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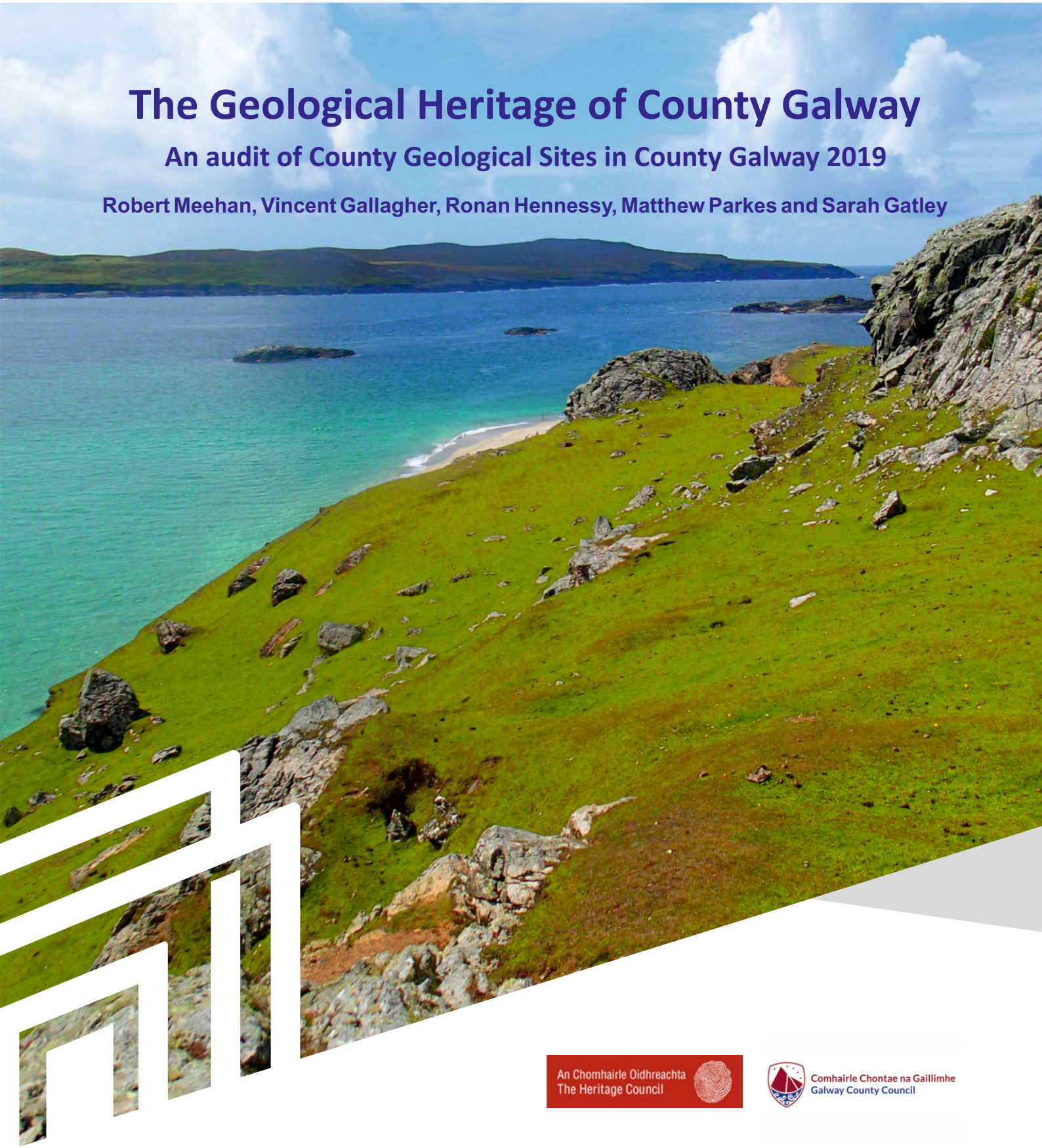
# The Geological Heritage of County Galway

## An audit of County Geological Sites in County Galway 2019

Robert Meehan, Vincent Gallagher, Ronan Hennessy, Matthew Parkes and Sarah Gatley



An Chomhairle Oidhreachta
The Heritage Council

Comhairle Chontae na Gaillimhe
Galway County Council

Geological Survey Ireland is a division of the Department of Communications, Climate Action & Environment

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**by Robert Meehan, Vincent Gallagher, Ronan Hennessy, Matthew Parkes and Sarah Gatley**

**2019**

**The County Galway Geological Heritage Project was supported by**

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Comhairle Chontae na Gaillimhe
Galway County Council

**This report is a contribution to the programme of work in the County Galway Heritage and Biodiversity Plan 2017 – 2022**

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**IGH 1 Karst**
**Site Name**
*Aran Islands [see IGH7, IGH13, IGH14]*
*Aughnanure Castle*
*Ballydotia*
*Ballyglunin Cave*
*Ballylee Hammerhead Sinks*
*Ballymaglancy Cave*
*Beagh Sink – Pollduagh System*
*Boyounagh Turlough [see IGH16]*
*Bullaunagh Sinks*
*Caherglassaun Turlough [see IGH15]*
*Cappacasheen Epikarst*
*Cong Springs and Pigeon Hole [see IGH16]*
*Coole Cave and Polldeelin*
*Coole – Garryland Complex*
*Corranellistrum*
*Corranroo Springs*
*Croaghill Turlough [see IGH16]*
*Gortgarrow Spring [see IGH16]*
*Inishmacatreer Rohrenkarren [see IGH14]*
*Kilkerrin Turlough [see IGH16]*
*Kiltullagh Lough [see IGH7]*
*Kinvara Springs*
*Knockmaa [see IGH3, IGH7, IGH12]*
*Knockmaa Quarries [see IGH8, IGH12]*
*Levally Lough [see IGH7]*
*Lough Corrib [see IGH7, IGH14]*
*Lough Coy*
*Lough Lurgeen Bog/Glenamaddy Turlough [see IGH7, IGH16]*
*Moran's Cave*
*Peterswell Turlough*
*Pollaloughabo*
*Pollbehan*
*Pollnadirk*
*Rahasane Turlough*
*Summerville Lough [see IGH16]*
*Williamstown Turloughs [see IGH16]*

**IGH 2 Precambrian to Devonian Palaeontology**
**Site Name**
*Not represented in County Galway*

**IGH 3 Carboniferous to Pliocene Palaeontology**
**Site name**
*Knockmaa [see IGH1, IGH7, IGH12]*

**IGH 4 Cambrian-Silurian**
**Site name**
*Altnagalghera-Benchoona-Salrock-Rosroe [see IGH11]*
*Bunnacunneen*
*Gorumna Island [see IGH11]*
*Lough Nafooey Waterfall [see IGH14]*
*Mannin Thrust [see IGH5]*
*Owenduff Bridge*

**IGH 5 Precambrian**
**Site name**
*Bun na gCeapán [see IGH11]*
*Cleggan Head*
*Cloonlooan*
*Cornamona*
*Cregg Quarry [see IGH15]*
*Cur Hill*
*Derryclare Marble Quarry [see IGH6]*
*Derrylea Road Cutting*
*Glencoaghan [see IGH7]*
*Knockanbaun Ridge [see IGH6]*
*Lackavrea [see IGH6]*
*Lough Nahasleam [see IGH11]*
*Mannin Thrust [see IGH4]*
*Maumeen [see IGH6]*
*Streamstown Bay Marble Quarry [see IGH15]*

**IGH 6 Mineralogy**
**Site Name**
*Bohaun [see IGH15]*
*Claddaghduff Barnahallia Lough [see IGH11, IGH15]*
*Claddaghduff Streamstown Bay [see IGH11]*
*Claggan Quarry*
*Clements Mine [see IGH15]*
*Cloonnacartan*
*Costelloe Murvey Granite Quarry [see IGH11]*
*Dawros [see IGH11]*
*Derryclare Marble Quarry [see IGH5]*
*Glengowla Lead Mine [see IGH15]*
*Inishark [see IGH7, IGH13, IGH15]*
*Inishbofin [see IGH7, IGH13, IGH15]*
*Knockanbaun Ridge [see IGH5]*
*Lackavrea [see IGH5]*
*Lough Oorid Quarry*
*Mace Head [see IGH11, IGH15]*
*Maumeen [see IGH5]*

**IGH 6 Mineralogy (continued)**
**Site Name**
*Murvey [see IGH11]*
*Oughterard - Owenriff Falls [see IGH8]*
*Sellerna Bay [see IGH11, IGH15]*
*Shannapheasteen Quarry [see IGH11]*
*Tully Shore [see IGH11]*
*Tynagh Mine [see IGH15]*

**IGH 7 Quaternary**
**Site Name**
*Annaghbeg Bog [see IGH16]*
*Aran Islands [see IGH1, IGH13, IGH14]*
*Aughrim Bog [see IGH16]*
*Ballinasloe Esker*
*Ballyconneely Bay Drumlin*
*Boleyneendorrish River*
*Carrownagappul Bog [see IGH16]*
*Castledaly*
*Derrynagran Bog and Esker [see IGH16]*
*Dogs Bay and Gorteen Bay [see IGH13]*
*Dunmore Esker*
*East Galway Moraines*
*Glencoaghan [see IGH5]*
*Gortgar Drumlins*
*Gowlan East [see IGH12]*
*Inishark [see IGH6, IGH13, IGH15]*
*Inishbofin [see IGH6, IGH13, IGH15]*
*Inveran Drumlin*
*Kanrawer Drumlin*
*Killary Harbour*
*Killimor Esker*
*Kiltullagh Lough [see IGH1]*
*Knockmaa [see IGH1, IGH3, IGH12]*
*Leenaun*
*Levally Lough [see IGH1]*
*Lough Corrib [see IGH14]*
*Lough Lurgeen Bog/Glenamaddy Turlough [see IGH1, IGH16]*
*Mannin Bay [see IGH13]*
*Maumtrasna [see IGH8]*
*Park Esker*
*Pollnahallia [see IGH12]*
*Ross Demesne – Ower Esker*
*Streamstown Peat*

**IGH 8 Lower Carboniferous**
**Site Name**
*Ballybanagher M17 Road Cut*
*Caherateemore M17 Road Cut*
*Hill 707*
*Knockmaa Quarries [see IGH1, IGH12]*
*Maumtrasna [see IGH7]*
*Oldchapel Quarry*
*Oughterard - Owenriff Falls [see IGH6]*
*Rahally M6 Road Cut*
*Roevehagh M18 Road Cuts*
*Toormore M6 Road Cut*
*Two Mile Ditch Quarry*

**IGH 9 Upper Carboniferous and Permian**
**Site Name**
*Not represented in County Galway*

**IGH 10 Devonian**
**Site Name**
*Not represented in County Galway*

**IGH 11 Igneous intrusions**
**Site Name**
*Altnagalghera-Benchoona-Salrock-Rosroe [see IGH4]*
*An Chaladh Mór*
*An Cnapach*
*Ardmore*
*Bóthar na Scrathóg*
*Bun na gCeapán [see IGH5]*
*Claddaghduff Barnahallia Lough [see IGH6, IGH15]*
*Claddaghduff Streamstown Bay [see IGH6]*
*Costelloe Murvey Granite Quarry [see IGH6]*
*Costelloe Road Cutting*
*Currywongaun*
*Dawros [see IGH6]*
*Dogs Bay*
*Doon Hill*
*Errisbeg Mountain*
*Glentrasna Road*
*Gorumna Island [see IGH4]*
*Gowla*
*Inish Granite*
*Knocknagreana*
*Letterfrack Granite*
*Lettershinna Hill*
*Lippa*

**IGH 11 Igneous intrusions (continued)**
**Site Name**
*Loch na gClocha Ballagh*
*Loch na nUilleann - Lochán an Bhurca*
*Lough Nahasleam [see IGH5]*
*Mace Head [see IGH6, IGH15]*
*Murvey [see IGH6]*
*Oughterard Granite*
*Roundstone Granite*
*Rusheenduff*
*Sellerna Bay [see IGH6, IGH15]*
*Shannapheasteen Quarry [see IGH6]*
*Tully Shore [see IGH6]*

**IGH 12 Mesozoic and Cenozoic**
**Site Name**
*Gowlan East [see IGH7]*
*Knockmaa [see IGH1, IGH3, IGH7]*
*Knockmaa Quarries [see IGH1, IGH8]*
*Pollnahallia [see IGH7]*

**IGH 13 Coastal Geomorphology**
**Site Name**
*Aran Islands [see IGH1, IGH7, IGH14]*
*Dogs Bay and Gorteen Bay [see IGH7]*
*Inishark [see IGH6, IGH7, IGH15]*
*Inishbofin [see IGH6, IGH7, IGH15]*
*Mannin Bay [see IGH7]*

**IGH 14 Fluvial and lacustrine geomorphology**
**Site Name**
*Aran Islands [see IGH1, IGH7, IGH13]*
*Inishmacatreer Rohrenkarren [see IGH1]*
*Lough Corrib [see IGH7]*
*Lough Nafooey Waterfall [see IGH4]*
*Lough Namackanbeg*
*Suck River Callows*

**IGH 15 Economic Geology**
**Site Name**
*Bohaun [see IGH6]*
*Caherglassaun Turlough [see IGH1]*
*Claddaghduff Barnahallia Lough [see IGH6, IGH11]*
*Clements Mine [see IGH6]*
*Cregg Quarry [see IGH5]*
*Curraghduff Middle*
*Derryoober Blast Furnace*

**IGH 15 Economic Geology (continued)**

**Site Name**

*Dooros*
*Glengowla Lead Mine [see IGH6]*
*Inishark [see IGH6, IGH7, IGH13]*
*Inishbofin [see IGH6, IGH7, IGH13]*
*Mace Head [see IGH6, IGH11]*
*Sellerna Bay [see IGH6, IGH11]*
*Streamstown Bay Marble Quarry [see IGH5]*
*Teernakill South*
*Tynagh Mine*

**IGH 16 Hydrogeology**

**Site Name**

*Annaghbeg Bog [see IGH7]*
*Aughrim Bog [see IGH7]*
*Boyounagh Turlough [see IGH1]*
*Carrownagappul Bog [see IGH7]*
*Cong Springs and Pigeon Hole [see IGH1]*
*Croaghill Turlough [see IGH1]*
*Derrynagran Bog and Esker [see IGH7]*
*Gortgarrow Spring [see IGH1]*
*Kilkerrin Turlough [see IGH1]*
*Lough Lurgeen Bog/Glenamaddy Turlough [see IGH1, IGH7]*
*Summerville Lough [see IGH1]*
*Williamstown Turloughs [see IGH1]*

## Executive Summary

County Galway is widely known for its geological heritage, but this is understood or expressed for most people as the landscape or the scenery. Since it is one of the largest of Irish counties, and because bedrock is in many parts generally well exposed, it has an extensive range of geological heritage sites. However, it also has some of the most complex geodiversity in the country leading to many significant geological sites. The County Council's support for this audit is critical in raising the profile of geological heritage in County Galway and for maximising its potential for foreign and domestic tourism and for Galwegians.

This report documents what are currently understood by the Irish Geological Heritage Programme (IGH) of Geological Survey Ireland to be the most important geological sites within County Galway. It proposes them as County Geological Sites (CGS), for inclusion within the County Development Plan (CDP). The audit provides a reliable study of sites to replace a provisional listing based on desk study which was adopted in the current 2015-2021 CDP.

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 to be of national importance as a best representative example of a particular geological formation or feature. They will be provisionally 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 actually founded upon the underlying geodiversity.

The commission of this audit and adoption of the sites within the CDP ensure that County Galway follows a now established and effective methodology for ensuring that geological heritage is not overlooked in the general absence of allocated resources for progress at national level. It brings County Galway 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 and the Planning department of County Galway Council. It should also be made available via the Council website for the people of County Galway. A chapter of the report includes recommendations on how to best present and promote the geological heritage of County Galway to the people of the county. It will also inform the work of the IGH Programme and be made available through the Geological Survey Ireland website 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 Galway, if the funding can be found to produce them. The audit also contributes to the knowledge base and definition of geological heritage sites within the area of the aspiring UNESCO Global Geopark of Joyce Country & Western Lakes in Counties Galway and Mayo.

# 1. County Galway in the context of Irish Geological Heritage

This report brings County Galway to the forefront of geological heritage within Ireland, as the majority of the counties have now commissioned such an audit within the scope of the county-based Heritage Plan, and Galway has a very significant share of the national total sites. By providing reliable data in a very cost-effective manner, it is hoped that the remaining local authorities, including those without an incumbent Heritage Officer, will 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, but 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.

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, Planning and Development Regulations 2001, 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 Irish Geological Heritage Programme (IGH) 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 IGH 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 IGH 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 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 are 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 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 Galway 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 examples, 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 (CGS) listing in the County Development Plan.

Currently, in 2019, a Master List of candidate CGS and NHA sites, originally compiled with the help of Expert Panels for all the 16 IGH themes, is being used in Geological Survey Ireland. 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. For example, in County Galway, some karst sites like Ballymaglancy Cave and Pigeon Hole were so far considered to be of national importance and had been put forward as a Natural Heritage Areas (NHA) for the IGH1 Karst Theme. Due to various factors, none have yet been formally designated as NHAs, therefore, inclusion of all sites as County Geological Sites (CGS) in County Galway's planning system will ensure that they are not inadvertently damaged or destroyed through lack of awareness of them outside of the IGH Programme in Geological Survey Ireland.

