GSA poster 2016fn23rd

Dataset · September 2016

2 authors:

Munazzam Ali Mahar
University of Texas at El Paso
10 PUBLICATIONS **4** CITATIONS
SEE PROFILE

Philip Goodell
University of Texas at El Paso
71 PUBLICATIONS **640** CITATIONS
SEE PROFILE

EVOLUTION OF FELSIC CALDERA-RELATED MAGMATISM IN THE EASTERN AND WESTERN PARTS OF THE SOUTHERN RIO GRANDE RIFT

MUNAZZAM ALI MAHAR[1], PHILIP C. GOODELL[1]

[1]DEPARTMENT OF GEOLOGICAL SCIENCES, UNIVERSITY OF TEXAS AT EL PASO, EL PASO, USA

ABSTRACT

Zircon U–Pb ages and Hf-O isotopic composition provided the important constraints for the timing and origin of caldera related alkaline magmatism at the western and eastern part of the southern Rio Grande Rift (RGR) that is, Sierra Candelaria in northern Chihuahua and Quitman Mountain in west Texas, respectively. Zircons from syenite samples collected from the Sierra Candelaria and Quitman Mountain are exclusively magmatic and U–Pb dating revealed no zircon inheritance. The weighted mean ages from four samples from Sierra Candelaria are tightly restricted around 29 Ma. One zircon grain recorded the oldest individual date of 36.1 Ma. Majority (85%) of the analyses yielded nonradiogenic initial hafnium isotope composition with εHf (t) ranging from -5.1 to +0.4. The weighted mean Hf isotope composition is less variable and ranges from -2.5 to -3.9. The Hf isotope composition from this western part of RGR is comparable to the 35 Ma syenite exposed in the Quitman Caldera (i.e., weighted mean εHf (t) = -5.1 ± 0.8) at the eastern margin of the RGR. The Quitman syenite inheritance free zircons yielded typical mantle-like oxygen isotope composition with mean $\delta^{18}O$ = 5.7 ‰. The U–Pb ages, absence of inheritance, mildly negative Hf isotope composition and mantle–like oxygen isotope composition suggest that the differentiated syenite magma is primarily derived from the partial melting of mildly evolved subcontinental lithospheric mantle. Predominance of negative Hf isotope composition precludes the significant contribution from asthenospheric melt. However, it is likely that the required heat is provided by the decompressing asthenospheric melt associated with the incipient rifting sometime before 35 Ma in the eastern and around 30 Ma in the western part of the rift. It is apparent that the caldera related thermal activity appeared 4 to 5 Ma later at the western part of the rift, suggesting asymmetric rising of the decompressing asthenosphere and related magmatism. Absence of zircon inheritance and typical mantle-like oxygen isotope composition suggests minimal input from the Precambrian crustal sources. The apatite U–Pb ages from Sierra Candelaria are indistinguishable from the corresponding U–Pb zircon ages suggesting shallow emplacement and fast cooling supporting the emplacement of syenite in a caldera setting.

INTRODUCTION

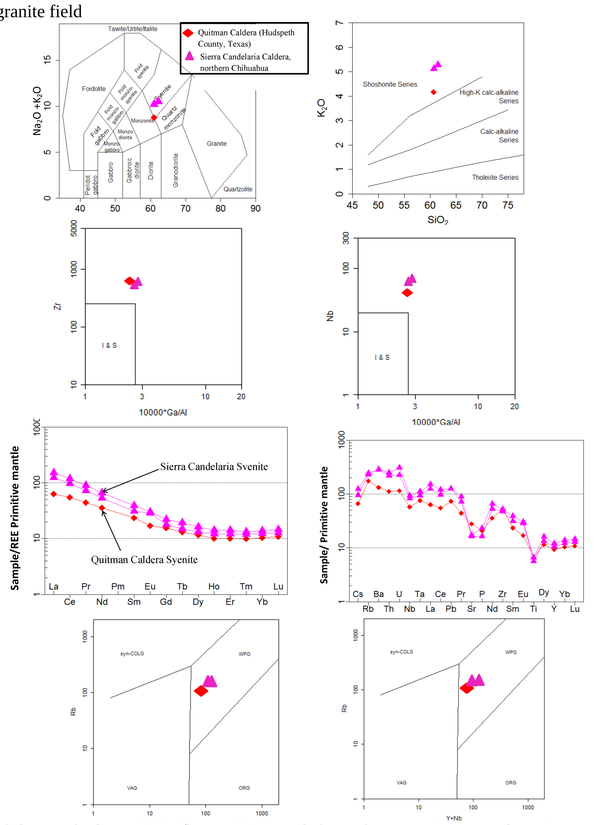
In the present work, we discuss petrology, geochemistry, emplacement and origin of felsic caldera-related magmatism in the eastern and western part of southern Rio Grande rift. **We provide the U–Pb ages on zircons and apatites and zircon Hf-O isotope composition of syenite samples** collected from Quitman Caldera syenite and Sierra Candelaria Caldera syenite exposed at the eastern and western part of southern Rio Grande Rift, respectively. The studied rocks revealed a typical A-type geochemical signature, consistent with the rift related magmatism. The zircon-apatite age pairs were used to constrain the thermo-magmatic evolution of the felsic magmatic rocks from > 800^{0}C to below 500^{0}C. The Hf-O isotope composition of the dated zircons provided the important constraints for the origin of magma source(s) involved in this region. The study showed implications for the thermomagmatic and tectonic evolution of the southern Rio Grande rift.

