A NOTE ON NIGGLI'S DIFFERENTIATION TRENDS OF SOME ULTRAMAFIC ROCK ASSOCIATIONS

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An attempt is made in the paper to evaluate the Niggli's Differentiation Trends of some ultramafic rocks in the context of modern observations. The characteristic features of Niggli diagrams of the ultramafic rock associations and their differences with the calc-alkaline series are brought out.

INTRODUCTION

The variation in the chemical composition of rocks belonging to a particular genetic sequence can be brought out by constructing various types of differentiation diagrams based on *certain parameters like the range in silica content, range in differentiation index (normative sal/fem ratio), percentage of solidity, ratio of oxides in certain groups to express variation in combination etc.* While each of the methods has its own advantages and disadvantages, that of Niggli's (1923) appears to be the simplest, most natural and effective in specifying petrographic series. It is the simplest because the procedure has been very much simplified; it is most natural for, the general combination of oxides is having a natural appeal; and it is effective in pointing out the petrographic series by their 'Isofalic' point, a point obtained by the intersection of 'al' and 'fm' curves in the variation diagram which indicates the 'si' content characteristic of the series. The isofalic point of a petrographic series is a definitive indicator, for the specific chemistry at the point of differentiation is a clear position to be reckoned with during magmatic differentiation. It is observed that the calk-alkaline series of rocks indicate isofalic points more than 'si'-160; those of alkaline series hardly exceed the value. These observations are of great significance in tracing the evolution of the earth's crust.

CALK-ALKALINE TRENDS

It is a well recognised fact that within the range of 'si' values about 100 to 450 and above, the 'al' and 'alk' curves are sympathetic as also the 'c' and 'fm' curves. But, the two sets of curves are with mutually opposing trends. However, for lower values than si-100, the curves tend to behave differently (Rajagopalan 1947).

Burri and Niggli (1945) made extensive studies about the differentiation trends of North American Cordillera and Mediterranean and related orogeny. Accordingly, the isofalic 'si' values for sections of the Cordillera range from 167 to 216. The granulite facies rocks of South India have been shown by Sriramarao (1947) and Rajagopalan (1947) to be calk-alkaline at Kondapalle with isofalic si-248 and at St. Thomas Mount, Madras with isofalic si-216 respectively.

In the above rock associations, both mafic and felsic groups are present. However, data on the alkaline trends as deduced by the Niggli's method are rather scanty. Further, not all the series which have isofalic 'si' less than 160 are alkaline, for, many ultramanc-mafic rock associations have less than si-135 isofalic points, as such the lower limit of alkaline series is uncertain.

Trend Lines of Ultramafic Rock Associations

The ultramafic rock associations in many occurrences tend to record 'si' values less than 135. This is evident from the Niggli's Differentiation diagram presented herein (Figs. 1 to 9) for some ultramafic rock associations. Selected chemical analyses of rock samples from the Skaergaard Layered Series, Greenland (Wager & Brown 1968), Rhum Island Suite of rocks (Wager & Brown 1968), Sittampundi Complex, South India (Subramaniam 1956), Stillwater Complex, Montana (Hess 1960), Tulameen body, Canada (Findley 1969), Jotunheimen, Norway (Murthy 1971, 1973), Wajrakarur and Lattavaram, South India (Murthy 1974), Majhagawan, M.P., India (Mathur & Singh 1963) and Salem, South India (Murthy 1975) have been studied for their Niggli's differentiation trends. It can be seen from the differentiation diagrams that the isofalic 'si' values recede from 134 in the case of the Skaergaard Layered Series to about 93 in the case of Sittampundi Complex. The Stillwater Complex and other bodies are characterised by the absence of any intersection point between the 'al' and 'fm' trend lines. In most of these cases the 'fm' line tends to oppose the 'c', 'al' and 'alk' line with decreasing 'si' values, with some exceptions as in the case of Skaergaard occurrence where the 'fm' and 'c' lines tend to become closer for extremely low 'si' values i.e., between 50 and 30, and in the case of Salem occurrence the 'fm' line slopes down from si-50 and rise at si-40.

