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## **The Nakanai Mountain Ranges of East New Britain, Papua New Guinea**



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Cover images

Main image: David Gill | *Opening to Mageni Caves, Nakanai Mountains, East New Britain* by, 2006

Background image: Free-Photos | [pixabay.com/photo-918570](http://pixabay.com/photo-918570)

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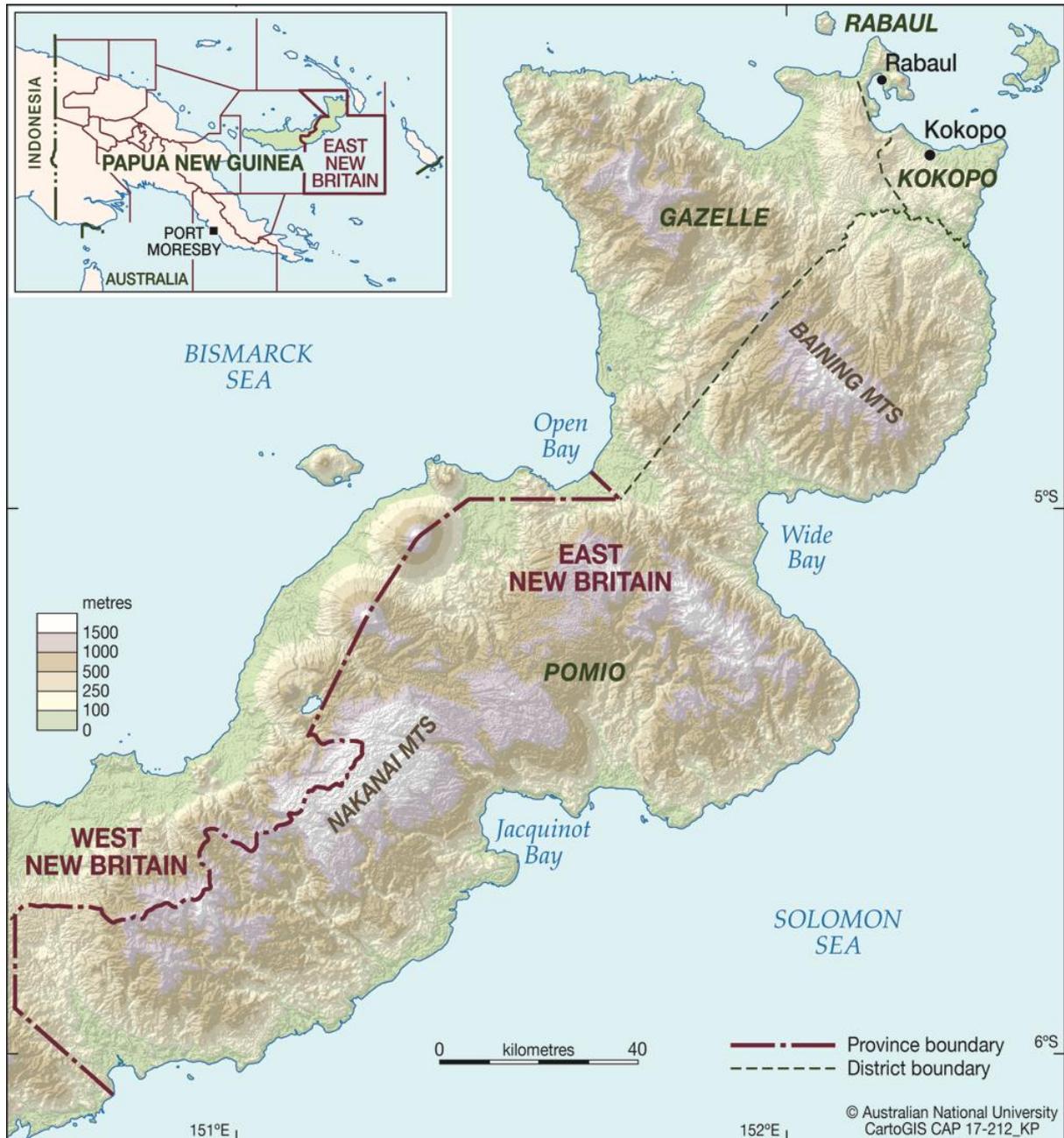
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## THE NAKANAI MOUNTAIN RANGES OF EAST NEW BRITAIN, PAPUA NEW GUINEA

Deep beneath the rain forests of New Britain, an island off the coast of Papua New Guinea, churning rapids jet through enormous passages, some of the largest, most remote river caves on the planet. To reach them, explorers must first descend into massive dolines—sinkholes where soluble rock, weakened by runoff from an estimated 18 feet of rainfall a year, has collapsed. From the air they appear like impact craters, as if a volley of meteorites had long ago pummelled the forest (Shea, 2006).



**Figure 1. Map of East New Britain Province showing Nakanai Mountains**  
Map source: Australian National University, reproduced with permission.

This E-Book on the Nakanai Mountains of East New Britain is in four parts. The first section provides an overview of the karst and cave attributes which led to the listing of Nakanai on the Tentative World Heritage List in a Serial Site known as *The Sublime Karsts of Papua New Guinea*. The next section provides a brief history of the region involving European encounters. This is followed with a brief overview of the archaeology of East New Britain. The fourth section highlights some of the unique flora and fauna of the Nakanai. The final section includes the UNESCO Justification for Significance on the Tentative World Heritage List.

### **Nakanai Mountains, Pomio District, East New Britain Province**

The Nakanai Mountain Range in East New Britain is located in Pomio District in primary rainforest with an area of over 3000 square kilometres (Gill, 2012, p. 1). The limestone karst area extends from the mountain summits to the southern coastline. Within the Nakanai mountains are some of the largest caves in the Southern Hemisphere, known collectively as the Nakanai Caves. The Nakanai Mountains contains some of the world's largest river cave systems, with some of the largest and fastest flowing underground rivers in the world.

These mountains are made up of layers of limestone that are about 22.5 to 10.5 million years old, covered with fragmentary layers of fine volcanic sediments. The heavy rain creates rivers in the mountain ranges, which over time create deep valleys. Over the last 200,000 years, eight giant canyons have formed in the Nakanai Ranges with depths reaching 600 – 1,000 metres. The upper reaches of these canyons and their side ravines contain some of the most powerful springs in the world—their sources are located in giant caves deep within the limestone layer.

Large underground passages and giant sinkholes (megadolines) have resulted partially from the erosion of soft limestone by underground streams. The deepest cave to date is called Muruk – at 17 kilometres in length and 1,178 metres in depth it was the deepest cave documented in the Southern Hemisphere at the time (Audra, Lauritzen & Rochette, 2011; Richards & Gamui, 2011).<sup>1</sup>

In 2007, the Nakanai area was nominated to the PNG World Heritage Tentative List within the serial site known as 'The Sublime Karsts of PNG'. Four decades of exploration has increased our knowledge of the caves and brought to light the significant biodiversity value of the area. An environmental study in 2009 identified over 100 new species of animals in the Nakanai mountain range previously unknown to science. In this booklet, we outline past and current initiatives to document and protect the natural and cultural values of the Nakanai Mountains, as well as providing a brief overview of the history, archaeology and flora of the region.

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<sup>1</sup> In 2014, Stormy Pot Cave on Mt Arthur in New Zealand, with a 10km passage, was recorded with a depth of 1200m, making it the deepest cave known to date in the southern hemisphere. <http://www.stuff.co.nz/science/9675130/Southern-hemispheres-deepest-cave-found>

## THE CAVES OF THE NAKANAI MOUNTAINS

The Nakanai caves are part of a globally unique system of limestone caves. They are located within the Nakanai Range, amongst primary rainforest extending from the mountain summits to the southern coastline (Gill, 2012). The Nakanai region comprises a limestone mountain range with an area covering approximately 4000 square kilometres. Cavers rely on aerial images to look for deep caverns to explore. In the images, large surface sinkholes, characteristic of the rainforest-covered karst landscape, look like enormous black holes of varying sizes. Once identified, professional cavers venture into the depths of giant caves. Major advances in understanding the Nakanai caves have been achieved through 45 years of expeditions, the first of which was undertaken by Australian cavers, followed by French and British international teams. The following expeditions have revealed significant information about the caves and the expansive underground cave river networks (see hyperlinks below).

### EXPEDITION TIMELINE

1. 1972/73 Pioneering Australian Expedition (Bourke et al.): Ora Dolines
2. 1978 First French Expedition (Sounier et al.): reconnaissance of Nare Doline and Minye Dolines
3. 1979: Swiss Expedition: Kavakuna
4. 1980 French Expedition (Sounier et al.): [Nare Doline, Kavakuna doline, Ka 2, Vuvu](#)
5. 1985 French Expedition (Sounier et al.): Minye, Muruk (- 637m)
6. 1984/1985 First British-led Expedition (Gill et al.): Nare, Pavie and Gamvo caves
7. 1988 French-International Expedition (Sounier et al.)
8. 1995 French-International Expedition (Sounier et al.): Muruk Cave Expedition
9. 1998 French-International Expedition (Sounier et al.)
10. 2002 French- International Expedition (Sounier et al.): [Bairaman River Expedition](#)
11. 2003 French-International Expedition (Sounier et al.): [Papou Expedition](#)
12. 2005 French- International Expedition (Sounier et al.): [Marana Kapate Cave](#)
13. 2006 British (Gill et al): [Untamed Rivers Expedition](#)
14. 2007 French-International Expedition (Sounier et al.)
15. 2008 British: BBC Documentary (Gill et al) [Pandi River Expedition](#)
16. 2010 French-International Expedition (Sounier et al.): [Vuvu Cave](#)
17. 2012 French-International Expedition (Sounier et al.): [Wowo Cave](#) system
18. 2014 French-International Expedition: (Sounier et al.) [Wara Kalap](#) Source
19. 2015 Japanese Expedition: [Kavakuna Cave](#)
20. 2016 French-International Expedition (Sounier et al.): [Black Hole Expedition](#)
21. 2018 French- International Expedition (Sounier et al.): [Ghost Rivers Expedition](#)

## History of Caving in the Nakanai Mountains

The Nakanai Mountains are up to 2,185 metres high in the central-eastern part of the island. They are bounded on the east by the Kol Mountains and to the west the Kapiura-Ania Divide which separates the Nakanai Range from the Whiteman Range. Vast limestone outcrops span over 550,000 hectares North, South and West. The topography, which is known as 'cock pit karst' is covered in dense tropical forest. An early report on the caves of New Britain noted that 'stories of great river effluxes and cave entrances are common for the area inland from Pomio' (Bourke, 1973, p. 15). An abundance of insects, and multiple species of bats and flying foxes could be found in a single cave in large numbers.

