PALEOMAGNETIC STUDY OF CRETACEOUS SEDIMENTARY AND VOLCANIC ROCKS IN NORTHERN CHILE

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1)Introduction

The northernmost part of Chile, or the Arica region is an important area because it just corresponds to the zone of Arica-Santa Cruz deflection. In this article, we report Cretaceous paleomagnetic data of this region from red sandstone of Atajaña Formation and from one dike swarm (Arica dike swarm). Detailed interpretations are given in other papers (Heki et al., 1983; Heki, 1983).

2)Geology

Jurassic Arica Group is overlain unconformably by Neocomian Vilacollo Group, which consists of two supposedly synchronous formations: Atajaña Formation and Sausine Formation (Salas et al., 1966). Both units are composed of andesitic volcanics and continental clastic sediments and are overlain unconformably by Tertiary Azapa and Oxaya Formations.

Atajaña Formation crops out at the Cordillera de la Costa and consists of conglomerates, sandstone and andesite lava flows. It was first defined by Cecioni and Garcia (1960) for the rocks in Atajaña mountain in the department of Pisagua. In the Coastal Cordillera of Arica department, lithologically very similar rock sequences overlying Arica Group were found and suggested to correspond to Atajaña Formation by Salas et al. (1966).

Along Quebrada Vitor, some 30km south of the city of

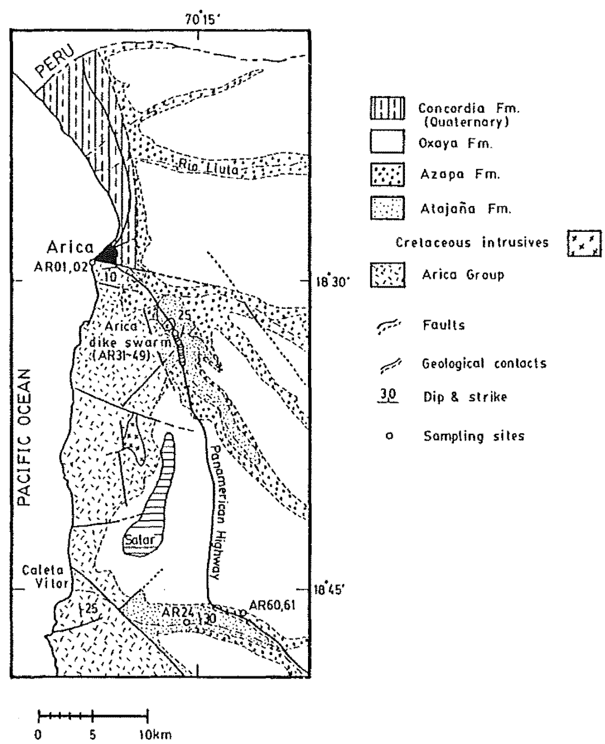


Fig.1 Geologic map (Salas et al., 1966) and sampling sites.

Arica, well stratified coase reddish violet sandstones crop out and are considered to correspond to the middle member of Atajaña Formation (Salas et al.,1966). 28 hand samples were taken from seven different horizons of very coarse to coarse grained sandstone layer in this exposure (AR24; 61, 51-54, 41-44, 31-35, 21-24, 11-14, 01-04, in ascending order). In Quebrada de la Higuera, some 10km southeast of the city of Arica, a basaltic and andesitic dike swarm was found in the red sandstone and tuff breccia layer of Atajaña Formation (named "Arica dike swarm"; Fig.1). Dikes trend generally east-west which is perpendicular to the general trend of dikes in Cuya dike swarm intruding into Jurassic strata (Heki et al., 1984) 50km south of Arica dike swarm. Thicknesses are typically 1-2m. Six hand samples were taken from each of 19 dikes (AR31-49) exposed along the Panamerican Highway. Country rocks have southward dip of about 15° with strike of N60°E. 6 paleomagnetic samples were also taken from the country rock (AR50) at the place far from the adjacent dikes. No thermal effects of dikes are considered to be present for AR50 samples.

