Geophysics

Palaeobathymetry from sinking shells

from Peter J. Smith

THE variety of phenomena from which information can be wrung about the geophysical past is a constant surprise. Consider, for example, the case of the sinking cephalopods.

A few years ago, J.S. Weaver and J.A. Chamberlain, building on earlier ideas and making use of the equations derived by naval architects to describe the sinking of ships, managed to work out the physics of the sinking of coiled and chambered shells (see, for example, *Math. Geol.* **10**, 673; 1978). They were able in particular to demonstrate, both theoretically and by laboratory experiment, that the depth to which an intact coiled cephalopod will sink with its plane of symmetry remaining vertical is governed only by the geometry of the shell. What was not clear at the time was whether, given the more chaotic conditions of the natural environment, observations of *in situ* vertical cephalopod shells could be interpreted sensibly in terms of palaeobathymetry. R.E. Crick has now shown that they can be (*Bull. Geol. Soc. Am.* **94**, 1109; 1983).

This is possible because of the remarkable series of events that overtakes chambered cephalopods after death. Gases released during the decay of the visceral mass often increase the buoyancy of a dead cephalopod so that the shell rises to the water surface where, unless it is stranded on a shoreline, it becomes waterlogged and sinks. But it doesn't just drop. Initially, the shell floats with its plane of symmetry vertical; but as it gradually absorbs water and sinks (and assuming it remains undamaged) it begins to rock from side to side until it finally becomes horizontal. The depths at which these changes occur depend on the shell's geometry. If the water is shallower than the rocking depth for a particular type of cephalopod, the shell will reach the bottom and become anchored, infilled and buried in a vertical position. Therefore, any ancient cephalopod shell discovered in a vertical position must have been deposited in water whose maximum depth can be estimated from the shell's geometry.

Of course, there are potential difficulties. For example, could a sinking shell, having reached the depth at which it becomes horizontal, nevertheless end up in a vertical position through impact at the bottom? That seems unlikely, for cephalopod shells float down much too gently to undergo a disorienting impact.

Second, could shells reaching the bottom in a horizontal state subsequently be turned to the vertical by bioturbation? They could indeed, although there are ways of detecting that in particular cases.

Third, it is necessary to assume (reasonably) that gravity, seawater density and atmospheric pressure have not changed since the shells sank.

Finally, if the method is to work, it is essential that not all shells that end up in a vertical position at the bottom should subsequently topple over; but as vertical shells are actually observed, this appears not to be too much of a problem.

Crick has applied the technique to the top of the Fort Worth limestone, which extends in a narrow belt southwards from the Texas-Oklahoma border and which formed during the extistence of the East Texas Embayment (Lower Cretaceous). There are enough vertical cephalopods (ammonites and nautiloids) to provide data at points throughout the whole length of the formation; and there were several different types of cephalopod present, so that maximum water depths can be determined over the range 1.6–2.6 m. Moreover, at the few points at which there are no vertical shells and hence at which it is not possible to specify maximum water depths, it has at least been possible to estimate minimum depths, for the depths must have exceeded those at which the particular types of cephalopod begin to deviate from vertical sinking.

The conclusions that Crick reaches are that the Forth Worth cephalopods were laid down in water depths of generally less than 2.6 m and that depths increased slightly to the east and south. In the context of local geology, this is a considerable advance in that previous estimates of water depth based on less reliable (sedimentological and palaeoecological) criteria lie in the range 15–40 m. More important than the specific results, however, is that the method appears to work and is evidently of wider applicability. The only condition is that the formation to be studied should contain cephalopods laid down in water of a depth not exceeding the depths at which the various types of shell begin to depart from vertically oriented fall. □

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Astronomy

IRAS circular 7

The source name consists of four parts: (1) the letters 'IRAS' to indicate the origin; (2) the right ascension (RA) in hours and minutes, seconds omitted; (3) declination (Dec) in decimal degrees, multiplied by 10 and then truncated (thus + 32° 42.3 becomes + 327); (4) an appendix starting with 'P' and followed by the number of the circular; this appendix stresses that the data are preliminary. Position is given at Equinox 1950.0. The measurements were made between epochs 1983.1 and 1983.6.

Source IRAS	RA (1950) h min s	Dec (1950) deg arc min	Flux density (Jy) 12 μm	25 μm	60 μm	100 μm
0000+818P07	00 00 12	+81 45.9	<0.2	<0.2	0.6	<1.6
0007+821P07	00 07 33	+82 08.4	<0.2	<0.2	0.6	<1.6
0119+868P07	01 19 26	+86 49.5	<0.2	<0.2	0.6	<1.5
0147+891P07	01 47 23	+89 06.7	<0.2	<0.2	0.8	1.9
0354+226P07	03 54 54	+22 33.8	<0.2	<0.2	<0.5	3.5
0358+194P07	03 58 04	+19 22.5	<0.2	<0.3	0.9	1.6
0358+202P07	03 58 12	+20 13.7	<0.2	<0.3	0.6	2.1
0359+169P07	03 59 52	+16 56.9	<0.2	<0.3	0.9	2.6
0412+024P07	04 12 11	+02 23.2	<0.2	<0.2	1.0	2.1
0413+023P07	04 13 40	+02 21.0	<0.2	<0.2	<0.6	2.1
0413+011P07	04 13 58	+01 03.8	<0.2	<0.2	<1.0	2.3
0417+008P07	04 17 40	+00 45.1	<0.2	<0.2	0.6	<1.5
0712+880P07	07 12 40	+87 57.8	<0.2	<0.4	0.9	<1.6
0845+515P07	08 54 16	+51 32.2	<0.2	<0.2	0.8	<1.4
0854+210P07	08 54 30	+21 00.4	<0.2	<0.3	0.9	<1.0
0855+108P07	08 55 59	+10 53.0	<0.2	<0.3	1.3	2.2
0902+128P07	09 02 33	+12 53.7	<0.4	<0.3	0.5	<0.7
0904+210P07	09 04 09	+21 00.2	<0.4	<0.3	0.5	<1.1
0910+234P07	09 10 58	+23 29.8	<0.2	<0.3	0.8	2.5
0915+511P07	09 15 08	+51 09.6	<0.2	<0.2	0.5	<1.3
0920+023P07	09 20 05	+02 19.6	<0.3	<0.3	0.6	<1.1
1010+865P07	10 10 21	+86 28.6	<0.2	<0.2	0.6	<2.0
1100+792P07	11 00 51	+79 15.6	<0.2	<0.2	0.8	1.5
1108+772P07	11 08 36	+77 12.9	<0.2	<0.2	0.9	2.1
1150+829P07	11 50 23	+82 52.8	<0.3	<0.2	0.5	<1.6
1157+860P07	11 57 35	+85 59.9	<0.2	<0.2	0.5	<1.6
1221+844P07	12 21 11	+84 26.7	<0.2	<0.2	0.6	<1.6
2359+846P07	23 59 08	+84 35.1	<0.2	<0.2	0.8	<1.6

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