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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^2

(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.

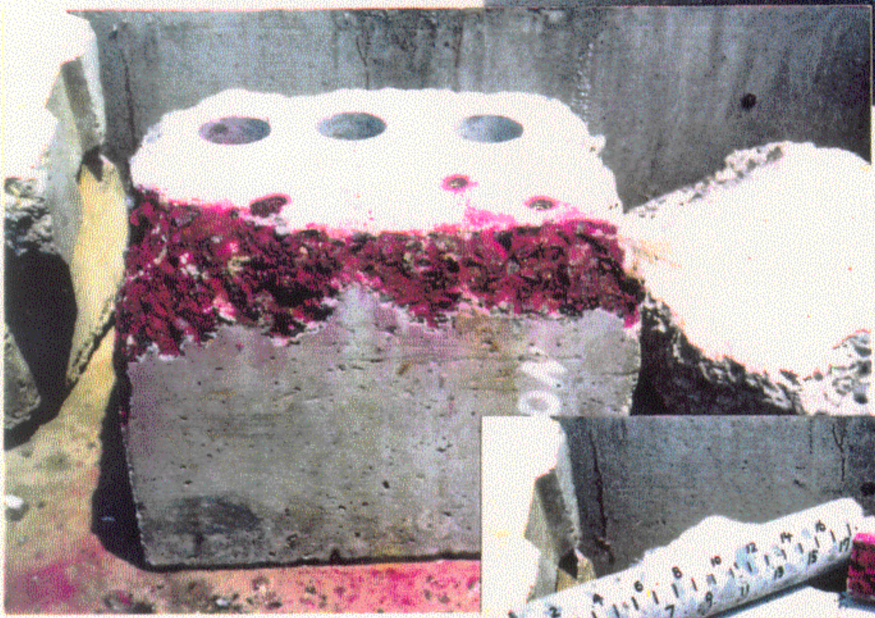
Figure-4. State of crystal growth at a depth of 20cm from surface.

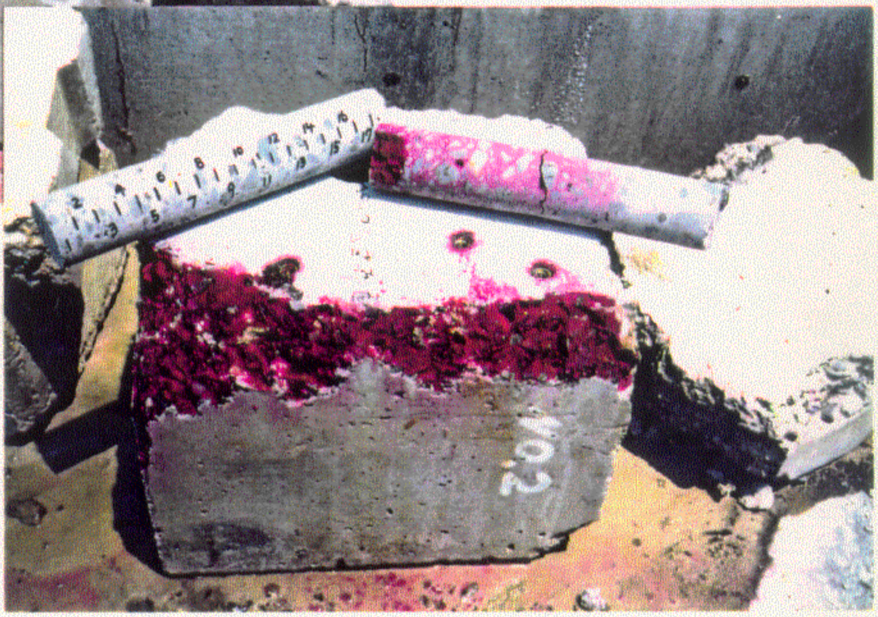
Figure-5. State of crystal growth at a depth of 30cm from surface.

