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LOW RAW MAGMA STUDY

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INTRODUCTION

Crystallization of sucrose from liquid sugar solutions represents an important phase in the sugar processing. The vacuum pan, where the crystallization takes place consists of steam chest, agitator, instrumentation, syrup manifold, barometric condenser and vacuum pump. In most of the sugar factories this is a batch process and only one stage evaporation system, thus it is a relatively time consuming and energy inefficient process. In order to boil a good quality massecuite, called the pan product, good equipment is required, as well as high quality skills and experience. While white and high raw massecuites, finished in vacuum pans are sent to centrifuging, the low raw strikes require an additional crystallization in water-cooled crystallizers. After crystallization, the crystals are separated from "mother liquor" by means of screening in high gravity force centrifugals. It is a common practice that during centrifugal separation, sugar crystals are washed with a fine mist of water to help in the removal of "mother liquor" residue adhered to the crystal surfaces. In addition to its benefits, the wash water is somewhat damaging, since it is a ballast that must be removed later by evaporation. The wash water also dissolves some already crystallized sugar, thus creating further damage. The efficiency of separation and the required volume of wash water water depends on many parameters, among them the massecuite quality. The primary objective of this project was the improvement of white massecuite quality and through it to achieve positive impact on pan capacity, centrifugal separation and energy consumption.

MAGMA PROJECT - PRINCIPLES

Traditionally, in the American beet sugar factories the number of vacuum pans is critically small. The pan capacity in an average American factory is not more than 25 to 30% of that in a similar sized factory in Europe. This creates a serious drawback in many respects, i.e.: reduced boiling time, inefficient heat economy, bottleneck during material flow surges, etc. The pan boiling time is governed rather by the volume of incoming syrups, not by prudent and requested technological values. Concurrently, in order to have a large material flow in a relatively small number of vacuum pans, the high speed boiling is an accepted fact. Because of high speed boiling, the massecuite in the vacuum pan is kept at an unusually high supersaturation level; consequently, in spite of pan agitation, there is a persistent jeopardy of creating conglomerates. This threat is especially high in the boiling phase when the crystal sizes are at the range of 50 to 120 microns (1). Under these conditions massecuite quality becomes jeopardized, i.e.: crystal conglomeration, mixed grain, low sugar exhaustion, high viscosity massecuite, etc. The negative consequences of all the above mentioned are obvious. The problems are even more compounded with the fact that the American sugar quality standards are, in most cases, more demanding than the European.

There are various schemes for low raw sugar preparation, The most conventional consist of: low raw pans, crystallizers, and continuous centrifugals. The centrifuged low raw sugar is scrolled into the melter, dissolved and blended with high raw sugar, evaporator thick juice and high wash, filtered and sent to the standard liquor tank. Both dissolved raw sugars, joined by thick juice and high wash, serve as material for white pan boiling. As pointed out earlier, there are many variations in low raw schemes, but each calls for dissolving the centrifuged sugars. There is only one exception to that, the "Einwurf" scheme, where the low purity, fine grain, low raw sugar is used as seed for the high raw pan. It has been observed that in the "Einwurf" process some identifiable impurity occlusion occurs within the small crystal used as seed. The findings were documented by published works and a recent paper from G. Vaccari, G. Mantovani and G. Sgualdino (2). Further, Shore et al. (3) "have shown that the main portion of the coloring matter of the sugar is located in a small central part of the crystals. "Van der Poel et al. (4)" pointed out that there is an increase of color around the nucleus of the crystals, indicating occlusions incorporated in the period during or shortly after the seeding".

The authors reported a similar experience in an earlier project that was published at the 25th ASSBT General Meeting (5) and in inter-company documents (6).

A project was initiated In The Western Sugar Company's Bayard, Nebraska factory, during the 1990/1991 campaign with the objective to test the possibility of using affinated low raw sugar magma as seed in white pan boiling. The basic idea was to introduce the prepared magma into undersaturated standard liquor charge. This way conditions were created to remelt the top, high color, layers of affinated sugar; more-over, in this environment the fine fractions and dust from magma would be remelted. This was done in hopes that the method would yield relatively better seed, purged from colored top layer, for the white pan boiling. This way the average seed size during graining of the white pan was over 100 microns; hence, the critical conglomeration range was by- passed. We hoped that this method would yield even size seed and better quality finished product, enable fast crystallization due to large crystal surface, beneficially affect the vacuum pan capacity and have a positive impact on fuel economy.

BAYARD FACTORY - SUGAR END SCHEME

The low raw massecuite from the pan (G) is dropped to crystallizers (J). After gradual cooling to 45 degrees C. and crystallization during a retention time of 48 hours, the massecuite overflows to Stevens coil heater (K) where the massecuite temperature is elevated to 56 degrees Centigrade. The flow continues to affination centrifugals #1 (O) where it is purged with a minimum amount of wash water and steam. The raw sugar continues to mingler #1 (S), through automatic density control equipment, a controlled amount of affination syrup, from tank (Y) is added in order to recreate an intermediate (raw) magma that is pumped into tank (L) and sent to affination centrifugals #2 (P). After second purging, thick juice is added to the sugar in order to recreate the seed magma (T) and pumped to magma storage (D). The white pan (B) is started with a charge of standard liquor from tank (A) and at the appropriate time, 200 to 250 Cu. Ft. of magma is introduced through a manifold. Next, the white massecuite is dropped to mixer (H) and purged in white centrifugals (M). The white sugar is sent through scroll (Q) to the granulator dryer while the high wash joins the purged high raw sugar and thick juice in the high melter (V). After melter, the liquor is pumped through "Industrial filters" (not shown in scheme) to standard liquor tank (A). The high green from tank (U) is sent to the high raw pan supply tank (C) and pan (E).

