Proc. Univ. Bristol Spelaeol. Soc., 2015, 26 (3), 217-228

É-A MARTEL AND ARCH CAVE

trans. by

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ABSTRACT

A new translation of the chapter on Arch Cave, Co. Fermanagh, Northern Ireland, from É-A Martel's classic book *Irelande et Cavernes Anglaises,* first published in 1897, is presented.

INTRODUCTION

Édouard-Alfred Martel, often referred to as the father of modern caving, did perhaps more in the way of cave research and exploration in the UK and Ireland in the late nineteenth and early twentieth centuries than any other contemporary figure, and was among the first to enter many of them. He was also a prolific writer, and perhaps the title most familiar to English speakers, given its relevant subject matter, is *Irlande et Cavernes Anglaises.*

In 1914, a translation of the Derbyshire section of this volume was undertaken by Winder and Phillips, who remarked that "It is perhaps difficult to realise that the only comprehensive work on English and Irish caves has not been written in the English tongue" (Martel, 1914: III). Short summaries in English of two of Martel's most famous endeavours in the British Isles – the exploration of Marble Arch and the descent of Gaping Gill – have also appeared in The Geographical Journal (Martel, 1897b: 501 and 509), but to date, no translation has been made of the remainder of this seminal work.

Here, then, is another chapter: Arch Cave, which I hope will go some way towards remedying this oversight. My aim as a translator is to bring this oft-overlooked source of historical information to the attention of English-speaking readers, finally allowing Martel's significant contribution to the history and science of caving in the British Isles to be read in the native tongue of those carrying on his work today. For those wishing to delve further into the life and works of Martel, the excellent bibliography by C. Chabert, *E.-A. Martel, 1859–1938: Bibliographie,* and N. Casteret's biography, *E.A. Martel, explorateur du monde souterrain*, are recommended reading.

A brief note on language: Martel's use of language is unusual even for his time, with various aspects of his background noticeably marking his style of writing. Influence from his career as a lawyer can often be detected in the language he uses: he tends to opt for a high register, and sometimes selects unusual descriptive terms. For example, on page 59, he states that the size of the stream '*dénonce*' (betrays) the area of the drainage basin, and on page 64 he tells us that Kinahan, another geologist, has '*parfaitement admis*' (accepted) a particular theory on cave formation.

As a pioneering explorer, Martel came across features for which often, no conventional term existed, and so created his own terms. In some cases, these terms did not become mainstream and were therefore rather difficult to render in the translation. One such neologism was the term '*diaclase-fuseau*' (page 54). Martel seems to describe this particular type of joint as being formed by phreatic action, yielding the culturally equivalent term '*phreatic joints*'. The '*fuseaux*' themselves appear to be solution pockets, known in modern French as '*cavité de dissolution*'.

A second term, '*Strux. et Del.*' (page 55, inter alia), proved even more elusive. It appears on most plans and elevations, so is not a misprint, but it appeared to have since fallen out of use. Extensive research turning up nothing more than further references to Martel's texts. A clue was provided by the plans and elevations drawn up by the Mendip Caving Group [online] – many of their figures, dating back many decades in some cases, bear the epithet '*Surveyed and Drawn*'. This seemed to fit perfectly, and was later confirmed by Jacques Chabert: it is an abbreviation from the Latin *struxit et delineavit*, which translates literally to '*constructed and sketched* '.

Editor's notes: in the original version, footnote numbering re-starts on each page; here the numbers are sequential through the text. The figures are all reproduced from the original, with translations of the labelling kept in the captions. Figure 3, from page 61 of the original, has been touched up slightly where a clean reproduction was not possible. All text emphasis, italic, bold and capitalisation, is from the original. Page numbers have been changed to reflect this volume.

ARCH CAVE

The natural tunnel at Boho. – Arch Cave spring and waterfall. – The cave's incomplete formation. – The role of fissures in the ground. – The relationship between caves and valleys. – Temperature anomalies in springs. – Feeding Arch Cave, the swallow holes. – Noon's Hole. – Irish vengeance. – Pollanafrin. – Excavations and cave-ins. – The legend of the dog.

Opposite Cuilcagh, north of the railway that runs from Enniskillen to Sligo, and the River *Arney*, which carries the waters of *Lough Mac Nean* into Lough Erne, *Belmore* Mountain (400 m), situated between Lough Mac Nean, Lough Melvin and Upper Lough Erne, is also made up of limestone rock, and its subterranean hydrology merits some examination.

Although the state of the streams, engorged by abundant rain, did not permit me to carry out as extensive examinations as were possible at Marble Arch, I was able nonetheless to make several extremely interesting observations.

