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# A NOTE ON THE AGES OF THE ALKALINE ROCKS OF THE PESHAWAR PLAIN ALKALINE IGNEOUS PROVINCE, NW PAKISTAN

D. R. C. KEMPE
Department of Mineralogy, British Museum (Natural History),
London SW7 5BD, UK.

## ABSTRACT

*The available ages published for the alkaline rocks and carbonatites of the Peshawar Plain alkaline igneous province are reviewed, with no new data, and briefly discussed. Repeated magmatism has apparently occurred, over the period ca 315 to 31 m.y. ago, due to rifting and the development of thrust planes.*

## AGES OF THE ALKALINE ROCKS

As Maluski and Matte (1984) pointed out, very few geochronological data have been published on the magmatic and metamorphic rocks formed during obduction and collision in the northwestern Himalaya region of northern Pakistan.

Attempting to remedy this by a series of $^{40}Ar/^{39}Ar$ dates, Maluski and Matte established a three stage series of events in the area :

(1) Blueschist metamorphism present in tectonic/ophiolitic melanges along the suture (Main Mantle Thrust) and dated at 80 ± 5 m.y.

(2) Alpine Barrovian metamorphism developed in the sedimentary cover and orthogneisses of the Indian plate during post-collisonal, northward underthrusting following obduction onto this plate of the Kohistan island arc complex and the structurally higher Eurasian plate. This event is dated at 50–30 m.y.

(3) Finally, the intrusion at Malakand of post-metamorphic leucogranite, dated at 23 m.y.

The present note collects and correlates with the above scheme the ages of some of the more or less metamorphosed alkaline igneous rocks from complexes forming the alkaline province (Kempe and Jan, 1970), and which occur generally within the southern third of the Alpine Barrovian belt of Maluski and Matte (1984), immediately to the north of the Main Boundary Thrust. The complexes listed from one to nine by Kempe and Jan (1980) and Kempe (1983). Dates are available for six of the complexes (Fig. 1), but not for complexes Nos. 1, 2 and 6.

**No. 3. Loe Shilman**

Le Bas *et al.,* (in press) have determined a K/Ar age of 31±2 m.y. for the carbonatites of this complex, with some resetting due to deformation at 24 m.y. This agrees with complex No. 5, the Silai Patti carbonatite of Malakand.

**No. 4. Warsak**

Kempe (1973) reported a K/Ar age of 41 m.y. for the riebeckite from a coarse, undeformed facies of the main Warsak alkaline granite, regarding it as, effectively, the age of intrusion. Maluski and Matte (1984) have determined $^{40}Ar/^{39}Ar$ ages on three granites: two riebeckites from finer-grained, more deformed samples of the main granite (40±5 and 43.5±5 m.y.) and one biotite from a sample of garnet microgranite (42±4 m.y.), the latter being the most metamorphosed of the microgranites and regarded by Kempe (1973) as likely to be older than the alkaline microgranites and certainly older than the main alkaline granite. It is therefore very interesting that all four Warsak ages are so close in age. As already stated, Kempe regarded the 41 m.y. age as an age of emplacement; Maluski and Matte (1984) treat their ages as representing deformation-recrystallization, since the rocks have suffered some metamorphism, but agree (personal communication, 1985) that emplacement probably took place almost immediately before metamorphism.

An additional K/Ar age was determined on hornblende from the acicular hornblende schist, a metamorphosed basic tuff described by Kempe (1978). This age – 184±17 m.y. – is the oldest so far determined from the western half of the province.

**No. 5. Malakand**

Maluski and Matte (1984) have obtained an $^{40}Ar/^{39}Ar$ age of 22.8±2.2 m.y. and Zeitler *et al.* (1982) had previously obtained a fission track age of 20 m.y. for this granite. Kempe and Jan (1980) and Kempe (1983) included with the Malakand granite, No. 5, an occurrence of carbonatite dykes and sills at Silai Patti, some 31 km west of Dargai, reported by Ashraf and Chaudhry (1977). Le Bas *et al.* (in press) have determined a K/Ar age of 31±2 m.y. for these (see also No. 3, Loe Shilman).

**No. 6. Shewa-Shahbazgarhi**

Ages have not so far been determined for these microgranites, which closely resemble those of Warsak.