Figure-6. State of crystal at a depth of 10cm from surface in the non-applicated 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:mutiplicative
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





1) 打設2日後 脱型
2) 水洗後表乾状態でXC上塗塗布
3) 2日 乾燥
4) 湿布×7日間養生
5) 以後は屋外放置 (3年間)

赤色は中性化していない フェノールフタレインによる発色

Sample Name

NO.5 P-2

Image

SEM

Magnification

X1000

Element

Line

Acc.Volt. kV

Current × 10 A

F.S. cps

T.C. sec

NOTE

Sample Name

No.5 P-3

Image

SEM

Magnification

X1000

Element

Line

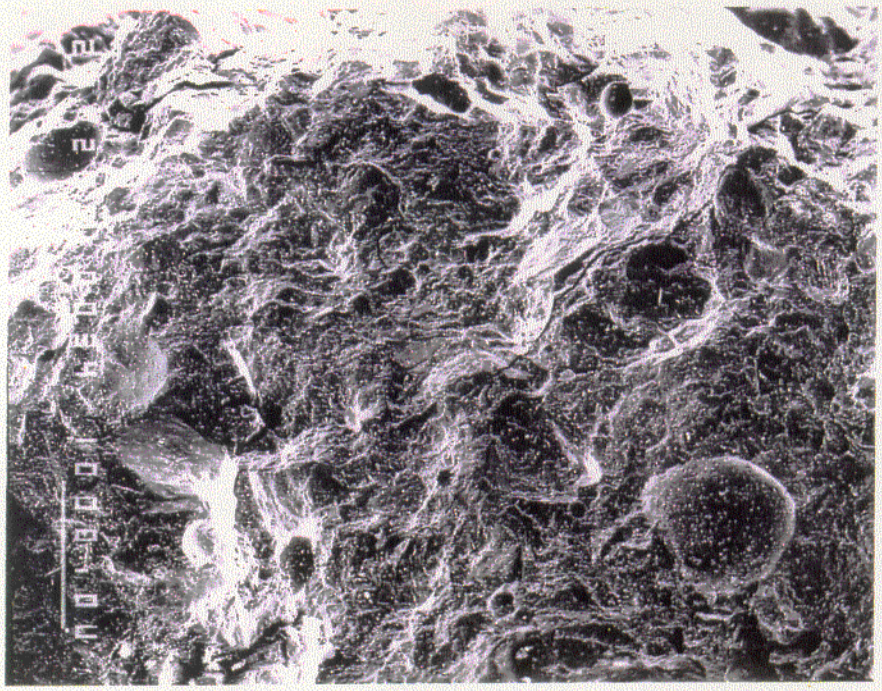
Acc.Volt. kV

Current × 10 A

F.S. cps

T.C. sec

NOTE



Sample Name

No.10 (20cm)

Image

SEM

Magnification

×20

Element

Line

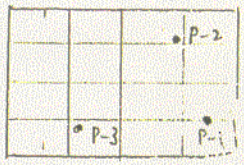
Acc.Volt. kV.

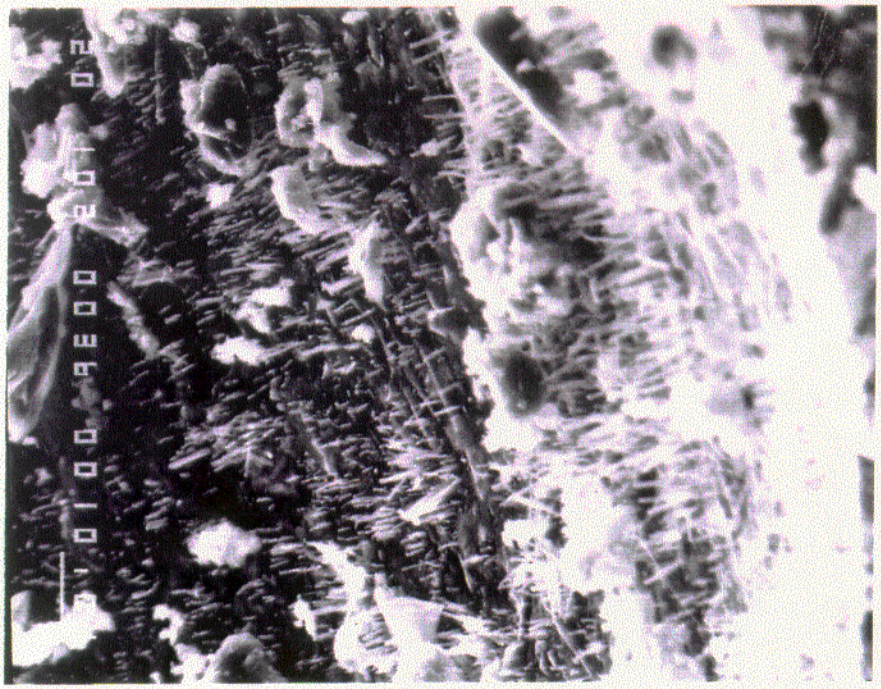
Current ×10 A.