**The sites proposed here as County Geological Sites (CGS) have been visited and assessed specifically for this project, and represent our current state of knowledge**. It 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 County Galway County Geological Sites

| Site Name | Designation | IGH Primary | IGH Secondary | IGH Third | IGH Fourth | GIS Code |
|---|---|---|---|---|---|---|
| Altnagalghera-Benchoona-Salrock-Rosroe | County Geological Site; recommended for Geological NHA | IGH4 | IGH11 | | | GY001 |
| An Chaladh Mór | County Geological Site | IGH11 | | | | GY002 |
| An Cnapach | County Geological Site | IGH11 | | | | GY003 |
| Annaghbeg Bog | County Geological Site; may be recommended for Geological NHA | IGH7 | IGH16 | | | GY004 |
| Aran Islands | County Geological Site; recommended for Geological NHA | IGH1 | IGH7 | IGH13 | IGH14 | GY005 |
| Ardmore | County Geological Site | IGH11 | | | | GY006 |
| Aughnanure Castle | County Geological Site | IGH1 | | | | GY007 |
| Aughrim Bog | County Geological Site | IGH7 | IGH16 | | | GY008 |
| Ballinasloe Esker | County Geological Site | IGH7 | | | | GY009 |
| Ballybanagher M17 Road Cut | County Geological Site | IGH8 | | | | GY011 |
| Ballydotia | County Geological Site | IGH1 | | | | GY012 |
| Ballyglunin Cave | County Geological Site | IGH1 | | | | GY013 |
| Ballylee Hammerhead Sinks | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY014 |
| Ballymaglancy Cave | County Geological Site | IGH1 | | | | GY015 |
| Beagh Sink – Pollduagh System | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY016 |
| Bohaun | County Geological Site | IGH6 | IGH15 | | | GY017 |
| Boleyneendorrish River | County Geological Site; recommended for Geological NHA | IGH7 | | | | GY018 |
| Bóthar na Scrathóg | County Geological Site | IGH11 | | | | GY019 |
| Boyounagh Turlough | County Geological Site | IGH1 | IGH16 | | | GY020 |
| Bullaunagh Sinks | County Geological Site | IGH1 | | | | GY021 |
| Bun na gCeapán | County Geological Site | IGH11 | IGH5 | | | GY022 |
| Bunnacunneen | County Geological Site; recommended for Geological NHA | IGH4 | | | | GY023 |
| Caherateemore M17 Road Cut | County Geological Site | IGH8 | | | | GY024 |
| Caherglassaun Turlough | County Geological Site; recommended for Geological NHA | IGH1 | IGH15 | | | GY025 |
| Cappacasheen Epikarst | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY026 |
| Carrownagappul Bog | County Geological Site; recommended for Geological NHA | IGH7 | IGH16 | | | GY027 |
| Castledaly | County Geological Site | IGH7 | | | | GY028 |
| Claddaghduff Barnahallia Lough | County Geological Site | IGH6 | IGH11 | IGH15 | | GY029 |
| Claddaghduff Streamstown Bay | County Geological Site; may be recommended for Geological NHA | IGH6 | IGH11 | | | GY030 |
| Claggan Quarry | County Geological Site | IGH6 | | | | GY031 |
| Cleggan Head | County Geological Site | IGH5 | | | | GY032 |
| Clements Mine | County Geological Site | IGH15 | IGH6 | | | GY033 |
| Cloonlooan | County Geological Site | IGH5 | | | | GY034 |
| Cloonacartan | County Geological Site | IGH6 | | | | GY035 |
| Cong Springs and Pigeon Hole | County Geological Site; recommended for Geological NHA | IGH1 | IGH16 | | | GY036 |
| Coole Cave and Polldeelin | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY037 |

| Site Name | Designation | IGH Primary | IGH Secondary | IGH Third | IGH Fourth | GIS Code |
|---|---|---|---|---|---|---|
| Coole-Garryland Complex | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY038 |
| Cornamona | County Geological Site | IGH5 | | | | GY039 |
| Corranellistrum | County Geological Site | IGH1 | | | | GY040 |
| Corranroo Springs | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY041 |
| Costelloe Murvey Granite Quarry | County Geological Site; may be recommended for Geological NHA | IGH11 | IGH6 | | | GY042 |
| Costelloe Road Cutting | County Geological Site; may be recommended for Geological NHA | IGH11 | | | | GY043 |
| Cregg Quarry | County Geological Site | IGH5 | IGH15 | | | GY044 |
| Croaghill Turlough | County Geological Site | IGH1 | IGH16 | | | GY045 |
| Cur Hill | County Geological Site; recommended for Geological NHA | IGH5 | | | | GY046 |
| Curraghduff Middle | County Geological Site | IGH15 | | | | GY047 |
| Currywongaun | County Geological Site; may be recommended for Geological NHA | IGH11 | | | | GY048 |
| Dawros | County Geological Site; may be recommended for Geological NHA | IGH6 | IGH11 | | | GY049 |
| Derryclare Marble Quarry | County Geological Site | IGH6 | IGH5 | | | GY050 |
| Derrylea Road Cutting | County Geological Site; recommended for Geological NHA | IGH5 | | | | GY051 |
| Derrynagran Bog and Esker | County Geological Site | IGH7 | IGH16 | | | GY052 |
| Derryoober Blast Furnace | County Geological Site; recommended for Geological NHA | IGH15 | | | | GY053 |
| Dogs Bay | County Geological Site | IGH11 | | | | GY054 |
| Dogs Bay and Gorteen Bay | County Geological Site; recommended for Geological NHA | IGH13 | IGH7 | | | GY055 |
| Doon Hill | County Geological Site; recommended for Geological NHA | IGH11 | | | | GY056 |
| Dooros | County Geological Site | IGH15 | | | | GY057 |
| Dunmore Esker | County Geological Site; may be recommended for Geological NHA | IGH7 | | | | GY058 |
| East Galway Moraines | County Geological Site | IGH7 | | | | GY059 |
| Errisbeg Mountain | County Geological Site | IGH11 | | | | GY060 |
| Glencoaghan | County Geological Site; recommended for Geological NHA | IGH5 | IGH7 | | | GY061 |
| Glengowla Lead Mine | County Geological Site; may be recommended for Geological NHA | IGH6 | IGH15 | | | GY062 |
| Glentrasna Road | County Geological Site | IGH11 | | | | GY063 |
| Gortgar Drumlins | County Geological Site | IGH7 | | | | GY064 |
| Gortgarrow Spring | County Geological Site | IGH1 | IGH16 | | | GY065 |
| Gorumna Island | County Geological Site; recommended for Geological NHA | IGH11 | IGH4 | | | GY066 |
| Gowla | County Geological Site | IGH11 | | | | GY067 |
| Gowlan East | County Geological Site; may be recommended for Geological NHA | IGH12 | IGH7 | | | GY068 |
| Hill 707 | County Geological Site; recommended for Geological NHA | IGH8 | | | | GY069 |
| Inish Granite | County Geological Site | IGH11 | | | | GY070 |
| Inishark | County Geological Site; may be recommended for Geological NHA | IGH15 | IGH6 | IGH13 | IGH7 | GY071 |

| Site Name | Designation | IGH Primary | IGH Secondary | IGH Third | IGH Fourth | GIS Code |
|---|---|---|---|---|---|---|
| Inishbofin | County Geological Site; may be recommended for Geological NHA | IGH15 | IGH6 | IGH13 | IGH7 | GY072 |
| Inishmacatreer Rohrenkarren | County Geological Site; may be recommended for Geological NHA | IGH1 | IGH14 | | | GY073 |
| Inveran Drumlin | County Geological Site | IGH7 | | | | GY074 |
| Kanrawer Drumlin | County Geological Site | IGH7 | | | | GY075 |
| Kilkerrin Turlough | County Geological Site | IGH1 | IGH16 | | | GY076 |
| Killary Harbour | County Geological Site; recommended for Geological NHA | IGH7 | | | | GY077 |
| Killimor Esker | County Geological Site | IGH7 | | | | GY078 |
| Kiltullagh Lough | County Geological Site; may be recommended for Geological NHA | IGH1 | IGH7 | | | GY079 |
| Kinvara Springs | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY080 |
| Knockanbaun Ridge | County Geological Site | IGH5 | IGH6 | | | GY081 |
| Knockmaa | County Geological Site; recommended for Geological NHA | IGH1 | IGH12 | IGH3 | IGH7 | GY082 |
| Knockmaa Quarries | County Geological Site | IGH1 | IGH8 | IGH12 | | GY083 |
| Knocknagreana | County Geological Site; may be recommended for Geological NHA | IGH11 | | | | GY084 |
| Lackavrea | County Geological Site | IGH5 | IGH6 | | | GY085 |
| Leenaun | County Geological Site; may be recommended for Geological NHA | IGH7 | | | | GY086 |
| Letterfrack Granite | County Geological Site | IGH11 | | | | GY087 |
| Lettershinna Hill | County Geological Site | IGH11 | | | | GY088 |
| Levally Lough | County Geological Site; may be recommended for Geological NHA | IGH1 | IGH7 | | | GY089 |
| Lippa | County Geological Site | IGH11 | | | | GY090 |
| Loch na gClocha Ballagh | County Geological Site | IGH11 | | | | GY091 |
| Loch na hUillean – Lochán an Bhurca | County Geological Site | IGH11 | | | | GY092 |
| Lough Corrib | County Geological Site; recommended for Geological NHA | IGH14 | IGH7 | | | GY093 |
| Lough Coy | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY094 |
| Lough Lurgeen Bog/Glenamaddy Turlough | County Geological Site; recommended for Geological NHA | IGH1 | IGH7 | IGH16 | | GY095 |
| Lough Nafooey Waterfall | County Geological Site | IGH4 | IGH14 | | | GY096 |
| Lough Nahasleam | County Geological Site | IGH5 | IGH11 | | | GY097 |
| Lough Namackanbeg | County Geological Site; recommended for Geological NHA | IGH14 | | | | GY098 |
| Lough Oorid | County Geological Site; may be recommended for Geological NHA | IGH6 | | | | GY099 |
| Mace Head | County Geological Site; recommended for Geological NHA | IGH6 | IGH11 | IGH15 | | GY100 |
| Mannin Bay | County Geological Site | IGH13 | IGH7 | | | GY101 |
| Mannin Thrust | County Geological Site; recommended for Geological NHA | IGH4 | IGH5 | | | GY102 |
| Maumeen | County Geological Site | IGH5 | IGH6 | | | GY103 |
| Maumtrasna | County Geological Site; recommended for Geological NHA | IGH7 | IGH8 | | | GY104 |
| Moran's Cave | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY105 |

| Site Name | Designation | IGH Primary | IGH Secondary | IGH Third | IGH Fourth | GIS Code |
|---|---|---|---|---|---|---|
| Murvey | County Geological Site | IGH11 | IGH6 | | | GY106 |
| Oldchapel Quarry | County Geological Site | IGH8 | | | | GY107 |
| Oughterard Granite | County Geological Site | IGH11 | | | | GY108 |
| Oughterard – Owenriff Falls | County Geological Site; may be recommended for Geological NHA | IGH6 | IGH8 | | | GY109 |
| Owenduff Bridge | County Geological Site; may be recommended for Geological NHA | IGH4 | | | | GY110 |
| Park Esker | County Geological Site | IGH7 | | | | GY111 |
| Peterswell Turlough | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY112 |
| Pollaloughabo | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY113 |
| Pollbehan | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY114 |
| Pollnadirk | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY115 |
| Pollnahallia | County Geological Site; recommended for Geological NHA | IGH7 | IGH12 | | | GY116 |
| Rahally M6 Road Cut | County Geological Site | IGH8 | | | | GY117 |
| Rahasane Turlough | County Geological Site; recommended for Geological NHA | IGH1 | | | | GY118 |
| Roevehagh M18 Road Cuts | County Geological Site | IGH8 | | | | GY119 |
| Ross Demesne – Ower Esker | County Geological Site | IGH7 | | | | GY120 |
| Roundstone Granite | County Geological Site | IGH11 | | | | GY121 |
| Rusheenduff | County Geological Site; may be recommended for Geological NHA | IGH11 | | | | GY122 |
| Sellerna Bay | County Geological Site | IGH6 | IGH11 | IGH15 | | GY123 |
| Shannapheasteen Quarry | County Geological Site | IGH6 | IGH11 | | | GY124 |
| Streamstown Bay Marble Quarry | County Geological Site; may be recommended for Geological NHA | IGH5 | IGH15 | | | GY125 |
| Streamstown Peat | County Geological Site | IGH7 | | | | GY126 |
| Suck River Callows | County Geological Site | IGH14 | | | | GY127 |
| Summerville Lough | County Geological Site | IGH1 | IGH16 | | | GY128 |
| Teernakill South | County Geological Site | IGH15 | | | | GY129 |
| Toormore M6 Road Cut | County Geological Site | IGH8 | | | | GY130 |
| Tully Shore | County Geological Site | IGH11 | IGH6 | | | GY131 |
| Two Mile Ditch Quarry | County Geological Site | IGH8 | | | | GY132 |
| Tynagh Mine | County Geological Site | IGH15 | IGH6 | | | GY133 |
| WIlliamstown Turloughs | County Geological Site; recommended for Geological NHA | IGH1 | IGH16 | | | GY134 |

## 1.2 Rejected, Combined and Renamed Sites

A range of sites had been previously flagged for consideration in the IGH Master Site List, and some were assessed as unsuitable for County Geological Site status in this audit. Others have been combined and some have been renamed. As these sites have been in the public domain previously as provisional listings, there is some more detailed explanation of why they have been rejected or combined in Appendix 10, for reference purposes. Additionally, new sites that were visited but then rejected are also listed here.

An Ghualainn
Anglingham Quarry
Ballygar Bog
Bunnahown
Carna
Coolcam Turlough
County Council Quarry near Gort
Crookmoithan
Dawros Gabbro
Finavara-Aughinish
Glann
Kiltevna Springs
Kylemore Abbey Esker
Lough Nahasleam metagabbro
Maghera Cornstones
Maumeen (Tungsten)
Maumfin
McGrath's Quarry, Cong
Murvey Quarry
Na hUilliní
Oranmore Bay
Rinville
Roundstone
Tawin Island
Top Quarry, Ballinasloe
Twelve Bens
Waterloo Bridge Synform

# 2. Galway Council Policies regarding geology and geological heritage

The completion of this geological heritage audit will ensure that the listing of Galway's County Geological Sites is provided for inclusion in the new County Development Plan (CDP) with a robust selection of sites that are genuinely important in County Galway. Whilst some are candidates for NHA designation in the future, many new sites that are purely of local, Galway, importance have been added to previous draft versions supplied to the Heritage Officer. Equally some sites have been rejected following the field auditing process (see Appendix 10 for details).

### Existing Objectives relating to Groundwater

The CDP puts groundwater and source protection firmly in frame with relation to the Water Framework Directive 2000, with extensive objectives and one in particular:

> **Objective WS 11 – Regionally and Locally Important Aquifers**
> Protect the regionally and locally important aquifers within the County from risk of pollution and ensure the satisfactory implementation of the groundwater protection schemes and groundwater source protection zones, where data has been made available by Geological Survey Ireland.

### Existing Objectives relating to Mineral Extraction

The CDP has detailed policies relating to mineral extraction and quarries in Chapter 6, and in particular the Geological Survey Ireland/Irish Concrete Federation Guidelines (Gatley and Parkes 2008) are referred to in DM Standard 37: Extractive Development - regarding guidelines for use:

> **a) Guidelines**
> Compliance with the provisions and guidance, as appropriate, contained within Section 261 of the *Planning and Development Act, 2000* (as amended), by Section 74 and Section 75 of the *Planning and Development (Amendment) Act 2010*, the DoEHLG *Quarries and Ancillary Facilities Guidelines* 2004 and the *EPA Guidelines for Environmental Management in the Extractive Sector* 2006. Where extractive developments may impact on archaeological or architectural heritage, regard shall be had to the D*AHG Architectural Conservation Guidelines 2011 and the Archaeological Code of Practice 2002* (including any updated/superseding documents) in the assessment of planning applications. **Reference should also be made to the *Geological Heritage Guidelines for the Extractive Industry 2008* (including any updated/superseding documents).**

### Recommended amendments to Objectives relating to Mineral Extraction

Our suggested place to include 'County Geological Sites' is in this objective:

> **Objective EQ1 – Protection of Natural Assets**
> Protect areas of geo-morphological interest, groundwater and important aquifers, important archaeological features Natural Heritage Areas and European Sites from inappropriate development.

Revised as:

> **Objective EQ1 – Protection of Natural Assets**
> Protect County Geological Sites, areas of geo-morphological interest, groundwater and important aquifers, important archaeological features Natural Heritage Areas and European Sites from inappropriate development.

In addition, Objective EQ2 is a relevant objective, with the first part (EQ2 c) relating to identified geological heritage of eskers as important. Also EQ2 recognises the need not to sterilise potential reserves by allowing one-off houses in the middle of them**, but is understood not to include those that are otherwise protected as natural heritage**, with any such designation taking precedence. Geological Survey Ireland is a critical

source of data for aggregate potential mapping, which has been completed for Galway and the whole country (see https://www.gsi.ie/en-ie/data-and-maps/Pages/Minerals.aspx#APM:).

**Objective EQ 2 – Management of Aggregate Extraction**
**(c)** Have regard to the *Landscape Character Assessment of the County* and its recommendations including the provision of special recognition to the Esker areas as referenced in Galway County Council *Galway's Living Landscapes – Part 1: Eskers;*

**(f)** Protect all known un-worked deposits from development that might limit their scope for extraction.

## Existing Objectives relating to Natural Heritage

The CDP has extensive objectives relating to natural heritage and biodiversity but the only one presenting detail on geological heritage is Policy NHB 5 and its paired objective:

**Policy NHB 5 – Geological and Geo-Morphological Systems**
Protect, conserve and enhance important geological and geo-morphological systems in the County and seek to promote access to such sites where possible.

