Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Archives of Applied Science Research, 2011, 3 (3):77-84

(http://scholarsresearchlibrary.com/archive.html)

ISSN 0975-508X
CODEN (USA) AASRC9

Mineral analysis in beach rocks of Andaman Island, India by spectroscopic techniques

R. Ravisankar[a*], A. Chandrasekaran[b], S.Kalaiarsi[a], P.Eswaran[c], C.Rajashekhar[e], K. Vanasundari[a], and Alok Athavale[e]

[a]*Post Graduate and Research Department of Physics, Government Arts College, Tiruvanamalai, Tamilnadu, India*
[b]*Department of Physics, Sacred Heart College, Thirupattur, Tamilnadu, India*
[c]*Department of Physics, Vel Tech Dr. R R. Dr. S R Technical University, Avadi, Chennai*
[e]*Paleobiology Group, Agharkar Research Institute, Pune, India*

ABSTRACT

Beach rock is a peculiar formation when compared to other types of rock formations. It is found in many places in the world and a few places in India. One such formation is found in Andaman and Nicobar Island of India. It needs intensive and extensive investigation on its formation. The present work aimed to collect the beach rock samples along the Coast of Andaman Island and subjected to mineral analysis using spectroscopic techniques. The presence of mineral in beach rock samples is identified by FT-IR spectroscopic technique. The constituents of minerals present in the beach rocks are further confirmed by XRD technique. Both FT-IR and XRD techniques reveals the mineral composition and cementing minerals in beach rocks of Andaman Island, India. Results are discussed and the conclusions are drawn.

Keywords: Beach rocks, Mineral Analysis, FT-IR, XRD.

INTRODUCTION

Beach rock formation is peculiar compared to other types of rock formations. It is a sedimentary formation commonly appearing as layered deposit inclined towards the sea. It is influenced by the effects of carbonate cement-aragonite or magnesium calcite initially formed in the inter-tidal zone. Beach rock forms most commonly on beaches composed of calcareous shell and coral grains, but it can also develop in beaches of quartz sand or other mineral composition. The natural factor of the beach, such as gentle slope of the foreshore, sufficient shell content and ground water temperature have also favored the formation of beach rocks. Essential to beach rock development is ground water with enough calcium to provide cementing effect.

Beach rock formation is found in many places in the world [1-3] and few places in India [4-6]. The beach rock samples of Tamilnadu were analyzed for cementating minerals and to study the elemental composition Instrumental Neutron Activation Analysis (INAA) and Particle Induced X-ray Emission (PIXE) techniques were used [7-9]. One such beach rock formation is found in the Andman Island [10]. The Quaternary rocks of Andaman-Nicobar Archipelago are very significant as they have various types of sediments capable of unravelling the climatic history, sea level variations and neotectonic activity, shore sand, beach rock, raised beaches, corals and sediments associated with mangroves are the important constituents of the Holocene deposits. Of these entire beach rocks are very significant as they represent the former strandline and hence sea level variations. The beach rocks are common all along the coastal tract of Andaman-Nicobar Archipelago. These islands are represented by an active sub-ariel ridge located between the Arakan-Yoma In the north and Java-Sumatra in the south (Lat 6 45 N to 13 43 N ; Long 92 15 E to 94 00 E). Geologically the Andaman basin is very interesting as they have a long sedimentary record ranging from Cretaceous to Recent. The basin is studied for its geology and paleontology since a century and several valuable contributions have been made [11-12]. A detailed examination is required to understand the process of cementation of beach rocks of Andaman Island by studying mineral composition.

MATERIALS AND METHODS

2.1. Sample Collection and Preparation

The samples were collected at three locations (Wandoor-B_1-B_2), (Neill Island- B_3-B_4), (Chidyatapu-B_5-B_8) using global positioning system (QueM5 with accuracy: up to 10m). A detailed geological survey was carried out before the fieldwork. At these localities the samples were collected along the tide line i.e. along the horizontal transect. In each location 3 to 5 samples of 2 kg bulk of beach rock samples were collected in a polythene bags. All the samples were cleaned, weathered surface removed and the remaining fresh materials crushed into small pieces. These samples are powdered using agate mortar and dried for 24 hrs at a temperature of 110°C and then pulverized to particle sizes not greater than 2mm mesh screen. The typical beach rocks are shown in Fig-1 & 2.

