Pristine Slab Melts Crystallized at Depth in the Subduction Environment: End-members of Adakites (Eastern Cuba Mélanges)

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INTRODUCTION.

In the subduction zones, several conditions can be attached and instigate the melting of the slab or the overlying mantle wedge. Under normal subduction zones the geothermal conditions of the slab may not attain P–T conditions for melting at sub-arc depths, but dehydrates and release LILE-enriched hydrous fluids that metasomatize the overlying mantle wedge and instigate its melting (e.g. Tatsumi and Kogiso, 1997). Adakites are volcanic or intrusive igneous rocks interpreted to form in subduction zones from the mixing of mantle material with felsic partial melts of descending slabs of oceanic crust basalt. Distinctive geochemical features are SiO_2>56 wt.%, high Na_2O contents (4.5-9wt.%), (K_2O/Na_2O)≈0.42, Mg#≈50, LREE enrichment, HREE depletion, and high La/Yb and Sr/Y.

Examples of pristine slab melts reaching the Earth's surface are scarce. In rare cases of subduction complexes, such as the Catalina Schist mélange (California), partial melting of metabasite and metasomatic mass-transfer processes in the slab have been described (Sorensen, 1988; Bebout and Barton, 1993). The melts produced in this mélange were considered as primary adakitic liquids (e.g., Martin, 1999) generated at intermediate pressures due to the onset of subduction.

In the Sierra del Convento mélange (E Cuba) pristine primary slab melts generated under water-saturated partial melting conditions were recently described (García-Casco et al,. 2008; Lázaro & García-Casco, 2008).

New rocks enriched in mobile elements (K, Ba, Rb.....) have been catalogued and studied in Eastern Cuba mélanges. These rocks resemble to the rocks considered pristine primary slab melts and their residues but present geochemical and petrological (presence of magmatic muscovite) differences that link them to adakites.

ANALYTICAL TECHNIQUES.

Whole-rock major element and Zr compositions were determined with a PHILIPS Magix Pro (PW-2440) X-ray fluorescence equipment (University of Granada) using a glass beads, made of 0.6g of powdered sample diluted in 6g of $Li_2B_4O_7$. Trace elements, except Zr, were determined by ICP-MS (University of Granada) after HNO_3 + HF digestion of 0.1000 g of sample powder in a Teflon-lined vessel at ~180ºC and ~200 p.s.i. for 30 min, evaporation to dryness, and subsequent dissolution in 100 ml of 4 vol.% HNO_3. Whole rock samples for Sr and Nd isotope analyses were digested in the same way as for ICP-MS analysis, using ultra-clean reagents and analyzed by thermal ionization mass spectrometry (TIMS) in a Finnigan Mat 262 spectrometer after chromatographic separation with ion exchange resins.

RESULTS AND DISCUSSION.

Amphibolites-bearing muscovite range from picro-basaltic to basaltic compositions and have medium-K to high-K calc-alkaline affinity (Fig. 1). Samples have diverse Na_2O contents and two groups can be observed; however, similarly to amphibolites from the Sierra del Convento, they are metaluminous. Ms-trondhjemites have dacite to rhyolite composition and low-K tholeiitic to medium-K calc-alkaline affinity (Fig. 1). Between the two groups of rocks there is a gap in silica content from 52 to 64 wt.% SiO_2, suggesting partial melting of amphibolites and melt extraction.

Importantly, the Ms-trondhjemites are Al-saturated (i.e. peraluminous; ASI = 1.089-1.247) and plot close to the alkali feldspar-white mica mixing line delineated similar to acid rocks from Catalina mélange and experimental liquids.

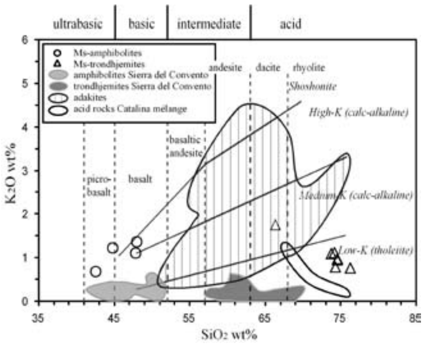

fig 1. K_2O vs. SiO_2 diagram (Peccerillo and Taylor, 1976) with subdivision of volcanic series in shoshonite, high-K, medium-K and low-K and TAS based names of rocks of the subalkaline series. Data for comparison as Lázaro & García-Casco (2008). All analyses normalized to 100 wt% anhydrous.

Ms-amphibolite patterns of element distribution are similar in abundances to N-MORB and homogeneous through Sm to Ni. The most important deviations from N-MORB compositions are enrichments in Ba, La, Pb, Sr, and Eu, and variable enrichment/depletion in Th and Zr (Fig. 2a). The chondrite-normalized REE diagrams are characterized by enriched LREE patterns. The $(La/Yb)_n$ ratio (normalized to chondrite) varies from 0.7 to 5.5, showing slightly fractionated patterns (Fig. 2c).

Spider diagrams for Ms-trondhjemites show fractionated patterns (Fig. 2b). Ms-trondhjemites, N-MORB-normalized, are especially enriched in Ba and Pb. The $(La/Yb)_n$ ratio values range from 2 to 114, so patterns are from slightly to strongly fractionated (Fig. 2d).

