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*Supplement of*

## **Deciphering the metamorphic evolution of the Pulo do Lobo metasedimentary domain (SW Iberian Variscides)**

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## UTM coordinates of samples

Sample	UTM coordinates	
PLB-	X	Y
71	656571	4202532
73	656937	4201969
74	657683	4201284
76	657817	4200264
77	658462	4197940
79	658244	4194716
80	657370	4194128
81	657412	4191653
82	657768	4189514
84 (map 2)	657448	4186921
85	658363	4185606
86	669833	4186562
87	669676	4187664
88 (map 1)	669708	4187924
89	669869	4188826
91	674526	4196530
93 (map 3)	674985	4196974
7C	669881	4188776

## Chlorite thermometry

The approach of Vidal et al. (2005 and 2006) is based on five chlorite end-members, which are Mg-amesite ( $\text{Al}_2\text{Mg}_4[\text{Al}_2\text{Si}_2]\text{O}_{10}(\text{OH})_8$ ), Fe-amesite ( $\text{Al}_2\text{Fe}_4[\text{Al}_2\text{Si}_2]\text{O}_{10}(\text{OH})_8$ ), daphnite ( $\text{AlFe}_5[\text{AlSi}_3]\text{O}_{10}(\text{OH})_8$ ), clinochlore ( $\text{AlMg}_5[\text{AlSi}_3]\text{O}_{10}(\text{OH})_8$ ) and sudoite ( $\text{Al}_3\text{Mg}_2\text{□}_1[\text{AlSi}_3]\text{O}_{10}(\text{OH})_8$ ), while the Bourdelle thermometer (Bourdelle et al., 2013) uses as end-members Al-free Fe-chlorite ( $\text{Fe}_6\text{Si}_4\text{O}_{10}(\text{OH})_8$ ), Al-free Mg-chlorite ( $\text{Mg}_6\text{Si}_4\text{O}_{10}(\text{OH})_8$ ), Mg-amesite ( $\text{Al}_2\text{Mg}_4[\text{Al}_2\text{Si}_2]\text{O}_{10}(\text{OH})_8$ ), Fe-amesite ( $\text{Al}_2\text{Fe}_4[\text{Al}_2\text{Si}_2]\text{O}_{10}(\text{OH})_8$ ), Fe-sudoite ( $\text{Al}_3\text{Fe}_2\text{□}_1[\text{AlSi}_3]\text{O}_{10}(\text{OH})_8$ ) and Mg-sudoite ( $\text{Al}_3\text{Mg}_2\text{□}_1[\text{AlSi}_3]\text{O}_{10}(\text{OH})_8$ ). To estimate chlorite temperature by using the Bourdelle thermometer, quartz and water activities are considered equal to 1 and all iron is considered as  $\text{Fe}^{2+}$ . Besides, the approach of Vidal et al. (2005 and 2006) proposes a coeval estimate of  $\text{Fe}^{3+}$  content in chlorite and equilibrium temperature at a given pressure. This approach is based on multiequilibrium, i.e. it calculates simultaneously four chlorite-quartz equilibria. The position of these equilibria depends on chlorite end-member, quartz and water activities. In this work, temperatures and  $\text{Fe}^{3+}$  content were estimated for each chlorite analysis by considering water activity equal to 1, and 5 kbar as the maximum reasonable pressure. According to Vidal et al. (2005 and 2006), thermodynamic equilibrium is obtained when, considering the minimum  $\text{Fe}^{3+}$  proportion, the temperature difference between the four used equilibria is less than 30 °C (Lanari et al., 2012 and references therein). Grosch et al. (2012) have shown that maximum temperatures are derived for minimum  $\text{Fe}^{3+}$  contents, but equilibrium between the four chlorite equilibria can be maintained at lower temperature for increasing  $\text{Fe}^{3+}$  contents. Several crystallochemical and thermodynamic criteria, specific to each model, allow discarding inadequate compositional analysis, such as those including smectitic compositions.

Bourdelle, F., Parra, T., Chopin, C., Beyssac, O.: A new chlorite geothermometer for diagenetic to low-grade metamorphic conditions, *Contributions to Mineralogy and Petrology*, 165(4), 723-735, 2013.

Grosch, E.G., Vidal, O., Abu-Alam, T., McLoughlin, N.: P-T constraints on the metamorphic evolution of the Paleoproterozoic Kromberg type-section, Barberton greenstone belt, South Africa, *Journal of Petrology*, 53(3), 513-545, 2012.

Vidal, O., Parra, T., Vieillard, P.: Thermodynamic properties of the Tschermak solid solution in Fe-chlorite: application to natural examples and possible role of oxidation, *American Mineralogist*, 90, 347-358, 2005.

Vidal, O., de Andrade, V., Lewin, E., Muñoz, M., Parra, T., Pascarelli, S.: P-T-deformation- $\text{Fe}^{3+}/\text{Fe}^{2+}$  mapping at the thin section scale and comparison with XANES mapping. Application to a garnet-bearing metapelite from the Sambagawa metamorphic belt (Japan), *Journal of Metamorphic Geology*, 24, 669-683, 2006.

