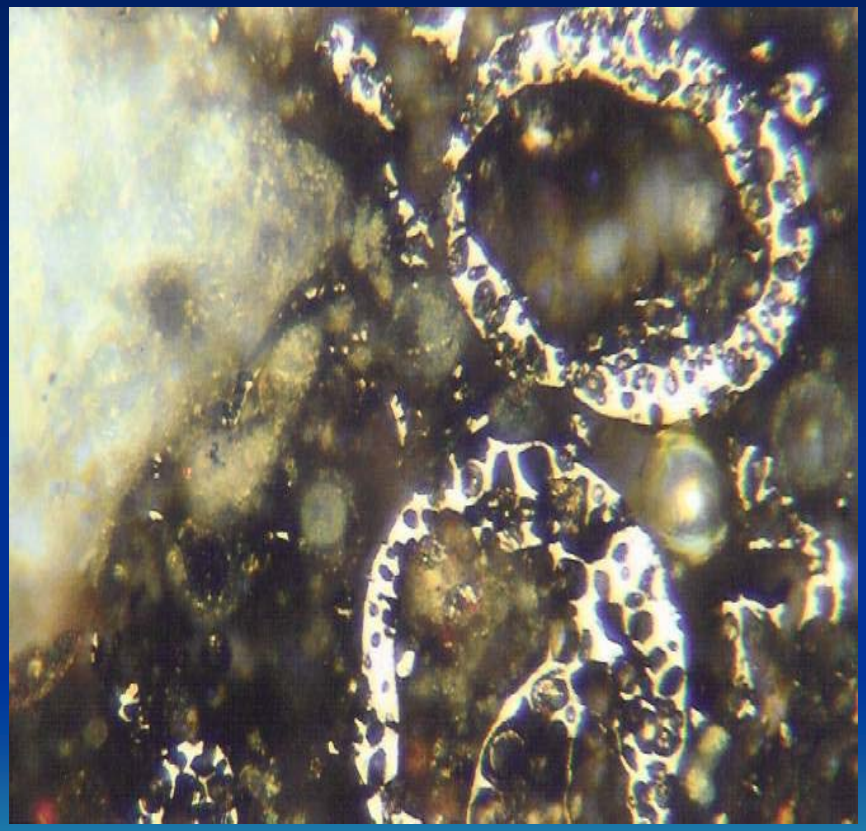
Petrographic Classification of Carbon in Fly Ash

Fly Ash

Is the residue from coal combustion.

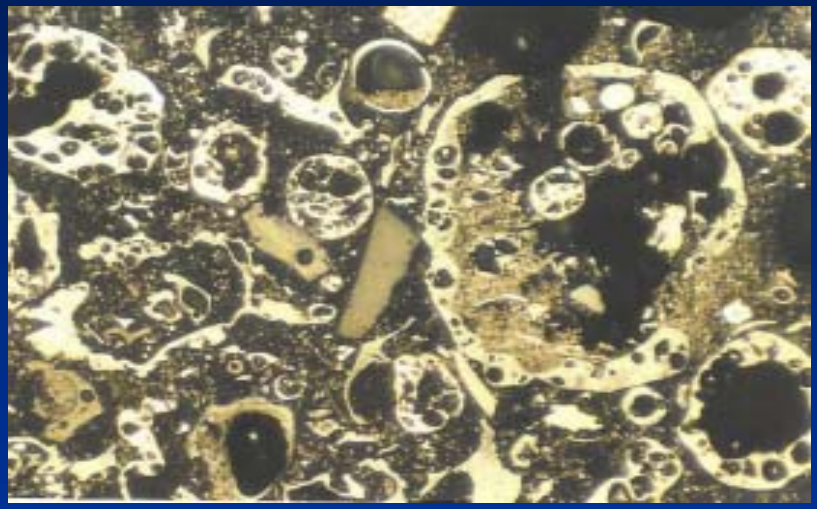
It consists of:

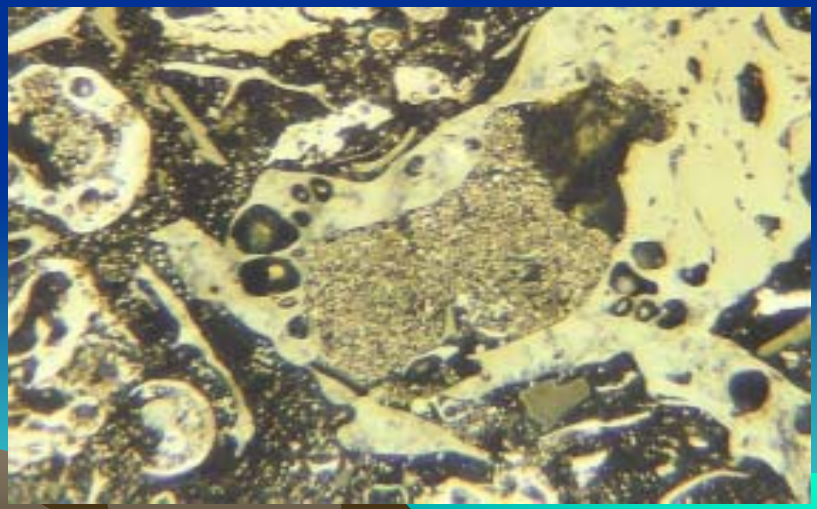
1. **ash from minerals**
2. **coke from coal**



