sergiu Jiduc
Report Co-Author: Oliver Forster

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1. Abstract

The Karakoram Anomaly Project (hereafter KAP) was a multidisciplinary endeavour, which combined scientific research, community development, creative media and mountaineering in the tallest mountain range on Earth, The Karakoram of Pakistan. The project's driving aim was to assess the likelihood of occurrence of one of the least understood natural hazards on the planet, glacial lake outburst floods (hereafter GLOFs), and help to protect the people whose lives are under threat in the Shimshal Valley of Hispar Muztagh Group, Central Karakoram. Secondary objectives comprised an alpine style, first ascent of Yukshin Garden Sar (7530m) via the southeast face (also known as Yukshin Garden glacier route) as well as to carry out a comprehensive video and photographic documentation of the expedition and its associated activities. The KAP employed over 70 local people comprising porters, drivers, field assistants and guides, generating value and revenue across the Hunza and Shimshal Valleys of Central Karakoram.

The fieldwork area of the KAP, namely the Karakoram Mountains is the source of innumerable rivers, which in turn support the livelihoods of more than one billion people in Asia. Worldwide, glaciers are shrinking. In contrast, the Karakoram glaciers seem to be stagnating or even advancing – a mysterious phenomenon, termed the Karakoram Anomaly (KA) by Kenneth Hewitt and others. Investigation of the KA has so far proved ineffective, suffering from the remote nature of the glaciers in the region. This is a critical issue because the KA could be increasing the region's exposure to natural hazards such as GLOFs. The proposed link between the KA and GLOFs is that rapidly advancing glaciers damn river valleys, causing an accumulation of melt-water, increasing the risk of GLOFs. This was the underlying scientific rationale of the KAP and this report will present the story of our expedition through the lens of science, exploration and creative art.

The project research team comprising Sergiu Jiduc and Oliver Forster found a low likelihood of occurrence of a GLOF in the Khurdopin and Yukshin glacial system of Shimshal Valley at present. However, the team has highlighted that the next five years are critical due to the limited damming headroom (20m) between the Khurdopin/Yukshin glacier snout and the Northern Shimshal valley flank as well as the predicted surge periodicity of 20 years. More research and continuous monitoring of the climatic, topographic, hydrologic, geomorphologic and glaciological parameters is required in order to more accurately quantify the risk of catastrophic floods and aid hazard and crisis management, mitigation and adaptation strategies in the region. The preliminary findings of the KAP as well as several proven adaption and mitigation solutions to GLOFs, food and water insecurity from across the world, were presented successfully to the local community in Shimshal village as well as to the Pakistan Meteorological Department and UNDP GLOF Project in Islamabad. The aim of these workshops was to raise awareness about the studied scientific topics and facilitate international problem solving and innovation.

In regards to media outputs the KAP generated over 4TB of high quality photographs and video material, and published a series of articles in the British media such as the Daily Telegraph. The KAP team also presented the expedition story and its key findings at the prestigious Royal Geographical Society "Explore Seminar" in November 2015. From a total of over 25,000 photographs taken during the two and half month expedition by the three photographers (i.e. Tim Taylor, Mathew Farrell and Sergiu Jiduc), a careful selection of images was made in order to advance the project's marketing campaign, meet sponsor demands and organise photographic exhibitions to raise public awareness about all the dimensions of the project and the issues tackled. In addition, the team has crafted a video trailer and is currently working on a 45min long video documentary that will tour the world.

2. Introduction

2.0. The Formation of the KAP

The 2015 KAP is building on previous research carried out in the Ladakh subrange of the Himalaya in the Jammu and Kashmir region of Northern India. Here in 2013, Sergiu Jiduc, Oliver Forster and Dr Hugh Sinclair from the University of Edinburgh, investigated in part the effects of extreme convective storm events on the geomorphology of high elevation glaciated catchments in the arid Ladakh Range of Indian Himalaya. The project's driving hypothesis described the speculation whether the 6th of August 2010 Leh cloudburst event was responsible for the triggering of a series of catastrophic GLOFs, which in turn resulted in the death of more than 600 people in Leh and surrounding rural settlements.

The scientific rationale for the 2013 Ladakh study described convective storms occurring at the steep edges of broad high topography such as the Himalaya being infamous for producing sudden and infrequent (>100 yrs) high magnitude storm events that geomorphically define the landscape and devastate fragile communities through mudslides, debris flows and flash floods. The exact response of glaciated catchments in high altitude, semiarid (annual precipitation <200 mm) regions to these sudden releases of large quantities of precipitation is shrouded in uncertainty.The 2010 monsoon caused extensive flooding, landslides and debris flows around the western Himalaya, with the maximum impact across the floodplains of Pakistan. In the upper Indus Valley in Ladakh, at least 60 small villages were devastated, and several hundred lives were lost. Because this is an arid part of the interior of the mountain chain, the Indian Meteorology Department did not consider it a high priority for monitoring with weather stations. Consequently, there is little recorded information on the scale and distribution of this storm.

In order to test the hypothesis that the cloudburst event and the GLOF are either cause and effect or a simple correlation, the team used the geomorphic record of channel overbank sedimentation and debris flows, combined with topographic analysis to reconstruct the river discharge and precipitation record of the storm event. This was the first time such techniques have been used in this way. Moreover, by using statistical modeling and remote sensing techniques the team was able to assess whether such a storm can generate GLOFs.

The 2015 KAP and 2013 Ladakh GLOF Project are similar as they both tackle GLOFs in remote, high topography mountainous regions. Additionally, both projects included a methodology comprising in part geomorphological tools. A crucial difference between the two projects is the underlying scientific rationale pertaining to hazard causation (i.e. convective storms versus surging glaciers). Nevertheless, the interplay between the two is an area to be explored and perhaps "future KAP" will be able to provide some insights into this fascinating topic.

Figure 1. General physical map of Central Asia, showing the location of the Karakoram Mountains and fieldwork area.

2.1. Motivation of the KAP

The motivation behind the KAP was to advance the scientific understanding of surging glaciers and the notorious glacial lake outburst floods. Furthermore, the team wanted to help the local vulnerable mountain communities to better equip themselves with knowledge and tools to adapt to dangerous climatic and environmental change and associated glacial and hydrological hazards. The work of KAP was considered an important field initiative to understanding the Karakoram Anomaly, surging glaciers, GLOFs and their associated effects on the local geomorphology and hydrology and ultimately mountain communities. Understanding these critical issues could help gauge the future availability of water for hundreds of millions of people as well as to provide insights on how glaciers will change in the future. But most importantly, mapping and quantifying the risk of GLOFs in the area could save thousands of lives.

2.2. Brief Scientific Rationale

GLOFs are caused when an ice or moraine dam containing a glacial lake bursts catastrophically due to a triggering mechanism such an earthquake, extreme storm event or avalanche. The resulting torrent of water, ice and rock rushes downstream, much like a tsunami. Much of the damage created during glacial lake outburst floods is associated with the large amounts of debris that accompany the floodwaters. Damage to settlements and farmland can take place at very great distances from the outburst source. The Karakoram has suffered more than 30 of these devastating outbursts in the last 20 years, and it is believed that 80,000 people in the region are currently at risk.

"During glacial lake outburst floods, there is severe loss of lives and physical assets." UNDP Pakistan

GLOFs are not a new phenomenon. However, with the current environmental and climatic changes, their probability has risen in most mountain ranges. Glacial lakes are particularly dangerous in the Karakoram as they occur at low elevations and close to settlements. In some cases, potential outbursts allow only 10 to 40 minutes to trigger an alarm for the threatened population to evacuate to safety.

It is a key time to understand GLOFs in the Karakoram, because of a phenomenon termed the Karakoram Anomaly (KA). The KA is one of the biggest mysteries of glacial science. It describes the observation of growing glaciers in the Karakoram, in contrast to shrinking glaciers in the rest of the world.

"*The Karakoram Anomaly describes the expansion of glaciers in central Karakoram in contrast to declining glaciers around the world." Dr Kenneth Hewitt, Wilfrid Laurier University*

There's a link between the KA and GLOFs: rapidly advancing glaciers dam river valleys, causing the accumulation of glacial melt-water, increasing the risk of glacial lake outburst floods.

2.3. Project Expectations and Driving Scientific Hypothesis

The KAP had three main scientific expectations, better summarized as driving aims. These were: i) to qualitatively assess the state of health of glaciers in Hispar Muztagh and Panmah Muztagh regions; ii) to quantify, map and report on present glacial hazard risks (i.e. GLOFs) in the area and iii) to present the scientific results through accessible academic and multimedia means. These aims were supported by secondary objectives such as: i) to craft detailed geomorphic maps of glacial lakes, glacier snouts, moraine complexes and meltwater drainage pathways; ii) to measure surface ice flow velocity; iii) to measure meltwater discharge at glacier snout; iv) to reproduce historic photographs of glacier termini; and v) to record geomorphic processes via time-lapse photography and drone videography. The specific scientific questions and hypothesis of pre-expedition KAP were as follows:

Key Scientific Questions
i) To what extent Karakoram glaciers are advancing in contrast to the global trend?
ii) Are the advancing glaciers impounding glacial lakes and increasing the risk of GLOFs?
iii) What is the longevity of the Karakoram Anomaly?

Scientific Hypothesis
1) Glaciers in Hispar - Muztagh and Panmah - Muztagh region are currently demonstrating accelerated surging behaviour.
2) The risk of GLOFs in Hispar - Muztagh and Panmah – Muztagh is greater now then when the last observations were taken in 2001.

Important: Due to financial and time constraints, the KAP only carried out fieldwork in Shimshal Valley in the Hispar Muztagh Subrange of the Central Karakoram. In addition, the KAP science team did not measured meltwater discharge at the snouts of glaciers.

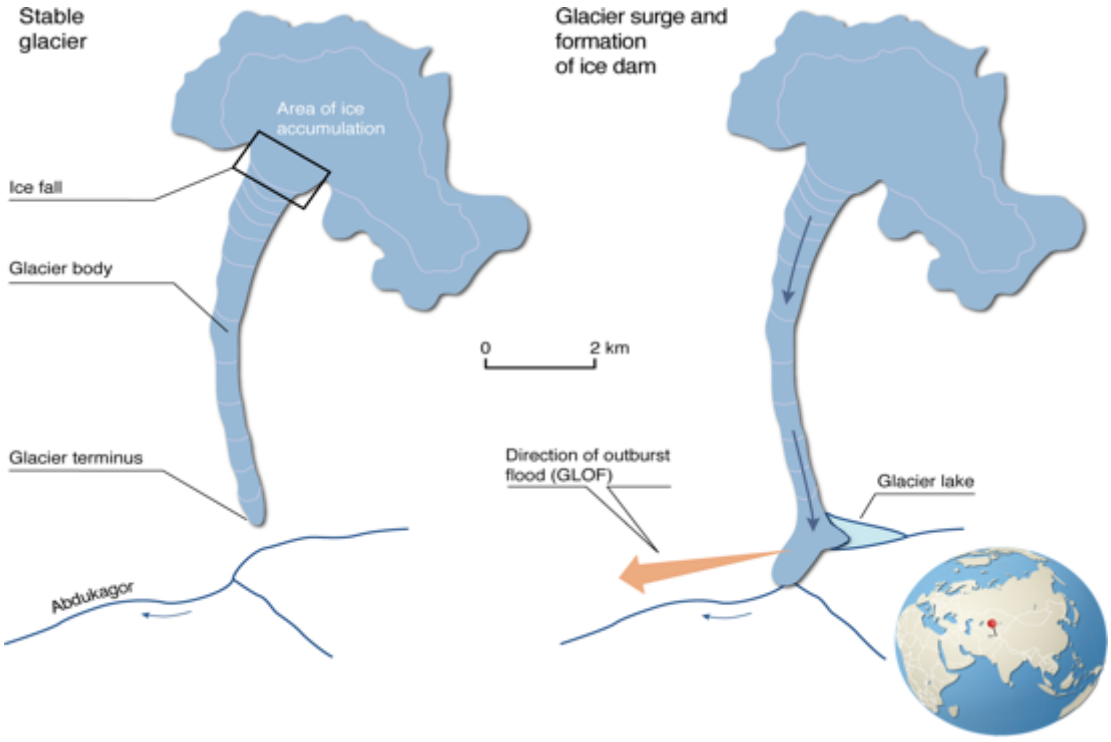

Figure 2. Diagram showing the formation of lakes and glacial lake outburst floods (GLOFs). Example from Medvezhi Glacier, Pamir Mountains. Surging glaciers cyclically store ice mass at elevation during periods of quiescence and discharge it down-glacier during periods of activity. Recent studies have quantified dramatic changes in Karakoram-wide glacier velocities.

2.5. Summary of Key Fieldwork Activities

The key scientific objectives of the KAP was to investigate the state of health of surging glaciers in Shimshal valley and assess the likelihood of occurrence of GLOFs – described as the sudden and catastrophic release of water from a glacial lake due to failure of a moraine or ice dam formed at the end of these lakes.

It is estimated that more than 80,000 people in the Karakoram are at risk of GLOFs. Over 30 such flooding events occurred in the central region of the Karakoram over the past 200 years, and affected the livelihoods of thousands of people living downstream of these glaciers. Almost half of these GLOFs have originated from the notorious Shimshal valley, a remote valley in Northern Pakistan.

Over a two-month period in the summer of 2015, the KAP team carried out a comprehensive scientific fieldwork using an array of techniques such as GNSS real time kinematic survey, geomorphic mapping and repeat photography to investigate how the glaciers are changing in Shimshal Valley, and how this might be impacting the GLOF risk. Some of the data generated by the KAP included quantitative data about the surface velocity of two key glaciers in Shimshal as well as qualitative information about the distribution, morphology and genesis of glacigenic landforms and associated melt water channels. Moreover, the team has carried out a qualitative assessment of glacial changes using repeat photography. By recreating photographs taken by the first European explorers to enter the Karakoram in the late 19th and early 20th century the team was able to assess whether the glaciers have advanced or retreated over the past 100 years.

A secondary key goal of KAP was aid the development of adaptation and/or mitigation strategies to protect local communities from GLOFs now and in the future. For this purpose the KAP carried

out community development workshops, where the scientific context about the formation and initiation of GLOFs as well as possible adaptation measures to these hazards was exemplified through cases studies from Peru, and India. In addition, the team leader introduced the concept of hydroponic farming to the local Shimshali community using a case study from Kenya.

To this end the KAP conducted a workshop in Shimshal village and Islamabad with the Shimshal Trust, Pakistan Meteorological Department and United Nations GLOF Project in order to help local natural disaster and climate change mitigation and adaptation schemes.

In addition the media team comprising photographer, Tim Taylor and cinematographer Mathew Farrell documented the expedition using still and moving imagery for the purpose of crafting a video documentary, photographic essays and marketing campaigns to raise awareness about GLOFs and associated hazard implications. Some of this material has been presented at the Royal Geographical Society Explore Seminar in London earlier this November and several other seminars are planned over the next few months of 2016.

Last but not least, Mathew and Sergiu attempted a world first alpine style ascent on the south face of a notorious technical mountain called Yukshin Garden Sar (7530m). The two-member team reached an altitude of about 7000m from which bad weather forced them to abandon the ascent. A more detailed description of this ascent is presented below in the “Mountaineering” section of this article proposal.

Overall, the project has been described by some critics as being unique and modern in the sense that: i) it used a variety of funding techniques including grants, sponsorships and crowd funding; ii) combined several different but complementary objectives into one project bringing value not just to the public and sponsors in the form of entertainment and marketing but especially to the people who’s lives are depended on the ecosystems services provided by the mountains; and iii) it used cutting edge technology such as a professional drone, high precision GNSS devices and laser rangefinders, communication means such as radios, satellite phones and laptops.

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2.6. Founders, Members and Key Partners of the KAP

The KAP was founded and led by Explorer, Sergiu Jiduc (UK, 24yrs old, contact: hello@sergiujiduc.com) and supported in part by the Royal Geographical Society (UK), Mount Everest Foundation (UK), Gilchrist Educational Trust (UK), Trimble Navigation (US), Laser Technology (US), Captain Scott Society (UK), American Alpine Club (US), Forum for the Future (UK), Imperial College London, and University of Edinburgh (UK) as well as through a crowd funding campaign on Indiegogo (UK).

The project team included Oliver Forster (UK, 24yrs old, oliverjforster@gmail.com) as geoscientist, Mathew Farrell (AUS, 34yrs old, contact: info@flowstate.com.au) as cinematographer, Tim Taylor (UK, 33yrs old, contact: info@timtaylorphotography.com) as photographer and Sergiu Jiduc as leader and geoscientist. Local counterparts included Ali Muhammed Saltoro (PAK, climb@adventureguide.com.pk) as guide, Moscow Ali (PAK) as kitchen chef, Ali Sher (PAK) and Ali Isaac (PAK) as base camp and fieldwork assistants, as well as 50 porters from the village of Shimshal. Key local collaborators included the Alpine Adventure Guides (PAK), Shimshal Trust (PAK), United Nations GLOF Project (PAK) and the Pakistan Meteorological Department (PAK).

Figure 3. KAP team from left to right: Sergiu Jiduc (leader and geoscientist), Oliver Forster (geoscientist), Mathew Farrell (filmmaker) and Tim Taylor (photographer).

Figure 4. Complete KAP team from top left to right: Oliver Forster, Moscow Ali (Chef), Ishuq (camp assistant), Sergiu Jiduc, Mathew Farrell, Sher Ali (camp assistant), Ali Muhammad Saltoro (guide) and Tim Taylor.

