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A Grenvillian anorthosite-mangerite-charnockite-granite suite in the basement of the Andes: The Ilo AMCG suite (southern Peru)

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Introduction

Only a few anorthositic rocks of Proterozoic age are so far described from the basement of the Andean coastal belt. These are from the northern part of Colombia (e. g. Santa Martha area; Restrepo-Pace et al., 1997 and references therein) and from the Western Sierras Pampeanas of Argentina (Casquet et al, 2005). A new occurrence (the Ilo Anorthosite) is located in the Arica elbow (southern Peru) at about 150 km to the SW of the mid-Proterozoic Arequipa and Mollendo-Camana blocks (Wasteneys et al., 1995; Martignole and Martelat, 2003) some 15 km to the N of the harbor of Ilo.

Field occurrence

A 12 km-long inlier of Precambrian rocks occurs along the shoreline of the Pacific Ocean, in the Arica elbow, in the vicinity of the Southern Peru Copper smelter (Fundición), at about 14 km from Ilo (Fig. 1). A few hundred metres from the coast, the Precambrian rocks are burried under Pleistocene deposits. To the east of the smelter, they are overlaid by Cretaceous volcanics whereas to the north, they are unconformably overlaid by graded and cross-bedded (Upper Paleozoic?) quartz-arenites steeply dipping to the N and considered to be at the base of the Chocolate Formation (Jurassic).

In the Precambrian inlier, rafts and boudins several tens of metres wide of pale, cataclastic to mylonitic anorthosite are embedded within SW-dipping gneissic or mylonitic porphyric granitic to charnockitic gneisses. Recrystallised leuconorite and norite with cm-scale layering is locally interlayered with the anorthosite. Evidence of sinistral normal shear is noted at several localities and mylonitic inclusions are found within slightly deformed m-scale mafic (Lower Ctretaceous?) dykes. In spite of the limited size of the outcrops and intensity of deformation/alteration, these rocks bear most of the characters of a dismembered Anorthosite-Mangerite-Charnockite-Granite (AMCG) suite.

Petrography

The anorthosite is white (hololeucocratic), medium to coarse grained with numerous relicts of grayish plagioclase megacrysts and occasional pink K-feldspar clasts. It is made of over 95% of an intermediate plagioclase (sodic labradorite) with less than 5% altered mafic minerals. Leuconorites and norites consists of the same type of plagioclase plus strongly altered pyroxene nests, remnants of a sub-ophitic texture. Charnockitic gneisses and mylonites are grayish to green, with traces of garnet, attesting to a granulite-grade, post-magmatic metamorphic event. Finally, pink, porphyric orthogneiss, are strongly reminiscent of A-type granites generally associated with massif-type anorthosite of the Grenville Province. Epidote, zoïzite, calcite, leucoxene and

chlorite, especially abundant in the leuconorites and the norites attest to a late greenschist-grade metamorphic overprint.

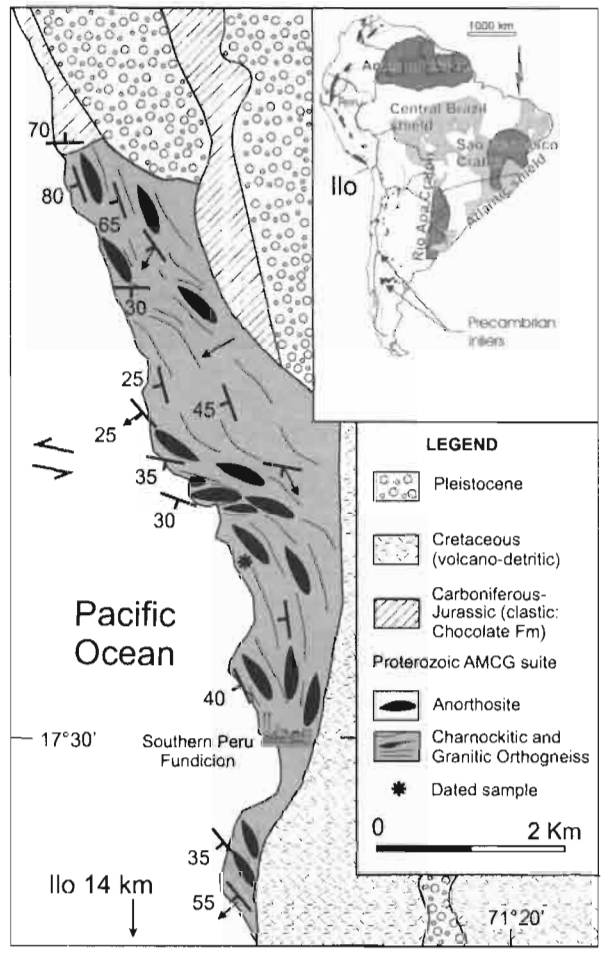

Fig. 1: The Ilo anorthosite and associated Proterozoic AMCG rocks

Geochemistry and geochronology

Major elements in the Ilo Anorthosite do not depart significantly from those of massif type anorthosite (e.g. Adirondacks, Buddington, 1972; Morin, Martignole, 1974). The main differences reside in the relatively low SiO_2 and relatively high K_2O content (2.4%) that result in the absence of normative quartz and the presence of normative corundum and nepheline (Table 1). This may be attributed to local deformation-enhanced metasomatism that involves potassium mobility and desilicification.

