Correlations between Tatarian (Permian) type section (Russia) and the Salt Range (Pakistan): palynology and palaeomagnetism

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ABSTRACT
The position of palaeomagnetic zones together with the occurrence of some miospore species in the section of Salt Range enables its correlation with the reference sections of Tatarian on the Russian Platform. So the Wargal Limestone corresponds roughly to the Vishkilsky Horizon (newly proposed name instead of Sevedrodvinsky Horizon) both boundaries of the former being slightly younger than the corresponding boundaries of the latter. The analogs of the lower part of Vishkilsky Horizon and of the whole early Tatarian are seemingly absent in the Salt Range. The Amb Formation is most probably of Kazanian age.

KEY WORDS
Palaeomagnetism,
palynology,
stratigraphic correlations,
Permian,
Salt Range,
Russian Platform.

RÉSUMÉ
Corrélations entre la coupe type (Russie) du Tatarian (Permien) et le Salt Range (Pakistan) : palynologie et paléomagnétisme.
La position des zones paléomagnétiques associée à la présence de quelques espèces de miospores dans une coupe du Salt Range, permet des corrélations avec les coupes de référence du Tatarien de la Plate-forme russe. Ainsi le calcaire de Wargal correspond à l'horizon de Vishkilsky (nouveau nom de l'horizon de Sevedrodvinsky) dont les limites sont légèrement plus jeunes que celles du calcaire de Wargal. Les analogues de la partie inférieure de l'horizon de Vishkilsky et de l'ensemble du Tatarien sont absents dans le Salt Range. La Formation Amb est plus probablement datée du Kazanien.

MOTS CLÉS
Paléomagnétisme,
palynologie,
corrélations stratigraphiques,
Permien,
Salt Range,
Plate-forme russe.

INTRODUCTION

The well-known section of Permian and Triassic in the Salt Range (Pakistan) is in two respects of great importance for the palynostratigraphy. Firstly, it yields abundant and well-preserved miospores along with normal marine fauna. And although the calibration of this section in terms of common Tethys scale is not quite distinct as yet (Foster & Jones 1994), it still provides a hope on the correlation between marine and non-marine scales of Upper Permian and Lower Triassic.

Secondly, since the basic work by Balme (1970) it is evident, that the miospore assemblages from the Salt Range demonstrate a mixture of forms typical for different phytochoria of the past including those of both northern and southern hemispheres. It proves to be very useful for interregional palynostratigraphic correlations proper, especially in the Late Permian conditions of the highest phytogeographical differentiation of the Earth. So, Foster (1982) outlined the palynological correlation of the Salt Range with the Eastern Australia while Gomankov (1992) did the same for the Salt Range and the Russian Platform.

The last correlation may be however defined much more exactly due to the data on the palaeomagnetism of the section of Nammal Gorge (Salt Range) published by Haag & Heller (1991).

PALYNOLOGICAL AND PALAEOMAGNETIC CORRELATIONS

The Tatarian of the Russian Platform is usually subdivided into two substages and three horizons (from below upwards): Urzhumsky, Vishkilsky [the name "Vishkilsky Horizon" was recently proposed instead of the name "Severodvinsky Horizon", which turned to be invalid by nomenclature reasons (Gomankov 1997)], and Vyatsky, the first of them being early Tatarian and the two others being late Tatarian. Besides that the type section of the Tatarian at the Vyatka River was divided by Forsch (1963) into eleven units called "beds" each of them having received its own geographical name (Fig. 1). Due to the numerous palaeomagnetic studies of the Russian Platform Permian (e.g., Boronin 1979, 1990; Burov *et al.* 1996b), six palaeomagnetic zones were recognised in the Tatarian, three of them (R_1P, R_2P, R_3P) being of reversal polarity, one (NRP) of variable polarity, and two (N_1P, N_2P) of normal polarity (see Fig. 1 for relationship of this zonation with the above mentioned subdivisions of the Tatarian).

The boundaries of the palaeomagnetic zones in the Salt Range may be localised as following (Burov *et al.* 1996a, b). R_1P and NRP zones are not revealed. The R_2P/N_1P boundary lies in the lower part of Wargal Limestone (between the units 24 and 27 of Nammal Gorge section). The N_2P/R_2P boundary lies in the upper part of Wargal Limestone (between the units 17 and 18). The R_3P/N_2P boundary lies in the upper part of Chhidru Formation (in the lower part of the unit 72, approximately 18 m below the top of the formation), the structure of the upper zone being analogous to that of the R_3P zone of the Russian reference section.

