Charles Kovacs

Geology and Astronomy

Waldorf Education Resource

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Foreword

This book contains the lesson notes of Charles Kovacs, made when he was a class teacher of Class 6 pupils in Edinburgh. To some extent they have been revised and updated. In the geology notes the local area – in this case Edinburgh – is emphasised, and this is quite deliberate, as it serves as an example of relating what has been learned to the familiar, local area. One might expect lessons on geology to start from a description of Plate Tectonics — the great discovery arrived at during the 1960s. But this is the point — modern geology had existed for nearly 200 years and was a very advanced science before these discoveries could be made and appreciated. It is all too easy to give children 'ready-made' conclusions; conclusions which, in reality, evolved only gradually. The unfortunate result can then be that the conclusions are indeed accepted, but accepted as somewhat undigested dogma, not truly understood. The consideration of Plate Tectonics might come much better in the ninth grade, when time can be spent considering the diverse evidence — the 'detective story' which, eventually, led to such astonishing conclusions about the structure of the Earth.

In astronomy too the approach is to start from observations of sun, moon and stars — phenomena which have been experienced and understood — without special equipment or theories — for millennia. Once again, the upper grades are a better place to consider how the more recent concepts evolved. The later chapters on discoveries with the telescope are the most difficult to keep up to date, as new discoveries are con-

tinually being made, both with more powerful telescopes and with space probes.

We hope that these notes can serve as a stimulus to the creativity of individual teachers, rather than be followed as a scheme. This would be in keeping with the wishes of Charles Kovacs.

Howard Copland

Geology

1

The Children of the Earth

In the winter it can get very cold, but no matter how cold it can get here in our part of the world, there are places where it can get much, much colder. In which direction would we travel to find lands where it gets much colder than here? Would it be east, where the sun rises? South, where the sun stands highest at noon? West, where the sun sets? Or north, the direction in which we never see the sun moving across the sky? To find the colder lands we would travel north.

Travelling north we would come to lands which are much colder than ours; and the further we go north the colder it would get, until we come to parts of the world which are so cold that the ice and snow never melt completely and the ground is always frozen — summer and winter. Think of Greenland, Northern Canada, Alaska or Northern Russia. These are the lands around the North Pole, the polar region, the region of everlasting ice and snow.

On such a journey to the frozen north we would discover something else. We would notice something about the plants. In our part of the world there are two kinds of trees. First the leafy trees which, every winter, shed their leaves and stand bare. Then there are the trees that have only green "needles" for leaves; in botany we call them conifers or evergreens. Here, in our part of the world, we have these two kinds of trees, but going further north the leafy trees get fewer and fewer. There you would hardly see anything but the dark green of pines, firs and larches; the trees which have green needles as leaves.

Can you guess why this is so, why the trees with broad leaves get fewer and fewer the further we go north? Because a broad leaf tree needs more sun and cannot stand being frozen. Where there is less sunlight and it is less warm the trees with narrow leaves, or needles, can live better than the others. One could say that the leaves "shrink" and become needles as we go further north. Not only the leaves shrink as you go north; the trees themselves get smaller. The pines, firs and larches that grow far to the north of us are like dwarfs compared with our trees; they would barely reach to your shoulders. In the regions where these dwarf trees grow there is still a kind of summer. The snow *does* melt and then plants and flowers grow and have lovely blossoms; but they all have only tiny, tiny stalks, much shorter stalks than our flowers here. If we go still further north we come to the regions where nothing grows at all — not even dwarf trees or tiny flowers. These are the regions near the North Pole, the regions of everlasting ice.

But how would things change if we travelled further and further south — in the direction where the sun stands at its highest at noon? We know of course that it would get warmer and warmer. We would come to lands where people never have winter. How do the plants change as we go further south? Going south the needle trees become fewer and fewer, as they don't like too much sunlight, and the leafy trees increase; we come to trees with very large leaves indeed, like the palm trees. Think how long and broad and thick the palm leaves are. The trees also get taller and the other plants, the flowers, shoot up too. They have long stalks, long leaves and large blossoms in the hot lands of the tropics.

