Application of Thermoluminescence Dating Techniques to Middle to Upper Pleistocene Tephras and Sediments from Oga Peninsula, Northeast Honshu, Japan

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ABSTRACT

The study applied thermoluminescence (TL) dating to seven sandy sediments and five tephra of Katanishi and Shibikawa Formations, northeast of Honshu Island Japan. The TL ages of the sandy sediments are 102 to 156 ka for the Katanishi Formation. Three TL ages of the Toya tephra are 139, 151 and 169 ka, and two of the Oga and Toga pumices are 253 and 241 ka, respectively. Two TL ages of sandy sediments with fossils are too old in comparison with the reported ages of the Katanishi Formation. This can be explained by a weak bleaching event during of re-sedimentation process at the sea floor.

The TL ages of the sandy sediments coincide well to reported ones when 65% is used for residual TL intensity obtained by bleaching experiments. The TL dating of sandy sediments can be used to estimate the approximate age determination with careful bleaching experiment.

In case of TL dating of tephra, selection of essential material is indispensable. Volcanic glass and quartz are selected for TL dating of the Toya tephra, Oga and Toga pumices. Ages of the Toya tephra, Oga and Toga pumices have big differences from reliable reported ages. Accordingly, we make a trial to adjust α-ray internal contribution rate of 0.32 to the Toya tephra and water contents of 64% to the Toya tephra and Oga pumice in underground term so as to coincide with the reported ages. This correction process can be only applied for known-age samples and is only under experimental work. The obtained a value and water content are rough but this trial starts to get better precise figures.

Keywords: Thermoluminescence dating, Pleistocene, Tephra, Oga peninsula, Japan

INTRODUCTION

Age determination of sedimentary formations is difficult by conventional physical dating techniques. Thermoluminescence (TL) is one method to obtain age of sedimentary rocks and has been intensively studied by many researchers in Europe (e.g., Wintle and Huntley, 1982; Aitken, 1985; Murray et al., 2002) and also some Japanese researchers (Hashimoto et al., 1987; Tanaka et al., 1997). There are many TL techniques for dating sediment samples and volcanic ash samples (Berger, 1992). McKeever (1994) introduced the models for optical bleaching, and Walther and Zillers (1994) studied the bleaching model of sedimentary quartz by electron spin resonance (ESR) method. However, such trials are not successful due to the difficulties of achieving the precise determination of start condition (zeroing) and evaluation of physical and chemical changes during long geologic time. The optically stimulated luminescence (OSL) method is one good resolution for zeroing condition and many research works have been done so far (e.g., Huntly et al., 1985; Aitken, 1994; Shitoaka and Nagatomo, 2001). The OSL method can solve a zeroing problem, but it has no advantages for other factors and can be applied for only young samples. Accordingly, we applied TL-dating method to Oga samples.

Pleistocene formations are widely distributed and have been intensively studied in the Oga Peninsula, Akita Prefecture, Northeast Japan. Among the Pleistocene
formations, the Shibikawa and Katanishi Formations which expose continuously at the sea cliff of Anden, northeast coast of the peninsula, intercalates by several age-known tephra layers (Kitazato, 1975; Machida et al., 1987; Machida, 1991; Shiraiishi et al., 1992; Shirai et al., 1997). The tephra succession is as follows: the Oga pumice tuff (Oga), the Baegdusan-Oga (B-Og), Aso-1, Toya, and Aso-4 tephras in ascending order.

In this study, we tried to clarify the factors that control TL-dating of sedimentary products by making use of known age samples. Therefore, the Toya tephra is selected as the most prominent geochronological marker for the Late Pleistocene age in northern Japan. So we present the application and limitation of TL dating technique.

**GEOLOGICAL SETTING**

The thick, mainly marine, Pleistocene formations are distributed in the Oga peninsula and well exposed along the coastal line. Many stratigraphic models have been proposed in this area (e.g., Huzioka, 1959; Takayasu, 1962; Kitazato, 1975; Shuto et al., 1977; Okada, 1979; Research Group on the Katanishi Formation, 1983; Shirai et al., 1997; Shiraiishi, 2000). Kitazato (1975) subdivided Pleistocene sediments into 4 formations, namely the Kitaura, Wakimoto, Shibikawa, and Katanishi Formations, in an ascending order. Recently Shiraishi (2000) re-examined the Katanishi Formation and proposed the Iriai Formation unconformably overlying the redefined Katanishi Formation. The sand dune covers the Shibikawa and Katanishi Formations in the area along the northern coast of the peninsula.

