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Grain Size Analysis of Lake Sediments from Schirmacher Oasis (Priyadarshini) and Larsemann Hills, East Antarctica

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ABSTRACT

The polymodal distribution pattern of glacio-fluvial sediments from both, Priyadarshini lake (Schirmacher Oasis) and lakes from Larsemann Hills, indicated different energy regimes in transportation and deposition of sediments within these lacustrine systems . More than one natural process is involved in the sedimentation process. The log plot of grain size distribution pattern of these sediments indicate saltation and suspension as main modes of sediment transportation at both the locations. The negative skewness values from sediments of Larsemann Hills and lower horizons of Schirmacher Oasis signify high energy conditions of the depositing media, that is the glacial melt water and within lacustrine environments. Heavy mineral assemblages are indicative of high rank metamorphic and siliceous igneous rocks in the provenance.

Keywords: Sediment, Larsemann Hills, Schirmacher Oasis, Polymodal, Glaciofluvial.

INTRODUCTION

Priyadarshini lake is one of the largest lakes in Schirmacher Oasis (Fig. 1), East Antarctica, forming one of the biggest drainage area of this region. This lake receives glacial melt water and sediments mainly from southern catchment and contributions from eastern and south western sides. The drainage is mainly in northern and north western direction. The largest lake of Bharati island, Larsemann Hills **(Fig. 1)**, East Antarctica lies in the coastal environment and hence represent totally different physiographic set up as compared to Priyadarshini lake. These lakes are mainly fed by glacial melt besides seasonal snow.

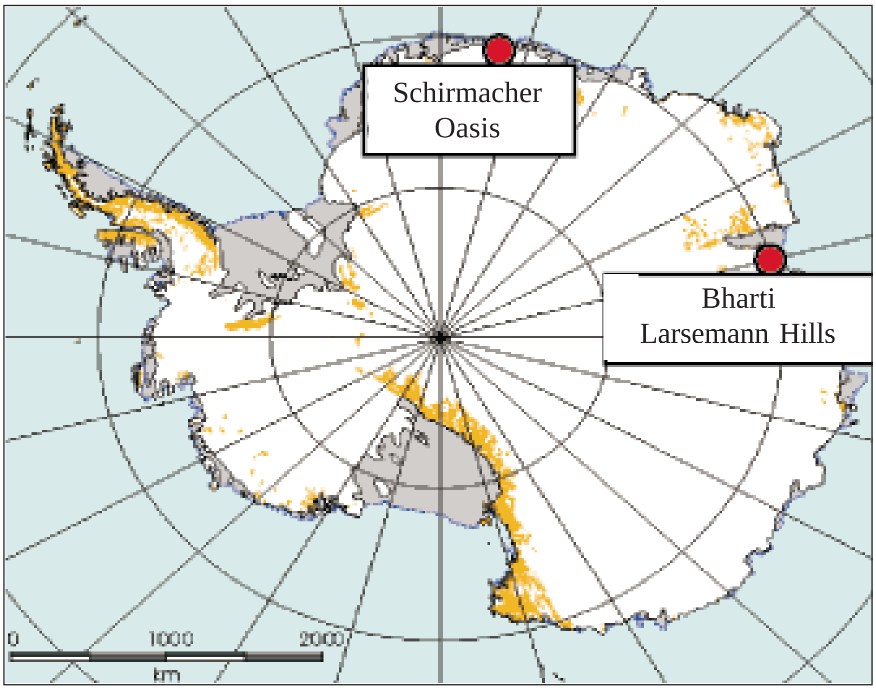

Fig. 1 : Location map showing Schirmacher Oasis and Bharti, Larsemann Hills

An attempt has been made to understand the dominant processes involved in sedimentation and modes of sediment transportation. The study of heavy minerals provide an idea about the provenance rock.