The first very preliminary exploration to the Nakanai Mountains was undertaken in 1968 by Chris Borough and Kevin Reid of the Port Moresby Speleological Society. The team sought to explore the Minye dolines near Tuke Village. C. J. Borough, writing in the *Niugini Caver* (1973), of his experience locating what he called the 'BIG HOLE' in 1968, described the Nakanai karst landscape as consisting of endless sinks with almost vertical sides near the outer edge of each and clothed in dense forest. Borough wrote:

It can only be described as impossible country and I never succeeding in pursuing more than a km into it from one edge. Army maps show two remarkable features on one of the limestone plateaux North of Pomio in Eastern New Britain. They are a large hole about 1.5 km long and 460 m deep and a smaller hole, 0.5 km wide and 380 m deep. For the average caver, this is too much and I drooled at the prospect of seeing these immense holes (Borough, cited in Bourke, 1973, p. 25).

C. J. Borough and his caving colleague, Kevin Reid, arrived in Tuke Village by helicopter. To locate the 'BIG HOLE', local people were recruited as guides, but would not accompany Borough and Reid all the way to the sinkhole, as it was regarded as a place of foreboding, where devils and ravenous crocodiles may lay in wait at the bottom. Upon descending around 60 metres into the hole, the realisation that a full descent to the 300 metres would require specialist equipment saw Borough and Reid return to the village.

The first official caving expedition to the Nakanai Mountains was undertaken by an Australian team in 1972 when Michael Bourke led an expedition (4 men and 2 women) from the University of Queensland Speleological Society to the Ora dolines. Bourke had previously conducted an 8-day trip to the Oro dolines in April 1972, entering the northern doline but not reaching the bottom. During the 1972-73 expedition, the team explored the northern doline, following a river at the bottom to a cave chamber 15-27 metres wide and about 27 metres high. They charted 168 metres of passage before progress was halted by a waterfall that occupied the entire cave floor. The Australian team noted that it should be possible to explore further by traversing above the waterfall.

Moving upstream from the bottom of the doline they entered a large cave chamber 600 metres long and 67 metres deep, with huge stalagmites hanging from the roof. By moving through the chamber in a southerly direction they emerged out in the bottom of the twin doline. Walls as high as 100 metres rose up from the bottom. Re-entering the cave from the southern doline, the cavers followed an old stream passage back to the river. Downstream was a spectacular waterfall, and upstream they moved through a beautiful section along the river to a lake: "Calcite curtains, candle wax stalagmites, flowstone and stalactites, lavishly decorate this area" (Bourke, 1973, p. 30).

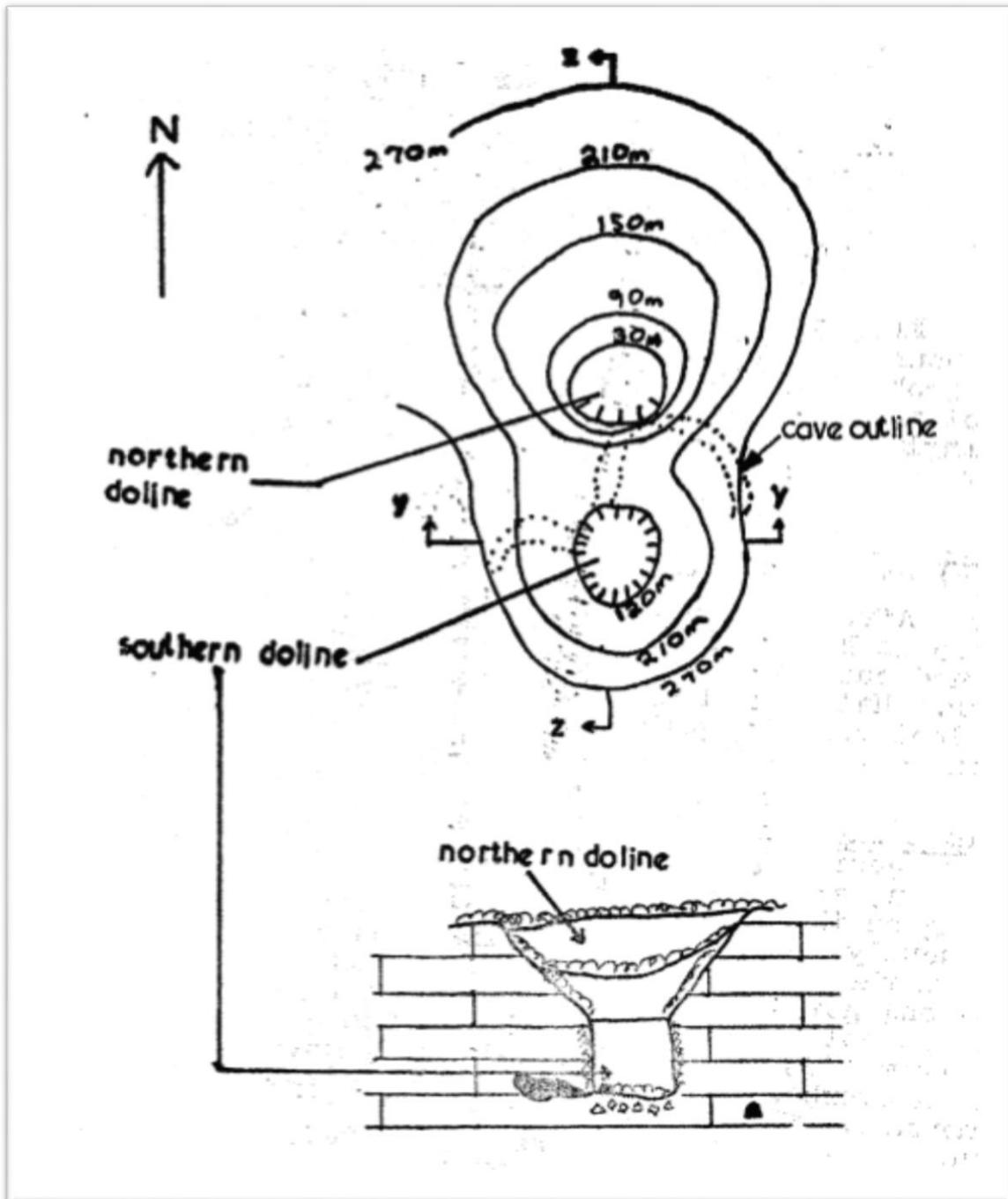
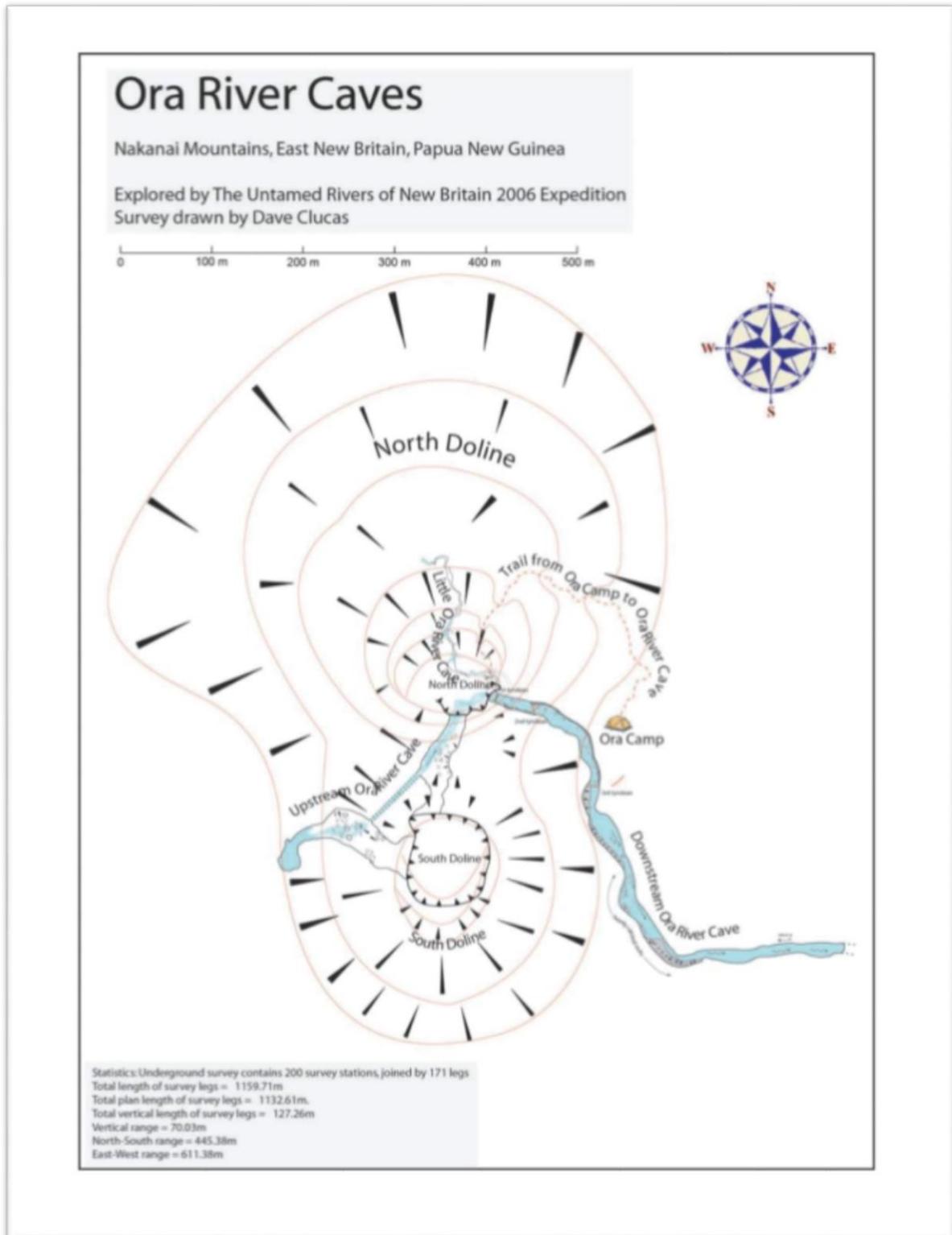


