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Genesis and Geophysics

The beginning of the book of Genesis is one of the most awe-inspiring and influential of all writings. Alone among ancient myths of creation it can still be read with profit, after the lapse of thousands of years. All other creation myths of antiquity are bedevilled by fighting gods, 'vulgar, spiteful and cantankerous, perverse and cruel—all as men made them, after the likeness of their own weak and erring flesh'. They tell of the jealous love-making of the gods and of bloody triumphs on a cosmic field of battle, while man himself is enmeshed in a tangled web of fetishism and sorcery.

In Genesis all is different. God is at the centre: nature itself is God's creation and it is good. God has no serious rivals while man, made for fellowship with a companionable and loving Creator, has his destiny placed safely in his Creator's hands. As a result, the book of Genesis has taken possession of the minds of men. It has evoked beauty, truth and wit, but also folly and fanaticism. It has been instrumental in moulding language, literature and civilization.[1]

Yet how far is the Genesis story true? Does it accord with the findings of science? There are, of course, those who would argue that science—not by any means always right—cannot be used to interpret the Bible: to check the truth of what God has said by a merely human yardstick is presumptious folly.

Many will feel sympathy for this view, yet it is two-edged. If the scientist is often wrong, so is the biblical interpreter, as history shows all too clearly. As knowledge of the ancient world increases, scholars learn more about the meanings of words and of the canons of interpretation. The older doctrine that there are two books of God—the Bible and nature—has much to commend it.

The early earth and science

Earth scientists are slowly building up a picture of what our planet must have been like in its early days. Although the origin and very early development are ill-understood, it is generally believed that it

1. Solomon Goldman, *In the Beginning*, 1949.

was slowly built up by accretion of debris in space, as it travelled round the sun. This debris may have been thrown out by a nova (exploding star) at some earlier stage and certainly much of it was radioactive. According to this view, the earth was not at first hot; however, there seems no doubt that at some stage, whether very early as was once supposed, or later, as the result of gradual heating due to radioactivity, it became very hot indeed: the crust at least was molten. Molten rocks dissolve water, which is forced out as they cool and this, it is believed, is the origin of much of the water in the oceans.

Water

But at first there was no sea, only very hot steam above the so-called *critical temperature* (374°C for water), where there is no difference in density between hot liquid and hot steam or vapour. When the molten rocks forming the earth's crust began to solidify at the surface and the steam to cool somewhat, then rather suddenly a water surface must have formed—for this is what happens with all liquids if they are heated above their critical temperature (when they cannot be condensed) and then cooled.

As condensation begins, a fog appears because the liquid droplets weigh very little more than the vapour, so that they fall slowly and do not readily coalesce. In the early earth, when once the water had separated in this way, its density would have been little greater than that of the steam above its surface. We may be sure, then, that even small disturbances raised enormous waves. Not only was there wind, caused by the sun's heat at the top of the atmosphere, but the outgassing of the gases dissolved in the cooling crust must have disturbed the ocean to an almost unbelievable degree. Everywhere the seas were in turmoil, covered with ever-moving mountainous waves.

The situation for the cooling earth is even more complicated! Cooling takes place only from the top of the atmosphere, the lower part being kept heated by the hot rocks below. This being so, the lower layers would have remained above the critical temperature much longer than those higher up. Under such conditions, we should expect liquid to form first of all quite high up in the atmosphere, and for a time this liquid would have floated on the much more highly compressed, and so heavier, steam below. It is difficult to imagine the scene of chaotic violence which must have ensued—not only at the upper surface, but at the lower surface of the pristine sea as well! Only when the surface of the solidified crust of the earth reached the critical temperature of steam was it possible for the ocean to come down from the sky!

Light

For a long time, the newly forming ocean was enshrined in the blackest night. While the bulk of the water of the oceans was still in vaporous form no ray of light could have penetrated the dense clouds, to lighten the sea below, for water, whether as liquid or its equivalent in steam, does not allow light to penetrate far. Today, in clear water it is almost dark a few hundred feet down, and at first much more water must have been in the atmosphere than the equivalent of this in its liquid form.

An interesting point arises in connection with electric discharges. Water, especially at high temperature, is a fairly good conductor of electricity. It would be impossible for high voltages to develop in steam at a high pressure, so that corona discharges and lightning flashes would not occur. Only at a later stage, when the atmosphere consisted mainly of gases other than water vapour, would such discharges be possible. We may be fairly sure that at a very early stage, when the ocean had only partly condensed, it would be in darkness.

