The Geological Heritage of County Cork

An audit of County Geological Sites in County Cork

by Ronan Hennessy, Robert Meehan, Vincent Gallagher and Clare Glanville

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Comhairle Contae Chorcaí Cork County Council

For:

Irish Geological Heritage Programme
Geological Survey Ireland
Dept. of the Environment, Climate and Communications
Block 1
Booterstown Hall
Booterstown
Blackrock
County Dublin
A94 N2R6
01-6782837

and

Conor Nelligan
Heritage Officer and Communications Co-ordinator, Planning and Development
Cork County Council
Floor 3
County Hall
Cork
County Cork
T12 R2NC
021 428 5905
email. conor.nelligan@corkcoco.ie

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Executive Summary

County Cork is widely known for its unspoilt landscape and stunning scenery, but relatively few people are aware of its rich geodiversity which is considered in this audit report as the geological heritage of the county. For its relatively modest size, County Cork has an extensive and diverse range of geological heritage sites. Many of them represent the primary geological foundation of uplands composed of Old Red Sandstone rocks, coupled with extensive limestone lowlands throughout the main bulk of the county's area. Associated with the upland areas are a range of different sandstone strata, and development of karstic landscape features, as well as glacial landforms, abound on the lowlands. The County Council's support for this audit is critical in raising the profile of geological heritage in County Cork and for maximising its potential for foreign and domestic tourism and for the people of the county.

This report documents what are currently understood by the Geoheritage Programme (Irish Geological Heritage Programme) of Geological Survey Ireland (GSI) to be the most important geological sites within County Cork. It proposes them as County Geological Sites (CGS), for inclusion within the County Development Plan (CDP). The audit provides a reliable, field-based study of sites to replace a provisional outline list of sites based on desk study that were adopted in Cork County Development Plan 2014. The inclusion of these sites in future CDPs will be crucial in affording them consideration in future planning decisions.

County Geological Sites do not receive statutory protection like Natural Heritage Areas (NHA) but receive an effective protection from their inclusion in the planning system. Some of the sites described in this report are considered of national importance as a best representative example of a particular geological formation or feature. They may have been notified to the National Parks and Wildlife Service (NPWS) by Geological Survey Ireland for designation as a Natural Heritage Area (NHA). Designation would only occur once due survey and consultation with landowners is complete. In parts of the county, many of the sites fall within existing pNHAs and SACs where the ecological interest is founded upon the underlying geodiversity.

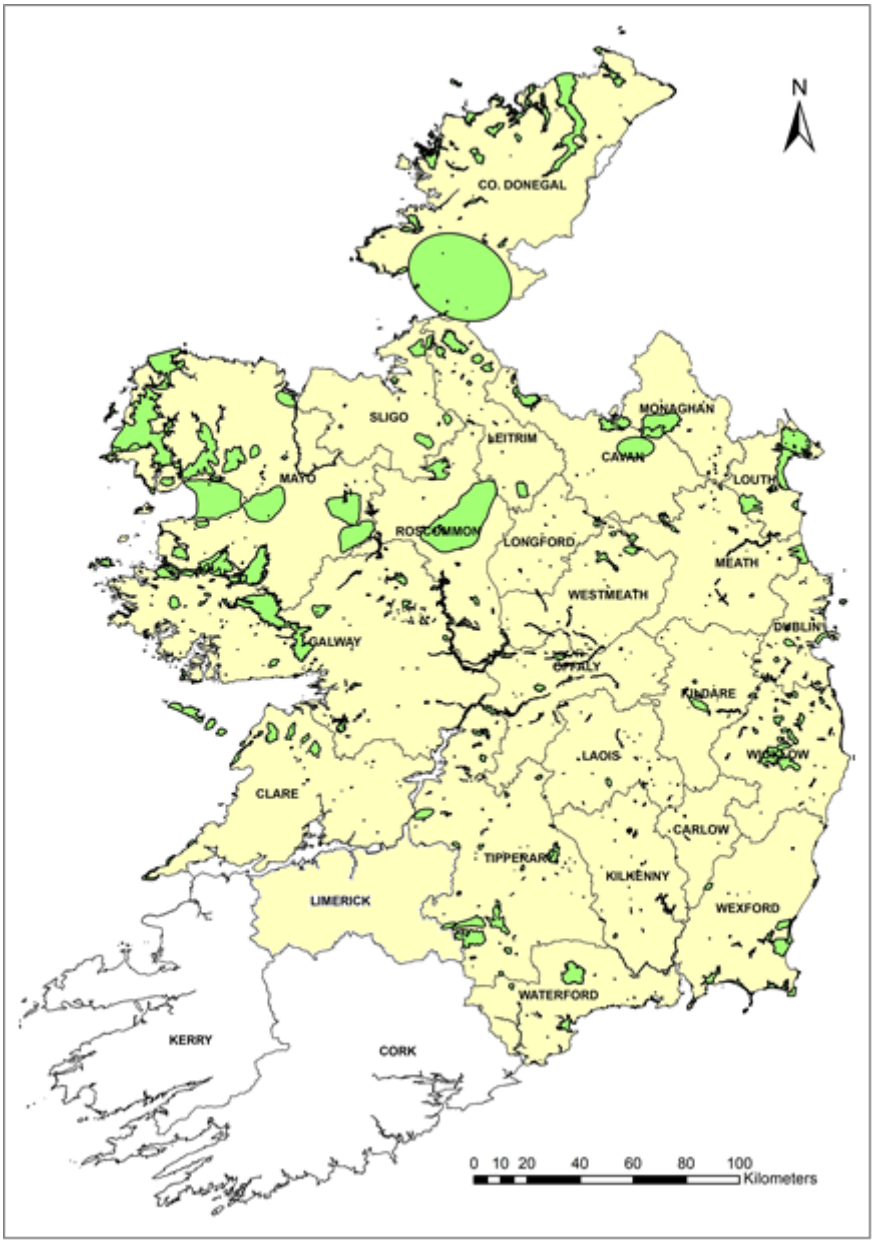
The commission of this audit and adoption of the sites within the CDP ensure that County Cork follows a now established and effective methodology for ensuring that geological heritage is not ignored in the absence of progress with designation of geological NHAs at national level. It brings County Cork to the forefront of geological conservation in Ireland.

This report is written in non-technical language (with a glossary for unavoidable geological terminology) as a working document for use by the Heritage Officer, Area Engineers and the Planning Department of Cork County Council. It should also be made available via the County Council website for the people of County Cork. A chapter of the report includes recommendations on how to best present and promote the geological heritage of County Cork to the people of the county. It will also inform the work of the GSI Geoheritage Programme and be made available at www.gsi.ie.

The preliminary sections, summary geological history and accompanying map, timescale and stratigraphical column particularly may be used as they stand to preface a booklet or as website information in the development of this work, and for information, as seen fit by the Heritage Officer, and as funding permits. The contents also provide the essential ingredients for a public-oriented book or other publications on the geological heritage of County Cork if appropriate financial funding can be secured for production and publication costs.

1. County Cork in the context of Irish Geological Heritage

This report brings County Cork to the forefront of geological heritage within Ireland, now that almost all counties have completed a geological heritage audit within the scope of the county-based Heritage Plan. The provision of reliable data in a very cost-effective manner should encourage the remaining local authorities to follow what is now a tried and trusted methodology. In the absence of significant political and economic resources available at a national level to the relevant bodies for conservation of geological heritage as Natural Heritage Areas (NHA), it represents a significant level of progress in defining and safeguarding Ireland's geological heritage. In essence, County Geological Site audits are the only effective geological conservation at present, albeit only with advisory capacity (within the context of County Development Plans) and no real statutory protection where it is required, although the statutory County Development Plan provides capacity to preserve sites where necessary.



Counties shown as yellow have been audited prior to 2023.

It also represents a significant commitment on the part of the Local Authority to fulfil its obligations to incorporate geology into the spectrum of responsibilities under the Heritage Act 1995, the

Planning and Development Act 2000 (as amended), Planning and Development Regulations 2001 (as amended), and the Wildlife (Amendment) Act 2000 and the National Heritage Plan (2002). Geological Survey Ireland views partnerships with the local authorities, exemplified by this report, as a very important element of its strategy on geological heritage (see Appendix 1).

The Geoheritage Programme in Geological Survey Ireland complements other nature conservation efforts of the last decade, by assessing Ireland's geodiversity. Geodiversity is the foundation of the biodiversity addressed under European Directives on habitats and species by the designations of Special Areas of Conservation (SAC) and on a national scale by the introduction of Natural Heritage Areas (NHA) as the national nature conservation method. As a targeted conservation measure to protect the very best of Irish geology and geomorphology the Geoheritage Programme fills a void which has existed since the end of the Areas of Scientific Interest scheme, listed by An Foras Forbartha in 1981.

The Geoheritage Programme does this by identifying and selecting the most important geological sites nationally for designation as NHAs. It looks at the entire spectrum within Irish geology and geomorphology under 16 different Irish Geological Heritage (IGH) themes:

IGH THEMES

1. Karst
2. Precambrian to Devonian Palaeontology
3. Carboniferous to Pliocene Palaeontology
4. Cambrian-Silurian
5. Precambrian
6. Mineralogy
7. Quaternary
8. Lower Carboniferous
9. Upper Carboniferous and Permian
10. Devonian
11. Igneous intrusions
12. Mesozoic and Cenozoic
13. Coastal geomorphology
14. Fluvial and lacustrine geomorphology
15. Economic geology
16. Hydrogeology

A fundamental approach for NHA selection is that only the minimum number of sites necessary to demonstrate the particular geological theme is selected. This means that the first criterion is to identify the best national representative example of each feature or major sequence, and the second is to identify any unique or exceptional sites. The third criterion, identifying any sites of International importance, is nearly always covered by the other two.

Designation of geological NHAs will be by the Geological Survey Ireland's partners in the Programme, the National Parks and Wildlife Service (NPWS). Once designated, any geological NHAs will be subject to normal statutory process within the County Cork Planning Department and other relevant divisions. However, compared to many ecological sites, management issues for geological sites are generally fewer and somewhat different in nature. The subsequent section considers these issues.

From a national perspective, as a result of extensive comparison of similar sites to establish the best among them, there is now a good knowledge of many other sites, which are not the chosen best example, but which may still be of national importance. Others may be of more local importance or of particular value as educational sites or as a public amenity. All these various important sites are proposed for County Geological Site listing in the County Development Plan.

Prior to the completion of a county geological heritage audit, a Master List of candidate CGS and NHA sites is the primary resource in use by Geological Survey Ireland and local authorities. The IGH Master List was originally compiled with the help of Expert Panels for all the 16 IGH themes. For several themes, the entire process has been largely completed and detailed site reports and boundary surveys have been done along with a Theme Report. Due to various factors, none have yet been formally designated. Therefore, inclusion of all sites as County Geological Sites in County Cork's planning system will ensure that the sites are not inadvertently damaged or destroyed through lack of awareness of them outside of the Geoheritage Programme in Geological Survey Ireland.

The sites proposed here as County Geological Sites have been visited and assessed specifically for this project and represent our current state of knowledge. The audit does not exclude other sites being identified later, or directly promoted by the Council itself, or by local communities wishing to draw attention to important sites for amenity or education with an intrinsic geological interest. New excavations, such as major road cuttings or new quarries, can themselves be significant and potential additions to this selection.

It was not possible within the scope of this study to identify landowners except in a few sites, but it is emphasised that CGS listing here is not a statutory designation and carries no specific implications or responsibilities for landowners. It is primarily a planning tool, designed to record the scientific importance of specific features, and to provide awareness of them in any decision on any proposed development that might affect them. It thus also has an educational role for the wider public in raising awareness of this often-undervalued component of our shared natural heritage.

1.1 Cork County Geological Sites

Site Name	Designation	IGH Primary	IGH Secondary	IGH Third	IGH Fourth	GIS Code
Ballingeary Esker	County Geological Site	IGH7				CK001
Ballinglanna Cove	County Geological Site	IGH8	IGH9			CK002
Ballinatona, Meelin Spring	County Geological Site	IGH16				CK003
Ballintra West	County Geological Site	IGH7	IGH10			CK004
Ballybeg Quarry	County Geological Site	IGH3	IGH8			CK005
Ballyclogh Quarry	County Geological Site	IGH8				CK006
Ballycotton	County Geological Site	IGH10				CK007
Ballycotton Bay	County Geological Site	IGH7				CK008
Ballycroneen Bay	County Geological Site	IGH7				CK009
Ballycrovane Harbour	County Geological Site	IGH8	IGH10			CK010
Ballycummisk Mine	County Geological Site	IGH15	IGH6			CK011
Ballydonegan Strand	County Geological Site; recommended for Geological NHA	IGH13	IGH15			CK012
Ballygarvan Quarry	County Geological Site	IGH8				CK013
Ballygiblin Quarry	County Geological Site	IGH12	IGH1	IGH8		CK014
Ballyknock	County Geological Site	IGH10				CK015
Ballytrasna	County Geological Site	IGH10				CK016
Baltimore Beacon	County Geological Site	IGH10	IGH13			CK017
Bantry Drumlins	County Geological Site	IGH7				CK018
Barley Cove	County Geological Site; recommended for Geological NHA	IGH13	IGH10			CK019
Barley Lake	County Geological Site	IGH7				CK020
Benduff Slate Quarry	County Geological Site	IGH15				CK021
Bere Island	County Geological Site	IGH10				CK022
Black Ball Head Diatreme	County Geological Site	IGH11	IGH8			CK023
Black Ball Head Trachyte	County Geological Site	IGH11	IGH8			CK024
Broadstrand	County Geological Site; recommended for Geological NHA	IGH8	IGH9	IGH10	IGH7	CK025
Brow Head Mine	County Geological Site	IGH15	IGH6			CK026
Bweeng Quarry	County Geological Site	IGH10				CK027
Caminches Mine	County Geological Site	IGH15	IGH6			CK028
Cape Clear	County Geological Site	IGH2	IGH10			CK029
Carraigcleena	County Geological Site	IGH10				CK030
Castlehaven	County Geological Site	IGH10				CK031
Castlepook Cave	County Geological Site; recommended for Geological NHA	IGH7	IGH1	IGH12		CK032
Church Bay	County Geological Site	IGH10				CK033
Cloyne Cave	County Geological Site	IGH1				CK034
Cod's Head	County Geological Site	IGH11	IGH10			CK035
Coom Mine	County Geological Site	IGH15	IGH6			CK036
Coomhola River	County Geological Site	IGH8				CK037
Cork-Mallow Road Cut	County Geological Site	IGH10				CK038
Courtmacsherry Estuary	County Geological Site	IGH13				CK039

Crookhaven Mine	County Geological Site	IGH15	IGH6			CK040
Derrycarhoon	County Geological Site; recommended for Geological NHA	IGH15				CK041
Dhurode Mine	County Geological Site	IGH15	IGH6			CK042
Dooneen Mine	County Geological Site	IGH15	IGH6			CK043
Dower Spring	County Geological Site	IGH16	IGH8	IGH1		CK044
Dunmanus Bay	County Geological Site	IGH8	IGH10	IGH13		CK045
Foley Cave	County Geological Site; recommended for Geological NHA	IGH7	IGH1	IGH12		CK046
Galley Head	County Geological Site	IGH8	IGH10	IGH13		CK047
Glandore Mine	County Geological Site	IGH15	IGH6			CK048
Glengarriff Harbour	County Geological Site	IGH10				CK049
Glengarriff to Adrigole R572 Road	County Geological Site	IGH10				CK050
Gortavallig Mine	County Geological Site	IGH15	IGH6			CK051
Gortnabinna	County Geological Site; recommended for Geological NHA	IGH10	IGH2			CK052
Haulbowline and Rocky Islands	County Geological Site	IGH15				CK053
Howe's Strand	County Geological Site	IGH7				CK054
Kealoge Mine (North)	County Geological Site	IGH15	IGH6			CK055
Kealoge Mine (South)	County Geological Site	IGH15	IGH6			CK056
Killumney Moraine	County Geological Site	IGH7				CK057
Knockadoon Head	County Geological Site	IGH7				CK058
Lady's Well, Mallow	County Geological Site	IGH16				CK059
Lady's Well Mine	County Geological Site	IGH15				CK060
Laharran Quarry	County Geological Site; recommended for Geological NHA	IGH6				CK061
Lough Hyne	County Geological Site	IGH13	IGH7			CK062
Macroom (Hartnett's Cross)	County Geological Site	IGH10				CK063
Madranna Slate Quarry	County Geological Site	IGH15				CK064
Midleton Distillery	County Geological Site	IGH1	IGH16			CK065
Mount Gabriel	County Geological Site; recommended for Geological NHA	IGH15				CK066
Mountain Mine	County Geological Site; recommended for Geological NHA	IGH15	IGH6			CK067
Myrtleville	County Geological Site; recommended for Geological NHA	IGH8	IGH10			CK068
Old Head of Kinsale	County Geological Site; recommended for Geological NHA	IGH8	IGH10	IGH9	IGH3	CK069
Owentaraglin River	County Geological Site	IGH14				CK070
Pass of Keimaneigh	County Geological Site; recommended for Geological NHA	IGH7				CK071

Ram's Head to Weaver's Point	County Geological Site	IGH10				CK072
Rathmore Esker	County Geological Site	IGH7				CK073
Reenydonagan Point	County Geological Site; recommended for Geological NHA	IGH8	IGH3			CK074
Relane Point	County Geological Site; recommended for Geological NHA	IGH8	IGH7			CK075
Ringabella Bay	County Geological Site	IGH8	IGH3	IGH7		CK076
Ringaskiddy	County Geological Site; recommended for Geological NHA	IGH8	IGH7			CK077
Rock Farm Quarries	County Geological Site; recommended for Geological NHA	IGH3	IGH8	IGH15		CK078
Shanballymore	County Geological Site	IGH1	IGH16			CK079
Shot Head	County Geological Site	IGH10	IGH8			CK080
Simon's Cove	County Geological Site; recommended for Geological NHA	IGH7				CK081
Subulter Quarry	County Geological Site	IGH8	IGH12			CK082
The Gearagh	County Geological Site; recommended for Geological NHA	IGH14				CK083
Toe Head	County Geological Site	IGH10	IGH2			CK084
Trinity Well	County Geological Site	IGH16				CK085
Whiddy Island	County Geological Site; recommended for Geological NHA	IGH9	IGH7			CK086
White Bay	County Geological Site	IGH8				CK087
Youghal Bay	County Geological Site	IGH13				CK088
Youghal Lighthouse	County Geological Site	IGH10				CK089

1.2 Rejected, Combined and Renamed Sites

Of the range of sites flagged for consideration in the Irish Geological Heritage (IGH) Master Site List, some sites were assessed as unsuitable for County Geological Site status in this audit. Sites supplementary to the IGH Master List were also considered and included for consideration for County Geological Site status. It should be noted that for several sites in Cork, along with other counties, the original expert panel process of developing a IGH Master Site List yielded some of the issues described below. Some of the sites were poorly defined either in terms of location or naming, or the information proved too vague to assist in proper identification of the features of interest and heritage value. The renamed, combined or rejected sites are listed below with brief notes as to why they were considered for renaming, combining, or assessed as unsuitable for inclusion.

Ardmore
Ardmore was listed in the IGH Master Site List under the IGH10 Devonian Theme, but the locality had no grid reference associated with it, and the only comment within the spreadsheet was to 'extend IGH8 site'. The 'Geology of South Cork' bedrock geology booklet (Sleeman and Pracht, 1994) has two 'Key Localities' listed towards the end of the booklet, at the 'Ardmore Area' and 'Ardmore Pier', but these have grid references at and adjacent to Ardmore in Waterford. Localities at and adjacent to Ardmore do appear as County Geological Sites in the County Waterford Audit of IGH so it may be that the Ardmore sites are what was meant in this Cork listing. There are three townlands named 'Ardmore' in Cork; one on Namurian shales near Charleville and does not match the brief description in the IGH Master List; one on bedrock of Cork Group Sandstones near Timoleague and does not match the IGH Master List description; while the third is outside Passage West and is on Devonian bedrock. This locality was visited during field work, but apart from a few poorly exposed pockets of bedrock subcrop, there is little in terms of bedrock exposure in the locality. The Ardmore site in County Cork was therefore rejected as a County Geological Site.

Ballydehob Mine
Ballydehob mine was operated for a short time in the 1850s, with small amounts of copper ore being raised. Several shafts are marked on the old OSI 6-inch maps and were surveyed for the HMS-IRC study of Irish mines (Stanley et al. 2010) but the site was not considered worth being subjected to detailed consideration. Few traces of mining remain today, and the site does not warrant designation as a County Geological Site.

View over area of former mine site at Ballydehob.

View downwards of shaft at Ballydehob mine (photo: 2007).

Ballydesmond

The site at Ballydesmond is listed in the IGH Master Site List under the IGH7 Quaternary theme on the basis of there being a quarry that '*exhibits the best example in the country of tundra frost polygons formed during the last glaciation'*. The site is listed as an Area of Scientific Interest (ASI) in the 1986 Goodwillie Report on Areas of Scientific Interest in County Cork. The report states: "*Frost polygons are the feature of interest here, exposed in the face of a working quarry. The polygons are formed by ridges of stones which collect between frost hummocks in tundra conditions. They occur close to an icesheet when a layer of permafrost affects soils with little vegetational cover. It is thought that Ballydesmond was not covered by ice during the last glaciation since it lies between the southern limit of the main (Midlandian) icesheet and the northern limit of the Cork-Kerry icesheet. The polygons were formed at this time, perhaps 15,000 years ago*." Since publication of the report, there is a widespread acceptance that this area was covered by ice during the last glaciation. The frost polygon features were reported in the early 1980s. The quarry has expanded significantly since Ordnance Survey Ireland the aerial surveys in the 1990s and thereafter. The features no longer extant, and as a result, the site is not considered for County Geological Site designation. The quarry is currently in operation.

Ballyhass Lakes

Ballyhass Adventure Park is situated just over 10 km northwest of Mallow and specialises in Water Sports and Outdoor Adventure Activities. The site utilises a disused quarry into pure bedded, karstified limestone as the basis for its water sports and high rope zipline activities. Thus, the site was therefore examined to investigate any Geological Heritage Potential.

Ballyhass Lakes, with a relatively short and unimpressive reach of outcrop despite being set within a disused quarry.

The quarry has been flooded to allow the lakes to form, and the majority of the old rock faces have been graded and/or vegetated, such that little rock remains visible. Where it can be seen, the quarry is cut along the faces of the beds, so sheer slopes are in evidence, and little of the structure of the bedrock can be seen. There are no karst features exhibited or present in the old quarry. In a general sense, then, the outcrop is of poor quality, and upon this basis the site is rejected as a County Geological Site.

Ballyheady

Ballyheady is listed in the IGH Master Site List under the IGH 3 Carboniferous - Pliocene Palaeontology theme. The site is also sometimes listed in literature as 'Ballyheedy'. Fossil fish (Coelocanthus elongatus) specimens were identified in Namurian White Strand Formation rocks at the site. The fossils were first described by T.H. Huxley, in 1866, in a memoir of the Geological

Survey of the United Kingdom. Early edition GSI 6" Field Sheets mark a locality indicating 'Fossil fish and shells' on the west of the church at Ballyheady, on a site now occupied by a dwelling property. The site is not considered a candidate County Geological Site.

Dwelling to the west of church at Ballyheady.

