Pb ISOTOPES REVEAL BASEMENT DOMAINS OF THE ALTIPLANO, CENTRAL ANDES.

Susan J. AITCHESON (1), Russell S. HARMON (2), Stephen MOORBATH (1), Albrecht SCHNEIDER (3), Pierre SOLER(4), Eduardo SORIA-ESCALANTE. (1), George STEELE (5), Ian SWAINBANK (2), and Gerhard WÖRNER (6).

(1) Earth Sciences Dept., University of Oxford, Parks Rd., Oxford, OX1 3PR, U.K.
(2) NIGL, Kingsley Dunham Centre, Keyworth, Nottingham, NG12 5GG, U.K.
(3) Proyecto de Cooperación Geológica Alemania-Bolivia (BGR - GEOBOL), casilla 2729, La Paz - Bolivia.
(4) ORSTOM, UR1H, 213 rue Lafayette, 75480 Paris cedex 10, France.
(5) Dept. of Geology & Petroleum Geology, University of Aberdeen, Meston Building, Kings College, Aberdeen AB9 2UE, U.K.
(6) Inst. für Geowissenschaften, Universität Mainz, Obere Zahlbacher Straße 63, D-6500, Mainz, Germany.

RESUMEN: Datos isotópicos de Pb en mineralización y rocas volcánicas del Altiplano permiten definir tres dominios de basamento diferentes: Altiplano Norte, Altiplano Sur y Cordillera Oriental. Los dominios del Altiplano Norte y Sur se encuentran conectados mediante una zona de transición localizada en la Serranía Intersalar, mientras que el límite con el dominio de la Cordillera Oriental parece ser abrupto. Existe una buena correlación entre los dominios isotópicos definidos y estructuras evidentes en mapas gravimétricos publicados.

KEY WORDS: Altiplano, Andes, Ores, Pb-isotopes, Structure, Volcanics

INTRODUCTION

Almost all of the Pb in hydrothermal ore deposits of the Central Andes must have been scavenged directly from the crust with which the ore-forming fluids came in contact since such fluids are initially Pb-poor and their circulation is restricted to the shallow upper crust where open fractures can occur. In addition, quantitative geochemical modelling (Aitcheson and Forrest, 1993) suggests that over three quarters of the Pb in the volcanic rocks of the Central Andes is derived directly from the crust which was in contact with the magmas through crustal contamination processes. When there is such a large proportion of crustal Pb present in ore deposits and volcanic rocks the Pb isotopic composition of these materials can also be regarded as a crude average

for the composition of the crust through which the magmas or fluids passed. Where large regional differences in crustal Pb isotopic composition exist and basement exposures are scarce or absent, as in the Altiplano region of the Central Andes, ore deposits and volcanic rocks are powerful tools for mapping out the different crustal isotopic domains. Such maps can in turn provide insights into the gross crustal structure of the region.

RESULTS FROM THE CENTRAL ANDES

Central Andean igneous rocks and Pb ores of Miocene-Recent age from 16-23°S have a similar and wide range of Pb isotopic compositions ($^{206}Pb/^{204}Pb$=17.3-19.0, $^{207}Pb/^{204}Pb$=15.51-15.85, $^{208}Pb/^{204}Pb$=37.4-39.4) which are interpreted to reflect the isotopic character of the local basement. The data map out several distinct crustal domains which are otherwise hidden by superficial deposits (Fig. 1):

(1) N. Altiplano domain

This domain occupies the northern Altiplano from the volcanic front to Lago Poopo and extends as far south as the Salar de Uyuni at 19.5°S. It is characterized by relatively unradiogenic Pb, i.e. low values of $^{206}Pb/^{204}Pb$ (<18.3) , $^{207}Pb/^{204}Pb$ (<15.619) and $^{208}Pb/^{204}Pb$ (<38.5). This domain may be an extension of the Proterozoic Arequipa Massif of Peru, which is also characterized by relatively unradiogenic Pb isotopic compositions.

(2) E. Cordillera domain

This domain has more radiogenic Pb, i.e. higher values of the Pb isotope ratios ($^{206}Pb/^{204}Pb$ >18.6, $^{207}Pb/^{204}Pb$ >15.64 and $^{208}Pb/^{204}Pb$ >38.9), and extends eastwards from L. Poopo into the E. Cordillera. At L. Poopo this domain is separated from the N. Altiplano domain to the west by a sharp N-S-trending boundary (probably a major fault) which appears to be offset south of L. Poopo ("B" in Fig. 1). At L. Titicaca the two domains appear to be separated by the NW-SE-trending Copacabana Fault Zone.

(3) S. Altiplano domain

This domain occupies the southern half of the Altiplano and is isotopically similar to the E. Cordillera domain, except for its slightly lower $^{208}Pb/^{204}Pb$ ratios (38.5-38.9). The boundary between the N. Altiplano and S. Altiplano domains is a broad transition zone (TZ, Fig. 1) between 19.5°S and 21°S where both (radiogenic and unradiogenic) types of crust are present. This transition zone might represent a single south-dipping thrust zone (Wörner et al., 1992) or a more complex zone in which the two types of crust are tectonically-interleaved.

The boundaries of the three main isotopic domains correspond to important tectonic boundaries inferred by previous workers. Some of the features of the isotopic maps also have an expression in the Bouguer gravity map of the region (Cady, 1992); for example, there is a change from NW-SE trending gravity anomalies in the N. Altiplano to NNE-SSW-trending gravity anomalies in the S. Altiplano, which presumably reflects the different orientations of basement structures in the two areas, while smaller-scale Pb isotopic anomalies such as "A" in Figure 1 seem to correspond to small gravity anomalies.

