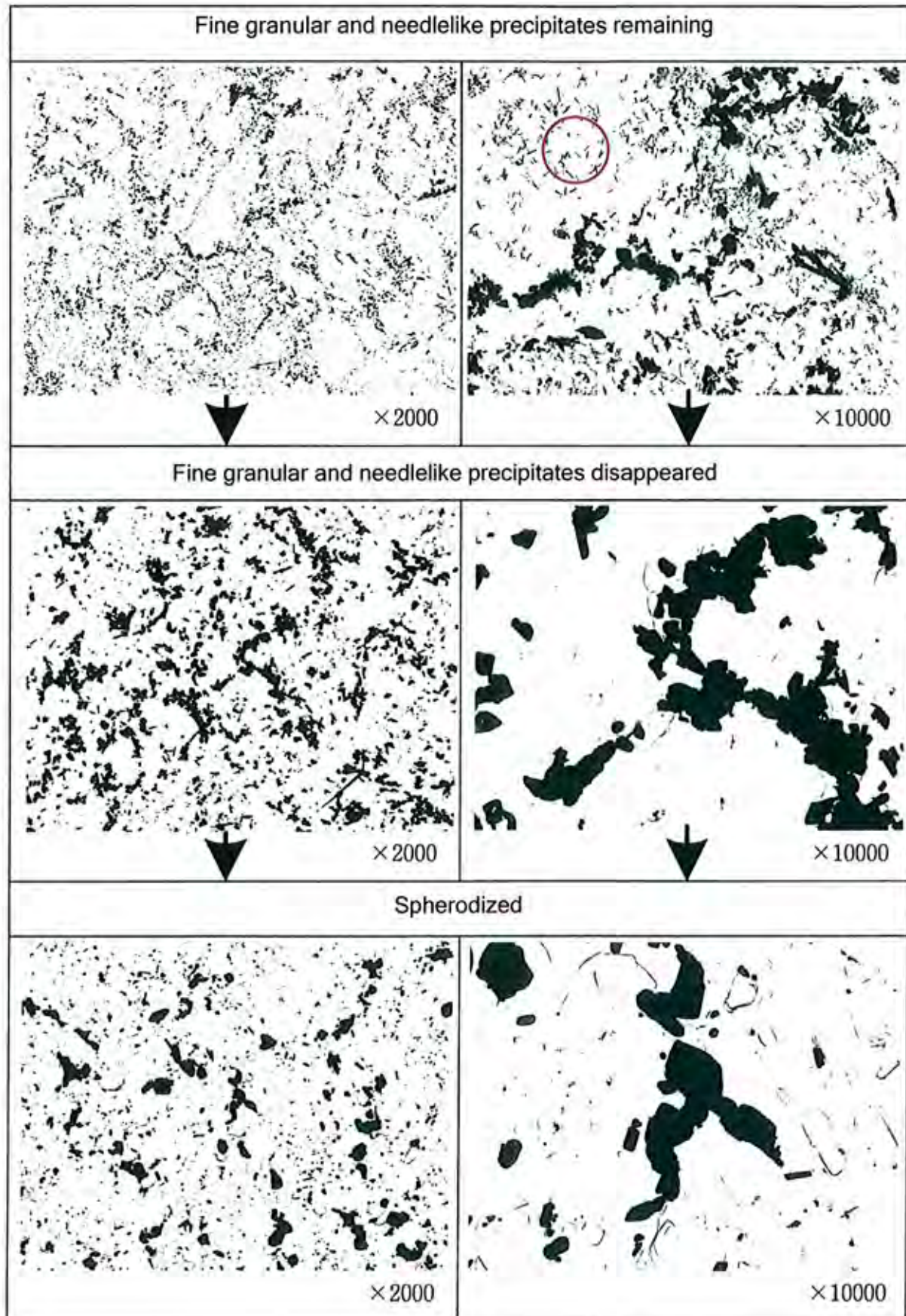
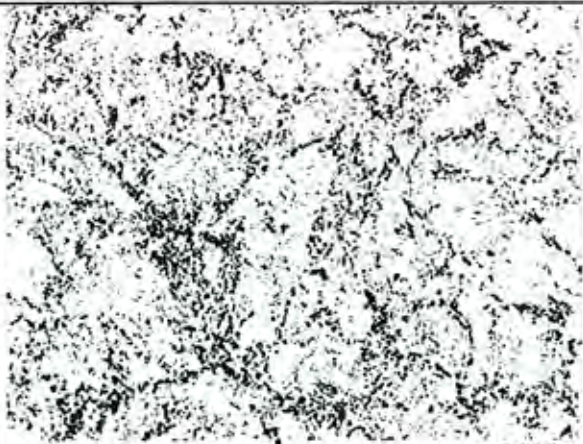
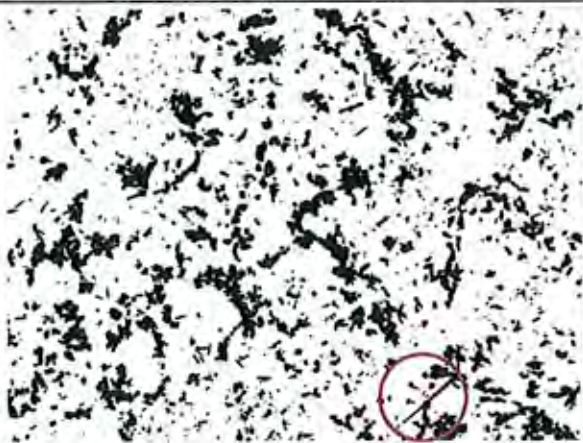


Reference microstructure by TEM observation  
SA 213 T22 Fine grain HAZ



Reference microstructure by TEM observation  
SA 213 T22 Fine grain HAZ

|  |  |
|--|--|
| No attenuated plate-shaped precipitates  |  |
|  <p>× 2000</p>  |  |
| Attenuated plate-shaped precipitates appeared  |  |
|  <p>× 2000</p> |  |
|  |  |
|  |  |

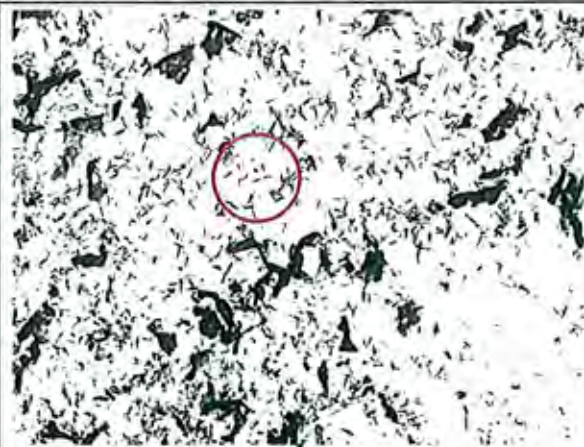


Refererence microstructure by TEM observation  
SA 213 T22 Coarse grain HAZ

Fine granular and needlelike precipitates remaining

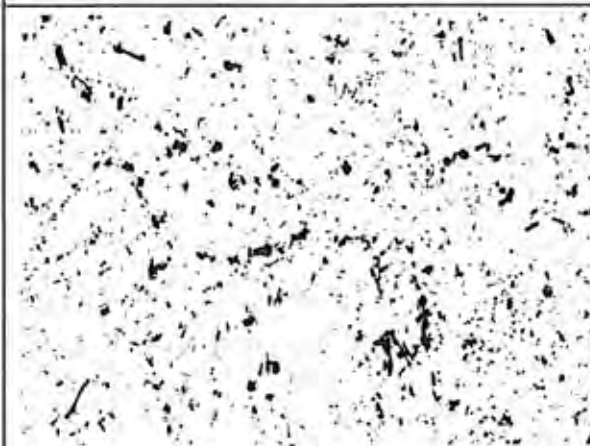


× 2000



× 10000

Fine granular and needlelike precipitates disappeared

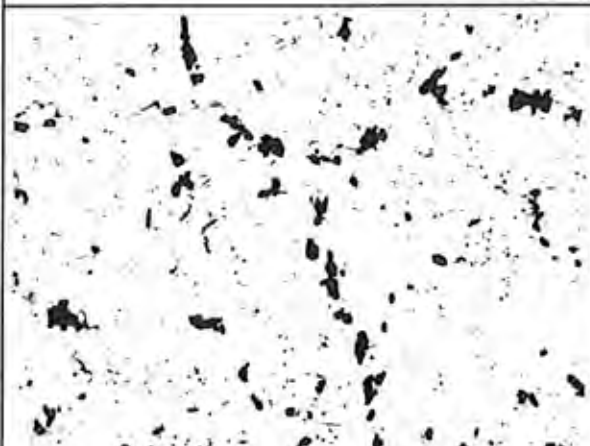


× 2000



× 10000

Spherodized



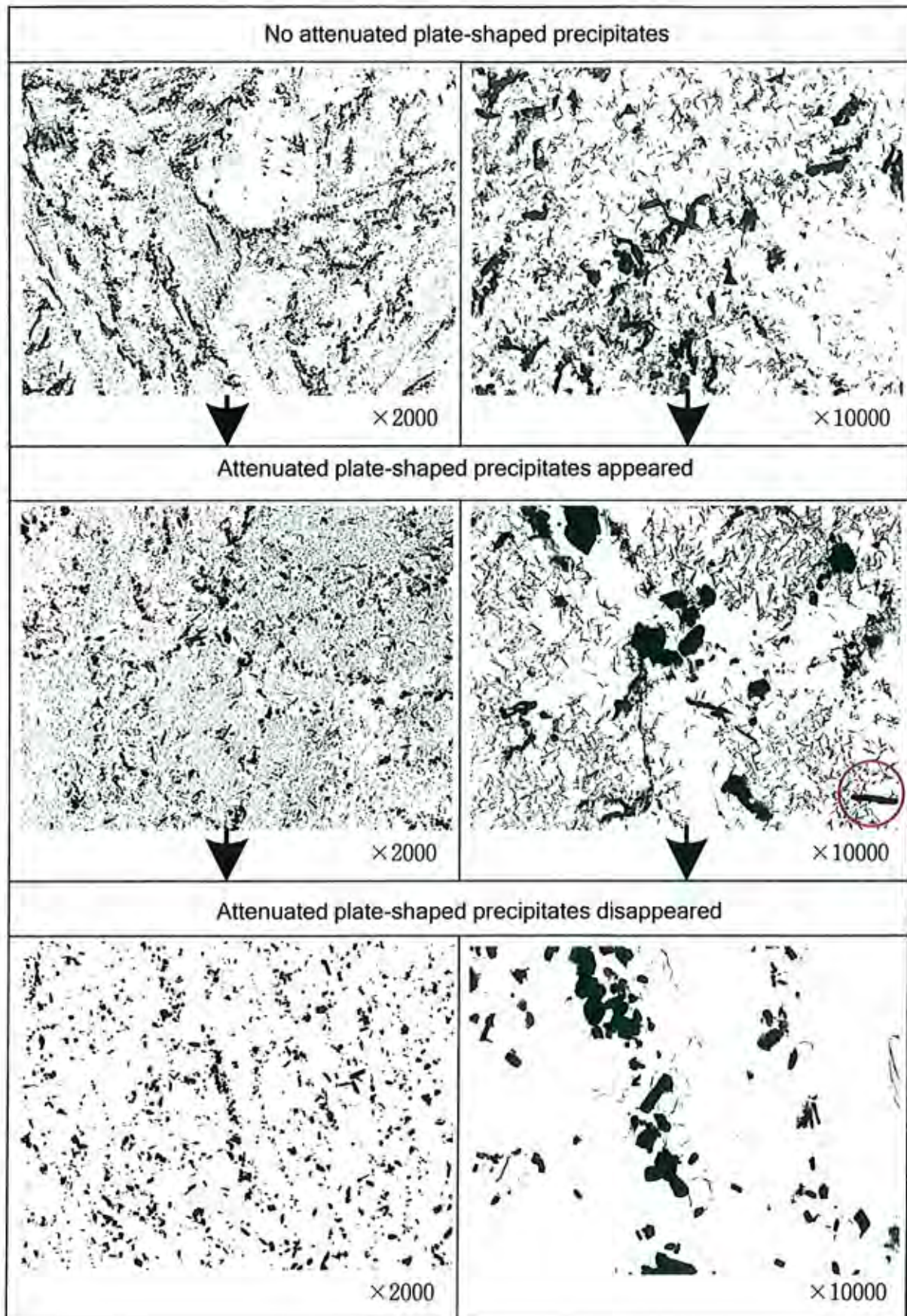
× 2000



× 10000

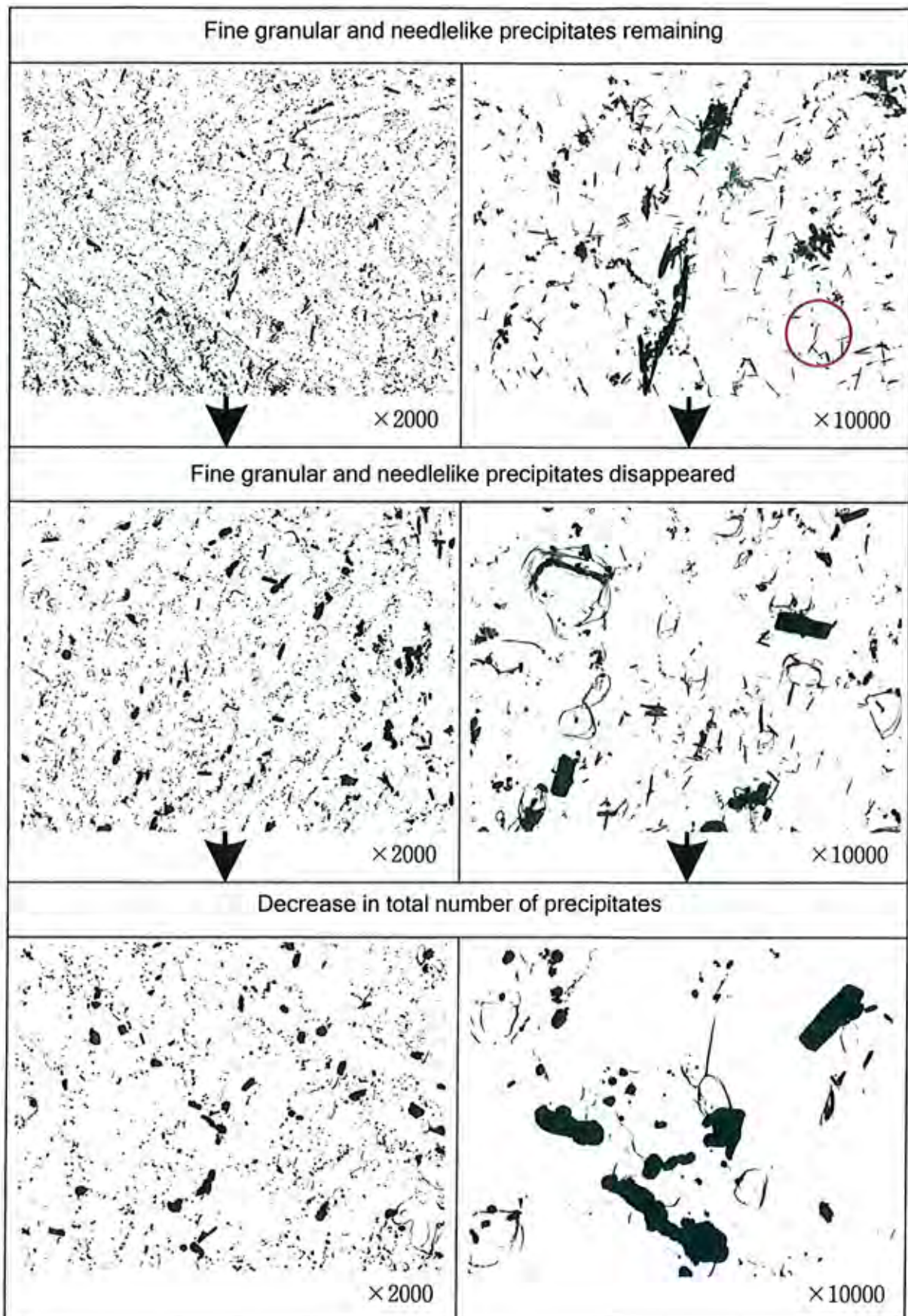


Refererence microstructure by TEM observation  
SA 213 T22 Coarse grain HAZ

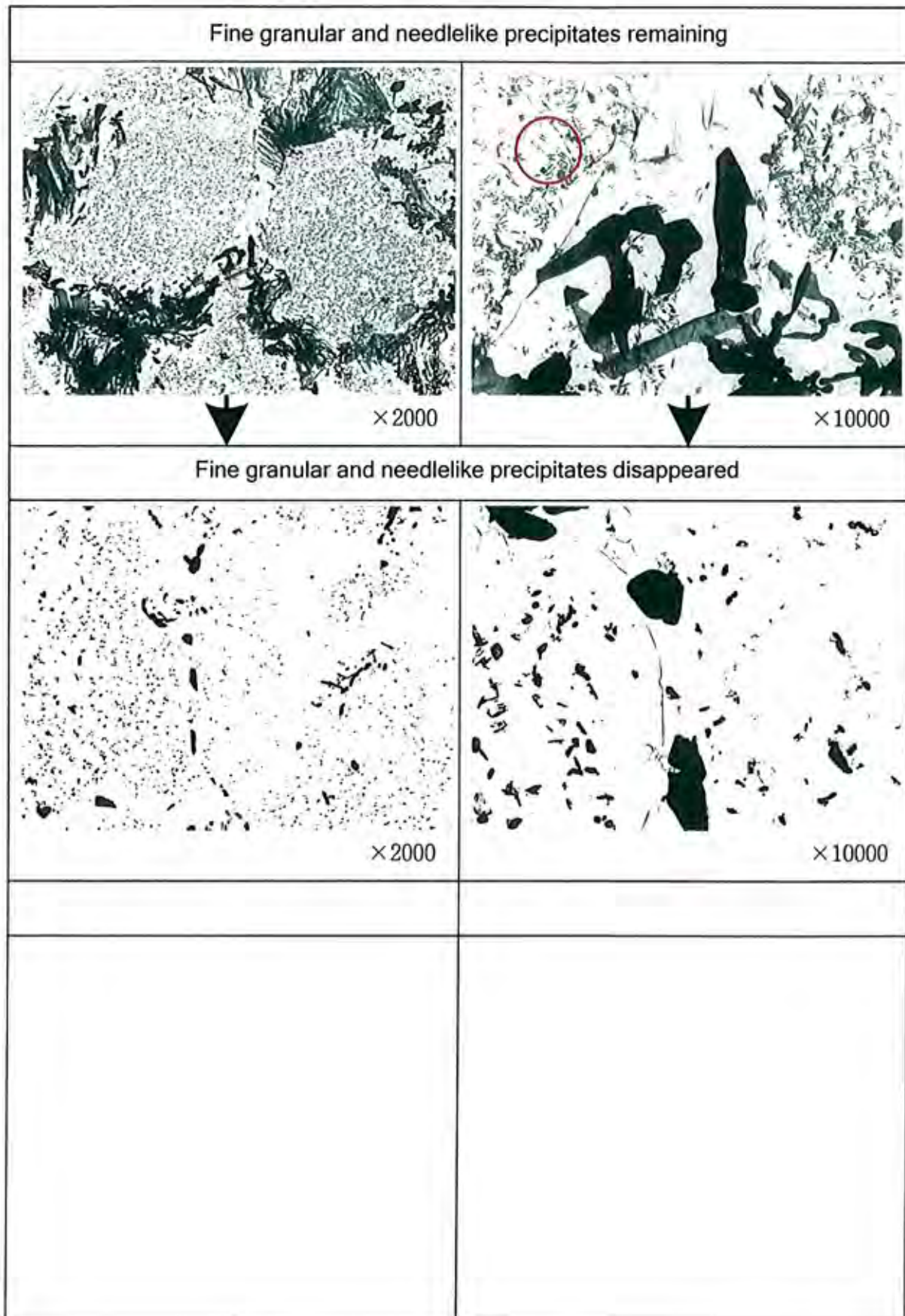




Reference microstructure by TEM observation  
SA 213 T22 Weld metal



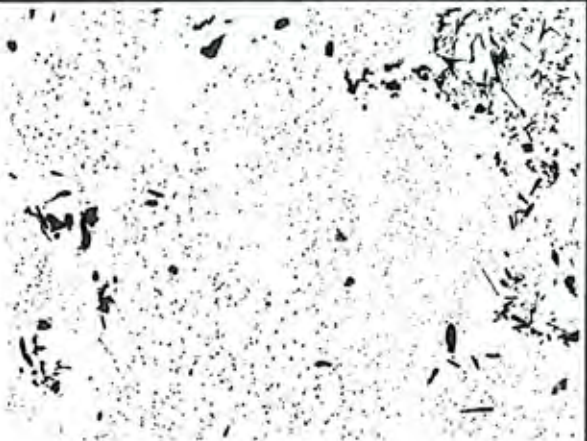
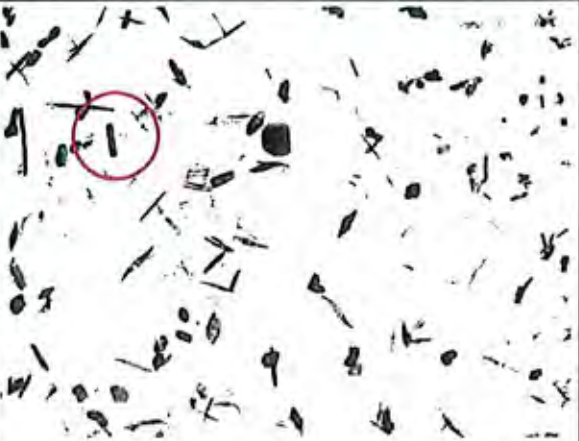


Referrence microstructure by TEM observation  
SA 213 T11 Base Metal



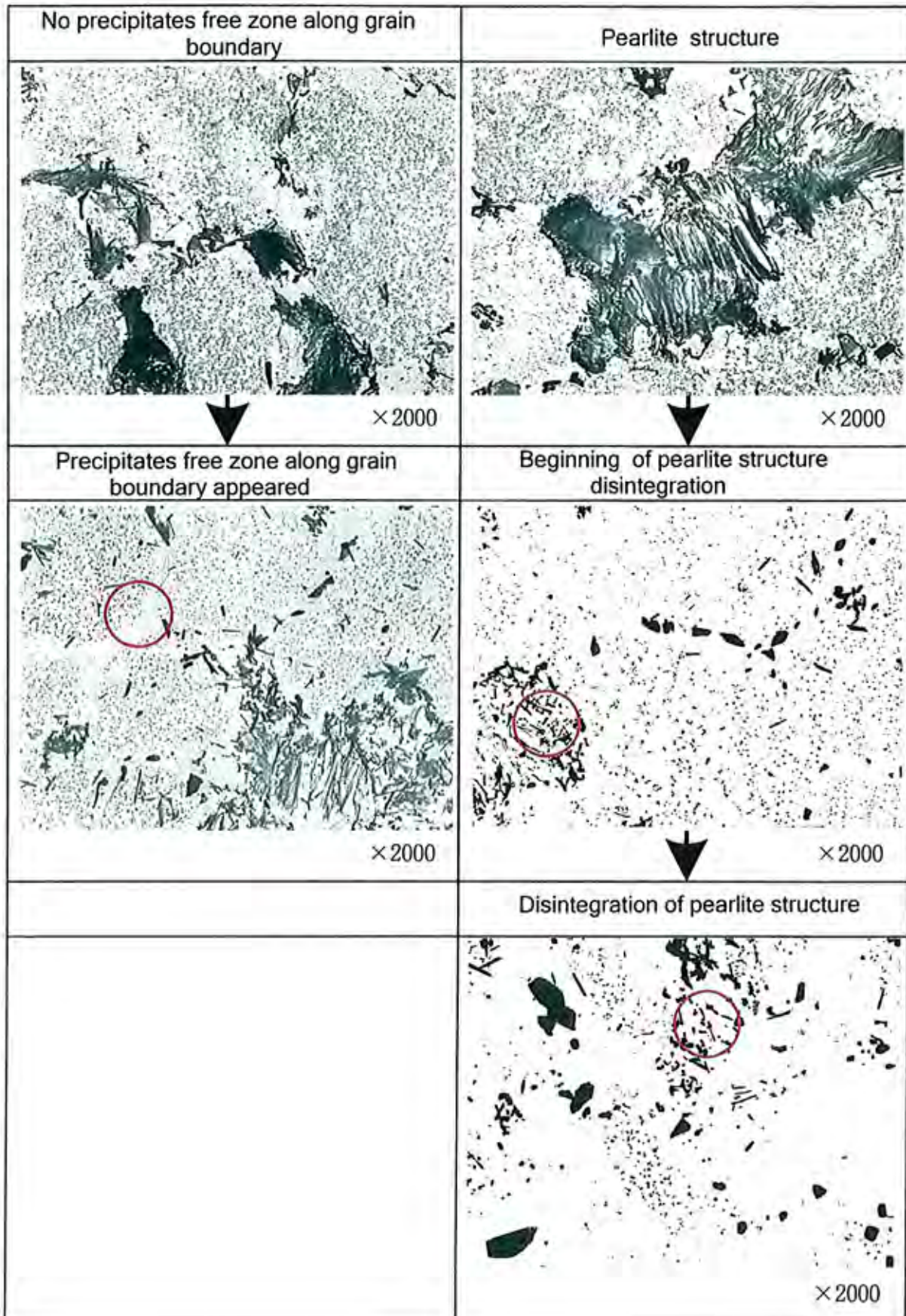


Referrence microstructure by TEM observation  
SA 213 T11 Base Metal

| No rod-shaped precipitates   |  |
|--|--|
| <br>× 2000  | <br>× 10000  |
| Rod-shaped precipitates appeared   |  |
| <br>× 2000 | <br>× 10000 |
|  |  |
|  |  |



