more albitic (Table 1, Fig. 2). This suggests that the gabbros originated from multiply-saturated basaltic liquids undergoing slow cooling and fractional crystallization with some crystal settling contributing to the formation of cumulate gabbros.

Most gabbros from the MR are deformed and the extent of deformation is generally correlated with the extent of alteration/metamorphism of primary phases, except in brecciated rocks. These were apparently brecciated by brittle fracturing at low temperature, and contain chiefly clays as secondary minerals. In contrast, most deformed gabbros contain higher temperature metamorphic assemblages (see Tables 1 and 2). A continuous gradation from fresh gabbro to completely amphibolitized gabbro occurs among MR samples. This transformation is characterized by: (1) increase in the abundances of Cl-bearing amphibole (Table 2) at the expense of pyroxenes, and (2) concomitant decrease in the anorthite component in plagioclase: in completely amphibolitized gabbros, the scant plagioclase is albite, which may be retrograde. Additional evidence for retrograde metamorphism in the amphibolitized gabbros includes the presence of epidote (for example, Ps_{15-25} in sample 8–24; Ps_{14} in 8–17), prehnite ($Fe_2O_3 < 0.8$ wt% in samples 8–1, 8–18), albite veins, tremolite ($Trem_{66}Act_{34}$ in sample 8–16, $Trem_{62}$ in 8–24), chlorite, analcime, and quartz and quartz + Ep veins that cut foliation. The quartz veins contain polyphase fluid inclusions which sometimes contain a salt crystal. These inclusions and the Cl content of amphiboles indicate that late hydrothermal fluids were quite saline[11,27].

The serpentinite (82% talc/serpentine, 2% spinel, 16% clay and amphibole) contains Al = rich Cr-spinels [$Cr/Cr + Al = 0.4$; $Fe^{3+}/Fe^{3+} + Al + Cr = 0.01$; $Mg/Mg + Fe^{2+} = 0.64$–0.70] that have very rare inclusions of olivine (Fo_{91}). The spinels form coarse amoeboid grains, similar to a texture inferred by Dick[28] to occur characteristically in peridotite that has been partially melted. By contrast, cumulate spinel grown from a melt is normally euhedral[28]. Therefore, textural evidence, together with the Al-content of the Cr-spinel, suggests that the serpentinitized peridotite represents partially-melted oceanic upper mantle material. Altered diabase recovered in dredge 8 contains secondary albite but relict clinopyroxene ($En_{51}Fs_{11}$) and is relatively unfractionated with $TiO_2 = 1.05$ wt%, Cr = 370 p.p.m., La = 2.68 p.p.m. and $(La/Sm)_N = 0.58$ (ref. 29 and work in preparation). Most of the MORB lavas recovered are also relatively unfractionated. Those from dredge 7 have Mg number = 74, MgO = ~10 wt%, $TiO_2 = 0.72$ wt%, Cr = 500 p.p.m., Ni = ~200 p.p.m., La = 1.0 p.p.m. and $(La/Sm)_N = 0.35$, while the most fractionated one, a MORB lava from dredge 8 has Mg number = 65, $TiO_2 = 1.28$ wt%, Cr = 270 p.p.m.

Plutonic rocks recovered in the MR are broadly similar to other oceanic gabbros, but they comprise a relatively fractionated suite. Detailed differences such as a lack of cumulus spinel, which is present in DSDP site 334 cumulates[4], will be considered elsewhere. The suite of volcanic and plutonic rocks from the MR is similar to that found in ophiolites[30]. However, because both dredges in MR troughs contained all rock types, we have no constraints on stratigraphical thicknesses, or even whether an orderly stratigraphy is exposed. If there is an orderly stratigraphy, then oceanic crust at the MR is very thin (<600 m, from Fig. 1). Otherwise, processes such as tectonic disruption or diapiric rise of serpentinite may have occurred. The chemical contrast between unfractionated MORB lavas and diabase and the relatively fractionated gabbros might suggest that these rocks are in tectonic contact, and gabbroic breccias that formed at low temperature may have resulted from such tectonism. The timing of the presumed tectonic activity is poorly constrained, but some could have postdated the cessation of spreading and the inferred morphological changes associated with gradually decreasing spreading rate of the MR. We favour the notion that fractionated gabbros originated while the MR was spreading rapidly, whereas less fractionated MORB lavas were produced during the transition of the MR to its present slow-spreading morphology, because this is consistent with petrological and geophysical data for presently active slow and fast-spreading ridges[24–26]. Choosing between this hypothesis and the possibilities discussed above will require further detailed studies of the MR and the stratiagraphical/structural relationships of the rocks exposed there.