F.S. cps.

T.C. sec.

NOTE





Sample Name

No-10 (20cm) P-2

Image

SEM

Magnification

×1000

Element

Line

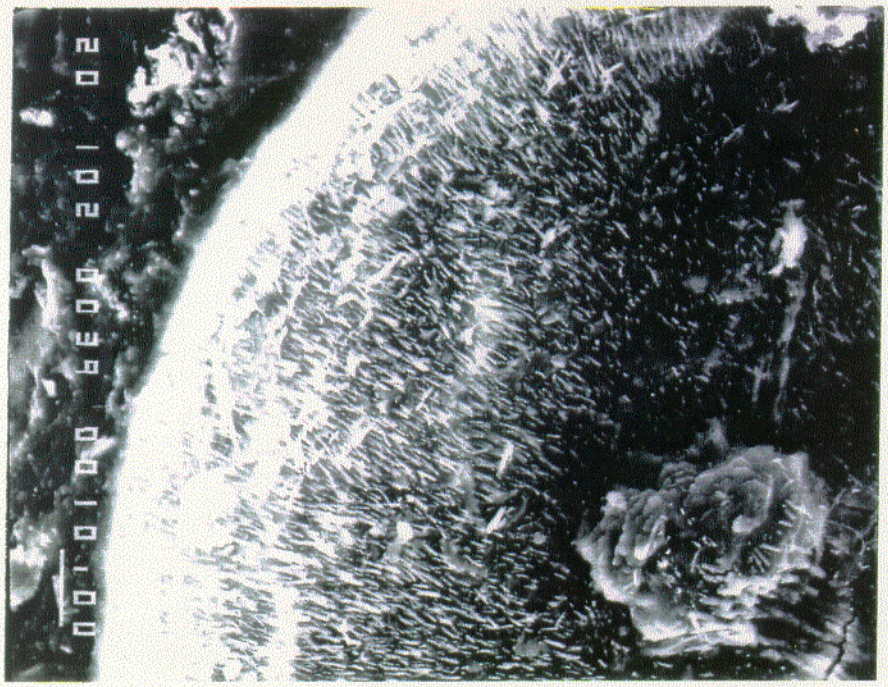
Acc.Volt. kV.

Current ×10 A.

F.S. cps.

T.C. sec.

