Geochemical Studies of Clays from Red Sediments of Visakhapatnam Coast, East Coast of India

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Red sediments, characterised by badland like topography, found along the Visakhapatnam—Bhimunipatnam coast and associated with khondalite hill ranges comprise 60-70% (quartz + heavies), 20% silt and 10% ferruginous clay. Kaolinite and illite proportions are dominant in the clays of the red sediments and compare fairly with the clays from the offshore region. The similar concentration of elements — K, Fe, Ti, Cr, Co, Ba, Sr and Pb — supports the clay input from the red sediments into the shelf region. Ti, V, Mn, Co with Fe and Sr, Ba, Pb with K show positive relationship, which reflects alteration of detrital magnetite and ilmenite and orthoclase in the source rocks.

The red sediments, displaying badland like topography are prominent along Visakhapatnam—Bhimunipatnam coast. These sediments (15-30 m thick and 60-75 m high) comprise 60-70% sand (quartz + heavies), 20% silt and 10% ferruginous clay. The heavies are mainly of magnetite, ilmenite, garnet, sillimanite, zircon and rutile. The pebbly and lateritic gravel-silt zones at the bottom of red sediments indicate the different stages of deposition by fluvial processes. The red sediments occurring in the vicinity of the major khondalite hill ranges are the products derived and deposited during erosional process. Statistical studies of zircon supports the khondalite parentage.

The incipient to advanced stages of alteration of sillimanite and orthoclase into gibbsite, kaolinite and illite are noticed in the scarf zones of khondalite hill ranges, which supports the pronounced chemical alteration of detrital minerals, sillimanite and feldspars, in the sediments into kaolinite and illite. The magnetite and ilmenite have altered into hematite and imparted red colour to the sediments. The clays are ferruginous and characterised by dominating kaolinite and illite. X-ray studies of clays have indicated the presence of 70-95% kaolinite and 5-30% illite. Clays from the shelf have indicated dominating illite and kaolinite (75-80%) and less smectite (<25%). The high Fe₂O₃ content (6-11%) is characteristic of lateritic soils and sediments.

In the present study geochemistry of clays from shelf sediments and red sediments has been studied to understand the influence of clays transported from land to shelf region.

Materials and Methods
Sampling was done at 16 stations along Visakhapatnam coast (Fig. 1) during 1978-79. Fe (as total iron) and K₂O in clays from the red sediments and clays from the offshore are determined using colorimeter and flame photometer respectively. Trace elements — Ti, V, Cr, Mn, Co, Ni, Sr, Ba and Pb — were determined on Jarrell Ash 850-4 atomic absorption spectrophotometer. One percent solutions were prepared from the clay fractions of sediment

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samples, using Teflon bombs. The solutions were run on AAS, using the specified wavelengths and fuel (air acetylene and or/nitrous oxide), following the method of additions.

Results and Discussion

Presence of trace elements in clays can be attributed to adsorption, chemisorption and anion-exchange. Organic matter and calcium carbonate may also influence to a certain extent the trace elemental concentration but are not taken into consideration in present study. The data of Fe, K and trace elements from different clays are given in Table 1 and the correlation coefficient values are given in Table 2.

Iron—Fe (Fe₂O₃) in clays of red sediments varies from 3-11% and from 3-9% in the clays of the offshore. Fe shows good positive correlation with Mn, Ti, Cr and V in both the clays of coastal red sediments and offshore sediments (Table 2).

Titanium—Ti content in the clays of red sediments is higher (3200 to 8140 ppm) when compared with that of the offshore clays (2300 to 6500 ppm). The heavy minerals are the source for the enrichment of Ti in the coastal red sediments, which are subsequently transported into offshore region. Ti shows good positive correlation with Mn, Cr, Co and V in both the clays, in addition it also shows good correlation with Ni in the clays of coastal red sediments. Fe has good correlation with Ti in both the clays (Table 2). Linear relationship is established between Ti and total Fe in deep sediments.

Vanadium—V gets concentrated in aluminium hydroxide and released during the decomposition of clay minerals. The clays from red sediments show a range of 80 to 265 ppm of V, which varies from 84 to 204 ppm in the clays of the offshore region. V shows good positive correlation with Cr, Mn and Ni in both the clays and in addition V also shows good correlation with Co in the clays of the coastal red sediments. Fe has also good correlation with V (Table 2).

Chromium—Cr varies from 30 to 100 ppm in red sediments and 35 to 84 ppm in the clays of the offshore region. It may be related to the presence of Fe in the sediments. Cr has good correlation with Mn and Co in clays from offshore, while it shows good correlation with Mn in the clays of coastal red sediments. Fe also has good correlation with Cr (Table 2). Cr concentration may be the result of adsorption of hydrated ferric oxide in different sub-environments of red sediments and the offshore sediments. Cr generally increases in reducing environments along with Fe. The presence of Cr in the sediments of the Bay of Bengal is related to the continental origin and transported with alumino-silicates.

