INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
34100 TRIESTE (ITALY) - P.O.B. 586 - MIRAMARE - STRADA COSTIERA 11 - TELEPHONE: 2240-1
CABLE: CENTRATOM - TELEX 460392 - I

H4.SMR/167 - 7

SCHOOL ON PHYSIC IN INDUSTRY

27 January - 14 February 1986

THE PHYSICS OF BAUXITE WASTE RESEARCH IN JAMAICA

presented by

Arun S. WAGH
Materials Laboratory, Physics Department
University of the West Indies
Mona, Kingston 7
Jamaica, West Indies

I. JAMAICA – AN ISLAND IN AGONY.

Jamaica, an island country of 200 miles by 60 miles size has the third largest alumina industry in western world (Table 1, fig. 1). Four alumina ~~companies~~ factories are dumping highly caustic waste in natural ~~vallies~~ valleys (fig. 4) which is contaminating ground water, killing bird and plant life and such a storage can simply be a disaster in an earthquake zone like caribbean. Our project deals with study of this waste, its eventual control and utilisation.

II. THE DEVELOPING NATIONS – JAMAICA GENERALISED:

As in fig. 1, Jamaican problem is common to many developing countries. Two typical examples are, Brazil and India. In the first case (fig. 2) the alumina factories are very close to population concentration while in the second case, the whole country is overpopulated and hence there is a problem with large amount of waste. Both countries are developing their alumina industries to much larger scale. So the problem will magnify soon.

III. THE RESEARCH PROGRAM AND ITS PHYSICS:

In 1983 we set out to study the following three components of research in the field with the funding from International Development Research Centre, Canada.

(1) Physico-chemical characterisation of the waste (fig. 4).
(2) The development of predictive dynamic model of the pond.
(3) Utilisation of the waste as building material.

Table 2 and 3 summarise the basic physical properties and the elemental constitution of the waste. Note the causticity and also high content of iron. The particle size is also very small (< 1μ).

The flow chart in fig 3 gives the logistics of the project. The physical properties of the waste has led to its utilisation, but radioactivity in it has demanded more investigation in it. The study of atmospheric parameters such as wind, solar energy, evaporation shed light on the water balance, caustic soda balance in the pond, while the hydrodynamics governs the settling rate, consolidation and ease of pumping in the pond. These are all to be tied up with basic study of the interparticle interaction and its effect on settling, dust viscosity and in general rheology of the waste. We consider few aspects here.

a) Radioactivity (fig. 5)

The table 4 gives the level of uranium and thorium in the waste which is 25–40 ppm and 80–120 ppm respectively. In fact in an old pond of Revere we have found uranium content double the value given above. This logically means there is high content of these elements in original bauxite and one fourth of Jamaica is made of bauxite. So a detailed study of old houses (made of bauxite) ~~are~~ is necessary for radiation hazard. Gamma radiation, Radon build up and inhalation of dust are the three aspects one should look into (for details see ref. 2).

b) Nonlinear Transport Properties (fig. 6, 7, 8)

We follow kinetic theory of gases for this purpose. The suspended particles can be considered like a gas if one averages over Brownian motion. Once this is done, one can apply Boltzmann equn., its linear and nonlinear soln. to find settling velocity and viscosity in terms of average hard core potential, which will allow eventually to change the characteristics of the waste to adjust to the most suitable settling and transport properties. (for details see ref. 3)

c) Ceramics (fig. 9, 10, 11 table 5)

We have developed ceramic tiles which need to be sintered at lower temperature (1050°C) and still give strength better than commercial tiles.

At present a prototype Red Mud waste house is being built and radioactivity study is being done in it to prove that ventilation does not allow excessive radon build up. (for details ref. 4).

d) Dynamics of the Pond:

We are developing a model for water balance and in general material balance, which will reflect on the future status and contamination of the pond. It involves the study of

i) the effluent input ii) the precipitation study
iii) the evaporation iv) the permeability of ground surface
v) depth profiles and permeability of the waste and
vi) the settling properties of the waste.

At present the evaporation studies are being done for one of the pond mud models are being developed.

