

PLATES 17a and 17b ILLUSTRATE SURFACES FOLLOWING
THE CAVITRON ULTRASONIC SCALER AT THREE QUARTER
AMPLITUDE SETTING

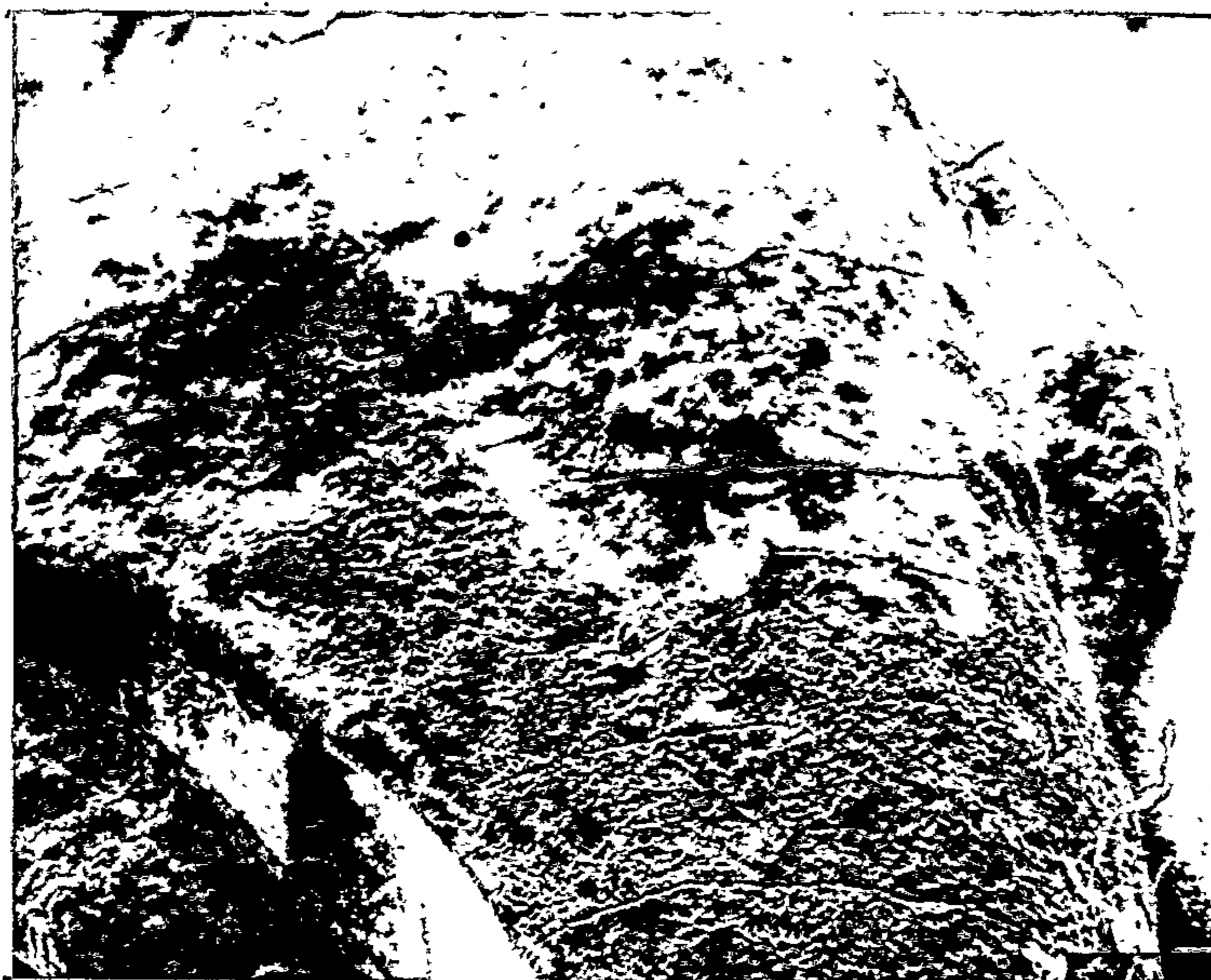


PLATE 17a (Upper Photograph) -- Infra-attachment
root surface (20x). No dentine exposed;
cementum intact.

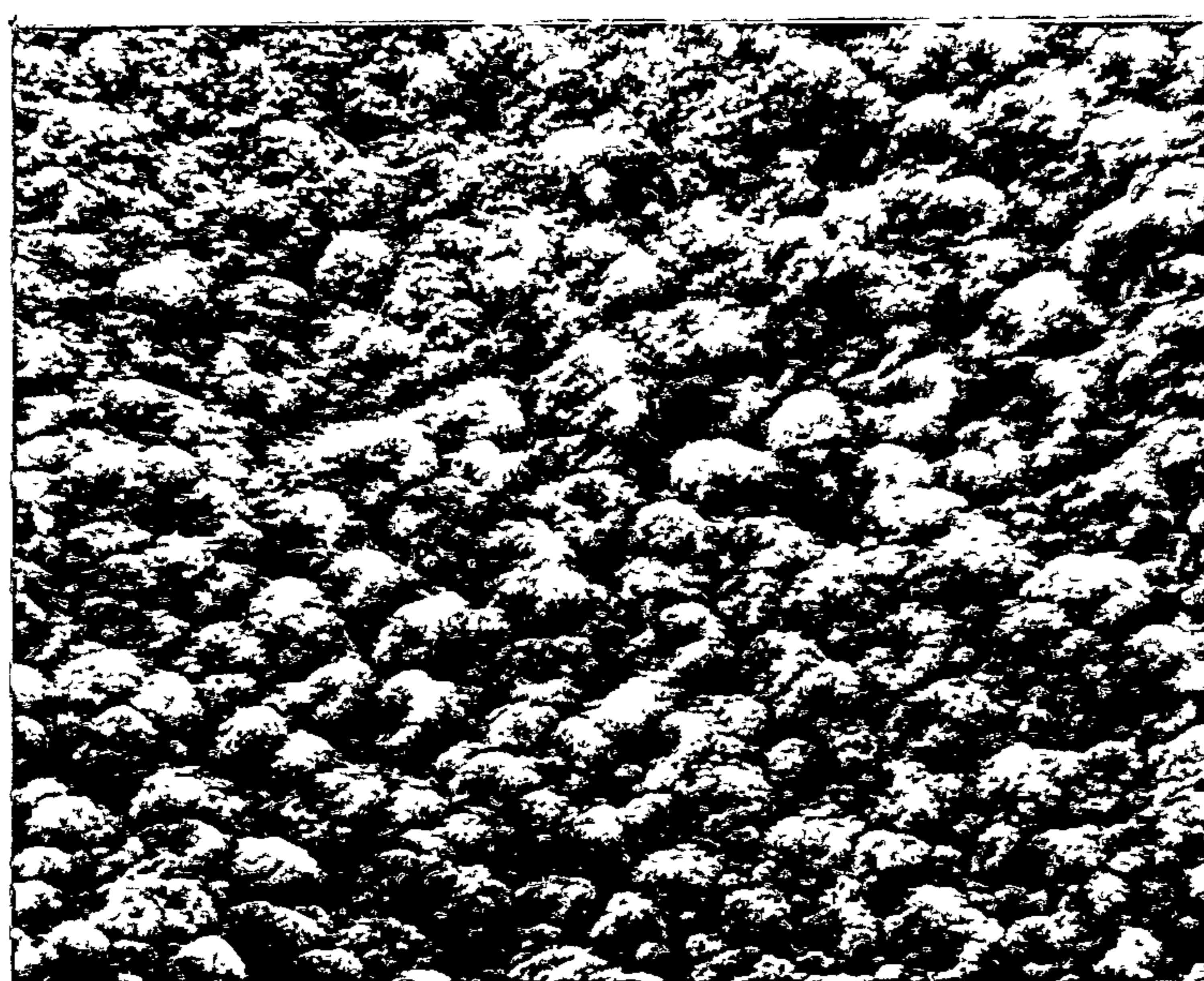


PLATE 17b (Lower Photograph) - Infra-attachment
root surface (1000x). Sharpey's fibre mounds
present.

PLATES 18a and 18b ILLUSTRATE SURFACES FOLLOWING THE CAVITRON ULTRASONIC SCALER AT THREE QUARTER AMPLITUDE SETTING.



PLATE 18a (Upper Photograph) - Supra-attachment root surface (20x). No dentine exposed; cementum intact.

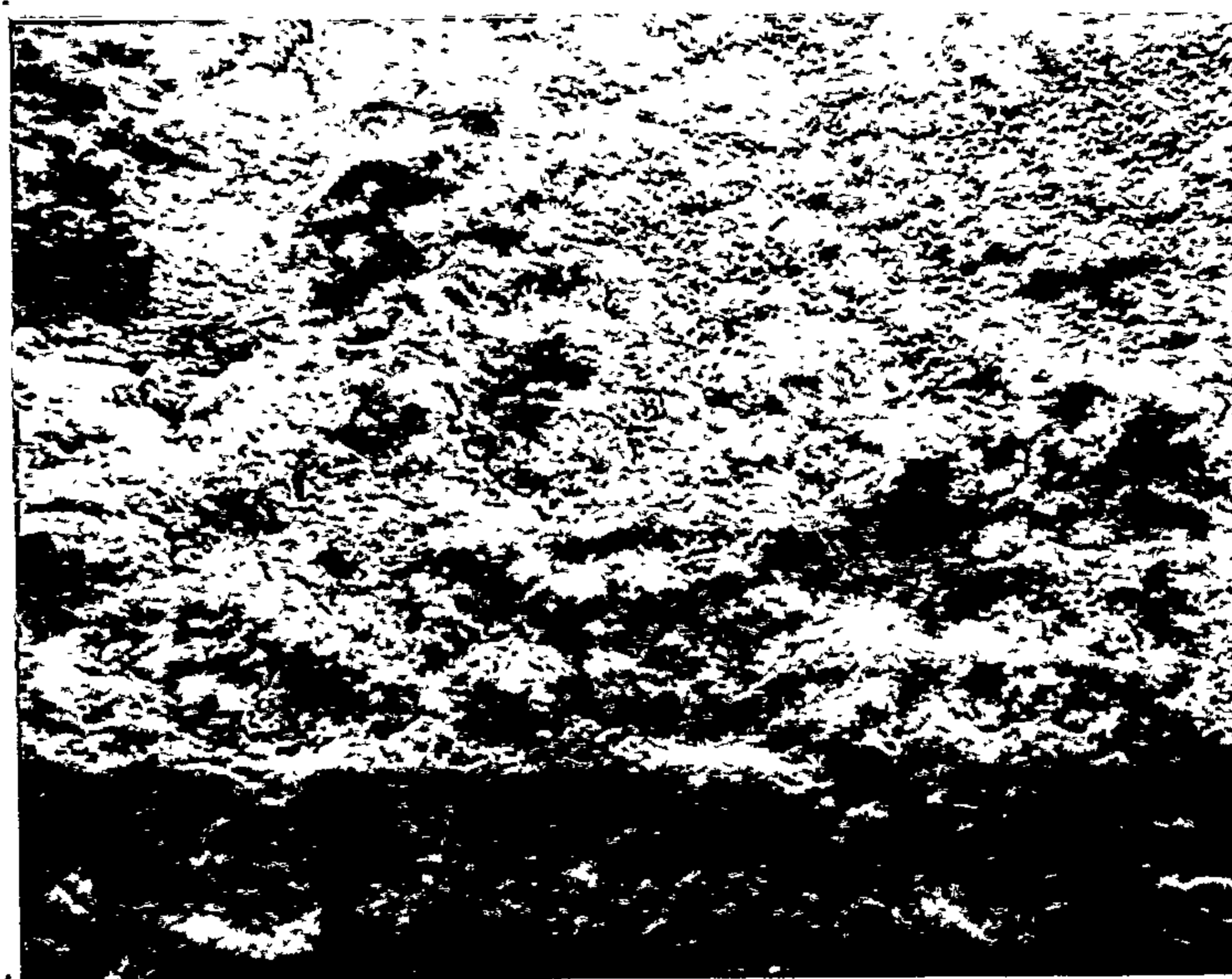


PLATE 18b (Lower Photograph) - Supra-attachment root surface (1000x). Mineralized pellicle masking underlying cementum.

PLATES 19a and 19b ILLUSTRATE SURFACES FOLLOWING
THE CAVITRON ULTRASONIC SCALER AT THREE QUARTER
AMPLITUDE SETTING.



PLATE 19a (Upper Photograph) - Acrylic surface (20x)
Little alteration to surface.

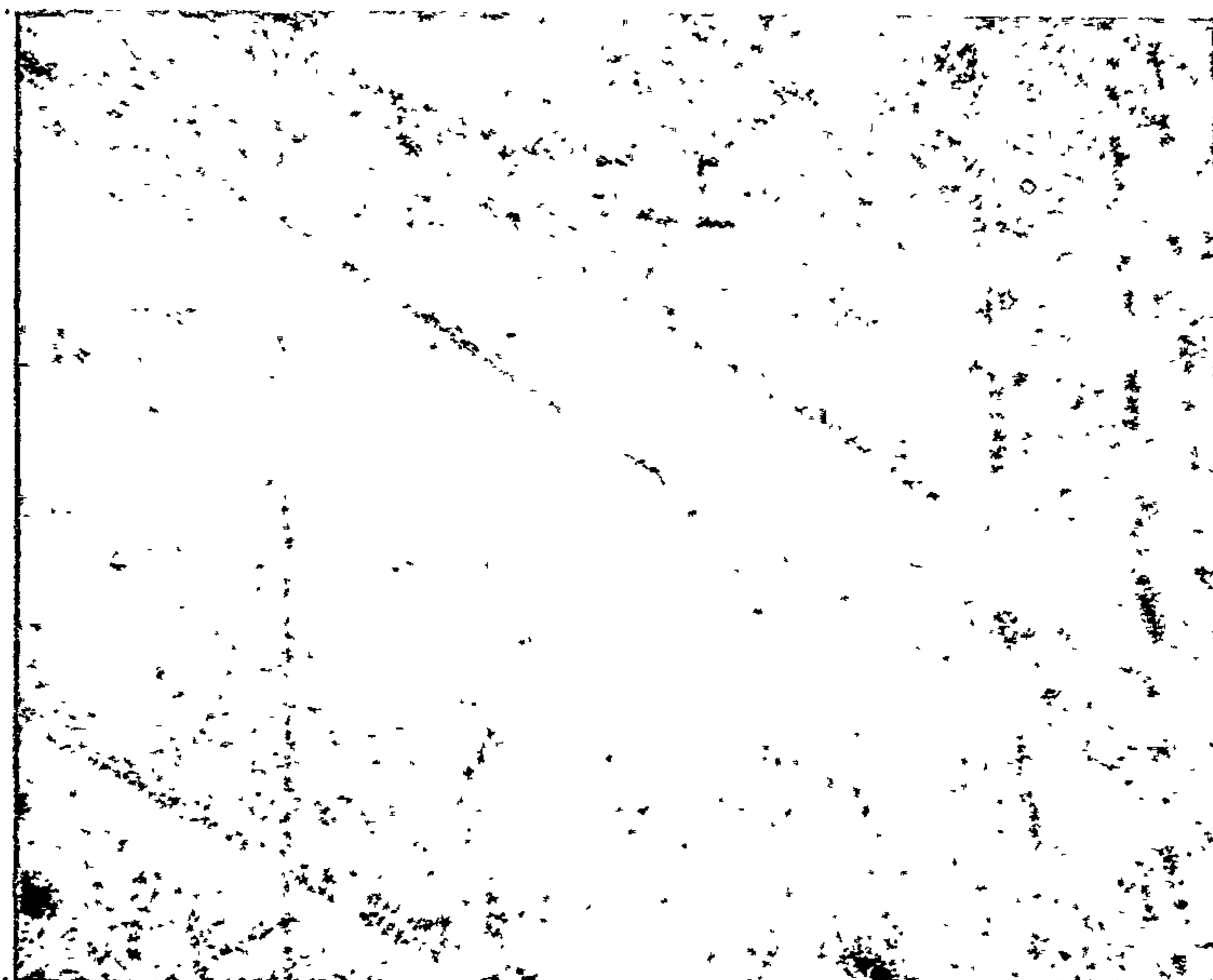


PLATE 19b (Lower Photograph) - Acrylic surface (1000x)
Shallow scratch marks occur in areas.

PLATES 20a and 20b ILLUSTRATE SURFACES FOLLOWING
THE CAVITRON ULTRASONIC SCALER AT FULL AMPLITUDE
SETTING.



PLATE 20a (Upper Photograph) - Infra-attachment
root surface (20x). Dentine exposed in large area;
surrounding areas of cementum intact.

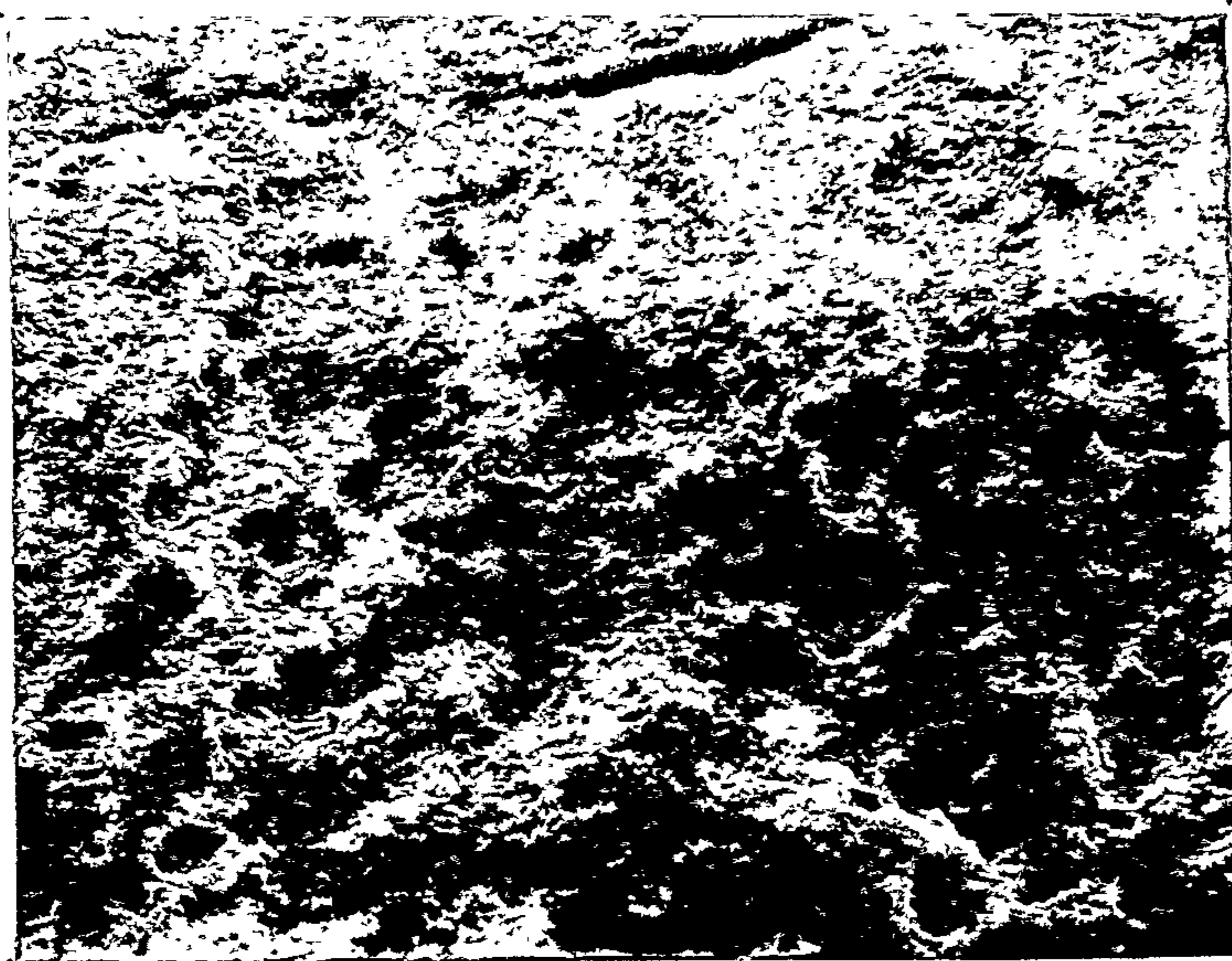


PLATE 20b (Lower Photograph) - Infra-attachment
root surface (1000x). Some shallow irregularities;
other areas relatively smooth.

PLATES 21a and 21b ILLUSTRATE SURFACES FOLLOWING THE CAVITRON ULTRASONIC SCALER AT FULL AMPLITUDE SETTING.



PLATE 21a (Upper Photograph) - Supra-attachment root surface (20x); heavy operator pressure used. Shows large area of exposed dentine; calculus is present in upper right hand corner.



PLATE 21b (Lower Photograph) - Supra-attachment root surface (1000x); heavy operator pressure used. Shallow irregularities in areas; other areas relatively smooth.

PLATES 22a and 22b ILLUSTRATE SURFACES FOLLOWING THE CAVITRON ULTRASONIC SCALER AT FULL AMPLITUDE SETTING.



PLATE 22a (Upper Photograph) - Acrylic surface (20x).

Removal of acrylic in large area; surrounding areas of acrylic intact.

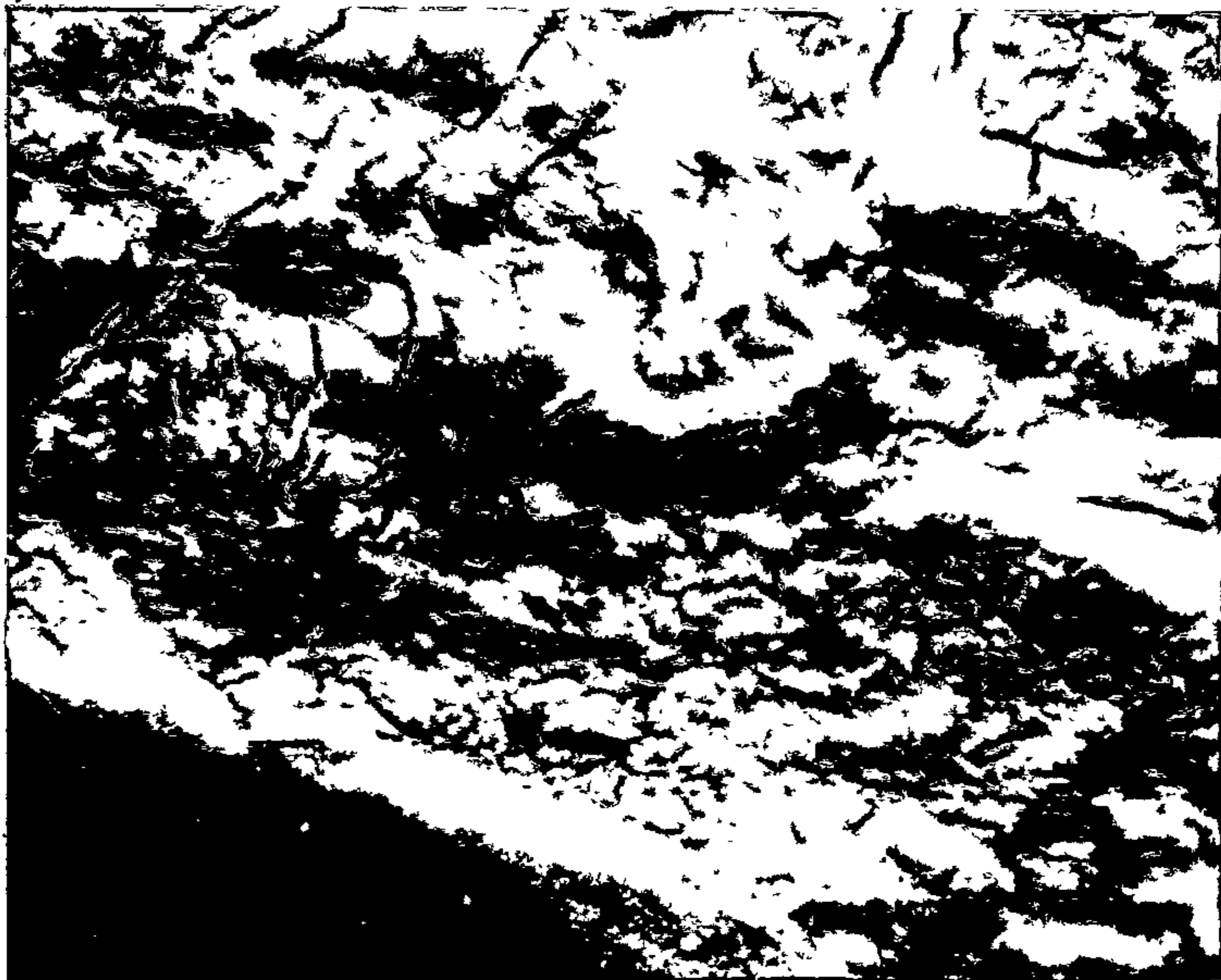


PLATE 22b (Lower Photograph) - Acrylic surface (1000x).

