

An Enhancement in the Nature of Concrete with a Multiplicative  
Cement Crystal Type Concrete Material.

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## 1. Introduction

Xypex, a multiplicative cement crystal type inorganic application material, makes cement gel and a crystal structure inside concrete dense and tight, and also improves the water permeability of the concrete. Thereby, it is widely used in many countries including America and Canada. In Japan, we have many actual results of application of this material as a counter measure against water penetration into cracked concrete in various job sites such as the fields of construction of tunnels.

The most important features of this material are the ways in which the applied ingredients penetrate and diffuse into the concrete for a long time after application, it also reacts with the cement material, and fills up the cracks or voids inside the concrete with multiplied crystals as a result of a chemical reaction. This is the first report as the research which has been undertaken in order to investigate the improvement mechanisms in the nature of concrete by use of this material.

## 2. Observation of crystal growth inside the concrete with a scanning electron microscope (SEM).

Measurement of crystal growth rate and observation of the crystal status inside the concrete affected by this improvement material were carried out using a scanning electron microscope (SEM).

### (1) Experimental samples and their curing.

The composition of the experimental samples of concrete are shown in Table-1. The dimension of the samples is W60cm×L70cm×H40cm, as shown in Figure-1. The curing condition of the samples is as follows. The sample was taken out from the molding box just one day after molding. Then, this material, Xypex, was applied to the sample, and the sample was cured in a dry-atmosphere and under water sprinkler, for two days and successive seven days, respectively. Further, it was left in the outdoors for about one year. A specimen for observation by SEM was a core of concrete with the length of 40cm, which was cut out from the sample perpendicularly to the surface on which the Xypex was applied. Further, it was cut into 18 pieces having equal length and each piece was crushed into an appropriate grain size (Figure-2).

Table-1. Composition of concrete for test-sample.

slump	W/C	s/a	W	Compression strength
8cm	65%	39.4%	149kg	212kgf/cm <sup>2</sup>

## (2) Measurement by SEM.

Measurement was carried out using the Super Probe 733 which is a SEM made by Nihon-denshi corp. The grain of the test sample was dried and carbon was used for evaporation to obtain the target of the microscope. First, a rough observation of the crystal growth part in the hardened cement paste inside the concrete was made with a 20 times magnification factor. Then, the status of the crystal growth was taken by photograph with a 1,000 times magnification factor.

## (3) Conclusions.

Typical microscopic photographs obtained in this research are shown in Figure-3,4, and 5. Further, the microscopic photograph of the sample which was not applied with any treatment is shown in Figure-6 for comparison. From these results, it will be clear that the needle crystals are growing inside the concrete as a result of the application of Xypex and that the amount of them increases as the surface on which Xypex was applied is neared. Furthermore, it is shown that the crystal growth is progressing even at a depth of 30cm below the surface. From these experiments, it will be proved that, although the concrete itself has no water permeability, Xypex has penetrated and diffused into the concrete with a speed of over 30cm per year.

The needle crystal observed is expected to be C-S-H crystals from a qualitative analysis of the concrete by an energy scattering type X-ray analysis method. It is considered that the C-S-H contributes to the mechanism of making concrete dense and tight. However, a further more accurate observation by an electron beam diffraction analysis using a transparent type electron microscope is required to investigate the tightening mechanism of concrete as a contribution of application of this material.

## (4) Future direction.

In the future, this research will go on to investigate quantitatively the effect of Xypex on water permeability, compression strength and durability, as well as to develop analyzation of the crystal growth mechanism.

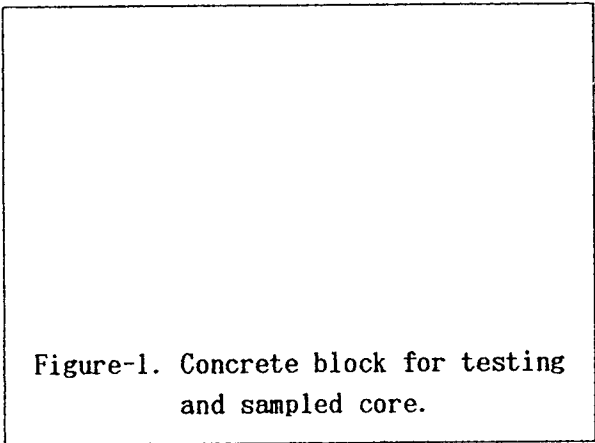


Figure-1. Concrete block for testing and sampled core.

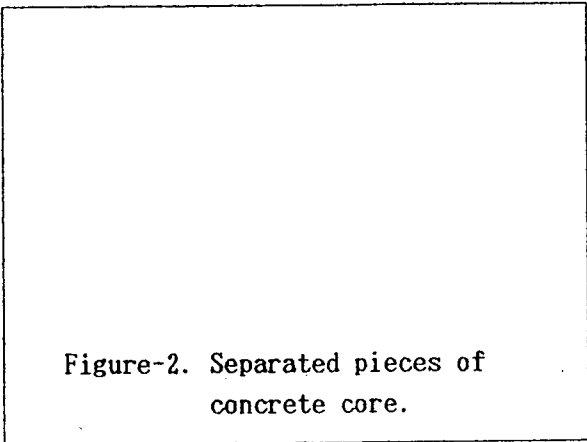


Figure-2. Separated pieces of concrete core.

Figure-3. State of crystal growth at  
a depth of 10cm from surface.

