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# Do theories tell us what to see? The 19th-century observations of Darwin, Ramsay and Bonney on glacial features

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**Abstract**
Theories can lead us to omit or minimize certain observations when making an argument, or they may provide insights leading us to alternative arguments. Darwin did not see glacial features on his first visit to North Wales, UK, but on his second visit when he knew about glaciation he then saw it all around him. Glacial theorists such as Ramsay and Bonney discussed the relationship between glacial erosion and lake formation, arguing by analogy and comparison, but Bonney refused to be swayed by Ramsay's theories, arguing the need for greater evidence and proof.

**Keywords**
Bonney, Darwin, glacial excavation, glacial lakes, Ramsay

## I Darwin, diluvium and glaciation

In the context of scientific observation Pimm (1991: 338) felt that: 'theories tell us where to look and when we readily find what we are looking for, we gain confidence in both the theories … and the data'. In similar vein, the power of ideas and of images were discussed by Simmons (1993: 39) who asserted that 'there is a danger of projecting onto nature what we wish to believe anyway', and by Bishop (1992: 17) who felt that 'images do not raise consciousness, they force it to descend'. In other words, these 1990s writings suggest that prior knowledge can limit our ways of seeing.

Around a century earlier, Charles Darwin (1887: 11) had written in his autobiography: 'I had a striking instance of how easy it is to overlook phenomena, however conspicuous, before they have been observed by any one'. This is, then, the obverse point that *without* a theory, prior knowledge or image it could be that we do not know what to see. Darwin was writing about his visit to North Wales, UK, an area which we now see as glaciated. Darwin did not see this at all on his first visit but, tellingly, on his second visit when he knew about glaciation he then saw it all around him. In this context, later glacial theorists such as Ramsay and Bonney discussed the relationship between glacial erosion and lake formation, arguing by analogy and comparison as Darwin came to do, but it is also instructive how Bonney refused to be swayed by Ramsay's theories, and while he was

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right to do this he essentially came to the wrong conclusions.

In the 18th century, the pervading belief, following the authority of the Bible, was that many superficial deposits on the Earth were obviously laid down in deluge of Noah's Flood (see, for example, Winchester, 2001: 44–45). Here was the explanation for swathes of jumbled sediments known as 'diluvium', complete with fossils of drowned organisms. In the manner described by the 1990s authors above, the evidence found was fitted to this orthodoxy.

Thus the idea of glaciation was not in people's minds when observing and interpreting the upland North Wales landscape. In this area we now see as glaciated, Condry (1966: 177) records how the Reverend John Evans made a tour of North Wales in 1798 (Evans, 1800). Evans had visited a site in the Snowdonia area of North Wales where there is a lake below an area of curved cliffs at Cwm Idwal. He thought that the lake, Llyn y Cwn, was a relic of a much larger sheet of water once poised high above the cliffs of Cwm Idwal, and that this lake had burst through the impounding cliffs to create the chasm called the Devil's Kitchen and the resultant flood strewed all the shattered rocks around the area.

In 1831 Charles Darwin came to Cwm Idwal and also failed to perceive the evidence of glaciation there. Condry writes: 'however, though when it was pointed out to him some years later he admitted it was obvious enough'. In 1842, Darwin then went on to describe the glaciation of Cwm Idwal in some detail. He recorded both his first visit with the Cambridge geologist Adam Sedgwick and his second, more aware, visit in his autobiography:

> Next morning we started for Llangollen, Conway, Bangor, and Capel Curig. This tour was of decided use in teaching me a little how to make out the geology of a country. Sedgwick often sent me on a line parallel to his, telling me to bring back specimens of the rocks and to mark the stratification on a map. On this tour I had a striking instance of how easy it is to overlook phenomena, however conspicuous, before they have been observed by any one. We spent many hours in Cwm Idwal, examining all the rocks with extreme care, as Sedgwick was anxious to find fossils in them; but neither of us saw a trace of the wonderful glacial phenomena all around us; we did not notice the plainly scored rocks, the perched boulders, the lateral and terminal moraines. Yet these phenomena are so conspicuous that, as I declared in a paper published many years afterwards in the 'Philosophical Magazine' [Darwin, 1842], a house burnt down by fire did not tell its story more plainly than did this valley. If it had still been filled by a glacier, the phenomena would have been less distinct than they now are. (Darwin, 1887)

