Was explosive volcanism in the Precambrian geologic record happening during Creation Week?

Max Hunter

The Precambrian geologic record, which many young-earth creationists argue was deposited during Creation Week, contains volcanic lava sequences up to 22 km thick, and abundant evidence of explosive volcanic eruptions. Fragmental pyroclastic accumulations from explosive eruptions in the Precambrian attain thicknesses exceeding 1 km. Ashfall tuffs, accretionary lapilli, and ballistically erupted volcanic bombs are evidence of extremely violent explosive eruptions that dispersed volcanic ash widely through the atmosphere. Some ignimbrites, pyroclastic rocks which form some of the largest eruptive units known, exceed 1 km in thickness. The explosive eruption of Mt St Helens volcano in Washington State, USA on 18 May 1980, produced pyroclastic deposits just 80 m thick. The atmospheric eruption column from the Mt St Helens eruption comprised an uncompacted volume of just 0.73 km^3. Precambrian explosive volcanic eruptions were many times more destructive than the Mt St Helens eruption.

Such destructive volcanic activity in the Precambrian seems irreconcilable with the creative activity of the first six days of Creation Week recorded in Genesis 1:1–31. The Precambrian geologic record is thus considered to have been deposited during a particularly destructive stage of the Genesis Flood cataclysm; probably the first 40 days, as the floodwaters were rising toward their maximum level.

The place of the Precambrian geologic record, and the location of a pre-Flood/Flood boundary in the global geologic record, in a Genesis Flood geological model, have been discussed at length in the creationist literature. Today, almost three quarters of a century since the publication of Whitcomb and Morris's inspirational book *The Genesis Flood* in 1961, these fundamental issues remain unresolved. Opinion remains divided as to how much, if any, of the Precambrian is Flood deposited, and how much may have been formed during Creation Week and/or the antediluvian period. The resolution of the Precambrian issue is crucial to the development of a viable Genesis Flood geologic/tectonic model.

An awareness of the nature of destructive geologic activity during deposition of the Precambrian geologic record should assist in the resolution of the Precambrian issue.

Throughout the Precambrian geologic record, and especially in the earliest Precambrian, there is much evidence of massive volcanic activity, including 22-km-thick lava accumulations. Much of that volcanic activity was explosive, as evidenced by accumulations of volcanic fragmental pyroclastic rocks throughout the global Precambrian record.

In this work, documentation regarding the magmatic pyroclastic products of the comprehensively observed, documented, and publicized Mt St Helens explosive volcanic eruption in Washington State, USA, on 18 May 1980 is reviewed. The nature of explosive volcanism and its pyroclastic products is examined, and some occurrences of pyroclastic accumulations throughout the Precambrian rock record are documented. The thicknesses and volumes of pyroclastic accumulations from explosive eruptions found throughout the Precambrian are compared to the thickness and volume of magmatic pyroclastic accumulations from the Mt St Helens explosive volcanic eruption. The implications of destructive explosive volcanic activity during Creation Week are considered, and the placement of the Precambrian in a biblical Creation Week/Genesis Flood timeframe is assessed regarding those implications.

Radiometric dates quoted in the secular literature are accepted as approximately correct relative to each other, and Precambrian correlations are recognized as being established by a combination of lithostratigraphic correlation and radiometric dating.

Mt St Helens explosive eruption

The explosive eruption of Mt St Helens volcano began at 8.32 am on 18 May 1980 and continued for some nine hours. The explosive eruption and its pyroclastic products are the most comprehensively observed, documented, and publicized explosive volcanic phenomena ever recorded. The explosive ejection of magmatic material from Mt St Helens resulted in the deposition of two main classes of pyroclastic deposits:

(1) proximal (near vent) pyroclastic flow, surge, and ashfall deposits, and (2) downwind atmospheric ashfall deposits.

The proximal flow, surge, and ashfall deposits, which extend to about 10.0 km from the volcano vent, are comprised of, from the base up, a 12-m-thick basal layer of lithic-rich material, an approximately 20-m-thick layer of pumice and ash-flows, an 8–35-m-thick layer of ash-flows, and a 12-m-thick terminal upper layer of sheetlike ash-flow tongues.[1] Criswell measured the maximum aggregate thickness of these proximal pyroclastic ash flow, surge, and fall deposits at approximately 79.0 m. The uncompacted volume of these deposits is estimated to be approximately 1.37 km^3.

The downwind atmospheric ashfall deposits from the Mt St Helens eruption extend for at least 1,000 km from the vent and included pumice lapilli, pumice ash, and lithic ash. Sarna-Wojcicki *et al.*[2] measured the thickness of these downwind atmospheric ashfall deposits from the eruption column and recorded a maximum thickness of just 70 mm near the volcano vent. They calculated an approximate volume of the uncompacted downwind ashfall deposits of 0.73 km^3 which, if compacted, they estimated would comprise a volume of just 0.14 km^3.

The total uncompacted thickness of magmatic material explosively ejected from the Mt St Helens volcano is thus estimated at approximately 80.0 m, and the total uncompacted volume is estimated at approximately 2.10 km^3. These thicknesses and volumes of magmatic pyroclastic material from the Mt St Helens eruption can be compared with the thicknesses of explosive pyroclastic accumulations found throughout the Precambrian geologic record. This gives a rough comparison of the magnitude of explosive volcanic episodes during the Precambrian with that of the Mt St Helens explosive eruption, with which many readers may be familiar.

