Quartz Luminescence as a Light-sensitive Indicator of Sediment Transport in Coastal Processes

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ABSTRACT


Samples of sand collected from a beach profile after a storm were studied using thermoluminescence (TL) and optically stimulated luminescence (OSL). Both methods yield signals from quartz which are depleted as a function of the duration of previous light exposure, but with different fractional loss constants for TL vs. OSL. A strong gradient in the TL signal intensity as a function of position on the beach profile was found. This apparently arises because of differences in the duration of natural light exposure experienced during the six hour period after the sand was moved from the nearshore underwater environment onto the beach. Laboratory experiments established that TL signals can distinguish between exposure time differences ranging from about 30 minutes to about 6 hours for the quartz from the locality studied. OSL signals were absent in both offshore and onshore samples, as would be expected because OSL signals can be completely depleted within seconds to minutes for most quartz sediments. Use of TL differences with quartz exposure times is proposed as a tool for study of various coastal depositional processes, with obvious implications for engineering of coastal structures and sand mining. It is hoped that professionals in these areas and sedimentologists might consider how this tool, which should be very simple to apply, might be applicable to their own particular areas of interest.

INTRODUCTION

The sensitivity of quartz to light exposure is routinely used in luminescence dating of sedimentation events in coastal, fluvial and aeolian environments. The optical exposure at the time of transport induces a disequilibrium in the population of trapped electronic charge in the quartz lattice, which is detected in the laboratory using the luminescence signal size and laboratory irradiations. Natural radiation restores an equilibrium state if the quartz grains are continually buried in darkness for several hundred thousand years. The age estimate is based on a determination of the sensitivity of the quartz to known fluxes of radiation in the laboratory, and a measurement of the local environmental radiation flux at the burial site. For short time periods (up to hundreds of years) the initial state of disequilibrium may be used as a monitor of the degree of light exposure which the sample received during transport. This forms the basis of its possible use as a tool in the study of the production of coastal and nearshore landforms by sedimentary processes.

Luminescence is the emission of light from the quartz crystal during light exposure or heating. The former is termed optically stimulated luminescence (OSL) and the latter is known as thermoluminescence (TL). The light emission in both cases occurs during transport of electronic charge among donors and acceptors in the defect structure of the quartz crystal (Figure 1). The TL or OSL signal intensity quantifies the relative change in the donor and acceptor concentration at the time of measurement in the laboratory. The signal intensity is a measure of the duration of light exposure if the approximate initial signal intensity (before light exposure) can be estimated. During natural transport of quartz grains, donor sites are depopulated to the extent of the flux of incoming light (ultraviolet and visible photons). Different sets of donor-acceptor systems exist in quartz. The donor-acceptor system of thermoluminescence has a long response time to light exposure (hours to days), while optically stimulated luminescence donors are much more sensitive, responding on the scale of seconds to minutes. Both techniques can be applied to a given natural sample, and the response to natural light can be studied in detail using laboratory irradiations and natural lighting cycles. Since natural radiation fluxes are very low, information about the last light exposure is retained for periods up to tens to hundreds of years. After thousands of years of continuous burial, the effects of natural radiation flux generate a large increase in the population of the donor sites, which erases the initial state of disequilibrium and thereby obscures the information about the degree of natural light exposure.

Nearshore sediment transport has been studied extensively using tracer sand marked with fluorescent dyes (e.g., WHITE and INMAN, 1989a), and refined with the additional use of pressure sensor arrays (WHITE and INMAN, 1989b). Radioactive tracers have also been employed (e.g., INMAN and CHAMBERLAIN, 1959). The objective of most studies has been to quantify the distribution in longshore and or cross shore...
direction of the tracer injected at a known time through a subsequent time interval, with various sampling options in the vertical and horizontal domain. The time domain of these experiments tends to range from minutes to hours. A more passive approach involves the use of traps to accumulate transported sediment over periods of days to years (e.g., Dean, 1989).

