FRAGMENTATION, FORM AND FLOW IN FRACTURED MEDIA

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FRAGMENTATION, FORM AND FLOW IN FRACTURED MEDIA

Proceedings of the F^3 – Conference
held at Neve Ilan (Israel), 6–9 January, 1986

Edited on behalf of the Israel Physical Society by

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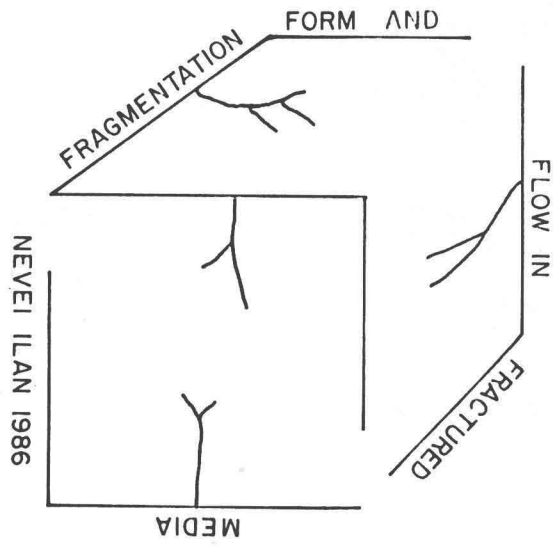

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FORWARD

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The Society organizes an annual national general conference. In addition it co-sponsors many interanational conferences, of a more specialized nature, held in Israel. The Society publishes the "Annals", which primarily serve as a vehicle for rapid publication of the Proceedings of international conferences held under its sponsorship. The "Annals" also occasionally publishes an up-to-date review of a topical field in which many of our members are active.

C. G. Kuper and R. Weil

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347 pages. 1984. ISBN 0–85274–775–6. ISSN 0309–8710.

P R E F A C E

The collection of articles in this volume is the record of an attempt to bring together researchers from two widely differing backgrounds to confront issues connected with fracture. The "attempt" was the F^3 Conference in Neve-Ilan, attended by materials engineers and scientists with experience in fragmentation, on one hand, and physicists with interest in probabilistic processes, on the other. The expectation was that the former group will inform itself of modern concepts and tools, that can enrich its future understanding and that the latter group will learn the real needs of the trade. To what extent this expectation has approached realization in Neve-Ilan can be seen from the following Conference-snapshots: Aharony (when prodded by Jaeger) presents the theoreticians' shopping list to the structural geologist and engineer (p.129), Krajcinovic refers to this work as pre-fractal (p.263), Avnir says "what the fractal-business has done is to tell people not to be afraid of irregularities" (p.550) and Guyon in his frequent interventions emphasizes the need for the flow of subjects *from* the practitioner *to* the modelizer.

Before the Conference the organizers drew up a list of topics in which more progress and understanding are required.

(A) Geometry and Topology of Voids and Cracks.

1) Scaling between macro- and micro-cracks.
2) Experimental techniques and results to obtain crack populations.
3) Conductive and mechanical properties, their dependence on crack density.
4) Critical properties near the fragmentation point.
5) Fractal form of surfaces and of broken solids.
6) Effects of sample size.

(B) The Blasting Process.

1) Characterization of commercial explosives and their action in breaking and heaving.
2) Interrelations between alternative fragmentation mechanisms, including that

caused by the expanding gas.

3) Damage models versus statistical codes for fragmentation.
4) Motion of bulk and surface cracks under impact or mechanical and thermal stress.
5) Particle size distributions and texture in fragmented media.
6) Prospects of particle distribution control.

(C) Post-Explosion Flow

1) Flow in near-percolative media.
2) Permeability-Porosity relations by effective medium theories and beyond.
3) Hydraulic-fracture enhancement of flow.
4) Bounds of bulk-property parameters in two-phase media.

For the background to the F^3 meeting we should first note the resurgence of interest by theoretical physicists in macroscopic phenomena and objects during the last few years. On the other side of the activities, in the "Nobel Art of Rock Fragmentation", one has a complex and far from satisfactory situation summarized by Grady and Kipp in the sentence:

"A complete theory of dynamic fragmentation is not yet available, however, and in many cases observed phenomena lack even a qualitative explanation" (J.Appl.Phys. 58, 1210(1985))

In further details we list a few questions of fundamental nature.

Given that pictures, photographs etc. of cracks in nature are two-dimensional objects, how does one visualize real cracks in three dimensions: those that are present in the solid before the fragmentation process (microcracks, etc.) and those that develop during the process?

What are the conditions for cracks to propagate across other cracks and to cut across grain boundaries? What are the laws of interaction between cracks; in particular, are they short- or long-range?

Does fragmentation occur as a result of crack coalescence or of the proliferation of cracks? Is it a sudden process or a gradual one (on the scale of crack speeds)?

