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# GEOCHEMICAL STUDY OF SHALLOW SUBSURFACE SEDIMENTS OF A PART OF UPPER ASSAM

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**Abstract:**

Although modern sediments have gained importance in sedimentological research, but investigations on Quaternary alluvial sediments in North Eastern India are still very limited. In a DST sponsored research work four drilling and coring ware carried out up to a depth of 50m in the Quaternary alluvium in Upper Assam. These drilling points were selected in such a way that becomes almost equally placed in a north-south direction from the river Brahmaputra towards south close to the foot of the Naga Hills. The Dholla well is the northern most point followed by Dum Duma well ,Chota Tingrai well and Naharkatiya well towards south. Undisturbed core sediments of these wells were selected for Geochemical analysis. Chemical analysis of the major oxides are carried out by the X-ray Flourescence (XRF) method in the Sophisticated Instrumentation Centre (SIF), University Scientific and Instrumentation Centre (USIC), Gauhati University. The interpretations of Geochemical results indicates that the sediments of ChotaTingrai and Dhola may have probably been derived from quartz diorites and granites. The $SiO_2$ vs. $K_2O/Na_2O$ plot of the sediments shows that the sediments are of Active Margin tectonic setting, which matches with the present tectonic setting of the area. It indicates that the present tectonic setting of the area has not been changing since the deposition of these sediments.

**Key words:** Alluvial sediments, Brahmaputra valley, geochemical analysis, active margin tectonic setting.

## 1. INTRODUCTION:

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The study is a part of south easternmost part of the Brahmaputra valley. The locations of the three drilling points Dhola, Dum Duma, and ChotaTingrai are in Tinsukia District and the Naharkatiya point under the Dibrugarh District. Both Tinsukia and Dibrugarh District are South Eastern districts of the State Assam popularly known as Upper Assam. In a DST sponsored major research project SSS where the author was a JRF from the Applied Geology Department of Dibrugarh University. Drilling and coring of four wells up to a depth of 50m in the Quaternary alluvium in Upper Assam was a part of that project. These drilling points were selected in such a way that becomes almost equally placed in a nearly north-south direction from the river Brahmaputra towards south close to the foot of the Naga Hills. The Dholla well is the northern most point followed by Dum Duma well ,Chota Tingrai well and Naharkatiya well towards south. The Brahmaputra Valley comprises very thick Quaternary alluvium in Upper Assam. The alluvium had been drilled for coring up to about 50m depth. Although modern sediments have gained importance in sedimentological research, but investigations on Quaternary alluvial sediments in North Eastern India are still very limited. Geochemical analysis of sediments of each well was carried out from six different depths to estimate major oxides percentages. These data were used for several calculations and plots following earlier established works which gives some important information about the geology of the area.