So you see how the whole earth changes from north to south. In the south, in the tropics, it is always summer — it is sunny and hot and we find tall trees, long stalks, big leaves and large flowers. The further north we go the trees are smaller, the leaves shrink, the stalks get shorter and, in the end, we come to lands where it is always winter and there is always ice and snow. Of course if you go beyond the equator, as far south as

you can go, you finally end up at the South Pole and it is again extremely cold.

What I have just described is about the whole earth. The whole earth changes like this from south to north, or from equator to pole. But think of a very high mountain. Let us take the highest mountains there are in the world; the Himalayas. At the foot of the Himalayas you have a hot climate, the hot weather of India. You would see tall, broad-leaved flowers and trees. But as you go up into the mountains the air gets cooler and cooler, and the trees and plants become smaller. At a certain height you might think you are in Scotland — there are pines, larches, there is even heather, but there are also oak trees and beech trees. You go still higher and soon there are only needle trees and they become smaller. There are mountain flowers, like gentian, with short stalks. If you go still higher up there is, again, everlasting snow and ice. The summits of such high mountains are just like the polar regions and nothing can grow in the frozen, snow-covered heights.

Every high mountain is like the whole earth. Just as children often look like their father or their mother, so the high mountains of the earth are children of the earth, and they have a likeness to their mother, the earth.

2

The Story that the Mountains Tell

The hills and mountains of Scotland are very beautiful, but even our highest mountains in Scotland, the Cairngorms and Ben Nevis, cannot give you the kind of feeling that you have when you stand before the really high mountains of the world. If you have never seen the Alps before and are in Switzerland for the first time it can happen that you look up into the sky and think, "That's a strangely shaped white cloud up there." But when you look again, you see that it is not a cloud at all, but a range of snow-white mountain peaks, towering in the sky.

These mighty, powerful, majestic giants, reaching up into the clouds, leave you feeling something like awe before that power and greatness. But looking at these towering peaks you can also feel how immeasurably old these giants are. They have stood there for millions of years and they will stand there for millions of years to come. If these mighty peaks could speak they would tell us the life story of earth itself. We walk on the earth, we build our houses and cities on the earth and we use stones taken from the earth for our buildings, but what do we know about the story of the earth? The ancient, mighty mountains can tell us something about the story of the earth. Let us see what the mountains can tell us.

The first thing is that the great mountains of the world do not stand alone like proud giants, they are mostly to be found in groups or in long rows. These rows of mountains

sometimes curve across the face of the earth for hundreds or even thousands of miles, and are called mountain chains or mountain ranges. The Alps are a mountain range, so are the Urals, and if you look at a map you will find that there are many, many more of these ranges. You can see that the Alps are really part of a much longer range that curves its way far to the east.

The next thing is that they are extremely old, unimaginably old, but — and this may sound strange — the mountains are not all of the same age; there are young and old mountains. The Alps are young and the Urals are old. Of course, even a "young" mountain at which you may be looking is much older than anything you can think of, but it is still young compared with another mountain.

Now we will compare the earth with the moon, the earth's companion in space. Astronauts have travelled to the moon and scientists have studied the rocks and mountains there. There are many great mountains on the moon, but they are all very old indeed — and they have hardly changed in the millions and millions of years since they were first created. The moon is beautiful, but its surface is like a barren desert, forever dead and unchanging; there are no young mountains at all, everything is very ancient.

Here on earth the young mountains are usually the biggest and tallest, with their jagged snowy peaks reaching far up above the clouds. Old mountains are not so big, although, when they were young, they too were just as tall as young mountains — like the Alps — are now. The old mountains have changed through time, they have been worn down and "rounded off."

So mountains tell us that the earth is not a dead place like the moon, it is active; old ranges are broken down and new ones are created. Always, somewhere on earth, there is destruction going on, but somewhere else there will always be new creation. Our earth is not just like some big lump of stone, it is a living, changing place — even when it comes to the seemingly lifeless rocks and mountains.

