patterns into mantle (m), crust (c) and mantle-crust (mc) types and to make a second-order subdivision according to the nature of the mantle and/or crust involved;. further subdivisions according to the nature of the fractionation processes are also possible.

The mantle patterns are defined as those derived from a mantle-derived parent magma with no subsequent crustal involvement. Thus m_d and m_e patterns are found in granites whose parent magmas were derived respectively from incompatible element depleted (N-MORB-related) and enriched (plume-related) mantle sources while m_{ds} and m_{es} patterns result when the depleted or enriched mantle source had been modified by addition of a (LIL element rich) subduction component.

The crustal patterns are defined as having been solely derived from fusion of the continental crust. c_s and c_i patterns represent those derived from closed-system fusion of sedimentary and ingeous source region respectively and c_{vs} and c_{vi} patterns result from open-system fusion of these regions in which elements such as Rb have been selectively gained due to influx of a volatile phase. Effects of variable source composition and varying degrees of partial melting on pattern shape were otbained from analyses of partly assimilated xenoliths and autoliths, from analyses of leucosomes, palasomes and segregated granitic bodies in gneiss terranes and from granitic rocks derived from well-defined crustal sources. Mantle-crust patterns result from mixing of mantle-derived melts with crustal-derived melts and will vary according to the components involved and whether mixing precedes, accompanies and/or follows crystallization of the magma.

From our data base of granitic rocks from the main tectonic environments, ocean ridge granites (ORG) exhibit patterns of m_d to m_e type if from normal to anomalous ridge segments respectively and of m_{ds} type if from supra-subduction zone ridge segment. Within plate granites (WPG) intruded into attenuated lithosphere are predominantly of m_dc_s to m_ec_s type, although c_s patterns have been indetified in a few localities; WPG intruded into normal continental lithosphere yelds m_e to m_ec_s patterns; and WPG in oceanic island generally give m_e patterns, although m_{es} patterns can result if the mantle source had a major DUPÁL component. Volcanic arc granites (VAG) exhibit m_{ds} patterns if of oceanic origin and range from m_{es} to $m_{es}c$ at active continental margins.

Collision granites (COŁG) range from c_{vs} and c_{vi} to c_s and c_i in syn-collision environments. In post-collision environments, $m_{es}c_s$ patterns now dominate, although c_i and c_s patterns also exist and may have been more important in the Archaean.

Linear programming and pattern recognition techniques can be used to interpret trace elements patterns by providing quantitative measures of the proportions of crust and mantle components and the probabilities of tectonomagmatic assignments.

* Department of Geology, The University, Newcastle upon Tyne, U.K. ** Department of Earth Sciences, The Open University, Milton Keynes, U.K.

PITCHER W.S. - *Andean batholiths: the generation of I-type granitoids at a plate margin*

The chain of great granitoid batholiths that cores the Western Cordilleras of the central and southern Andes provides a type example of silicic magmatism at an active plate edge of a continent. The magmas were generated in the upper mantle by processes initiated during crustal extension connected with Mesozoic subduction. Despite emplacement into the continental margin their composition had little to do with old crust, except where residence was prolonged locally. Overall the magmas made a major contribution to crustal growth.

Such batholith have been regarded as forming the roots of volcanic arcs developed above subduction zones. There is a close spatial relationship with evidence of a plutono-volcanic interface, but there is also a significant compositional and time hiatus as expressed in the cyclic nature of magma-tectonics events, viz. basinal volcanicity, compression, granitoid intrusion and finally uplift, which suggests that the nature of the source differed with time.

The Coastal Batholith of Peru illustrates well the nature of this type of silicic magmatism. A linear array of hundreds of plutons was stoped out of the axial zone of a precursor back-arc basin of Lower Cretacoeus age. The latter had been infilled with lavas, volcanosclasic deposits, feeder gabbros and basic dykes, and subjected to a non-deformative, episodic, burial metamorphims which was enhanced by the contact effects of granitoid intrusion.

Calc-alkaline, magnetite-bearing, I-type tonalites and granodiorites predominate, though the compositional spectrum is widened to include both K-rich diorites and evolved granites. All these rocks occur in well-defined, time-separated, consaguineous rock suites, each with its own identity as defined in terms of chronology, modal and chemical composition, textural characteristics, enclave population and dyke-swarm association. Overall the isotopic data are wholly in accord with a primary mantle source. Nevertheless the extraction processes seems to have required the early pillow lavas, gabbros and basic dykes. A mid-Cretaceous compressional phase triggered the equilibrium melting of this basic substrate with ėpisodic production of hot, relatively dry magmas which fractionated on upwelling, the concentrates accreting on the walls of the conduits.

The Coastal Batholith represents a simple case of the generation of magma along a single megalineament, and over the long time interval of 112-32 Ma. An analogue is the event longer-lasting Patagonia Batholith, 155-10 Ma, with like dimensions, near identical compositions, a similiar history, and again with a close time and space relationship with the development of a back-arc bassin. Only the frame is different; a complex, accreted forearc terrane of Paleozoic age instead of the ancient gneisses of the craton as in Peru.

Such a Paleozoic understory persists into central and northern Chile carrying similar back-arc basial deposits of Mesozoic age. Here, however, both the volcanic belts and the linear batholiths show an easterly migration with time into the continental lip, with a correspondingly increasing influence of the old crust on the composition of the granitoid magmas.

