The Granite Chaos at Huelgoat in Brittany: The product of millions of years erosion, or a sudden catastrophe?

Martin Johnson* and M.J. Austin**

Abstract

This paper reviews the historic and accepted explanations requiring millions of years of erosion for an unusual geological feature, the granite Chaos at Huelgoat in central Brittany, where huge granite boulders are jumbled together along a narrow valley. The geological evidence from the site does not support such a gradualist explanation, and is consistent instead with a sudden catastrophic flood of water such as might be caused by an outburst flood. The present geography of the site shows that a lake of sufficient size could once have been retained in the valleys upstream of the Chaos, by a natural dam across the present location of the Chaos. Archaeological evidence from nearby Palaeolithic, Mesolithic, and Iron Age sites coupled with Roman history points instead to an event in the time range 3,000–4,000 B.P. Supposedly anomalous radiocarbon dates, once adjusted in line with errors such as have been found in radiocarbon dating in the wider region, support this analysis, but call into question the currently accepted dating of the Palaeolithic and Mesolithic eras. This suggests that the events at this location were much more recent and possibly contemporary with Bronze Age cultures in the Mediterranean region.

Introduction

The small town of Huelgoat in Brittany, the westernmost province of France, has given its name to the granite massif in which it sits—today a heavily wooded area. The word Huelgoat means "high forest" in Breton (a Celtic language). The region was home to lead and silver mining for around 2,000 years, and the small lake alongside the town was first created some 300 years ago to provide water for powering machinery used in mining processes.

A principal tourist attraction of the town is the Chaos; a field of enormous granite boulders found in the small valley extending from the present outfall of the lake to approximately 500 m down the valley (Figures 1, 2, and 3). While many of these boulders, which range in size from around one to greater than 100 cubic meters, give the appearance of having been rounded in flowing water, their sheer size has led to their causation being attributed to the result of erosion and onion-skin weathering (e.g. Bellard, 2001; Chauris, 2008).

The geologists researching this area have likely not suggested that the

* Martin Johnson, independent researcher

** M.J. Austin, Harrison Group Environmental Ltd., Norwich, UK

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boulders were caused by high-level river flows for two reasons. First, the farthest watershed points of this valley system in the Monts d'Arrée are only eight to ten kilometers distant from the Chaos, with maximum stream lengths (e.g. the Fao river; the larger of two small streams feeding the present lake) of around 10–12 km.

Second, while most of the boulders are at the bottom of the valley, some remain lodged high up on the valley side, including the "Roche Tremblante" (Trembling Rock), which is 7 m long and 3 m high, with an estimated weight of 137 tons. It is located just above the 175-meter contour and presumably originated at an even higher point. This is about 15 meters above the valley bottom, and there are several other large and rounded boulders at or above this level.

It is highly improbable that a river (as opposed to an outburst flood) could have formed at any time with a depth of 20 m or more in this valley system. As will be seen below, the evidence shows that there has never been any river flow of significant force through this valley since the boulders were formed. This conclusion was reached by examining the bases of several boulders and observing the lack of any undercutting of the large boulders in the valley bottom at their bases, as would be caused by smaller rocks abrading their bases during such a flow.

A study of the boulder field in 2019 by the authors shows that the weathering explanations overlook contradictory evidence from the Chaos itself. This evidence is more consistent with the effects of a massive flow of water cutting away the clay layers between the granite beds, which then collapse and break up. Then, the broken rocks in a turbulent water flow jumble up to produce the rounded boulders we can now see.

An explanation from local folklore is that these boulders are really "polished pebbles from the sea," thrown there by an angry giant seeking to punish the

Figure 1. Start of Chaos, beside old ore-crushing mill. Boulder diameters over 10 m (people circled for scale).

Figure 2. Approximately 150 m down the Chaos. Boulder diameters over 5 m (people circled for scale)

Figure 3. Approximately 300 m down the Chaos, boulders 1–2 m diameter.

people of Huelgoat (Finistère Tourisme, 2019). We shall see that this story contains some observations more in line with the actual evidence than the explanations relying on erosion and weathering.

The Huelgoat massif is one of the highest regions in central Brittany. Set far away from any present, major water sources, it is approximately 30 km south of the north coast at Morlaix and 50 km east of the west coast at Brest (see Figure 7).

We will consider the possibility that there was once a much larger lake than the present one, retained by a natural dam. We suggest the failure of such a dam could have released sufficient water to cause the formation of the "giant pebbles" of the Chaos. We will explore the possible time period for when this could have happened and consider geological and archaeological evidence for a late Pleistocene event. We will also consider evidence placing that era much more recently than secular dates of ten- to twelve-thousand years ago. This not only has implications for the dating of the end of the Ice Age, but also the Palaeolithic and Mesolithic periods. The evidence will show that the best explanation for the Chaos at Huelgoat is a glacial lake outburst flood, near the end of the Ice Age.