I will note at this point that, while awaiting my arrival, Mr Jameson[1] visited a cave (*Coolarkin*) in *Boho*, near Lough Ross, to which he attributes some 300 to 400 metres of passageway. Having two entrances, this cave offers the opportunity of making a trip in one entrance and out the other. It is rather rare, in fact, that no obstacles such as scree, sumps, earth plugs or stalagmites block the way between the known entrances of a natural underground passage. Examples of exceptions to this rule include the natural tunnels at Mas d'Azil (Ariège), Pong, Nam Hinboun, Xe Bang Fai (Laos), Bramabiau (Gard)[2] and Dubocka (Serbia)[3], among others.

On 14 and 15 July 1895, upon the most excellent advice of Mr Plunkett of Enniskillen, who took care of all the necessary preparations for my excursions in the country, and who

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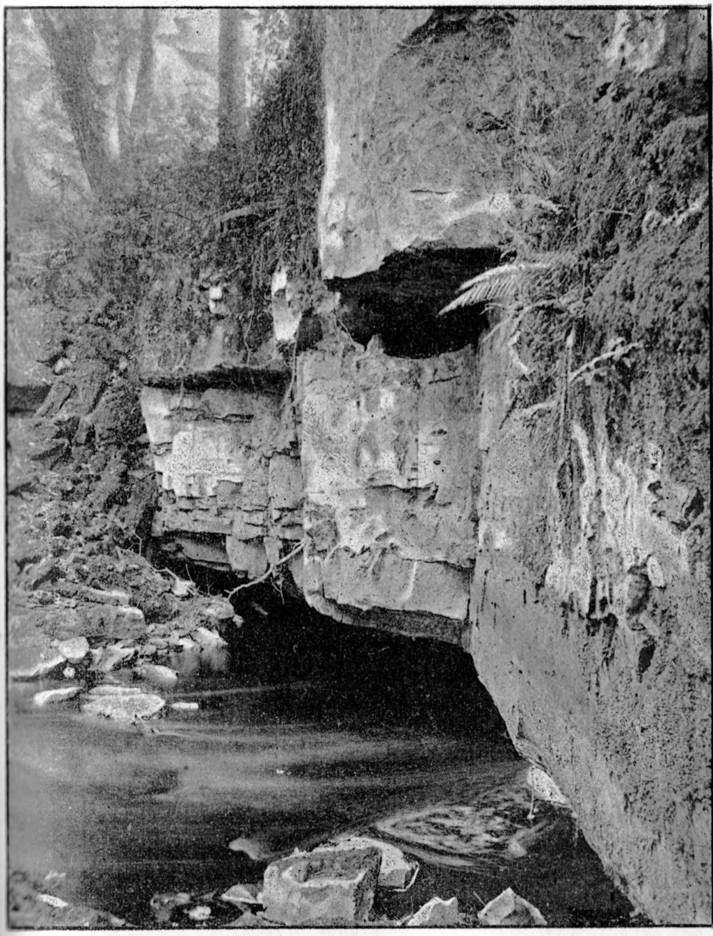
1 *Exploration of the caves of Enniskillen* (*Irish Naturalist*, April 1896; Dublin).

2 *See Les Abîmes* p. 453.

3 *See* prof. Cvijic in *Bulletin de la Société de spéléogie* No. 3. July–September 1895.



PERTE DE LA RIVIÈRE DE PULLINS (*V.* p. 66).

Figure 1. *Photograph on page 51 of the original: Sink of the Pullins river* (*See* p. 228).

himself has carried out archaeological excavations of prehistoric sites in several small caves in the cliffs of Knockmore (100 metres high)[4], Mr Jameson and I examined the drainage basin of the *Arch Cave* or *Waterfall Cave* spring.

This spring, situated approximately 13 km east of Enniskillen and 2 km from Lough Ross, is one of the most peculiar I have ever observed: its setting is less spectacular than the

[4] *See* W. F. Wakeman, *Knockmore Cave (Proceed. Royal Irish Academy,* vol. X, 1870, p.229–232); T. Plunkett, *Knockninny Cave (ibidem,* 2nd series, vol. 1, 1879, p.329–338 and 1875–77, p.465-483); IDEM, in *Brit. Assoc. Reports* for 1877, p. 76; 1878. p. 183; and 1880, p. 623. In May 1896, Mr Plunkett recovered a wonderful *Ursus spelaeus* head in the caves at Knockmore. He hopes to discover the rest of the skeleton. In three years of excavations prior to this, he had never come across cave bears, which were rare in Ireland. (*See* Hull, *Phys. Geol., p.305.)*

