
Quaternary of Scotland

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Access to the countryside

This volume is not intended for use as a field guide. The description or mention of any site should not be taken as an indication that access to a site is open or that a right of way exists. Most sites described are in private ownership, and their inclusion herein is solely for the purpose of justifying their conservation. Their description or appearance on a map in this work should in no way be construed as an invitation to visit. Prior consent for visits should always be obtained from the landowner and/or occupier.

Information on conservation matters, including site ownership, relating to Sites of Special Scientific Interest (SSSIs) or National Nature Reserves (NNRs) in particular counties or districts may be obtained from the relevant country conservation agency headquarters listed below:

Scottish Natural Heritage 12 Hope Terrace, Edinburgh EH9 2AS.

Countryside Council for Wales, Plas Penrhos, Ffordd Penrhos, Bangor, Gwynedd LL57 2LQ.

English Nature, Northminster House, Peterborough PE1 1UA.

Foreword

One of the great insights of nineteenth century geology was the recognition that the environmental backdrop against which the drama of human evolution and history had been played was not static, as had been hitherto assumed, but had changed dramatically on relatively short timescales. The young Swiss geologist, Louis Agassiz, who played a major role in bringing about this change in thinking, visited Scotland in 1840 to advocate his new glacial theory, which suggested that the northern continents had suffered widespread glaciation in the recent past. Scottish geologists such as Lyell, Jamieson, MacLaren, Croll and Geikie were quick to pick up his ideas and, seeing ubiquitous evidence of change in their own country's dramatic landscape, led the world in exploring the implications of this revolutionary new concept. These pioneers established the flow patterns of the ice masses which had moulded the rock slabs of the Cuillin of Skye and had dispersed the rocks of Ailsa Craig into England; demonstrated rebound of crust after ice disappearance, which uplifted old shorelines around Oban and Mull high above modern sea level; and showed that great floods of meltwater from the decaying ice masses had produced the hummocky ridges on which many of Scotland's best golf courses are now built. They also showed that there had been rapidly alternating warm and cold periods in the past and that the ultimate drive for

climatic change was the Earth's fluctuating orbit around the Sun.

Only recently, however, has the advent of techniques such as pollen analysis, uranium-series dating and radiocarbon dating been able to place a precise timescale on these events. They have revealed the dramatic overlap between an almost unimaginable geological past and a human present as reflected in prehistory and history, showing for example, that 11,000–10,000 years ago, when Jericho was a thriving city, the sites of many modern cities in Scandinavia, and many towns and villages in the Scottish Highlands, were overlain by more than a kilometre of ice.

It is only in the last two decades, with increasing public awareness of the fragility of the ecosystem, of the fact that well-protected botanical reserves appear to 'deteriorate', and of the vulnerability of the Earth's climate itself, that the significance of the geological record of Quaternary environmental change has been generally realised. The record tells us about the frequency and magnitude of natural change in the past, how mean annual temperatures have changed by as much as 5°C in the period of a human lifetime; how floral assemblages have changed rapidly, both in response to climatic change and without any apparent climatic drive; and how the composition of the atmosphere, including its 'greenhouse gases', has varied cyclically and in phase with the climate. The record also tells us about the frequency and magnitude of natural change that long-term dwellers on this Earth should expect, what the consequences of an increased atmospheric greenhouse gas concentration might be, and what processes should be taken into account in theories about future climate and environmental change.

This understanding is drawn from natural geological archives such as those represented by the sites described in this volume. Many of these archives have been well-read and understood: many others, no doubt, await new techniques or new insights before they yield up their secrets. Just as no civilised person would lightly destroy the books in an ancient library, no more should we lightly contemplate the destruction of this record of the past. However, roads need to be built, minerals need to be mined, food must be grown and people need to be housed, and Quaternary sediments are soft and easily destroyed or removed. Moreover, farmers, in their desire to improve their pastures, may wish to drain bogs containing superb records of past climate and ecological change, whilst elsewhere some of our finest surviving eskers are the most readily available source of sand and gravel for building. Clearly there are difficult decisions to be made about the balance between the need to preserve the geological archive and the need for us to use the land. Such decisions as these, which must be made as a result of debate involving the new natural heritage organisations, need information about the extent and nature of our heritage. This splendid volume is of fundamental importance in helping to define that heritage.

