What Have Volcanoes and Soils Told Me? | BY GRAHAM WILL

Introduction I was born in New Zealand and have spent most of my life there. It is a small country consisting of two main islands which lie along the boundary between the Pacific and Indian-Australian Plates in the crust of the earth. Lying on the ring of fire around the Pacific Ocean, many parts of the landscape in the North Island of New Zealand have been formed by the action of volcanoes.

When I began my university studies in science in 1946, my majors were in chemistry and zoology. Although I had quite an interest in gardening (and in general the surface of the ground), I didn't dare include geology in my studies because many in my church expressed the belief that the geological column was in some way associated with Satan and his delusions.

Having finished my studies, I spent some time in physical work laying water mains in my hometown. Although I was in and on soil for several months, I didn't really come to understand all that much about it. I was still very much in the same position as the average man-in-the-street who looks at and possibly walks on a soil of some type without knowing or even thinking much about it. For me the situation was to change quite dramatically as I took up a position as a chemist at the New Zealand Forest Research Institute. The Institute is situated in Rotorua, which is a city in the central region of the North Island. It lies beside a lake which is 26 miles in circumference, and they lie in a very large caldera left behind after what must have been a huge volcanic eruption many years ago. I became one of a team studying poor tree growth as it was related to soil mineral deficiencies.

A Few Basic Facts About Soils[1]

I soon learned that in nature the soil in one place can be very different from the soil in another part of the country and in some cases even different from that only a few meters away. As in other countries there are hundreds of different soils in New Zealand: these are the result of (1) different parent rocks, (2) different climates—heat and cold, rain and wind, (3) different land slopes and (4) time. Soils are formed as the rocks weather (break apart) into smaller and smaller mineral particles, and plants become established. The plants add organic matter (humus) to the surface, and soil fauna (worms, insects, etc.) help move it down into the soil itself.

It is perhaps hard to appreciate just what complex systems soils are. They are also living and dynamic. On a dairy farm the weight of the animal life in the soil under the pasture can be several times greater than the weight of the animals grazing the pasture. A teaspoon of soil can contain 100 billion bacteria and 15 km of fungal threads! A number of soil properties and reactions are related to the surfaces of the clay particles: a teaspoon of the clay mineral allophane has a total surface area equal to a football field!

As a soil develops, several horizons (layers) are formed, and together they are called a Soil Profile: these can be seen on the edges of excavations such as roadside cuttings. A very simplified description of soil horizons is as follows:

A horizon	Topsoil	Surface layer, usually dark in colour due to the humus it contains.
B horizon	Subsoil	Next layer down. Less humus and biological activity but still much chemical activity under the influence of rain as it washes through.
C horizon	Parent Material	Bottom layer. Unconsolidated weathered rock. Little or no biological activity.
R horizon	Underlying bedrock	

As my knowledge and experience grew, I became fascinated by soils, and although some were obviously older and more developed than others, I thought (hoped) that maybe they were not as old as they looked and were dated by scientists. A worldwide flood could not have left any soils in place on the surface of the earth, so every soil that we examine today must have had to begin its development less than 5,000 years ago to fit in with Usher's or a similar time scale.

Some of the thoughts that went through my mind included the following questions. The deep and well-developed soils on alluvial flats were obviously quite young, but what about the soils that had developed on hard rocks such as granite? How long did it take for the rock surface to weather to the place where pioneer plants could gain a foothold and then the soil formation processes begin? Rock slabs in cemeteries, many hundreds of years old, show only a few mms or less of weathering; how old are the soils where the weathering has penetrated several metres into solid rock?

Pumice Soils in the Central Region of the North Island

Then one of my research projects involved trees growing on Pumice Soils near Rotorua and how deep their roots went below the surface. Digging down, we went through the normal A, B and C horizons only to find a deeper series of dark layers that looked similar to topsoil (see Photo 1, *page 66*). Other scientists on the same campus were making a study of these layers. They explained that they were paleosols (buried soils) that had formed before they were covered by pumice ash from a subsequent volcanic eruption. I was then faced with the task of finding an explanation as to how there could have been time for not one but six soils to form in the last 5,000 years. There is good evidence that the last eruption (Taupo) occurred about 2,000 years ago, and when it occurred, at one site, it flattened a mature 700-year-old forest growing on the existing topsoil.[2] Allowing time for colonization by pioneer species before the climax forest became established, there must have been at least 1,000 years between the Taupo eruption and the one before it. That leaves only about 2,000 years or less for the formation of several lower buried soils.