After the high raw massecuite is finished, it is dropped to receiver (I) and purged on continuous centrifugals (N).As can be seen, the Bayard plant sugar end scheme is quite simple design with relatively easy access to equipment.

TEST RESULTS

The magma seed was prepared on the low raw affination station that consisted of first group of centrifugals (O), second group of centrifugals (P), and two minglers (S & T). The first group of centrifugals were "Western State - Hamilton"; WS 81185-2 and WS 81185-2. In order to decrease the incoming massecuite viscosity, it's temperature was elevated to 56 degrees C. in the Stevens coil (K) and 645.6 lbs./h water was added to the centrifugal feed. The molasses purity obtained on centrifugals was in the range of 58.51. That was slightly elevated due to the minor amount of small size crystals carried through the centrifugal screens.

The first group centrifugal results were:

	RDS	P	Purity	Color
Sugar	97.80	90.54	92.58	11719
Molasses	85.65	50.11	58.51	over 95000

Sugar obtained from first group of affination centrifugals was sent to the mingler (S) and mixed with affination syrup in order to obtain a raw magma having a density RDS = 92.00. This raw magma was pumped to the second group of affination centrifugals for the second purge.

The second group of affination centrifugals consisted of a "Western State"; WS 81185-1 machine. In order to obtain high quality sugar that could be used as white pan grain, a minor amount of steam and 937.9 lbs./h water was introduced into the centrifugal spray nozzles during purging.

The second group centrifugal results were:

	RDS	P	Purity	Color
Sugar	98.56	97.84	99.26	762
Aff.Syrup	78.27	62.15	79.40	over 30000

The sugar from the second group of low raw centrifugals was sent to the mingler (T) and with a controlled amount of thick juice, the magma seed was prepared. Both minglers (S) and (T) were supplied with automatic density controllers that functioned based on the motor load measurements on the agitator drives, load controllers and motor valves on syrup inlets. The magma seed was pumped to a hot water jacketed storage tank supplied with a slow moving agitator (D) and was kept at 85 degrees C. temperature.

The seed magma characteristics were as follows:

Volume . . . . 5.01 tons/h
RDS . . . . 91.0 %
Purity 98.02
Crystal content . . . . 73.9 %

The data for average standard liquor feed was:

Volume	51.67 tons/h
RDS	71.0 - 72.0 %
Purity	93.0 - 93.8
Color	2160 - 2170 Icumsa

The white pan was started on absolute pressure of 5.2 inches/Hg, temperature 75 degrees C., calandria covered with standard liquor, steam gauge pressure at 7 psi and pan agitator running with 40 Amp. load. The seed magma was introduced ten minutes later into the under saturated liquor. The volume ratio standard liquor/magma was adjusted to 2:1. Observation through pan microscope confirmed a period of slight crystal dissolving; crystal edges rounded while the very small crystal fraction disappeared. During this time the average, very uniform size seed was in the range of 100 microns. The further pan boiling was continued without any slow down until the crystal sizes reached the average of 300 to 350 microns. Opposing a conventional white pan boiling time in the Bayard factory that takes an average of 100 minutes, the pan seeded with magma required an average of 67 minutes. However, it must be noted than when the crystal sizes reached the target and the crystallization had to be stopped, only 75 to 80% of the pan volume was used.

The average white massecuite data were:

Volume	45.74 tons/h
RDS	90.80 %
Purity	93.88
Crystal content	52.12 %
Temperature	76.0 (C)

The white massecuite was sent to the receiver (H) and purged on Western States batch centrifugals. Sugar quality obtained from successful strikes met the requested standards. Due to documented technical problems during tests, some strikes yielded slightly higher sugar conductivity values.

As shown in the following table, a typical magma grained strike, as strike No. 803, yielded high quality sugar with more uniform size grain than a pan grained with fondant; i.e.: strike No. 801.

	Fondant strike 801	Magma strike 803
Color (ICUMSA)	31.00	39.00
Conductivity (Mhos/cm)	1.7	2.40
MA (Inch)	0.0144	0.0140
CV (%)	29.00	26.00

VISUALS

All syrup, massecuite and crystal samples were analyzed under an electro scan microscope. Additionally, white strike crystal samples were surveyed under a light transmission microscope. (Print copies are attached to this report.)

Code designations:

Sample # 1 = Low raw massecuite (G).

Sample # 2 = Low raw sugar from affination centrifugals; group #1.

Sample # 3 = Raw magma from mingler #1 (S).

Sample # 4 = Low raw sugar from affination centrifugals; group #2.

Sample # 5 = Molasses from low raw centrifugals; group #1.

