Engaging the public with geoscience through 'virtual guided walks'

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Abstract

Scratching the Surface is a set of ten 'virtual guided walks' interpreting geology and landscape in the countryside around Swansea, presented as illustrated leaflets supported by a website and 'live' talks and guided walks. A summary of the design, planning and execution of the project provides a case study of how public engagement can produce lasting and effective materials that convey an understanding of geology, geodiversity and landscape evolution to non-specialists of all ages, while also contributing to wider social agendas, such as public engagement with science and rural economic wellbeing. This article provides an overview of the project and offers guidelines for using fieldwork to convey an effective public understanding of geology and landscape.

Keywords

Public engagement

Geological outreach

Science communication

Geoconservation

Geology of South Wales

1. The rationale: public engagement and virtual guided walks

'Public engagement describes the myriad of ways in which the activity and benefits of higher education and research can be shared with the public' (NCCPE, 2015). In relation to science, 'the purpose of public engagement is to enable people to learn about, consider, question and debate science issues and to be inspired by and understand the benefits that science brings to society' (NERC, 2009). In 'A vision for Science and Society' the Department for Innovation, Universities and Skills sought to develop 'A society that is excited about science, values its importance to our social and economic wellbeing, feels confident in its use, and supports a representative well-qualified scientific workforce' (DIUS, 2008).

Successful engagement with the general public in relation to academic research, science in general and geoscience in particular recognises and addresses public curiosity about science, and represents a return to the public for public investment in academic research. It improves public understanding and enriches the quality of debate on important social issues such as energy sources and their sustainability, environmental and climatic change, and waste disposal (Stewart and Nield, 2013).

In the context of public engagement, 'science' refers not only to scientific issues and specific research findings, but also to the processes and logic by which scientific research progresses: 'Having an engaged public means recognising that science is not just a body of facts, but a discipline with established methods of inquiry' (DIUS, 2008). This is particularly significant in relation to field-based research; it is important to dispel the misunderstanding that geological reconstructions of the Earth's past are simply guesswork, and to demonstrate that such reconstructions are based on the interpretation of evidence using sound scientific principles.

It is within this framework of public engagement with field-based geoscience that the project *Scratching the Surface* arose with the aim of

simulating the experience of expert-led geological guided walks in an effective self-guided format.

Many people who enjoy the countryside want to know and understand more about the landscape around them - how it formed, how it has changed through time, what kinds of rocks underlie it, how they formed, how they can be used, how this impacts on the environment, and how the many diverse aspects of landscape link together through ecology, archaeology, history, industry, culture and agriculture. Although they may not realise it, they want to engage with geoscience in order to know and understand more about geology and physical geography.

Expert-led guided walks are a tried and tested way of conveying an understanding of geology and landscape (or ecology, history or archaeology) to audiences ranging from undergraduate students and school pupils through special-interest groups to the non-specialist general public. An 'expert' - often with an academic background - leads a group of interested people around a set route, explaining features encountered along the route to provide an interpretation and understanding of their significance and of the principles on which the interpretations are based. In these ways an expert-led, interpretive guided walk differs from a simple guided walk in which the prime purpose is the activity of walking; an expert-led, interpretive guided walk is very much an academic and pedagogic activity.

Difficulties with this format of public engagement, however, include the limited availability of suitable experts and the practical logistics of organising activities. Guided walks are often hosted at events such as science festivals or through the programmes of special-interest groups, but this can limit the ability of many members of the public to participate in them, either because they are not in the right place at the right time or because they are not aware of the event taking place.

The experience of an expert-led, interpretive guided walk can be reproduced, without the expert being present, through a variety of media,

including both traditional, tangible forms - books, leaflets, display boards - and digital technologies such as apps, podcasts and audio-trails. These 'virtual' guided walks vary widely in their ease of use, the level of prior knowledge and understanding they expect from the user, and whether they focus on explaining features or aim to provide a deeper understanding of geological principles, regional geology, resource geology or landscape evolution.

Four main challenges can be identified to the successful reproduction of the experience of an expert-led guided walk: (1) ensuring that users don't get lost; (2) making sure users look at the right things; (3) successfully conveying an understanding of what those things mean, ideally in terms of underlying principles and deductive processes as well as basic information (Stewart and Nield, 2013; Fullan and Langworthy, 2014); and (4) maintaining people's interest and safety from start to end. In a 'live' guided walk the extent to which these challenges are met depends largely on the personal, academic and pedagogic skills, experience and effectiveness of the 'expert' leader, but in a virtual guided walk the leader is not present.

The aim of the *Scratching the Surface* project was to cater for the public interest in geology and landscape by producing an attractive and effective set of self-guided interpretive materials for short walks. The walks encourage people to visit less-frequented, rural parts of Swansea, contributing - albeit in a small way - to rural economic wellbeing. This article will outline the context in which the project arose, discuss some of the guiding principles that shaped it, and show how it achieves the challenges faced by a successful virtual guided walk. It is hoped that others undertaking guided walks for the public, producing virtual guided walks or involved in public engagement activities in general will benefit from this sharing of experience.

2. The project: City and County of Swansea Rural Development Business Plan

Scratching the Surface was a project within City and County of Swansea's Rural Development Business Plan, which ran from 2011 to 2014. The Plan distributed funding from the European Agricultural Fund for Rural Development and the Welsh Government to projects that could contribute to economic wellbeing in rural parts of Swansea. The rationale behind *Scratching the Surface* was that support materials for themed walks would attract people to rural areas where they might support local businesses such as pubs, cafes, shops, accommodation and public transport. The theme of geology and landscape satisfied my own educational and academic interests as a university-based academic.

The project addresses additional criteria required by the Business Plan. The activity of walking promotes health and wellbeing through excercise and activity. An environmental focus contributes to the awareness and understanding of issues such as sustainability, and climatic and environmental change. Linking trails and leaflets to a website addresses sustainability and accessibility. It was decided to focus on support materials rather than infrastructure such as path improvements or signage because those would require ongoing maintenance to prevent deterioration. All of these factors were important considerations in the application for funding under the Rural Development Business Plan.

The application was initially unsuccessful but was funded in a second round of submissions. Funding ran from early 2012 until the end of 2014, covering a time contribution by myself and a physical geography colleague, Professor Siwan Davies, plus travel and equipment costs, leaflet and website design (by Icon Creative Design of Newport, Gwent), Welsh translation (by Dyfed Elis-Gruffydd), website design (also by Icon), audio recording of some trails (by Audio Trails Ltd) and printing of 5000 copies of each of 10 leaflets, allowing the leaflets to be distributed free of charge.

This project enabled me to combine my interests in geology, public engagement and walking in the countryside, and to build on previous experience of publishing interpretive guides for short walks through leaflets produced for the Geologists' Association South Wales Group (www.swga.org.uk/pubs) and a book of short geological walks (Howe, Owen and Sharpe, 2004). From an academic and educational point of view, this was an opportunity to use the funding provided by the Rural Development Business Plan to develop interpretive materials for the geology of an area. Similar opportunities to link education and public engagement to other agendas such as economic development may arise through collaboration with bodies such as Geoparks.

3. The product: *Scratching the Surface*

The title *Scratching the Surface* reflects the need to at least imagine removing the veneer of vegetation, soil and human structures to see through to the sediments and rocks beneath in order to understand geology and its role in forming the landscape. The subtitle *Discover geology and landscape: walking trails in rural Swansea* gives a concise explanation of the scope of the project.

The twin focus on geology and landscape recognises that landscape often captures the public interest and imagination ahead of rocks. Many people who enjoy walking in the countryside and along the coastline are curious about the landscape and its origins, particularly in relation to long timescales. They want to understand the elements of spectacular or familiar views and are fascinated by the permanence - or otherwise - of landscape. What did this landscape look like in the past? Has it changed? What caused those changes? What elements of the landscape are the legacy of glaciers? When did that river start to flow? Why does it follow that course? Has it always done so? Why is this valley here? Why is that valley so narrow? Surely these hills were never under the sea? The answers to these questions and many more require an understanding of geology - the materials beneath the surface, the processes

that formed them and the history they can tell. It is these kinds of questions that *Scratching the Surface* set out to address.

