C. E. P. Brooks pointed long ago to the similarity of the Mayan sequence with the history in the next centuries of the Khmer empire, in southeast Asia between the Mekong river and the frontier of Thailand, whose capital. Angkor, at latitude 14 °N, was founded in AD 860 and flourished for four or five centuries before disappearing in ruins into the increasing jungle.[7] With such vegetation changes there is clearly a strong case for believing that some climatic shift was at work, but in spite of the increasing interest in climatic research in recent years we still lack knowledge of the details that might firmly resolve the background to the rise and fall of the civilizations in Central America and southeast Asia.

The difference of timing of the dry – or at least drier – periods in southern Mexico and Cambodia (Kampuchea) may reasonably be related to the difference of a few degrees of latitude and, presumably, some changes in the incidence of the southeast Asian monsoon. This history of the Khmer civilization in Indo-China, however, belongs to the period with which the next chapter deals.

10

THROUGH VIKING TIMES TO THE HIGH MIDDLE AGES

ASYMMETRY OF THE MEDIEVAL WARMTH OVER THE NORTHERN HEMISPHERE

As indicated in the last chapter, there seem to have been some regions of the world – particularly in low latitudes and in the Antarctic, possibly also around the north Pacific and in parts of the Arctic – where the rather greater warmth of the climate established around AD 300–400 continued, with variations but more or less unbroken, for several centuries longer and in some cases right through to AD 1000–1200. In Europe and much of North America, as well as in the European Arctic, there clearly was a break. But by the late tenth to twelfth centuries most of the world for which we have evidence seems to have been enjoying a renewal of warmth, which at times during those centuries may have approached the level of the warmest millennia of post-glacial times.

China and Japan evidently missed this warm phase. A warm period can be discerned in the historical records in those countries from about AD 650 to 850, more or less covering the time when Europe had its colder break. But in the eleventh and twelfth centuries the data collected by the late Dr Chu Kochen make it clear that the climate of China took a much colder turn, with frequent references to snow and ice in the winters and snows a month later in spring than in the present century. The plum trees were disappearing in north China; frosts killed the mandarin trees in the coastal province near Shanghai and the lychees in parts of the south. In Japan the long records of the dates of the cherry blossom in the royal gardens at Kyoto indicate on average the earliest springs in the ninth century and the latest springs of the whole record in the twelfth century, when the mean date was a fortnight later than it had been three hundred years earlier. There are hints that this was a cold time generally in and around the wide expanse of the North Pacific Ocean. If so, part of the explanation of the medieval warmth in Europe and North America, extending into the Arctic in the Atlantic sector and in at least a good deal of the continental sectors on either side, must be that there was a persistent tilt of the whole

circumpolar vortex (and of the climatic zones which it defines) away from the Atlantic and towards the Pacific sector, which was rather frequently affected by outbreaks of polar air.

In this chapter we shall concentrate our study on the Atlantic side of the hemisphere and the lands where the warmth of the high Middle Ages was most marked, since it happens that these are the areas where both the climatic and the human historical record are at present most accessible.

THE MEDIEVAL SEQUENCE IN NORTHERN EUROPE AND THE NORTHERN ATLANTIC

The reconstituted western empire of Charles the Great did not coincide with a particularly favourable climatic period. Nor did it last very long. The campaigns by which it was established between about 770 and 800 seem to have been in a time with more than usual tendency to cold winters; the other seasons, although perhaps more often dry than wet, revealed both drought years and some years when floods created difficulties. There is a suggestion in this that it may have been one of those times when 'blocking of the westerlies' by anticyclones in this or that longitude in 45–65 °N was frequent, with a consequent disposition to extreme seasons of various, even opposite, sorts depending on where the stationary anticyclone lay: but further evidence is required before we can be sure of this.

Where there is no reasonable doubt is that over the next three to four centuries, as reports indicating the character of the seasons in Europe become more numerous, we see that the climate was warming up (cf. figs. 30 and 59), until there came a time when cultivation limits were higher on the hills than they have ever been since. Trees seem also to have been spreading back towards the heights. Certainly the upper tree line in parts of central Europe (cf. fig. 53) was 100–200 m higher than it became by the seventeenth century. The isotope record from the Greenland ice-sheet (fig. 36) shows us that the climate had already been in a relatively warm phase in the far north since AD 600, though the warmth there too was becoming more sustained and was increasing. On the heights in California the tree ring record (fig. 52) indicates that there was a sharp maximum of warmth, much as in Europe, between AD 1100 and 1300.