Sample # 6 = Affination syrup from low raw centrifugals; #2.

Sample # 7 = Magma seed from magma storage (D).

Sample # 8 = White pan massecuite after graining (B).

Sample # 9 = White pan massecuite; half level (B).

Sample #10 = White pan massecuite; feed stopped (B).

Sample #11 = White pan massecuite; magma grained strikes (H).

Sample #12 = Granulated sugar from magma grained strikes (H).

Sample #13 = White pan massecuite; <u>fondant grained</u> strikes (H).

Sample #13 = Granulated sugar from <u>fondant grained</u> strikes (H).

Sample #14 = Standard liquor (A).

NOTE:

1. Sample #2: Crystals heavily covered with molasses.
2. Sample #4: Affinated sugar with light syrup cover on crystals.
3. Sample #5: Molasses contains 18 x 41 micron crystal fractions.
4. Sample #6: Affination Syrup contains 4 x 8 micron crystal fractions.
5. Sample #7: Even 100 x 130 micron crystals with minor amount of fines in the seed magma.
6. Sample #12: Magma seeded finished product; well developed, relatively clean crystals with few conglomerates. Light transmission microscopy found no traces of syrup and/or color inclusion on seed crystal surfaces.
7. Sample #14: Fondant seeded finished product, large amount of conglomerates with syrup and color inclusions.

When in fast sugar boiling affinated low raw magma seed is used for graining the white pan with the described methods, combined survey with scanning electron and light transmission microscope documented the following:

A. The finished product is less clustered.
B. The crystal size distribution is improved.
C. There is no syrup or color inclusion on the surface of the seed that is inside the finished crystal.

CONCLUSION

High quality white sugar is obtainable by using affinated low raw sugar magma seed in the white pan.
The potential advantages of this boiling scheme are:

1. White pan capacity increase = 20 - 30 %
2. Grain uniformity increase = 10 - 15 %
3. Evap. capacity demand decrease = 1.5 -2.0 % Water/Beets

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MAGMA PROJECT; 2500T.B/D; DR.L.TOTH, D.McFARLAND.

