PLUME AND SPREADING TOR* ASSEMBLAGES, SPREADING RATE, RIDGE SEGMENTATION AND GEOPHYSICAL FIELDS DISTRIBUTION

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The initial material includes over 14 000 abyssal glass compositions (published and our original data, [Smithsonian Catalog, 1999; LDEO Data Base, 1999]), satellite marine gravity files with 2 arc minute resolution [McAdoo&Laxon, 1997; Sandwell&Smith,1997], the record of ridge seismisity data for the last 30 years [NEIC, USA, 1997], data on geoid surface [Lemoine et al, 1996] and seismic tomography [Zang&Tanimoto, 1992] for zero-age events of lithosphere formation along Mid-Atlantic ridge (MAR) and East Pacific Rise.(EPR).
PT (pressure-temperature) conditions of TOR cotectic crystallization have been reconstructed by [Danyushevsky, 1998] methodic. The empiric discriminant function «D1» for identification of plume and spreading TOR assemblages by major element chemistry has been used [Dmitriev et al, 1999]. The synthesis of this material allows to the following.
Petrological parameters, ridge morphology, deep mantle architecture, free-air and Bouguer anomalies, geoid surface and seismisity well correlate within the detailed studied North MAR axial zone during zero age period of its formation under slow spreading rate. It is in consistent with ridge geodynamic segmentation. The degree of this correlation is gradually lowered with spreading rate (with transition to South MAR and to Central EPR).
In all regions TOR spreading assemblages evolved with polibaric fractionation while for plume assemblages the transition to magma chambers formation is characteristic.
Productivity of magmatism, depth of magma chambers, PT limit of cotectic crystallization, volume of spreading assemblages are growing with spreading rate.
Both TOR plume and spreading assemblages are developing independently and forming the certain basaltic provinces under low spreading rate conditions. The boundaries between them disappear with spreading rate.
The main petrological features of basaltic magmatism are controlled by geodynamic condition of melting and do not depend on geochemical type of mantle source.

TOR – **T**holeiite of the **O**ceanic **R**ifts – the alternative term of MORB [Dmitriev et al, 1978].

TECTONIC-MAGMATIC HISTORY OF THE NORTH ATLANTIC LITHOSPHERE FORMATION BY THE ISOCHRONE GRAVITY PROFILING

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The recent study, based on the representative data on abyssal glass composition, satellite altimetry, seismic events, deep mantle tomography and geoid surface, demonstrates the

existence of two main basalt assemblages formed under plume (PB) and spreading (SB) conditions along «zero-age» North Mid-Atlantic Ridge (MAR) axes, and stable quantitative correlation between petrological-geochemical parameters of magmatism, ridge geodynamic segmentation and geophysical fields. This result stimulates the reconstruction of tectonic-magmatic conditions of the oceanic lithosphere formation in historical aspect by the use of gravity field distribution along the chosen magnetic anomalies.

The Atlantic area between 15^o and 40^o N has been studied. In this area zero age PB assemblage as the south part of Azores megaplume lies to 30^oN MAR and placed as small spots near 15-20 FZ and near 22^oN. SB assemblage takes most part of MAR between 15^o and 30^oN.

Free air and Bouguer anomalies with 2 arc minute resolution have been reconstructed along West and East 5, 13, 21 and 30 magnetic lineations as the isochronic gravity profiles. The shape of gravity field along each pair of isochrone profiles looks similar that is consistent with theory. However some changes of profiles shape are well seen as the signature of certain geological events which accompanied the regular lithosphere spreading. The detailed comparison of all isochrone profiles (including zero-age isochrone along ridge axes) within the studied area permits to suppose the following.

1.The area between Kane and Atlantis transform zones looks most stable tectonically during at least 65 Ma and was formed by undisturbed regular spreadung . 2.The separation of the area into provinces with PB and SB assemblages have been existing for at least 65 Ma as well. 3.The chemical types of basalt sampled off ridge axes are consistent with basalt assemblages defined by application of geophysical correlation criteria to PB and SB identification. 4.Complications of geophysical fields symmetry at both sides of the MAR are not connected to paleo magmatic conditions of correspondent age zone derived from magnetic data. 5.Taking into account the correlation of petrological and geophysical parameters for zero-age ridge axes and along non-zero magnetic lineations, during at least 65 Ma the plume geodynamic condition was propagated southward from 40^o N to 30^o N.