The variations shown by the more than one-thousand-years'-long record of the tree rings in European oaks from the lowlands of Germany are harder to interpret climatically, because both temperature and rainfall come into it. The records from different areas agree in producing the extreme narrowest and the extreme widest ring series both within the times covered by this chapter. The extremely narrow rings prevailing in the tenth century, especially between about 910 and 930 and again in the 990s, must surely indicate prolonged and repeated drought. One cannot suggest that any general coolness of the summers was responsible; the sparse documentary

records point more to some of the summers being notably hot. The impression on present data is rather that the tenth century saw a remarkable amount of anticyclonic weather over Britain, Germany and southern Scandinavia, giving low rainfall, rather warm summers and rather cold winters. The latter point seems to be confirmed by the numerous bone skates revealed by the archaeological investigations in York from the Anglo-Scandinavian period in that city. The other extreme of the German oak chronologies occurred between about the years 1052 and 1160, when the decade average ring widths were 35–80 per cent wider than in the tenth century. We may deduce, if not excessive wetness (apart from isolated years), at least more moisture than in the 900s and general warmth of the growing seasons. Of this warmth we shall see further evidence in the following pages.

There is no mistaking the fact that there was a general opening out of the European world in the period we are considering in this chapter. How much of it was directly dependent on the more genial climatic regime which developed?

There had been European seafarers occasionally wandering out over the northern Atlantic long before Viking times. Prominent among them were Irish monks apparently seeking peaceful shores on which to establish a foothold far from the troubled times of cultural decay and barbarian migrations in Europe in the fifth and sixth centuries and after. It has been suggested that the annual migrations of the wild geese to and from Iceland and the Arctic gave them confidence that there was land to find in the north. One must suppose that there is some substratum of fact in the legendary voyage of St Brendan at some time between around AD 520 and 550 and that he got far enough in the direction of Greenland to encounter icebergs. Certainly Dicuil, an Irish monk writing AD 825,[1] assures us that

> there are many other islands in the ocean . . . which can be reached in two days and two nights direct sailing from the northernmost parts of the British Isles with full sails and a fair wind. . . . Some of these islands are very small . . . separated from one another by narrow sounds. On these islands hermits who have sailed from our Scotia [i.e. Ireland] have lived for about a hundred years. But, even as they have been . . . uninhabited from the world's beginning, so now because of Norse pirates, they are empty of anchorites, but full of innumerable sheep and a great many different kinds of seafowl.

The islands here described are by general agreement the Faeroes, which were therefore settled by Irish monks as early as about AD 700–25. (I have used the translation given by Gwyn Jones in *A History of the Vikings*, Oxford University Press, 1968.) But they left around 800, when the Vikings first appeared. The Vikings' first recorded exploration to Iceland (under Floki Vilgerdason) was not until about 860, though two earlier Scandinavian

voyages had been blown there accidentally a few years before. The Norse settlement on the island seems to have begun during the 860s. But they found that Irish monks had preceded them. Dicuil reports one visit as early as the 790s. The Irish account records that the sea was frozen one day's sail north from Iceland, and Floki's party observed one of the big fjords of northwest Iceland (Arnarfjord) choked with ice. But after that time there is little mention of ice – only brief and, according to Lauge Koch,[2] doubtful reports of it in 1010–12, 1015, 1106, 1118 and 1145 – on the seas near Iceland until the 1190s, when it reappeared in some strength between Iceland and Greenland, and in July and August of the year 1203 it was at the coast of Iceland.

It seems likely that the beginning of the era of Scandinavian sea-going explorations, as of the rough story of Viking raids which harried the coasts of Europe from the 790s onwards, came with the mastery of sail by the northern peoples. Even then, they had no lodestone or compass until centuries later. But the spread of their voyages north into the Arctic and west to Greenland, and ultimately to Newfoundland and apparently into the Canadian Arctic north of Baffin Island, surely owed a great deal to the long period of retreat of the sea ice and probably a relative immunity from severe storms. Ottar, or Othere, whose home was in north Norway, told King Alfred in England of an exploration he had made about AD 870–80 beyond the customary range of the whalers of those days, evidently to the White Sea. And Harald Hardråde who was king of Norway and England is reported by Adam of Bremen to have explored 'the expanse of the Northern Ocean' some time between 1040 and 1065 with a fleet of ships, beyond the limits of land (Spitsbergen or Novaya Zemlya?) to a point where he reached ice up to 3 m thick and 'there lay before their eyes at length the darksome bounds of a failing world'. The medieval Icelandic sailing directions covered voyages, reckoned to take four days, north to Svalbard 'in the polar gulf', which it seems from the sailing time must have meant the east Greenland coast between 70 and 72 °N (not the Spitsbergen archipelago, to which the name is now applied). This coast was discovered in 1194; and seals, walrus and whales were hunted there already before the year 1200. Very soon, however, the increasing ice evidently put a stop to this, and the same coast seems to have been rediscovered in an easier year about 1285; but by 1342 the ice was so much increased that the old sailing route from Iceland to Greenland at the 65th parallel of latitude had to be abandoned for one farther south. Later, communication with Greenland was lost altogether.

