Origin and evolution of early life forms recovered from Precambrian strata

Archaen life forms: The oldest life forms so far recorded are from the Warrawoona Group of Western Australia (3.556 by). This Group of rocks includes both stromatolitic deposits (with & without microfossils) and cherts that contain preserved microfossils (Schopf & Packer, 1987). The relatively high diversity of the fossil assemblage indicates that life arose much earlier than 3.556 by ago. The 4 types of simple filaments in this microbiota are:

i) Very narrow forms; *Archaeotrichion* that range from 0.3 to 0.7 μm in diameter & up to 180 μm in length.

ii) Septate filaments up to 340 μm long & about 1μm in diameter named as *Eoleptonema*.

iii) Large tubular sheaths 3-9 μm wide & up to 600 μm long named as *Siphonophycus*.

iv) Large septate filaments up to 120 μm long consisting of isodiametric cells 4-6 μm in diameter named as *Primaevifilum*.

Morphologically, the organisms have been compared with a number of eubacteria & cyanobacteria. Perhaps, the most important fossils from this microbiota are the unicells about 8 – 20 μm in diameter enclosed by lamellated sheaths. Morphologically, the fossils have been compared with Chroococcalean cyanobacteria and perhaps are the earliest evidences of photoautotrophs.

Cellular remains are also known from the 3.4 by old Swartkoppie formation of Onverwatcht group in South Africa.

Onverwatcht Group

Swartkoppie formation – 3.4 by

Kromberg Fm.

Hoegenog Fm.

Komati Fm.

Theespruit Fm.

Sandspruit Fm. – 3.7 by

From the Swartkoppie Fm. Barghoorn & Schopf (1966) and Schopf & Barghoorn (1967) described *Archaeosphaeroides barbartonensis* (resembling Chroococcales type of Cyanobacteria) and *Eobacterium isolatum* (resembling Bacilli).

[Overlying the Onverwatcht group is the Fig-Tree Series (3.2 by old)] Barghoorn & Schopf were originally reported by local geologists that their samples belonged to the Fig - Tree series which was 3.2 by old. However, they later on reported that the strata from which Barghoorn & Schopf described their biota, in fact, belonged to the 3.4 by old Swartkoppie Fm. underlying the Fig-Tree Series. In addition, Pflug (1966) described from Swartkoppie Fm. chains of unicells some of which were covered by a sort of gelatinous sheath.

Proterozoic life forms: A well known Proterozoic assemblage is from Gunflint formation of lake Ontario of Canada which is 2.6 by old. From there, several life forms have been described which are *Animikiea* (resembling modern *Lyngbya*), *Gunflintia* (Uniseriate filament with constriction near the attachment of the cell), *Huroniospora* (resembling spores of modern eubacteria) and *Eoastrion* (resembling some iron-oxidizing bacteria). The most interesting organism of Gunflint Fm. is *Kakabekia umbellate* (a mould-like organism with a bulbose base, more or less slender stipe and the umbrella like head). The organism has a modern extant counterpart *Kakabekia barghoorniana* described by Siegel and Siegel (1966). They were working on microorganisms of ammonia rich environment (soil sample). They obtained an organism in culture which was very much

similar to *Kakabekia umbellate* described by Barghoorn from Gunflint Fm. because of the considerable time gap, Siegel and Siegel named their organism as a separate species of *Kakabekia*, i.e. *K*. *barghoorniana*. *Kakabekia* has been thriving on earth from the Precambrian. So, it is a very good example of living fossil.

A more or less similar microbiota has been recovered from the **Duckcreek dolomite** of Western Australia which is approx. 2 by old.

Another well known Proterozoic assemblage is from **Bitterspring formation** of Central Australia which is 0.9 by old. This assemblage shows more diversification of the prokaryotic biota. In addition to the apparent prokaryotes such as *Oscillatoriopsis, Palaeolyngbya* and *Palaeoanacystis*; Bitter Spring assemblage contains *Eotetrahedrion* (a group of 4 cells in tetrahedral tetrad and individual cell with triradiate mark presumably a product of meiosis or mitosis). *Eotetrahedrion* probably represent the oldest evidence of eukaryotic organism. Further proliferation of aquatic life is noticed in the 700-800 my old Svanbergfjellet shales of Spitsbergen (Norway). Most significant part of this assemblage is fossils closely comparable with multicellular Cladophoralean green algae.

