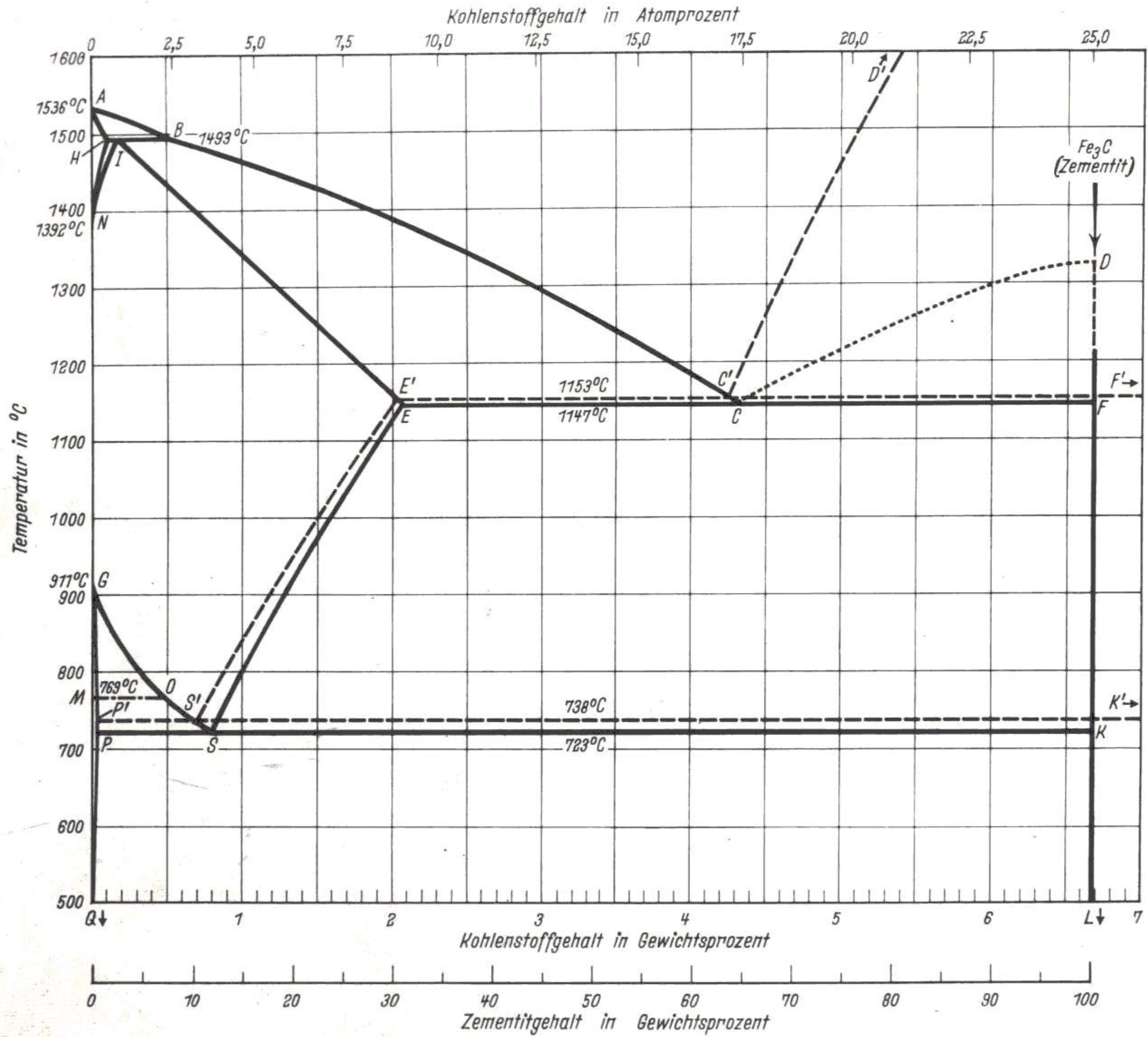


Das Zustandsschaubild - Eisen-Kohlenstoff

(Die gestrichelten Linien beziehen sich auf das stabile, die ausgezogenen Linien auf das metastabile System)



Aus: Werkstoffausschuß-Bericht Nr. 180 (DIN A 4, 24 Seiten, 4. Auflage 1961, im Auftrage des Werkstoffausschusses des Vereins Deutscher Eisenhüttenleute unter Mitwirkung von Fachgenossen neu bearbeitet von Dietrich Horstmann)
zu beziehen vom Verlag Stahl Eisen m. b. H., Düsseldorf.

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(n. dem Werkstoffausschuß des Vereins Deutscher Eisenhüttenleute, VDEH) siehe Seite 7
The structural forms of phosphides
The detection of sulphides

2. Cast iron (grey cast iron)

- I. Cast iron with lamellar graphite (grey cast iron) (GG)
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- III. Cast iron with lamellar graphite (grey cast iron)
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- V. Cast iron with lamellar graphite with special magnetic properties (grey cast iron)
- VI. Special cast iron (grey cast iron)
- VII. Resistant to corrosion cast iron alloy and heat-resisting cast iron alloy (GGL)
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3. Nodular graphite cast iron (GGG)

4. Chill cast iron

- I. Fully white iron
- II. Surface chilled iron
- III. Semi-chilled iron

5. Malleable cast iron

- I. (White) malleable cast (GTW) decarburised annealed
- II. (Black) malleable cast (GTS) not decarburised annealed

since 1960: Iron-carbon - cast material

that requires: Cast-iron with lamellare graphite,

(grey cast iron) DIN 1691

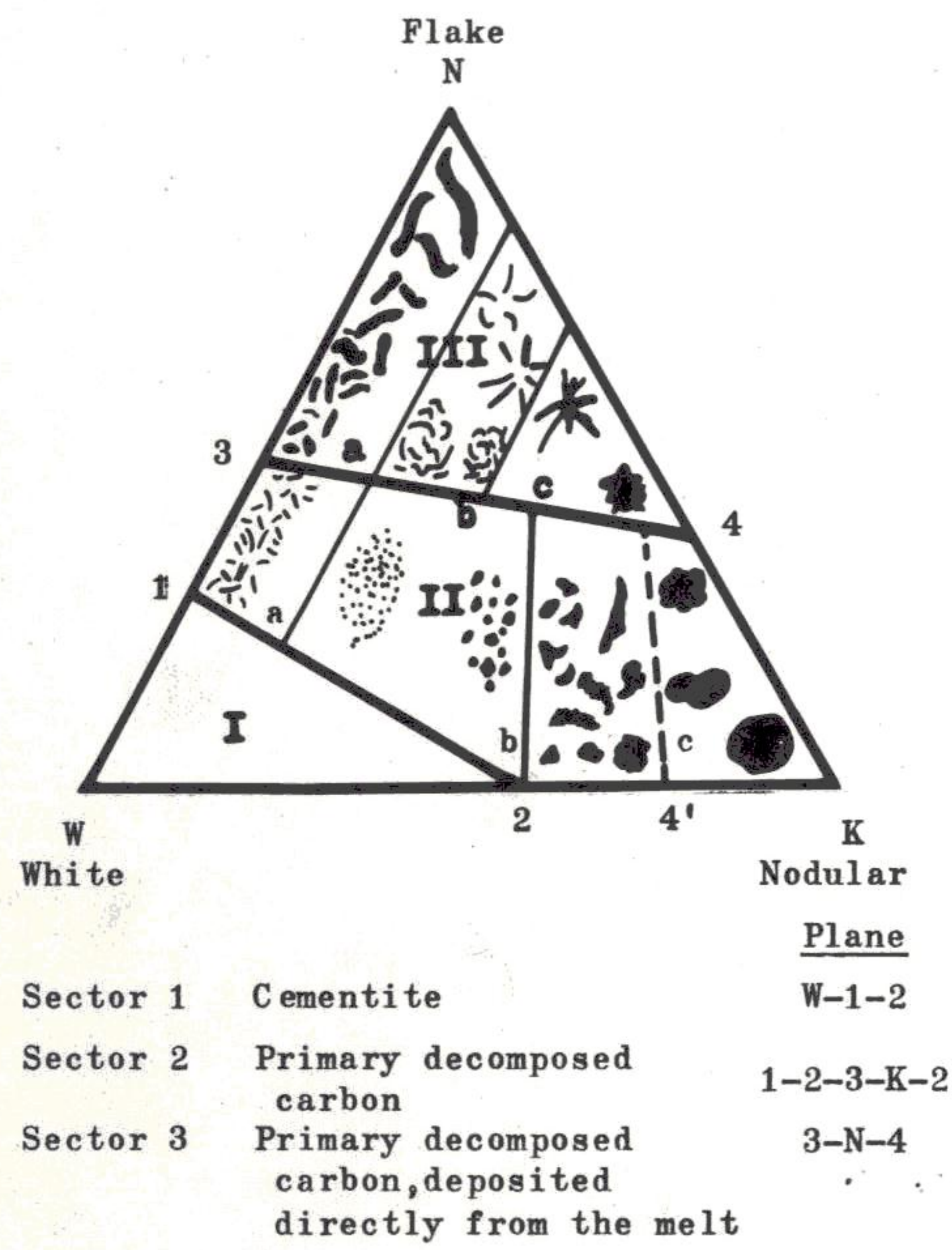
Cast-iron with spheroidal graphite, DIN 1693

Malleable cast, DIN 1692

Cast-iron alloy - special cast

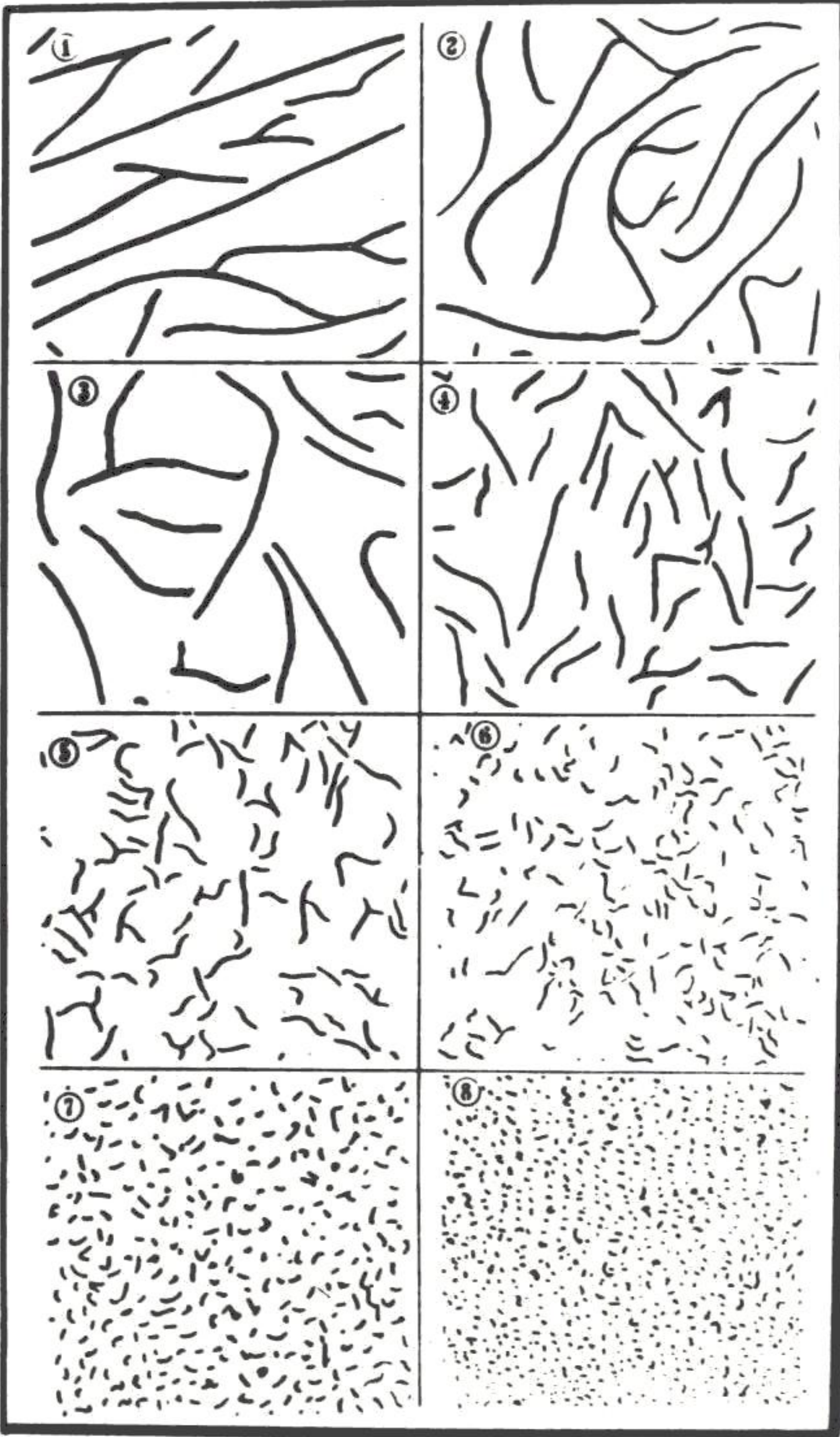
The characteristic forms of Carbon

according to Mitsche and Onitsch-Modl.



Graphite flake size chart für grey cast iron

as proposed by:
American Foundrymens Association
(A.S.T.M. Designation A.247(1942)
Standards Part 1.





No. 677 Grey Bessemer pig iron Magnified: 250:1
 low in phosphorus GG-25

Analysis:

Bound carbon . . . 1,95
 Graphite . . . 2,75
 Silicon . . . 1,46
 Manganese . . . 1,66
 Sulphur . . . 0,030
 Phosphorus . . . 0,101
 Nickel . . .
 Chromium . . .
 Tungsten . . .
 Vanadium . . .
 Molybdenum . . .
 Cobalt . . .

Treatment and special properties:

cast
 pearlite - cast iron

Texture:

matrix of fine lamellar
 pearlite, graphite needles
 traces of phosphide eutectic

Etching:

2% alcoholic nitric acid



No. 672 Grey Bessemer pig iron Magnified: 500.
as before

Analysis:

Bound carbon
Graphite
Silicon
Manganese
Sulphur
Phosphorus
Nickel
Chromium
Tungsten
Vanadium
Molybdenum
Cobalt

as before

Treatment and special properties:

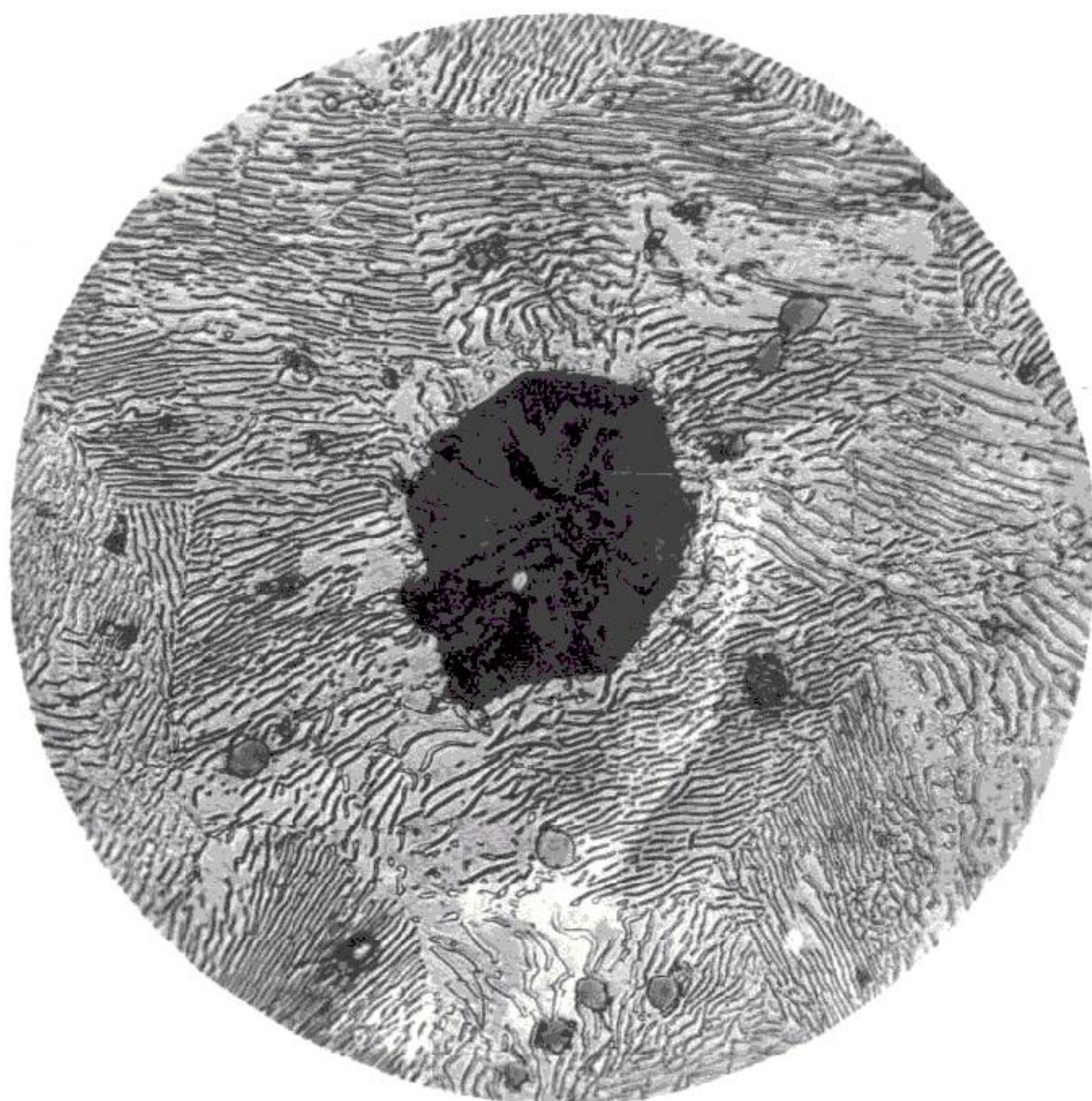
cast

Texture:

pearlite and graphite
in higher magnification

Etching:

as before



No. 69 White-heart malleable casting GTW-40 Magnified: 250:1

Analysis:

Bound carbon	1,60
Graphite comb.	0,50
Silicon	0,60
Manganese	0,40
Sulphur	0,20
Phosphorus	0,10
Nickel	
Chromium	
Tungsten	
Vanadium	
Molybdenum	
Cobalt	
Temperkohle	1,10

Treatment and special properties:

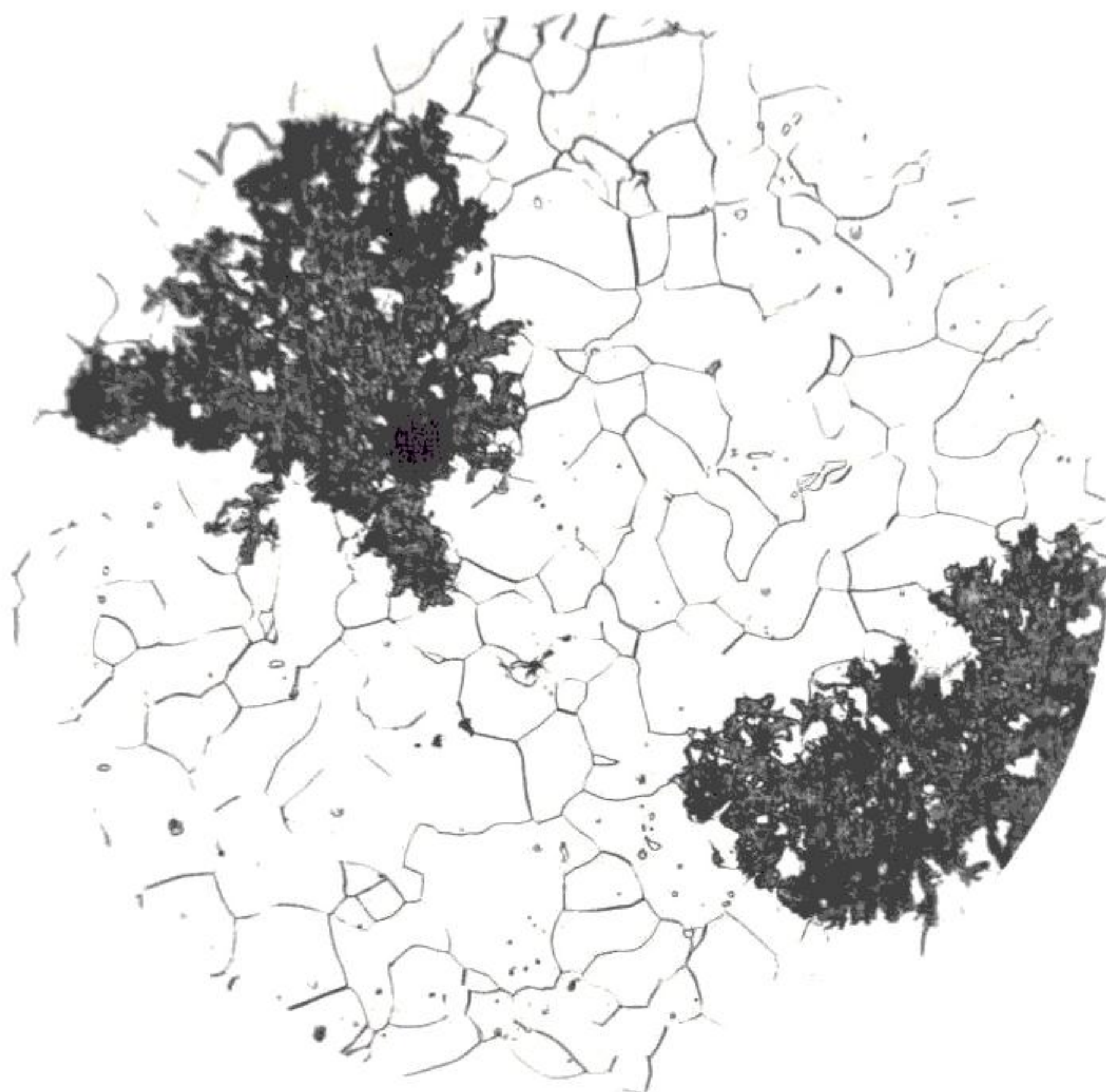
bars of 20x20 mm cast in white pig iron, low in phosphorus, and soaked for 7 days in ferric oxide at 860°C

Texture:

lamellar pearlite and islets of graphite surrounded by ferrite

Etching:

2% alcoholic nitric acid



No. 70 Black-heart malleable Magnified: 250:
 casting GTS - 35

Analysis:

Bound carbon	0,06
Graphite	7,33
Silicon	0,65
Manganese	0,27
Sulphur	0,07
Phosphorus	
Nickel	
Chromium	
Tungsten	
Vanadium	
Molybdenum	
Cobalt	

Treatment and special properties:

white cast iron annealed according to the american process

Texture:

centre:
 ferrite and islets
 of graphite

Etching:

as before



a

Mag. 200:1



b

Mag. 200:1



c

Mag. 200:7

The different structural forms of graphite

Special properties:

a) coarse graphite flakes

n. Richtreihe A 1-2

b) medium coarse graphite flakes

n. Richtreihe A 1-3

c) fine, medium length graphite flakes, evenly distributed

Structure:

VIG

(Verein Dt. Gießereifachleute, Düsseldorf)

Merckblatt - P 447, August 1962

„Richtreihen zur Kennzeichnung der Graphitausbildung“

Etching:

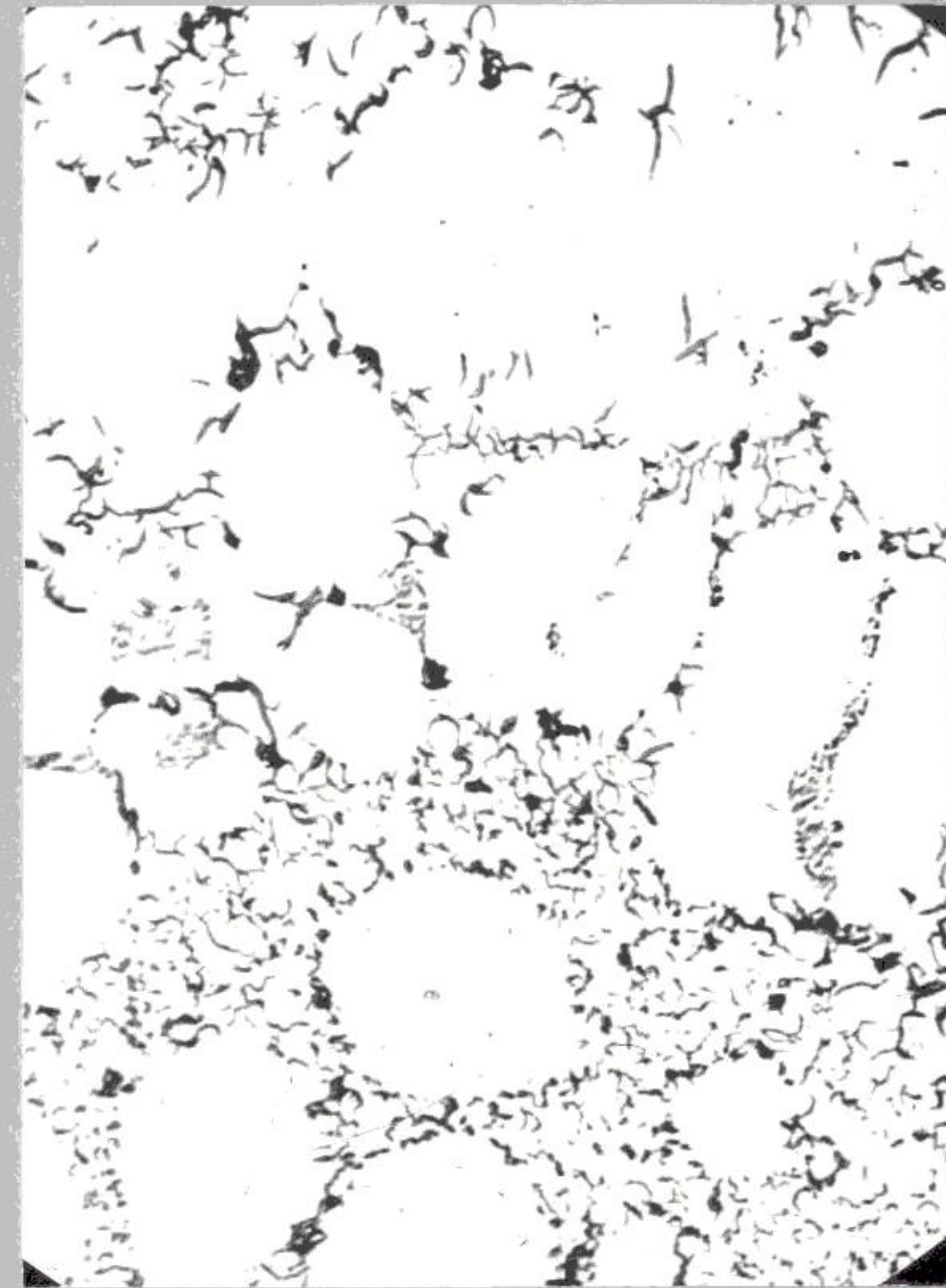
unetched



d Mag 200:1



e Mag 200:1



f Mag 200:1

The different structural forms of graphite

Special properties:

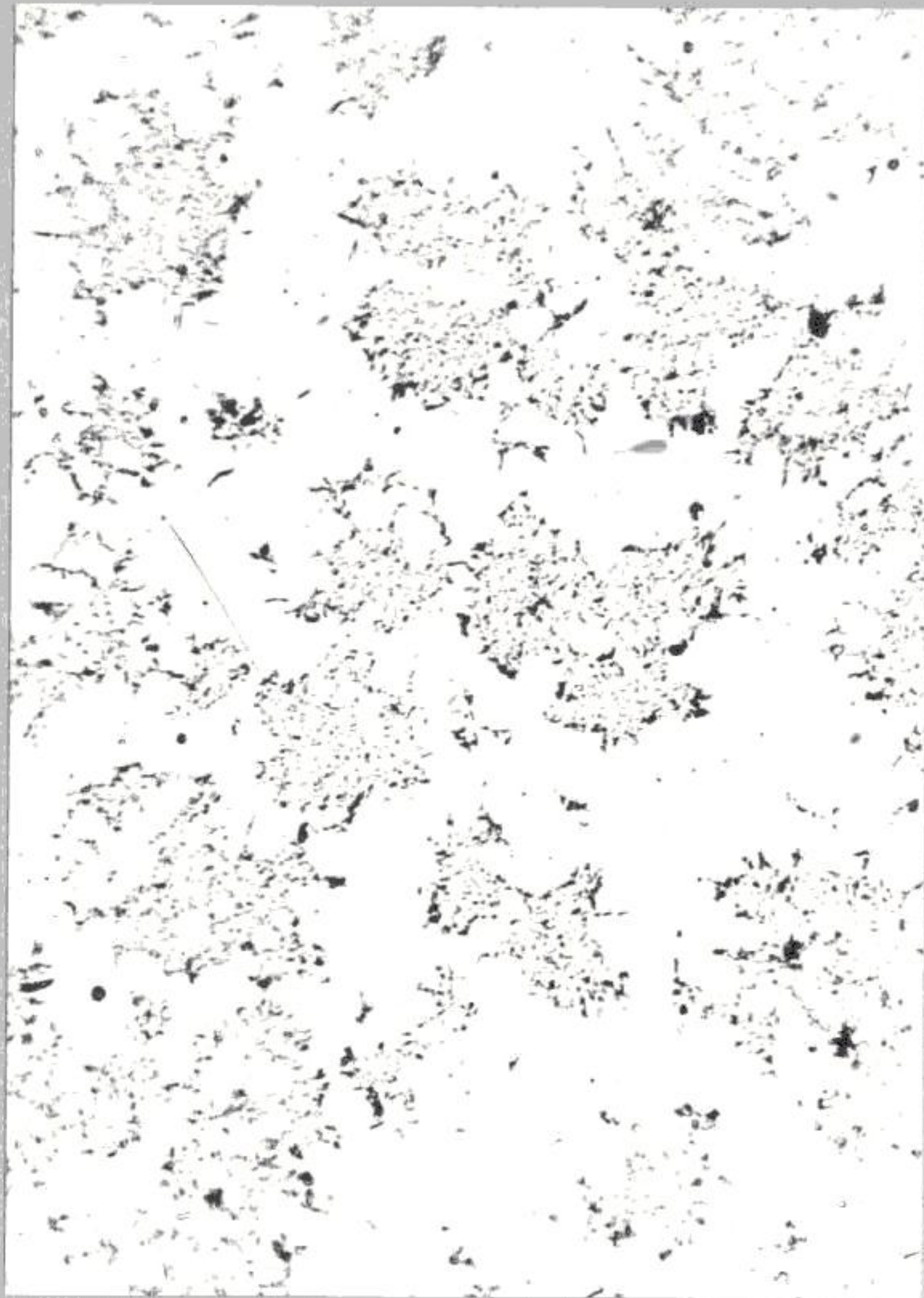
- d) fine lamellar and medium coarse graphite, evenly distributed (interdendritic)
- e) fine deposited graphite produced by superheating the melt
- f) eutectiform graphite