Fig-1- Beach rocks of Chidayatapu

Fig-2- Beach rocks of Wandoor

2.2. FT-IR Analysis:
The major and minor minerals are qualitatively determined by FT-IR technique. The Bruker Alph series FT-IR is available in Department of Chemistry, Tiruvanamalai. Tamilnadu, India is made use of in the present work for recording IR spectra of the samples at room temperature in the received state. The KBr pellet technique (1:20) pellets were followed for the mineral analysis .For each samples five to six pellet specimens are prepared and the spectra were taken in the mid region of 4000-400cm^{-1}. The typical FT-IR spectrum is shown in Fig-3.

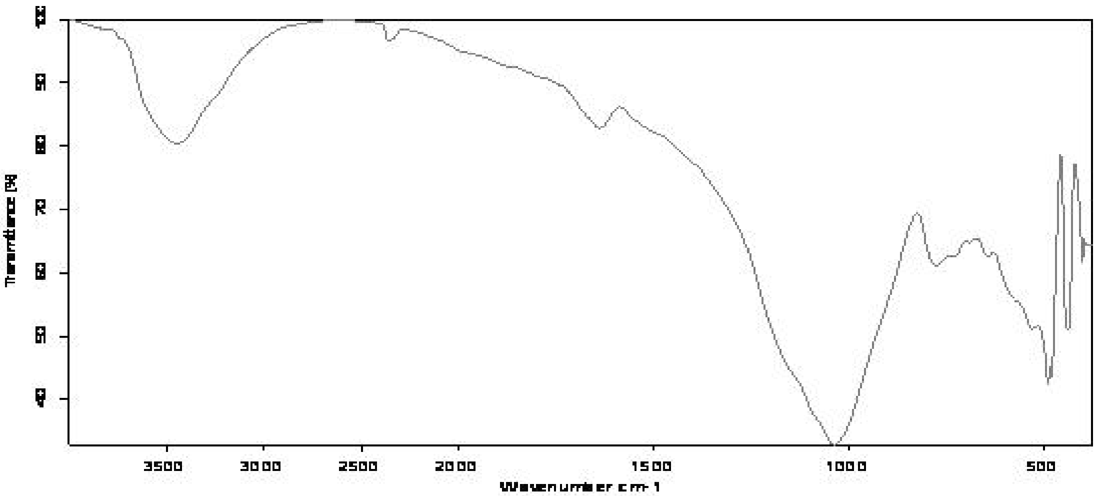

Fig.3. A Typical FT-IR spectrum of beach rocks of Andaman Island

2.3. XRD Technique:
The X-ray patterns of beach rock samples were recorded at room temperature by using X-ray diffractometer (D500, Siemens) having a curved graphite crystal diffracted monochromator, with a source of CuKα radiation and NaI(Tl) scintillation detector from Indian Institute of Technology, Chennai,Tamil Nadu, India. Qualitative mineralogy of the beach rock samples is determined with the standard interpretation procedures of XRD.

RESULTS AND DISCUSSION

3.1. FT-IR Analysis

The absorption frequencies of the peaks in the spectra of each site in wave number unit (cm^{-1}) are reported in table-1. By comparing the observed frequencies with available literature, the minerals such as quartz, orthoclase, albite, kaolinite, montmorllinite, calcite and aragonite are identified. The mineral wise discussion is as follows.

3.1.2. Quartz

Quartz is ubiquitous mineral and forms one of the abundant constituent in all the samples. It is an important component of many sediments as well as sedimentary and igneous rocks. The characteristic peaks of quartz are reported by several workers [13-22]. It could be observed from Table-1 that the infrared absorption bands appearing at 1160, 795, 775, 695 and 455cm^{-1} may suggest the presence of quartz. Out of the five peaks observed for quartz, the bands at 795–800cm^{-1} and 775–780 cm^{-1} may be assigned due to symmetrical stretching modes and those at 690–695 cm^{-1} and at 455–460 cm^{-1} may be due to symmetrical bending mode and asymmetrical bending respectively. Out of these two stretching modes and two bending modes, 795–800 cm^{-1} and 690–695cm^{-1} are widely used as the diagnostic peaks for quartz. From Table-1, it is seen that quartz present invariably in all the samples indicates, it plays vital role for the formation of beach rocks of coastal area concerned.