## Raman Spectroscopy of carbonaceous material calculations

Spectra were processed with the software Peakfit. For higher temperature rocks (330-650 °C), Beyssac et al. (2002) established a correlation between temperature and CM Raman ratio parameter R2 (defined as  $R2=D1/(G+D1+D2)$ , where G is the area of a single main spectral band  $\approx 1580 \text{ cm}^{-1}$  that corresponds to the Raman spectrum of perfect graphite, and D1 and D2 are the areas of minor bands at  $\approx 1350 \text{ cm}^{-1}$  and  $\approx 1620 \text{ cm}^{-1}$ , respectively, which correspond to disorganized CM). The R2 parameter is temperature dependent through the equation  $T(^{\circ}\text{C})=-45R2+641$ . R2 ranges from 0 to 0.7 and is inversely proportional to the temperature, which varies from 330 to 650 °C  $\pm 10-15 \text{ }^{\circ}\text{C}$  (Beyssac et al., 2004). For lower temperature rocks (<330 °C), the spectrum is more complex and composed of the graphite G band that overlaps with the D2 band ( $\approx 1620 \text{ cm}^{-1}$ ), D1 band ( $\approx 1350 \text{ cm}^{-1}$ ), plus D3 ( $\approx 1500 \text{ cm}^{-1}$ ) and D4 ( $\approx 1200 \text{ cm}^{-1}$ ) bands. There are two area ratios (RA) that relate the evolution of the Raman spectrum with increasing metamorphic grade:  $RA1=(D1+D4)/(D1+D2+D3+D4+G)$  and  $RA2=(D1+D4)/(D2+D3+G)$ . The relationship between the area ratios and the temperature is  $RA1=0.0008T+0.3758$  and  $RA2=0.0045T+0.27$ .

Beyssac, O., Goffé, B., Chopin, C., Rouzaud, J.N.: Raman spectra of carbonaceous material in metasediments: a new geothermometer, *Journal of Metamorphic Geology*, 20, 859-871, doi: 10.1046/j.1525-1314.2002.00408.x, 2002.

Beyssac, O., Bollinger, L., Avouac, J.P., Goffé, B.: Thermal metamorphism in the lesser Himalaya of Nepal determined from Raman spectroscopy of carbonaceous material, *Earth and Planetary Science Letters*, 225, 233-241, doi: 10.1016/j.epsl.2004.05.023, 2004.



RA1 and RA2 values and calculated maximum temperatures from all the Raman Spectra (RS) of CM analyzed in samples from the Santa Iría formation. Std Dv: standard deviation. Std Err: standard error (calculated as the standard deviation divided by  $\sqrt{n}$ ).

RS (n=17)	RA1	T <sub>max</sub> (°C)	RA2	T <sub>max</sub> (°C)	RS (n=16)	RA1	T <sub>max</sub> (°C)	RA2	T <sub>max</sub> (°C)
<b>Mean</b>	<b>0.629</b>	<b>316</b>	<b>1.696</b>	<b>317</b>	<b>Mean</b>	<b>0.638</b>	<b>327</b>	<b>1.761</b>	<b>331</b>
<b>Std Dv</b>	<b>0.009</b>	<b>12</b>	<b>0.067</b>	<b>15</b>	<b>Std Dv</b>	<b>0.007</b>	<b>9</b>	<b>0.053</b>	<b>12</b>
<b>Std Err</b>		<b>3</b>		<b>4</b>	<b>Std Err</b>		<b>1</b>		<b>3</b>
<b>PLB71-39</b>	0.634	323	1.731	325	<b>PLB73-1</b>	0.631	319	1.712	321
<b>PLB71-41</b>	0.605	286	1.531	280	<b>PLB73-14</b>	0.630	318	1.701	318
<b>PLB71-42</b>	0.634	323	1.733	325	<b>PLB73-17</b>	0.628	316	1.691	316
<b>PLB71-43</b>	0.636	326	1.750	329	<b>PLB73-20</b>	0.633	321	1.724	323
<b>PLB71-44</b>	0.633	322	1.726	324	<b>PLB73-21</b>	0.636	325	1.748	328
<b>PLB71-45</b>	0.630	317	1.699	318	<b>PLB73-22</b>	0.629	317	1.696	317
<b>PLB71-46</b>	0.640	330	1.779	335	<b>PLB73-23</b>	0.641	332	1.786	337
<b>PLB71-47</b>	0.628	315	1.689	315	<b>PLB73-24</b>	0.637	327	1.756	330
<b>PLB71-48</b>	0.638	327	1.759	331	<b>PLB73-25</b>	0.633	322	1.725	323
<b>PLB71-49</b>	0.614	298	1.592	294	<b>PLB73-26</b>	0.633	321	1.724	323
<b>PLB71-50</b>	0.636	325	1.747	328	<b>PLB73-27</b>	0.643	335	1.805	341
<b>PLB71-52</b>	0.623	309	1.654	308	<b>PLB73-28</b>	0.648	341	1.844	350
<b>PLB71-53</b>	0.633	322	1.728	324	<b>PLB73-29</b>	0.645	337	1.820	344
<b>PLB71-54</b>	0.637	326	1.753	330	<b>PLB73-30</b>	0.643	334	1.800	340
<b>PLB71-55</b>	0.622	308	1.648	306	<b>PLB73-31</b>	0.644	335	1.806	341
<b>PLB71-56</b>	0.626	313	1.674	312	<b>PLB73-6</b>	0.648	340	1.837	348
<b>PLB71-57</b>	0.620	305	1.630	302					