THE GEOLOGY OF KERRY

an exhibition devised by
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Kerry County Museum
Príomh Mhúsaem Chiarraí

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This booklet contains some, but not all of the information displayed on the panels of the exhibition *The Geology of Kerry,* and is laid out in the same order as the exhibition.

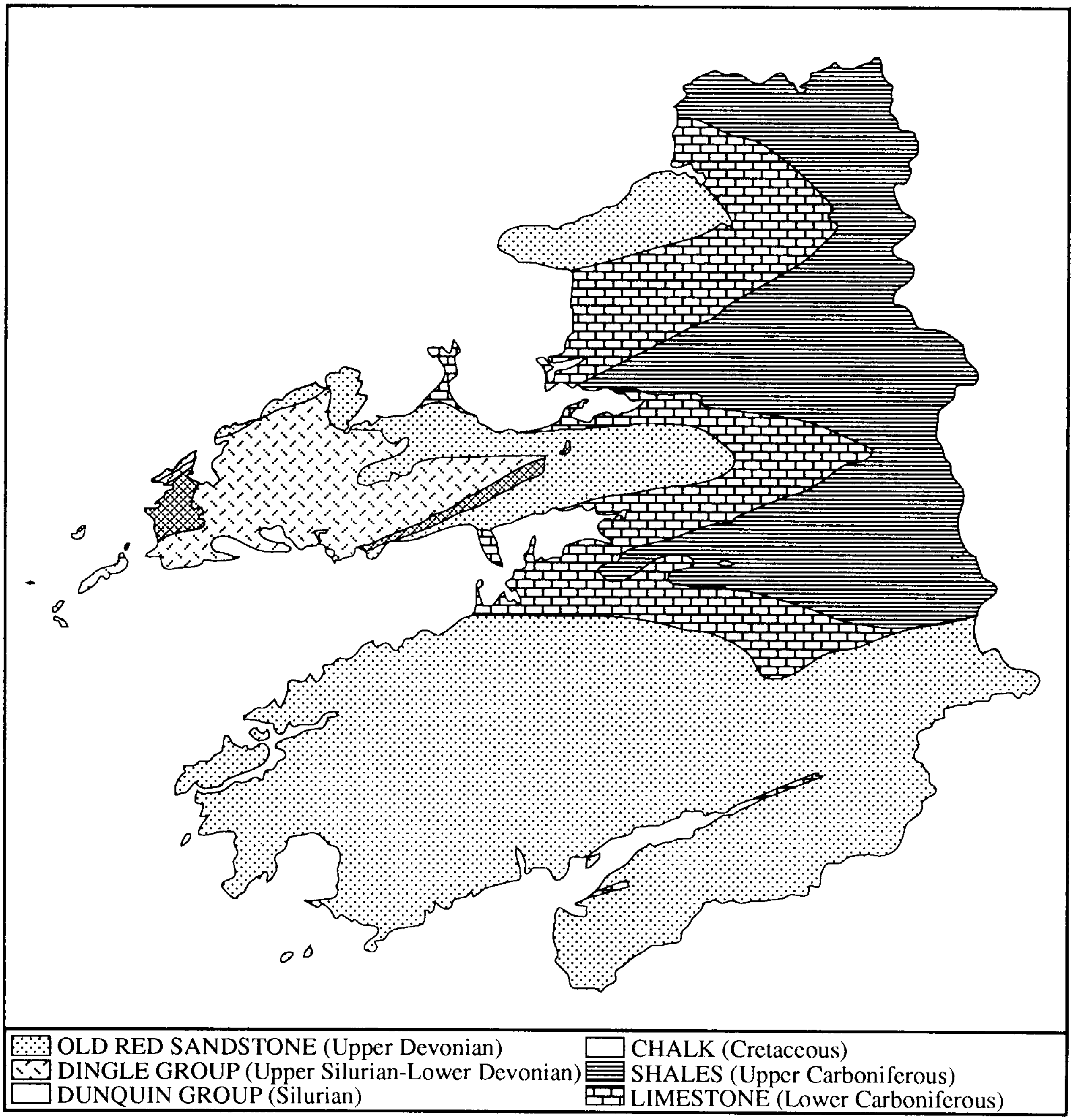
Acknowledgements: I have used a number of illustrations from research papers and other sources in this booklet and on the exhibition panels. For this I thank the authors: P. Coxon, M. Forkin, J.R. Graham, D. Hogarth, C.H. Holland, G.F. Mitchell, J. Parkin, G.D. Sevastopulo and D.J. Siveter.

1. The Geology of County Kerry.

The geology of Kerry is the history of Kerry, the history going far, far back into the past, beyond 440 years, beyond 440,000 years as far back as 440,000,000 years.

Over this vast span of time the landscape has changed many times. The land where Kerry is now built has at different periods been smothered in the ash of fiery volcanoes, submerged deep beneath the waves, heaved up to build mountain ranges, and baked by a subterranean pool of molten rock. It has been bathed in the clear warm water of a tropical coral sea, shaken by violent earthquakes, and buried beneath a kilometer of ice.

The exhibition illustrates and explains in non-technical terms these dramatic events from the past.



2. What kind of rock is under your house: purple, brown, red, blue or white?

If you dig a hole in your garden you will find, under the soil, yellowy-brown clay, sand or gravel. This is depicted by the yellow layer under the house. If you dig even further you will eventually hit hard rock. Geologists call this hard layer bedrock. The kind of bedrock you hit depends on where you live and will be one of five broad types. These are shown here by the colours purple, pink, red, blue and white.

The only places you can easily see bedrock are where the 'yellow' sand, gravel and clay layers have been worn away or actually removed by man. Such places include the rocky sea shore, hill tops, road cuttings and quarries.

?

3. How old are Kerry's rocks?

Geological time is unimaginably long. It is measured, not in years, but rather in millions of years. If the age of the Earth (4,500 million years) were scaled down to a single year, then all human history since the birth of Christ would reduce to just 14 seconds.

Yellow deposits (Quaternary): The clay, sand and gravel which blanket the hard bedrock are relative youngsters. They were formed at the end of the Ice Age between 10,000 and 15,000 years ago shortly before man colonized Ireland.
White rocks (Cretaceous): The chalk with its flint nodules, which is confined to a valley just north of Killarney, was deposited between 100 and 65 million years ago during the Cretaceous Period.
Blue rocks (Carboniferous): The limestones and mudstones, which are most common in north Kerry, shown in blue are younger still. They were formed between about 340 and 320 million years ago.
Red rocks (Middle -Upper Devonian): The sandstones, conglomerates and slates which are collectively known as the Old Red Sandstone, shown in red, were deposited in river and in desert environments about 370 million years ago during the later part of the Devonian Period.
Brown rocks (Upper Silurian-Lower Devonian): These siltstones and sandstones which make up the Dingle Group, exposed in the western half of the Dingle Peninsula, were deposited towards the end of the Silurian Period and in the early part of the Devonian Period.
Purple rocks (Silurian): The sandstone, mudstone, quartzite and volcanic rocks shown in purple are the oldest rocks found in County Kerry. The siltstones, mudstones and volcanic rocks found near Dunquin, on Inishvickillane, and in a strip between Annascaul and Derrymore Glen were probably formed a little over 430 million years ago during the Silurian Period.

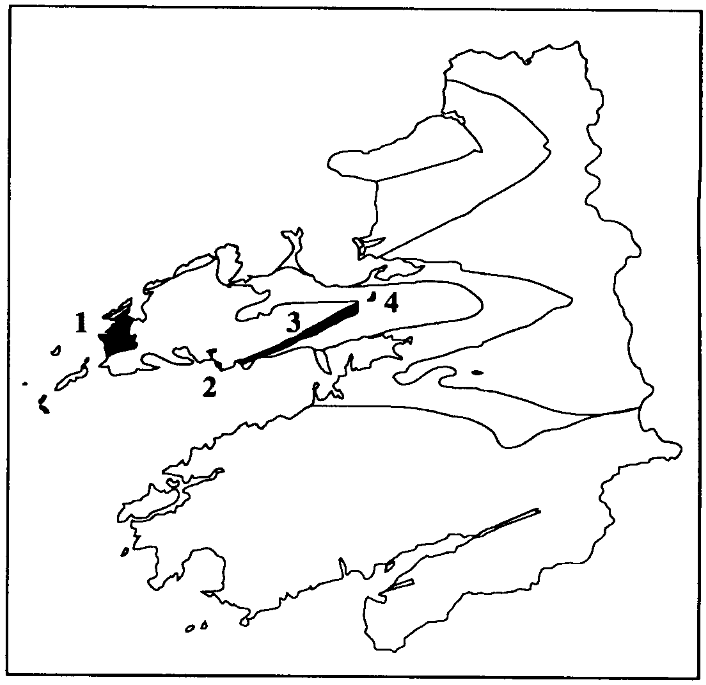
Era	Geological Period	
Cainozoic	QUATERNARY	2
	TERTIARY	65
Mesozoic	CRETACEOUS	144
	JURASSIC	213
	TRIASSIC	248
Palaeozoic	PERMIAN	286
	CARBONIFEROUS	360
	DEVONIAN	408
	SILURIAN	438
	ORDOVICIAN	505
	CAMBRIAN	590
Archean	PRECAMBRIAN	
	Origin of the Earth	4,500

4. The Silurian of Kerry 1: sediments and fossils.

Rocks of Silurian age crop out in a number of inliers on the Dingle Peninsula: 1, in the Dunquin area; 2, at Bull's Head; 3, in a thin strip between Annascaul and Caherconree; 4, in Derrymore Glen. These rocks are collectively known as the Dunquin Group.

An inlier is an area of older rock which is surrounded by younger rock.

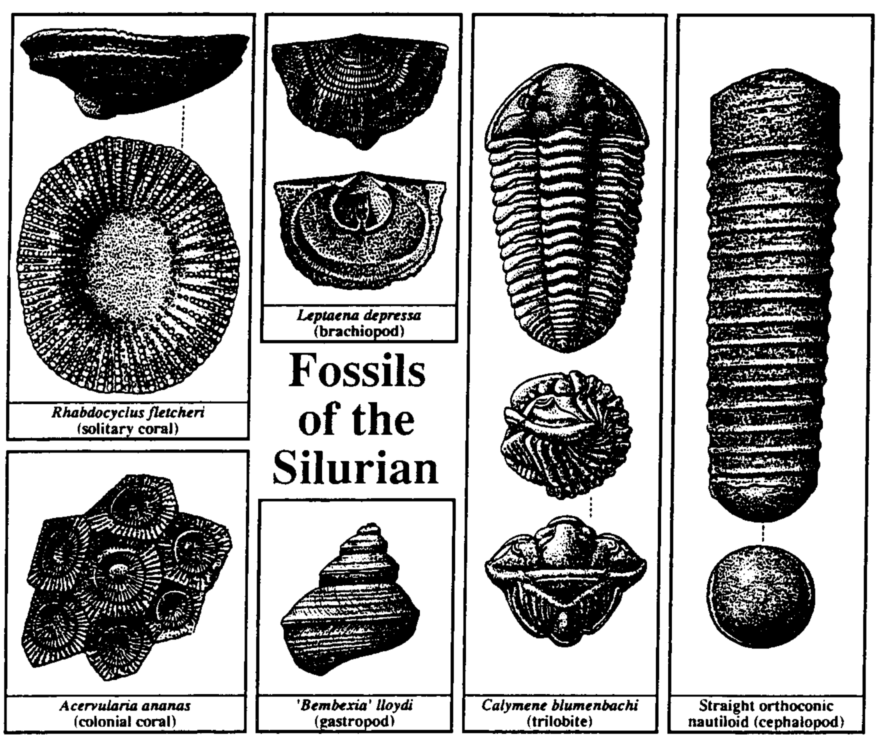
The Silurian inliers contain a succession of shallow water to deep water sedimentary rocks (which contain a rich fossil fauna) and volcanic lavas and ashy tuffs.



