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

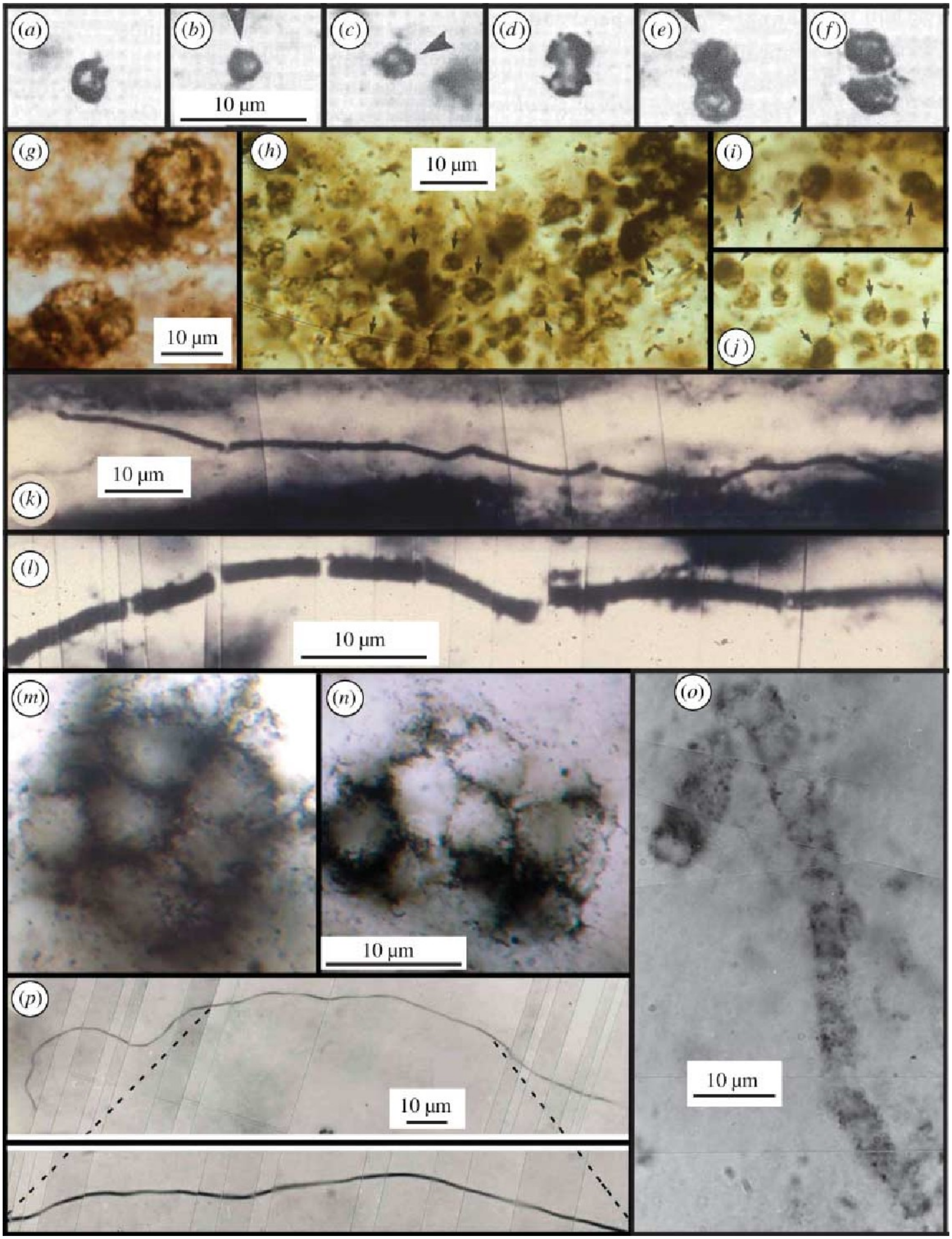
From the Swartkoppie Fm. Barghoorn & Schopf (1966) and Schopf & Barghoorn (1967) described *Archaeosphaeroides barbartonensis* (resembling Chroococcales type of Cyanobacteria) and *Eobacterium isolatum* (resembling Bacilli).