Explosive volcanism

There are three types of explosive volcanic eruption mechanisms: (1) magmatic, (2) phreatomagmatic, and (3) phreatic. *Magmatic explosive volcanic eruptions* occur when volatiles are exsolved from magma as it rises toward areas of lower pressure near the earth's surface. The dominant volatile components in magmas associated with explosive volcanic activity are CO_2 and H_2O. The solubility of these two volatile components is controlled, in part, by confining pressure, and their solubility decreases as magmas rise toward shallow crustal levels which have lower confining pressures. At some point CO_2 and H_2O begin to exsolve from the magma as separate fluid and gaseous phases. Crystallization of the magma concentrates the dissolved volatile components, resulting in higher vapour pressure, leading to boiling if vapour pressure becomes equal to the confining pressure.

Cas and Wright note: "The exsolved phase causes an enormous increase in pressure within the magma chamber … and the potential increase in volume of the system during this crystallisation and boiling can be up to 53%."[3] They also note that, once exsolved to this stage, "explosive fragmentation of the magma due to exsolution of volatiles can occur".[3] *Phreatomagmatic explosive volcanic eruptions* occur when interaction of hot magma with external water causes explosive fragmentation and eruption of magmatic ejecta driven by exsolution of volatiles from both the magma and the external water. *Phreatic* (*steam*) *explosive volcanic eruptions* occur when molten magma interacts with subsurface groundwater or a surface body of water. Contact of the hot magma with water causes superheating, boiling, volatilization of the water, and build-up of gas pressure in the water and explosive expansion of the gas.

Cas and Wright note that explosive volcanic eruptions produce fragmental pyroclastics, which they define as "those aggregates formed by explosive volcanic activity *and* deposited by transport processes resulting directly from this activity [emphasis original]."[4] Pyroclastic deposits, they note, "form directly from the fragmentation of magma and rock by explosive volcanic activity."[5] They can be grouped into three types according to their mode of transport and deposition: falls, flows, and surges.

Pyroclastic fall deposits are those formed by fallout of tephra from an atmospheric eruption column. Large fragments explosively ejected follow ballistic trajectories through the atmosphere and fall back to the earth's surface as volcanic blocks or bombs. Pyroclastic flow deposits are those left by surface flows of pyroclastic debris comprising high-particle-concentration gas–solid aggregates. Pyroclastic surge deposits are those deposited by transport of pyroclastic debris as turbulent, low-particle-concentration gas–solid dispersion.

Volcaniclastic rocks are fragmental aggregate volcanic rocks, irrespective of mode of origin, such that all pyroclastic rocks are volcaniclastics, but not all volcaniclastic rocks are pyroclastics (i.e., of explosive origin). Some Precambrian fragmental rocks described in the Precambrian literature as volcaniclastics may be pyroclastics.

Subaerial and subaqueous explosive volcanic eruptions

Explosive volcanic eruptions can be subaerial or subaqueous. In subaerial explosive eruptions, primary pyroclastic deposits are formed by eruptive fragmentation, followed by transport of ejected material through the atmosphere and subsequent fall to the earth's surface. In subaqueous explosive eruptions, primary pyroclastic deposits are formed by eruptive fragmentation, followed by transport through the water column. Two additional factors that exist in subaqueous explosive eruptions are the effect of hydrostatic pressure and the physical interaction between hot magma and cold water. White[6] notes that deposits from subaqueous explosive eruptions form by settling from the water column or by subaqueous density currents. He also notes that, because of the preservation bias in favour of subaqueous deposits, the preserved volumes of subaqueous deposits probably exceed those of subaerial deposits.

Some products of explosive volcanism

Cas and Wright note:

> "Pyroclastic deposits are composed of pyroclasts, a loose term for any fragment released in a volcanic explosion or eruption. Pyroclasts can have a wide range of sizes … . Fragments greater than 64 mm in diameter are called *blocks* or *bombs*, those between 64 mm and 2 mm … are called *lapilli*, and those less than 2 mm … are called *ash* [emphases in original]."[7]

There are three principal kinds of pyroclasts found in pyroclastic deposits: (1) juvenile fragments—samples of the erupting magma; (2) crystals—free crystals and angular fragments of crystals released by the explosive fragmentation of magma; and (3) lithic fragments. Some pyroclastic products of explosive volcanic eruptions found in the Precambrian rock record are as follows:

- *Blocks/bombs*—large fragments (>64 mm) of mantle magma or country rock material which are ejected into the atmosphere from the volcano vent, follow ballistic paths, and fall back into pyroclastic deposits.
- *Lapilli*—fragments between 64 mm and 2 mm.
- *Accretionary Lapilli*—lapilli-sized pellets of ash found in pyroclastic fall, surge, and flow deposits. They are formed by the accretion of fine ash around a nucleus, including water droplets as rain flushing an eruption column or an ash cloud of a pyroclastic flow. They also form in the steam-rich columns of phreatomagmatic and phreatic eruptions.
- *Lapillistone*—the lithified form of accretionary lapilli.
- *Ash*: the fine grained (<2 mm) product of explosive volcanic eruptions. There are three main types of ash: (1) lithic ashes, which comprise volcanic or igneous rock fragments; (2) vitric ashes, which comprise uncrystallized glass fragments; and (3) crystal ashes which dominantly comprise crystals.
- *Tephra*—a collective term for all pyroclastic deposits/fragments, including those deposited in pyroclastic falls, flows, and surges.
- *Tuff*— "the lithified equivalent of an ash deposit". The term is applied to "aggregates that have been demonstrably fragmented *and deposited by pyroclastic processes*, and in which the grainsize of the pyroclasts is <2 mm [emphasis in original]."[8] Tuffs can be air fall tuffs, ash-flow tuffs, or ash surge tuffs.
- *Lapilli tuff*—a tuff with fragments 2–64 mm.
- *Agglomerate*— "a coarse pyroclastic deposit composed of a large proportion of rounded, fluidally shaped, volcanic bombs … . a fall deposit … a very good indicator of proximity to the vent."[9]

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Figure 1. Eruption column of 18 May 1980 explosive eruption of Mt St Helens. The atmospheric eruption column, which reached a maximum height of 25 km, comprised an uncompacted volume of about 0.73 km^3 of tephra, and deposited a maximum thickness of 70 mm of magma-derived ashfall material close to the volcano vent.

