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Research Article

DISTRIBUTION AND PETROCHEMICAL PATTERNS OF CARBONATITES-ALKALINE COMPLEX OF SAMALPATTI, DHARMAPURI DISTRICT, TAMILNADU, INDIA

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ABSTRACT
Carbonatites are uncommon carbonate rich igneous rocks generally found in continental intraplate regions and often associated with rift. Carbonate magmatism is a crucial surface expression of deep mantle processes. Carbonatites in Tamil Nadu were discovered in 1967, and form probably the second most important carbonatite province in India. The first known occurrence of carbonatite in South India was reported from Koratti in Tamil Nadu. The carbonatites of Koratti were initially considered to be a band of crystalline limestone with abundant magnetite and apatite crystals, adjacent to the verimiculite bearing pyroxenites. I chose distributional and petrochemical patterns of Samalpatti carbonatite, Tamil Nadu. Samalpatti are mainly composed of dunite, pyroxenite, syenite of various types and different varieties of carbonatites. The trace elements data indicate that the dunite of this area have 40-1400 ppm of Ni, 20-80 ppm of Co, 16-24 ppm of V, and no traces of Mo, Cr, Ag and Bi. The trace element if syenite from the four localities indicate not much variation in Cr, Ni, Co and Mo, but the Senrayanmalai syenite shows higher values of Pb and Zn. Salamarathupatti shows very high value i.e. 300 ppm of V. There is no trace of Cr, Ag, Bi and Mn.

Keywords: *Carbonatites, Rare Elements, Alkaline, Petrochemical*

INTRODUCTION

The rare earth elements (REE) are using various field and its high-technological applications. Globally, few countries are produce and supply of REE from little sources (Verplanck and Van Gosen, 2011). 95% of rare earth elements produced by China, they are to restrict exports of these elements, the price of REE has increased and industrial countries are concerned about supply shortages (Tse, 2011). Carbonatite and alkaline intrusive complexes, as well as their weathering products, are the primary sources of REE (Long *et al.,* 2010). A wide variety of commodities have been exploited from carbonatites and alkaline igneous rocks, such as REE, niobium, phosphate, titanium, vermiculite, barite, fluorite, copper, calcite, and zirconium. Other enrichments include manganese, strontium, tantalum, thorium, vanadium, and uranium (Verplanck and Van Gosen, 2011).

Carbonatites have long been recognized as magmatic rocks (Bell, 1989). Very low silica and high incompatible trace element contents make them unique amongst igneous rocks. Alkaline rocks form an expansive category of igneous rocks. Using a broad definition, alkaline rocks are deficient in SiO_2 relative to Na_2O, K_2O, and CaO (Winter, 2001). Carbonatite-alkaline rocks generally divide in two subclasses namely carbonatites and peralkaline rocks. Carbonatites are defined by the International Union of Geological Sciences (IUGS) system of igneous rock classification as having more than 50 modal percent primary carbonate minerals, such as calcite, dolomite, and ankerite, and less than 20 percent SiO_2 (Le Maitre, 2002). Most identified carbonatites are intrusive bodies, but a few extrusive examples are known, most prominently an active carbonatite volcano in northern Tanzania, Oldoinyo Lengai volcano (Woolley and Church, 2005). Recent work has shown that carbonatites can be quite diverse and likely originate from multiple processes (Woolley, 2003; Mitchell, 2005). Alkaline intrusive rocks also contain elevated concentrations of rare earth elements; these rock types tend to be spatially associated with carbonatites, but not in all examples (Verplanck and Van Gosen, 2011). Alkaline rocks can be further classified based on their chemistry. Peralkaline rocks are one subset of alkaline rocks, defined by $(Na_2O + K_2O)/(Al_2O_3)>1$, and they commonly are enriched in rare earth elements. As a result, understanding the distribution and origin of REE deposits, and identifying and quantifying our nation's rare earth elements resources have become priorities.

