Centre Terre présente une expédition nationale de la Fédération Française de Spéléologie

ULTIMA PATAGONIA 2006

expédition géographique franco-chilienne en Patagonie
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expedición geográfica Franco-Chilena a Patagonía
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www.centre-terre.fr
Madre de Dios: a unique heritage revealed at last

Madre de Dios, a name that has become a symbol, an unknown archipelago at the south of the world, a sample of what the world was like before Man. Unreal, between the ocean and the clouds, strange marble glaciers slide between emerald magellanic forest. It was in this forgotten world that the Alakaluf people survived for thousands of years in a constant battle against the wind and tide. But who now remembers those people who once lived there? José Emperaire immortalised them as “Nomads of the Sea”.

Ultima Patagonia 2006 was the continuation of the 2000 expedition which laid the foundations of research into these caves and mountains. It was cave exploration that led us to the discovery of the first Alakaluf burial caves. With the help of the base at Guarello, the 2006 expedition became truly multi-disciplinary. Coastal speleology in the sub-polar region was born. It has allowed us to find first class sites: in archaeology, the Pacific Cave (Grotte du Pacifique) with the first Alakaluf rock art; in paleoclimatology, Moraine Cave (Grotte de la Moraine), with its archive of glacial deposits and stalagmites; and finally Whale Cave (Grotte de la Baleine), with its palaeontological whale cemetery providing testament to the post-glacial uplift. The aquatic fauna of the island shows surprising biodiversity. Lastly, a world record for surface rock solution was measured and a complex geological history is being revealed bit by bit.

Madre de Dios! A long ignored unique heritage; a symbol of Franco-Chilean cooperation; a Last Hope for humanity so uncertain for the future. We have a duty to understand this island, to love it, to protect it, and have it recognised by UNESCO for its exceptional value.
For more than fifteen years Association Centre Terre has continued its objective of exploration, both sporting and scientific, of the untouched limestone mountains of our planet and the caves that they contain. These explorations have taken us to Papua New Guinea, Borneo, Mongolia and ultimately to the Chilean Patagonia.

When, in 1997, the Centre Terre reconnaissance expedition first approached Madre de Dios, they never imagined that this island, ignored by researchers because of its natural obstacles, would reveal an exploration potential that couldn’t be realised by the two strong expeditions in 2000 and 2006, and would require a new project in 2008...

Our first explorations in 1997 showed us that Madre de Dios had large areas of limestone. Virgin territory which had never been explored and subject to continuous rains that have formed larger than expected subterranean networks. The island is covered with extensive areas of karst with spectacular erosion features: “marble glaciers” that demanded a more systematic exploration.

Centre Terre contacted the Chilean Authorities, Sernageomin (Chilean Govt. Geology), and the University of Chile with a view to a first expedition. In the year 2000 all the support and sponsorship came together, amongst which was the prestigious Rolex Award for Exploration. Thirteen speleologists, three geomorphologists, one archeologist and three Chilean geologists sailed from Puerto Natales, for three weeks. On this first expedition they made several significant discoveries, despite the terrible weather and constant mechanical problems with the boat that served as a mobile base camp.

At a speleological level, they explored the two biggest caves in Chile: the Sumidero del Futuro (Future Sink), the second deepest cave in South America (~376 meters), and the Sumidero del Tiempo (Time Sink) which was 2500 meters long. In total, eight kilometres of caves passage in 32 caves was explored. In one of the rare days of fine weather they found a huge cave opening directly onto the Pacific Ocean. Inside, and several meters above the highest tide level were complete skeletons of whales and dolphins, but there was no time to study the find. At the same time scientists made a floral and faunal reconnaissance of the island, including subterranean fauna, discovering an Alakaluf burial cave along the way. They studied the hydrology and karstogenesis of the caves they explored and recognised the exceptional natural heritage value of Madre de Dios, and began cataloguing the surface erosion forms, some of which, like the rock comets, are unique in the world.
Ten years of research and exploration

A documentary ‘Deepest Patagonia’ (“L’expédition Ultima Patagonia”) and an article in National Geographic Magazine as well as various articles in scientific journals reinforced our efforts to make this exceptional place known to the wider public.

But all this only went to show that we had barely touched the tip of the iceberg, especially in the field of exploration. We had not even begun to explore the northern and most extensive part of the island. The sheer volume of scientific research left to do was enormous.

It took six years to organise a group of specialists and the required funds to run a second expedition that by necessity was bigger than any previous expedition. Thanks to the support of the French Embassy we forged many good contacts with various government ministries, three universities, Bienes Nacionales and the Bicentenary Commission. The Aceros del Pacifico corporation offered the expedition a solid base camp at their mine on the nearby island of Guarello from where we could reach our objectives in inflatable boats.

In January and February 2006, 31 speleologists and scientists (20 French, 5 Chilean, 3 Spanish, 2 Quebec and 1 Australian) went to work on increasing our understanding of Madre de Dios. The findings detailed in the report of this expedition, like the others are characterised by the abundance of rain and violent wind. One unexpected discovery on the 21st of January was to have important consequences: the Pacific Cave had been inhabited by humans. It had the remains of fireplaces, shell middens, and above all impressive indigenous rock art, the first ever found on the islands of Patagonia.

They were attributed to the Alakaluf, sea nomads, who in their bark canoes, were the only people able to reach the shores of these islands. This discovery justified a visit by Chilean experts who were able to visit for a few days when part of our team changed. They could only make a preliminary assessment of the discoveries and see the necessity of further studies.

During the expedition other burial sites were found on the shores of Seno Barros Luco, an arm of the sea oriented east-west that almost cuts the island in two. But the fragility of our transport made it impossible to front the Pacific. We had only one small inflatable boat that we had to carry across the island on our backs.

The north of the island remains almost completely untouched. Exploration of the south of the island continued: new areas explored, research started or continued and more than a hundred new caves explored. Some of them such as Moraine and Finisterre Caves started to produce important climatic data. The Mt. Roberto zone was reaffirmed as the most productive in the south part of the island. The most promising cave, “Restful Cave”, which carried an underground stream was left at a depth of ~305 m due to lack of time and equipment.

Also for the first time we released “real time” reports on the progress of the expedition to the scientific, and world in general, by means of our web page (www.centre-terre.fr), which was supplied day by day with reports and photographs from base camp. The base camp at Guarello mine was vital, but some travel distances were still long and the north of the island remained inaccessible despite our belief that it must be as prolific as the south. At the same time the discovery of the Pacific Cave and the burial sites in Barros Luco opened a new chapter in the history of Madre de Dios research. Studying them will require a prolonged campaign of excavations which can only be carried out with vessels considerably more suitable to ocean travel than our modest inflatable boats.

Once the 2008 expedition is underway, we will have both concrete objectives and obligations. We can count both on the experience gained on previous expeditions, and that we have been recognised as a group that is very willing to work alongside the Chilean Authorities, a partnership that is ever expanding.

Our shared long-term desire is to have Madre de Dios listed as a UNESCO World Heritage area and our future studies will contribute to this objective.

Lost in the islands of Patagonian Chile, Madre de Dios is an extraordinary natural conservatorium. It is a unique natural laboratory that has been preserved from human influence by its inaccessibility. Well beyond cataloguing its riches, our speleological and scientific focus has made it clear that we can use it to study the evolution of our climate over the past tens of thousands of years while observing their subtle variations as they happen, a subject that is causing much scientific and public concern today.
The Expedition: day by day
When the Mama Dina rounded the northeast point of the island of Guarello on the 14th of January 2006, all 22 members of the expedition were on the bridge: Madre de Dios appeared in the distance, under a heavy sky, under the roaring fifties... The veterans of previous expeditions remember the unique landscape engraved on their memories, the uninitiated see the marble “glaciers” that have attracted them here first appear then grow larger.