Figure-4. State of crystal growth at  
a depth of 20cm from surface.

Figure-5. State of crystal growth at  
a depth of 30cm from surface.

Figure-6. State of crystal at a  
depth of 10cm from surface in the  
non-applied sample.

セメント結晶増殖型無機質塗布材:multiplicative cement crystal type inorganic  
application material

塗布材:application material

塗布する:apply

増殖型:multiplicative

透水性:water permeability

対策:counter measure

緻密な:dense or tight

防水対策:a counter measure against water penetration

改良機構:improvement mechanism セメント結晶増殖型:multiplicative

脱型する:take out from molding box, 打設する:mold(?)

気乾養生:cure in dry atmosphere(?) 養生:curing

散水養生:cure under water sprinkler(?)

走査型電子顕微鏡:scanning electron microscope (SEM)

倍率:magnification factor 緻密化:tightening(?)

針状結晶:needle crystal 結晶成長:crystal growth

電子線回折:electron beam diffraction

透過型電子顕微鏡:transparent type electron microscope

圧縮強度:compression strength 耐久性:durability

スランプ (土木用語):slump, slump test

W/C:Water/Cement ratio s/a:(?) W:Weight

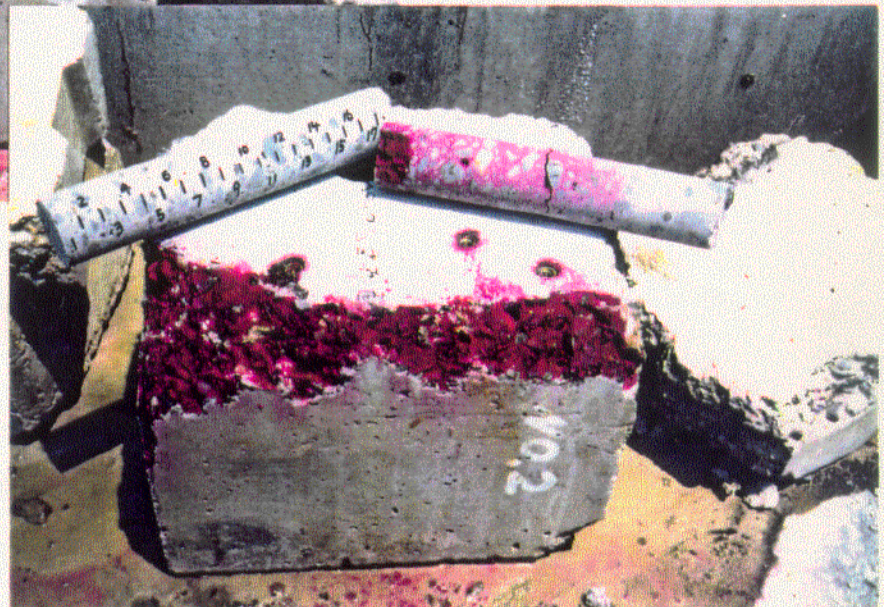
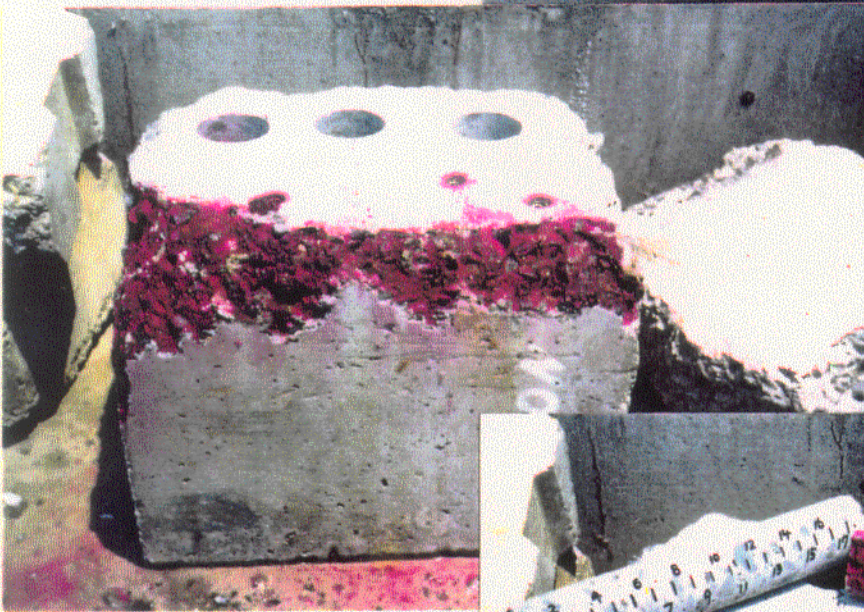
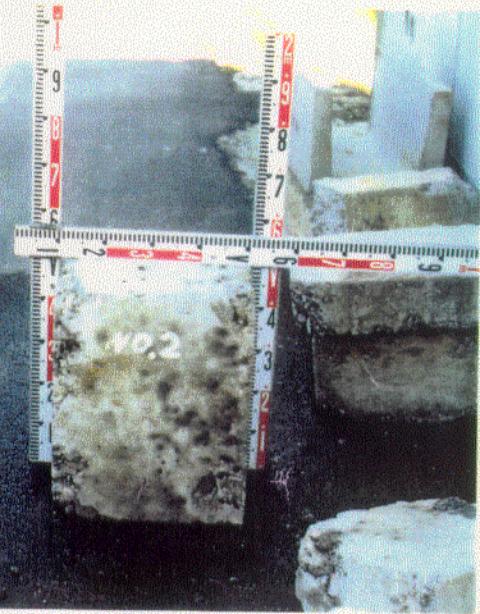
定性分析:qualitative analysis 定量的に:quantitatively





