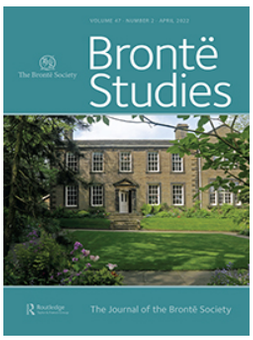

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Anne Brontë and Geology: a Study of her Collection of Stones

SALLY JASPARS, STEPHEN A. BOWDEN, ENRIQUE LOZANO DIZ and HAZEL HUTCHISON

This research is focussed on Anne Brontë's collection of stones, which are housed at the Brontë Parsonage Museum, and how they connect to her time in Scarborough. Obtained during the 'golden age' of geology, the collection was recently recharacterized using Raman spectroscopy. In this interdisciplinary study, we explore possible sources of the stones and the different factors that may have influenced Anne to obtain and maintain her collection of stones. The significance of Anne Brontë's stones and her connections to mineralogy and geology reveal Anne's interest, knowledge and abilities within these fields.

KEYWORDS Anne Brontë, collection, Scarborough, geology, science, stones, minerals, carnelians, Raman spectroscopy, Museum, Rotunda, Sir Humphry Davy

Introduction

Exhibited in the Brontë Parsonage Museum is a collection of stones (Figure 1) that belonged to Anne Brontë, which were previously connected to her time in Scarborough.[1] The collection was formed at a time when the popularity of mineralogy and geology was increasing; indeed, the period from 1825 to 1875 was later known as the 'golden age' of geology.[2] This study investigates the material culture, context and significance of Anne's collection, which was described by Juliet Barker as 'unpretentious' and also considered by Deborah Lutz, Samantha Ellis and Adelle Hay.[3]

Working across the disciplines of literature, history and science, this research adds to the existing knowledge of the stones, and refocuses the perception of Anne as a well-informed, well-read young woman who participated in scientific activity. We have re-examined the stones, a process that involved geological description and photographing of the collection and analyzing it using Raman spectroscopy.[4] This allowed the origins and possible sources of the collection to

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FIGURE 1 Anne Brontë's collection of stones, as displayed at the Brontë Parsonage Museum. Courtesy of the Brontë Society.

be further investigated. Anne's motives for building and maintaining her collection are also discussed by placing applied and contemporary science alongside cultural inquiry to gain a greater interdisciplinary perspective of Anne's stone collection. This approach mirrors Anne's direct referencing of geology in her novel *The Tenant of Wildfell Hall* (1848).[5] As Ralph O'Connor demonstrated, during the nineteenth century, scientific ideas were regularly expressed in literary forms, and writing on science was seen as an integral part of literature, not as a separate field of knowledge.[6] Opening with a summary of the Raman spectroscopy findings relating to the stones, this study then explores how and why they came into Anne's possession, and how they can help us to better understand her scientific interests and skills.

Anne's stones

Geological Hand Specimen Description uses two main characteristics to categorize rocks: mineralogical composition (what minerals are present) and texture (the size, shape and disposition of the mineral components). The stones in Anne's collection are mostly cryptocrystalline, which means that individual mineral components (grains or crystals) cannot be easily identified by visual or optical means. Consequently, without the removal of the samples to a laboratory or applying destructive analytical techniques, further investigation of the samples is limited. However, Raman spectroscopy can be performed by portable equipment and provides detailed mineralogical description.

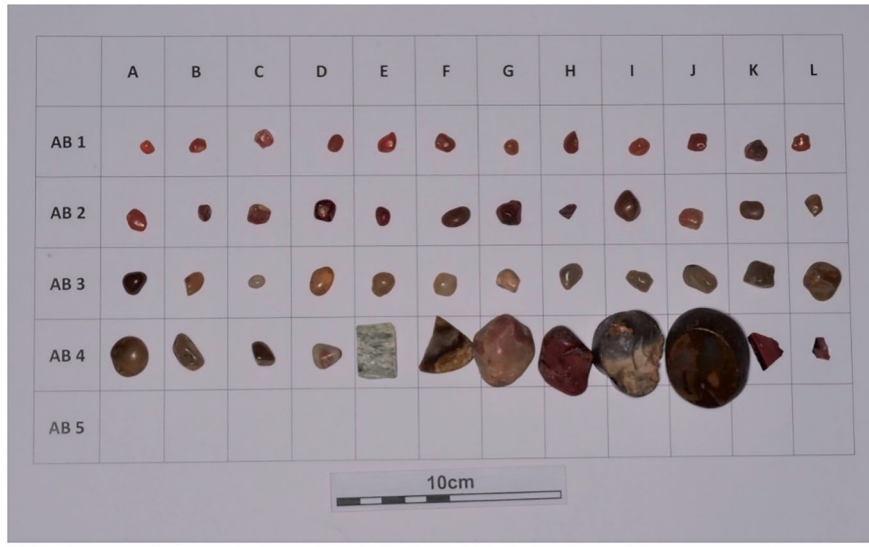

FIGURE 2 Anne Brontë's collection represented by a grid structure, highlighting stone similarities and differences.

We applied Raman spectroscopy to Anne's stones and identified their mineral composition, which in combination with the Geological Hand Specimen Description provided a fuller perspective on their nature and thus significance by providing information that could not be obtained from visual inspection alone. Anne's stones are presented in a display grid (Figure 2), broadly grouped by category and Geological Hand Specimen Description. Sample descriptions and protocols for Raman spectroscopy are described in the Appendix. The majority of these stones are carnelians or similar; that is, small, rounded pebbles generally less than 2 cm across and ranging in colour from pale orange to dark red. Three additional small red stones are, for the first time here, identified as mahogany obsidian (Figure 2: AB2-H, AB4-K, AB4-L). These stones are also red in colour and of similar size to others in Anne's collection, but they are angular in shape. At some point, the obsidian was broken into fragments to reveal sharp edges.

Larger stones within the collection include a piece of speleothem flowstone (Figure 2: AB4-E). Flowstone is one of many types of speleotherm or cave deposits, along with stalactites and stalagmites. This is the first time that the flowstone has been identified in Anne's collection. Although stalactites can possess growth rings and banding when cut in sections, this piece of speleothem does not. It does, however, have a rind on its exterior and ribbon-like folds, terminating at each end in artificially cut surfaces. Calcite is much softer than steel, which means cutting and sectioning of it was achievable with the simpler steel tools of Anne's time, although without the correct tools it is unlikely that Anne would have done this.

There are also three large agates and a small white agate with concentric orange banding (Figure 2: AB4-F, AB4-I, AB4-J, AB4-D) and larger quartz-rich

pebbles, all of which can be classed either as carnelians or jaspers (Figure 2: AB4-G, AB4-H).[7] Some of the agates have at some point been broken and show a haggled or uneven surface; some have also been cut and reveal a polished surface with a high level of finish. This is a non-trivial process and whoever cut and polished the agates would have possessed specialized skills, knowledge and tools. Raman spectroscopy produces unique signals (spectra) that can be used to identify the presence of a given mineral in a particular rock (Figure 3). In the case of some of the carnelians and the mahogany obsidian, these spectra may also have use in the future for determining the geological point of origin of each stone.

It is possible to deduce the geological point of origin for the carnelians in Anne's collection where a small, but measurable, proportion of moganite is present. Chalcedony comprises a variable mixture of quartz and moganite within carnelians. Thus, by measuring the relative proportions of moganite and quartz from Raman spectra, a metric can be obtained, and from this the similarity between samples acquired from a locale and those in Anne's collection can be determined. However, we were not able to do this for the carnelians we sampled for this work. The pebbles we collected from Scarborough, for example, generally had a microscopic component of moganite. The low but measurable amount of moganite in Anne's stones itself is unusual, and this characteristic might be used to rule out geological sources with a high moganite content. It does not, however, rule out the locales where pebbles have a low moganite content that is hard to detect, as detecting small amounts of moganite is technically challenging,