METHODOLOGY

During the 23rd and 24th Indian Antarctic Expedition, one sediment core each from of the lakes of Schirmacher Oasis and Bharti Island of Larsemann Hills area were raised for a detailed sedimentological investigation. Sediments were macerated properly and studied for grain size analysis by standard sieving techniques. This was followed by separation of heavy minerals using bromoform as heavy media for the provenance study.

OBSERVATIONS

Sediments from the lake of Bharati Island, Larsemann Hills were having different shades of grey, odorless and highly unsorted. The sediments from the depth 24 to 30 cm were poorly sorted having poly-modal distribution **(Fig. 2**) of grain sizes, meso-kurtic and coarsely skewed in

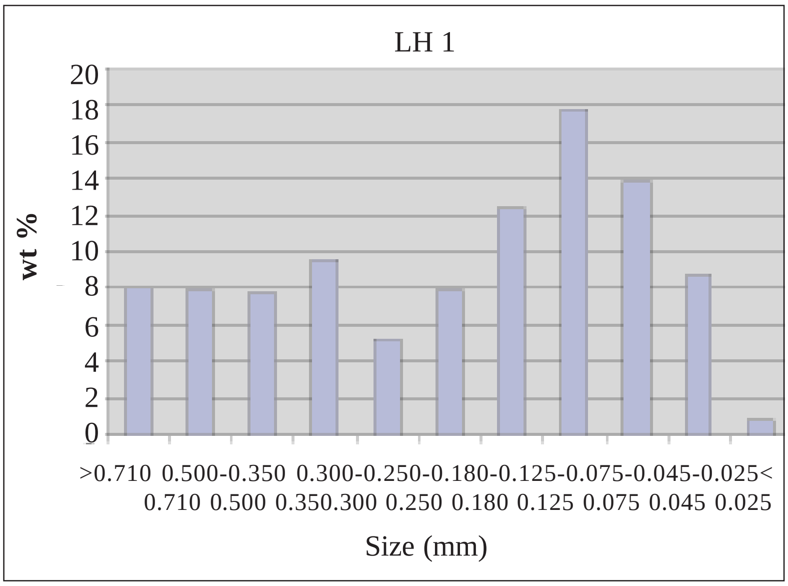

Fig. 2 : Grain size distribution of LH-1 sediments from the lake of Bharti Island, Larsemann Hill

sediment characteristics. The central tendency of distribution was dominated by finer sediments but the weight of coarser particle was more because of the occurrence of pebble fractions. The sediments from the depth of 18 to 24 cm, showed poor sorting, polymodal distribution **(Fig. 3**) of grain sizes, mesokurtic and coarsely skewed. The central tendency of distribution was dominated by finer sediments along with some pebbles whereas, sediments from the horizon of 12 to 18 cm, exhibited poor sorting, unimodal distribution **(Fig. 4**) of grain sizes with a secondary modal class of coarsest grains, mesokurtic and coarsely skewed. The central tendency of distribution was dominated by finer sediments but the weight of coarser particle was more because of some pebbles. The sediments from the depth of 6 to 12 cm, showed poor sorting, polymodal distribution **(Fig. 5**) of grain sizes, mesokurtic and almost symmetrically distributed grain sizes. The central tendency of distribution was dominated by finer sediments but the weight of coarser particle was more because of the occurrence of some pebbles. The sediments from the depth of 0 to 5 cm, showed poor sorting, polymodal distribution **(Fig. 6)** mesokurtic to leptokurtic and almost symmetrically distributed grain sizes. The central tendency of distribution was dominated by finer sediments (**Table 1**).