**Objective NHB 4 – Geological and Geo-Morphological Systems**
Protect and conserve geological and geo-morphological systems, sites and features from inappropriate development that would detract from their heritage value and interpretation and ensure that any plan or project affecting karst formations, eskers or other important geological and geo-morphological systems are adequately assessed with regard to their potential geophysical, hydrological or ecological impacts on the environment.

The CDP also registers geological heritage in Development Standards in Chapter 13:

**l) Heritage and Biodiversity**
**Proposals in relation to heritage and biodiversity would include any recommendations for the site to be considered as part of the geological heritage of the County** and any proposed measures with regard to the protection and promotion of the environment and biodiversity, including any proposals for rehabilitation. The Council will require an Ecological Impact Assessment for all proposals within or in the vicinity of an SPA, SAC or NHA. Where a quarry development falls within a conservation designation, the developer is advised to consult with the DECLG prior to making an application. Evidence of such consultation should be submitted to the Planning Authority at application stage. It shall also be a requirement that all new proposals that are likely to have an impact on SAC or SPA shall be screened for the need to undertake a Habitats Directive. The Council will require that the operator of the quarry shall put in place an Environmental Monitoring System, to monitor all environmental standards (noise, dust, blasting etc.) on an on-going basis.

## Recommended amendments to Objectives relating to Natural Heritage

With this report and accompanying GIS data providing all relevant information, a new CDP should be able to include more specific objectives relating to County Geological Sites, and to include a listing of them in an appendix or a map of their locations as provided herein.

## Existing Objectives relating to Tourism

Tourism permeates many aspects of the CDP since it is a fundamental economic activity of County Galway, and is largely founded upon the superb geodiversity present throughout the county, but most especially obvious in the broader Connemara region. Chapter 4 of the existing CDP is the most relevant with detailed policies and objectives.

**Objective DS 5 – Protection and Management of the Assets of the County**
Protect and manage the assets that contribute to the unique visual and environmental character and sense of identity of County Galway, and which underpin tourism, heritage, biodiversity and quality of life.

## Recommended amendments to Objectives relating to Tourism

One objective which could be specified within the context of a broad strategic aim:

> To facilitate economic growth in the rural economy of the County in the form of appropriate farm diversification, green tourism and sustainable micro rural enterprise;

is to encourage some landowners of County Geological Sites, where appropriate, to view their landscape asset as a possible source of income from providing access, parking, interpretation, tours, or other actions in a niche area of geotourism, or even for a broader general tourist audience. Whilst this is already recognised to an extent within the table of strengths of the county, there is a need to acknowledge the County Geological Sites in particular, but also the wider geological and geomorphological landscape that they are representing, as a specific asset within tourism strategies and objectives.

An example specific objective where it is easy to integrate geological heritage is:

**Objective EDT 21 – Off Shore Island Tourism**
Facilitate the development of sustainable and green tourism which draws on the cultural, linguistic, archaeological, marine/coastal and ecological wealth of the off shore islands of County Galway while simultaneously safeguarding their integrity.

It would be simple to include 'geological and geomorphological' into this objective, and it would be more realistic in terms of what it is that makes islands attractive as visitor sites.

## Recommended amendments to Objectives relating to Geoparks

It is noted, and discussed elsewhere in this report, that Galway County Council is a strong supporter and partner of the proposed Joyce Country and Western Lakes Geopark. Creation of a Geopark, and its recognition by UNESCO is a powerful means of delivering multiple strategic objectives in tourism, community and rural development, economic activity and environmental protection of the physical asset. It is also noted that a UNESCO Global Geopark is of equivalent status to a World Heritage Site within UNESCO perspectives. For this reason it is strongly recommended that the Council's support for the Joyce Country and Western Lakes proposed Geopark is more strongly identified in the new CDP than it is in the current one (highlighted in bold) in the paragraph below:

> *4.12.2 Conamara Tourism*
> Tourism infrastructure and facilities in the County need to be constantly maintained and improved in order to sustain the industry locally and attract new and repeat visitors. The tourist experience of County Galway is strongly influenced by the availability of things to see and do. Therefore access to existing tourist attractions needs to be safeguarded and continued efforts made to strengthen tourist resources in the County. Fáilte Ireland is committed in this regard having recently delivered the Derroura Mountain Bike Trail Capital Investment Project near Oughterard. Fáilte Ireland is also currently spearheading a tourism initiative for County Galway in conjunction with Galway County Council through the *Connemara Infrastructure and Interpretation Plan 2012*.
> **Galway County Council supports the development of a Geo Park in the Clonbur area.** Furthermore, Galway County Council is fully supportive of the initiative to develop the Pearse Commemorative Centre in Rosmuc and realises the historical significance associated with it, especially in the lead up to the centenary celebrations of the 1916 Rising. Galway County Council is also supportive of the

Emigrants and Diaspora Commemorative Centre in Carna and realises the symbolic and historic significance of this project in the West Conamara Gaeltacht.

The process of applying for UNESCO Global Geopark status is a long and demanding one, requiring sustained commitment, especially for a County Council which is normally required to provide the necessary co-ordination, funding and infrastructural support needed to reach the UNESCO endorsement. There are also restrictive limits on the number of applications which can be in train from any one nation or territory at any one time. Consequently, the recommendation herein is strongly to maintain the current approach in relation to the World Class geological heritage of the Gort-Kinvara area and its numerous County Geological Sites. It would be impractical to seek to make this a separate Geopark, but to expand the Burren and Cliffs of Moher Geopark territory to include the terrain would make perfect geological and practical sense and therefore Objective EDT23 b) is strongly endorsed.

*4.12.6 The Burren*

The Burren is a major tourism, landscape, heritage and cultural asset in south County Galway and north County Clare and is on the tentative list of sites for Unesco World Heritage Site status. Its unique character which has evolved over many millennia, owing to the complex interaction of geology and physical landscape, natural beauty, wildlife, monuments and culture, makes it one of Europe's most cherished landscapes. The Burren Charter, which is a community led charter supported by the two Local Authorities is actively promoting the tourism, cultural and landscape assets of the Burren. Galway County Council will support the development of a Burren Lowlands Geopark which would support people and organisations in South/East Galway to ensure a cared for landscape and better understood heritage and sustainable tourism.

**Objective EDT 23 – East Galway, Lough Derg and The Burren**

**a)** Facilitate the sustainable development of East Galway, Lough Derg and the Burren as cultural and tourist destinations while simultaneously safeguarding their integrity;

**b)** Galway County Council to explore with Clare County Council, the proposal to add Burren Lowlands areas to the Burren and Cliffs of Moher Geopark;

**c)** Promote active collaboration between all stakeholders both in Co.Galway and adjoining counties and region.

# 3. Geological conservation issues and site management

Since **geodiversity is the often forgotten foundation for much of the biodiversity** which has been identified for conservation through SAC or NHA designation, it is unsurprising that many of the most important geological sites are actually in the same areas as SAC and pNHA sites. In these areas, the geological heritage enhances and cements the value of these sites for nature conservation, and requires no additional designation of actual land areas, other than citation of the geological interest.

**Broadly speaking, there are two types of site identified by the 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 Galway, the Knockmaa site is a large area of international importance for a suite of Pliocene karstic landforms intermixed with Quaternary and Holocene development.

It is also important from a geological conservation perspective that planners understand the landscape importance of geomorphological features which may not in themselves warrant any formal site designation, but which are an integral part of the character of County Galway. A lack of awareness in the past, has led to the loss of important geological sites and local character throughout the country. In County Galway a Landscape Characterisation Assessment was completed and incorporated into the County Development Plan 2003-2009, and carried through to the current plan. This provides a tool for planners to help maintain the character of the County and informs things like wind energy strategy. 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 in order to protect the scientific interest. In some cases, paradoxically, the geological interest may even be served better by a development exposing more rock. **The important thing is that the relevant planning department is aware of the sites and, more generally, that consultation can take place if some development is proposed for a site**. In this way, geologists may get the opportunity to learn more about a site or area by recording and sample collection of temporary exposures, or to influence the design so that access to exposures of rock is maintained for the future, or occasionally to prevent a completely inappropriate development through presentation of a strong scientific case.

In many counties, working quarries may have been listed because they are the best representative sections available of specific rock sequences, in areas where exposure is otherwise poor. 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 like Two Mile Ditch Quarry in Galway are now included as County Geological Sites in County Galway. These issues are briefly explored in a set of Geological Heritage Guidelines for the Extractive Industry, published jointly by Geological Survey Ireland and the Irish Concrete Federation in 2008.

A new quarry may open up a window into the rocks below and reveal significant or particularly interesting features such as pockets of fossils or minerals, or perhaps a karstic depression or cave. Equally a quarry that

has finished working may become more relevant as a geological heritage site at that stage in its life. It may need occasional maintenance to prevent overgrowth of vegetation obscuring the scientific interest, or may be promoted to the public by means of a viewing platform and information panel.

Nationally, specific 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. Few of County Galway's sites are really likely to require such an approach, but quarries such as Shannapheasteen have their own controls already in place by the owners.

**Waste dumping**

An occasional problem throughout the country, including in County Galway, is 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 or disused gravel pits, they may leach into the groundwater table as they 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. County Galway was included in a national scheme for Groundwater Protection in 2012, thus ranking the county land surface into vulnerability categories of 'Extreme', 'High', 'Moderate' and 'Low', and helping planners to assess which developments are suitable or not in some areas of County Galway.

**New exposures in development**

One less obvious area where the Local Authority can play a key role in the promotion and protection of geology is in the case of new roads. **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 a mind-set which is difficult to change. However, it leads to sterile and uninteresting roads that look the same throughout the country. Leaving rock outcrops exposed where they are intersected along the road, improves the character and interest of the route, by reflecting the geology and landscape of the locality. Sympathetic tree or shrub planting can still be done, but leaving bare rocks, especially where they show interesting features, not only assists the geological profession, but creates new local landmarks to replace those removed in the construction of the 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 Galway, the recent opportunity for such rock road cuttings has been dependent on the geological character of the part of the county. The works on roads around Galway itself, over recent years, have often not been deep enough to require cuttings. In big motorway works like the M6 approaching Galway from Dublin, superb quarry-style cuttings have been retained providing a landmark for the approach of the City and some have been selected as County Geological Sites. In more remote and mountainous areas, like the N59 improvements at Derrylea near Clifden, the rock cutting is included here as a County Geological Site. This is despite some of the original geological interest being lost, but new interest has been exposed. 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 Global Geoparks**

An extremely interesting development in geological heritage, not just in Europe but internationally, has been the rapid recent growth and adoption of the Geopark concept. A Geopark is a territory with a well-defined management structure in place (such as Local Authority support), where the geological heritage is of outstanding significance and is used to develop sustainable tourism opportunities. Initially it was largely a European Geoparks Network (EGN) but since 2004 has expanded worldwide as the Global Geoparks Network

(GGN). Geoparks were elevated to full United Nations Educational, Scientific and Cultural Organisation (UNESCO) status in 2015. 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. Geopark branding therefore helps promote the geological heritage resource so that the community can benefit from it. However, significant management support from local authorities, such as the County Council, has proven to be virtually essential across the network.

There are three UNESCO Global Geoparks on the island of Ireland; the cross-border Marble Arch Caves UNESCO Global Geopark in Counties Fermanagh and Cavan ( www.marblearchcavesgeopark.com ); the Copper Coast UNESCO Global Geopark in County Waterford [ www.coppercoastgeopark.com ]; and the Burren and Cliffs of Moher UNESCO Global Geopark in County Clare [ www.burrengeopark.ie ]. An application from Mourne Gullion Strangford in Counties Down and Armagh is due for submission to UNESCO in late 2019 and the Joyce Country & Western Lakes project in north Galway and south Mayo is progressing.

## 3.1 Joyce Country and Western Lakes Geopark Project

Joyce Country geopark has been a concept since 2008 and it made good progress through the work of volunteers. With Geological Survey Ireland as lead partner, and in collaboration with Údarás na Gealtachta, Galway County Council, Mayo County Council and Coillte, funds of €1.19 million were secured, mainly from the Rural Regeneration and Development Fund in the Department of Rural and Community Development under Project Ireland 2040 for the development of a geopark and to apply for UNESCO status in the future. The aspiring Geopark is being managed by Joyce Country and Western Lakes Geo Enterprise in Tourmakeady, Co Mayo. Four full-time staff will be employed until December 2021 for the development of the geopark and it is anticipated that a robust management and financial plan is in place by the end of 2021 for the long-term future.

Geological Survey Ireland and Galway County Council are already committed to the geopark project and this audit should contribute to ongoing promotion of the area's outstanding geological heritage and to local commitment to the geopark. The production of county geological publications based on this audit or geological map for tourists would help further enhance the geopark.

## 3.2 Gort - Kinvara lowland karst

Groundwater flooding events in Ireland predominantly occurs within the lowland karstified limestone areas of the west of the country, in low-lying basins and valleys. The flooding is inherently linked to the underlying bedrock geology where extensive interactions between ground and surface waters predominate, with sinking and rising rivers/streams common with surface water features absent completely in many areas. The dominant drainage path for many catchments is through the karstified limestone bedrock; however, the limited storage within such secondary porosity dominated rocks, means that the fractures or conduits within the limestone are unable to convey recharge fast enough during intense or prolonged rainfall, the result being surcharging of groundwater above the surface. This flood water is usually contained within low-lying topographic depressions known as turloughs, which represent the principal form of extensive, recurrent groundwater flooding in Ireland. In Ireland, the most susceptible region to groundwater flooding is the Gort Lowlands in South Galway which is a lowland karst catchment covering an area of approximately 500 $km^2$.

This lowland area between Gort and Kinvara is a very special landscape, and one of the most intensively karstified in the country. The drainage is virtually entirely subterranean aside for short stretches of river risings between sinks and turloughs. Sites such as Pollaloughabo and Pollbehan are windows into major conduits (with cross sectional areas up to 40 $m^2$) carrying water from Gort to Kinvara springs. There is also generally distributed flow in the uppermost 30 m or so of the pure bedded limestones, but there is also an active epikarst flow within the highly weathered top 2 metres or so of limestone. This is not normally easy to

see but is well demonstrated at Cappacasheen. The 15 sites selected across the Gort Kinvara lowlands exemplify this special area, although one boundary around the whole complex would have been a more desirable approach.

The combination of high rainfall periods with a saturated drainage system in 1994 and 1995 meant there was larger than usual flooded areas and politically it meant money was available to research the 'problem'. Consequently, and with subsequent research into flooding and groundwater generally the Gort Kinvara lowlands especially are one of the most studied areas of lowland karst in the world. However Groundwater demands and the Water Framework Directive have also led to much of East Galway's limestone lowlands being intensively studied and our knowledge is greatly increased as a result. Numerous sites in this audit have been included simply because these groundwater studies have made their importance and their interest known as geomorphological features.

The dramatic nature of the flooding associated with these turloughs has also led to considerable groundwater flooding events in more recent years, beyond their established upper seasonal boundaries following exceptional rainfall events. This has caused considerable damage and disruption. An extreme groundwater flooding event took place in the Gort Kinvara catchment during the winter of 2015/2016; this represented the most extensive groundwater flooding ever recorded here. A number of homes and farmyards were flooded with extensive damage caused by floodwaters. The nature of groundwater flooding gives rise to lands being inundated for extended periods of time in the order of many months; during the 2015/2016 flood, many homes and farms were cut off for extended periods of time due to roads becoming impassable – see photograph below. Large areas of farmland were flooded impacting on agricultural activity and causing livestock welfare concerns.

***Groundwater flooding in the vicinity of the Coole – Garryland Complex during January 2016 (Image courtesy Patrick Morrissey and OPW)***

Drew (2018) and Naughton *et al*. (2018) provide the most recent, excellent summaries for the Gort Kinvara area.

## 3.3 Connemara Marble

In a 2018 paper (Wyse Jackson, Caulfield, Parkes and Joyce 2018) Connemara marble was proposed as a Global Heritage Stone to represent Ireland. Connemara Marble is an iconic resource from Galway, which is an unusual green coloured marble that is very recognisable and widely used in decorative situations, especially in churches. It is only used inside buildings, as in external use it rapidly loses its colour and weathers very poorly.

There are many historical quarries that worked the marble in the past and some like Cregg Quarry and Streamstown Marble Quarry have been selected as County Geological Sites. There are others such as the Connemara Marble Quarry near Recess that is worked today for large sheets of polished marble to be used as wall panelling inside prestige buildings. The Streamstown Marble Quarry, run by Ambrose Joyce, is still worked using mostly small quantities of marble to make jewellery, ornaments, trophies and souvenirs, mainly for the tourist market. This output is sold in Moycullen in well established tourist stops.

Connemara Marble is a big feature used in the Museum Building of Trinity College Dublin, on pillars, balconies and stair banisters. An intensive study of this building, its construction, its architecture and the stone used has recently resulted in a scholarly study being published (Christine Casey and Patrick N. Wyse Jackson (eds) *The Museum Building of Trinity College Dublin: a model of Victorian craftsmanship.* Dublin, Four Courts Press). There is further information available on https://makingvictoriandublin.com/

## 3.4 Knockmaa Landscape

The Irish landscape has a distinct and striking imprint from the last Ice Age, which occurred between approximately 100,000 and 10,000 years ago. This can be seen in Galway in the ice sculpted corries and valleys of the Beanna Beola and the Maumturks, and the drumlin fields of south Galway and the Tuam area. So destructive and erosive was that glacial event, that it almost completely obliterated almost all record of the previous glaciations. Only a few sites survive countrywide, cherished and long-studied.

