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Traces of Lower-middle Liassic Volcanism in the Crinoidal Limestones of the Tuscan Sequence in the Montemerano Area (Grosseto, Northern Apennines)

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ABSTRACT

In the Montemerano area (province of Grosseto, Northern Apennines) the Crinoidal Limestone (Lower to Middle Lias) contains some red impure calcilutite intercalations. In these intercalations, angular volcanic fragments of alkali-olivinebasalt composition occur, indicating volcanic events in the Tosco-Umbrian province during Liassic times. These events most probably were related to tensional movements in the crust during the early phase of the opening of the Tethyan Ocean. The formation of this paleo-ocean is discussed.

RIASSUNTO

Nei Calcari a Crinoidi del Lias inferiore-medio che affiorano nei dintorni di Montemerano (Grosseto, Appennino Settentrionale) sono state osservate alcune intercalazioni di calcilutiti rossobrune contenenti frammenti vulcanici di natura alcali-olivinbasaltica. Sulla base di questi ritrovamenti gli autori sostengono l'ipotesi che durante il Lias si siano verificati nel dominio tosco-umbro alcuni episodi vulcanici in seguito allo stiramento della crosta durante la fase iniziale dell'apertura oceanica della Tetide. La formazione di questo paleo-oceano vien discussa.

Introduction

At the end of the Trias and during the Jurassic, the Tosco-Umbrian province was the site of a synsedimentary block-faulting, probably related to a stretching of the crust, which during the same period affected also the southern Alps and Sicily. These tectonic movements are related to the beginning of the opening of the Tethyan Ocean (see also LAUBSCHER 1969) which was accomplished in the Upper Jurassic. They were at times accompanied by volcanic activity. In Sicily, in relation to these movements, volcanic activity of trachytic type in the Upper Lias (JENKYNS 1970) and of basalt type in the Dogger (TREVISAN 1937; WENDT 1963) are locally evident. Recently in the Altipiano di Asiago (Southern Alps) traces of trachytic-rhyolitic volcanism in the Rosso Ammonitico Superiore (Upper Jurassic) have been found (BERNOULLI and PETERS 1970).

Up to now no volcanic activity has been recorded in the Tosco-Umbrian province. Traces of volcanism in the Crinoidal Limestone of the Lower-Middle Lias which outcrop near Montemerano (Grosseto) are described in this paper (Fig. 1).

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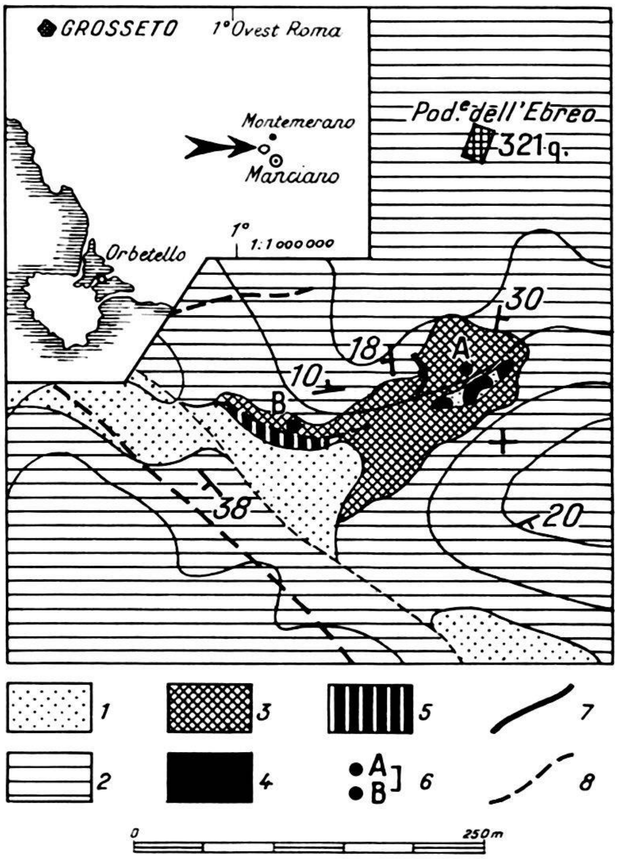

Fig. 1. Geological map of the "Podere dell'Ebreo" area (Montemerano). From PASSERINI and PIRINI (1965) simplified. 1: Alluvium (Quaternary); 2: calcarenites and Macigno formations (Tertiary); 3: Crinoidal Limestone (Lower-Middle Lias); 4: gray bedded limestones (Rhaetian (?)-Lower Lias); 5: *Rhaetavicula contorta* Limestones (Rhaetian-Hettangian); 6: A, B. Location of sections; 7,8: faults: observed (7), inferred (8).