- *Ignimbrite* ('pumice-flow deposit')—"the rock or deposit formed from pumiceous pyroclastic flows irrespective of the degree of welding or volume".[10] Cas and Wright note that "Ignimbrites are the most voluminous of volcanic products. Some are the largest single eruptive units known, covering thousands of square kilometres and having volumes of more than 1000 km^3 … they must be the most cataclysmic of all geological phenomena."[11]
- *Eruption column*—(figure 1) comprises gas, dust, ash, etc. ('*tephra*'), discharged into the atmosphere from the volcano vent. Eruption columns can rise to a 45 km height in the atmosphere.

Combinations and variations of these explosive volcanic products are found throughout the Precambrian literature.

The Precambrian record of explosive volcanism

Records of some occurrences of pyroclastic deposits from explosive volcanic eruptions found in the Precambrian geologic record throughout the globe (figure 2) are documented as follows.

Antarctica

Late Precambrian porphyritic silicic igneous rocks dated at c. 0.60–0.70 Ga, comprising pyroclastic crystal-rich silicic tuffs characterized by a coarse crystal assemblage, occur in

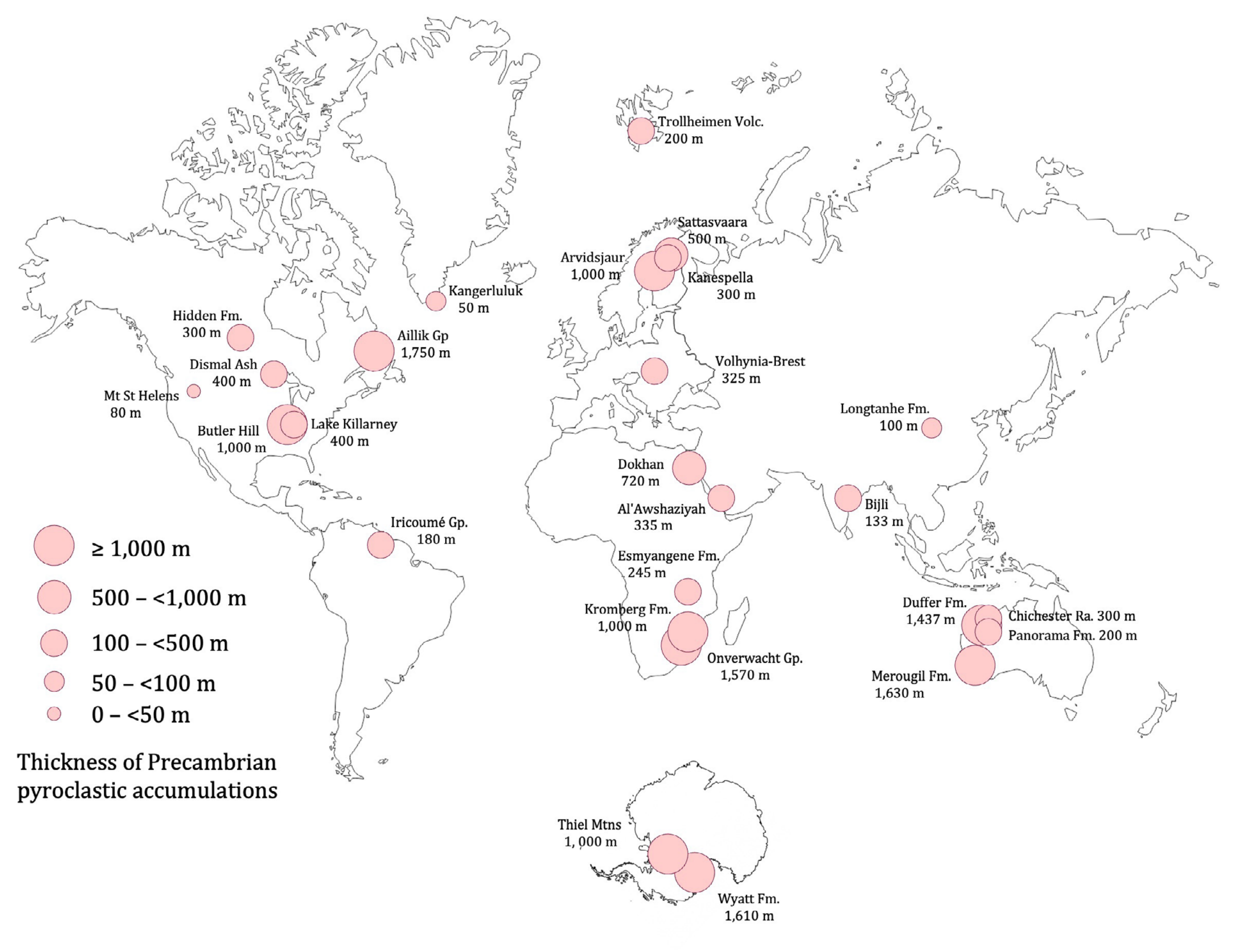

Figure 2. Global distribution of some selected explosive pyroclastic accumulations throughout the Precambrian geologic record. Pyroclastic accumulations probably exist in Precambrian rocks of the Aldan and Anabar Shields of Russia, and in the North China, South China, and Tarim Cratons in China, but information is difficult to access.

the Thiel Mountains in Antarctica. Ford and Sumsion note, regarding these pyroclastic rocks:

> "Eruptions must have occurred on an immense scale to have produced the great volumes of tuffaceous material, which in the Thiel Mountains alone total at least an estimated 5,000 km^3. Explosive episodes likely produced ash-flow tuffs, in addition to air-fall and waterlain deposits."[12]

Murtaugh[13] documented the geology of the metavolcanic rocks of the c. 0.63 Ga *Wyatt Formation* in the Wisconsin Range of Antarctica. Murtaugh notes that the *Wyatt Formation* comprises quartz fragments and felspar crystals set in a matrix of aphanitic quartz and felspar, and that the nature of the fragments is suggestive of a pyroclastic origin. Noting that neither the thickness nor the attitude of the *Wyatt Formation* is known, Murtaugh estimated its thickness to be perhaps more than one mile (1,610 m). Katz and Waterhouse[14] note that probable correlatives of the *Wyatt Formation* rocks in the Queen Maud Range are also largely of pyroclastic origin.

