Madre de Dios Speleo 2008

In Search of Past Climate in Remote Island Caves of Southern Chile

An approved Oxford University expedition
Leader: Chris Day [chris.day@earth.ox.ac.uk]
Expedition Overview

Rarely visited, Madre de Dios and neighbouring islands are part of one of the harshest wilderness areas in the world where gale force winds and up to 8 m of annual rain have sculpted a unique karst landscape of spectacular limestone rock formations. A small but experienced expedition will explore limestone coastal areas of Madre de Dios and neighbouring islands, in search of vital records of past climate captured in speleothems developed in this one of the most southerly karst regions on earth. The expedition will be based on a 70 foot yacht, “Ocean Tramp”, skippered by a scientist and adventurer with 20 years experience of the seas in this region. Using zodiacs to access the shore for periods of 1 to 5 days the expedition will explore and survey new caves and sample speleothems and cave waters for climate research. A film will aim to document the expedition bringing together the adventure, the wilderness, and the science.
Orientation
Aims & Objectives

The expedition has three core aims: cave exploration, recovery of speleothems for climate change studies, and film-making. We regard the first two aims as essentially complementary. Specifically the expedition objectives are to:

- Locate, explore, and survey caves along the northern shores of Madre de Dios and neighbouring islands.

- Use this exploration primarily to prospect for suitable speleothem-containing fossil caves and chambers for the extraction of a limited number of stalagmite cores targeted for their likely contribution to climate record analysis.

- Make a one hour adventure documentary that captures the remote wilderness, the excitement and challenges of exploration, and is scientifically informative.
Background

Just under half of Madre de Dios island is composed of karstic limestone of Permian and Carboniferous age (260 to 350 million years old). The landscape is characterised by some of the most unusual and spectacular surface karst in the world. High annual rainfall of around 8 m together with the karstic nature of the limestone deposits has resulted in large scale karren, shafts and dolines. Erosion rates of 10 mm a century are thought to be some of the highest in the world. Pioneering caving expeditions from France (1995, 1997, 2000, 2006) and Poland (2003) have discovered large scale cave development beneath this landscape. Despite harsh weather conditions and difficulty in moving through the karstic terrain the French team have explored more than 8 km of cave passage with a maximum depth 280 m below the surface. There is, however, still huge potential for cave exploration on the island. The French are continuing land-based exploration from the south in early 2008. Our expedition will be boat-based and will aim to explore different areas, focussing on the coastal limestone areas in the north of Madre de Dios, but also other nearby limestone islands. Miners work seasonally on the south of the island, and it is at their outpost that the French expeditions are based, but reaching the northern parts of the island is difficult by land and hence these areas are rarely visited by anyone. We will liaise closely with this French expedition to ensure coordination of our exploratory and scientific work. We have been liaising with Charlie Porter, an American boat skipper with years’ of experience in the waters around Southern Chile. He has visited Madre de Dios, has found several caves himself, and has Chilean contacts who are able to show us the location of more cave entrances in areas that are apparently unexplored by Chilean or foreign cavers. The expedition will be based on Charlie Porter’s boat “Ocean Tramp”.

The caves on Madre de Dios and neighbouring islands are the most southerly in the world. They are therefore of great significance in climatological studies to investigate millennial-scale abrupt climate events and the linkages between climate changes in Antarctica and the rest of the world, and to predict future climate changes. Existing palynology and glacier studies from Southern Chile provide an insight into the region’s climate history (e.g. Sugden et al. 2005; Moreno et al. 2001). Palynological studies provide qualitative information on the temporal variation in vegetation types and glacial moraine studies provide local information on glacial advance and retreat but neither technique results in a detailed climate record. Past climate records captured in speleothems are a particularly powerful palaeoclimatic archive because they offer high resolution and continuous records that can span thousands of years (Hu et al., 2005; Johnson et al., 2006). Our expedition will be particularly focused on searching for older fossil caves where there are speleothems that can be used for climatological study.
Cave Exploration Methods

