# The age of the Diring Yuriakh archaeological site

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The question of the age of the Diring Yuriakh paleolithic archaeological site in Siberia has been a difficult one to answer ever since the site was discovered in 1982. It is thus with great interest we read that Waters *et al.* (1997) have pinned it down to between 260 and 370 ka on the basis of thermoluminescence ages obtained from sediments overlying and underlying the artifact layer. The purpose of this letter is to give cause to readers to think about this result. We have several questions.

1. The event being dated using thermoluminescence is the last exposure of the mineral grains to sufficient daylight to empty the relevant electron traps. Can Waters *et al.* convince us that sufficient daylight exposure occurred before burial of the sediments they measured?

With regard to the sediment overlying the artifacts, Mochanov (1988) and Alekseev *et al.* (1990) conclude it to be alluvial whereas Waters *et al.* show the grains to have aeolian characteristics, observations that are not necessarily conflicting. Whether or not the grains were exposed to daylight before burial depends on the environmental process, which, at present remains unknown. If we suppose the sediments to be aeolian, since they are now at the top of a ~ 100 m cliff above the Lena River it is possible that their source is the banks and river bottom of the Lena and that they were transported upwards by strong winds during a storm. During such a process, even if it were to occur in the daytime, very little daylight exposure to the grains is to be expected. In fact examples of cases in which cliff-top aeolian sediments did not receive adequate daylight exposure for thermo-luminescence dating or optical dating to yield the correct ages exist; three can be found in Huntley *et al.* (1983, site Hark-1) Lamothe and Auclair (1997, sample MR3) and Huntley and Lian (in press).

2. The equivalent doses reported by Waters *et al.* of the order of 1000 grays are usually obtained for samples close to TL saturation, and the information provided shows this to be the case here. It is well known that such equivalent doses are not necessarily the correct ones for the ages, but can result from a dynamic equilibrium between trap filling and trap emptying. Example data given by Mejdahl (1988) are very similar to the data described by Waters *et al.*; the dose rate was 2.73 Gy/ka the extrapolated dose axis intercept was 1120 Gy, and a laboratory dose of 2500 Gy increased the thermoluminescence by 50%. If an age had been calculated it would have been 410 ka yet the sample was actually of tertiary age (> 1.6 Ma). It thus appears that the ages of 240 ka or more obtained by Waters *et al.* should be regarded as lower limits, and that they do not preclude the possibility that the archaeological material is well over 1 million years old as suggested by Mochanov. Can Waters *et al.* argue to the contrary?

3. Waters *et al.* are quoted as having obtained an age of 500 ka (Morell, 1994). Why the difference between this and ~300 ka now?

4. Mochanov (1988) and Alekseev *et al.* (1990) report some sediments above the artifact layer to be reversely magnetized. This is strong evidence that the site is older than 780,000 years. How do Waters *et al.* discount this?

We thus conclude that the ages quoted should be regarded with caution, and not representing the actual ages of the deposits until satisfactory answers to these questions are obtained.

We have been independently pursuing the same objective, and have conducted thermoluminescence dating and optical dating studies on sediments above and below the artifact layer. Included among these is optical dating on inclusions within quartz grains as suggested by Rink (Holden, 1997). The results of these will be presented for publication in due course, but we do not consider them to be useful indicators of the age of the artifact layer for the reasons given in points 1 and 2 above (one preliminary result can be found in Hu, 1994). Our main effort has been directed at quartzite pebbles from the layer that includes the artifacts. The evidence presented by Mochanov (1988) leads us to expect that these pebbles were lying on the surface for some time, during which they would be exposed to daylight. We have devoted a considerable effort aimed at developing techniques for determining how far sunlight effectively penetrates the surface and for determining equivalent doses for the surface layers (Richards, 1994). We have shown that there can be sufficient light penetration for optical dating to be used on a surface layer. However, for most samples the quartz gave so little luminescence in response to optical stimulation that our attempts to obtain reliable equivalent doses have so far been defeated. One indicative result was obtained, however, optical dating measurements on single aliquots from the upper and lower surfaces of a pebble from the artifact layer where it was covered by Mochanov's stratum 6 (Unit III of Waters *et al.*) were similar and indicative of saturation (Richards, 1994). While we are unwilling to draw any firm conclusions about the age of the site from these data we consider them to be much better evidence of significant antiquity for Diring Yuriakh than that provided by Waters *et al.* We feel that this approach is more likely to yield a believable age for Diring Yuriakh, or perhaps a lower limit to it, than are measurements on the sediments. If both together can be used to form a coherent picture that would be better still.

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# The age of the Diring Yuriakh archaeological site: reply to Huntley and Richards

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Huntley and Richards have raised several issues concerning the stratigraphy and age of Diring Yuriakh, Siberia. Most importantly, they suggest that our TL measurements may be in error and the site significantly older than we suggested in our article in *Science* (Waters, Forman, and Pierson, 1997). We address the points raised by Huntley and Richards, and offer additional insights into problems they may encounter in measuring TL from gravels collected from the artifact-bearing deflation surface.

