The proposition also fits in with the known physical properties of rocks, especially their thermal properties. Rocks conduct heat quite poorly and also hold a lot of heat well. This is just the sort of situation where, if a massive amount of heat is injected through friction, a section of rock will melt and possibly become 'superheated' enough for the heat to spread slowly into adjacent rocks.

If the heat input is great enough, or is created close enough to the surface, it may spread enough to melt its way through to the surface and create a volcano — essentially an artesian molten-rock flow or rock 'gusher'. If there is not enough heat for this, the molten rock will slowly cool, insulated by the surrounding rock, and allow crystallization to occur — visible crystals are specially characteristic of acidic rocks such as granite.

Igneous Rocks

An important corollary of Proposition 8D relates to the rock the volcanos produce, and also to other igneous rocks. That is, that igneous rocks are produced by domain friction, and are not 'primeval' products left over from the Earth's assumed molten beginnings.

> *Proposition 8E*
> *Igneous rocks are produced locally, through domain rubbing, and not from a 'primeval' Earth source*

The existence under the surface of vaguely spherical bodies of igneous rocks is well known; smaller ones are represented as 'magma chambers' (magma is molten rock), and larger, solidified ones as 'batholiths'. An interesting point is that batholiths are normally *elongated* along the line of a mountain chain.

Figure 8.2 is a conventional representation of the rise of hot molten rock from the Earth's largely unknown inner reaches, and its further ascent to form a volcano. Shown is a large batholith, at the base of a thick layer of crustal rocks, itself connected to a magma chamber which has intruded into the layers of sedimentary rock beneath the land surface. This again is connected through a magma pipe with the cone and mouth of a volcano formed by the rock which solidified after flowing out from it.

Why should the magma come up from below and force its way through at this particular point? This is assumed to be due to 'weaknesses' in the Earth's crust at those points.

Now Figure 8.2 is obviously very diagrammatic and not to scale, but the situation it illustrates is, in my view, nonsense. No credible mechanisms have ever been suggested for why immense batholiths should happen to form at particular places, no reason for magma to be intruded and melt out 'chambers' at odd points within the sedimentary layers. In fact such behaviour is quite contrary to what we know about the flow of heat through materials such as rocks.

Worst of all, as we shall see in the next chapter, there is no evidence that the inner reaches of the Earth are made up of molten rock in the ordinary sense. This takes away the whole basis for the supposed pushing out of molten rock from volcanos through pressure from reserves within the Earth.

The concept of igneous rocks being formed locally, through the heat of friction caused by domain-edge rubbing, provides a far more satisfactory explanation for the observed facts. It explains why bodies of molten rock can be formed at quite different depths (friction having been more active there, due to waviness of the domain-edge surfaces). It removes the need to explain how molten rock manages to intrude into particular spots of the crust and melt out chambers. And it explains why batholiths are elongated, they are elongated along the rubbing domain edges.

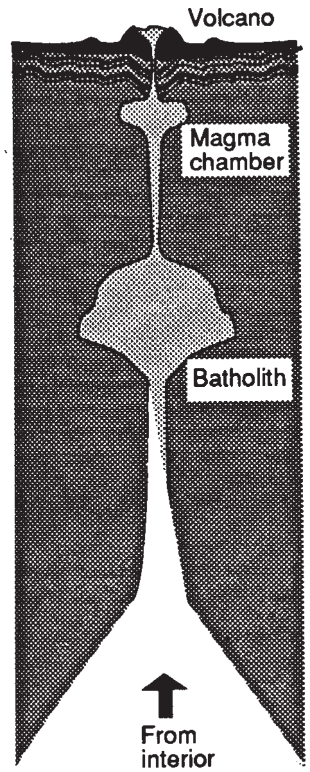

Fig. 8.2. Conventional representation of volcanos and batholiths

Geysers and Hot Springs

As well as volcanos, there are a number of other 'geothermal' phenomena which are not so dramatic in nature, such as geysers and hot springs.

With geysers, visible jets of hot water and steam are emitted periodically from holes in the earth, and some well-known ones have remarkably regular intervals between eruptions. Geysers and hot springs are very often associated with volcanic regions, but they need not be. Along the Perth coastal sandplain, just inland from Rottnest and close to the low granite hills of the Darling Range, some hot springs and hot artesian bores are known. There is no sign of volcanic activity in the area.

From the domainographic viewpoint, these more minor geothermal phenomena are just a natural consequence of less dramatic domain movements. In the Perth case, the sandplain area is a slowly-moving microdomain shuffle belt, wending its way south with just enough frictional movement to produce the odd hot spring.

> *Proposition 8F*
> *All geothermal phenomena obtain their heat components from domain rubbing*

Metamorphic Rocks

Intermediate between the igneous rocks, cooled down from the molten state, and the sedimentary rocks made from aggregates of erosion particles there lie the metamorphic rocks.

Metamorphic rocks are ones which have been changed or 'metamorphosed' from their original condition. Mostly they were once sedimentary rocks, such as limestone, which can be metamorphosed into marble, although igneous rocks can be metamorphosed too. Often they show marked layering; this can be a relic of the original sedimentary layering, but is sometimes clearly a result of the metamorphic process. The sheets of the transparent mineral known as mica are an example.

It is hard to explain some of the features of metamorphic rocks on the conventional concept of minor heat flows from a hot inner core. How could such minor heat flows lead to the perfectly level layered features found in metamorphic rocks, tens or hundreds of kilometres above the presumed heat source?

A natural explanation is found in the domainographic approach, which can supply the required localized sources of heat and pressure from the grinding together of moving domain edges.

> *Proposition 8G*
> *Metamorphic rocks are formed by the heat and pressure produced by rubbing domain edges*

Earthquakes

What causes earthquakes? Even though earthquakes have been an object of terror since the earliest days of man, and have been studied in detail for several centuries, no satisfactory answer to this question has ever been given.

