DIAGENESIS - VERY LOW GRADE METAMORPHISM IN THE METAPELITES ON BUÇACO SYNCLINE, PORTUGAL

F. Rocha

Industrial Minerals and Clays Centre, Dpt. Geociencias, Univ. Aveiro, 3810-193 Aveiro, Portugal, frocha@geo.ua.pt

INTRODUCTION

Different geothermometers can be used on areas affected by low temperature metamorphism. Fluid inclusion data, illite or chlorite «crystallinities» and vitrinite reflectance are quite widely used parameters. A scientific program for the assessment of the above mentioned geothermometer data consistency in various Portuguese low grade metamorphic formations has been established and is under development. For the development of the scientific program of testing geothermometer data consistency, a first sampling campaign was carried out in lithologies of different ages in the Buçaco syncline. The main goal of this work is to present data concerning clay mineralogy (in particular, illite and chlorite «crystallinities») and to compare these results with those from organic petrology and fluid-inclusion study of these metapelitic materials.

In the Central Iberian Zone of Portugal, several anticlines and synclines occur in which a Lower Palaeozoic sequence overlays Precambrian-Cambrian metasediments. The Early Ordovician to Early Devonian rocks were affected by very low to low temperature metamorphism during the Variscan orogeny. The stratigraphical sequence comprises a series of detrital rocks (conglomerates, quartzites, slates and black shales) in a general transgressive sequence. In the Upper Ordovician a volcanic succession of diabases and intrusive dolerites is also present. The Buçaco syncline, in Central Portugal (Figure 1), presents an almost continuous sequence from Lower Ordovician to Silurian. Above an unconformity upper Carboniferous terrestrial sediments also occurs. Several Cretaceous and Quaternary sediments cover part of the syncline.

MATERIALS AND METHODS

A sampling campaign was carried out in lithologies (blackshales, slates and graywackes) of different ages in the Buçaco syncline. A total of 30 samples from 5 geological sections (Dornes, Penacova, Poiares, Ceira and Buçaco) were collected. For each sample the mineralogical composition of both total rock and clay fraction (separated by sedimentation, according to Stokes law), was determined by X-ray diffraction (CuKα-radiation) on Philips PW1130/90 and X'Pert PW3040/60 equipments. The clay fraction (<2μm) was analysed on oriented aggregates. Qualitative and semi-quantitative mineralogical analyses followed criteria recommended by Thorez (1976), Mellinger (1979) and Pevear & Mumpton (1989). Illite «crystallinity» was assessed through the Kübler (1964) index, according to Kisch (1991). Esquevin (1969) index was also assessed.

RESULTS AND DISCUSSION

Preliminary results presented by Rocha and Gonçalves (2004) showed that Illite, being always the predominant clay mineral, decreases from bottom to top of the studied sequence, followed by Chlorite, whereas Kaolinite shows an opposite trend. Some Ordovician samples show evidences of the presence of irregular 10-14 mixed-layers (in general, Illite-Chlorite type). The definition and evolution of clay minerals associations along the studied sections (Table 1) allowed us to characterize the different units:

- Silurian (D Unit) is characterized by an Illite + Kaolinite (+ Chlorite) association;
- Top levels of Upper Ordovician (C4 Unit) is characterized by an Illite + Kaolinite + Chlorite (+ mixed-layers Illite-Chlorite) association;
- Lower levels of Upper Ordovician (C1 and C2 Units) are characterized by an Illite (+ Kaolinite + Chlorite) association;

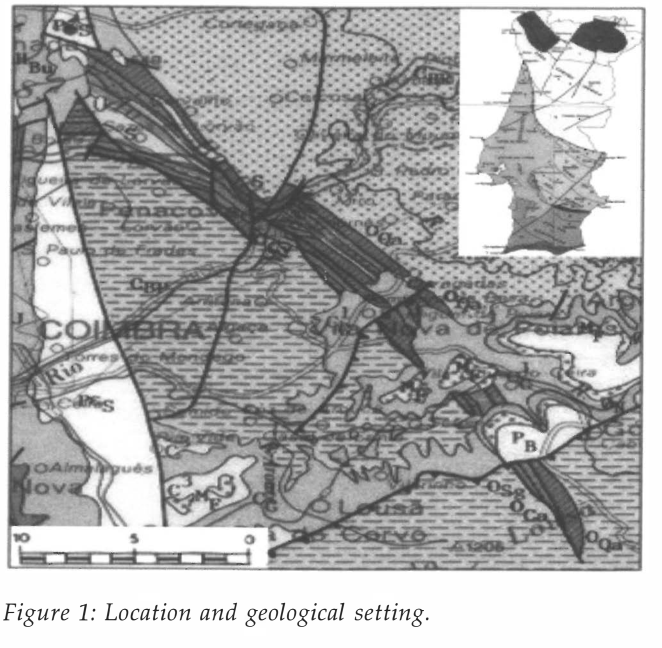

Figure 1: Location and geological setting.

