Farnham Geological Society

(A Local Group within the Geologists' Association)

Newsletter September 2001 Vol. 4 No. 5

This time of year is the 'silly season' of the popular press when there is usually no solid news so that Editorials take off in flights of fancy. Our flight of fancy will be next April when we visit five volcanoes in and around Italy. A recent programme of the BBC about teset spectacular phenomena showed that hard hats and perhaps high melting point footwear will be de rigueur.

We have to thank Dorcas Cresswell for updating the forthcoming society events and limericks from the Irish field trip. Peter Cotton provided the report on this trip in the Farnham Herald. David Stephens gave the Book review on Strata by Jon L Mortimer. Cyril Dutton gave an essay on Plate Tectonics.

Contents

Extract from the Farnham Herald 15 June 2001

Thirty members of the Farnham Geological Society have recently returned from 15 days in Ireland visiting sites of geological interest in the north and midland counties of the island.

There had been a worry that foot-and-mouth restrictions would have affected the itinerary but, apart from disinfectant precautions entering Northern Ireland and crossing the border, there was' little problem.

Ireland is a treasure-trove for the geologist and several of the sites visited are well-known landmarks for the tourist, the first being the Giant's Causeway in the lovely county of Antrim.

Guides from several universities joined the group for different locations and Dr Paul Lyle, an expert on the basaltic lavas that erupted along a line crossing north-east Ireland, told members about the Causeway formation.

When the north Atlantic opened up 60 million years ago one of the basalt lava flows was dammed in a fresh water valley where it slowly cooled to form the hexagonal columns of the Causeway.

The last two days in Northern Ireland were spent in the counties of Tyrone and Fermanagh where two particular features were studied, one being the dramatic effect on the scenery as the ice field retreated 10,000 years ago after burying the area around the Sperrin Mountains.

The other feature was the Marble Arch cave formation where water has dissolved the limestone rock to form a huge labyrinth of caves through which the river Cladagh flows.

On day seven the party crossed the border-der into County Donegal, a wild and beautiful area in the extreme north west.

With three nights stay in the pleasant county town of Donegal the party; visited the Blue Stack Mountains which are one of several granite masses formed when the ancient Iapetus Ocean closed, generating vast quantities of magma.

Another visit was made to a newly opened Ecocentre which has displays demonstrating renewable energy techniques and also of rocks found in the region which it is thought was a site where a large meteorite crashed 400 million years ago.

After Donegal the route followed was to the south west through Sligo and past the Ox Mountains to a stay in Westport in the county of Mayo.

This was the base for a circular tour round the large peninsular south of Clew Bay where myriads of islets. are dotted which were the places where post glacial drumlins were formed.

On this peninsular some eight miles from Westport is the holy mountain of Croagh Patrick where the saint is reputed to have fasted for 40 days and which is now a major pilgrimage site.

From Westport to Galway and en route a visit to an old Connemara marble quarry where samples of the greenish marble were collected. The party arrived in Galway early enough to make a tour of this university city including a visit to the splendid modern cathedral. This is a lively place with a great number of restaurants and shops.

On the other side of Galway Bay (where according to the song one watches the sun go down) there is The Burren which is a landscape of interest to geologists, archaeologists and botanists.

Its geological structure is a vast limestone pavement some 100 square miles in extent where the jointing in the limestone beds has, been progressively enlarged, by the dissolving effects of Rain-water to form ideal sheltered habitats for a marvelous variety of flowers which attract visitors from all over the world.

Also on these terraces ancient Irish man lived and died leaving behind his dolmens or ancient burial sites which would originally have been covered in turf but are now just the massive stone supports for these 4,500 year old constructions.

On the way back to Galway City from The Burren the party visited the Cliffs of Moher which offer some of the most spectacular coastal scenery in Western Europe.

Rising from the Atlantic ocean to heights of 700 feet they provide a geological record of events over 300 million years ago when a large delta system deposited successive layers of sandstones, shales and siltstone.

On day 14 the group headed back east across the Midlands of Ireland which were the cradle 'of Irish civilisation and the Celts spiritual home.

The scenery is in sharp contrast to the west and north and represents the agricultural heartland of the Republic. As in earlier stages of the tour the great masses of yellow gorse and white may create a very colourful backcloth.