Carbonatites were not recognized in India until 1963, when the Amba Dongar complex in Gujarat was first described by Sukeshwala and Udas (1963). Carbonatites in Tamil Nadu were discovered in 1967, and form probably the second most important carbonatite province in India. The first known occurrence of carbonatite in South India was reported from Koratti in Tamil Nadu. The carbonatites of Koratti were initially considered to be a band of crystalline limestone with abundant magnetite and apatite crystals, adjacent to the verimiculite bearing pyroxenites. Deans and Powell (1968) have carried out age dating of biotite-pyroxenite adjacent to Koratti carbonatites and place them at 720±30 million years. Borodin *et al.*, (1971) carried out their investigation for mapping and studying Koratti area as well as other carbonatite occurrences in Tamil Nadu. The Samalpatti carbonatite described by Udas and Krishnamoorthy (1970) is quite different from Koratti carbonatite. This complex occupies an area of about 150 km^2, it's an oval shaped body with the syenite forming the core, enveloped by the ultramafic rocks. Srinivasan (1977), while comparing the carbonatite complex of Hogenakkal with other carbonatite deposits in Tamil Nadu, stated that were emplaced along NNW-SSW fracture zones with in Precambrian gneissic complex. Carbonatite occurs in three distinct zones within Sampalpatti complex explained by Krishnamoorthy *et al.*, (1990).

An outer discontinuous ring of para-ankeritic carbonatite extends in an arcuate fashion within the ultramafic rocks from Pallasulakarai in the south through Mettusulakarai to Reddipatti in the west. Therefore, I chose the distributional and petrochemical nature of cabonatite-alkaline complex of Samalpatti, Tamil Nadu.

MATERIALS AND METHODS

Study Area

In the present study carried out in Samalpatti, is located in Dharmapuri District, Tamil Nadu (Figure 1). It is represented in the portion of Survey of India topographic sheet numbering 57 L/7, published in 1972. The area understudy lies between North Latitude 12º 15′ and 12º 21′ 15′ and East Longitude 78º 22′ 54′ and 78º 30′.

The total extent of the study area is 150 km^2. The Samalpatti complex comprises of dunite, pyroxenite, syenite and carbonatite. The complex as a whole intrudes in a discordant fashion, within the country rock the hornblende epidote gnesis.

According to Moralev *et al.*, (1975) based on the K-Ar method of age determination from the carbonatite occurrences; the age of the complex is considered to be $700 \pm 30 X 10^6$ years. Anilkumar and Gopalan (1991) determined the age of the pyroxenite and carbonatite of Samalpatti and Sevattur complex by Rb/Sr method and found the precise and concordant age of $771 \pm 18 X 10^6$ years.

Geological Sequence of Study Area

The rock types around Samalpatti comprise the Precambrian complex. The stratigraphic position of Carbonatite consist of Calcite carbonatite, Para-ankaeritic carbonatite, Ankaeritic carbonatite rock types.

Sampling Procedure

In each and every outcrop locality, and in well sections, specimens were collected and numbered serially. Characteristic mineralogical variations were carefully noted. Investigating geological features were photographed and detailed description about them was noted down in the field note book. About 16 samples were collected in the area investigation. Samples were collected from Kanjanur, Reddipatti, Balathottam and Parandapalli for investigation of dunite, Olaipatti, Kanjanur, Onnakarai, Mattusulakkarai for pyroxenite, Jogipatti, Salamarathupatti, Kottari and Senrayanmalai for syenite, Olaopatti Garigepalli, Onnakarai and Pallasulakkarai for carbonatite.

Petrochemical and Statistical Analysis

Selected soil and rock samples were petrochemically analyzed using tritration methods. In addition to that, a good amount of geochemical data were availed from Department of Geology and Mining, Tamil Nadu. Chemical analysis of carbonatite, dunite, pyroxenites and soil samples were interpreted.

RESULTS AND DISCUSSION

Results

This study showed that different petrochemical pattern in carbonatite of Dharmapuri district. The petrochemicals range is different in various locations of study area. The results are presented in Tables (1-5).

