ZIRCON FISSION TRACK DATING OF THE HUACHON GRANITE FROM THE EASTERN CORDILLERA OF CENTRAL PERU : EVIDENCE FOR LATE PALAEOZOIC AND LATE JURASSIC COOLING EVENTS.

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Abstract : Des datations sur zircons, par traces de fission, du granite de Huachon (Cordillère orientale du Pérou central) indiquent deux périodes de refroidissement, vers 270 Ma et 160 Ma. Le refroidissement à 270 Ma est interprété comme l'âge de mise en place du granite. Dans le Pérou central, le refroissement a 160 Ma se corrèle avec un soulèvement et une forte érosion dans la Cordillère orientale, et d' épais conglomérats dans la zone subandine.

Key words : *zircon F-T dating, Late Jurassic cooling and uplift event, Eastern Cordillera, Andes of central Peru.*

Zircon fission track ages of three samples from the Huachon granite (75° 55'W and 10° 40'S) which lies in the eastern Andes of central Peru, approximately 200 km NE of Lima (Fig.1) are presented. The purpose is to constrain the age of emplacement of the pluton and to improve the knowledge of the uplift history of the Eastern Cordillera of central Peru where no F-T studies of uplift have been made. Apatite dating has also be made in this study, but it is not considered in this paper (*). The time scale of Odin & Odin (1990) is used here and all calculations and discussions assume a geothermal gradient of 30 ° C/km.

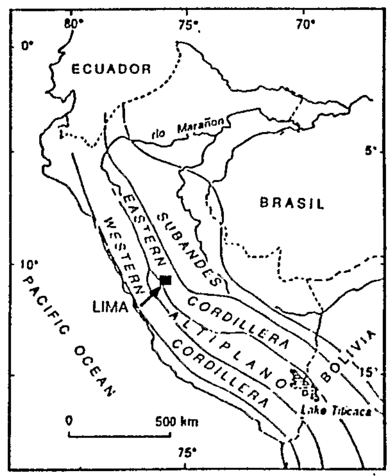

Fig. 1 : Location of the study zone

GEOLOGICAL SETTING

The Andes of central Peru are made up of the Western and Eastern Cordilleras that reach elevations of more than 6000 m and 5000m, respectively (Fig.1). In the study area, the two ranges are separated by the 50 to 100 km wide Altiplano which attains a height of approximately 4000m.

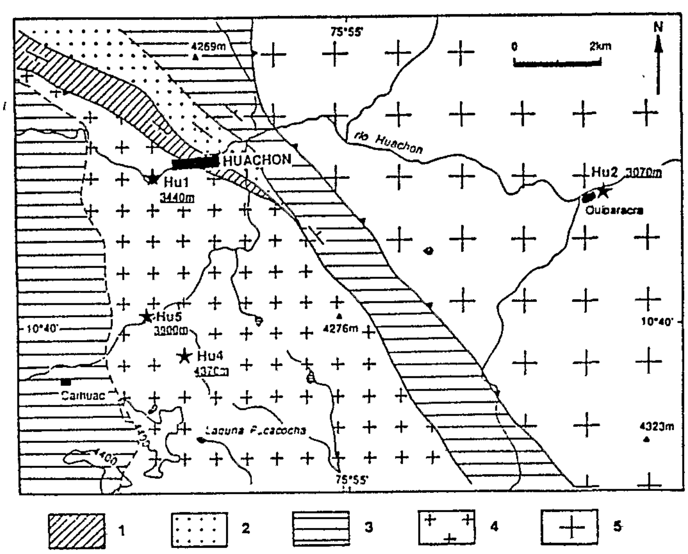

Fig. 2 : Geological sketch map of the Huachon area and location of the samples (stars). 1 : Pucara Group (Triassic and Liassic limestones); 2: Mitu Group (Permian and Triassic red beds); 3: undifferenciated low to intermediate metamorfic rocks of Lower Palaeozoic and Precambrian age; 4 : composite batholith including Precambrian to Andean granites.