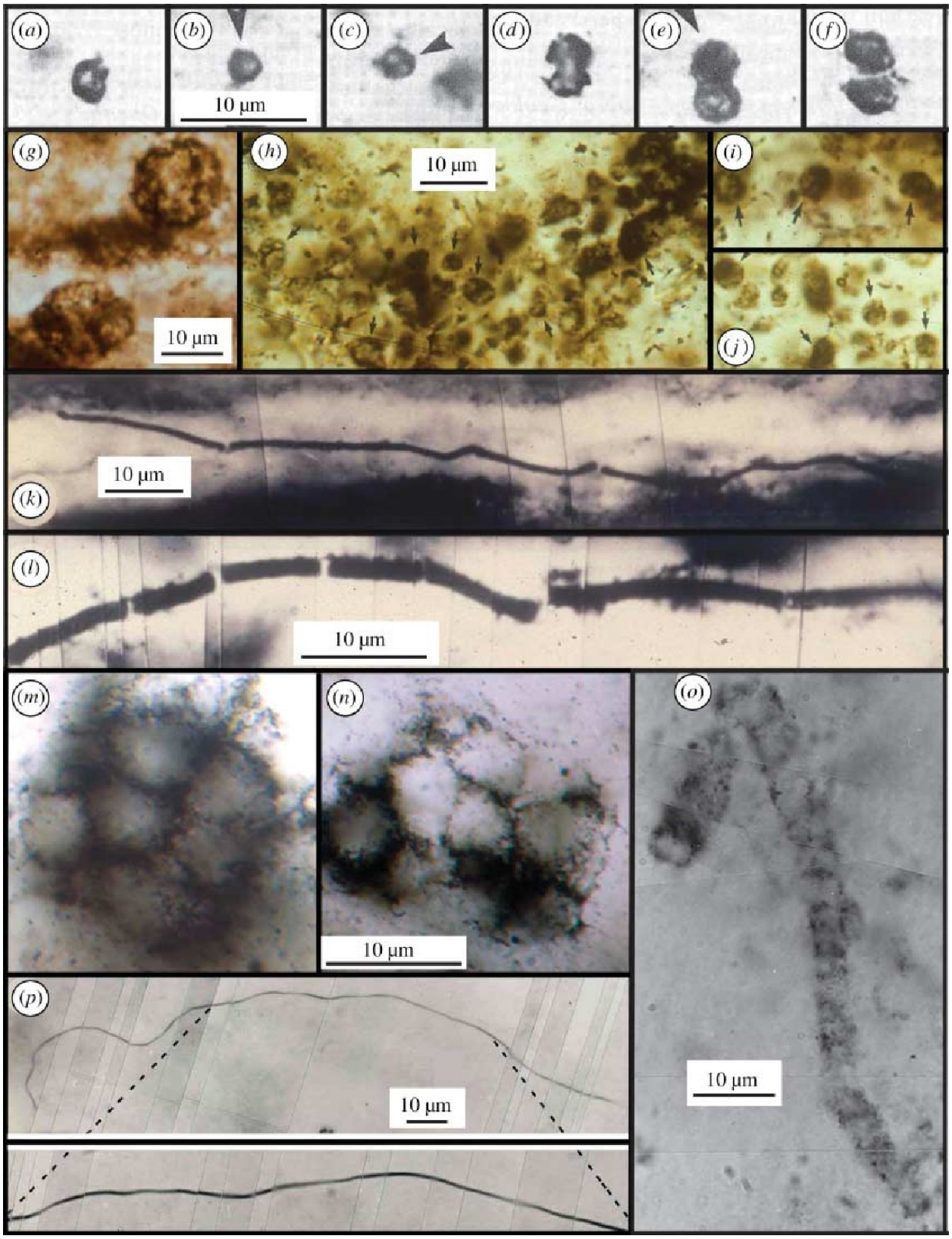
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Figure. More than 3200 Myr old Archaean microfossils photographed in petrographic thin sections. (a–f) Solitary and paired prokaryotic (bacterial or cyanobacterial) coccoidal unicells from the ca 3260 Myr old Swartkoppie Formation of South Africa, in (b–f) ordered in a sequence inferred to represent stages of cell division (Knoll & Barghoorn 1977); arrows point to dark organic contents within cells; scale for parts (a–f) shown in (b) (modified after Knoll & Barghoorn 1977). (g) Solitary prokaryotic (chroococcacean cyanobacterium-like) coccoidal unicells (Archaeosphaeroides barbertonensis) from the ca 3245 Myr old Sheba Formation of South Africa (Schopf & Barghoorn 1967); photo courtesy of A. H. Knoll. (h–j) Solitary, paired (denoted by arrows) and clustered prokaryotic (bacterial or cyanobacterial) coccoidal unicells from the ca 3320 Kromberg Formation of South Africa (Muir & Grant 1976; Schopf & Walter 1983); scale for parts (h–j) shown in (h). (k) Narrow prokaryotic (bacterium-like) filament and (l) broader prokaryotic (bacterial or cyanobacterial) filament from the ca 3320 Kromberg Formation of South Africa (Walsh & Lowe 1985; Walsh 1992; Schopf et al. 2002). (m,n) Colonial ensheathed prokaryotic (chroococcacean cyanobacterium-like) coccoidal unicells from the ca 3388 Myr old Strelley Pool Chert of Western Australia (Schopf & Packer 1987; Schopf 1992); scale for parts (m) and (n) shown in (n). (o) Broad septate prokaryotic (oscillatoriacean cyanobacterium-like) filament (Primaevifilum septatum) and (p) narrow prokaryotic (bacterium-like) filament (Archaeotrichion contortum), reported by Awramik et al. (1983) from stromatolitic cherts collected at a locality that maps within the ca 3470 Myr old Mount Ada Basalt (Van Kranendonk et al. 2003). Of unconfirmed stratigraphic provenance (Schopf 1999, pp. 83–84), these fossiliferous samples may be from a chert unit of the overlying ca 2700 Myr old Fortescue Group.

