CHRONOLOGY AND SPACIAL DISTRIBUTION OF MAGMATIC ACTIVITY DURING UPPER CRETACEOUS AND CENOZOIC TIMES IN CENTRAL PERUVIAN ANDES

A PLATE DYNAMICS INTERPRETATIVE SCHEME

PIERRE SOLER

ORSTOM, UR 606, 213 rue Lafayette, 75010 PARIS, FRANCE- CNRS UA 384 "Pétrologie et Métallogénie, Université PARIS VI, 4 place Jussieu, 75005 PARIS, FRANCE and Groupe des Sciences de la Terre, Lab. Pierre Sue, CEA-CNRS, C.E.N. de Saclay, 91191 GIF/Yvette, FRANCE.

On the basis of a compilation of the published radiochronological data and of original K-Ar datations on magmatic rocks from a transect of central Peruvian Andes, it can be demonstrated that during the andean orogenesis, which began in upper-Albian times in this segment, magmatism appeared in this area in a series of pulses of very different volumetric importance, separated by episodes of often apparently complete magmatic quiescence. The number of datations presently available and the coherency of this data set permit to affirm that this "episodicity" of magmatism is quite real and is not the result of an statistically unrepresentative sampling. However, it needs to be better precised on some points and new elements of dating are still necessary.

During orogenic period, magmatic arc geometry changed in a very sensitive manner; the Inner Magmatic Front (IMF - the first appearance of magmatism towards the Peru-Chile trench) and the Outer Magmatic Front (OMF - the last appearance of magmatism towards the Brazilian shield) have migrated in different ways, and by jumps or in a continuous manner according to the periods. The average eastwards IMF migration rate has been 0.6 km/M.a. since Upper-Albian but has neither been continuous nor monotonous. This magmatism may be divided in two major periods and four episodes :

- the first period from Upper-Albian to mid-Eocene is characterized by the setting of the Coastal Batholith, that constitutes the most important outcropping plutonic suite. The available radiochronological data suggests the distinction of at least nine pulses and their grouping into five more or less continuous episodes (102-97 M.a., 95-90 M.a., 85-77 M.a., 74-59 m.y;, 54-49 M.a. - figure), separated by periods of apparent magmatic quiescence, the number of radiochronological data seems very low in comparison with the number of individual plutons that constitute the whole batholith. With respect to the geometry of the arc during that period, two episodes may be distinguished :
  - A. (102 to 80-75 M.a.) with a very slow eastwards migration of IMF (< 0.25 km/M.a.) and a progressive broadening of the magmatic arc (OMF migrated more rapidly than IMF during this episode) from 15 to 35 km;
  - B. (80-75 to 50 M.a.) with a rapid IMF migration (± 1 km/M.a.) without jump respect to period A and a weak broadening of the magmatic arc from 20 to 30 km (with a west' 'ards OMF jump between periods A and B);

- the second period, from upper-Eocene to Pliocene is characterized by the setting of a great number of stocks (often subvolcanic) and of a thick volcanic series (Eocene to Upper-Miocene Calipuy group and Pliocene ignimbrites), partly within the Coastal Batholith itself and chiefly to the East of it. Six pulses, grouped in two major episodes, may be distinguished :
  - C. (42 and 29 M.a.) with pulse I (42-36 M.a.) of great volumetric importance,

represented by numerous intrusive stocks and a thick volcanic series, and pulse II (32-29 M.a.) less important in volume, represented by dykes, sills and stocks of small size. Present-day available data suggests the existence of an episode of magmatic quiescence between pulses I and II. After a neat westwards jump (10-15 km) of IMF and an abrupt broadening of the arc between periods B and C (from 30 to 100 km - it reached then the High Plateaus), this episode is marked by a rapid (± 2 km/M.a.) eastwards migration of IMF and OMF. At the end of this period (pulses I and II), the magmatic arc extended all over the High Plateaus and probably reached the Eastern Cordillera.

- D. (25 and 3 M.a.) with a series of four pulses, separated by poorly demonstrated episodes of magmatic quiescence : pulse III (25-19 M.a.), pulse IV (18-12 M.a.), and pulse V (11-6 M.a.), all three of great volumetric importance, and finally pulse VI (6-3 M.a.) of weak volumetric importance. No magmatic activity subsequent to 3 M.a. is known in this area. After a new westwards jump (10-15 km) between C and D, IMF seems to oscillate at the level of the medium Pacific slope of the Western Cordillera but available data is not sufficient to give a precise scheme of these oscillations. During that period, OMF migration is also difficult to appreciate because magmatism in the Eastern Cordillera is till poorly known. The broadening of the arc, which began during the former episode, seems to proceed till pulse IV, during which the arc reached the Amazonian slope of the Eastern Cordillera and was some 160 km wide.