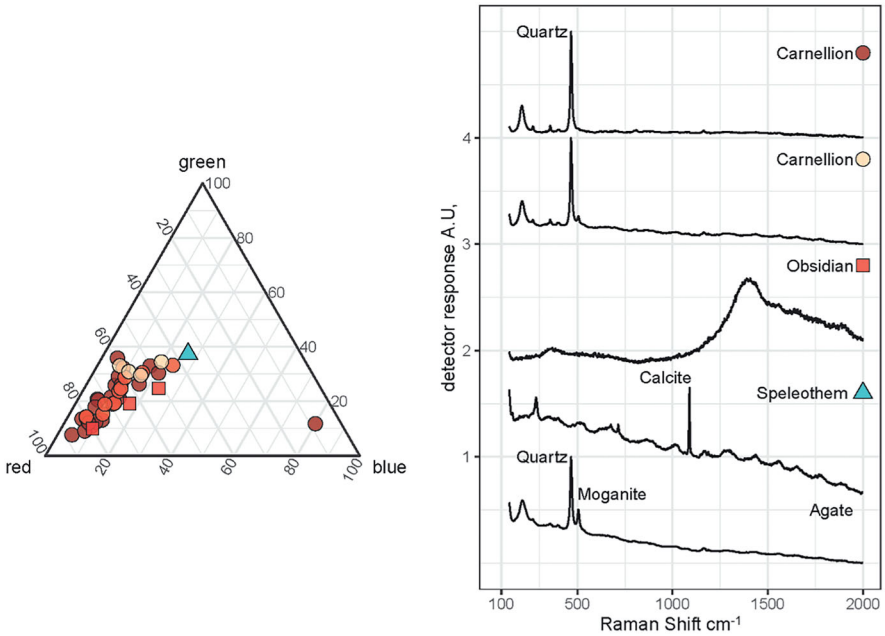

FIGURE 3 LHS: graphical representation of the median colour of the smaller stones, illustrating their redness. RHS: Diagnostic Raman Spectra for Anne Brontë's rocks, illustrating unique composition.

and this technical difficulty may misrepresent what is actually present. Stone Age tools made from obsidian have also had their geological sources traced, in part at least, by use of Raman spectra.[8] Thus the red obsidian in Anne's collection may also be able to have its geological point of origin deduced from Raman spectra alone.

As we can see in Figure 3, the stones in Anne's collection are predominantly red, which might suggest she chose them for their colour. However, it is not universally the case that the carnelians within Anne's collection are deep red. Carnelians in the collection that are mineralogically similar (as deduced from their Raman spectra) and might be expected to be from the same geological source can vary in redness. This implies that Anne's stones were not collected solely for their colour. Moreover, the small carnelians within the collection are not particularly well dressed. For example, many have pitted, haggled or uneven surfaces, and do not evidence the smooth finish that results from the polishing and tumbling of semiprecious stones intended for use in jewellery. This also makes it unlikely that most of the 'red' stones would have been initially purchased or acquired for their appearance, although it is conceivable that one or two the better-looking stones could have been collected or bought with this in mind.

The most noteworthy stones in the collection are the larger flowstone and agates. The flowstone forms from the precipitation of carbonate from water in a cave. Unlike a stalactite, the flowstone does not have a clearly defined internal structure or evidence growth rings. The flowstone has two cut surfaces, implying that it has counterpart pieces that might be physically matched by comparing the cross-sectional areas and flow-patterns on the exterior. The agates, too, where cut and polished, reveal an internal banding that might also be matched to counterpart pieces. A final distinctive feature of one of the agates is an internal tube, visible on an unpolished surface due to the transparency of the sample. The tube gives the impression of being biological, such a spicule, perhaps suggesting the fossilized skeleton of a sponge, but currently no formal identification has been made.

On review, Anne's collection can be seen to comprise stones that are sufficiently unusual and scarce to lead us to theorize that their accumulation could result only from deliberate decision. They do not belong to a range of stones one would likely encounter while gardening or walking, for example. Furthermore, while all but the mahogany obsidian can be obtained from geological sites in Yorkshire, there is no single geological locality that would yield all the rock types one might encounter in a single visit. Thus, multiple visits to multiple localities would be required, either by Anne or by somebody else, to bring this collection together. Nevertheless, there was a specific location where Anne would most certainly have had the opportunity for this exact kind of activity.

Scarborough and geology

Scarborough was described by Augustus Granville in 1841 as the 'Queen of English sea bathing places' and a 'bay of Naples'.[9] Anne felt a strong affinity to

Scarborough, and she spent the longest time there of all the Brontë siblings. The town of Scarborough features a castle atop a cliff, the North Sands on one side and a vista leading to the South Sands, flanked by green topped cliffs that sweep down to the sea in succession as far as the eye can see. The visible topography of Scarborough makes a lasting impression; as Winifred Gérin said, it is 'a place of incomparable natural beauty'.[10]

Anne made several visits to Scarborough during the 1840s in her capacity as governess for the Robinson family, who spent several weeks there each year.[11] Her brother Branwell also joined them there in 1843, as tutor to the youngest child of the Robinson family, Edmund. Anne also visited Scarborough in May 1849 with her sister Charlotte and close friend Ellen Nussey.[12] Anne's lodgings in Scarborough were always at The Cliff, which was situated directly above the beach on South Sands. After Anne's death in 1849, Charlotte continued to associate her with the sea. She wrote to James Taylor that 'the distant prospects were Anne's delight, and when I look round, there she is in blue tints, the pale mists, the waves and shadows of the horizon'.[13]

Anne describes the topography of the cliffs south of Scarborough in detail in her novel *The Tenant of Wildfell Hall*:

> At length our walk was ended. The increasing height and boldness of the hills had for some time intercepted the prospect, but on gaining the summit of steep acclivity, and looking down, an opening lay before us — and the blue sea burst upon our sight! — deep violet blue — not deadly calm, but covered with glinting breakers [...] I looked at my companion to see what she thought of this glorious scene. (*TWH*, p. 65)

Granville draws attention to the geological features of the scenery around Scarborough for the visitor of the 1840s: 'In natural phenomena we have the strongly marked geological formation of the coast, right and left of Scarborough, with its cavern and promontories — its clefts, its dislocations, and its elevation — all sufficiently denuded to exhibit a very museum to the lover of geology'.[14] Granville concluded that the intellectual establishments in Scarborough were better than any other spas, and suggested visiting Mr. Bean's Museum, informing his readers that the geologist 'Lyall' [*sic*][15] and the mineralogist Sowerby[16] were 'expected to visit' this establishment, which displayed shells and geological specimens in cabinets.[17] Mentioning such important figures in the field added gravitas to those readers who sought to improve their geological knowledge when visiting Scarborough. The Museum (Figure 4), now called The Rotunda, opened in 1829 and was highly recommended by Granville. One of the world's first purpose-built museums, based on designs by the geologist William Smith, it provided information on and improved knowledge of the local geology.[18]

Although there is no evidence that Anne visited the Museum, it is highly likely that she did given her evident interest in stone collecting and as it was just minutes away from her residence at Woods Lodgings at The Cliff. There she would have seen the collections and displays in the Museum, and the encircling

FIGURE 4 N. Whittock, *The Museum and New Bridge, Scarborough* (London: Hinton, 1828).

mural of the geological cross-section of Yorkshire that was painted on the top floor.[19] Certainly, Branwell described the Museum with accuracy. Gérin notes that Branwell visited the Museum with his charge Edmund in 1843. She points out that a passage in his unfinished novel, *And the Weary are at Rest* (1845), demonstrates 'his very exact knowledge of Scarborough front'.[20] In this text, Branwell asks, 'Would not even the little Circular Museum hold forth [...] more interesting specimens of geological and zoological history than those afforded by the cornelian pebbles or limpit [*sic*] shells or starfish that sprawled among [...] the sand and seaweed?'. He goes on to muse that while this might be true, not even 'science and the picturesque combined' can produce 'the incommunicable emotion' of 'inward reflected joy'.[21] One guidebook to Scarborough for younger readers, *The Scarborough Natural Historians* (1821), describes the experiences of three visitors, including a ten-year-old boy, who walk on South Sands and discuss the merits of the Museum: 'Mr. Fernando called Edward's attention to the Museum, at the foot of the Cliff Bridge, which belongs, observed he, to a society whose object is to promote science, and to investigate the local natural history of Scarborough and its vicinity'.[22] The Museum was clearly a regular venue for educators of young people, and it would seem likely that Anne also visited there with her charges. It is also evident that in the early-nineteenth century, Scarborough was a lively hub for geological activity, both on a recreational level and on the level of serious scientific inquiry.

Anne as collector

The Raman spectroscopic analysis of Anne's stones revealed a mineralogical precision that rules out any ideas that this collection grew out of a casual

accumulation of stones or by happenstance. Instead, we argue that Anne's stones must have been collected carefully, purposefully and knowledgeably from unusual geological sources, or transferred to her by others who had access to these sources. Despite these broad deductions about the collection's origins, it is not known how these individual stones were brought together or how they came into her possession.

