Pyrite trace element chemistry of black shales in the McArthur Basin: A recorder for atmospheric oxygenation and exploration tool for Zn-Pb SEDEX style deposits

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Black shales have long been a subject of research as they yield a variety of geochemical and geobiological information. Black shales are excellent hosts for various ore deposits and microfossil assemblages; they are source rocks for hydrocarbons, and provide a good representation of organic matter distribution in time. Black shales have also been targeted to study redox conditions of the ocean and the atmosphere as the shales contain redox sensitive trace metal concentrations that can potentially be used to track atmospheric oxygenation through time. These trace elements can act as proxies for ocean acidification, redox structure, productivity and atmospheric oxygenation. Pyrite in black shales has been studied in more detail recently as pyrite is an excellent adsorber of most of these redox-sensitive trace elements.

Understanding pyrite trace element chemistry of black shales of McArthur Basin is important primarily for two main reasons. Firstly, Proterozoic ocean chemistry and atmospheric oxygenation is only partially understood, and there is a need for newer proxies to shed light on the sedimentological, paleontological, structural and tectonic history of the Paleo-Mesoproterozoic McArthur Basin. Secondly, the basin is also known to host various types of sediment-hosted ore deposits including world class SEDEX-style Zn-Pb deposits such as the McArthur River Mine. Exploration companies continue to explore the basin for similar deposits. This paper attempts to show how application of pyrite trace element chemistry using LA-ICP-MS can aid in exploration for stratiform Zn-Pb deposits.

Three marine black shale formations from three different groups of the McArthur Basin have been studied in terms of their sedimentary environment and marine pyrite trace element chemistry. These formations are Wollogorang (~1730 Ma), Barney Creek (~1640 Ma) and Velkerri (~1400 Ma) from the Tawallah, McArthur and Roper groups respectively. Each of these groups is part of a depositional package that has a characteristic age, lithofacies composition, volcanic activity, basin-fill geometry and microfossil-assemblage. Sedimentary pyrite chemistry of black shale formations of these groups is presented and results are discussed in terms of changes in trace element (TE) availability in the ocean during the 1800 to 1350 Ma time span. Nutrient TE variations are related with biologic activity using available paleontological information. The study also included the analysis of sedimentary pyrites in black shales of the Barney Creek Formation from three drillholes of varying proximity to the McArthur River Mine. Ratios of certain trace elements that may prove to be a useful guide to stratiform mineralisation, such as Zn/Ni in pyrite, are discussed. A comparison is made between conventional analysis techniques and the LA-ICP-MS approach in order to highlight advantages and disadvantages of both techniques.

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