THE DEVELOPMENT OF THE STRZELECKI DESERT DUNEFIELDS,
CENTRAL AUSTRALIA

With 4 figures and 2 tables

ERNST LÖFFLER and MARJORIE E. SULLIVAN

**Zusammenfassung:** Zur Entwicklung der Dünenfelder in
der Strzelecki-Wüste, Zentralaustralien

In einem früheren Aufsatz postulierten die Autoren, daß
große Gebiete der Strzelecki- und Simpson-Wüsten von
einem Riesensee – Lake Dieri – bedeckt gewesen waren und
dafür die regelmäßigen Längsdünen, die heute die Wüsten
überziehen, entstanden, als sich Lake Dieri aufgrund fort-
schreitender Austrocknung langsam zurückzog. Der Sand,
der die heutigen Dünen aufbaut, soll größtenteils von ehe-
maligen Stranddünen stammen, die im Lee des Riesensees
entstanden waren und die ihrerseits ihr Material von
den von Osten und Nordosten her kommenden Flüssen er-
hielten.

Zur Verifizierung der Lake Dieri Hypothese wurde eine
Reihe von Sandproben entlang zweier Traversen östlich
der Salzseen Lake Frome und Lake Callabonna gesammelt
und analysiert. Die Analysen zeigen, daß längs des Dünen-
felds weder deutliche Unterschiede in der mittleren Korn-
größenvorliegung bestehen, noch daß es deutliche Hinweise
in der Korngrößenvorliegung gibt, die auf unterschiedliche
Länge des Sandtransports schließen lassen. Hingegen be-
steht ein deutlicher Abfall im Feldspatgehalt mit steigender
Entfernung von den heutigen Salzseen. Diese Tatsachen
zeigen, daß erstens der Sand von einem relativ einheitlichen
Lieferegebiet stammt, daß zweitens der Sand nicht über das
gesamte Dünenfeld äolisch transportiert wurde und daß
drittens der Grad der Verdünnung (= Verlust an Feldspat)
damit das relative Alter der Dünen mit größer werdend
Entfernung von den heutigen Salzseen zunimmt. Das
bedeutet aber, daß sich die Dünen von Osten und Nord-
osten her entwickelten in Übereinstimmung mit dem Lake
Dieri Konzept.

**Introduction**

In an earlier paper (Löffler a. Sullivan 1978) we
suggested from an interpretation of satellite imagery
that a former lake occupied much of the area now
covered by the dunefields of the Strzelecki and
Simpson Deserts, its legacy being series of pans
aligned more or less concentrically and following the
trend of the present eastern and northern shorelines of
the chain of salt lakes between Lake Eyre in the
northwest and Lake Frome in the southeast (Fig. 1).

Although the inherited pattern recognized suggested
a former enlarged lake – Lake Dieri – no supporting
field evidence was available.

The existence of a former Lake Dieri has since been
accepted by subsequent workers (Wasson 1983 a, b)
but there is disagreement as to the development of the
longitudinal dunes which we saw as directly linked
with the history of Lake Dieri. We argued that the
regular longitudinal dunes which extend from the
chain of salt lakes in a fan-like pattern developed as
Lake Dieri receded, and that the sand originated
largely from littoral dunes which formed along the lee
side of the lake. With the gradual retraction of the lake
shores, new sets of littoral dunes were formed and
sand from the older shoreline dunes was blown out
and incorporated into the longitudinal dune system.