Australia

Blake[15] notes that the upper part of the lower Chichester Range Megasequence, dated at c. 2.77–2.72 Ga, in the Nullagine Synclorium, in the eastern Pilbara Basin of Western Australia, comprises six tuff-to-basalt cycles. Blake notes that the basal tuff horizons, one of which attains a thickness of 300 m, are the product of explosive pyroclastic volcanism due to the interaction of rising magma with ground or surface water.

DiMarco and Lowe[16] note the *Duffer Formation*, dated at c. 3.40 Ga, in the early Archean Warrawoona Group in the East Pilbara Block, Western Australia, comprises up to a 5.0 km thickness of dacitic to rhyolitic volcaniclastic breccia deposited by debris flows, interbedded tuff layers, and mafic lava. One turbiditic tuff and tuff-breccia unit in the *Duffer Formation* is some 1,437 m thick, and a graded breccia unit is some 2,294 m thick.

Brown *et al.*[17] note that the *Panorama Formation*, dated at c. 3.46–3.43 Ga, which overlies the *Duffer Formation*, attains a thickness of up to 1.0 km and comprises silicified volcaniclastic sandstone, tuff, and tuff breccia, with lesser silicified breccia, conglomerate, siltstone, felsic lava and chert. DiMarco and Lowe[18] note a 200-m-thick accumulation of subaqueous ashfall tuff within the *Panorama Formation* and attribute an upward increase in the proportion of ash-sized detritus in the felsic sequence to a progressive increase in explosive pyroclastic activity with time.

The late Archean *Early Merougil Formation*, dated at c. 2.67 Ga, in the Eastern Goldfields of the Yilgarn Craton, Western Australia, is some 1,630 m thick and comprises massive, coarse-grained quartz-rich sandstone, dominated by large grains of volcanic quartz and minor felspar crystal fragments. Squire *et al.* note as follows regarding the *Early Merougil Formation*:

> "… the abundance of juvenile volcanic lithic fragments, including broken volcanic quartz crystals and lesser feldspar … the strikingly homogenous detrital-zircon age population … and the large volumes of crystal-rich sandstone are consistent with these units being sourced from a major pyroclastic eruption."[19]

Canada

Hinchey[20] documents the c. 1.88–1.85 Ga volcano-sedimentary *Aillik Group* in the Proterozoic (Orosirian) strata of the Makkovik Province, Labrador, Canada. Hinchey notes that the *Aillik Group* has a minimum stratigraphic thickness of 14.9 km and comprises a variety of volcaniclastic and pyroclastic lithologies. Between Ford's Bight and Big Bight on the Labrador coast the *Aillik Group* sequence is some 8.71 km thick. Some 4.5 km (52%) of that sequence comprises massive coarse felsic tuff and fine lapilli. Between the Narrows and Ford's Bight on the coast, the *Aillik Group* sequence is some 9.62 km thick, of which some 6.71 km (70%) comprises pyroclastic and volcaniclastic lithologies, including tuffaceous conglomerate with volcanic and pyroclastic clasts, tuff, and lapilli tuff, stratified tuff, and lapilli. Hinchey considers the 4.5–6.7 km thick pyroclastic and volcaniclastic components of the *Aillik Group* to be well-preserved examples of the products of subaqueous to intermittently subaerial phreatomagmatic explosive pyroclastic volcanism and sedimentation.

Schaefer[21] studied the *Dismal Ashrock Formation*, dated at c. 2.70 Ga, in the Steep Rock Group in the Wabigoon Subprovince of the Superior Province, Ontario, Canada. Schaefer describes this unit as a 100–400 m thick accumulation of komatiitic pyroclastic deposits, comprising komatiitic lapilli-tuff, with subordinant komatiitic volcaniclastic rock, mafic lava flows, and komatiitic volcanic breccia. Schaefer concludes the presence of pillowed lavas associated with the *Dismal Ashrock Formation* indicates subaqueous deposition, and that the presence of composite lapilli is unequivocal evidence that the pyroclastic deposits are the result of phreatomagmatic explosive volcanism.

The *Hidden Formation* in the Paleoproterozoic Flin Flon arc assemblage, dated at c. 1.91–1.88 Ga, in the Schist-Mandy area, Canada, comprises interbedded mafic breccias and megabreccias, tuff breccias, scoria breccias, lapilli-tuffs, lapillistones, crystal-rich tuffs, and pillowed basalt lavas. DeWolfe and Pittman[22] document a >300-m-thick unit within the *Hidden Formation*, comprising tuff breccia, lapillistone, tuff, and crystal-rich lapilli tuff in the southern part of the Schist-Mandy area.

They conclude the mafic tuff and plagioclase crystal-rich volcaniclastic components of the *Hidden Formation* succession were deposited by subaqueous eruption-fed density currents derived from phreatomagmatic explosive eruptions.