Gradually, very gradually, the surface of the sea rose as more and more steam condensed, and yet more came welling up out of the rocks below. It is possible, too, that comets colliding with the earth added a substantial amount of water.[2]

All this time we may be confident that violent discharges of electricity were common. Boiling water separates electrical charges: older books describe how electrical machines can be made by the boiling or fine spraying of water. In the thick darkness of the early days, the light would not have penetrated far, but soon a diffuse, intermittent light, like continuous sheet lightning, would have been present everywhere. The darkness had gone and there was light. But there were still thick vapours: the light of the sun had not yet penetrated to the surface of the earth.

Eventually, as steam condensed and the ocean cooled, electrical discharges declined and the light of the sun began to penetrate the thick layer of cloud. For the first time, day and night were distinguishable, perhaps as they are today in cloudy weather, although the sun remains hidden by day and the moon by night.

In the early stages of the condensation, the surface of the ocean must have been covered with a fine spray, as ever-new droplets of water condensed and fell slowly into the waters below. But at some point, while the sea was still hot, this stage of affairs must have ceased

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2. Christopher Chyba, *Nature*, 1988, **330**, 632.

when the bulk of the oceans had condensed, and the temperature was well below the critical temperature, the cloud layer would have begun to rise in the air. From henceforth there was clear, moist air between the surface of the water and the clouds above, from which fell rain as at the present time.

Again, it is widely believed by scientists that the moon was not originally a satellite of the earth, but was captured from outer space. If so, the ocean tides raised by the event may have risen to a height of miles, as the moon settled into its new orbit.[3]

It has been recognized for some time that in the early days the earth must have been covered completely by ocean, before the continents (Gondwanaland and Eurasia) appeared. It was earlier supposed that the world-wide ocean persisted for perhaps 1000 myr. A more detailed study suggests that this state of affairs may have lasted a good deal longer.[4]

Land

Meanwhile, what was happening beneath the waters? After the earth's crustal rocks, to a considerable depth, had melted, they separated into a lighter layer about 12 km thick—called sial—of which continents are made, and a heavier, lower layer of basalt. As the earth cooled at its surface, the upper layer began to solidify from the top downwards, so that the crust gradually increased in thickness. At first the crust, still hot and thin, was extremely brittle. Below, as cooling continued, the still hot sial and basalt gave rise to great numbers of volcanic eruptions as gases were discharged into the atmosphere. Basalt, which remains liquid longer than sial, was often forced up into fissures and found its way to the surface, as happens with present day volcanoes.

We can well imagine what happened when the upper (sial) crust had completely solidified (the temperature at the bottom would then have been about 750°C) with molten basalt forced up through the cracking crust in great quantities, solidifying under the sea in the form of mountains. The thin crust of sial could not support the weight so, as a mountain grew larger, the further it descended into the liquid basalt. When the sea had condensed, its depth was about 2.5 km, but for a mountain to break the surface it is calculated that it would have had to be about 15 km in height.

Over a large fraction of its life—perhaps up to as late as 1000 myr

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3. D. E. Turcotte et al., *Nature*, 1974, **251**, 124.
4. P. M. Hurley & J. R. Rand, *Science*, 1969, **164**, 1229.

ago—the earth was entirely covered with ocean. Not until sufficient magma had solidified, was the crust able to take the weight of land masses. Probably a single, large continent—Gondwanaland—came into being at first.[5]

The early ocean was hot and for a long time afterwards it must have remained warmer than it is today. In recent years a natural thermometer has been found, which leaves a record of sea temperatures in ancient times. By reason of the many substances extracted by both hot water and steam from ancient rocks, whether solid or molten, the sea is a complex chemical mixture. Through the ages its cooling waters have deposited many chemical substances, which geologists study today. One of these is silica which, in a form known as chert, consists of minute crystals covered with hydroxy groups, -OH. They are very firmly attached and even the hydrogen atoms are not displaced by 'heavy' hydrogen (deuterium) when the ore is boiled with heavy water (deuterium oxide, D_2O). When the crystals are heated to a high temperature, however, the hydroxy groups link up together and water is removed:

$$\text{—crystal-OH} + \text{HO-crystal—} \rightarrow \text{—crystal-O-crystal—} + H_2O$$

This water can be studied.

A small proportion of the hydrogen atoms in sea water, like all water found on earth, is present as deuterium atoms. Likewise, a small proportion of the oxygen present is heavy oxygen (O–18 instead of the more common O–16). It is found that, when silica crystallizes from sea water, the ratios of heavy to ordinary hydrogen and of heavy to ordinary oxygen atoms depend on the temperature at which crystallization takes place. In this way, by dating the minerals and fossils mixed with the cherts, it has proved possible to measure the temperature of the sea at different geological ages. Results confirm the view that, despite minor variations with ice ages, the sea was fairly hot in pre-Cambrian times (2 billion years ago). No fossils are found when the temperature was higher than about 50°C. In the early pre-Cambrian (3 billion years ago) it seems to have been about 70°C. Above that temperature cherts probably did not form.[6] For comparison, the average temperature today is 13–15°C.