One of the crucial tests of this interpretation is
relative age of the sand across the dunefield. If it can
be established that the dune system developed from
outside in, i.e. that sand within the dunes furthest
away from the present lake system is oldest and that
sand within those nearest to the lake chain is youngest
the earlier interpretation would be supported. For
this reason a number of sand samples were collected on
two traverses across the Strzelecki Desert (Fig. 2) and
mechanical and chemical analyses were carried out
on the sands to characterize them and to identify any
trends which may have bearing on their age or origin.
The two traverses followed the only two tracks
crossing the desert from west to east and southwest
to northeast respectively. Traverse 1 followed
the Strzelecki Track from Lake Callabonna to Innamincka
and traverse 2 a track from Lake Frome to Hawker
Gate (Fig. 2). Because of the proximity of the Strze-
lecki Creek with its considerable sand load in the first
traverse it was difficult to collect sand that was not
influenced by recent sand transport from the creek
bed and the samples could therefore not be collected
in fixed intervals as on the second traverse where two
sand samples were taken every ten kilometres. Where
possible surface samples were taken from the dune
crest where the sand is loose (Samples A) and from the
indurated sand at the toe of the dune (Samples B).
Fig. 1: Landsat image (quarter scene) of northernmost part of Lake Frome and Lake Callabonna (top) and the pattern of aligned pans and northeasterly trending longitudinal dunes east of the lakes. The alignment of the pans transverse to longitudinal dunes is accentuated because the pans are filled with water after heavy rain and show up clearly on the infrared band of the Landsat imagery.

Landsatszene (¼ Ausschnitt) mit nördlichem Abschnitt des Lake Frome und Lake Callabonna und dem Muster der nebeneinander gereihten Tonpfannen und Längsdünen östlich der Seen. Das Muster der Tonpfannen wird dadurch hervorgehoben, daß die Tonpfannen zur Zeit der Aufnahme wassergesüßt waren, was sich besonders deutlich auf dem infraroten Kanal (Band 7) zeigt.
Sand analyses

Mechanical analyses of the sand were carried out by dry sieving duplicate 100 g samples through a set of nested Endecott test sieves at 0.5 phi intervals. Cumulative percentage weight values were plotted, sorting and skewness parameters calculated according to the method described by Folk (1974), and descriptions of the sand samples made using Wentworth size classes (Folk 1974). These analyses were carried out to characterize the sands and to detect any major changes which may reflect the origin of the sediment or the method of its deposition.

Optical and chemical analyses were carried out on small subsamples of these sands to determine their contained proportion of feldspar and quartz, and the total amounts of iron (both ferric and ferrous). This was done to detect any chemical changes or variations in the sands that may have some bearing on the relative ages of sands across the dune field. In particular the increase in reddening across the dune field has been interpreted as an increase in age (Wopfner a. Twidale 1967). Initially three methods were used on a number of selected samples of traverse 1 to determine the feldspar/quartz ratios in order to establish the most economic working method.

The three methods are:
1. Analyzing the sand for Al, Na and K and calculating the amount of feldspar. A representative sample was agitated in water with sodium hydroxide and calgon to disperse the sediment and remove clay from the sand grains. The clean sand was then submitted for chemical analysis to determine the proportions of the feldspar cations.
2. Making a thin section from a resin-impregnated block of clean sand and counting the proportion of quartz and feldspars in 500 grains on the assumption that there is no systematic difference in grain size between quartz and feldspar sand grains.
3. Preparing a resin impregnated block of clean sand, staining the surface using hydrofluoric acid
and sodium cobalt nitrate, and point counting for quartz, potassium feldspar and plagioclase.

The results of the analyses are shown in Table 1. The results of all three methods were similar in so far as they were internally consistent however the total amount of feldspar varied between methods with the total amount the feldspars being considerably lower in method 2 than in methods 1 and 3.

The very low count of feldspar grains in method 2 is partly due to the difficulties of differentiating microscopically between quartz and feldspar. Grains below 30 to 40 μm in size were not counted because of the increased difficulties of identification, due in particular to the decreased chance of characteristic feldspar twinning being displayed in a small area.

Also feldspar grains may have been mis-identified as quartz in cases where they are untwinned or oriented not to show twinning, or do not show signs of cleavage or alteration. An underestimate of the amount of feldspar is therefore likely.

Methods 1 and 3 however produced similar results even though the exact amount of feldspar may differ. Only these two methods were used for analyzing the samples collected at a later date along traverse 2. We consider method 1 to be the most satisfactory because it produced the most consistent results and is simplest and cheapest.

Results of the mechanical and chemical analyses

Mechanical analyses of the dry sand indicated a relatively uniform body of sand throughout the sampled area. The sand was moderately to moderately well sorted, fine skewed fine to medium sand. Local examples of coarse skewed sand occurred, generally from near pan surfaces where a more gravelly lag was concentrated.

