Limits and applicability of Standard Growth Curve

4.1 Introduction

A typical Single Aliquot Regeneration (SAR) method employs a 5-point cycle of measurements in which each cycle involves sequential steps of irradiation, preheat and OSL measurement (Murray and Wintle, 2000; 2003). Typically a SAR run implies ~50-100 minutes or more of OSL reader time per disc depending upon the age of the sample and the beta dose rate of the reader. In case of well-bleached aeolian samples, a tight cluster in single aliquot paleodoses (P) distribution is generally expected (assuming there is no adverse effect on account of beta dose heterogeneity) (Clarke, 1996; Olley et. al, 1998). This implies that a measurement of ~30 discs may be sufficient for a high precision (<5%) estimates of paleodose. However, in the case of partially and in homogeneously bleached sediments (fluvial sedimens), a larger data set of paleodoses (typically ~60-100) have to be analyzed for most appropriate paleodose estimation using a variety of approaches (Thomas et al., 2005). This implies at least 4-5 days of reader time per sample, making the data throughput rather small. To reduce the time needed for generating a set of paleodoses sufficient for a statistically reliable analysis, the use of

"standardized growth curve (SGC)" in evaluating paleodose was recently suggested with encouraging results on aeolian quartz and polyminerallic fine-grains, (Roberts and Duller, 2004). We examined this aspect further to determine the applicability of the SGC-SAR on coarse-grained quartz from fluvial and aeolian sediments. Based on these, practical criterion that enable a decision on a reliable use of SGC in routine application was developed.

In a fluvial system, partial bleaching is anticipated. For young sediment, the use of minimum paleodoses is suggested rather than taking average of all paleodoses (Olley et.al., 98; Jain et.al. 2004). However, this aspect was not discussed in Roberts and Duller (2004). It discussed only for average paleodose. Present work examines this part in detail to see the effect on minimum paleodoses (here average of least 10% of the doses obtained) of a dose distribution in fluvial system with special reference to Himalayan sediments.

4.2 Concept and Methodology

In the standard SAR method, a growth curve is constructed by giving laboratory beta doses to the aliquot followed by preheat and OSL measurement (Murray & Wintle 2000). The luminescence yield at each dose point is corrected for sensitivity change by measuring the OSL yield for a test dose. A plot of the sensitivity corrected regenerated OSL signal with dose enables the construction of a growth curve and sensitivity corrected natural luminescence intensity is interpolated onto this curve to obtain the equivalent dose or paleodose.

In construction of SGC, a limited set of regenerated growth curves are merged to construct a master growth curve, termed Standard Growth Curve (SGC). On this curve, sensitivity corrected natural intensity of other aliquots is read. However, what should be the appropriate number of growth curves required was not discussed in Roberts and Duller (2004). In present work, this aspect was examined to provide a more practical recipe for the application of SGC. A suite of fluvial samples from three different geological archives in Himalaya was examined for the present study. The location and

stratigraphic description of all these samples are discussed in detail in Chapter-5 of the thesis.

4.3 Standard Growth curve (SGC)

4.3.1. Construction of SGC

The SGC of a sample was obtained by merging the SAR growth curve of 20 aliquots. Recuperation in these samples was <3% and because of this the SAR growth curves were forced through the origin. Figure 4.1 provides typical growth curves of some samples. The growth curves of samples in general fitted a linear or polynomial and the regression coefficients (R^2) ranged from 0.57-0.93. The paleodose of remaining aliquots of the sample was obtained by interpolating the sensitivity corrected natural luminescence onto the SGC. Both the minimum 10 % and the mean of all the paleodoses values were calculated and tabulated (Table 4.1). In general, mean values of paleodoses from SAR methods and SGC were comparable within errors; however, the minimum paleodoses values differed in a range of 2-40 %. This difference was less for the samples characterized by higher regression coefficient of the SGC growth curves (i.e. $R^2 > 0.9$).