Our Chilean hosts at the mine on the island of Guarello greet us warmly. They will look after us for two months lodge us, feed us, without once losing their patience or good humour despite the complications and risks that inevitably come with a band of cavers on expedition: indecent hours, last minute changes to plans, unavoidable noise that’s hardly compatible with workers on night shift. The magnificent conditions in the mine’s base camp and the wonderful treatment by the personnel of the Aceros del Pacífico Company contributed enormously to the success of our expedition.

The first few days of the expedition are delicate: make contact with our hosts, move everybody in, assemble and fit-out our fleet of Zodiacs and Bombards, prepare our equipment...

Maritime speleology

From the 16th, groups spread out across the countryside, through the heavy rain that fell every day. The unusual thing about Patagonia caving is that you leave base camp each morning and return each evening, usually after a long voyage to Madre de Dios in Zodiac. Whipped up by the violent winds, mists of salt and fresh water combine to soak us well before we can set foot on land. Everybody tries their own technique to keep the water out, but in the end, there’s nothing for it. We just resign ourselves to return tomorrow to the storms and curtains of rain. Suddenly everything calms and like a blessing, the sea becomes like a lake.

A strong attack

One group makes a reconnaissance trip to Isla Tarlton, another limestone island to the south of Madre de Dios. At the very end of Seno Conteras we need to find a land route to Seno Barros Luco. It is only accessible by the open sea and our fragile inflatables are not up to the task. A land passage is the key to accessing the north of the island.

Another three groups check objectives that we couldn’t visit in 2000. The first of these is the Sumidero de los Condors sink, accessible from Seno Conteras after six hours of walking through a wild traverse of lakes and rock outcrops. The cave is actually a sort of active subterranean canyon 150 meters long, and in exceptionally violent state after the rains. It runs below the hill that blocks the cirque and exits down a 50 m cascade into a lake whose waters rapidly mingle with those at the very north of Seno Eleuterio.
Condor Sink

The Condor Sink system is a typical steep underground canyon. Discovered in 2000 on the aerial photo and only briefly visited at the time, it was explored and mapped in 2006. The sink swallows the water from a basin various kilometres in area and includes two lakes.

The outflow from these lakes disappears into an impressive canyon-sink. The underground stretches of cave are short as the roof has collapsed into the canyon in several places. Some 20 m further on, Condor Sink passes through a flooded section before dropping into a collapse zone.

Some caves (such as Hummingbird Cave) on the left bank have also been partially breached by receding stream erosion. At the downstream end of the system, the water emerges from a cliff as a spectacular 50-100 m high waterfall.

The Condor Sink system in reality constitutes a canyon that was formed by glacio-karstic processes and later altered by post-glacial erosion. Upstream, an extensive glacial cirque fed by waters from the Patagonian icecap, must have fed this glacio-karst system. When the glacier receded (or perhaps beneath the glacier), the water flow excavated Condor cave that grew and was breached by later erosion. The area is geomorphologically very interesting. The influences of ice are associated with karst solution in a compact area where there has virtually always been a surface canyon and a cave sinkhole. Due to many similarities, it is reminiscent of Future Sink, explored in 1997 on Diego Almagro island. The study of this type of system will help us better understand karst processes during and after glaciation on Madre de Dios and the entire archipelago.

Stéphane Jaillet

The waterfall at the downstream end of the system.
## List of caves explored in 2006

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Long. West</th>
<th>Lat. South</th>
<th>Alt</th>
<th>Length</th>
<th>Length Mapped</th>
<th>Depth</th>
<th>Comments</th>
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<tr>
<td><strong>A CAMP 600</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Contact Pit</td>
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<td>50° 18,900'</td>
<td>629</td>
<td>87 m</td>
<td>87 m</td>
<td>-47 m</td>
<td>Mapped</td>
</tr>
<tr>
<td>2</td>
<td>Cave beneath the Glacier</td>
<td>75° 20,760'</td>
<td>50° 18,828'</td>
<td>745</td>
<td>55 m</td>
<td>55 m</td>
<td>-15 m</td>
<td>Highest altitude entrance found</td>
</tr>
<tr>
<td>3</td>
<td>GLS 04</td>
<td>75° 20,893'</td>
<td>50° 18,953'</td>
<td>635</td>
<td>52 m</td>
<td>52 m</td>
<td>-38 m</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>AJPPO2A</td>
<td>75° 20,980'</td>
<td>50° 19,075'</td>
<td>579</td>
<td>50 m</td>
<td>50 m</td>
<td>-32 m</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>AJPPO2B</td>
<td>75° 20,980'</td>
<td>50° 19,075'</td>
<td>50 m</td>
<td>50 m</td>
<td>50 m</td>
<td>-32 m</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>UL03</td>
<td>75° 20,014'</td>
<td>50° 19,029'</td>
<td>48 m</td>
<td>48 m</td>
<td>48 m</td>
<td>-33 m</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>AJPPO1A</td>
<td>75° 20,998'</td>
<td>50° 19,055'</td>
<td>46 m</td>
<td>46 m</td>
<td>46 m</td>
<td>-32 m</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>AJPPO1B</td>
<td>75° 20,998'</td>
<td>50° 19,055'</td>
<td>46 m</td>
<td>46 m</td>
<td>46 m</td>
<td>-32 m</td>
<td></td>
</tr>
<tr>
<td><strong>C CAMP 400 North</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>1</td>
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<td>50° 18,200'</td>
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<td>111 m</td>
<td>111 m</td>
<td>-85 m</td>
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<td>Moral sink</td>
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<td>50° 17,985'</td>
<td>360</td>
<td>128 m</td>
<td>128 m</td>
<td>-68 m</td>
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<tr>
<td>3</td>
<td>As you like it Cave</td>
<td>75° 21,072'</td>
<td>50° 18,510'</td>
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<td>93 m</td>
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<td><strong>C CAMP 400 South</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>635</td>
<td>52 m</td>
<td>52 m</td>
<td>-38 m</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>AJPP02A</td>
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<td>50° 19,075'</td>
<td>579</td>
<td>50 m</td>
<td>50 m</td>
<td>-32 m</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>AJPP02B</td>
<td>75° 20,980'</td>
<td>50° 19,075'</td>
<td>50 m</td>
<td>50 m</td>
<td>50 m</td>
<td>-32 m</td>
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</tr>
<tr>
<td>9</td>
<td>AJPPO1A</td>
<td>75° 20,998'</td>
<td>50° 19,055'</td>
<td>46 m</td>
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<td>-32 m</td>
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<tr>
<td>10</td>
<td>AJPPO1B</td>
<td>75° 20,998'</td>
<td>50° 19,055'</td>
<td>46 m</td>
<td>46 m</td>
<td>46 m</td>
<td>-32 m</td>
<td></td>
</tr>
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</table>

**Length explored:** 7,919 m

**Length mapped:** 5,494 m

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### Advanced Camps 2006

- A Camp 600
- B Camp 400 South
- C Camp 400 North
The cave divers continue exploration of the siphon “At the end of the Seno” that re-emerges after 140 m of underwater passages and on their way out set traps for aquatic fauna.

The final group is composed of veterans of Madre de Dios. They begin the “incursion of the fifty year olds” in an attempt to forge an overland route to Whale cave on the Pacific coast that was only reached on one exceptionally calm day by Zodiac in 2000.

Inside this huge cave whose mouth opens some six meters above the high tide mark, the 2000 team discovered whale bones. This intriguing mystery, probably related to the uplift of the island after it was liberated from the weight of the ice sheet as it melted at the end of the last ice age, demanded more detailed study. But after walking for two days in rain and wind that at times made it difficult to them to stay on their feet, they retreated without reaching their objective.

In base camp, a magnificent day was dawning, the first of three in a row and something unknown in these islands. Global warming had reached Madre de Dios. Some groups took advantage of the calm to begin exploration of the southern part of the island between Senos Soplador and Eleuterio. They installed two “high altitude” camps in promising zones, one at 400 m and the other at 600 m. The first caves were found and exploration began.