Vaucluse, the Foux de la Vis (Hérault) the Boundoulaou (Aveyron), the Ombla in Dubrovnik, the Buna in Herzegovina and the Rijeka in Montenegro, yet it can compete with any one of the above thanks to the exceptionally picturesque appearance of the fulsome river that gushes forth from within. Approaching from the hillside, among the brambles and scree which serve to hamper access, one finds oneself halfway down a steep ravine, in the vicinity of a curved archway, between 10 and 12 metres high and broad, its black maw gaping at the foot of a cliff which closes off the ravine. At 115 metres altitude, a stream flows out of it (and, scarcely having reached the open air, immediately leaps from waterfall to waterfall, dropping down in this fashion 55 m to the bottom of the ravine, over a horizontal distance of less than 100 m. This marvellous waterfall spring, set in a semicircle of rocks and greenery, far surpasses in extent the falls at Comadina and Dreznica, which likewise issue from caves in the Neretva Gorge (Herzegovina)[5].

In Switzerland or England, such a site would be successfully capitalised upon, but this being Ireland, there is not even a path leading up to it. Only after scratching one's hands on thorns and one's knees on stones is one able, stumbling several times into the bargain, to reach the entrance to the cave. The boulders and scree which obstruct the entrance are slippery and awkward, but with a little care, the interior of the cave can be gained without being wetted or swept along by the torrent, which rumbles and foams between the boulders littering its stream-bed. After 60 metres, and having barely lost sight of daylight, the scree comes to an end at the edge of a deep sump pool surrounded on all sides by rock. It is possible that this is a fairly thin section of rock, the base of which is submerged, as at the Marble Arch spring; perhaps behind it the roof rises and the cave extends without obstruction. This hypothesis seems plausible when we take into account the general appearance of the cave: as the plan and the elevation show, it is in fact simply six parallel phreatic joints, perpendicular to the direction of the current. The faces of these joints and the boulders lying in the stream clearly reveal the cave's history. The black Carboniferous limestone in this area, itself very hard and very compact, was found to be divided by horizontal *bedding planes* and by two sets of vertical *joints*, one set perpendicular and the other parallel, often taking the form of regular shapes such as cubes[6]. Between these

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5 *See les Abîmes* p. 482.

6 For Quatremère de Quincy (*Dictionnaire d'architecture*) and Larousse (*Grand Dictionnaire*), joints are, as a general rule, *spaces which separate stone, natural fissures which run through rock,* regardless of direction.

Viollet-le-Duc (*Dictionnaire d'architecture*) and the *Grande Encyclopédie* reserve the term joints for rock faces which 'lie adjacent to one another laterally', and give the name *beds* specifically to planes of 'horizontal separation'.

Others, whose opinion is also adopted by Larousse's *Dictionnaire*, use the terms *bedding joints* for horizontal planes and *sheer joints* for vertical planes.

In the field of geology, the same confusion arises:

Arago, firstly, wrote that tertiary formations are stratified, that is to say, composed of superimposed layers which are separated, like the layers in a wall, by distinct and clear-cut *joints.* (*Notice sur les puits artésiens: Annuaire du Bureau des longitudes* of 1835, p. 203.) For him, joints seem to be *planes of stratification*.

The Irish geologist Kinahan distinguishes three types of *slot* or *joint* in stratified rocks: firstly, *minor* joints, which are localised and limited to one or more strata; secondly, *master* joints, which cross all strata, and thirdly, *joint lines*, or bedding planes. (*Valleys and their Relations to fissures and faults;* London, Trubner, 1875, in-8º p. 13 and 18.)

Mr Daubrée has shed light on the issue thus: 'Cracks in rock are usually called *joints*, as adopted by English geologists; this name, borrowed from the field of architecture, where it designates the planes according to which the layers of a structure are assembled, seems inaccurate, since conversely, it concerns slots in the rock, parallel and perpendicular to the direction of the current, the water flowed under *hydrostatic pressure*; the process of *corrosion* enlarged the cracks, *erosion* forced grains of sand and chips of rock like wedges through the cracks, and together, the three effects loosened the cubes of rock one by one. Once fallen, the cubes were progressively ground down and reduced in size; some, embedded more firmly in the rock, resisted, and forced the water to rise up in the *joints.* With a swirling motion, the water hollowed out solution pockets, those eroded domes so commonly found in caves, until a *bedding plane* on a lower level, having at last been enlarged downstream, allowed the liquid to flow into the adjacent joint. Step by step, and fracture by fracture, five bedding planes opened up between six consecutive joints (having the effect, in several places, of varying the height of the cave between less than 1 metre and over 15 metres), and, once the sixth was breached, the waterfall gushed forth outside, but not without firstly having forced an opening in the roof of the sixth joint. This opening must formerly have been the water's sole (*sumped*) exit, at a time when the current archway had not yet collapsed. This whole *process* is etched plainly on the walls of Arch Cave.