A plot of the P_{SGC} *vs.* P_{SAR} is shown in Fig. 4.2. In an ideal case, the plot of P_{SGC} against P_{SAR} should fall on the line of slope 1. The trend line of the data does not fall on line of slope 1 and the regression coefficient ranges from 0.27 to 0.91, suggesting that although mean P_{SGC} values were comparable to P_{SAR} values, it was difficult to compare a particular subset of data (e.g. least 10% data) of the two P values because of variability.

4.3.2. Minimum aliquots needed for SGC

Another aspect that we examined was, the appropriate number of growth curves that should be used to form a standard growth curve (SGC). Towards this SGC were constructed using 5, 10 and 20 regenerated growth curves of each sample (Table 4.1). The average P was calculated of all disc from SGC and compared with the SAR P. Sample RW-1, RW-2, RW-4, RW-11, RW-12, OTS-1, OTS-2, OTS-5, OTS-4 & KT-5 have average SGC P (constructed from 10 and 20 aliquots) close to the SAR P compared
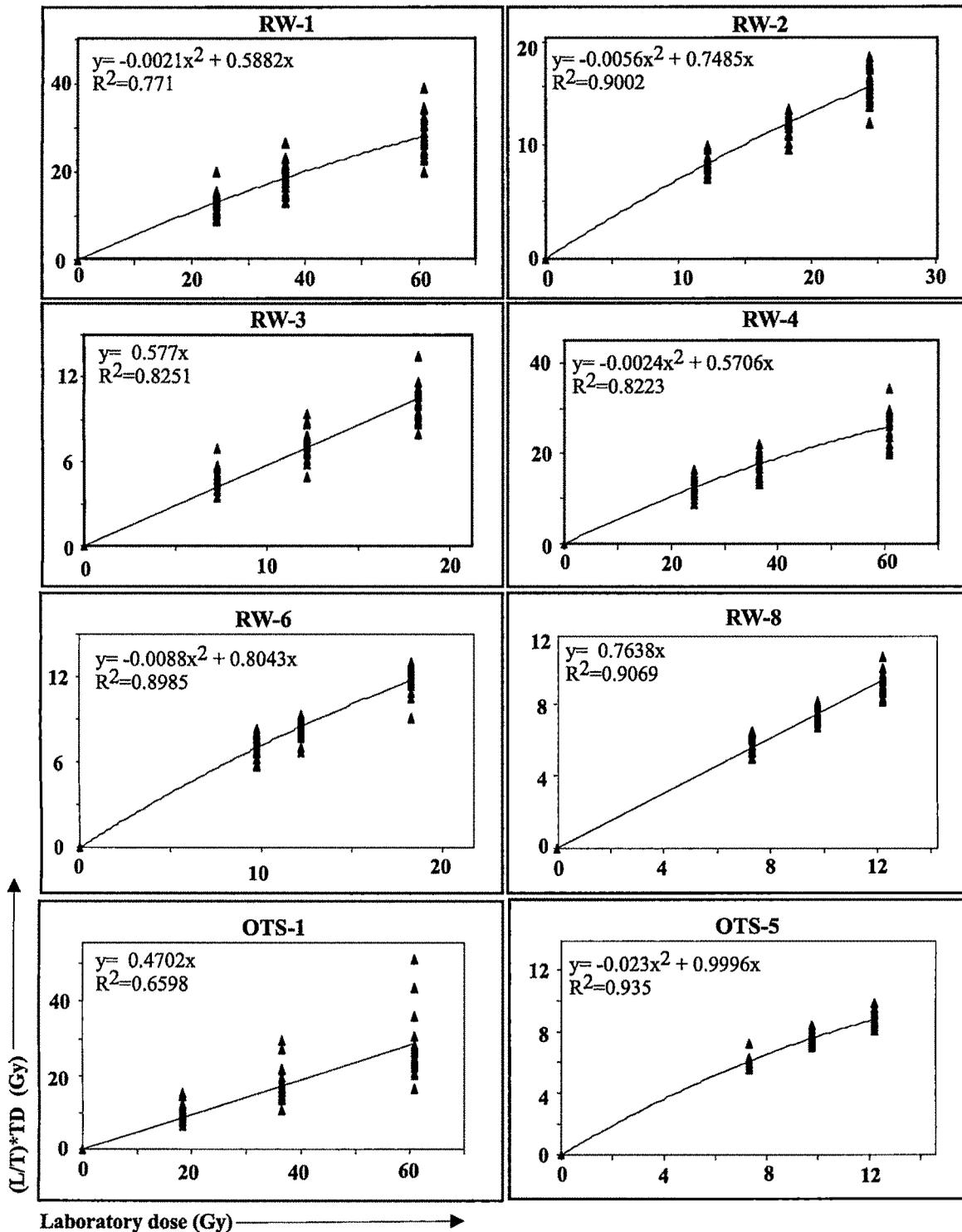
Fig. 4.1. Standard Growth Curve of samples from various locations in Himalaya. The 20 data points are merged for each dose point to construct a master growth curve termed as Standard Growth Curve
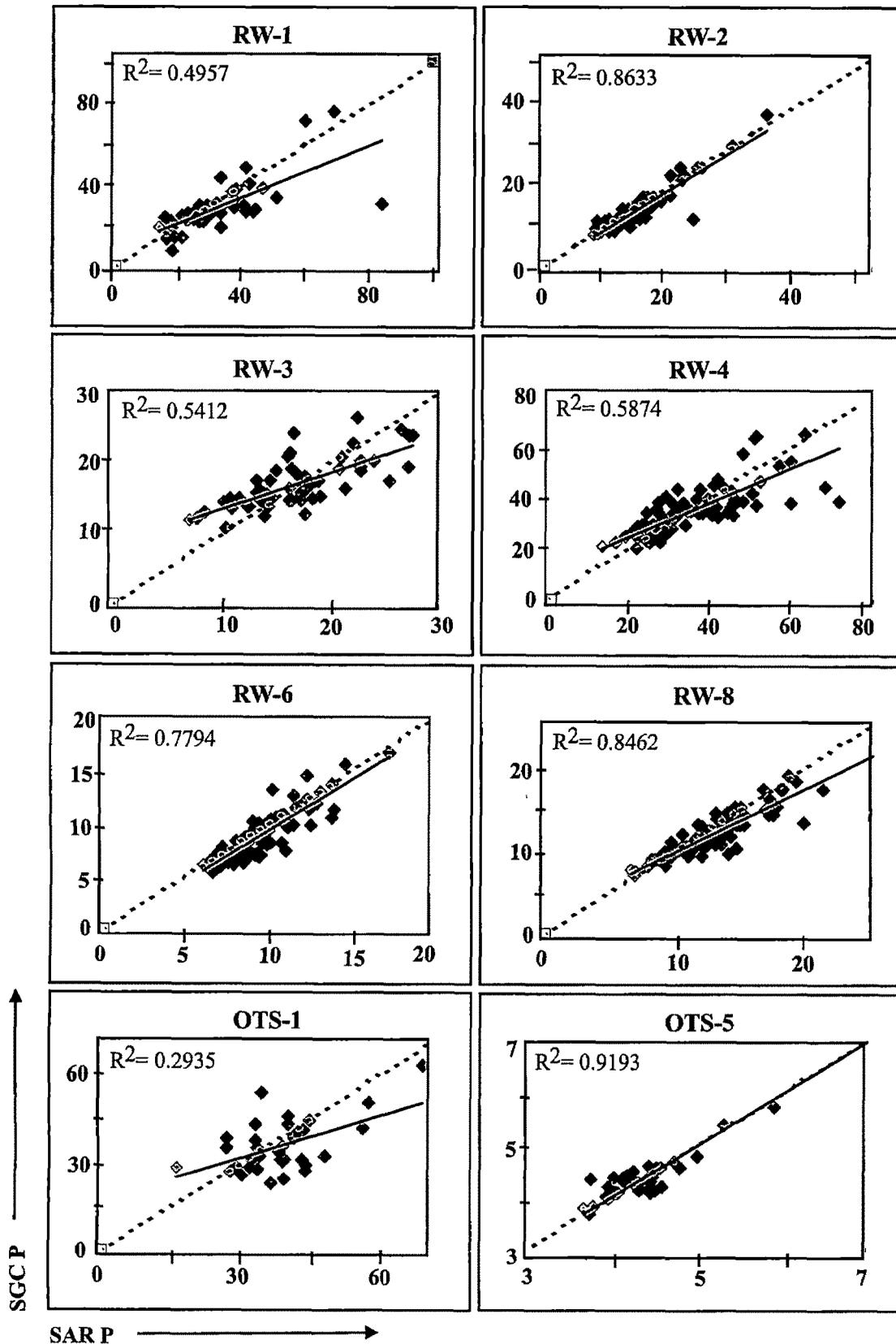
Fig. 4.2. A comparison between paleodoses calculated by SGC and their corresponding paleodose calculated using SAR. Dotted line represents the line of slope 1 and the solid line is the best fit line of these points representing the scatter in the data.