The Shibikawa Formation consists mainly of fine-grained sandstone and siltstone with several intercalated thin gravel and lignite layers. Sequence stratigraphic analysis using tephra marker as time controls (Shirai et al., 1997; Shiraiishi and Tada, 2000) delineates the 5th and 6th order glacio-eustatic sea level fluctuation over the deposition of the formation, and the fluctuation can be well correlated with SPECMAP oxygen-isotope curve from stage 12 to 6. At the Anden coast, thickness of the formation is about 100 m and lignite layer over 1 m thick is recognized at the base of the formation.

The Katanishi Formation unconformably overlies the Shibikawa Formation and underlies the Iriai Formation (Shiraishi, 2000) at the Anden coast. The Katanishi Formation is characterized in the lower part by bioturbated.
massive, fine-grained sandstone beds enriched in molluscan fossils (the Anden member of the Katanishi Formation; Shiraiishi, 2000), and in the upper part by laminated fine-grained sandstone beds. Thickness of the formation is about 50 m at the Anden coast. Two tephra layers, including Toya and Aso-4 tephas are found in the lower part of the Anden member and the uppermost part of the formation, respectively.

The age range of the Shibikawa and Katanishi Formations is approximately estimated from 450 to 80 ka based on oxygen isotope stratigraphy (Shirai et al., 1997; Shirai and Tada, 2000). Reported radiometric ages of these two formations are 0.42 and 0.42 Ma (Ar-Ar and FT dating techniques, respectively) for Toga pumice, and 0.39 Ma (FT) for Oga pumice tuff (Kano et al., 2002), 130 ka (FT) and 119 ka (TL: Takushima et al., 1992) for the Toya tephra, and 78.4 ka (TL: Nagatomo, 1990) and 89 ka (K-Ar; Matsumoto et al., 1991) for Aso-4.

**SAMPLES**

Six localities were selected for TL-dating of sediments and are shown in Fig. 1. Fourteen samples were collected from the Shibikawa Formation, Anden member of the Katanishi Formation and sand dune. Geologic columns of sampling sites are shown in Fig. 2.

At the Anden site, one sample (A5) from Oga pumice tuff of medium to coarse grain size was collected from the base of the Shibikawa Formation. Two samples (A2, A3) were collected from the Toya tephra layer and two sand samples (A1, A4) were from lower and upper layers of the Toya tephra. A1 and A4 are medium to coarse grain size and contain fossil shells and shreds. A2 and A3 are very fine-grained sediments containing glassy volcanic ashes and some fossil shells.

At the Kotokawa we collected, two samples from the volcanic ash (K1) and sand layer (K2). K1 is a very fine-grained glassy volcanic ash and is considered as the Toya tephra from field observation and volcanic glass shape. K2 is well-sorted medium-grained sand.

We collected four samples (T1 to T4) at the Tarusawa. T1 was a sandy clay with volcanic ash. The ash is identified as the Toya tephra (by Shiraiishi and Takeuti, 1999); even though the content of essential volcanic glass is low. T2 and T3 are fine-grained sand, whereas T4 is very fine-grained silty sand with black clay peat.

As shown in Fig. 1, another sample was collected from Toga (Tg1). The sample is coarse-grained pumice collected from the type locality of the Toga Pumice Tuff, which is considered as source of Oga at the Anden coast (Huzioka, 1959).
SAMPLE PREPARATION AND EXPERIMENT

Sample Preparation

The samples for TL measurement were carefully collected at depth deeper than 5 cm from the surface in order to avoid sunlight and weathering. Each of these samples was dried in the dark oven at 50-60°C and subsequently crushed into powder for gamma ray spectrometry and mineral separation. Water contents were also measured for all samples by simple heating at 105°C for one day.

Based on preliminary experiment for coarse and fine grain methods, we selected coarse grain method for TL dating. The procedure was almost similar to Takashima and Watanabe (1994) except for glass separation for the Toya tephra. Followings are simplified procedure of sample preparation and TL measurement (Fig. 3).

