The Age, Origin and Evolution of Granite: A Geological Young-Earth Challenge

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ABSTRACT

Granite is the defining coarse-grained rock of the continental crust, and its origin has attracted interpretations ranging from the mainstream igneous model to various aqueous and catastrophic proposals. This paper examines how granite forms, why granite bodies so often appear as rounded masses, and how granite is dated. Working from field observation and the mainstream geological literature, I argue three points. First, granite is a crystallized silicate melt emplaced and cooled slowly within the crust, a conclusion supported by its texture, its mineralogy, and its field relationships. Second, the rounded forms that dominate granite landscapes are produced predominantly by weathering acting in place. Third, the radiometric ages returned by granite, which run from millions to billions of years, are consistent across independent isotopic systems. I then assess the young-earth creationist proposal that granite plutons formed and cooled within a single year-long flood and conclude it is an inadequate explanation.

Keywords: *Granite formation; Silicate melt crystallization; Continental crust; Granite weathering; Radiometric dating; Granite plutons; Flood geology*

1. Introduction

Few rocks are as familiar, or as consequential, as granite. It builds the cores of mountain ranges, forms the great domes and tors of exposed uplands, and constitutes much of the continental crust that distinguishes the continents from the ocean basins. Having worked stone for a living across many years, I have been struck repeatedly by a simple field observation: granite so often presents itself in rounded form, as boulders, corestones, and smooth domes, rather than in the sharp angular blocks one might expect of a rock quarried from depth. That observation naturally invites a question. Does the roundness of granite record the action of water, and if so, could granite itself owe its origin to an aqueous setting rather than to fire?

The mainstream account of granite is as a crystallized melt, but I examine the true role that water plays in granite genesis, and then turn directly to the origin of rounded granite forms. I next address how granite is dated and why those ages come back old rather than young. Finally, I evaluate the young-earth creationist claim that granite can be formed rapidly, within the compass of a single global flood, and I explain why that claim cannot be sustained. I make no attempt to fix a single figure for how long granite takes to form, but the evidence assembled here places that span firmly in the range of tens of thousands to many millions of years, and the age of the granite bodies themselves in the range of millions to billions of years. None of this aligns with the young earth timeline, but I will showcase in three different ways how and why granite looks and is old.

2. Granite as a crystallized melt

The mainstream geological account holds that granite is an intrusive, or plutonic, igneous rock. It is magma that rose into the crust, stalled below the surface, and crystallized there rather than erupting as lava. Several independent lines of evidence converge on this conclusion.

The first is texture. Granite is composed of interlocking crystals of quartz, alkali feldspar, plagioclase, and mica, grown together with no pore space between them and with crystal boundaries that mutually accommodate one another. This interlocking fabric is the signature of a liquid that crystallized in place, not of grains that settled or precipitated from water and were later cemented into rock. Granite can form below the ocean floor, but not from ocean water.

The second is mineralogy. The minerals of granite, and the temperatures and pressures at which they crystallize, are reproduced in the laboratory by cooling silicate melts of granitic composition. Experimental petrology has mapped the melting and crystallization behavior of these compositions in detail, and natural granite falls squarely within the field predicted for a cooling melt. This places a natural cooling time for granite which depends on pluton size, shape, depth, surrounding rock temperature, water content, and heat loss. One thermal-modeling paper estimated about 20.4 thousand years for a relatively small silicic intrusion to cool from liquidus to solidus, while also noting that published magma-reservoir timescales range from tens of thousands to millions of years depending on the system and method (C.H. Jiang et al 2023)

The third is field relationship. Granite bodies cut across the rocks they intrude, sending veins and dikes into the surrounding country rock. They bake and alter that country rock along their margins, producing contact metamorphic aureoles whose intensity decreases outward from the granite. They enclose fragments of older rock, called xenoliths, that were caught up and partially digested by the magma. And they frequently show finer-grained chilled margins where the melt cooled quickly against cold surrounding rock. All of them are expected of a hot melt intruded into a cooler crust.