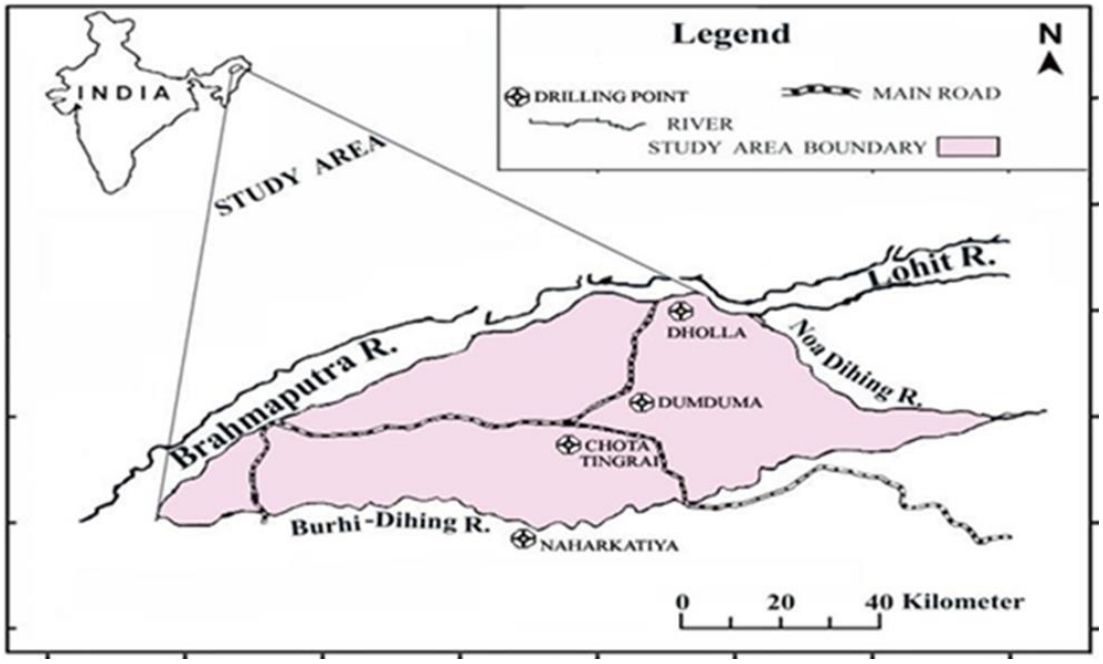


Fig. 1: Location Map of the study area

## 2. GEOLOGY OF THE AREA:

Upper Assam valley is an alluvial plain of the river Brahmaputra and forms a part of the shelf area of the Assam-Arakan basin. Here the Precambrians are overlain by thick Tertiary sediments. The

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Tertiary sediments are unconformably overlain by the Quaternary sediments. The Quaternary sediments of the basin have classified into Older Alluvium and Newer Alluvium. In the southern part of the Upper Assam valley the recent alluvial deposits rest unconformably over the Dihing Group of Plio-Pleiosocene time. The Older Alluvium forming High Level Terraces and the Newer Alluvium superimposed over the Older Alluvium close to the foothills as fans and within narrow flood plain of the present rivers defined by their paleo banks as Low Level terraces. There are five major episodic Terraces have recognised in Quaternary Alluvial sediments of Upper Assam Valley, viz.T5,T2,T1 and T0 (Gogoi C 2013)[1]. Disposition of these Terraces is believed to be structurally controlled and related to the major tectonic phases (subsidence and uplift). A generalized lithostratigraphic succession of the Quaternary deposits of Brahmaputra basin by Kar et al. (1997)[2], is given in Table -1.

Table-1: A generalized lithostratigraphic succession of Quaternary deposits of Brahmaputra valley.

| **Age** | | **Lithostratigraphy** |
|---|---|---|
| Holocene | Newer Alluvium | Channel Alluvium ($T_0$) |
| | | Terrace Alluvium ($T_1$) |
| | | Terrace Alluvium ($T_2$) |
| | | Alluvial Fan ($F_a$) |
| | Disconformity | |
| ? Middle to Upper Pleistocene | Older Alluvium | Older Terrace Alluvium ($T_3$) |
| | Unconformity | Older Terrace Alluvium ($T_4$) |
| | | Older Terrace Alluvium ($T_5$) |
| Upper Pliocene To | Kimin (Upper Siwalik) and Dihing Formation | |

## 3. GEOCHEMICAL ANALYSIS RESULTS:

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Geochemical analysis of sediments of each well was carried out from six different depths to estimate major oxides percentages. To study the Geochemistry of shallow subsurface sediments of the four wells viz., Dholla, Dum Duma, ChotaTingrai, and Naharkatiya, 23 samples were prepared. Chemical analysis for the major oxides was evaluated by the X-ray Flourescence (XRF) method. The XRF study was carried out in the Sophisticated Instrumentation Centre (SIF), University Scientific and Instrumentation Centre (USIC), Gauhati University.

### 3.1 Chemical Composition of Dholla well Samples:

The Chemical analysis of the major oxides for the six core samples of Dholla well are given in the Table-2. The value of $SiO_2$ ranges between 49.24-58.93% with an average of 51.49%; while the percentage of $Al_2O3$ ranges between 10.67-15.25% with an average of 14.05%; the value of $Fe_2O_3$ ranges between 2.99-8.04% with an average of 4.80%; value of MnO ranges between 0.07-0.21% with an average of 0.12%; value of MgO ranges between 0.48- 1.87% with an average of 1.77%; value of CaO ranges between 3.68-6.30% with an average of 4.72%; value of $Na_2O$ ranges between 2.39-3.13% with an average of 2.63%; value of $K_2O$ ranges between 1.81-3.07% with an average of 2.15%; value of $TiO_2$ ranges between 0.42-1.26% with an average of 0.70%; value of $P_2O_5$ ranges between 0.13- 0.81% with an average of 0.30% for the sediments of Dhola.

