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AUTHOR'S NOTE

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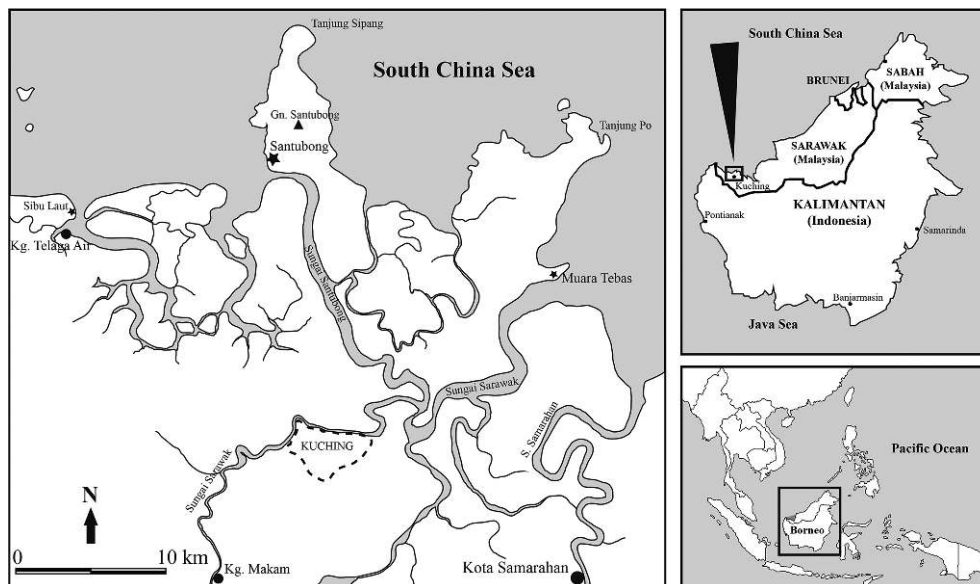
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Introduction

- 1 The ancient history of the northern coast of the Borneo Island remains largely unknown, especially for the period spanning the middle of the first to the middle of the second millennium CE. Two core areas have particularly attracted the attention of historians, archaeologists and epigraphists since the 1950s. The first core area is the present Sultanate of Brunei, about which research has focused in particular on the analysis of Chinese sources, the excavations of several archaeological sites, a corpus of Islamic tombstones, and local literature of a historical nature. The second core area is the Sarawak River Delta (**fig. 1**). It was indeed from the 1950s that archaeological research revealed the existence of several sites of great historical value. The Sarawak River Delta is the subject of this article, especially the Sungai Jaong site, where a new phase of archaeological research has been undertaken since 2018. Here are presented the first observations and reflections drawn from fieldwork conducted in 2018, 2019, and 2022.

Fig. 1. Sarawak River Delta map.



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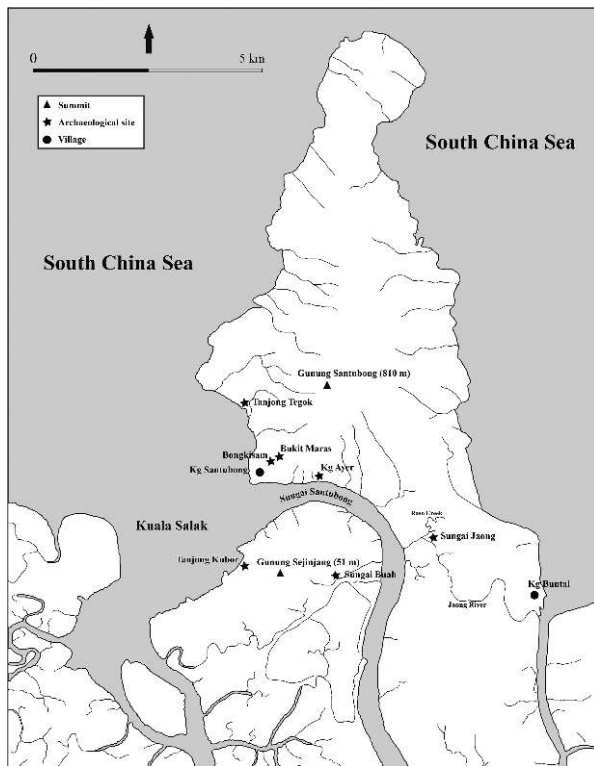
Brief Overview of the Coastal Sites in the Sarawak River Delta

- 2 The region described as the Sarawak River Delta, which borders the South China Sea, stretches as the crow flies some 40 kilometers between Kampung Telaga Air in the west and the mouth of the Samarahan River in the east (**fig. 1**). Still as the crow flies, this very indented coastline is about fifteen to thirty kilometers from the northwest to the northeast of Kuching, the current capital of the State of Sarawak. About 120 kilometers long, the Sarawak River, which gives its name to the delta, has its source in the Upper Kapuas range and spreads over a basin of some 2,500 km². The deltaic plain, covered

with mangroves and nipah swamps, is criss-crossed by a network of rivers including seven mouths, among them that of the Sarawak River to the east of Kuching, and that of the Santubong River to its north, which flows into the South China Sea in front of the village of the same name.

- 3 On the coastline, the mouth of the Santubong River hosts several sites, some of which have been excavated intermittently between 1947 and 1966 (**fig. 2**).

Fig. 2. Sarawak River Delta map – archaeological sites.



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- 4 They are located at the foot of Gunung Santubong. Culminating at an altitude of 810 m, this steep and rocky ancient sandstone massif was certainly an important landmark for navigators in ancient times (**fig. 3**).

