ΠΕΤΡΟΛΟΓΙΑ.— **Dykes and sills of diabase within the tectonites (harzburgites) and their significance,** *by George M. Paraskevopoulos**. Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Ἀγγέλου Γαλανοπούλου.


ABSTRACT

The diabase occurrences in the tectonites have mainly a fine grained and occasionally microlithic texture. In the margins of the diabase dykes and sills there occur, as a rule, chilling phaenomena, indicating that the passage of the diabase material through the tectonite and its crystallization took place at a time when the material of the tectonite was in a cool status. From the study of the mineralogical composition, the texture and the chemistry of the diabase dykes and sills in the tectonites the following types can be distinguish.

1. A part of the diabase occurrences are characterized by a holocrystalline medium grained texture. These diabases constitute a transitionale type to the dykes and sills of gabbro occuring in the tectonites.

2. A part of the diabase occurrences represents rocks which derived from the crystallization of more or less strongly differentiated melts. These rocks have hypophitic, ophitic or intermediate, as well as microlithic texture, are fine grained to massive. From their mineralogical composition, they are characterized by the presence of large amounts of green hornblende and plagioclase enriched in Ab. In many cases within these diabases there are concentrations of sulphide minerals of hydrothermal origin. From less differentiated melts the pyroxenitic diabases are derived. The ratio FeO*: MgO is mainly high.

3. A very small amount of the diabase occurrences represents the meladiabases. They are usually characterized by spinifex texture, but there could also exist at the same time a variolithic texture.

The presence of the spinifex texture and the skeletal and the deutritic or sheaf-like crystallization of the pyroxenes are important in, that they indicate that the temperatures of the melts, from which they originated, were higher than those of the tholeiitic lavas. The spinifex texture includes both coarse and fine grained. Regarding the mineralogical composition, the meladiabases consist of pyroxenes, glassy ground mass and chromite grains. Plagioclase is missing. Some pseudomorphosis after serpentine remind olivine, but this could not be checked. The ratio FeO*: MgO is usually very low. It is worth mentioning the high CaO : $Al_2O_3$ ratio (0,81-2,07), a characteristic, which together with the spinifex texture is observed in the komatiites, rocks which were derived,


* Γ. Μ. ΠΑΡΑΣΚΕΥΟΠΟΥΛΟΥ, **Φλέβες καὶ κοῖται διαβάσου ἐντὸς τῶν τεκτονιτῶν (χαρτζβουργιτῶν) καὶ ἡ σημασία αὐτῶν.**

as it is known, from primary undifferentiated melts. Therefore it is considered that the meladiabase occurrences within the tectonites derived from melts, the composition of which approaches that of the parental ophiolite melt. If there differentiation took place, this should have been of a small degree.

In contrast to the coarse grained texture (pegmatitic texture) of the gabbros, the diabase occurrences in the tectonites, have mainly a fine grained and occasionally microlithic texture. In the margins of the diabase dykes and sills there occur, as a rule, chilling phenomena, indicating that the passage of the diabase material through the tectonite and its crystallization, took place at a time when the material of the tectonite was in a cool status. This means that the formation of most of the diabase occurrences took place at a later stage in comparison with the formation of the gabbro and pyroxenite dykes crossing the tectonites.

The following are some examples of ophiolite complexes with diabase dykes within the tectonites, both from personal observations as well as from reports of other authors, particularly from greek complexes. Thus in the Pindos complex there has been established the presence of numerous diabase dykes, which cross the tectonites between Kambos Despoti and Katara area. Some of these dykes contain disseminated sulphide mineralization especially of pyrite accompanied by hydrothermal quartz dykes or veins and quartz concentrations in general. Figure 1 shows a section of diabase dykes crossing the tectonites, whereas in the right part of the section, there is also a gabbro dyke crossing the tectonites. The diabase of the last dyke to the SE of the section, exhibits at many points variolithic texture and in thin section feathery or sheaf-like structures of pyroxenes are observed. Similarly fig. 2 shows a diabase dyke crossing the tectonites at Argolis, in the area between Vothikion and Stavropodion. Some of the diabase dykes belong to meladiabase. They are usually characterized by spinifex textures of pyroxenes observed together with feathery or sheaf-like structures. The spinifex texture, which is referred from komatiitic rocks, is a textural term and is characterized by the criss-crossing sheaths of olivine or pyroxene crystals or by parallel assemblies of flattened olivine crystals or needle-like pyroxene crystals. This texture is formed as a result of supersaturation induced in a nuclei-free melt. N. T. Arndt et al. (1979) report that in the phenocryst-free upper sections of lava flows, where temperature and perhaps composi-