IV CONCLUSIONS

We started with an ecological problem and unrestricted physics in it. The result was a mud, a nuisance, has turned into a resource for building material. Anil Agarwal in 'New Scientist' argues that developing countries have one source in common and that is mud (soil!). So we should do more research on it. In Jamaican Physics department has taken that up, and it is yielding dividends.

REFERANCES :

1. R. Yong and A. Wagh : Annual Reports to I.D.R.C. (1984, 1985).
2. A. Wagh, W. Graham and W. Pinnock, Levels of Radioactivity in Jamaican Bauxite Waste and Possible Health Hazards communicated to J. Health Physics.
3. J Knight, A. Wagh, W. Reid, The mechanical Properties of Ceramics of Bauxite Waste, To be published in J. Materials Science (GB).

TO PARTICIPANTS

THE ORIGINAL TALK COULD NOT BE REPRODUCED FOR TECHNICAL REASON. THOSE WHO WISH TO HAVE IT SHOUD PUT THEIR ADDRESS IN MY MAIL BOX. I HAVE VERY FEW COPIES OF REFERANCES TOO. PLEASE CONTACT ME BEFORE 3rd JANUARY NIGHT OR WRITE TO ME. THANKS.

ARUN WAGH.

TABLE 1.

ALUMINA PRODUCTION IN JAMAICA

ALCAN KIRKVINE	500,000 TPY
ALCAN EWARTON	500,000 TPY
ALPART	1,200,000 TPY
ALCOA	450,000 TPY
REVERE	250,000 TPY

TABLE 2.

PHYSICAL PROPERTIES

	% Solids	Sp. Gr. Dry mud	pH
ALCAN			
Mud at discharge	23	3.53	12.95
ALCOA			
Mud at discharge	7	3.55	12.9
ALPART			
mud at discharge	15	3.5	11.9
MUD IN LAKES	25-60	3.5	11-13.

TABLE 3.

XRF STUDIES

Element	Content in Mud
Al	9.8%
Si	1.7%
P	.9%
S	.25%
K	.07%
Ca	4.55%
Ti	5.1%
Cr	.25%
Mn	.78%
Fe	31.5%

Table 4: The uranium and thorium content (ppm) in Jamaican bauxite waste, according to method of analysis.

Sample	Gamma Ray Spectrometry			Neutron Activation Analysis	
	eU-238		eTh-232	U-238	Th-232
	190 kev Ra-226	290 kev Pb-214	240 kev Pb-212		
Alpart - Fresh (last washer)	25	21	115	30	120
Alpart - Pond (surface)	29	23	107	21	82
Alcan - Fresh (last washer)	23	30	112	33	90
Alcan - Pond	32	26	107	36	116
Alcoa - Fresh (9th stage washer)	24	21	69	31	69
Alcoa - Pond (surface)	31	23	96	30	64

Table 2: The uranium and thorium content in a stagnant pond by depth (m) by gamma ray spectrometry (mean of samples at four positions in the pond in ppm)

Depth in m	eU-238 Concentration		eTh-232 Concentration
	186 kev	300 kev	
1	38	31	92
2	37	40	83
3	40	45	96
4	41	38	95
5	36	37	74
6	42	36	87

TABLE 5: Some Data on Strength and Porosity of Ceramic Tiles

Stress Intensity Factor Make	KIC (MNm3/2)	Compression Strength (psi)	Porosity	Measured By
'CERAMIC' TRINIDAD LTD. Glazed one side	0.42+0.02	11800	19.04%	UWI
HUNGARIAN (UNIDO) Floor tiles unglazed	0.55+0.02	4300	38,4%	UWI
HUNGARIAN (UNIDO) Floor tiles glazed	0.85+0.02	7300	38.4%	UWI
U.S.Recommendation		3000	13% (water absorption) 25%	ACS
UWI tILES (Unglazed)	0.67-1.57 +0.02	3600	40 - 48%	UWI