FUJICOLOR 87

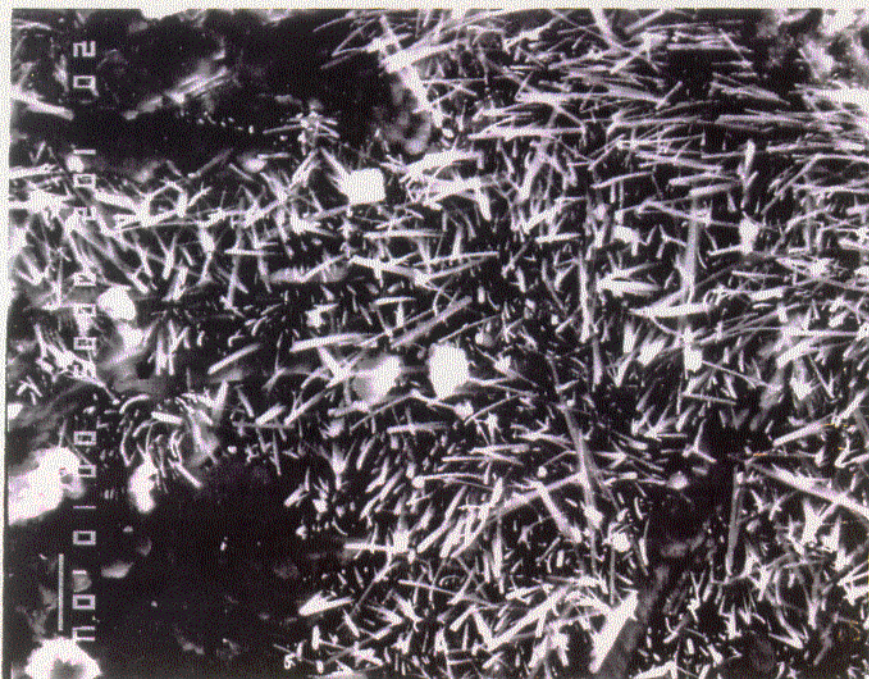
工事名 サイバツタ製品交換工事  
 工種 補修 NO. 2  
 現場 工法・サイバツタ二層重布  
 施工日 昭和59年6月6日  
 試料採取日 昭和62年5月8日  
 施工 つかぎマサイバツタス



- 1) サイバツタ二層重布
  - 2) 木造表装状態でXC二層重布
  - 3) 二層重布
  - 4) 現場×7日養生
  - 5) 木造表装状態でXC二層重布
- 市色養生: サイバツタ二層重布



Sample Name	Sample ID	Sample Type	Sample Location	Sample Date	Sample Time	Sample Status	Sample Notes
Sample 1	101	Water	Well A	2023-10-26	10:00	OK	Clear water, no odor.
Sample 2	102	Water	Well B	2023-10-26	10:15	OK	Clear water, no odor.
Sample 3	103	Water	Well C	2023-10-26	10:30	OK	Clear water, no odor.
Sample 4	104	Water	Well D	2023-10-26	10:45	OK	Clear water, no odor.
Sample 5	105	Water	Well E	2023-10-26	11:00	OK	Clear water, no odor.
Sample 6	106	Water	Well F	2023-10-26	11:15	OK	Clear water, no odor.
Sample 7	107	Water	Well G	2023-10-26	11:30	OK	Clear water, no odor.
Sample 8	108	Water	Well H	2023-10-26	11:45	OK	Clear water, no odor.
Sample 9	109	Water	Well I	2023-10-26	12:00	OK	Clear water, no odor.
Sample 10	110	Water	Well J	2023-10-26	12:15	OK	Clear water, no odor.
Sample 11	111	Water	Well K	2023-10-26	12:30	OK	Clear water, no odor.
Sample 12	112	Water	Well L	2023-10-26	12:45	OK	Clear water, no odor.
Sample 13	113	Water	Well M	2023-10-26	13:00	OK	Clear water, no odor.
Sample 14	114	Water	Well N	2023-10-26	13:15	OK	Clear water, no odor.
Sample 15	115	Water	Well O	2023-10-26	13:30	OK	Clear water, no odor.
Sample 16	116	Water	Well P	2023-10-26	13:45	OK	Clear water, no odor.
Sample 17	117	Water	Well Q	2023-10-26	14:00	OK	Clear water, no odor.
Sample 18	118	Water	Well R	2023-10-26	14:15	OK	Clear water, no odor.
Sample 19	119	Water	Well S	2023-10-26	14:30	OK	Clear water, no odor.
Sample 20	120	Water	Well T	2023-10-26	14:45	OK	Clear water, no odor.
Sample 21	121	Water	Well U	2023-10-26	15:00	OK	Clear water, no odor.
Sample 22	122	Water	Well V	2023-10-26	15:15	OK	Clear water, no odor.
Sample 23	123	Water	Well W	2023-10-26	15:30	OK	Clear water, no odor.
Sample 24	124	Water	Well X	2023-10-26	15:45	OK	Clear water, no odor.
Sample 25	125	Water	Well Y	2023-10-26	16:00	OK	Clear water, no odor.
Sample 26	126	Water	Well Z	2023-10-26	16:15	OK	Clear water, no odor.
Sample 27	127	Water	Well AA	2023-10-26	16:30	OK	Clear water, no odor.
Sample 28	128	Water	Well AB	2023-10-26	16:45	OK	Clear water, no odor.
Sample 29	129	Water	Well AC	2023-10-26	17:00	OK	Clear water, no odor.
Sample 30	130	Water	Well AD	2023-10-26	17:15	OK	Clear water, no odor.
Sample 31	131	Water	Well AE	2023-10-26	17:30	OK	Clear water, no odor.
Sample 32	132	Water	Well AF	2023-10-26	17:45	OK	Clear water, no odor.
Sample 33	133	Water	Well AG	2023-10-26	18:00	OK	Clear water, no odor.
Sample 34	134	Water	Well AH	2023-10-26	18:15	OK	Clear water, no odor.
Sample 35	135	Water	Well AI	2023-10-26	18:30	OK	Clear water, no odor.
Sample 36	136	Water	Well AJ	2023-10-26	18:45	OK	Clear water, no odor.
Sample 37	137	Water	Well AK	2023-10-26	19:00	OK	Clear water, no odor.
Sample 38	138	Water	Well AL	2023-10-26	19:15	OK	Clear water, no odor.
Sample 39	139	Water	Well AM	2023-10-26	19:30	OK	Clear water, no odor.
Sample 40	140	Water	Well AN	2023-10-26	19:45	OK	Clear water, no odor.
Sample 41	141	Water	Well AO	2023-10-26	20:00	OK	Clear water, no odor.
Sample 42	142	Water	Well AP	2023-10-26	20:15	OK	Clear water, no odor.
Sample 43	143	Water	Well AQ	2023-10-26	20:30	OK	Clear water, no odor.
Sample 44	144	Water	Well AR	2023-10-26	20:45	OK	Clear water, no odor.
Sample 45	145	Water	Well AS	2023-10-26	21:00	OK	Clear water, no odor.
Sample 46	146	Water	Well AT	2023-10-26	21:15	OK	Clear water, no odor.
Sample 47	147	Water	Well AU	2023-10-26	21:30		