From our mobile base we will identify areas around the coast of Madre de Dios and other limestone islands that look to be of speleological interest, if necessary using zodiac inflatables to reconnaissance the coastline. Where surface karst features are identified we will search for a safe means of accessing the shore to undertake a land-based reconnaissance. We will be particularly interested in rivers or streams discharging into the sea which on the limestone are likely to have originated from springs or cave resurgences. Zodiac inflatables will be used to access the shore, whilst the yacht remains at a secure anchorage. Rolfo and Ardrizzi’s nautical guide (2004) provide details of safe anchorages in this region. Periods ashore will depend upon the speleological potential of a particular area and the safety aspects associated with the sea and the weather, but shore trips may last from a few hours to several days if there are several caves to explore. On shore the team may at times split into two groups of three people to cover a larger area more efficiently (e.g. one team going up the coast and one team going down the coast, or one team searching near sea level and one team exploring at a higher elevation). If multi-day trips are required, a shore base camp will be established using tents.

In addition we will visit a number of sites that are known to Charlie Porter and his Chilean contacts from previous trips to the area. At these sites it is possible that very little cave exploration has been undertaken beyond the cave entrance, but there are known to be speleothems at some sites and this therefore provides a more reliable means of ensuring that the scientific goals of the trip are achieved if we are unsuccessful at locating new caves.

Cave entrance positions will be logged using GPS and marked on field maps. Caves of more than 50 m in length will be surveyed to BCRA grade 3 or above. We will use a Disto laser range finder for measuring distance between survey points (but will take tape measures for backup) and a compass-clinometer. Hand drawn surveys, including information on passage characteristics, formations, and deposits, will be drawn in the
field, and data will be entered into Survex or a similar programme to enable digital viewing of the data on the field laptop. Surveys are an integral part of the proper scientific documentation of caves, and will be essential for characterising the environments in which speleothem samples have grown. They are also important tools for facilitating exploration itself, since they provide cavers with a better understanding of the three dimensional properties of the systems they are exploring, helping to identify joints, faults, or important lines of weakness likely to have promoted speleogenesis.

Caves will be explored as far as is logistically feasible and as far as is safe. Vertical descending sections will be secured with hand-drilled spits and anchors, or good natural belays, using widely practiced Single Rope Techniques. Handlines and life-lines will be used for easy climbs, and aid-climbing will be used for steep ascending sections if these look promising (since it is likely that the best preserved speleothems will be found in fossil passages or galleries). The density and coverage of exploration will depend on many factors including the accessibility, safety, and abundance of entrances. In areas that are too difficult to work in, or where caves are inaccessible, estimates of potential will be made for future exploration by others. All information will be documented and shared with interested parties and authorities to ensure that we play our part in the proper scientific exploration and future protection of this important wilderness.

**Climate Science Methods**

In accord with the Chilean National Park authorities, a small number of stalagmites will be removed for climatological study. Stable isotope and trace metal analyses of these samples will form the bulk of the palaeoclimate reconstruction work and radiometric dating will be performed to establish the chronology of these climatic evolutions. Chris Day will be completing this work in conjunction with Professor Gideon Henderson in Prof. Henderson’s laboratories at the University of Oxford and in full collaboration with Drs. Dominique Genty and Richard Maire of the French Ultima Patagonia expedition.

We are acutely aware that damage to caves or the excessive removal of speleothems is unacceptable. Charlie Porter (the boat skipper) has secured permission for us to undertake this scientific study from the Chilean authorities. Scientific work will be conducted in collaboration with the French Ultima Patagonia 2008 expedition to help avoid duplication and to maximise the expedition’s effective contribution. We intend to ensure that we only take a small number of samples (maximum 6) and that we take the most suitable samples for the study. Ideally, samples will come from geographically distinct locations on the island (e.g. north and south) to ensure that their records represent regional climate variation rather than just local influences. Our experience of speleothem work provides us with qualitative means of assessing the suitability of individual samples, thus allowing us to target the most
appropriate samples. The most promising samples will be examined further by retrieving a small 15mm diameter core and examining the texture and composition of the internal calcite. These procedures, allow us to obtain a maximum amount of climate information with a minimum of disturbance to the cave.

