CCNet SPECIAL: K/T MASS EXTINCTION DEBATE KICKED WIDE OPEN AGAIN

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--Gerta Keller, CCNet, 1 November 2003

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CHICXULUB - THE NON-SMOKING GUN

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CHICXULUB PREDATES THE KT BOUNDARY AND IS NOT THE CAUSE FOR THE
END-CRETACEOUS MASS EXTINCTION. This conclusion was announced by Keller, Stinnesbeck and Adatte at the April (2003) EGU-AUG meeting in Nice, France, based on over 10 years of KT research (1) culminating with the new drill core Yaxcopoil-1 in the Chicxulub crater. This evidence has triggered a renewed debate over the cause and impact location of the KT mass extinction and the role of Chicxulub. A public debate is sponsored by the Geological Society of London beginning with its November 1 (2003) issue of Geoscientist. (Log on to www.geolsoc.org.uk, or email the Editor c/o ted.nield@geolsoc.org.uk. To participate.)

Jan Smit questioned this evidence in CCNET of Oct. 9, 2003. He claimed that the varied evidence in Mexico presented by Keller and her collaborators can all be explained by the mechanisms of "tsunamis, mass wasting, slumping and earthquakes triggered by the impact" which make explanation of the KT sedimentary deposits "very complicated indeed." Here we address the major issues and demonstrate that the complicated explanations by Jan Smit and his collaborators are born of the belief that the "Chicxulub is the KT impact" theory is a proven fact, and that therefore any contrary evidence must somehow be explained to fit into this theory. However, this theory can no longer be supported by empirical evidence - Chicxulub is not the smoking gun that caused the end-Cretaceous mass extinction.

EVIDENCE LINKING CHICXULUB AND KT: Ever since the discovery of the Chicxulub subsurface crater in the early l990's many scientists have assumed that this is the crater of doom that caused the demise of the dinosaurs and many other animal groups at the end of the Cretaceous. This very attractive theory was supported by: (a) 39Ar/40Ar ages of about 65 Â± 0.2 Ma of melt glass in the Chicxulub breccia and impact ejecta in the form of glass spherules (microtektites) in Haiti and NE Mexico, (b) the geochemical similarity of microtektites with melt rock from Chicxulub, and (c) the stratigraphic proximity to the K-T boundary in localities throughout Mexico, Guatemala, Belize and Haiti.

TSUNAMI & BURROWS? But increasingly, detailed stratigraphic, geochemical and paleontological analyses failed to support the central thesis that Chicxulub is of KT age. The first complicating factor to a KT age of the Chicxulub ejecta surfaced early in NE Mexico where a thick siliciclastic unit separates the spherule ejecta layer(s) from the overlying KT boundary and Ir anomaly. To reconcile the ejecta with the KT irdium anomaly as a single impact origin, Smit et al. (2) interpreted the siliciclastic unit as impact-generated tsunami deposits. In this scenario the glass spherules settled out first, followed by a megatsunami depositing the siliciclastic unit and finally settling of fines depositing the Ir anomaly.

This interpretation was proven wrong by the discovery of multiple horizons of burrows within the siliciclastic unit that indicates the repeated colonization of the ocean floor during deposition (3, 4). This meant not only that deposition of this unit occurred over an extended time period, which far exceeded a tsunami event, but also that rapid deposition (gravity slumps) alternated with normal sedimentation. The spherule ejecta below this unit could therefore not be of the same origin and age as the Ir anomaly above the siliciclastic unit.

LIMESTONE LAYER WITHIN EJECTA DEPOSIT: Another problem that surfaced early on was the presence of a 15-20 cm thick sandy limestone layer separating the impact spherule layer below the siliciclastic unit in outcrops spanning a region of more than 300 km (5, 3). The top of this sandy limestone layer was subsequently found to contain J-shaped burrows infilled with spherules and terminated by an erosional upper surface, followed by another spherule layer. Similar J-shaped burrows were also observed in the sandstone of the siliciclastic unit above (4). The presence of the limestone layer sandwiched between two spherule beds indicates that spherule deposition occurred in two phases separated by normal limestone deposition and burrowing colonies on the ocean floor. These two spherule ejecta layers could therefore not represent deposition during a single event - as assumed by Smit et al. (7-8). The abundance of shallow water debris and benthic foraminifera indicated that these spherule layers were reworked and re-deposited from shallow water environments.