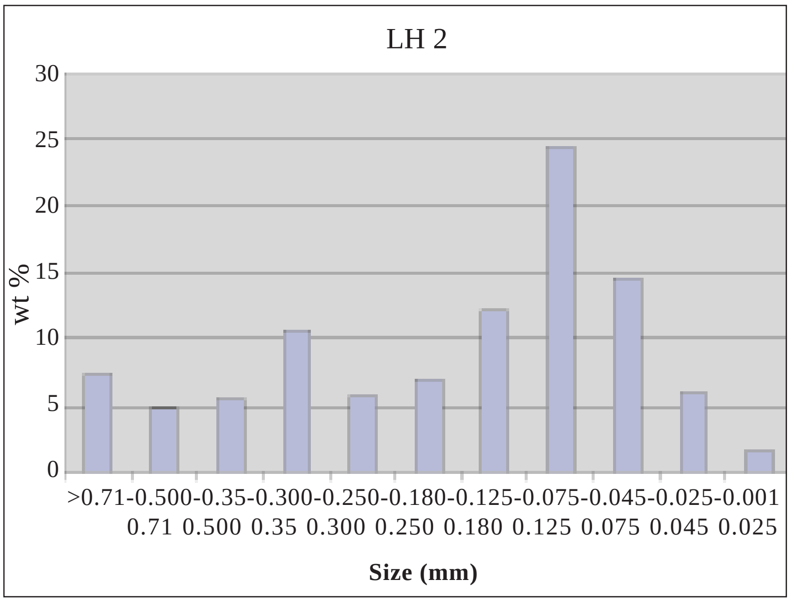

Fig. 3: Grain size distribution of LH-2 sediments from the lake of Bharti Island, Larsemann Hills

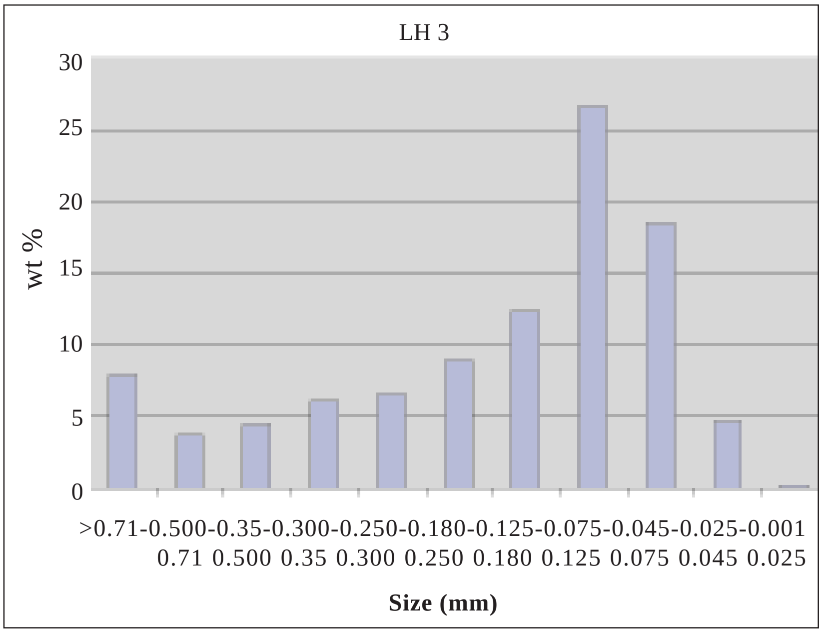

Fig. 4: Grain size distribution of LH 3 sediments from the lake of Bharti Island, Larsemann Hills