Table-2

| Major Oxides in % | Dhola well | | | | | |
|---|---|---|---|---|---|---|
| | DHL#1 | DHL#2 | DHL#3 | DHL#4 | DHL#5 | DHL#6 |
| $SiO_2$ | 58.93 | 50.39 | 49.46 | 52.67 | 48.25 | 49.24 |
| $Al_2O_3$ | 10.67 | 15.25 | 15.12 | 14.59 | 14.56 | 14.09 |
| $Fe_2O_3$ | 8.04 | 4.01 | 5.89 | 2.99 | 3.84 | 4.05 |
| MnO | 0.21 | 0.10 | 0.16 | 0.07 | 0.08 | 0.09 |
| MgO | 4.07 | 1.87 | 1.54 | 1.06 | 1.31 | 0.48 |
| CaO | 3.97 | 5.62 | 6.30 | 3.68 | 4.11 | 4.63 |
| $Na_2O$ | 2.54 | 3.13 | 2.44 | 2.88 | 2.40 | 2.39 |
| $K_2O$ | 3.07 | 2.02 | 1.94 | 1.93 | 2.12 | 1.81 |
| $TiO_2$ | 1.26 | 0.57 | 0.87 | 0.43 | 0.54 | 0.55 |
| $P_2O_5$ | 0.81 | 0.25 | 0.26 | 0.13 | 0.17 | 0.13 |

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### 3.2 Chemical Composition of Dum Duma well Samples:

The Chemical analysis of the major oxides for the six core samples of **Dum Duma well** are given in the Table-3.The value of $SiO_2$ ranges between 48.25-56.72% with an average of 53.16%; while the percentage of $Al_2O_3$ ranges between 12.58-18.06% with an average of 14.25%; the value of $Fe_2O_3$ ranges between 0.39-4.09% with an average of 1.81%; value of MnO ranges between 0.001-0.087% with an average of 0.034%; value of MgO ranges between 0.15- 2.24% with an average of 1.04%; value of CaO ranges between 0.04-5.61% with an average of 2.40%; value of $Na_2O$ ranges between 2.17-2.55% with an average of 2.27%; value of $K_2O$ ranges between 0.98-2.36% with an average of 1.51%; value of $TiO_2$ ranges between 0.32-0.79% with an average of 0.57%; value of $P_2O_5$ ranges between 0.02-0.45% with an average of 0.107%; for the sediments of Dum Duma.

Table-3

| Major Oxides in % | Dum Duma well | | | | | |
|---|---|---|---|---|---|---|
| | DMA#1 | DMA#2 | DMA#3 | DMA#4 | DMA#5 | DMA#6 |
| $SiO_2$ | 53.77 | 48.25 | 53.12 | 56.72 | 55.93 | 51.17 |
| $Al_2O_3$ | 14.32 | 15.07 | 12.85 | 12.65 | 18.06 | 12.58 |
| $Fe_2O_3$ | 1.12 | 4.09 | 0.62 | 0.39 | 3.73 | 0.89 |
| MnO | 0.001 | 0.087 | 0.013 | 0.004 | 0.082 | 0.019 |
| MgO | 0.68 | 0.60 | 0.81 | 0.15 | 2.24 | 1.74 |
| CaO | 0.04 | 5.61 | 2.43 | 1.75 | 1.99 | 2.60 |
| $Na_2O$ | 2.17 | 2.55 | 2.24 | 2.22 | 2.23 | 2.23 |
| $K_2O$ | 0.98 | 2.36 | 1.11 | 1.19 | 1.94 | 1.49 |
| $TiO_2$ | 0.798 | 0.56 | 0.34 | 0.32 | 0.99 | 0.43 |
| $P_2O_5$ | 0.03 | 0.45 | 0.05 | 0.02 | 0.03 | 0.06 |