These observations are significant especially from the point of recent studies in Greenland (Windley 1973) where it was tried to establish the early stages of Precambrian stratigraphy by conceiving the evolution of upper mantle based on evidences of ultramafic-anorthosite succession.

The composition of pyrolite (Ringwood 1969) is at si-68. The closest isofalic point to the 'si' value of pyrolite is that of Sittampundi Complex with 'si'-92. This indicates that the 'si' value of the oceanic crust is closer to that of pyrolite. This also suggests that the oceanic crustal evolution may not be possible at 'si' values lower than the value defined by ultramafic-anorthosite successions. While the composition of pyrolite defines the position of undifferentiated mantle, the section of the Niggli's Differentiation diagram between 'si' values 68 and about 90 would clearly show the preoceanic-crustal evolution of the mantle. Similarly, if the 'si' values of ultramafic rocks rich in containing zones of economically important mineral deposits could be defined, they will serve as important markers.

Tectonic Significance

While smoothness in Niggli's Differentiation trendlines indicates undisturbed conditions of magmatic evolution, angularity in the lines means tectonic effects by emplacement, assimilation etc. The ultramafic igneous layered bodies are thus, tectonically relatively undisturbed as compared to the alpine type bodies. While

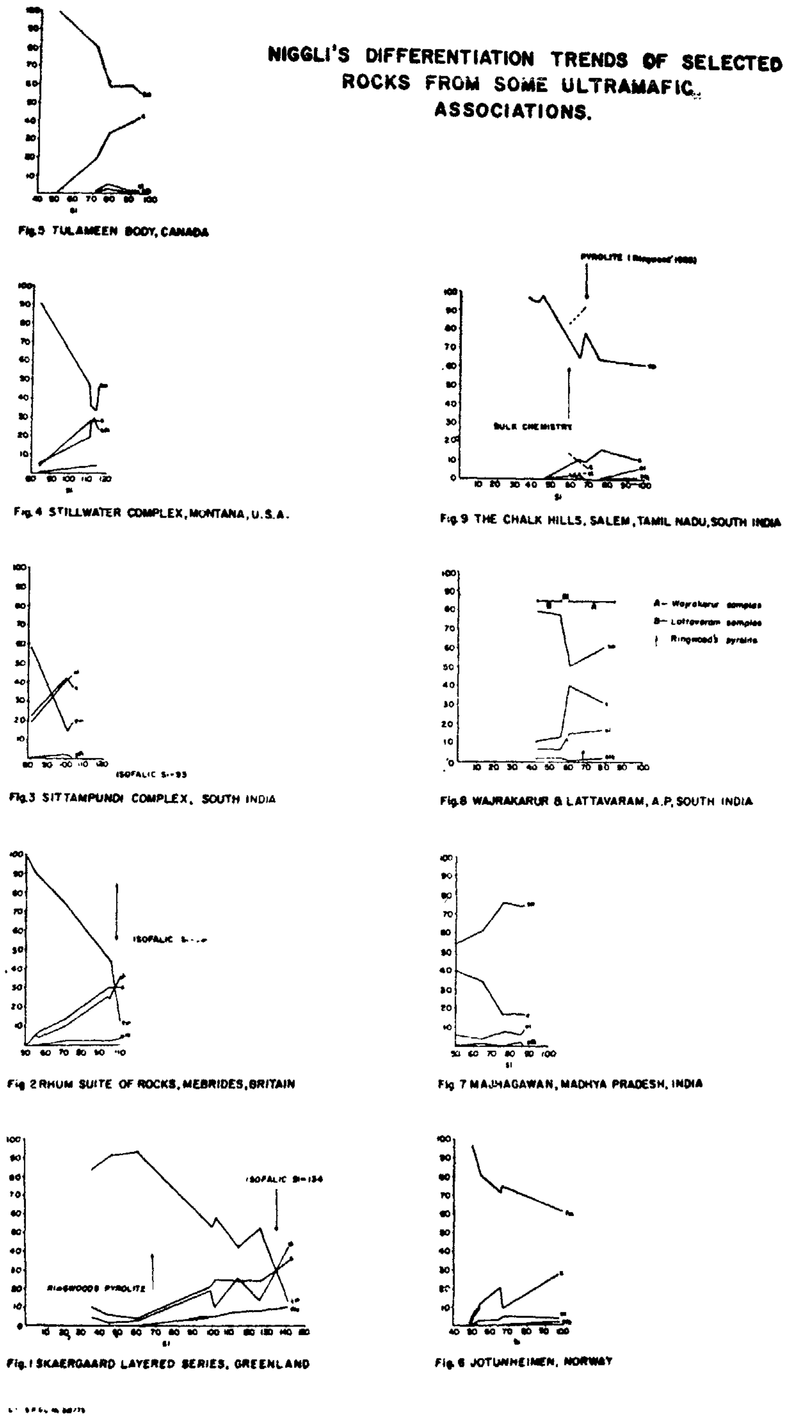
NIGGLI'S DIFFERENTIATION TRENDS OF SELECTED ROCKS FROM SOME ULTRAMAFIC ASSOCIATIONS.
Fig.5 TULAMEEN BODY, CANADA
PYROLITE
BULK CHEMISTRY
Fig.4 STILLWATER COMPLEX, MONTANA, U.S.A.
Fig.9 THE CHALK HILLS, SALEM, TAMIL NADU, SOUTH INDIA
A— Wajrakarur samples
B— Lattavaram samples
Ringwood's pyrolite
Fig.3 SITTAMPUNDI COMPLEX, SOUTH INDIA
Fig.8 WAJRAKARUR & LATTAVARAM, A.P, SOUTH INDIA
ISOFALIC
Fig 2 RHUM SUITE OF ROCKS, HEBRIDES, BRITAIN
Fig 7 MAJHAGAWAN, MADHYA PRADESH, INDIA
RINGWOODS PYROLITE
Fig.1 SKAERGAARD LAYERED SERIES, GREENLAND
Fig.6 JOTUNHEIMEN, NORWAY