The Quaternary of Scotland documents the most important known Quaternary sites in Scotland and provides a basic factual archive, although there are, no doubt, other sites which are known which will prove to be equally important as a result of new insights and new methods, and others as yet undiscovered which will also join these ranks in the future. The site-by-site observational information described in this volume is associated with interpretations, which indicate the significance of each site in adding to our understanding. The site descriptions are incorporated into regional and Scottish syntheses, so that the role of the individual observations in determining the large-scale theoretical framework can be seen. So great is the amount of the data now available that few syntheses are able to go back to the primary observations, but are based on second and third hand sources. John Gordon and Donald Sutherland have not only done a great service to conservation but also to Quaternary geology in relating the facts to the interpretive framework. Much of the speculation may not survive changes in scientific fashion and theory, but the basic observations will.

The text has great clarity for such a complex subject and the quality of the illustrations is a reminder of that great lure to field science in Scotland: the beauty of the land.

Geoffrey Stewart Boulton FRS, FRSE Regius Professor of Geology, The University of Edinburgh

Preface

Structure of the volume and terminology used

This book contains scientific descriptions of 138 localities of national importance for Quaternary geology, geomorphology and environmental change in Scotland. It consists of two chapters that provide a general overview, followed by 16 regional chapters. The objective of the former chapters is to permit the reader to understand how the details of individual sites fit into the national scheme.

The locations of the regions are shown in (Figure 1.1). Each of the regional chapters has a brief introduction which outlines the Quaternary geology and geomorphology and places the individual sites in their regional context. The individual site descriptions form the core of the book. In each chapter they are arranged, broadly, from oldest to youngest, although many of the sites cover significant periods of time. Each site report consists of a description of the evidence; interpretation of that evidence, with correlation, where relevant, with other localities; and assessment of the significance of the site in a regional, national or international context. Where sites form part of a wider network, then cross-reference is made to related sites to provide fuller understanding of the feature or period being discussed. In addition, where sites are of particular historical significance, then the history of study of the site is dealt with in detail.

There is at present no universally accepted system of terminology for the subdivision of Quaternary deposits in Britain. Mitchell *et al.* (1973) proposed a correlation scheme based on standard stages. Since that date, however, not only has there been a great increase in knowledge of the Quaternary succession so that the 1973 system is now incomplete, but also certain of the stage names proposed at that time have been questioned as to their suitability or even existence. To avoid confusion, therefore, (Table 1) and (Figure 2.7) have been compiled to show the terminology and approximate accompanying chronology that is used in this book; a simplified summary chart showing the position of each site in the chronology is given in Table 2. The basis of the chronology is the oxygen isotope signal recognized in deep-sea sediments. This signal has been shown to be a function of the Earth's orbital parameters (Hays *et al.*, 1976), and astronomical data have been used to 'tune' the geological time-scale (cf. Imbrie *et al.*, 1984; Prell *et al.*, 1986; Ruddiman *et al.*, 1986, 1989; Martinson *et al.*, 1987). For the period back to about 620 ka, the time-scale is that developed by Imbrie *et al.* (1984), which has been substantiated by later work (Prell *et al.*, 1986; Shackleton *et al.*, 1990). For the earlier part of the Quaternary, the revised time-scale of Shackleton *et al.* (1990) is adopted.

Where radiocarbon 'dates' (age estimates) are cited, they are quoted in radiocarbon years before present (AD 1950). It should be noted that the radiocarbon time-scale diverges from the calendrical one, and although calibration is available back to 9000 years in detail (cf. Pitcher, 1991) and to 30,000 years in outline (Bard *et al.*, 1990), the interpretation of radiocarbon measurements, particularly during parts of the Late Devensian is additionally complicated (cf. Ammann and Lotter, 1989; Zhinden *et al.*, 1989).

Table 2 Summary of stratigraphical positions of sites described in this volume. Sites appear more than once where they have multiple interests or interests of different ages. Sites with features pre-dating the Late Devensian are grouped together because of uncertainties over dating

		Inverness Area		Western Highland Boundary	Western Central Lowlands
	Orkney		South-west Highlands		
Shetland	Caithness	North-east Scotland		Eastern Highland Boundary	Lothians and Borders
Western Isles	North-west Highlands	Eastern Grampians	Inner Hebrides		South-west Scotland
				Fife and Lower Tay	

Holocene

			Dores			
			Barnyards	Glenacardoch	South Loch	
			Munlochy	Point	Lomond	
			Valley	Kingshouse	Rim Point	
		Ward Hill	Ben Wyvis	Pulpit Hill	Western Forth	
			Findhorn	Loch Cill an	Valley	
		Loch of	Terraces	Aonghais	Mollands	Dundonald
		Winless				Burn
	Garths Voe		Muir of Dinnet	Eas na Broige	Tynaspirit	
		An Teallach				Tinto Hill
	Ronas Hill		Philorth Valley	Western Hills	Dryleys	
		Sgùrr Mòr		of Rum		Din Moss
	Borve		The		Maryton	
		Loch	Cairngorms	West Coast of		Newbie
	Gleann Mòr	Sionascaig		Jura	Milton Ness	
			Abernethy			Loch Dungeon
		Lochan an	Forest	Gribun	Stormont Loch	
		Drum			Carey	Round Loch of
			Loch Etteridge	Loch an		Glenhead
		Loch Maree		t-Suidhe	Silver Moss	
			Allt na Feithe			
			Sheilich	Loch Ashik	Pitlowie	
			Coire Fee	Loch Cleat	Kincraig Point	
			Glen Feshie	Loch Meodal	Black Loch	
			Morrone			