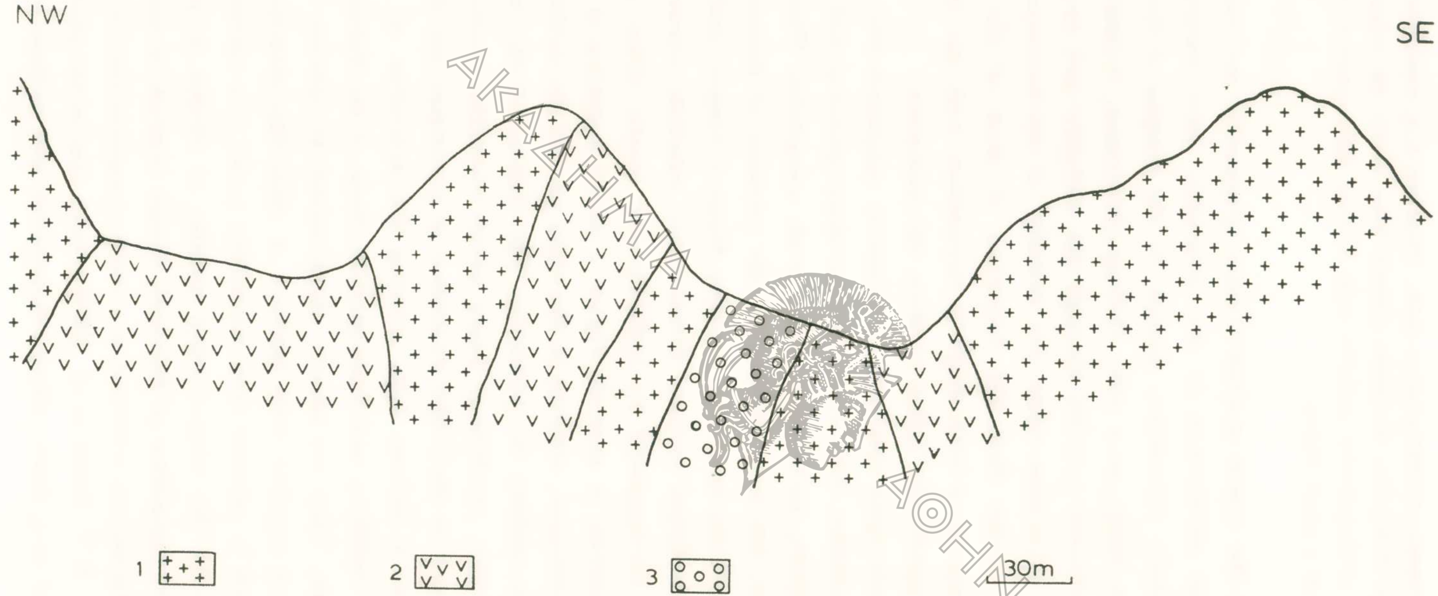


Fig. 1. Diabase dykes and a gabbro dyke intruding tectonites in the Katara area of the Pindos complex. The last SE dyke of diabase shows variolithic texture.

