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# GEOCHEMICAL FEATURES AND RADIOLARIAN AGES OF VOLCANIC ROCKS FROM THE IZMIR-ANKARA SUTURE BELT, WESTERN TURKEY

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The Izmir-Ankara Suture Belt (IASB) in northern Turkey includes the remnants of the Neotethyan Izmir-Ankara Ocean (IAO; Göncüoglu et al., 2000; Robertson, 2004) and is one of the key areas in the Eastern Mediterranean to study the formation of ophiolites and related oceanic rocks. A series of geochemical studies performed by the first two authors in the western and central parts of the IASB (Fig.1) revealed volcanic rocks derived from mid ocean ridges, island arcs, oceanic islands and fore- and back-arc basins (Göncüoglu et al., 2000; Yaliniz & Göncüoglu, 2005; Floyd et al., 2003; Köksal-Toksoy et al., 2001). On the other hand, paleontological study of radiolarian cherts within the same units was realized by the last author (Bragin and Tekin, 1996; Tekin et al., 2002; 2006). This study aims to combine the geochemical and paleontological data for a better understanding of the geological evolution of the IASB.

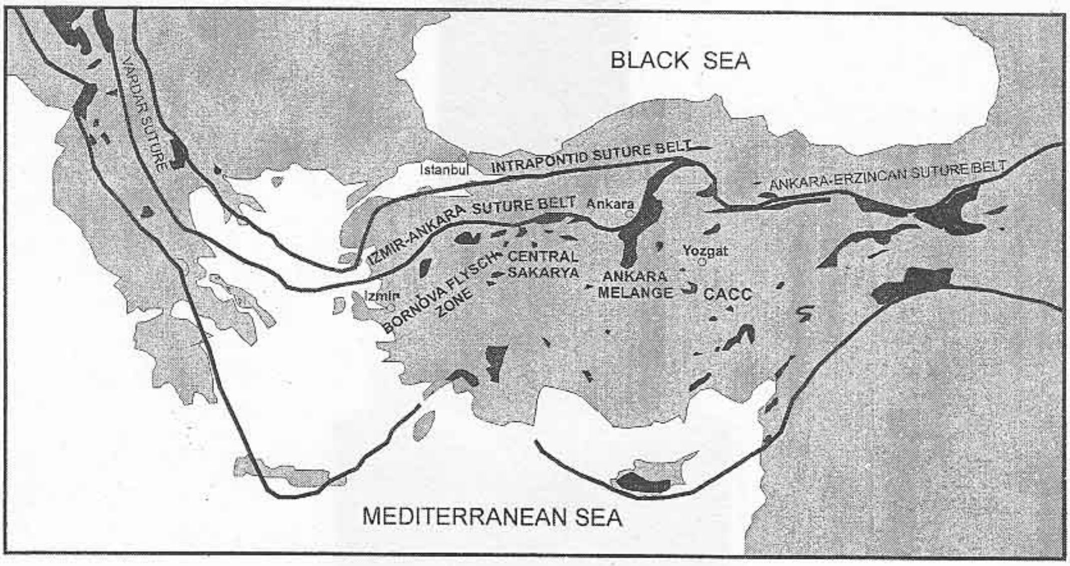

Figure 1- Distribution of the mélange complexes along the IASB and the locations of allochthonous volcanic blocks studied by geochemical and paleontological means.

## Geological Framework

Within the IASB allochthonous assemblages of the Neotethyan Izmir-Ankara-Ocean, including the radiolarian chert-basalt associations, occur in three different nappes, which were emplaced onto the Tauride-Anatolide Platform during Late Cretaceous. The northern and uppermost one consists of huge bodies of more-or less complete ophiolitic sequences. They comprise sub-ophiolitic metamorphics, variably serpentinized harzburgites with chromite pods, dunite- wehrlite-clinopyroxenite–clinopyroxenite-gabbro cumulates together with troctolites, two-pyroxene gabbros and gabbro-norites, in ascending order. They are followed by layered gabbros with distinct hydrothermal metamorphism. Members of the dyke complex and lava sequence are less frequently observed.