TECTONIC-MAGMATIC HISTORY OF NORTH ATLANTIC LITHOSPHERE FORMATION BY ISOCHRONE GRAVITY PROFILING

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1.Introduction and Reasoning.

The recent study, based on the representative data on abyssal glass composition, satellite altimetry, seismic events, deep mantle tomography and geoid surface, demonstrates the existence of two main basalt assemblages formed under plume (PB) and spreading (SB) conditions along «zero-age» North Mid-Atlantic Ridge (MAR) axes, and stable quantitative correlation between petrological-geochemical parameters of magmatism, ridge geodynamic segmentation and geophysical fields. These results are represented at "**Plume and spreading TOR assemblages, spreading rate, ridge segmentation and geophysical fields distribution"** poster by Dmitriev L.V. (1), Silantiev S.A. (1), Sokolov S.Yu, (3) of current EGU meeting (see the illustrations of this poster). The perfect correlation between listed above parameters restores physically approved relationships between the type of magmatism and its productivuty and therefore specific performance of newly borned oceanic crust in geophysical fields. Clear relationship between basaltic properetie and geophysical fields at zero age zone stimulates the reconstruction of tectonic-magmatic conditions of the oceanic lithosphere formation in historical aspect by the use of defined relationships of gravity field and magmatism properties from gravity values distributed along non zero magnetic anomalies.

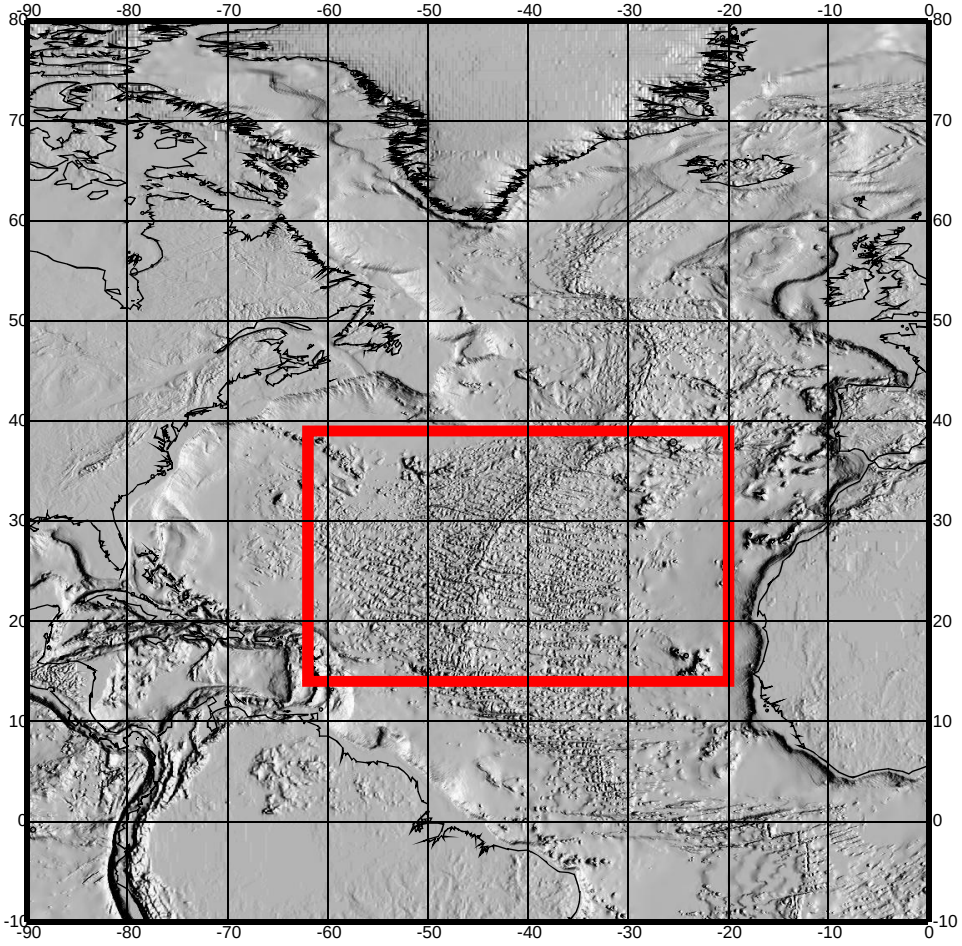

Figure 1. Location of studied area in the Atlantic Ocean.