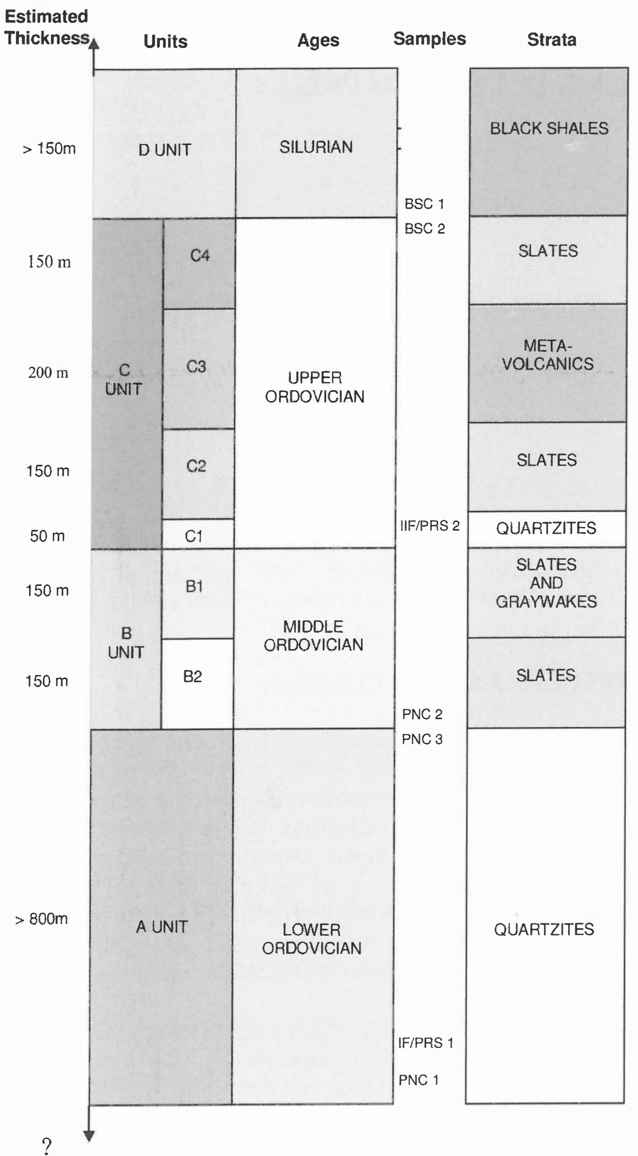

Figure 2: Schematic stratigraphic column (showing the studied sections position).

·Middle Ordovician (B1 and B2 Units) is characterized by an Illite (+ Kaolinite + Chlorite + mixed-layers Illite-Chlorite) association;

·Lower Ordovician (A Unit) is characterized by an Illite (+ Kaolinite) association.

The obtained Kübler Index values (Figure 3) show that Illite crystallinity increases from the Upper Ordovician to the Lower Ordovician (the majority of the samples being plotted in the Very Low Grade Metamorphism field with a few samples being plotted in the Low Grade Metamorphism field). From the obtained Esquevin Index values it is possible to conclude that almost all the samples are Al-rich (showing values upper than 0.4). As Chlorite is not present in all samples, it was not possible to assess Chlorite crystallinity for all studied units; nevertheless, the obtained values show an evolution along the studied stratigraphic sections in good agreement with KI values. We have also made a simple qualitative estimate of the existence of Illite polytypes by comparing two Illite peaks heights, the 2.58 Å reflection, present in both polytypes, and the 2.80 Å reflection, which appears only in the 2M1 polytype. Only the polytype $1M_d$ has been identified in all samples. However, we found evidences of polytype $2M_1$ in some of the samples showing a slightly higher metamorphic grade. On the other hand, it was not found any evidence of paragonitic component.

From these results, some considerations can be put forward concerning the post-sedimentary evolution. All studied samples show evidences of very advanced diagenesis reaching the Very Low Grade Metamorphism field for the major part of them, with a normal increasing trend from top to bottom of the sequence; the Upper Ordovician samples show a positive anomaly towards this trend, most probably in relation to the volcanic and intrusive activities. Greywackes in general show minor evolution than shales and slates, in particular those outcropping in Poiares section. On the other hand, the absence of Paragonite, the scarce occurrence of Illite polytype $2M_1$, and the persistency of irregular 10-14 mixed-layers are evidences of not reaching the Low Grade Metamorphism field.