Table -1 Observed Absorption Frequency in the region of 400 – 4000 cm^{-1}

Sample No	Quartz	Feldspar		Clay Mineral			Carbonate Minerals		
		Orthoclase	Albite	Kaoilinite	Montomorilinte	Iltite	Calcite	Aragonite	Dolomite
B1	1160,455, 775, 795	435, 540,	405	1035, 3660	3440	-	715, 875, 1425, 1800, 2515	1080, 1475	-
B2	455, 775, 795	435	406, 585	1035 3620	475, 3440	915	715, 875, 1800, 2515	855, 1080	-
B3	457,695, 775	435,540,	405,	1035	475, 3445	915	715, 875, 1795, 2515	855, 1080, 1475, 1785	2525
B4	456, 775, 795	435, 540,	405, 585	1035, 3690	3445	-	715, 875, 1425, 2515,2875	1080 1475	-
B5	455, 775	435, 540,	405	1035	3445	915	715, 875. 2515	855,1080 1475,1785	-
B6	457, 695 775, 795	435, 540,	405	1035, 3690	3445	915	715, 875, 1425, 1800,	855, 1080,	2525
B7	455, 795	435	405, 585	1035, 3660,	475	-	715, 875, 1425, 1795	855, 1080, 1475,1785	2525
B8	695, 775	435, 540,	405, 585	1040, 3660, 3690	3445	-	715, 875, 1425, 1800, 2515,2875	1085, 1785	2525

3.1.3. Feldspar

The feldspars are the most important mineral groups in all rock types. They are the silicates of aluminium with potassium, sodium and calcium and rarely barium. Feldspar group of minerals have been analyzed by IR spectroscopic technique and the frequencies of absorption were reported by many workers [13-20]. The infrared absorption frequency of the bands at 585cm^{-1}, 540cm^{-1}, 435cm^{-1} & 405cm^{-1} may suggest the presence of feldspar. The peaks at 435 & 540cm^{-1} are indicating the presence of orthoclase in the samples where as 405 & 585 cm^{-1} in all the samples indicates the presence of albite. The band assignments for different minerals are given in Table-2.

Table -2 Band assignments for different minerals of Beach rocks of Andaman Island

Minerals	Frequency (cm^{-1})	Tentative assignments	References
Quartz	455 695 775 795	Si - O asymmetrical bending vibration Si - O symmetrical bending vibration Si - O symmetrical stretching vibration Si - O symmetrical stretching vibration	18
Feldpar	535 585	Si - O asymmetrical bending vibration O - Si(Al) - O bending vibration	18
Kaolinte	1035 3620 3690	Si-O Stretching Inner OH stretching vibrations Inner surface OH stretching vibrations	18

The invariable presence of quartz and feldspar present in almost all the samples indicates that these are ubiquitous minerals in sediments. Quartz is primarily a detrital mineral, although it is authigenic in origin. Feldspar also plays a role subordinate to that of quartz in sediments. Beach rock can form from sand and gravel of almost any composition, including quartz and feldspar but carbonate sand provides the most common framework for formation. In view of this, quartz and feldspar may be considered to be the constituents of beach rocks and sediments. In the study area these two minerals are found to occur but forming lower proportion as reflected from the number and area of the peaks.

3.1.4. Carbonate Minerals (Calcite, Aragonite and Dolomite)

The major absorption bands of carbonate spectra in the 5000–666 cm^{-1} region have been attributed to the fundamental vibrations of the carbonate radical, CO_3^{2-} and various bands have been assigned to correspond to the vibrations of the carbon and oxygen atoms along the crystallographic axial directions.

From the table-1, the presence of calcite in samples is identified from i.r. absorption bands occurring at 2875, 2515, 1800, 1425, 875 & 715cm^{-1} [13-22]. The i.r. absorption bands at 1785, 1475, 1080 & 855cm^{-1} are present in the samples identified by aragonite by comparing with other workers [13-20]. Dolomite is identified by the presences of i.r, absorption band at 2525cm^{-1}

The large number peaks of calcite in the i.r. spectrum indicate the abundance of calcite in the samples and it may be due to the typical beach rock formation. Beach deposits along many coasts were cemented with either aragonite or calcite because some of these “beach rock” derive their cement from seawater. Seawater is several times supersaturated with respect to calcitse and aragonite and also it is the source of the cementing agent calcium carbonate.