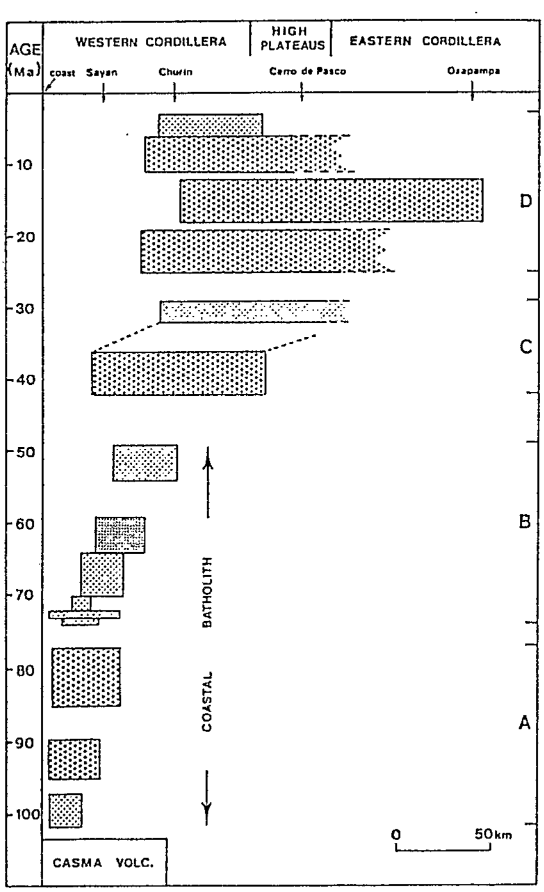

Figure : Chronology and spatial distribution of magmatic activity on a transect of Central Peruvian Andes.

Finally, the arc width decreased to some 60 km during Pliocene pulse VI and magmatic activity ceased in central Peru some 3 M.a. ago.

What the genetic models for andean margin magmatism could be, the part played by the subduction of Nazca (Farallon) plate beneath South-American continent appears as essential. The episodicity of magmatism and the variations of arc geometry may be interpreted, in most of the cases, as consequences of modifications occured in the modalities of the subduction.

Period D is directly correlative with a high convergence rate (>10 cm /year) episode which iniciated near to 25 M.a. ago and continues till to-day. Upper Eocene pulse I appears as closely associated with high convergence rate (12 to 16 cm/year) period. The first three pulses of the Coastal Batholith (episode A) correspond also to a high convergence rate (14-18 cm/year) period.

Then, the magmatic pulses of major volumetric importance correspond sys[illegible]cally to high convergence rate (over 10 cm/year) periods. The episodes of magmatic quiescence seem to be always low convergence rate (< 7 cm/year) periods. However the relation is not a bijective one, some of the magmatic pulses took place during low convergence rate periods. - for example period B and pulse II of period C.

The slow migration of IMF during episode A may be interpreted by both a progressive decrease in slab dip (conceivably due to a decrease in the lithospheric age of the down-going slab) and the tectonic shortening of the continental coastal area during "Peruvian" tectonic period .

The rapid eastwards migration of IMF during episode B may be explained by the aument of the absolute motion of South-American plate near to 80 M.a. ago and the resulting decrease in the dip of the down-going slab, and by tectonic shortening.

The period of magmatic quiescence and the westwards jump of IMF between periods B and C appear as associated with a low convergence rate episode. The broadening of the arc between B and C, which constitutes the major change in arc geometry during andean orogenesis and is observed alond the greatest part of Central Andes, is demonstrated to be a consequence of the rapid decrease in the lithospheric age of down-going slab between 55 and 40 M.a. ago. The "Inca" tectonic is contemporaneous with these changes in arc geometry.

The episode of magmatic quiescence between C and D, which is observed all along the central Andes, may be interpreted as a consequence of the blocking of Pacific-Farallon expansion zone in California near to 30 M.a. and of the resulting very low convergence rate, although short, episode all along central andean margin. This seems to be associated with a decrease in absolute motion of South-American plate. Both factors explain the westwards migration of IMF between C and D.

The beginning of period D is directly correlative to the breaking off of Farallon plate into Cocos plus Nazca plates and the consequent increase in convergence rate and modification of convergence obliquity respect to the trench in Central Peru. Episode D corresponds with a nearly constant and high convergence rate; the clear decrease in the lithospheric age of the slab since 10 M.a. may account for the eastwards migration of the IMF between pulses V and VI.

The ceasing of magmatic activity near to 3 M.a. appears as a consequence of a decrease in the dip of down-going slab which would be the result of subduction of the buoyant Nazca asismic ridge. The hypothesis according to which this change in the dip of the slab might be integrated in a normal evolution of the subduction process is demonstrated to be unsatisfactory.

The frontal erosion of the continental margin and of an hypothetic accretionnary prism appears to have played a part in the modifications of arc geometry only during the initial period of the formation of the Coastal Batholith.

The proposed interpretative scheme, which also accounts, with some shades, for Upper Cretaceous and Cenozoic magmatism in Southern Peruvian and Chilean Andes, has to be completed by calling upon the possible blockings of the down-going slab at mesosphere level; in particular, these could probably explain episodicity of magmatism and tectonics during high convergence rate periods, as episodes A and D.