Anne's godmother Elizabeth Franks (née Firth) visited Scarborough for holidays in both 1816 and 1820. She kept accounts of her activities and records of her financial transactions in diaries. In Scarborough, she collected pebbles and purchased 'cornelians', carnelians, other unnamed stones, a 'snake stone' and an ammonite, possibly from 'Pebblers'.[23] Elizabeth Firth's entry for 28 August 1816 reads: 'we gathered pebbles upon the north sands',[24] and on 20 April 1820, she 'talked with the Pebblers'.[25] Her accounts for 1820 show that she paid one shilling for a 'snake stone' and one shilling and six pence for 'Cornelians &c.'.[26] In 1819, she visited the Cumberland Caves in Derbyshire and purchased a 'snow fossil', a 'double reflecting stone' also known as fluor spar, a 'screw stone' and some lead.[27] Although Anne's own collection shows some similarity with her godmother's collection through the presence of carnelians, it does not show evidence of snake stone, snow fossil, double reflecting stone, screw stone or lead. Likewise, Elizabeth Firth makes no mention of agate, obsidian or flowstone.

It could be that Anne purchased some or all of her stones, that they were gifted to her or that she collected some or all of them herself. Certainly, during the period, advice on collecting was available within local guidebooks. These recommended visitors to search for particular stones, including carnelians, at various locations as a means of edification and amusement and for promoting exercise. Potential collectors were warned that:

> Quartz is very common, it is transparent when wet, but dull when dry; many a young collector has filled his pockets with it, mistaking it for carnelian, and has afterwards been surprised to find that his glittering treasures had become dull and unprofitable.[28]

Another way of obtaining particular stones was cited in *Poetical Sketches of Scarborough* (1813), which suggested making a purchase in one of the curiosity shops or lapidaries found in Scarborough. The book advises that:

> The rocks and shores are capable of affording ample gratification to the naturalist. The variety of sea-weed, corallines, pebbles and petrifications which they furnish is very considerable; but persons, who prefer a less fatiguing mode of collecting, may purchase very good specimens at the shops in the town.[29]

In 1840, a list of trades, services and shops in Scarborough records seven lapidaries were operating in the town.[30] Anne may have been given or have purchased her mahogany obsidian specimens at one of these local curiosity shops, which imported items from abroad.[31] Mahogany obsidian, an igneous rock formed from the rapid cooling of molten rock is not found in Britain and is

relatively rare; sources include Mexico, North America and Brazil.[32] It is also possible that Anne found the agate stones and had them polished at one of the lapidaries or jet workshops that were situated along the short walk between Woods Lodgings and the Museum. In Emma Davenport's *Fickle Flora and her Seaside Friends* (1863), which is set in Scarborough, Caroline's mother, Mrs Leslie, says to her daughter and her friend Flora, 'Come my dear girls […] we must hurry home. Do not collect any more pebbles now. I will have these cut at by a lapidary. It is a pretty process, and you shall see it done'.[33]

Similarly, Anne's specimen of flowstone could have been purchased as a local example that was cut into pieces for sale or sourced in the limestone of the 'Holmes and hollows behind the Castle at Scarborough'.[34] Alternatively, this rock may have been a gift from Charlotte. In July 1845, Charlotte visited Ellen Nussey in Hathersage, Derbyshire.[35] Ellen wrote to Mary Gorham about their trip to Castleton and Peak Cavern. They went 'through the caverns', and Ellen noted that 'Charlotte was very much pleased with the caverns'.[36] Charlotte may have obtained the neatly cut section of flowstone from one of the workers at the cave or from a shop in Castleton and brought it back for Anne. [37]

If, however, Anne did collect the carnelians and agates herself, there are three possible locations in and around Scarborough where she might have done so, namely, North Sands, South Sands and Carnelian Bay (Figure 5). In Davenport's *Fickle Flora*, Caroline and Flora are informed by Mrs Leslie that 'there are

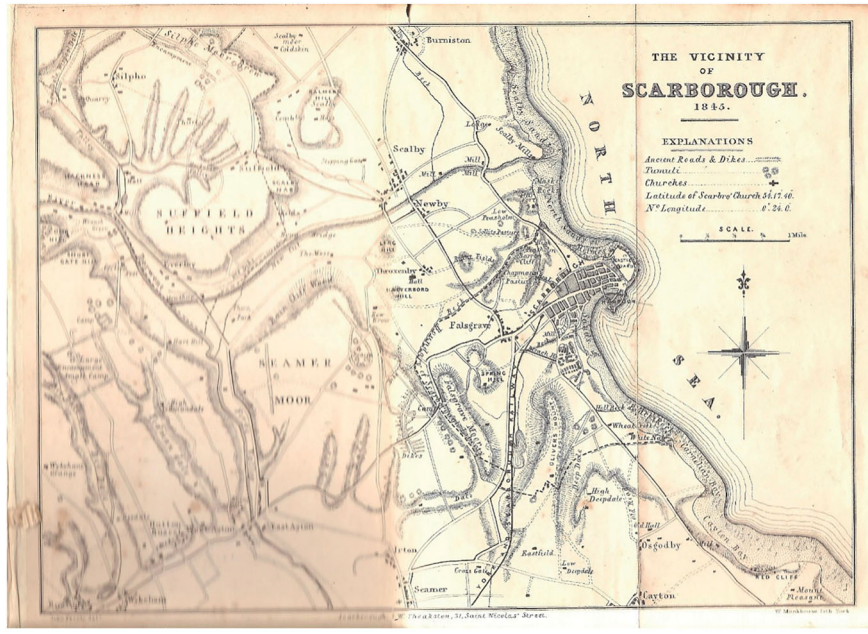

FIGURE 5 *Theakston's Pictorial Scarboro' Guide: Embellished with a New and Accurate Plan of the Town, A Map of the Towns and Walks in the Vicinity and Thirty-Eight Illustrations* (Scarborough: S.W. Theakston, 1845).

carnelians, onyxes and agates on this coast'.[38] They walk across the town to the North Sands in order to collect some stones. Mrs. Leslie refers to the Castle Cliff as being 'steep and inaccessible'.[39] The path down to the beach is described as 'rather steep and muddy, being supported here and there by rude steps of wood'.[40] For Anne, walking through the town and reaching North Sands would have taken some time, and Anne's own leisure was limited by her duties as governess to the Robinson children. In a 'Birthday Note' to Emily on 30 July 1841, Anne mentions that she was writing late at night: 'I am now at Scarborough. My pupils are gone to bed and I am hastening to finish this before I follow them'.[41] Edward Chitham is of the opinion that Anne had little time to call her own: 'If Lydia was in bed, Anne must have been writing deep into the night, for surely Lydia would not be one to leave social gatherings early'.[42]

The second location, South Sands, was within easier reach for Anne. It was the beach below Woods Lodgings where she stayed with the Robinsons, and to reach it she would simply have walked down a series of paths to the beach. Anne's knowledge of South Sands and its tides is apparent in a pivotal scene in Chapter 24 of *Agnes Grey* (1847), 'The Sands', where her description matches the location. Agnes sets out early in the morning as 'the church clock struck a quarter to six' to enjoy the sight of 'the bright morning sunshine on the semi-circular barrier of craggy cliffs and the low rocks out at sea — looking, with their clothing of weeds and moss, like little grass-grown islands — and above all, on the brilliant sparkling waves' (*AG*, p. 164). [43] As the tide comes in, she realizes that 'the water was rising; the gulfs and lakes were filling; the straits were widening, it was time to seek some safer footing; so I walked, skipped and stumbled back to the smooth, wide sands' (*AG*, p. 165). Writing about Anne's last visit to Scarborough with Charlotte and Ellen Nussey in May 1849, Ada Harrison and Derek Stanford assume South Sands to be the point of origin for Anne's carnelians: 'They must have hired the little carriage from near the fishing boats and driven to where, among the rocky pools, in past holidays, she had found the cornelians'.[44]

A Guide to Scarborough (1840) describes 'Carnelian Bay, the Beach near the Spaw', by which they mean South Sands, and 'Mill Bay, to the south' as the best places to collect and classify specimens because these beaches:

> generally present large quantities of gravel, which is of as varied a character as it is possible to conceive. It contains Onyx, Sardonyx, Chalcedony, Green Mocha, Veined Agate in endless variety and of great beauty, Jasper Agate, Prehnite, Heliotrope or Bloodstone, Hornstone, Porphyry, Woodstone, Gneiss, Granite, Amygdaloid, Adularia or Moonstone etc.[45]

The third location to consider is Carnelian Bay, which lies further south from South Sands, past an area called Black Rocks and around a promontory known as White Nab. In *The Tenant of Wildfell Hall*, Gilbert Markham and Helen Graham join a party of friends on a 'Bay excursion', which could easily be a reference to Carnelian Bay or Cayton Bay (*TWH*, p. 72). However, none of the party actually descends to the shore. Instead, Gilbert mentions 'a little, active

clambering' to Helen, who is seated sketching on 'a narrow ledge of rock at the very verge of a cliff which descended with a steep, precipitous slant, quite down to the rocky shore' (*TWH*, p. 67). Helen makes herself less accessible and puts herself at risk, revealing her vulnerability by sitting on the cliff edge and using the rocky topography to distance herself from Gilbert. This makes her less attainable, physically and metaphorically. Gilbert's attempts in reaching Helen reflect the effort involved in trying to attain her affections, and the perilous conditions of the cliff can be interpreted as a metaphor for her troubled relationship with Huntingdon.