The process of detachment of these cubes of rock is still ongoing; indeed, we have seen boulders only very recently torn down from the roofs and walls: perhaps the boulder which now causes the cave to sump will be dislodged one day, and in doing so will open up access to a long passageway, as at Marble Arch. At the very least, there is no doubt that changes will occur in Arch Cave, within time frames which are impossible to predict at the present moment. It is also a given that the state of progress in the caves here is far behind those in the Causses and Karst regions: they continue to be hollowed out on an enormous scale, and we will subsequently consider a good deal more supporting evidence for this opinion. At this juncture I will mention just one point, pertaining to the relatively great height at which the mouth of Arch Cave is situated: the waterfalls outside the cave flow over limestone, between strata through which the underground stream has not yet carved out a path lower than that in the cave itself. Contrary to the case in the Rijeka in Montenegro, the Boundoulaou in Aveyron, etc,

fracture faces... Joints, although part of the same family, are smaller than faults, to which they are sometimes joined.' (*Études de géologie expérimentale* p. 300–306, 325, 333, 351.) He then proposes the very fitting general terms *lithoclases* and *diaclases.* The only inconvenience with this classification is that in declaring that 'diaclases cut across stratified planes', (*Eaux souterraines,* vol. *I, p.*133), Mr Daubrée seems to adopt Viollet-le-Duc's definition of planes as 'lateral spaces', contrary to Arago's definition; furthermore, he does not suggest a name for planes of stratification.

Mr Édouard Dupont took note of this, asserting as follows: 'Diaclases are slots which run across banks, which do not interrupt the continuity of the latter's plane...; they divide limestone masses into enormous blocks, as they combine *with a third plane, that of stratification*'. (*Les Phénomènes des cavernes: Annales de la Sociéé belge de géologie*, vol. VII, 1893, p.14.)

Likewise, Mr de Lapparent's interpretation: '*Joints* or *diaclases* may come about either as a result of the rock receding due to desiccation, or due to movement within the ground, and to these may be added horizontal slots which may be produced by stratification beds'. (De Lapparent, *Leçons de géographie physique,* p. 85.)

I have found myself so often beset by confusion in these descriptions, that I have decided to apply the term *bedding planes [joints]* solely to planes of stratification, while for all other cracks I adopt the name and subdivisions of *joints [lithoclases]*, created by Mr Daubrée This seemed to me to be so convenient and well-suited to what has thus far been observed in caves that I would propose the drawing of a distinction between joints and *bedding planes.* It has been observed that these joints, which in principle are horizontal, are often to be found at a sharp angle to the horizontal, due to subsequent movement of the sedimentation (at Han-sur-Lesse, Adelsberg, etc.; *Abîmes* p. 429, 438, 442, 447, etc.), sometimes occurring even up to the vertical (potholes of the Ragas [Var], Caussols [Alpes Maritimes], etc.) (*Abîmes*, p. 417). Consequently, it is both unnecessary and impractical to seek any distinctiveness (as Viollet-le-Duc wrongly did for buildings) in the horizontality or verticality of *bedding planes.*

the Bonnette in Tarn-et-Garonne[7], etc, the upper cave has not yet been reduced to playing the role of overflow chamber, dry in periods of low water; it remains the sole outlet for the flow of water, which has not yet finished its excavations – Arch Cave is a young cave which has not yet finished growing, despite its location in a geological formation which is even older than the Jurassic! This is most probably due to two principal causes: the first is the resistant nature of the black Carboniferous limestone – much harder and more compact than most secondary limestones; the second is the existence of a thick, spongy, impervious carpet of peat on the surface of the plateau which is drained by the spring, a *bog*, which holds surface water and prevents the percolation of all of said water down into the cracks in the rock; the rock, protected by this hydrophilic felt (as Kinahan outlined in *Valleys,* p. 74) absorbs the rivers and rainwater via a much smaller number of *channels* than the deforested and barren tablelands of the Causses and Karst regions. In short, underground water flow seems less intensive in Ireland than in the other two aforementioned regions, and its effect greatly impeded. Nevertheless, rain is a good deal more abundant there – indeed, 'of all the lands of Europe, Ireland is the most liberally irrigated'. (Reclus, IV, p. 765) (0.6–2 m of rain annually).