Fig. 3. Gunung Santubong seen from the village of Santubong.



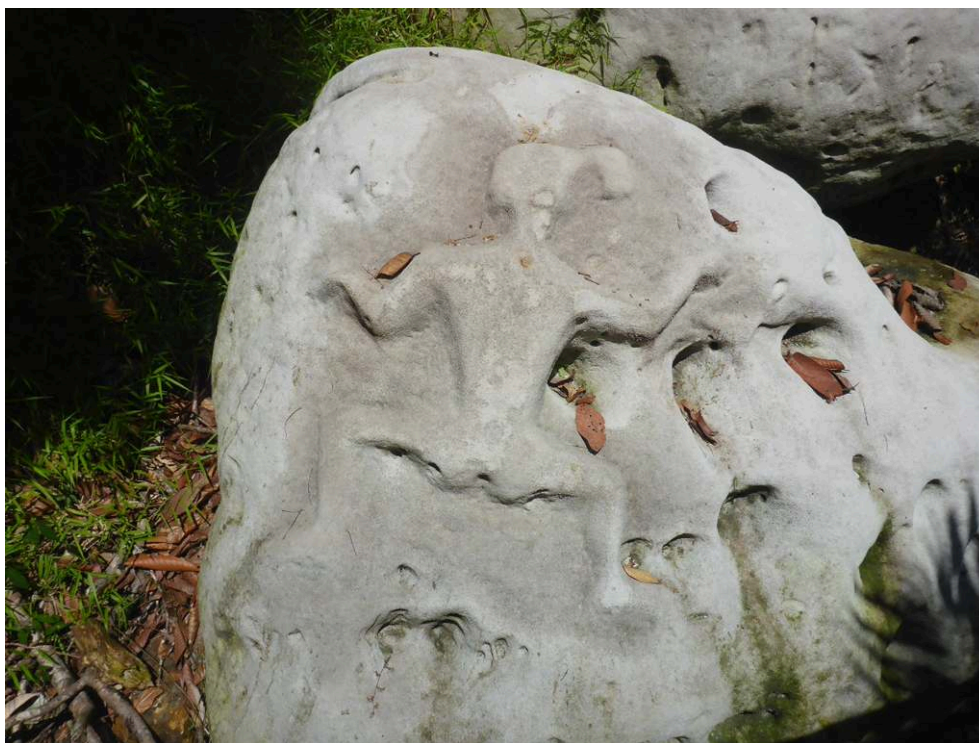
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- 5 On the right bank of the Santubong River, from upstream to downstream, these sites are: Sungai Jaong (N 01° 43.015'; E 110° 20.688'), the site discussed in this article; Kampong Ayer (N 01° 43' 6.2"; E 110° 19' 30.8"),¹ Bongkisam (N 01° 43.150'; E 110° 19.398'), today situated within the village of Santubong; Bukit Maras (N 01° 43.142'; E 110° 20.688'), on the hillside above Bongkisam; the coastal cemetery of Tanjong Tegok to the northwest of Santubong. The sites are less numerous on the left bank: Sungai Buah and the coastal cemetery of Tanjong Kubor.

Early Archaeological Research at Sungai Jaong (1947-1966)

- 6 The name associated with pioneering archaeological research in the Sarawak River Delta is that of Tom Harrisson. Appointed as curator of the Sarawak Museum and government ethnologist in 1947, he explored the region to try to shed light on its prehistory and its history, fields for which everything remained to be done at the time, and found out that the Sarawak River Delta figured among the most promising areas.²
- 7 Harrisson visited the Sungai Jaong site as early as 1947,³ most likely first interested in a high-relief half-size anthropomorphic figure carved on a dome-shaped sandstone boulder, spotted by a local in 1886 and named Batu Gambar⁴ (fig. 4).

Fig. 4. The Batu Gambar carving at Sungai Jaong.



© D. Perret, July 2022.

- 8 He also knew that locals found a number of ancient artifacts there, including a headless figure believed to be associated with Hindu religious practices.⁵ Although it is not easy to follow precisely, using his publications, the detail of Harrison's field activities in the Sarawak River Delta, we know that between 1947 and 1951, he had a first trial trench dug at the foot of the Batu Gambar rock.⁶ The discovery of iron slag led him, probably in early 1952, to carry out systematic pedestrian surveys using army mine detectors. He thus found that the low undulating hillock sheltering the Batu Gambar was covered with iron slag, and noticed the presence of iron slag scatters, on the one hand for nearly 1,400 meters in a southeasterly direction to the other side of the peninsula in the Buntal Bay, on the other hand in a northwesterly direction, for nearly 1,600 meters along the Santubong River between the village of Ayer, a few hundred meters from Sungai Jaong and the village of Santubong, at the mouth of the river of the same name.⁷
- 9 Harrison conducted extensive excavations at Sungai Jaong from 1952,⁸ leading three other seasons of digs there (1955, 1957, 1966).⁹ The total area excavated during these four seasons at Sungai Jaong is not specified in his publications, which are also lacking a detailed map of the digs, but they were very probably concentrated in a single sector. Based on remains of trenches still visible today on the ground near the confluence of the Jaong River and the Raso Creek, the excavation surface area is estimated at some 550 m². The digs were carried out in arbitrary level spits of at least three different thicknesses: 15 cm (most likely the commonly adopted method), 5 cm and exceptionally 2.5 cm.¹⁰ None of the publications relating to these excavations is accompanied by stratigraphic sections. Indeed Harrison mentions stratigraphic observations, but in general considers that the stratigraphy is "slight, non-existent, and has been heavily

disturbed by ironworking related activities, by agricultural activities, by the root factor.”¹¹