The North American coast, Vinland (or Wineland) to the Norsemen, like Iceland and Greenland (where the first Norse settlement was established in the 980s) before it, was discovered by accident, by ships being blown off course, about AD 1000. The site of only one settlement, at L'Anse aux Meadows in northern Newfoundland, has so far been discovered,

though another farther south is also referred to in the sagas. It seems, in any case, that the settlement and the America voyages were discontinued after a few years, and it appears that difficulties with the native inhabitants rather than weather or sea ice were the cause. Further accounts indicate that crossings from the Old Norse settlements in west Greenland to Markland (Labrador) were resumed much later, in the fourteenth century (one as late as 1347), when the climate and ice conditions had deteriorated and communications with Europe had almost ceased, to collect timber for building.

That the waters off west Greenland in the heyday of the Norse settlements were at least as warm as in the warmest periods of the present century is indicated by the abundance of cod which the inhabitants caught, the bones of which are found in their middens. We may probably safely conclude that an even greater warm anomaly occurred in the quiet waters within the fjords of southern Greenland west of Cape Farewell from another circumstance, a rare case where the limits of tolerance of man himself may yield reliable information on past temperatures. For it is recorded in the *Landnámabók*, a book written in Iceland about 1125 cataloguing the settlement of Iceland a couple of centuries earlier and describing the Old Norse settlement of Greenland between AD 985 and 1000, that one of the first Greenland settlers, Thorkel Farserk, a cousin of Erik the Red who founded the colony, having no serviceable boat at hand, swam out across Hvalseyjarfjord to fetch a full-grown sheep from the island of Hvalsey and carry it home to entertain his cousin. The distance was well over two miles. Dr L. G. C. E. Pugh of the Medical Research Laboratories, Hampstead, has given his opinion, from studies of the endurance of Channel swimmers and others undertaking similar exploits, that 10 °C would be about the lowest temperature at which a strong person, even if fat, not specially trained for long-distance swimming, could swim the distance mentioned. As the average temperatures in the fjords of that coast in August in modern times have seldom exceeded 6 °C (+3 to +6 °C being more typical), it seems that the water must have been at least 4 °C warmer than this limit in the year in which Thorkel swam it and brought home his sheep.

Other items point to a similarly great departure of the temperatures ashore in that area: for Old Norse burials took place deep in ground which has since been permanently frozen. It is harder, however, to be sure of the climatic implications of another report from the time of the old Greenland colony. Lauge Koch cites a medieval report that in 1188 or 1189 – i.e. at a time when the climate in the area may already have begun to be colder and the sea ice to reach somewhat farther down the coast towards south Greenland – a ship, the *Stangfolden,* on passage from Norway to Iceland came to be wrecked off the east coast of Greenland. Some years later, about 1200, the dead bodies of seven of the ship's company were found in a rocky cave near that coast, among them the clergyman Ingemond who had

left a written report in runic letters on their fate beside him. Ingemond's brother, also wrecked about the same time, is reported to have succeeded, with two other men, in crossing the southern part of the inland ice, only to perish when near the main Norse settlement in Greenland, the so-called East Settlement (actually their southernmost settlement), a little west of Cape Farewell. This suggests that the inland ice in that neighbourhood was not thought of as such a hostile environment that one would not venture on it in an emergency, but nevertheless the going would be easier in the absence of melting and a crossing would doubtless require some days of reasonably good weather without strong winds.

By about AD 1250 the *King's Mirror* (*Konungs Skuggsjá*), a Norwegian work of that time, reports that

> as soon as the great ocean has been traversed there is such a great superfluity of ice on the sea that nothing like it is known anywhere else in the whole world and it lies so far out from the land that there is no less than four or more days journey thereunto on the ice, but this ice lies more to the NE or N outside the land than to the S and SW or W.

A further passage about Greenland around 1250 in the same work reports that 'men have often tried to go up into the country and climb the highest mountains to look about and see whether there was any land free from ice and habitable'. A number of reports indicate that in this period of the early stages of the climatic deterioration the Norse Greenlanders were induced once more to roam more widely afield in search of materials and hunting food, including penetration farther north than before to the west of Greenland, reaching Baffin Bay and making contact with the Eskimos who were tending to move south.