From both transects but particularly from transect 2, it was apparent that the upper loose sand was slightly coarser than the basal sand. The sand of the dunes of traverse 2 is more uniform than those from traverse 1 and the reason for this is probably the proximity of the Strzelecki Creek bed in traverse 1. In all samples of traverse 2 the upper loose sand (a) is moderately well sorted, fine skewed medium sand, while the lower (b) sample is invariably slightly less well sorted fine skewed fine sand (Fig. 3).

In the samples from traverse 1 the same trend is present but less well defined, with the upper loose sand being slightly better sorted and slightly coarser than the lower sand. The upper sand is moderately sorted coarse skewed to symmetrical fine sand.

The chemical analyses show that there is no apparent trend in the iron content (both ferric and ferrous) with increasing distance from the lakes (Tables 1, 2), despite an obvious change in colour from pale yellow to bright red across the dune field. This is in agreement with general observations that the amount of iron is no measure for redness in dune sands (GARDNER a. PYE 1981). WASSON’s (1983 b) results show a slight increase in iron content from west to east, but as WASSON points out his sample is too small to draw any conclusions. Only two samples of his traverse show higher iron content. Our results also do not support his conclusion that the red sands have a higher iron content than the pale sands. If anything there is a slightly higher iron content in the pale sands near the salt lakes (Tables 1, 2).

The lack of any systematic differences in modal grain size sorting across the dunefield and the relative consistent Fe content indicate that the dune sands probably derived from a single sand source of mixed sediments. Since there is also no indication from the grain size distribution of great differences in the distance over which sands have been transported, it is unlikely that the dune sands were transported by wind across the whole dunefield, a result that is also supported by the findings of WASSON (1983 a). The difference between upper and lower dune sand probably indicates the effect of prolonged illuviation moving slightly finer sand fractions from the upper sand into the lower horizon (see e.g. CORBET 1969, TWIDALE 1981). While there is no difference in sorting from one end of the dunefield to the other there is a striking decrease in feldspar content with increasing distance from the present lakes. Again this trend is
**Table 1:** Feldspar and total iron content of dune sands traverse 1.
Note that Method 3 was not carried out on all samples. Dash indicates no analysis.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Distance from Lake Callabonna</th>
<th>Feldspar in %</th>
<th>Method 1</th>
<th>Method 2 % feldspar in 500 grains</th>
<th>Method 3 % feldspar</th>
<th>Total iron</th>
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<td>210</td>
<td>0.6</td>
<td>6</td>
<td>2</td>
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<td>1 B</td>
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**Table 2:** Feldspar and total iron content of dune sands traverse 2

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<th>Method 1 % feldspar</th>
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<td>0.77</td>
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*Fig. 4:* Feldspar content in dunes across Strzelecki Desert using results from Method 1.
Feldspatgehalt (nach Methode 1) der Dünen entlang der Strzelecki-Wüste.
more pronounced and more consistent in traverse 2
than in 1 (Fig. 4, Tables 1, 2), where the amount of
feldspar decreases from 1–2% at the outer margin of
the dunefield to 15–20% near the present salt lakes.

Discussion and conclusions

Both the mechanical analyses and the iron analyses
indicate the likelihood that there was a relatively
homogeneous sand source for the dunefield of the
Strzelecki Desert and that the difference between the
loose top sand layer and the often indurated “core”
of the dune may be due to local reworking and
illuviation of clay from top to base. There is no trend
in the amount of iron with increasing distance from
the present lakes, nor does the sand sorting show
any significant trends except that the sand appears
slightly finer near the present lakes. The slight in-
crease in Fe downwards in the dune profile indicates
eluviation of clay minerals and sand coatings from the
upper loose sands and illuviation into the lower parts
of the dune. This eluviation/illuviation also causes
the differentiation of the “dune profile” into slightly
coarser well sorted upper sands and slightly finer less
well sorted lower sands.