Change of scene

21 January. While trying to reach Whale cave by following ledges on the limestone cliffs Thibault and Laurent made an unexpected find. Right where Seno Azul empties into the Pacific they found a small cave only 200 m² with two entrances and plenty of light. Covering the floor were thousands of shells and the remains of fireplaces, clear evidence of human habitation.

Suddenly ochre paintings and traces of charcoal came into view on the back wall! More than 40 paintings of a form previously unknown amongst the Alakaluf Indians (only they could have reached these islands in their canoes).

The anthropomorphic figures and geometric designs, some covered with a thin layer of calcite, took advantage of a natural prominence in the rock wall to represent a marine creature.

In Santiago, where the news of the find had been beamed immediately, the effect was like a bomb going off. On the island, the expedition had no alternative but to switch priorities to the Pacific Cave where it was necessary to first protect the site, then effect some initial studies.

Eleven people and 600 kg of equipment was immediately unloaded in the most terrible swell, all the time attempting to avoid the numerous sharp rocks that continuously threatened to shred the Bombard. They then installed a camp in “normal”, that is terrible,
conditions. That first night the group tent was flattened by the violent squalls. They had to quickly move it and lash it down behind a rock with caving ropes to avoid its total disintegration. They mapped in a quadrangle, made a careful inventory of the paintings and documented everything with movie and still cameras. The Chilean prehistory world was very excited and the authorities followed our findings closely. In base camp, the telephones rang continuously as it was announced that an official mission would arrive to take advantage of the mid-expedition team rotation between January and February and make a preliminary study of the site. We posted several photographs on the internet and the press.

Hard yards to explore

Despite the archeological reorientation imposed by events we also continued with the work we had come to do: our cave explorations continued. We resumed scientific studies in Moraine Cave, discovered on the NW coast of Guarello Island in 2000. Most of the caves in the island of Patagonia are young, formed after the last glaciation. Moraine cave is older. It has impressive 20 m thick moraine deposits and finely layered “varve” deposits (formed from glacial rock dust), in a side passage. It is a veritable climatic archive that demands to be studied.

We took advantage of the Pacific Cave camp to make a further attempt to reach Whale cave by land, but on the 26th we failed definitively: an impassable cliff rose before
Madre de Dios and its myriad of fjords. Don’t be fooled by appearances (below): the sun and summer flowers in front of the Pacific Cave (note the “African mask” appearance of the entrance). The next day a wild storm raged in this same place...

On the 27th we moved the camp back to base and celebrated our discoveries. On the 28th, another team returned to 600 camp to continue prospecting. The numerous caves we descended all had modest dimensions: barely 40 m! At least the spectacular scenery and magnificent lapiaz was some compensation for our lack of results.

On the 29th we installed a more remote base camp at the very end of Seno Conteras with the aim of reaching Seno Barros Luco.

On the 30th we established a route and the next day we portaged the tiny Bombard and its motor. It was necessary to pass an unexplored col at 350m altitude carrying more than 30 kg loads, including enough equipment for a further advanced camp. This “camp at the end of the earth” would be occupied almost continuously until the end of February by small reconnaissance teams on rotation. The first voyage took place on the 1st of February with an escort of dolphins beneath an immaculate sky. This first day turned up various discoveries. We first found and mapped a resurgence 100 m long before we were stopped at a 6 m waterfall. Four Alakaluf burial caves, three on the limestone and in the shales of Isla Ramûn in the waters of Barros Luco proved that the Alakalufs didn’t hesitate to sail the Pacific beyond the safety of the island – the only route to get there by water. The relieving team found another resurgence with a breeze that they were able to penetrate for some 50 m.

Monte Roberto, six years on

On the 30th of January we installed another five day camp on the southern slope of Mt. Roberto at an altitude of 400 m to continue exploring the limestone-sandstone contact. Here, during the 2000 expedition, we found several important caves, among those, the Future Sink, the deepest cave in Chile at –376 m. We found several new caves, four of which...
The Mystery of the Alakaluf Indians

BY LUC-HENRI FAGE

To discover a cave adorned with paintings is nothing extraordinary. To discover one on the coast of the restless Pacific even less so. But to find one in the heart of the Patagonian archipelago in the most isolated place imaginable, is something extraordinary. Then to find four more burial caves just a few days later on the shores of Barros Luco is also in the realm of exceptional... All of this was just part of the discoveries that follow on from those of the 2000 expedition and have allowed us to date a skull at 4,500 years old.

Eternal busybodies into the most hidden corners of our planet, cavers have been the first to discover, here and there, vestiges of the past. These discoveries from Chilean Patagonia are proof of the existence of a group of humans lost to the past. The “Nomads of the Sea” were studied by José Emperaire in the 1940s, displayed through fiery tales by Jean Raspail, and above all scientifically studied by Dominique Legoupil and her Franco-Chilean group of archaeologists for the past 25 years.

The Alakaluf indians, also known as the Kaweskar, lived in the Patagonian “canales”, they hunted and collected shellfish, almost naked, they travelled around in bark canoes and maintained a fire burning in a clay basin. Such a rough life, on the edge of survival, that even the great Charles Darwin while passing through the Beagle Canal on his voyage around the world wrote, before later retracting the statement, that they couldn't quite be called human.

Until that famous 21th of January 2006, the date of the discovery of Pacific Cave, there was no evidence of art on their part except for some body paintings and ochre smears on their canoes and oars. This seaside cave hid some forty motifs painted on it’s gloomiest walls, half were in ochre, the rest in charcoal. They are principally human representations (anthropomorphs), as well as geometric designs (circles, points, etc), reminiscent of the body paintings and decorations of some of the ethnological objects of the Alakaluf. We still Don’t know the age of the discoveries.

Situated only a few meters above sea level, the cave must have been submerged in the recent past (4000 years) when the sea level was higher and the island had hardly risen after the ice age. Observing the paintings made us think that they must have been done in successive stages, the most recent done just prior to modern times. Probably in the period between 3,000 and 200 years ago.

At an archeological level, the most interesting part appears to be the floor of the cave. Half of the 200 m² of the cave floor is covered in piles of shells and the remains of marine and terrestrial food animals that the cave’s hosts occasionally ate, as well as a conical fireplace in the centre of the cave. It is the first shell midden found inside a cave in the archipelago and is perhaps a unique possibility to study the diet of these marine hunters.

We recalled that in 2000, during a stopover in Puerto Eden, where the last of the Alakaluf now live, we interviewed Magdalena. With her husband, they are the last nomads of Madre de Dios (situated 160 km south of Puerto Eden), for six months of the year. We learned from them that they usually hunted young seals on the rocks near the mouth of Seno Azul. Surely they, like their predecessors, took refuge in Pacific Cave while they waited for the weather to ease so that they could put to sea. Given the fragility of their craft, this must have been very risky... Excavations in this cave and in the burial caves of Barros Luco will be one of the principal objectives of archaeologists during the next Patagonia expedition.

The paintings mainly represented anthropomorphic figures such as these dancing silhouettes 4 m up the wall.

The paintings have been documented photographically and sketched allowing us to make a faithful scale reproduction.
exceeded -70 m deep and one -120 m deep.

On the 5th of February, on a day trip to this sector we found “Hourglass sink” on the contact between the limestone and the sandstone. Its moss-filled entrance was hidden beneath the Nothofagus where an active stream littered with sandstone blocks continued into the limestone. We explored 150 m and mapped to -45 m.

At last the caves we were finding were reaching a reasonable depth. Our perseverance began to pay off as Mt. Roberto reaffirmed itself to be the area with the best potential.

Making the most of a period of fine weather, two of the team made a lightning attempt toward the Pacific. Although they got in sight of Whale Cave, they didn’t have to 80 m rope that they needed to descend the vertical cliff down to its entrance...

On the 4th of February, on the island of Guarello we found Finisterre Cave. A strong, cold breeze was rushing out and we explored over 200 m, and it continued...

