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The Gamagara Formation revisited: stratigraphy, sedimentology, origin and metallogenic significance

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Between 80 and 90 percent of the potential iron ore reserves in the Griqualand West basin of the Northern Cape Province, South Africa is situated in the Asbesheuwels Iron-formation (IF) immediately below an unconformity that separates it from the Gamagara Formation of the Paleoproterozoic Olifantshoek Supergroup. A considerable portion of the lowermost member of the Gamagara Formation consists of carbonaceous silty shales, overlain by a highly ferruginous siltstone commonly referred to in the mining industry as "flagstone". In past studies, the iron input in the ferruginous facies has always been interpreted as primary detrital accumulations thought to be derived from the high grade iron ores of the Asbesheuwels IF.

Following investigations from ten newly available drill-cores selected from across the Maremane Dome, this study provides a renewed sedimentological and lithostratigraphic outlook of the Gamagara Formation with particular emphasis on the carbonaceous and ferruginous facies, interpreted here to be genetically linked. The carbonaceous silty shales and ferruginous siltstone are considered remnants of benthic microbial mats. Irregular internal laminae, palimpsest ripples, domal buildups, patterns of particle trapping, disruption of soft sediment deformation and filamentous microbiota provide evidence for this interpretation. Framboidal and euhedral pyrite grains occur in distinct pyrite horizons between thin wavy silt/sand laminae in the carbonaceous shale. The mechanism for pyrite formation is suggested to have operated by means of iron hydroxides flocculating in near-shore areas and becoming trapped on sticky gelatinous mat surfaces. The subsequent transformation into pyrite occurred following incorporation into the buried reducing layers of the mat.

Petrographic evidence and rare earth element data indicate that the cubic and rounded hematite grains in the ferruginous siltstone are pseudomorphs after euhedral and framboidal pyrite respectively. The rate of pyrite formation and thus the variations in laminae composition are related to factors that include microbial mat growth; iron supply from continental runoff; energy levels and O_2 content within the water column; and the rates of reduction below the mat surface. Periods of lower energy may have stimulated growth, allowing more iron hydroxide colloids to settle and trap, and ultimately increased the overall iron content in this lithofacies. Preliminary petrographic and geochemical evidence suggests Fe mobilization in the ferruginous siltstone may have further concentrated the total Fe content in this lithofacies. The indications that microbial mat deposits exist in the Gamagara Formation, provide grounds for an alternative working hypothesis that may eventually lead to more comprehensive interpretations of both existing and new sedimentological observations on these rocks.