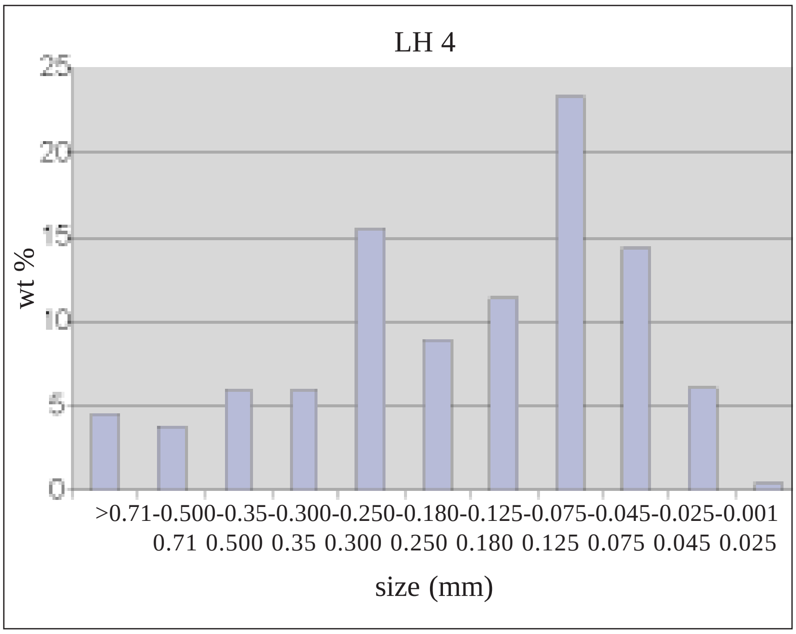

Fig. 5: Grain size distribution of LH-4 sediments from the lake of Bharti Island, Larsemann Hills

Table 1—Statistical parameters of lake sediments from Bharti, Larsemann Hills

ϕ Value	24 - 30 cm	18 - 24 cm	12 - 18 cm	06 - 12 cm	0 - 5 cm
ϕ	**LH 1**	**LH 2**	**LH 3**	**LH 4**	**Lake Bed**
95	4.47	4.51	4.27	4.35	3.49
84	3.88	3.88	3.82	3.86	3.05
75	3.49	3.54	3.59	3.51	2.49
50	2.61	2.85	2.86	2.72	1.85
25	1.55	1.65	1.83	1.81	1.54
16	0.95	1.4	1.47	1.6	0.93
5	0.36	0.31	0.11	0.53	0
Mz	2.480	2.710	2.717	2.727	1.943
SD	1.355	1.256	1.218	1.144	1.059
Sk	-0.114	-0.189	-0.253	-0.069	0.036
Ks	0.868	0.911	0.969	0.921	1.506

Likewise, the sediments from Priyadarshini lake, Schirmacher Oasis from the depth of 10 to 16 cm showed poor sorting, polymodal distribution **(Fig. 7)** of grain, leptokurtic and almost symmetrically distributed grain sizes. The central tendency of distribution was dominated by finer sediments. The sediments from the depth of 16 to 22 cm, showed poor sorting, polymodal distribution **(Fig. 8)** of grain, leptokurtic and almost symmetrically distributed grain sizes with respect to central tendency. The central tendency of distribution wss dominated by finer sediments. The sediments from the depth of 22 to 28 cm, showed poor sorting, polymodal distribution **(Fig. 9)** of grain, leptokurtic and almost symmetrically distributed grain sizes. The central tendency of distribution was dominated by finer sediments with a secondary modal class of coarsest grains. The sediments from the depth of 28 to 34 cm, showed poor sorting, polymodal distribution **(Fig. 10)** of grain, leptokurtic and almost symmetrically distributed grain sizes. The central tendency of distribution was dominated by finer sediments with a secondary modal class of coarsest grains. The sediments from the depth of 34 to 40 cm, showed poor sorting, polymodal distribution **(Fig. 11)** of grain, platykurtic and almost symmetrically distributed grain sizes. The central tendency of distribution was dominated by finer sediments with a secondary modal class of coarsest grains. The slight negative Sk value arised because of some pebbles. The sediments from the depth of 40 to 46 cm, showed poor sorting, polymodal distribution **(Fig. 12)** of grain, leptokurtic and almost symmetrically distributed grain sizes. The central tendency of distribution was dominated by finer sediments with a secondary modal class of coarsest grains. The slight negative Sk value arised because of some pebbles. The sediments from the depth of 46 to 52 cm, showed poor sorting, polymodal distribution **(Fig. 13)** of grain, leptokurtic and almost symmetrically distributed grain sizes. The central tendency of distribution was dominated by finer sediments with a secondary modal class of coarsest grains. The slight negative Sk value arised because of some pebbles. The sediments from the depth of 52 to 58 cm, showed poor sorting, uimodal distribution **(Fig. 14)** of grain, very leptokurtic and almost symmetrically distributed grain sizes. The central tendency of distribution was dominated by finer sediments with a secondary modal class of coarsest grains. The sediments from the depth of 75 to 80 cm, showed poor sorting, polymodal distribution **(Fig. 15)** of grain, leptokurtic and almost symmetrically distributed grain sizes. The central tendency of distribution was dominated by finer sediments with a secondary modal class of coarsest grains. The slight negative Sk value arised because of some pebbles **(Table 2)**.