1 = tectonites 2 = diabase 3 = gabbro

tion gradiens are steep, spinifex textures form by rapid growth of mafic minerals from chilled flows-tops down into supercooled ultrabasic liquids. Some authors accept the dehydration quenching as an alternative cause of supersaturation of the melt (C. H. Donaldson, 1974). The variolithic texture as well as the spinifex texture are considered as quench textures. The presence of the spinifex texture and the skeletal and the deutritic, or sheaf-like crystallization of the pyroxenes are important in, that they indicate

Fig. 2. Dyke of diabase (meladiabase) crosses tectonites in Argolis complex, Greece.

that the temperatures of the melts, from which they originated, were higher than those of the tholeiitic lavas. Higher temperature of the melt means higher basicity of it.

The dykes develop above the tectonites into diabase flows and pillow lavas. K. Sideris (1966) reports a case of a dyke of spilite, apparently of primary diabase, crossing the peridotites of the Perivoli area of south Pindos, whereas K. Economou (1973), reports that in the ophiolite complex of Crete the diabase appears also in the form of intrusions within the peridotites and shows also one such case from the Spilion area in a geological section.

Numerous isolated diabase dykes crossing the harzburgites and the overlying cumulates are reported by T. Juteau et al. (1977), in the Antalya complex of Turkey. These dykes have chilled margins, suggesting a later intrusive phase for them, at a time when the intruded host rocks were already cold.

Table 1 lists the chemical analyses of various diabase dykes, which cross the tectonites of the Pindos and Argolis complexes.

From the study of the mineralogical composition, the texture and the chemistry of the diabase dykes in the tectonites, the following conclusions can be drawn :

(i) Among these diabase dykes there are some types, which are intermediate types in comparison with the dykes of gabbro in the tectonites (intrusive gabbros). These diabase dykes are characterized by a holocrystalline medium grained texture and are macroscopically similar to the holocrystalline no massive diabases.

(ii) A part of the diabase dykes represents rocks derived from the crystallization of more or less strongly differentiated melts. These rocks have hypophitic, ophitic or intermediate, as well as microlithic texture, are fine grained to massive. From their mineralogical composition, they are characterized by the presence of large amounts of green hornblende and plagioclase enriched in Ab. In many cases within these dykes, there are impregnations or concentrations of sulphide minerals of hydrothermal origin. The hydrothermal phenomena are localized mainly in the diabase and rarely in the borders of the surrounding tectonite. Hydrothermal quartz and hydrothermal alterations of diabase, especially the formation of chlorite and epidote, accompany the metallogenetic phenomena. It is known that these hydrothermal metallogenetic phenomena are genetically related with the differentiaded diabase residual melts and represent the final stages of magmatism. From less differentiated melts, the pyroxenitic diabases are derived. The ratio FeO* : MgO is sufficiently high, whilst the ratio MgO : (MgO+FeO*) varies between 0,28 - 0,58 (anal. No. 5, 9, 14, 15 $ARG_2$, $ARG_2'$ and $ARG_4$ of table 1) (FeO*= Fe total as FeO). An additional indication of the source of derivation of the differentiated melts is the excess amount in $SiO_2$.

(iii) A very small amount of the diabase dykes represents the meladiabases. These have been observed in the Pindos complex and the area between Vothikion - Stavropodion of the Argolis complex. The are usually

TABLE 1.

**Diabase dykes into the tectonites of some alpine ophiolite complexes from Greece, normalized to 100 per cent, without LOI.**