02/08/91 SUGARS V2.41 MATERIAL BALANCE RESULTS (US UNITS) 09:24:04

%DS, PURITY & %CRYS. ARE ONLY FOR SOLUBLE PORTION OF FLOW

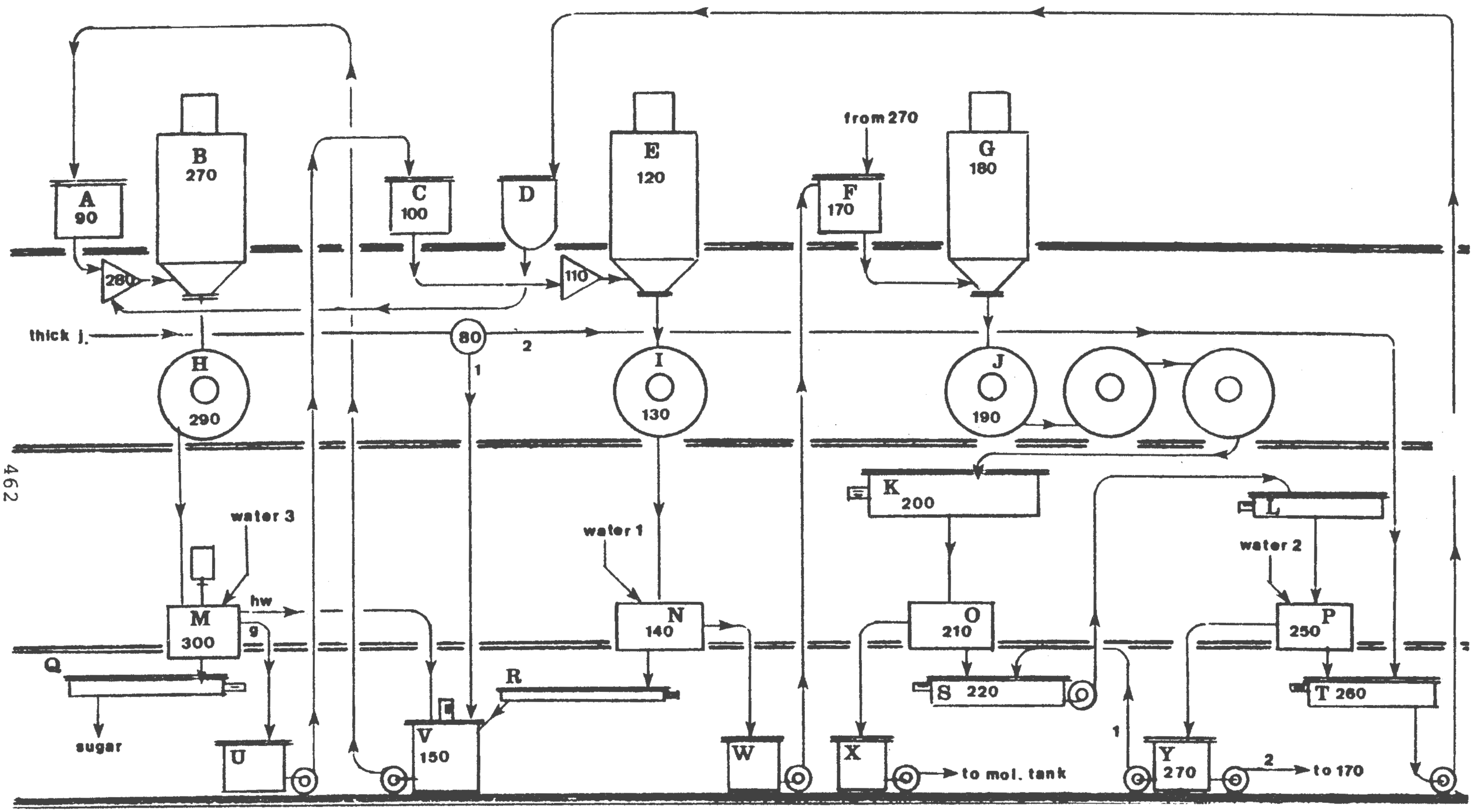
EXTERNAL FLOWS INTO FACTORY

FLOW	NAME	GOES TO	TONS/HR	%TDM	%SUGAR	%DS	PURITY	%CRYS.	TEMP(C)	%ISNS	%GAS
1	THICK JUICE DISTR.	80	41.10	64.00	58.37	64.00	91.20	0.00	75.0	0.00	0.00

STATION FLOWS WITHIN FACTORY

STATION	NAME	GOES TO	TONS/HR	%TDM	%SUGAR	%DS	PURITY	%CRYS.	TEMP(C)	%ISNS	%GAS
80	THICK JUICE DISTR.										
	OUTPUT #1	150	40.00	64.00	58.37	64.00	91.20	0.00	75.0	0.00	0.00
	OUTPUT #2	260	1.10	64.00	58.37	64.00	91.20	0.00	75.0	0.00	0.00
90	STANDARD LIQU. TANK										
	TO STORAGE	OUT	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00
	OUTPUT FLOW	280	51.67	71.55	66.81	71.55	93.37	0.00	95.0	0.00	0.00
100	HIGH GREEN TANK										
	TO STORAGE	OUT	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00
	OUTPUT FLOW	110	26.09	79.04	69.38	79.04	87.78	0.00	80.0	0.00	0.00
110	HRP FEED	120	26.09	79.04	69.38	79.04	87.78	0.00	80.0	0.00	0.00
120	HR PAN	130	22.30	92.50	81.20	92.50	87.78	42.37	85.0	0.00	0.00
130	HIGH RAW CRISTALL.	140	22.30	92.50	81.20	92.50	87.78	47.05	75.0	0.00	0.00
140	HR CENTRIFUGALS										
	GREEN	170	11.10	84.82	63.80	84.82	75.22	0.32	70.0	0.00	0.00
	SUGAR	150	11.46	97.82	96.18	97.82	98.33	89.31	68.0	0.00	0.00
150	HIGH MELTER	90	51.67	71.55	66.81	71.55	93.37	0.00	95.0	0.00	0.00
170	LRP FEED TANK										
	TO STORAGE	OUT	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00
	OUTPUT FLOW	180	13.60	83.62	63.50	83.62	75.94	1.59	66.0	0.00	0.00
180	LR PAN	190	12.11	93.90	71.31	93.90	75.94	23.91	87.0	0.00	0.00
190	LR CRISTALLIZERS	200	12.11	93.90	71.31	93.90	75.94	45.79	45.0	0.00	0.00
200	LR MENGLER #1	210	12.11	93.90	71.31	93.90	75.94	45.79	56.0	0.00	0.00
210	AFF.CENTRIFUGALS #1										
	GREEN	OUT	6.49	85.65	50.11	85.65	58.51	3.47	49.6	0.00	0.00
	SUGAR	220	5.95	97.80	90.54	97.80	92.58	82.34	48.0	0.00	0.00
220	LR MENGLER #2	250	8.46	92.00	82.11	92.00	89.25	60.03	48.3	0.00	0.00
250	AFFINATION CENTRF.#2										
	GREEN	270	5.02	78.27	62.15	78.27	79.40	7.20	48.8	0.00	0.00
	SUGAR	260	3.92	98.56	97.84	98.56	99.26	94.60	38.7	0.00	0.00
260	LR MENGLER #3	280	5.01	91.00	89.20	91.00	98.02	73.90	51.9	0.00	0.00
270	AFFINATION SY. TANK										
	OUTPUT #1	220	2.51	78.27	62.15	78.27	79.40	7.20	48.8	0.00	0.00
	OUTPUT #2	170	2.50	78.27	62.15	78.27	79.40	7.20	48.8	0.00	0.00
275	WHITE PAN	290	45.74	90.80	85.24	90.80	93.88	48.05	85.0	0.00	0.00
280	WHITE PAN FEED	275	56.69	73.27	68.79	73.27	93.88	6.54	92.5	0.00	0.00
290	WHITE MC. CRIST.	300	45.74	90.80	85.24	90.80	93.88	52.12	76.0	0.00	0.00
300	WHITE CENTRIFUGALS										
	GREEN	100	26.09	79.04	69.38	79.04	87.78	0.00	80.0	0.00	0.00
	WASH	150	0.21	76.32	70.93	76.32	92.94	0.00	80.3	0.00	0.00
	SUGAR	OUT	20.97	98.96	98.92	98.96	99.96	96.15	53.6	0.00	0.00