Figure 2. Ora Dolines or Uvala: Schematic 1972-73 Expedition

Image source: Bourke, 1973, p. 33.



**Figure 3. Ora River Caves schematic by Dave Clucas**

Image source: Gill, 2012, p. 13.

Following the Australian expedition, a French caving expedition continued the research in 1978. Numerous expeditions came later. The 1979 Swiss expedition to Kavakuna Cave and descent to 320 metres, resulted in tragedy when one of the cavers drowned in a caving mishap, and the rescue

helicopter, en-route to Rabaul, had engine failure and crashed into the river (Bourke, 1982, pp. 89-95).

In 1980, a French-international team led by Jean Paul Sounier, explored the three entrances of Kavakuna Cave and undertook the initial exploration of the Nare river cave near the village of Nutuve. In 1984 and 1985 the British caving team completed the exploration of Nare Cave, the Pavie River Cave and the Gamvo Cave system. Towards the end of the expedition a reconnaissance trip looked at the Ora dolines. The British team felt that the cave warranted a further visit, but it was to be over twenty years before they returned (Gill, 2012).

The 1985 expedition to Nakanai, undertaken by the French international team<sup>2</sup> explored Minye Cave, and Muruk Cave. A decade later during the 1995 expedition, the French team dived the final sump (a passage in a cave that is submerged under water) and enabled Muruk to become the first 1,000-metre-deep cave documented in the Southern Hemisphere (Audra et al., 2011).

In 1998, during a helicopter reconnaissance flight over the area between Galowe Gorge to the east, and the huge Wunung Gorge to the west, French caving expedition leader Jean-Paul Sounier was surprised to see that, unlike Galowe Gorge, no rivers poured into this 1,000-meter-deep Wunung Gorge canyon. This begged the question: where was the water flowing into the mouth of the coastal Wunung River coming from? The mysterious ghost rivers of the Wunung Gorge became the subject of an expedition in 2016 and 2018.

The British cavers returned in 2006 with a team of twelve from the UK, France, and the United States. The UK expedition, led by David Gill, involved a two-month expedition to complete the [Untamed Rivers Expedition](#), first commenced in 1984. The primary purpose was to complete the exploration and mapping of the Ora river cave and to search for other caves in the area. The secondary objective was to gather data with the aim of establishing a Nakanai Conservation Area which would be proposed for World Heritage status to protect the cave area from destruction by logging. Funding was obtained from the National Geographic Society, the Royal Geographic Society and the Ghar Parau Foundation. The National Geographic Society sent along a photographic team and published an article about the River Caves of East New Britain (Shea, 2006).

During the British expedition, over twelve kilometres of river caves were explored and mapped. The Phantom Pot cave was mapped during the early stages of the expedition at an altitude of 1,045 metres. Phantom Pot was surveyed for 3.9 kilometres, over a depth of 191 metres (Gill, 2012, p. 14). Exploration upstream of the [Ora River Cave](#) led to the discovery of the Little Ora River Cave. The total length of the Ora River Cave system was recorded as 1,220 metres with a depth of 317 metres from the lowest point of the doline rim. Upstream, the British documented a 67-metre-long, 58-metre-wide lake which was named Lake Myo. Further upstream from the main river inlet was a ten-metre-high waterfall, Myo Falls. On a helicopter flight into Ora Village a large cave entrance was seen emerging from high up on the cliff face to the south of the village. Entry into the cave required a fifty-metre abseil descent and a climb along the cliff to the 80-metre waterfall named Mageni by the local people. Beyond the waterfall were more than five kilometres of cave tunnels—but the team only explored the

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<sup>2</sup> The French caving team, led by Jean Paul Sounier, have continued to explore and extensively document the underground caves and underground passages, returning in 1998, 2002, 2003, 2005, 2007, 2010, 2014, 2016, and 2018.

main tunnel. The Mageni cave system<sup>3</sup>, mapped to a total length of 9.4 kilometres, lies parallel to the underground Ora River cave system. Another cave located they called Triosaurus Cave—a small cave 61 metres long and 43 metres deep.

To promote conservation of the caves, meetings were held with the Department of Environment and Conservation, the National Research Institute, the Provincial Government of East New Britain, the Governor of East New Britain, the Tourism Authority, the Local Level Government Pomio District and non-government conservation organisations, as well as with local villagers and logging company management. A presentation was given to the World Heritage Department in Port Moresby. The expedition eventually led to the area gaining Tentative World Heritage listing status (Gill, 2012).

In 2010, a French-Swiss caving team led by Jean Paul Sounier returned to the Nakanai Mountains and found the junction of two big caves, which form the Wowo cave system. The expedition in 2012 by the French-Swiss team went back to the Wowo cave system; and with more than 20 kilometres of charted galleries it is now the most extensive cave system known in New Britain Island. The team also discovered and explored a 423-metre-deep cave known as Khou.

The first attempt to understand the underground river network known as the *Wara Kalap* resurgence was made by a French-Swiss team comprising 15 cavers in 2014. The *Wara Kalap* (or 'leaping waterfall') cascades onto the beach on the western side of Jacquinet Bay at around 5 cubic metres per second<sup>4</sup> from an opening, roughly 1 metre wide by 1.8 to 2 metres high. It is one of three waterfalls along the coastal beach, whose source lies deep inside the forested Nakanai Mountains.

In January 2016, an international team led by French caver Jean-Paul Sounier explored a gigantic black sinkhole spotted in aerial images. On a plateau along the left bank of Wunung Gorge, a black and white mark indicated a surface sinkhole with a black hole almost 100 meters wide and 100-150 metres deep. During the 'Black Hole' Expedition in 2016, the team, spent four weeks surveying and mapping caves and galleries. One cave was named Wild Dog Cave after a long howl, similar to that of a wolf pierced the previous night. In the sinkhole they initially named Dooble, the ceiling is magnificently decorated with white stalactites and streams, waterfalls, and underground lakes flow through the galleries. The discovery of the 714-metre-deep cave named as Dooble was re-named the Christian Rigaldie Cave to honour a caver who was part of the first French expedition to the Nakanai Mountains in 1980. Although he never returned to Nakanai, Christian Rigaldie contributed to the funding of several expeditions and died of illness in 2015. At 714 metres deep the Christian Rigaldie cave now ranks as the second deepest cave in Papua New Guinea, after the Casoar (Muruk) cave network (Sounier, 2017)<sup>5</sup>.

In 2018, the French-led team returned to explore the underground drainage system of the Christian Rigaldie Cave network, which flows deep beneath the Wunung Gorge. The 'Ghost Rivers' expedition documented sixteen cave chambers beneath the Nakanai Mountains. The Ghost Rivers Expedition, was concerned with exploring the source of the *Wara Kalap* waterfall, first commenced in 2014. The 2014 team set up three camps at different elevations (400m, 650m and 100m), with the highest camp

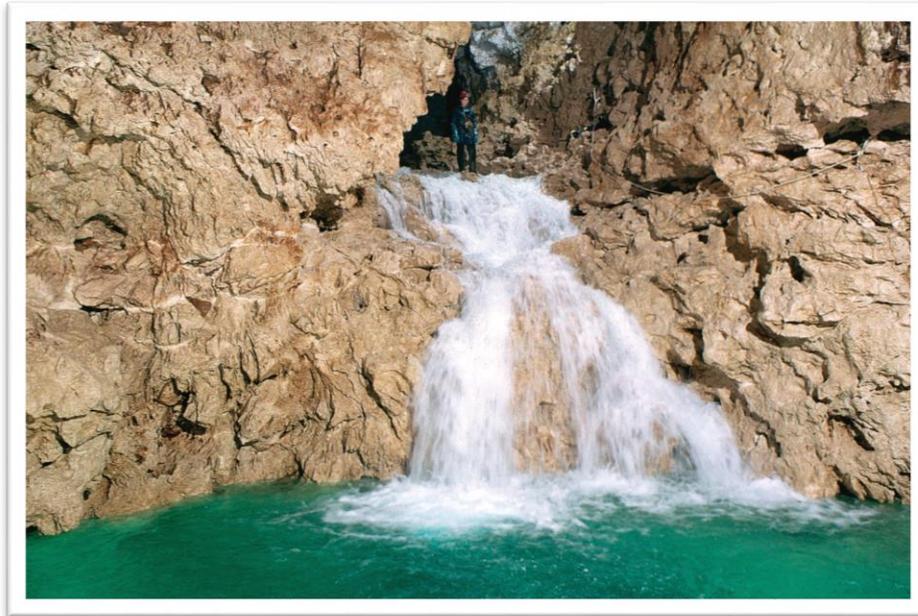
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<sup>3</sup> The Mageni cave featured in the BBC documentary '*The Lost Land of the Volcano*', April 2008.