This is a study of differences in the luminescence signal intensity between nearshore and onshore sediment. As a working hypothesis, the nearshore sandbody apparently acts as a reservoir of quartz which has experienced some light exposure but to a lesser extent than that which moves onshore. The difference in TL signals between nearshore and onshore sediments can easily be attributed to the residence time of the grains in water because water acts as an optical filter that reduces the intensity and changes the spectral composition of light reaching grains in the underwater nearshore. Water is particularly effective at filtering ultraviolet (UV) radiation, and UV is much more effective at depleting TL than are visible wavelengths (Spooner, 1987). The latter author also showed that the 325°C region of TL is much more easily bleached by visible light, but that UV wavelengths also caused a strong depletion in the 375°C region. UV is also apparently more efficient than visible wavelengths at depleting OSL, based on trends observed using visible wavelengths (Ditlefsen and Huntley, 1994). Because quartz TL and OSL is less sensitive to low energy photons (red to green) than to higher energy ones (blue to UV), one can use low energy lighting (orange to red) for sample preparation without significantly affecting the luminescence signal intensity corresponding to previous natural exposures.

Previous studies of bleaching of quartz TL in the ocean were carried out by Rendell et al. (1994). Quartz TL was reduced to between 40 and 60% of its initial intensity after three hours of exposure in offshore water depths between 4 and 11 m in the English Channel near Plymouth. However, no significant difference between the fractional reductions could be observed because of the relatively large uncertainties ranging from 6 to 16%. From studies of marine optics, it is known that transmittance of light in seawater is strongly reduced due to turbidity and because of the preferential absorption of short (UV) and longer (IR) wavelengths, which results in the exposure to grains by a spectral component mainly in the 500 to 600 nm range (Jerlov, 1968). Coastal waters of 1 m depth (from the surface) have been shown to transmit only 0 to 20% of 350 nm (UV) of incident downward irradiance and 40 to 85% of 500 nm light (visible) of downward irradiance, while for deep ocean marine waters the corresponding values are 65 to 90% (350 nm) 85 to 95% (500 nm) (Jerlov, 1976). From first principles, it is obvious that grains which remain underwater (hereafter referred to as subaqueous) will be depleted of luminescence at a slower rate than grains that are exposed to the more effective UV plus visible spectrum which they experience under subaerial conditions.

The short response time of the OSL signal to daylight has been quantified by Godfrey-Smith et al. (1988). They showed that even in cloudy conditions subaerial light reduced exposed monolayers of southeastern Australian (Woolloomool Range) quartz sand to about 1% of their initial OSL value in approximately 4 minutes, although the difference in initial levels between that study and the present study are not known. They also showed that longer bleach times of several hours are needed to achieve the same fractional reduction for a substantially weaker initial signal (the depletion is exponential being rapid at first and then asymptotically approaching zero).

More studies are needed to establish the degree of TL homogeneity within a subaqueous sand body, but the initial findings can be used to suggest some possible applications of the technique for studying sediment transport. In contrast to use of tracers injected into the subaqueous bedload, the reservoir of sand constituting the subaqueous bedload itself would be a tracer which could be used to monitor movement onshore in various processes with substantially different rates. This would allow more flexibility in experimental design of coastal process studies because the tracer is de facto a part of the subaqueous bedload, rather than a material which is added at a particular moment.

**SAMPLES AND EXPERIMENTAL METHODS**

The samples were collected 150 m northeast of the cut into Naufrage Harbour on the northeastern shore of Prince Edward Island (PEI), which is located near the southern shore of the Gulf of St. Lawrence in eastern Canada. In late August 1996, the 35-m-wide beach was separated from a swampy area by a dune ridge with a higher (~ 3.0 m) and lower (~ 2.5 m) crest, with a distinctly developed foredune ridge with sparse vegetation located at the rise to the dune face. The main sources of the Naufrage Beach sand are the local Lower Permian sandstones and conglomerates of the Pectou group, which underlies most of the island and is exposed in high cliffs along most of the northeastern shore of the island, including the area just west of the cut into Naufrage Harbour.