3. Fieldwork and Research

3.0. Scientific Rationale

Regional climate change directly affects glaciers and their hydrological systems (Parry et al., 2007). Besides the reduction in mass, glaciers also exhibit a broad range of responses to climate change. The speed and magnitude of the response to climate sensitivity of a particular glacier depends, among other factors, on its geometry, and can have significant variations (Banerjee and Shankar, 2013). Therefore, it is considerably challenging to relate climate change to the variations in the response to climate of individual glaciers. For example, some glaciers may undergo surging phases, which are periods of sudden advance and/or episodes of exceptionally high-speed flow, caused by factors that are not necessarily related to climate change (Meier and Post, 1969; Kamb et al., 1985, 1987; Kotlyakov et al., 2004, 2008). Given the rapid and severe changes the system undergoes during surges, it is important to observe both how the surface is affected and how the mass of the glacier changes during the quiescent (stagnation) period.

The Karakoram Mountains represent an important region to study these extreme processes especially since the return periods of Karakoram glacier surges are poorly quantified. Surging activity needs to be better understood if accurate mass balance assessments of Hindu-Kush–Karakoram–Himalaya glaciers are to be made. The distinctive surface morphology of Yukshin Gardan and Khurdopin glaciers in Shimshal Valley such as large, looped moraines is indicative of glaciers that have surged many times in the past, and reports of periodic ice dams blocking the Shimshal River (and associated outbursts from Virjerab Lake) have historically coincided with surge events, some of which dating back to the late 1800s (Visser, 1926; Todd, 1930; Iturrizaga, 2005).

As well as recording and interpreting the changes in the glacier, the presence of surges has hazard-related implications such as GLOFs due to the formation of ice dams and thus, the study of this behaviour is of paramount importance, particularly given the many lives that are under threat (Kääb et al., 2005). Glacial-dammed lakes play a prominent role in the natural landscape shaping processes of the Karakoram. At present, about 30 potential glacier dams are recorded; over half of them are situated in the western and central Karakoram. Shimshal valley is perhaps the most notorious case reflecting these catastrophic GLOFs.

Furthermore, glaciers in the Karakoram-Himalaya play a significant role in providing water to over 1.3 billion people in Asia. Determine and understanding the changes affecting glaciers and the resulting water in these regions is crucial for the sustainable development of local populations.

3.1. The Glacial Situation in the Shimshal Valley

The Shimshal valley at the Karakoram North side, 60 km in length, is one of the few unglacierized trunk valleys (Figure 5). The parallel-running Hispar valley is taken up by a 62 km long glacier, as well as the neighbouring Batura valley (58 km). But instead, the N-exposed tributary glaciers Khurdopin/Yukshin Gardan (47/17 km), Yazghil (31 km) and Malungutti (23 km) advance into the Shimshal valley and form potential glacier dams over a horizontal distance of merely 25 km.

The three glacier dams Khurdopin/Yukshin Gardan, Yazghil and Malungutti are spread over the Shimshal valley floor, which is up to 2 km broad. In the last century, on average every five years, glacier lake floods occurred in the upper Shimshal valley. The valley flanks in the Shimshal valley are covered with thick slope moraines up to several hundred meters above the valley floor, which are

reworked into transglacial debris accumulations since the deglaciation (Iturrizaga, 1999, 2002b). During glacier lake outbursts the unconsolidated debris accumulations are eroded and tremendous amounts of debris is transported downstream. These hyperconcentrated glacial mudflows possess a high-erosion potential. The sediment yield of the Hunza River amounts 4.800 t km^2/yr (Ferguson, 1984: pp. 581) and also the Shimshal River is fed by suspension-rich tributary rivers. Peak discharge amounts of glacier lake outbursts in the East-Karakoram reached up to 7100 m^3/s (Hewitt, 1982: 267 Feng and Qinghua, 1991).

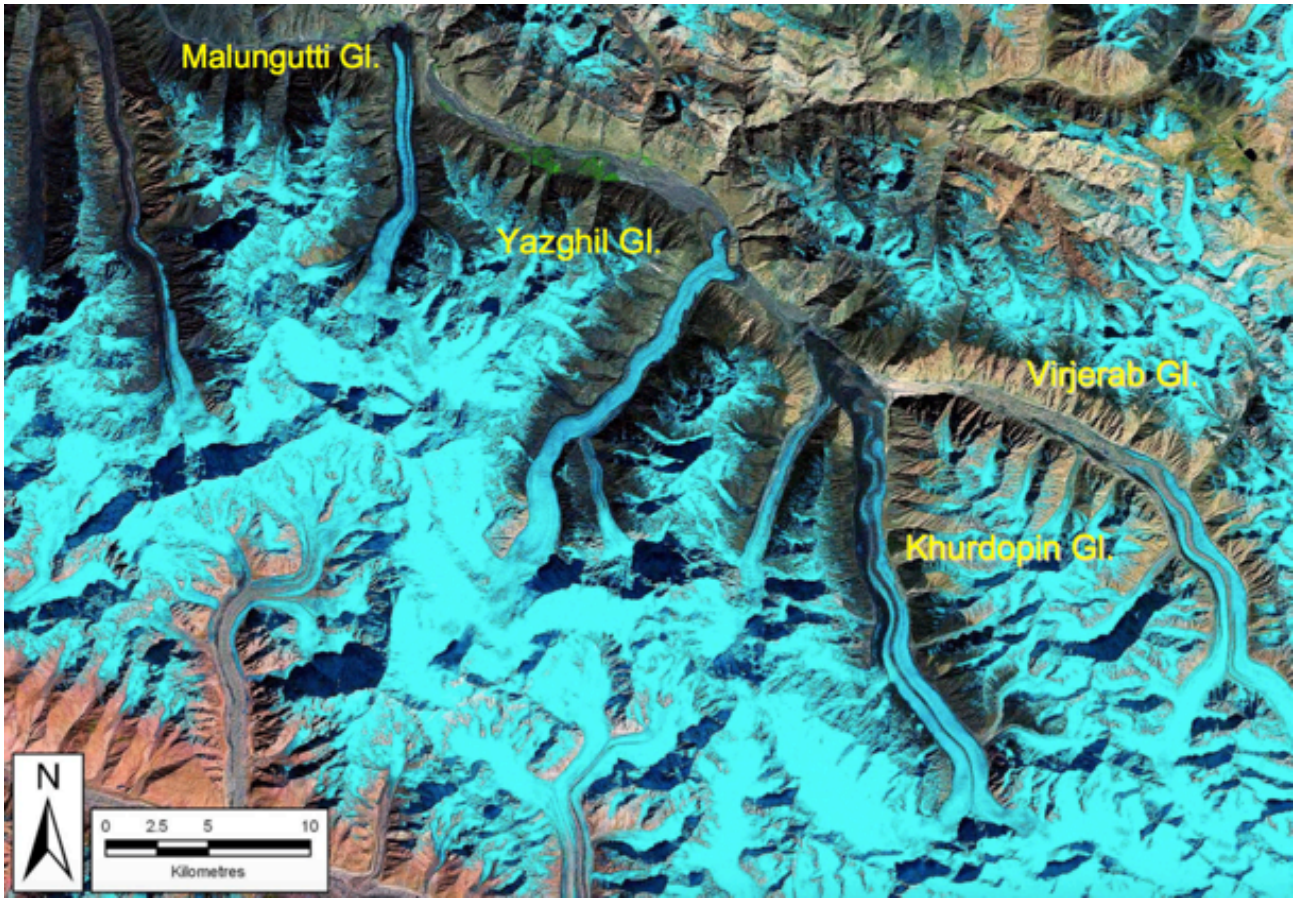

Figure 5. The KAP fieldwork area. Our Focus was on Khurdipin glacier and Yukshin Gardan glacier. Shimshal Valley is dry trunk valley 60km where several glaciers as long as 60km slide their tongues into the valley. GLOFs are a huge problem in Shimshal Valley due to the cluster of so called surging glaciers, which often block the valley leading to the formation of dangerous glacial lakes. Glacial-dammed lakes play a prominent role in the natural landscape shaping processes of the Karakoram. At present, about 30 potential glacier dams are recorded; over half of them are situated in the western Karakoram.

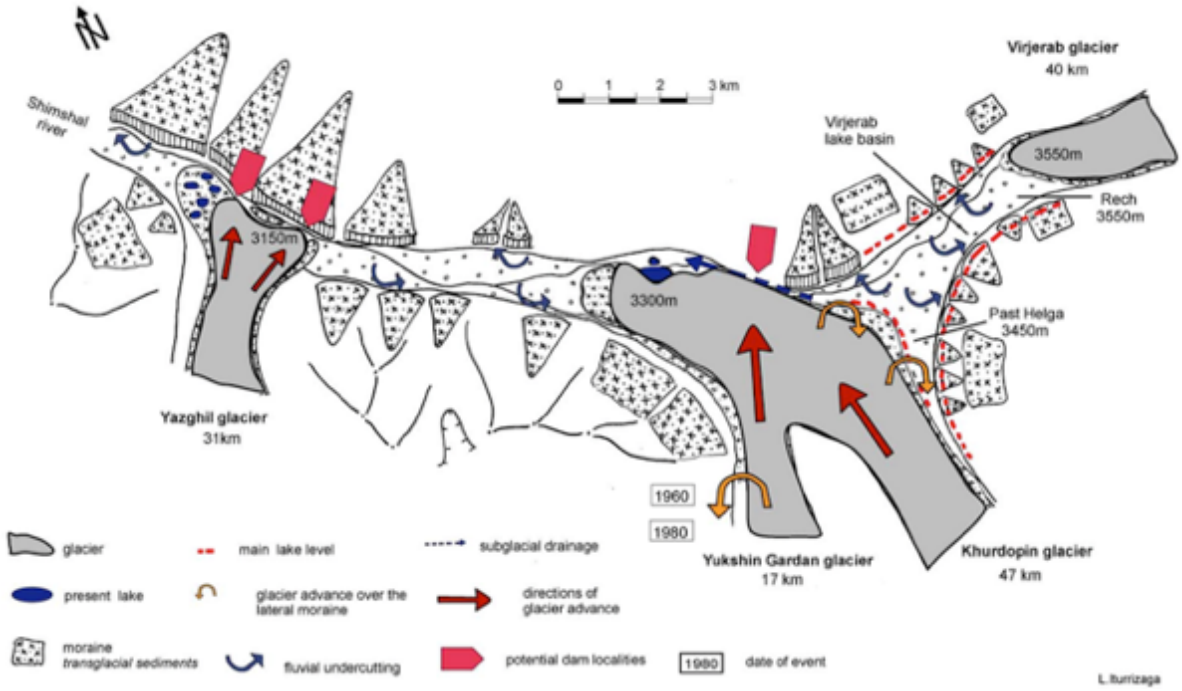

Figure 6. Geomorphological map of Shimshal Valley. Narrow red arrows show the direction of glacier advancement. Wide pink arrows show potential dams. After Itturizaga, (2001).

3.1. Methodology

In order to assess the state of health of glaciers in the Central Karakorum required two sets of data: i) glacier terminus position and ii) glacier velocity. To assess the risk of GLOFs the KAP science team gathered one set of data: iii) field based geomorphological mapping of glacigenic landforms.

i) Glacier terminus position or the physical position of the snout of the glacier was estimated using repeat photography. A series of historic photographs taken by the early 20th century European Expeditions across the Karakoram was acquired from the Royal Geographical Society with IBG in London. Based on landmarks in the photograph, the position of the terminus was approximated and sketched on a map. Photo pairs provided visual representations of glacier change over time and mapped terminus positions were used to estimate changes in glacier length. Repeat photography methodology included: photo site selection and establishment, photography, and terminus plotting. The photographs will be later georeferenced and the terminus position precisely digitized using Geographical Information System (GIS).

ii) Glacier surface velocity was measured using a GPS Real Time Kinematic (RTK) Survey (more details about this technique in Section). Velocity stakes were installed on the glacier surface and their position was repeatedly surveyed using high precision Trimble R10 GNSS receivers. Methodology included: velocity stake installation, data collection, post-processing, and velocity calculation (Karpilo, 2009). The science team looked for till deformation processes and estimated the glacier's profile in order to determine whether the glacier is in quiescence or surging state. The velocity data collected in field is currently analyzed at Imperial College London.

iii) Geomorphological mapping of the glacier terminus provided information about: i) the spatial distribution of glacigenic landforms; ii) their genesis; iii) the distribution of periglacial process; iv) the extent of supraglacial debris cover; v) the meltwater drainage mechanisms; and vi) lake

outburst flood probability. We particularly looked for surging evidence such as: concertina or zig-zag eskers, thrust moraine complexes, crevasse-squeezed ridges, multiple stacked diamictons, tectonised sediments and hummocky moraine complexes. The mapping procedure followed the guidelines explained by Hubbard and Gasser, (2005) and Otto and Smith, (2011) and was divided into three steps: 1) pre-field preparatory activities; 2) actual fieldwork; and 3) post-mapping activities. The identification and mapping of glacigenic landforms will use the criteria developed by Hambrey (1994), Bennett and Gasser (1996), Benn and Evans (1998), Kirbride et al. (2001) and Lukas (2002).

The likelihood of occurrence of a GLOF was estimated using data gathered by the geomorphic mapping procedure. By using an empirical model developed by McKillop and Clague, which incorporates parameters such as: lake surface area, dam height, lake volume, moraine width, moraine height, elevation, slope of moraine fan and lithology of moraine, we were able to generate a quantitative probability that a GLOF will occur, as well as estimations of outburst peak discharge, maximum volume of material, travel distance and maximum area of inundation (McKillop et al. 2007). The regression equation to assess glacial lake outburst flood risk is:

$$\mathbf{P(Y=1)} = \{\mathbf{1} + e^{-[\alpha+\beta_1(M_{kw})+\sum\beta_1(ice_{core})+\beta_2(Lk_{area})+\sum\beta_k(geology_k)]}\}^{-1}$$

where α is the intercept;, β_1 β_2 β_i β_k are regression coefficients for M_{hw} (ratio of lake surface height to moraine width), Lk_{area} is lake area; Ice_{core} is ice present or absent in the moraine and $Geology_k$ is lithology of the moraine.

3.2. Specialist Equipment and Technique

In order to calculate the surface ice flow velocity of Yukshin Gardan glacier, the KAP research team used an innovative differential GNSS survey technique called Real Time Kinematic (RTK). The RTK technique is based on the use of carrier measurements and the transmission of corrections from the GPS base station, whose location is well known, to the rover, so that the main errors that drives the stand-alone positioning cancel out.

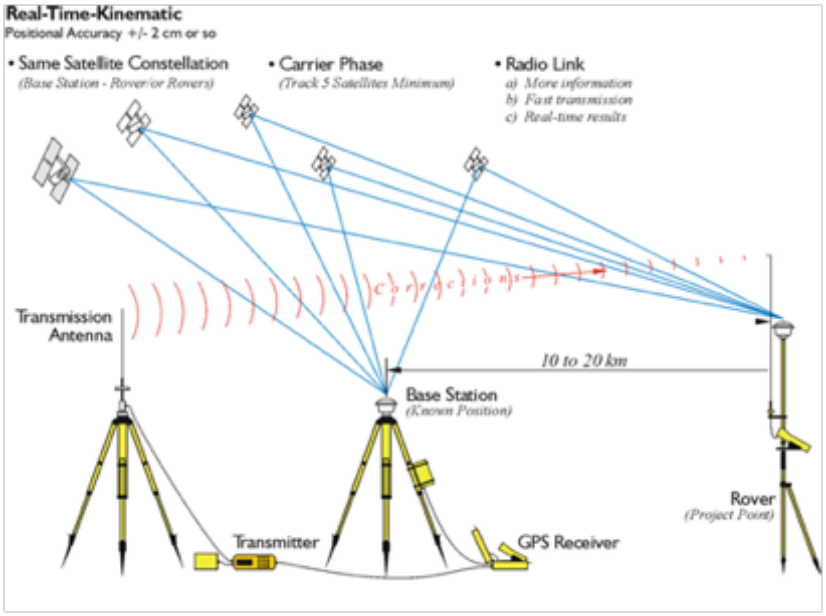

Figure 7. Diagram showing the Real Time Kinematic GNSS procedure. Note that we did not use a third transmission antenna (left), as both our rover and base station system has been equipped with transmission antennas.

Figure 7. Images showing the base station configuration as seen from the top of Yukshin glacier western lateral moraine (left image) and the rover system on the surface of Yukshin glacier (right image). Copyrights, Tim Taylor, 2015.

GNSS Measurements

a) Planning the GNSS surveys

- **GNSS survey goal:**
  Main goal: To calculate the relative surface velocity of i) Yukshin glacier (terminus + Equilibrium Line Altitude areas) and ii) Khurdopin glacier (terminus area)
  Supporting objective: To construct an array of 40+ points across Yukshin and Khurdopin glaciers and measure their precise positions over a predetermined time interval using an accurate real time GNSS technique (RTK).

- **GNSS survey plan:**
  Planned to carry out RTK measurements by establishing an on-site base station, which can transmit real time differential corrections to the rover through the radio module. The base has been centred on a solid point on static ground (moraine) and its coordinates have been precisely logged (on site reference system). The same coordinates have been used as the reference for all the surveys. The key objective was to see how a point on the glacier moves throughout time at RTK precision.

- **Schedule:**
  4 days drilling to establish the velocity points followed by 4 additional days marking boulders, 20 days survey time interval, with 2 surveys each requiring 4 days to perform. In total we have worked 16 days on the GPS survey. The survey lasted for 36 days including all preparatory activities and waiting time.

- **Contingency plan for the fieldwork**:
  Use tagged boulders instead of velocity stakes if they fail or too difficult to carry out; Reduce coverage area

- **Check all equipment prior to mobilization to site**
  Due to the many constituent parts of GNSS receiver systems, especially RTK systems: batteries, antennae, receivers, radios, data cards or loggers, associated cables and sundries, it was good practice to check all equipment prior to mobilisation.