Early edition 6" GSI Field Sheet showing fossil locality (black asterisk)

Ballykenly

Just north of Glanworth and along the road to Glenahulla, emerges Ballykenly Spring, which was commissioned as a water supply source in 1947. The pumphouse is located on the main road in the townland of Ballykenly. The spring source is 150 m north of the pumphouse in a concrete sump, and the water is fed from the source by gravity to the pumphouse, where pumps send water to the nearby Johnstown and Dunmahon reservoirs. The spring itself is unremarkable, and as the pumphouse is separated from it by some distance, the site does not lend itself to a concise narrative regarding our groundwater heritage. Given this, the site is rejected as a County Geological Site.

The pumphouse site at Ballykenly.

Baltimore Harbour

Baltimore Harbour is listed in the IGH Master Site List for County Cork, under the IGH13 Coastal Geomorphology Theme, as the locality comprises a "sheltered inlet with coves in which grey gravelly beaches [slope] down to low tide mudflats and segments of planed-off rocky strata". The harbour itself is indeed a wide coastal embayment, but many of the listed features (gravelly

beaches, mudflats, coves) are much better expressed in the Courtmacsherry Estuary County Geological Site, as well as several other coastal Geological Heritage sites in Cork (e.g. Barley Cove, Youghal Bay). The coastal cliffs and narrow inlets also mentioned in the site description have been included as part of the Baltimore Beacon County Geological Site, in any case. Upon this basis, the 'Baltimore Harbour' site was rejected, but the unique elements of it have been combined into the Baltimore Beacon County Geological Site.

The wide, sheltered inlet of Baltimore Harbour, viewed from the east.

Baneshane Quarry

Baneshane Quarry appears on the IGH Master Site List as a Cork Red Marble Quarry, under the IGH8 Lower Carboniferous Theme. The quarry is known from the literature also (Nevill, 1962) and is listed as a key locality in the 'Geology of South Cork' bedrock booklet (Sleeman and Pracht, 1994), mentioned as 'a small, old marble quarry which exposes the red marble; it contains replacement chert in considerable quantity'. The quarry was visited a number of times but the landowner would not grant access to it, save some photographs from the perimeter, though it was seen that the quarry is backfilled in the majority, with no faces intact. Thick, dense vegetation also covers the (now shallow) pit. There are no exposures of marble exhibited or present in the old quarry. In a general sense, the outcrop is of poor quality, and upon this basis the site is rejected as a County Geological Site.

Baneshane Quarry (left) from the roadside, and (right) the dense vegetation covering the (now shallow and poorly exposed) pit.

Boggeragh Mountains

The Boggeragh Mountains are listed on the IGH Master Site List under the IGH14 Fluvial and Lacustrine Geomorphology theme as hosting particularly good examples of unusual river channels. The mountains were visited, and form domed upland ridges, which have been covered by blanket peat in the majority.

One of the incising streams emerging from the Boggeragh Mountains at Knocknagappul.

Though there are a number of radially-arranged, incised stream channels emanating out from the centre of the upland area, these are in no way unusual, and are similar to those found across all of the upper slopes of the Old Red Sandstone uplands across the country. There are no distinct or unusual Ice Age landforms either, across the mountain area. The Boggeragh Mountains are rejected as a County Geological Site.

Caminches Stamps

Caminches Stamps is a site previously assessed as part of the HMS-IRC study (Stanley et al. 2010). At three points along the north bank of the Ballydonegan River, on either side of the road, stamp batteries were operated in the 19th century to process the ore from Caminches mine, which lies half a kilometre to the north. The site was presumably chosen to exploit water power to run the stamps. There are two waste heaps on the site and both have iron-rich horizons that are typical of stamps waste. While the waste heap on the west side of the road is still visible, that on the east side, on the bank of the river, is largely obscured by thick overgrowth of vegetation, a significant change in the last 15 years. Better exposed and more extensive examples of such waste are present on other sites in the Allihies district. Moreover, the Kealoge South site contains the much more extensive, albeit overgrown, remains of an ore processing site that include stamp batteries. In the absence of other features of interest, the presence of mine waste is not, in itself, sufficient to warrant including this site as a County Geological Site.

Main extant pile of mine stamps waste beside unsealed farm road. Site of former stamps battery was immediately behind waste pile.

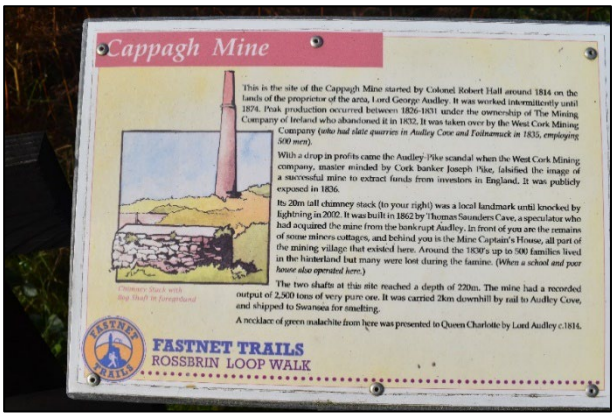
Area of largest waste pile and former stamps battery on north bank of Ballydonegan River, on east side of sealed road, now largely overgrown.

Cape Clear

The IGH Master Site List includes a listing for Foilcoagh Bay (IGH2 Precambrian to Devonian Palaeontology) and NE coast of Clape Clear (IGH10 Devonian). These two sites were combined and renamed as Cape Clear to reflect the location of the County Geological Site on the islands.

Cappagh Mine

Cappagh mine was visited for the HMS-IRC study of Irish mines (Stanley et al. 2010) but was not considered worth a detailed survey. It is included in the Fastnet Trails Rosbrin walking trail and a signboard provides a summary of the history of the site and lists extant mine features. Most prominent among these are the remains of a chimney, felled by lightning in 2002, and some derelict miners' cottages. The mapped sites of former shafts, reaching a depth of over 200 m, are obscured by vegetation. While Cappagh appears to have been a relatively extensive and even successful mine, the poorly preserved remaining mine features do not warrant designating it as a County Geological Site.



Fastnet Trails signboard, providing an overview of the history of Cappagh mine, located beside road overlooking the remains of miners' cottages at western side of site.

View southeastwards over the former mine site, with miners' cottages on right and remains of chimney visible on left in front of trees.

Carrigaline Church St. Mary's Church

St. Mary's Church in Carrigaline is listed as a key locality in the 'Geology of South Cork' bedrock booklet (Sleeman and Pracht, 1994), where it is stated that …

"This locality is interesting and important because it was one of the localities cited by Jukes (1864) in support of his thesis that the "Carboniferous Slate" was laterally equivalent to the Carboniferous Limestone. The small exposure of sandstone and mudstone in the bank opposite the church assigned to the White Strand Formation, contains miospores belonging to the Namurian (El) part of the NC miospore zone. The adjacent limestones behind in the new housing estate and on the Rock beside Carrigaline Castle belong to the Little Island ormation and contain Asbian conodonts and foraminifera."

Bank facing St. Mary's Church, Carrigaline

Church Grounds (right).

The church and its' grounds were visited and surveyed, as was the bank opposite it. However, potentially owing to relatively recent road and amenity grassland improvements around the church and it's facing road, there is no exposure in the bank opposite the church; neither are there any outcrops or exposures around the church itself. The site is therefore rejected as a County Geological Site.

Cloyne

Near Cloyne in East Cork the Carboniferous Limestone contains numerous cavities, some infilled with colloidal clays that were exploited in the 1930s and 1940s under the trade name "Colbond Clay". The clay was extracted from two pits about 1 km southwest of the town, in Lissanly and Spital townlands. Modern research has dated the clays as Lower-Middle Jurassic in age. Almost forty years ago the pits were reported to be infilled (Spital) or worked out (Lissanly). Today, no trace remains of these pits and there are no known outcrops of the clay in the area. In the absence of any such features, there is no basis for considering the site as a County Geological Site.

Site of Spital Pit, view southeast from road along boundary between Spital and Lissanly townlands.

Site of Lissanly pit, view southwest from road along boundary between Spital and Lissanly townlands.

Coolacareen

Coolacareen is listed as a Key Locality, Appendix 1, in the GSI Report for Sheet 25 South Cork (Daly et al. 1994). The report reads: 'a good locality of the Ballytrasna Formation can be seen at Coolacareen, about 1 km to the east of Macroom in a wood'. Much of this area is now covered by well-established forestry, or by felled forestry. Outcrops are not easily accessible, and as a result the location is not considered a suitable candidate County Geological Site.

Bedrock exposed on hillside after tree-felling at Coolacareen.

Cooladreen Slate Quarry

Three separate pits formed the famous Rosscarbery Slate Quarries of the nineteenth and early twentieth centuries: Benduff Slate Quarry and Madranna Slate Quarry, which have both been listed as County Geological Sites, and Cooladreen Slate Quarry. All three sites were visited, but the locality at Cooladreen near the village of Leap has long since been abandoned, and has been completely landscaped into the hill within which it rests. Nowadays the quarry comprises only a 40 m-deep gouge into the side of a hill at Cooladreen. The base of the quarry is flooded And its sides are blanketed with dense broadleaf forestry. There is little rock exposure visible. Upon this basis, the site was rejected as a County Geological Site.

The abandoned, flooded and landscaped Cooladreen Slate Quarry.

Coomhola River

The IGH Master Site List site *(East) Glengarriff Harbour to Ardnamanna Point* comprises inaccessible sections of Devonian and Carboniferous stratigraphy between Glengarriff Harbour and Ardnamana Point, and is not considered to be a suitable County Geological Site in its entirety. Features of geological interest along the *(East) Glengarriff Harbour to Ardnamanna Point* section

are now represented by two County Geological Sites which have been renamed *Coomhola River* and *East Glengarriff Harbour*

Corkbeg Island

Corkbeg Island is listed on the IGH Master Site List for 'Waulsortian at refinery', referring to the fact that part of the Whitegate Oil Refinery is sited on Corkbeg Island. Much of the island has been concreted over, and new concreting was being completed in Summer 2022 when the site visit for this audit took place. There are still some outcrops around the basal fringe of the island along the western and southeastern edges, but these have mostly been covered by rock armour to stop coastal erosion and are poorly exposed and expressed. The site was therefore rejected as a County Geological Site.

View across the exposure along the southeastern side of Corkbeg Island (left), with a close up of the current nature of the locality (right).

Cork Harbour

The IGH Master List for County Cork states, under an entry for 'Cork Harbour':

"On the western side of Cork Harbour is the Crosshaven Peninsula, where the Old Red Sandstone comes up in a Southern Anticline trending east-west, exposed on Weaver's Point, flanked by Carboniferous Limestone to the north. An emerged ("raised") beach can be traced around the shores of Cork Harbour, but there are discrepancies in the levels of Late Quaternary sediment sequence levels on either side of the harbour which could result from Holocene warping (Devoy). Near Rostellan on the eastern side of the bay a dolmen (megalithic tomb) built 3000-4000 years ago is submerged at high tide."

This locality has again been audited as part of both the surveying carried out between Ram's Head and Ringabella Bay as part of this audit, in surveying the 'Courtmacsherry Raised Beach' at Broadstrand Bay and Seven Heads Bay along the southwestern side of Courtmacsherry Bay, at Ballycotton Bay and Ballycroneen Bay, at Howe's Strand in the northern portion of Courtmacsherry Bay, and at Simon's Cove near Clonakilty, as well as in surveying the Rostellan site.

Thus, all elements of this 'Cork Harbour' site have been captured in the County Geological Site reports for Ram's Head to Weaver's Point (IGH10 Devonian), Church Bay (IGH10 Devonian), Myrtleville (IGH8 Lower Carboniferous, IGH10 Devonian), Ringabella Bay (IGH8 Lower Carboniferous, IGH3 Carboniferous to Pliocene Palaeontology, and IGH7 Quaternary), Broadstrand Bay (IGH9 Upper Carboniferous, IGH10 Devonian, and IGH7 Quaternary), Ballycotton Bay (IGH7 Quaternary), Ballycroneen Bay (IGH7 Quaternary), Howe's Strand (IGH7 Quaternary) and Simon's

Cove (IGH7 Quaternary). The Rostellan site is not included at all as that is solely an archaeological feature.

The Rostellan Dolmen, between Cloyne and Whitegate, an archaeological feature which is submerged at high tide.

Cork Red Marble

'Cork Red Marble' appears on the IGH Master Site List as a separate entry for County Cork, but with three discrete localities listed: Baneshane, Little Island and/or Midleton, all under the IGH15 Economic Geology Theme. As all three of these localities are sites in themselves, 'Cork Red Marble' is therefore rejected as a County Geological Site in and of itself.

Courtmacsherry Bay – Old Head of Kinsale

Courtmacsherry Bay – Old Head of Kinsale was listed in the IGH Master List for Cork, under the IGH13 Coastal Geomorphology and the IGH8 Lower Carboniferous Themes, but the locality had many features listed within bedrock outcrops around the Old Head of Kinsale, the coastal features of the Courtmacsherry Estuary and the Quaternary-age Courtmacsherry Raised Beach. Both the Old Head of Kinsale and Courtmacsherry Estuary are defined as separate, individual County Geological Sites, with the former also recommended for Geological NHA. They include all the features listed in the IGH Master list for the proposed Courtmacsherry Bay – Old Head of Kinsale site. Therefore, this 'Courtmacsherry Bay – Old Head of Kinsale' site is rejected as a County Geological Site.

Courtmacsherry Beach – Raised Beach

Courtmacsherry Beach – Raised Beach was listed in the IGH Master List for County Cork under the IGH7 Quaternary Theme, but the only data on the beach feature was 'raised beach overlain by till', and a grid reference given near Ballinspittle. In reality, raised beach sands and gravels are found intermittently around the southern coast of Ireland at numerous localities, including at Broadstrand Bay and Seven Heads Bay along the southwestern side of Courtmacsherry Bay, at Ballycotton Bay and Ballycroneen Bay, at Howe's Strand in the northern portion of Courtmacsherry Bay, and at Simon's Cove near Clonakilty. In Irish glacial literature this feature is called the 'Courtmacsherry Raised Beach', and each of the above-listed sites forms one of the type-sites for the raised beach. All relevant sites have been surveyed as part of this audit and have been listed as County Geological Sites and, in the case of Simon's Cove, recommended for Geological NHA. Thus, the 'Courtmacsherry Beach – Raised Beach' site was rejected, as its salient features have been covered in all of the other County Geological Site surveys.

Ferricreted raised beach sands and gravels at Seven Heads Bay, part of the Broadstrand County Geological Site, and part of the regional feature known as the 'Courtmacsherry Raised Beach'.

Dunmanus Bay

Two sites (*Dunbeacon Castle-Dunmanus Bay* (IGH 8 Lower Carboniferous) and *Dunmanus Castle Northwards* (IGH 10 Devonian)) listed on the IGH Master List occupy a section on the south coast of Dunmanus Bay. The Devonian stratigraphy at *Dunmanus Castle Northwards* continues conformably into the Lower Carboniferous stratigraphy at *Dunbeacon Castle-Dunmanus Bay*. The two sites are combined and renamed as *Dunmanus Bay* (IGH 8 and IGH 10).

East Toe Head

East Toe Head was listed in the IGH Master Site List for County Cork, under the IGH10 Devonian Theme, but the listing did not include any information as context for the site other than that it is located in 'Gortacrossig' townland. The site 'Toe Head' was also listed, and that site had a detailed grid reference (in Gortacrossig Townland) and also had data giving the reason for its listing, as well as an entry under two themes: IGH2 Precambrian - Devonian Palaeontology and IGH10 Devonian. That latter 'Toe Head' site was surveyed in the field and has been listed as a County Geological Site, and upon this basis the 'East Toe Head' site is rejected, as it is considered that both listings for Toe Head and East Toe Head cover one and the same site.

Fountainstown Creek to Ringabella Beach, Ringabella Section - Fountainstown - Myrtleville - Rams Head, Myrtleville to Ram's Head, and Ringabella Bay and Point

Four separate entries in the IGH Master List for County Cork, Fountainstown Creek to Ringabella Beach, Ringabella Section - Fountainstown - Myrtleville – Ram's Head, Myrtleville to Ram's Head, and Ringabella Bay and Point, are listed under the IGH3 Carboniferous – Pliocene Palaeontology, the IGH7 Quaternary, the IGH8 Lower Carboniferous and the IGH10 Devonian Themes. All sites include coastal sections in Quaternary sediment and underlying bedrock exposures between Ram's Head, to the east of Crosshaven, and Ringabella Bay, east of Minane Bridge.

The entirety of this 14 km-long coastal section was considered and visited and surveyed in full as part of this audit, and the four Master List entries have been listed as County Geological Sites, with some renaming, some conflation, and some rationalisation. The four County Geological Sites (from north to south), and their IGH theme are:

- Ram's Head to Weaver's Point (IGH10 Devonian),
- Church Bay (IGH10 Devonian),
- Myrtleville (IGH8 Lower Carboniferous, IGH10 Devonian), and

- Ringbella Bay (IGH8 Lower Carboniferous, IGH3 Carboniferous to Pliocene Palaeontology, and IGH7 Quaternary).

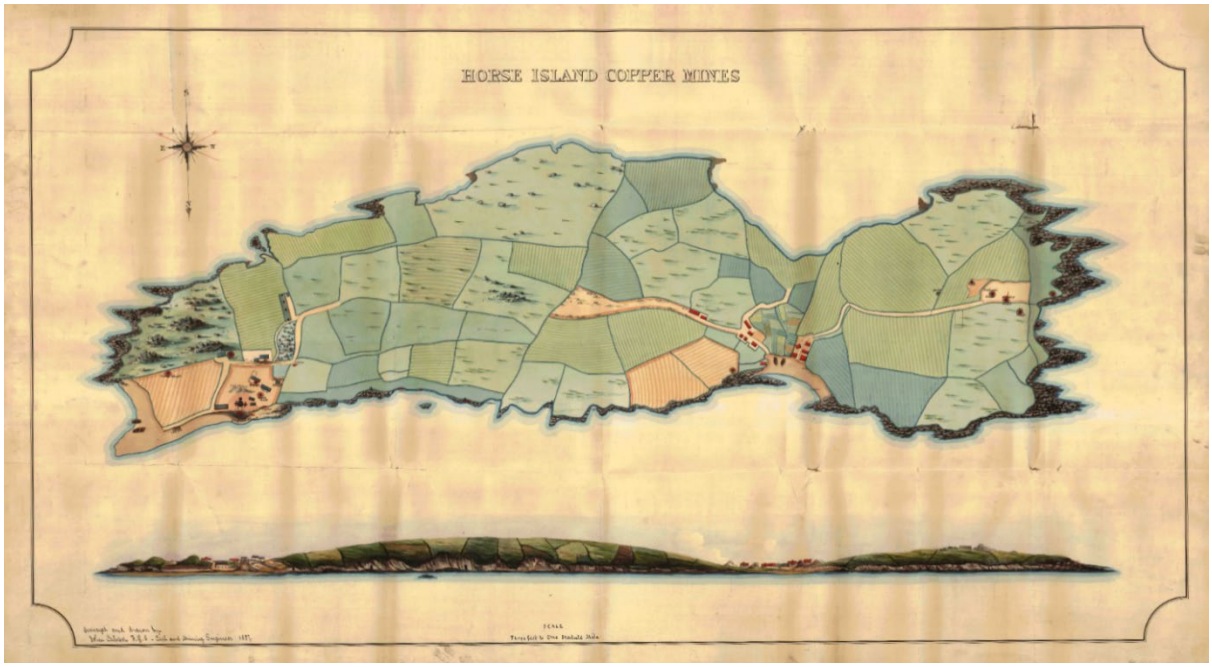
Part of the delineated 'Myrtleville' County Geological Site, formerly part of three Master List entries - Fountainstown Creek to Ringabella Beach, Ringabella Section - Fountainstown - Myrtleville - Rams Head, and Myrtleville to Ram's Head.

Glengarriff to Adrigole R572 Road
The IGH Master Site List includes *Glengarriff towards Castletownbere* (IGH 10 Devonian). This has been renamed the *Glengarriff to Adrigole Road* (IGH 10 Devonian) because a representative section of road cuttings occurs between Glengarriff to Adrigole.

Glengarriff Harbour – Gun Point to Reenydonagan Point
This section is listed as a Key Location in the GSI Geology of West Cork Report to accompany the GSI Sheet 24 1:100,000 Scale Bedrock Map, published in 2002. Features of geological interest along this section are represented at two County Geological Sites: *East Glengarriff Harbour and Reenydongan Point*.

Glengarriff Harbour
The IGH Master Site List includes *(East) Glengarriff Harbour to Ardnamanna Point* (IGH 10 Devonian). This has been renamed the include sites that represent an accessible continuous sequence of Upper Devonian stratigraphy in this area at the head of Bantry Bay.

Horse Island (Cu)
Situated in Roaringwater Bay, *Horse Island (Cu)* is listed in the IGH Master List under the IGH15 Economic Geology Theme. The island represents one of many copper mines that were worked in the nineteenth century in West Cork. The island is private property and there is no public access via ferry to the island. It is important considering its industrial heritage, but it is not included as County Geological Sites in County Cork.



Surface plan and section of Horse Island. (Item No. 18 of 125/4/2 on p. 5 of old Catalogue for Cork, Source: GSI Goldmine website)

Letter Mine

Letter mine was surveyed for the HMS-IRC study of Irish mines (Stanley et al. 2010) and, as such, was included as a potential site for this audit. The mine is subdivided into two separate sites, one a copper mine and the other a barite mine, located close together on the eastern flank of the Mount Gabriel massif, on private land. Previously, access was possible, via an unsealed road, from the Schull - Mount Gabriel road. However, this road is now barred by a padlocked gate. Letter Mine produced small amounts of copper and barite from two separate veins in the 19th century. The HMS-IRC survey of the site in 2007 revealed a few remaining mine features, including the remains of a dressing floor, some small mine waste heaps and an overgrown shaft. Given the lack of available access and the relative paucity of mining remains, Letter Mine does not warrant designation as a County Geological Site.

Padlocked gate on road leading to Letter mine site.

Overgrown shaft (foreground) with mine waste heaps in background (photo: 2007).

Kanturk (Munster Coalfield)

The Munster Coalfield supposedly covered an area of 1600 km^2 in counties Clare, Kerry, Limerick and Cork. The most important workings were in the area between Kanturk and Church Hill, 15 km to the southwest. The coal was of poor quality and the various mines appear never to have been economic. The remains of several shafts, adits and some waste heaps are scattered throughout the area. No coal seam exposures were noted in County Cork in a survey by GSI of the entire coalfield three decades ago. A survey of mine features carried out by GSI a decade ago indicated that, of these features, only the somewhat unusual shaft at Dysert merited consideration from a geological heritage perspective. This shaft occurs within a wooded area at the edge of pasture. It has a somewhat unusual shape in plan, rectangular but with rounded corners. The shaft is open, unfenced and partly overgrown. It is of some, limited interest from a mining heritage perspective but the site contains no other extant features that would warrant designating it as a County Geological Site.

Interior wall of uncapped shaft showing rounded corners.

View of overgrown exterior wall of Dysert shaft.

Kilcolman Bog

Another site not mentioned as a locality on the IGH Master Site List, the bog at Kilcolman just northwest of Buttevant, is a designated Special Protection Area (SPA). The bog occupies a glacially eroded hollow in Carboniferous limestone, and comprises a quaking fen fed by calcareous groundwater, with areas of reed swamp, freshwater marsh and wet grassland. Furthermore, in terms of hydrogeology, there is a small permanent lake, and a large flooded area is usual in winter. The site is typical of the limestone lowlands of Ireland, and there is little unusual in terms of the geomorphology or hydrogeology of the site. As the site is designated based on bird communities, and as there has been nothing remarkable found historically in terms of its habitats or natural heritage (neither has there been during this audit), this site is rejected as a County Geological Site.