2) Experimental procedure and paleomagnetic results

Red sandstone (AR24) Magnetic remanences of AR24 red sandstones were measured using a Schonstedt spinner magnetometer in University of Tokyo. Original NRM intensities are fairly uniform irrespective of their sampling horizons and are typically around 1×10^{-5} Am^2/kg. Alternating field (AF) demagntization performed up to 200mT only destroyed one fourth of the original intensity and was found to be ineffective. Instead of AF, stepwise thermal demagnetizations were performed on all specimens. Blocking temperatures were found to be distributed up to over 650°C suggesting the existence of hematite as the major carrior of the remanences (Fig.2). Magnetization directions showed little

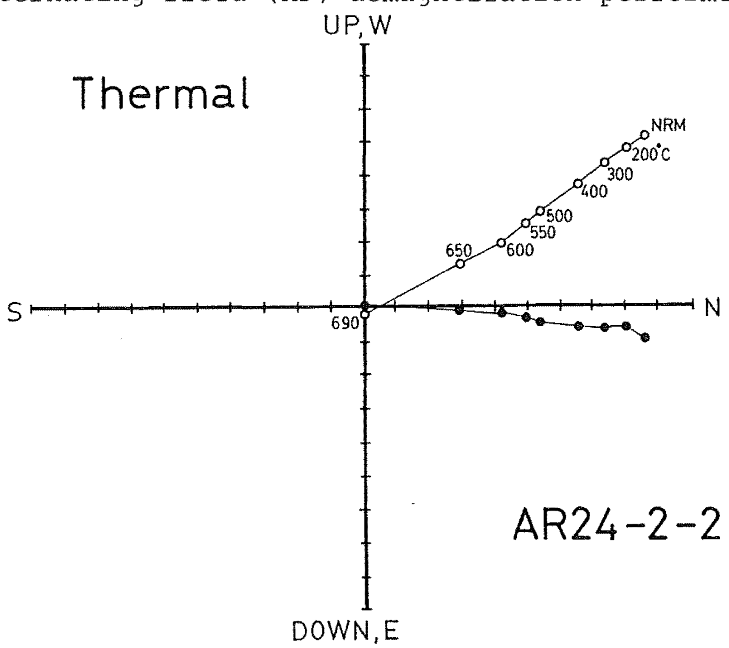


Fig.2 Zijderveld diagram in thermal demagnetization on AR24-2-2. Open and solid symbols denote projections onto vertical and horizontal planes respectively.

change after the demagnetization up to 600°C. As paleofield directions, those at 600°C step were adopted. Bedding corrections were made on these directions. All specimens showed normal polarity directions with the declination a little counterclockwisely deviated from north. No significant direction/intensity differences were detected among seven horizons. Paleomagnetic results are listed and illustrated in Table 1 and Fig.3 respectively.