Having to this extent taken the measure of the early medieval warm period at the limits of the Arctic region reached by the contemporary Europeans, let us now look at the evidence from other regions. The northern limits of the cultivation of grains show a corresponding expansion of range during the centuries with which this chapter is concerned. Grain was grown in Iceland from the time of the first Norse settlers there, apparently fairly continuously, until its abandonment in the late sixteenth century. There was also undoubtedly more scrub birch woodland there in the early days of the settlement than at any time since, though the settlers themselves seem to have been largely responsible for its destruction. Its area is believed to have been reduced from perhaps a fifth of the country to 1 per cent by the thirteenth century. Investigation by Dr G. S. Boulton, with colleagues from the University of East Anglia and from Iceland, of a farmhouse site at Kvisker in southeast Iceland that has been occupied for a thousand years revealed that the oldest of the successive houses on the site, dated before the volcanic ash layer of AD 1090, was the biggest and richest.

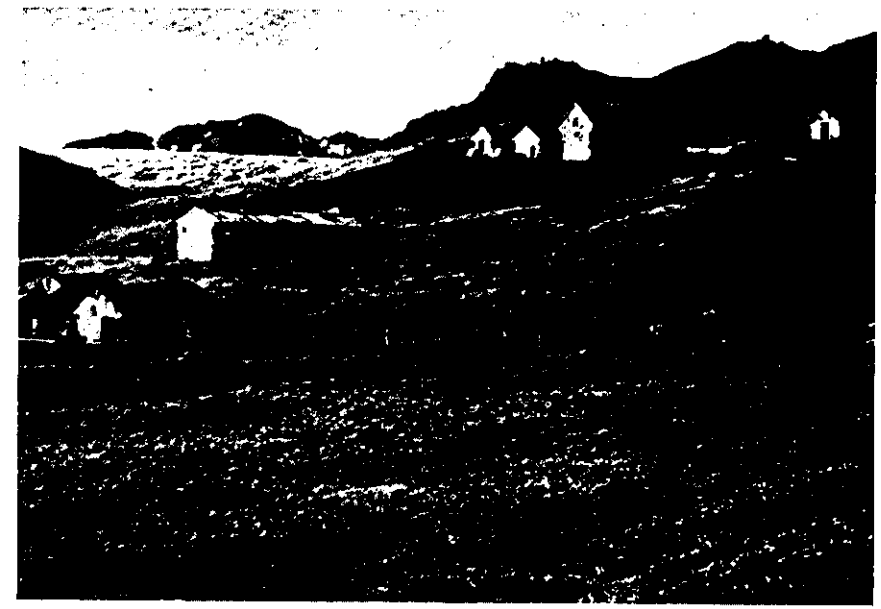


Fig. 62 One of the ancient farms, Svinafell, in southern Iceland, established in the earliest settlement times on a south slope. A great glacier can be seen now filling the valley close to the site of the farm. (Kindly supplied by Dr Sigurdur Thorarinsson of Reykjavik and reproduced by permission.)

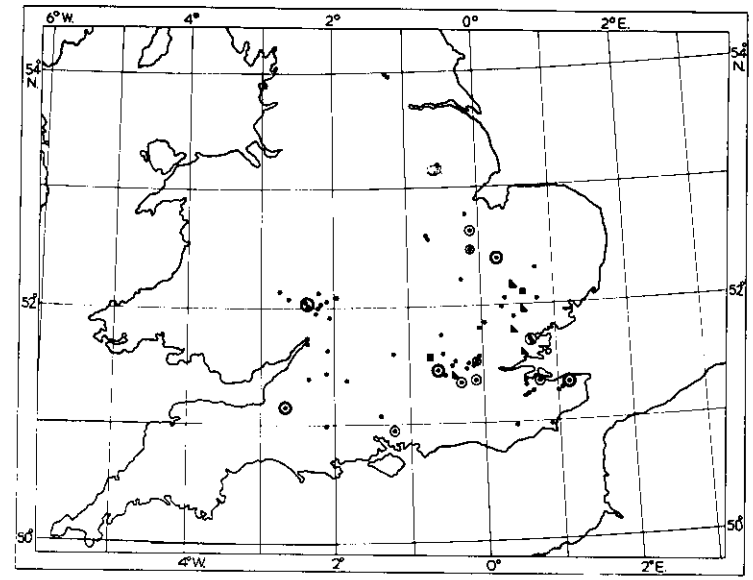
Its midden contained relics of diverse and luxurious foods, including (imported) oysters. And the forest surrounding the farmed land there produced birch stumps of a good size, never attained since. From pollen analysis it appears that the farmer at Kvisker gave up growing oats about AD 1200 and reduced the amount of barley grown by about a half. In the next century much of the ground was covered by river gravels and part of it by a glacier (see fig. 62).