Manganese—Mn in the clays of red sediments is more compared to clays of the offshore sediments due to the distribution rate of almandine garnet (with appreciable spessartite molecule) being more in the source rocks khondalite. Mn varies from 200 to 820 ppm in the clays of coastal red sediments and 350 to 750 ppm in the offshore sediments. Mn shows good positive correlation with Co in both the clays and Fe has also good correlation with Mn (Table 2).

Cobalt and Nickel—Although Co and Ni are geochemically related elements they differ with respect to their occurrence. Co content is less when compared with Ni in both the clays of red sediments and the offshore sediments (Table 1). Co has good correlation...
Table 2—Correlation Coefficients of Trace Element Data of Clays

<table>
<thead>
<tr>
<th></th>
<th>Coastal Red Sediments</th>
<th>Offshore Sediments</th>
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</thead>
<tbody>
<tr>
<td>Fe</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>K</td>
<td>-0.560</td>
<td>0.178</td>
</tr>
<tr>
<td>Ti</td>
<td>0.685</td>
<td>0.946</td>
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<tr>
<td>V</td>
<td>0.743</td>
<td>0.786</td>
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<tr>
<td>Cr</td>
<td>0.842</td>
<td>0.865</td>
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<tr>
<td>Mn</td>
<td>0.778</td>
<td>0.954</td>
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<tr>
<td>Co</td>
<td>0.356</td>
<td>0.601</td>
</tr>
<tr>
<td>Ni</td>
<td>0.269</td>
<td>0.394</td>
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<tr>
<td>Sr</td>
<td>-0.326</td>
<td>0.147</td>
</tr>
<tr>
<td>Ba</td>
<td>0.500</td>
<td>0.296</td>
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<tr>
<td>Pb</td>
<td>-0.384</td>
<td>0.147</td>
</tr>
<tr>
<td>Co</td>
<td>0.601</td>
<td>0.296</td>
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<tr>
<td>Sr</td>
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<tr>
<td>Ba</td>
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<td>0.296</td>
</tr>
<tr>
<td>Pb</td>
<td>-0.461</td>
<td>0.296</td>
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</tbody>
</table>

Fe K Ti V Cr Mn Co Ni Sr Ba Pb

Level of significance of ρ value 0.427

with Ni in both the clays but Co also shows good positive correlation with Ba in the clays from offshore which is an anomaly (Table 2). The presence of Co and Ni in both the clays may be related to adsorption.

Potassium—K occurs as univalent cation with radii 1.33 Å. K is largely incorporated in potash feldspars. Weathering of these minerals contribute K into the solutions that leach K, where it is fixed or adsorbed by clays. The source of K, reported as illite, in the clays of the red sediments is related to the orthoclase present in khondalites, which abound the coast. K shows good positive correlation with Ba, Sr and Pb in the clays of coastal red sediments, while in the offshore clays K shows positive correlation with Cr and Ba. The relationship between K and Cr is an anomaly (Table 2).

Strontium—Sr shows good correlation with Ba and Pb in the clays of coastal red sediments but in the offshore clays Sr has good correlation with Pb only (Table 2). K also has good correlation with Sr in the clays of the coastal red sediments. Kaolinite present in both the red sediments and in the offshore sediments is capable of allowing Sr into Al by means of ion-exchange due to broken bonds around the edges of the silica and alumina units. Smectite in both the clays of the sediments is significantly less.

Barium—Ba varies from 282 to 930 ppm in the clays of red sediments and from 462 to 726 ppm in the offshore sediments. Ba shows good correlation with Pb in the clays of red sediments and K has good correlation with Ba (Table 2). The presence of illite in higher amounts in clays of offshore sediments indicates that barium could have been adsorbed by illite.

Lead—Pb (ionic radius-1.32 Å) can replace K (ionic radius-1.33 Å) diadochially. Clays that are formed from potash feldspars, which are originally rich in Sr, Ba, and Pb show higher amounts. There is good correlation between Ba and Pb in both clays. K has very good correlation with Pb (Table 2).

The similar enrichment of trace elements in the clays of coastal red sediments and in the clays of the offshore sediments is related to the input of clays from the coastal red sediments as well as inland red sediments into the shelf region of the Bay of Bengal along Visakhapatnam—Bhimunipatnam.

The khondalites are enriched with potash feldspars rich in Sr, Ba and Pb and subsequently these potash feldspars are altered into illite and transported right from the coast to the offshore region. The sillimanite and orthoclase have altered in situ into kaolinite and illite and are transported through drainage into the shelf region. These minerals are the real source for the trace elemental concentration in the clays. Magnetite and ilmenite are altered into hematite and being originally rich in Fe, Ti, V and Cr are responsible for
the enrichment of these elements in the clays. It may be concluded that the concentration of trace elements in the clays of coastal red sediments and offshore sediments is due to the alteration of land derived detritus minerals. Distribution of the trace elements and their geochemistry is largely controlled by the mineralogy of land derived detritus and chemical conditions of the environment in which the sediments are deposited.

Acknowledgement

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References