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Exsolution lamellae and other microstructures in oxides as an influence on magnetic anomalies

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Magnetic anomalies on Earth are being measured with increasing accuracy over a wide range of length scales and elevations, from near surface to satellites. Crustal anomalies, which are deviations from Earth's planetary field, reflect the magnetic minerals, the geographic locations where these minerals were magnetized, and the intensity of the planetary magnetic field at the time of magnetization. Anomalies are also influenced by the geometry of the geological bodies, their fabric, the magnetic and mineralogical properties of the rocks, and any subsequent change, such as metamorphism or alteration following initial magnetization. Magnetism of the continental crust is commonly described in terms of bulk ferrimagnetism of crustal minerals, and most anomalies are attributed to induced magnetization. Remanent magnetization proved crucial for dating the ocean floor, yet the contribution of remanence to continental magnetic anomalies is still underestimated. In the study of the mineral sources of continental anomalies, we have explored the nature of different exsolution intergrowths and microstructures, which enhance the remanent component, either by providing additional magnetizations, such as lamellar magnetism, or by enhancing stability due to fine-scale intergrowths. Here we show that lamellar magnetism is responsible for numerous remanent continental magnetic anomalies. Anomalies may differ depending on whether multi-domain magnetite coexists with one or more lamellar magnetic phases, or whether the rock only contains lamellar magnetic phases. Due to its high thermal and magnetic stability, lamellar magnetism can be an important contributor to deep-seated anomalies on Earth, and to anomalies on other planets, like Mars. Understanding of the fundamental nature and stability of magnetic minerals in direct relation to their geological setting will continue to expand in importance with the growing demand for mineral exploration by magnetic methods.