Of course, when Continental Drift was discovered, impacts between drifting 'plates' were suggested. Unfortunately for this idea, the 'fat' mountains formed by impact are not the usual places where earthquakes appear. Earthquakes are almost invariably associated with 'long' mountains.

Then, when the idea of hot-rock 'convection cells' was put forward, the movements associated with these were a candidate. This was closer, in that earthquakes *are* associated with active mid-ocean ridges, supposed sites of upwelling hot rock. But they are not associated with the deep ocean trenches, into which subducted material was supposed to be disappearing. And the convection cells had no immediate connection with the established mountain chains which are the real places where earthquakes are most active.

We can see now that earthquakes are a natural consequence of domain movement, in fact, they *are* domain movements. When one Earth domain moves relative to another adjacent one, it is performing an earth movement, which is another name for an earthquake. The stating of this proposition is therefore almost a logical redundancy:

> *Proposition 8H*
> *Earthquakes are the relative movements of adjacent domains*

A few points which clearly support this proposition. First, it is common in earthquakes for surface displacements to occur, to create 'steps' in railways or roads of a metre or more. This would be expected if one domain was moving relative to another. Moreover, the displacements give the direction of relative domain movements. For example, on the California coast, which is accepted as moving north compared to the adjacent main mass of North America, displacement should normally reflect this relative movement.

Then there is the matter of the depth of earthquakes. The focus of an earthquake, the point

where it is most active (the assumed actual shearing zone), is not usually on the surface of the Earth, but deeper down. In a particular broad area, the earthquake foci are not at identical depth, but they do tend to cluster at somewhat similar depths. The focus can lie anywhere from a few kilometres down to as much as 700*km* below the surface. The cause of these last 'deep' earthquakes is completely unknown.

If the inner Earth is expanding, and this may be in a very regular way, then adjustments to the surface can be expected to extend quite deeply down. And, more important, a rational reason can be given for the fact that earthquake foci occur at different depths. The differences are due to differences in the size, shape, and physical compositions of the different domains.

So far, we have mostly looked at domains as two-dimensional objects, flat areas on the surface of the Earth. To get a more exact idea of what is happening with earthquakes, it is necessary to consider domains as three-dimensional objects, with not only width and breadth, but also height.

We had the first intimation of this concept with Proposition 5E, where it was suggested that the split of the original holodomain of continental material into Laurasia and Gondwanaland was not an isolated event, but was just the time when continuing expansion had reached the point of exposing underlying oceanic rock for the first time. Now we need to look at the outer layer of the Earth as being made up of layers of domains of varying thicknesses and sizes.

> *Proposition 8I*
> *Domains are three-dimensional objects of varying thicknesses, and the surface domains which are directly observable may be underlain by other domain-type structures*

An incidental consequence of this Proposition is that there will be considerable heat generated by friction between surface domain bottoms and sub-domain tops. A more important consequence is that multi-level domain concepts can be developed in a quantitative way which, for the first time, gives a real possibility of being able to *predict* earthquakes. This would be a very useful thing to be able to do.

Earthquakes happen when shearing occurs between the sides of two adjacent domains. Before the actual earthquake, huge tensions build up as the rock faces are compressed or stretched; it is sometimes possible to detect these forces with strain gauges. Although very rigid, different rocks have known physical properties, and the tearing, stretching or compression they will undergo under given conditions can be calculated quite precisely.

I can see no reason why it would not be possible to calculate where and when earthquakes will occur, once a better knowledge of the physical dimensions of domains and of the physical properies of their component materials is obtained, and a value for the rate of Earth expansion assumed. Such calculations may be complex and tedious, but there is nothing basically new about them.

> *Proposition 8J*
> *It should be possible to calculate where and when earthquakes will occur, once fuller data on the domains involved is known*

Hot Spots

Another mountain-building phenomenon which has been suggested in recent years is known as 'hot spots'. According to this theory, within the Earth there are a number of localized sources of heat, of unknown origin. As the 'tectonic plates' pass over these hot spots, each in a string of volcanic mountains is formed over the hot spot. From the ages of the various members of a volcanic-mountain string, the direction and speed of the associated plate movement can be calculated.

The hot-spot theory does not fit in at all with the concepts I have proposed. It is undeniable that strings of volcanic mountains exist, and it is perfectly feasible to join up the isolated points and conclude they represent the path of a tectonic plate over a hot spot. I believe this conclusion is wrong.

I suspect that the apparent 'hot spots' are what is called an 'artifact'. They can be seen, but paradoxically, they are not real. Like a moving dislocation vacancy in a crystal structure, or the passage of an electron 'hole' in a semiconductor, the movement is only apparent, not real. The situation is comparable to when the head of an organization resigns and is replaced by his deputy, who is replaced by his deputy, and so on down the tree until eventually a new recruit is taken in at the bottom.

In this situation, the job 'vacancy' starts at the top, and appears to move downwards through the organizational tree until it is filled by the new recruit sucked in at the bottom. In the same way, I suspect that the apparent 'hot spots' are only artifacts, created perhaps by opposing chance protrusions in adjacent domain boundaries happening to come together as the domains move.

> *Proposition 8K*
> *'Hot Spots' in the Earth are artefacts created by domain edge movements, and not real phenomena*

Of course the acceptance of this Proposition removes the nagging need to explain the *source* of the energy needed to drive the hot spots. These sources would have to be pretty special, if they were able to raise mountain after mountain, maintaining their power for many millions of years unchanged.

We have now spent some time looking at the surface of the Earth and its uppermost layers. We are ready now to plunge down, deep into the core of the planet.

