resources conserved by tribal and rural families will help to get them benefits as and when national and global biodiversity funds are established. Such registers and databases will also help to chronicle dying wisdom in matters relating to the conservation and use of biodiversity. It will be appropriate to accord legal recognition to such local level Biodiversity Registers.

Governments, NGOs and other stakeholders should promote social marketing of the need for benefit-sharing and access regulations. Public awareness and concern will be necessary to stimulate political action. Mass media can play a critical role in generating public opinion for both conservation and sustainable and equitable use. Media Resource Centres should be established for providing media credible information. Media representatives should be associated with all stakeholder groups.

In the development of national laws relating to the provisions of CBD, it will be necessary to ensure widespread public and stakeholder participation. The process adopted in preparing the legislation is as important as the product. The development of a national access and benefit-sharing strategy is an exciting adventure in stakeholder participation and partnership. By generating a sense of symbiotic partnership, undesirable practices like biopiracy can give way to an era of biopartnership based on procedures like co-patenting and credit and profit-sharing. South–South partnership is as important as North–South partnership for using biodiversity for public good, since the centres of diversity of most economic plants occur in the South.

The CBD marks a transition from an exploitative and inequitable relationship between the providers of biodiversity and its users to one of partnership between them based on the principles of equity and ethics. Since biodiversity constitutes the feedstock for the biotechnology industry and serves as the foundation of sustainable food, health and livelihood security, the paradigm shift introduced by CBD in the relationships among communities and nations is an extremely significant one from the point of harmony both within human societies and between humankind and the rest of nature. We therefore urge all nations to implement the provisions of CBD relating to conservation, sustainable use and equitable sharing of benefits both in letter and spirit. The complexity associated with matters related to benefit-sharing should not become an excuse for inaction. A learning process will be involved before perfection can be achieved in legal provisions and implementation procedures. Hence we appeal to the forthcoming COP-4 and to the GEF General Assembly in New Delhi not to let these unique opportunities pass without developing consensus on basic principles and deciding to initiate concerted and cooperative action on methods of achieving the desired goals.

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Earth sciences go the fractal way*

The impact of fractals on the earth sciences was the subject of a recent workshop. The lectures delivered covered introductory aspects of fractals, percolation, and other related matters in full detail together with a wide range of their applications in earth sciences.

The general introduction done very extensively, highlighted not only the fascinating mathematical and physical aspects of the concept of fractals but also the aesthetic appeal it has. It pertains to objects that are 'self-similar' at various length scales and therefore exhibit the dilatory symmetry. The best examples of fractals are indeed found in nature – in and around us – and there are perhaps simple reasons for it. The concept has been known for a long time to mathematicians and physicists who have analysed it extensively and have also found numerous applications. Earth scientists and physiologists in the West have recognized the potential of its application to their fields and are already using the idea (of fractals) and all that goes along with it in their research. It is high time we caught up with the world in these areas of research. For this reason the Workshop was the much needed and crucial first step.

The first two days were devoted to preparing the background by understanding: (i) the basics of fractals and multifractals – various definitions and illustrations, different methods of estimation of fractal dimensions such as similarity-, capacity-, information-, and correlation-dimensions; (ii) chaos – the Lyapunov exponent, and strange attractors; (iii) self-organized criticality; (iv) stochastic differential equations; and (v) the percolation theory.

The latter 3 days were devoted to the applications of the above to geological, geomorphological, geohydrological, gravity, magnetic, seismic, rock mechanical, and climate studies. The underlying phenomena exhibit power law spectra. The ones discussed included frequency–size distribution of earthquakes, faults, rock formation, volcanic eruptions, mineral deposits, well logging, and electromagnetic as well as generalized inductions.

The famous Gutenberg–Richter frequency–magnitude relation

$$\ln N = a - bM$$

is a power law applicable to a range of magnitudes of earthquakes. Here N is the number of earthquakes of magnitude M and greater; a and b are constant. The constant b which is a measure of seismity of a region is half the fractal dimension. A number of interesting aspects were explained and also

*Report of the Workshop on Application of Fractals in Earth Sciences organized at the National Geophysical Research Institute, Hyderabad during 22–26 September, 1997.