Arch Cave's elevated position lends weight to the argument in favour of the theory positing that many dry caves, currently situated high on the sides of deep valleys, were once springs which dried up and were subsequently refilled by infiltration; examples include certain river caves of the Meuse, Lesse, Jonte and Dourbie rivers, among others. It was once believed that such caves had been formed laterally, filled by ancient rivers before the deepening of the valleys. Arch Cave clearly demonstrates that this latter idea should not constitute a general explanation, but neither should it be completely abandoned – the classic cave Trou de Belvaux, where the Lesse river disappears into the Han-sur-Lesse caves; the Lhomme cave in Rochefort; the large Rancogne cave (Charente), which swallows a large portion of the Tardoire river; and Arcy-sur-Cure (Yonne), among others, are all excellent and typical examples of caves formed, or at least enlarged, by lateral outflow from rivers.

Once again, then, it can be seen that two opposing hypotheses regarding subterranean hydrology, having caused a great deal of controversy, may both be correct and substantiated, with one or the other being applicable under particular conditions.

Although Arch Cave is at a rather lower altitude than Marble Arch, the temperature of its water (at the sump) is 3.3 ºC colder (8.5 ºC rather than 11.8 ºC). This is a further exception to the law according to which springs at the same altitude usually have a similar temperature, revealing the average annual temperature of the local area[8]. In this case, it is simple to determine the reason for this exception, since the waters which feed Marble Arch have flowed on the surface for quite some time, in the streams which snake across the northern slopes of Cuilcagh. This allows them to reach air temperature; and they do not then spend long enough underground to decrease (in summer at least) to the temperature of those layers of earth which are free from the influence of external variations. One such stream (Monastir) gave a temperature reading of 14.5 ºC at Pollywaddy swallow hole. As we shall see, upstream of Arch Cave it is a different matter, with the open-air streams being neither long enough nor large enough to warm up on the surface (in summer, naturally) and to thereby increase the temperature of the spring. This is why the temperature of the latter is much closer to the area's annual average (9.1 º in Enniskillen, at an altitude of 50 m): the majority of its inflow comes from true infiltration, contrary to the situation at Marble Arch.

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7 *See Annuaire du Club alpin* for 1894, my seventh underground expedition, and *Annales des Mines*, July 1896, pl. I.

8 *See Comptes Rendus de l'Académie des sciences*, 12 March 1894, and *les Abîmes* p. 561.

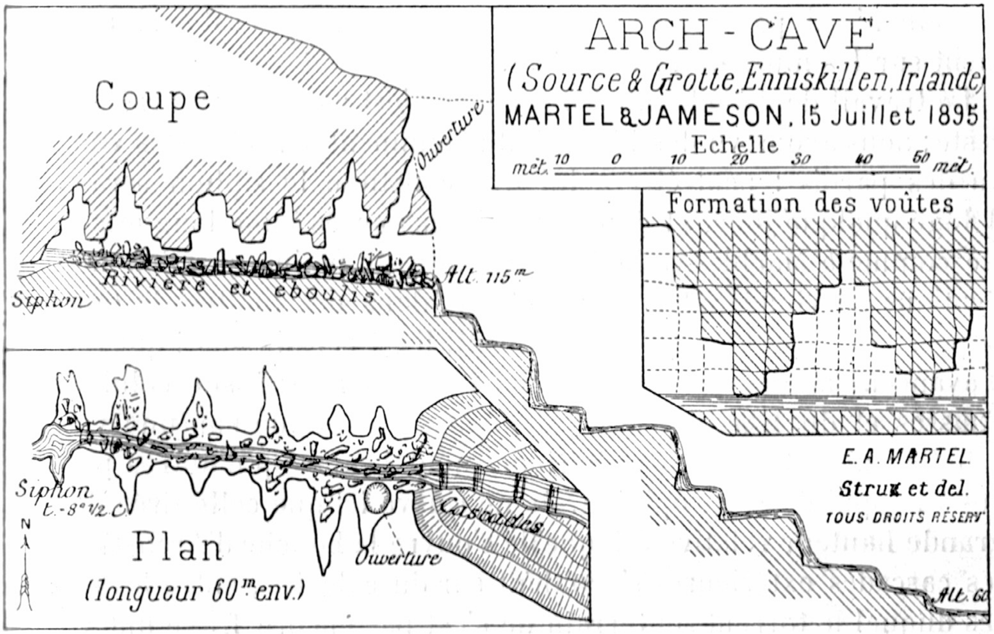

Figure 2. *Drawing on page 55 of the original. Text translations as follows: ARCH-CAVE (Spring & Cave, Enniskillen, Ireland) - MARTEL & JAMESON, 15 July 1895 - Scale - Elevation - Mouth - Sump - River and scree - Alt. 115 m - Alt. 60 m - Cave roof formation - Sump - Temp. 8.5 º - Plan - (length approx. 60 m) - Mouth - Waterfalls -* E. A. MARTEL *- Surveyed and drawn. -* ALL RIGHTS RESERVED.