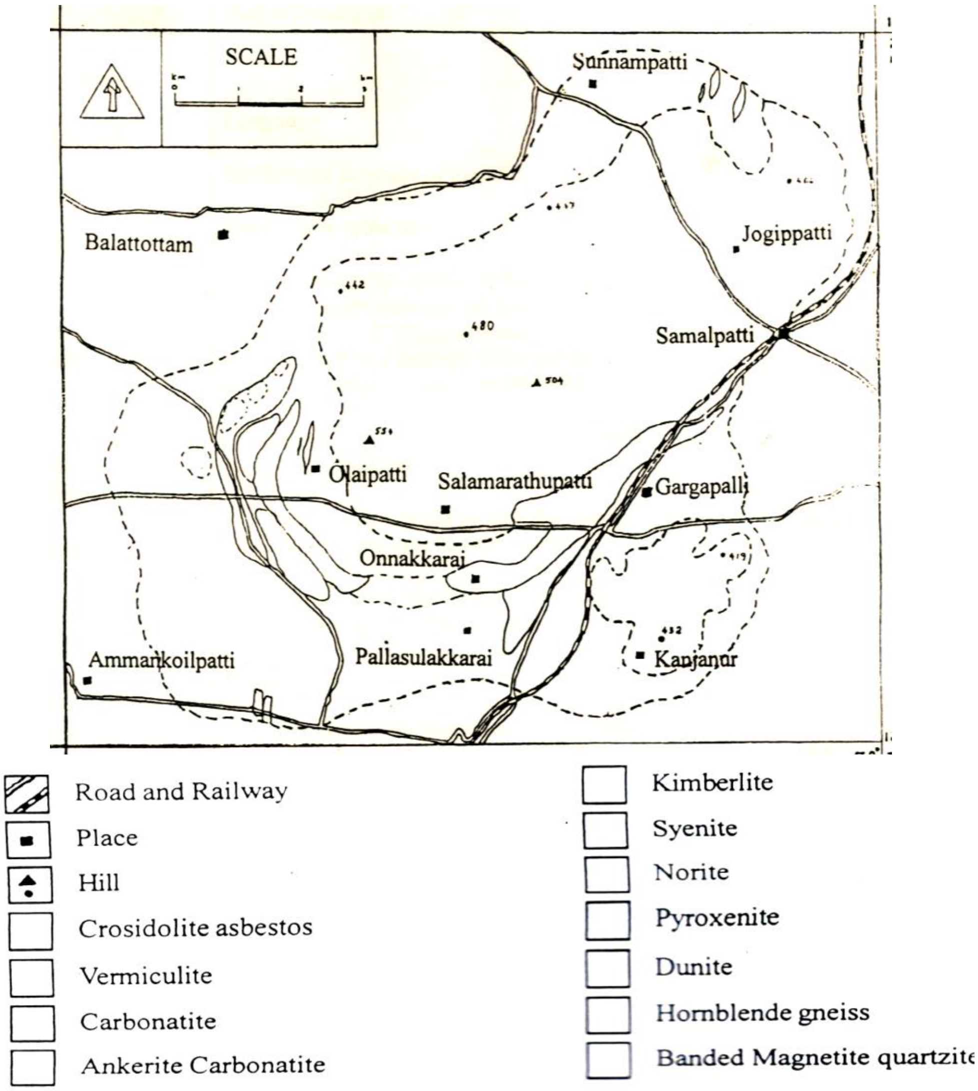

Figure 1: Map Showing Study Area of Dharmapuri District, Tamil Nadu

Discussion

The carbonatite complexes are commonly enriched in carbon, fluorine, phosphorous, manganese, strontium, niobium, barium and the rare earths, especially the lighter lanthanides. In many cases there is also enrichment of vanadium, copper, zinc, molybdenum, lead, thorium and uranium. The ultra-alkali syenite-carbonatite complexes of Samalpatti are mainly composed of dunite, pyroxenite, syenite of various types and different varieties of carbonatites. Good amount of geochemical data are available from the department of geology and mining, Tamil Nadu for the entire alkaline belt of Samalpatti. However, there is no uniformity in the quantum of data available for the pluton as well as for the individual lithologies in terms of major oxides, trace elements, and rare earth elements. An attempt is made in this work to synthesize and present the available data from the published analytical results of different workers (Table 1) in order to understand the geochemical behavior of this carbonatite complex.

The major oxides indicate that the Kanjanoor and Reddipatti dunites are more Mg rich than Balathottam and Parandapalli dunite and vice versa for Ca content. These samples are rich in CaO and this feature is peculiar and different from normal dunite. The trace elements data indicate that the dunite of this area have 40-1400 ppm of Ni, 20-80 ppm of Co, 16-24 ppm of V, and no traces of Mo, Cr, Ag and Bi (Table 2).