Location of section

Near Montemerano, in the Podere dell'Ebreo area, Triassic-Jurassic carbonate formations of the Tuscan sequence are exposed and were recently studied by PASSERINI and PIRINI (1965). They comprise, from bottom to top:

a) "*Rhaetavicula contorta* Limestones" (Rhaetian-Hettangian);

b) "grey bedded limestones" (Rhaetian (?)-Lower Lias);

c) "pink nodular, massif limestones" (Crinoidal Limestone) of the Lower-Middle Lias.

Lower-Middle Eocene calcarenites follow unconformably above this sequence.

According to PASSERINI (1962) and PASSERINI and PIRINI (1965) – to whose works we refer to for the description of the single formations – the hiatus between the Crinoidal Limestone and the overlying Eocene calcarenites is of stratigraphic nature and of submarine origin.

In the last ten metres of the Crinoidal Limestone we observed a few lenticular intercalations of red and brownish-red impure calcilutites containing lithic fragments ranging up to 1 cm in size (Fig. 2, stratigraphic column A). The texture of these fragments clearly shows that they are of volcanic origin. Some of these lenses contain angular limestone fragments rich in crinoid remains (Fig. 3).

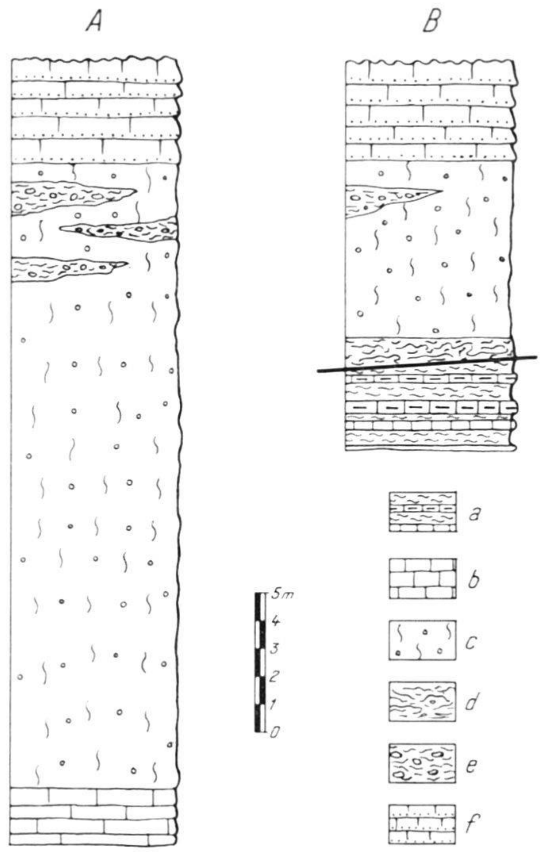

Fig. 2. Columnar sections of the sequences in "Podere dell'Ebreo" area. a: *Rhaetavicula contorta* Limestones (Rhaetian-Hettangian); b: gray bedded limestones (Rhaetian (?) – Lower Lias); c: Crinoidal Limestones (Lower-Middle Lias); d: volcanic level; e: red levels; f: calcarenites (Lower-Middle Eocene).

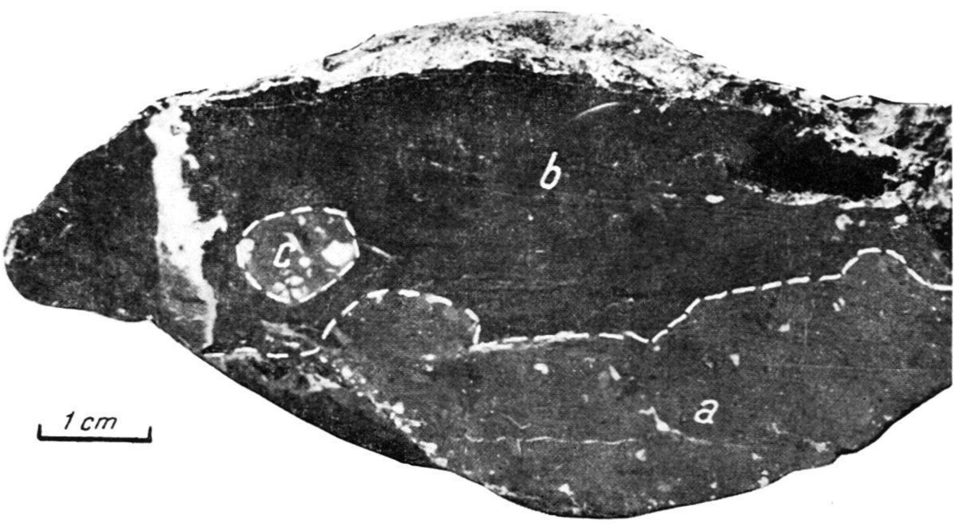

Fig. 3. Crinoidal Limestone (a), overlain by lenticular impure red calcilutite (b) which includes Crinoidal Limestone fragments (c) and volcanic fragments. Polished block.