In camp 400 south, we began to see results. We descended Colander Cave to -135 m and it continued... Unfortunately, Hourglass Cave reminded us that time was running out.

Fresh troops

The day arrived for the January team, The Mama Dina approached. On the morning of the 7th of February, after a difficult voyage, nine “Febuarians” were unloaded to relieve nine “Januarians” that were to embark the following day, along with various officials from Santiago and Punta Arenas who had come to inspect the archeological site: an archeologist, an anthropologist and government representatives. During these two days the expedition team was dedicated to public relations, taking some to the Pacific Cave and other to the advanced base at the end of Seno Conteras to allow them to make contact with the reality of the terrain.

The weather was on our side. On the 8th of February, after a ceremony to unveil a plaque to commemorate the expedition, the
“Januarians” re-embarked for Puerto Natales.

On the 9th, the new team started work despite the weather having returned to normal: the wind forced back a Zodiac that was heading for Finisterre Cave resulting in a duel with the elements in Seno Eleuterio.

One team returned to Colander Cave, while another returned to Hourglass Cave to continue exploration of the limestone-sandstone contact on Mt. Roberto towards the south where they found a superb 33m deep bell-shaped shaft that swallowed a waterfall: “Restful Cave”. It rapidly reached –100 m, then –150 m.

On the 10th, Hourglass Cave reached –150 m in an active meander.

On the 15th, the divers went to Kawtcho Sink in Seno Soplador and reached –30 m.

We installed another Roberto camp as the day trips were becoming too long and relieved the teams every three days.

On the 16th we finalised the exploration of Colander Cave. It ended in a squeeze at –180 m so we derigged the cave and moved the camp to a nearby area to explored Huequito Cave that had reached –200 m.

The camp at Barros Luco saw successive teams continue exploration of the shores towards the huge lapiaz to the north. In total we explored over 150 km of shoreline in these unknown waters.

The Country of Extremes

While the climate punished those in the precarious camps lashed by winds; the horror of putting on cold wet clothing from the day before and any intent to light a fire was a near impossible task...others recharged their batteries in the comfortable refuge of Guarello base, designed so that all the activities of normal life could be carried out without ever poking your nose out into the outside world. We walked in covered passageways in t-shirts while on the other side of the windows, the rain fell by the bucket-load.

We listen to the howling wind as the machines clean and dry our clothing that we’ll soak once again on Madre de Dios...And so pass the days, oscillating between the discomforts on land and the comforts in base. Little by little, our notebooks fill up and the caves we are exploring become deeper.

By definition cave divers aren’t afraid of water: at the most, they put on their dry suits in the comfort of the base in the morning and stay that way until they return in the evening. Day after day they lay line and set fauna traps. The best siphon that has been explored so far is the Wolf Siphon (“Lobos”, named after the sea lions-sea wolves in Spanish that live in the entrance). They continued exploring this undersea resurgence that was discovered in 2000 and explored to –49 m. The part explored six years ago turned out to be nothing more than just one branch of a complex underwater network centred...
Restful Cave

Situated 400 m south of Hourglass Sink, Restful Cave begins with a 33 m pitch very close to the limestone-sandstone contact. The cave is mainly vertical and is characterised by a flat roof and a cascading profile that is oriented to the west and later to the south until it reaches a 17 m pitch at -160 m. From this pitch, the morphology changes to become a meander. The narrow “Shark Meander” is occasionally interrupted by vertical drops and numerous downclimbs, and takes the cave towards the north. With a length of over 200 m, the Shark Meander continued beyond the mapped limit (-276 m) to a level of -305 m. A “sporting” climb out for its entire length, Shark Meander will be equipped with rope next time as it would be problematic with high water levels. It is without doubt one of the principal objectives of the next expedition.
Hourglass Sink

At the bottom of a depression, beneath the exuberant vegetation that covers the rocks, a permanent stream continues its journey to the ocean as it enters the limestone mass. The entrance zone is a tangle of blocks and sand fill. Various diffuse sinks supply the underground stream of some 10 l/s. After about 100 m along a meander, a 30 m pitch indicates a change in the cave's profile. With short meanders, the caves heads north until it reaches -121 m after which it becomes very vertical, characterised by a flat roof and cascading profile that moves to the southwest. The way on continues down parallel shafts on occasions to avoid the risk of floods that we can't ignore, proof of which is the complete absence of sand anywhere. At the base of the pitches (-220 m), the caves once again becomes an occasionally tight meander heading northwest and occasionally cut by climb downs. After fifty meters, the last pitch gives access to a large room where flood foam is visible 5 m up the walls. Once again we hit a chaos of blocks and sand fill that we explored to -271 m. At this point we must be very close to the "Forgotten Sink" explored on the 2000 expedition.
on an extensive smooth-walled passage where the current varied from violent to tranquil. The halocline between the fresh and salt water is visible from time to time. You can go 90 m in this passage to reach a depth of –49 m. The system merits a more systematic exploration.

The Whale at last!

We still continued to make attempts to reach Whale Cave every time that even the smallest window of fine weather opened. You need two days of calm weather so that you can take a chance the sea will be calm enough on the third. On the 9th, a cruising yacht anchored in Guarello, its crew attracted by newspaper articles about our discoveries. “No, you can’t visit Pacific Cave, but if you’d like to visit Whale Cave perhaps we can come to some arrangement...!” This would be our fourth failure. Despite the size of the boat we turned back due to the Pacific swell and strong wind...

18th of February, another incursion by Zodiac... and another failure.

On the 19th, with only one metre waves a team of eight took to the Pacific. In two hours they reached the cave and made a commando-style landing thanks to the divers. The enormous cave held even more remains than expected. There are five whale skulls and numerous bones, as well as the remains of dolphins and seals. Some took samples for dating and DNA analysis, while others made a photographic record of the cave. On the way home they found another cave which they explored 300 m beyond a cascade.

Beyond –300 m

This week our efforts were concentrated on Mt. Roberto where rotating teams avoided the constant floods thanks to “high flying rigging”. On the 21st, Hourglass Sink reached a level of –271 m. At this point, the water disappeared into a narrow sump at the contact between the limestone and the sandstone that left no hope: the final chamber carried flood marks five meters up the walls... The countdown had begun: only a few days remained to recover the equipment from the outlying camps, including our boat from Barros Luco, clean and dry everything, tidy up the paperwork. Our stay was nearing its end.

We made our last attack on Restful Cave and continued exploration and mapping until the 23rd without reaching the end. Thanks to some calm weather and low water, the deepest point we reached was estimated to be –305 m. It will continue as one of our major objectives for the next expedition, along with exploration of the extensive lapiaz of the northern part of the island.

The return

On the 28th of February we made one last visit to Finisterre Cave and a last dive. We wanted to enjoy Patagonia right up to the end. On the 2nd of March, Mama Dina left Guarello then entered Seno Conteras heading toward West Canal. The fog horn saluted the miners of Guarello who had become our friends. By the time that the huge lapiaz that descends to the sea beneath a leaden sky had disappeared we were already making plans. In 2008 Centre Terre will be back!
Finisterre Cave

The entrance of Finisterre Caves is located on the extreme south west of Guarello Island at the foot of a tall cliff that dominates the low marshy country between the cliff and the sea. The entrance itself is a 1.5 m diameter pressure tube close to a waterfall. A low wet passage gives way to a heavily decorated passage that has areas of aragonite and helictites. Afterwards, a meander leads to a steeply sloping passage.

Uphill, the cave is developed parallel to the cliff and has moraine deposits. The cave continues to three entrances, the first one of which is impenetrable and 90 m above the first entrance, making it the highest point in the cave. A small stream in a side passage ends in a climb waiting to be explored. Downward, a short dig through sand gives access to a narrow, sloping passage to a climbdown and the main stream (10L/s). Upstream, the stream is in a narrow meander while a high, dry fossil passage above it has considerable clay deposits. The river is fed by two streams; one comes from an impenetrable siphon, while the other was followed to a chimney that wasn’t climbed. Downstream, the river runs into a siphon at the lowest point in the cave (-41 m). This siphon isn’t far from an impenetrable area visible at the foot of the cliff.