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Why is Mrs Thatcher interrupted so often?

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If a conversation is to proceed smoothly, the participants have to take turns to speak. Studies of conversation have shown that there are signals which speakers give to inform listeners that they are willing to hand over the conversational turn[1–4]. Some of these signals are part of the text (for example, completion of syntactic segments), some are non-verbal (such as completion of a gesture), but most are carried by the pitch, timing and intensity pattern of the speech; for example, both pitch and loudness tend to drop particularly low at the end of a speaker's turn. When one speaker interrupts another, the two can be said to be disputing who has the turn. Interruptions can occur because one participant tries to dominate or disrupt the conversation. But it could also be the case that mistakes occur in the way these subtle turn-yielding signals are transmitted and received. We demonstrate here that many interruptions in an interview with Mrs Margaret Thatcher, the British Prime Minister, occur at points where independent judges agree that her turn appears to have finished. It is suggested that she is unconsciously displaying turn-yielding cues at certain inappropriate points. The turn-yielding cues responsible are identified.

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Mrs Thatcher's interviews display a distinctive pattern—she is typically interrupted more frequently than other senior politicians, and she is interrupted more often by interviewers than she herself interrupts[5]. This pattern is consistent across a wide variety of interviewers (including Denis Tuohy, Brian Walden and Llew Gardner) and across a wide variety of topics[6]. Butting-in interruptions are particularly common in her interviews. These occur where her interviewer interrupts but fails to get the floor, as in the following example where Denis Tuohy (D.T.) tries to take the floor from Mrs Thatcher (M.T.) (*TV Eye*, April 1979).

M.T.: ... if you've got the money in your pocket you can choose/whether you spend it on things which attract Value Added Tax/or not
D.T.: (You s-
(
M.T.: (and the main necessities don't
D.T.: You say a little on Value Added Tax

where /indicates unfilled pause ≥200 ms

(word 1 / (word 2 indicates simultaneous speech

A series of experiments was designed to test the hypothesis that Mrs Thatcher is often interrupted because she displays turn-yielding cues at points where she has not completed her turn. Forty extracts were selected from the Denis Tuohy *TV Eye* interview (ITV, April 1979): 10 were turn-final (that is, utterances at the end of a turn immediately preceding a smooth speaker-switch), 20 were turn-medial (utterances from within a turn), and the remaining 10 were turn-disputed (utterances immediately preceding an interruption by Tuohy). These extracts all contained at least one sentence. The extracts were presented to subjects who had to judge whether Mrs Thatcher's turn was complete or not, in a forced choice procedure. The extracts were presented on video to 79 subjects, on audio only to 29 subjects (in the audio presentation, only the final tone group of each utterance was presented, with two exceptions in which the last two tone groups were played because the final tone group comprised only one word), on vision only to 14 subjects, and typescripts of the extracts were presented to 20 subjects. There were different numbers of subjects in conditions because the extracts were presented in university classes. All subjects were students at the universities of Sheffield or Sussex. For each of the 40 extracts in each of the 4 modes of presentation, the percentages of completion judgements were calculated (see Table 1).