CHAPTER 9

INSIDE THE EARTH

"The goal of scientific endeavour is to learn the truth of nature,
and not to win debates"

Man lives, together with the complex assembly of plant and animal life which make up the biosphere, on the surface of the Earth. So it is natural that we know most about the surface, which is a surprisingly thin piece of real estate. When we go beneath the surface, down into the depths of the Earth, we can make direct observations for only about one-fifth of one percent of the way down. Everything we know about the other 99.8% has had to be deduced from indirect evidence and assumption and calculation — so it is again natural that the picture we have may be inaccurate.

In fact almost everything we have worked out about the insides of the Earth comes from a study of one thing — earthquake waves. When an earthquake occurs, it produces shock waves which run through and around the Earth.

These waves do not just radiate out and dissipate, they actually bounce off various levels within the Earth, called discontinuities, where the physical properties of the rocks change. Observations of the waves reveal just where under the surface the discontinuities are located, and give an indication of the properties of the rocks on either side.

Figure 9.1 shows a conventional summary of what has been deduced about the properties of the Earth, from its surface to its centre (about 6370*km* down). A fuller explanation can be found in any modern text (e.g. [Physical, 1977]), but the main features are these:

• **Feature A** • Four discontinuities, at depths of around 20, 200, 2900, and 5150*km*, where there are abrupt changes in density;

• **Feature B** • Density increasing from about 2.7 (*g/cc*) at the surface to about 13.6 at the centre;

• **Feature C** • Assumed chemical composition changing from oxides high in silicon and aluminium (Sial) or high in silicon, magnesium, iron and calcium (Sima) at the surface, down through layers with increasingly less silicon and more iron, until a core region is reached containing mostly iron oxides;

• **Feature D** • Temperature increasing from around 20 (°C) at the surface to 3000 at the centre.

The Lithosphere

Virtually everything in the area of domainography which has been mentioned so far concerns the region called the lithosphere, which lies beween the uppermost solid surface and a depth of around 60-100*km*.

This region is made up of the Crust and the uppermost division of the Mantle. The boundary between these two is the first discontinuity, called the Moho (after Mohorovicic, who discovered it). There the density changes abruptly, from 2.9 to 3.3.

The Moho varies in position from about 10 to 35*km* below sealevel. Under the seabeds, where the oceanic basic rock or Sima is exposed, it is at its shallowest, while it is furthest down under the continents, which consist mostly of continental acidic rocks, or Sial. Where Sial exists, in the continental areas, it is nevertheless believed to have Sima underneath it, so the Sima extends over the whole of the Earth. The Moho also extends over the whole Earth, apparently almost entirely within the Sima.

There is no doubt that the Moho, and the other three discontinuities mentioned in Feature A, all exist. What is not certain is what their nature is. They have been associated with changes in chemical composition to some extent, but this is purely speculative. Even the Moho is only just within the range of feasibilility for reaching by modern drilling techniques (the current record depth is around 11*km*), but to date no drill core recovered has provided hard evidence that rock below the Moho is of different composition to that above.

From all the evidence produced to date, it is clear that extensive domain movements have occurred in the past, and it seems that the influence of these movements has extended at the very least to the base of the lithosphere, up to 100*km* down. On the old plate tectonic theory, the ‘plates’ were supposed to be drifting on the mushy rock layer, the asthenosphere, immediately below the lithosphere.

It is interesting that as long ago as 1782, Benjamin Franklin speculated that “the surface of the globe might be a shell, capable of swimming on an internal fluid”. We will see later that this attractive idea, which has now actually reached general acceptance, is false.

It seems logical that if such ‘floating’ movements occurred, they could not leave intact a boundary based on differences in chemical composition. Even on Continental Drift principles, we have taken it for granted that one such ‘chemical boundary’, that between the Sial and the Sima, has already been broken up by domain movements.

It therefore seems likely that the Moho is a physical boundary. Its most probable nature is that of a *phase change*, brought about by increasing pressure. A given mineral or compound can exist in different states or ‘phases’, caused by the application of external pressures — an example is diamond and graphite, both of which are phases of carbon. Diamonds can be made from graphite by application of very high pressures — amusingly enough, they have actually been made from peanuts, after extracting the carbon from these.

> *Proposition 9A*
> *The Moho discontinuity represents a phase change boundary where the rocks are changing their phase in response to increasing pressure*

From this Proposition it follows directly that if the Moho is dependent on pressure, it will alter its position as the pressures change, as will happen when domains move and break up.

> *Proposition 9B*
> *The position of the Moho will change as the pressure of overlying rock changes in consequence of domain movement*

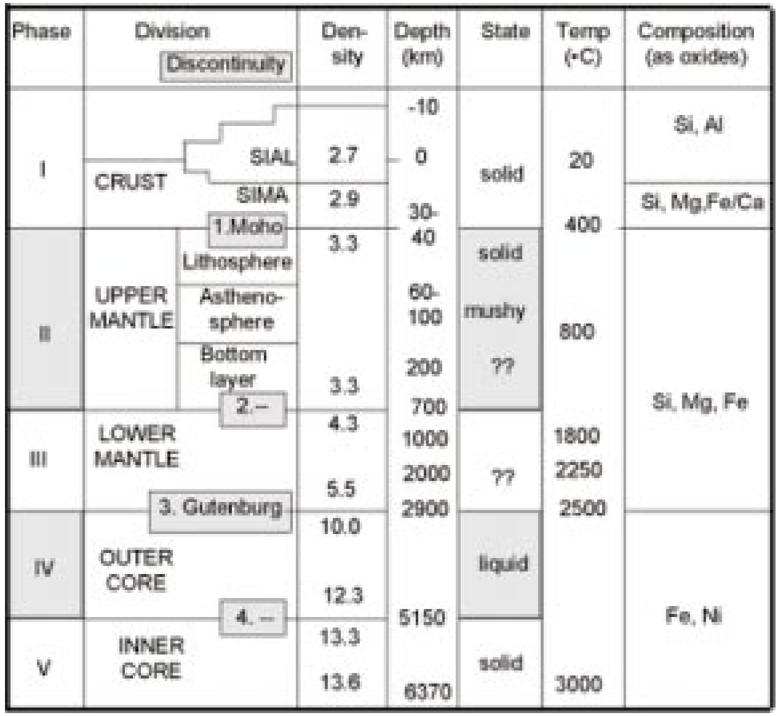

Fig. 9.1. Structure of the Earth, from surface to centre

These propositions are in accord with Features A and B above, but Feature C looks a bit more shaky. Let us now look further at the matter of chemical compositions.