Shallow irregularities in areas; other areas relatively smooth.

PLATES 23a and 23b ILLUSTRATE SURFACES FOLLOWING
THE AMBENT ULTRASONIC SCALER AT THREE QUARTER
AMPLITUDE SETTING.

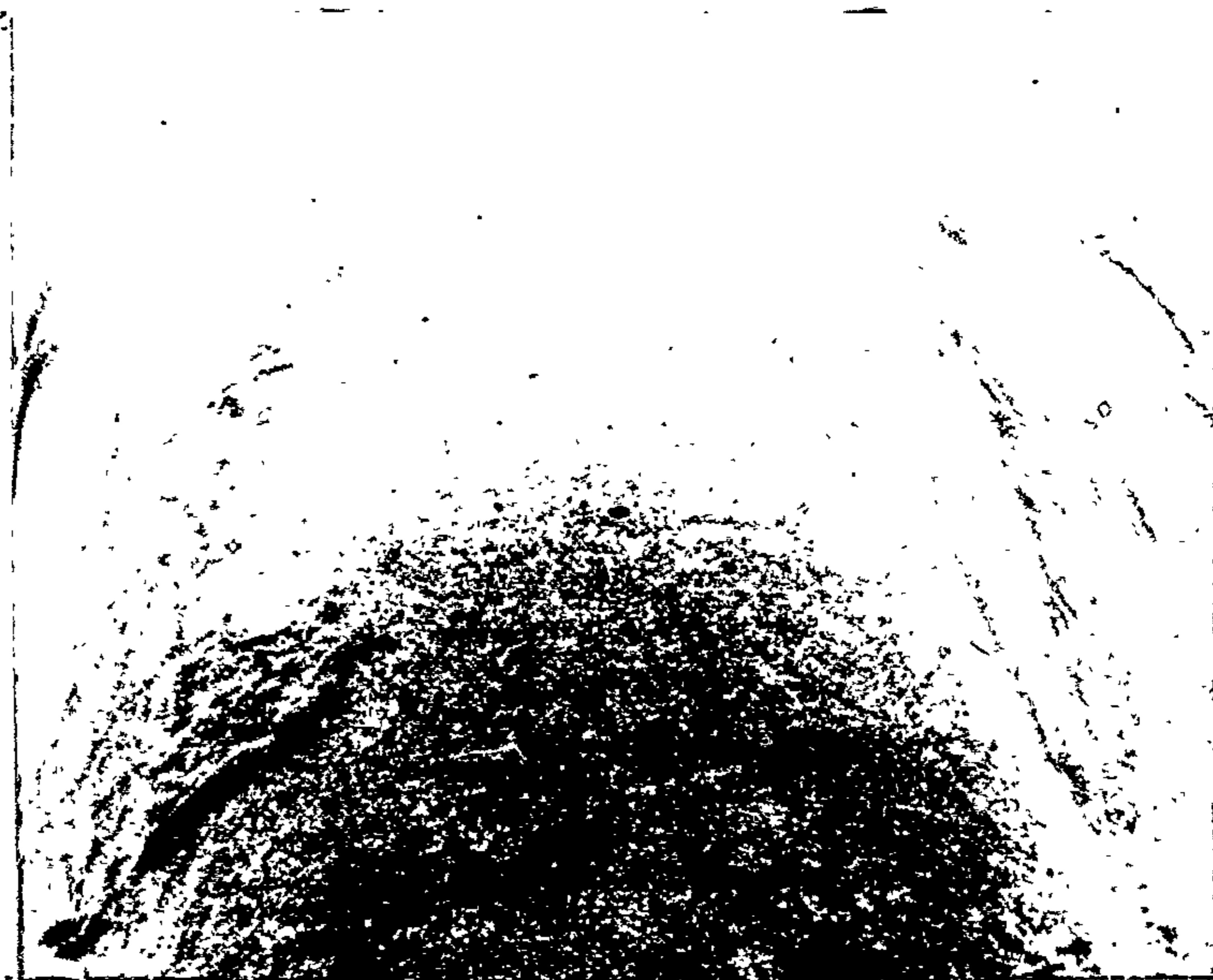


PLATE 23a (Upper Photograph) - Infra-attachment
root surface (20x). No dentine exposed;
cementum intact.

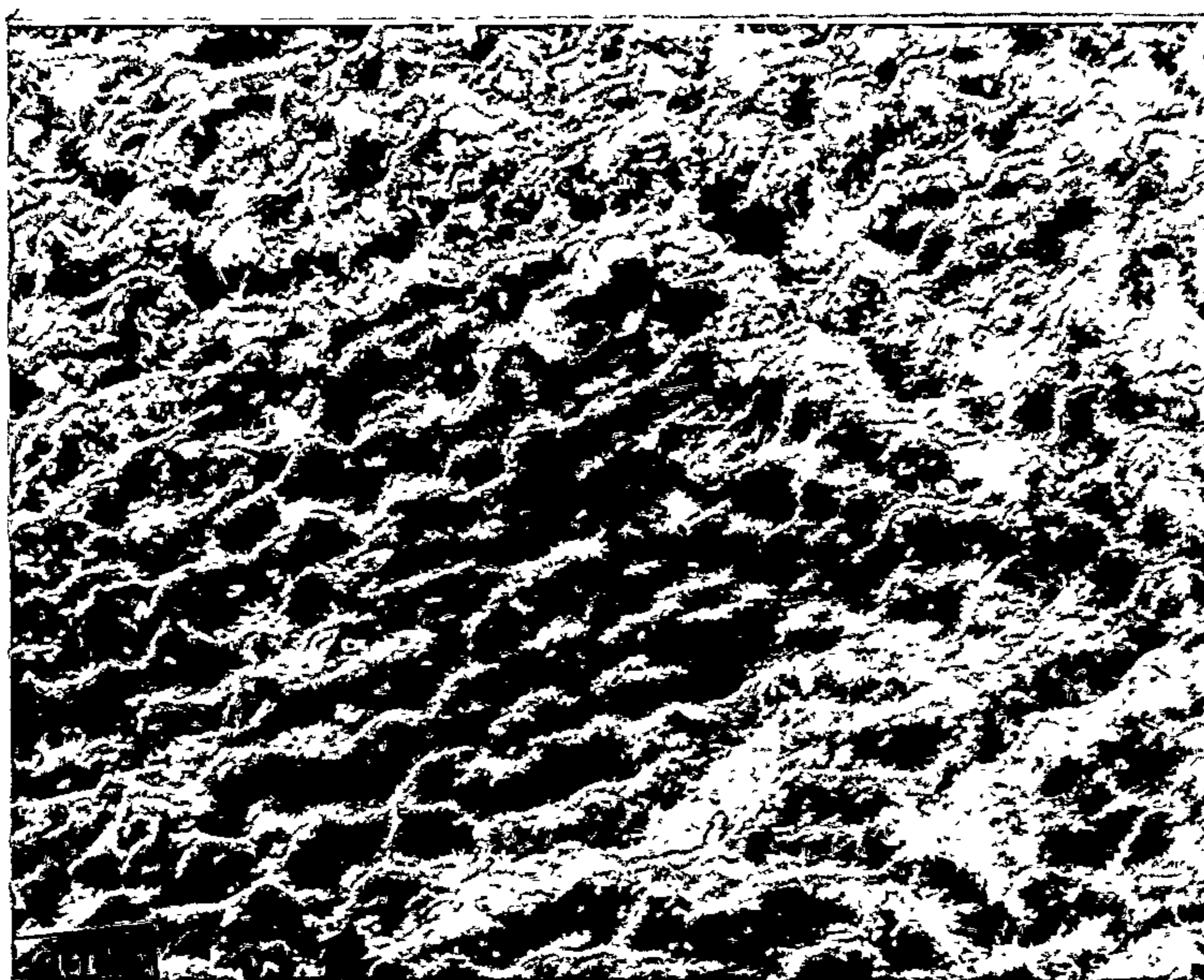


PLATE 23b (Lower Photograph) - Infra-attachment
root surface (1000x). Sharpey's fibre mounds are
present, however, slightly masked by surface fibrils.
Artefactual cracks occurred during specimen preparation.

PLATES 24a and 24b ILLUSTRATE SURFACES FOLLOWING
THE AMBENT ULTRASONIC SCALER AT THREE QUARTER
AMPLITUDE SETTING.

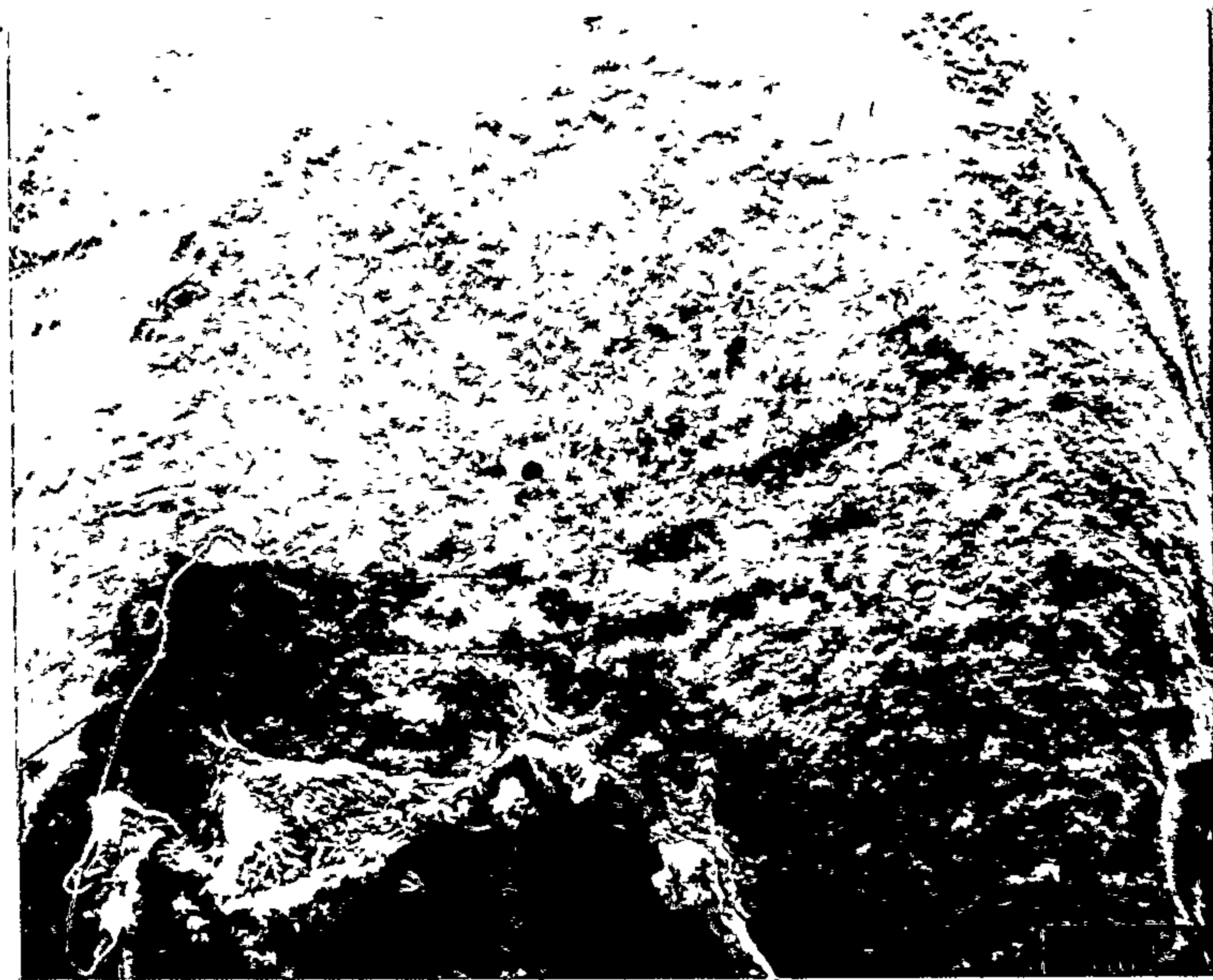


PLATE 24a (Upper Photograph) - Supra-attachment
root surface (20x). No dentine exposed;
cementum intact.

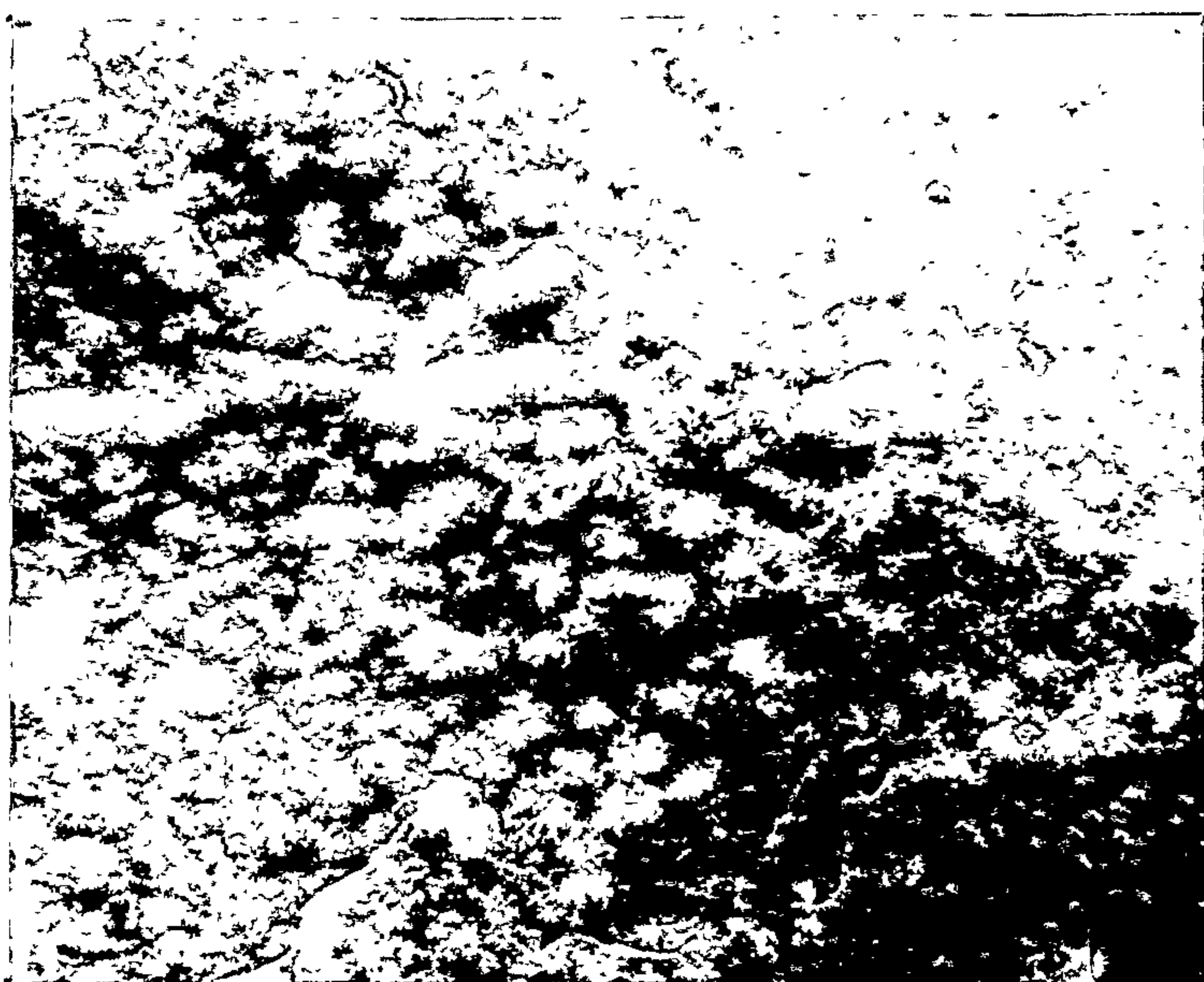


PLATE 24b (Lower Photograph) - Supra-attachment root
surface (1000x). Mineralized pellicle (upper right
of picture) masking underlying cementum.

PLATES 25a and 25b ILLUSTRATE SURFACES FOLLOWING
THE AMDENT ULTRASONIC SCALER AT THREE QUARTER
AMPLITUDE SETTING.



PLATE 25a (Upper Photograph) - Acrylic surface (20x).
Little alteration to surface.

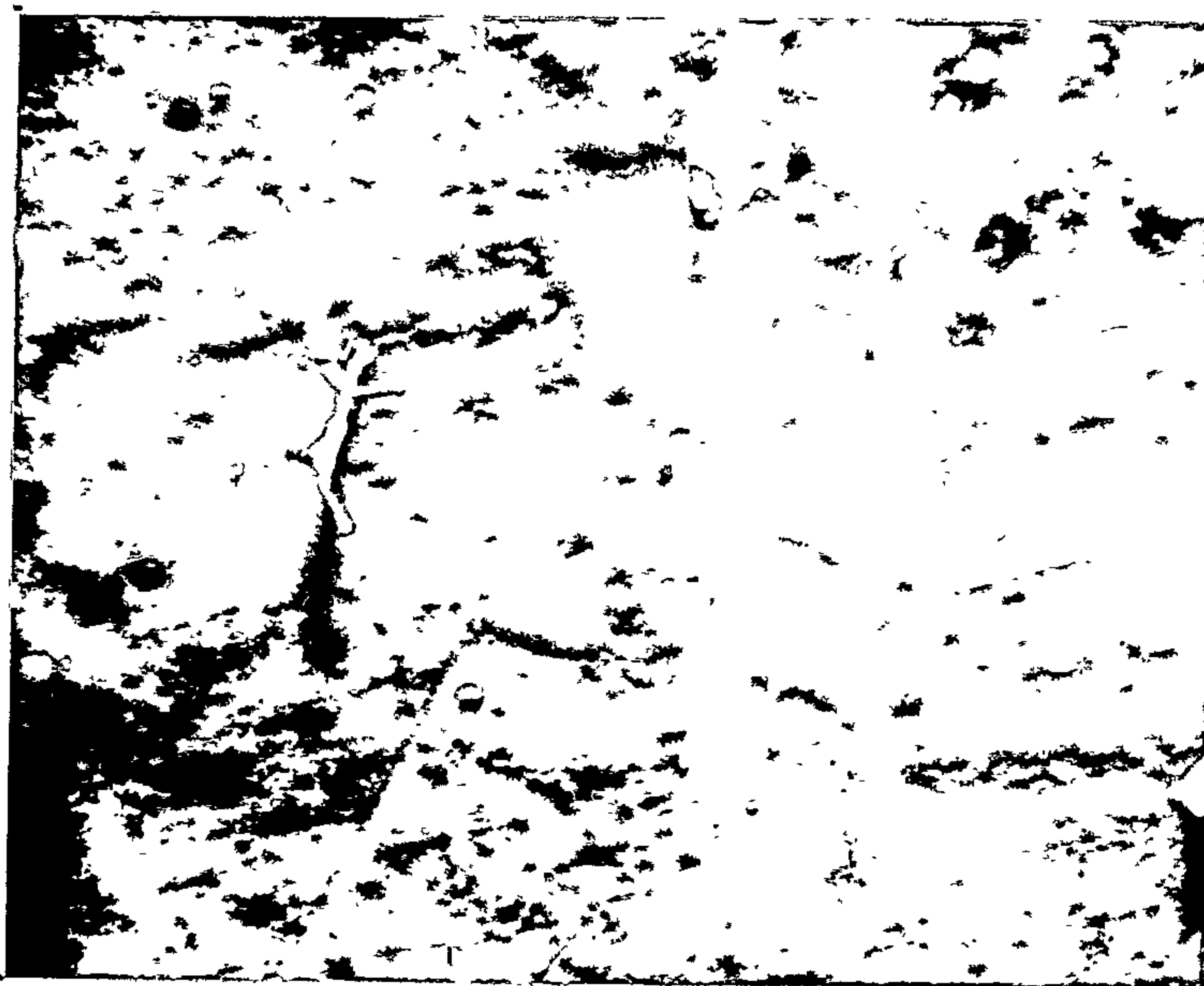


PLATE 25b (Lower Photograph) - Acrylic surface (1000x).
Shallow scratch marks occur in areas.

PLATES 26a and 26b ILLUSTRATE SURFACES FOLLOWING
THE AMBENT ULTRASONIC SCALER AT FULL AMPLITUDE
SETTING.

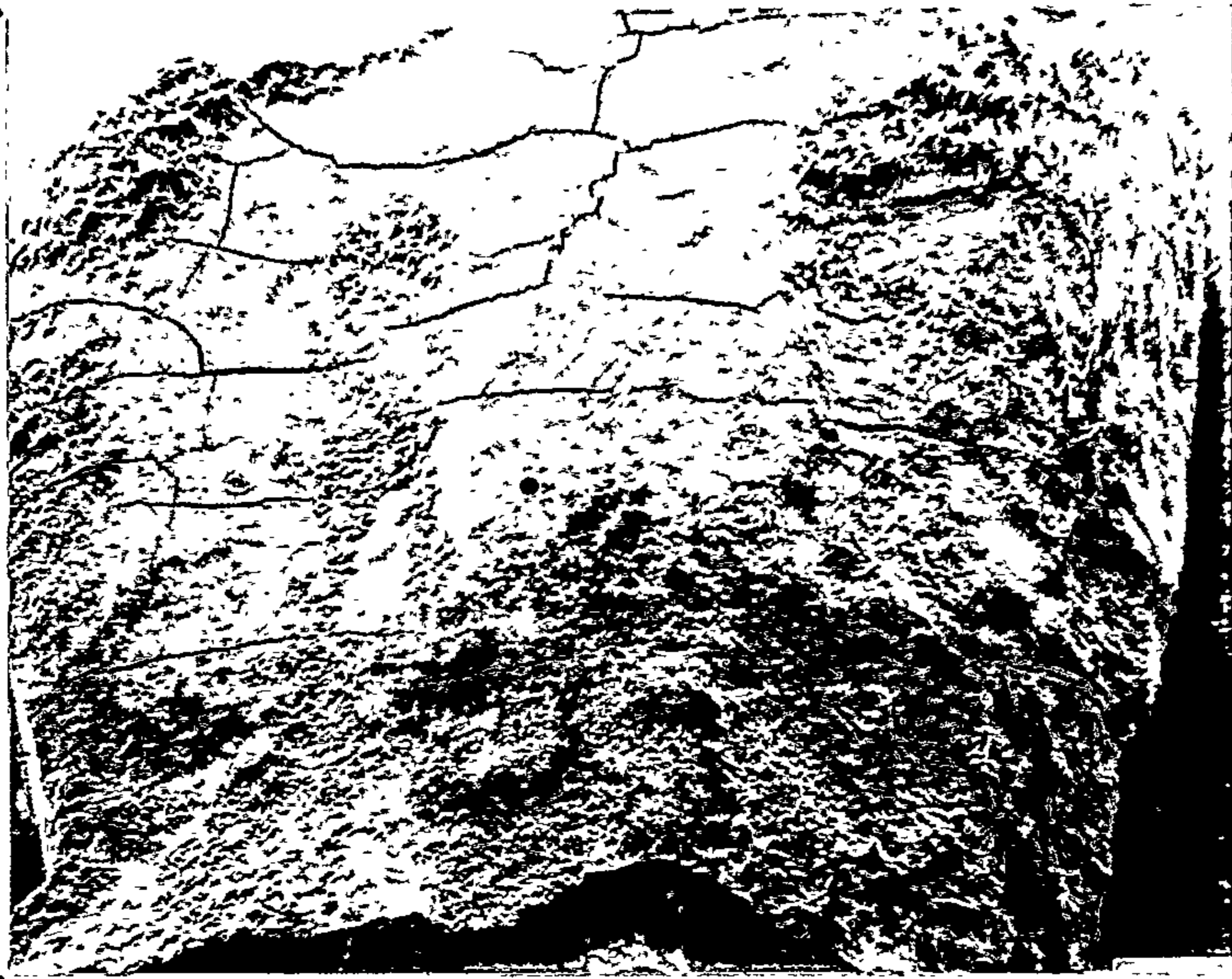


PLATE 26a (Upper Photograph) - Infra-attachment
root surface (20x). Cementum intact.