NOTE



Sample Name

NO.10 9 P-2

Image

SEM

Magnification

×1000

Element

Line

Acc.Volt. kV

Current × 10 A

F.S. cps

T.C. sec

NOTE

Sample Name

NO.10 9 P-3

Image

SEM

Magnification

×1000

Element

Line

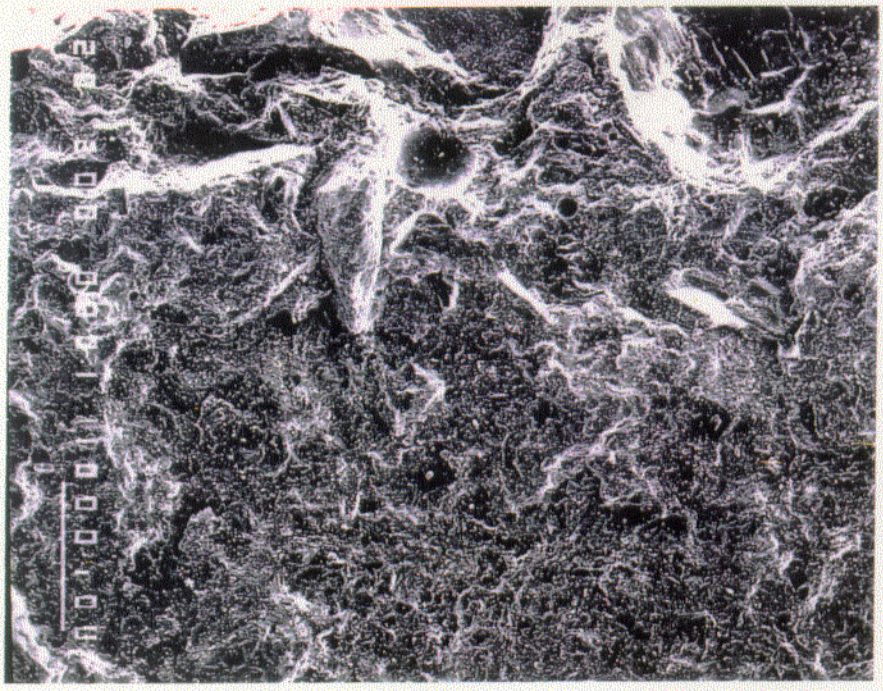
Acc.Volt. kV

Current × 10 A

F.S. cps

T.C. sec

NOTE



Sample Name

NO.5 (10cm)

Image

SEM

Magnification

X20

全体図

Element

Line

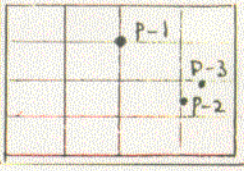
Acc.Volt kV

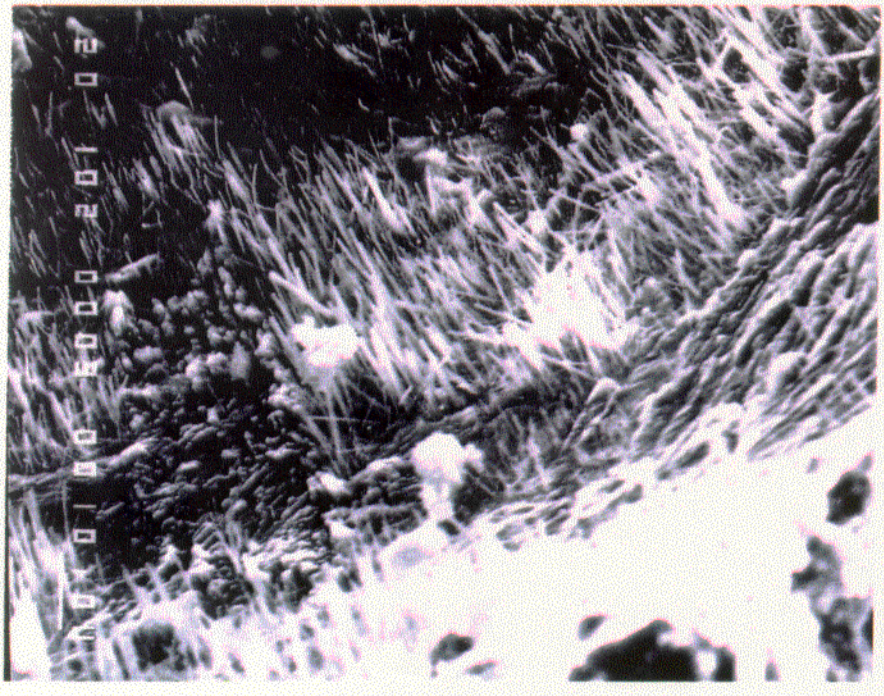
Current × 10 A

F.S. cps

T.C. sec

NOTE





Sample Name

No.5 (10cm) P-1

Image

SEM

Magnification

×1000

Element

Line

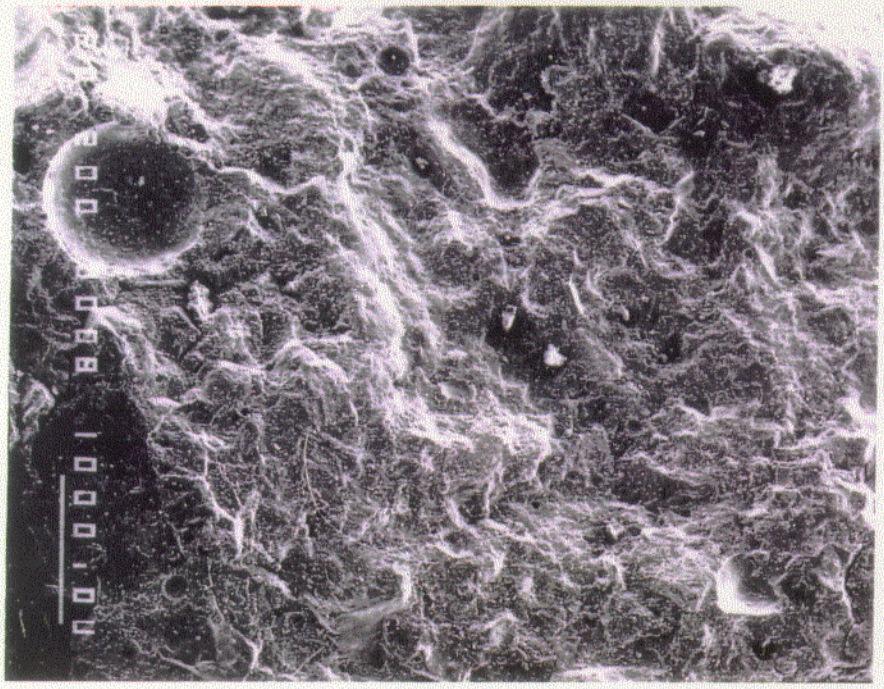
Acc.Volt kV.