The concept is a series of walking trails in which the activity of walking comes first, with relevant features of geological interest pointed out along the way; the geology is subsidiary to the walk. This contrasts with many interpretive trails in which walking (or driving) is a necessary activity to connect sites of geological interest, and it targets the project firmly at people who enjoy walking but might profess to have no interest in geology.

Ten leaflets accompany ten trails spread through rural parts of the City and County of Swansea (Fig. 1; Table 1). Electoral wards in the City and County of Swansea defined as 'rural' form two clusters separated by the urban areas of Swansea, Gowerton and Gorseinon. One is the Gower peninsula, designated Britain's first Area of Outstanding Natural Beauty in 1956 and long popular with visitors from Swansea and further afield who come to admire its scenery and cannot avoid noticing its prominent geology (Strawbridge and Thomas, 1999; Mullard, 2015). An inland plateau of Carboniferous Limestone terminates at spectacular coastal cliffs interspersed with sweeping sandy bays (Fig. 2). Hills of open grazing land are underlain by Old Red Sandstone in the cores of Variscan anticlines. Upper Carboniferous strata are poorly exposed in the north-east, a less frequented area of former coal mining and heavy industry. The second area lies north of the M4 motorway and the settlements of Pontarddulais, Felindre and Clydach. This is a dissected plateau of rough open grazing underlain by Pennant Sandstone in the central part of the South Wales Coalfield Syncline (Fig. 3). The valleys of the rivers Loughor, Dulais, Lliw and Clydach drain southwards off the plateau and were the sites of working coal mines until the 1970s. This area is virtually undeveloped for tourism and its geology is much less well exposed than on the Gower peninsula.

Like many academic geologists, I frequently lead field meetings and geological walks for the general public and for special-interest groups. Locally, these have always focussed on the Gower peninsula and never the northern area. It would have been straightforward to produce interpretive materials for

popular walking trails based on ‘honey-pot’ localities on the Gower peninsula such as Rhossili, Worm’s Head, Port Eynon or Oxwich. However, it seemed that the aims of the Rural Development Business Plan could be better served by developing trails in less popular areas of both the Gower peninsula and the northern area, and the proposal included at least one trail in each of the Council wards defined as rural. This resulted in practical challenges to devise circular routes of a suitable length along clear paths with public right of access that were well marked, unobstructed, and with prominent geological and landscape features of interest. A paucity of rock exposures and little variety of geology in the northern area led to a focus there on industrial heritage and its legacy in the landscape, which proved appropriate and important for this former coal-mining area.

Short walking routes were devised using existing paths with public access through rights-of-way or open-access arrangements. Where possible, routes pass close to local businesses, such as pubs, cafes or shops, and the starting points are accessible by public transport. A maximum length of 8 km was the target, so that each walk could be comfortably completed in half a day or less; in the end, several trails exceed 8 km and one extends to 11 km (Table 1), although an alternative start from an unofficial parking area shortens this to 7 km. It was originally intended to offer a range of shorter and longer options for each trail, but this proved too demanding for the limited space available. The routes are not aimless rambles, but most have a specific destination (Table 1) such as a lofty view-point (Llanmadoc Hill, Graig Fawr, Ryer’s Down) or a feature of local interest (Upper Lliw Valley Reservoir, Gellionnen Chapel, Three Cliffs Bay). Although the focus is firmly on geology and landscape evolution, attention is also drawn to features of archaeological, historical and ecological interest, although space limitations prevent detailed accounts of these aspects.

3A. The leaflets

Although there are modern, digital approaches to producing interpretive materials, traditional paper leaflets were chosen as the main output on account of their durability, practicality in the field, ease of distribution, compatibility with 'live' events, and ease of use by everyone everywhere. This also allowed us to focus on the science and communication rather than the technology. Ten leaflets accompany the ten trails (Fig. 4), each designed to be used on its own. A map showing the locations of all ten trails is on the back cover of each (Fig. 1).

The format and design of the leaflets were fundamental considerations. It was essential that they should be practical and usable in the field, particularly in the kinds of weather conditions that are commonly - although often unjustifiably - associated with South Wales. 'Concertina-type' folding was preferred over designs that must be completely unfolded; it is appropriate to the progressive narrative that is consistent with the 'virtual guided walk' concept, and is more user-friendly in inclement weather conditions. A 'footprint' size of one-third A4 was preferred over the larger format used, for example, in leaflets produced by the British Geological Survey and the Herefordshire and Worcestershire Earth Heritage Trust (e.g. Gibbons, 1987; Thornhill, 2001) because the smaller size is easier to slip into a pocket in the event of rain and to open out in a strong wind. Good quality plain paper was also preferred over the laminated card of those publications because of its ease of folding into a pocket. An overall A2 paper size produces a leaflet that is not too bulky, with 12 'panels' of content on each side, each one-third A4 in size.

Working in Wales, it is expected that products should be bilingual. Producing separate Welsh and English leaflets would have added to printing costs and not produced a genuinely bilingual product. The designers' preference was to have images, map and bilingual route information on one side and geological narrative in Welsh and English on the other. I resisted this option. It would separate the geology and the walk, losing the sense of a 'virtual guided walk'; the text-only (geological) side would be unattractive; the need to

unfold the leaflet completely to switch between text and map would be unwieldy and impractical, particularly in inclement weather; and the mixing of Welsh and English text can lead to confusion. The preferred option was to replicate text, map and images in Welsh on one side and English on the other, laid out so that each leaflet can be folded so as to be entirely Welsh or entirely English. Front and back cover information is provided in both Welsh and English on each side to emphasise that the leaflets are bilingual. This makes the leaflet easy to use in the user's chosen language, although it requires duplication of visual and background material and reduces the available space in each leaflet from 24 to 12 'panels', each of one-third A4 size. After some experimentation, it became clear that the maximum number of words that could be comfortably accommodated together with maps and images was about 1900. General trail description and background information took about 250 words, leaving roughly 1600-1700 words to cover everything related to route-finding, observations and geological interpretations. The choice of design also caused difficulties for the designers since the space occupied by the text differs in Welsh and English, yet both had to follow the same pattern.

The text in each leaflet includes both route information and geological information, the latter keyed to distinct stopping points (Fig. 5). The two types of information are integrated, but printed on different coloured backgrounds, allowing users who (at least initially) feel they have no interest in geology to use the leaflets purely as a guide to a walking route. The narrative at most stopping points begins with a description of something that can be seen, such as a rock exposure or a view, which it then explains. Some interpretive guides do little more than explain specific features, but it was intended from the outset that *Scratching the Surface* would aim to develop a deeper understanding of geology and landscape formation by addressing the relationships between features and not just the features in isolation (Stewart and Nield, 2013). This was a major challenge in writing the narrative given the limited space permitted by the bilingual leaflet format and the need for repetition between leaflets of some fundamental principles so that each leaflet works on its own.

The leaflets are illustrated with photographs and simple interpretive diagrams. Geological maps and stratigraphical columns are not included; once the narrative had been written it was considered that these were not essential to conveying understanding, and they might be off-putting to the non-geologist. An extract from the Ordnance Survey 1:25 000 (Explorer) map is included under licence arrangements with City and County of Swansea (Fig. 5). The route and stopping points are marked on the map, so users can follow the route on the map or through the words. Ten-figure grid references are provided for the starting point and each point of interest, rendering the route compatible with gps navigation devices, and GPX files will be available as downloads from the website.

The front cover of each leaflet has an attractive image taken from the walk, together with a title (location of the walk - e.g. *Graig Fawr*), subtitle (a key theme for that trail - e.g. *Upland landscapes of the Pennant plateau*), walk length and approximate duration, erring on the generous side to allow for users walking slowly, getting lost, and (it is hoped) spending time studying the geology (Fig. 6). An inner panel contains information about the starting point, path conditions, relevant Ordnance Survey and British Geological Survey map sheets, opportunities for refreshments, and sources of further information (Fig. 7). Space did not allow for a full discussion of safety advice and code of conduct, so web links are provided to the Countryside Code and the Geological Fieldwork Code, and specific advice is provided relating to roads, tides and path conditions for each trail. The back cover contains more images from the walk, a brief summary of the walk's key features, and an index map showing the location of all 10 walks (Fig. 8). Given that each leaflet dedicates two panels to front and back covers, one to general information and two to the map, 7 panels remain for the route description and geological information (Fig. 9).