On the shore at Carnelian Bay, the stones that could be found were described in *Poetical Sketches*:

> At last Carnelian-bay they tread
> With all its myriad treasures spread;
> Gems of all kinds — red, white, square, round —
> A new Golconda above ground![46]

When questioned about the accessibility of Carnelian Bay, Dave Horsley of the RNLI Lifeboat Station in Scarborough explained to us that the promontory between South Sands and Carnelian Bay, known as White Nab, is rocky and treacherously slippery with seaweed. A person walking to Carnelian Bay by that route risks being cut off by an incoming tide.[47]

In *The Scarborough Natural Historians*, Edward and his grown-up companions 'proceed to Carnelian Bay, a celebrated place of resort' by the more dangerous route around White Nab, 'clambering over rocky cliffs in their progress'. On their return, they experience the dangers of the incoming tide:

> As they were returning with their pockets and baskets full of minerals of one description or another, they were intercepted by the tide, and necessitated to clamber up the rocky cliffs to save themselves from a severe ducking; in doing which, Edward let slip his basket, which was never heard of again. This circumstance he lamented, as it contained, he thought, some rich treasures.[48]

Contemporary guidebooks recommended that tourists visit Carnelian Bay. The agates and carnelians, which form part of Anne's collection, were becoming rarer to find at Carnelian Bay by the time she visited in Scarborough. *A Guide to Scarborough* (1840) suggests that the health benefits gained from searching may also bring reward in itself:

> Carnelian bay is principally resorted to by individuals, for the purpose of Pebble Hunting which is a favourite amusement with most who visit Scarborough; and although, from the great search made for agates during the last twenty years, they have necessarily become scarce, yet many interesting specimens may be collected by those who are ardent in the pursuit. Supposing, however, that Agate and Carnelian do not greet the eye at every step, there is a gem more precious, which oft is gained by exercise.[49]

If Anne had visited Carnelian Bay to collect stones, then she would have been encumbered by the long skirts of her dress and would have faced a precarious journey around the headland and back if she chose this route. The guidebooks suggested organizing transportation:

> A walk to Carnelian Bay is usually embraced by Visitants, as it gives rise to much mirth by parties clambering over rocky cliffs on their progress to this small but picturesque bay of Carnelians; nor does this portion of the visit constitute the chief delight; for, when arrived, the search for Carnelians or other pebbles diverts the mind and occupies the period till the time for a return to dinner is necessary, which may be varied by proceeding along the Bridlington road, which will be less fatiguing than over the Sands. Parties indeed may order their carriages to be waiting there, as we conceive the tour of the rocks will afford sufficient exercise for the day, and create an eager appetite for the substantial meal above specified. Particular enquiries should be made respecting the time suitable, as Visitants are sometimes caught by the tide.[50]

As a governess, Anne would not likely have been able to afford to hire a carriage, or to take the time needed to make such an excursion due to her commitments to the Robinson family. However, she could have potentially travelled there for an outing with the Robinson family. Considering the amount of time that would have been needed to collect the stones, perhaps two hours either side of the low tide, which would have to include reaching Carnelian Bay from South Sands and returning safely to her lodgings at The Cliff as the tide came in, it would have been a feat to obtain the stones from Carnelian Bay by herself and in her own time.

Another factor to consider is safety with respect to tides along the coast. *The Perambulator's Guide, to the Scarborough Sands* (1822) gives salutary tales of drownings and rescue missions at nearby locations and informs the reader that:

> it is not at all to be wondered at that many persons should in their everyday walks in search of health, and happiness, and marine productions, be exposed to the danger of being caught by the Tide, if not at risk of their lives, at least, to the creation of great alarm and personal inconvenience both to themselves and their friends.[51]

Care had to be taken even when walking on South Sands. *Poetical Sketches* warns that 'The sudden tides, and short breakings of the sea, which often come with great impetuosity, render it advisable to employ guides and machines'.[52] Certainly, staying in such close proximity to the beach at Woods Lodgings would have allowed Anne to observe the tides and see first-hand whether it was safe to walk along the South Sands. It is possible that Anne had knowledge of the tides. Horsley explained that local knowledge of the tides and observation of them is extremely important for safety. He also added that as the tide comes in on South Sands, a walking pace in front of the tide to get to safety is then possible.[53] In the 1840s, tide tables were usually printed in the weekly papers during the

Season. Anne may have read about currents in *Blackwood's Magazine* and seen detailed explanations of tides in books that were available for loan from the Keighley Mechanics' Institute.[54] Horsley has suggested that in visiting South Sands, there would be a two-hour window either side of a low tide to be safely on the beach. However, a spring tide could mean reduced safety because the tide comes in more quickly due to a larger discrepancy between the very high and very low tide.[55]

In order to see when Anne could have collected her stones, we took tidal readings for the dates of her visits, mapping when it would have been feasibly safe for Anne to access South Sands (Figure 6). Anne's collection times would have been limited to daylight, and for some of those times she may have been engaged in her working duties as governess.[56] In *Agnes Grey*, Anne creates a clearly delineated time frame for Agnes's walk across the South Sands. Agnes leaves to walk down to the sands at 5.45am, noting that 'half the world was in bed' at this time. She meets Mr. Weston, who checks the time at 7.05am and they turn around at this point to walk home, indicating that the duration of Agnes's entire walk is around two hours.[57] Analysis of the tidal data revealed that if Anne was collecting by herself, early in the morning between 6.00am and 8.00am before the working day began, then her opportunities to go to the beach on South Sands were limited to between six and nine times for each visit of up to five or

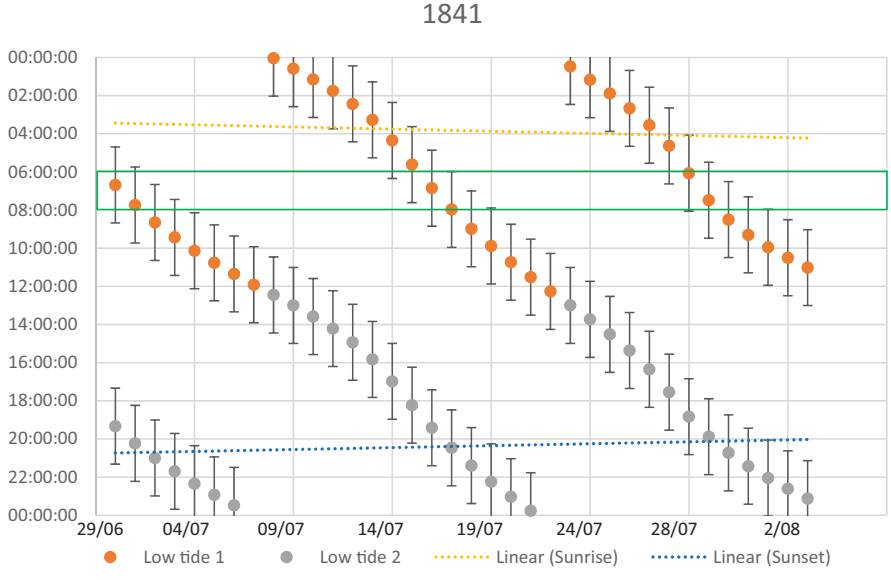

FIGURE 6 Graph to show potential collection times for South Sands, 29 June to 3 August 1841. The band between the parallel bars shows when Anne could have accessed South Sands safely in the morning between 6.00am and 8.00am. (Reproduced with permission from HMNAO, UKHO and the Controller of Her Majesty's Stationery Office, '© Crown Copyright and/or database rights. Reproduced by permission of The Keeper of Public Records and the UK Hydrographic Office (www.GOV.uk/UKHO).')

six weeks spent in Scarborough. This does not take into account the possible occurrence of inclement weather.