3.1.5. Clay Minerals (Kaolinite, Montmorillonite & Illite)

- **Kaolinite**

Kaolinte is a clay mineral crystallizing in the monoclinic system and forming the chief constituent of ***china clay*** and Kaolin. It is a hydrous aluminum silicate commonly formed by weathering and decomposition of rocks containing aluminum silicate compounds; feldspar being the chief source. Kaolinite is present in the samples by the absorption band at 3690, 3660, 3620, &1035cm^{-1} variably in the samples under investigations as is evidenced from the Table-1 [19-22].

- **Montmorillonite**

Montmorillonite is a very soft phyllosilicate mineral that typically forms in microscopic crystals, forming clay. From the values reported in Table-1, the presence of montmorillonite is shown by the absorption band at 475 & 3445cm^{-1} [19-22]. The most distinguishing feature of the montmorillonite spectrum is the broad absorption band that ranges from 3300 to 3500 cm^{-1}. This band typically centered around 3400 cm^{-1} may be due to H-O-H stretching of water molecules present in the interlayer region of montmorillonite [19-22].

- **Illite**

Illite is a non-expanding, micaceous mineral. It occurs as an alteration product of muscovite and feldspar in weathering and hydrothermal environments. It is common in sediments, soils and argillanceous sedimentary rocks as well as in some low grade metamorptic rocks. Infrared features of illite are rarely diagnostic because it is so variable in chemical composition. The presence of peak around 915cm^{-1} in the samples is attributed to illite, it is reported in table-1 [19-20].

Clay minerals such as kaolinite and montmorillonite are present in almost all the samples. Kaolin and montmorillonite appears to arise from the weathering of many kinds of rocks under various climatic conditions. All, therefore, are found in residual soils. Although the clay minerals occur in sediments, kaolinite is the characteristic mineral of an acidic fresh water environment whereas illite or montmorillonite signify an alkaline or sodic lake. The presumed differences however, seem not to be applicable to the fresh, brackish and marine facies of the mollasse. Hence the presence of clay minerals in the samples may contribute towards the occurrence of beach rock formation.

3.2. XRD analysis:

Qualitative mineralogy of the beach rock samples is determined with the standard interpretation procedures of XRD. Major mineral in the studied sample is quartz and calcite. The mineral wise discussion is as follows.

3.2.1. Quartz:

Quartz is ubiquitous and forms one of the most abundant mineral in all the samples. It is identified by the distinctive reflection at 4.26A°, 3.34A°, 2.46A°, 2.28A°, 2.24A°, 1.85A°, 1.67A°, 1.54A°, 1.45A°, 1.38A° and 1.18A°.

3.2.2. Feldspar:

The feldspar mineral is invariably present in all samples. Albite is identified by basal reflection at 4.03A°, 3.64A°, 3.24A°, 3.13A°, 3.18A°, 3.14A°, 2.93A°, 2.84A°, 2.27A° and 1.98A°. The basal reflection at 3.771A°, 3.21A°, 2.98A°, .499A° 1.44A° and 1.333A indicate the presence of orthoclase.

3.2.3. Clay Mineral:
The clay mineral kaolinte is identified in the samples by basal reflection at 1.66A°, 1.78A°, 3.54A° and 3.59A°.

3.2.4. Carbonate Minerals
- **Calcite**

Calcite is identified as the most abundant mineral in the samples by the presence of large no of peaks in diffractogram. It is identified distinct reflections in the d spacing of 3.03A° 3.838A°, 2.832A°, 2.278A°, 2.090A°, 1.925A°, 1.909A°, 1.872A°, 1.621A°, 1.602A°, 1.521A° and 1.438A°.

- **Aragonite**

It is identified by the basal reflections at 3.391A°, 2.693 A°, 2.487 A°, 1.977 A°, 1.619 A°, 1.436 A° and 1.415 A°.

CONCLUSION

The qualitative identification of the minerals in beach rock samples was carried out by using FT-IR and XRD techniques. The combined techniques reveal the presence of minerals such as quartz, orthoclase, albite, kaolinte and montmorlinte in the samples. Beach rock is mostly composed of marine shell fragments (e.g., molluscs, coralline algae, foraminifera) and terrigenous detritus (e.g., quartz and feldspar). The presence of quartz and feldspar in our study indicates that they also play a role for the cementation of beach rock samples.

From the IR and XRD spectra of the samples, the peaks indicating the abundance of minerals such as carbonate groups calcite and aragonite occupy large portion of total peak areas. The high abundance of calcite in the samples was due to the typical beach rock formation. This is may be due to the beach deposits along many coasts were cemented with either aragonite or calcite because some of these “beach rock” derive their cement from seawater. Seawater is several times supersaturated with respect to calcite and aragonite and also it is the source of the cementing agent calcium carbonate. The bulk mineralogy of beach rock samples from the IR and XRD studies reveals that calcite, aragonite and slightly lesser extent quartz are the dominant minerals. A similar mineralogical composition characterizes the beach rocks of other locality.