China

Xiang *et al.*[23] studied the Neoproterozoic volcaniclastic, pyroclastic, and sedimentary rocks of the *Longtanhe Formation*, dated at c. 0.70 Ga, on the northern margin of the Yangtze Block, China. The *Longtanhe Formation* is 2,000 m thick and is comprised of volcanogenic sediments, including tuffaceous sandstones and siltstones, several primary volcaniclastic and some pyroclastic (tuff) interlayers. A conservative estimate of the aggregate thickness of the pyroclastic/volcaniclastic (mainly tuffaceous) component in the *Longtanhe Formation* is 100 m.

Egypt

The *Dokhan Volcanics*, a succession of intermediate and felsic lava flows and pyroclastics up to 1,200 m thick, dated at c. 0.70–0.65 Ga, covers large areas of the Eastern Desert and Sinai Peninsula in Egypt. The *Dokhan Volcanics* includes a high percentage of acidic lavas, pyroclastic agglomerates, and ignimbrites. El Sundoly *et al.*[24] note that the *Dokhan Volcanics* succession comprises rhyodacite porphyry flows, rhyolitic tuffs, crystal tuffs, lapilli tuffs, lithic tuffs, welded tuffs (ignimbrites), and rhyolitic and andesitic agglomerates. Assuming 60% as a high percentage, a reasonable (conservative) estimate of the thickness of the pyroclastic component of the *Dokhan Volcanics* is 720 m.

Finland

Saverikko[25] notes that in the Archean of the Baltic Shield in Finland komatiitic explosive volcanism was regional in extent and included "enormous magmatic explosions during the terminal stage of mantle upwelling". Saverikko[26] studied the mainly pyroclastic amphibole-chlorite (basaltic komatiite) strata of the Kumittsoiva komatiite complex area in the Jauritso Greenstone Belt of the Baltic Shield in northern Finland. At the nearby Kanespella komattiite occurrence, in the Salla Greenstone Belt, there is a unit of coarse pyroclastic rocks comprising agglomerates, pyroclastic breccias, and lapillistones, dated at c. 2.45–2.60 Ga. This unit is up to 915 m wide in outcrop, and its thickness is conservatively estimated at 300 m.

Saverikko[27] has documented the geology of the Archean *Sattasvaara komatiite complex*, dated at c. 2.43 Ga, in the Baltic Shield in Finland, noting that it is part of an extensive zone of explosive komatiitic volcanism. Pyroclastic rocks in the complex include tuffs and lapilli tuffs, lapillistone, lithic, vitric, and crystal ejecta, and pyroclastic breccia. Associated pillowed komatiitic lavas are evidence of subaqueous eruptions. Lapillistone strata extend for some 22 km along strike with outcrop widths of 1.0 km, giving a conservative estimate of their thickness at 500 m.

Greenland

Mueller *et al.*[28] studied the c. 1.80 Ga Paleoproterozoic 200–300-m thick volcanosedimentary sequence at Kangerluluk, southeast Greenland. This sequence includes a pyroclastic lithofacies up to 50 m thick, comprising a 1–30-m thick planar to cross-bedded tuff-lapilli tuff and a 5–15-m thick bedded lapilli tuff breccia. Mueller *et al.* interpret the bedded lapilli tuff breccia as having been emplaced by subaqueous mass flows, with ballistically emplaced ejecta being derived from contemporaneous explosive activity.

India

Mukhopadhyay *et al.*[29] studied the Paleoproterozoic *Bijli Rhyolites* in the Nandgaon Group of the Dongargarh Supergroup, in Central India. The *Bijli Rhyolites* unit, dated at c. 2.48 Ga, attains a maximum thickness of 4,500 m and comprises rhyolitic volcanics (ignimbrites) with lenses of fragmental coarse ash to lapilli tuffs, welded coarse ash tuffs, breccias, and agglomerates. In the Salekasa-Sonartola area, a 133-m-thick pyroclastic accumulation comprises, from bottom up, a 45 m basal layer of welded massive ash-flow tuff, 50 m of matrix supported tuff with floating lapilli, 20–23 m flow-laminated rheomorphic tuff, and 15 m of autobreccia. Mukhopadhyay *et al.* consider the *Bijli Rhyolites* are pyroclastic in origin and that the basal welded ash-flow tuff is the result of a gas-charged initial explosive phase, and the ash-flow tuffs are products of atmospheric eruption column collapse.

Norway

Ohta[30] documents abundant pyroclastics, including tuffs, and relatively small amounts of lava in the *Trollheimen volcanics*, dated at c. 0.90 Ga, in the late Riphean Precambrian strata of central western Spitsbergen, Norway. Ohta notes the *Trollheimen volcanics* unit is more than 200 m thick and comprises tuffs, tuff breccias, block lavas, and tuffaceous sediments, with minor pillowed basic lavas.

Saudi Arabia

Leo[31] documents the late Proterozoic *Al'Awshaziyah Formation* volcaniclastic strata, dated at c. 0.61 Ga, in the north-eastern part of the Arabian Shield. The *Al'Awshaziyah Formation*, Leo notes, is sourced from a large subcircular-shaped caldera marked by ash-flow sheets up to 200 m thick, and comprises welded tuff layers 20–40 m thick, interlayered with fine-grained rhyolitic to dacitic ashfall and ash-flow tuffs, volcaniclastic sediments, and minor conglomerate. Some individual ash-flow tuff units, Leo notes, are up to 200 m thick. A section of tuffs of the *Al'Awshaziyah Formation* at Jabal Dharaf is 335 m thick, and an estimated total thickness of the *Al'Awshaziyah Formation* is likely to be several km. The overlying volcanic and volcaniclastic *Aqab Formation*, Leo notes, is some 5,000 to 6,000 m thick and comprises andesites and basalts interlayered with rhyolitic and dacitic tuffs, felsic fragmental tuffs, and crystal tuffs.