The overnight stop was in Athlone and on the way to this city the group visited two contrasting zinc and lead mining sites, the first at Tynagh which is now closed and is a desolate blot on the landscape because it was opencast-mined.

The second mine at Galway is a model of eco-friendly operations consisting of a drift mine which produces 150,000 tonnes of concentrates per annum which are shipped to Avonmouth and Holland for refining.

From Athlone to Dublin the party visit-ed a vast peat bog, the Blackwater Bog in County Offaly, covering an area of 8,000 hectares and producing fuel to power a nearby electricity power station as well as peat for domestic use.

The raised bog is traversed by a light railway and a guide explained the various processes involved in the extraction of this peat which developed up to 7.5 metres depth over the past 8,000 years.

When this peat is worked out over the next 20 years it is the intention to convert it into a forest, the first plantations of coniferous trees having already been started.

On to Dublin for a brief afternoon visit before leaving from Dun Laughaire on the following morning to Holyhead and home.

A Quiz emanating from the contorted brain of Cath Clemesha.

1. Sounds like a dry mineral (9)
2. Hell (5)
3. All the oil gone (3,4)
4. A cockney laughing (1,1)
5. Curved equine (7)
6. Jurassic down before up (5)
7. A way in (5)
8. Arctic explorer (5,6)
9. Go too far (8)
10. Sounds lke fibbers (4)

FORTHCOMING GEOLOGY FIELD & DAY TRIPS PLANNED

FIELD TRIPS - 2001

EAST SUFFOLK – SATURDAY 27th – SUNDAY 28th October with Dr. Paul Davis
This trip will be for one night only and will be run with Horsham Geological Society. Arrangements can be made for those wishing to come for the Annual Dinner and the Suffolk trip to stay at the Farnham House Hotel for the Friday night.

We are also hoping to arrange a week-end visit to the GA Festival – November 2-4th if anyone is interested.

DAY TRIPS - 2001

THE WESTERN WEALD – SUNDAY 16th SEPTEMBER with John Gahan

ASHDOWN FOREST – SUNDAY 7th OCTOBER with Sue Hay & Brian Harvey

FIELD TRIPS – 2002

ITALY 10TH – 24TH APRIL with Dr. Paul Olver. Non-refundable deposits of £100 in to Dorcas by September 1st please.
NORTH WALES – re-scheduled for 16th – 23rd AUGUST with David Cronshaw
PORTUGAL 24TH –1ST OCTOBER & 1ST OCTOBER – 8TH OCTOBER with Lyn Linse.
A possible third week can be arranged if needs demand.

FIELD TRIPS - 2003
AEGEAN in MAY with John Williams

FIELD TRIPS 2004
GRAND CANYON with John Williams

If you wish any further details or would like to put your name down for any of the trips do contact Dorcas Cresswell (Field Secretary) on 01252 793884.

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PLEASE NOTE
THE ANNUAL DINNER THIS YEAR WILL BE ON FRIDAY 26TH OCTOBER, AT THE FARNHAM HOUSE HOTEL NOT AS STATED ON THE PROGRAMME.

PROPOSED FOUR YEAR PLAN FOR THE FARNHAM GEOLOGICAL SOCIETY FIELD TRIPS

2000

SCOTLAND - 9-19 SEPTEMBER WITH SUE HAY AND STEVE CRIBB

SOUTH WALES - GOWER COAST & GLAMORGAN - 3 - 5 NOVEMBER WITH PAUL DAVIS

2001

PEAK DISTRICT WITH PAUL DAVIS - 4 DAY TRIP IN MARCH

NORTHERN & SOUTHERN IRELAND - 13 - 27 MAY WITH SINEAD McCLURE

North Wales
~~LAKE DISTRICT~~ -JULY OR AUGUST WITH DAVID CRONSHAW

2002

MARCH - LAST TWO WEEKS TO THE VOLCANOES OF ITALY WITH PAUL OLVER

SEPTEMBER / OCTOBER TRIP TO TENERIFE

2003

TRIP TO AMERICA WITH JOHN WILLIAMS OR PAUL DAVIES TO VISIT THE GRAND CANYON

SOME OF THE EXCELLENT LYMERICS HANDED IN FOR THE LIMERICK COMPETITION HELD ON THE IRISH TRIP

Cath's very attached to her brolly,
Some think this is a folly,
But when it gets wet
I think you can bet
That she won't have to spend too much lolly.
Cath Clemesha