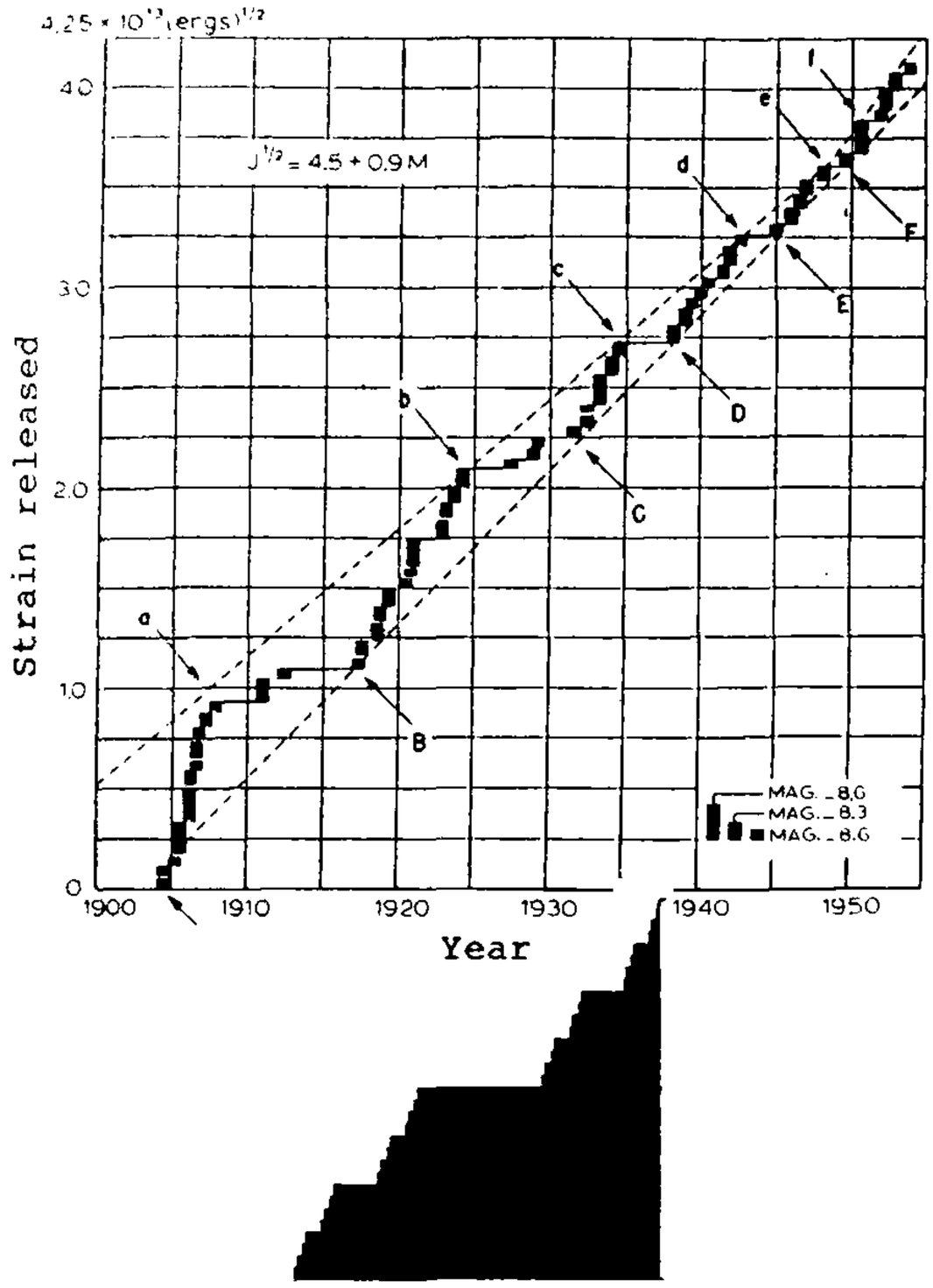

Figure 1. Devil's staircase from Cantor dust to earthquakes – strain release from certain earthquakes during 1904–1955 (plot (*c*) is from ref. 1); ***a***, Cantor dust; ***b*** and ***c***, Devil's staircase.