[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.



(a)
(b)
10 μm
(c)
(d)
(e)
(f)
(g)
10 μm
(h)
10 μm
(i)
(j)
(k)
10 μm
(l)
10 μm
(m)
(n)
10 μm
(o)
10 μm
(p)
10 μm

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.

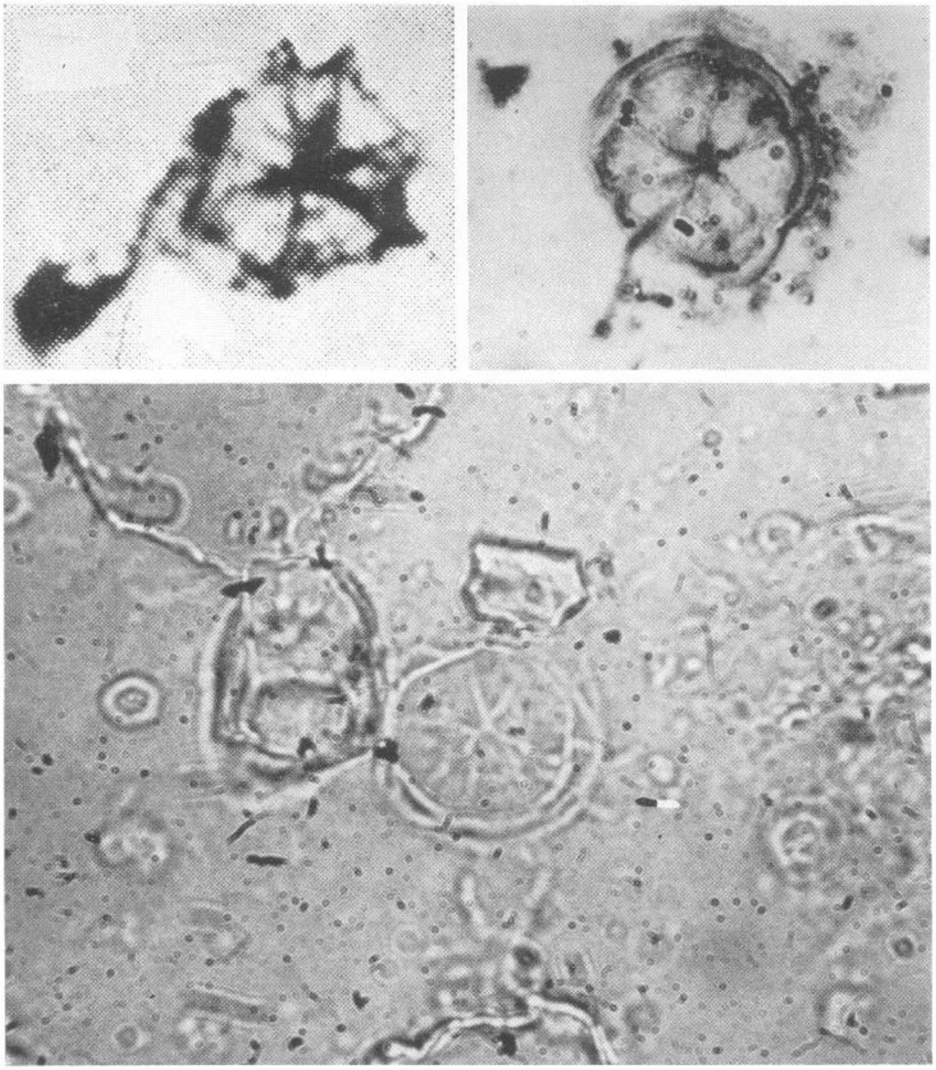


FIG. 1. Representative fossil and living *Kakabekia*. *Upper left:* *K. umbellata*, petrographic specimen; Fig. 7, no. 6 (by permission of Barghoorn and Tyler, 1965). *Upper right:* *K. barghoorniana*, type specimen Harlech, Wales (Siegel and Siegel, 1968). *Lower:* *K. barghoorniana*, Mendenhall Glacier,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

Megafloral succession during Siluro-Devonian periods

The floristics over the globe, at least up to the level of the uppermost Devonian, cannot be classified in to clear-cut Phytochoria (floral provinces). Therefore, the existence of a global land flora during the Siluro-Devonian time is generally believed. Banks (1980) divided the Siluro-Devonian time into seven floristic zones. Each zone is denoted by the name of the characteristic genus which does not necessarily correspond in range to the entire zone. The classification has later been slightly modified by Meyen (1987).