Carbon in Fly Ash

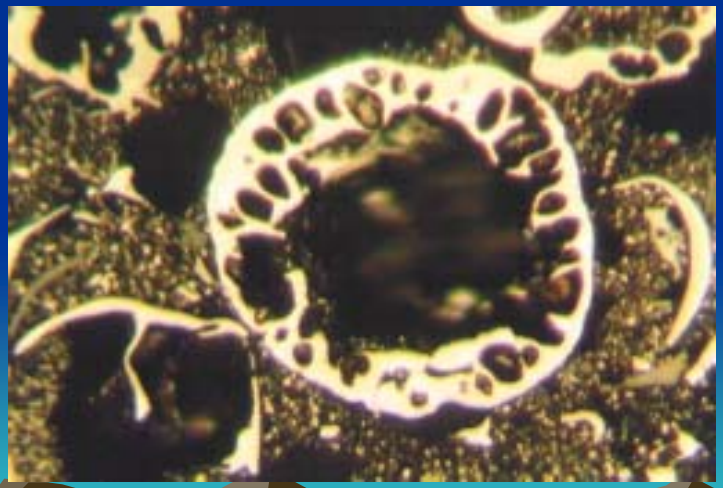
Is mostly porous coke or cenospheres from coal.





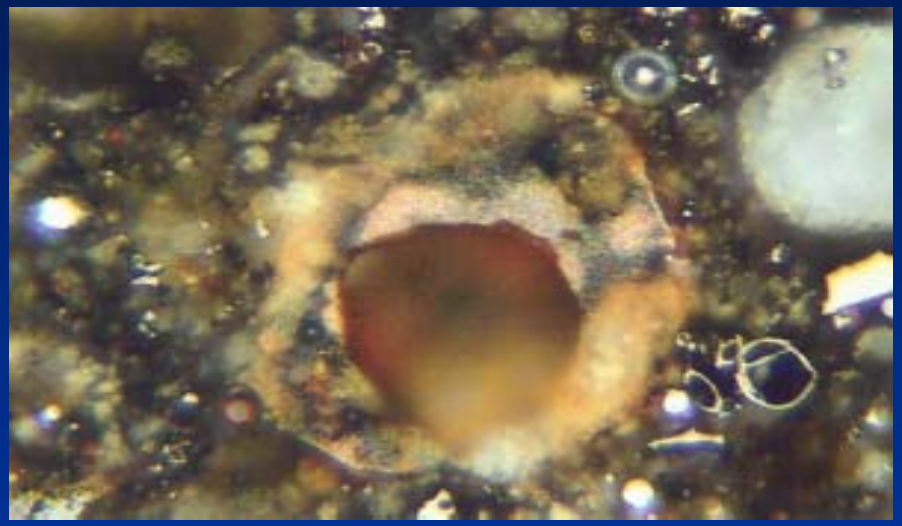
The Term - Cenosphere

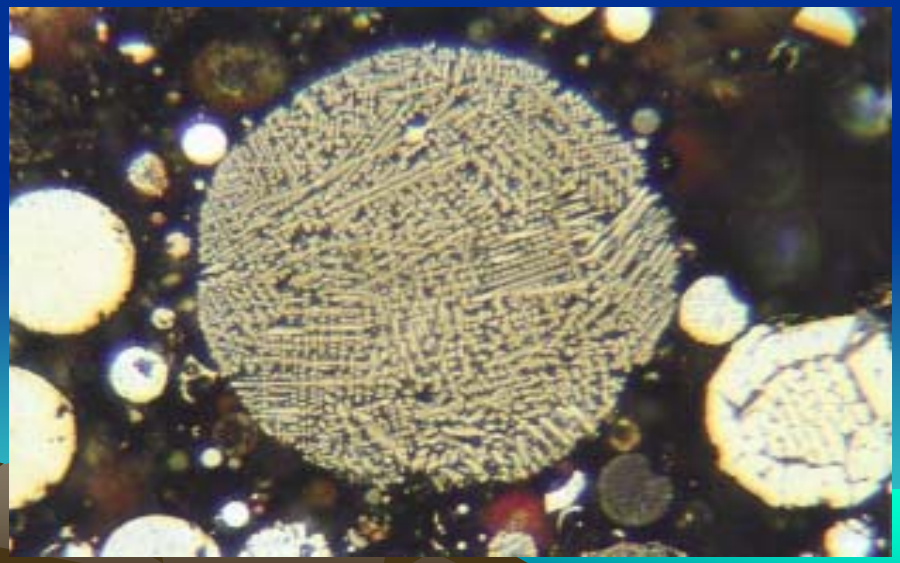
- At the Second Internal Conference on Bituminous Coal, Nov. 19-24, 1928.
- F. S. Sinnatt noted that when particulate bituminous coal is rapidly heated in an unconfined space it passes through a plastic state then solidifies to form hollow spheres of coke which are called cenospheres.