So that is the third thing: young mountains appear, old mountains wear down, and we learn that the earth is a place where great changes are always happening. And the way that mountains form in ranges tells us that the changes do not happen haphazardly — there is a pattern to them.

3

Young and Old Rocks: Granite

There are young mountains and old mountains but — and this is not the same thing — there are also young rocks and old rocks. Old mountains are made of old rocks and so you might think that young mountains must be made of young rocks, but this is not necessarily so. When nature makes a new mountain it uses rocks that are already there, just as a builder can use blocks of old stone to make a new house. In nature it is normal to recycle everything, and a young mountain range will be made of many different ages of older rocks. So there are young rocks, there are very ancient rocks and there is everything in between. What, then, are the oldest rocks?

To find the oldest rocks you need to look deep down into the earth. The oldest rock of all, the rock which lies under all the land and mountains of the earth under all our lakes and land, fields and forests, cities and roads — that kind of rock is a light-coloured rock called *granite*. Granite lies deep within all the continents of the earth. Beneath the soil on which we walk there may be clay and beneath the clay there may be limestone or sandstone and beneath that there may be something else — but if we go deep enough we shall always find granite. (Later we shall look at what is below the granite.)

But granite is not *only* to be found deep down, it can sometimes be found around us or at great heights. The Alps are partly limestone and other kinds of rock, but their highest peaks are of granite. Granite can reach from the deepest depth below to the highest heights above. We have granite in Scotland also: our Highlands, the Cairngorms for instance, are

granite mountains. If you walk on this granite you walk on very old rock, you walk on rock that reaches deep into the earth and you walk on something that belongs to the very beginning of our earth.

There is a beautiful legend about granite.*

God wanted to create the strong, solid stone and rock upon which man should walk firmly through life. He turned to his helpers, the spirits and angels who serve him and he said, "Bring to me the gifts which you have so that the first of all rocks may be made."

Now there were three groups of angels around God. The first group were the angels of wisdom. The highest of the angels of wisdom came forward and he brought God the Father a stone that was as clear as water — it was transparent. The Angel said, "You, Father have given us the light of wise thought. This is the stone which is like the light of wisdom and the thought of man shall be like this shining crystal."

Then came the second group, these were angels of strength and power. The highest of these angels came before God and carried in his right hand a black stone, and in his left hand a white stone. The angel said, "These two stones, black and white, are the stones of strength. They will give man energy and strength so that his wise thoughts will lead him to deeds."

The third group were the angels of warmth and love. The highest of them brought a green stone and a red stone. He said, "In these stones we have put the warmth of our hearts. These stones can have many forms and will serve man in many ways."

And from these three gifts of the angels God made the first, the oldest of all the rocks, granite — from the gift of light, the gift of strength and the gift of warmth. There are many varieties of granite, but it always is a mix-

* From *Erziehungskunst,* December 1952

ture of these three things: a clear, transparent stone called *quartz*, a black or white stone called *mica* (which glistens and sparkles in the light), and lastly a pinkish, white or greenish stone called *feldspar* (which gives granite its colour). As we shall find out later, the best soil for farming comes from feldspar. The bread we eat comes from feldspar earth.

The mighty granite rock, the oldest of rocks, is made up of three parts: quartz, the gift of *light*, mica, the gift of *strength* and feldspar, the gift of *warmth*.

4

The First Rocks

When a house is built the first thing is that a foundation is laid for the house. The foundation carries the whole weight of the house. Granite, the oldest of the rocks, is the foundation, the mighty giant that carries all other stones, rocks, earth and seas on its back. Beneath the oceans of the world, it is slightly different: the rock that supports the great oceans is a dark rock called *basalt*. Basalt is a relative of granite; you could say that it is like a younger brother. Basalt is dark in colour while granite is light, because basalt contains more iron and less of the clear quartz than granite. Iron is to be found in the basalt which forms the rocky bed of the great oceans. So the continents are supported on light-coloured granite and the oceans on dark-coloured basalt. Together these two "brothers" make up the foundations of the earth.

