A Crack in the Edge of the World

The Great American Earthquake of 1906

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Prologue

The created World is but a small parenthesis in Eternity.

Sir Thomas Browne, 1716

O wad some Pow'r the giftie gie us
To see oursels as others see us!

Robert Burns, *c.* 1785

1 *The Well-illumined Earth*

Some while ago, when I was half-idly browsing my way around the internet, I stumbled across the home page of an obscure small town in western Ohio with the arresting name of Wapakoneta. It rang a distant bell. Once, very much longer ago, I had passed by the town on what I seem to recall was a driving expedition from Detroit down to Nashville. But, so far as I remember, I didn't stop there, not even for a cup of coffee. It only struck me at the time as being a rather attractive name for a town – a name that was (I subsequently read) a settler adaptation from a word in the language of the local Shawnee Indians.

The town these days is nothing too exciting – which is what one might expect of a place that lies just off that part of the Eisenhower Interstate Highway System known as the I-75, not very far from the rather better-known and quintessentially Mid-western Ohio city of Lima. It has some 10,000 inhabitants, and the way that it was built and ordered and settled a century or so ago makes it very similar to uncountable other cities found between the bookends of the Rocky Mountains and the Appalachians.

It is, in other words, a classic example of the modern Middle American community. A place that Sinclair Lewis would have favoured. A place of unexceptional ordinariness, known locally for the making of light machinery, car parts and rubberware, and surrounded by large and generally family-owned farms where soybeans and corn are grown and where the animals Americans call hogs are raised. Reading between the lines, one can perhaps detect the faintest tone of fretfulness: a concern for the town's future, born of such newfangled developments as the spread of manufacturing to Mexico, the outsourcing to Asia of much of the service economy and the drumbeat growth of China. No doubt wishing to encourage new businesses, the Chamber of Commerce makes a claim for Wapakoneta that is shared with many other towns similarly unburdened with excessive splendour: that by virtue of its strategically important location, with all the roads and railway lines that run near by, it is something called 'a transportation hub'.

It is a town with a past built on the solid bedrock of America's previous success, a present that clings by its fingernails to its own notion of stability, and yet a future in which the old Ohio bedrock seems not quite as firm as had initially been supposed, one that most people in consequence care not to ponder too closely.

However, those who expect Wapakoneta to be only blandly Middle American, and perhaps little unadventurous and dull, might be surprised to find another side to its history. The astronaut Neil Armstrong, born in the town in 1930, went to the local high school and, quite rightly, no one will let you forget it. (Only two other luminaries of the town are thought worthy of mention, and both are by contrast memorably forgettable: one a heavily moustachioed hero of the Civil War who fought at Vicksburg, the other the screenwriter of *The Bells of St Mary's*, who also happened to have invented a device allowing naval vessels to lift mines harmlessly from the seabed.)

The town's website is where all this is so serendipitously revealed. It opens with a scratchy sound recording of an unnamed baritone reading a launch-pad countdown. He follows this with the announcement of the *liftoff*, in July 1969, of the Apollo 11 spacecraft, a ship that is destined, he says gravely, *for the moon.* And while his voice is intoning on what turns out to be an original NASA recording, an image of the moon swirls and grows steadily bigger on the screen – until it is eventually replaced, with a booster's flourish, by an image of a bustling community and, in bold, the name of the town: Wapakoneta.

It is fitting that this small town should celebrate so eagerly the exploration of space: the worldwide excitement over the samples of lunar rock brought back to earth is just one small indication of the value, in real scientific terms, of America's having sent up a man to get it. But there was an unanticipated and less obvious consequence of the expedition, the effect of which has been, in many ways, rather more enduring.

For it appears now that one field of scientific discovery was changed for ever by the journeyings of Neil Armstrong and all those others who have gone to the moon in the years since. This sea change has come about specifically in the science of geology, and it is a change that has its origins in a very simple fact: when Wapakoneta's first citizen was teetering gingerly about up there on the moon, he was able to do something that had never been done before, and that provided science with a profound, paradigm-shifting moment of unforgettable symbolism: he was able to stand on the lunar surface and *look back at the earth.*

To be sure, earlier astronauts who had gone into orbit in the years beforehand were also able to see the totality of the planet; but there was something wholly remarkable in being able to stand upright on one world and gaze back at another, more than 200,000 miles away.