Zone I. Cooksonia zone:

This zone begins in the uppermost Wenlockian & continues up to the Predolian (Edwards & Fannings 1985). The vascular plant *Cooksonia*, represented by tiny specimens with slender axes, associated with the algae *Parka*, *Prototaxites*, *Pachytheca*, are the major elements of this assemblage. Flora of this zone are known only from a few localities viz. Podolia, Czechoslovakia, England, Ireland, New York state. The morphological characteristics of plants in the Cooksonia assemblage zone are:

i. Small, simple, little differentiated vascular plants;
ii. Dichotomous branching (equal dichotomy);
iii. No leaves;
iv. No roots;
v. Terminal sporangia;
vi. Slender xylem strand, centrarch.

Zone I may also comprise the plant assemblages of Australia containing *Baragwanathia*, *Salopella* & *Zosterophyllum* (Garratt et al. 1984). The Silurian (Wenlockian – Ludlovian) age of this assemblage from the Yea formation of Australia is based on graptolite remains (Garratt & Rickards, 1984) and is much debated. Another genus of vascular plants that occur in Pridolian strata is *Steganotheca* (Edwards, 1970).

Zone II. Zosterophyllum zone:

This zone ranges from the onset of the Gedinnian to the early Siegenian. The flora of this zone, in composition & overall habit, is similar to that of Zone I, however, a little different due to the appearance & wide occurrence of *Zosterophyllum* & at places *Sporognites*. In the upper part of zone II, Parka disappears. Localities yielding the floras of Zone II include Scotland, Spitsbergen, Czechoslovakia, Belgium & Wales.

Morphological characterstics of plants in Zone II include those for Zone I in addition to:

i. Lateral sporangium;
ii. H branching;
iii. Exarch xylem.

Zone III. Psilophyton zone:

This zone is extended from late Siegenian to the end of Emsian. The flora of this zone is, in general referred to as the Lower Devonian flora & sometimes termed as Psilophytic flora. About 30 genera of land plants have been identified from this zone. This zone is marked by the Trimerophytes & Lycopsids. Rhyniophytes were represented by *Cooksonia, Taeniocrada, Rhynia, Horneophyton*; Zosterophylls by *Zosterophyllum, Sawdonia, Gosslingia, Renalia, Crenaticaulis*; Trimerophytes by *Psilophyton, Trimerophyton, Pertica*, Lycopsids by *Asteroxylon, Drepanophycus, Baragwanathia, Protolepidodendron, Leclercqia* and *Kaulangiophyton*. Probable progymnosperms or their precursors are *Oocampsa* and *Chaleuria*; Barinophytes are *Barinophyton* and *Protobarinophyton*. Floras of zone III are known from Western Europe (including Scotland, Siberia, Kazakhastan), China, N. America, S. America and Australia. Some authors (Hueber, 1983) believe that the *Baragwanathia* flora of Yea Fm. in Australia which for long has been regarded as Silurian may also belong to zone III. The new morphological characteristics that appear in zone III are:

i. Pseudomonopodial branching due to overtopping;
ii. Appearance of enations on stem;
iii. Tufts of terminal sporangia;
iv. Microphyllus leaf;
v. Sporophyll bearing adaxial sporangium;

vi. Paracytic stomata (*Drepanophycus*);
vii. Incipient heterospory (*Chaleuria*);
viii. Presence of ligule;
ix. Actinostelic xylem strand.