The second unit includes tectonic mélanges of the accretionary complex. The complex mainly comprises blocks of spilitic metabasalts, radiolarian cherts, blueschists, pelagic limestones, serpantinites, and neritic limestones of Mesozoic age. Blocks of amphibolite, intermediate volcanics (mainly andesites), layered gabbros, pyroclastic rocks and volcanoclastic sandstones are of minor amounts. The limestone blocks may be up to several kilometers across and have sharp contacts against adjacent ones. Polymictic breccias and greywackes are dominated by clasts of basic volcanic rocks and red cherts locally occur as a matrix between blocks. The mélange in general is strongly sheared and faulted. Locally, sheared and folded successions, up to 50 meters thick, of volcanogenic sandstones and argillaceous sediments with thin chert interlayers can be observed. Pillowed and massive basaltic rocks dominate over other knockers and are associated in some cases with red to brick-colored cherts, micritic limestones and red, black and violet mudstones.

The third and structurally lower unit including oceanic assemblages is a Maastrichtian-Early Paleocene flysch complex with olistoliths and olistostromes. It was formed as in peripheral fore-land basin on the northern edge of the Tauride-Anatolide Platform, in front of the southward advancing ophiolitic nappes.

## Geochemical features of the volcanic rocks

About 95 whole-rock samples were collected for major, trace and REE analyses from different areas. All samples were variably metamorphosed; hence only tectono-magmatic discrimination diagrams involving less mobile elements were used to interpret the tectonic setting. Regarding the magma series, the volcanics include alkaline as well as subalkaline samples with a distinct group plotting on the demarcation line. Tectonic discrimination diagrams with the data points (Fig. 2 A, B, and C; Yaliniz & Göncüoglu, 2005) indicate the presence of four main groups: MORB, OIB, IAT and CAB, the first two types clearly dominating over the others.

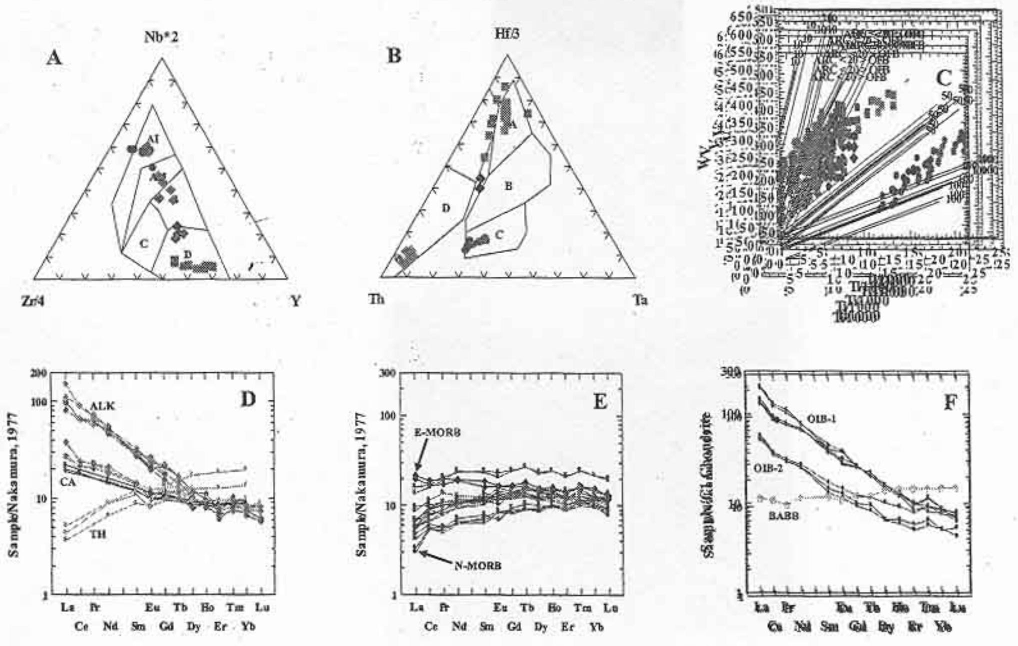

Figure 2- Tectonic discrimination and REE diagrams of the volcanic rocks from the IASB. **A**) Zr-Nb-Y (AI: within-plate alkali basalt, AII: within-plate tholeiite, B) E-MORB, C) WPT & volcanic arc basalt, D) N-MORB & VAB; **B**) Th-Hf-Ta (A: N-MORB, B: E-MORB, WPT, C: WPAB, D: IAT; **C**) Ti-V; REE diagram to distinguish **D**) the IAB-type with calcalkaline (circles), tholeiitic (gray) and alkaline (diamonds) subtypes, **E**) the MORB- type with N-MORB and E-MORB subtypes; **F**) the OIB-type with two subgroups with differences in the level of enrichment and the Triassic back-arc volcanics (gray).