The Silurian inliers of the Dingle Peninsula (marked in black)

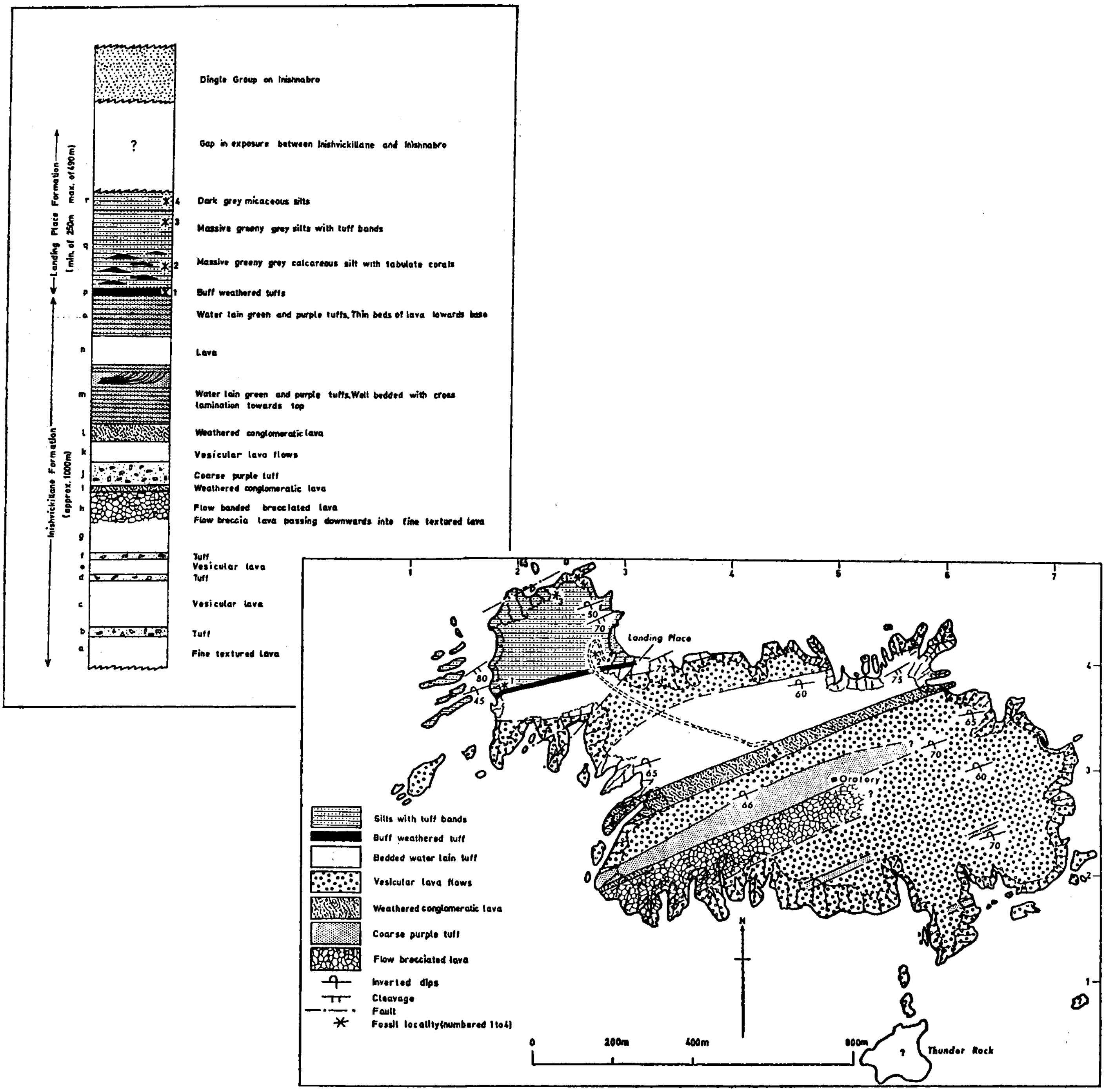
400 million years as the Iapetus Ocean closed the area which is now the Dingle Peninsula lay on the northern margin of a great continent. The Silurian sedimentary rocks exposed on the Dingle Peninsula are mostly shallow marine (best seen along the western coast at Dunquin and Ferriter's Cove), but some deep water deposits are found in Derrymore Glen, and some terrestrial (land) sediments are also found in the Dunquin area.

In the Dunquin inlier the succession is nearly 2,000 metres thick. The shallow water grey, purple and orange-coloured siltstones contain a diverse and rich fauna of bivalves, brachiopods, bryozoans, cephalopods, corals, gastropods, and trilobites. The deeper water grey siltstones found in Derrymore Glen contain fossils called graptolites.



5. The Silurian of Kerry 2: Dingle's volcanic past.

420 million years ago the northern part of Ireland was separated from the southern part by a large ocean called Iapetus. Over the previous 100 million years this ocean slowly closed as the two continents drifted closer, and as it did, volcanic eruptions and earthquakes occurred in the Dingle area, where a series of offshore volcanic islands developed west of the Blasket Islands. The volcanic rocks may be best seen on Inishvickillane and at Clogher Head near Dunquin, and include include lavas (erupted as molten rock), tuffs (ash), and ignimbrites (ash welded by heat). As one moves eastwards from Inishvickillane to Clogher Head lavas decrease and are replaced in importance by tuffs. At Caherconree, 20 miles east, there are thin layers of tuff preserved between sedimentary rocks.



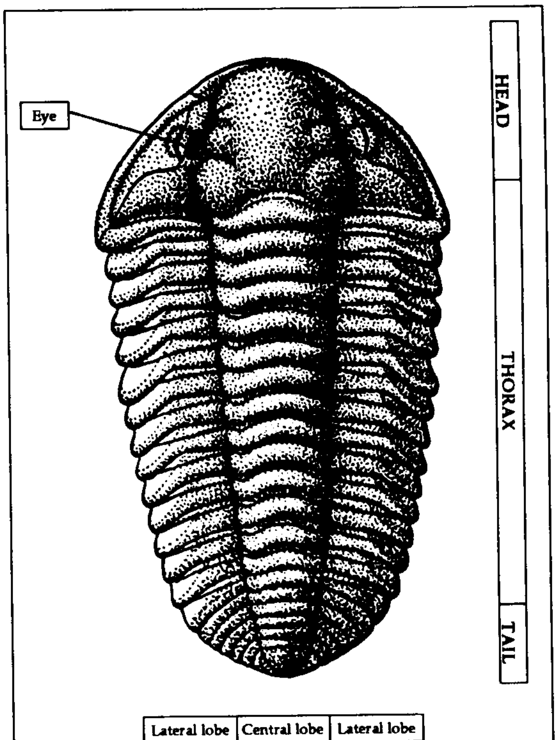
Inishvickillane, Blasket Islands: geological map and succession.

6. Trilobites from the Dingle Peninsula.

Trilobites are an extinct group of arthropods occupying an important position in Lower Palaeozoic times. They are entirely marine organisms found mainly in shallow sea deposits, where they probably crawled over the sea bottom in search of food, or borrowed in the sediments. There is some indication that some trilobite forms may have been swimmers or floaters rather than crawlers.

Their body is covered by a hard shell which is divided into three longitudinal lobes by two axial furrows. Three transverse lobes divide the shell into head, thorax and pygidium (tail). The range in size of adult trilobites is <5mm to 70cm.

Trilobites first appeared in the Early Cambrian. They had a strong development and radiation through the Middle Cambrian and attained maximum development in Late Cambrian time, They were still very numerous in the Ordovician but began to decline in the Silurian. Still fairly abundant in the Devonian Peroid, they diminished rapidly during the Late Palaeozoic and completely disappeared by the close of the Permian.



Morphology of a trilobite

Trilobite	Abundance
Styginid trilobite	
Kosovopeltis aff. *allaarti*	0.3%
Interproetus galvani	24.0%
Copoparia hollandi	2.1%
Scharyia sp.	0.6%
Cheirurus sp. nov.?	1.5%
Cheirurus sp.	0.6%
Calymene endemopsis	2.6%
Calymene sp.	1.5%
Ananaspis aff. *stokesii*	20.3%
Odontopleura (O.) ovata	30.7%
Primaspis mendica	6.1%
Leonsapis coronata coronata	3.1%
Leonaspis parkini	5.5%
Dicranopeltis salteri?	0.9%
Trochurus? sp. indet.	0.3%

Faunal list and abundance of trilobites at Caherconree

Probably the finest Silurian trilobites in Ireland have been fould at Caherconree Mountain on the Dingle Peninsula. They occur in a hard limestone, and were extracted by Dr Derek Siveter (formerly of Trinity College, now of Oxford Museum) using a dentists drill. The fauna is quite diverse with at least sixteen different trilobites.

Ananaspis* aff. *stokesii

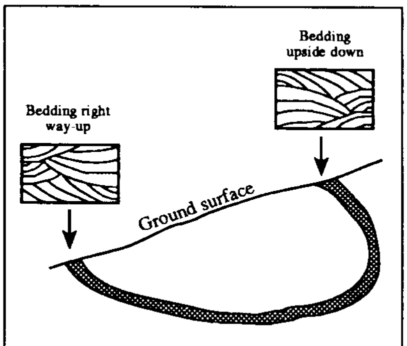
7. The Dingle Group rocks: way-up determination, unconformities and age.

Resting directly on the rocks of the Dunquin Group is a sequence of sedimentary rocks which have been formally called the Dingle Group. These rocks, which comprise purple, green and brown coloured siltstones, sandstones and conglomerates are found in the western part of the Dingle Peninsula.

Are the rocks of the Dingle Group late Silurian in age? Are they early Devonian in age? Are they both? In the past some geologists thought that the Dingle Group rocks were Old Red Sandstone of late Devonian age - this is certainly not true as there is a clear gap (or unconformity) between the two.

Cross-stratification and its use in determining the way-up of rocks.

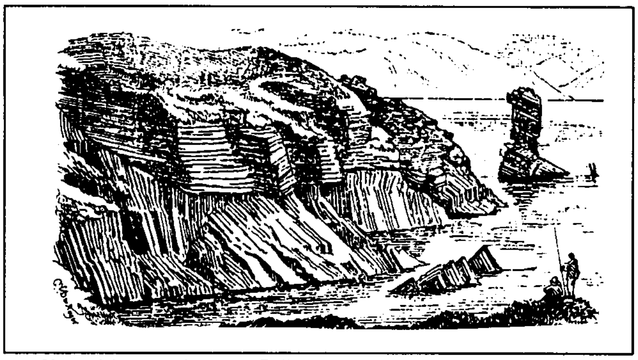
Cross-stratification is a type of bedding produced when oblique layers of sand are laid down as ripples form. Often the tops of the ripples are removed by water currents and new ripples are deposited on top. Such bedding is quite common in sandstones, and is used to tell if the bed or layer of rock is in its original position of it it has been overturned. This method of determining the "way-up" of beds was first demonstrated by Patrick Ganly in the 1830s who had found fossil ripples in Donegal. He tested his theory in Dingle in 1838 when he examined a folded bed of sandstone of the Dingle Group. He showed that one bed was the right way up while the other was inverted. He published his findings in 1856 in the *Journal of the Geological Society of Dublin*. Ganly's findings in Donegal and Dingle remain fundamentally important to geologists today.



Redrawn from J. Archer 1985. Patrick Ganly. In *Some People and Places in Irish Science and Technology*. R.I.A.

An unconformity: a gap in the geological record.

An unconformity is where there is a break in the rock succession (either caused by erosion, or by non-deposition of sediment).
In places such as Bull's Head on the Dingle Peninsula, one can see younger rocks lying on top of older rocks which are dipping at a high angle. The junction between the two rock types is called an unconformity. This happened when after the deposition the older Dingle Group rocks, they were folded and then eroded, afterwhich the younger Old Red Sandstone (Upper Devonian) was deposited on top. Missing are Middle Devonian rocks.



View of the unconformity at Bull's Head between steeply dipping purple sandstones of the Dingle Group and the overlying Old Red Sandstone [drawn by G.V. Du Noyer of the Geological Survey of Ireland 1863]

The rocks contain no shelly fossils and consequently have proved difficult to date. A spore, from an early plant, which suggested a Devonian age was apparently recovered from these rocks but this evidence has been discounted as it has been impossible to locate any more plant spores with which to confirm this earlier finding.