An overview of Kilcolman Bog.

Kilworth

The IGH Master Site List includes a 'Victorian Pumping Station of a major spring at Kilworth' under the IGH16 Hydrogeology theme. Following discussions with David Ball, Hydrogeologist, who had proposed the site, it was ascertained that the spring lay inside Kilworth Army Camp. The camp traces its origins back to the establishment by the British Army of a large garrison barracks in nearby Fermoy, and towards the end of the nineteenth century, the British military identified Kilworth as an ideal training camp and purchased 14,000 acres of land there. In 1922, the camp was taken over by the National Army of the newly-established Irish Free State. The camp is still used by the Irish Defence Forces and over 4,500 personnel are assigned to Kilworth for training every year.

All that remains of the old Victorian water supply at Kilworth Camp is the original pumphouse.

Upon visiting the site and discussing the water supply for the facility with Senior Camp Personnel, it was discovered that the use of the Victorian Pumping Station as part of the water supply dated back to the late 1800's, but that new boreholes had been drilled there in the 1990's. Though the original spring chambers and Victorian Pumping Station were still retained on-site at that time, a dog drowned in one of the chambers ten years ago, and it was decided that they should be filled in and the old water supply decommissioned. Thus, as the hand pump is no longer extant, it is rejected as a County Geological Site.

Little Island

Little Island was listed in the IGH Master Site List, under both the IGH3 Carboniferous – Pliocene Palaeontology theme, as well as the IGH8 Lower Carboniferous Theme, and it was mentioned that 'Little Island provides the type section for the Cork Red Marble Formation'. This is true, and is the case, but all exposures of Cork Red Marble on the eighteenth century six-inch field sheets wereas part of the 'Rock Farm Quarries', which are listed in their own right. Further from this, 'Little Island' is listed as a key locality in the 'Geology of South Cork' bedrock booklet (Sleeman and Pracht, 1994), but in its entry it is stated …

> *"Little Island - Rock Farm Quarries (grid ref: 17595 07137) … Little Island and Clashavodig Formations… These quarries belong to the Cork Golf Club course from whom permission to enter should be obtained. Please keep off the greens. The sections in these quarries provide the best information about the upper part of the Carboniferous Limestone succession in the Cork Syncline."*

Thus, as the Little Island site refers to the Rock Farm Quarries site, 'Little Island' in and of itself is rejected as a site; it only duplicates another site locality and gives its own name to that as well as the 'Rock Farm Quarries' name which is the correct label for the site.

Lough Beg Section

Along the southern shoreline of the headland at Ringaskiddy, a long laneway extends through Loughbeg Townland. The end of this laneway is termed the 'Loughbeg Section' and is included on the IGH Master Site List, under the IGH8 Lower Carboniferous Theme, as a 'coastal section'. The section is also listed as a key locality in the 'Geology of South Cork' bedrock booklet (Sleeman and Pracht, 1994), mentioned as a representative section of both Waulsortian limestones and the Loughbeg Formation.

> *"The topmost beds of the Waulsortian Limestone are seen adjacent to the end of the lane at Loughbeg (Sleeman et al. 1986 Fig. 9). These limestones are bedded crinoidal wackestones and pass up to cherty and nodular calcareous mudstones of the Loughbeg Formation (Sleeman et al. 1986). The topmost bed is seen in the core of the Loughbeg Syncline. Walking a further 400m south along the foreshore to Loughbeg Point, the higher parts of the Waulsortian Limestone on the south limb of the syncline can be examined at low water (Sleeman et al. 1986)."*

Today, owing to both erosion in the recent decades, associated beach deposition, and some rock armouring, there is little exposure of bedrock at all at Loughbeg. Virtually none exists at the end of the laneway which was described in the literature as the best exposed rock, and along the eastern side of the small bay at Lougbeg, though there is bedrock of the Waulsortian limestones and Loughbeg Formations visible relatively close to each other, there is little noteworthy or unusual about the site, and owing to this it is rejected as a County Geological Site.

The remaining bedrock outcrop at the end of the laneway at Loughbeg.

Meenskeha

Studies carried out at Meenskeha East and Meenskeha West townlands in the mid-1980s revealed pingo remnants exhibiting an overlapping and cluster form typical of open system pingo development. A 2 m sediment core from the central depression of one pingo remnant yielded radiocarbon dates ranging from 9740 to 8290 years before present (BP). The sediment core yielded a detailed pollen record from the first 1500-2000 years of post-glacial times in this region of SW Ireland, and a valuable insight into plant colonisation at this time. Pingos are ice-cored mounds that form under periglacial conditions due to water intrusion and subsequent freezing. The pingos at Meenskeha measure within a range of 50 m – 100 m in diameter. The area was planted with coniferous forestry in the 1990s. Ordnance Survey Ireland aerial photography from the 2000 survey shows some pingo features. The entire area mapped and studied in the 1980s is now under mature forestry. Whilst the site is important as a location for Quaternary research, it is not a suitable County Geological Site owing to the obscuration of features by forest cover.

View south towards N72 junction. Pingo remnants under forest cover on left (east).

View east towards forest cover and site of pingo remnants.

Mizen Head Mine

The Mizen Head mine was included in the HMS-IRC (Historic Mine Sites - Inventory and Risk Classification) study of Irish mines (Stanley et al. 2010) and, as such, surveyed for this audit. In reality, it was at best a speculative venture designed to raise money from investors in the early 19th century, rather than a fully-fledged mine. It was operated from 1853 to 1854 and only seven tons of poor-quality copper ore were raised. Nevertheless, a small ore processing area remains

visible and contains minor amounts of mine waste in which several hundred mg/kg or more of copper has been recorded. The minimal remaining mine features on the site do not justify designating this site as a County Geological Site.

General view towards north of extant surface remains of processing area of mine site at Mizen Head.

Close-up of crushed rock waste on processing floor.

Nohaval Cove - Turrets

Nohaval Cove - Turrets was listed in the IGH Master Site List for County Cork under the IGH8 Lower Carboniferous Theme, but the locality had no information save the text 'base of Kinsale Formation' on the Master List notes. Nohaval Cove is a secluded site, located at the end of a long, narrow laneway. Parking is difficult. The rocks themselves are visible only within a very narrow area, as the cove is exceptionally narrow and has high cliffs on either side of it. There are coastal features (caves, stacks and arches) and the relicts of an old slate quarry, but access to the adjacent cliff tops is impossible as the lands are private, and walkers are not welcome. Given the fact that access to the site is particularly difficult and that it is, in any case, difficult to see the rock faces, and that the Old Head of Kinsale site has excellent exposure into the base of the Kinsale Formation, the site at Nohaval Cove was rejected as a County Geological Site.

The rocks of the base of the Kinsale Formation at Nohaval Cove.

River Blackwater

The River Blackwater is listed in the IGH Master Site List under the IGH14 Fluvial/Lacustrine Geomorphology theme on the record of 'straths' being present in the Rathmore to Millstreet section on the upper river valley. The river is a significant fluvial feature considering its length of around 170 km, and a total catchment area of 3,324 km^2. However, the features for which river was listed are not deemed to be requiring County Geological Site designation.

View east downstream from N72 Duncannon Bridge, Rathmore.

View west upstream from R583 Keale Bridge, Rathmore.

River Sullane

The River Sullane (An Sulán) is listed in the IGH Master Site List under the IGH14 Fluvial and Lacustrine Geomorphology theme. The River Sullane drains from the mountains on the Cork-Kerry border near Cúil Aodha, and flows west towards Macroom, converging with the River Lee southeast of Macroom. The river is an important waterway in this part of County Cork, and a prominent natural feature of the landscape, however it is not considered a necessary County Geological Site.

River Sullane viewed looking upstream from Macroom Bridge.

River Sullane viewed looking downstream from R618 bridge, east of Macroom.

Rock Forest

Rock Forest was the location of a quarry in Carboniferous limestone where an extremely rare form of quartz was discovered in 1875 or 1876. The quartz was found in a vein of calcite-quartz-ferruginous mud within the limestone by a Miss Cotter, niece of the local landowner, and was subsequently named "cotterite". Cotterite has an unusual pearly metallic lustre rather than the vitreous lustre typical of quartz. Specimens of cotterite were distributed to institutions in Ireland and Britain and 34 Rock Forest specimens remain today. Possibly the largest specimen is held by the School of Biological, Earth and Environmental Sciences in UCC. The location of the source

quarry is unknown and by 1878 cotterite was apparently no longer to be found. The absence of a demonstrable location for the source of cotterite combined with the apparent exhaustion of its supply within a few years of its discovery mean that Rock Forest it is not suitable for listing as a County Geological Site.

Cotterite specimen on display at Geology Department, UCC.

Sandycove to East Toe Head

Sandycove to East Toe Head was listed in the IGH Master List for Cork as another potential site, under the IGH10 Devonian Theme, but the listing did not include any information as context for the site other than that it is located in 'Castlehaven, Glasheenaulin, Ballycahane, Scobaun, Farranconnor, Gortacrossig' townlands. As above, the site 'Toe Head' was also listed, and that site had a detailed grid reference (in Gortacrossig Townland) and also had data giving the reason for its listing, as well as an entry under two themes; IGH2 Precambrian - Devonian Palaeontology, and IGH10 Devonian. That latter 'Toe Head' site was surveyed in the field and has been listed as a County Geological Site, and upon this basis the 'Sandycove to East Toe Head' site is rejected, as it is considered that both listings for Toe Head and Sandycove to East Toe Head cover one and the same site. A separate County Geological Site, 'Castlehaven', also includes portions of bedrock outcrops in Castlehaven and Glasheenaulin Townlands, thus the potential "Sandycove to East Toe Head" site actually has elements of its outcropping bedrock displayed and listed as part of two listed County Geological Sites.

The East Toe Head locality at Gortacrossig, listed in three potential sites from the Cork IGH Master List (East Toe Head, Sandycove to East Toe Head, and Toe Head), and merged as one 'Toe Head' County Geological Site.

Subulter and Subulter Quarry
The IGH Master Site List records both Subulter (IGH8 Lower Carboniferous) and Subulter Quarry (IGH12 Mesozoic and Cenozoic). These records both refer to the same site and have been combined into the Subulter Quarry County Geological Site.

Tullacondra
Tullacondra is the site of a small limestone quarry mapped by GSI in the 19th century when "traces of copper" were noted. Exploration in the 1970s led to the discovery of a near-surface, vertical zone of sub-economic copper mineralization. The mineralization is hosted in limestone, shale and other rocks near the base of the Lower Carboniferous (Mississippian) where it overlies the ORS. The quarry is partly overgrown and has gradually been infilled with loose rocks from field clearances. No outcrop of is visible within the quarry and no traces of mineralization were noted in the abundant limestone and shale material within and surrounding it. Although the site stands on a known mineral deposit, there is no surface expression of mineralization that would merit designating it as a County Geological Site.


Tullacondra Quarry, view from east.


Floor of Tullacondra Quarry, view to east side.

Youghal Road Cut
The Youghal Road Cut is on the N25, at the western side of Youghal Bridge, which spans the Blackwater River north of the town. The c. 250-long rock face along the northern side of the road originally provided a good exposure through the top of Upper Devonian Ballytrasna Formation and its contact with the overlying Gyleen Formation. However, the rock face is now largely obscured by vegetation and, given the heavy, high-speed traffic that characterizes the road, pedestrian access to the site is unsafe. There are several sites in East Cork where the Ballytrasna Formation is better exposed, including its type locality (Ballytrasna CGS). Other sites display the contact between the Ballytrasna Formation and the Gyleen Formation (e.g. Church Bay CGS, Ballyknock CGS). The Youghal Road Cut site is therefore rejected as a County Geological Site on the grounds of lack of good exposure and unsafe access.

Youghal Road Cut: view northeast along site. Road cut is on left of road, largely obscured by vegetation.

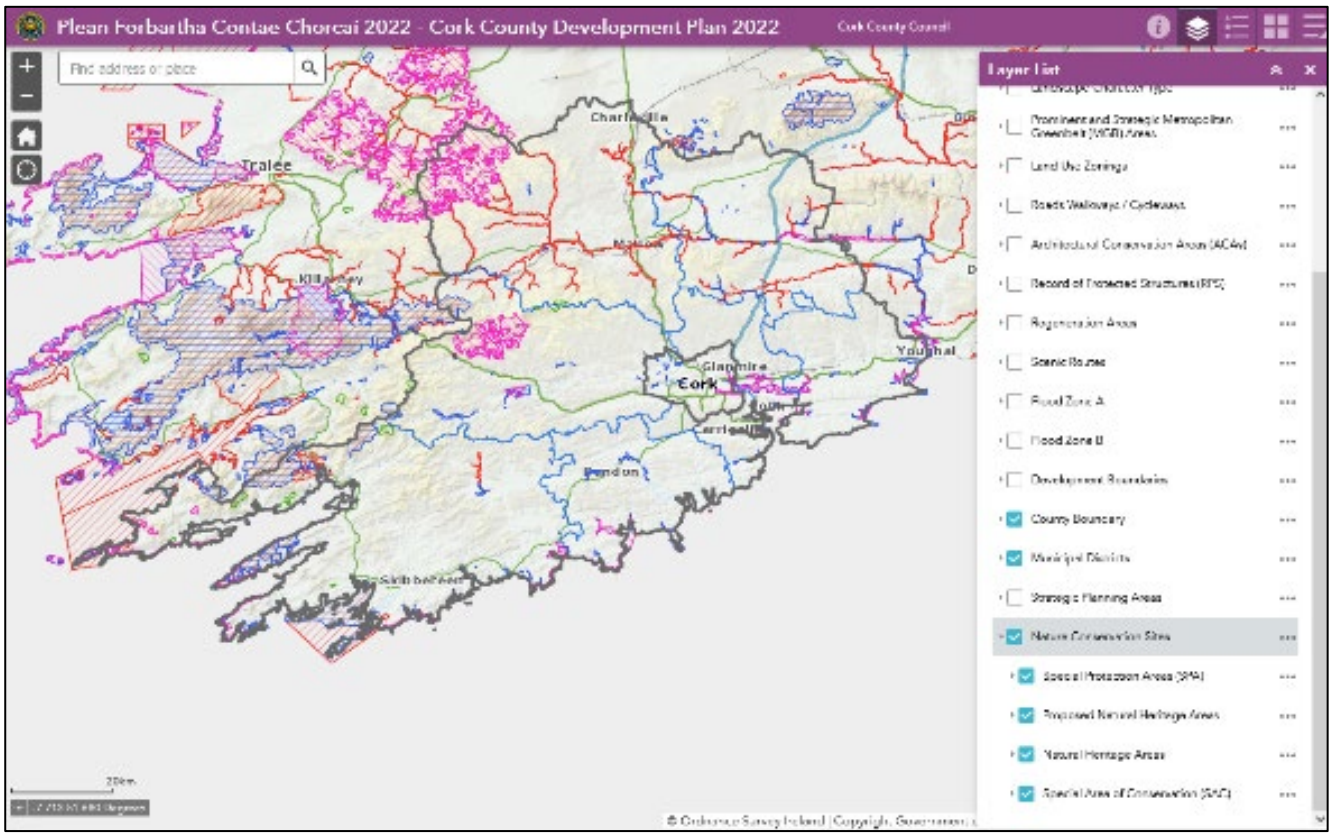
Youghal Road Cut: rock face is partly visible beneath vegetation.

2. Cork County Council Policies regarding geology and geological heritage

The completion of this county geological heritage audit will ensure County Cork's County Geological Sites are considered in the County Development Plan. Several policies and objectives in the County Development Plan 2022-2028 make reference to geological heritage and geological characteristics in the county.

In addition to listing the IGH Master List County Geological Sites for County Cork, the Cork CDP 2022 makes the reference to groundwater protection, geological characteristics and natural heritage, which includes geological heritage. Published prior to the completion of this audit report, the County Development Plan 2022–2028 makes general reference to County Geological Sites and geological conservation, and includes the original Master List of County Geological Sites (Areas of Geological Interest). The sites presented in this audit represent the updated list of County Geological Sites.

CDP 2022 Volume Two (Table 2.3.5) lists Areas of Geological Interest in County Cork. This list is derived from the IGH Programme (IGHP) Master List of sites that served as the baseline of sites for consideration for this audit. This audit presents the updated list of County Geological Sites in County Cork. The inclusion of the Cork County Geological Sites as a map layer on the Cork County Development Plan 2022 Map Browser is an expected outcome of this audit.



Screengrab of Cork County Development Plan 2022 Online Map Browser.

Objectives concerning tourism in the *Cork CDP 2022 Volume One: Main Policy Material* include:

CDP Objective - TO 10-1: Promotion of Sustainable Tourism in County Cork

Promote a sustainable approach to the development of the tourism sector within Cork County…;
a) Ensuring the protection of the natural, built and cultural heritage assets of the county, including Natura sites, which are in themselves part of what attracts visitors to the county
b) Having regard to cumulative impacts increased visitor numbers and visitor facilitates can have on local infrastructure, sensitive areas and sites, water quality, biodiversity, soils, ecosystems, habitats and species, climate change etc.

CDP Objective: TO 10-2 Wild Atlantic Way and Irelands Ancient East

Continue to encourage and promote the development of the Wild Atlantic Way and Irelands Ancient East regional brands through sustainable tourism, which will enable visitors to have enjoyable experiences while having regard for the cultural heritage and environmental impacts, including the protection of Natura 2000 sites.

Groundwater

A Groundwater Protection Scheme has been completed for County Cork by GSI, which gives land surface zoning objectives in terms of groundwater protection for every portion of County Cork. This scheme allows an assessment of the vulnerability of groundwater to pollution for any proposed development, and all proposed schemes must adhere to associated Groundwater Protection Responses. This audit compliments the Groundwater Protection Scheme, having considered karst sites within the county, and defined boundaries to these sites, offering an extra element of protection as these sites in the CDP.

Cork CDP 2022 Volume 1: Main Policy Material, Chapter 11 - Water Management

Groundwater Protection:
11.3.21 A groundwater protection scheme, prepared by the Geological Survey of Ireland (GSI), incorporates land surface zoning and groundwater protection responses. The Council recognises the importance of preparing groundwater protection schemes to ensure that key aquifers and groundwater resources in the County are identified and protected.

11.3.22 The Geological Survey of Ireland (GSI) has compiled a Groundwater Protection Scheme for Cork County Council that examines the soil, subsoil, and rocks in the County to determine what the vulnerability of each part of the County is and provides a vulnerability rating. The Plan includes:

- *Assessment and categorisation of the vulnerability of Groundwater.*
- *Mapping lands in accordance with their vulnerability categorisation.*
- *Development of Protection Response Matrices. The most common one in the planning context is the Groundwater Response Matrix for one off housing wastewater treatment.*

11.3.23 In association with the Groundwater Vulnerability mapping, the GSI, EPA, and Department of the Housing, Local Government and Heritage have developed a guide on the

restrictions that apply to each vulnerability type to protect the groundwater in general. This guide, where restrictions for various land uses are given, can be accessed here.

11.3.24 The catchment area around a groundwater source, which contributes water (Zone of Contribution) to a borehole or spring, is known as a Source Protection Zone. The GSI have prepared Groundwater Source Protection reports for a number of public supplies in Cork and these are available on the GSI website.

CDP Objective: WM 11- Groundwater Protection

a) Preserve and protect groundwater and surface water quality throughout the County.
b) Prevent or limit, as appropriate, the input of pollutants into groundwater and prevent the deterioration of the status of all bodies of groundwater.
c) Protect, enhance and restore all bodies of groundwater and ensure a balance between abstraction and recharge of groundwater with the aim of achieving good groundwater quantitative status and good groundwater chemical status.
d) Reverse any significant and sustained upward trend in the concentration of any pollutant
resulting from the impact of human activity in order to progressively reduce pollution of groundwater.
e) Achieve compliance with any standards and objectives established for a groundwater dependant protected area included in the register of protected areas.

CDP Objective: WM 11-4 - Groundwater Protection Schemes and Zones

In order to protect groundwater quality, new developments must have regard to any Groundwater Protection Scheme and/or Groundwater Protection Zones in place and existing developments and abstractions

CDP 2022 Volume 1 Chapter 14: Green Infrastructure and Recreation relates the council's commitment to supporting rural recreation initiatives in the region that would help to promote access to and information about geological heritage. Policy objectives include:

CDP Objective: GI 14-7 - Countryside Recreation
Support the diversification of the rural economy through the development of the recreational potential of the countryside in accordance with the National Countryside Recreation Strategy.

CDP Objective: GI 14-8 – Rights of Way
To examine the feasibility of identifying and mapping Public Rights of Way across the county in the context of emerging national guidance over the lifetime of the plan.

CDP Objective: GI 14-9: Landscape
a) Protect the visual and scenic amenities of County Cork's built and natural environment.
b) Landscape issues will be an important factor in all land-use proposals, ensuring that a pro-active view of development is undertaken while protecting the environment and heritage generally in line with the principle of sustainability.
d) Protect skylines and ridgelines from development.

CDP Objective: GI 14-12: General Views and Prospects

Preserve the character of all important views and prospects, particularly sea views, river or lake views, views of unspoilt mountains, upland or coastal landscapes, views of historical or cultural significance (including buildings and townscapes) and views of natural beauty as recognized in the Draft Landscape Strategy.

CDP Objective: GI 14-13: Scenic Routes

Protect the character of those views and prospects obtainable from scenic routes and in particular stretches of scenic routes that have very special views and prospects identified in this Plan. The scenic routes identified in this Plan are shown on the scenic amenity maps in the CDP Map Browser and are listed in Volume 2 Heritage and Amenity Chapter 5 Scenic Routes of this Plan.

CDP Objective GI 14-14: Development on Scenic Routes

Require those seeking to carry out development in the environs of a scenic route and/or an area with important views and prospects, to demonstrate that there will be no adverse obstruction or degradation of the views towards and from vulnerable landscape features. In such areas, the appropriateness of the design, site layout, and landscaping of the proposed development must be demonstrated along with mitigation measures to prevent significant alterations to the appearance or character of the area.

Volume 1 CDP 2022 Chapter 15 Biodiversity and Environment includes the policy objective recognising the heritage value of the county's geological characteristics.

15.1.1 "The biodiversity of Cork includes our native plant and animal species, and the places (habitats and ecosystems) where they live. Our landscape has been shaped by our geographical position on the southern coast of the country, our geology dominated by sandstone ridges and limestone valley floors, and the influence of the people who have settled here. These elements determine the range of native plants, animals, habitats and ecosystems that make up the unique biodiversity of the county."

CDP Objective: BE 15-2 Protect sites, habitats and species

a) Protect all natural heritage sites which are designated or proposed for designation under European legislation, National legislation and International Agreements. Maintain and where possible enhance appropriate ecological linkages between these. This includes Special Areas of Conservation, Special Protection Areas, Marine Protected Areas, Natural Heritage Areas, proposed Natural Heritage Areas, Statutory Nature Reserves, Refuges for Fauna and Ramsar Sites. These sites are listed in Volume 2, Appendix A of the Plan.

d) Recognise the value of protecting geological features of local and national interest.

