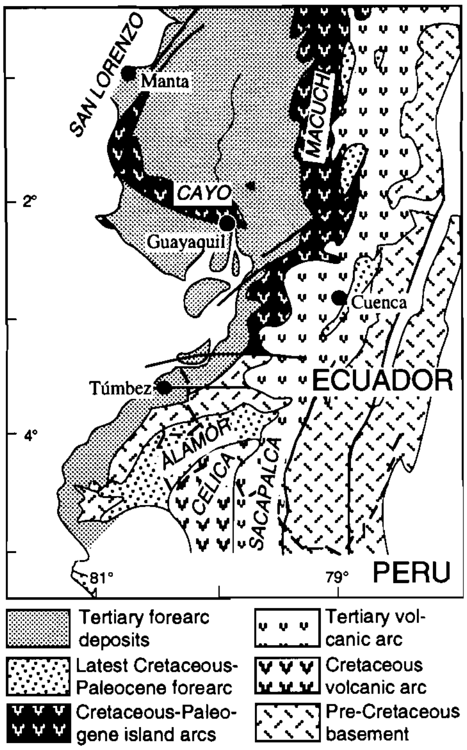


Fig. 1 : Location of the studied area.

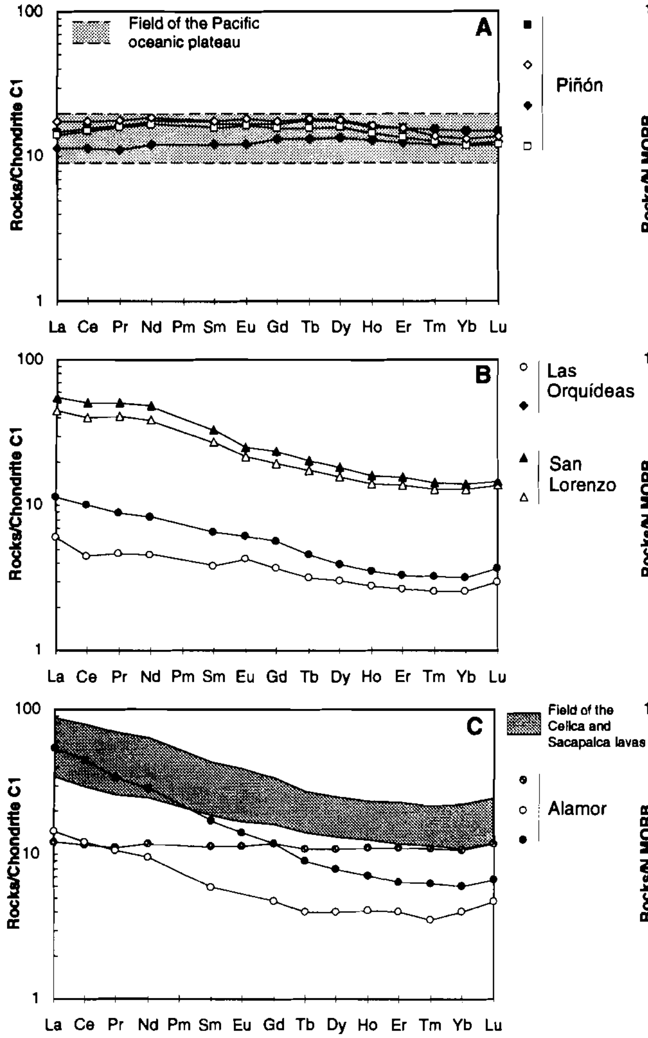
The volcanic rocks of **oceanic origin** (Piñón and San Lorenzo Fms, Las Orquídeas beds) show mafic (MgO>5%) to intermediate compositions and are mainly dolerites, basalts and andesites. Basalt is the main rock type of the Piñón Fm and Las Orquídeas beds. Dolerites occur in the Piñón and San Lorenzo Fms while andesites are only found in the San Lorenzo Fm. All these rocks are formed of plagioclase, clinopyroxene and Fe-Ti oxides. The crystallization sequence in the basalts and dolerites of Pinon and Las Orquídeas Fms. is: plagioclase -> cpx -> oxides while in the rocks of the San Lorenzo Fm, Fe-Ti oxides crystallize before plagioclase. Orthopyroxene is uncommon. Plagioclase predominates (50 to 80 % of modal composition) in all the rock-types and shows normal zoning with labradorite core (An_{75}) and oligoclase rim (An_{10}). Clinopyroxene exhibits augite composition (En_{45}, Fs_{12}, Wo_{43}). In the San Lorenzo andesite, clinopyroxene shows diopside core rimmed by augite. Oxides are Ti-rich (TiO_2 ~ 5%) magnetites.