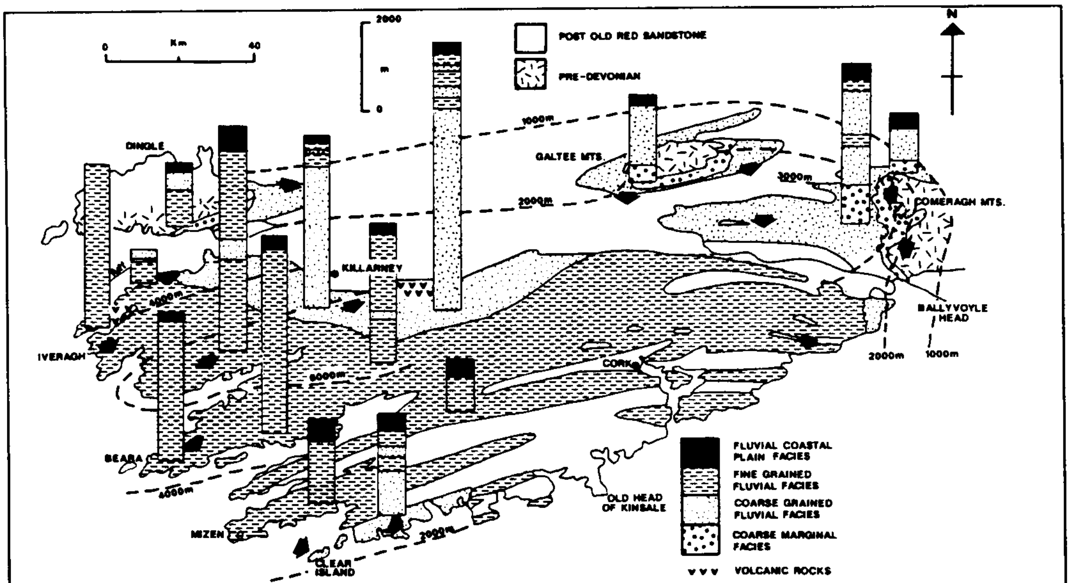
Today geologists are still undecided; some place the whole of the Dingle Group in the Silurian, while others say that it ranges in age from late Silurian to early Devonian.

Whatever the age of these rocks, they show two features which are of importance to geologists: 1, way-up evidence and 2, an unconformity.

8. The Old Red Sandstone: river deposits & desert sands.

In the Devonian period Ireland was situated on the southern side of a large landmass in which dry arid conditions prevailed. During the Upper Devonian a succession of rocks was deposited that are known as the Old Red Sandstone. These sediments are terrestrial having been laid down by river systems and in desert conditions.

In southern Ireland Old Red Sandstone was deposited in what has been termed by geologists the Munster Basin, that extended from Kerry in the west to the Comeragh Mountains in County Waterford in the east. Here up to 6.5 km of sediment was deposited by extensive river systems. The sediments are coarse near the northern edge of the Munster Basin and become increasingly finer southwards. At the end of the Devonian period the northern land mass became submerged beneath the sea which migrated northwards during the succeeding Carboniferous period.



Map of the Munster Basin showing the thickness of the sediment in the basin (in metres) and the distribution of the different sediment styles (or facies):

Coarse marginal facies: around Dingle Bay found at Inch and Dolus Head. Consists of coarse conglomerates with cobbles of 50 cm in diameter, and coarse grained sandstones some of which are aeolian in origin deposited in desert conditions (found at Kilmurry Bay). [Oldest]

Coarse grained fluvial facies: contains both sand and gravelly sediments. They were deposited by rivers which carried different sized grains in different places. Found in the Slieve Mish area and north Iveragh Peninsula from Killarney to Glenbeigh.

Fine grained fluvial facies: these riocks comprise the greatest volume in the Munster Basin. They are fine sandstones and siltstones which often contain burrows and dessication cracks. Deposited by rivers which were prone to widespread flooding. Widespread in Iveragh Peninsula.

Fluvial coastal facies: non-red sediments of sand and mud. Both river and lake deposits occur in the Munster Basin. In County Kerry this facies is quite thin relative to other facies. [Youngest]

[from J.R. Graham & G. Clayton, 1988. In *Devonian of the World*. Canadian Society of Petroleum Geologists 1,325-340]

9. Conglomerates in Kerry: what are they made of?

Conglomerates are coarse grained clastic sedimentary rocks that were deposited in river beds and in alluvial fans. In the Old Red Sandstone of Kerry they are an important component of the succession, where they are most commonly found in the marginal northern and eastern area of the Munster Basin.

They consist of cobbles of rock, greater than 2 mm in diameter, which have been cemented together in a matrix, usually of sand. Bedding is often easy to pick out as frequently the sediment is well-sorted into size fractions with the coarse cobbles being at the base of the bed and finer material above. The cobbles have become rounded as they were transported most often along river beds from their source.

Examination of the cobbles will often give geologists an idea from where they have come and when the source rock that produced them was subjected to erosion. In the Old Red Sandstone there are several different conglomerates which contain noticibly different cobbles. All however, contain white quartz. The Lough Slat Conglomerate of the Dingle Peninsula also contains small clasts of blood red Jasper.

The Inch Conglomerate, Dingle Peninsula, Kerry

This conglomerate consists of cobbles of a number of stone types that are set in a matrix of coarse sand. The clasts include quartz (white in colour) and some metamorphic rocks. The source for the metamorphic clasts is unknown. Quartz is very resistant to breakdown and could have been transported a very long distance.

The hammer is about 30 cm in length.

Conglomerate of the future?

Cobbles of stone in a river bed near Tralee, County Kerry. These cobbles are all greater than 5 cm in diameter and are all well-rounded. They consist of red sandstone, grey limestone and rare examples of conglomerate!

The sand above the cobbles is faintly rippled.

Classification of clastic sedimentary rocks.

CLASTIC (INORGANIC) SEDIMENTS (composed of cemented fragments of rock; classified according to size of the fragments).

RUDACEOUS (Cobbles: >2mm) → BRECCIA (angular) / CONGLOMERATE (rounded)

ARENACEOUS (Sand: 2 - $\frac{1}{16}$ mm) - SANDSTONE

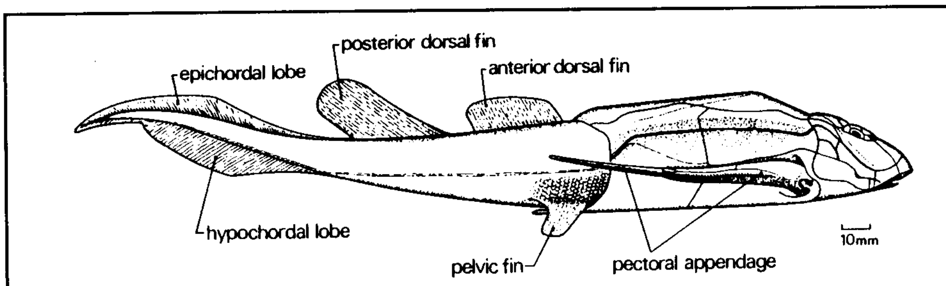
ARGILLACEOUS (Silt: $\frac{1}{16}$ - $\frac{1}{256}$ mm) - SILTSTONE; SHALE; GREYWACKE

The Old Red Sandstone comprises a variety of different clastic rocks - those made out of particles weathered from older rocks (eg gravel, sand, silt and mud). They are classified according to the size of the particles.

10. Fish fossils from the Iveragh Peninsula.

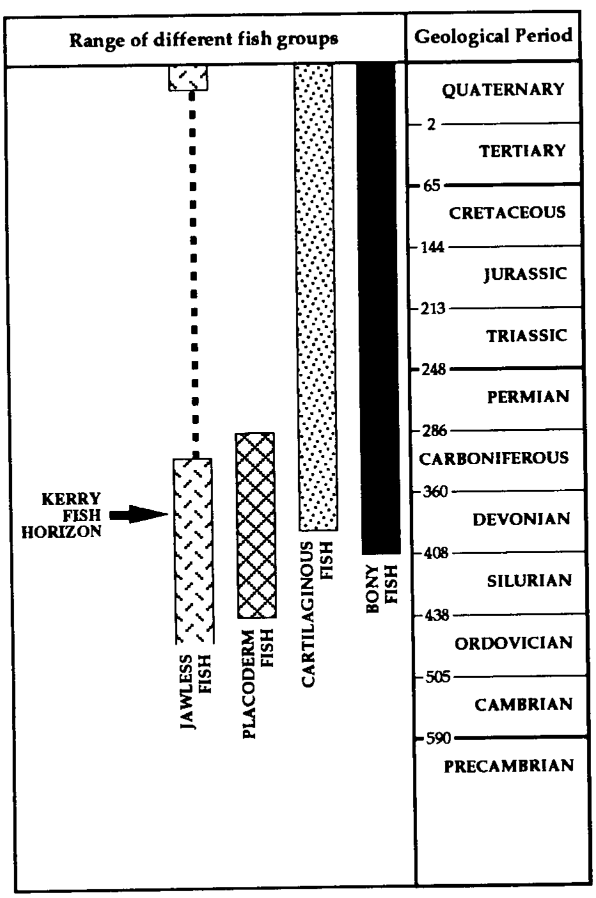
Fish first evolved probably during the Ordovician period but underwent a major radiation in the Devonian 400 million years ago (known as the 'Age of Fishes'), when a number of different groups emerged. These were the Jawless fish, Placoderm fish, the Cartilaginois fish, and the Bony fish.

The jawless fish fed by sucking sediment from the lake or river bed, placoderms had jaws and an armoured head shield, the cartilaginous fish had skeletons made of cartilage (as do modern-day sharks and dogfish), while the bony fish had skeletons of bones (as do modern-day salmon and trout).



Reconstruction of *Bothriolepis* sp.

At the western end of the Iveragh Peninsula several horizons in the Old Red Sandstone have yielded fragments of the placoderm fish *Bothriolepis* and the bony fish *Sauripterus*.



Bothriolepis grew to a length of about 50 cm. It had an armoured head and had several fins along its back and two pectoral fins splayed out from its sides. It has been suggested that these pectoral fins were used to stabilise the fish on the lake bottom and that the fish may have used them to "walk".

11. Roofs and billiard tables: slate extraction on Valentia.

In the past slate largely for roofing has been exploited from a number of locations in Ireland. Of these Killaloe and Valentia are perhaps the best known.

The Valentia slates are pale purple siltstones which have been compressed and folded. They developed a good cleavage which allows them to be split into thin sheets. The slates are Middle-Upper Devonian in age.

The slate quarry on the northeast side of Valentia was opened in 1816 by Sir Maurice FitzGerald, the 18th Knight of Kerry. It employed between 150 and 400 men and sometimes women.

In 1876 quarrymen were paid 1 shilling and 8 pence (8p in todays money) for a 12 hour day. Slates were extracted from the hillside in large blocks and were split with chisels. Flagstones were cut and shaped by saws powered by steam engines.

Valentia Slates were prized because they could be split into large but thin slabs 14 feet by 6 feet which were very flat and smooth. They were ideal for billiard tables, but were also used for shelving and roofing.

Notable buildings slated with Valentia Slate include the Paris Opera House, London's House of Commons and House of Lords, and Charing Cross and Waterloo Railway Stations. The Public Record Office in London has over 26 miles of shelving of Valentia Slate.

The quarry closed in 1911 leaving a hole over 100 feet high in the hillside. The chimney of one of the engine houses can still be seen. Occasionally Peregrine Falcons nest in the vicinity of the old quarrys.

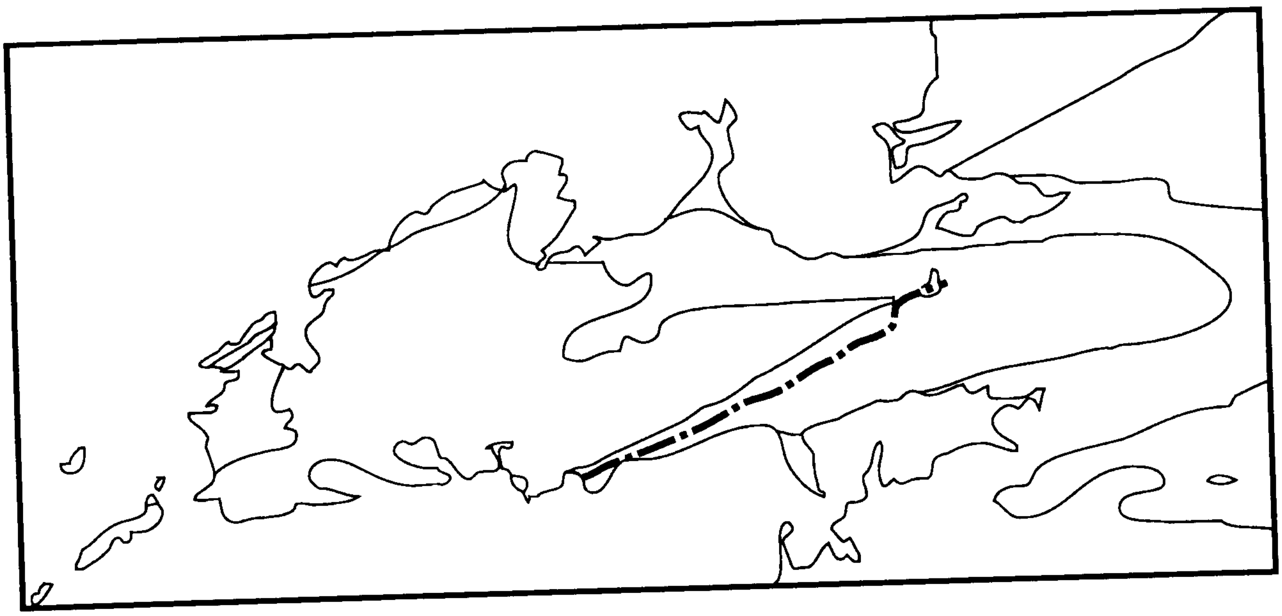
Uses for Valentia Slate

- Altars
- Billiard tables
- Decorative carvings
- Headstones
- Paving and flooring
- Roofing
- School writing slate
- Seats
- Sundials
- Walls
- Washing boards
- Window sills
- Worktops

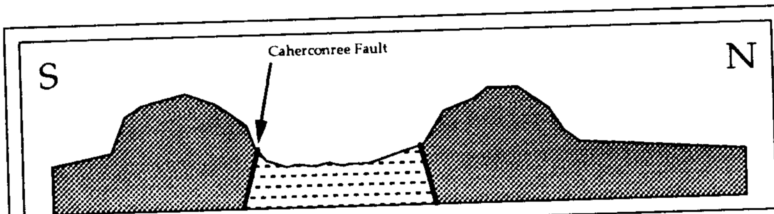
Production in all Irish slate quarries ceased in the early part of this century as a result of cheaper imported slates from Wales. In 1990 production began again at Killaloe.