By 1842, not only had Darwin travelled widely (Herbert, 1991) but Agassiz (1840) had published his theory of glaciation. Darwin was also then apprised of the arguments of the geologist William Buckland. Buckland was known for his penchant for eating every variety of animal, a trait which his son inherited (Burgess, 1967: Chapter 1; Chorley et al., 1964: 100–118; see also Lewry, 2008) but he also developed highly significant ideas on glaciation and the limitations of the diluvial theory (Chorley et al., 1964: 207–210). A key realization is that water-lain flood deposits are normally laid down in stratified layers, with the coarser material below the fine, while the glacial deposits are unstratified and mixed in size. Thus, in contrast to his earlier 1831 lack of glacial observation, Darwin wrote:

> Guided and taught by the abstract of Dr. Buckland's memoir 'On Diluvio-Glacial Phænomena in Snowdonia and the adjacent parts of North Wales' I visited several of the localities there noticed, and . . . I have been enabled to make a few additional observations. Dr. Buckland has stated that a mile east of Lake Ogwyn there occurs a series of mounds, covered with hundreds of large blocks of stone, which approach nearer to the condition of an undisturbed moraine, than any other mounds of detritus noticed by him in North Wales. By ascending these mounds it is indeed easy to imagine that they formed the north-western lateral moraine of a

> glacier, descending in a north-east line from the Great Glyder mountain. But at the southern end of Lake Idwell the phænomena of moraines are presented, though on a much smaller scale, with perfect distinctness. (Darwin, 1842: 180)

Darwin then gives a detailed description of the glacial features:

> On entering the wild amphitheatre in which Lake Idwell lies, some small conical, irregular little mounds, which might easily escape attention, may be seen at the further end. The best preserved mounds lie on the west side of the great black perpendicular face of rock, forming the southern boundary of the lake. They have been intersected in many places by streams, and they are seen to consist of earth and detritus, with great blocks of rock on their summits. They at first appear quite irregularly grouped, but to a person ascending any one of those furthest from the precipice, they are at once seen to fall into three (with traces of a fourth) narrow straight linear ridges. The ridge nearest the precipice runs someway up the mountain, but the outer one is longer and more perfect, and forms a trough with the mountain-side, from 10 to 15 feet deep. On the eastern and opposite side of the head of the lake, corresponding but less developed mounds of detritus may be seen running a little way up the mountain. It is, I think, impossible for any one who has read the descriptions of the moraines bordering the existing glaciers in the Alps, to stand on these mounds and for an instant to doubt that they are ancient moraines; nor is it possible to conceive any other cause which could have abruptly thrown up these long narrow steep mounds of unstratified detritus against the mountain-sides. (Darwin, 1842: 180)

A lesson we learn comes from 'It is, I think, impossible for any one who has read the descriptions … for an instant to doubt that they are …' giving us the key point that without prior knowledge the glaciation went unnoticed in 1831 but having heard of, seen and/or experienced glacial landscapes by 1842, the interpretation is inescapable. A further lesson stems from 'nor is it possible to conceive any other cause' which means that the new interpretation may then exclude other possibilities. More recent research in the area, while not refuting the basic idea, now shows some more detailed interpretations (Graham and Midgley, 2000; Worsley, 2007).

## II Ramsay, Bonney and glacial lakes

There are similar insights to be gained from later writings on glacial action. Here the idea of glaciation was accepted but the nature of any glacial erosion was debated. Sir Andrew Crombie Ramsay was a Scottish geologist who became Professor of Geology at University College London, President of the Geological Society of London and a Director General of the Geological Survey. Having that much authority invested in him, in 1862 he published 'On the glacial origin of certain lakes in Switzerland, the Black Forest, Great Britain, Sweden, North America and elsewhere' (Ramsay, 1862). This started with the 'erroneous' idea that erratic blocks had been transported by rivers and firmly argued for a glacial origin of lakes. Nonetheless, in 1893 Bonney still felt able to ask the question: 'Do glaciers excavate?' (Bonney, 1893). This paper has salutary arguments concerning logic, observation and – as with Darwin – the role of prior knowledge.