Table 1 Results of completion–judgment experiments to assess the reasons Mrs Thatcher is interrupted so often

Mean percentage of utterances judged to be complete

	Mode of presentation			
	Video	Vision only	Audio only	Typescript
Turn-final	83.530	76.430	62.230	63.500
Turn-disputed	40.120	38.570	55.860	50.500
Turn-medial	23.045	18.570	32.405	58.250

Correlations between presentation modes (% completion judgements for each utterance)

Vision only	Audio only	Typescript	
0.898	0.676	0.083	Video
	0.586	0.000	Vision only
		−0.080	Audio only

An analysis of variance (ANOVAR) revealed that both 'type of utterance' ($F = 23.265$; $P < 0.0001$) and 'mode of presentation' ($F = 8.282$, $P < 0.0001$) significantly affected judgements of completion. There was also a significant interaction effect between type of utterance and mode of presentation ($F = 7.692$; $P < 0.001$). As predicted, turn-final utterances produced the

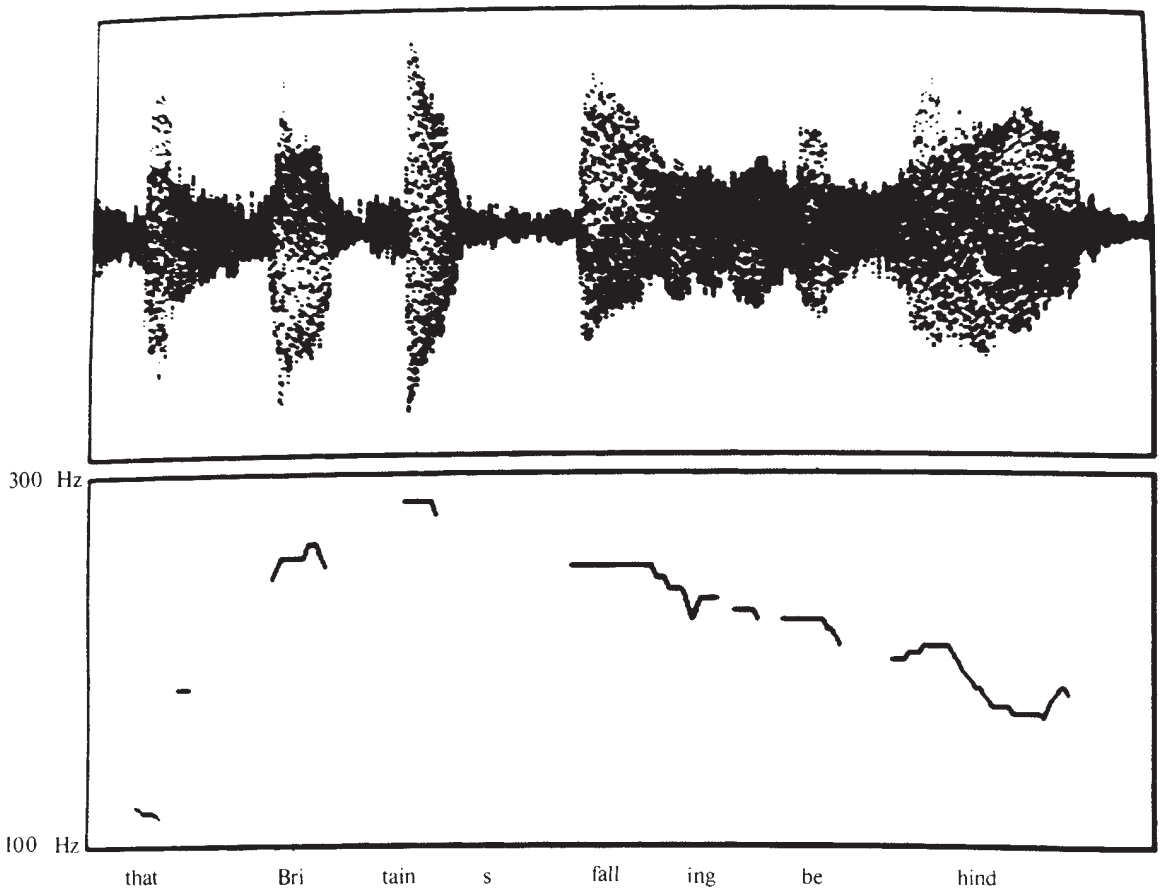

Fig. 1 Amplitude trace and pitch contour of turn-medial utterance, showing slow fall in utterance pitch.