Fly Ash Minerals

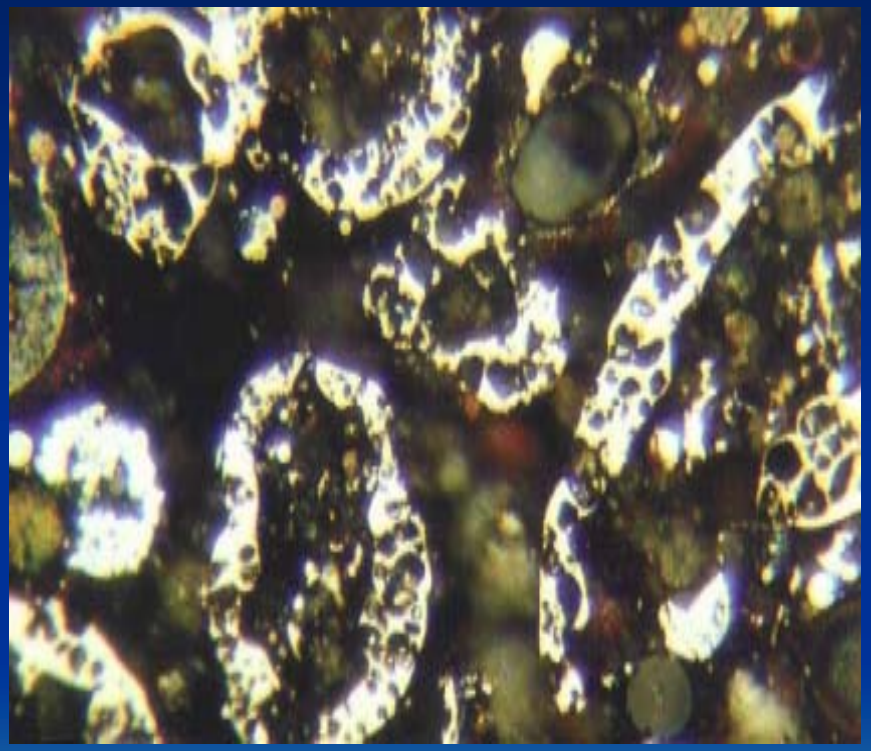
- Combustion ash residues from coal minerals such as clay, other silicates, carbonates, quartz pyrite.





Fly Ash LOI

- Loss on ignition is a measure of carbon content of fly ash.



Carbon Carry over = Loss of BTU'S

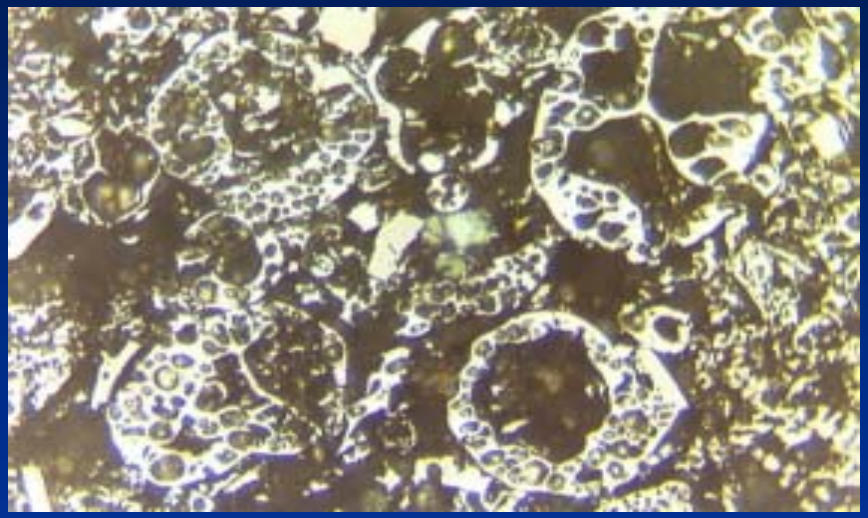
1. *Contaminates Mineral Ash Fraction*
2. *Carbon Separation = BTU Recovery*

A.) Carbon separation makes the ash fraction more useful.