- 10 What strikes Harrisson during surveys and digs at Sungai Jaong, as well as at the neighboring sites of Bongkisam and Sungai Buah, is the considerable quantity of residues from metallurgical activities, especially iron slag and fragments of clay cylinders.¹² Nowhere in his publications did he mention the exact quantity of iron slag found at Sungai Jaong, but explains that as early as 1952 “two good landing piers from the excavated detritus of iron slag” were built in the Raso Creek, to facilitate access to the site by boat.¹³ Such landing piers, which certainly required dozens of tons of iron slag, are no longer visible today.
- 11 This strange decision to throw away archaeological finds at the beginning of a research project is not, however, the mark of a lack of interest in the finds. Indeed the first volume published from the excavations is entirely devoted to the metallurgical residues, and the activities possibly linked to these residues occupy a large place in the second volume. Both volumes appeared in 1969, only three years after his last excavation season in the delta.
- 12 Noting the absence of reliable archaeological data and discussions on the issue of ancient iron industry in Southeast Asia at the time,¹⁴ Harrisson stated that he was the first to have excavated sites devoted to ironworking activities in the region. This opinion led him to search for documentation in the archaeological literature relating to Iron Age, mainly European, as well as works on iron industry in general, in particular those relating to India and China. He also relied on ethnographic observations in Southeast Asia.¹⁵ Well aware that iron slag and clay cylinders represent residues of smelting and/or blacksmithing activities, he was nevertheless baffled by the fact that he did not find clear remains of any furnace in his excavations. Moreover, he noticed the absence of mentions of such metallurgical activities regarding the delta in ancient written sources, Chinese sources especially.¹⁶ This context led Harrisson to formulate, then modify or discard all sorts of hypotheses. Finally,¹⁷ he suggested that smelting practice to produce raw iron was the main ironworking activity at Sungai Jaong, following a process similar, but locally adapted, to that used in ancient times in South India and Sri Lanka. Part of this raw iron would have then been reheated in clay crucibles to make steel, according to the crucible steel process, hence the idea that a site like Sungai Jaong produced cylindrical ingots approximately one inch in diameter, based on the dimensions of the clay cylinder fragments found in the excavations. To both these activities Harrisson added forging for tools, on a smaller scale.
- 13 Other categories of finds from Sungai Jaong’s excavations are not overlooked but, with the exception of the gold objects, either total counts or even synthetic inventories are absent in the publications. According to Harrisson, two types of stone tools are associated with metallurgical activities: elongated oval pebbles in hard stone showing pitted percussion marks weighing less than 900 grams, interpreted as “hammerstones”; larger and heavier tools made of the same type of stone pecked to form a waist round the approximate centerline of the stone, interpreted as “waisted stones” used in particular to break the ore and to purify the raw metal (operation to separate iron slag from bloom).¹⁸
- 14 By the late 1960s, studies on Chinese stoneware from excavations were still few in Southeast Asia, as were excavation reports on dated production sites in China. Moreover the use of the radiocarbon dating method for Southeast Asian archaeological

sites was probably still very limited at the time. In this context, it is not surprising that Harrisson's absolute dating suggestions were not consistent from one publication to another. He asserted, however, that on the basis of the Chinese ceramics collected at Sungai Jaong, the occupation of the site "can be safely put around and before 1000 AD."¹⁹ Elsewhere, he published other chronological hypotheses whose combination would situate the beginning of the occupation by the turn of the 9th century CE, and even in the 7th century, and its end by the turn of the 11th century.²⁰

- 15 Sungai Jaong yielded another important set of artefacts, that of gold artefacts, in fact the sole type of artefact for which Harrisson published a detailed catalogue. He interpreted these fifty gold objects as grave or death ritual furniture or grave-related regalia, including notably the typical "leaf-shaped" foils with a median cut breach-slit.²¹ At least one sector of the Sungai Jaong site was therefore a burial ground.²²
- 16 During his excavations, Harrisson realised that Sungai Jaong rock art was not limited to the Batu Gambar carved in high relief. In fact he managed to document almost 100 engraved figures and marks on natural boulders. Moreover he noticed traces of debitage on a number of sandstone boulders, in the shape of roughly cut rectangular parallelepipeds.²³
- 17 Harrisson was convinced that Sungai Jaong was occupied by indigenous peoples, and that ironworking activities, rock carvings, burials and small finds were all contemporaneous. For him no doubt Sungai Jaong together with the other coastal sites in the Sarawak River Delta formed a major trade entrepôt over centuries.²⁴ It would take more than half a century before new archaeological research was carried out at Sungai Jaong.

New Archaeological Research at Sungai Jaong (2018, 2019, 2022)

a) Preliminary survey

- 18 The outlines of a new archaeological project devoted to the Sarawak River Delta were defined in 2017, through a cooperation between the École française d'Extrême-Orient and the Sarawak Museum Department. At the same time, the Sarawak Museum Department was in the final preparation stages of its Santubong Archaeological Park project, of which the Sungai Jaong site was one component. Previous visits to the site since 2012 left a positive impression of archaeological potential remaining intact since Harrisson's excavations, the limits of which were still clearly visible near the confluence of the Jaong River and the Raso Creek. Moreover, in a forested environment on the edge of the mangrove, the site did not seem to have been disturbed by any construction. The following year (2018), authorization was given to carry out a survey at Sungai Jaong in a mosaic of private plots.
- 19 The main purpose of this survey was to carry out bore holes using a hand-operated auger in order to try to obtain a large number of soil samples, the results of which would guide the choice of sectors to be excavated. Sixty-seven bore holes were thus augered at altitudes varying between 2.50 m and 12 m under difficult conditions: dense forest cover with many roots of various sizes, high density of large sandstone boulders both on the surface and at various depths, high density of iron slag. While 19 bore holes