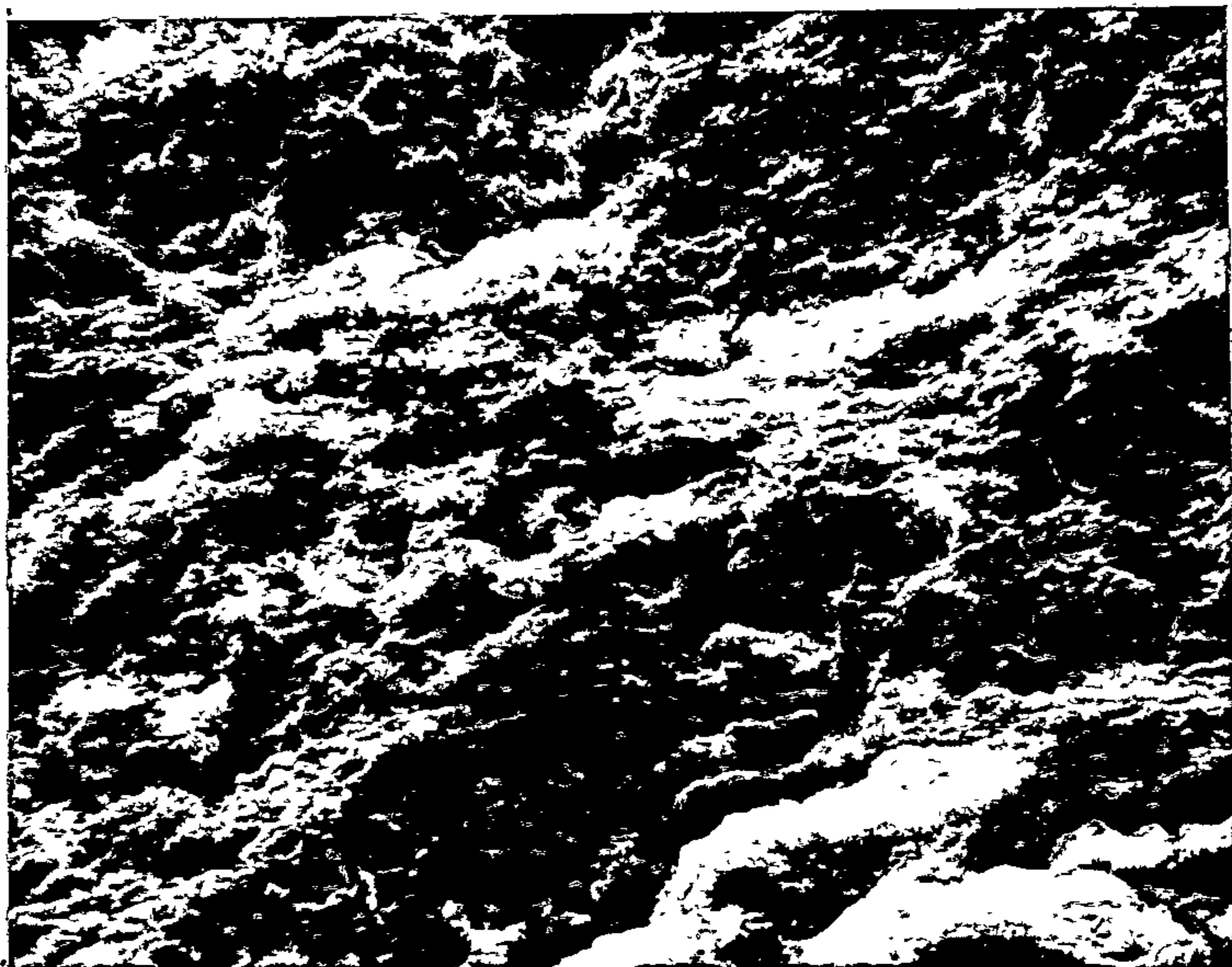


PLATE 26b (Lower Photograph) - Infra-attachment
root surface (1000x). Shallow irregularities in
areas; other areas relatively smooth.

PLATES 27a and 27b ILLUSTRATE SURFACES FOLLOWING
THE AMBENT ULTRASONIC SCALER AT FULL AMPLITUDE
SETTING.

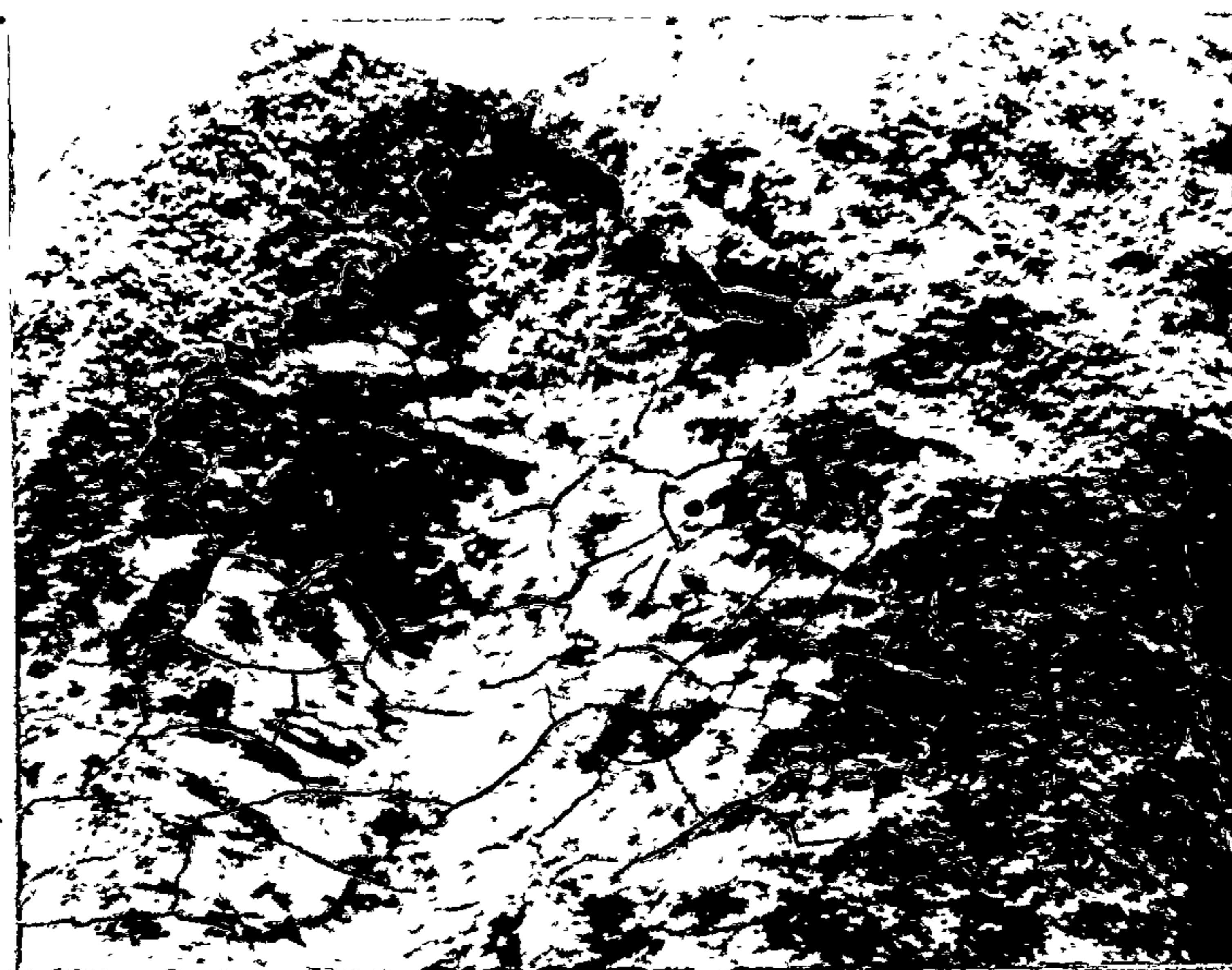


PLATE 27a (Upper Photograph) - Supra-attachment root
surface (20x). Cementum intact; calculus is present
in upper right and upper left hand corners.



PLATE 27b (Lower Photograph) - Supra-attachment root
surface (1000x). Shallow irregularities in areas;
other areas relatively smooth.

PLATES 28a and 28b ILLUSTRATE SURFACES FOLLOWING
THE AMBENT ULTRASONIC SCALER AT FULL AMPLITUDE
SETTING.

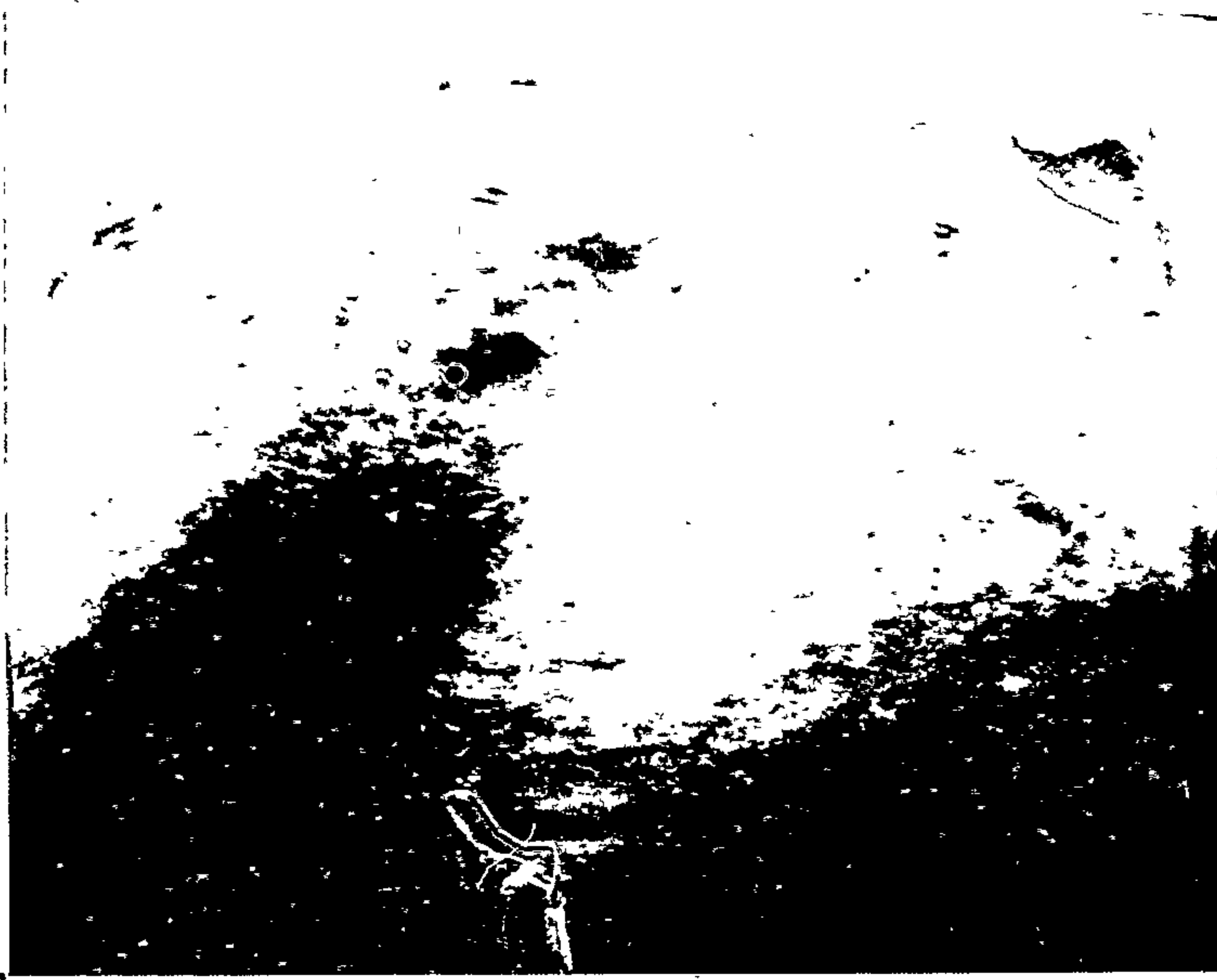


PLATE 28a (Upper Photograph) - Acrylic surface
(20x). Little alteration to surface.



PLATE 28b (Lower Photograph) - Acrylic surface
(1000x). Shallow scratch marks are evident.

PLATES 29a and 29b ILLUSTRATE SURFACES FOLLOWING
THE ODONTOSON ULTRASONIC SCALER AT HALF
AMPLITUDE SETTING



PLATE 29a (Upper Photograph) - Infra-attachment
root surface (20x). Dentine exposed in area;
surrounding areas of cementum intact.

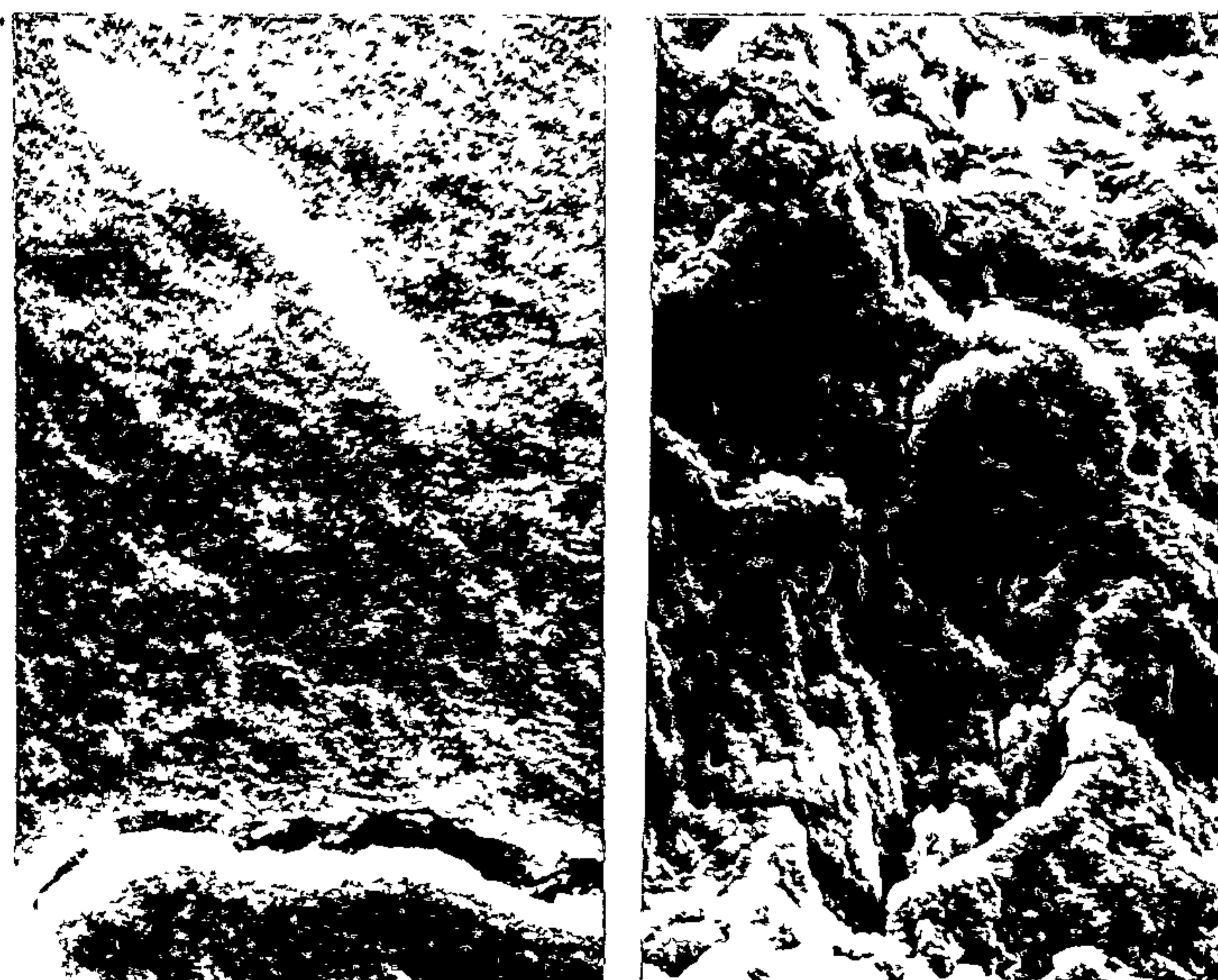


PLATE 29b (Lower Photograph) - Infra-attachment
root surface (1000x). Right picture shows deep
irregularities; left picture shows a relatively
smooth adjacent area.

PLATES 30a and 30b ILLUSTRATE SURFACES FOLLOWING
THE ODONTOSON ULTRASONIC SCALER AT HALF
AMPLITUDE SETTING

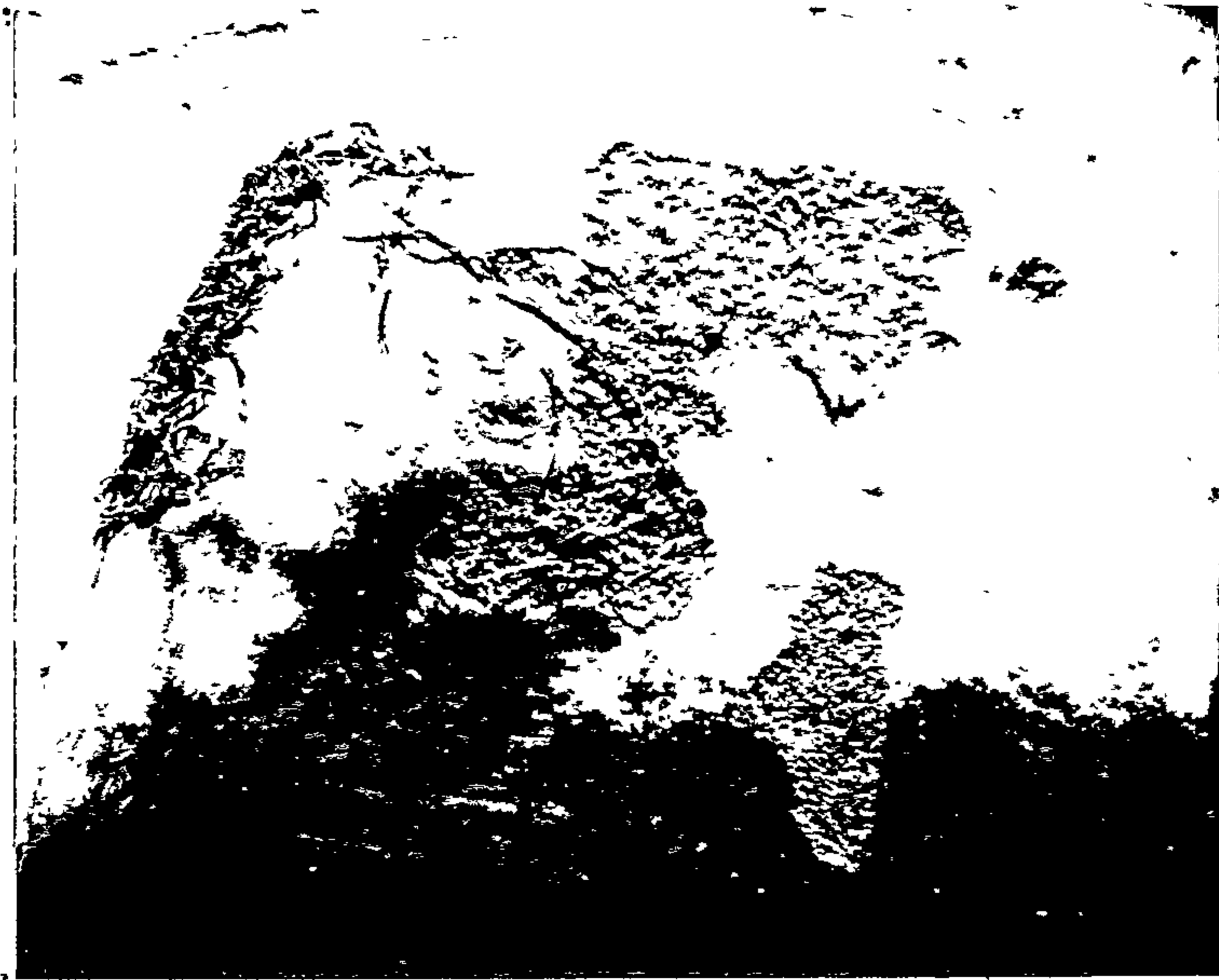


PLATE 30a (Upper Photograph) - Acrylic surface
(20x). Removal of acrylic in large area;
surrounding areas of acrylic intact.

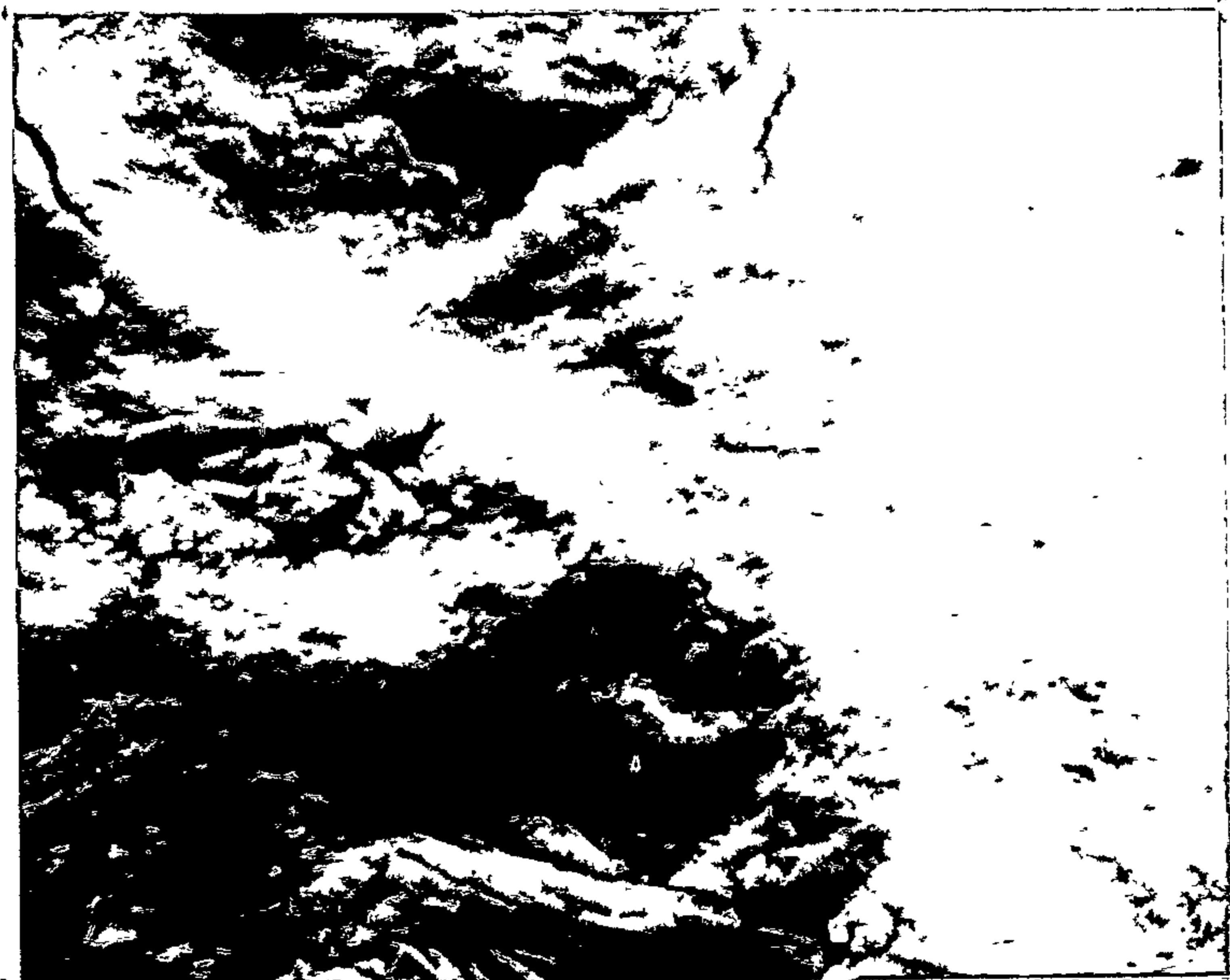


PLATE 30b (Lower Photograph) Acrylic surface
(1000x). Deep irregularities in areas; other
areas relatively smooth.