MORE SPHERULES EJECTA LAYERS IN LATE MAASTRICHTIAN: More evidence of multiple spherule ejecta layers was discovered in the late l990's by five masters students from the Universities of Neuchatel and Karlsruhe and under the supervision of my collaborators Thierry Adatte and Wolfgang Stinnesbeck. These students mapped and analyzed the KT boundary, siliciclastic units, spherule ejecta deposits, and underlying late Maastrichtian Mendez marls over an area spanning about 60km2. This first detailed investigation of the late Maastrichtian Mendez marls revealed the presence of three additional spherule deposits interbedded in 10-12 m of pelagic marls of the Mendez Formation (8, 9). Only some small local slumps spanning a few meters were observed. Impact triggered slumps, mass wasting, or earthquakes cannot account for these normally stratified Mendez marls (10, 11). To date, the spherule layers can be correlated over 100 km.

PRE-KT AGE OF SPHERULE LAYERS: In over three dozen sections examined, these multiple spherule layers are within planktic foraminiferal zone CF1, which spans the last 300 ky of the Maastrichtian (1). The stratigraphically oldest spherule layer is near the base of this zone and we consider it to represent the original ejecta layer because it consists of almost pure spherule debris with only very rare clasts or foraminifera. All subsequent layers contain clasts of marls or spherules and reworked foraminifera, suggesting that these layers are reworked from the original ejecta deposit.

It is all of this evidence, - the KT and Ir anomaly above the siliciclastic unit, the bioturbation within this unit that indicates deposition over an extended time period, the two spherule layers separated by a burrowed limestone layer below the siliciclastic unit that indicate deposition occurred during two separate events, and the up to three additional spherule layers below it, - that Smit refers to as making "the deposits very complicated indeed" to interprete. In fact, this evidence not only makes it very complicated, it makes it impossible to reconcile with the KT impact hypothesis.

CHICXULUB A PRE-KT CRATER: And more evidence against Chicxulub as the KT impact event was discovered with the new drilling of the Chicxulub crater. The new core, Yaxcopoil-1 (Yax-1), was drilled within the Chicxulub crater and was expected to provide unequivocal evidence that Chicxulub is the KT impact crater that caused the mass extinction. Instead, the evidence supports a pre-KT age based on stratigraphy, sedimentology, geochemistry, paleomagnetism and paleontology, consistent with the evidence in NE Mexico.

The critical evidence is within a 50 cm thick laminated partially dolomitized micritic limestone that unconformably overlies the suevite breccia and underlies the KT boundary. This interval contains diverse planktic foraminiferal assemblages of zone CF1, similar to NE Mexico, typical Maastrichitan carbon isotopes values, and paleomagnetic chron 29R, all of which support an age within the last 300 kyr of the Maastrichitan. Sediment deposition occurred in variable, but low-energy pelagic environments (see below).

BACKWASH & CRATER INFILL? In order to have a common origin for the suevite breccia and the KT boundary, this 50 cm layer must be interpreted as part of the impact event, such as backwash and crater infill, as argued by Smit (12). In support of this interpretation he claims the presence of cross bedding and grain size grading. Sediment analysis, however, reveals neither cross bedding nor grain size grading. The larger grains, and " coated sand grains", that Smit refers to are diagenetic dolomite crystals; no grains are found in insoluble residues, except for glauconite or glauconite coated grains in five green layers. The cross-bedding Smit refers to are three <1cm thick layers of oblique bedding that suggest temporarily slightly more agitated bottom waters. The absence of grain size grading in these minor oblique bedding layers indicate that they are not cross beds.