| | 1 | 5 | 9 | 14 | 15 | ARG1 | ARG2 | ARG2′ | ARG4 | ARG6 |
|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 44.44 | 51.82 | 50.92 | 51.75 | 51.05 | 40.86 | 44.93 | 43.16 | 48.19 | 43.38 |
| $Al_2O_3$ | 16.24 | 13.94 | 15.65 | 15.04 | 14.21 | 12.80 | 14.96 | 14.54 | 15.33 | 12.79 |
| FeO* | 9.26 | 14.63 | 7.67 | 10.76 | 13.87 | 9.86 | 8.29 | 6.85 | 8.55 | 8.31 |
| MnO | 0.24 | 0.18 | 0.14 | 0.24 | 0.25 | 0.15 | 0.18 | 0.14 | 0.11 | 0.18 |
| MgO | 14.73 | 5.78 | 10.64 | 8.78 | 6.17 | 8.47 | 7.35 | 8.02 | 5.77 | 13.14 |
| CaO | 13.21 | 6.86 | 11.66 | 9.21 | 9.04 | 26.44 | 20.02 | 22.38 | 14.66 | 20.64 |
| $Na_2O$ | 0.52 | 4.08 | 2.35 | 2.85 | 3.02 | | 2.44 | 2.40 | 3.43 | 0.51 |
| $K_2O$ | 0.07 | 0.02 | 0.10 | 0.24 | 0.17 | 0.34 | 0.45 | 1.07 | 1.62 | 0.13 |
| $TiO_2$ | 1.30 | 2.49 | 0.77 | 1.18 | 2.17 | 0.98 | 1.22 | 1.27 | 2.21 | 0.83 |
| $P_2O_5$ | 0.06 | 0.22 | 0.10 | 0.04 | 0.15 | 0.07 | 0.17 | 0.14 | 0.07 | 0.10 |
| MgO : (MgO+FeO*) | 0.61 | 0.28 | 0.58 | 0.45 | 0.31 | 0.46 | 0.47 | 0.54 | 0.40 | 0.61 |
| FeO* : MgO | 0.63 | 2.53 | 0.72 | 1.23 | 2.25 | 1.16 | 1.13 | 0.85 | 1.48 | 0.63 |
| FeO* | 9.26 | 14.63 | 7.67 | 10.76 | 13.87 | 9.86 | 8.29 | 6.85 | 8.55 | 8.31 |

1 Meladiabase dyke. Lambanovon valley, Pindos complex
5 Diabase dyke. 1 km W Tragopetra, Pindos complex
9 Diabase dyke. Kambos Despoti, Pindos complex
14 Diabase dyke. Tragopetra, Pindos complex
15 Diabase dyke. Tragopetra, Pindos complex
ARG1 Meladiabase dyke. 100 m SW of Vothikion bridge, at the Vothikion - Stavropodion road, Argolis complex
ARG2 Diabase dyke. 200 m SW » » » » » » » » » »
ARG2′ Diabase dyke. 180 m SW » » » » » » » » » »
ARG4 Diabase dyke. 300 m SW » » » » » » » » » »
ARG6 Meladiabase dyke. Near the large bend of Vothikion - Stavropodion road, by Stavropodion

Analysis: 1, 5, 14, 15, ARG1, ARG2, ARG2′, ARG4, ARG6 : University of Southampton, Department of Geology, England, 9 : Prof. Dr. M. Weibel, E. T. H., Zürich characterized by spinifex texture, but there could also exist at the same time a variolithic texture. The spinifex texture includes both coarse and fine grained. The coarse spinifex texture is represented by criss-crossing sheaths crystals of pyroxenes (Fig. 3). Among these crystals there may also be skeletaly, feathery and sheaf-like pyroxene crystals. Occasionally the individual rays of a sheaf are formed by linear chain-like arrangement of small pyroxene crystals. The fine grained spinifex texture is characterized by