12. A fossil earthquake shakes the Dingle Peninsula.

420 million years ago Ireland was split in two, and either side was situated on opposite sides of a wide ocean. As this ocean closed huge forces caused folding and faulting of rocks. One such fault, the Caherconree Fault runs for 15 miles east-west along the Dingle Peninsula from Derrymore Glen in the east to Minard Bay in the west. The Silurian rocks moved upwards, on this fault and another parallel to it, relative to the Old Red Sandstone rocks on the south and the Dingle Group rocks on the north. Many earthquakes would have shaken the Dingle Peninsula as this movement took place.



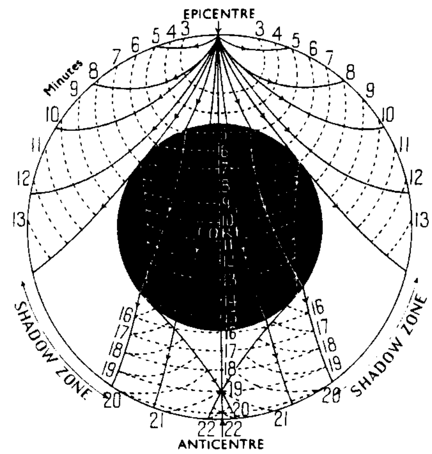
Map of the Dingle Peninsula showing the Caherconree Fault (bold dashed line) between Derrymore Glen in the east and Minard Head in the west.



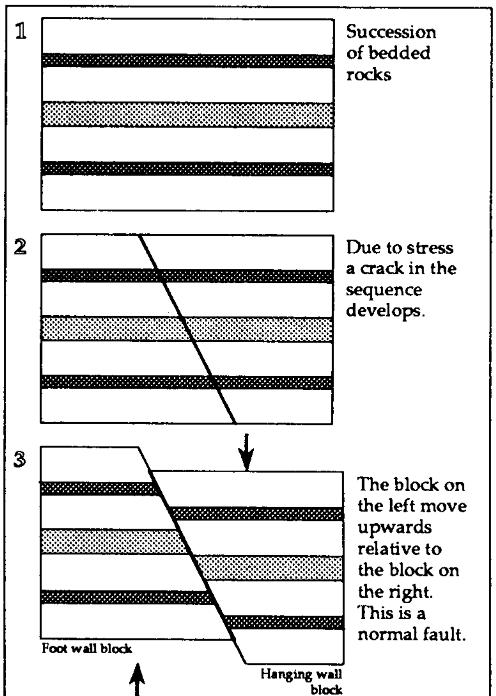
Stylised cross-section through the Dingle Peninsula showing the faulted Silurian rocks sandwiched between younger rocks.

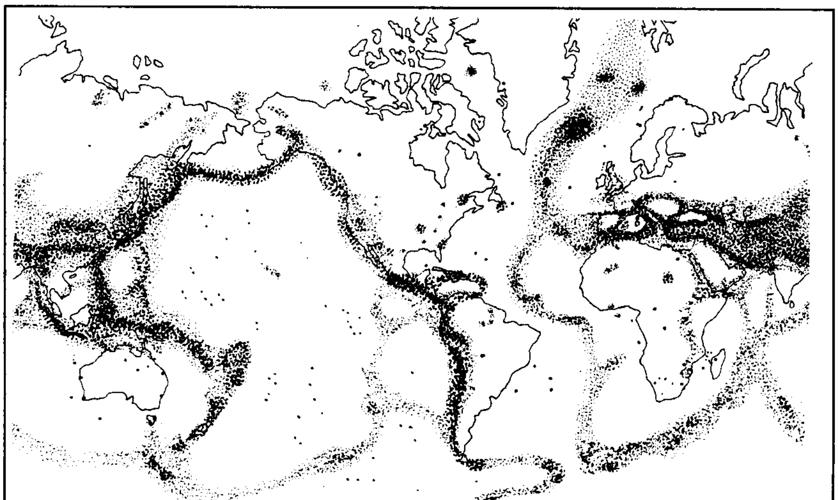
13. The how, where and why of earthquakes.

Throughout geological time earthquakes have rocked the earth, and many have caused serious devastation and loss of life. Earthquakes take place when stress that has built up in rocks is suddenly released and movement takes place along a fault or plane of weakness. Today the majority of all earthquakes occur when there is movement along the margins of the rigid plates that make up the Earth's crust. Here earthquakes of large magnitudes occur frequently, but it is not unknown for earthquakes to happen along any major fault line. A number of years ago a small earthquake shook the Irish Sea and was felt in Dublin. Fortunately Ireland is largely earthquake-free as it lies within a stable piece of continental crust.



When an earthquake takes place it produces shock waves of different types. Rayleigh Waves travel close to the Earth's surface, while Compression (P) and Shear (S) waves travel through the Earth. P waves can travel through solid and liquids but S waves can only travel through solids. If an earthquake occurs in Iceland then only P and Surface waves will be detected in Australia. This is because S waves cannot travel through the outer core which must be liquid. It takes P waves only 20 minutes to travel right through the Earth.





Location of Earthquakes:
most are situated at the junctions of major crustal plates

14. The Lower Carboniferous: a time of warm shallow seas.

The Lower Carboniferous (360-320) million years ago in Ireland was a time when a shallow sea migrated northwards at a rate of 3 cm per year over the Devonian continent. At the end of the Lower Carboniferous most of Ireland was covered by a shallow warm sea, in which limestones, both shelf and reefal, were deposited.

Limestones are rocks composed of calcium carbonate ($CaCO_3$). Several important types of limestone may occur. They indicate that deposition took place in a warm, clear-water environment. Organic limestones are those made up of the shells and skeletons of animals. Other limestones are precipitated from sea water where as small calcium carbonate spheres called ooliths.

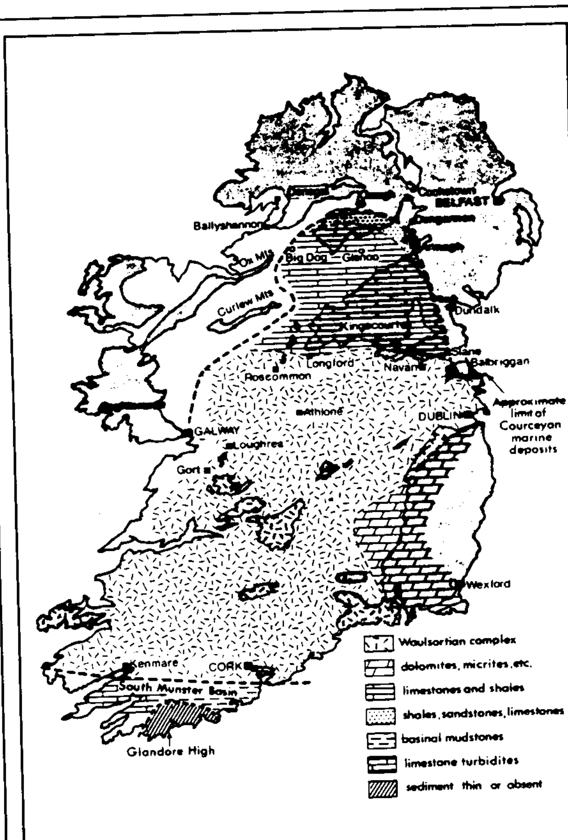
Generally limestone is deposited in flat horizontal layers (or beds) on the shallow sea floor. These are shelf limestones and are well developed in Ballybunnion and in many parts of Ireland. Limestone also accumulates as reefs where a dome of limestone developed from the sea floor and grew towards the water surface. Reefs, such as those around Fenit, contain many fossils.

SEDIMENTS OF CHEMICAL ORIGIN (formed by precipitation from solution, or by replacement of one mineral by another).

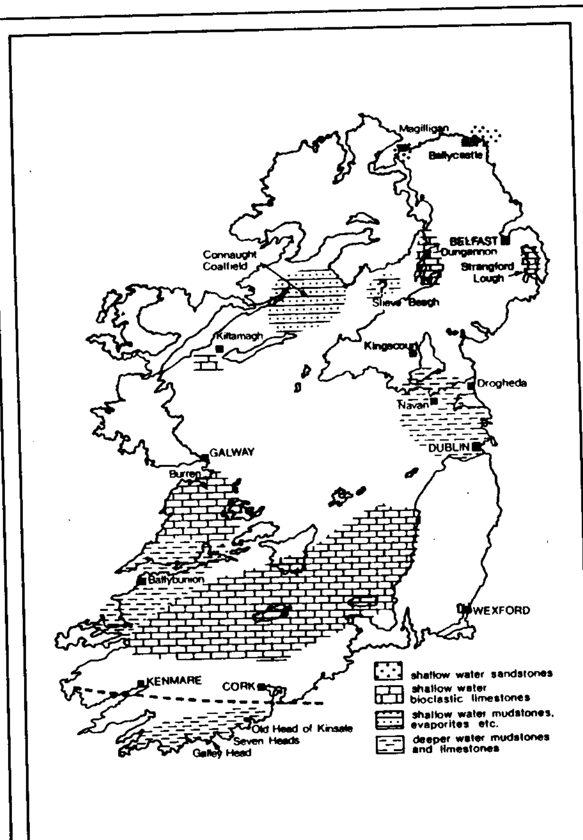
CALCAREOUS (Limy) - OOLITIC LIMESTONE ($CaC0_3$); TRAVERTINE; DOLOMITE ($MgC0_3$)
SILICEOUS (Composed of silica) - FLINT (pale); CHERT (dark)
FERRUGINOUS - IRONSTONE
EVAPORITES (Saline) - ROCK SALT

SEDIMENTS OF ORGANIC ORIGIN (formed by accumulation of plant or animal organic matter).

CALCAREOUS (Limy $CaCO_3$) - LIMESTONE
CARBONACEOUS (rich in carbon) - COAL
PHOSPHATIC - BONEBED (PHOSPHATIC ROCK)



Map showing the position of land and sea during the early Lower Carboniferous (360 million years ago)



Map showing the position of land and sea during the late Lower Carboniferous (320 million years ago)

15. Minute life: microfossils from Irish Carboniferous limestone.

Many rocks, such as those of Carboniferous age in Ireland, contain macrofossils (large enough to see with the naked eye). They may also contain fossil remains of many different microscopic animals and plants. Tiny arthropods (ostracods), teeth-like structures from a worm-like animal (conodonts), single-celled animals (foraminifera), single-celled plants (diatoms, dinoflagellates, acritarchs and coccoliths), and plant spores and pollen are all found.

These small microfossils can be extracted, and then are used in correlation of rock successions (by age or type) from area to area. In the petroleum industry it is important to know the age of rocks that are drilled through in search for oil and gas. The study of microfossils (micropalaeontology) provide a basis by which ages of rocks can be deduced.

In Ireland recent studies of miospores and conodonts from Lower Carboniferous rocks have led to the erection of biozones, which are characterised by assemblages of certain of these microfossils. In addition these fossils change colour as they are subjected to heat, going from pale to dark as heat increases. This allows researchers to estimate the temperatures that sedimentary rocks reached when they were subjected to heating from orogenic activity.

FORAMINIFERA: These are unicellular organisms belonging to the rhizopod Protozoa (Protista). Their protoplasm, differentiated into endoplasm and ectoplasm, is emitted in the form of retractile pseudopodia which are used in catching prey, in locomotion and in the creation of the skeleton. The feature that distinguishes foraminifera is the possession of a mineraalized, intra-ectoplasmic skeleton or test formed from chambers that are interconnected by openings or foraminifera. The interior of the test is lined with a basal organic chitinoid layer.

