Researchers from Wits University challenge common notions on the inner workings of Earth's magma chambers

A recent study show that magmatic ore deposits that are generally referred to form by settling of crystals in magma chambers are instead shown to form in place

JOHANNESBURG, GAUTENG, SOUTH AFRICA, November 2, 2022 /EINPresswire.com/ -- Scattered through the Earth's crust are ancient, solidified magma chambers that become exposed at the surface of our planet by the forces of erosion. For many decades, they have been used as natural laboratories to understand magmatic processes. However, these fossilized magma chambers contain many puzzling features that have left geologists in the dark.

Generally, magmas are expected to crystallize minerals in well-defined ratios which are referred to by geologists as cotectic proportions. However, fossilized magma chambers occasionally have rock layers with minerals in quantities that may deviate dramatically from the expected proportions. These are almost universally inferred to arise due to some physical mechanism redistributing the mineral grains, such as magmatic currents or crystals settling from suspension out of a melt.

This assumption is challenged by some layers of rock from South Africa's Bushveld Complex, the largest solidified magma chamber on Earth. These layers consist of a rock called magnetitite, named so due to the predominance of the magnetic, Fe-rich mineral called magnetite that makes up the rock. Within the magnetitite occurs another silicate mineral called plagioclase, which contrasts dramatically with the dark-coloured magnetite grains. The plagioclase content of the magnetitite gradually increases in abundance upwards to form a light-coloured rock called anorthosite.

"We expect magmas to crystallize magnetite and plagioclase in a very specific ratio of roughly 10% magnetite and 90% plagioclase," says Dr. Willem Kruger, a postdoctoral researcher at the School of Geosciences of the University of the Witwatersrand. "However, across the contact between the magnetitite and anorthosite, magnetite contents vary from more than 90 to 20%. In the past, we would simply infer that such a contact was produced by the settling of magnetite and plagioclase onto the floor of the chamber that was held in suspension in the magma. On closer inspection, we realized that the story could not be so simple".

"Some textural and chemical features of the magnetitite strongly suggest that the magnetite and plagioclase grew in place," says Prof. Rais Latypov, also from the School of Geosciences of the University of the Witwatersrand. "It was clear that a novel approach was needed to explain the origin of these interesting rocks."

An answer was found by examining what exactly occurs when an extremely dense mineral, like magnetite, crystallizes on the floor of a magma chamber. As the magnetite crystals grow, they extract primarily Fe from the surrounding melt, causing a thin film of melt to develop around the magnetite crystals with a lower density compared to the overlying melt. Eventually, this film of melt becomes gravitationally unstable and breaks away from the growing magnetite crystal.

"Initially, the melt in the magma chamber crystallizes only magnetite. However, this removal of iron from the film of melt causes it to become enriched in the chemical ingredients necessary to grow plagioclase crystals," says Willem Kruger. "A film of melt may become saturated in plagioclase, but it is then quickly removed as it becomes gravitationally unstable, and plagioclase crystallization stops. This interruption of plagioclase growth causes the plagioclase to grow in abundances lower than the expected cotectic proportions."

These films of melt, enriched in the ingredients to make plagioclase, mix with the overlying melt in the magma chamber, causing the whole system to become richer in plagioclase components. This causes each film of melt to produce slightly more plagioclase before it is removed under the influence of gravity, producing the gradational contact from magnetitite to anorthosite.

"Magnetitite layers of the Bushveld Complex challenge our commonly accepted notions regarding the inner working of magma chambers, and represent an interesting case where non-cotectic rocks can be produced without the mechanical sorting of crystals," says Rais Latypov.

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