Dried samples of 300-400 g were crushed to pass 20 mesh (under 0.85 mm). The sieved samples of 200-290 g were put in the plastic vessel (diameter is 80 mm) for gamma ray spectrometry. For quartz separation, 50-100 g of sample was sieved to 35-60 mesh grains (0.5-0.25 mm) for sand and 20-35 mesh grains (0.84-0.5 mm) for pumice. Then both of sieved samples were gently crushed to obtain 60-200 mesh grains (74-250 μm). Clay and fine silt fractions of the sieved samples were removed by washing with water. The samples were dried in a dark oven, and were separated into magnetic and non-magnetic portions using an isodynamic magnetic separator. Non-magnetic grains were treated with 35% HCl for 1 hour at 50-60°C. Then the grains were etched in 24% HF for 40 minutes at 50-60°C and were washed several times in distilled water. The samples were treated again with 35% HCl for 2 hours at 50-60°C. The samples were rinsed three or four times in distilled water until the samples are white in color.

It is very important to select appropriate materials for TL dating of tephra. Machida et al. (1987) showed that volcanic glass is essential for TL dating of the Toya tephra. However, quartz has a possibility of secondary origin from surrounding sandy sediments. Accordingly, we select essential volcanic glass for TL dating of the Toya tephra. Sodium polytungstate (SPT) with the specific gravity of 2.50-2.65 is used for glass separation. Purity of glass was approved XRD experiments. Then glass sample was stored in the aluminum wrap when 10% or less mineral fractions are recognized.
TL Measurement and Gamma Ray Spectrometry

The TL emission of the coarse-grained quartz was measured by using Kyokkko 2500 TL/CL spectrometer with the heating rate of 200°C per minute in air condition room. About 20 mg of the quartz sample were filled in a glass tube and placed on a molybdenum heater. Filter system was a combination of an IR-cut filter (Toshiba InRA-10) and a long wave pass filter (ESCO Products, OG-550) with a bi-alkaline photomultiplier tube. The receiving wavelength of the system is around 550-660 nm (with the photocathode radiant sensitivity over 1%), which is enough for receiving orange to red color signal of quartz.

The TL emissions of coarse-grained glasses were detected by using a hand-made instrument. It consists of C1230 photon counter (Hamamatsu Photonics), SU-10 temperature controller (Chino Co.), and FM-8 computer (Fujitsu Co.). Filter system and photomultiplier tube type are almost similar to that of the 2500 TL dosimeter. The heating rate is about 120°C per minute with N2 purge condition. Ten milligrams of the coarse-grained glass is measured in this process.

A kind of regeneration method (Takashima and Honda, 1989) is used for equivalent dose (ED) determination. Both natural-and gamma ray-irradiated samples are measured. The gamma ray source for irradiation is a 60Co with the intensity of 1.1 x 10^14 Bq and absorbed dose rates are about 100 to 1000 Gy/h. Both pre-heated at 320°C for 5 hours and natural samples were irradiated in different doses. After irradiation, the unstable signals of the samples must be excluded by heating at 130°C for 1 day. The 375°C peak height of TL glow is used for determination of equivalent dose. Five aliquots were selected from quartz concentrated. The TL glow measurements were carried out three times for each aliquot.

The chemical analyses were performed by gamma ray spectrometry. The plastic vessel with 290 g sample is put in the 75 mm-diameter NaI scintillator unit with multi-channel analyzer. Standard samples are NBL (0.5%U and 0.05% Th), chemical regent (K2CO3) and blank powder (SiO2, Fe2O3, 95:5 in weight). We made 50 ppm and 5% standards for U/Th and K2O powder, respectively, and mixed with blank powder. Dose rate (D) is calculated from chemical data of U, Th, K2O and water contents with the equation proposed by Bell (1979). Grain sizes of quartz for beta correction are 0.5 mm for sand and 0.84 mm for pumice based on sieving. Cosmic ray contribution is considered to be 0.1 m Gy/a, which is the mean value of deep bury and surface irradiation for geological past (Bell, 1979).

In the case of sedimentary rocks and glasses, many factors control age determination. The results are separately indicated in the following chapter according to rock types.

Optical Bleaching Experiments

In case of TL dating for sedimentary rocks, optical bleaching experiments are important. The samples were exposed to some kinds of light sources. Sunlight, UV-ray lamp (365 nm), and xenon lamp were the main light sources for bleaching experiments. The bleaching experiment was carried out in sunny days during the summer period for sunlight. The spaces between the light sources and the samples were 15 mm for UV light and 50 mm for xenon lamp, respectively. Most samples were illuminated by UV light from the recommendation of previous works (Spooner et al., 1988; McKeever, 1994; Tanaka et al., 1997).

