We are left with the problem that too many spherules are found to be produced by meteorite or fireball parent body spalation alone. Indeed, according to Parkin *et al.* X-ray microprobe chemical analysis and examination with a scanning electron microscope indicate considerable differences between spherules and meteorite fusion crusts. To them the spherules seem to have survived the passage through the atmosphere relatively unscathed. Where did they come from?

The authors point to the asteroid belt and suggest that spherules are quenched sparks formed by colliding asteroids. They even went so far as to collect rounded, quenched grindwheel sparks from a wheel being used to grind a steel bar and to claim that there were distinct similarities to the deep sea spherules. Microdebris from asteroid collision would take about 10^6 y to spiral in to the Earth's orbit under the influence of the Poynting-Robertson effect, ample time to adsorb solar wind. It is even possible to imagine a temporary hot oxidising atmosphere at the collision site due to the abundance of hydrated minerals thus producing the requisite wüstite. But are asteroid collisions frequent enought to produce 5,000 tonnes of spherules per year?

Many people think that the asteroids have been around since the dawn of the solar system and that this permanence relies to a considerable extent on a collision rate which is decreasing with time. Individual collisions may produce swarms of spherules followed by long time periods when the production rate is much smaller. The beauty of core analysis is that, assuming a constant sedimentation rate, you have a perfect means of measuring the spherule influx rate as a function of time. In a note added in proof the authors claim to be able to see evidence for individual collision events. By considering the way in which spherule size varies as a function of core depth and the spiraling time varies as a function of particle size these events are placed in the asteroid belt.

Adherents to the first 'meteoritic ablation' theory are still not convinced. U-2 aeroplanes flying in the stratosphere at altitudes of 20 km collect many particles with meteoritic, extraterrestrial compositions. Brownlee, Blanchard, Cunningham, Beauchamp and Fruland (*J. Geophys. Res.* **80**, 4917; 1975) find that about 10 per cent of them are spherules. To them X-ray diffraction, mineralogy and texture all point to a very strong similarity between spherules and meteorite fusion crusts. It is possible that both theories are right and spherules can be formed either from ablation droplets or from quenched asteroid sparks. Indeed, still further sources are not ruled out — maybe comets contain spherules and maybe planetary cratering events produce spherules in the ejector. We have plenty of possibilities available. What is needed are more scientific investigators. □

Did the Santorini eruption destroy the Minoan world?

from Jörg Keller

THE recent report in *Nature*[1] of the discovery of volcanic ash from Santorini on the island of Rhodes raises once again the possibility that Minoan Crete was destroyed by the effects of a volcanic eruption.

Marinatos[2] was the first to postulate a direct connection between two of the most dramatic events in the early history of the Aegean area — the tremendously powerful eruption of the volcano of Santorini (Thera) early in the 15th century BC and the sudden and enigmatic decline of the flourishing Minoan civilization on Crete.

Seismic tidal waves, volcanic earthquakes and ash-fall were the physical effects considered most likely to have seriously damaged Minoan settlements all over Crete. A blanket of ash, thick enough to suffocate the agricultural economy on Crete, was widely thought to have fallen since deep-sea sediment cores drilled north and south of Crete had proved that the tephra had reached the island[3].

Since 1967, the settlement of Akrotiri has been excavated from underneath a thick pumice cover on the island of Thera (Santorini). An unexpectedly wealthy, cosmopolitan Minoan community has come to light. Countless examples of fine pottery, both of local manufacture and imported from Crete, and frescoes of incomparable beauty were found in three-storied houses and mansions[4]. The catastrophic dimensions of the Santorini eruption are very obvious. With increasing knowledge, however, the original idea of the direct physical destruction of Crete by volcanic phenomena has become more and more questionable[5,6].

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Recent research in the Aegean area, both on land and in the deep sea has produced a distribution map for the Minoan ashfall[7,8], which shows an easterly dispersion away from the volcano towards Western Anatolia. Substantial fall-out must have affected the Eastern Aegean Sea and Western Anatolia (for example 30cm of tephra have been found on the Island of Kos[8]), but it is inferred that Crete received only a few centimeters of ash, too thin to account for the desertion of the Late Bronze age settlements.

The findings on Santorini also suggest that the volcanic destruction of the city of Akrotiri occured one stage earlier on the pottery-based time-scale of the archeologists than the devastation of Minoan cities and palaces on Crete. The Bronze age pottery style "Late Minoan IA" is fully developed in Akrotiri and the pottery record ends with this stage. In contrast, all over Crete LM IA is followed by pottery of Late Minoan IB, with its highly characteristic decoration showing marine subjects. It is thought that the time difference between the two substages is about 30-50 years. This suggests a date of 1500-1480 BC for the end of Akrotiri on Santorini and 1450 BC for the sudden end of the Minoan civilization on Crete.

Various ideas have been presented to account for the difference in the timing of the two events. Multistage volcanic activity, the possibility that the pottery might have been more old-fashioned in provincial Akrotiri, the destruction of Akrotiri by precursor earthquakes, or evacuation of the settlement some 30 years before the fatal eruption, have all been considered as explanations.

Only when Dorothy and Charles Vitaliano[9,10] found microscopic traces of Santorini tephra in archeological sites on Crete and Melos, and within strata believed to be uncontaminated Late Minoan IA did the possibility emerge that the climax of the Santorini eruption actually preceeded the end of the Minoan civilization by about 30 years.

This interpretation seems now to be fully supported by the new findings on Rhodes. The future investigations which Doumas and Papazoglou have announced will hopefully yield a complete pottery inventory from both below and above the tephra layer. They should characterize a possible LM IB destruction level. But already their conclusions appear to be inevitable: life continued without any significant break after the ash fall. The later destruction of Minoan Crete is once more an enigma. The influence of other civilizations especially neighbouring Mycenae, will certainly have to be re-evaluated. Whether a Mycenaean invasion and conquest of Crete happened during the aftermath of one of the most catastrophic volcanic eruptions known in the Mediterranean will only be revealed by continuing research. □

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