The great American biologist and philosopher Lewis Thomas wrote in 1974 of the symbolic importance of mankind having this new perspective:

Viewed from the distance of the moon, the astonishing thing about the earth, catching the breath, is that it is alive. The photographs show the dry, pounded surface of the moon in the foreground, dry as an old bone. Aloft, floating free beneath the moist, gleaming, membrane of bright blue sky, is the rising earth, the only exuberant thing in this part of the cosmos. If you could look long enough, you would see the swirling of the great drifts of white cloud, covering and uncovering the half-hidden masses of land. If you had been looking for a very long, geologic time, you could have seen the continents themselves in motion, drifting apart on their crustal plates, held afloat by the fire beneath. It has the organized, self-contained look of a live creature, full of information, marvelously skilled in handling the sun.

Five years later a British chemist and environmentalist named James Lovelock, thinking along much these same lines, used the moon-view of the earth to advance a long-considered idea, which he called the Gaia Hypothesis. The idea – which he christened with the Ancient Greeks' name for the earth goddess, Gaia or Ge, and which has been rechristened as the even more plausible-sounding Gaia Theory, now that his supporters believe so much of it has been proven holds that the earth in its totality is very much a living entity. It is alive, it is fragile, and everything that is in it preserves a complex balance with everything else in a state of mutually beneficial equilibrium. It so happens, to the dismay of many present-day scientific philosophers, that mankind's current disharmonious behaviour is affecting this careful balance; there is a growing feeling that it must be changed, radically and soon, if life on earth is to continue and to flourish.

This is not an environmental book, by any means. It is, more simply, the story of one remarkable and tragic event that befell California a century ago, when a 300-mile-long swathe of the earth briefly shifted, and wrecked the cities that lay atop it. But, though it is not intended to be a Gaia book, it seems right to tell the story of the events that so ruined the city of San Francisco in 1906 within the *context* of the Gaia idea. There is, for a start, an interesting synchronicity at work: at the moment when Thomas and Lovelock were putting forward their ideas (in the late 1960s, at the same time as the beginning of space travel and, in part, because of it, of course), the geological sciences were also changing very profoundly, as we shall see.

Neil Armstrong was able to gaze across the quarter of a million miles that separate these two small planetary bodies and look directly towards that area of America from which he had come, at the hills and valleys of the selfsame rocks where he had grown up – rocks that established geology and the fossil record tell us belong to the Silurian Age. And I have no doubt that it was in large measure because of this most extraordinary vision – extraordinary both for Neil Armstrong and, in time, for the rest of us too – that the birth was signalled of what is now coming to be regarded as an entirely new science. It was a science that was born and then helped to its feet quite simply by virtue of this new perspective that Neil Armstrong's view, even though it had been long anticipated by those who sent him and his colleagues into space, would shed on our planet.

What he saw – and what we saw through his eyes, which we now perhaps take somewhat for granted – was a thing of incredible and fragile beauty. It was a floating near-spherical body, tricked out in deep blue and pale green, with the white of polar ice and mountain summits, with great grey swirls and sheets of clouds and storms, and with the terminator line dividing darkness and light seeming to sweep slowly across the planet's face as it turned into and out of the sun. It was a lovely aspect to contemplate. And it was a view that in time compelled mankind *to take stock*.

To see ourselves as other see us, as Robert Burns had written. Here, and now, all of sudden, we realized that we could do just that – and, with this unanticipated ability to do so, something about us suddenly changed. Almost overnight, and essentially because of this new world view to which we had access, we discovered a whole raft of new reasons to ponder on the oldest of age-old questions: on just where we stood in the celestial scheme of things, on what the universe and its creation might mean, and on how the very earth itself may have first come into being. And such ruminations led, in short order, to the makings of the scientific revolution – and, most specifically, to the geological revolution – that is central to this story.

2 A Born-again Science

Like alchemy and the medicine of the leech and the bleeding-rod, the Old Geology is a science born long ago (most formally in the eighteenth century), one that, unlike so many of its sister sciences – chemistry, physics, medicine and astronomy – never truly left the era of its making. Since its beginnings geology was a field mired in some alluvial quagmire, defined by dusty cases of fossils, barely comprehensible diagrams of crystals and the different kinds of breaks that were made in the earth's surface (as well as by unlovely Teutonic words like *graben*, *gabbro* and *greywacke*), and explained with cracked-varnish wall roller-charts showing how the world may or may not have looked at the time of the Permian Period. To me it remains the most lyrical and romantic of the sciences; but in terms of glamour, and when compared to astrophysics or molecular biology, the Old Geology is somewhat wanting.