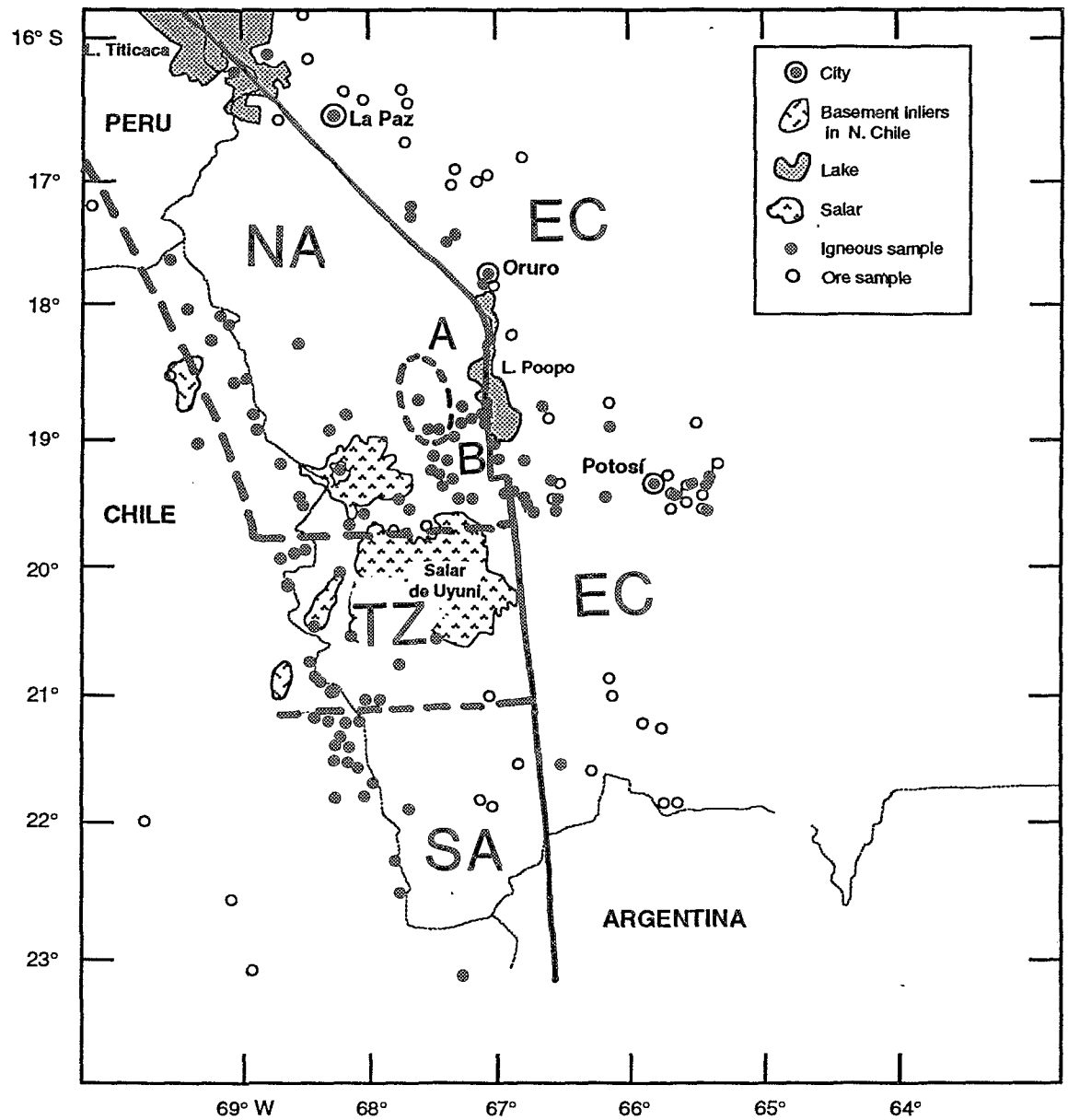

Figure 1: Principal crustal domains of the Altiplano (Bolivia and N. Chile), inferred from Pb isotopic data from ore deposits and volcanic rocks (data from this work, Davidson & de Silva (1992), Wörner et al. (1992), McFarlane et al. (1990) & references therein, and Harmon et al. (1984)). NA = Northern Altiplano domain, SA = Southern Altiplano domain, EC = Eastern Cordillera domain, TZ = Transition Zone between N. & S. Altiplano domains. "A" is a Pb isotope anomaly which corresponds to a small gravity anomaly. "B" is an apparent offset of a domain boundary, perhaps by faulting.

CONCLUSIONS

(1) Pb isotope data from ores and volcanic rocks in the Altiplano region define three distinct basement domains corresponding to the N. Altiplano, S. Altiplano and E. Cordillera.

(2) The data indicate that the boundary between the northern and southern Altiplano domains is a broad transition zone situated in the Salar de Uyuni area, but the boundary between the E. Cordillera and the Altiplano domains appears to be very abrupt.

(3) Most of the isotopic domain boundaries correspond to major tectonic boundaries inferred by previous workers and some also find expression in published gravity maps of the region. Pb isotope data from volcanic rocks and ores thus seem to be an excellent remote sensing tool for mapping large-scale crustal structure in poorly exposed areas.

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