Current × 10 A.

F.S. cps.

T.C. sec.

NOTE



Sample Name

NO. 18 (40cm)

Image

SEM

Magnification

X20

Element

Line

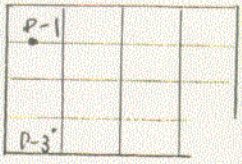
Acc.Volt kV

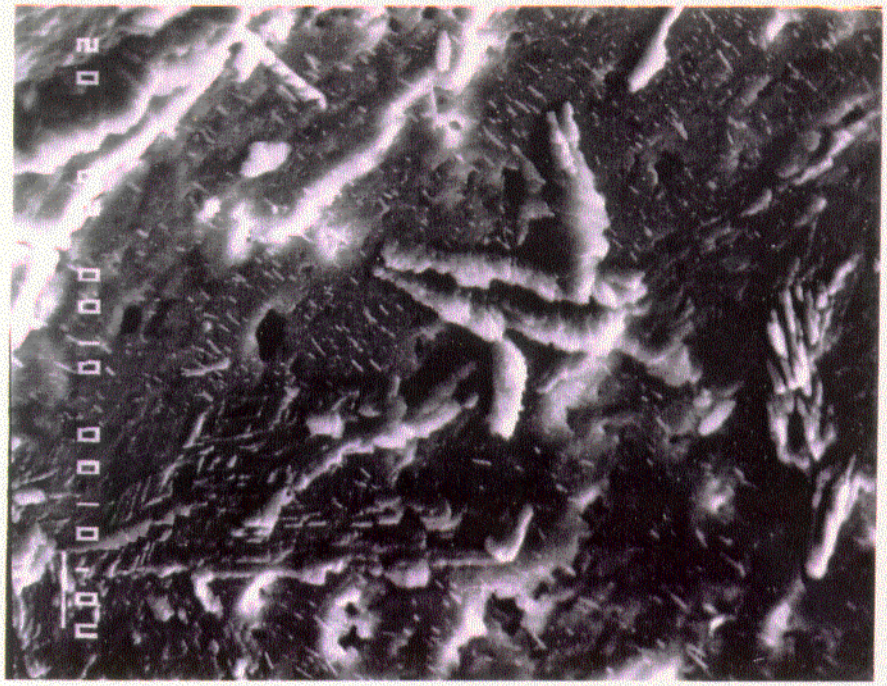
Current ×10 A

F.S. cps

T.C sec

NOTE





Sample Name

NO 18 P-1

Image

SEM

Magnification

X 1000

Element

Line

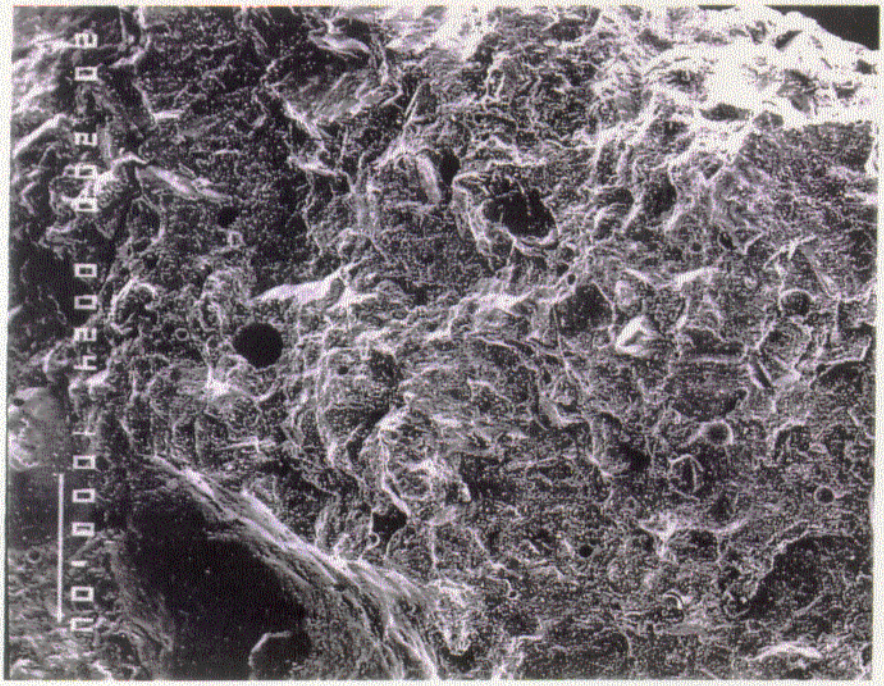
Acc.Volt kV

Current ×10 A

F.S. cps

T.C sec

NOTE



Sample Name

NO.15 (30cm)

