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Terranes in the Variscan Belt of France and Western Europe

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Conference Reports

Project 233

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Terranes in the Variscan Belt of France and Western Europe

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An international conference, with field excursions, held 26-31 August 1988 at Montpellier, France, was organized by P. Matte, D. Santallier, J.D. Keppie and R.D. Dallmeyer under the auspices of IGCP Project 233. About 100 people attended the conference hailing from several countries around the Atlantic including France, East and West Germany, Austria, Switzerland, Spain, Portugal, United Kingdom, Eire, Norway, Sweden, Czechoslovakia, USA and Canada. There were about 20 people on each of the field trips. A total of 81 papers were presented and 8 posters were displayed.

In the introductory overview session, J.D. Keppie (Canada) showed the "Map of Pre-Mesozoic Terranes in Circum-Atlantic Phanerozoic Orogens" compiled by many of the participants of IGCP Project 233, and indicated some of the results including: (1) the presence of Archean and Early Proterozoic rocks in all the major circum-Atlantic cratonic terranes; (2) the presence of Middle Proterozoic (Grenvillian) rocks in all the major circum-Atlantic cratonic terranes except the West African craton; (3) that Pan-African Orogens are developed across all of these older basements, but are limited to the southeastern part of the map area, namely, central and western Europe, southern British Isles, southeastern Appalachians, northwest Africa and northern South America; (4) that accretionary deformation associated with the Pan-African Orogens overlaps the birth and spreading of Iapetus suggesting that these parts of the present circum-Atlantic lay in different oceans in Precambrian-Cambrian times; (5) many of the Pan-African Orogens preserve an abundance of magmatic arc and peri-arc terranes compared with the circum-Atlantic Paleozoic Orogens — possibly related to the absence of continent-continent collision in some of the Pan-African Orogens; (6) Late Precambrian-Early Proterozoic disrupted terranes composed of tectonic melanges occur along the margins of many of the major cratonic terranes and represent imbrication of the continent-ocean transition; (7) most ophiolites, magmatic arcs and peri-arc basins in the vestiges of Iapetus are Late Cambrian-Early Ordovician, except in central and western Europe where they range from Silurian-Devonian — the ophiolites generally appear to represent small ocean basins; (8) the main accretionary events appear to be Early Paleozoic in the Appalachians-Caledonides, with accretionary events persisting into the Late Paleozoic in the Variscan Orogeny — Late Paleozoic events in the Appalachians-Caledonides may be related to progressive transpression while convergence was still taking place in Europe; (9) faunal provinciality evident in the Cambro-Ordovician, which becomes cosmopolitan in the Siluro-Devonian supports closure of Iapetus by the end of the Ordovician. This terrane map will be the base for other thematic maps and provides one tool in the search for a palinspastic model for these orogens. Current models based purely on paleomagnetic data provide widely divergent views and need to be integrated with terrane analysis.