with the SGC P constructed from 5 aliquots only, however they are same within error limits. So we can construct a SGC from 5 aliquots or more, however it will be more reliable to have a large number of aliquots (10-20) to represent more appropriately the overall intrinsic variability of the luminescence sensitivity of the sample. In our study 20 aliquots were used to construct the SGC.

4.3.3. Universal SGC for an entire stratigrahic sequence

Roberts and Duller, 2004, examined a possible application of the SGC to a complete stratigraphic sequence with samples having identical depositional environment. However, it may be difficult to apply this on the samples examined from Himalayan rocks because of variability in luminescence properties leading to the variable fitting parameters (linear and polynomial in the same stratigraphic sequence), defining a fit of the SGC in the present scenario.

4.4 Results and Summary

During the construction of SGC, it was observed that scatter in growth curve for 20 aliquots were variable and the R^2 ranged from 0.57-0.94 (Fig. 1). It was also seen that growth curves of samples with regression coefficients $\geq$ 0.9 (RW-2, RW-6, RW-8 & OTS-5) in a 20 aliquot SGC exhibited a good concordance between P_{SAR} and P_{SGC} values (Fig. 2). These samples shows less than 8% difference in their minimum 10 % P's compared from SGC and SAR seperately. Based on this, it can be suggested that a regression coefficient of >90% in a growth curve would be a minimum condition for a successful application of SGC on the dating of young fluvial sediment where minimum values are important due to partial bleaching, however in an old sample where partial bleaching is masked by the amount of signal build up during time of burial, it can be applied to any set of sample. The present study shows that,

(i) The SGC analysis can be applied to any set of sample, where the regression coefficient of a SGC based on 20 aliquots is >90%. Application to samples with lower regression coefficients is likely to be less accurate if one wish to apply this

on very young fluvial sediments where minimum P's has to be accounted for Paleodose calculation.

(ii) Chances of success of SGC will be more for homogenized sediments of similar characteristics.

Table 4.1. Variation in mean De computed by varying no. of aliquots selected randomly.