Reasons for collecting

It is unlikely that we will ever know exactly why Anne was motivated to collect and retain her stones, and to bring them back to Haworth. There may have been a combination of reasons. A carnelian necklace with spherical beads, graduated in size, is exhibited at the Brontë Parsonage Museum, and a watercolour portrait of Anne painted by Charlotte Brontë in 1834 shows Anne wearing a necklace of carnelian beads.[58] The aesthetic quality of Anne's collection of stones may have held visual and tactile appeal for her. The colours and textures of the stones contrasted with the visible grey millstone grit that characterizes the moors around Haworth. Perhaps they were a souvenir of a place for which she felt a strong affinity. Her stones could also have been a physical memento of the imagined meeting of Agnes Grey and Edward Weston on South Sands. Juliet Barker suggested that they brought her comfort, 'no doubt to be brought out and reminisced over at less pleasant times'.[59] In collecting the stones, Anne may have tapped into the Victorian tenet of doing something useful while exercising the mind and body. She may have seen her stones as evidence of the wondrous creation of God. The variety of the collection, their provenance and representations and connections to the wider world may have been of particular interest. She may have witnessed other people collecting stones either for themselves or to sell to museums or one of the curiosity shops in Scarborough.

In *The Tenant of Wildfell Hall*, Gilbert Markham mentions how his bond with Helen develops on an equal footing through shared intellectual interests: 'So we talked about painting, poetry, and music, theology, geology and philosophy' (*TWH*, p. 73). Clearly, in Anne's mind, an interest in geology was a key sign of a sensitive and capable mind. Gilbert also buys a copy of Sir Walter Scott's *Marmion* (1808) for Helen (*TWH*, p. 73), which mentions Whitby and the 'reliques of the snakes [...] still found about the rocks [...] Ammonitae'.[60] A manuscript discussing scientific ideas written by Anne and held at the Brotherton Library shows evidence of her inquiry into the origins of the earth.[61] Clare Flaherty, who transcribed the manuscript in 2013, suggested that Anne may have written the manuscript in 1847, around the same time as *Tenant*. The manuscript is based on the work of Penzance born Sir Humphry Davy, who wrote *The Last Days of a Philosopher* (1830), which Anne references in *Tenant*.[62] The fact that Anne was exploring various theories at a time when 'early geology had unmatched popularity' shows that she was very much in tune with the cultural interests of the period.[63] In her manuscript, she writes, 'Let us take Sir Humphry Davy's theory, found in his Last days of a Philosopher: I know not any more sensible or philosophical view, of the geological history of the earliest stages of the world we inhabit'.[64]

Anne's interest in geology may also have been piqued by the mineralogical and geological achievements of her maternal relatives. Anne's mother Maria (née Branwell) and Maria's sister Elizabeth Branwell, who later came to live at the parsonage in Haworth, grew up in Penzance.[65] Joseph Carne was mentioned in a copy of *Blackwood's Edinburgh Magazine* that Anne would likely have seen.[66] He was also cited in a contemporary textbook by the geologist John Philips, nephew of geologist and stratigrapher William Smith, which was available at the Keighley Mechanics Institute library and also listed other eminent geologists.[67] Joseph Carne's daughter, Elizabeth, went on to distinguish herself as one of a generation of female geologists who contributed to the growing body of knowledge in that field during the nineteenth century.[68] In the Museum at Scarborough, Anne could have seen the collections and material donations from men and women, including Frances Richardson Currer.[69]

Anne's own family also took a keen interest in geology and other natural sciences. Her father, the Revd Patrick Brontë, wrote texts about the bog burst of September 1824.[70] Branwell mentioned the 'famous French naturalist'[71] Cuvier in 1829 as a postscript in a miniature book called *A Collection of Poems by Young Soult the Ryhmer* [*sic*].[72] Branwell is also thought to have inscribed a sketch of a small figure drawn by Charlotte as 'Baron de Cuvier' four months earlier.[73] Cuvier, an eminent palaeontologist was also discussed extensively throughout the Brontës' own copy of *The Gardens and Menagerie of the Zoological Society Delineated* (1830).[74] The Brontë siblings would also have had access to articles about natural history in certain editions of *Blackwood's Magazine*.[75] Branwell also owned a copy of *Rambles by Rivers* (1844), which referenced Dr Mantell, a famous geologist of the period,[76] and enjoyed walks with his friend Sutcliffe Sowden, a 'noted geologist'.[77] The Revd Drury, a friend of Anne's father and founding member of the Keighley Mechanics' Institute, donated local specimens of millstone grit to the Yorkshire Philosophical Society.[78] Geology was very much part of Anne's upbringing and reading.[79] Anne also includes references to rocks, stones and topography in her poetry.[80] Her interest connects with that shown by other family members including Charlotte and Emily in nature, natural events and their surroundings, using metaphors and references to rocks and topography in their writing.[81]

Conclusion

Anne's stones were clearly of great significance to her because she brought them back to Haworth, and the collection was retained amongst Anne's possessions after her death. As we have mentioned, she probably had a variety of sources and motivations for building her collection. She took an interest in mineralogy and geology, not only as a 'searcher for specimens' but also as a well-informed reader who was clearly curious about the origins of the earth. As we have discussed throughout this article, Anne's collection took skill to recognize and collect. Using Raman spectroscopy, this study has characterized her stones and has

revealed that some of these are of a high quality; they are a collection of semiprecious gemstones and geological curiosities and not simply an assortment of eye-catching pebbles. The exceptional quality of some of the carnelians shows that Anne was a keen observer who was knowledgeable in acquiring these particular stones.

Anne's desire to reveal an equal relationship between her female and male characters is conveyed through their shared interest in geology. In the Preface to the second edition of the *The Tenant of Wildfell Hall* she writes:

> All novels are or should be written for both men and women to read, and I am at a loss to conceive how a man should permit himself to write anything that would be really disgraceful to a woman, or why a woman should be censured for writing anything that would be proper and becoming for a man. (*TWH*, p.3)

By choosing geology as an area of common ground for Gilbert Markham and Helen Graham, Anne is directly informing readers of both sexes that she herself is interested in this modern field of early-nineteenth century scientific enquiry.

Anne's stones may be referred to as a mineral collection, and Anne can be described as an informed collector with a serious interest in geology. Her participation came at an important time in geological theory and discovery, in a location which was extremely important to the development of this field of knowledge.

In 1840, Charlotte Brontë wrote to Henry Nussey asking, 'do you think I am a Blue-stocking? — Chemistry? Or Astronomy? Or Mechanics? Or Chonchology [*sic*] or Entomology or what other ology? I know nothing at all about any of these — I am not scientific'.[82] Just a few years on, Anne Brontë had created her own mineral collection, and was confidently referencing geology in her private studies and public work.

Acknowledgements

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Notes

[1] Ref 1916: Sotheby's sale, lot 664 [8/- for a collection of items] by Mrs Ellis Chadwick, 1947: purchased at Sotheby's sale, lot 463 [£11 for a collection of items]: Dr Juliet Barker, *Sixty Treasures* (Haworth: Brontë Society, 1988), unpaginated.

[2] Douglas A. Robson, *Pioneers of Geology* (Newcastle: The Natural History Society of Northumbria, 1986), p. 7.

[3] Barker, *Sixty Treasures*, unpaginated; Deborah Lutz, *The Brontë Cabinet* (New York: Norton, 2015), p. 50; Samantha Ellis, *Take Courage: Anne Brontë and the Art of Life* (London: Chatto and Windus, 2017), p. 308; Adelle Hay, *Anne Brontë Reimagined: A View from the Twenty-first Century* (Salford: Saraband, 2020), pp. 142–143.

[4] Conventional spectroscopy uses differences in the wavelength of emitted, transmitted or reflected light to characterize materials. Raman spectroscopy differs from classical reflected or transmitted light spectroscopy in that it uses spectra generated by the 'Raman' effect, a phenomenon in which a monochromatic light incident on a material (a single colour of light such as a laser) has its wavelength shifted before being re-emitted. Compared to conventional spectroscopy, for certain materials, Raman spectra provide a higher degree of characterization that is both more specific and clearer. Geologists use Raman spectroscopy to obtain information on the minerals present within a sample, which is particularly useful when the minerals cannot be identified by eye or even hand lens or microscope (as they are too small or lack a visual 'tell'). In most cases, as for the work reported here, Raman spectroscopy is a non-destructive analytical technique.

[5] Anne Brontë, *The Tenant of Wildfell Hall*, ed. by Stevie Davies (1848; repr. London: Penguin, 1996), p. 73; hereafter *TWH*.