RESULTS

TL Measurement and Gamma Ray Spectrometry

Fig. 4 shows the TL glow curves of glass from the Toya tephra (A3). A very clear peak is recognized at 375°C. We used this peak for obtaining equivalent dose (ED) as shown in Fig. 5. The ED obtained by this procedure can be used for TL age calculation of the tephra and tuff samples because complete zeroing is established for them.

Contents of U, Th and K2O are obtained from gamma ray spectrometry (Tables 1 and 2). Errors of chemical analyses are roughly estimated about 10% in total based on statistic error in counts and standard deviation of 2 to 5 times of measurement.

Optical Bleaching

Fig. 6 illustrates the bleaching experiments of A4 sample. The residual intensities (RI) became stable by 6-hour exposure to sunlight, 14-hour exposure to the UV-ray and 24-hour exposure to the xenon lamp. We measured all samples and the range of RI was 63% to 68%. Accordingly, we used 65% as an average RI value for all UV-ray bleaching tests. This value is almost the same to those achieved from Hashimoto et al. (1989).

Fig. 7 displays the TL glow curves (a) and bleaching experiment data (b) of A4 sample. Fig. 8 shows the growth curve and portion of RI corrected equivalent dose (bED). This bED is used for the base of TL age calculation of sandy and silty sedimentary rocks.
Fig. 4. TL glow curves of A3 volcanic glass sample.
N: Natural, N+300Gy: Data for 300Gy of gamma ray irradiated to Natural sample, H+300Gy: Data for 300Gy of gamma ray to heated (320°C SH) sample.

Fig. 5. TL growth curve of A3 sample for determination of equivalent dose (ED).
Table 1. Summary of TL age data from sandy sediments for middle to upper Pleistocene formations.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Sample no.</th>
<th>U (ppm)</th>
<th>Th (ppm)</th>
<th>K_{2}O (%)</th>
<th>Water content (%)</th>
<th>Dose rate (mGy/a)</th>
<th>Equivalent Dose* (Gy)</th>
<th>TL age (ka)</th>
<th>Location</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4</td>
<td>2.61</td>
<td>3.62</td>
<td>1.61</td>
<td>8.1</td>
<td>1.99</td>
<td>348</td>
<td>175 ± 39</td>
<td>Anden</td>
<td>Fossil bed</td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>2.29</td>
<td>3.12</td>
<td>1.53</td>
<td>3.8</td>
<td>1.94</td>
<td>374</td>
<td>193 ± 35</td>
<td>Anden</td>
<td>Fossil bed</td>
<td></td>
</tr>
<tr>
<td>K2</td>
<td>1.82</td>
<td>4.96</td>
<td>2.19</td>
<td>3.3</td>
<td>2.46</td>
<td>307</td>
<td>125 ± 19</td>
<td>Kotokawa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Katanishi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>2.01</td>
<td>4.83</td>
<td>1.56</td>
<td>13.9</td>
<td>1.78</td>
<td>283</td>
<td>156 ± 20</td>
<td>Tarusawa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>1.90</td>
<td>4.36</td>
<td>2.24</td>
<td>4.6</td>
<td>2.44</td>
<td>246</td>
<td>102 ± 20</td>
<td>Tarusawa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T3</td>
<td>2.21</td>
<td>3.66</td>
<td>2.18</td>
<td>4.5</td>
<td>2.41</td>
<td>281</td>
<td>117 ± 21</td>
<td>Tarusawa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T4</td>
<td>2.40</td>
<td>4.29</td>
<td>1.92</td>
<td>9.9</td>
<td>2.16</td>
<td>290</td>
<td>134 ± 19</td>
<td>Tarusawa</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Residual intensity (RI) of bleaching is 65% for all samples

