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STRATIGRAPHIC CONTROL FOR THE AGE OF PESHAWAR-PLAIN MAGMATISM, NORTHERN PAKISTAN

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ABSTRACT

Recent mapping and stratigraphic analyses in the area at the north-eastern edge of the Peshawar plain has resulted in the recognition of a bimodal suite of basic and acidic volcanics. These volcanics occupy specific stratigraphic horizons in the Jafar Kandao Formation, whose age is well constrained between Carboniferous and Early Permian, on the basis of conodont studies. It is suggested that the basic volcanics are extrusive equivalents of the extensive suite of basic dykes and sills found in the internal zone of the Indian plate, while the acid volcanics are counterpart of the A-type granites of Warsak, Ambela, and Shewa-Shahbazgarhi. This study provides a stratigraphic control for the age of the Peshawar-plain magmatism.

INTRODUCTION

A restricted part of the internal zone of the Indian plate comprising Peshawar plain and lower Swat foothills is characterised by an assemblage of plutonic igneous rocks which define an alkaline igneous province in this region (Kempe & Jan, 1970, 1980; Kempe, 1973, 1983, 1986; Le Bas et al., 1987; Jan & Karim, 1990). The various igneous complexes of the province include Shilman, Warsak, Tarbela, Shewa-Shahbazgharhi, Ambela, Koga, Malakand and Silai Pattai, and comprise a diverse assemblage of rocks including peralkaline to alkaline granites, syenites, feldspathoidal syenites, carbonatites, ijolites, and albitites. A phase of tholeiitic basic magma is closely associated, both in space and time, with the alkaline magmatic activity in the Peshawar plain alkaline province. This basic magmatism occurs in both plutonic and hypabyssal bodies in the form of intrusive sheets, dykes and sills (e.g. Warsak, Tarbela). Hitherto, no extrusive equivalents of alkaline or acidic composition have been reported, though Kempe (1978) described some of the basic rocks at Warsak to be metamorphosed tuffs and lava flows.

One of us (SRK) has recently carried out detailed mapping in parts o. the Swabi, Mardan and Buner districts, at the northeastern edge of the Peshawar plain (Fig. 1). We report closely spaced, both in space and time, bimodal volcanism from this part of the Peshawar plain. Data are presented for stratigraphic control on the age and nature of emplacement for these igneous rocks. We consider that the acid volcanics reported here are extrusive equivalents of the subvolcanic Shewa-Shahbazgarhi and Warsak microporphyries (porphyritic microgranites of Kempe, 1973), whereas the basaltic volcanics are correlative with the Panjal volcanics of Kashmir and Kaghan valleys and the extensive suite of tholeiitic basic dykes spread over most parts of the internal zone of the Indian plate (Attock-Cherat-Khyber ranges, Peshawar plain, Swat, Hazara and Kashmir areas). The occurrence of these volcanics at specific stratigraphic positions in the Late Paleozoic succession of the Peshawar plain and lower Swat has important implications for the age and nature of the magmatism in the alkaline province.

GEOLOGICAL SETTING

The area discussed in this paper lies approximately at the junction of the Swabi, Mardan and Buner districts (Fig. 1). The southwestern part of the mapped area comprises a 35 square kilometers isolated outcrop of microporphyries of Shewa-Shahbazgarhi (Martin et al., 1962; Kempe, 1973; Ahmed et al., 1990). The foothills to the Swat Himalayas in the northeast comprise a large lopolithic body of A-type granites termed the Ambela Granite Complex (Rafiq & Jan, 1989). The Ambela Granite Complex is intruded in a succession of predominantly sedimentary rocks which are exposed at its southwestern and northwestern contacts. The volcanic rocks being reported in this paper are part of this stratigraphic succession.

A systematic stratigraphic analysis of the Peshawar Plain and lower Swat, including the country rocks of the Ambela Granitic Complex, have recently been completed by S. R. Khan (in preparation) and Pogue et al. (in press). They divide the rocks exposed at the southwestern and northwestern contacts of the Ambela Granite Complex into Jafar Kandao and Baroch Formations and Tor Kamar Dolomite (Fig. 1). These formations constitute the upper part of a thick Palaeozoic-Early Mesozoic succession (Fig. 2), envisaged to have been deposited in a subsiding (rifting) basin which gave way to the Tethys ocean. On the southern side the Ambela Granite Complex is in contact with the Tanawal Formation, Misri-Banda Quartzite, Panjpir and Nowshera