[6] Ralph O'Connor, *The Earth on Show: Fossils and the Poetics of Popular Science, 1802–1856* (Chicago: University of Chicago Press, 2007), p. 13. Literary scholarship has only recently examined the fiction of Charlotte and Emily Brontë in relation to the scientific ideas of their time. See for example, Alexandra Lewis, ed. *The Brontës and the Idea of the Human: Science, Ethics and the Victorian Imagination* (Cambridge: Cambridge University Press, 2019); Kari Nixon, 'Salvation in the Cesspit: The Brontës, Sanitary Science and Redemptive Contagion', *Brontë Studies*, 46 (2021), 102–17.

[7] A distinction between carnelians and red jasper is determined by quartz content and optical clarity. Carnelians comprise chalcedony, a mixture of the minerals moganite and quartz, while jasper generally has a higher quartz content. In this case, the softness of the polish imparted and the clarity and translucency implies carnelians. Jaspers are opaque and often appear as aggregates of different components.

[8] Elizabeth J. Carter, Sarah J. Kelloway, Nina Kononenko and Robin Torrence, 'Raman Spectroscopic Studies of Obsidian', in *Analytical Archaeometry: Selected Topics* (London, Royal Society of Chemistry, 2012), ed. by Howell Edwards and Peter Vandenabeele, pp. 318–44 (pp. 323–9).

[9] A. B. Granville, *Spas of England and Principal Sea-Bathing Places*, 2 vols (1841; repr. Bath: Adams and Dart, 1971), I, 150.

[10] Winifred Gérin, *Anne Brontë: A Biography* (Edinburgh: Thomas Nelson and Sons, 1959), p. 161.

[11] Juliet Barker, *The Brontës* (1994; repr. London: Abacus, 2010), pp. 420–21, 511, 515; Edward Chitham, *A Brontë Chronology* (Hampshire: Palgrave Macmillan, 2003), pp. 116–22, 130–40, 147–48; Mick Armitage, *A Brontë Chronology*, <http://www.mick-armitage.staff.shef.ac.uk/anne/bromte.html> [accessed 1 March 2021].

[12] Ellen Nussey, 'A Short Account of the Last Days of Dear A.B.', in *The Letters of Charlotte Brontë*, ed. Margaret Smith, 3 vols (Oxford: Clarendon Press, 1995–2004), II, p. 739.

[13] *The Brontës, Their Lives, Friendships and Correspondence*, ed by Thomas James Wise and John Alexander Symington, 3 vols (1933; repr. Oxford: Blackwell, 1980), III, p. 138.

[14] A. B. Granville, *Spas of England and Principal Sea-Bathing Places*, 2 vols (1841; repr. Bath: Adams and Dart, 1971), I, p. 153.

[15] Sir Charles Lyell was a geologist and author of Charles Lyell, *Principles of Geology* (London: John Murray, 1830–1833) 3 Volumes: Martin Rudwick, 'Lyell, Sir Charles, first baronet (1797–1875)', in *Oxford Dictionary of National Biography* <doi:10.1093/ref: odnb/17243>.

[16] James De Carle Sowerby was a mineralogist, naturalist and artist: R. J. Cleevely, 'Sowerby, James De Carle (1787–1871)', *Oxford Dictionary of National Biography* <doi:10.1093/ref: odnb/26074>

[17] Granville, I, p. 190.

[18] *The Scarborough Heritage Trail* (Scarborough: Scarborough Borough Council and Scarborough and District Civic Society, 2009), p. 12.

[19] Ralph O'Connor, *The Earth on Show: Fossils and the Poetics of Popular Science, 1802–1856* (Chicago: University of Chicago Press, 2007), p. 274.
[20] Winifred Gérin, *Branwell Brontë* (Edinburgh: Thomas Nelson and Sons, 1961) p. 229,; Edward Chitham, *A Life of Anne Brontë* (Oxford: Blackwell, 1991), p. 110, cited p. 199.
[21] Branwell Brontë, *The Works of Patrick Branwell Brontë*, ed. by Victor Neufeldt, 3 vols (London: Garland, 1999; repr. London: Routledge, 2015), III, p. 427.
[22] *The Scarborough Natural Historians or, A Visit to that Celebrated Watering-place* (Scarborough: John Cole, 1829), pp. 44–47.
[23] *Diaries of Elizabeth Firth (1797–1837)*, M.S.58 A Elizabeth Firth Manuscripts, University of Sheffield, p. 181.
[24] *Diaries of Elizabeth Firth*, p. 78.
[25] *Diaries of Elizabeth Firth*, p. 170.
[26] *Diaries of Elizabeth Firth*, pp. 78, 170, 181.
[27] *Note Book of Elizabeth Firth (1797–1837)*, M.S.58 B Elizabeth Firth Manuscripts, University of Sheffield, pp. 148, 157–58.
[28] *A Guide to Scarborough*, 8th edn (Scarborough: W., T., and J. Ainsworth, 1840), p. 88.
[29] J. Green, *Poetical Sketches of Scarborough* (1813; repr. Driffield: Frank Fawcett, 1893), p. xii.
[30] William White, *History, Gazeteer, and Directory of the East and North Ridings of Yorkshire* (Sheffield: Robert Leader, 1840), p. 482.
[31] *Cole's Scarborough Guide* (Scarborough: John Cole, 1825), p. 68.
[32] For example, in 1828, the Yorkshire Philosophical Society received from a donation from Captain Colquhon of '15 specimens of obsidian, from Real del Monte, Mexico', which provides evidence that mahogany obsidian was available to collectors in Britain at this time: 'Donations to the Society's Museum Mineralogy, April 1828' in *Annual Report of the Council of Yorkshire Philosophical Society for MDCCCXXVIII* (York: 1829), p. 35, Biodiversity Heritage Library.
[33] Emma Davenport, *Fickle Flora and Her Seaside Friends* (London: Griffith, Farran, Okeden, and Welsh, 1863), p. 44.
[34] Francis Kendall, *A Descriptive Catalogue of the Minerals and Fossil Organic Remains of Scarborough and the Vicinity* (Scarborough: T. Coultas, 1816), pp. 50–52; *The Scarborough Natural Historians*, pp. 8–9.
[35] W. Hartmann Hoult, 'Charlotte Brontë's Holiday in the Peak District', *Brontë Society Transactions*, 14:4 (1964), 19–27 (p. 24).
[36] Ellen Nussey to Mary Gorham, 22 July 1845, in *The Letters of Charlotte Brontë*, II, p. 404.
[37] *Pigot and Co's Royal National and Commercial Directory and Topography* (London: J. Pigot and Co., 1842), p. 21.
[38] Davenport, p. 43.
[39] Davenport, p. 42.
[40] Davenport, p. 43.
[41] Winifred Gérin, *Anne Brontë: A Biography*, p. 165.
[42] Edward Chitham, *A Life of Anne Brontë*, (Oxford: Blackwell, 1991), p. 86; Christine Alexander and Margaret Smith, *The Oxford Companion to the Brontës, Anniversary Edition*, with Preface by Clare Harman (Oxford: Oxford University Press, 2018), p. 432.
[43] Anne Brontë, *Agnes Grey*, ed. by Robert Ingelsfield and Hilda Marsden, with Introduction by Sally Shuttleworth (1847: repr. Oxford University Press, 2010), p. 164 (Hereafter, *AG*).
[44] Ada Harrison and Derek Stanford, *Anne Brontë Her Life and Work* (London: Methuen, 1959), p. 157.
[45] *A Guide to Scarborough*, p. 88.
[46] Green, pp. 93–4. Golconda is a region in India known for its gems.
[47] Dave Horsley, telephone conversation, 26 July 2016.
[48] *The Scarborough Natural Historians*, pp. 37–8.
[49] *A Guide to Scarborough*, p. 87.
[50] *The Scarborough Repository and Mirror of the Season* (Scarborough: John Cole, 1824), p. 18.
[51] *The Perambulator's Guide to the Scarborough Sands; or a Tide Table from the Spring to the Autumnal Equinox 1822 for the Numerous Visitors at the Beautiful Watering Place* (York: John Bleckley, 1822).
[52] Local women assisted visitors to step into the sea from bathing machines which were pulled into the sea by horses: Green, p. x.
[53] Dave Horsley, telephone conversation, 28 February 2018.
[54] *Blackwood's Magazine*, Vol 3 (17), August 1818, p. 580, refers to currents as a 'most important subject'. Examples of titles on tides and currents at the Keighley Mechanics' Institute library include Richard Phillips, *A Million of Facts of Correct Data and Elementary Information Concerning the Entire Circle of the Sciences* (London: Ward, Lock and Co, 1839), pp. 326–34; Robert Mudie, *The Sea* (London: Thomas Ward and Co, 1835); No author, 'Where the Brontës Borrowed Books', *Brontë Society Transactions*, 11:5 (1950), 344–58.