The New Geology is, on the other hand, a creature fashioned wholly from the science of the space age, from the attitude that was born when Neil Armstrong first looked back and gazed at the earth. It is a science that now presents us with an entire canon of new ways in which we might look at this planet and at our stellar and solar neighbours.

It seems to me quite fair and proper that the principles of this new science should underpin everything that follows: the terrifying and extraordinary event that enfolded the small but fast-growing Western American city of San Francisco one twilit California morning in the middle of April 1906.

Many other scientific disciplines that are revolutionary and dauntingly modern – cosmology, genetic engineering, quantum mechanics – have been formed or founded in recent years, and had no past to hold them back. But geology is different. It is a very old science indeed and hugely proud of its origins: portraits of the bearded ancients of its founding priesthood invariably hang in esteemed positions in departments from Anchorage to Adelaide.

Its antiquity, however, has long been a problem for it, one that has tended to inhibit too many of its practitioners from escaping the glutinous hold of its earliest ideas. Students who remember measuring the umbos of brachiopods or trying to fathom the mysteries of recumbent folding can reach through the centuries and join hands with students who were taught the same topics at the time of George IV and President John Adams. It was only when the professors happened to mention in more modern classes such wonders as the K–T boundary event, with the massive dinosaur extinctions that were mysteriously triggered at the end of the Cretaceous Period (perhaps by a monstrous collision with an immense asteroid), that taught geology seemed, briefly, to come alive.

Now, however, thanks to a number of recent developments – space travel being one of them, the most spectacular but in terms of science not in fact the most important – geology has suddenly and seriously changed, and at a pace so rapid as to bewilder and astonish all who come up against it anew, or return to it after a while away. It is probably fair to say that never before has any long-existing science been remodelled and reworked so profoundly, so suddenly and in so short a time. Wholly unimagined new ways of thinking allow us to contemplate our planet in brand-new ways. These means have evolved right before our eyes, and, to the less prescient among us, they have done so well-nigh invisibly and, moreover, in rather less than half a century.

Thanks to the attitudes and instruments and scientific philosophies of the new science, all the events of great geological moment – with chief among them the earthquakes and volcanoes that so plague humankind – can now be seen and interpreted in an entirely fresh context, and in a manner that had rarely before occurred to those who practised the confusing and cobweb-bound older science with which (from memories of school and university) we are still so vaguely familiar.

It was not Neil Armstrong's venture alone that brought about this transformation. It is fair to say that geology flowered as rapidly as it did because at almost the exact same moment as the rockets started to soar up through the stratosphere from their bases in Florida (and from the cosmodromes in Baikonur – for this new perspective was one offered to Russians scientists too, of course) something else occurred. A previously little-known professor in Toronto (a man whose very ordinary surname – Wilson – might have kept him marooned in the shadows for ever, had not one of his given names – Tuzo – been so strange) drew up the foundations of an entirely new geological subdiscipline, the now all too familiar theory known as *plate tectonics*.

Plate tectonics and space travel each burst on to the world stage at the same time – plate tectonics becoming fully developed by 1967, manned lunar exploring getting under way in 1969 – and it is this that led to the unprecedented evolution of the science that was common to both. I shall try to explain the more relevant details of plate tectonics later in the story; but in essence it was a theory that also happened to encourage its believers to stand back, as it were, just as Neil Armstrong was doing at that moment. Plate tectonics allowed us – compelled us, even – to view the world as a complete entity, for the first time to look and to see *the earth entire*.

For it should be remembered that every single one of those Old Geologists – the tweedy figures who, with hammer and lens and acid bottle, had explored and observed and thought and written since the days when it was first realized that the earth is actually very old and that rocks are laid down with some natural purpose and that no deity had anything much to do with the actual manufacture of the planet – found their evidence for the theories and principles of the Old Geology in the rocks, fossils, faults and minerals that were scattered around simply and solely *on the surface of the earth*. They made crucially important discoveries, true; they laid the foundations for this most elemental of disciplines, true; but they did so by examining only the topmost layers – or at most the topmost few miles of thickness, if you will – of the planet.