There followed a series of papers outling the use of metamorphism (R.P. Raeside, Canada), metallogenesis (J.F. Slack, USA and H.S. Swinden, Canada), $^{40}Ar/^{39}Ar$ dating (S. Costa and H. Maluski, France) and U-Pb zircon ion-probe dating (D. Gebauer, Switzerland, W. Compston and I.S. Williams, Australia; M. Grunenfelder, Switzerland) in terrane identification. The topic of metallogeny and terranes occupied the balance of the day. Slack and Swinden pointed out that while metallogenic data can be used to aid terrane identification, complications arise when (1) mineralization is repeated at different times within one terrane; (2) similar mineralization may occur in different terranes; (3) similar, but tectonically unrelated, deposits may be structurally juxtaposed; and (4) post-accretionary mineralization may superimpose epigenetic ores on previously formed deposits. They gave examples of these complexities using examples from the northern Appalachians. Later, H.S. Swinden (Canada), A.P. LeHuray and J.F. Slack (USA) showed how lead isotopic compositions from volcanogenic massive sulphide deposits provide a fingerprint of the host terrane: (a) deposits in most of the Avalon composite terrane plot in a restricted field close to crustal growth curves — an exception is from SE Newfoundland; (b) deposits in the northern and central Exploits Subzone of Newfoundland have moderately radiogenic lead; in contrast to (c) deposits in the southern Exploits Subzone have consistently more radiogenic lead; (d) deposits in the Notre Dame Subzone of Newfoundland have relatively non-radiogenic lead. The lead isotope data support some correlations along the Appalachians, while some plot in diffuse fields overlapping those defined in Newfoundland. However, caution was urged because basement-derived lead isotopic compositions may be contaminated by more radiogenic lead in sedimentary depositional environments. R.A. Ayuso (USA) and M.L. Bevier (Canada) presented a paper on a related topic of lead isotopic variations in northern Appalachian grantic plutons, which shows four regionally distinct groups of plutons indicative of several different source regions. J.D. Keppie (Canada) showed that in the northern Appalachians, there was a close correlation between mineral deposit type and tectonic environment prior to accretion, but this is replace by widespread, superimposed, polymetallic mineralization related to Devonian(-Carboniferous) stitching plutonism following accretion. M. LeBlanc (France) showed that mineralization in the Appalachian-Bohemian Massif was comparable to the zonality exhibited in active orogenic zones, with some complications resulting from tectonic slicing. Several papers dealing with various aspects of metallogeny in France were presented: associated with Paleozoic granites, uranium and Au-U in shear zones.

The next session dealt with the application of geophysics to terrane analysis. H. Perroud (France) review Variscan paleomagnetic data and concluded that reliable data for the Paleozoic are far from complete and limitations of the method may not allow distinctions between neighbouring terranes to be made. Other papers in this session applied various types of geophysical data (gravity, magnetic, seismic) to tracing terrane boundaries beneath overstepping sequences both on- and off-shore, the most comprehensive of which was presented by J.P. Lefort (France) to be published shortly as a book.

A whole day was devoted to terranes in the Variscan belt in France. Only in the northern part of the Armorican Massif are the Cadomian (Late Precambrian) terranes preserved without the obscuring effects of the Variscan orogenesis. Here, from NW to SE are (1) a Late Precambrian magmatic arc built upon a 2000 Ma old basement, bordered by (2) a back-arc basin all thrust southward over (3) a continental margin sequence bordering (4) a continental block with (5) a turbidite basin on its southern side. The southern part of the Armorican Massif and all of the Massif Central were involved in strong Variscan orogenesis involving mainly E to W nappe transport and cut by large generally dextral transcurrent shear zones and faults. At least six major nappes have been recognized in the Massif Central (P. Ledru and A. Autran, France) which may correlate with nappes in the southern Armorican Massif (M. Colchen, P. Bouton, P. Meidom and D. Poncet, France; P.L. Guillot and J.P. Floc'h, France; P. Matte, France). The nappes from bottom to top consist of: (a) Early Paleozoic volcanic arc (Thiver-Payzac Unit); (b) ophiolite (Genis Unit); (c) Late Precambrian-(?)Paleozoic miogeocline; (d) Late Precambrian-Early Paleozoic continental rise (Lower Gneiss Unit); (e) Early Paleozoic peri-arc basin (Upper Gneiss Unit); and (f) Carboniferous rift volcanic and sedimentary rocks. Dismembered ophiolites also occur at the base of nappes (d) and (e) (G. Dubuisson, C. Mercier and J. Girardeau, France). D.S. Santallier and others (France) showed that the metamorphism associated with the Variscan Orogeny progressed from high pressure during the Ordovician and Silurian through medium pressure in the Devono-Carboniferous to low pressure in Late Carboniferous times. While the high-pressure metamorphism is attributed to subduction processes, the latter two are accompanied by widespread plutonism (A. Ploquin, J.M. Stussi, A. Bourguignon and M. Cuney, France; G. Vitel, France; J.L. Bouchez, France). Papers were also presented on correlatives in the Maures and Tanneron Massifs (M. Seno and A. Vauchez, France); in the French Alps (R.P. Menot, France), in the eastern Alps (F. Neubauer, Austria) and in the Ardennes (F. Meilliez, France, A. Blieck and L. Andre, Belgium). Papers on correlatives in the Bohemian Massif (J. Chaloupsky, Czechoslovakia; G. Hirschmann, W. Germany; P. Matte, France, and P. Rajlich, Czechoslovakia; E. Stein and C. Wagener-Lohse, W. Germany, K. Weber and A. Vollbrecht, W. Germany; W. Franke, J. Schmoll, C. Reichert, G. Dohr and H.J. Durbaum, W. Germany; P. Fluck, J.B. Edel, A. Pique, J.L. Schneider and H. Whitechurch, France), the Schwarzwald and Vosges (G.H. Eisbacher and E. Luschen, W. Germany; A. Krohe, W. Germany), and in the Variscan foreland (W. Brochwicz-Lewinski, Poland; B. Le Gall, France; F. Bernard, B. Doligez, A. Mascle, M. Cazes and T. Rossi, France; C. Bois, O. Gariel, B. Pinet, J.P. Lefort, J.C. Sibuet and M. Cazes, France) were also presented. Other sessions included papers on UK, Eire, Scandinavia, Iberia, Northwest Africa and the Appalachians. Two publications are planned: (1) a book on "The Pre-Mesozoic Terranes in France and Correlative Areas" in English; and (2) a special issue of *Tectonophysics* with a selection of papers from the conference.