NO.5 P-2

Image

SEM

### Magnification

$\times 1000$

## Element

Line

Acc.Volt. \_\_\_\_\_ kV

Current  $\times 10^{-7}$  A

F.S. \_\_\_\_\_ cps

TC \_\_\_\_\_ sec

### NOTE

[illegible]

No. 5 P-3

Image

## SEM

### Magnification

 $\times 1000$ 

Element

Line

Acc.Volt. \_\_\_\_\_ kV

Current \_\_\_\_\_  $\times 10$  A.

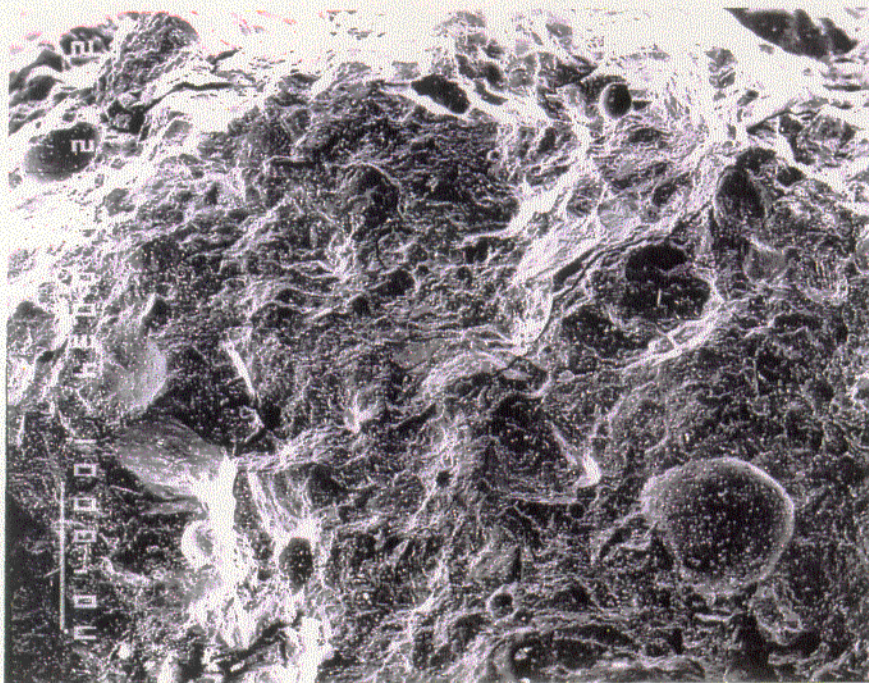
F.S. \_\_\_\_\_ cps.

T.C. \_\_\_\_\_ sec.

## NOTE







Sample Name

NO.10 (20cm)

Image

SEM

Magnification

X20

△ 10000

Element

Line

Acc.Volt. kV.