Internal Chemistry of the Earth

Once we descend below the 10*km* or so of the Crust which can be analysed directly, our knowledge of the Earth’s chemistry is purely speculative. So we are quite within our rights to question some of the assumptions made, assumptions often repeated as fact, from textbook to textbook through the decades, without any real evidence.

One of these ‘facts’ is that the core of the Earth is very rich in iron and poor in silicon. According to the text used to construct Fig. 9.1 [Physical, 1977], some 90% of the core consists of iron oxides, and another 8% of nickel oxide, leaving 2% unspecified. Where did this idea come from?

Well, firstly there is the fact that the core material is very dense, and both iron and its oxides are also dense, though not as dense as the core material. So this does not get us far. Perhaps the strongest argument comes from material assumed to be derived from outside the Earth, from meteorites.

Meteorites are solid objects falling to the Earth from space, of a size great enough to survive vaporization through the friction of falling through the atmosphere (another instance of the great heat available from friction). They are of two types, either stony, made of rocks similar to those found on Earth, or of iron (with some nickel).

It has been suggested that meteorites are the remains of a planet similar to Earth which broke up at some time in the past. The proportion of stony to iron meteorites falling on Earth is similar to the proportion of iron to stone within the Earth if its core was made of iron. And this appears to be the main argument for an iron core.

This connection is not only tenuous, it is also flawed. The iron in meteorites is native metal, while the iron assumed to be in the core is represented as iron oxides. No mechanism has ever been suggested whereby, if a planet broke up, the bits of iron oxide from its core could all be converted to iron metal.

There is one further possible link, with magnetism. The Earth has an appreciable magnetic field, and iron and its compounds are normally linked with magnetism. However, any possible connection with the core is ruled out by the fact that magnetic materials lose their magnetism when heated up — this is the basis of the technique of paleomagnetism, mentioned in Chapter 3, whereby newly-created rock from volcanos took on the direction of the local magnetic field as it cooled down.

So it appears that the idea that the Earth has an iron-rich core is without basis.

> *Proposition 9C*
> *The Earth does not have an iron-rich core*

What then is the basis for the density discontinuities in the Earth's inner structure? I think it is reasonable to assume that all four of the known discontinuities mentioned in Feature A are, like the Moho, the result of pressure-induced phase changes.

> *Proposition 9D*
> *The four discontinuities marking the boundaries between the Earth's Crust, Upper Mantle, Lower Mantle, Outer Core, and Inner Core are all due to pressure-induced phase changes*

This Proposition is at least as reasonable as any other. It is supported by the manner in which masses of molten rock material segregate. Some segregation might be expected, perhaps with lighter components rising closer to the surface (as with the Sial and Sima), but not a sharp division based on chemical composition.

A corollary of Proposition 9D is that all pressure-dependent discontinuities may be expected to alter their position as the Earth expands, as suggested for the Moho.

> *Proposition 9E*
> *All the density discontinuities within the Earth may be expected to change position as internal pressures change with Earth expansion*

Heat of the Earth

Of the four Features listed above, the one most open to attack is the one which assumes that the Earth's temperature increases continuously towards its centre. After all, why should it?

When confronted with this question, probably the responses of most geophysicists would fall into two areas. One is to say, whatever the reason for the phenomenon, it describes known behaviour — it does get hotter as you go downward in the Earth. The other response might be to say that pressures are very great within the Earth (this is undisputed), and high pressures and high temperatures are usually associated.

Neither of these responses hold water. The most obvious manifestation of heat from within the Earth is through geothermal phenomena such as volcanos. We have already seen that these essential *local* phenomena are, in fact, an expected outcome of domain rubbing (Proposition 8D).

Well then, what about the observed fact that temperatures increase as you go downwards in mines? This is perhaps the strongest argument which can be produced, and we need to look at it more closely.

Temperatures down mines

As you go progressively deeper in the Earth, temperature variations due to seasonal and climatic effects smooth out, and in an undisturbed site the temperature is virtually constant when a depth of 20-30*m* is reached. Of course this constant temperature is different for different sites and depths.

As you go deeper still, the temperature invariably rises regularly. The rate of rise, at least for the more shallow mines, is around 1°C for each 40*m* of descent (equivalent to 25°C/*km*), but it does vary by a factor of two, and even varies at different depths in the same mine. This effect has been known since mines were first dug.

More recently, information has been gained from deep oil wells, showing a similar picture [Bergman, 1989]. Producing oil wells have been drilled, in different parts of the world, down to depths of around 8*km*. The temperature of the oil produced varies according to the area of production and the geology of the host rocks, but invariably increases with the depth of origin. Oil from a depth of 1*km* might be at a temperature of 55°C, that from the deepest wells could reach 240°C. Again these figures represent rises of around 25°C/*km*.

The pertinent question now is whether these rises increase regularly as you go even deeper, and if so, what the source of the deep heat is. For the first part, a regular rise of the type found in the accessible top 10*km* implies a temperature at the Earth's core of over 150,000°C. This is the sort of temperature believed to exist only in the interiors of very hot stars, and no one has ever suggested it as a real possibility for the Earth — 3000°C is a conventional figure.

