Stream Sediments Geochemistry from Dili and Manatuto Districts. Implications for mineral resources exploration

Nogueira, P.1, Vilanova, V.2, Rodrigues, D.3

Abstract
A field campaign was conducted aiming to verify a significant number of mineral occurrences in the geological literature of Timor-Leste. During this campaign a set of 45 samples of stream sediments were collected and analysed for 35 elements. The results of this campaign are presented discussing the confirmation and refute of the occurrences.

Resumo
Uma campanha de amostragem foi realizada procurando confirmar um número significativo de ocurrências minerais que se encontram descritas na bibliografia geológica sobre Timor-Leste. Foram recolhidas 45 amostras de sedimentos de linha de água e analisados para 44 elementos. Neste trabalho são apresentados os resultados obtidos e discutida a confirmação e refutação das descrições existentes.

Introduction
Since the first geological studies in Timor Leste by the team of Wittouck (1937) a series of mineral occurrences have been described in the territory. Latter studies in the decade of 60's of last century from Leme (1968) and Audley-Charles (1968), provided further descriptions of the mineral occurrences. Under Indonesian occupation Lacerda (1999) provided a compilation of the mineral resources of Timor Leste.
It is necessary to underline that none of this occurrences was ever explored in an industrial scale, exception given to some small extension exploration of Marble in Behau, Manatuto District.
In order to confirm or refute the presence of mineral potential in some of the identified areas a stream sediment sampling campaign. The samples were subjected to mineralogical and geochemical studies.
This work presents the results obtained by the geochemical anaçysis providing new insights for mineral resources exploration in the DIli and Manatuto Districts.

Geological Setting
Haig et al (2008) defined four main tectonostratigraphic units for Timor: (1) Gondwana Megasequence deposited in the East Gondwana Rift System during the latest Carboniferous to Middle Jurassic; (2) the Australian-Margin Megasequence deposited between the Late Jurassic to early Late Miocene in a plateau contiguous with the Australian mainland; (3) Banda Terrane with Mesozoic metamorphic basement and sedimentary cover units of Asian affinity; and (4) Synorogenic Megasequence deposited during the latest Miocene to Pleistocene.
The cartography of the geological formations was defined by Leme (1968) and Audley-Charles (1968) in a 1:500.000 and 1:250.000 scales respectively.

Sampling and data analysis

For this work 44 samples were collected in stream sediments (Figure 2) from the districts of Dili and Manatuto, mainly focusing in localities where previously mineral occurrences have been described.

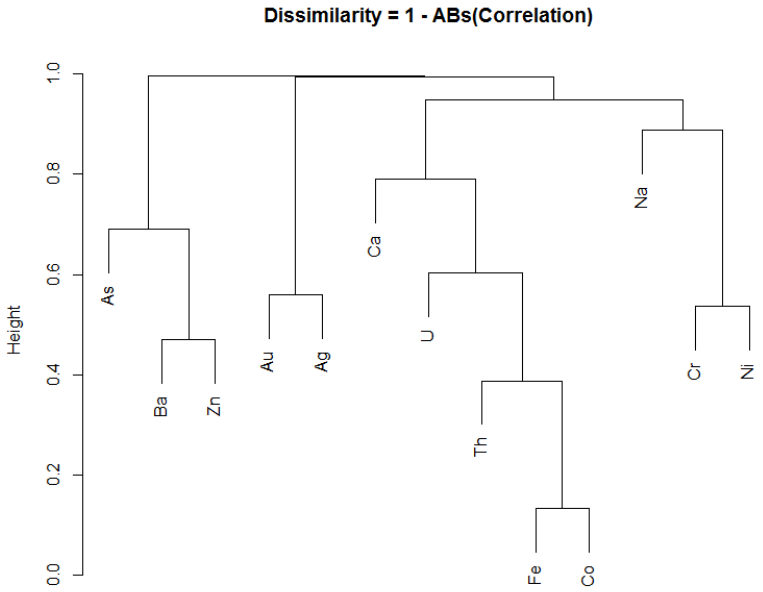
The stream sediments have been sieved to minus 100 microns, the sieved fraction was further homogenized and prepared ready for analysis in the Activation Laboratories Ltd, Ancaster, Ontario, Canada. The concentrations of 35 minor and trace elements was determined by Inductively Coupled Plasma- Mass Spectrophotometer (ICP-MS). Of the elements analysed Ir, Mo and Sr displayed values below the limit detection of the method and were excluded from the analysis.