GLAUCONITE RULES OUT BACKWASH: Sedimentologically, the critical 50 cm interval between the impact breccia and KT boundary consists of laminated mciritic limestone with five thin green burrowed glauconitic intervals. XRD and ESEM analyses indicate that no altered impact glass (e.g. Cheto smectite) is present in the green layers, contrary to Smit's earlier claim (13). Since glauconite forms at the sediment-water interface in environments with very slow detritus accumulation, these layers indicate long pauses in the overall quiet depositional environment, the formation of glauconite, sediment winnowing, clast generation and small-scale transport by minor currents. Thus, far from backwash and crater infill by reworking over a short time period, the sediments reveal normal low energy pelagic deposition over an extended time period following the Chicxulub impact and preceding the KT boundary.

MICROFOSSILS OR CRYSTALS? Smit reports that he and Arz (Zaragoza group) could not distinguish the foraminifera from "dolomite crystal overgrowths of sand grains". This is not surprising, since they apparently searched for foraminifera in the dolomitic intervals where it is well known that the large dolomite crystals absorb any evidence of the original fossils. The recrystallized foraminifera are preserved in the micritic limestones where the overall morphology of species is preserved. Although thin section analysis of microfossils takes some experience and can be time consuming, particularly in micritic limestones, I am confident that with diligent search of the micritic limestone layers they will find them throughout the section. They have now been documented from all micritic limestone layers.

REWORKING? Smit claims that even if they missed the foraminifera, their presence should be attributed to reworking in the backwash and crater infill. However, there is no evidence that this zone CF1 late Maastrichtian assemblage is reworked, as there are no fossil species from diverse age intervals as would be expected in any reworked assemblage, no reworked clasts of the breccia or fossils from the underlying lithologies, and no evidence for high energy deposition (see above). Moreover, the Yucatan platform prior to the impact event was too shallow to support planktic foraminifera. This means that they would have had to be transported by high-energy currents over long distances from the Gulf of Mexico; this would also have involved reworked species from different age intervals. There is no evidence for reworking and transport of the zone CF1 foraminiferal assemblage.

CONCLUSION: The evidence from sedimentology and microfossils of Yaxcopoil-1 indicates that the critical 50 cm interval between the breccia and KT boundary was deposited under normal pelagic condition during the last 300 ky of the Maastrichtian. Yaxcopoil-1 is not alone. Limestones containing late Maastrichtian planktic foraminifera have been reported from sediments overlying the impact breccia in wells T1, Y6 and C1 (14) - a fact also supported by e-log correlations (15). The new evidence from Yaxcopoil-1, combined with the spherule ejecta evidence from NE Mexico, indicates that the Chicxulub impact predated the KT boundary by about 300k y. Chicxulub therefore was not the cause for the KT mass extinction. The KT impact crater still remains to be found.

References

1. Keller et al., Earth Science Reviews 62, 327-363 (2003).
2. Smit, J., et al.. Geology 20, 99-104 (l992).
3. Keller, G. et al. GSA Bull. 109, 410-428 (l997).
4. Ekdale, A.A. and Stinnesbeck, W., Palaios 13, 593-602 (l998).
5. Keller et al., Field Guide, LPI Contr. No. 827, 110p. (l994).
6. Smit et al., GSA Special Paper 307, 151-182 (l996).
7. Smit, J., Ann. Rev. Earth Planet. Sci. 27, 75-113 (l999).
8. Stinnesbeck, W., et al., Canadian J. of Earth Sciences, 38, 229-238 (2001).
9. Keller, G., et al., Geol. Soc. America, Special Paper 356, 145-161 (2002).
10. Soria, A.R., et al., Geology, 29, 231-234 (2001).
11. Keller, G. et al., Geology, 30, 382-383 (2002).
12. Smit, J., et al. Geophys. Res. Abstracts 5, 06498 (2003).

13. Lopez Ramos, E. Vol. 3, New York, Plenum Press, 257-282 (1975).
14. Ward, W. et al., Geology, 23, 873-876, (l995).

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Do you agree with Keller, Adatte and Stinnesbeck? Or do you think that Chicxulub really is the smoking gun of the dinosaur extinction? Log on to www.geolsoc.org.uk to take part in another GSL Forum, or email the Editor c/o ted.nield@geolsoc.org.uk. As usual, contributions will be edited for length and clarity â•„ and, possibly, legal reasonsâ•œ