3b The website

The leaflets will be supported by a dedicated website, designed by Icon Creative as part of the project and hosted by Swansea University Department of Geography with the url http://geography.swan.ac.uk/scratchingthesurface/. At the time of writing, the site is still under construction.

The website design mirrors the colours and layout of the leaflets (Fig. 10). Its main function is to provide PDF downloads of the leaflets, representing a lasting legacy once print copies become depleted, and making the trail experience accessible to people with mobility issues and those not based in south Wales.

The home page (Fig. 10) provides links to separate pages for each trail. These are illustrated with images from that trail and have buttons for the following features (Fig. 11).

- A PDF of the trail leaflet. The size and format of the leaflets means each can be produced full-size on four pages.
- A PDF text document with updates to the route information, such as path diversions or modifications.
- A GPX file of the starting point and the stops on each trail to aid navigation and location of the correct stopping points.
- The funding from the Rural Development Business Plan enabled three of the trails to be recorded in the field as audio trails, each available in English or Welsh as a single track or as separate tracks for each stop (Fig. 12). These recordings further enhance the accessibility of the project. The website design allows for the addition of further trail recordings in the future.

Another feature of the website will be an ‘ask an expert’ page (Fig. 13), which will route directly to my university email address. This will enable users to further develop their interest and understanding, and represents an important

educational component of the project. A final page will provide links to sources of further information about geology and the countryside, including the Geologists' Association South Wales Group, Gower Society, National Trust, and the walking pages on the local authority website. A relevant selection of these links is listed in each leaflet.

Parallel English and Welsh web pages will be available, each linking to the appropriate language for the PDF download of the leaflet and, where available, the audio trail.

The full implementation of the website will be a key element of the overall *Scratching the Surface* concept. The challenges of developing a linked website include technical issues and ongoing maintenance, but these are far outweighed by the benefits of a lasting legacy, enhanced accessibility, opportunities for interaction, wider exposure, and measurement of engagement through website hits, downloads and queries.

4. Impact to date

The leaflets were produced in March 2015, with a print run of 5000 copies of each of the 10 leaflets, of which roughly two-thirds were folded with the English side outwards and one-third with the Welsh side outwards. The main measures of impact so far are evaluation comments from users, which have been universally positive, and distribution numbers (Table 2, Fig. 11).

Distribution began in earnest in May 2015. By the end of July 2016, over 40% of the total stock had been distributed. Two boxes of each title (10% of the total stock) were distributed by the walking officer from City and County of Swansea. Most of the remaining distribution has been through direct approaches to potential outlets and at events such as the Gower Show and the Urdd Eisteddfod, where leaflets have been displayed on the stands of Swansea Council and Swansea University. At this rate, stock of some titles will be low 3 years after publication; 5000 copies of each title seems the right number to have produced.

A reliance on existing tourism infrastructure means that fewer leaflets have been distributed for the northern area compared with the Gower peninsula, although the northern area has more need to benefit from investment and an increase in visitors. However, these leaflets are just one cog in the wheel of the rural economy, and it is pleasing that many leaflets for the northern area have been distributed.

As well as representing ‘virtual guided walks’, the leaflets have provided a stimulus and focus for ‘live’ talks and guided walks, which have been held for general-interest groups (Local History Association, Probus), special-interest groups (Geologists’ Association South Wales Group, U3A Geology Network), in conjunction with organised events (Swansea Love Your Countryside Festival, Gower Walking Festival) and through local branch libraries. The leaflets have made it much easier to ‘steer’ interested groups to the less well-known northern areas, which is very much in the spirit of the Rural Development Business Plan.

5. Guidelines for successful public engagement with geoscience

Based on the experience of producing *Scratching the Surface*, including the leaflets, website and linked 'live' events, I offer the following twenty 'top tips' for others involved in planning and delivering public engagement projects in general and 'virtual guided walks' in particular.

5.1 Plan meticulously. Public engagement activities need to be planned, prepared and delivered with as much care and attention to detail and as much concern for pedagogical principles as more traditional lectures, practical classes and field classes that form the 'day job' of university academics. Make sure you know what you want to do, what you want to achieve, what message you want to convey and who you want to target.

5.2 Use appropriate media. Consider carefully whether you can best convey your message through a talk, walk, dance, blog, app, leaflet, book or website. The most appropriate medium depends on the message you want to convey, the audience, and on you and your talents, so remember that the most trendy form is not necessarily the most appropriate. Some of the pros and cons of different modes of delivery are summarised in Table 3.

5.3 Use a variety of media and presentational forms. *Scratching the Surface* leaflets include text, photographs, diagrams and maps, and are supported by a website with PDF downloads, audio downloads, GPX navigation files, updates, links and an 'ask an expert' feedback form. This range of media caters for a wide range of users and maximises inclusivity and accessibility.

5.4 Encourage interaction. Ask questions, structure an explanation around a rhetorical question, or provide the means for people to contact you.

5.5 Offer additional support. If the activity is successful, users will want to know and understand more, so make sure you provide advice on further reading, future activities, other places to visit or opportunities to join

special-interest groups. Most *Scratching the Surface* trails refer to other trails in the series and an index map on each leaflet shows their locations.

5.6 Don't demand too much. Keep to the point and theme of your presentation; don't digress or waffle. *Scratching the Surface* trails are long enough to provide an enjoyable walk, but not so long as to be daunting and off-putting.

5.7 Be yourself. Tell jokes, provide interesting snippets of information or show funny pictures if that's what you normally do; but don't if it isn't! I love the quirky content of Lynas (1996), for example, but I know I could not present successfully in that way.

5.8 Know your target audience. What is their level of prior experience? What is most likely to interest them? What misconceptions might they have? Field guides already exist for people with an understanding of geology; *Scratching the Surface* aims at those who enjoy walking in the countryside and are curious to find out more about it, but don't have any prior experience of geology or geography.

5.9 Expect a variety of uses and audiences. The clear separation of route directions from information and explanation in *Scratching the Surface* leaflets allows users to just follow the walk if they aren't interested in the geology. That's fine with me; there is always a chance they will be 'hooked' by the geology!

5.10 Consider how people will use your product. Is it a one-off experience, like a talk or performance, or should it provide a lasting legacy, like a book? Does it fill a specific time slot or can users undertake it at a time of their choice? *Scratching the Surface* trails aimed for a length of 5-8 km (3-5 miles) and duration from a couple of hours up to half a day.

5.11 Integrate a range of activities. *Scratching the Surface* provides users with a leaflet they can use to guide themselves around a walk. The

website will provide additional dimensions including audio downloads and external links. 'Live' guided walks have been held for local groups and events, and linked talks have been held at public libraries.

5.12 Know what you're going to say. Preparing a good 'script' is an essential part of any activity, whether a presentation, performance, guided walk, video, audio-trail, app or website. Even if you plan to speak without notes, you need to know where to begin, how you will end, and the order of what comes in-between. The more attention that is paid to the quality of the script, the more likely the activity is to be successful.

5.13 Tell a story (Stewart and Nield, 2013). This doesn't mean you have to construct a fiction or dress things up in a contrived manner, but use the craft of the story-teller to capture your audience's interest. Link pieces of information together and weave them together using familiar themes. Highlight an interesting feature early on and develop an explanation by gradually revealing the evidence. For a supreme example of this, see Orndorff et al. (2006). Have a culmination or climax, preferably towards the end. *Scratching the Surface* walks 'tell a story' by each having a specific destination (Table 1) and developing understanding of a few key points based on observations. In this way, they contribute to public understanding of scientific method (DIUS, 2008) as well as scientific information and issues.

5.14 Have a focus. Aim to convey a small number of clear messages. *Scratching the Surface* trails each have a subtitle drawing attention to a particular aspect of geology or landscape, and many of them have a focal point for the walk such as a summit or viewpoint.

5.15 Begin with observations. Audiences need to understand why technical issues are being addressed, and in *Scratching the Surface* this is achieved by beginning with a view, a fossil or an exposure, and building up interpretation and understanding.

