*in* BOUCHET P., LE GUYADER H. & PASCAL O. (Eds), *The Natural History of Santo*. MNHN, Paris; IRD, Marseille; PNI, Paris. 572 p. (Patrimoines naturels; 70).

# Caves as Archives

Denis Wirrmann, Jean-Christophe Galipaud, Anne-Marie Sémah & Tonyo Alcover

Hereafter we will present a few examples of the archives which we have retrieved in different sites (caves, rock shelters and dolines) from the limestones realm of Santo (Fig. 325).

The caves from a karst system play a very important role as sedimentary archives, because they are the place of very large sedimentation, and accumulate various kinds of deposits, like clastic fragments in association with calcite secondary precipitates

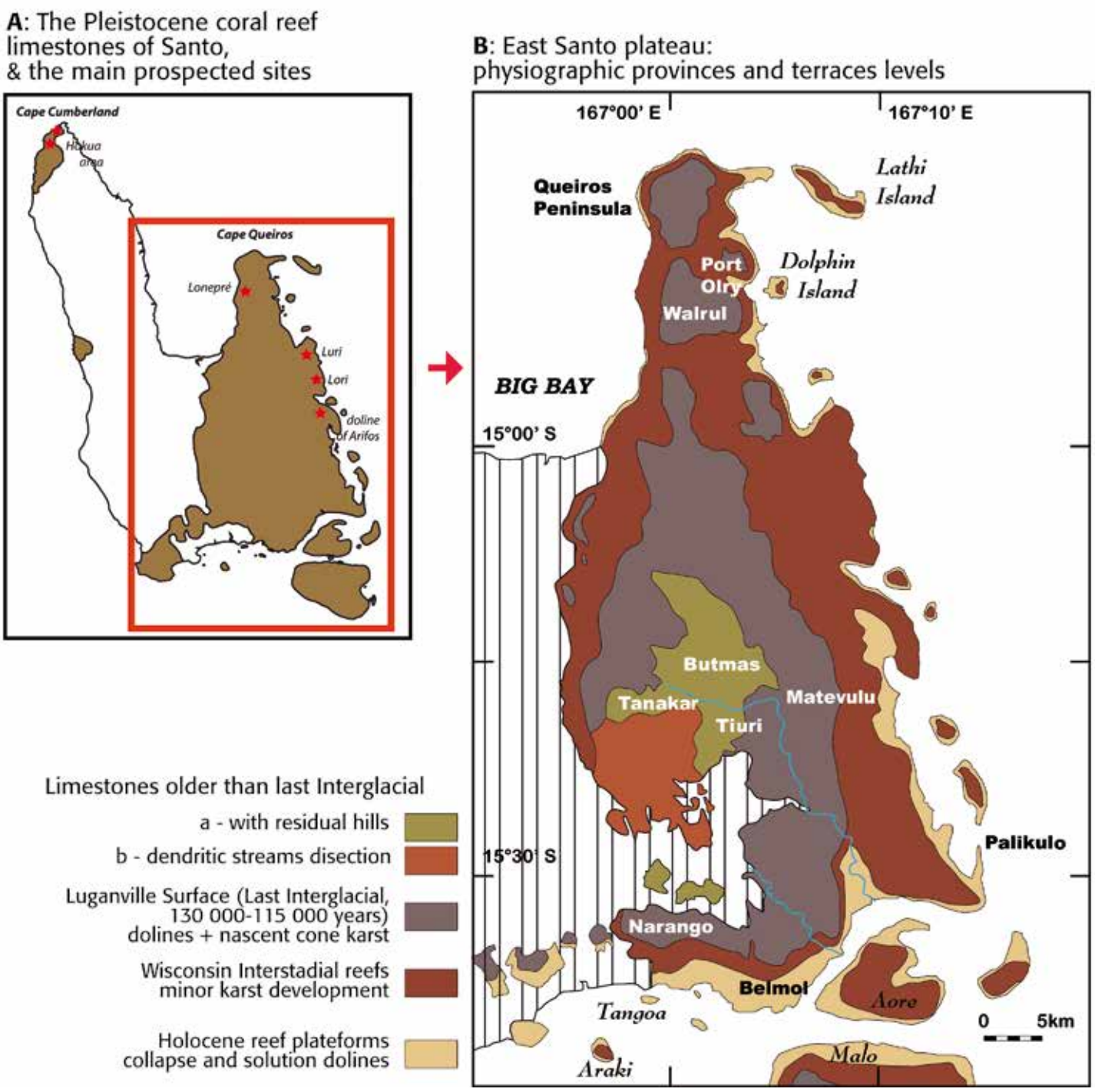



Figure 325: The main prospected sites (**A**) and (**B**) detailed geological pattern of the karst of Santo, redrawn by D. Wirmann after Strecker *et al.* (1987).

and other chemical and/or organic debris. Due to their natural environment (absence of light, difficult access) the caves tend to be preserved from degradation and aerial erosion. Morever, their deep interiors remain mostly stable in temperature and atmospheric composition, representing often particularly rich undisturbed sites. They represent protected repositories amongst the other continental environments and preserve a large spans of time medium for palaeoenvironmental studies.They are also very valuable for archaeological research, the caves or assimilated structures having frequently played and playing still a role of shelters, accomodations or habitats. That is why, for example, human artefacts are often very common into cave entrances and rock shelter deposits (burials, rock drawings, cave paintings, potsherds, etc.) and in a lesser extent in cave interior deposits.

One can ascertain that all the clastic, organic or precipitated sediments formed within a cave or the deposits transported into it, will allow a multiproxy study of the karst environmental fluctuations, which will encompass hydrogeology, geology (e.g. palaeoseismology), climatology, biodiversity and human palaeontology.

## STALAGMITES

A few stalagmites and stalactites from the Fapon Cave (Butmas Plateau) have been sampled during a three-month field trip (Sémah and Wirrmann in 2005) before the Santo 2006 expedition. Their study is in course and their dating by Thermal Ionisation Mass Spectrometry (TIMS, U-series