The V-Ti diagram, on the other hand, clearly separates MORB and IAT field respectively. The third group plots in the OIB field, however, we are unable to see CAB geochemical character on this diagram. The REE patterns (Fig. 2 D, E and F) are in perfect accordance with the typical patterns of IAB, MORB and OIB-types in well-studied areas. Moreover, they clearly demonstrate the presence of subtypes such as of N-MORB and E-MORB types within the spreading ridge of IAO; calcalkaline, alkaline and tholeiitic types within the arc-related volcanics and two distinctly separate subtypes of OIB basalts that differ in the level of enrichment.

The fifth and yet inadequately studied group of volcanic rocks found in IASB in Sakarya area (Yaliniz et al, in review) in association with the early Late Triassic cherts (Tekin et al., 2002) displays typical geochemical features of BAB.

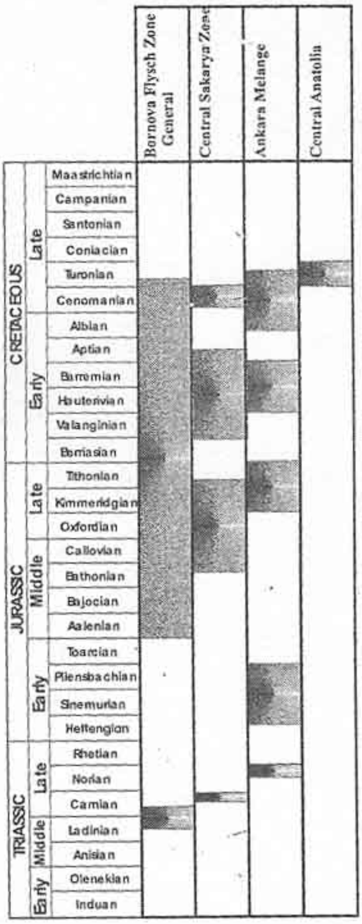

Figure 3- Age distribution of radiolarian cherts in IASB.

## Radiolarian Ages

Radiolarian cherts, associated with volcanic rocks in the form of intra-pillow-fillings or m-thick alternations with lava-flows were studied to date the volcanism in the IAO. The composite chard in Figure 3 summarizes the fossil findings in Bornova Flysch Zone (Tekin et al., 2006), Central Sakarya (Göncüoglu et al., 2006), Ankara Melange (Bragin & Tekin, 1966) and Central Anatolia (e.g. Yaliniz & Göncüoglu, 1998).

Within the Bornova Flysch zone the oldest radiolarian cherts are Ladinian- early Carnian in age and associated with turbidites with volcanoclastic material. In the Central Sakarya area, radiolarian cherts associated pillow lavas of early late Carnian age display typical features of back-arc volcanism (Fig. 2 F).

Radiolarian cherts associated with the dominating OIB-type volcanic rocks in the Bornova Flysch Zone yielded a wide range of ages starting with middle Middle Jurassic (Bajocian). A concentration of the radiolarian ages in Callovian-Tithonian and Valanginian-Barremian intervals is very typical. Although less frequent, OIB-type volcanic rocks of early Aptian age are the youngest products of plume-related volcanism within the IA oceanic crust (Tekin et al., 2006).

Oldest MORB-type volcanic rocks found in the Bornova Flysch Zone are Aalenian in age. As it is the case with the OIB's, MORB-type volcanism was effective along Middle-Upper Jurassic and Lower Cretaceous. The youngest age obtained from the Central Sakarya MORB's is Cenomanian, indicating that the spreading lasted until at least until early Late Cretaceous.

The subduction-related volcanic rocks with a vide variety chemical designations including the "supra-subduction-type" basalts in general terms or more specifically island-arc-related volcanic rocks of both pre-mature and mature type have yielded late Early Cretaceous and Cenomanian ages. In Central Anatolian Ophiolites, the Turonian age obtained from SSZ-type volcanic-volcaniclastic rocks is the youngest age determined yet from sediments associated with volcanic rocks. It is important to note that Late Triassic (Norian) to Early Jurassic oceanic volcanic rocks have not yet been encountered from the studied areas in the IASB.

## Conclusions

New geochemical and paleontological findings from four different areas of the IASB reveal that IAO opened already at early Late Triassic. The sea-floor spreading and the formation of OIB-type intra-plate seamounts within the IAO started already in late Bathonian and persisted until early Aptian. The formation of the intra-oceanic subduction and the generation of supra-subduction-type volcanism have commenced until early Santonian and the spreading-ridge of the IAO plate has not been subducted until Cenomanian.

**Key words:** Evolution, Izmir-Ankara Ocean, Neotethys, volcanism, geochemistry, radiolarian ages.

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