						Isle of Lismore		
			Ward Hill	Coire Dho	Moss of			
			Loch of Winless	Fort Augustus	Achnacree			
			Achnasheen	Dores	South Shian	Aucheneck		
			An Teallach	Barnyards	Glen Roy	Croftamie		
			Baosbheinn	Munloch Valley	Pulpit Hill	Gartness	Loch Skene	
			Beirut Alligin	Ben Wyvis	The Cuillin	South Loch Lomond	Bearrig Moss	
Late Devensian	'Loch Lomond Stadial	Burn of Aith Ronas Hill	Cnoc a'Mhoraire	Muir of Dinnet	Beirut Shiantaidh	Rhu Point	Dunbar	
			Coire a'Cheud-chnoig	The Cairngorms	Western Hills of Rum	Western Forth Valley	Tauchers	Bigholm Burn
			Creag nan Uamh	Lochnagar	Northern Islay?	Tynaspirit	Redkirk Point	
			Cam Loch	Loch Etteridge		Stormont Loch		
			Lochan an Druim	Morrone	West Coast of Jura?	Black Loch		
				Glen Feshie	Loch an t-Suidhe			
				Coire Fee				
					Loch Ashik			
						Croftamie		
						Gartness		
				Ardersier		South Loch Lomond		
				Findhorn Terraces	Glenacardoch Point	Geilston		
			Loch of Winless	The Cairngorms	South Shian	Rhu Point Tynaspirit	Bearrig Moss	
Lateglacial Interstadial		Burn of Aith	Cam Loch	Lochnagar	Pulpit Hill	Dryleys	Bigholm Burn	
			Lochan an Druim	Loch Etteridge	West Coast of Jura	Milton Ness	Redkirk Point	
				Abernethy Forest	Loch an t-Suidhe	North Esk & West Water		
				Morrone	Loch Ashik	Stormont Loch		
				Glen Feshie		Inchcoonans & Gallowflat		
						Kincraig Point		
						Black Loch		

		Clava			
		Ardersier			
		Struie			Afton Lodge
		Channels			Nith Bridge
		Kildrummie			Greenock
		Kames			Mains
	Den Wick?	Littlemill		Croftamie	
	Mill Bay?	Torvean		Gartness	Carstairs
		Findhom	The Cuillin	Geilston	Kames
North-west	Baile an	Terraces	Scarisdale	Nigg Bay	Clochodrick
Coast	t-Sratha?	Boyne Quarry	Beinn	Burn of	Stone
of Lewis	Drumhollistan?	eindland	Shiantaidh?	Benholm	Falls of Clyde
Port of Ness	Leavad?	Castle Hill	Northern Islay	Almondbank	Agassiz Rock
Tolsta Head	Gairloch	Kippet Hills	West Coast of	Shochie Burn	Hewan Bank
Glen Valtos	Moraine		Jura	North Esk &	Keith Water
	An Teallach	Muir of Dinnet		West Water	Carlops
	Corrieshalloch	Kirkhill			Rammer
	Gorge	Bellscamphie			Cleugh
		The			Port Logan
		Cairngorms			Bigholm Burn
		Loch Ettendge			
		Glen Feshie			