Volume 2 Cork CDP 2022 Chapter 3 - Heritage and Amenity refers to Nature Conservation Sites:

> *3.1.1 The overall planning policies for nature conservation sites in County Cork are set out in Volume One, Chapter 15 Biodiversity and Environment. The lists of designated sites in County Cork are set out below in the following order; Special Areas of Conservation (SACs), Special Protection Areas (SPAs), Natural Heritage Areas (NHAs), proposed Natural Heritage Areas (pNHAs), and Geological Sites.*

Volume 1 Cork CDP Chapter 13 - Energy and Telecommunications includes*:*

> *Development Proposals*
> *13.7.1 All planning applications for wind energy development should include a comprehensive assessment of the potential impacts of the proposed development on the receiving environment and landscape. The Planning Authority will require the following criteria to be covered by prospective applicants;*
>
> - *Geology and ground conditions, including peat stability; and management plans to deal with any potential material impact. Reference should be made to the National Landslide Susceptibility Map to confirm ground conditions are suitable stable for project.*
> - *Potential impact of the project on natural heritage, to include direct and indirect effects on protected sites or species, on habitats of ecological sensitivity and biodiversity value and, where necessary, management plans to deal with the satisfactory co-existence of the wind energy development and the particular species/habitat identified.*
>
> *Hydro Power*
> *13.9.5 Larger scale schemes, whilst delivering significant benefits, may have environmental impacts which may include;*
> - *Impact on water quality, water courses / bodies and water dependent habitats and species.*
> - *Landscape or visual impact;*
> - *Geological/groundwater impacts*

The reference to natural heritage in Section 13.7.1 takes into consideration the biotic aspects of natural heritage (ecological sensitivity, biodiversity, species, habitats), but does not refer to elements of abiotic natural heritage, of which geological heritage is a key element. The omission geological heritage as a key element of natural heritage is regretfully commonplace, and this is one of the objectives of geological heritage audits: to raise the profile of geological heritage and the importance of geology, sediment deposits, soil, groundwater, coastal geomorphology and physical landscapes.

County Cork Biodiversity Action Plan 2009-2014 includes the following:

> *"Much of the County Cork countryside has been shaped by agriculture and a range of agricultural land uses together with varying geological influences has created a diversity of agricultural landscapes." P.9*

"(Biodiversity) also includes the backdrop of the living world in terms of geology and landscape and importantly describes the variation between individual creatures at the unseen, genetic level. In short, biodiversity is an attempt to represent in a single word the natural world in all its kaleidoscopic richness." P.9

"Cork's coastline is very varied largely as a result of geological processes. This variation contributes to an outstanding assemblage of coastal habitats which make up one of the most important elements of the county's wildlife resource." P.17

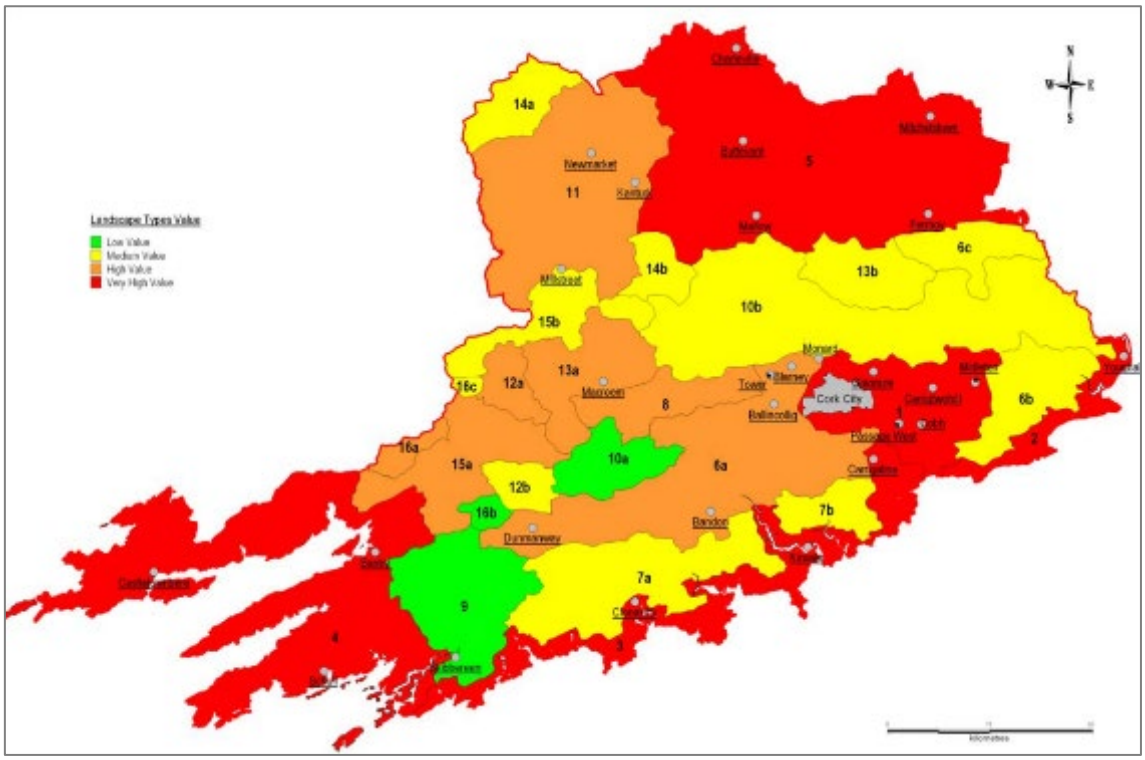
3. Geological conservation issues and site management

Geodiversity is often overlooked as the foundation for much of the biodiversity that has been identified for conservation through SAC or NHA designation. In fact, many of the most important geological sites are located in the same locations as SAC and pNHA sites. Within these designated areas, the geological heritage directly influences and enhances the biotic and abiotic value of these sites for nature conservation. The inclusion of features of geological heritage interest requires no additional designation of designated sites, other than citation of the geological interest with the associated documentation.

Broadly speaking there are two types of sites identified by the Geoheritage Programme (IGH Programme). The first, and most common, includes small and discrete sites. These may be old quarries, natural exposures on hilly ground, coastal cliff sections, or other natural cuttings into the subsurface, such as stream sections. They typically have a feature or features of specific interest such as fossils or minerals or they are a representative section of a particular stratigraphical sequence of rocks. The second type of site is a larger area of geomorphological interest i.e. a landscape that incorporates features that illustrates the processes that formed it. The Quaternary theme and the Karst theme often include such sites. In County Cork, these include Courtmachsherry Bay-Old Head of Kinsale raised shoreline, Bantry Bay Drumlins and Castlepook Cave.

It is also important from a geological conservation perspective that planners understand the landscape importance of geomorphological features that may not in themselves warrant any formal site designation, but which are an integral part of the character of County Cork. A lack of awareness in the past, has led to the loss of important geological sites and local character throughout the country. In County Cork, a Landscape Characterisation Assessment was completed for the Cork County Draft Landscape Strategy 2007. This provides a tool for planners to help maintain the character of the County. However, it is a methodology that could be considered to place inadequate value on the underlying geodiversity in defining landscape character areas. The Strategic Environmental Assessment within the County Development Plan also provides tools. In addition, the now routine pattern of consultations with Geological Survey Ireland, either by the planning department or by consultants carrying out Environmental Impact Assessment, plus strategic environmental assessment (SEA), has greatly improved the situation.

There are large differences in the management requirements for geological sites in comparison to biological sites. Geological features are typically quite robust and generally few restrictions are required to protect the scientific interest. In some cases, paradoxically, the geological interest may be served better by a development exposing more bedrock. **It is important that the relevant planning department is aware of the county geological sites and, more generally, that consultation can take place if some development is proposed for a site**. In this way, geologists may have an opportunity to learn more about a site or area by recording data and sample collection at temporary exposures, or to influence planning design so that access to exposures of rock is maintained for the future, or in extreme cases to advise on developments through presentation of a strong geoscientific case.



Landscape Character Type Values (County Cork Draft Landscape Assessment 2007).

In many counties, working quarries are listed as County Geological Sites because they are the best representative sections available of specific rock sequences in areas where exposure is otherwise limited. No restriction is sought on the legitimate operation of these quarries. However, maintenance of exposure after quarry closure is generally sought in agreement with the operator and planning authority in such a case. At present, working quarries such as Ballygiblin Quarry or Ballybeg Quarry are now included as County Geological Sites in County Cork. These issues are explored in a set of Geological Heritage Guidelines for the Extractive Industry, published jointly by the Geological Survey Ireland and the Irish Concrete Federation in 2008.

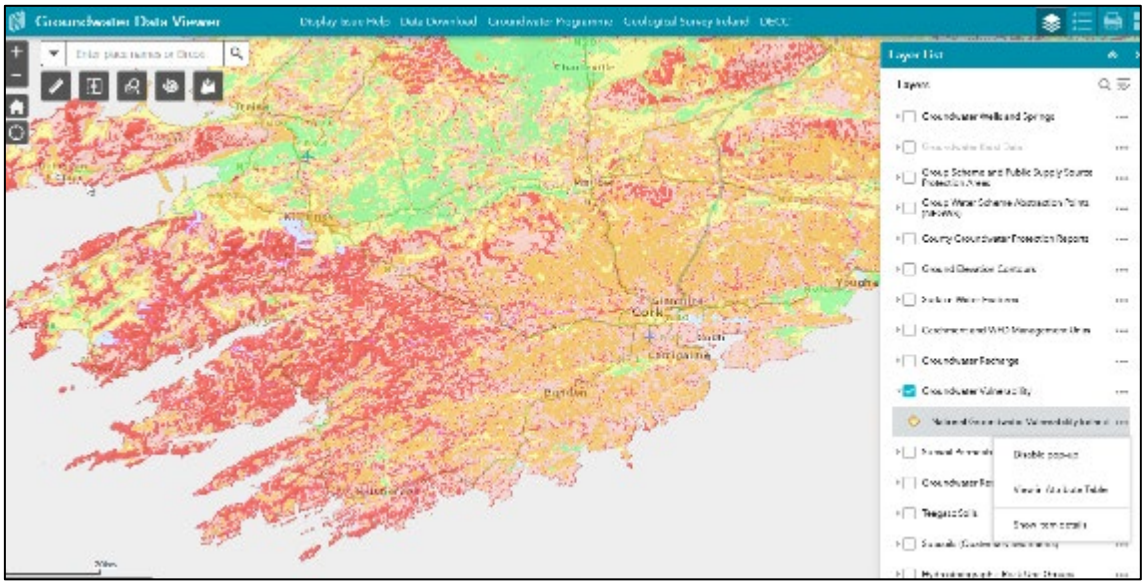
New opened quarry works may reveal a window into the fresh bedrock and expose significant or interesting geological features such as fossils assemblages, mineral occurrences, karstic features such as depressions or caves, or structural features such as fold limbs or faults. Similarly, a quarry that has finished working, and is no longer active may become more relevant as a geological heritage site, by preserving a window into the geological subsurface. A disused quarry may require occasional maintenance to prevent overgrowth of vegetation that could otherwise obscuring features of the scientific interest. Furthermore, a disused quarry may be suitable as a public amenity site and promoted to the public by means of a safe path access and information panels, such as at Quarry Park, Newtowncashel, Co. Longford.

Nationally, specific county geological sites may require restrictions and a typical case might be at an important fossil locality or a rare mineral locality, where a permit system may be required for genuine research, but the opportunity for general collecting may need to be controlled.

Waste dumping

An occasional problem throughout the country, County Cork included, is fly-tipping and the dumping of rubbish in the countryside. The dumping of waste is not only unsightly and messy, but when waste materials are dumped in areas where rock is exposed, such as in quarries, disused gravel pits, or bare karst limestone, waste can leach into the groundwater table as the materials

degrade. This can cause groundwater pollution and can affect nearby drinking water supplies in wells or springs. Groundwater Protection Schemes (DELG, 1999) help to combat pollution risks to groundwater by zoning the entire land surface within counties into different levels of groundwater vulnerability. The National Groundwater Vulnerability data ranks the county land surface into vulnerability categories of 'Extreme', 'High', 'Moderate' and 'Low', helping planners to assess where groundwater needs to be considered in relation to proposed developments.



GSI Groundwater Data Viewer – Groundwater Vulnerability

New exposures in development

Local Authorities through Ireland can play a key role in the promotion and protection of geology where the development or modification of new roads is concerned. **Wherever major new carriageways are to be built,** or in other major infrastructural work, it should be a policy within the Planning Department, that **where new rock exposures are created, they be left open and exposed** unless geotechnical safety issues arise (such as where bedding dips are prone to rock failure). The grading and grassing over of slopes in cuttings is largely a civil engineering convenience and an established mindset that may be challenging to overcome. However, this approach leads to sterile and uninteresting roads that do not promote the natural geological character of place. Rock outcrops that rare preserved and left exposed along roadsides can enhance the character and visual interest along routes. One such example is at the Macroom bypass, where Upper Devonian sandstones have been exposed. Sympathetic tree or shrub planting can be carried out, leaving bare rocks exposed especially where the outcrops show interesting features. This not only assists the geological profession but creates new local landmarks to replace those removed in the construction of a roadway. This can also potentially save money on the construction costs. It may also contribute to road safety by providing diversity of surroundings to maintain drivers' attention. In planning for other roads in the county likely to be significantly upgraded, the option should be borne in mind for all future road improvements.

UNESCO Geoparks

The rapid growth and adoption of the UNSECO Global Geoparks concept over the past two decades represents an extremely interesting development in geological heritage and geological conservation. An UNESCO Geopark is a territory with a well-defined management structure in place, such as with the support of a local authority (e.g. County Council), where the geological heritage is of outstanding significance and is used to develop sustainable tourism opportunities.

The initiative largely grew from the European Geoparks Network (EGN), expanding worldwide as the Global Geoparks Network (GGN) from 2004. The Geoparks programme is fully assisted by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) [see www.globalgeopark.org and www.europeangeoparks.org]. A fundamental theoretical basis of the Geopark is that it is driven from the bottom up – the communities in the Geopark are the drivers of the project and are the main beneficiaries. UNESCO Geopark branding helps promote the geological heritage resource so that the community can benefit from it. However, significant management support from local authorities has proven to be essential across the network.

In Ireland, there are three members of the UNESCO Geoparks Network. The Cuilcagh Lakelands Global Geopark (previously Marble Arch Caves Global Geopark) in County Fermanagh and County Cavan is a cross-border geopark [see https://cuilcaghlakelands.org/]. The Copper Coast Geopark in County Waterford [www.coppercoastgeopark.com] joined the Network in 2001, and the Burren and Cliffs of Moher in County Clare [www.burrengeopark.ie] in 2011. Joyce Country and Western Lakes Geopark, located in counties Mayo and Galway [https://joycecountrygeoparkproject.ie/] is currently an aspiring UNESCO Global Geopark. In addition, there is one UNESCO global geopark in Northern Ireland [Mourne Gullion Strangford; see https://mournegullionstrangfordgeopark.com/].

This audit can assist with the required geological appraisal and knowledge required for the consideration of potential future applications for establishing a UNESCO Geopark in the southwest of Ireland.

3.1 Copper mining in West Cork

West Cork is notable for its mining heritage, in particular for a large number of abandoned copper mines. The oldest of these mines date back to the Bronze Age and are among the earliest examples of copper mining in northwest Europe. Yet, apart from the well-known copper mines at Allihies at the western end of the Beara Peninsula, West Cork's mining heritage remains largely unremarked outside of specialist circles. As a consequence much of the physical, surface evidence of mining, including stone-built engine houses, miners' villages, chimneys, magazines, processing floors and spoil heaps, have gradually disappeared, whether intentionally dismantled, destroyed by natural weather events, or lost beneath encroaching vegetation.

Copper mineralization in West Cork occurs essentially in one of two forms, either stratabound disseminations of copper sulphides, with associated mineralized quartz veinlets, or in thick polymetallic quartz veins (lodes) that, in addition to copper, contain minerals of molybdenum, lead, bismuth, arsenic, barite, and others. The disseminated mineralization, known from over 100 locations in the region, occurs toward the top of the Devonian succession, in the upper part of the Castlehaven Formation and the lower part of the overlying Toe Head Formation. The mineralization has been interpreted as forming by remobilization of metals from enclosing red bed strata into the reduced green-grey sandstone that typically hosts it. The disseminated mineralization was exploited during the Bronze Age at Mount Gabrel and Derrycarhoon but its low grade, typically less than 1 % copper, mean it was not subsequently exploited in a major way.

The most productive copper mines in West Cork were those that worked the thick quartz veins, in which grades of copper could exceed 10 % in particularly rich zones. Those in the southern part (Mizen peninsula) are generally hosted by the Upper Devonian Toe Head and Old Head Sandstone Formations, whereas those to the west, at Allihies, occur at a lower stratigraphic level (Caha Mountain Formation). Most veins are hosted by faults that typically strike E-W, parallel to the

bedding. These faults have been interpreted as basin-controlling extensional faults, with development of mineralization coinciding with development of the Munster Basin. Previous work has suggested the vein mineralization formed during the Variscan Orogeny at the end of the Carboniferous Period but recent research has dated the Allihies mineralization at c. 366 Ma, indicating that it formed not long after deposition of the host rocks.

Bronze age mine on Mount Gabriel.

The earliest identified copper mines in West Cork date from the Bronze Age. At Mount Gabriel, considered to be one of the best-preserved Bronze Age mining landscapes in Europe, copper was extracted from secondary copper mineralization (malachite) in the stratabound ores by fire setting between 1800 and 1400 BC. At Derrycarhoon, from between 1400 and 1000 BC, copper was extracted from the same mineralization using stone tools. Subsequent records of mining date from the beginning of the 19th century. Between 1810 and 1850 exploration and mining was at its peak, both in Allihies and the Mizen area. The bulk of the ore produced came from Allihies, and specifically the Mountain Mine, but small mines such as Cappagh and Glandore, were locally significant operations, at least for short periods. The period from 1850 to 1855 was notable for the number of speculative ventures, so-called “bubble companies”, that raised cash from investors but rarely produced any significant amounts of ore. Ballycummisk was a notable success between 1855 and 1865, becoming the most successful copper producer in West Cork outside of Allihies, but the period until around 1880 was mostly notable for the gradual decline in the price of ore and, with it, production. By 1880, mining had largely ceased in West Cork. Exploration in the 20th-century, notably at Allihies between 1956 and 1962, was short-lived and unsuccessful. Although there has been renewed exploration interest in West Cork copper mineralization in recent years, there is as of yet no sign that this is likely to lead to a resumption of mining in the region.

The best examples of physical mining heritage in West Cork are preserved at Allihies, where a mine museum and trail provide a level of access to the mine sites that is not typical of other sites in the region. Good examples of mine heritage at Allihies include the Man Engine House, Coom Engine house, Puxley’s Engine house and Kealoge processing floor. Elsewhere, other significant mining remains include the magazine (powder house) buildings at Crookhaven and Dhurode mines, the engine house at Glandore Mine, the Brow Head mine site and the Bronze Age mine site

at Mount Gabriel. Yet while they survive, many of these examples are in poor condition and their long-term survival must be in doubt without significant conservation efforts.

Allihies Copper Mine Museum.

While these sites display relatively well-preserved examples of mine heritage, there are numerous sites where such heritage is in danger of disappearing or has already been lost. Cappagh Mine is a good example of a formerly extensive mine site where little in the way of obvious mine heritage is visible today. The former engine house chimney collapsed in 2002 following a storm and what remains of the site is largely overgrown. At Ballycummisk, probably the most successful copper mine in West Cork outside of Allihies, most of the site has disappeared beneath gorse and other vegetation, with only a large waste heap and minor building remains still visible.

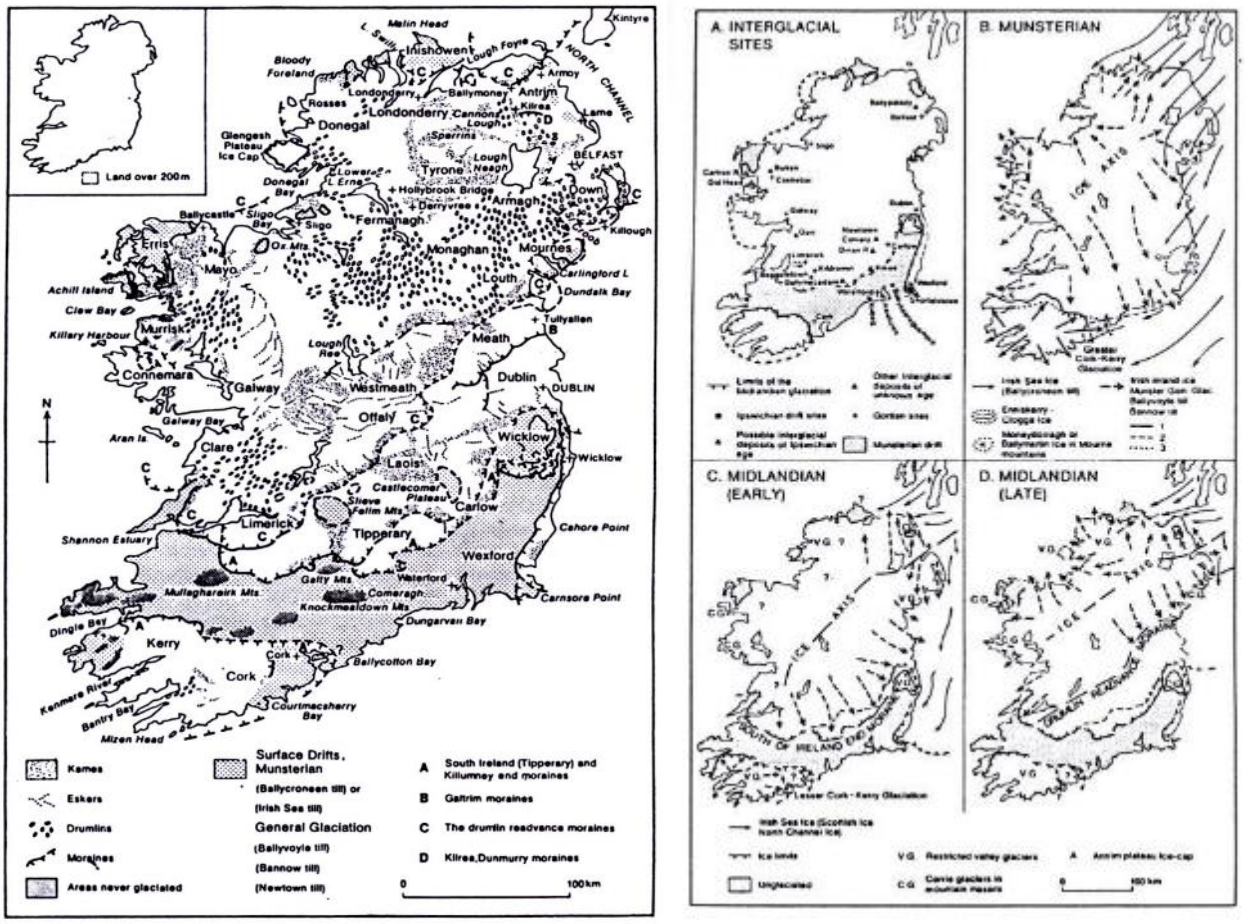
To date, among all the examples of mining heritage in West Cork, only the Man Engine House in Allihies has undergone conservation in modern times. The impact of this, and the renewed focus on the mining heritage in the village through the development of the Mining Museum, has seen Allihies develop into a significant tourist destination. While other mine sites in West Cork may lack Allihies' advantage in terms of scale and accessibility, they contain numerous excellent examples of mine heritage that could benefit from a focus on conservation that, in turn, could yield significant benefits for local communities.