### 3.3 Chemical Composition of ChotaTingrai well samples:

The Chemical analysis of the major oxides for the five core samples of ChotaTingrai well are given in the Table-4.The value of $SiO_2$ ranges between 45.47-56.36% with an average of 51.83%; while the percentage of $Al_2O_3$ ranges between 12.89-14.59% with an average of 13.69%; the value of $Fe_2O_3$ ranges between 1.05-3.40% with an average of 2.16 %; value of MnO ranges between 0.022-0.083% with an average of 0.048%; value of MgO ranges between 0.27- 1.36% with an average of

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0.79%; value of CaO ranges between 1.18-4.57% with an average of 2.98%; value of $Na_2O$ ranges between 2.19-2.68% with an average of 2.46%; value of $K_2O$ ranges between 1.26-3.21% with an average of 2.17%; value of $TiO_2$ ranges between 0.42-0.75% with an average of 0.56%; value of $P_2O_5$ ranges between 0.07-0.26% with an average of 0.16%; for the sediments of ChotaTingrai.

Table-4

| Major Oxides in % | Chota Tingrai well | | | | |
|---|---|---|---|---|---|
| | CH.TNG#1 | CH.TNG#2 | CH.TNG#3 | CH.TNG#4 | CH.TNG#5 |
| $SiO_2$ | 53.64 | 53.31 | 56.36 | 45.47 | 50.39 |
| $Al_2O_3$ | 14.33 | 14.59 | 13.36 | 13.28 | 12.89 |
| $Fe_2O_3$ | 1.85 | 3.06 | 1.46 | 3.40 | 1.05 |
| MnO | 0.039 | 0.071 | 0.027 | 0.083 | 0.022 |
| MgO | 1.36 | 0.68 | 0.27 | 0.52 | 1.12 |
| CaO | 1.18 | 4.57 | 2.16 | 4.47 | 2.53 |
| $Na_2O$ | 2.19 | 2.62 | 2.44 | 2.38 | 2.68 |
| $K_2O$ | 1.26 | 3.21 | 1.89 | 2.86 | 1.62 |
| $TiO_2$ | 0.75 | 0.48 | 0.42 | 0.66 | 0.51 |
| $P_2O_5$ | 0.15 | 0.26 | 0.07 | 0.24 | 0.07 |

### 3.4 Chemical Composition of Naharkatiya well samples:

The Chemical analysis of the major oxides for the six core samples of Naharkatiya well are given in the Table-5.The value of $SiO_2$ ranges between 52.02-58.92% with an average of 54.80%; while the percentage of $Al_2O_3$ ranges between 11.72-14.29 % with an average of 12.77%; the value of $Fe_2O_3$ ranges between 0.15-0.87% with an average of 0.47%; value of MnO ranges between 0.001-0.007% with an average of 0.003%; value of MgO ranges between 0.14- 1.62% with an average of 0.72%; value of CaO ranges between 0.01-2.05% with an average of 0.69%; value of $Na_2O$ ranges between 2.17-2.23% with an average of 2.20%; value of $K_2O$ ranges between 0.96-1.15% with an average of 1.05%; value of $TiO_2$ ranges between 0.31-0.75% with an average of 0.48%; value of $P_2O_5$ ranges between 0.01-0.03% with an average of 0.02%; for the sediments of Naharkatiya.

Table-5

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| Major Oxides in % | Naharkatiya well | | | | | |
|---|---|---|---|---|---|---|
| | NHK#1 | NHK#2 | NHK#3 | NHK#4 | NHK#5 | NHK#6 |
| $SiO_2$ | 54.57 | 53.58 | 58.92 | 52.02 | 56.28 | 53.44 |
| $Al_2O_3$ | 13.76 | 11.72 | 12.36 | 12.39 | 12.11 | 14.29 |
| $Fe_2O_3$ | 0.86 | 0.15 | 0.30 | 0.37 | 0.28 | 0.87 |
| MnO | 0.001 | 0.001 | 0.001 | 0.007 | 0.001 | 0.005 |
| MgO | 1.61 | 0.93 | 0.14 | 0.49 | 0.54 | 0.58 |
| CaO | 0.01 | 0.61 | 0.57 | 2.05 | 0.87 | 0.01 |
| $Na_2O$ | 2.17 | 2.21 | 2.21 | 2.23 | 2.21 | 2.19 |
| $K_2O$ | 0.96 | 1.04 | 1.09 | 1.01 | 1.05 | 1.15 |
| $TiO_2$ | 0.73 | 0.31 | 0.35 | 0.34 | 0.40 | 0.75 |
| $P_2O_5$ | 0.03 | 0.02 | 0.03 | 0.03 | 0.02 | 0.01 |

## 4. DISCUSSION:

Data of the Chemical analysis of the major oxides for the four wells were used to determine mainly the dominant nature of the sediments, maturity of the sediments, sediment source rock and tested for active tectonic setting using earlier established workers models.