And that, it is now realized, was a very limiting way indeed of conducting the science – a science that, after all, should more properly be concerned with the nature and history of the earth *in its entirety*, and not with its surface alone. Before the 1970s we had knowledge about the earth's outer cover, and not much more. What we wanted to know involved, if we thought about it, much, much more. We wanted to know – and geology was, in its theoretical essence, established purely so as to enable us the better *to* know – was about the earth as a whole. And when the intellectual revolution of the sixties came about, we started swiftly to understand that up until that point we had, quite literally, only been scratching the surface; we had never considered the earth as it truly deserved to be considered.

It promptly started to dawn on those sixties geologists who had listened to Tuzo Wilson or his acolytes, or who had seen the spacecraft pictures, that it was somewhat misleading for a science to draw conclusions about the earth entire by examining only those minor features that occurred upon, or just beneath, the planet's outer covering. A fault in Scotland or the relic of a volcano in Montana or the succession of types of trilobite that had been found buried in a shale high on a hillside in British Columbia – such things might be interesting in and of themselves, but only when they were viewed in the context of the big picture, of the planet as a whole, were they able to offer up evidence that allowed the whole-earth portrait to be inked in and made to look something like complete.

So this, then, lies at the heart of the New Geology. The world is these days viewed by most as one entire and immense system, the most refined of its details all interwoven with the biggest of big concepts. It is a living system four and a half billion years old. In a purely physical sense it is an entity warmed up from inside by radioactive decay, with fragments of its fairly recently cooled crust moving about on top of its more mobile inner self, and with solid rocks that have formed (or are still forming) on or beside these fragments creating continents or the floors of oceans. These rafts of solid rock have since been (or are still being) folded or lifted or broken apart as the plates on which they ride move about until they collide and bounce and dive beneath one another. In places the rock rise up to great heights; these are eventually eroded, causing the formation of sediments. A geological cycle of creation and decay continues, endlessly. And meanwhile there is life, almost in global terms a brief irrelevance; animals and plants evolve and disappear by turns on the various wet or dry surfaces of the planet according to a series of complex sets of rules that have been laid down by the practical realities of tectonics, of temperature, of pressure and of almost limitless quantities of time.

The finer details of these things have been studied for decades – such arcane niceties as the suture lines of ammonites (by which one can determine the species and subspecies of this particular beast, which floated gently about in the Mesozoic seas), or the varying degrees of sphericity of the ooliths in a Jurassic limestone, or the patterns of those parts of bivalved creatures that are inelegantly known as muscle scars. But now, in the light of the whole-earth, Big Picture view of the science of which they are so infinitesimal a part, they seem tangential to the broad realities of the New Geology, as the pores in an elephant's skin do to a biologist or the volume of sap that courses through the leaves of a live oak from San Antonio does to a forest botanist.

Which is not to say that such things are unworthy of our fascination. Small piece of puzzles can often to lead to grand ideas: the beaks of the Galapagos finches, after all, led Charles Darwin to his big notions about natural selection, the origin of species and evolution. But it is important to remember that Darwin had at the time all of what was known of earth's biology at his intellectual disposal – every beak and claw, every feather and fin was there, and his journeys took him to far and remote parts of our planet, so that he saw and thought about evidence from all manner of perspectives. When he sat down to write and think at his desk in Down House, he had an immense and almost unimaginable accumulation of information available to him, the finches' beaks being just a scattering of tiles from the great mosaic of biological knowledge.

But, by contrast, geology, at least before the 1960s, was able to lay out before its practitioners only the tiniest portion of available information – very little more than the superficial, the minute, the peripherally relevant. And then, in the nick of time (for without it, where would geology have gone?), everything altered: along came the astronauts and the unmanned satellites and the space-born magnetometers and gravimeters and mass-spectrometers and ion probes, and along came J. Tuzo Wilson and a whole army of like-minded tectonicists. They, combined with the new way of looking at the earth, taught the Old Geological community that there was much, much more to know – and what was once merely a hunch, an inner feeling, became a settled idea. It became abundantly clear that very few grand theories could actually ever be derived from minutiae such as ammonite suture lines and oolith sphericities and relative umbo sizes alone, except forensically; and that nowadays the grand geological ideas are the ones that truly matter.