The Reverend Professor Thomas George Bonney (Figures 1–3) was a tutor at St John's College, Cambridge, from 1868 and lecturer in geology then Professor of Geology in University College London 1877–1901, secretary and president of the Geological Society 1884–1886, president of the Alpine Club 1881–1883, and elected a Fellow of the Royal Society on 6 June 1878 (see Anon, 1901; Bulman, 2008; Lake, 1924; Watts, 1926). He had no qualms about challenging any previous orthodoxies by way of demanding proof of their veracity.

Bulman commented on Bonney that:

> Lack of formal education in geology may have contributed to that independence of outlook which constantly questioned dogma, and his insistence on proof may be attributed to his mathematical

**Figure 1.** Thomas George Bonney at St John's College Cambridge, around 1870
*Source*: Reproduced by permission of the Master and Fellows of St John's College, Cambridge

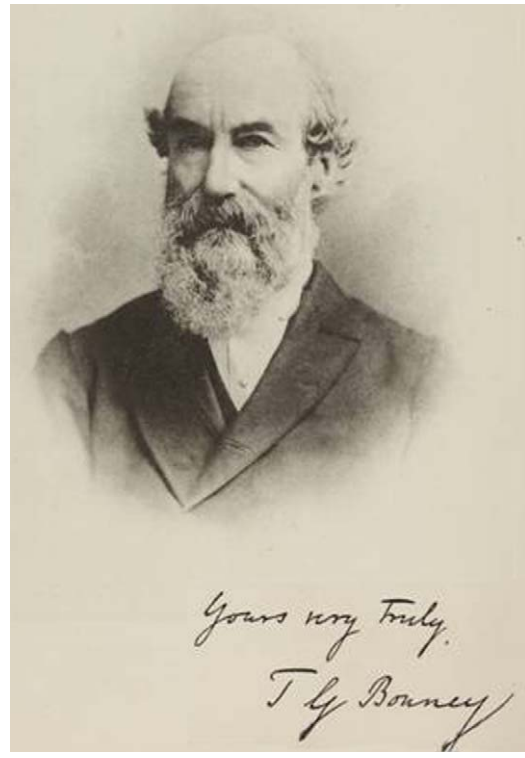


**Figure 2.** Thomas George Bonney as shown in the 1901 celebration in the *Geological Magazine*
*Source*: Reproduced from Anon (1901), Eminent living geologists: The Rev. Professor T. G. Bonney. *Geological Magazine* 38 (Decade IV), Issue 09, Sep 1901, pp. 385–400.

> training. Bonney would accept no theory until it was exhaustively proved, and he inevitably became a formidable controversialist in nineteenth-century geology: '*Fine phrases unsupported by facts prove to be no better than cheques without a balance at the bank*'. (Bulman, 2008)

Bonney commented on Lyell's contribution to the field of geology at the time (Bonney, 1895; Chorley et al., 1964: 128–129) but specifically on glaciation and Ramsay. Bonney wrote:

> The publication of the late Sir A. Ramsay's paper on the Glacial Origin of certain Lakes in Switzerland, full thirty years since, marks an epoch in the study of an important branch of physical geology. It … propounded a hypothesis, which from its own plausibility and its author's scientific position and literary skill, attracted general attention. It was, however, opposed by Sir R. Murchison and Sir C. Lyell. The results of my own study of the question were given in a group of papers published between the years 1871 and 1877 inclusive … so far as I am aware, no advocate of Sir A. Ramsay's hypothesis has ever attempted to meet my objections by precise and definite statements, or has really added, except in one respect, to the arguments which the author originally advanced. New instances of the erosive action of glaciers are not unfrequently cited, but when regarded with a sceptical eye, they are only valid in the event of the original hypothesis being correct, that is to say, they depend upon instead of confirming it. (Bonney, 1893: 481)

