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Termite mound as an Effective Geochemical Tool in Mineral Exploration: A Study from Chromite Mining Area, Karnataka, India

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Abstract

In Byrapur chromite mining area, the ore element Cr and other associated trace elements Viz., Co, Ni, Pb, Zn, Cu, Fe, Mn, and Mo were determined for termite mounds and their adjoining surface soils unaffected by termites. A biogeochemical parameter called "Biological Absorption Co-efficient" (BAC) of these mounds is computed which helps in the evaluation of the mounds in the geochemical orientation surveys and in mineral exploration. The maximum BAC value 19,090 for Cr element in termite mounds is attributed to the influence of chromite mineral zone in the study area. Since the BAC values of Cr element in all termite mounds are classified as "positive" reflecting the enrichment of the chromium element in the termite mound with reference to the surface soil. The concentration of ore element Cr in termite soils is from 1400 to 4500 ppm, and that of soils it is from 220 to 960 ppm reflecting the element Cr in the termite soils in the study area. These studies reveal that the mounds exhibit indicator characteristics especially for Cr element and also for other associated elements viz., Co, Ni, Pb, Zn, Cu, Fe, Mn, and Mo. Hence termite mound may be considered as a tool in mineral exploration.

Keywords: Termite mound, mineral exploration, chromium, BAC, Byrapur.

Introduction

Termites popularly known as "white ants" exist throughout the tropical and most of the warm temperature countries. They are the most dominant macro invertebrates in many tropical and subtropical ecosystems. They often build earthen mounds of various sizes and shapes forming important features of tropical landscape. Termites are often mentioned as an example of ecosystem engineers. They drastically alter the physical, chemical and biological characteristics of the soil environment. They have been considered as objects of worship in India since the time immemorial. Termites decent through subterranean galleries ramified over wide tract, and sample the sub surface geological formations for their construction material. They may form large, stable nest and can concentrate the organic materials they collect as forage in the vicinity of the nest, in the form of inedible debris, and stored food. In a mineralized area, termites bring up partly dissolved mineralized water from the water table to maintain the required high humidity and they precipitate the mineral matter carried jaws to the site and cemented with a mixture of clay and saliva for the construction of the mounds. When these mounds are sampled and subjected to trace element analysis the evidence of mineralization can readily be obtained and geochemical anomalies can be easily rapidly and effectively determined to locate the concealed ore deposits. Termite mounds in the study area are generally found in association with different types of vegetation, soil and rock. They have varied shapes (figure-1) as conical, elongated, bald and rounded even irregular. The mounds under study area from 45cm to more than 2.5 meters in height with the base diameter varying from 0.7 meters to 3.5 meters. In Byrapur chromite mining area the mounds occurring on amphilobites are dark reddish brown those occurring on tremolite schist are brown colour.

Termite Mound in Mineral Prospection

Varahamihira's Brihat Samhita describes termite mound as one of important bioindicators in exploration mineral resources[1-4].In Russia, geochemical features of termite mounds have been studied[5]. Biogeochemical studies have demonstrated that in tropical parts of India these mounds can be used as tool in the exploration for copper[6], tin[7], lead[8], gold[4,9] and barite[10,11] deposits. Similarly modern works also deal with termite mounds in geoexploration[12]. Earlier workers have studied ecological[13,14], biological[15,16] and geological[17-21] aspects of the termite mounds. Comparative studies of termite mound and the adjacent soils had been carried out in previous researches [22-24]. In the present study, termite soils and their adjoining surface soils were studied tin the chromite mining area of Byrapur, Hassan district to examine the potential of the termite mounds as an indicator in mineral exploration. In the study area the mounds are barren, monophytic, and polyphytic vegetation.

Area of the Study

Byrapur (Lat. 13^o 06' 20' to 13^o 06' 56" N; Long 76^o 24' 30" to 76^o 24'40" E) is located in Hassan District, Karnataka. It is included in the Survey of India Toposheet No 57 C/8. Byrapur chromite area is an important mineralized zone in the Nuggihalli schist belt. The chromite ore bodies in and around Byrapur is a linear and narrow band of metamorphic basic and ultrabasic rocks and occur as lensoid bodies. The ultra-basic rocks are intrusive into Dharwar schistose rocks. The Nuggihalli schist belt is one of the ultramafics rich ancient belts in the Dharwar craton[25]. These deposits are mainly fissure type. In this area the important rock types are amphibolite, dolerite, serpentinite talc, tremolite schist, dunite, pyroxinite, peridotite and titaniferrous magnetite. The chromite mineralization usually occurs as lenses, tabular or irregular bodies in the Nuggihalli Schist Belt. In this mineral zone, the ore have been mined by underground method. Earlier workers studied the oxidation character of chlorite[26], and chemical studies chromo chlorite[27, 28] of Byrapur chromite area.