THE PEAK OF MEDIEVAL WARMTH IN EUROPE

In Norway some kind of corn, probably barley, was grown as far north as Malangen (69½ °N) in north Norway, at least from Ottar's time (around 880) until the eleventh century, and wheat in Trøndelag, the district about Trondheim, where pollen studies and other records again indicate that it came to an end sharply in the later Middle Ages. Professor Andreas Holmsen[3] reports that it was just between about AD 800 and 1000 that the area of forest clearance and settled farming in Norway, which had long remained more or less static, spread 100–200 m farther up the valleys and on to the higher ground. Most of this ground was lost again after AD 1300.

Fig. 63 Relics (ridge and furrow) of medieval tilled fields between 350 and 400 m (1150–1300 ft) above sea level on the heights of Dartmoor in southwest England beside the abandoned settlement of Houndtor which lies just to the left of the picture. The Greator rocks are seen in the picture. (Photograph, copyright by G. Beresford, who kindly supplied it for this book.)

Fig. 64 Ridge and furrow, the result of thirteenth-century tillage, seen on the fells on a south-facing slope above Redesdale, Northumberland at 300–320 m above sea level.



LEGEND

- Vineyard, usually 1–2 acres or size not known.
- Vineyard, 5–10 acres.
- Vineyard, over 10 acres.
- Denotes evidence of continuous operation for 30–100 years.
- Denotes evidence of continuous operation for over 100 years.

Fig. 65 The distribution of known medieval vineyard sites in England.

In many parts of Britain, also, tillage was extended to greater heights than for some long time previously or since, on Dartmoor in the southwest (fig. 63) to about 400 m (1300 ft) and in Northumberland, near the Scottish border (fig. 64) to 320 m (1050 ft). In AD 1300 one grange at 300 m (roughly 1000 ft) above sea level, belonging to Kelso Abbey, in the south of Scotland had over 100 hectares of tillage, 1400 sheep and sixteen cottages for shepherds and their families. An approximate gauge of the temperatures prevailing in the summer half of the year in England and central Europe, serving as a check upon the figures derived by the method used in fig. 30 and explained on pp. 84–5, may be obtained by consideration of the limits of vine cultivation in the Middle Ages and comparing the present climates of those sites with the modern limits of wine production. Fig. 65 is a map of the distribution of known medieval vineyards in England. The comparison indicates that the average summer temperatures were probably between 0.7 and 1.0 °C warmer than the twentieth-century average in England and 1.0–1.4 °C warmer in central Europe. (The quality

Fig. 66 The medieval English vineyard site at Tewkesbury, Gloucestershire. The ground slopes gently northwards to a ditch in the middle ground of the picture. Surely a frost hollow site, which suggests that the medieval cultivators were not much troubled with late frosts in May after blossom time.

of the English medieval wine is indicated by the efforts of the French trade at that time to have them closed down under a treaty). In England particularly it seems that there must have been less liability to frost in May in the period between 1100 and 1300. (Fig. 66 is interesting in this connection.)

Thus, it seems that the great period of building of cathedrals in the Middle Ages, in what Kenneth Clark[4] has called the first great awakening in European civilization, and the sustained outburst of energy of the European peoples, which produced among other things the more controversial activities of the Crusades, coincided with an identifiable maximum of warmth of the climate in Europe. Hugh Trevor-Roper[5] makes no comment on the climate but notes the time around AD 1250 as the turning point:

> the highest point of the European Middle Ages. . . . Up to that date we see – from about 1050 onwards – only advance . . . growth of population, agricultural revolution, technological advance. The frontiers are pushed forward in all directions. . . . Already in the middle of the thirteenth century the territorial expansion had been halted . . . in 1242 the eastward advance of the Teutonic knights . . . was held up by the ruler of the Russian Slavs. . . . By 1300 all that remained of the Eastern Empire of Christendom was a few shrinking relics of Greece.

The warm phase, which had already passed its peak in Greenland in the twelfth century, seems to have broadly continued in Europe until 1300 or 1310 though with a marked increase in the incidence of severe storms in the North Sea and the Channel and with flooding disasters on the low-lying coasts. The warmth may even have reached its maximum at this late stage: for there are documentary records to tell us that it was in the 1280s that the tillage reached so high on the Pennines and Northumbrian moors that there were complaints from the sheep farmers that too little land was left for grazing. Such a peak of warmth in the last stages before Europe itself was affected by the down-turn of temperatures in the Arctic would be meteorologically consistent with the development of a strong thrust forward of the Arctic regime in the longitudes of Greenland and Iceland, distorting the pattern of the circumpolar vortex with a sharp trough there and a recurrent warm ridge over western Europe. Something like this pattern seems to have recurred at times in the middle and later parts of the fourteenth century, bringing notable droughts in Europe after an extremely wet phase which had marked the first break in the early part of that century. (It is likely that some of the troubles about this time with the massive buildings – cathedrals, churches and castles, with collapsing towers and cracking walls and arches (fig. 67) – were not so much due to faults of design as to soil moisture changes and consequent settling.)