emerged out of discussions, e.g. that the spatial and temporal correlation dimension of distribution of epicentre of earthquakes tells us about the clustering of events; that there is curious intimate connection between the Cantor dust/Devil's staircase and the strain released from large shallow earthquakes[1] (Figure 1); and recent significant findings that fractal dimension, and spatial and temporal correlation dimensions of distribution of earthquakes change before a major earthquake.

Another general issue discussed was concerning the gravity and magnetic studies. The geophysical problems are generally formulated assuming a random distribution of the source. However the susceptibility data obtained extensively from around the globe show its variation to be fractal. New techniques for applications to field examples were discussed for determining the fractal source parameters that tie up with a given fractal nature of the crustal magnetization[2].

Polygonal networks of cracks and fractures found in mud, frozen ground, limestone and other media which undergo volume changes and surface stresses is another interesting subject discussed in the Workshop. Any such arrangement of non-overlapping space filling cells obeys a curiously simple Euler's relation[3]

$$C - E + V = \text{constant},$$

C, E and V respectively being the numbers of cells, edges and vertices (Figure 2).

Application of the renormalization group method to electrical connectivity model of percolation theory was discussed in order to understand the reported discrepancy in the results on conductivity of the crust investigated in the field and in laboratory, and also to appreciate the connection between rock types and different values of scaling exponents.

Applications of percolation theory to islands, lakes, river networks and earth topography were discussed. 'Path of percolating fluid' was discussed in connection with the geological processes which depend on the geometry of rock matrix. The tortuosity near the percolation threshold and its connection with the fractal dimension of the fluid paths are some of the important issues. Distinction between surface fractals representing rock surface and volume fractals representing the bulk was discussed in some detail. Whether the two types of fractals could have the same dimension is an important question.

In isolated pockets across the country, earth scientists have been using the concepts of fractals and percolation in their research for the last several years though without much pretence. This Workshop not only brought them together and attempted to initiate some younger earth scientists into the subject to step up the activity, but also brought earth scientists in contact with physicists and mathematicians who have pursued research on fractals, percolation, chaos and self-organized criticality, etc. at international level for many decades.

The last aspect above, I think, is particularly significant. The earth scientists ought to benefit from this advantage *at least* at this stage of development of the subject. The following three steps in this direction, also discussed at the conclusion of the Workshop, could provide impetus to the activities:

(a) A seminar circuit involving both, earth scientists and physical scientists, along the lines of the DST-supported 'theoretical physics seminar circuit', should promote a healthy mixing of active workers and also provide inspiration to the upcoming ones.

(b) Workshops and meetings – initially of introductory nature but becoming more topical to have intensive