The REE content is low with 2.65 ppm Nd and 0.47 ppm Sm compared to Adirondacks values (Ashwal and Wooden, 1983). The $^{147}Sm/^{144}Nd$ and $^{143}Nd/^{144}Nd$ ratios are 0.1064 and 0.512149 (± 0.00003) respectively. A positive ε_{Nd} of +3.8 is calculated at 1.15 Ga (reference age corresponding to the emplacement of the Adirondacks, Morin and Lac St. Jean anorthosites) suggesting long-term depleting mantle as a source for the Ilo Anorthosite. This value is within the +0.4 to +4.1 ε_{Nd} range obtained for the anorthosites and leuconorites from the Adirondacks (Ashwal and Wooden, 1983, calculated at 1.2 Ga). With a T_{DM} model age of 1.42 Ga, the Ilo

Anorthosite stands as another evidence for the presence of a Grenville-age crustal addition to the Andean basement of southern Peru (Fig. 2).

Table 1: Major elements analyses of Ilo Anorthosite. Analyses from Adirondacks Anorthosite (Buddington, 1972) and Morin Anorthosite (Martignole, 1974, average) for comparison.

	ILO	ADIRONDACKS	MORIN
SiO_2	52.46	54.28	54.75
TiO_2	0.11	0.53	0.42
Al_2O_3	27.98	25.55	26.39
Fe_2O_3	0.34	0.73	1.10
FeO	0.44	1.81	0.70
MnO	0.02		0.01
MgO	0.27	1.31	0.44
CaO	9.31	10.24	10.38
Na_2O	4.40	4.56	4.74
K_2O	2.40	0.90	1.02
P_2O_5	0.04	0.09	0.05
norm			
Qtz		0.60	1.30
Co	1.32		
Or	14.17	5.30	6.01
Ab	31.94	38.6	40.25
An	45.89	46.6	46.12
Ne	2.85		
Di		3.00	2.37
Hy		3.70	0.18
Ol	0.77		
Mt	0.50	1.10	1.11
Il	0.20	1.10	0.81
Ap	0.09	0.20	0.11

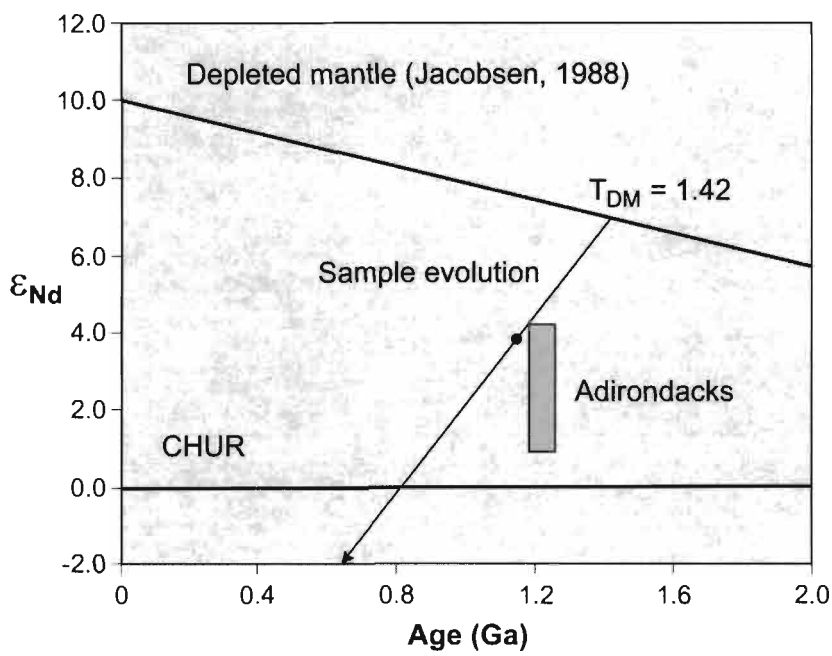

Fig. 2. Age *vs* ε_{Nd} for Ilo Anorthosite (UTM: 1729181/712197). Data for the Adirondacks Anorthosite included for comparison (from Ashwal and Wooden, 1983).

Conclusion

The Ilo AMCG suite, in spite of restricted exposition and intense deformation presents several of the characters (petrographical, chemical, isotopic) of AMCG suites from the southern part of the Grenville Province (Adirondacks, Morin). The occurrence of shallow-water sediments unconformably overlying the Ilo AMCG suite shows that a Grenville type Proterozoic basement has been involved in the evolution of the Andean coastal cordillera since the end of the Paleozoic and the beginning of the Mesozoic, a benchmark in any Rodinia reconstruction for South America.

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