Table 1: Mineral Distribution in Carbonatite and Pegmatite of Samalpatti, Dharmapuri District, Tamil Nadu (after Subramanian *et al.*, 1978)

Chemicals	**Calcite, Calcite-Dolomite Carbonite**	**Paraankeritic Carbonatite**	**Benstonite Carbonatite**	**Ankeritic Carbonitite**	**Pegmatite Carbonatite**	**Pegmatite**
Calcite - $CaCO_3$	X	-	-	-	-	-
Dolomite – CaMg $(CO_3)_2$	X	X	X	-	X	-
Paraankerite (CaMgFe) $(CO_3)_2$	X	X	X	X	X	-
Ankerite CaFe $(CO_3)_2$	-	X	X	X	X	-
Bastonite $(CeFO_3)$	-	X	-	-	-	X
Benstonite Ca_2Ba $(CO_3)_3$	-	-	X	-	-	-
Monazite (Ca PO_4)	-	X	-	X	X	X
Apatite Ca_5 $(PO_4)_3F$	X	X	X	-	X	-
Magnetite (Fe F_2O_4)	-	X	X	X	-	-
Ilmeno rutile (TiFe, Nb)O_2 (Nb-rulite)	X	X		X	X	X
Ilmenite Fe TiO_3	X	X	X	X	-	X
Pyrochlore (Ca U)$_2$ Nb_2O_7	-	-	-	-	-	X
Chevkinite $Ce_4Fe_2Ti_3Si_4O_{22}$	-	-	-	-	-	X
C-Fergusonite (Y NbO_4)	-	-	-	-	-	X
Thorite (Th SiO_4)	-	X	X	X	X	X
Zircon (Zr SiO_4)	-	X	X	X	X	X
Perovskite Ca TiO_3	-	-	-	-	-	-
Allanite Ce Ca Fe $Al_2Si_{13}O_{12}(OH)$	-	-	-	-	-	X
Phlogopite $K(MgFe)_3AlSi_3O_{10}(OH)_2$	X	-	-	-	-	-
Olivine $(MgFe)_2SiO_4$	X	-	-	-	-	-
Aegirine $NaFeSi_2O_6$	-	-		X	-	-
Diopside $Ca(MgFe)Si_2O_6$	X	X	-	-	-	-
Vesuvianite $Ca_{10}Al_4MgSi_9O_{34}(OH)_4$	X	-	-	-	-	-
Wollastonite $(CaSiO_3)$	X	-	-	-	-	-
Orthoclase K Al Si_3O_8	X	-	-	-	-	X
Albite Na Al Si_3O_8	-	-	-	-	-	X
Quartz SiO_2	X	-	-	-		X
Baryte (Ba SO_4)	-	X	X	X	X	X
Serpentine $Mg_6Si_4O_{10}(OH)_2$	X	-	-	-	-	
Garnet (Ca_3 Fe_2 Si_3O_{12})	-	-	-	-	-	X
Sphene (Ca TiO_3)	X	-	-	X		X
Riebeckite $Na_2Mg_3Fe_2Si_8O_{22}(OH)_2$	-	X	X	X	X	X
Galena PbS	-	-	-	-	-	X
Pyrite FeS_2	X	-	-	X	X	X
Pyrrhotite Fen +Sn+	X	-	-	-	-	-
Chalcopyrite Cu Fe S_2	X	-	-	-	-	-

Note: X= Present, - = Not recorded

Table 2: Different Chemical Characters of Dunite in Samalpatti, Dharmapuri District, Tamil Nadu

		Locations			
		Kanjanur	**Reddipatti**	**Balathottam**	**Parandapalli**
Major Oxides (in %)	**SiO_2**	33.64	40.68	51.41	5.4
	Fe_2O_3	13.14	6.23	2.71	7.44
	TiO_2	0	0.89	0.11	0
	Al_2O_3	13.56	2.3	15.21	0.58
	CaO	1.38	21.45	22.21	44.37
	MgO	26.68	15.39	3.11	3.58
	K_2O	0	0.41	2.91	0
	Na_2O	0.17	1.04	0.31	0.15
	MnO_2	0.08	0.32	0.01	0.08
	P_2O_5	0.02	0.09	0.01	0.01
	LOI	11.11	11.66	1.21	38.75
	Total	99.78	100.46	99.71	100.36
Trace Elements (in ppm)	**Cu**	10	10	10	10
	Pb	40	40	40	40
	Zn	-	10	10	20
	Ni	1400	40	910	585
	Co	30	20	60	80
	Mn	-	260	-	260
	V	20	16	20	24
	Mo	-	-	-	-
	Cr	-	-	-	-
	Ag	-	-	-	-
	Bi	-	-	-	-