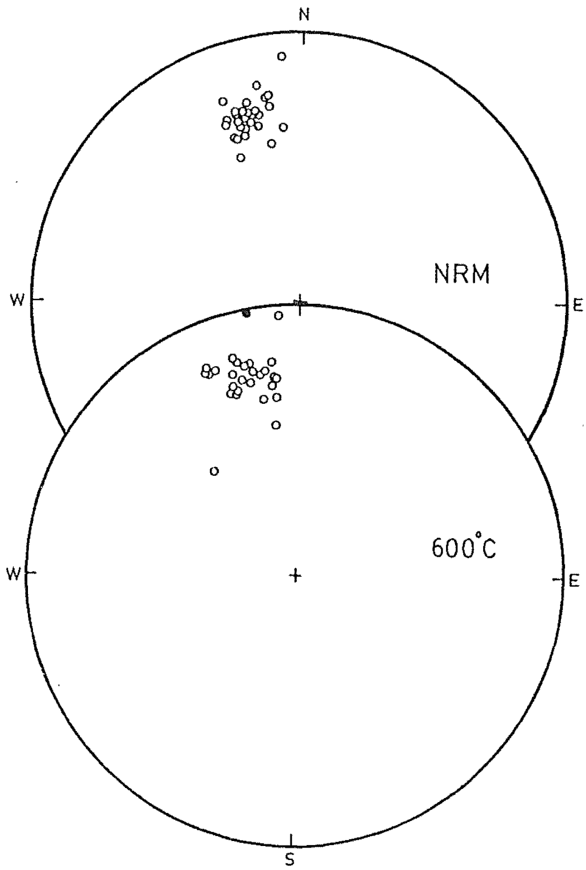
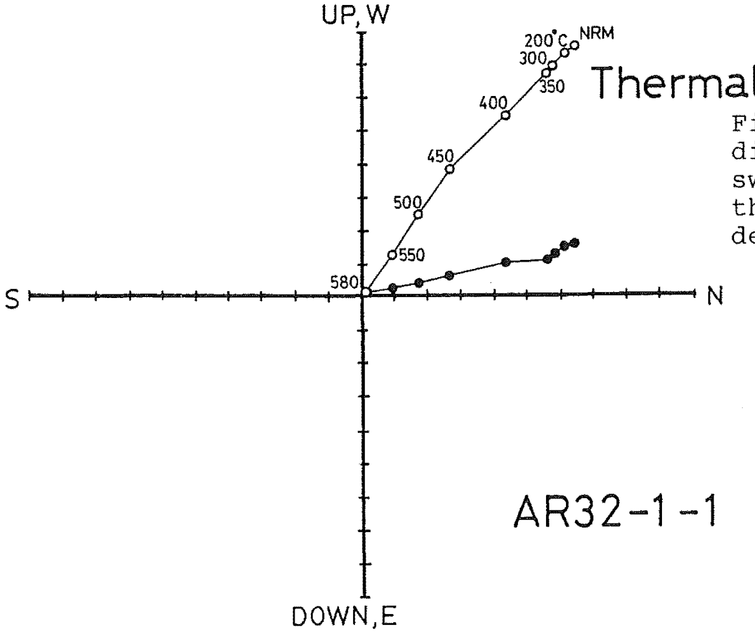


Fig.3 Lambert equal area projection of the field direction of AR24 at NRM step and 600°C step. Open and solid circles indicate negative and positive inclinations respectively.

<u>Dikes (AR31-49) and their country rocks (AR50)</u> Also a spinner magnetometer was used in these rocks. Dikes showed NRM intensities typically of the order of 10^{-5} Am^2/kg. Each dike specimen was stepwisely demagnetized in AF. MDFs were generally between 10 and 15mT. Several specimens were also thermally demagnetized. Zijderveld diagrams (Fig.4) of both kinds of demagnetization demonstrate that NRMs consist of stable single component with minor amount of secondary overprint. Paleofield directions were determined from the gradients of the linear portions of the demagnetization diagrams in principle. For several dikes (AR46, 49) which had large secondary magnetization and did not present sufficient length of linear portion, certain optimum demagnetization steps were selected by minimum dispersion criterion. No structural corrections were made on field directions because the intrusions are considered to be post-folding from the field observation of the attitude of dike contacts. All these directions showed normal polarities and also deviate by 10°-20° from north. Dike mean field directions are illustrated and listed in Fig.5 and Table 1 respectively.

For the host rocks (AR50), AF demagnetization up to 200mT reduced about a half of their original NRM intensities. Direction of remanent magnetization slightly changes its direction after AF demagnetization at 200mT. Stepwise thermal demagnetization was carried out on the specimens after AF demagnetization and showed