It was at this stage that I was taken to another locality, a roadside cutting near Rotorua Airport, where there are seven paleosols under the Taupo ash—seven soil-forming sequences to fit in 3,000 years! (see Photo 2, *page 67*). But then I learned that farther to the north there were soils (and paleosols) on even older volcanic ash showers and further north still even older ones.[3] How old? Perhaps the clay content could give an estimate. Clays are the smallest mineral particles in a soil being less than 0.002 mm in diameter. By comparison the finest sand particle is 100 times this diameter. The clays in pumice soils are secondary minerals, that is, they have formed by the original ash being dissolved and the new minerals precipitating out of the soil solution. This is a slow process. The amount of clay that has formed in the Taupo soil since it started forming 2,000 years ago is about 2% of the total mineral component of the soil. The older ash soils have up to 80% clay.[4] Two percent clay in 2,000 years preceded by 70+% in 3,000 years? It didn't seem to add up to me. The rates of chemical reactions are temperature regulated; perhaps it was warmer in the past. But New Zealand's history of glaciation suggests that it was probably colder.

Not far to the north of Rotorua there are lakes where over the years peat sediment has built up on the lakebed. Cores from these lake bottoms show layers of volcanic ash separated by deposits of peat sediment. Some of the ash layers are from the same eruptions that produced the paleosols at the Rotorua Airport. The depths of the peat layers between the ash layers gives further evidence that considerable periods of time must have elapsed between these volcanic eruptions.[5]

It does not seem possible to explain the presence of all the paleosols in the Rotorua district, the highly weathered state of the older pumice ashes and the peat/ash sequences in lake beds all within an Usher short chronology. Topsoil, clay content and lakebed sequences support C14 dating of 50,000 plus years.[6]

Soils Formed on Basalt Volcanoes Near Auckland

What about other soils? How long have they taken to develop? Another series of soils that I have looked at are the basalt soils in and near Auckland, a city which is about 150 north of Rotorua. Pumice ash eruptions are explosive, throwing ash high into the air for it to fall and cover large areas up to tens or hundreds of thousands of hectares. In contrast, basalt eruptions flow or fountain over very much smaller areas. Within the immediate vicinity of Auckland City there have been more than 40 basalt eruptions leaving individual volcanic cones (hills).

The last eruption (and the largest) formed Rangitoto Island in the entrance to Auckland's harbor. From a distance the island gives the appearance of some age, being seemingly covered in forest. However, walking about on the island reveals that large areas are still bare lava flows, and where vegetation has become established, the roots only penetrate between the rocks and scoria or exist in the shallow layer of organic debris that has built