Structure:

as before

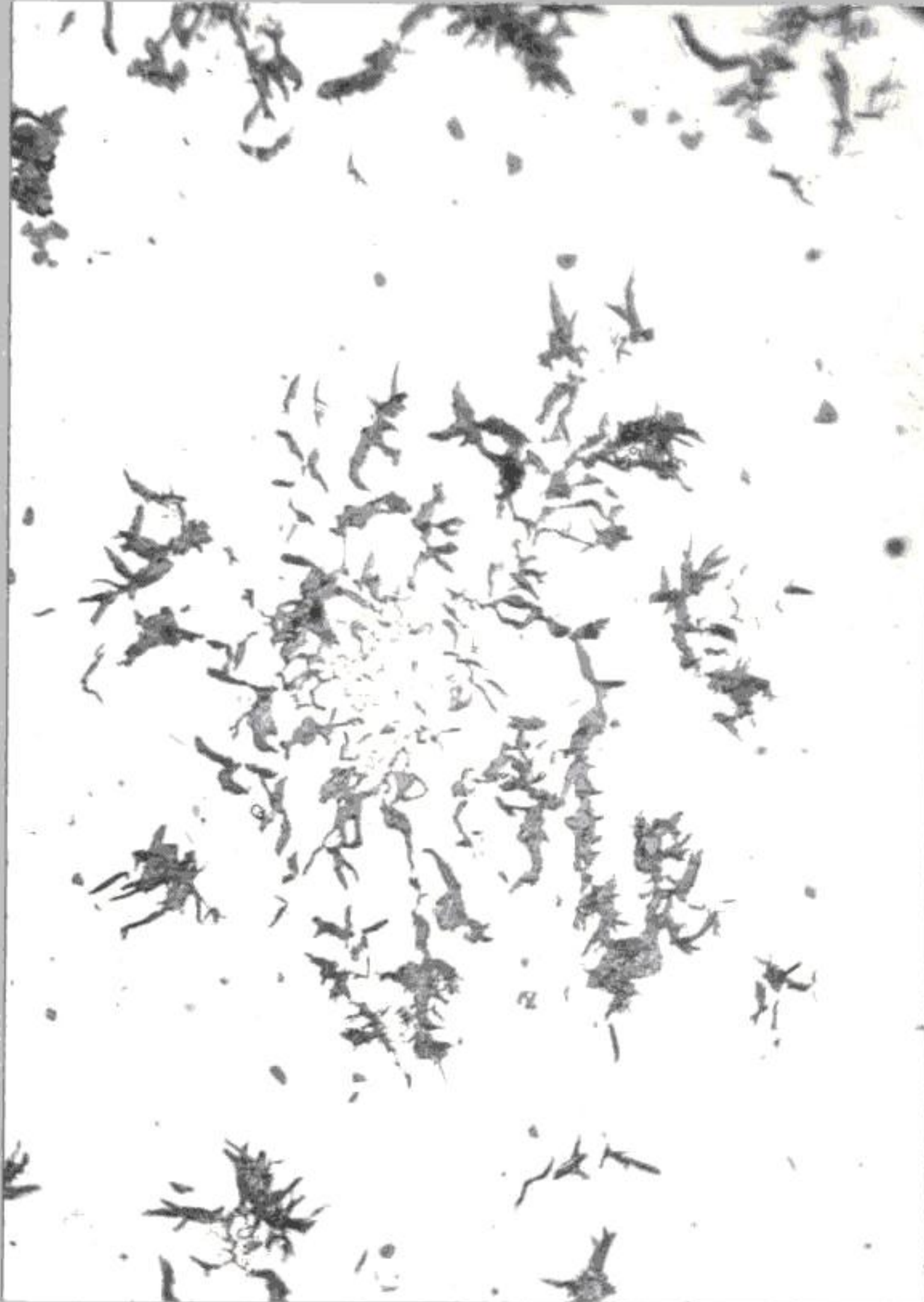
Etching:

unetched



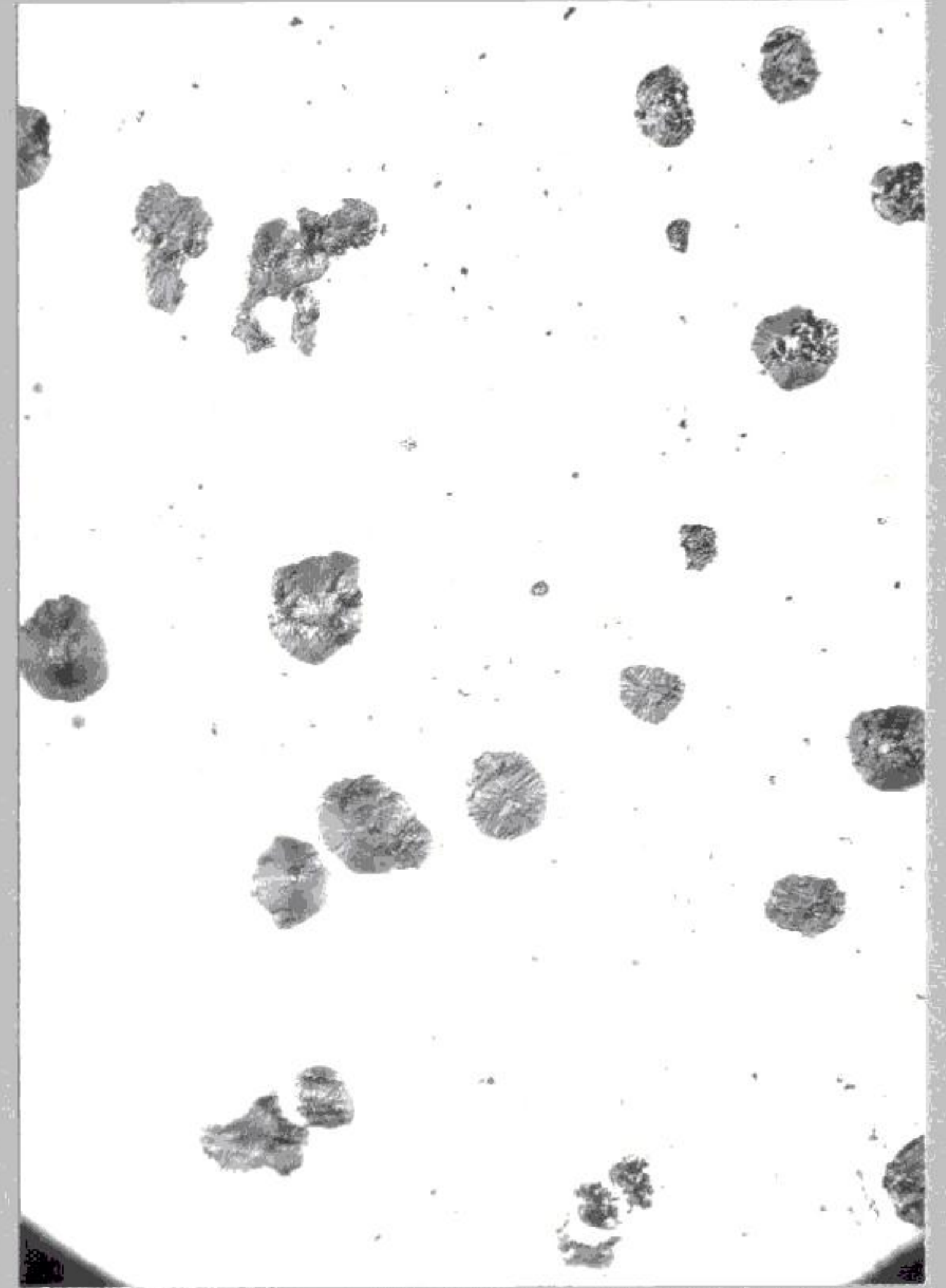
g

Mag. 200:1



h

Mag. 200:1



i

Mag. 200:1

The different structural formes of graphite

Special properties:

g) flake aggregate
graphite

h) rosette graphite

i) nodular graphite

Structure:

as before

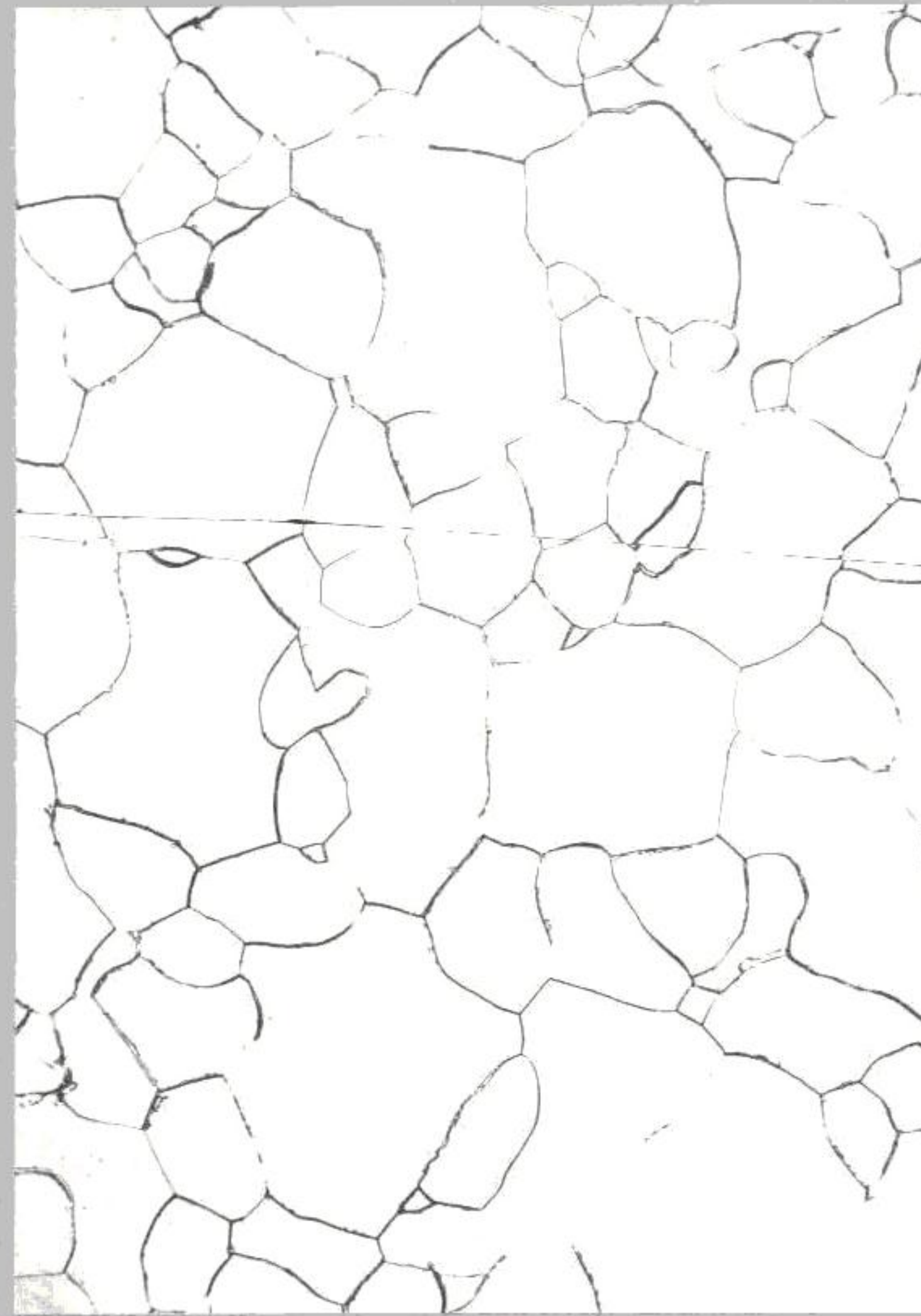
Etching:

unetched



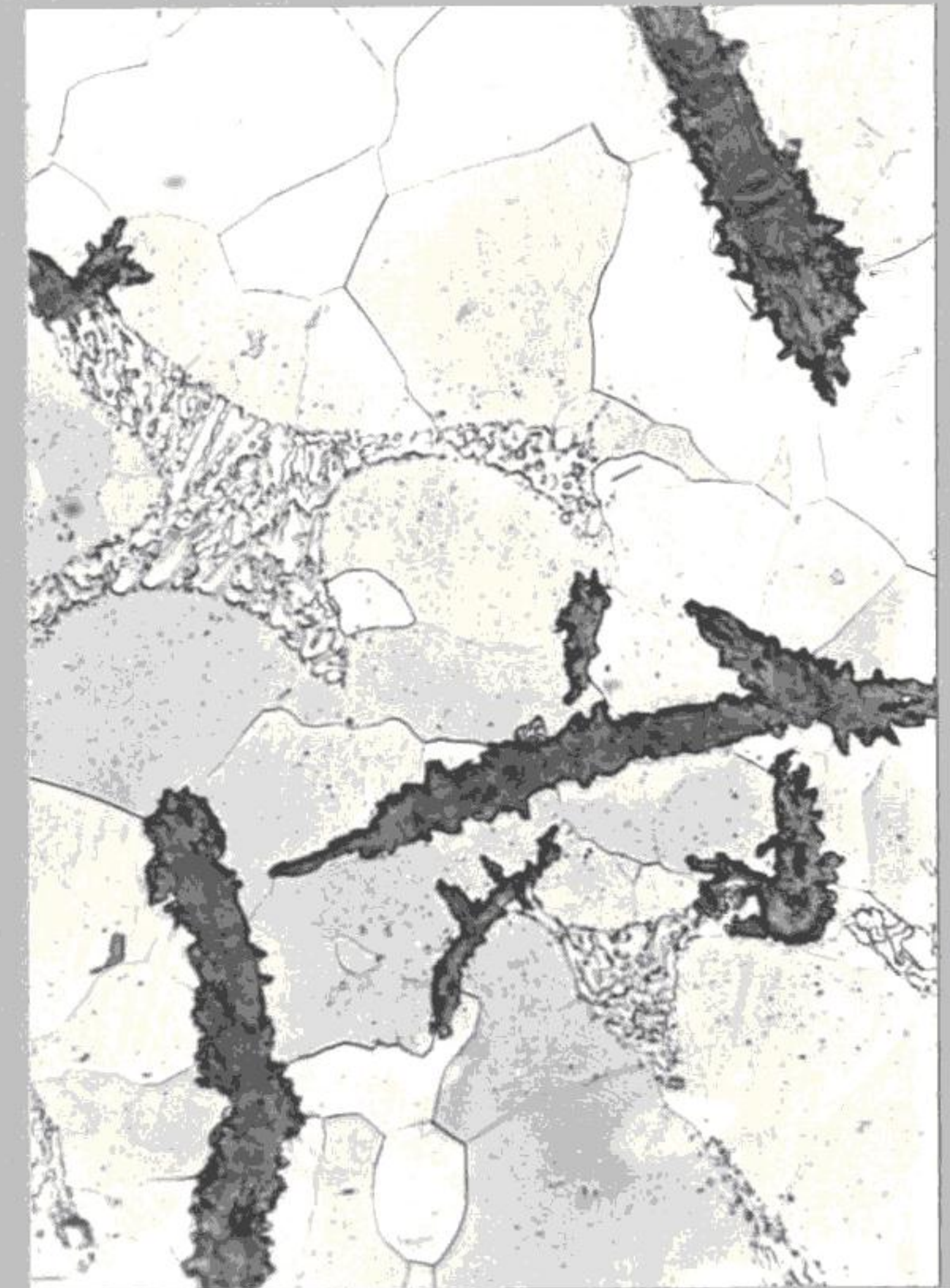
a

Mag. 500:1



b

Mag. 250:1



c

Mag. 500:1

Examples of the identification of micro-constituents

Special properties:

- a) as cast
- b) annealed for 2 hours at 800°C in atmosphere of hydrogen (carbonyl iron)
- c) annealed

Structure:

- a) ledeburite consisting of:
1 = cementite 2 = solid solution
- b) pure ferrite
- c) ferritic matrix with graphite and phosphide eutectic

Etching:

2% alcoholic nitric acid

S. 7-11 n. Erläuterungen des Eisen-Kohlenstoff-Diagramms, Werkstoff-ausschußbericht Nr. 180/4. Auflage 1967 Verlag Stahleisen, Düsseldorf



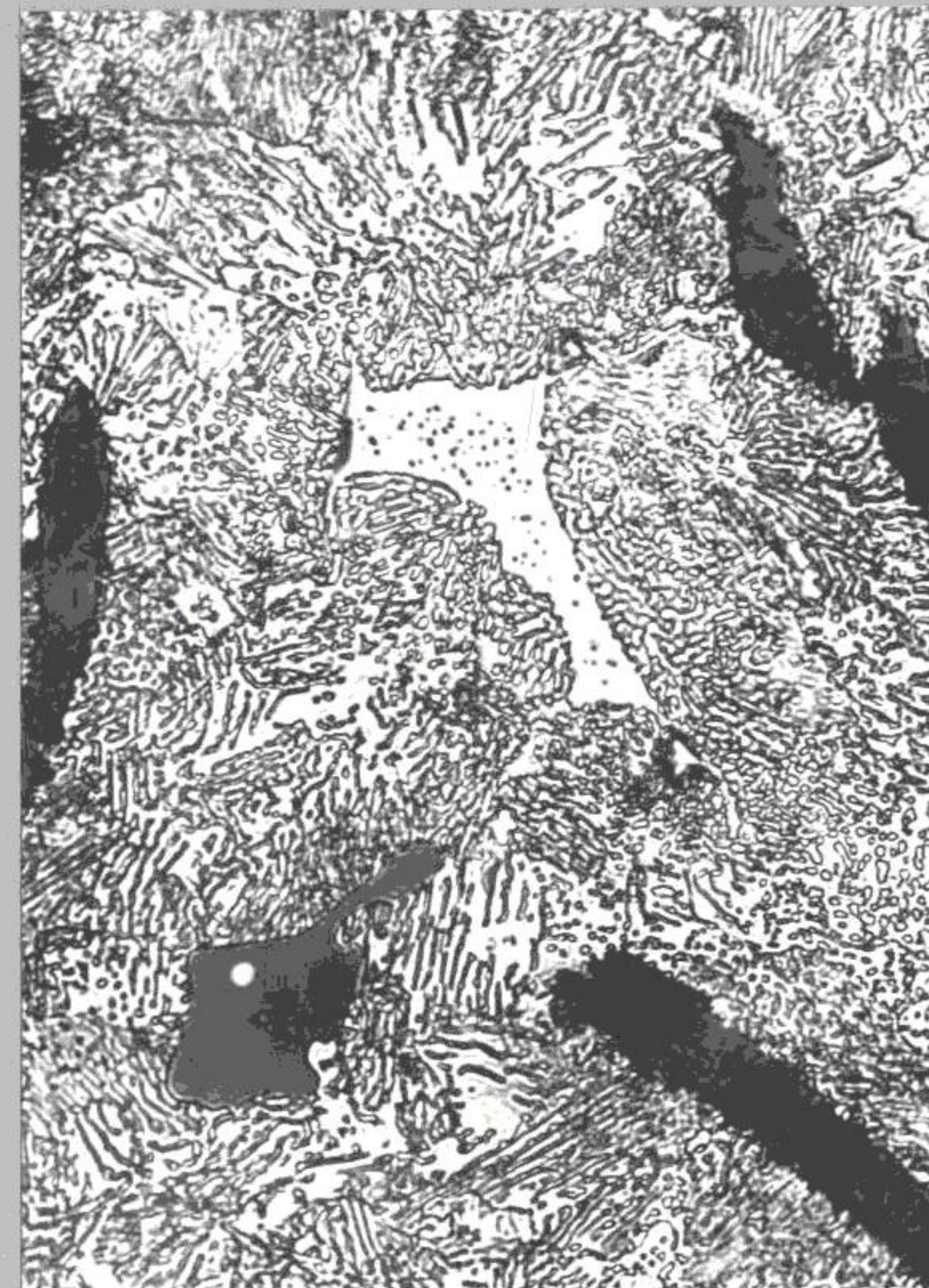
d

Mag. 500:1



e

Mag. 500:1



f

Mag. 500:1

Examples of the identification of micro-constituents

Special properties:

d) cooled in air from the as cast state
(0,5% C)

e) normalised
(0,7% C)

f) grey cast iron
normally cooled

Structure:

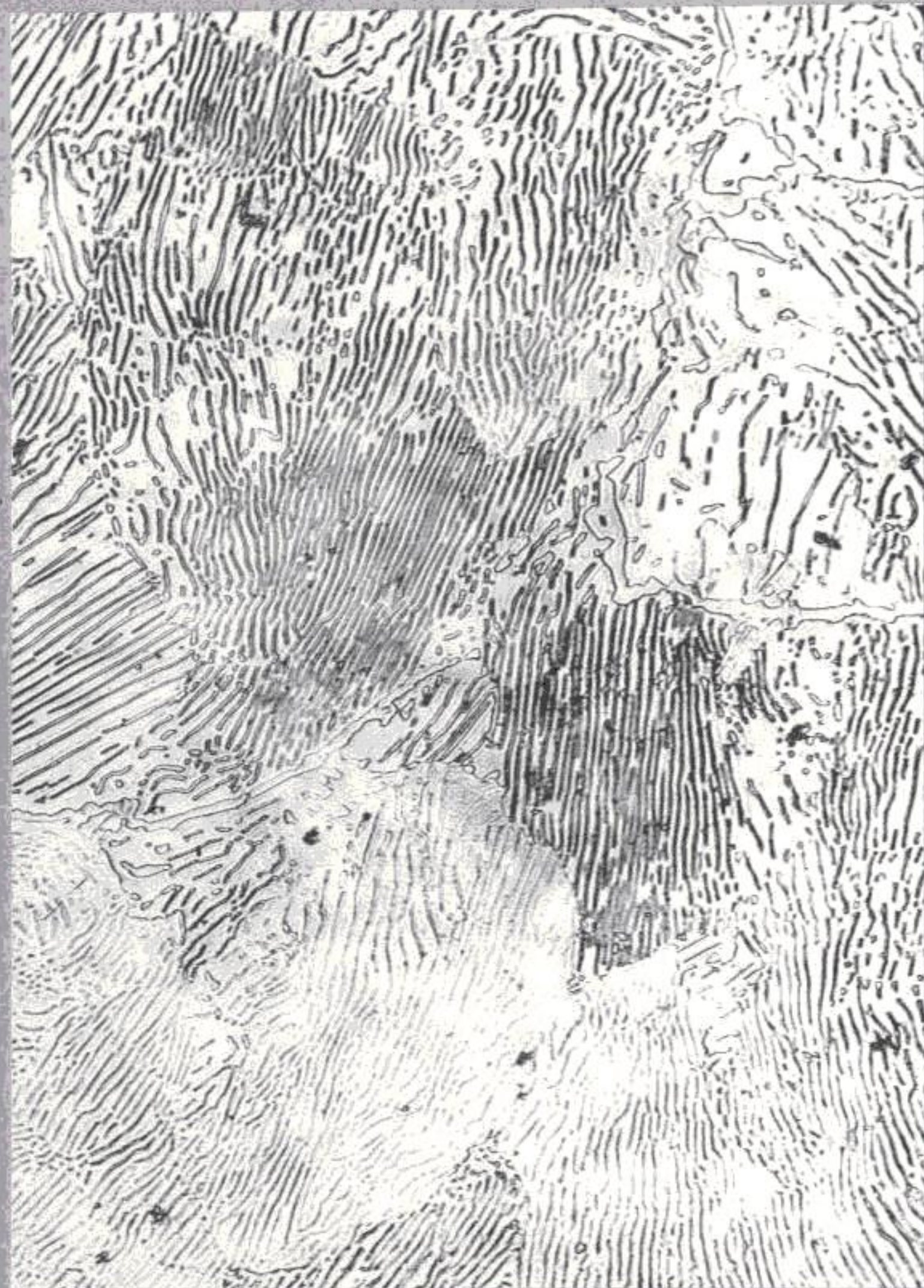
d) ferrite - pearlite (coarse),
hypoeutectic
Widmannstätten structure

e) ferrite - pearlite (fine)

f) graphite and ternary phosphide
eutectic,
pearlite

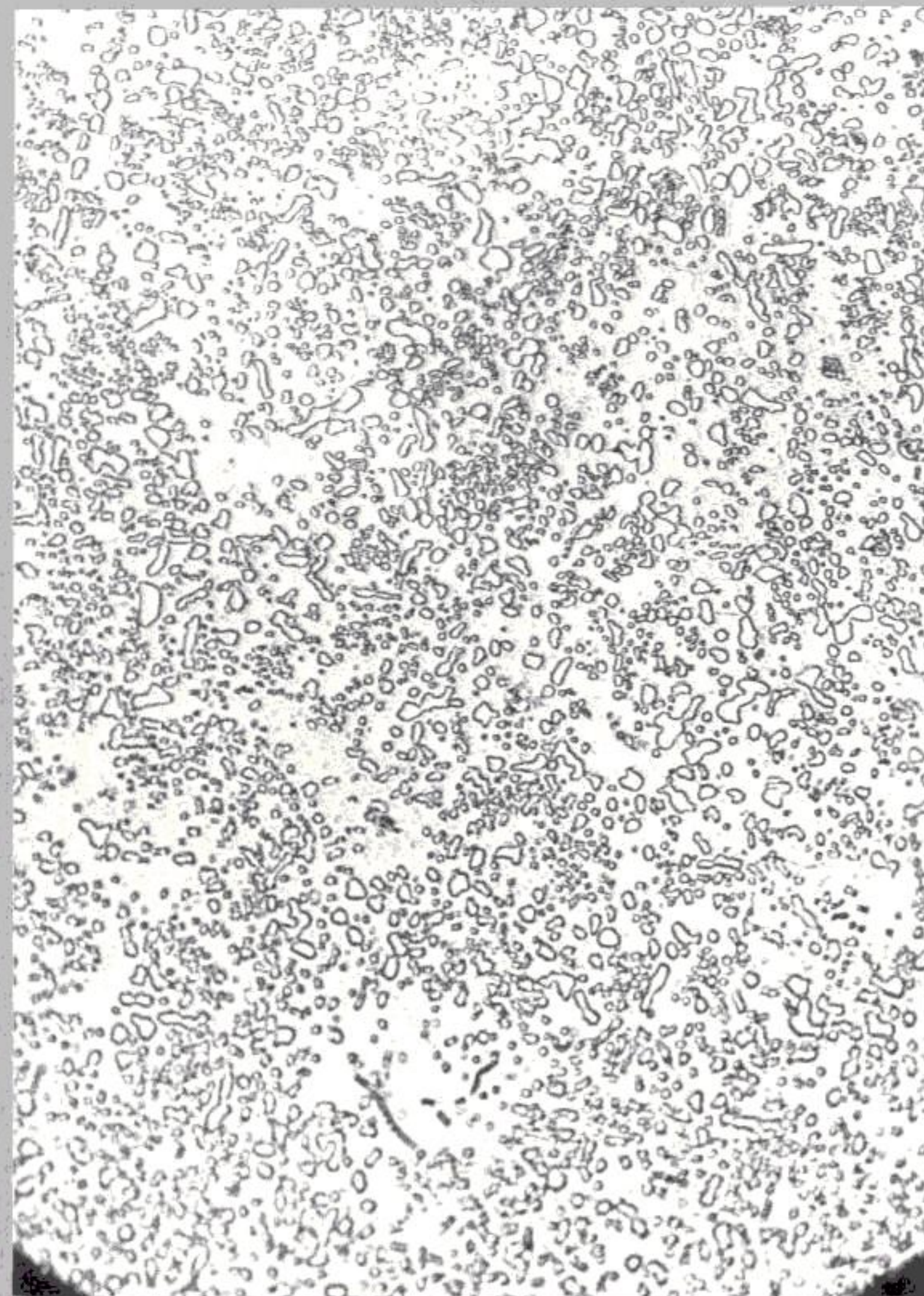
Etching:

2% alcoholic nitric acid



g

Mag 500:1



h

Mag 500:1



i

Mag 500:1

Examples of the identification of micro-constituents

Special properties:

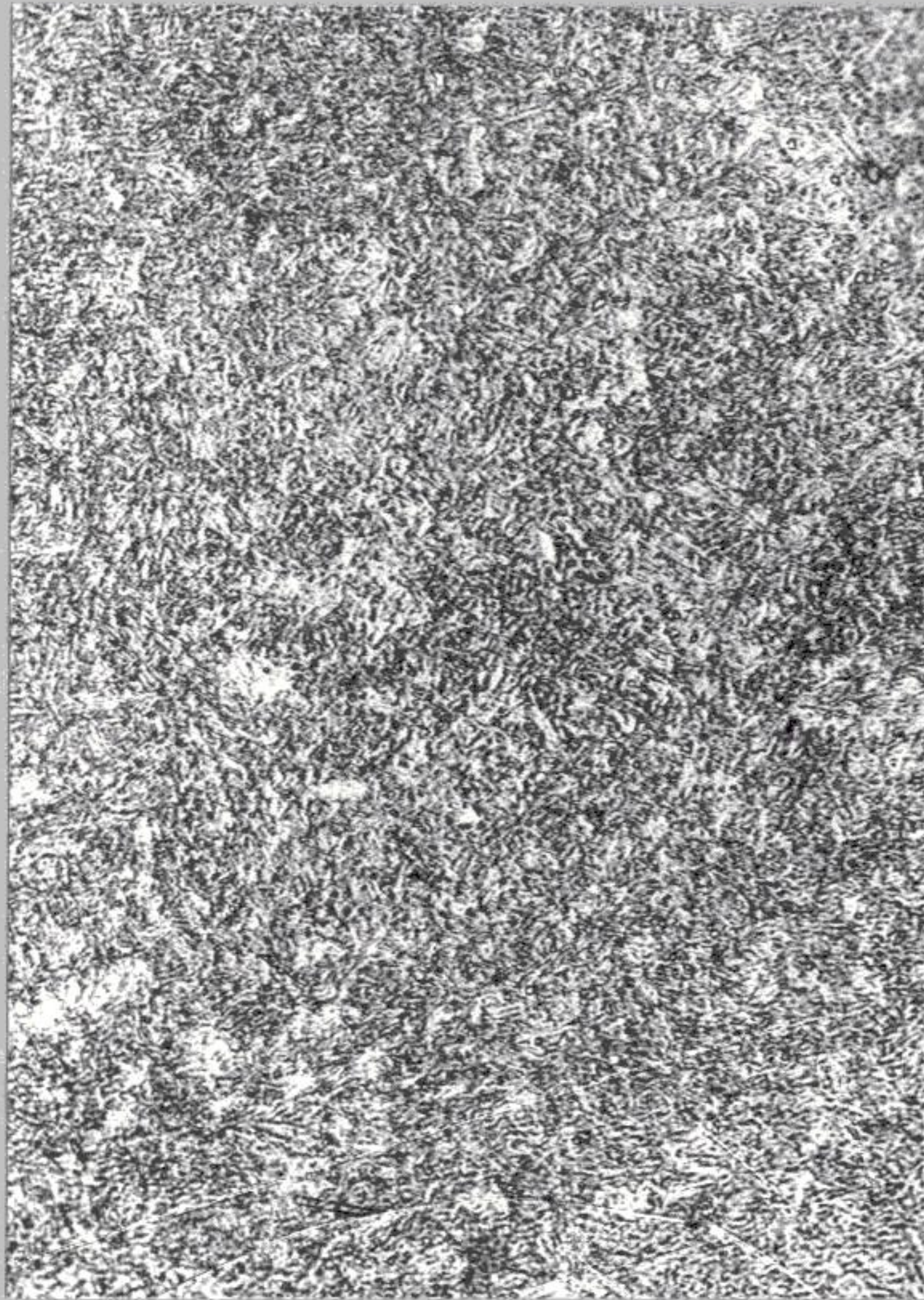
- g) heated to above the upper change-point AC_3 , slowly cooled,
- h) spheroidised at AC_1
- i) cooled quickly in air from the as-cast state

Structure:

- g) lamellar pearlite and network of cementite (hypereutectic)
- h) granular pearlite (cementite in ferritic matrix)
- i) sorbite (very fine lamellar pearlite), graphite and some ternary phosphide eutectic

Etching:

2% alcoholic nitric acid



k

Mag. 500:1



l

Mag. 500:1



m

Mag. 500:1

Examples of the identification of micro-constituents

Special properties:

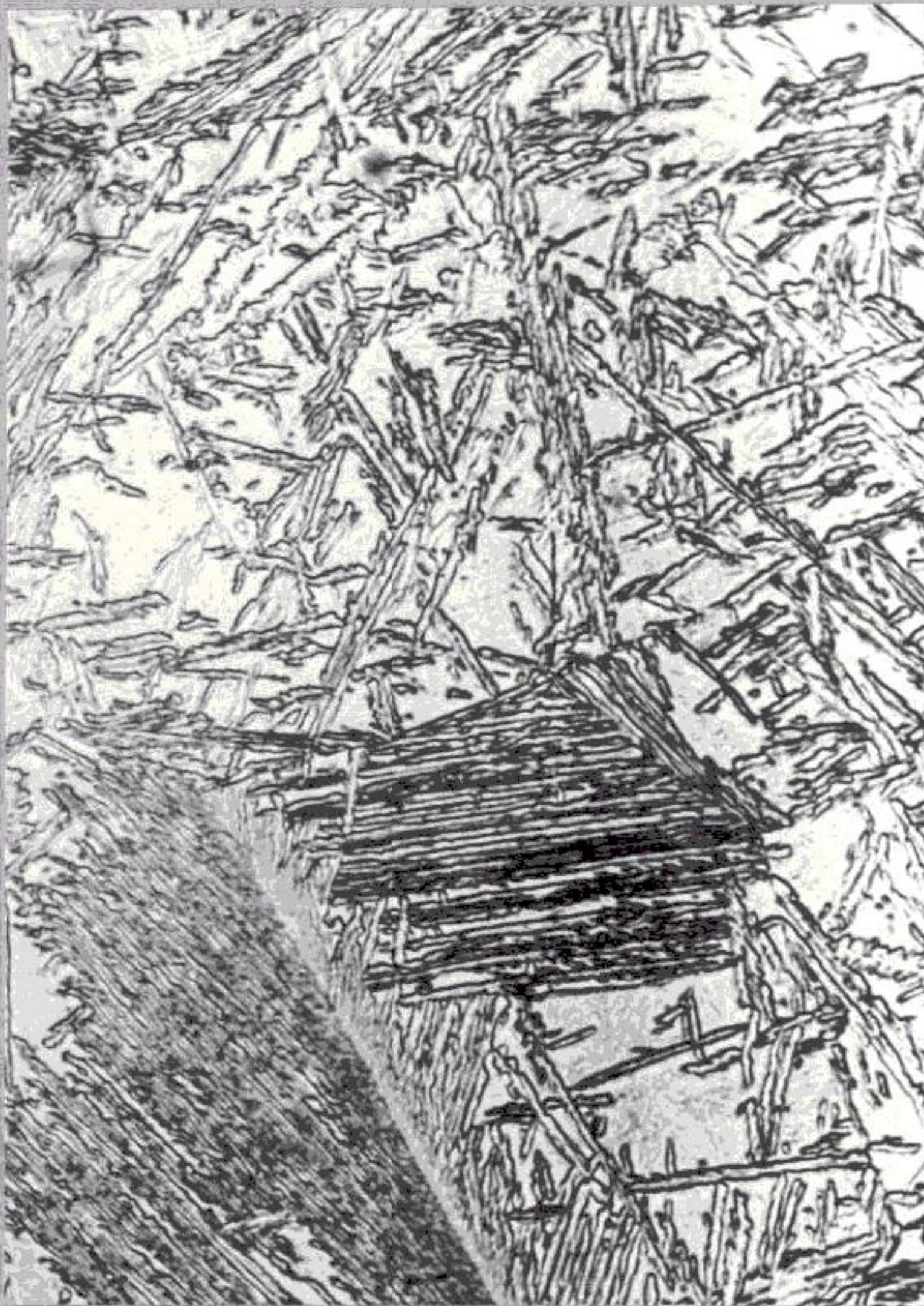
- k) quenched
(very quickly)
from above A_{C3}
- l) incompletely quenched
(950°C)
- m) overheated and
quenched from 1150°C

Structure:

- k) pure, finely divided martensite,
- l) pearlite and martensite-
austenite (troostite)
- m) coarse martensite-austenite,
white martensite needles
(tetragonal martensite)

Etching:

2% alcoholic nitric acid



n

Mag 900:1

Mag.....