The occurrence in medieval York of the bug *Heterogaster urticae* (F.), whose typical habitat today is on stinging nettles in sunny locations in the south of England, discovered by the city of York archaeological investigations to have been present there both in the Middle Ages and in Roman times, presumably indicates prevailing temperatures higher than today's. Another revelation from insect studies is the abundance also in medieval York of a beetle *Aglenus brunneus* (Gyll.) whose habitat preferences indicate high temperatures generated in decaying vegetable refuse. Both these discoveries hint at rather high prevailing temperature of the urban environment itself in the tightly built-up medieval city centre.

There are many indications that in eastern Europe, as in Greenland and Iceland, a colder, more disturbed climate set in already in the 1200s. And, indeed, as far west as the Alps, some trouble was caused by advancing glaciers during the thirteenth century. During some part of the warmest period, perhaps in the tenth and early eleventh centuries, there seems to have been concern about drought in the Alps: for a water supply duct, the Oberriederin, was laid from high up near the Aletsch glacier to the valley below, and similar water supply installations were engineered in the Saastal

Fig. 67 An arch deformed by subsidence in Carlisle Cathedral. No movement seems to have occurred after about 1300–50. Compaction of the site through drying out of the soil in the previous centuries has been suspected as the cause of the damage seen (see pp. 197–8).

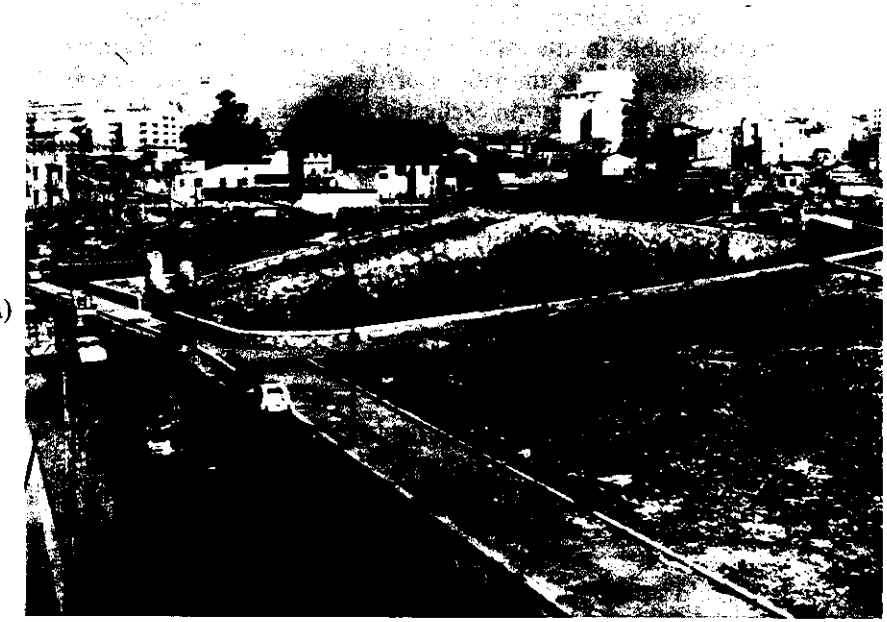
(also in Switzerland) and in the Dolomites, only to be overwhelmed by the advancing glaciers between 1200 and 1350.

The ancient gold-mines in the Hohe Tauern in Austria and other high-level mines in central Europe, abandoned before the time of Christ, were opened up and worked again in the warmth of the high Middle Ages, only to be abandoned again later. Underground water began to cause difficulties about 1300: at Goslar it was reported in 1360 that water had been increasing in the mines in the Harz Mountains for more than fifty years. In Bohemia the same difficulty led to some mines being abandoned as early as 1321. In the Alps some of the mine entrances were again closed by the glaciers.

THE CONTEMPORARY SCENE IN THE MEDITERRANEAN, EASTERN EUROPE AND ASIA

In the Mediterranean, as also in the region of the Caspian Sea and on into central Asia, the period of warmth in high latitudes in the Middle Ages seems to have been a time of greater moisture than the present century. Lake levels were high, the Caspian Sea as much as 8 m above its present level during much of the time between the ninth and fourteenth centuries.

(a)



(b)

Fig. 68 (a) The medieval bridge (Ponte dell'Ammiraglio – Bridge of the Admiral) at Palermo, Sicily, built in 1113 to span a much larger river than now exists there. The River Oreto, which has now been diverted, as seen in (b), was used by ships up to this bridge when it was first built. (Photographs kindly supplied by General Fea of the Servizio Meteorologico, Aeronautica Militare Italiano, Rome.)