Results obtained

The data was processed using the R statistical software and for presenting the results the software QGIS was used. Table 1 presents the summary of the results obtained for some of the more relevant elements divided according to Goldschmidt classification.

Litophyle					
Ca (%)	**Na (%)**	**Ba (ppm)**	**Th (ppm)**	**U (ppm)**	**Cr (ppm)**
Min. : 3.000	Min. :0.2500	Min. : 300	Min. : 1.900	Min. :2.70	Min. : 40
1st Qu.: 5.000	1st Qu.:0.6600	1st Qu.: 700	1st Qu.: 7.975	1st Qu.:3.60	1st Qu.: 70
Median : 6.000	Median :0.7100	Median : 1250	Median :11.250	Median :4.45	Median : 160
Mean : 5.857	Mean :0.7602	Mean : 4068	Mean :12.493	Mean :4.45	Mean : 2473
3rd Qu.: 7.000	3rd Qu.:0.8600	3rd Qu.: 4075	3rd Qu.:16.225	3rd Qu.:5.10	3rd Qu.: 870
Max. :10.000	Max. :1.7500	Max. :24700	Max. :23.200	Max. :6.90	Max. :35800
NA's :31	NA	NA's :11	NA's :1	NA's :23	NA
Siderophile					
Fe (%)	**Au (ppb)**	**Co (ppm)**	**Ni (ppm)**		
Min. : 3.88	Min. : 14.0	Min. : 8.00	Min. : 500		
1st Qu.: 7.02	1st Qu.: 39.0	1st Qu.: 23.00	1st Qu.: 500		
Median :10.30	Median : 48.5	Median : 33.00	Median : 600		
Mean :13.36	Mean : 243.6	Mean : 41.07	Mean : 700		
3rd Qu.:18.50	3rd Qu.: 173.2	3rd Qu.: 55.00	3rd Qu.: 800		
Max. :27.70	Max. :1160.0	Max. :117.00	Max. :1100		
NA	NA's :33	NA	NA's :40		
Calcophyle					
Zn (ppm)	**Ag (ppm)**	**As (ppm)**			
Min. :200.0	Min. :10.0	Min. : 8.00			
1st Qu.:200.0	1st Qu.:10.5	1st Qu.: 18.75			
Median :300.0	Median :11.0	Median : 33.00			
Mean :321.1	Mean :11.0	Mean : 54.68			
3rd Qu.:350.0	3rd Qu.:11.5	3rd Qu.: 70.50			
Max. :800.0	Max. :12.0	Max. :285.00			
NA's :26	NA's :43	NA's :1			