- **Order/check fundamental control station data:**
  The coordinates for the base control station were the same for every survey. Backed up data.

b) Geodetic control

Geodetic control has been established on day one at a fixed location near our base camp (3678m) on the top of the 100m high lateral moraine. The on site reference base station had clear views across the glacier for a distance of over 20km. The base station location and its coordinates have been determined in VGS system and precisely registered in the field notebook using an ordinary GPS as well as the Trimble R10 receiver. The base station had remained centered on the fixed point (painted dot) throughout the length of the survey (30 days). The same reference point has been used for both surveys.

Base Point name: 1000
Location: Lat: 36°19'37.01400"N / Long: 75°26'27.62734"E
Elevation: 3678.039m
Coordinate system & Projection: UTM (Universal Transverse Mercator)
Zone: 43 North
Datum: WGS 1984
Antenna height: 2.039m

c) Survey Style & Method

- Equipment used: 2x Trimble R10 (one rover and one base) and 1 x TSC3 controller
- High-Precision Real-Time kinematic (RTK) - differential GNSS technique.
- On the Fly (initialization type)

Does not require an initialization on a known baseline. Thus, the survey can tolerate periodic loss of lock during the survey, as the 'integer ambiguity' can be determined whilst the rover is moving to the next point. In such surveys, as the receiver at which the baseline solution is being calculated is moving, a short epoch setting is needed. Typically an epoch setting of one or two seconds is used for standard detailing for land surveys. In the on-the-fly technique, the most advanced baseline solution methods are used to determine the baseline initialization and then to test it, to ensure it is the correct one when initializing on-the-fly surveys it is important to move to a location, which has an open view of the sky. Once the initial baseline is computed, the coordinates of the roving receiver are computed for each epoch. The integer ambiguity of the baseline is known from the initialization process and thus the new baseline solution at each epoch can simply be determined from the change in the satellite observations.

- **43 points GPS** have been measured on the glacier surface of which 3 have been compromised

d) Precision and quality control on the GNSS observations

We have used the most advanced GNSS commercial solution with a precision of 8mm +0.5 ppm horizontally and 15mm +0.5 ppm vertically. Carrier phase measurements are therefore extremely precise (down to fractions of a millimetre), but they contain an unknown integer initialization constant, the so-called "phase ambiguity". RTK positioning resolves the integer ambiguities to achieve the high level of precision (called initialization). Convergence time is needed to fix the phase ambiguities. This time depends on the processing algorithm and the distance between base and rover, and ranges from a few seconds to a few minutes. RTK technique is based on the following high-level principles:

- In clear-sky locations, the main errors in the GNSS signal processing are constant, and hence they cancel out when differential processing is used. This includes the error in the satellite clock bias, the satellite orbital error, the ionospheric delay and the tropospheric delay.
- The noise of carrier measurements is much smaller than that of the pseudo-code measurements. However, the processing of carrier measurements is subject to the so-called carrier phase ambiguity, an unknown integer number of times the carrier wave length, that needs to be fixed in order to rebuild full range measurements from carrier ones.
- The phase ambiguity can be fixed for dual-frequency differential measurements for two close receivers.

e) Quality Control

The survey measurements, field records, sketches, and other documentation were examined to verify compliance with the specifications for the intended accuracy of the survey (i.e. 1cm horizontal, 2cm vertical). This examination may lead to a modification of the intended accuracy. The survey accuracy was checked by comparing minimally constrained adjustment results against established control. This comparison takes into account the network accuracy of the existing control, as well as systematic effects such as crustal motion or datum distortion.

Accuracy is the measure of the difference between a particular measured coordinate and its true value, often quoted as the root mean square error (rms).

Key Quality Control: Occupied a control point with known coordinates. This ensured that the displayed co-ordinates are correct.

f) Executing Survey Measurements

- GNSS rover antenna was mounted on top of a 2m pole, the operator used a hand-held data logger (controller)
- Operator performed 2 -3 observed control point measurements per survey, per point each, consisting of 360 Epochs (6min) per point. We have carried out 2 surveys in total.
- Surveys have been carried out from higher to lower elevations (e.g. 4000m to 3500m) on high stable landforms such as ice pinnacles, debris mounds as well as in depressions such as supraglacial valleys.
- A higher resolution of points was used at the confluence of Yukshin – Khurdopin in order to assess the ice flow interaction between Yukshin and Khurdopin glaciers.
- Logged each measurement in a field notebook such as name, location, elevation, date, time, author, comments
- Used the same coordinate values when performed the two surveys
- Did not mix receiver and antenna types
- Re-measured the base station antenna height at the end of the survey.
- Download data daily
- Recharged all batteries overnight.

g) Processing and Results

- We have gathered the GPS data using Trimble Access Software. Post processing of data has been carried using Trimble Business Centre, Excel, & AutoCAD software. Processing activities included exportation of dxf, csv files, conversion and calculation of displacement (DGPS) using AutoCAD at GISCAD Trimble Dealer, Romania. Our working precision was less than 1

cm.
- We have used the manufacturer's defaults for processing parameters.
- GIS, processing will follow shortly with the creation of a DEM, glacier polygons and velocity vectors. In addition, we will use remote sensing to extrapolate the vectors across the glacier.

3.3. Preliminary Results

- Khurdopin glacier is moving relatively slowly or at normal quiescence velocities of approx. 1 to 5cm/day or 3 to 20 m/year); Yukshin glacier on the other hand is moving faster with recorded velocity values of 5 to 35cm/day or 20 to – 130m/year depending on location. It is worth mentioning the Yukshin glacier is an avalanche fed type glacier situated in a steeper sloping valley, hence the higher velocities.

- However, measured surface displacements of Khurdopin during surging reached > 5 km/year. Therefore we can conclude, that the glacier is not surging and it is in a quiescent phase. Therefore the people of Shimshal are safe for now! From the topographic relief point of view, the glacier is changing every year due to continuous ice degradation. The surface of Yukshin and Khurdopin glaciers showed an increase in the number of thermokarst features such as rapidly size and form-changing depressions and supraglacial ponds. The surge surface topography became less chaotic and smoother as compared with previous observations. However, the issue of debris cover may complicate the story.

- Beyond the glacier response to changing climatic conditions, glacier topographic factors (e.g. aspect, altitude, slope, morphology) will influence glacial dynamics. In the case of debris-covered glaciers, the influence of the debris cover must be deeply considered. Previous studies revealed that glaciers with extensive debris cover have a qualitative difference in their response to a warming climate as compared with bare ice glaciers (Banerjee and Shankar, 2013). Depending on its thickness, the debris cover might enhance or alternatively hamper glacier ablation (Mihalcea 2006; Benn and Evans 2010). At similar latitudes and elevation, but in the Northern Hemisphere, Mihalcea et al. (2006) found ablation rates that varied between 3 to 6 cm/day with a debris layer of 18 cm to 0 cm thickness for the debris-covered Baltoro glacier in the Karakoram (4178m, 35° N) with GNSS surveys. In the Bagrot Valley (Karakorum, 36° N), the lowest ablation rates were ~2.3 cm/day, with a debris cover thickness averaging 37.5 cm, between 2500 m to 3350 m (Mayer et al., 2010).

3.4. Preliminary Interpretations

- At present there is no significant risk of GLOF. The Shimshal River drains trans-glacially along the length of its contact with Khurdopin glacier. There are small patches of the sub-glacial drainage but they are limited. Khurdopin-Yukshin galcier would need to advance at least 20m in order to damn the river. Glaciers in the region are retreating overall as our repeat photos demonstrate (see Figure 5 below). Moreover, everyone we have spoken to in Pakistan has also indicated that in the last few years the glaciers have gone backwards and their levels have gone down suggesting recession and thinning.

3.5. Preliminary Recommendations

- The next five years are critical in region because Khurdopin surge periodicity is believe to be approximately 20yrs, with the last surge occurring in the late 1990's.
- The influence of Yukshin Gardan glacier remains uncertain. It could have a role in creating a GLOF (more research is needed)
- Continuous monitoring of the two glaciers over the next 5 years is paramount
- Installation of a water level, a permanent GPS receiver and a weather monitoring station on Khurdopin and Yukshin glaciers could provide valuable information, which can aid mitigation and adaptation strategies and government action in the region.
- Close monitoring of the area is recommended during critical times (e.g. summer & surging phase) in order to inform an early warning system

Figure 8. Repeat image series shoring Passu glacier in 2015 (left) and in 1887 (right). Historic image, courtesy of Royal Geographic Society and Tim Taylor Photography, 2015.

Figure 9. Repeat image series shoring Rakaposhi and its western flowing glacier in 2015 (left) and in 1927 (right) as taken by Capt. J. C. Morris. Historic image, courtesy of Royal Geographic Society. Tim Taylor Photography, 2015.

4. Adventurous Activities

4.0. Mountaineering – Yukshin Gardan Sar (7530m)

The rope is fully tensed. Matthew must have fallen in another crevasse. I hold my belay system diligently and kneel down in the soft fresh snow to better control the forces that are pulling me across the edge into a deep abyss. All around us the blizzard has completely engulfed the giant, jagged peaks of Shimshal valley, many of them over 7500m high. Visibility has been reduced to less than 20 meters. I feel so weak that I can barely manoeuvre the rope to rescue Matthew out of the ice tomb. The last 2 days have been particularly hard, as we had no chance to make water and prepare water. If it wasn't for the towering seracs marking the crevasse edges, we would have been long dead. Where are we you may ask? It must be hell...

In the summer of 2015, as part of a multidisciplinary project entitled the Karakoram Anomaly Project, Mathew Farrell and Sergiu Jiduc attempted to climb a remote and poorly explored 7000m+ peak in the Hispar – Muztagh Group, a sub range of the mighty Karakorum Range of Pakistan. Known as Yukshin Gardan Sar, the mountain measures 7530m above sea level and lies about 15 km northeast of Khunyang Chhish (7852m) and 5 km northwest of Kanjut Sar (7760m), - two other giants of the of this planet, barely missing the membership of the 8000m+ club. Yukshin Gardan Sar is flanked on the northwest by the Yazghil Glacier and on the northeast by the Yukshin Gardan Glacier, which both drain into the notorious Shimshal River.

Yukshin Garden Sar is a technically difficult mountain that had not been climbed since 1986. With only three small teams attempting their luck on the mountain it is fair to say that the peak is poorly documented in literature. In fact most peaks of Shimshal valley, have neither been climbed nor properly described. The route via the south face of Yukshin Gardan Sar that we attempted had never been climbed before and no information whatsoever was available about this face. Therefore our risk assessment was primarily based on Google Earth Maps and on site observations. It is worth mentioning that the sense of perspective in the Karakoram can change dramatically – the shear size of glacier features here is enormous and beyond anything we have ever seen.

Figure 10. Left. The North Face of Yukshin Garden Sar as seen from base camp in the evening. Copyrights: Mathew Farrell, 2015. Right, Yukshin Gardan and base camp early in the morning. Copyrights: Sergiu Jiduc, 2015.

Having already established a base camp on the western lateral moraine of Yukshin glacier, the next important leg of the mountaineering quest was to set up an advanced base camp (ABC) from which

we could attempt several ascents up the extremely fragmented ice fall that was separating us from the col. The terrain was very complex, riddled with hanging seracs and menacing crevasses, but so remote as to make any hope of help impossible. No wonder no one has ever tried to climb this route. After establishing ABC at 4100m under the icefall and equipping it with gas, food and climbing kit, Mat and I decided to make an attempt and so packed with supplies, camping gear and warm clothes we began climbing the steep maze of towering seracs and bottomless crevasses. Often we would look back on the slope that we had already traversed; they appeared impassable. So could tomorrow, until tomorrow turns into yesterday. Instead of reaching our proposed camp I in one day as estimated it took us 2 full days of climbing unstable crevassed terrain, jumping from and climbing giant seracs the size of buildings. This was the icefall climb (from advanced base camp at 4100m to camp I at 5150m), by far the most dangerous section of the whole climb. When you venture into these unchartered landscapes, you have to surrender and just put your head down. It took two days to work through that maze of crevasses; it felt that I could get through anything.

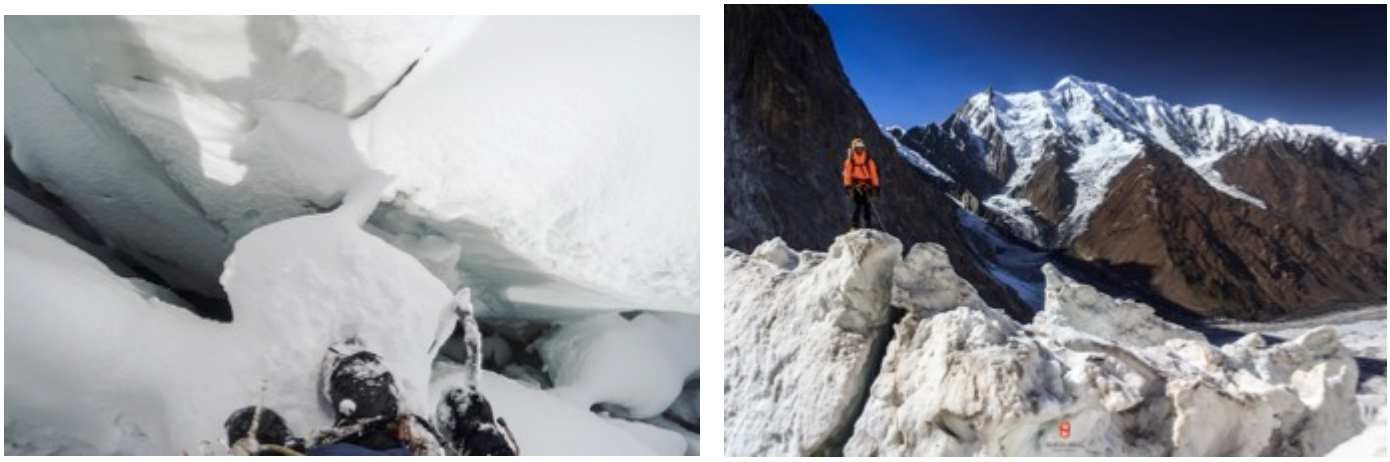

Figure 10. Yukshin Gardan Ice fall Climb (4100 to 5100m). Left. Jumping over one of hundreds of crevasses. Copyrights: Mathew Farrell, 2015. Right. On top of a giant serac at around 4500m. Copyrights: Sergiu Jiduc, 2015)

Figure 12. Left. Camp I (5150m) on top of the Ice Fall (Copyrights: Sergiu Jiduc). Right. Camp II (5800m) as seen from above. Copyrights Mathew Farrell, 2015)

In addition to the objective hazard posed by the nature of the glacier, the changing and unpredictable weather conditions and the extreme cold were not on our side especially in the high camps. Every big mountain constructs its own microclimate, which can be very unpredictable. Therefore, weather forecasts for big and remote mountains, are only 50% accurate, making decision-making quite difficult. Experience, and on-site observations as well as intuition play a major role in deciding whether to push forward or abandon a climb. We tried twice to reach the summit from camp 3 at 6400m. However, our contingency time ran out and so did our supplies. Two failed summit attempts due to the extreme cold (-35°C) and high avalanche risk resulted in an

overconsumption of our supplies. We decided to get off the mountain as soon as possible. On day 10 on the mountain we were in camp 2 (5800m) and here we realised that our gas was used up. This marked the moment where our situation became very problematic. In addition, all around us the mountain was strongly expressing its presence with frequent rock and ice avalanches blasting from the rupture of hanging ice seracs and running down the south face barely missing us. To make matters worse the blizzard, which started during our summit attempts, was omnipresent.

Figure 13. Left. Camp III (6400m). Copyrights: Mathew Farrell, 2015. Right. Camp View across the Central Karakoram from Camp III (6400m). Copyrights Sergiu Jiduc, 2015.

Not having enough gas to melt snow in order to make water and cook food was a huge problem especially since we were a long way from safety (2000m level difference to be precise). In addition we were experiencing whiteout conditions, and feeling exhausted and lost. The survival mission back to advance base camp took us 3 days and involved no water and food whatsoever, falling in dozens of crevasses, and dragging ourselves through fresh deep snow on possibly the worst glacier we have ever been on in our lives.

Figure 14. Left. Mat, negotiating crevasses and seracs on the way down to ABC (4150m). Right Abseiling in storm conditions from Camp III. Copyrights Sergiu Jiduc, 2015.

We even tried to call for a rescue helicopter from the military, but these issues take time, a commodity we could not afford at that time. However, in the end our strong motivation, good teamwork and luck pushed us to safety. We descended safely to ABC without being rescued by a helicopter. This was due to an inspired decision to cross the icefall laterally and enter the north face of the mountain where we found water and abseiled in a steep and gigantic gully using some 40+ rappels.

Fatigue is a moment of surrender. We are more aware of our surroundings; we feel rather than think and this leads into our first discovery, an icy couloir, carved into the vast, limestone north face of the mountain. Inside this gully, a voluptuous world made of calcium carbonate and hundreds of million years old little fossils. Long and sinuous, the gully has holes in its fabric and a white snow and blue ice cover. In its details, we see beauty that is the result of consequence. Everyone should be so lucky to witness such grace.

My quest for beautiful lines up mountains where I find peace and clarity through intense mental focus where I can tune everything else out and just focus on that next step will continue. Risks are always calculated but there are moments when it just doesn't feel right. Having a passion can be both a great uplifting thing and a curse.