Man Engine House at Mountain Mine, Alllihies.

3.2. The Southern Irish End Moraine

Much confusion has existed in the past in Irish glacial literature about the exact positioning of glacial features. Whilst the interpretation of drumlins, eskers and glacial deposits is bound to vary over time and between different researchers, there has been remarkably little agreement on the nature and distribution of the actual landforms and deposits. This is problematic, as a 'glacial map' should form the basis of any reconstruction. Surely the exact position of the features should never be in doubt, as the process only involves their placement on a map!

However, systematic and consistent mapping at the ice sheet scale has only recently been achieved in Ireland. It is thus no surprise that the historical reconstructed behaviours differ greatly. Previous studies were conducted at different scales, with different authors working in the same area including some features and disregarding others. Hence the models built by each researcher were bound to differ, and it is difficult to compare these with each other as features seen as important by one researcher are disregarded by another.



(Left) General Quaternary geomorphology map of Ireland, as modelled pre-1990s. (Right) Montage of General ice movements as interpreted during the 1960's and early 1970's. A) Interglacial sites B) Munsterian ice flows. C and D) Midlandian ice flows (all maps from Davies and Stephens, 1978). Note the 'Southern Irish End Moraine' stretching across the country from Limerick to Wicklow, through Tipperary, suggesting that much of County Cork was not covered by ice during the last glaciation – this has since been disproven.

Thus, before the 1990s, it had been assumed that the glacial landforms of Ireland were broadly grouped into two provenances associated with two Pleistocene cold phases, termed the Munsterian (older) and Midlandian (younger), which were separated by the 'Southern Irish End

Moraine'. Further north, the 'Drumlin Readvance Moraine' separated the area comprising fresh, 'Midlandian' landforms into those formed by drumlin-moulding ice, and those not. Detailed field mapping in the 1990s showed that no such features existed on the ground and the features have since been rejected based on sedimentological evidence and on a stratigraphic basis.

It is now widely accepted that the entire island of Ireland was smothered by an ice sheet during the last glacial cycle, with ice limits extending well offshore to the south and west.

3.3. Lowland Karst Areas of North Cork

Approximately 40% of the island of Ireland is underlain by Carboniferous limestone. Consequently, karst is a significant aspect of Irish geology. The karst of upland areas, such as the plateaux of the northwest in Sligo and Leitrim, and areas such as the Burren have long been the subject of research. However, little work has been done on the lowland karst, which forms a much more complex system as it interfingers with, influences and is in turn influenced by glacial and postglacial sediments of varying thicknesses. This system of buried karst underlies most of the lowland of north County Cork.

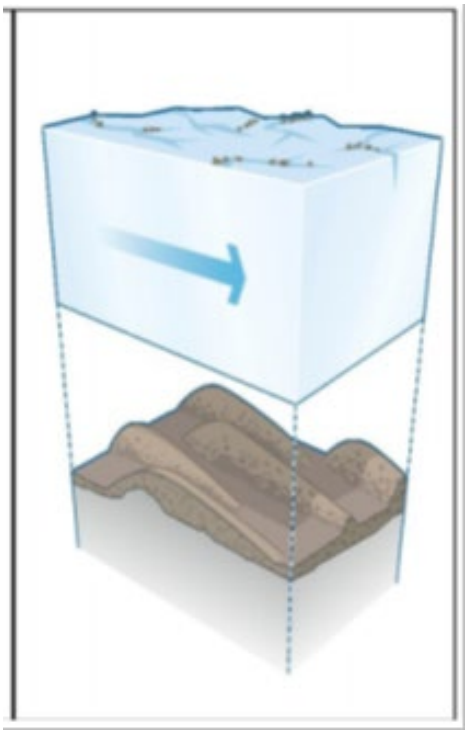
Karstification involves the enlargement of rock fissures when groundwater dissolves the fissure walls as it flows through them. As a consequence, water disappears down vertical passages, rather than moving laterally as a surface stream. Fissures become master fissures and *swallow holes*, or sink-holes, are created. A swallow hole is basically an opening in the bed of a river that flows over limestone. At this opening the river takes its course underground and winds it way under the ground surface. Some swallow holes develop into small-to-medium-sized closed depressions, or *dolines*; water moving laterally beneath the surface as underground rivers forms *caves* from fissures. Other karst features that develop include *dry valleys*, the beds of streams that once flowed at the surface and then disappeared underground; *springs*, where water reappears at the surface from underground fissures; and *estavelles*, which act as swallow holes during dry periods of the year and springs during wet. Low-lying spots close to springs and swallow holes may flood in winter, as *turloughs*. Karst features can even be recognized on what may seem the most bland rock outcrops, with many limestone surfaces pitted with hollows or runnels, collectively termed *karren*.

From reading this it can correctly be assumed that the lowlands of north Cork existed in the Tertiary Period as merely an extensive karst basin, with sporadic hums (hills). The ice sheets of the Pleistocene would then have planated and smoothed the basin, causing the almost bowl-shaped lowland in existence today. The total area of the region is approximately 500 km^2, bounded by the Boggeragh and Mullaghereirk Mountains at the West, the Knockmealdown Mountains at the east, and the Ballyhoura Mountains at the north. All of the area is underlain by pure, well bedded, karstified limestone, much of this is at or just below the surface. The majority of the area lies below 100 m AOD.

3.4. Subglacial bedforms in County Cork

The ice sheets that covered County Cork during the last Ice Age have had a profound influence on its present landscape. Most of the low ground in the county is underlain by deep deposits of glacial till, or 'boulder clay', obscuring the bedrock geology beneath. Over much of the county this till was moulded by the moving ice sheet into drumlins. The name "drumlin", used internationally, comes from the Irish 'dromnín' meaning 'low hill'. Drumlins are mounds of debris left behind by

melting ice sheets and are typically streamlined in the direction of icesheet flow. The following illustrations show the formation of drumlins under a moving ice sheet. The ice sheet of the last glaciation flowed generally north to south or northeast to southwest across Cork, a fact illustrated by the orientations of the drumlins, which are all generally aligned north-south or northeast to southwest.



The drumlins around Bantry Bay.

4. Summary and Recommendations

4.1 Proposals and ideas for promotion of geological heritage in County Cork

This section presents specific references to geological heritage in Cork County Development Plan (CDP) 2022 and provides specific suggestions as to how these may be implemented, supported or enhanced by the audit of geological heritage sites in the county.

Cork CDP 2022 Volume 1: Main Policy Material, Chapter 15 - Biodiversity and Environment

Protecting Sites, Habitats and Species – Legislative Context:

15.3.5 Natural Heritage Areas (NHAs) and proposed Natural Heritage Areas (pNHAs) are sites that are designated or proposed for designation under the Wildlife (Amendment) Act 2000. These are sites that are of national importance, and they generally support a range of habitats, plant and animal species and, in some cases, geological features.

15.3.11 As part of the Irish Geological Heritage Programme, there is currently a process underway of auditing the Geological Sites of County Cork. In anticipation of the completion of this work in the lifetime of the Plan, the Planning Authority will seek to protect and maintain the conservation value of such sites from inappropriate development.

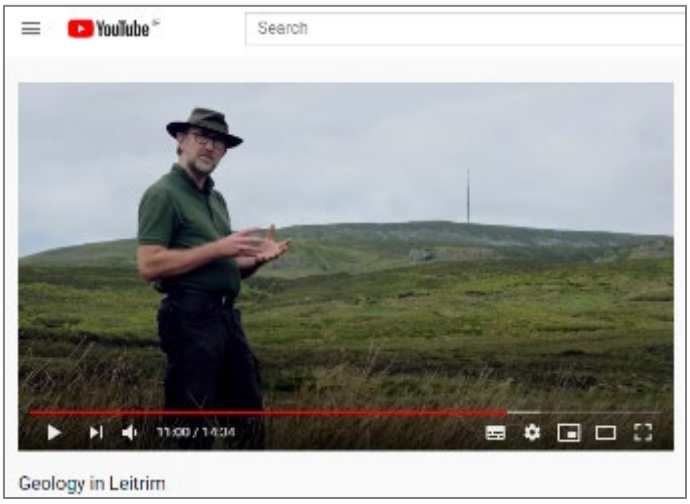
County Development Plan Objective BE 15-2: Protect sites, habitats and species

> d) Recognise the value of protecting geological heritage sites of local and national interest, as they become notified to the local authority, and protect them from inappropriate development

Whilst the later objective is fulfilled by this geological heritage audit which includes field mapping to define the site and GIS definition of site boundary, the audit can only assist in the first objective by providing information.

Geological Survey Ireland Online Mapping Viewer & HeritageMaps.ie
Each report for the County Geological Sites in County Cork (and each other county in Ireland) is available on the GSI Geoheritage Programme website (www.gsi.ie), and via the online GSI Public Mapping Viewer and HeritageMaps.ie (https://heritagemaps.ie). The spatial (GIS) layers are also available in the council's mapping system for staff within Cork County Council, and in the Cork CDP Online Map Browser.

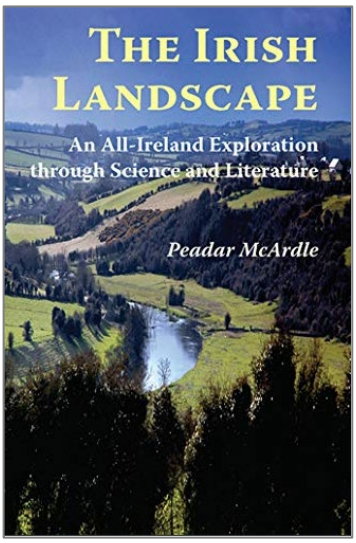
Online Video and DVD projects
In 2020, Leitrim County Council's 'Connecting Through Heritage' Project (funded by the Heritage Council) produced a series of videos to celebrate the natural, built and cultural heritage of the area by interviewing heritage experts. One of the series of videos included a 15 minute video introducing the geological heritage of Leitrim, presented by Dr. Robbie Meehan. Online and publicly accessible productions such as the *'Connecting Through Heritage'* videos are a valuable means of showcasing geological heritage to a wide audience. Such videos could easily be produced regarding aspects of the geological heritage of Cork.



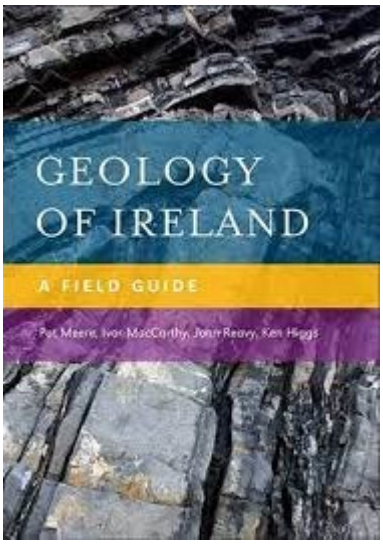
Screengrab of Geology in County Leitrim 'Connecting through Heritage' YouTube video (2020).

Leaflets

There is huge potential for public information leaflets on the geological heritage of County Cork to be published both hard-copy paper and made available as PDF downloads on the Council's website to avoid printing costs and reduce paper usage. Such a format has been adapted by the 'Visit Ballyhoura' committee, whereby the booklet guides to sites in the mountains can be downloaded from the Visit Ballyhoura website. Similarly, the Mizen Head Visitor Centre has information available on https://mizenhead.ie/guide/mizen_displays/mizen-geological-sequence-dioramas/.



The Irish Landscape: An All Island Explosation through Science and Literature (McArdle 2015)



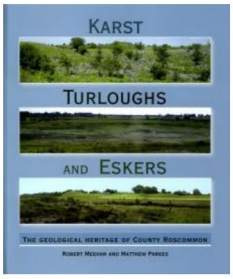
The Geology of Ireland (Meere et al. 2013)

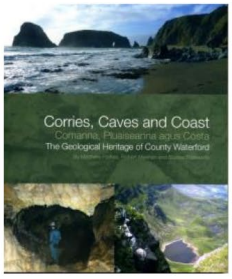
Guides

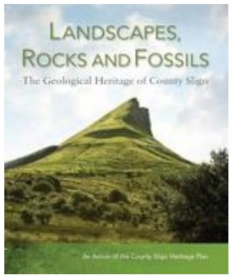
Several book publications and guides include chapters and sections on the geology of County Cork. These include *The Geology of Ireland* (Meere et al. 2013*)* and *The Irish Landscape An All-Ireland Exploration Through Science and Literature* (McArdle, 2015).

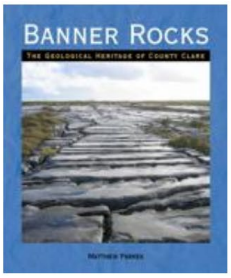
The Irish Quaternary Research Association (IQUA) has published Field Guides relating to County Cork and southwest Ireland, including *Beara Peninsula* (McCarron, S.G. and Stefanini, B.S. 2010) and *Waterford and East Cork Field Guide No. 12* (Quinn and Warren 1989*).* The 1:100,000 Scale Geological Survey Ireland map reports for Sheets 21, 22, 24 and 25 cover all of County Cork and are an essential resource.

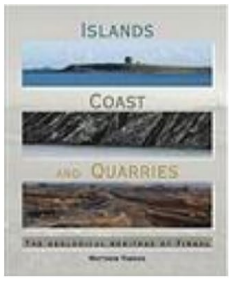
There is potential for guides to be published at varying levels of detail and accessibility for non-specialists and enthusiasts. A wide range of leaflets, booklets, books and other media are all feasible, but the research and production of appropriate text and images can prove challenging to achieve successfully, in the absence of appropriate experience, and adequate time and resources. It is suggested that with modest editing and reorganisation the main content of this report an informative general guide to the geological heritage of County Cork could be produced, in a broadly similar style to those books produced for Counties Sligo, Fingal, Mayo, Waterford, Roscommon, Clare, Longford, Wicklow and Leitrim following the completion of county geological audits in those counties. A shorter guide has also been published by Cork City Council to showcase the geological heritage in the city; this was based on the Geological Heritage Audit of Cork City published in 2022.

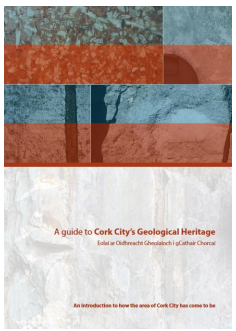












Signboards

Simple explanatory or interpretive signboards may be advisable at key geological heritage locations, but if these are considered, their locations and individual siting should be very selective, since a proliferation of different interest groups may provoke a 'rash' of panels all over the county. The Planning Section should clearly have a controlling input, in conjunction with the Heritage Office. It is most likely that a panel combining various heritage interests at one discrete place, such as those at the Gougan Barra Forest Park, is preferable to single interest panels. It is important to consult with potential partners in the planning stage so that duplication does not occur. The successful integration of text and graphics on information panels is a fine art, and the IGH Programme can offer input if signs are planned for key visitor localities. The authors of this report are also able to write, review or provide content on geological heritage for any proposed panels.

Museum exhibitions
An outcome of this audit is the collation of material that is suitable for a panel-based exhibition. Supplemented by additional research concerning for example human dependence on geology and resources, an interesting exhibition could be collated for display in the Cork County Council buildings, County Library or other similar venues. Previous examples of this approach were employed following completion of geological audits in Carlow, Dun Laoghaire-Rathdown, Waterford, Wicklow, and Longford.

New media
There are increasing examples of new methods of promoting Geology and Earth Sciences via mobile apps, online video and podcast content and other electronic media. Examples of self-guiding apps on specific sites, such as those produced by Ingenious Ireland (www.ingeniousireland.ie) for Dublin City geology and the app for tourists in the Burren and Cliffs of Moher UNESCO Geopark. Plans for such products would require some considerable effort to produce and imaginative effort, to link sites in any coherent ways.

Geoschol
Geoschol is an educational project, now essentially represented by a website [http://www.geoschol.com/ireland.html] which was largely aimed at providing educational materials about geology for primary schools. A four-page PDF document summarising the geology of County Cork is available from Geoschol (see Appendix 8).

County Geological Heritage Research Archive
A geological heritage research archive was produced for the Burren and Cliffs of Moher UNESCO Geopark, with public access to PDF publications, reports and academic papers. The reference lists provided in this audit report could form the foundation for such an initiative in County Cork. The availability of technical references of direct relevance to County Cork's geology and geomorphology would assist many users and researchers into the future. The literature is extensive, and is specialist in nature, such that a geological heritage section with a select bibliography on the County Council Heritage web pages would suffice for most users with general interest in heritage.

Paper Maps
The inclusion of County Geological Sites as a feature layer in future publications of paper editions of Táilte Éireann (Ordnance Survey Ireland) 1:50,000 Discovery Series maps would be a value-added initiative. Hard-copy map publications produced by East-West Mapping (https://eastwestmapping.ie/) include geological data from Geological Survey Ireland.

5. A summary of the Geology of County Cork

5.1 Concise Summary of the geology of County Cork

County Cork has several main episodes in its geological story. The first and oldest episode is represented by a small area near Ballyhoura to the north of Mitchelstown, where Silurian marine rocks, from around 425 million years ago are found in patches, where erosion of the uplands has stripped off the younger Devonian sandstones and conglomerates that overlay the Silurian rocks. The Devonian rocks surround the Silurian rocks in these mountain ranges, as well as forming most of the area of the uplands along the Beara peninsula. The next main episode in the geological history of County Cork is marked by changes from terrestrial Old Red Sandstone (mostly Devonian age) to marine shelf mudstones and limestones of Lower Carboniferous (also known as Mississippian) times, around 359 to 330 million years ago. Following this period, Upper Carboniferous (also known also as Namurian and Pennsylvanian) shales and sandstones were deposited and can be seen in the Mullaghereirk Mountains and northwest County Cork, in isolated areas in south Cork, and on Whiddy Island in Bantry Bay. Some minor occurrences of rocks dating from Jurassic and Palaeogene times are found in County Cork. The most significant events to shape the county as we see it today were the Quaternary glaciations which ended about 14,000 years ago. Large ice sheets covered the entire county for extensive periods of time, extending several tens of kilometres offshore, and eroded the surface rocks. When the ice eventually melted away, the meltwaters reorganised the sediments into iconic landforms of glacial moraines, eskers, drumlin-type landforms, and outwash terraces of sand and gravel.

AGE (Million Years Ago)	*ERA*	*PERIOD*	*EVENTS IN CORK (non-italics)*	*IF THIS TIMESCALE WAS A DAY LONG...*
2.58	Cenozoic	Quaternary	Several ice ages smothering Cork, followed in the last 10,000 years by the spread of vegetation, growth of bogs and arrival of humans. Sculpting of corries in the West Cork mountains. Deposition of (till) boulder clay in drumlins and till plains, as well as sands and gravels in outwash terraces. Dissolution of limestone beneath Quaternary sediments.	Ice ages would begin 38 seconds before midnight
23		*Neogene*	Erosion, especially limestone. Turloughs, swallow holes, cavities, underground streams develop in lowlands of north Cork and valleys of central Cork. Deposition of sediments and associated vegetative remains in cavities at localities in north Cork.	Neogene period begins at 11.52 pm
66		Palaeogene		Palaeogene period begins at 11.40 pm
145	Mesozoic	*Cretaceous*	*Erosion. No record of rocks of this age in Cork.*	11.15 pm
201		Jurassic	Uplift and erosion. Some rocks of this age in Cork – the Colbond clays of Cloyne.	Age of the dinosaurs, starting at 10.55 pm
252		*Triassic*	*Desert conditions on land.* *No record of rocks of this age in Cork.*	10.42 pm
299	Palaeozoic	*Permian*		10.30 pm
359		Carboniferous	Namurian (middle Carboniferous) shales and sandstones around Cork. Land became submerged, limestones with some shales and sandstones deposited in tropical seas across much of Cork. Limestones remaining today are pure and unbedded in the majority, with smaller areas of muddier limestones at the edges. Shales and sandstones deposited in the uplands of northwest Cork, and just south of Carrigaline.	Inundation of land by sea around 10.10 pm
419		Devonian	Caledonian mountain building and extrusion of volcanic rocks east of Kanturk. Sandstones deposited across much of mid- and west Cork, today forming much of the high ridges there.	'Old Red' Sandstone deposited at 9.52 pm
443		Silurian	Shallow seas following closure of Iapetus Ocean. Greywacke and shales deposited around Ballyhouras, and to the north of Mitchelstown.	Starts at 9.42 pm
485		*Ordovician*	Iapetus Ocean divides Ireland into two. *No record of rocks of this age in Cork.*	Begins at 9.28 pm
541		*Cambrian*	*Opening of the Iapetus Ocean.* *No record of rocks of this age in Cork.*	Starts at 9.11 pm
2500	Proterozoic	*Precambrian*	*Some of Irelands oldest rocks deposited in Mayo.*	Beginning 11.00 am
4000	Archaean		*Oldest known rocks on Earth.*	Beginning 3.00 am
4600			*Age of the Earth.*	Beginning 1 second after midnight

The Geological Timescale and County Cork.

5.2 More detailed summary of the geology of County Cork

Covering an area of around 7,500 km^2, County Cork is the largest county in Ireland. The landscape and coastal seascape varies widely, comprising mountains with elevations greater than 700 m OD, elevated plateau terrain (> 100 m OD), hills, lowlands, steep-sided glaciated valleys, wide river valleys, large peninsulas, rocky headlands, wide bays, small embayments, and offshore islands. Bedrock in County Cork is almost entirely of Palaeozoic age, with the minor exception of some Mesozoic rock localities occurring in the Cloyne area.

The oldest rocks in County Cork occur in the low-lying terrain between the Ballyhoura Mountains and the Galtees. This area hosts greywacke, shale, and calcareous siltstones that were deposited on a deep ocean floor during Silurian (Llandovery-Wenlock) times around 435-430 million years ago.

An east-west trending band of Middle Devonian continental red beds occurs across the middle of the county, from the Caha Mountains and Shehy Mountains eastwards to Watergrasshill, as well as occupying high ground south and west of Millstreet, and a small area southwest of Coppeen.

Upper Devonian-Lower Carboniferous Old Red Sandstone makes up over 50% of the county and occupies the bulk of the central part of the county, as well as most of the three western peninsulas and their contiguous inland ridges, as well as the high ground around the Galtee Mountains and Kilworth hills.

Upper Devonian-Lower Carboniferous marine sandstones and mudstones occupy the low-lying terrain at the head of Bantry Bay and Dunmanus Bay, the low-ground from Drimoleague to Bandon, and Skibbereen to Clonakilty, and most of area around the Bandon River and eastwards to the coast. These lithologies record episodes of marine transgression that occurred at the end of the Devonian as the sea encroached from the south onto the land. The Upper Devonian-Lower Carboniferous marine sandstones and mudstones comprise almost 20% of the total area of the county. These include the ‘Cork Beds’.

Limestone and calcareous shales occur in the east-west valley floors (troughs) such as occur from Crookstown through Cork City to Youghal Bay, Carrigaline east to Shanagarry, Rathcormack to Tallowbridge, and in the low-lying terrain from Mallow to Mitchelstown.

