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PLATE TECTONICS AND METALLOGENIC PROCESSES IN ETHIOPIA (PRELIMINARY REPORT)

ABSTRACT. — In the framework of an ethio-italian bilateral programme of researches, preliminary investigations, performed in Wollega (Western Ethiopia) allowed to check the wide extension of the ultramafic bodies in the area Yubdo-Tullu Dimtu.

The study of a first group of samples, collected along the eastern slopes of the Tullu Dimtu Mt., pointed out the existence of several metallic minerals in the silicatic groundmass: among them chromite, magnetite and small grains referred to Pt-Group elements, still under analysis. Taking into account the secondary deposits of Pt and Au, formerly exploited at Yubdo, these first results are clues of a possible wider distribution of this type of mineralization.

From a structural point of view, the existence of regional lineaments is stressed, having transverse trend relatively to that of the Rift Valley, which cut across the cratonic area of the Ethiopian Central Highlands. Among them, the most important seems to be an E-W trending structure, 600 km long, from Addis Ababa to the Sudan border, crossing through the area where the ultramafic complexes outcrop.

The study of the structural significance and magmatological implications of the E-W lineament, as well as detailed investigations on the associate mineralizations, are expected to be able to clear the relations existing between crustal evolution and metallogenic processes in the area.

RIASSUNTO. — Nel quadro di un programma di ricerca bilaterale italo-etiopico, indagini preliminari condotte nel Wollega (Etiopia occidentale) hanno permesso di verificare l'importanza dell'estensione areale dei corpi ultramafici del settore Yubdo-Tullu Dimtu. Lo studio di un primo gruppo di campioni, raccolti lungo le falde orientali del Tullu Dimtu, ha evidenziato l'esistenza, nella massa silicatica, di frequenti minerali metallici tra cui cromite, magnetite ed individui riferibili ad elementi del gruppo del Pt, tuttora in corso di analisi. Tenuto conto delle concentrazioni secondarie di Pt e Au note e coltivate in passato presso Yubdo, questi primi risultati rappresentano l'indizio di una possibile maggiore diffusione di tale tipo di mineralizzazioni.

Da un punto di vista strutturale, la ricorrenza di lineamenti regionali ad andamento trasversale rispetto alla Rift Valley etiopica, interessanti l'area cratonica degli Altipiani Centrali, il cui maggiore rappresentante, costituito da una struttura disgiuntiva E-W estesa per oltre 600 km tra Addis Ababa ed il confine sudanese, interseca il settore in cui affiorano le masse peridotitiche, suggerisce alcune ipotesi sul significato di questa particolare correlazione e sulle relazioni genetiche tra evoluzione crostale e processi metallogenici in generale.

Introduction

An Italian-Ethiopian bilateral programme of field and laboratory studies is carried on by Italian specialists in Economic Geology, Igneous and Metamorphic Petrology, Volcanology, Geophysics, Geochemistry from the universities of Pisa, Rome, Naples and Cagliari, and Ethiopian Colleagues belonging to the Geology

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Aim of this programme is the identification of the possible links existing between crustal evolution of the region and formation of ore deposits, whose occurrence (as economic accumulation or simple clues) is known or suspected, in close association particularly with the Precambrian basement: the title of the programme, in fact, is « *Plate tectonics and metallogenic processes in Ethiopia* ».

The programme will take into account also some processes connected with the present evolution of the Rift structures, namely the behaviour of Fluorine, which characterizes the surface waters with exceptionally high contents.

General geology

Geology of Ethiopia is characterized by the occurrence of a very wide variety of rocks, different in age, origin and evolution. The oldest ones (600 ÷ 3000 m.y.) set up the Precambrian basement with various lithological types, more or less intensively affected by metamorphism: gneisses, phyllites, quartzites, schists, granitoids, mafites and ultramafites in dikes, bodies or complexes of variable size and importance. The Precambrian rocks were interested by the orogenic event known as Pan-African Orogeny. They belong to the so called Mozambique belt (KAZMIN, 1971), which was peneplained during the Paleozoic. Marine sediments were deposited during Mesozoic: sandstones, limestones, conglomerates, evaporites etc. cover unconformably the Precambrian basement.