There once was a fellow called Mike
Who led on a wonderful hike
From rocks to lead mines
We had some great finds
He sure was a fellow to like.
Sally Hurst

There was a young man called Moles
Who wanted to show us some holes
He showed us some slides
And took us for rides
To the bay where we slipped on the coals.
Colin and Jill Brash

There was a Westport wine-waiter – not bright
Who sent his pants to the laundry each night
Each request had a docket
Which he put in his pocket
No wonder the hotel income was light.
Geoffrey Levett

There is a coach driver called Brian
A man you can really rely on
After doing our digs
He says "You mucky kids"
Then starts up his coach to just fly on.
Sally Hurst

There is a young lady called Sally
Who slaves for us all in the galley
Making coffee and tea
One for you, one for me
While Brian drives slow up the valley.
Geoffrey Levett

Membership News:

At the end of July, membership of the Society stood at 116 following the recruitment of 3 new members during the May/June period. New members are always welcome, and all present members are encouraged to try and introduce new blood into the Society.

Attached, as an Appendix to this newsletter, is the latest list of members together with addresses and telephone numbers. Please let me know of any inaccuracies, omissions or other changes that are required.

Finally, also included in this newsletter, is a full listing of the mineral collection kindly donated to the Society by Jean Graham, the widow of one of our founder members, Dr James Graham. The collection has been catalogued and boxed, and is currently stored at Peter Luckham's barn.

M J Weaver
Membership Secretary
31 July 2001

FGS – Programme of Meetings 2001

Oct 12	Dr Iain Stewart, Brunel University Mediterranean earthquakes; past, present & future
Oct 26	**Society Dinner**
Nov 9	Dr Tony Barber, Royal Holloway Mud volcanoes, shale diapirs & melanges
Dec 14	Roger Birch, Colliers College, Horsham Vulcanology of Tenerife
Jan 18	2002 AGM

News letter

Book Review: ***Strata:***

How William Smith drew the First Map of the Earth in 1801 & Inspired the Science of Geology

By John L Mortimer, Published by Tempus of Stroud, 2001

Paperback, 160 pages. ISBN 0-7524-1992-7 £9.99

This book describes the life of William Smith, 1769 – 1839. He was born and brought up in Churchill, Oxfordshire, the son of a blacksmith. He became a Civil engineer, and was employed by John Rennie in 1793 to be responsible for surveying the Somerset Coal Canal. He was interested in geology and this work enabled him to record the geology of the area around Bath. He realized that fossils helped to identify individual strata.

He worked over much of England advising landowners on management of the land, drainage, mining, quarrying, and canal construction. In 1801 he produced a map of the strata and their fossil contents, found in England and Wales, which was presented to the Geological Society of London in 1831. Professor Adam Sedgwick of Cambridge University named him "The Father of English geology."

The book has required copious research, and is well illustrated including one of his geological maps and explains how he spent his own income and assets on his fieldwork.

John Mortimer's account was particularly interesting to me as we'd fairly recently walked *William Smith's Localities* described by Reg Bradshaw in the field guide entitled Geological Excursions in the Bristol District published by Bristol University.

David Stephens

(This book is available from booksellers, the publishers or
John L Mortimer - post free at £9.99 – signed if required
Brocken Spectre
Horsham
West Sussex
RH13 6BY)