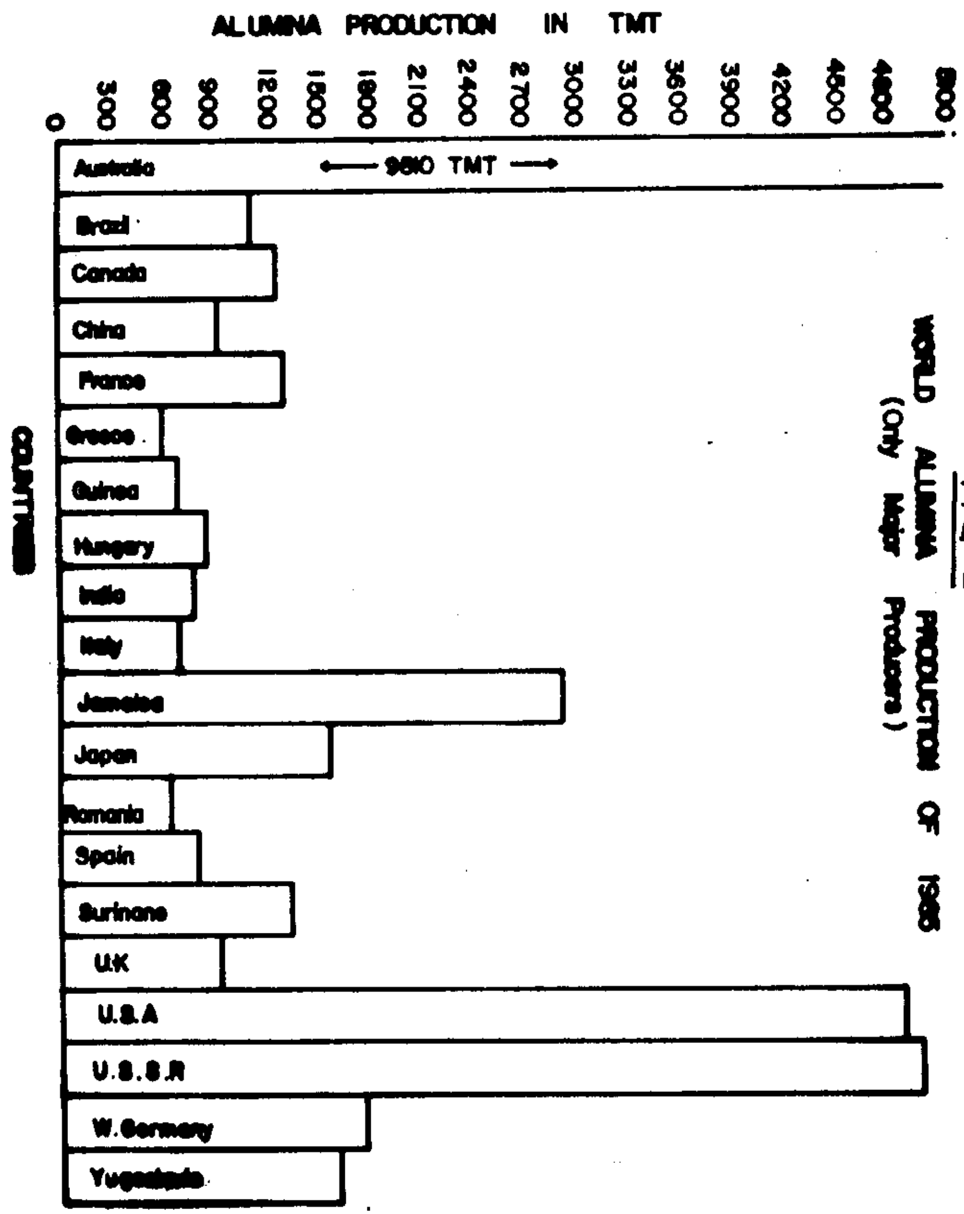
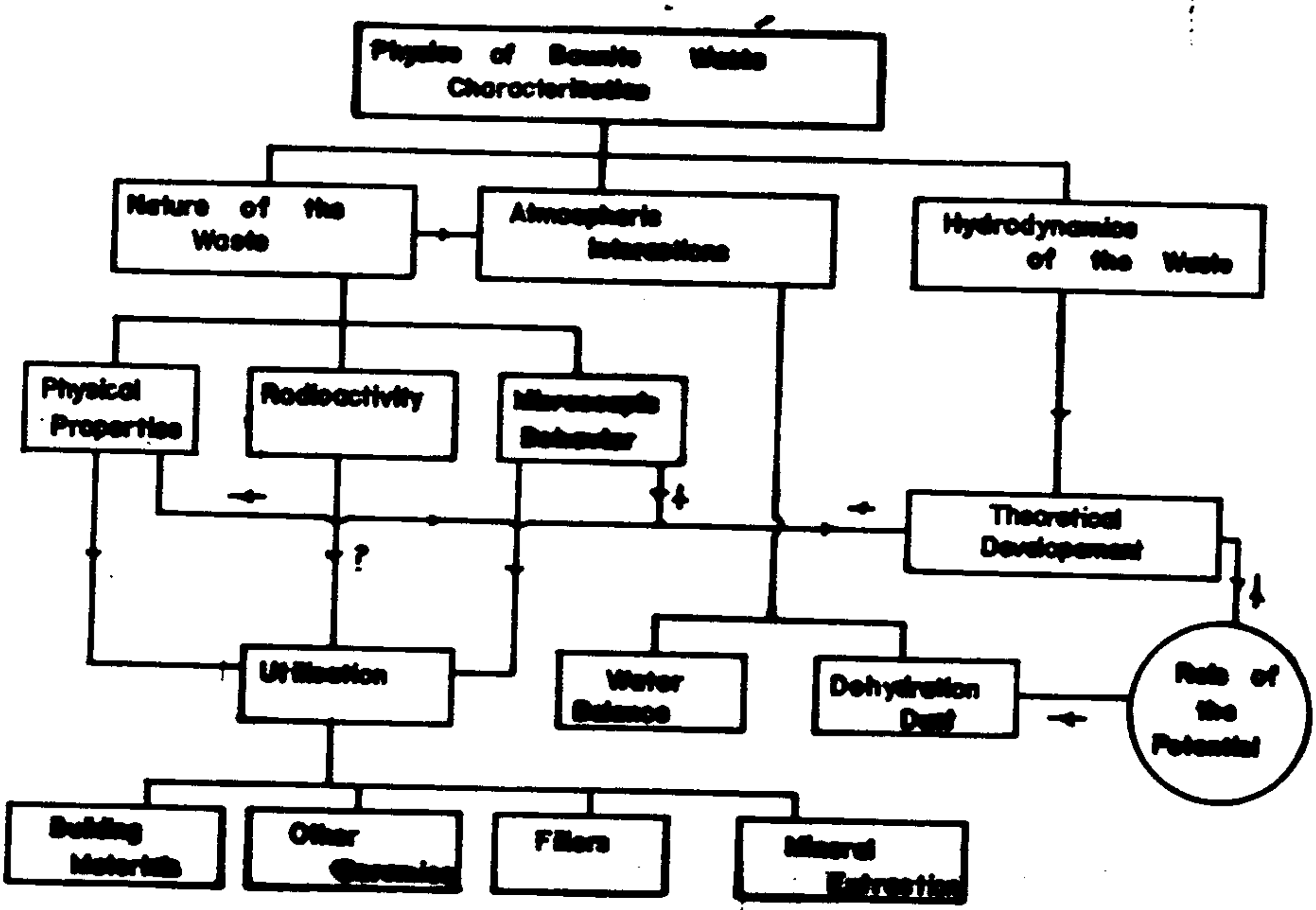