Another lenticular level of violet-brown, friable, pyroclastic material, with hard, cemented nodules of the same material, occurs between the "*Rhaetavicula contorta* Limestones" and the upper part of the Crinoidal Limestone, which here are brought into direct contact by a fault (Fig. 2, stratigraphic column B). This layer consists exclusively of volcanic or pyroclastic material identical with the fragments in the lenticular intercalations described above. In our opinion, the volcanism is contemporary with the deposition of the Crinoidal Limestone.

Petrographic description

Red layers

These levels consist of impure calcilutite (25–35 % of insoluble residue) in which euhedral calcite crystals, about 20 microns in size, are surrounded or impregnated by an hematitic pigment. A few recristallized zones show calcite crystals with larger diameter (up to 150–200 microns). A few effusive fragments of maximum size of about 5 mm, often angular and with an opaque rim, are scattered in the rock. These fragments are strongly calcitized and show an intersertal texture typical of basaltic rocks and similar to that of the layer described below. At times the fragments are very small (less than 500 microns); well rounded and completely limonitized (Fig. 4). Several of these fragments have a concentric structure typical of ferrous pisolites. Sometimes it is possible to observe small cavities filled by drusy sparry calcite and by chalcedony. It is also possible to find some authigenic quartz and a few chlorite lamellae, 30–40 microns in width. The latter show a light olive green pleochroism; they are optically negative and have a very low 2V. Fossils are completely absent.

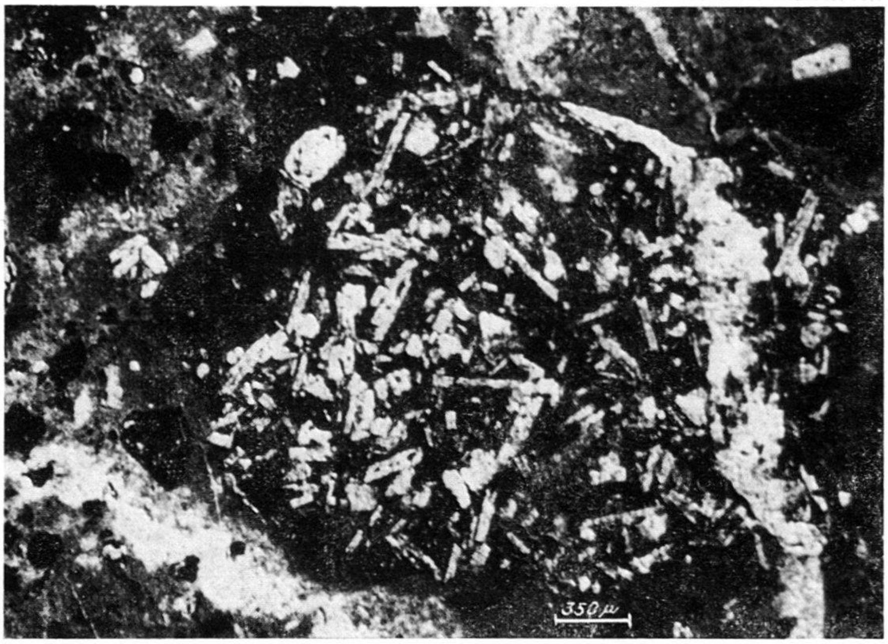

Fig. 4. Basaltic fragment with intersertal texture in impure red calcilutite. To left: few small fully limonitized grains. Parallel nicols.

Volcanic level

The lenticular level, shown in column B of Figure 2, is generally friable because of strong weathering. Some hard nodules are, however, present. This level is apparently a clastic deposit made of angular clasts of volcanic rocks of different texture.

In these nodules the fragments are separated by films of sparry calcite. The fragments are of basaltic nature and of two main types. One type shows an intersertal texture with numerous vesicles ranging in size from a hundred microns up to one cm, filled with calcite, brown stained due to impurities (Fig. 5), and quartz. The groundmass consists of numerous plagioclase crystals that are largely replaced by calcite, and of calcite crystals surrounded by limonitic material. In the fragments with vesicles, phenocrysts are very rare and the quantity of opaque material, assumed to be originally glass, is about 20%. The second type of fragments also shows the intersertal texture and is characterized by the total or partial absence of vesicles. Also in these fragments the groundmass is composed of largely calcitized plagioclase in a very abundant opaque groundmass (more than 30%, Fig. 6) and by large phenocrysts. The latter are composed of plagioclase (Fig. 7) and of calcite showing a habit typical of olivine (Fig. 8). This habit is recognizable also in some groundmass crystals.

