UNIVERSITI PUTRA MALAYSIA

ELEMENTAL ASSESSMENTS OF SOUTH CHINA SEA MARINE SEDIMENTS ALONG THE EAST COAST OF PENINSULAR MALAYSIA

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By

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DEDICATION

This thesis is dedicated to:

“My Dear Lavin”

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

ELEMENTAL ASSESSMENTS OF SOUTH CHINA SEA MARINE SEDIMENTS ALONG THE EAST COAST OF PENINSULAR MALAYSIA

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Malaysia is located in the west of the South China Sea and is divided into two major land masses, i.e., Peninsular Malaysia and East Malaysia on the Island of Borneo, with a total coast line of 4675 km (Peninsular Malaysia 2068 km; East Malaysia 2607 km). As most seas, the majority of pollution occurs in the South China Sea arise from the land namely waste that comes from large cities (sewage, industrial waste and hydrocarbons) and agricultural runoff (nutrients, pesticides and fertilizers). The aim of this research is to access information on horizontal elemental distribution of coastal surface sediments and on vertical elemental distribution of offshore core sediments and to determine the status of pollution in the surface and core marine sediments. The results of this research together with experimental data from other

researches on marine sediments on the east coast of Peninsular Malaysia may be used to establish a baseline data for this region.

All together 43 elements were identified and then classified according to heavy metals (As, Cd, Cu, Cr, Ni, Pb and Zn), trace elements (B, Ba, Be, Bi, Br Co, Cs, Ga, Ge, Hf, Li, Mo, Nb, Sc, Rb, Sb, Sn, Sr, Ta, V, W, Y and Zr), rear earth elements (Ce, Dy, Eu, La, Lu, Nd, Sb, Sm and Yb), major elements (Al, Ca, K, Fe, Mg, Mn Na, P, S and Ti), and actinides elements (Th and U) depending on their physical and chemical characteristics. The elemental concentrations of the surface sediments from 10 stations and the core sediments from 5 stations have been determined using the Instrumental Nuetron Activation Analysis (INAA) at Nuclear Agency Malaysia and the Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) at Geological Survey of Iran (GSI) laboratories. To know the status of contamination in heavy metals and trace elements, the enrichment factor, geoaccumulation index (I_{geo}) and modified degree of contamination (mC_d) methods were used to interpret the results. Where appropriate the linear regression analysis, pearson's correlation factors, first and second of the principal component analysis and the cluster analysis were performed to determine the relationships between obtained results.

For the surface elemental distributions, heavy metal Pb was found to be originated from anthropogenic sources at the stations at the larger river mouths of Kelantan, Pahang and Rompin rivers, possibly due to land-based anthropogenic activities, automotive emission and gas industries. However, the average I_{geo} and mC_d values indicate that the heavy metals of the surface sediments are uncontaminated in all sampling stations. The same situation was true for trace elements, except for Hf

which has the enrichment factor greater than 2 in EC8 station. The high concentration of Hf at this station was a natural occurring because of it has negative correlation with Zn in this station similarity with those in nature. Shale averages and chondorite normalized were used to normalize rare earth elements (REEs). Ce was found anthropogenic element, possibly due to occurrence of +4 oxidation states, while other REEs are of non-anthropogenic sources. Most REEs have lower concentrations at the larger river systems and Ce and Eu anomalies occurred in samples taken from the mouths of Kelantan and Pahang rivers. For major elements, Al, Ca, Mg, Na, and Ti were of anthropogenic sources, possibility due to tropical weathering. Both actinides Th and U were non-anthropogenic for all sampling stations except for Kuala Dungun possibility due to a radioactive related factory like among in that area.

For the vertical element distribution, heavy metals As, Cd and Pb; trace elements Br, Hf, Sr and Zr; major elements Ca and Na and actinide element Th were of anthropogenic sources. However, by considering the average I_{geo} and mC_d values, most of the layers in the east coast of Peninsular Malaysia were uncontaminated. Only Hf was the most polluted in affected stations and were classified as moderately to stronger contamination. The chondrite-normalized ratios of REEs showed LREEs enrichment and flat HREE depletion. No Ce anomaly was observed in sediments of all layers in all the stations. Overall, the results showed that the normalized patterns of REEs of the core sediments followed a general pattern of REEs of the world.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

ANALISIS UNSUR ENDAPAN LAUT DARI LAUT CHINA SELATAN SEPANJANG PESISIRAN PANTAI TIMUR SEMENJUNG MALAYSIA

Oleh

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Malaysia terletak di bahagian barat Laut China Selatan dan ia boleh dibahagikan kepada dua kawasan utama iaitu Semenanjung Malaysia dan Malaysia Timur di Pulau Borneo dengan panjang pantai 4675 km (2068 km di Semenajung; 2607 km di Malaysia Timor). Seperti berlaku di kebanyakan laut, pencemaran di Laut China Selatan adalah bersumber daripada tanah dataran oleh sisa buangan daripada kotaraya (air kumbahan, sisa industri dan hidrokarbon) dan sisa pertanian (nutrien, racun serangga dan baja). Tujuan kajian ini adalah untuk mendapatkan maklumat tentang taburan mendatar unsur daripada endapan laut permukaan dan taburaan mencacang daripada endapan laut teras dan seterusnya menentukan status pencemaran permukaan dan teras endapan laut. Keputusan daripada kajian ini bersama-sama dengan data eksperimen daripada kajian-kajian lain mengenai

endapan laut di pantai timur Semenanjung Malaysia boleh digunakan sebagai membena pengkalan data untuk kawasan ini.