Moreover, the underground temperatures I gathered over the course of this expedition in Ireland and in England show some extremely odd anomalies, which I believe I ought to mention here, so as not to return to the question later.

The springs at *Cong* (West of Ireland) are at a temperature of 16 ºC (18 July), despite an annual average air temperature of 10.6 ºC, since they flow underground out of the large and rather shallow Lough *Mask* (4 km away), whose large surface area is warmed most effectively by the summer sun.

In Derbyshire, England, in *Castleton,* three springs at the foot of Peak Cavern, just 100 m apart, gave readings (on 27 July) of 8 ºC for one (as expected), and 9.3 ºC for the two others (anomalous). It is clear that despite being so close together, they come from different sources.

In Yorkshire, on the south-east slopes of *Ingleborough* mountain, on the date of 1 August 1893, the chasm of *Gaping-Ghyll* absorbed *Fell Beck* stream at a temperature of 12 ºC and disgorged it through Ingleborough Cave, 1600 metres away and 150 metres lower down, at 9.8 ºC. However, the puddles of seepage in the latter, fed only by infiltration from the mountain, have a temperature of just 8.3 ºC, corresponding to the area's average temperature.

On Ingleborough's western flank, *Weathercote Cave* contains two underground waterfalls. One is at a temperature of 8.5 ºC, since its water comes from other caves some distance away. The temperature of the other is 10.4 ºC, because its origin is a surface stream which sinks only 850 metres away.

There is no doubt that in winter, a complete reversal would come about as regards the differences in these temperatures, with the water from icy, open-air areas surely being found to be colder than that from seepage. Therefore, not only must we slightly amend the following principle, which states that 'springs (apart, of course, from thermal springs) generally provide a good indication of the average temperature of the area in which they emerge[9]', but also, it seems that we may draw the following practical conclusion from the aforementioned observations: If the temperature of a spring appears to be lower in winter and higher in summer than the area's average annual temperature, this is because it has not been formed in its entirety underground; it is because it has come, for the most part at least, from one or more surface streams, which have been exposed to fluctuations on the surface, and which have not been underground for a sufficiently long period to balance their temperature. Such information would be indispensable, in many situations, for the accurate identification of links between a spring and a river lost upstream, and for the subsequent protection of said river against any contamination which may be passed on as it sinks.

After this meteorological diversion, let us now consider what may be the origins of the powerful Arch Cave spring, the volume of whose water betrays the fact that it drains a rather large surface area.

This surface is a plateau composed of three tiers or terraces. It stretches to the west of the cave and forms the gentle eastern slope of the Tullybrack Hills (373–381 m.).

The map opposite, based on the 1:10560 County Map and the observations I made of the area together with Mr Jameson, shows two *swallow holes* on the first terrace, at an altitude of 180 to 210 metres above sea level. On the second terrace, at 210 to 250 metres above sea level, around fifteen can be seen, while the third terrace, which exceeds 300 metres in altitude, has an even greater number which do not appear on the map. All these swallow holes are the means by which atmospheric precipitation is absorbed. Their number, although somewhat higher than on Cuilcagh, is nonetheless limited, as I mentioned above, by the thick peat bogs which carpet the three terraces. Almost all swallow true streams, very short, it must be said, due to the shallow inclination of the plateau, but sustainable, since they continually drain the peat bogs. The latter, I will repeat once more, since it is a crucial fact, have obscured, blinded if you will, the majority of the natural fissures in the underlying limestone. They support a great amount of moisture on the surface of the three terraces, and only after passing through breaks in the peat blanket can water flow into the rock's larger crevices or seep through continuously.

This water travels for a longer period underground than on the surface, and that is why it resurges in Arch Cave at the same temperature as the upper layers of the ground, which is equal to mean annual air temperature.

The majority of these swallow holes (or *pipes*) are impenetrable, riddled with pebbles and clods of earth, like France's *bétoires* and the *sauglöcher* of Austria, but two at least are open and can be entered as pot holes, and we descended them.

The first, *Sumera* or *Noon's Hole*, is the most interesting as well as the deepest: the plumb line attributes 47 metres to it, some 66 metres above the exit of Arch Cave, since the hole opens at 228 metres altitude. It is a true pothole, but like Arch Cave itself, it is not complete – the river which has already served to enlarge it continues in this work, falling into it continuously and with such force that we were obliged to limit our descent to 20 metres. At a

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[9] *See* DAUBRÉE *Eaux souterraines actuelles,* vol. I, p. 421, and DE LAPPARENT, *Gé*ologie, 3rd edition, p. 193.