3 The View from On High

And seen in that great and glorious context is the earth of the California morning of what Western Christian mankind had chosen to call 18 April, 1906. Had any geologist at the time been able to look down at the planet in its entirety and witness what took place then, he would at the very least have been utterly amazed by the physical context of the event, even if the event itself, when viewed from on high, appeared less than overwhelming.

For, as context, the planet would have been memorably beautiful. Had he been standing on the moon, say – had he been a 1906 version of Neil Armstrong, scanning with a hugely powerful telescope the surface of the blue and green and white ball that was hanging in his ink-black sky – he would have seen illuminated in front of him (assuming that the cloud cover was not too dense) a tract of the world that extended from what some of mankind called India to what others called the Rocky Mountains, all of which would have been bathed in the brilliant white light of sunshine.

He readily could have made out all of Europe and Africa, Asia

Minor and Arabia; he could have seen the deep blue of the Atlantic Ocean, the pure white mass of Greenland to its north, the blinding white immensity of the Antarctic deep below. The corpulent mass of what we now know as Brazil would have been brilliantly illuminated, with the city-smudged eastern coasts of North America and Patagonia only slightly less so, places peopled with a humanity that was just waking on what many of earth's inhabitants would call a Wednesday, a day that thousands of miles away, in the darkness of China and all points east, was in any case already coming to its end.

At the moment that we find interesting – five o'clock in the morning, give or take – he could have seen the terminator line of western darkness pushing its way rapidly towards the Pacific. The earth would have been moving relentlessly at a speed of some hundreds of miles an hour eastwards towards it, opening ever more populated parts of the land masses to the light of the dawning day.

The line at that very moment would seem to begin in the north near Melville Island in the Canadian Arctic, pass on down through Banks Island and the unpopulated and ice-bound wilderness of the Northwest Territories and the Yukon, through Saskatchewan and Alberta, raggedly on down through the newly created state of Montana, through the bison-and-Cherokee country of Wyoming and Colorado and New Mexico, across the Rio Grande towards Acapulco, and arrive at a point on the coast where it would finally slide off the North American land mass and eventually illuminate the still inky emptiness of the Pacific Ocean.

To the east of the line, all would have been bright and daylight. To the west, an impenetrable dark. And on the line itself, an uncertain penumbra of a few hundred miles of a swathe of half-dark and half-light. On earth this penumbral vagueness would have translated itself into the morning twilights that early risers were experiencing just then in cities and on farms and in small villages all the way from Vancouver Island in the north down to Baja, California, in the south, where the day designated as 18 of April was about to begin.

It is fanciful to suppose that anyone watching so far away, in distance or in time, would have had access to a spy-glass that was large enough to do the job. But, assuming that such a device did exist and that the person at this lunar viewing-point had its brass and glassware trained precisely on the northern coast of California at that very particular moment in time, with the terminator line brightening his view inch by inch – what, precisely, would he have seen?

The answer is inevitably dismaying to all of those who like to think that the earth and its inhabitants and the events that occur upon it have any importance at all, in a cosmic sense. For from that distance he would have seen, essentially, nothing.

Yet at a few minutes past five in the morning of that day something did, indeed, happen.

The planet very briefly *shrugged*.

It flexed itself for a few seconds, perhaps a little short of a minute. If our observer had been acutely aware of his geography, and if he been fortunate enough to have been staring at a very precisely defined spot in the north of California at exactly the right moment, then he would have seen what appeared to be a tiny ripple spurt in towards the coast from the sea. He would, moreover, have seen that spreading ripple as it moved slowly and steadily inshore, and then watched as it moved, fan-like and subtle, up and down the coastline as a tiny *shudder*. It would have seemed to him a momentary loss of focus, something that would have made his vision suddenly blur very slightly, and then just as quickly clear again.

If he had blinked, he would have missed it. Having noticed it, however, he would probably have assumed it was more of a problem with his lens and his telescope than with the surface of the planet below. And even if he had realized that the ripple and the shudder had in fact occurred on the green and blue and white planet that floated serene in the lunar sky, he would have been quick to conclude that whatever it was had been momentary, trivial and utterly forgettable. No more, for the earth entire, than a gentle and momentary shrug.