There are many features of the area surrounding Knockmaa Hill, between Headford and Tuam, that represent a glimpse of Ireland's pre-Pleistocene (pre Ice Age) landscape. Biostratigraphical dating of pollen assemblages within gorge and cave sediments at a locality near here in Pollnahallia Townland indicates a late Pliocene (c. 3 million years ago) or early Pleistocene (c. 2.5 million years ago) age.

The quarry at Pollnahallia itself exposes a sediment-filled gorge. The area around it and Knockmaa Hill also includes large shallow depressions, deep depressions, sand filled caverns, turloughs, isolated hills and other karstic features which must have developed in the late Neogene Period (c. 10 million years ago). The age of this landscape is an important element of the debate as to the age and origin of turloughs within the Irish landscape. It also has implications for understanding the variation in local effect on the landscape of Pleistocene glaciations, since here there is little modification, yet it is widely held that ice covered the area for a very long time period, and had a major influence.

The distinctive white sands and associated lignite exposed at Pollnahallia and in the area of Knockmaa have gained a wider reputation not only as a mineral resource, and also as a rare fragment of Ireland's landscape history. Extensive drilling and field investigations in the 1980's and 1990's in and around the sand pit at Pollnahallia revealed the network of gorges and caves in the limestone, over which are draped wind-blown sands, and later glacial sediments including till. Palynological results suggest that the organics (including lignites) infilling the base of the limestone gorge, are probably Pliocene in age. An organic bed lying on the surface of the limestone shows alternation of organic-rich sediment and clays and silts with sand horizons at the base of the gorge. This suggests deposition in water of varying energy regimes. At least 9 m of

windblown sands overlie these materials, with some partial glaciofluvial reworking. All of these materials were capped by a glacial lodgement till, which contained huge ice rafted blocks of limestone.

One striking element of the pollen recovered from sediments at Pollnahallia is the exotic nature of some of the flora. Many of the taxa recorded are no longer native to Europe, with many only occurring in North America and Asia today. The important biostratigraphical elements of the pollen diagram include the presence of typical late Cenozoic taxa: *e.g*. Sequoia, Swamp Cypress, Sourgum, Sweetgum, Sweet chestnut, Hop-hornbeam, Walnut, Japanese umbrella, Hickory and Wingnut. Such taxa are frequently found in Pliocene deposits in the Netherlands, and this correlation with the Netherlands taxa, the absence of pre-Pliocene marker taxa and the apparent climatic deterioration recorded in the upper part of the sequence, allows a probable correlation to be made to the Reuverian of the Netherlands, possibly Reuverian C (late Pliocene, 2.5-5.3 million years ago).

## 3.5 Mineralisation and mining in Galway

County Galway has an abundance of mineral deposits, with a variety of commodities and mineralization styles unmatched by any other county in Ireland. This variety reflects its complex geological history and consequent diverse bedrock geology.

Occurrences of mineralization are found widely in rocks of most ages in Galway, in various styles that reflect variable controls on their formation, including synsedimentary events, igneous intrusions, faulting and shearing. Host rocks include (i) Dalradian metasediments (lead, copper, sulphur, tungsten, gold), (ii) mafic intrusions of the Ordovician Connemara Metagabbro and Orthogneiss Complex (chromium, talc), (iii) veins and disseminations in the Caledonian Galway Granite and its wallrock (copper, molybdenum, uranium) and (iv) Carboniferous limestones (zinc, lead, barium, copper, silver).

Several small iron mines in east Galway, such as at Woodford and Eyrecourt, were among the earliest recorded metal mines in the county, exploiting bog iron ore in the 17$^{th}$ and 18$^{th}$ centuries. There was also a lead mine at Tynagh at least as early as the 17$^{th}$ century. However, Galway's mining history dates largely from the 19$^{th}$ century when numerous small lead, copper and pyrite (sulphur) deposits west of the city were developed. The resulting mines were typically small and short-lived with, at best, limited economic success. The more significant operations in the county included Glengowla (lead), the Glann district, including Curraghduff (copper and lead), Teernakill South (copper and sulphur) and Clements (lead). The latter appears to have begun production in the early 19$^{th}$ century but most production took place between 1907 and 1908.

In terms of size and production, the most important mine in Galway was the modern Tynagh mine, which produced lead, zinc and barite from 1965 to 1980. Tynagh was discovered following modern exploration in the area of the old 17$^{th}$-century Tynagh mine. It was was the first of the large Lower Carboniferous-hosted "Irish-type" Zn-Pb mines to be discovered and developed in the 20$^{th}$ century following commencement of modern exploration in Ireland in the late 1950s. As such it occupies an important place in Ireland's modern mining history and led the way to the country becoming a major producer of zinc and lead.

Other commodities reported from Galway, but as yet not mined, include tungsten, chromium, talc and uranium, typically found as small occurrences of limited extent and at best sub-economic grades, although exploration in the 1970s and 1980s has shown that tungsten is almost ubiquitous in the Dalradian strata of Connemara. Recent exploration in the county has focused mainly on gold as well as the well-known copper-molybdenum deposit at Mace Head.

# 4. Summary and Recommendations

## 4.1 Proposals and ideas for promotion of geological heritage in County Galway

This section briefly examines the existing objectives in the County Galway Heritage and Biodiversity Plan (2017-2021) relating to geological heritage and provides specific suggestions as to how these may be implemented, supported or enhanced by the audit of geological heritage sites in the county. There are many aspirational objectives in the plan that could very loosely be related in some way to this audit, but only two are specific about geology:
*Education and Training*
*Assist the business and industry sector with biodiversity and natural heritage education and training e.g. in the areas of ecotourism,* ***geotourism****, sustainable resource management, natural capital.*

*Research and Information*
*Promote and develop biodiversity and natural heritage mapping* ***e.g. geological heritage sites*** *and freshwater and marine heritage sites.*

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. The sites in Joyce Country in particular will help with geotourism there, but the recommendations in each site report about prospects for promoting the site to a general audience will help the Heritage Officer, the Council or local communities with prospective sites that can be promoted as attractive visitor destinations. For many where there is already a public access, this audit helps to make clear the geological interest in an amenity site which is undervalued, unexploited or simply not clearly understood.

## 4.2 Proposed future phases of this project

**Interactive planning tool**
It is proposed that this report and all of the County Geological Site reports should be made into an interactive tool for better use by planners and other staff within Galway County Council. Hyperlinks should be added to bring the reader to individual site reports from within the document itself.

**Film and audio projects**
Two digital media resource development projects funded by Galway County Heritage Forum, Galway County Council and The Heritage Council saw the production of DVDs between 2004 and 2008. These DVDs focused on 3D animations and interactive aspects of Connemara geological landscape, and in particular the Twelve Bens and the Dog's Bay area. More of such resources should be added, in particular short films (2-5 minutes long) about specific sites and geoheritage features of interest or landscape interpretations that can be added to pins on website https://galwaycommunityheritage.org/ and used on the Vimeo channel.

**Educational workbooks**
Existing Heritage Office workbooks for Primary School level children (on Alcock and Brown Landing Site and the Battle of Aughrim) should be used as templates for the creation of geological heritage based workbooks that make use of the Audit data but develop it further in strong alignment with the curriculum.

**Leaflets**
No existing leaflets on the geological heritage of County Galway are known, other than the Geoschol one included as an appendix here. There is scope for further development of additional leaflets covering

different geological heritage areas. Any leaflets produced could be made available as PDF downloads on the Council's website to avoid large costs of printing. It is suggested that any leaflets as online pdfs can also be made interactive with internal links to other pdfs and resources, especially on the Galway Heritage website.

**New media**

There are increasing numbers of examples of new methods of promoting Geoscience, via mobile phone applications and other electronic media. Self-guiding apps on specific sites would be one of these, such as those produced by Ingenious Ireland for Dublin city geology and the app for tourists in the Burren and Cliffs of Moher UNESCO Global Geopark. Such products would require considerable effort to produce and imaginative effort, to link sites in any coherent ways, other than simply by their county.

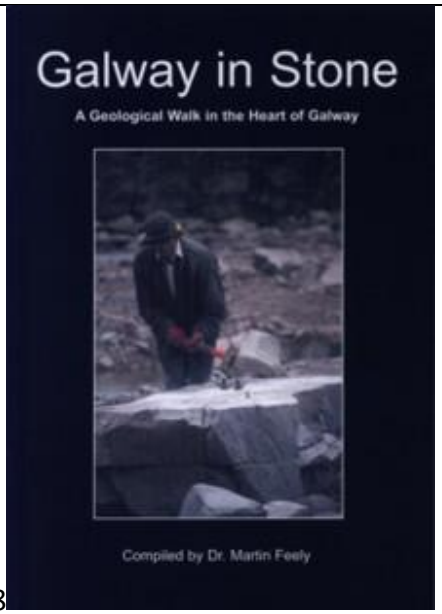
It is recognised that apps have a relatively short lifespan and need renewal or replacement as technology develops rapidly. However, 'reading the landscape' type products have great potential.

**Reading the landscape**

It is recommended that geological heritage and County Geological Sites be integrated into any future iterations of the 'Reading the Landscape' book or the related training course that has been produced by Galway County Council.

**Guides**

There are several guides including sections on the geology of County Galway. These include Galway in Stone - A Geological Walk in the Heart of Galway, (Feely *et al*. 2002) [plus a revised version]; Geology of Ireland: A Field Guide (Meere *et al*. 2013); A Geological Guide to the Granites of the Galway Batholith, Connemara, Western Ireland (Feely *et al*. 2006); and Galway's Living Landscapes: Eskers Pt. 1 (Hennessy *et al*. 2010)

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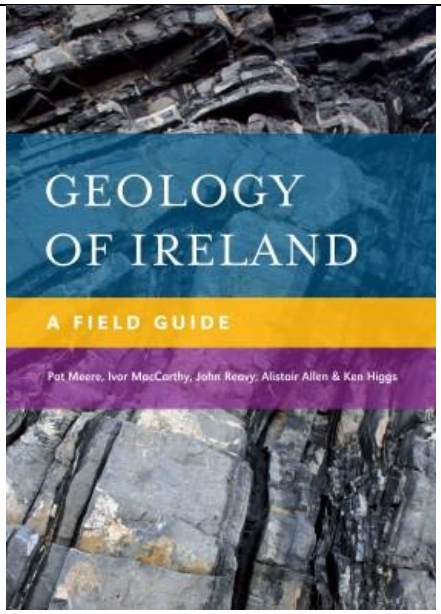
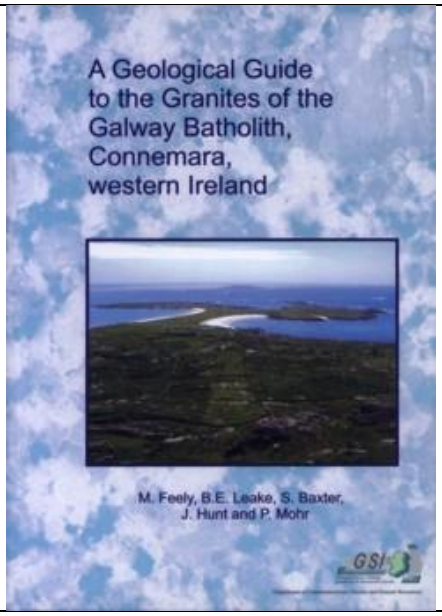
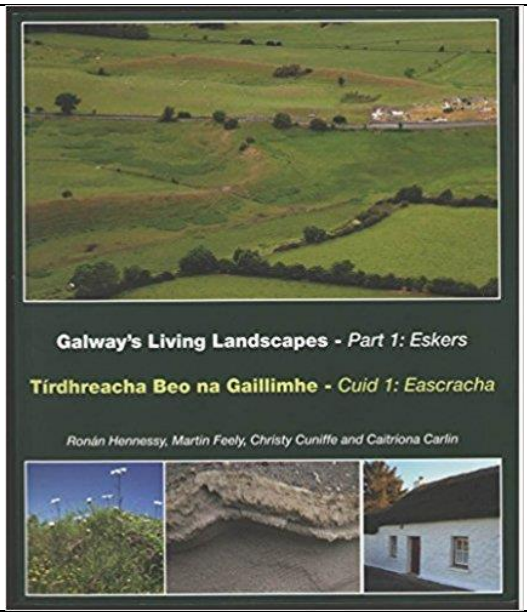





The 1:100,000 GSI map report for Sheets 10, 11, 12 and 14 cover County Galway and are an essential resource.

There is scope for guides at different levels of detail and accessibility to non-specialists. A wide range of leaflets, booklets, books and other media are all feasible, but the research and production of appropriate text and images is a difficult task to do well without appropriate experience, and adequate time and resources. It is suggested that **with only modest editing and reorganisation the main content of this report would distil into a good general guide to the geological heritage of County Galway**, in a broadly similar style to those books produced for Sligo, Fingal, Waterford, Roscommon, Clare and Longford following audits in those counties.

**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 a place is preferred 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.


The extensive promotion of the Wild Atlantic Way by Fáilte Ireland has recently led to a widespread installation of information panels at positions of interest and viewpoints etc. Whilst those we have seen are well designed and attractive, it seems that little Geoscience content has been included, and this is a wasted opportunity when the very scenic features people are stopping for, are not explained in favour of historical or cultural asides.

**Museum exhibitions**

As a result of the work to produce this report, the material for a panel-based exhibition has been largely compiled. With some extra research covering human dependence on geology and resources, an interesting exhibition can be put together for display in the Galway Council Offices, County Library branches or other venues. The model followed was that used for Carlow, Dun Laoghaire-Rathdown, Waterford, Wicklow, Longford etc. The James Mitchell Museum at the National University of Ireland Galway currently hosts a selection of fossils, minerals and rock samples from County Galway. However, access is not always available, and the apparent support from the NUIG authorities to make it a public attraction is not forthcoming.

**Earth Science Ireland Group and magazine** [www.earthscienceireland.org]
Earth Science Ireland was an all-Ireland group promoting awareness of Earth sciences and supporting educational provision in the subject. A main vehicle for the efforts was the twice a year magazine *Earth Science Ireland.* Sadly, this organisation has ceased operating but the magazines remain available online, and include various articles relating to Galway.

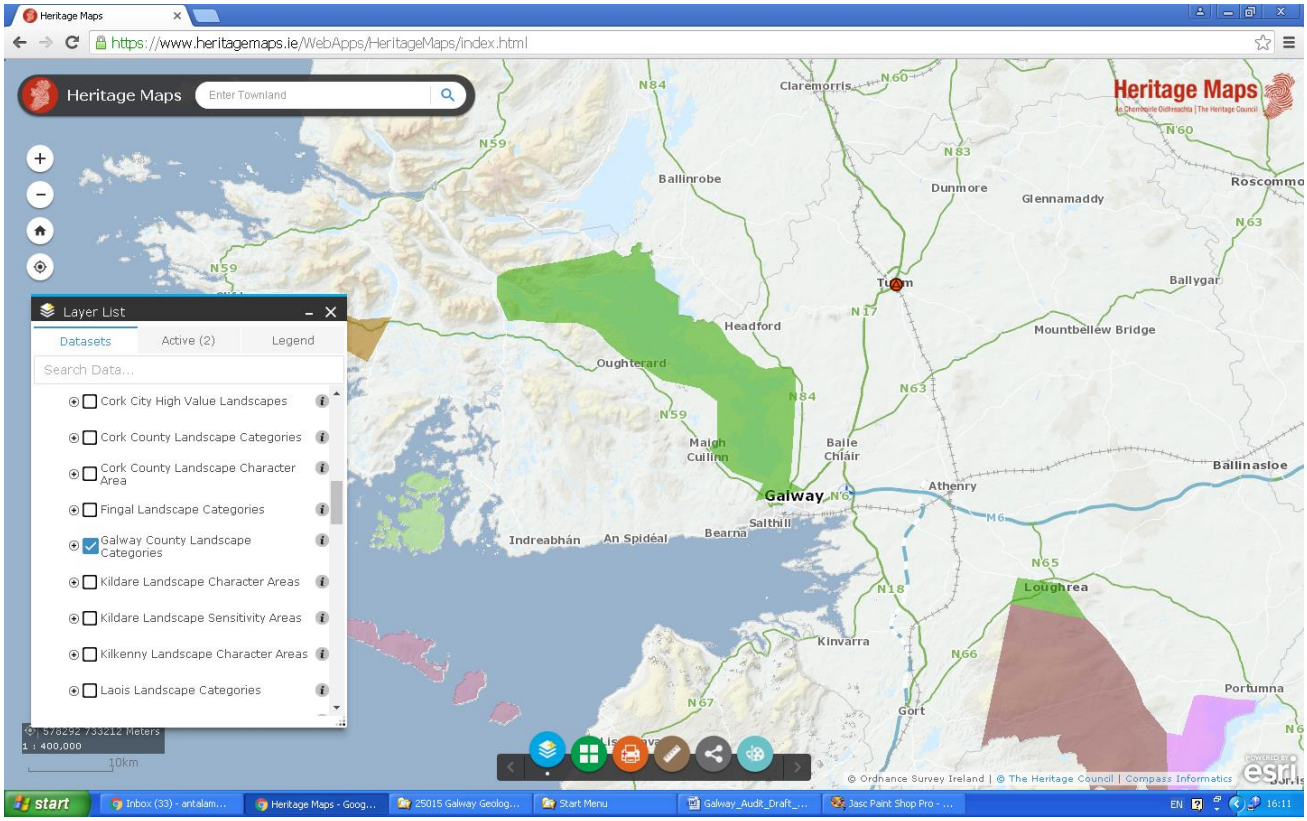
**Geoschol website [**www.geoschol.com]
Geoschol is an educational project, now essentially represented by a website, which was largely aimed at producing educational materials on geology for primary schools. A four page pdf summarising the geology and some highlights of County Galway is already part of the available material (see Appendix 6). Working links to the Heritage section of County Galway Council's website, as well as to other heritage websites, should be established.

