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Origin and Occurrence of calcretes from Red sediments of Visakhapatnam-Bhimunipatnam coast, East Coast of India

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ABSTRACT

The red sediments with calcretes along Visakhapatnam- Bhimunipatnam (83° 17.5′-83° 33′N and 17° 41 -17° 59′ E) of Andhra Pradesh state, India is of scientific interest. Morphologically, calcretes are classified as rhizo-concretionary, mottled, massive, corn like structures with micrite cement. The possible mechanism of its formation has been discussed.

Key words: Morophology, Clacretes, Red sediments, Visakhapatnam- Bhimunipatnam coast, Corn like structures.

INTRODUCTION

Calcretes are near surface, terrestrial, accumulations of calcium carbonate that vary from powdery to nodular to highly indurated forms. They result from cementation and the introduction of calcium carbonate into soil profiles, bedrock and sediments (Goudie, 1973;Wright and Tucker,1991). Indicators of subaerial exposure (Esteban and Klappa, 1983), semiarid to arid climate climatic conditions (Goudie, 1983;Alonso-Zarza 2003), stable geomorphic surfaces (Machette,1985), and non-active areas in alluvial systems (Alonso-Zarza,2003). Calcretes are typically associated with soil profiles in surficial or subsurficial locations. Calcrete development is controlled by the nature of host sediment, availability of carbonate-rich environment and climatic conditions. However, calcrete develops during arid to semi-and intervals that follow humid climatic intervals. Pedogenic calcrete is rhizoconcretionary (Khalaf, 2007). Most calcrete profiles are polygenetic, where different processes may act during their evolution leading to fabric transformation and facies superimposition (Durand et al., 2007; Khalaf,2007). In the study area, calcrete occur in different forms and weathered and dislodged calcretes from host sediment scattered in drainage channels Figure 1.

This investigation is aimed to study the morphological features of calcretes occurring in red sediments, to understand the geochemical nature of the calcrete and to record the possible mechanism of its genesis in red sediments.

STUDY AREA

The study area from Visakhapatnam to Bhimunipatnam (83° 17.5′-83° 33′N and 17° 41′ - 17° 59′E) extends for 24 km on the East coast of Andhra Pradesh, India Figure 2. This coastal strip bounded on the east by the Bay of Bengal and the west by the tectonically stable Eastern Ghats which comprise of isolated hills and hill ranges. The prominent among them are the Yarada, Kailasa and the Kambala konda. The red sediments along Visakhapatnam-Bhimunipatnam are known for their characteristic badland topography (Jagannadha Rao et al., 2012).

A total of 8 calcrete samples were collected from different sites of Visakhapatnam-Bhimunipatnam coast Figure 2 for this study.

Geology and Geomorphology

The study area is characterized by Garnet- sillimanite-biotite gneisses (khondalites), hypersthene granites (charnockites), garnetiferous granites (leptynites), quartzites and pegmatites are the rock types that occur as bedded and banded as well as massive Formations. This area covered with denudational hills of range between 30 to 594m. Kailasa and Yarada are extending nearly east to west, and thus deviate from the NE-SW trend of Eastern Ghats. The geomorphic features resulted from coastal and landward processes (Jagannadha Rao, et al., 2012)

The sediments are the prominent features and attain a height of 30 meters above the sea level.

METHODOLOGY

Geochemical analysis

The sand sized particles were removed mechanically and the cementing material of the calcretes was analyzed for major elements like Ca, Mg, Ba, Fe, Ti, Al, Na, and K and trace contents like Mn, P, Cu, Co, Ni, Cr, Ga, Sr, Sn were determined (Table-1) using AAS, instrument (Perkin Elmer 2380, Vogel 1989).

Figure 1. Eroded calcretes from red sediments from drainage channels.

Figure 2. Calcrete sample location Map.

Figure 3. Calcretes within red sediments.

Morphological features of Calcrete:

The calcretes Figure 3 are classified as Rhizoconcretionary, mottled, massive and corn stone like structures. Rhizoconcretionary/Root like calcretes are formed in the form of roots and root forms of existing plant root systems, under the influence of ground water and capillary work of root systems. Figure 4. Corn stone like calcrete (1-4cm diameter) are distributed widely over the surface of red sediments. Figure 5. The Mottled and massive calcretes occur beneath the surface and are reported along the coast.

Calcrete facies:

The calcrete facies is restricted to the red sediments, present day inland red soils and the dunes along the coast are devoid of the calcrete formation. The composition of the calcrete is $CaCo_3$ with sand lithified and compacted. The composition of the sand is similar to host red sediment. The calcretes are devoid of clay content which is present in the red sediments. The calcium carbonate is filled in the intergranular spaces of the red sands. The core of the calcrete is marked by the presence of finely divided white calcite (micrite).