Serial No.	Sample	SAR P mean (Gy)	SGC(constructed from 5 aliquots) mean P (Gy)	SGC(constructed from 10 aliquots) mean P (Gy)	SGC(constructed from 20 aliquots) mean P (Gy)
1	RW-1	31.8 ± 14	33.7 ± 13.7	30 ± 12.8	29 ± 12.3
2	RW-2	12.9 ± 4.6	13.8 ± 5.1	13 ± 4.7	12.5 ± 4.7
3	RW-3	17 ± 5.2	17.2 ± 3.6	17.2 ± 3.6	17.3 ± 3.6
4	RW-4	35.2 ± 12.5	34.9 ± 10.9	34.7 ± 11	35 ± 11
5	RW-6	9.5 ± 2.1	9.1 ± 2.4	8.9 ± 2.2	8.9 ± 2.2
6	RW-8	12.9 ± 4.2	12.3 ± 3.4	12.3 ± 3.4	12.2 ± 3.4
7	RW-11	12.9 ± 4.2	13.7 ± 4.2	13.8 ± 4.4	12.9 ± 3.8
8	RW-12	7.6 ± 1.8	8 ± 1.6	8 ± 1.6	7.8 ± 1.6
9	OTS-1	37.7 ± 9.8	31.1 ± 7.6	33.8 ± 8.3	35.6 ± 8.7
10	OTS-2	8.1 ± 1.6	8.5 ± 1.9	8.2 ± 1.8	8.4 ± 1.8
11	OTS-4	31 ± 13	33 ± 15.8	30.5 ± 11.4	29.7 ± 11.3
12	OTS-5	4.4 ± 0.7	4.6 ± 0.8	4.5 ± 0.8	4.4 ± 0.7
13	KT-5	17.5 ± 5.3	19.9 ± 6.2	18.2 ± 5.8	18.6 ± 6.3
14	KT-6	13.7 ± 3.5	15 ± 4	15.6 ± 4.2	14.3 ± 3.8

Table 2. Curve fitting and regression coefficients of SGC and the effect on mean and least 10% of the paleodose

Serial No.	Sample	Curve Fitting	R^2 of SGC	SAR P (least 10%) (Gy)	SGC P (least 10%) (Gy)	% change = ((SGC P-SAR P)/SGC P)*100	SAR P (mean) (Gy)	SGC P (mean) (Gy)	% change = ((SGC P-SAR P)/SGC P)*100
1	RW-1	Poly.	0.77	15.6±1.4	19.7±4.1	20.8	31.8±14	29±12.3	9.7
2	RW-2	Poly.	0.90	8.2±0.5	8.9±0.9	7.9	12.9±4.6	12.5±4.7	3.2
3	RW-3	Linear	0.82	8.7±1.6	12.7±1.4	31.5	17±5.2	17.3±3.6	1.7
4	RW-4	Poly.	0.82	19.5±3.1	24.2±3.1	19.4	35.2±12.5	35±11	-0.6
5	RW-6	Poly.	0.90	6.7±0.3	6.4±0.6	-4.7	9.5±2.1	8.9±2.2	-6.7
6	RW-8	Linear	0.91	7.9±1	8.5±0.9	7.1	12.9±4.2	12.2±3.4	-5.7
7	RW-11	Poly.	0.86	7.8±0.5	9.6±1	18.8	12.9±4.2	12.9±3.8	0
8	RW-12	Linear	0.78	5.3±0.3	6.8±0.4	22.1	7.6±1.8	7.8±1.6	2.6
9	OTS-1	Linear	0.66	23.8±5.3	35.1±4.7	32.2	37.7±9.8	35.6±8.7	-5.9
10	OTS-2	Linear	0.57	5.8±0.5	6.1±1	4.9	8.1±1.6	8.4±1.8	3.6
11	OTS-4	Poly.	0.68	14±2.2	16.2±1.2	13.6	31±13	29.7±11.3	-4.4
12	OTS-5	Poly.	0.94	3.7±0.1	3.9±0.3	5.1	4.4±0.7	4.4±0.7	0.2
13	KT-5	Poly.	0.79	11.7±0.8	14.8±2	20.9	17.5±5.3	18.6±6.3	5.9
14	KT-6	Linear	0.82	9.4±0.5	11±1.6	14.5	13.7±3.5	14.3±3.8	4.2

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