At the practical level, say, from the point of view of a mining engineer, one adds further questions:

What is the dependence of fragment-size distributions on rock and explosive parameters? In particular, which of these parameters are critical for the size distribution? In any given process and geotechnical situation, what are the percentages of undesirable matter: of "fines" and of boulders? How do the latter arise? What is the relation between fragmentation and mass movement?

Are there any scaling laws or other reliable rules of thumb in excavation design that are theoretically founded? In particular, how should bench-blasting be planned in the presence of joint sets?

Defining quarrying efficiency as the ratio of created surface-energy to the energy in the explosive, is there a theoretical limit to this quantity? Can it be pushed to this limit by good design? How is the energy partitioned?

What is the relative importance of detonation pulse shape with respect to its energy? In a nonideal explosion, what are the transient detonation effects?

Participants were invited personally, on the basis of their recognized expeience or their potential to contribute to the topics of the Meeting. The papers that we received for this Volume were not refereed; the role of the peer-review was assumed by questions from the audience (recorded and reproduced after editing in the "Discussions" that follow in the Volume the papers of each Session). The questioning has been keen and at times gruelling. Yet, the Discussions had also their lighter moments (thanks perhaps to our sunny and bright January) and these were not expurgated from these Proceedings.

ACKNOWLEDGEMENTS

" Many are the thoughts in the heart of man,..." but to implement then we needed the help of as many. The earliest encouragment given to us to try organize the conference was by two senior officials of the Department of Energy in Washington, Drs. A.M. Hartstein and Miles Greenbaum. Their counterpart in Jerusalem, Dr. Avraham Arbiv was equally enthusiastic. Dr. Yossi Bartov, Director of the Geological Institute in Jerusalem we could (of course) always depend on.A largeness of spirit (and not only of that) was consistently shown to us by the Directorate of our own Institution at Soreq (of whom we would name our present Divisional and Departmental heads: Ishay Levanon and Yair Yariv). Our Library and Documentation Department deserves thanks for its cheerful assistance (and not the least for its acquiescing in Zeev Jaeger's rival private library facility). Our capable secretaries Ilana Shabtay, Michael Mahbub and Shoshana Ben-Shimol did the Hebrew typing and put our visitors in Neve Ilan at their ease. Yehezkel Menuhin put the audio-visual equipment to work (and work it did!). Mrs. Neta Schwartz made the drawings and Mrs. Vicky Baum worked tirelessly and devotedly on the conference's English correspondence and on the typescripts of the Proceedings. The humorous welcome to the conference premises ("Glossary of F^3 - terms") was Dr. Rafi Ruppin's doing (it can be told now). The visiting ladies'program was managed to general liking by Mrs. Naomi Brandon.

We had the good fortune to have Prof. Eliahu Foa as the Conference Coordinator. He injected good-sense and responsibility in the organization of F^3.

And what else was injected?

The conference took place under the auspices of the Israel Ministry of Energy and Infrastructure, the Ministry of Science and the Soreq Nuclear Research Centre. Support was received from the following sources:

The Ministry of Commerce and Industries; The Negev Phosphates Ltd,(Dimona); the Israeli Military Industries; the National Council for Research and Development; Armament Development Authority (Rafael); Israel Atomic Energy Commission; United Mizrahi Bank; Oil Exploration of Paz Ltd.; Petroleum Services Ltd. (Tel-Aviv); Israel Chemicals Ltd.; Oil Exploration (Investments) Ltd.; Control Data Corp. Scientific and Technological Base, Ministry of Defence and the Detonation Research Group, ICI, Stevenston, Scotland.

The Conference Organizers worked hard but enjoyed doing that, just as they enjoyed the contact with their colleagues: visitors to F^3 or those who could not come but stated their wish to read these Proceedings. Regretably, our contact with our families has correspondingly diminished and we have to use this Preface to make our apologies for our long absences to them; especially, to Hertzlina and Rannie Jaeger and to Nehama Englman.

בין: "והמלאכה היתה דים"... "ולתת עליכם היום ברכה", אדר א' תשמ"ו ביבנה.

Yavne[o], February 86.

R. Englman and Zeev Jaeger
Conference Organizers and
Editors

[o]The township of Yavne gained historical fame in about 70 C.E., shortly before the destruction of the second Temple, when Rabbi Yohanan Ben Zakkai (leader of the dovish faction in the besieged Jerusalem) requested from the Commander of the Roman legions (later Titus) that Yavne and its learned men be spared. The request was granted and the Sanhedrin, the Jewish High Court, sat for a while in Yavne. At present times, Yavne is a flourishing town, with industry and the Soreq Nuclear Research Center in its outskirts.

C O N T E N T S

*Article not indexed