Refererence microstructure by TEM observation  
SA 213 T11 Base Metal



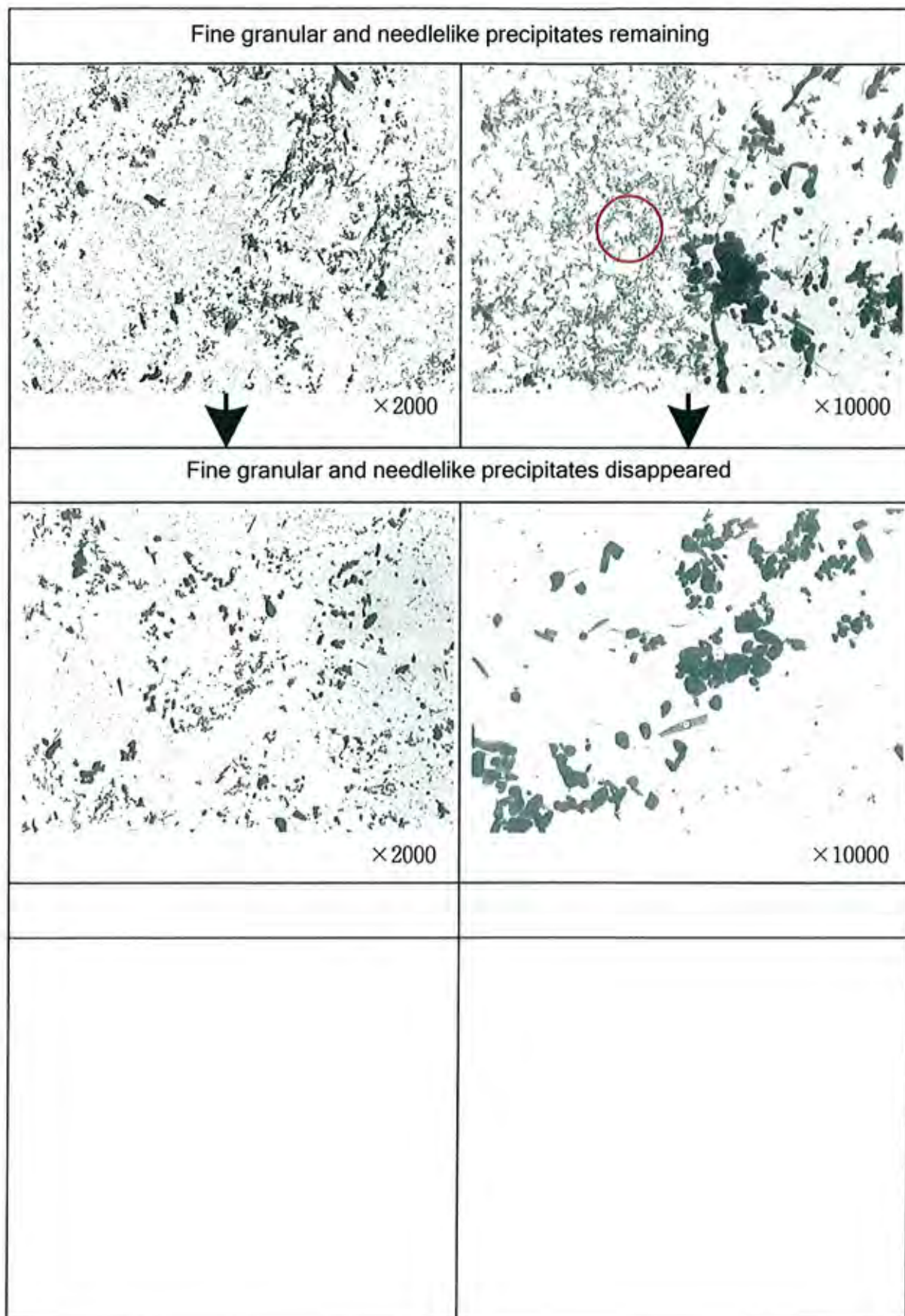


Reference microstructure by TEM observation  
SA 213 T11 Base Metal

|   |  |
|---|--|
| No attenuated plate-shaped precipitates   |  |
|  <p>×2000</p>  |  |
| Attenuated plate-shaped precipitates appeared   |  |
|  <p>×2000</p> |  |
|   |  |
|   |  |

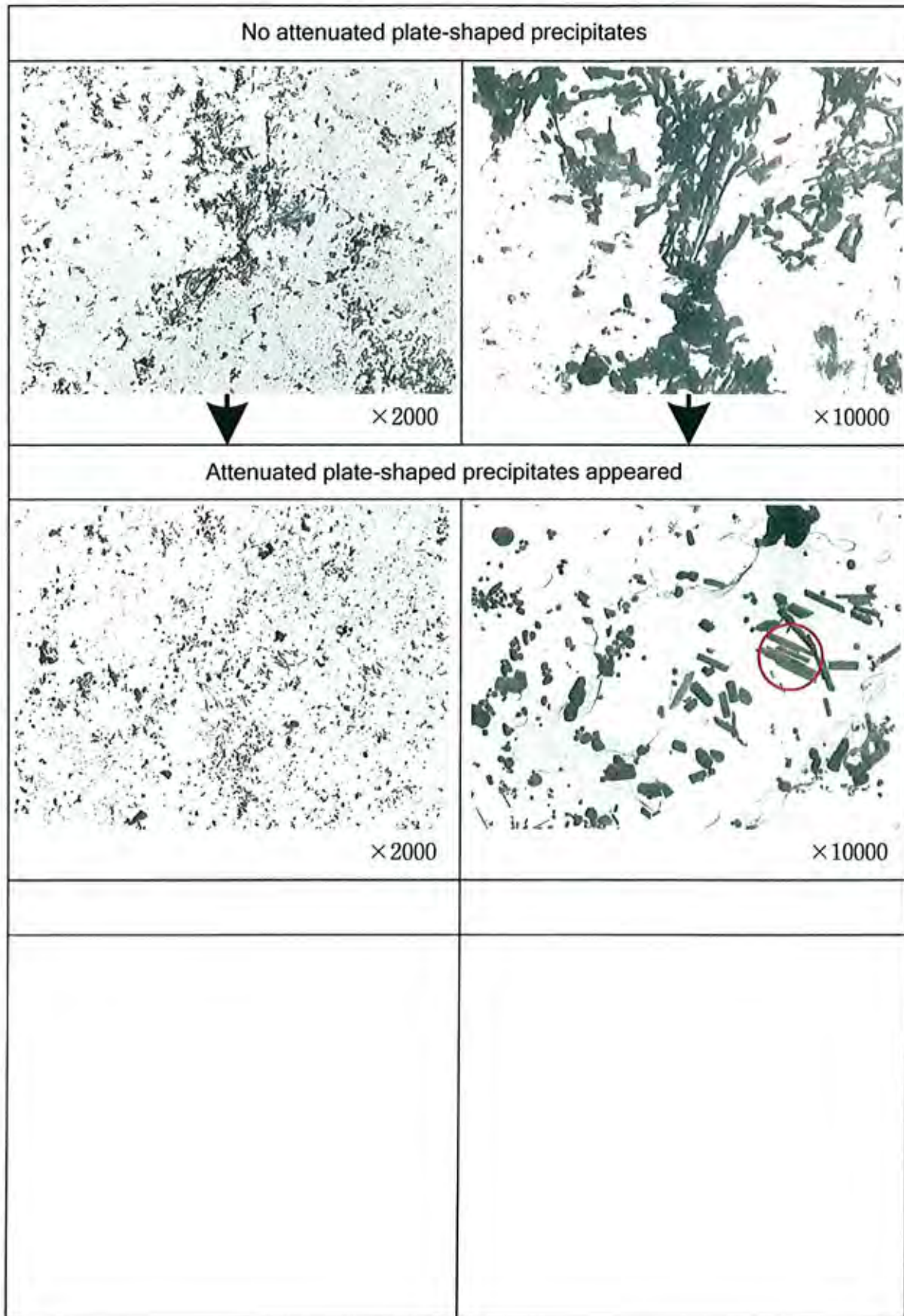


Referrence microstructure by TEM observation  
SA 213 T11 Fine grain HAZ



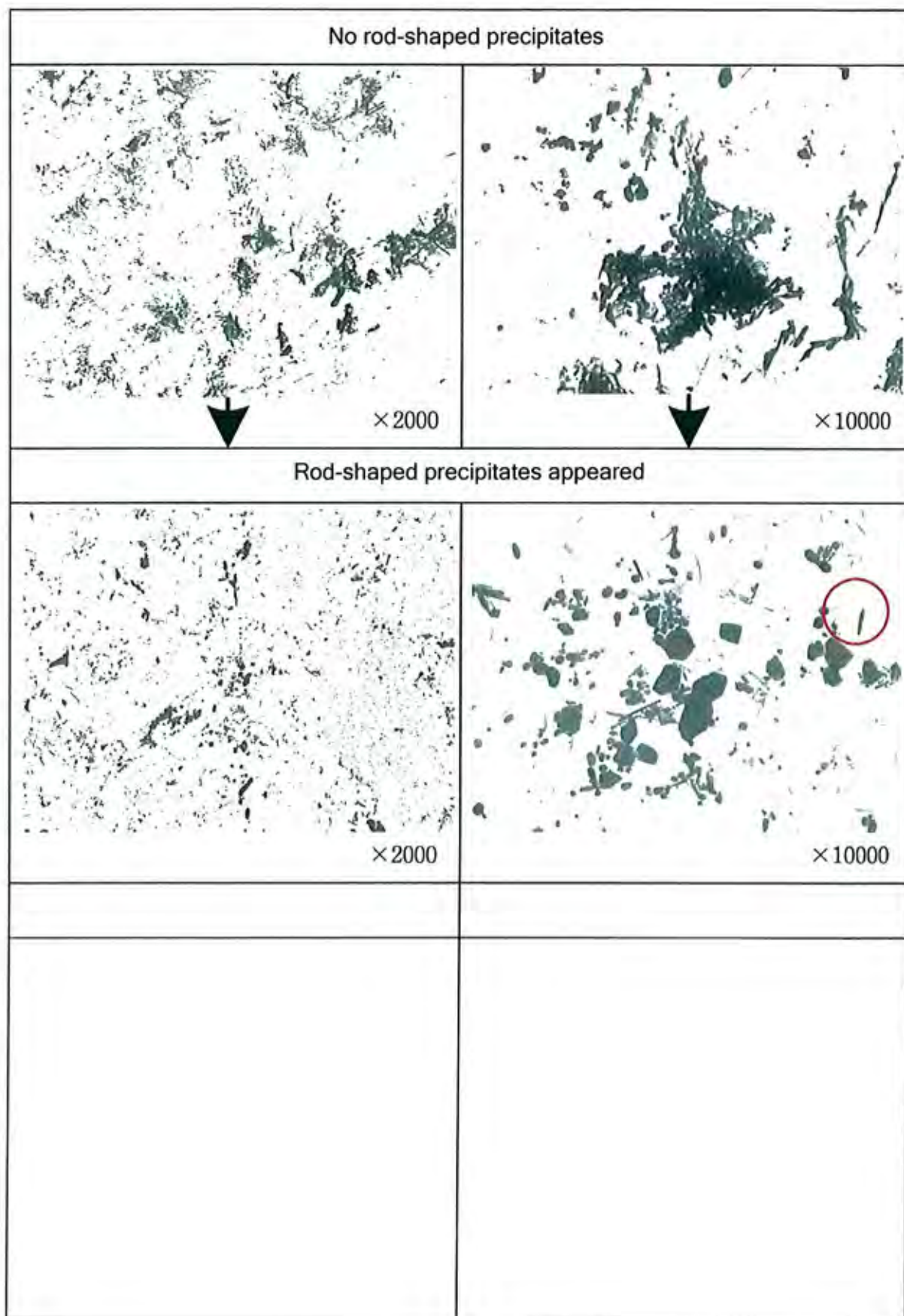


Refererence microstructure by TEM observation  
SA 213 T11 Fine grain HAZ

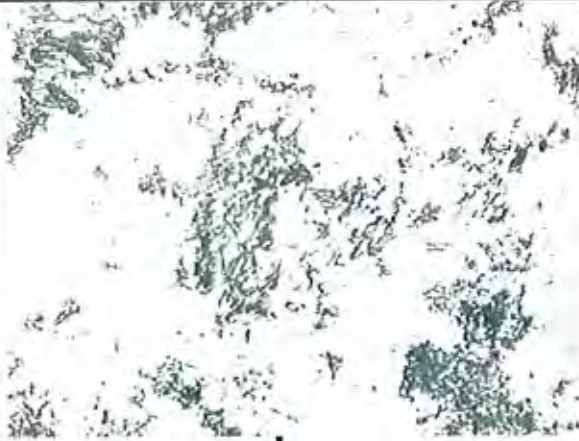
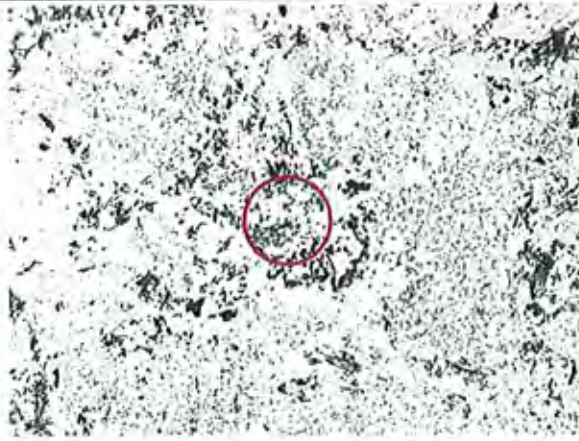




Refererence microstructure by TEM observation  
SA 213 T11 Fine grain HAZ

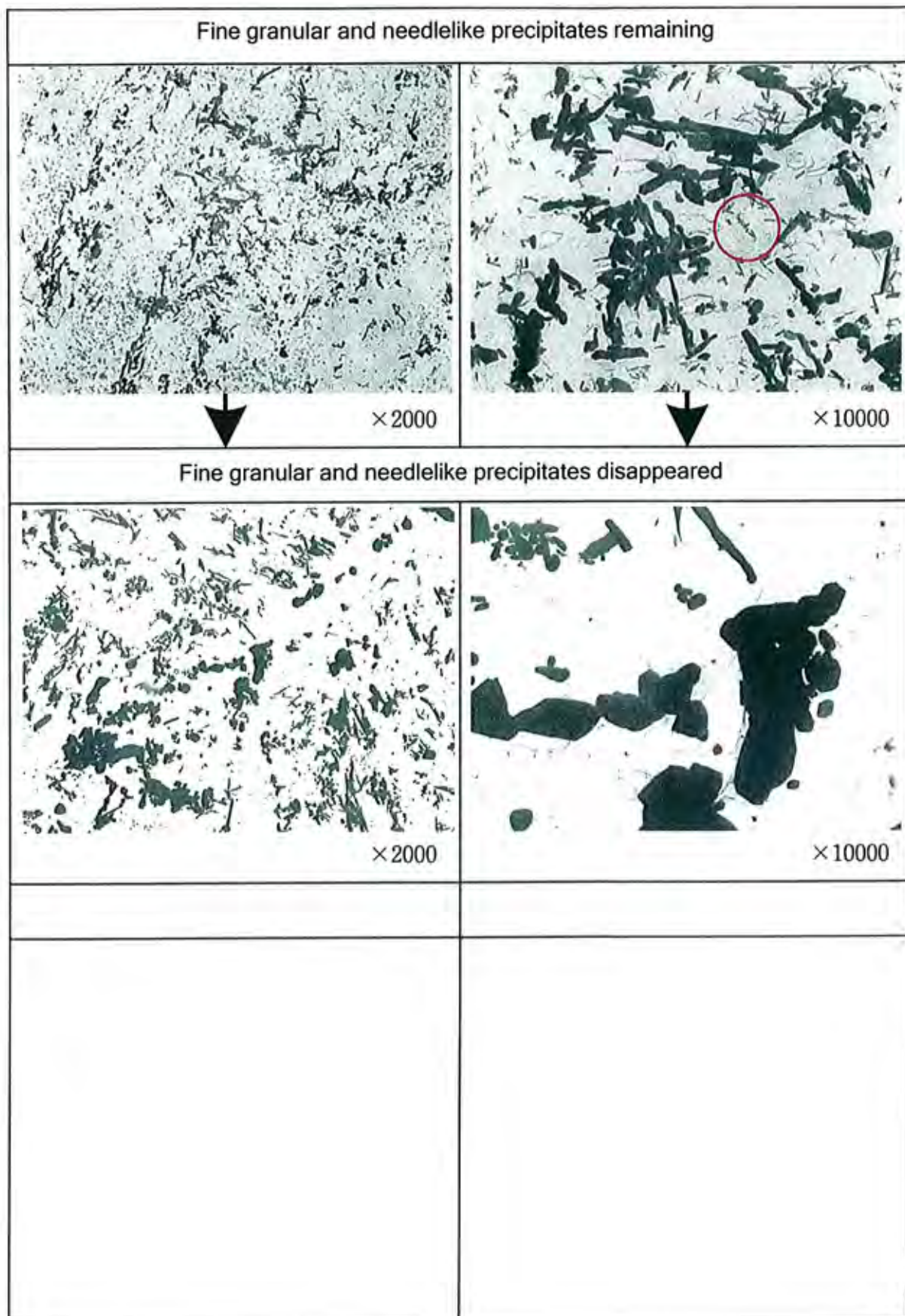


Refererence microstructure by TEM observation  
SA 213 T11 Fine grain HAZ

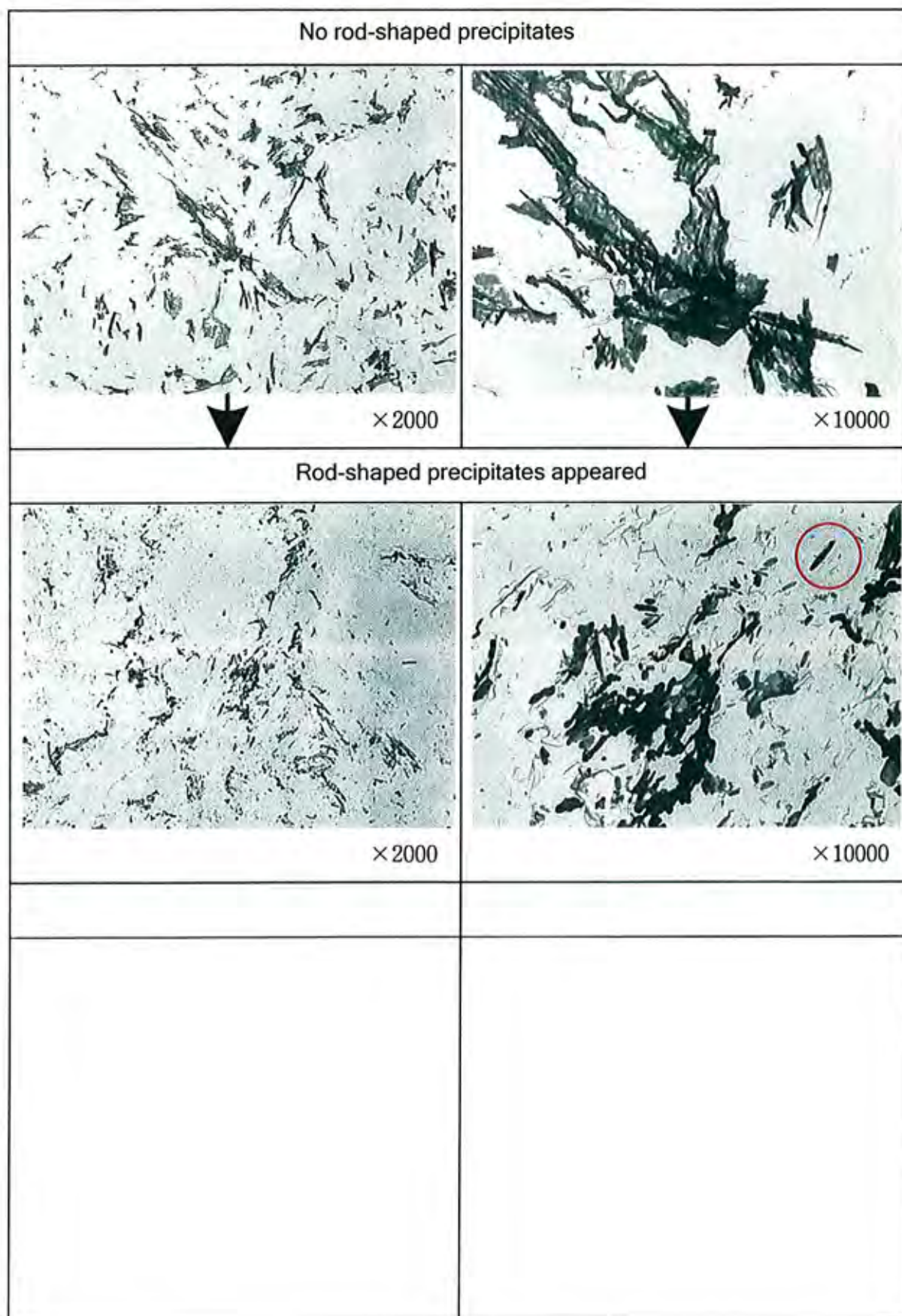
|  |  |
|--|--|
| Pearlite structure   |  |
|  <p>× 2000</p>  |  |
| Disintegration of pearlite structure   |  |
|  <p>× 2000</p> |  |
|  |  |
|  |  |