The perfectly preserved habit of such replaced olivine crystal suggests that they did not react with the liquid magma. The chemical composition of the rock cannot be determined because of the high degree of alteration. Therefore the possibility of distinction between the two series of tholeiitic or alkali-olivinebasalt magma is based only on the habitus of olivine. It seems generally recognized that olivines with reaction rims are characteristic of tholeiites. On the other hand, they do not occur in alkali-olivinebasalts, which furthermore show olivines both as phenocrysts and in the groundmass (WILKINSON 1967). In view of this we suggest that the original magma in

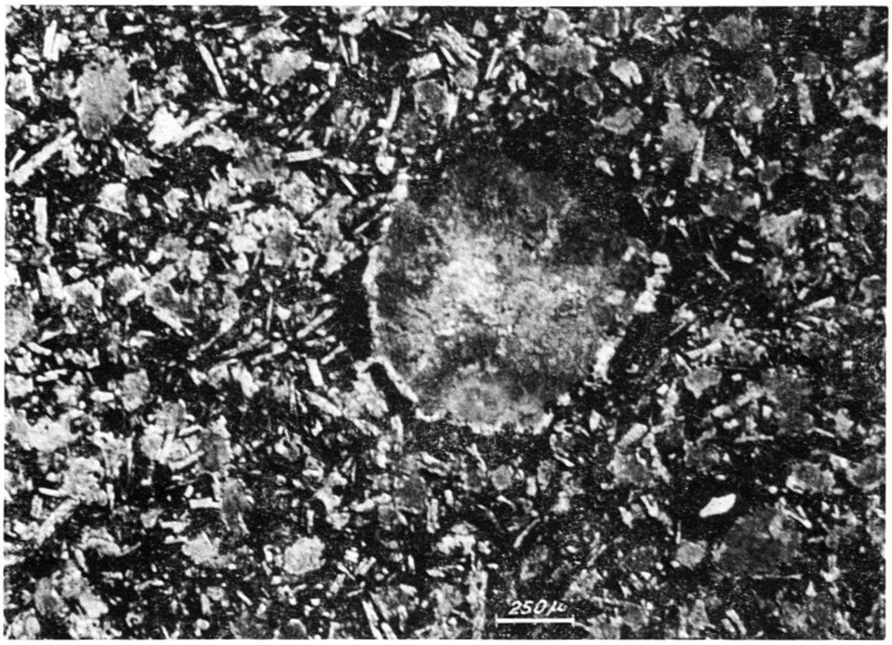

Fig. 5. Basaltic fragment with vesicles filled by brownish calcite. The groundmass is composed of limonite (black), calcitized plagioclases and small round crystals of calcite. Thin section. Parallel nicols.

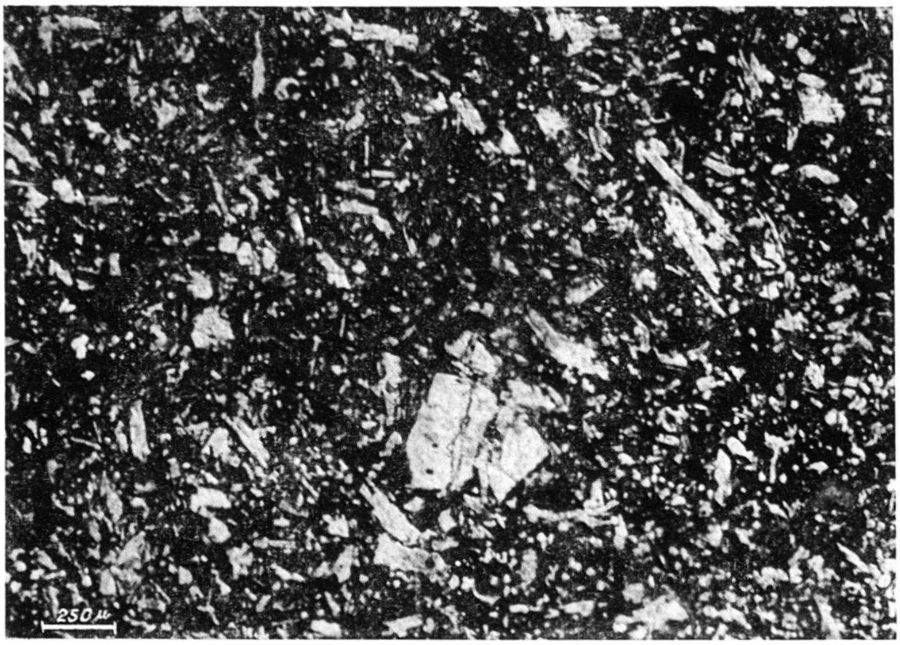

Fig. 6. Intersertal groundmass of a basaltic fragment without any vesicles. Parallel nicols.