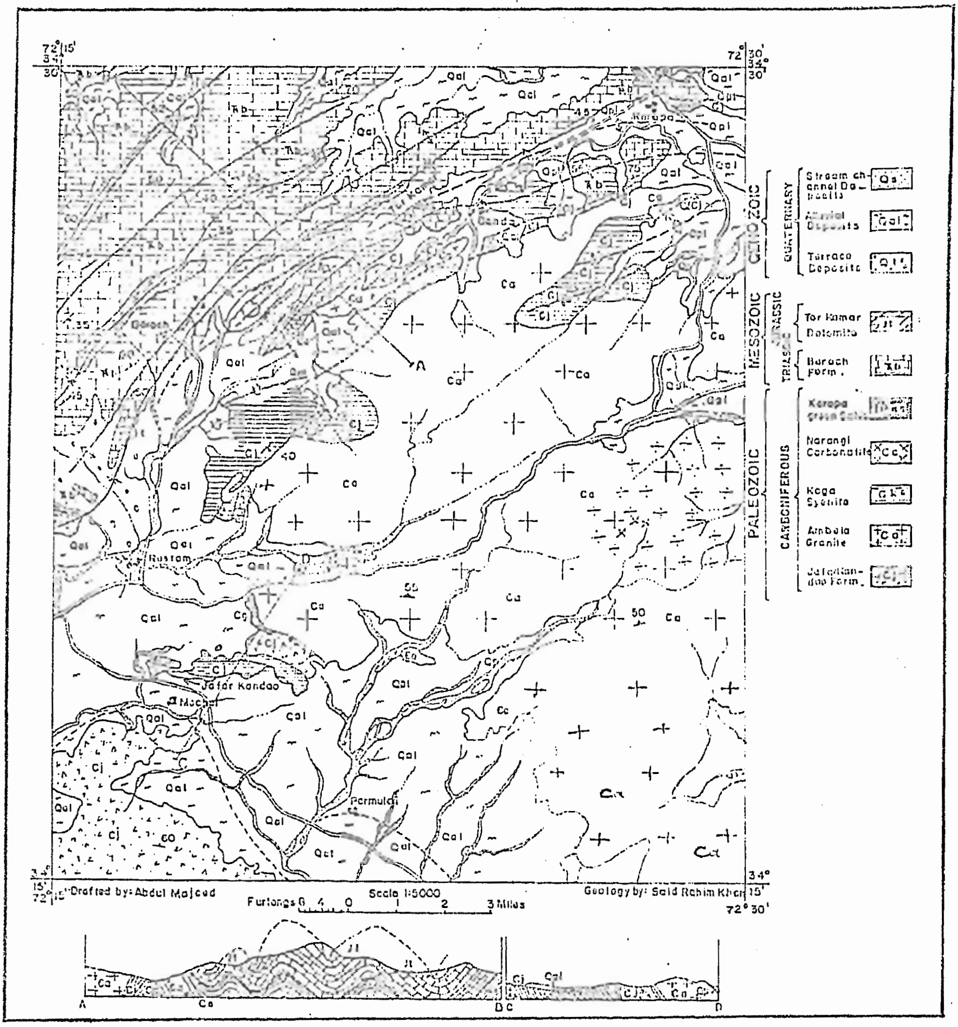

Fig. 1. Detailed geological map of the area around Rustam, covering parts of the Mardan, Swabi, and Buner districts.

Formations, which form the basal part of the stratigraphic succession in this region (Fig. 2). Readers are referred to the work of Pogue & Hussain (1987), Pouge et al. (in press), Hussain et al. (1990), and S. R. Khan (in preparation) for details of stratigraphy in this region. In this paper we shall restrict ourselves to the description of the Jafar Kandao Formation, which hosts the bimodal volcanism under discussion.