The most important fact with respect to our Lake
Dieri concept, however, is the clear trend towards an
increase in the quartz/feldspar ratio with increasing
distance from the present lakes and hence an increase
in weathering and relative age across the dunefield.
while we do not know how the lake receded and how
significant fluctuations and occasional regressions
may have been there can be no doubt that the outer
margins of the lake were exposed first and that the
dunes occupying this area and the area downwind of
it were formed from the sand which was exposed
earlier while the dunes further west and south were
formed from sand exposed later.

The littoral dunes of Lake Dieri probably provided
a uniform single sand source of mixed sediments
derived from drainage into the lake basin from pre-
dominantly quartzitic and granitic rocks exposed in
the uplands to the N and E. This function as a
distributor of sand laterally across the lake and along
the lake shore (and hence across the present dunefield
at right angle to the predominant wind direction)
from the mouths of the main rivers is an important
role as the sand of the Strzelecki Desert can not
have derived from the small catchments of the rivers
draining the Flinders Ranges nor can it have derived
from a local source beneath the present dunefield
which in the central and southern Strzelecki Desert
consists of Tertiary clays. Lateral transport of sand
must be considered in any hypothesis that tries to ex-
plain the Strzelecki Dunefields. Wasson (1983 a) has
argued against this concept of longitudinal dunes de-
velling from lake fringing dunes on the grounds that
most of the sediments underlying the northern Strze-
lecki and Simpson deserts are alluvial in origin. How-
ever he does agree that the aligned pans must be
remnants of lacustrine strandlines of some kind if only
for the reason that “there is no other explanation for
it”. He also presents evidence from an area east of
northern Lake Frome where in fact longitudinal du-
nes have developed from transverse lake fringing
dune ridges.

We do not see any real contradiction between Was-
sorn’s explanation that “the longitudinal dunes east of
Strzelecki Creek have been formed by aeolian redi-
tribution of lacustrine sediment, lake-shore trans-
verse dunes and beach deposits, and fluvialite depos-
it” (Wasson 1983 a, p. 112) and our Lake Dieri
concept. Wasson’s (1983 a) findings that in the area
west of Strzelecki Creek the dune material derived from
muddy alluvium and in the southern Simpson Desert
from deflation of pans are also not contra-
dicting our concept since there is no denying that ulti-
mately all the dune material derived from the uplands
to the east, northeast and north and was brought into
the basin by major river systems draining the eastern
highlands. The question, however, as to how these
deposits were distributed across the dunefields trans-
verse to the general wind direction can as far as the
Strzelecki Desert is concerned not be answered by al-
luvial redistribution alone. Lateral transport of the
sediments along a former lake shore must be in-
volved.

Our original interpretation represented an attempt
to explain a pattern clearly visible on the satellite ima-
gery and the striking pattern of aligned pans is still
one of our strongest arguments for the existence of
Lake Dieri. From the satellite view coming down
to earth has proved more difficult and unequivocal
evidence for the existence of the lake has so far not
been found. The published stratigraphy of the lake
basin is complex (cf. Wasson 1983 a) and there is still
no information on the timing of the lake or the events
following its disappearance (Callen 1977, King
1956, Wopfner a. Twidale 1967). However we feel
that the data presented here and in particular the
clear trend of the quartz/feldspar ratio with increasing
distance from the present remnant lakes do support
our view of the existence of a former Lake Dieri fol-
lowed by the establishment of the present dunefields in
the Strzelecki Desert.
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References


BERICHTE UND MITTEILUNGEN

URBAN HEAT ISLAND DEVELOPMENT IN MEDIUM AND LARGE URBAN AREAS IN MEXICO

With 4 figures and 1 table

ERNESTO JAUREGUI

1. Introduction

A typical example of man-made modifications on the city climate due to the urbanization process is the so-called heat island effect. The phenomenon of air temperature often being higher in the city than in its surrounding country side, has long been recognized and documented for mid-latitude cities. Studies on heat island effects are so numerous for the temperate zone that it seems possible now to draw some generalizations regarding its morphology and time variations (see for example OKE 1982).

By contrast, urban climate studies in the tropics are relatively recent and very sparse. The few studies that have been undertaken in tropical cities have been mainly based on urban/rural thermal contrasts established from climatological records. The need for information on tropical urban climates has been