When the Earth's crust explodes

By M. Elaine Kennedy

A study of the volcanos around the Pacific Rim helps us understand the factors causing earthquakes and eruptions.

You live in California and you are proud of your beautiful home. It overlooks the blue waters of the Pacific Ocean. One sunny afternoon, you are sitting on your favorite chair on the deck, watching the white waves tirelessly, but rhythmically, beating away now with gentleness, now with thunder. The radio is playing your favorite music, and life seems so quiet, sweet, and enjoyable. Suddenly the music is interrupted. An early warning emergency system goes into operation. A possible volcanic eruption accompanied by earthquake on the rim of the ocean seems imminent, and you along with your neighbors are asked to evacuate to a safer location.

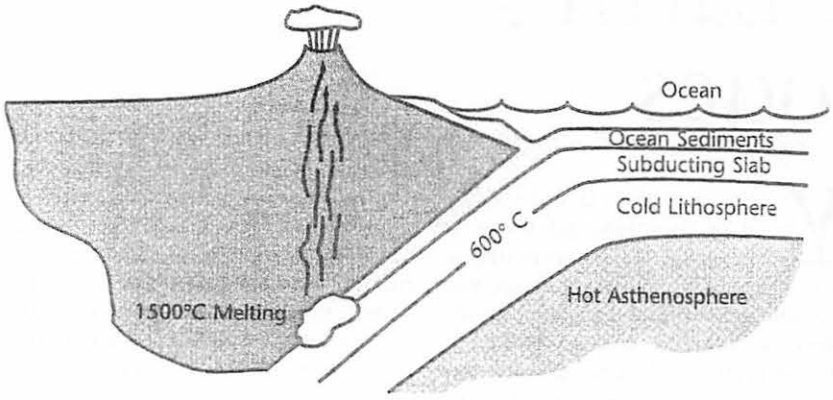
Fiction? Not any more. A ring of volcanic and earthquake activity is being felt around the rim of the Pacific Ocean. Volcanologists, with the help of modern technology, are able to monitor dormant and active volcanos in the Pacific Rim, identify indicators of increased activity that may lead to eruptions, and issue early warning to communities living along the Pacific Coast.

Such an increased understanding of the subsurface processes may also increase the predictive power of the volcanologists. But understanding these processes does not answer the crucial human question, "Why does this happen?" Other information sources are needed to help us grapple with that issue. The answer remains speculative, but some basic information about the processes that produce some of the molten rock within the earth may be helpful. Since there is a volcanic rim around the Pacific Ocean, this essay will begin by looking at that region.

The ring of fire

Along the margins of the Pacific Ocean there are deep trenches. The Pacific Ocean floor sinks into these trenches and slides below the rocks that form the continental crust. (See figure.) This process is referred to as subduction,[1] and volcanologists suggest that this subduction process produces the source material for most of the volcanism surrounding the Pacific Ocean, hence the phrase "Ring of Fire." The subducting oceanic slab carries seawater and some crustal material with it. The more deeply these materials are subducted, the higher the temperatures and pressures around the rocks. Eventually the combination of volatiles or gases produced from the seawater and crustal material combined with increasing pressures and temperatures cause melting of the subducted slab and upper mantle.[2] The melted rock or magma then begins to rise through the continental crust, generating new, and utilizing old, fractures and faults and incorporating additional crustal material as it moves.[3] (See figure.)

When the crustal rocks melt, some rock types chemically decompose and release gases such as carbon dioxide and sulfur dioxide. The rising magma may mix with magmas from other sources, which also contribute volatiles. Gases increase the pressure within the magma and decrease its density, which aids in the upward movement of the molten rocks along faults.[4] However, molten rock moving along fractures does not mean that a volcano is about to erupt. Vulcanologists look for specific indicators of imminent volcanic activity.