Here Bonney reveals a key aspect of his sceptical approach – new instances are seen as depending on the original hypothesis rather than testing or proving it, thus confirming the 1990s authors cited in my opening paragraph. He continues with his more open mind: 'It may be well

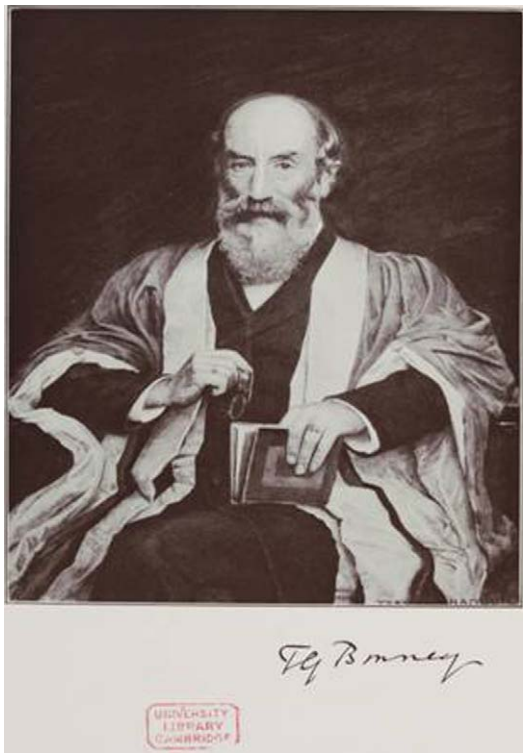


**Figure 3.** Thomas George Bonney as shown in his Royal Society Obituary (Watts, 1926)
*Source*: Watts (1926), Obituary notices of fellows deceased. *Proceedings of the Royal Society of London Series B* 99, 699, pp. i–xxxvii+xxxviii–xlviii. T G Bonney, xvii–xxvii.

to call attention at the outset to the fact that lakes – as all admit – may be formed in various ways' (Bonney, 1893: 482).

## III Glacial excavation: lakes and logic

Bonney (1893) then rehearses the range of ways in which lakes may be formed, including subsidence. He then argues against subsidence as a cause for the alpine lakes but sees the glacial hypothesis as remaining as viable rather than proven:

> I admit that … the great Alpine lakes … [and] tiny tarns high up in the mountain fastnesses, occupy true rock basins, which … are attributed by the school of Ramsay to the erosive action of glaciers. … I think that the rock-basins of the Alpine lakes could not have been produced by any kind of local subsidence, or by fissures in the Earth's crust or by the erosive action of the rivers themselves. It was pointed out that they were abundant in regions which had been formerly occupied by glaciers, and it was urged that ice could erode and scoop. So, as no other hypothesis remained as a competitor, its advocates claimed a verdict in its favour. (Bonney, 1893: 482)

He then follows a course of logical argument which is worth careful consideration in terms of the use of evidence. It includes the idea of the role of mountain building which he sees as yet to be refuted and the existence of lakes in non-glacial areas.

> Two weak points in this argument at once suggest themselves to careful and somewhat sceptical readers of Sir A. Ramsay's paper. The first one, why the lakes are so few and occur so low down in the valleys. The second is that a mode of forming a series of lake basins which brings them into close connection with processes of mountain – making, has been entirely overlooked. Subsequent attempts to strengthen Sir A. Ramsay's argument have been directed rather to supplying the deficiencies in the former case, than to dealing destructively with the latter difficulty, and later defenders of his hypothesis have apparently deemed silence on this topic more prudent than speech.
>
> The discussion then as to the erosive power of glaciers may be sub-divided into three propositions. These are the following:
>
> (1) Lakes are abundant in glaciated regions;
>
> (2) Glaciers are potent excavating agents;
>
> (3) No agent but ice is competent to produce a lake basin.
>
> The first may be briefly dismissed, for I do not dispute its truth. (Bonney, 1893: 482)

Bonney then lists a large number of examples of lakes in glaciated regions but goes on to cite lakes on other regions which clearly cannot be formed by glaciation:

> the great lakes of North America, … those which feed the Nile, the Congo and the Zambesi in Africa. But no one, so far as I am aware, regards these lakes as the results of glacial erosion, or attributes to this either the Dead Sea or Lake Van, either the Aral or the Caspian. But such inland basins are hardly separable from the basins of the Mediterranean and of the outer oceans. Obviously then, if some rock-basins have been excavated by ice, dimples also exist on the Earth's face, which are due to other causes, and the concession still leaves individual cases open to discussion. (Bonney, 1893: 482)

It is implicit in Bonney's line of reasoning that if lakes can form by processes other than glaciation – for example, by tectonic movements – why might not some alpine lakes be formed in this way? This argument also clearly refutes his proposition (3) above. He then turns to excavation, citing areas of recent glacial retreat in evidence and resorts to the classic 'U'-shaped valley argument. He does not dispute that glaciers erode but distinguishes this from excavation:

> As to the second proposition, that glaciers are potent excavating agents, it may be well to remark at the outset that abrasion and excavation are not identical terms, and that it is not enough to prove the existence of the former in order to establish the latter. How a glacier works must be ascertained by studying the contours of its bed; these can be most readily examined in districts from which the ice has disappeared so recently (geologically speaking) that its foot-marks are still fresh.
>
> But the [effect], if any, is never more than one of degree. My experience of the Alps is extensive and of long standing, and I make this statement confidently and without reservation. Rocks worn by glaciers should testify to the action of a scooping tool, and any valley materially deepened by such a substance as ice (a more or less plastic solid) should exhibit a section bearing some resemblance to the letter U. (Bonney, 1893: 484)

Bonney then makes his key point about logic in relation to expectation:

> Let us compare the contours of a region such as Sinai, where glaciers, if ever present, must have been always unimportant features. The differences in outline presented by mountain ridges out of the reach of glaciers, whatever may be the cause, depend much more upon the character of the rock than upon altitude above sea-level or the temperature of the region. Frost no doubt is more destructive than heat, but the dominant outlines are alike in climates warm or cold. Place before a geologist a series of photographs of Sinai, the Alps, the Caucasus, the Himalayas, the Lofoten Islands, or New Zealand, and if a little snow be introduced into some, and vegetation carefully concealed in all, he will be unable to determine the locality if he is not aided by actual knowledge of the views. (Bonney, 1893: 484)

Bonney then argues for moulding of the landscape rather than excavation:

> What contours are exhibited in those parts of the valleys which have been once overflowed by glaciers? The Alps are well adapted for answering this question. This is the sum of their evidence: toothed prominences have been broken or rubbed away, the rough places have been made smooth, the rugged hill has been reduced to rounded slopes of rock 'like the backs of plunging dolphins.' But the crag remains a crag, the buttress a buttress, and the hill a hill; the valley also does not alter its leading outlines, the V-like section so characteristic of ordinary fluviatile erosion still remains; all that the ice has done has been to act like a gigantic rasp; it has modified not revolutionised, it has moulded, not regenerated. (Figure 4)
>
> No sooner do we come to study in detail the effects of the ancient glaciers in the upper valleys of the Alps than we are struck by their apparent inefficiency as erosive agents. Here, where the ice has lingered longest, just beneath the actual glacier, we see that a cliff continues to exist. Again and again in a valley we may find that on the lee side of prominences crags still remain, sometimes in sufficient frequency to be marked features in the scenery. Alpine valleys appear to be much older than the Ice age, and to have been but little modified during the period of maximum extension of the glaciers. (Bonney, 1893: 485)

He then considers the lakes themselves and the paper then cited other examples which threw

