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A non-methanogenic archaeon within the order *Methanocellales* in highly reduced serpentinized setting

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Methanogenesis and acetogenesis via acetyl-CoA pathway have been proposed as the earliest metabolic inventions of life, providing energy metabolism and carbon fixation. Serpentinization, a geochemical process found on modern and ancient Earth, provides ultra-reducing environment that could support these metabolic functions. Here, we circularized genome of Met12, an archaeon in the order *Methanocellales* detected from serpentinized springs in The Cedars, California, and revealed it to be the first member of the traditional methanogenic orders that have an acetyl-CoA pathway but lack essential genes for methanogenesis including the methyl-coenzyme M reductase, heterodisulfide reductases and hydrogenases. *In situ* transcriptomic analyses identified high expression of a multi-heme *c*-type cytochrome and the heterologous expression demonstrated that this cytochrome is capable of accepting electrons but not donating. All these indicated that Met12 is a CO_2-reducing electron-fueled acetogen without electron bifurcation, which possibly represents a trace of primordial carbon fixation before the advent of archaeal methane metabolism.