South Africa

Thompson Stiegler *et al.*[32] note the presence of multiple layers of ultramafic komatiitic pyroclastic debris interstratified with komatiites, basalt komatiites, and felsic lavas of the *Onverwacht Group*, dated at c. 3.55–3.27 Ga, in the Barberton Greenstone Belt, South Africa. Pyroclastic deposits, including tuff layers up to 60 m thick, silicified komatiitic ash, and accretionary lapilli, comprise some 30–40% of the total accumulation, for an aggregate thickness of pyroclastic material of some 1,570 m. Noting that these pyroclastic deposits are the result of the explosive interaction of high Mg (komatiitic) melts with external water, Thompson Stiegler *et al.* note:

> "The regionally uniform bed thicknesses, great lateral extent, and low lithic contents suggest these were not restricted phreatic or littoral eruptions … but large explosions that generated plumes that dispersed ash over wide areas."[33]
>
> And
>
> "The wide distribution and abundance of such tuffs … indicates that large-scale explosive komatiitic eruptions were normal components of komatiitic volcanism … . these results indicate that komatiitic volcanoes could also generate extremely violent eruptions that dispersed fine ash widely through the atmosphere."[34]

Ransom *et al.*[35] document mafic pyroclastic sequences of the middle (K2) member of the *Kromberg Formation* of the Onverwacht Group in the Barberton Greenstone Belt, South Africa. Unit K2 of the *Kromberg Formation*, dated at c. 3.40 Ga, comprises a basal 0–100 m of fine-grained tuff, 300–1,000 m of massive lapillistone and lapilli tuff, and a thin capping layer of silicified ash and dust. They note that a 1,000-m-thick section of pyroclastic debris, comprising coarse lapillistone with accidental blocks of chert, was deposited

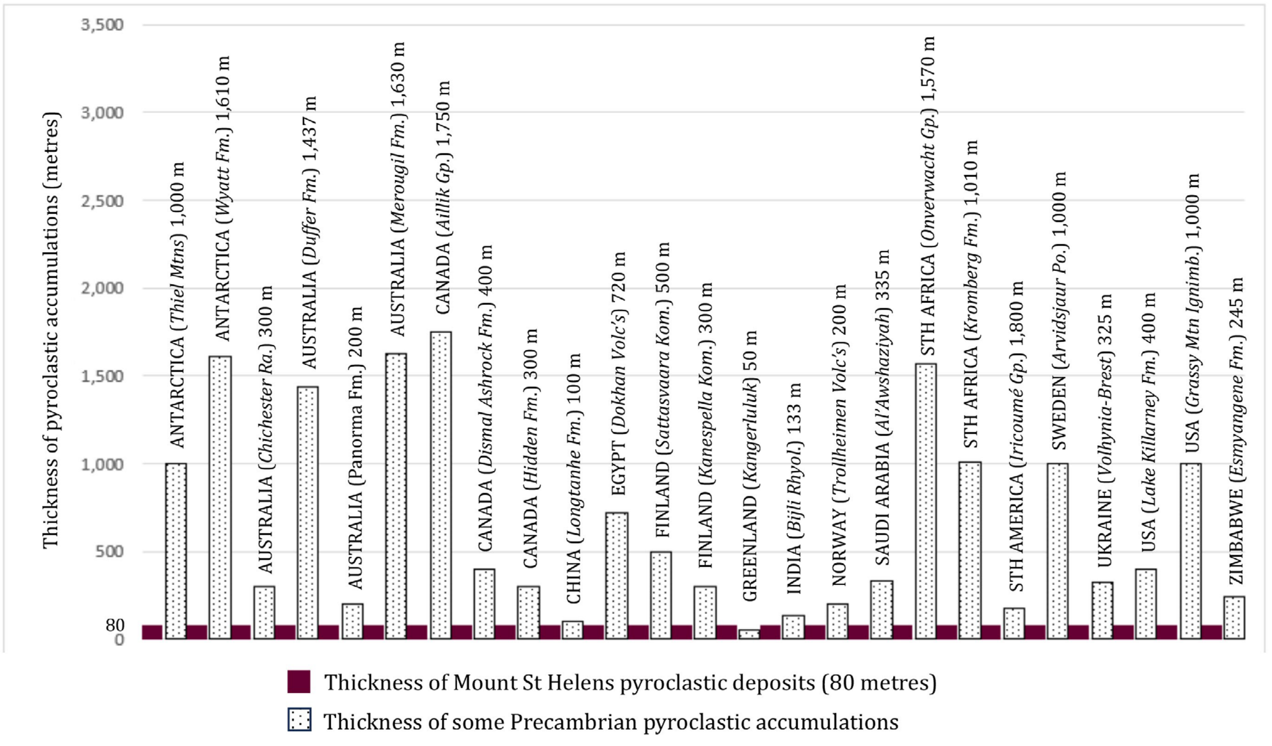

Figure 3. Thicknesses of pyroclastic accumulations throughout the Precambrian geologic record and thickness of magmatic pyroclastic deposits from the explosive eruption of Mt St Helens, on 18 May 1980

mainly by coarse subaqueous sediment flows and pyroclastic fall deposits, and represents the fill of a phreatomagmatic explosion crater.

South America

Baretto *et al.*[36] studied the *Iricoumé Group* in the Erepecuru-Trombetas Domain of the southern central Guiana Shield, South America. This unit is part of the widespread volcanic accumulation of the Uatuma volcano-plutonic event, dated at c. 1.89–1.87 Ga, which covers some 1.2 million km^2 on the Guiana and Brazil Central shields of the Amazonian Craton. The Uatuma volcano-plutonic event comprises abundant explosive, effusive and intrusive rocks.