The advantages of the proposal of FT-IR and XRD approach with respect to the traditional one are tremendous and preparation (no acidic dissolution is necessary), experimental procedure, cleanliness and simplicity) and analysis time. The combined technique gives the information for the cementing minerals in the beach rocks and its formation.

REFERENCES

[1] Gischler E & Lomando, J.A.L. *Sed.Geo.,* 110 **(1997)** 277.
[2] Kneale, D & Viles**,** H.A**,** *Sed.Geo*., 132 **(2000)** 165.
[3] Cooper, J.A.G.,*Mar.Geo*., 98 (**1991)** 145.
[4]. Reddaiah, K, Sivaprakasam, T.E., & Subba Rao., *Ind.Mar.Sci.,* 36 **(1974)** 36.
[5]. Wagle, B.G., *Geo.Mar.Lett.*, 10 **(1990)** 111.
[6] Ravisankar, R, Manikandan, E, Dheenathayalu, M, Brahmaji Rao, M, Seshadressan, N.P & Nair, K.G.M., Nucl. Inst. *Methods in Physics Res* B**.** 251 **(2006)** 496.
[7] Ravisankar, R., *EARFAM*., 19 **(2009)** 372.

[8] Ravisankar, R, Eswaran, P, Seshaderssan, N.P & Brahmaji Rao, M., *Nucl.Sci.Tech*., 18 **(2007)** 204.
[9] Ravisankar, R , Rajalakshmi, A, Eswaran, P, Meenakshisundram, V.M Manikandan, E, Magudapathy, P, Panigrahi, P & Nair, K.G.M., *IJPIXE*, 17 **(2007)** 193.
[10] Ravisankar, R, Eswaran, P, Vijay Anand, K, Rajalakshmi, A, Prasad, M.V.R. Satpathy, K.K, Rajashekhar, C & Alok Athavale., *Nucl. Sci.Tech*., 20 **(2009)** 93.
[11] Karunakaran, C., Ray, K.K. & Saha., *J.Geo.Soc.India*., 9 **(1968)**32.
[12] Srinivasan, M.S., *Oil and Coal News*, (**1968)** 19.
[13] Lyon, R.J.P., Infrared Absorption Spectroscopy, Physical Methods in Determinative Mineralogy, (Ed.Zussman, J.,) Academic press, New York, **(1976)** 371.
[14] ClarenceKarr, Jr., Infrared and Raman Spectroscopy of Lunar and Terrestrial Minerals. Academic Press, Newyork, **(1974)** 10.
[15] Russell, J.D., Infrared methods, A Hand Book of Determinative Methods in Clay Mineralogy, (Ed.Wilson, M.J.,) Blackie and Son Ltd. **(1987)** 85.
[16] Ghosh, S.N., *J.Mat.Sci*., 13 **(1978)** 1877.
[17] Farmer, V.C., Infrared Spectroscopy, Data Hand Book for Clay Materials and other Non-metallic Minerals, Ed.Van Olphen and Fripit, First Edition, Pergaman Press, Oxford, London, **(1979)** 65.
[18] Ravisankar, R, Senthilkimar, G, Kiruba, S, Chandrasekaran, A. & Prince Prakash Jebakumar, *Ind.J.Sci.Tech*., 3(7) (**2010)** 775.
[19] Ravisankar, R, Eswaran, P, Senthilkimar, G, Chandrasekaran, A. & Kiruba, S *E-Journal of Chemistry*. 7(S1) **(2010)** S185.
[20] Ravisankar, R, Rajalakshmi, A. & Manikandan, E. *Acta Ciencia Indica***,** Vol. XXXIIP, No.3 **(2006)** 341.
[21] Ravisankar, R, Kiruba, S, Chandrasekaran, A, Senthilkumar, G.& Maheswaran,C *Ind.J.Sci.Tech*., 3 (8) **(2010)** 858.
[22] Ravisankar, R, Kiruba, S, Chandrasekaran, A, Naseeritheen, A, Seran, M. & .Balaji, P.D., *Ind.J.Sci.Tech*., 3(9) **(2010)** 1016.