Judicael Arnaud

ASSOCIATION CENTRE TERRE

Chiffre 15 sur le plan de situation p. 9.
Giant solution runnels

With its outstandingly huge solution runnels, the lapiaz of Madre de Dios constitutes a new geomorphological heritage. Thanks to these drainage forms that imitate hydrologic networks in miniature, it is possible to observe the action of water on rock as it happens. All the major forces of terrestrial karst erosion are there: fluvial incision, meander formation, regressive step erosion, etc. And the other factor without which we would never have this beautiful landscape: wind, that give rise to “hydro-eolean” lapiaz. Other forms of differential dissolution are the “rock comets” that are caused by a laminar flow of wind-driven rainwater. With an annual rainfall of 6 to 10 m, the rate of surface dissolution is a record. At 400 m altitude, there are erratic block stranded on limestone pedestals 1.6 m high showing the amount of dissolved limestone that has “melted away” since the retreat of the glaciers 10,000 years ago a world record for surface dissolution of 16 mm/century.

To measure the flow, the dissolution, and the evolution of these landforms, we installed a hydrological and hydrochemical measuring station on Guarello, in a small basin at the junction of several runnels. The parameters measured were rainfall, wind speed, temperature, flow volume and dissolution rate.

Karst drainholes: young models of subterranean systems

The rainwater flows across the lapiaz and goes underground taking advantage of the intensely fractured rock. On the marble domes, the thousands of pits and cracks narrow down or end in loose blocks between 30 and 80 m deep. For cavers, the most interesting caves are those on the contact between impermeable and permeable rock. For example, the rainwater flowing across the sandstone of Monte Roberto concentrates into a stream underground right on the contact with the limestone. Various pits reach...

Above: the vertical runnels of Guarello Island were studied to measure their rate of dissolution mode of formation. Below: unusual karst erosion “teeth” beneath a calcareous block on Tarlton Island.

KARSTOLOGY

A Unique Geomorphological Heritage

BY RICHARD MAIRE, STÉPHANE JAILLET, BENJAMIN LANS AND LAURENT MOREL
The comparison between the growth rings of the nothofagus and those of the calcite formation may clarify some doubts about the evolution of Madre de Dios. Below: an erratic block sitting atop its 1.6 m limestone pedestal, shows how much limestone has been dissolved since the end of the last glaciation 10,000 years ago.

between 200 and almost 400 m deep on this part of the island. Devoid of formations and other deposits these cave/sinks are made up of a series of meanders and pits. Like the surface lapiaz, these active caves, especially dangerous during floods, are models of accelerated erosion. They must be less than 15,000 to 10,000 years old. There are also older caves, which is the case with Whale Cave on the Pacific shore, Moraine Cave on Guarello and Ophiolite Cave on the lower flanks of Monte Roberto. These have preserved traces of another environment that would be useful to decipher.

The paleoclimatic archives of Moraine Cave

On the NE coast of Guarello, Moraine Cave is a large cave filled with glacial sediments 20 m thick. The wall inside has two horizontal glacial notches, the first time such a feature have been seen below ground. The cave has served as a receptacle for rocky leftovers carried by the glacier in the last cold period. You can see blocks embedded in gravel (typical moraine), gullied surfaces (erosion episodes), and finely laminated clays and sand: these are glacial "varves" formed by sedimentation in a glacial meltwater lake.

We made measurements and took samples to help decipher the evolution of the climate and environment. These varves could correspond to sudden warm phases that have been noted in the polar icecaps. We intend to see if they are caused by sudden changes or a succession of various glaciations. Finally, we have dated a stalagmite that has formed after the moraine deposit using thorium/uranium dating in the Lab. Sc. Climat et de l’Environnement, UMR 1572, CEA-CNRS, Saclay. The five dates so far obtained show that it has an age of less than 10,000 years. These dates will be correlated with paleotemperature dates obtained by oxygen and carbon stable isotope dating.

We know that stalagmites form during warm periods owing to carbonic acid formed in soils by vegetation. It is very important to learn more about this post-glacial warm period that allowed the formation of this stalagmite, as there are no other records of this type so far south in the world.

There is a comparative study being undertaken between the most modern stalagmite and the growth rings of the Nothofagus (beech) trees with the aim of getting precise information on the warming climate of the past 150 years.
Whale Cave opens onto the vast Pacific Ocean with a mouth that looks like the entrance to a cathedral. Inside, in a semi-dark atmosphere, safe from the wind and waves, we find a genuine marine cemetery. In this place, the clock has been turned back thousands of years to an epoch when waves entered the heart of the mountain.

This cave was partially explored during the 2000 expedition, was one of the main objectives of the Ultima Patagonia 2006 expedition.

Situated at the foot of a cliff and close to jagged reefs, the cave is very difficult to reach. It only received a cursory exploration in 2000 during a day of exceptionally good weather. The team that day mapped the cave and observed whale bones over 100 m inside the cave. In 2006 it took seven attempts, both by land and sea, before we could return to the cave on the 19th of February by inflatable boat.

Once again we could set foot in this cave that we had worked so hard to reach. It has been severely altered by the small stream that runs through the cave and by the rocks that have fallen from the roof. On close examination we also found signs of older streams. We could also see the remains of various cetaceans (we found six skulls), as well as dolphins, sea lions and seals. There were also remains of many sea birds. Some of these were mixed with the mammal bones, while others were articulated skeletons that lay on top of the bones and appeared to be from birds nesting in the cave.

In addition to the usual dating methods we could also date the bones by using the calcite formations that had begun to form on them. For the moment, the mystery of Whale Cave is yet to be deciphered. The special feature of Whale Cave is that after the whales were beached, it offered very favourable conditions for the preservation of their bones. The scientific interest in a marine cemetery like this is enormous.

One thing for sure: with the exploration of this sanctuary-cave, sea cave exploration in this southern land has only just begun.
Whale Cave

Whale Cave is 270 m long and 6 m above current sea level. The entrance chamber is the largest yet discovered on the Madre de Dios archipelago, with dimensions of 150 m long, 40 m wide and a height of between 20 m and 70 m, it has an approximate volume of 270,000 m³.

The cave continues as an inclined tube that we must explore on a future trip. The floor of the cave is flat, clayey and damp. Water drops from the ceiling to join occasional streamlets that eventually flow into the sea. At the end of the cave is a squeeze that gives access to a small dead-end chamber.

Also at the back of the cave and 100 m from the sea, several skeletons of cetaceans cover the floor, mixed with the remains of dolphins, sea lions and seals. The bones are spread everywhere, some stuck in the clay, others covered in foam. It’s an ancient deposit that intrigues us. Leftovers of Alakaluf meals?, not likely. The remains are a long way from the entrance, to get them there would be difficult, and the only access is by sea. We found no indications to support this hypothesis. Deposited by storm perhaps?, it’s possible, but the cave mouth isn’t oriented directly towards the open ocean, but instead, well protected. These remains could really be even older, dating from a time when the sea-level was higher, or the continent lower.

20,000 years ago during the last glaciation, the weight of the ice caused the continent to sink. When the ice retreated, the sea rapidly rose over 100 m, while the continent still continues to rise more slowly. Whale Cave was once an enormous sea cave, regularly lashed by ocean waves for thousands of years. It is possible that during that time, cetaceans and other marine animals were washed in, marooned and died. Their remains were finally uplifted along with the cave over the thousands of years that followed.

Without doubt, Whale Cave has not yet revealed all its secrets. Carbon 14 and DNA analysis is ongoing and we wait impatiently for the results that may allow us to better understand the origin of this intriguing cemetery.

Remains of five whales, two dolphins (above), reinforce the hypothesis of a marine cemetery...