5.16 Don't assume too much of your audience. You can lose them if you assume understanding they do not have. Explain simply and clearly, but keep it brief so as not to put off those who do understand already. Don't overload people with unnecessary information. Do people need to know 'Late Carboniferous' (perhaps they do) or will 'Carboniferous' do? Or just 'several hundred million years ago'?

5.17 But don't dumb down. Never! If you feel the need to dumb down for your audience, consider whether it's actually your ability to explain that is inadequate, not your audience's ability to understand. Try harder! Don't misrepresent complex concepts by over-simplifying them, but try not to avoid them either; explain them clearly and concisely. Communication is more than just words; use photographs, diagrams and maps to help, or analogies, gestures and actions in a live performance. Successfully conveying the subtleties, complexities, and intricacies of a subject is one of the most rewarding experiences of good teaching.

5.18 Write clearly and well; draft and re-draft. But don't lose sight of the key points you want to get across and make sure they are not lost in a mass of detail. Ask someone else to read through your draft and ask them if they have understood your key points.

5.19 Look good! Pay attention to your appearance and make sure you appear as you want to appear. The professional design input into *Scratching the Surface* leaflets provides an attractive product that people want to pick up and explore. Edit carefully. Your writing, script or narration needs to be concise, clear and unambiguous. Check spelling and grammar and make sure errors don't creep through into a final version.

5.20 Know when to stop. At some stage your audience will have had enough - at least for the time being. You can't explain everything in one go or turn novices into experts in one guided walk. *Scratching the Surface* trails have more points of interest near the start of the walk, leaving fewer stops for later on when people can see the end in sight.

6. Summary

This co-ordinated set of interpretive materials shows how academic expertise can be applied to enhance public understanding and awareness of geology and geoconservation, while at the same time addressing other social agendas such as exercise, environmental awareness, accessibility and rural economic wellbeing.

At the start of this article I identified four challenges to the successful reproduction of an expert-led interpretive guided walk in 'virtual' form, and here I summarise how these have been addressed in the *Scratching the Surface* project.

Make sure users don't get lost. *Scratching the Surface* allows users to follow the route in a variety of ways - the line on the map, the words in the narrative, or a GPX file downloaded from the website. At the planning stage, it is important to ask someone else to try and follow the route from the instructions provided.

Make sure users know what to look at. *Scratching the Surface* identifies features of interest using verbal descriptions, photographs, points marked on a map, grid references and GPX files downloaded from the website. Again, it is important to test these out at draft stage with a non-geologist to ensure they lead people to the appropriate features.

Make sure users understand the significance of what they see. This is achieved by the narrative text (or audio guides), supported by images. Opportunities to further develop understanding are provided through web links and the 'ask an expert' function on the website. Once again, walking through each trail at draft stage with a non-geologist is essential to highlight inadequacies in the material.

Maintain users' interest and safety. The leader on a 'live' guided walk can alert people to hazards and sense when their interest is flagging, but this is more challenging in a 'virtual' guided walk. Safety information is provided in the

overview of the trail and at appropriate points throughout. The stops are spread out rather than clustered, even though this means there is less of interest at some stops; keeping a problem unresolved means it can be addressed at such points. Telling a story keeps people moving towards the end in order to solve a puzzle. Bring in the 'wow' factor every so often, with a stunning viewpoint or an amazing geological fact or by revealing a critical part of the story.

In summary, *Scratching the Surface* addresses adopts a range of approaches in order to successfully reproduce the experience of engaging the public with geoscience through an expert-led, interpretive guided walk. Its distinctive features are the prioritising of walking over geology, the continuous narrative of the text which tells a story to reproduce the experience of an expert-led walk, the target audience of the general public, and the integration of leaflets, website and 'live' activities.

Acknowledgements

The author thanks Jim Rose and John Hiemstra for encouraging him to write this article. Richard Porch and Paul Relf from Swansea Council provided sterling support throughout the project, as did Kelly Rees at Swansea University. Much of the character of the final product is thanks to collaborator Siwan Davies, translator and geologist Dyfed Elis-Gruffydd, designers at Icon Creative Design Ltd. (xxxxxxxxxxxx), and Dan Boys of Audio Trails Ltd. Steve Shaw provided technical support and Rhian Meara helped with the audio recordings.

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Title	Subtitle	Length	Stops	Walk focus	Main geological focus
Gower peninsula					
Bishopston Valley and Barland Common	Contrasting landscapes of limestone and shale	6 km	14	Stream resurgence	Karst features of the Carboniferous Limestone
Penmaen and Three Cliffs Bay	Geology, prehistory and history in South Gower	9.5 km	10	Sandy bay	Tectonic structures of the Gower peninsula
Paviland cliffs	Spectacular South Gower: cliffs and caves in Carboniferous Limestone	5.5 km	7	Cliff-top views	Carboniferous Limestone geology, caves and archaeology
Llanmadoc Hill	Gower rocks and scenery	9.5 km	12	Summit view-point	Folding of Carboniferous Limestone and Old Red Sandstone
Landimore, Cheriton and Ryer's Down	Varied landscapes of North Gower	6 km	11	Summit view-point	Geology of the Gower peninsula
Penclawdd and the Morlais Valley	A corner of the Coalfield in north-east Gower	9.5 km	11	Inland common	Influence of bedrock geology on landscape
North Swansea					
Graig Fawr	Upland landscapes of the Pennant plateau	7 km	7	Summit view-point	Bedrock and superficial geology; geological influence on landscape
Cefn Drum and Cwm Dulais	Coal and coal mining	11 km (7 km)	11 (9)	Summit view-point	Coal-mining methods and their legacy
Lliw Valley reservoirs	Flooded valleys and old mines	7 km	9	Dam and reservoir	Coal and coal mining
Cwm Clydach and Gellionnen Chapel	Forming the South Wales landscape	9 km	9	Remote chapel	Coal-mining and structure of the South Wales Coalfield

Table 1 Titles, subtitles, length, number of stops and focus of each of the *Scratching the Surface* trails. The Cefn Drum trail has an alternative starting point on an area of waste ground which is not an 'official' parking area, which allows a shorter trail with fewer stops.

Type of distribution outlet	**%**
Swansea Council	26
Major events (e.g. Gower Show, Eisteddfodau)	11
Caravan parks and camp sites	10
Tourist attractions (e.g. Gower Heritage Centre)	10
Miscellaneous (mostly distribution to individuals)	9
Linked activities (walks, talks)	8
Libraries	6
Cafes, pubs, shops	5
Organised groups (GA, U3A, OUGS, Ramblers)	4
Holiday accommodation (B&B, holiday homes)	3
Swansea University	3
Community Centres	3
Schools, Colleges, teachers	2

Table 2 Distribution of leaflets (by end of July 2016) by type of outlet. The total number distributed by this date was 21,858.

	Advantages	Disadvantages
Live activity	• Personal contact - your personality can make a positive contribution • Adaptable - you can vary what you do depending on audience response or ambient (e.g. weather) conditions	• Ephemeral • Dependent on availability of 'performer' and audience • Weather conditions
Leaflets	• Easy to use • Individually cheap - can be free of charge	• Space is severely limited • Basic material has to be repeated in each leaflet • Ephemeral - readily discarded
Book	• Lasting and durable • Space to develop ideas • Fundamental principles can be covered in an introductory section	• Expensive • Bulky • Less attractive to non-specialists
Digital media	• Modern • Versatile • Lasting • Accessible • Imaginative possibilities	• Off-putting to some • Technology failure - battery loss, signal loss • Weather-dependent

Table 3 Advantages and disadvantages of different media for public engagement.

Figure captions

Fig. 1 Location of the ten *Scratching the Surface* trails. This index map appears on the back cover of each leaflet.

