slowly and smoothly; they do not show the sudden breaks that should occur at the limits of olistostrome blocks, at least some of which would have rotated during emplacement. Rotations of this kind have been found in several synsedimentary slide masses 5–15 m thick in the turbidite-bearing Furlo section[63]; they are not present at Gubbio, or in any of the entirely pelagic sections which have been studied.

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1. Renz, O. *Eclog. Geol. Helv.* **29,** 1 (1936).
2. Luterbacher, H. P. & Premoli Silva, I. *Riv. Ital. Paleont. Stratigr.* **68,** 253 (1962).
3. Luterbacher, H. P. & Premoli Silva, I. *Riv. Ital. Paleont. Stratigr.* **70,** 67 (1964).
4. Premoli Silva, I., Paggi, L. & Monechi, S. *Mem. Soc. Geol. Ital.* **15,** 21 (1976).
5. Premoli Silva, I. *Bull. geol. Soc. Am.* **88,** 371 (1977).
6. Monechi, S. *Proc. Cret. Tert. Bound. Events Symp.* **11,** 164 (1979).
7. Wonders, A. A. H. *Bull. Utrecht Micropaleont.* **24,** (1980).
8. Lowrie, W. & Alvarez, W. *Nature* **251,** 285 (1974).
9. Premoli Silva, I., Napoleone, G. & Fischer, A. G. *Boll. Soc. Geol. Ital.* **93,** 647 (1974).
10. Lowrie, W. & Alvarez, W. *J. geophys. Res.* **80,** 1579 (1975).
11. Channell, J. E. T. & Tarling, D. H. *Earth planet. Sci. Lett.* **25,** 177 (1975).
12. Van den Berg, J., Klootwijk, C. T. & Wonders, A. A. H. *Prog. in Geodynamics*, Roy. Ned. Acad. Arts & Sci. 165 (1975).
13. Klootwijk, C. T. & Van den Berg, J. *Earth planet. Sci. Lett.* **25,** 263 (1975).
14. Lowrie, W. & Alvarez, W. *Mem. Soc. Geol. Ital.* **15,** 41 (1976).
15. Napoleone, G. *Mem. Soc. Geol. Ital.* **15,** 51 (1976).
16. Larson, R. L. *Mem. Soc. Geol. Ital.* **15,** 61 (1976).
17. Roggenthen, W. M. *Mem. Soc. Geol. Ital.* **15,** 73 (1976).
18. Van den Berg, J. *Mem. Soc. Geol. Ital.* **15,** 83 (1976).
19. Wonders, A. A. H. *Mem. Soc. Geol. Ital.* **15,** 91 (1976).
20. Channell, J. E. T. *Mem. Soc. Geol. Ital.* **15,** 119 (1976).
21. Lowrie, W. & Alvarez, W. *Bull. geol. Soc. Am.* **88,** 374 (1977).
22. Roggenthen, W. M. & Napoleone, G. *Bull. geol. Soc. Am.* **88,** 378 (1977).
23. Alvarez, W. *et al. Bull. Geol. Soc. Am.* **88,** 383 (1977).
24. Lowrie, W. & Alvarez, W. *Geophys. J.* **51,** 561 (1977).
25. Van den Berg, J. Klootwijk, C. T. & Wonders, A. A. H. *Bull. geol. Soc. Am.* **89,** 133 (1978).
26. Alvarez, W. & Lowrie, W. *Geophys. J.* **55,** 1 (1978).
27. Channell, J. E. T. *et al. Earth planet Sci. Lett.* **39,** 199 (1978).