Left: a whale vertebrae covered with calcite testifies to the antiquity of the site.
Madre de Dios: a Patagonian archipelago lost “at the end of the earth”; dominated by a karst that extends to the horizon; exceptionally severe climatic conditions, the worst on the planet: record rainfall, violent winds, cold...; recent past glaciation, with extensive Patagonian glaciers only 10,000 years ago that descended from the Andean Cordillera and covered the entire island. It seemed that Madre de Dios had all the requirements to be a biological “desert”. Despite these expectations, our biological explorations revealed an unexpected floral and faunal diversity and surely previously unknown species.

Many different environments were explored during the 2006 expeditions: rivers, caves, peat bogs, forests, transition zones... Two environments were especially studied owing to the specialisation of the biologists present: rivers and their underground circulation and caves. We also took advantage of the presence of Chilean biologists to begin the first inventory of vertebrates of the archipelago. From the vegetation point of view, a lot of work was done collecting and defining species in the Nothofagus rainforests, the peat bogs and on the “high” altitude steppes.

Principal results

The biological sampling done in the rivers during this expedition were the first done in this part of the world. They revealed a surprising diversity of benthic (those that live on the bottom of the river), and hyporheic (those that live in sediments) invertebrates. At least 15,000 aquatic vertebrates were collected. So far we have identified more than 40 different taxa from at least 20 different insect families. To get a more precise estimate of the biodiversity of the rivers of Madre de Dios we’ll have to work a little longer...

Actually, there was no previous data pointing to such a number of invertebrates in this part of the world. Specimens have been sent...
to experts all over the world. It’s highly probable that they will identify new species.

Underground collecting has also revealed an unexpected faunal biodiversity. The underground aquatic fauna is especially rich and some species are stygobites (only found in underground waters), which is surprising given the magnitude of the last glacial episodes. The most notable discovery comes from underwater sampling in two marine resurgences. These caves, classified as anachaline, hide a fauna that is totally different from the other underground habitats that we found and where various species are new to science. Anachaline caves are noted for their great biodiversity, but it is the first time that they have been described from these latitudes.

Numerous mammals and at least 30 species of birds were observed during the expedition. Our Chilean colleagues also observed indications of the presence of many others.

In conclusion, even though Madre de Dios is a very hostile environment to Man, it constitutes a true biodiversity reserve and reference ecosystem largely unaffected by man in Chile. From now on it is vital that we preserve and protect this environment and we will work in this direction.
The exploration of a karst massif includes its flooded part if it is accessible. As in 2000, the team had cave divers to explore and pass siphons that often block the exploration of cave systems and explore and study the water-filled caves.

Cave diving on Madre de Dios has some special difficulties: transporting diving equipment to very isolated dive sites, the hypersensitivity of the underground networks to the rapid increase of water into the caves, and finally, the almost complete possibility to deal with a diving accident. These parameters controlled our underwater cave exploration focus.

We made several dives in the sea looking for possible submarine resurgences and found several outflows of fresh water in Seno Soplador, but the size of these outflows didn’t permit the entry of a diver. Nevertheless, the sea dives allowed us to observe the vertical relief of the Patagonian fjords that on occasions reach hundreds of meters deep. We could also observe the fauna and flora while the seals and sea lions never failed to visit and observe our actions...

Our main objective consisted of locating the exit points of water that had disappeared into the caves of the massif.

We mainly dived in three caves during the 2006 expedition: two resurgences and a sink. Both the resurgences had been partially explored on the 2000 expedition and awaited the return of divers. The sink was previously unexplored.

**Future objectives**

Apart from looking for new siphons and resurgences in unexplored parts of the archipelago, we will continue to study and explore the two most promising caves: Kawtcho and Lobos. From the pure exploration point of view, the large volume and number of branching passages is especially promising. These two networks are very different to each other: one is a sink and the other a resurgence.

The continuation of their exploration will allow us to better understand the general organisation of the underwater passages of Madre de Dios. They are affected by the recent geological history of the island, characterised by a lowering of the sea level during the glaciation, that allowed the formation of cave passages below the present sea level. These siphons of the marine sea shore are representatives of a unique flooded habitat that shelters a very interesting aquatic fauna that we will continue to study in 2008.
Kawtcho Cave

This cave is 30 minutes walk from the end of Seno Soplador and was the object of our second series of dives. The nomad Alakaluf indians who roamed these canals before the arrival of westerners gave this name: Kawtcho, to a malevolent spirit, a giant that lives underground to escape from the daylight. The entrance is at the sandstone-limestone contact and was known since 2001 but not fully explored. The cave’s impressive size justifies the name we gave it. A river enters as a cascade that rapidly disappears into rocks on the floor of the passage. After heavy rain the river emptying into it converts the cave into a lake. The approach isn’t very long but it is through a dense forest with heavy diving equipment that must be kept to a minimum.

Once at the entrance, the diver must descent a four metre drop to reach the siphon a few meters beyond. The first siphon is passed in a few minutes and gives way to a larger room. The 9°C water is stained as it crosses the peat bogs in its catchment outside. The second siphon is in the form of a small lake that constitutes the surface of a flooded pit. It is only fed by the first siphon in times of high flow. Descending the pit we arrive at a horizontal passage that opens into a large flooded room. The exploration finished at 212 m from the entrance and –38 m deep — well below sea level. We also found another pit that headed towards the interior of the massif, but it was not explored.

Resurgence at the end of the seno

Our first exploration of the expedition was in the resurgence at the end of the seno, situated at the end of one of the branches of seno Eleuterio. In 2000, Alan Warild dived this resurgence for 85 m in a shallow passage (-16 m). The cave continued.

A halocline (surface between salt and fresh water) is present throughout the cave. The water, while clear, is rich in humus and the colour of tea. After 85 m the passage opens into a large room with an open surface, in the middle of the forest. A second siphon begins on the left with a depth that remains at -16 m.

At 186 m from the entrance there is another opening to the exterior that is too small for a diver to fit through. The room is smaller and fed entirely by a creek emptying into it from the surface. This violent current represents the entire drainage of an extensive lake that is only 30 m away. The exploration allowed us to traverse the entire length of the caves hydrological development. We also collected subterranean fauna samples. These samples showed a very rich fauna and a new species of amphipod from this cave is currently being described.

Lobos resurgence

Our third and last exploration dive was in the Lobos resurgence at the end of seno Emperador and is in the form of a natural swimming pool. The water emerges from several points and combines in a canal that flows to the seno.

In 2000 Michel Philips and Javier Lusarreta explored the flooded passage 210 m from the entrance to a depth of ~49 m. The dives we did allowed us to extend the cave. Successive dives revealed a complex system. As it is a submarine resurgence, the large volumes of fresh water mix with sea water a long way into the cave.

Several apertures and a monumental flooded entrance permit access to the network, but only just, owing to the strong current that becomes violent at the slightest disturbance within the passage and makes movement very difficult.

Our sampling of the underground fauna allowed us to discover something uniquely different from the samples from other caves. We reached the end of the previous exploration and continue some 90 m further in the ramifications of this deep passage. Due to lack of air we couldn’t explore all of the flooded passages. The cave is of notable size and the siphon continues.