RESULTS AND DISCUSSION

It is observed that the elemental concentrations Ca (19.95 to 35.08 wt%, Mean: 30.28 wt%), Fe (1.40 to 2.671 wt%, Mean: 1.86 wt %), Mg(0.530 to 1.055 wt%, Mean: 0.758 wt%), Na(0.044 to 0.073wt%, Mean: 0.058 wt %) , K (0.340 to 0.522 wt %, Mean: 0.433 wt%), Mn(0.185 to 0.518 wt%, Mean: 0.353 wt%), Ba (2.30 to 2.81 wt%, Mean: 2.51 wt%) are in higher concentrations. However, the Sr concentration is registered comparatively low values, Sr (0.042 to 0.059 wt% Mean: 0.05 wt%). Ca content in calcretes varies from 39.5-44.5%, whereas Mg is reported to be less than 3% and is corroborating with the results of Gouide, (1972). The Ca content has been observed to range from 19.95 to 35.08, whereas the Mg concentration is indicated in a range of 1.05% to 0.53%.

Calcrete derivation is attributed to the process initiated by the evaporation of supersaturated ground water forming calcretes due to capillary action, drawing of water by the plants and other vegetation.

It is further established that Sr concentration will be more in meteoric water, which is resulted by high evaporation and concentration followed by decease of CO_2.

The calcretes formed by the process of evaporation are indicated by high Sr/Ba, and low Na concentration ratios (Khadkikar et al. 2000). The calcretes from present study indicated low Sr/Ba ratios and high Na concentrations thus ruling out the involvement of process of evaporation.

The higher Fe and Mn content will be commonly observed in calcretes formed by the influence of groundwater (Brand and Veizer, 1980).

Rhizoconcretionary, corn like and mottled massive calcretes present in the area are localized in zone of capillary rise and thus established that the calcretes are close to the process of evapotranspiration of groundwater enriched with excessive $CaCO_3$ helped by vegetation, whereas massive calcrete is in the vadose zone (Jagannadha Rao, 1985).

The formation of calcretes in the present study area are distributed both in vadose zone and zone of capillary rise formed by the influence of groundwater.

Rhizo-concretionary calcrete

These calcretes are formed like root systems in the red sediments using pellicular waters. Once the water is charged with $CaCO_3$ the capillary intake of this water by the root systems of the plants result the precipitation of $CaCO_3$ in the inner walls of the roots. Successive deposition of $CaCO_3$ lead to concentrically laminated rhizoconcretions. Plant roots remain alive even if encased by a calcrete coating up to 2 mm to 4 mm thick. After the coating of the outer surface of the root, core is filled with the pure $CaCO_3$ devoid of sand grains and the plant tends to die.

Table 1. Chemical analyses of calcretes (in wt %)

Sample No	1	2	3	4	5	6	7	8	Average
Al	0.664	1.07	0.78	0.94	0.715	0.715	0.709	0.875	0.80
Fe	1.40	1.87	1.73	1.622	1.636	1.608	2.671	2.385	1.86
Mg	0.669	0.530	0.977	0.579	1.055	0.989	0.729	0.542	0.75
Ca	30.26	29.20	31.74	29.70	33.03	19.95	35.08	33.34	30.28
Na	0.05	0.045	0.066	0.059	0.073	0.044	0.059	0.068	0.058
K	0.464	0.547	0.415	0.522	0.448	0.348	0.340	0.381	0.43
Mn	0.366	0.518	0.348	0.317	0.309	0.425	0.356	0.185	0.35
Ba	2.40	2.78	2.34	2.54	2.30	2.81	2.40	2.516	2.51
Sr	0.042	0.0432	0.0446	0.048	0.0569	0.0507	0.0596	0.0554	0.05

Figure 4. Rhizo concretions/Root like calcrete.

Figure 5. Corn stone like calcrete.

Corn stone like Calcrete

It is formed on the areas that lack plant growth generally nearer to the ground water level. The corn like calcrete occurs in various sizes depending upon the supply of $CaCO_3$ from underneath.

Mottled and massive calcrete

Pellicular water not taken up by plants ultimately evaporates and leaves an interstitial precipitate of $CaCO_3$ as calcrete and this is known as mottled calcrete. Massive calcrete is formed when the $CaCO_3$ supply reaches a certain stage where the mottled interstitial precipitates join together to form a mass. It occurs in subsurface and above the ground water table. Once the roots penetrate through the main calcrete sheet, they die and decay and forms a hole.

The hole becomes a channel for later root system to enter; further supply of $CaCo_3$ from the ground water enables the formation of a thick calcrete sheet which prevents the roots to reach the ground water. This may

be one of the causes for present day sparse vegetation on the red sediments and along the coast, the ground water hardness is higher when compared to that of water from inland (Hareram 1983).

CONCLUSION

The field observations, morphology and geochemistry of calcretes occurring within the red sediments along Visakhapatnam and Bhimunipatnam coast revealed that the calcretes are formed both in vadose zone and zone of capillary rise. This can be attributed to the process initiated by the evaporation and deposition of $CaCo_3$ in root systems. This is resulted by process of capillary intake of $CaCO_3$ super saturated groundwater by the by root systems of plants and other vegetation.

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