4.1. Motivation for Climbing Yukshin Gardan Sar

Why did we attempt this mountain? Nobody has been on it since 1986 when a Spanish team comprising Alejandro Arranz, Iñaki Aldaya, Alfredo Zabalza, and Tomás Miguel climbed it via the southwest ridge. In fact only three teams have ever attempted this mountain and no human being has ever set foot on the southeast face. A world first on this face sounded like an interesting mission.

However, Yukshin is a esthetically beautiful mountain! A rock and ice pyramid, almost perfectly symmetrical towering more than three and half kilometres above Yukshin glacier, it cuts the sky like Poseidon's trident. Climbing this majestic peak would have been a great honour. We also appreciated the fact that the mountain is located in the valley where our scientific research was being carried out and thus an attempt to climb it meant easier logistics as we could avoid moving our camp to another valley.

4.2. Reflections while on the Mountain

Our real lives are a night sky, full of constellations. Everything we anticipated is only half of what happened; remote is a definition, not an emotion. Connecting to the endless is possible; out in the dark and in the wild is where we allow it. Packed up, listening for an engine, it was a lifetime ago that we were friends. Now we are a family whose only purpose is to keep moving. If we could, we would stay out here, forever. This is our real life. This is where we belong.

Lewin's equation described human behaviour as a function of personality plus environment. It was the first theory of understanding human nature that gave importance to a person's momentary situation, rather than relying entirely on the past. As humans, we have all encountered turning points, moments of decision-making that will affect the course of our lives, whether we recognize it in the moment or not. To be steadfast is to have known the weakest part of yourself and moved through that territory into an unwavering commitment. No one here is rough or raw. They are unshakable, tightly bound, like industrial cable that will not fray, meeting whatever happens with muscle and guts, humility and grit.

5. Administration and Logistics

5.0. Destination Area

The destination fieldwork area of the KAP was Shimshal Valley (36.30495°N; 75.43068°E) of the Hispar-Muztagh group of the Central Karakoram Mountains (see below map)

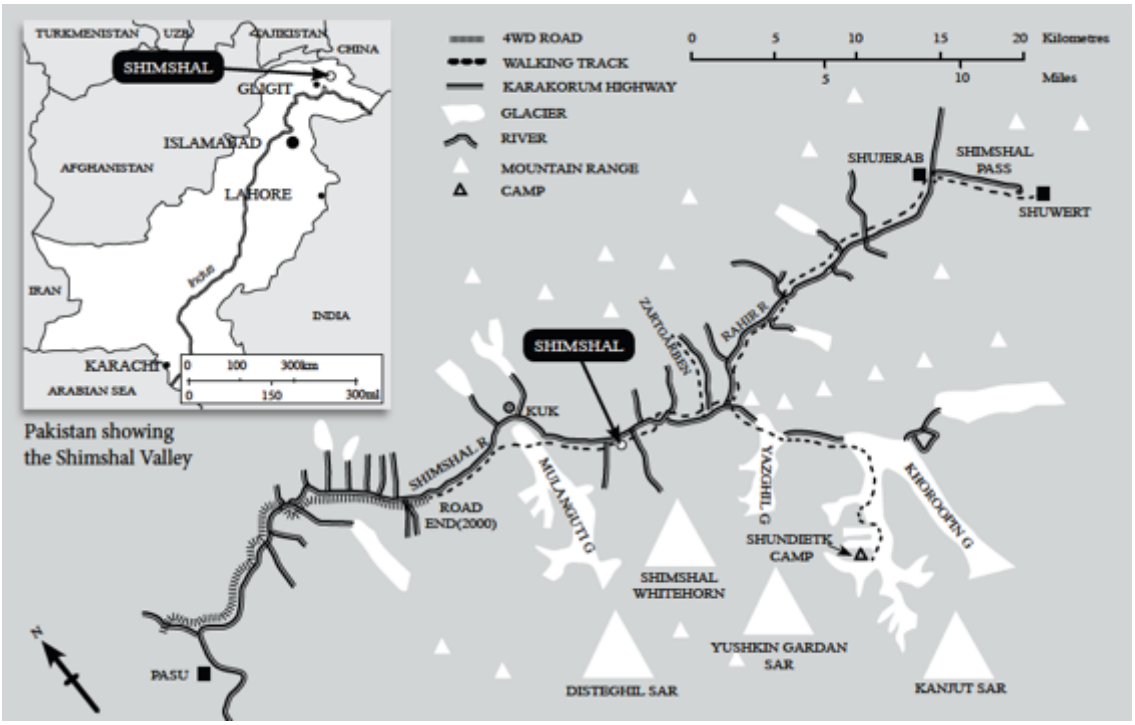

Figure 15. Map of Shimshal valley with inset showing its location in Pakistan.

Shimshal is a relatively large Wakhi-speaking village supported by vast herds of sheep, goats and yaks that are moved up and down the valley with the seasons. The valley of Shimshal was closed to visitors until 1986, after which an increasing number of adventurers braved the mountain trail through the narrow and dangerous Shimshal gorge. It was from the upper Shimshal, even as late as the 1890s, that raiders harried caravans heading to Kashmir. In 2003 a jeep road was inaugurated that finally linked Shimshal village to the KKH.

The road to Shimshal leaves the KKH at the snout of the Batura Glacier, 6km north of Passu. It crosses the Hunza River on a suspension bridge and then enters the narrow gorge of the lower Shimshal River; a more ominous gateway would be hard to imagine. After about an hour of negotiating a shifting, cliff-hugging jeep track and crossing a couple of daunting bridges, an experience definitely not for the faint hearted, we had arrive at Dut, a reforested oasis with no permanent settlement but a few huts for shepherds and road workers. Soon after Dut the valley opens out, closes in again, and glaciers approach the road. It's hard to picture more awe-inspiring and stark scenery. Flowing off the lofty white mass of Distaghil Sar (7885m) – the 19th highest mountain in the world, Malungutti Glacier descends right to the road, calving its ice into the rapidly flowing Shimshal River.

Figure 16. Left. Shimshal Gorge and the sketchy road cut into the valley flank. Copyrights: Tim Taylor, 2015 Right. Two of our yaks carrying supplies towards base camp. Copyrights: Sergiu Jiduc, 2015.

Shimshal is made up of three villages: Aminabad, Shimshal and Khizarabad. Aminabad is announced by vast fields of stones hemmed in by drystone walls, and fortress-like houses of stone and mud. As one approaches Shimshal a glimpse of Adver Sar (6400m), also known as Shimshal Whitehorn can be seen. Shimshal has hydroelectricity for five months of the year (when the water isn't frozen). According to local tradition, Shimshal has been inhabited for 400 to 500 years. A charming legend tells of the first settler, Mamu Singh, the son of the wazir (prime minister) of Hunza, who fell in love with a girl from the Wakhan and defied his family by marrying her and eloping to the remote Shimshal valley to live. Shimshal was later used as a penal colony by the mir of Hunza who exiled criminals and troublemakers to this remote valley. It was also from the hidden valley of Shimshal that the Hunzakuts raided caravans crossing the mountains from China to India, even as far as the Karakoram pass in Ladakh, 200km away. The trade route from Leh to Yarkand.

The reason why Shimshal was located in such an out-of-the-way place is because this is where the Mir (ruler) of Hunza used to send his people who were found guilty of crimes and also those who he just did not like! Shimshalis are now a proud and hardy folk. Their hospitality is legendary and the natural beatify that they inhabit make tourists feel that perhaps the Mir sentenced them to heaven, not hell. Shimshal is the oldest of the Whaki speaking villages in Gojal. Some claim that it is an attraction for society lovers as the only place where the culture and values of Hunza is still alive. These all make Shimshal as one of the best place to visit in Hunza.

C. J. Morris, 1928 described Shimshal valley in The Geographical Journal as follows: "The whole of this region must be one of the most desolate in the world. Everything here is grim and desolate, and the general effect of the scenery is depressing in the extreme. Even the glaciers with which this country abounds are dirty and covered with debris, and the giants of the Karakoram, but for which this country could only be described as hideous, seem to lift their heads above this scene of desolation only in disdain".

5.1. Research Material and Information Sources

The KAP used a combination of historic and modern material in order to craft the research component. In particular, the team used 53 historic photographs and seven maps from the Royal Geographical Society Archives. The key photographs used by the KAP were taken by Capt. C. J. Morris in 1927, Ph. C. Visser in 1925 and C. P. Skrine in 1922-1924 whereas the maps were made by the members of the E. E. Shipton 1939 Expedition to the Karakoram, H.J Schneider in 1967 and Wala Jerzy in 1990. Furthermore, the science team used over 54 academic journals from several prominent publications including Glaciology, Natural Hazards, Science, Nature, and many others to describe the various concepts use din the projects such as the: The Karakoram Anomaly, GLOFs,

and surging glaciers. Google Earth, and NASA also provided key remote sensed imagery, which aided logistics and research.

5.2. Training and Equipment Testing

The KAP team has roughly trained for duration of six months starting with January 2015. This training included fitness, aerobic and strength sessions. Exercises comprised swimming, running, and cycling sessions, high-intensity exercises such as "Spartacus" as well as climbing both outdoors and indoors. Equipment testing such as the GNSS GPS receiver, laser rangefinders, compass clinometers, and the drone, has been carried out prior to our departure in the field in open field areas in the UK and Australia. These testing were in the form of mock GPS and geomorphological mapping activities meant to recreate fieldwork conditions as well problems that might arise while on the glaciers. The tests have been a success although recreating the exact conditions with ice and rock terrain has been a challenge if not impossible. Therefore, most testing has been carried our boulders or grassy terrain.

The key to the successful functioning of the KAP team is effective communication on both intellectual and emotional levels, in order to develop a healthy team climate and effective team process. To achieve this, the project leader tried to develop openness, trust and self-disclosure, support and respect amongst team members by communicating the vision with passion to motivate, encourage and guide team members to perform whilst outside of their comfort zone.

5.3. Permission and Permits

We have acquired a trekking and mountaineering permit from the Gilgit-Baltisan Tourism Council in Pakistan prior to our arrival in the field. This permit worth USD600 comprised environmental and climbing fee. In addition we have purchased a Karakoram National Park fee worth USD200 in order to gain access in the area. Last but not least, all expedition members received a 3month month tourism visa from the Pakistani Embassies and Consulates in the UK and Australia. We advise future travellers who wish to carry out a similar project in the area to allow at least four months for the paperwork processes to be finalized before departure to Pakistan.

5.4. Fundraising and Finance

The KAP used a variety of funding techniques including: i) grants from organizations such as the Royal Geographical Society (UK), Mount Everest Foundation (UK), Gilchrist Educational Trust (UK), Captain Scott Society (UK), American Alpine Club (US), Forum for the Future (UK); ii) sponsorships in the form of equipment from Trimble Navigation (US), Laser Technology (US), Mountain Fuel (UK); iii) crowd-funding campaign on Indiegogo (UK) and iv) personal contributions. Judging from the KAP experience, the expedition leader wishes to expresses a few thoughts in regards to the fundraising and budgeting matter.

- Anyone wishing to pursue a similar project endeavor should allow at least 6 months for the fundraising process.
- An expedition needs not to be expensive and so assessing whether one needs sponsors in the first place is very important. This is because getting sponsorships can take a lot of time, which could be better, spent exploring or training.
- Research is important and so individuals need to make sure that they know everything bout their project and related topics.

- Marketing is very important, especially in the case of crowd-funding campaigns. Unless one has very wealthy friends, willing to empathize with he/she and thus contribute financially, a team needs a well-thought marketing and communication plan accompanied by adequate branding. Allow time for this and in the case of crowd funding, one needs to make sure he/she tell/s everyone at least a month before launching the campaign.
- Honesty and openness is key. There is no need for hyperbolae and potentially sponsors will appreciate one's sense of realism.
- Bringing something back to one's supporters makes the difference between the end and continuation of exploration projects. Sponsors appreciate when they are kept updated and about the evolution of the project. Small gifts such as a branded calendar, a T-shirt, a DVD copy of the video documentary usually make a good gift to offer sponsors.

Besides the fundraising methods used by the KAP, it should be emphasized that there are other methods such as raffles, trading activities, charitable organizations and local authorities that can be equally successfully if tackled ingeniously. The key is to be creative, realistic and professional.

The KAP has an expedition account opened by the expedition leader as well as a cashier, Dr Ambrose Smith. Funds have been transferred to Pakistani counterparts using Western Union and cash. A detailed expedition costs pertaining to logistics in the field is summarized below:

Karakoram Anomaly Project Costs

Item	No & type of items	Cost in GBR
Transportation (in Pakistan)		
Return Vehicle Journey: Islamabad-Hunza	Team & Pakistani Counterparts	£496.00
Airport transfers	2 journeys	£62.00
Return Lake Journey: Ata Abad crossing fee	2 journey	£80.60
Road Journey Ali Abad to Ata Abad and Ata Abad to Passu	1 vehicle	£9.30
Return Road Journey from Passu to Shimshal	7 vehicles/ 3 sections	£496.00
Road Journey Ata Abad Lake to Karimabad	2 vehicles	£49.60
Total Transportation Costs		**£1,193.50**
Hotel Accommodation (in Pakistan)		
Islamabad double rooms	6 nights x 2 double rooms	£352.78
Passu double rooms	2 nights x 2 double rooms	£311.86
Aliaabad double rooms	2 nights x 2 double rooms	£86.80
Karimabad double rooms	4 nights x 2 double rooms	£111.60
Shimshal guest house	6 nights x 2 double rooms	£555.89
Total Accommodation Costs		**£1,418.93**
Expedition Staff (in Pakistan)		
Guide payment	58 days / PKR 1800	£647.28
Cook payment	52 days / PKR 1500	£483.60
Guide & the cook's kit payment	2 people	£124.00
Assistant cook payment	52 days / PKR 1200	£386.88
Assistant guide payment	52 days / PKR 1200	£386.88
Assistant guide & cook's kit payment	2 people	£80.60

Staffs guide and Cook Insurance	4 people	£50.57
Total Staff Costs		**£2,159.81**
Trekking and Expedition Food (in Pakistan)		
Food for members and staff	45 days, 8 people, 3 meals, BC	£1,004.40
Kerosene Oil	Cooking	£173.60
Camping fee and bridge crossing fee		£55.80
Karakorum national park entry fee US$ 50 per person		£125.24
Camping materials and generator		£124.00
Trekking & Expedition Foods Total Costs		**£1,483.04**
Porters Payment (in Pakistan)		
Porters from Shimshal village to Virjerab	49 porters x 4 stages at PKR 550	£2,108.00
Porters from Yukshin Gardan Base Camp to Shimshal village	29 porters x 4 stages at PKR 550	£395.56
Two Poters from Passu to Shimsal	2 porters	£83.08
4 Poters Shimsal to BC Tim's Gear and Foods	4 porters	£117.80
Total Porter Costs		**£2,704.44**
Other Expenditures (in Pakistan)		
Yukshin Gardan Sar royalty and pollution fees		£388.26
Tim's Gear Custom & duty charges		£185.61
Mat's custom clearing charges		£88.82
Auger machine		£189.72
Mazhr travel expense & Foods		£92.07
Porter tip's		£34.10
Goat (meet)		£74.40
Hotel foods		£52.98
Hasil Shah tip		£9.30
Miscellaneous		£231.82
Total Other Costs		**£1,347.07**
Sub Total of Logistics Costs		**£10,306.79**
Company Profit 13% of sub Total		£951.63
Fieldwork Equipment		
Laser Technology TruPulse 360B Laser range Finders	2 items (yellow and grey)	£2,800.00
Trimble GNSS R10 GPS receivers	2 x R10, 1 x TSC3 Controller, Access Soft.	£32,000.00
Portable Solar Panel	1 x item	£70.00
Portable 6TB Hard drives	3 x Seagate 2TB HDD	£180.00
Professional Drone	Spreading Wings	£1,800.00
Camera Accessories	Several Items	£500.00
Climbing Equipment	Half ropes, ice screws, etc	£400.00
Personal Equipment (Clothing and Camping)	4 people	£1,400.00
Notebooks, paperwork, printing of maps, photographs	2 x Chartwell Survey, 60 x RGS material	£150.00

Total Fieldwork Equipment Costs		**£39,300.00**
High Altitude Subsistence		
Mountain Fuel Isotonic Drinks	270 items	£290.00
Mountain House Freeze Dried	60 items	£320.00
Total High Altitude Subsistence		**£610.00**
Return Travel to Pakistan		
Air travel	4 x return flights London - Islamabad	£3,200.00
Airport transfers (London, Budapest and Perth cumulatively)	4 x return transfers	£160.00
Total Air Travel Costs		**£3,360.00**
Marketing and Crowd-funding		
Facebook Advertising	Post Boosts	£136.00
Indiegogo Perks	30 x T-shirts, H2O Bottles etc.	£600.00
Total Marketing Costs		**£736.00**
Grand Total KAP Costs		**£64,224.14**

Karakoram Anomaly Project Income

Sponsor	Amount in GBR
Royal Geographical Society	£1,000.00
Mount Everest Foundation	£675.00
American Alpine Club	£310.00
Captain Scott Society	£2,500.00
Lord Mayor's 800th Anniversary Award	£200.00
Gilchrist Fund	£750.00
Forum for the Future	£500.00
Trimble Geospatial	£32,000.00
Laser Technology	£2,800.00
Indiegogo	£3,105.00
Other Sponsorships	£2,000.00
Personal Contributions	£18,384.14
Total Income	**£64,224.14**

5.5. Insurance

Expedition members acquired an insurance cover from the Alpine Association Worldwide Service (AWS), provided by GENERALI Versicherung AG as part of the Osterreichischer Alpenverein (OAV) membership. This insurance plan was meant to cover the costs for repatriation, rescue, transfer, and medical treatment for accidents occurring in the courser of leisure activities or business as well as for illness. The insurance also covered personal liability and legal; expenses up to EU 3,000,000 and EU 35,000 respectively.