The main volcanic rocks of the *Iricoumé Group* in the area studied are massive and stratified ignimbrites, comprising pumice, fiamme, and glass shards, lithic clasts up to lapilli size, and up to 40% crystal fragments of plagioclase, sanidine, and quartz, all transported by pyroclastic density currents during explosive events. In the Pitinga Mining District, some 375 km west of the area studied, Pierosan *et al.*[37] note that the *Iricoumé Group* covers some 4,500 km^2 and comprises porphyritic trachytes and rhyolites with crystal-rich ignimbrites and co-ignimbritic fall tuffs and surges. Flow foliation in the ignimbrites in this area is horizontal to subhorizontal, and the topographic relief is about 240 m. An approximate thickness for the *Iricoumé Group* is then some 240 m and, assuming some 75% of the Group comprises pyroclastics, a reasonable estimate of the thickness of the pyroclastics is 180 m. The volume of the *Iricoumé Group* in this area is similarly estimated at about 600 km^3.

Sweden

Lilljequist and Svenson[38] studied Precambrian Mesoproterozoic volcanic rocks of the *Arvidsjaur Porphyrie*s, dated at c. 1.57 Ga, around the Lake Rakkur area in northern Sweden. The *Arvidsjaur Porphyries*, they note, comprise felsic intrusive rocks and extrusive andesitic basic lavas and acid pyroclastic rocks (ignimbrites). The acid pyroclastic sequence comprises tuff lavas, agglomerates, dacitic and rhyolitic tuffs, lapilli tuffs, and welded tuffs (ignimbrites). A moderately to steeply dipping mapped sequence of the pyroclastic lithologies is some 1,200 m wide, giving a stratigraphic thickness of about 1,000 m.

Ukraine

Nosova *et al.*[39] studied the Neoproterozoic strata of the Volhynia–Brest magmatic province in the western East European Craton, dated at c. 0.55 Ga. The Volhynia–Brest strata comprise dominantly basaltic and tholeiitic lavas with interstratified tuffs and tuffaceous sandstones. A borehole (Borehole 1) through the sequence intersected 325 m of tuffs.

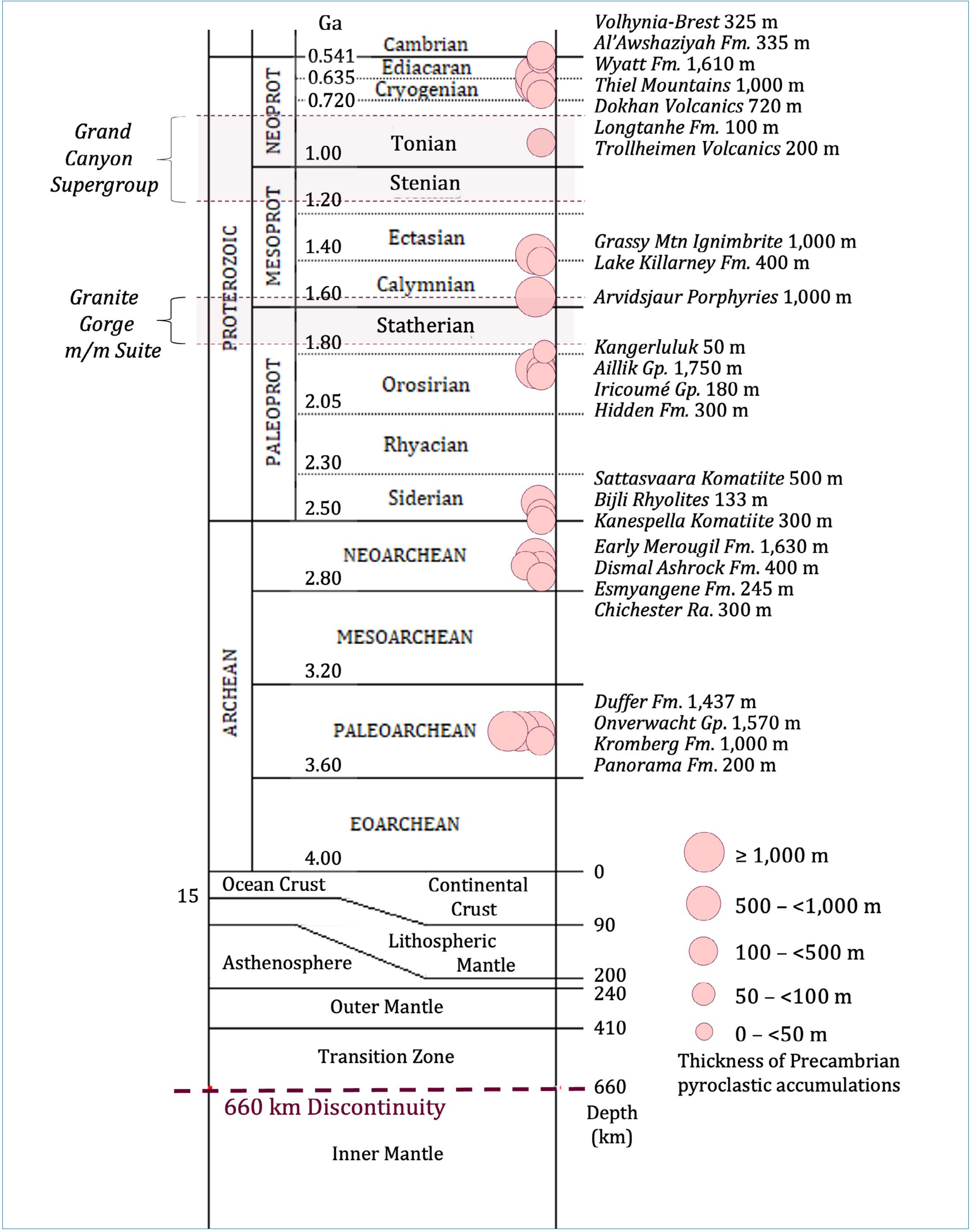

Figure 4. Distribution of pyroclastic accumulations from explosive volcanic eruptions throughout the Precambrian geologic record. Also showing the Grand Canyon Precambrian strata in the global geologic record.