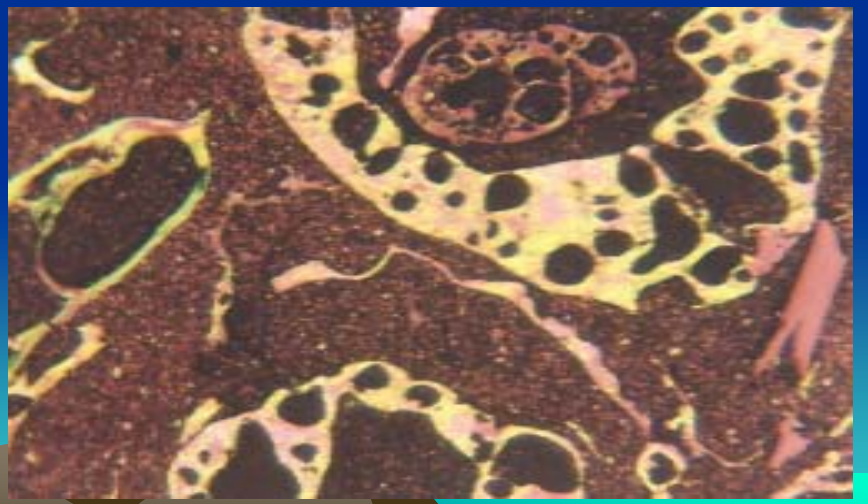
B.) Carbon should be less than 6% for cements and concrete.

Carbon/Cenospheres

- More or less symmetrical porous coke particles.



- Shape, porosity and carbon forms microtextures are largely determined by coal type and rank.



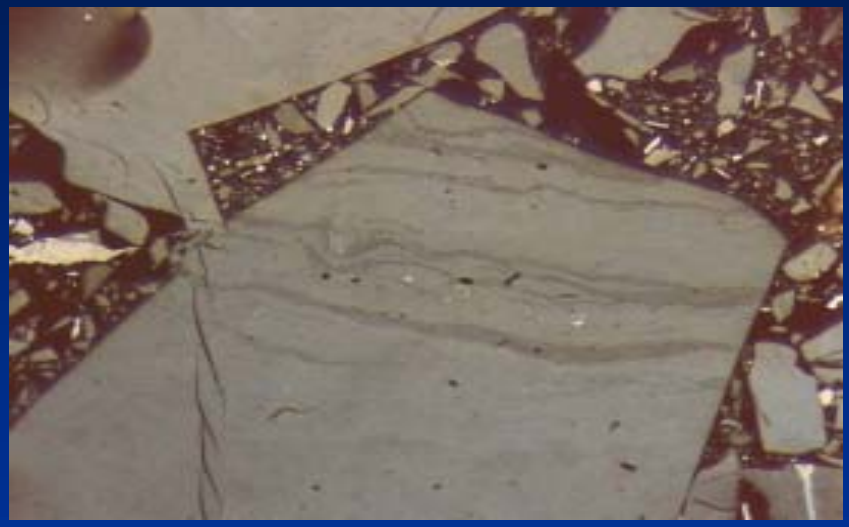
Coal Type = Determined by Maceral Content