In contrast, in the northern Andes, a Pacific island-arc terrane was accreted into the true continental margin, affording a sharp contrast between the voluminous, compositionally expanded, I-type granitoids of the liminal environment, and the small volume of compositionally restricted M-types of the oceanic arc.

Thus, overall, the evolution of the Andean batholiths provides a model for the origin of one type of granitic rocks at an active, continental plate margin. It is the thickness of the continental crust, combined with high heat flow, which provides the conditions for especially vigorous melting. During the extentional phase new crust was generated by extraction of a basic progenitor from the mantle. Then relatively mild phases of compression both triggered the remelting and generation of major batches of magma, and sufficiently sealed the thickned crustal carapace to provide the increased travel distances and times necessary to advance the differentiation process.

It is doubtful whether such a Pacific-type margin environment, with its voluminous production of K-poor, Ca-rich granitoids, ever formed an important element in the geological evolution of the European crust.

* University of Liverpool. U.K.

PUPIN J.L.* - *Granites as indicators in paleogeodynamics*

The typologic study of zircon populations (PUPIN 1976; PUPIN and TURCO, 1972, 1981) is more and more employed to solve problems dealing with endogenous or exogenous petrology (i.e. plutonic and volcanic rock petrogenesis, origin of ortho and para-derived metamorphic rocks, origin of detritals in sedimentary rocks, metallogenesis associated with magmatism...). Among them, the use of granitic rocks as magmatic indicators in paleogeodynamics seems to be one of the most fruitful in the future.

Genetic classification of granites using the typologic diagram (PUPIN 1980, 1981a) is one of the most powerful concerning the discrimination of anatectic mobilisates, mantle derived granites (alkaline, tholeiitic) and hybrid granitic rocks (calc-alkaline s.l., K-calc-alkaline = magnesiopotassic and K-subalkaline = ferropotassic) where sialic crust and mantle materials ratio vary largely. The origin can be determined even on little, homogeneous and/or altered bodies in a very rapid and easy way.

The mean points distribution of zircon populations from granites sampled in the same area visualize very clearly the contrast previously mentioned by PITCHER (1979) for acidic magmas in «alpinotype», «andinotype» and «hercynotype» environments. Moreover, the comparison of the different typological characteristics (mean points ($\bar{A}$,$\bar{T}$), typological evolutionary trends T.E.T.) lead to define magmatic zonings in ancient orogens (PUPIN 1981b, 1982, 1985). The nature and complexity of these zonings are depending upon numerous factors, i.e. duration of subduction, importance of the compressional and tensional tectonics, structural level of observation.

Several examples of magmatic zoning are proposed. They are characterized by the abundance or scarcity of granitic bodies and/or associated rhyolites, the importance of crustal anatexis, the temperature and water content of the melts — especially concerning calc-alkaline granites —.

— Cenozoïc period: Mexico, New Caledonia, Western Alps, Elba-Tuscany, Aegean Sea.
— Hercynian cycle: french Massif Central, Brittany, Corsica-Provence, Morocco.
— Caledonian cycle: Belgium.
— Brazilian cycle (late precambrian): Southern Brazil.

The complete zoning is generally characterized, with more or less overlapping, by the following succession towards internal zones:

1) Calc-alkaline granites derived from water rich magmas; tonalites.
2) Aluminous anatectic granites (linked with collision processes).
3) Calc-alkaline and K-calc-alkaline granites derived from «hotter and drier» magmas.
4) K subalkaline granites: (alkaline granites).

From the groups 1 to 4, an increase of $\bar{T}$ indices of populations is registred. The $\bar{T}$ values of calc-alkaline granites are higher for active margins with a long duration of the subduction process than for collision following limited subduction zone.

The use of such magmatic indicators is of interest notably for the study of very complex orogenic domains as i.e. the hercynian belt in western Europe, the patchwork distribution of the magmatism probably resulting of the working of several microplates. Thus, acid magmatism is likely to provide excellent criteria of polarity capable of solving the problems of paleogeodynamics.

REFERENCES

PITCHER (1979) - J. Geol. Soc. London, 136, 627-662.
PUPIN (1976) - Thèse Doct.es Sc. Univ. Nice (France), 394 pp.
PUPIN (1980) - Contrib. Mineral. Petrol. 73, 207-220.
PUPIN (1981a) - C.R. Acad. Sci. Paris 292 (II), 405-408.
PUPIN (1981b) - C.R. Acad. Sci. Paris 293 (II), 597-600.
PUPIN (1982) - Intern. Colloq. «*Pétrologie et géochimie des granitoïdes*», C.N.R.S. Clermont-Ferrand.
PUPIN (1985) - Schweiz. mineral. petrog. Mitt. 65, 29-56.
PUPIN AND TURCO (1972) - Bull. Soc. Fr. Mineral. Cristallogr. 95, 348-359.
PUPIN AND TURCO (1981) - Bull. Soc. Fr. Mineral. Cristallogr. 104, 724-731.

* Laboratoire de Pétrologie et Minéralogie, Université de Nice (France).

PUZIEWICZ J.* - *Origin of a gradual transition of the Koźmice granodiorite (Sudetes, SW Poland) into its wall rocks*

The Koźmice granodiorite forms a few-meters thick