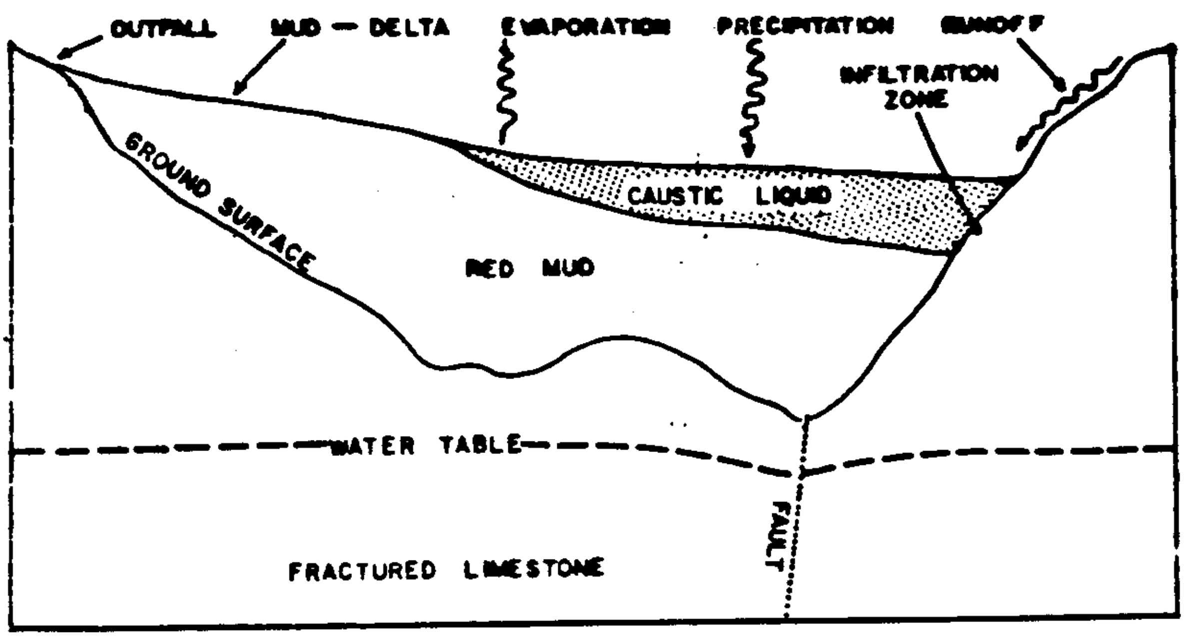
FIG. 1.