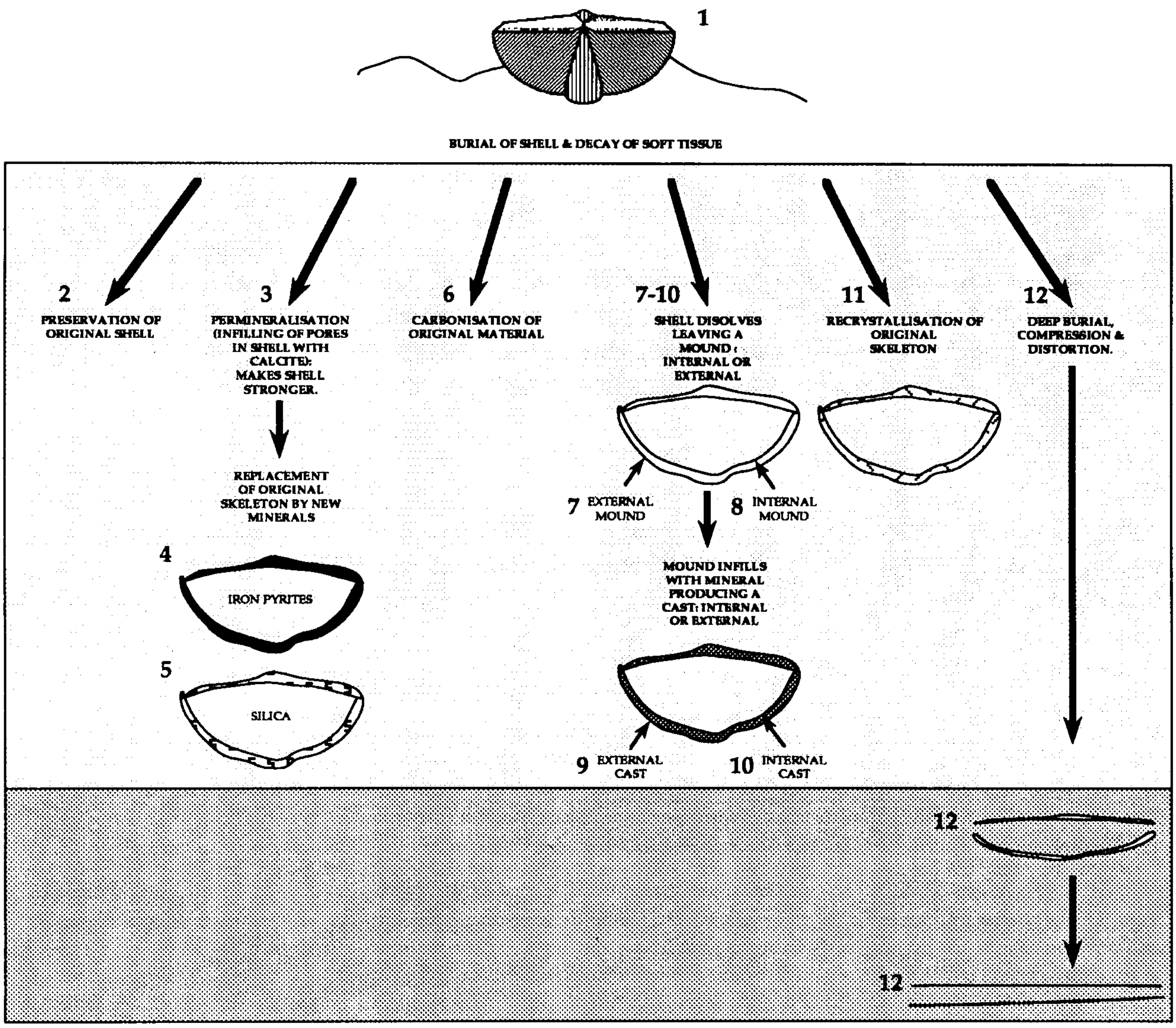
OSTRACODS: Arthropods which have bodies that appear unsegmented. The head, thorax and appendages are ill defined and are contained in a calcitic carapace, the two valves of which are linked dorsally by an elastic ligament and a hinge. The body hangs inside the carapace like a sac. There are seven pairs of appendages which serve as sense organs and for the capture and mastication of food, for locomotion and for cleaning the internal cavity. Ostracods possess a digestive system, complex genital organs, a central nervous system and a median eye within the carapace.

CONODONTS: Conodonts, like vertebrate bones, consist of calcium phosphate and this unusual chemical composition distinguishes them from all other microfossils. They are small structures which are either opaque, translucent, black or amber in colour and their length ranges from 0.2 to 6mm. They fall into three groups: Simple, with the appearance of a tooth or a hook; Composite, with a principle tooth flanked laterally by denticulate blades; Platform, a blade partially bordered by two lateral extensions covered with nodules and ridges. For many years these microfossils baffled palaeontologists who wondered what animal they came from. A few years ago it was demonstrated that they belong to a group of jawless craniates.

Palynology, the study of spores and pollen grains is an interdisciplinary field involving medicine, botany, agronomy, archaeology and various other subjects. In micropalaeontology however, the term is used in a more restricted way to designate the study of non-mineralized organic microfossils called palynomorphs or sporomorphs. All microfossils are of course of organic origin and when palynologists describe certain varieties as organic they are referring not to the origin but to the chemical composition.

SPORES: Spores and pollens, the reproductive organs of higher plants, are produced by the diploid sporophyte following double division and halving of the chromosome complement of the mother-cell. Spores and pollens are emitted by plants that live, for the most part, in areas that are continental and subaerial. As a result of their enormous power of dispersion, they are found as fossils not only in different continental sediments but also in a wide variety of marine deposits.

16. Fossils: how do they form?



Fossils are the remains of animals and plants which have become preserved in rocks. Hard parts such as shell and bone is most commonly preserved, although in exceptional cases soft tissue may be fossilised.

Stages of fossilisation:
1. The living animal or plant dies, the soft tissues decay and the hard parts are covered in sediment.
2. The original material remains intact - e.g. Tertiary shells, Wooly Mammoth frozen in ice.
3. Permineralisation (petrifaction): pores in shell and bone becomes infilled with calcite or another mineral which strengthens it.

4 & 5. Replacement: the skeletal material is replaced by another mineral such as Iron Pyrites or Silica

6. Carbonisation: organic plant tissues and graptolites may become altered to a film of carbon under pressure.

7-10. Shell dissolves in sediment leaving a hollow or mould of the inside or the outside. If this becomes subsequently infilled a cast of the original shell is produced. This might be of the interior or exterior of the shell.

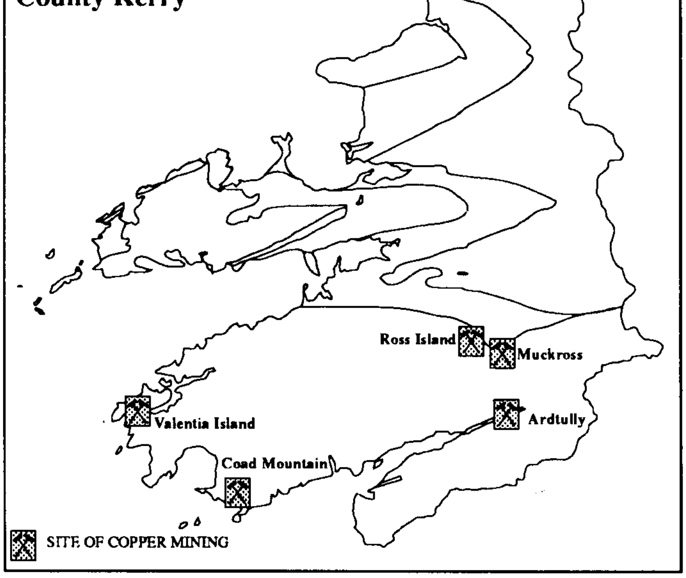
11. Under pressure the original skeletal material of shells may become recrystallised.
12. Fossils may become flattened and distorted under the pressure of overlying layers of sediment. Graptolites are often preserved in shales in this way.

17. Copper mining in County Kerry.

For over 4000 years until the late 1800s copper was extracted from a number of localities in County Kerry. This metal has always been valuable and was used by early settlers to make bronze weapons, which were more effective than those made of iron. In the Bronze Age Kerry was an important mining and metal working centre.

The metal occurs as a brassy-coloured mineral called Chalcopyrite ($CuFeS_2$) which is a mixture of copper, iron and sulphur. Small amounts of green Malachite and blue Azurite (copper oxides) were also extracted. Rarely the metal is found pure as Native Copper (Cu).

Copper is used to produce (1) Bronze, an alloy (mixture) of copper and tin; (2) Brass, an alloy of copper and zinc. Today the metal has many uses, principally in electrical goods and in piping for plumbing.



Localities where copper was formerly mined in County Kerry

- ROSS ISLAND, Killarney: Copper had been exploited at Ross Island since 2000 BC prior to being commercially exploited in the early 19th century. The ore is disseminated within Carboniferous limestone. In 1804 Colonel Hall sunk mine shafts on the shores of Lough Leane at Ross Island and 3,220 tons of ore (worth £80,000) was extracted in four years. This was shipped to Swansea where it was sold. Between 1827 and 1829 Thomas Weaver reopened the mines and 1,529 tons of ore containing 14% copper was extracted. The mines employed 500 people. Keeping the mine free of water that seeped in from the lake was a serious problem and this resulted in their final closure in 1829. These shafts are now flooded and very dangerous.
- COAD MOUNTAIN, near Caherdaniel: site of ancient copper mines. One was later converted into a hermits cell. In the 17th century many were reworked by William Petty the cartographer, and later through to the 19th century by others. The copper ore was contained within quartz lodes up to eight feet wide, and it had 13% copper metal.
- MUCKROSS, Killarney: From 1749 to 1754 large quantities of yellow copper ore was extracted from mines at Muckross, owned by the Herbert family. Mining recommenced in 1785 and continued until 1818. The ore was probably disseminated throughout the Carboniferous limestone although it was reported to occur in distinct lodes (bands of ore). It contained up to 26% copper, and also cobalt and arsenic. By the time the mine was abandoned it had reached a depth of 30 fathoms. For a time the mines were managed by Rudolf Erich Raspe, a mineralogist and adventurer who died in Muckross in 1794.
- CROW ISLAND, east of Ross Island, Killarney: A small working which produced just over 100 tons of ore in the mid 1800s. The shaft reached a depth of 6 fathoms.
- VALENTIA ISLAND: A small working which opened in about 1861 and operated for two years. In that time 100 tons of ore containing 24% copper was extracted.
- ARDTULLY, near Kenmare: Over eight copper lodes and four lead lodes are found in the area around Kenmare. They are each given names including Forge Lode, Mamby's Lode, and Trinity Lode. They have been worked for considerable time from the 1660s with limited success. The lead ore was contained within Carboniferous limestone while the copper was hosted in limestone, Old Red Sandstone or slate. In the 1830 copper was won by open cast and shaft mining. The open cast mines reached a depth of 7 fathoms while the shaft was sunk to 13. In 1840 77 tons of copper ore was sold for £1132. Mining continued into this century when 59 tons of ore with 4% copper was lifted in 1911. The cost of extracting the ore was often more than its value and assuccession of mining companies (including one from Trinity College, Dublin) lost money in the area.

18. Chalk in County Kerry and the Dinosaur mystery.

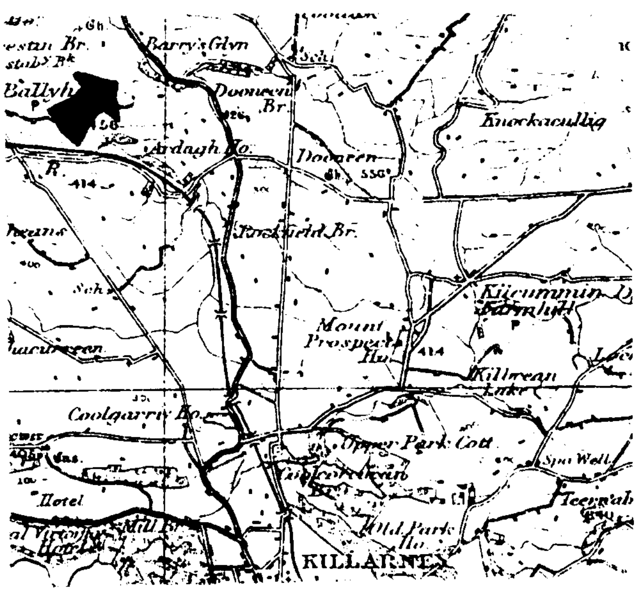
During the Cretaceous period most of the British Isles were covered by seas. In these seas Chalk, which is almost pure calcium carbonate [$CaCO_3$] and largely made up of coccoliths, was deposited. Within the thick succession of Chalk are found bands of flint nodules. In the south of England the Cliffs of Dover are made of Chalk. Overlying the Cretaceous Chalk a variety of muds and sandy sediments of Tertiary age were deposited, as well as volcanic lavas in County Antrim. It is assumed that much of Ireland was once covered with Chalk, but most of it has been eroded away. The Antrim basalts have protected the underlying Chalk and other older Mesozoic rocks from this erosion, and Chalk is known from a number of places offshore Ireland, which have been drilled in the search for oil and gas.