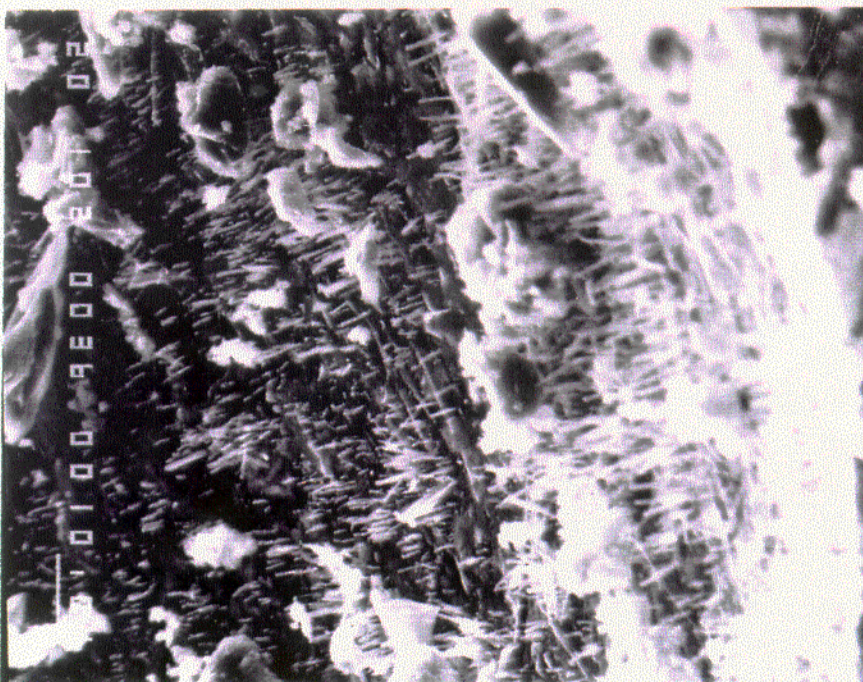
Current  $\times 10^{-10}$  A.

F.S. cps.

T.C. sec.

NOTE

			P-2
	P-3		P-1



Sample Name

No-10 (20cm) P-2

Image

SEM

Magnification

X1000

Element

Line

Acc.Volt. kV.

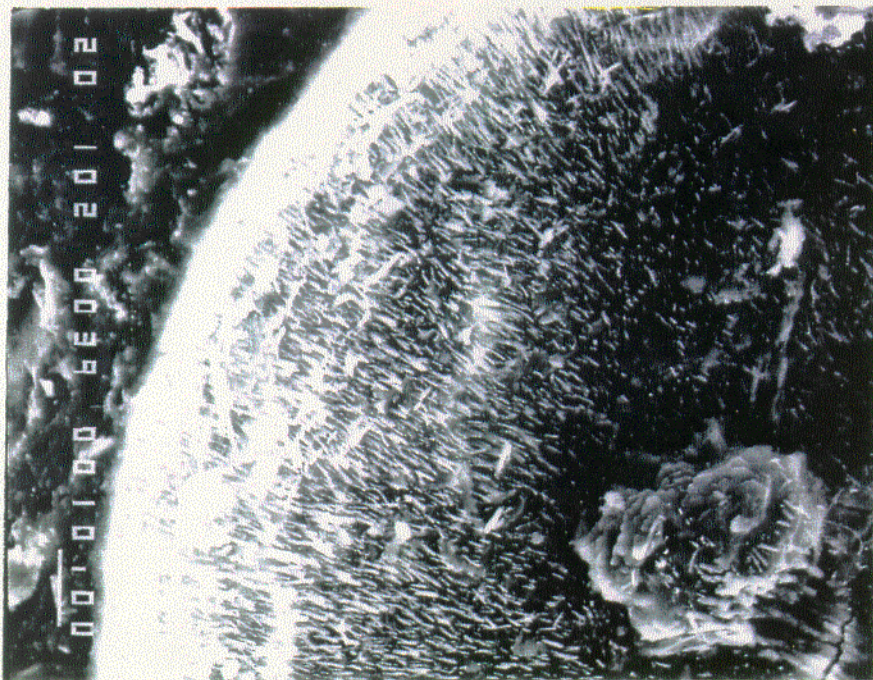
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F.S. cps.

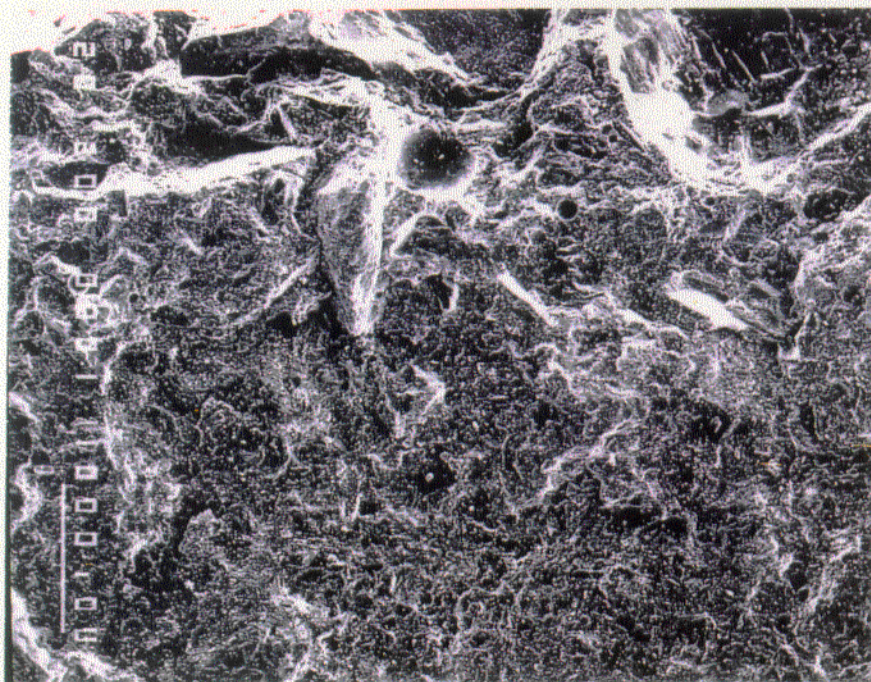
T.C. sec.