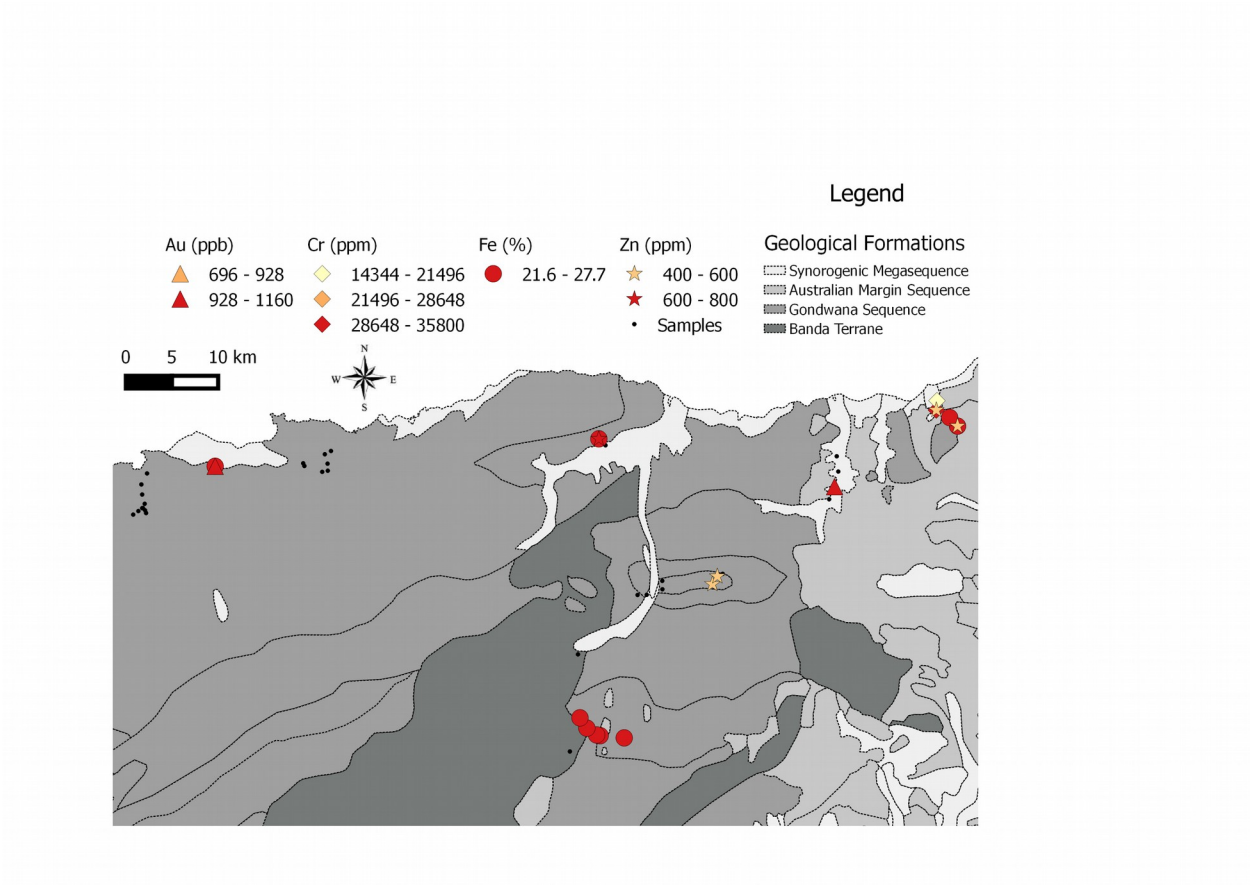
A hierarchical cluster analysis was done using the selected elements using the factor 1-abs(correlation). The values obtained were plotted as dendrogram in figure 2.



From this data it is clear the existence of four groups of elements that can be related with different types of mineral occurrences. The group that includes - Ca, U, Th, Fe and Co is clearly related with the existence of iron nodules presented in some of the carbonate formations. The group that comprises Na, Cr, Ni is related with the ultrabasic rocks present in the Ilimanu ranges (near Manatuto), the group of Au and Ag is clearly related with alluvial gold, present in the sediments around dili streams. The As, Ba and Zn group is somewhat more difficult to relate with some of the geological formations but the higher values occur in the sequences of para-autochthon rocks from Audley-Charles (2011).

Conclusions

The data obtained from our samples allows to confirm the existence of mineral potential for gold, chromium and iron (and possibly manganese as nodules). In figure 2 a map was created with the values that correspond to the right tail of the distribution (anomalous values).
With this results it is already possible to outline further detailed geological and geochemical studies in the potential areas defined in this work,



Acknowledgements

Part of this work was funded by the Secretaria de Estado dos Recursos Naturais in the year of 2011.

References

Audley-Charles, M. G. (1968). The Geology of Portuguese Timor. Mem. Geol. Soc. London 4, 1–76.

Haig, D. W. (2004). Stratigraphic reconstruction of Timor Leste and correlation to the Bonaparte Basin (abstract). PESA (Petroleum Exploration Society of Australia) Newsletter, December.

Haig, D.W., McCartain, E.W., Keep M., & Barber, L. (2008). Re-evaluation of the Cablac Limestone at its type area, East Timor: Revision of the Miocene stratigraphy of Timor. J. Asian Earth Sci. 33(5-6), 366-378.

Keep, M., Haig, D.W., 2009. Deformation and exhumation in Timor: Distinct stages of a young orogeny, Tectonophysics.

Lacerda, Vicente. (1999). Data Statistik Bahan Galian Tambang Daerah Timor Timur. Unplublished.

Lacerda, Vicente. (1999). Data Statistik Bahan Galian Tambang Daerah Timor Timur. Informal report for the Voluntary Mining and Resource Comission, Dile. East Timor.

Leme, J. de Azeredo. 1968. Breve ensaio sobre a geologia da provincia de Timor. Curso de Geologia de Ultramar 1, 105-161.

Wittouck, S.F., 1937. Exploration of Portuguese Timor. Report of Allied Mining Corp. to Asia Investment Co. Ltd., Amsterdam (Kolff).