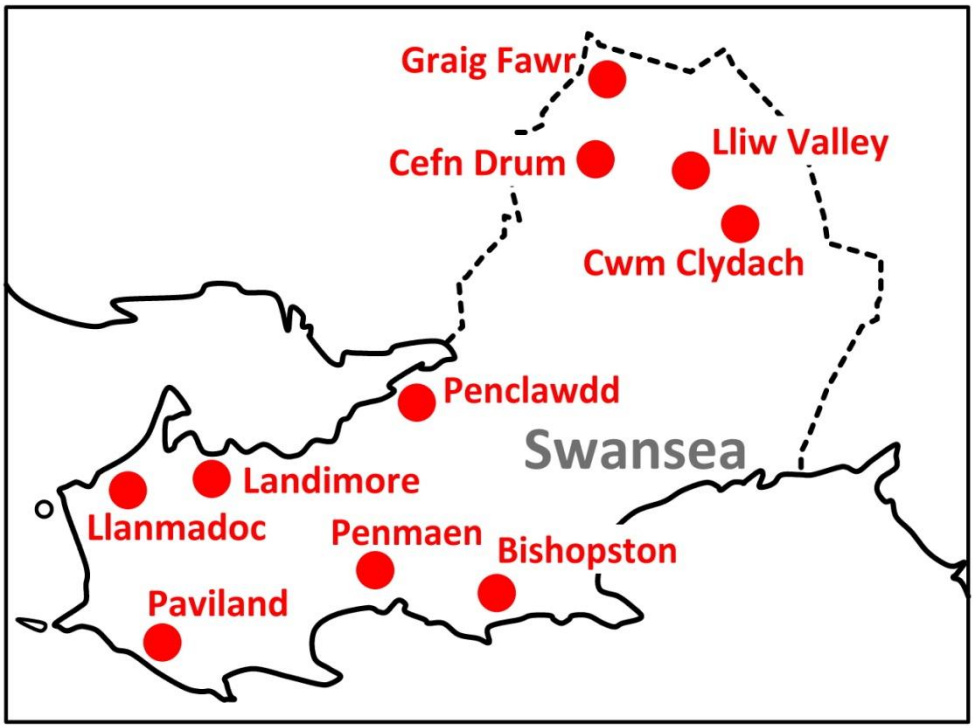


Fig. 2 Typical landscape of the Gower peninsula from Stop F on the Paviland Cliffs trail. The high ground is underlain by Old Red Sandstone in the core of an anticline, with exposures in natural crags and small disused quarries. The plateau surface is underlain by Carboniferous Limestone, which is well exposed in coastal cliffs.

Fig. 3 Typical landscape of the northern part of City and County of Swansea from Stop G on the Cwm Clydach trail. Although there is little exposure, scarp and dip features on the skyline are formed by the interbedding of sandstone and mudstone in the Upper Carboniferous Pennant Sandstone.

Fig. 4 The ten *Scratching the Surface* leaflets (including both Welsh and English versions of Paviland Cliffs and Llanmadoc Hill).

Fig. 5 An extract (3 ‘panels’) from the trail guide to Penmaen and Three Cliffs Bay (Geology, prehistory and history in South Gower). Notice the distinction between route information (pale background) and geological information in the text.

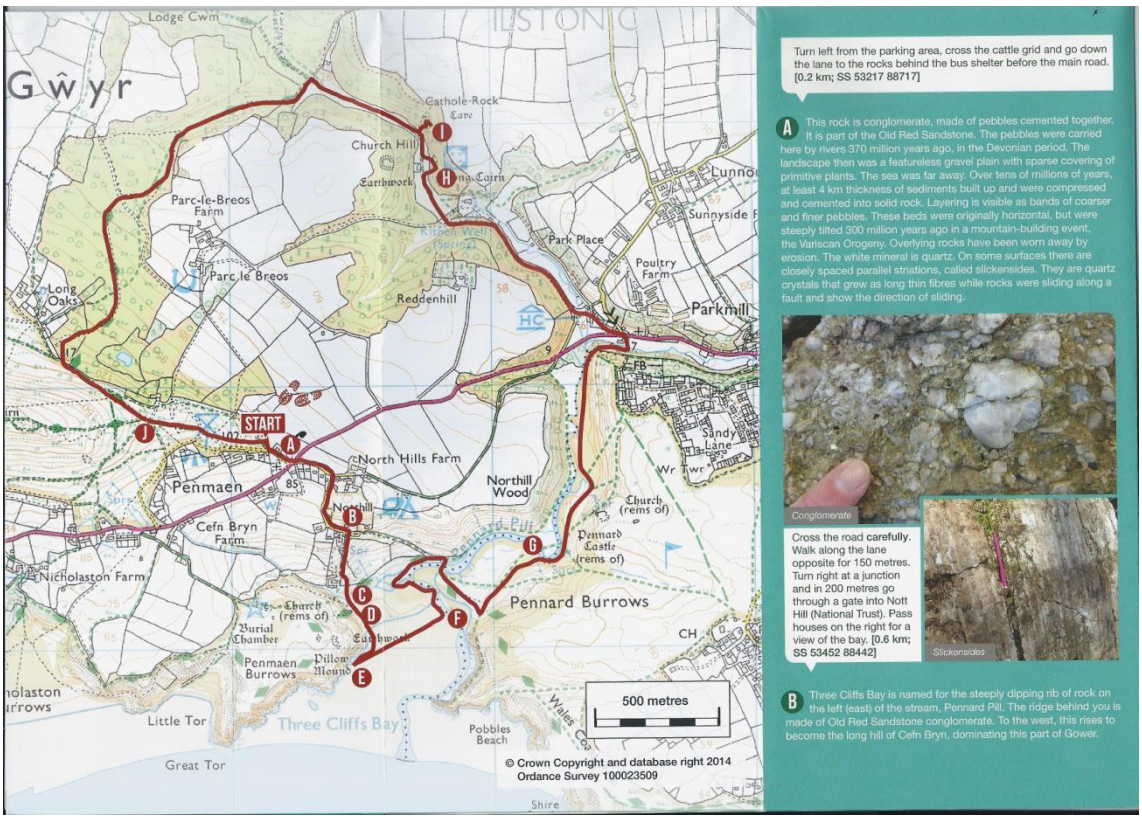


Fig. 6 Front cover of the trail guide to Penmaen and Three Cliffs Bay, introducing the trail in Welsh and English.