Huelgoat geology

The Huelgoat massif forms an ellipse about 10 km by 15 km, approximately 100 km^2. It is composed of several different types of granite with different chemical, mineralogical, and granular compositions. The Huelgoat granite found near the town itself (and in the Chaos) is a medium- and large-grained rock, light gray to dark gray-blue, with potassium-feldspar megacrystals and euhedral cordierite. Several probable fault lines have been identified in the area, including one running NW–SE just to the north of Huelgoat, and another running SW–NE just 2 km south of Huelgoat, along the southern edge of the massif (Castaing et al., 1984, pp. 2–14; Castaing et al., 1988b, pp. 3–18; Castaing & Debeglia, 1990). Figure 4 gives a perspective view of the Huelgoat Massif with the Monts d'Arrée, the highest ridge, running southwest to northeast along the northern side, showing Huelgoat and its valley system in the upper right quadrant, and the much larger valley system containing the Reservoir St. Michel at the center (retained by a hydro-electric dam).

The first "geological" attempt at explaining all these rounded granite boulders near Huelgoat, both those in the Chaos and others scattered on nearby hillsides, was by Alexander von Humboldt, who visited the area in 1813. He thought that they were basically bubbles of molten granite that had somehow risen up through lower layers of molten rock, which had eventually become exposed as a result of long erosion (Humboldt, 1823). This idea was dismissed long ago, and it is generally accepted that a granite Chaos is formed as a result of erosion, the fracturing of granite layers into blocks, and then an "onion skin" weathering process affecting thin outer layers of the rock, which rounds off the shape of the blocks (Chauris, 2008), as illustrated by Vincent Bellard below (Figures 5 & 6). Chauris (2008) has shown that there were once many more, very large exposed boulders in the Huelgoat area, but several have been cut up and used as building stone. This does not seem to have affected the Chaos as much as boulders in more easily accessible locations.

The final stage is the erosion of the ground around the blocks, which fall under gravity into the valleys where a Chaos may be found. It is perhaps noteworthy that expert geologist Christian Castaing, who has studied this area very thoroughly, seems to avoid this explanation (e.g., Castaing et al., 1988b, p. 17).