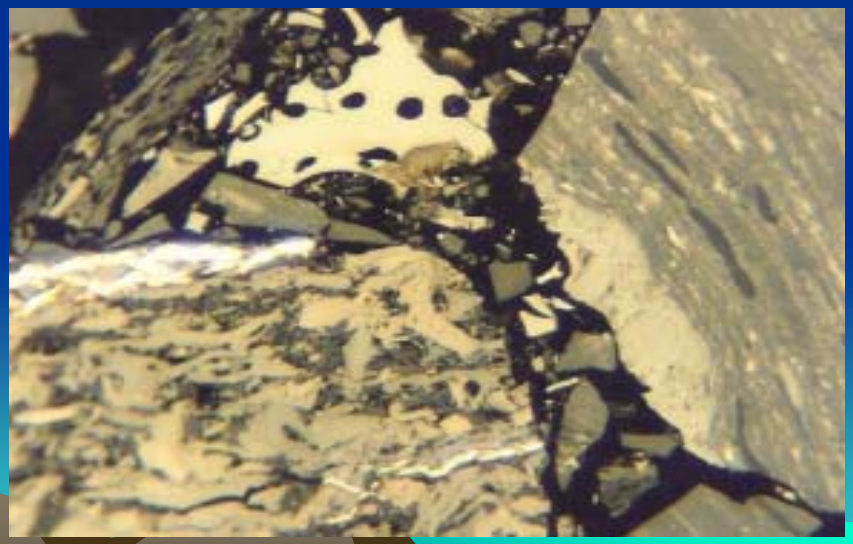
- Reactives

A. Vitrinite
(High in Hydrogen)
B. Liptinite

- Inerts

A. Inertinite
B. Semifusinite
(High in Carbon)
C. Fusinite
D. Mineral Matter



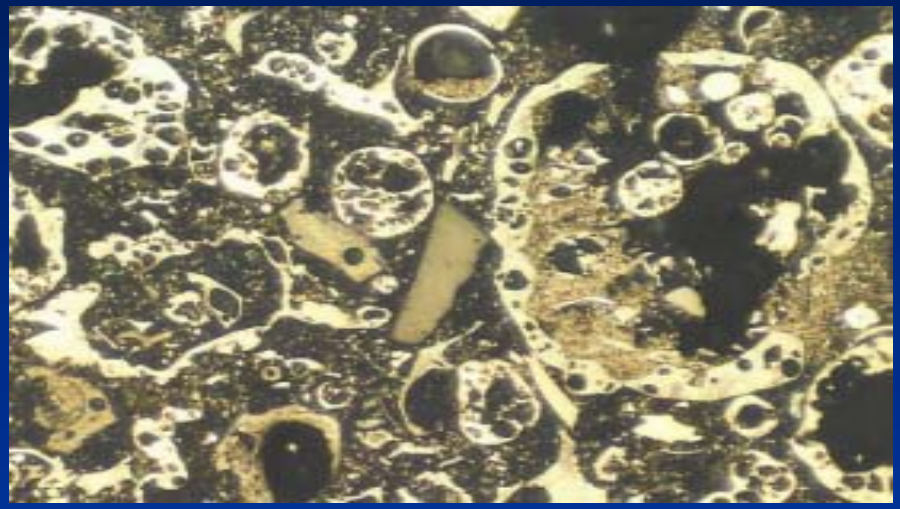


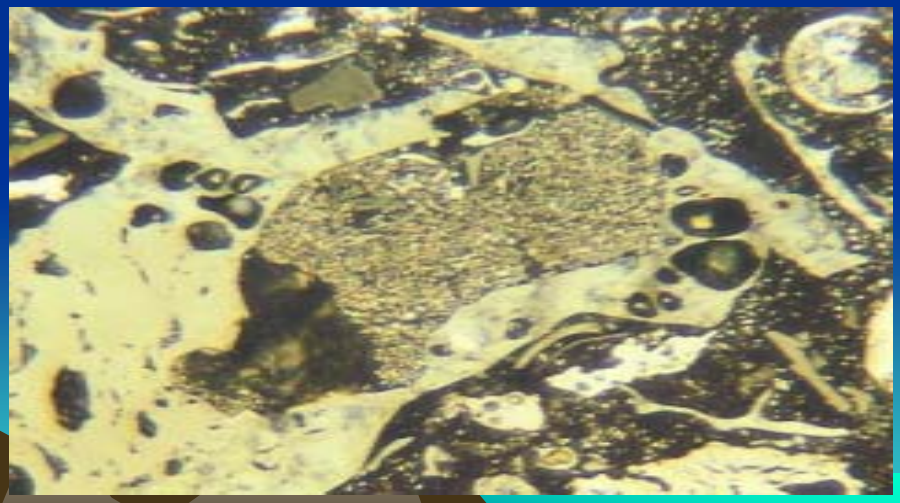
Cenosphere Microstructure

Coal Type

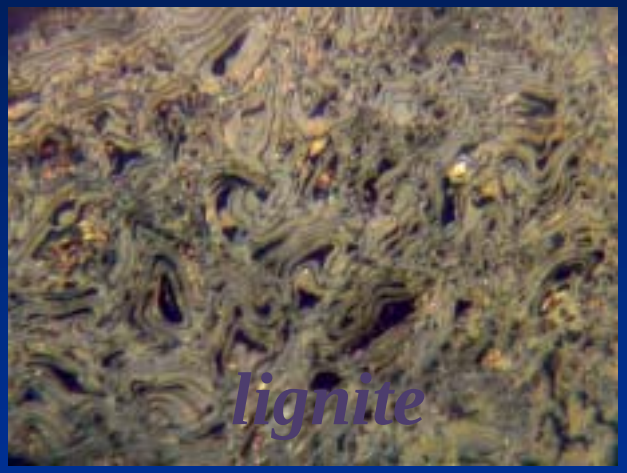
A. *Vitrinite & Liptinite increase porosity.*