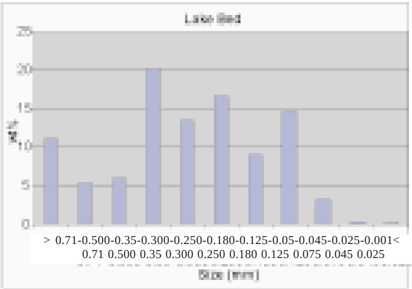

Fig. 6 : Grain size distribution of lake bed sediments from the lake of Bharti Island, Larsemann Hills

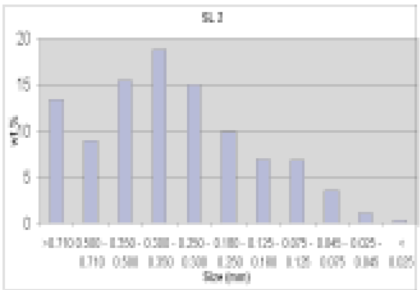

Fig. 7 : Grain size distribution of SL 2 sediments from the lake of Priyadarshini Lake, Schirmacher Oasis

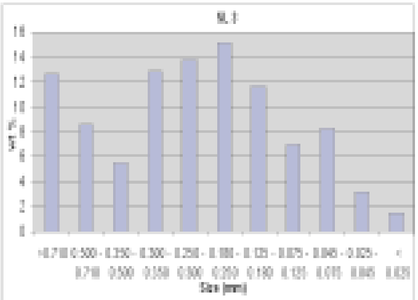

Fig. 8 : Grain size distribution of SL 3 sediments from the lake of Priyadarshini Lake, Schirmacher Oasis

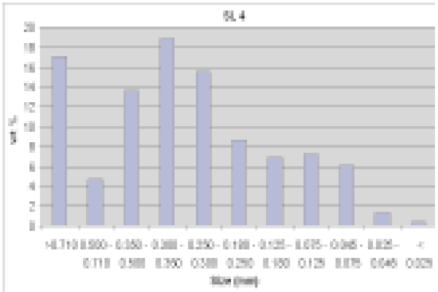

Fig. 9 : Grain size distribution of SL 4 sediments from the lake of Priyadarshini Lake, Schirmacher Oasis

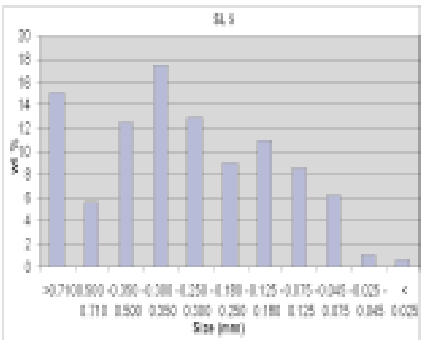

Fig. 10 : Grain size distribution of SL 5 sediments from the lake of Priyadarshini Lake, Schirmacher Oasis

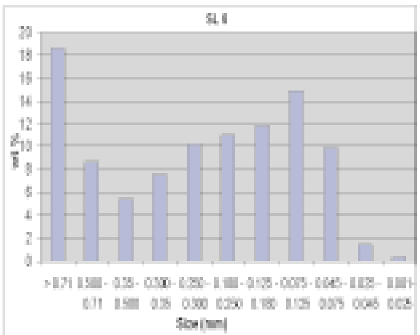

Fig. 11 : Grain size distribution of SL 6 sediments from the lake of Priyadarshini Lake, Schirmacher Oasis

