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Studies on Ophiolites in Selected Regions of the World

Report by *J. Bertrand**), *M. Delaloye**) and *M. Vuagnat**)

WESTERN ALPS

MONTGENEVRE MASSIF (FRANCE AND ITALY)

- Field and laboratory work clearly demonstrate that the «Flasergabbros» of the Chenaillet area have been deformed before the intrusion of the doleritic dykes, which are considered to be possible feeders for the pillow basalts resting on the gabbros. Evidence of a very early, deep oceanic floor deformation phase accompanied by metamorphism in the amphibolite facies may be emphasized (VUAGNAT, 1975; STEEN, VUAGNAT and WAGNER, 1977). There is general agreement between our results and those of MEVEL et al. (*Earth Planet. Sci. Lett.*, 39, 98-108, 1978).
- Detailed mapping of the saddle between the Chenaillet and the Grand Charvia (or Soureou) indicates the existence of a serpentinitic melange zone here. There are blocks and lenses of serpentinitized peridotites, ophispherites, dolerites, spilites, pillow lavas and pillow breccias, ophicalcites, and rare clastic sediments. The matrix is often a serpentinite breccia, which in places, has an important calcareous cement, probably of sedimentary origin. Ophispherites are derived from fragments of pillow basalts, dolerites or gabbros. This serpentinite melange zone is tentatively compared to similar zones observed on the ocean floor and considered to result from ultramafic diapirs. This zone has undergone further alpine deformations.

HIGHLY DISMEMBERED OPHIOLITIC SEQUENCE IN THE FLYSCH OF LES GETS (HAUTE -SAVOIE; FRANCE)

K-Ar ages have been determined on hornblende gabbros-diabases and on albite-chlorite pillow basalts.

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Most of the individual ages obtained range between 200 and 100 m.y. (BERTRAND and DELALOYE, 1976). New analyses were recently done because of technological and methodological improvements in K-Ar geochronology and development of new graphical methods permitting the verification of the presence of excess ^{40}Ar . The results from whole rocks and from melanocratic concentrates agree closely. The most probable age is mid-Jurassic; there is no evidence of excess ^{40}Ar .

A detailed electron microprobe study has been done on most important mineral phases (basaltic hornblende, pyroxene, plagioclase) of the main rock types in order to obtain a reasonable idea of the nature of the original magma(s) of the rocks, some of which were almost unaffected by metamorphism. Two main groups of basic rocks may be distinguished: hypabyssal gabbros-diabases with basaltic hornblende and/or pyroxene and intermediate to sodic plagioclase, and spilitic pillow basalts with albite and chlorite, very exceptionally with small relics of pyroxene (MEVEL C. and VELDE C., *Earth Planet. Sci. Lett.* 32, 158-164, 1976). Rare earth element distribution is also being studied in the main groups of this ophiolitic sequence.

ALPINE GRAYWACKES OF TERTIARY AGE

Detailed mapping, SW of the river Arve in the Thônes syncline, revealed that the metamorphic grade of the Taveyanne Formation in this area is lower than that further east between the rivers Arve and Giffre (SAWATZKI, 1975). Relics of heulandite are found in some places.

Geochronological and petrographical work show that ophiolitic fragments in the conglomerates equivalent to the Val d'Illeiez Graywackes, have been metamorphosed, in an alpine context, prior to their erosion and deposition. Diabases of the «Grès du Val d'Illeiez» give Lower Eocene radiometric age. Whole rock ages of mid-Oligocene were obtained for the andesitic fragments of the «Grès de Taveyanne». Both these ages are interpreted as ages of metamorphic events (FONTIGNIE, 1977).

In order to further over understanding of the pumpellyite-actinolite facies, work was done on the metamorphic minerals of the Taveyanne graywackes of the Loèche region (Valais, Switzerland) (COOMBS et al., 1976).

OPHIOLITES OF THE HAUTE-UBAYE (FRANCE)

The geological mapping, petrographical, mineralogical and chemical studies, have been completed (STEEN, 1975; STEEN and BERTRAND, 1977). A metamorphic history of this large ophiolitic sequence has been established: a high pressure-low temperature phase (blue amphiboles, lawsonite, jadeitic pyroxene and jadeite) has been followed by retromorphism in the greenschist facies.

APENNINES OPHIOLITES

A mineralogical and petrographical study (CRIVELLI, 1976) on the ophiolitic sequence of the Pisa-Livorno area has pointed out tectonic nature of the contacts between the different units of the trilogy. Numerous diabasic dykes form, in some places, true sheeted-complexes, but on a very small scale. A least two metamorphic events affected these rocks; the first one (low greenschist facies) in the ocean floor and the second one (pumpellyite-prehnite facies) during the alpine orogeny.

CENTRAL AND SOUTH AMERICA

CARIBBEAN OPHIOLITES: GUATEMALAN ULTRAMAFIC BELTS

Petrological and geochemical investigations of rocks collected in several outcrops of the two main belts of ultramafics of Guatemala have confirmed that these are part of an ophiolitic sequence (BERTRAND et VUAGNAT, 1977).

Pillow lavas (BERTRAND et VUAGNAT, 1975) have been found in the Motagua fault zone with textures well preserved although these basalts have been subjected to a prehnite-pumpellyite facies metamorphism.