NOTE









Sample Name

NO.5 (10cm)

Image

SEM

Magnification

X20

全体像

Element

Line

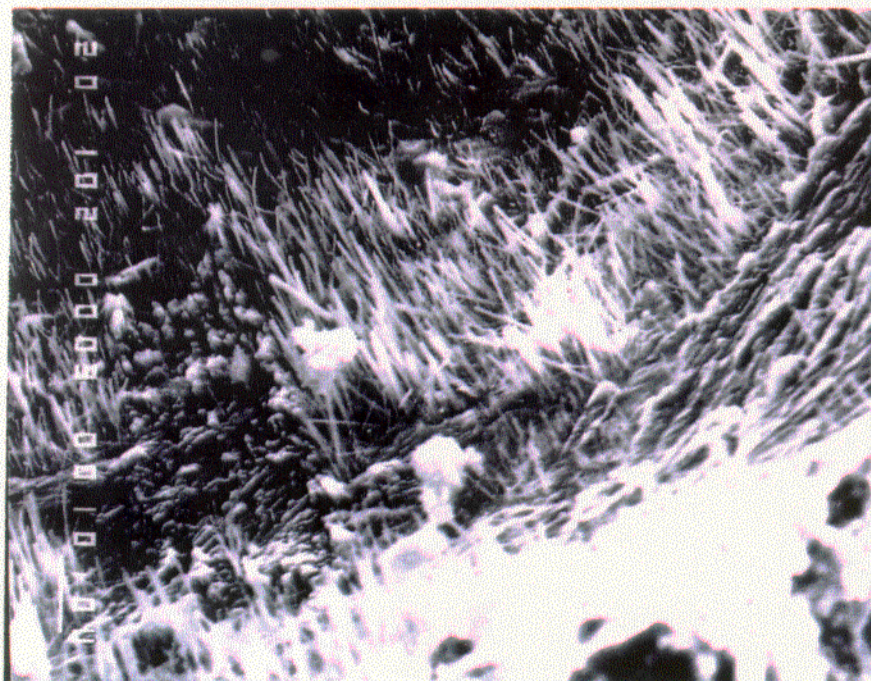
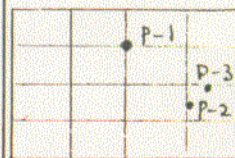
Acc.Volt. kV

Current  $\times 10$  A

F.S. cps

T.C. sec

NOTE



Sample Name

No.5 (10cm) p-1

Image

SEM

Magnification

X1000

Element

Line

Acc.Volt. kV

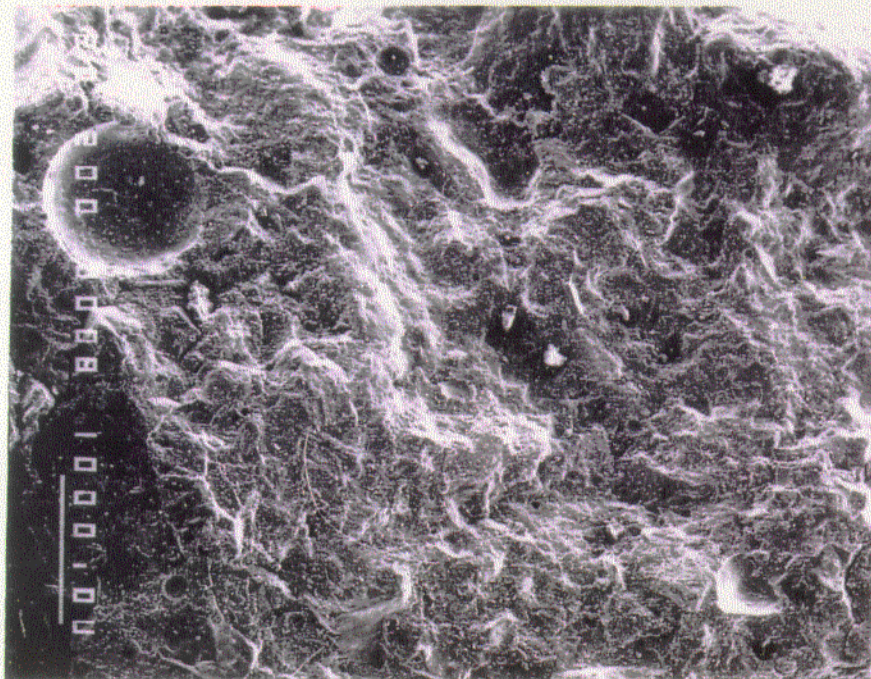
Current  $\times 10$  A

F.S. cps

T.C. sec

NOTE





Sample Name

NO. 18 (40cm)