This last figure represents an average rise of less than half a degree per kilometre, so even on the conventional view it is accepted that any rate of rise must fall off as you go deeper.

For the second part, the accepted origin of the heat rising from the Earth's interior is that it comes from the molten core, presumed to be left over from when the planet was first formed in a molten state. We now look at the flow of this heat.

Heat Flow in the Earth

The matter of the flow of heat through the body of thy Earth has received considerable attention in the past. Rocks are poor conductors of heat, and so if the centre of the Earth was once very hot, it can be expected that it would take some time for the inner heat to escape. But just how long?

Towards the end of the last century, the famous physicist Lord Kelvin (William Thomson) looked at this problem in an attempt to work out the age of the Earth. Kelvin was an expert in matters relating to heat flow, in fact the absolute scale of temperature, that starting from absolute zero (around -273°C), is measured in degrees K (K for Kelvin).

Kelvin concluded that if the Earth started off very hot, it could not take more than 400*my* for it to cool down to its present temperature, and it could be as little as 20*my*. His study was one of the earlier scientific attempts to work out the age of the Earth, and his result of 20-400*my* was accepted as valid. It had already been realised that previously assumed values, of a few thousands of years only, were far too low, but the full extent of the Earth's age had not yet been guessed at.

After the discovery of radioactivity, it was realized that the radioactive decay of elements in rocks provided a way of working out their age. Many elements have forms, called radioactive isotopes, which are unstable, that is they break down to form other elements and give out radioactivity. For example, a uranium isotope may change slowly into lead.

Each radioactive isotope decays at a fixed rate, called its half-life (the time taken for half of all the original isotope atoms to change). This half-life may vary, for different isotopes, from many thousands of years down to a fraction of a second. Isotopes with long half-lives can be used to work out ages of rocks. This is done by analyzing the amount of a particular radioisotope in a mineral and the amount of the element it is changing into — the ratio and the half-life give the time since the original mineral was formed.

What this method showed, when applied to rocks, was that most of them were very much older than Kelvin's result suggested. Confirmation of this great age came from other results also, so the Earth was clearly too old for its internal heat to be 'left over' from when it was first formed.

The next suggestion for the origin of this heat again was connected to radioactivity. When radioisotopes decay, they give off heat — it is this heat which is used in nuclear power stations. All rocks contain a larger or smaller amount of radioactive material, and a currently suggested cause for the Earth's heat is that it stems from the decay of radioactive material within the crust, perhaps at depth.

There are problems with this theory. The main one is that the rocks which are richer in radioactive material are known to be concentrated in continental-type rocks, rather than oceanic ones. Upward heat flow does vary in different parts of the Earth, but not in a manner which has any relationship with content of radioactive materials. Another problem is that the content of radioactive material in the rocks is quite insufficient to produce the amount of heat actually recorded, especially since the evidence is that concentrations of radioactives, always relatively uncommon, are mostly confined to the topmost continental Sial layer of the Earth.

The Encyclopaedia Britannica article on the Earth's heat concludes that 'no satisfactory theory ... yet formulated explains the Earth's thermal constitution' [Britannica/ 6:26]. In summary, it appears that there is no convincing evidence that the core of the Earth is very hot.

> *Proposition 9F*
> *The core of the Earth is not especially hot*

Where then does the observable heat flow originate? We already have an answer — from domain movements. In this case, however, we probably need to include the deeper domains, down to a depth of around 100*km*. We will see later, in Chapter 16, that there are other possible contributions to this heat, but this is suggested as the main source.

> *Proposition 9G*
> *The principal source of the heat observed to flow from the depths of the Earth is friction from movement of domains, including deeper domains*

Is the Earth Made of Brown Sugar?

The Earth is not made of any sort of sugar. But in some respects we get a better intuitive picture of what is happening with the Earth if we regard it as made of a substance similar to sugar crystals, rather than of a baked-clay material as implied by the term 'plate'.

The hardness and physical strength of various rock materials are readily observed and measured, and so people have an intuitive feel for how a boulder or pebble will behave. There is a difficulty when this feeling is extended to something on quite a different scale, such as a mountain range. The behaviour of a microdomain is not the same as that of a boulder of the same material, scaled up in proportion.

An instance of this has already been looked at, in Rule 3 of Chapter 7, where it was noted that rotation of domains was not normally observed, say when one collided obliquely with another. What actually happens in such an impact is that the material at the point of impact just crumples up, like a mass of sugar crystals, rather than a whole 'plate' swinging about the point of first contact.

The sugar picture also gives a better feel for what happens with deeper domains and under-domains. If a surface domain is split apart by Earth expansion, its edges will be 'soft and crumbly' on the larger scale, and if sub-surface domains split, like sugar cubes embedded in a mass of crystals, the higher material will tumble down into the gaps.

Figure 9.2 is a representation of how surface and subsurface domains might be represented in a cross-section of the top 100*km* of the Earth's surface. If they are looked at as lumps and cubes of sugar in a sugar crystal matrix, this may give a better feel for the situation than one showing them as single rigid flat plates floating on a molten surface (the conventional picture). Another image might be that of a dry-stone wall, pieces of rock fitted together with only smaller rock fragments and no mortar in the gaps.

Another advantage of these pictures is that they make it easier to visualize the independent movement of domains and sub-domains at different levels. The old tectonic plate image only considers movement of one-layer massive plates of more or less uniform thickness, around 100*km*.