All of the samples were collected within a two hour period on the morning of 31 August 1996. The sky remained full of low heavy cloud cover for the entire morning before and during sample collection. During the previous night, a storm had
driven waves well up onto the beach, but they did not reach
the base of the dune escarpment. Figure 2 shows the locations
on the Naufrage beach profile where the samples were col-
lected. The surface of the beach was sampled with a skim-
morning technique (samples 2, 3 and 4) using a 1.5-cm-diameter
tube opened on one end. The tube was swept along under a
black cloth to collect the uppermost ~ 1 cm of the beach sur-
face, and then immediately put into a dark bag. Sample 2
was collected from the beach face in the active swash zone at
that time. Sample 3 was collected from the berm and lay
about 1 m away from, but lower than the high water mark
of the storm of the previous night. Evidence of higher water
levels associated with earlier storms was found about 10 m
closer to the dune ridge in the form of 1-3 m long, 7-25 cm
diameter logs laying on the beach oriented at approximately
N45W orientation (whereas the coastline was oriented ap-
proximately E-W). Sample 4 was collected from the lower
of the two crests on the dune ridge. Sample 1 was collected un-
derwater at a point about 6 m from shore, consisting of the
uppermost ~ 5 cm of the sand at a water depth of about 1
meter. The sediment on the bottom was grab sampled by
hand and then placed into a black bag within 30 seconds. The
water column was relatively free of suspended sediment, un-
like that closer to shore where waves were breaking, where
course grains were in suspension due to the constant agita-
tion of passing swells.

In the laboratory, the sand samples were prepared for lu-
minescence studies under low intensity orange lighting con-
ditions. The samples were treated with 10% HCl and 35%
hydrogen peroxide to remove any carbonates and organic ma-
terial, followed by sieving to obtain the 150-180 µm fraction.
The quartz fraction was isolated by using sodium polytung-
state heavy liquid separation, and then was etched using con-
centrated HF acid for 40 minutes, which removed all surface
coatings and exposed fresh quartz surfaces prior to etching.
Reddish coatings (probably iron oxides) were present on the
grain surfaces. All of the luminescence measurements were
made using a 20-sample Daybreak automated luminescence
detection system, using standard measurement conditions for
working with quartz TL and OSL. Four aliquots of each sam-
ple were loaded onto aluminum discs using silicone spray as
a fixative and the natural (NAT) thermoluminescence (TL)
was measured using a ramp rate of 5°C/sec, and detected us-
ing a Corning 7-59 and Schott BG-39 filter combination
(325-490 nm detection window). A standard background run
immediately after the natural TL run was made and sub-
tracted to obtain the TL data without the effects of the ther-
mal background. After removal of the thermal background,
the NAT TL intensities of a single disk were normalized
throughout the temperature range using the thermolumines-
cence response of the individual disk at 365–380°C to later
beta irradiation of 24 Gy (1 Gy = 1 joule/gram, and a typical
natural radiation dose to beach sand would be in the range
of 0.5 to 1 Gy per thousand years). The same normalization
procedure was used for the disks exposed to natural lighting
at Hamilton, Ontario. Optically stimulated luminescence
(OSL) measurements were made using a 514 ± 17 nm stim-
ulation spectrum (18 mW/cm² power at the sample), detected
using a Hoya U-340 filter (270–380 nm detection window).

Samples for daylight exposure experiments in Hamilton
were taken from the quartz separates prepared in the man-
ner described above. Quartz grains (90-150 µm) from the
subaqueous sediment (sample 1) were deposited under low-
intensity orange light conditions in the laboratory as a mono-
layer of grains on aluminum disks with silicone spray. The
daylight exposures were performed in the open daylight at
ground level.