Eruption precursors

Data on volcanos is collected worldwide because scientists want to know when the next eruption will occur. Information that seems most useful includes seismic (earthquake) activity and types of gases that are emitted. Common gases released from volcanic fissures and craters include sulfur dioxide, carbon monoxide, carbon dioxide, hydrogen sulfide, and water vapor.[5] Earthquake activity increases dramatically just prior to an eruption. Most of the activity is about 4 or less on the Richter Scale; however, larger-scale earthquakes can occur with loud noises, liquefaction, and other earthquake-related activity.[6] As pressures build within the magma chamber due to the incorporation of volatiles from the surrounding crustal rocks, the potential for eruption increases.[7]

The eruption

Eruption occurs when the pressure in the magma chamber exceeds the pressure exerted by the weight of the overlying rocks. Loud explosions and earthquakes often precede and accompany the ejection of lava, incandescent rocks, gases, and ash.[8] Once the eruption occurs, many people are interested not only in what happened but also ask, "Why did this occur?"

Christian framework

Within religious communities, earthquakes and volcanic eruptions have been of interest since they have been commonly referred to as "acts of God." Some think that in the past, people attributed volcanoes and earthquakes to God or evil spirits out of ignorance but the Book of Job makes it clear that both God and Satan act in nature (see Job 1:6-12). Now that more is known about the processes involved in the eruptions, people no longer consider such activity as divine or mystical intervention. The Christian community recognizes the difficulty in knowing how or when God might use natural processes to His purpose (see Matthew 21:18-22; Luke 13:4, 5). Thinking that we know how something works does not mean that God is not involved in the timing of the event or the process. The concept is a difficult one since we do not know the mind of God. We do not know if any or all of the events include divine intervention or if most are simply processes that occur randomly in our world. Our lack of knowledge on this topic should lead us to be cautious with our comments about end of the world events and judgments (see Mark 13:8; Luke 21:9-11, 25-28).

Volcanism during the Genesis Flood

There is another aspect of volcanism that should be considered from a biblical-Christian perspective. The continental and oceanic rocks contain an extensive record of volcanism. Seventh-day Adventists believe that most of this record is part of the Genesis flood. The inclusion of volcanism in the Flood account increases the complexity and devastation of that event. (See page 15.) Aerially extensive basalt flows such as the Siberian Traps, Deccan Traps in India, Parana Basalts in Brazil, and the Columbia River Basalts in the northwestern United States, may have begun during or near the end of the Genesis flood. In addition, widespread volcanic ash beds are found interbedded throughout the rock layers of earth's crust.

During discussions of the biblical flood, Christians comment on the destructive power of the flood waters but seldom refer to the volcanic and earthquake-related devastation that accompanied that event. As Christian scientists continue to study the geologic record, their awareness of the complexity of the Genesis flood increases.

Conclusion

Very little is really known about the subsurface processes that contribute to volcanism. Most of the theories are developed from surface measurements. As volcanologists attempt to study these processes, they hope to explain why eruptions occur.

Within the Christian community there is an awareness of a power beyond the physical and chemical processes observed in nature. The biblical interpretation of volcanos, earthquakes, floods as judgments causes Christians to question the randomness of events. Many Christians consider most natural disasters to be random events, part of a sinful world. The biblical perspective ties these

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Ellen G. White on volcanism and earthquakes

Ellen White made several comments on volcanism and earthquakes.* One of the most complete statements, included in a book first published in 1890, is this:

"At this time [the Genesis Flood] immense forests were buried. These have since been changed to coal, forming the extensive coal beds that now exist, and also yielding large quantities of oil. The coal and oil frequently ignite and burn beneath the surface of the earth. Thus rocks are heated, limestone is burned, and iron ore melted. The action of the water upon the lime adds fury to the intense heat, and causes earthquakes, volcanoes, and fiery issues. As the fire and water come in contact with ledges of rock and ore, there are heavy explosions underground, which sound like muffled thunder.