PLATES 31a and 31b ILLUSTRATE SURFACES FOLLOWING
THE ODONTOSON ULTRASONIC SCALER AT THREE QUARTER
AMPLITUDE SETTING.

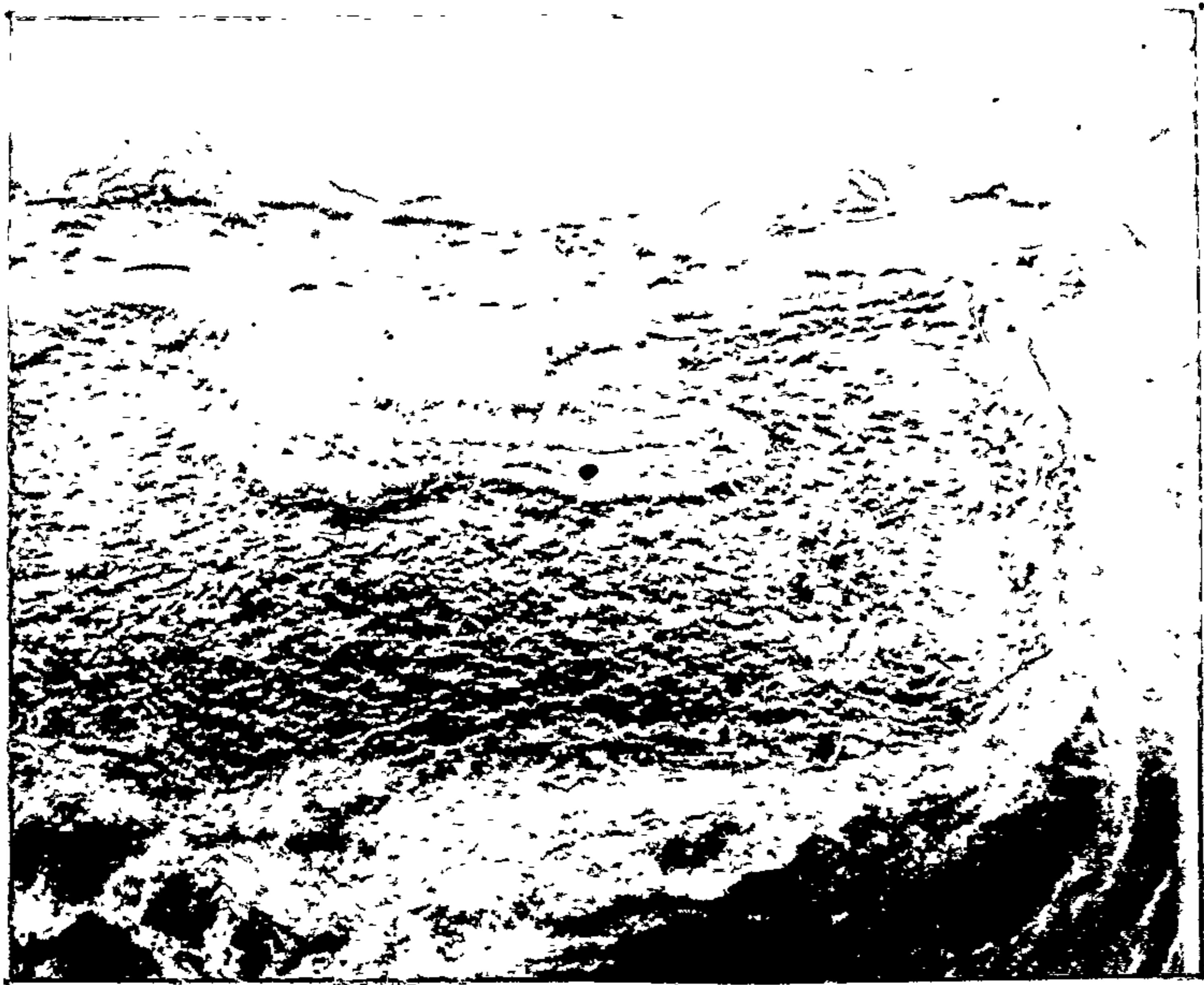


PLATE 31a (Upper Photograph) - Infra-attachment
root surface (20x). Dentine exposed in large
area.

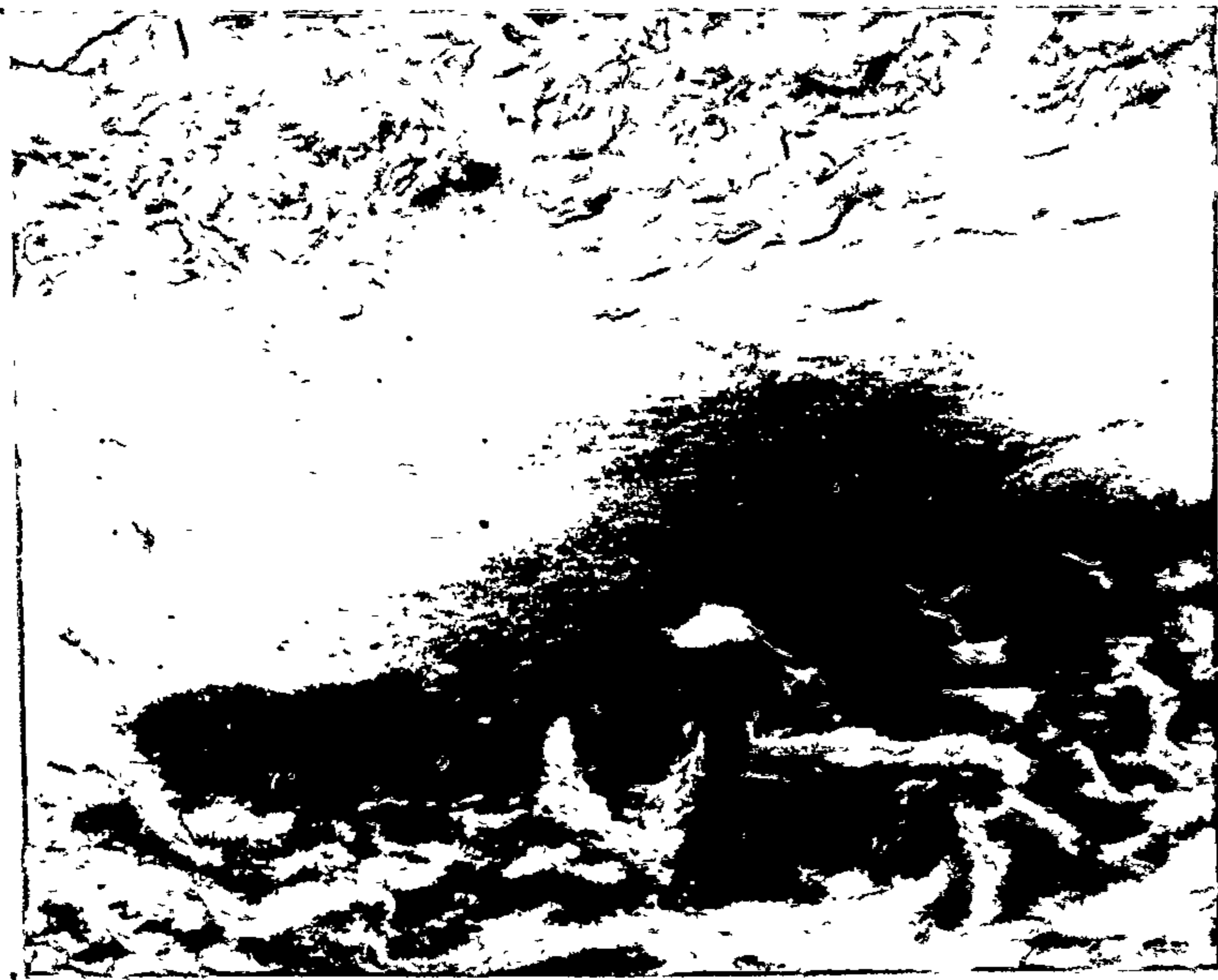


PLATE 31b (Lower Photograph) - Infra-attachment
root surface (1000x). Deep irregularities in
areas; other areas relatively smooth.

PLATES 32a and 32b ILLUSTRATE SURFACES FOLLOWING
THE ODONTOSON ULTRASONIC SCALER AT THREE QUARTER
AMPLITUDE SETTING

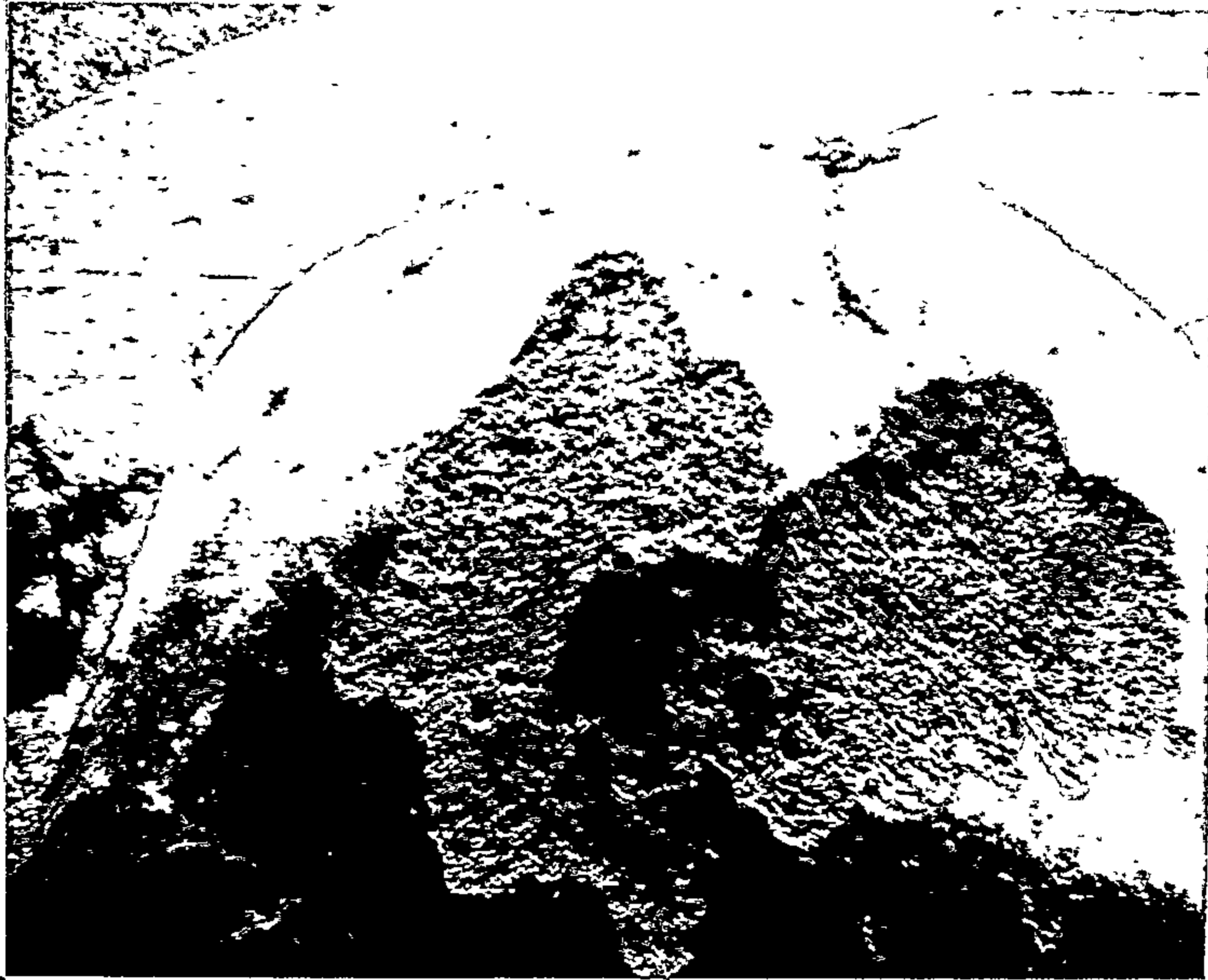


PLATE 32a (Upper Photograph) - Acrylic surface
(20x). Removal of acrylic in large area;
surrounding areas of acrylic intact.

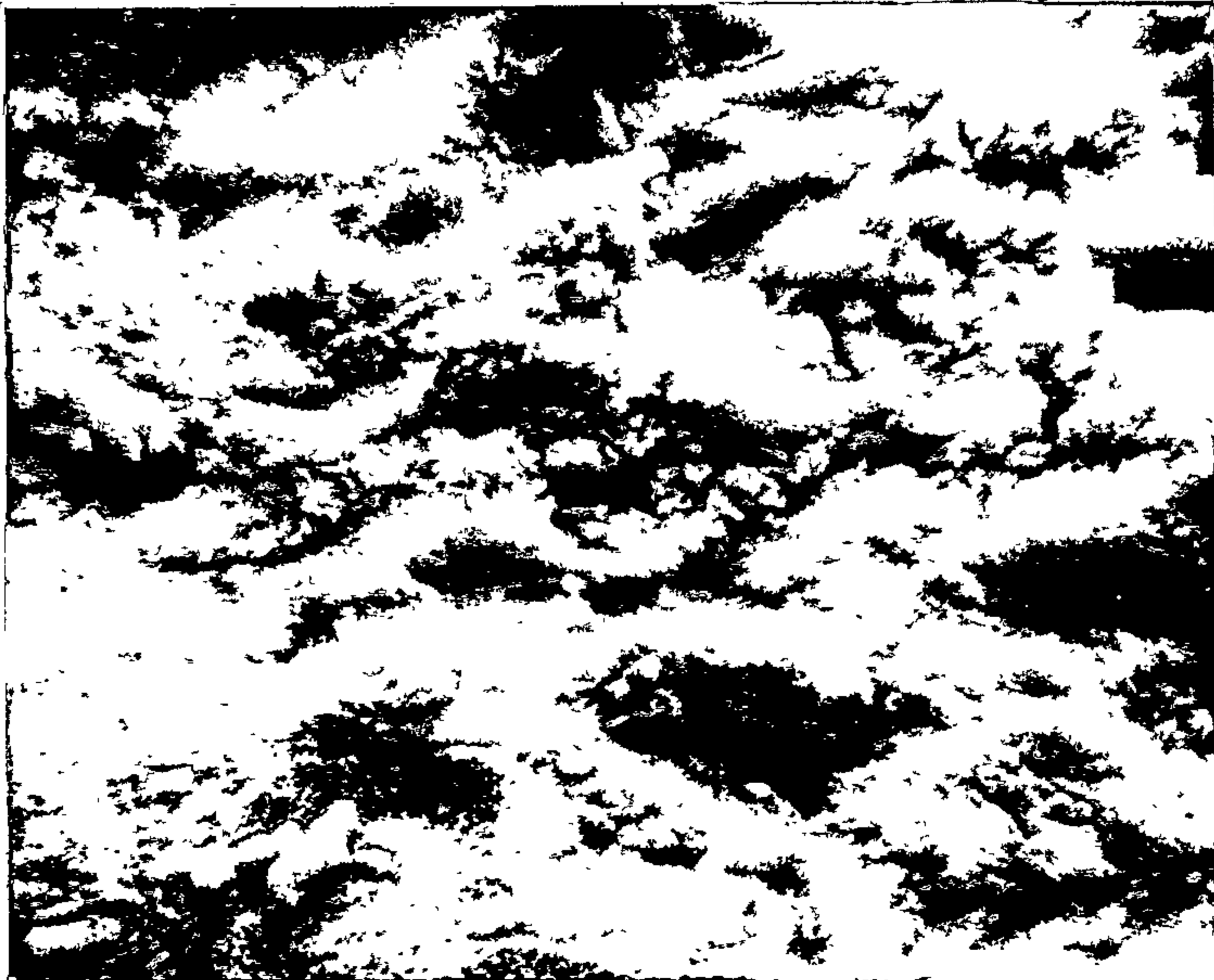


PLATE 32b (Lower Photograph) - Acrylic surface
(1000x). Deep irregularities in areas; other
areas relatively smooth.

PLATES 33a and 33b ILLUSTRATE SURFACES FOLLOWING
A SHARP CURETTE

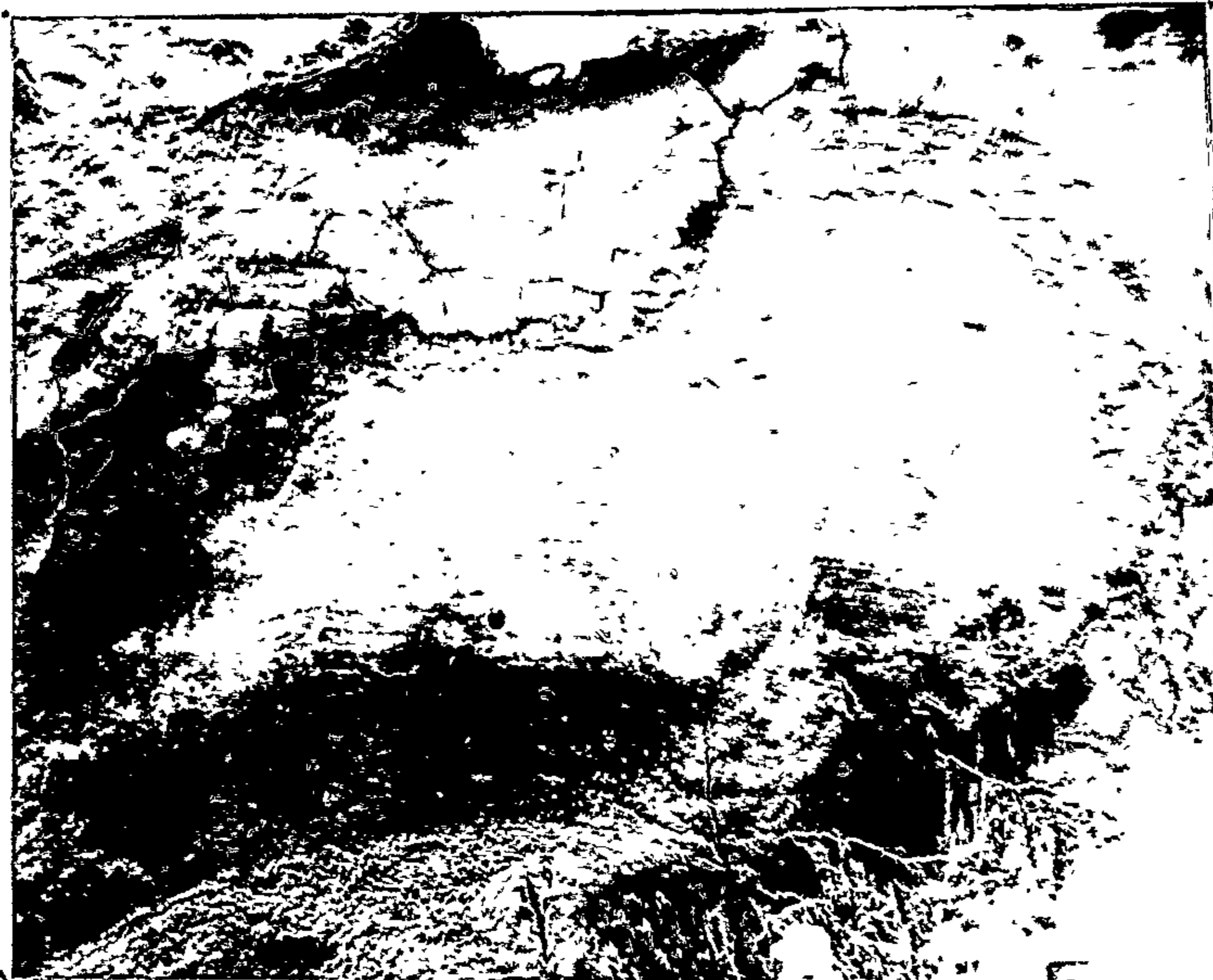


PLATE 33a (Upper Photograph) - Infra-attachment
root surface (20x). Dentine exposed to uniform
depth in most of instrumented area.

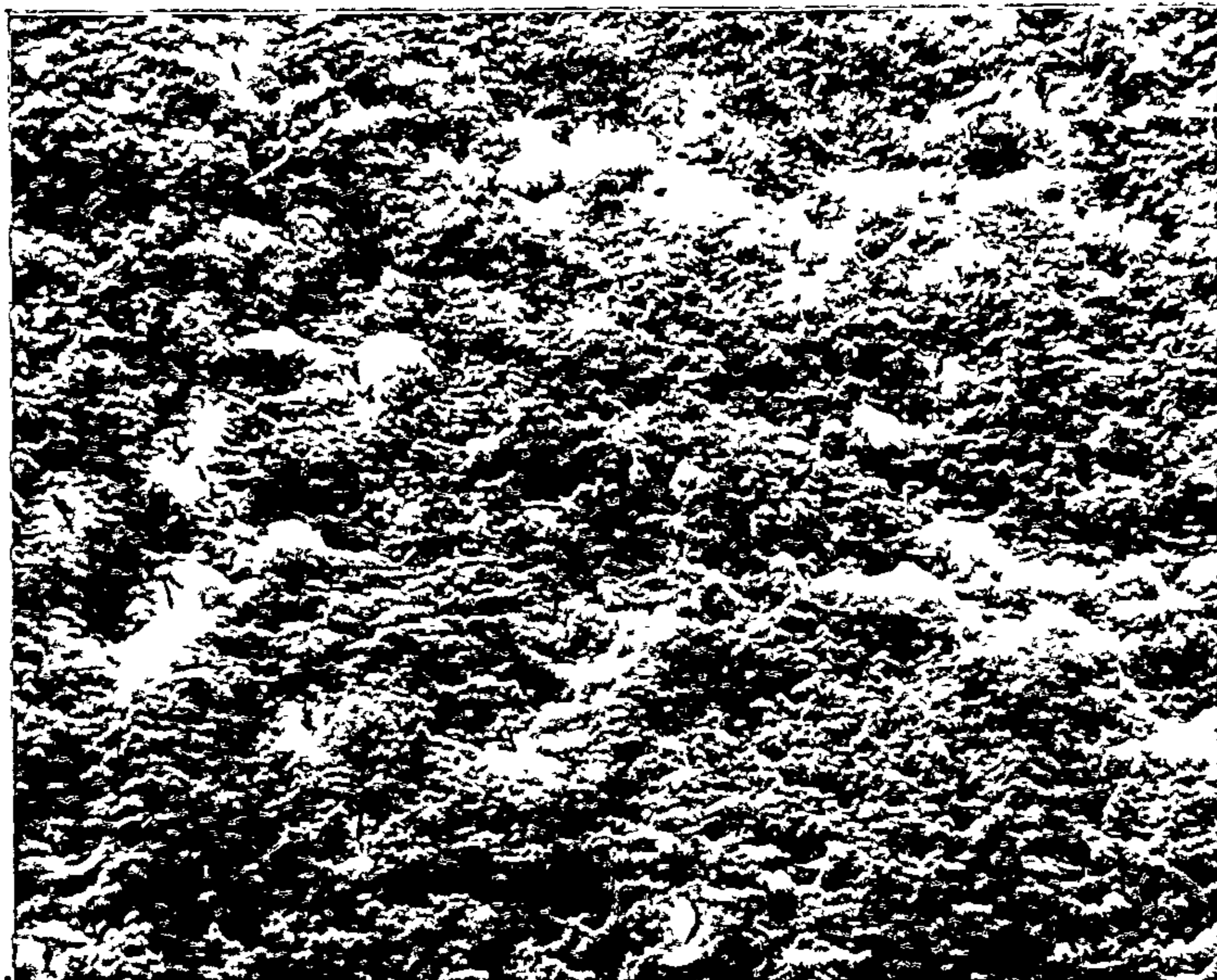


PLATE 33b (Lower Photograph) - Infra-attachment
root surface (1000x). Shallow irregularities over
most of instrumented area.