WORLD ALUMINA PRODUCTION OF 1985
(Only Major Producers)

FIG. 2.

FIG. 4.





DIAGRAMMATIC SECTION ACROSS RED MUD POND

FIG. 3.

THE RADIOACTIVITY

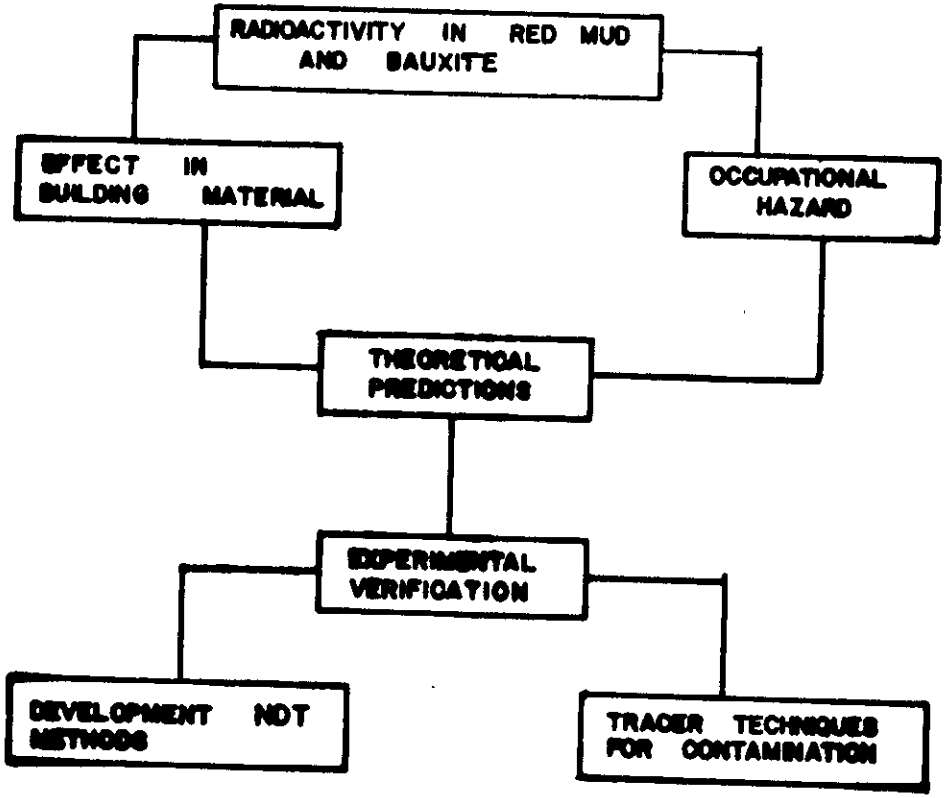


FIG. 5.