The air is hot and suffocating. Volcanic eruptions follow; and these often failing to give sufficient vent to the heated elements, the earth itself is convulsed, the ground heaves and swells like the waves of the sea, great fissures appear, and sometimes cities, villages, and burning mountains are swallowed up. These wonderful manifestations will be more and more frequent and terrible just before the second coming of Christ and the end of the world, as signs of its speedy destruction" (*Patriarchs and Prophets* [Mountain View, California: Pacific Press Publ. Assn., 1958], pp. 108, 109).

Ellen White's description of processes contributing to volcanism are very similar to the ideas published by the geologists of her day. This explains why much of the language used is more descriptive than scientific. A century ago, plate tectonic theory had not been developed and the geologic community focused solely on the eruption process. Four aspects of these descriptions are discussed below:

1. "Coal and oil frequently ignite and burn. . . . limestone is burned."

The phrase "ignite and burn" may be an attempt to describe the incorporation of coal and oil into the molten rock rising through the crust. This process occurs continuously as magma rises within the continental crust. In another reference,* White notes that volcanoes are not typically found near the major coal, oil, and gas deposits. This statement may indicate her awareness that it is not the burning of the coal that melts the surrounding rocks but rather that the molten rock ignites the coal and oil. However, she does support the idea that coal and oil contribute to volcanism in some way. She does not specify the process that "ignites" the coal and oil, so the phrase "thus the rocks are heated" may not refer to the "burning" coal and oil but rather to the process responsible for the burning, i.e., ascending magma (an unknown concept at that time). It is interesting to note that she refers to limestone as burning and iron ore as melting, again indicating the destruction of the limestone into its various components.

2. "The action of the water upon the lime adds fury to the intense heat, and causes earthquakes, volcanoes, and fiery issues. As the fire and water come in contact with ledges of rock and ore, . . ."

In non-scientific language the author describes the importance of the volatiles within the magma chamber relative to the eruption process. Coal and oil primarily produce carbon, sulfur, and hydrogen as they come into contact with the ascending molten rocks. Water is present as a gas and limestone is the source of carbonate ions ($CO_3^=$) that recombine to form a variety of gases. These components form the gases monitored by vulcanologists today.

3. "The earth itself is convulsed. . ."

Those who were close to Mount St. Helens on May 18, 1980 and lived to tell the tale spoke to reporters about the "hot and suffocating" air as well as the explosions. Earthquake activity is frequently associated with volcanic eruptions due to the increasing subsurface pressures that generate some of the "explosions underground" as well as surface waves (the "ground heaves and swells").

"Great fissures appear, and sometimes cities, villages, and burning mountains are swallowed up."

The phrase "great fissures appear" sounds as though these fissures "swallowed up" cities, etc. While it is true that large regions are engulfed, the destruction is due to the lava and ash that erupt through the new vents, thus the villages may be "swallowed up" by the flowing lava. This reading of the passage is more consistent with the opening phrase "Volcanic eruptions follow; . . ." and it may be understood in this context that the earthquakes generate the fissures that may form vents that allow additional lava and ash to escape.

The frequent reports of volcanic and earthquake activity in the public news broadcasts do not include a Christian perspective. Ellen G. White cites volcanoes and earthquakes as powerful reminders that catastrophic destruction is a very real part of our world and that our world can and will end quickly. White also assures us that there is a larger context and, as is typical of her writing, it is her final sentence in this paragraph that points us to the second coming of Jesus Christ.

**A list of additional sources for these comments may be obtained from the author at Geoscience Research Institute, Loma Linda University; Loma Linda, California 92350; U.S.A.*

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events to the end of the world, and their occurrence should strengthen our faith in the second coming of Jesus. A sudden notable increase in the frequency of natural calamities is predicted just prior to the return of Christ. Although friends and family may perish during one of these disasters, Christians have faith in the abiding, undying love of the Father for His children. These processes remind us of the greatness of God's power, and His ability to control the forces of nature.

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Articles on related subjects published in this journal: Harold G. Coffin, "Coal: How Did It Originate?" (6:1); William H. Shea, "The Flood: Just a Local Catastrophe?" (9:1).

Notes and references

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