462



A.- Standard liqu.tank
B.- White pan
C.- High Green tank
D.- Magma storage
E.- High Raw pan
F.- Machine Syrup tank
G.- Low Raw pan
H.- White Massc. receiver

I.- High Raw MC. receiver
J.- Low Raw crystallizers
K.- Stevens coil
L.- Magma mixer
M.- White centrifugals
N.- High Row centrifugals
O.- Affination centrifugals #1
P.- Affination centrifugals #2

Q.- White sugar scroll
R.- High Raw sug. scroll
S.- Mengler #1
T.- Mengler #2
U.- High Green tank
V.- High melter
W.- Machine Syrup tank
Y.- Affination Syrup tank

WESTERN SUGAR COMPANY, DENVER, COLORADO.
MAGMA TEST IN BAYARD FACTORY, NEB.
DATE: CAMPAIGN 1990/91
RESEARCH: DR. LASZLO TOTH & DAVE McFARLAND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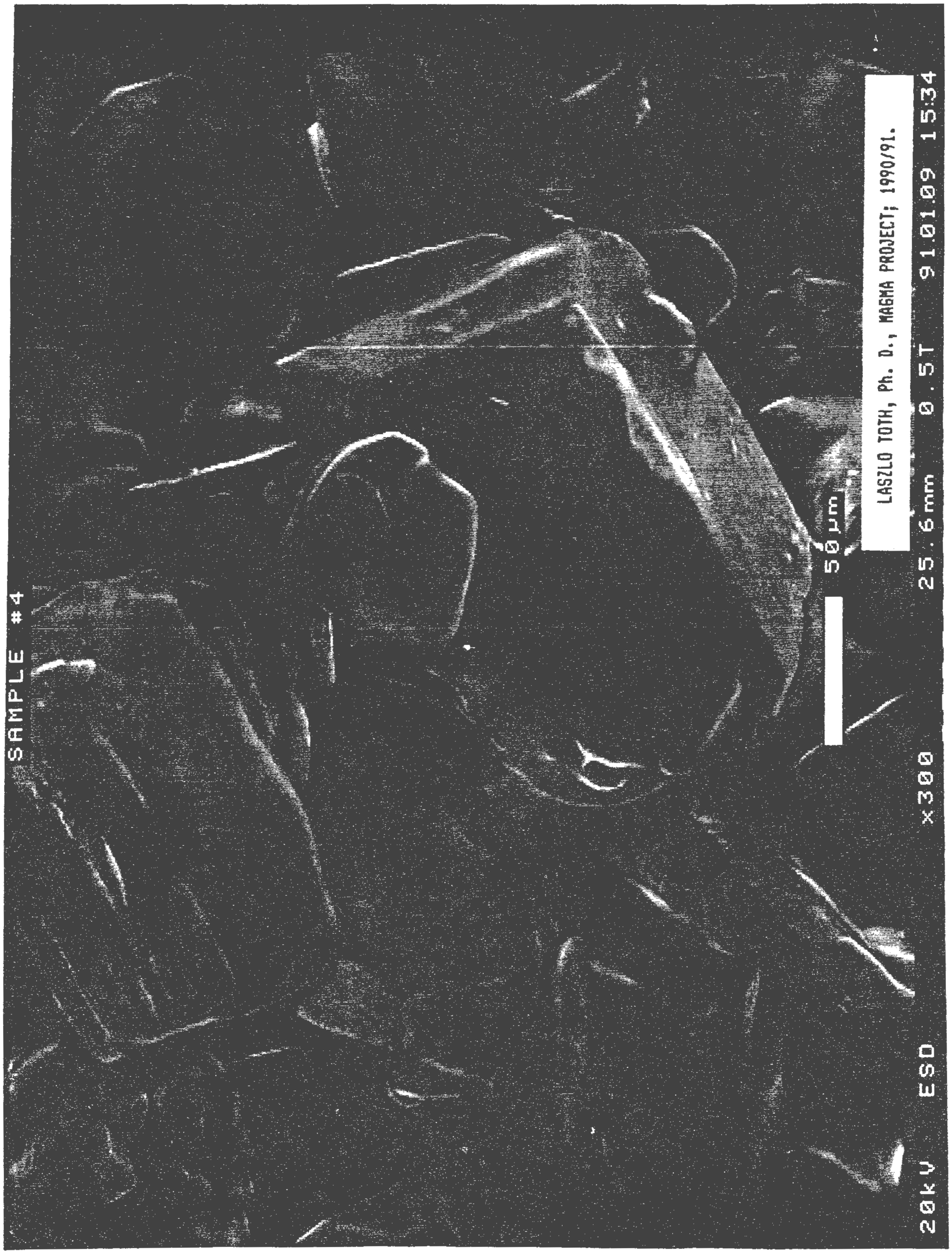
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LASZLO TOTH, Ph. D., MAGNA PROJECT; 1990/91.
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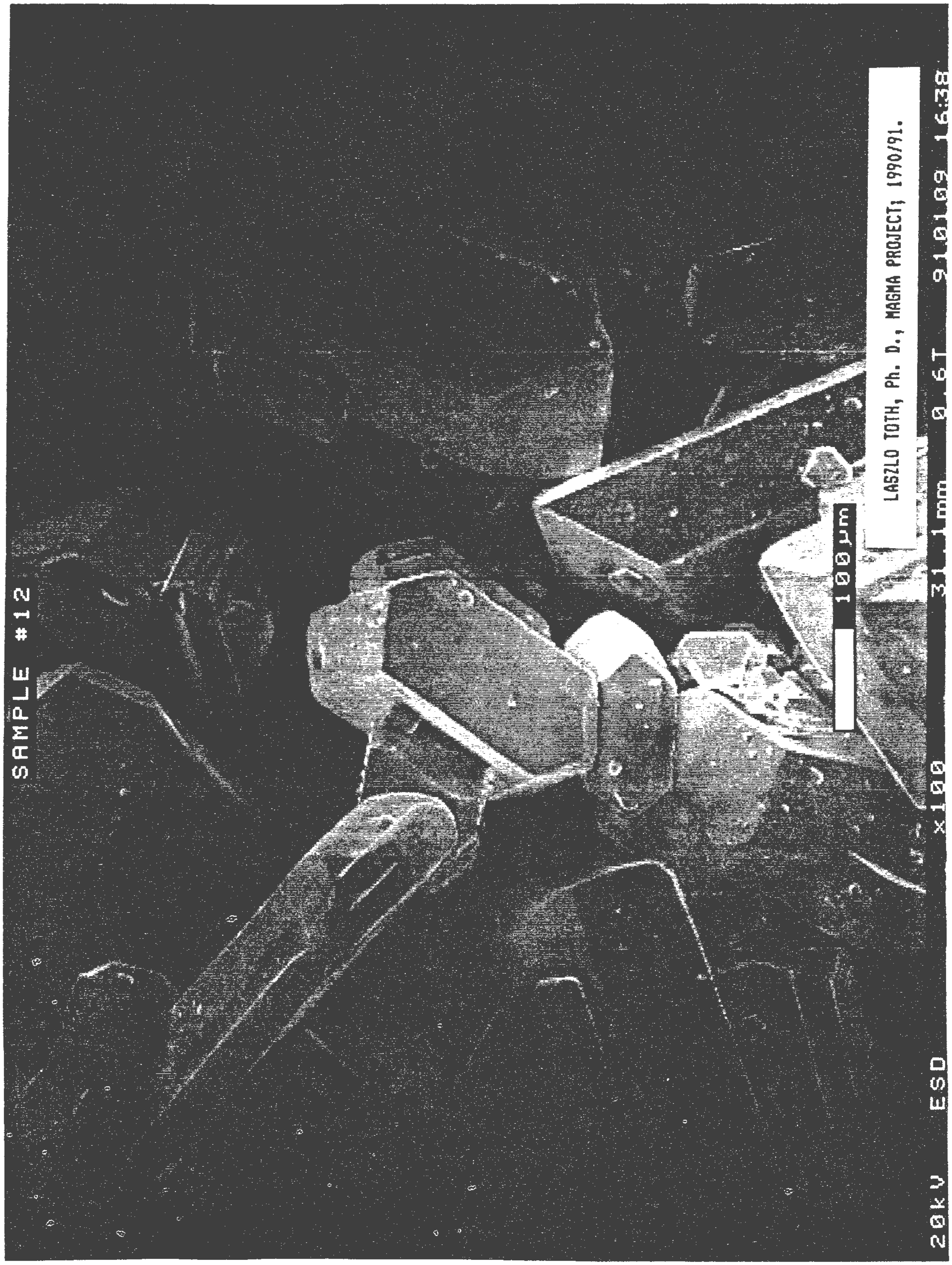
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20kV ESD x100