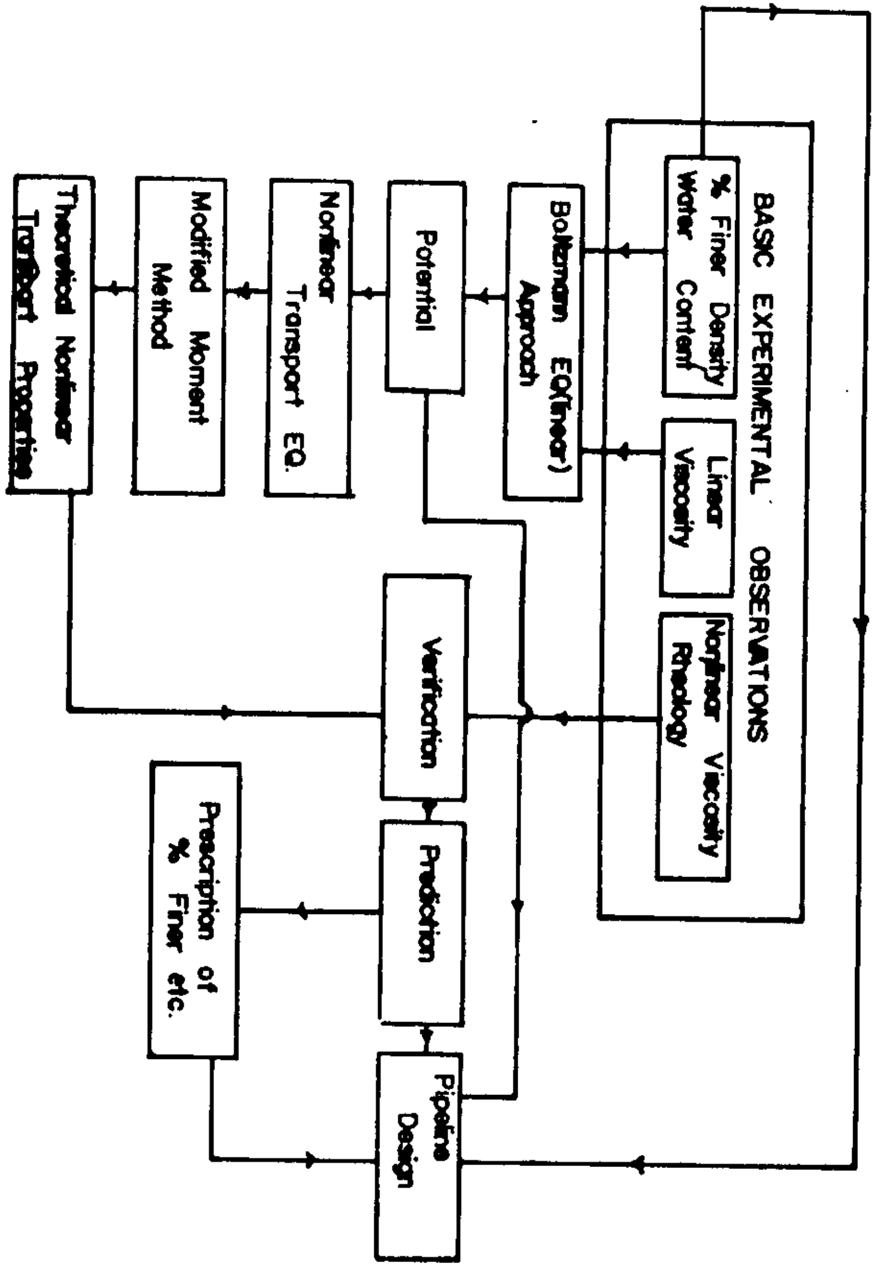


FIG. 6. STUDY OF TRANSPORT OF SLURRY

BOLTZMANN TRANSPORT EQ^n.

$$\frac{\partial f}{\partial t} + \frac{p}{m}\cdot\nabla f + \frac{F}{m}\cdot\nabla_p f = \text{collision term}$$

$$= -\frac{f - f_{eq}}{\tau}$$

Use

1) Relaxation time approx
2) Chapman-Enskog soln.
3) Modified moment method.