It is surprising that a small patch of Chalk survives in County Kerry, just northwest of Killarney. It is not clear how much Chalk actually exists, but it is probably not extensive. The Chalk contains fragments of black shale of Upper Carboniferous age which is common in east Kerry.

It is probable that the Chalk is lying directly on Upper Carboniferous shales, and may be faulted on all sides, which allowed it to move downwards relative to the older surrounding rocks. In the last century much of the Chalk was burnt in a limekiln to produce lime for the land.

Flint is composed of quartz and is usually pale to brown in colour. It is hard-wearing and these nodules are frequently found on beaches, even around Kerry. Flint can be broked to produce a sharp edge, and was used by early settlers in Ireland for implements for slicing meat and hunting.

There is actually no mystery why only one dinosaur bone has so far been found in rocks in Ireland. Dinosaurs lived in the three periods of the Mesozoic Era: the Triassic, Jurassic and Cretaceous. However, rocks from these periods are not common in Ireland today because most of them have been eroded away. In County Antrim there are some Mesozoic rocks from which the only dinosaur bone has been found, and there is Cretaceous chalk in Kerry. Unfortunately dinosaurs are not common in Chalk as it was laid down in a deep sea where dinosaurs did not live.



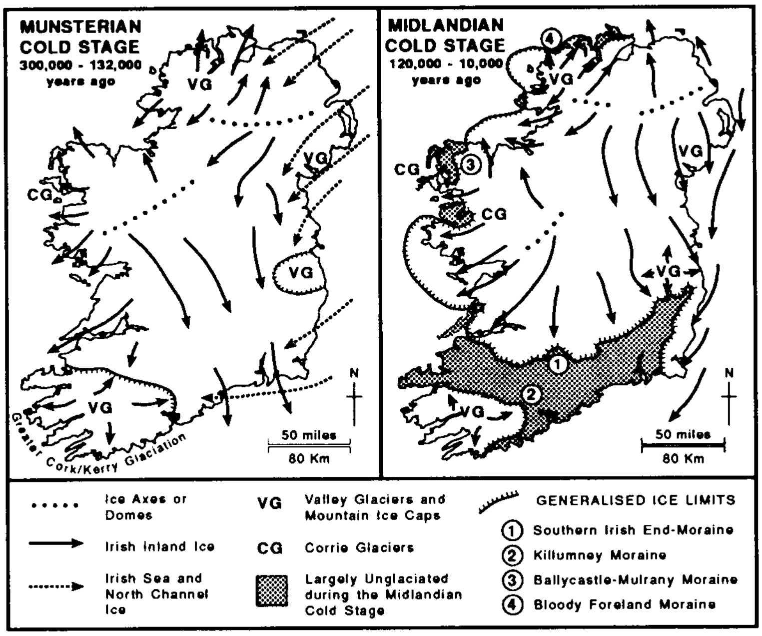
Location of the small outlier of Chalk north of Killarney

Coccoliths (hard parts of algae) which make up most of the Chalk

19. Kerry in the grip of an Ice Age.

Global cooling that began during the Tertiary culminated in a series of step-like, sudden, changes in climatic conditions over the last two million years as the climate began to 'seesaw' from cool to warm and the massive polar ice caps expanded and contracted. This period from 1.7 million years ago to the present is known as the Quaternary period. At our latitudes the warmer periods are known as temperate stages (or interglacials - periods between glaciations) and the cooler periods as cold stages (or glacials).

During the cooler periods the polar ice caps and local ice masses underwent major expansion at least 8 times in the last 700,000 years. Although Kerry has been affected by many glaciations in the past it is the last two glaciations (Munsterian 300,000-132,000 years ago; Midlandian 120,000-10,000 years ago) that have most strongly imprinted on the landscape, since each successive glaciation removes much of the evidence of previous glaciations.



Lough Doon, County Kerry and its importance to historians of geology in Ireland.

Corries are bowl shaped depressions carved by ice from the sides of mountains, which now often contain circular lakes. In the 1840s many doubted that glaciers once existed in Ireland. Evidence for them was first demonstrated by John Ball in 1849. Ball had visited the Alps and there seen glaciers and other glacial features. On his return to Ireland he recognised the significance of a topographical feature (an armchair-like depression on the side of Slieveanea Mountain) at Lough Doon near the Connor Pass, on the Dingle Peninsula. He wrote a paper titled "Notice of the former existance of small glaciers in the County of Kerry" which was published by the Geological Society of Dublin in which he presented evidence from Lough Doon which proved the existance of a former Irish glacier.
Lough Doon is one of the most important sites for the history of Irish geology.

The Munsterian glaciation was a long cold period that lasted over 150,000 years. In the Kerry area ice masses developed on the mountains and corries fed valley glaciers. During the succeeding Midlandian glaciation ice did not cover the northern part of Kerry. Ice masses developed on the Macgillycuddy's Reeks.

The mountains and valleys of County Kerry display many features that are glacial in origin: corries and deepened U-shaped valleys, many of which contain glacial moraines (debris carried by ice) at their entrances.

20. A mucky mixture: what does boulder clay contain?

Boulder clay or till is material that has been left behind after the melting of glaciers and ice sheets. This material which was removed by the ice as it moved over the ground surface, is dumped from beneath or from the surface of the ice, in an unsorted mass of rock particles. These range in size from rock flour (very small) to boulders (huge). A great deal of Ireland is covered with boulder clay which reaches a maximum thickness of 122 metres in Co. Kildare. Some glacial deposits were laid down from glacial meltwater. These are called fluvio-glacial deposits and are usually finer than boulder clay and generally well sorted.

Stones collected at Camp beach, Dingle Peninsula which were washed out of the cliffs of boulder clay.
Lower Carboniferous limestone
Silurian siltstone
Black chert (found in layers in limestone)
Quartz
Conglomerate
Old Red Sandstone

At Camp on the Dingle Peninsula, County Kerry there are cliffs of boulder clay or glacial till 6 metres high. You can see some crude layering of material. Towards the base of the cliffs are coarse unsorted cobbles, above which the sediment is finer. The boulder clay is topped by soil which has developed in the last 10,000 years.

The boulder clay at Camp consists of an unsorted mixture of large cobbles (up to 15 cm in diameter) and fine pulverised rock (called rock flour). The cobbles are not all the same type.

Erratics (other glacial deposits): ice was able to carry huge boulders a great distance. These transported blocks are called erratics. When the ice melted they were dropped, often onto rock of a different type. If one knows the source of erratics then their distribution can be used to tell where the ice travelled from.

Glacial erratic, Carrigacapeen, near Kenmare: a large block of Old Red Sandstone perched on top of younger Carboniferous Limestone. The Old Red Sandstone block was dumped here by ice. Many such examples can be found in the Kenmare region, and equally can blocks of limestone be found perched on Old Red Sandstone

(drawing taken from Geological Survey of Ireland Memoir on Killarney and Kenmare 1927).

21. The Giant Irish Deer: victim of the Ice Age.

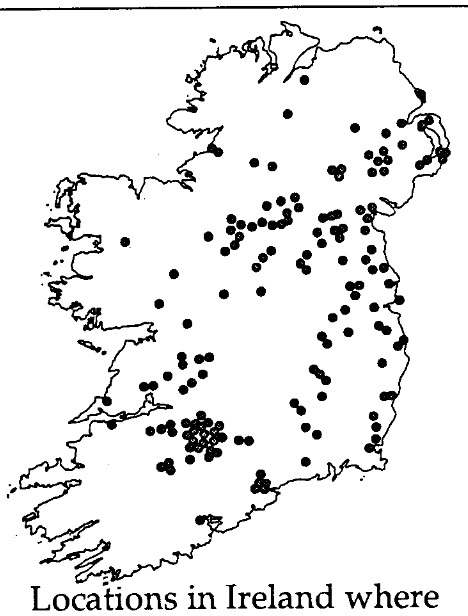
The extinct Giant Irish Deer *Megaloceros giganteus*, roamed Ireland during the Pleistocene age at the end of the last Ice Age, about 12,500 - 11,000 years ago. Although this animal lived in mainland Europe as well as in the British Isles, its fossilised remains have been found in large numbers in Ireland. After the ice of the last Ice Age melted some 12,500 years ago, many animals returned to Ireland from the south via France and Britain. A cold spell which occurred about 11,000 years ago caused the extinction of the Giant Irish Deer.

Like all deer the Giant Irish Deer probably spent most of its time in herds of the same sex, both of which came together only to breed. The males overwintred in the lowland valleys near lakes, while the females spent the winters on higher ground. When the females died their carcases were scavanged and eaten by various predators , leaving little remains; while the bodies of the males that died in the winter were likely to end up at the bottom of the lakes where they were later covered by sediments and preserved.

Q How big were Giant Irish Deer?

A The deer stood about six feet high at the shoulder, and up to ten feet high at the tips of the antlers. Only the males carried antlers, which were enormous: they were 4 metres wide and weighed about 35 kilogrammes. The antlers had to be regrown each year.

Professor Frank Mitchell (6')
standing underneath the male Giant Irish Deer
in the Geological Museum, Trinity College.



Locations in Ireland where
Giant Irish Deer have been found

(from Mitchell, G.F. & Parkes, H.M. 1949. The Giant Deer in Ireland. *Proceedings of the Royal Irish Academy* 52, 291-314)

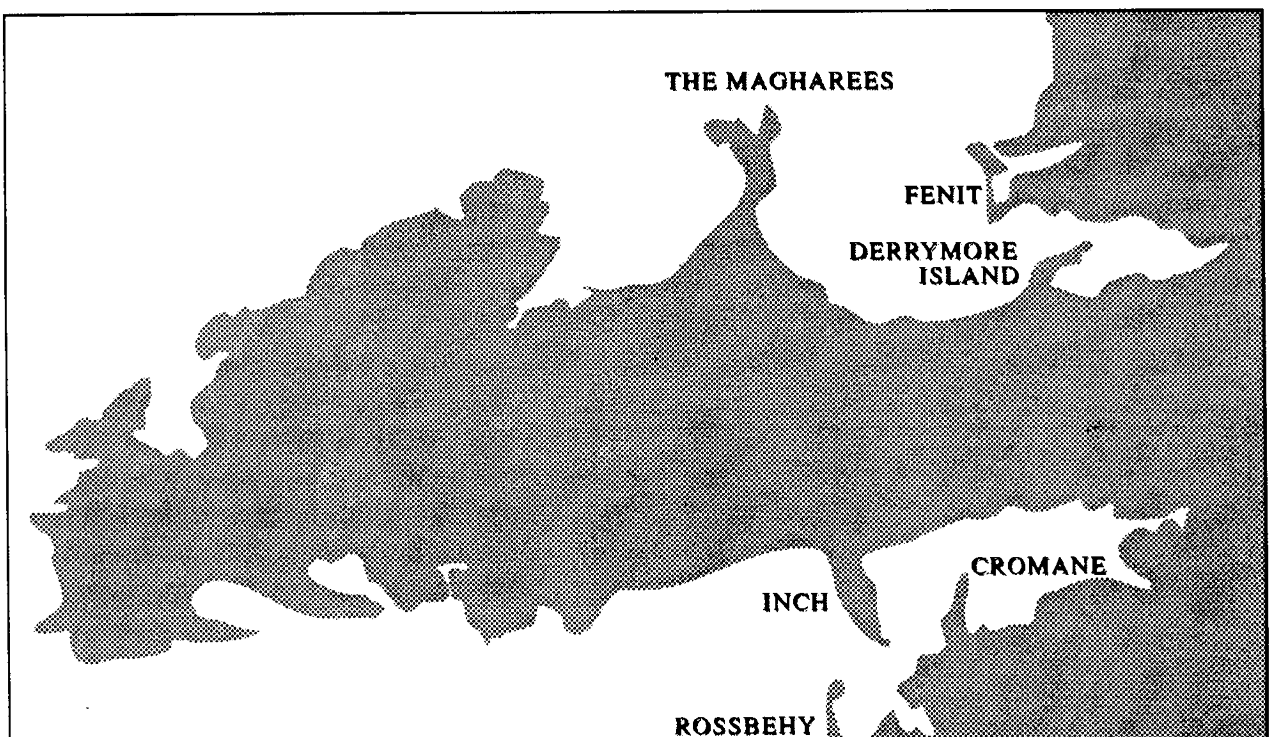
Recent work suggests that the antlers were beneficial as displays to attract females and to dominate rival males. Dr A.D. Barnosky of the Carnegie Museum, Pittsburg, U.S.A., has demonstrated tht the antlers are not abnormally large for the body size, that they balance around the head-joint in an efficient manner, and that the oversized neck vertebrae would have held adequate muscles for support and manulpulation of the antlers.