Zone IV. Hyenia zone:

This zone encompasses the entire Eifelian. *Calamophyton* and *Hyenia* mark the base of zone IV. These genera are accomplished by continuing members of zone III such as *Psilophyton, Protolepidodendron*. The Progymnosperm *Rellimia* is also an early member of this zone. Higher up in zone IV, the evolutionary ramification is apparent by the appearance of the Progymnosperm – *Aneurophyton*, the Cladoxylalean – *Pseudosporochnus* and the Lycopsid *Colpodexylon*. Towards the close of the zone IV, the Progymnosperms *Tetraxylopteris* and *Triloboxylon* appear.

Localities in which this assemblage is found include Eastern North America, Belgium, Czechoslovakia, Western part of Germany and Siberia. New morphological characteristics introduced in zone IV are:

i. Whorled position of leaves and sporangiophores;
ii. Lobed protostele;
iii. Bifacial cambium (*Rellimia*);
iv. Precursor of megaphyllus leaf (Aneurophytes);
v. Plant with cryptogamic reproduction but gymnospermous anatomy.

Zone V. Svalberdia zone:

This zone covers the major part of the Givetian. Zone V is defined by the appearance of archaeopteridelian progymnosperm *Svalberdia*. The most notable feature of this zone is the abundance and wide geographic distribution of the genera that had already made their appearance in zone IV. In addition to *Svalberdia*, the other advanced progymnosperms that appeared in this zone are *Actinoxylon* and *Actinopodium*. The three genera altogether are closely related to *Archaeopteris* and sometimes considered as species of the genus *Archaeopteris* (Beck, 1970). Two important lycopsids *Archaeosigillaria* and *Lepidodendropsis* and the Sphenopsids *Ibyka* and *Iridopteris* first appear in this zone.

Important localities of zone V are Bohemia, Germany, Belgium, New York State, Siberia and Spitsbergen.

New morphological characteristics that appeared during this interval are:

i. Arborescent habit (*Lepidodendropsis*);
ii. Periderm;
iii. Eustele.

Zone VI. Archaeopteris zone:

This zone extends from Frasnian to Middle Famenion. This zone again is heavily populated by the genera continuing from older strata, viz. *Aneurophyton, Tetraxylopteris, Pseudosporochnus*, *Archaeosigillaria*, *Drepanophycus, Colpodexylon, Triloboxylon, Eospermopteris, Sawdonia*. The plant that serves as an index for beginning of zone VI is *Archaeopteris, Callixylon*. Other newer plants in this assemblage are *Protolepidodendropsis, Proteokalon, Cystosporites.*

Zone VI is best developed and wide spread in North America and South Western Siberia.

New morphological characteristics that appeared during this zone:

i. Megaphyllous leaf (*Archaeopteris*);
ii. Heterospory with heterangy (*Archaeopteris*);
iii. Single functional megaspore (*Cystosporites*).

Zone VII. Rhacophyton zone:

This zone covers Upper Famennian. Appearance of the genus *Rhacophyton* marks the onset of this zone. Other elements of this assemblage are Cyclostigma, Pseudobornia, Archaeopteris, Sphenophyllum, Sphenopteridium, *Protolepidodendropsis*, Sphenopteris, Eviostachya, Barinophyton, Archaeosperma, Moresnetia, Elkinsia, Spermolithus (flattened seed).

Localities are Bear Island, Ireland, North Western Pennsylvania, Virginia and South Western New York State.

New morphological characteristics that appeared in this zone:

i. Complex sphenopsid cones (*Eviostachya*);
ii. Pre-ovular structures (*Archaeosperma, Moresnetia, Elkinsia*);
iii. Seeds with both radial and dorsi-ventral symmetry.