PLATES 34a and 34b ILLUSTRATE SURFACES FOLLOWING
A SHARP CURETTE

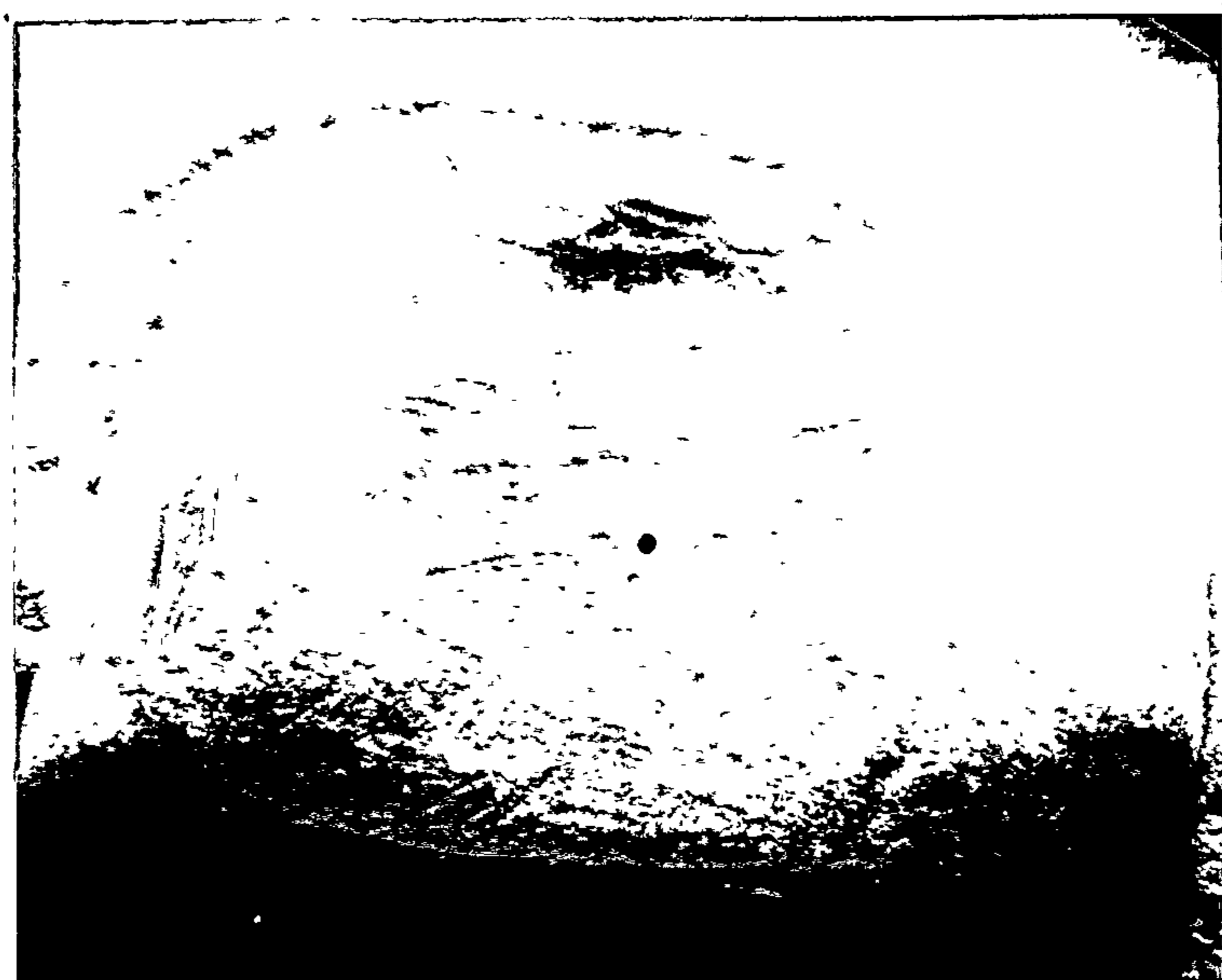


PLATE 34a (Upper Photograph) - Acrylic surface
(20x). Acrylic removed in most of instrumented
area.

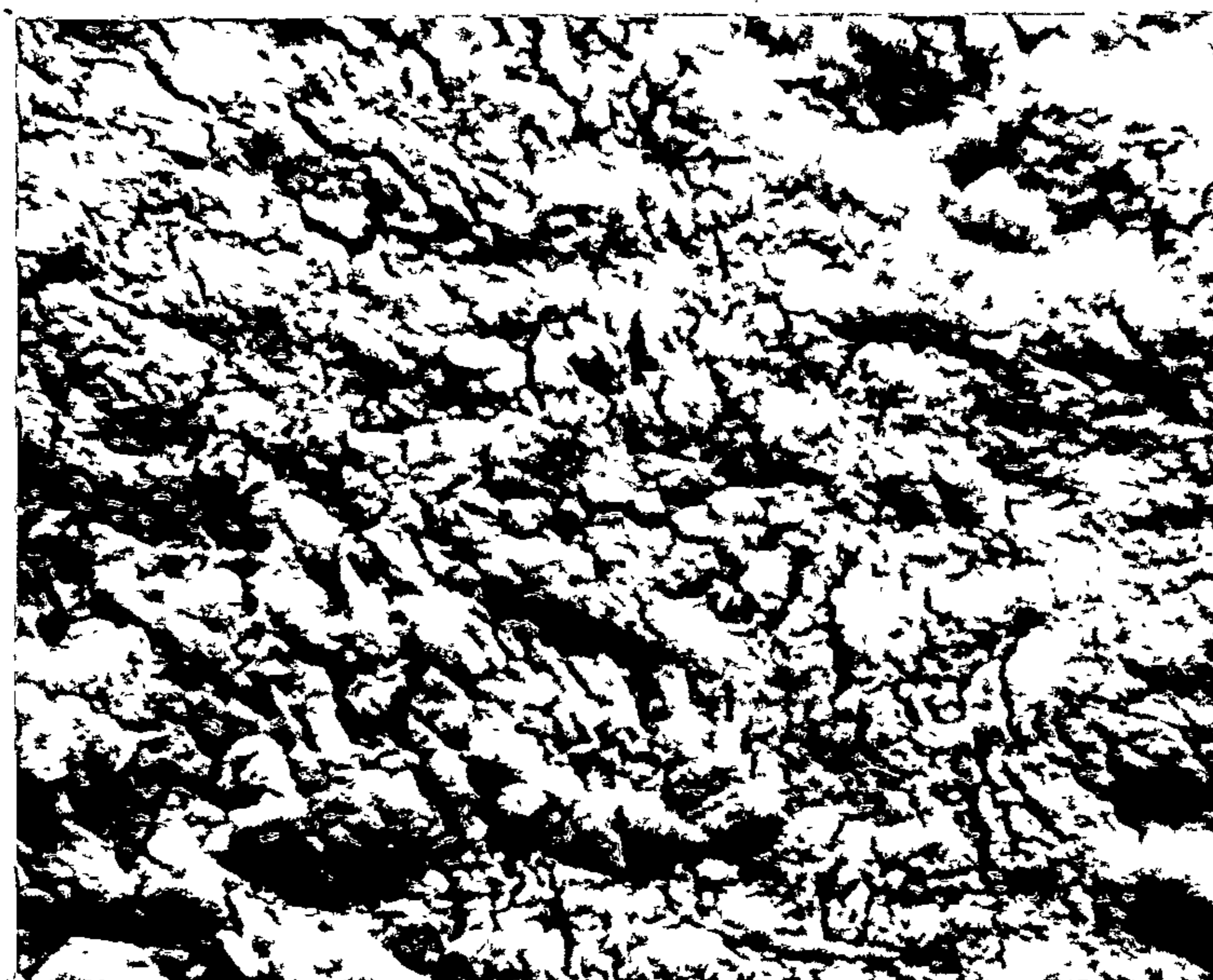


PLATE 34b (Lower Photograph) - Acrylic surface
(1000x). Shallow irregularities over most of
instrumented area.

PLATES 35a and 35b ILLUSTRATE SURFACES FOLLOWING
SHARP HAND INSTRUMENTS

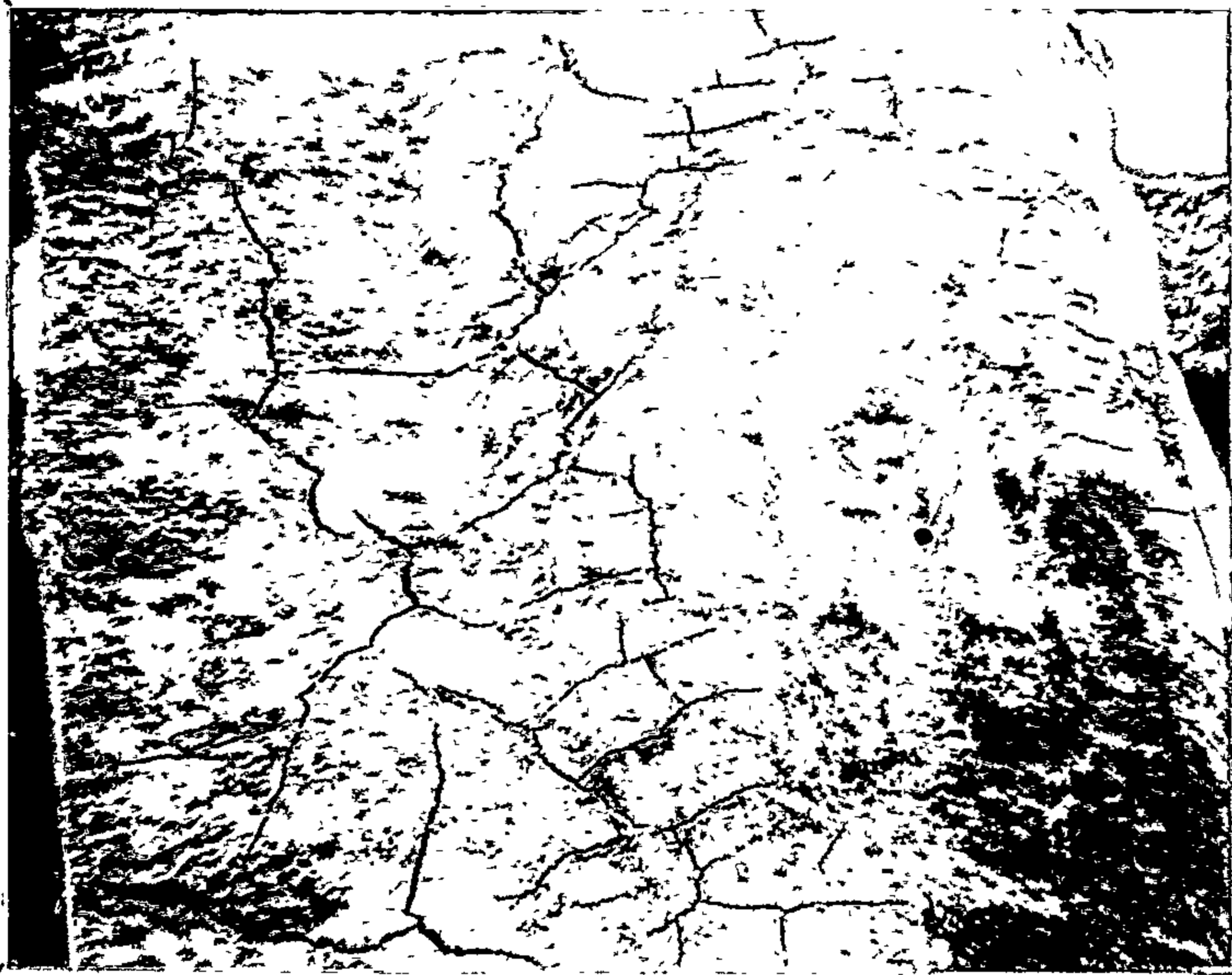


PLATE 35a (Upper Photograph) - Infra-attachment
root surface (20x) following use of a sharp hoe.
Dentine exposed in large areas (right of picture);
varying depths of tooth structure removed.

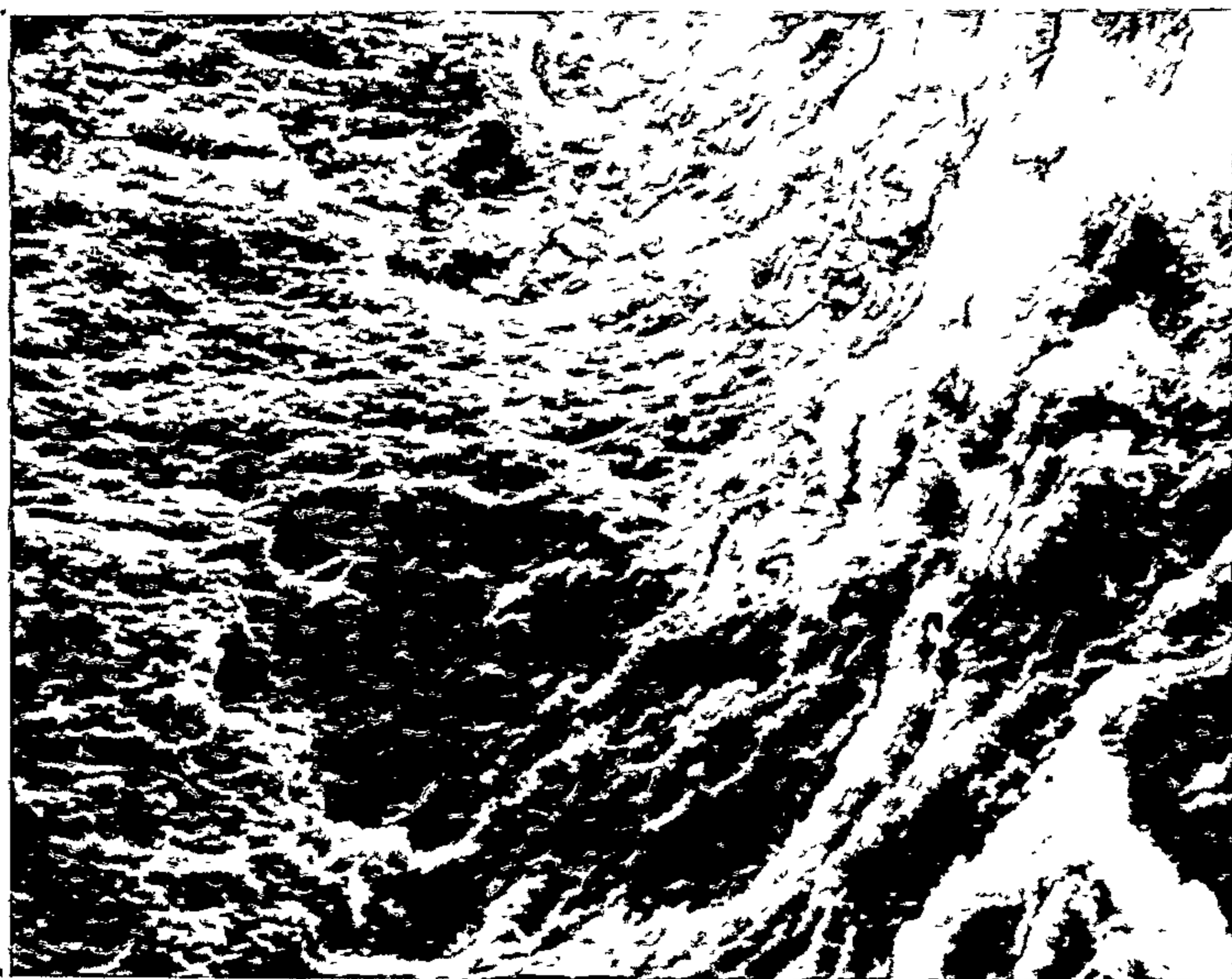


PLATE 35b (Lower Photograph) Infra-attachment root
surface (1000x) following use of a sharp hoe.
Deep irregularities evident.

PLATES 36a and 36b ILLUSTRATE SURFACES FOLLOWING
SHARP HAND INSTRUMENTS

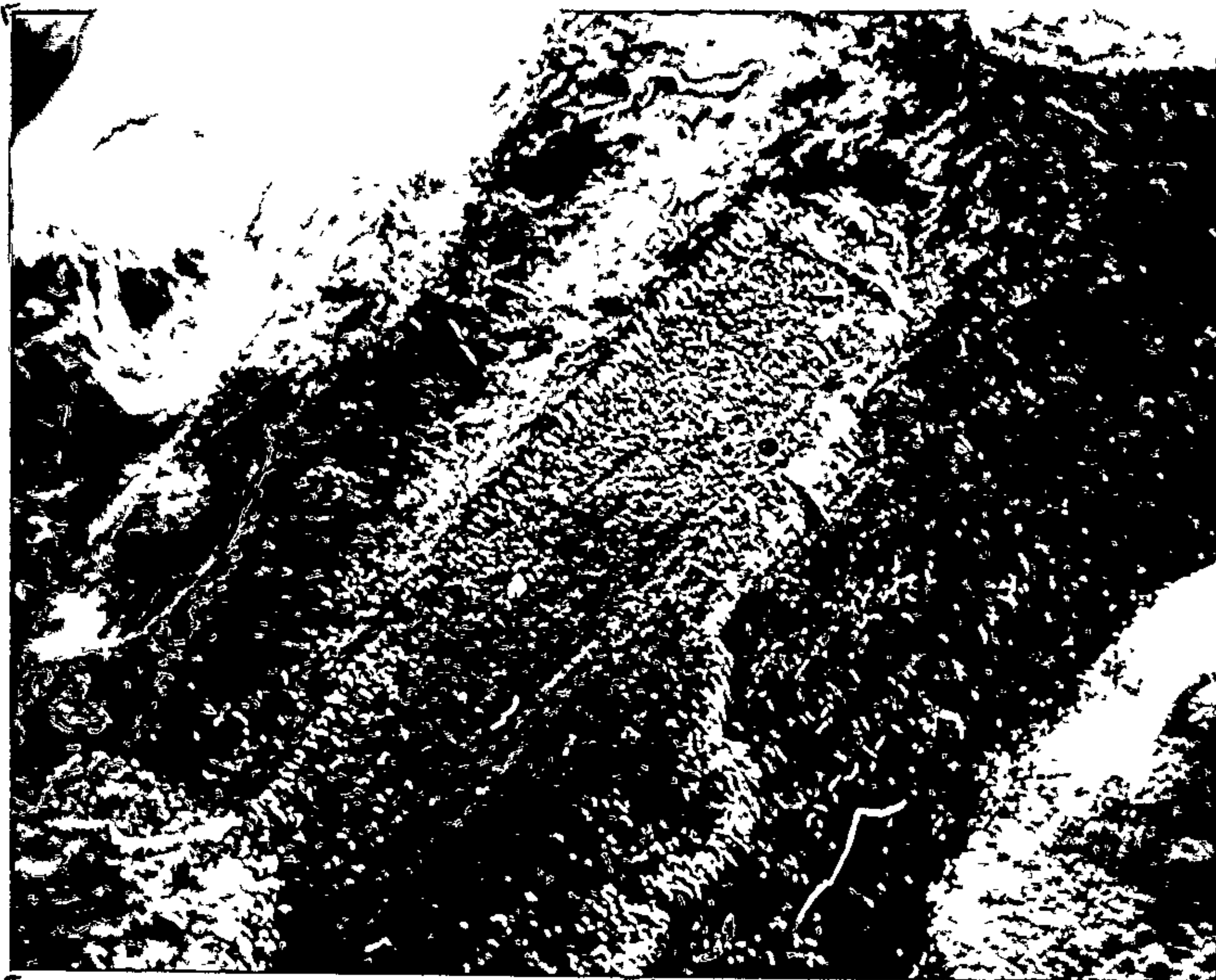


PLATE 36a (Upper Photograph) - Supra-attachment
root surface (20x) following use of a sharp
scaler. Dentine exposed in large area.

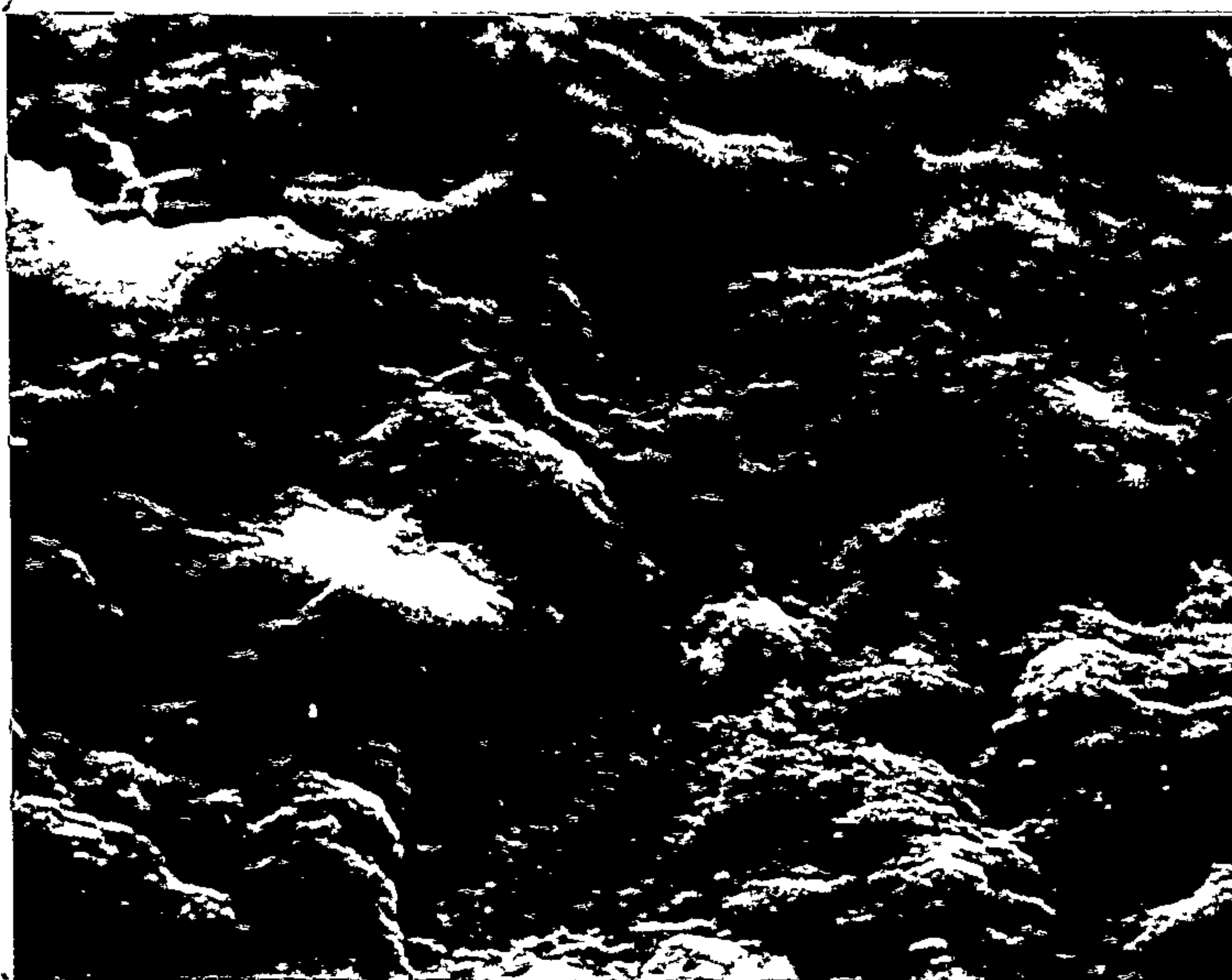


PLATE 36b (Lower Photograph) - Supra-attachment
root surface (1000x) following use of a sharp
scaler. Deep irregularities evident.