<sup>4</sup> There are several areas where the water flow is around 20m<sup>3</sup>/second.

<sup>5</sup> Other named caves included Wild Frank Cave, Arche Cave, and Surprise Cave, after it was discovered while looking for another cave (Sounier, 2017, p. 45).

about 6 to 7 hours trek from the ocean through almost impenetrable primary rainforest. After three weeks exploring blocked cave entrances, the team found a collection basin with fast-flowing



underground rivers, exploring and charting 6 kilometres of networks with two major cavities more than 500 metres deep. The biggest of these cavities, at around 580 metres deep, was named Phillipe Pato Cave (to pay homage to a former porter), the third deepest cave in Papua New Guinea.

**Figure 4. Muruk underground river**

Image source: Jean Paul Sounier.

### **Mega-dolines of the Nakanai Mountains**

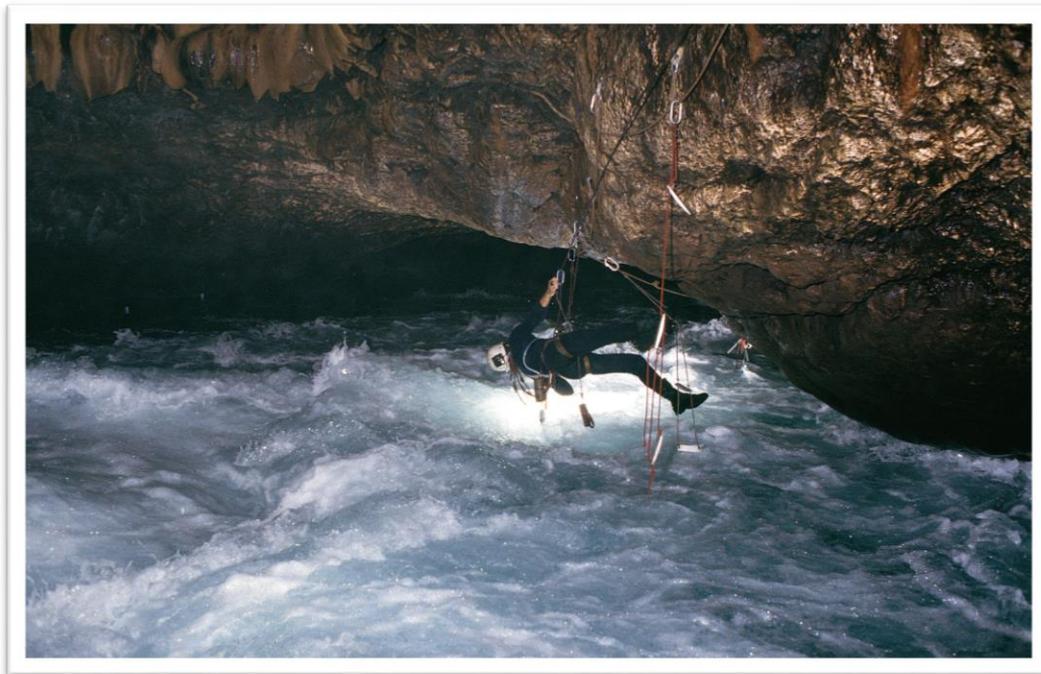
Four exceptionally large dolines ('megadolines') are known from the north of Pomio. One is only a few kilometres north-west of Pomio (Bourke, 1973, p. 28). A doline or sinkhole is a collapsed cave system that provides entrances to the underground world. Huge limestone cliffs on the plateau are formed where rivers cut through the limestone. Cliffs as tall as 300 metres high are common, with some reaching up to 900 metres high (Bourke, 1973, p. 28).

Giant sinkholes ('megadolines') of the Nakanai Mountains have been surveyed and found to be among the largest and most impressive in the world. Nare, Kururu, Poipun, and Liklik Vuvu are just a few of the cavernous dolines explored by international teams of cavers. The massive Ora dolines are known as a 'double doline' or *uvala*, with a bridge across the centre. From above, the Ora dolines look like giant holes in the dense green jungle, visible even in comparatively blurry satellite images. They are situated in thick limestone, around 1,130 metres above sea level. The Ora dolines are the largest in the limestone plateau. Ora's twin dolines have been surveyed to be 1,400 metres in length, 750 metres across and 200 metres in depth (Gill, 2012, p. 9).

The Minye doline (coordinates 5.2432 S 151.5049 E) lies on a plateau at an elevation of 1,000 metres, close to the village of Tuke, located near the Namure resurgence where the Minye River comes out. The area of the Minye sinkhole is around 75,000 square metres, and water volume is up to 26 million cubic metres. The doline is 350 metres in diameter with a depth of 400 – 510 metres. Because Minye is located on a slope, the upper rim is 100 metres higher than the lower rim. The floor of the sinkhole

is crossed by a powerful river—from the upper rim it may look like a narrow stream, but the volume of the stream is 15-25 cubic metres per second, increasing significantly after torrential rain. The cave passages at the bottom of Minye have been explored to a length of 5,421-metres, but this may be just a small part of the system. Powerful subterranean rivers require large passages—and the caves under Minye are giants. Tuke chamber is one of the largest cave chambers in the world. It is estimated at 240 metres long, 160 metres wide and 180 metres high. The floor area of this chamber is around 48,000 square metres, with total water volume estimated at 6.24 million cubic metres.

The Nare doline (coordinates - 5.2940 S 151.6399 E) is around 150 metres in length and 120 metres wide. The depth is between 240 to 310 metres, with water volume estimated around 4.7 million cubic metres. The walls of the sinkhole are vertical and not covered with jungle. All of the limestone, which earlier filled the present hole, has been washed down the ranges by the subterranean river, named Nare River (the huge downstream passage has been named the 'Flying Dutchman gallery'), flowing across the bottom of sinkhole. The volume of this river flows around 15-20 cubic metres per second, and after heavy rain, the discharge can be up to 50 times higher. The mighty subterranean river in Nare Cave is extremely loud and earplugs are required to endure exploration. French cavers descended into this doline in 1978 and 1980, exploring cave passages up to four kilometres in length. British cavers continued exploration in 1985.



***Figure 5. Minye underground river***

Image source: Jean Paul Sounier in Audra et al., 2001.



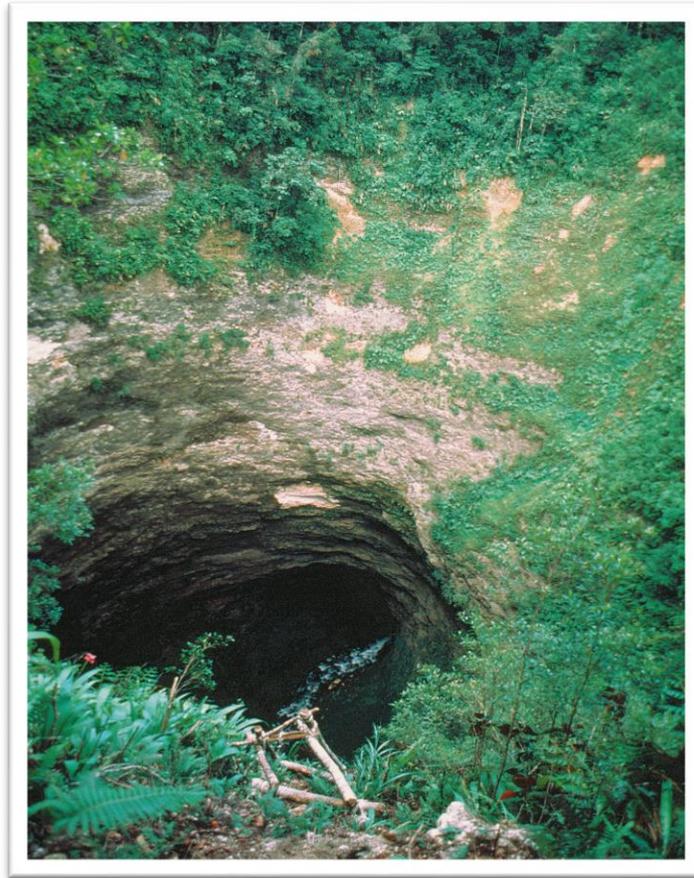
***Figure 6. Minye Doline from above***

Image source: Jean Paul Sounier (1985) in Audra et al., 2001.



***Figure 7. Nare Doline***

Image source: David Gill, 2006.



**Figure 8. Nare Doline on the Nakanai Plateau**

Image source: Jean Paul Sounier (1985) in Audra et al., 2001.

### **History of the Region: Early European Encounters**

The first European references to the southern shore of the island of New Britain come from the voyage of William Dampier when he passed by the island in the late 17<sup>th</sup> Century. In 1699 he sailed in the *Roebuck* past the north coast of New Guinea. In February 1700, he visited the large island to the east of New Guinea and determined that it is separate from New Guinea. He then sailed along its southern coast and named it Nova-Britannia (New Britain). He sighted and named Cape Orford, after his patron and Admiral of the Fleet, Edward Russell but passed by the study area of Jacquinet Bay with no mention in the ship's log of any features along this part of the south coast (Dampier, 1906, pp. 533, 543; 1939, pp. 208-210).