METHODOLOGY

U-Pb and Hf analysis were carried out by LA-ICP-MS at LaserChron lab facility, University of Arizona. Oxygen isotopic measurements were performed at WiscSIMS lab at University of Wisconsin Madison. The studied rocks were also analyzed for whole rock major and trace element composition. Oxygen isotope data were collected only from Quitman quartz monzonite.

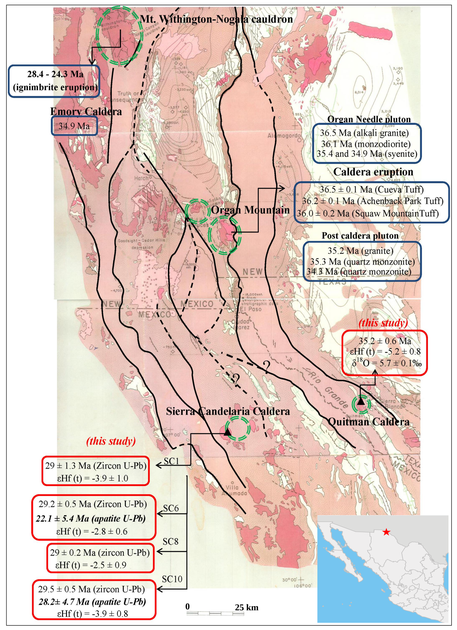
WHOLE ROCK GEOCHEMISTRY

Geochemically, the studied rocks are high-K and fall in the shoshonite field, the Sierra Candelaria samples are classified as syenite while Quitman Caldera sample falls at the boundary between syenite, monzonite and quartz monzonite. Based on the petrographic mineralogical composition we referring the Quitman sample as syenite in present work. Syenites from both Calderas show similar REE and trace element pattern on the primitive mantle normalized plots. On the tectonic discrimination plots rocks fall in the within plate granite field



Rocks are slightly enriched in LREE, flatter HREE and show almost no Eu anomalies. Syenites from both eastern and western part of the southern RGR show identical REE and trace element pattern. However, Sierra Candelaria is slightly more enriched than the Quitman. showing enrichments in Rb, Th and U and depletion in Sr, Nb and Ti.

STUDY AREA



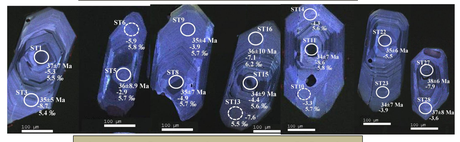
Sierra Candelaria Caldera is located in northern Chihuahua north of town of Villa Ahumada and Quitman Caldera is located in Hudspeth county west Texas. U-Pb ages and Hf-O isotopic data is shown, for comparison, we also showed the ages for the emplacement of caldera-related rocks in northern Mexico

Quitman Caldera Complex, known as Quitman Mountains located on the eastern flank of Rio-Grande Rift . Quitman Mt. marks the western extremity of volcanic centers in west Texas. The stock is 7.5 km long and 3.5 km wide, west of the town of Sierra Blanca. Quitman Mt. is composed of both extrusive and intrusive rocks with layered tuffs, rhyolitic to trachytic units in the center while intrusives surrounds the volcanics.