The Eastern Cordillera is predominately made up of basement rocks of Precambrian and Palaeozoic age which have undergone a complexe pre-Andean orogenic history: Intense deformation and metamorfism associated with magmatism occured during Late Precambrian and Late Paleozoic (Mégard *et al.* 1971; Dalmayrac *et al.* 1980). Upper Permian to Middle Triassic coarse continental red beds (Mitu group) were deposited during a period of intense volcanism and plutonism (Mégard 1978; Dalmayrac *et al.* 1980; Soler & Bonhomme 1987). The Andean deposits of the Eastern Cordillera consist of Upper Triassic to Upper Cretaceous marine and continental deposits. After Santonian time, the central Peruvian Andes emerged and from Late Eocene to the Present, the Eastern Cordillera has undergone deformation, strong uplift and deep erosion (Mégard *et al.* 1984).

The samples dated in this study were collected in the Huachon valley (Fig.2) that drains eastward to the Amazon lowlands. Three samples of the Huachon granite Hu-1, Hu-5 and Hu-4 were collected at 3440m, 3900m and 4370m of altitude respectively (Fig.2). The Huachon granite is a coarse-grained and porphyritic homogeneous batholith, intruded into Precambrian metasedimentary and igneous rocks. Two conventional K/Ar ages of 202 ± 9 Ma and 151 ± 7 Ma, have been obtained on potassic feldspars of two samples of the Huachon granite by Bonhomme, in Soler (1991).

METHODS

Zircon grains were recovered using heavy liquids and magnetic separation. F-T ages of zircons were determined using the external detector method (Naeser 1976, 1979). Zircons were prepared (Gleadow *et al.* 1976) and irradiated along with neutron dose monitors (U-doped glass SRM 962 for zircon and sphene) (Carpenter & Reimer 1974) in the U.S.Geological Survey reactor in Denver, Colorado. Thermal neutron dose was determined from the track density in calibrated muscovite detectors that covered the glass standards during the irradiations. Ages were calculated using the zeta method of calibration and calculation (Hurford & Green 1983) and the following age standarts : Fish Canyon Tuff, Tardree Rhyolite, and Buluk Tuff. Uncertainty in the age was calculated by combining the Poisson errors on the spontaneous and induced track counts, and the track counts in the detector covering the dosimeter (McGee *et al.* 1985).

RESULTS

The F-T data and ages for the three zircon concentrates dated are shown in table 1 below.

SAMPLE	DF-	MINERAL	NUMBER GRAINS	ρ_s x 10^6 t/cm^2	FOSSIL TRACKS COUNTED	ρ_i x 10^6 t/cm^2	INDUCED TRACKS COUNTED	X^2	DOSIMETER DENSITY x 10^5 t/cm^2	DOSIMETER TRACKS COUNTED	Ma	±2σ (Ma)
HU-1	6037	zircon	7	24.7	3490	7.83	553	F	1.915	2694	190	19
HU-4	6038	zircon	6	21.5	994	6.83	158	F	1.915	2694	189	33
HU-51	6040	zircon	5	30.7	2420	5.82	229	F	1.915	2694	314	45
HU-52	6040	zircon	4	27.6	1534	6.62	184	F	1.915	2694	249	40

[1] with 587 Ma grain; [2] without 587 Ma grain; ZETAS Zircon (SRM 962) ; t/cm^2 = Tracks/centimeter^2 ;
DF = Laboratory Number ; X^2(Chisquare probability) = Pass (P) or Fail (F) Chisquare test at 5%

The zircon ages show a significant spread and a complex cooling history. Of the 18 grains counted from the three samples, 17 have ages between 104 Ma and 358 Ma. One zircon crystal from sample Hu-5 has an age of 573 ± 175 Ma. At this time, we consider this older age to be unreliable, because no other ages come close to supporting this result. It will not be included in any of the discussion. The probability density and histogram plot (Fig.3) show two peaks of ages, one at ≈270 Ma, and the other at ≈160 Ma.

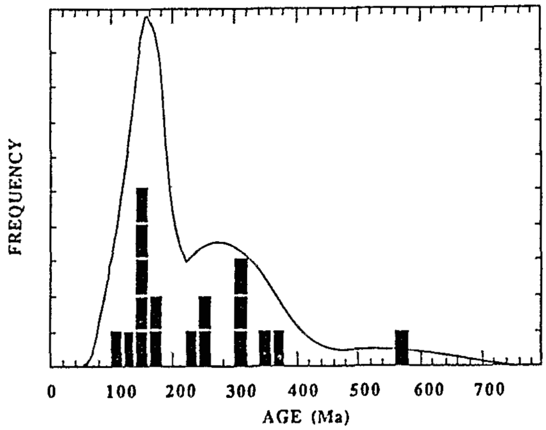

Fig. 3 : Probability density distribution for all zircons dated from the three samples of the Huachon granite. The solid rectangles represent each individual grain analysed.