**Geological Heritage Research Archive**
If the Heritage Officer wanted to do something similar to that produced in the Burren and Cliffs of Moher Geopark, with downloadable (or links to) free access papers, then a lot of groundwork is already provided by the reference lists in this audit. Making available technical references of direct relevance to County Galway geology and geomorphology will assist many users and researchers into the future. However, the literature is so extensive, and much is very specialist in nature, that a geological heritage section with a select bibliography pdf on the Heritage web pages for Galway might suffice for most users with general interest in heritage.

**Maps**
It is hoped that geological heritage sites as a data layer might be adopted by Ordnance Survey Ireland in their future paper map editions of the 1:50,000 Discovery Series, for all counties where an audit has been completed (similar to the East-West Mapping maps of Wicklow, Mayo etc. which include such data from Geological Survey Ireland).

**Ordnance Survey Geohive**
The Ordnance Survey website Geohive now offers a superb resource with maps at different scales, air photos and an enormous range of datasets available to peruse online in a GIS viewer. The Geological Survey Ireland data on bedrock, Quaternary geology, minerals, water and geological heritage sites is already freely available, along with NPWS and other protected site data. It draws on live data from Geological Survey Ireland, NPWS etc. http://map.geohive.ie/mapviewer.html

**Heritage Council Heritage Viewer**
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 off shore. This viewer allows you to look at a wide range of built and natural heritage data sets in map form. The outlines of and data on each individual County Geological Site in Galway will be visible on the HeritageMaps.ie viewer once the audit is completed.


Heritage Maps
https://www.heritagemaps.ie/WebApps/HeritageMaps/index.html
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Legend
Search Data...
Cork City High Value Landscapes
Cork County Landscape Categories
Cork County Landscape Character Area
Fingal Landscape Categories
Galway County Landscape Categories
Kildare Landscape Character Areas
Kildare Landscape Sensitivity Areas
Kilkenny Landscape Character Areas
Laois Landscape Categories
Claremorris
Ballinrobe
Dunmore
Glennamaddy
Roscommo
Ballygar
Tuam
Headford
Mountbellew Bridge
Oughterard
Maigh Cuilinn
Baile Chláir
Ballinasloe
Athenry
Galway
Salthill
Bearna
Indreabhán
An Spidéal
Loughrea
Kinvarra
Portumna
Gort
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# 5. A summary of the Geology of County Galway

## 5.1 Concise, simple summary of the geology of County Galway

Galway is county of two contrasting halves. East Galway is dominated by plains, with bedrock of Carboniferous Limestone underlying. The limestone is heavily karstified in places, often showing evidence of pre-glacial weathering processes. Groundwater is important in this area, with many turloughs. A thin veneer of glacial sediments masks some of the older landscape features but limestone walls and rich grassland are evidence that there are relatively few drumlin fields like counties to the east and north. Only in the south, in Slieve Aughty, are there older Silurian and Devonian rocks exposed in the uplands. The western half of Galway is by contrast, incredibly geologically diverse. The oldest, Precambrian, rocks are highly deformed, and form the backbone of Connemara. They are known as the Dalradian inlier and are part of an assemblage of ancient crustal segments, or terranes, which were assembled during the Silurian to form the shape of Ireland that we know today. Ordovician and Silurian rocks from marine environments form north Galway (and South Mayo) are faulted against Connemara. To the south of the Twelve Bens and Maumturk metamorphic spine, there is a massive area of Devonian granite intrusions in south Connemara, which reveal a very complex history. Glacial erosion shaped the mountains, and glacial deposits drape the lower ground. The power of the sea and the resistance of different rocks has been a significant control on the shape of the Galway coast, and its islands.

## 5.2 More detailed summary of the geology of County Galway

East Galway is dominated by plains underlain by bedrock of Carboniferous Limestone. The limestone is heavily karstified in places, often showing evidence of pre-glacial karstic weathering processes, such as between Headford and Tuam, including at Pollnahallia where wind-blown sands may have filled a cave and a gorge millions of years ago. Groundwater is important in this area, with many turloughs, as well as flood risk in winter periods. A thin veneer of glacial sediments masks some of the older landscape features but the presence of limestone walls and rich grassland are evidence that there are relatively few drumlin fields, features common in Counties to the east and north. However eskers, formed by rivers beneath the ice sheets clearly prove that east of Galway was ice covered during the Quaternary Period.

Only in the south, in Slieve Aughty are there older Silurian and Devonian rocks exposed in the uplands. Slieve Aughty is one of many inliers of older Silurian rocks surrounded by younger rocks across the Irish Midlands. During the Carboniferous Period they were probably islands in the warm tropical sea that formed the widespread limestone rock so familiar throughout Ireland.

West Galway is by contrast, incredibly geological diverse. The oldest Precambrian rocks are highly deformed and form the backbone of Connemara. This metamorphic succession, termed Dalradian, has many different rocks types included in a highly deformed very complex structure. The best known rocks are the quartzites which now form the Twelve Bens and the Maumturks as they are more resistant to erosion than the surroundings schists and marbles. The famous Connemara Marble Formation is a thin unit which has been economically important and is now iconic for Connemara and Ireland. Faulted against the Dalradian are various Ordovician and Silurian sequences. These were largely marine rocks formed in the margins of the Iapetus Ocean adjacent to an ancient part of what is now North America. Collectively, they are part of an assemblage of ancient crustal segments, or terranes which were assembled during the Silurian to form the shape of Ireland that we know today.

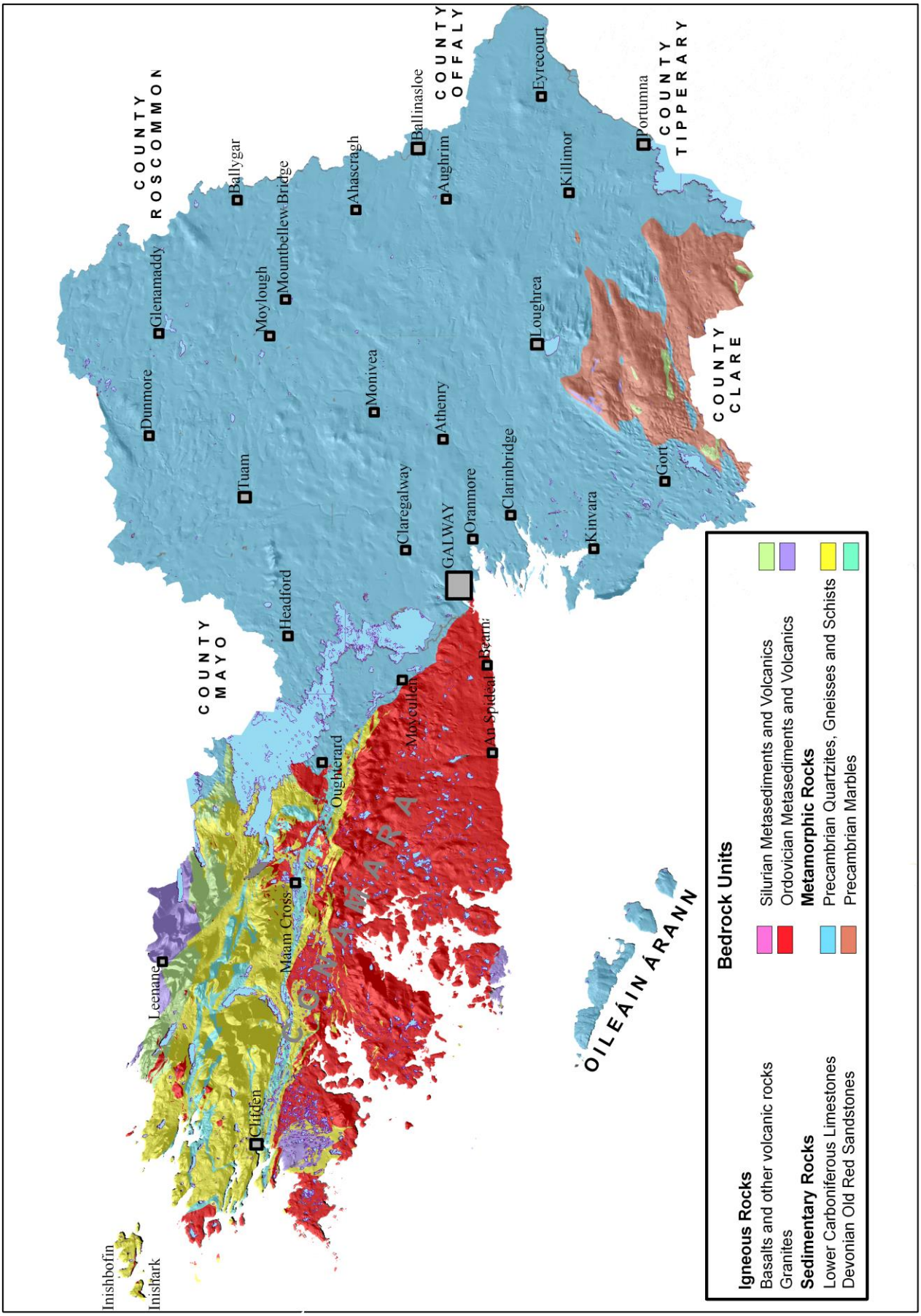
To the south of the Twelve Bens and Maumturks metamorphic spine, there is a massive area of Devonian granite intrusions in south Connemara which reveal a very complex history. Three different blocks have been faulted up at different relative levels from within the crust, and the whole of the ‘Galway Granite’ is made up

of multiple granite bodies intruded over some 30 million years. There is a variety of granite types, with many associated mineral deposits such as at Shannapheasteen Granite Quarry and Mace Head.

During the last 2.6 million years, glaciation had a major effect on the landscape of today. Glacial erosion shaped the mountains, with corries and the fjord of Killary Harbour, and glacial deposits such as eskers and drumlins draping the lower ground. The power of the sea and the resistance of different rocks has been a significant control on the shape of the coast and its islands.

| *Age (Million Years Ago)* | *Era* | *Period* | *Events in County Galway* | *If this timescale was a Day long ...* |
|---|---|---|---|---|
| 2.58 | Cenozoic | Quaternary | Several ice ages smothering Galway, followed in the last 10,000 years by the spread of vegetation, growth of bogs and arrival of humans. Sculpting of corries and U-shaped valleys in the Twelve Bens and Maumturk mountains. Deposition of (till) boulder clay in drumlins and till plains, as well as sands and gravels in eskers, fans and deltas. Dissolution of limestone beneath Quaternary sediments. | The ice ages would begin 38 seconds before midnight |
| 23.03 | | *Neogene* | *No record of rocks of this age in Co Galway.* | Begins at 11:52 pm |
| 66 | | Palaeogene | Erosion, especially of limestone. Caves, swallow holes, cavities and underground streams developing in the lowlands of south and east Galway. Deposition of sediments and associated vegetative remains at Pollnahallia, near Tuam. | The Palaeogene Period begins at 11.40 pm |
| 145 | Mezozoic | *Cretaceous* | Erosion.<br>*No record of rocks of this age in Co Galway.* | 11.15 pm |
| 201 | | *Jurassic* | Uplift and erosion.<br>*No record of rocks of this age in Co Galway.* | The age of the dinosaurs, starting at 10.55 pm |
| 252 | | *Triassic* | Desert conditions on land.<br>*No record of rocks of this age in Co Galway.* | 10.42 pm |
| 299 | Palaeozoic | *Permian* | Desert conditions on land.<br>*No record of rocks of this age in Co Galway.* | 10.30 pm |
| 359 | | Carboniferous | Land became submerged, limestones with some shales and sandstones deposited in tropical seas across much of south and east Galway. Limestones remaining today are pure and unbedded in the majority, with smaller areas of muddier limestones in southeast County Galway. | Inundation of land by sea around 10.10 pm |
| 419 | | Devonian | Caledonian mountain building. Galway Granite and satellite granites, including Omey Granite, intruded, forming the mountains and rock basement of most of Connemara. | Granite intruded into west Galway, at 9.52 pm |
| 443 | | *Silurian* | Shallow seas, following closure of the Iapetus Ocean. Slates, greywackes, sandstones and shales deposited along the southern side of Killary harbour, and in Joyce Country. | Starts at 9.42 pm |
| 485 | | Ordovician | Sandstones, conglomerates, ignimbrites and mudrocks form around Lough Nafooey, and as far northwest at Killary Harbour. Volcanic metagabbros extruded near Ballyconneely, representing a magmatic arc there. Mafic and ultramafic rocks of Currywongaun and the Dawros peninsula, north of Clifden, emplaced.<br>Intrusion of Oughterard Granite. | Begins at 9.28 pm |
| 541 | | *Cambrian* | Opening of the Iapetus Ocean.<br>*No record of rocks of this age in Co Galway.* | Starts at 9.11 pm |
| 2500 | Proterozoic | *Precambrian* | Some of Ireland's oldest rocks deposited; sedimentary rocks, which later became metamorphic rocks such as gneisses, quartzites, schists and marbles, were deposited in northern Connemara, in a broad band between Lough Corrib and Inishbofin (Connemara Dalradian). | 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 Galway***




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

# 6 Acknowledgements

The authors would like to gratefully acknowledge the assistance of Marie Mannion, Heritage Officer from Galway County Council in the development of this project. Funding from the Heritage Council and Galway County Council is also acknowledged. We also acknowledge the many members of the IGH Programme Expert Panels who helped define the sites which were considered for County Geological Site status.

- Ambrose Joyce for all things Connemara Marble
- Alan Lees for information on Waulsortian Limestone quarries near Moycullen and on Oldchapel Quarry
- Barry Long for some helpful discussions / insights into specific sites and general geology of Connemara
- Pat McDermott for discussion and lots of work over the years at Gortgarrow Spring
- Miko Conneely for discussions on the landscape and karst around Kiltullagh-Gortgarrow
- Mattie Joyce for lots of helpful information about Levally Lough
- Dr Mike Simms, Natural History Museaum, Belfast, for detailed discussion about karst around Lough Corrib
- Gary McTigue and Damian McGivney for help and access to McTigues Quarries, Knockmaa Hill
- Oliver Mortimer and Trevor Mortimer for help and access to Mortimers Quarries, Knockmaa Hill
- Dr Pete Coxon, Trinity College Dublin, for discussion regarding Pollnahallia
- Henning Moe of CDM Smith, and Dr David Drew, Trinity College Dublin for discussion regarding the karst of Summerville Lough
- Nicky Mulchrone, Safety Officer at McGraths Quarry, Cong
- Michael Walsh for information on Derryoober Blast Furnace
- Stephen Ceelen for guidance at Hill 707
- David Reynolds, Roadstone Area Manager and his team at Two Mile Ditch Quarry

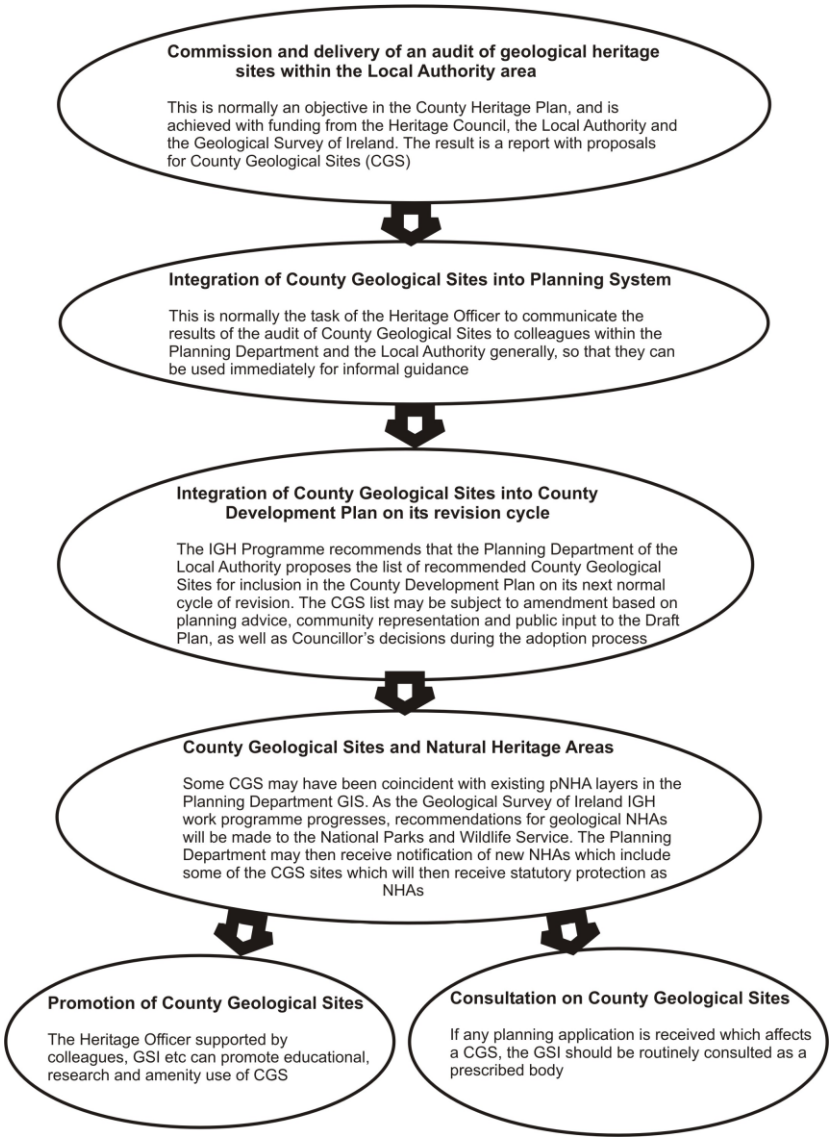
## Appendix 1 – Geological heritage audits and the planning process

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 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 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 Galway

**Shortlist of Key Geological References**

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

Appendix 2 is for the full reference list of all papers, books, articles and some unpublished reports etc. relating to the geology and geomorphology of County Galway that could be traced. Some papers that refer to regional geology may or may not be specifically relevant to County Galway.