The Motagua zone appears as a typical melange zone (BERTRAND et VUAGNAT, 1976). Deformed dykes and several blocks of different origin (rodingites, albitites, albite-granites, amphibolites, etc.) are inbedded in a serpentinite matrix. There are clear indications that some of these blocks have been retro-morphosed from high pressure-low temperature assemblages. This is in agreement with the description of eclogitic and jadeitic «boulders» by several authors for instance MCBIRNEY et al (Americ. Miner., 52, 908-918, 1967). Ultramafics of the northern belt are less deformed. In some associated dykes of gabbro there is evidence of rodingitization; in one outcrop the new mineral vuagnatite was found for the first time in Guatemala (BERTRAND et SARP, 1976).

Several K-Ar age determinations were made on specimens collected mainly in the southern belt (BERTRAND, DELALOYE, FONTIGNIE et VUAGNAT, 1978). An isochron age of 58.5 ± 3.7 m.y. was obtained. A Palaeozoic age of metamorphism and emplacement of these rocks can thus be excluded.

COLUMBIAN OPHIOLITES

A study of the ophiolites from the Patia basin in the Andes has almost been finished (Ph. D. Thesis, A. ESPINOSA). The relationship between the ophiolitic sequence and the different geological formations has been described for the

first time. A model of the tectonic evolution of this area has been proposed. A geochronological study of the Altamira Range ophiolitic rocks is in progress. Cretaceous to Paleocene ages has been recorded.

EASTERN MEDITERRANEAN

OPHIOLITES OF GREECE

In collaboration with Drs C. Economou and St. Skounakis, of the Department of Mineralogy and Petrology of the University of Athens, petrographical, mineralogical and chemical investigations have been undertaken (J. BERTRAND) on part of the ophiolitic sequence from central Euboea and the Othris Massif. The zone studied in Central Euboea, with chrysotile-lizardite serpentinites, rodingites and other xenoliths, associated with a chaotic complex of diabasic-sedimentary composition mainly, appears very similar to certain ophiolitic areas of the Apennines for example.

OPHIOLITES OF CRETE

The ophiolite and melange terrains in Crete were investigated by K-Ar dating (DELALOYE, ECONOMOU et SKOUNAKIS, 1977). Two major groups of ages were found: Lower to mid-Cretaceous and Eocene. The Cretaceous ages agree fairly well with the general model of rifting of the continental crust and collapse of an ocean basin. Eocene dates reflect the emplacement ages.

OPHIOLITES OF TURKEY

Several Ph.D. theses on ophiolitic areas of the Taurus Chain (Turkey) have been completed (TUZCU, 1972; PISKIN, 1972; YAZGAN, 1972; SARP, 1976).

In continuation of one of these studies (SARP et al., 1976, 1977, 1978), several new mineral species (vuagnatite, chantalite, parthéite) of the lime silicate suite of rodingitic rocks have been discovered in collaboration with the laboratory of X-Ray crystallography of the University of Geneva and the mineralogical Department of the Museum of Natural History of Geneva.

OPHIOLITES OF THE KIZIL DAGH (HATAY; TURKEY)

The geological study of the Kizil Dagh ophiolite began in the sixties. Three major aspects have been investigated: geochemistry, geochronology and paleo-

magnetism (COGULU, DELALOYE, VUAGNAT, et WAGNER, 1976). These were backed by microtectonic, petrological and mapping studies.

Chemical analysis of major and trace elements including REE were used to identify the parental magma(s) of the ophiolite as well as of some lavas of komatiitic affinities in the area.

The ophiolite crystallized on the Tethysian ocean floor between 110 and 150 m.y. ago and subsequent metamorphic events took place between 90 and 30 m.y. These are probably related to the emplacement history of the massif (DELALOYE, VUAGNAT et WAGNER, 1977).

The detailed mapping, at scale of 1:50.000, and the microtectonic study are currently in progress. It is already possible to describe in great detail the tectonic relationships existing between the various members of the ophiolitic complex.

OPHIOLITES OF CYPRUS

The Troodos ophiolite, studied in collaboration with the team of Prof. Rocci in Nancy (DESMET et al., 1978), was investigated in order to compare its age and chemistry with that of the Hatay massif especially. It now seems evident that the Troodos is 10 to 20 m.y. younger than the Hatay (DELALOYE et DESMET, 1979).

OPHIOLITES OF IRAN

The Iran Ophiolites (in collaboration with J. Desmons, Nancy), were extensively dated by K-Ar method.

Melanges and ophiolite complexes composed of ultramafic units mainly represent block margins active in Alpine times. Crystallization, emplacement at continental margins and melange formation are post-Palaeozoic events that are considered, from stratigraphical data, to be pre-Upper Cretaceous to Cenozoic in age (DELALOYE et DESMONS, 1979).

OTHER REGIONS

OTHER OPHIOLITES

It is also worth mentioning geochronological studies made on ophiolites from New-Zealand, Norway (Alta-Kwaenangen Window), Italy (Apennines and Calabria) and Turkey.

Many of these ophiolites are more or less dismembered but age data from them are useful for a better knowledge of the history of the areas in which they occur.

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