[55] Dave Horsley, telephone conversation, 26 July 2016.
[56] Data from the UK Hydrographic Office.
[57] *Agnes Grey*, Chapter 24.
[58] *The Brontë Society Gazette*, 74 (2018), p. 6. Source on loan to the BPM. See also Christine Alexander and Jane Sellars, *The Art of the Brontës* (Cambridge: Cambridge University Press, 1995), pp. 159, 211.
[59] Barker, *Sixty Treasures*, unpaginated.
[60] Walter Scott, *Marmion: A Tale of Flodden Field* (London: John Sharpe, 1809), p. xivi.
[61] Clare Flaherty, 'A Recently Rediscovered Unpublished Manuscript: The Influence of Humphry Davy on Anne Brontë', *Brontë Studies*, 38:1 (2013), 30–41; James A. Secord, *Visions of Science* (Oxford: Oxford University Press 2014), p. 27.
[62] Sir Humphry Davy, *Consolations in Travel; Or the Last Days of a Philosopher* (London: John Murray, 1830), referenced in *The Tenant of Wildfell Hall*, p. 125. Kerrow Hill suggested that Anne's family was related to Sir Humphry Davy: Kerrow Hill, *The Brontë Sisters and Sir Humphry Davy: A Sharing of Visions* (Penzance: Jamieson Library, 1994), p. 7.
[63] Simon Knell, *The Culture of English Geology 1815–1851: A Science Revealed Through its Collecting* (Farnham: Ashgate, 2000), p. xi.
[64] Transcript of Anne Brontë's Unnamed Manuscript, pp. 6, 7: Flaherty, p. 38., Appendix 1.
[65] Kerrow Hill mentions Elizabeth Branwell's 'pride in Penzance, her longing for it' (p. 7).
[66] *Blackwood's Edinburgh Magazine*, Vol 6 (31), October 1819, p. 99: Christine Alexander and Margaret Smith, *The Oxford Companion to the Brontës* (Oxford: Oxford University Press, 2006) p. 47.
[67] Douglas Palmer, 'Carnal Delights', *Geoscientist Online* (2012) <https://geol.soc.org.uk> [accessed 6 October 2019]; John Phillips, *A Guide to Geology* (London: Longman, 1836), p. 177; 'Where the Brontës Borrowed Books', p. 353.
[68] Melissa Hardie-Budden, 'Elizabeth Catherine Thomas Carne: A Nineteenth Century Hypatia', *Transactions of the Royal Geological Society of Cornwall*, 23:1 (2014), pp. 16–39. Elizabeth Carne (1817–1873) was the first woman member of the Royal Geological Society of Cornwall (RGSC) in 1865., She was published in the transactions of the RGSC and painted and sketched 'geological formations in fine, precise, detail' (Hardie-Budden, p. 20). Elizabeth Carne built a museum to house her father's mineral collection, which she inherited.
[69] Frances Richardson Currer had links with the Brontë family, and was a subscriber to the Keighley Mechanics' Institute, and a donor of books, minerals and fossils to the Museum at Scarborough and the Yorkshire Philosophical Society. Her mineral donations to the Museum/Rotunda, Scarborough, include Malachite (SCARB: 1940 260.6), Amethyst (SCARB: 1940.676), Mica (SCARB: 1955.1035), Azurite (SCARB: 1940.283) and Calcite (SCARB: 1940.41).
[70] No author, 'Brontë Bibliography', *Brontë Society Transactions*, 1:1 (1895), 5–34 (pp. 7–8); Shawna Ross, 'Remembering the 1824 Crow Hill Bog Burst: Patrick Brontë as a Science Writer', *Bronte Studies*, 46:3 (July 2021), 228–40; *The Oxford Companion to the Brontës*, pp. 338–40.
[71] *The Oxford Companion to the Brontës*, p. 339.
[72] *The Works of Patrick Branwell Brontë: Volume 1, 1827–1833*, ed. by Victor A. Neufeldt (New York and London: Garland Publishing, Inc. 1997), p. 62.
[73] Alexander and Sellars, pp. 162–63.
[74] Zoological Society, *The Gardens and Menagerie of the Zoological Society Delineated* (Chiswick: Thomas Tegg, 1830); Alexander and Smith, p. 152.
[75] *Blackwell's* printed a section titled 'Literary and Scientific Intelligence' from April 1817 to January 1821, where scientific news was printed as individual articles.
[76] James Thorne, *Rambles by Rivers* (London: Charles Knight, 1844), p. 78.
[77] Barker, *The Brontës*, p. 434.
[78] 'Donations to the Society's Museum Mineralogy: April 1836', in *Annual Report of the Council of Yorkshire Philosophical Society* (1836), p. 12.
[79] Bob Duckett, 'Where did the Brontës get their Books?', *Brontë Studies*, 32:3 (2007), 193–206.
[80] Anne Brontë, *The Poems of Anne Brontë: A New Text and Commentary*, ed. Edward Chitham (London: Macmillan, 1979). See 'Alexander and Zenobia', p. 54; 'Call Me Away', p. 107; and 'The Three Guides', p. 146.
[81] Adelene Buckland, *Novel Science* (Chicago: University of Chicago Press, 2011), pp. 131–76.
[82] *The Letters of Charlotte Brontë*, I, p. 220.

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Appendix

Geological description and Raman spectroscopy

Methods: A BWTek iRaman Plus 785S attached to the BAC151B microscope accessory was used to acquire Raman spectra, using a 20× magnification microscope. This is a portable instrument, and analyses were performed on location at the Brontë Parsonage. A 785 nm, 350 mW diode laser was used at 50–70% output. Spectra were acquired over an integration time of 3 seconds (2 averages). The microscope was carefully focussed on surfaces that were representative of each sample's composition and care was taken to avoid surface irregularities.
Geological description: Anne Brontë's stones comprise chalcedony in varies forms (including carnelians), three pieces of agate, one piece of speleothem flowstone and three pieces of red (mahogany) obsidian.

Carnelian pebbles (and jaspers) range in colour from red to orange, with a subset being almost pale yellow or light orange. Raman spectra (Figure A1) for the pebbles show the paler pebbles to have a higher proportion of moganite (band at 501 cm^{-1}) although quartz (band at 465 cm^{-1}) is still the main component (Kingma and Hemley 1994; Schmidt et al. 2014).[1,2] The high quartz content is a feature typically assigned to Jasper. The pebbles have a polish or smoothness, some of which could be from abrasion in a sedimentary environment, although in part this is likely artificial. It is noticeable that surface scratching is more prevalent on the lighter orange

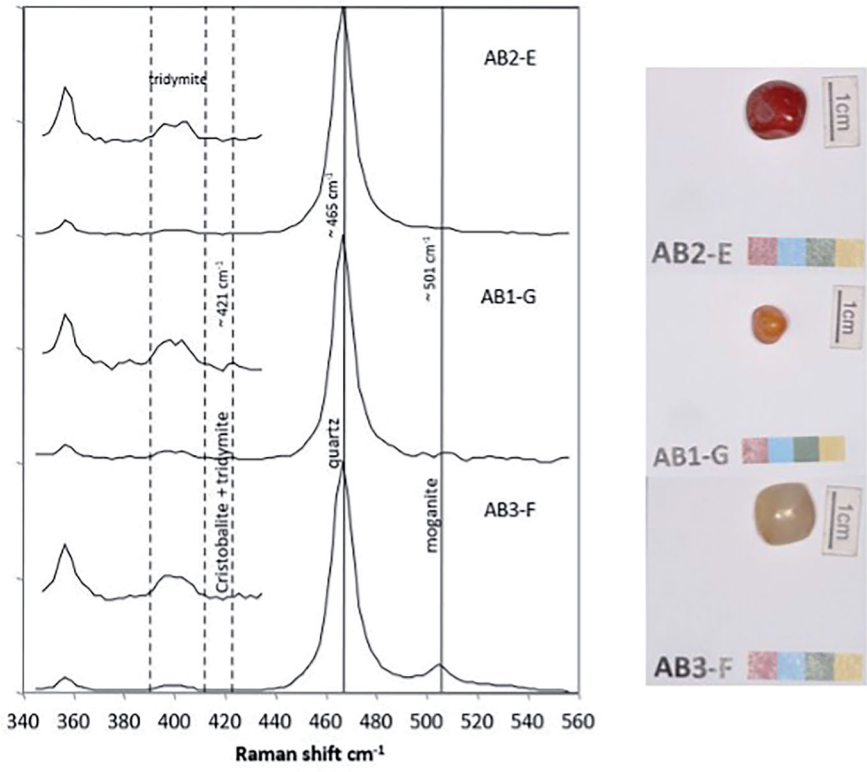

FIGURE A1 Raman spectra and images of carnelians typifying those within Anne Brontë's collection. Bands are shown for quartz and moganite, the main component of chalcedony (solid vertical lines), and dashed lines show the position of bands associated with opal (in this case weakly developed). Images show contrasting colours; the more quartz-rich samples (tending to jaspers) are redder and harder. The softer samples are lighter coloured and often more scratched. Reference bands taken from Kingman and Hemley, 1994.

pebbles, which have a greater proportion of moganite (moganite is softer than quartz, e.g. 6 vs 7 on Mohs scale of hardness).