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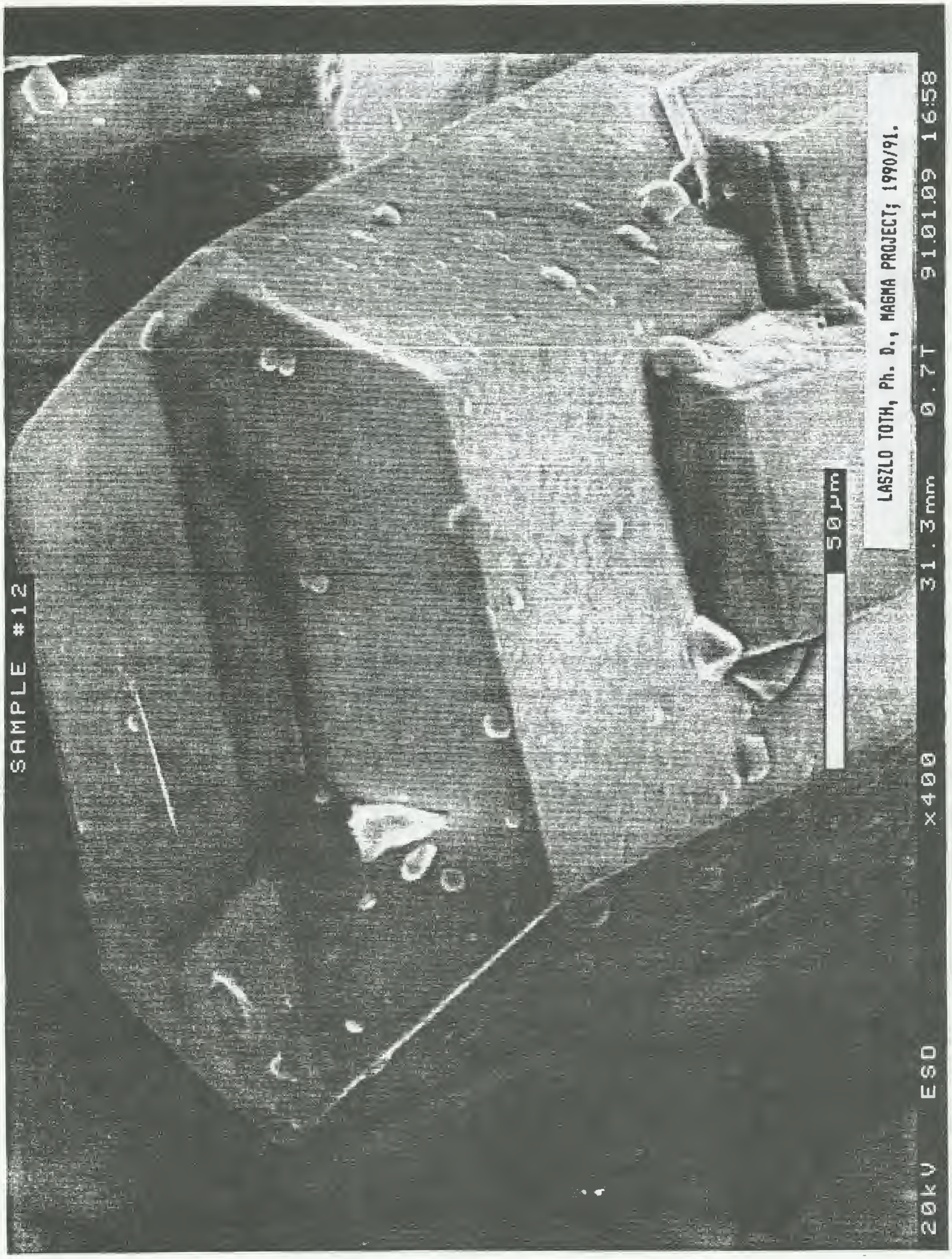
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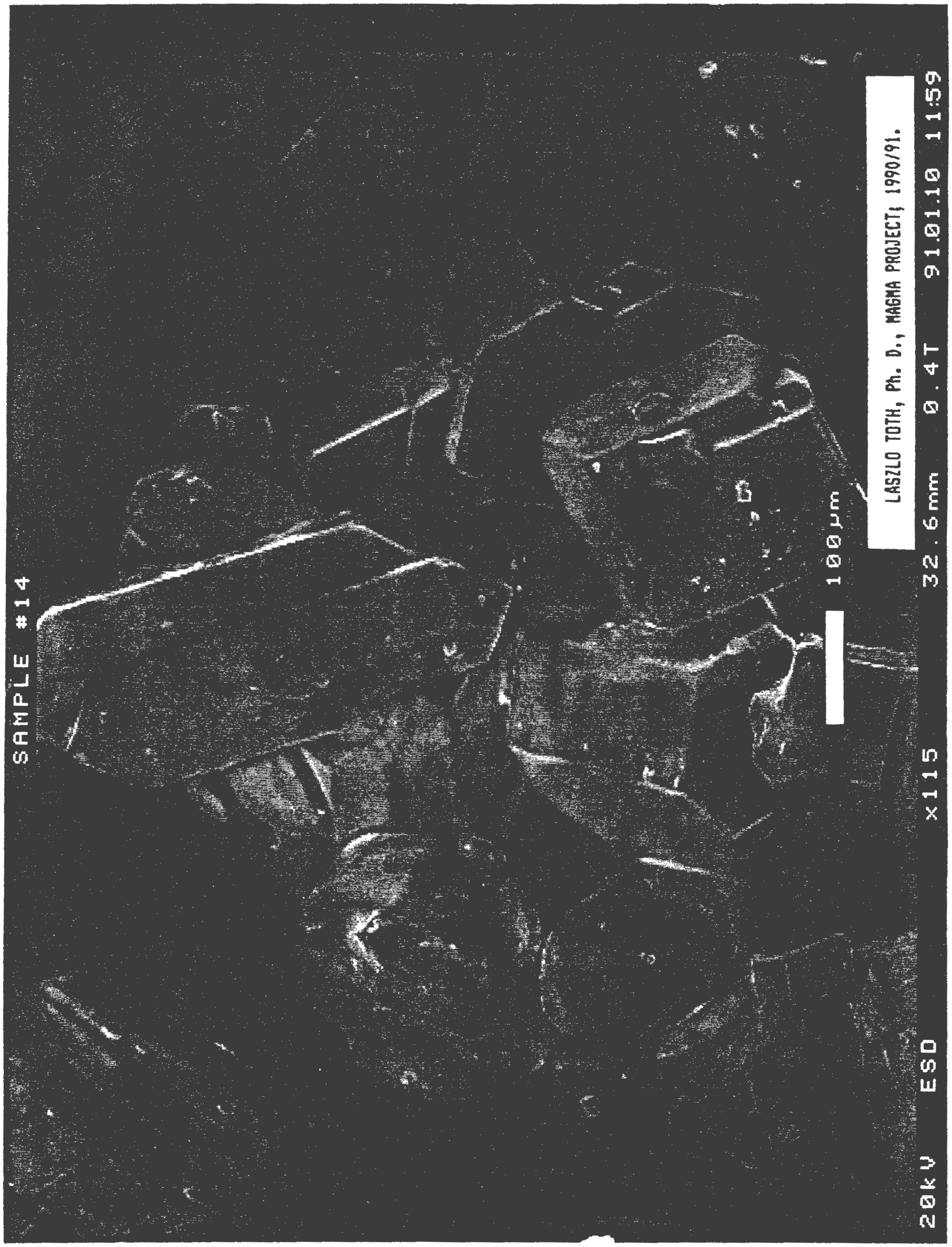