Permo-Carboniferous floras

Up to the level of Famennian – Tournaisian transition, it has been possible to discuss the evolution of earth's vegetation in its entirety. For younger periods, individual phytochoria are required to be treated separately. The number of phytochoria and the differences between them increase steadily from the early Carboniferous onwards. However, scientists advocated that the existence of a global Lepidodendropsis flora during the early part of the carboniferous and subsequently separation of the floristics in to distinct phytochoria became apparent. Majority of the scientists believed that in the Early Carboniferous, the Angara and Euramerian areas represented independent floral provinces. Based on palynological assemblages, the same time marks the separation of the Gondwana area (Clayton, 1985). Beginning from the Stephanian of Carboniferous, Cathaysian area gradually separates from the Euramerian. The division of the vegetation cover in to phytochoria was closely associated with the climate. The Euramerian and Cathaysian floras were restricted to the equatorial belt where a tropical and sub-tropical climate prevailed. The Angara flora was primarily northern extra tropical. The Gondwana floras correspond to the southern extra tropical zones.

Euramerian floras:

This flora occurs in the Carboniferous and Lower Permian throughout North America, North Africa, Europe, Caucasus, Asia Minor and Central Asia. In China and South East Asia, only the Early Carboniferous floras may be assigned to the Euramerian area. Higher up in the sequence they give the way to floras of the Cathaysian area as a province since Upper Carboniferous. The Tournaisian assemblages of the Euramerian province chiefly consist of Lycopsids (*Lepidodendropsis* and *Lepidodendron*) in association with ferns (*Adiantites, Sphenopteridium, Triphyllopteris*), Sphenopsids (*Archaeocalamites*), Pteridosperms (*Lyginopteris, Calamopitys, Hydrasperma*) and Progymnosperm (*Protopitys*). The Visean flora is chiefly similar in aspects to that of the Tournaisian. Visean ferns belong to the Zygopteridales and Botryopteridales;

Cladoxylales disappear. Medullosaceae appear for the first time (*Neuropteris* foliage, *Trigonocarpus* seeds). Lepidophytes diversified further, *Sigillaria* and *Lepidophloios* appear. *Cheirostrobus* is a characteristic element of Visean assemblage. During the Visean-Namurian transition, the floras undergo a basic change, an abrupt reduction in species composition is noticed. This floral break corresponds in time to the cooling of the climate.

The Westphalian flora of the Euramerian area has been extensively investigated and in general, it is referred to as the traditional Carboniferous flora. Where the flora shows the peak diversity, it is primarily represented by Lycopsids (*Lepidodendron, Lepidophloios, Chaloneria, Sigillaria*), Zygopteridales (*Corynepteris*); Botryopteridales (*Botryopteris, Oligocarpia*); Marattiales (*Scolecopteris, Psaronius*); Calamitales (*Calamites, Anularia, Asterophyllites, Calamostachys*); Sphenophyllales (*Sphenophyllum, Bowmanites*); Medullosaceae (*Neuropteris, Alethopteris, Linopteris*, *Medullosa, Pachytesta*); Lyginopteridaceae (*Lyginopteris, Sphenopteris, Lagenostoma*); Callistophytaceae (*Callistophyton*); Cordaitales (*Cordaites, Cordaitanthus*). By the Stephanian time, the Lycopsids decreased much in number with simultaneous increase in ferns. The Upper Carboniferous assemblages in Euramerian area are dominated by Marattiales, Cordaitales, Calamitales, Sphenophyllales and Pteridosperms. Conifers (*Utrechtia, Ernestiodendron*), and Peltasperms (*Callipteris*) made their appearance. Lycopsids were represented mainly by *Sigillaria*s.

Upwards, through the Carboniferous sequence, peculiarities increase in the floras of China and Tibet. Although, the Westphalian flora in this area as a whole is Euramerian aspect, certain differences became apparent:

i. Large percentage of endemic species;
ii. A few endemic genera;
iii. Absence of many species and even genera (Sigillaria).

From this time onwards, the Cathysian province tends to become independent.

At about the Carboniferous-Permian transition, the Euramerian floras exhibit an increase in the number of conifers (*Utrechtia, Ernestiodendron*), and Peltasperms

(*Callipteris*, *Lepidopteris*) with decrease in number of Lycopsids. Otherwise, the Lower Permian Euramerian flora is closely comparable to the Upper Carboniferous one.