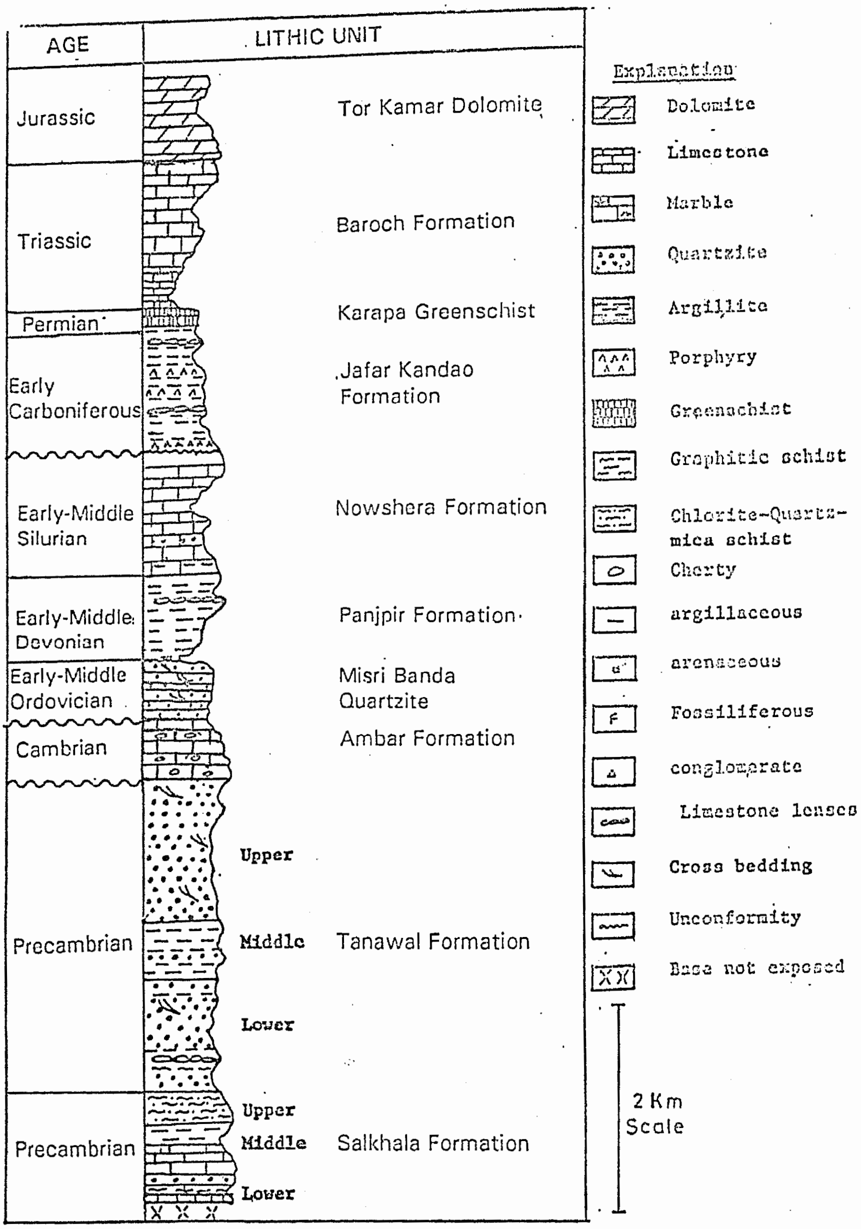

Fig. 2. Generalised stratigraphic column for the sedimentary succession in Peshawar basin. Timings of emplacement of igneous rocks in the region are indicated.

Jafar Kandao Formation

The bulk of the lithologies in the Jafar Kandao Formation is sedimentary, but a minor component of the formation includes both basic and acid volcanics.

The field distribution of the Jafar Kandao Formation is restricted to the vicinity of the Ambela Granite Complex (Fig. 1), the type locality being about five kilometers to the southeast of the village Rustam. The lower contact of the formation is not exposed in this area, but just to the north of Swabi, the Jafar Kandao Formation overlies unconformably the Early Devonian Nowshera Formation. The upper contact of the Jafar Kandao Formation is gradational with the Triassic Baroch Formation. Detailed studies on conodonts obtained from successive limestone horizons have resulted in well constrained ages between latest Devonian to Early Permian for the Jafar Kandao Formation (Pogue et al., in press).

The basal most part of the Jafar Kandao Formation consists of a discontinuous bed of conglomerates, which contain pebbles and cobbles of quartzite and argillite in an argillaceous matrix. The lower one third of the formation is argillaceous with lenses of limestone, conglomerate and quartzite. The middle one third is made up of interbedded argillites, limestone and pebbly quartzite. The upper one third is again predominantly argillaceous with lenses of limestone and conglomerate. The acidic volcanics are intercalated with the argillites, quartzites and limestones, and are found throughout the formation while the basic volcanics are restricted to one horizon in the uppermost parts of the formation.

Basic volcanics

The Jafar Kandao Formation contains a thick greenschist horizon at its top. The unit is best exposed near village Karapa, south of Daggar, where its thickness is in excess of 50 metres. The lower contact with argillite beds of the Jafar Kandao Formation is sharp. The greenschist unit is overlain by argillites and thick bedded to massive limestone of the Baroch Formation. Although metamorphism has obliterated primary igneous textures, the presence of local but conformable intercalations of sediments within the greeschist unit suggests an emplacement as lava flows rather than as intrusives.