As miospores are concerned, the Wargal/Amb boundary is characterised by the disappearance of *Hamiapollenites* and *Corisaccites* pollen grains as well as by the first appearance of *Lueckisporites virkkiae* Potonie & Klaus [here and below all ranges of miospore taxa in the Salt Range are adduced according to Balme (1970)]. At the Russian Platform *Hamiapollenites* and *Corisaccites* do not occur above the Tatarian/Kazanian boundary. At the same boundary appears *Lueckisporites virkkiae* (Fig. 2A), which ranges then throughout the whole Tatarian. Consequently only Kazanian (in any case Pre-Tatarian) age may be ascribed to the Amb Formation, the stratigraphic gap being assumed at the Wargal/Amb boundary corresponding at least to the whole early Tatarian. The presence of this gap can be confirmed by the data on fauna as well. Thus according to E. Ya. Leven (pers. comm.), the Amb Formation corresponds by its fauna to the Bolorian and the Wargal Limestone to the Midian of the Tethys marine scale, whereas the fauna of Murgabian type was not found at all in the Salt Range.

It is interesting that pollen grains of *Sulcatisporites nilsoni* Balme disappear at the

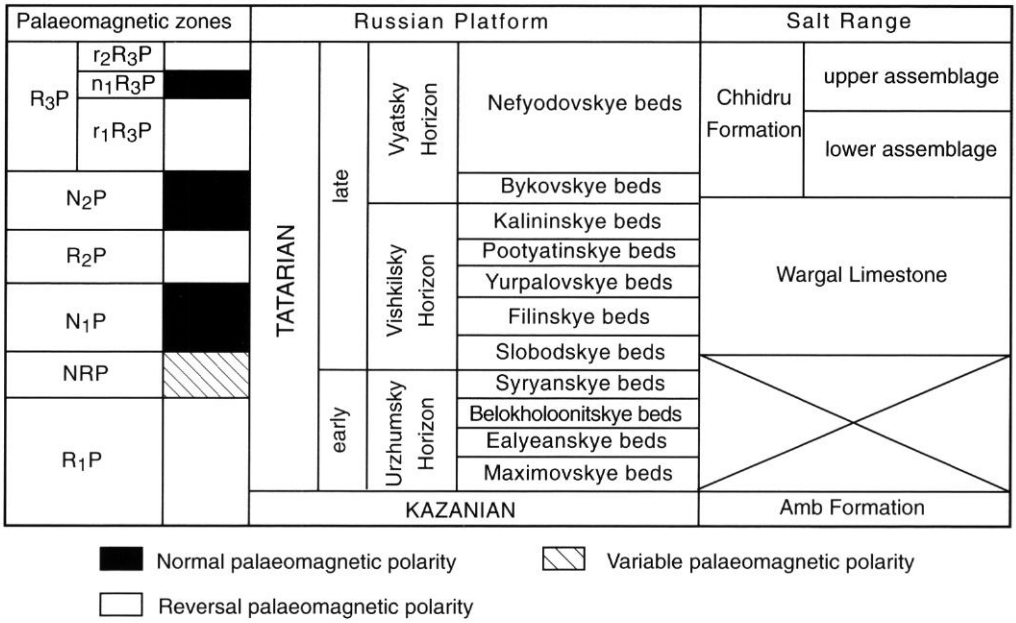

FIG. 1. — Correlating chart for the Upper Permian of Russian Platform and Salt Range.

Wargal/Amb boundary as well. These miospores demonstrate a striking similarity with "classic" forms of *Vesicaspora* ex gr. *magnalis* (Andreyeva) Hart (Fig. 3A) observed in the Kazanian of Russian Platform (Meyen & Gomankov 1971), and for instance they have the same split-like sulcus, whereas pollen grains of *V.* ex gr. *magnalis* from the Tatarian does not possess such a sulcus (Fig. 3C). It may be assumed that in the Kazanian and Tatarian of the Russian Platform the pollen grains designated as *V.* ex gr. *magnalis* belonged in fact to two different species being therefore of a big stratigraphic importance. It is also characteristic that these different types of pollen grains were attributed to different species of *Phylladoderma*: (1) the Kazanian one – to *P. meridionalis* S. Meyen and *P. arberi* Zalessky (Meyen & Gomankov 1971; Gomankov & Meyen 1980; Anonymous 1986); (2) the Tatarian one – to the species of subgenus *Aequistomia* (Anonymous 1986).

Other palynological changes indicated by Balme (1970) at the Wargal/Amb boundary (i.e. the disappearance of *Verrucosisporites* cf. *planiverrucatus* Imgrund and *Pyramidosporites racemosus* Balme as well as the appearance of *Punctatisporites* cf. *minutus* Ibrahim) give nothing for the correlation with the Russian Platform, where the mentioned species are absent.