Farnham Geological Society - The *Graham* Mineral Collection

Box No.	Specimen Size (Inches)	Description	Composition	Catalog No.
B 1	3	Adularia (Orthoclase)	$KAlSi_3O_8$	G59
R 3	10	Almandine garnets in a mica schist	$Fe_3Al_2(SiO_4)_3$	G31
B 2	4	Aragonite crystals	$CaCO_3$	G36
C 1	5	Atacamite with Chrysocolla	$CuCl_2.3Cu(OH)_2$	G32
A 1	5	Azurite + Malachite	$2CuCO_3.Cu(OH)_2$	G53
R 11	10	Barite crystals covered with small Chalcopyrite crystals	$BaSO_4$	G188
A 2	4	Bayldonite + Mimetite	$(Pb,Cu)_3As_2O_8.(Pb,Cu)(OH)_2.H_2O$	G43
C 2	6.4	Beryl - large crystal	$Be_3Al_2Si_60_8$	G18
B 3	1	Boleite	$9PbCl_2.8CuO.3AgCl.9H_2O$	G202
A 3	3	Bornite	Cu_2FeS_4	G85
A 4	4	Brochantite	$CuSO_4.3Cu(OH)_2$	G42
C 3	4	Calciocarnotite (Tyuyamunite)	$CaO.2UO_2.V_2O_5.\ nH_2O$	G9
C 4	5	Calcite crystals - large	$CaCO_3$	G48
B 5	4	Calcite Rose cluster	$CaCO_3$	G88
B 22	5	Campylite - brown, barrel-shaped crystals	$(PbCl)Pb_4(AsO_4)_3$	G25
R 12	8	Celestite crystals	$SrSO_4$	G99
B 6	2	Cerussite on Galena	$PbCO_3$ + PbS	G11
A 5	4	Chalcanthite	$CuSO_4.5H_2O$	G61
D 1	5	Chalcedony nodules - cut & polished	SiO_2	G210a/b
D 2	5	Chalcedony nodules - cut & polished	SiO_2	G211a/b
D 3	5	Chalcedony nodules - cut & polished	SiO_2	G212a/b
R 13	6	Chalcedony nodules with Quartz crystal infil	SiO_2	G213
A 6	3	Chalcocite	Cu_2S	G86
A 7	1	Chalcopyrite	$CuFeS_2$	G206
R 4	8	Chalcopyrite on Calcite	$CuFeS_2$	G5
B 7	4.1	Charite - vivid purple	$(Ca,Na)_2KSi_4O_{10}.(OH,F)H_20$	G203
A 8	3	Conichalcite + Calcite	$(CuCa)_3.As_2O_8.(Cu,Ca)(OH)_2.½H_2O$	G60
A 9	4	Copper - native	Cu	G38
A 10	4	Cuprite & Olivenite	Cu_2O	G44
A 11	3	Cuproadamite	$Zn_3As_2O_8.Zn(OH)_2 + Cu$	G41
C 5	6	Dioptase - Emerald Copper	$CuO.SiO_2.H_2O$	G179
A 12	4	Duftite on Calcite	$(Pb,Cu)_3(AsO_4)_2\ (Pb,Cu)(OH)$	G40
C 6	5	Eilat Stone	Chrysocolla, Turquoise & Malachite	G15
C 7	5	Fluorite crystals (var. green)	CaF_2	G21
R 1	9	Fluorite crystals - var. blue	CaF_2	G83
R 2	7	Fluorite crystals - var. light green	CaF_2	G160
R 6	8	Fossil Wood	Siliceous material	G215
B 8	4	Galena with Pyrites & Sphalerite	PbS	G51
B 9	3	Gypsum - var Satin Spar	$CaSO_4.2H_2O$	G37
D 4	6	Hematite - var Specularite	Fe_2O_3	G90
D 5	5	Hematite var. Kidney Ore	Fe_2O_3	G208