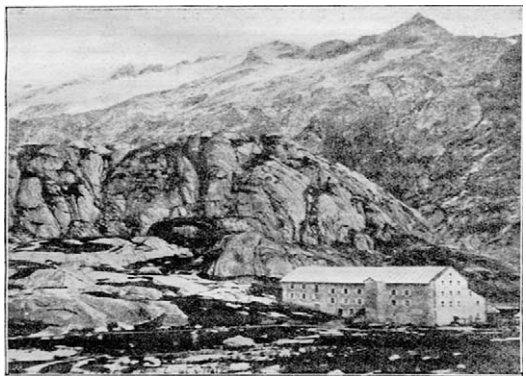

**Figure 4.** Picture of an alpine landscape used by Bonney in his 1893 article showing: 'rocky headland worn by ancient glaciers of the Aar at the Grimsel Hospice, Switzerland'.

doubt on the existence of any one overarching cause of lakes in glaciated regions. There was then an extensive discussion which sought to clarify the two questions: how lakes are formed in glacial regions and whether glaciers excavate.

A Dr. Blanford (this is probably Dr W.T. Blanford, President of the Geological Society 1889–1890; see Anon, 1905) is recorded as having spoken at the end of Bonney's proposition and promptly made arguments based on analogy from other areas in the Himalayas. He said:

> The chief points I should like to urge upon you are first, that I think Professor Bonney rather underrates the effect of erosion by ice. Not the ice but the stones imbedded in it scrape away the rocks upon which they impinge, just as the emery or diamond dust on the wheel of a lapidary grind down a gem. I cannot admit that the shape of a valley eroded by a glacier is the same as that caused by ordinary fresh water action. In Europe we are likely to forget that the big valleys among our mountains are glacial valleys, but if you go into countries where no glaciers ever acted and come upon the typical V-shaped valleys you see the difference immediately. In the Himalayas there are U-shaped valleys at higher and V-shaped at lower elevations, the higher ranges are the same in appearance as in the Alps, but the different form of the lower valleys strikes you at once. The evidence of erosion in glaciers does not depend upon what a glacier in its most effete stage can do, but the proof that glaciers do erode is to be found first of all in the very simple fact that the water issuing from beneath a glacier is always thick with mud. If ice has no effect in eroding what is the origin of the boulder clay? (Bonney, 1893: 499)

## IV Perspectives

Today we can but concur with Blanford and see Bonney as coming to a wrong conclusion. Bonney, however, is important and salutary in terms of his thought processes involved. It must surely be laudable to contest plausible pre-existing theories and to demand proof of argument. It is also clear, however, that Ramsay, Bonney and Blanford all argued by using the knowledge of their own observations together with analogy and comparison with their pre-existing knowledge. With hindsight we are content with a generalized explanation of the origin of the Alps through tectonic action, together with a specific formation of valleys by fluvial action, followed by glacial excavation of a pre-existing landscape with both excavation and moulding. We now also understand the importance of the thermal regime at the base of a glacier as a significant factor in the subglacial erosion process. What this Archives paper reveals is the difficulties of argument when the protagonists are in possession of what we now see as partial knowledge.

Rather than feeling superior in our hindsight, however, we might learn to ponder and ask, as Darwin learnt to – how partial is my knowledge? What am I seeing and not seeing – and how is this influenced by what has been said before? We should also ask, as Bonney did: is the way we see far too influenced by others and precluding other observations and arguments? This should make us more careful when arguing by analogy – prior theories and images can indeed influence what we see (Trudgill, 2003). However, this may lead us to omit or minimize certain aspects when making any one particular argument, or it may provide comparative

insights which can lead us to a different argument. We should thus have Bonney's open sceptical mind about any argument. Which argument turns out to be defensible can only be found through iteration in the context of further relevant evidence.

We may but ponder, and heed well, the thoughts of Feyerabend in *Conquest of Abundance: A Tale of Abstraction Versus the Richness of Being*:

> Variety disappears when subjected to scholarly analysis. This is not the fault of scholars. Anyone who tries to make sense of a puzzling sequence of events, his or her own actions included, is forced to introduce ideas that are not in the events themselves, but put them in perspective. There is no escape; understanding a subject means transforming it, lifting it out … and inserting it into a model or theory. (Feyerabend, 1999: 12)

In this context Bonney, a sharp-minded sceptical academic, makes the contribution of alluding to the fact that asking the question 'what could *dis*prove a hypothesis' is more important than being able to amass further information to confirm what we think we already know.

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