One afternoon was devoted to discussion of the various thematic maps being prepared by participants of the project, *e.g.*, terranes, metamorphism, structure, igneous petrology, geophysics. It is a tribute to the linguistic capabilities of French-speaking geologists that the papers at the conference were presented in English which added greatly to dissemination of information around all regions in the circum-Atlantic — congratulations and thanks.

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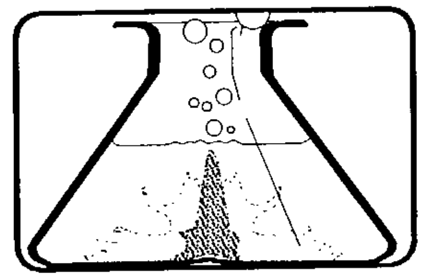

Geochemical Self-Organization

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The conference Geochemical Self-Organization was held June 26-July 1, 1988 at The University of California, Santa Barbara campus. The goal of the conference was to bring together scientists working on non-equilibrium, and self-organized geologic systems. This report gives a brief overview of self-organization and focusses on the Canadian participation at the conference.

Self-organization can be defined as the spontaneous transfer of a system from an unpatterned to a patterned state without the intervention of an external template. A familiar example is convection in a fluid, the so-called Benard instability, where at a particular vertical temperature gradient billions of molecules become arranged into coherent macroscopic convection cells, rather than a collection of independent molecules vibrating on a scale of 10^{-8} cm. Geological examples thought to be due to self-organization include disequilibrium textures such as spherulites, layering in certain sedimentary, metamorphic and igneous rocks and ore deposits, zoning in some crystals, the patterns of concretions, dendritic drainage patterns, and frost-heaved patterned ground. What leads to self-organization? Non-equilibrium, feedback, and noise.

Nicolis and Prigogine (1977) show that entropy change (dS) can be characterized by two terms, entropy production dSp, and entropy exchange dSe. The production term represents entropy produced within the system through irreversible processes and is therefore invariant in sign, whereas entropy exchange can be either positive or negative *e.g.*, a reversal of the direction of heat exchange of a system with its environment. For isolated systems dSe = 0 by definition. In contrast, open systems can in principle have an associated entropy flow such that -dSe = dSp > 0, and the final state may be more ordered than the initial state (Nicolis and