Farnham Geological Society - The *Graham* Mineral Collection

Box No.	Specimen Size (Inches)	Description	Composition	Catalog No.
B 23	3	Jamesonite - var. fibrous	$Pb_4FeSb_6S_{14}$	G216
B 10	4	Kyanite - blade like crystals	Al_2SiO_5	G77
C 8	5	Langite	$CuSO_4.3Cu(OH)_2.H_2O$	G45
A 13	3	Libethenite	$Cu_3P_2O_8.Cu(OH)_2$	G200
A 14	3	Linarite	$(Pb,Cu)SO_4.(Pb,Cu)(OH)_2$	G33
A 15	3	Malachite	$Cu_2CO_3(OH)_2$	G204
C 9	5	Microcline (var. Amazonstone)	$KAlSi_3O_8$	G81
B 11	4	Microcline crystals	$KAlSi_3O_8$	G56
B 12	4	Nephrite jade - polished	Complex Ca, Mg, Fe, hydrated silicate	G80
A 16	3	Olivenite	$Cu_2(OH).AsO_4$	G34
D 6	5	Opal on matrix	$SiO_2.nH_2O$	G231
A 17	2	Pentlandite	$(FeNi)_9S_8$	G207
B 13	4	Pericline + Quartz	$NaAlSi_3O_8$	G58
B 14	2	Pharmacosiderite & *minor* Scorodite	Hydrated iron arsenates	G84
A 18	3	Plancheite + Malachite	$3CuSiO_3.H_2O$	G201
R 5	9	Quartz (Amethyst) crystal cluster	SiO_2	G1
D 7	5	Quartz (Rose)	SiO_2	G189
D 8	5	Quartz and Calcite crystal cluster	$SiO_2 + CaCO_3$	G74
B 15	4	Quartz crystal - blue synthetic	SiO_2	G13
D 9	6.2	Quartz crystal - large	SiO_2	G76
R 14	9	Quartz crystals & Albite crystals	$SiO_2 + NaAlSi_3O_8$	G50
R 15	8	Septarian nodule with yellow Calcite crystal infil		G213
B 16	3	Smithsonite	$ZnCO_3$	G62
B 17	4	Smithsonite	$ZnCO_3$	G69
B 18	4	Smithsonite	$ZnCO_3$	G91
D 10	5	Sodalite	$Na_8Al_6Si_6O_{24}Cl_2$	G209
B 4	3	Stibnite needle cluster	Sb_2S_3	G92
A 19	4	Tetrahedrite	$3Cu_2S.Sb_2S_3$	G35
C 10	6	Torbenite - hydrated phosphate of copper & uranium	$Cu(UO_2)_2.P_2O_8.12H_2O$	G39
C 12	4.4	Tourmaline - large crystal "twinned" with spear of mica schist	Complex borosilicate of aluminium	G3
C 11	5.4	Tourmaline - large single crystal	Complex borosilicate of aluminium	G4
D 11	5	Tourmaline crystals in massive Quartz	Complex borosilicate of aluminium	G17
B 19	1	Trinitite		G205
B 20	3	Tugtupite (1400 Ma)	$Na_8Al_2Be_2Si_8O_{24}.(Cl_2,S)$	G16
A 20	4	Turquoise	$CuO.3Al_2O_3.2P_2O_5.9H_2O$	G87
A 21	2	Volborthite	Hydrous Vanadate of Cu, Ba, Ca	G57
B 21	3	Witherite	$BaCO_3$	G23
A 22	3	Woodwardite	$Al_2O_3,CuO,SiO_2,SO_3,H_2O$	G46

Life on Other Worlds. A Geological problem

By A T F Comer

Lately there has been much speculation as to whether life is widespread in the universe, or alternatively whether any life exists elsewhere in the universe other than here on earth. Certainly there are millions of stars not unlike our sun. Surely some of them must have earth-like planets, although at present none have been detected, and among them might there not be some that have developed life as we know it? Not that it is likely to be in step with ours, of course. If Dinosaurus Sapiens had evolved sixty million years ago, he might have asked the same questions. Intelligent beings with whom we might claim a relationship might therefore have evolved millions of years ago, or equally might be millions of years behind us, so the prospect of meeting alien people is not, in my opinion, very bright for many different reasons.

For the present, therefore, although we might look wistfully into space, we must accept that there is only one known planet on which life can be studied, and that is our own.

Fortunately the geological sciences are now revealing a great deal about the history of the earth since it was first formed, and the fossils contained in the rocks of the earth chart with reasonable certainty the history of life here, life that has been nurtured by the earth from its beginning to its present state of development. Surely, therefore, we should be able to deduce the conditions required for its long progression, and might not this information be useful if ever we learn to see other planets in distant space. They would need to have something in common with this Earth if life as we know it were to develop there.

This essay makes no attempt to define 'intelligent', nor is it concerned with the inanimate chemistry of life or the spark that transformed it into living organisms. It looks only at the signs left by living things in the rocks of the earth, and from them tries to deduce a logical path from its inception to its present state of development.