**Quaternary References**

Due to the very extensive influence of glaciation on the Irish landscape, and the relative accessibility for study there is an enormous body of literature on the Quaternary, or Ice Age geology of Ireland, and Galway. The references in Appendix 3 cover this. They are split into references specifically covering sites or features in County Galway, and a section of national or regional papers which have some data from or on County Galway included.

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## Appendix 3 - Bibliography – County Galway Quaternary References

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**QUATERNARY REFERENCES ON A NATIONAL OR REGIONAL TOPIC WITH INFORMATION CITED ON SITES OR AREAS IN GALWAY**

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## Appendix 4 – Geological heritage versus geological hazards

Ireland is generally considered to be a country with very low risk of major geological hazards: there are no active volcanoes, Ireland's location on stable tectonic plates mean earthquakes are relatively rare and its recorded human history is not peppered with disastrous landslides, mudflows or other geological catastrophes. There are of course risks of one-off events such as tsunamis from collapse of volcanos in the Canary Islands, and this section briefly looks at the specific record and nature of geological hazards in County Galway and the relationship of the 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, and then quiet periods in between. The 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. However, in County Galway 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. There were over 75 events recorded in Galway. The relatively recent landslide at Derrybrien in the Slieve Aughtys, in 2003, illustrates the destructive forces associated with such events. See https://www.gsi.ie/en-ie/programmes-and-projects/geohazards/activities/Pages/National-Landslide-Mapping.aspx

**Flooding**
There are two types of flooding which need consideration. River flooding occurs inland when the rainfall exceeds the capacity of the ground to absorb moisture and the river channels cannot adequately discharge it to the sea. The OPW website, www.floods.ie, can be consulted for details of individual flood events in County Galway. Karstic flooding can occur when underground passages are unable to absorb high rainfall events. The Carboniferous limestone bedrock in southwest County Galway is particularly prone to karstic flooding, especially the ground between Kinvaras, Craughwell and Gort. Sites such as Caherglassaun Turlough and the Coole-Garryland Complex, which are inundated with groundwater every winter, illustrate all too starkly the destructive element of such flooding.

**Radon**
Radioactive minerals and gases at higher concentrations can be carcinogenic. Radon can seep into homes and workplaces and can be carried in water supplies. A map showing the areas predicted to be at particular risk from radon in Ireland, called High Radon Areas, can be seen on the EPA website at http://www.epa.ie/radiation/#.VRu9OVROPcs. The Radiological Protection Institute of Ireland was formerly responsible for this but has been merged with the EPA.

**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. Galway, particularly east Galway, is a county 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 Galway

This section is a brief summary of relevant Geological Survey Ireland datasets, to assist any enquiry concerning geology and to target possible information easily. Geological Survey Ireland has very many datasets, accumulated since it began mapping Ireland's geology in 1845. A Document Management System (called GOLDMINE) is freely available online, into which about half a million documents and maps have been scanned. This means that any user can search on screen for data of relevance to them. **Data is available free of charge**.

Key datasets include:

**GOLDMINE** (**G**SI **O**n**L**ine **D**ocument, **M**aps and **I**nformatio**N** **E**xplorer).
The Geological Survey Ireland online digital archive enables visitors to search its online data archive database and download full-size resampled pdfs and/or original high resolution TIFF image files. The data consists of: Scanned Capture of 450,000 pages and maps, including all of Geological Survey Ireland principal datasets, (Mineral Exploration Reports-Open File, Geotechnical Reports, boreholes & tests, Historic 6":1 mile and 1":1 mile Geological Maps, Geological Survey Ireland Publications, Bulletins, Published and Unpublished Reports, Groundwater Well Hydrographs, Marine Maps, Airborne Geophysical Maps, Mineral Locality Reports and Mine Record Reports and Maps). The database runs on Oracle© and the stored imagery is currently 1.4TB in size. https://secure.dccae.gov.ie/goldmine/index.html

**1:100,000 Map Report Series**
All historical, modern and other mapping has been compiled into very useful maps and reports that describe the geology of the entire country. Sheets 10, 11 and 14 covers all of County Galway.

**19th century 6 inch to the mile fieldsheets**
These provide an important historical and current resource, with very detailed observations of the geology of the entire country.

**19th century one inch 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 83, 84, 85, 86, 87, 93 – 98, 94, 95, 96, 97, 103-, 104, 105, 106, 107, 108, 114-, 115, 116, 117 and 124-126 cover County Galway. Each sheet or several sheets were accompanied by a Memoir which described the geology of that area in some detail. These still provide valuable records of observations even though interpretations may have changed with better geological understanding. Memoirs are scanned and uploaded on GOLDMINE.

Historical geological mapping is now available via a website:
http://www.geologicalmaps.net/irishhistmaps/history.cfm

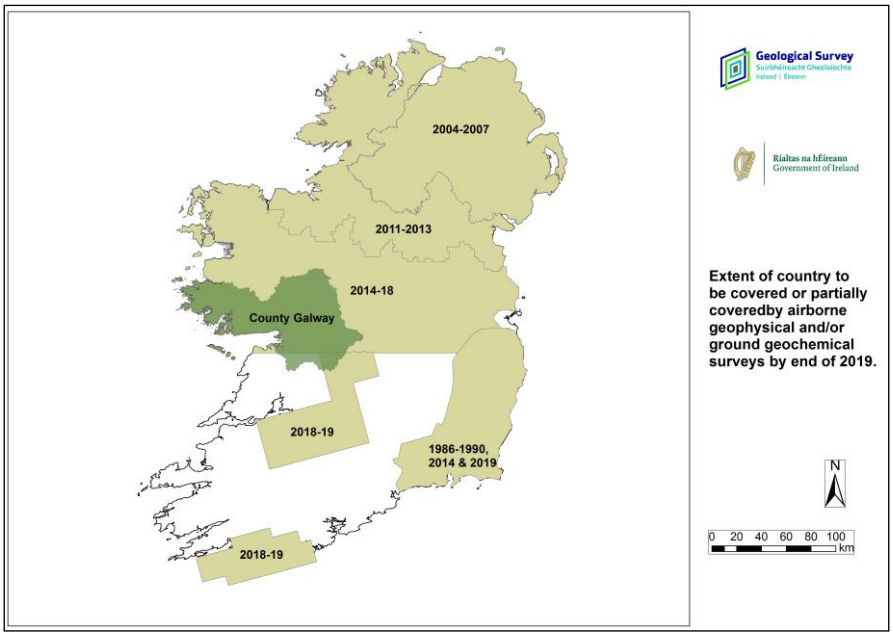
**Open File Data**
Each Mineral Prospecting Licence issued by the Exploration and Mining Division (EMD), currently of the Department of Communications, Energy and Natural Resources, carries an obligation on the exploration company to lodge records of the work undertaken, for the common good. These records are held by the Geological Survey and are available as Open File Data, once a period of time has expired. They may include geological interpretations, borehole logs, geophysical and geochemical surveys and so on. Licences relate to numbered prospecting areas, and these are available on a map from EMD. See also www.mineralsireland.ie

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

**Subsoils Mapping**
Since a Groundwater Protection Scheme has been completed by Geological Survey Ireland (2012) for the whole country, a modern map of the subsoil types and depths across County Galway exists, as well as the previously completed bedrock mapping. This provides a significant resource in general terms as well as for groundwater protection. Customised output is possible. Furthermore, detailed compilation of glacial geology datasets, including a revision published by Geological Survey Ireland in late 2014, now provides more data. Specific groundwater public supply sources such as Dunmore-Glenamaddy, Kilkerrin, Mid-Galway and Mountbellew have had more detailed studies completed for them.

Digital mapping of many different datasets is now available via an easy to use public viewer on the Geological Survey Ireland website: www.gsi.ie

**Tellus Mapping**
**Tellus is a regional mapping project, combining airborne geophysical and geochemical surveys to provide geoscientific information for the island of Ireland.** Since 2004, almost 50,000 km$^2$ of the island of Ireland has been surveyed or partially surveyed through the **Tellus** surveys, which support mineral exploration, environmental management, agriculture and research activity. Geological Survey Ireland aims to complete both geochemical and geophysical Tellus surveying of the country by the end of 2028. Geophysical and geochemical surveying has been carried out over most of County Galway. Data are freely available at https://www.gsi.ie/en-ie/programmes-and-projects/tellus/Pages/Data-and-Maps.aspx




**Historic Mine Records**
Abandonment plans and varied other material exists for the various mining ventures in the country. The range of data varies from single items for some historical mine sites in Connemara, to immensely detailed series of plans for more modern mine sites such as Tynagh Mine. Virtually all of these are scanned and available on GOLDMINE (see above) but there is occasionally additional material in the paper records, such as photographs, that did not get scanned. Additionally, the scanned material did not include some very historic or rare plans and documents that were stored in a separate archive.

**INFOMAR data**
The original Irish National Seabed Survey, carried out by Geological Survey Ireland and the Marine Institute (1999-2005), focused on deep-water mapping at the outer margins of Ireland's territorial seabed, moving closer shoreward over time. Its successor programme, INFOMAR (INtegrated mapping FOr the sustainable

development of Ireland's MArine Resource) is in the process of mapping inshore areas, having identified 26 priority bays, including Galway examples

Further information about INFOMAR data can be obtained on www.infomar.ie

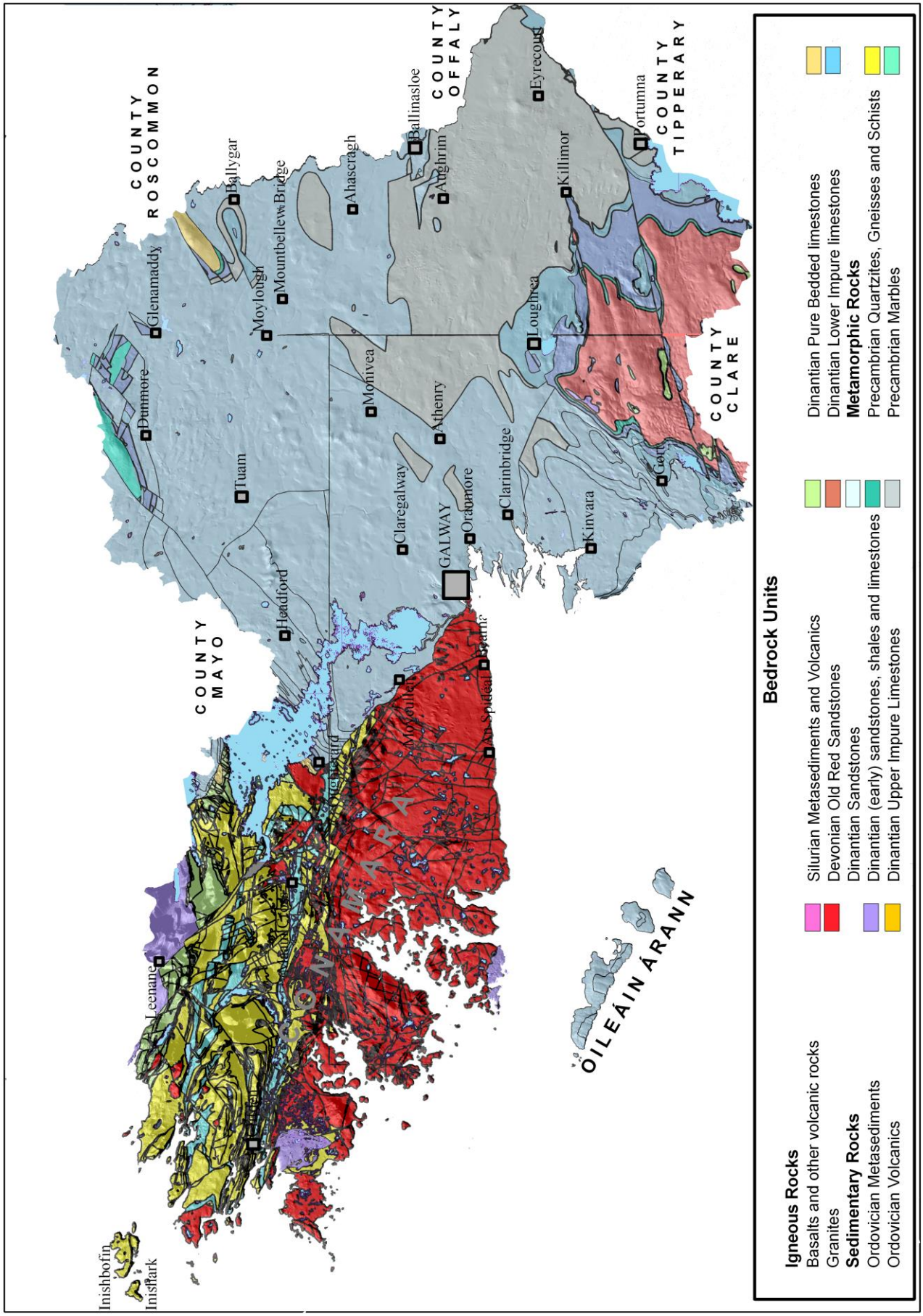
## Appendix 6 – Further sources of information and contacts

Geological Survey Ireland staff in the Geological Heritage and Planning Programme, can be contacted in relation to any aspect of this report. Marie Mannion, the Heritage Officer of Galway County Council is the primary local contact for further information in relation to this report. Other contacts include the Conservation Rangers of the National Parks and Wildlife Service, currently in the Department of Culture, Heritage and the Gaeltacht. The names and phone numbers of current staff may be found in the phone book, or at www.npws.ie.

**Web sites of interest**

www.gsi.ie - for general geological resources
www.geologicalmaps.net/ - for historical geological maps
www.geology.ie – the website of the Irish Geological Association who run fieldtrips and lectures for members, including many amateur enthusiasts
www.earthscienceireland.org - for general geological information of wide interest
http://www.iqua.ie - for information, fieldtrips, lectures etc in relation to Ireland's Ice Age history
http://www.progeo.se/ - for information about ProGEO the European Association for the Conservation of Geological Heritage
www.coastalhelicopterview.ie/ - national coastal photograph archive captured from helicopter

## Appendix 7 – Detailed geological map of County Galway



## Appendix 8 – Geoschol leaflet on the geology of County Galway

# GALWAY

**AREA OF COUNTY:** 6,148 square kilometres or 2,373 square miles

**COUNTY TOWN:** Galway

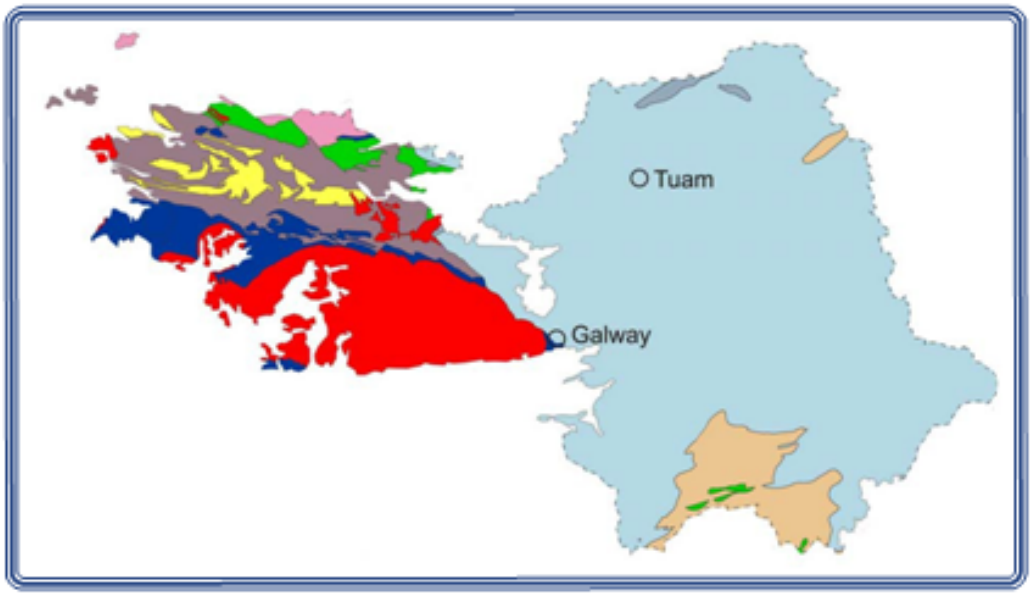
**OTHER TOWNS:** Athenry, Ballinasloe, Clifden, Gort, Loughrea, Oughterard, Portumna, Tuam.

**GEOLOGY HIGHLIGHTS:** Galway Granite, Connemara metamorphic rocks and mountains, Connemara marble, Glengowla Mine, Aran Islands

**AGE OF ROCKS:** Precambrian; Cambrian-Carboniferous; Tertiary

**Bencollaghduff, Twelve Bens, Co. Galway**

The ancient quartzite peaks of the Twelve Bens, deeply eroded by glaciers during the last Ice Age.




**Geological Map of County Galway**

**Pale purple:** Precambrian Dalradian rocks; **Pale Yellow:** Precambrian quartzites; **Pink:** Ordovician; **Dark blue:** Ordovician igneous & volcanic rocks; **Green:** Silurian; **Red:** Granite; **Beige:** Devonian sandstones and conglomerates; **Blue grey:** Lower Carboniferous sandstones; **Light blue:** Lower Carboniferous limestone.