### 4.1 Carbonate nature dominant:

Dholla sediments show value of MgO ranges between 0.48- 1.87% with an average of 1.77%; and CaO ranges between 3.68-6.30% with an average of 4.72%. Dum Duma sediments show value of MgO ranges between 0.15- 2.24% with an average of 1.04%; value of CaO ranges between 0.04-5.61% with an average of 2.40%. ChotaTingrai sediments show value of MgO ranges between 0.27- 1.36% with an average of 0.79%; value of CaO ranges between 1.18-4.57% with an average of 2.98%. Naharkatiya well sediments show value of MgO ranges between 0.14- 1.62% with an average of 0.72%; value of CaO ranges between 0.01-2.05% with an average of 0.69%. From the geochemical study of sediments of four wells, the oxides value shows that CaO dominates over MgO for all the sediments of three wells which are Dholla, Dum Duma and Chota Tingrai. The dominance of CaO over MgO indicates that the sediments are of carbonate nature.

### 4.2 Maturity of the sediments:

The mature quartz rich sediments have high $SiO_2/Al_2O_3$ ratios by virtue of the absence of aluminosilicates and in immature sediments the value of ratio $SiO_2/Al_2O_3$ is lower (Pettijohn et al., 1973)[3]. The average ratio of $SiO_2/Al_2O_3$ for sediments of Dhola, Dum Duma and Chota Tingrai are

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3.66, 3.73 and 3.78, respectively and for Naharkatiya it is 4.29. It is evident that maturity of the sediments of Naharkatiya well is maximum.

### 4.3 Sediment source rock:

The triangular plot of percentage value of $Fe_2O_3$, MgO and $TiO_2$ of sediments of four well shows clustering of most of the sample of Chota Tingrai and Dhola in and around the 'Granite and Quartz Monzonite' and 'Quartz Diorite and Granodioritic field' field of Condie, (1967)[4] (Fig.2). Thus the sediments of Chota Tingrai and Dhola may have probably been derived from quartz diorites and granites. The samples of the Naharkatiya well depict a separate field and none of the sample any one of the defined field.