Mag.....

Examples of the identification of micro-constituents

Special properties:

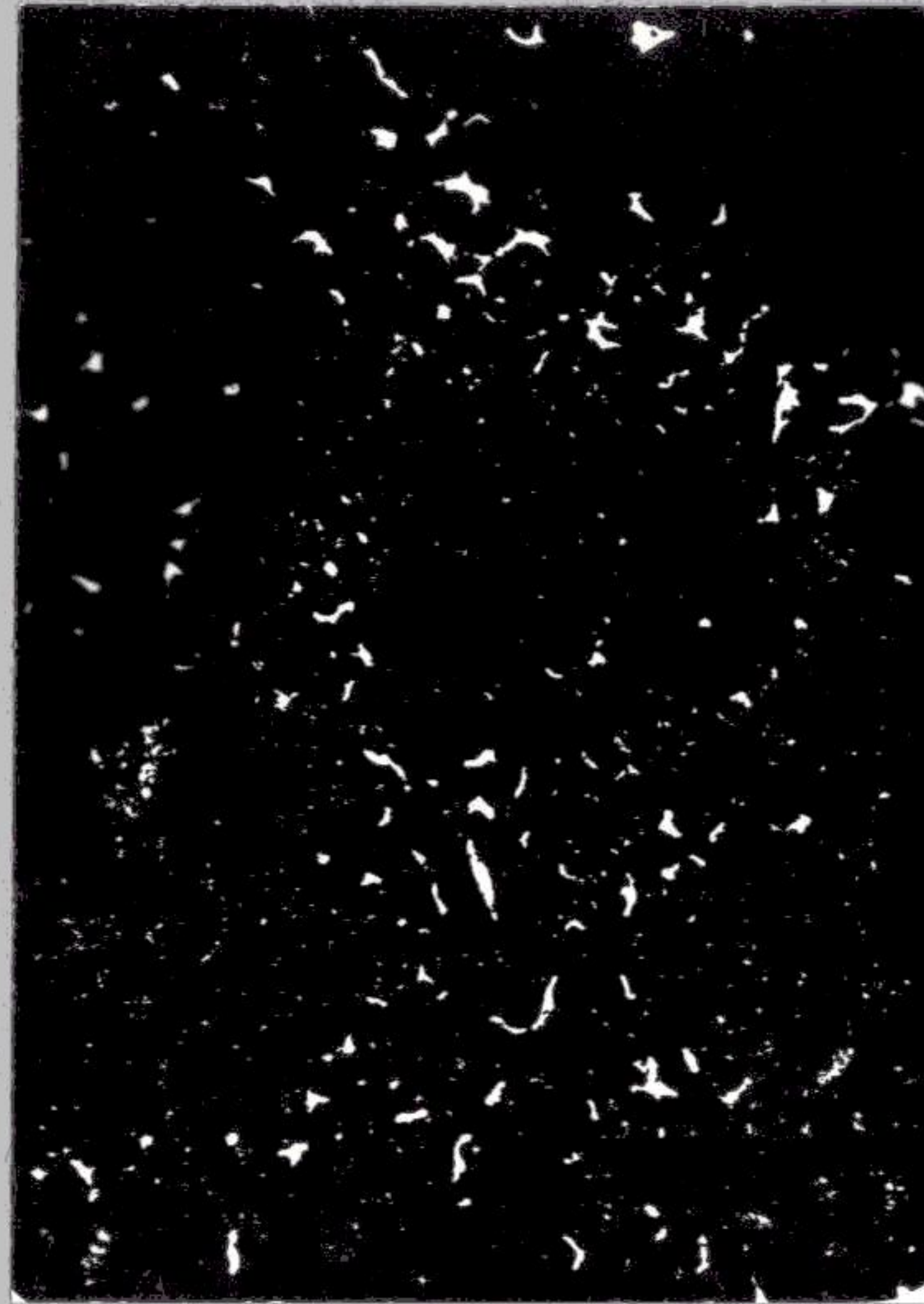
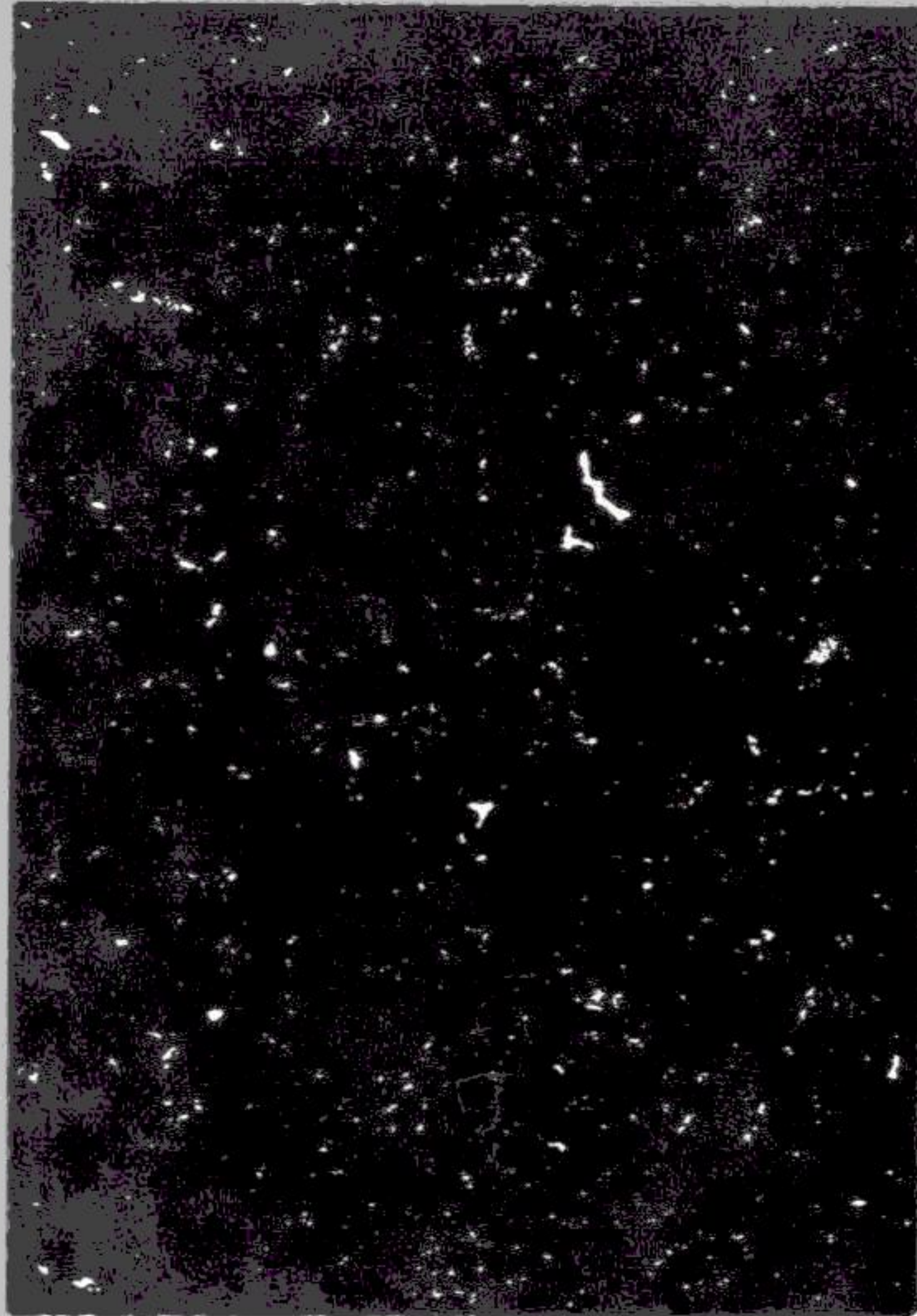
isothermal transformation

Structure:

transition structure (bainite)

Etching:

3% alcoholic nitric acid



a) 0,09% P Mag. 50:1 b) 0,42% P Mag. 50:1 c) 0,87% P Mag. 50:1

Structural forms of phosphides, including their orientation

Special properties:

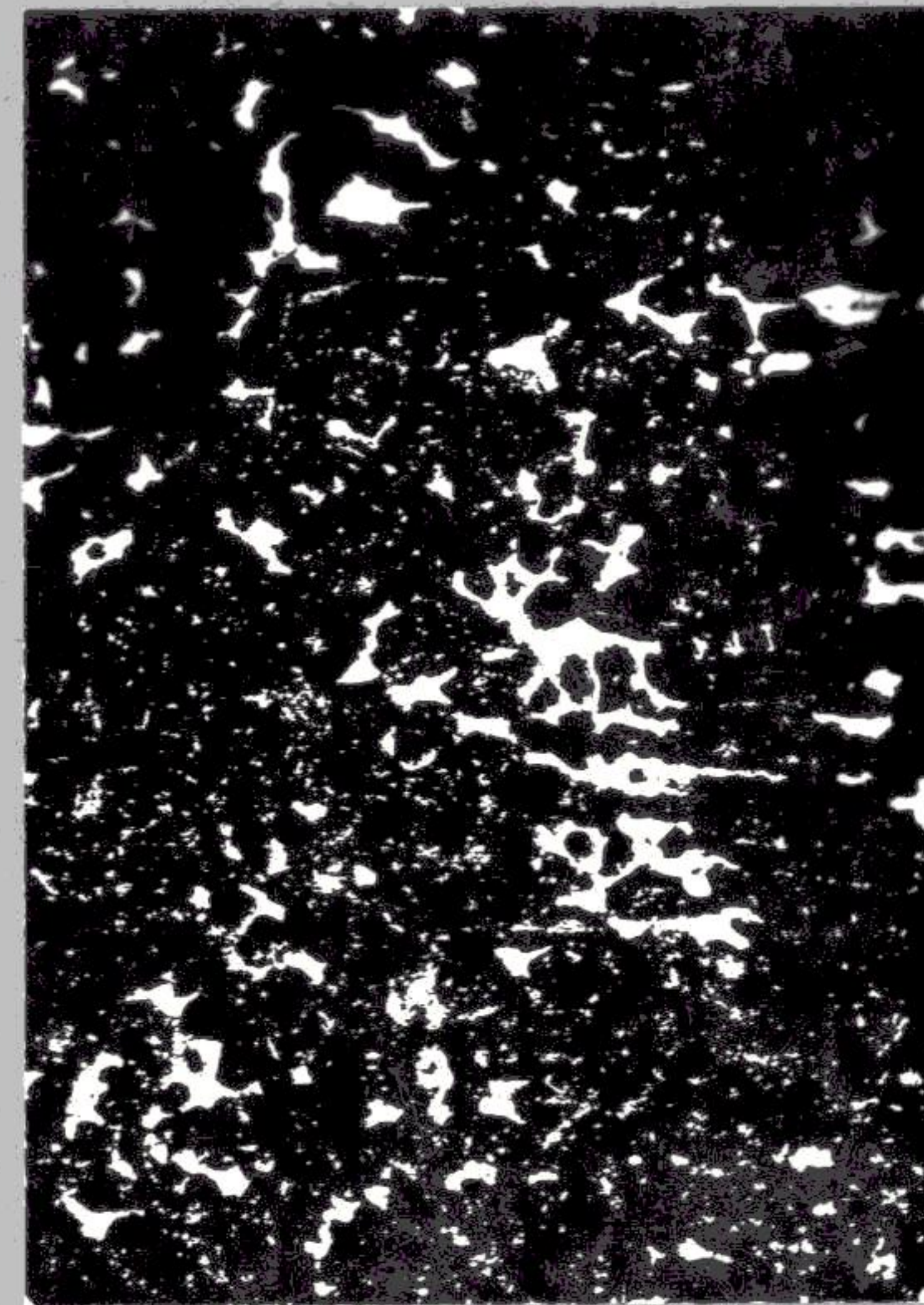
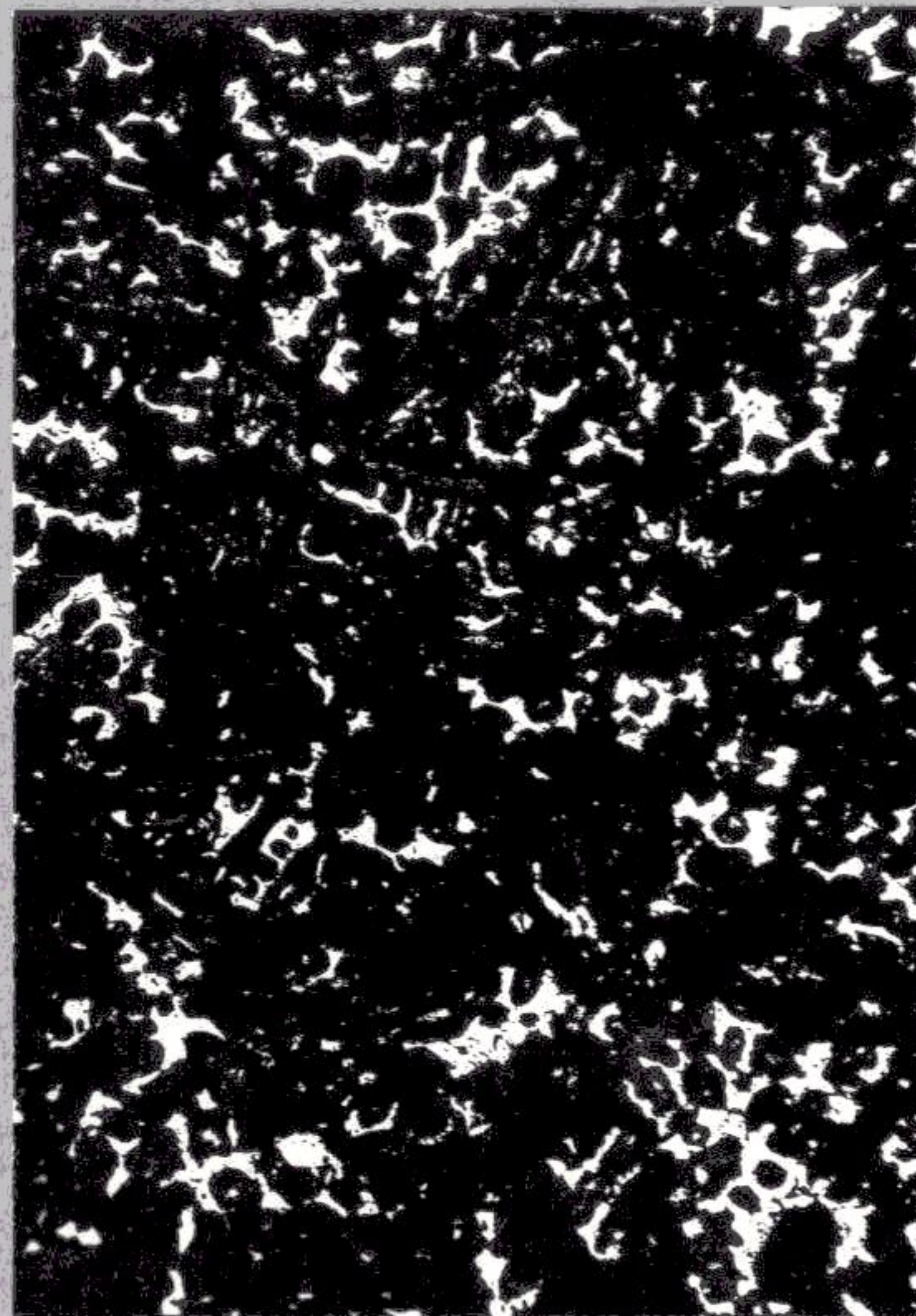
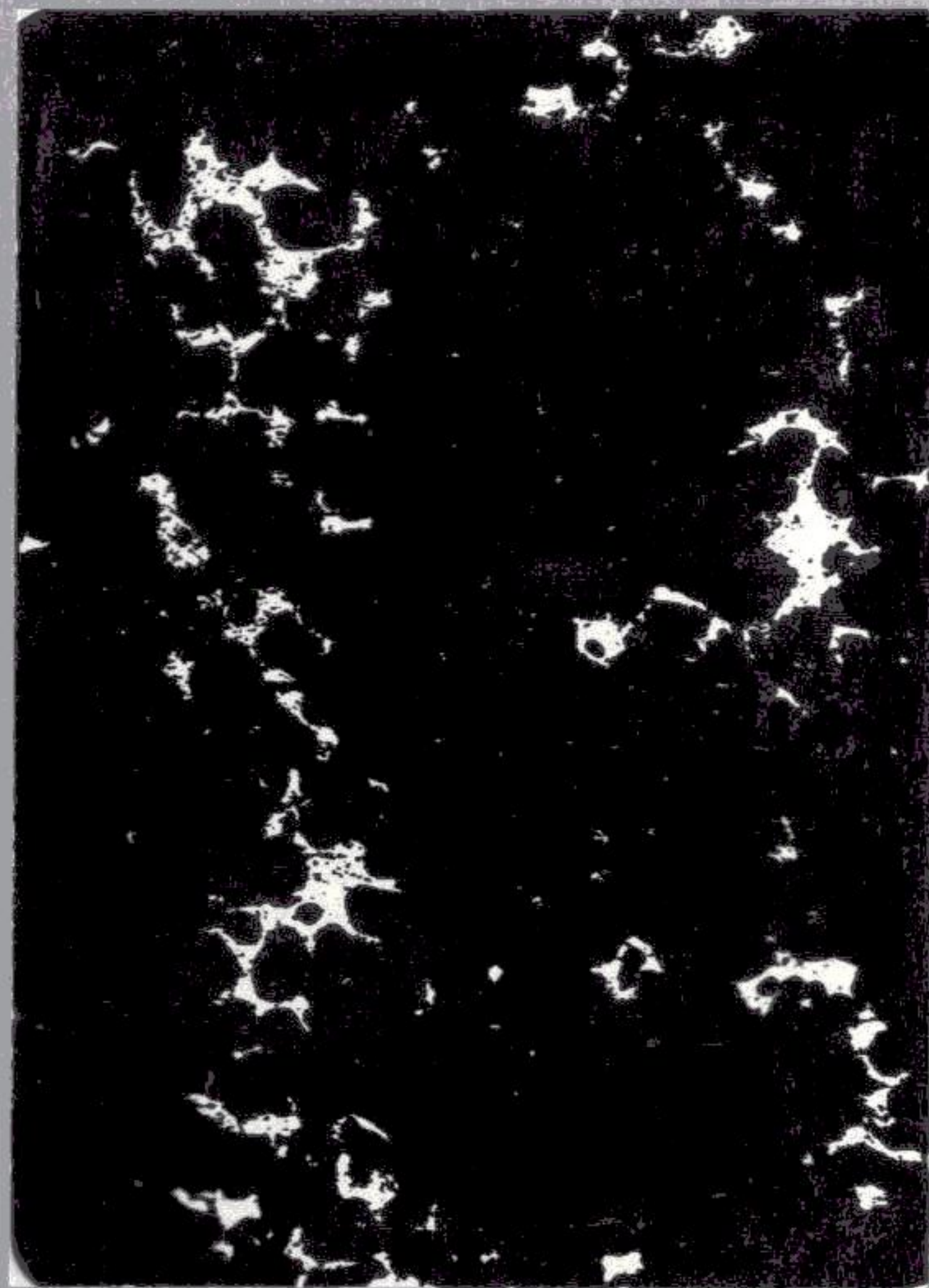
deep etch to compare
the phosphorus contents

Structure:

the matrix is blackened, the
phosphide eutectic and the
free cementite remains un-
attacked

Etching:

deep etch with 20% nitric
acid



d) 1,16% P Mag 50:1 e) 1,41% P Mag 50:1 f) 1,72% P Mag 50:1

Structural forms of phosphides, including their orientation

Special properties:

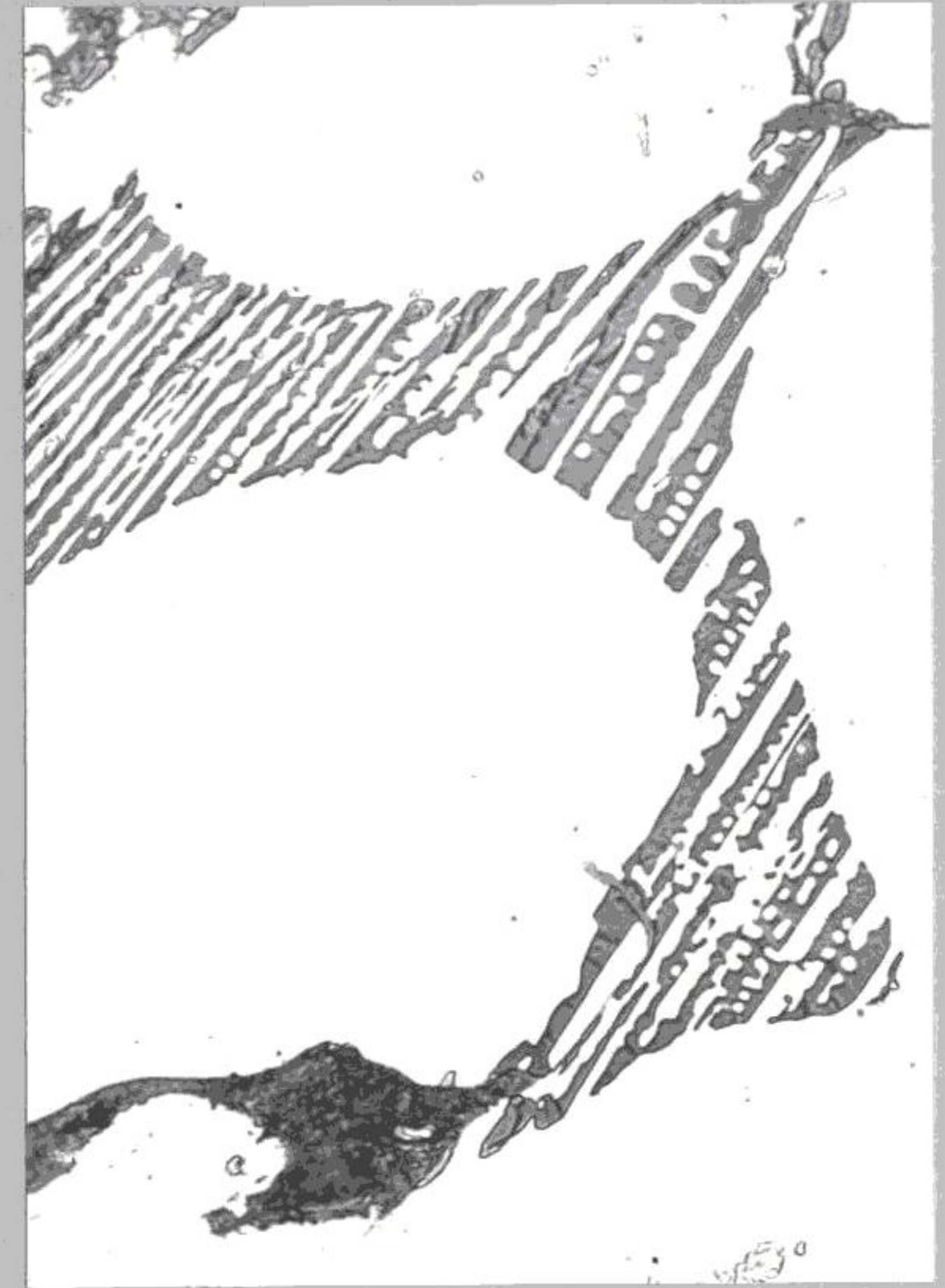
as before

Structure:

as before

Etching:

as before



a) 1,16% P Mag. 1000:1 b) 1,16% P Mag. 1000:1 c) 1,16% P Mag. 1000:1

Structural forms of phosphides

Special properties:

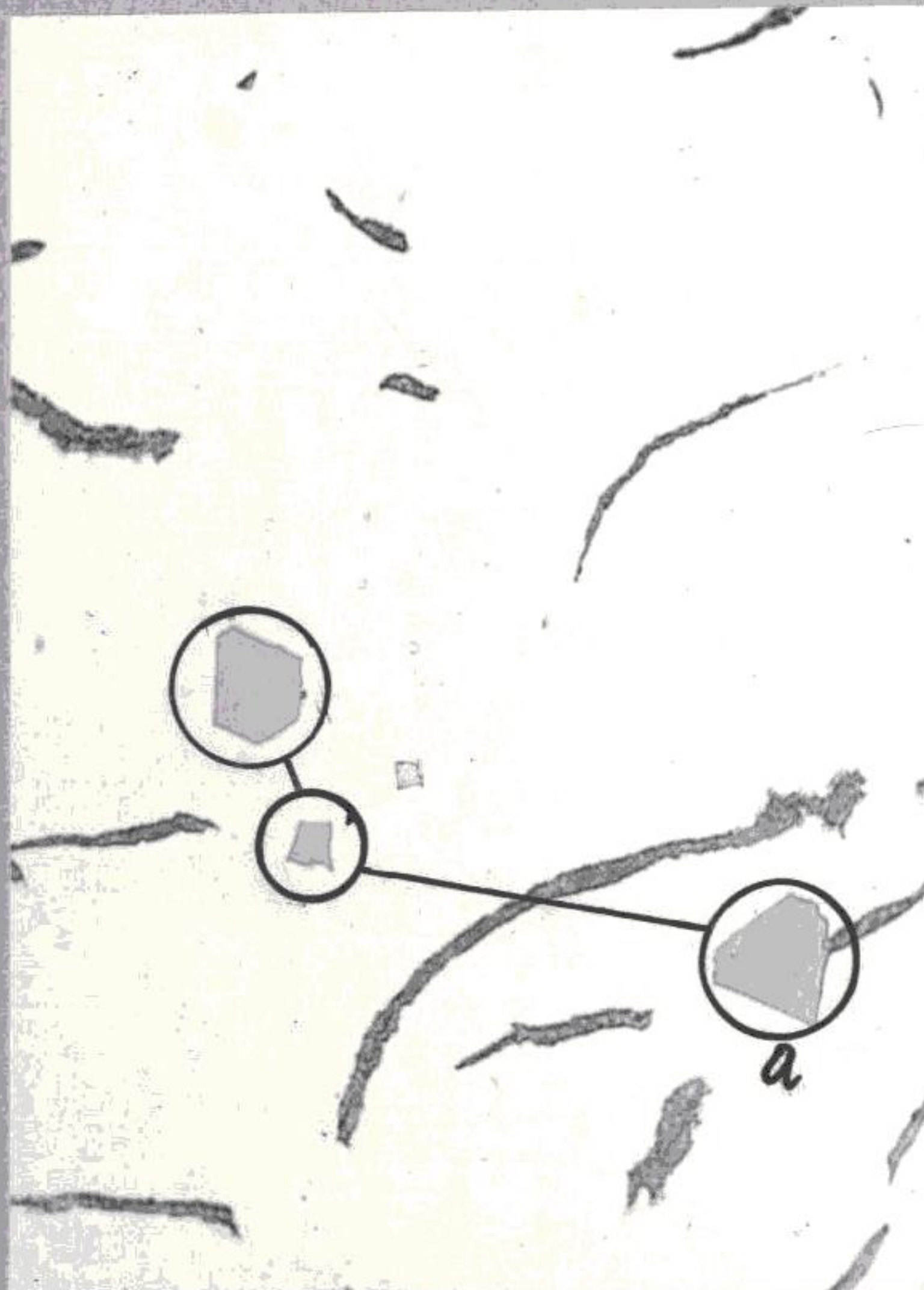
special etching technic
to distinguish the
micro-constituents
(P= 1,16%)

Structure:

- a) ternary phosphide eutectic in a matrix of laminated pearlite
- b) the cementite as constituent of the ternary phosphide eutectic and of the pearlite is tinted black by etching
- c) tinting of the phosphide (black)

Etching:

- a) 2% alcoholic nitric acid
- b) sodium picrate
- c) potassium ferricyanide



a

Mag. 500:1



b

Mag. 200:1



c

Mag. 200:1

Detection of sulphides

Special properties:

a) S = 0,11% Mn = 0,6%

b) S = 0,16% Mn = 0,4%

c) S = 0,16% Mn = 0,2%

Structure:

- a) blue-grey manganese sulphides
- b) extensive accumulation of manganese-sulphides
- c) the blackened sulphide inclusions are associated with white envelopes, as a result of the etching-reagent

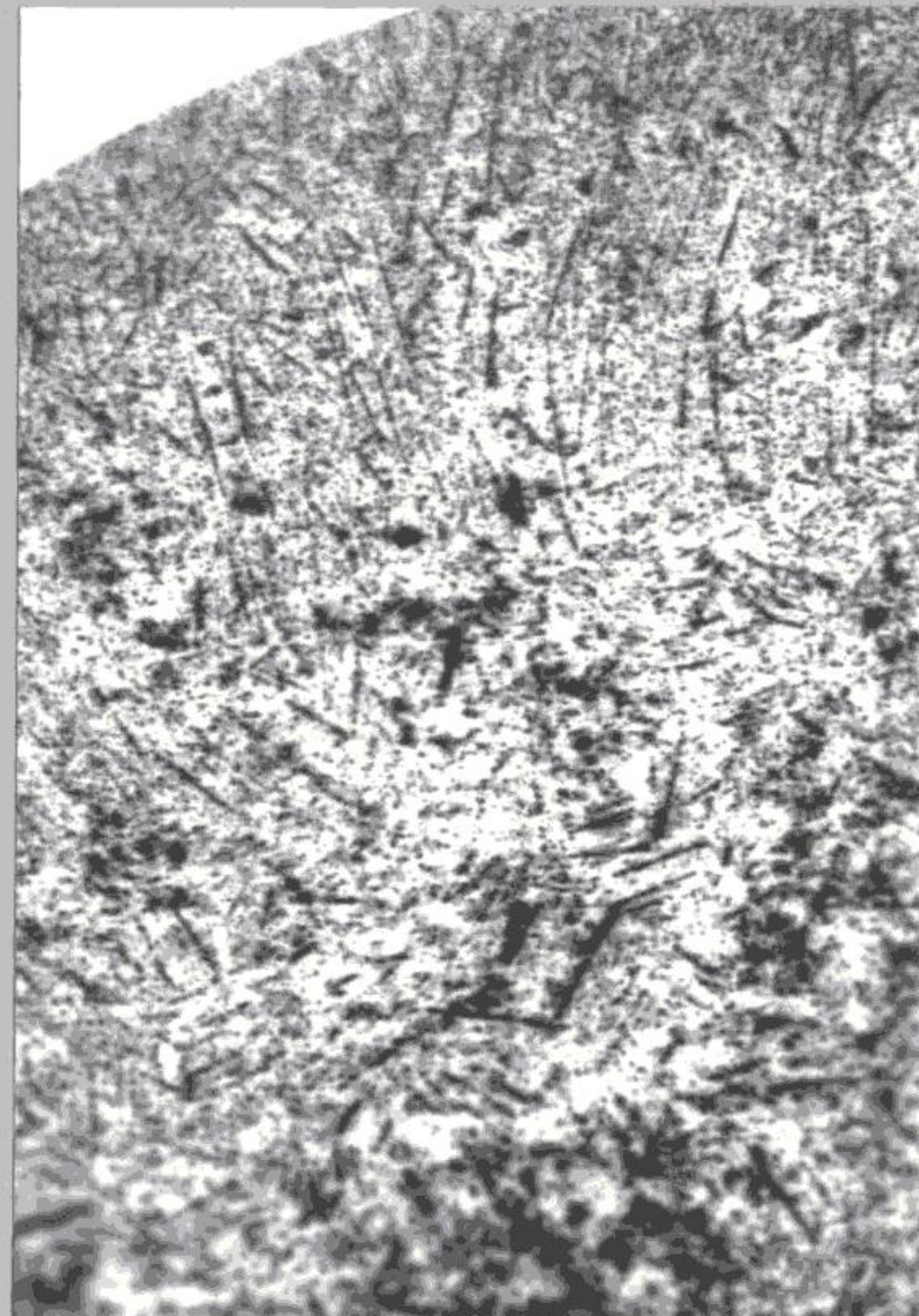
Etching:

- a, b) unetched
- c) gelatine-silver nitrate (after Künkele)



d

Mag. 500:1



e

Mag. 7:7

Mag.