3. Cooling, crystal size, and the architecture of plutons

Granite's coarse texture is often explained, in broad terms, by slow cooling. Because granitic magma bodies are large and are emplaced deep within the crust, they lose heat slowly to their surroundings, and their constituent minerals have time to grow into crystals large enough to see with the unaided eye. Most granitic plutons complete their crystallization at depths in the range of roughly 8 to 20 kilometers, where the surrounding rock is warm and heat escapes gradually.

The relationship between cooling and crystal size is real, but it is not simple, and honesty requires stating the nuance. Crystal size depends not only on cooling rate but also on the rate at which crystals nucleate, on the viscosity and composition of the melt, on pressure, and, importantly, on the amount of dissolved water and other volatiles. This matters, because it is the very point on which young-earth arguments about granite most often turn, and I return to it below. The age of a granite, however, is not read from its crystal size, if that were the case it is true that both sides can calibrate a date to match. Instead it is read from radiometric dating, from the thermal physics of cooling large magma bodies, the shape of some surface level granite and from field relationships with dated surrounding rock.

Individual magma bodies that crystallize in the crust are called plutons. Where many plutons are emplaced side by side and merge over a region, the resulting composite mass is a batholith. The Sierra Nevada batholith of California is a classic example, a vast assemblage of granitic plutons that together form the backbone of a mountain range. The scale of these features, extending over hundreds and even thousands of square kilometers, is itself a constraint on any model of their formation.

4. The role of water in granite genesis

Water dissolved in magma, along with other volatiles, lowers the temperature at which silicate rock melts and strongly influences how the melt crystallizes. In subduction zones, where oceanic crust descends beneath a continental margin, water carried down with the subducting slab is released into the overlying mantle and lowers its melting point, generating the magmas that feed continental granites. In this genuine and important sense, the water of the oceans is bound up in the origin of granite, but as an agent that promotes melting at depth, not as a medium from which crystals settle.

Water also acts after the bulk of a pluton has crystallized. Late-stage magmatic fluids and circulating hydrothermal waters move through the cooling and cooled rock, depositing minerals in veins and altering the granite along fractures. These processes are recorded in the rock and are well understood.

5. Why granite terrains are rounded

A lot of granite we find tends to be round. The roundness of granite is one of the most reliable field observations one can make, and I suggest two related weathering processes are responsible.

The first is spheroidal weathering. Granite in the subsurface is divided into blocks by intersecting fractures, or joints. Water penetrates along these joints and chemically alters the rock inward from every exposed surface. Because a block is attacked from two directions at an edge and from three at a corner, edges and corners decay fastest, and the block is progressively rounded from the outside in. The altered material forms concentric shells that peel away like the layers of an onion, leaving a rounded core of fresher rock, called a corestone, surrounded by decayed rock known as saprolite. When later erosion strips away the soft saprolite, the rounded corestones are left standing as the boulders and tors that characterize granite country.

The second is exfoliation, driven by pressure release. Granite forms under kilometers of overlying rock. As that overburden is slowly removed by erosion and the granite is unloaded, the rock expands slightly and cracks form parallel to the land surface. Sheets of rock spall away along these curved fractures, rounding hills into the smooth domes seen in granite landscapes.

The essential point is that both processes act in place. The rounded granite that we see in the field I believe was rounded where it sits, by chemical alteration and by pressure release. The specialist literature notes explicitly that rounded weathering forms are frequently mistaken for shapes produced by water transport, even though they are now considered to have formed in situ Bonar et al. (2023) and Twidale (1971).

There is a further implication worth stating plainly, because it bears on the age question. Rounding granite by weathering is slow. Chemical alteration must work its way through solid crystalline rock, corestones must be freed, saprolite must be eroded away, and overburden must be removed before domes can exfoliate. The rounded granite landscape is a monument to prolonged weathering, and therefore to considerable time, not a young earth.

6. Dating granite

Granite is unusually well suited to radiometric dating, and this is not an accident of convenience but a consequence of its mineralogy. As granite crystallizes, its minerals incorporate trace amounts of radioactive elements. Zircon, a durable accessory mineral, takes up uranium and thorium while rejecting lead, so that essentially all the lead found in a zircon crystal today is the product of radioactive decay since the crystal formed. Micas and feldspars incorporate potassium and rubidium. Each of these systems is a clock.