When you look at a granite mountain — in the mighty Alps, or the Highlands of Scotland, or even at small pieces of granite — you are looking at something so unbelievably old, so ancient, something that came into existence so long ago, that no one can know for certain how it happened. So there are two different ways of explaining how granite came to be.

Before the first explanation I want to tell you of something I saw as a child in Austria. During the holidays my parents used to take us to a little town called Baden, which means *bath*. Why was it called that? Because this town had a spring of water that came from deep down in the earth and this spring of water was hot. It was nearly boiling hot as it came from the earth. It was not heated by people but by the earth itself. It also

had a peculiar smell, like eggs going bad. To take a bath in this hot, smelly water was a very good cure for rheumatism and so people came from far and wide to take these baths. And there are hot springs in many other parts of the world: England, Iceland, New Zealand, America, Japan.

This water is heated deep down in the earth. When people dig deep mines for coal and for iron they find that the deeper a mine-shaft goes, the warmer it gets. In some mines the shafts go so deep that they need special cooling systems, or the men could not work there at all. We saw earlier that the higher we go the colder it gets; now we can see that the deeper down we go the hotter it gets.

In steel-works the furnaces produce a heat in which iron melts and flows like water, it becomes a white-hot liquid. If one could dig down deep enough it would be so hot that there would no longer be any hard, solid rock. Even rock would melt and be a red-hot liquid. In our time one would have to dig a shaft of about two thousand miles through the rock to get there and, of course, no one can do that. But some people who study these things say that in a far-away past, millions of years ago, you did not have to dig down to find this great heat in which even stones and rocks were flowing like water. They say that the surface of the earth, where we walk about now, was like that, was so hot that there were no rocks or stones. It was all a fiery-hot liquid. Now in time this surface of the earth began to cool down — at first only the outside, then a bit deeper down, and then still deeper down. As the outside surface slowly, very slowly, cooled down over thousands and thousands of years, it hardened — just as molten iron hardens when it cools down — and a hard skin, a hard crust formed on the surface of the earth. Now this first, hard, solid skin of the earth was granite.

That is one way of explaining how granite came to be; it is called the "hot-earth" theory. But there are people who think differently, they prefer the "cold-earth" theory. They say it is not surprising that it is terribly hot in the depths down there: if you press with your hand hard on the desk, it will get quite

hot — and so if all the heavy mountains and oceans and rocks press down, it must get hotter and hotter the deeper down you go. But, they say, this does not mean that it was ever so hot on the surface. Now these people say that the earth is not just a great dead chunk but is more like a living being. We know how, for example, shellfish — crabs, lobsters, sea urchins, — form a hard shell around themselves, well perhaps the earth could have formed a hard shell around itself, and that shell is granite.

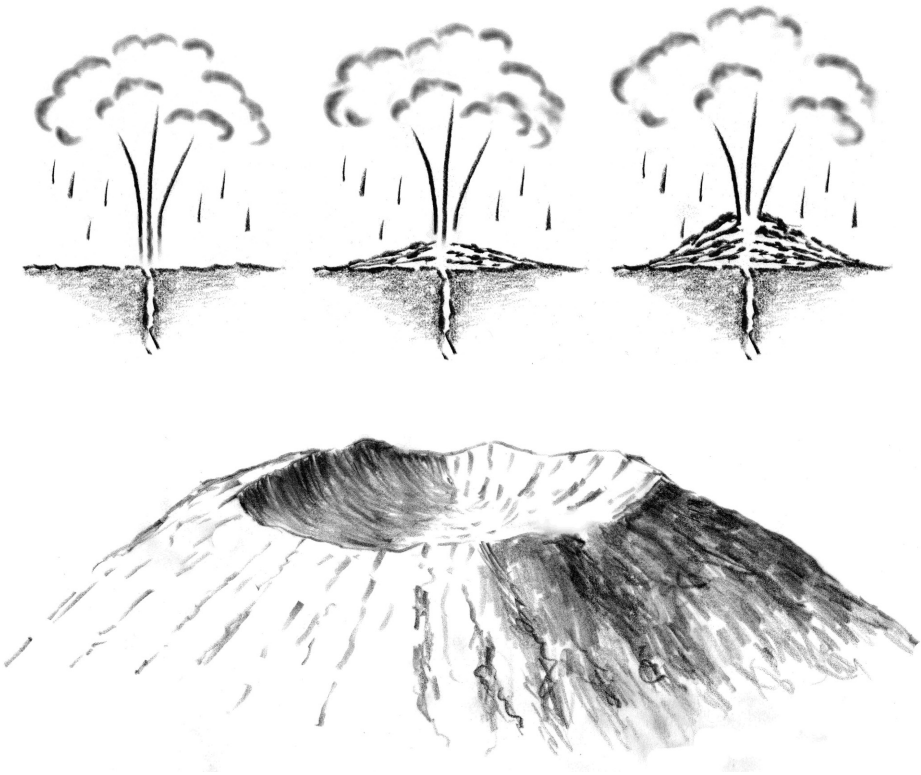
But the time when the first granite came into being is so terribly long ago that no one can say for certain how it was. Granite, that oldest of rocks, that mixture of three stones, is still keeping the secret of how it first came into existence.