Acidic volcanics

Unlike the basic volcanics which occur as one specific unit in the uppermost part of the Jafar Kandao Formation, the acid volcanics occur as minor intercalations at several horizons within the formation. The principal exposure of this type of field relationship is observed just to the north of the village Machai (Fig. 1), where meterscale rhyolite units are found interbedded with argillites (Fig. 3). In one 12 meter thick rhyolite unit, there are more than five horizons comprising fresh, fine-grained rhyolite, which alternate with flows and tuffs studded with clastic material derived from granites, quartzites and argillites. The close intercalations between clast-free and clast-bearing rhyolites is strongly suggestive of emplacement mode in the form of lava flows rather than as sills. Presence of spectacular columnar joints in the fine grained rhyolites further support a subaerial extrusion (Fig. 4).

Stratigraphically, the uppermost horizon of the porphyritic rhyolites occurs within the Karapa greenschists. This verifies the bimodal nature of magmatism in the Peshawar plain.

IMPLICATIONS

Whereas the external zone of the Himalayan thrust fold belt is completely devoid of magmatic rocks, they are not uncommon in the internal zone. Leaving apart the basement gneisses, such as those exposed in the Nanga Parbat and Besham syntaxes (Coward et al., 1988; Treloar et al., 1989; Baig, 1990), there are at least two major phases of granite magmatism since Cambrian (Le Fort et al., 1980; Jan et al., 1981; Shams, 1983). The first phase is characterised by peraluminous, porphyritic, two-mica augen gneisses. These include Swat and Mansehra granites which are of Cambrian age (Le Fort et al., 1980; Baig, 1990). We tend to include the Chinglai gneisses exposed on the southern border of the Ambela Granitic Complex in this group on the basis of its megacrystic composition, mineralogy characterised by two micas, and peraluminous geochemistry. This implies that the Chinglai gneisses are genetically unrelated with the Ambela Granitic Complex as believed by Siddiqui et al. (1968), and Rafiq (1987). The second phase is distinctly alkaline to peralkaline in chemistry and resembles closely with postorogenic A-type granites (Whalen et al., 1987). These granites are typically distributed in a semicircle around the western, northern and northeastern fringes of the Peshawar plain. They are spatially associated with a suite of undersaturated to mildly oversaturated alkaline to peralkaline magmatism which gives rise to a diverse assemblage of rocks ranging from carbonatites, through ijolites, feldspathoidal syenites to syenites and quartz syenites. Together with the A-type granites, they have been considered to define an alkaline province in the area occupied by Peshawar plain and its surroundings. Then there is the basic magmatism which occurs in the form of an extensive suite of basic dykes and sills. This may be less voluminous than the A-type granites but, unlike the latter, is much more widespread in its distribution from Attock-Cherat range in the south to the Upper Kaghan and Kashmir valleys in the north.

All these igneous rocks are subject of detailed petrological studies for the last several decades. However, little was known, until recently, about the stratigraphy of the

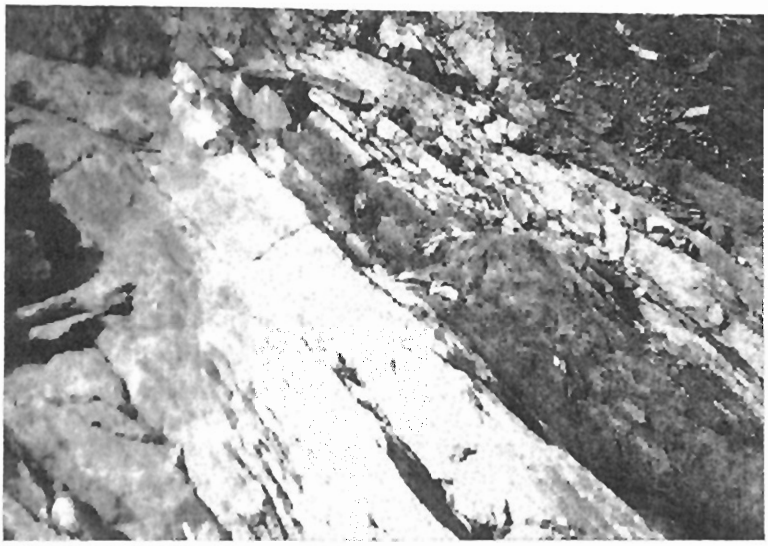

Fig. 3 (Top). Photograph showing the field relations of lava flows and tuffs of rhyolitic composition (white) intercalated with the argillites (grey) of the Jafar Kandao Formation.