Even with the low temperature prevailing today, about half the earth is covered with cloud, on average. The vapour pressure of

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5. R. B. Hargreaves, *Science*, 1976, **193**, 363.
6. L. P. Knauth & S. Epstein, *Geochimica et Cosmochimica Acta*, 1976, **40**, 1095.

water rises rapidly with temperature and the earth would not have to be warmed much for the cloud cover to be virtually complete. Geologically speaking, the appearance of sun, moon and stars through pockets of cloud-free areas in the atmosphere is probably quite recent. Since the formation of a continental land mass must have been associated with violent volcanic activity, it is not unlikely that the appearance of the heavenly bodies was delayed to a later stage.

Summary

We have seen how the early development of the earth was conditioned by the ordinary laws of nature. The earth, it is believed, like the other planets in the solar system, was formed from colliding pieces of rock—the so-called planetesimals. As the proto-planet grew in size, gravity became increasingly important. Growth of the earth ceased only when the earth and her sister planets had swept their orbits clear of debris.

It is not known how long it took for the earth to reach its present size. If this happened rapidly—say, within a few thousand years—the energy lost by the planetesimals when scooped up might have been sufficient to keep the earth in a molten state. If the falls were less frequent, the earth may have remained fairly cold for a time, but later it would have heated up and melted, for radioactive energy was intense at that time. As they cooled and solidified, the rocks gave up vast quantities of water vapour, together with nitrogen and carbon dioxide (and, some would add, methane). Although volcanoes liberate these gases today, it is believed that a sizeable fraction of the water of the sea was liberated at a very early stage in earth's history.

By taking note of what happens in laboratory experiments with rocks and steam etc. under pressure, scientists can gain a good idea of what was likely to have happened in the early stages of the earth and, to a considerable extent at least, find their expectations realized when working backwards in time from the present state of the earth. The facts that the earth was once much hotter than it is today and that it was once covered with oceans are, for instance, confirmed by isotopic ratios in rocks and by the measurable recession of the moon.

In broad outline these are the findings of scientists over recent decades. It is fascinating to compare these findings with what we are told in Genesis about the early history of the earth.

The Genesis account

How far is the Genesis story true? This will depend on how we interpret Genesis; this is the subject of a separate paper. Meanwhile it seems reasonable to assume that the Genesis account is concerned with appearances—with phenomena—rather than with their scientific interpretation. Thus, the fact that day and night are mentioned before the sun was 'made', makes sense only if phenomena are in focus: it refers to what an imaginary observer on earth might have seen, for day and night do not depend on the visibility of the sun. Moreover, as Clerk Maxwell pointed out, 'both light and darkness imply a being who can see if there is light but not if it is dark'.[7]

Keeping firmly in mind that the Genesis account of the early earth is written as the record of an imaginary eye witness, it is remarkable that the biblical and scientific descriptions run closely parallel.

At first 'the earth was formless' (Gen. 1:2)—a chaotic mass of broken rocks. An ocean covering the entire planet formed early 'and darkness was upon the face of the deep'. Here, the book of Job (38:8, 9) gives further detail—'the sea . . . burst forth from the womb when I made clouds its garment, and thick darkness its swaddling band'.

Next we are told that the 'spirit' or 'wind' of God moved 'over the face of the waters'. The expression 'of God' in the OT usually means 'mighty'[8,9,10] and commentators, some writing many centuries ago (with no modern scientific axe to grind!), have often translated 'a mighty wind [that] swept over the face of the waters' (NEB). A huge commotion of the sea is clearly indicated.

'God said, "Let there be light" and there was light.' (Gen. 1:3). Light which is independent of the day and night (which follow later) again fits the scientific picture. Next, God separated the light from the darkness: again there is agreement. With the penetration of the sun's light and heat, the mists lift from the ocean and clear air—the 'firmament' through which birds fly at a later stage (1:20)—separates the waters below from the waters (clouds) above. Once more the interpretation is very odd and in no way concocted to make the passage fit with science.

'Let the waters under the heavens be gathered into one place, and let the dry land appear' (Day 3, Gen. 1:9–10) is given as the next event. In accordance with geophysics once again, this happens before the appearance of the heavenly luminaries on Day 4 (Gen. 1:14–18). This could happen only when Earth's cloud cover fell below 100 per cent.

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7. Lewis Campbell & William Garnett, Letter to Bp. C. J. Ellicot, p. 394 in *Life of James Clerk Maxwell*, 1882.
8. J. M. P. Smith, *Old Testament Essays*, 1927, p. 166f.
9. F. F. Bruce, Question 1729, *Horizon*, Sep. 5, 1970.
10. Gerhard von Rad, *Genesis: A Commentary*, 1972, (SCM, Eng. Trans.).

