

LITHOSPHERIC-SCALE TRANSCURRENT FAULT SYSTEMS IN ANDEAN SOUTHERN PERU

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INTRODUCTION

Although Andean southern Peru forms the northwestern termination of the Bolivian Orocline, knowledge of its geology has little progressed in the last 20 years, partly due to the civil war that spread in the region during the 1980s and early 1990s. As a consequence, outdated information and concepts are generally still used in current assessments and syntheses, and updated data are needed. This short descriptive contribution presents the principal tectonic elements we currently recognise in southern Peru, and their relationships with syntectonic sedimentary basins. We observe that the most prominent deformational systems in this part of the Bolivian Orocline are dominantly transcurrent, and that many magmatic manifestations are associated with them.

LARGE-SCALE TECTONIC STRUCTURE OF ANDEAN SOUTHERN PERU

One of the main structural and paleotectonic element in southern Peru appears to be the Cusco-Lagunillas-Laraqueri-Abaroa structural corridor (CECLLA in Spanish), which strikes ~N150E and shows a remarkable 20°-obliquity to the regional Andean trend (Fig. 1). This large dextral wrench system is ~40-to~80 km-wide and displays a variety of tectonic, magmatic and sedimentary features:

- Along the CECLLA, pre-Oligocene rocks are locally intensely deformed (folded, sheared, and/or pervasively fractured), whereas northeast of it they are not, and reverse and strike-slip faults are observed. Paleozoic rocks crop out only northeast of the CECLLA, which moreover coincides with the northeastern limit of the Dogger-age deep-water facies of the Jurassic Arequipa basin. Immediately southwest of the CECLLA, the rarely exposed pre-Cenozoic rocks are much deformed Jurassic strata and unconformable, less deformed, mid-Cretaceous deposits. Immediately northeast of the CECLLA, the little deformed Jurassic strata are preserved below the Early Cretaceous erosional unconformity, and contrastingly display terrestrial and subordinate shallow-marine facies (Sempere et al., 2000). In the latest Jurassic - Early Cretaceous interval, deformational and thermal phenomena affected at least parts of the CECLLA, which locally resulted in an angular unconformity, and uplifts (Newell, 1949; Clark et al., 1990; Sempere et al., 2002). South of 15°S, thick Late Cretaceous - Paleogene strata, representing the foreland fill of the paleo-Andes, are known only from northeast of the CECLLA (excepted one occurrence within it). Eocene plutons (southwest of Cusco, north of Tacna) are known only from west of (or within) the CECLLA (Andahuaylas-Yauri batholith southwest of Cusco; Ataspacatitaco batholith northeast of Tacna-Mal Paso). Due to these characteristics, the Intra-Andean Boundary Fault (FLIA in Spanish) conjectured by Sempere (1995) should be identified with the CECLLA.

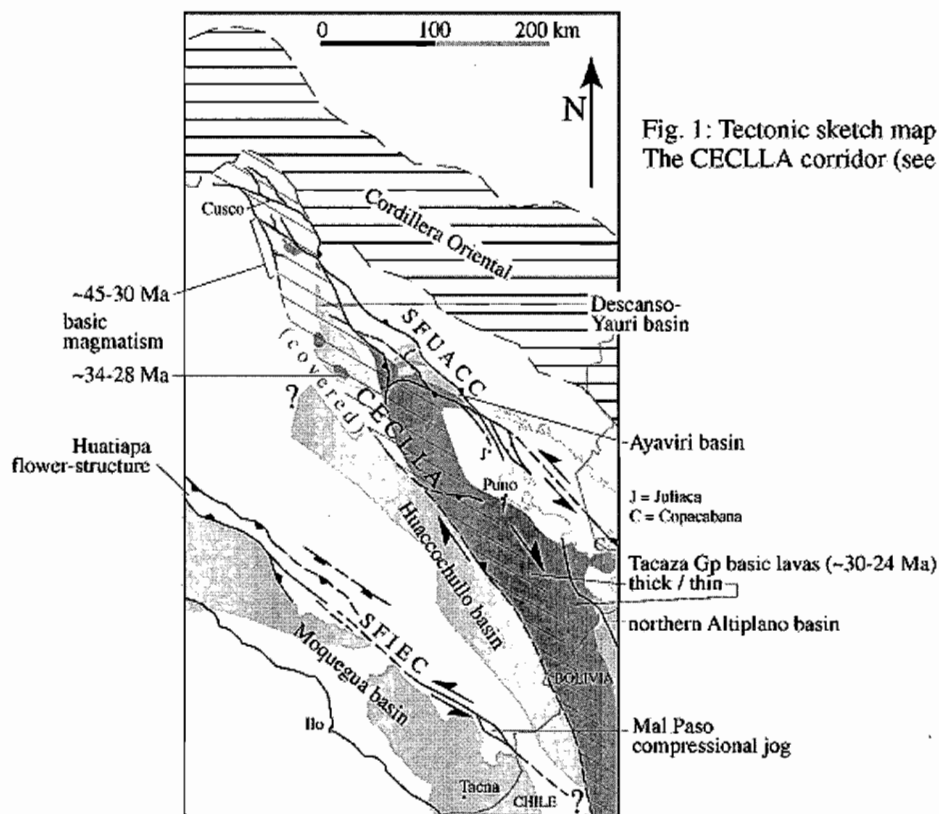


Fig. 1: Tectonic sketch map of Andean southern Peru. The CECLLA corridor (see text) is obliquely hatched.