Image

SEM

Magnification

×20

Element

Line

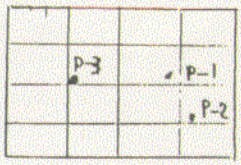
Acc.Volt kV

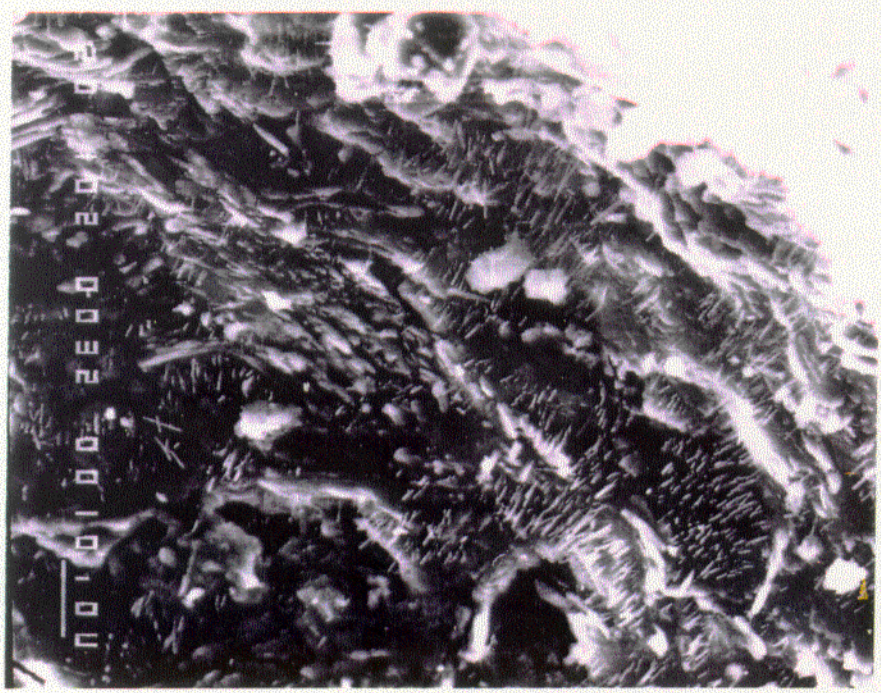
Current ×10 A

F.S. cps

T.C. sec

NOTE





Sample Name

No-15 (30cm) P-3

Image

Magnification

Element

Line

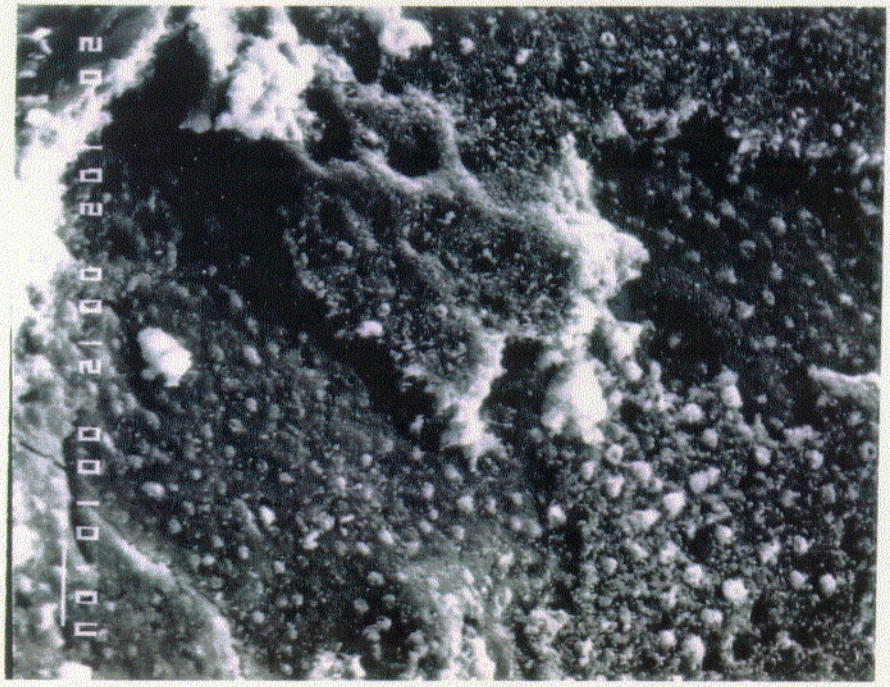
Acc.Volt kV

Current ×10 A

F.S. cps

T.C. sec

NOTE