In those caves identified for speleothem sampling, an extensive programme of field measurements and data monitoring will take place that allow us to relate the chemical signatures measured in the speleothem calcite to the general climate of the region. Amongst others, we will undertake a full survey of the explored cave, sample drip waters, measure temperature, pCO2, humidity, and measure modern calcite growth.

**Film-making Methods**

Tim, Lou, and Ben have all been involved in making expedition films before (e.g. [http://www.banffcentre.ca/mountainculture/media/2003/filmfestivalawards.htm](http://www.banffcentre.ca/mountainculture/media/2003/filmfestivalawards.htm)), although Madre de Dios will present special challenges. A Sony A1 high definition video camera, with waterproof housing, will be the main tool used for documenting the expedition, with Tim and Lou acting principal camera operators. Two back-up cameras will also be taken, a Sony P9 and a Sony PDX10. We will also use a waterproof helmet-mounted pencil-cam, particularly for underground POV shots. Lighting will be using home-made hand-held 50w halogen lamps powered by standard 12v Yuasa lead-acid batteries. The aim will be an ultra-light-weight approach that minimises the dulling impact that traditional film-crew operations inevitably have on adventure film-making. The technique will be to use a mixture of set-up sequences, diary sequences, and fly-on-the-wall reality sequences to try and capture the essence of the expedition challenges as they unfold, and to try to represent the importance of both wilderness preservation and climate science in an engaging style. Material will be edited in Final Cut Pro with the aim of making a one hour film for the Festival Circuit. Wider dissemination through broadcast TV may be possible if the material is sufficiently strong, and we will use our media contacts to pursue this.

**Justification**

The aims of the trip have arisen out of the interests of the expedition members and their collective desire to participate in an adventure in this remarkable wilderness area, and to ensure that work is undertaken that will be of benefit to others. The expedition will lead to personal development as those skilled in cave exploration/sailing/science and film making pass on their knowledge to other members with less experience, and all expedition members will benefit from learning to operate as a team to overcome the physical and mental challenges that will arise as we work in this harsh and remote area. But in addition to these personal benefits we all feel strongly that we want accomplish objectives with wider value.
Cave exploration will be undertaken in a methodical way ensuring that we create a dataset comprising an accurate location, survey and photographic record of caves which will be available to aid future cave exploration or scientific expeditions to the area. The team includes people with many years’ experience of cave exploration to ensure that these tasks are performed in such a way that the information will be of benefit to future expeditions and scientists. Cave exploration is also fundamental to achieving the aim of obtaining speleothem samples for climate studies.

Understanding past changes in climate enables scientists to predict future changes, and speleothems are now recognised as an important means of reconstructing past climates. Because Madre de Dios is the most southerly known karst area where speleothems grow, samples from here will provide the closest climate record to Antarctica where it is thought changes in climate are triggered. Chris Day has been working on speleothems at Oxford University and has experience of field sampling and laboratory analysis. There will be close collaboration with other climate specialists, particularly American and French scientists. The results will be disseminated to both a general and a scientific audience. Expedition members will be involved in writing journalistic style adventure articles (e.g. for caving magazines/newspapers) and giving presentations (e.g. at the BCRA caving conference and at university clubs) which will include the scientific aspects of the expedition. The data will also be used for scientific presentations (e.g. BCRA cave science symposium) and will be published in peer reviewed scientific journals.

There are very few true wilderness areas in the world: places which exist in a pristine state where there is no sign of change as a consequence of human activity. Caves are one of the last true wildernesses. The paradox of exploration is that it teaches humans the value of what is natural, yet is the first step in altering a pristine environment, and has historically often lead to exploitation and development. We hope that one aspect of the film-making and post expedition reporting and presentations will be to provoke discussion and reflection about the issue of wilderness and remoteness conservation in the wider community. Ben, Tim, and Lou have all been actively involved in cave conservation in the UK, and Ben has written articles on the importance of wilderness conservation.
**Personnel**

**Chris Day** 3rd year doctoral student at University College and Department of Earth Sciences, Oxford, aged 29.


**Louise Maurice** Karst hydro-geologist at the British Geological Survey, member OUCC, lives in Oxford, aged 32.

**Roles.** Karst hydrogeology and cave safety. Cave explorer and surveyor. Film-maker.

Tim Guilford
Professor of Animal Behaviour, Department of Zoology, and Fellow at Merton College, Oxford, aged 48.