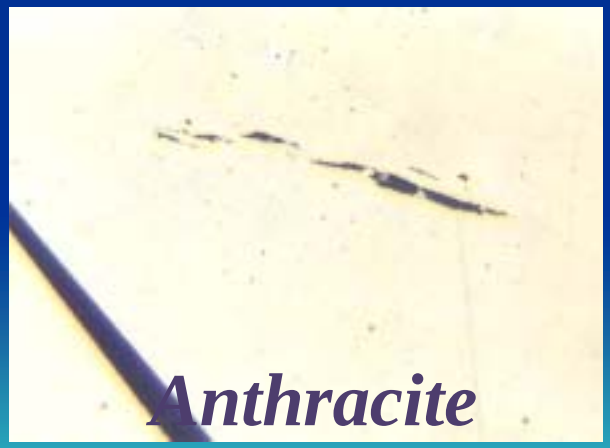
B. *Inertinite increases density.*





Coal Rank – by Reflectance

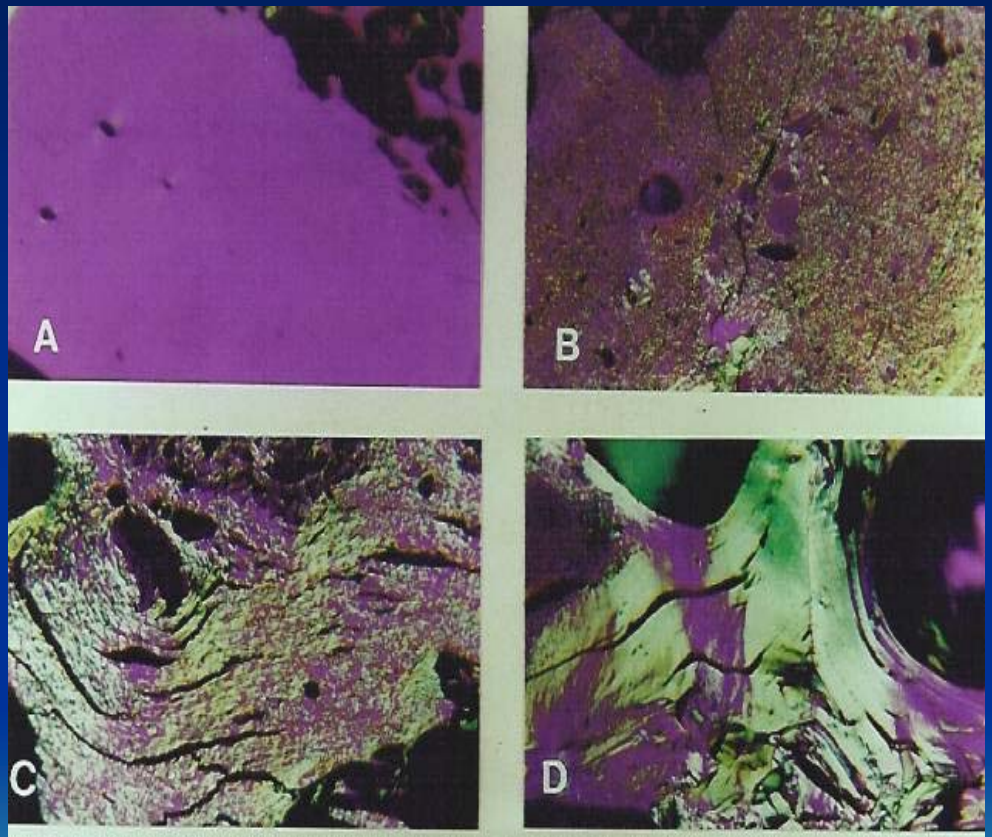




Cenosphere Microtexture

Coal Rank

- *As the coal rank increases the anisotropic carbon forms increase.*

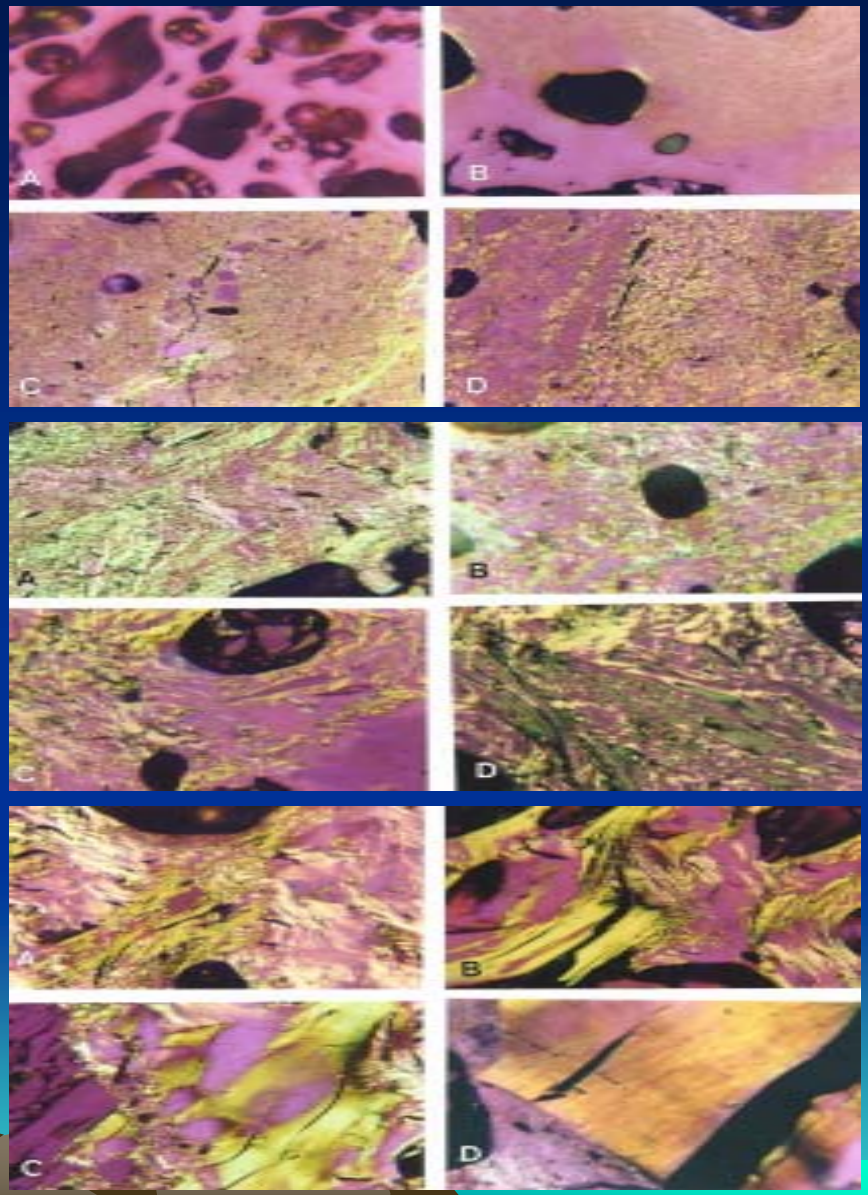


IGURE 1: PHOTOMICROGRAPHS SHOWING COKE CARBON FORMS: A=ISOTROPIC, B=CIRCULAR, C=LENTICULAR AND D=RIBBON MICROTEXTURES.