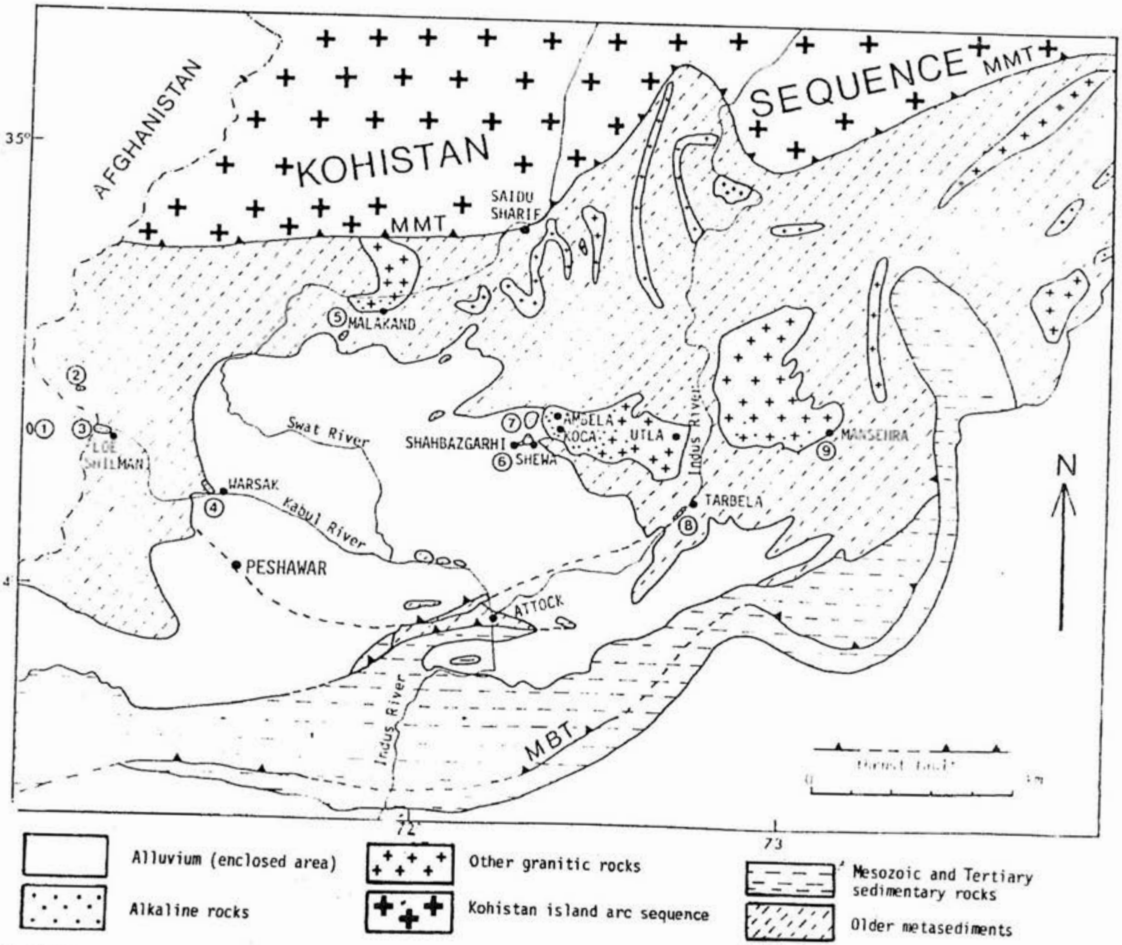


Fig. 1. Geological sketch map of the Peshawar Plain alkaline igneous province, showing the positions of the alkaline granites and other alkaline complexes and intrusions, numbered 1 to 9, mentioned in the text. MMT: Main Mantle Thrust; MBT: Main Boundary Thrust. After Kempe and Jan (1980).

**No. 7. Koga-Ambela-Utla**

Kempe (1973) reported a K/Ar age of 50 m.y. for the Koga syenite, determined earlier for S.F.A. Siddiqui. Maluski and Matte (1984) determined the $^{40}Ar/^{39}Ar$ age of biotite from the 'Ambela syenitic gneisses' as $47.5 \pm 1.5$ m.y.; this rock probably corresponds with the Babaji syenite (cf. Kempe, 1983). More recently, Le Bas *et al.* (in press) report, by Sr/Rb isochron, a Carboniferous age for the Koga nepheline syenites and one ijolite, of between $315 \pm 15$ and $297 \pm 4$ m.y. They regard the Naranji Kandao carbonatites as being of similar age. It should be mentioned that in a recent paper Chaudhry *et al.* (1981) give a new account of the petrology of the Koga rocks, with 56 chemical analyses.

**No. 8. Tarbela**

These rocks are very difficult to date because of the problem of finding suitable minerals for extraction. The microgranites were covered up during construction of the dam; the albitites and albite-carbonate rocks are unsuitable; and the metasomatic scapolite in the Salkala limestones proved impossible to separate. However, a K/Ar date on hornblende from an amphibole albitite gave an age of $350 \pm 15$ m.y.