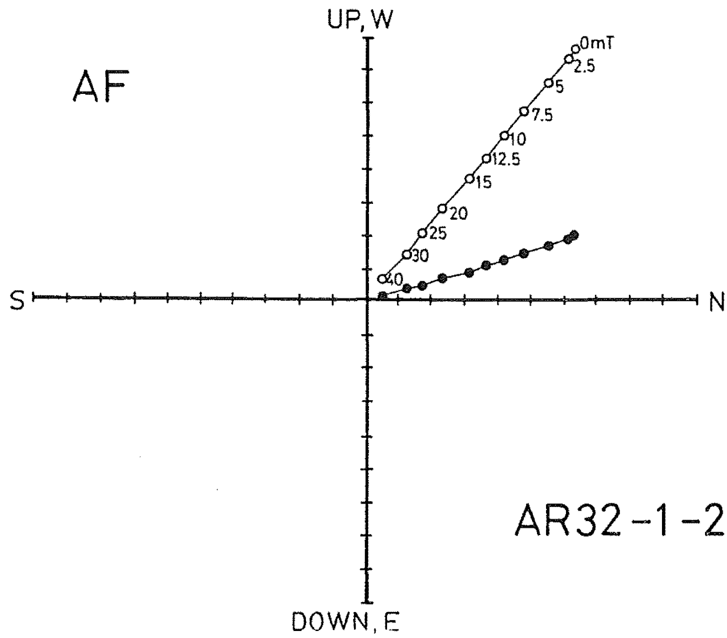


Fig.4 Zijderveld diagram of Arica dike swarm specimens in thermal and AF demagnetization.

that upon further thermal treatment the direction of decreasing remanence remain steady, proving only one component was left after AF demagnetization. Field directions of AR50 after 200mT AF demagnetization were compared with that of AR24 red sandstone which was sampled in Quebrada Vitor some 20km south of AR50 and has a bedding plane different from AR50. Positive fold test

(Graham, 1949) shows these remanences are pre-folding (Fig. 6) and structural corrections are necessary on these directions.