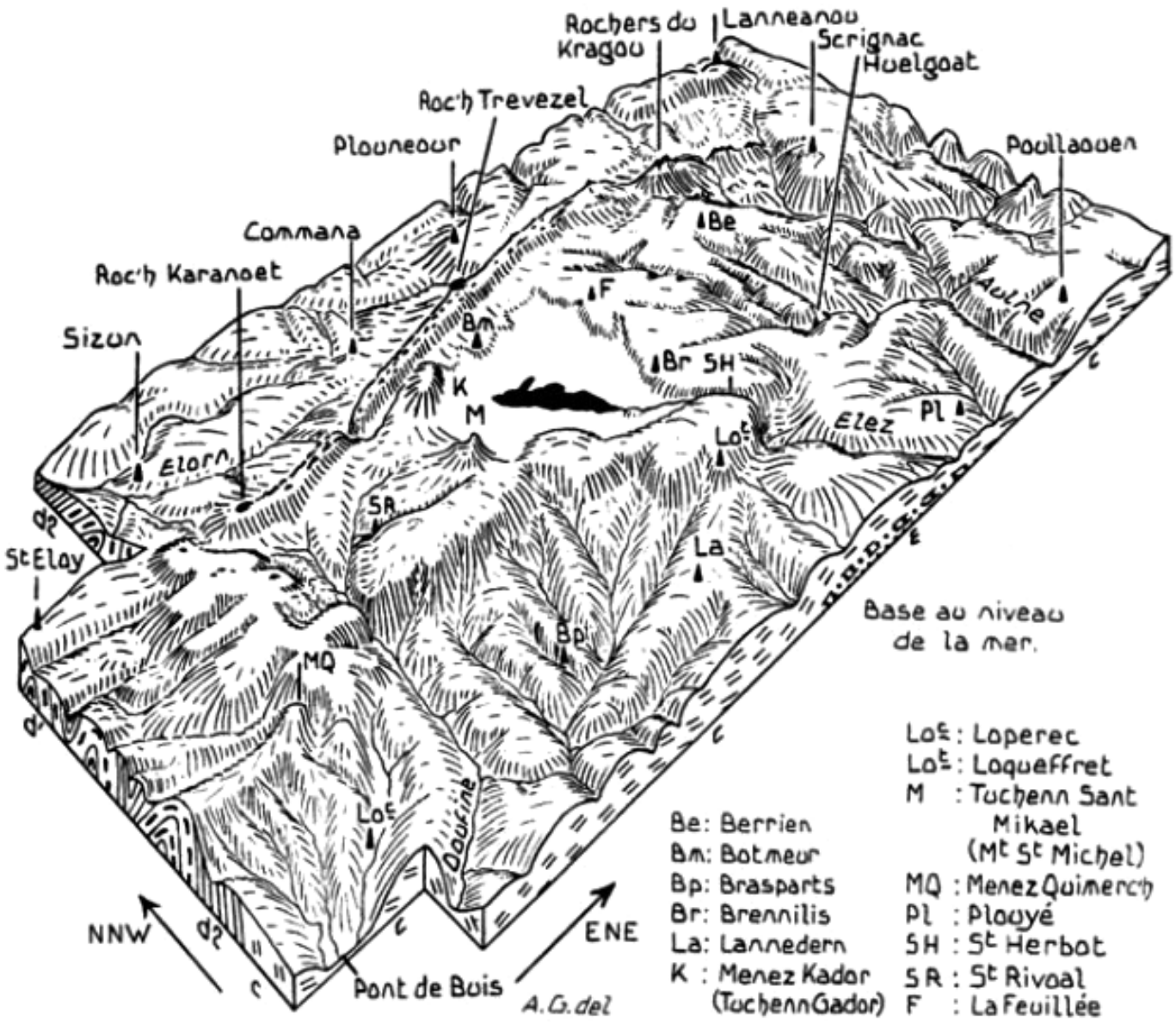

Figure 4. Perspective view of the Monts d'Arrée and Huelgoat Massif (Guilcher, 1949).

The evidence in the Huelgoat Chaos

The authors visited the Huelgoat Chaos in August 2019, and made the following observations:

1. The average boulder size decreases downstream along the length of the valley, from diameters in the order of greater than 10 m close to the present lake (see Figure 1), down to about 1–2 m diameter at 400 m downstream (Figure 3).
2. Many of the boulders at the start of the Chaos are angular in shape, becoming more rounded further down the valley.
3. This valley and others in the area are "V" shaped, indicating no major glaciation has taken place.
4. The boulders are Huelgoat granite, the same as exposed bedrock.

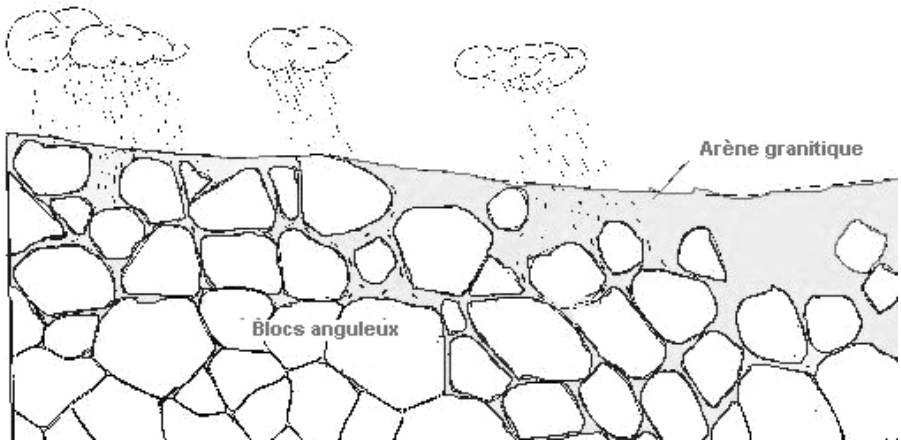

Figure 5. Stage 1 of Chaos formation: water and frost action fissures granite layers into blocks

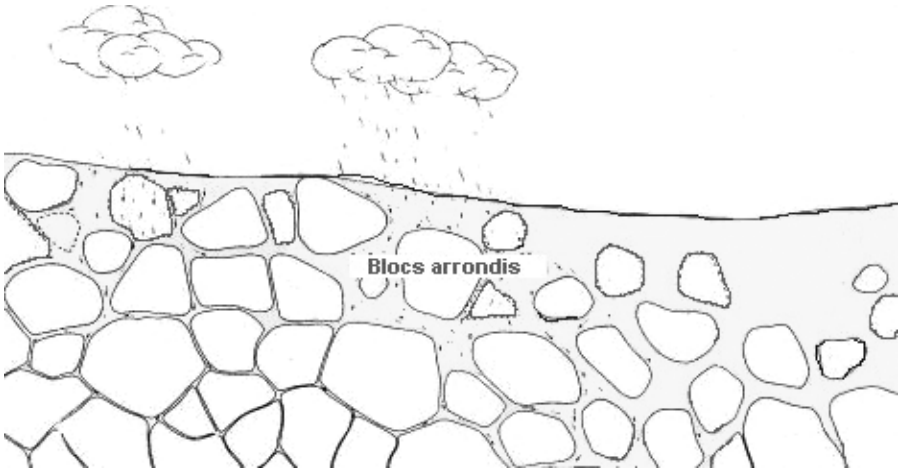

Figure 6. Stage 2 of Chaos formation, "Onion-skin" weathering rounds off edges of blocks in layers through water and frost action in outer layers of blocks.

