PETROCHEMICAL COMPARISION OF VENUS' ROCKS WITH TERRESTRIAL OCEANIC IGNEOUS ROCKS USING THE DISCRIMINANT METHOD. A. M. Abdrakhimov, Vernadsky Institute, Kosygina 19, Moscow, 117975, Russia, albert@geokhi.ru.

Introduction: Five Venus' surface materials were measured in only K, U, and Th by GRS [1-3] and three were measured in major petrochemical elements without Na2O by XRF[4-5], all close in their chemistry to basalts. The goal of this work is to compare the analyzed Venus' rocks and terrestrial igneous rocks to search for similariries/dissimilarities in their chemistry, which at some degree is correlated with geodynamic environment. With the aim of planetological geochemical comparisons databases of their chemical analyses were compiled for each considered geodynamic enviroment[6-7].

Procedure: It have been shown that all Venus' rocks are much more rich in incompatible elements (K, U, Th) than Earth' Normal Mid-Ocean Ridge Basalts (N-MORB)[6]. On Earth igneous rocks enriched in incompatible elements are known to occur both in continental and oceanic settings. Since the presence of continental-crust material on Venus is problematic while the basaltic crust does exist, we will address further to the intra-oceanic environments where contamination of ascending magmas by continental crustal materials is not expected.

The compiled databases include petrochemical data, Th and U contents as well as petrographical alteration characteristics of the individual rock samples for three "pure" tectonic environments of the terrestrial oceanic magmatism: (1) Mid Ocean Ridges (MOR)[6], (2) Ocean Island Arcs (OIA)[7], and (3) Intraplate oceanic hot spots (IO). "Pure" means that no continental crust is present in the sampling place and in all sampling places the mentioned environments are not intermixed.

Data were selected for individual samples characterized: chemically - major-elements (or at least K2O content) and the contents of Th and U analyzed with precision better than 10-12%, petrographically - a lack of traces of high-temperature alteration, and tectonically -unambiguously clear tectonic position. By petrographical characteristics the studied samples were divided into groups: petrographically fresh (with no or a few percent of secondary phases), petrographically altered, without petrographic description, without reported alteration. By geochemical criteria they were divided into series: tholeitic (MOR, OIA, IO), calc-alcaline (OIA), alkaline (IO).

To select the samples unaffected by secondary alteration, which is known to change the initial contents of K and U, for the MOR and OIA databases a technique of chemical-petrographical discriminants [6-7] was used.

Fig.1. OI Tholeites, Group: Fresh vs. Altered

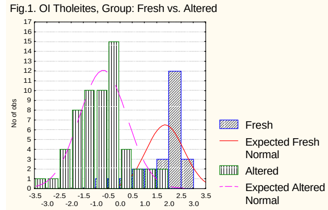
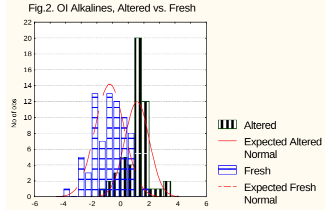


Fig.2. OI Alkalines, Altered vs. Fresh



For the IO database a statistical discriminant method[8] was successfully applied for this selection. The statistical discriminant method bases on deviation minimization within each group (altered and fresh) and maximization of deviation between selected group in multivariate space of chemical compositions. It was calculated the canonical discriminant function D=-2.02*Th +3.51*U +0.41*TiO2 -0.94*Al2O3 -0.97*FeOtotal -3.31363*MnO -0.46*MgO -0.11*CaO -1.22*Na2O +1.47*K2O +2.40*P2O5 +31.98 and respectively standardized discriminant function Dstand.= -1.91*Th +0.85*U +0.18*TiO2 -2.10*Al2O3 -0.79*FeOtotal -0.13*MnO -2.28*MgO -0.20*CaO -0.63*Na2O +0.44*K2O +0.21*P2O5 for the samples of IO tholeitic series; and D= 0.60*Th -1.30*U-0.74*TiO2 +0.05*Al2O3 +0.20*FeOtotal -11.99*MnO -0.15*MgO -0.44*CaO +0.04*Na2O -2.51*K2O -0.05*P2O5 +9.32 and Dstand.=1.53*Th -0.80*U -0.56*TiO2 +0.10*Al2O3 +0.36*FeOtotal -0.49*MnO -0.54*MgO -0.99*CaO +0.04*Na2O -1.77*K2O-0.06*P2O5 for the samples of IO alkaline series (Fig. 1-2). Coefficients in standardized functions show a contribution of the elements in discrimination. As an example, fig. 3-4 show that H2O content is higher in altered rocks then in fresh ones.

Fig.3. IO Tholeites: altered vs. fresh rocks H2Osum.

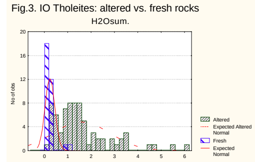
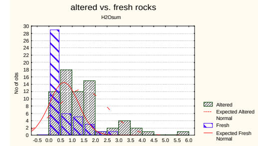