USA

In the St Francois terrane of southeastern Missouri, USA, Precambrian Mesoproterozoic rhyolitic ignimbrites in excess of 1.0 km thickness occur over a considerable area. The *Lake Killarney Formation*, dated at ca. 1.40 Ga, in the Lake Killarney Caldera, was formed as an initial intracaldera eruptive. It is 300–400 m thick and comprises rhyolitic ash-flow tuffs, crystal-rich lithic tuff (brecciated in part), welded crystal tuff, autobreccias, minor lavas, and some discontinuous volcaniclastic horizons.[40,41]

The *Grassy Mountain Ignimbrite*, dated at c. 1.38 Ga, is the most widely distributed volcanic unit in the eastern St Francois Mountains area. In the Butler Hill Caldera this rhyolite ignimbrite with some lithic fragments of granophyre, basalt/diabase, and earlier ignimbrite, is about 1.0 km thick. Lowell[40] estimates the minimum original volume of this ignimbrite unit at some 100 km^3.

Zimbabwe

Williams[42] mapped the volcanic stratigraphy of the Zimbabwe Midlands area, noting that nickel sulphide deposits occurred at, or near, the contact between the Paleoproterozoic Sebakwian Group, and the Bulawayan Group. The Shangani nickel sulphide deposit is hosted in the *Esmyangene Formation*, dated at c. 2.70 Ga, which comprises acid to intermediate tuffs and agglomerate. At the Shangani Mine a felsic tuff unit and an agglomerate attain a thickness of some 245 m.

Discussion

In addition to 22-km-thick volcanic lava accumulations in the Precambrian geologic record,[43] there are significant accumulations of fragmental pyroclastic rocks, which are the products of explosive volcanic eruptions (figure 4). Some of these Precambrian pyroclastic accumulations are in excess of 1.0 km thick, and some comprise volumes in excess of 100 km^3. A turbiditic tuff in the *Duffer Formation* in the Warrawoona Group, Western Australia, for example, is 1,437 m thick.[18] The pyroclastic and volcaniclastic rocks of the *Aillik Group*, in Canada are 4.5–6.7 km thick.[20] The *Iricoumé Group* ignimbrites in the Pitinga Mining District of Brazil comprise a volume of some 600 km^3,[36] and the *Grassy Mountain Ignimbrite* in southeastern Missouri comprises a minimum volume of 100 km^3.[41]

By comparison, the magmatic pyroclastic products of the Mt St Helens explosive volcanic eruption are just 80 m thick and comprise an approximate total compacted volume of just 2.10 km^3. Some Precambrian pyroclastic accumulations from explosive eruptions are 10–20 times thicker than that of Mt St Helens,[16,19,32,35] and some may be up to 84 times thicker (figure 3).[20]

The Precambrian rock record is thus seen as a record of destruction on an almost unimaginable scale. Explosive volcanism, the most outstanding form of destructive geological activity, has produced, throughout the Precambrian, broken crystals, broken rock fragments, blocks and bombs, etc. Ashfall tuffs, accretionary lapilli, lapillistone, and volcanic blocks/bombs throughout Precambrian pyroclastic accumulations are evidence of huge subaerial atmospheric eruption columns (figure 1) comprising ash, dust, and gas, and ballistically ejected blocks/bombs. Atmospheric eruption columns during the Precambrian may have been 10–20 times, or more, larger than that of Mt St Helens.

The notion that the Precambrian rock record was deposited during Creation Week necessitates the belief that, in addition to the deposition of massive lava accumulations up to 22 km thick, widespread destructive explosive volcanism, producing huge atmospheric eruption columns, was occurring throughout Creation Week.

At the end of Day 6 of Creation Week, "God saw everything that He had *made*, and indeed "*it was very good*" (Gen. 1:31 NKJV, emphasis added). It might reasonably be argued that, in the context of six days of miraculous perfect creative acts by God, at the end of Day 6 He may not have regarded as "very good" massive accumulations of broken rock, broken crystals, and dirty atmospheric eruption columns from explosive volcanic eruptions. This would be especially pertinent if, on Day 7, at the end of Creation Week, much of the deposited pyroclastic material was still hot and wet, there was still remnant ash and dust in the atmosphere, and massive ignimbrite deposits were still very hot.

After the Flood, when God told Noah that "never again shall there be a flood to *destroy the earth*" (Genesis 9:11, emphasis added), He confirmed, as promised in Gen. 6:13, that destructive geological activity occurred during the Genesis Flood cataclysm.

Conclusion

Evidence of destructive geological activity occurs throughout the Precambrian geological record, including 22-km-thick lava flows and pyroclastic deposits from explosive volcanic eruptions discharging gas, dust, and ash into the atmosphere. This type of destructive geological activity seems irreconcilable with the notion that the Precambrian was deposited during Creation Week. The evidence indicates the Precambrian was deposited during a particularly destructive stage of the Genesis Flood cataclysm. I suggest the geological evidence strongly implies that the Precambrian geologic record was deposited during the first 40 days of the Genesis Flood cataclysm, as the floodwaters were rising toward their maximum level.

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Maxwell Hunter *received a Fellowship Diploma in geology from RMIT University, Melbourne, Australia in 1968. Prior to retiring in 2018, Maxwell worked for 50 years in mineral exploration and mining geology throughout Australia. During that time, Maxwell has been involved in exploration for and/or mining of nickel in Precambrian Archaean terrains in Western Australia, base metals and gold in Precambrian Proterozoic terrains in northern Australia, and gold in Paleozoic terrains throughout eastern Australia.*