DECOMPRESSION AT DECREASING TEMPERATURES IN ECLOGITE-FACIES METAPELITES (EL ORO METAMORPHIC COMPLEX, SW-ECUADOR): A RECORD OF FAST EXHUMATION RATES.

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GEOLOGICAL SETTING

The « El Oro province » is located in the south-westernmost Ecuador. The **El Oro metamorphic complex** (about 24000 km2) belongs to the displaced Amotape-Tahuin block (Mourier et al. 1988). The metamorphic complex comprises lithologies and assemblages, the ages of which range from the Palaeozoic to the Cretaceous, that are interpreted as a former accretionary prism (Aspden et al., 1995). According to the most recently published geological map (Aspden et al., 1995), this area is cross-cut by several E-W striking fault systems that subdivide the El Oro metamorphic complex in different smaller units.

The E-W-trending Raspas ophiolitic complex is bounded to the North and the South by the "La Palma - El Guayabo" and the "Tahuin Dam" faults, respectively. It consists of greenschists, serpentinised harzburgites, pelitic schists, blueschists and eclogites, described in detail first by Feininger (1980), and recently interpreted as a late Jurassic-early Cretaceous tectonic mélange representing an accretionary prism (Aspden et al., 1995). K-Ar data on phengite (132 ± 5 Ma, Feininger, 1980) suggests a Lowermost Cretaceous age for the high-pressure metamorphism (Duque, 1993).

The studied metapelites come from the « **La Chilca unit** », located in the northern part of the Raspas ophiolitic complex. K-Ar data on phengite (132 ± 5 Ma : Feininger, 1980) suggest a Lower Cretaceous age for the high-pressure metamorphism (Duque, 1993).

The aim of this paper is to present a revised P-T path for the Raspas complex, based on the garnet-bearing **metapelites**, in order to constrain their exhumation mechanisms.

PETROGRAPHY

The studied metapelites are medium- to coarse-grained graphite-bearing schists, where the high-pressure paragenesis consists of quartz, white mica, garnet , chloritoid, kyanite and rutile (98RR2 ; 98RR10 ; 98RR11 ; 98RR12 ; 97Cc5). The **white mica** defines the main schistosity which corresponds in the field to the regional schistosity. The phengite is idioblastic or sub-idioblastic and usually is concentrated in millimeter-thick layers alternating with **quartz**-rich, granoblastic layers. **Garnet** poikiloblasts contain inclusions of quartz, kyanite, chloritoid, rutile. The porphyroblasts overgrow an older schistosity mainly defined by minute graphite inclusions and showing isoclinal folds. The presence of rotational structures in porphyroblasts indicates that garnet growth was synkinematic with respect to the event that generated the older schistosity. Compared to the main schistosity (the phengitic one), the garnet is mostly pre-tectonic. Three different generations of **chloritoid** are identified, namely (1) relict xenoblastic crystals included in the garnet ; (2)-xenoblastic to sub-idioblastic crystals dispersed in the matrix and aligned along the main schistosity; and (3) - idioblastic chloritoids randomly oriented across the schistosity or pseudomorphing garnet. **Kyanite** is observed in the garnet and/or in the matrix. It often shows a reaction rim with chlorite and white mica, and also a pseudomorphic replacement by chloritoid and white mica. **Rutile** and **graphite** are the main accessories.

MINERALOGY

The chemical composition of garnet, white mica and chloritoid were determined using the wavelength dispersive electron microprobe (CAMECA SX50). Representative analyses are listed in **Table 1**. **Garnet** shows a regular decrease in Mn content and a regular increase in Mg content from core to rim. Average core and rim compositions are Alm60-62%, Sps6-7%, Prp2-4%,Grs22-24% and Alm59-64%, Sps0.3-1.5% Prp10-12%, Grs20-23%, respectively. **Chloritoid** inclusions in garnet cores and garnet rims have an XMg of 0.15 and 0.30, respectively. Matrix chloritoid has compositions similar the most magnesian inclusions in the garnet grains. Finally, the randomly-oriented grains in the matrix and the chloritoid grains pseudomorphing garnet are less magnesian (XMg = 0.21). **White micas** are phengitic muscovites, with a relatively high Si content analyses (from 6.35 to 6.45 atoms p.f.u on the basis of 22 oxygens) and the Mg+Fe(tot) content vary between 0.35 and 0.55 atoms p.f.u..