## Geological history

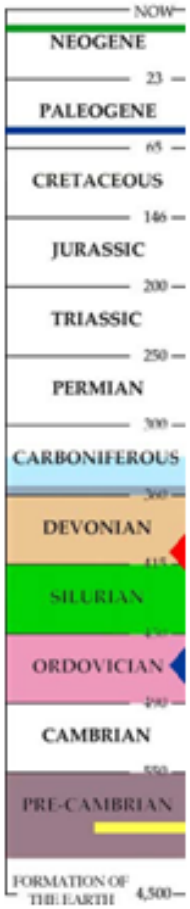
Galway has some of the most complex geology in the whole of Ireland. Ancient metamorphic rocks such as schist and gneiss (pronounced as 'nice') occur through Connemara from Galway City to Inishbofin. The whole of Connemara is a very big structure with massive folds. It is part of the Dalradian sequence that also occurs in North Mayo, Donegal and through into western Scotland. There are even older Precambrian rocks in a very few places exposed by massive faults. Many large areas, such as Connemara, are defined as terranes. These are sequences of rocks that were formed in one place and are now alongside other sequences that were originally formed a long way apart. Major faults in the Earth's crust have brought them together over millions of years.

The Twelve Bens of Connemara are made of metamorphosed sandstone, which is quartzite. They form hills because they are more resistant to erosion over long periods than the other rocks. Running along the base of the hills are areas of metamorphosed limestone, which is marble. Marble is white if the

**Drumlin at Salthill - this is a good place to see a cross-section through such a structure.**

limestone was pure, but the addition of a few impurities means that the Connemara marble has green bands through it.

The Galway Granite is found in south Connemara from Galway City through to Roundstone. It is not one single rock type, but was formed by the intrusion of nine or so large granite masses (called batholiths or plutons) about 400 million years ago. It was formed underground and the molten igneous rock cooled slowly. The rocks that covered it have since been eroded away.



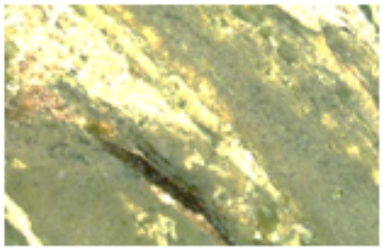

At the same time as the granite was injected below ground, Devonian age rivers were eroding hills and depositing sands and gravels in lower lying areas. Some of these sandstones and conglomerates are seen in Slieve Aughty in the south of the county. Appearing as small inliers, or 'windows' to see below these rocks, are Silurian age slaty rocks. Virtually all of Galway east of the city is covered by limestone, deposited in a shallow tropical sea around 330 Ma ago. This has been eroded down over millions of years, since it was formed and then raised to become land. Although it has some caves in it and some karstic features it has not become like the Burren in Clare because in the Ice Ages a thin veneer of sediment was deposited on most of it. So the limestone terrain of east Galway has good soils for grazing with neat fields and limestone walls. In the Aran Islands, the terrain is more like the Burren, with the only evidence of glaciations being some odd boulders of Galway Granite on the bare limestone pavement.

Rocks younger than the Carboniferous are found in only a few tiny patches in Co Galway (not shown on map). A few dolerite dykes, fractures up which volcanic lava moved around 60 Ma ago in the Paleogene (blue on timescale), have been found in the extreme west. Near Headford, pockets of sand and lignite (brown coal) around 3 Ma are preserved in deeply weathered limestone (green on timescale).

**Geological timescale showing age of rocks in Galway.**

## Galway fossils

The metamorphic and igneous rocks of Connemara do not contain fossils, but the limestone plains of east Galway include many fossils, as the limestone represents a former tropical sea, teeming with life. Some of the Ordovician and Silurian rocks between Killary harbour and the Connemara mountains do contain fossils of shells, trilobites, graptolites and nautiloids for example but only in certain places.



**Quarry at Streamstown, Clifden (left) where Connemara Marble (right) is extracted**

## Mining & Building Stones

Historical mining of lead, zinc and other minerals took place in many small mines in the 1800s, but especially around Oughterard and Maam. The tourist show mine at Glengowla is the best place to see how these mines operated. Stone extraction has been a feature of Galway for centuries with such diversity of rock types. Most notable are the Connemara marble quarries around Clifden and Recess. This marble has the mineral serpentine giving it a streaky green appearance, well known for ornamental uses. Limestone quarries near Galway City also produced Galway Black Marble – really a very dark polished limestone. In the 1950s revival of Irish mining, Tynagh Mine took special place as the first of the big new mines that produced metal ores in Ireland. Near Headford, some wind-blown pure sands collected in hollows and caves and have been quarried for glassmaking in recent decades.

## Suggested reading


• Martin Feely, 2002. *Galway in Stone. A Geological Walk in the Heart of Galway*. Geoscapes, Dublin.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Map adapted with permission from Geological Survey of Ireland 1:1,000,000 map 2003.
Image credits: Mike Simms 1; Matthew Parkes 3, 4 (left); Patrick Wyse Jackson 4 (right).



www.geoschol.com

Text by Matthew Parkes & Mike Simms

## Appendix 9 - Glossary of geological terms

| Geological term | Definition |
|---|---|
| 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. |
| Amphibolite | a metamorphic rock rich in the minerals amphibolite and plagioclase. |
| Anthracite | a coal of high rank, that is high in carbon and low in gas and volatile components. |
| Aquifer | a permeable water saturated rock unit. |
| Artesian Well | a well from which water flows under natural pressure without pumping. |
| Batholith | A large igneous intrusion (100 km² or more) |
| 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. |
| Blanket Bogs | bog covering a large, fairly horizontal area, which depends on high rainfall or high humidity, rather than local water sources for its supply of moisture. |
| Boulder Clay | unconsolidated, unsorted glacial deposits consisting of boulders and cobbles mixed with very finely ground-up rock or silt. Also known as till. |
| Bryozoa | invertebrates belonging to the phylum Bryozoa, ranging from Ordovician to present, often found as frond-like fossils. |
| 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. |
| Chironomid | a family of flies, similar in size and form to mosquitoes. |
| Coal Seam | a coal seam is a strata or bed of coal, outcropping over a wide area, but not necessarily very thick. |
| Crag and tail | a steep resistant rock mass (crag), with sloping softer sediments (tail) protected from glacial erosion or deposited as glacial debris on the crag's 'downstream' side. |
| Crinoid | a variety of sea-urchin, with a long flexible stem, usually anchored to the sea-floor and a body cup with arms which may be branching (a sea lily). |
| Delta | |
| Diamict/Diamicton | lithified, poorly-sorted deposits comprising clasts of various sizes in a mud 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. |
| Doline | circular/oval closed depression found in karst terrain. |
| 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. |
| Dyke | a sub-vertical sheet-like igneous intrusion, typically in-filling a fracture in the earth's crust |

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| Echinoderm | marine organisms with interlocking plates (skeletal) covered by spines. |
| 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 |
| 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. |
| Estavelle | Sinkhole on the path of a waterway whose flow can change according to the respective water levels, such that the estavelle acts as a discharge when water levels rise; and as a sinkhole when levels fall. |
| Eutrophic | lakes and similar habitats rich in organic and mineral nutrients, supporting abundant plant life, which in the process of decaying depletes the oxygen supply for animal life. |
| 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. |
| Flush/Flushing bog | wet soak or pool in a peat bog that receive mineral nutrients from sources other than rainfall, usually groundwater or flowing surface waters. |
| Fluvial | pertaining to a river or stream. |
| Fjord | a long, narrow arm of the sea bordered by steep cliffs: usually formed by glacial erosion. |
| Geodes | spherical to subspherical rock structures with an internal cavity lined with mineral materials. |
| 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. |
| Glaciomarine | sediment, which originated in glaciated land areas and has been transported to the oceans by glaciers or icebergs. |
| 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). |
| Gour pools | a cave pool feature that forms where water is ponded within a barrier or rim of calcite. |
| Gully | a deep valley created by running water eroding sharply into bedrock or subsoil. |
| Hum | residual, isolated hill formed through karst processes, sometimes stubby and smoothed out by later erosional processes, e.g. glaciation. |
| Hummock | a small hill or knoll in the landscape, which may be formed by many different processes. |
| Iapetus Ocean | ancient ocean that separated NW Ireland (Laurentia) from SE Ireland (Avalonia). Ocean closed 480-430 million years ago, and closure zone in Ireland is marked by the Iapetus Suture). |
| 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. |
| Inlier | area of older bedrock completely surrounded by younger bedrock. |

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| Interglacial | the time interval between glacial stages, or pertaining to this time. |
| Isthmus | a narrow strip of land adjoining two larger masses of land with water on each side |
| Joint | a fracture in a rock, which shows no evidence of displacement. |
| Kame | a mound or hill composed of sand and gravel deposited by meltwater derived from melting glaciers. |
| Kettle/Kettle hole | a depression in glacial outwash drift made by the melting of a detached block of glacial ice that was wholly or partially buried. |
| Lake basin | a lake basin is a geographic land area draining into a lake; also referred to as drainage basin or watershed. |
| Lava | magma extruded onto the Earth's surface, or the rock solidified from it. |
| Leucogranite | coarse-grained, light-colored, crystalline igneous rock with almost no dark minerals. |
| Leucosome | light-coloured quartzo-feldspathic band or zone found between dark-coloured melanosome in regionally metamorphosed or partially melted rocks. The leucosome represents the partially melted component containig quartz and feldspar, the melanosome the undissolved or unmelted mineral residue left over from original rock after removal of quartz and feldspar. |
| Limestone | a sedimentary rock consisting chiefly of calcium carbonate (CaCO3), 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. |
| Meander | a bend in a sinuous watercourse or river which forms when moving water in a stream erodes the outer banks and widens its valley, and the inner part of the river has less energy and deposits fine sediment. |
| Meltwater | water from melted snow or ice. |
| Meltwater channel | a channel cut by glacial meltwater, either under, along or in front of an ice margin. |
| Metamorphic | referring to the process of metamorphism or to the resulting metamorphic rock, transformed by heat and pressure from an originally igneous or sedimentary rock. |
| Metasediments | metamorphosed sediments. |
| Moraine | any glacially formed accumulation of unconsolidated debris, in glaciated regions, such as during an ice age. |
| 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. |
| Quaking bog | a bog formed over water or soft mud, which shakes underfoot |
| Raised bog | an area of acid, peaty soil, in which the centre is relatively higher than the |
| Skarn | calc-silicate rock formed by chemical reaction between limestone and adjacent rocks of different composition leading to replacement of original carbonate by calc-silicate minerals. |
| 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. |
| Speleothem | secondary mineral deposits formed in caves by flowing, dripping, or seeping water, e.g. stalagmite |
| Spring | the point where an underground stream reaches the surface. |
| Strata bound | confined to a single stratigraphic unit. |
| Stratigraphy | the study of stratified (layered) sedimentary and volcanic rocks, especially their sequence in time and correlation between localities. |

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| 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. |
| Turlough | a seasonal lake that fills and empties through springs and sinkholes. |
| Uvala | term used for large and complex dolines. |
| Volcanic Rock | any rock produced from volcanic material, e.g. ash, lava. |
| 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. |

## Appendix 10 – Rejected, Combined and Renamed Sites

A range of sites had been previously flagged for consideration in the IGH Master site list, and some were assessed as unsuitable for County Geological Site status in this audit. Similarly a range of additional sites were assessed in the audit, based on the authors' expert knowledge of County Galway's geology, especially in the main mountain areas of Joyces Country and Connemara (in 2017), the limestone lowlands portion at the northeast of the county (in 2018) and the Gort lowlands (in 2019). It was known, for example, that some quarry localities had not been adequately considered in the preparation of the IGH Master Site List. Other sites were visited on spec during fieldwork; some were then rejected.

It should be noted that in a number of cases in Galway, along with other counties, the original expert panel process of developing a Master Site List has created some of the issues described below. Some of the sites were poorly defined in the first instance and there were multiple names used for the same site in different themes. The rejected, or otherwise modified sites are listed below with brief notes as to why they were assessed as unsuitable for inclusion.

**An Ghualainn**
An Ghualainn is listed in the original Master List for Galway for an occurrence of a Devonian dacite dyke with coeval fault relationships. The dyke is part of the Ard Mhóir – Gabhla – An Gharmain (AGG) dyke set, one of the most extensive Late Caledonian dyke systems in Connemara. The dyke set strikes approximately north–south for at least 20 km between Galway Bay and Recess in a zone up to 600 m wide. The dyke complex is represented by the Ardmore CGS where the most significant features are very well displayed at a readily accessible location. An Ghualainn is not considered to add sufficiently to the geological interest to warrant a separate listing.

**Anglingham Quarry**
Historically, Anglingham Quarry and Menlough Quarry occupied the same quarry site that straddled the Anglingham townland and Menlough townland boundary. Today, the quarry area in Anglingham townland is a farm pasture site, with no noticeable trace of past quarrying activities. Early edition 25" scale OSI maps indicate a 'Lime Kiln' at the Anglingham quarry, and Anglingham Quay on the lakeshore, where stone was taken by boat to Galway City, via the River Corrib. As Menlough Quarry remains in existence, the Anglingham Quarry record in the IGH Master List will be included in the Menlough Quarry site report when Galway City is audited as this site falls within the City boundary.

**Ballygar Bog**
Ballygar Bog is situated immediately northwest of Ballygar Town, and is designated a Natural Heritage Area (site code 000229) based on the presence of both intact high bog and cutover bog. Upon visiting the site it was seen that the site is small and relatively inaccessible, and as the diagnostic features for which it has been designated are well demonstrated at other County Geological sites in the general region (*e.g.* Annaghbeg Bog, Carrownagappul Bog, Lough Lurgeen Bog) it is therefore not included as a County Geological Site.

**The restricted area of the intact dome of Ballygar Bog.**

**Bunnahown**

Bunnahown is included in the Master List as an example of the break-up of metagabbro by granitic gneiss, a feature of the Connemara Metagabbro and Orthogneiss Complex. The Metagabbro and Gneiss Complex was intruded during the D2 and D3 phases of the Grampian Orogeny, the gabbros followed by the felsic igneous rocks. Fracturing of the gabbros during deformation and intrusion of the felsic rocks led to net-veining of gabbro by quartz diorite and granite. Bunnahown contains numerous well-exposed examples of the intrusion and net-veining of metagabbro by quartz diorite gneiss. However, the CGS site at Lettershinna Hill, 3.5 km to the north, contains equally good examples of net-veining of metagabbro by quartz diorite. In addition, it has extensive exposure of the more restricted, late-stage K-feldspar orthogneiss. The Bunnahown site is reached via a private road and permission must be sought to enter. In contrast, the Lettershinna Hill site is on open ground beside a public road. As Lettershinna Hill has more features of interest and is more accessible, Bunnahown has been omitted.

**The Bunnahown site, with restricted access.**

**Metagabbro veins at Bunnahown.**

**Carna**

This undefined site is described in the Master List as containing "several Ordovician mingled plutonic exposures (Agmatites) east of Cashel". Two possible grid references are provided; both close to Carna village, but no lithologies of this kind were found there. The site is also described as being "east of Cashel" so this listing may be a reference to lithologies commonly observed in the Connemara Metagabbro and Gneiss Complex, where granitic rock is intruded into near contemporaneous metagabbro leading to apparent reaction between and mixing of felsic and mafic magma. Such lithologies are well displayed at Lettershinna Hill CGS.

**Coolcam Turlough**

Coolcam Turlough is situated adjacent to the Roscommon county boundary, 4 km west of Williamstown, and is designated a Special Area of Conservation based on the presence of a turlough. Upon visiting the site it was seen that the site is quite remote from roads and relatively inaccessible, and as the diagnostic features for which it has been designated are well demonstrated at other County Geological sites in the general region (*e.g.* Boyounagh Turlough, Croaghill Turlough) it is therefore not included as a County Geological Site.

**The southern edge of Coolcam Turlough.**

**Crookmoithan**
The Crookmoithan (the Crook Moithan Suite in Aucott 1966 and Date, 1969) site listed in the Galway County Geological Site Master List refers to Cnoc Mordáin, north of Cill Chiaráin. The name *Crookmoithan* is not referenced in any literature or maps relating to the area published in the recent times, nor is the name used as a placename. Cnoc Mordáin (354m) is the highest topographical landscape feature on the Galway Granite Batholith. The site was included in the IGH Master List for 'layering in the Galway Granite'. The mountain area is remote and difficult to access, and as two other sites hosting granite 'layering' are included as County Geological Sites (Dog's Bay and Lippa), the site is not included as a County Geological Site.

**Cnoc Mordáin viewed looking north from Flannery's Bridge on the R340 road.**

**Dawros Gabbro**
This site in the Master List is the same site as "Dawros (Cr)", described as Dawros CGS.

**Finavara-Aughinish**
The southeastern coast of Galway Bay was recorded in the IGH Master List as '*irregular and generally low lying, on drift-mantled limestone, with gravelly beaches and some salt marshes .... causeway to Auginish Island. This ends westward in cliffs cut in glacial drift, and in a bay on its northern shore Traught Beach has cobbles and pebbles arranged in berms behind a sandy shore exposed at low tide. A recurved spit has grown southward from the southern shore. Finavarra Point has low limestone cliffs and a gravel beach on its northern shore, the beach continuing westward as a shingle spit with patches of shelly sand, and a martello tower at the end*'.

As Finavarra Point and Aughinish Island are in County Clare, they are therefore not included as part of the County Galway audit.

**Glann**
The Glann mining district north of Oughterard is included in the Master List as an example of mineralization in the Dalradian, in this case skarn-hosted Cu and W. The Glann area lies southeast of Curraghduff Middle CGS, although some may consider Curraghduff Middle to be part of the Glann mining district. The Glann mine sites, also referred to as Barratleva mines, are not readily accessible or easily found, being located

within forestry plantations or woodland on the slopes of a steep hill. In contrast, Curraghduff Middle is readily accessible, has several extant mine features as well as abundant examples of mineralization present in outcrop and mine waste rock. As Curraghduff Middle serves as a good example of a mine site and associated mineralization in the Dalradian succession of this part of Galway, and is more accessible, the Glann mines have been omitted.