**No. 9. Mansehra**

These older granite gneisses (Cambrian) and younger granites, described by F.A. Shams and his co-workers, have had various ages ascribed to them. Le Fort *et al.* (1980) obtained a whole rock Rb/Sr isochron of $516 \pm 6$ m.y. for the older, Cambrian granites. Calkins *et al.* (1975) report an age of 80 m.y. on a sample of granite, as did Shams (1967), by K/Ar, on Hakale granite muscovite (165); Mansehra granite biotite (83); and Susalgali gneiss biotite (79 m.y.). Maluski and Matte (1984), using $^{40}Ar/^{39}Ar$, present an integrated age on biotite of 215 m.y. and on muscovite of $45 \pm 4$ m.y., both from the same sample of deformed augen gneiss. These authors tend to disregard the older age and note the agreement of the younger (45 m.y.) age with those of the Warsak granites.

## DISCUSSION

If these age determinations (Table 1 and Fig. 1) are considered as a whole, they show that the rocks of the alkaline igneous province conform generally with the two younger of the three stages of events proposed by Maluski and Matte (1984).

The age of the older Mansehra granite – 516 m.y. – stands alone. An interesting Palaeozoic to Jurassic series follows: 350 my. at Tarbela; 297–315 at Koga; and 184 at Warsak. The 215 m.y. Mansehra age may perhaps be placed here, in what is presumably a group of metamorphic events that preceded the Alpine-Himalayan activity.

TABLE 1. THE AGES OF THE ALKALINE AND RELATED ROCKS OF THE PESHAWAR PLAIN ALKALINE IGNEOUS PROVINCE.

| | | W | | E |
|---|---|---|---|---|
| thrusting | carbonatite | Loe Shilman (31) Silai Patti (31) | | |
| rifting | granite, alkaline granite | Warsak (40–44)<br>Malakand (20–23) | Koga-Ambela-Utla (47–50) | Mansehra (45)<br>(also 79–83) |
| | granite and syenite | | Koga-Ambela-Utla (297–315) | Mansehra (215) |
| | metabasic rocks, | Warsak (184) | Tarbela (350) | |
| | granite, alkaline granite, syenite and carbonatite | | | Mansehra (516) |
| | granite | | | |

Ages (m.y.) by K/Ar, $^{39}Ar/^{40}Ar$, Rb/Sr and fission track methods

The alkaline rocks were not involved in the tectonic event which generated blueschist metamorphism but those of Warsaw, Koga-Ambela-Utla and Mansehra are ranged between 40 and 50 m.y. with an additional group of Mansehra ages of 79–83 m.y. The minimum age suggested by Maluski and Matte (1984) for the Alpine Barrovian metamorphism – 30 m.y. – does not feature in their own determinations on these rocks but the later work by Le Bas *et al.* (in press) dates the Loe Shilman and Silai Patti carbonatites at 31 m.y. Finally, the post-metamorphic leucogranites are represented by Malakand with an age of 23 m.y.

The main alkaline igneous activity at Warsak, Koga-Ambela-Utla, and possibly at Mansehra, is explained by the rifting, caused by relief tension or compression release, as suggested by Kempe and Jan (1980) and Kempe (1983). This episode falls within the Alpine Barrovian metamorphic phase of Maluski and Matte (1984) and dated at 50–30 m.y. The final stages are marked by the minor carbonatite intrusions at Loe Shilman and Silai Patti (31 m.y.).

Le Bas *et al.* (in press) do not accept that rifting was involved, treating the younger carbonatites as having been intruded along thrust planes. This is accepted here, as is the rather surprising Carboniferous age for the Koga syenite and carbonatite. But rifting is still regarded as having taken place, following the early stages of the plate collision which began at 53 m.y. and during the Alpine Barrovian metamorphic phase. Le Bas *et al.* (in press) ignore the three Warsak and one Ambela ages falling between 47.5 and 40 m.y. (Maluski and Matte, 1984) and those, quoted by Kempe and Jan (1980) and Kempe (1983), of 41 m.y. (Warsak) and 50 m.y. (Koga).

Perhaps the best analogy for Loe Shilman, Silai Patti and Koga-Ambella-Utla is that of the alkaline rocks and carbonatites of, for example, west and south Greenland, where extreme age ranges are found. A possible explanation for this repetition of alkaline magmatism over very long periods is that the magmas are generated within the lithosphere, which has undergone metasomatism which persists from one period of magmatism to the next (Woolley, in preparation and personal communication 1987).

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