did not reveal any iron slag, all the others yielded slag, the thickness of the deposit varying between a few centimeters to one meter, a purely indicative figure, since the deepest figure was linked to the limits of use of the hand-operated auger in this context. Despite the difficulties, this first fieldwork made it possible to delimit an area yielding traces of metallurgical activities and ancient artefacts, namely the slope of the hillock facing the Jaong River, which represents an area estimated between 7,000 and 9,000 m². Several areas dense with iron slag to be favored for future excavations were identified. This survey was also an opportunity to examine the state of a number of rock engravings and cut boulders already reported by Harrison. The acquisition of the site land by the State of Sarawak in the months following this survey paved the way for the conduct of excavations in 2019, resumed in 2022 after an interruption due to the Covid-19 pandemic.

b) Workshop floors related to metallurgical activities

- 20 Trench SJ1 (N 01° 43.016'; E 110° 20.694', 3 m x 3 m) was dug near the south limit of the large sector excavated by Harrison. A promising bore hole was carried out there in 2018 (CS-SJ66). At an altitude of about 4.60 m, SJ1 overlooks the Jaong River flowing about fifteen meters below. Unsurprisingly, the excavation has been hampered by the dense network of tree roots down to a depth of 40 cm, requiring the use of shears and even a saw. Scattered reddish soil fragments appearing from a depth of 15 cm indicate the proximity of a first workshop floor made of compact burnt clay mixed with metallurgical wastes. In fact the excavations revealed three sufficiently well preserved floors with more or less undulating profiles at depths between 20 and 55 cm.²⁵ These floors can be interpreted as working floors on which metallurgists have settled to develop their activities. A few centimeters thick, their colour varies from weak red to red²⁶ (fig. 5). Radiocarbon dating of a charcoal fragment sampled from floor no. 1, the closest to the current ground surface (-32 cm, alt. ca. 4.30 m), yielded a 13th century CE calibrated dating.²⁷ Floors no. 2 and no. 3 remain to be radiocarbon dated.

Fig. 5. Trench SJ1, east section showing working floors.



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- 21 The basal sterile layer is reached at a depth of about 80 cm. It is made up of sandstone in balls and very fine beige/whitish sands.²⁸ These detrital deposits have no specific organization and form a massive deposit. They are the product of the long physico-chemical weathering of the local sandstone substrate, facilitated by the hot and humid climate of Borneo. The sandstone, from the Tertiary era, is fragmented into large blocks, then altered into centimetric balls before complete degradation into fine unconsolidated deposits (sandy and silty). Seemingly devoid of organic remains, this layer will probably prove difficult to date.
- 22 Remains of workshop floors are not specific to trench SJ1. Cleaning of two soil profiles nearly a meter thick, marking the limit of Harrisson's excavation some fifteen meters southwest of SJ1, revealed five floors separated by layers of tap slag, reflecting the disposal of the wastes during or after the smelting processes (**fig. 6**). Radiocarbon dating of a charcoal fragment extracted from the floor closest to the current ground surface (ca. -35 cm, alt. ca. 4.00 m), yielded a calibrated dating between the 10th and early 11th century CE.²⁹ Here also, the deepest floors remain to be radiocarbon dated.

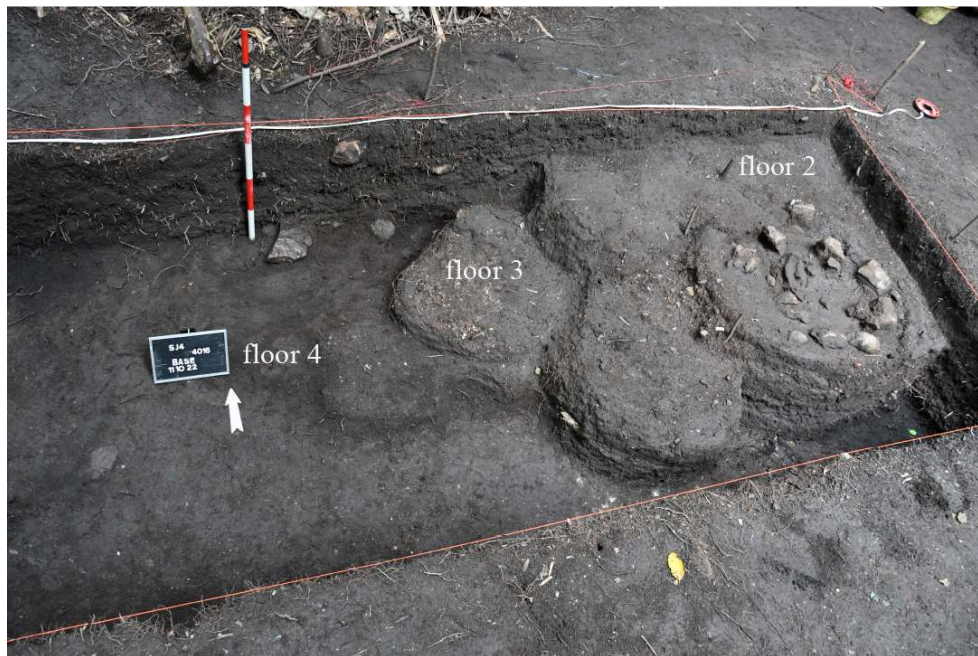
Fig. 6. Refreshed section from T. Harrison's excavations showing working floors.