THE TEAM
A multi disciplinary international team

France
1 Bernard Tourte caver, expedition leader, president of Centre Terre
2 Richard Maire caver, karstologist, expedition scientist in charge, director of research CNRS, Bordeaux,
3 Judicaël Arnaud caver
4 Frank Bréhier cave diver, biologist, Muséum Histoire naturelle, Paris
5 Sylvain Boutonnet caver
6 Serge Caillaud caver, photographer
7 Georges Castello caver
8 Thibault Darty caver, biologist, Cemagref Lyon
9 Pierre-Eric Designe cave diver, photographer
10 Luc-Henri Fage caver, film maker, photographer
11 Grégory Guillaume caver
12 Stéphane Jaillet caver, karstologist, CNRS/Univ de Savoie
13 Benjamin Lans karstologist, doctoral student CNRS/Bordeaux
14 Tristan Lefébure caver, biologist LEFH Lyon
15 Stéphane Maiffret caver
16 Georges Marbach caver, treasurer of Centre Terre
17 Patrick Mauroy sound engineer
18 Laurent Morel caver, hydrologist, CEGELY
19 Nathalie Rizzo caver, company director
20 Jean-Philippe Toustou caver

Chile
20 Marcelo Agüero Faridoni Chilean expedition coordinator, naturalist
Andrés Charrier biologist specializing in vertebrates
21 David Quiroz Pincheira geologist, Sernageomin
22 Nicolas Lira film assistant, interpreter
Fernando Sepúlveda geologist, University of Chile
Sebastian Martini geologist, University of Chile

Spain
23 Marta Candel caver, geographer, industrial rescue specialist
24 Alfredo Moreno caver, company director
25 Enrique Ogando caver, photographer, rescue specialist

Canada
26 Pierre Bergeron caver, mountaineer
27 Guillaume Pelletier caver

Australia
28 Alan Warild caver, cave diver

The Aceros del Pacifico (Pacific Steel) and Centre Terre commemorate the second speleological expedition to Madre de Dios with a plaque in front of the offices of the mining base at Guarello.
Since its creation, Centre Terre has paid special attention to publicising its expeditions around the globe. This has allowed the local inhabitants to learn about speleology on their doorstep, and for the greater public to be informed about the discoveries made during each project. To this end, the Ultima Patagonia 2000 expedition supported the production of a 52 minutes documentary, that has received several prizes in film festivals, and made for France 2 by Luc-Henri Fage.

The 2000 team also publicised its findings widely via the print media, in particular through the international edition of National Geographic Magazine, but also in the Chilean newspapers and monthly magazines such as Grands Reportages, Terre Sauvage, etc. The awarding of the Rolex Award for Exploration further increased the prestige and public visibility of the expedition.

The 2006 expedition in real time

In 2006, publicity was increased in print and radio media in both Chile and France. This added up to more than 150 articles and interviews over the course of the expedition. Most notable was the eight page article in the French edition of National Geographic Magazine, and how listeners of both France-Inter and Radio Bio-bio (Chile) could follow the course of the expedition through weekly updates via satellite telephone. A thick press-book of some 100 pages and two more press-books assembled by the Burson-Master agency were also produced.

www.centre-terre.fr

At the same time, the Centre-Terre website regularly updated and published photographs thanks to the internet connection at Guarello base. This was very well received with more than 10,000 visitors following the team’s progress.

The page supplied up to date information, press releases and France-Inter interviews.

A movie for the wider public

Finally, a movie for the general public is in production. It especially concentrates on a new type of speleology: maritime speleology, with the discovery of Alakaluf artifacts. It is due for release in 2007.

A book

A book is also being written that describes the various Centre Terre expeditions to the Patagonian archipelago.

It will be distributed in France and Spanish speaking countries. Personalised versions featuring the company logo on the cover will be produced for sponsors.
The Ultima Patagonia Expedition was under the patronage of Mr Jacques Chirac, President of the Republic of France and the Chilean Bicentenary Commission 1810/2010 – President of Chile

IN COLLABORATION WITH:

IN FRANCE

Fédération Française de Spéléologie
CNRS-Université Bordeaux 3 : UMR 5185 ADES-Dymset, Prof. Guy Di Méo et François Bart.
CNRS-Université de Savoie : UMR 5204 EDYTEM, Prof. Jean-Jacques Delannoy.
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• CEMAGREF (Lyon)
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Ministerio de Bienes Nacionales, Sr. Sebastian Infante de Tezanos Pinto
Sernatur, Servicio Nacional de Turismo
CONADI Corporacion Nacional De Desarrollo Indigena (Sr. Nelson Aguilara Iguia).
Universidad de Chile (Santiago) : Prof. Francisco Hervé y Reynaldo Charrier.
Universidad de la Catolica, Santiago de Chile
Naturaleza sin limites
SERNAGEOMIN: Servicio Nacional de Geología y Mineria (Sr. Luis Sougarret Seitz).
Instituto Chileno de Campos de Hielo (Sr. Horacio Toro Iturra).
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Energizer

COLLABORATION IN COMMUNICATIONS

National Geographic France
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Spelunca – le magazine de la Fédération Française de Spéléologie
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Ultima Patagonia 2008
The explorations in Madre de Dios will take place during the months of January and February of 2008. Planning has already begun. We have collected all types of scientific information about the archipelago and will use it to try to understand and preserve this exceptional heritage by continuing the research begun by the Centre Terre team in 2000 and 2006 and compiled in the report of the expedition. This operation brings together a number of public and private organisations who will work within the framework of a Franco-Chilean scientific cooperative effort.

Our objectives for the 2008 expedition are based on those of the previous two expeditions.

1 - Monte Roberto Sector

Restful Cave, discovered in 2006 and explored to a depth of -305 m, continues. It is one of our primary objectives. It will be explored from a high altitude camp set up in the area. This camp will also be used for scientific research. We have yet to carry out any faunal sampling in this area.

2 - Sandstone-limestone contact zone above Pacific Cave

This sector was seen in 2006 from the Monte Roberto camp and appears to have relatively easy access from base camp at Guarello. It has a geological facies similar to that at Monte Roberto where we have found our most important caves such as “Future Sink”. At -376 m deep, it is the deepest cave in Chile. Exploration in this zone will be difficult: its situation facing the Pacific means that it is subject to especially severe climatic conditions. Its exploration will demand all of our technical skill and experience.

3 - Pacific Cave

Houses over fifty indigenous ochre and charcoal paintings and was our most beautiful discovery of 2006. It is an exceptional plus for Chile that has very few caves with this type of artifact. With the aim of making a detailed study, our team will be complemented with Chilean archaeologists who are specialists in “Nomads of the Sea” (Alakaluf).

4 - Prospecting in the north and western zones

One of our main objectives in 2008 will be to finalise the exploration of the perimeter of the island, an operation begun in 2000. The West (Pacific) and North (canal Trinidad) coasts await our exploration. We expect to find fresh water resurgences and
more archeological remains. A camp on the shores of Canal Trinidad will be one element in ascertaining routes once used by the Alakalufs to reach Seno Barros Luco.

These western and northern zones however, will be extremely difficult to reach by sea. Their exploration will not be possible without the support of the Chilean Navy.

5 – Seno Barros Luco

There remains a lot of work to be done in and from this navigable harbour:
- from a speleological point of view, in 2006 we saw two possible ridges that may provide access to higher areas. They will allow us to put in advanced camps that will be indispensable for reconnaissance, systematic prospecting and scientific research in these as-yet unexplored areas of limestone.
- from an archeological point of view, we have already discovered three caves facing the sea that house bones in their interiors, an unmistakable sign of human use. In 2008, studies will attempt to ascertain whether these caves were used to live in or solely for ceremonial purposes, and to determine their age.

Comprehensive studies in this zone will not be possible without a lot of logistic support that only the Chilean Navy is in a position to give.

6 – Central Zone

So far it has only been possible to make a light reconnaissance of the interior of the island towards Seno Barros Luco. Weather and thick vegetation were the most notable features of exploration in this region. We need to try once again to forge a central route to the groups that will work in Barros Luco and at the same time be sure to make a systematic exploration of the large areas of limestone visible on the air photos.

7 – Whale Cave

It was discovered in 2000 and revisited in 2006, but only after seven attempts. Situated on the Pacific coast and more than 15 nautical miles from the mouth of Seno Azul, it requires a difficult and dangerous voyage through the open ocean: rocky reefs, the violence of the wind, large waves...

This cave houses a great mystery that has only become greater the farther into it that we have delved. But we are trying to solve it. We know that the bones of at least six whales are dispersed over 100 m from the entrance, which is surprising, as today this part of the cave is some six meters above sea level.