Table 2. Summary of TL age data from the Toya tephra and the Oga and Toga pumices.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Sample no.</th>
<th>Material for glow meter</th>
<th>U (ppm)</th>
<th>Th (ppm)</th>
<th>K_{2}O (%)</th>
<th>Water content (%)</th>
<th>Dose rate (mGy/a)</th>
<th>Equivalent Dose* (Gy)</th>
<th>TL age (ka)</th>
<th>Location</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A3</td>
<td>Glass</td>
<td>2.50</td>
<td>5.51</td>
<td>3.48</td>
<td>8.1</td>
<td>4.97*</td>
<td>693</td>
<td>139 ± 16</td>
<td>Anden</td>
<td>Toya tephra</td>
<td></td>
</tr>
<tr>
<td>Katanishi</td>
<td>A2</td>
<td>Glass</td>
<td>2.50</td>
<td>5.51</td>
<td>3.48</td>
<td>8.1</td>
<td>4.97*</td>
<td>750</td>
<td>151 ± 24</td>
<td>Anden</td>
<td>do.</td>
</tr>
<tr>
<td>K1</td>
<td>Glass</td>
<td>1.86</td>
<td>5.00</td>
<td>2.52</td>
<td>0.0</td>
<td>4.09*</td>
<td>690</td>
<td>169 ± 57</td>
<td>Kotokawa</td>
<td>do.</td>
<td></td>
</tr>
<tr>
<td>Shibikawa</td>
<td>A5</td>
<td>Quartz</td>
<td>6.80</td>
<td>20.00</td>
<td>4.15</td>
<td>33.7</td>
<td>3.67</td>
<td>930</td>
<td>253 ± 46</td>
<td>Anden</td>
<td>Oga pumice</td>
</tr>
<tr>
<td>Tg1</td>
<td>Quartz</td>
<td>5.80</td>
<td>17.90</td>
<td>4.48</td>
<td>33.1</td>
<td>2.15</td>
<td>805</td>
<td>241 ± 53</td>
<td>Togagawa</td>
<td>Togagawa</td>
<td></td>
</tr>
</tbody>
</table>

* Internal α-ray contribution is considered.

Fig. 6. Optical bleaching test for A4 quartz sample by light sources of sunlight, UV, and xenon lamp.
Age Determination

TL ages are obtained for samples with three different groups of geologic origins and characters. The first group is the quartz concentrate separated from sandy to silty sediments. The second group is the glass concentrate separated from volcanic ash (tephra). The last group is the quartz concentrate separated from pumice. In all cases, dose rates are calculated from U, Th, K₂O, and water contents with the equation of proposed by Aitken (1985), Bell (1979) and Mejdahl (1979). Grain size for beta correction was 0.5 mm, 0.2 mm and 0.8 mm for sandy sediments, Toya tephra and Toga and Oga pumices, respectively. Cosmic ray contribution is roughly assigned as 0.1mGy/a for all samples.

Sandy Sediments

TL ages for sandy sediments were calculated by the bEd and D because complete zeroing was not expected. RI used for bEd calculation was 65%. Table 1 shows the results of TL age determination of the sediments.

The ages of the Katanishi Formation are in a range from 98 to 154 ka, except for two fossil bed samples. These ages are roughly corresponding to the stratigraphic estimation (Shirai et al., 1997). Two age data for the Katanishi Formation are 191 and 195 ka and are different from the expecting ages of 119 ka (TL; Takashima et al., 1992) and 130 ka (FT; Okumura and Sangawa, 1984) for the Toya tephra. The causes of such difference are discussed later.

Present in-situ water-contents were used for calculation of dose rate because all formations become terrestrial condition after isotope age of 5b (Shirai, 2000 and personal comm.) and water contents had been kept to present values. However, actual ages are shift to older side by water correction before uplift to terrestrial condition at isotope age of 5b and discussed later.

Toya Tephra

In case of tephra, bleaching was not considered because complete zeroing was expected at the deposition time. Accordingly, ED calculation was followed to the procedure shown in Fig. 3. TL dating of the Toya tephra was carried out by using separated glass. In this case, internal dose must be considered. The equation for calculation (Bell, 1979); is shown in equation (1)
\[ D_\alpha = (2.783 \text{ U} + 0.738 \text{ Th}) \times a \]  

(1)

Where,

- \( D_\alpha \) : dose rate of alpha internal dose,
- \( \text{U} \) : concentration of uranium in ppm,
- \( \text{Th} \) : concentration of thorium in ppm and
- \( a \) : coefficient of effectiveness of alpha ray

The 0.13 is used for coefficient of effectiveness of alpha ray from the mean value of previously reported volcanic ash data (Berger, 1985). Using this figure, obtained TL ages of the Toya tephra are 139 to 169 ka (Table 2) which are older than the reported FT (Okumura and Sangawa, 1984) and TL (Takashima et al., 1992) values. We consider the reason for this difference by the use of small a value (see discussion below).

**Oga and Toga Pumices**

Bleaching effect for the Oga and Toga pumices was not considered. Obtained TL ages for Oga and Toga pumices are 253 and 241 ka (Table 2), respectively. These ages are younger than reported ages of 0.42 Ma (\(^{40}\text{Ar}/^{39}\text{Ar}, \text{FT}) and 0.39 Ma (FT) by Kano et al. (2002). The reason for this difference is discussed later.