Sample Preparation

Termite Soils and Soils: Samples were collected from 8-10 spots from different parts of the exterior of the termite mound and were combined to form a composite sample. Similarly the adjoining surface soils occurring in a radius of 8-10 m were collected and combined to represent a composite sample. Thus, a total of 10 pairs of termite soils and their adjoining surface soils unaffected by termites were collected in and around the mining area. All the samples were oven dried at 110^oC to expel moisture. These dry soils were lightly disintegrated with porcelain mortar and pestle to break lumps if any with care to avoid the breaking of individual and were then sieved to pass through 2mm sieve mesh. From this material required quantity of each representative sample was obtained by coning and quartering. These samples thus obtained were finely powdered in an agate mortar and ignited at 500^{o}c in a muffle-furnace for six hours. Then the samples were digested in aquaregia and analyzed for Cr and other associated elementsCo, Ni, Pb, Zn, Cu, Fe, Mn, and Mo by atomic absorption spectrophotometry (AAS). The elemental data is shown in table 1.

Figure-1
Termite Mounds in the Byrapur Chromite Mining Area, Karnataka

Elemental Analysis of Soils and Termite Soils: From the data (table 1) it is revealed that generally, concentration of Cr and other associated elements Co, Ni, Pb, Zn, Cu, Fe, Mn, and Mo are higher in thermite soils than those of their adjoining surface termite free soils. The concentration of ore element Cr in termite soils is from 1400 to 4500 ppm, and that of soils it is from 220 to 960 ppm reflecting the element Cr in the termite soils in the study area. Raghu and Prasad[10] stated that the termites continuously modify the trace elements distribution within their mound habitat, as consequences of this cultivation of appropriate plant species as an important adaptation to maintain homeostatic equilibrium. The elemental concentration Cu and Zn of the termite mounds are influenced by the presence of vegetation on the mounds and suggested barren and monophytic mounds for mineral exploration[29]. Due to biogeochemical cycling of elements, the ore element Cr and other associated element shave migrated into sub-soil horizons depleting the concentration of these elements in the surface soil[30]. From these subsoil horizons termites bring mineral particles for their mound construction and incorporate in the mound, thus enriching these elemental concentrations in the termite mound[10].

Biological Absorption Co-efficient (BAC)

A biogeochemical parameter, Biological Absorption Co-efficient (BAC), which is the ratio of concentration of the element in termite mound (C_{Ts}) to that of its adjoining surface soil (C_{Ss}) can be applied while using termite mounds in the mineral exploration[4].Thus, it may be written as: BAC= C_{Ts}/C_{Ss}

Classification of Termite Mounds Based on BAC

Biological Absorption Co-efficient (BAC) values of elements in termite mounds are classified as positive and negative. The BAC Value of unity is taken as the datum line. If the value is more than one it is treated as positive reflecting an enrichment of the element in the mound with reference to its adjoining surface soils; similarly if the value is less than one it is treated as negative reflecting depletion of the element in the mound.In the present study BAC has been calculated for the termite mounds. On this basis the BAC of various elements viz., Cr, Co, Ni, Pb, Zn, Cu, Fe, Mn, and Mo in the termite mounds has been classified. The BAC values for various elements are shown in table 2.

Table- 1
Concentration of trace elements (in ppm) in termite soils (Ts) and in surface soils (Ss)

Sample	Cr		Co		Ni		Pb		Zn		Cu		Fe		Mn		Mo	
No	Ts	Ss	Ts	Ss	Ts	Ss	Ts	Ss	Ts	Ss	Ts	Ss	Ts	Ss	Ts	Ss	Ts	Ss
1	1850	650	15	10	60	25	30	12	42	30	25	18	150	110	50	25	8	3
2	3600	890	20	13	72	18	45	26	55	40	32	22	130	90	100	76	6	2
3	1400	530	13	10	45	32	25	18	40	26	24	20	80	64	75	40	8	5
4	4500	470	25	16	38	28	42	35	46	19	50	38	125	80	40	22	4	2
5	2300	590	18	12	64	50	34	24	38	22	32	26	145	120	30	15	5	3
6	4200	220	20	10	40	34	19	16	52	38	24	18	75	68	25	18	4	3
7	1900	300	35	20	44	20	22	15	60	44	40	34	140	125	80	55	6	2
8	3150	730	24	19	55	38	18	14	35	30	15	12	200	160	60	52	8	3
9	2920	960	31	27	46	26	20	16	50	26	35	20	120	100	70	55	10	7
10	1640	710	18	15	52	40	15	12	54	32	12	10	95	60	90	78	5	3