PLATES 37a and 37b ILLUSTRATE SURFACES FOLLOWING
DULL HAND INSTRUMENTS

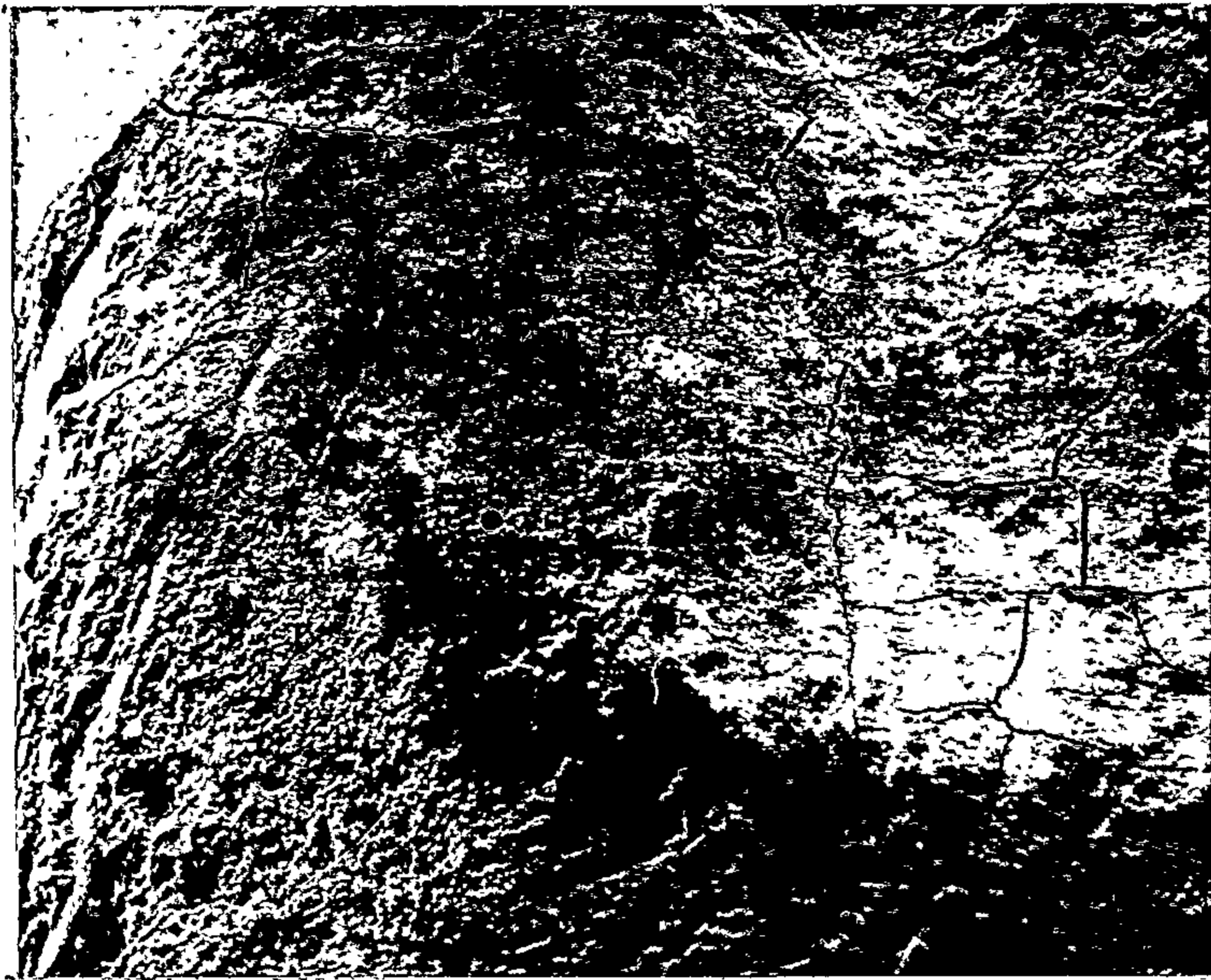


PLATE 37a (Upper Photograph) - Infra-attachment
root surface (20x) following a dull curette.
Small areas of dentine exposed; most of cementum
intact.

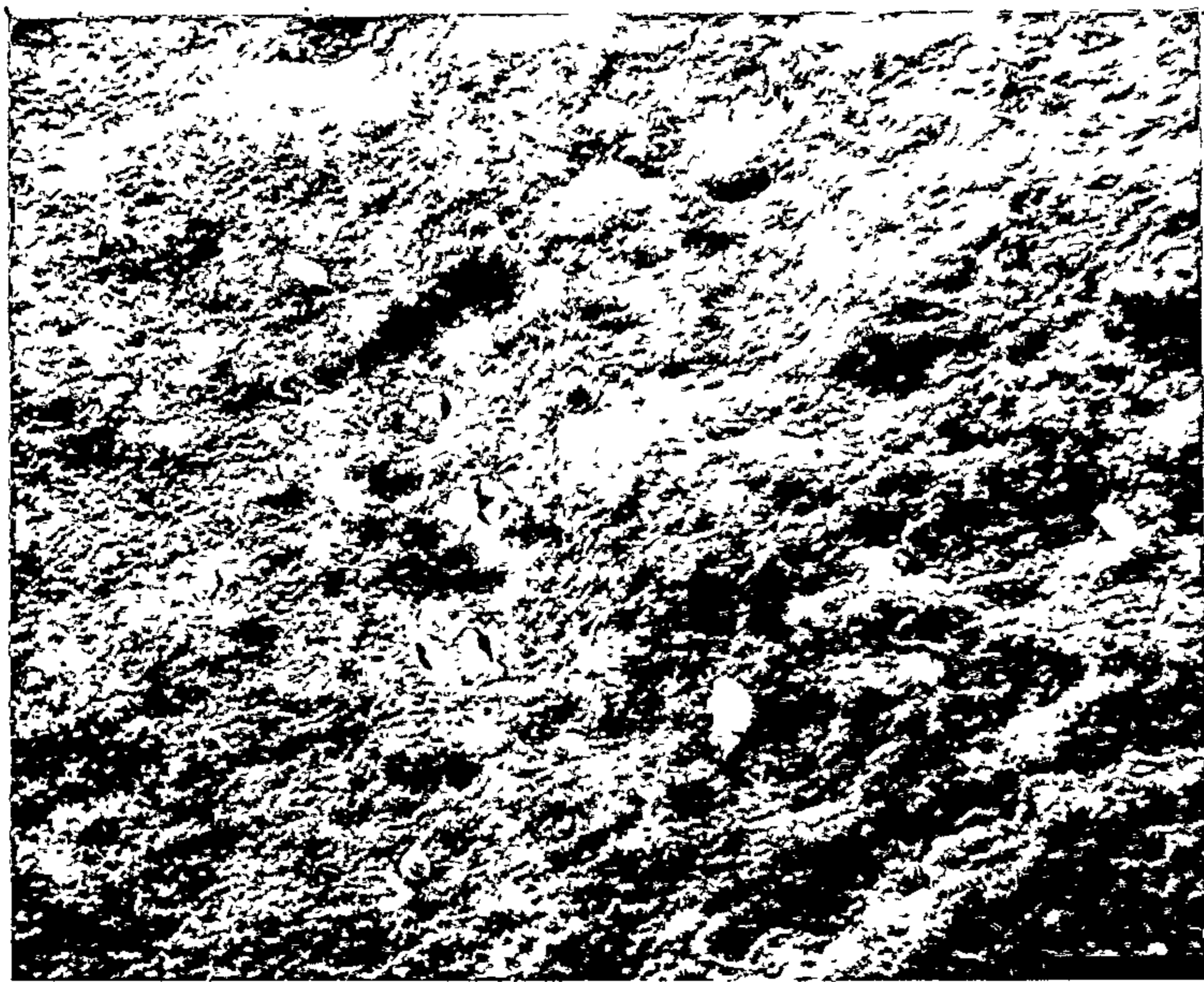


PLATE 37b (Lower Photograph) - Infra-attachment
root surface (1000x) following a dull curette.
Smoothness over most of instrumented area.

PLATES 38a and 38b ILLUSTRATE SURFACES FOLLOWING
DULL HAND INSTRUMENTS



PLATE 38a (Upper Photograph) - Supra-attachment
root surfaces (20x) following a dull scaler.
Small areas of dentine exposed; most of cementum
intact.

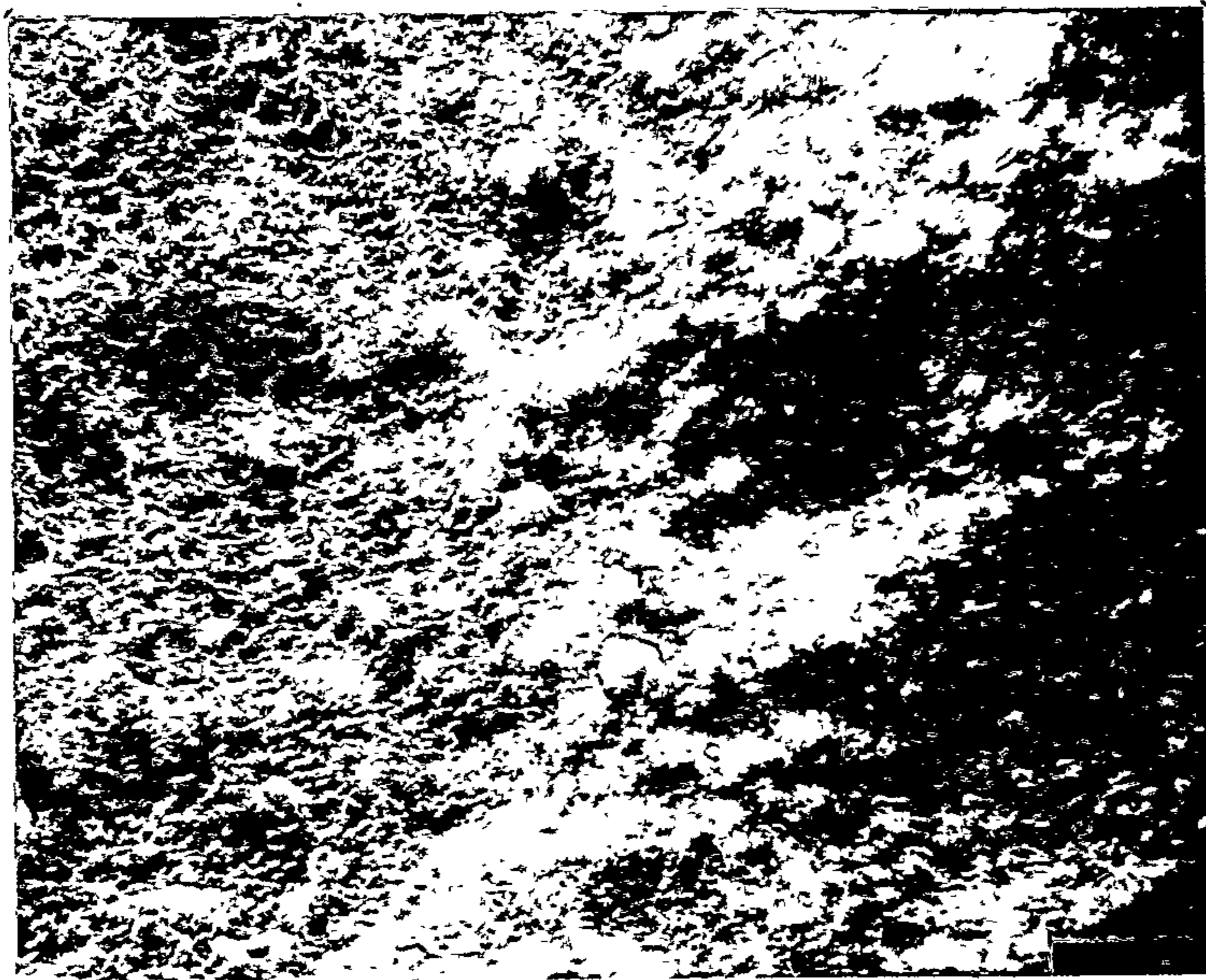


PLATE 38b (Lower Photograph) - Supra-attachment
root surface (1000x) following a dull scaler.
Smoothness over most of instrumented area;
mineralized pellicle not removed.

PLATES 39a and 39b COMPARE SURFACES FOLLOWING
COMBINATIONS OF HAND AND ULTRASONIC INSTRUMENTS
WITH A SURFACE FOLLOWING A SHARP CURETTE

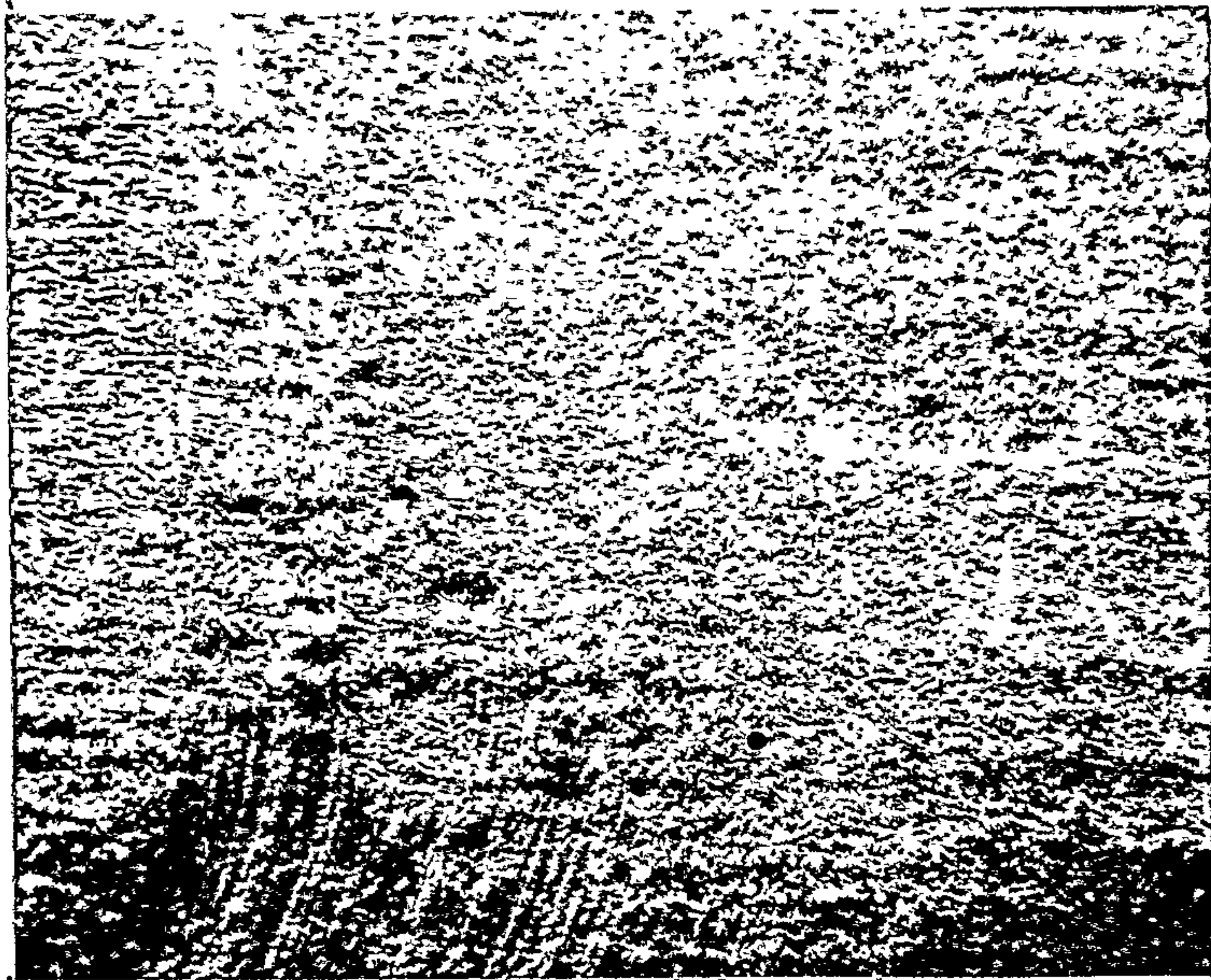


PLATE 39a (Upper Photograph) - Infra-attachment root
surface (100x) following a sharp curette. Dentine
surface shows friction-produced undulating ridges
running perpendicular to direction of stroke.
Shallower, finer grooves run vertically across the
larger ridges.

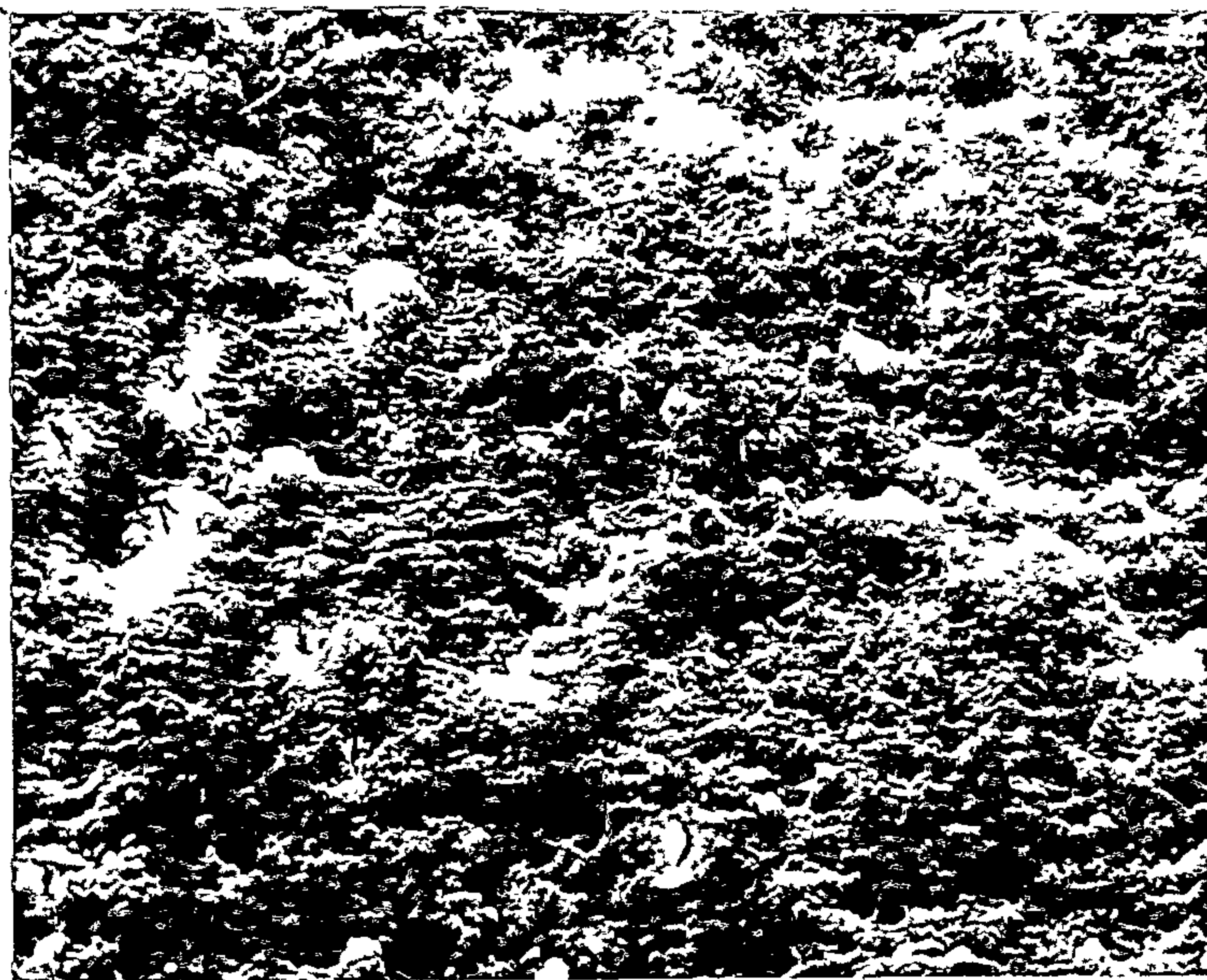


PLATE 39b (Lower Photograph) - Infra-attachment root
surface (1000x) following a sharp curette.
Shallow irregularities are present.

PLATES 40a and 40b COMPARE SURFACES FOLLOWING
COMBINATIONS OF HAND AND ULTRASONIC INSTRUMENTS
WITH A SURFACE FOLLOWING A SHARP CURETTE



PLATE 40a (Upper Photograph) - Infra-attachment root surface (100x) following a sharp curette, then Cavitron at three quarter setting. Perpendicular ridges and finer grooves have been smoothed in areas by the ultrasonic instrument.

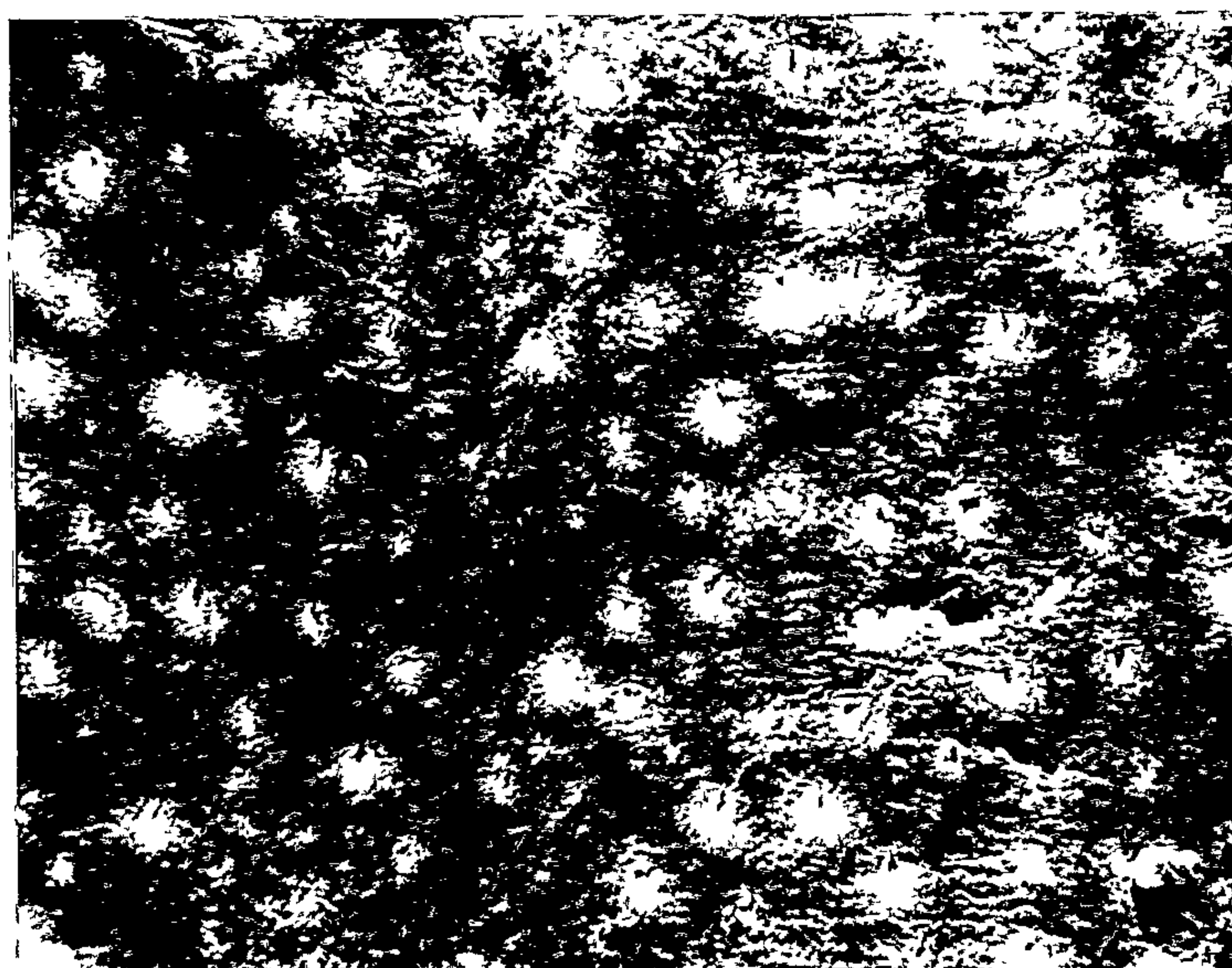


PLATE 40b (Lower Photograph) - Infra-attachment root surface (1000x) following sharp curette, then Cavitron at three quarter setting. Shows relatively smooth area. (Cut dentinal tubules can be seen).