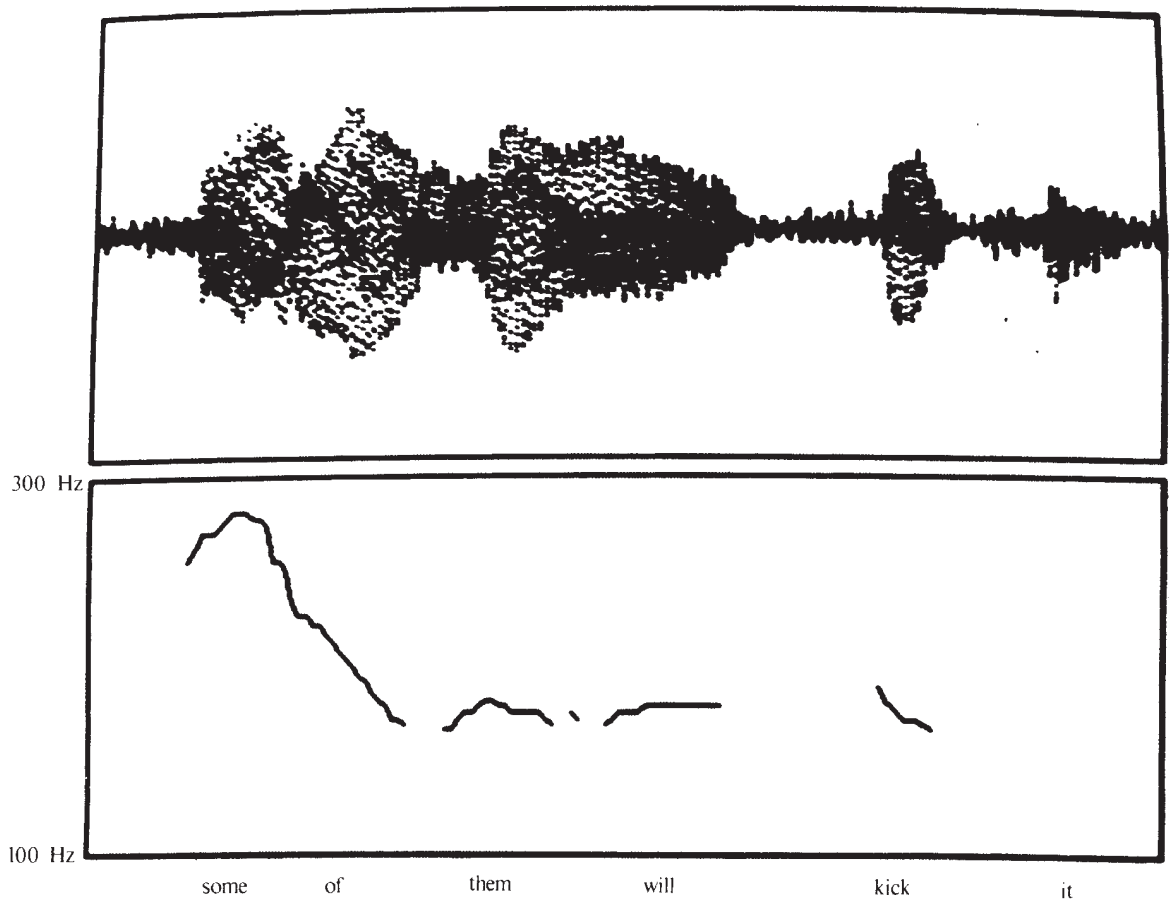

Fig. 2 Amplitude trace and pitch contour of turn-final utterance, showing fast fall in utterance pitch.

most completion judgements, and the turn-medial the lowest, with the disputed turns falling somewhere in between these two. One-factor ANOVARs revealed that 'type of utterance' had a significant effect in the case of the video presentation ($F = 34.791$, $P < 0.0001$), audio presentation ($F = 5.129$, $P < 0.02$) and vision-only presentation ($F = 25.486$, $P < 0.0001$). With the typescript, however, there was no significant effect ($F = 1.185$, not significant). (Note that significant effects did emerge in conditions with smaller numbers of subjects than the typescript condition, thus in fact demonstrating the robustness of the effects.) A comparison of means, using the Tukey HSD procedure (see ref. 12, p. 87) revealed that judged completion scores were significantly higher for turn-disputed utterances than for turn-medial utterances for the video presentation ($F = 5.53$, $P < 0.05$), the audio presentation ($F = 5.15$, $P < 0.05$) and the vision-only presentation ($F = 6.09$, $P < 0.05$).