FIG. 1.

the alpine ophiolite bodies, being closer to the undifferentiated mantle may define essentially lower 'si' values, perhaps between si-30 and -50, the alpine root zone type bodies appear to define 'si' values between 50 and 100 but without marking any isofalic point. The layered bodies may range in their 'si' values from 30 to over 134 but define the isofalic point. In combination with their regional, distributional, petrographic and other evidences, their Niggli 'si' values may help demarcating the ultramafic bodies into the various recognised groups.

In case of root zone bodies, especially involved in crystalline nappes, plotting of 'si' values of individual outcrops may reflect the fold patterns. Since each and every outcrop is a unit of the original magma at stages with specific differentiation level as defined by its Niggli's 'si' value. It is contended that all those units with certain 'si' values should belong to specific magamtic stage or the 'si-range'. The bulk chemistry of the outcrops of specific magmatic evolutionary stage may on demarcation define the fold pattern.

Conclusions

The behaviour of Niggli's Differentiation trends of some ultramafic rock associations indicated that:—

1. Their 'c' lines are not generally sympathetic to their 'fm' lines but follow the trend of 'al' and 'alk' lines.
2. Their isofalic points indicate 'si' values generally less than 135.
3. Their 'al' and 'fm' lines do not generally intersect for 'si' values less than 90.
4. Their bulk chemistry is closer to that of theoretical pyrolite.
5. The range of Niggli's 'si' values of extremely basic rocks in the Precambrian ultramafic-anorthosite succession would serve as an index of oceanic crustal evolution.
6. In addition to other evidences Niggli 'si' values also serve as a criteria to their genetic classification.

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