In July 1827, Dumont D'Urville's French ship *Astrolabe* also sighted the south coast of New Britain. During the course of this voyage, D'Urville mapped part of the southern coast of New Britain and it was at this time that Jacquinet Bay is named after the 2<sup>nd</sup> in command of the exploration fleet, Charles-Hector Jacquinet (1796-1879).

### **Early Commercial and Missionary Activity**

Missionary efforts in Oceania had commenced in late 18<sup>th</sup> Century in Polynesia and had moved to Micronesia by the early 19<sup>th</sup> Century. Melanesia was the last area in Oceania to be Christianised (Ernst & Anisi, 2016). The Catholic Church established the Apostolic Vicariate of Melanesia in 1844 with the first Marist missionaries to Melanesia arriving in the following year. They first set up in the Solomon's

and later on Woodlark Island. This initial effort failed and successful missionary efforts had to wait until the end of the 19<sup>th</sup> Century. In the 1870s the Rev George Brown established a mission at Port Hunter, Duke of York Island, organised by the Australasian Wesleyan Methodist Mission. During his stay on the island he travelled to both New Britain and New Ireland and reported on his observations of the land and its inhabitants (Brown, 1881, 1887).

In 1882, Pope Leo XIII appointed the Missionaries of the Sacred Heart (MSC), a French order, to evangelise the vacant vicariates of Melanesia and Micronesia. Fr. Couppé (MSC), from France, arrived at Yule Island, British New Guinea in 1886 and three years later was appointed Vicar Apostolic of Melanesia Christianised (Ernst & Anisi, 2016)<sup>6</sup>. The establishment of European missions in New Britain, the latter part of the 19<sup>th</sup> Century, was largely focused on the Gazelle peninsula. Missionary activity outside this area was scant but Bishop Couppé visited Jacquinot Bay in late November 1899 in the company of Fr. Rascher and the Imperial Administrator Heinrich Schnee (Schneider, 1954). It was probably during the 1899 visit to Jacquinot Bay that the land for the future Mal Mal mission was purchased or the site chosen.<sup>7</sup> However no development of this mission was to take place until the next century.

The New Guinea Compagnie (NGC), a mercantile venture that would be closely associated with the development of the German possessions in New Guinea, was a speculative enterprise, set up in 1884. It had originally been established to colonise and exploit the resources of the new colony. The exploitation of the colony was to be primarily undertaken through the establishment of plantations directed by European colonists directing local labour.

## World War I

In 1912 the NGC purchased land at Jacquinot Bay that was to become the plantation of Palmal. However, WWI intervened, and Australia occupied the German possessions including New Britain. As a result of the determinations at Versailles, the German colonies in the south Pacific were stripped from Germany and the former colony of New Guinea was mandated to Australia. Land formerly owned by German companies and individuals was expropriated by the Australian Government and auctioned off to former Australian Imperial Force (AIF) soldiers. The land holding at Palmal was expropriated by the Australian Government auctioned in 1926 to J. Chapman. Chapman had purchased a number of other plantations in New Britain at the same time and it would appear he was in fact “dummying” or acting for a larger company in the purchase. That company was W.R. Carpenter and Co Ltd a large trading firm based in Sydney, Port Moresby and later Solomon Islands. By the 1930s the plantation was managed by Paul ‘Kar Kar’ Schmidt an experienced plantation manager.

The NGC also purchased land on the north coast of Jacquinot Bay that was to eventually become Cutarp Plantation. The original indigenous name for the locality was Malavapun. The Custodian of Expropriated Property submitted the site for auction as lot 145, offered as the third group of expropriated properties, in February 1927. Two Australian ex-soldiers; Frank Oakley Cutler and Victor

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<sup>6</sup> Couppé was to remain Vicar Apostolic until 1923 when he resigned. He died in 1926 in Douglas Park, NSW and was reburied at Vunapope the following year.

<sup>7</sup> Couppé was reportedly refused many areas of land he had chosen for his missions by the Governor. He claimed to have interviewed officers at the German Foreign Office during a trip there and “talked them over” into meeting his land requirements without them realising there had been an official refusal; see MacKellar, 1912, p. 77.

A. Pratt bought the 1,000 hectares of 'virgin land' on the central coast of Jacquinot Bay for £831. Cutler was to eventually acquire Pratt's interest in Cutarp and run the plantation until the beginning of WW2.

The 1930s was a period of change in the Bay. On May 12, 1931 the Mission motor launch *Teresa*, accompanied by the cutter *Toriu*, set out from Vunapope carrying the first missionary (Fr. William Culhane M.S.C) to the Mungen village Malmal in Jacquinot Bay. The initial construction at the Malmal mission, on land already owned by the Church, consisted of a church 60 feet by 21 feet which the locals had built out of bush materials on their own initiative ("South Sea cannibals", 1932, p. 21). Due to poor siting of this church it did not remain in use for very long and was replaced by the present church, presbytery and some ancillary buildings, and a small motorboat, all built from wood sawn at the sawmill at Ulamona. The presbytery was situated on a small hill 200 yards from the water ("South Sea cannibals", 1932, p. 21). Fr. Culhane's initial presbytery consisted of a small dwelling and a detached 'prayer house', both made of bush materials (Fr. Clarence Paru – Mal Mal Mission, personal communication). Father Edward (Ted) Harris arrived in Rabaul in 1940 and by April 1941 he had replaced Fr. Culhane (who moved to Gasmata) as the missionary at Mal Mal Mission at Jacquinot Bay (Dawes, 1959, p. 45).

During the 1930s, Wunung plantation was also established. In the 1920s and 30s a saw-mill, run by Cecil "Charlie" Bowles, operated on the land that would later become Wunung plantation (Gwarpoon, 1945; Waldersee, 1975, p. 560). In 1937 the saw-mill, was moved to Waterfall Bay and was still operated by the Bowles family<sup>8</sup> (Mackenzie, 1942, p. 5). This report indicates that it was not until this time that Wunung Plantation itself was established (Gwarpoon, 1945, p. 3).

## World War II

On January 22<sup>nd</sup>, 1942 Japanese Military forces, known as the *Nankai Shitai* (South Seas Detachment) landed at Rabaul to establish a major base to be served by Simpson Harbour (formerly known as Simsonhafen under German administration). The defenders were known as 'Lark Force', and consisted of the 2/22<sup>nd</sup> AIF Battalion, the local New Guinea Volunteer Rifles, artillery and anti-aircraft units and support services (Wigmore, 1957). The defeat and dispersion of Lark Force at Rabaul saw their retreat through the jungles towards the west. The remnants moved away from Rabaul, along both the north and south coasts where movement on foot was easiest. Some of those moving to the south were victims of a massacre, by Japanese Forces, at Tol Plantation. Those able to avoid Japanese forces moved further west and gradually coalesced at Palmalmal, Wunung and Drina Plantations. The exhausted and demoralised troops were assisted by the occupants of the plantations and most notably by Fr. Harris at Mal Mal mission.

After several weeks of recuperation at the missions the survivors were picked up by HMAS *Laurabada*, on April 10, 1942, who took 156 back to relative safety at Port Moresby. This included many from the plantations who had assisted the Australian troops. However, despite many entreaties, Fr. Harris refused to leave his parishioners. He was subsequently murdered by the Japanese and his body has never been found. Many of the locals left, after they had seen the treatment of Fr. Harris, or were forced from their homes by the Japanese. Some lived in caves nearby for the duration of the war. However, some also stayed as collaborators (Korba of Tokai) while others resisted and were able assist

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<sup>8</sup> see Mackenzie's reference to Mrs Bowles sawmill at Waterfall Bay, 1945, p. 5

the Allied Forces during the period 1942-44 (Golpak, Luluai at Sali). Many no doubt largely continued with the lives they led prior to the war hoping to maintain a level of normalcy in their lives.

The Japanese occupied the area of Jacquinot Bay and there is evidence of an early warning radio position at Cape Cunningham, and anti-aircraft position and headquarters building at Palmalmal, along with use of existing buildings at Palmalmal, Mal Mal, and Cutarp for storage and accommodation. The Japanese also constructed sections of road around the bay and bridges crossing major water courses but many of these had become derelict and unusable by 1944.

Allied activity between 1942 and 1944 that impinged on the locals around the bay was focussed on airstrikes at the facilities at Palmalmal, Mal Mal, Cutarp and the small anchorage at Kalmalgaman, near Cape Jacquinot. Some structures were badly damaged while others such as St Patrick's church at Mal Mal survived the war. Friendly locals aided the airmen shot down in these raids as well as supporting the Coastwatchers and guerrilla forces that gradually took control of the area—so that by mid-1944 Japanese control of Jacquinot Bay was very fragile. In April 1944 the Japanese garrison at Palmalmal was attacked by Australian led local guerrillas (Long, 1963). At the time, this garrison reportedly consisted of 17 Japanese naval personnel, 14 of whom were killed during the attack and three taken prisoner.