© S. Leroy, July 2019.

- 23 In one of his publications, Harrison indeed mentions “one or more layers of heavily impacted soil often burned in color, packed hard”, that he was forced to smash in order to pursue a “properly layered excavation”.³⁰ Therefore, eager to follow the arbitrary level spit method, he actually passed through remains of ancient structures without questioning their possible link with the metallurgical activities.
- 24 Some 70 meters to the northeast of SJ1, trench SJ4 (N 01° 43.061'; E 110° 20.710', 5 m x 2 m) was opened in September 2022 on the crest of the hillock, at an altitude of about 12.50 meters. Here too, a compact layer of mixed material made of burnt clay with metallurgical wastes (10R4/3-weak read) was revealed in the northeast corner of the trench, about 20 cm below the current ground surface. This first section of working floor (SJ4-FL1, alt. ca. 12.34 m) is approximately 3 cm thick. The continuation of the excavation in SJ4 in fact revealed four other successive vestiges of working floors (**fig. 7**), at the following approximative depths: 26 cm (SJ4-FL2, alt. ca. 12.28 m), 51 cm (SJ4-FL3, alt. ca. 12 m), 67 cm (SJ4-FL4, alt. ca. 11.84 m), and 84 cm (SJ4-FL5, alt. ca. 11.62 m). Radiocarbon dating of charcoal fragments extracted from floors FL2, FL3 and FL5, yielded the following respective calibrated dates: late 12th-13th century CE,³¹ mid-11th-late 12th century CE,³² mid-11th-mid-12th century CE.³³ The other floors remain to be radiocarbon dated. Apart from preserved areas, in SJ4 the sterile layer³⁴ was reached at a depth of about 90 cm.

Fig. 7. SJ4: successive vestiges of working floors.



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c) Furnaces remains

- 25 Again in trench SJ4, remains of a circular structure made of stones appeared about twenty centimeters below the current ground surface near the east limit of the trench (**fig. 7**). The size and shape of this structure, partially set in a pit some 25 cm deep, allow it to be linked with high probability to the base of an iron ore reduction furnace consisting of a circular stone layout (about 80 cm in diameter) partially covered with a clay coating on the inner side (**fig. 8**).

Fig. 8. SJ4: remains of iron ore reduction furnace.



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- 26 It turns out that the second working floor (FL2) partially covers the wall of the pit housing the base of this furnace. This working floor is therefore contemporaneous with the furnace, and the radiocarbon dating mentioned above, that is late 12th-13th century CE, is also relevant for this structure. The base of the stone wall, of which at most three levels remain, is covered with a clay coating or lining about 5 mm thick on its concave internal part. These stones are heterogeneous, at the same time through their natures, their shapes and their sizes. In fact, this structure includes both roughly cut blocks of sandstone showing traces of heating and large oblong pebbles in hard material.³⁵ At least three of these pebbles show a groove round the approximate centerline of the stone. These “waisted stones”, according to Harrison’s terminology, have very clearly been reused to build (or rebuild) the furnace. The state of the remains does not allow to easily deduce, at this stage of the research, the details of the smelting operation and the related technical elements, such as the supply air mechanism used and the elevation of the superstructure. The heterogeneity of the remaining technical elements as well as the absence of the superstructure might suggest the dismantling of the walls after each smelting process to pull out the raw metallic mass.
- 27 Although data are still lacking on some technical details, the nature of the excavated structure, the organization of the remains, and the tap slag found nearby the base of the structure represent the first sufficiently clear evidence of an ancient iron smelting furnace in the Santubong region, and more generally in the Sarawak River Delta. It could even be the first iron smelting furnace dated late 12th-13th century CE identified so far on the whole island of Borneo.
- 28 These furnace remains in SJ4 need to be linked to remains found in the excavations of trench SJ2 (N 01° 43.020'; E 110° 20.707', 4 m x 2.5 m), extended on its west side through trench SJ3 (1 m x 1.6 m), located at an altitude of about 4.80 m, at the foot of the hillock, about twenty meters northeast of SJ1. The bottom of a probably circular stone

structure (smelting furnace? smithing operation?) with blocks showing traces of heating was observed near the northern wall of SJ2, at a depth of about 60 cm. A boulder close to these remains seems to have been round cut (furnace wall?). In SJ3, at a depth of about 25 cm, a composite find, made of a number of layers looking like lining layers (**fig. 9**), was probably part of a base of an iron smelting furnace having undergone several successive repairs.

Fig. 9. SJ3: base of unit 3003 showing the composite find (to the right of the signboard) and the reddish sandstone block (in the centre of the picture).



© D. Perret, September 2022.

- 29 At the boundary between trenches SJ2 and SJ3, a parallelepiped-shaped sandstone block (approx. $50 \times 15 \times 10$ cm), clearly showing reddish traces of heating, was uncovered in 2019 (**fig. 9**). This discovery is a clue to explain the block-cuts in boulders. Sandstone boulders were cut into rectangular parallelepiped-shaped blocks to be used directly or roughly recut into smaller blocks intended for the building of iron smelting furnace walls. Moreover, the excavation of SJ2 uncovered a boulder showing traces of unfinished cutting (**fig. 10**), and the bottom of the trench, at a depth of about 50 cm, is strewn with sandstone blocks of various sizes and shapes, which were either intended for the building of furnace walls, or represent the scattered remains of dismantled furnaces. Invisible when the excavation started in 2019, this boulder was totally covered by the accumulation of metallurgical wastes, especially iron slag, resulting from the multiple successive smelting operations carried out over time.