From early Tertiary a large part of East Africa (including Ethiopia and the present Arabian peninsula) started uplifting and, at the end of Oligocene, an important process of break-up initiated, with the formation of three major arms of rift valley structures: the Gulf of Aden, the Red Sea and the East African Rift System so defining three major lithospheric plates, Nubia, Arabia and Somalia, the latter two showing diverging movements relatively to the former and to each other (BARBERI et al., 1975; GASS, 1975). This process of plate divergence was almost continuously accompanied by eruptions of huge volumes of magma (mainly basaltic) and is still active now (ALLARD et al., 1979; BARBERI et al., 1970; BARBERI et al., 1973; BARBERI and VARET, 1977; GOUIN, 1979).

At present, the main tectonic features of the Horn of Africa are therefore represented by two active diverging plate boundaries, i.e.:

- 1) the Afar depression of Ethiopia and Djibouti Republic. Afar, as well as the central trough of the Red Sea is the boundary between the NE drifting Arabian plate and the stationary Nubian plate (BARBERI et al., 1975; RUEGG, 1975);
- 2) the Ethiopian Rift Valley (an important portion of the major East African Rift System), which is the boundary between the SE drifting Somalian plate and the stationary Nubian plate (BARBERI et al., 1975; BARBERI and VARET, 1978; BIZOUARD and DI PAOLA, 1978; DI PAOLA, 1962).

A third plate boundary is represented by the Gulf of Aden oceanic spreading

ridge which separates the Arabian from Somalian plate (BARBERI et al., 1975; BARBERI and VARET, 1977; LAUGHTON et al., 1970). These three plate boundaries meet in Central Afar of Ethiopia where they constitute a complex triple junction (McKENZIE et al., 1970).

Outline of the research

While the age, structural and magmatological significance of the Rift System of Ethiopia (and Djibouti Rep.) are at present fairly well known, as above quoted, data concerning other important tectonic lineaments of Ethiopia are either poor or absolutely lacking. There exist in fact some major structures which mostly affect the SE plateau of Ethiopia with a transverse trend relatively to that of Ethiopian Rift Valley and some of them have been active since Precambrian (MOHR, 1974; KAZMIN and SEIFE M/BERHE, 1979). Some of these transverse structures can be followed across the Rift floor towards its western margin (DI PAOLA and SEIFE M/BERHE, 1979). Among them, the most impressive one is that visible on western plateau of Ethiopia at the latitude of Addis Ababa (9°00' N) which develops for 600 km (Addis Ababa - Lekemti - Yubdo - Sudan border) with an East-West trend. Practically nothing is known about the age, the structural and magmatological significance of this tectonic line, however some evidences already suggest its relevant importance in terms of plate tectonics and metallogenesis. These evidences are:

- 1) even though nothing is yet known about the beginning and nature of movements along this fault, there are clear evidences that important dislocations (which seem to be mainly vertical) occurred also during Tertiary time (middle-upper Miocene) as indicated by the Tertiary basaltic series which covers the Mesozoic marine sediments and/or the Precambrian crystalline basement;
- 2) the degree of metamorphism of the basement rocks outcropping north of this line is strikingly much different (low grade) than that of the rocks outcropping south of it (high grade);
- 3) the presence along this line of peridotitic complexes such as at Yubdo (the most important Pt resource of Ethiopia presently known) or Tullu Dimtu, may suggest some similarities with what is known from presently active oceanic transform faults (BARBERI et al., 1974 a). It is well known, as a matter of fact, that the nature of magma is the best marker of crustal structures and plate boundaries, both active and fossil (BARBERI et al., 1974 b);
- 4) Tertiary and Quaternary (?) volcanic rocks related to the Addis Ababa-Sudan border transverse tectonic line have a composition which reflects a completely different structural environment relatively to that of the Rift System of Ethiopia. In fact basalts are definitely alkalic, bearing ultramafic nodules while those related to the Rifts range in composition from transitional to tholeiitic (BARBERI et al., 1970; BARBERI and VARET, 1970; BARBERI et al., 1975). Basalts with a tholeiitic affinity seem to be rather common also among the Tertiary series of

the Ethiopian plateau (PICCIRILLO et al., 1979). Moreover, the differentiated end members related to the Addis Ababa-Sudan border lineament seem to be definitely undersaturated (mostly phonolites, with abundant modal nepheline) while those related to the Rifts are exclusively represented by highly silicic terms (DI PAOLA, 1972; GIBSON, 1972).