PLATES 41a and 41b COMPARE SURFACES FOLLOWING
 COMBINATIONS OF HAND AND ULTRASONIC INSTRUMENTS
 WITH A SURFACE FOLLOWING A SHARP CURETTE

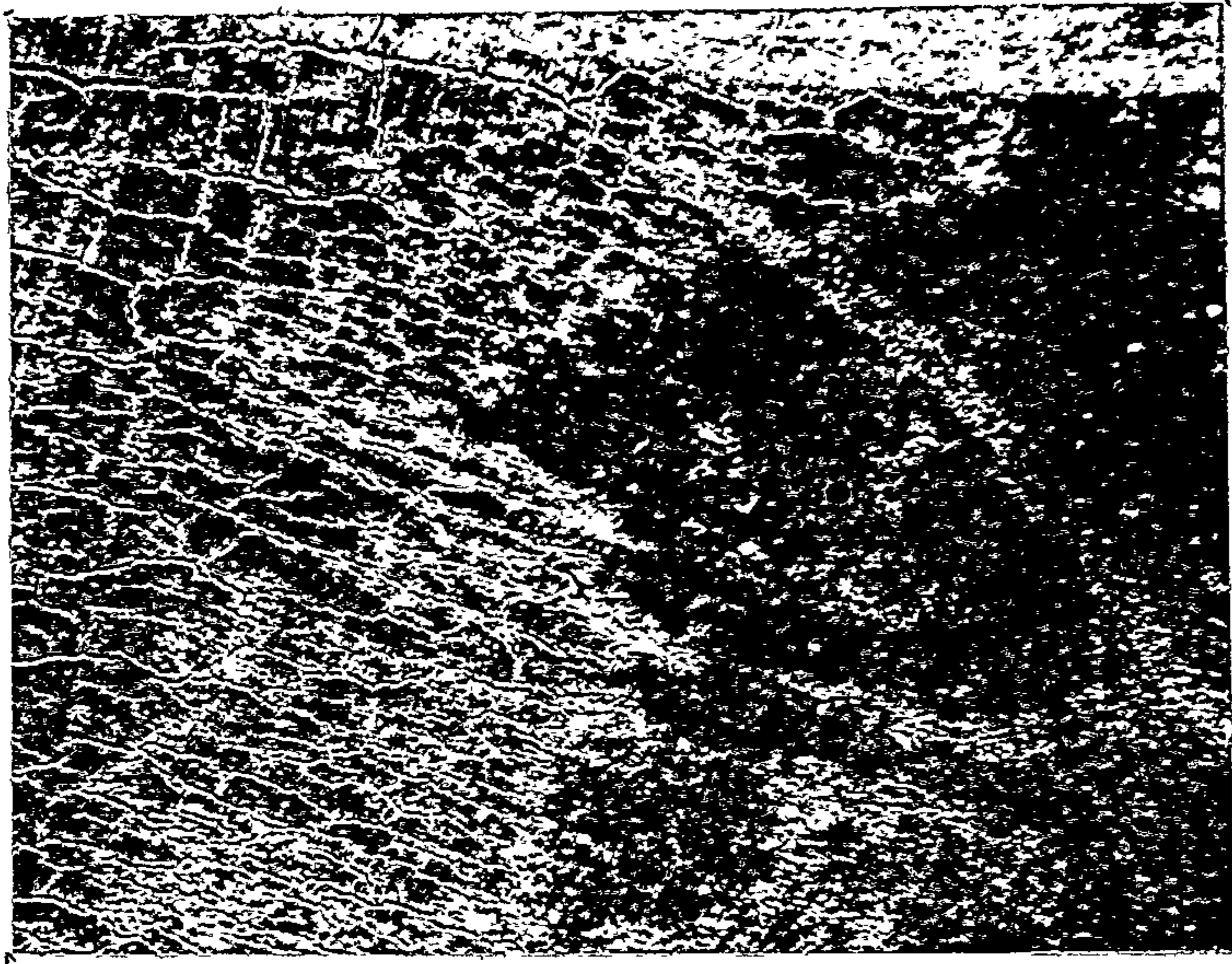


PLATE 41a (Upper Photograph) - Infra-attachment root surface (100x) following Cavitron at three quarter setting, than a sharp curette. Perpendicular ridges and finer grooves (though shallower than in Plate 39a) can be seen.

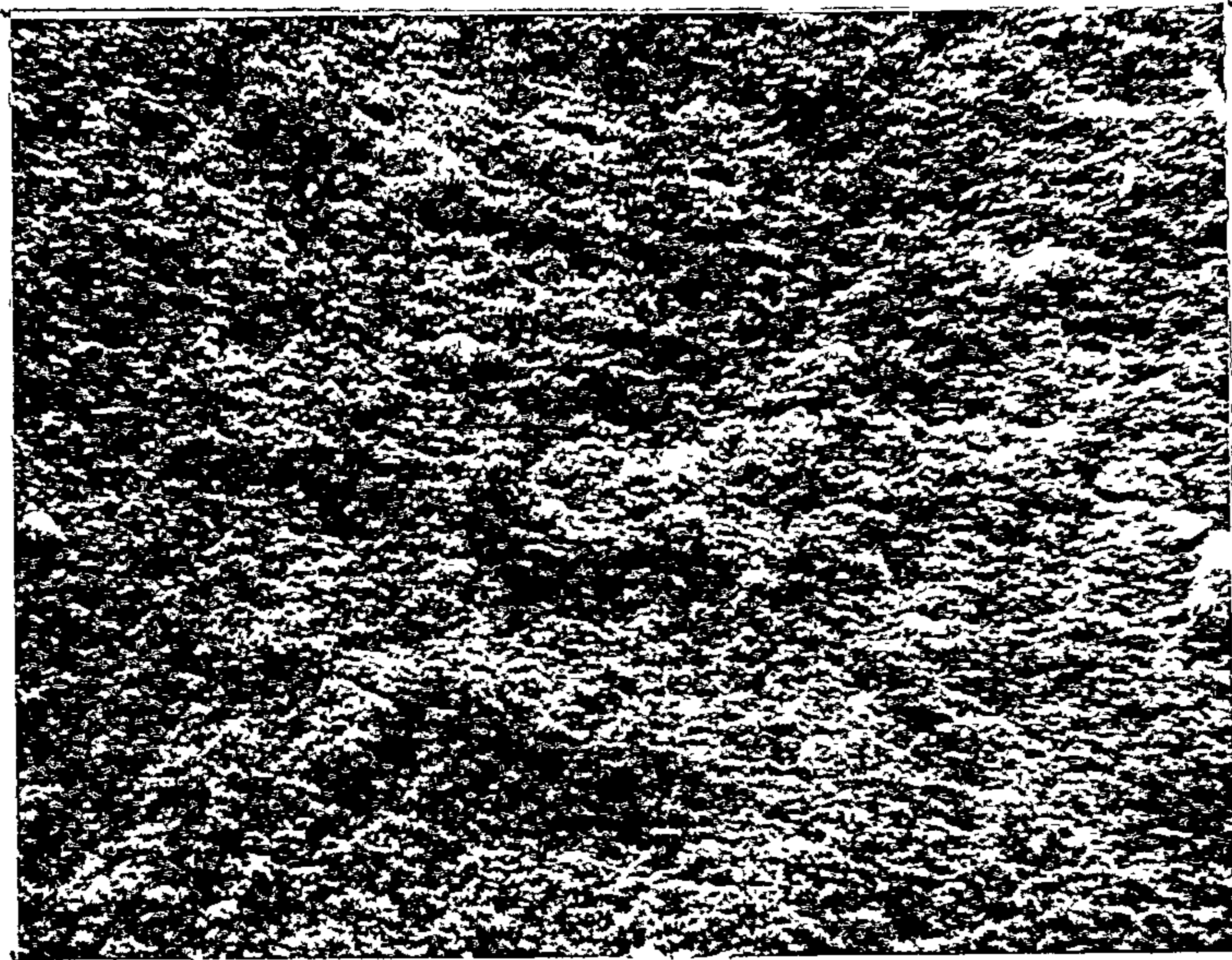


PLATE 41b (Lower Photograph) - Infra-attachment root surface (1000x) following Cavitron at three quarter setting, then a sharp curette. Shallow irregularities (as produced by the Curette in Plate 39b) are present.

SUMMARY OF RESULTS

TABLE 4

Comparison of tooth root surfaces and acrylic surfaces following instrumentation

INSTRUMENT	TOOTH ROOT SURFACE	ACRYLIC SURFACE
Cavitron three-quarter setting	i.a.* Little alteration to original surface. Sharpey's fibre mounds visible (1000x) (Refer. Plate 17) s.a.* Surface relatively smooth Mineralized pellicle still adherent (1000x) (Refer Plate 18).	Little alteration to original surface. Shallow scratch marks occur in some areas. (1000x) (Refer Plate 19)
Cavitron full setting	Tooth substance removed in moderately large areas (20x) . Shallow irregularities in areas; other areas relatively smooth (1000x) (Refer Plate 20)	Acrylic substance removed in moderately large areas. (20x) Shallow irregularities in areas; other areas relatively smooth (1000x) (Refer Plate 22)
Amdent three-quarter setting	As for Cavitron three-quarter setting. (Refer Plates 23, 24)	As for Cavitron three-quarter setting. (Refer Plate 25).
Amdent full setting	Little removal of tooth substance. (20x) Shallow irregularities in areas; other areas relatively smooth (1000x) (Refer Plate 26)	Little removal of acrylic substance (20x) Shallow scratch marks in areas; other areas relatively smooth (1000x) (Refer Plate 28).

* A distinction between infra-attachment (i.a.) and supra-attachment (s.a.) root surfaces in these cases was made; i.e. here, post-instrumentation differences in surface features were observed.

TABLE 4 (Continued)

Comparison of tooth root surfaces and acrylic surfaces
following instrumentation

INSTRUMENT	TOOTH ROOT SURFACE	ACRYLIC SURFACE
Odontoson half setting	Tooth substance removed in moderately large areas (20x), Deep irregularities in areas; other areas relatively smooth (1000x) (Refer Plate 29)	Acrylic substance removed in moderately large areas. (20x) Deep irregularities in areas; other areas relatively smooth (1000x) (Refer Plate 30).
Odontoson three-quarter setting	As for Odontoson half-setting (though throughout larger area) (Refer Plate 31)	As for Odontoson half-setting (Refer Plate 32)
Sharp curette	Tooth substance removed to approximately uniform depth; (20x) shallow irregularities occur throughout area (1000x) (Refer Plate 33)	Acrylic substance removed to approximately uniform depth (20x); shallow irregularities occur throughout area (1000x) (Refer Plate 34).

TABLE 5 - Smoothing of tooth root surfaces

(A) Criteria for describing instrumented surfaces
(Evaluated 1000x)

- .Surface type 1 - Smoothness over most of instrumented area.
- .Surface type 2 - Shallow irregularities in areas; other areas relatively smooth.
- .Surface type 3 - Shallow irregularities over most of instrumented area.
- .Surface type 4 - Deep irregularities in areas; other areas relatively smooth.
- .Surface type 5 - Deep irregularities over most of instrumented area.

(B) Instrumentation producing different types of surfaces

(1) Surface type 1 was produced by:-

- Cavitron three-quarter setting on supra-attachment surface (Refer Plate 18b)
- Amdent three-quarter setting on supra-attachment surface (Refer Plate 24b)
- Sharp curette then Cavitron three-quarter setting (Refer Plate 40b)
- Sharp curette then Amdent three-quarter setting
- Dull curette (Refer Plate 37b)
- Dull scaler (Refer Plate 38b)

(2) Surface type 2 was produced by:-

- Cavitron full setting (Refer Plate 20b)
- Amdent full setting (Refer Plate 21b)

(3) Surface type 3 was produced by:-

- Cavitron three-quarter setting on infra-attachment surface. (Refer Plate 17b)
- Amdent three-quarter setting on infra-attachment surface (Refer Plate 23b)
- Sharp curette (Refer Plate 33b)
- Cavitron three-quarter setting then sharp curette (Refer Plate 41b)
- Amdent three-quarter setting then sharp curette.

(4) Surface type 4 was produced by:-

- Odontoson set half (Refer Plate 29b)
- Odontoson set three-quarters. (Refer Plate 31b)

(5) Surface type 5 was produced by:-

- Sharp hoe. (Refer Plate 35b)
- Sharp scaler (Refer Plate 36b)

TABLE 6 - Removal of tooth root structure

(A) Criteria for describing instrumented surfaces

(Evaluated at 20X)

- .Surface type 1 - No dentine exposed; cementum intact.
- .Surface type 2 - Small areas of dentine exposed, most of cementum intact.
- .Surface type 3 - Dentine exposed in moderately large areas; however, surrounding areas of cementum intact.
- .Surface type 4 - Dentine exposed in large areas. Varying depths of tooth structure removed.
- .Surface type 5 - Dentine exposed to uniform depth in most of instrumented area.

(b) Instrumentation producing different types of surfaces

(1) Surface type 1 was produced by:-

- Cavitron three-quarter setting (Refer Plates 17a, 18a)
- Amdent three-quarter setting (Refer Plates 23a, 24a)
- Amdent full setting (Refer Plates 26a, 27a)

(2) Surface type 2 was produced by:-

- Dull curette (Refer Plate 37a)
- Dull scaler (Refer Plate 38a)

(3) Surface type 3 was produced by:-

- Cavitron full setting (Refer Plates 20a, 21a)
- Odontoson half setting (Refer Plate 29a)
- Odontoson three-quarter setting (Refer Plate 31a)

(4) Surface type 4 was produced by:-

- Sharp hoe (Refer Plate 35a)

(5) Surface type 5 was produced by:-

- Sharp curette (Refer Plate 33a)
- Sharp scaler (Refer Plate 36a)
- Cavitron three-quarter setting, then sharp curette
- Amdent three-quarter setting, then sharp curette
- Sharp curette, then Cavitron three-quarter setting
- Sharp curette, then Amdent three-quarter setting.

DISCUSSION

Previous reports in the literature* comparing the effects of ultrasonic versus hand instrumentation of root surfaces, point to the controversy which remains as to the nature of the surface produced.

Profilometer studies have reported the following findings:

- The curette produces a "smoother" surface than the Cavitron ultrasonic instrument^{66, 100, 192, 262}.
- The Cavitron used on a surface previously curetted, did not significantly affect root "smoothness" obtained with the curette²⁶².
- A curette used after the Cavitron, produced a "smoother" surface than the one produced by the Cavitron alone^{100, 262}.

Reports from studies using scanning electron microscopy vary, and at first sight, seem in conflict with many profilometer studies. Jones and co-workers⁹³, and Pameijer and co-workers¹⁶³, claim that the Cavitron leaves the root surface virtually unaltered and microscopically smoother than hand curettes. Results from the author's present study agree with these findings for the Cavitron at three-quarter (medium) amplitude setting, though the same is not necessarily true for the Cavitron at high amplitude setting (Refer Tables 5 and 6). Ewen and Gwinnett³⁹ agree

* 39, 66, 93, 100, 147, 163, 262, 271.

with the reports that a dull ultrasonic tip at medium setting leaves a smooth surface on supra-attachment root surfaces. At lower magnifications, Pameijer and co-workers¹⁶³ found that hand cures removed substantially more tooth structure than did the Cavitron. Sharp cures effectively planed the root surface. Other studies^{15, 25, 34, 153}, claim that surface structure is also removed with the ultrasonic scaler. The author agrees with this for the Cavitron at high amplitude setting, and the Odontoson at half and three quarter amplitude settings. (Refer Table 6).

Contrary to the findings by Jones and co-workers⁹³, by Pameijer and co-workers¹⁶³, and by Ewen and Gwinnett³⁹; three scanning electron microscope studies^{147, 262, 271}, have reported that the Cavitron ultrasonic scaler produces a "rougher" surface than the sharp curette.

The degree and depth of tissue effects observed following instrumentation may be influenced by several factors. Those considered important to a discussion of the results obtained by the author, as compared to previous researchers, comprise the following aspects:

- (1) the instrument itself;
- (2) the dental hard tissues being instrumented;
- (3) the operator; and
- (4) the method of observation and evaluation of surface changes.

Instrument Variables

Variables associated with the instrument which may affect the surface produced, are both macroscopic and microscopic.

The shape of the blade or tip is important. The sharp end of some ultrasonic tips directed towards the tooth surface will produce surface irregularity^{26, 39, 163}. Wilkinson and Maybury²⁷¹, when evaluating hand and ultrasonic instruments on tooth roots, used sharp sickle-shaped Cavitron P-11 tips. These, by virtue of their shape, would tend to gouge the root surface. Other studies of this type have used dull P-10, or the modern equivalent TFI-10 "universal" tips.

The relative dimensions, thickness, and flexibility of the blade, shank, and handle are also important. These may influence the operator's ability to reach the area required to gain tactile sense, and to effect control of the instrument.

In addition, one should consider the unique features of the ultrasonic instrument when compared with hand instruments. For example, the power (amplitude) setting is adjustable. Specific power settings have not been reported in many studies^{39, 93, 100, 163, 275}, when evaluating effects produced by the ultrasonic instrument. The present study has shown significant differences between surfaces produced by the Cavitron at medium amplitude setting, and surfaces produced by the Cavitron at high amplitude setting. (Refer Tables 5 and 6). The Odontoson unit possesses a much higher frequency (42 kHz) than either the Cavitron or

the Amdent (25 kHz). The Odontoson also claims to have a lower amplitude than the other two brands⁵⁶.

Different claims have been made for the pattern of vibratory motion by the three ultrasonic scaling units used in this study. The Cavitron claims elliptical motion⁶, the Amdent linear motion²¹⁹, and the Odontoson rotary motion⁵⁶. It may be that the degree of surface changes (shown in Tables 5 and 6,) is related to the type of motion for each instrument. In the clinical situation, it has been pointed out by Jacobson⁸⁹, that the irregular anatomy of the tooth makes it difficult to keep the angle between instrument motion and the tooth at its correct theoretical value at all times.

The water available at the tip of ultrasonic instruments may also vary in relation to the amount and direction of the water spray present. (Refer Table 2). Allen and Rhoads⁴, reported increased irregularities produced where sufficient water was not available at the tip.

Where the energy output of the unit was low, the hand pressure light, and the tip broad and polished where it contacted the tooth, it was possible to perform a certain amount of instrumentation in which the surface was not changed. As the factors listed above increase the amount of energy per unit area, the likelihood of changing the surface texture increased. (Refer Tables 5 and 6.) If a surface alteration occurred, the surface produced was

relatively characteristic of the type of instrumentation. The author found the "all-or-none" type of phenomenon, described by Clark²⁶, was most noticeable for surfaces following use of the Odontoson ultrasonic scaling unit. (Refer Plates 29 to 32).

Microscopic features of the instrument may also affect the type of surface produced. For example, grain size, and the material used in the construction of the instrument blade, have been found to produce slight differences in the surface finish of tooth roots⁹³. The edges of steel instruments are more rounded than those of tungsten-carbide instruments. Any grooving produced can be expected to be shallower and less angular⁹³. Similarly, the radius of curvature of an edge suffers increasing plastic deformation in use⁹³. Dull cures have been found to produce "smoother" surfaces than sharp cures³⁹. The author has substantiated these findings (Refer Table 5).

Dental Hard Tissue Variables

Features of the dental hard tissues may affect the surface observed following instrumentation. The tissue may be predominant Sharpey fibre cementum, or partial Sharpey fibre cementum, or it may be dentine. The root surface may have been exposed to the oral environment, or it may be covered with periodontal fibres. Where an instrument has little tendency to alter the surface, such as a Cavitron or Amdent ultrasonic scaler at medium amplitude setting, the

resultant surface would exhibit features characteristic of its own morphology, rather than features caused by the instrument. This aspect has been neglected by workers such as Van Volkinburg and colleagues²⁶², Figure 3, who have interpreted normal cemental features in an infra-attachment root surface as irregularities due to the Cavitron; and by Ewen and Gwinnett³⁹, Figure 17, who have described a smooth "cemental surface", which is actually a mineralized pellicle sheet on a supra-attachment root surface.

The physical properties of the dental hard tissues may vary. These include hardness, scratch resistance, abrasion resistance, and acoustic impedance. Properties may vary with age, state and duration of the disease; from person to person, from tooth to tooth in the same person, and from area to area in the same tooth. Routiola and Craig¹⁷⁷ showed, however, that cementum exposed by periodontal disease had similar Knoop hardness values as normal cementum. Further, hardness values for the dental hard tissues are not necessarily related to the ease with which they may be removed by curettage³².

It was found, in this study, that polished acrylic surfaces proved useful as an easily controlled, homogeneous, model surface to test the potential for periodontal instruments to damage tooth roots.

(Refer Table 4).

Operator Variables

Operator variables which may affect the surface produced include the following aspects:

- (1) Knowledge - how the instrument is used;
- (2) Aims - what the operator wishes to achieve;
- (3) Access - related to many factors including design of instrument, position of tooth in arch, depth of pocket, root morphology, and patient cooperation.
- (4) Manual dexterity - This may vary with certain factors such as fatigue.
- (5) Thoroughness and care during use of technique, including amount of pressure applied, direction of stroke, number of strokes, continuity of stroke, and angle of application.
- (6) Criteria for completion of instrumentation desired. Some step differences between tooth substance and acquired accretion, or between tooth substance and adherent fibre debris, may be too small to register by touch.

The operator may intend to remove acquired accretions only, or he may wish to definitively plane the root surface, ideally removing pathologically affected cementum and producing a clinically smooth surface*. Tables 5 and 6 in the present study show results obtained for each of these desired features.

* 16, 22, 23, 83, 101, 109, 179, 202, 246, 248.

The claimed advantages of definitive root planing include the following:

On exposed roots, cytotoxic substances such as endotoxins, whether in plaque entrapped in surface imperfections, in mineralized pellicle, or bound within the structure of cementum, may be more predictably eliminated by removal of the cementum itself. This would enhance the chances of new attachment^{1, 2, 45, 185}.

Removal of substances which may bind to hydroxyapatite such as lipoteichoic acids and endotoxins may temporarily affect the ability of organisms to adhere to the tooth¹⁰⁵.