28. Van der Berg. J. *Geol. Ultraiectina* **20,** (1979).
29. Lowrie, W. *et al. Geophys. J.* **60,** 263 (1980).
30. Lowrie, W., Channell, J. E. T. & Alvarez, W. *J. geophys. Res.* **85,** 3597 (1980).
31. Gratziu, C. & Schiaffino, L. *Atti Soc. tosc. Sci. nat.* **74,** 502 (1967).
32. Arthur, M. A. & Fischer, A. G. *Bull. geol. Soc. Am.* **88,** 367 (1977).
33. Arthur, M. A. thesis, Princeton Univ. (1979).
34. Wonders, A. A. H. & Verbeek, J. W. *Proc. K. ned. Akad. Wet.* B **82,** 171 (1979).
35. Alvarez, W. *et al. EOS* **60,** 734 (1979).
36. Alvarez, W. *et al. Geol. Soc. Am. Abstr. Prog.* **11,** 350 (1979).
37. Vannucci, S. *et al. Ateneo Parmense Acta Nat.* **15,** 261 (1979).
38. Renard, M. *Bull. B.R.G.M.* **4,** 133 (1979).
39. Alvarez, L. W. *et al. Science* **208,** 1095 (1980).
40. Wezel, F. C. *Ateneo Parmense Acta Nat.* **15,** 243 (1979).
41. Surlyk, F. *Nature* **285,** 187 (1980).
42. Coccioni, R. *Ateneo Parmense Acta Nat.* **14,** 223 (1978).
43. Premoli Silva, I. & Luterbacher, H. P. *Riv. Ital. Paleontol.* **84,** 667 (1978).
44. Centamore, E., Jacobacci, A. & Martelli, G. *Boll. Serv. Geol. Ital.* **93,** 155 (1973).
45. Guerrera, F. *G. Geol.* **42,** 109 (1977).
46. Lowrie, W. *et al. Bull. geol. Soc. Am.* (submitted).
47. Napoleone, G. *et al. Bull. geol. Soc. Am.* (submitted).
48. AGIP Mineraria, *Microfacies Italiane* (1959).
49. Crescenti, U. *Mem. Soc. Geol. Ital.* **8,** 155 (1969).
50. Crescenti, U. *et al. mem. Soc. Geol. Ital.* **8,** 343 (1969).
51. Centamore, E. *et al.* Note Illustr. Foglio 291 Pergola, Serv. Geol. Ital. (1975).
52. Chiocchini, M. *et al. Stud. Geol. Camerti* **2,** 7 (1976).
53. Ganapathy, R. *Science* **209,** 921 (1980).
54. Smit, J. & Hertogen, J. *Nature* **285,** 198 (1980).
55. Asaro, F. *et al.* (in preparation).
56. Tauxe, L. *et al. Geol. Soc. Am. Abstr. progr.* **12,** 533 (1980).
57. Chave, A. D. *EOS* **61,** 944 (1980).
58. Irving, E. & Major, A. *Sedimentology* **3,** 135 (1964).
59. Kent, D. V. *Nature* **246,** 32 (1973).
60. McElhinny, M. W. & Opdyke, N. D. *Bull. geol. Soc. Am.* **84,** 3697 (1973).
61. Barton, C. E., McElhinny, M. W. & Edwards, D. J. *Geophys. J.* **61,** 355 (1980).
62. LaBrecque, J. L., Kent, D. & Cande, S. C. *Geology* **5,** 330 (1977).
63. Alvarez, W. & Lowrie, W. *Bull. geol. Soc. Am.* (1981).
64. Kyte, F. T., Zhou, Z. & Wasson, J. T. *Nature* **288,** 651 (1980).
65. Lowrie, W. & Alvarez, W. *Geology* **9,** 392 (1981).