The combined analysis of the obtained results (concerning Illite crystallinity, Illite polytypes and clay mineral associations) with those obtained by Dória *et al.* (2002),

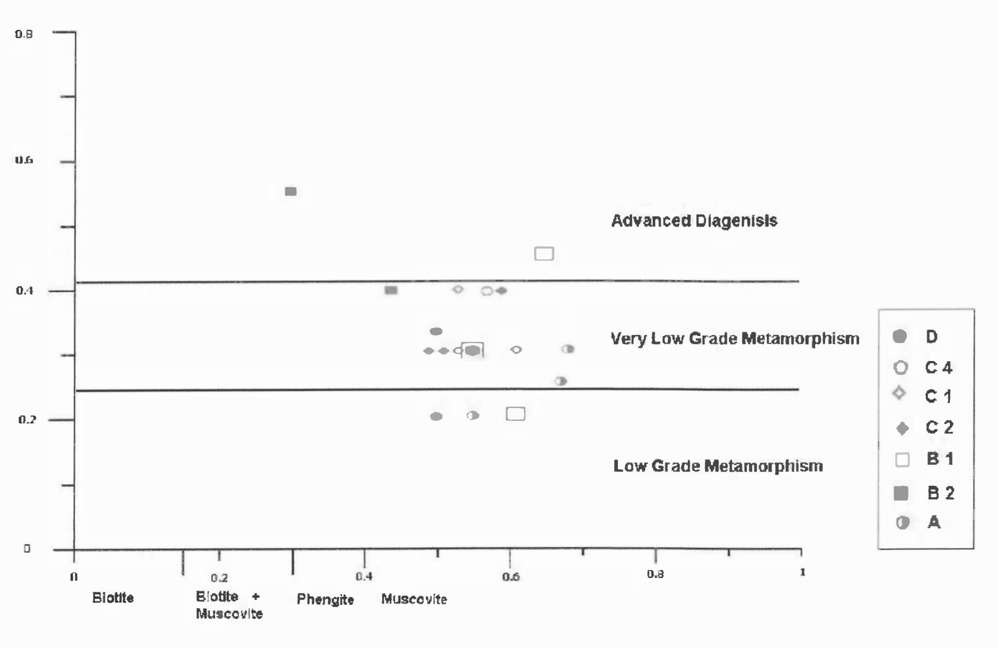

Figure 3: Kübler and Esquevin Indexes values.

Ages	Units	Penacova section		Buçaco section		Poiares section	
Upper Ordovician	D			Esquevin I.	0,56	Esquevin I.	0,5 - 0,55
				Kübler I.	0,3	Kübler I.	0,2 - 0,3
				Clay Ass.	I	Clay Ass.	IK - IKC
Middle Ordovician	C4			Esquevin I.	0,57		
				Kübler I.	0,4		
				Clay Ass.	IKC(10-14)		
	C2					Esquevin I.	0,49 - 0,59
						Kübler I.	0,3 - 0,4
						Clay Ass.	IC - IK
	C1					Esquevin I.	0,53 - 0,61
						Kübler I.	0,3 - 0,4
						Clay Ass.	I - Ikc
Lower Ordovician	B2					Esquevin I.	0,55 - 0,64
						Kübler I.	0,2 - 0,45
						Clay Ass.	IK - Ik(10-14)
	B1	Esquevin I.	0,55			Esquevin I.	0,32 - 0,43
		Kübler I.	0,3			Kübler I.	0,4 - 0,55
		Clay Ass.	I			Clay Ass.	IKc
Silurian	A	Esquevin I.	0, 67 - 0,68			Esquevin I.	0,55
		Kübler I.	0,25 - 0,3			Kübler I.	0,2
		Clay Ass.	I			Clay Ass.	IK

Table 1: Clay minerals associations, Kübler and Esquevin Indexes along the studied sections.

trough Vitrinite reflectance and fluid inclusions, show good consistency, all data together pointing to a range of temperatures from 150^0 C to 200^0 C in the Lower to Middle Ordovician and of 100^0 C to 150^0 C in the Upper Ordovician to Silurian.

CONCLUSIONS

Lower part of the section is almost monominerallic (illitic) in what concerns clay minerals. The majority of the samples show KI values corresponding to the Very Low Grade Metamorphism field. The results obtained for the KI showed good correlation with those obtained by Organic Petrography, namely the vitrinite reflectance. The combined analysis of Illite crystallinity, Vitrinite reflectance and fluid inclusions allowed to establish temperature ranges discriminating Lower to Middle Ordovician from Upper Ordovician to Silurian.

REFERENCES

Dória, M.A.; Fernandes, J.; Flores, D.; Fontoura, M.J.; Lemos de Sousa, M.J.; Marques, M.; Nogueira, P.; Noronha, F. y Pereira, G. (2002). Abstr. 54th ICCP meeting, Maputo and Pretoria, 1-3

Esquevin, J. (1969). Bull. Centre Rech. Pau, 3, 147-154

Kisch, H.J. (1991). J. Metamorphic Geol., 9, 665-670.

Kübler, B. (1964). Rev. Inst. Fr. Pétrole, 19, 1093-1112.

Mellinger, R.M. (1979). Saskatchewan Research Council (Canada) SRC Report G-79, 1-46.

Pevear, D.R. y Mumpton, D.R. (1989). CMS Workshop Lectures, 1. The Clay Minerals Society, Colorado (USA).

Rocha, F. y Gonçalves, A.C. (2004). Acta Mineral. Petrogr. Abstr. Ser., Univ. Szeged (Hungary), 4, 92.

Thorez, J. (1976). Practical identification of clay minerals. Editions G. Lelotte, Belgique. 99 pp.