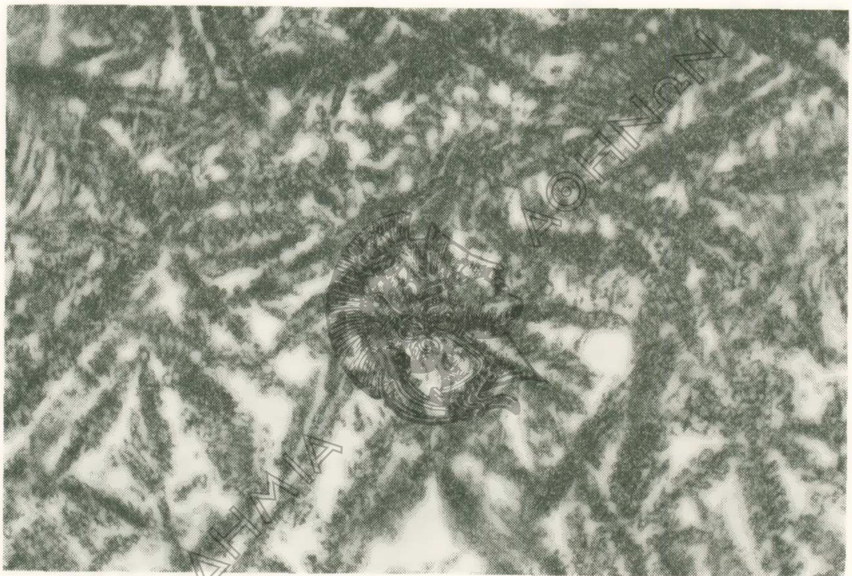

Fig. 3. Coarse spinifex texture formed by criss-crossing sheaths of pyroxene crystals. Dyke of meladiabase crossing tectonites near the bridge of the village Vothikion in Argolis comlex, Greece. Nicols II, × 120.

needle-like pyroxene crystals arranged parallel to each other. Regarding the mineralogical composition, the meladiabase types reported above, consist of pyroxenes, glassy ground mass with occasional development from it of secondary products of devitrification of the glass, and chromite grains. Plagioclase is missing. Some pseudomorphosis after serpentine, remind olivine, but this could not be checked. The ratio FeO* : MgO is very low, whilst the MgO : (FeO*+ MgO) ratio varies between 0,31 — 0,61 indicative of melts with a small degree of differentiation or possibly primary undifferentiated melts (anal. No. 1, ARG1 and ARG6 of table 1).

It is worth mentioning the high (0,81 - 2,07) CaO : $Al_2O_3$ ratio, a characteristic, which together with the spinifex texture is observed in the komatiites, rocks which were derived, as is it known, from primary undifferentiated melts.

Therefore it is considered, that the dykes of meladiabases in the tectonites represent melts, the composition of which approaches that of the parental ophiolite melt. If there differentiation took place, this should have been of a small degree. In anyway the variation of the FeO*: MgO ratio for the meladiabases (anal. No. 1, ARG1 and ARG6) is small.

## ΠΕΡΙΛΗΨΙΣ

Αἱ ἐμφανίσεις τῶν διαβασῶν ἐντὸς τῶν τεκτονιτῶν παρουσιάζουν συνήθως λεπτόκοκκον, ἐνίοτε δὲ καὶ μικρολιθικὸν ἱστόν. Εἰς τὰ ἄκρα τῶν διαβασικῶν φλεβῶν καὶ κοιτῶν ἐμφανίζονται κατὰ κανόνα φαινόμενα ἀποψύξεως, δηλοῦντα ὅτι ἡ διέλευσις τοῦ διαβασικοῦ ὑλικοῦ διὰ τῶν τεκτονιτῶν καὶ ἡ κρυστάλλωσίς του ἔλαβε χώραν ὅταν τὸ ὑλικὸν τῶν τεκτονιτῶν ἦτο ἐν ψυχρᾷ καταστάσει. Ἐκ τῆς μελέτης τῆς ὀρυκτολογικῆς συστάσεως, τοῦ ἱστοῦ καὶ τοῦ χημισμοῦ τῶν διαβασικῶν φλεβῶν καὶ κοιτῶν ἐντὸς τῶν τεκτονιτῶν δυνάμεθα νὰ διακρίνωμεν τὰς κατωτέρω κατηγορίας.

1. Ἓν μέρος τῶν διαβασικῶν ἐμφανίσεων χαρακτηρίζεται ἀπὸ ὁλοκρυσταλλικὸν μεσόκοκκον ἱστόν. Οἱ διαβάσαι οὗτοι ἀποτελοῦν μεταβατικὸν τύπον πρὸς τὰς φλέβας καὶ κοίτας τῶν γάββρων ἐντὸς τῶν τεκτονιτῶν.