A reply by F. C. Wezel

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I thank Alvarez and Lowrie for their comments on my paper on the Scaglia Rossa[1]. However, I found their comments scientifically unsatisfactory for at least two reasons. First, although my work was published two years ago they present no new observed facts. Rather they seem to have adopted a model to which all data must be fitted. Second, although I raised the problem of Miocene foraminifera in the Scaglia Rossa turbidites, I did not, in fact, conclude that they were Miocene in age.

Further, Alvarez and Lowrie seem to have misinterpreted the spirit of my paper. In dispelling the alleged cliché of the Scaglia Rossa as "a conformable, complete and pelagic sequence of oceanic type"[2,3], I stressed the rudimentary state of our factual geological knowledge of the formation and the urgent need for more research "before continuing to pursue other striking speculations remote from facts"[1]. It is regrettable that Alvarez and Lowrie have ignored some basic points of my paper contradicting the inferred pelagic origin of the Scaglia Rossa limestones. For example, (1) The palaeogeographic reconstruction indicating a series of narrow and current-influenced troughs in a probable taphrogenic regime, marked by a combination of subsidence and distension. (2) The facies and palaeocurrent analysis showing the distal basinal environment of the Bottaccione section. (3) The basin-wide regional megarhythmicity of the vertical sequences, expressing temporal changes in sedimentation rate as a consequence of the structural activity of the passive margin tectonics.

The micropalaeontological data of Coccioni (personal communication) clearly show the presence of Miocene foraminifera in clay interbeds from various sections of the Scaglia Rossa. This work was carried out in our laboratory by painstakingly washing 400 kg of sample; 238 Miocene foraminiferal tests were recovered. Alvarez and Lowrie's statement that "not a single Miocene foram was found . . . in detailed examination of about 200 thin sections of Scaglia limestone beds from six localities . . . ", is not at all surprising. It rather pinpoints the methodological inadequacy of thin section studies. The presence of Miocene microfossils represents undoubtedly a real problem which has not yet been solved. With our current knowledge, I am now inclined to believe that the Scaglia Rossa is probably Cretaceous–Eocene in age, but complete disregard of the observed younger foraminifera is not an adequate solution to the problem.

Alvarez and Lowrie did not take into account a vast fund of geological information. They state once more the presence of an anomalously high iridium concentration at the Cretaceous–Tertiary boundary in the Bottaccione and other four sections of Scaglia Rossa. They stated that "No iridium anomaly is yet known at any other level in any pelagic sediment". Possibly one could believe in such "iridium anomaly" after many analyses have been undertaken in other beds of the sedimentary column (see ref. 4). Unfortunately, however, the concerted effort of the catastrophists[5–7] focused almost exclusively on the 'magic' thin Cretaceous–Tertiary boundary clay. In such conditions, without a thorough and detailed examination of numerous other clay interbeds and consideration of the minero-petrographic and geochemical contexts, it would be wrong to interpret a unique event as a catastrophe.

Some very significant recent results have now demonstrated other iridium anomalies at different levels. For example, a series of analyses carried out on the 1-m thick cherty black shale ('Bonarelli level', considered Turonian in age), located ~240 m under the Cretaceous–Tertiary boundary, has unequivocally shown an anomalously high iridium concentration, about twice as great as the K/T clay[8]. Recent geochemical and petrographic investigations[9] suggest that this iridium anomaly could be imputed to volcanic activity and not to a second even more drastic extraterrestrial catastrophe.

Finally, I should like to re-emphasize the crude relationship I observed between magnetic properties and variations in lithology. Palaeomagnetic data from the thick coarser-grained turbidites may be controlled by depositional currents, whereas those from the finer-grained beds may more accurately record the Earth's magnetic field.

Therefore the conclusions by Alvarez and Lowrie do not seem to be supported by adequate facts and thus the 65-Myr catastrophic event may be considered an imaginative but unproven hypothesis. I therefore urge, once again, a critical assessment of the different aspects of the Scaglia Rossa geology.

1. Wezel, F. C. *Ateneo Parmense, Acta Nat.* **15,** 243–259 (1979).
2. Pialli, G. (ed.) *Mem. Soc. Geol. It.* **15,** 1–128 (1977).
3. Alvarez, W. *et al. Bull. geol. Soc. Am.* **88,** 383–389 (1977).
4. Surlyk, F. *Nature* **285,** 187–188 (1980).
5. Smit, J. & Hertogen, J. *Nature* **285,** 198–200 (1980).
6. Hsü, K. J. *Nature* **285,** 201–203 (1980).
7. Alvarez, L. W. *et al. Science* **208,** 1095–1108 (1980).
8. Wezel, F. C. *et al. C.r. hebd. Séanc. Acad. Sci., Paris* **293** (in the press).
9. Vannucci, S. *et al. Rend. Soc. It. Min. Petr.* **37(1)** (in the press).