Table 1 Representative chemical compositions for minerals in listed samples

Chloritoids				Garnets				White micas			
Sample	98RR2	98RR2	98RR2	98RR10	98RR10	97Ce5	97Ce5	98RR11	98RR12	98RR2	97 Ce 5
	Random	matrix	relic	rim	core						
Point n°	10	11	23	225	251	10	14	16	35	11	43
SiO2	24.39	24.09	24.10	37.79	37.29	37.58	37.14	47.04	47.64	47.73	48.52
TiO2	-	-	-	0.16	0.21	0.17	0.01	0.49	0.42	0.44	0.44
Al2O3	41.11	41.01	40.70	21.05	20.37	21.20	21.03	32.61	33.14	33.16	32.45
Cr2O3	-	-	-	0.02	0.00	0.00	0.00	0.00	0.03	0.05	0.06
FeO*	23.08	23.17	25.16	30.08	29.38	33.59	35.44	1.42	1.07	1.18	1.34
MnO	0.34	0.18	0.23	0.14	2.73	0.37	0.42	0.01	0.00	0.00	0.01
MgO	3.39	3.87	2.49	3.00	0.61	2.21	1.98	1.65	1.54	1.61	1.62
CaO	0.00	0.01	0.01	8.45	9.96	5.79	4.86	0.00	0.01	0.04	0.00
Na2O	0.06	0.00	0.03	0.00	0.00	0.04	0.01	1.14	1.16	0.93	1.21
K2O	-	-	-	-	-	-	-	8.77	8.79	8.81	8.94
Total	92.39	92.33	92.71	100.70	100.55	100.94	100.90	93.13	93.81	93.96	94.60

REACTION HISTORY AND P-T CONDITIONS

Microstructural relations and compositional data reveal that the assemblage chloritoid-kyanite-quartz was stable during garnet growth. Theoretical (e.g. Harte and Hudson, 1979; Vuichard and Ballèvre, 1988; Ballèvre et al, 1989) as well as calculated KFMASH (e.g. Powell and Holland, 1990) grids show that the assemblage Grt-Cld-Ky is stable within a narrow temperature range at high pressure. Specifically, the lower temperature limit is defined by the incoming of almandine + kyanite at the expense of Fe-chloritoid, and the upper temperature limit by the breakdown of chloritoid through the univariant reaction Cld = Grt + Chl + Ky.

The observed change of garnet and chloritoid chemistry records the progressive change in P-T conditions during garnet growth then resorption. Increasing Mg content from garnet core to garnet rim and correlative increasing Mg content of chloritoid (inclusions from garnet core to garnet rim, and matrix grains) indicate increasing temperatures during garnet growth. The same continuous reaction took place during garnet resorption, as indicated by the observed textures (garnet and kyanite pseudomorphs consisting of fine-grained chloritoid and quartz aggregates) and the decrease in Mg content of the late generation of chloritoid. The backreaction is incomplete, probably because H_2O was a limiting constituant during the retrograde history.

According to the KFMASH grids calculated by Powell et al (1998), the assemblage Grt-Cld-Ky is stable at higher pressures than 12 kbar, in the temperature interval 560-600°C. The Si content of phengite is buffered at relatively low values by the assemblage Grt-Cld-Ky, but experimental data on the assemblage Alm-Ky (Massonne and Szpurka, 1997) indicates pressures of the order of 20 kbar (at 600°C).

IMPLICATIONS FOR THE EXHUMATION RATES

The observed decrease in temperature which follows peak pressure conditions provides severe constraints on the exhumation mechanism of the eclogite-facies rocks, because it means that a low geothermal gradient was still stable during exhumation. Such a process is consistent with an active setting, where subduction of relatively cold material continues below the accreted material during its exhumation, and/or that the exhumation rate, whatever its mechanism, is much faster that the thermal relaxation of the crust. This would explain the excellent preservation of the high-pressure paragenesis, except in the zones ot ductile deformation that bound the Raspas Complex, which may have formed later during the final emplacement of the Raspas metamorphic rocks at high structural levels.

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