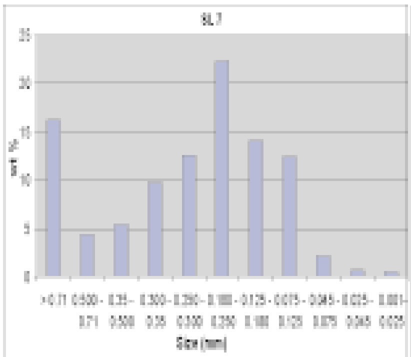

Fig. 12 : Grain size distribution of SL 7 sediments from the lake of Priyadarshini Lake, Schirmacher Oasis

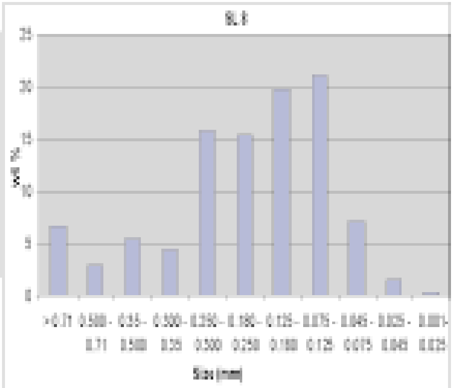

Fig. 13 : Grain size distribution of SL 8 sediments from the lake of Priyadarshini Lake, Schirmacher Oasis

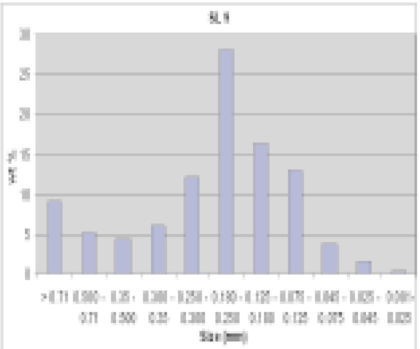

Fig. 14 : Grain size distribution of SL 9 sediments from the lake of Priyadarshini Lake, Schirmacher Oasis

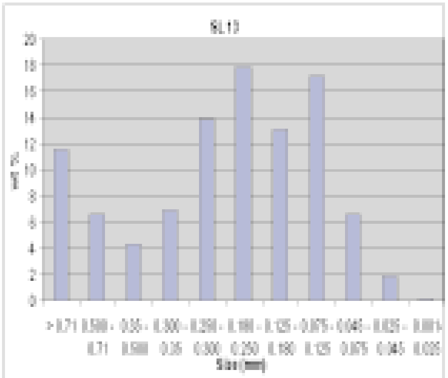

Fig. 15 : Grain siz distribution of SL 13 sediments from tehe lake of Priyadarshini Lake, Schirmacher Oasis

DISCUSSIONS

Polymodal distribution of sediments indicates dominance of more than one process involved in the deposition of sediments under lacustrine environments. The plots of glacio-fluvial sediments on log-log scale, between cumulative wt % and particle sizes from different horizons of lakes of Larsemann Hills and Schirmacher Oasis, showed suspension and saltation as the most dominating modes of transportation. However, the uppermost horizons from lake sediments of Larsemann Hills as well as the middle horizons from Schirmacher lake showed saltation and suspension as major modes of transportation along with a little influence of traction

Table 2—Statistical parameters of sediments from Priyadarshini lake, Schirmacher Oasis