Referrence microstructure by TEM observation  
SA 213 T11 Coarse grain HAZ

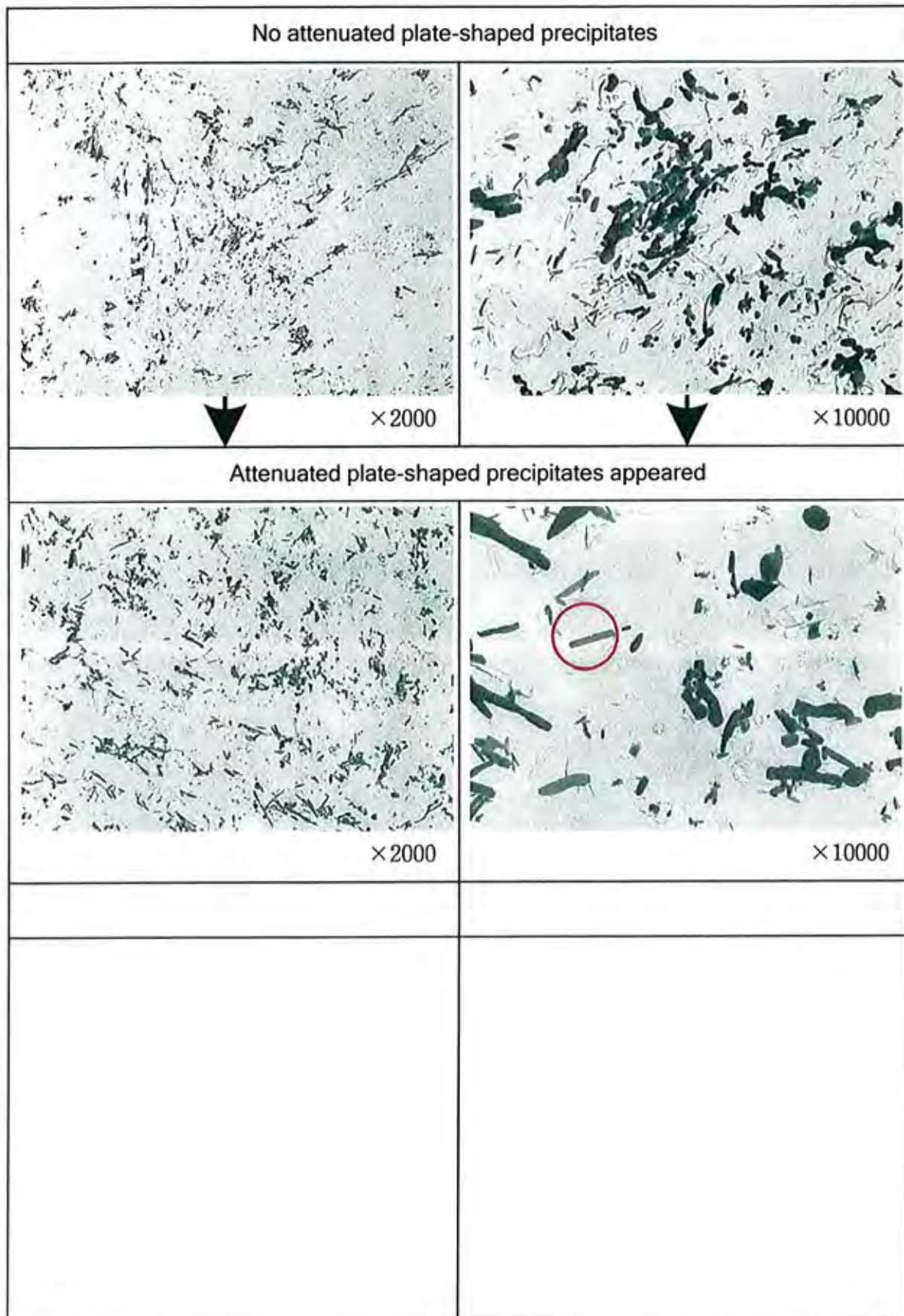


Refererence microstructure by TEM observation  
SA 213 T11 Coarse grain HAZ

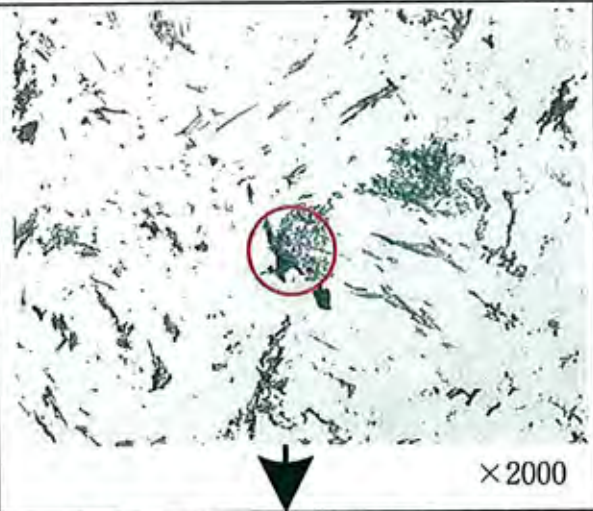
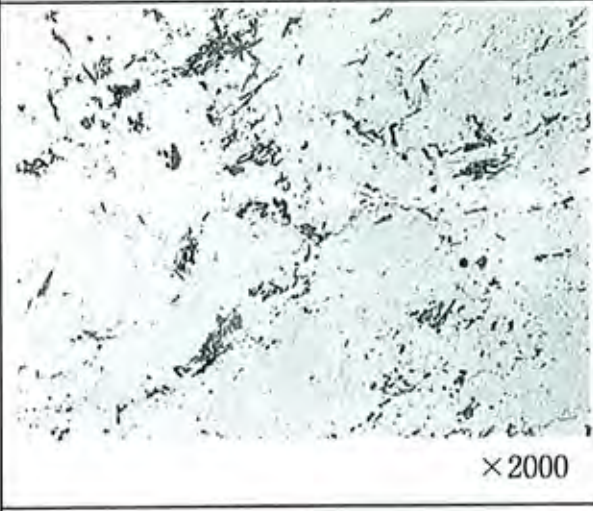




Refererence microstructure by TEM observation  
SA 213 T11 Coarse grain HAZ

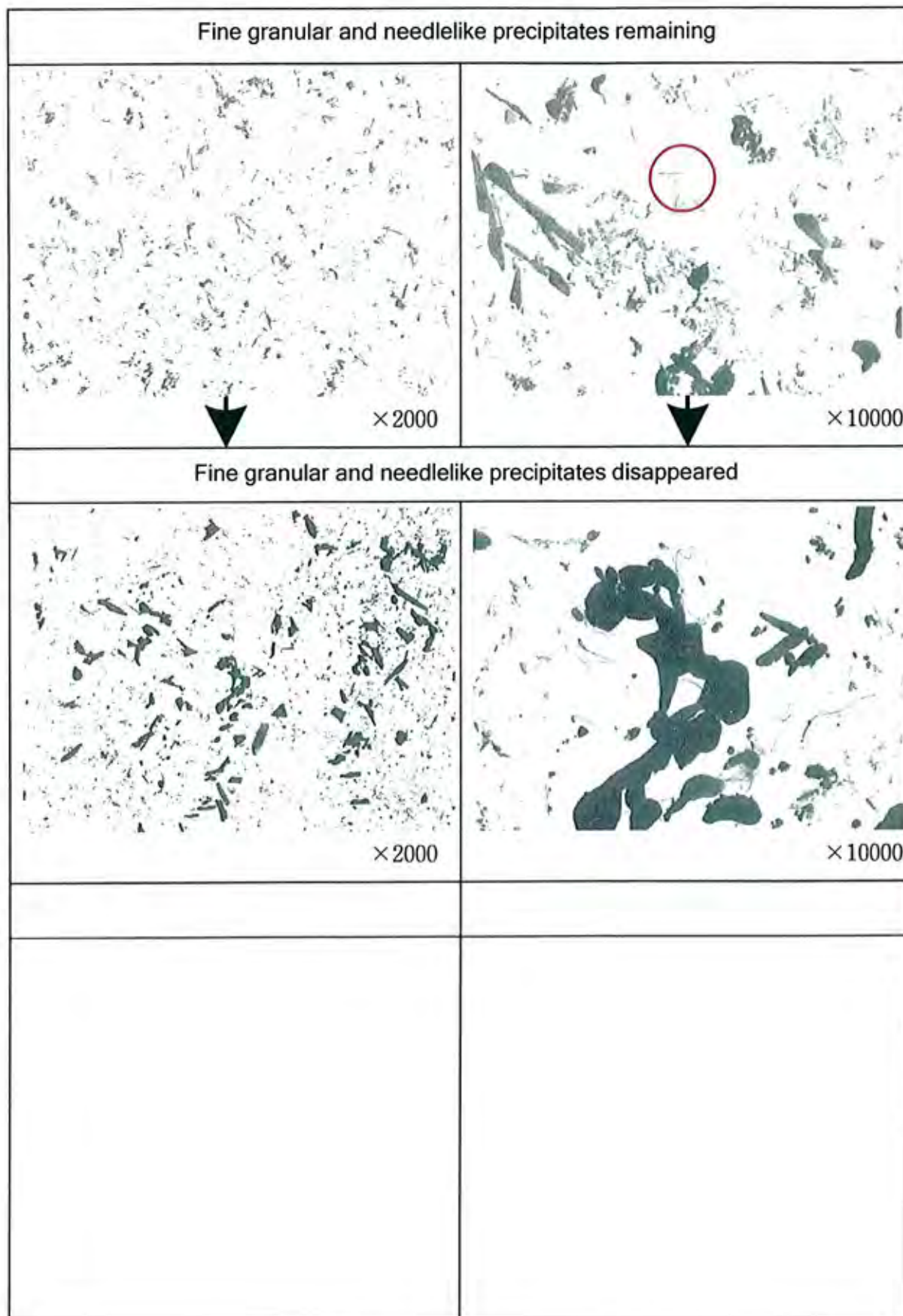


Refererence microstructure by TEM observation  
SA 213 T11 Coarse grain HAZ

|   |  |
|---|--|
| Normal agglomerated precipitates structure  |  |
|  <p>×2000</p>  |  |
| Agglomerated precipitates structure disintegrated   |  |
|  <p>×2000</p> |  |
|   |  |
|   |  |



Refererence microstructure by TEM observation  
SA 213 T11 Weld metal

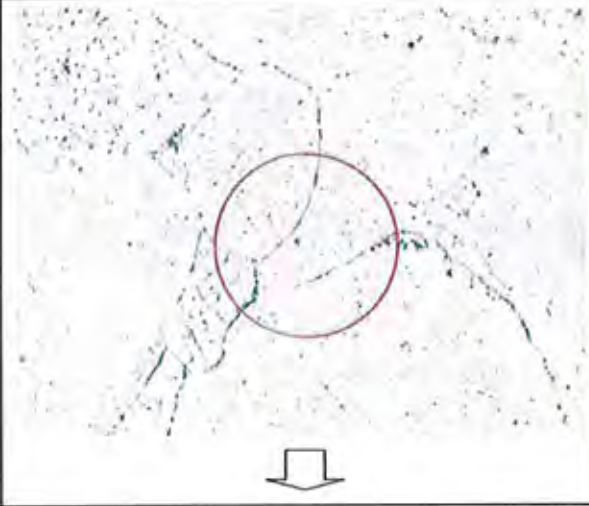
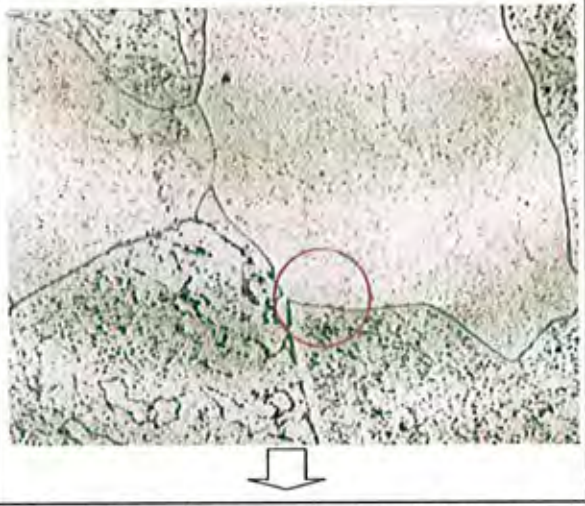
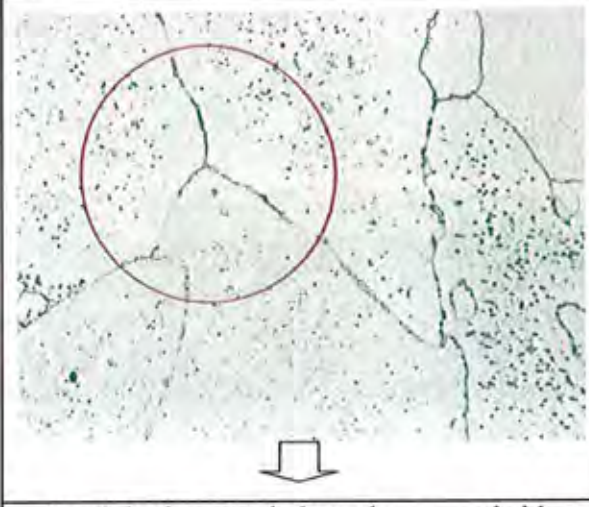
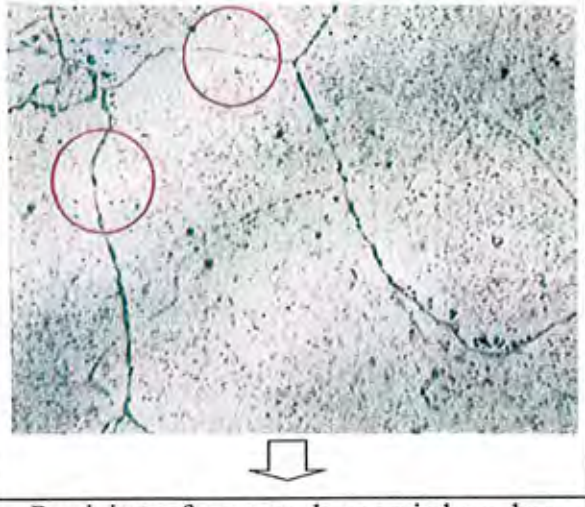




Reference Picture  
of Microstructural Comparison Method  
for Pipe



Reference microstructure by Optical microscope observation 1-1  
SA 335 P22 Base Metal



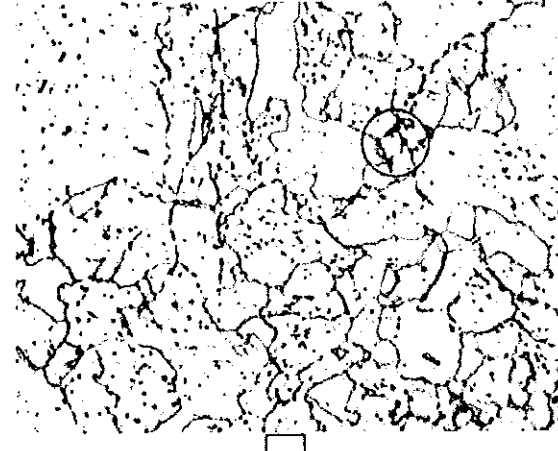
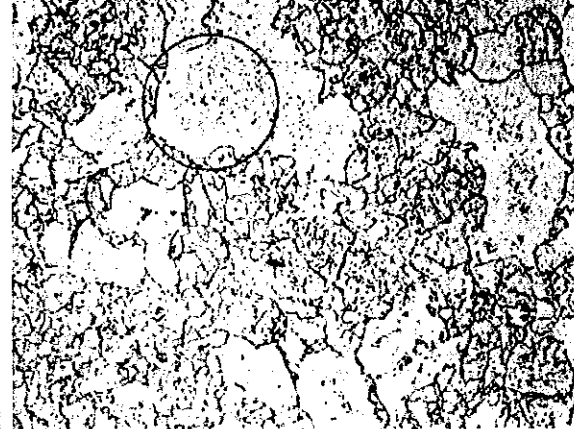

×1000

| No precipitates at grain boundary   | No precipitates free zone along grain boundary                                       |
|---|--|
|    |    |
| Precipitates at gain boundary appeared  | Precipitates free zone along grain boundary appeared                                 |
|   |   |
| Precipitation at gain boundary remarkably appeared                                  | Precipitates free zone along grain boundary remarkably appeared                      |
|  |  |

Reference microstructure by Optical microscope observation 1-2  
SA 335 P22 Intercritical zone (for reference)

×1000






×400

| No precipitates at grain boundary   | No precipitates free zone along grain boundary                                      |
|---|---|
|    |   |
| Precipitates at gain boundary appeared  | Precipitates free zone along grain boundary appeared                                |
|   |  |
| Precipitation at gain boundary remarkably appeared                                  |   |
|  |   |



Reference microstructure by Optical microscope observation 1-3  
SA 335 P22 Fine grain HAZ









×1000

|   |  |
|---|--|
| No precipitates at grain boundary   |  |
| <br>    |  |
| Precipitates at gain boundary appeared  |  |
| <br> |  |
| Precipitation at gain boundary remarkably appeared  |  |
|    |  |

Reference microstructure by Optical microscope observation 1-4  
SA 335 P22 Coarse grain HAZ

×1000

×400

|   |   |
|---|---|
| <p>No precipitates at grain boundary</p>            | <p>Normal bainite lath structure</p>   |
| <p>Precipitates at grain boundary appeared</p>   | <p>Bainite lath disappeared</p>    |
| <p>Precipitation at grain boundary remarkably appeared</p>   |   |



Reference microstructure by Optical microscope observation 2-1  
SA 335 P12 Base Metal

Rod-shaped precipitates in ferrite grain slightly appeared

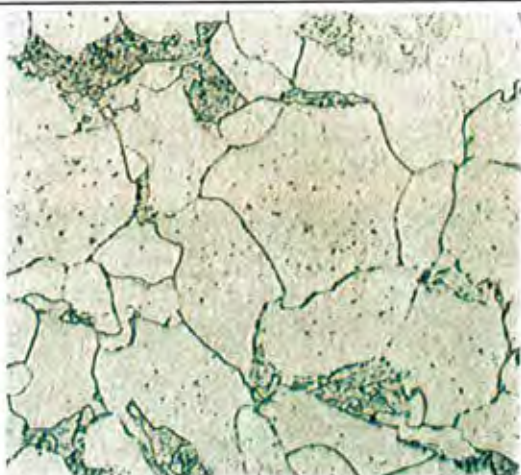


× 4 0 0



× 1 0 0 0

Rod-shaped precipitates in ferrite grain remarkably appeared

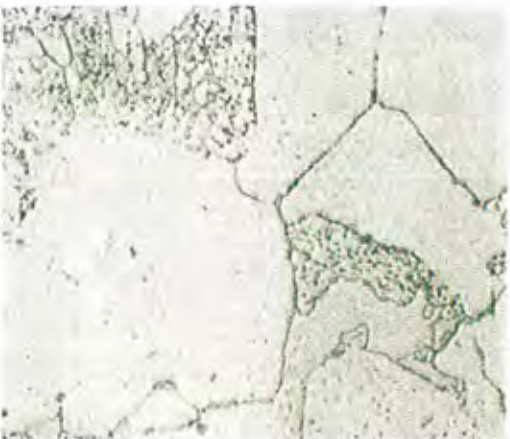
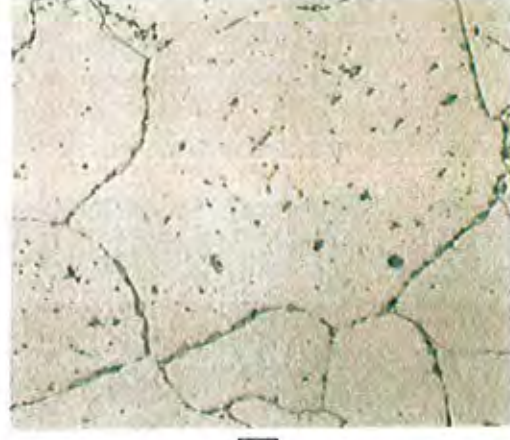
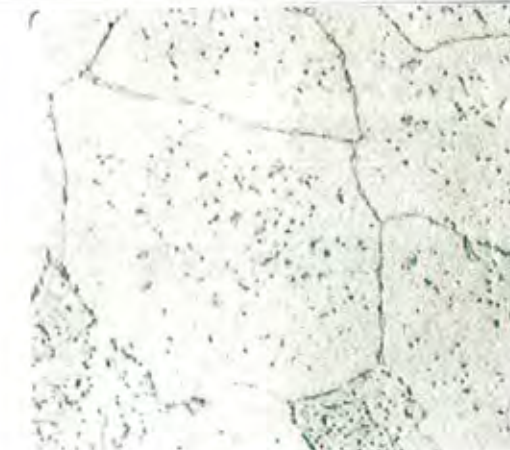



× 4 0 0



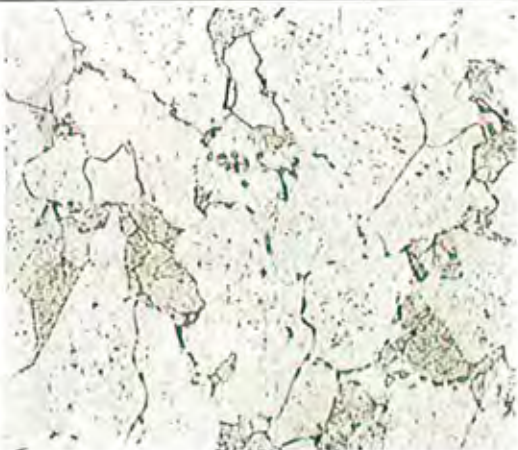

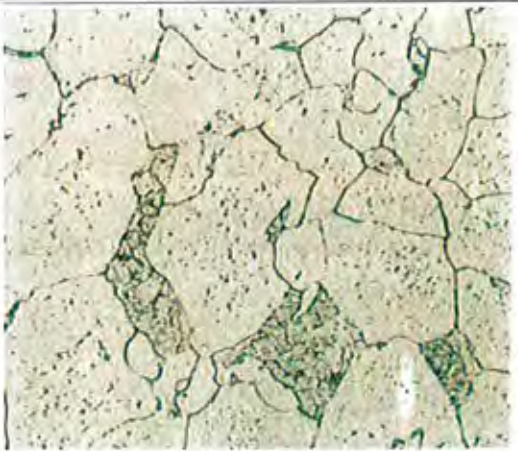

× 1 0 0 0

Reference microstructure by Optical microscope observation 2-2  
SA 335 P12 Base Metal

|   |  |
|---|--|
| A little precipitates at gain boundary  |  |
|  <p style="text-align: right;">× 1 0 0 0</p>   |  |
| Precipitates at gain boundary remarkably appeared   |  |
|  <p style="text-align: right;">× 1 0 0 0</p>  |  |
| Precipitates at gain boundary remarkably appeared   | Coarsened precipitates at gain boundary  |
|  <p style="text-align: right;">× 1 0 0 0</p> |  <p style="text-align: right;">× 1 0 0 0</p> |



Reference microstructure by Optical microscope observation 2-3  
SA 335 P12 Base Metal

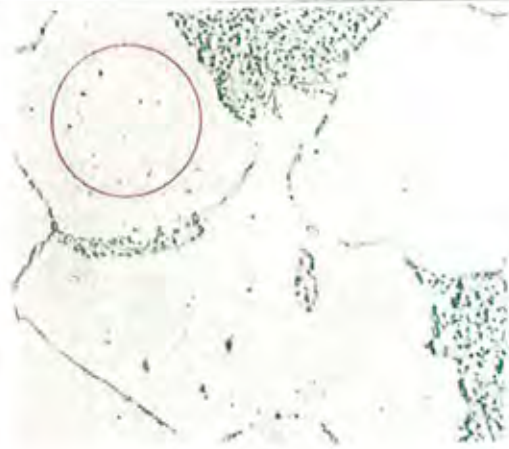
| No precipitates free zone along grain boundary  |  |
|---|--|
|  <p>↓ × 4 0 0</p>  |  <p>↓ × 1 0 0 0</p>  |
| Precipitates free zone along grain boundary appeared  |  |
|  <p>↓ × 4 0 0</p> |  <p>↓ × 1 0 0 0</p> |
|   |  |
|   |  |

Reference microstructure by Optical microscope observation 2-4  
SA 335 P12 Base Metal

A little granular precipitates in ferrite grain

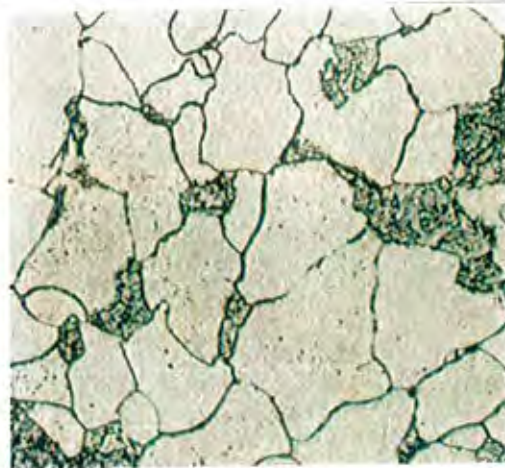


× 4 0 0



× 1 0 0 0

Granular precipitates in ferrite grain remarkably appeared



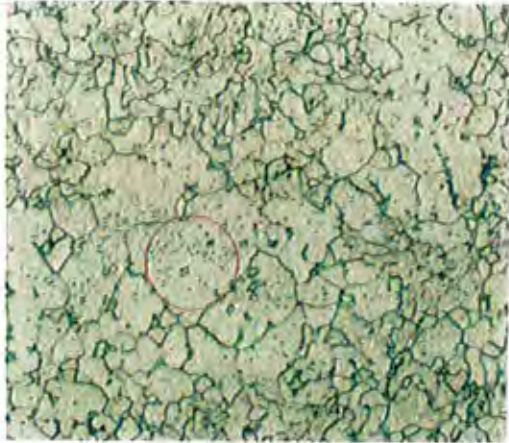
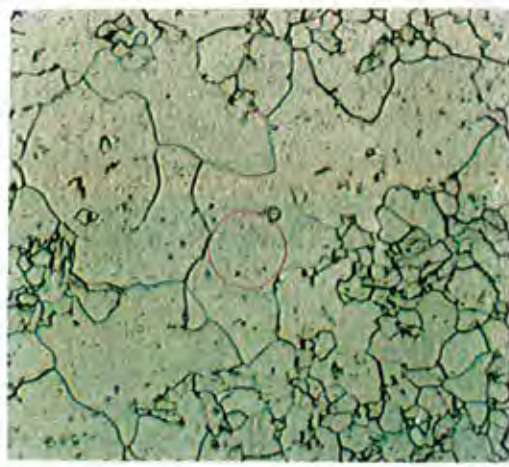
× 4 0 0