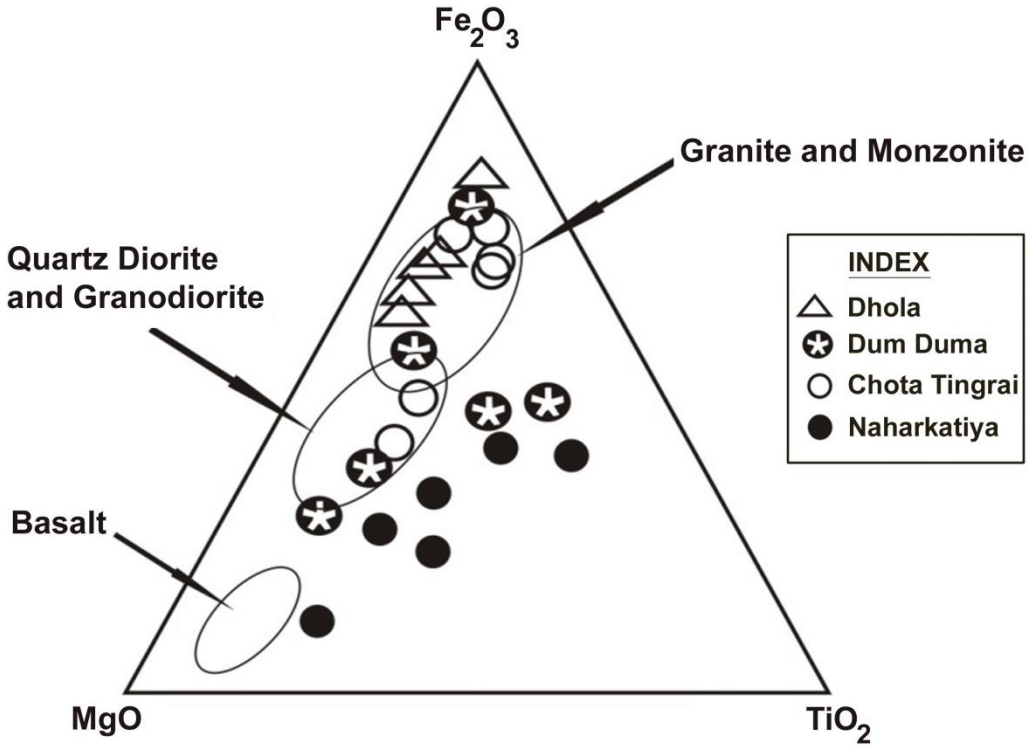


Fig.2 The triangular plot of percentage value of $Fe_2O_3$- MgO and $TiO_2$ of sediments of four wellindicating their origin(Fields after Condie, 1967)

In order to have an idea of the source of the sediments the triangular plot of CaO-$Na_2O$-$K_2O$ (Condie et al.)is used. The plot shows that majority of the percentage values of the relevant oxides of the sediments of four wells fall in and around 'Quartz Diorite' and 'Basalt and Andesite' fields. Thus the sediments may have probably been derived from quartz diorites and basalt and andesitic

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rocks (Fig. 3). However the sediments of Naharkatiya well are mostly concentrating around quartz diorite field.

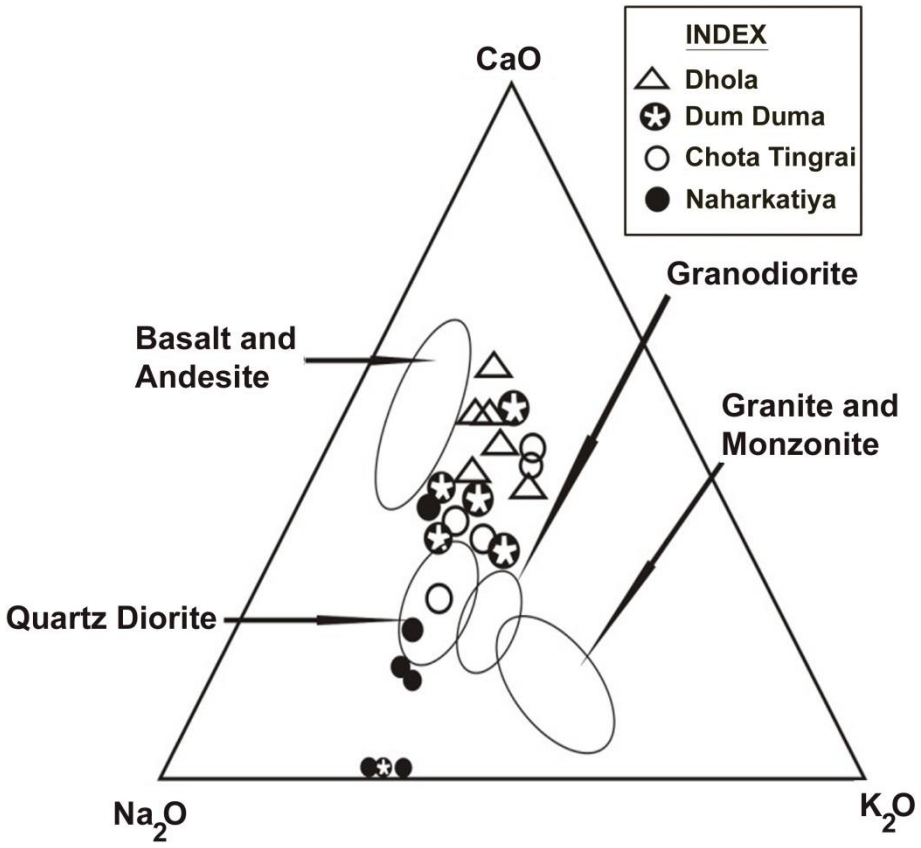


Fig.3 the triangular plot of CaO-$Na_2O$-$K_2O$ (Condie et al.)