Sample Name

NO18 a P-2

Image

SEM

Magnification

×1000

Element

Line

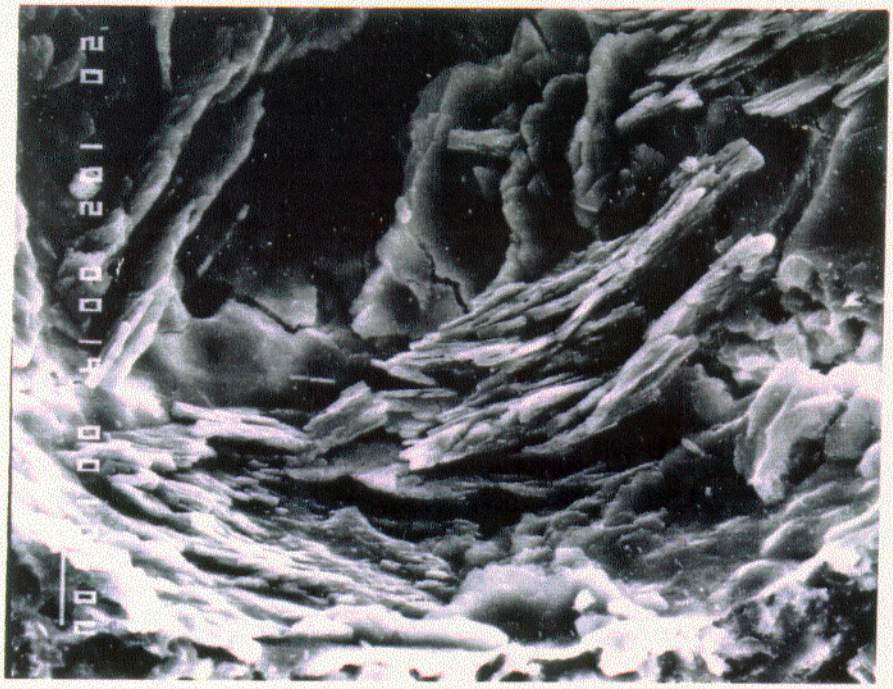
Acc.Volt kV

Current × 10⁻ A

F.S. cps

T.C. sec

NOTE



Sample Name

No.18 - P-3

Image

SEM

Magnification

×1000

Element

Line

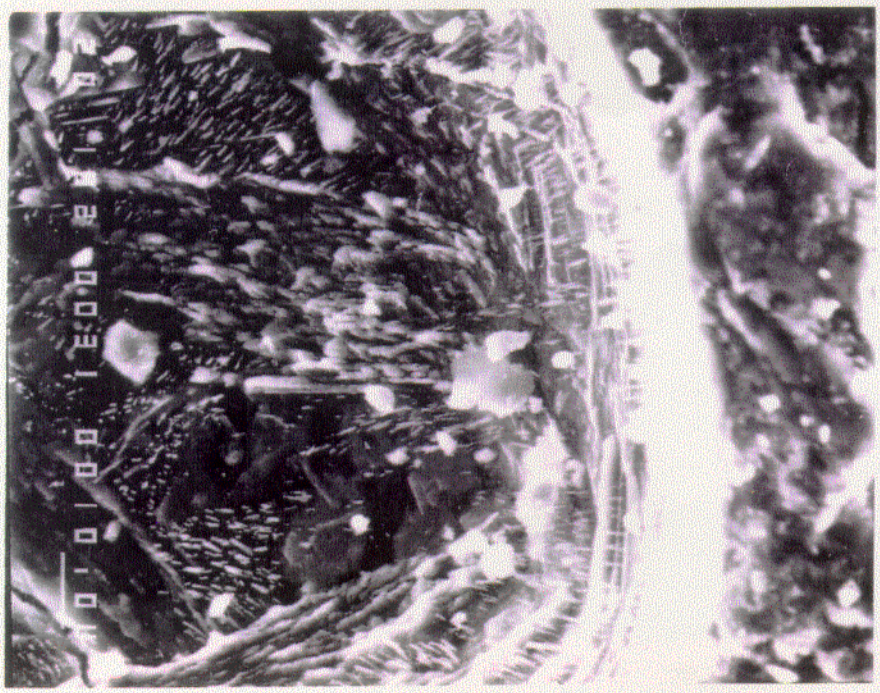
Acc.Volt kV

Current × 10⁻ A

F.S. cps

T.C. sec

NOTE



Sample Name