Fig. 7. Basaltic fragment with strongly alterated plagioclase phenocryst. Parallel nicols.

the volcanism just described was of alkali-olivinebasalt type. Unfortunately, the criterion proposed by McDonald and Katsura and described in Wilkinson (1967), for determining derivation from an alkali-olivinebasalt series – "presence of titanian augite, of true groundmass olivine and of interstitial alkali feldspar" – cannot be applied here because of the high degree of alteration of the rock. The texture of the fragments suggests that those with numerous vesicles are fragments of slag, while the ones with phenocrysts and lacking vesicles are typical of lava flows. The presence of slag fragments and the weak reworking of volcanic elements made evident by their

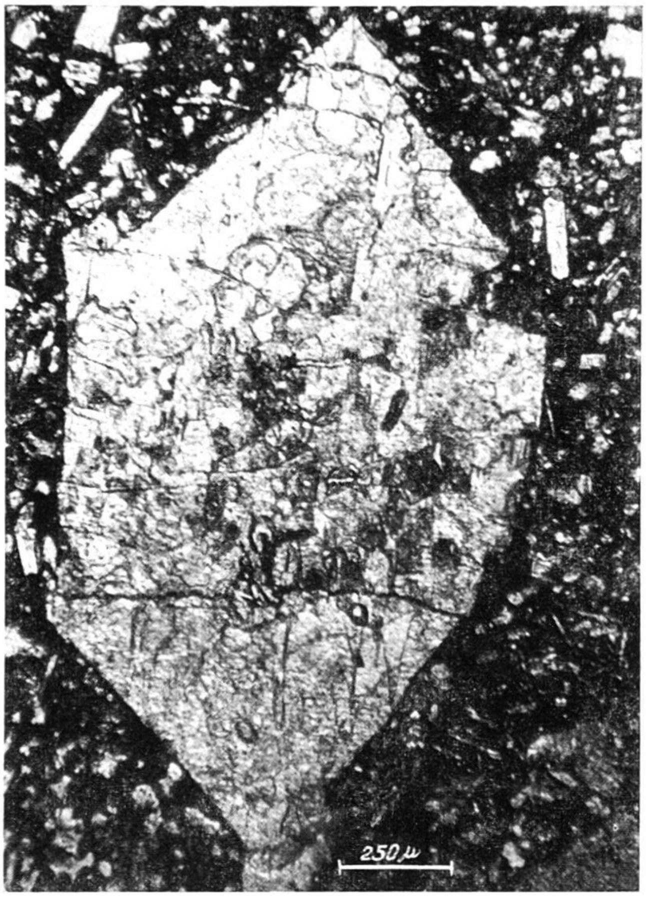

Fig. 8. Large olivine phenocryst fully calcitized in a basaltic fragment. Parallel nicols.

angular aspect, indicate that the eruptive centre cannot have been too far away and probably was submarine.

Crinoidal Limestone

The most common microfacies is represented by micrite with ubiquitous crinoidal remains and with few ammonites and foraminifera. At times, intraclasts consisting of pure micrite or of micrite with organic remains (especially fragments of ammonites) are present. In the crinoidal remains, that from their irregular distribution seem not to have been displaced to deeper environments, algal borings were observed. The cavities bored by algae are filled with a very fine, dark micrite which at times surrounds the whole crinoidal fragments (Fig. 9). The presence of these algal borings suggests that the formation was deposited in a relatively shallow marine environment, i. e. probably less than 50 metres deep, in the photic zone.

In a sample taken near the reddish lens-shaped layers, limonitic "cauliflower" structures have been found, varying from about 220 to 3000 microns in size, at times replacing the crinoidal fragments (Fig. 10). According to JENKYNS (1970) these structures may be considered a result of the diagenetic migration of iron.

