Paper Number: 3605

An Early Multicellular Holozoan from the 1 Ga Torridon Group, Scotland

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The phosphatic nodules that are found sporadically through the non-marine Torridonian Sequence of Northwest Scotland have long been known to harbour microfossils [1], however, it is only in recent years that micropaleontologists have begun to assess the diversity, ecology, and systematic relations of the biota [2, 3]. Here we describe a new multicellular protist which possesses two distinct cell types, making this taxon a very early example of complex multicellularity in a world dominated by unicells and simple (non-branching) filaments.

The mature form consists of an inner, spheroidal mass of tightly-packed cells (Fig. 1a) that is tightly enclosed by elongate, sausage-shaped, thick-walled cells forming a surficial layer that is one cell in thickness (Fig. 1a-b). Exceptional preservation in different populations, shows individual specimens at successive stages of differentiation (e.g., Fig. 1c) enabling us to reconstruct a partial life-cycle for the fossil that includes all intermediate forms in the generation of a mature, multicellular stage.

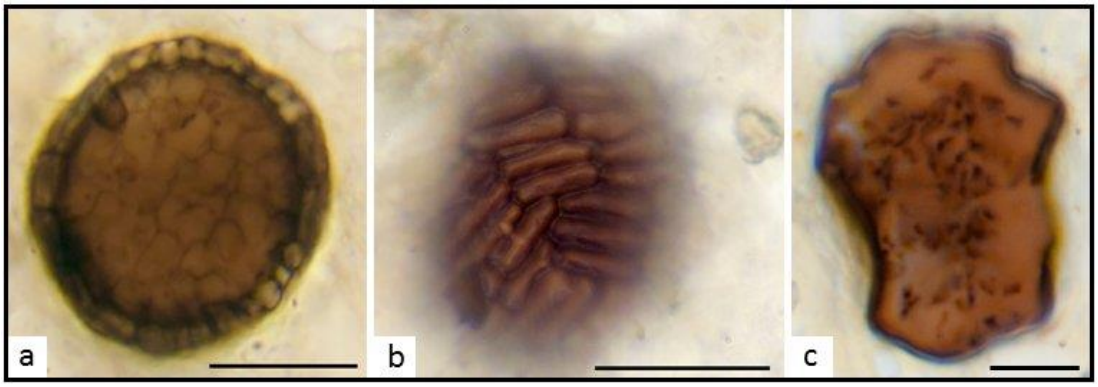

Figure 1: (a) Medial cross section view of mature specimen showing interior isodiametric thin-walled interior cells and outer layer of thick-walled cells. (b) Surface view of a second specimen demonstrating the sausage-shaped nature of the outer layer of thick walled cells. (c) Specimen at proposed early (syncytial) stage of differentiation showing the multinucleate condition.

We have performed high spatial resolution morphological and chemical analysis of the interior bodies at different stages of differentiation in order to help determine how this protist attained multicellularity. We will present results from light microscopy, NanoSIMS ion mapping, confocal laser scanning microscopy and 2D & 3D electron microscopy which compare and contrast the composition of the intracellular bodies with that of the cell membranes and walls. These analyses allow us to identify that

multicellularity was achieved through the formation of a syncytium, a process today which occurs in the free-living ichythosporean, *Creolimax fragrantissima* – a saprophytic basal holozoan. This fossil adds to a growing body of evidence indicating that multicellularity in metazoans evolved via the co-option of developmental pathways that had evolved previously in ancestral unicellular holozoan protists.

References:

[1] Peach BN et al. (1907) *The Geological Structure of the North-West Highlands of Scotland*

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[3] Battison L and Brasier MD (2012) Precambrian Research 196-197:204-217