The Upper Permian flora of Euramerian province is composed chiefly of Conifers (*Ullmannia, Pseudovoltzia*) with a small admixture of other plants viz. *Lepidopteris, Pseudoctenis, Sphenobiera, Taeniopteris, Neocalamites, Pecopteris* etc. The flora is not rich and is characterized by practically a complete absence of ferns and Cordaitales.

Cathaysian flora:

In the Upper Carboniferous (Stephanian), the Cathaysian province became an independent area. Although many Euramerian genera viz. *Lepidodendron, Sphenophyllum, Annularia, Odontopteris, Cordaites* etc. and even their various species continue to exist here, the overall flora is different due to presence of endemic genera viz. *Tingia, Cathaysiodendron* and also by the endemic species of *Lepidodendron, Sphenopteris, Callipteridium*.

The Lower Permian Cathaysian flora as a whole is characterized by the gradual increase and appearance of typical Cathaysian elements viz. *Lobatannularia, Zigantopteris, Cathysiopteris, Plagiozamites*, and also the endemic species of *Sphenopteris, Pecopteris, Taeniopteris* etc.

During Upper Permian, the Early Permian elements continue with the increase of endemic forms of the genera *Schizoneura, Sphenophyllum, Rhipidopsis*. During the Late Permian, the Cathaysian flora spread out westward in Turkey, Saudi Arabia and Syria.

Angara flora during Late Palaeozoic (Permo-Carboniferous) age:

Independent status of the Angara phytochorium from the beginning of the Carboniferous is disputed by some Palaeobotanists. However, many genera typical of Euramerian floras have not been found here.

The Tournaisian assemblage of Angara area was dominated by Lepidophytes viz. *Eskaldia, Ursodendron, Lepidodendropsis* and ferns viz. *Adiantites, Triphyllopteris*, in association with *Sphenophyllum*.

Beginning from Visean, practically nothing in common remains between the Euramerian and Angara floras. The Angara flora of Lower Carboniferous was predominantly a Lepidophyte-fern flora. Lycopsids were represented by *Tomiodendron, Lophiodendron* and *Angarophloios*. Fern like plants were *Angaropteridium, Chacassopte*.

The paucity and peculiarities of Angara flora during the Early Carboniferous are attributed to the aridity of the climate.

During the Lower-Upper Carboniferous transition, the Angara flora underwent a complete changeover. Lepidophytes decreased markedly. *Angaropteridium* and the possible pteridosperm *Rhodeopteridium* were the most dominant elements. This assemblage includes the first Cordaitales and the Sphenopsids like *Mesocalamites, Paracalamites* etc. This pteridosperm flora was subsequently replaced by numerous Cordaitaleans, Sphenopsids and ferns.

The overall Upper Carboniferous Angara assemblage can be summarized as:

Lycopsids: *Angarodendron, Angarophloios, Caenodendron*.

Sphenopsids: *Paracalamites, Sphenophyllum, Calamostachys, Phyllotheca, Annularia*.

Ferns: *Neuropteris, Dicranophyllum, Paragondwanidium, Sphenopteris, Pecopteris*.

Pteridosperms: *Angaropteridium, Angaridium, Telangiopsis*.

Cordaitales: *Rufloria, Cordaites*.

Incertae sedis (Plants of uncertain affinity): *Vojnovskya paradoxa*

The Permian assemblage of the Angara Province is dominated by Cordaitaleans and Sphenopsids of the former assemblage. Quite abundant are ferns like *Prynadaeopteris, Comsopteris, Pecopteris* and Ginkgophytes like *Psygmophyllum, Rhipidopsis, Ginkgoites*. The pteridosperm frond *Callipteris* is a common element.

Gondwana flora:

The Gondwana flora, in general, is referred to the assemblages dominated by *Gangamopteris* and *Glossopteris* foliages. It is also called as the Glossopteris flora. The flora is well distributed in all the Southern Hemisphere land masses of the Late Palaeozoic globe, viz. South America, Africa, Madagascar, India, Australia and Antractica. The flora originated after the Carboniferous glaciation. The floras of the preglaciation time have been found to be closely related to Euramerian. They are known from Argentina, East Australia and Kashmir. The major components are *Lepidodendropsis, Cyclostigma, Archaeosigillaria, Rhacopteris, Archaeocalamites*.