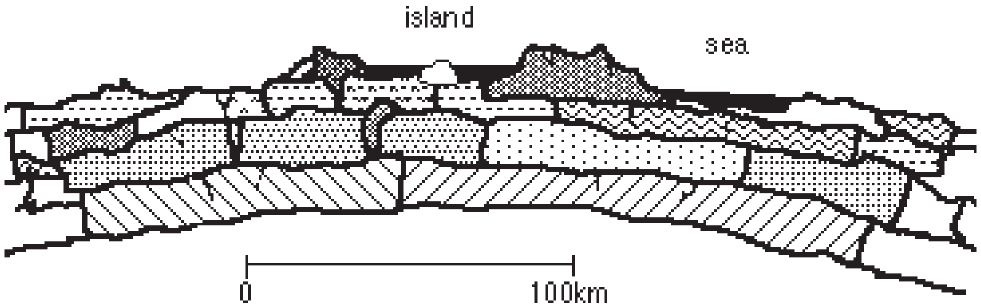

Fig. 9.2. A domainographic representation of the Earth's upper layers

Having looked inside the Earth, we now return to its surface, but this time we look not at the solid land, but at its rolling oceans.

CHAPTER 10

THE ROLLING OCEANS

"Earth, Ocean, Air — beloved brotherhood"
— Shelley: Alastor 1:1

The vast majestic oceans which cover so much of the Earth are intricately interlocked with the history of our planet. Accepted as the medium in which life itself began and evolved, and covering some 70% of the surface of the Earth, their 'unfathomable deeps' might seem as ponderous and unchanging as the most stable object in nature.

In fact the oceans have been subjected to the same sort of massive upheavals and tortured history as we have seen overtook the lands. In some ways the changes have been greater, as they have altered the very nature and composition of the seas.

The Extent of the Oceans

Only around 30% of the Earth's surface is land, and of this land probably a good deal less than 30% does not show clear signs of marine inundation of some sort in the past. So no more than 10%, and possibly very much less, of the current land surface has escaped a period under the waves.

The average depth of the oceans [Guinness, 1983] is around 3.5*km*, and the average height of the land above sealevel is only about 750*m*. The deepest spot in the oceans is believed to be the Marianas Trench, off the Philippines, with a depth of 11*km* (more than the highest mountain, at 9*km*).

How does this situation fit in with the aspect of Expanding-Earth domains, and in particular, what is known or believed in regard to changes in sealevel? This turns out to be a complex question, with a number of forces active, some in opposition and some together.

To clear the field a bit, it must first be reiterated that all measurements and deductions of where the sea reached on different pieces of terrain in the past, and former comparative sealevels in different parts of the world, are close to worthless. In the image of jostling, moving, and rising and falling domains and microdomains which we have arrived at (Fig. 9.2), the unqualified comparison of the present heights above sealevel of two distant points on the Earth is meaningless.

So also is a deduction that the sea has risen or fallen generally, working from the present position of a point in relation to local sealevel. As an example, a recent drilling programme for a gas production platform off the Northwest Shelf of Western Australia showed that seabed strata 125*m* below the seabottom (itself over 100*m* down) had been dry land in geologically recent times, and yet were sandwiched between strata believed deposited in water deeper than 100*m*.

The normal inference from this information would be that the sea had retreated at least 225*m* in the past at the time the dry-land formation was created. While this is quite possible, it is equally possible that that portion of the seabed was on a domain which had risen and fallen by this distance relative to a sea of unchanged level.

> *Proposition 10A*
> *Most observations and deductions on the position of sealevel relative to particular points on land today are meaningless when applied to general sealevels in the past*

This Proposition (or at least the reasoning behind it) is already accepted in detail, if not in large. Measurements and calculations are often produced and accepted which claim that Continent A is rising relative to Continent B by several millimetres each year, and so on. One millimetre per year is one metre in a thousand years, or 1*km/my*, so that a tiny change of this sort continued on for what is a short time by the standards we have been using — less than the existence of the human race — would be ample to sink all current landmasses beneath the sea and raise new ones.

And yet, maps are still being drawn for geological textbooks, showing the position of the sea in Carboniferous times, 300 million years ago!

Volume of the Sea and Earth Expansion

Whether on the conventional view or using the outlook explained in this book, it does, in reality, appear that land areas in the past were by and large the same bits of real estate as the land areas now. The domains involved may have sunk or risen relative to the local sealevels, or vice versa, but virtually all the deep ocean beds are less than 200*my* old. We have seen the reason for this — these seabed areas did not exist in any form on the pre-expanded Earth — but this still leaves us with a problem. Why wasn't the entire globe underwater in earlier times?

Assume that, at the beginning of Devonian times, 400*my* ago, the Earth had half its present radius. Its surface area would be a quarter of that now. If the water in the present oceans was spread uniformly over the present Earth, it would form a layer about 2.5*km* thick. On the Devonian Earth, the same water would be 10*km* thick. If the Earth had the similar landforms to now, except that all the present land areas were pushed together to cover a half-radius Earth, not even the tallest mountain would be above the surface.

The first life on land, both plant and animal, appears to have emerged around the Devonian, so real land areas clearly existed then. What is the explanation of this paradox?

The simple answer is that there was much less seawater on the Earth in Devonian times. This leaves with another problem, explaining where the 'new' water has come from, but that is another issue. For the moment we should accept this explanation.

> *Proposition 10B*
> *In earlier ages the Earth had a smaller total volume of water on its surface*

This is not to say that the total *land* area was any greater in those days, in fact the converse is probably true. Although life appeared in profusion some 600*my* ago, its earliest records date back 3500*my* — microbial lifeforms found in the rocks of northern Western Australia. Of course all these early forms of life were water-living creatures; it is only when we reach the comparatively short time of 400*my* ago that the first land creatures appear.

Why did it take so long? We have seen that lifeforms evolve really quite rapidly, with major changes occurring during a few million years. The vast majority of extant lifeforms, and their immediate and more distant ancestors, have all evolved during the Tertiary Era, the last 70*my*. Why was there no life on land till the Devonian, while 200*my* of intense evolution had just taken place in the sea?