NO.15 P-2

Image

SEM

Magnification

x 1000

Element

Line

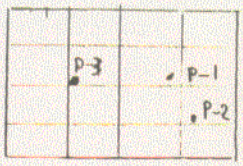
Acc Volt kV

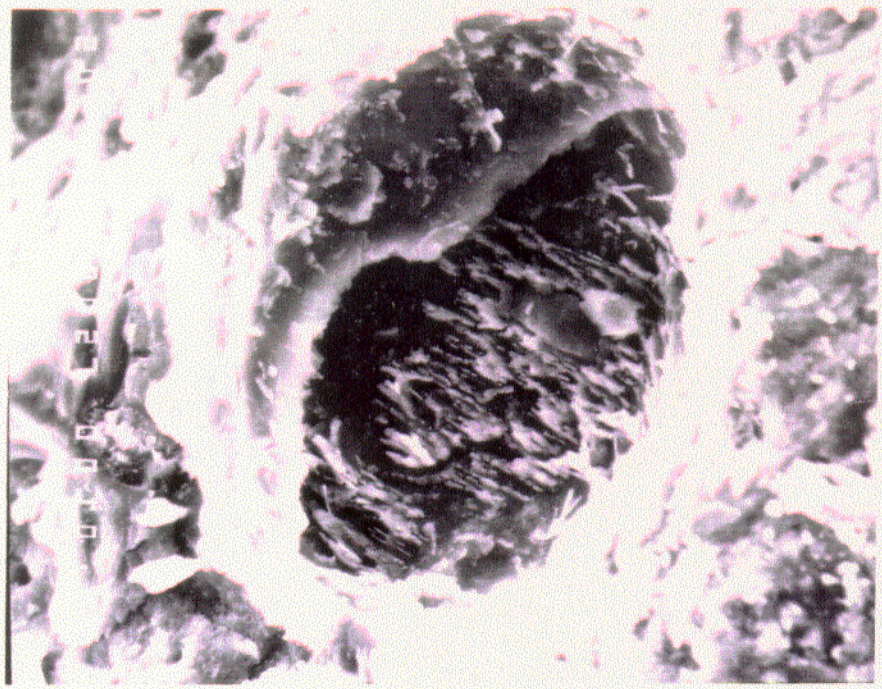
Current $\times 10^{-}$ A

F.S. cps

T.C sec

NOTE





Sample Name

NO.15 P-1

Image

SEM

Magnification

x 1000

Element

Line

Acc Volt kV

Current $\times 10^{-}$ A

F.S. cps.

T.C sec.

NOTE