In respect to our expedition activities, the insurance cover would have, in theory covered all related costs to carry out a rescue mission from a 6000m peak. The rescue costs (up to EU 25,000) were understood as those costs of local rescue organizations (including costs of rescue organizations of neighbouring countries for incidents occurring to national frontiers) incurred when the insured person has suffered an accident, or must be rescued, whether injured or uninjured, from mountain or aquatic distress. Rescue costs were deemed as the demonstrable costs incurred in searching for and transporting the injured person to the nearest road open to traffic or to the hospital nearest the site of accident. Helicopter rescue costs were in theory part of this insurance plan.

While reading this insurance cover felt like “melody to our years”, the actual effectiveness of it left much room for debate. During our “on the edge” descent off Yukshin Garden Sar”, we tried arranging a helicopter rescue as our situation was quite desperate. From a spot on the icefall at about 5000m we tried calling the OAV using our satellite phone in order to arrange a helicopter rescue. To our despair, we have been transferred to a poor secretary in Innsbruck who had no idea how to manage the situation. Our team in base camp, whom we contact by UHF Radio, confirmed that the OAV handling of the situation was useless and so we turned our attention to the Pakistan military, which for a sum of USD 30,000 in cash would had been able to send a helicopter to Shimshal in less than 2 hours. We managed to get off the mountain without a helicopter thanks to an inspired decision to enter the north face of Yukshin. It is debatable whether OAV would have been willing to reimburse the costs of a helicopter rescue later and since we have abandoned communication with them, this issue has not been exploited.

Our advice for future expeditions wishing to purchase this insurance cover is to communicate the whereabouts and circumstances of the expedition to OAV prior to departure in order to arrange an emergency plan with them in advance.

5.6. Travel, Transport and Freighting

Travel to Pakistan has been made by air from London, Budapest and Perth depending on the location of each expedition member. While the international flights have run smoothly, in Pakistan the story had changed dramatically. The internal flight from Islamabad to Gilgit, the closest city to Hunza and the gateway from Pakistan to China, is a temperamental affair. At the first sign of bad weather the flight is cancelled. Safe to say bad weather prevented our travel north for four days running. We were forced to drive.

The drive north from Islamabad is notorious. Whilst we were careful to avoid the Karakoram Highway, which is black listed as no-go by the British Foreign Office for security reasons, the alternatives still present a whole host of difficulties. Most of these originate from the mountainous landscape where even small amounts of rain create road-blocking landslides. One of these halted our progress for five hours, as we waited for the impressive clearance operation that kicked into action – large bulldozers came rumbling down the road and promptly began to shift industrial amounts of earth.

Having driven for two days we reached the spectacular Hunza valley. The backdrop to Hunza is Ultar Mountain (7388m) and across the valley in Nagar, the gleaming snows of Rakaposhi (7788) thrust a vertical five kilometers skywards. The many glaciers surrounding the valley have gifted the valley water for crops, and the rich green of the valley floor contrasts markedly with the browns, greys and whites of the surrounding mountains. The glaciers have even provided a historic defense to the people of Hunza. Baltit fort, which stands high upon an old glacial moraine above the valley and dates to the first century, was for centuries protected from attack to the north by a large glacier.

That glacier has long since retreated into the snowy mountains from whence it came, but it serves to illustrate the significance of glaciers in defining civilization in Hunza.

"The great mountain explorer Eric Shipton once called Hunza valley - 'The ultimate manifestation of mountain grandeur and at 2400m above sea level, it is indeed a fairytale land, rich, fecund and of an ethereal beauty". The tiny terraced fields ripple down the mountainside, neatly arranged like fish scales, each supported on a high dry stonewall. The colours change with seasons: emerald green in the spring, orange and red in autumn. Everywhere the slender poplar trees cut strong vertical lines in the horizontal terraces and stand against the glacier-scoured rock.

In the upper end of Hunza Valley, a massive lake was standing in our way. The lake known as Ata Abad was formed due to a massive landslide that occurred on January 4, 2010. The landslide killed twenty people and blocked the flow of the Hunza River for five months. The lake flooding displaced 6,000 people from upstream villages, stranded (from land transportation routes) a further 25,000, and inundated over 19 km of the Karakoram Highway. The lake reached 21 km long and over 100 meters in depth by the first week of June 2010 when it began flowing over the landslide dam, completely submerging lower Shishkat and partly flooding Gulmit.

Difficulties did not end here. After crossing Ata Abad with our 1000 kg of supplies and equipment and our 8 men team including two local assistants, a fantastic chef with experience of working in Moscow's top restaurants and extremely resourceful mountain guide, Ali Muhammed Saltoro, our journey reached yet another obstacle: The entrance into the Shimshal valley, a deeply cut and treacherous gorge has been blocked by a giant rock avalanche. Here we had to call the only available vehicles in the remote Shimshal village to come and take over the load and us from the avalanche point.

Some of the equipment has been sent in advance to our mountain guide in Pakistan by commercial services offered by TNT. Unfortunately, their services have been poor, as some of our bags have arrived two weeks late, thus causing much inconvenience.

In regards base camp logistics, we have hired 50 porters, 10 donkeys and 2 yaks in Shimshal village to carry the approximately 1000kg of supplies and equipment to the base camp (3700m), situated on the western lateral moraine of Yukshin Garden glacier. A two days trek through the desolated Shimshal valley. While our guide, Ali Saltoro has communicated to us the weight allowance and haulage cost per porter in advance, the actual story in the field was much different. Each porter decided to carry 5kg less than expected and wanted double the fare. After a long negotiation process, driven by our resourceful guide, we have managed to lower the price slightly. Nevertheless, the overall porter costs were almost double as expected. See project costs above.

Accessibility into the fieldwork area of Shimshal is very hard and subject to changing weather, geomorphic mass movements, and unstable local community politics. We advise travellers carrying out a similar project in the area to either perform a reconnaissance visit before the expedition in order to set up the framework for the proposed expedition or choose local guides and collaborators with much care and following references. Overall we have used 8 different vehicles, 2 boats, 50 porters, 10 donkeys, 2 yaks and one goat in our expedition to carry 1000 kg of supplies and equipment in order to sustain the 8 base camp people.

5.7. Food and Accommodation

In regards to food, we have used a combination of local and specialized food. Local Pakistani food is great and affordable and we whole-heartedly recommend it. For the alpine ascent on Yukshin Garden Sar, we have used Mountain House freeze-dried food and Mountain Fuel Isotonic and breakfast drinks, which have been purchased in the UK. We have used local water supplies comprising bottled water in the cities and glacier water in the field, which was purified using UV filters. Accommodation was provided by tent for most of the time in the field (45 days). Our tent configuration included two x three person sturdy mountain tents for the KAP team, one kitchen tent for cooking activities and the Pakistani team as well as one large eating and leisure tent for social and eating activities. In the cities and villages we have used a combination of guesthouses and hotels suggested by our tour company Alpine Adventure Guides.

5.8. Risk and Hazards

The KAP expedition leader carried out a continuous risk assessment throughout the evolution of the project. In addition, the leader has also crafted a crisis emergency plan in order to provide a framework on how to deal with difficult situations. Below the initial risk assessment and crisis management plan can be seen.

a) Risk Assessment

The KAP can be completed within the stated budget and the grant period of one year. The project is for a specific period of time and we have considered all costs carefully therefore reducing the risks associated with time and expenditure to the minimum. We have carefully assessed the time interval needed to perform our study and will book transport accordingly. We have evaluated the expedition costs and completed a full breakdown of budget implications, also including a contingency sum of £2,000 for exceptional circumstances.

The project involves exploring remote regions of Central Karakoram and travelling to high altitudes. There are physical risks associated with this project but we are already very experienced in such activities. We have completed a full risk assessment using the University of Edinburgh Fieldwork Risk Form, which is under review by the University of Edinburgh Expeditions Committee. The risk assessment includes an evaluation of physical, biological, chemical, and man made hazards and also takes into consideration personal and third party safety, environmental impact and poor decision making. All team members will have travel and medical insurance for the full length of the expedition covering activities associated with trekking and mountaineering.
In a nutshell our risk assessment will follow the acronym:

C - Clarify the hazards and risks
R - Reassess and revise it where necessary
I - Involve all participants in the process
S - State it simply in writing
I - If it's too risky – don't do it!
S - Share knowledge and experience

Hazard (s)	Risk L/M/H	Control Measures	Risk after Control L/M/H
Physical Hazards (extreme	**H**	The team members have trekked and climbed above altitudes of 4,000m in Europe, Asia, Africa, South and North America. We are aware of the effects of high altitude	**L**

weather conditions; rock/ /ice/ snow avalanches; falls, slips; high altitude sickness)		on our bodies. These include reduced oxygen concentration and lower atmospheric pressure. In order to prevent illnesses such as: acute mountain sickness, high altitude cerebral or pulmonary edema, we will follow a 10 day acclimatization process. Acclimatization increases respiration, produces more red blood cells and increases pressure in the arteries of the lungs, forcing blood into parts of the lung that are not used at sea level. In order to achieve this we will: ascend slowly; go higher during the day and then return to a lower elevation for the night; increase sleeping elevation by 500m per night; consume at least 3 litres of water a day; and increase our carbohydrate intake. These steps will make our bodies 70% more efficient in the acclimatization process. As every person acclimatises at a different pace regardless of physical fitness, we will monitor ourselves for the following symptoms indicative of illness: headache, fatigue, loss of appetite, nausea or vomiting, inability to sleep, change in mental status, ataxia, shortness of breath at rest, persistent productive cough, or gurgling sounds from the lungs. We will trek through hummocky, glacier and rough valley terrain in order to perform our measurements. The control measures we will take to reduce hazards include: careful route selection, use of competent guides, use of ropes, sturdy boots, trekking poles, ice axes and crampons, no activity after dark, safety and medical kit carried at all times and group risk assessment before each day's activity. The weather forecast will be checked prior to our weekly excursions. In case of emergency, we will make use of our satellite phone to call for rescue. The porters, liaison officer, mountain guide and expedition UK members are insured in the case of accident and mishap. Injured individuals will be rescued via a Pakistani helicopter from the fieldwork area and transported to a hospital. A list of hospitals and useful contacts in Skardu and Gilgit can be viewed here: http://www.tourism.gov.pk/important_information_skardu.htm and http://gilgit-baltistan.com/useful-information/. The District Hospital in Skardu (contact: 92-05750-2413 and 92-0575-2413) is a strong preference for emergency situations.	
Biological Hazards (soil or water micro organisms; insects)	**L**	A potential hazard comes from microorganisms, and insects that can poison team members or the water and food that we use. Pakistan has numerous sanitation problems, therefore the washing of hands, fruit and vegetables will be a high priority. Drinking water taken from lakes and rivers will be treated before usage and heated at high temperatures using a highly efficient portable stove and purification tablets such as Puritab. We will carry a complete medical first aid kit. This kit will include at least the following: • Flagyl (Giardia antibiotic) • Cipro/Ciprofloxacin (Salmonella, E.Coli, dysentery antibiotic) • Bactroban Cream (open skin infections) • Nifedipine/Adelat (acclimatization) • Diamox (acclimatization) • Decadron/Dexamethascone (pulmonary edema, cerebral edema) • Gravol (nausea) • Ibuprophen (mild pain killer, anti-inflammatory) • Demerol (extreme pain relief) Fortunately, there is no malaria or yellow fever risk in areas located above 2000m in the Gilgit-Baltisan region of Pakistan. However, a higher risk of polio may exist in some areas. For this purpose all expedition members will have polio vaccination prior to departure.	**L**

Chemical Hazards (dusts; contaminated soils; chemicals on site)	**L**	We will ask for information from local authorities in Skardu for details regarding chemical hazards in the areas we are visiting. In extreme situations we will avoid the contaminated areas, although we are confident that such hazards are highly unlikely.	**L**
Man-made hazards (electrical equipment; vehicles; insecure buildings; slurry pits; power and pipelines)	**L**	Man-made hazards are rare as we are visiting remote mountain regions. Nevertheless, extra care will be taken with stoves, electrical equipment as well as village buildings and infrastructure. Regarding transportation, we will use accredited 4x4 drivers provided by our tour company, Alpine Adventure Guides. In the case of vehicle accidents, injured members will be transported urgently to the District Hospital in Skardu. Their families will be contacted by phone and the travel and medical insurance coverage will be enforced. Please see crisis management plan below.	**L**
Personal Safety (attack on person or property; first aid)	**L**	During our expedition several porters, a liaison officer and our guide, Ali Muhammad, will accompany us, ensuring a high degree of protection. The local authorities in Skardu will be notified prior to our visit. Additionally we have connections in the local Pakistan government following friendships forged at Edinburgh University with Benazir Bhutto's family. We are all well trained in first aid procedures.	**L**
Environmental impact (pollution; disturbance of eco-systems)	**L**	As environmentalists we are aware of our potential environmental impact. We have appointed an environmental manager, Oliver Forster who has crafted an environmental impact assessment and environmental management plan. We have minimized the number of members to four, which in turn will minimize the number of porters, and our supplies, waste, and transportation requirements. All waste will be evacuated from the national parks and natural areas and deposited in designated areas. We will consider the environmental impact on gateway towns. Toxic waste such as batteries will be brought back to the UK. All meal waste will be collected including organic material. Human waste will be disposed in small pits that we will dig away from paths, water resources and busy areas. Expedition members will not disturb the local flora and fauna.	**L**
Other hazards (decision making)	**L**	Poor decision-making could also cause hazards. Our guide, Mr Ali Muhammad will advise us in our weekly activities. Please note that we have consulted local people and experienced guides when we designed this project.	**L**

Please note: The Northern Areas of Pakistan is a surprisingly safe part of the world to visit - certainly more so than Nepal at present. In order to avoid dangerous situations we will stay clear of any political demonstrations or parades, especially religious ones. Pakistan is also often thought of a country with strong anti-Western sentiment. While there is undoubtedly such sentiment along with tribes along the Afghan border climbers have never experienced any anti-Western sentiment in their trips to Northern Pakistan. One climber stated for SummitPost.org that Pakistani people tend to be some of the friendliest and hospitable he as ever met anywhere in the world and has made new friends on every visit. Most people he met in the mountains simply wanted to get to know the visitor and his/hers reasons for choosing to visit their valleys. Shimshal, is home to some of the friendliest people in the Karakoram - and some of the best local climbers.

b) Crisis Management Plan

Below is a detailed crisis management plan that will be used if an emergency situation arises. This includes plans for communication and emergency evacuation.

A major incident/emergency could include the following situations

- where the expedition is in a place characterised by an outbreak of civil unrest, outbreak of hostilities or similar which has affected or might affect the safety or well being of expedition members collectively or individually
- where the expedition is in or near the scene of a natural disaster or emergency which might affect the safety or well being of expedition members collectively or individually
- when anyone on the expedition is missing and cannot be satisfactorily accounted for
- when an expedition member has died or is missing presumed dead
- when an expedition member has suffered serious injury, is seriously ill or is experiencing some other medical problem which affects the conduct of the expedition overall

When emergency plans will be executed

The decision as to whether or not these procedures should be executed is entirely that of the expedition leader or other member of the leadership team. He may obtain appropriate advice before making this decision. However, no leader will ever be criticized for deciding to invoke the procedures if it subsequently transpires that this action was not needed; the approach is that it is better to be safe than sorry. In rare circumstances, the procedures may be triggered by someone other than the leadership team.

The expedition will have an agreed communication plan to allow the expedition leadership to maintain contact with potential saviours. The expedition will be equipped with relevant communication devices such as Thuraya satellite phone, handheld transceivers and laptop and people trained to use these. Expedition planning includes investigation of potential communication problems and this is built into the communication plan.

Communication with the expedition leadership:

The emergency contact will immediately establish a clear and reliable communication channel with the leadership on the ground. All communication with the expedition leadership will be channelled through this arrangement.

Actions to be taken by leader:

The leader is thoroughly aware that the first priority is to respond to/deal with the situation safely, effectively and expeditiously. Seeking explanations, investigating why something happened, and worrying about reputations are all secondary considerations at this stage. Although obviously important, these will need to be looked at after the immediate incident/emergency crisis has been handled.

Fatality or suspected fatality

Where a fatality or a suspected fatality is involved, as soon as the position is reasonably confirmed, the team leader will:

- inform and obtain details of the authorities dealing with the matter locally
- inform the local police force for the person concerned, providing as much information as possible, and ask the police force to inform the next of kin and provide any follow up support they need
- instruct the emergency contact to establish contact immediately with the next of kin, ideally in person, after they have been informed by the police; to offer any assistance required in addition to arrangements sanctioned by the travel insurance company

- communication between the next of kin and the leadership of the expedition will normally be channelled though this emergency contact, at least initially, so as to minimize pressure on the leadership in the field

Key initial factors

- immediately implement the above arrangements if a fatality or suspected fatality is involved
- make immediate contact with the insurance company (Snowcard Insurance, UK) and other relevant agencies and follow any instructions/advice they issue carefully
- establish and maintain a clear line of communication with the expedition
- inform all relevant agencies in the UK
- inform all next of kin of expedition members and establish a means of communication with them in conjunction with the insurance company and travel agency. Make arrangements for any transport home of expedition members if necessary, including reception of returnees and any necessary counselling in conjunction with the insurance company. Make or assist with making arrangements for next of kin to visit the location of the incident/emergency

Other actions

Expedition members will

- maintain a detailed log of the incident/emergency and its handling, both in the field and at home
- make arrangements quickly for an investigation by a suitably qualified and experienced person
- make arrangements quickly for media relations to be handled reactively and proactively, including the maintenance of up to date information on the expedition's website (www.karakoram.co)
- arrange for a senior member, referees or home country emergency contact to make a personal visit to the next of kin as soon as practicable to offer sympathy and support; however, it will not normally be possible to discuss specific details of what has happened since this may well not be properly established and/or be subject to investigations
- conduct an internal review as soon as practicable afterwards, to complement any external review commissioned under the above provisions; ensure that all relevant staff and volunteers are properly briefed and trained in these procedures
- where there are or are likely to be any consequential legal proceedings, make arrangements via insurance companies to ensure that expedition member are properly represented legally ensure that there is adequate financial provision to cover the non-insured costs which will flow from an incident of this nature.

