Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *A hard rain's a-gonna fall.*

The K-T boundary, standing for the Cretaceous-Tertiary boundary – presumably applying the same logic that makes EKG stand for electrocardiogram – is a geological feature found at various places around the world where a sharp division exists between that stratum of sedimentary rock representing the Cretaceous period – and the next stratum up representing the Tertiary period.

As you are probably aware, the Cretaceous period had lots of dinosaurs, particularly the ones featured in Jurassic Park, because Cretaceous Park… well, you know. But when you look at fossils from the Tertiary period there aren't any dinosaurs, apart from those that had evolved into birds.

Most people are in agreement that there was a huge meteorite impact around this time, although a debate about whether this is correlation or causation of the dinosaur extinction continues. The site of the impact, that happened around 65.5 million years ago, is at Chicxulub crater – which is in the general vicinity of the Gulf of Mexico. Its centre is just off the coast of the Yucatan Peninsula and almost half of the 180 kilometre-wide crater is on land, so the fact that the much larger Gulf of Mexico looks a bit rounded in places should not be confused with the crater.

In fact, Chicxulub crater is virtually invisible by satellite or other means. Its existence has been reliably deduced from rock samples showing shock-metamorphic geology, meaning it's rock made of a mix of materials that have of obviously been jammed together in a rapid, violent and very energetic event.

Incidentally the Yucatan sinkholes and underwater caves (or *los senotes*) featured in the *Caves* episode of the David Attenborough-narrated *Planet Earth* series are thought to be the result of Chicxulub crater's formation.

As noted earlier, this was thought to have been a somewhat violent event, the result of a collision by a 10 km diameter object, quite possibly a carbonaceous chondrite asteroid.

To get the terminology right, the asteroid (since it was big enough not to be considered a meteoroid), entered the earth's atmosphere to become, exceedingly briefly, a meteor (albeit one bigger than Mt Everest), which then hit the Earth's surface to become, again exceedingly briefly, a meteorite, before being vapourised by it's own kinetic energy to become, well, a K-T boundary.

The event is estimated to have followed by mega-tsunamis thousands of feet high and the spraying outwards of superheated ejecta which may have ignited global bushfires, sorry wildfires, while shockwaves from the impact may have spawned earthquakes and volcanic eruptions all over the planet.

The result of all of that may have been a decade of atmospheric dust clouds sufficient to inhibit photosynthesis by plants all over the world, as well substantially cooling the Earth's climate. All of which, we can assume was not very dinosaur friendly.

Now, naturally, you are wondering how it is that we know the asteroid was carbonaceous chondrite. The K-T boundary is characterised by a thin greenish layer, which is iridium rich at 455 parts per billion, clearly suggesting an extra-terrestrial, rocky chondrite source, since most terrestrial iridium sunk down to the Earth's core during the planet's formation, leaving the Earth's crust with only 0.3 parts per million of iridium. The K-T boundary is also chromium-rich, with chromium isotopes like those found in relatively rare carbonaceous chondrite meteorites.

So, a bit of a smoking gun there. Incidentally, on the 2nd of November 1969, there was a fall of carbonaceous chondrite meteorites near Murchison, Victoria in Australia. Apparently locals saw a fireball, felt a tremor and subsequently collected over 100 kg of fragments from over a 13 km square area.

The Murchison meteorite was found to have over 100 types of amino acids, 70 of which are not found elsewhere on Earth – as well as nucleobases similar to the purines and pyrimidines found in DNA. All of which confirms such chemistry was already present in the early solar system – and is likely to be found elsewhere in the solar system now (like on Mars for example).

At the time, the meteor find was considered to be an important confirmation of the Miller-Urey experiment, conducted in 1952, which showed that organic molecules were likely to develop from inorganic molecules under the right conditions. For example, if you heat a mixture of water, methane, ammonia and hydrogen – and zap it with artificial lightning, you get amino acids.

The carbonaceous chondrite source of the Chicxulub object also offers a clue as to its origin. It has been suggested, based on possible trajectories and the relative rareness of these types of asteroids that about 160 million years ago a larger asteroid, around 170 kilometres wide, broke up in a collision with a smaller body, sending some chunks spiralling in towards the inner solar system. These chunks are referred to as the Baptistina family, the largest remnant of which is 298 Baptistina, a prominent main belt asteroid up 30 km in diameter.

As well as one family member hitting Chicxulub, it is proposed that the prominent Moon crater Tycho, formed 108 million years ago, may have been the result of a Baptistina fragment. Tycho crater is the one with all the bright rays of ejecta radiating out from it – either down and to the left of the Moon's face if you are in the Northern hemisphere – or up and to the right if you are in the southern hemisphere.

But anyway, the evidence for the Baptistina origin is a bit circumstantial – and the conclusion is a bit contentious, like that of the Alvarez theory that has the Chicxulub impact being solely responsible for wiping out the dinosaurs.

Apparently, in some areas, the K-T boundary signature has a two metre layer of sandstone embedded within it, which could suggest the Chicxulub impact was as much as 300,000 years before the dinosaur extinction – although Alvarez theory proponents argue this is just sand laid down by the monstrous tsunamis caused by the impact itself.

Other researchers point to the Deccan Traps in India, the remnants of a massive volcanic event near the end of the Cretaceous era. This event may have persisted for 30,000 years, spewing lava over an area half the size of India and having a substantial global warming effect, adding nearly eight degrees centigrade to global temperatures.

On this basis, it could be argued that the Chicxulub impact was just the last straw for an already decimated dinosaur population. Others argue there might have been a string of Baptistina family impacts, including a hypothesised 40 km one that produced the disputed and unconfirmed 4-to-600 km wide Shiva crater, on the ocean floor west of India – which is further proposed to be the cause of the Deccan Traps volcanism.

Oh well, at least no-one really disputes that bad things have fallen from the sky during Earth's history – and it's not too soon for the planet's brief experiment in intelligence to consider that this will happen again some day. And get this… *I heard the sound of a thunder, it roared out a warnin', Heard the roar of a wave that could drown the whole world*. Bob Dylan, copyright, 1963.

I mean, Nostradamus *who*?

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where you might be talking far, really far – but we're talking cheap, like uber-cheap. No ads, no profit, just good science. Bye.