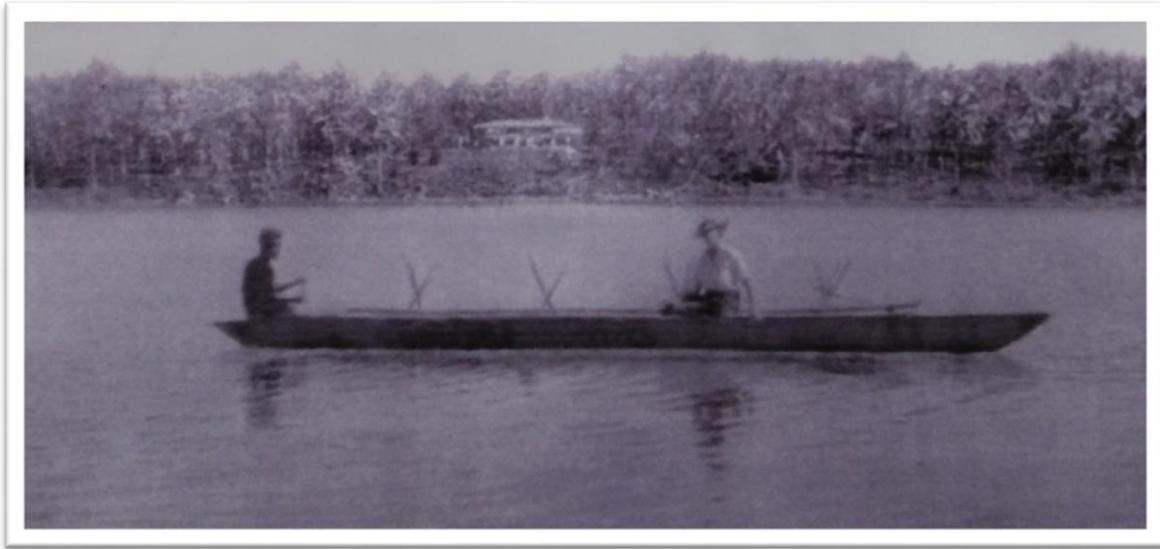
In October, units of the Australian Army and Navy landed at Palmalmal and Mal Mal to establish a base for a push on to the major Japanese garrison at Rabaul. Large areas of plantation at Palmalmal and Wunung were cleared to establish store areas and encampments of the 5<sup>th</sup> Australian Division. Units of this division quickly pushed out north to contest the approaches to Rabaul while the area around Jacquinot Bay continued to be built up with military stores, troops and facilities. This included the establishment of the airfield at Jacquinot Bay which remains today as the airfield for the region.

When a big military offensive on Rabaul was decided against the base at Jacquinot Bay gradually wound down and by the end of the war many units had left. Civil administration was quickly reinstated and people's lives gradually returned to normal. Those that had fled the coast returned, gardens were reestablished, and compensation paid for war damage to villages and gardens. Many of the locals took the opportunity to utilise discarded equipment and materials in their new homes and some villages took on the aspect of 'shanty-towns' to the chagrin of the area's patrol officers.

## Post War

The activities at Mal Mal mission were also resumed quickly with new priests having arrived at Jacquinot Bay by late 1945. Fr. John Askew was installed as the first post-war priest—to replace Fr. Harris. The church and presbytery had survived with some superficial damage from Allied air attacks. The plantations had suffered more damage, the substantial plantation house at Palmalmal was completely destroyed as were the copra drying and bagging huts and worker accommodations. Similarly, Cutarp and Wunung plantations took some time to recommence operations but Frank Cutler's association with Cutarp appears to have ended; perhaps a combination of his age and the

work resulting from war damage compelled him to sell the concern to the firm of Colyer Watson Ltd. Watsons installed a series of managers at Cutarp through the 1950s and 60s.



**Figure 9. View of Palmal plantation house on the small rise showing the house in relation to the plantation**

Image source: Baumann & Dassel, 2007.



**Figure 10. Members of a company HQ Patrol of the 14/32nd Infantry Battalion leaving the Mal Mal Mission church. Note the damage to façade of the church, probably from RAAF strikes. These remain as patched sections in the current façade**

Image source: Australian War Memorial 076664 <https://www.awm.gov.au/collection/C77133>



**Figure 11. Remains of the plantation homestead at Cutarp Plantation, Jacquinot Bay, 15-December 1944**

Image source: Australian War Memorial 084323 <https://www.awm.gov.au/collection/C82889>



**Figure 12. An old copra drying shed on Palmalmal Plantation which had been used as a Japanese kitchen during the occupation, 21st November 1944**

Image source: Australian War Memorial 077159 <https://www.awm.gov.au/collection/C20333>

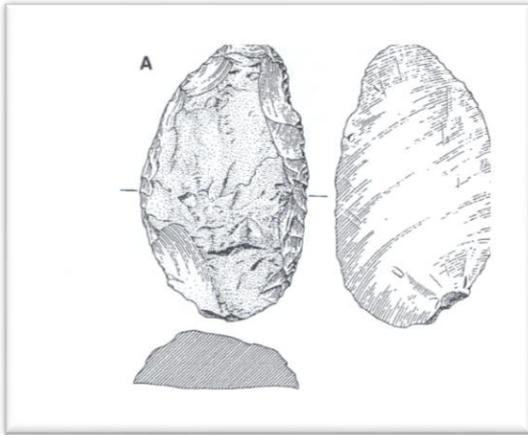
## Archaeology of the Region: A Brief Overview

New Britain was first occupied from about 40,000 years ago by hunter-gatherers originating from the island of New Guinea. They crossed the Vitiaz Strait from the Huon Peninsula landing in the vicinity of Cape Gloucester and moving rapidly to the east, across the St. Georges Channel and into New Ireland, filling up New Britain along the way. They made stone tools from locally available stone (including obsidian, see below) and used these tools for hunting the locally available animals such as reptiles, large rats, bats and reef fish and in the collection of wild plant foods including nuts. After settling-in to New Britain, they dispersed into Bougainville and the Solomon Islands by about 30,000 years ago and Manus soon after.

New Britain has a long archaeological record punctuated by an impressive series of volcanic and other natural environmental events. These events have had a major impact on New Britain since the first arrival of peoples. The absence of evidence for people on the south coast of New Britain from that early time is probably the result of extensive landscape changes caused by rising sea levels after the last glacial period. At the coldest stage of the last glacial period, around 20,000–24,000 years ago, sea levels dropped to about 120 metres below its present level, and many of the islands along the south coast were small hills linked to the mainland by narrow coastal plains. The land thus exposed would have provided good opportunities for people to settle the coastline, though evidence for this has been limited by the rise of sea level after the glacial period when the sea rose to its present level, flooding the land between the small hills and the mainland of New Britain to form the present-day off-shore islands. The process of island formation is exemplified by the Arawe Islands in west New Britain. Further landscape change was caused by the deposition of tephra from volcanoes on the north coast of New Britain. Their erosion has contributed to the formation of swamps on the south coast (cf. Torrence, Neall & Boyd, 2009). Also around 24,000 years ago archaeologists can see the first evidence of trade in the New Guinea Islands regions, in particular, obsidian quarried/collected from sources in the Mopir and Talasea areas on the north side of New Britain. Obsidian was traded into southern and central New Ireland (Summerhayes & Allen, 1993). This is the earliest evidence for trade in the region.

The Pomio area is likely to have experienced a similar geological and human history. Geological studies of the coastline show that it has risen in several stages over the last 10,000 years, forming a series of limestone terraces in which we can expect to find caves and shelters suitable for human use (Riker-Coleman et al., 2006). The oldest terrace so far identified is about 10,000 years old. The earliest evidence for the presence of people is likely to be located inland from the present-day coastline.

Little is currently known about the early human history of the Pomio area, but some clues can be found elsewhere in New Britain and the Bismarck Archipelago. The earliest migrants consisted of small groups of hunter-gatherers who often moved to new camp sites (Pavlidis, 2004). There is good evidence of people living in the Willaumez Peninsula region for 40,000 years and in the Passismanua area inland of Kandrian from about 38,000 to 35,000 years ago. Evidence from Talasea and Kandrian indicates that people dispersed along both the northern and southern sides of the Whiteman Range occupying both inland and coastal regions. People who were visiting the Passismanua area were attracted to the region by its high-quality chert stone resources that provided raw material for making the tools that were essential for survival (Pavlidis & Gosden, 1994). One such stone tool, called an ovoid scraper, is illustrated below.



**Figure 13. An ovoid scraper from Yombon**

Image: Courtesy of Pavlides, 2004, p. 103.

Obsidian was used by people for the production of stone tools in the Willaumez Peninsula by 35,000 to 40,000 years ago. It is a black or grey volcanic rock with a high silica content (often 70% or more), giving it the appearance of glass. Obsidian was fashioned into a range of tools and ceremonial objects and just like glass, obsidian flakes have a very sharp edge. It was also traded, from one group to another, 'down-the-line' as far as southern and central New Ireland by about 24,000 years ago (Summerhayes & Allen, 1993).

By 10,000 years ago things started to change dramatically. Archaeological evidence from across the Bismarcks suggests that populations started to rise remarkably. Potential cultivars, such as bananas (Lentfer, Pavlides & Specht, 2010) began to be exploited. All this occurred between periodic volcanic eruptions that forced people move across New Britain only to return once it was safe. Obsidian continued to be used by people across New Britain. A stemmed obsidian tool is reported from the Pomio area (Specht, 2005a, Fig. 28.7). This is attributed to the Kutau/Bao obsidian source of Willaumez Peninsula on the north side of New Britain (Torrence, Kelloway & White, 2013, p. 283), where such tools are dated to the early-middle Holocene, between about 9,000 and 3,500 years ago (Torrence & Swadling, 2008). Stemmed tools have been found elsewhere in New Britain and also in New Guinea and throughout the New Guinea Islands.

A new phase of New Britain's history began around 3,300 years ago with the arrival of people making Lapita pottery. These people arrived on canoes from the north (Carson, Hung, Summerhayes & Bellwood, 2013). They originally landed on selected small off-shore islands within the region, namely, at Mussau, Emirau and Anir in New Ireland as well as Watom, the Duke of York Islands, the Talasea area, and Kandrian and the Arawe Islands in New Britain.



**Figure 14. Chert from a location inland from Kandrian - probable age is around 6,000-3,500 years**

Image courtesy of Jim Specht.