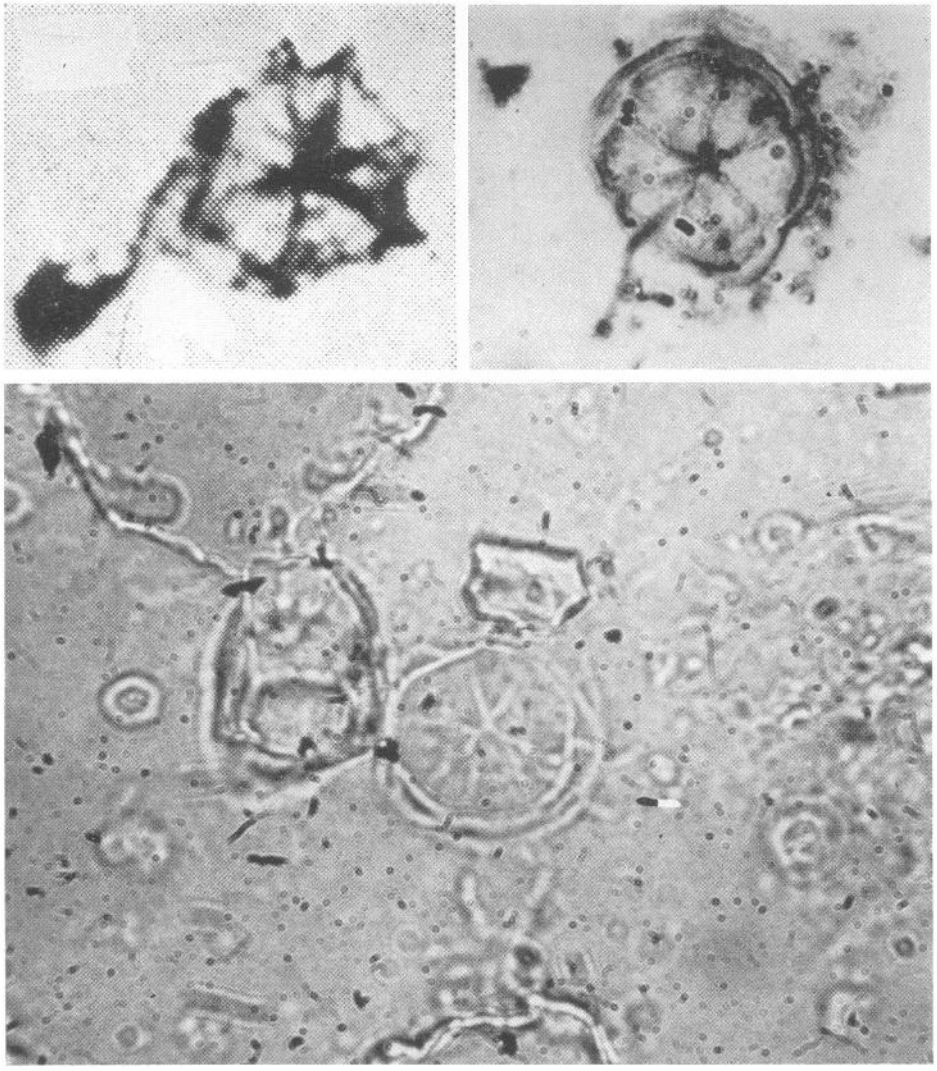

FIG. 1. Representative fossil and living *Kakabekia*. *Upper left: K. umbellata*, petrographic specimen; Fig. 7, no. 6 (by permission of Barghoorn and Tyler, 1965). *Upper right: K. barghoorniana*, type specimen Harlech, Wales (Siegel and Siegel, 1968). *Lower: K. barghoorniana*, Mendenhall Glacier, Alaska. *K. barghoorniana* from Wales is safranin stained; Alaskan specimen is unstained. About 3840× magnification in all three illustrations.