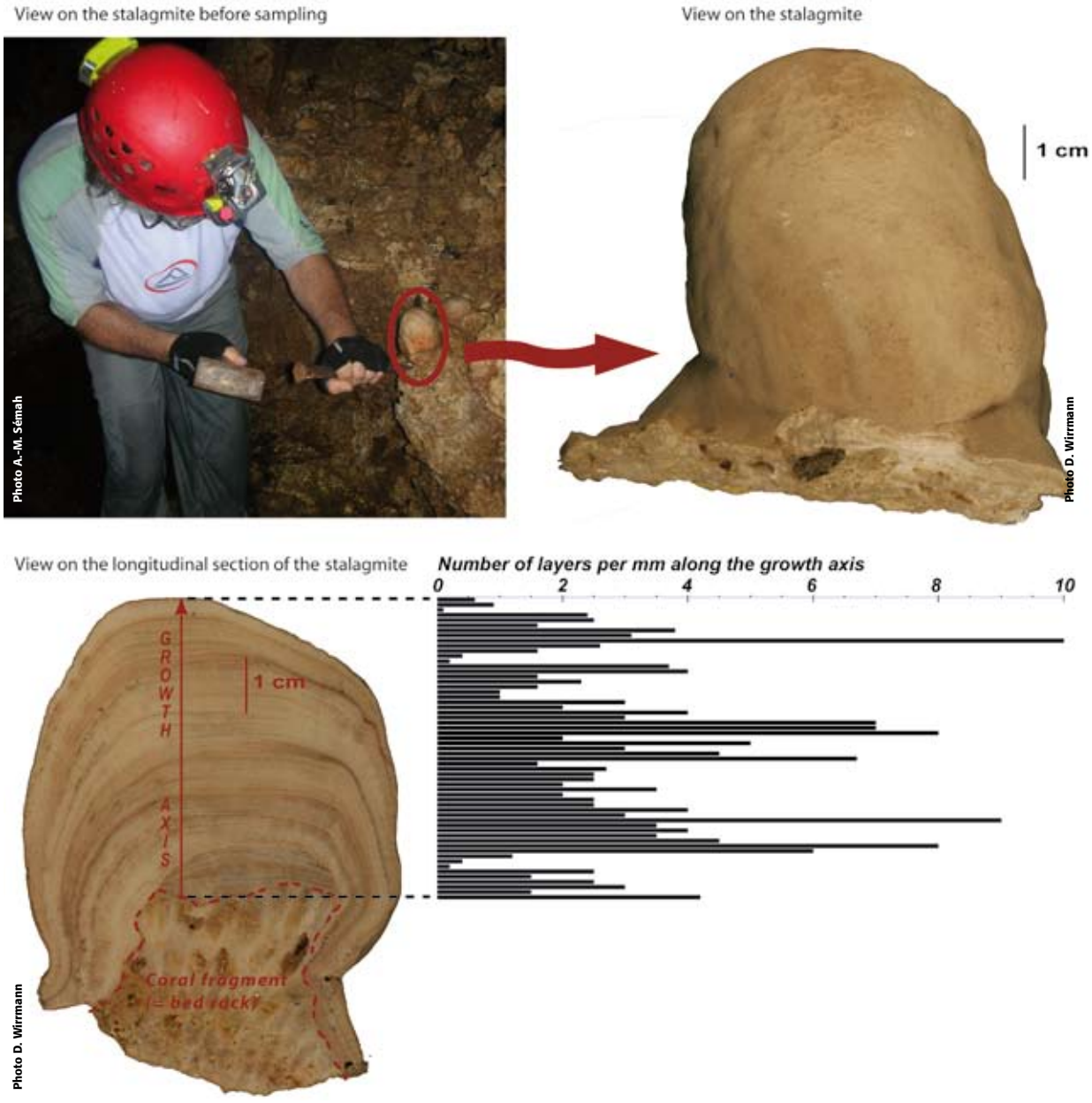



Figure 326: The FAP1 stalagmite.

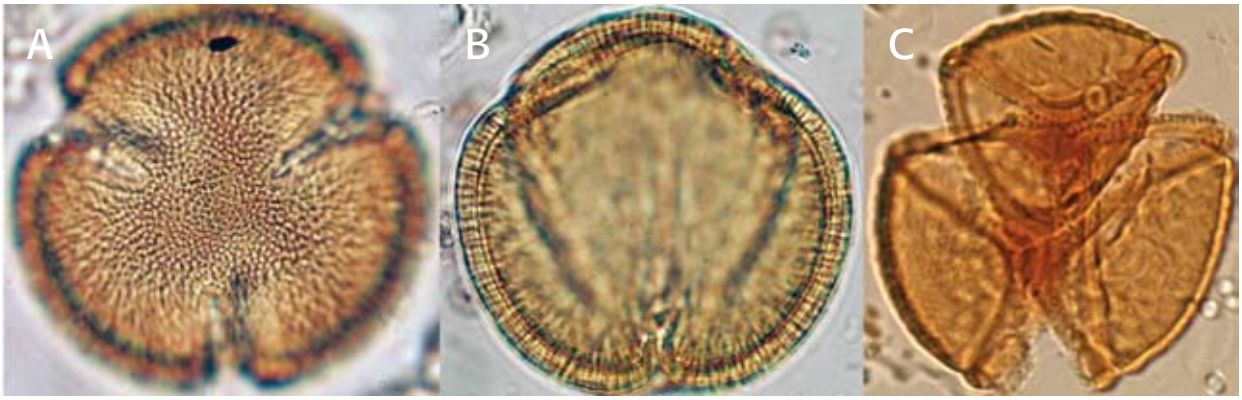



Figure 327: Example of grains of pollen from Santo sediments. **A-B**: *Merremia peltata* (Convolvulaceae), the invasive creeper (diameter size 60 µm). **C**: *Barringtonia novae hiberniae* (Lecythidaceae), endemic to the Vanuatu Archipelago (size 54 x 45 µm). (Photos A.-M. Sémah).

methods) will provide the basis for the respective relative age models.