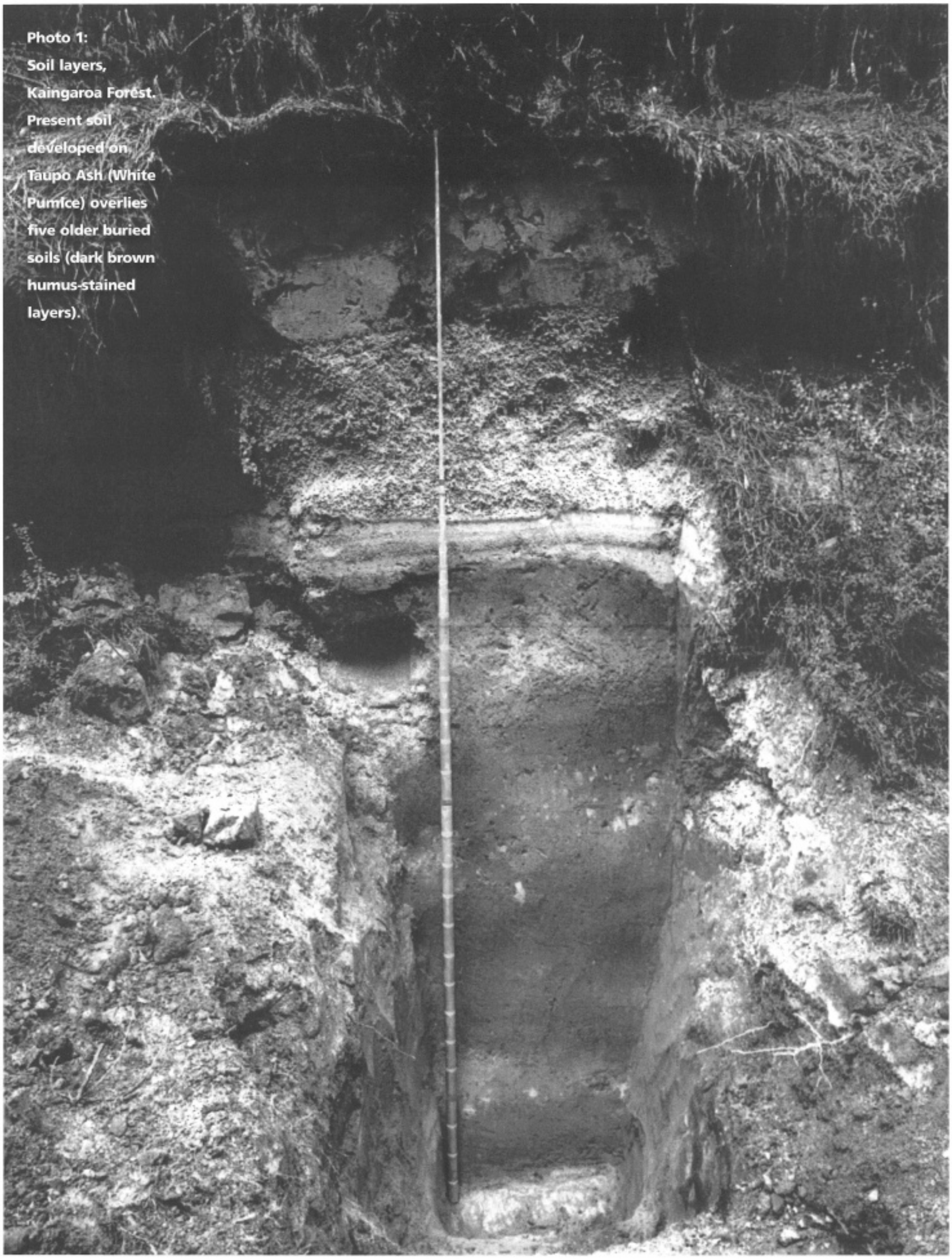

Photo 1:
Soil layers, Kaingaroa Forest. Present soil developed on Taupo Ash (White Pumice) overlies five older buried soils (dark brown humus-stained layers).

up on the surface (see Photo 3, *page 68*). There has been no significant soil formation. How long has Rangitoto Island been in this incipient soil formation stage? Available evidence from tree ring counts and archeology suggests up to 500–700 years.

In Auckland City "One Tree Hill" is a much older volcanic cone. There remain a few basaltic boulders in the crater and on the lower slopes, but by and large the volcanic cone is covered by young shallow soils that grow good grass to feed the farm animals that graze there. However, the shallow depth of the soils and the slope of the land mean that any mechanized cultivation is impossible. Compared to Rangitoto Island, the appearance of the present One Tree Hill soil agrees with an assigned age of 15,000 years plus.

The Bombay Hills lie some 20 km south of Auckland City. This district is one of the largest market gardening centers in New Zealand. Many of the soils have formed on pumice ash from volcanic eruptions farther south (see above), but the tops of the hills are covered in soils developed from the basalt rock which formed the hills themselves.[7] Here the distinctive red soils are both deep and easily cultivated. It has been estimated that on many of the slopes up to a meter of soil has eroded away due to continuous cultivation for many years. This indicates that the depth of weathering and the extent of soil formation were originally many, many times greater than on One Tree Hill. When compared to Rangitoto Island, it is a completely different scene! An age of 100,000 years plus seems to fit in with the visual evidence and our knowledge of soil weathering and development processes.

If after 500 years there has been absolutely minimal soil formation on the basalt flows on Rangitoto Island, the shallow soils on One Tree Hill and the deep soils on the Bombay Hills seem to have developed over considerable periods of time. The soil evidence doesn't support a short chronology but rather a longer period for the development of a deep soil on basalt rock.

Some Non-Volcanic Soils in New Zealand

Glacial Moraine Soils In the south of the South Island (Fiordland and the Southern Alps) there has been extensive glaciation in the past, and as the glaciers have retreated they have left behind series of moraines of progressively younger ages. These have formed the parent materials for a sequence of soils. Considerable changes have occurred as the soils have formed and aged. As the parent rock has weathered, over half the phosphorus it contained has been either combined with organic matter or leached (washed) out of the soil. Soil scientists estimate that it has taken 20,000 years for these soils to form.[8]

From an earth covered by a flood, how long must it have needed for glaciers to (1) form, (2) cut fiords and canyons thousands of meters deep, (3) and retreat, leaving behind moraines on which (4) soils have then formed and aged?