- The CECLLA was the locus of emplacement of the Tacaza Group igneous rocks, which include mostly alkaline basic volcanics (dated 30-24 Ma; Fornari et al., 2002) and basic to felsic intrusions that also display alkaline affinities (Mamani and Ibarra, 2000). Their geometric and geochemical characteristics show that this magmatic corridor was not directly linked to subduction but rather functioned as a lithospheric-scale wrench system that permitted mantle melts to access the surface. Folding of the Tacaza basic flows in the CECLLA is post-dated by Late Miocene or younger strata.

- The Tacaza Group *sensu lato* also includes volcano-sedimentary units that were deposited in twin Oligo-Miocene basins west (Huacochullo basin, Peru) and east (northern Altiplano basin, Bolivia) of the CECLLA during its tectonic-magmatic activity; the infills of these two basins display noteworthy stratigraphic similarities and symmetries. The basal Tacaza volcano-sedimentary strata commonly post-date previous strata with an angular unconformity even outside the CECLLA. Some smaller basins, such as the Early-Middle Miocene Descanso-Yauri basin and the Late Miocene Paruro basin, developed within the CECLLA.

- Normal or transtensional faulting is currently particularly active within the CECLLA (areas of Pomacanchis, Langui-Layo, Lagunillas, etc.), creating hemigrabens in which lakes are formed. Senestral N120E faulting (including one focal mechanism solution for a crustal seism in the Lagunillas area) is common, and compatible with the dextral, ~N150E-oriented, CECLLA system. Late Neogene basic volcanism and hydrothermalism are also documented in the corridor area.

The ~N130E-trending Urcos-Ayaviri-Copacabana-Coniri fault system (SFUACC in Spanish) is a senestral transcurrent system that bounds the Cordillera Oriental domain and has an important SW-verging reverse component (Fig. 1). Although it was previously considered as a thrust in nearby Bolivia (Sempere et al., 1990), many SFUACC faults appear (sub) vertical. The close association of Neogene magmatism with the SFUACC (Redwood and Macintyre, 1989), including mantle-derived rocks occurring right on the main faults in Peru (Carlotto, 1998) and Bolivia (Hérail et al., 1993), definitely demonstrates that it is a crustal to lithospheric wrench system. The CECLLA and SFUACC become coalescent south of Cusco and in their NNW prolongation the Cordillera Oriental presents a major oroclinal deflection (Fig. 1). The development and syndepositional deformation of the rhombic Oligo-Miocene Ayaviri basin was controlled by major SFUACC faults.

The structure of southernmost Peru is dominated by the senestral, N125E-trending, Incapuquio-El Castillo fault system (SFIEC in Spanish; Jacay et al., this symposium), which is still seismically active and includes large and small flower-structures that have exhumed Precambrian basement (Fig. 1). Faults in this system have dips ranging from 90° (dominant) down to 35°, and a reverse component generally uplifting the NE compartments. The SFIEC serves as a first-approximation boundary for the plateau that extends to the northeast and supports the Plio-Quaternary volcanoes. At least east of 70°10'W, specific SFIEC faults display gouge facies that grade into subvertical mylonite bands (reaching ultramylonite and possibly even pseudotachylite facies in the east), which are ~100 m to ~3 km - wide. These fault rocks are particularly found in restraining bends and compressional jogs of the eastern SFIEC, i.e. in the internal region of the symmetry axis of the Bolivian Orocline. Conglomerate distribution and thickness show that the SFIEC formed the active northeastern boundary of the Oligocene Moquegua basin. It is likely that the abundant arc magmatism represented by the nearby, deformed, Late Cretaceous-Early Paleogene Toquepala Group was emplaced in relation with transpression along the SFIEC (following Saint-Blanquat et al.'s [1998] model); significantly enough, many coeval plutons occur in the Huatiapa flower-structure. Although it is largely buried in northern Chile below the thick Neogene volcanic rocks of the Cordillera Occidental, the SFIEC may interrupt against the CECLLA or coalesce with it.

CONCLUSIONS

Because magmas tend to ascend subvertically from depths ranging from the mid-crust to the lithospheric mantle, the close association of igneous rocks, partly derived from the mantle, with the CECLLA, SFUACC, and SFIEC, demonstrates that these fault systems are of lithospheric scale and subvertical.

We believe that recognition of lithospheric-scale wrench zones in southern Peru challenges the paradigmatic assumption that the Bolivian Orocline Andes were built by pure crustal shortening. Tectonic and magmatic phenomena akin to lateral expulsion of large lithospheric blocks now appear to have played significant roles. It is probably no coincidence, for instance, that $>30^\circ$ counterclockwise tectonic rotations of the Moquegua basin (Roperch et al., 2002) and intense mantle-derived magmatism along the CECLLA (Fornari et al., 2002) both developed during the Oligocene.

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