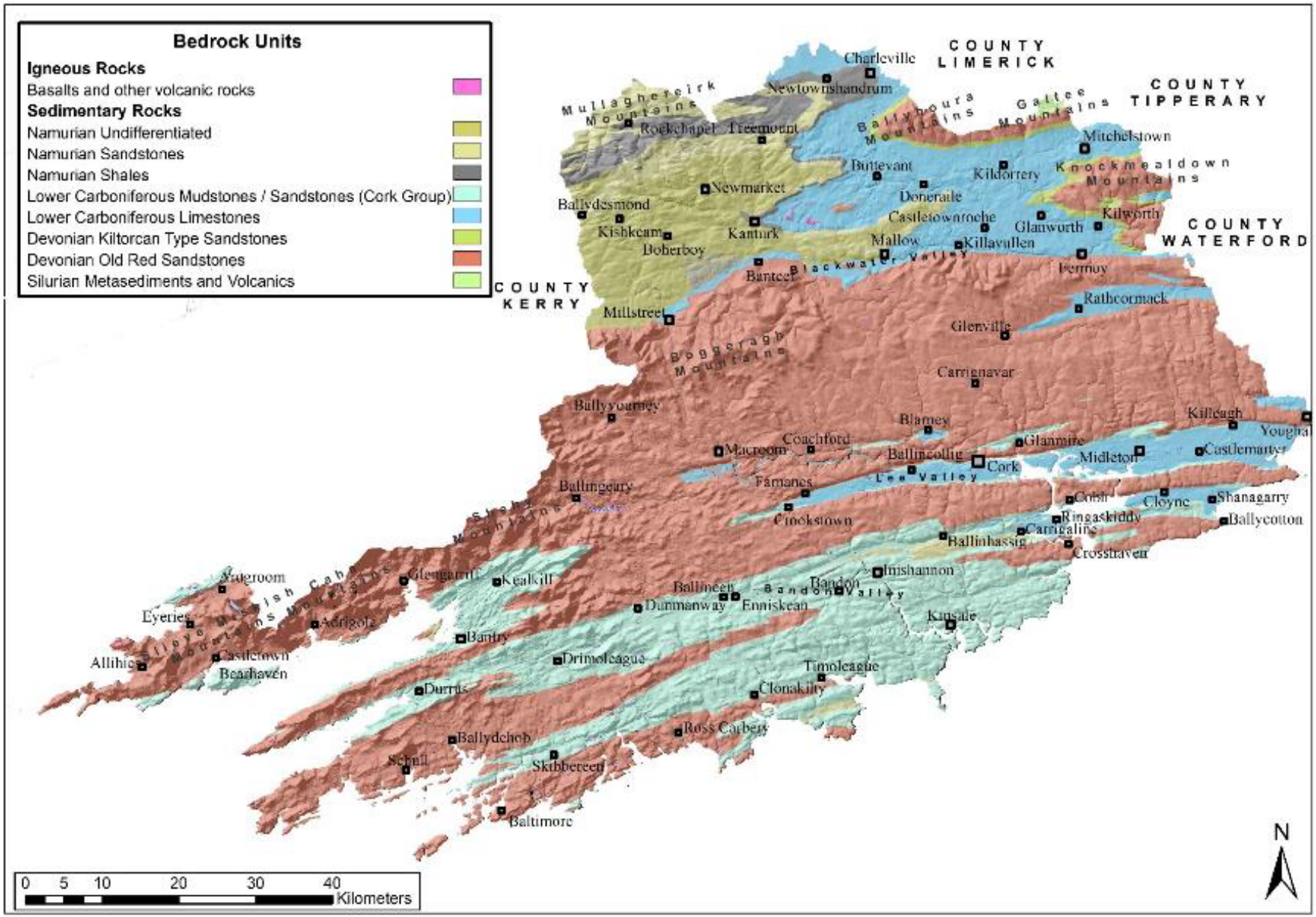
Changes in marine environment during middle Carboniferous times is recorded in Namurian mudrocks and sandstones that were deposited in a deep, marine water. Namurian rocks comprise about 12% of the area of the county and are found on Whiddy Island, around Seven Heads and Broadstrand Bays, in the vicinity of Cloyne, and across much of the northwest portion of the county, north of the N72 Mallow-Rathmore road, and west of the N20 Mallow-Charleville road.

The occurrence of volcanic rocks and intrusive igneous rocks provides evidence of episodes of tectonic activity during Devonian and Carboniferous times. Basalts that were intruded into red sandstone beds during Devonian times are found at Dursey Island and Cod’s Head, north of Allihies. Trachytes that intruded into Upper Devonian-Lower Carboniferous rocks are found on the southwest coast of the Beara Peninsula at Black Ball Head and on Bear Island. A thin band of dolerite and gabbro occurs some 3 km north of Bandon. Pyroclastic volcanic rocks occur about 5 km east of Kanturk.

Some minor occurrences of rocks dating from Jurassic and Palaeogene times are found in Cork, as the Colbond Clays of Cloyne.

The most significant events to shape the county as we see it today were the Quaternary glaciations which ended about 14,000 years ago. Large ice sheets covered the entire county for extensive periods of time, extending several tens of kilometres offshore, and eroded the surface rocks. Only a small number of the highest mountains in the county stood up above the ice; the rest of the county was smothered. As the ice moved out across it's substrate, glacial tills were deposited, especially thick in the valleys of Cork, and forming the drumlins around Bantry. Elsewhere across the county, much of the rock surface was planed, sculpted and eroded, visible across the bedrock outcrops common in West Cork. During this time, sea levels around Ireland were 120 m lower than they are today.

When the ice eventually melted away, the meltwaters reorganised the sediments into iconic landforms of glacial moraines, eskers, and outwash terraces of sand and gravel which today flank the county's main rivers, such as the Lee and the Bandon. Deep meltwater channels were cut, such as at the Pass of Keimaneigh. Since the ice sheet melted, the Cork landscape has been dominated by processes related to water, such as karstification of limestone where it occurs, rivers flooding, the formation of blanket peat in the uplands, and coastal processes along the Atlantic seaboard.



A simplified geology map of County Cork outlining the main geological units.

6. Acknowledgements

The authors gratefully acknowledge the assistance of Cork County Heritage Officer Conor Nelligan in the development of this project. Funding from the Heritage Council and from Cork County Council is also acknowledged. We also acknowledge the many members of the Geoheritage (IGH) Programme Expert Panels who originally helped define the sites that were considered for County Geological Site status.

The authors especially thank all the landowners and others who have provided information and help in the field visits to sites, but for their assistance and generosity, we especially thank the following people:

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Gerard Brown, Regional Manager, Roadstone, Ballybeg Quarry.
Gerard O'Leary of Greenvalley Plant Hire, Ballygiblin.
Cornelius Kehir of Irish Industrial Explosives Limited.
Brendan and Jimmy of Irish Industrial Explosives Limited at Ballygiblin Quarry.
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Dr. Thorsten Kahlert of Queen's University Belfast and Dr. Marion Dowd of IT Sligo for discussions on Foley Cave.

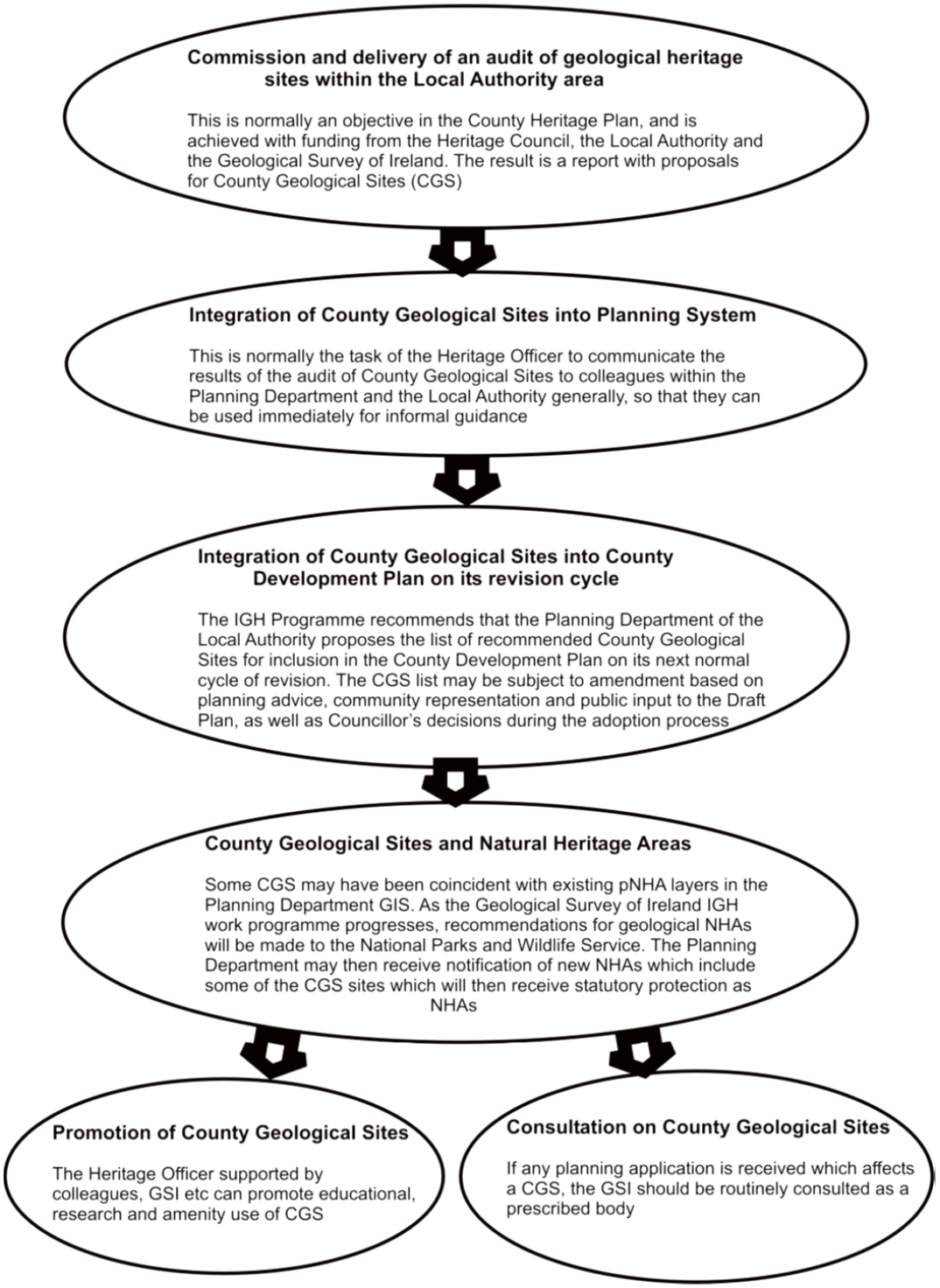
Appendix 1 – Geological heritage audits and the planning process

This appendix contains more detail on the legal framework behind geological heritage audits conducted by County Councils, and the process which operates as a partnership between the Geological Heritage and Planning Programme of the Geological Survey Ireland and the local authority Heritage Officer.

Geology is now recognised as an intrinsic component of natural heritage in three separate pieces of legislation or regulations, which empower and require various branches of Government, and statutory agencies, to consult and take due regard for conservation of geological heritage features: the Planning and Development Act 2000 [e.g. Sections 212 (1)f; Part IV, 6; First Schedule Condition 21], the Planning and Development Regulations 2001, the Wildlife (Amendment) Act 2000 (enabling Natural Heritage Areas) and the Heritage Act 1995. The Planning and Development Act 2000 and the Planning Regulations in particular place responsibility upon Local Authorities to ensure that geological heritage is protected. Implementation of the Heritage Act 1995, through Heritage Officers and Heritage Plans, and the National Heritage Plan 2002, allow County Geological Sites to be integrated into County Development Plans.

The chart below illustrates the essential process, established by the Geoheritage (Irish Geological Heritage) Programme in Geological Survey Ireland, over the course of numerous county audits since 2004.

County Geological Sites - a step by step guide



Appendix 2 - Bibliography – Geology of County Cork

Shortlist of Key Geological References

This reference list includes a few key papers, books and articles on the geology and geomorphology of County Cork that are recommended as access points to County Cork's geological heritage.

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Appendix 3 - Bibliography – Quaternary Geology of County Cork

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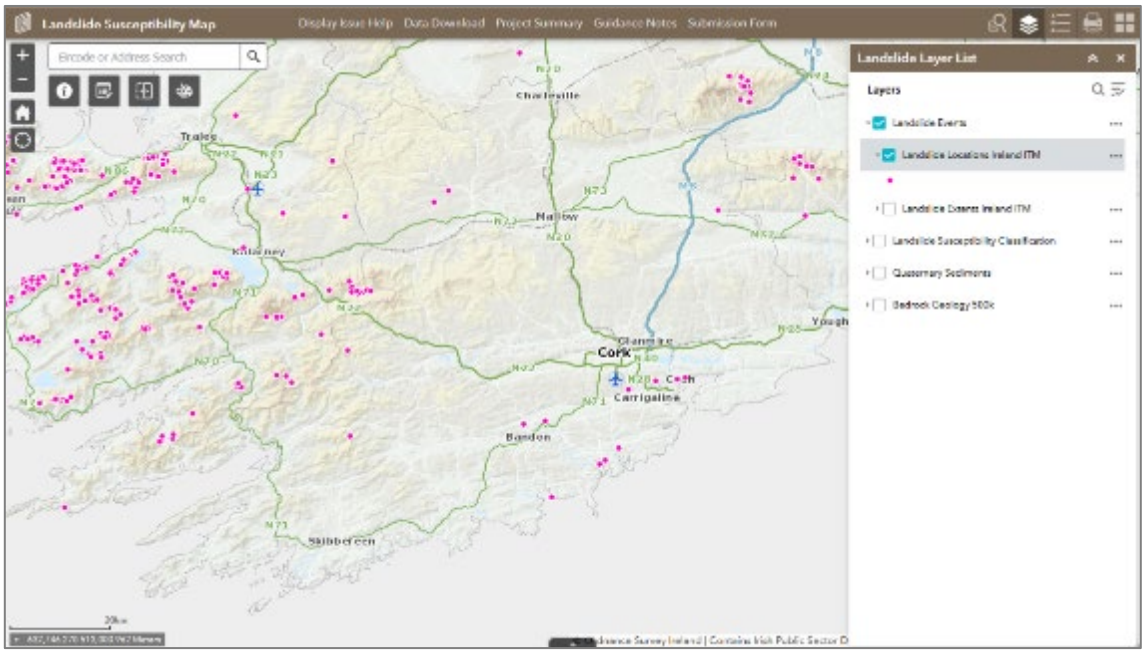
Appendix 4 – Geological heritage versus geological hazards

Ireland is generally considered to have a very low level of risk in terms of major geological hazards: there are no active or dormant volcanoes in Ireland. The island is located on stable tectonic plates which means earthquakes are rare, and disastrous landslides, mudflows, flood events or other geological catastrophes are rare throughout recorded history. This section considers the specific record and nature of geological hazards in County Cork and the relationship of County Geological Sites to those hazards.

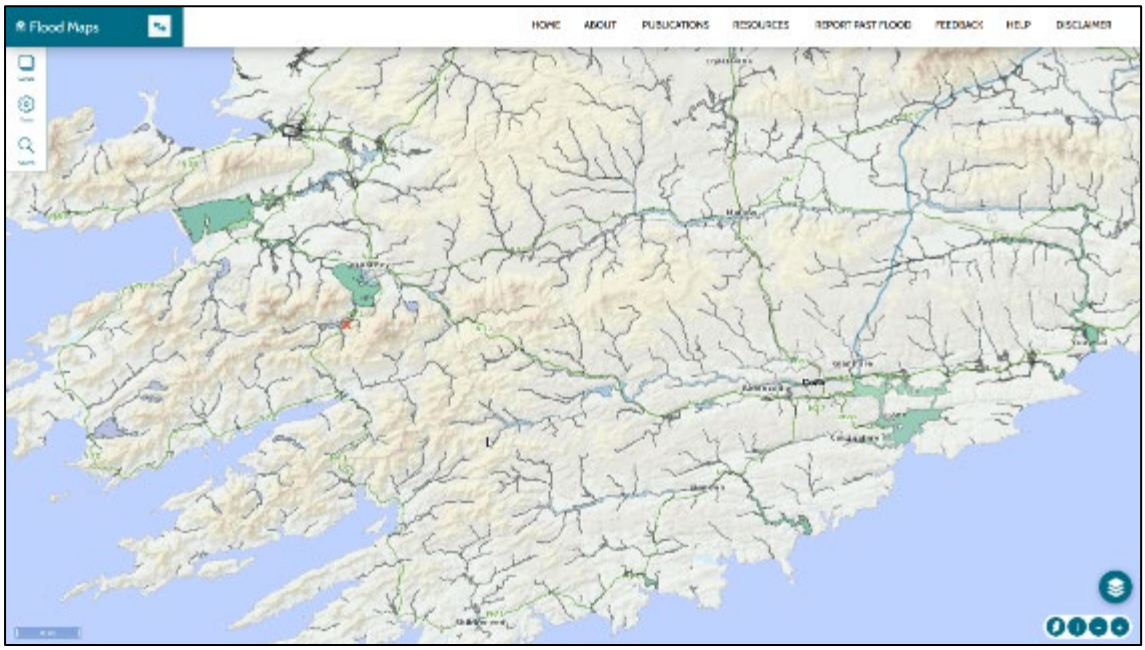
The difference between human timescales and geological timescales can be difficult to comprehend but, for many geological processes, there are periods of sudden activity encompassing major events, followed by long, quiet periods in between. The County Geological Sites in this audit represent evidence of past geological environments and processes, such as the building of high mountain chains, ice sheets covering the land surface and so on. Presently in County Cork there are relatively few sites representing the active geomorphological or land-forming processes of today.

Landslides and bog flows
Geological Survey Ireland has been compiling national data on landslides in the past decade. The database records sixteen landslide events in County Cork. For more information, see the GSI Geohazards Programme webpage (https://www.gsi.ie/).



Screengrab of GSI Landslide Susceptibility Map showing County Cork.

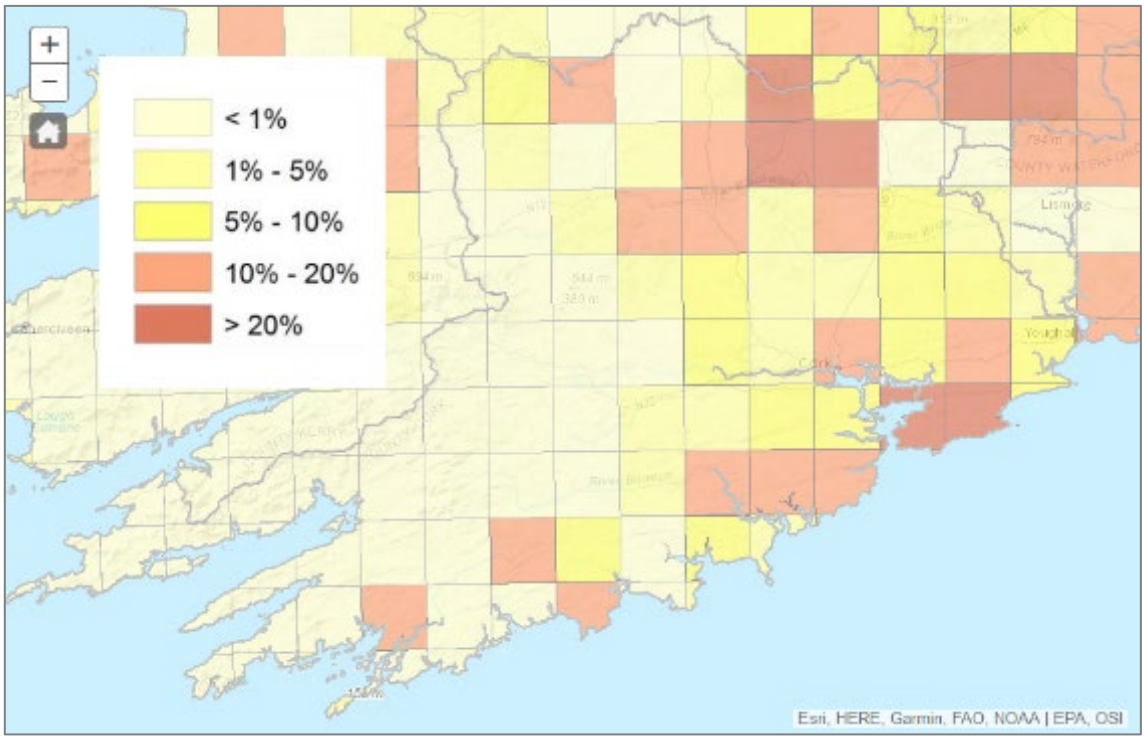
Flooding
There are two types of flooding which need consideration. River flooding occurs inland when rainfall exceeds the capacity of the ground to absorb moisture, and the river channels cannot adequately discharge it to the sea. The Office of Public Works (OPW) website (https://www.floodinfo.ie/) provides details of individual flood events in County Cork.



Screengrab of OPW Flooding Probability Map showing most of County Cork.

Radon

Radioactive minerals and gases at high concentrations can be carcinogenic. Radon can seep into homes and workplaces and can be carried in water supplies. A map showing the areas of predicted risk from radon in Ireland, called High Radon Areas, can be viewed on the Environmental Protection Agency (EPA) website (www.epa.ie).



Screengrab of EPA Radon Map showing County Cork

Groundwater pollution

Whilst not such an obvious hazard as physical collapses, flooding and landslides, the pollution of groundwater supplies carries a serious risk to human health. County Cork is quite dependent on groundwater supplies, and therefore the risk is more serious than for most other counties. As the

groundwater is largely contained within limestone, it should be noted that karstic springs are especially vulnerable to pollution since the flow is mainly within fissure conduits allowing rapid transmission of pollution from source to water supply. The opportunity for microbial attenuation of pollutants is far less in limestone fissures (as there are no natural barriers to stop pollutants) than it would be in granular deposits, which act as natural filters.