RESULTS

Optically stimulated luminescence measurements on the
quartz separates from onshore and from subaqueous loca-
tions showed that no OSL signal remained in the samples.
This was expected for the onshore samples, because GOD-
FREY-SMITH et al. (1988) also found that the natural OSL
signals were absent from a modern intertidal sand sample
(presumably collected onshore), which still exhibited a natu-
ral TL signal. Our findings are thus in agreement with this
earlier study of an intertidal zone. The fact that the sub-
aqueous samples recovered underwater at PEI also showed
no OSL signal means that there is some likelihood that
the surface of the subaqueous sand reservoir may be com-
pletely lacking OSL signals, but more systematic sampling is
needed to establish how these signals might be distributed in
the subsurface of the nearshore. Although the sampling pro-
cedure did expose a small proportion of the grains to more
natural light than would have been ideal (15–30 seconds),
the individual grains inside the wet mass of sand would not have
been affected, and constituted more than 95% of all grains.
Thus it is unlikely that this sampling procedure could have
cased the observed absence of OSL signal.

Figure 3 shows the natural TL as a function of sample po-
sition on the beach. The dune sample (4) has only about 1/2
the peak intensity of the submerged sample (1) collected from
the water, showing that there is a large difference between
the degree of daylight light exposure of the submerged sand
and that of the windblown sand behind the beach. Samples

Figure 2. Positions of samples taken on Naufrage Beach, Prince Edward
Island, Canada. Elevations are approximate and lateral distances were
determined by the pace method.
2 and 3, from the berm and swash zones respectively, show intermediate TL peak intensities. The four samples show a strong gradient in natural TL as a function of position on the beach, with decreasing TL the further the distance from the water, which is consistent with increasing lengths of exposure to full spectrum daylight. There are at least two scenarios that could have led to these observations:

I. The distance of transport up the beach is directly related to the time of daylight exposure which is in turn directly related to the degree of TL signal reduction.

II. New sand with strong TL was admixed with older sand (with reduced TL) and therefore the more the sample was admixed during transport, the more the apparent reduction of TL signal.

In scenario I the gradient between samples 1 and 2 and 3 was observed because the sand sampled in 2 and 3 was moved from submerged areas onto the beach during the storm on the previous night and was subsequently exposed (under air) to full spectrum daylight during the next morning before the samples were collected.

In scenario II, depending upon the thickness accumulated during the latest storm, samples 2 and 3 could consist of an admixture of sediment from the surface of the pre-storm beach below and the top layer of storm deposited nearshore material. The pre-storm beach would have had considerable exposures during the previous days (the two previous days were sunny), thus it is possible that a very thin veneer of storm deposited grains (maximum thickness of about 5 mm) with a strong TL signal could have been sampled along with the uppermost 5 mm of the relatively depleted TL signals in the uppermost pre-storm beach (for the berm sample especially). The latter explanation seems more complex, but is not totally implausible. Though scenario II is not totally implausible, I chose to use scenario I as a working hypothesis and to proceed with testing its validity.

Tests of scenario I were conducted as follows. Firstly, I checked that the results shown in Figure 3 were easily reproducible using a different set of multiple aliquots prepared from the same quartz extracts used in the first set of experiments. Following the confirmation that the natural signal gradient could be reproduced, I prepared a large number of aliquots from the original laboratory processed submerged sample (1). This sample was subjected to a series of different daylight exposures followed by a measurement of the induced changes in the TL signals. Simulations of the light exposure on the PEI beach were attempted under cloudy conditions at Hamilton, Ontario in May, 1997. Samples of purified quartz from the subaqueous sediment (sample 1) were deposited under low-intensity orange light conditions in the laboratory as a monolayer of grains on aluminum disks with silicone spray. These were subsequently exposed for different lengths of time during a single cloudy day. The results are shown in Figure 4, superimposed on the natural signals from the samples collected on the beach. The equivalent daylight exposure (but to grain monolayers) of the natural samples is obtained. The swash zone sample (3) had the equivalent exposure of 0.5 to 1.0 hours, while the sample on the berm (2) near the high water mark of the storm shows an equivalent exposure of 1 to 2 hours. The dune sample (4) shows an equivalent exposure of only 2–4 hours. From Figure 4 it is apparent that optical exposures of less than 0.5 hours can easily be resolved at the early stages of exposure, and perhaps events of even shorter duration can be resolved considering that the natural depletion rates are somewhat smaller. During later stages the depletion rate is slower, which would reduce the resolu-