Petrographic thin sections were prepared all along the stalagmites growth axis, in order to analyze the carbonate fabrics and the laminae under an optical polarizing microscope. Enlarged photographs of the thin sections were also used as analytical aid for mineralogical fabric observation and laminae counting. Along its growth axis the FAP1 sample (Fig. 326), a stalagmite of 9 cm length, shows many layers with distinctive widths and colors: the fluctuation of their number per millimeter illustrates the variation of the feeding conditions during the time of growth, in relation with the available dissolved calcite and water at the origin of the precipitation of secondary calcite into the cave.

The study of pollen, the reproductive male cell (mean size about 30 µm) from spermatophytes (flower plants), is a valuable bio-marker used in "classical" sedimentology since the 1950s for environmental reconstitution. As each plant species is characterized by a specific grain of pollen, the reconstitution of a palynological spectra and its variations during the time will in turn allow the reconstitution of the climate. Nevertheless, it is only from the 1970s that it has been used for such a purpose in stalagmites, flowstone and spring travertine. Usually, the deduced representation of the contemporary vegetation of the deposit does not correspond solely to the true live picture. It will privilege for example the local vegetation at the expense of the regional one, knowing that the sedimentation of the pollen may be more or less hampered by the wind circulation, or by change in aquifer plumbing, or by the percolating system over the cave and/or transformed by allogenic contributions (anthropic activities).

It will be particularly interesting to analyse the samples retrieved in Santo (speleothems, dolines and caves fillings) for precising the apparition of the alien *Merremia peltata* (Convolvulaceae), this invasive creeper which alters the structure and functioning of the insular ecosystem and about which we have no data for it first introduction in Vanuatu. It will be important too, to understand the distribution in stratigraphy of some endemic (*novae hiberniae*) vs pandemic (*asiatica*) species in the *Barringtonia* genus, for instance (Figs 327 & 328).

## CAVE FILLINGS

In almost all the twenty caves and rock shelters whe have prospected (Lori, Luri, Lonepré and several sites from Cape Cumberland, Fig. 325A), the artefact rich levels ly often under a more or less thick superficial bats or swiftlets guano layer.

We have put at the day anthropic levels. These levels, still not dated but probably recent according to their stratigraphical position, contained airfall tephras, charcoals, ceramic potsherds and tiny animal bones remains. Beside these sites, a few other places corresponded to burial caves, rich in human remains and pig canines (the well known "tusks" of Vanuatu) as burial accompaniments. In all these places we have sampled superficial and deeper sediments in order to analyse their pollen content.

### ••• The North Cumberland area

The karst environment of the Cape Cumberland area has been for many centuries an important

Table 31: Datings of Hokua shelters (after Galipaud, 1997).

| Sample n° (Lab. Miami, USA) | $\delta^{13}C$ ‰ vs standard Pee Dee Belemnite | Conventional Age BP |
|---|---|---|
| Beta 96570 | -27.4 | 1 110 ± 80 |
| Beta 97558 | -25.3 | 340 ± 60 |

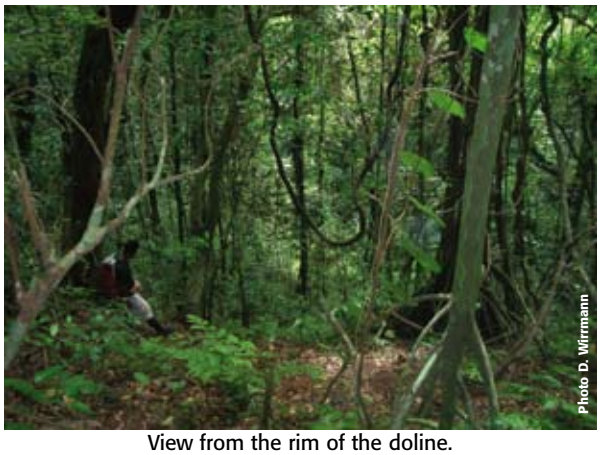
population center for the west coast controlling the exchanges with the Banks islands to the North- East. This is a very active environment with one of the bigger uplift rate in Santo, between 2.1 and 5.5 mm/ year. Several caves with important anthropic levels have been previously surveyed near the actual village of Hokua. Datings of stone ovens (Table 31) in two shelters near the irrigated taro gardens of Hokua have allowed to attest an occupation of this area during the last 1000 years.