The earth formed about 4,500 MY ago from a cloud of cosmic debris that obviously had in it all the material the planet now contains, a date that is very widely accepted by astronomers and geologists alike, confirmed by careful radio-active dating of many source materials. After the material had collected it must have been quite a jumble. There must also have been a lot of heat involved caused by friction and increase in pressure as it settled into a sphere, more so if radio-activity was involved and if oxygen and hydrogen combined into water by burning during its formative years. Some melting of the cold material must surely have taken place — what else could account for the earth's present nickel-iron core, surrounded by its less dense rocky exterior.

There is not a lot of evidence to tell us what conditions on earth were like for the first 1000 MY, but by about the end of that time it seems to have settled down into a surprisingly spherical rocky mass with huge lumps on its solid surface that became the continents, protruding an average of 7 or 8 Kms above it. Between these had accumulated all the vast quantity of water that had been squeezed out of the accumulating mass.

In other words, after one thousand million years, which is after all a very long time, it is thought that conditions on its surface had probably become fairly stable. Sedimentary rocks of this age are occasionally found, showing that oceans existed, and that land surfaces also existed and were subject to erosion by weathering. Surface temperature must therefore have fallen to much as it is today, or the water of the sea could not have been in its liquid phase. However, there is no evidence of life on earth at that time, either on land or in the sea, in the few samples of rock of that age that have survived.

But here is a problem that is still not fully resolved. Weather would surely cause erosion of the protruding land masses, which were of course the mainly granitic continents floating in isostasy on the incompetent basaltic mantle below. Why in the time available were they not completely worn away? Why after a further 3500 MY do we not have an even, spherical, rocky world covered by an even layer of water several Kms thick, with an atmosphere above it forming still another layer?

Fortunately it didn't happen that way. There appear to be dynamic forces that move the continents. Whether movement is caused by currents, possibly convection currents deep inside the earth, as many people believe, or by gravitational or centrifugal forces that seem to me to be just as probable, but it does appear to be a fact that the continents are in perpetual movement at about the speed that our fingernails grow, which would be quite a long way in 3000 MY. During such journeys they would collide and jostle each other many times, incidentally tamping each other up to their original height, which is governed by the strength of the materials of which they are composed. These phenomena are nowadays collectively known as Plate Tectonics.

But even in those far-off days, earth processes would be similar to those of today. Climate and weather would have been established, giving rain, clouds, winds and climatic zones, controlled as today by heat from the sun in equilibrium with radiation into space. The pattern of solar radiation reaching the spherical surface of the earth would have been the same then as now, and is shown in Fig 1,* which represents annual totals of insolation at all latitudes from the equator to the poles.