Tests for correlation revealed significant positive correlations (all at the 0.001 level or beyond) among the video, vision-only and audio-only conditions for proportion of completion judgements for each utterance. The typescript condition judgements, however, did not correlate significantly with any of the other conditions (see Table 1). Thus, although, for example, the means for the turn-final utterances in the audio and typescript conditions are similar, the individual utterance ratings which comprise the means are obviously quite different.

Thus the basic hypothesis was supported—those utterances immediately preceding an interruption by the interviewer were judged to be complete more often than turn-medial utterances and this was not on the basis of syntactic or semantic content (present in the typescript) because, of course, no significant effect emerged in the case of the typescript, but on the basis of information carried in the audio channel and in the visual channel of the interaction, as models of turn-taking such as that of Duncan[2] would predict. Subsequent analyses sought to determine exactly which signals were giving rise to subjects' perceptions of these utterances as complete.

First, the 40 extracts from the Denis Tuohy interview with Mrs Thatcher were digitized and coded into LPC (linear predictive coding) parameters, and a value for the fundamental frequency of each sample was extracted. All 40 utterances terminated in a pitch fall with one exception, a question which ended in a rise; this exception was excluded from further auditory analysis. The value of the fundamental frequency in cycles per second was determined for the highest and lowest points (peak and trough) of each terminal fall. The mean values for the three types of utterance are displayed in the first two columns of Table 2. Column 3 shows the mean pitch range covered by the fall (that is, the difference between columns 1 and 2), and column 4 gives the mean time in milliseconds over which the fall was realized.

ANOVARs on these four measures showed that on two of them, the three conditions differed significantly: (1) The trough of the fall; the difference between conditions was significant ($F = 5.75$, $P < 0.01$), and Scheffé *post- hoc* comparisons showed that the turn-final utterances ended significantly lower than the other two groups, which did not differ significantly from one another.

(2) The timespan over which the terminal fall was realized; the difference between conditions was significant ($F = 4.61$, $P < 0.02$), and Scheffé *post-hoc* comparisons showed that this effect was due to the turn-medial falls being slower than either of the other two types of utterance, which did not differ significantly (see Figs 1, 2). There was no significant difference between the three types of utterance on either the height of the pitch peak or the range of the fall.

This analysis suggests that the turn-disputed utterances may, in fact, have conflicting cues: a fast fall like the turn-final utterances, but a fall which does not descend very low, like the

Table 2 Mean peak and trough values for three types of utterance

	Peak	Trough	Δ	Span
Turn-final	238	141	97	693
Turn-disputed	263	167	96	463
Turn-medial	275	161	114	953

turn-medial utterances. This, in turn, suggests that while the speaker is actually giving a number of cues to the end of her turn, the cue which she considers paramount may be different from the cue which her interlocutor considers paramount. If she considered that her most decisive cue to the end of her turn was letting her voice drop to around 140 Hz instead of keeping it no lower than 160 Hz, whereas her interlocutor considered that her most decisive cue was a rapidly executed final fall rather than a slow fall, their respective decisions as to whether or not she had finished her turn would differ in precisely those cases which were disputed in the present sample of utterances.

One of the authors, trained in phonetic transcription, then transcribed the 40 utterances without knowledge of the position of the utterances in the speaker's turn. The transcriptions of the turn-final and turn-medial utterances were then separately inspected, and the prosodic and vocal quality features occurring in three or more of these utterances listed. Five 'final' features were found: pitch downstep (rapid drop) before the main fall (tonic); double falling contour; allegro portion before the tonic; whispery voice; and creaky voice. Three 'medial' features were found: allegro continuing through the tonic; pitch upstep before the final fall; and a non-falling sustained contour after the fall. (Note that because all our sample utterances ended in falls, we must have underestimated the complete range of cues when non-falling utterances are included. For example, many turn-medial utterances end in a fall–rise.)