5. The boulders show a lack of any significant weathering, despite the high rainfall and temperate climate of the region.
6. There has been no noticeable erosion of the lower boulders by the existing river (i.e., a lack of undercutting which would be expected if there had been a strong waterflow tumbling smaller stones against the base of the large boulders over any significant period of time).

Taken together, this evidence points to the creation of the Chaos having been the result of a single event involving a massive flow of water over a relatively short space of time, and no more than a few thousand years ago. There would have been less sorting of the boulders by size along the valley if the flow had been of a long duration; large boulders would have been broken up and moved further downstream. The progressive rounding of the boulders down the valley also shows that there was too short a time to have rounded off the ones at the start.

The lack of evidence for glaciation, especially in this valley, rules out the possibility that this was a glacial moraine, as has been suggested for a much smaller Chaos near St Herbot, some 8 km away (Le Bel, 1920). Saint Herbot can be identified in Figure 4, by the initials "SH" near the outflow valley from the Reservoir St Michel (center), raising the possibility that this chaos may also have been caused by an outburst flood.

Huelgoat archaeology

On the top of a ridge 1 km north of Huelgoat is the Camp d'Artus; a large Iron Age Hill Fort which was excavated by Sir Mortimer Wheeler in 1938. He considered that it was constructed prior to the Roman invasions of the 1st Century BC and abandoned not long afterwards. Close by on the same ridge were silver and lead mines that had been worked at that time. It is thought to have been the main center for the Osismes, a Gallic (Celtic) tribe, which then occupied the region. The ongoing mining for silver and lead in the area, together with the quarrying of granite for buildings, means that few traces of the early mine workers and their activities remain (Duval, 1959). The locations of their mines, below this ridge, and at the edge of the massif just to the east of the town, however, means that the event which created the Chaos must have happened prior to the Celtic occupation of the area. That event could have exposed the seams of silver and lead ore which the Celtic metal workers discovered and mined.

The Osismes are believed to have arrived in Finistère around the middle of the first millennium BC (though the first written records showing their existence are those of the Roman invasion of 51 BC). The next main population movements into the region are the migration of more Celtic peoples (Ancient British) from the British Isles during the 4th and 6th centuries AD (Éveillard, 2015). This indicates a continuity of Celtic (now Breton) culture spanning some 2,500 years in this area.

Two km northwest of Huelgoat, the remains of a stone-age site have been excavated in and near the rock shelter of Kerbizien (Marchand et al., 2014). This site is near the 231 m summit located 750 m northwest of the village of Kerbizien (Figure 8). Thousands of stone tools and fragments have been found at this site. Many of these artifacts have been identified as Azilian (a late-Palaeolithic culture usually found much further south in Europe), as well as others from the Mesolithic era. On conventional chronology, this indicates occupation during a period about 12,000–5,000 BP. The lack of bones found at this site has been explained by the acid nature of the soil. Above the Azilian material, small quantities of wind-blown loess were identified in positions indicating they were deposited by northerly winds. This suggested to the archaeologists that a suddenly warming climate happened at the end of the Ice Age during the Bølling-Allerød period (ca 14,700–12,700 BP). There was no evidence found of Neolithic Bronze or Iron-Age occupation. The archaeologists were puzzled by two aspects, first, why this site was abandoned, leaving large quantities of usable tools, and second, how they managed for a water supply, being so far from and high above any obvious present-day water sources.

The archaeologists reported finding many charcoal fragments (mainly hazel) among the Azilian material, which were carbon dated to between 3,980 and 5,220 BP. They concluded that these dates were incorrect (among late-Palaeolithic artifacts), and that these must have been intruded by burrowing animals and water circulation. The fact that this process should also have mixed Mesolithic and Azilian artifacts (but did not) was not considered. This fails to address the question of what might have happened to charcoal remnants from the cooking fires of the Azilian occupants over centuries or even millennia. If the ground was capable of preserving the charcoal fragments that were found, then it should have preserved more ancient examples too. Figure 7 shows the distribution of known Azilian and Mesolithic sites in Brittany, with Kerbizien included.