These new arrivals spoke Austronesian languages, produced pottery with highly distinctive decorations. They lived in houses, often on stilts and worked gardens, collected and consumed nuts and brought pigs, dogs and chickens into the Bismarck Archipelago for the first time. Within a few hundred years the Lapita people moved from the smaller off-shore islands onto the larger islands. One such village existed at the mouth of the Liton River in Jacquinot Bay and in the Kandrian area and Arawe Islands further to the west. Soon after settling-in, they integrated with the pre-existing hunter-gatherers of the region.

Some people, like the Baining and Sulka kept their old languages while others took on the new Austronesian languages. Soon after, we see the first evidence of people moving out of the New Guinea Islands to the east ultimately to fill-up almost the entire Pacific region. For the first few hundred years they maintained social relations with the New Guinea Islands, returning to exchange brides and trade food and other objects, including obsidian tools. After a few hundred years these links to the east subsided and were replaced by more localised coastal trading networks.

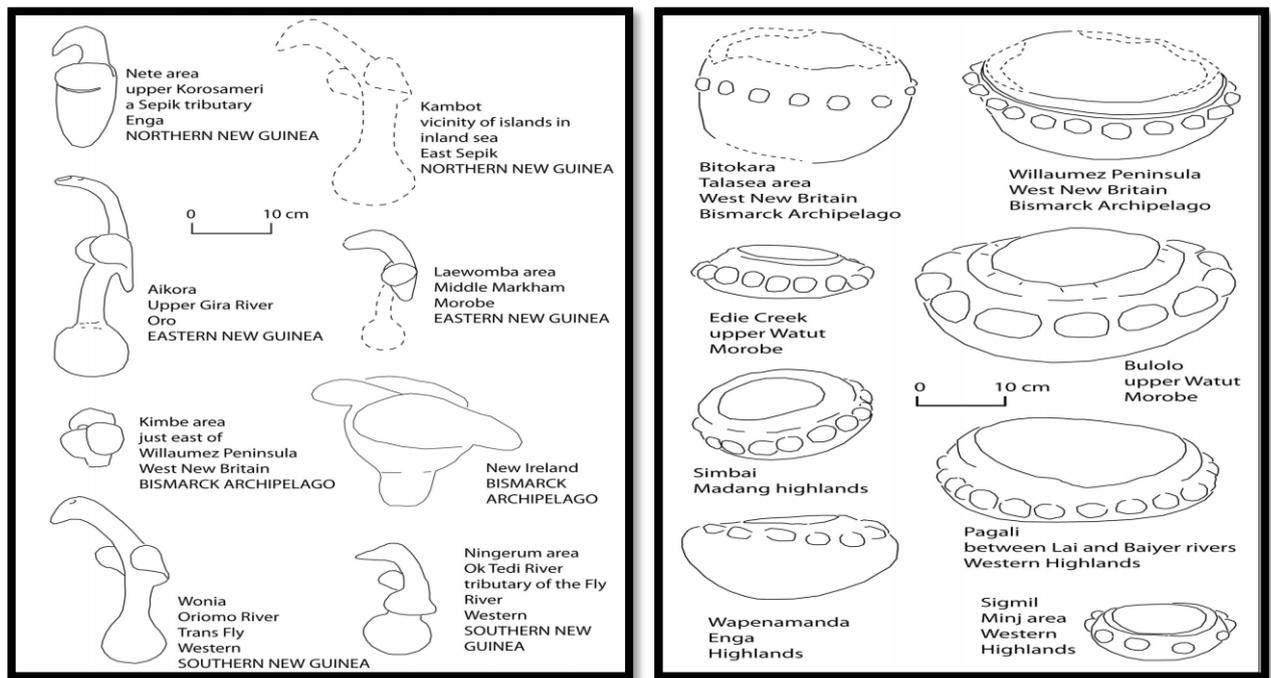


**Figure 15. Lapita sherd found at the Liton River mouth, Jacquinot Bay**

This site was first reported by Mr Patrick Sarar with assistance from his son Andrew (see Leavesley & Sarar, 2013).

There are many unusual objects and art works found in New Britain that, to date, have not been dated or identified why they were made. The rock art consists of engravings, and red and black paintings on boulders and rock cliff faces throughout New Britain. The paintings on the Beehive Rock (Dawapia) in Rabaul harbour were painted after the massive volcanic eruption of about 1200 years ago that devastated the Rabaul area and formed the harbour.

The engraved rock art is undated and may be no older than about 3000 years, but that is only a rough estimate. Among the unusual objects found in New Britain are stone pestles and mortars of various shapes and sizes. These, too, are not dated yet, but by comparing them with others in the New Guinea islands and on the mainland, some could be as old as 3000 or more years.



**Figure 16. Selected bird pestles (left image). Selected mortars (right image). The distribution of the 'bird' pestle from across the region suggests some cultural connectivity in the past**  
 Sketches source: Torrence & Swadling, 2008, pp. 606, 608.



**Figure 17. Find spot of the stone pestle; New Britain, Jacquinot Bay**  
 Image source: Felix Speiser; 1930 © (F)Vb 68; Museum der Kulturen Basel.

## UNIQUE FLORA AND FAUNA OF THE REGION

The Nakanai region is an extremely bio-diverse ecosystem, harbouring large numbers of endemic species of plants and animals.

In April 2009, a team of scientists from Conservation International and the Papua New Guinea Institute of Biological Research joined with local landowners to survey the biodiversity of East New Britain's rainforest-covered Nakanai Mountains. The 2009 Rapid Assessment (RAP) Survey was conducted at three sites along an elevational gradient between 200 metres and 1,590 metres. Exceptional results were obtained.

A report entitled *Rapid Biological Assessments of the Nakanai Mountains and the upper Strickland Basin: Surveying the biodiversity of Papua New Guinea's sublime karst environments* outlines the findings (Richards & Gamui, 2011). The survey documented more than sixty-four species of birds in the Nakanai Mountains, seven of which are endemic to the Island. The most significant of these was a very rare sighting of the slatey-backed goshawk (*Accipiter luteoschistaceus*), an uncommon species endemic to New Britain and nearby Umboi Island.

More than 100 species of spiders were documented, of which at least 50 appear to be undescribed:

Given the current knowledge of New Britain's spider fauna and known levels of endemism, over 50% of the spider species are likely to be new to science, i.e. 50+ species. This high diversity and the large number of species new to science, some of which are likely to be endemic to the Nakanai Mountains, confirm the significance of World Heritage nomination for this area as an important step in the conservation of New Britain's rich but poorly known fauna (Richards & Gamui 2011, pp. 20-21).



**Figure 18. Previously undescribed species of  
*montane mouse***

Image source: Richards & Gamui, 2011, p. 44.

The survey of mammals around three sites in the Nakanai Mountains – Lamas, Vouvou, and Tompoi -identified 26 species, including 10 species of terrestrial mammals. It appears that three species of mammals from the high elevation site are undescribed, including two rats and a white-tailed mouse that represents a previously unknown genus. The long-tailed mouse was located at the high elevation site (1590m above sea level) in the Nakanai Mountains. Although it resembles the prehensile-tailed tree mice of PNG, this remarkable new species has no close relatives and represents an entirely new genus.

The newly documented mouse has narrow feet and forward-directed incisors that may be used for digging and carrying soil, suggesting that it might be a burrower that lives most of its life at or near the forest floor. Its long, pure white tail tip distinguishes it from all other mice in the area. The results of the mammal survey confirmed that the island has its own endemic species of mammals.

A total of 23 frog and 16 reptile species were documented in the Nakanai Mountains. Four species of frogs are new to science, with the highest proportion of previously undescribed frog species located at the site with the highest elevation—Tompoi (1,500-1,700 metres). Amongst the newly discovered frogs is a striking, yellow-spotted species of the genus *Platymantis* (*Platymantis sp. nov.*). This unique frog was found only at the highest elevations surveyed in the Nakanai Mountains (Richards & Gamui, 2011).



**Figure 19. A shrub-dwelling *Platymantis* is new to science and known only from the highest elevations accessed during the 2009 Nakanai Mountains survey**

Image source: Richards & Gamui, 2011, p. 42.

<http://www.bioone.org/doi/pdf/10.1896/054.060.0103>



**Figure 20. The *Platymantis* species is new to science and known only from the cold, wet forests atop the Galowe Plateau in the Nakanai Mountains**

Image source: Richards & Gamui, 2011, p. 42.

<http://www.bioone.org/doi/pdf/10.1896/054.060.0103>

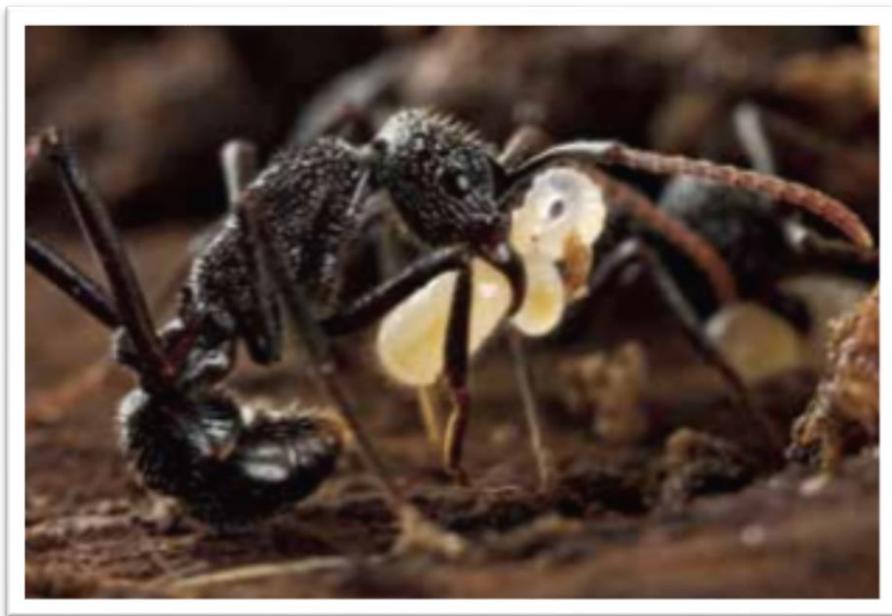
Thirty-two species of dragonflies and damselfies (*Odonata*) were collected in the Nakanai Mountains at three different elevations between 200-1,700 metres and, to a minor extent, on the coastal fringe of Jacquinot Bay. Ten species were recorded from New Britain Island for the first time (Richards & Gamui, 2011).