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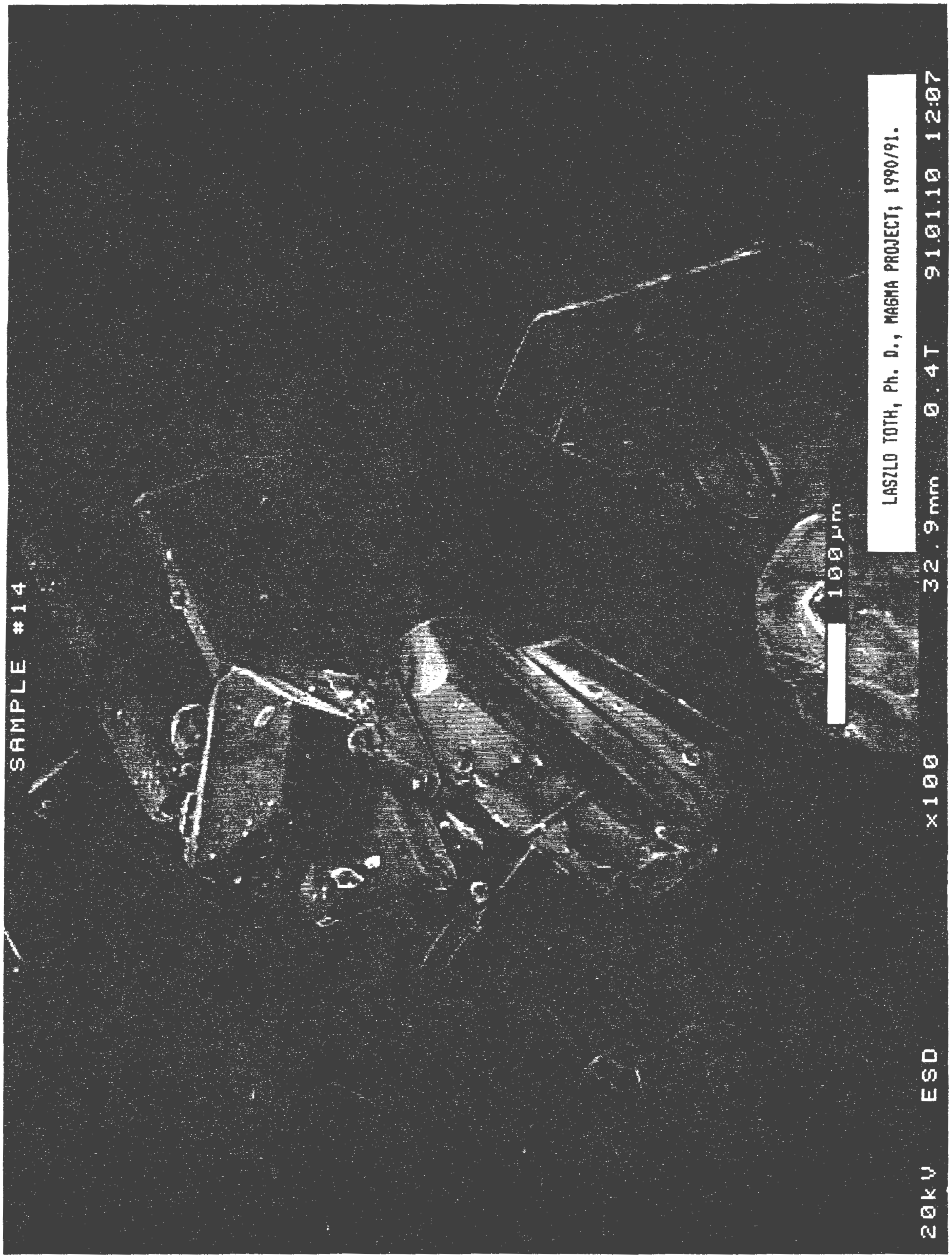
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