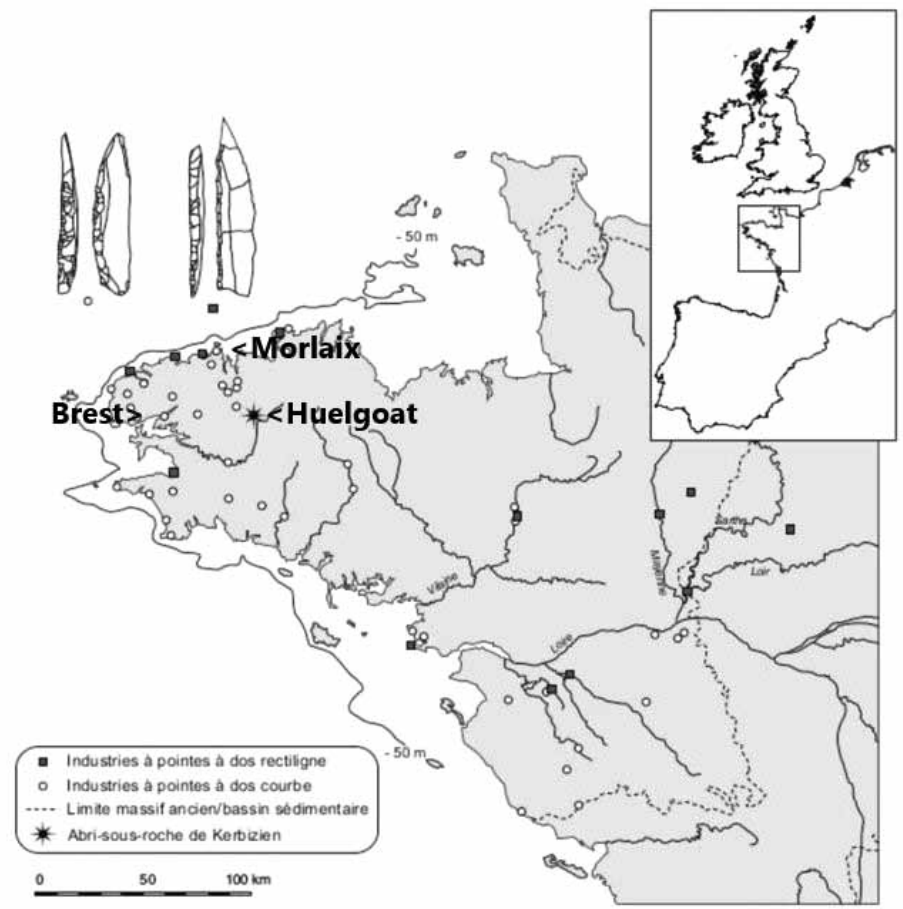

Figure 7. Map showing Azilian and Mesolithic sites in Brittany, including Kerbizien. Typical "curve-back" Azilian implements shown compared with "straight back" Mesolithic implements (Marchand et al., 2014).

A possible late-Ice Age lake

A study of the terrain shows that if the valley where the Chaos is now was blocked in the past, a lake would form and could easily rise above the 200 m contour. The present lakebed is about 160 m At the 200 m contour, such a lake would have a surface area of approximately 5 km^2, an average depth of 20 m, and