Basalts and dolerites of the Piñón Fm show E.MORB affinities with flat REE patterns [0.9<(La/Yb)C <1.3, fig. 2A) and Nb, Hf, and Ta enrichments relative to N.MORB (fig. 3A). They cluster in the E.MORB field in the Hf/3-Th-Ta diagram (Wood 1980, fig. 4). Basalts, dolerites, andesites of the Las Orquídeas beds and San Lorenzo Fm differ from the E.MORB of the Piñón Fm by LREE enriched patterns [2.31<(La/Yb)C<3.9, fig. 2B] and a depletion in Nb, Hf, and Ta relative to N.MORB (fig. 3B). They are enriched Ba, Rb, Sr relative to N.MORB (fig. 3B). All these rocks fall in the calc-alkaline field in the Hf/3-Th-Ta diagram (fig. 4). The REE abundance of the basalts and dolerites of the Las Orquídeas beds is 10 times the chondritic abundance and markedly lower than that of the San Lorenzo rocks. Moreover, the igneous rocks of Las Orquídeas beds show a significantly depletion in HREE, Zr, Ti, and Y, compared to the calc-alkaline rocks of San Lorenzo and more generally to the calc-alkaline mafic rocks of oceanic arcs (Wilson 1989).

The Piñón E.MORB tholeiite is characterized by an εNd, back calulated at 110 Ma, of +7 (fig. 5) which falls in the range of Oceanic Island Basalts. The Las Orquídeas calc-alkaline rocks show similar εNd ratios, back calulated at 110 Ma, that range between +6 and +7 (fig. 5). These εNd ratios fall in the range of oceanic arcs. In contrast, the initial ($^{87}Sr/^{86}Sr$)i ratios of the E.MORB tholeiite and calc-alkaline lavas, back calculated at 110 Ma exhibit a wide range of values (-4.2<εSr<+4.2). The enrichment of both rocks in radiogenic Sr is probably linked to hydrothermal alteration experienced by these submarine lavas.

Thus, the basalts and dolerites of the Piñón Fm display E.MORB tholeiitic affinities, very similar to those of oceanic plateau basalts (Floyd 1989). Moreover, they share in common with the Late Cretaceous tholeiites from Curaçao (Kerr et al. 1996) and the Cenomanian-Coniacian E.MORB tholeiitic basalts from Hispaniola (Dupuis 1995), flat REE patterns, Ta, Nb, Hf enrichments relative to N.MORB and εNd ratios of +6/+7. The Las Orquídeas and San Lorenzo calc-alkaline rocks display petrological and geochemical features of intra-oceanic arc-rocks. The low HREE and Y contents of the Las Orquídeas rocks suggest the presence of residual garnet in the mantle source.

The lavas exposed on the **continental margin** (Celica, Alamor and Sacapalca Fms) show contrasting petrological and geochemical features with respect to the E.MORB tholeiites and calc-alkaline rocks. They occur as flows or fragments in pyroclastic breccias. They show intermediate to felsic compositions. Dacite is the most common rock-type. Mafic to acidic andesites are also present. Plagioclase is the most abundant mineral (30 to 80% of phenocrysts) and exhibits anorthite composition (An_{90}). Two groups of rocks may be distinguished on the basis of the nature of the ferro-magnesian phenocrysts. The lava in flows and pyroclastic breccias of the Celica Fm are clinopyroxene- and orthopyroxene-phyric, respectively. The andesites and dacites of the Alamor and Sacapalca Fms are amphibole- phyric. The dacites include quartz phenocrysts. Amphibole is always zoned ; it is a K-poor (K_2O<1%) hornblende. Fe-Ti are TiO_2 (4 to 6%) rich magnetite and crystallize before the plagioclase and clinopyroxene.