Several new shelters revealing further human activities in the area have been localized during the Santo 2006 expedition.

The most surprising and unexpected discovery was of a burial site well hidden in a very small cavity, partially blocked by accumulated rocks near the ancient village of Salea (14° 40.421' S; 166° 37.202' E). The site was arbitrary named "Abri aux dents de cochons".

In this cavity we discovered human bones from more than three individuals, in association with a child skull (younger than ten years), suidae's teeth (22 tusks) and maxilla, and pottery pieces (Figs 329 & 330). The site is probably the tomb of a man of high rank as attested by the number of well developped pig tusks. A decayed piece of woven cotton as well as the relatively well preserved pig tusk suggested that the burial was not of great antiquity. Half of an open bowl with red slip further confirmed a inhumation during the last millenium. We took a pig molar for datings and submitted the sample to the Waikato laboratory (New Zealand). The result, (Sample n° Wk 20296, C14 Age BP = 209 ± 10, modern activity = 97.6 %) indicates that this inhumation dates to the last phase of the Santo prehistory, between the 17th and the 19th century.

In the same area, the "Abri Palatin" (14° 40.178' S; 166° 37.407' E) includes three adjoining chambers



View from the rim of the doline.

View on the hillside.

Bottom of the doline.

A 65 cm deep borehole sampled in the doline bottom.

Figure 328: Example of a doline, the doline of Arifos.


Figure 329: View on human bones and tusks in "*Abri aux dents de cochons*".

containing human bones (Fig. 331). In the right chamber, more than five individuals were discovered, while on the left side, there was only one post cranial skeleton remains associated with two potsherds.

The third cavity contained another skeleton and faunal remains plus charcoals. In several other shelters from the same area, blocked chambers or scattered human bones suggest that such burial practices were frequent in the region during the second millenium. No such practices had been evidenced in Santo prior to this survey.

Further west along the same area, a dry cave named Malaostitir in the local language (14° 39.673' S; 166° 37.291' E; Figs 332 & 333), revealed traces of red and black drawings partly covered by calcite. Fragments of pottery with red slip on the surface suggest an occupation at the same period as the previously described burial sites. the drawings which are difficult to see correspond to geometrical forms of squares and crosses.

### ••• The Cape Quiros area

This region encompass a well developed underground karst system. We will focuse here on one of its largest cavity, the Lonepré Cave (14° 59.227' S; 166° 59.160' E). Fallen rocks block partly its entrance, wich is oriented north-west south-east and makes a porch which opens in the first coastal crest over the forested littoral belt. A survey in this shelter made by J.-C. Galipaud and R. Pineda in late 2005, following its discovery by F. Brehier on 4 November 2005 uncovered large pieces of red-slip pottery under a the large and small coral blocks scattered on the surface. A one square meter


Figure 330: Fragment of a red slipped bowl, "*Abri aux dents de cochons*".

pit near the back wall of the shelter, revealed a homogenous dark clayish sediment with scatters of charcoals.

In 2006, a one square metre pit, reaching 60 cm depth, has been done in the middle of the entry. No well marked stratigraphy is observed. Nevertheless, different remains have been collected according to the depth of sampling: between 20 and 40 cm many mollusks fragments are present, the following level 40-45 cm is very rich in microcharcoals and below the sediment becomes dustier, ash-like and sterile. After 50 cm there are again numerous microcharcoals


Figure 331: Human remains in "*Abri Palatin*".