The Chhidru/Wargal boundary finding itself on the palaeomagnetic grounds in the lower part of N_2P zone lies therefore somewhere near the boundary of Vyatsky and Vishkilsky horizons. In palynological respect it is characterised by the disappearance of the quasimonosaccate pollen grains of *Potoniesporites novicus* Bharadwaj and the appearance of the monolete spores of *Laevigatosporites callosus* Balme, *Polypodiisporites mutabilis* Balme, *Lunulasporites vulgaris* Wilson and pollen grains of *Densipollenites indicus* Bharadwaj (infraturma Monopolsacciti), *Klausipollenites schaubergeri* (Potonie & Klaus) Jansonius, *Cedripites priscus* Balme (infraturma Disacciatrileti), *Potoniesporites microcorpus* (Schaarschmidt) Clarke (infraturma Striatiti) and *Marsupipollenites triradiatus* Balme & Hennelly (infraturma Praecolpati). Of these species *L. callosus*, *P. mutabilis*, *L. vulgaris*, *D. indicus*, *P. microcorpus* and *M. triradiatus* are not known at the Russian Platform. *K. schaubergeri* appears

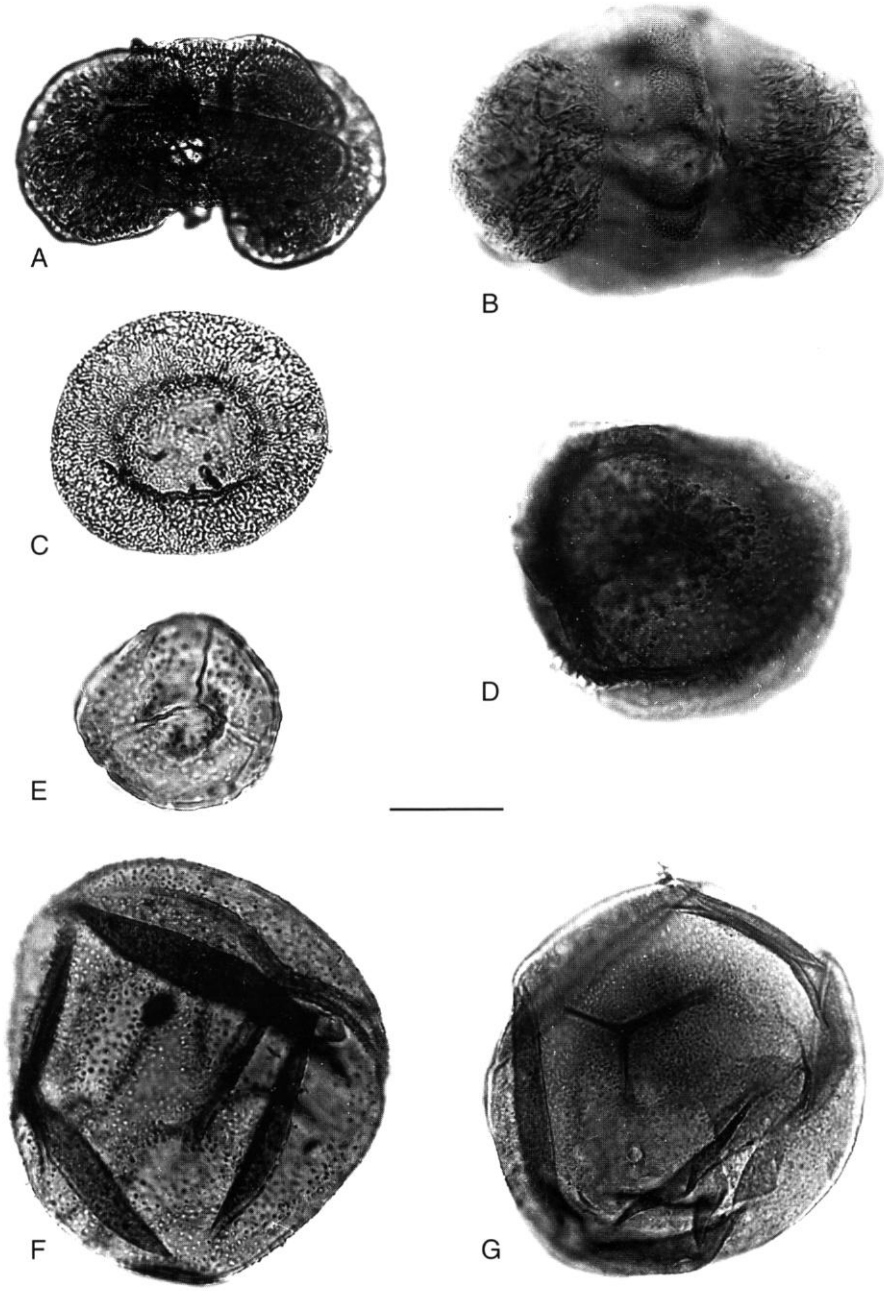

FIG. 2. — Miospores from the Kazanian and Tatarian of Russian Platform. All specimens are kept in the Geological Institute of the Russian Academy of Sciences, Moscow, Russia. **A**, *Lueckisporites virkkiae* Potonie & Klaus, spec. 4100/100-4-213, Urzhumsky Horizon; **B**, *Hamiapollenites* sp., spec. 4492/32b, the Kazanian; **C**, *Cordaitina* sp. (quasimonosaccate pollen grain), spec. 4388/1-3-1-1, Vyatsky Horizon; **D**, *Kraeuselisporites* sp., spec. 4552/371-4-184, Vyatsky Horizon; **E**, *Limatulasporites* (= *Nevesisporites*) *fossulatus* (Balme) Helby & Foster, spec. 3774/3-x-49-22, Vyatsky Horizon; **F**, *Osmundacidites senectus* Balme, spec. 4388/1-3-2-412, Vyatsky Horizon; **G**, *Calamospora* aff. *landiana* Balme, spec. 4552/371-4-70, Vyatsky Horizon. Scale bar: A, B, D-G, 0.02 mm; C, 0.04 mm.