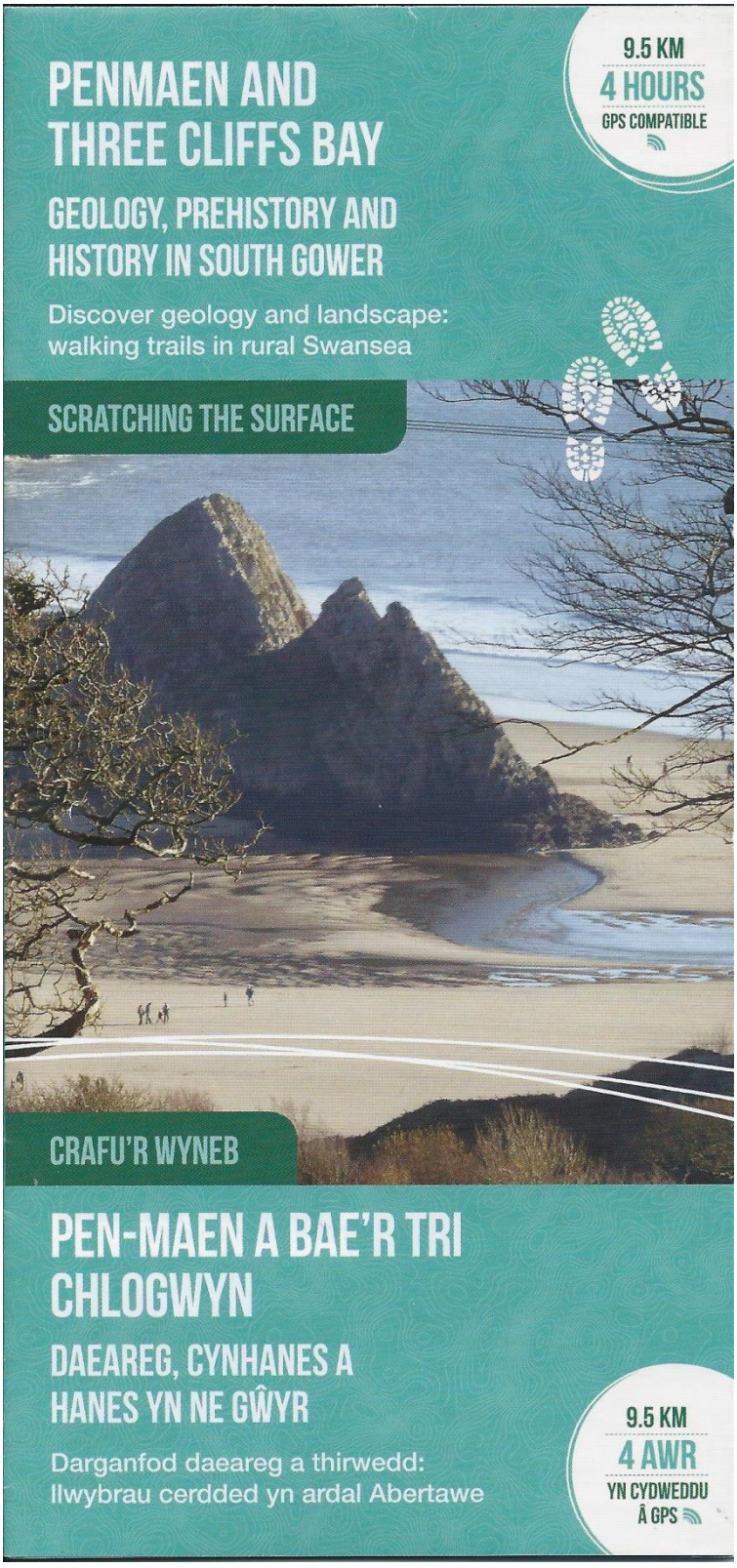


Fig. 7 Information panel inside the front cover of the Penmaen and Three Cliffs Bay leaflet.

START
GRID REF.
SS 53123 88789

near Penmaen church where there is parking (National Trust). Penmaen is served by bus.

PATH CONDITIONS

The trail follows marked paths. There is a steep descent into Three Cliffs Bay, which may be inaccessible at very high tides.

MAPS

Ordnance Survey 1:50,000 map 159 (Swansea & Gower)

1:25,000 Explorer map 164 (Gower)

Geological Survey 1:50,000 Sheet 247 (Swansea)

REFRESHMENTS

Parkmill

SAFETY

Take care crossing and walking along roads. Be aware of the tide in Three Cliffs Bay. The stepping stones between E and F may be slippery and are submerged at some stages of the tide. Grid references are for guidance only. Follow the Countryside Code (**http://naturalresourceswales.gov.uk**) and the Geological Fieldwork Code (**www.rockwatch.org.uk/geological_code**). Respect people, protect the environment and stay safe. Wear sensible clothing and footwear.

FURTHER INFORMATION

Local walking groups **www.swansea.gov.uk/walking**
Local geology **www.swga.org.uk**
For junior geologists **www.rockwatch.org.uk**
Geology and geological maps **www.bgs.ac.uk**
Gower Society **www.thegowersociety.org.uk**
National Trust **www.nationaltrust.org.uk**
Archaeology **www.ggat.org.uk**
Caves **www.swcc.org.uk**

The Geology of South Wales: A field guide
by Gareth T. George (gareth@geoserv.co.uk, 2008)

A Guide to Gower edited by Don Strawbridge and Peter J. Thomas (Gower Society, 1999)

Text and images: **Geraint Owen, Siwan Davies (Swansea University)**
Welsh translation: **Dyfed Elis-Gruffydd**
Design: **iconcreativedesign.com**

Fig. 8 Back cover of the Penmaen and Three Cliffs Bay leaflet, providing a summary of the walk's features, an index map of other trails in the series, contact information and the funders' logos.

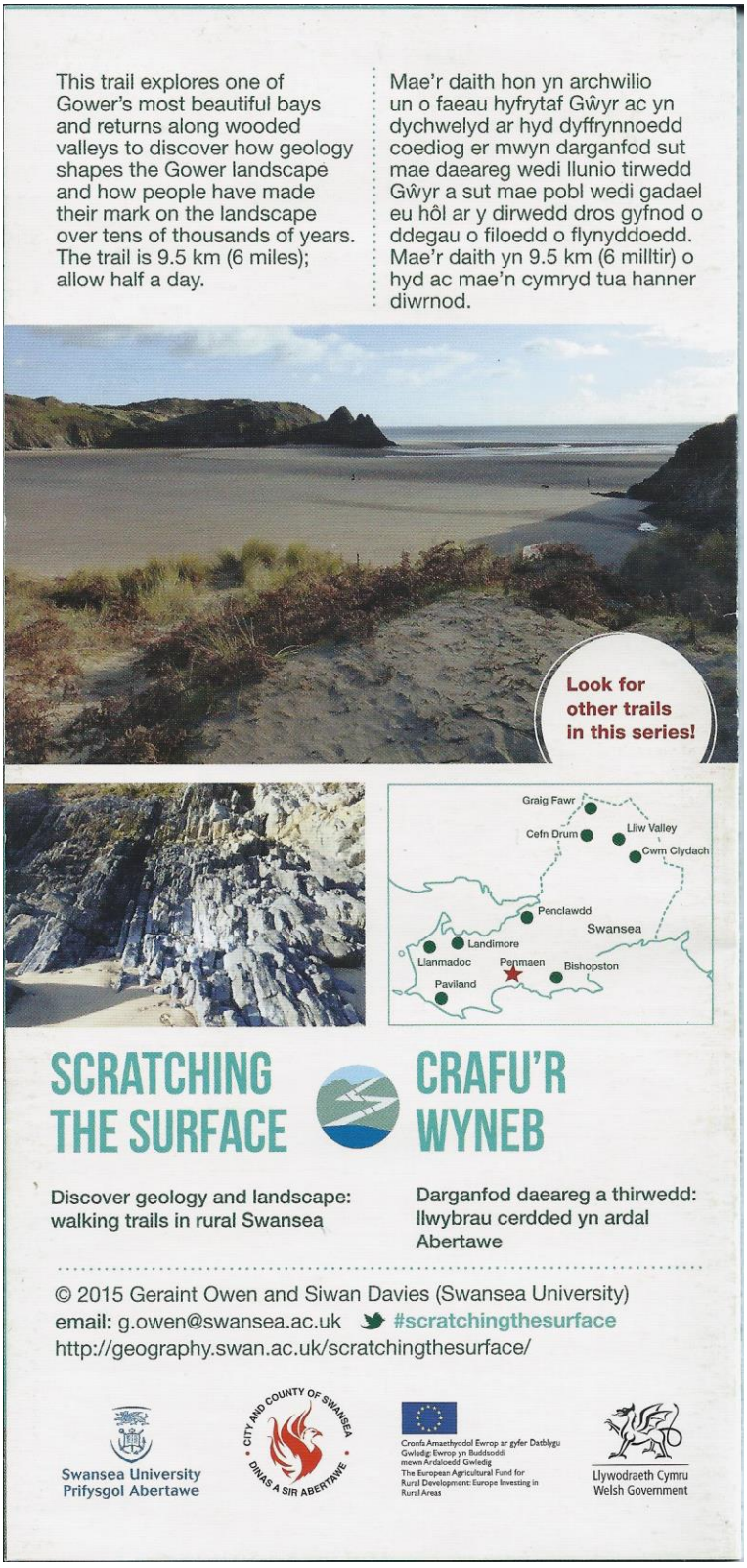
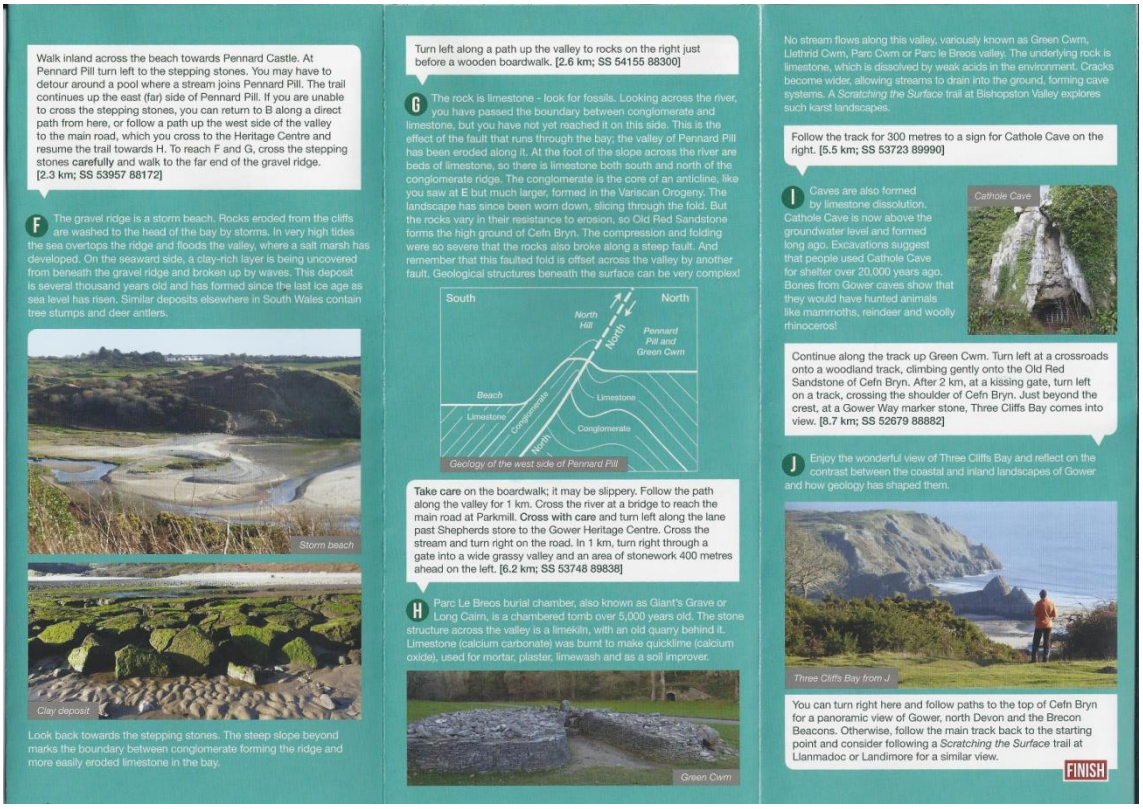