Image

SEM

Magnification

X20

全生像

Element

Line

Acc Volt kV

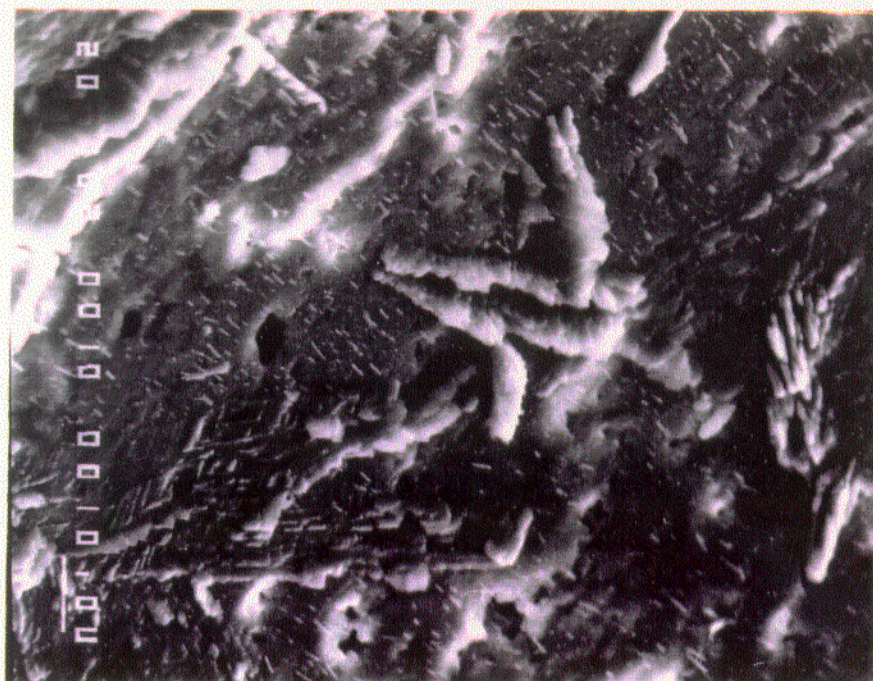
Current  $\times 10^{-8}$  A

F.S. cps

T.C. sec

NOTE

P-1			
P-3			



Sample Name

NO 18 a P-1

Image

SEM

Magnification

X 1000

Element

Line

Acc Volt kV

Current  $\times 10^{-8}$  A

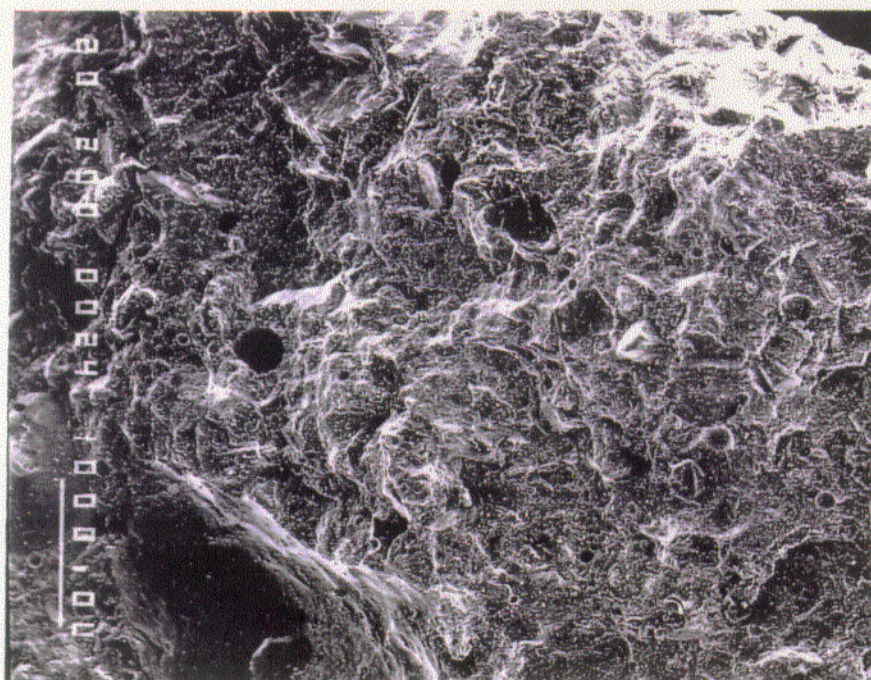
F.S. cps

T.C. sec

NOTE



8/16



Sample Name

NO.15 (30<sup>cm</sup>)