How did the whales get here? During an exceptional storm? A tsunami? Or due to the island rising after the melting of the ice that once covered it? There are still a lot of unanswered questions...

The bones are being dated, but it is still necessary to take further samples.

We are also planning to prospect for caves in this area that is so difficult to access.
For over two million years, after each glaciation, life has returned to these islands: the forests, animal species, and finally man. This competition for life has favoured specialisation and adaptation. The “refuge” habitat has survived, even during the coldest periods. To study the last post-glacial reconquest constitutes a particularly interesting line of investigation. One passes from one world dominated by a single parameter: cold, to a new, more complex world with various influences.

1 – A limestone world frozen 20,000 years ago is now liberated after the thaw

20,000 years ago, a mantle of glaciers extended from the Andes to the Pacific shore. The entire Patagonian archipelago appears to have been covered by ice; its movement favoured the excavation of valleys by glacial erosion. Today, these valleys have been invaded by the sea, canals or “senos”, owing to a higher sea level.

The directions of our 2008 research will be:

- Geological mapping and geomorphology to closely define the contacts between limestone, sandstone and granites.
- The geological and geomorphological history of the archipelago from the end of the primary period.
- Recording the climatic changes from the cave deposits, in particular the dating of stalagmites by U/Th (TIMS) and paleotemperature analysis using stable oxygen and carbon isotopes.
- Recording the sea-level rise as well as the uplift of the island (isostatic rebound), by studying the marine notches. These can be dated thanks to studies in Whale Cave.
- The morphological indices that allow us to study surface dissolution.
- Hydrological measuring stations in experimental basins connected to meteorological stations.
- Measurement of cave flood events with the help of “liurographes” (specialised water depth recorders).

2 – Measuring climatic change

During the retreat of the glaciers, new caves began to be formed. The caves were fed by the abundant run off and locally filled with large amounts of sediments. In the case of Moraine Cave, an accumulation of 20 m of sediment provides proof of sedimentation...
that is contemporaneous with the last glaciation, or perhaps the last two. We began a careful study of this deposit in 2006 that will continue with the aim of learning the age of the sediments using U/Th dating of stalagmites on it.

Cave formations grow in the warmer interglacial periods. Their detailed study tells us about climatic variations. Growth rings, the nature of the crystalization and contaminations within the deposits give us information about the nature of this warming. Cross-correlation of these data with those obtained from Nothofagus growth rings will give us even more precise data on climatic variation from more recent times.

3 – The surprising biodiversity of the archipelago

The surprising biodiversity observed in 2006 presents us with two main scientific problems:

- Admit that there was no life in the archipelago during the last glaciation? How could the rivers have been colonized to such a degree, in so little time, and where did the colonizing species come from?

- Was the last glaciation as severe as the glaciologists believe? Could Madre de Dios have been a biological refuge during the last glaciation owing to its extreme western location?

On the next expedition we will study the biodiversity of all the habitats on Madre de Dios, looking closely at the rivers and caves so that we can answer the questions posed. These studies will be focused on two objectives:

the first objective will be to complete our study by exploring the sectors that we didn’t visit in 2006 and intensifying our sampling in the richest habitats.

A second objective will be to establish a sampling protocol that will allow us to make DNA analyses and establish whether or not Madre de Dios was a biological refuge during the last glaciation.

Apart from the animal biodiversity, we will study the soils and forests of the magellanic forests, their physiology and associated effect of their physical position (protected, exposed, rock type...). We also hope to study the wet grasslands and peat bogs, both those on hillsides as well as those on the flat sandstone areas.

4 – The time of man: the Alakaluf

Late, only during the last few thousand years has man colonised these wild and inhospitable lands.

Living by hunting and collecting shell fish, travelling in bark canoes, the Alakaluf people have left very few traces: huts, middens, burial sites and paintings on cave walls. Caves have provided a refuge the world over, and Madre de Dios has been no exception, both for man and animals.

These days, in caves by the sea shore, speleologists and archaeologists are finding traces of a people that have disappeared less than 50 years ago. The discovery of Pacific Cave, with its paintings, its fireplaces and its shell middens has resulted in a mapping campaign, a photographic report of the study site, excavations, and dating. Our geomorphologists will help the Franco-Chilean archeological and ethnological team to understand the physical environment.

Prospecting the shore line for further traces will continue so we can better understand the lives of the Alakaluf on Madre de Dios.
Solid logistics

Base camp

Thanks to the help of the Aceros del Pacifico Company we will once again establish our base camp in the mining base at Guarello. The living and logistic conditions of the base make for an optimum environment for our research: rooms where expedition members can rest, spacious store rooms, medical post, mechanical workshop, etc...

Container and equipment

The personnel on this next expedition will increase by 25% with respect to last year’s expedition. For this reason, the amount of group and personal equipment that must be transported will increase significantly to an estimated total of some 16 tones of cargo. Apart from the necessary scientific equipment, close to three kilometres of rope, a complete kit of exploration equipment, fifteen tents and three fully equipped Zodiacs will be packed in a shipping container and sent by sea from France.

Getting around

It is essential to have a suitable, efficient means of getting to our proposed objectives. In good weather it will be easy to return to some parts of Madre de Dios from our base camp using Zodiaks. On the other hand, it will be impossible to adequately explore sectors such as Whale Cave, Seno Barros Luco or Canal Trinidad with only this type of boat.

The 2008 team will have 8 Zodiaks with a range of capacities and motors at our disposal. Depending on the objective, we will also have a boat supplied by the Guarello mine for the duration of the expedition. We are also negotiating the support of Chilean Navy to enable us to reach the most exposed areas.

External communications

For the 2006 expedition, Centre-Terre developed a web-based information distribution system:

http://www.centre-terre.fr

- an initiative that met with resounding success as we registered over 10,000 visits during the two months of the expedition.

The 2008 project will take this initiative and improve it with a larger part dedicated to our partners. The expedition will have more satellite telephones that will cover the advanced camps with a broadband connection.

This will also guarantee high quality interruption-free transmission of information to send photographs and even movies and also to have direct contact with schools and universities associated with our project.

Provisional logistics

January 3 – Departure of the pre-expedition team. The eight members will have eight days to receive the container of equipment, buy and arrange the food and technical equipment to last the two month duration of the expedition. This team will also arrange the official meetings and press conferences before travelling to Puerto Natales, the embarkation point for Guarello base.

January 8 – The boat transporting the team to Guarello will set sail with over 25 participants who arrive the day before in Punta Arenas. Some will stay two months, others will be relieved at the beginning of February.

February 3 – Another boat from Puerto Natales will bring the relief team. A group of officials (institutional and private collaborators), will take advantage of this trip to make a site visit during the expedition.

February 4 – The January group returns to Puerto Natales.

March 1 – End of the expedition. The container that is to return the equipment to France will be sealed at the end of the day.

March 2 – Goodbye to Guarello base. The boat that has arrived the evening before from Puerto Natales returns all the participants and a huge quantity of collected data to the continent.

March 6 – Team presentation in a press conference in Santiago de Chile with our preliminary results...with the expectation of more detailed findings from the laboratory.

March 8 – The last of the team departs Santiago de Chile for Europe.

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Scientist in charge
Richard Maire
Director of Research, CNRS
University of Bordeaux
33607 Pessac CEDEX – France
Tél. +33 5 56 84 68 34
e-mail : rmaire@ades.cnrs.fr

Expedition leader, president of Centre Terre
Bernard Tourte
25, rue Louis de Broglie
31100 Toulouse – France
Tel : +33 5 34 60 95 63
Fax : +33 5 34 60 95 64
Portable/movil : +33 6 08 75 95 29
e-mail : btourte@wanadoo.fr

Chilean expedition coordinator
Marcelo Agüero Faridoni
Av. Blanco Encalada 1823, depto. 405
Santiago de Chile – Chile
Fono: (56 + 2) + 6717 935
Movil : 09 88 555 21
e-mail : proyectos@unlimited-nature.cl

www.centre-terre.fr