The major oxides of pyroxenite shows higher values of Cao in Kanjanoor, Onnakarai, Mettusulakarai but low in Olaipatti. It may be due to it close association with carbonatite with veins or having carbonatite veins within pyroxenite. Fe_2O_3 values are high indicating the presence of discrete magnetites associated with pyroxenites.

Trace elements of pyroxenites indicate an interesting association. Pyroxenite of Kanjanur has comparatively in the amount 175 ppm of Ni, 1000 ppm of Cr, 32 ppm of V and 80 ppm of Bi. Cr, Ag, Bi are absent in Olaipatti, Onnakarai and Mettusulakarai. The Ni value varies from 40-175 ppm, 8-100 ppm of V, Co and Pb are high in pyroxenites and range from 10-35 ppm and 40-135 ppm respectively (Table 3).

The syenite forms an important rocks unit in this complex. The syenites are saturated syenites and are mainly composed of alkali feldspar with accessory amount of plagioclase and mafic minerals. From the major oxides, it is indicated that MgO content of Salamruthupatti are nil and FeO in Jogirpatti is 0.07% but the CaO shows higher concentration from, 1.97% to 12.23%.

The concentration of K_2O and Na_2O are high in Joripatti and in Senrayanmalai and very low in Kottur and Salamarathupatti.

The trace element if syenite from the four localities (Table 4) indicate not much variation in Cr, Ni, Co and Mo, but the Senrayanmalai syenite shows higher values of Pb and Zn. Salamarathupatti shows very high value i.e. 300 ppm of V. There is no trace of Cr, Ag, Bi and Mn.

Table 3: Behaviour of Major Oxides and Trace Elements of Pyroxenite in Samalpatti, Dharmapuri District, Tamil Nadu

		Locations			
		Olaipatti	**Kanjanoor**	**Onnakarai**	**Mettusulakarai**
Major Oxides (in %)	**SiO_2**	55.35	49.44	41.52	37.78
	Fe_2O_3	13.15	10.18	6.06	11.75
	TiO_2	0	0.4	0.62	0.75
	Al_2O_3	2.42	3.03	10.19	0.12
	CaO	6.35	20.01	35.83	21.3
	MgO	15.3	15.98	0.13	8.71
	K_2O	0.61	0	1.17	0.32
	Na_2O	0.01	0.28	0.57	2.93
	MnO_2	0.16	0.08	0.06	0.15
	P_2O_5	0.01	0	0.14	0.09
	LOI	2.67	0.48	3.78	16.6
	Total	99.55	99.88	100.07	100.5
Trace Elements (in ppm)	**Cu**	10	10	35	10
	Pb	130	40	50	40
	Zn	10	25	15	15
	Ni	40	175	40	40
	Co	20	30	20	20
	Mn	-	300	-	-
	V	24	32	8	100
	Mo	-	2	2	2
	Cr	-	1000	-	-
	Ag	-	4	-	-
	Bi	-	80	-	-

Four different localities show higher concentration of CaO ranging from 24.88% to 50.84%. Out of the four localities, the Olaipatti and Pallasulakarai indicate higher concentration of SiO_2. The MgO content of Olaipatti and Garigepalli is almost nil, but in Palasulakkarai and Onnakarai, it is nearly 6.25%. The higher concentration of MgO and FeO in Onnakarai, Olaipatti, Pallasulakkarai indicate them as para-ankeritic variety. In addition, the samples show the enrichment of phosphorous and sulphur. This may be due to apatite, monazite pyrite and chalcopyrite respectively. The chalcopyrite contains concentration of major elements such as Cu, Pb, Zn, Ni, Co, V and Mo. Among the trace elements the Ni and V concentration is significant. The Ni value is high in Pallasulakkarai and V is high in Olaipatti (Table 5).
According to Le Bas (1980), the subvolcanic domes associated with carbonatite ring complexes are in part generated by the metasomatism, or fenitization, produced by the emplacement of materials of the

carbonatite-alkaline rock association. Sub volcanic domes may also be produced by the emplacement of local clusters of steeply dipping cone sheets.