**4.4 Tectonic setting of the source rock:**

The $SiO_2$ vs. $K_2O/Na_2O$ plot (Fig.4) of the sediment shows that the sediment of Active Margin tectonic setting (Fields after Roser and Krosch, 1986)[5]. Also, the plots of $K_2O/Na_2O$ vs. $SiO_2/Al_2O_3$ (Fig. 5) indicates that the samples fall within Active Margin tectonic setting (Fields after Roser and Krosch, 1986).

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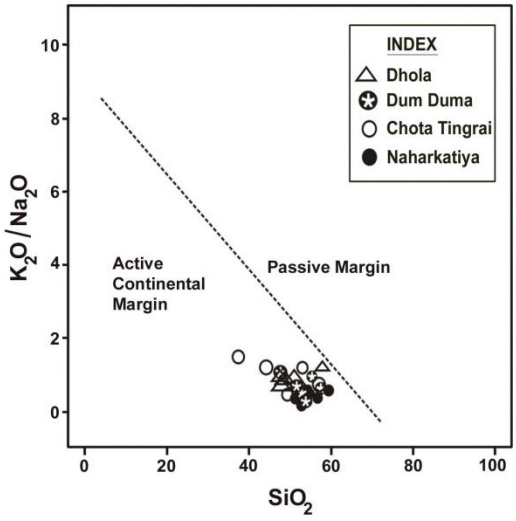


Fig. Major element composition plot for tectonic setting discrimination of the sandstones of four sub-surface wells of Upper Assam. All the samples fall in the field of Active Margin tectonic setting
(Fields after Roser and Korsch, 1986).

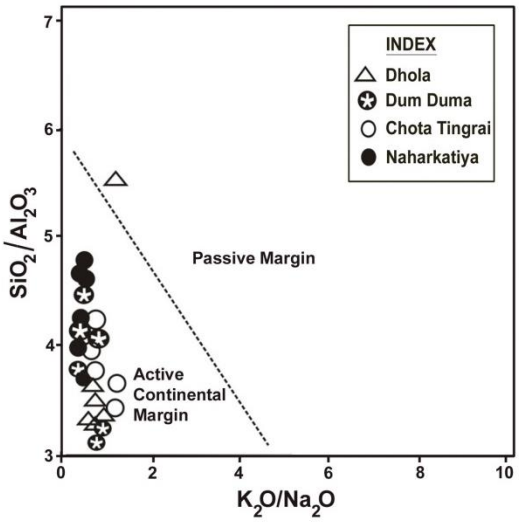


Fig. Major element composition plot for tectonic setting discrimination of the sandstones of four sub-surface wells of Upper Assam. Almost all the samples fall in the field of Active Margin tectonic setting.
(Fields after Roser and Korsch, 1986).

Fig.4 & 5

## 5. CONCLUSIONS

The dominance of CaO over MgO in all the sediments of three wells Dholla, Dum Duma and Chota Tingrai indicates that the sediments are of carbonate nature.

The maximum value of $SiO_2/Al_2O_3$ shown by the Naharkatiya sediments (4.29) indicates that maturity of Naharkatiya sediments is relatively higher as compared to the other three wells.

The triangular plot of percentage value of $Fe_2O_3$, MgO and $TiO_2$ of sediments of four well shows clustering of most of the sample of Chota Tingrai and Dhola in and around the 'Granite and Quartz Monzonite' and 'Quartz Diorite and Granodioritic field'. Thus the sediments of Chota Tingrai and Dhola may have probably been derived from quartz diorites and granites. Whereas the sediments of Naharkatiya well shows a separate field away from the defined field inferring that the source of these sediments are different from the other three wells.

Triangular plot of CaO-$Na_2O$-$K_2O$ shows that majority of the percentage values of the relevant oxides of the sediments of four well falls in and around 'Quartz Diorite' and 'Basalt and Andesite' field. Thus the sediments may have probably been derived from quartz diorites and granites.

The $SiO_2$ vs. $K_2O/Na_2O$ plot of the sediments shows that the sediments of Active Margin tectonic setting, which is true for the present tectonic setting of the area. The plots of $K_2O/Na_2O$ vs. $Sio_2$ /$Al_2O_3$ indicate that the samples fall within active margin tectonic setting. This indicates that the present tectonic setting of the area has not been changing since the deposition of these sediments.

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