Fig. 4. IO Alkaline series: altered vs. fresh rocks H2Osum



For geochemical comparisons between unaltered set of terrestrial oceanic volcanics and Venus rocks we used discriminant analyses too. First, we found canonical discriminant roots dividing tholeitic, alkaline, and calc-alcaline series: D1 = 0.5237*SiO2 - 0.2172*TiO2 + 0.3962*Al2O3 + 0.3285*FeOtotal -3.7563*MnO +.3395*MgO +0.4166*CaO -0.9101*K2O-40.7104 and D2= - 0.25119*SiO2 - 0.02785*TiO2 -0.27014*Al2O3 - 0.01063*FeOtotal + 2.60397*MnO -.19849*MgO - .38027*CaO - 1.50547*K2O +23.19388 (or standardized roots: D1stand.= 2.310926*SiO2 -0.173331*TiO2 + 0.858199*Al2O3 + 0.645778*FeOtotal-0.178392*MnO + 1.066310*MgO + 0.917919*CaO - 0.550599*K2O; D2stand.= - 1.10838*SiO2 - 0.02223*TiO2 - 0.58517*Al2O3 - 0.02090*FeOtotal +0.12367*MnO - 0.62335*MgO - 0.83795*CaO -0.91081*K2O). Then we put on the diagram the figurative points for Venus' rocks. Fig. 5 shows that Venera 14 composition falls within tholeitic field; Venera 13 one, within alkaline field; and Vega 2 one is near the intersecting of alkaline and tholeitic fields, although closer to alkaline field. To distinguish between tholeites of IO, OIA, MOR was found discriminant roots: D1= -1.2515*SiO2 -6.0250*TiO2 - .8935*Al2O3 -.7477*FeOtot -.1455*MnO -1.3545*MgO - 1.1866*CaO -.4746*K2O +117.9877 and D2= -2.0475*SiO2 -2.9511*TiO2 -2.3987*Al2O3 -1.9076*FeOtot - 8.9312*MnO -2.0784*MgO -1.6410*CaO -8.2331*K2O +204.0259 (or standardized D1stand.= -4.20380*SiO2 - 1.76748*TiO2 -1.22605*Al2O3 -1.07878*FeOtot - 0.00722*MnO -2.95498*MgO -1.86630*CaO - 0.08216*K2O and D2stand.= -6.87755*SiO2 - 0.86574*TiO2 -3.29139*Al2O3 -2.75231*FeOtotal - 0.44323*MnO -4.53420*MgO -2.58102*CaO - 1.42516*K2O). Fig. 6 shows that Venera 14 data are closer to the tholeitic field of MOR.

Comparison of the Venus' rocks with the terrestrial volcanics in terms of K, U, and Th contents shows the Venera 8 data fall within the K2O-U and K2O-Th fields for IO alkalines (Fig. 7). The Venera 9 material differs from the IO tholeites because it have too high Th content, but it is close to IO alkaline series field.

The Venera 10, Vega 1 and Vega 2 GRS data fall within the K2O-U and K2O-Th intersecting fields for IO tholeites and OIA tholeites. Also Vega 1 and Vega 2 materials are similar to the IO alkaline rocks. But the Venera 10 material is outside the IO alkaline field having less K. Because there are no signs of plate tectonics on Venus, no geodynamic analogs of oceanic island arcs and mid-oceanic ridges, it is most probably the Venera 10, Vega 1 and 2 materials formed in a way similar to IO (hot-spot) tholeites.

Results: So this work has shown that the application of the statistical discriminant analyses is very usable in planetological geochemical analyses. This technique shows that Venera 14 material chemically resembles more MOR tholeites. Venera 13, Vega 2, Venera 9 materials resemble more IO alkalines. Venera 10, Vega 1, Vega 2 GRS analyses resemble more IO tholeites. Based on these results we could suggest that the main magmatic processes on Venus show chemical similarities with terrestrial hot-spot magmatism and MOR divergent magmatism (with no plate tectonics).

References: [1] Vinogradov et al. (1973) Icarus, 20,253-259, [2] Surkov et al. (1976) Kosmich. Issledov., 5, 704-709, [3] Surkov et al. (1987) Kosmich. Issledov., 5,762-767), [4] Barsukov et al. (1989). Planet Venus, M.: Nauka-press, 291-300. [5] Barsukov et al. (1984) Geokhimia, 12, 1811-1820. [6] Nikolaeva (1995) Geochem. Intern., 12, 1-11, [7] Nikolaeva (1997) Geochem. Intern., 35, 424-447. [8] Davis (1986) Statistics and Data Analysis in Geology, 478-491, 621 p.

Fig. 5. Tholeitic, alkaline, and calc-alkaline series

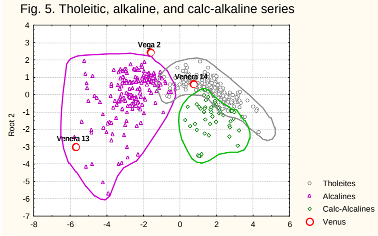
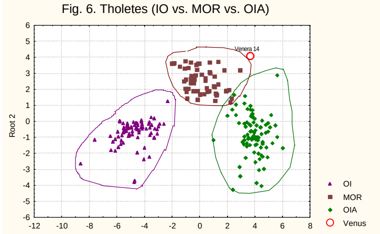


Fig. 6. Tholetes (IO vs. MOR vs. OIA)



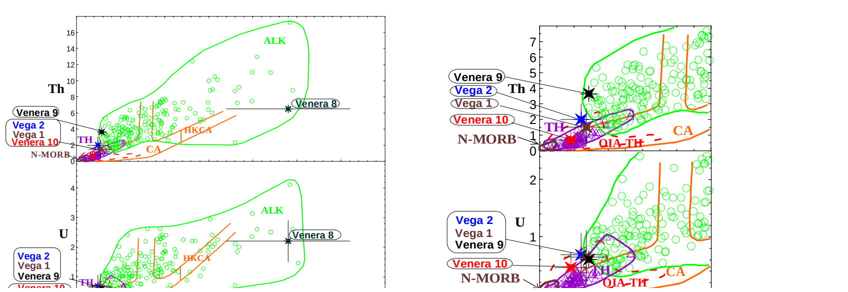


Fig. 7 a,b. K-U-Th diagram. Fields:ALK - IO alcalines; TH-tholeites; CA-calc-alkalines; HKCA-high-K calc-alcalines[7]; OIA-TH -OIA tholeites; NMORB - MOR tholeites