Please note: We have helicopter rescue cover as part of our trek and insurance pack. All injured individuals including the mountain guide, liaison officer and porters will be transported by air to the nearest hospital and treated accordingly.

Emergency contact details

Please provide full contact details of the home contact in the UK and in-country contact while the research team is in the field

Home agent (UK): Dr Ambrose Smith, CBE
Address: Whaley Bridge, United Kingdom
Tel: +44 (0) 131 650 2518
Email: ambrosmith@aol.com

In-country contact: Ali Muhammad Saltoro

Address: Islamabad, Pakistan
Tel: 0092 3009780886
Email: agpakistan@gmail.com

Emergency contacts in Skardu

Important Telephone Numbers of Skardu
Deputy Commissioner (92-0572) 55062
Senior Superintendent of Police (92-0572) 2424
Assistant Commissioner (92-0572) 55075
PIA Airport (92-0572) 2492
PIA Booking Office (92-0572) 2941,3325
PIA Cargo (92-0572) 2291
CAA Airport Tower (92-0572) 2413
Police Station (92-0572) 2444
Municipal Committee (92-0572) 2618

Emergency contacts in Gilgit

Chief Secretary, Northern Areas Tel: (92-0572) 2501
Deputy Commissioner Tel: (92-0572) 2521
I.G. Police Tel: (92-0572) 2403
A.I.G. Tel: (92-0572) 2366
S.S.P. Tel: (92-0572) 2502
Airport Police Station el: (92-0572) 3266
Special Branch Police el: (92-0572) 3356
Intelligence Bureau Police Tel: (92-0572)2496
PIA Booking Tel: (92-0572) 3390
Airport Security Tel: (92-0572) 3852

5.9. Medical Arrangements & Communication

Tim Taylor has been assigned as the expedition doctor. Being a reserve marine in the British Naval Forces, Tim has been trained in complex fist aid procedures that can be delivered during the time of war. In addition he has brought to the Karakoram several complete first aid kits including a large one for base camp use and a smaller one for the high altitude ascent. Some of the drugs that were included in the first aid kit have been mentioned above in the risk assessment.

Two Thuraya satellite phones facilitated communications with the outside world, whereas communication in the field with expedition members was provided by two UHF Radio transceivers. Occasionally we would send messages via the satellite phone to our communications officer, Mr Alin Buda in the UK, who in turn would update the world via the expedition social media channels.

5. Itinerary and Diary Log

The KAP expedition itinerary included some 64 days of activities. Overall we have spent 42 nights in the tent, 20 nights in hotels or guesthouses, one night in the vehicle and one night on the plane. Below is the brief breakdown of our daily activities throughout the length of the expedition.

Day No.	Date	Activity	Location	Accommodation
Day 0	19/07/15	Flight to Islamabad; Airport transfer to Hotel; rest	Islamabad	Hotel
Day 1	20/07/15	Welcome Reception; Team Meeting; Planning	Islamabad	Hotel
Day 2	21/07/15	Logistics Preparations; Supplies	Islamabad	Hotel
Day 3	22/07/15	Delayed Departure to Hunza	Islamabad	Hotel
Day 4	23/07/15	Drive to Karimabad City	On the Road	Vehicle
Day 5	24/07/15	Arrival in Ali Abad Village; Explore Hunza	Ali Abad	Guest House
Day 6	25/07/15	Ata Abad Lake Crossing; Drive to Passu Village; Repeat Photography	Ata Abad & Passu Village	Guest House
Day 7	26/07/15	Acclimatisation Trek to Passu Glacier (3500m); Return to Passu Village	Passu Glacier	Guest House

Day 8	27/07/15	Drive to Shimshal Village	Shimshal Village	Guest House
Day 9	28/07/15	Explore Shimshal Village; Take Interviews with Local People	Shimshal Village	Guest House
Day 10	29/07/15	Prepare Expedition to Yukshin Garden Base Camp; Arrange Porters	Shimshal Village	Guest House
Day 11	30/07/15	Trek towards Khurdopin Glacier	Khurdopin Glacier Basin	Camp at Khurdopin
Day 12	31/07/15	Trek towards Yukshin Garden (YK) Moraine; Set up Base Camp (BC)	Yukshin Gardan Glacier	YK Base Camp
Day 13	01/08/15	Ice Drilling Activities	Yukshin Gardan Glacier	YK Base Camp
Day 14	02/08/15	Ice Drilling Activities	Yukshin Gardan Glacier	YK Base Camp
Day 15	03/08/15	Ice Drilling Activities	Khurdopin Glacier	YK Base Camp
Day 16	04/08/15	Ice Drilling Activities	Khurdopin Glacier	YK Base Camp
Day 17	05/08/15	GPS Survey Activities	Yukshin Gardan Glacier	YK Base Camp
Day 18	06/08/15	GPS Survey Activities	Yukshin Gardan Glacier	YK Base Camp
Day 19	07/08/15	GPS Survey Activities	Khurdopin Glacier	YK Base Camp
Day 20	08/08/15	GPS Survey Activities	Khurdopin Glacier	YK Base Camp
Day 21	09/08/15	Rest Day	Yukshin Gardan Glacier	YK Base Camp
Day 22	10/08/15	Rest Day	Yukshin Gardan Glacier	YK Base Camp
Day 23	11/08/15	Trek to Virjerab Lake Basin; Explore Virjerab Glacier	Helga (Virjerab Glacial Basin)	Satellite Camp
Day 24	12/08/15	Geomorphic Mapping in Khurdopin/Virjerab Basin	Helga (Virjerab Glacial Basin)	Satellite Camp
Day 25	13/08/15	Geomorphic Mapping in Khurdopin/Virjerab Basin	Helga (Virjerab Glacial Basin)	Satellite Camp
Day 26	14/08/15	Geomorphic Mapping in Khurdopin/Virjerab Basin; Trek back to YK BC	Khurdopin Glacier/Yukshin Glacier	Satellite Camp
Day 27	15/08/15	Acclimatization Trek to 4700m	Yukshin Gardan Glacier	YK Base Camp
Day 28	16/08/15	Rest Day	Yukshin Gardan Glacier	YK Base Camp
Day 29	17/08/15	Trek to Advanced Base Camp (ABC) at 4100m; Equip ABC with gear & supplies	Yukshin Gardan Glacier	YK Base Camp
Day 30	18/08/15	Trek to ABC, Establish Permanent Camp	Yukshin Gardan Glacier ABC	ABC
Day 31	19/08/15	Climb Yukshin Gardan Ice Fall to Camp I; Reached 4700m	Yukshin Gardan Ice Fall	Camp I (First Attempt)
Day 32	20/08/15	Climb Yukshin Gardan Ice Fall to Camp I; Reached 5150m; Establish Camp I	Yukshin Gardan Ice Fall	Camp I
Day 33	21/08/15	Return to Advanced Base Camp	Yukshin Gardan Ice Fall	Camp
Day 34	22/08/15	Return to Base Camp	Yukshin Gardan Glacier	Camp
Day 35	23/08/15	Rest Day; Prepare Final GPS Survey and Supplies for Yukshin Garden Ascent	Yukshin Gardan Glacier	Camp
Day 36	24/08/15	GPS Survey Activities	Yukshin Gardan Glacier	Camp
Day 37	25/08/15	GPS Survey Activities	Yukshin Gardan Glacier	Camp
Day 38	26/08/15	GPS Survey Activities	Khurdopin Glacier	Camp
Day 39	27/08/15	GPS Survey Activities	Khurdopin Glacier	Camp
Day 40	28/08/15	Trek to ABC (4100m)	Yukshin Gardan Sar	Camp

Day 41	29/08/15	Climb to Yukshin Gardan Sar Camp I (5150m)	Yukshin Gardan Sar	Camp I
Day 42	30/08/15	Climb to Yukshin Gardan Sar Camp II (5850m); Leave Gear & Supplies, Return to Camp I	Yukshin Gardan Sar	Camp I
Day 43	31/08/15	Climb to Yukshin Gardan Sar Camp II (5850m)	Yukshin Gardan Sar	Camp II
Day 44	01/09/15	Rest Day in Camp 2 / Acclimatization	Yukshin Gardan Sar	Camp II
Day 45	02/09/15	Climb to Yukshin Gardan Sar Camp III (6400m); Leave Gear & Supplies, Return to Camp II	Yukshin Gardan Sar	Camp II
Day 46	03/09/15	Climb to Yukshin Gardan Sar Camp III (6400m)	Yukshin Gardan Sar	Camp III
Day 47	04/09/15	Rest Day	Yukshin Gardan Sar	Camp III
Day 48	05/09/15	Failed Summit Attempt; Reached 6600m	Yukshin Gardan Sar	Camp III
Day 49	06/09/15	Rest Day	Yukshin Gardan Sar	Camp III
Day 50	07/09/15	Failed Summit Attempt; Reached 7000m; Return to Camp II (5850m)	Yukshin Gardan Sar	Camp II
Day 51	08/09/15	Descent to Camp I (5150m)	Yukshin Gardan Sar	Camp I
Day 52	09/09/15	Descent to Improvised Camp (4700m)	Yukshin Gardan Sar	Camp
Day 53	10/09/15	Descent to ABC (4100m)	Yukshin Gardan Sar	ABC
Day 54	11/09/15	Return to Base Camp; Return to Shimshal Village; Dismantle Base Camp	Yukshin Gardan Glacier; Shimshal	Guest House
Day 55	12/09/15	Rest Day; Prepare Workshop for Local Community	Shimshal Village	Guest House
Day 56	13/09/15	Community Development Workshop	Shimshal Village	Guest House
Day 57	14/09/15	Leave Shimshal; Repeat Photography & Geomorphic Mapping; Cross Ata Abad, Arrive in Hunza	Ali Abad	Guest House
Day 58	15/09/15	Rest Day in Hunza Valley	Ali Abad	Guest House
Day 59	16/09/15	Drive to Islamabad / Rawalpindi	Rawalpindi	Hotel
Day 60	17/09/15	Rest Day in Rawalpindi	Rawalpindi	Hotel
Day 61	18/09/15	Rest day; Explore Rawalpindi	Rawalpindi	Hotel
Day 62	19/09/15	Rest Day; Explore Rawalpindi	Rawalpindi	Hotel
Day 63	20/09/15	Departure; Expedition Closure	Air	Airplane

Day 1: Flight to Islamabad; Airport transfer to Hotel; rest

The team landed in Islamabad where we met with our expedition guide, Ali Muhammad Saltoro. Ali had a classic Pakistani moustache, and a face weathered by many years of exposure to the elements. He quickly established himself as an authority on all things Karakoram, wowing us with stories of previous expeditions. Trango, G1, Nanga Parbat. The list was long. Stories of Ali's adventures were a mainstay of our trip, and Ali could always be depended on – to make you laugh in base camp, and to look after you when danger loomed.

We took a taxi to our guesthouse in Islamabad – a somewhat soulless city that misses the chaotic vibrancy of its older counter part Rawalpindi. Our guesthouse was unremarkable, but it was exciting to be all together as a team for the first time.

Day 2 & 3: Welcome Reception; Team Meeting; Planning; logistics; supplies

We had anticipated flying from Islamabad airport to Gilgit, but inclement weather meant that the flight was cancelled. Ali informed us that this happens about 50% of the time, so is worth anticipating.

We used the down time to familiarise ourselves with Pakistani customs, build strong relationships in the team and test our equipment. We also travelled to the UNDP Pakistan GLOF Project and inform them of our intentions.

Day 3: Delayed Departure to Hunza

We left our hotel in Islamabad at 1am in a large van to remain inconspicuous, and avoid Islamabad traffic. Our equipment was tied to the roof and covered with tarpaulin earlier in the night of the journey. The drive north towards Hunza took a grand total of 22 hours – including a long detour around the Karakoram Highway that took us over towards the Indian boarder.

As we approached the Himalaya, crowned in Pakistan by the mighty Nanga Parbat, a landslide blocked our passage. The landslide had apparently come barrelling down the mountain minutes before we reached its location, and we would have been finished had we come a few moments earlier. The military quickly arrived and cleared the road using huge bulldozers.

We arrived at about 3am on day 4 in Karimabad in Hunza. We were absolutely shattered following the 22-hour drive. Ali had checked us into a hotel in advance.

Day 4 & 5: Exploring The Hunza Valley

We awoke the next morning to find ourselves in the spectacular Hunza Valley. We were awed by the snowy peaks around us, which had been hidden by the darkness the night before. Lush greenery lined the valley bottom, and fruit trees sagged under the weight of their apricots, apples and pears.

We had breakfast in a local café. Here we met our Pakistani team; Moscow Ali our cook, Ishuq Hushe our field assistant and Sher Ali assistant cook. Over the next few months these men would become our good friends.

We had a collection of old photographs that we had collected from the Royal Geographical Society Archives in London, many of which had been taken in the Hunza area during the heyday of British India. We spent the next few days driving around Hunza in an attempt to find the original location of these photographs. The idea was that by retaking the photos we could quickly assess how things had changed. To our delight we were able to find many of the photograph locations. Many of them had been taken in the vicinity of Baltit Fort. The Fort is an absolutely spectacular building, dating back to the 4th century and perched high on an old glacial moraine. It commands impressive views of the valley and Rakaposhi, the 19th highest summit in the world.

As well as recreating old photographs we interviewed some local people about the Hunza area, focusing particularly the wide array of hazards that originate from the mountains. The curator of Baltit fort is a particularly knowledgeable and informative individual. He told us about how GLOFs had devastated infrastructure and cattle, particularly when he was a boy in the 60s.

Day 6: Ata Abad Lake Crossing; Drive to Passu Village; Repeat Photography

To head north towards Shimshal we had to cross Ata Abad Lake. The lake was formed in 2001 by a biblical scale landslide that blocked the passage on the Hunza River. The Lake is a beautiful blue colour, but has an eerie quality, surrounded as it by the remnants of lost villages. The crossing took us about 2 hours, but was enjoyed by all. We were incredulous to learn that this was Ishuq's first ever time on a boat!

Having crossed the lake we started off into the Karakoram proper. As the jagged peaks started to become more pronounced, excitement, mixed with a pinch of fear, took hold in the team. We spent the night at Ambassadors Lodge in Passu, which is excellent, if a little expensive for our means.


Figure 18. Left. Ata Abad lake Crossing. Right. Upper Hunza valley near Passu. Copyrights: Tim Taylor, 2015

Day 7: Acclimatisation Trek to Passu Glacier (3500m); Return to Passu Village

After a large breakfast we started out for Passu glacier. Passu, whilst rather more modest than the near by Batura, is still over 40km long and is a perfect environment to acclimatise and sharpen rusty ice climbing skills. We walked all day. By the end of the day Oliver was sick with altitude and dehydration, and we returned to Ambassador Lodge tired and in need of food.

Day 8: Drive to Shimshal Village

We set out for Shimshal Village having loaded two large 4*4 Toyota's with our equipment. The entrance to Shimshal Gorge is absolutely spectacular. The Shimshal River snakes between vertiginous cliffs, into which a dirt track has been blasted. From afar you would have no idea that there was a valley here at all.

We drove for about an hour before we reached a roadblock. The previous night a landslide had destroyed the road, which was now mostly in the river. We moved quickly to transport our equipment across this dusty earth, which shifted continuously beneath our feet. A fall here would mean a swim in the freezing swirling water below.

After a two-hour wait we clambered aboard a solitary Wallis Jeep, leaving behind all of our equipment and our Pakistani Team. They were to come behind by tractor with our kit. We drove on for about three hours. Eventually we reached a bridge that had been literally obliterated by flooding. We had to ford the river. Remarkably our driver managed to get his Wallis Jeep through the water without much fuss. For our part we stripped down our underwear and ran across clutching our shoes. The water was cold enough to make you draw breath.

Another two hours passed before we arrived in Shimshal Village. Shimshal is a green idyll, an oasis of fields and trees amongst desolate mountains. There is only one road, and the village subsists entirely on its own produce. When we arrived orange evening light was kissing the tops of the wheat, which swayed as if enchanted. From the perspective of an outsider at least, Shimshal in summer is a good approximation of paradise on earth.

Day 9: Exploring Shimshal Village; Taking Interviews with Local People

As we wandered around in the morning the complete splendour of Shimshal was revealed. We interviewed a handful of people on life in Shimshal and began to plan our journey onwards, pouring over maps and talking to local men about the various summits that surround the village.

Day 10: Prepare Expedition to Yukshin Garden Base Camp; Arrange Porters

We continued to plan our expedition, buying extra supplies. Following another acclimatisation trek towards the Yazghil glacier, Ali made us aware that he was having trouble gathering enough porters to carry our equipment. This was in part because many of the Shimshali men were tending to the village's Yak herd at the Shimshal Pass, a good three days walk away. Once Ali had managed to source porters, by rousing men young and old from every house in the village, the trouble became how much weight each would take. It turned out that Shimshal had self-imposed a 20kg weight limit on porter loads, and the head of the porters refused to negotiate on this.