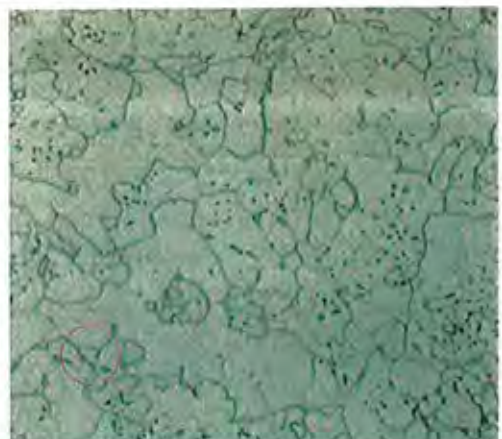
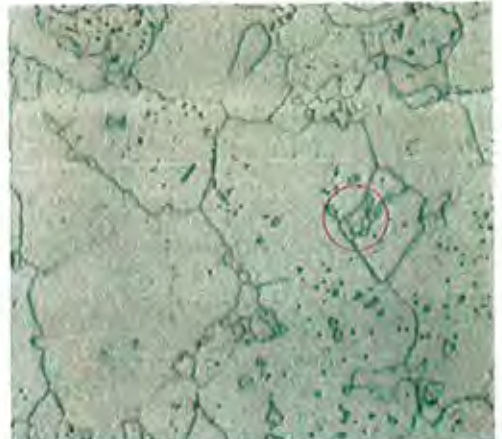
× 1 0 0 0



Reference microstructure by Optical microscope observation 2-5  
SA 335 P12 Intercritical zone (for reference)

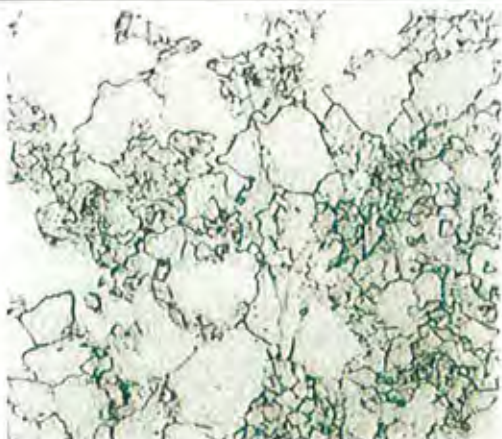
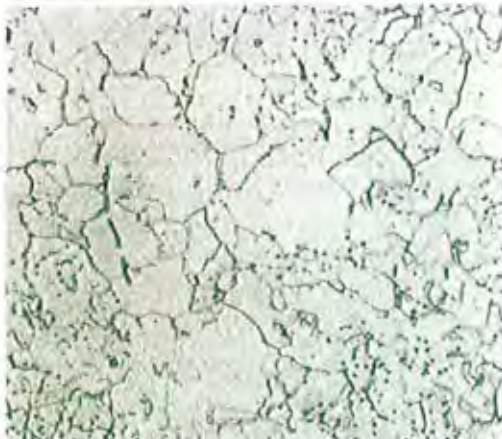


|  |  |
|--|--|
| A little granular precipitates in ferrite grain<br>(gray color area)   |  |
|  <p style="text-align: right;">× 400</p>  |  |
| Granular precipitates in ferrite grain<br>disappeared  |  |
|  <p style="text-align: right;">× 400</p> |  |
|  |  |
|  |  |

Reference microstructure by Optical microscope observation 2-6  
SA 335 P12 Intercritical zone (for reference), Fine grain HAZ

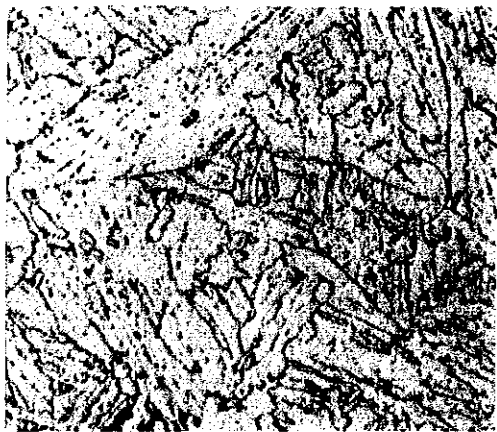

|  |  |
|--|--|
| No precipitates at grain boundary  |  |
|  <p style="text-align: center;">↓ × 1000</p>  |  |
| Precipitates at gain boundary remarkably appeared  |  |
|  <p style="text-align: center;">↓ × 1000</p> |  |
| Precipitates at gain boundary  | Coarsened precipitates at gain boundary  |
|  <p style="text-align: center;">× 1000</p>  |  <p style="text-align: center;">× 1000</p> |



Reference microstructure by Optical microscope observation 2-7  
SA 335 P12 Intercritical zone (for reference), Fine grain HAZ


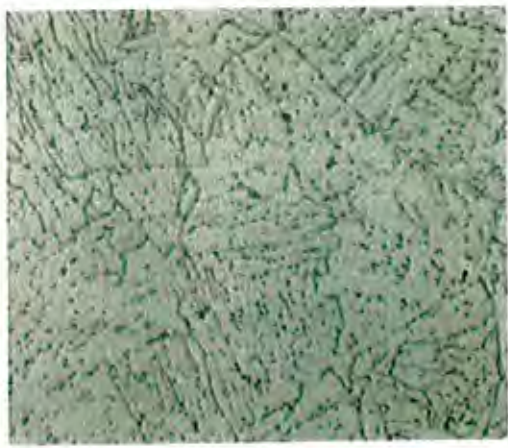
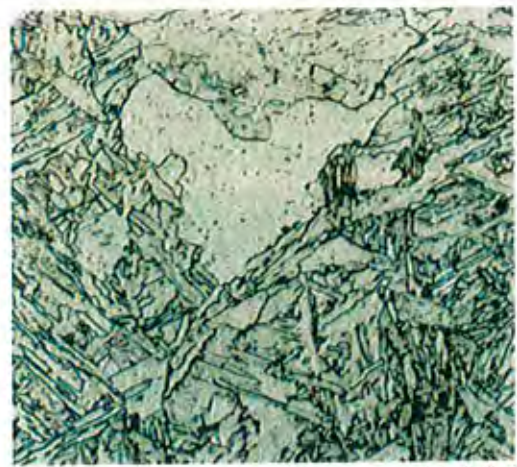
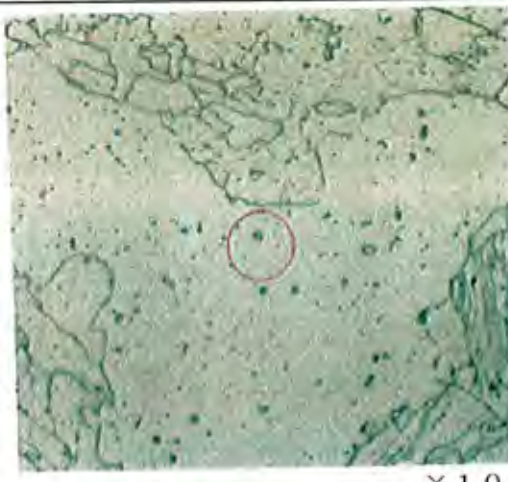
| Coarse granular precipitates   |   |
|--|---|
|  <p>↓ × 4 0 0</p> |  <p>↓ × 1 0 0 0</p> |
| Coarse granular precipitates appeared  |   |
|  <p>× 4 0 0</p>  |  <p>× 1 0 0 0</p>  |
|  |   |
|  |   |

Referrence microstructure by Optical microscope observation 2-8  
SA 335 P12 Coarse grain HAZ

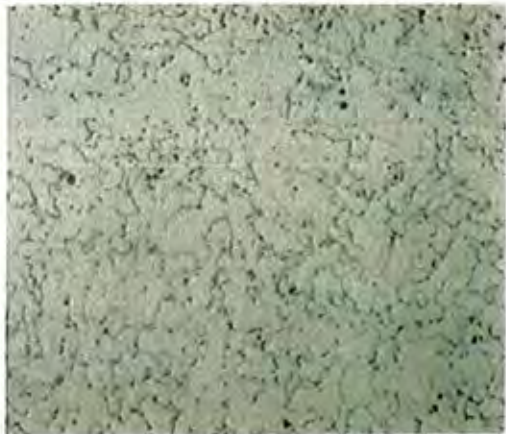

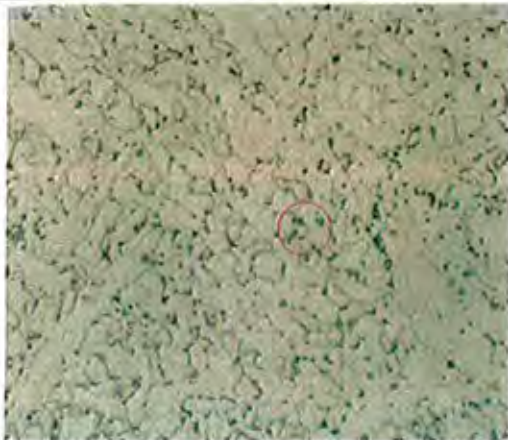

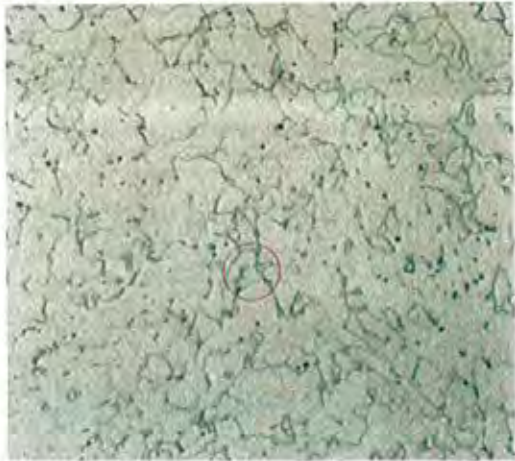
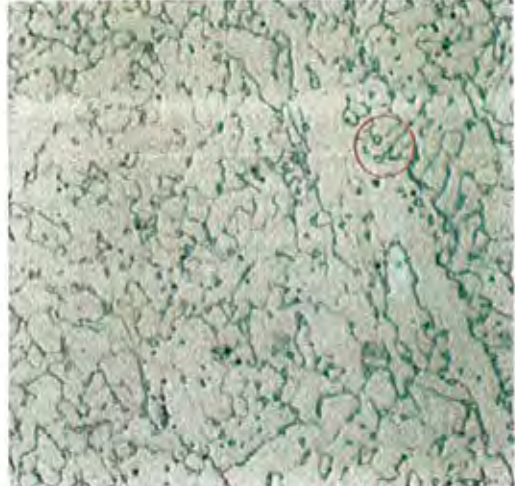
|  |  |
|--|--|
| No precipitates at grain boundary  |  |
|  <p>↓ × 1 0 0 0</p> |  |
| Precipitates at gain boundary remarkably appeared  |  |
|                    |  |
|  |  |
|  |  |



Reference microstructure by Optical microscope observation 2-9  
SA 335 P12 Coarse grain HAZ

| No coarse granular precipitates  |   |
|--|---|
|  <p>↓ × 4 0 0</p> |  <p>↓ × 1 0 0 0</p> |
| Coarse granular precipitates appeared  |   |
|  <p>× 4 0 0</p>  |  <p>× 1 0 0 0</p>  |
|  |   |
|  |   |


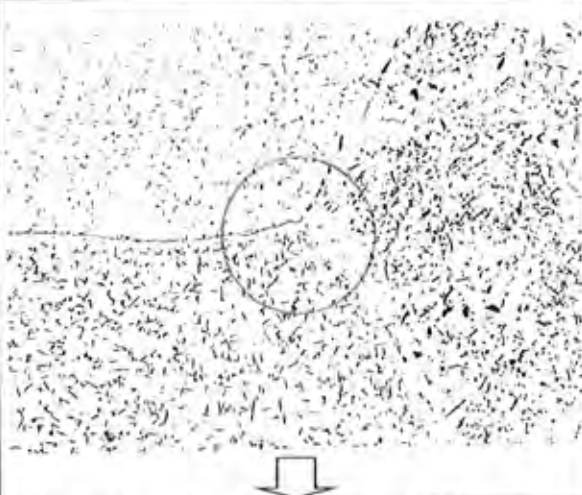
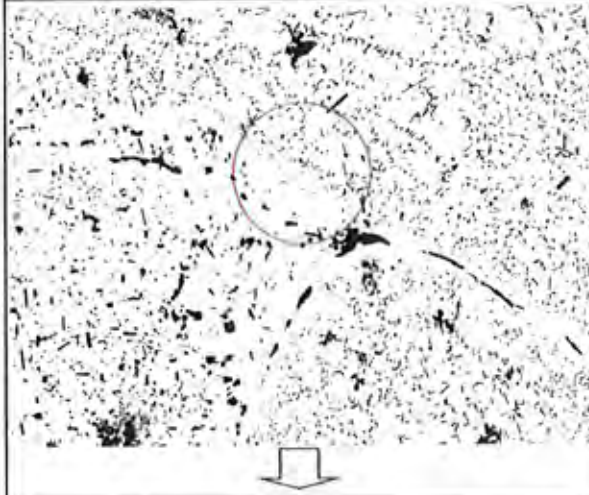
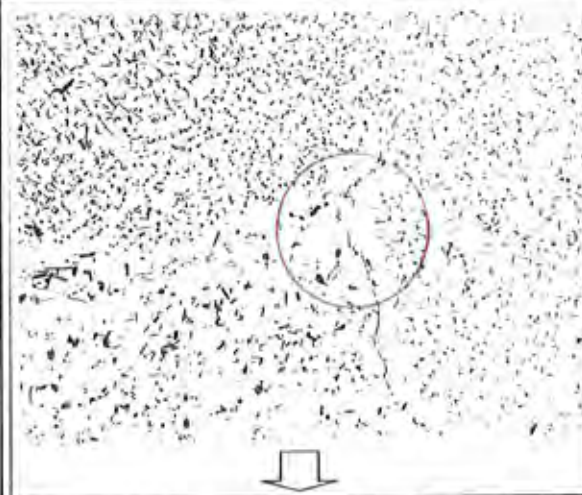

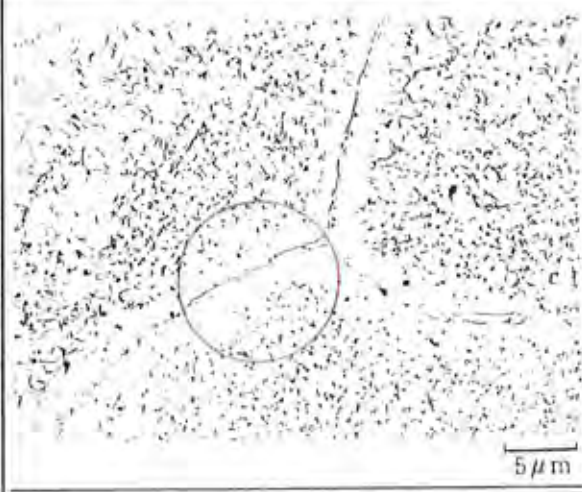
Reference microstructure by Optical microscope observation 2-10  
SA 335 P12 Weld metal

|  |  |
|--|--|
| No granular precipitates   |  |
|  <p style="text-align: center;">  <span style="margin-left: 100px;">× 1 0 0 0</span> </p>    |  |
| Granular precipitates appeared   |  |
|  <p style="text-align: center;">  <span style="margin-left: 100px;">× 1 0 0 0</span> </p> |  |
| Granular precipitates  | Coarse granular precipitates   |
|  <p style="text-align: center;"> <span style="margin-left: 100px;">× 1 0 0 0</span> </p>  |  |



Reference microstructure by TEM observation 3-1  
SA 335 P22 Base Metal

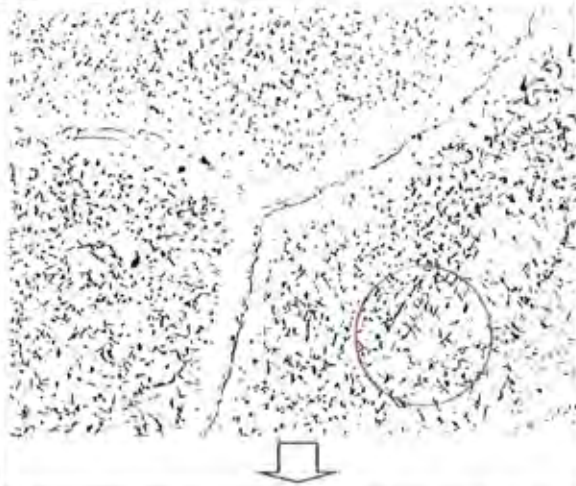


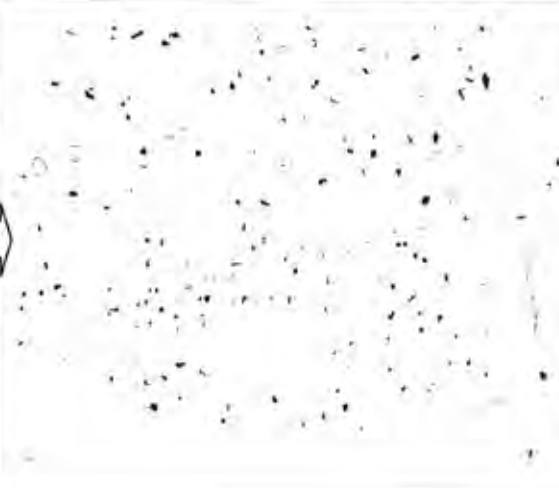
× 2000

| Featherlike precipitates  | No precipitates free zone along grain boundary                                       |
|---|--|
|    |    |
| Featherlike precipitates partially disappearing                                     | Precipitates free zone along grain boundary appearing                                |
|   |   |
| Featherlike precipitates isappeared   | Precipitates free zone along grain boundary remarkably appeared                      |
|  |  |

507

Reference microstructure by TEM observation 3-2  
SA 335 P22 Base Metal

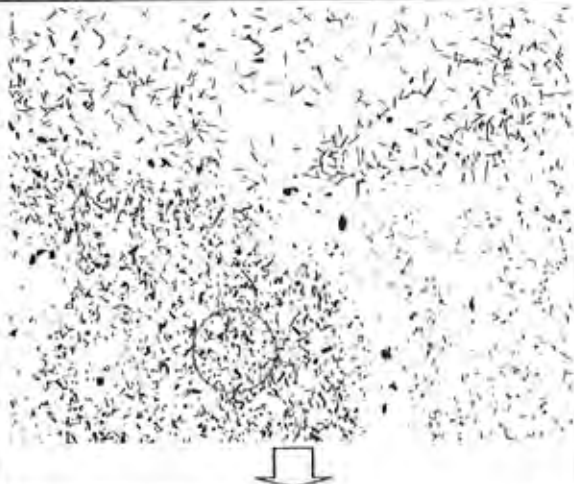
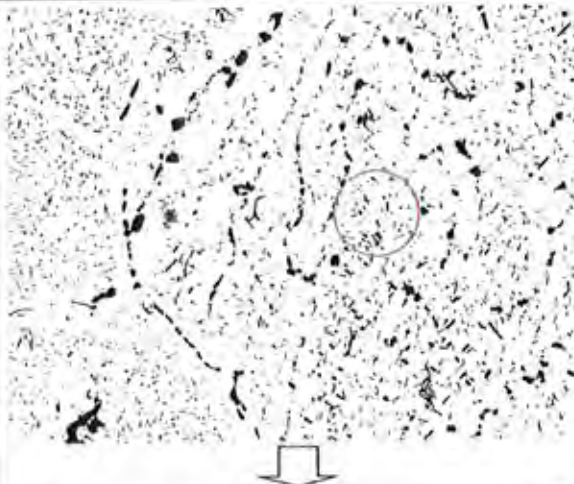

× 2000

|   |  |
|---|--|
| Needlelike precipitates in ferrite grain  |  |
|    |  |
| Decrease in needlelike precipitates in ferrite grain                                |  |
|   |  |
| Small granular precipitates in ferrite grain disappeared                            | Decrease in total number of precipitates   |
|  |  |



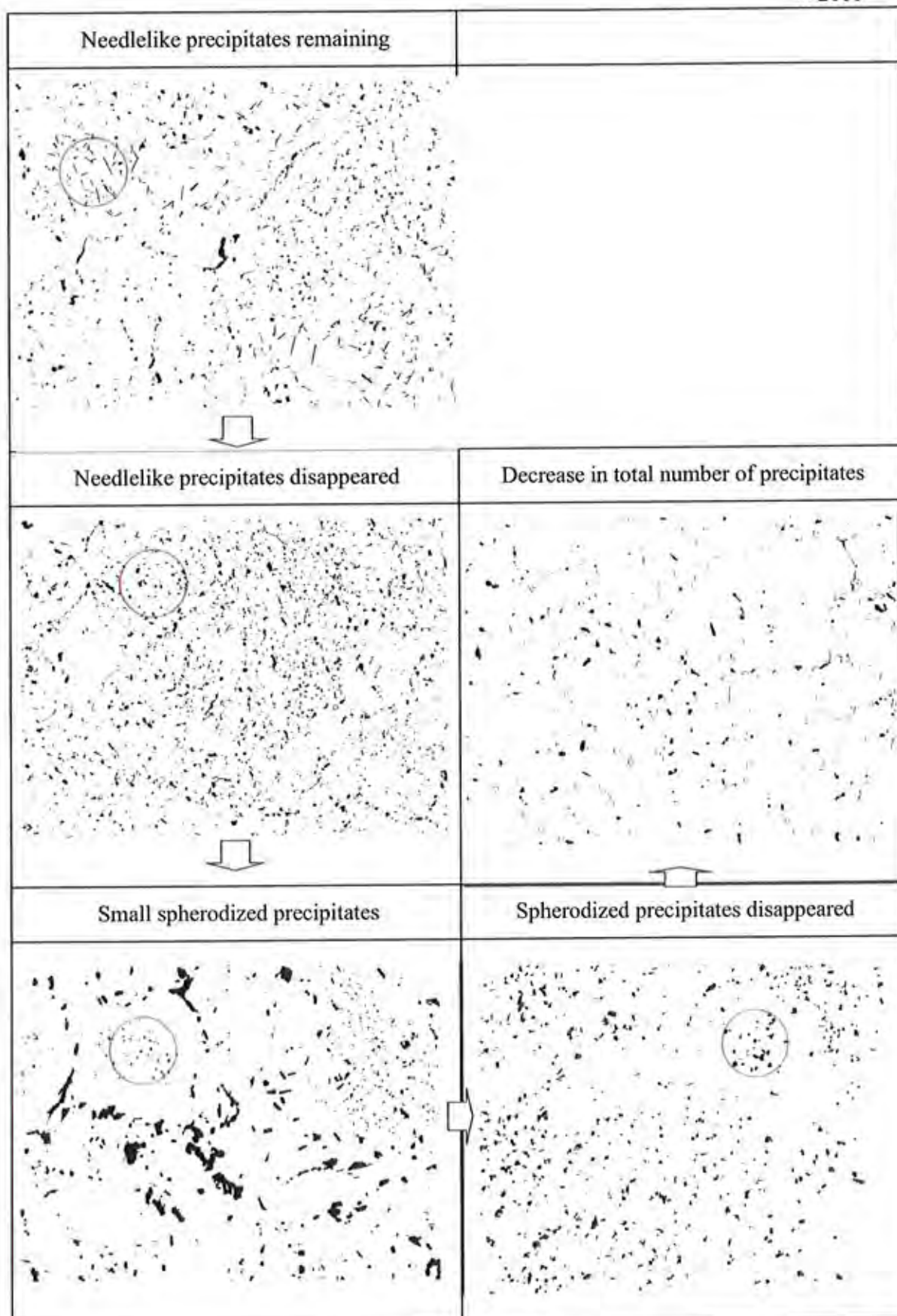
Reference microstructure by TEM observation 3-3  
SA 335 P22 Base Metal

×2000

|   |  |
|---|--|
| Fine needlelike precipitates in bainite grain                                       |  |
|    |  |
| Fine needlelike precipitates in bainite grain remaining                             |  |
|   |  |
| Fine needlelike precipitates in bainite grain disappeared                           |  |
|  |  |

