

Composition and Distribution of the Surficial Sediment in Lake Abaya

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Four major units of surficial sediment deposits of Lake Abaya were recognized: (1) silty-sand; (2) clayey-sandy-silt; (3) sandy-silty-clay; and (4) silty-clay. These divisions are based on in situ visual inspection of the fresh samples used in this study. Most of the sediments of Lake Abaya consist of silty clay; pure sand rarely lies at the mouth of main rivers and near shore; yet most sand also contains silt and clay in significant amount. The distribution pattern is basically simple with a natural sorting of sediment units reflecting the different energy-regimes of the lake. Samples from near the mouth of the major rivers as well as exposed shallow regions parallel to the shorelines are characterized by the high sand contents.

In shallow areas, particularly in the northernmost of the lake at Bilate River delta, the sand silt deposit extended southward. Marked increase in the sand population of samples taken near the mouth of major tributaries and the narrow passage between Gidicho Island and east shoreline in the north basin suggests a possible higher energy environment. Regions of highest energy in the lake occur around the periphery of the lake in the nearshore zone. This zone predominates in the northern and eastern shores of the lake and is absent from regions with hilly surrounding topography. The bulk of the remainder of the lake is composed of sediment with high fine fraction which indicates the main depositional basin and part of the nearshore zones. These zones representing decreasing energy from nearshore to offshore environment verified by the textural characteristics.

The basin sediments are composed of fine grained, soft, sandy-silty-clay, and black, greyly black, grey, to reddish brown in colour. Near the shore line the sediment colour is dark grey to black except the water-sediment interface. A thin oxidized microzone of reddish brown, varying in thickness was observed at the surface of all mud samples. The black grey colour dominates near the east shores of the northern part of the south basin and the north basin, whereas the grey to brown colour is present near the west shore. The reddish brown clay at the most top surface of the recent mud increases towards the centre and south. This increasing reddish brown clay at the top suggests the fine materials derived mainly from suspension are deposited at the low energy zones. The coarsening of the grain sizes can be observed by the decrease of the reddish brown at the most top at the water sediment interface and darkening of the underlying light grey and brown to black grey and black onshore.

The sediments of Lake Abaya contain variable amounts of quartz, feldspar (essentially sanidine and andesine), clay minerals, calcite, and organic and carbonate carbons, with possible traces of hematite, magnetite, pyrite and hornblende in some samples. Hematite and magnetite were often detected in several samples. The presence and absence of these different minerals is a clear function of location.

The quartz content is found to be within the range of <1 to 40 percent. With respect to quartz concentrations in surficial sediments, the lake basin may be partitioned geographically. Percent content of quartz is high (> 20 percent) in the areas close to the mouths of the major rivers entering the lake in the north basin, except Shope River where the quartz fraction settled in the flat flood plain before reaching the lake. The influence of major streams in the distribution of sediment in the north basin is illustrated by the fact that sediments of the quartz fraction carried significant distance from the river mouth by flow current before setting. The general trend for horizontal distribution of quartz minerals is decrease to the centre of the main basins and from north to the south. The main depositional zone of sediments in the north basin contain quartz content in the range of 5 to 10 percent, whereas the south basin has less than 5 percent in the majority of samples both from onshore and offshore. Considering the quartz population in Lake Abaya, it is convenient to define the north end as the area of high concentration and the south end as the area of low concentration.

One of the most abundant constituent minerals in Lake Abaya sediments is feldspar. Lake Abaya sediments contain substantial quantities of feldspar ranging from 3 to 76 percent (overall mean total feldspar of about 28 percent). All surficial sediments collected from Lake Abaya contain feldspar. However, there is considerable variability: relatively high concentrations associated with nearshore sediments and with stream deltas where the winnowing (erosion) action of waves or currents is not effective in preventing deposition of feldspar rich inputs. The distribution of feldspar followed nearly similar patterns in both north and south basins. Highest feldspar contents (more than 60 percent) are observed along the west and north shorelines near the mouths of major tributaries and the lower feldspar contents occur around the centre of the main basins. The distribution structure at the area of the narrow connection of the north and south basins at the bottleneck parallels that of the nearshore zones. Samples taken from the station close to the shoreline but within the influence of cliffs or hilly surrounds have lower feldspar content. The general feldspar concentration is less than 20 percent in the main basin, distribution in the north basin being slightly more variable than in the south basin.

Clay minerals are the most abundant mineral fractions in Lake Abaya sediments, ranging from 6 to 96 percent with a mean of 61 percent. Relatively low concentration of clay minerals is associated with nearshore sediments and stream deltas where the winnowing action of waves or currents is effective enough in preventing deposition of fines. Sediments with less than 25 percent of clay (hence mostly sandy) are restricted to the west shoreline and northernmost part close to the mouth of major rivers. Clay minerals show the expected general distribution pattern, with relatively low values in nearshore sediments increasing to maximum concentration at the centres of the main basins. Further noticeable patterns in clay distribution are: (1) increasing clay concentration in the nearshore sediments collected from stations surrounded by cliffs or hills; (2) generally low clay concentration at the narrow bottleneck transition and narrow passage between the largest Gidicho Island and east shore; and (3) southward increasing tendency.