In addition to the carnelian pebbles, there are three large pieces of agate. The two large agates have cut and polished-surfaces on a single side; one piece has concentric banding, while the other is divided into opaque-white and translucent regions. This later agate is notable for a haggled, uncut surface (opposite side to the cut and polished surface), which is sufficiently translucent that a hollow tube can be seen within. The agates have relatively high moganite contents (Figure A2).

A piece of stalactite (flowstone) exhibits Raman spectra (Figure A3) for calcium carbonate, with a strong Raman band at 1085 cm^{-1}, and bands due to lattice vibrational modes between 100 and 400 cm^{-1} (Rutt and Nichola 1974).[3] The bands at 155, 280 and 1085 cm^{-1} are found in both calcite and aragonite, but the position of the $\nu 4$ Raman bands at 710 cm^{-1} is indicative of calcite and not aragonite

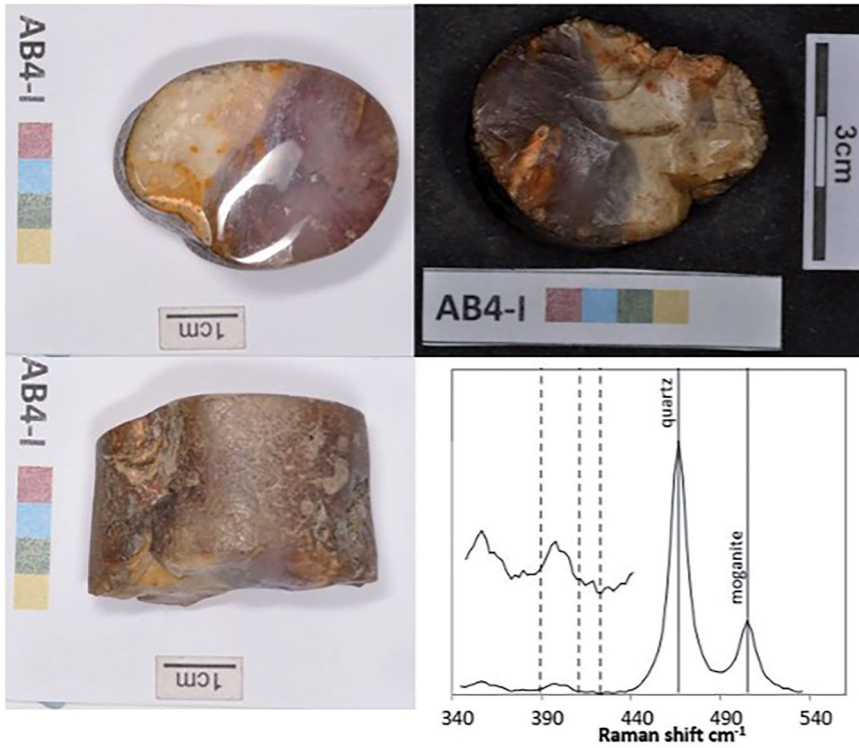

FIGURE A2 Raman spectra diagnostic for chalcedony and agate (note the greater relative abundance of moganite). The sample shown is translucent, and within it can be seen a pale tube.

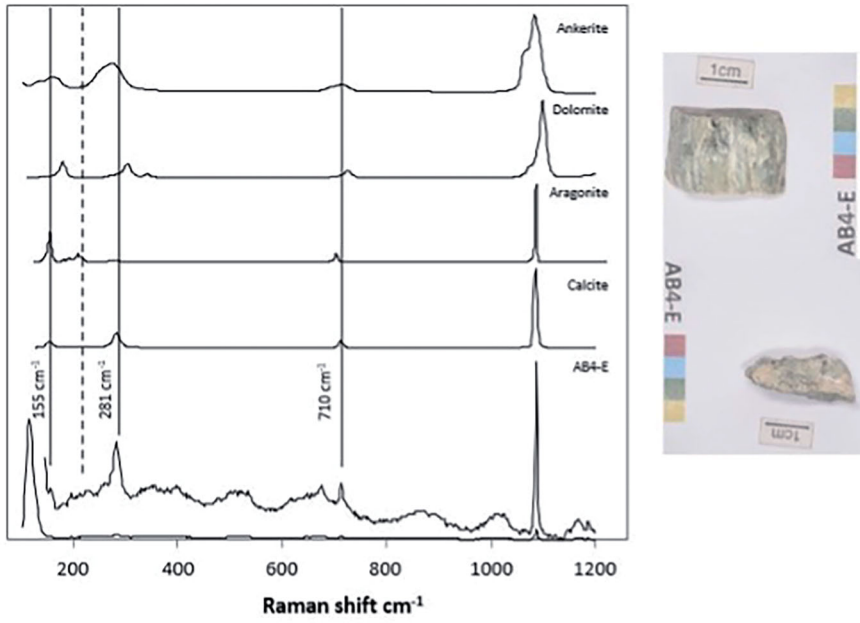

FIGURE A3 Raman spectra and images of the speleothem flowstone. Reference spectra for calcite, aragonite, dolomite and ankerite are from the rruff mineral database (rruff.info), samples R050128, R040078, R050241, R050197. Raman bands diagnostic for calcite are shown as solid lines.

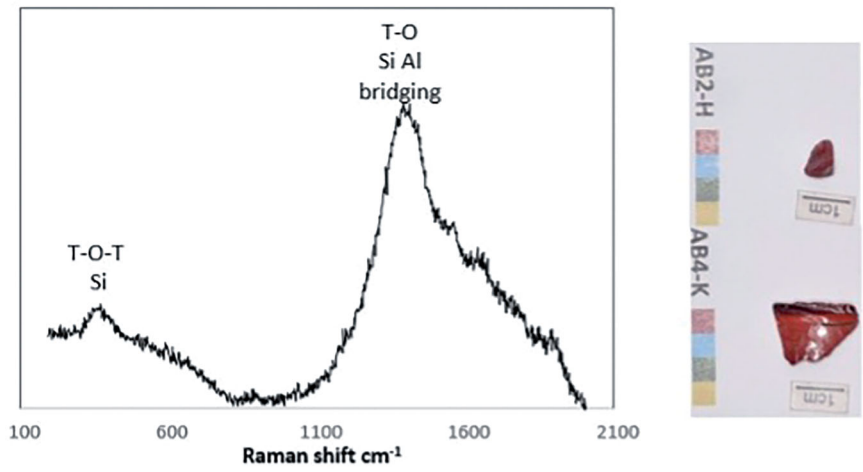

FIGURE A4 Raman spectra and images of samples of Red Obsidian. Labelling of bands is taken from LeLosq et al., 2012. T-O-T, Si refers to vibrational modes generated by the tetrahedron-oxide-tetrathedron portion of silicate glass, and T-O, Si Al to vibrational modes generated at bridging locations between sheets, where non-Si bonds may also be present.

(Decarlo 2018).[4] The surface of the flowstone exhibits layering corresponding to the growth of the stalactite via the precipitate of sheets, which although irregular and lumpy are smooth to the touch. The piece is sectioned to present flat surfaces at each end. The surfaces are cut with a light polish that reveals an internal structure that is not zoned and does not have the growth rings typical of true stalactites.

Three pieces of mahogany obsidian (Figure A4) can be identified by their hardness, choncoidal fracture, glassy surface and light heft (low density). As a glass, the mahogany obsidian lacks the crystalline structure capable of generating Raman spectra with well-resolved bands, instead there are broad bands at 200–400 and 1200–1400 cm^{-1} representing vibrational modes due to tetrahedron-bridging and non-bridging linkages (LeLosq et al. 2012).[5] Red (Mahogany) obsidian is scarce — all samples of red obsidian listed within the Natural History Museum's collection originate from outside of the British Isles (Natural History Museum 2014).[6] At the present day, no geological source of red Obsidian is known within Yorkshire or the British Isles.

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