Reference microstructure by TEM observation 3-4  
SA 335 P22 Fine grain HAZ

× 2000

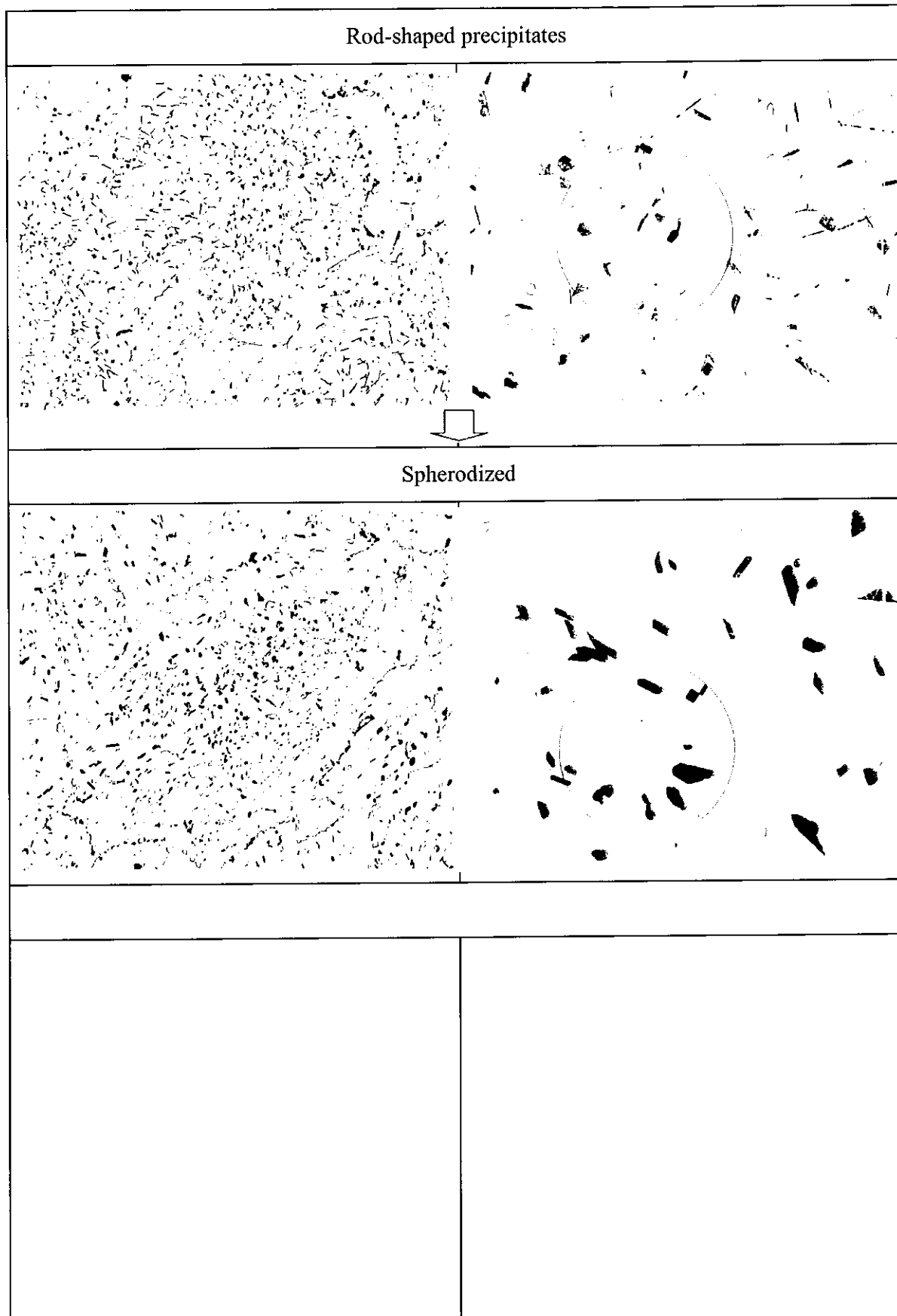




Referrence microstructure by TEM observation 3-5  
SA 335 P22 Fine grain HAZ

×2000

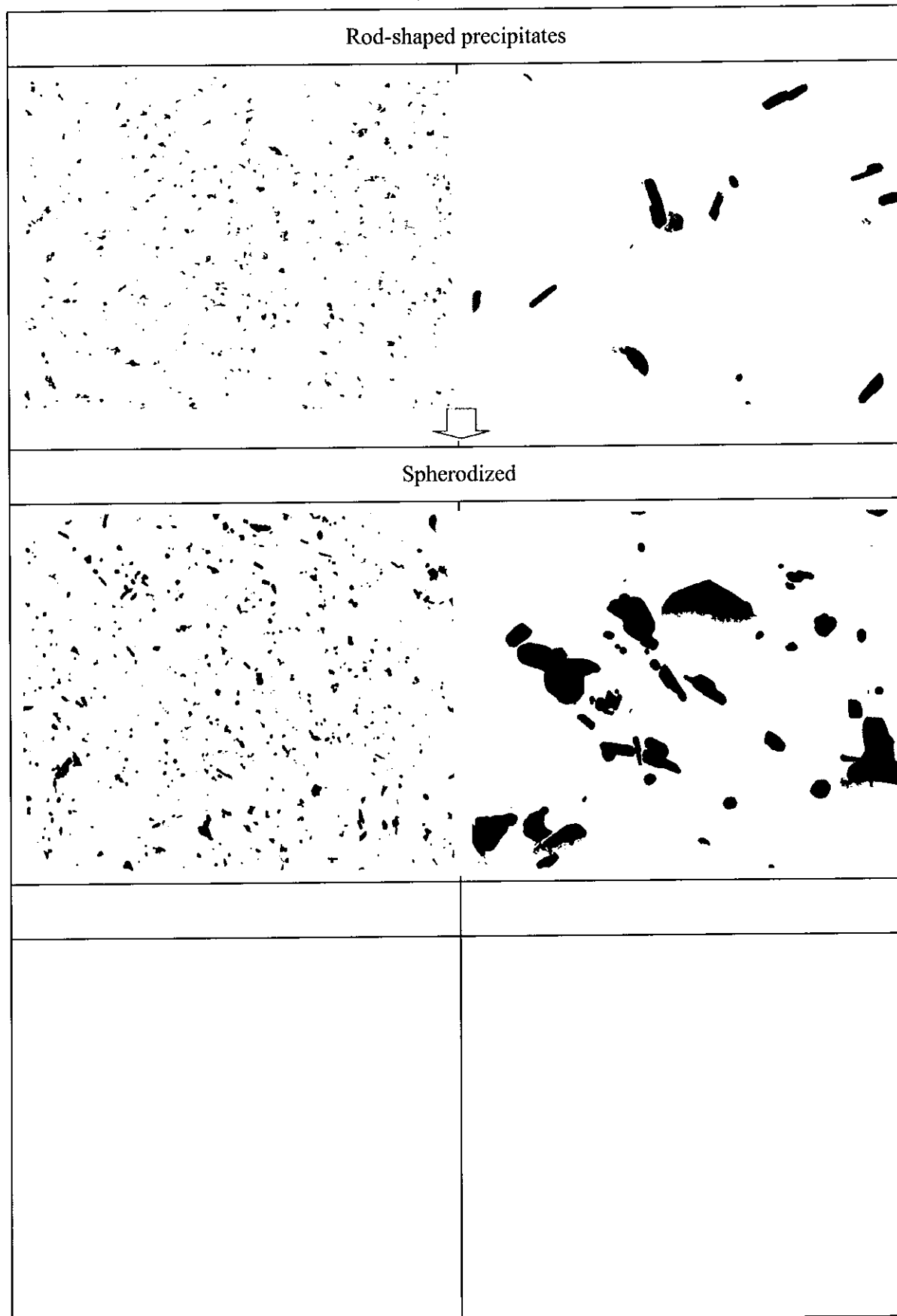
×10000



Refererence microstructure by TEM observation 3-6  
SA 335 P22 Coarse grain HAZ

×2000

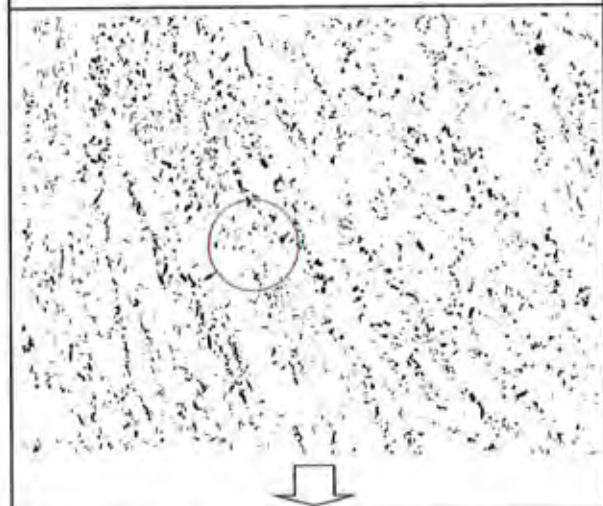
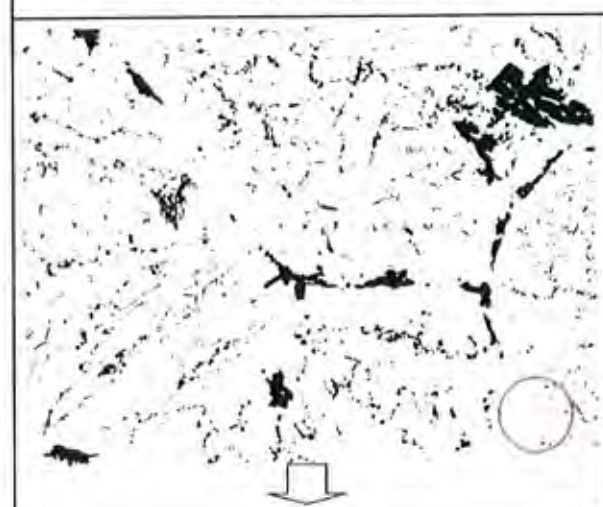
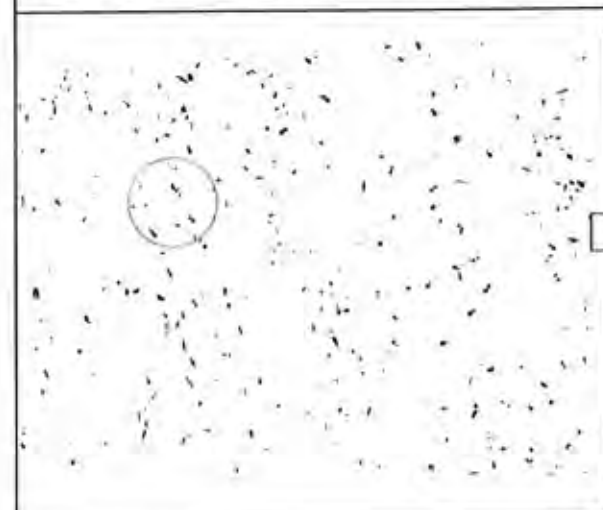

×10000






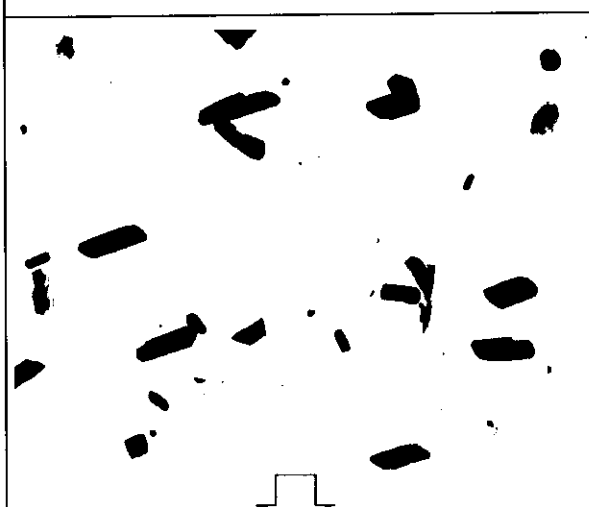
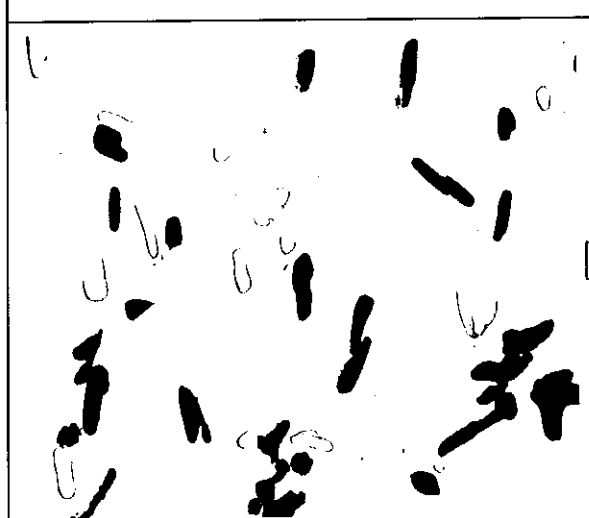
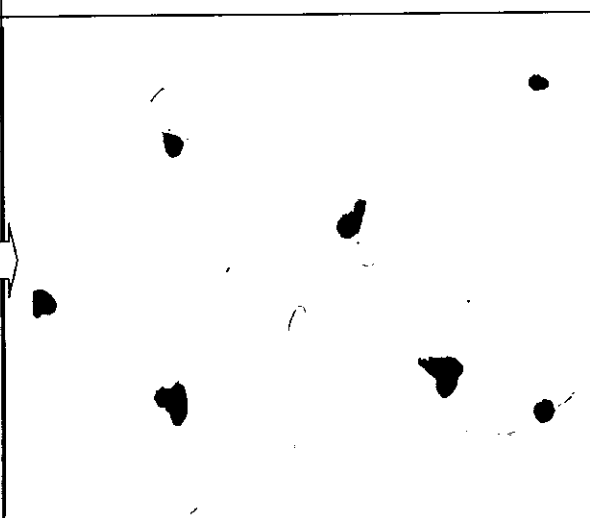
Reference microstructure by TEM observation 3-7  
SA 335 P22 Coarse grain HAZ, Weld metal

×2000

|   |  |
|---|--|
| Fine needlelike precipitates  |  |
|    |  |
| Fine needlelike precipitates remaining  |  |
|   |  |
| Fine needlelike precipitatesdisappeared   | Fine needlelike precipitatesdisappeared  |
|  |  |

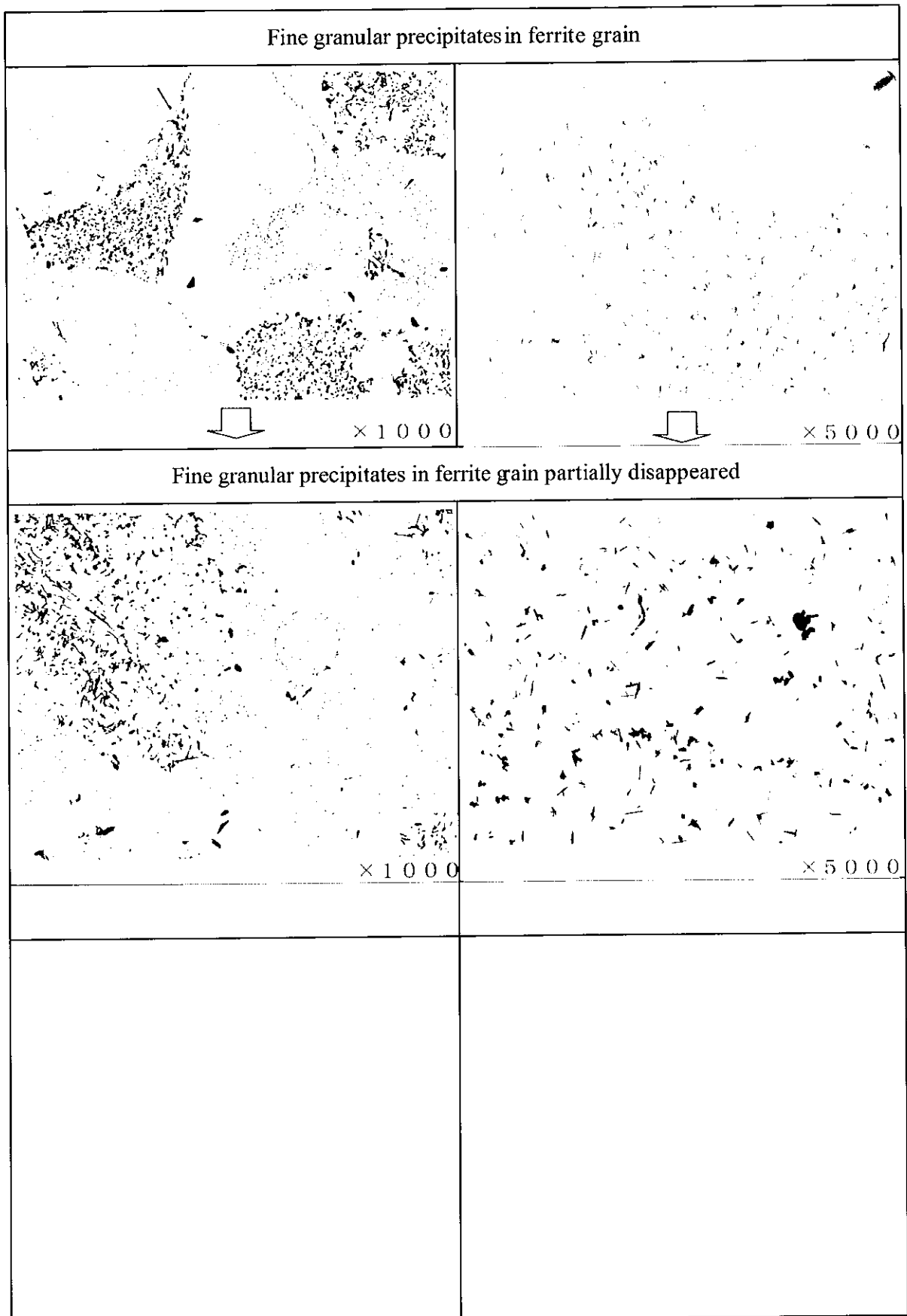
Reference microstructure by TEM observation 3-8  
SA 335 P22 Weld metal

×10000

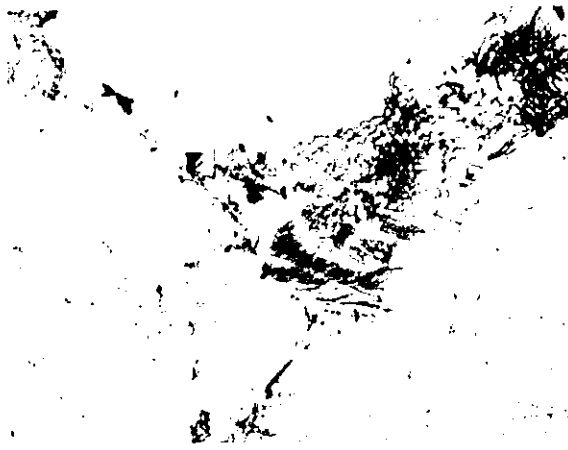
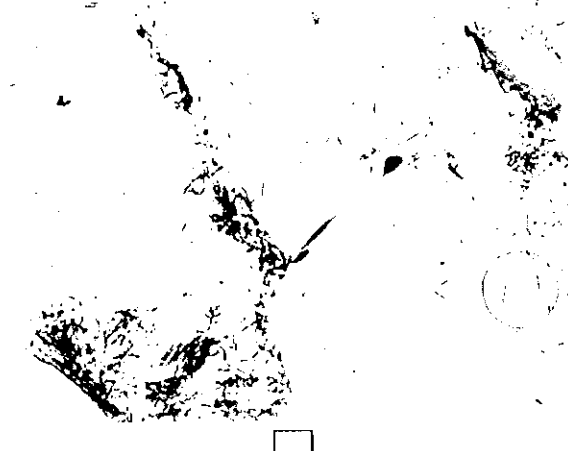
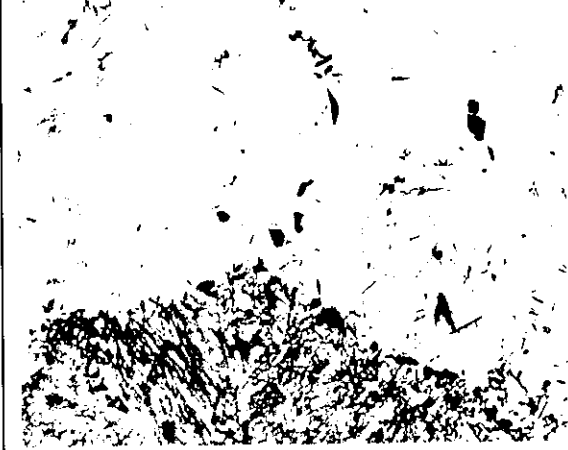
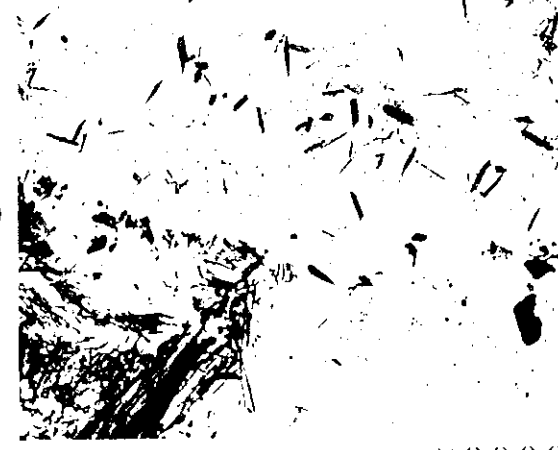
|   |  |
|---|--|
| Coarse granular precipitates  |  |
|    |  |
| Spherodizing  |  |
|   |  |
| Spherodized   | Decrease in number of precipitates   |
|  |  |



Referrence microstructure by TEM observation 4-1  
SA 335 P12 Base Metal

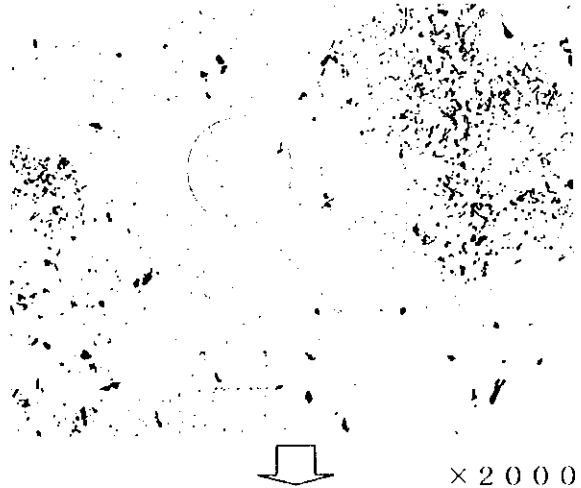
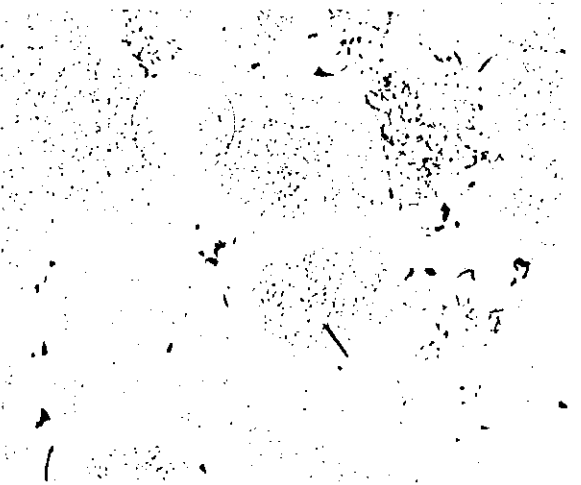