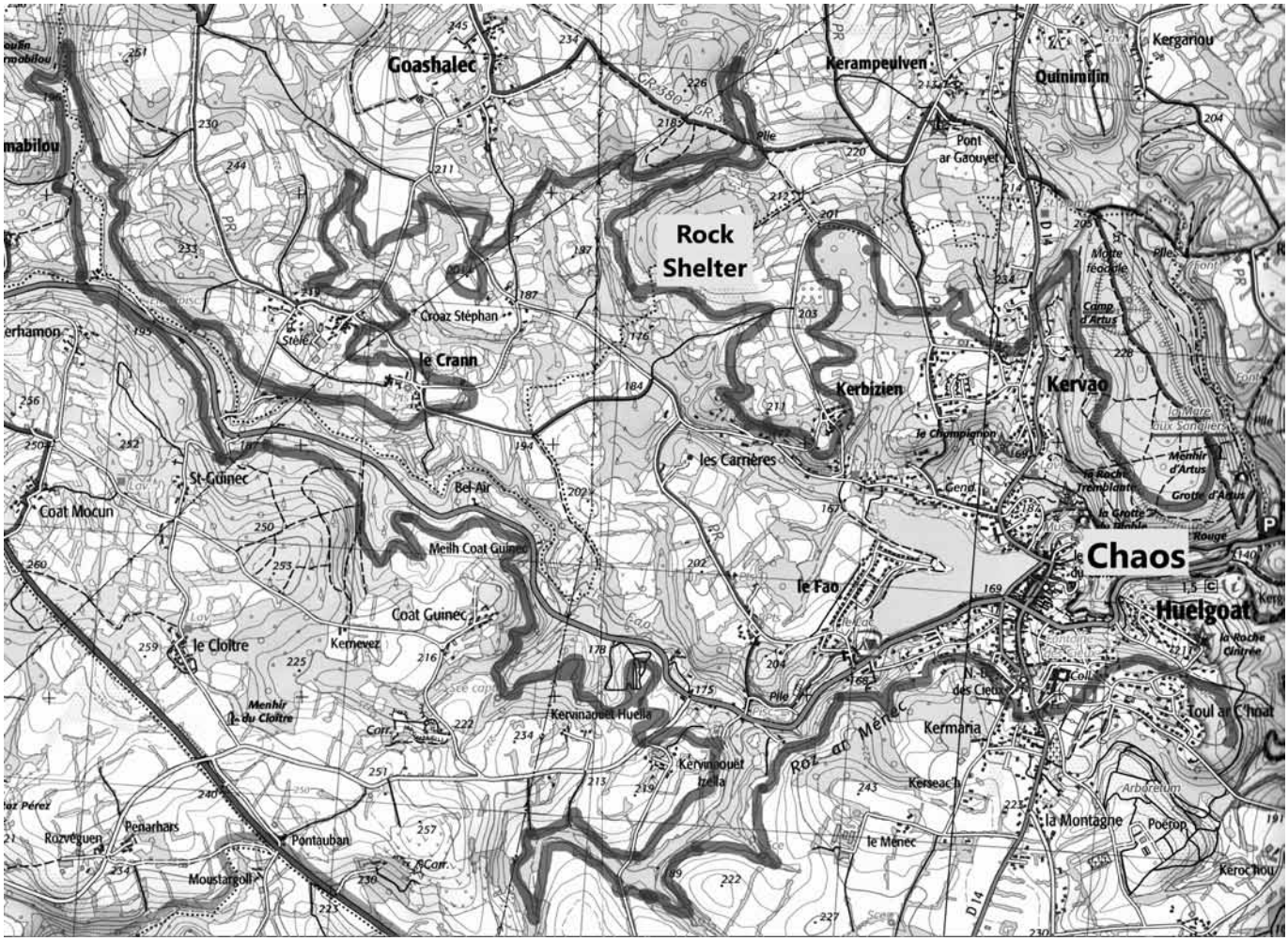

Figure 8. Map of Huelgoat showing 200 m contour (blue) with locations of the Chaos and the Kerbizien Rock Shelter (Extract from: Top 25 Randonnée et Plein Air 0617 OT Huelgoat Monts d'Arrée 1:25,000).

contain about 100,000,000 m^3 of water (Figure 8).

The present rainfall at Huelgoat is 1,400 mm per year. On the one hand, this amount of rainfall means that the hillsides of the valleys above Huelgoat must have been eroded during recent centuries (making the potential lake area smaller in the past). Equally, that erosion will tend to have filled the bottom of the valleys with sediment (making the valleys deeper in the past). Overall, therefore, the potential volume of such a lake would not have been very different from now. Warming conditions at the end of the Ice Age would help provide the water to fill it.

We attempted to identify possible historic lake shore levels by looking for wave-cut platforms. This is difficult for several reasons. The extensive forestation of the area blocks views of the relevant hillsides. The more level areas of land have been farmed for centuries (resulting in artificial levelling) and are intersected by built-up field boundaries typical of bocage countryside (making levels hard to see). There has been quarrying for building stone in several locations in these small valleys, removing stretches of hillside, and building, which has resulted in areas being artificially levelled. In addition, the high rainfall of the area would likely have eroded such platforms creating run-off inclines.

Reviewing the map (Figure 8) it can be seen that the steep and narrow valleys along the southwest side of the possible lake offer no obvious possible platforms. In addition, nothing suitable can be seen along the roadside going northwest up the Fao valley. Taking note of the fact