Keseluruhannya 43 unsur telah dikenalpastikan dan dikelaskan menurut sebagai logam berat (As, Cd, Cu, Cr, Ni, Pb and Zn), unsur surih (B, Ba, Be, Bi, Br Co, Cs, Ga, Ge, Hf, Li, Mo, Nb, Sc, Rb, Sb, Sn, Sr, Ta, V, W, Y dan Zr), unsure nadir bumi (Ce, Dy, Eu, La, Lu, Nd, Sb, Sm dan Yb), unsur utama (Al, Ca, K, Fe, Mg, Mn Na, P, S dan Ti) dan unsur aktinides (Th dan U) yang ditentukan bergantung kepada cirri-ciri fizik dan kimia. Kepekatan unsur endapan laut permukaan daripada 10 station dan endapan laut teras daripada 5 station telah ditentukan dengan mengunakan Analisis Instrumentasi Pengaktifan Nuklear (INAA) di Agensi Nuklear Malaysia dan mengunakan Aruhan Terganding Plasma-Spektroskopi Penyinaran Atom (ICP-AES) di makmal Geological Survey of Iran (GSI). Untuk mengetahui tahap pencemaran logam berat dan unsur surih, kaedah faktur pengkayaan, indek pengumpulan geologi (I_{geo}) dan darjah pencemaran terubahsuai (mC_d) telah digunakan untuk mentafsirkan keputusan. Dimana-mana yang sesuai analisis regresi liner, faktor korelasi pearson, analisis dua komponen pertama dan analisis guggusan telah dilakukan untuk menentukan hubungan di antara keputusan-keputusan yang diperolehi.

Untuk taburan di permukaan unsur logam berat Pb adalah bersumber antropogen di station bertentangan dengan muara sungai besar iaitu sungai Kelantan, Pahang dan Rompin, kerana banyak aktiviti antropogen di dataran. Walau bagaimanapun, purata nilai I_{geo} and mC_d menunjukkan bahawa endapan di permukaan tidak mengalami pencemaran daripada logam berat di semua station. Keadaan yang sama juga berlaku kepada unsur surih, kecuali Hf yang didapati mempunyai faktur pengkayaan

melebihi 2 di station EC8. Kepekatan tinggi pada Hf di station tersebut berlaku secara semulajadi kerana ia mempunyai kolorasi negative terhadap Zn di station itu sama terdapat pada semulajadi. Purata nilai ternormal terhadap shale dan chondorite telah digunakan untuk unsur nadir bumi. Didapati bahawa Ce adalah antropogen kerana berkemungkinan terdapat keadaan pengoksidan +4 unsur tersebut, sedangkan unsur nadir bumi lain tidak antropogen. Kebanyakan unsur nadir bumi mempunyai kepekatan rendah dalam sistem sungai besar dan anormali Ce dan Eu hanya berlaku pada sampel bertentangan muara sungai Kelantan dan Pahang. Unsur utama Al, Ca, Mg, Na, dan Ti adalah antropogen, berkemungkinan kerana keadaan luluhhawa tropika. Kedua aktinides Th dan U adalah tidak antropogen di semua station kecuali di Kuala Dungun berkemungkinan daripada kilang berkaitan bahan radioaktif seperti among di kawasan ini.

Untuk taburan unsur serenjang logam berat As, Cd dan Pb; unsur surih Br, Hf, Sr dan Zr; unsur major Ca dan Na dan unsur aktinide Th didapati adalah antropogen. Unsur-unsur lain adalah tidak antropogen. Bagaimanapun, dengan mengambil purata nilai I_{geo} and mC_d kebanyakan lapisan sampel teras bagi pantai timur Semenenjung Malaysia sebenarnya tidak mangalami pencemaran. Kecuali Hf adalah unsur paling tercemar di station yang terlibat dan dikelaskan di antara pencemaran serdahana dan pencemaran berat. Untuk unsur nadir bumi nisbah ternormal terhadap chondrite menunjukkan pengkayaan unsur nadir bumi ringan dan pengurangan unsur nadir bumi berat. Tiada anormali Ce terdapat pada semua lapisan sampel endapan teras di semua station. Keseluruhannya daripada keputusan kajian ini menunjukkan corak unsur nadir bumi bagi endapan teras adalah sama seperti ditempat-tempat lain di dunia.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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