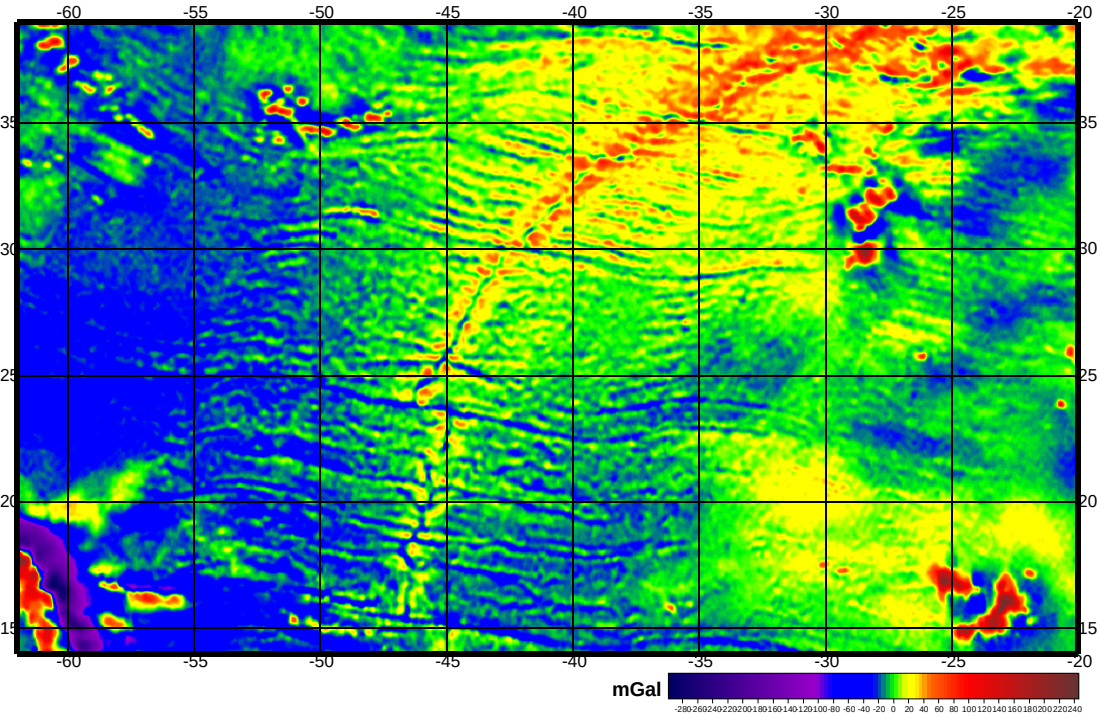

Figure 2. Sattelite drived free air gravity anomalies (Sandwell, Smith, 1997)

The shape of gravity field along each pair of isochrone profiles **(See Figure 4)** looks similar that is consistent with theory. Theoretically the areas of one age located from both sides of MAR historically were jointed and should prsent equivalent (symmetrical) field behavior. However some changes of profiles shape are well seen as the signature of certain geological events which accompanied the regular lithosphere spreading. Such changes, certainly, shouldn't be regarded as the events of the period related to magnetically dated age. Any disturbance of symmetricity must be withdrawn from the picture of symmetrical gravity field distibution.