Reference microstructure by TEM observation 4-2  
SA 335 P12 Base Metal

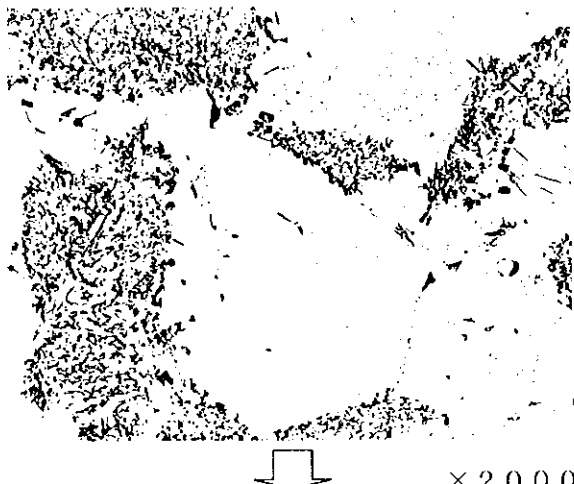
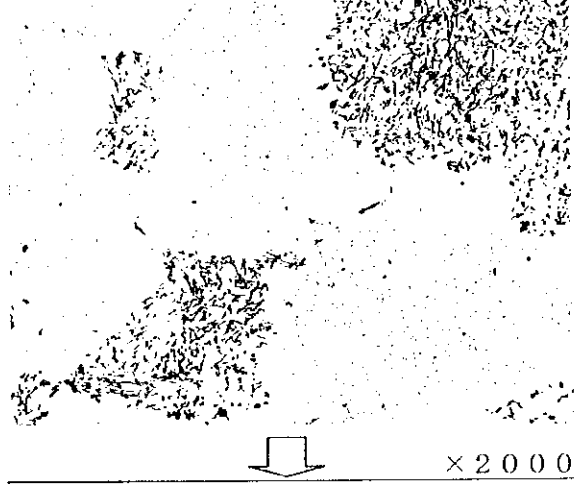
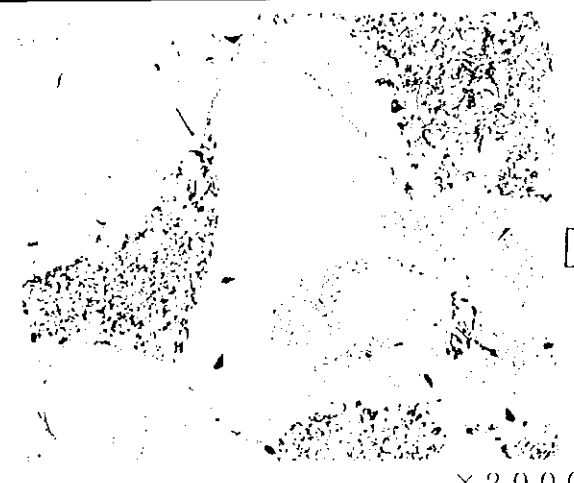
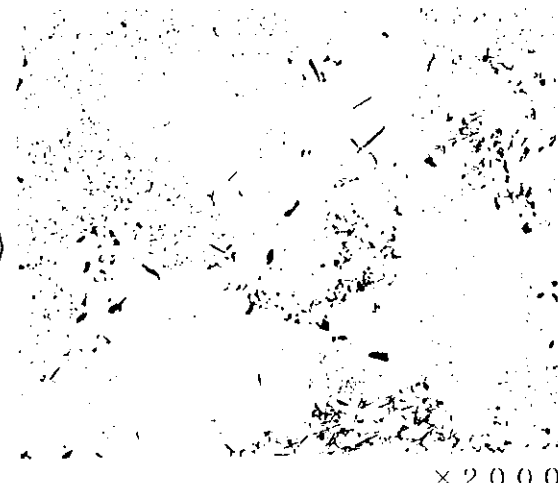
|  |   |
|--|---|
| No attenuated plate-shaped precipitates  |   |
|  <p>× 2 0 0 0</p>   |   |
| Attenuated plate-shaped precipitates appeared  |   |
|  <p>× 2 0 0 0</p>  |   |
| Attenuated plate-shaped precipitates   | Coarsened attenuated plate-shaped precipitates  |
|  <p>× 2 0 0 0</p> |  <p>× 2 0 0 0</p> |



Reference microstructure by TEM observation 4-3  
SA 335 P12 Base Metal

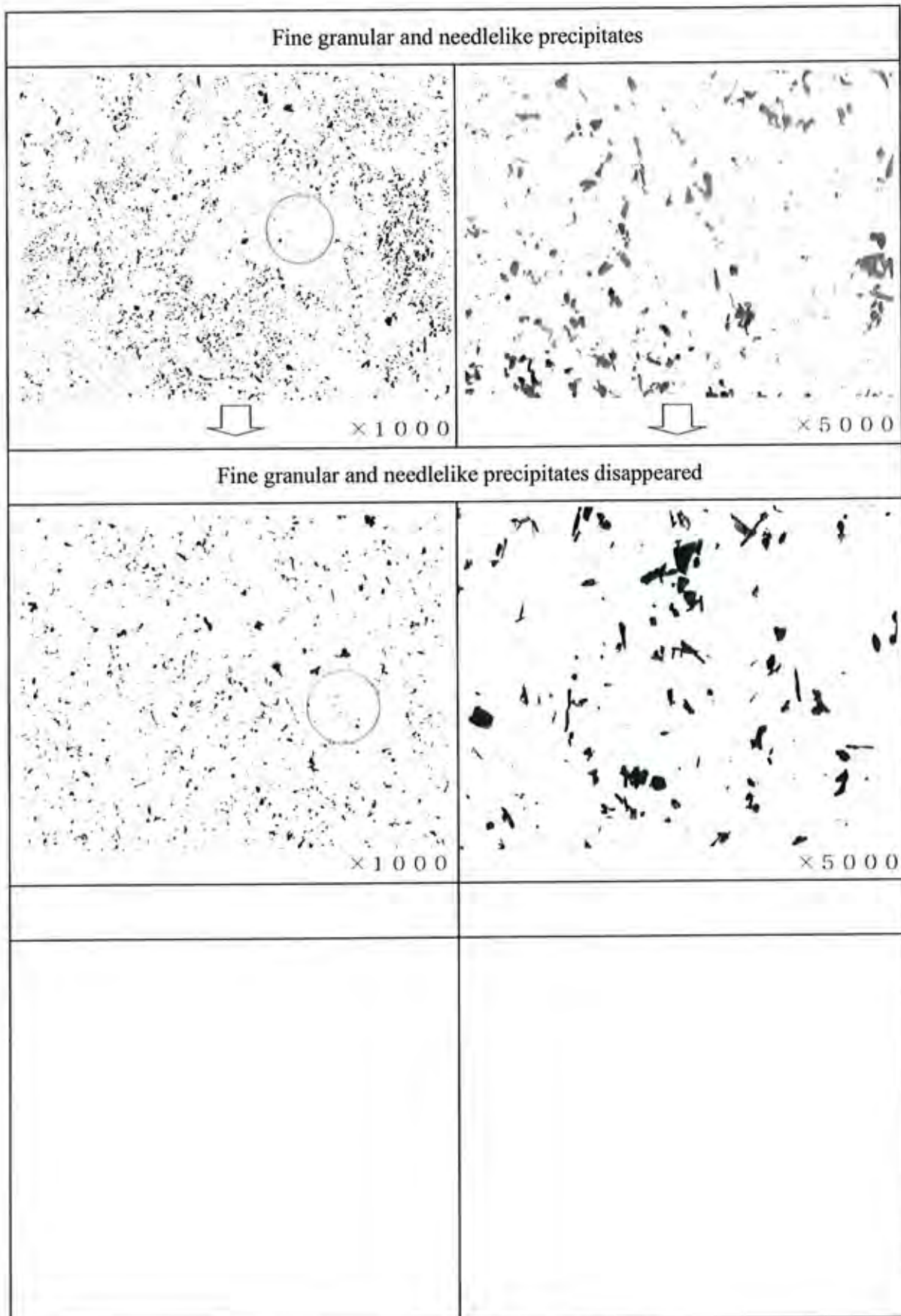
|  |  |
|--|--|
| No precipitates free zone along grain boundary   |  |
|  <p>× 2 0 0 0</p> |  |
| Precipitates free zone along grain boundary appeared   |  |
|                  |  |
|  |  |
|  |  |

Reference microstructure by TEM observation 4-4  
SA 335 P12 Base Metal

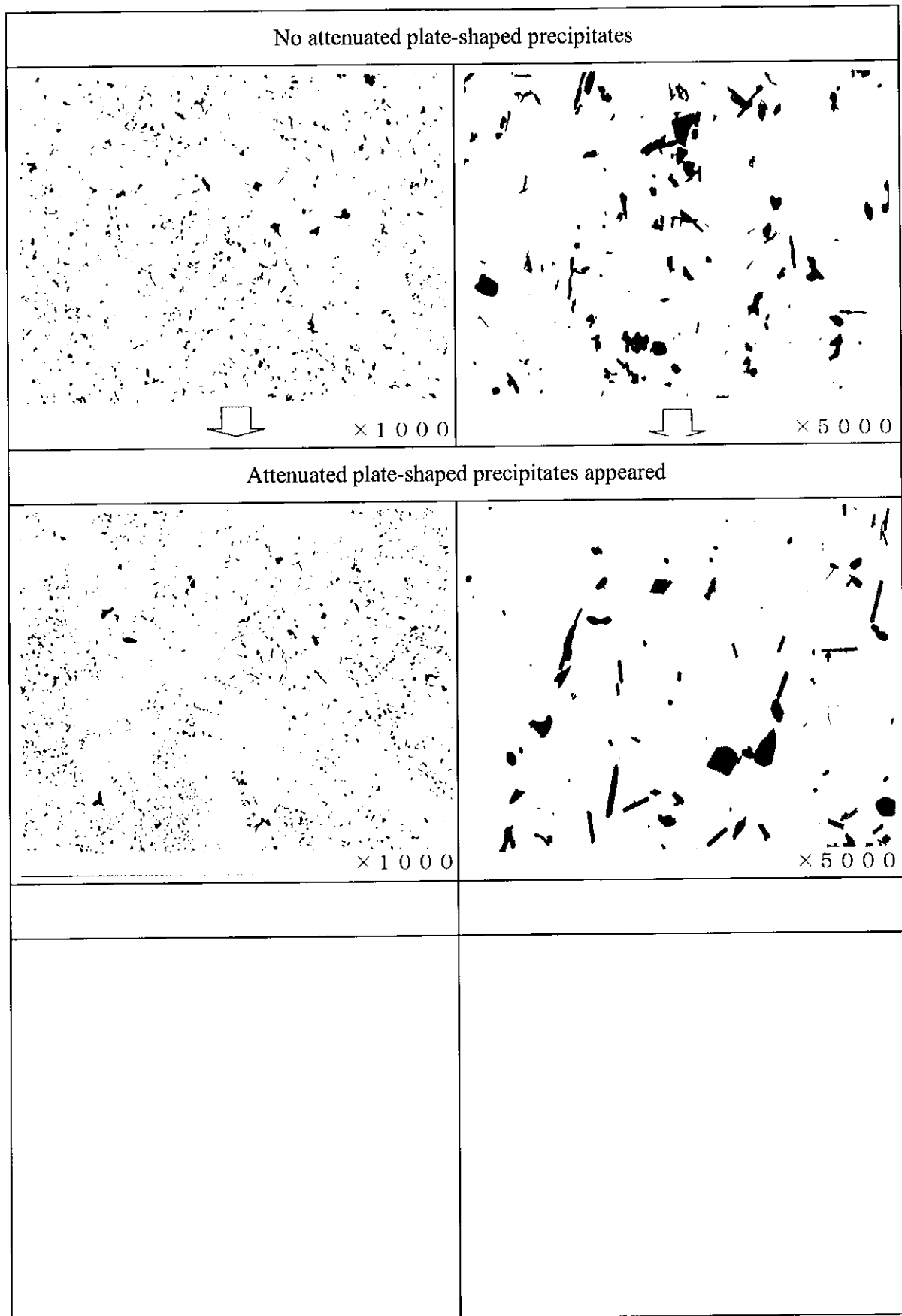
|  |   |
|--|---|
| Bainite structure  |   |
|  <p>× 2 0 0 0</p>   |   |
| Bainite structure disintegrating   |   |
|  <p>× 2 0 0 0</p>  |   |
| Bainite structure disintegrating   | Bainite structure remarkably disintegrated  |
|  <p>× 2 0 0 0</p> |  <p>× 2 0 0 0</p> |



Referrence microstructure by TEM observation 4-5  
SA 335 P12 Fine grain HAZ

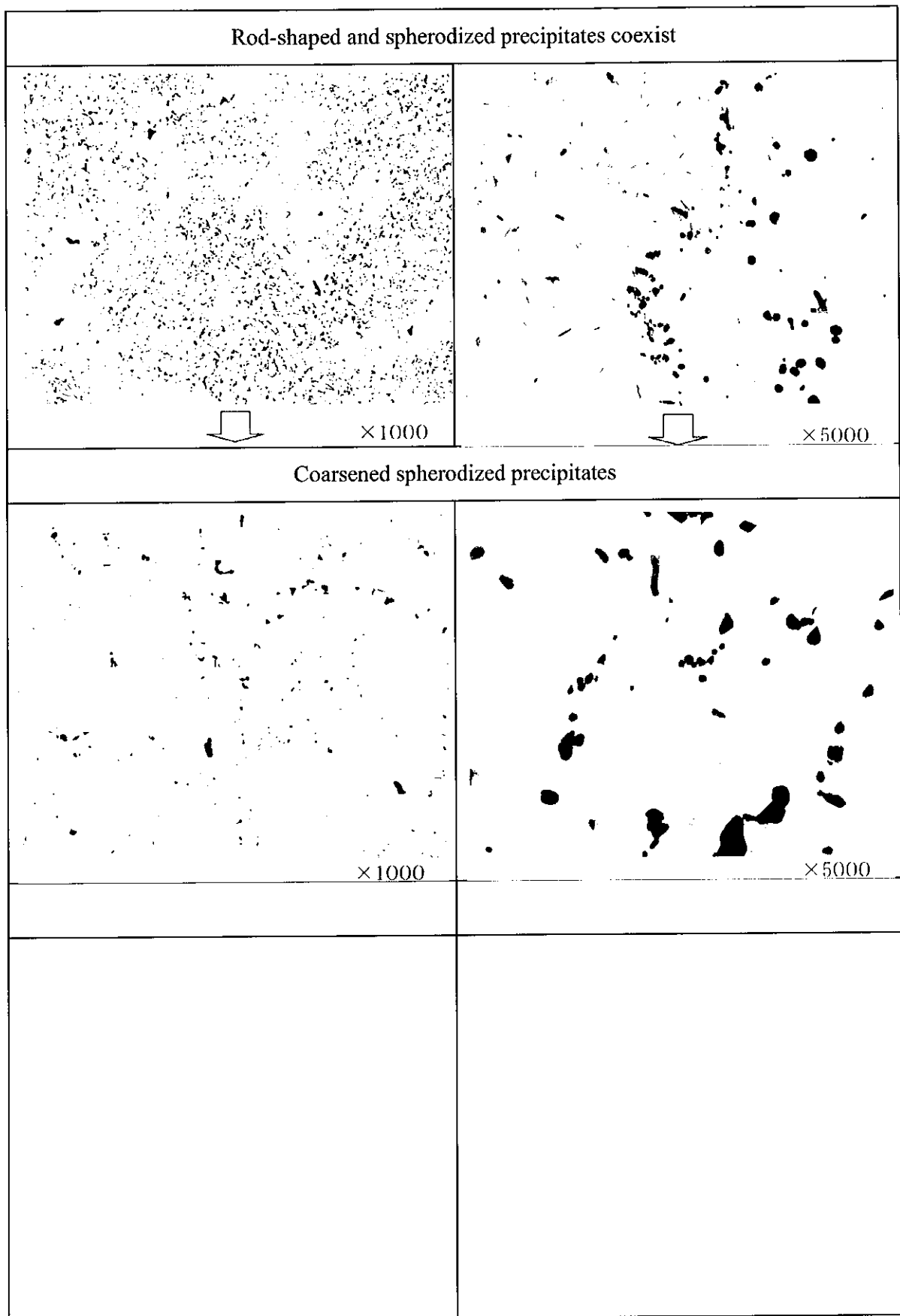


Reference microstructure by TEM observation 4-6  
SA 335 P12 Fine grain HAZ

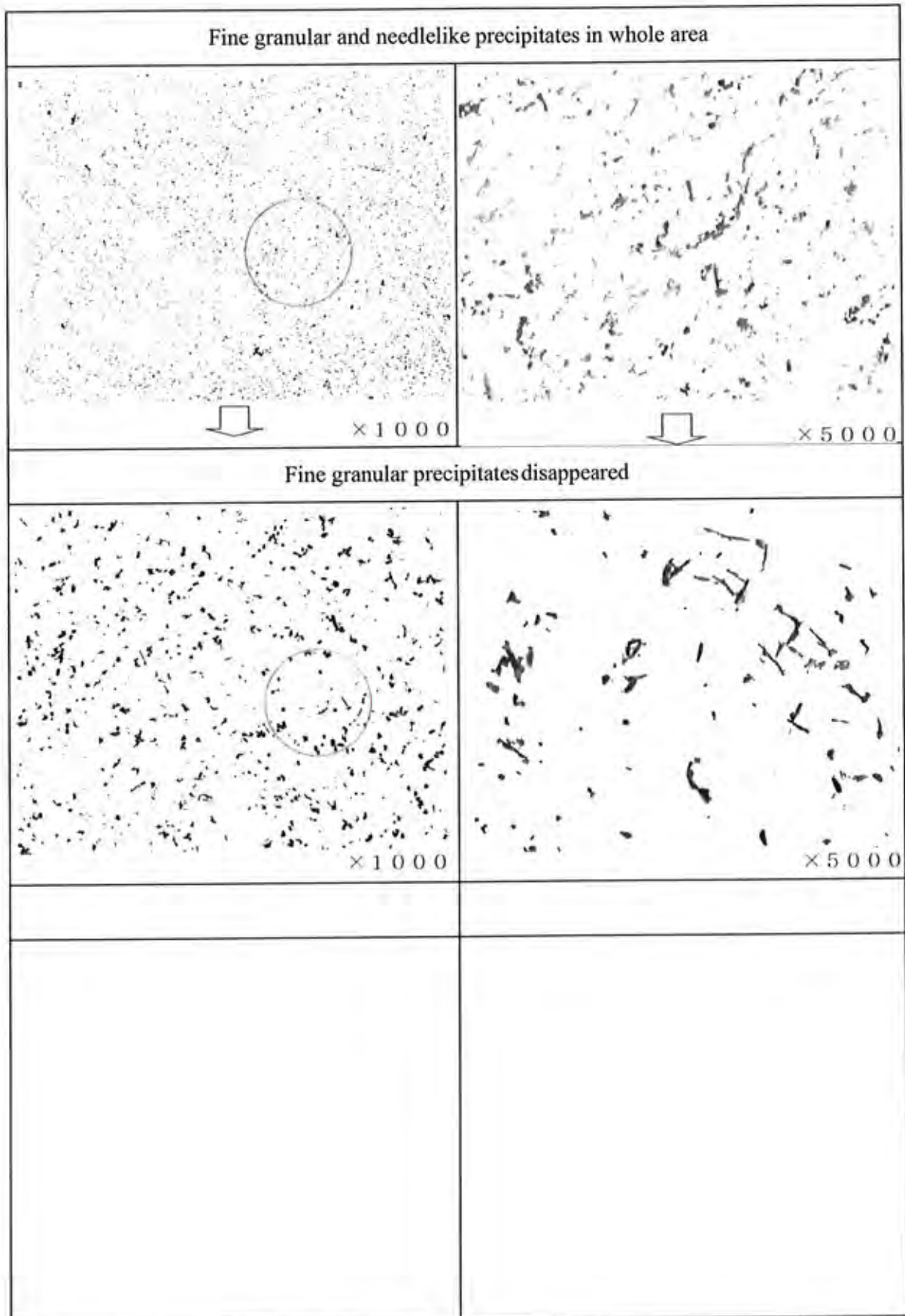




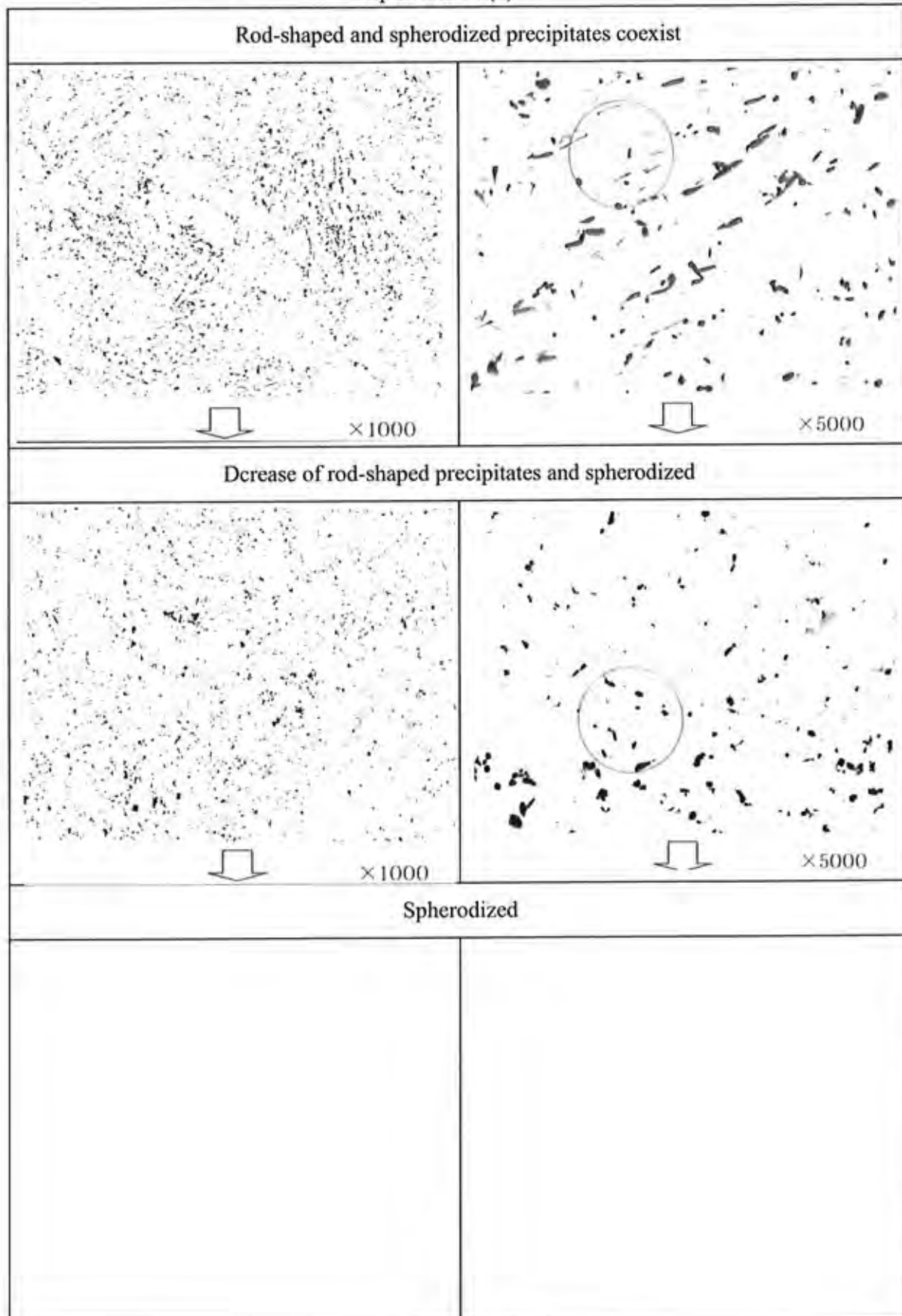
Reference microstructure by TEM observation 4-7  
SA 335 P12 Fine grain HAZ