Loess Soils On the eastern side of the South Island there are extensive plains where soils have formed in loess. This is fine material originating from the rocks of the Southern Alps. The rocks have weathered under the influence of glacial action, and the fine material has been transported by rivers out onto the floodplain. This fine material has then been blown out of riverbeds by strong winds and deposited over wide areas. In places, many kilometers from the rivers, the loess has accumu-

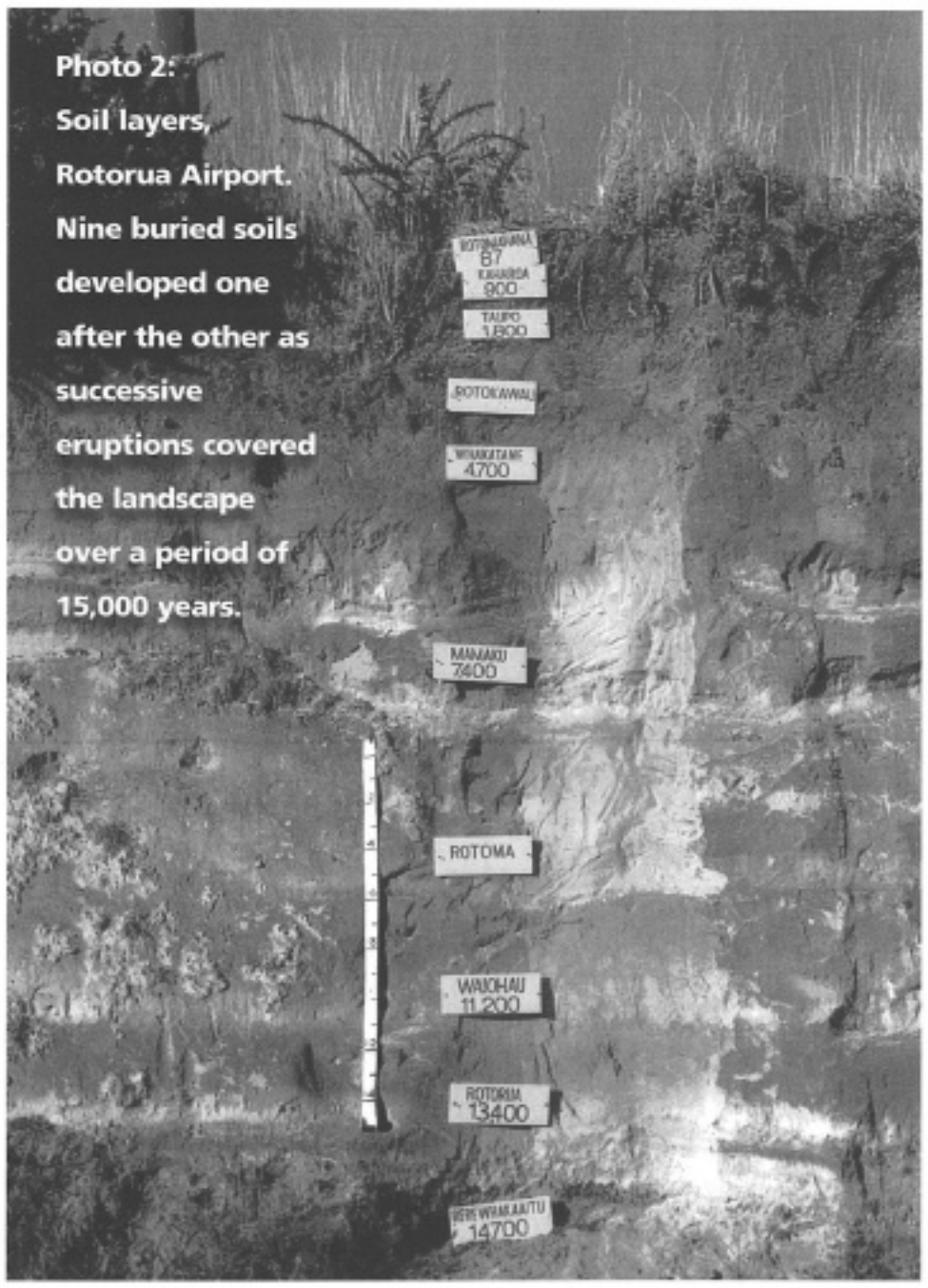

Photo 2: Soil layers, Rotorua Airport. Nine buried soils developed one after the other as successive eruptions covered the landscape over a period of 15,000 years.