CONCLUSIONS

The "**maximum**" **age at about 270 Ma** (Fig.3) suggest an important late Lower Permian cooling stage that we interpret as the emplacement age of the **Huachon granite.** The F-T ages of the zircons are compatible with the minimum ages of 202 and 151 Ma obtained by Bonhomme (in Soler 1991). The F-T ages suggest that it was emplaced at a depth where the temperature was between ≈150°C and ≈250°C during the Permian and remained at that depth (temperature) until a cooling (uplift/erosion) episode ≈160Ma. Residence of the samples in this temperature range would permit the annealing of the high uranium grains, while the tracks remained stable in the lower uranium grains.

The zircon data indicate that approximately 50°C-100°C cooling took place at ≈160Ma. This event cooled the rocks to a temperature where tracks were retained in the zircons (<175°C). This temperature was between ≈120°C and ≈200°C. Assuming a closure temperature of 200° ± 50°C for zircon and a geothermal gradient of 30°C/km, this indicates a period of exhumation and up to 3 km of materiel were removed from the roof of the Eastern Cordillera at this time.

Geological evidence of this Jurassic uplift event is recorded in several regions of Peru. In the eastern Andes and the Altiplano of central Peru, an important late-Middle to Late Jurassic uplift event is recognized by a lack of sedimentation during the Bathonian and Malm and strong erosion after deposition of the Chaucha formation of Bajocian age prior to the deposition of the Goyllarisquizga formation, whose base is thought to be Tithonian to Berriasian in age (Mégard 1978; Moulin 1989). This event has been assigned to extensional faulting related to Nevadian movements by Mégard (1978). The total thickness of post-Hercynian to Bajocian continental and marine sediments covering the Eastern Cordillera was over 2-3 km. Evidence of this Jurassic uplift event is also recorded in the Upper Sarayaquillo formation which outcrop approximately 100km east of the study area, in the Subandes. The Sarayaquillo formation, thought to be Bathonian to Malm in age (Koch 1962; Mégard 1978), consists of several hundred meters of thick red sandstones that grade upward into very coarse conglomerates (10 to 40cm clasts). These conglomerates become progressively finer and thinner to the east. Field observations (Laubacher, unpublished data) show that the lower strata of the conglomerates contain a few limestone clasts from the Pucara Group (Late Triassic and Early Jurassic) and abundant volcanic clasts of the Mitu Group (Late Permian to Early Triassic). The clasts in the conglomerates grade upward into significant percentages of quartzite and limestone derived from the Tarma and Copacabana Groups (Carboniferous to Lower Permian). The uppermost conglomeratic strata contain only a few limestone clasts but large amounts of metamorphic and igneous clasts derived from Lower Palaeozoic and Precambrian rocks. Stream directions and petrogaphy of the conglomerates in the Sarayaquillo formation indicate a western source which was approximately at the location of the present Eastern Cordillera area. The clasts in the Sarayaquillo formation record progressively deeper erosion of the pre-Andean basement. This provides evidence for a progressive and plurikilometric uplift of the Eastern Cordillera which was probably related either to a strong normal faulting or to a left-lateral transform offset of the Peruvian margin (Jaillard *et al.* 1990) reactivating old, possibly Hercynian, structures.

In summary, the zircon data indicate that the Huachon granite emplaced at approximately 270Ma and that 50°C-100°C cooling took place in the Eastern Cordillera at about 160 Ma. This latter event cooled the Huachon granite to a temperature where tracks were retained in the zircons (<175°C). The cooling indicate up to 3 km erosion of the roof of the Eastern Cordillera in central Peru at about 160 Ma. This exhumation event correlates with uplift and tectonism in the Eastern Cordillera and deposition of coarse conglomerates in the Subandes of central Peru during Bathonian to Malm times.

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