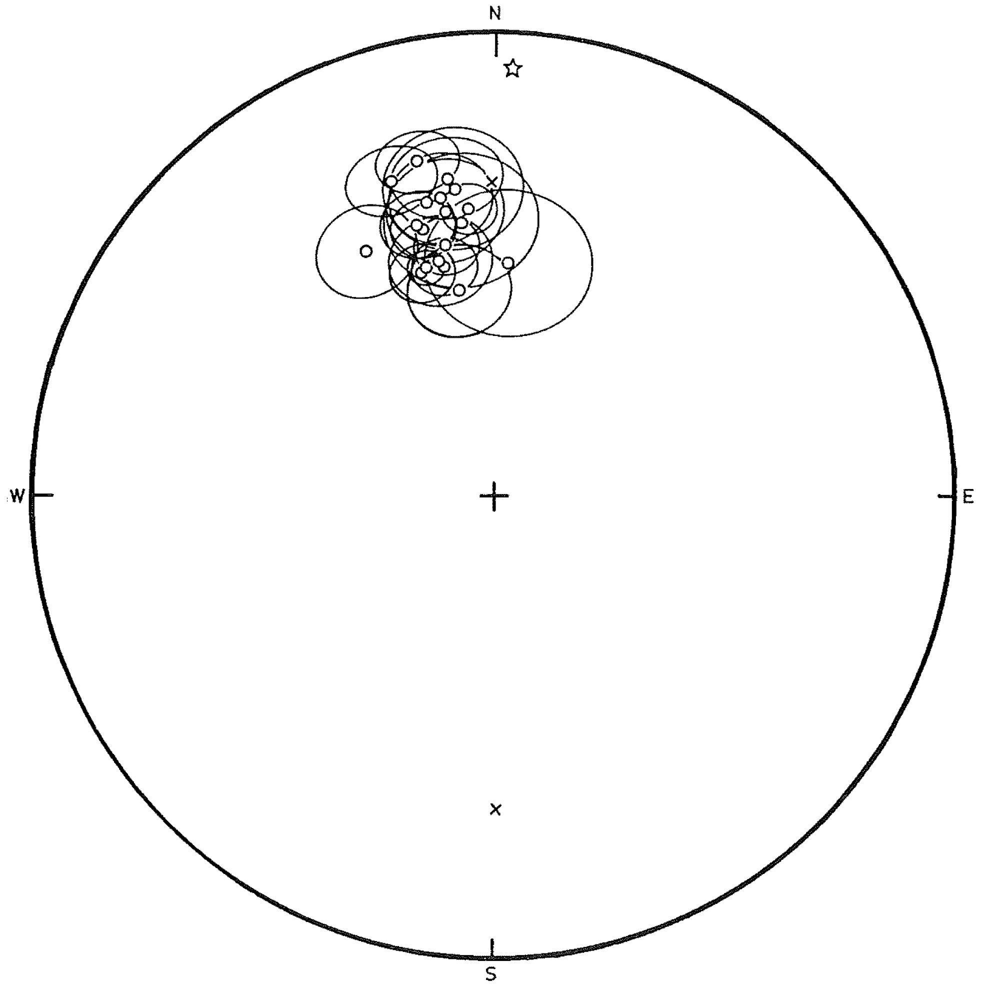


Fig.5 Lambert equal area projection of field direction obtained in Arica dike swarm (AR31-49). 95% confidence circles after Fisher (1953) are also illustrated. Star indicate present field direction in Arica region. X shows present axial dipole field direction. All inclinations are negative (upward).

3) Discussion

Paleofield directions of 28 specimens in AR24 were averaged and the pole corresponding to this mean direction was calculated. This pole is very similar to the Jurassic poles of this region in Heki et al. (1984).

VGPs of 19 dike mean field directions yielded the angular standard deviation (ASD) value of 7.2° with 95% confidence interval between 5.9° and 9.4°. This is considerably small in comparison with the value expected from Late Cenozoic global trend (McElhinny and Merrill, 1975). There are two possible

Table 1. Paleomagnetic directional data of Cretaceous rocks in northern Chile

Site	N	Incl. (°)	Decl. (°)	R	k	α_{95} (°)	Step (°C,mT)	Pole Lat. (°N)	Pole Long. (°E)
(sedimentary rocks)									
AR24									
1-4	4	-27.3	-7.7	3.9859	213	6.3	650	81.5	-132.2
11-14	4	-21.7	-16.4	3.9827	173	7.0	600	72.5	-137.7
21-24	4	-23.2	-11.7	3.9094	33	16.2	600	77.0	-132.0
31-34	4	-25.5	-19.5	3.9775	133	8.0	600	70.6	-147.7
41-44	4	-24.9	-12.8	3.9633	82	10.2	600	76.5	-138.0
51-54	4	-25.5	-13.3	3.8266	17	22.7	600	76.2	-140.2
61-64	4	-30.0	-24.7	3.8876	27	18.1	600	66.3	-158.1
total	28	-25.6	-14.9	27.4089	46	4.1	600	74.7	-142.1
(volcanic rocks)									
AR31	5	-39.0	-5.3	4.9825	228	5.1	LSF	84.0	164.1
AR32	7	-45.0	-11.6	6.9526	127	5.4	LSF	76.7	160.9
AR33	5	-36.1	-13.8	4.9709	138	6.5	LSF	76.9	191.2
AR34	5	-32.6	-8.8	4.9508	81	8.5	LSF	81.6	-155.8
AR35	6	-41.0	-15.4	5.9646	141	5.7	LSF	74.8	178.2
AR36	3	-48.1	-17.0	2.9986	1388	3.3	LSF	71.3	162.4
AR37	5	-38.7	-10.0	4.9448	73	10.0	LSF	80.1	179.0
AR38	6	-41.0	-28.1	5.9161	60	8.8	LSF	63.4	184.2
AR39	5	-30.4	-18.8	4.9646	113	7.2	LSF	71.9	-156.1
AR40	6	-53.5	-10.2	5.9216	64	8.5	LSF	72.1	138.2
AR41	6	-40.0	-16.1	5.9567	116	6.3	LSF	74.4	181.5
AR42	4	-41.4	-7.1	3.9355	47	13.6	LSF	81.6	160.4
AR43	6	-47.9	-13.6	5.9285	70	8.1	LSF	73.8	157.3
AR44	6	-48.9	-13.2	5.9658	146	5.6	LSF	73.6	154.2
AR45	5	-49.4	3.1	4.8797	33	13.5	LSF	78.0	96.7
AR46	6	-36.1	-10.5	5.9054	53	9.3	10	80.0	189.8
AR47	6	-48.8	-18.2	5.9690	161	5.3	LSF	70.1	162.4
AR48	6	-28.0	-13.4	5.9532	107	6.5	LSF	76.6	-146.2
AR49	5	-34.9	-7.7	4.9180	49	11.1	12.5	82.7	193.5
AR50	6	-30.9	-10.1	5.9811	265	4.1	LSF	80.2	-150.5
AR50	6	-27.9	-23.3	5.9873	395	3.4	200	67.4	-154.2

N:number of samples studied, R:length of the resultant vector, k:precision parameter, α_{95}:radius of 95% confidence circle, Step: optimum demagnetizing step (LSF means that field direction was determined by least square fitting to the linear portion of the demagnetization diagram).