22. Spits and tombolos: recent sedimentation in Kerry.

In a number of places around the coast of Ireland spits and tombolos have developed in the last 10,000 years. These are bars of sand or gravel which are usually perpendicular to the coastline. They have formed due to the action of currents which have caused sand to build up by longshore drift.

Tombolos are sand bars that either connects two islands together, or connects islands to the mainland. They may be made of sand or shingle or both, and often have well-developed sanddune systems associated with them. The tombolo that connects Castlegregory to some of the Magharee Islands is one of the best examples in Ireland, and provides a good habitat for Ireland's only toad, the Natterjack Toad.

Spits are narrow tongues of sand or shingle, or both, that project into the sea and which are attached at one end to the coast. In County Kerry sand spits are well developed in Castlemaine Harbour where they occur at Cromane, Rossbehy and Inch. In Tralee Bay the spit at Derrymore Island is unusual because it is made of shingle, and has a curved end which parallels the coastline.



Spits and tombolos in County Kerry

23. Geologists: what do they do?

BRANCHES OF GEOLOGY

STRATIGRAPHY: the study of stratified rock sequences and their position in time.
PALAEONTOLOGY: the study of fossils.
PETROLOGY: the study of rocks.
MINERALOGY: the study of minerals.
ECONOMIC GEOLOGY: the study of economically useful rocks & minerals.
STRUCTURAL GEOLOGY: the study of folds, faults and other aspects of rock movement and deformation.
SEISMOLOGY: the study of earthquakes.
VULCANOLOGY: the study of volcanoes.
HYDROGEOLOGY: the study of the geological aspects of water.
GEOCHEMISTRY: the study of the distribution of the elements in the Earth.
QUATERNARY STUDIES: the study of the last 2 million years of the Earth's history.

Quarrying

Mineral exploration

Waste disposal

Road building

Volcanic monitoring

Palynologist

Water resources

Teaching

Researcher

Astronaut

Earthquake prediction

Mining

Monitor coastal erosion

Construction industry

Coal industry

Oil & gas exploration

24. Collecting and identification of geological material: helpful hints.

Collecting geological material can be interesting and good fun. However, the collector should take a number of things into account before embarking on this as a hobby.

Remember that many sites are of great scientific interest as well as being part of our national heritage. Please do not over collect, or remove *in situ* material if loose material is to be had nearby. Parts of County Kerry have been around for over 400 years, we want them to last into the next generation!

Remember the country Code: do not damage fences, leave gates open or leave behind anything that might be dangerous.

Tell someone where you are going and when you expect to be coming back. If possible go on excursions with other people.

Don't climb up steep slopes, as you might either fall, or dislodge loose material which might fall on top of someone beneath.

Always seek the permission of the owner of the land from which you wish to collect, or pass through.

A collection is of little value if there is no documentation with it. Record where (to the precise location and geological horizon) and when you collected the material. Label your specimens and give them each a unique number and record these in a catalogue. Keep your specimens in a cabinet or similar storage place where they will be safe.

Equipment needed for collecting geological material:

A: a geological hammer (not a carpenter's hammer).
B: a chisel (this and the hammer should be used as little as possible).
C: a topographical map and/or geological map.
D: a notebook for recording details of your collecting sites and their geology.
E: a waterproof marker for marking your specimens.
F: a pencil and mapping pen (for recording information on your map and in your notebook - these can be inked in at home in the evenings).
G: newspaper and bubble wrap for wrapping your specimens.
H: a canvas bag for carrying your specimens.
I: a compass, or compass clinometer (for taking the orientation of rock structures).
J: a whistle and torch (in case you get lost after dark).

Stages in fossil collection and identification:

i. gathering site information and documentation.
ii. collection of specimens.
iii. preparation of material (washing, cleaning, removal of matrix).
iv. identification and curation of specimens (labelling, cataloguing and storage).

There are many introductory books to geology available in the bookshops. The following are reasonably cheap and useful:

The Country Life Guide to Minerals, Rocks and Fossils,
by W.R. Hamilton, A.R. Woolley and A.C. Bishop.
Contains good photographs of many mineral and fossil species and different rock types, together with descriptions.

A Dictionary of Geology (Penguin)
by D.G.A. Whitten with J.R.V. Brooks.

British Palaeozoic Fossils
by the Natural History Museum, London.

25. Where can I get more information about Kerry's geology?

In the last 200 years a great deal has been written on the geology of County Kerry. Below is a list of some papers published since 1940. Most of these appeared in specialist geological journals, many of which may be obtained from the Geological Survey of Ireland or University geological departments.

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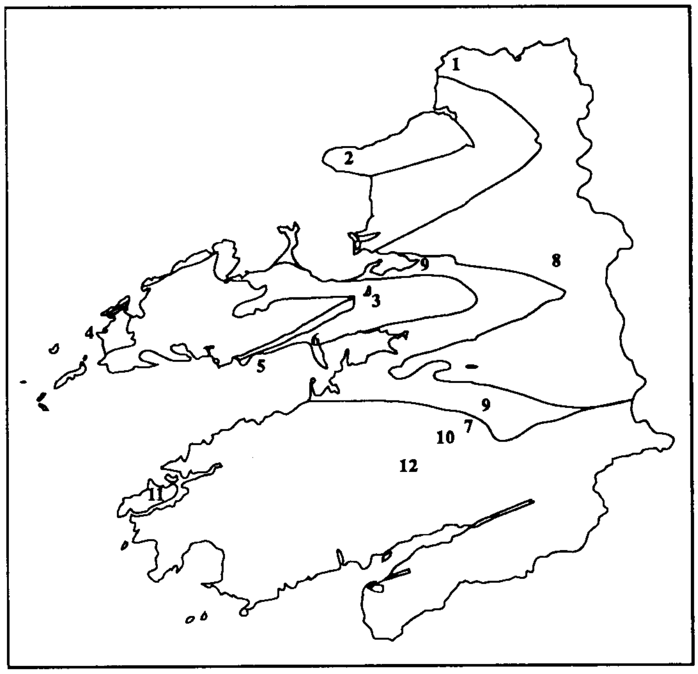
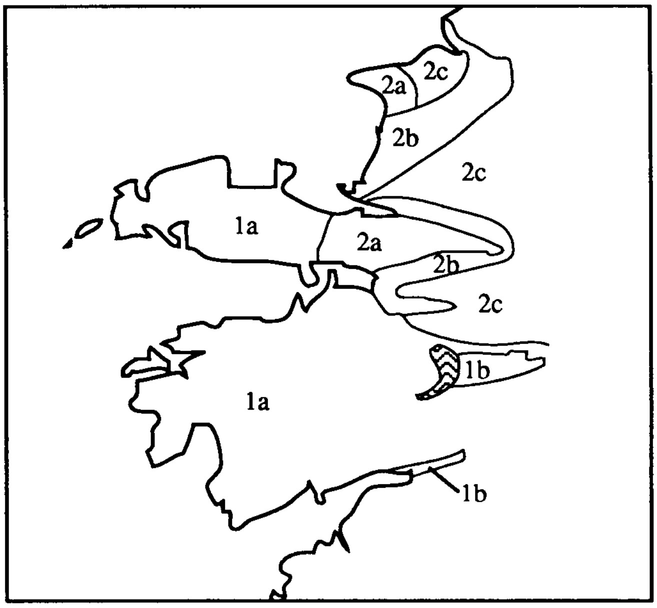
26. Where can I see good geology in the Kerry area?



1. Ballybunnion: good exposures of Lower Carboniferous limestones and younger Upper Carboniferous shales may be seen. A raised beach is present to the south of Ballybunnion.
2. Ballyheigue and Kerry Head: Old Red Sandstone makes up Kerry Head. These sandstones are more resistant to erosion and weathering than is the Carboniferous limestone of the surrounding lowlands. At Ballyheigue early Devonian plants may be found.
3. Derrymore Glen: an attractive glaciated valley with two corries at its head. Silurian sediments are exposed in the valley and are overlain by Old Red Sandstone conglomerates and purple sandstones which are best seen in the cliffs surrounding the corrie lakes.
4. Clogher Head and Ferriter's Cove: good exposures of Silurian volcanic rocks, including banded white ignimbrite occur at Clogher Head. Thinly bedded siltstones, also of Silurian age, which contain many fossils may be seen at Ferriter's Cove.
5. Kilmurry Bay and Minard Head: at Kilmurry Bay sandstones of Devonian age show large scale dune bedding. At Minard Bay the Caherconree fault separates Silurian siltstones (to the north) from Old Red Sandstone (to the south). Fault breccia is present along the fault plane.
6. Inch: is best known for its magnificent sand spit with fine sand dunes which extends into Castlemaine Harbour. Purple sandstones containing fossilised ripple marks and the Inch Conglomerate crop out at the landward end of the spit.
7. Ross Island: here, by the shores of the Lakes of Killarney, copper ore was mined until the mid-1800s. This ore was contained in lodes in the limestone. The old mine shafts are now flooded. Beware these are dangerous! Ross Castle is built of local Carboniferous limestone.
8. Crag Cave: one of the best examples in Ireland of an underground cave system . All the typical karstic features may be seen: stalactites, stalamites, and columns. This cave system was probably excavated by water from melting glaciers 10,000 years ago.
9. Tralee and Killarney towns: towns are good places to observe geology - look at the buildings! In Tralee and Killarney most older buildings are of limestone. Local sandstone was also used. Modern concrete buildings are faced with thin slabs of native and imported stone often granite.
10: The Gap of Dunloe: this gash through the northern edge of the Macgillycuddy's Reeks, is a glacial feature. It was carved by meltwater escaping northwards at the end of the Ice Age. Moraines (dumped debris from melted glaciers) are extensively developed here.
11. Valentia Island: this island is well-known for its many antiquities. It is made of Devonian sediments of which slate is the most abundant. The slate was quarried for many years and used for roofing, shelving, and billiard tables.
12: Macgillycuddy's Reeks: these mountains which contain most of the highest peaks in Ireland are made of Old Red Sandstone. They have been extensively glaciated and U-shaped valleys, corries, aretes, ribbon-lakes, and glacial moraines may be seen.

27. Geological maps of the Kerry area from the early 1800s to the present day.

Thomas Weaver's Geological map of the south of Ireland (1855): This is a tracing of a map compiled by Thomas Weaver who was a mining geologist. The map is a crude representation of Kerry's geology which is divided into five rock types. The oldest are from the Transition series: greywackes and slates (1a) and limestones (1b). Carboniferous rocks are divided into Old Red Sandstone (2a), limestone (2b) and coal (2c). In the light of modern geological knowledge the map is quite inaccurate. Weaver's work in southwest Ireland in the 1830s was nevertheless important an laid the foundations for future geologists.



Tracing of Weaver's 1833 map

Richard Griffith's Geological Map of Ireland (1839-1855): Richard Griffith (1784-1878) was an important figure in nineteenth century Ireland. He was a various times Mining Engineer to the Royal Dublin Society, a road and bridge-builder in Munster, a Railway Commissioner, engineer to the Bog Commissioners, Deputy Chairman of the Bord of Works, and the Commissioner of the (Land) Valuation. For these public services he became a baronet in March 1858.

