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Pre-Mesoproterozoic crustal architecture and implications for the Mesoproterozoic evolution of the SW Angolan Shield from structural, geochemical, and isotopic evidence

DR. ENRIQUE MERINO MARTÍNEZ[1], EZEQUIEL FERREIRA[1], PABLO VALVERDE-VAQUERO[1], JOSÉ FELICIANO RODRIGUES[2], JAVIER ESCUDER-VIRUETE[1], JOSÉ LUIS GARCÍA LOBÓN[3], ARATZ BERANOAGUIRRE[4], MARÍA DEL CARMEN FERIA[5], CARMEN REY-MORAL[1], PAULO BRAVO SILVA[6], PABLO GONZÁLEZ-CUADRA[7], JOÃO CARLOS SOUSA[7], JULIÁN POTTI[7], JAIME MAXIMO[7], MIGUEL GUTIÉRREZ-MEDINA[7], JUAN CARLOS GUMIEL[1], GUSTAVO GALÁN[7], TANIA MOCHALES[1], JOSE MANUEL[8], DOMINGOS CORDEIRO[8], COLOMBO TASSINARI[9], PILAR MONTERO[10], KEI SATO[9], JOSÉ MANUEL FUENLABRADA[11] AND CARMEN GALINDO[12]

[1]Instituto Geológico y Minero de España (IGME-CSIC)
[2]Laboratório Nacional de Energia e Geologia
[3]Instituto Geológico y Minero de España
[4]Institut für Geowissenschaften, Goethe-Universität Frankfurt
[5]Sistemas Avanzados de Tecnología, S.A. (SATEC)
[6]Laboratório Nacional de Energia e Geologia (LNEG)
[7]UTE PLANAGEO (IGME/LNEG/IIA)
[8]Instituto Geologico de Angola (IGEO)
[9]University of São Paulo
[10]IBERSIMS. The University of Granada
[11]CAI de Ciencias de la Tierra y Arqueometría. Universidad Complutense de Madrid (UCM)
[12]Facultad de CC. Geológicas. Universidad Complutense de Madrid (UCM)

Several studies suggest the existence of multiple tectonic domains within the Angolan Shield [1], yet the Archaean to Palaeoproterozoic basement of SW Angola and NW Namibia remains largely unexplored. Similarly, distinct Mesoproterozoic (1534–1065 Ma) igneous suites are documented in the SW Angolan Shield, including the largest known gabbro-anorthosite complex (~42,500 km²), the Kunene Complex (KC), but the geological evolution of the region during the Mesoproterozoic is still debated. Traditionally linked to anorogenic contexts [2], recent studies propose a collisional setting for the KC [3].

A combined isotopic (U-Pb, Sr-Nd), gravimetric, and structural approach allows for a refined crustal framework of the SW Angolan Shield and provides new insights into the emplacement of the KC and the regional evolution of the southern Congo Craton. This integrated dataset delineates several Archaean to Palaeoproterozoic domains surrounding the KC, featured by a specific gravimetric response and geochronological time span: Cassinga Zone (2667–2568 Ma and 1982–1971 Ma), Central Eburnean Zone (2038–1947 Ma; intruded by 1844–1744 Ma magmatism in its southern region, the Lubango Area), Namibe and Epupa Zones (1861–1739 Ma), and the Kalahari Area (~1775 Ma?). These contrasting crustal domains significantly influenced the genesis and emplacement of the KC.

The KC formed through protracted magmatism spanning ~160 Ma (1500–1344 Ma). Structural and geochemical evidence suggests mantle underplating along Pre-Mesoproterozoic large-scale crustal weakness zones. Crustal thinning and partial melting of isotopically heterogeneous lower-crustal sources triggered episodic felsic magmatism coeval with the KC anorthosites. Crustal contamination is evident in gabbro-anorthosites (εNd -12.7 to +6.5), indicating interaction with wall rocks and granite melts during ascent. These features support a convergent (arc-related) setting.

Intrusion relations and deformational features within the KC and adjacent Pre-Mesoproterozoic basement suggest synchronic lateral compression during KC-related magmatism. KC emplacement during Early to Middle Mesoproterozoic times (1534-1344 Ma) occurred through combined transpressional and transtensional mechanisms under a westward-propagating contractional regime. The transition to an extensional scenario in the Late Mesoproterozoic (<1325 Ma) is marked by widespread metasedimentary deposition [4] and 1234–1065 Ma sublithospheric and mantle-derived magmatism, indicating a shift in regional geodynamics preceding the breakup of Columbia.