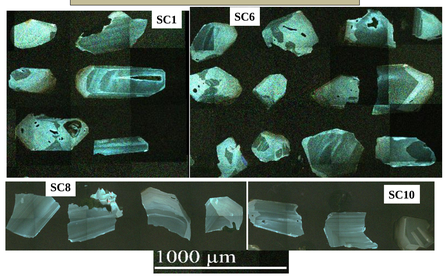
The geology of Sierra Candelaria is poorly known prior to this work, Sierra Candelaria is located in the negative region which has subjected to the extensional tectonics as manifested by multiple sedimentary basins. A large amount of syenitic intrusions are present in the area. Poorly defined volcaniclastic rocks are present and associated with Tertiary felsic volcanism. To the south, typical caldera-related basaltic and andesitic rocks are exposed, In the western part of the caldera, poorly defined volcaniclastic rocks are present that are associated with the Tertiary felsic volcanism. SE of Sierra Candelaria the Lomos de Calaveras constitute unwelded and partially zeolitized ash flow tuffs. The geological and structural characteristics suggest a Caldera origin for the rocks exposed in this region

Morphology of studied zircons

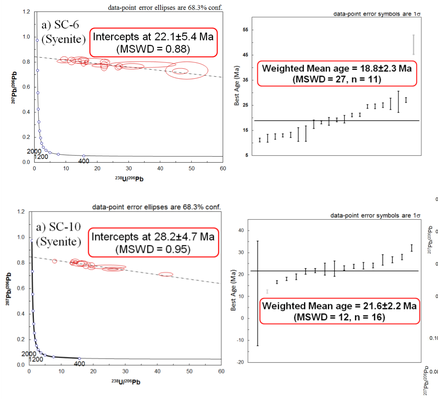
zircons from Quitman Syenite



zircons from Sierra Candelaria



U-Pb apatite Ages, Sierra Candelaria

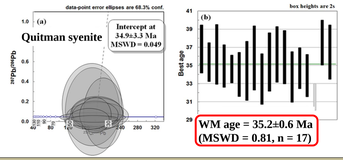


LA-ICP-MS U-Pb GEOCHRONOLOGY

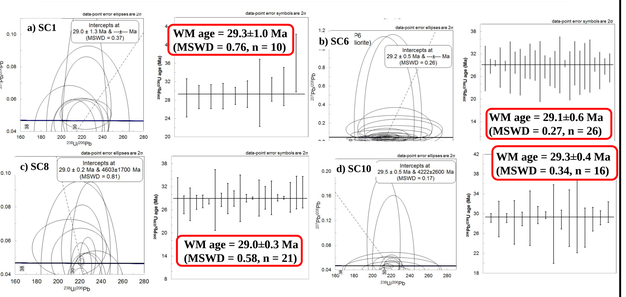
The weighted mean ages from Sierra Candelaria are tightly restricted around 29 Ma. One zircon grain recorded the oldest individual date of 36.1 Ma. while in the east, Quitman Caldera syenite yielded an age of 35.2 Ma. The apatite U–Pb ages from two samples collected from Sierra Candelaria are indistinguishable from the corresponding U–Pb zircon ages suggesting shallow emplacement and fast cooling. The zircons are exclusively magmatic showing oscillatory zoning. Quitman zircons are euhedral while zircons from Sierra Candelaria have euhedral to subhedral zircon morphology. In both localities sector zoning is also observed.

No inheritance from Proterozoic granitic basement was observed. This suggest minimal role of partial melting of pre-existing Proterozoic basement in the generation of source magma for the syenite. The zircon U-Pb age from Quitman Caldera is well correlated with the syenitic rocks exposed in the core of the Organ caldera located about 60 km north of Quitman Caldera. The age of Sierra Candelaria (29 Ma) is well correlated with the other calderas located in the western part of northern RGR.

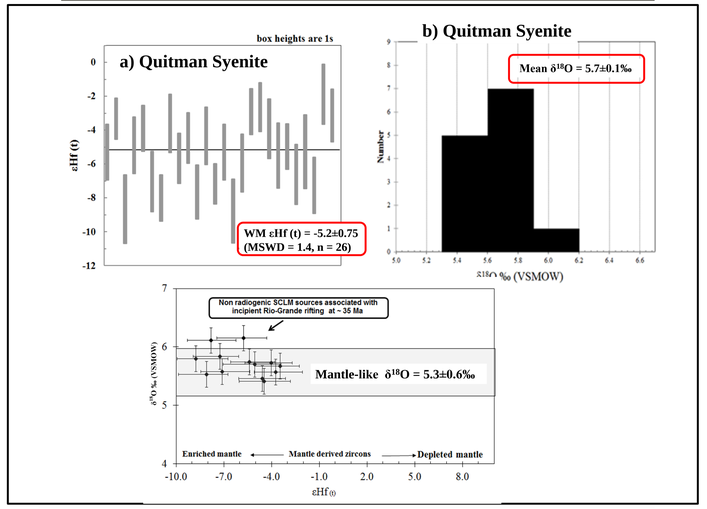
Zircon U-Pb Age, Quitman Caldera, eastern part of RGR