According to Le Bas (1980), thickening of the continental crust is due to the rising heat, probably associated with the degassing of the deep mantle. The process is enhanced by decompression melting and partial melting by enriched volatile components which causes the flexing and arching up to form crustal domes.

As the dome develops, magma streams towards the central decompressed region. An attempt was made by Sethna (1974) on the updoming and rifting phenomena in relation to the Amba Dongar and surrounding carbonatite.

A great similarity in origin is observed for the study area. Structurally, the Samalpatti carbonatite complex is a ring within the hornblende genesis. The attitude of the rocks are confocal layers or lenses of steeply dipping cones as if they were occupying the concentric cone cracks developed during the updoming of mantle derived carbonatite-alkaline magma along the early developed NE-SW deep main fault.

Table 4: Different Chemical Characters of Syenite in Samalpatti, Dharmapuri District, Tamil Nadu

		Locations			
		Jogipatti	**Salamarathupatti**	**Kottur**	**Senrayanmalai**
Major Oxides (in %)	**SiO_2**	60.88	51.7	68.15	52.4
	Fe_2O_3	40.14	14.22	2.09	10.48
	TiO_2	0.3	1.62	0	0.99
	Al_2O_3	19.3	12.93	19.37	12.26
	CaO	4.16	12.23	1.97	8.48
	MgO	0.77	0	0	6.01
	K2O	7.54	5.18	0.32	4.26
	Na_2O	2.18	0.41	0	3.11
	MnO_2	0.03	0.15	0.65	0.02
	P_2O_5	0.03	0.05	0.02	1.53
	LOI	0.93	1.37	2.6	0.49
	Total	99.99	99.86	95.17	100.03
Trace Elements (in ppm)	**Cu**	10	15	15	20
	Pb	<40	<40	<40	535
	Zn	25	35	10	100
	Ni	<40	<40	<40	<40
	Co	<20	<20	<20	<20
	Mn	-	-	-	-
	V	40	300	60	80
	Mo	<2	<2	<2	<2
	Cr	-	-	-	-
	Ag	-	-	-	-
	Bi	-	-	-	-

Table 5: Comparison of Chemical Behaviour of Carbonatite in Four Different Localities of Samalpatti, Dharmapuri District, Tamil Nadu

		Locations			
		Olaipatti	**Garigepalli**	**Onnakarai**	**Pallasulakkarai**
Major Oxides (in %)	**SiO_2**	30.97	6.5	9.5	27.28
	Fe_2O_3	21.68	0.78	7.6	14.07
	TiO_2	1.08	1.68	0.25	0
	Al_2O_3	2.7	1.01	9.36	1.47
	CaO	2.7	50.84	31.54	25.92
	MgO	24.88	0.85	6.25	6.13
	K_2O	0	0	0	0.63
	Na_2O	3.57	0	0.19	2.97
	MnO_2	0.21	0.09	0.19	0.63
	P_2O_5	1.37	0.02	16.79	0.05
	LOI	13.66	37.86	17.43	20.81
	Total	100.22	99.63	99.3	99.96
Trace Elements (in ppm)	**Cu**	285	25	15	10
	Pb	65	85	60	40
	Zn	65	15	40	10
	Ni	45	40	40	420
	Co	85	20	20	50
	Mn	-	-	-	-
	V	80	40	60	20
	Mo	5	20	2	
	Cr	-	-	-	-
	Ag	-	-	-	-
	Bi	-	-	-	-

Conclusion

Petrologically important kimberlite is identified and reported for the first time in the study area. Mineralogically interesting, crocidolite asbestos is also reported for the first time and their possible paragenesis has been discussed. The area was previously studied for platinum group minerals, molybdenum and radioactive minerals. It is important to recall that location of the study area falls within NE-SW deep main fault, which has played a major role in the emplacement and rare mineralization of carbonatite-alkaline complex. Detailed and correlative study of this carbonatite complex with those of various rift systems containing carbonatite-alkaline complexes. Recent study based on their temporal and spatial association and genetic setting with hydrocarbon deposits considers them indicator for exploration of hydrocarbon/gas hydrate deposits (Ramasamy *et al.*, 2009).

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