5

Volcanic Rocks

Think of a very high granite mountain. Its peak is so high up that it is forever winter, covered with ice and snow. But the granite goes on under the earth, deeper and deeper down, so far down that it comes to the terrible heat below where the rocks and metals are burning hot. The granite mountain reaches from the terrible heat below to the terrible cold above. But we living beings, humans and animals and plants, we live on the surface of the earth, just between the two extremes — we live in between the terrible cold of the heights and the terrible heat of the depths. You see, life is always something that keeps to a middle path between the extremes of too much or too little. That is something to remember for our own life; that the middle path is the best.

In some parts of the earth's crust — not everywhere, only in certain places — the heat is so great only a few miles down that the rock has melted and become a red-hot thick liquid. This molten rock is called *magma* and it forms an underground magma chamber. The magma can remain there for long times, but it does not always stay down in the depths. At certain places and at times which no one can foretell this magma comes spurting up from the depths. And it is always an awe-inspiring thing when this happens. Many years ago, magma came spurting out at one place. It had such a terrific strength that it forced a path, like a long pipeline, through the rock, through the soil and everything on top, then came spurting out through a big hole in the ground. It was fiery-hot, but in the cool air on the surface the magma soon cooled down and hardened. It



A volcano forming a crater

hardened into stone, into rock. What remained was a little hill of hardened rock with a hole in the middle where the magma came out. The next time there was such a spurting of magma from the depths it did not force a new path; it came out where there was already a hole. So a new hill was formed on top of the old one, but the old hole still remained. The next time the same thing happened the hill grew and, in time, became a great mountain with a crater. The deep hole through which the eruptions come is called a *crater* — the Greek word for a mixing-bowl.

Now the Romans had a god who was a metal-smith called Vulcan. He made the weapons for the other gods. They said,

"As a human smith has a smithy where he heats iron until it is soft so that he can work on it, so this god has an enormous smithy, deep down in the earth. Magma comes from the smithy of this god Vulcan." The mountains formed by magma are called *volcanoes* after this god. So you see, a volcano is quite different from other mountains. A volcano is like a man who is quarrelsome, an ill-tempered person who does not get on with other people and so has to keep to himself; the mountain ranges on the other hand are like friends who stand together. Volcanoes are not formed by the slow process that forms mountain ranges but by sudden fiery outbursts called *eruptions* — quite a different story!

A volcanic eruption can be a fearful thing. First there is a deep rumbling noise from inside the earth, then a puff of steam, ash and smoke comes from the crater. Another deep rumbling comes and the earth is shaken for miles around. Then from the crater a fountain of fiery liquid erupts and runs down the mountain slope, like red-hot snakes. At the same time an enormous cloud of fiery smoke and ash forms above the volcano's peak. This cloud darkens the sky until it is dim as night, and a rain of ash falls down on the surrounding countryside for miles around. But this terrible, fiery-hot cloud can also come right down to earth, rolling down the mountain-side with unstoppable force and speed. When this happens it burns and destroys everything in its path; it can even destroy a whole town if it happens to be in the way.