Two of the rivers of Sicily, the Erminio and the San Leonardo, were described as navigable in the twelfth century – something which would now be impossible even for the vessels of those times. Bridges were built, as across the Oreto at Palermo in Sicily (fig. 68), of a size not required by the present rivers. (The famous Pont d'Avignon finally built across the lower Rhone in southern France in 1177–85 at a difficult point, where roads converge but the current is always strong and the Romans had been unable to bridge the river, suffered many collapses of parts of the bridge in the following years but was not finally abandoned half destroyed until 1680.) There was also in the high Middle Ages more general flow of the streams in Greece and in the wadis of north Africa and Arabia. Fig. 45 (p. 131) indicates a more adequate rainfall in medieval times also in the dry area of northwest India.

These features seem likely to be explained partly by a displacement of the anticyclone belt of the desert zone during the warm epoch north of its present usual position to an axis from the Azores to Germany or Scandinavia as in some of our modern fine summers. Such partly meridional wind circulation patterns, with a cold trough deformation of the circumpolar vortex, commonly thrust cold surface air south over eastern Europe and western or even central Asia, and from there it would be deflected by the mountains westward and southward towards the Mediterranean. This is an eastern position for such a development in the circumpolar vortex, requiring a longer wave-length (or spacing of the troughs and ridges) than commonly prevails in the upper wind flow from the more or less fixed disturbances over North America caused by the Rocky Mountains. Such a longer wave-length would be likely to occur at a time when the main flow of the winds was displaced towards higher latitudes and particularly when, as in the thirteenth century, Arctic cooling strengthened the thermal gradient and the winds.

Our knowledge of the past variations of lake levels – archaeologically determined in the case of the Caspian Sea – indicates that the barbarian movements out of Asia which troubled the Roman empire over a long period can be associated with times of drought in central and western Asia around AD 300, which also returned around 800. By contrast, the great outbreak of Mongolian tribesmen in the thirteenth century seems to have occurred in a moist period, when the Caspian Sea was rising. The sudden outburst of energy of the peoples of inner Asia, which brought Genghis Khan and his Mongol hordes within the space of twenty years, between 1205 and 1225, deep into European Russia, to the Indus and to the gates of Peking, could reasonably be supposed to have had its origin in a build-up of population in the arid heart of Asia in times when the pastures were in better than usual shape. But its suddenness, and the coincidence of its timing with what we know of the cooling in high latitudes from the isotope record in northern Greenland and the great advance of the Arctic sea ice towards Iceland, raises a suspicion that some more sudden event connected

with the cooling may have triggered it off. This could have been some invasion of the heart of Asia by colder Arctic air than before, the effects of which would be particularly noticeable if it happened in summer. This is speculation, but China had long been experiencing a cold regime and some scientists have thought that this anomaly gradually spread westwards until it enveloped Europe in the Little Ice Age of later centuries.

There was clearly some difference between the sectors of the northern hemisphere with which these paragraphs have been concerned and the situation over east Asia, where the climatic zones seem to have been pushed south over a long period of which the twelfth century marked the climax. The swing to the southeast of the isotherms and of the flow lines of the circumpolar vortex from a northward displacement (or ridge) over the Indian sector to a southward displacement (or trough) over east Asia is a pattern which seems liable to have introduced an anticyclonic tendency over Thailand and northern Indo-China, reducing rainfall there. This meteorological speculation suggests an explanation of temporarily easier – i.e. drier – conditions favouring the Khmer empire of Angkor in Cambodia (Kampuchea) in the region, which after 1300 returned to jungle.

EFFECTS ON SEA LEVEL AND LOW-LYING COASTS

Our survey of the European scene during the warmer centuries of the Middle Ages would not be complete without mention of the things that suggest a slightly higher stand of the sea level, which may have been gradually rising globally during that warm time as glaciers melted – and particularly in the area around the southern North Sea where the land-sinking due to the folding of the Earth's crust in that basin was presumably going on then as now. Fig. 60 draws attention to the greater intrusions of the sea in Belgium, where Brugge (Bruges) was a major port, and in East Anglia, where a shallow fjord with several branches led inland toward Norwich. The English fenland south of the Wash provided an extensive watery landscape of shallow brackish channels and low islands, fringed by reeds and brushwood, in which the island of Ely was so cut off that the Anglo-Danish inhabitants were able to hold out for seven to ten years after the Norman conquest of the rest of England. And the coastal plain of the Netherlands and Belgium had a fluctuating population in the eleventh and twelfth centuries, as the state of flooding varied, leading finally to a more general emigration to Germany.[6]