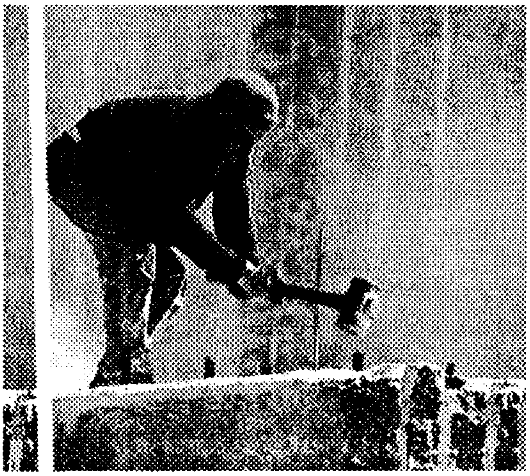
Griffith developed an interest in geology in his youth. His major geological ambition was to produce a large scale geological map of Ireland. It is thought that he began compiling the map in 1809, and he first exhibited a draft map, with geological lines traced on a base map, in 1814. Much of Griffith's early geological surveying was carried out while employed by the (Royal) Dublin Society and for many subsequent years he accumulated geological information. In 1827 Griffith was appointed Commissioner of the General Survey and Valuation of Rateable Property and was responsible for supervising valuators for the next 35 years. These men travelled the country valuing property and making soil surveys. In addition Griffith charged his men also to make a geological assessment of the areas surveyed. Much of the information on post-1839 maps was collected by Patrick Ganly, a Valuation Surveyor, and others, and not by Griffith who took credit for it.

In 1836 Griffith was appointed one of the four Railway Commissioners who were to report on the promotion of this new mode of transport. The Commissioners at Griffith's coaxing arranged for the production of a map of Ireland at a scale of a quarter of an inch to one mile, and it was to this base map, prepared by Thomas Larcom, that Griffith added his geological boundaries. The large scale geological map was first published on 22nd May 1839. It cost of 20 shillings uncoloured. By 1847 5,406 copies had been distributed, but only a small proportion were coloured geologically. Colouring was a laborious task: it took seven to eight days to apply the 24 tints. Between 1839 and 1855 (when the final version of the map appeared) Griffith and his associates revised much of the geology on the map. In the revised version of 1852 the number of geological colours increased to 46. This is a copy of the 1855 edition of the map showing the geology of the Kerry area.

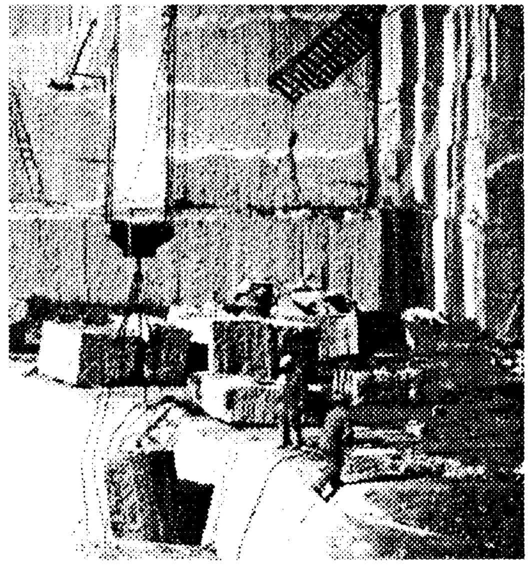
Geological Map of Tralee and surrounding area (1859-1883): This map, drawn at a scale of one inch to one mile, illustrates the solid geology underlying Tralee and the immediate countryside. The map was published by the Geological Survey of Ireland in 1901, and forms part of a complete geological survey of the island, begun in 1845, which was published on 205 maps. The first edition of the Tralee map (Sheet 162) was published in September 1859 and was first revised in 1883.

Extract from a map of Mineral Deposits of Ireland (1984): This enlarged extract of the geology of County Kerry is taken from a recently produced map of the various mineral deposits found in Ireland. This map is the most recently published generalised map of Ireland's geology. It was compiled from information supplied by various academic and industrial sources, and was published by Crowe, Schaffalitzky & Associates and Environmental Resources Analysis Ltd. While the map is drawn at a small scale of 1:1000000 it shows reasonable geological detail, and lithologies are indicated by the use of 31 colours. Faults are shown by heavy dashed lines.

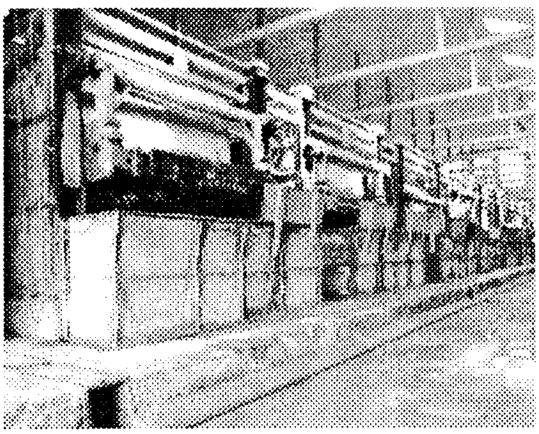
28. Stone: from extraction to the finished product.



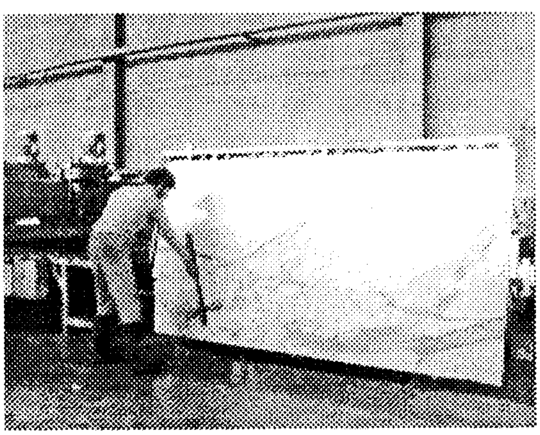
1 Driving inwedges to split off 25 tonne block of stone



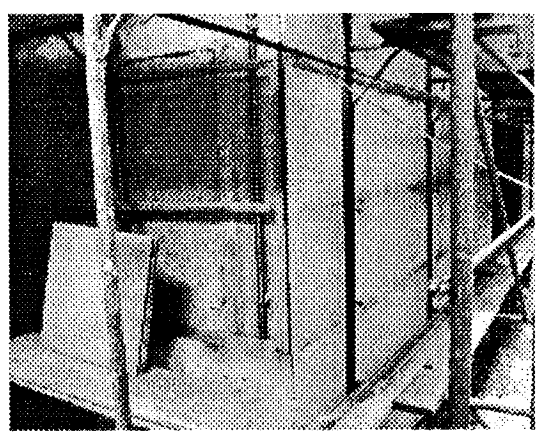
2 Lifting blocks of stone from the quarry



3 Cutting stone into slabs 2 cm thick with frame saws



4 Polishing a large slab of marble



5 Fitting finished slab onto a building using metal ties

29. From medieval to modern times: the use of stone in Tralee and Kerry.

Stone is one of the most versatile building materials. It can be cut, broken, sawn, drilled, and carved. The use of stone in Ireland reflects the geology, and for the most part local stone was used in the past, when transportation was difficult. Stone gives urban Ireland a regional character, and this is reflected in the present urban landscape. The use of stone for building in Ireland goes back at least 5,000 years. The pre-Christian inhabitants used local stone to build burial places: dolmens, and passage graves, including Newgrange (4,500 years old), and also stone forts such as Staigue fort.

Early Christian churches were simple, like the 7-8th century oratory at Gallarus in Co. Kerry, where no mortar was used. This binding agent was introduced later, and the earliest records of its use in Ireland occurs in 9th and 10th, when it was used in the construction of century round towers and later 11th century churches. At this time, differential use of stone types appeared: local stone was used for the bulk of building and more exotic material was used for architectural features such as carved architraves around windows. This is well developed in St Brendan's Cathedral, Ardfert, Co. Kerry.

During medieval times most buildings were constructed of locally derived stone. In the 18th century many important public buildings were built. Walls were largely of rubble and faced with cut stone blocks of limestone or granite. Brick was also commonly used for domestic houses. Slate for roofing was largely Welsh, although Irish slate was available from Ashford, Co. Wicklow, Killaloe, Co. Clare and Valentia Island, Co. Kerry. The Victorians exploited many Irish marbles as decorative stones. The chief marbles included the Connemara green serpentinite marble, the red Cork 'marbles' and the black Kilkenny and Galway 'marbles'. In the last thirty years most buildings are constructed of concrete which is usually covered with a thin veneer or cladding of cut stone. Granite and other igneous rocks, from Wicklow or imported from Scandinavia, Brazil, and elsewhere, are most common today.

400 BC: Staigue fort, Caherdaniel: a large ring fort, built of local Old Red Sandstone.

7-8th century: Gallarus Oratory, Dingle Peninsula: a dry stone corbelled church built of local sandstones and conglomerates.

12th century: Church, Kilmalkedar, Ballyferriter: ornately carved in local pale coloured sandstones of the Dingle Group.

Pikeman 1798 Memorial, Denny Street, Tralee: built of grey Carboniferous Limestone with features in pinkish Cork Red Marble.

1835: The Courthouse, Tralee: built of Limestone (from the Castle Green quarry) which contains corals and brachiopod fossils.

late 1800s: Dingle town: a small house built of local stone with red brick used sparingly around windows and doorway.

1928: Thomas Ashe Memorial Hall: an impressive building constructed of flat blocks (ashlar) of Old Red Sandstone.

1970s: AIB bank, Denny Street, Tralee: cladding of thin slabs of pale Granite from Co. Wicklow and blue Larvikite from Norway.

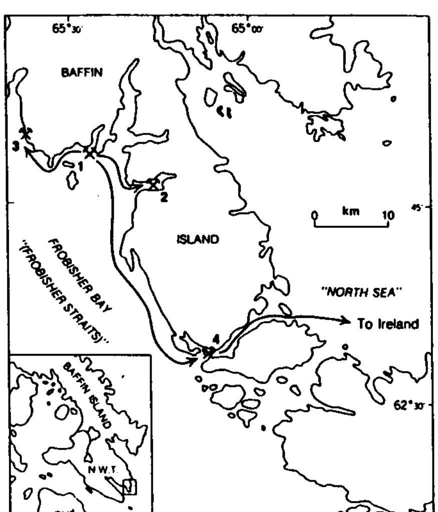
1980s: Woodchester, Denny Street: a fine example of a façade of Ballinasloe Limestone - a pale grey stone.

30. Martin Frobisher and the Canadian 'ore' in Smerwick Harbour.

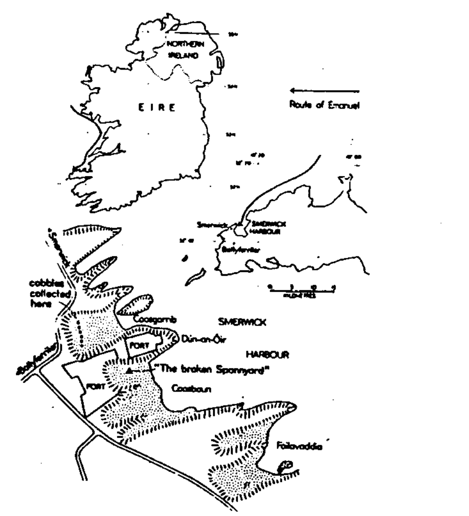
Martin Frobisher was a noted Elizabethian explorer who in 1576 set off with two small wooden ships to find the Northwest Passage. It was thought that a route via northern Canada to eastern Asia could be found. Frobisher headed for the mouth of the St. Lawrence River which he had seen on a map. However, he sailed further north to Baffin Island and into a stretch of water (now called Frobisher Strait) which he believed was open ended. He brought back to England a number of souviners including an eskimo, and a piece of black rock. His financier told him that the rock contained gold, so Frobisher returned to Baffin Island in 1577 and mined 160 tons of the "ore". This material was examined by various experts in England who could not find any trace of gold or silver in the rock.

Nevertheless a mining concern the Cathay Company was established and 400 men in 15 ships were dispatched to Baffin Island in 1578. Four mines were opened and nearly 1200 tons of "ore " was shipped back to England. 11 of the ships were owned by the Cathay Company while four were privately owned by Frobisher and others. One of the latter The Emanuel loaded with 110 tons of "ore" . This ship got into difficulties and on 25th September 1578 ran aground in Smerwick Harbour on the Dingle Peninsula, Kerry. 100 tons of "ore" was brought ashore in a vain attempt to lighten the ship so that she could be repaired. Some of the "ore" was sent to England but much was probably incorporated into a stone fort afterwhich it was called Dún-an-Oir. Soon afterwards it was finally realised by all that the "ore" contained no precious metals at all. In all the three expeditions cost £20,000. Frobisher wrote a manual of Arctic seamanship which became a valuable document for subsequent explorers of the region.

In 1988 a Canadian geologist Don Hogarth collected some cobbles from the beach at Dún-an-Oir and compared them with material from Baffin Island and the remains of "ore" still in Kent, England. The rocks from Kerry matched exactly and are very rare examples of an igneous rock that contains the minerals hornblende, pyroxene, olivine and traces of others including forsterite, vanadium and nickle. In fact Frobisher's "ore" contains less gold than the average rock from the Earth's crust.



Location of the mines on Baffin Island, Canada



Location of Dún an Oír and Frobisher's "Ore"