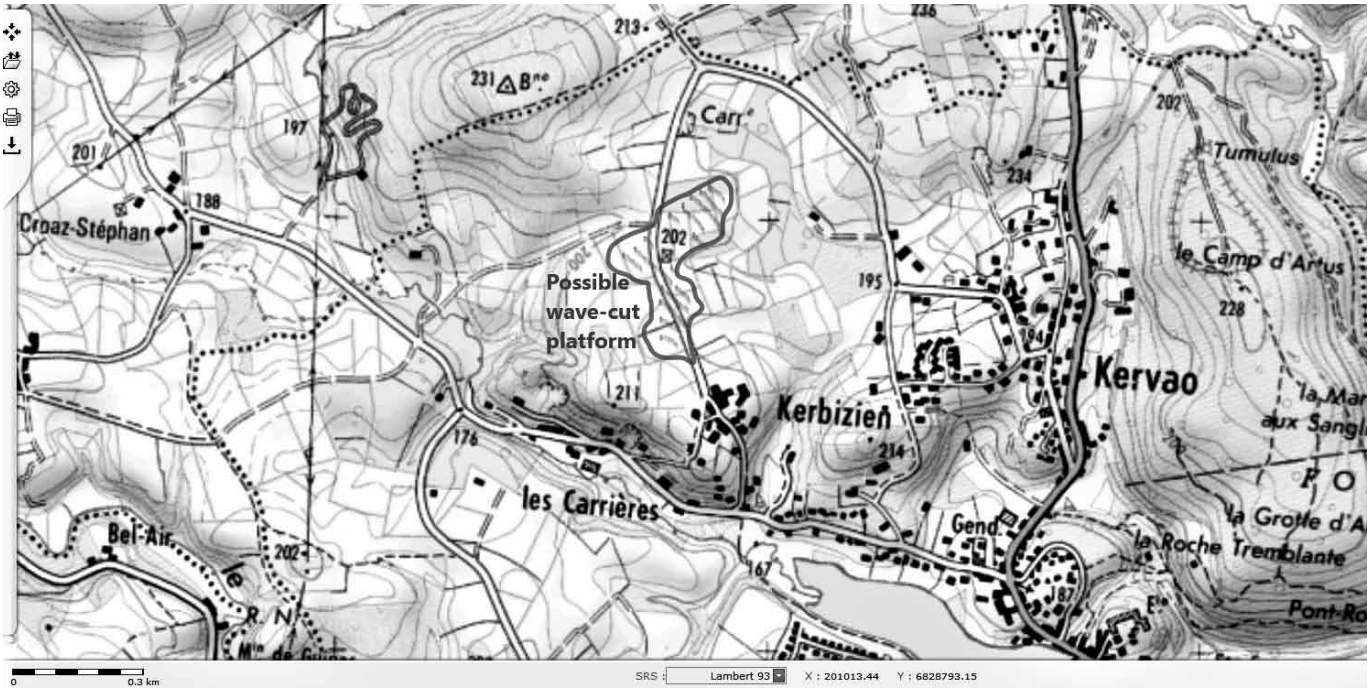

Figure 9. Map enlargement showing Kerbizien village and the location of a possible wave-cut platform (Extract from: SIGES Bretagne http://sigesbre.brgm.fr/?page=carto 1:8,000).

that the prevailing winds over Brittany come from the southwest (because Brittany sticks out into the Atlantic Ocean), the obvious place to study is the low ridge, with the village of Kerbizien at its southern end. This ridge would have been at the heart of the northeast side of the possible lake in its widest part. A small road runs north from Kerbizien for 900 m to a junction, where there is a spot height of 201 m. Five hundred m north of Kerbizien is another spot height of 202 m. The village and road are sheltered for some 200 m by ground rising about 7–8 m higher on the western side, to the 211 m spot height. Then the ridge remains level to within 1 m for about 300 m, to around the 202 m spot height (Figure 9). This forms a platform ranging from 100–300 m wide with small undulations, and would be consistent with wave action "planing off" the top of the ridge if the water was just above that level. There are two more stretches along the line of the road where there appear to be natural ledges at this general height level—the last being just before the road junction. Figure 9 shows the area around Kerbizien, including where a possible wave-cut platform may be. The 231 m spot height in the top left corner is just above the rock shelter where the Azilian and Mesolithic artifacts were found.

This was surveyed using Google Earth Pro (GEP) to make elevation sections at distances averaging 50 m northwards along the line of the road and stretching from the main Fao valley to the west across to the hillside above Kervao. The baseline was drawn from the centre of Kerbizien across the center of Kervao. A discrepancy was found between the map elevations and GEP at the spot heights, of between 1–2 m (GEP higher), which is typical (e.g., El-Ashmawy, 2016), though the GEP relative elevations were otherwise consistent.

The lake could have been retained either by a dam formed from land slippage, possibly as a result of movement of the faults to the north and east of Huelgoat, or by ice from the Ice Age. This dam could have failed either as a result of sudden warming at the end of the Ice Age leading to the overlapping of the dam, or from another landslip triggered by increasing pore pressures within the rock mass due to the rising water level, or as a result of an earthquake.

The failure of such a dam would result in the lake emptying within a few hours, days, or weeks at most. The water would undercut the layers of granite in the valley sides, breaking the jointed and exposed slabs into blocks, which

when unsupported, would then fall downwards, and grind against each other in the flow producing the rounding now evident. The longer the granite blocks spent in the water flow, the smaller and rounder they would become, thus explaining the reducing size coupled with increased rounding of the boulders further down the Chaos. The evidence from the boulders in the Chaos suggests a very rapid emptying of the lake.

A comparison of outburst flood damage

A useful comparison can be made with the breaching of the Möhne Dam by the Royal Air Force on the night of May 16 and 17, 1943. The Möhnesee reservoir above the dam contained 132.2 million m^3 of water that night. One hundred sixteen million m^3 of water emptied within 12 hours at an initial flow rate estimated at 8.8 million m^3 per second. The power stations immediately below the dam completely disappeared, all bridges were destroyed for 50 km downstream, as were all houses and buildings on low-lying land near the river for 65 km. The complete disappearance of two power stations built of stone and reinforced concrete was a shocking sight. (Kirschmer, 1949) Of course, the area below the Möhne Dam was much wider and more open than the valley at Huelgoat, meaning that a similar volume of water would take longer to drain at Huelgoat. The force it would have exerted would have been easily capable of first carving out the present valley along a possible fault or shear line, and then undercutting the granite layers on the sides of the valley. This process would be more than adequate to create the granite boulders now in evidence.