The remaining utterances were then checked for the presence of these features, which were assumed to be characteristic of turn-final and turn-medial utterances, respectively. The five 'final' features occurred on average 2.2 times per turn-final utterance, but 0.2 times per turn-medial utterance. Turn-disputed utterances, with a mean of 1.6, were closer to the turn-final utterances than to the turn-medial utterances. The three 'medial' cues occurred on average 0.65 times per turn-medial utterance, but 0.10 times per turn-final utterance. Turn-disputed utterances again fell in between with a mean of 0.30.

The number of acoustic cues present in each utterance was then correlated with the results of the audio perception test, and the proportion of completion judgements for each utterance was found to have a significant positive correlation with the mean number of 'final' cues present in that utterance ($r = 0.46$, $P = 0.003$), but a significant negative correlation with the mean number of 'medial' cues ($r = -0.45$, $P = 0.004$). Thus, the listeners in this experiment seem to have been making use of these phonetic and vocal quality cues in making their forced choice judgements.

In terms of the visual channel, the main signal guiding completion judgements must have been eye gaze because, in a large proportion of instances, the camera angle was such that no information was available on other aspects of nonverbal behaviour such as gesture (gesture termination being an important turn-yielding signal, and gesture maintenance an important turn-holding signal, according to Duncan). Eye gaze has been shown in the past to be implicated in turn regulation[7–9]. Analysis of the video revealed that in 100% of the turn-final utterances, Mrs Thatcher was looking at her interviewer at the end of the utterance, compared with 55% of turn-medial utterances. Turn-disputed utterances were again intermediate with 80%.

We have argued that some interruptions in conversation may arise from the transmission of turn-yielding cues at inappropriate points rather than from any desire on the part of either participant to dominate or disrupt the conversation. It has often been suggested that conversation can be regarded as a highly skilled performance[10,11]. Successful manipulation of these very subtle turn-taking signals must certainly rank as one important aspect of this conversational skill.

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Is annual reproduction in deep-sea echinoderms a response to variability in their environment?

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The deep-sea environment has traditionally been considered as one of the least variable on the surface of the Earth[1–3]. However, recent evidence[4–6] suggests that there may be a seasonal fluctuation in the physicochemical environment, and there is further evidence[7–11] that annual reproductive periodicities may occur among populations of deep-sea invertebrates. We report here evidence for annual periodicities and considerable between-species synchrony in the reproductive cycles of five deep-sea echinoderms, spawning occurring in late winter and early spring. These species also show a similar mode of early development that suggests adaptation to a seasonally varying food supply.

One of the aims of a long-term time series sampling programme initiated by the Scottish Biological Association in the Rockall Trough (north-east Atlantic)[12,13] is to test the hypothesis that annual periodicities may occur in deep-sea invertebrates. In 1975 a permanent station was established at 2,900 m depth (54°40′ N; 12°16′ W). In 1978 this station was supplemented by a second (station 'M') at a depth of 2,200 m nearer the base of the Hebridean Slope (57°18′ N; 10°23′ W). Samples of the benthic fauna have been taken from both stations, using either an epibenthic sledge or an Agassiz trawl at approximately 4-monthly intervals to the present date.

Although a wide variety of deep-sea benthic invertebrates have been collected, echinoderm species dominate in terms of biomass. Seven echinoderm species (Table 1*a*) were collected in sufficient numbers to determine any seasonal reproductive cycles. A further seven species have been examined but were collected irregularly or in insufficient numbers to determine reproductive periodicity (Table 1*b*). In addition, echinoderm material is available to us from a number of other recently obtained samples from the Rockall Trough[14], and fine-meshed rectangular midwater trawl (RMT 1; mesh diameter 0.33 mm) samples have been obtained over station 'M' to look for echinoderm larvae (Table 1*c*).

To investigate the reproductive cycle of each species, the gonads of each specimen were dissected out and processed to paraffin wax, sectioned and stained. In all species examined the sexes were separate and equal in numbers, and since gametogenesis is more easily determined in females, we use data on oocyte size frequencies (Fig. 1*a–c*) to study reproductive seasonality. The diameters of at least 100 oocytes per specimen were measured and from these data oocyte-size/frequency diagrams constructed (Fig. 1*a–c*).

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