TERRESTRIAL MULTIPLE IMPACT EVENTS John G. Spray[1] and Simon P. Kelley[2], [1]Planetary and Space Science Centre, Department of Geology, University of New Brunswick, 2 Bailey Drive, Fredericton, NB E3B 5A3, Canada; jgs@unb.ca; Simon P. Kelley, Department of Earth Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, U.K. S.P.Kelley@open.ac.uk

Evidence for multiple impact events affecting Earth is limited. However, we only know of a small fraction (currently about 160) of the craters that have been generated through geological time. This is due to the relatively rapid destruction of craters by erosion or subduction on our tectonically active planet. A more pertinent question concerns the plausibility of Earth being bombarded by disaggregated asteroidal or cometary bodies, given Earth's relatively small size compared to Jupiter, and the complex orbital dynamics required to bring in such bodies to produce a crater chain. From our current understanding of orbital dynamics and other considerations, it appears that the probability of multiple impact on Earth remains very low.

However, two purported crater chains have received attention in the last few years. The first is the 700-km long linear array of eight circular structures located in the southern midcontintent United States, extending from Kansas, through Missouri to Illinois [1]. There is good evidence for some of these structures being impact generated: Decaturville and Crooked Creek. But, until further detailed mapping, sampling and radiometric dating are performed on the remaining structures, it is difficult to assess the possibility of their being a true crater chain.

The second multiple impact candidate concerns at least four craters that span central North America and Eurasia [2]. Redating of the Rochechouart impact structure of France [3] has drawn attention to the similarity in ages of four impact structures: Manicouagan, Canada (214±1 Ma) [4], Obolon, Ukraine (215±25 Ma) [5], Rochechouart (214±8 Ma) [3], and Saint Martin, Canada (219±32 Ma) [6]. A fifth structure, Red Wing, U.S.A. (200±25 Ma) [7], is also close in age. If the continents are repositioned for Late Triassic times at 214 Ma, the three largest impact structures (from east to west), Rochechouart (25 km diameter); Manicouagan (100 km) and Saint Martin (40 km), are co-latitudinal at a mean paleolatitude of 22.8°, with a root mean squared deviation of 0.88, and a latitudinal width of about 1.2°. This is a remarkably good fit to a small circle path about the Earth's spin axis. The spread in paleolongitude is 42.8° (4462 km).

The two smallest impact structures, Obolon (15 km) and Red Wing (9 km), have essentially identical trajectories with respect to the latitude-parallel trajectory of the other three. Obolon and Rochechouart (easternmost pair) define (by definition) a great circle that has a declination of 37.5°, while Red Wing and Saint Martin (westernmost pair) define (by definition) a great circle that has a declination of 42.8°. They thus have the same sense and essentially the same magnitude of rotation with respect to the small circle trajectory. If the longitudinal offset of 42.8° is removed for Red Wing and Saint Martin, while maintaining their latitudes, and a best fit great circle is computed for the four "end" craters (Red Wing, Saint Martin, Rochechouart and Obolon), the best fitting great circle has a pole at 37.21°N, 92.35°W, and hence a declination of 37.21°. Deviations of these data from the best fit great circle are remarkably small (<0.4°).

From the age and spatial constraints, we conclude that Saint Martin, Manicouagan and Rochechouart were generated by projectiles that were probably co-axial with respect to each other (like Shoemaker-Levy 9 [8, 9]). The projectile that generated Obolon probably impacted at the same time as, and co-linearly with, the projectile that generated Rochechouart. Similarly, the projectile that generated Red Wing probably impacted at the same time as, and co-linearly with, the projectile that generated Saint Martin.

Lack of unequivocal projectile

signatures in impact melt rocks associated with the five impact structures do not allow determination of projectile composition, and whether comet or asteroid. Rochechouart shows some evidence for a chondritic projectile [10]. Interestingly, the largest impact structure (Manicouagan) is at the centre of the five, while the smaller craters (Red Wing and Obolon) are peripheral - a feature noted for the Shoemaker-Levy 9 crater chain distribution on Jupiter [11,12]. However, we consider it probable that there were more than five impact structures generated by the fragmented bolide. Those fragments that hit the Tethys ocean rather than Pangea, however, would have been subsequently destroyed by subduction.

Using ^{40}Ar-^{39}Ar laser spot dating of melt sheet and fault-related pseudotachylyte samples, we present new age data on the Saint Martin impact structure of Manitoba in an attempt to improve on the existing age of 219±32 Ma [6] and so further test the likelihood of Saint Martin being part of a late Triassic crater chain.

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