Refererence microstructure by TEM observation 4-8  
SA 335 P12 Coarse grain HAZ

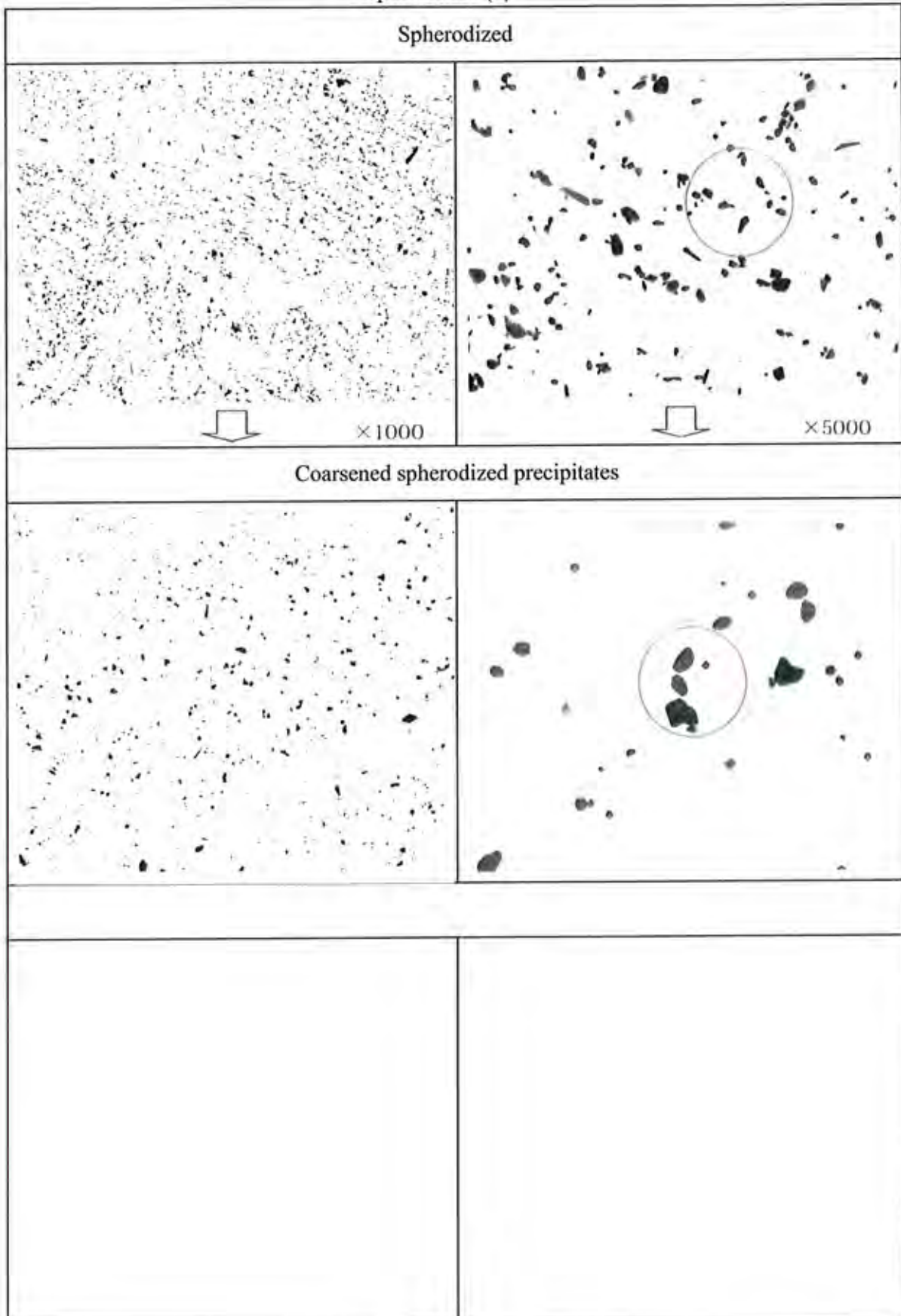


Reference microstructure by TEM observation 4-9  
 SA 335 P12 Coarse grain HAZ  
 Spherodized (1)

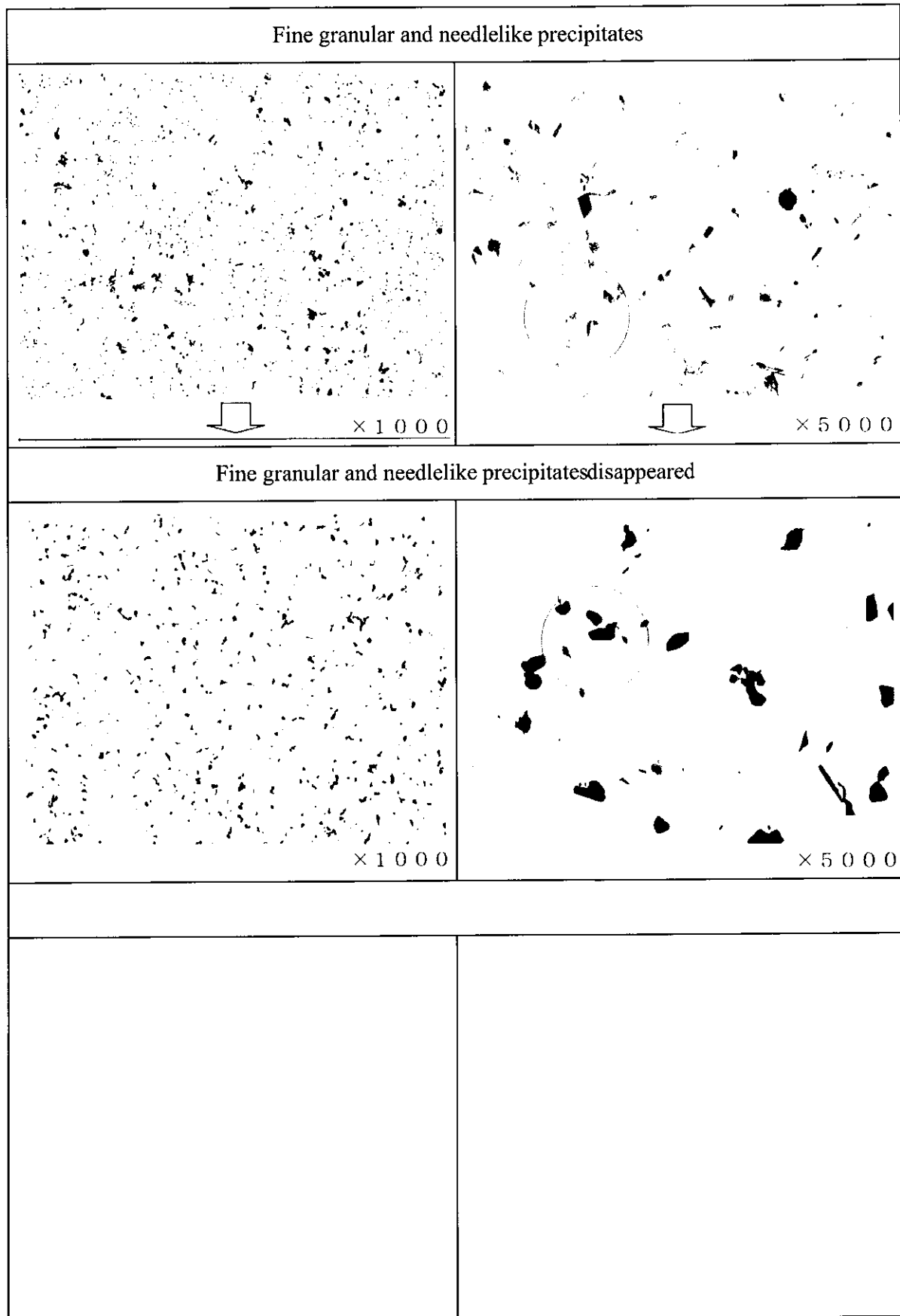





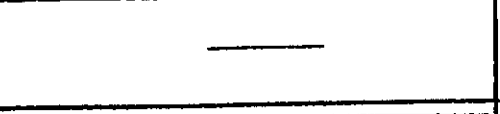
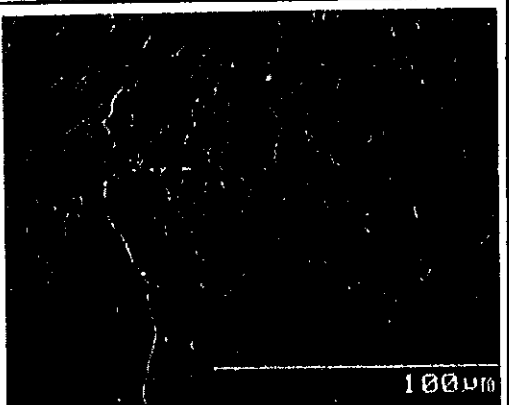
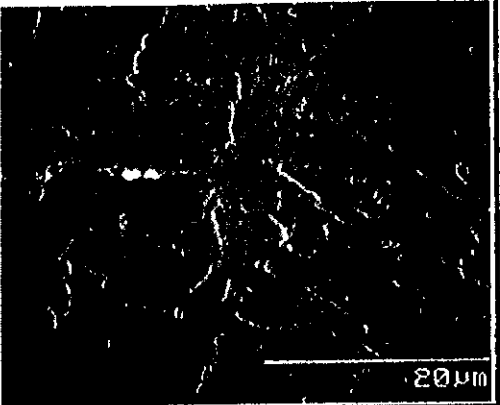
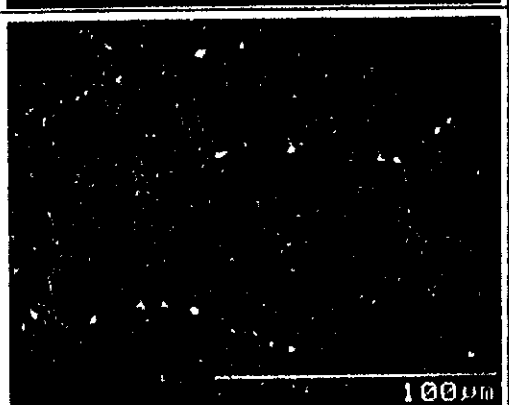

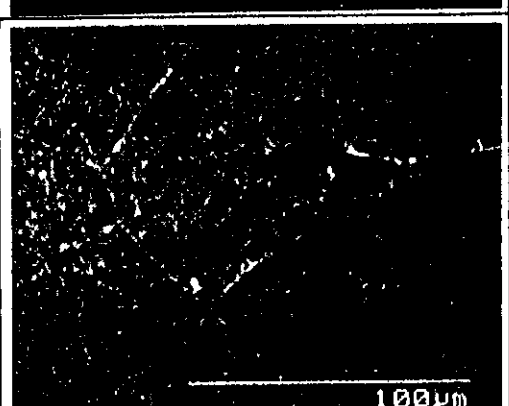
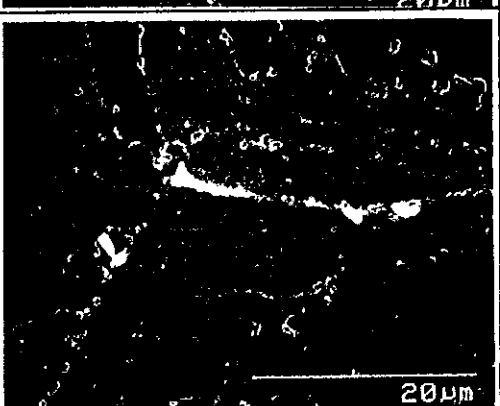
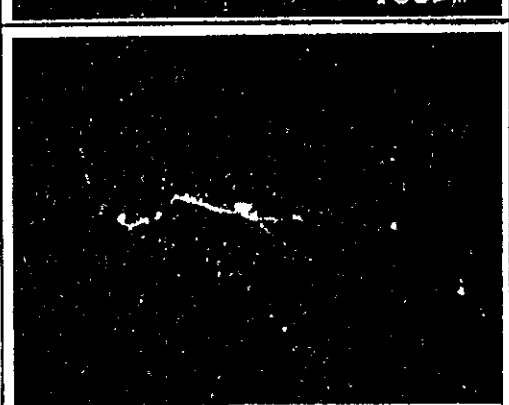

Reference microstructure by TEM observation 4-10  
 SA 335 P12 Coarse grain HAZ  
 Spherodized (2)



Referrence microstructure by TEM observation 4-11  
SA 335 P12 Weld metal



Reference picture of creep void 5-1

| Grade | ×400  | ×1800  |                                     |
|-------|---|--|-------------------------------------|
| 1     |    |    | No void                             |
| 2     |    |    | Isolated void                       |
| 3     |   |   | A number of voids on grain boundary |
| 4     |  |  | Linkage of voids (<50μm)            |
| 5     |  |  | Macro crack (≥ 50μm)                |

629

34

(Stress direction)





The Study  
on  
Enhancing Efficiency of Operating  
Thermal Power Plants in NTPC-India

Boiler Remaining Life Assessment  
Safety Management Procedure

JICA Study Team (Kyusyu Electric Power Co.,Inc.)  
Kyudensangyo Co.,Inc

## Table of Content

|   |    |
|---|----|
| 1. Objectives .....   | 1  |
| 2. Date of inspection .....   | 1  |
| 3. Location.....  | 1  |
| 4. Scope.....   | 1  |
| 4 - 1 Objectives of boiler components .....                             | 1  |
| 4 - 2 Scope of work .....   | 1  |
| 5. Inspection schedule .....  | 3  |
| 6. Related standard .....   | 3  |
| 7. Work Organization System.....  | 5  |
| 8. Emergency Notification System .....                                  | 3  |
| 9. General adherence matters.....                                       | 7  |
| 10. Flow sheet of scope of work .....                                   | 13 |
| 11. Safety and Quality Control Table .....                              | 14 |
| 12. Procedure   |    |
| 12-1 Thickness measurement.....   | 15 |
| 12-2 Detection technique for scale deposition of SUS (Austenite Steel ) |    |
| boiler tube inside .....  | 18 |
| 12-3 PT (Liquid Penetrant Testing).....                                 | 24 |
| 12-4 UT (Ultrasonic testing).....                                       | 27 |
| 12-5 TOFD (Time of Flight Diffraction) Inspection .....                 | 30 |
| 12-6 Sample tube inspection.....  | 34 |
| 12-7 Sampling of replica and extracted replica .....                    | 39 |
| 12-8 Boiler remaining life assessment technique.....                    | 40 |
| 12-9 Creep rupture test .....   | 49 |
| 13. Members certification .....   | 52 |

## **1. Objectives**

Objectives of this study is to carry out boiler remaining life assessment for coal-fired thermal power plants in NTPC-India as one of the activities to improve the efficiency and transfer to counterpart the technology.

## **2. Date of inspection**

October 27 2009 ~November 1 2009 (Singrauli #6 unit)

November 4 2009 ~November 9 2009 (Unchahar #2 unit)

## **3. Location**

Thermal power plants in NTPC-India

- Singrauli Super Thermal Power Station #6 unit  
P.O. Shaktinagar-231 222, Distt. Sonebhadra,Uttar Pradesh
- Feroze Gandhi Unchahar Thermal Power Station #2 unit  
P.O.Unchahar,Dist.Rai Bareilly,Uttar Pradesh-229406

## **4. Scope**

### **4 - 1 Objectives of boiler components**

- Waterwall
- Super heater
- Reheater
- Super heater header
- De super heater pipe
- Reheater header
- Main steam pipe

### **4 – 2 Scope of work**

Scope of work is shown in Table 1.



Table 1 Scope of work

| NO. | Parts  | INSPECTION                      | Singrauli #6  | Unchahar #2  |
|-----|--|---------------------------------|---|--|
| 1   | WATER WALL                                       | VT                              | *Mainly at burner level<br>*Erosion part  |  |
| 2   |  | THICKNESS MEASUREMENT           | *20 points(5points each from 4corners)  |  |
| 3   | SUPER HEATER                                     | VT                              | *Mainly Platen super heater   |  |
| 4   |  | THICKNESS MEASUREMENT           | *50 points around soot blower   |  |
| 5   |  | SAMPLE TUBE INSPECTION          | 1 tube with 1m length for Platen SH including weld joint portion  | 2 tubes with 1m length from Final SH, 1 tubes with 1m length from Platen SH including weld joint portion that is selected by steam oxide scale measurement result. |
| 6   |  | CREEP RUPTURE TEST              | *3 specimens from base metal, 3 specimens from weld joint from the tube identical to above.                             | *3 specimens from base metal, 3 specimens from weld joint from the tube identical to above.  |
| 7   |  | SUS SCALE DEPOSITION INSPECTION | *50 points of bottom bend portion of austenitic steel tubes   | *29 ×3 points of bottom bend portion of austenitic steel tubes   |
| 8   |  | VT                              | *Mainly around soot blower.   |  |
| 9   | REHEATER   | SAMPLE TUBE INSPECTION          | 2 tubes with 1m length for Final RH (one each from furnace inside and penthouse) including weld joint portion.          |  |
| 10  |  | CREEP RUPTURE TEST              | *3 specimens from base metal, 3 specimens from weld joint from the tube identical to the one of the above sample tubes. |  |
| 11  |  | SUS SCALE DEPOSITION INSPECTION | *50 points of bottom bend portion of austenitic steel tubes   |  |
| 12  | SUPER HEATER HEADER                              | VT                              | *Visual inspection in penthouse   |  |
| 13  |  | PT(DPT)                         | *4 portions at stub weld of Inlet header .  | *4 portions at stub weld of Platten inlet header   |
| 14  |  | UT                              |   | *1ring of circumferential weld of Final outlet header right side with UT and TOFD identical to the replica portion   |
| 15  |  | REPLICA INSPECTION              | *1 point on 1ring of circumferential weld of left outlet header.<br>*1 point on base metal of left outlet header.       | *1 point of circumferential weld portion of right side of Final outlet header.   |
| 16  | DE SUPER HEATER PIPE                             | REPLICA INSPECTION              | *2 points ( one each from 1ring of circumferential weld right and left).  |  |
| 17  | REHEATER HEADER                                  | VT                              | *Visual inspection in penthouse   |  |
| 18  |  | UT                              | *1ring of circumferential weld of outlet header with UT and TOFD identical to the replica portion                       |  |
| 19  |  | REPLICA INSPECTION              | *2 points (one each from circumferential weld of left and right of out let header.                                      | *3 points of circumferential weld portion of right and left side outlet header.  |
| 20  | MAIN STEAM PIPE (near the stop valve weld joint) | REPLICA INSPECTION              | *2 points on a circumferential weld of left main steam pipe   | *2 points on two circumferential welds of right main steam pipe  |
| 21  | HOT RHEAT PIPE                                   | REPLICA INSPECTION              |   | *1 point on a circumferential weld of right High temperature reheater pipe.  |

## 5. Inspection schedule

Inspection schedule is shown below, and daily schedule is shown in Table2.

| Schedule for Boiler RLA |                        |         |    |    |     |    |    |    |            |          |    |     |    |           |    |    |    |           |    |     |    |  |
|-------------------------|------------------------|---------|----|----|-----|----|----|----|------------|----------|----|-----|----|-----------|----|----|----|-----------|----|-----|----|--|
|                         | Month                  | October |    |    |     |    |    |    |            | November |    |     |    |           |    |    |    | ~ January |    |     |    |  |
|                         | Day                    | 24      | 25 | 26 | 27  | 28 | 29 | 30 | 31         | 1        | 2  | 3   | 4  | 5         | 6  | 7  | 8  |           | 9  | 10  | 11 |  |
|                         | Day of the week        | Sa      | Su | Mo | Tue | We | Th | Fr | Sa         | Su       | Mo | Tue | We | Th        | Fr | Sa | Su |           | Mo | Tue | We |  |
| Singrauli<br>UNIT 6     |                        |         |    |    |     |    |    |    | 10/27-11/1 |          |    |     |    |           |    |    |    |           |    |     |    |  |
|                         | Boiler Inspection      |         |    |    |     |    |    |    |            |          |    |     |    |           |    |    |    |           |    |     |    |  |
| Uncharhar<br>UNIT 2     | Meeting                |         |    |    |     |    |    |    |            |          |    |     |    |           |    |    |    |           |    |     |    |  |
|                         | Boiler Inspection      |         |    |    |     |    |    |    |            |          |    |     |    | 11/4-11/9 |    |    |    |           |    |     |    |  |
|                         | ◇ Examination in Japan |         |    |    |     |    |    |    |            |          |    |     |    |           |    |    |    |           |    |     |    |  |

## 6. Related standard

- Technical standard base on electric utility law 「Technical Standards for Thermal Power Generating Facilities」
- JIS Z 2305;2001 Non-destructive testing—Qualification and certification of personnel
- JIS B 8201:2005 Stationary steel boilers - Construction
- JIS Z 3060:2002 Method for ultrasonic examination for welds of ferritic steel
- JIS Z2343-1 ~3:2001 Non-destructive testing—Penetrant testing—
  - Part 1 : General principles—Method for liquid penetrant testing and classification of thepenetrant indication
  - Part 2 : Testing of penetrant materials
  - Part 3 : Reference test blocks
- JIS Z2355:2005 Methods for measurement of thickness by ultrasonic pulse echo technique
- JIS Z 2245:2005 Rockwell hardness test - Test method