Appendix 5 – Data sources on the geology of County Cork

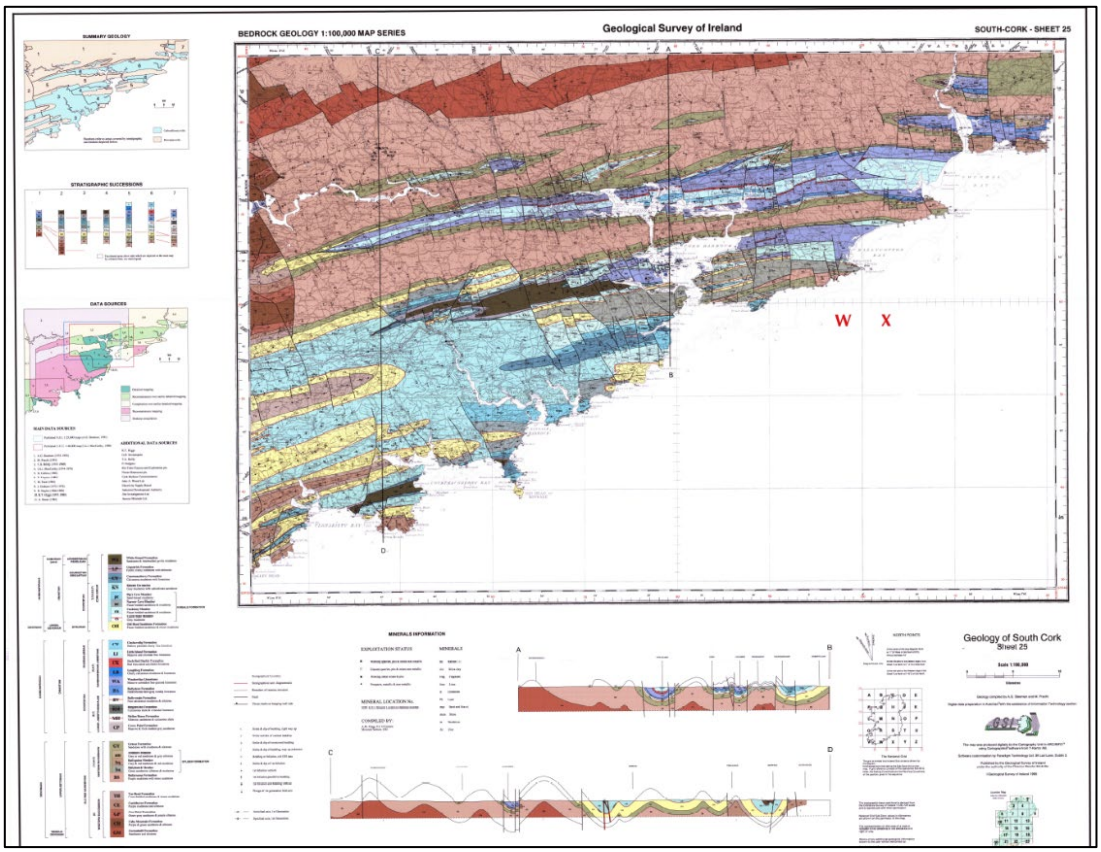
This section provides a summary of publicly available Geological Survey Ireland data and services, to assist with any enquiry concerning geology. Geological Survey Ireland has a vast library of data accumulated since it began mapping Ireland's geology in 1845. A Document Management System called GOLDMINE is freely available online and hosts almost digital 500,000 documents and maps. All GOLDMINE data is publicly available free of charge. Key datasets include:

GOLDMINE

Goldmine (**G**SI **O**n**L**ine **D**ocument **M**aps and **I**nformatio**N** **E**xplorer) is Geological Survey Ireland's online digital archive database. The service provides public access to reports, publications and maps in PDF or high-resolution TIFF image formats. The library consists of scanned documents and maps which include Geological Survey Ireland principal datasets, Mineral Exploration Reports, Geotechnical Reports, boreholes and test data, historic 6" and 1" scale geological maps, official Geological Survey Ireland publications, bulletins, published and unpublished reports, groundwater well hydrographs, airborne geophysical maps, mineral locality reports and mine records. Search online for GSI Goldmine as the departmental website address associated with the Goldmine website may change (Department of the Environment, Climate and Communications at time of publication).

1:100,000 Map Report Series

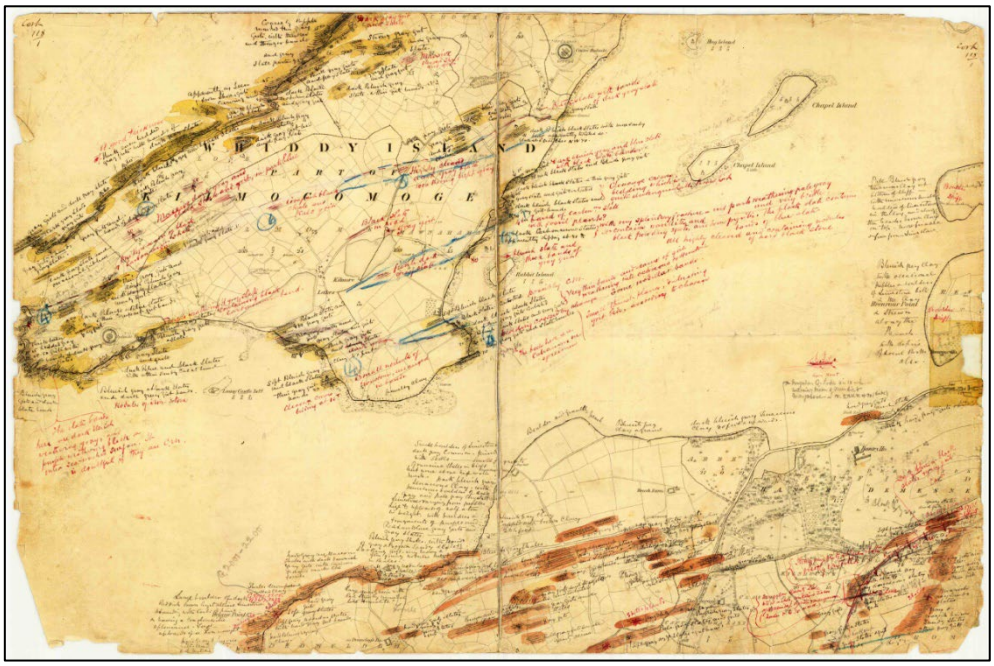
Historical and more recent survey data mapping has been compiled into very useful maps and reports that describe the geology of the entire country. Map Report Sheets 21, 22, 24 and 25 cover all of County Cork.



GSI Bedrock Geology 1:100,000 Series Sheet 25 South Cork

19th Century Six Inches to One Mile (1:10,560) Field Sheets

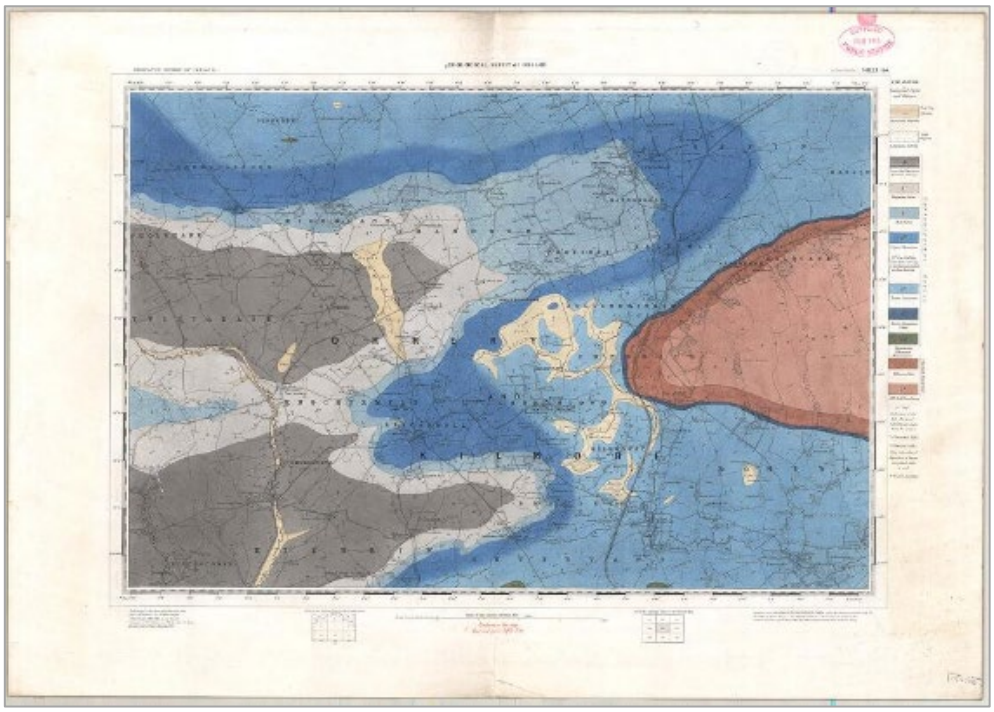
The 6 Inches to One Mile scale field sheet series (6 Inch maps) provide an important historical and current resource with very detailed observations of the geology of the entire country. Produced in the mid-18th century, these sheets are digitally available the public via Geological Survey Ireland's Interactive Web Data Delivery System (IWDDS) and GOLDMINE service.



GSI 6 Inch Field Sheet Cork 118 showing Whiddy Island and inner Bantry Bay.

19th Century One Inch to One Mile (1:63,360) Maps and Memoirs

Information from the detailed 19th century mapping was distilled into one inch to the mile maps, of which parts of parts of Sheets 163-166, 174-177, 185-188, 191-196, and 197-205 cover County Cork. Each sheet is accompanied by a memoir describing the geology of the area. The maps and memoirs provide valuable records of observations, though some interpretations may have changed since publication with better geological understanding.



GSI 1 Inch Field Sheet Cork showing the
Ballyhoura-Buttevant-Freemount area of north County Cork

Memoirs are publicly available in scanned PDF format on the GSI GOLDMINE website. Maps and memoirs are publicly available in on the BGS/GSNI/GSI Irish Historical Geological Maps website.

INFOMAR Bluescale Maps

INFOMAR (Integrated Mapping for the Sustainable Development of Ireland's Marine Resource) publishes high-resolution bathymetric maps of Ireland's coastal waters called the Blue Scale Map Series. Developed by a dedicated team of hydrographers, data processors and cartographers, the maps highlight the topography of the coast in remarkable detail. See https://www.infomar.ie/

Open File Data

Each Mineral Prospecting Licence issued by the Exploration and Mining Division (EMD), currently a line division of the Department of Communications, Climate Action and Environment, carries an obligation on licence holders to submit exploration reports and data on the works carried out under a prospecting licence. Reports and data are held confidentially for 6 years or until licence surrender, whichever is the sooner. After 6 years or upon surrender of the licence, the data is released publicly via the EMD interactive map viewer and a searchable database. Records include geological interpretations, borehole logs, geophysical and geochemical surveys. Licences relate to numbered prospecting areas and are available on a map from EMD (www.mineralsireland.ie)

MinLocs Data

The MinLocs Database records all known mineral occurrences, however small, from Geological Survey Ireland records, such as data drawn from 19th century field sheets and Open File data.

Screengrab of GSI Public Data Viewer displaying Mineral localities in County Cork.

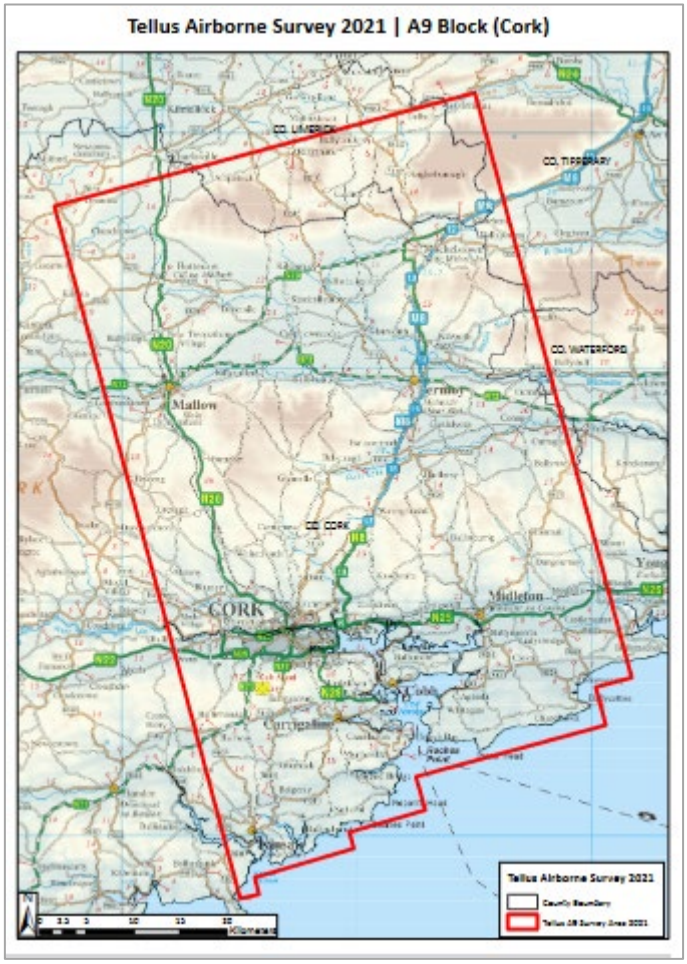
Subsoils Mapping

In 2012, Geological Survey Ireland completed the final county-scale Groundwater Protection Schemes (GWPSs), in partnership with Local Authorities, and there is now national coverage of GWPS mapping. Subsoil and bedrock mapping provides a significant resource for groundwater protection, as well as for other purposes. Detailed compilation of glacial geology and geomorphology datasets, including a revision published by Geological Survey Ireland in 2014, has amplified data pertaining to groundwater and the Quaternary history of Ireland. Digital mapping of many different datasets is now available via the Geological Survey Ireland Public Data Viewer (www.gsi.ie).

Tellus Mapping

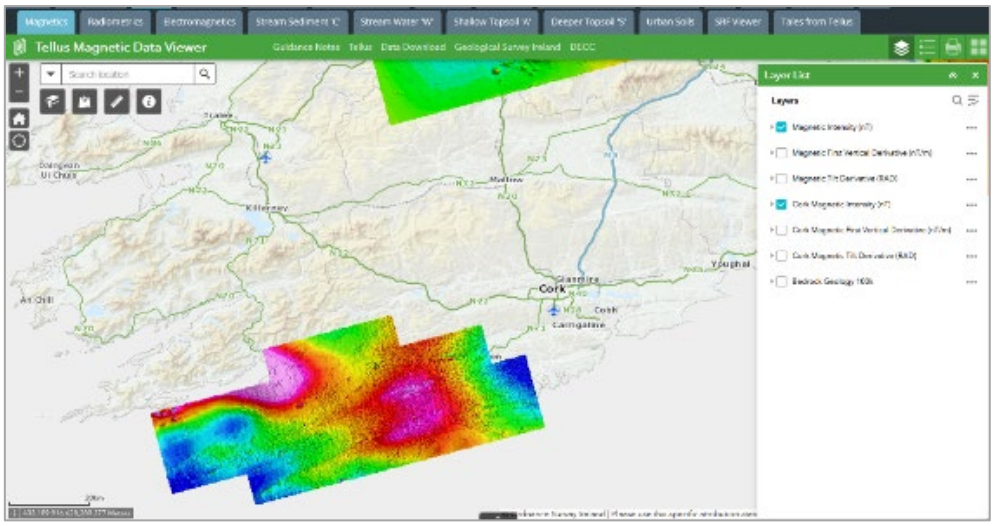
Tellus is an island-wide mapping project, combining airborne geophysical and geochemical surveys to provide geoscientific information for the island of Ireland. Tellus surveying was completed in the border region of Ireland in 2013 and has since moved southwards. As of 2021, parts of County Cork have been completed, and will be fully completed in the coming years. Geophysical and geochemical surveying has also been completed over parts of County Cork. Tellus Border was an EU INTERREG IVA-funded regional mapping project and was a cross-border initiative between the Geological Survey of Northern Ireland, the Geological Survey of Ireland, Queen's University Belfast and Dundalk Institute of Technology. All data from Tellus is made available free of charge online.

As of 2021, the Tellus airborne geophysical survey has mapped 75% of the country. The Tellus surveys support mineral exploration, environmental management, agriculture, and research activity (www.gsi.ie).



2021 aerial survey coverage over A9 Block, County Cork.

Data are freely available from the Tellus programme page of the Geological Survey Ireland website (www.gsi.ie).

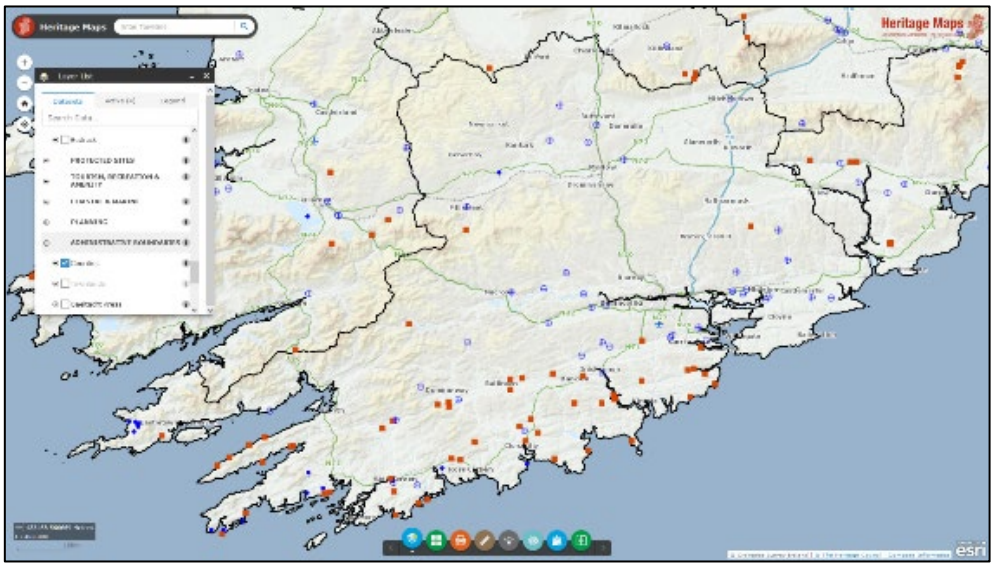


Screengrab of GSI Tellus Data Viewer displaying Magnetic Intensity in County Cork.

Historic Mine Records in Geological Survey Ireland
Abandonment plans and varied other material exist for the various mining ventures in the country and are stored in Geological Survey Ireland. The range of data varies from single items for some historical mine sites in Cork, to immensely detailed series of plans for more modern mine sites. An array of scanned material is available on the GSI GOLDMINE website. Additional material, such as photographs, may be stored in the paper records and held in GSI archives. Additionally, scanned material does not include some very historic or rare plans and documents that are stored in a separate GSI archive, part of the National Archive.

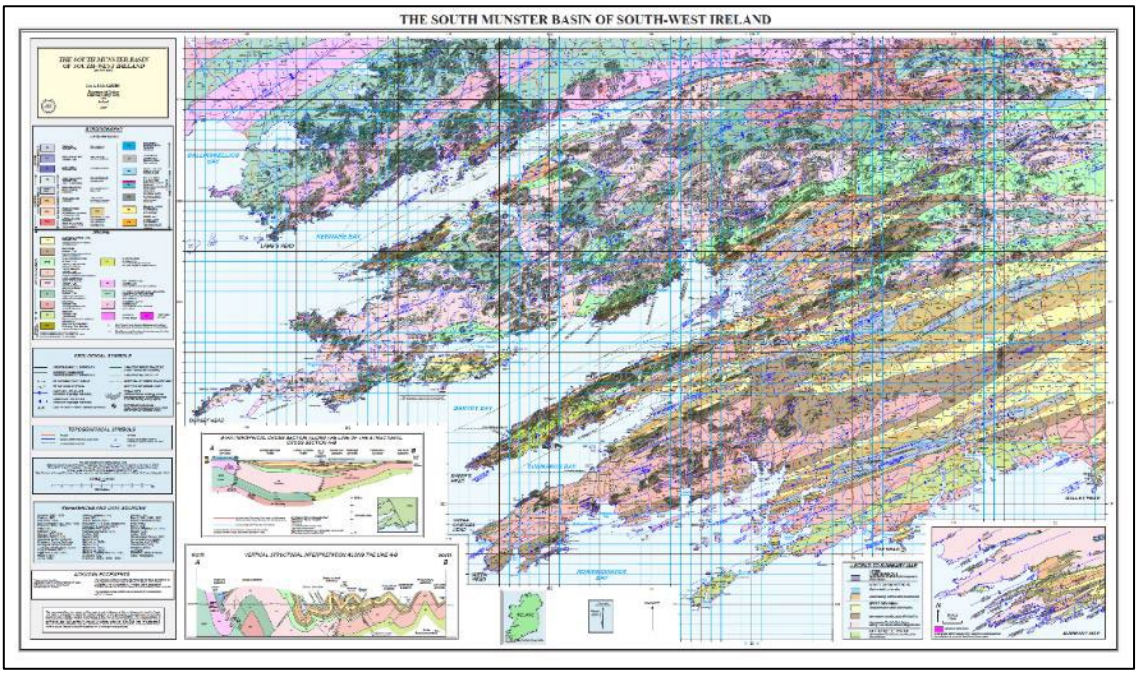
Ordnance Survey Geohive
The Ordnance Survey Ireland (OSI) online mapping website Geohive (https://www.geohive.ie/) offers a superb resource with OSI maps at different scales, colour and black & white air photos, and a varied range of datasets available to view online.

Heritage Council Heritage Viewer
HeritageMaps.ie (https://www.heritagemaps.ie/) is a web-based spatial data viewer, co-ordinated by the Heritage Council, and working with the Local Authority Heritage Officer network, which focuses on the built, cultural and natural heritage around Ireland and offshore. The viewer allows users to look at a wide range of built and natural heritage data sets online. The outlines of and data on each individual County Geological Site in Cork will be available on the HeritageMaps.ie viewer when the county audit is completed.



Screengrab of Heritage Maps Viewer displaying Active Quarries (blue) and Slate Quarries (red) in County Cork.

The South Munster Basin of southwest Ireland Map
The map below was published in 2007 in the Journal of Map (Vol. 3). It illustrates the bedrock geology of an area of about 3,500km of the western part of the Devonian and Carboniferous South Munster Basin of southern Ireland at a scale of 1:75,000.



1:75,000 Scale Map of the South Munster Basin of southwest Ireland (MacCarthy, 2007)

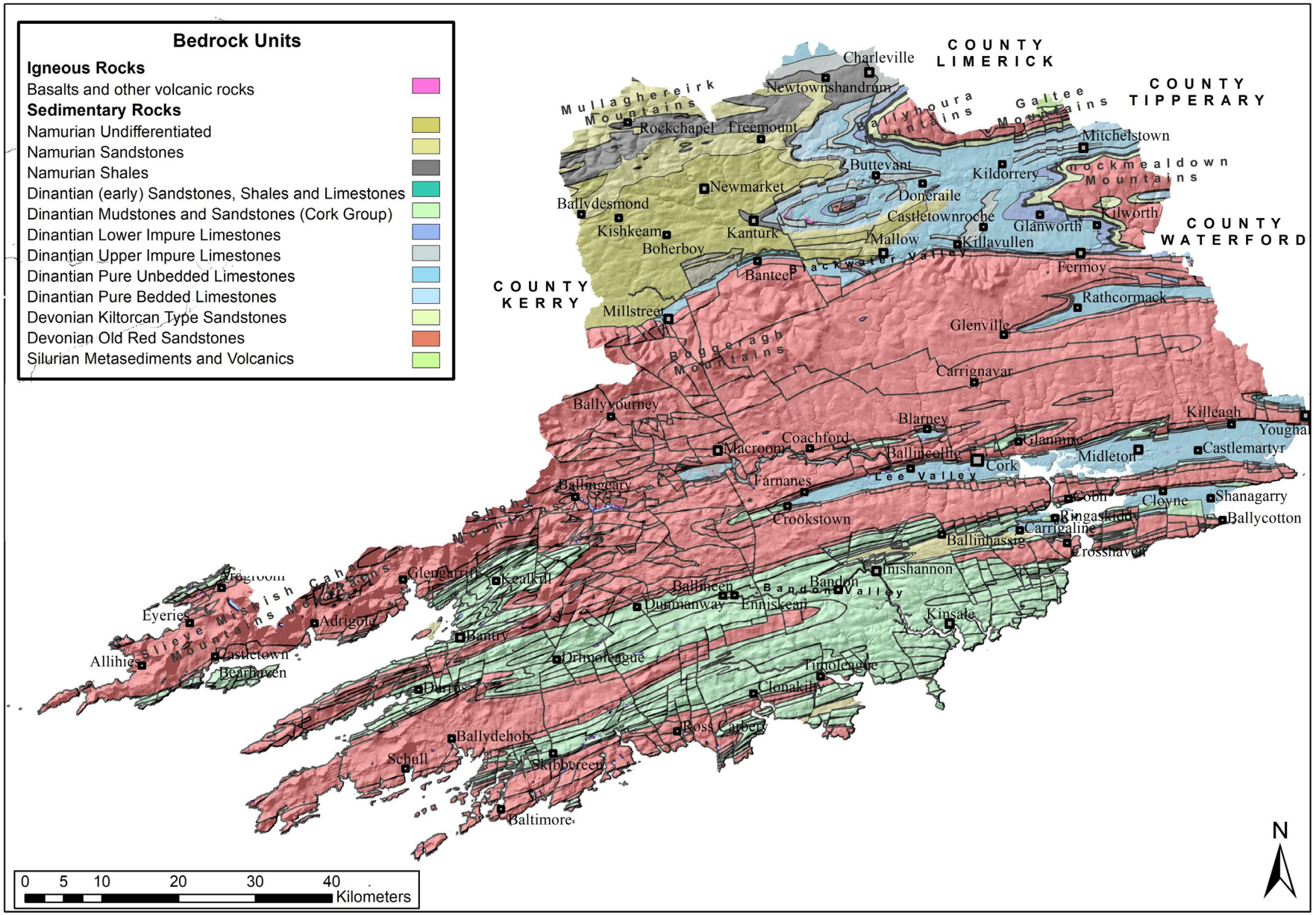
Appendix 6 – Further sources of information and contacts

Geoheritage Programme staff at Geological Survey Ireland may be contacted in relation to any aspect of this report. Conor Nelligan, Cork County Heritage Officer is the primary local contact in County Cork for further information in relation to this report. Other contacts include National Parks and Wildlife Service Conservation Rangers. See National Parks and Wildlife Service (www.npws.ie) for contact details.