**DISCUSSION**

1. Factors Controlling TL Age of Sandy Sediments

The evaluated TL ages of the Katanishi Formation are roughly concordant with reported values (Shirai et al., 1997) except for A1 and A4 samples. The ages of 195 and 191 ka for A1 and A4 samples are older than the expected ages. A1 and A4 samples were collected from the fossil bed. One reason to explain this phenomenon is the secondary (or reworking) sedimentation of the fossil bed on the sea floor. Sun bleaching is weak in such sedimentary process and the large residual TL intensity according yield quite an old age.

Non-fossil sandy sediments show reasonable TL ages. However, many factors influence TL age of sediments (e.g., change of water content, chemical leaching, grade of sun bleaching). Therefore, the TL dating of sedimentary rocks can be used for rough age determination if such conditions are unknown. The sampling formation at Anden beach became terrestrial condition at just after Aso-4 deposit (Shiraishi, 2000). If such event was occurred at 80,000 years ago then, TL ages show in Table 1 will shift to older side by 20\%.
2. TL Age Correction for the Toya Tephra and Oga Pumice

In case of the Toya tephra and Oga pumice, the obtained TL ages do not coincide with the reported data. The reliability of the reported ages for the Toya tephra and Oga pumice is relatively good because their ages were cross checked by both radiometric and SPECMAP oxygen-isotope curve.

The TL ages of the Toya tephra are older than the reported value of 120 ka which is tentatively selected from the expected age range of 100 to 120 ka. We selected A2 sample for a correction process. Two factors are considered for correction of TL age of A2 sample. One is the change of water contents during underwater time. The other is the coefficient of effectiveness of α ray contribution (α value described in III-3.2). In TL dating, many factors must be considered (Takashima, 1995) but factors other than previously stated are relatively small effect and not considered in this paper. Fig. 9 shows the process of correction. The TL age in Table 2 is simply calculated following dotted line to obtain 151 ka (point A in Fig. 9(a)). We considered that an A2 sample was kept in water until about 80 ka by the stratigraphic consideration (Shiraishi, 2000). During such underwater condition, we estimates water contents as 64% which is in the range proposed by Tanaka et al. (1997). The other factor considered is an α value. An α value of 0.32 is expected for obtaining 120 ka (point B in Fig. 9(a)).

Correction of Oga pumice (A5 sample) is relatively simpler. High water content of 64% from deposition time to 80 ka is enough to obtain the expected age of 420 ka. The procedure of this correction is shown in Fig. 9(b).

The above two correction processes can only apply for known-age samples and are only trial. The obtained a value and water content are rough but this trial becomes start to get precise figures.

3. Reliability and Strategy of the TL Dating for Tephra

Tephra is a good target material for TL dating of sediments in Japan. However, we need further study for controlling factors like internal α contribution and environment changes in the geological past. We obtained an α value of about 0.32 for volcanic glass of the Toya tephra. Normal a value ranges from 0.065 to 0.18 for volcanic ash (Berger, 1985). However, such coefficient is still unknown and supposed to be higher values, such as 0.3 and 0.5 for CaSO₄:Dy and CaF₂:Dy TLD detectors (Aitken, 1985:328p.), respectively.

The other very important point is selection of essential materials. In case of the Toya tephra, much accidental quartz is mixed with volcanic glass during sedimentation and bioturbation process.

Determination of time from underwater to terrestrial condition is also very important, and the change of water contents must be carefully considered. With this
study, the water content over 70% cannot be used for TL age determination.

CONCLUSIONS

From the TL age-dating data of the known tephra and sediments, following conclusions are obtained.

1. The TL ages of sandy sediments by a proper correction of bleaching effect are acceptable for rough estimation of deposition time.

2. The TL dates of the fossil shell bed are relatively older than the expected ages because bleaching rate is smaller than the normal sandy sediments.

3. For the TL dating of tephra, selection of essential material is indispensable. In case of the Toya tephra, the selection of volcanic glass must be preferable.

4. The TL ages of the Toya tephra and Toga and Oga pumices does not coincide well with the reported ages when the presently obtained experimental data and the widely accepted a value, are applied.

5. Trial of correction to the known-age samples gives a way to get a value and water contents at underwater time.

6. TL dating of some sediment becomes unreliable due to the ambiguous factors in geologic environments even if the laboratory measurements can yield the precise data.

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(J) in Japanese

(J+E) in Japanese with English abstract.