When once sufficient oxygen had collected in the earth's atmosphere, life became possible in the sea and geologists are agreed that animals of the sea preceded those of the land—which is once again the order given in Genesis. But from a scientific point of view it is not possible to say whether advanced marine life began to appear before or after the clearing of the clouds. In any case, there is no reason for thinking that the order given in Genesis is incorrect.

In view of this remarkable agreement, it is difficult to think that early Genesis can be dismissed as mythical. It can of course be objected that these events, as scientists picture them, took place over long epochs of time, whereas Genesis might give the impression that the entire physical creation took a mere four days. But the passage can hardly mean this. Nowhere is it said that God created *on* the specific days which are mentioned; only that 'there was evening and there was morning, one day' etc. That creation did not take place in six literal days of 24 hours seems obvious from the fact that the days are mentioned before the appearance of the sun and moon.

Again, if plant life had not had time to spread abroad, which could hardly have happened in a matter of hours, there would have been no food for animals and man when these were created on Day 6. Similarly, if sun, moon and stars were created on Day 4, why is it said that the heavens were created on Day 1? If the heavens contained no sun, moon or stars, what else was there to create?

There is no need, however, to suppose, as did St. Augustine, that the 'days' stand for millions of years. A widely held view is that they stand for literal days of revelation.[11] Later references to the creation in connection with the Sabbath day strongly suggest this view. 'In six days the Lord made (or 'did', 'revealed', 'shewed', etc—the word is translatable in nearly a hundred ways) heaven and earth and on the seventh day he rested and refreshed himself' (in older versions 'was refreshed') (Ex. 31:17). It seems clear that a theophany is in view. The Lord appeared in human form, perhaps to Adam (if we take Adam literally) in the Garden of Eden. He worked day by day to explain how the world had been created in ages past, and after six days he rested and refreshed himself. God himself had no need of rest but he rested for man's sake: for as Jesus taught, the Sabbath was made for man. Adam, then, was taught by example. This lesson would hardly have sunk home if Adam appeared freshly created on the sixth literal day, having seen nothing of what had transpired!

11. D. J. Wiseman (Ed), *Clues to Creation in Genesis*, 1977, (Reprint of *New Discoveries in Babylonia About Genesis* (1936) and *Creation Revealed in Six Days* (1948), by P. J. Wiseman).

Conclusion

Such then is a comparison between Genesis and the views of today, and the question arises as to how the agreement we see could possibly have come about. Without a fairly up-to-date knowledge of science it does not seem at all obvious why the dry land and sea should not have existed from the very beginning—or at least since there was any water on the earth. After all, continents are much higher than the ocean basins and as water condensed it would surely have flowed at once into the latter. Then again, what is the meaning of the statement that there was a vast commotion on the surface of the deep? Why should the sea have been much rougher than it is at present? The writer can hardly have been in a position to study the critical properties of liquids or the moon's origin!

Why, again, was the early ocean in darkness, and why should there not have been a firmament, or clear sky, from the very beginning of the time when the oceans began to condense? Then, too, it is hard to see why an ancient writer, using his commonsense, should necessarily put light with day and night before the appearance of the sun. Had he indeed an inkling that the world was once covered with vapour, having been very hot, and that the vapours would at first obscure the sun? And how did he guess that the clear sky would come once light from the sun had appeared on the earth? Surely these points would not be at all obvious to one who shared the ignorance of physical principles possessed by the ancients. Furthermore, why did the writer of Genesis place the plants after the light but before the actual appearance of the sun and moon? (Direct sunlight is not necessary for photosynthesis to take place.) And why did he introduce plants before animals, seeing that he could have had no inkling of the fact that the plants supplied the oxygen of the atmosphere, which was necessary for other forms of life?

There are many points here which seem to defy any kind of explanation in terms of coincidence or guesswork. But is there any other way of regarding them? As the facts stand they strongly support the traditional view of Genesis, which has been so widely abandoned in the light of modern biblical criticism. According to the traditional view, the facts should be exactly as we have found them to be, but if the passage consisted of mere tradition or guesswork by an ignorant ancient writer, the events described should bear no obvious relationship with the results of scientific enquiry.

It is difficult to see how any more direct test of the traditional view of the Bible could be made, and the fact that this view has been more than ever substantiated is not one which ought to be quietly ignored.

Is it possible that, even if the human element did enter at times into the Hebrew scriptures, their writers may yet have had a source of information not available to us at the present time—a source which we wholly fail to understand? That at any rate seems to be the natural conclusion to be drawn from the facts we have been considering.