Most samples contain only small quantities of calcite, and its amount ranges from less than 1 to 24 percent. Similar distribution patterns are observed in the north and south basins. Calcite is relatively more abundant in the shoreline than in the main basins sediment samples of both north and south basins. No general trend is observable, but higher calcite values occur around narrow passages such as the area of bottleneck connection and to the east of Gidicho Island. Similar amounts of calcite values observed in the west shoreline of south basin.

Organic carbon is generally low throughout the lake ranging from less than 1 to 16 percent. Few values of organic carbon exceed 3 percent and most of them contain between 0.5 and 1.0 percent in both south and north basins. The highest organic carbon content was observed in the delta of Gelana River. Organic matter is more evenly distributed in the main basin and high organic carbon contents are confined to nearshore zones. Organic carbon distribution suggests that organic muds settled more rapidly close to the input points. A decline in organic carbon to the west is observed around the area of narrow bottleneck transition. Sediments from the western part of the narrow transition were mostly depleted of organic carbon. A marked difference is apparent between the organic sediment distribution in the sediment samples from deltas of the eastern and western major tributaries. Sediment samples from the deltas of eastern major tributaries showed higher relative abundance of organic carbon. Similar amounts were observed in the northern part of the south basin.

Carbonate carbon is generally low throughout the lake ranging from 0 to 3 percent. No general trends observable but higher carbonate carbon values occur along the eastern shoreline and in the bottle neck connection in the middle. Few values of carbon exceed 1 percent and most of the sediments in Lake Abaya contain less than 0.5 percent carbonate carbon. The sediments of the narrows have increased carbonate carbon. From x-ray diffraction results, all the carbonates appear to be in the form of calcium carbonate with no siderite or dolomite resulting parallel distribution pattern with calcite.

Trace minerals detected by X-ray diffraction are principally hematite, magnetite, pyrite and hornblende. Widespread traces of hematite occurred in surficial sediments of Lake Abaya. The general distribution pattern shows increasing tendency southward. The amount of hematite observed in the north basin is mainly less than 2 percent with occasional occurrence between 2 – 4 percent. It is observed that hematite is an important constituent of samples from south basin. The distribution in the south basin does not have obvious pattern except increase towards the centre of the basin.

The distribution of magnetite in the surficial sediments of Lake Abaya is quite variable over the lake basin; increasing tendency towards the mouth of main streams in the western side is evident. It is interesting to note that the maximum concentration is observed in the deepest sampling site in the south basin. Similarly, increasing concentration in the north basin was observed around the deepest zone. Another feature of magnetite distribution is that most of the samples from south basin are found to have magnetite than the counterpart samples from the north basin.

The pattern of spatial variability for concentration of pyrite has some similarity with that of hornblende. Both minerals detected rarely and showed no obvious trend in both south and north basins. Pyrite was detected in more samples from the south basin than from the north basin. The concentration of hornblende also exhibited similar but less pronounced patterns. Larger concentration of pyrite and hornblende are found in the south basin surficial sediments than in surficial sediments of the north basin. The largest pyrite was found near the Hare and Amesa deltas. Like pyrite, the largest concentration of hornblende was also found in the Hare Delta. On the other hand, pyrite concentrations were substantially smaller (less than 5 percent) than hornblende concentration (5 to 13 percent).

The textural trends observed in Lake Abaya may assist the interpretation of the transport and deposition of sediments relative to increasing or decreasing energy regimes due to wave and

current activity. The general pattern of textural distribution characteristics of the lake sediments is probably a direct function of different energy regimes. It suggests that relatively higher energy regimes exist in the northern due to stronger lacustrine currents and wave activities.

The strong current near shore zone will have considerable importance for dispersal of any effluents near shore. Southward and offshore and into the central basin of bottom water flow is indicated by increase in suspended sediment concentration at station further south in the north basin. Major tributaries are expected to cause appreciable horizontal current in the offshore direction in the vicinity of river mouths, particularly near the bottom. Since onshore winds are stronger than offshore wind, current at the bottom and surface layers are quite strong and opposite in direction than in the case of offshore winds and then suspended sediments are transported away from the river by the large currents. In general, much of the river sediments would be deposited when the weak offshore wind causes insignificant bottom shear stress. These sediments, however, can later be resuspended, owing to the presence of strong onshore wind, and can be transported offshore by the strong currents near the bottom layer. It is, therefore, apparent that repeated accumulation, erosion, and transport results in the long-term transport of sediment from river to the deep portion of the basin.

It has been shown that decreasing percent sand (feldspar + quartz) is negatively correlated with increasing percent of clay in Lake Abaya bottom sediments. In addition, percent sand decreases and percent clay increases with increasing depth. These mineralogical trends are due to hydrodynamic sorting by high-energy conditions at shallow proximal areas and declining energy as water depths increase at deep distal portions. The rapid energy decrease at stream mouths appears to allow deposition of much of the sand and silt. As the energy level further decreases out into the lake clay particles begin to flocculate and the floccules are deposited alongside the remaining sand and silt. Any major trends in mineralogy trends at deltas of major tributaries are likely to reflect source variation. Thus this investigation recognizes that mineral sorting trends of lake deposits, containing large amounts of detrital origins, might be used in interpretation of circulation and sediment transport patterns in shallow lake basins.

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