THE SEQUENCE IN NORTH AMERICA AND SOME COMPARISONS

In North America east of the Rocky Mountains there is evidence that the prevailing temperatures followed a sequence very similar to that in Europe

and that there were interesting and important changes in the moisture climate. Only in northern Labrador and the neighbouring Ungava region is there no sign so far of a medieval interruption in the cooling off that began 3000–3500 years ago and put the forest into retreat before the advancing tundra. In northern Quebec and in the North-West Territories west of Hudson Bay, the extensive pollen-analytical researches co-ordinated by Dr Harvey Nichols of the University of Colorado Institute of Arctic and Alpine Research indicate some recovery of the forest, associated with warming of the summers, from about AD 500 to some time about 1000–1200 or 1250. Farther south, in the Middle West of the United States, the archaeological studies of Baerreis and Bryson at the University of Wisconsin have indicated that the Indian people of the Mill Creek culture grew corn (maize) in northwestern Iowa before the year 1200, in an area which today is somewhat marginal as regards enough rainfall for the crop. Elk and deer, both woodland animals, which they evidently hunted, together accounted for most of the flesh in their diet before about 1100; in the twelfth century the proportion of these among the bones in the middens rapidly declined and was overtaken by bison, an animal of the open plains. The abundance of bison bones increased towards the west where the climates are drier, in the 'rain-shadow' of the Rocky Moutains. But from about AD 700 onwards the climates of the whole region seem to have become moister than before, the prairie giving way to landscapes with more trees, until an abrupt reversal about the year 1200. Farming peoples were spreading their occupation northwestward on the plains, moving northward into Wisconsin and on up the Mississippi and other valleys into Minnesota as early as the eighth century. They maintained a thriving culture until 1200, when their sudden disappearance coincides with evidence of drought and vegetation change. Such a change in the region concerned is readily explained by increased sway of the westerly winds, intensifying and extending the rain-shadow of the mountains, as the thermal gradient increased with the cooling of the Arctic then setting in. We have referred to the evidence of this on Greenland and Iceland waters.

The climatic history reviewed in this chapter has led one historian[7] to summarize the matter by saying: 'intriguingly, the profile of long-run average temperature in England shows a crude but clear congruence with that of material welfare broadly conceived'. And he goes on 'The medieval expansion, the crises of the fourteenth and late sixteenth centuries, and the revivals of the fifteenth (to early sixteenth), eighteenth and nineteenth centuries, broadly correspond with movements in the trend line of temperature.' Yet, he argues that climatic change has little explanatory value and that one cannot assert that the course of European history would have been much different if the climate had not changed. The period covered by the next chapter will give us an opportunity to examine this contention a little more closely.

11

DECLINE AGAIN IN THE LATE MIDDLE AGES

THE DOWN-TURN OF CLIMATE IN THE ARCTIC

The deterioration in their situation which announced itself to the Old Norse Greenlanders in 1197–1203 by the increase of ice encroaching on the seas that were used for their links with Iceland and with Europe, at first in occasional years but later on seeming permanent, clearly had to do with a cooling of the Arctic (see fig. 36, p. 93).

Already during the twelfth century the Eskimos of the Dorset culture, once (about 700 BC) widespread across the eastern Canadian Arctic, who had returned to high latitudes after AD 800–900, had been moving south. Archaeology suggests that this was partly because another Eskimo culture, developed near Thule in northwest Greenland, was more successful in hunting the resources of the far north; but it is probable also that increasing ice and dwindling seal and walrus populations were making the competition more difficult. And so it was around 1200–50 that Norsemen and Eskimos first came into contact in Greenland. At first some trading went on between them. But about 1350 the smaller of the two Norse centres in Greenland, with only about seventy-five farms, the Vesterbygd ('West Settlement'), which was the more northerly of the two areas occupied in west Greenland, was wiped out either by conflict or disease, possibly the plague. (Some cattle and sheep were found wandering unattended by any human owners when a ship visited the area from the other settlement.)

The larger Østerbygd ('East Settlement'), where there were about 225 farms, survived until about the year 1500, though in evident decline: the average stature of the grown-up men buried in the graveyard at Herjolfsnes in the fifteenth century was only 164 cm (5 ft 5 in.) compared with about 177 cm (5 ft 10 in.) in the early period of the settlement. By about 1342 it is recorded that the old sailing route along the 65th parallel of latitude between Iceland and Greenland was finally changed to a route farther south because of the increase of ice. After the wreck off Norway of one of the ships used in the late medieval royal monopoly trade in 1369 regular communication between Europe and the Greenland colony ceased. Some