REFLECTED POLARIZED LIGHT, WITH GYPSUM PLATE, IN OIL, X 450.

Carbon Microtextures

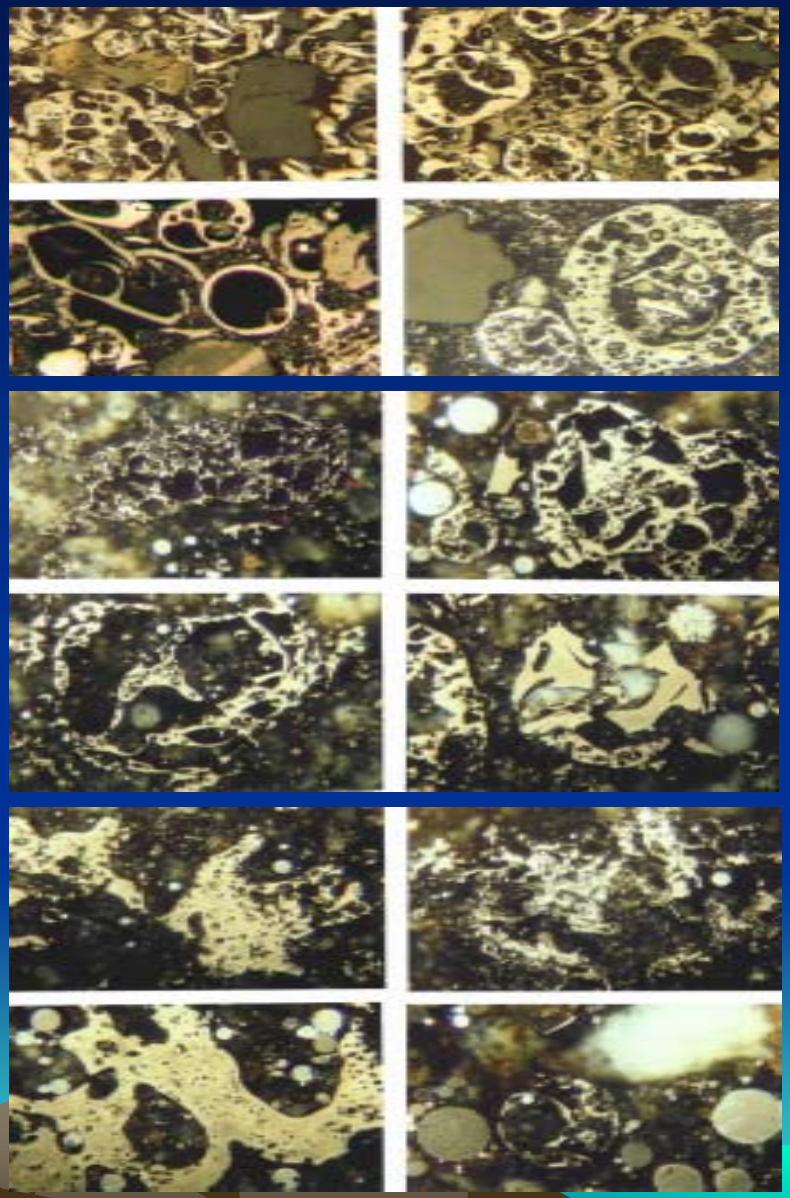
- Isotropic
- Incipient
- Anisotropic –Circular
  - Fine
  - Intermediate
  - Coarse
- Anisotropic - Lenticular
  - Fine
  - Intermediate
  - Coarse
- Anisotropic – Ribbon
  - Fine
  - Intermediate
  - Coarse