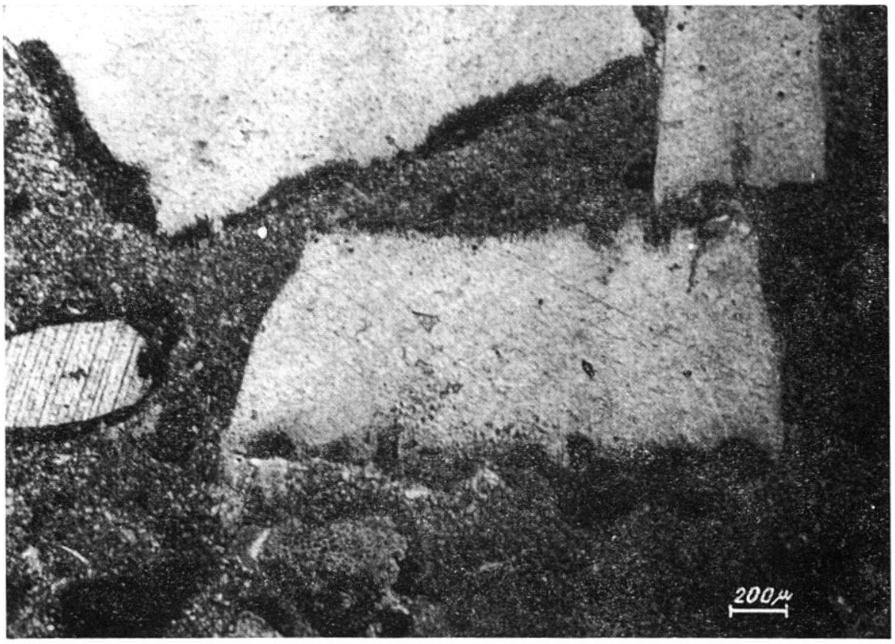

Fig. 9. Crinoidal remains with rims bored by algal activity and circumcrusted by dark micrite. Crinoidal Limestone; parallel nicols.

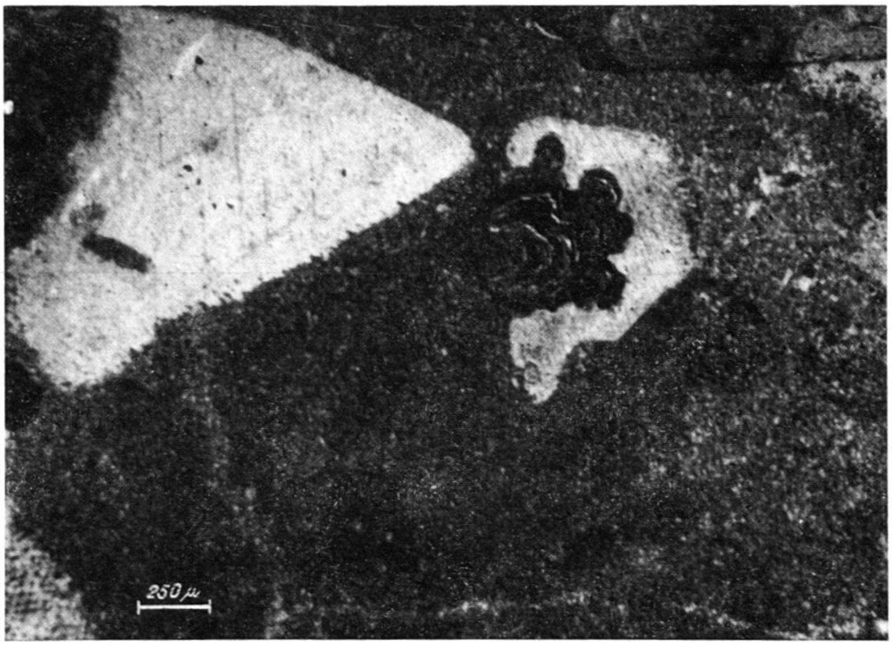

Fig. 10. Limonitic "cauliflower" structure cutting a crinoidal fragment. This shows the non-syngenetic origin of these structures. Crinoidal Limestone; parallel nicols.

Volcanic events and liassic tectonism in Tuscany

Recently a few authors who have studied the Mesozoic carbonate formations of Tuscany have shown the existence of a Liassic tectonic phase (FAZZINI and PAREA 1966; BOCCALETTI, FICCARELLI, MANETTI and TURI 1969; GELMINI and MANTOVANI 1970). The facts in favour of this tectonic phase are: the occurrence of quartzitic deposits intercalated in the Calcare Massiccio (Upper Rhaetian to lowermost Lias) in a few outcroups around Grosseto (FAZZINI and PAREA 1966); and the occurrence of dykes of Rosso Ammonitico within the Calcare Massiccio of the area around Roselle (Grosseto) (GELMINI and MANTOVANI 1970). As a further proof of a Liassic tectonic phase of regional extension, we have observed dykes of Rosso Ammonitico within the Calcare Massiccio in several outcrops of Southern Tuscany. The areas, besides the ones pointed out by GELMINI and MANTOVANI (1970) are: Semproniano, Batignano, Caldana, Collecchio, Isola di Cerboli (Grosseto); Sassetta, Suvereto, Monti di Campiglia Marittima (Livorno). The sedimentary dykes are generally filled by red micrite with crinoidal, ammonite and foraminiferal fragments. The dykes generally have sharp edges, a regular vertical arrangement and are wider in their higher part. At times, as is the case in the Caldana area, angular elements of Calcare Massiccio are included in the calcilutite (Fig. 11). A few dykes, however, have a much more irregular arrangement: at times they form a thick network and their sides are covered by sparry alabaster-like calcite with scarce or absent micritic fillings. There are also smaller pinkish dykes filled with calcite and/or dolomite, with grains larger in size than 100 microns, forming a hypidiotopic mosaic.