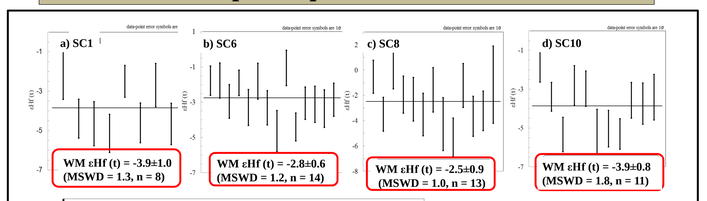
Zircon U-Pb Ages Sierra Candelaria Caldera, western part of RGR

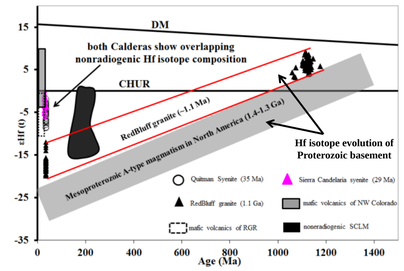


Zircon Hf-O isotope composition of Quitman Syenite



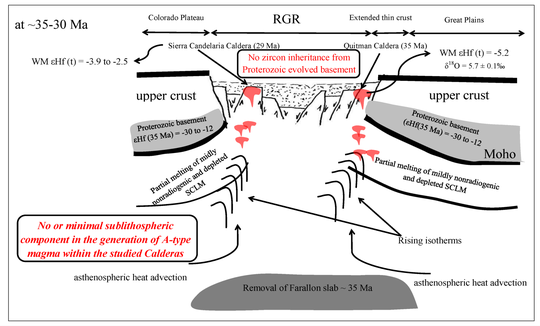
Zircon Hf isotope composition of Sierra Candelaria





The Hf isotope composition of Sierra Candelaria (εHf (t) = -2.5 to -3.9) from western part of RGR is 1-2 epsilon units more radiogenic than the Quitman syenite (i.e., weighted mean εHf (t) = -5.1 ± 0.8) at the eastern margin of the RGR. This indicates some contribution of less evolved mafic sources during a 6 Ma younger thermal event.

The Quitman syenite inheritance free zircons yielded typical mantle-like oxygen isotope composition with mean $\delta^{18}O$ = 5.7 ‰.



CONCLUSION

- **The caldera-related, alkaline magmatism in the eastern and western part of the southern Rio Grande Rift is recorded at 35 Ma and 29 Ma, respectively. These ages are consistent with the previous ages reported from the Calderas in the central and northern RGR. The westward younging pattern is consistent with previous geochronological data. The indistinguishable U-Pb apatite ages indicates shallow emplacement and rapid cooling at least from > 800 ^{0}C to less than 500 ^{0}C.**
- **During 35 to 30 Ma the progressive removal of Farallon plate is manifested by regional scale extension that has facilitated the formation of Rio Grande rift and Basin and Range structures of western North America.**
- **The removal of Farallon plate assisted the heat advection from asthenosphere which partially melted the mildly nonradiogenic Subcontinental Lithospheric Mantle (SCLM) possibly, along the entire eastern and western parts of the RGR producing peralkaline A-type parental magmas that has emplaced in the Calderas. However the observed Hf isotope composition is too nonradiogenic to consider any material contribution from sublithospheric mantle.**
- **We did not encountered any zircon inheritance from Proterozoic basement. This coupled with mantle-like oxygen isotope composition suggest minimal role of partial melting of preexisting crustal sources, possibly such a basement might have replaced by upwelling decompressing asthenosphere and/or SCLM.**

ACKNOWLEDGEMENTS

We are grateful to Dominique Giesler and Mark Pecha from University of Arizona for technical assistance in the isotopic data (U–Pb and Hf) acquisition and zircon BSE & CL-imaging. Authors also thank to Arturo Ramirez for construction the regional and local geological maps.