Fig. 10. SJ2: sandstone boulder showing traces of unfinished cutting.



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- 30 Once again, Tom Harrison noticed these traces of “rough but strong parallelograms”, but he tried to decipher a symbolic meaning behind these shapes³⁶ without thinking of the possibility of a more prosaic link with the metallurgical activities.

d) Small finds

- 31 Amounting to five tonnes from five trenches for a total surface area of 43 m² and a depth rarely exceeding one meter, the large quantity of iron slag is typical of a site devoted to iron smelting activities. The vast majority of the slag is made up of small-sized fragments, classified as tap slag, that is slag flowing outside the furnace, taking various shapes: plates, simple or superimposed cords. Internal slag, that is slag remaining in the furnace during the smelting process, and cooled inside the furnace, remains rare so far in the Sungai Jaong excavations, or proves difficult to differentiate very clearly. The weight of the fragments uncovered in the excavations rarely exceeds a few hundreds grams,³⁷ and the majority does not show a length superior to a few centimeters.
- 32 The comparison of iron slag densities per litre of excavated sediment (see **table 1**) is enlightening insofar as those of the trenches located at the foot of the hillock in the western part of the site (SJ1, SJ2-SJ3) are ten times higher (respectively 341 g/l and 505 g/l) compared to those of the two other trenches, namely SJ4 at the top of the crest of the small hillock (37 g/l) and SJ5 (45 g/l) some 90 meters northeast of SJ2, that is a little upstream on the Jaong River.

Table 1. Iron slag density (g/liter) at Sungai Jaong site (2019 and 2022 excavations).

Trench	Surf. area (m ²)	Vol. of exc. sediment (l)	Iron slag (kg)	Density (g/l)
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SJ1	9	4,419	1,507	341
SJ2-SJ3	11.6	5,707	2,884	505
SJ4	10	6,224	234	37
SJ5	12.5	8,384	381	45
Total	43.1	24,734	5,006	

- 33 From the entire set of sorted slag and metallurgical wastes, a total of fifty samples of tap slag from the Sungai Jaong excavations have been selected so far for compositional analysis, with the objective of determining the chemical fingerprint of the iron ore(s) used for the reduction as well as the characteristics of the processes implemented locally. Analyses will be conducted through Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Atomic Emission Spectroscopy (ICP-AES)³⁸ in order to quantify both trace and major elemental composition of the samples. The compositional analyses from this production site will be compared by applying a specific methodology based on the determination of chemical signatures and statistical data processing.³⁹ This method will finally allow us to highlight any variation in chemistry in space and time on the site, as well as variations linked to the use of different types of ores and/or the implementation of various reduction processes. It will also help us to hypothesize the nature of the metal (iron or steel) locally produced. On a more general level, these data will feed a reference database in order to improve current knowledge on the iron production and exchange or distribution of iron products in the region but also more widely in Southeast Asia for this period.
- 34 Still in connection with metallurgical activities, the excavations yielded just over 250 kg of fragments of mixed material composed of burnt clay and metallurgical wastes, fragments among which it is often difficult to distinguish fragments of working floors from fragments of lining (furnace walls).
- 35 While the 2019 excavations yielded only two grooved stones (in SJ1), identified as “waisted stones” by Harrison in his own excavations, the 2022 excavations yielded 15, all in SJ4, including three reused in the furnace wall. Apart from this clear and very interesting occurrence of reuse, the function of these “waisted stones” in the context of metallurgical activities in Sungai Jaong remains enigmatic. They may have been used as hammering or crushing tools.
- 36 Excavation of the five trenches also yielded almost thirty kilograms of tuyères,⁴⁰ mainly represented by some 2,400 fragments of clay “cylinders”. Harrison had suggested interpreting these artefacts as crucibles, but this interpretation has since been refuted twice by identifying them as tuyères.⁴¹ From the rapid investigation of the 2019 and 2022 finds during the drying and cataloguing stages, the identification as tuyères is confirmed, an observation that at the same time provides some clues regarding the air supply mechanism related to the furnaces. The fact that complete specimens are absent could be related to the dismantling or cleaning phases of the furnaces, which do not allow the reuse of the tuyères in their original state. The comparison of tuyères densities between the five trenches gives a heterogeneous picture showing wide variations (see **table 2**).

Table 2. Tuyères densities (g/liter) at Sungai Jaong site (2019 and 2022 excavations).

Trench	Surf. area (m ²)	Vol. of exc. sediment (liters)	Tuyères (g)	Density (g/l)
SJ1	9	4,419	4,105	0,93
SJ2-SJ3	11.6	5,707	2,808	0.49
SJ4	10	6,224	7,436	1.19
SJ5	12.5	8,384	14,544	1.73
Total	43.1	24,734	28,893	

- 37 The relevance of the density figure for trench SJ5 needs to be qualified. Indeed, the location of this trench, just at the bottom of a relatively steep slope in this area, was chosen with the idea that many small finds would have accumulated there naturally through runoff, thus yielding a representative sample of the variety of artefacts in use throughout the period of occupation of the site (fig. 11).

Fig. 11. SJ5, a few meters away from Sungai Jaong, at the foot of the hillock.



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- 38 The excavation of SJ5 did not reveal any indubitable traces of in situ metallurgical activity or dwelling (postholes for example). The natural accumulation process in SJ5 is confirmed by the densities of earthenware and stoneware sherds, which prove very much higher than the densities observed in the other trenches (see table 3).