The answer to this, I believe, is that land itself only appeared around the Devonian. Before this, the Earth had not expanded enough to expose more than perhaps a few peaks through the surface of whatever seas existed at that time.

> *Proposition 10C*
> *The first substantial land appeared above the sea around 400 million years ago*

The scenario is thus of an expanding but much smaller Earth, with less water distributed over its surface, but sufficient to cover irregularities in the surface almost completely until the highest of these were exposed in the Devonian — the Earth having already reached more than 90% of its present age.

This scenario is consistent with the fact that marine sedimentary rocks exist over so much of the present land.

Where Has the Water Come From?

To return to the matter of where so much of the present ocean water has come from, and to highlight a related point. Way back in Chapter 5, the suggestion was made (Proposition 5M) that in making pre-expanded Earth constructions, domain boundaries should be taken as the present sea-level boundaries, ignoring continental shelves.

This proposition still holds, and will be further supported by more evidence later, but it will now be clear that this proposition does *not* imply that domains with current sea-level boundaries had sea-level boundaries in those older periods. Nevertheless, there has been a very approximate preservation of land areas since the Devonian, implying some continuing source of new water since then to at least partly keeps the oceans 'topped up' as their basins expanded away under them.

The problem of explaining where the present ocean water came from is heightened by the fact that, as we shall see in the next chapter, the Earth has lost very considerable amounts of water into space.

The only credible source for this water would be one which tended to keep pace with the expansion process. I believe that this source derives from the expansion process itself.

The point is that Earth expansion continually exposes new rock to the surface, or at least takes it into the lithosphere where domain churning lets it be worked on. Although not obvious, it seems quite probable that this rock contained some water. The fact that volcanos give out steam, as well as other gases, is well known. In analysis of rocks, any water present is usually assumed to have come from groundwater, or from the sea in the case of seabed cores, and the water is often not taken into account as a rock component.

> *Proposition 10D*
> *Water is being added to the Earth's hydosphere from internal materials brought into the active domain zone by Earth expansion*

This proposition is a reasonable explanation of the position, since the volume of rock brought into play will be proportional to the new surface area created by expansion, thus releasing enough 'new' water to keep pace, partly at least, with the new ocean volume. Any other explanation unconnected with expansion — such as the Earth gathering hydrogen from interplanetary space during its passage, which is still a distinct possibility — would not have this important proportional feature.

Also, from the cosmological viewpont, hydrogen is the most common element in the universe, and oxygen is the most common element on Earth. Water is a compound of these two elements, and however the Earth was formed, it seems reasonable that a significant proportion of these two elements should exist right throughout the Earth's substance.

Is the amount of 'new' water generated enough to keep the oceans fully topped up? I suggest that it is not, and this causes a continuing small fall in average sealevels, with the result that the total land area of the Earth is increasing. Let us try and put some figures to this.

The Level of the Seas

For the moment we will only be concerned with long-term change in sealevel which stem from Earth expansion, and will not think about short-term or local effects due to ice ages, Greenhouse effects, or domain jostling.

According to the latest figures [Carey, 1988], the current rate of increase of the Earth's radius is around 3*cm/yr*. If there was no 'new' water coming in from below, we would expect the average sealevel to be dropping because of this each year.

The actual amount is quite hard to calculate (it needs to make assumptions on the average rate of slope of the solid surface over all the Earth's seashores and seabeds, and the places where the actual expansion shows up), but it looks to work out at only around one-thousandth of a centimetre per year (I am open to correction on this). This is equivalent to a drop of 1 metre in 100,000 years, or 10*m/my*, and clearly can have no short-term effect.

Even so, on the longer term this figure looks to be of the right order. The drop in sealevel since the Devonian, 400*my* ago, would be 4000*m* or 4*km* — about half the 7.5*km* difference between the current 2.5*km* thick layer and the 10*km* layer which would have existed if the same water had been present on a half-radius Earth.

> *Proposition 10E*
> *The average annual fall in mean world sealevel as a result of Earth expansion is of the order of one hudredth of a millimetre per year*

In the next chapter, evidence will be brought forward supporting the suggestion that Earth has also lost a huge amount of water into space. As a very approximate first stab, let us assume that the other half of the 7.5*km* drop in sealevel is due to this mechanism, which thus produces a similar rate of fall.

> *Proposition 10F*
> *The average annual fall in mean world sealevel as a result of loss of water to space is also of the order of a hundredth of a millimetre per year*

Both these figures are admittedly open to considerable adjustment and correction from a more detailed approach to the calculations involved — since all the mechanisms involved have only now been put forward in a broad context, with even the existence of such figures perhaps suggested for the first time, it is a bit rash to put numbers to them. Where angels fear to tread ....?

Early Man and Shorter-term Sealevel Changes

It is currently believed that the earliest creatures which might be regarded as the direct ancestors of modern man existed some five million years ago. These were not men in the modern sense, but were a distinct branch of the higher primates — about as different from the other apes as chimpanzees are from gorillas.

True men have probably existed for much less than a million years, with the beginnings of civilization no more than 20,000 years in the past. Our knowledge of the evolution of man is sparse — only relatively isolated remains have been found, really quite a small number of 'missing links' between the apes and man.

Against this 5*my* background, perhaps the most important physical events have been the Ice Ages. These were times when the polar icecaps apparently covered much larger areas than now (however, see proposition 7H), and there were a number of cycles of advancement and retreat. The oldest was around 110,000 years ago. The most recent was only about 10,000 years ago (we may be in the middle of a cycle now), so the Times of Ice were well known to man, perhaps even civilized man.