Roles. Film-maker. Cave explorer and surveyor.


Rick Padfield 2nd Year Geography undergraduate, St. Peter’s College, Oxford. OUCC Equipment Officer, aged 19.

Roles. Equipment Officer. Cave explorer and surveyor.

Ben Lovett  Qualified Podiatrist, former
surveyor, living and working in South Wales,
aged 39

Roles. Medical Officer. Cave explorer and
surveyor.
Experience. Many years’ caving, climbing,
mountaineering, and general wilderness
experience. Caving expeditions: Dachstein,
Austria (1993); Goufre Berger, France (1996);
OUCC Picos de Europa expeditions. (2000,
2007); Uzbekistan (2000). Mountaineering
trips/expeditions: Trans-Greenland – east west
ice cap self-sufficient traverse (1995); Summer
Field Assistant (surveyor) with British
Shipton’s Lost Valley: successful Anglo-
Indian Expedition re-attempting Shipton and
Tillman’s 1934 attempt to find a route between
the Hindu Temples of Badrinath and
Kedarnath in the Garhwall Himalaya (1998). Alps Mountaineering summer - 81, 83, 85,
87, 91, 94. Winter – Jan 01. Extensive UK cave exploration & surveying experience.
Assisted in 5 cave rescue operations with Gwent Cave Rescue.

Simon Headford
Freelance IT specialist,
sailor, caver, living in
Oxford, aged 47.

Roles. Treasurer. Marine
Logistics and Safety. Cave
explorer and surveyor.
Advance Field Liaison.
Experience. Many years’
ocean sailing, caving, and
climbing. Sailing
expeditions: Papua New
Guinea (1989-1993)
including 2 x Australia to PNG yacht races; Sailed single-handed and two-handed
Australia to Solomon Islands (1994); Indonesia, Torres Straight and Coral/Arafura Seas
(1995); Durban to Southampton via Cape Town, St Helena, Ascension Is and the Azores
(2004). Paragliding expeditions: Multiple world record camps (Texas, South Africa),
current British paragliding distance record holder. Trans-pyrenees vol bivouac traverse
(2002). Extensive experience of UK cave exploration and surveying.

Home Agent: Prof. Steve Roberts, St. Edmund Hall. OUCC President.
Field Agent: Charlie Porter, 0056 61621177
Provisional Itinerary

The expedition will run from 11th March until 19th April 2008. This is the time of year when conditions are least windy and therefore most suitable for a boat-based approach. See maps on page 3 for orientation.

11th March 2008. Simon departs for Chile as advance party, flying to Punta Arenas Airport and travelling by bus to Puerto Natales.

11th March to 22nd March. Simon undertakes final preparation for the expedition locally. He will make contact with Charlie Porter to help prepare and supply the boat, discuss sailing logistics and potential caving sites. They will discuss final expedition details and logistics, liaise with Chilean authorities as required. Simon will try to gather as much local information as possible on the caves, meteorology and geology on Madre de Dios and the surrounding islands.

22nd March. Simon travels by regular commercial ferry from Puerto Natales to Puerto Eden arriving 23rd March.

22nd March. The remaining expedition members arrive in Puerto Montt.

24th March. Regular commercial ferry from Puerto Montt to Puerto Eden, arrive 26th March.

26th March. Expedition departs for Madre de Dios aboard Charlie Porter’s boat.

26th March to 16th April. The exploration period. We will explore the northern coasts of Madre de Dios and other limestone islands going ashore by Zodiac to search for and explore caves. The duration of shore trips will depend upon weather conditions and caving potential, but may be predominantly day trips or may be trips of 2 to 5 days if a good caving area is discovered.