2. The Studied Area and Profiles Positioning.

The Atlantic area between 15° and 40° N has been studied. **(See Figure 1)**.In this area zero age PB assemblage as the south part of Azores megaplume lies to 30°N MAR and placed as small spots near 15-20 FZ and near 22°N. SB assemblage takes most part of MAR between 15° and 30°N (See Figures of another poster by Dmirtriev et. al). Free air anomalies with 2 arc minute resolution have been reconstructed for the studied area **(See Figure 2)** after the data of (Sandwell, Smith 1997)**.** The interpretations for magnetic lineations for studied area **(See Figure 3)** were reconstructed from data of (Cande et. al., 1993) along West and East 5, 13, 21 and 30 magnetic lineations as tracklines for the isochronic gravity profiles.

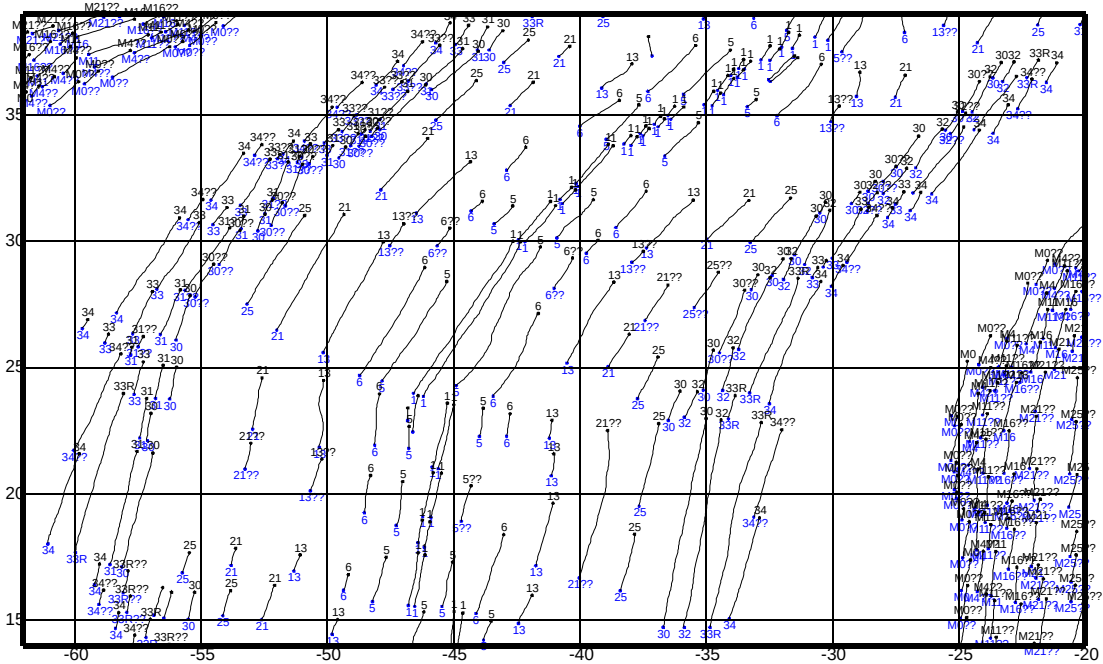

Figure 3. Indexed Magnetic lineations from magnetic data (Cande et. al. 1993)