The $\varepsilon Nd_{(114\ Ma)}$ value of analyzed Ms-trondhjemites (+6.99 and +3.99) point to a double source origin, such as a very young oceanic crust, differentiated from a depleted mantle with significant input of external sources (i.e. continental crust components) (Fig. 3). The $\varepsilon Nd_{(114\ Ma)}$ of Ms-amphibolites (+8.8 and +9.4, except one sample) do not overlap the Ms-trondhjemite value (Fig. 3). These rocks show other component contribution

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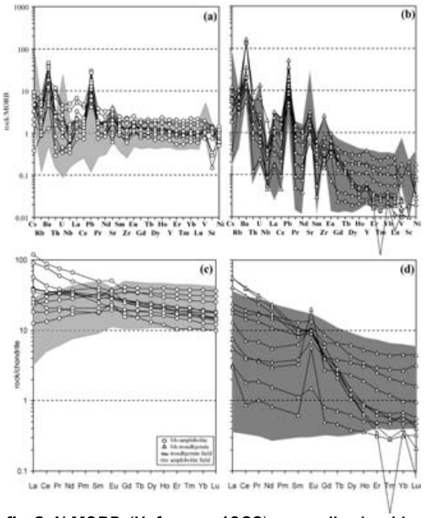

fig 2. N-MORB (Hofmann, 1988) normalized spider diagrams for: (a) Ms-amphibolites, (b) Ms-trondhjemites, and Chondrite (McDonough and Sun, 1995) normalized REE patterns for: (c) Ms-amphibolites, (d) Ms-trondhjemites from Sierra del Convento mélange. Amphibolite and trondhjemite fields from the Sierra del Convento mélange (Lázaro & García-Casco, 2008), for comparison.

(fluids derived from a sedimentary source) plus the oceanic crust differentiated from a depleted mantle source as established for the amphibolites of the Sierra del Convento (Lázaro and García-Casco, 2008). In this case, the partial melting process involved fluid-present conditions, likely caused by the influx of external fluids into the amphibolites (García-Casco et al., 2008).

Field relations, petrological analysis, and elemental and isotope geochemistry allow us to infer that Ms-trondhjemites generated by partial melting of two source protolith (amphibolites + sedimentary cover released fluid) during subduction at ca. 15 kbar and 750 °C (García-Casco et al., 2008; Lázaro et al., 2009).

The peraluminous character of these rocks suggests that they do not represent oceanic plagiogranites or adakitic magmas s.s., which are typically metaluminous but Ms-trondhjemites of the Eastern Cuban mélanges are comparable with peraluminous melts of the Catalina Schist formed during partial melting and metasomatism of subducted oceanic crust (Sorensen, 1988; Bebout & Barton, 1993).

In arc magmas, elevated concentrations of certain LILE relative to HFSE are considered key indicators of fluid addition to arc magma source regions worldwide. These fluids are released by dehydration of down going slabs or dehydration of the sedimentary cover developed with the growth of the subduction zone. In some conditions these enriched fluids can react with the subducted oceanic crust, that simultaneously is suffering partial melting conditions, and imprint their signatures both in melts (Ms-trondhjemites) and the residual rocks (Ms-amphibolites).

So, Ms-amphibolite signatures were modified by fluids precedents from the sediments in the subduction channel. The lack of plagioclase and scarcity of clinopyroxene in the Ms-amphibolites support fluid-present melting at near-solidus conditions.

This process and the P-T conditions reached during the subduction triggered the partial melting in the slab producing the Ms-trondhjemites. The similitude of Ms-trondhjemitic melts to adakites signatures and, due to these rocks did not react with the mantle wedge, allow us to consider the Ms-trondhjemites to be one of the end-member sources (pristine slab melt) of adakites, trapped, not erupted, and crystallized at depth in the subduction channel.

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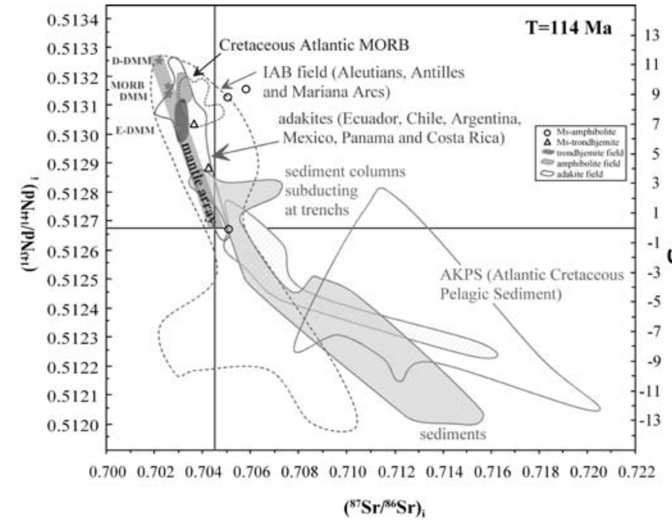

fig 3. (87Sr/86Sr)i vs. (144Nd/143Nd)i and εNdi diagrams. Samples were corrected for T=114 Ma (see Lázaro et al., 2009). Data for comparison as Lázaro & García-Casco (2008).