Several independent methods exploit these clocks. Uranium-lead dating of zircon, the most robust and widely used, measures the accumulation of lead isotopes from the decay of uranium and yields the crystallization age of the mineral. Potassium-argon and argon-argon dating measure argon produced by the decay of potassium. Rubidium-strontium dating uses the decay of rubidium to strontium. When these methods are applied to the same granite, they characteristically agree, and this concordance across systems with different parent elements, different daughter products, and different half-lives is a powerful internal check that the ages are real. Let's assume now that they do not agree, let's say they are wrong even 50% of the time. That means they would be unreliable at dating anything accurately but it still means the dates that they give are nowhere near young earth ages. Since that's the entire point of this paper, I allow for the dating methods to still be wrong yet still refute a young earth.

The results are not ambiguous in the direction that matters here. Granite bodies return ages of millions to billions of years all the time. Deep crustal granites of the continental basement commonly yield ages well over a billion years. These are the ages that the isotopic clocks record, and they come back old rather than young. The reason granite is dated at all is that it contains the very isotopes required for dating, and when those isotopes are read, they do not report thousands of years. Even young earth organizations admit this, it is not a made up theory.

7. The young-earth challenge

Young-earth creationist writers have long recognized that granite poses a difficulty for a six thousand to seven thousand year timescale, and they have responded along multiple lines.

The first line argues that granite can form quickly. Here the multi-factor control on crystal size is pressed into service. Since crystal size depends on more than cooling rate alone, it is argued that large crystals need not imply slow cooling, and that plutons could therefore have been emplaced and crystallized rapidly, within the year of a global flood, through catastrophic plate tectonics and accelerated cooling by circulating fluids. Coarse texture, in this view, is held to be no barrier to rapid formation. If granite formed in the young earth model it formed during creation week, not Noah's flood.

The second line concedes that the isotopic clocks have recorded a great deal of decay but argues that the decay happened fast. The Radioisotopes and the Age of the Earth project, known as RATE, is the central effort here. RATE researchers reported that deep zircons from crystalline basement retain more helium than they should if roughly one and a half billion years had elapsed at present-day leak rates, and they concluded that the decay must have occurred within thousands of years through a past episode of accelerated nuclear decay.

8. Why the young-earth model fails

Both lines fail, and it is worth being specific about why.

The rapid-formation argument proves less than it needs to. It is true that crystal size alone does not fix cooling rate, and mainstream petrologists say as much. But the age of a granite is not established from crystal size. It is established from radiometric dating, from the thermal physics of cooling large magma bodies, and from field relationships with dated surrounding rocks.

The accelerated-decay argument fails more decisively, and on the creationists' own ground. I can acknowledge what they found and even conceded it as true, but would like to point out that they themselves admit that accelerating radioactivity this much to obtain this helium would melt the earth.

The deeper difficulty is that the young-earth model must simultaneously accelerate decay, dispose of the resulting heat from that, account for the concordance of independent dating methods, and then explain why weathering features that take a long time to form are so thoroughly developed across granite terrains. Each of these is a serious obstacle on its own. Together they are destructive.

9. Conclusion

The question that opens this paper, prompted by the rounded granite a stonemason like myself meets in the field, has a clear answer. Granite is a crystallized silicate melt, emplaced and cooled within the crust, as its texture, its mineralogy, and its field relationships show. Water is genuinely involved in its origin, as a promoter of melting at depth and as a later agent of alteration, but not as a medium from which granite is deposited. The rounded forms of granite are the work of weathering acting in place over long spans of time, and they testify to an old granite rather than a young one. The isotopic clocks locked into granite's own minerals return ages of millions to billions of years, even across independent methods. The young-earth attempt to reduce those ages, whether by rapid crystallization or by accelerated decay, does not survive its own consequences, and it founders in particular on the heat that accelerated decay would generate. On the weight of the evidence, granite is ancient. It formed by fire tempered with water, deep in the crust, across a great deal of time.

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