This infuriated Ali, and forced us to cut weight from our food supplies in order to keep to budget. We spent the night crouched over barrels of food, trying to sort and redistribute every last bag of rice. Despite our best efforts our tonne of equipment was still predicted to require some 50 porters to carry.

The 20 kg porter limit is well worth anticipating on future expeditions to Shimshal. It stands in contrast to much of Pakistan, including the Baltoro area, where porters happily carry 30 or even 40kgs.

Day 11: Trek towards Khurdopin Glacier

We rose at 6am to find our porters assembled outside. Animals accompanied them – 2 Yaks, 10 Donkeys and a goat. The donkeys and yaks were loaded with our equipment and supplies. We watched the porters and animals set off towards the Yazghil glacier, and after breakfast we followed on.

We caught up with them at the snout of Yazghil glacier. The donkeys were struggling across the ice. (The yaks walked straight over the glaciers without slowing or changing direction!). We helped push/lift the donkeys across the steeper areas. Having crossed Yazghil glacier, the valley widens and becomes both very dry and very hot. It is a long walk across this area, and the crossing should only be attempted with ample water.

Having reached the far end of this part of the valley, where the Khurdopin-Yukshin Gardan system comes down to meet the river, we met a few porters who had remained ahead of us. They were sitting down, and looked as if they had no intention of continuing. Ali soon informed us that the porters wanted to stay here for the night and continue the next morning. We spent the night under a million stars.

Figure 19. Porters and Yaks carrying supplies and equipment towards base camp (3700m. Copyrights: Tim Taylor, 2015.

Day 12: Trek towards Yukshin Garden (YK) Moraine; Set up Base Camp (BC)

The final leg of our journey required hiking over the snout of Khurdopin glacier and then up the western edge of Yukshin Gardan glacier. It was hard going, the boulders, which cover Khurdopin shift and slide as you walk over them.

We reached the location that was to become our camp for two months just after noon. To reach it we hiked up a beautiful waterfall (this waterfall supplies clean water for drinking and bathing until the beginning of September, when its head waters freeze). Compared to the surrounding areas the base camp area was lush. Gnarled (and mostly dead) trees provided excellent wood for fire, and the base commands excellent views south towards Yukshin Gardan Sar and Kanjut Sar. It also provided good access to our field area, the Khurdopin-Yukshin Gardan system.

Our tents were soon erected, including a spacious mess tent (blue) for eating and socialising and a kitchen tent (red), in which our Pakistani team also slept. Things immediately began to feel homely. Our porter caravan continued to arrive for another few hours.

Once all the porters arrived it came to the issue of payment. A number of issues arose. Although we could not understand, the most pressing seemed to be that Ali was not carrying enough cash to pay all the porters immediately. The negotiations started to become heated. The Shimshalis were arguing about who should receive the money which Ali had, and who should wait for money when Ali returned. Soon there was shouting, and a fracas ensued, complete with punching and wrestling.

Feeling somewhat intimidated, we stayed quiet whilst everyone calmed down. It is worth noting that no one directed aggression towards us in any way during this episode, the fighting was rather between Shimshalis. Eventually the dispute was sorted. It was decided that the younger porters – who had to go off to school in the coming weeks – would be paid first, and the elders who could afford to wait would be paid second. Having been paid the porters left quickly. Ali was angry, calling the villagers stupid and telling us that this would never have happened in Baltoro. Still, we had reached base camp! Our journey was complete and we felt eager to get to work.

Day 13 to 16: Ice Drilling Activities

In order to complete the scientific objectives of the project, we needed to set up a stake array on the Khurdopin-Yukshin Gardan glacier system. These stakes needed to be drilled into the ice, and there position measured using our Trimble GNSS R10 receiver. Our plan was to then wait for about three weeks, before returning to the stakes and measuring their position for a second time in order to deduce glacial movement. (You can read more about this in the Summary of Key Fieldwork Activities, above).

Our first task then, was to place our stake array. This was no mean feat! It required lugging a 20kg auger (or ogre as we called it) around the glacier, climbing up to a high point and then drilling a 40cm hole for about 15 minutes. Despite Ali's earlier assurances it emerged out that auger was designed for drilling holes in peoples gardens...not through the hard ice of Yukshin Gardan glacier. After 3 hard days we had drilled 45 holes and erected 45 stakes.

Figure 20. Drilling activities on ice pinnacles on Yukshin Gardan glacier. Copyrights: Tim Taylor, 2015.

Day 17 to 20: GPS Survey Activities

You can imagine our disappointment when we returned on day 17 to find that our holes had melted and many of our stakes had collapsed! We had thoroughly underestimated the melt rate on the glacier surface. Although we were disappointed, the situation was soon rectified. Rather than drilling stakes into the glacier, we resorted to tagging large boulders with spray paint and then marking the exact position of the centre of a cross on their surface.

Recording the exact position of each boulder meant steadying the GPS unit above each using a built in tripod. We then had to wait for six minutes whilst the GPS satellite array took 360 measurements of position. Sometimes, if there were strong winds, the GPS would shift enough to render the position compromised, and we would have to start the measurement all over again. Swear words directed towards 'the satellite gods' were a main stay of these few days! But after three days all of the points initial locations were recorded and we returned to camp for a well-deserved rest.

Figure 12. GNSS RTK Survey Activities. Copyrights: Tim Taylor, 2015.

Day 21 and 22: Rest Day

Rest days were vital to our recuperation. On rest days we typically washed our clothes, played a Romanian game with rocks called 'moara', ate copious quantities of food, collected fire wood, charged equipment (and ourselves), watched movies, listened to the Chinese equivalent of the BBC World Service on a handheld radio and/or played catch with Ishuq and Sher Ali (who were seriously good cricketers). We even spent some time stalking Ibex – on one occasion Ishuq got within stones throwing distance of one, but it soon leaped to safety up what can only be described as a sheer cliff. Whilst Ishuq may have been 'the Pakistani machine', able to climb the most hazardous slopes in worn out old trainers, he was no match for an ibex.

Day 23: Trek to Virjerab Lake Basin; Explore Virjerab Glacier

Reaching Virjerab lake basin was a key aim of the project. The lake basin was the origin of the devastating GLOFs of the early 20th century, and mapping its features was integral to assessing the risks the people of Shimshal face now and in the future.

Reaching the basin required trekking for about five hours across first Yukshin Gardan and then Khurdopin glaciers. The difficult conditions underfoot were compounded by our rucksacks, which had cooking equipment, ropes and food hanging off them – 'Christmas trees' Sergiu described them as. We intended to stay a few nights in Virjerab so needed to take enough supplies to keep us going independent of base camp.

Reaching Virjerab was an exhilarating experience. We felt the hairs on the back of our neck stand as we first glimpsed the enormous lake basin. A herd of semi wild yaks wandered through the sands, kicking up dust as they roamed. In the foreground there was a small Wakhi settlement. Above each doorway was a pair of Ibex horns, and yak hides were hanging inside many of the shelters. The whole scene was reminiscent of Mos Eisley in Star Wars, or an Indiana Jones movie.

Maps revealed to us that the Wakhi settlement is called Past Helga. It is only inhabited for short periods when the Shimshali's herd the Yaks before the winter months. It makes for a fantastic place to camp. There is a natural spring at its northern edge, from which crystal clear (and freezing cold) water eschews. The spring is recognisable from some distance, as bull rushes grow around the pools it creates. The water likely originates from Khurdopin glacier, and travels a short distance underground to form the spring.

Day 24 to 26: Geomorphic Mapping in Khurdopin/Virjerab Basin; Trek back to YK BC

The days we spent in the lake basin allowed us to explore the northern terminus of the Khurdopin/Yukshin Gardan system. We made detailed geomorphic maps of the glaciers snout relative to the valley flank, with a view to assessing how likely the glacier was to block to Shimshal River, which flows between the two.

Skirmishing along the front of the glacier was difficult in places. Where the river channel was confined by the glacier and the valley flank it became a raging, freezing torrent. On occasions we traversed precipitously above the wild waters below for lengths of 100m or more.

Mapping the lake basin itself was a more tranquil experience. The Shimshal River here is calm, and braids into little channels, which flow slowly across the old lake sediments. The old depth of the lake water can be seen on the northern and southern flanks of the valley here approximately 100m up.

On the last day before returning to base camp we mapped a glacial lake trapped between Khurdopin's large terminal moraine (over 100m tall!) and the glacier. There were signs that a GLOF had originated from here before, as evidenced by a 20 by 20m U-Shaped breach dug into the terminal moraine. When we surveyed it this lake posed little danger, but we figured any increase in its size would begin to change that.

For the trek back to base camp we were once more 'Christmas tree'd', but we made the journey in less than 4 hours, now knowing the routes across the glacier well.


Figure 22. Geomorphic mapping activities. Copyrights: Tim Taylor, 2015.

Day 27: Acclimatization Trek to 4700m

In anticipation of the high altitudes to be experienced on the Yukshin Gardan Sar summit attempt, we went on an acclimatisation trek up the ridge behind base camp. This involved a lot of scrambling on loose scree, and was certainly hard work. We eventually reached a col at the snowline, and not having our ice climbing equipment we returned to base camp for sundown.

Day 28: Rest Day

Day spent washing clothes and exploring the waterfall above camp.

Day 29 and 30: Trek to Advanced Base Camp (ABC) at 4100m; Equip ABC with gear & supplies, Establish a Permanent Camp

Before team members Sergiu and Mat attempted to summit Yukshin Gardan Sar, the whole team set up an advanced based camp (ABC) closer to the intimidating north face of the mountain. ABC was about a day walk from base camp proper, and everyone including Ishuq and Sher Ali helped move ropes, food, gas and cameras for the climb. ABC consisted of a three-man north face tent, for sleeping, and a *Ferino* high altitude tent, which we used for storage.

It was exhilarating to be camped straight on the ice for the first time. We could hear the glaciers vital signs as we slept, a constant shifting and creaking came from within, and it was difficult not to think that the glacier was breathing. The mountain itself grumbled from time to time, as avalanches cascaded down the north face.

From here the team split up, with Mat and Sergiu attempting to establish a camp 1 Yukshin Gardan Sar with support from Oliver and Tim at Base Camp. The diary entries here are written by Oliver. For Sergiu's version of events please see the mountaineering section, above. The team are reunited on Day 34.

Day 31: Return to Base Camp/Climb Yukshin Gardan Ice Fall to Camp I; Reached 4700m

Tim and I returned to base camp. We explored the upper reaches of Yukshin Gardan glacier, winding through the labyrinth of paths carved into the ice by melt water. At one point Tim dived into a glacial lake to 'cool off'...

Day 32 and 33: Rest Day/Climb Yukshin Gardan Ice Fall to Camp I; Reached 5150m; Establish Camp I

Tim and I established radio connection with Sergiu and Matt over a couple of military grade walkie-talkie's which Ali had acquired. We agreed to check in every day at 9am, 1pm and 7pm. Tim began editing photo's from the first half of the trip. I spent the time teaching Ishuq and Sher Ali the wonder of Moara, which we all enjoyed. Moara is a Romanian game not dissimilar to drafts and, only requiring rocks, paper and a pen, was well suited to the mountains. Ishuq then taught me 'wolves and sheep' a bizarre game that only the sheep ever won. Perhaps it kept shepherds happy on lonely nights...

Day 34: Sergiu and Mat Return to Base Camp

Beautiful sunshine warmed base camp. Tim and I moved our table outside and ate breakfast. Towards lunchtime Sergiu and Mat arrived back, looking tired but otherwise well. They were in good spirits, and told us about the 'craziest glacier they had ever seen.'

The Yukshin Gardan Ice Fall, it turned out, was even more difficult than it had looked from afar. The ice was contorted so that crevasses cut its surface in every direction. This meant progress was incredibly slow, as the team would advance just a few metres only to find that it was impossible to go on. Sergiu showed us some go-pro footage of him leaping across a crevasse and burying his ice axes into the snow on the other side.

Day 35 Rest Day; Prepare Final GPS Survey and Supplies for Yukshin Garden Ascent

Day 36 to 39: GPS Survey Activities

The time had come to complete our GPS survey of the Yukshin Gardan and Khurdopin glaciers. We prepared ourselves, with some dread it has to be said, to walk for about half a week around the grey and boulder strewn glaciers.

Finding the boulders we had tagged 3 weeks before proved our first challenge. The glaciers had changed – there were new glacial lakes and ice bridges. A flock of ducks had inhabited one of the larger lakes, and we were glad to have the company of some fauna amongst the otherwise baron ice.

To find our survey points we used our Trimble R10 system, which was able to map both the points, which we had previously recorded, and our position. This didn't make it quite as easy as it sounds (don't think iPhone + Google Maps!), as moving with the Trimble unsheathed over the slippery glacier seemed like a recipe for disaster, so we normally had to stop and take a rough bearing. Sometimes we had to do this 3 or 4 times between survey points.

Once we found each survey point it was a case of erecting the Trimble and waiting 6 minutes for the GPS to again record the exact position of the glacier. We were happy to find that of the 44 boulders we tagged only 3 were unrecoverable (in all cases our tagged boulder had rolled over).

The most exciting moment of the GPS survey took place on the morning of the 39th day. Sergiu and I were sitting on the ice waiting for a GPS recording. We were in good spirits, and looking back towards our now tiny base camp – a speck of red nestled beneath Yukshin Gardan Sar. Suddenly, a SUV sized boulder broke from its icy incarceration. It fell straight down, seemingly hanging in the air, before causing an explosion of water and ice in a glacial lake below. The whole glacier groaned and heaved. Shock waves, at least a metre high, bounced around the lake. Sergiu and I clung to the rock we were sitting on, swearing loudly! After what seemed like hours the glacier calmed, and peace returned to the valley. It was a Spielberg moment – and a graphic reminder of the danger and violence of mountain environments.

Day 40: Trek to ABC (4100m) and Return to Base Camp

The whole team accompanied Sergiu and Mat once more to base-camp, taking more supplies of food and gas. I spoke extensively with Ishuq, who told me about his life and his village, Hushe. Ishuq had an incredible life story. He was only 19, but had won a long battle with his father to get married to the women (girl) he loved. Remarkably, his marriage had been the first 'love marriage' (as opposed to an arranged marriage) ever in Hushe! He described how his wife's brothers had tried to kill him, how he had had to hide from his father in his mum's cupboard and how he had eventually won the approval of his family and his community. Ishuq must have a Hollywood film made about him soon; I told him that Brad Pitt would be a good match!

Day 41 to Day 53: The Mountain Rescue

The week after Sergiu and Mat began their ascent was dominated by events towards the end of the week that will remain in my memory forever.

Having established frequent radio contact with the mountain climbing team, Tim and I settled into the rhythm of base camp activity. The days were straight forward, and we lived the simple life depicted as fantasy in urban blogs. The days were bookended by our radio check-ins, once when we woke up, and once before we slept.

From base camp, the summit attempt seemed to be going well. The weather was fine, and Serg and Mat were making good progress. On the evening of day 47 the guys informed us they were going to attempt the summit the next morning. Spirits were riding high.

At radio check-in the next morning we learnt that this summit attempt had failed (due to extreme cold), but that the team would attempt to summit again after a day of rest.

We soon received news that this second summit push had failed, and we waited on news of the duos decent. Over Days 51 and 52 the weather worsened, and thick snow clouds covered our base camp. The quality of our walkie-talkie reception was interrupted, and conversations with Serg and Mat became a frustrating series of R2D2 like beeps and crackles.

On the evening of the second day we managed to obtain signal with Sergiu and Mat for a brief moment. *'Guys, were in a bit of a pickle. We need you to get the helicopter.'* 'Can you repeat. Over.' '*We haven't had water for 2 days, get the helicopter*.'

At this point I started to get the feeling that your biology reserves for moments when decisions of great consequence have to be made in too little time. A kind of adrenaline mixed with determination. After about 10 minutes deliberation with our Pakistan team, Tim and I decided that I would head to Shimshal to reach Ali and his satellite phone (Ali had gone to get food supplies from the village). Tim would head to ABC, taking food and water with him.

I quickly gathered my things. I knew every minute counted. I started off for Shimshal with Sher Ali. I was suddenly able to march fast. The walk to Shimshal had previously taken at least a day, but Sher Ali and I made the journey in less than 4 hours.

I found Ali and explained to him what happened. A grave expression came over his face. We started making phone calls – to the military, to the embassy, to our insurance, to Tim's Dad in the UK. All the while our satellite phone credit was running out, which only added to the stress. With a helicopter no closer to arriving, we had 50c credit remaining...

The great problem was that the Pakistani rescue helicopter service requires $10,000 in cash upfront before they launch a rescue. $10,000! This situation must be taken into account by all future expeditions. They *really* won't launch the helicopter until you give them $10,000. *(You can take out a rescue loan prior to your expedition under a scheme with the Pakistani Mountaineering Assoc. You'll get the money back if you don't use it, but you'll be charged $400 for the privilege).*

The time was now 11pm and all hope was dwindling. Ali made one last call. His friend, a man who also ran a mountaineering company answered. He had the money. After I personally guaranteed him that I would pay him back if our insurance failed, he agreed to go to the army base tomorrow with the cash. The helicopter would be sent.

I spent a sleepless night pacing back and forth at our home stay. I was gripped by a feeling of powerless – we had done all we could and now all there was to do was wait. Ali laid out climbing equipment in front of our room. His plan was for the helicopter to set down on the Shimshal cricket pitch. We were then going to board, before directing the helicopter driver towards the icefall. We would complete the rescue by winching Sergiu and Mat up to the helicopter (Ali told me that the helicopter would be a simple military helicopter, not a *rescue* helicopter, so wouldn't have ropes on board).

Dawn broke. Little changed except for the lifting of the darkness. We continued to wait. Ali's friend called to say that he was on route to launch the rescue helicopter.