Creation of "fresh" areas during planing produces dentine and cemental resorption, which in turn tends to accentuate cemental redeposition when the root surface is covered by a soft tissue flap^{167, 237}.

Removal of mineralized fibres running parallel to the exposed root surface may encourage new attachment at these sites²⁷⁶.

The increased time that root planing takes, may also improve the chances of removing otherwise untouched bacterial deposits⁹³.

The lodgement of calculus into crevices of cementum surfaces means that some removal of tooth substance is necessary if total accretion removal is to be achieved^{94, 95, 199, 277}.

Zander²⁷⁷ and Schaffer²⁰² suggest that planing aids in achieving a smooth tooth surface. However, the

damage to tooth surfaces following many types of instrumentation often produces a surface of increased roughness^{94, 95}. Total removal of all cementum does not appear to be related to successful microscopic smoothing of the root surface¹⁵³. The present study illustrates this. (Refer Plates 20 and 26).

The possible disadvantages of definitive root planing include the following:

Clinical and microscopic findings suggest that root planing alone is of rather short-lived benefit to the patient^{5, 249}. In studies where root planing was performed without definitive pocket elimination procedures^{198, 201, 231}, inflammation in the gingival corium, although diminished after two weeks, returned to pretreatment levels by four to eight weeks.

Sensitive cervical root areas are a common result of definitive root planing.

In flap procedures, removal of tooth structure may also involve removal of fibre ends attached to root surfaces. Under such circumstances, connective tissue attachment levels may be decreased^{107, 228, 232, 233, 236}.

A discussion of factors relating to smoothness during root preparation will now be presented.

A smooth surface is claimed to minimize the rate of recurrence of deposits^{22, 25, 66, 259, 271}, though no well controlled studies have shown surface texture, by itself, to be a direct determinant in the rate of plaque deposition. Clayton and Green²⁷ have shown that surfaces which were smoother than could be obtained

with any type of conventional periodontal instrument, still required regular mechanical cleaning to prevent accumulation of dental plaque. In this respect, all tooth surfaces are relatively rough when considered at an ultrastructural level, and perhaps the grosser "roughness" may not be important^{93, 215}. It is, however, conceivable that grooves may act as micro-stagnation areas, which would provide an environment that encourages colonization of the surface⁹³. Many procedures traditionally thought to "smooth" the root surface, do so on a macroscopic scale, where levelness is a criterion; but tend to produce a greater microscopic roughness, as in the case of sharp curettes^{93, 163}. (Refer Table 5.)

A smooth surface is also said to make plaque removal easier for the patient^{*}. However, studies by Donze and colleagues²⁹, and by Rosenberg and Ash¹⁹², have not demonstrated any biological significance to differences in degrees of roughness following different types of periodontal instrumentation.

Where dentogingival healing is concerned, it is possible for epithelial cells to attach to a great variety of surfaces, whether they are smooth or not.^{122, 125, 126, 127, 208}. However, microscopic roughness of the tooth surface seems to favour adhesion of the cells of the junctional epithelium^{18, 122, 206}. Such roughness may also facilitate the attachment of connective tissue following definitive periodontal treatment^{25, 271}.

* 18, 22, 23, 61, 66, 93, 163, 248, 259, 265, 266, 275.

Variables Associated with the Method of Observation and Evaluation

Clinical evaluations of root surface texture, as performed by Forrest⁴¹, and Stewart and colleagues²⁴⁴, were immediately limited by both tactile and unaided visual senses. Histologic, or dissection microscopic methods^{4, 11, 92, 153, 199, 240}, were limited by resolution. More recently however, the profilometer has been advocated as being a reliable, objective method of evaluating root surface roughness^{20, 66, 100, 147, 192, 262}. However, its shortcomings have been noted^{93, 163, 263}. (Refer Introduction)

Volchanský and co-workers²⁶³, performed four simple assessments using the profile tracings of different materials. Although criteria for assessing recordings appeared valid, (ie using line-length index, peak per mm, maximum peak-to-valley height, and visual), different orders of roughness for each method were found.

When studying root surface texture using the profilometer, investigators^{20, 66, 100, 192, 262}, have used a "centre-line average (CLA) index, ie, a numerical assessment of the average height of the irregularities²⁶³. However, the CLA value is used in engineering only on planar surfaces, or surfaces having a regular curvature. It is not suited to measuring irregular tooth surfaces²⁶³. At best, the profilometer values cited in the literature, report the

degree of surface flatness, not microscopic smoothness*.

* A smooth surface has been defined as being "free from projections, irregularities, or inequalities; presenting no roughness or unevenness to the sight or touch"²¹⁸. There are two main components in this definition. One refers to a microscopic assessment; that is, not rough, "free of projections, points, bristles"²¹⁸. The second component refers to a more macroscopic assessment; that is, evenness, "flat, plane, level"²¹⁸, "being without gross deviation from a geometrical plane"²⁶⁸. Where the profilometer tracing device is limited to a more macroscopic assessment of levelness^{93, 163, 263}, microscopic smoothness should not be implied.

For example, Table 5 shows surface types for removal of tooth substance, assessed at 20X magnification. Surface type 5, was produced by a sharp curette. This "flat, even" surface would show on profilometer tracings as a "smooth" surface. Table 6, however, assessing surface texture at 1000X magnification, shows the sharp curetted surface to consist of shallow irregularities over most of the instrumented area. Similarly, supra-attachment root surfaces following the Cavitron at medium amplitude setting were assessed by the author as "smooth" at 1000X magnification. However, since the surface was not planed, the profilometer tracing would record normal cemental undulations as irregularities. This has been interpreted by investigators^{100, 147, 262}, as surface roughness due to the instrument.

The use of scanning electron microscopy has given valuable information regarding root surface morphology following periodontal instrumentation^{93, 163, 271, 275}.

Two studies^{147, 262}, have used scanning electron microscopy in conjunction with the profilometer. Unfortunately, neither study utilized sufficient magnification to observe the more minute surface texture as used by the present author. Both Van Volkinburg and co-workers²⁶², and Meyer and Lie¹⁴⁷, reported a correlation between profilometer and scanning electron microscope results. This is reasonable, since low magnification electron images only show gross surface topography. The author's results in

Table 6 at 20X magnification, also indicate that the sharp curette produces the most uniform topography.

The limitations of a scanning electron microscope study are apparent, in that it does not produce quantitative results. Meyer and Lie¹⁴⁷, did use a S.E.M. Roughness Index (SRI) for quantitating results, however, all scoring was performed at a standard magnification of 72X, which only indicates gross topography. The results shown in Tables 5 and 6 may be modified to quantitate results in future studies.

SUMMARY AND CONCLUSIONS

Scanning electron microscopy was used to examine tooth root surfaces and polished acrylic surfaces following hand and ultrasonic instrumentation.

Gröss topography was assessed at 20X magnification; more minute surface texture was assessed at 1000X magnification.

It was evident that different methods of instrumentation produced dissimilar root surface topography.

Polished acrylic proved useful as an easily controlled model surface to test the potential for periodontal instruments to damage root surfaces.

An instrument blade, or tip with a dull working edge, produced a smoother surface texture than its sharp counterpart; however, it had less tendency to remove tooth structure.

Although the removal of some surface structure is possible with the ultrasonic instrument, true, definitive root planing, where the operator wishes to remove tooth structure in a given area, is probably best performed with a sharp curette.

The flattest root surfaces (assessed 20X) were produced by:

- a sharp curette;
- a sharp scaler;
- a Cavitron or Amdent at three-quarter (medium) amplitude setting, followed by a sharp curette; and

- a sharp curette, followed by a Cavitron or Amdent at three-quarter (medium) amplitude setting.

The smoothest root surfaces (assessed at 1000X) were produced by:

- a Cavitron, or Amdent at three-quarter (medium) amplitude setting, on supra-attachment root surfaces;
- a sharp curette, followed by either a Cavitron, or Amdent at three-quarter (medium) amplitude setting;
- a dull curette; and
- a dull scaler.

Mineralized pellicle was still present on supra-attachment root surfaces following instrumentation by the Cavitron at medium setting, the Amdent at medium setting, and a dull scaler.

The Cavitron and Amdent ultrasonic instruments at similar amplitude settings produced surfaces of similar texture. The Cavitron, however, showed a tendency to remove more tooth structure than the Amdent. The Odontoson produced areas with deeper irregularities than the other two types of ultrasonic scalers.

Whether or not there is a biological significance corresponding to the differences in root surface topography following use of various methods of root surface instrumentation, has not been definitely established.

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APPENDIX

APPENDIX

PLATES 42a (100x) and 42b (1000x)

Supra-attachment root surface following Amdent ultrasonic scaler at high amplitude setting.

The burnished calculus layer was not detected by instrument touch.

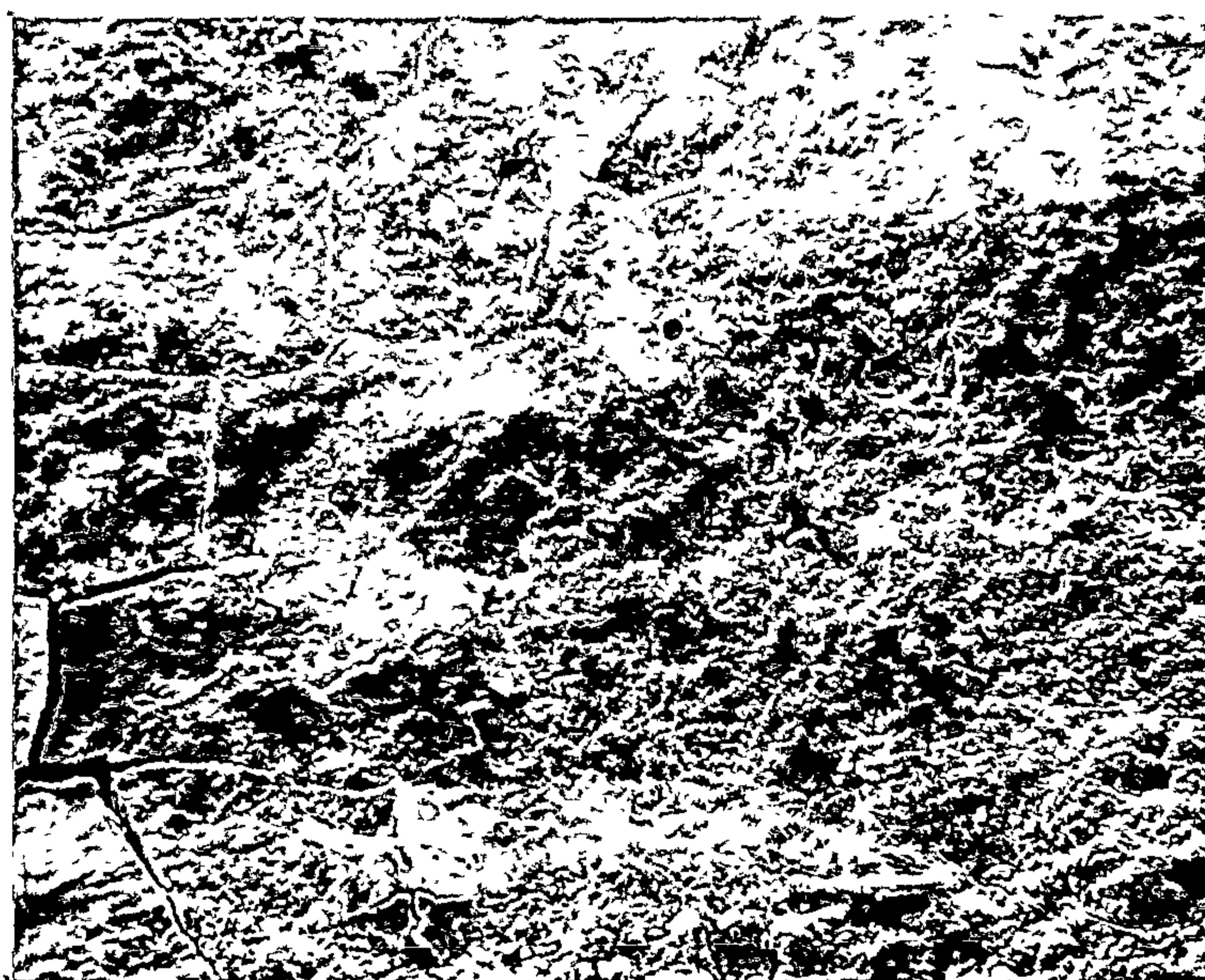


PLATE 42a (100x)

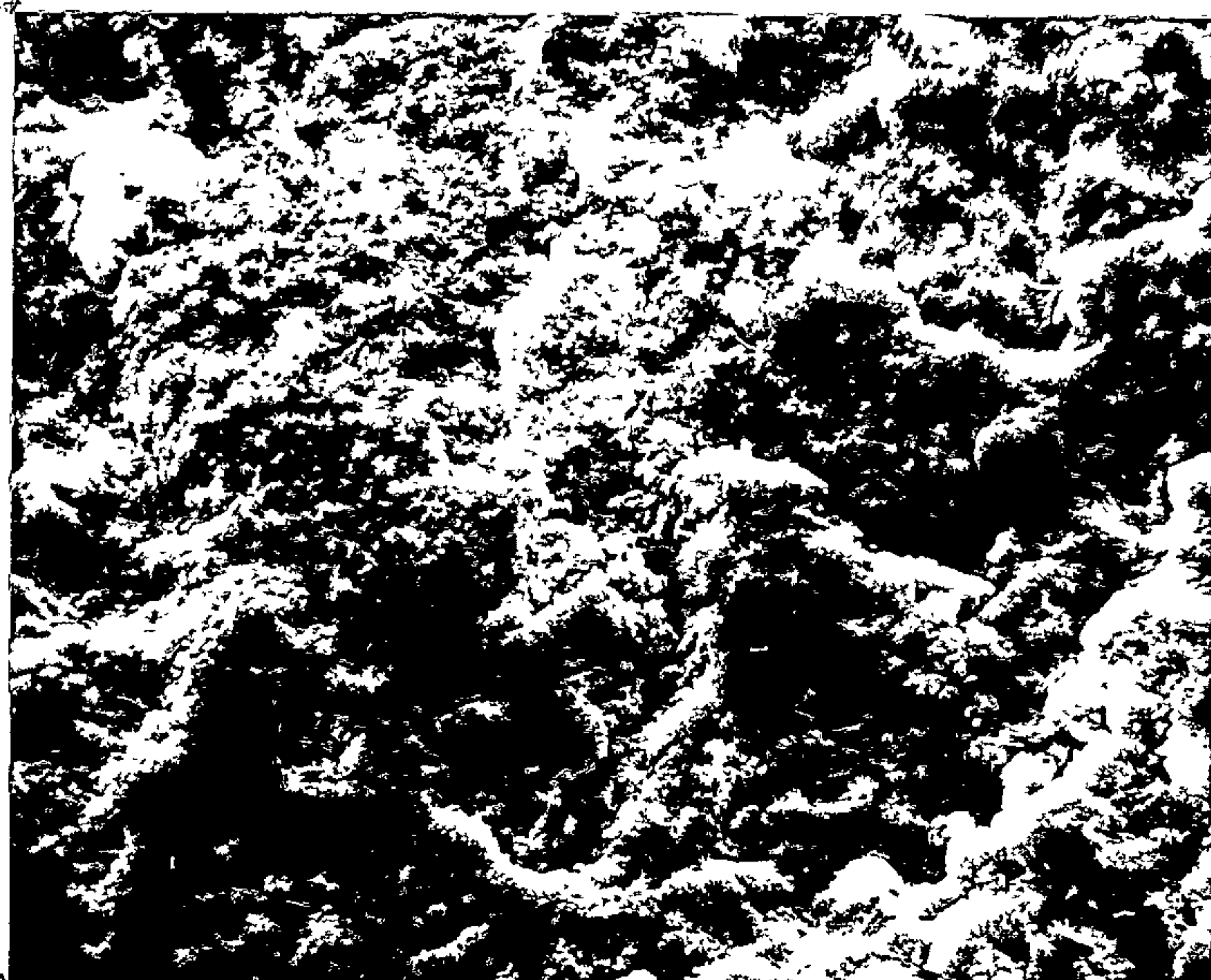


PLATE 42b (1000x)

PLATES 43a (100x) and 43b (1000x)

Infra-attachment root surface following Amdent ultrasonic at three quarter (medium) amplitude setting. Periodontal fibre remnants were not detected by instrument touch.

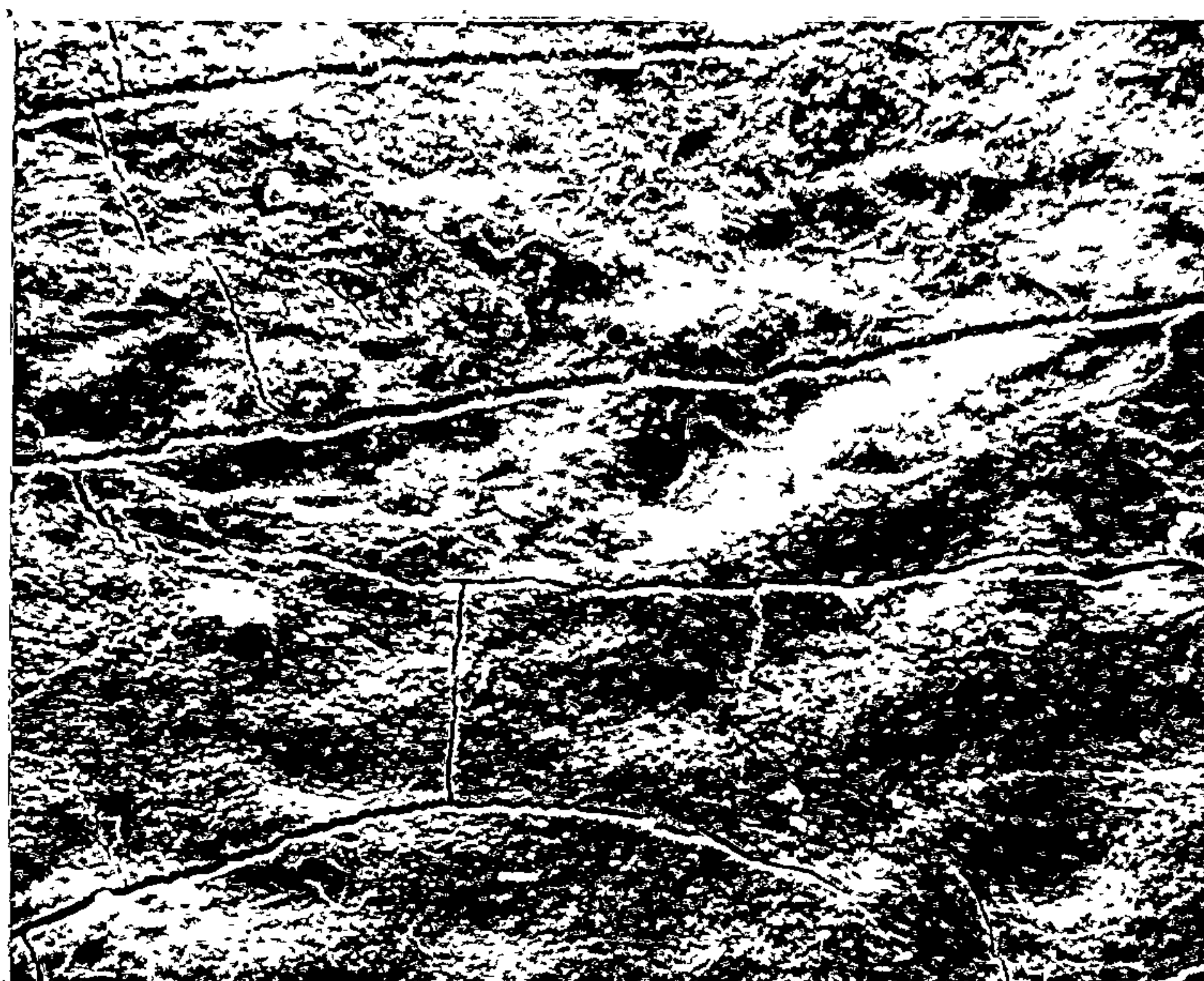


PLATE 43a (100x)

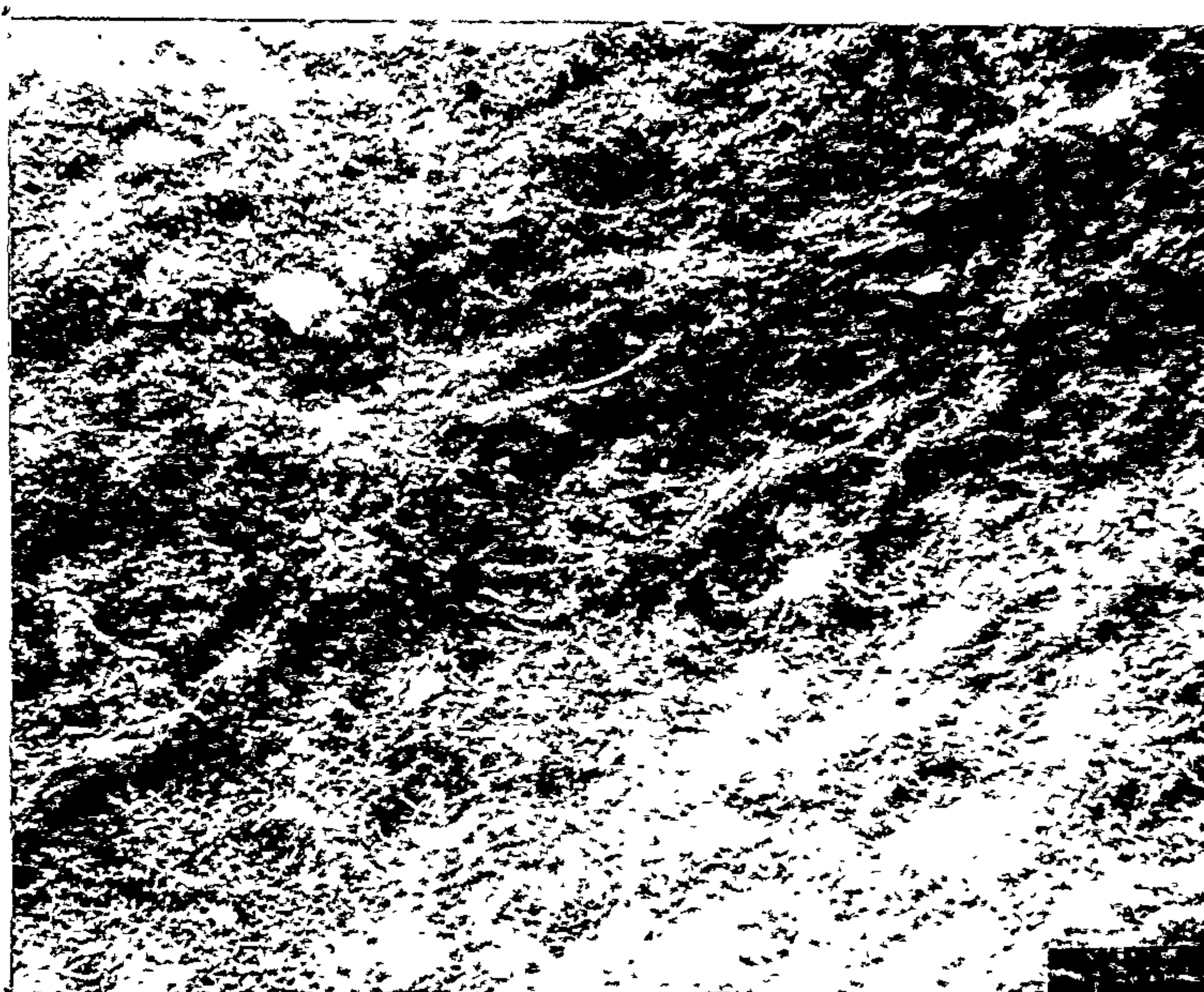


PLATE 43b (1000x)

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