Fig. 9 Final part of the narrative section of the Penmaen and Three Cliffs Bay leaflet, showing 3 ‘panels’ of route information, geological information, and illustrations.



Walk inland across the beach towards Pennard Castle. At Pennard Pill turn left to the stepping stones. You may have to detour around a pool where a stream joins Pennard Pill. The trail continues up the east (far) side of Pennard Pill. If you are unable to cross the stepping stones, you can return to B along a direct path from here, or follow a path up the west side of the valley to the main road, which you cross to the Heritage Centre and resume the trail towards H. To reach F and G, cross the stepping stones **carefully** and walk to the far end of the gravel ridge. **[2.3 km; SS 53957 88172]**

F The gravel ridge is a storm beach. Rocks eroded from the cliffs are washed to the head of the bay by storms. In very high tides the sea overtops the ridge and floods the valley, where a salt marsh has developed. On the seaward side, a clay-rich layer is being uncovered from beneath the gravel ridge and broken up by waves. This deposit is several thousand years old and has formed since the last ice age as sea level has risen. Similar deposits elsewhere in South Wales contain tree stumps and deer antlers.

Storm beach

Clay deposit

Look back towards the stepping stones. The steep slope beyond marks the boundary between conglomerate forming the ridge and more easily eroded limestone in the bay.

Turn left along a path up the valley to rocks on the right just before a wooden boardwalk. **[2.6 km; SS 54155 88300]**

G The rock is limestone - look for fossils. Looking across the river, you have passed the boundary between conglomerate and limestone, but you have not yet reached it on this side. This is the effect of the fault that runs through the bay: the valley of Pennard Pill has been eroded along it. At the foot of the slope across the river are beds of limestone, so there is limestone both south and north of the conglomerate ridge. The conglomerate is the core of an anticline, like you saw at **E** but much larger, formed in the Variscan Orogeny. The landscape has since been worn down, slicing through the fold. But the rocks vary in their resistance to erosion, so Old Red Sandstone forms the high ground of Cefn Bryn. The compression and folding were so severe that the rocks also broke along a steep fault. And remember that this faulted fold is offset across the valley by another fault. Geological structures beneath the surface can be very complex!

Take care on the boardwalk; it may be slippery. Follow the path along the valley for 1 km. Cross the river at a bridge to reach the main road at Parkmill. **Cross with care** and turn left along the lane past Shepherds store to the Gower Heritage Centre. Cross the stream and turn right on the road. In 1 km, turn right through a gate into a wide grassy valley and an area of stonework 400 metres ahead on the left. **[6.2 km; SS 53748 89838]**

H Parc Le Breos burial chamber, also known as Giant’s Grave or Long Cairn, is a chambered tomb over 5,000 years old. The stone structure across the valley is a limekiln, with an old quarry behind it. Limestone (calcium carbonate) was burnt to make quicklime (calcium oxide), used for mortar, plaster, limewash and as a soil improver.

Green Cwm

No stream flows along this valley, variously known as Green Cwm, Llethrid Cwm, Parc Cwm or Parc le Breos valley. The underlying rock is limestone, which is dissolved by weak acids in the environment. Cracks become wider, allowing streams to drain into the ground, forming cave systems. A *Scratching the Surface* trail at Bishopston Valley explores such karst landscapes.

Follow the track for 300 metres to a sign for Cathole Cave on the right. **[5.5 km; SS 53723 89990]**

I Caves are also formed by limestone dissolution. Cathole Cave is now above the groundwater level and formed long ago. Excavations suggest that people used Cathole Cave for shelter over 20,000 years ago. Bones from Gower caves show that they would have hunted animals like mammoths, reindeer and woolly rhinoceros!

Cathole Cave

Continue along the track up Green Cwm. Turn left at a crossroads onto a woodland track, climbing gently onto the Old Red Sandstone of Cefn Bryn. After 2 km, at a kissing gate, turn left on a track, crossing the shoulder of Cefn Bryn. Just beyond the crest, at a Gower Way marker stone, Three Cliffs Bay comes into view. **[8.7 km; SS 52679 88882]**

J Enjoy the wonderful view of Three Cliffs Bay and reflect on the contrast between the coastal and inland landscapes of Gower and how geology has shaped them.

Three Cliffs Bay from J

You can turn right here and follow paths to the top of Cefn Bryn for a panoramic view of Gower, north Devon and the Brecon Beacons. Otherwise, follow the main track back to the starting point and consider following a *Scratching the Surface* trail at Llanmadoc or Landimore for a similar view.

FINISH

Fig. 10 Home page of the website, showing links to individual trail pages (Figs 11 and 12) through a drop-down menu, and link to Welsh pages at top right.