Then a strange thing happened. Ishuq appeared. He was waving his arms, shouting in Urdu and English. Sweat had soaked through his tattered mountain hardware fleece. 'Don't launch' he shouted, gesticulating wildly.

Sergiu and Mat were safe. They had managed to descend the icefall to ABC after three days without food and water. I would later learn that a break in the weather had allowed them to orient themselves. The sun had melted the snow, revealing the location of the icefalls many crevasses. Tim had met Sergiu and Mat at ABC, nursing them with water and food. Tim radioed Ishuq, who ran from base camp to Shimshal to pass us the message.

And so the helicopter was called off. Ali's friend told us he was 5 minutes walk from the helipad. 5 minutes from handing over $10,000. It was a lucky escape on our part. But I was past caring about the helicopter. Sergiu and Mat were alive, that was all that mattered.

Day 54: Sergiu and Mat Return

Sergiu and Mat returned to Shimshal the following day. They were worn out. Their ribs were more prominent than before. Mat's fingers had cracked from the cold. Raw wounds glared from the inside of his knuckles. I felt elated to see them both, but tiredness remained over the whole team. Their return was not quite a jubilant as perhaps it might have been.

Porters carrying the contents of our base camp trickled into Shimshal for the rest of the day. Our home for two months was reduced to a pile a rucksacks and barrels on the floor outside our guesthouse.

Day 55: Rest Day; Prepare Workshop for Local Community

After a few good meals strength began to return to Sergiu and Mat. We started to prepare for our workshop in Shimshal. The purpose of the workshop was to communicate what we had found with the people of Shimshal. We wandered through the wheat fields, which had now been harvested. No longer subtle greens rippling in the wind, but browns and yellows. Winter was coming.

We went to the village shop and bought a hundred or so packets of biscuits, figuring that these might encourage people to come. Word seemed to spread around the village easily. I went to the local school and spoke to someone in the geography department. Ali found us a projector. Everything was in place for the following day.

Day 56: Community Development Workshop

We spent the morning finessing our presentation and arranging the meeting room. By lunchtime people began arriving: a whole class of geography students (both boys and girls), teachers from the local school, representatives of the Shimshal Nature Trust and village elders. They made up over 100 people.

We began by asking everyone to imagine the room as a world map. Where would they like to go if they could go anywhere in the world? We asked that they stand in that location. After initial reluctance, this 'icebreaker' worked immensely well – people were laughing and smiling. Now everyone was more relaxed we moved into our presentation proper. We told the Shimshalis that they were not at current risk of a GLOF, but that due to past observations of the surging nature of the glacier, the next five years marked a critical period (*see 3.4 Preliminary Results*). We also communicated possible solutions to the GLOF problem from elsewhere in the world – Peru, Ladakh, and Kenya.

One of the chief aims of this workshop was to find out the solutions the Shimshalis thought might mitigate the GLOF problem. We thought that the Shimshalis would probably understand the nature of the problem as well as we did, and would be well placed to design solutions. We were to act as a medium, communicating these suggestions with the Pakistan GLOF Project in Islamabad.

Most of the Shimshalis thought weather and GPS stations monitoring the movement of the glacier snout and sensors detecting the presence of a glacial lake were probably the best solution. Both of these are in place in Passu. We later went on to present these ideas to the Pakistan GLOF project.

Figure 23. Community Workshop. Copyrights: Sergiu Jiduc, 2015.

Day 57: Leave Shimshal; Repeat Photography & Geomorphic Mapping; Cross Ata Abad, Arrive in Hunza

The following morning we loaded our equipment onto the village jeep to leave. Our host Hasil Shah and his family warmly sent us off. As the jeep rolled through the picturesque fields, we marvelled one last time at the village, which tourism missed and the massive landscape which surrounded it.

On the return journey through the Shimshal gorge we managed to take a repeat photographs of the spectacular Malangutti and Momhil glaciers. The former originates from the towering Dastaghil Sar, which at 7,885m is the 19th tallest mountain on earth. We mapped the snout of Malangutti, which could present a GLOF risk equal to that of Khurdopin if it were to grow by 50m or so.

We had lunch at the Ambassadors Lodge once we reached Hunza Valley, before crossing Ata Abad Lake and stopping at about 10pm in Karimabad. It had been a long day, and we slept for many hours.

Day 58 to Day 63: Return Home

The last week in Pakistan was basically a long and rather melancholic trip back to Islamabad and ultimately to our homes in Europe and Australia. It has been a fantastic expedition, which comprised a mountain of experiences that has surely changed us to the core. We were nevertheless excited to return to our friends and families and share the stories from this expedition. We all agreed that the project was a success, however, we should not forget that it was filled with risk and uncertainty in places. A proper adventure! Our return home consisted of a drive back to Islamabad/Rawalpindi. We stayed in a hotel in Rawalpindi and explored the old city. Good food, laughter and relaxation were the key activities of this week. Stage two of the project was ending. What follows next, is stage three of the KAP which consists of processing of results, writing reports, crafting videos and photographic exhibition, attending lectures and seminars. Basically, spreading the word about this project internationally.

6. Conclusion

The Karakoram Anomaly Project research has concluded that there is no significant risk of GLOF in the Khurdopin – Yukshin garden glacier System. The Shimshal river drains trans-glacially along the length of its contact with Khurdopin. There may be small patches of the sub-glacial drainage but it is limited. Khurdopin-Yukshin glaciers would need to advance at least 20m in order to damn the river and lead to the formation of dangerous glacial lake. Overall, glaciers in the region are in quiescence phase and are retreating. This has been confirmed by our quantitative and qualitative investigations but also by anecdotal evidence as everyone we have spoken to in the valleys has indicated that in the last couple of years the glaciers have gone backwards and their level has gone down. We recommend a continuous monitoring of the glaciers in the next 5 years and to install a water level gauge, and permanent GPS and weather monitoring stations on Khurdopin & Yukshin glaciers. Furthermore, it is paramount to keep a close eye during critical times (e.g. summer & surging phase)

Our mountaineering story describes: i) how extremely difficult it is to climb the poorly explored and technical peaks of the Karakoram. Remoteness and high difficulty are not a good mix when it comes to multidisciplinary expeditions limited by time, and resources; ii) how important is risk assessment, dealing with uncertainty and appropriate resource allocation in difficult mountaineering quests; iii) how difficult it is to lead cutting edge multidisciplinary projects, which aim to innovate in several areas at the same time; iv) how important training and effective teamwork is in such endeavours and v) how powerful forces such as intuition can guide an individual towards safety. Adequate planning is crucial.

Overall, the project has been a tremendous success. We have generated valuable scientific data and over r 3TB of video and photographic material that will be used to compile a video documentary and photographic essay. Already we have published several articles including in the Telegraph and UK Climbing magazines. We aim to finalize media outputs by the end of the year and present the story of the Karakoram Anomaly Project to the world in its entirety.

7. Acknowledgements

The Karakoram Anomaly Project team wishes to thank all sponsors and collaborators of the project for the effort, support and commitment directed towards the project throughout its lifetime. In particular we would like to thank Edinburgh University staff, Dr Kate Heal, Dr Hugh Sinclair and Dr Anthony Newton for providing recommendations and constructive feedback as well as insightful advice. In addition, we thank Mr Alin Buda for designing and sponsoring a branding and visual identity for the project as well as several online marketing channels such as the project's website. We also thank Dr Ambrose Smith for his on-going financial support towards the expedition. Furthermore, we would like to thank Mr Ali Muhammed Saltoro, and his Pakistani assistants whose knowledge, expertise, patience, and hospitality made our expedition, logistically possible. We particularly thank the Royal Geographical Society for providing valuable historic photographs and funding. Furthermore, we would particularly like to thank Trimble Navigation and Laser Technology for sponsoring the project with valuable scientific equipment as well The Mount Everest Society, American Alpine Club, Captain Scott Society, Lord Mayor London Award, Forum for the Future and Mountain Fuel. Last but not least, Sergiu would like to thank Mrs Paula Petru, Mr Horia Pasculescu, Mr Razvan Muntianu, Mr Vlad Lascu, and the rest of his sponsors in Romania.

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https://www.mountainfuel.co.uk/

http://www.adventureguide.com.pk/

http://www.pmd.gov.pk/

https://www.americanalpineclub.org/

http://www.captainscottsociety.com/

http://www.alpinexpe.ro/

8. Distribution List

This report represents the intellectual property of the Karakoram Anomaly Project team and shall not be used for commercial or marketing purposes without consent from the expedition leader, Sergiu Jiduc. The report will be distributed to the project sponsors and collaborators as well as other interested parties.

9. Address List and Web Links

www.antarcticglaciers.org/
www.bl.uk/
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www.gilgit-baltistan.com/
www.lakescientist.com/
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www.pmd.gov.pk/
www.rgs.org/HomePage.htm
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www.scienceworldreport.com/
www.summitpost.org/
www.tourism.gov.pk/
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10. Appendix

Table 1. List of historic photographs acquired from the Royal Geographical Society

RGS Historic Photographs

RGS Reference No.	Name	Author	Year	Comments
88271	Malangutti and Dasto Ghil seracs in the foregrounds	Moris, C. J. Capt	1927	Photograph
88272	Malangutti and Dasto Ghil - from centre of glacier	Moris, C. J. Capt	1927	Photograph
88288	Looking down Malangutti and across Shingshal Valley	Moris, C. J. Capt	1927	Photograph
88286	The Momhil Glacier	Moris, C. J. Capt	1927	Photograph
88299	Looking down the Nardigarban showing Yazghil and Kanjut	Moris, C. J. Capt	1927	Photograph
88315	Shingshal Village	Moris, C. J. Capt	1927	Photograph
88275	Pasu and the Shingshal Gorge	Moris, C. J. Capt	1927	Photograph
88274	Pasu	Moris, C. J. Capt	1927	Photograph
88326	Rakaposhi (from near Nilt)	Moris, C. J. Capt	1927	Photograph
88316	Rakaposhi from Ali Abad	Moris, C. J. Capt	1927	Photograph
88273	Rakaposhi from Ali Abad	Moris, C. J. Capt	1927	Photograph
88269	Crossing the Batura Glacier	Moris, C. J. Capt	1927	Photograph
88281	Bridge across Momhil	Moris, C. J. Capt	1927	Photograph
88260	Baltit Fort showing houses	Moris, C. J. Capt	1927	Photograph
88804	Mountain peaks rissing from the Pasu Glacier (southern side)	Ph. C. Visser	1925	Photograph
8884	Kunyang glacier (on workmans' map "Lake glacier") Dasto Ghil in the clouds (right side)	Ph. C. Visser	1925	Photograph
88818	Zardigarbin Valley - a valley on the northern side of the Shingshall valley	Ph. C. Visser	1925	Photograph
88833	Moraine Valley along the Malangutti glacier	Ph. C. Visser	1925	Photograph
88832	Ice pyramids in the Yazghil glacier	Ph. C. Visser	1925	Photograph
88831	Yazghil glacier (with side glacier)	Ph. C. Visser	1925	Photograph
88829	A lake in the Virjerab Valley	Ph. C. Visser	1925	Photograph
88827	High mountains near the Khurdopin glacier about 18 miles from the snout	Ph. C. Visser	1925	Photograph
88826	Khurdopin glacier	Ph. C. Visser	1925	Photograph
88823	Khurdopin glacier	Ph. C. Visser	1925	Photograph
88836	Shingshal Valley near the Malangutti glacier	Ph. C. Visser	1925	Photograph
88825	The Kanjut Peak near the Khurdopin glacier	Ph. C. Visser	1925	Photograph
88824	Typical glacier lake beside the Khurdopin Glacier	Ph. C. Visser	1925	Photograph
88822	Khurdopin glacier	Ph. C. Visser	1925	Photograph
Rgs536376 MR China S/S.218	Valleys and Glaciers in Hunza in Geographical Journal Vol. LXXI. No. 6	Moris, C. J. Capt	1928	Map
rgs 537631 MR India S.12	Hispar-Biafo Glacial Regions (Karakoram)	Members of the E.E.Shipton Expedition	1939	Map
rgs 537621 MR India S.12	Karakoram Expedition Survey - Panmah Glacier Photo Survey 1/42-121	E.E.Shipton	1939	Map
rgs 537621 MR India S.13	Karakoram Expedition Survey - Panmah Glacier Photo Survey 1/42-123	E.E.Shipton	1939	Map
rgs541894 Pakistan S/S 49	NW Karakoram - Minapin. Rakaposhi Range	H.J Schneider	1967	Map
rgs537257 mr India D.36	Shingshal Muztagh Area	N/A - key map	1936	Map
	Karakoram: orographical sketch map	Wala, Jerzy	1990	Map
87670	Pasu Glacier		1939	Photograph
87669	Pasu Glacier		1939	Photograph
87672	Between Pasu and Gulmit		1939	Photograph
87673	Between Pasu and Gulmit		1939	Photograph
PR/030999 & S0025131	Pasu Glacier	Prof. W.T. Thiselton	1887	Photograph
88143	Pasy and the Hunza Gorge with mountains of Shoonuk	K. Mason	1926	Photograph
X 38/018281 & B10766	Glacier and peaks above Pasu, Hunza State	(lower, left corner of the large composite)		Photograph
88604	The Pasu Glacier	Capt. A.R.B. Shuttleworth	1909	Photograph
88628	Hopar Glacier, Nagar, right half	C.P. Skrine	1922-4	Photograph
88627	Hopar Glacier, Nagar, left half	C.P. Skrine	1922-4	Photograph
88637	Looking up Nagar Valley towards Hispar	C.P. Skrine	1922-4	Photograph
88638	Looking across from hunza side of river to nagar and the Hispar	C.P. Skrine	1922-4	Photograph
88640	Rakaposhi from banks of Hunza River above Chalt	C.P. Skrine	1922-4	Photograph
88636	Minapin village, Hunza Valley	C.P. Skrine	1922-4	Photograph
88645	Looking down hunza valley from Nilt	C.P. Skrine	1922-4	Photograph
88639	Baltit with Hisper shows in background	C.P. Skrine	1922-4	Photograph
88646	In the Hunza Valley, Ata Abad - Gulmit Section	C.P. Skrine	1922-4	Photograph
88651	Looking up towards Hopar, Nagar State	C.P. Skrine	1922-4	Photograph
88649	Hussaini village, Hunza Valley	C.P. Skrine	1922-4	Photograph
88666	Panorama of Hunza Valley and mountains of Nagar from Baltit	C.P. Skrine	1922-4	Photograph
88665	Panorama of Hunza valley, Rakaposhi from Baltit	C.P. Skrine	1922-4	Photograph
88664	Panorama of Hunza valley, Baltit	C.P. Skrine	1922-4	Photograph
88661	Panorama of hunza valley and mountains of Nagar from Baltit	C.P. Skrine	1922-4	Photograph
88663	Panorama of Hunza valley, Baltiti	C.P. Skrine	1922-4	Photograph
88662	Panorama of Hunza valley, Baltiti	C.P. Skrine	1922-4	Photograph

Table 2. List of equipment and supplies with individual weights transported to base camp from Shimshal Village

Item	Weight (Kg)
Flour (White bag)	21
Rice (White Bag)	26
Flour (White bag)	22
Tomato (wooden box)	12
Ropes	12
Potato	20
Fruit and pasta	20
Suger	20
Sheets for the tent	8
Tent poles	20
Dal	16
Tables * 2	10
Kitchen tent and potato	22
Generator (red)	24
Dome tent (kitchen)	20
One chair, kitchen poles and ga	20
plastic pipes and veg	20
Vegetables + drill	20
More vegetables + toilet	20
vegetables + thermos	20
Tent + porter kit	20
Chairs	20
Blue generator	21
Kerocene Fuel	125
Medical box + cooking oil	20
Eggs	20
Stoves * 2	16
Ogre	7
Snowboard bag	23
Mats Blue Rucksack	27
Red rucksack	16
Grey Banana Bag	28
Food barell	26
Food barell	24
Food barell	27
Food barell	24
Food barell	25
Food barell	22
Food barell	23
Food Barell	20
Cardboard box	29
Barell (also food)	32
Member personal kit	146
Total weight	1114

Table 3. Brief Environmental Impact Assessment for the KAP

Activity	Flights	Internal Transport	Trekking	Sustenance
Duration	20 hours	3 days	56 days	76 days
Output	Engine Emissions 1.07 tonnes CO2 per person (London – Islamabad Return) 0.19 tonnes CO2 per person (Islamabad – Gilgit Return)	Engine Emissions	Walking	Food packaging Food waste (e.g. peel, skin etc)
Nature of Impact	Global climate change Noise pollution	Dust Global climate change Local air pollutants	Erosions of footpaths Noise pollution Dirtying of snow and ice	(Potentially) Littering, destabilization of ecosystems Local food resource depletion
Scope (Extent)	Global	Climate change (global) Air pollution, dust (local)	Local	Local
Persistence (Longevity)	Long term	Climate change (long term) Air pollution, dust (medium)	Short-medium	Long Term
Intensity	(v) High	Climate change (low) Air pollution, dust (medium)	Low	High
Probability	High	Medium-high	High	Low
Significance	High	Medium	Medium	High
Type of Effect	Direct, cumulative	Direct	Direct, indirect	Direct, indirect
Mitigation	Carbon offsetting (Through ClimateCare.org)	Reduce journey numbers to a minimum, use designated roads.	Sticking to paths where possible, all walking in a line, avoiding sensitive areas	Assessment of waste disposal options prior to and on arrival. Potentially waste repatriation

Figure 23. GNNS Survey measuring points as visualised by the Trimble TSC3 controller and Google Earth.

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Note: For a complete bibliography please contact the expedition leader.

Thank you for reading this report!

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