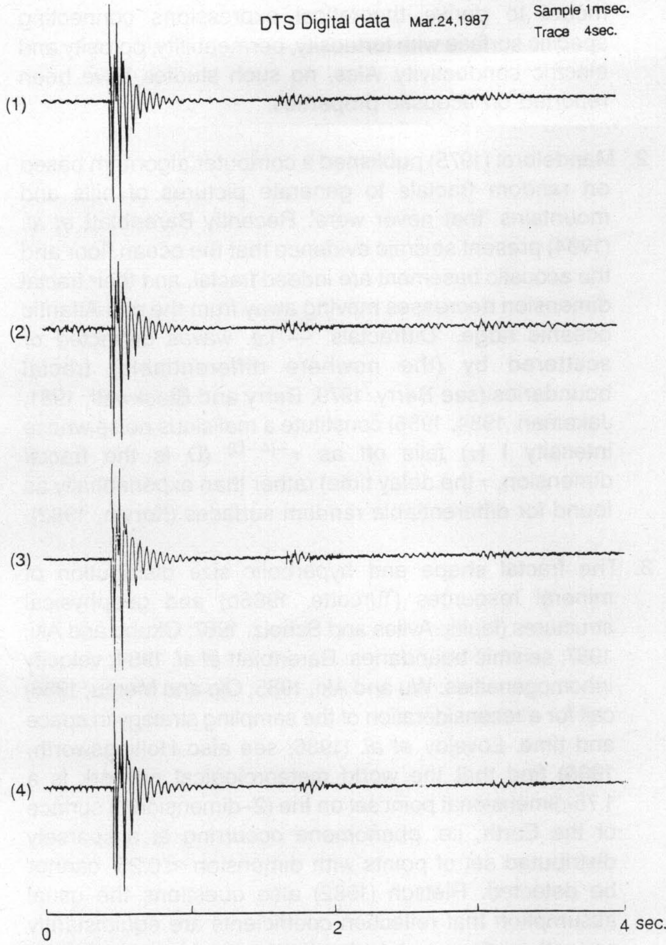

FIGURE 5
Digital data retrieved at the field test on May 23, 1987. First arrival wavelet (direct wave) and following wave train are recorded in good quality.

system. The present configuration of the system allows 5 hours of recording a 1ms sampling rate, 4 s record length and 10 s shot interval. Data quality obtained suggests that post processing could improve seismic profiles.

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Fractals in Applied Geophysics — A Guided Tour

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Summary

The geometrical patterns encountered in geophysics are irregular and fragmented at all scales. This expository talk reviews the possible applications of ther novel ideas of fractal geometries (Mandelbrot, 1982) to diverse fields of applied geophysics and rock physics. Examples include the internal surfaces of porous rocks, the irregular shape of earth materials and the fine structure of sedimentary sections.

Discussion

'A fractal is a mathematical set or object whose form is extremely irregular and/or fragmented at all scales'. So runs Mandelbrot's definition of the term he coined and widely popularised in his monograph (1982). One well-known example is the coast line of Britain (Mandelbrot 1967) whose length increases when the resolution of measurement l tends to zero as l^{1-D}, where D is called the *fractal dimension* of the curve (for the west coast of Great Britain it is 1.25). The fractal dimension measures the density with which the curve fills the space into which it is embedded. For higher dimensions, if spherical balls of Euclidean dimension E and of radius r are centred on every point of an object with fractal dimension D then the total volume covered by the balls scales as r^{E-D}.

The size-distribution of fractal objects is usually hyperbolical: out of a total number N of such objects there are Nr^{-D}

greater than a given size r, where *D* is the fractal dimension (see Mandelbrot, 1975 for islands; Kent and Wong, 1982 for lakes; Curl, 1986 for caves; Turcotte, 1986a for fragmented rocks; Rothrock and Thorndike, 1984 and Matsushita, 1985 for drift sea ice).

The peaceful scenery of Fig. 1 (from Schwenk, 1980) allows a glimpse of the fractal zoo. Just to name a few fractal objects, from top to bottom, we have:
— clouds (Lovejoy and group, 1982–86; Rys and Waldvogel, 1986a, b);
— mountains (Mandelbrot, 1975, 1982);
— the boundary of the lake (Kent and Wong, 1982);
— irregular rocks (Orford and Whalley, 1983; Turcotte, 1986a);
— trees, vegetation, insects (Loehle, 1983; Morse *et al.*, 1985);
— the turbulent water (Mandelbrot, 1982).