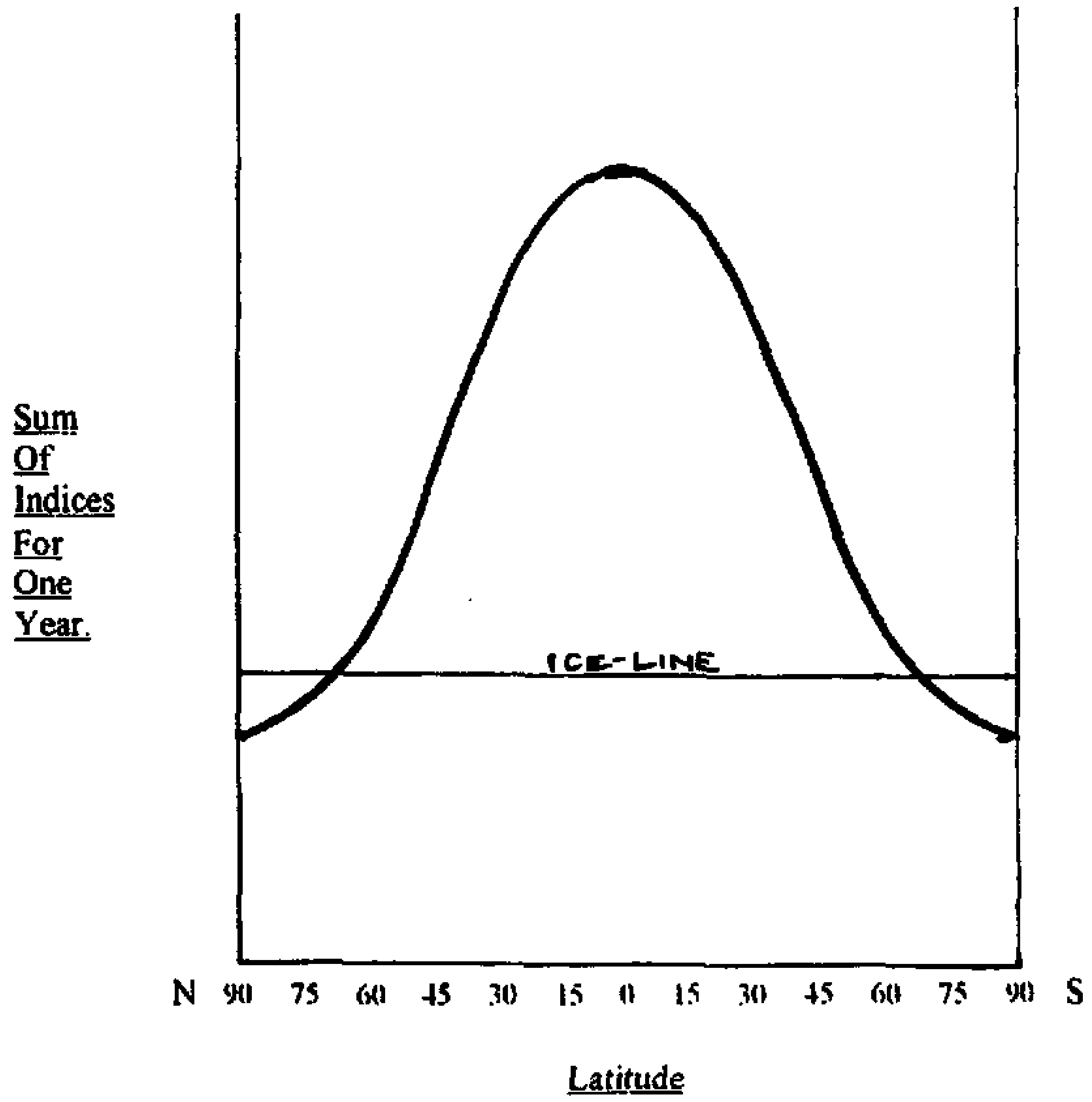

Figure 1. Annual Insolation based on 15° steps of latitude.

It shows why it is warmer in the tropics even though the sun is out of sight for twelve hours every day, and why cold conditions are established at the poles, made much worse by the fact that, because of the tilt of the earth's axis, no sunshine is seen at all for six months of each year. In these conditions it is inevitable that there must have been some freezing around the poles from very early times in earth history, and it follows also that seawater at its temperature of maximum density must have sunk and accumulated on the ocean floors just as it does today. Once this has happened, there is no mechanism that can change the temperature of abyssal water. 80% of ocean water today is at a temperature of 2°C (±about 0·5° according to salinity), despite the fact that we are now in an interglacial. It therefore seems logical to suppose that very durable and stable conditions were developed in the oceans from very early times in earth history. 60%—70% of the earth's sub-aerial environment would therefore have been free of any short term change of temperature, pressure, salinity, or even excessive turbulence, for vast periods of time, ideal circumstances for the development of life whatever may have been its original spark. The fossil record shows without any doubt that, wherever it may have been created, life did develop in the sea, and remained there for something like three thousand million years before it had to face the problems of living on dry land, to develop into all that we would find familiar.

There are many ideas under discussion concerning the actual origin of life on this planet. Professor Hoyle and his colleagues, who are eminent astronomers, have published work that suggests that life was originally seeded here from space, as indeed were major evolutionary steps as diverse as the wings of flying creatures and many viruses that have caused mass extinctions. At the Royal Metreological Society's recent conference, suggestions were made that aerosol droplets thrown up from the surface of the sea, containing the necessary chemicals in solution, may have been changed by solar radiation. Other scientists point to the diverse life forms in seemingly impossible places around "smokers" on the ocean floors, suggesting that they may have a bearing on the subject, and of course there is the widely prevalent view that Life arose by a Conscious Act of Creation, though its chronology by this route is difficult to comprehend.