Detection of sulphides

Special properties:

d) iron sulphide

e) Baumann print
(chill cast roll)
260 mm ϕ
(section)

Structure:

d) sulphides

e) dendritic structure and
concentrations of man-
ganese sulphide

Etching:

d) unetched

e) Baumann print

Gußeisen mit Lamellengraphit (Grauguß)

DIN 1691

Cast iron with lamellar graphite (grey cast iron)

Die neue Sorteneinteilung nach dieser Norm stimmt überein mit der ISO-Empfehlung *) ISO/R 185 — 1962; siehe Erläuterungen.

1. Begriff

Gußeisen mit Lamellengraphit (GG) ist ein Eisen-Kohlenstoff-Gußwerkstoff, dessen als Graphit vorliegender Kohlenstoffanteil weitgehend lamellar ist.

2. Sorteneinteilung

Die Sorteneinteilung (siehe Tabelle 1) fußt auf der Zugfestigkeit von Zugproben, die aus getrennt gegossenen Probestücken mit einem Rohgußdurchmesser von 30 mm entnommen sind (Normalproben).

Die Wahl der Sorte ist Angelegenheit des Bestellers. Ihre gießtechnische Eignung für das vorgesehene Gußstück ist vom Gußhersteller zu prüfen. Hinweise für die Auswahl der Werkstoffsorte siehe DIN 1691 Beiblatt.

Für Gußeisen mit Gewährleistungswerten, die über die der Tabelle 1 hinausgehen, sind die Abschnitte 5.1, 5.2, 9.1.3, 9.1.4 und 10 zu beachten.

Tabelle 1. Gewährleistete Eigenschaften an getrennt gegossenen Probestücken

Kurzzeichen	Sorte		Zugfestigkeit ³⁾ σ_{zB}		Probenabmessung	
	nach DIN 1691 Ausg. 11.1949 x, bis auf weiteres zugelassen Kurzzeichen ¹⁾	Werkstoff- nummer ²⁾	Normal- probe ⁴⁾ kp/mm ² mind.	Sonder- probe ⁵⁾ kp/mm ² mind.	Rohguß- durchmesser des Probestücks mm	Nenn- durchmesser der Zugprobe mm
GG-10		0.6010	10		30	20
	GG-12	0.6012	12		30	20
	GG-14	0.6014	14		30	20
GG-15		0.6015		23	13	8
				18	20	12,5
			15		30	20
				11	45	32
GG-20	GG-18	0.6018	18		30	20
		0.6020		28	13	8
				23	20	12,5
			20		30	20
GG-25	GG-22	0.6022	22		45	32
		0.6025			30	20
				33	13	8
				28	20	12,5
GG-30		0.6026		21	30	20
			25		45	32
					30	20
		0.6030		33	20	12,5
GG-35				26	30	20
					45	32
		0.6035		38	20	12,5
			35		30	20
GG-40				31	45	32
		0.6040			30	20
			40		45	32
				36	30	20

*) ISO = International Organization for Standardization

¹⁾ Diese Sorten können bei Benutzung von bestehenden Unterlagen weiter verwendet werden, wenn die Umstellung auf die neuen Sorten aus besonderen Gründen nicht vorgenommen werden kann.

²⁾ Eine Norm über Werkstoffnummern ist in Vorbereitung. Die kursiv gesetzten Zahlen sind vorgeschlagen.

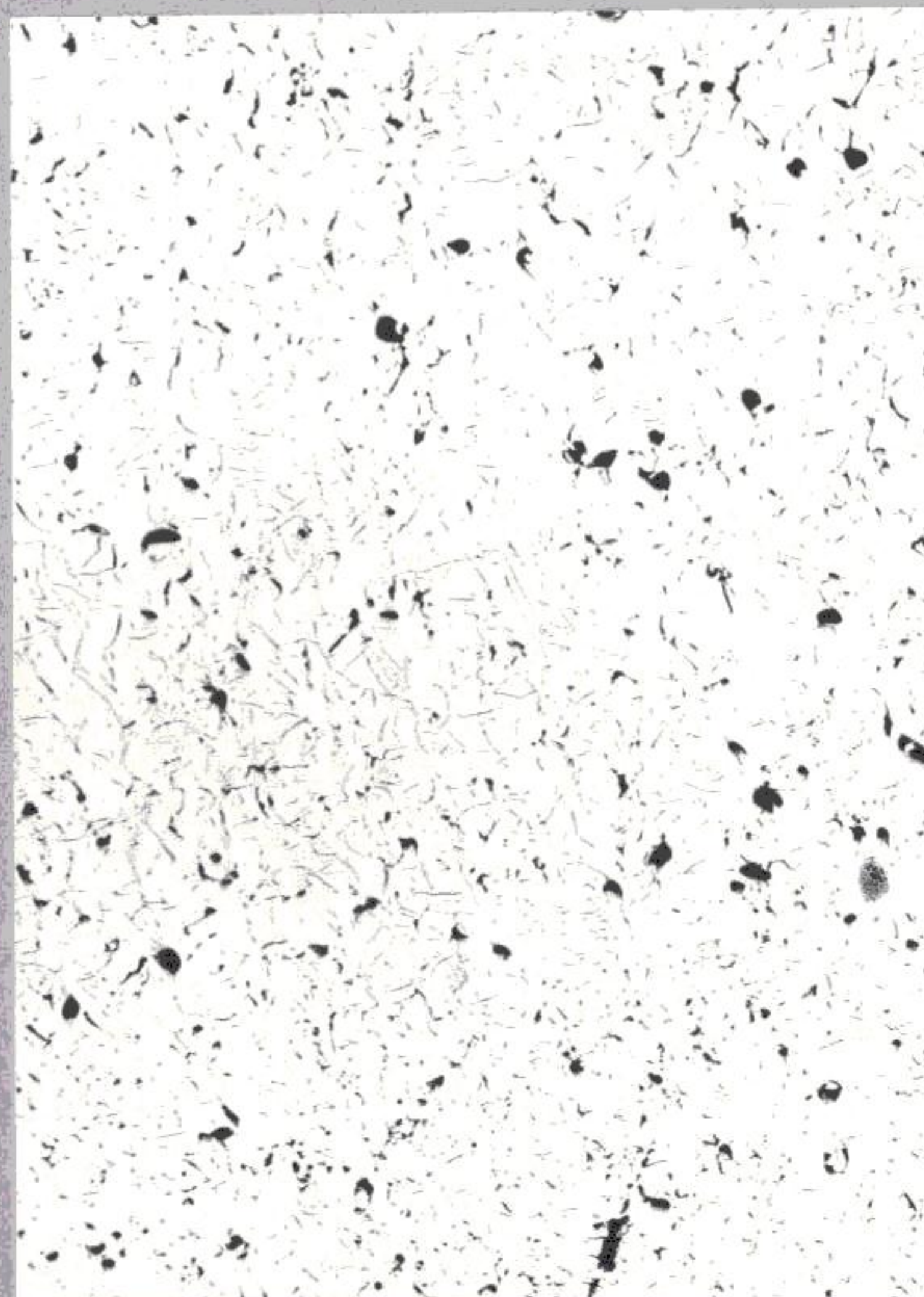
³⁾ Die Mindestwerte der Zugfestigkeit der Gußeisensorten GG-15 bis GG-40 dürfen um höchstens 10 kp/mm² überschritten werden, wenn bei der Bestellung nichts anderes vereinbart wurde.

⁴⁾ Siehe Abschnitt 9.1.1.

⁵⁾ Siehe Abschnitt 5.3 und 9.1.2.

Fortsetzung Seite 2 bis 4
Erläuterungen Seite 4

Fachnormenausschuß Gießereiwesen (GINA) im Deutschen Normenausschuß (DNA)
Fachnormenausschuß Eisen und Stahl (FES) im DNA

Specimen No. 1a25:1b200:1c500:1

Analysis type:

Total carbon	<u>3,3</u>
Graphite	<u>2,8</u>
Combined carbon	<u>0,5</u>
Silicon	<u>1,9</u>
Manganese	<u>0,5</u>
Phosphorus	<u>0,6</u>
Sulphur	<u>0,12</u>

Special properties:

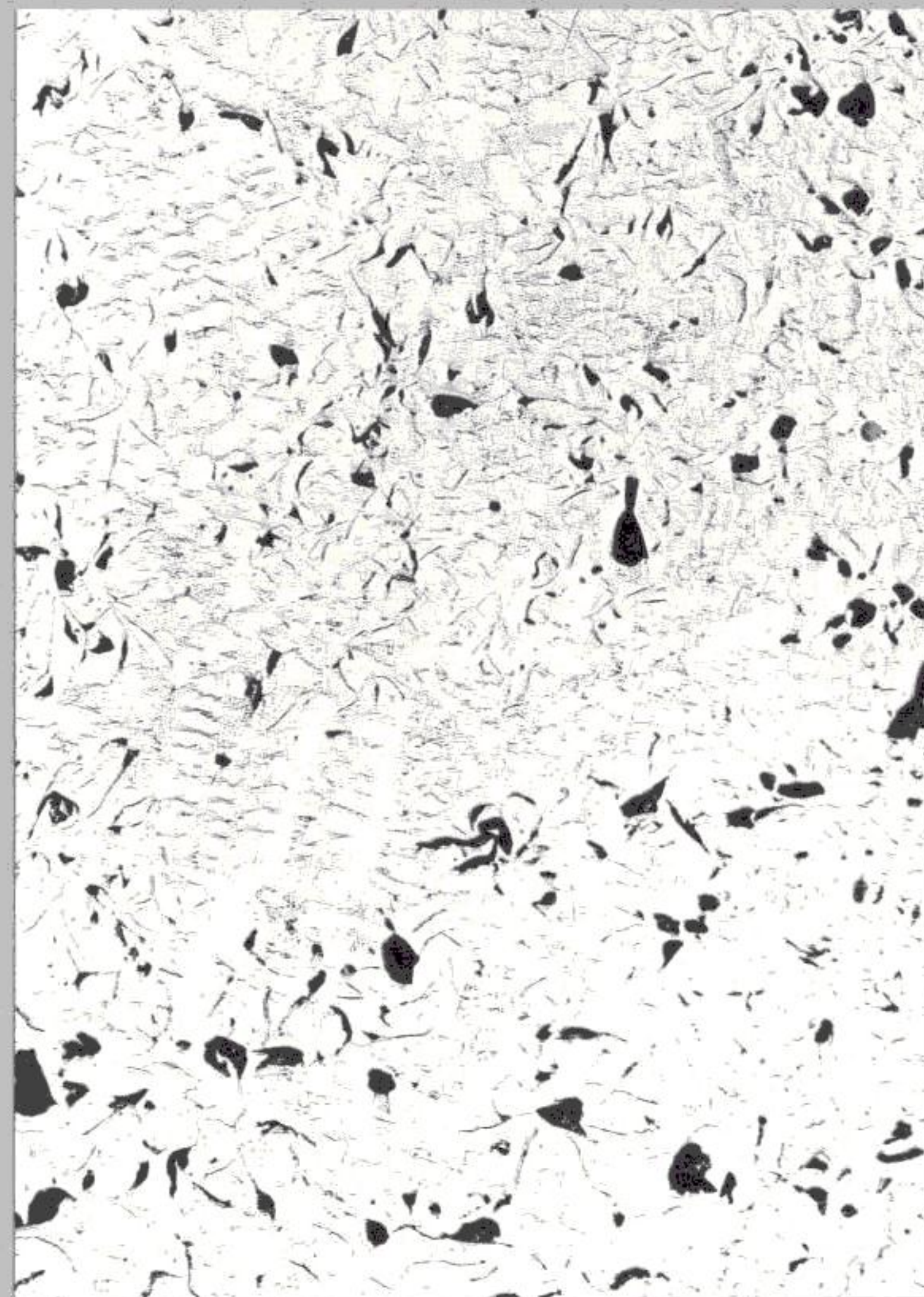
section thickness:30 mm

Physical properties:

Brinell hardness: 760 kplmm²
tensile strength: 74 " "

Structure:

a,b) medium length graphite flakesc) 1 = ferrite2 = pearlite3 = graphite4 = ternary phosphide eutectic5 = fine pearlite (sorbite)Etching: 0 = sulphidea,b) unetchedc) 2% alcoholic nitric acid



a



b



c

Specimen No. 5

25:1

200:1

1000:1

Analysis type:

Total carbon	3,4
Graphite	2,6
Combined carbon	0,8
Silicon	1,8
Manganese	0,4
Phosphorus	1,2
Sulphur	0,15

Special properties:

✓

Physical properties:

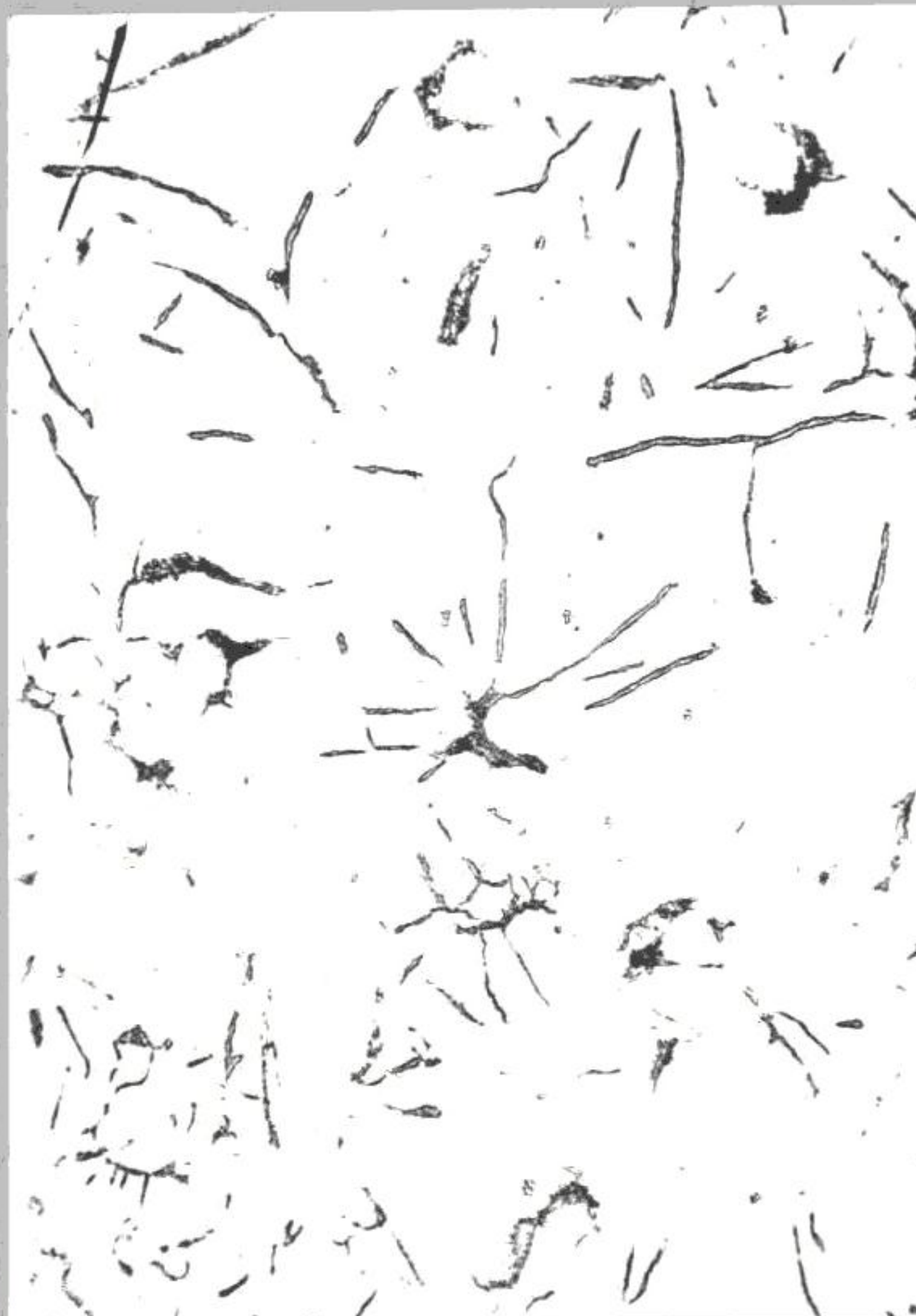
Brinell hardness: 170 kplmm²
 tensile strength: 75 " "

Structure:

- a) medium coarse graphite formation
- b) extensive accumulation of manganese-sulphides
- c) ternary phosphide eutectic in a matrix of ferrite and pearlite, graphite

Etching:

- a,b) unetched
- c) 2% alcoholic nitric acid



a

b

c

Specimen No. 6

25:1

200:1

500:1

Analysis type:

Total carbon	3,6
Graphite	2,9
Combined carbon	0,7
Silicon (+)	2,8
Manganese	0,4
Phosphorus	0,8
Sulphur	0,72

(+) according to the section thickness

Special properties:

ornamental cast iron plate

casting section: 16 mm

Physical properties:

Brinell hardness:
approx 200 kp/mm²

Structure:

a, b) short lamellar graphite, flake aggregates at the edge

c) pearlitic matrix with ternary phosphide eutectic

Etching:

a, b) unetched

c) 2% alcoholic nitric acid

Group

III

Cast iron

GG 12-18

Specimen No. 7

a

25:1

b

200:1

Analysis type:

Total carbon	<u>3.3</u>
Graphite	<u>2.7</u>
Combined carbon	<u>0.6</u>
Silicon (+)	<u>2.0</u>
Manganese	<u>0.7</u>
Phosphorus	<u>0.5</u>
Sulphur	<u>0.1</u>

Special properties:

thin sectioned
engineering cast iron
section thickness: 15 mm

Structure:

dendritic structure

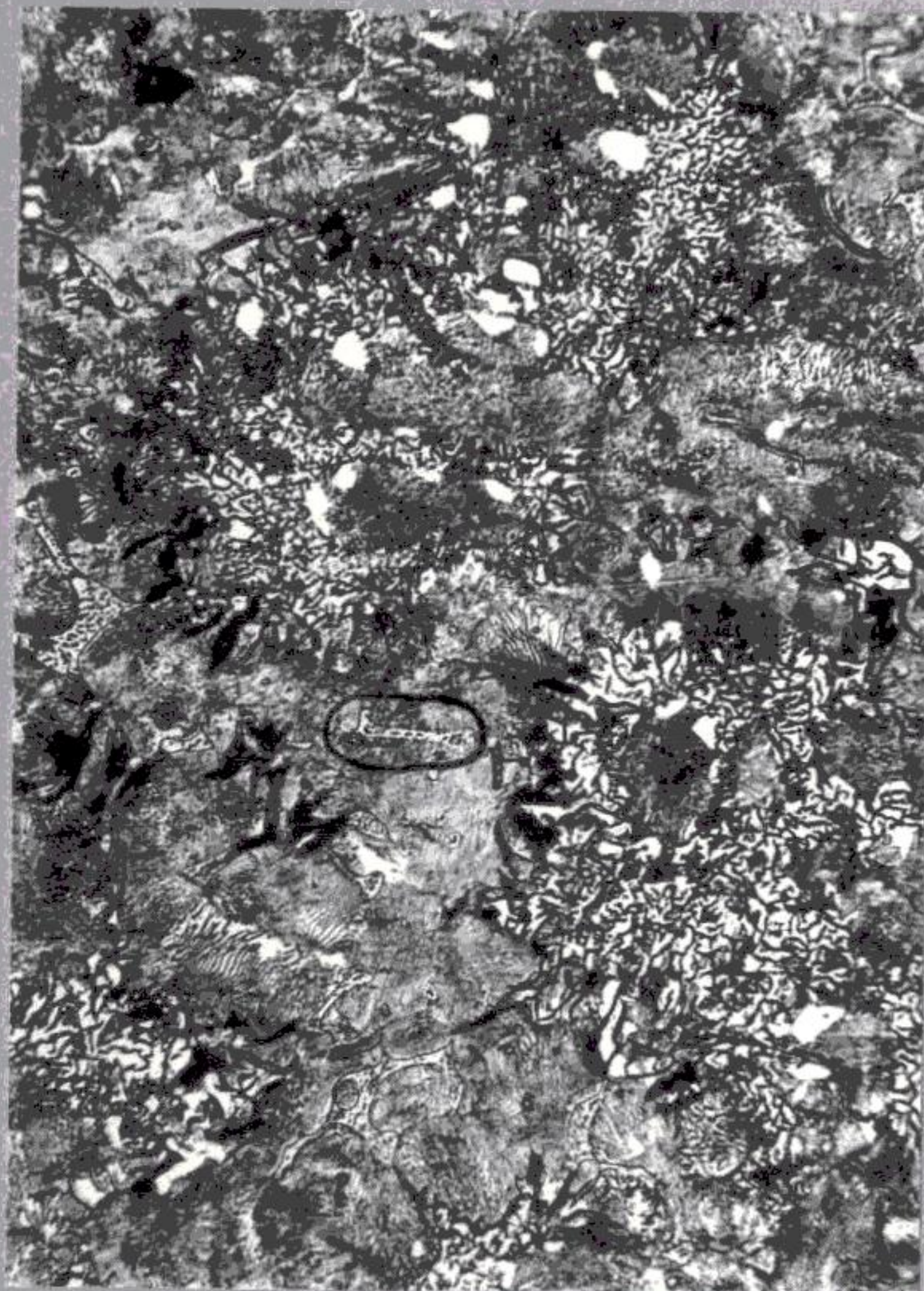
Physical properties:

tensile strength: 17 kN/mm²
Brinell hardness: 160 " "
transv. rupt. stress: 34 " "
deflection: 9 mm

Etching:

unetched

(*) according to the
 section thickness



c



d



e

Specimen No. 7

200:7

500:7

500:7

Analysis type:

Total carbon

Graphite

Combined carbon

Silicon

Manganese

Phosphorus

Sulphur

as before

Special properties:

as before

Physical properties:

as before

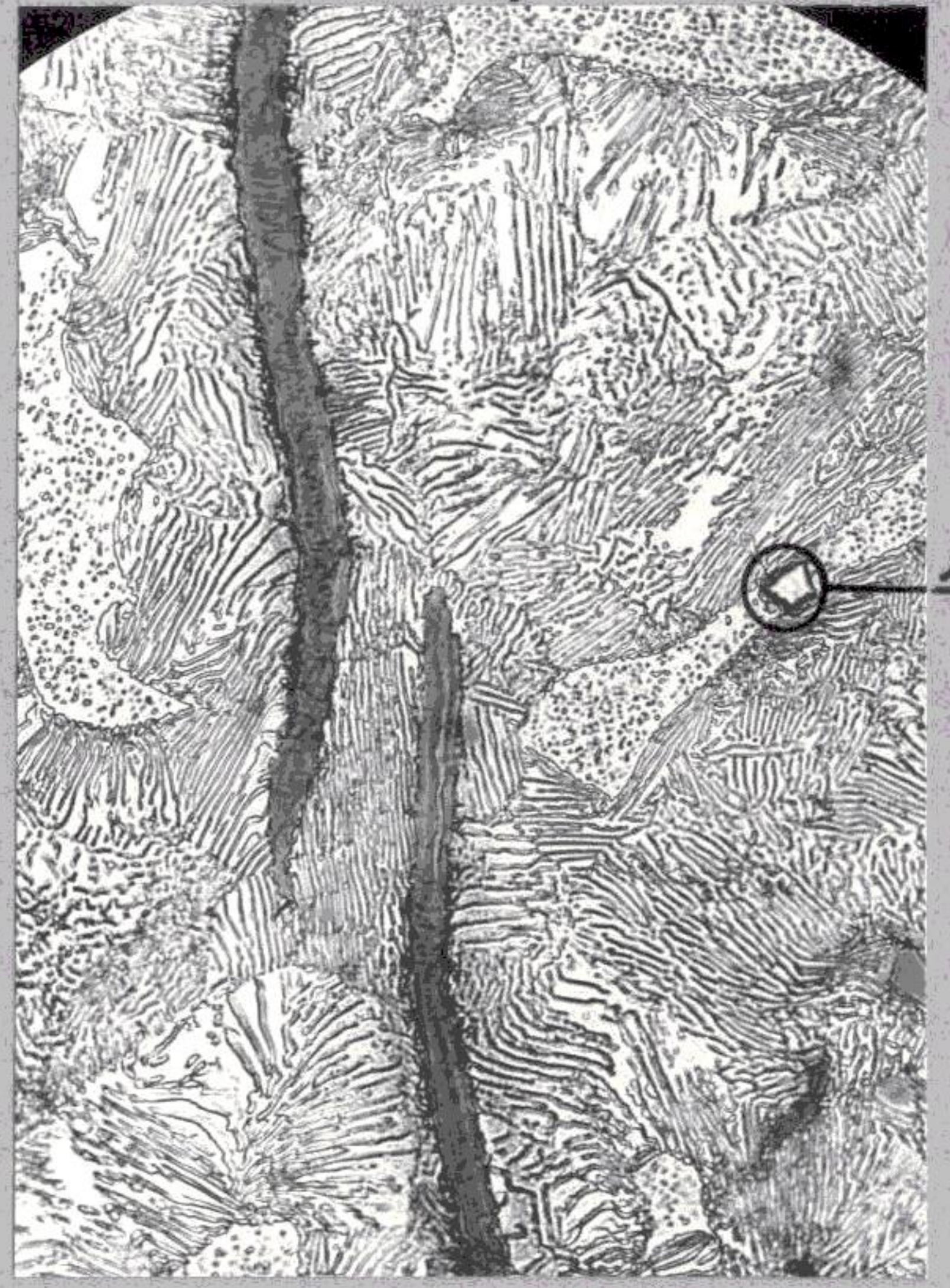
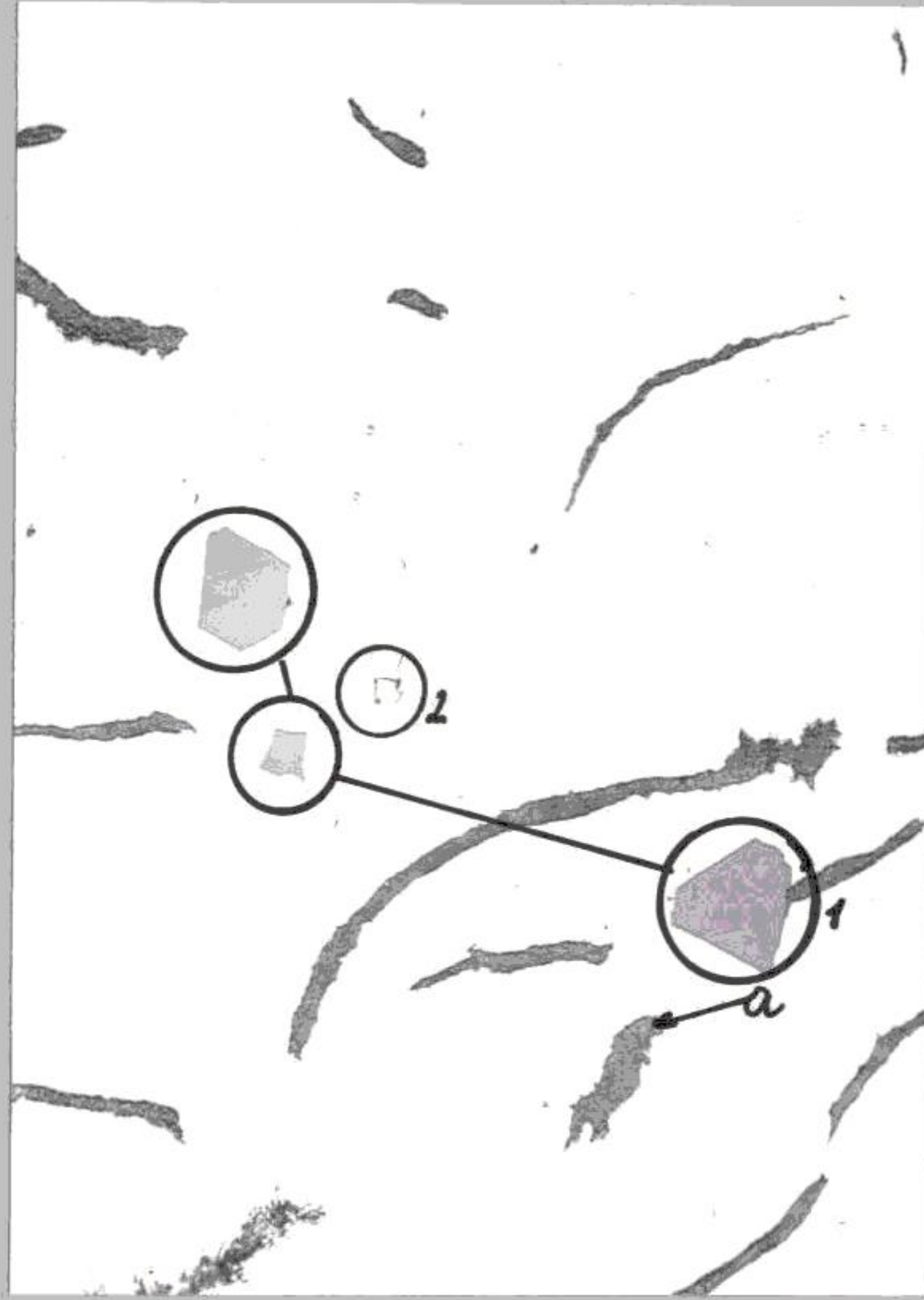
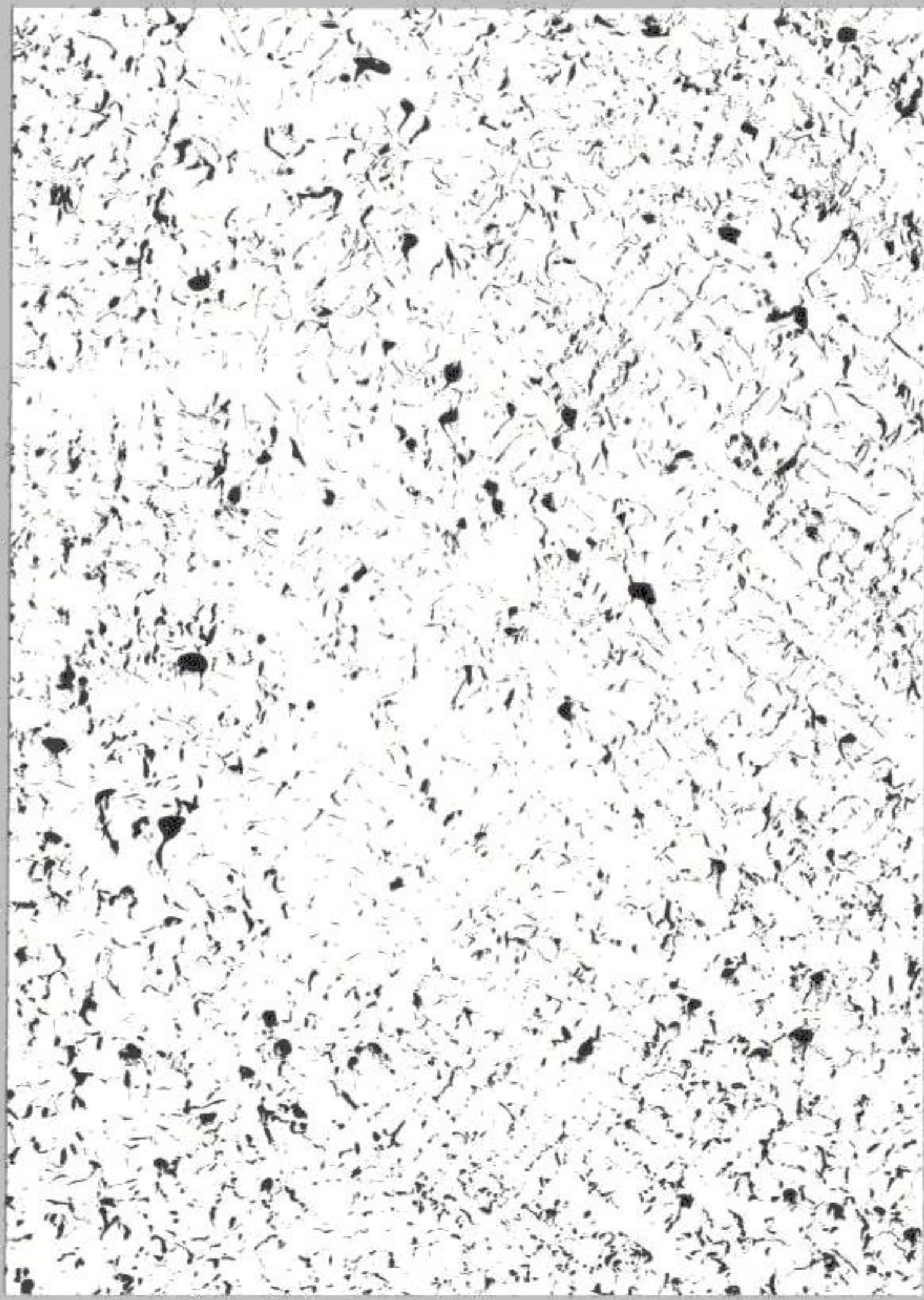
Structure:

c,e) pearlitic matrix with
some ferrite, flake aggre-
gate graphite and ternary
phosphide eutectic

d) graphite and ternary
phosphide eutectic

Etching:

c,e) 2% alcoholic nitric acid
d) potassium ferricyanide



Specimen No. 10

a

25:1

b

500:1

c

500:1

Analysis type:

Total carbon	<u>3,2</u>
Graphite	<u>2,4</u>
Combined carbon	<u>0,8</u>
Silicon (+)	<u>1,4</u>
Manganese	<u>0,6</u>
Phosphorus	<u>0,4</u>
Sulphur	<u>0,11</u>

Special properties:

high duty cast iron

Physical properties:

Brinell hardness: 195 kp/mm²
tensile strength: 23 " "
transrupt. stress: 52 " "
deflection: 12 mm

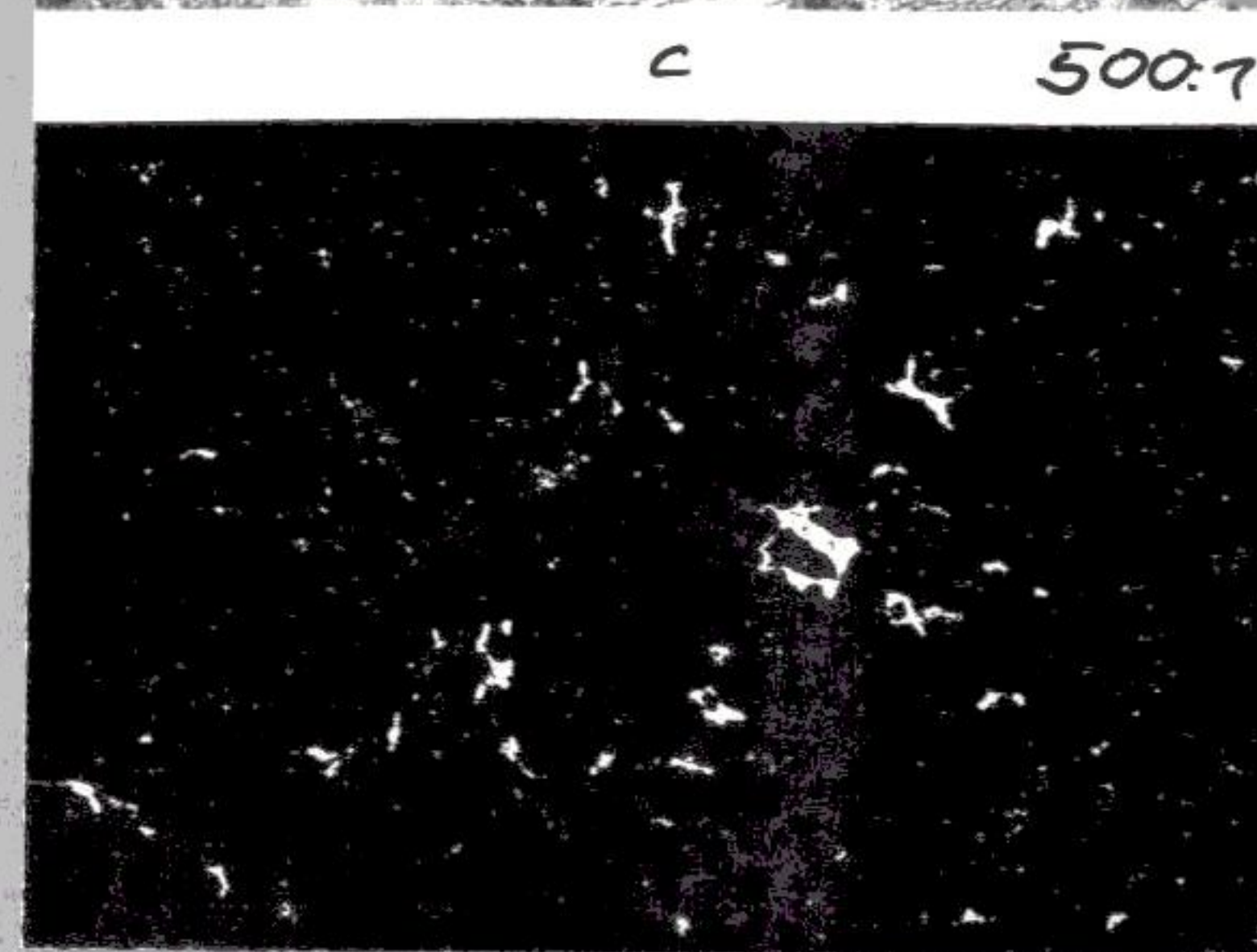
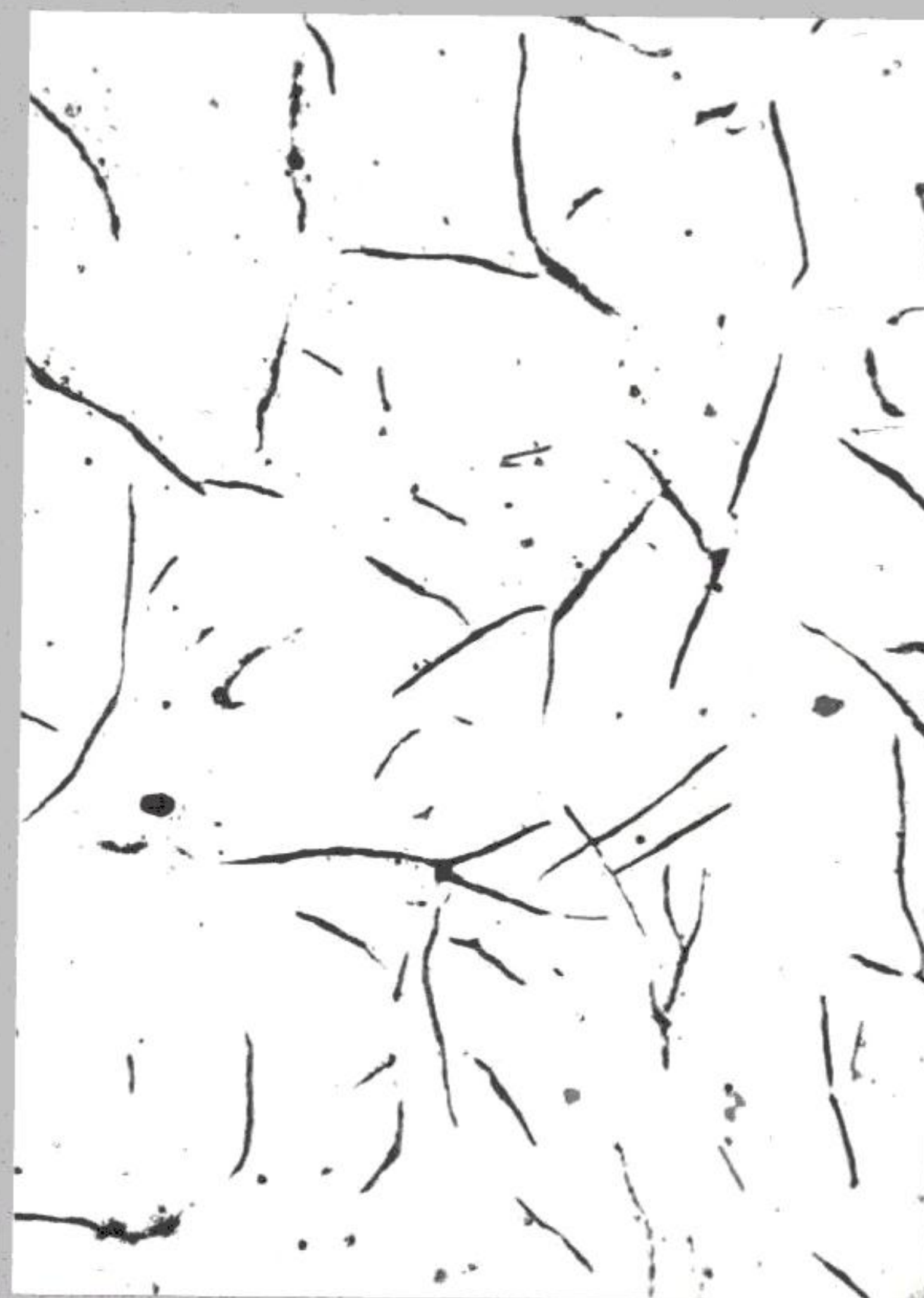
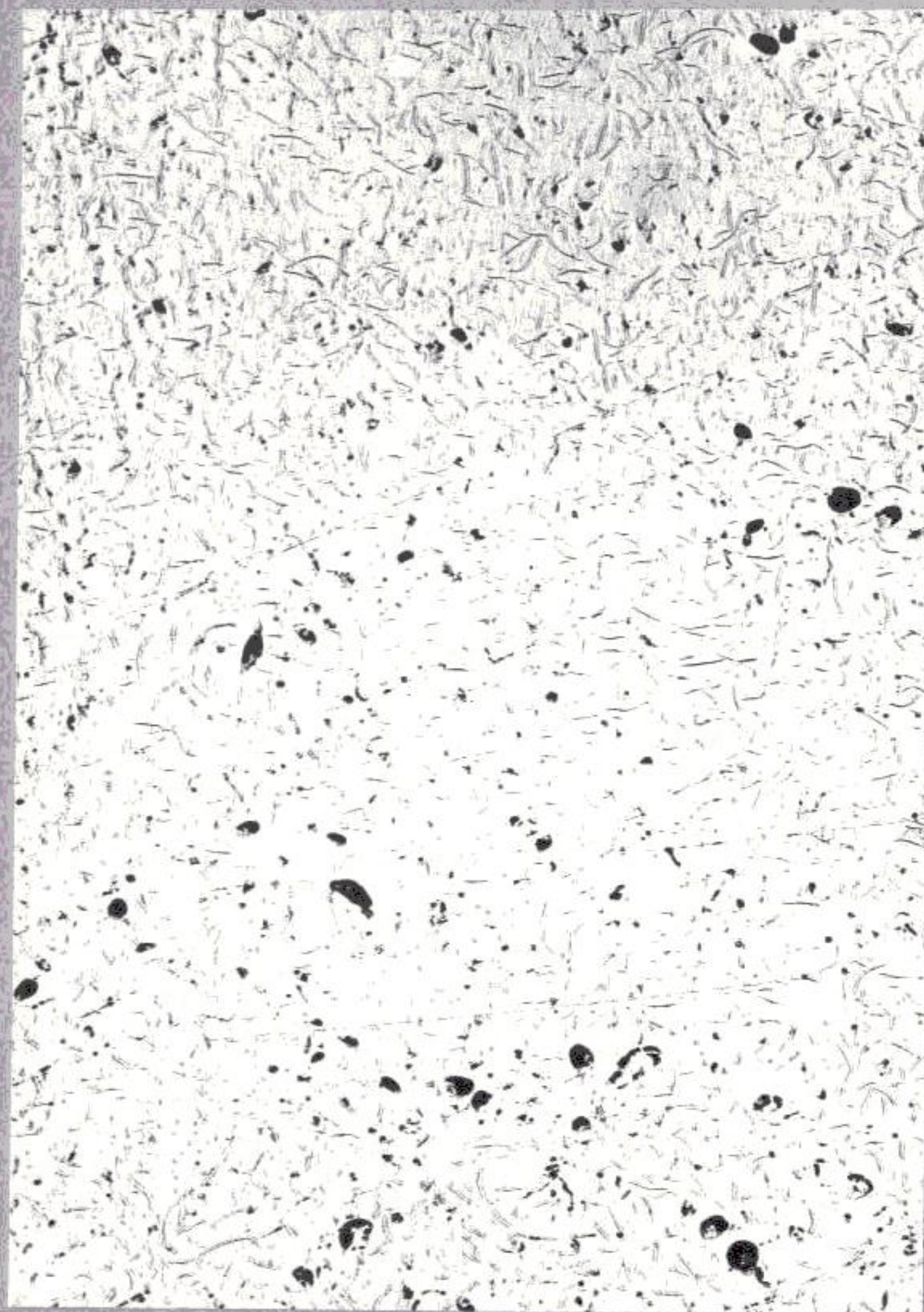
Structure:

- a) evenly distributed, medium fine graphite
- b) 1: blue-grey manganese sulphides
2: pink titanium nitride
- c) lamellar pearlite, ternary phosphide eutectic, titanium nitride, graphite

Etching:

- a, b) unetched
- c) 2% alcoholic nitric acid

(+) according to the section thickness



Specimen No. 24

a

25:1

b

200:1

c

50:1

Analysis type:

Total carbon	3,2
Graphite	2,5
Combined carbon	0,7
Silicon (x)	1,7
Manganese	0,9
Phosphorus	0,4
Sulphur	0,11

(x) according to the section thickness

Special properties:

not superheated
before pouring

Physical properties:

Brinell hardness: 180 kp/mm²
tensile strength: 23 " "
transrupt stress: 45 " "

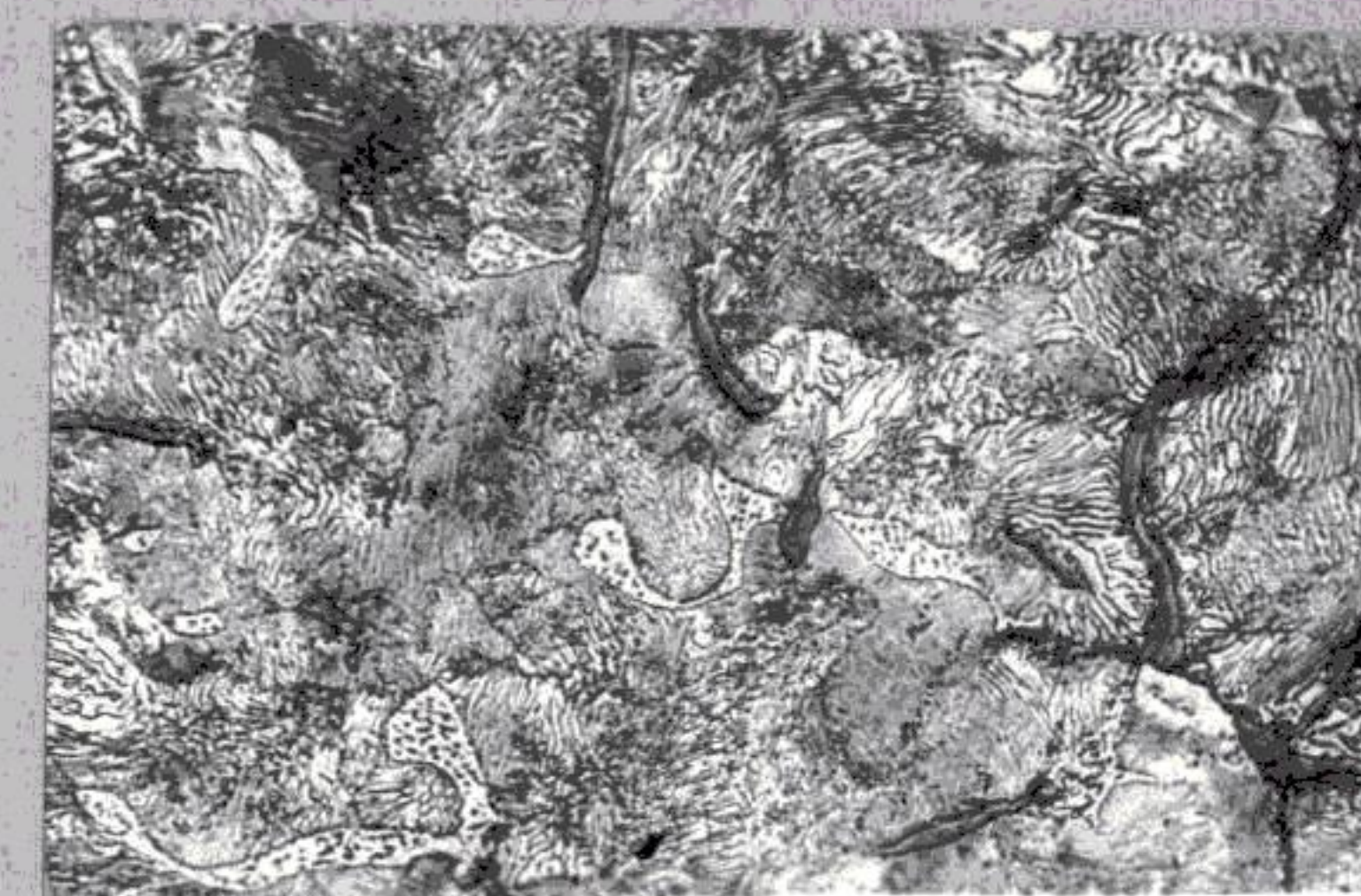
Structure:

a, b) fine medium length graphite
Richtreihe A3
c) pearlitic matrix with ternary
phosphide eutectic, graphite
d) deep etch to show the amount
and distribution of phosphide
eutectic

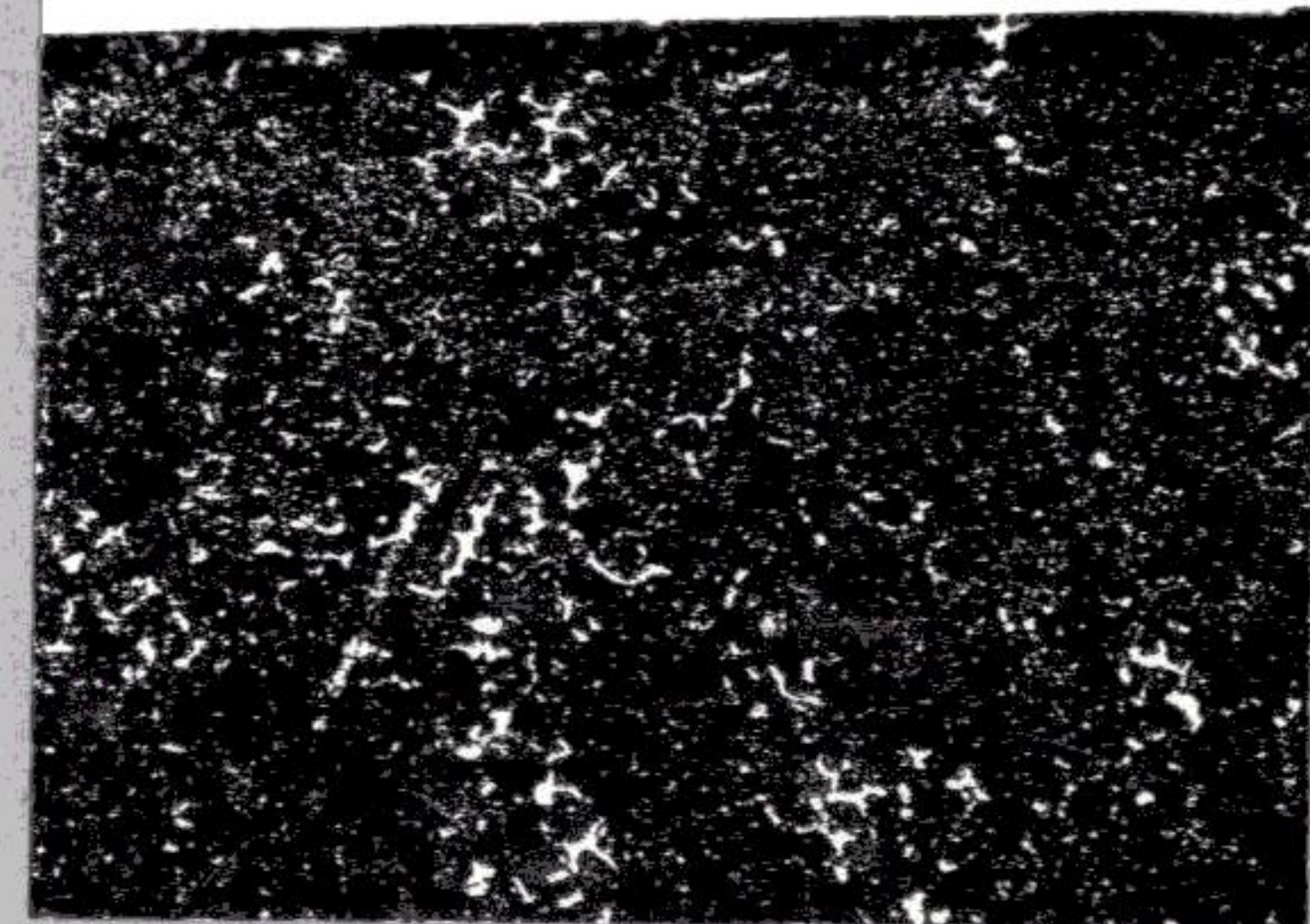
Etching:

a, b) unetched
c) 2% alcoholic nitric acid
d) deep etch with 20% nitric acid

Group

IVCast iron

c 500:1

Specimen No. 25

a

25:1

b

200:1

d

50:1

Analysis type:

Total carbon	<u>3,2</u>
Graphite	<u>2,5</u>
Combined carbon	<u>0,7</u>
Silicon	<u>1,9</u>
Manganese	<u>0,7</u>
Phosphorus	<u>0,7</u>
Sulphur	<u>0,1</u>

Special properties:

superheated and
poured
(compare with №24)

Physical properties:

Brinell hardness: 200 kp/mm²
tensile strength: 26 " "
transv. rupt. stress: 50 " "
deflection: 9 mm

Structure:

a, b) partial reduction in size and
number of the graphite nuclei,
hence refinement of the graphite
formation
c) finer distribution of graphite
d) phosphide eutectic in a more
uniform grouping

Etching:

a, b) unetched
c) 2% alcoholic nitric acid
d) deep etch with 20% nitric acid



Specimen No. 17

a

25:1

b

200:1

c

500:1

Analysis type:

Total carbon	3,0
Graphite	2,7
Combined carbon	0,9
Silicon (x)	1,7
Manganese	0,9
Phosphorus	0,2
Sulphur	0,108

Special properties:

pearlitic cast iron
(special cast iron)

Physical properties:

Brinell hardness: 270 kplmm²
tensile strength: 30 " "
high resistance to repeated
impact and wear as compared
with normal engineering cast iron

Structure:

a) b) medium length, fine graphite
lamellare,
evenly distributed, sulphides
c) the whole matrix consists of
extensive fine laminated
pearlite, graphite
some ternary phosphide

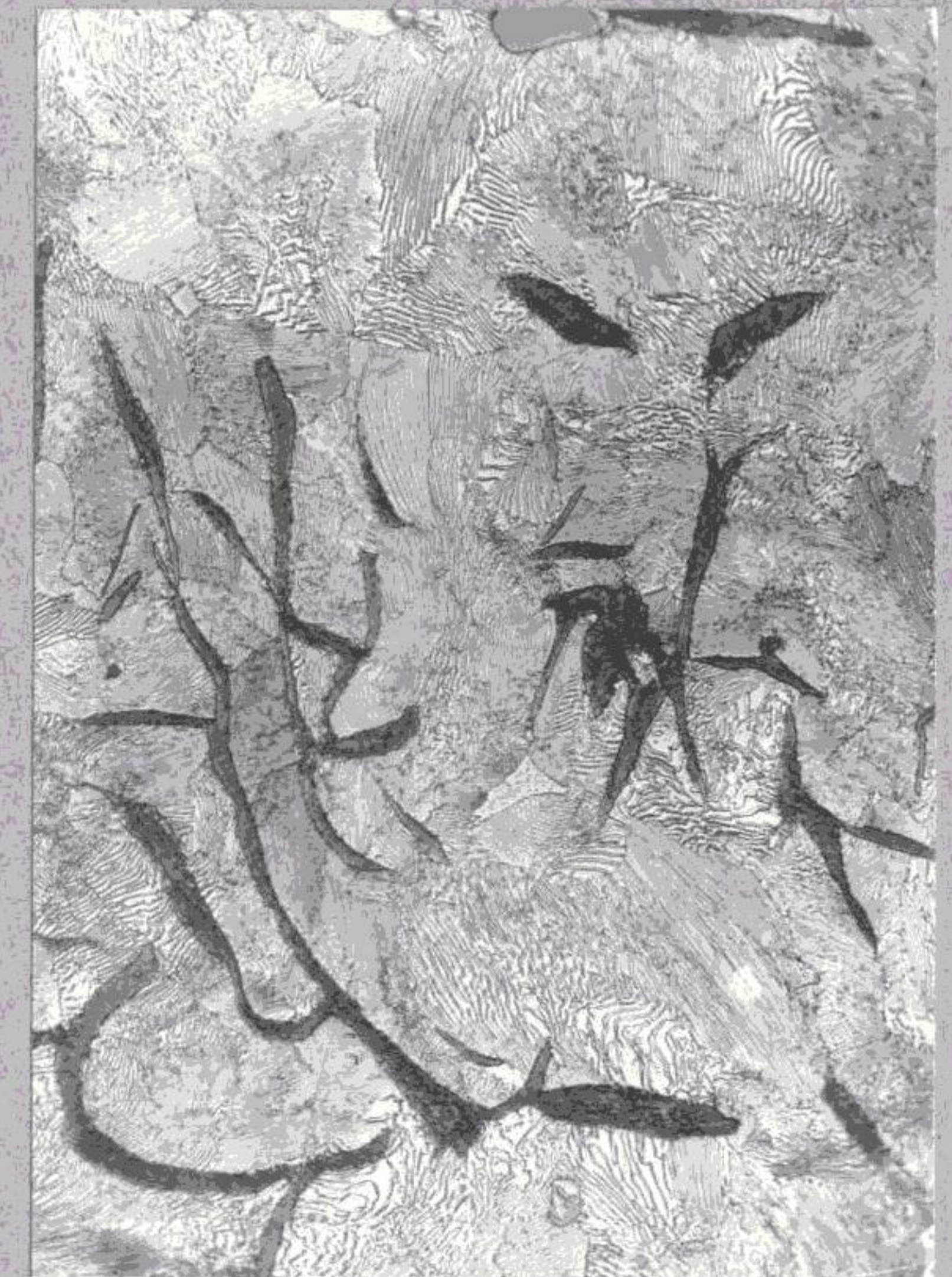
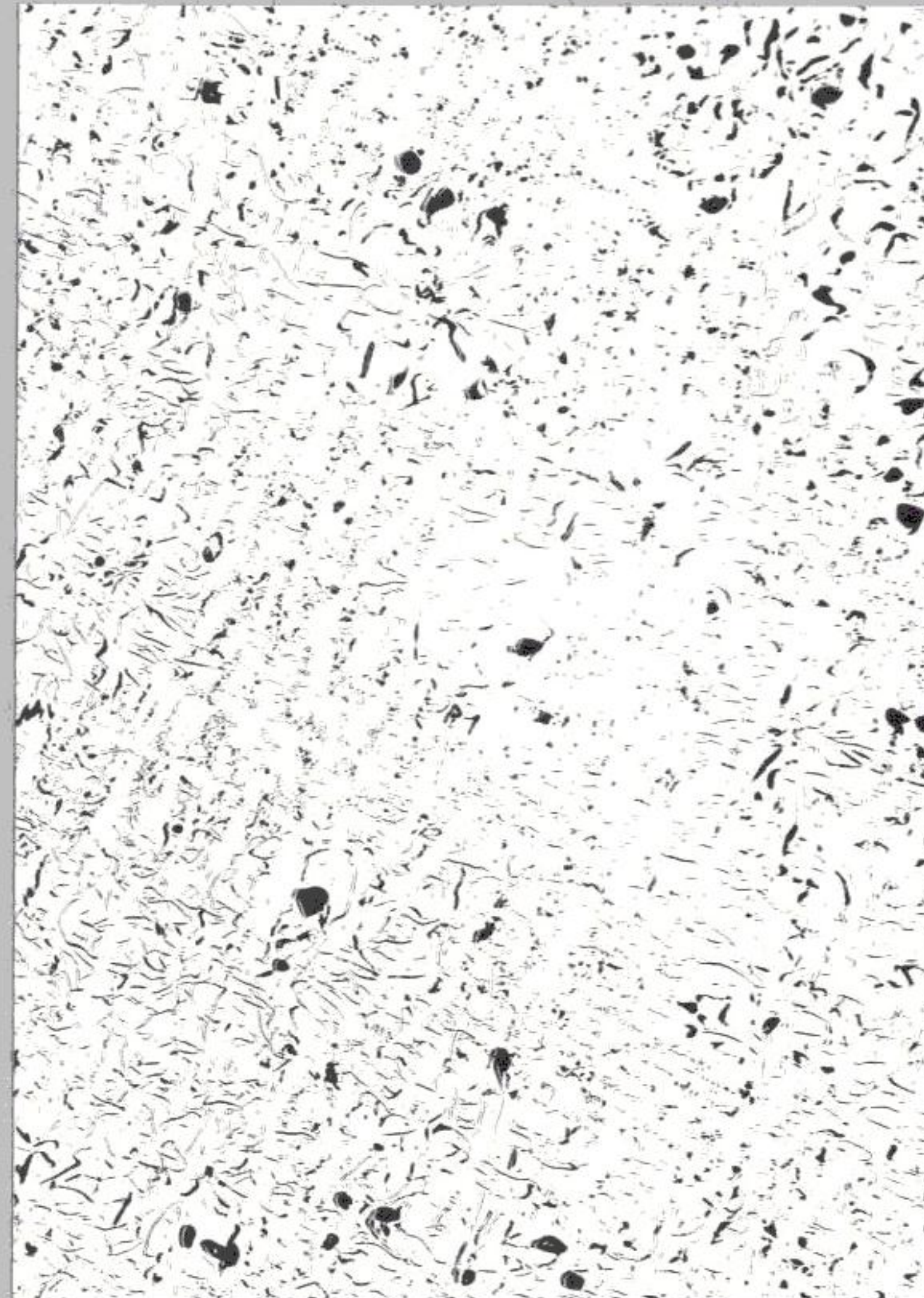
Etching:

eutectic

a, b) unetched

c) 2% alcoholic nitric acid

(x) according to the
section thickness

Specimen No. 74a25:1b200:1c500:1

Analysis type:

Total carbon	<u>3,0</u>
Graphite	<u>2,2</u>
Combined carbon	<u>0,8</u>
Silicon	<u>1,9</u>
Manganese	<u>0,7</u>
Phosphorus	<u>0,1</u>
Sulphur	<u>0,12</u>

Special properties:

charge made up with
over 50% steel

Physical properties:

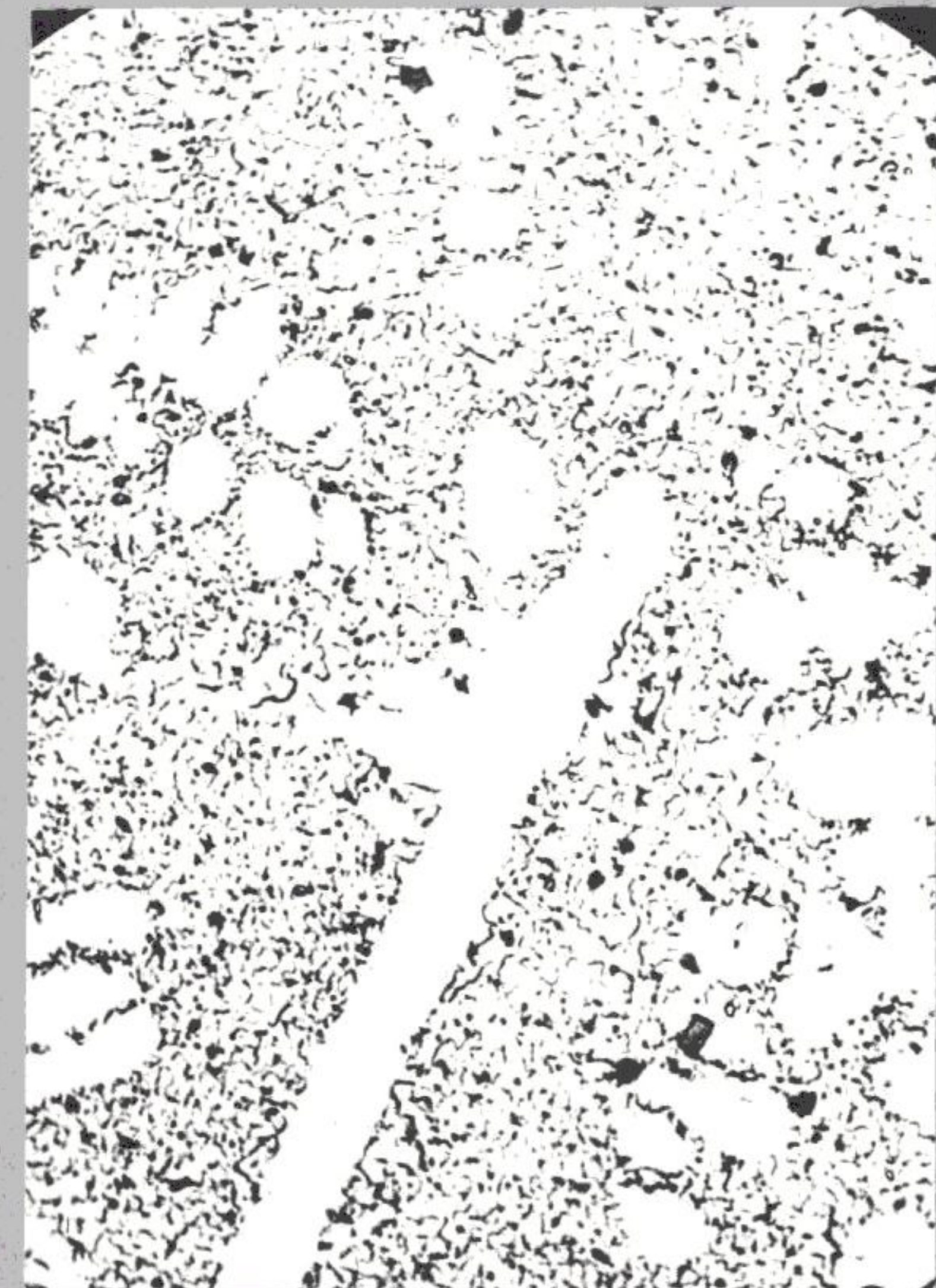
Brinell hardness: 190 kpl/mm²
tensile strength: 31-35 " "
transv rupt. stress: 53 " "
deflection: 10 mm

Structure:

a,b) fine lamellar and medium
coarse graphite, partly in
dendritic orientation,
sulphides
c) pearlitic matrix with little
accumulation of ternary
phosphide eutectic, graphite,
sulphide

Etching:

a,b) unetched
c) 2% alcoholic nitric acid



Specimen No. 76

a

10:1

b

50:1

c

500:1

Analysis type:

Total carbon	3,3
Graphite	3,7
Combined carbon	0,2
Silicon	3,2
Manganese	0,7
Phosphorus	0,12
Sulphur	0,05

Special properties:

cast against chills
and annealed at
approx 800°C

Physical properties:

Brinell hardness: 730 kpl/mm²
tensile strength: 33 " "
transv. rupt. stress: 62 " "
deflection: 12 mm

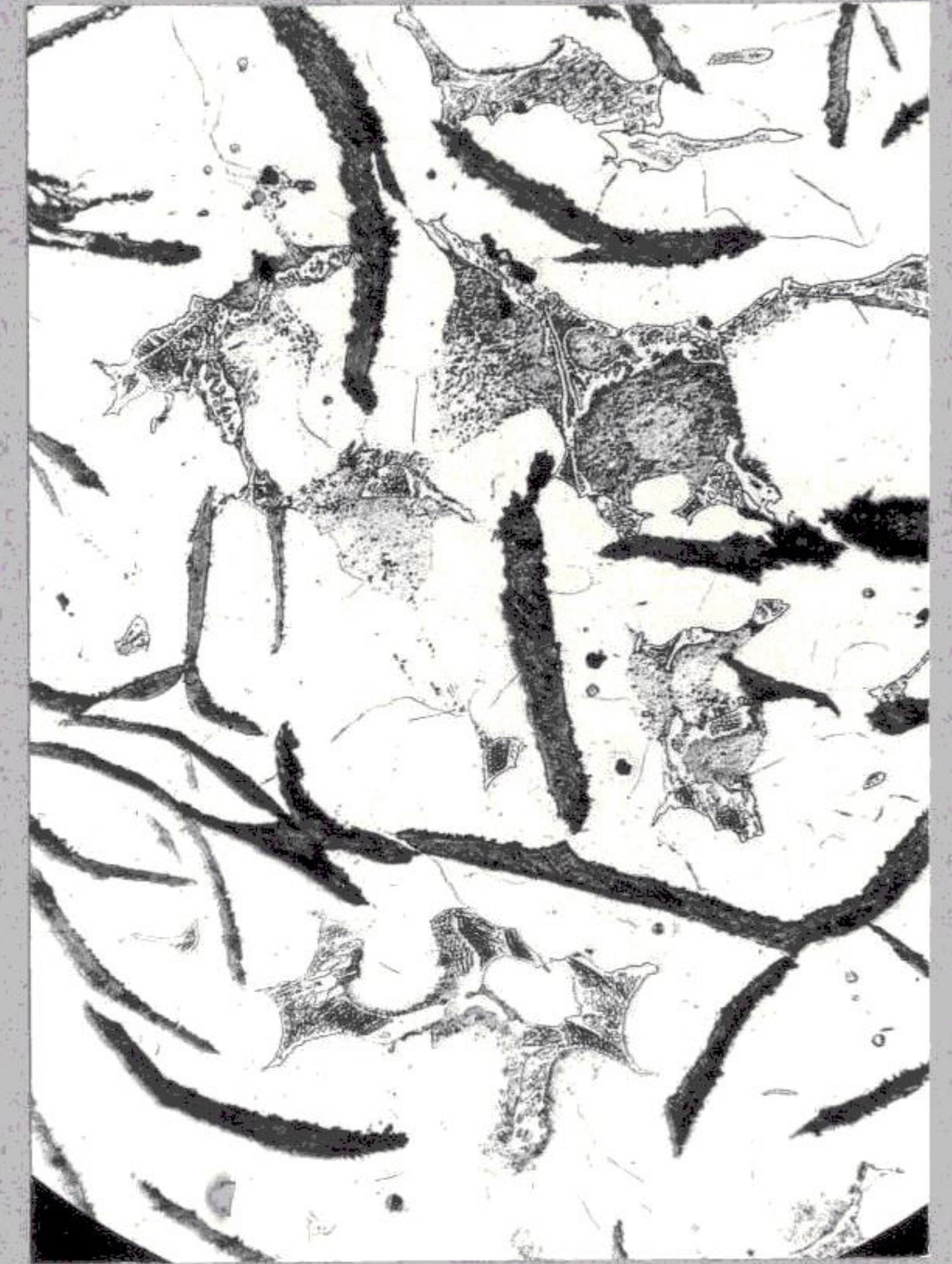
Structure:

a) general view with edge
b) ferrite-graphite eutectic, the
grain refinement is brought
about by the rapid cooling at
solidification; the fine graphite
formation through the influence
of the high silicon content

Etching: c) ferrite, very finely distributed
leuctectiform graphite

a) unetched
b, c) 2% alcoholic nitric acid

Group V cast iron with special magnetic properties GG 70,9



Specimen No. 8

a

25:1

b

200:1

c

200:1

Analysis type:

Total carbon	3,1
Graphite	3,0
Combined carbon	0,1
Silicon (+)	2,2
Manganese	0,3
Phosphorus	0,6
Sulphur	0,1

Special properties:

thick sectioned castings
section thickness: 45 mm

Structure:

a, b) coarse graphite formation
c) ferrite,
coarse graphite,
ternary phosphide eutectic

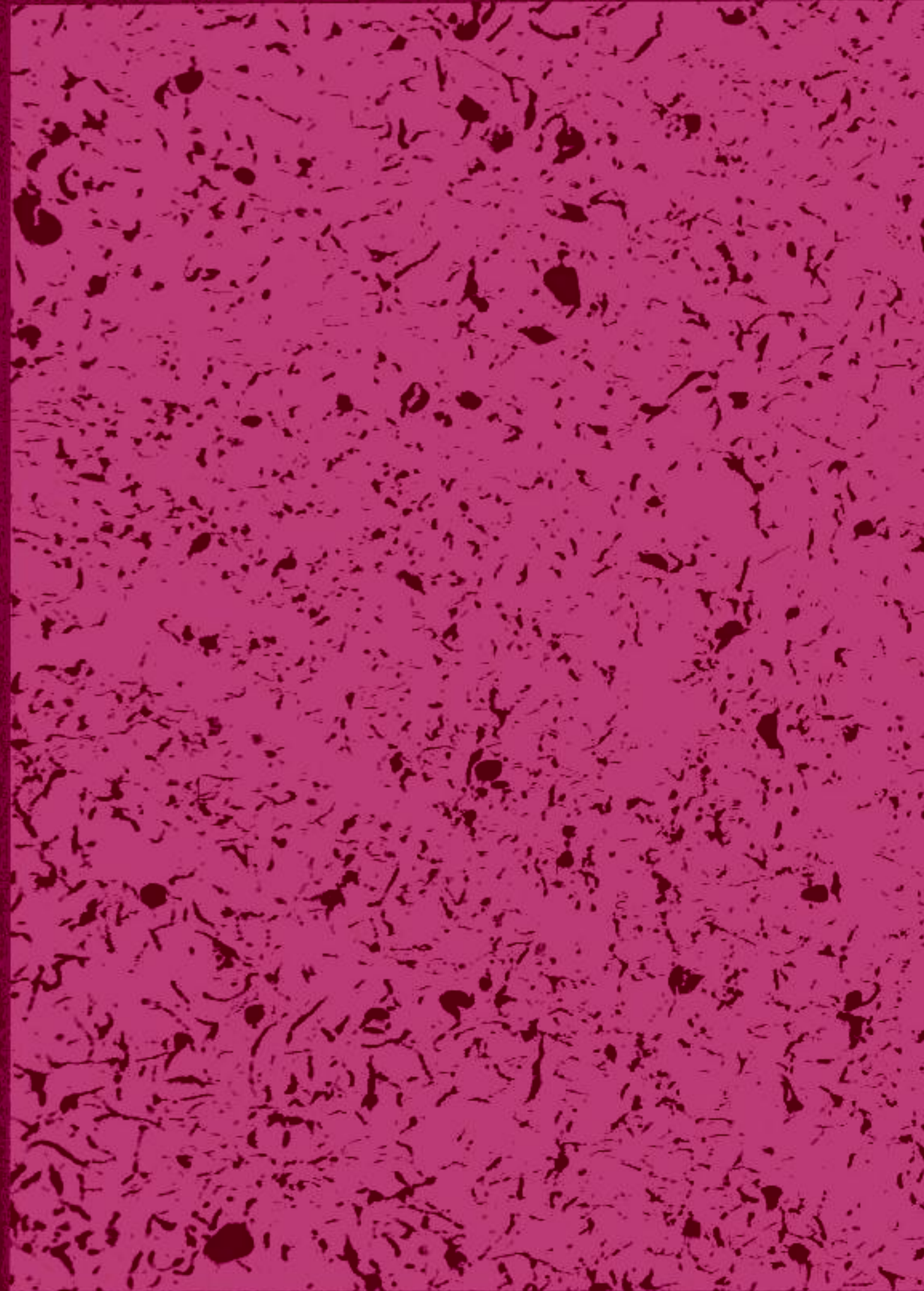
Physical properties:

Brinell hardness: 140 kpl/mm²
tensile strength: 73 " "
transv. rupt. stress: 35 " "
deflection: 8 mm

Etching:

a, b) unetched
c) 2% alcoholic nitric acid

(*) according to the
section thickness



Specimen No. 20 25 200 500

Analysis type:

Total carbon	3,3
Graphite	3,3
Combined carbon	-
Silicon	1,5
Manganese	0,4
Phosphorus	0,4
Sulphur	0,1

Special properties:

annealed twice at
800°C

Physical properties:

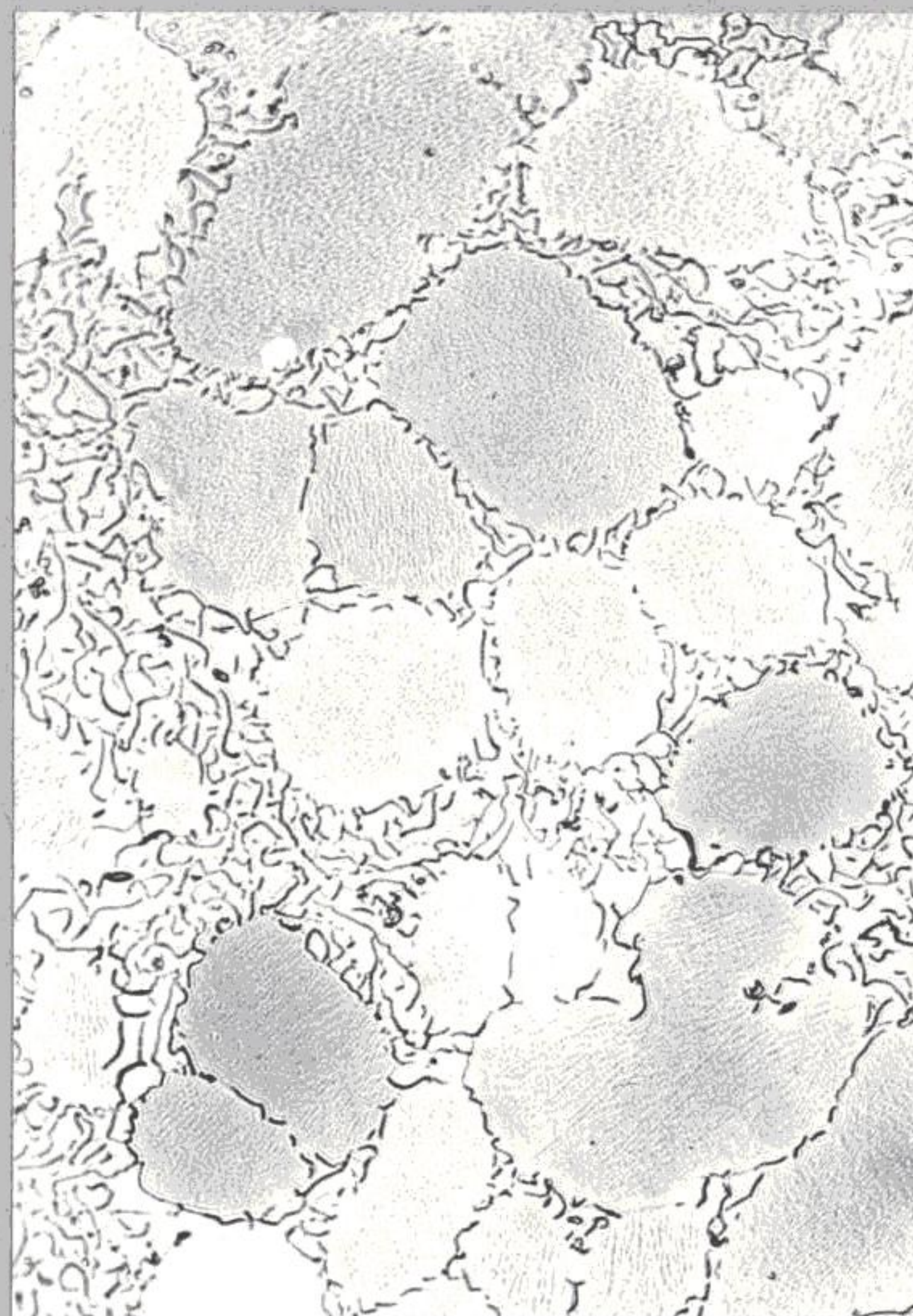
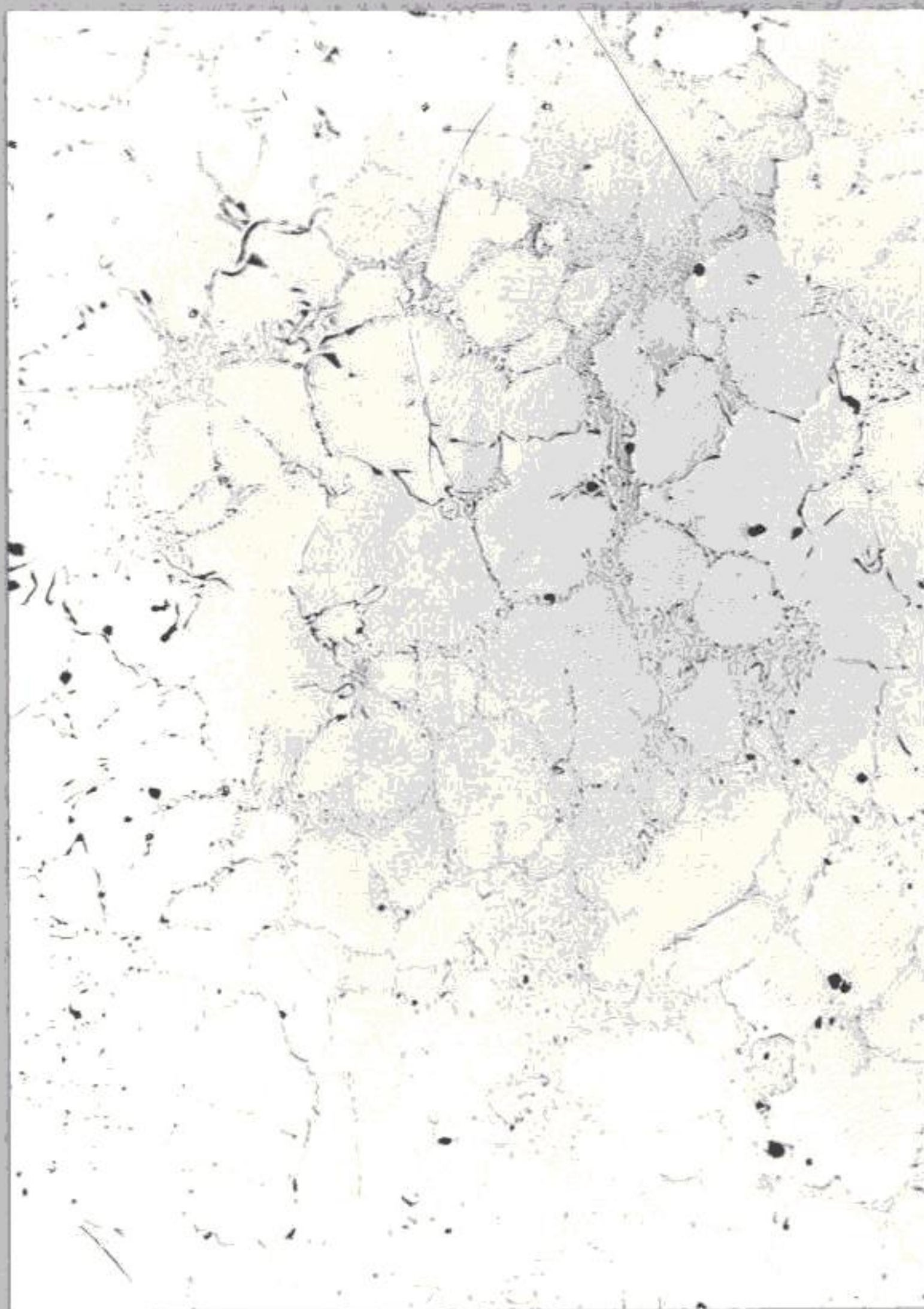
Brinell hardness:
120 kp/mm²

Structure:

a, b) short lamellar graphite,
manganese sulphides
c) completely ferritic matrix
with phosphide eutectic
Super-imposition of the decom-
posed graphite, formed during
annealing, on the already

Etching:

L present graphite flakes
a, b) unetched
c) 2% alcoholic nitric acid

Specimen No. 17a200:1b500:1

Analysis type:

Total carbon	<u>2,0</u>
Graphite	<u>2,0</u>
Combined carbon	<u>-</u>
Silicon	<u>75,0</u>
Manganese	<u>0,5</u>
Phosphorus	<u>0,05</u>
Sulphur	<u>0,02</u>

Special properties:

acid resisting

Physical properties:

Brinell hardness: 300-350 kp/mm²
tensile strength: 15 " "
transv. rupt. stress: 10-20 " "
deflection: 2-3 mm

Structure:

a) graphite in fine sinuous flakes
b) solid solution of iron and silicon with graphite round the grain boundaries

Etching:

a) unetched
b) aqua regia

Group

VIINiresist (Ni-Cu cast iron)Specimen No. 37a200:16200:1

Analysis type:

Total carbon	3,0
Graphite	2,3
Combined carbon	0,7
Silicon	2,0
Manganese	1,5
Phosphorus	0,3
Sulphur	0,02
Nickel	12,9
Copper	5,2
Chromium	3,2

Special properties:

resistant to corrosion
and scaling
(sand castings)

Physical properties:

Brinell hardness: 183 kp/mm²
tensile strength: 24 " "
transv. rupt. stress: 36 " "
deflection: 19 mm
elongation: 1,2%

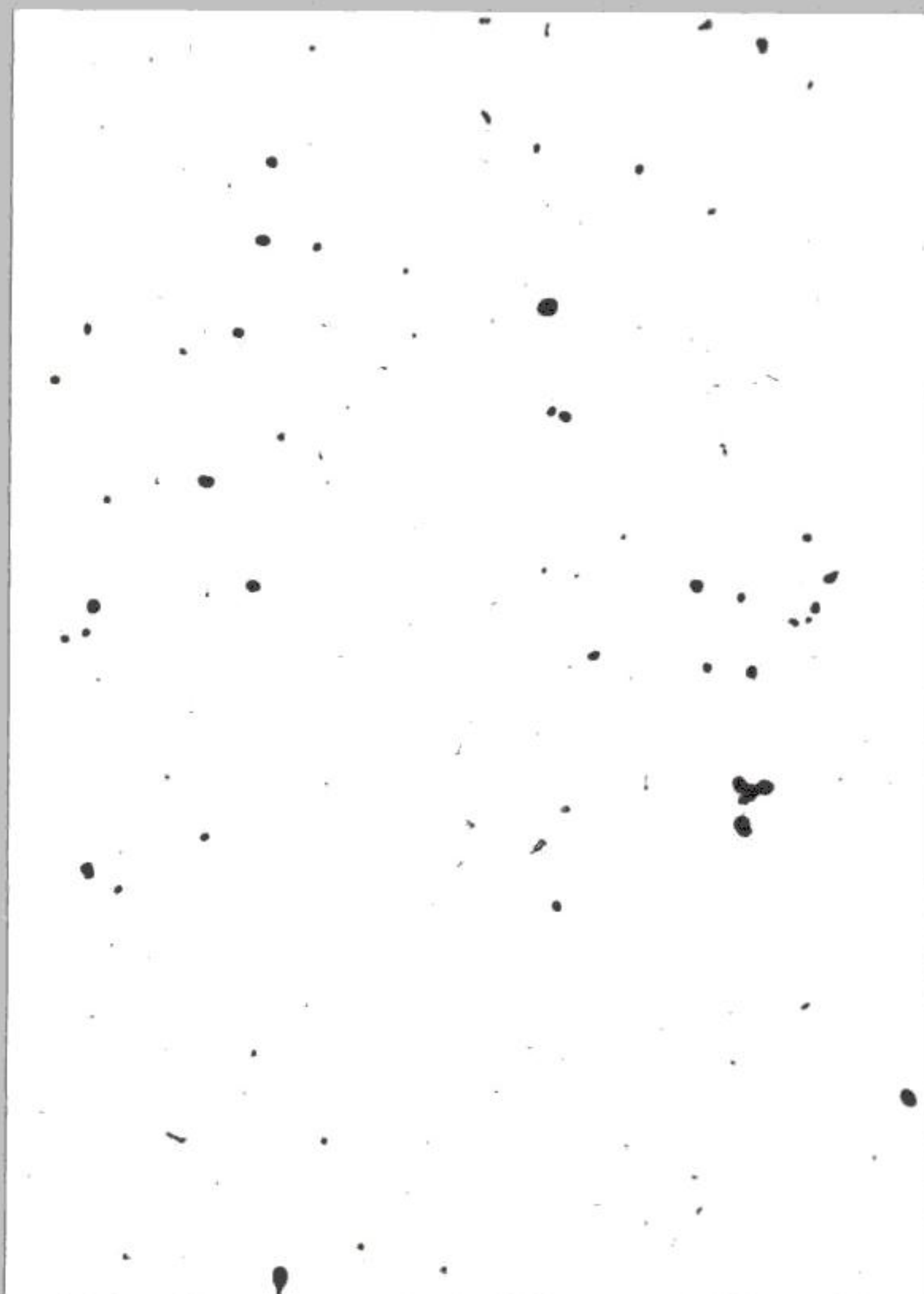
Structure:

a) fine graphite lamellare,
carbide
b) lamellare graphite and
iron chromium in austenitic
matrix carbides

Etching:

a) unetched
b) 2% alcoholic nitric acid

Group

VIIChromium alloy cast ironSpecimen No. 32a200:1b1000:1

Analysis type:

Total carbon 1,3
 Graphite
 Combined carbon 1,3
 Silicon 2,0
 Manganese 0,5
 Phosphorus 0,1
 Sulphur 0,07
 Chromium 29,0

Special properties:

high chromium cast
iron,
corrosion and heat
resistant

Physical properties:

Brinell hardness: 280kp/mm²
tensile strength: 45 "
elongation: 0%

Structure:

a) no graphite,
small amounts of chromium
oxides and silicates
b) matrix with double carbides,
silicates inclusions,
ledeburite structure,
iron and chromium carbide.
 Etching: and oxides

a) unetched
b) 2% alcoholic hydrochloric acid



Specimen No. 34

a

300:1

b

750:1

Analysis type:

Total carbon	3,55
Graphite	0
Combined carbon	3,55
Silicon	0,55
Manganese	0,60
Phosphorus	0,78
Sulphur	0,08
Nickel	4,02
Chromium	1,99
Molybdenum	0,55

Special properties:

sand-cast (chill casting gives a more refined structure) cast iron with great hardness and high resistance to wear and

Physical properties: abrasion

tensile strength: 33 kplmm²
 transv. rupt. stress: 45 " "
 Brinell hardness: 412 " "
 elastic modul: 17.000 " "
 Izod impact: 3,0 " "

Structure:

austenite - martensite -
 cementite and carbides

Etching:

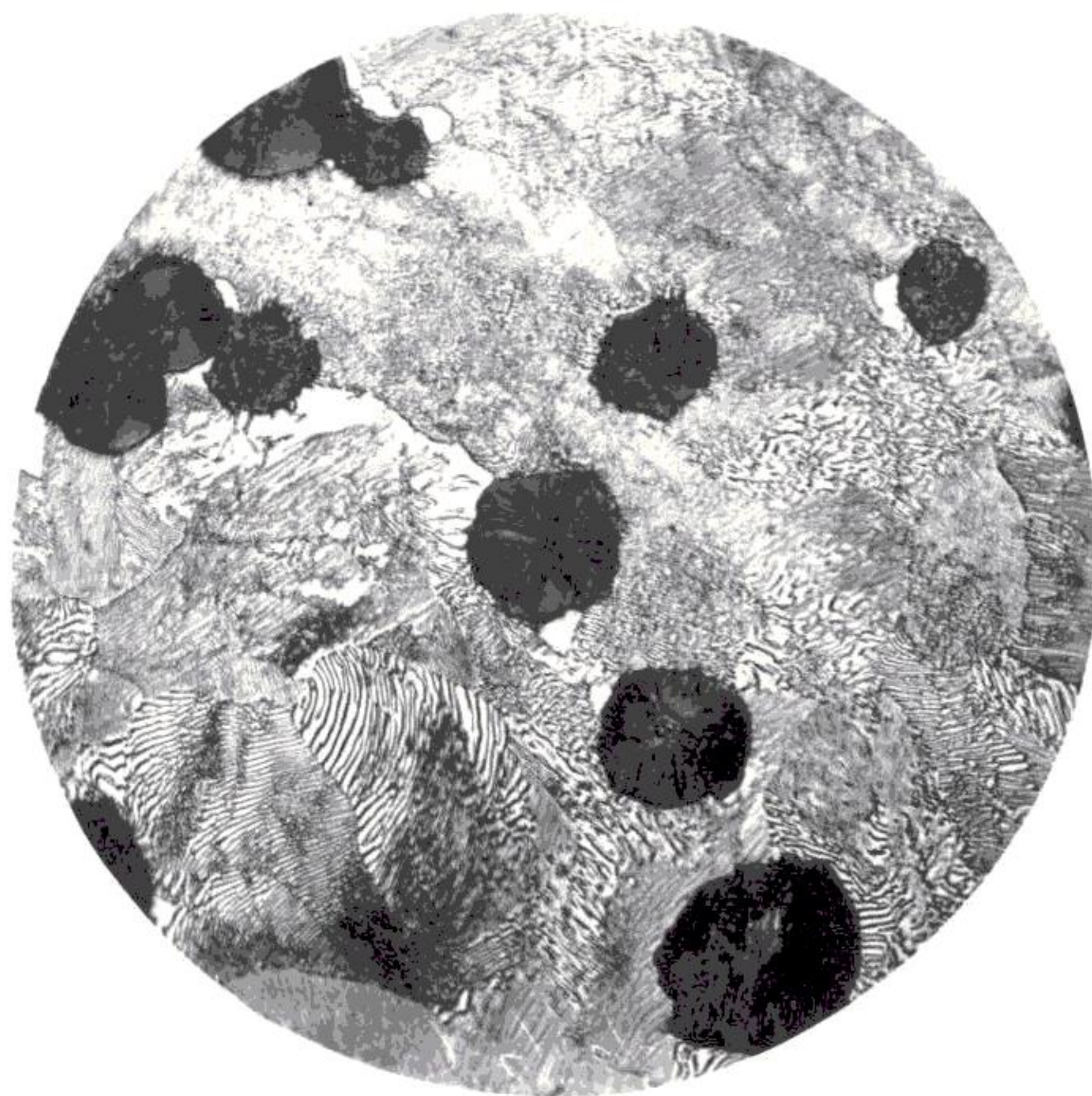
3% alcoholic nitric acid

3. Cast iron with nodular graphite

(GGG) n. DIN 1693, Sep'tember 1961

a) mechanically polished

b) electrolytically polished



No. 37a Cast iron with nodular graphite (as cast state) GGG-45 Magnified: 500:1

Analysis:

Bound carbon	3,70
Graphite	
Silicon	2,60
Manganese	0,30
Sulphur	0,02
Phosphorus	0,04
Nickel	1,00
Chromium	
Tungsten	
Vanadium	
Molybdenum	
Cobalt	
Magnesium	0,06

Treatment and special properties:

cast into green or dry sand moulds

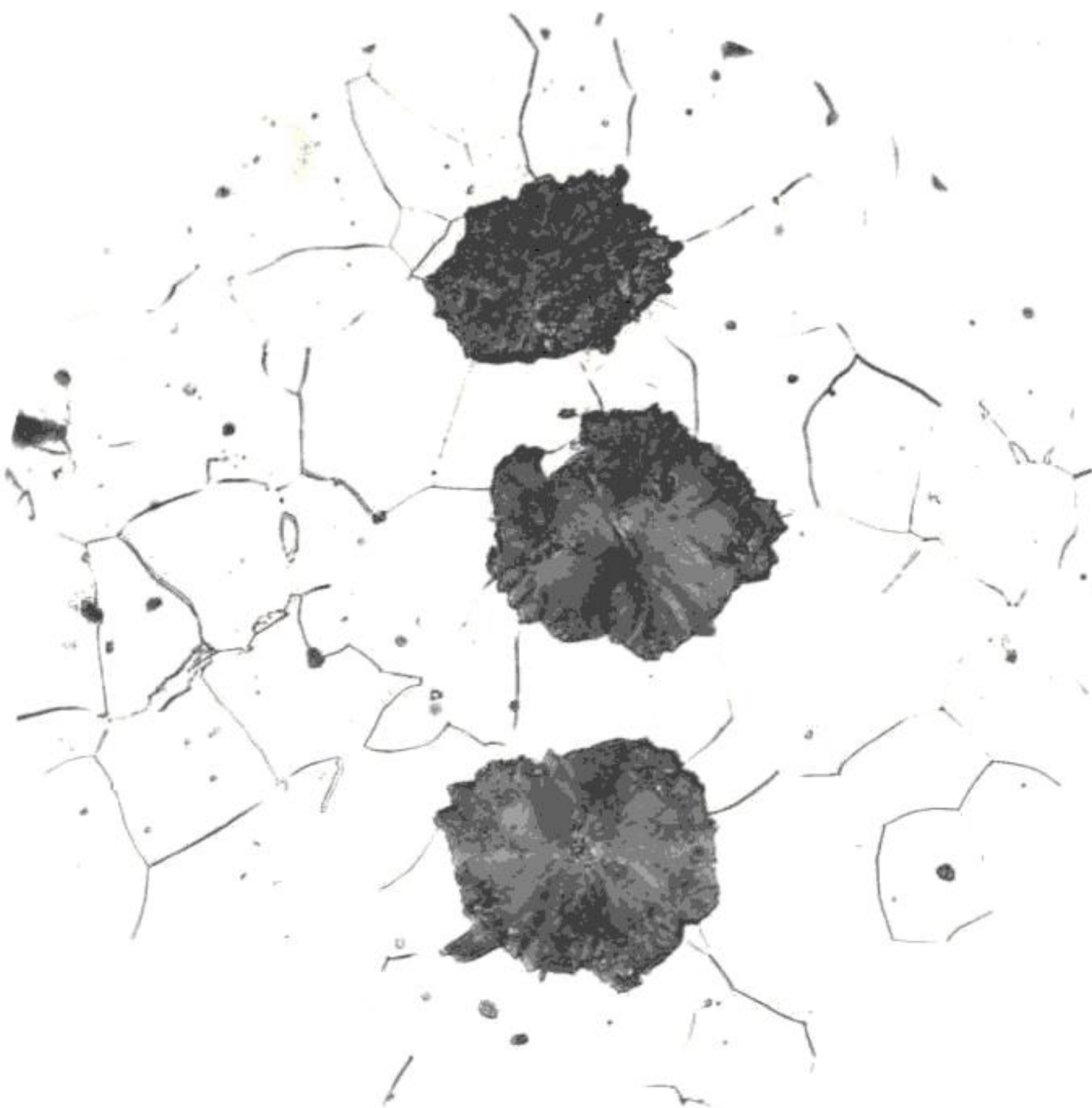
tensile strength: 50 kplmm²
elongation: 2%

Texture:

nodular graphite in a ledeburitic-ferritic matrix, nodular graphite associated with ferritic envelope

Etching:

2% alcoholic nitric acid



No. 38a2 Cast iron with nodular graphite (annealed) Magnified: 500:1 GGG-45

Analysis:

Bound carbon

Graphite

Silicon

Manganese

Sulphur

Phosphorus

Nickel

Chromium

Tungsten

Vanadium

Molybdenum

Cobalt

Treatment and special properties:

annealed at 800 to 820°C

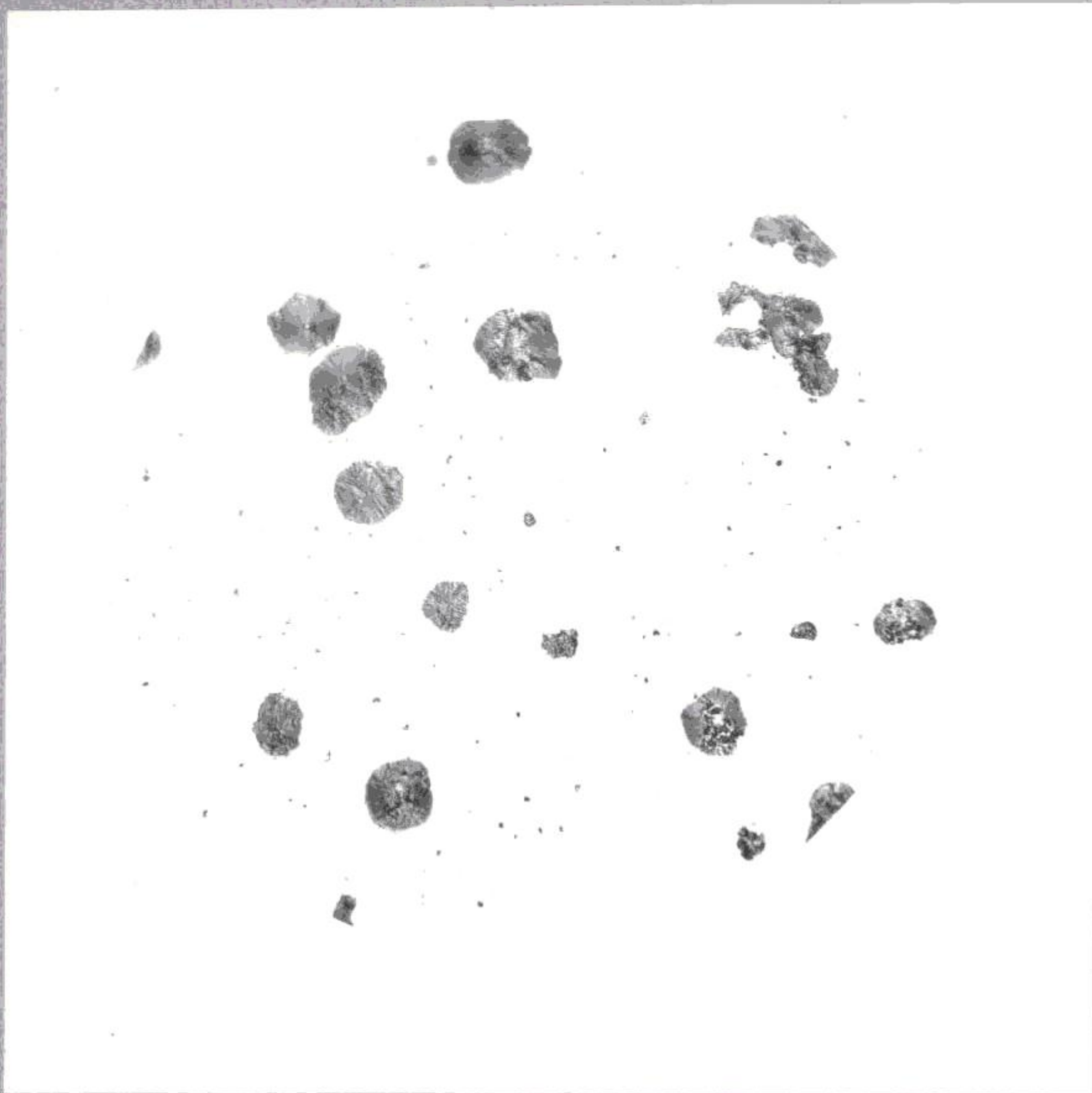
tensile strength: 50 kpl/mm²
elongation: 18%

Texture:

ferritic matrix with nodular graphite

Etching:

as before



No. 3761 Cast iron with nodular graphite (as cast state) GGG-45 Vergr.: 200:1

Analyse:

Kohlenstoff	3,70
Graphit	
Silizium	2,60
Mangan	0,30
Schwefel	0,02
Phosphor	0,04
Nickel	1,00
Chrom	
Wolfram	
Kobalt	
Vanadium	
Molybdän	

Polier- und Ätzverfahren:

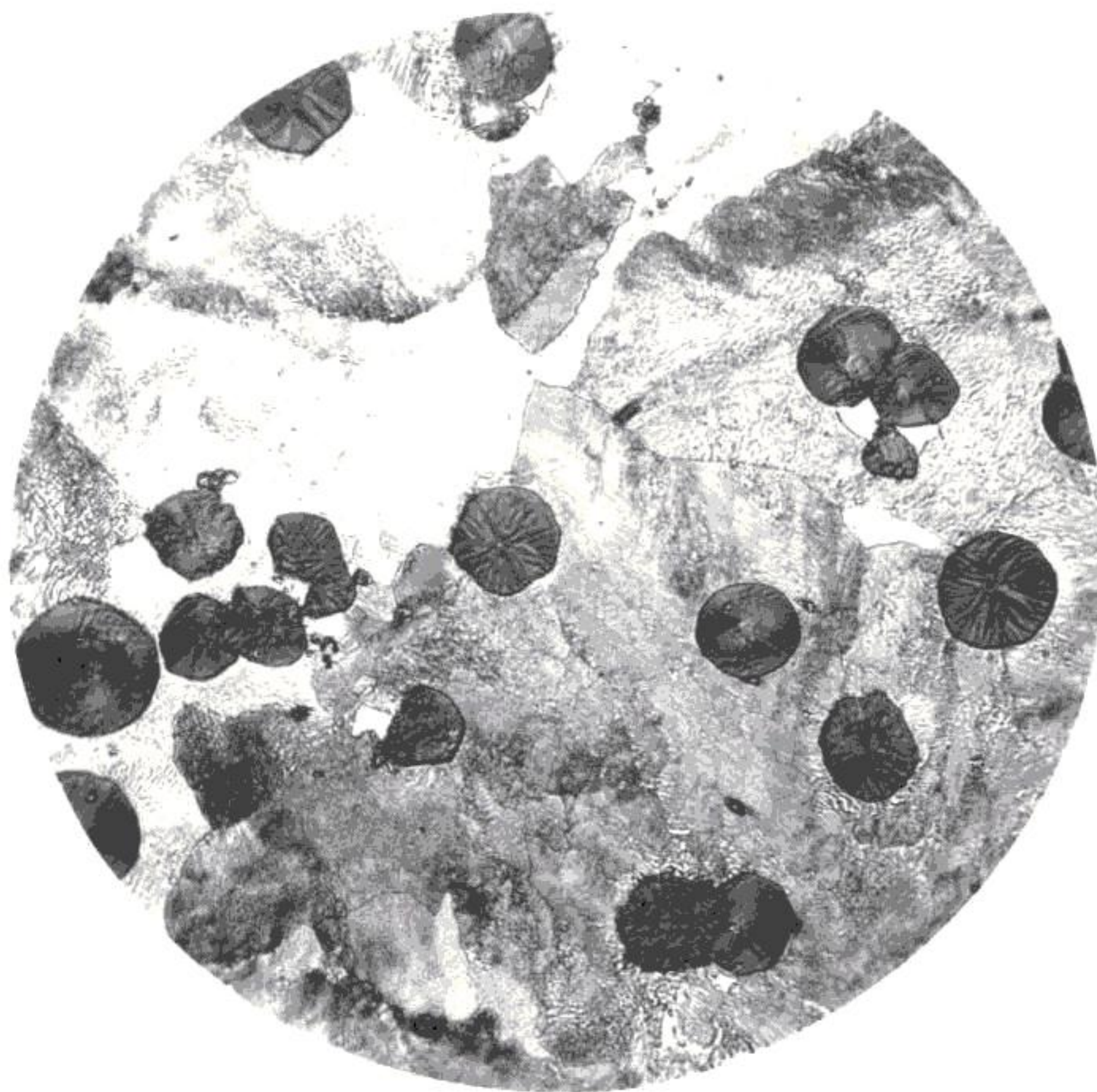
elektrolytisch
 vorgeschliffen: emery paper 0-00
 Blende: 8x8 mm
 Polierung: 6 sec. 11,1 amp. (+)
 Ätzung: unetched
 Elektrolyt: II-15 n. Dujardin

Gefüge:

nodular graphite in
 unetched state

Bemerkungen:

Magnesium 0,06 (*) mechanically polished for
 30 sec. after the electro polishing



No. 3762 Cast iron with nodular graphite (as cast state) GGG-45 Vergr.: 500:

Analyse:

Kohlenstoff
Graphit
Silizium
Mangan
Schwefel
Phosphor
Nickel
Chrom
Wolfram
Kobalt
Vanadium
Molybdän

as before

Polier- und Ätzverfahren:

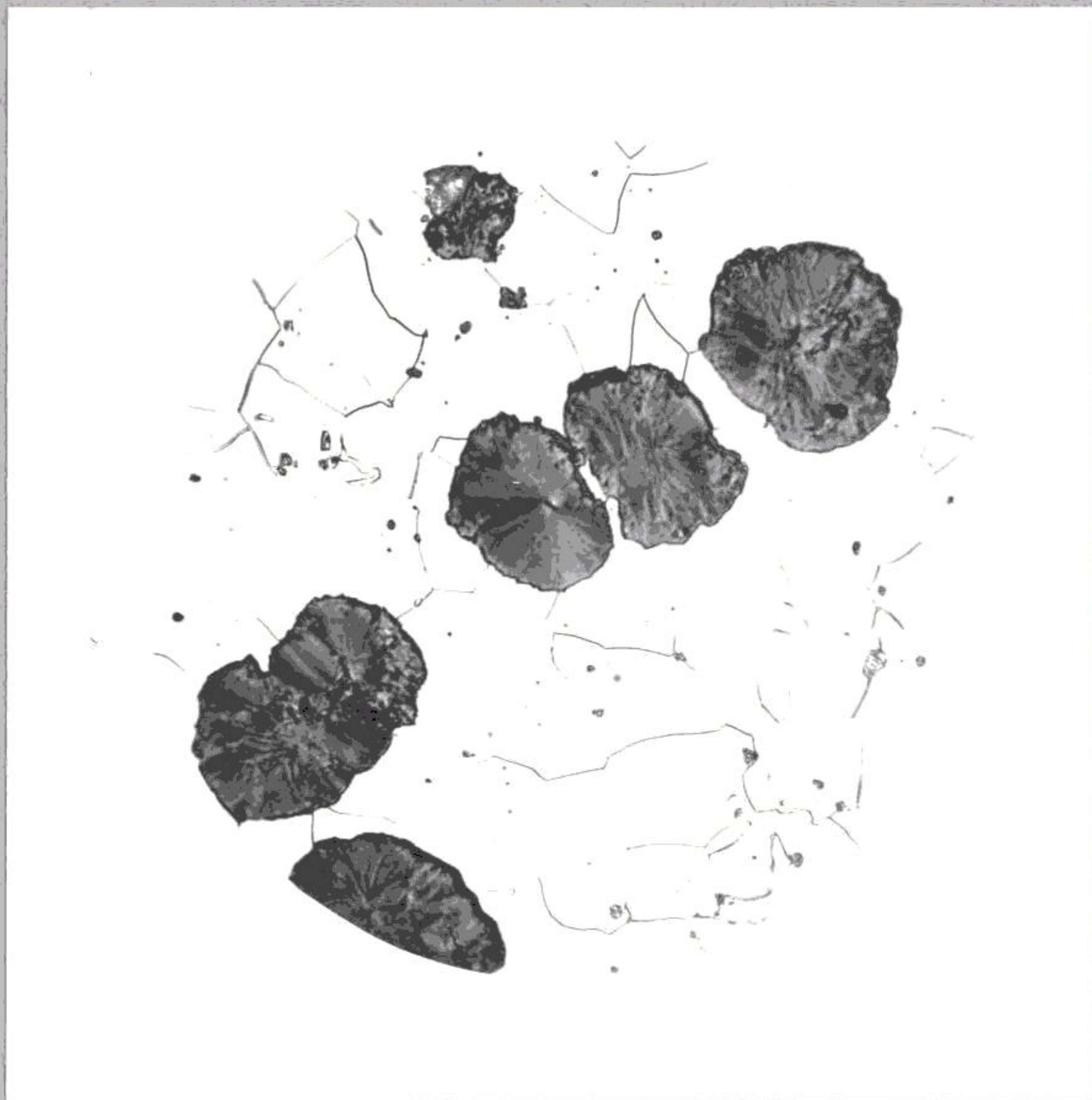
elektrolytisch
vorgeschliffen: emery paper 0-00
Blende 8x8 mm
Polierung: 6-8 sec. 11,7 amp. (+)
Ätzung: 2 " 1 " 1 "
Elektrolyt: as before

Gefüge:

nodular graphite in ledeburitic-pearlitic matrix, nodular graphite associated with ferritic envelope

Bemerkungen:

(+) as before



No. 3863 Cast iron with nodular graphite (annealed at 800°C) GGG-45 Vergr.: 500:1

Analyse:

Kohlenstoff
 Graphit
 Silizium
 Mangan
 Schwefel
 Phosphor
 Nickel
 Chrom
 Wolfram
 Kobalt
 Vanadium
 Molybdän

Polier- und Ätzverfahren:

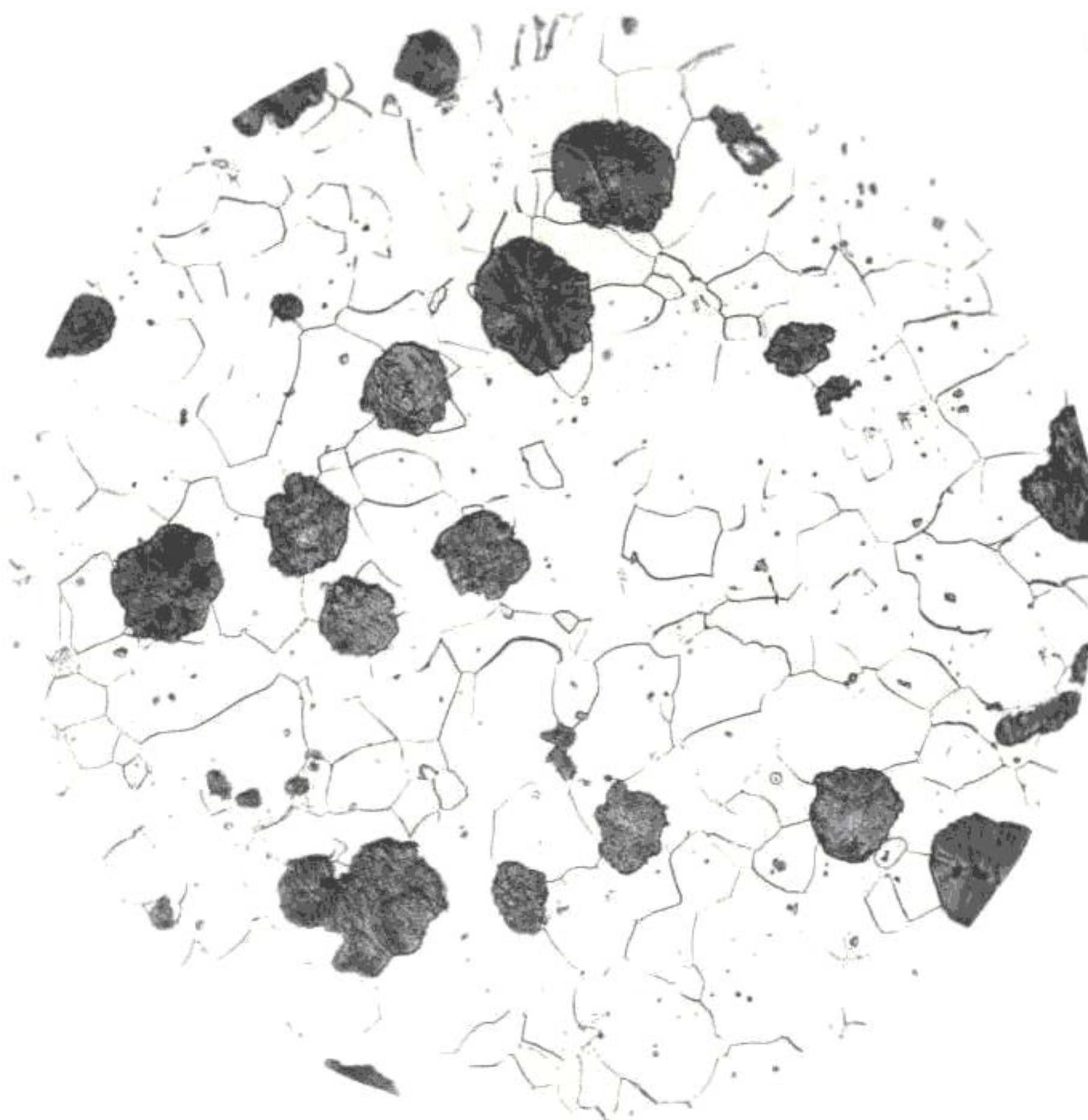
elektrolytisch
 vorgeschliffen: emery paper 0
 Blende: 8 x 8 mm
 Polierung: 10 sec. (1,7 amp. (+))
 Ätzung: chem. with 2% nitric acid
 Elektrolyt: J-75 after Ilujardin

Gefüge:

nodular graphite in
 ferritic matrix

Bemerkungen:

(+) see No 3767



No. 3864 Cast iron with nodular
graphite GGG-45

Vergr.: 200: -

Analyse:

Kohlenstoff
Graphit
Silizium
Mangan
Schwefel
Phosphor
Nickel
Chrom
Wolfram
Kobalt
Vanadium
Molybdän

Polier- und Ätzverfahren:

elektrolytisch
vorgeschliffen: *as before*
Blende " "
Polierung: " "
Ätzung: " "
Elektrolyt: " "

Gefüge:

as before

Bemerkungen:

as before

Group

I

Fully white iron GH



Specimen No. 18

a

1:1

b

200:1

c

500:1

Analysis type:

Total carbon	3,8
Graphite	-
Combined carbon	3,8
Silicon	0,8
Manganese	0,3
Phosphorus	0,6
Sulphur	0,16

Special properties:

white iron plate

section thickness:
30 mm

Physical properties:

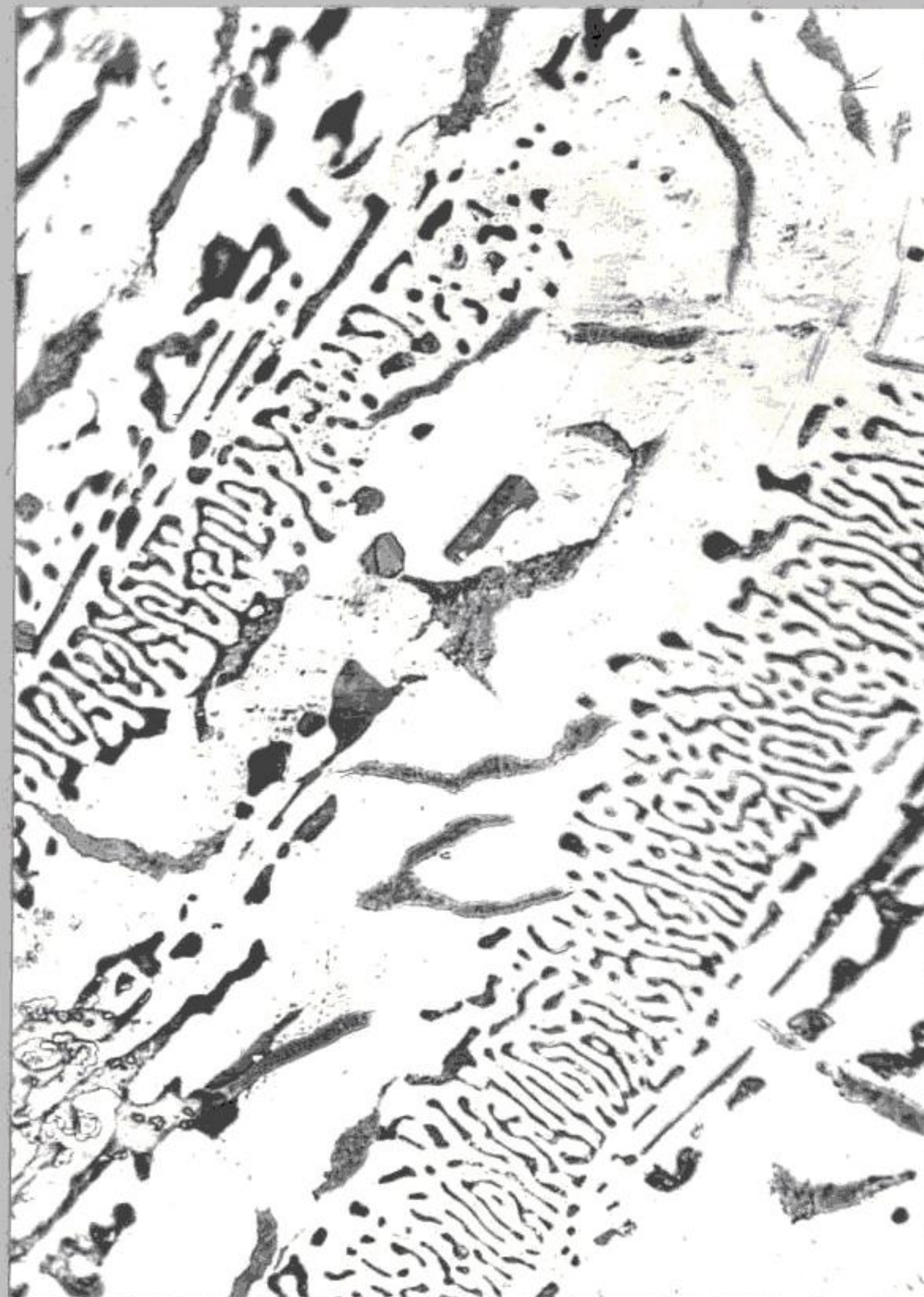
Brinell hardness:
450 kp/mm²

Structure:

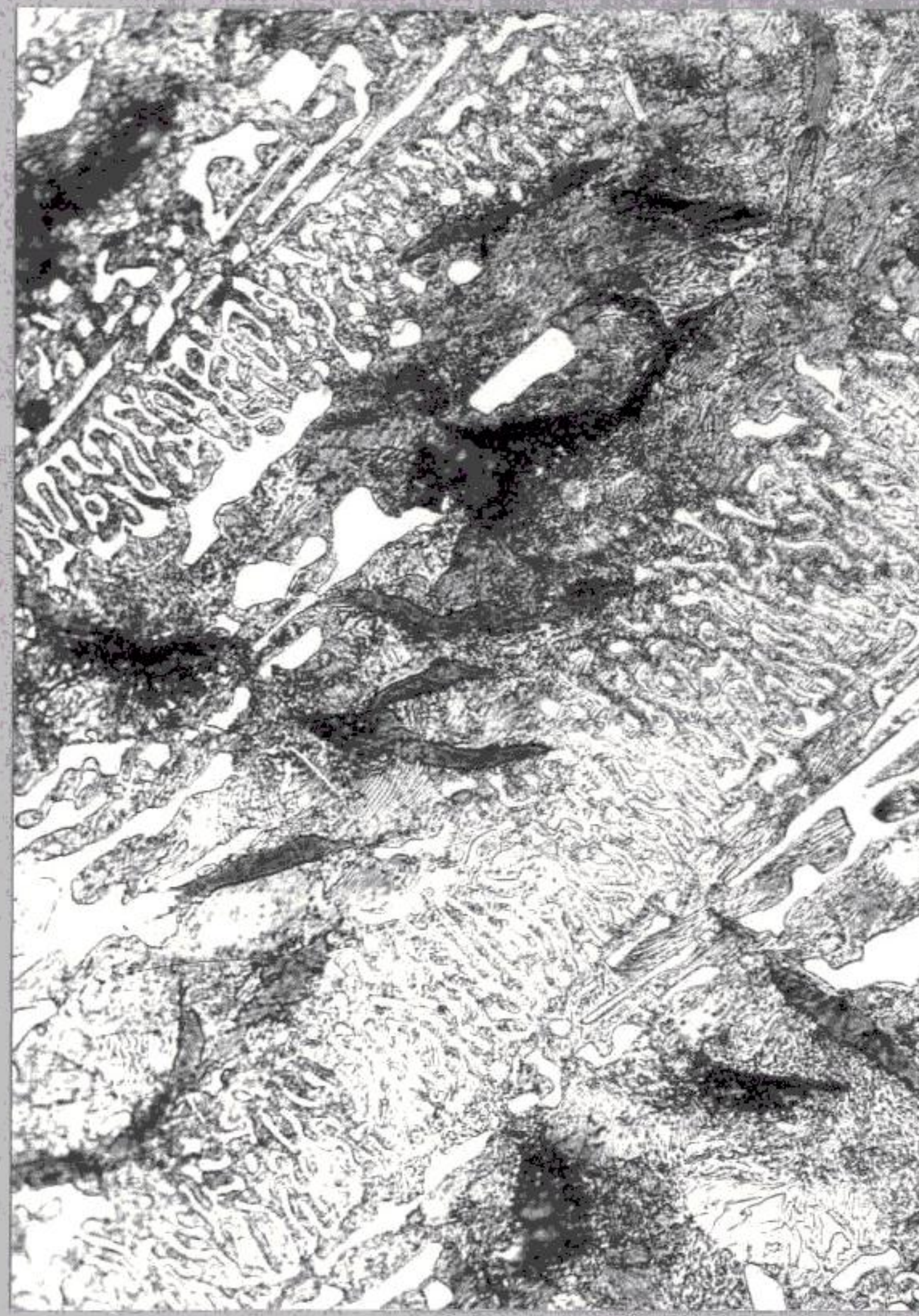
- a) general view
 b) no graphite as a result of the white structure,
 blue-grey manganese sulphides,
 c) ledeburitic matrix consisting and solid solution, cementite,
 fine, globular ternary phosphide