lated to depths of up to 10 meters and is made up of four distinct layers with a soil developed on each. This seems to indicate time periods of continuous accumulation separated by periods of a different and less favorable climate. Scientists estimate that major deposits of loess date back 10,000–80,000 years. It is of particular interest to note that, in China, loess deposits up to 300 meters have been found in which 20 paleosols have been identified.[9]

Weathering action in the mountains has reduced huge quantities of rock to fine material prior to its transport by river and wind. What period of time must have been involved in this sequence of events?

Photo 3: Five-hundred-year old lava flow, Rangitoto Island. No soil formation occurred; scattered vegetation with roots among rocks is visible.

Conclusions

I have been a Seventh-day Adventist all my life. I firmly believe in a Creator-God and have been thrilled as advances in molecular biology have revealed the handiwork of a master designer. However, as I have studied soils and their development, I cannot reconcile what I see and what careful scientific studies have shown with a short chronology for the history of the earth.

In the light of evidences for a longer period of earth history than allowed for in a short chronology, how are faith and science reconciled within the Adventist Church? I believe that it is absolutely essential for there to be an ongoing and regular dialogue.

In 1892 Ellen White wrote regarding searching the scriptures: *"We have many lessons to learn and many, many to unlearn. God and heaven alone are infallible. Those who think that they will never have to give up a cherished view, never have to change an opinion, will be disappointed."*[10] This statement is associated with a plea for much more study of the Scriptures. I believe that if this applied to the Bible in her day, it is not out of context to apply it to the Bible, as well as nature and science, today. Ellen White made another statement: *"The book of nature and the written word shed light upon each other."*[11] To me that means it's not a one-way street, but there's a real place for students in both disciplines to keep talking to each other. Maybe I will be led to change my opinion (and that would solve some other theological problems for me!), or maybe others will be led to change theirs. Research scientists live with uncertainty and not knowing all the answers. If a research sci-

entist were certain about all the answers, there would be nothing to research, and researchers would be out of a job! There is a need for everyone interested in faith and science studies to adopt a truly scientific outlook. I don't know all the answers, but I want to have a part in finding at least some of them. As knowledge increases, I want to hear about it and enter the discussion. ■

Footnotes

1. There are a number of soil science textbooks available, but an easy-to-read book about soil formation and New Zealand soils has been written by Les Molloy. See Malloy, Les. 1988. *Soils in the New Zealand landscape: The living mantle*. New Zealand Society of Soil Science.

2. Clarkson, et al. 1988. "Composition and structure of forest overwhelmed at Pureora Central North Island, New Zealand, during the Taupo eruption (c.AD 130)." *Journal of the Royal Society of New Zealand* 18: 417–436.

3. Lowe, D. J. 2002. "Norman Taylor Memorial Lecture: The Time Machine." *New Zealand Soil News* 50.6: 124–135. This review article cites numbers of relevant articles.

4. *See* Molloy, 1988, 19.

5. Lowe, D. J. 1988. "Stratigraphy, age, composition and correlation of late Quaternary tephras interbedded with organic sediments in Waikato lakes, North Island, New Zealand." *New Zealand Journal of Geology and Geophysics* 31: 125–165. This article gives a full description of the occurrence of 41 ash and lapilli layers that have been found in 14 lakes. The layers are from c.2 to 110 mm in thickness.

6. Vucetich, C. G., and W. A. Pullar. 1973. "Holocene tephra formations erupted in the Taupo area and interbedded tephras from other volcanic sources." *New Zealand Journal of Geology and Geophysics* 16:745–780.

7. Schofield, J. C. 1958. "Notes on volcanism and structure Franklin County." *New Zealand Journal of Geology and Geophysics* 1:541–59.

8. *See* page 19 in Molloy above (footnote #1).

9. Burbank, D.W. and Li Jijun. 1985. "Age and Paleoclimatic significance of the loess of Lanzhou, North China." *Nature* 316:429–31.

10. White, Ellen G. *Review and Herald* (vol. 7 1892): 26. There are similar statements in other publications.

11. White, Ellen G. *Education*. 128.

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