FIG. 7.

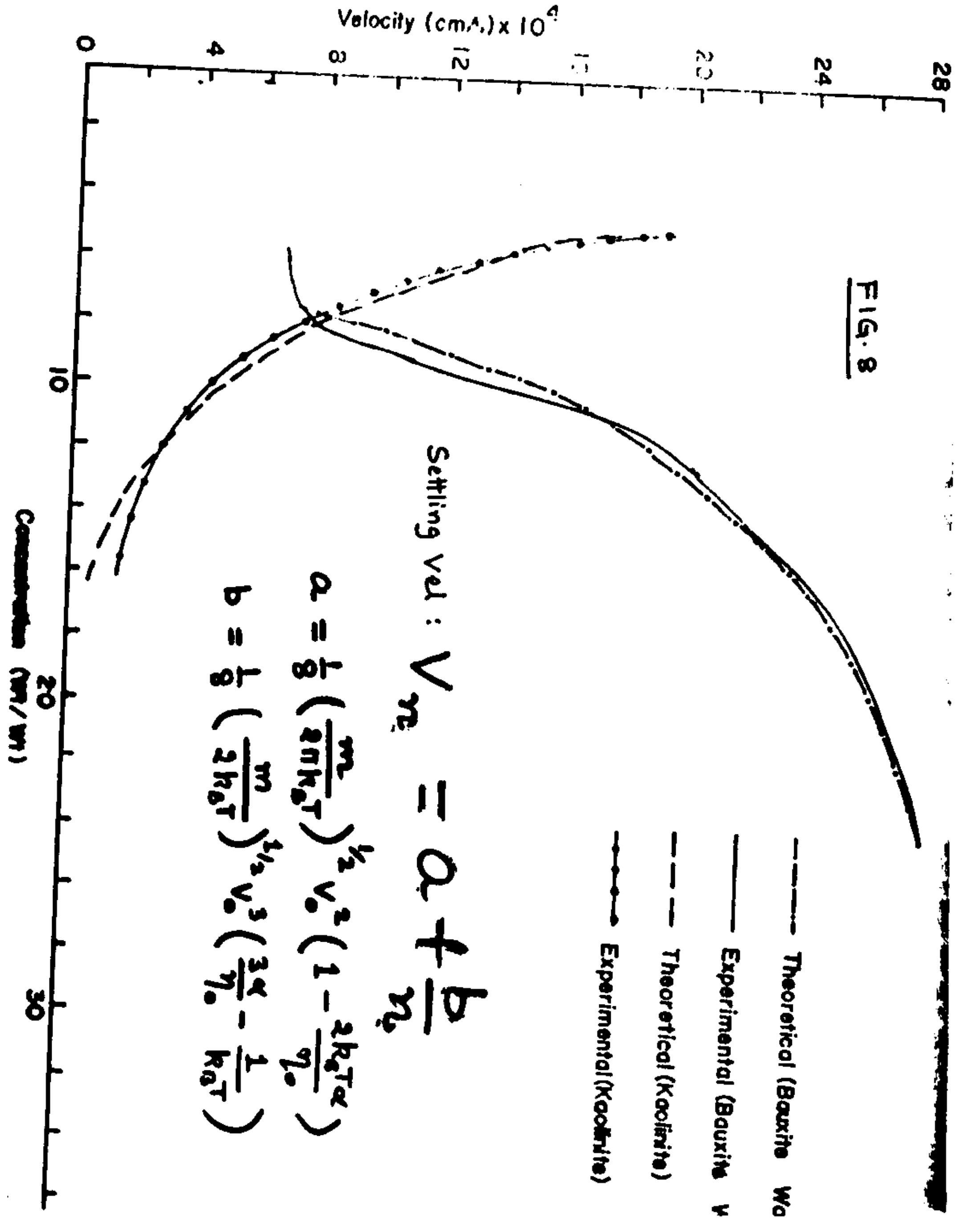


FIG. 8

FIG. 9.

CERAMICS.