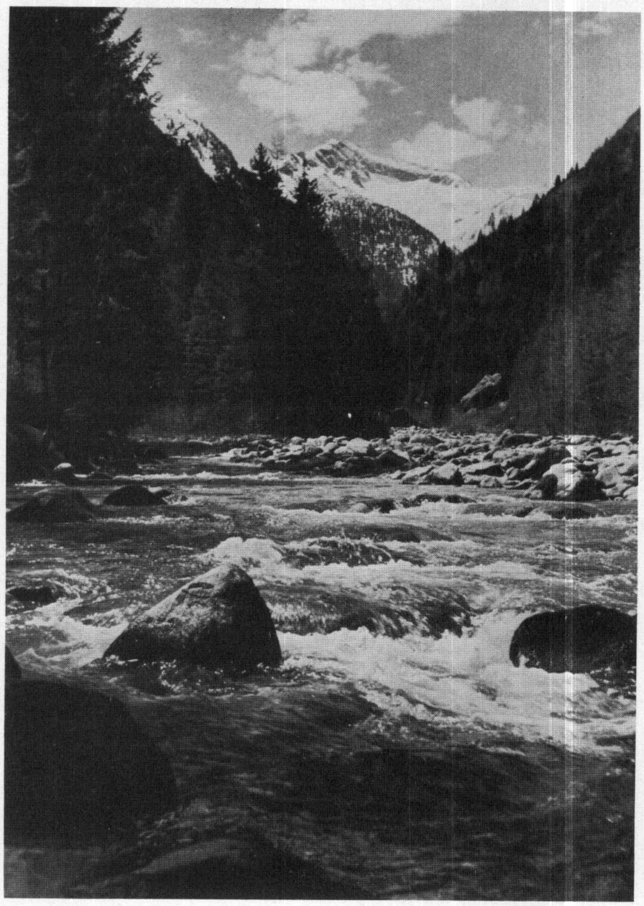

FIGURE 1
Fractal Landscape

The second part of the discussion reviews four topics relevant to exploration geophysics:

1. The pore space of sedimentary rocks has a self-similar, fractal structure. The fractal dimension of pore surfaces ranges between 2.5–2.8 in sandstones and shales (Avnir, 1986; Katz and Thompson, 1986; Krohn and Thompson, 1986; Wong *et al.* 1986 etc.). Wong *et al.* (1986) describes a sandstone sample where quartz grains are completely covered by illite clay making surface dimension as high as 2.96. The Clausthal school (Pape *et al.*, 1982–85) approximated pore structure by a fractal pigeon-hole model to derive theoretical expressions connecting specific surface with tortuosity, permeability, porosity and electric conductivity. Alas, no such studies have been reported on acoustic properties.

2. Mandelbrot (1975) published a computer algorithm based on random fractals to generate pictures of hills and mountains 'that never were'. Recently Barenblatt *et al.* (1984) present seismic evidence that the ocean floor and the acoustic basement are indeed fractal, and their fractal dimension decreases moving away from the mid-Atlantic oceanic ridge. 'Diffractals' — i.e. waves diffracted or scattered by (the nowhere differentiable) fractal boundaries (see Berry, 1979; Berry and Blackwell, 1981; Jakeman ,1984, 1986) constitute a malicious noise whose intensity I (τ) falls off as $\tau^{-(4-D)}$ (D is the fractal dimension, τ the delay time) rather than exponentially as found for differentiable random surfaces (Korvin, 1982).

3. The fractal shape and hyperbolic size distribution of mineral resources (Turcotte, 1986b) and geophysical structures (faults: Aviles and Scholz, 1987; Okubo and Aki, 1987; seismic boundaries: Barenblatt *et al.* 1984; velocity inhomogeneities: Wu and Aki, 1985; Ojo and Mereu, 1986) call for a reconsideration of the sampling strategy in space and time. Lovejoy *et al.* (1986, see also Hollingsworth, 1986) find that the world meteorological network is a 1.75-dimensional point set on the (2-dimensional) surface of the Earth, i.e. phenomena occurring at a sparsely distributed set of points with dimension <0.25 cannot be detected. Rietsch (1982) also questions the usual assumption that reflection coefficients are equidistantly spaced, on the grounds that the fractal microstructure of sedimentary layers should be evident to 'everyone who has ever looked at the layering of rocks exposed at road cuts' (*op cit.* p. 64, see also Walden and Hosken, 1986). Do we have to include dimensional analysis besides the Nyquist rule and pursue fractal snarks with fractal networks, (fractal) forks and hope?

4. There is a negative log-linear relationship between sedimentation rates and the time span over which they are measured i.e. sedimentation appears slow when measured over long time spans and rapid over short spans (Sadler, 1981). Plotnick (1986) attributes this to a fractal 'Cantor bar' model of stratigraphic hiatuses within a given section. As hiatuses (unconformities and diastems) go together with velocity and/or density jumps, Plotnick's ideas conform with the observed fractal nature of the series of reflection coefficients (Walden and Hosken 1986). As, by Faust (1951), the magnitude of acoustic impedance jumps presumably correlates with the length of the nondeposition epoch between the layers, reflection coefficients might bear information on deposition history.

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Inversion of Time Domain Spectral IP Data

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Summary

A part of the Tasmanian Mines Department's Mount Read Volcanics Project involved the collection of IP data from a variety of materials to define the expected signatures of massive sulphides, barren sulphides, alteration zones and relatively unaltered host rocks. In all data were collected from some 70 sites using time domain equipment. These data provide a unique uniform collection of in situ property measurements for western Tasmania.

The possibilities of mineral discrimination by fitting Cole-Cole models to the in situ data appear excellent. The economic massive sulphides are characterised by a distinct field of m-tau values bounded on the lower m side by a class of black shales and on the low tau side by other sulphide mineralization.

Discussion

In terms of polarizable targets, the West Coast of Tasmania contains a variety of ecomomic and barren sulphide deposits, together with black shales. These form a number of world-class mines including the Renison Bell tin mine, the Mt Lyell