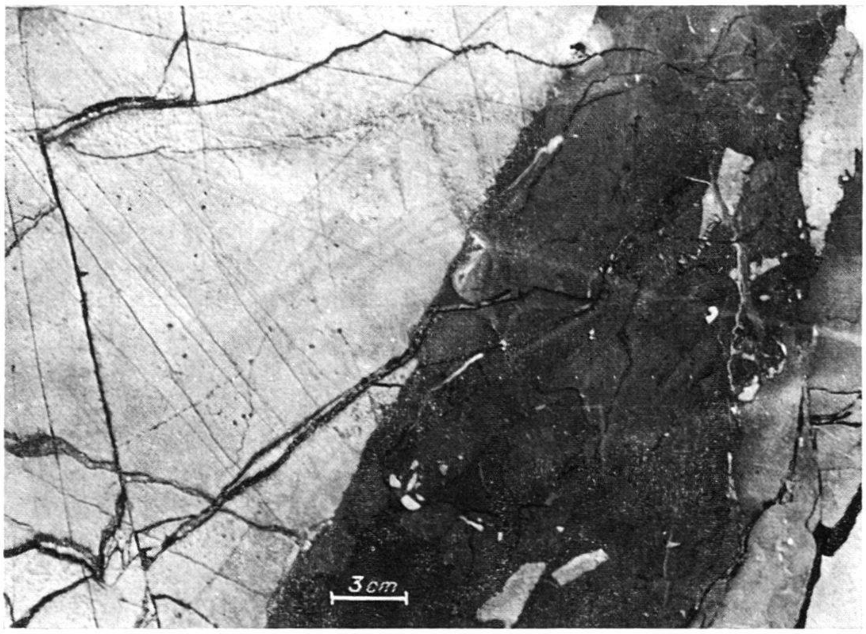

Fig. 11. Sedimentary dyke of Rosso Ammonitico in the Calcare Massiccio. The filling red calcilutite is intermixed with white angular fragments of Calcare Massiccio. Polished block.

In our opinion, the genesis of the fractures, successively filled up, is related to tectonic phenomena which have affected the already lithified Calcare Massiccio. The early lithification of the Calcare Massiccio has taken place penecontemporaneously in a shallow subtidal to supratidal environment. Emersion and karstification is suggested by the occurrence of alabaster-like bands which at times cover the sides of some smaller dykes and which, for their formation, need a vadose circulation. Moreover, some of the thicker fractures show an irregular arrangements that suggests that karstic dissolution has taken place, widening sometimes preexisting fractures.

Similar conclusions have been reached by COLACICCHI et al. (1970) for coeval sediments in Umbria occuring below sequences of reduced thickness.

In this context, the discovery of volcanic traces, even if areally limited, of alkali-olivinebasalt type in the Montemerano area corroborates the hypothesis of a Liassic tectonism of tensional type in the Tosco-Umbrian province, which probably was followed by irregular pulsations throughout the whole Jurassic.

Conclusions

In the Montemerano area (Grosseto) the Crinoidal Limestone (Lower-Middle Lias) contains red impure calcilutite lenses with lithic fragments of alkali-olivine-basalt type.

The occurrence of Lower-Middle Liassic volcanic traces of such a composition confirms the hypothesis, corroborated by other data, of synsedimentary block-faulting, starting with the Lower Jurassic and affecting the whole Tosco-Umbrian province. These movements, however, are not limited to this area, but extend also to the Southern Alps and to Sicily, showing their regional importance. This disjunctive tectonics (which apparently went on throughout the Jurassic, not continuously but with irregular pulsations) has recently been interpreted as one of the first results of the Jurassic opening of a Tethyan paleo-ocean. The formation of this paleo-ocean which was completed in the Upper Jurassic by separation of the paleo-African and paleo-European plates might have determined block-faulting in the future continental margins subject to tension. Ascending sub-crustal magma presupposes fissures originating from relatively deep levels of the upper mantle. Generally the alkali-basalts are found on continental areas and as outflows from fissure systems in isostatically stable zones. Therefore basaltic eruptions are not necessary related to intense tectonic phases; but tensional effects which cause fissures in a rigid crustal plate, may sufficiently explain the facts.