φValue	10 - 16 cm	16 - 22 cm	22 - 28 cm	28 - 34 cm	34 - 40 cm	40 - 46 cm	46 - 52 cm	52 - 58 cm	75 - 80 cm
	SL 2	**SL 3**	**SL 4**	**SL 5**	**SL 6**	**SL 7**	**SL 8**	**SL 9**	**SL 13**
95	3.66	4.16	4.01	3.94	3.97	3.46	3.82	3.74	4.21
84	2.63	3.24	2.78	2.9	3.35	2.9	3.29	3.07	3.27
75	2.1	2.62	2.17	2.51	3	2.57	3	2.67	2.85
50	1.61	1.89	1.64	1.72	1.98	2.02	2.4	2.16	2.14
25	1.08	1.39	1.15	1.21	0.83	1.45	1.78	1.73	1.62
16	0.61	0.65	0.43	0.58	0.39	0.49	1.34	1.17	0.83
5	0.2	0.16	0.01	0	0	0	0.28	0.19	0.12
Mz	1.617	1.927	1.617	1.733	1.907	1.803	2.343	2.133	2.080
SD	1.029	1.254	1.194	1.177	1.342	1.127	1.024	1.013	1.230
Sk	0.097	0.089	0.078	0.072	-0.036	-0.219	-0.142	-0.076	-0.031
Ks	1.390	1.333	1.607	1.242	0.750	1.266	1.189	1.548	1.363

also (after Visher 1969; Figure 02 a&b). The effect of traction was evident from the presence of some pebbles. The sediments were subjected to turbulence of transporting media and reworking before their final deposition. Pronounced skewness and kurtosis indicate multi-sources for these sediments (Asthana and Chaturvedi, 1998). The upper horizons of lakes of Larsemann Hills and upper and lower horizons (excluding the middle horizon) of Schirmacher lake, especially showed marked difference in skewness and kurtosis. Presence of skewed sediments in different sedimentary environment is due to mixing of two populations (Folk and Ward 1957, Mason and Folk 1958). In the case of lakes of Schirmacher Oasis, wind blown sediments may have been another contributing factor for the deposition of sediments, especially in the upper and lower horizons. Negative Sk values from sediments of Larsemann Hills and from lower horizons of Schirmacher Oasis, can be correlated with the high energy environment. Friedman (1961,1962 and 1967) explained that the variation of sign in skewness is due to varying energy conditions. The upper horizons from Schirmacher lakes showed slight positive value of Sk, due to excess supply of fine materials.

From the frequency distribution curves, it is evident that the entire distribution pattern shows polymodality in their distribution pattern and scarcity of certain class of sediments. There can be several explanations for the absence or scarcity of certain size of sediments. One may presume that sediments of particular size have been produced by weathering, disintegration and/or decomposition, but have never been deposited as a modal class due to some hydrodynamic conditions. The instability of certain minerals or reworking of deposited sediments may also cause scarcity of certain class of sediments (Petijohn 1984). Also the absence of particular type of sediments in the source rock may also cause polymodal distribution of sediments. In general, disintegration and decomposition of coarse grained acid igneous rocks and gneisses produce granular sediments. Glacial grinding is one of the major causes of formation of silt size sediments and further finer variants of sediments.

Heavy minerals, from these sediments, mainly include hornblende, garnet, Opx, Cpx, chromite, andalucite, rutile, staurolite, and some other opaque and ferromagnesian minerals. Blue green variety and brownish green variety of hornblende would have been derived from high rank metamorphic and siliceous igneous rock, respectively. Aegerine, andalucite, Opx and Cpx grains are angular while chromite and staurolite are sub-angular to sub-rounded. Staurolite contains very tiny grains of quartz. The rounded rutile grain is indicator reworked sediments. The distribution pattern of these heavy minerals was almost the same in all the horizons of the vertical profile of sediment column. This indicates about the discordant relationship among the different types of source rock (Krynine 1942 and Van Andel 1959, Petijohn 1984).

CONCLUSION

It is evident from the granulometric analyses of the lacustrine sediments from lakes of Schirmacher Oasis and Larsemann Hills that saltation and suspension modes of sediment transport constitute the main processes of sediment transportation. More than one process is involved in the genesis, transport and final deposition of these sediments. Negative Skewness values from sediments of Larsemann Hills and lower horizons of Schirmacher Oasis, was due to fluctuating and high energy conditions.. Heavy mineral assemblages indicate high grade metamorphic and siliceous igneous rock in the provenance.

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