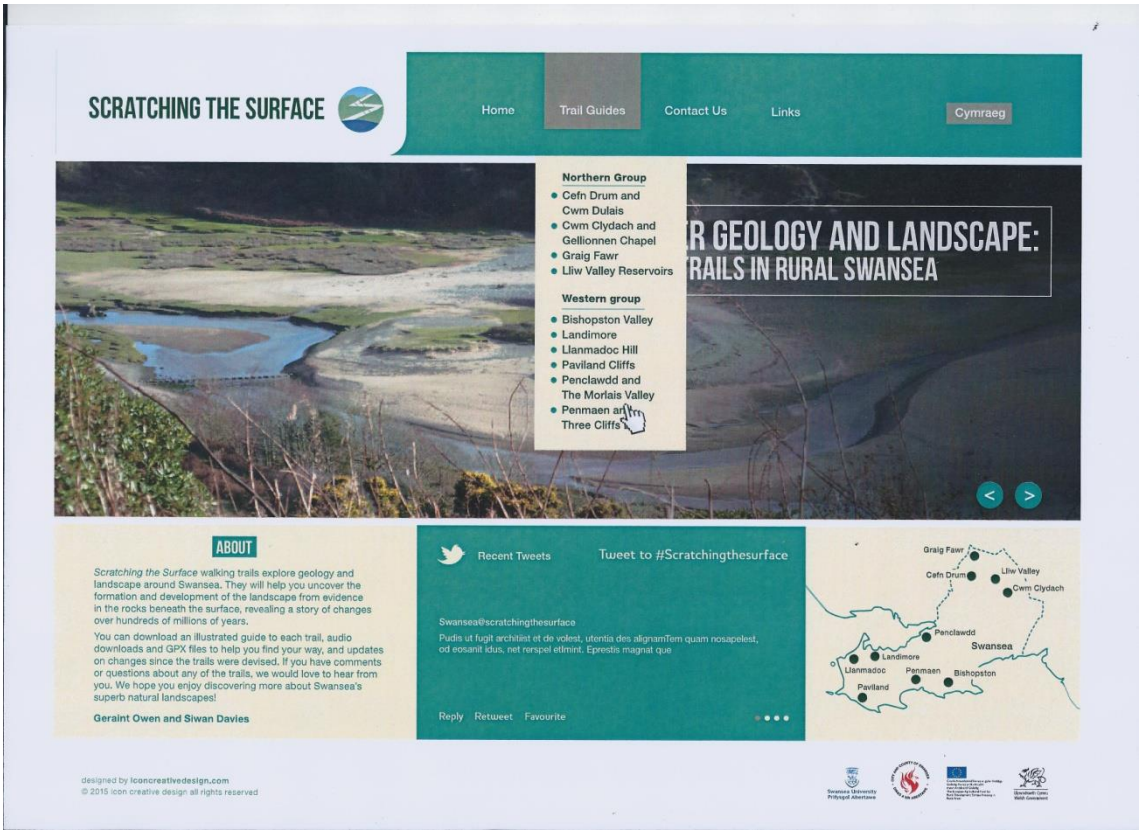


Fig. 11 Web page for the Cwm Clydach trail showing button links to the PDF download for the leaflet, updates to the route and paths, and a GPX file for the route. The two buttons on the right are inactive and allow for audio guides to be produced in the future.

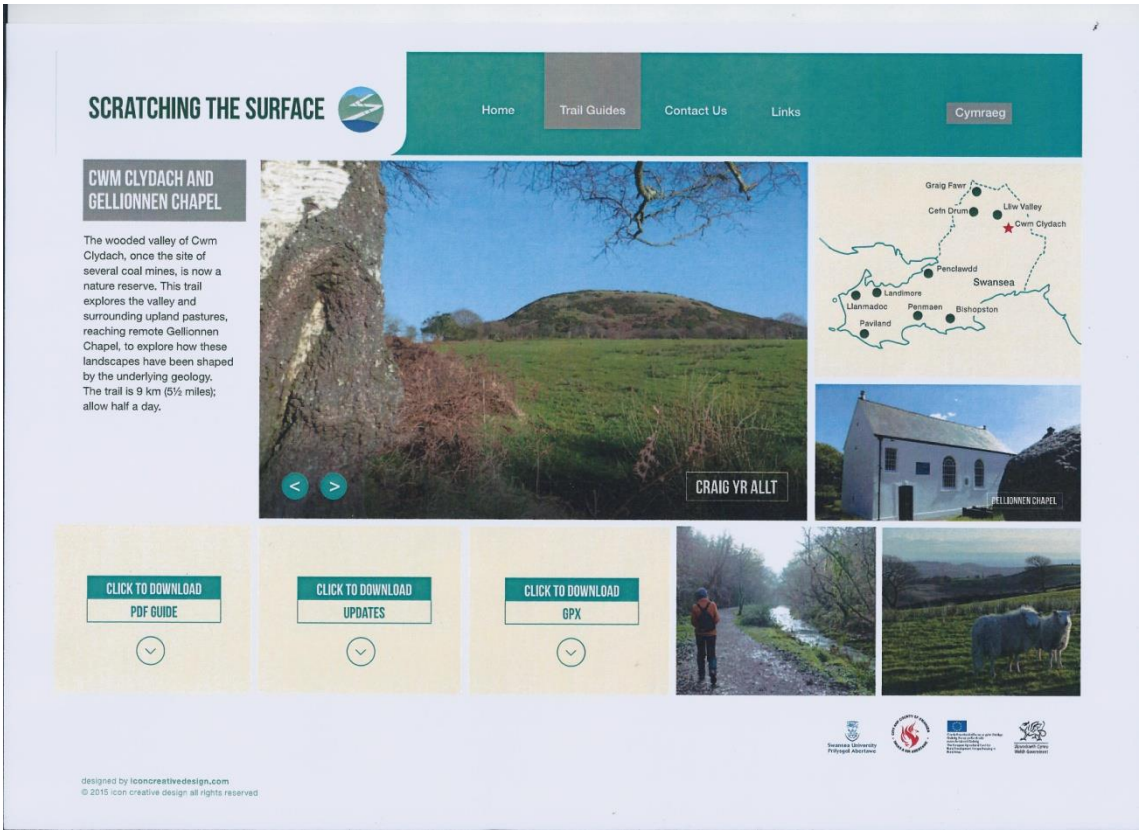


Fig. 12 Web page for the Paviland Cliffs trail showing button links to the PDF download for the leaflet, GPX file and audio guides, which can be downloaded as a single track or as separate tracks for each stop. The second button from the left is inactive and can be used when updates to the route are necessary.

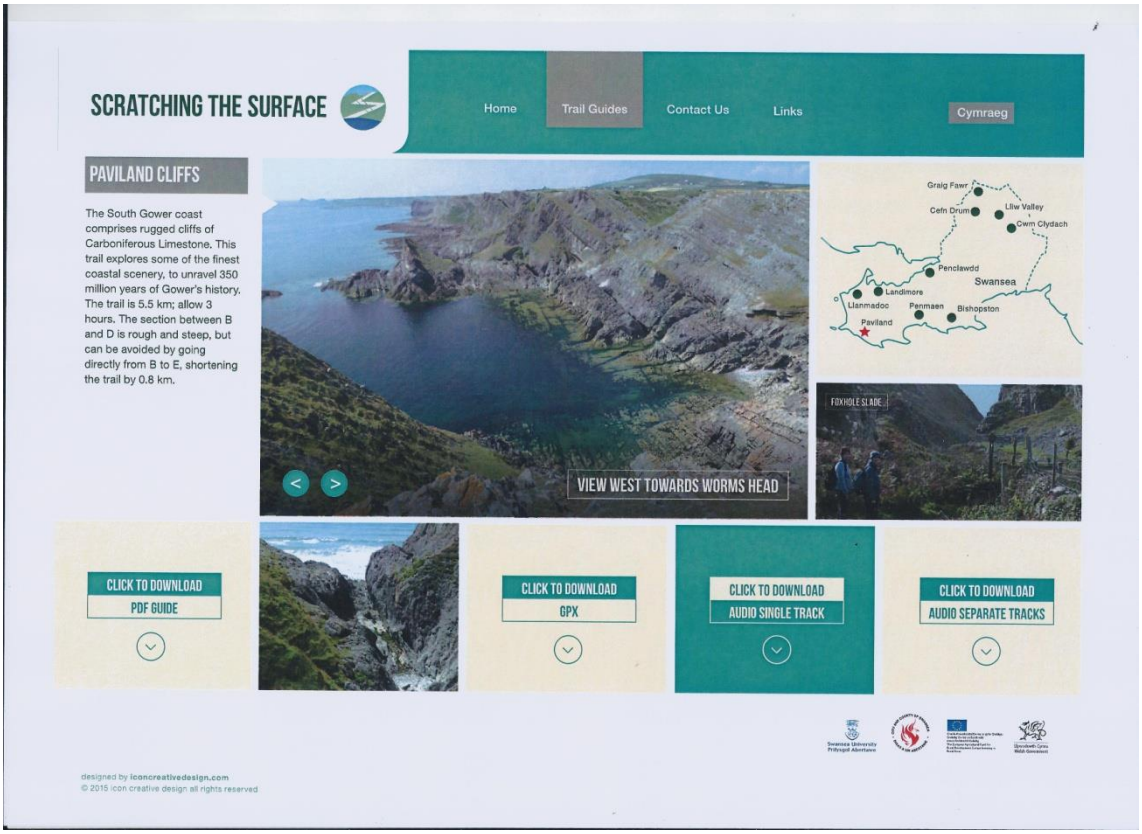


Fig. 13 The ‘Ask an Expert’ web page, accessed through ‘Contact Us’ on the menu bar.