Point 1: There is unequivocal evidence for the eolian origin of the sediments at Diring Yuriakh. The sedimentologic succession, granulometry, and SEM surface textures all indicate eolian transport. The eolian sands are not cliff edge sands, but reflect deposition of a regional sand sheet. Sand sheets form with the migration of low angle bedforms across the landscape and not just during "storm events." Sand grains can receive repeated light exposure over many days with movement and deposition in a sand sheet (e.g., Dijkmans, J. W. A., 1990). However, we dated the fine-grained (4-11 μm) polymineral extract from these eolian sediments which received greater light exposure, than sand grains, during suspension settling onto the landscape. This finer fraction is primary because the presence of permafrost prevents secondary translocation of fines.

We differ with the comment of Huntley and Richards that "the environmental processes . .. at present remains unknown..." for deposition of eolian sands. There is a long and rich literature on the physics of eolian transport and deposition starting with Bagnold (1941) to more recent treatment by Pye and Tsoar (1990), that clearly provides specific processes for eolian sand transport and deposition, that yields sediments with a low TL residual.

TL emissions from sediments from Diring Yuriakh were rapidly reduced with exposure to sunlight, with >84% reduction remaining after exposure to 16 hours sunlight and more rigorous treatment with exposure to UV-dominated light from a 275-watt sunlight bulb. It is also important to note that minerals with different susceptibilities to solar resetting, quartz and polymineral extracts, yielded statistically similar ages; a testament to the solar resetting of TL.

The majority of ages for the older sediments are not on eolian sand, but on overlying loess of Unit IIIe. This loess is a regional deposit and received prolonged (days) light exposure with exposure on a floodplain source area, atmospheric entrainment, and deposition on the paleolandscape, similar to processes identified in the Loess Plateau of China (e.g., Liu et al., 1981).

Point 2. It is poor practice to compare the TL ingrowth between a Tertiary (10s Ma and not >1.6 Ma) feldspar and a Late Quaternary unconsolidated eolian sediment, unearthed from permafrost. The Tertiary sediment during burial may have been exposed to elevated temperatures (>200° C) and the sediment may have been diagenetically altered, disrupting traps and elemental composition, effecting dose rate calculations.

None-the-less, we agree that the ages reported in Waters *et al.* (1997) are at the upper limit of luminescence geochronology and should be viewed as minimums. However, we weigh the analysis of Unit IIIe loess that yielded ages of 240 ± 19 (OTL538), 251 ± 21 (OTL487Q2), 264 ± 22 (OTL487), and 267 ± 22 (OTL507) ka, which are not saturated and provide a minimum limiting age on the artifact bearing horizon. There is no indication of a considerable diastem (1000s ka) between Unit IIIe and the artifact bearing surface covered by Unit IIIa, thus the two ages bounding the artifact bearing horizon of 267 ± 24 ka (OTL471) and 366 ± 32 (OTL472) are apparently consistent. A conservative treatment of these data place the age of Diring Yuriakh at >260 ka as stated in Waters *et al.* (1997).

Point 3: The TL age reported by Morell (1994) in her news column was based on incomplete analysis of one of the bracketing samples. Morell reported that this was a preliminary, approximate age and that this represented a maximum age for the site. It was further reported that this age would be refined once the analysis was completed.

Point 4: A paleomagnetic stratigraphy was developed for Diring (Mochanov, 1993). However, we feel that a paleomagnetic reversal stratigraphy is inaccurate given that the site has been subjected to cryoturbation and solifluction processes. The Russian scientists reported that care was taken not to sample sediments that were obviously disturbed by secondary processes. However, this selection appears flawed. Many magnetic reversals were obtained from the most disturbed deposits (Units IIIa-d). Both reverse and normal signals were obtained from the large intrusive sand wedges (Unit II), a cryogenic feature. Because of the geological context of these samples, the reliability of the magnetic signals is highly suspect.

Finally, we have a few additional comments concerning Huntley's and Richards' attempt to date the occupation surface at Diring by luminescence response of quartz grains from artifacts found on a deflation surface. It is critical to note that many of the clasts on the deflation surface have been sand-blasted, sometime(s) after deposition. Thus, the artifact surface does not correspond to the last period of use, but a later process of sand blasting. It is important that Huntley and Richards specify where the clasts were collected at Diring. If they collected their samples from the re-exposed deflation surface near the front of the terrace, then these samples would have been re-exposed to sunlight for an unknown period of time prior to reburial as dune migration occurred during the late Pleistocene. Indeed, the Russian archaeologist who helped Huntley collect samples at Diring showed Waters some of the exact locations where "Huntley collected samples." One of these locations is directly under the younger dune sands (15 ka old). Hopefully, additional clast samples were collected from deeper sections that were not reworked.

We stand by our original ages for Diring Yuriakh and fully recognized they may be minimum estimates. We welcome other efforts to date this site. We wish Huntley and Richards success in this endeavor.

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