Table 3. Earthenware and stoneware densities (sherds/liter) at Sungai Jaong site (2019 and 2022 excavations).

Trench	Vol. of excavated sediment (l)	Earthenware (sherds)	Density (sherds/l)	Stoneware (sherds)	Density (sherds/l)
SJ1	4,419	71	0.016	107	0.024
SJ2-SJ3	5,707	145	0.025	61	0.010
SJ4	6,224	380	0.061	83	0.013
SJ5	8,384	2,104	0.251	571	0.068
Total	24,734	2700		822	

- 39 A quick examination of the earthenware sherds reveals that the vast majority belongs to fine paste wares, a very atypical feature compared to contemporaneous settlement sites elsewhere in Maritime Southeast Asia. What is certain is that the containers include water vessels (*kendis*).
- 40 Amounting to just over 23 percent, the proportion of stoneware in relation to all the sherds comprising stoneware and earthenware is quite comparable to that of contemporaneous coastal settlement sites in northern Sumatra, for example Kota Cina on the Strait of Malacca (26 percent) and Barus-Bukit Hasang on the west coast (25 percent).⁴² Although indubitable traces, such as postholes, remain elusive, this statistic suggests that Sungai Jaong was inhabited more or less permanently at the same time as metallurgical activities were conducted. On this aspect, the preliminary study carried out in 2019 by Tang Hui and Bing Zhao⁴³ on nearly 200 stoneware sherds from SJ1 and SJ2-SJ3 revealed the predominance of 12th-13th-century vessels, an observation fitting very well with the results of radiocarbon datings carried out so far.
- 41 The other finds are quantitatively very marginal. Rather surprisingly, iron artefacts are rare: SJ4 and SJ5 have yielded four nails and some 40 fragments, possibly originating from only a couple of iron implements. The rest of the finds includes less than 20 glass beads, a single glassware sherd, and several fragments of elongated faceted stones found in SJ5.

Conclusion

- 42 The survey conducted in 2018 at Sungai Jaong led to the identification of the most promising area to conduct excavations. It covers the slope of the hillock facing the course of the Jaong River, between its confluence with its tributary, the Raso Creek, and the anthropomorphic sculpture in high relief called Batu Gambar located a few hundred meters upstream at the foot of the hillock on the bank of the Jaong River.
- 43 Despite an excavated surface area limited to five trenches covering some 40 m², fieldwork carried out in 2019 and 2022 revealed remains of structures that had escaped the attention of the first diggers active on the site between the turn of the 1950s and 1966. These remains include successive floors of iron smelting workshops made up of a more or less compact layer of burnt clay a few centimeters thick, mixed with

metallurgical wastes. Thirteen floors have been identified so far, including eight at the foot of the hillock and five on its ridge. Radiocarbon dates obtained on five of these floors place metallurgical activities at Sungai Jaong between the 10th and 13th centuries, but the presumed oldest floors at the foot of the hillock remain to be dated.

- 44 On the top of the hillock, one of the floors (in trench SJ4), is associated with a circular iron smelting furnace partially buried, laid out using heterogeneous stones. It could be the first iron smelting furnace dated late 12th-13th century CE identified so far on the whole island of Borneo. Other, more tenuous remains of furnaces have also been identified at the foot of the hillock (in SJ2-SJ3). The use of stones to build the furnace walls explains why sandstone boulders were cut into rough rectangular parallelepipeds on the site.
- 45 The 2019 and 2022 excavations produced five tons of very irregularly distributed iron slag over the site, indicating, at this stage of the research, that the metallurgical activities were most intensively conducted at the foot of the hillock, near the confluence of the Jaong River and Raso Creek. It is unfortunately on this sector that Harrison concentrated his extensive excavations between 1952 and 1966. Still in connection with the metallurgical activities, the recent excavations yielded tuyères whose distribution on the site as well as their typo-morphology vary widely, variations perhaps related to the use of different technological processes. Grooved stones found in two trenches (SJ1, SJ4) may have been used as hammering or crushing tools.
- 46 Other finds include earthenware sherds, almost exclusively belonging to the fine paste category, a feature which distinguishes Sungai Jaong (and probably the neighboring sites of the delta), from contemporaneous settlement sites elsewhere in Maritime Southeast Asia, whether in Peninsular Malaysia, Java, or Sumatra. As for the stoneware, the preliminary observations on the sherds collected during the 2019 excavations indicate vessels contemporaneous with the metallurgical activities on the site. The earthenware/stoneware proportion agrees well with figures obtained for other contemporaneous coastal settlement sites in Maritime Southeast Asia.
- 47 The excavation season planned for 2023 will aim to discover other remains of metallurgical activities, in particular furnaces, if possible better preserved and associated with the oldest workshop floors. Such a discovery would allow us to observe the continuity or the possible changes in iron smelting processes during the three or four centuries (or more) of metallurgical activities at Sungai Jaong. The uncovering of other workshop floors figures also among the objectives, since such structures have usually good potential to date metallurgical activities. In this regard, new samples will be taken from the presumed oldest floors in trench SJ1, as well as from one or more sections still clearly visible from Tom Harrison's excavations. Moreover this third season will also endeavour to enrich the various categories of small finds and hopefully to reveal traces of dwelling structures.
- 48 Lastly, further investigations are planned in order to define the geomorphological contexts of the site and to supplement the lithostratigraphic data already collected. Hopefully, this new fieldwork phase will help to understand the interactions between the ancient occupation of the site and the environment over the *longue durée*.