After the Carboniferous glaciations, the *Gangamopteris* flora emerged. The first appearance of this flora varies from Late Carboniferous to Early Permian in various parts of the Gondwanaland. During the Late Carboniferous - Early Permian time, the Gondwana flora was primarily represented by *Gangamopteris, Noeggerathiopsis* with meager representation of *Glossopteris*, pteridophytes (*Phyllotheca* and *Botrychiopsis*) and Conifers (*Paranocladus*). During the later part of the Permian, the flora exhibited increasing diversity reaching its zenith. In Upper Permian time, the Gondwana flora was dominated by Glossopteris leaves, with other organs, viz., *Vertebraria* (root), *Araucarioxylon*/ *Dadoxylon* (stem), *Glossotheca*, *Eretmonia* types of male fructifications, female fructifications like *Dictyopteridium, Denkania, Lidgettonia, Partha*. The associated elements of this assemblage are Sphenopsids – *Phyllotheca, Schizoneura* and *Trizygia*; ferns – *Neomariopteris, Dichotomopteris, Dizeugotheca, Asterotheca*; Cycads – *Pteronilssonia, Pseudoctenis*; Ginkgophytes – *Rhipidopsis, Ginkgoites* and

Conifers – *Walkomiella, Buriadia*. Interestingly, the arborescent lycopsids which are prevalent in the contemporary floras of Euramerian and Angara provinces are strikingly absent in Late Palaeozoic Gondwana excepting the rare occurrence of fragmentary stem assigned to *Cyclodendron*.

Triassic flora of Molteno Formation of South Africa (Umkomas Valley):

The flora of Molteno formation has been worked out in detail by Anderson & Anderson (1983). The overall assemblage is as follows:

Bryophyta – *Marchantites, Muscites*.

Sphenopsids – *Phyllotheca, Schizoneura, Neocalamites, Equisetites*.

Ferns – *Todites, Asterotheca, Cladophlebis, Dictyophyllum*.

Peltasperms – *Rhipidopteris, Peltaspermum, Antevsia, Lepidopteris*.

Corystospermaceae – *Dicroidium, Xylopteris, Pteruchus, Umkomasia, Pachypteris.*

Glossopterids – *Glossopteris*

Cycads – *Taeniopteris, Yabiella, Pseudoctenis*.

Bennettitales – *Nilssoniopteris*

Ginkgophytes – *Ginkgoites, Baiera*

Conifers – *Elatocladus, Desmiophyllum*.

Incertae sedis – *Dejerseya, Saportea, Linguifolium*.

Dicroidium is the most abundant element in this assemblage represented by more than 8 spp. *Lepidopteris* is next in abundance. Ferns, Ginkgophytes and Conifers are quite common in occurrence. On the basis of fossil evidences, both floral and faunal, the Molteno formation has been dated to be Upper Triassic in age.

Triassic flora of Chinle Formation of Arizona:

The flora has been worked out by Sydney Ash (1972). The overall assemblage is as follows:

Lycopsids – *Isoetites, Chinlea, Lycostrobus*.

Sphenopsids – *Neocalamites, Equisetites*.

Ferns – *Todites, Cynepteris, Wingatea, Phlebopteris, Clathropteris, Cladophlebis*.

Cycads – *Lyssoxylon*

Bennettitales – *Pterophyllum, Ottozamites, Nilssoniopteris, Zamites and Williamsonia*

Ginkgophytes – *Baiera*.

Cordaitales – *Pelourdea, Samaropsis.*

Conifers – *Araucarioxylon, Pagiophyllum, Brachyphyllum, Woodwarthia, Dinophyton.*

The overall assemblage is dominated by conifers and ferns. On the basis of floral and faunal remains, it has been dated as Upper Triassic.