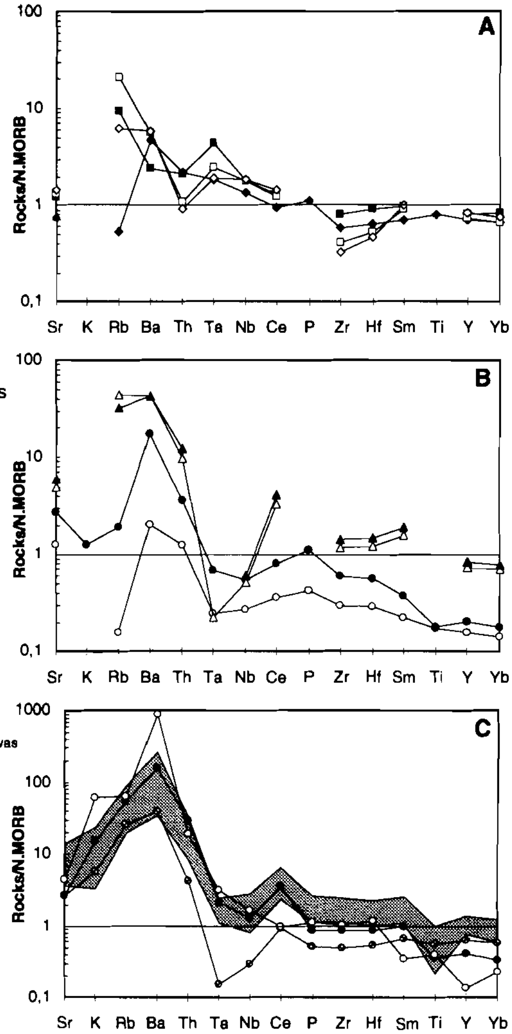


Fig 2 : Rare Earth Element normalized abundance normalized to C1 chondritic meteorite values (Normalisation values : Sun and Mc Donough, 1989).
A : Piñón Fm.
B : San Lorenzo Fm. and Las Orquídeas Beds.
C : Celica, Alamor and Sacapalca Fms.

Fig 3 : N.MORB-normalized spiderdiagrams (Normalisation values : Sun and Mc Donough, 1989).
A : Piñón Fm.
B : San Lorenzo Fm and Las Orquídeas Beds.
C : Celica, Alamor and Sacapalca Fms.

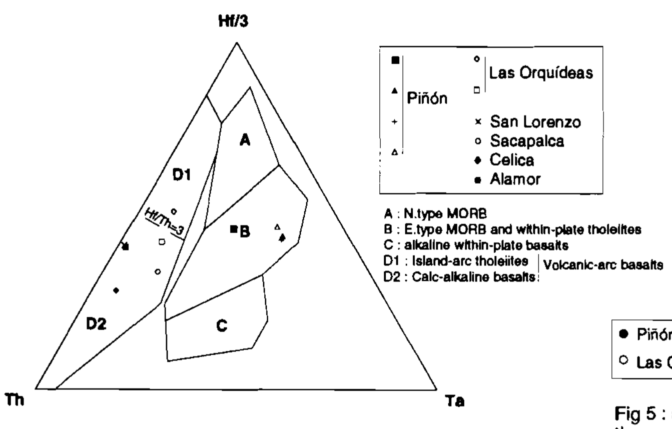


Fig 4 : Hf/3-Th-Ta discrimination diagram (after Wood, 1980).

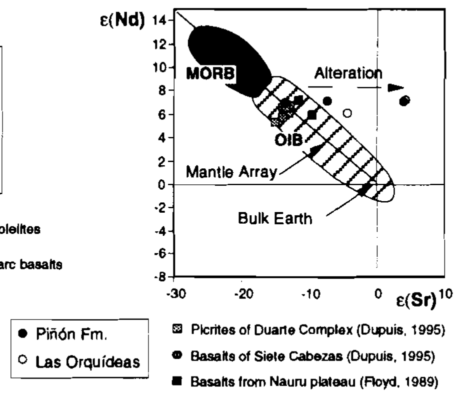


Fig 5 : ε(Nd) vs ε(Sr) isotopique correlation diagram showing the position of the Piñón and Las Orquídeas samples (calculated at t=110 My).