Whatever the conclusions are about these matters, there is evidence in the rocks of the earth which indicates that after a thousand million years of sterile existence, something happened in the oceans. Some sedimentary rocks of about 3500MY of age show markings that are interpreted by some as "organised molecules", and by others as primitive single-celled living creatures, and from then onwards interpretation becomes more reliable, particularly as more evidence is coming to light. It shows without much doubt that development has probably been continuous ever since, without the interruptions and re-creations that featured in Victorian science and are still sometimes quoted.

Geologists have no difficulty with the basic concept that older fossils are below younger ones, and from this many local chronologies have been worked out since the days of William Smith, extended by the diligent work of many palaeontologists over many years until a world-wide pattern has been established. However, converting this relative chronology into an absolute chronology had to await the development of accurate dating by radio-active methods, until now we can reliably interpret time on a coarse scale of years. Rocks 3,500MY old show the first signs of life, and rocks 2,500MY old show without much doubt that more advanced creatures, probably related to jellyfish or worms, had developed. By implication there must also have been food for them to live on, although details have not been preserved. Development was somewhat faster in the next 1000MY. By late pre-cambrian times it is certain that chitinous carapaces and hard calcitic shells had developed, implying that food was plentiful and also that evolution was adapting to the basic principles of offence and defence. From then on, development seemed to accelerate. By Cambrian times when the Burgess shales were laid down, recognisable shellfish, arthropods, segmented worms, and free-swimming creatures, were present in the sea, most of them long extinct but clearly the forerunners of modern lifeforms, all of which are very well described in Simon Conway Morris's book, the Crucible of Creation.

From that time onwards development of life in the sea became very rapid in geological time. After only a few more million years most of the creatures familiar today were present in their early forms, including, by the late Silurian, bony fishes that would not look unusual in the nets of a modern fisherman, Not long afterwards there took place the biggest revolution of all, the emergence of life on to dry land, first plants and with them the arthropods, followed by the amphibians when there was enough for them to eat, a few species being very large indeed, approaching the size of modern elephants. Imagine the problems over which evolution had triumphed. Tides, stranding, and dehydration were only the first of many, as were direct exposure to the sun, large diurnal and seasonal temperature changes, weather, and fresh water instead of salt, but storms, earthquakes, and eruptions may also have had greater importance on land than in the oceans. An important factor on this timescale must have been the tectonic movement of continents through the climatic zones, which was too slow to have any effect on individuals although on the evolutionary timescale it was probably responsible for many extinctions, which in turn improved the prospects for future development. Extinction is of great importance in the broadest sense of evolution, to make room for others.

Thus life can be traced through the fossil record over a vast period of time, from its beginning 3,500MY ago through many stages of development. From its initial spark it needed the stability provided by the oceans in which its very slow progress could take place, and only after thousands of millions of years could the unstable and more variable land surfaces be challenged, on which people like ourselves might develop to speculate about life on other planets.

So what should we be looking for if we seek "life as we know it" out there in the Galaxy? We are unlikely to hear voices from space, but if such a miracle should happen the people who sent the message might well be extinct by the time we receive it because of the distance involved. But we might well discover a means of detecting planets around some of the many suns in our corner of the galaxy. What should they be like if they could sustain life with which we might relate.? It seems that they must not have a crippling gravity, as would Jupiter or Saturn, and they must have a suitable atmosphere, with water in its three states on its surface, solid, liquid, and vapour, suggesting temperatures in which we could exist, with a density not far removed from our own which would suggest a similar minerology. If ever such a planet is found, it would be fully justified to send them a long message, in the hope that people there are at the right stage of development to understand it when it arrives.

Allan Comer, August 2000.

* Fig 1 reveals the pattern of distribution of solar energy over the surface of the earth, excluding any attenuation due to local weather but allowing for sphericity and an axial tilt of 23·5°. It was obtained by assessing the total amount of solar radiation at locations in 15° steps of latitude, on the 22nd of every month in the year (so that the solstices are included), then adding these indices to obtain annual totals.

The ice-line shows the limit of permanent polar sea-ice — annual insolation below this line is insufficient to cause complete melting. At present with an axial tilt of 23·5° permanent ice extends from the poles to about 72° (± about 3° according to prevailing ocean currents), but these figures would change if axial tilt should alter.