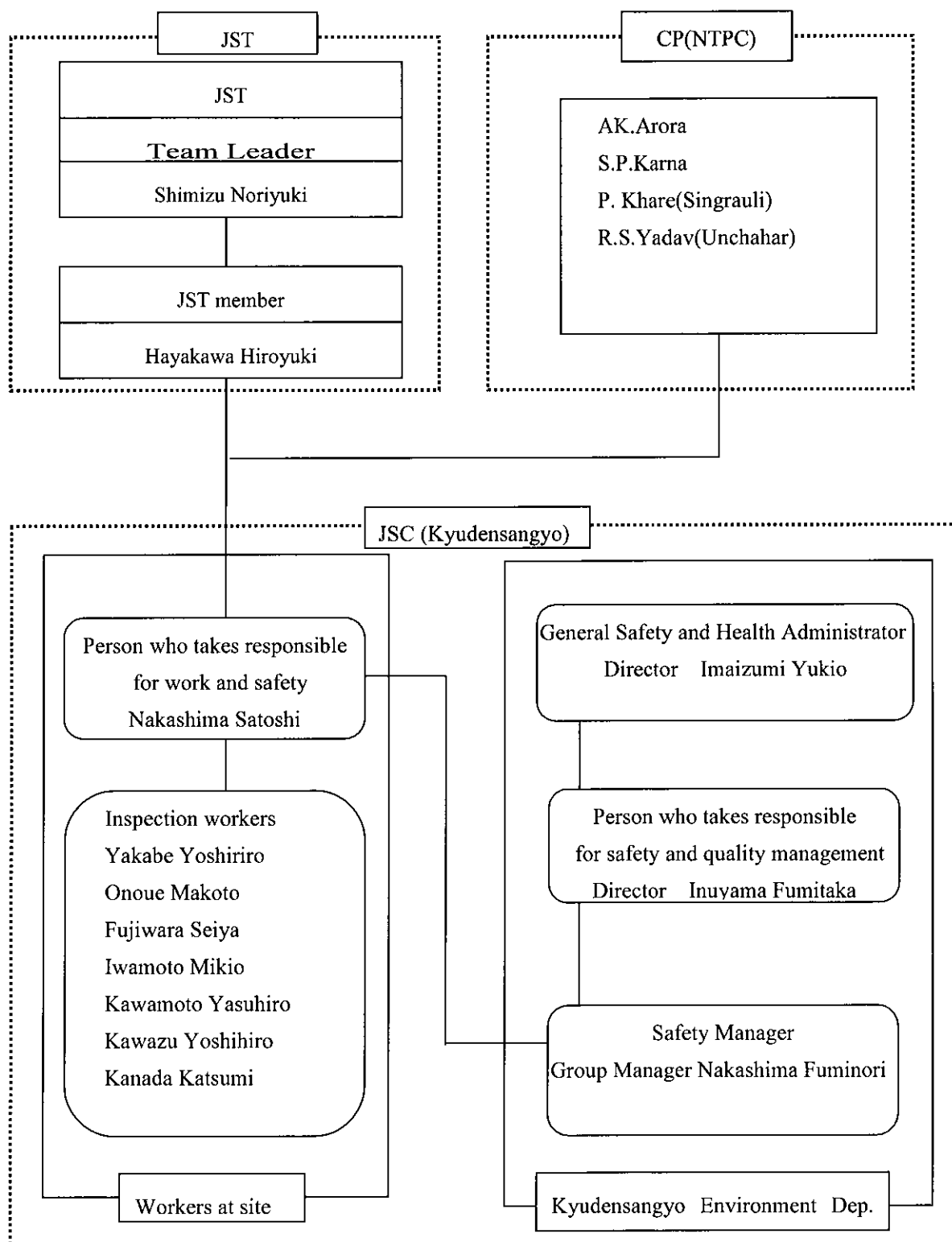
Table2 Daily schedule

| Item*Contents:                                     |                                 |   | In charge | 1               | 2 | 3 | 4 | 5 | 6 | ~2010 Feb  |
|--|---------------------------------|---|-----------|-----------------|---|---|---|---|---|--|
| Checking of work site                              |                                 |   | JST,JSC   | All members     |   |   |   |   |   |  |
| Meeting before work                                |                                 |   | JST,JSC   | All members     |   |   |   |   |   |  |
| Water wall tube                                    | Visual check                    |   | JST,JSC   | AD              |   |   |   |   |   | <div>-JST Hayakawa<br/>-JSC member A<br/>-JSC member B<br/>-JSC member C<br/>-JSC member D<br/>-JSC member E<br/>-JSC member F<br/>-JSC member G<br/>-JSC member H</div> |
|  | Thickness measurement of tubes  | Grinding  |           | BD              |   |   |   |   |   |  |
|  |                                 | Measurement   | JST,JSC   | BD<br>Demo      |   |   |   |   |   |  |
| SH tube  | Visual check                    |   | JST,JSC   | B,C,E,F,G,H     |   |   |   |   |   |  |
|  | Thickness measurement of tubes  | Grinding  |           | BD              |   |   |   |   |   |  |
|  |                                 | Measurement   | JST,JSC   | BD              |   |   |   |   |   |  |
|  | SUS scale deposition inspection | Grinding  |           | EF              |   |   |   |   |   |  |
|  |                                 | Measurement   | JST,JSC   | EF<br>Demo      |   |   |   |   |   |  |
|  | Tube sampling                   | Cutting   | P.S.      |                 |   |   |   |   |   |  |
|  |                                 | Restoration   |           |                 |   |   |   |   |   |  |
|  |                                 | Preparation for shipping                            | JSC       |                 |   |   |   |   |   |  |
|  |                                 | Examination of tube                                 | JSC       |                 |   |   |   |   |   |  |
|  |                                 | Creep rupture test                                  | JSC       |                 |   |   |   |   |   |  |
| FBI tube   | Visual check                    |   | JST,JSC   | B,C,E,F,G,H     |   |   |   |   |   |  |
|  | SUS scale deposition inspection | Grinding  |           | EF              |   |   |   |   |   |  |
|  |                                 | Measurement   | JST,JSC   | EF              |   |   |   |   |   |  |
|  | Tube sampling                   | Cutting   | P.S.      |                 |   |   |   |   |   |  |
|  |                                 | Restoration   |           |                 |   |   |   |   |   |  |
|  | Preparation for shipping        | JSC   |           |                 |   |   |   |   |   |  |
|  | Examination of tube             | JSC   |           |                 |   |   |   |   |   |  |
|  | Remaining life assessment       | JSC   |           |                 |   |   |   |   |   |  |
| SH header  | Visual check                    |   | JST,JSC   | A,C,G,H         |   |   |   |   |   |  |
|  | PT (stub)                       | Grinding  |           | GH              |   |   |   |   |   |  |
|  |                                 | Inspection  | JST,JSC   | GH<br>Demo      |   |   |   |   |   |  |
|  | UT (Circumferential weld)       | Grinding  |           | GH              |   |   |   |   |   |  |
|  |                                 | UT(TOFD) detection                                  | JST,JSC   | E,F,G,H<br>Demo |   |   |   |   |   |  |
|  | Replica inspection              | Replica sampling                                    | JST,JSC   | A,D<br>Demo     |   |   |   |   |   |  |
|  |                                 | Examination of replica                              | JSC       |                 |   |   |   |   |   |  |
| Desuperheater                                      | Visual check                    |   | JST,JSC   | A,C,G,H         |   |   |   |   |   |  |
|  | Replica inspection              | Replica sampling                                    | JST,JSC   | A,D<br>Demo     |   |   |   |   |   |  |
|  |                                 | Examination of replica<br>Remaining life assessment | JSC       |                 |   |   |   |   |   |  |
| FBI header   | Visual check                    |   | JST,JSC   | B,D             |   |   |   |   |   |  |
|  | Replica inspection              | Replica sampling                                    | JST,JSC   | B,D             |   |   |   |   |   |  |
|  |                                 | Examination of replica<br>Remaining life assessment | JSC       |                 |   |   |   |   |   |  |
| Main steam pipe                                    | Visual check                    |   | JST,JSC   | B,D             |   |   |   |   |   |  |
|  | Replica inspection              | Replica sampling                                    | JST,JSC   | B,D             |   |   |   |   |   |  |
|  |                                 | Examination of replica<br>Remaining life assessment | JSC       |                 |   |   |   |   |   |  |
| Preparation for shipping of inspection instruments |                                 |   | JSC       |                 |   |   |   |   |   |  |

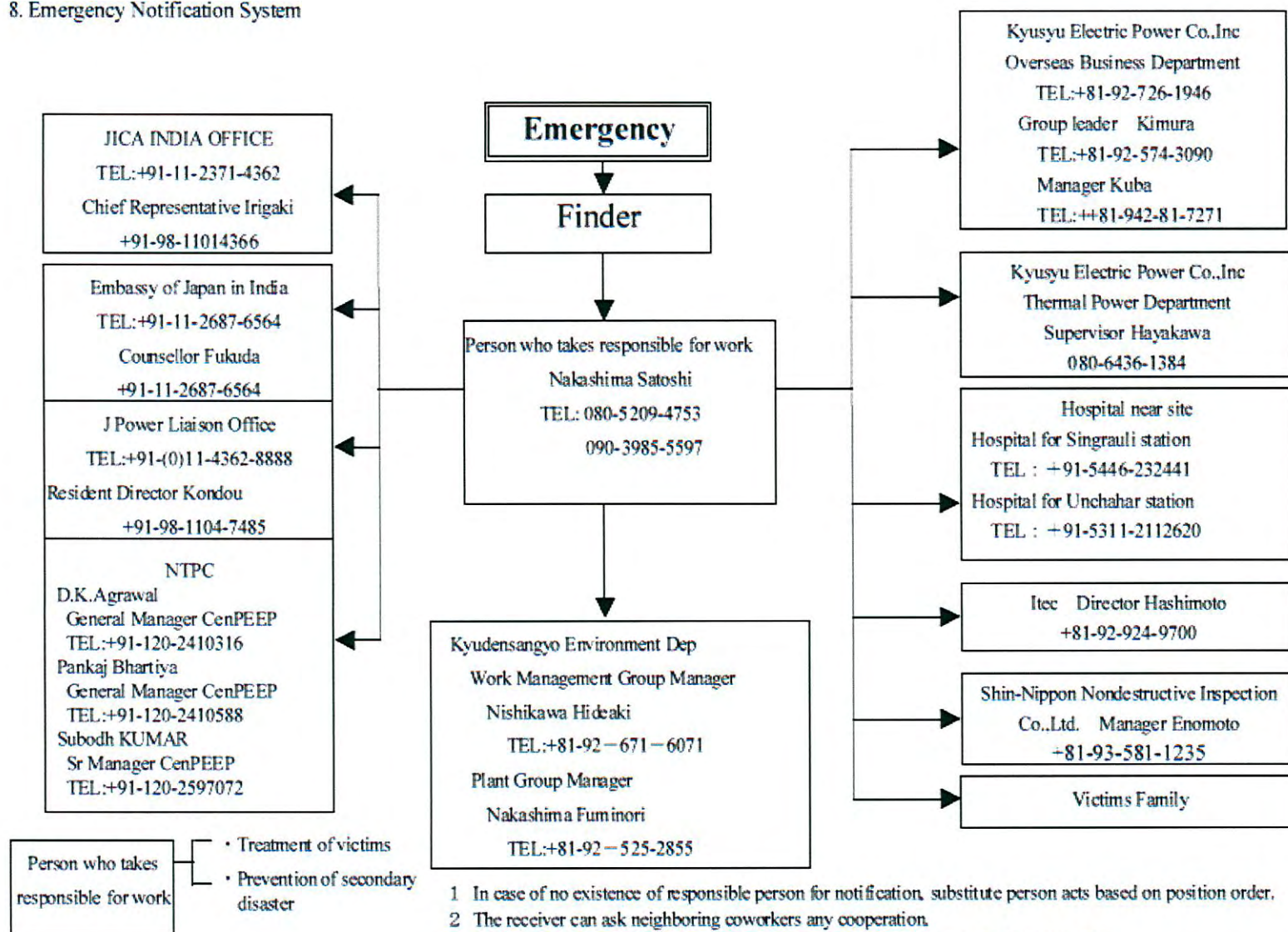
JST : JICA Study Team, JSC : Japanese Service Company, P.S.: Power station



## 7. Work Organization System



## 8. Emergency Notification System



## **9. General adherence matters**

### **1) Ensure safety working instructions**

- ① Responsible person for work must explain
- ② Work procedures and safety measures to all members and make them understood at the meeting.
- ③ The meeting has to be held by using KYM and QCM blackboards prior to working.
- ④ When a worker finds any abnormal condition of other worker, the worker has to gasp the situation and the cause of the condition, and follow the emergency reporting system to take appropriate action and report to the responsible person.

### **2) Prevention of falling, flying, and drop accidents prevention**

Since falling accidents account for about 80 percent of serious accidents, the maximum care must be paid to prevent these accidents.

In case of work at a site higher or deeper than 1.5m, lifting equipment with 30cm width or wider has to be set.

- ① In case of work at a site higher than 2m, safety belt should be worn for any reason. At a site where it is difficult to ensure a lifeline, parent ropes should be attached, and safety nets should be added, depending on the conditions.
- ② OPENING should be enclosed, cured and displayed for attention using handrails, etc., to prevent the fall of people and goods.
- ③ In bad weather conditions such as strong winds over 10m / s, heavy rain and heavy snow, works at high place and loading and unloading by mobile crane should be suspended in principle.

### **3) Prevention of electric shock accidents**

As it is highly possible that electric shock accidents lead to serious disasters, thorough attention has to be paid to prevent these accidents. Live-line work is strictly prohibited.

- ① The earth leakage circuit breakers has to be set on power supply.
- ② When electrical equipment is used, the insulation test should be conducted to make sure its soundness. "Permit to use certificate" has to be mounted to the qualified instrument.

### **4) Prevention of disasters caused by hydrogen sulfide and lack of oxygen**

Since many fatal accidents have been caused by oxygen deficiency at workplaces, in case of work in the airless sites, it is necessary to measure the oxygen concentration with careful work planning for the air circulation and ventilation as to prevent the accidents.

- ① Strict observance of the work procedure instruction for prevention of disasters caused by hydrogen sulfide and lack of oxygen.

Entrance to the airless work places such as tanks, ducts, pits, furnace, condenser are only



permitted after the chief person for work with oxygen deficient risks measures the oxygen and hydrogen sulfide concentration levels to confirm that the concentration of oxygen in the air exceeds 18% and the concentration of hydrogen sulfide is below 5ppm, and the measured values have been displayed at the entrance, and the sufficient ventilation is secured.

- ② All workers have to attend the special meeting on oxygen deficient risk before the work starts.
- ③ To make it clear who are in the workplace and who are not, nametags of present workers must be displayed at the entrance and the workplace must be always monitored.

## **5) Keeping up working environment**

Workers must make every best effort to ensure safety and maintain well-organized work environment..

- ① To ensure safe passage, no objects, tools or materials should be placed on the passage and stuffs. Hoses and codes must be attached at 1.8m or higher place with S shaped rings.
- ② Smoking is allowed only at specified spot with a stub box. Smoking while walking, driving and working is prohibited.
- ③ At the end of the work, workers must organize and clean the workplace, and clean up the cigarette butts before leaving the workplace.
- ④ Workers must make sure to close the gas valve of Oxygen and acetylene and switch off the power at lunchtime and the end of the work. Power switch must be turned off on unnecessary equipment.
- ⑤ Waste from work has to be fractionated into valuable and industrial waste , and the industrial waste is sorted into combustible and non-combustible materials and insulation waste to be carried and kept in the specified location, according to prescribed rules.

## **6) Particular emphasis on Specified hazardous work**

### **(1) Specification of "Specified hazardous work"**

"Specified hazardous work" is specified as below.

- ① Work at high place
- ② Work with heavy goods
- ③ Work near electric charging parts
- ④ Work near high pressure and high temperature parts
- ⑤ Work with the risk for lack of oxygen

### **(2) Particular emphasis items**

Work guidelines, work procedures and safety measures must be reaffirmed at the pre-work meeting before work.

- ① Check of command, order and system

- ② Check of role of each worker
- ③ Check of safety on work methods and tools
- ④ Risk prediction and counter measures(Management of technical matter)
- ⑤ Qualification for work
- ⑥ Placement of full-time guardsman
- ⑦ Instruction for presence of supervisors required
- ⑧ Other required items

## **7) Thorough prevention of contamination**

- ① In overhaul, inspection, maintenance and assembly work, workers must be committed to preventing contamination.
- ② For components that have a risk of contamination, the interval for a risk of contamination must be set.
- ③ Contamination risk work is identified with the signs or boundaries so that workers in the area recognize it.
- ④ Responsible person for work must plan how to manage to carried in tools and ensure no lost tools at required point on the process. In case where any tool is lost, workers must stop the process to search the lost tools. When the missing item has not been found, workers must report the loss and follow the order.
- ⑤ Workers in contamination control area have to manage the carried-in and carried-out goods and report the chief worker that no goods are lost.
- ⑥ During the removal of parts in contamination control area, workers must make sure no parts have been lost in assembling process.
- ⑦ On recovery of equipment in contamination control area, inspection and visual check must be conducted for contamination right before it becomes impossible to stay and work inside, and the results must be recorded as inspection and test items on work instructions.
- ⑧ When working inside equipment, workers must follow "the control standards on work inside equipment" of the power station.

### **Examples at workplace**

- ① "Tool management check sheet " is submitted prior to work to carry in tools to the workplace and confirmed by the responsible person.
- ② Soon after the casing has been removed, tools are covered by plastic film.
- ③ Openings, if any, are cured with shutter plates before any work is done.
- ④ Rope are attached to tools to avoid falling.
- ⑤ In case of working inside the components, workers take all the goods out of the pockets.
- ⑥ No tools or parts are on the casing of the equipment.

## **8) Appropriate disposal of industrial waste**

- ① Unnecessary materials produced during work including industrial waste must be properly stored and processed.
- ② Unnecessary materials must be fractionated into industrial waste and valuable and be stored in the specified location.
- ③ Temporary storage has to be well-handled not to affect the environment.
- ④ In case of disposal as industrial waste, the manifest must be complied up to the final disposal. If the final process of the disposal of industrial waste has not completed before the while work is finished, photos of waste boarding on the vehicle upon carry-out or photos of temporary storage have to be attached to the report.

## **9) Thorough information management**

- ① Cell phone and cameras devices are prohibited to carry into the workplace. If it is necessary for work, notification of use has to be submitted.
- ② Workers must thoroughly ensure information security management by preventing the risk of loss, destruction, tampering, leaks and theft of confidential information.
- ③ Confidential information can be used only within the purpose of the work.
- ④ Confidential information can not be disclosed or provided to third parties, without the approval.
- ⑤ In case of happening and foreseeing of confidential information loss, destruction, falsification, leaks and theft, workers must report immediately.

Thorough information security management must be conducted by workers including partnering companies on confidential information.

Confidential information: Management information and other technical and business related confidential information and personal information to be ruled by the law on protection of personal information.

## **10) Safety management guideline**

- ① Always check upon release of power.
- ② Each work (non-destructive inspection) is performed by qualified personnel.
- ③ Protective equipment is always worn.
- ④ Electrostatic clothing and shoes are worn.
- ⑤ Anti explosive tools are used in working at dangerous area.
- ⑥ Measures to prevent equipments and tools from falling (net and sheet to secure, rope for prevention of falling, portable bag for small stuff) are conducted
- ⑦ Operation of switches and valves are prohibited without permission.
- ⑧ When the work is completed, return the equipment to the state before work.
- ⑨ When handling asbestos-containing joint sheet, the elected asbestos operation chief instructs workers and submits a report.



### **11) Quality management guideline**

- ① Calibrated and managed equipment must be used for measuring and testing.
- ② Work must be conducted based on drawings, manual procedures and instructions.
- ③ Use the suitable tools for work.
- ④ Take care of storage, transportation and handling of machinery facilities and parts for damage, rust, and loss.
- ⑤ Collate and confirm with the drawing (type and size of material) in case of replacement of parts.
- ⑥ Work done by qualified personnel.
- ⑦ Take measures to prevent manual tools and small parts from falling.
- ⑧ Make sure that there is no blockage of the tank vent pipe with the dust, paint or waste every time at the end of the tank inspection and repair (including painting).
- ⑨ Open the drill holes not to be completely closed structure, in case of repairing the refractory to be sealed with metals (especially water mixed refractory such as casters).
- ⑩ After unweaving the wire and cable, a cap or insulation tape processing for the terminal must be implemented immediately.

### **12) Others**

- ① The work instructions (including safety and quality control) must be submitted and approved by the construction manager before any of the construction work starts.
- ② If there are any comments concern on security measures, consult with a counterpart as soon as possible.
- ③ Work is performed based on the safety and quality control flowchart.
- ④ Workers must thoroughly understand the general work rules and workers rule.
- ⑤ When the responsible person leaves the workplace, the chief person of partnering company must be informed of the requirements and the absent time and take in charge of site management on behalf of the responsible person (special armband must be worn).
- ⑥ The company's management guideline for asbestos handling work must be complied upon the safety measures and guidelines for the handling of asbestos joint sheet
- ⑦ The guidelines and compliance activities based on Kyushu Electric Power Group action charter must be announced at the training prior to the commencement of the work. The open culture for workplace must be ensured through the cautionary tale and video training during the morning meeting.

### **13) Safety measures on this work**

- ① Falling ..... In danger of falling, working at 2m high altitude
- ② Lack of oxygen ..... In danger of lack of oxygen, working in the boiler furnace
- ③ Dropping ..... In danger of equipments dropping at hanging in and out

Maximum weight .....50..... kg

In danger of manual tools small parts dropping.

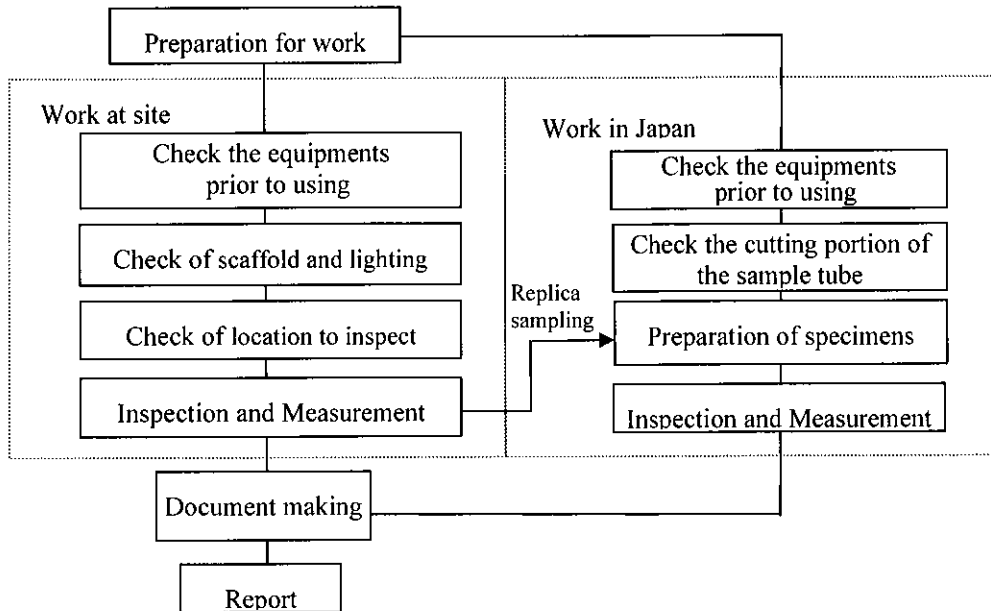
- ④ Asbestos used in seat rope gotten rid of before working. If the asbestos sill remains, make sure the site and keep away from it. Stop working if asbestos treating work begins.
- ⑤ The other ..... Since the periodical inspections are planned to be conducted along with this work, full attention should be paid on the work environment.

#### **14) Duties of operator in chief**

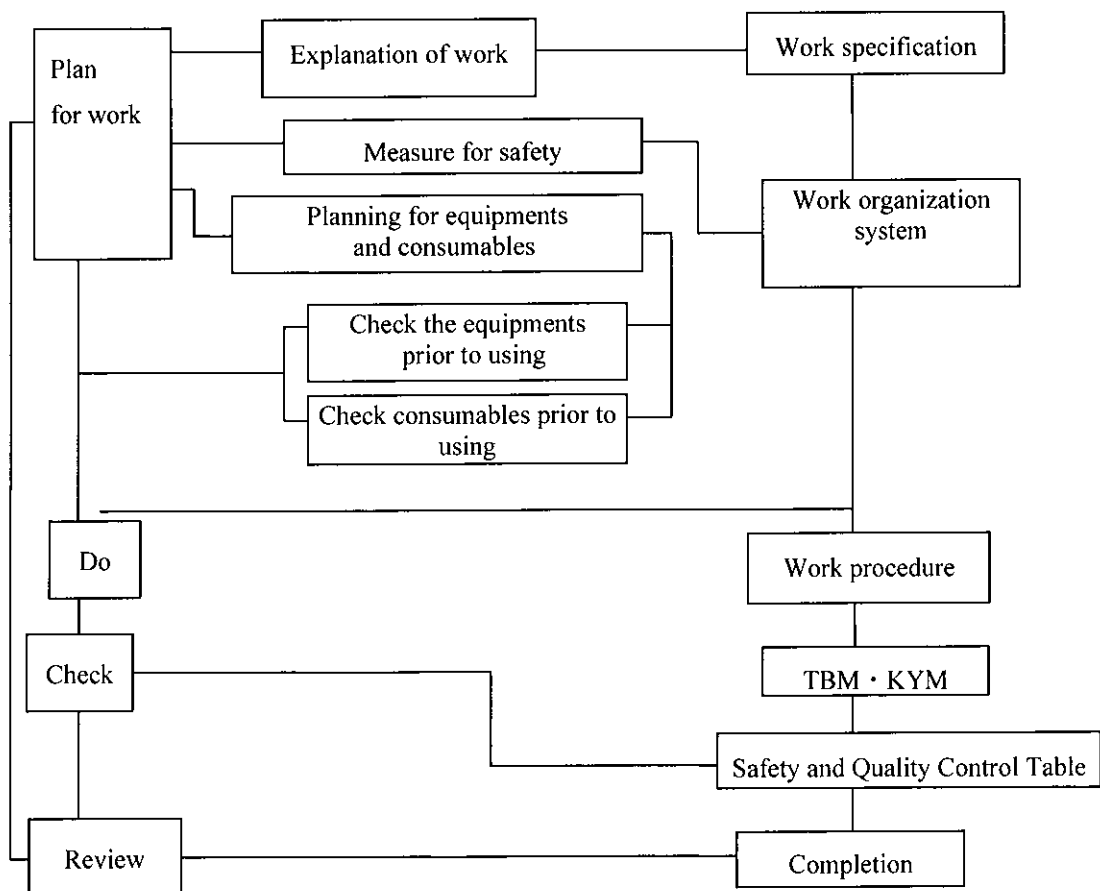
- ① Handling of organic solvents.
- ② Work associated with the risk of oxygen deficiency.

## 10. Flow sheet of scope of work

### Flow sheet for work



### Flow sheet for check item prior to work





## 11. Safety and Quality Control Table

| Task |                                 | Check point<br>for Safety and Quality Control  | Reference |
|------|---------------------------------|--|-----------|
| 1    | Preparation for work            | <b>1. Safety Control</b><br>1-1 Carrying out KYM・TBM.<br>1-2 Meeting before working.<br>1-3 Check the condition of equipments with the client.<br>1-4 Check the condition of work place with the client,<br>display “on working” if it is necessary.<br>1-5 Name plates are displayed at the entrance of manhole.<br>1-6 Usage of protective equipments.<br>1-7 Prevention of work by one person.<br>1-8 Check of equipments prior to using.<br>1-9 Attention around hand and foot.<br>1-10 Ensure enough lighting for work.<br>1-11 Usage of boxes for small equipments for inspection.<br>1-12 Vertically adjacent work strictly prohibited.<br>1-13 Enforcement of 3S |           |
| 2    | Check of scaffold and lighting  |  |           |
| 3    | Grinding                        |  |           |
| 4    | Thickness measurement           |  |           |
| 5    | SUS scale deposition inspection |  |           |
| 6    | PT inspection                   |  |           |
| 7    | UT inspection                   |  |           |
| 8    | TOFD inspection                 |  |           |
| 9    | Replica inspection              |  |           |
| 10   | Document making                 |  |           |
| 11   | Report                          |  |           |
|      |                                 |  |           |
|      |                                 |  |           |
|      |                                 | <b>2. Quality Control</b><br>2-1 Check the delivery of equipments.<br>2-2 Check the scope of work and objective components prior to work..<br>2-3 Check the location to grind.<br>2-4 Visual check of grinding surface.<br>2-5 Appropriate usage of test pieces for inspection points and method.<br>2-6 Check the designed dimension of inspection points.<br>2-7 Appropriate application of Acceptance Criteria.   |           |
|      |                                 |  |           |
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