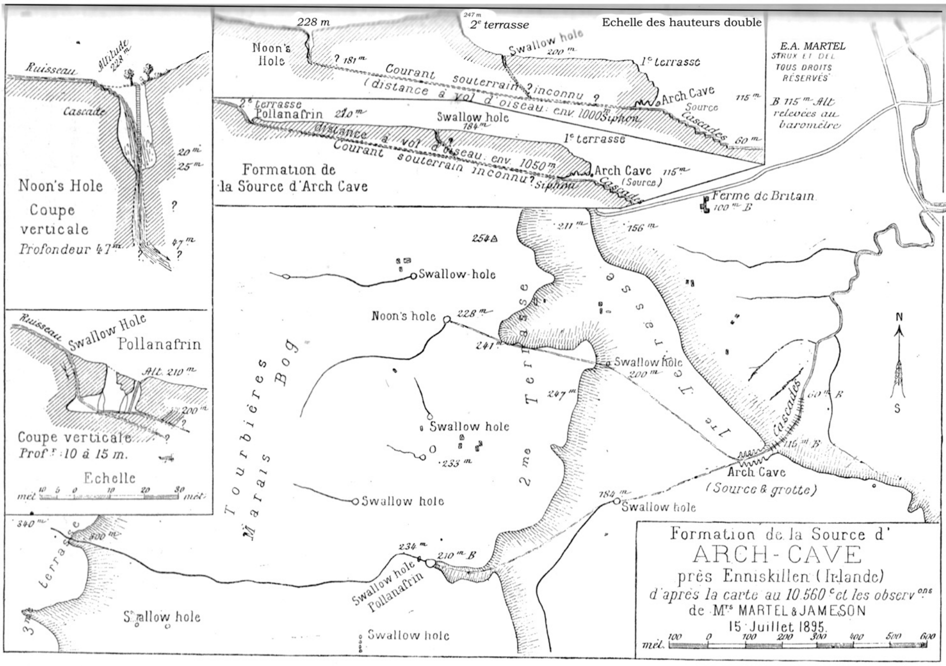

Figure 3. *Drawing on page 61 of the original. Text translations as follows: [Top left box] Stream - Altitude 228 m - Waterfall - Noon's Hole - Vertical cross-section - Depth 47 m. [Middle upper box] Noon's Hole 228 m - Underground stream - ? Unknown? - (distance as the crow flies around 1000 m) - 2nd terrace 249 m - Swallow-hole 200 m - Sump - Height scale doubled - 1st terrace - Arch Cave - Spring 115 m - Waterfalls 60 m. [Middle second box] Formation of the Arch Cave spring - 2nd terrace - Pollanafrin 210 m - Swallow-hole 184 m - Distance as the crow flies around 1050 m - Underground stream, unknown - Sump - 1st terrace - Arch Cave (Spring) 115 m - Waterfalls - [Left middle box] Stream - Swallow-hole - Pollanafrin - Alt. 210 m - Vertical cross-section - Depth 10– m - Scale. [Main box] 3rd terrace - Swallow-hole - Peat Marsh Bog - Noon's Hole - Pollanafrin Swallow-hole - 2nd Terrace - Swallow-hole - 1st Terrace - Arch Cave (Spring & Cave) - Waterfalls - Ancient British farm 100 m - 115 m. Alt. increased according to barometer. E. A. MARTEL - SURVEYED AND DRAWN - ALL RIGHTS RESERVED.[Bottom right box] Formation of the ARCH CAVE spring - near Enniskillen (Ireland) - based on the 1:10560 map and the observations - of Messrs MARTEL & JAMESON - 15 July 1895*

depth of 25 metres, the cavity narrows to a diameter of no more than one metre, compared to the five to eight metres at the surface, and the waterfall occupies the entire space. We were unable to even consider an attempt at passing this obstacle through a shower exerting more than two atmospheres' pressure. (*See* cross section, above.)

In order to reach the bottom of the pothole and the rest of Noon's Hole cave, the descent must be reattempted in a drier season – somewhat of a rarity in Ireland.

I hope that Mr Jameson will take care of this some day.