Fig.6 Field direction of Atajaña formation in AR24 and AR50 before (small symbols) and after (large symbols) the bedding correction. 95% confidence circles are also illustrated for directions after the correction.

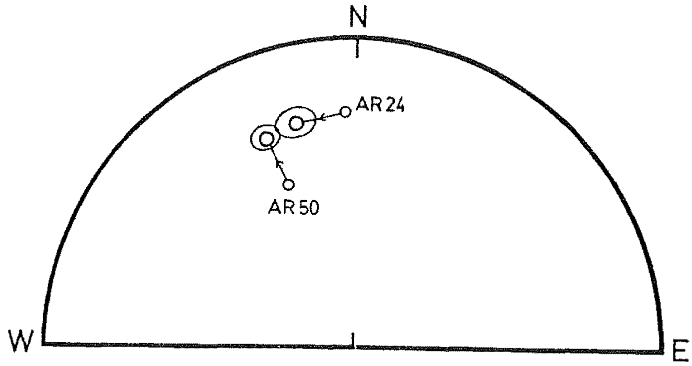
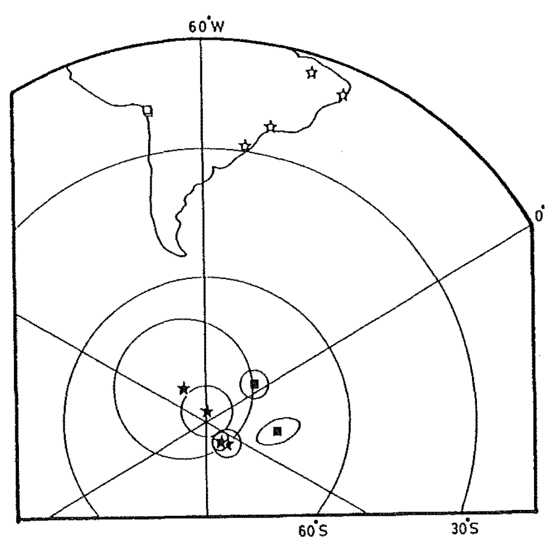


Table 2. Cretaceous poles in the northern Chile.

Rock unit	Locality Lat. (°S)	Locality Long. (°W)	Age	Pole Lat. (°S)	Pole Long. (°E)	dp (°)	dm (°)	A_{95} (°)
Atajaña Formation (AR24)	18.6	70.3	Kl	74.7	37.9	2.4	4.4	
Arica dike swarm (AR31-49)	18.6	70.3	K	77.2	352.4			3.3

Poles are converted to southern hemisphere poles. dp:radius of confidence oval measured in the direction from site toward pole, dm:radius of 95% confidence oval measured perpendicular to dp, A_{95}:radius of 95% confidence circle, K:Cretaceous, Kl:Lower Cretaceous.

Fig.7 Cretaceous paleomagnetic poles of Arica region (squares) and stable platform (stars) and their 95% confidence circles/ovals. Corresponding sites are illustrated as small open symbols in the map. After Heki (1983).



explanations: one that paleosecular variation is considerably smaller in the Cretaceous time than in Late Cenozoic time (Irving and Pullaiah, 1976) and another that these dike intrusions occurred in relatively short time length than the sufficient time span to contain the whole paleosecular variation periods. If the latter interpretation is correct, there might be small departure of their mean pole from true time-averaged pole. Cretaceous paleomagnetic poles of Arica region reported here are listed in Table 2 and are illustrated in Fig.7.

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