Table-2
Biological Absorption Co-efficient (BAC) values for various elements

Sample No	BAC value of Cr	BAC value of Co	BAC value of Ni	BAC value of Pb	BAC value of Zn	BAC value of Cu	BAC value of Fe	BAC value of Mn	BAC value of Mo
1	2.846	1.500	2.400	2.500	1.400	1.388	1.363	2.000	2.66
2	4.044	1.538	4.000	1.730	1.375	1.454	1.444	1.315	2.00
3	2.641	1.300	1.406	1.388	1.538	1.200	1.250	1.875	1.60
4	9.754	1.562	1.357	1.200	2.421	1.315	1.562	1.818	2.00
5	3.898	1.500	1.280	1.416	1.727	1.230	1.208	2.000	1.666
6	19.090	2.000	1.176	1.187	1.368	1.333	1.102	1.388	1.333
7	6.333	1.750	2.200	1.466	1.363	1.176	1.120	1.454	3.0
8	4.315	1.263	1.447	1.285	1.166	1.250	1.250	1.153	2.666
9	3.041	1.148	1.769	1.250	1.923	1.750	1.200	1.272	1.428
10	2.309	1.200	1.300	1.250	1.687	1.200	1.583	1.153	1.666

The distribution of BAC of termite mounds for various elements in different classes is shown in table 3. From the data (table 3), it has been observed that in all the termite mounds, BAC values are consistently positive trend. It is significant and interesting to note that Cr is almost dispersed in "positive" category throughout the enriched scale. BAC for the Cr element majority mounds fall in 2, and 3 categories and few mounds are also fall in 4, 5, and 6 categories of enrichment. The elements Co, Pb, Zn Cu, Mn and Mo fall in 1and 2 categories of enrichment; and Ni fall in 1, 2, and 3 categories of enrichment. It is significant to note that no element fall under depletion side. In general, it may be noted that the elements are more mobile in termite soils when compared to those of the surface soils due to the activity of the termites. Since the BAC values of Cr element in all termite mounds are classified as "Positive" reflecting the enrichment of the chromium element in the termite mound with reference to the surface soil. The maximum BAC value of chromium (19.090) in termite mounds is attributed to the influence of chromite mineral zone in the study area. The rest of the elements viz., elements Co, Ni, Pb, Zn, Cu, Fe, Mn, and Mo have less values of BAC when compared to the ore element chromium. Earlier Raghu and Prasad[10] reported that Ba, Sr, Cu, Mn and Zn showing more than unity in termite mounds. Raghu[11] reported the average BAC values for Al, Ca, K, Na, Ti, B, Cr, La, Li, Ni, V, Y and Zr showing more than unity in termite mounds.

Conclusion

In the study area the concentrations of the elements viz.,Cr, Co, Ni, Pb, Zn, Cu, Fe, Mn, and Mo are higher in termite soils than those that of adjoining surface soils, suggesting indicator characteristics of the mounds for these elements, especially for chromium in geochemical prospecting. In the study area, amongst all the elements, Cr concentration (14500 ppm) was much greater in the termite mounds reflecting the enrichment of chromium. Similarly the maximum BAC value 19.090 for Cr element in termite mounds is attributed to the influence of chromite mineral zone in the study area. Thus, termite mounds are useful indicators and find application in mineral exploration. The Cr in termite mounds may derive from the soil carried by termites from the sub-soil in the course of construction their mounds. Thus, the concentration of trace elements viz.,Co, Ni, Pb, Zn, Cu, Fe, Mn, and Mo may be utilized to monitor the levels of soil pollution. Metal concentration in termite mounds may depends on the chemical speciation of metals in soil and soil solutions. Therefore, based on these geochemical investigations termite mounds can be ideally used as possible application in mineral exploration; agricultural reconnaissance surveys; and monitoring of the state of pollution levels of the mining environment.

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Table -3
Distribution of Termite Mounds Based on classification of Biological Absorption of Co-efficient (BAC) for various elements

Category	Class intercals	BAC Range	Cr	Co	Ni	Pb	Zn	Cu	Fe	Mn	Mo
	6. Hyper	>15.59	1								
Enrichment	5.Intensively strong	9.00- 15.59	1								
	4. Very strong	5.20-9.00	1								
	3. Strong	3.00- 5.20	4		1						
	2. Moderate	1.73- 3.00	3	2	3	1	2	1		4	5
	1. Week	1.00- 1.73		8	6	9	8	9	10	6	5
--------------Datum line-----------		--------BAC=1 -----									
Depletion	1. Week	<1.00- 0.58									
	2. Moderate	0.58- 0.33									
	3. Strong	0.33- 0.19									
	4. Very strong	0.19- 0.11									
	5.Intensively strong	0.11- 0.66									
	6. Hyper	<0.66									

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