2. Ἓν μέρος τῶν διαβασικῶν ἐμφανίσεων παριστοῦν πετρώματα προελθόντα ἐκ τῆς κρυσταλλώσεως κατὰ μᾶλλον ἢ ἧττον ἰσχυρῶς διαφοροποιημένων τηγμάτων. Ἔχουν ἱστὸν ὑποφειτικόν, ὀφειτικὸν ἢ ἐνδιάμεσον ὡς καὶ μικρολιθικόν. Εἶναι πετρώματα λεπτόκοκκα ἕως συμπαγῆ. Οἱ διαβάσαι οὗτοι χαρακτηρίζονται ἀπὸ τὴν παρουσίαν ἀφθόνου πρασίνης κεροστίλβης καὶ πλαγιοκλάστων ἐμπλουτισμένων εἰς μόρια Ab. Εἰς πολλὰς περιπτώσεις ἐντὸς αὐτῶν παρατηροῦνται συγκεντρώσεις θειούχων ὀρυκτῶν ὑδροθερμικῆς προελεύσεως. Ἀπὸ ὀλιγώτερον διαφοροποιημένον ὑλικὸν προῆλθον οἱ πυροξενικοὶ διαβάσαι. Ἡ σχέσις FeO*: MgO εἶναι κυρίως μεγάλη.

3. Ἓν πολὺ μικρὸν μέρος τῶν διαβασικῶν ἐμφανίσεων παριστᾷ μελαδιαβάσας. Χαρακτηρίζονται συνήθως ἀπὸ σπινοειδῆ ἱστὸν ἐνῶ ταυτοχρόνως δύναται νὰ ὑπάρχῃ καὶ βαριολιθικὸς τοιοῦτος. Ἡ παρουσία τοῦ σπινοειδοῦς ἱστοῦ καθὼς καὶ αἱ σκελετικαί, δενδριτικαὶ καὶ δεματοειδεῖς κρυσταλλώσεις τῶν πυροξένων, δηλοῦν

ὅτι αἱ θερμοκρασίαι τῶν τηγμάτων ἐκ τῶν ὁποίων προέρχονται τοιοῦτοι ἱστοὶ εἶναι ὑψηλότεραι ἐκείνων τῶν θολεϊιτικῶν λαβῶν.

Ὁ σπινοειδὴς ἱστὸς περιλαμβάνει ἁδρομερῆ καὶ λεπτόκοκκον τοιοῦτον. Οἱ μελαδιαβάσαι ἀποτελοῦνται ἀπὸ πυροξένους, ὑελώδη κυρίαν μᾶζαν καὶ κόκκους χρωμίτου. Πλαγιόκλαστα ἐλλείπουν. Μερικαὶ ψευδομορφώσεις κατὰ σερπεντίνην ὑπενθυμίζουν ὀλιβίνην, ἀλλὰ τοῦτο δὲν κατέστη δυνατὸν νὰ ἐλεγχθῇ. Ἡ σχέσις FeO*: MgO εἶναι συνήθως μικρά. Ἀξιοσημείωτος εἶναι ἡ ὑψηλὴ σχέσις CaO : $Al_2O_3$ (0,81 - 2,07). Τοῦτο ὁμοῦ μὲ τὸν σπινοειδῆ ἱστὸν παρατηροῦνται εἰς τοὺς κοματιΐτας, πετρώματα τὰ ὁποῖα, ὡς γνωστόν, προῆλθον ἀπὸ πρωτογενῆ ἀδιαφοροποίητα τήγματα. Οὕτω, αἱ ἐμφανίσεις τῶν μελαδιαβασῶν ἐντὸς τῶν τεκτονιτῶν προέρχονται ἀπὸ τήγματα τῶν ὁποίων ἡ σύστασις προσεγγίζει τὴν σύστασιν τοῦ μητρικοῦ ὀφιολιθικοῦ τήγματος. Ἐὰν ἔλαβε χώραν διαφοροποίησις, αὕτη ὀφείλει νὰ ἦτο μικροῦ βαθμοῦ.

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