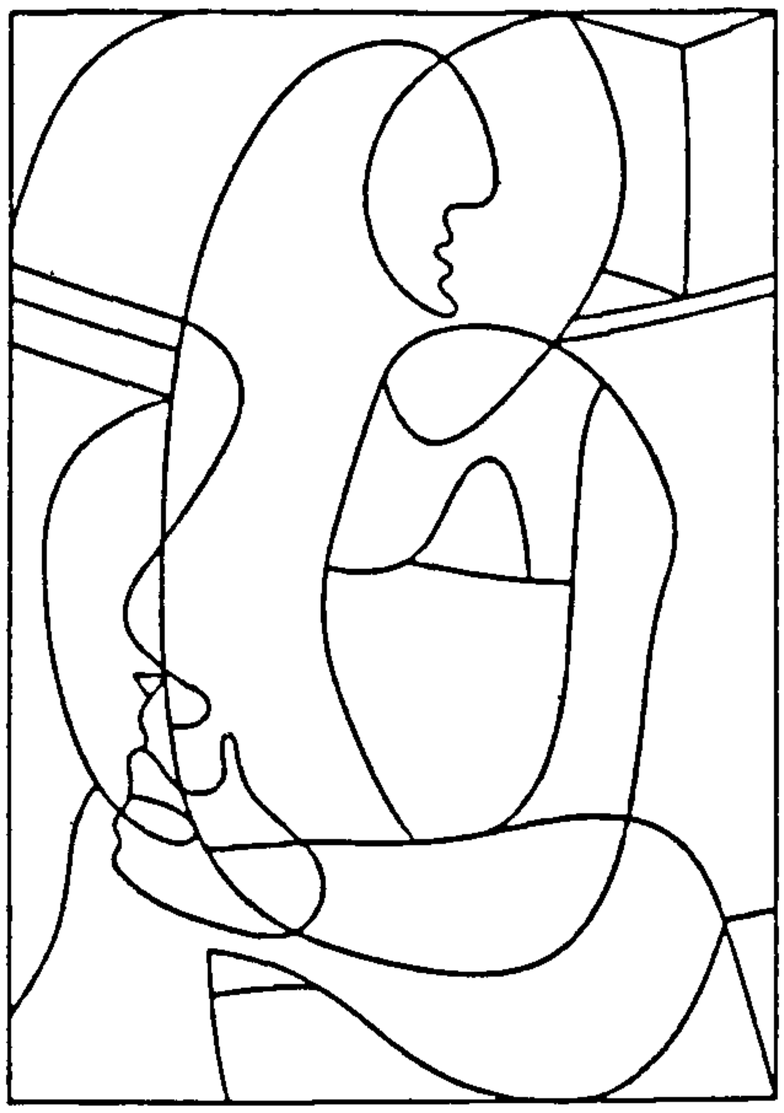

Figure 2. Picasso's drawing obeys Euler's equation as well as the cracks and space filling irregular polygonal cells do.

discussions – should be organized at different centres on a regular basis, with at least one meeting per year.

(c) Registrations for Ph D with joint supervision – one supervisor from earth sciences and another from physics – should, in due course of time, produce a new generation of earth scientists with good proficiency in the involved aspects of relevant physics ideas and tools.

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Polar plumes and the solar wind: New clues from SUMER/SOHO

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Polar plumes are ray-like structures aligned along open magnetic field lines in polar coronal holes. Although apparently free to escape along open field lines, the plume gas is some 3–5 times denser than the interplume background[1,2]. This large density variation implies that the coronal heating rate is not uniform over the hole and, in particular, that enhanced energy dissipation must take place near the plume base (ref. 3 and references therein). Figure 1 shows the polar plumes and equatorial streamers.

Coronal holes are well-defined regions of strongly reduced EUV and X-ray emission in the solar atmosphere and are associated with high-speed solar wind (composed of charged particles, ions and electrons). Spacecraft measurements show that the solar wind has two components which may be described as 'slow' and 'fast'[4]. The slow wind has a speed of about 400 km/s while the high-speed wind travels twice as fast. The slow wind is an expected consequence of the corona's high temperature. It is quite variable in terms of temperature, composition, magnetic field strength, etc. and is not in equilibrium with the corona and transition layer at its base. But no one really knows what gives the high-speed wind its additional push. In contrast to the slow wind, the fast wind has the characteristics of being relatively uniform and stable. The spacecraft Ulysses also characterized two kinds of solar wind at solar minimum conditions. At high latitudes, Ulysses observed relatively smooth solar wind originating from the coronal holes in the polar regions. The fast wind departed very little from a velocity of about 750 km/s. Slow wind, at about 400 km/s and originating in the streamer belts was observed in a relatively narrow latitude band on either side of the ecliptic plane.

One can safely assume that the emission in coronal holes is low compared to the 'non-hole' corona because the plasma density and temperature at the base of the corona are reduced by the outflow in the open magnetic field