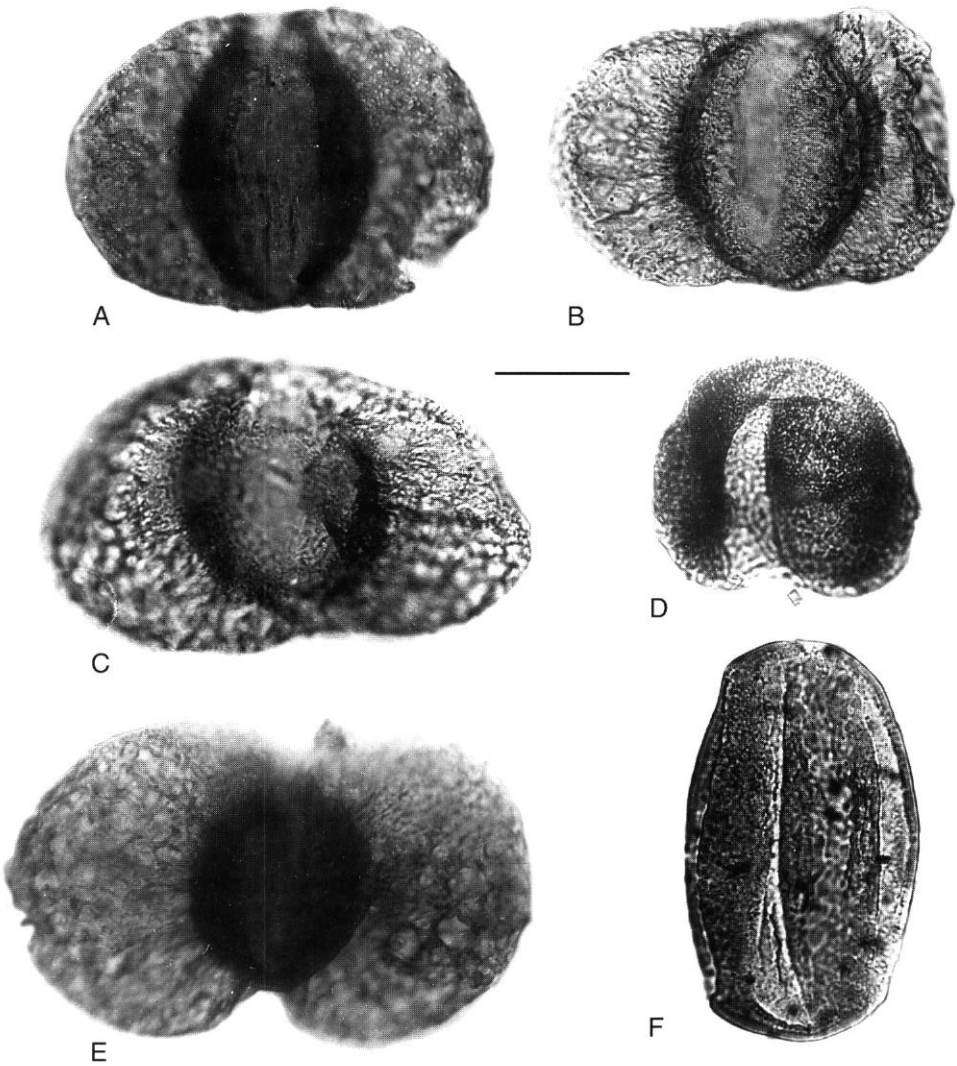

FIG. 3. — Miospores from the Kazanian and Tatarian of Russian Platform. All specimens are kept in the Geological Institute of the Russian Academy of Sciences, Moscow, Russia. **A**, *Vesicaspora* ex gr. *magnalis* (Andreyeva) Hart, pollen grain with a split-like sulcus, spec. 3775/246b-14, the Kazanian; **B**, *Falcisporites* sp., spec. 3774/3x-a(5A), Vyatsky Horizon; **C**, *Vesicaspora* ex gr. *magnalis* (Andreyeva) Hart, pollen grain without split-like sulcus, spec. 4552/371-4-47, Vyatsky Horizon; **D**, *Cedripites priscus* Balme, spec. 4552/371-4-148, Vyatsky Horizon; **E**, *Fimbraesporites* ? sp., spec. 4552/177-2-32, Vyatsky Horizon. Scale bar: A-C, E, F, 0.02 mm; D, 0.04 mm.

trustworthy at the Russian Platform only in the Vetluzhskaya Formation of Triassic age, i.e., it has confidently another stratigraphic range. Quasimonosaccate pollen grains (Fig. 2C) occur throughout the Tatarian, although its abundance decreases strongly upwards and it becomes exceptionally rare in the Vyatsky Horizon. As *Cedripites priscus* is concerned, the very similar pollen grains (Fig. 3D) are highly abundant at the socalled oxbow-lake level in the middle of Vyatsky Horizon, which yields most of palynological samples of Vyatsky age. However, *Cedripites* sp. is also known in Isady locality of Vishkilsky age. Miospore assemblage from the base of Vyatsky

Horizon was described only once by Molin & Koloda (1972) from Kalikino locality. This contains quasimonosaccate pollen *Florinites luberae* Samoilovitch (though as a single specimen) and seemingly lacks pollen which could be assigned to *Cedripites*. On these grounds, one may consider the Chhidru/Wargal boundary lying slightly higher than the base of Vyatsky Horizon but still lower than the oxbow-lake level, where several forms typical for the uppermost Chhidru Formation appear (see below).