ASTM has a standard for carbon microtexture



Char Morphology Classification

1) *Unaltered Coal*
2) *Altered Coal to Semicoke*
3) *Simple Cenosphere*
    1) *Tenui*
    2) *Crassi*
4) *Complex Cenosphere*
    1) *Tenui*
    2) *Crassi*
5) *Mixed Morphology*
    1) *Porous*
    2) *Dense*
6) *Organic Inerts*
    1) *Fusiniod*
    2) *Inertoid*
7) *Coarse Fragments*
    1) *Porous*
    2) *Dense*
8) *Fine Size fragments*
9) *Coke / Semi Coke*
10) *Mineral / Ash*

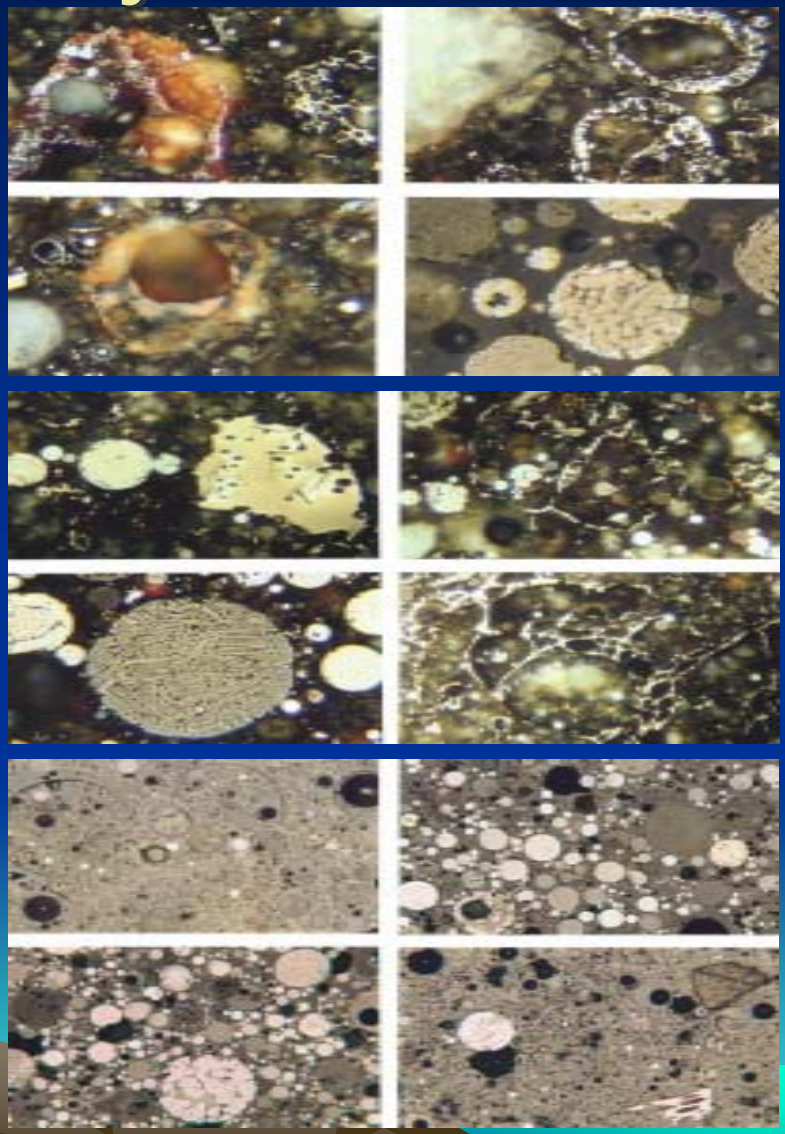


ICCP – International Committee for Coal Petrology is developing a procedure for Cenosphere Analysis

ISO - International Standards Organization is also working standard procedure

Origin or Morphology of Inorganic Residue in Fly Ash

- Clay
  - Angular
  - Rounded
- Quartz
- Carbonates
- Glassy Spheres
  - Hollow
  - Solid
- Spheres With Eutectic Structures
- Spheres From Pyrite
- Combined Mineral/Ash and Carbon
  - Original Association
  - Association By Contact



Summary – Use of Optical Microscopy in Determining the Origin of Unburnt Carbon in Fly Ash

- Carbon in fly ash causes problems:
  - Reduces the economics
  - Increases Pollution
  - Limits use of fly ash
- Increased Carbon in fly ash is due to:
  - More coal burned due to greater demand for electricity
  - More low NOx burners
  - Greater pulverization
  - Coal blending is more common
- Coals used for combustion differ in:
  - Rank – maturity
  - Type – maceral makeup
  - Grade – Impurities
- Maceral Combustibility
  - Liptinite/Exinite – higherst in H_2 and easiest to burn
  - Vitrinite – Generall abundant and has intermediate properties
  - Inertinite – Highest in carbon and least combustable