**Adit at Barratleva, Glann district.**

**Kiltevna Springs**

Though not mentioned as a locality on the IGH Master list, it was known that there were a number of relatively large karst springs at Kiltevna, between Dunmore and Williamstown. However, the springs are either remote and on private farmland, or are sealed fully as part of a Group Water Supply Scheme, and it was felt that the spring at Gortgarrow near Glenamaddy was a better representative site for the large karst springs of northeastern Galway. The Kiltevna spring sites were therefore rejected.

**Tobernara springs in Flaskagh More Townland, Kiltevna.**

**Kylemore Abbey Esker**

The Kylemore Abbey Esker site was included on the IGH Master Site List, as being a well-known esker exposure, with complex geomorphology surrounding, in an unusual valley setting. Some exposure into the

esker does still exist at the site, but the majority of the esker itself has been quarried away, and the locality is dominated by spoil heaps and scrubby wasteland. Thus, the site was not deemed worthy of County Geological Site status.

**The remaining portion of the Kylemore Abbey Esker, adjacent to Tullywee Bridge at Addergoole.**

**Lough Nahasleam metagabbro**

Lough Nahasleam is listed for "high amphibolite facies migmatites (related to Ordovician heating events). Metagabbro to north of Lough Nahasleam." The migmatites are the focus of the Lough Nahasleam CGS. The metagabbro intrusion is c. 700 m west of the migmatite site, on the north shore of Lough Nahasleam. The relatively small exposure displays metagabbro emplaced concordantly into schist. While this is a good exposure of metagabbro, such occurrences are not uncommon in Galway (e,g, Bun na gCeapán CGS) and the location does not warrant CGS status either along with or as part of Lough Nahasleam CGS.

**Metagabbros at Lough Nahasleam.**

**Maumeen (Tungsten)**

The Maumeen area is host to six metallic mineral deposits (Maumeen-1 Fe; Maumeen-2 Fe, Cu, W; Maumeen-3 Fe, Cu, W; Maumeen-4 Fe, Cu, W; Maumeen-5 Fe, Cu, W; Maumeen-6 Fe, Cu). Maumeen-2 was the only important deposit. The site is well reported by Geological Survey Ireland, however considering many other metallic mineral locations in Connemara that are not listed as County Geological Sites, this site is

not deemed to be in need of County Geological Site designation. Records note that substantial trials were made on pyritic mineralization at Maumeen, where a trench 30m long by 5m wide was dug to test the Fe-Cu-W mineralization. The location of two trenches remain (albeit filled in), as do spoil heaps. The mineralization is understood to be hosted at the top of the Lakes Marble Formation, although it is mapped within the Kylemore Formation. Lakes Marble Formation lithologies occur in spoil. Sulphide may form up to 80% of these samples, and also occurs disseminated in a coarse gritty felsic psammite lithology, with wolframite and scheelite. The locality was investigated by Central Mining Finance Ltd and Irish Base Metals Ltd during the 1970s but no extensive mineralization was discovered. Tungsten (wolfram) mineralization in the Connemara region is generally associated with copper, molybdenum or iron sulphides. Scheelite is the principal tungsten mineral although wolframite (iron-magnesium-tungsten oxide), is known at this Maumeen site. It has been suggested that the sulphide and tungsten mineralization is associated with the principal episode of volcanism during the deposition of the Lakes Marble Formation (Morris et al. 1995)

**View across the rejected Maumeen (Tungsten) site.**

**Maumfin**
This was recently added in error as a possible location for several sites on the Renvyle peninsula.

**McGrath's Quarry, Cong**
Though not included in the IGH Master List, McGrath's Quarry at Cong was visited as it is an extensive opening into the bedrock geology of the Cong area, where extensive karstification has historically been known to occur. In the quarry, however, no karst features have been uncovered, and there is little in the way even of epikarst. The limestone in the quarry seems to be a different formation, therefore, than the surrounding, pure, bedded limestone. Given its massive nature, and with little or no features of karstic, sedimentary or palaeontological interest found, it was not deemed worthy of County Geological Site status.

**Face into massive (Waulsortian?) limestones in McGraths Quarry at Cong.**

**Murvey Quarry**
The Murvey Quarry site listed in the IGH Master List has been included in the Murvey site. The two sites are in the same locality, share the same lithologies and are within 300m of each other.

**Na hUilliní**
This is listed as a site in the Master List but in fact it simply refers to the dyke swarm of this name. Two CGS sites, Lochán na gClocha Ballach and Loch na hUillean - Lochán an Bhurca, are included as representative examples of the na hUilliní swarm.

**Oranmore Bay**
Oranmore Bay had been mentioned as a locality on the IGH Master list, for peninsula and spit features extending out into the bay. Upon mapping around the bay feature, it became apparent that these peninsula and spit features were in fact part of the headland assemblages of Tawin island (see below); therefore Oranmore Bay was rejected as a site.

**Oranmore Bay, here viewed from the southern side, looking northeast. Though picturesque, it has little unique geological or geomorphological interest within the embayment itself.**

**Rinville**

Rinville was mentioned as a locality on the IGH Master list, for having an Asbian carbonate mound displayed. From examination of old mineral locality maps of the area, also, an old mine (Rinville Mine, beneath 'Leadmine Hill') with occurrences of galena, lead and zinc was noted adjacent to the beach there. As well as this, noticeable brown patching was observed on boulders in some of the stone walls of the locality. The bedrock outcrop and stone walls along the shoreline are now adjacent to the Galway Bay Golf resort course.

Upon mapping and thorough examination of the outcrop extent, the exposure was seen to be poor, and no remains of the old mine shaft were seen. Though some of the brown boulders are observable, with little else visible the site was therefore rejected as a County Geological Site.

**Bedrock exposure beneath Leadmine Hill at Rinville (left) and brown gossan staining in stone walls adjacent to the Galway Bay golf resort (right).**

**Roundstone**

'Roundstone' was mentioned as a locality on the IGH Master List as it had been recorded that there were '*scattered beaches of white calcareous sand, derived largely from foraminifera, on an indented coastline, the beaches have steep gradients, foraminiferal sand being of lower density, and forming steeper beaches than quartz or shell sand of similar calibre*'. However, this actually refers to the adjacent sites of Dogs Bay, Gorteen Bay and Mannin Bay, so Roundstone itself is not included as a County Geological Site.

**Tawin Island**

Oranmore Bay had been mentioned as a locality on the IGH Master list, for peninsula and spit features extending out into the bay. It became apparent during mapping, that these peninsula and spit features were in fact part of the headland assemblages of Tawin island, 5 km to the southwest of the bay. A visit to Tawin Island allowed the peninsulas there to be examined and mapped, and though designated as part of the Galway Bay Complex SAC on the basis of it being a shallow, intertidal inlet, there is little unique geomorphologically about the locality.

**The low peninsulas of Tawin Island during high tide.**

**Top Quarry, Ballinasloe**

This quarry was not included since it proved impossible to trace owners, to get permission to access it and no access was made. When it was suggested for the Master Site List, it was then still working as a stone quarry for dimension stone or cladding work. The workshops and sheds are still extant but looking quite abandoned and heading towards derelict. High quality air photos of the quarry suggest it is really quite a limited site and with restricted interest and it has been excluded as a County Geological Site.

**Twelve Bens**

The Twelve Bens were mentioned as a site locality on the IGH Master list as 'one of the best areas in Ireland to view an alpine glaciated landscape'. This is true, but the Glencoaghan site has all of the salient features therein, and comprises almost one third of the entire Twelve Bens area. Thus, this site solely is included for its wide array of features of alpine glaciations. The entirety of the Twelve Bens is therefore not included as a County Geological Site; just Glencoaghan.

**Waterloo Bridge Synform**

The original proposal of this site was somewhat ill defined and it was not possible to determine any specific individual locality. The Waterloo Bridge Synform is one of a number of very tight fold structures in the major Connemara antiform and as such is a long linear fold axis. There is a valley cross section across part of the fold very close to Waterloo Bridge, a few km east of Clifden. Despite some potential as a geological site that might be used to train students, through detailed study of the rocks in this valley, it was decided not to include as it is only a limited section of the whole structure, and with limited exposures, despite the stream cutting through the east-west ridge. Better expert knowledge and better delineation might make this site worth future reassessment.

**The poorly exposed Waterloo Bridge Synform structure.**

**Derrybrien Landslide**

The Derrybrien landslide occurred in the Slieve Aughty Mountains on 16 October 2003, on the side of Cashlaundrumlahan hill. The landslide dislodged 450,000 cubic metres of peat, following a number of days of dry weather. While initially coming to rest 2.5 km away, it moved further three weeks later when rain came, entering the Derrywee River, and eventually spilling 20 km away into Lough Cutra.

The landslide is no longer visible on the ground, having been subsumed into regenerating peatland. Thus, as the feature itself is invisible, it will not be included as a County Geological Site.

**A portion of the Derrybrien landslide site, where the substrate exposed during the peat slide is still visible. The outline of the landslide itself is no longer visible however, with regenerating peat and young forestry plantation obscuring its footprint.**

**Coolagh Quarry**

Though not included in the IGH7 Master List, Coolagh Quarry just north of Galway City was visited as it is an extensive opening into the bedrock geology of the area, where extensive karstification has historically been known to occur. In the quarry, however, no karst features have been uncovered, and there is little in the way even of epikarst. The limestone in the quarry seems to be a different formation, therefore, than the surrounding, pure, bedded limestone. Given its massive nature, and with little or no features of karstic, sedimentary or palaeontological interest found, it was not deemed worthy of County Geological Site status.

**Face into limestones in Coolagh Quarry at Coolagh / Castlegar.**

**Coolagh Buried Valley**

In 2017, site investigations for the proposed M6 'ring' road bypassing Galway City uncovered a deep, buried valley beneath the townland of Coolough, just north of the city. This feature is a depression of 100 m vertical depth below surface, 100 m in width, and approximately 300 m long, and has been infilled with a variety of unconsolidated sediments by natural depositional processes.

Little can be seen of the feature on the ground, so the buried valley is not included as a County Geological Site.

**The location of the deep, buried valley at Coolagh (note monitoring borehole to the right of the horses).**

**M17 Road Cut Bullaun**

A road cutting along the eastern flank of the M17 motorway exposes pure bedded limestone at Bullaun. The exposure is approximately 150 m long and up to 4 m high, but is poorly chiselled and does not have a clean section through the rock beds. For this reason, the section is not included as a County Geological Site.

**The M17 Motorway cut in Bullaun Townland.**

**County Council Quarry near Gort**
This site was poorly defined in the original Master Site List, with some conflicting detail. Examination of original flip chart data gathered by the Expert Panel for the Lower Carboniferous Theme failed to clarify detail on the locality at desk study stage.

Subsequent field investigation of a former quarry site about a kilometre north of the town was limited, as the site is fenced off. The site may be under potential development as a biogas plant, but has been re-landscaped such that only a single, low rock exposure survives.

This outcrop and its extent is not deemed of sufficient importance to merit CGS status.

**Maghera Cornstones**
This site was also poorly defined in the Master Site List and no site was identified representing the specified interest of cornstones in the Devonian strata of the Slieve Aughty region.

There is very little Devonian rock exposed in the district, other than sections such as those at Clare Glens. It is possible that the 'Maghera' site was confused with Maghera Quarry, which is a CGS from the Slieve Aughty district of County Clare, but the geological interest there is quite different, being volcanic pyroxene tuffs. Consequently, without an identifiable site, no CGS can be defined for the 'Maghera Cornstones' in this audit, although new information in the future may alter this situation.

## 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 Galway. These have been specially prepared for this Report in order to make the information accessible to planners and others without geological training. For most sites more detailed reports and information files are held in the IGH Programme in Geological Survey Ireland. These are available for consultation if required. Further sites may become relevant as IGH Programme work develops.

Each site report has primary location information, a mention of the main rock types and their age, and a short description of the key aspects of scientific interest. A section outlining any particular management or other issues specific to the site is included, along with several low resolution photographs exemplifying the site. **A CD accompanying this report will include further pictures of most sites at higher resolution, should they be required for a glossy booklet or leaflet for the general public**. Grid references are given for a central point in the site generated from the GIS mapping (a shapefile) of the site boundary. They are only indicative of the location, but the site extent is best shown on the included maps.

The names for County Geological Sites located within, or partly within the Gaeltacht, are derived from the Irish Geological Heritage Programme Master Site List, and/or from the site name commonly used or referred to in geological literature, research publications, or among the geoscience community. These site names are descriptive, reflecting topographic features, settlements, townlands, islands, rock exposures, coastal locations, or waterbodies, and are in both Irish and English. Throughout the site report text, townland names, towns and villages and other placenames situated in the Gaeltacht are given in Irish, reflecting the legal placename for localities within the Gaeltacht. Irish placenames are sourced from the Placenames Database of Ireland website (www.logainm.ie).

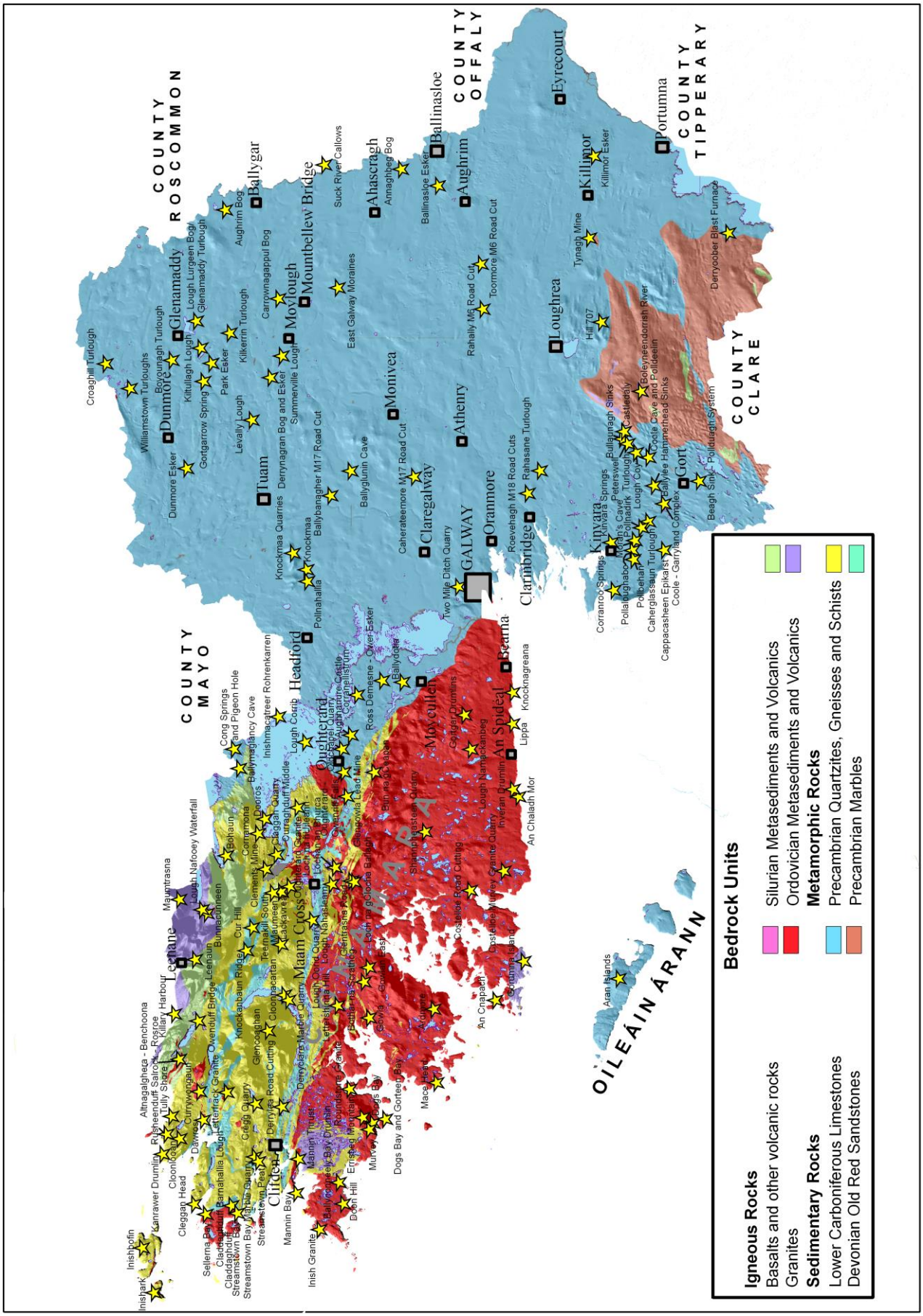
**Coordinate Projection System – IRENET95 ITM**

Irish Transverse Mercator (ITM) is the geographic projection co-ordinate system now in use for Ireland, and has been applied to all site localities in the site reports. It is the standard co-ordinate system for Ordnance Survey Ireland (OSi) maps, including the new Discovery map series, but a coordinate conversion tool is available on the OSi website at: https://www.osi.ie/services/geodetic-services/coordinate-converter

**A series of maps are provided with an outline of the site boundary. 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 such site is fully assessed for NHA status in the future, such a boundary may require small revisions.

For sites that have been recommended 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. Areas which have been designated as Special Areas of Conservation (SAC) under European Habitats Directives 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 Dr Clare Glanville, Head of the Irish Geoheritage Programme, in Geological Survey Ireland, Beggars Bush, Haddington Road, Dublin D04 K7X4 Phone 01-6782837. Email: Clare.Glanville@gsi.ie**




**Simplified Geological Map of County Galway with site locations indicated.**