The fiery stuff that comes from the crater and flows down like snakes is called *lava*. Lava is really the same as magma — it is called magma when it is beneath the earth and lava when it comes out on the surface. After a while the lava cools enough to become solid rock. Often, as it cools and hardens, it forms big wrinkles on its surface, looking like piles of rope; this is called "ropy lava." From lava, different varieties of rock are formed. It can happen that the magma does not reach the surface; then, because it is deep in the earth, it cools down slowly

and becomes *basalt*, the dark rock which also makes up the crust of the earth beneath the oceans. Then there is *obsidian*, a kind of natural glass that forms when lava cools quickly — it looks like dark bottle-glass and can be found in many colours. The Native Americans had not discovered the use of iron before Europeans came, but they made razor-sharp knives and arrowheads out of obsidian. Just as sea water foams or beer froths, so the liquid red-hot lava can also make a bubbling froth and when that hardens it becomes *pumice*, the stone you use to rub ink-stains off your fingers. It is a strange kind of stone — full of bubbles and so light that it floats on water.

If a volcano erupts regularly it is called an *active* volcano. But a volcano can be quiet, without any eruptions for a hundred years or longer, and then it suddenly erupts again. A volcano that has not erupted for a long time but that — one day — will erupt again, is called *dormant*, which means "sleeping." A volcano that is completely dead and will never erupt again is called an *extinct* volcano. As it happens, around Edinburgh there are a good many of these ancient volcanoes — Arthur's Seat, the Castle Rock, Calton Hill and, farther to the east, Berwick Law and the Bass rock. They are all dead, extinct volcanoes — but once they were fire-spouting and active.

It is a strange thing to go up a volcano which is still active but, for the time being, not erupting — like Mount Vesuvius, near Naples in Italy. On the lower slopes of the mountain are fields and vineyards, for volcanic soil is very rich. You walk further up on bleak, desolate slopes, raised in heaps like the waves of the sea — it is all hardened lava. In many places you walk on a layer of clinker. Every now and then the ground under you trembles and a rumbling noise comes from the earth. It is a very tiring walk up but at long last you reach the top and you look down into the immense crater. It is like an enormous basin with sheer sides and you can see that it is made of layers of lava one on top of the other. In places there are wisps of steam and there is the constant sound of small stones falling down into the crater. You climb down a short way into the big

crater of Vesuvius. The walls are hot to the touch: the heat of the earth. As you get down into the crater little lizards run away in different directions; they like the warmth in the crater.

Throughout history Vesuvius has erupted many times, but the most famous eruption was around two thousand years ago. About 10 km or 6 miles from Vesuvius (quite a long way!) lay the wealthy Roman town of Pompeii. In the summer of AD 79 a great eruption of the volcano threw up huge quantities of smoke and ash high into the sky. Day was turned into night and a heavy rain of ash came down until the town was completely buried. In our time it has been dug up again, revealing a lot about life in Roman times (it is said that the science of archaeology was born in the ruins of Pompeii). It is fascinating to visit Pompeii and walk around the streets of the ancient town.

In some other volcanoes — as on the Hawaiian Islands — you discover that there is almost continuous but much less violent activity. Inside the big crater there is liquid lava that spurts up in a red fountain — especially at night it is a spectacular sight. The fountain can be quite high, thirty metres (100 ft) or so and it throws out red-hot drops of lava that harden quickly once they are out and fall as "bombs." Again you feel the trembling of the earth and hear the rumbling below. Here and there you can see patches of yellow sulphur around the cracks where steam is coming out of the ground and there is a pungent smell in the air. When you see and hear and smell this, then you know that one does not have to dig deep down to reach the magma below the earth — in a volcano it is as if the inside of the earth comes up to the surface.

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