Figure 3. Thermoluminescence glow curves from natural surfaces of the beach at Naufrage Beach, Prince Edward Island, Canada. 1) Subaqueous samples collected underwater (depth 0.6–1.0 m) beyond the breaker zone of surf; 2) swash zone, about 1–2 m from shore; 3) berm, at a position furthest from shore but just overwashed by the last high water (storm tide in this case); 4) dune crest.

Figure 4. Comparison of natural signal intensities in as-collected quartz from Naufrage Beach, PEI (dashed lines) and changes in the intensity of sample 1 (solid lines) as a function of hours of daylight exposure in hours at Hamilton, Ontario. All thermoluminescence glow curves are the average of 3 to 4 disks after normalization using a 24 Gray beta irradiation dose following the first heating but before the second heating. The sample that received 0.00 hours of exposure is the subaqueous quartz extract (sample 1) which had been prepared under dim orange lighting in the laboratory.
tion of short events, but events of long exposure of at least 5–7 hours can be resolved relative to much longer exposures. The comparison of results are summarized in Table 1, where actual daylight exposure is based on the assumption that the sample experienced exposure on the beach only during the morning before sampling.

These results are entirely consistent with scenario I. The observed time differences are to be expected because of various differences between the natural exposure conditions on PEI and those used in Hamilton, and do not detract from the important observation that grains collected underwater and then subjected to a controlled subaerial exposure produces reduction in TL intensity of the same order as that observed in the natural setting. The disagreement in the exposure times are expected for a variety of reasons which include differences in the amount of clear sun vs. cloud, differences in the thickness of the grain layer exposed on PEI relative to the monolayer of grains exposed in the Hamilton experiment, and differences between the grain surface conditions during exposure. The important aspect of this data is that the trend observed matches that of the trend found on the natural beach, and suggests that the timescale of TL reduction is ideally suited for studies of natural subaerial light exposures of thin layers on a beach. These observations confirm that quartz TL may be a very important tool in grain transport studies, but further considerations of the experimental data below show that careful consideration has followed these initial observations.

The differential absorption of light in the lower part of the 1 cm beach layer relative to the upper part probably explains why the longer natural exposures did not produce as much TL signal loss as that of the grains exposed in monolayers (0.01 cm thick) at Hamilton. Although quartz is transparent, the visible light intensity striking the grain surfaces would be lower in the more deeply buried grains, but those lowermost grains would not be shielded from UV exposure by the overlying quartz grains because quartz is transparent to UV. Furthermore, the reddish coatings were present in the natural beach exposures, but had been removed from the grains used in the controlled light exposure experiment (the grains need to be free of coatings to measure the very weak light emission during TL). The possibility of their effects as a filter are further discussed below, but their presence in the beach light exposure is likely to have contributed to the less depleted levels found for those samples which experienced only the natural beach exposures. The heavier cloud cover during the natural beach exposure period may also be a contributing factor, because this generally decreases the proportion of incoming near-UV relative to full sunlight primarily because of the preferential shielding (additional Rayleigh scattering) of shorter wavelengths by the moisture in cloud cover.

In order to quantitatively describe the change in signal intensity with time and to provide a statistical analysis, the area under the thermoluminescence glow curves in Figure 4 were integrated at the peak intensities over the temperature range of 365–380°C. The average of 3–4 disks with the standard deviation (± 1σ) was determined and are reported in Table 2. The reported values are the average of 3–4 disks each treated the following way: (counts per second per °C of natural signal/counts per second per °C of 24 Gy before second heating).

