An alternative method to narrow the lines is to spin the sample at the "magic angle" 54.7° to the field. At this angle $3\cos^2\theta-1$ is zero and dipolar couplings and chemical shift anisotropies are averaged out. Schneider and coworkers in Prague report the application of this method to polyethylene (*Macromolecules*, **5**, 120, 125; 1970). A spin rate of up to 12 kHz can be produced using an air jet to drive a sample in the shape of a turbine, but for complete narrowing 50 kHz would be needed.

J. Schaeffer of Monsanto, St Louis has described a combination of these two techniques, using strong decoupling and cross polarisation to remove the high frequency part of the interactions and spinning at 3 kHz to remove what was left. The first published results (*Macromolecules*, **8**, 291; 1975) were not overwhelming but those presented at the American Physical Society meeting in Atlanta last month are very impressive (see *Bull. Am. Phys. Soc. Series II*, **21**, 443; 1976). Spectra with a resolution of 2 p.p.m., comparable with those of solutions, were shown for a range of glassy synthetic polymers, ebony and ivory though the last was not resolved as the spectrum is too complex.

Measurement of several relaxation rates associated with the NMR experiment provides information about molecular motions involving each of the carbon atoms in the MHz, kHz and Hz regions. Before, this was only available for the structure as a whole (for a recent review of broad line NMR see McBrierty, *Polymer*, **15**, 503; 1974). This will have a marked effect on our understanding of the glass transition and those secondary transitions in glasses which involve cooperative molecular motions.

In contrast to the sophisticated and expensive NMR apparatus, impact strength (toughness) is usually measured as the energy absorbed when a swinging hammer breaks a sample (a hundred dollars would buy a good one). The fracture process could be characterised by a time of about 100 μs, that is molecular motions at a frequency of 10 kHz. There have been many attempts to correlate this important property with structure and molecular motion but none is very convincing.

Vincent (*Polymer*, **15**, 111; 1974) has demonstrated a correlation of impact strength with dynamic modulus and mechanical loss but only by dividing the impact behaviour into four categories rather than using numerical data. One case that particularly demands explanation is polycarbonate, an exceptionally tough glassy polymer which loses its toughness on annealing. Schaeffer showed at the Atlanta meeting that for seven glassy polymers impact strength increased monotonically with the ratio of NMR relaxation time for main chain carbons at low frequency (T_{CH}) to that at around 10 kHz ($T_{1\rho}$). In other words, if a molecule can relax easily at 10 kHz it has a high impact strength. Polycarbonate had the highest value of $T_{CH}/T_{1\rho}$ and this decreases by 2½ times on annealing. Discussion of the connection between these motions and impact strength is still at the hand waving stage, but it is suggested that the plastic work of fracture which accounts for the energy absorbed on impact depends on slip between chains which in turn depends on the inter- and intra-chain interactions that govern the motions associated with $T_{1\rho}$. □

Predicting volcanic eruptions

from Peter J. Smith

A DISTINGUISHED British volcanologist recently claimed in a radio broadcast that most volcanic eruptions could be predicted if only adequate funds were to be made available for monitoring equipment. But although the prediction of volcanic activity may be easier than the prediction of earthquakes, knowledge of eruptive precursors is still far from complete. Moreover, as Weaver and Malone (*Geophys. Res. Lett.*, **3**, 197; 1976) now point out, even in existing types of data there may be more than meets the eye, especially where glacier-clad volcanoes are concerned.

The phenomenon that Weaver and Malone have in mind is seismic events of low frequency (predominant frequency content less than 5 Hz). Such events have been observed for a number of years in Japan where Minakami *et al.* (*Bull. Earthquake Res. Inst.*, **47**, 893; 1969) termed them type B events. They usually occur within 1 km of a volcanic crater and are apparently associated with eruptive and pre-eruptive processes, for in some cases they have been observed to increase in frequency both before and during actual eruptions. This has led to their being used to predict eruptions from some volcanoes, even though their precise origins are obscure.

Type B events have now been recorded in the vicinity of volcanoes in several parts of the world outside Japan, including Alaska, Indonesia and Central America. Apparently identical events have also been observed near quiescent volcanoes in the Cascade Range of Washington state (see, for example, Unger and Decker, *Bull. Seismol. Soc. Amer.*, **60**, 2023; 1970). Because of the obvious potential of such events for eruption prediction, Weaver and Malone have carried out a more thorough study of those associated with Mt Saint Helens, an historically active stratovolcano in the Cascade Range.

Of the thousands of low frequency events recorded, only a few hundred have yet been analysed in any detail. But all were found to have occurred on the glacier-clad north-eastern side of the mountain and all had very shallow depths (<200 m). In these respects, as well as in waveform characteristics, they were therefore easily distinguishable from the deeper (1–3 km) and much less frequent tectonic earthquakes. From this and related evidence, Weaver and Malone conclude that there is a 'compelling' case for attributing the low frequency events not directly to volcanic activity but to glacial movement ('glacier noise'). Indeed, two events studied in particular detail were found to have occurred at a depth of 45 ± 20 m, which is roughly the thickness of the ice in the areas concerned.

If Weaver and Malone are right, there are clearly going to be problems in using type B events for eruption prediction, at least for Mt Saint Helens. But Mt Saint Helens is quiescent, and so the question of prediction is presumably not urgent. By contrast, Mauna Loa, the largest of the five volcanoes making up the island of Hawaii, is in a quite different position.

Mauna Loa has been created by repeated eruptions over several hundred thousand years and during the past century or so has erupted at irregular intervals averaging 3–4 yr. From 1950 to 1975, however, it never erupted at all, although this 25-yr period of dormancy, the longest in the volcano's recorded history, was broken in July 1975. The 1975 eruption was small by Mauna Loa's standards, producing only 3×10^7 m^3 of lava. But according to US Geological Survey scientists it was highly significant, for historically there has been a cyclic pattern of activity comprising two small summit eruptions followed by a large flank eruption.

Assuming this pattern to be repeated, there is now a specific prediction for the second brief summit and major flank eruptions to take place before July 1978. Moreover, seismic data suggest that the flank eruption will occur along the north-east rift. In this case there will be some threat to Hilo, the island's principal city, which lies about 50 km away but in the direction of natural drainage channels which could guide the lava. However, there are contingency plans to redirect the lava if necessary. □