Fig. 4 (Bottom). Columnar jointing in the acidic lava flows of Jafar Kandao Formation, indicating subaerial eruption.

host rocks, except for those inter-stratified with the Panjal basic volcanics which yielded Permian fossils (Bhat et al., 1981). This led to a reliance solely on the radiometric data for the age of the magmatism in the Peshawar plain alkaline province, which were often misinterpreted. For instance, Kempe (1973) reported K/Ar ages of 41, 50 and 100 Ma determined on reibeckite, biotite and nepheline minerals separated from the Warsak granites and Koga syenites, and arbitrarily selected 50 Ma as the age of emplacement of the alkaline province magmatism. Maluski & Matte (1984) presented Ar/Ar data on amphibole and biotite from the Warsak granites yielding ages of 43.5, 40, and 42 Ma which they interpreted to be tectonometamorphic, but their age of emplacement for the Malakand granite (23 Ma) turned out to be much less than that determined by Zeitler (1988) on zircon (Carboniferous). Le Bas et al. (1987) presented Rb/Sr whole-rock isochron data for the Ambela granite and the Koga syenite yielding ages of 315 and 297 Ma, but considered the Sillai Pattai carbonatite to be emplaced at 31 Ma based on the basis of a K/Ar age on biotite, which is highly questionable in the light of existence of a tectonometamorphic event of this age in the same area (Treloar et al., 1989).

A detailed reappraisal of stratigraphy in the recent years in the parts of Peshawar plain and lower Swat valley has resulted in opening new avenues for dating the Peshawar Plain magmatism with a much greater reliability than before (S. R. Khan, in Prep.; Hussain et a., 1990; Pogue et al., 1990).

The volcanic nature of the basalts in the upper parts of the Jafar Kandao Formation confirms their Late Carboniferous-Early Permian age, which coincides closely with the age of the Panjal volcanics from northern Pakistan. Interestingly, whereas the strata older than this age are almost always cross cut by basic dykes, there is a sharp lack of basic dykes and sills in the younger (post Permian) strata (Pogue, personal communication). We assign all the plutonic and hypabyssal rocks in the Peshawar plain to this event of basic magmatism in Carboniferous-Permian. It has to be noted that a suite of dykes and sills in the Kaghan area has been considered by Papritz & Ray (1989) to be intrusive equivalents of the Permian Panjal volcanics. This would imply a widespread basic magmatic activity at the northern margin of the Indian plate in Late Carboniferous-Permian time.

There is a strong indication that the acid volcanism was erupted more or less simultaneously with the basic volcanics, but intercalations at several horizons in the Jafar Kandao Formation, both below and within the greenschist unit, suggest a wider span of the magmatic activity than that of the basic magmatism. Unlike the case of basic magmatism, there is an indication that the plutonic equivalents of the acid volcanics may be of the same age or younger. For instance, certain phases of the Ambela granite complex not only cross cut the Jafar Kandao Formation, but some intrude the Triassic Baroch Formation. A lack of deformation in the Ambela and Warsak granites compared to the tectonised acid volcanics of the Jafar Kandao Formation favors a younger age of some of the phases of the A-type granites in the Peshawar plain. It has to be noted that a similar relationship exists in the Warsak Igneous Complex where sheared micropor-hyries are cut across by relatively undeformed peralkaline granites. We suggest that there was a Carboniferous to Permian acidic magmatic activity (the magma was peraluminous but had A-type geochemical character), which was both erupted as lava flows and tuffs and emplaced as plutons {e.g., sheared garnetiferous microporphyries in Warsak (Tazeem Tahirkheli et al., this volume) and Shewa-Shahbazgarhi (I. Ahmed et al., this volume), early phase peraluminous-metaluminous granites in the Ambela complex (Rafiq & Jan, 1989)}. This was followed by a phase of peralkaline granites both in Ambela and Warsak, probably in Early Triassic.

There have been suggestions that the alkaline and peralkaline magmatism in the Peshawar plain is related with Permian-Triassic rifting of the Gondwana (Jan & Karim, 1990). Despite a contrasting composition, a more or less similar tectonic setting of origin is suggested by the basic magmatic rocks (T. Tahirkheli, 1990). This is however, not understood that why the A-type granites and peralkaline saturated to undersaturated rocks are restricted only to the Peshawar plain, whereas basic magmatic rocks are widespread throughout the Indian plate north of the Panjal fault.

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