16th April. Expedition sails for Puerto Natales

18th April. Expedition travels by bus from Puerto Natales to Punta Arenas.

19th April. Expedition departs from Punta Arenas for the UK.
Safety

Years of expedition experience have led the team to think very hard about the potential risks involved in all the adventurous activities they undertake, and to ensure that risks are always fully understood and minimised. For this expedition this process has already begun, but in Chile the risks will be constantly reassessed in response to circumstances that arise during the expedition.

There are many potential risks. One of the most obvious is the possibility of shipwreck or sinking of yacht or a Zodiac due to adverse weather conditions. Charlie Porter has many years experience in these waters, and his boat is of sufficient size to be able to cope with strong winds and tidal streams, and is fully equipped with safety equipment including a life raft, EPIRBS, and flares. Charlie has a satellite phone and a radio and he will receive weather information every day which will enable him to make informed decisions about where it is safe to go and where it is safe to anchor. There is a requirement whilst in Chilean waters to report our position and plan to the Chilean Navy every day. They will come searching in the area of our last reported position if they do not hear from us. The expedition will use two zodiacs so that if there is a problem with one, the other can provide assistance.

Whilst ashore the team will also have a satellite phone to enable communication with the yacht, and possibly radios to enable communication between groups, although it is likely that they may not function in the terrain. Callout systems will be used, both between the shore party and the yacht and amongst shore parties, both for above ground reconnaissance and when caving. People will not operate alone, and caving groups will usually consist of three, although in caves deemed to be low risk pairs may work in the cave.

Flooding is the greatest potential risk in the caves, and caves broadly fall into three categories; low risk fossil caves with no water, moderate risk caves with active streams with dry areas or evidence of low flood risk, and high risk caves with active immature streamways and evidence of flooding to the roof. Moderate risk caves will be explored cautiously and only to a very limited distance from an entrance. High risk caves will only be entered in the unlikely event of a prolonged dry period. With her knowledge of cave hydrology Lou will advise on this as cave safety officer.

Other risks in caves are falling rocks and injury. Caves formed of unstable boulder chokes will not be explored. All expedition members will have the correct equipment and backup lighting, and everyone is aware of the remoteness of the situation so will take extreme care whilst moving through the cave. In the event of an accident if the group cannot exit the cave independently, all expedition members will be brought in and work together to assist the injured caver out of the cave. In the unlikely event of an accident in which the group cannot resolve the problem, the satellite phone will be used to obtain assistance from the Chilean Authorities.

Ben is the expedition medical officer and has medical knowledge from his training as a professional podiatrist, and has long had a keen interest in expedition medical issues due to the remoteness of the places in which he has undertaken expeditions. All expedition members have undertaken expedition first aid courses and many have practical experience of helping injured cavers or paraglider pilots. The expedition will take a very extensive first aid kit that will go on all shore trips, and individual members will have small personal first aid kits which they will have with them at all times. If an injured or ill
expedition member requires a doctor or hospital and conditions permit the yacht will transport them to the mainland. We are investigating potential provision of local rescue services. All expedition members will have full medevac insurance.

Hypothermia is likely to be a risk and all expedition members will be properly clothed to deal with the wet and cold conditions (e.g. thermals, buffalo kit, balaclavas, good waterproofs). If ashore overnight, people will always have a complete set of dry clothes (that must not be used outside the tent) and a synthetic sleeping bag that can be used at the end of a cold wet day to warm up. Great care will be taken to ensure that tents remain dry. Mountaineering tents that have been tried and testing in severe winds will be used and rocks and extra guy lines will be used to secure them against strong winds.

Weather forecasts will be used to minimise the risk of the shore party becoming temporarily stranded if adverse weather makes it impossible to return to the base boat, but extra food will also be taken ashore for this unlikely eventuality. Buoyancy aids will be mandatory when on deck, on a Zodiac, or on land whilst working close to the shore.
References


Websites consulted:


Polish Caving Expedition (2003).  
http://www.sktj.pl/epimenides/jaskinie/PolishCaving05/page26.html