At least I was compensated by my observation of the almost exact parallel in terms of location, shape and even depth between Noon's Hole and the *Planagrèze* pothole in Lot. Comparing the cross section above to that of the latter pothole (p.335 of *Abîmes*), it is impossible to escape the conviction that the majority of these long and narrow vertical chasms in the Causses and Karst regions, so dry today, truly are the result of surface water, once absorbed but now run dry; that they formed from the top downwards through fissures in the ground enlarged by erosion and corrosion, and that my opposition to the excessive generalisation of the hypothesis of successive collapses proposed by Abbot Paramelle, instead insisting on this new theory, is completely justified.

The mountain of Ingleborough in Yorkshire provides us with many more stunning examples of chasms which even today still play their role as sinks taking water.

The first part of Noon's Hole, the only part which we were able to see, is a veritable kettle for giants. It is formed in a joint (oriented south-west north-east) and its walls are smooth, with channels here and there, polished by the tumbling water as well as by the pebbles the water carries.

The first 25 metres were first descended at the end of the last century, with the purpose of retrieving the body of an Irishman who, having been found guilty of betraying his fellow countrymen, had been thrown down as revenge. The body had not passed the constriction. As punishment for this treachery, the people of the countryside named the chasm after the traitor, who was called *Noon.*

The other penetrable pothole is *Pollanafrin*, which lies 750 metres to the south of Noon's Hole at an altitude of 210 metres. It is just 10 metres deep on one side and 15 metres deep on the other, and it has three entrances, between which the rock has been more or less broken up and forms natural arches. This hole, unlike the previous one, has certainly been the product of a collapse – the roof of a chamber of 10 to 15 metres' diameter subsided through the action of a stream flowing through it. This stream spills from the top and bottom of an elevated fissure, gradually narrowing to a few centimetres' breadth (*see* cross-section); after a brief journey on the cave floor, it sinks once again in impenetrable crevices, blocked with mud, branches and pebbles.

Outside, a few metres upstream and above the level of the holes, running water can be seen. Originating on the third terrace, it sinks through the slim crevices in the streambed, to be found once more at the bottom of Pollanafrin.

Here again, and for reasons already mentioned, we have an example of a natural sink able to take water even today.

The fact that such excellent examples of two different sorts of pothole formation are to be found so close together is certainly worth noting.

This ought to be sufficient to eliminate any further controversy regarding the issue. Moreover, the geologist Kinahan also accepts the parallel and opposing method of "churn hole" formation – either from top to bottom like the giant's kettles, or from bottom to top through collapse (*Valleys*, p. 136 and 142). Both methods begin in fissures in the ground and are the result of a combination of erosion and corrosion. They have a tendency to align along fissures. Kinahan adds that "swallow-holes, *formed from below*, mark the lines of subterranean streams"

The topography and geology of the local area give reason to believe that the water, swallowed at Noon's Hole and Pollanafrin (and in other swallow holes as well), resurges (*at least for the most part*) at Arch Cave, one kilometre away as the crow flies. The cross sections above render any further detail on this matter somewhat useless.

Figure 4. *Engraving on page 65 of the original. The spring at Arch Cave*

The volume of water in the spring during our visit was considerably higher than that in each of the swallow holes, meaning that it is the convergence point for the water from several swallow-holes, just as a river on the surface grows larger through its many tributaries.

There is of course a version of the consistent and indeed inevitable legend, which is to be heard as far away as Herzegovina and the Peloponnese, claiming that a dog thrown down Noon's Hole reappeared two months later at Arch Cave. It does not clarify whether the dog was alive or dead, but provides the additional detail that the dog's ears were filled with mushrooms!

We were pleased to note that the water at the spring, while not being completely limpid, was much less brown than the very dark water flowing out of the peat and disappearing down Noon's Hole and Pollanafrin, among other sinks. The incomplete filtering would appear to indicate very few obstacles along this underground drainage system.

However, to be able to say more than has already been said, and to advance further underground than the areas already explored, not only would it be necessary to complete the descent of Noon's Hole and to remove the blockages in Pollanafrin, but further research would also have to be carried out regarding whether other swallow holes nearby are also penetrable, and it would be necessary either to break through the sump at Arch Cave, or for the water to be low enough to pass.

Such has been the fortunate and insightful début to my underground campaign of 1895 in Great Britain. Several aspects of Ireland also proved most interesting and profitable.

According to Professor Grenville[10], to the north-west of Lower Lough Erne, between Donegal and Ballyshannon, there are more caves and sinking rivers to be studied in the vicinity of *Ballintra,* including, among others, *Piper's Cave,* an ancient subterranean riverbed decorated with stalactites; *Sheepskin Cave*, also furnished with stalactites, and the location at which the stream running through *the Pullins* (*see* engraving, p. 219) sinks.

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[10] See Hardmann, p. 375–78 of Wood-Martin, *History of Sligo,* vol. 1, Dublin, 1892.