From the point of view of the Ethiopian Rift Valley volcanic rocks, it is well known that the huge volumes of Tertiary and Quaternary differentiated effusive products are not only highly silicic but also peralkaline (mostly pantellerites with minor commendites) in composition (DI PAOLA, 1972; GIBSON, 1972; BARBERI et al., 1974c; DI PAOLA, 1976; BROTZU et al., 1979). Provided that peralkali rhyolites and in particular pantellerites commonly contain a quite large amount of (economically) interesting elements, it seems reasonable to devote attention to the geochemical behaviour of some of them, chiefly of Fluorine.

As a matter of fact, in the Ethiopian Rift Valley very high F anomalies (some to several tens of p.p.m.) have been found in surface and ground waters. Despite the very few data available it seems possible to assume the existence of widespread F anomalies in many parts of the Ethiopian Rift Valley: in some areas local people have suffered serious diseases due to an extremely high F content in waters.

Very high F anomalies cannot persist for a long time and over long distance in ground and surface waters, therefore precipitation of this element (generally as CaF_2) may be expected in the surrounding areas.

Research objectives

The main objectives of the present research are the determination of:

- 1) the age, structural meaning and magmatological expression of the Addis Ababa - Yubdo - Sudan border tectonic line;
- 2) the eventual role played by this structure in the Tertiary and Quaternary plate tectonics evolution of the Ethiopian Rift Valley;
- 3) the possible relationship between this, as well as other related structures, and the metallogenic processes which led to the formation of the mineralizations occurring in western Ethiopia. These mineralizations, mostly associated with the Precambrian metamorphic basement, can be classified into four main groups:
 - a) Pt, Cr, magnetite ores (minor Au) related to the ultramafic belt Yubdo-Tullu Dimtu;
 - b) Gold bearing primary deposits, feeding several placers at present partly on exploitation;
 - c) Mineralizations connected to the pegmatites of Didessa River, Gambela and Asosa area (Wollega, West Ethiopia) (related to acidic intrusions of uncertain age);
 - d) Cu-Pb-Zn sulphides, associated to metasediments and metavolcanics.

All these mineralizations, their genesis and economic importance are poorly known and probably they are clues of a very important metallogenic province.

Furthermore, considering the nature of the differentiated volcanic rocks there outcropping (phonolites), the existence of economically important carbonatite complexes may be expected;

- 4) the possible occurrence of economically important *F* ore deposits within the widespread lacustrine sediments and pyroclastics outcropping on the floor of the Ethiopian Rift Valley.

Preliminary data

As first step of the bilateral programme organization, a reconnaissance trip was performed in march 1980, across Wollega (Western Ethiopia). Particular attention was devoted to the ultramafic complexes outcropping at Yubdo, Tullu Dimtu and Daleti Mt. (between Gimbi and Nejo).

Tullu Dimtu peridotites and serpentinites were sampled along the eastern side of the relief. Polished sections cut from the samples revealed the presence of magnetite, chromite and Pt-Group elements (not better defined until now).

Samples and polished sections are processed at present in order to carry out geochemical and microprobe analyses, whose results will be announced as soon as possible.

These first results, however, stress the interest of the ultramafic rocks of this area as carriers of important minerals. The economic interest of the primary occurrences is to be considered doubtful, on the contrary the possibility of secondary accumulations is to be taken into careful account.

The above considerations, together with the possibility that Yubdo, Daleti and Tullu Dimtu bodies belong to an important district, partially unexposed at present owing to thick surface residual products, furthermore the genetic relations with the regional E-W trending lineament (still to be checked) enhance the interest of the themes selected for our researches.

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