SHEAR ZONE CONTROL OF ALKALI INTRUSIVES – EXAMPLES FROM ARGYLE AND WEST AFRICA.

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Introduction

The large scale regional controls of alkali intrusions have been given spasmodic attention in the literature. There is a tendency to associate the kimberlite pipes in West Africa with the landward extension of oceanic transform systems (Williams and Williams, 1977; Sykes, 1978). The argument is that the transforms first formed during the initiation of rifting by the reactivation of old major continental structures which were then mimiced within the developing oceanic crust. The resultant transforms may change direction during the formation of the oceanic crust as the rift direction changes. As a consequence there need not be parallelism between the oceanic transform and its continental parent. The corollary of the above is that there is an association between major continental shear or fault zones that form fundamental zones of weakness in the continental crust and alkali intrusives. This can also be illustrated by the lamproites in the Kimberley area of Western Australia (Jaques et al., 1986). The Argyle pipeis located within the Halls Creek Mobile Zone, another major zone of continental weakness. A question that remains is, what are the local structural controls for the emplacement of diamondiferous alkali intrusives. We have selected two areas where there is a clear local structural control to emplacement, viz. Argyle, Western Australia and Yengema, Sierra Leone, and show that at a local scale these intrusions are located by second or third order structures within major first order planes of weakness in the continental crust.

Proposed Structural Controls of the Argyle Pipe Emplacement

The Argyle pipe occurs within the Halls Creek Mobile Zone. This mobile zone along with the King Leopold Zone form the two major tectonic entities bordering the Kimberley Block in north-western Australia. White and Muir (1989) have recently argued that they formed a coupled, orthogonal tectonic system since the Early Proterozoic. They produce evidence that the King Leopold Zone mainly acted as a zone of vertical tectonics (extensional and compressional) which has been supported by additional observations by Tyler and Griffith (1990) and that the Halls Creek Mobile Zone mainly acted as a strike slip transfer zone to the vertical movements in the King Leopold Mobile Zone. It was during a phase of sinistral transfer movement during the late Proterozoic that local basin formation and the emplacement of the Argyle pipe occurred.

The individual faults (second order structures) in the Halls Creek Mobile Zone form a Reidel geometrical shear array based on the Halls Creek Fault and the Greenvale Fault as the main D-shears. Their geometries and kinematics are consistent with a late Proterozoic sinistral movement (Plumb, 1968; White and Muir, 1989). The Argyle pipe occurs in an area which was dominated by normal and Reidel faults and a dilational bend in the adjacent Halls Creek Fault. The fault interactions resulted in a local pull-apart type basin in which late Proterozoic sediments were deposited and the pipe emplaced.
At the local scale, the pipe is situated adjacent to the dilational intersection of the northerly trending Gap Fault, a dilational R-shear within the sinistral Reidel scheme, and the Razor Ridge Fault. The latter

is a dextral X-shear or conjugate shear within the Halls Creek Mobile Zone. A swarm of lamproitic dykes, the Lissadell Road dykes, are associated with it in the exposed basement. The dykes were emplaced along tension and R-shear gashes. Neither the Gap Fault nor the Razor Ridge Fault is a major fault, both are third order faults or shears. However, the area in which the dykes and pipe has been intruded is a major dilational area created by second order shears within a fundamental continental shear zone.

Proposed Structural Controls of Kimberlite Emplacement; Yengema

The Yengema field, centred on the town of Koidu in Sierra Leone, has been the main diamond mining centre in West Africa. The region contains swarms of kimberlite dykes and several small pipes.

A strong north-south foliation is present in the migmatitic Archaean basement. Prominent lineaments occur trending at 010°. The kimberlite dykes are confined between two such lineaments, the Oyie-Shongbo Fault in the west and the Yaamba fault in the east, and strike at 070°. They occupy a zone some 22km long by 10km wide. Other minor kimberlite dykes occur aligned at 030° and 045°. Only rarely are kimberlite dykes located on the main 010° lineaments.

The 070° trending dykes are discontinuous, lensic and often occur en-echelon. Horizontal slickensides are occasionally apparent on the walls of the dykes but measurable displacement of structures across the dykes is minimal. Movement must therefore have been limited. The 070° structures are minor structures. A substantial zone of joints trends in this direction. Outside of the fault-bounded Shongbo-Yaamba fault block these joints do not contain kimberlite.

The orientation of these structures conform to a Reidel array corresponding to movement in a dextral sense along the main 010° bounding faults. The principal 070° dyke direction is an antithetic strike-slip (R_1) structure with sinistral movement. The 030° and 045° dykes are related to synthetic (R) shears and tension gashes respectively. Both of these structures are poorly-developed compared to the main dyke direction.

Lineaments trending at 130° and 160° are also evident and indistinct 115° structures occur. Dolerite dykes of probable Early Mesozoic age intrude these structures and are cut by the Upper Cretaceous kimberlite dykes.

The main stress field operating as a result of dextral movement along the regional 010° faults caused structures with strikes in the 030°-070° direction to be in extension and these structures were filled with kimberlite to varying degrees. Structures in the 130°-160° direction were in compression and thus did not provide avenues for the intrusion of kimberlite.

Under a simple dextral shear stress regime, the most favourable sites for kimberlite emplacement are theoretically at the extensional intersections of the 010°, 030°, 045° and 070° structures. However, the situation is complicated by the presence of other pre-existing lines of weakness oriented at 115°, 130° and 160°. In the field, pipe location is broadly related to intersections of 010° and 130° structures with the 070° kimberlite dyke orientation.

Conclusions

The controls of kimberlite/lamproite emplacement at Argyle and Yengema show similar characteristics. In both areas, ancient, prominent lineaments were reactivated. Diamondiferous primary orebodies are locally governed by extensional lower order structures which form part of a regional Reidel shear array, rather than the main bounding faults of the array.

References

Jaques, A.L., Lewis, J.D. and Smith, C.B. The kimberlites and lamproites of Western Australia. Geol. Surv. Western Australia, Bull. 132, 268 pp. (1986).

Plumb, K.A., Lissadell, W.A. 1:250,000 Geological Series Bur. Miner. Resour. Aust. Sheet SE/52-2 (1968).

Sykes, L.R. Intraplate seismicity, reactivation of pre-existing zones of weakness, alkaline magmatism and other tectonism postdating continental fragmentation. Revs. Geophysics and Space Physics, 16, 621-689 (1978).

Tyler, I.M. and Griffin, T.J. Structural development of the King Leopold Orogen, Western Australia. J. Struct. Geol. 12, 703-714 (1990).

White, S.H. and Muir, M.D. Multiple reactivation of coupled orthogonal fault systems: an example from the Kimberley region in northern Western Australia. Geology, 17, 618-621 (1989).

Williams, H.R. and Williams, R.A. Kimberlites and plate tectonics in West Africa.Nature 270, 501-508 (1977).