Web sites of interest

www.gsi.ie	Geological Survey Ireland
www.npws.ie	National Parks and Wildlife Service
www.heritagecouncil.ie	The Heritage Council
www.corkcoco.ie/	Cork County Council
www.gsi.ie	GOLDMINE - Geological Survey of Ireland online archive
www.geologicalmaps.net	Historical Geological Maps
www.geology.ie	Irish Geological Association
www.iqua.ie	Irish Quaternary Association
www.progeo.ngo	ProGEO - The European Association for the Conservation of Geological Heritage
www.floodinfo.ie	Office of Public Works Flood Plans and Flood Maps
www.acmm.ie	Allihies Copper Mine Museum

Appendix 7 – Detailed geological map of County Cork



Appendix 8 – Geoschol leaflet on the geology of County Cork

CORK

AREA OF COUNTY: 7,457 square kilometres or 2,879 square miles

COUNTY TOWN: Cork

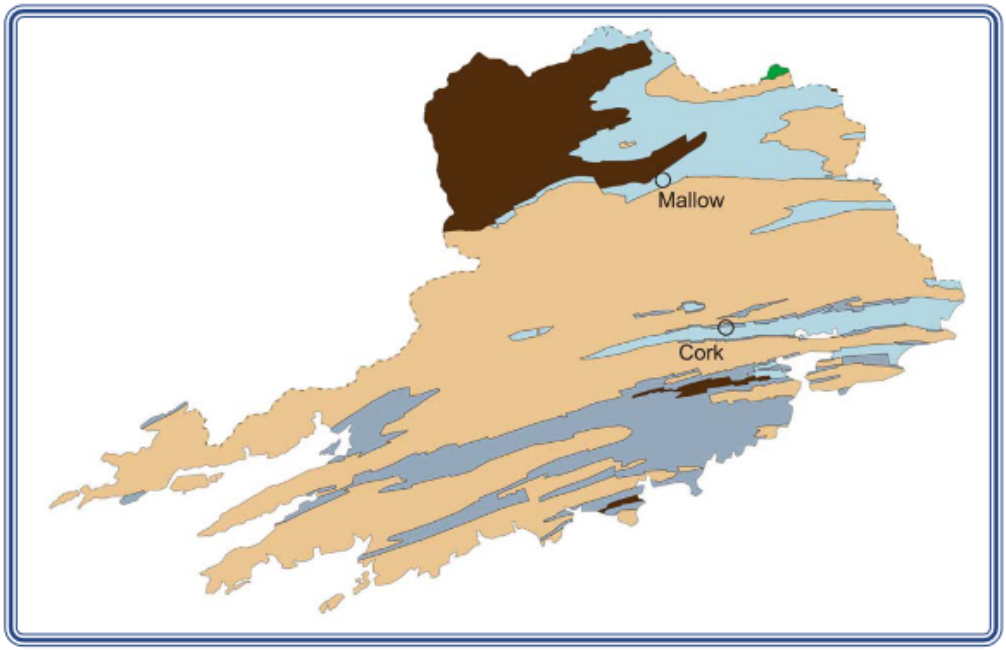
OTHER TOWNS: Bandon, Bantry, Charleville, Cobh, Mallow, Midleton, Millstreet, Skibbereen, Youghal

GEOLOGY HIGHLIGHTS: Copper mines, Cork Red Limestone, Kanturk coalfield, Jurassic and Palaeogene infill deposits.

AGE OF ROCKS: Silurian to Carboniferous; Jurassic; Paleogene

River Blackwater at Banteer, Co. Cork

The River Blackwater as well as the River Lee flow eastwards through Co. Cork in valleys underlain by Carboniferous Limestone. These are hemmed in by ridges of Devonian sandstones and conglomerates



Geological Map of County Cork

Green: Silurian; **Beige:** Devonian sandstones and conglomerates; **Dark blue:** Lower Carboniferous sandstones and mudstones; **Light blue:** Lower Carboniferous limestone; **Brown:** Upper Carboniferous shales and coal.

Geological history

The rocks in Co. Cork largely belong to the Devonian (415-360 million years ago [Ma] to Carboniferous (360-300 Ma] periods. However there is a small occurrence of older Silurian rocks in the northeast of the county on the edge of the Galtee Mountains. For millions of years during the Devonian Ireland was part of a large continent. In general the climate was seasonally wet, and a sparsity of terrestrial vegetation allowed dunes to form in places. Temporary rivers flowed towards the south and in times of rainfall these became torrents with flashflooding and they carried coarse cobbles and pebbles as well as sands downstream. These later were also lithified and are called conglomerates (coarse) and sandstone that collectively make up the Old Red Sandstone.

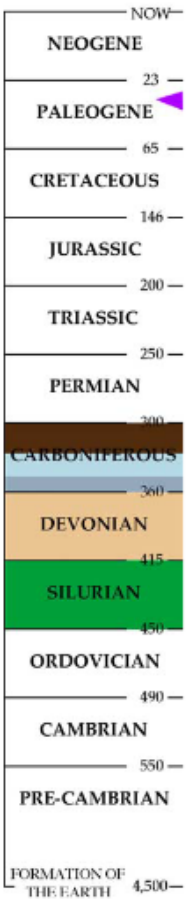
At the beginning of the Carboniferous an ocean began to spread northwards over Ireland. In south Cork a deep marine basin developed called the Munster Basin and this became infilled with shales and mudstones many

Quarry at Ballygiblin showing an orange clay that has infilled a solution hollow or cave in the Lower Carboniferous limestone. Pollen in this clay has proved that it is Paleogene (30 Ma) in age.

of which now contain flattened fossils. Overlying this were deposited limestones which were precipitated in a shallow, warm tropical ocean. Later in the Upper Carboniferous large southwest flowing rivers carried muds and shales into a deepening ocean, while close by at the same time forests in warm swamps thrived. The shales now cover the northwest of the county and the plants which had become compressed by overlying rocks turned into coal that was for many years mined at Kanturk.

Approximately 270 Ma during the Permian period a mountain-building event called the Variscan affected the rocks in Co. Cork. Two continents collided and the rocks were folded into a series of ridges (anticlines) and valleys (synclines) that have an east-west orientation. Across the ridges erosion has removed the younger rocks to expose the Old Red Sandstone while in the valleys the younger Carboniferous rocks still remain. By and large the rivers in Cork flow along the limestone synclines and in the west they have been drowned by seawater to form rias.

Metal deposits such as copper were carried by hot fluids into the rocks of west Cork and these were later mined. During the Jurassic, around 180 Ma, and later during the Paleogene, much of Ireland was land and the exposed limestone became riddled with caves and fissures. Some of these cavities became infilled with clay and are now the only rare evidence for these very young rocks or sediments in the county. Jurassic clays have been found at Cloyne, near Cork, while Paleogene clays are known from Ballygiblin, near Cecilstown.



Geological timescale showing age of rocks in Cork.

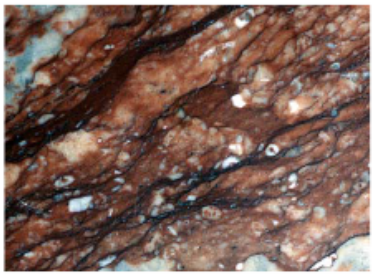
Copper Mining in west Cork

Copper was used by early settlers in Ireland to make bronze weapons. West Cork was an important site for copper mining during the Bronze Age 4000 years ago, and mines were opened at Mount Gabriel (top right). Here miners built fires against the rock and then quenched it with water to break up the stone. The metal ore was then picked out and smelted into useful objects.

Between the 1700s and the 1880s numerous copper mines were opened in the Bearhaven and West Carbury districts where miners came from Cornwall and Wales. The famous Man Engine House at the Mountain Mine, Allihies (centre right) was used to transport the miners down the mine. Other engine houses were used to pump water out of mines.

Cork Red Limestone

This Lower Carboniferous limestone (bottom right) was used for decorative work in churches and other buildings until the 1920s. Quarried at Baneshane, Cobh, and Midleton it contains small circular crinoid fossils and was easily polished. The red colour comes from iron oxides eroded from the underlying Old Red Sandstone.



Suggested reading

• William O'Brien and Anna Brindley: *Mount Gabriel: Bronze Age mining in Ireland* (1994) Galway University Press, Galway.

Map adapted with permission from Geological Survey of Ireland 1:1,000,000 map 2003.
Image credits: Mike Simms 1, 3; Matthew Parkes 4 (top); Mining Heritage Trust of Ireland 4 (centre); Patrick Wyse Jackson 4 (bottom).

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Text by Patrick Wyse Jackson & Mike Simms

Appendix 9 – Glossary

Glossary of geological terms

Geological term	Definition
Adit	a horizontal or only gently inclined mine tunnel dug to access coal or mineral ore, or to drain, ventilate or further develop a mine.
Alluvial Deposit	unconsolidated clay, silt, sand and gravel, deposited by a body of running water.
Alluvium	a term for unconsolidated clay, silt, sand and gravel, deposited by a body of running water.
Basin	low areas in the Earth's crust, of tectonic origin, in which sediments have accumulated.
Bedrock	a general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material.
Bioclast	fragment of a shell or fossil forming part of a sedimentary rock.
Blowhole	chamber with a relatively narrow exit at the top of a cliff, from which water and spray are forced when waves are driven against the coast; this is formed as sea caves grow landward and upward into vertical shafts and expose themselves toward the surface.
Boulder Clay	unconsolidated, unsorted glacial deposits consisting of boulders and cobbles mixed with very finely ground-up rock or silt. Also known as till.
Breccia	igneous or sedimentary rock comprising of large angular fragments within finer grained material.
Calcarenite	calcareous clastic sedimentary rock.
Calcite	a pale mineral composed of calcium carbonate, which reacts with dilute hydrochloric acid.
Calp	dark grey, fine-grained, muddy limestone.
Channel	a landform consisting of the outline of a path of relatively shallow and narrow body of fluid, most commonly the confine of a river, river delta or strait.
Chert	a sedimentary rock comprising of very fine-grained quartz.
Crinoid	a variety of sea-urchin, with a long flexible stem, usually anchored to the seafloor and a body cup with arms which may be branching (a sea lily).
Cyclothem	alternating layers of marine and non-marine sediments, indicative of cyclic depositional regimes; often interbedded with coal seams
Diamicton	unsorted or poorly sorted, terrigenous, or marine sediment containing a wide range of particle sizes derived from a broad provenance, usually with sand and/or coarser particles dispersed among a muddier matrix.
Diatom	a major group of algae, among the most common types of phytoplankton.
Dip/dipping	when sedimentary strata are not horizontal, they are dipping in a direction and the angle between horizontal and the inclined plane is measured as the dip of the strata or beds.
Dolomite	calcium- and magnesium-bearing carbonate mineral; also a rock composed of the mineral.
Drumlin	a streamlined mound of glacial drift, rounded or elongated in the direction of the original flow of ice.
Erratic	a large rock fragment that has been transported, usually by ice, and deposited some distance from its source. It therefore generally differs from the underlying bedrock, the name "erratic" referring to the errant location of such boulders. Tracing their source can yield important information about glacial movements.
Esker	an elongated ridge of stratified sand and gravel which was deposited in a subglacial channel by meltwaters. Eskers are frequently several kilometres in length.
Fan	a usually triangular deposit of sand and gravel deposited by a glacial stream, either under a lake or under air.
Fault	planar fracture in rocks across which there has been some displacement or movement.
Floodplain	a flat or nearly flat land area adjacent to a stream or river that experiences occasional or periodic flooding.
Fluvial	pertaining to a river or stream.

Gelifluction	the flow of water-saturated sheets of rock debris over perennially frozen ground, which may happen on slopes as gentle as 1 degree gradient.
Geo	an inlet, gully or a narrow and deep cleft in the face of a cliff, created by the wave-driven erosion of cliffs along faults and bedding planes in the rock.
Glacial	of or relating to the presence and activities of ice or glaciers.
Glacial striae	markings left on the surface of pebbles / boulders / bedrock by moving ice sheets.
Glaciofluvial	pertaining to the meltwater streams flowing from wasting glacier ice and especially to the deposits and landforms produced by such streams.
Grading	a sorting effect with the coarsest material at the base of the bed and finest grained material at the top.
Greywacke	an impure sandstone, characterised by poorly sorted, angular grains in a muddy matrix, that was deposited rapidly by turbidity currents (submarine avalanches).
Head	a sheet of poorly-sorted, angular rock debris, mantling a hillslope and deposited by gelifluction.
Hummock	a small hill or knoll in the landscape, which may be formed by many different processes.
Ice margin	the edge of an ice sheet or glacier.
Igneous	a rock or mineral that solidified from molten or partially molten material i.e. from a magma.
Impermeable rock	rock through which water cannot flow
Inlier	area of older bedrock completely surrounded by younger bedrock.
Interglacial	the time interval between glacial stages or pertaining to this time.
Joint	a fracture in a rock, which shows no evidence of displacement.
Karst	a landscape with distinctive hydrology and bedrock landforms that arise when the underlying rock is soluble.
Limestone	a sedimentary rock consisting chiefly of calcium carbonate ($CaCO_3$), primarily in the form of the mineral calcite.
Lithology	the description of rocks on the basis of such characteristics as colour, composition and grain size.
Meltwater channel	a channel cut by glacial meltwater, either under, along or in front of an ice margin.
Mississippian	earlier (first) of the two subdivisions of the Carboniferous Period, lasting from 358.9 to 323.2 million years ago.
Moraine	any glacially formed accumulation of unconsolidated debris, in glaciated regions, such as during an ice age.
Mudmound	Waulsortian limestone of Carboniferous age is characterised by forming as massive mounds or ridges or sheets of carbonate mud on the seafloor of the time. Mudmound is a general term to describe the varieties of forms.
Ore	a mineral which is concentrated enough to be exploited by mining.
Outcrop	part of a geologic formation or structure that appears at the surface of the Earth.
Pennsylvanian	later (second) of the two subdivisions of the Carboniferous Period, lasting from 323.2 million to 298.9 million years ago
Raised beach	a former beach, now found above the level of the present shoreline as a result of earth movement or of a general fall in sea level.
Shaft	a vertical or inclined hole dug in a mine for access, ventilation, for hauling ore out or for pumping water out.
Shale	A fine-grained sedimentary rock, formed by the compaction and lithification of clay, silt, or mud. It has a finely laminated (composed of layers) structure that gives it a fissility, or tendency to split along bedding planes.
Spring	the point where an underground stream reaches the surface.
Stratigraphy	the study of stratified (layered) sedimentary and volcanic rocks, especially their sequence in time and correlation between localities.
Terrace	terraces are remnants of the former floodplain of a stream of river, formed by the downcutting of a river or stream channel into and the abandonment and lateral erosion of its former floodplain.
Till	unconsolidated, unsorted glacial deposits consisting of boulders and cobbles mixed with very finely ground-up rock as sand, silt or clay.

Transgression	an incursion of the sea over land area
Type section	the designated exposure of a named layered stratigraphic unit or of a stratigraphic boundary that serves as the standard of reference
Volcaniclastic	the process by which magma and its associated gasses rise into the crust and are extruded onto the Earth's surface and into the atmosphere.
Volcanic Rock	any rock produced from volcanic material, e.g. ash, lava.
Waulsortian	Lower Carboniferous age limestones consisting of skeletal debris and carbonate mud. The sediments commonly form individual and coalesced mounds with depositional dips of 20-40 degrees. Named after rocks in Belgium.

Section 2 - Site Reports

Site Reports – General Points

The following site reports are brief non-technical summaries of the proposed County Geological Sites for County Cork. These have been specially prepared for this report with the objective of making the information accessible to planners and others without geological training. Further sites may become relevant as Geoheritage Programme and County Geological Site initiative develops in the future.

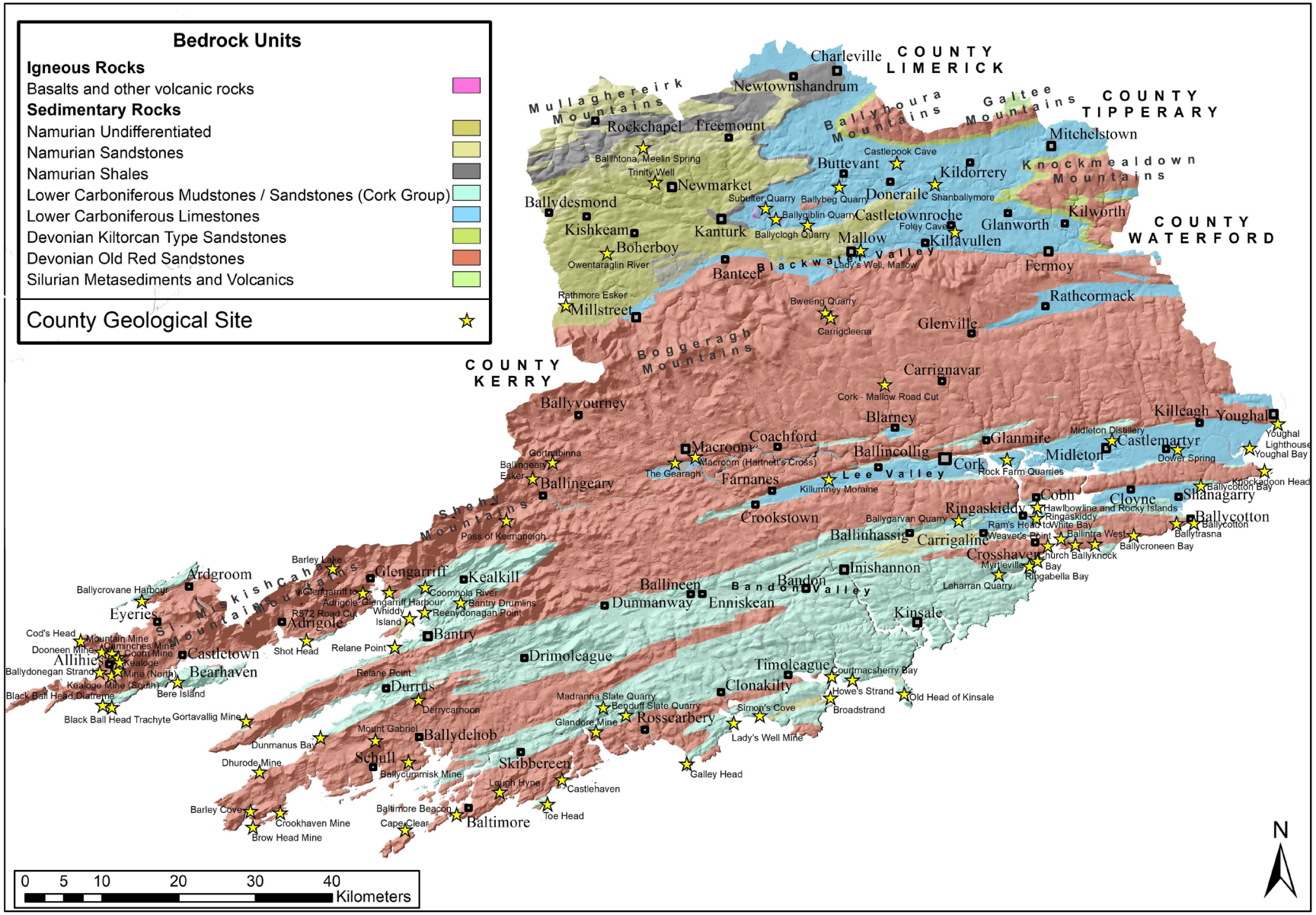
Each County Geological Site report has primary location information, a description of the main geological/geomorphological features and age, and a summary of the key aspects of scientific interest at the site. A section outlining any management or other issues specific to the site is included, along with several low-resolution photographs exemplifying the site. Grid coordinate references are given for a central point in the site generated from the GIS mapping (ESRI Shapefile) of the site boundary. Grid coordinates are indicative of the general site location. Two six-digit Irish Transverse Mercator (ITM) grid coordinates (X and Y) are presented for all CGS localities in the site reports. Irish Transverse Mercator (ITM) is the standard coordinate system for Ireland and is used in updated OSI Discovery series maps.

The site boundary extent is best shown on the included maps and is also published on the GSI Public Data Viewer mapping service. **It is important to note that these boundaries have no legal or definitive basis. They are indicative only of the limits of exposure or of geological interest, and not based on detailed field and boundary surveys, which were outside the scope of this contract.** Boundaries are drawn to include the geological or geomorphological interest of the site, but are extended to the nearest mappable boundary, such as a field boundary, stream, road or edge of forestry. On a few sites, such as in open mountain terrain, it is impractical to find a boundary within a reasonable distance and an arbitrary line may be defined. County Geological Sites are non-statutory and so this is not problematic. If any County Geological Site is fully assessed for NHA status in the future, such a boundary may require small revisions.

For sites that have already, or which will be recommended for NHA designation, detailed site boundary maps will become available to the Local Authority through NPWS as the designation process is undertaken. Some areas may already be available if they are proposed NHAs (pNHA), under the Wildlife (Amendment) Act 2000. Sites, which are situated in a designated Special Areas of Conservation (SAC) under European Habitats Directive will also have statutory boundaries already determined. The geological interest may be included within these wider areas of nature conservation.

In terms of any geological heritage site designation as NHA, due process of site reporting, boundary survey and very importantly, consultation with landowners where they can be readily identified, will take place before Geological Survey Ireland finalises recommendations with NPWS on the most important sites to be designated. Any landowner within areas or sites identified in this report with concerns over any aspect of this project is encouraged to contact the Head of the Geoheritage Programme, Geological Survey of Ireland, Block 1, Booterstown Hall, Booterstown, Blackrock, Co Dublin. Phone 01 678 2896.

Site Reports – County Geological Site Location Map



Simplified Geological Map of County Cork with site locations indicated.