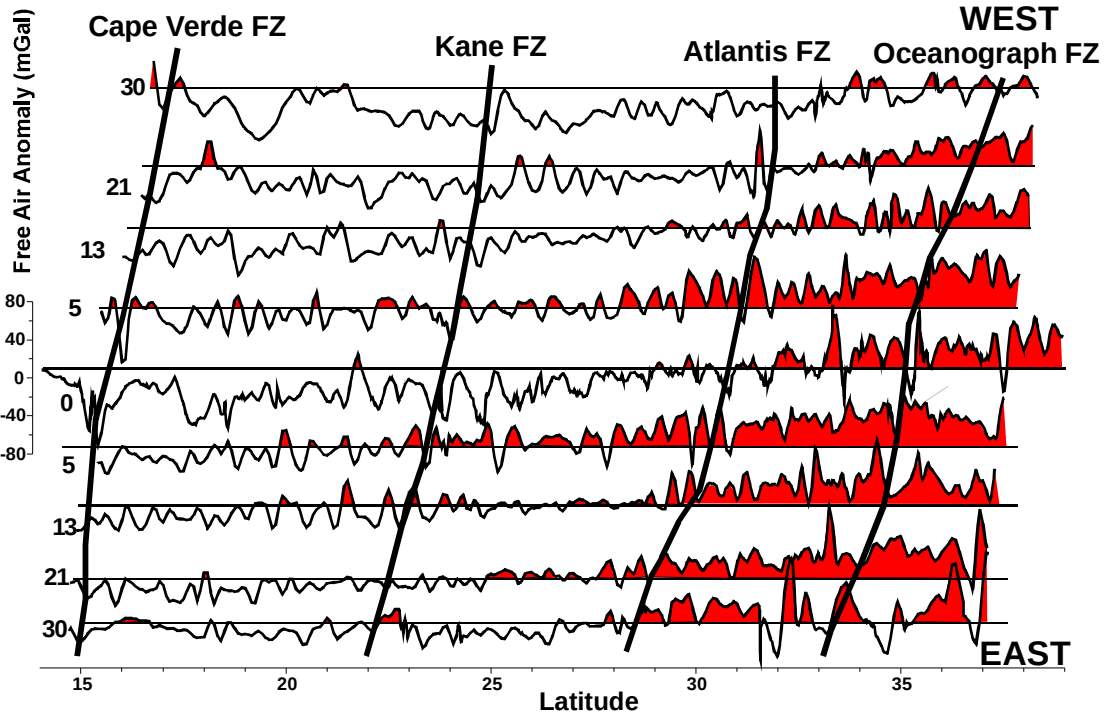

Figure 4. The shape of gravity profiles pairs along 5, 13, 21, 30 anomalies.

1. The area between Kane and Atlantis transform zones looks most stable tectonically during at least 65 Ma and was formed by undisturbed regular spreadung.

2. The separation of the area into provinces with PB and SB assemblages have been existing for at least 65 Ma as well.

3. The chemical types of basalt sampled off ridge axes are consistent with basalt assemblages defined by application of geophysical correlation criteria to PB and SB identification.

4. Complications of geophysical fields symmetry at both sides of the MAR are not connected to paleo magmatic conditions of correspondent age zone derived from magnetic data.

5. Taking into account the correlation of petrological and geophysical parameters for zero-age ridge axes and along non-zero magnetic lineations, during at least 65 Ma the plume geodynamic condition was propagated southward from 40°N to 30° N.

3. Superposition with glass data with PB and SB attributes.

Finally, the profiles corresponding to 5, 13, 21, 30 isochron pairs were superposed by positions of basaltic glass samples, that were processed and therefore attributed to PB or SB association **(See Figure 5)**. In this analysis we were especially intersted in data allocated distantly from MAR. Such data were found in Lamont Petrology DataBase, Smithsonian Instituite Geochemical Database and Petrology Database of Vernadsky Institute of Geochemistry. One could notify the presence of samples associated to PB far from MAR at northern part of studied area.

4. Results.

The detailed comparison of all isochrone profiles (including zero-age isochrone along ridge axes) within the studied area permits to suppose the following (see left below):