Discussion

The presence of a late-Ice Age lake above Huelgoat offers a solution for some of the mysteries about the Azilian and later Mesolithic occupation of the Kerbizien shelter. It would have provided the occupants with a ready source of water and food. Many of the stone artifacts were small arrow or spear heads, useful for hunting both fish and birds. Elsewhere it is common to find Mesolithic people living next to water. The disappearance of the lake would also explain why the occupants left and the site was never reoccupied.

The apparent anomaly of the radiocarbon dates for the charcoal found among the Azilian artifacts needs to be considered. It is only anomalous if the conventional dates for the late-Ice Age, late Palaeolithic and Mesolithic eras can be accepted without challenge. On the contrary, there is good precedent for arguing that those radiocarbon dates overstate the age of the items tested by a considerable margin, and that instead we should consider dates around 4,000 BP, and possibly more recent still.

A study of samples of mortar used in buildings in Pompeii and Herculaneum constructed between 100 BC and 79 AD gave radiocarbon dates ranging from 2,400–5,800BP. This is an error range from around +10% up to +290%. (Lindroos et al., 2007). Further evidence of the unreliability of radiocarbon dating has been given by Baumgardner (2005).

In light of this, we should neither accept the easy dismissal of these radiocarbon dates by Marchand et al., nor even the validity of the dates they have rejected. The radiocarbon dating of the charcoal samples found is instead direct evidence of much more recent dates for the Azilian and Mesolithic occupants of the Kerbizien site, thus challenging the present dating assumptions for these eras. It is reasonable to suggest that in fact these radiocarbon dates are actually evidence for dates of 3,000–4,000 BP as suggested above. When coupled with the presence of wind-blown loess, we are also suggesting a similar date range for the end of the Ice Age (Oard, 2007).

We have seen that the geological evidence found in the Chaos at Huelgoat is best explained by a massive flow of water acting on granite, such as could happen in a glacial lake outburst flood, rather than a gradual process of erosion and weathering. In this, we are doing no more than echoing the implications of the folklore concerning the Chaos, that the boulders resemble polished pebbles from the sea and were delivered in a single event "by a giant hand." It is the more recent attempts at gradualist geological explanations that have ignored the obvious evidence and produced explanations inconsistent with the facts.

The archaeological evidence indicates that such a flood event must predate the Celtic occupation of the area, setting it before ca. 500 BC, while also setting it after the Mesolithic occupation of the Kerbizien site. That also rests comfortably with the (Celtic) folklore, which makes no mention of a lake suddenly and catastrophically disappearing, but is rather an attempt to explain an existing fact.

This leaves a very wide time window (ca. 10,000–2,500BP) using conventional dating. If the radiocarbon evidence is accepted as belonging to the earlier Azilian occupants of Kerbizien, and adjusted as indicated, we should however consider a date around the beginning of the 2nd Millennium BC and towards the 1st Millennium BC. This means that the dating of the Palaeolithic and Mesolithic eras, together with the end of the Ice Age in Northern Europe all need reducing by several thousand years. It also implies that the late Palaeolithic and the Mesolithic eras at this location were compressed into one millennium or less and were probably contemporary with Bronze Age civilizations in the Mediterranean region. This should be no more surprising than the discovery of peoples in Australia and the Americas still using stone-age technology within recent centuries.

Conclusions

The geological evidence at Huelgoat strongly supports the hypothesis that the Chaos was created as a result of a glacial lake outburst flood, around the end of the Ice Age.

The archaeological evidence demonstrates occupation of the Kerbizien Rock Shelter by people or peoples whose stone tool style was originally that of the late Palaeolithic era (Azilian), changing at some point to Mesolithic styles before the site was abandoned, also at some time around the end of the Ice Age.

The radiocarbon evidence from the Azilian layers of the excavations sharply contradicts the conventional dating for the late Palaeolithic (ca. 12,000 BP), and we argue that those secular radiocarbon dates should be adjusted downwards based on comparable finds elsewhere.

The discovery of wind-blown loess deposits among the Azilian and Mesolithic deposits also points to a late-Ice Age occupation.

The otherwise unlikely location of this settlement (far above any present natural water supply) also supports the existence of a glacial lake.

The lack of weathering and erosion on the boulders of the Chaos supports a relatively recent date for the causative event (i.e., only a few thousand years ago). The causative event must, however, predate the first Celtic settlements at Huelgoat, presently estimated at 500 BC.

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