Etching: eutectic

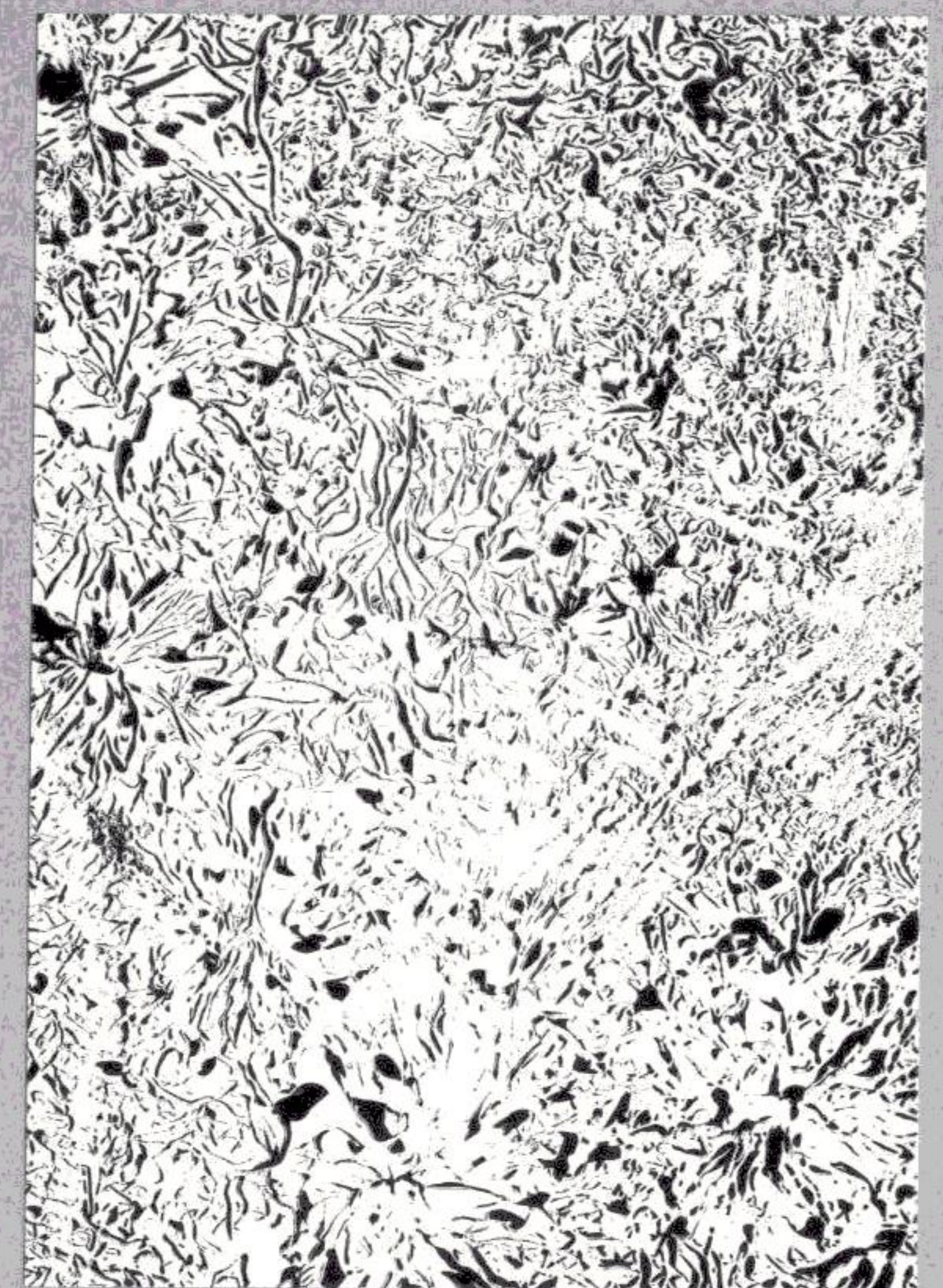
- a, b) unetched
 c) 2% alcoholic nitric acid



a) transition zone



b) transition zone



c) core

Specimen No. 19

500:1

500:1

25:1

Analysis type:

edge core

Total carbon	3,3	3,3
Graphite	-	2,8
Combined carbon	3,3	0,5
Silicon	1,5	1,5
Manganese	1,0	1,0
Phosphorus	0,2	0,2
Sulphur	0,1	0,1

Special properties:

cast against a chill to
harden the outer layer,
the edge is white as in
fully white iron,
core: grey

Physical properties:

Shore hardness:
surface > 80 (edge)

Structure:

a) tinting of the cementite,
component of the ledeburite
occurring at the edge
b) structure of the transition zone:
ledeburite and pearlite,
some graphite
c) graphite distribution in the core

Etching:

a) sodium picrate
b) 2% alcoholic nitric acid
c) unetched



Specimen No. 19

d

500:1

e

500:1

Analysis type:

Total carbon	3,3
Graphite	2,5
Combined carbon	3,0
Silicon	1,5
Manganese	1,0
Phosphorus	0,2
Sulphur	0,13

Special properties:

outer layers cooled
less quickly

Physical properties:

Brinell hardness:
220-280 kplmm²

Structure:

d) edge and core:
pearlitic-sorbitic matrix,
little phosphide eutectic
e) traces of ternary phosphide
eutectic in which the cemen-
tite has been tinted by etching

Etching:

d) 2% alcoholic nitric acid
e) sodium picrate

Temperguß - DIN 1692 (Juni 1963)

Tabelle 1. Sorten und Eigenschaften von entkohlend geglühtem (weißem) Temperguß

Sorte		Durchmesser des Probestabes mm	Zugfestigkeit kp/mm ² mindestens	0,2-Grenze ²⁾ kp/mm ² mindestens	Bruchdehnung ($L_0 = 3d$) % mindestens	Brinellhärte kp/mm ² höchstens	Kennzeichnende Gefügebestandteile
Kurzzeichen	Werkstoffnummer						
GTW-35 ³⁾		9	34	—	6	220	siehe Bild Keilprobe gegenüber GTW-40 größere Schwankungsbreite zulässig
		12	35	—	4		
		15	36	—	3		
GTW-40		9	36	20	10	220	siehe Bild Keilprobe Kern: lamellarer Perlit + Temperkohle
		12	40	22	5		
		15	42	23	3		
GTW-45		9	40	23	12	200	siehe Bild Keilprobe Kern: körniger Perlit + Temperkohle
		12	45	26	7		
		15	48	28	5		
GTW-55		9	52	34	7	240	siehe Bild Keilprobe Kern: feinkörniger Perlit + Temperkohle
		12	55	36	5		
		15	57	37	4		
GTW-65 ⁴⁾		9	62	41	4	270	siehe Bild Keilprobe Entkohlungstiefe gering; Vergütungsgefüge + Temperkohle
		12	65	43	3		
		15	67	44	2		
GTW-S38 ⁵⁾		9	32	17	15	200	siehe Bild Keilprobe Entkohlungstiefe besonders groß
		12	38	20	12		
		15	40	21	8		

Tabelle 2. Sorten und Eigenschaften von nicht entkohlend geglühtem (schwarzem) Temperguß

Sorte		Durchmesser des Probestabes	Zugfestigkeit	0,2-Grenze ²⁾	Bruchdehnung ($L_0 = 3d$)	Brinellhärte	Kennzeichnende Gefügebestandteile
Kurzzeichen	Werkstoffnummer	mm	kp/mm ² mindestens	kp/mm ² mindestens	% mindestens	kp/mm ²	
GTS-35 ⁴⁾		12 15	35	20	12	bis 150	Ferrit + Temperkohle
GTS-45		12 15	45	30	7	160 bis 200	Perlit (lamellar bis körnig) + Ferrit + Temperkohle
GTS-55		12 15	55	36	5	180 bis 220	Perlit (lamellar bis körnig) + Temperkohle, Ferritanteil möglich
GTS-65		12 15	65	43	3	210 bis 250	Perlit (lamellar bis körnig) + Temperkohle
GTS-70 ⁴⁾		12 15	70	55	2	240 bis 270	Vergütungsgefüge + Temperkohle

²⁾ Bei Tempergußsorten mit ausgeprägter natürlicher Streckgrenze liegt diese erfahrungsgemäß mindestens 2 kp/mm² höher als die 0,2-Grenze.

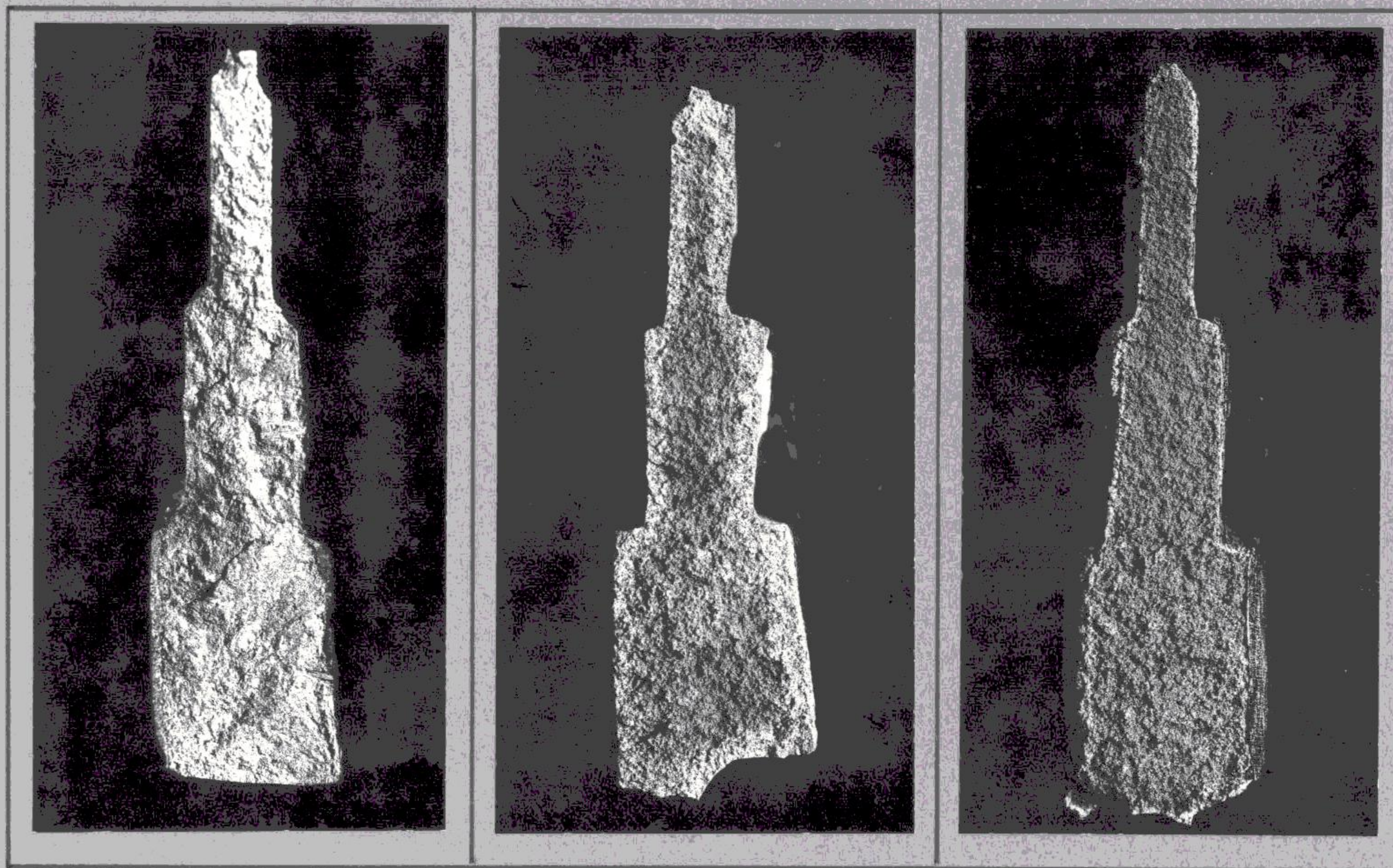
³⁾ Für Fittings muß eine höhere Dehnung gewährleistet werden.

⁴⁾ Vergütet (Begriff siehe DIN 17 014)

⁵⁾ Für Festigkeitschweißungen ohne thermische Nachbehandlung geeigneter GTW (S = schweißbar, siehe Abschnitt 3.5.1.)

⁶⁾ Früher GTS-38; siehe Erläuterungen

(mit Genehmigung des Deutschen Normenausschusses)



a 1:1

b 1:1

c 1:1

pig-cast iron - Analyse:

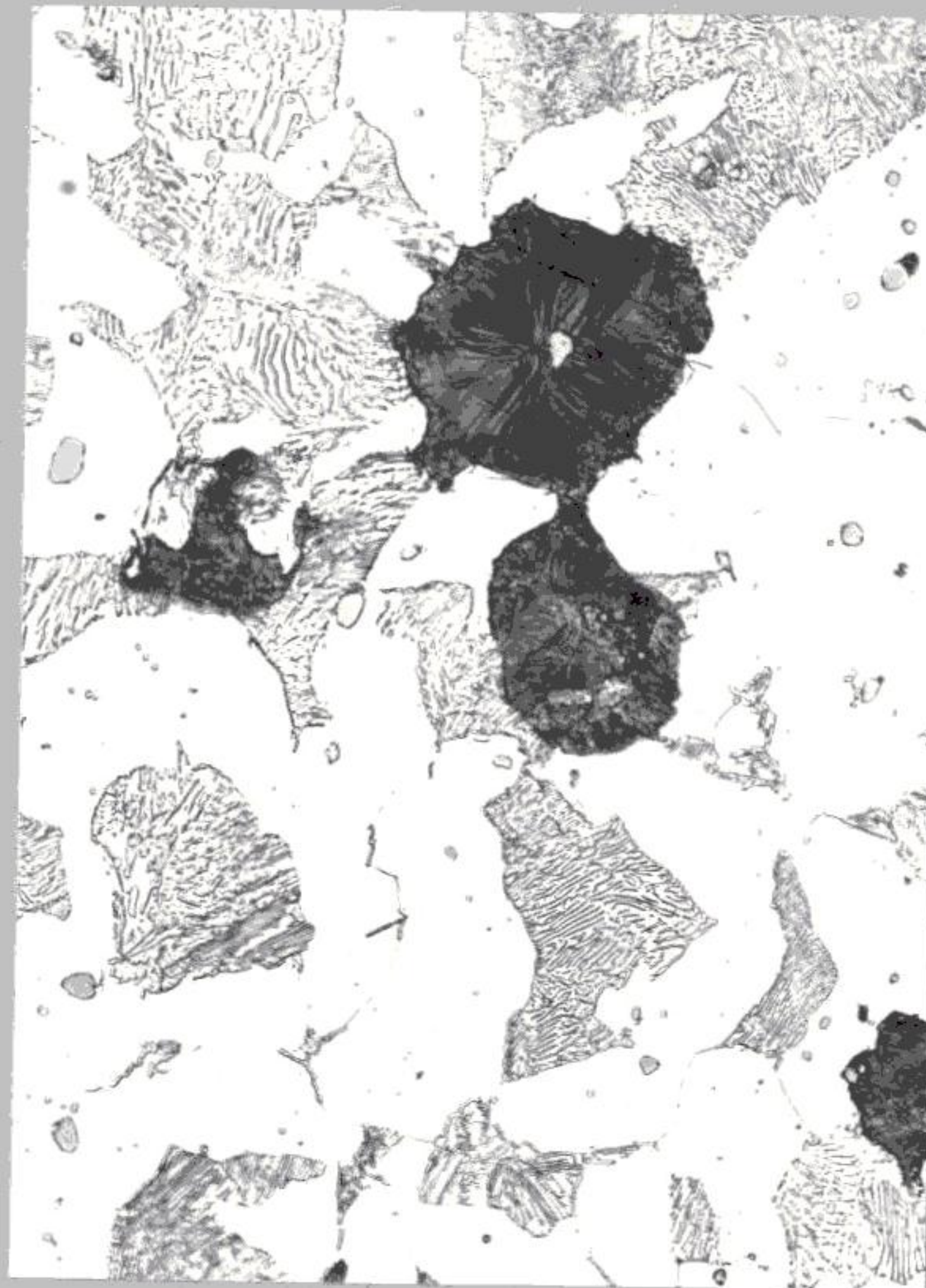
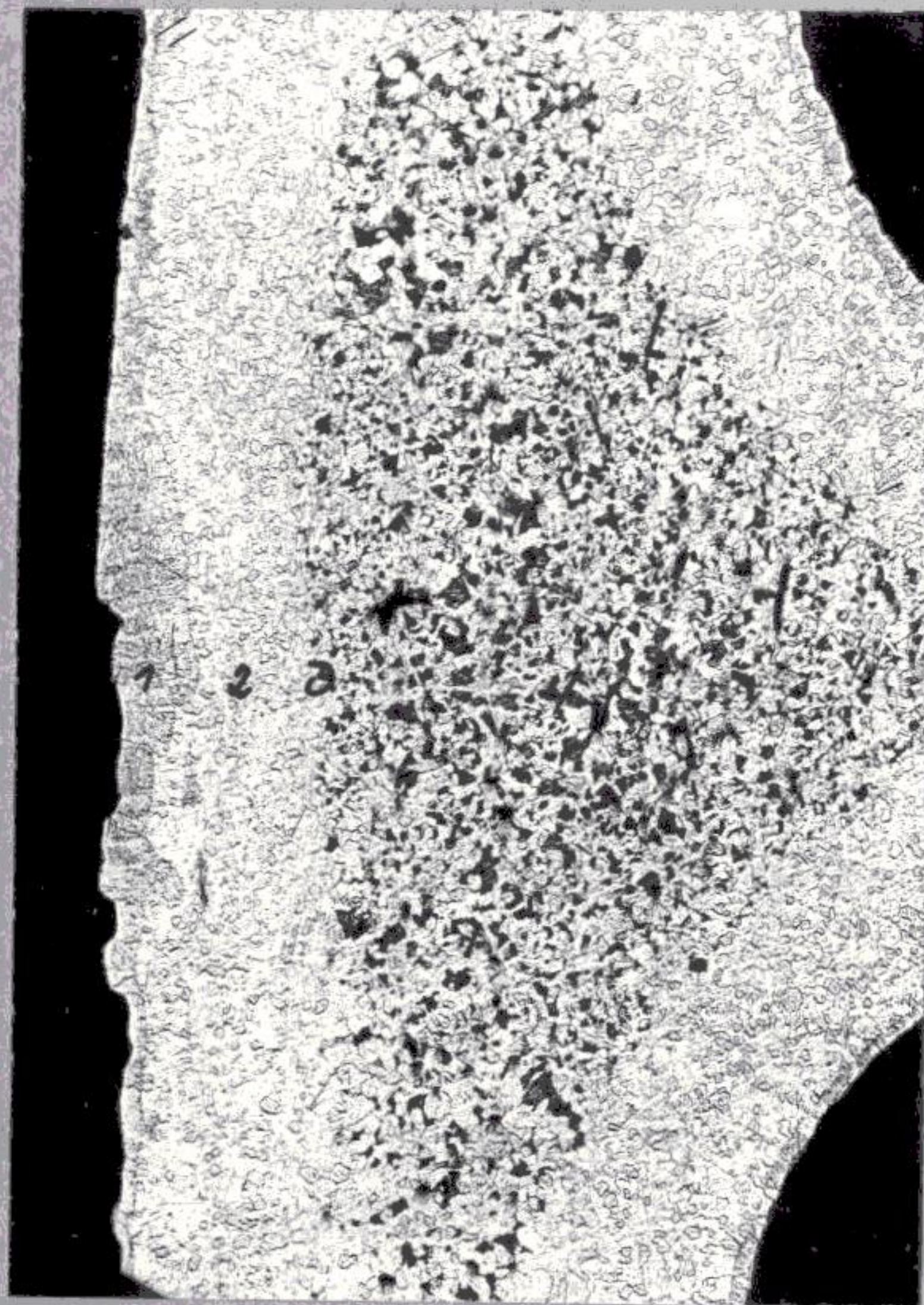
GTW		GTS	
C	3 - 3,5 %	2,5 - 2,7 %	
Si	0,75 - 0,55 %	1,5 - 1,0 %	
Mn	0,3 - 0,25 %	0,4 - 0,3 %	
P	< 0,12 %	< 0,12 %	
S	0,1 - 0,2 %	< 0,15 %	

a) malleable cast iron-stepped:

b) malleable cast iron-stepped (white), GTW:

c) malleable cast iron-stepped (black), GTS: black fracture

white fracture
 { core black
 edge white



pig cast iron } no
3% } malleablize
GTW 0,4% }
GTW 1,5% } malleablize

as standard analysis

	edge	core
total carbon	practically = nil	varying according to section thickness and extent of decarburisation (in this case = 1,2%)
temper carbon	—	variable (in this case = 1,0%)

Specimen No. 27

15:1

6

250:1

Analysis type:

Total carbon
(nodular)
Graphite

edge core
see above

Combined carbon

— 0,2

Silicon

0,6 0,6

Manganese

0,4 0,4

Phosphorus

0,1 0,1

Sulphur

0,19 0,19

Special properties:

cupola melted malleable
iron

malleablised by the German
gaseous annealing process
Section thickness: 6 mm

Physical properties:

Brin. hardn.: edge 130 kp/mm²
core 160 " "

tensile strength: 36 " " (*)

transv. rupt. stress: 18 " "

elongation: 16 %

(*) on 12 mm test bar

Structure:

a) general view:

1 = mildly recarburised layer

2 = ferritic zone

3 = transition zone: ferrite-pearlite

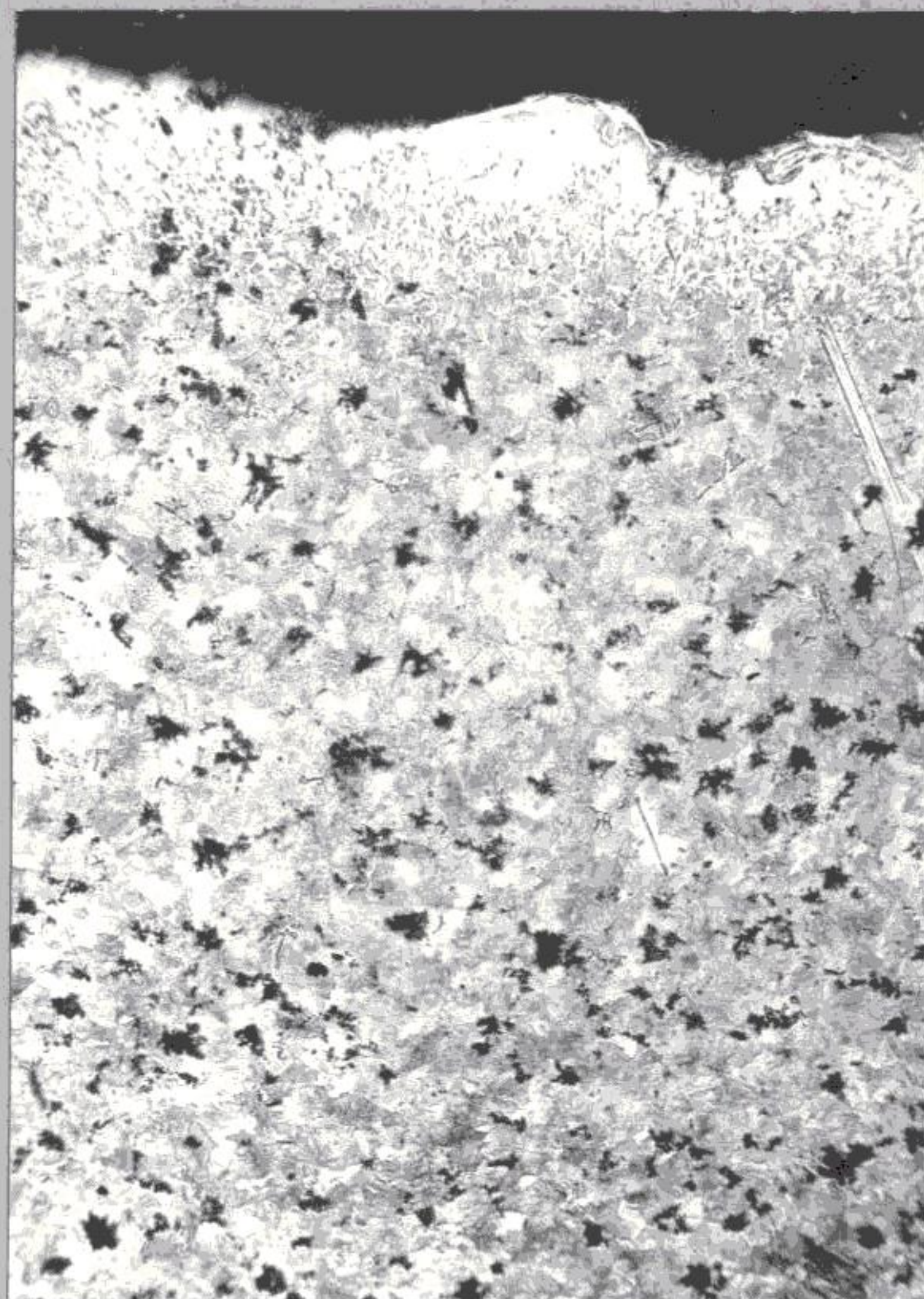
4 = ferrite-pearlite and temper carbon

b) core at higher magnification:

ferrite-pearlite-temper carbon

Etching: and iron sulphides

2% alcoholic nitric acid



Specimen No. 23

9

50:7

6

250:7

Analysis type:

Total carbon 2,35
Graphite -
Combined carbon 0,82
Silicon 0,65
Manganese 0,38
Phosphorus 0,08
Sulphur 0,12

Special properties:

air quench process:
870°C

Physical properties:

Brinell hardness: 220 kpl/mm²
tensile strength: 67 " "
elongation: L: 3d = 2,5 %

(+) 12 mm ϕ

Structure:

a) edge:
pearlite and temper carbon
b) core:
pearlite (finely lamellare)
sorbite and temper carbon

Etching:

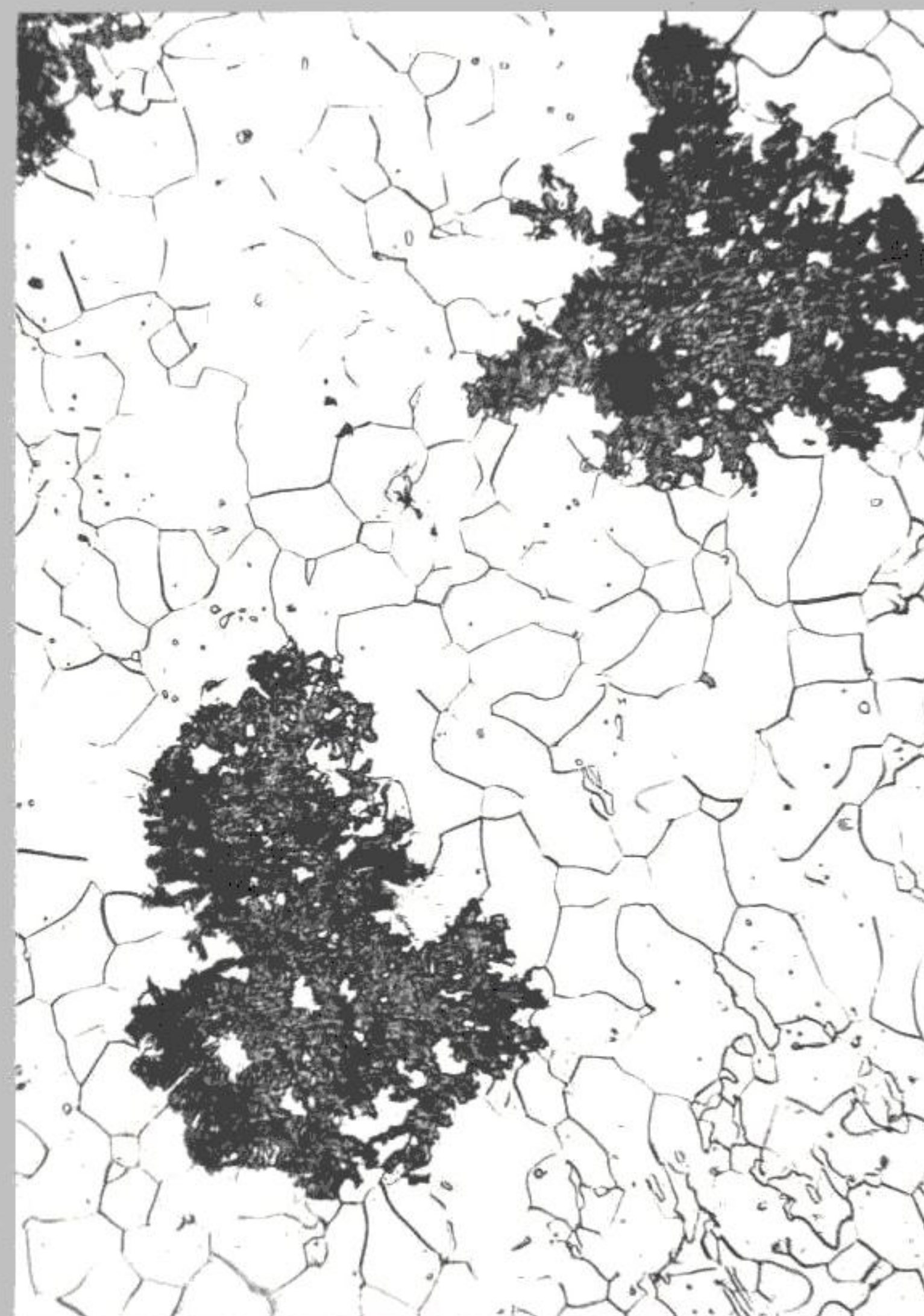
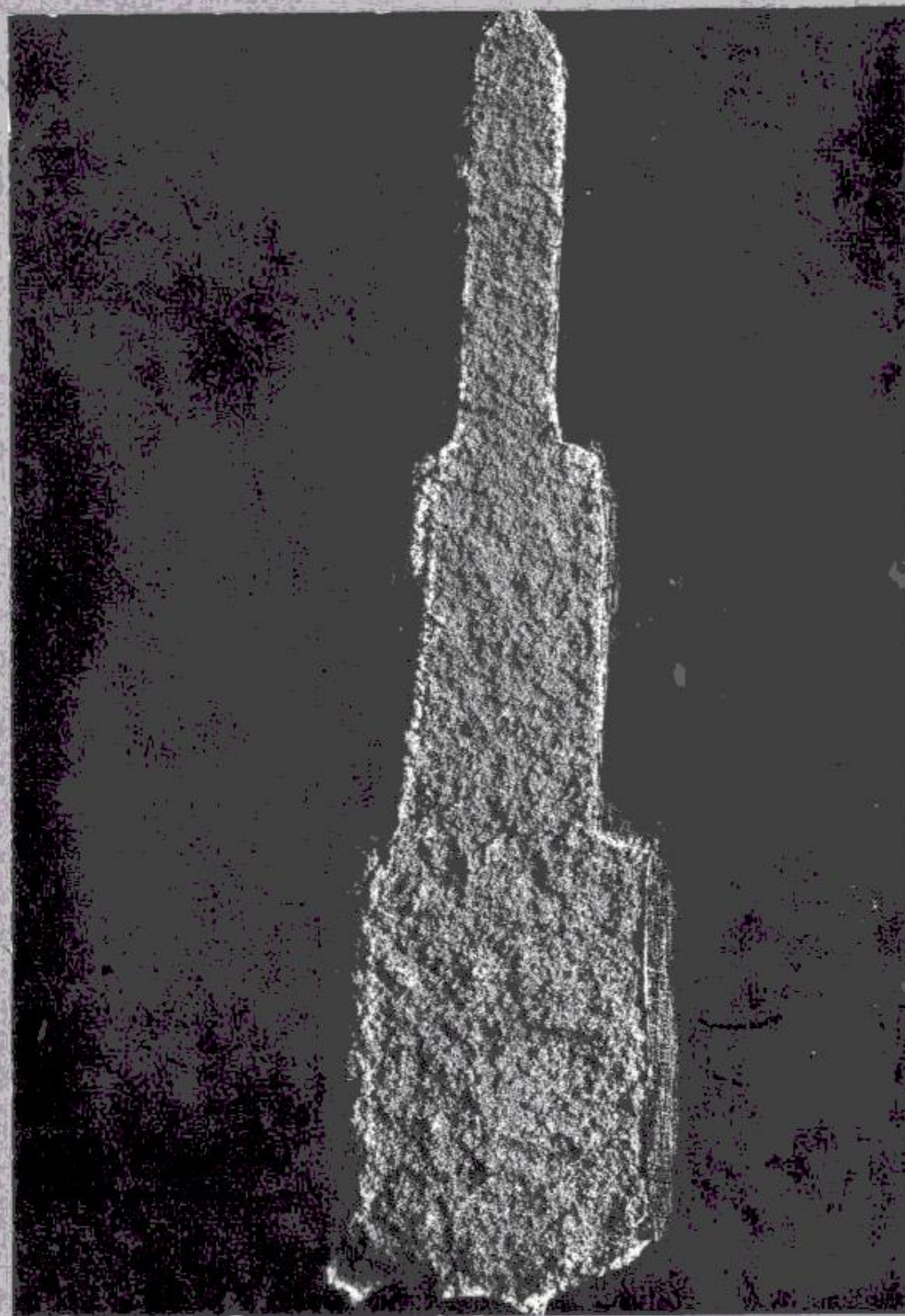
3% alcoholic nitric acid

Group

5

Blackheart malleable cast iron

GTS 35



Specimen No. 70

α

7:1

6

250:1

Analysis type:

Total carbon	2,2- 2,6
Graphite	varying
Combined carbon	- -
Silicon	1,0
Manganese	0,4
Phosphorus	0,07
Sulphur	0,15

Special properties:

a) annealed at 900°C
 b) annealed by slow cooling between 800 and 700°C

Physical properties:

Brinell hardness: 130 kp/mm²
 tensile strength: 40 " " (x)
 elongation: 14 %

(x) on 12 mm test bar

Structure:

a) fractured surface black
 b) ferrite and temper carbon

Etching:

2% alcoholic nitric acid