Image

SEM

Magnification

X 20

全生体

Element

Line

Acc.Volt kV

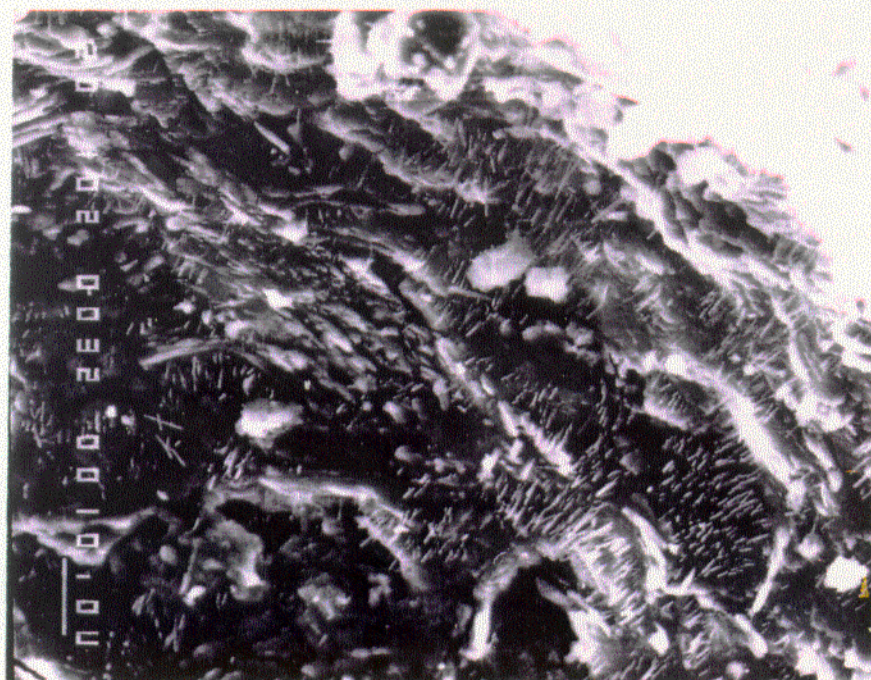
Current 10 A

F.S. cps

T.C. sec

NOTE

P-3		P-1
		P-2



Sample Name

No-15 (30<sup>cm</sup>) P-3

Image

Magnification

Element

Line

Acc.Volt kV

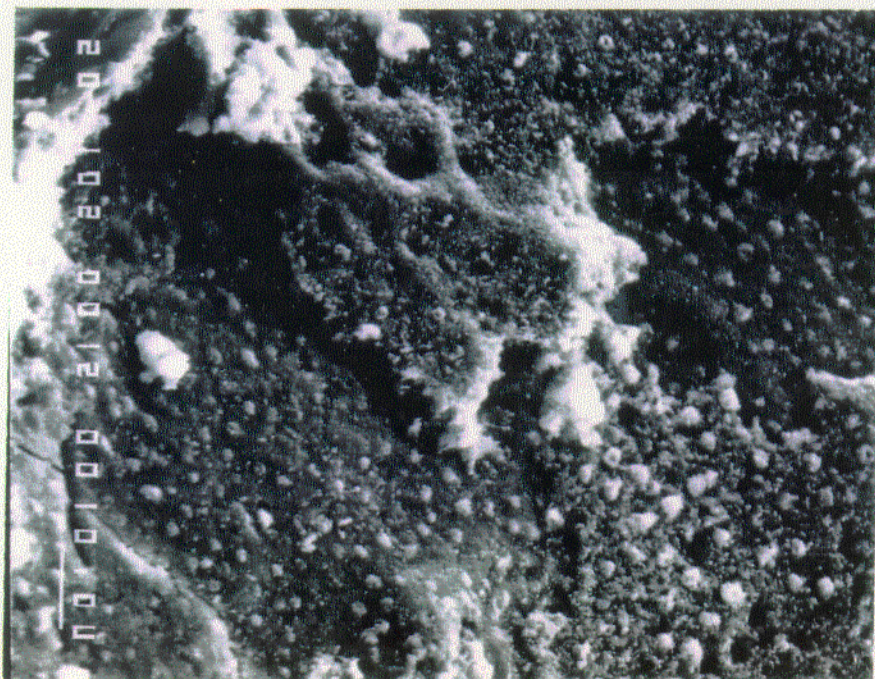
Current 10 A

F.S. cps

T.C. sec

NOTE





Sample Name

NO 18 a P-2

Image

SEM

Magnification

X1000

Element

Line

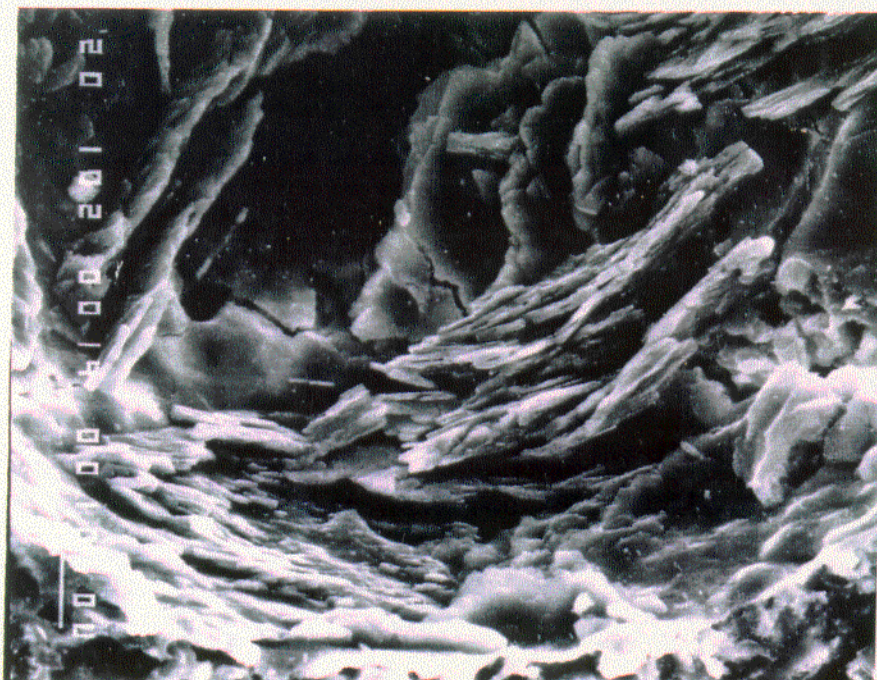
Acc.Volt. kV

Current  $\times 10^{-8}$  A

F.S. cps

T.C. sec

NOTE



Sample Name

No. 18 - P-3

Image

SEM

Magnification

X1000

Element

Line

Acc.Volt. kV

Current  $\times 10^{-8}$  A

F.S. cps

T.C. sec

NOTE