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REFERENCES

ABBATE, E., BORTOLOTTI, V., PASSERINI, P., SAGRI, M., and SESTINI, G. (1970): *Development of the Northern Apennines Geosyncline.* Sedim. Geol. *4* (3–4), 203–647.

BATHURST, R. G. C. (1966): *Boring Algae, Micrite Envelopes and Lithification of Molluscan Biosparites.* Journ. Geol. *5*, 15–32.

BERNOULLI, D. (1969): *Redeposited Pelagic Sediments in the Jurassic of the Central Mediterranean Area.* Colloquium on Mediterranean Jurassic Stratigraphy, Budapest 1969, Ann. Inst. Geol. Publ. Hungarici *54*/2, 71–90.

BERNOULLI, D., and PETERS, T. (1970): *Traces of Rhyolitic-Trachytic Volcanism in the Upper Jurassic of the Southern Alps.* Eclogae geol. Helv., *63*/2, 609–621.

BOCCALETTI, M. (1968): *«Slumps» intraformazionali e frane sottomarine nel Gruppo Calcareo Mesozoico della Serie Toscana.* Atti Soc. Tosc. Sci. Nat., Mem., ser. A, *75*, 525–530.

BOCCALETTI, M., and GUAZZONE, G. (1970): *La migrazione terziaria dei bacini toscani e la rotazione dell'Appennino Settentrionale in una «zona di torsione» per deriva continentale.* Mem. Soc. Geol. It. *9*/2, 177–195.

BOCCALETTI, M., FICCARELLI, G., MANETTI, P., and TURI, A. (1969): *Considerazioni sulla «serie (toscana) ridotta» a Sud dell'Arno.* Mem. Soc. Geol. It. *8*/3, 265–272.

COLACICCHI, R., PASSERI, L., and PIALLI, G. (1970): *Nuovi dati sul Giurese umbro-marchigiano e ipotesi per un suo inquadramento regionale.* Mem. Soc. Geol. It *9*/4, 839–874.

FAZZINI, P., and PAREA, G.C. (1966): *Contributo alla conoscenza dello Pseudoverrucano.* Mem. Soc. Geol. It. *5*/3, 189–224.

GELMINI, R., and MANTOVANI, M. P. (1970): *Ricerche geologiche nel Gruppo di M. Leoni (Grosseto, Toscana). II. La geologia di Poggio Moscona.* Mem. Soc. Geol. It. *9*/4, 817–838.

GLANGEAUD, L. (1968): *Les méthodes de la géodynamique et leurs applications aux structures de la Mediterranée occidentale.* Revue de Geogr. Phys. et de Géol. Dynam. *10*/2, 83–136.

JENKYNS, H.C. (1970): *Submarine Volcanism and the Toarcian Iron Pisolites of Western Sicily.* Eclogae geol. Helv. *63*/2, 549–572.

JENKYNS, H.C., and TORRENS, H.S. (1969): *Paleogeographic Evolution of Jurassic Seamounts in Western Sicily.* Colloquium on Mediterranean Jurassic Stratigraphy, Budapest 1969, Ann. Inst. Geol. Publ. Hungarici 54/2, 91–104.

LAUBSCHER, H. (1969): *Mountain Building.* Tectonophysics *7* (5–6), 551–563.

MERLA, G. (1951): *Geologia dell'Appennino Settentrionale.* Boll. Soc. Geol. It. *70*/1, 95–382.

PASSERINI, P. (1962): *Su un contatto stratigrafico fra il «Nummulitico» e un calcare massiccio di probabile età mesozoica nella Maremma grossetana.* Mem. Soc. Geol. It. *3*, 421–422.

PASSERINI, P., and PIRINI, C. (1965): *Stratigrafia del Mesozoico e dell'Eocene della Serie Toscana nella zona di Manciano e Montemerano (Grosseto).* Boll. Soc. Geol. It. *84*/3, 331–354.

TREVISAN, L. (1937): *Scoperta di formazioni basaltiche e piroclastiche presso Vicari (Palermo) e osservazioni sui fossili baiociani contenuti nei tufi.* Boll. Soc. Geol. It. *56*/3, 441–452.

WENDT, J. (1963): *Stratigraphisch-paläontologische Untersuchungen im Dogger Westsiziliens.* Boll. Soc. Paleont. Ital. *2*, 57–145.

WILKINSON, J.F.G. (1967): *The Petrography of Basaltic Rocks.* In: Basalts, ed. by HESS, H.H., and POLDERVAART, A., Interscience Publishers, New York, p. 163–214.