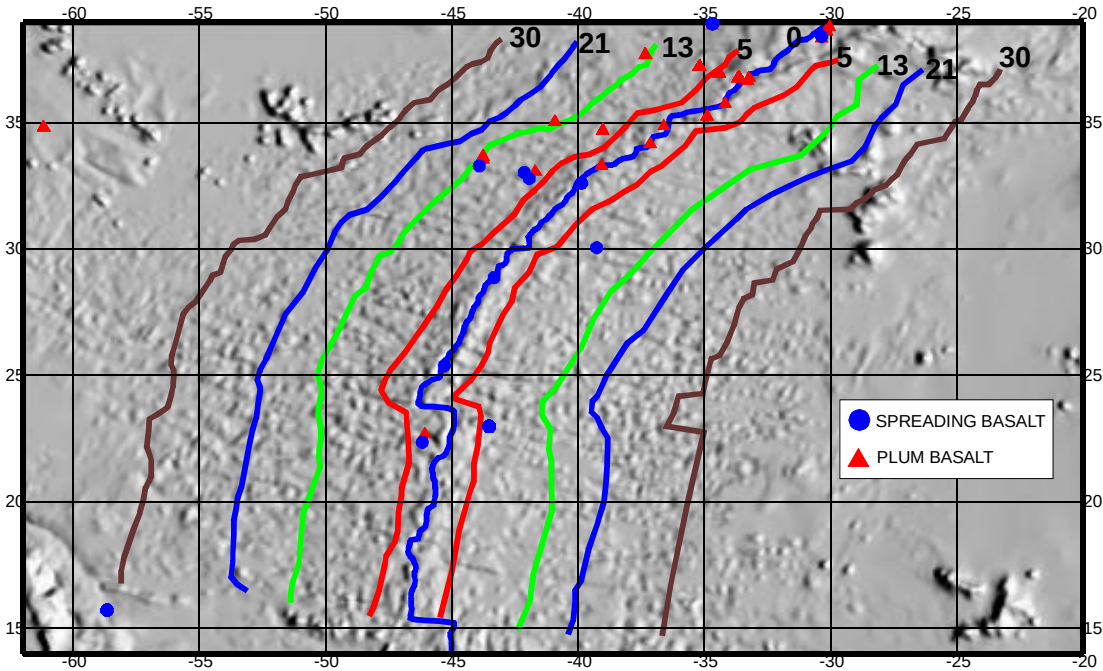

Figure 5. Allocation of PB and SB glass associations respect to magnetic age markers.

THE SERPENTINIZATION OF THE OCEANIC MANTLE PERIDOTITES AND THE EARTH FLUID REGIME

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It was known that process of serpentinisation by water - peridotite intreacion under the moderate pressure (P< 5 kbar) and temperature (T 25-350oC) leds to hydrogen generation in consistence with equation [Martin, Fyfe, 1970]:

$$6[(Mg_{1.5}\,Fe_{0.5})\,SiO_4 + 7\,H_2O = 3[Mg_3Si_2O_5(OH)_4] + Fe_3O_4 + H_2$$

THE METHANE IS FORMING BY THE INTERACTION OF HYDROGEN AND CARBON DIOXIDE DISSOLVED IN SEAWATER:

$$CO_2 + 4\,H_2 = CH_4 + 2\,H_2O$$

The similar PT conditions are characteristic for the initial (catagenesis) stage of oil-gas origin [Vassoevich, 1988; Dolenko, 1986].
Accordingly [Charlou et al, 1998] the large methane-rich plumes in seawater are common along Mid-Atlantic Ridge axial zone with outcrops of residual mantle peridotite ("Hess crust" formed uder slow spreading conditions) and formed due to these reactions.
The volume budget of H_2 and CH_4 in this process has been calculated for various water-rock ratio in this reaction with error bar $\pm$ 20 % (Grichuk, Borisov, Mel'nikova, 1985; Shvarov, Bastrakov,1999). The obtained results have been used for the estimation of H_2 and CH_4 budget for various geological setting.
1) Mantle peridotite covers about 10% of modern MAR rift valley bottom. The annual amounts of H_2 and CH_4 generated here by the serpentinization to the depth about 5 km (T ~400^{o}C - upper limit of this process) make up $3*10^4$ tn and $1.5*10^4$ tn each. During about 150 ma of Atlantic lithosphere formation $4.5*10^{12}$ tn H_2 and $2.25*10^{12}$ CH_4 may be generated in rift valley, dissolved in seawater or degassed into atmosphere.
2).About the same volume of H_2 and CH_4 might be generated at the 3rd seismic layer of Atlantic lithosphere (with the passive margins) during 150 ma of its formation by the potential serpentinization of mantle peridotites to the depth about 10-15 km (T~400^{o}C). These gases should collected in sediments and produce hydrocarbons.
3) Forearc basins could be the most perspective for H_2 and CH_4 generation because isotherm 400^{o}C is deepening here to 20-30 km and the thickness of serpentinized layer is maximal.
The calculated total amount of H_2 and CH_4 by the global serpentinization is more than the world resources of oil-gas deposits by several orders [Korchagina, 1999]. This needs to be considerated in light of Earth fluid regime problem in historical aspect. The obtained results look important also for fundamental and applyed question of oil-gas problem independently on both biogenetic and abiogenetic hypotheses.