Dispersion of the TL signal size in individual disks ranges from about 1% to 18% but most are in the range of 2–10%. The normalized integrated average TL signal is plotted as a function of exposure time in Figure 5. The signal size after the natural plus 7.5 hours of exposure is probably approaching the residual size which cannot be bleached by many days of exposure (see discussion below).

The temperature of the TL peaks is near 360–370°C (Figure 3), without any trace of a peak near 325°C. No growth of 325°C TL peaks were observed with subsequent irradiation (24 Gy), suggesting that this region of TL is not characteristic of this quartz before optical exposure. If it had been present upon subsequent irradiation, the loss of the 325°C peak, without the loss of the 375°C peak in subaqueous samples could have been explained by the relative efficiency of depletion of the 325°C peak by wavelengths near 500 to 600 nm (Spooner, 1987), which are enriched in the underwater spectrum of coastal waters.

### DISCUSSION

Since the sample (2) from the swash zone was in the truly active part of the beach at the time of collection, its light exposure history has been different than that on the berm (3), in that it has been mixed with additional subaqueous material by the action of waves during the morning exposure time, but after the depositional events of the storm. Thus its relatively intermediate value between that of berm and subaqueous environment could arise by 1) post-storm addition of
less depleted subaqueous material or 2) reduced subaerial exposure due to repeated motions of water over a storm-deposited layer (relative to the berm sample which lay above the swash zone). The berm sample may have been more stable on the beach relative to the time of deposition during the storm, but the light breeze in the morning may have caused saltation of the berm grains to give them greater exposure than if they had simply been laying motionless. In other words, the deeper portion of the 1 cm thick layer would be bleached less, but if saltation was occurring, this could achieve an overall greater degree of exposure. The result for the dune sample is perhaps surprising in that it would be expected that dune sand might have experienced a considerably longer average exposure than the equivalent exposure of 2.0-4.0 hrs. This might indicate that significant amounts of the bedload became part of the dune crest during and or just after the storm event. However, the effects of grain coatings might explain this also, as outlined below.

Regardless of the actual history of deposition and degree of subaerial exposure of grains sampled from the beach, it is clear that there is a strong difference in natural TL signal between the grains collected from underwater and that from grains which were on the beach. This probably indicates that for its entire residence time in a beach system, the material in the subaqueous environment spends much more time underwater than it does exposed on the surface of the beach. If the quartz remains underwater or under many centimeters of quartz grains, the UV exposure is greatly reduced, and thus it maintains more of its natural luminescence. If the cover of quartz grains is thick enough, it would also be protected from visible light (3-5 cm of burial), which would also keep its natural luminescence level elevated. However, longshore transport would give much exposure to visible light both in the water column and during run-up of sediment laden water onto the beach, and greater exposure to UV during transport in shallow water of the run-up. Thus events of subaerial exposure are apparently of short duration relative to other types of exposure, even averaged over many seasons of beach accretion and erosion. Although the residence time of grains in the bedload may not be known well for PEI, it would be interesting if the higher levels of luminescence in the subaqueous environment had persisted for hundreds to thousands of years.

The more rapid reduction observed in the samples exposed at Hamilton may be in part due to the fact that HF etching had removed reddish coatings from the grain surfaces. The natural reddish coating may have acted as a filter during the natural light exposure on the beach, yielding lower reductions with natural light exposures on the beach than for the case in which they were exposed at Hamilton after etching away the coatings. This might explain the disparity between the monolayer equivalent light exposures and the natural ones, but the differences in cloud cover still remain a significant possible explanation for this. Optical exposure before HF etching will allow this idea to be tested.