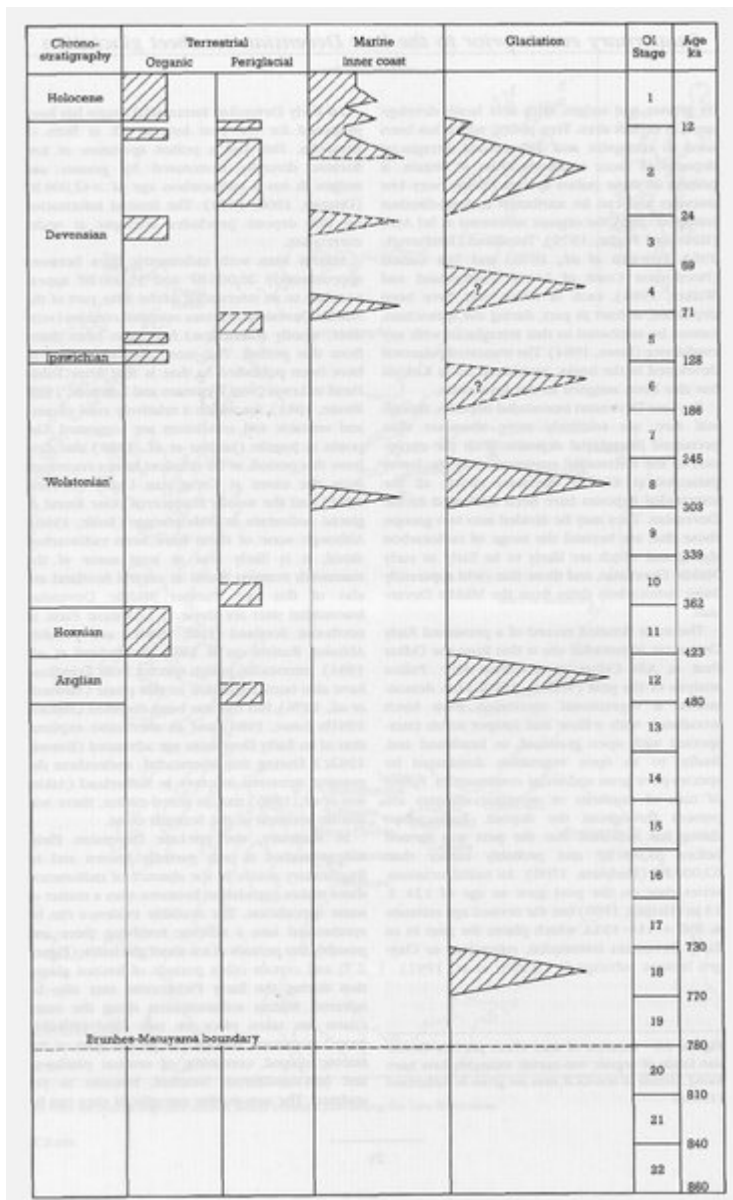
			Clunas			
			Dalcharn			
		Den Wick?	Allt Odhar			
		Mill Bay?	Clava			
		Muckle Head & Selwick	Windy Hills	Tangy Glen		
	Fugia Ness	Baile an t-Sratha?	Moss of Cruden	Glenacardoch Point	Nigg Bay	
	Sel Ayre		Hill of Longhaven	Isle of Lismore?	Burn of Benholm	Afton Lodge Dunbar
Pre-Late Devensian	North-west Coast of Lewis?	Drumhollistan	Kirkhill	Northern Islay	Milton Ness	
	Tolsta Head	Leavad?	Bellscamphie	West Coast of Jura	Kincraig Point	
		Corrieshalloch Gorge	Boyne Quarry?			
		Creag nan Uanth	Teindland			
			Castle Hill?			
			The Cairngorms			

The informal term 'lateglacial' (equivalent to Devensian late-glacial) is well established in the Scottish Quaternary literature and is used throughout this volume following the definitions of Gray and Lowe (1977a). The terms Lateglacial Interstadial and Loch Lomond Stadial are also used. These are climate-stratigraphic, or climatostratigraphic, terms, and as such differ from chronostratigraphic, or time-stratigraphic terms. The latter are intervals of time based on a definition tied to a particular rock-sequence. Climate-stratigraphic terms, however, are based on climatic inferences drawn from rocks, either at a site, or from several sites. The terms Lateglacial Interstadial and Loch Lomond Stadial describe the inferred nature of the climate towards the end of the Devensian Stage. In general terms, the former relates to the time between approximately 13,000 and 11,000 years ago, a time of overall climatic improvement, whereas the latter refers to the time between approximately 11,000 and 10,000 years ago, which corresponds to a time of climatic deterioration.

Comparison with the nomenclature used in Europe shows that the Lateglacial Interstadial corresponds with the Oldest Dryas, Bølling, Older Dryas and Allerød events. The Loch Lomond Stadial corresponds with the Younger Dryas. Attention is drawn to the latter in particular, in view of its importance as an international term in studies seeking to understand the Earth's climate system.

Finally, where the usage of certain local terms for particular landforms or deposits is widely accepted in the literature, these have been retained in the present volume; for example, corrie (cirque) and carse (estuarine silts and clays). Where possible, modern names of marine mollusca are used, following Smith and Heppell (1991).

[References](#)



(Figure 2.7) Summary of the principal glacial, periglacial, marine and terrestrial depositional events recognized in the Quaternary record in Scotland. Note that the time-scale is not linear. Only those events that can be related to specific deposits on land or on the adjacent continental shelves are plotted.