These Ice Ages are claimed to have had huge effects on sealevels, at times amounting to hundreds of metres, through the locking-up of water in the great icecaps. As an example, evidence has been put forward for the existence of a huge freshwater lake, dubbed Lake Carpentaria, in what is now the Gulf of Carpentaria [Fig. 10.1]. The lake existed between 26,000 and 10,000 years ago, caused by a drop in sealevel due to polar ice accumulation of 150*m* [Ford, 1985].

One item of supporting evidence is that the same species of freshwater frogs and turtles exist both in the Arnhem Land area of the Northern Territory and in Papua New Guinea and West Irian to the north. These are presumed to have dispersed through the lake.

The Aquatic Ape and the Missing Link

Marked falls in sealevel in the period of man's evolution have an interesting implication.

In 1982 Elaine Morgan published a book, 'The Aquatic Ape', containing a great deal of persuasive evidence suggesting that man had been through a partly aquatic phase in his evolution. This book was based on a proposition put forward by the British marine biologist, Sir Alister Hardy, in 1962. It is not possible to summarize a whole book in a couple of paragraphs here, but the evidence seems undeniable that man differs fundamentally from the other higher primates in ways which suggest a much higher degree of linkage to a water-dependent existence.

Physically, humans are notable for such things as hairlessness, deposits of fat under the skin, prominent mammaries in the female, 'flow lines' in remaining hair deposits, and tendency to webbing between the toes (up to 7% of the population). All these are features which are common to aquatic mammals but are completely lacking in the other land apes.

Psychologically, the love of mankind for water (swimming, sailing, and surfing are regarded as very pleasurable by many) and the tendency for towns and cities to be built on the edge of water are well known, again in contrast to the other apes, which generally have a strong dislike of water.

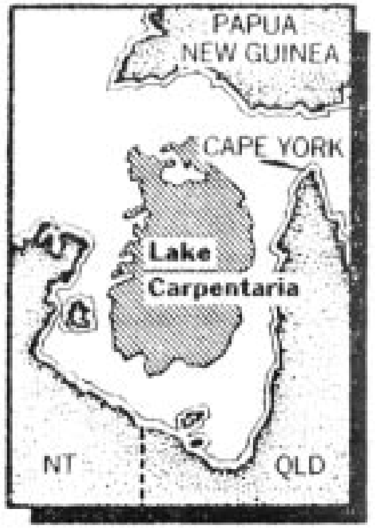

Fig. 10.1. Former 'Lake Carpentaria' between Australia and New Guinea

On the other hand, some non-primate mammals such as elephants and pigs possess many of these 'aquatic' features and are also believed to have had an aquatic phase in their evolution. Both are strong swimmers, elephants having been known to swim distances as far as 500*km* in the sea, of their own volition. It is not suggested that man was ever a completely water-adapted mammal, like the whale, only that during his evolution at least part of the race became adapted to very regular use of water and so brought in these 'aquatic' genes.

Here then is a possible explanation for the comparative dearth of hard fossil evidence of man's evolution. If much of this evolution took place in the shallow waters, or at least on the sea's edge, and water levels have since risen generally, they would conceal much of this fossil evidence.

> *Proposition 10G*
> *Most of man's evolution took place in a semi-aquatic environment, and rising sealevels have concealed most of the fossil evidence for this evolution*

Of course it is possible to try and verify this proposition. It seems highly likely that human evolution was especially active around the African and Asian shores of the Indian Ocean. It should be possible to select likely sites for underwater archaeology — the Red Sea and areas near river mouths in East Africa are possibilities — to try and recover such remains.

There is a further implication. Back in Chapter 6, I noted the apparent close genetic links beween the Pygmies of Africa and the Negrito people of the Philippines, and pointed out that the elapsed time was insufficient for these two groups to have evolved together and been later separated by Earth expansion. In Proposition 6D of the same chapter I suggested that the isocons for marine seashore creatures were thin and long — creatures could spread rapidly along the shores, but not over them into the land or the sea depths.

Putting these two together we have the possibility that early man lived mostly in the long, thin shallow-marine isocons and not in the squarer land isocons of most land animals. This does provide some sort of explanation for the Pygmy-Negrito puzzle.

The 'Land Bridges' of the Past

The short-term tying-up of large amounts of water in polar ice caps must inevitably lead to falls in average sealevels. But we know that this is not the only mechanism affecting sealevels, nor will sealevel changes necessarily be uniform over the whole globe.

There has been a tendency to find evidence that two areas of land now separated by sea were once linked, and assume that this was through a 'land bridge' between them. This then leads to the assumption that the sea had retreated generally, enough to expose the seabed to at least the depth needed to form a continuous land link, and the depths needed have sometimes been very large. Even between Rottnest and the mainland, this reasoning has been used to suggest that the sea must have receded the 24*m* needed to expose a land bridge between these points in the comparatively recent past.

We can see now that this reasoning may be defective in two ways. Firstly, two currently separated domains may have been moved apart by normal domain movement, so that there was never an actual 'land bridge' between them which has since been inundated. Secondly, specific relative movements of sealevel may have been purely local phenomena due to domain shuffling, rather than general movements of sealevel.

> *Proposition 10H*
> *Geological and biological evidence explained in the past by hypothesized land bridges may be more readily explicable through domain movements*

Again this is a proposition where the implications are already accepted in detail, if not in large. Relative rises and falls of two continents of the order of 1*cm/yr* have been calculated and accepted generally in the past. This is equivalent to a change of 1 metre in 100 years or 1*km* in 100,000 years, the period of active modern human evolution. Changes of this order through domain movements can clearly explain many observed variations in apparent sea-level.

The Salty Sea

Of the more than 200 islands larger than 10*ha* which lie off the coast of Western Australia, Rottnest is unique in possessing a salt-lake complex [Saunders, 1985]. In fact the salt-lake system dominates the eastern half of the island, and in total occupies 229*ha*, more than 10%