In general, TL signals in quartz reach a nearly stable residual value, and do not reach a zero value with continued exposure. Experiments with different types of quartz (not from PEI) exposed for more than 40 days of simulated sunlight showed that non-zero levels of TL signals still remained (Rink et al., 1994) in all cases. Figure 4 shows that the difference in TL signals between the 4.48 hours and 7.5 hours of exposure exhibits a much smaller relative change than for earlier stages of the experiment, and indicates that 7.5 hours of exposure has produced a near residual level. There may be a longer response time of grains in their natural state (with oxide coatings) for the reasons explained above, which would mean that longer exposures would be required to reach the residual value. This would mean that a greater dynamic range of sensitivity to light could be accessed for studies of coastal processes on PEI than the 6 to 7 hours suggested by the experiment. This would vary from region to region depending upon the amount of coating and the intrinsic light sensitivity of the quartz which dominates the sediment of that region. If it is already known that quartz of differing geological origins have different sensitivity to optical exposure (Rink et al., 1994).

Another factor would be the proximity to the source of sediment nourishing the local coastal segment, because very near the sediment source one might find increased levels of signal in the subaqueous reservoir. This would lead to an even stronger contrast between the TL in the dune sand and that of the subaqueous sand reservoir. These would stem from the short distance travelled in the subaqueous environment, thus less exposure subaerially in the swash and berm zone environment and less incorporation into the backshore and into dune environments during storms and subsequent recycling back into the subaqueous zone by large storms. Indeed, studies of longshore transport near the sediment source might be possible using natural levels of luminescence in the bedload. This would be particularly useful near the end of a single summer period, before winter storms produce deep cuts into the newly established fill pattern of that season.

The use of other light-sensitive minerals for these potential
applications extends to the feldspar family, which comprises a number of different mineral varieties which are sensitive indicators of previous light exposure. For example GODFREY-SMITH et al. (1988) showed that buried Woomolbool Range (southeastern Australian) quartz extracted under dark conditions was depleted in TL signal size by a factor of 7.5 after 20 hours of direct sunlight to a monolayer, while a feldspar from St. Pierre Quebec was depleted in TL signal size by a factor of 60 under the same conditions. This large difference may be due in part to the relative differences in initial signal size that might not be found in the same coastal sand, but suggests the real possibility that coupled use of feldspar and quartz thermoluminescence might provide more accurate evaluation of light exposure levels in certain time domains.

CONCLUSIONS

The results of the study directly suggest the possibility of studying the accretionary history of a beach, which typically occurs over summer periods. Furthermore, it offers the possibility of linking the dune systematics with that of the foreshore, foreshore and subaqueous environment. Trenching studies of the onshore subsurface are needed to study the possible linkages between sedimentation events recorded in the beach substructure and the TL signals in the constituent grains. Studies of the nearshore subaqueous subsurface are needed to establish details of the OSL and TL record in the active and more quiescent parts of the subsurface. If the signal intensities are found to be rather uniform in the subaqueous environment, then the utility of the method for studying longshore transport might be limited to zones near the sediment sources. From the viewpoint of coastal engineering, the absence of OSL signals in quartz might be useful to determine the relative modernity of trapped sandbodies in the subaqueous environment, and would certainly be significant for issues of natural replenishment related to offshore sand mining. Direct OSL dating of the grain burial times of sandbodies which have been buried for a few hundred years or more is also possible (OLLERHEAD et al., 1994).

The total absence of OSL signals suggest that the repeated exposure to light during transport, regardless of the duration of transport in water, has proven sufficient for total depletion of the remnant signal which might have been present when the grains were added to the bedload from the sediment source.

Though this means that OSL is not useful for studies of modern sedimentation, the good news is that TL is very useful due to the filtration of UV wavelengths in water and the slower response time of quartz TL to UV even after subaerial exposure. This is fortuitous both for the potential use of TL as a transport indicator but also because it makes the sample collection requirements much less stringent. As opposed to OSL dating where extreme caution must be used to prevent light exposure during collection, this tool using TL allows minimal additional exposure during collection and requires a much simpler laboratory protocol than used in dating. Without suggesting that this method is already a useful tool, collecting with minimal additional light exposure and storing in darkness are the only requirements foreseen for future applications.

Further studies of natural luminescence in the quartz and feldspar in Lake Erie at Presque Isle near Erie, Pennsylvania, USA and at Long Point, on the northshore in Canada, are underway.

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LITERATURE CITED


