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## The Fluids that Form Magnetite-Apatite Deposits

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The origins of magnetite-apatite deposits (also known as iron oxide-apatite, or IOA, deposits) are extremely contentious. Even basic questions, like what type of fluids can produce this type of mineralization, are still vigorously debated. Fundamentally, the problem is that we have been missing a known geologic fluid capable of mobilizing and depositing massive amounts of ferric iron and calcium phosphate, especially without simultaneously depositing voluminous quartz and other minerals. Here, I will describe recent progress in characterizing the fluids that formed these enigmatic rocks by analysis of fluid inclusions in minerals. The results reveal some surprises—especially, that a key commonality between magnetite-apatite deposits worldwide and in diverse geologic settings is a central role of hitherto unexpected liquids: salt melts dominated by sulfate, carbonate, and chloride components, and with appreciable concentrations of iron and titanium oxides and calc-silicate components besides. Melt inclusions representative of this novel category of ore-forming fluids are found in magnetite-apatite rocks from every continent and from at least Mesoproterozoic through to Quaternary times—in other words, such melt inclusions are a fundamental feature of magnetite-apatite deposits worldwide. Moreover, analysis of these inclusions shows that they represent samples of hot, chemically aggressive, low-viscosity ionic liquids that are capable of mobilizing high concentrations of a variety of metals and other components that are only sparingly soluble in hydrothermal aqueous fluids. This discovery paints a new picture of what magnetite-apatite deposits represent and helps explain many of the previously puzzling characteristics of these rocks.