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NOTES

1. Considering that this is the site surveyed by Doherty *et al.* in March 2006 (cf. DOHERTY *et al.* 2007). While Doherty *et al.* do not mention the name of Kampong Ayer, just 40 years earlier Tom Harrison conducted excavations there and provided indications on its location which fit with the information given by Doherty *et al.* (cf. HARRISSON & O'CONNOR 1969a, p. 8, 14, 30).
2. These biographical elements are taken from HEIMANN 1997.
3. HARRISSON & O'CONNOR 1969a, p. 10.
4. "picture rock".
5. HARRISSON 1949, p. 88, 91.
6. HARRISSON & O'CONNOR 1970, p. 8.
7. HARRISSON & O'CONNOR 1969a, p. 10, 28-30.
8. HARRISSON & O'CONNOR 1969a, p. 5, 10, 27-29, 37-40.
9. HARRISSON & O'CONNOR 1969a, p. 7.
10. HARRISSON & O'CONNOR 1969a, p. 34, 37-38, 41.
11. HARRISSON & O'CONNOR 1969a, p. 17, 34.
12. For a first observation by the end of the 1940s, cf. HARRISSON 1949, p. 87-88.
13. HARRISSON & O'CONNOR 1970, p. 6.
14. HARRISSON & O'CONNOR 1969a, p. 97.
15. HARRISSON & O'CONNOR 1969a, p. 5, 70, 72; HARRISSON & O'CONNOR 1969b, p. 341, 344sq.
16. HARRISSON 1967, p. 143; HARRISSON & O'CONNOR 1969a, p. 24; HARRISSON & O'CONNOR 1969b, p. 225.
17. See especially HARRISSON & O'CONNOR 1969a, p. 68, 103, 155, 164, 167; HARRISSON & O'CONNOR 1969b, p. 225, 247, 330, 332; HARRISSON & O'CONNOR 1970, p. 139.
18. HARRISSON & O'CONNOR 1969a, p. 26, 239-240.
19. HARRISSON & O'CONNOR 1970, p. 8.
20. HARRISSON & O'CONNOR 1969a, p. 19-20; HARRISSON & O'CONNOR 1970, p. 4; ZAINIE 1967, p. 85.
21. HARRISSON & O'CONNOR 1969b, p. 251; HARRISSON & O'CONNOR 1970, p. 34-38, 45, 53.
22. Harrison mentions that the surface area of this sector rich in gold artefacts was about 627 m² (HARRISSON & O'CONNOR 1970, p. 8), therefore slightly larger than our estimate based on the trenches remaining visible.
23. HARRISSON & O'CONNOR 1969b, p. 277-279; HARRISSON & O'CONNOR 1970, p. 111-114.
24. HARRISSON 1967, p. 143; HARRISSON & O'CONNOR 1969b, p. 278; HARRISSON & O'CONNOR 1970, p. 3-5, 117, 137, 197.
25. In the eastern section of the test-pit carried out in SJ1 in 2022.
26. 10 R 4/3 (weak red), 10 R 4/4 (weak red), and 10 R 4/6 (red) (Munsell Soil Color Chart).
27. Sample SJ1-2022-FL1, DirectAMS 049019 (Dec. 2022), 787±27 BP, OxCal 95.4%: 1220-1278 AD.

28. 10YR7/2 (light gray) + 10YR5/3 (brown).
 29. Sample SJ-SOL-1-2019, DirectAMS 034545 (Aug. 2019), 1071±23 BP, OxCal 95.4%: 925-1025 AD.
 30. HARRISSON & O'CONNOR 1969a, p. 69.
 31. Sample SJ4-2022-FL2, DirectAMS 049023 (Dec. 2022), 819±22 BP, OxCal 95.4%: 1179-1270 AD.
 32. Sample SJ4-2022-FL3, DirectAMS 049024 (Dec. 2022), 920±23 BP, OxCal 95.4%: 1038-1203 AD.
 33. Sample SJ4-2022-FL5, DirectAMS 049026 (Dec. 2022), 946±23 BP, OxCal 95.4%: 1034-1158 AD.
 34. Brown and grayish sand: 10YR5/1 (dark grey), 10YR5/3 (brown), 10YR7/2 (light gray).
 35. In the Santubong region, these materials are igneous rocks, mostly of gabbros and dolerites types, as well as hardened (hornfelsed) shale (DOHERTY *et al.* 2007, p. 67).
 36. HARRISSON & O'CONNOR 1969b, p. 278-279; HARRISSON & O'CONNOR 1970, p. 114.
 37. Harrisson reports a nine-kilogram slag in his 1952 excavations, unfortunately without indicating the exact location of this quite exceptional discovery compared to the results of recent excavations (HARRISSON & O'CONNOR 1969a, p. 29).
 38. For comparison purpose, fifteen samples from two other sites in the delta (Bongkissam and Sibulaut) have been selected so far for the same types of analyses.
 39. Developed in details in LEROY *et al.* 2012, p. 1080-1093.
 40. Clay nozzles for the piston bellows used for stoking the fire.
 41. CHRISTIE 1988, p. 15-16; DOHERTY *et al.* 2007, p. 73.
 42. PERRET forthcoming, appendix, table 5.
 43. CNRS, UMR 8155, Paris, France.
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INDEX

Year of Investigation: 2018, 2019, 2022

subjects <https://ark.frantiqu.fr/ark:/26678/pcrtbptj4SOA1W>, <https://ark.frantiqu.fr/ark:/26678/pcrtET0l280TUS>

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