**Figure 21. The colourful dragonfly, *Agrionoptera insignis similis*, was common near small streams in disturbed forest around Palmalmal Village**

Image source: Richards & Gamui, 2011, p. 41.

<http://www.bioone.org/doi/pdf/10.1896/054.060.0103>



**Figure 22. *Rhytidoponera* sp., an ant collected during the Nakanai RAP expedition**

Image source: Richards & Gamui, 2011, p. 38.

<http://www.bioone.org/doi/pdf/10.1896/054.060.0103>

## UNESCO WORLD HERITAGE TENTATIVE LIST: THE SUBLIME KARSTS OF PAPUA NEW GUINEA

In 2001 at the World Heritage Conference held at the Gunung Mulu National Park in Sarawak (Malaysia), the Nakanai Caves and the karst areas of Papua New Guinea were first touted as potential World Heritage sites (Audra, Gill, Hamilton-Smith, Sounier & Salas, 2005). The three Natural Heritage Properties that were identified, and now comprise the listing 'The Sublime Karsts of PNG' on the tentative world heritage list include Nakanai, Muller Plateau and Hindenburg Wall.

A proposal document entitled *Conserving the Sublime Karst of Papua New Guinea* was prepared under the Task Force on Cave and Karst Protection (Audra et al., 2005). The document outlined plans for the long-term goal of World Heritage status for the Nakanai Caves and other major karst areas in Papua New Guinea. The international working group included Maureen Ewai, representing Conservation International, and Florence Paisarea, then East New Britain Provincial Environment Officer. Supporting the long-term objective of creating the 'Nakanai Mountains Conservation Area', and eventually to propose the area for World Heritage Status, Professor Elery Hamilton Smith from Australia joined the group for meetings in Rabaul with Provincial Government officials (Gill, 2012).

In 2006, the Government of Papua New Guinea nominated seven areas to the World Heritage Tentative List, including The Sublime Karsts of Papua New Guinea. Places on the Tentative List are not necessarily already protected, but instead send a signal to the international community that Papua New Guinea possesses areas of outstanding universal value (World Heritage) and is committed to protecting these areas.

<b>The World Heritage Proposal Tentative List</b>		
<b>Name of Property</b>		
<b>The Sublime Karst of Papua New Guinea</b>		
<b>State and Provinces:</b>		
<b>East New Britain: Nakanai Range</b>		
<b>Southern Highlands: Muller Range</b>		
<b>Western: Telefomin and Hindenberg Range</b>		
<b>Latitude and Longitude</b>		
<b>Nakanai</b>	<b>150° 40' E - 151° 40' E</b>	<b>5° 20' S - 5° 55' S</b>
<b>Muller Range</b>	<b>142° 10' E - 142° 50' E</b>	<b>5° 30' S - 5° 50' S</b>
<b>Telefomin and Hindenberg</b>	<b>141° E - 142° E</b>	<b>5° S - 5° 30' S</b>

**Figure 23. World Heritage proposal tentative list**

Source: Gill, 2012, p. 27.

## Justification for Outstanding Universal Value

The following text is a reprinted in its entirety (unedited) from the report entitled *Untamed Rivers of East New Britain* (Gill, 2012, p. 27-33). While the *Sublime Karsts of Papua New Guinea* include Nakanai Range, Muller Range and Hindenberg Range, only the justification criteria for Nakanai Range are included below.

### **Nakanai Range**

(v) An outstanding example of a traditional human settlement, land use and sea-use which is representative of a culture (or cultures) and human interaction with the environment when it has become vulnerable under the impact of irreversible change (Gill, 2012, p. 29)..

The cultural significance of the indigenous clans is a vital and integral part of the Nakanai Mountains. Their traditions and beliefs are as important as the biodiversity and caves of this unique part of the world. As in many parts of Papua New Guinea, traditional culture and life-style remains relatively intact, in spite of persistent modernism. The bond to traditional lands provides a remarkably stable basis for both community and personal sense of identity. It offers a stable cultural basis from which the people have been able to adapt to and function well within the culture of modernism without abandoning their traditional culture. In the Nakanai, this means that the various villages generally remain true to their cultural traditions, pursuing a hunter-gather lifestyle integrated with simple agriculture.

(vii) Contains superlative natural phenomena and areas of exceptional natural beauty and aesthetic importance (Gill, 2012, p. 30).

The geological history covers a period of 43 million years and the mountains exhibit rapid uplifting, some of the highest recorded. The majority of the mountain range lies within the Yalam limestone and is a karst limestone up to 1.5 kilometres in thickness, deposited over a period of 17 million years. The limestone regions contain numerous white water rivers situated in spectacular one kilometre deep gorges. Large rivers can be seen issuing from caves as beautiful waterfalls from high above the river level. There are many massive sink-holes with collapsed dolines up to 400 metres deep and 500 metres in diameter. At the base of the dolines some of the world's largest and most turbulent underground rivers flow, some of them at over 20 tons of water a second in caves of outstanding natural beauty and immense proportions.

The caves are of international importance and are unique as they are considered to be among the most active river caves in the world and are certainly some of the most technically difficult caves in the world to explore. Muruk Cave is 17 kilometres long and 1178 metres deep, the deepest cave in the Southern hemisphere and one of the most beautiful 1000 metre deep caves in the world. The entrance pitch of Nare is one of the most impressive known being 250 metres deep with a massive river flowing along the base into one of the largest river passages in the world. Minye Cave possesses one of the biggest pitch entrances at 410 metres in depth. At the bottom a river, carrying 15 cubic metres of water per second, roars into the immense cave.

Kavakuna is also a giant doline with its 392 metre deep entrance pitch. One side is not vertical so this cave is suitable for adventure eco-tourism. A further newly discovered cave is more difficult to access but does provide for a journey of only medium difficulty and great beauty, so may be appropriate for

visitors seeking a degree of challenge. The coastal regions are also of exceptional natural beauty and exhibit raised coral reefs and terraces up to 200 metres above sea level with numerous pure white coral sand beaches fringed with palms.

(viii) An outstanding example representing major stages of earth's history, including the record of life, significant ongoing geological processes in the development of land forms, and significant geomorphic physio-geographic features (Gill, 2012, p. 29).

Although the very real problems of access have constrained research at this stage, and the region is still far from being fully understood, the geomorphology of the karst certainly has a multitude of distinctive features which result from its turbulent history of tectonic movement, volcanism, heavy rainfall, limestone deposition and intense karstification.

(ix) Outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals (Gill, 2012, p. 29).

As with so many of the isolated areas of Papua New Guinea, the Nakanai is unique in its geological evolution and its biodiversity. In particular, it demonstrates high levels of localisation and endemism, with various adaptations to the remarkable karst environment. Over 20 new species of troglobitic or stygiobitic fauna have been collected from the caves, although few of these have yet been named and described.

The mountains range in altitude from sea level to 2,185 metres and are predominantly covered by primary tropical rain forest of lowland and montane types but with relatively few large trees. Although the vegetation has not yet been adequately studied, it is particularly rich in epiphytic species and is considered of high biological importance. Many species are endemic to New Britain and are found nowhere else on earth. This is only a small proportion of the estimated total and no doubt there will be thousands more species identified with further research.

There are also a number of ecologically important mangrove swamp forests. Estuarine crocodiles and Leather Back Turtles inhabit the coastal waters along with a vast variety of marine species. The pristine and biologically important reefs lie close to shore with a huge diversity of coral forms and marine life.

(x) The most important and significance natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation (Gill, 2012, p. 30).

Although faunal and floral inventories are only at an early stage, there are at least eight species of endemic or near endemic mammals, and at least four of these are recognised as endangered. Similarly, there are 22 endemic or near endemic species of birds, including eight that are recognised as threatened.

### **Assurances of authenticity or integrity**

The ranges and plateau have only a very sparse human population, with only small villages generally on the lower lands. Various areas of flat or near flat land are used for cultivation, but then once harvested are left to fallow until secondary forest is re-established. Some natural disturbance results

from such causes as earthquakes or landslide. Thus, one can say that the natural forest has remained very much in its original, but nevertheless, is in a dynamic and constantly changing state.

### **Comparison with other similar properties**

As already emphasised, the Papua New Guinea environments must be recognised as distinctive, one can make superficial comparisons with a few World Heritage properties. Gunung Mulu (Malaysia), Thung Yai Hua Kha Kaeng (Thailand) and Phone Nha Ke Bang (Vietnam), each of which have large but morphologically very distinct cave systems with a rich but structurally distinctive forest on the surface. The underground rivers in these and most other cave systems have relatively gentle flows and relatively little fluctuation in water levels.

None of the other major underground rivers share the continuous volume and turbulence of the Nakanai Rivers. The giant Baliem River system in West Papua (and several other underground rivers) may be of similar volume only during short periods of massive flooding which may not even occur every year. Aerial reconnaissance suggests that the closest comparison may lie in a totally unexplored region of Halmahera in Indonesia.

### **Update**

In 2015, based upon the known values, it has been recommended in a formal review of PNGs Tentative World Heritage Sites that the PNG World Heritage Secretariat/Committee create a separate Tentative Listed area for the Nakanai Mountains (Hitchcock & Gabriel, 2015).

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