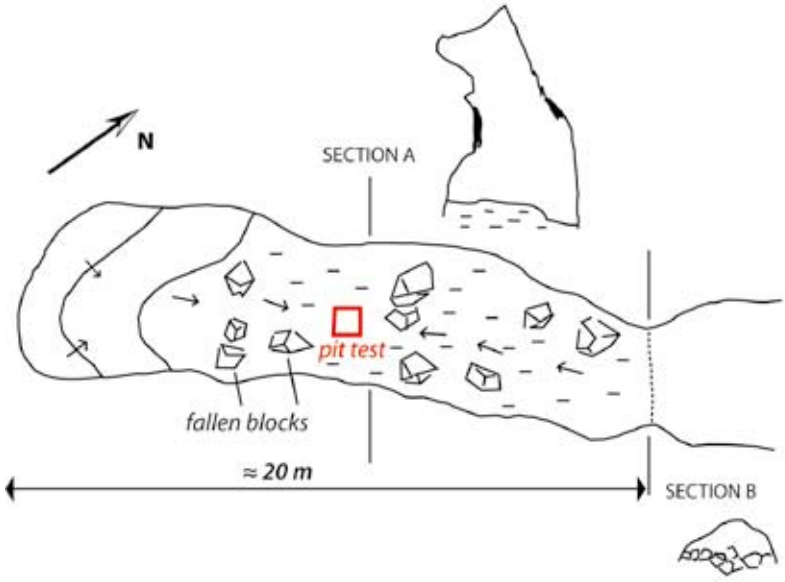



Figure 332: Sketch of The Malaostitir Cave. (15/09/2006, redrawn by D. Wirrmann after Lips & Lips, 2007)


Figure 333: The Malaostitir Cave. Cave entry.

and fallen calcareous blocks appeared from 60 cm depth. As the time allowed to this field trip was ended, we stopped the excavation and filled it with calcareous blocks and branches to protect it and to be able to excavate again easily in a next future. A total of 51 potsherds, 20 charcoals, twomicrofaunal bone fragments and seven mollusks has been collected in this excavation.

## CONCLUSION

Many small caves were discovered during two preliminary reconnaissance trips undertaken in 2005. After further deep explorations and sump diving during the expedition itself, several of these caves subsequently turned out to be very large indeed. The longest of Santo, the Funafu system, develops several kilometers of underground passages, and exploration is far from being completed. Another surprise came at the end of our stay, when we discovered huge subterranean galleries with big underground river near Butmas. Today, Santo has become the most promising karst in the Pacific islands outside New Guinea for the exploration of large underground systems.

The twenty rock shelters or caves sampled in the karstic zone of Cape Cumberland, Cape Quiros, east coast and Aore Island provided plenty of archaeological and palaeontological rests. Megapod birds, thought to have possibly existed in Santo, as in New Caledonia, were searched for, but no remains were found. On the other hand, we found, at almost every site, layers with ceramics (more than 1 000 years old), fire marks, sometimes tools and fossil remains (more than two species of rattus, birds, bats and lizards). Human bones were also discovered, sometimes associated with jaws and canines (tusks) of Suidae (pig family), indicating the importance of burial in these shelters.

Information extracted from the Santo karst is exciting in several respects. After a month of intensive sampling, Santo has become the best known island of the Pacific for cave and soil fauna. By the size of its karst, the easy access to its subterranean habitats, and the relatively low disturbance and high richness of its soils, Santo is a model island for testing key questions about the origin and evolution of biodiversity, well beyond its regional interest.

The use of multi-proxy studies of speleothems, involving combinations of geochemistry (isotopes and traces elements), mineralogy and palynology, integrated with parallel proxy materials from the same region (lake or swamps sediments, dolines fillings, coral cores, archaeology) will provide very useful data for identifying process controls and for working out the mechanisms of climate change and the exact timing of connections between climate and environmental changes.