It is noteworthy that the uppermost Chhidru Formation is characterised by a peculiar miospore assemblage, which plays an important part in the interregional correlations, especially concerning Gondwana (Foster 1982; Foster & Jones 1994). The exact position of this assemblage in the "Russian" scale was impossible to determine by pure palynological means since several species (*Nevesisporites fossulatus* Balme, *Kraeuselisporites* sp., *Osmundacidites senectus* Balme, *Calamospora landiana* Balme, *Pretricolpipollenites bharadwaji* Balme, *Fimbraesporites* ? sp., *Falcisporites stabilis* Balme), typical for it, were similar to miospores known from the Vyatsky Horizon (Figs 2D-G, 3B, E, F), while others [*Densoisporites* sp., *Lundbladispora obsoleta* Balme, *Gnetaceaepollenites sinuosus* (Balme & Hennelly) Bharadwaj, *Taeniaesporites noviaulensis* Leschik] appeared at the Russian Platform only from the base of Vetluzhskaya Formation (though pollen grains of *Ephedripites* are known in the Russian Platform Kazanian, in fact they do not occur in the Tatarian and appear in noticeable amounts also in the Vetluzhskaya Formation only). Balme (1970) did not define the precise range of this uppermost Chhidru assemblage, but it seems very likely, that there is a rather big unsampled interval between the uppermost samples of lower Chhidru assemblage and the lowermost samples of upper Chhidru assemblage. So the oxbow-lake level, from which the main large amount of palynological samples of Vyatsky Horizon comes, may well find itself in this unsampled interval of the Salt Range section. To judge from the distribution of Balme's samples in the Nammal Gorge, all samples with the upper assemblage come from the palaeomagnetic zone R_3P, while oxbow-lake level lies in the upper part of zone N_2P (at the boundary between the Bykovskye and Nefyodovskye beds). The boundary between the upper and the lower palynological assemblages of Chhidru Formation finds thus itself somewhere inside the Nefyodovskye beds.

As a result the stratigraphic correlation between the Russian Platform and the Salt Range may be represented as shown in the Figure 1.

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